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领域一

绿色水产养殖新技术新模式

“鱼-菜-鳅”养殖模式研究

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摘要: 为增加经济效益, 利用鱼菜养种模式中 PVC 漂浮浮床中央形成的空间养殖泥鳅。结果表明: 普通浮床与泥鳅养殖浮床空心菜产量差异较小, 在 PVC 漂浮浮床中央形成的空间养殖泥鳅不影响空心菜的生长; 普通浮床泥鳅养殖产量达 2.64kg/m²、最大 70g/尾、平均重 36.4g, 说明普通浮床不需要改进加深也可以进行泥鳅养殖; 网箱加深浮床泥鳅最高产量达到 3.8kg/m², 每平方米可增加纯收入 36.4 元, 经济效益高, “鱼-菜-鳅”养殖模式可行。

关键词: 鱼; 菜; 鳅; 养殖模式; 研究

Study on the culture mode of "fish vegetable loach"

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Abstract: In order to increase economic benefits, loach was cultured in the space formed in the center of PVC floating bed in fish and vegetable breeding mode. The results showed that: there was little difference in the yield of water spinach between ordinary floating bed and loach culture floating bed, and the space formed in the center of PVC floating bed did not affect the growth of water spinach; the yield of common floating bed loach reached 2.64 kg / m², the maximum of 70 g / tail, and the average weight of 36.4 g, indicating that the ordinary floating bed could be used for loach culture without improvement and deepening; the maximum yield of loach in cage deepening floating bed reached 38 kg / m², and the net income per square meter can be increased by 36.4 yuan. The "fish vegetable loach" culture mode is feasible.

Key words: Fish, food, loach, breeding mode, research

“三池两坝”多级组合工艺对内陆池塘养殖尾水的处理技术研究

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摘要: 针对内陆淡水池塘养殖尾水分布及污染特点, 采用沉淀池+过滤坝+曝气池+过滤坝+生态池(简称“三池两坝”)多级组合处理工艺对池塘养殖尾水进行处理, 并构建了一个数值优化模型。考察组合工艺对低污染、中污染、高污染类型对应的3个示范点尾水去除效果及各单元的沿程去除情况, 并对工程建设投资及运行费用进行分析。结果表明, (1)基于系统动力学模拟构建的三池两坝数值优化模型, 经过校准和验证, 水质测误差在20%以内, 可以用来优化各处理单元配比面积; (2)3个示范点对TSS、COD_{Mn}、TN、TP和NH₄⁺-N的去除率分别为48.1%-60.7%、50.4%-60.7%、52.5%-59.2%、64.2%-71.5%和72.1%-80.5%, 均能达标排放; (3)沉淀池对TSS去除效果最好, 为21.3%, 曝气池对COD_{Mn}和NH₄⁺-N的去除贡献最大, 为18.7%和28.7%, 生态池对TN和TP的去除贡献最大, 为16.3%和28.8%, 过滤坝则对各水质指标均具有良好的去除效果, 去除率为7.5%-11.8%; (4)3个示范点养殖池塘尾水工程建设费用分别为1.370万、2.775万和1.304万元/hm², 每年分摊到养殖池塘运行维护费用分别为0.325万、0.387万和0.400万元/hm²。

关键词: 三池两坝; 内陆养殖池塘; 养殖尾水; 达标排放; 循环利用

Application of "three ponds and two dams" combination ecological treatment system to improve aquaculture wastewater from inland aquaculture ponds

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Abstract: According to the distribution and pollution characteristics of aquaculture wastewater from inland ponds, the "sedimentation pond + filter dam + aeration pond + filter dam + ecological pond" (referred to as "three ponds and two dams") combined treatment system was adopted to purifying the aquaculture wastewater. (1) Numerical model of treatment system was established based on the System Dynamics. The error was less than 20% which can be used to optimize the ratio area of each treatment unit. (2) The results showed that the average removal rates of TSS, COD_{Mn}, TN, TP and NH₄⁺-N in the three demonstration sites ranged from 48.1% to 60.7%, 50.4% to 60.7%, 52.5% to 59.2%, 64.2% to 71.5% and 72.1% to 80.5%, respectively. Water quality at the outlets was improved obviously and meet the requirement of standard discharge. (3) Sedimentation pond has the best purifying effects on TSS with the removal rate of 21.3%. Aeration pond has the largest contribution to COD_{Mn} and NH₄⁺-N removal rates with 18.7% and 28.7%. Ecological pond has the largest contribution to TN and TP removal rates with 16.3% and 28.8%. The filter dam has good removal effect on all water quality indexes, and the removal range is 7.5%~11.8%. (4) The construction cost of the projects allocating to the ponds were only 13 700, 27 750 and 13 040 yuan/hm². The annual operating and maintenance costs allocating to the ponds every year were 3 250, 3 870 and 4 000 yuan/hm² respectively.

Key words: "Three ponds and two dams", aquaculture wastewater, up to standard discharge, Numerical model

3 种不同类型饲料对繁育期克氏原螯虾肌肉营养指标的影响

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摘要: 克氏原螯虾产业的快速发展为广大农民增收致富带来了新途径, 而在养殖阶段如何提高其营养摄取、降低饲料成本却是影响养殖收益的关键。本文利用 2 种配合饲料和大豆做营养来源投喂克氏原螯虾, 研究在不同营养条件下对克氏原螯虾繁育期肌肉营养指标的变化。结果表明, 在投喂 3 种不同蛋白含量的饲料对克氏原螯虾肌肉蛋白质含量有明显影响, 而对其脂肪含量并无明显影响, 蛋白质含量和脂肪含量呈现正相关。月份与蛋白质有着极显著相关性, 所选三种不同饲料对虾的蛋白含量有着极显著的影响 ($P < 0.05$)。

关键词: 克氏原螯虾; 蛋白含量; 营养指标; 配合饲料

Effects of Three Different Types of Feed on Muscle Nutritional Indexes in the Breeding Period of *Procambarus clarkii* in Breeding Period

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Abstract: The rapid development of *Procambarus clarkii* industry has brought a new way for farmers to increase their income. However, how to improve their nutrition intake and reduce the cost of feed is the key to affect the income of farming. In this paper, two kinds of compound feed and soybean were used as nutritional sources to feed *Procambarus clarkii* to study the changes of muscle nutritional indexes of *Procambarus clarkii* under different nutritional conditions. There was no significant effect on the protein content of the three diets. There was a significant correlation between the month and protein content, and the protein content of three different diets had a significant effect ($P < 0.05$).

Key words: *Procambarus clarkia*, protein content, nutritional index, formulated feed

“168”生态循环养殖模式

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摘要: 自 2018 年以来, 河南省经过 3 年时间探索创新, 总结出的一种新型集约化水产养殖模式, 该模式具有简单、高效、投资少、见效快等优点。本文介绍了该模式的技术要点、运行管理的注意事项以及关键技术。创新点是经过科学设计, 该模式改变了传统池塘养殖模式的弊端, 通过漏斗型底部池塘的高效集污排污.....

关键词: “168”; 生态循环; 养殖模式

“168” eco-cycled aquaculture model

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Abstract: After three years' exploration and innovation, Henan province summarizes an eco-cycled aquaculture new model which is simple to use and highly efficient, needs low investment and produces quick returns. It is stated in the article that what are the key technical points, how to manage the operation and what should be specially noticed. The innovations are that funnel type bottom is implemented so that leftovers and feces can be concentrated and removed from the system. This method avoids defects of traditional pond culture which is hard to get sludge out of water promptly. Bio-filtration.....

Key words: "168", eco-cycle, aquaculture model

水产养殖尾水处理技术与应用

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摘要: 目前, 我国水产养殖处于快速发展时期, 养殖规模逐渐扩大, 养殖尾水排放量增加, 导致环境污染日益严重。按照传统养殖方法, 大量的残饵和粪便排入水体, 致使水体悬浮物质、 COD_{Mn} 、含氮有机物和含磷有机物等污染物含量升高, 最终导致水体富营养化及养殖水域生态失调。因此, 养殖尾水达标排放或循环利用已成为研究水产养殖可持续发展的关键环节。本文主要分析了水产养殖尾水特点, 综合评述了目前尾水处理的物理、化学、生物三种技术优、缺点, 以及池塘、设施、人工湿地等三种尾水处理方式的研究现状。最后, 提出养殖尾水生态处理的开发与应用模式, 为今后水产养殖业健康、可持续发展提供参考。

关键词: 水产养殖; 富营养化; 尾水处理。

Technology and application of aquaculture tail water treatment

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Abstract: At present, China's aquaculture is in a period of rapid development, the scale of aquaculture is gradually expanding, and the discharge of aquaculture tail water is increasing, resulting in increasingly serious environmental pollution. According to traditional breeding methods, a large amount of residual bait and feces are discharged into the water body, causing the content of pollutants such as suspended matter, COD_{Mn} , nitrogen-containing organic matter and phosphorus-containing organic matter to increase, which ultimately leads to eutrophication of the water body and ecological imbalance of the breeding water area. Therefore, the discharge or recycling of aquaculture tail water has become a key link in the study of the sustainable development of aquaculture. This article mainly analyzes the characteristics of aquaculture tail water, and comprehensively reviews the current research status of the three methods of tail water treatment, including physical, chemical, and biological technologies, as well as ponds, facilities, and constructed wetlands. Finally, the development and application model of ecological treatment of aquaculture tail water is proposed to provide references for the healthy and sustainable development of aquaculture industry in the future.

Key words: Aquaculture, eutrophication, tail water treatment

基于电子舌技术评价不同产地中华绒螯蟹肉 滋味品质评价

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摘要: 口感滋味是科学定量评价各类商品规格中华绒螯蟹(大闸蟹)品质的重要方面。本研究对阳澄湖内围网养殖的大闸蟹(YCES)、市售标称为阳澄湖产大闸蟹(SCES)以及池塘养殖的江苏兴化泓膏大闸蟹(HGES)等三类中华绒螯蟹的鲜活个体进行烹蒸熟制,再利日本 INSENT SA402B 型味觉分析系统,对其蟹肉部分进行了酸、苦、咸、甜、鲜等味觉值的检测;在掌握大闸蟹总体滋味水平的基础上,比较分析上述三类大闸蟹各自的味觉特征,以期为客观评价不同来源大闸蟹滋味品质提供基础资料和理论依据。结果发现,新鲜蒸制的中华绒螯蟹样本都有非常突出的鲜味(18.7~20.8),较高的甜味(13.1~15.8),明显的味道丰富性(3.0~4.7),较低的苦回味(0.1~2.3)及个体味觉值差异较大的盐味(10.8~18.0)和苦味(4.8~10.2);总体而言鲜味对蟹肉的滋味贡献最大,苦回味值最小,样本均无酸味、涩味及涩的回味。主成分分析表明阳澄湖与其它两类蟹间的区分主要在鲜味和味道丰富性上。线性判别分析的结果显示,初始验证的判别准确率为100%。各类样本没有重叠现象。本研究表明,上述味觉分析系统所做模拟人味觉的识别实现了对酸、苦、咸、甜、鲜5种基本味和涩味等的量化评价。其结果可以较准确地描绘中华绒螯蟹的滋味轮廓,而滋味强度值具有区分产地或类型滋味特征差异性的潜力,适合作为快速评定中华绒螯蟹滋味特征的技术手段。

关键词: 中华绒螯蟹; 味觉分析系统; 滋味特征值; 主成分分析; 线性判别分析; 来源判别

Taste profile for meat of Chinese mitten crab (*Eriocheir sinensis*) from different origins by electronic tongue analysis

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Abstract: Taste is of high importance to Chinese mitten crabs (*Eriocheir sinensis*) from different origins. A taste sensing system (SA402B) was applied to evaluate the taste characteristics of the meats of genuine *Eriocheir sinensis* from the large purse seine culture area in the Yangcheng Lake of the Suzhou City, labeled Yangcheng Lake crabs in market of the Wuxi City and those crabs from the aquaculture pond area in Jiangsu Honggao Co., Ltd. of Chinese Mitten Crab in Xinghua City. The electronic tongue data showed that umami was the most predominant taste in steamed meat with a taste-active value (TAV) of 18.7–20.8, followed by sweetness (TAV = 13.1–15.8). Richness in all meat samples of the crab were obvious (TAV = 3.0–4.7). TAV for saltiness (TAV = 10.8–18.0) and bitterness (TAV = 4.8–10.2) varied widely among geographic origins. There were no TAVs in sourness, astringency, aftertaste-A and only slight TAVs in aftertaste-B (0.1–2.3). The principal component analysis (PCA) score plot exhibited a clear grouping trend among the three classifications of crab groups. Linear discriminant analysis revealed that the accuracy of initial verification was as high as 100%. The scatter plot showed that all the three crab groups could be clearly separated from each other. The results of the present study suggest that the taste sensing system can accurately profile the taste characteristics of *E. sinensis* from different crab groups and that the electronic tongue data have the potential to origin discrimination for the *E. sinensis* crabs.

Key words: *Eriocheir sinensis*, taste sensing system, taste-active values, principal component analysis, linear discriminant analysis, origin discrimination

养殖密度对流水养殖系统中虹鳟幼鱼生长性能及抗氧化能力的影响

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摘要: 本实验以初始体重为 $4.66\pm 0.26\text{g}$ 的虹鳟(*Oncorhynchus mykiss*)幼鱼为研究对象, 研究了 200 尾/池 ($2.33\text{kg}/\text{m}^3$, LSD)、400 尾/池 ($4.66\text{kg}/\text{m}^3$, MSD)、600 尾/池 ($6.99\text{kg}/\text{m}^3$, HSD) 三个养殖密度对虹鳟幼鱼生长、氧化应激能力的影响, 同时我们也进行了肌肉转录组的分析。研究结果如下: 不同养殖密度的幼鱼增重率和特定生长率未出现显著性差异。随着养殖密度的增加, 鱼体的质量不断降低。在实验结束时, 中高密度组的 SOD 活性和 MDA 含量显著高于低密度组 ($p < 0.05$), 高密度组的 CAT 和 GSH-ST 活性显著高于低密度组 ($p < 0.05$)。肌肉转录组分析发掘了 5501 个新基因, 4121 个新基因得到注释, 同时发现 4030 个非冗余 DEGs, 38 个 DEGs 为 3 个比较组共有的。

关键词: 养殖密度; 虹鳟幼鱼; 生长; 抗氧化; 肌肉转录组

Effects of stocking density on growth performance and antioxidant capacity of juvenile rainbow trout in flowing water breeding system

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Abstract: In this experiment, the initial weight of $4.66\pm 0.26\text{g}$ of Juvenile Rainbow trout (*Oncorhynchus mykiss*) was taken as the research object, and the influences of three stocking densities—200 tail/pond ($2.33\text{kg}/\text{m}^3$, LSD), 400 tail/pond ($4.66\text{kg}/\text{m}^3$, MSD), and 600 tail/pond ($6.99\text{kg}/\text{m}^3$, HSD) on the growth and oxidative stress of rainbow trout were studied. Meanwhile, muscle transcriptomics were also analyzed. The results were as follows: there was no significant difference between the weight gain rate and specific growth rate of juvenile fish with different breeding densities. With the increase of breeding density, the quality of fish decreases continuously. At the end of the experiment, SOD activity and MDA content in the MSD and HSD significantly higher than those in the LSD ($p < 0.05$), and CAT and GSH-ST activities in the HSD were significantly higher than those in the LSD ($p < 0.05$). Muscle transcriptome analysis revealed 5501 new genes, 4121 new genes were annotated, and 4030 non-redundant DEGs were found, 38 of which were common among the three comparison groups.

Key words: Stocking density, Juvenile Rainbow trout, growth, antioxidant, muscle transcriptomics

养殖密度对流水养殖系统中西伯利亚杂交鲟幼鱼生长性能及抗氧化能力的影响

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摘要: 为研究流水养殖系统中不同养殖密度对西伯利亚杂交鲟(西伯利亚鲟 *Acipenser baerii* ♀ × 施氏鲟 *Acipenser schrenckii* ♂) 幼鱼生长、肝脏抗氧化能力的影响及肌肉的转录组分析。实验所用西伯利亚杂交鲟幼鱼初始体重为 $7.89 \pm 1.45\text{g}$, 分别放置在 $1.19\text{kg}/\text{m}^3$ (低)、 $1.70\text{kg}/\text{m}^3$ (中)、 $2.30\text{kg}/\text{m}^3$ (高) 3 个养殖密度在流水池塘系统中进行养殖。研究结果如下: 低密度组幼鱼增重率及特定生长率显著高于中密度组和高密度组 ($P < 0.05$)。肝脏超氧化物歧化酶(SOD)和谷胱甘肽硫转移酶(GSH-ST)的酶活力在实验末期低、中密度组显著高于高密度组 ($P < 0.05$)。随着养殖密度的增加, 幼鱼肝脏 MDA 含量不断增加, 过氧化物酶(CAT)活力减弱。肌肉转录组分析发掘 15549 个新基因; 两两密度组比较, 出现了 611 个非冗余 DEGs, 其中有 1 个 DEG 是三个组共有的。

关键词: 养殖密度; 西伯利亚杂交鲟幼鱼; 生长; 抗氧化; 肌肉转录组

The influence of stocking density on growth performance and antioxidant capacity of Juvenile Siberian hybrid sturgeon in flowing water breeding system

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Abstract: The purpose of this study was to study the effects of different stocking densities on the growth and antioxidant capacity of the liver of Siberian hybrid sturgeon (*Acipenser baerii* ♀ × *Acipenser schrenckii* ♂) and muscle transcriptomics in flowing water breeding system. The initial weight juvenile Siberian sturgeons was $7.89 \pm 1.45\text{g}$. The three stocking densities of $1.19\text{kg}/\text{m}^3$ (LSD), $1.70\text{kg}/\text{m}^3$ (MSD) and $2.30\text{kg}/\text{m}^3$ (HSD) were respectively placed in the flowing water breeding system. The results were as follows: the juvenile weight gain rate and specific growth rate of the LSD were significantly higher than that of the MSD and HSD ($P < 0.05$). The activity of liver SOD and GSH-ST in the LSD and MSD was significantly higher than that in the HSD at the end of the experiment ($P < 0.05$). With the increase of culture density, MDA content in juvenile fish liver increased and CAT decreased. Muscle transcriptome analysis revealed 15,549 new genes. Comparing the density groups in pairs, 611 non-redundant DEGs appear, one of which is common to the three groups.

Key words: Stocking density, juvenile siberian hybrid sturgeon, growth, antioxidant, nutrients, muscle transcriptome

大口黑鲈(*Micropterus salmoides*)不同养殖模式氮磷收支及养殖效果研究

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摘要: 为了揭示池塘内循环流水养殖模式 (Inner-Pond Raceway Aquaculture, IPRA) 氮磷收支变化及养殖效果情况, 合理评价 IPRA 的经济与生态效益, 通过定期采样计算氮磷的输入和输出项目, 同时设置传统常规养殖池塘 (Usual Pond Aquaculture, UPA) 为对照组。结果表明: (1) 两种养殖模式中, 饲料是池塘氮、磷输入的主要来源, 分别占 IPRA 和 UPA 池塘氮输入的 $95.02 \pm 2.308\%$ 和 $93.19 \pm 2.75\%$, 占两种模式磷输入的 $93.19 \pm 2.75\%$ 和 $91.81 \pm 4.44\%$, 其它输入项目占比较小, 两者差异不显著 ($P > 0.05$); (2) 底泥沉积是氮、磷输出的主要方式, 占 IPRA 和 UPA 氮输出的 $45.16 \pm 1.31\%$ 和 $53.98 \pm 1.48\%$, 占磷输出的 $40.28 \pm 3.19\%$ 和 $59.59 \pm 4.45\%$, 差异显著 ($P < 0.05$); (3) IPRA 对氮的绝对和相对利用率高于 UPA, 但差异不显著 ($P > 0.05$), 而对磷的利用率显著高于 UPA, IPRA 提高了养殖对象对氮、磷的吸收利用率, 将氮、磷更优先转化为蛋白质; (4) IPRA 耗水系数、排水系数及排污系数均显著低于 UPA ($P < 0.05$), 但 IPRA 养殖效益显著高于 UPA ($P < 0.05$), 具有显著的经济和生态效益。

关键词: 池塘内循环流水养殖; 大口黑鲈(*Micropterus salmoides*); 氮磷收支; 养殖效果

A Comparative Study on Nitrogen and Phosphorus Budget and Aquaculture Effect of *Micropterus Salmoides* under IPRA and UPA

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Abstract: To discuss the changes of nitrogen and phosphorus budget and aquaculture effect of Inner-Pond Raceway Aquaculture (IPRA), expound its ecological characteristics, nutrient orientation, and rationally evaluate the ecological and economic benefits of IPRA, the input and output of nitrogen and phosphorus were analyzed through regular sampling. And Usual Pond Aquaculture (UPA) was set as the control treatment. Results showed that: (1) feed was the main source of nitrogen and phosphorus input, accounting for $93.19 \pm 2.75\%$ and $91.81 \pm 4.44\%$ of the nitrogen input, and $93.19 \pm 2.75\%$ and $91.81 \pm 4.44\%$ of the phosphorus input in IPRA and UPA. (2) Sediment deposition was the main mode of nitrogen and phosphorus output, accounting for $45.16 \pm 1.31\%$ and $53.98 \pm 1.48\%$ of nitrogen output as well as $40.28 \pm 3.19\%$ and $59.59 \pm 4.45\%$ of phosphorus output in IPRA and UPA with $P < 0.05$. (3) The relative and absolute utilization rates of nitrogen and phosphorus in IPRA were significantly higher than those in UPA ($P < 0.05$). IPRA improves the utilization rates of nitrogen and phosphorus in the breeding object. (4) Water consumption coefficient, drainage coefficient and pollution discharge coefficient of IPRA were significantly lower than those of UPA ($P < 0.05$). Benefit of IPRA was significantly higher than that of UPA ($P < 0.05$). Thus, IPRA has significant economic and ecological benefits.

Key words: IPRA, *Micropterus salmoides*, N and P budget, aquaculture effect

云龙石斑鱼胃排空特征和摄食消化特性研究

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摘要: 为阐明养殖新品种云龙石斑鱼(*E. moara* ♀ × *Epinephelus lanceolatus* ♂)摄食胃排空特征和消化酶活性变化规律, 本研究检测了体质量为(680.35±39.84) g 云龙石斑鱼摄食后胃内容物百分比, 比较了线性模型、平方根模型、立方模型 3 种数学模型对胃排空曲线的拟合程度, 分析了云龙石斑鱼摄食后血清中葡萄糖、皮质醇含量和肝脏消化酶活性变化, 并对胃排空率与消化酶进行了相关性分析。结果发现, 云龙石斑鱼摄食后, 胃排空率呈典型的先慢后快再慢的消化类型。3 种模型都能拟合云龙石斑鱼的胃排空数据, 其中立方模型拟合效果最佳。由立方模型可知, 云龙石斑鱼胃 80%排空(食欲基本恢复)时间为 9.5 h, 100%排空(食欲完全恢复)约为 14.8 h。血清中葡萄糖、皮质醇含量及肝脏中消化酶(淀粉酶、糜蛋白酶、脂肪酶)活性在摄食胃排空过程中均呈先升高后降低的趋势。综上, 基于云龙石斑鱼胃排空特征和摄食消化特性, 结合生产实践, 在食欲基本恢复后开始投喂, 投喂间隔为 10 h 左右, 每日投喂 2 次, 效果最佳。

关键词: 云龙石斑鱼; 胃排空率; 数学模型; 皮质醇; 葡萄糖; 消化酶

Characteristics of Gastric Evacuation and Feeding Digestion in “Yunlong” Groupers (*E. moara* ♀ × *Epinephelus lanceolatus* ♂)

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Abstract: In the present study, the gastric evacuation rates, hepatic and intestinal digestive enzyme activities, and serum glucose and cortisol concentrations in “Yunlong” groupers (*E. moara* ♀ × *Epinephelus lanceolatus* ♂; body weight 680.35 ± 39.84 g) were evaluated to illustrate the characteristics of gastric evacuation and digestive enzyme activity. In addition, the degree of fitting of the gastric emptying curve was analyzed using a linear model, square root model, and cubic root model. The gastric evacuation rates of “Yunlong” groupers exhibited a typical curve digestive pattern (slow-fast-slow) during the gastric evacuation process. All the three mathematical models could fit the gastric evacuation data of “Yunlong” groupers; however, the cubic model obtained the optimal result. According to the cubic model, 80% (appetite basic recovery) and 100% (complete recovery of appetite) gastric emptying occurred at feeding after 9.5 hours and 14.8 hours in “Yunlong” groupers, respectively. The hepatic and intestinal digestive enzyme (amylase, chymotrypsin, and lipase) activities increased significantly from 0 to 6 h, and then decreased from 9 to 24 h during the gastric evacuation process in “Yunlong” groupers. The concentrations of serum glucose and cortisol corresponded with digestive enzyme activities during gastric emptying in “Yunlong” groupers. In conclusion, the results reveal that the optimal interval feeding recommended is at 10 h and twice per day, based on the gastric evacuation rate and feeding digestion characteristics of Yunlong” groupers (*E. moara* ♀ × *Epinephelus lanceolatus* ♂) in captivity.

Key words: “Yunlong” groupers (*E. moara* ♀ × *Epinephelus lanceolatus* ♂), gastric evacuation rate, mathematical model, cortisol, glucose, digestive enzyme

面向深远海养殖的太阳能相变储热装置偏心优化数值模拟研究

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摘要: 光热综合利用是深远海养殖能源保障系统的重要组成部分, 相变储热效率的提高是实现太阳能高效应用的关键, 为探究水平管壳式相变储热装置通用的最佳偏心优化结构, 本文基于设计的新参数“间距比”, 利用数值模拟的方法研究了两组不同半径比模型及七个不同间距比(1:1-6:1&14:1)偏心结构的蓄放热过程, 对其传热规律和结构优化进行了分析和探讨。

关键词: 太阳能; 深远海养殖; 相变储热; 偏心优化; 数值模拟

Numerical simulation of eccentric optimization of solar energy phase change heat storage device for off-shore aquaculture

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Abstract: The comprehensive utilization of light and heat is an important part of the energy security system of deep sea aquaculture. The improvement of phase change heat storage efficiency is the key to realize the efficient application of solar energy. In order to explore the optimal eccentric structure of horizontal shell and tube phase change heat storage device, based on the design of a new parameter "space ratio", the heat storage and release of two groups of different radius ratio models and seven eccentric structures with different spacing ratio (1:1-6:1 & 14:1) were studied by numerical simulation, The heat transfer law and structure optimization are analyzed and discussed.

Key words: Solar energy, off-shore aquaculture, phase change heat storage, eccentric optimization, numerical simulation

马尾藻和海带对中间球海胆生存, 生长及抗逆的影响

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摘要: 筏式养殖的中间球海胆在夏季大量死亡问题, 极大阻碍了其养殖产业的发展。本文研究了中间球海胆在投喂马尾藻和海带 9 周后的生存、生长和性腺发育情况。随后分别在缓慢升温 and 剧烈变化的温度下, 通过观察海胆翻正、管足伸展和口器咬合行为评估其抗逆能力。投喂马尾藻的海胆患病率和性腺发育显著低于投喂海带组。一致的, 缓慢升温情况下, 马尾藻组的口器咬合行为也占有优势。这些结果暗示马尾藻可作为夏季筏式养殖海胆的潜在食物, 因为其在健康、能量储存 (避免由于发育性腺造成的能量损耗) 和抗逆性上的优势。相比之前, 投喂海带的海胆在水温剧烈变化情况下, 上述几种行为的表现均优于马尾藻组。这些结果清楚的表明在夏季冷水团存在的养殖海域, 海胆更适宜投喂海带从而避免温度剧烈变化带来的负面影响。

关键词: 中间球海胆; 龙须菜; 海带; 水产养殖

Effects of the brown algae *Sargassum horneri* and *Saccharina japonica* on survival, growth and resistance of small sea urchins *Strongylocentrotus intermedius*

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Abstract: Mass mortality of the long line culture of the sea urchin *Strongylocentrotus intermedius* in summer is the most serious problem for the development of the aquaculture. Here, a feeding experiment was conducted for ~9 weeks to investigate the survival, growth and gonadal development of small *S. intermedius* (~3 cm) fed either brown algae *Sargassum horneri* or *Saccharina japonica*. Subsequently, we assessed their resistant abilities via observing the behaviors of righting, tube feet extension and Aristotle's lantern reflex at both moderately elevated and acutely changed water temperatures. Sea urchins fed *S. horneri* showed significantly fewer diseased individuals and slower gonadal development than those fed *S. japonica*. Significantly greater Aristotle's lantern reflex occurred in sea urchins fed *S. horneri* at moderately elevated temperatures. These findings suggest that *S. horneri* has direct application potential as food for the long line culture of *S. intermedius* in summer because of the advantage in health, energy storage (avoid the energy loss caused by gonadal development at small body sizes) and resistance abilities. In comparison, sea urchins fed *S. japonica* outperformed those fed *S. horneri* for all experimental behaviors under the acutely changed water temperatures. These findings clearly suggest that *S. intermedius* fed *S. japonica* is more suitable for the areas with cold water mass in summer, because it can effectively avoid or reduce the negative impacts of acute changes of water temperature on sea urchins.

Key words: *Strongylocentrotus intermedius*, *Gracilaria lemaneiformis*, *Laminaria japonica*, aquaculture

降解 ZEN 和 DON 毒素的海洋微生物筛选

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摘要: 为了筛选获得对小麦赤霉病菌具有拮抗作用, 且能高效降解 ZEN 毒素和 DON 毒素的优良海洋微生物菌株。本试验以课题组从连云港海域分离纯化的 138 株海洋微生物菌株为研究对象, 通过平板对峙法测定不同海洋微生物菌株对小麦赤霉病菌的抑制作用; 采用含毒平板法和 HPLC 法筛选能降解 ZEN 毒素和 DON 毒素的海洋微生物菌株。研究表明, 有 16 株海洋微生物菌株对小麦赤霉病菌的抑菌带宽度都达到 20.0 mm 以上, 且能在含 ZEN 毒素和 DON 毒素平板上生长良好; 其中有 4 株海洋微生物菌株对浓度为 15 $\mu\text{g/mL}$ ZEN 毒素降解率达 69% 以上, 有 5 株海洋微生物菌株对浓度为 4 $\mu\text{g/mL}$ DON 毒素降解率达 20% 以上。本研究为海洋微生物菌株降解 ZEN 和 DON 毒素的机理研究奠定基础。

关键词: 海洋微生物; 赤霉烯酮毒素; 脱氧雪腐镰孢菌烯醇; 抑菌作用

Screening of Marine microorganisms for degrading ZEN and DON toxins

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Abstract: The study was aimed to screen the marine microorganism strains with antagonistic effect against *Fusarium graminearum*, and to degrade zearalenone (ZEN) and deoxynivalenol (DON). The inhibitory effect of 138 marine microbial strains isolated and purified from the sea area of Lianyungang on *F. graminearum* was determined by the plate confrontation method. Different marine microbial strains capable of degrading ZEN toxin and DON Toxin were screened by toxicity plate method and HPLC. The results showed that 16 strains of marine microorganism could grow well on the plate containing ZEN Toxin and DON Toxin, and the width of inhibition band was over 20.0 mm to *F. graminearum*. The degradation rate of 4 strains to 15 g/mL ZEN toxin was over 69%, and that of 5 strains to 4 g/mL DON toxin was over 20%. This study laid a foundation for the study on the mechanism of degradation of ZEN and DON toxins by marine microbial strains.

Key words: Marine bacteria, zearalenone, deoxynivalenol, bacteriostasis

一株兼具抑弧菌和降解氨氮功能海洋细菌的 筛选与鉴定

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摘要: 以副溶血弧菌(*Vibrio parahaemolyticus*)、创伤弧菌(*V. vulnificus*)为指示菌, 采用牛津杯法测定 95 株海洋细菌菌株无菌发酵液的抑菌作用; 将抑菌作用较强的菌株接种到氨氮质量浓度为 50mg/L 的培养基中发酵 48h, 采用靛酚蓝分光光度法测定不同菌株发酵液中的氨氮浓度, 筛选出兼具抑菌和降解氨氮功能的放线菌优良菌株。结果表明, 28 株细菌对副溶血弧菌和创伤弧菌均具有抑制作用, 其中菌株 HG-2 的抑菌作用最强, 对副溶血弧菌和创伤弧菌的抑菌圈直径分别为 $17.67\pm 2.27\text{mm}$ 和 $12.00\pm 0.71\text{mm}$; 抑菌作用较强的 28 个细菌菌株发酵液中的氨氮质量浓度均明显降低, 其中菌株 BMF04 和 HG-2 发酵液的氨氮降解能力最强, 降解率分别为 90.07% 和 85.34%; 结合抑菌作用测定结果, 认为菌株 HG-2 兼具较强抑菌和降解氨氮功能, 具有潜在的开发应用前景。

关键词: 海洋细菌; 弧菌; 抑菌作用; 氨氮降解

Screening and identification of a Marine bacterium that can inhibit vibrio and degrade ammonia nitrogen

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Abstract: The bacteriostatic effect of 95 Marine bacterial strains of aseptic fermentation broth was determined by Using Oxford cup method. The concentration of ammonia nitrogen in fermentation broth of different strains was determined by indophenol blue spectrophotometry. The results showed that 28 strains of bacteria had inhibitory effect on vibrio, among which HG-2 had the strongest inhibition effect. The fermentation broth of BMF04 and HG-2 had the highest ammonia-nitrogen degradation ability, with degradation rates of 90.07% and 85.34%, respectively. To sum up, the strain HG-2 has potential development and application prospects.

Key words: Marine bacteria, vibrio, bacteriostatic effect, ammonia nitrogen degradation

一株可降解亚硝酸盐和氨氮的硝化细菌的分离鉴定

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摘要: 为寻找对氨氮、亚硝酸盐有降解能力、稳定、安全的菌株, 采用硝化细菌富集分离技术从江苏连云港高公岛水域中的鲈鱼肠道内筛选出一株可降解氨氮、亚硝酸盐的硝化细菌 N-LY。根据菌落特征、菌体形态、生理生化试验、16SRNA 序列分析, 对分离的硝化细菌 N-LY 进行了鉴定, 其与 *Sphingomonas echinoides* (MG745876.1) 的序列同源性为 98.53%, 可判定所分离得到的菌株 N-LY 是鞘氨醇单胞菌属的海胆鞘氨醇单胞菌(*Sphingomonas echinoides*)。硝化细菌 N-LY, 以硫酸铵为碳源时, 30℃180r/min, 培养 72h, 氨氮降解率达 92.1%; 以亚硝酸钠为碳源, 对亚硝酸盐降解率达 66.7%, 其降解氨氮和亚硝酸盐能力较好, 对富营养化水体的治理有一定的参考价值。

关键词: 硝化细菌; 氨氮; 亚硝酸盐; 降解

Isolation and Identification of a heterotrophic nitrifying bacterium capable of degrading nitrite and ammonia nitrogen

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Abstract: In order to find the ability to degrade ammonia nitrogen and nitrite, stable, safe strain. A nitrifying bacterium N-LY which can degrade ammonia nitrogen and nitrite was screened out from the gut of perch in Gaogong Island of Lianyungang, Jiangsu province by the enrichment and separation technique of nitrifying bacteria. According to colony characteristics, morphology, physiological and biochemical tests, 16SRNA sequence analysis, the nitrifying bacteria N-LY were identified. Its sequential homology with *Sphingomonas Echinoides* (MG745876.1) is 98.53%. It can be determined that the isolated strain N-LY is the sea urchin sphingomonas sphingomonas genus. Nitrifying bacteria N-LY, with ammonium sulfate as carbon source, 30℃180r/min, Cultivation of 72 h; Sodium nitrite was used as carbon source; the degradation rate of nitrous oxide was 66.7%. It has good ability to degrade ammonia nitrogen and nitrite, and has certain reference value for the treatment of eutrophic water bodies.

Key words: Nitrifying bacteria, ammonia nitrogen: nitrite, degradation

淀粉基渔用复合纤维的制备与降解行为研究

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摘要: 为避免不可降解渔网造成的“白色污染”问题, 本文通过反应挤出和熔融纺丝法制备了可降解的淀粉基渔用复合纤维。研究了淀粉含量对淀粉基复合纤维结构与性能的影响, 并对淀粉基复合纤维在土壤中的降解行为进行了初探。随着淀粉含量的增加, 内部结构变得蓬松, 纤维的熔融温度和结晶度逐渐降低, 淀粉基复合纤维的断裂强度显著降低。在土壤中降解5个月后, 复合纤维的表面观察到絮凝层, 并且出现了大量的微纤维。随着淀粉含量的增加, 淀粉基复合纤维的失重率显著增加。

关键词: 淀粉; 复合纤维; 结构与性能; 降解行为

Starch-based Composite Fiber for fishing and Its Degradation Behavior

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Abstract: To avoid the "white pollution" problem caused by non-degradable fishing nets, the starch-based composite fibers were prepared by one-step reactive extrusion and melt spinning. The effects of starch contents on the microstructure and properties of starch-based composite fibers were studied. And the degradation behaviors in soil of the fibers were also investigated. As the starch content increased, the melting temperature and the crystallinity of the fibers gradually decreased due to fluffy internal structures and the breaking strength decrease significantly. After degradation in soil for 5 months, the surface of the composite fibers had been deteriorated, while flocculent layers were observed and a large number of microfibrils appeared. And the weight loss rate of the starch-based composite fibers significantly increased with increasing starch content.

Key words: Starch, composite fiber, structural and properties, degradation behavior

海水水产养殖 MBBR 快速启动研究

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摘要: 移动床生物膜反应器 (MBBR) 广泛用于去除海水水产养殖系统中的氨, 但通常会面临启动周期长的问题。本研究首先比较了 MBBR 和滴滤池 (TF) 的启动周期, 结果发现在相同的表面氨氮负荷下处理海水水产养殖废水时, TF 的硝化启动期比 MBBR 的短 41 天。将 TF 中成熟填料转移到一新 MBBR 中可立即启动硝化进程, 且无滞后时间, 表明 MBBR 的硝化启动可通过 TF 和成熟填料转移实现加速。该转移可增加微生物多样性, 使生物膜的理化特性向 MBBR 转变。另外, 通过硝化性能、生物膜特性、微生物群落结构对 5 种 MBBR 独立启动的策略进行了评估: R1 为对照; R2, 逐步降低氨氮浓度; R3, 逐步增加盐度; R4, 添加颗粒有机物; R5, 接种硝化细菌。结果表明, R3 在第 63 天完成硝化, 比其他策略快 16-18 天。进一步的微生物种群等研究结果也表明逐步增加盐度可作为高盐废水硝化启动的有效策略。

关键词: 硝化启动; 海水养殖废水; 滴滤池; 微生物多样性; 胞外多聚物

Study on fast start-up of MBBR in mariculture aquaculture

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Abstract: Moving bed biofilm reactor (MBBR) is widely used for ammonia removal in mariculture aquaculture systems but often faces a slow start-up problem. The start-up period between trickling filter (TF) and MBBR was firstly compared. It was found that the TF started up 41 days faster than the MBBR under the same ammonia surface loading rate, indicating that MBBR nitrification start-up can be accelerated via TF and biocarrier transfer. The new MBBR, incubated with the mature biocarriers transferred from the TF, had a satisfactory nitrification performance with no lag time. Interestingly, the transfer action increased the microbial diversity and made the biofilm physicochemical characteristics shift toward those of the MBBR. In addition, changes in nitrification performance, biofilm characteristics and bacterial community were assessed in response to various MBBR start-up strategies: R1 as the control; R2 with step-decrease of inlet $\text{NH}_4^+\text{-N}$; R3 with step-increase of inlet salinity; R4 added with particulate organic matter (POM) and R5 inoculated with nitrifying bacteria. Results show that nitrification was completed on day 63 for R3, 16–18 days faster than the other strategies. Results obtained make the elevated salinity strategy a promising alternative for the rapid nitrification start-up of saline wastewater.

Key words: Nitrification start-up, mariculture wastewater, trickling filter (TF), bacterial community, extracellular polymeric substance

微填充床反应器中臭氧氧化连续降解水产养殖废水

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摘要: 水产养殖中过量的杀菌剂和抗生素等危害物长期积累将对环境、生物和人类健康构成潜在的风险。由于传统的处理方法(如过滤法、活性污泥法和生物膜法)处理时间长(60min以上)、处理效果差(50%左右)。因此,本研究采用了一种微填充床反应器与臭氧氧化相结合的连续降解的新方法,对水产养殖废水中沙星类抗生素和杀菌剂进行了降解。结果表明,在连续降解2min后,沙星类抗生素和杀菌剂的去除率分别达到了95%-100%,COD去除率分别达到了65%-85%。整个处理系统实现了对水产养殖废水连续高效的降解。此外,本系统中未反应完的臭氧可100%转化为氧气,这不仅增加了水中的溶解氧,而且有利于整个水生生态系统的健康持续发展。这种方法将在水产养殖废水处理领域有着广泛的应用前景。

关键词: 微填充床反应器; 臭氧氧化; 水产养殖废水; 抗生素

Continuous degradation of aquaculture wastewater by ozonation in a micro-packed bed reactor

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Abstract: The long-term accumulation of excessive amounts of fungicides and antibiotics in aquaculture will pose potential risks to the environment, biology and human health. Due to traditional treatment methods (such as filtration method, activated sludge method and biofilm method), the treatment time is long (over 60min) and the treatment effect is poor (about 50%). Therefore, this study adopted a new continuous degradation method combining micro-packed bed reactor and ozonation to degrade the floxacillin antibiotics and fungicides in aquaculture wastewater. The results showed that after 2 minutes of continuous degradation, the removal rates of the floxacillin antibiotics and fungicides reached 95%-100%, and the COD removal rates reached 65%-85%. The entire treatment system realizes continuous and efficient degradation of aquaculture wastewater. In addition, the unreacted ozone in the system can be 100% converted into oxygen, which not only increases the dissolved oxygen in the water, but also benefits the healthy and sustainable development of the entire aquatic ecosystem. This method will have broad application prospects in the field of aquaculture wastewater treatment.

Key words: Micro-packed bed reactor, ozonation, aquaculture wastewater, antibiotics

EM 菌对中华绒螯蟹非特异性免疫力的影响

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摘要: 为探究水体中添加 EM 菌对中华绒螯蟹非特异性免疫力的影响, 将 EM 菌添加到中华绒螯蟹养殖水体中, 以无 EM 菌添加的养殖组为对照组, 每组 3 次重复。河蟹每次脱壳后进行采样, 检测河蟹各类血细胞数量、血清代谢指标、血清抗氧化能力、血清免疫能力和肝胰腺免疫相关基因的相对表达量。实验结果表明, 在水体中添加 EM 菌能提高河蟹的非特异性免疫力。河蟹血细胞主要分为透明细胞、半颗粒细胞和颗粒细胞, 半颗粒细胞主要起吞噬作用, EM 菌组半颗粒细胞数量略高于对照组。EM 菌对代谢相关指标影响较小, 2 壳 EM 菌组 TG 含量显著高于对照组, 3 壳雄蟹 TC 含量显著低于对照组。EM 菌显著降低了河蟹血清中 MDA 含量, 主要表现为 3 壳时 MDA 含量显著降低; EM 菌组雄蟹 5 壳 CAT 活力和 2 壳 LZM 含量均显著高于对照组。EM 菌对河蟹免疫相关基因表达影响显著, EM 菌组 *Toll2* 基因和 *Dorsal* 基因相对表达量显著高于对照组, 雄蟹 *Tube* 基因和 *Hsp90* 基因的相对表达量显著高于对照组。综上所述, 水体中添加 EM 菌能显著提高中华绒螯蟹的非特异性免疫力。

关键词: 中华绒螯蟹; EM 菌; 非特异性免疫; RT-PCR

Effects of EM on non-specific immunity of Chinese mitten crab

Eriocheir sinensis

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Abstract: In order to explore the effect of adding EM to the non-specific immunity of Chinese mitten crabs, EM were added to the Chinese mitten crab culture waters. The culture group without EM was used as the control group, and each group was repeated 3 times. Sampling was carried out every time the crab was shelled to detect the number of various types of blood cells, serum metabolic indicators, serum antioxidant capacity, serum immune capacity and relative expression of hepatopancreatic immune related genes. Experimental results show that adding EM to the water body can improve the non-specific immunity of river crabs. Crab blood cells are mainly divided into clear cells, semigranular cells and granular cells. Semigranular cells mainly play a phagocytic effect. The number of semigranular cells in the EM group is slightly higher than that in the control group. EM had little effect on metabolism-related indicators. The TG content of the 2-shell EM bacteria group was significantly higher than that of the control group, and the 3-shell male crab TC content was significantly lower than that of the control group. The EM bacteria significantly reduced the MDA content in the serum of river crabs, which was mainly manifested by the significant decrease in the MDA content in the 3 shells; the 5 shell CAT activity and the 2 shell LZM content of the male crabs in the EM bacteria group were significantly higher than the control group. EM bacteria have a significant effect on the expression of immune-related genes in river crabs. The relative expression levels of *Toll2* and *Dorsal* genes in the EM bacteria group were significantly higher than those in the control group. The relative expression levels of the *Tube* gene and *Hsp90* gene in male crabs were significantly higher than those in the control group. In summary, the addition of EM bacteria to the water body can significantly improve the non-specific immunity of Chinese mitten crabs

Key words: *Eriocheir sinensis*, effective microorganisms, non-specific immunity, RT-PCR

氨氮急性胁迫对许氏平鲷生理指标的影响

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摘要: 本研究采用 96h 半静态毒性实验的方法, 研究了氨氮急性应激对许氏平鲷生理指标的影响。结果表明, 在水温 $15.6 \pm 0.2^\circ\text{C}$, pH 7.85, 盐度 30 和溶氧 $8.6 \pm 0.5 \text{ mg}$ 的条件下, 平均体质量 $63.60 \pm 10.14 \text{ g}$ 、平均全长 $15.90 \pm 3.29 \text{ cm}$ 的许氏平鲷幼鱼总氨 (TAN) 和非离子氨 (NH₃-N) 96 h 的半致死浓度 (LC₅₀) 分别为 60 mg/L 和 0.68mg/L。氨氮浓度、暴露时间及两者交互作用对血浆皮质醇 (Cortisol)、胆固醇、甘油三酯、血氨、谷草转氨酶 (ALT)、谷丙转氨酶 (AST)、还原型谷胱甘肽 (GSH)、碱性磷酸酶 (AKP) 和血糖 (GLU) 含量/活性都存在显著影响; 其中, GSH、GLU 随暴露时间延长总体呈现先升后降的趋势; 胆固醇、血氨、AKP、AST、ALT 随暴露时间延长总体呈现先上升趋势; 甘油三酯随暴露时间延长总体呈现下降趋势。研究结果表明, 皮质醇、血浆血糖、GSH 可作为许氏平鲷氨氮急性胁迫的敏感指标, 相关研究结果为许氏平鲷幼鱼的养殖管理和行为数值模拟提供基础资料。

关键词: 许氏平鲷; 氨氮急性胁迫; 血液生理指标

Influence of ammonia nitrogen acute stress on physiological indexes of *Sebastes schlegelii*

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Abstract: The aim of this study was to provide a reference value for the safe regulation and control of ammonia in the aquaculture of *Sebastes schlegelii*. And obtain the corresponding biomarkers of blood physiological indexes under acute ammonia stress. The acute toxicity effect of ammonia on *Sebastes schlegelii* (averaged body weight $63.60 \pm 10.14 \text{ g}$) was studied by 96 h half-static toxicity test. The effects of different ammonia concentration and exposure time on plasma physiological indexes were determined. Results showed that the semi-lethal concentration (LC₅₀) of total ammonia (TAN) and non-ionic ammonia (NH₃-N) for 96 h were 60.00 mg/L and 0.68mg/L, respectively, under the condition of sea water temperature $15.6 \pm 0.2^\circ\text{C}$, pH value 7.85, salinity 30.0, and dissolved oxygen $7.85 \pm 0.5 \text{ mg/L}$. The Plasma Cortisol, Cholesterol, Triglyceride, Blood Ammonia, ALT, AST, GSH, AKP and GLU were significantly affected by Cortisol concentration, time of exposure and interaction. Among them, GSH and GLU showed a general trend of increasing first and then decreasing with prolonged exposure time. Cholesterol, blood ammonia, AKP, AST and ALT showed an overall upward trend with the prolonged exposure time. Triglyceride showed a decreasing trend with the prolonged exposure time. The results show that cortisol, GLU and GSH can be used as sensitive indicators of acute stress in *Sebastes schlegelii*, and the relevant research results provide basic data for the cultivation management and behavior numerical simulation of *Sebastes schlegelii*.

Key words: *Sebastes schlegelii*, acute ammonia Stress, plasma physiological indexes

盐度和氮磷浓度对海马齿净化水质及其生长的影响

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摘要: 以滨海滩涂耐盐植物海马齿(*Sesuvium portulacastrum*)为研究对象, 通过室内水培实验探究海马齿植株在不同盐度和氮磷浓度条件下对富营养化水体的净化能力, 以及植株生长生理变化。结果显示: 1) 在中、低盐度(0~20)条件下, 海马齿能健康正常生长, 对氮、磷的吸收效果明显; 而在高盐度(30~35)条件下, 其生长受到胁迫, 对氮磷的吸收作用明显弱于中低盐度组。2) 在低氮磷浓度(N:0~5mg/L, P:0~0.5mg/L)和高氮磷浓度(N:20~50mg/L, P:2~5mg/L)条件下, 海马齿都显示了较高的氮磷去除能力, 明显降低了水体中的氮磷浓度, 表明海马齿能有效净化养殖水体, 可用于养殖尾水净化, 改善养殖环境。

关键词: 海马齿; 盐度; 氮; 磷; 水质; 生长

Effects of salinity, nitrogen and phosphorus concentration on the water quality and growth of *Sesuvium portulacastrum*

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Abstract: Taking the *Sesuvium portulacastrum*, a salt-tolerant plant in coastal beaches, as the research object, an indoor hydroponic experiment was conducted to study the ability of *S. portulacastrum* to purify eutrophic water, as well as the physiological changes of growth under conditions of different salinity and nitrogen and phosphorus concentrations. The results showed that: 1) Under the conditions of medium and low salinity (0~20), *S. portulacastrum* can grow normally, and the absorption of N, P is obvious; while under high salinities (30~35), the growth of plants was stressed to some extent, the absorption of N, P was significantly weakened than that of the low-medium salinity groups. 2) Under the conditions of both low (N:0~5mg/L, P:0~0.5mg/L) and high N,P concentration (N:20~50mg/L, P:2~5mg/L), *S. portulacastrum* showed high N,P removal ability, which significantly reduced the N,P concentrations in the water, indicating that *S. portulacastrum* can effectively purify the aquaculture wastewater and improve the aquaculture environment.

Key words: *Sesuvium portulacastrum*, salinity, nitrogen, phosphorus, water quality, growth

黄条鰺幼鱼胃排空特征、消化酶活性及摄食调控基因表达分析

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摘要: 为阐明黄条鰺 (*Seriola aureovittata*) 幼鱼摄食消化特性构建最佳胃排空数学模型, 确立最适摄食投喂间隔。本实验检测了黄条鰺幼鱼 (63.96±5.63 g) 胃排空过程中内容物重量、肝脏和肠道中消化酶活性变化, 分析了垂体中摄食调控相关基因的表达, 比较了线性模型、平方根模型、立方模型 3 种数学模型对胃排空曲线的拟合程度。结果表明, 黄条鰺幼鱼肝脏和肠道中消化酶活性皆在摄食后 12~15 h 降至最低, 由拟合黄条鰺幼鱼胃排空实验数据的最佳数学模型-立方根模型可知 80% 胃排空时间 (食欲基本恢复) 和 100% 胃排空时间 (食欲完全恢复) 分别约为摄食后 14.5 和 19 h, 同时垂体中 NPY 和 Ore mRNA 水平均在摄食后 15 h 达到最高, 基于黄条鰺幼鱼摄食后胃排空特征和肝肠消化酶活性以及摄食调控基因表达变化, 建议在饲喂管理中按照 14.5 h 的间隔进行投喂。

关键词: 胃排空; 数学模型; 黄条鰺

Gastric evacuation characteristics, digestive enzyme activity and appetite-related genes expression in larval yellowtail kingfish (*Seriola aureovittata*)

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Abstract: To identify the digestion and gastric emptying characteristics of yellowtail kingfish (*Seriola aureovittata*), determine the optimal feeding interval; In the present study, the changes of contents weight and digestive enzyme activity in liver and intestine during gastric emptying of the larval yellow strips (63.96±5.63 g) were evaluated, feeding regulation of related gene expression was analyzed too. The degree of fitting of the gastric emptying curve was analyzed using a linear model, square root model, and cubic root model; The results showed that the digestive enzyme activity in the liver and intestine of larval yellowtail kingfish was reduced to the lowest from 12 to 15h after feeding. The best model cube root model for fitting the gastric emptying test data of juvenile yellowtail kingfish showed 80% gastric emptying time (appetite basic recovery) and 100% gastric emptying time (complete recovery of appetite) were approximately 14.5 and 19h, respectively. Meanwhile, the mRNA levels of neuropeptide Y and orexin in pituitary of juvenile yellowtail kingfish were the highest at 15h after feeding. Therefore, the optimal interval feeding is recommended to be fed at 14.5h based on the characteristics of gastric emptying hepatic, intestinal digestive enzyme activities and regulation of gene expression by ingestion after feeding.

Key words: Gastric evacuation, mathematical model, yellowtail kingfish *Seriola aureovittata*

不同 LED 光谱对红鳍东方鲀 (*Takifugu rubripes*) 幼鱼生长发育、摄食及消化酶活性的影响研究

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摘要: 为探究不同 LED 光谱对红鳍东方鲀 (*Takifugu rubripes*) 幼鱼摄食、生长发育和生理活性的影响, 在海水循环水养殖实验系统中选取 525 尾红鳍东方鲀幼鱼 (体长: 9.01 ± 0.70 cm, 体重: 18.05 ± 3.17 g), 分别放置在白光 ($\lambda 400-780$ nm)、红光 ($\lambda 625-630$ nm)、黄光 ($\lambda 590-595$ nm)、绿光 ($\lambda 525-530$ nm)、蓝光 ($\lambda 450-455$ nm) 五组不同 LED 光谱处理组中并对其进行监测。实验结果表明, 在 30d 实验周期中, 不同 LED 光谱对红鳍东方鲀幼鱼的存活、生长和摄食的影响具有显著性差异 ($P < 0.05$)。在消化酶活性方面, 五组不同 LED 光谱处理组的几种消化酶活性均存在显著性差异 ($P < 0.05$)。由此得出结论, 绿光对红鳍东方鲀幼鱼的生长发育具有更好的促进作用。

关键词: 红鳍东方鲀; LED 光谱; 生长发育; 摄食; 消化酶活性

Effects of different LED spectra on growth, feeding and digestive enzyme activities of juvenile *Takifugu rubripes*

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Abstract: In order to explore the effects of different LED spectra on growth, feeding and physiological activities of *Takifugu rubripes*, 525 juvenile puffer fish (body length: 9.01 ± 0.70 cm, body weight: 18.05 ± 3.17 g) were selected. They were placed in five different LED spectral processing groups, including white light ($\lambda 400-780$ nm), red light ($\lambda 625-630$ nm), yellow light ($\lambda 590-595$ nm), green light ($\lambda 525-530$ nm), and blue light ($\lambda 450-455$ nm). The results showed that the effects of different LED spectra on the survival, growth and feeding of juvenile *Takifugu rubripes* were significantly different ($P < 0.05$). In terms of digestive enzyme activities, there were significant differences among the five groups of different LED spectrum treatment groups ($P < 0.05$). It is concluded that green light has a better promoting effect on the growth and development of juvenile *Takifugu rubripes*.

Key words: *Takifugu rubripes*, LED spectrum, growth and development, food intake, digestive enzyme activity

海水养殖园区排放水生态化处理技术研究

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摘要: 为引导海水池塘养殖业绿色可持续发展, 减少海水池塘养殖自身污染对近岸海洋生态系统及自身环境的负面影响, 本研究以优化海水养殖环境为切入点, 集成物理、生物等多种环境工程生态优化技术, 构建了海水池塘养殖园区排放水生态化处理系统。结果表明: 生态化处理系统对 COD、NH₄-N、NO₂-N、NO₃-N、DIN 及 DIP 综合去除率平均分别为 40.84%、89.37%、86.88%、93.75%、78.74%和 59.73%。蛋白气浮分离技术对各指标去除率均随着温度的升高而降低, 分离出的有机泡沫可作为生物滤池中固定化微生物的持续营养源, 促使其在试验开展 120 天后仍然能维持较高的生物活性。通过池塘养殖园区排放水生态化处理技术可明显改善园区排放水质量, 基本可以实现各项指标的达标排放, 在一个养殖周期内可实现养殖园区每公顷减排 226.20 kg COD, 5.70 kg DIN 和 16.65 kg DIP。

关键词: 海水养殖; 池塘排放水; 生态化处理

Ecological Treatment Technique of Discharged Water from Aquaculture Pond in Large-scale Fishery Park

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Abstract: This study is committed to ensure the green and sustainable development of marine pond culture, and reduce the negative impact of pollution caused by aquaculture upon both the coastal ecosystem and the internal environment. This study considered the optimization of aquaculture environmental as the starting point, integrated various environmental engineering ecological optimization technologies such as physical and biological ones, and constructed an ecological treatment system of the discharge water in the marine-pond aquaculture park. Through the system, the concentration of COD, NH₄-N, NO₂-N, NO₃-N, DIN and DIP in the discharged water were reduced by 40.84%、89.37%、86.88%、93.75%、78.74% and 59.73% respectively. With sustainable nutrition in organic foam separated from the system, immobilized microorganisms in biofilter can still maintain high bioactivity after 120 days. Ecological treatment technology of discharged water from aquaculture pond can significantly improve water quality and basically meet the standard of discharge of all indicators. Through the water treatment system, 226.20kg COD, 5.70kg DIN and 16.65kg DIP can be reduced per hectare in the aquaculture park within a farming cycle.

Key words: marine culture, discharge water, ecological treatment

稻-鲤共养对表层土壤养分和细菌群落结构的影响

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摘要: 为探究稻田养鱼对表层土壤的影响, 实验设置水稻单作 (RM) 组和稻田养鱼 (RF) 组, 在放养鲤后第 20 天和 60 天采样分析对比不同层深 (0-2cm, 2-10cm, 10-20cm) 土壤养分和细菌群落特征。结果显示, 随着土壤深度的增加, 土壤养分和微生物生物量总体呈波动下降趋势。稻田养鱼初期 (20d), RF 组的 pH、有效磷和总磷含量显著高于 RM 组 ($P<0.05$)。后期 (60d) RF 组的有效磷、速效钾和微生物生物量磷含量显著高于 RM 组 ($P<0.05$)。高通量测序结果显示两组在酸杆菌门、厚壁菌门、变形菌门和芽孢杆菌属等菌群丰度上有显著差异。以上结果表明, 稻-鲤共养, 改善了土壤酸性和养分状况, 并影响了土壤部分菌群的分布。

关键词: 稻田养鱼; 土壤养分; 鲤; 细菌群落结构

Effect of rice-carp co-culture on soil nutrients and bacterial community structure

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Abstract: To explore the effect of rice-fish co-culture on the surface soil, our experiment set up rice monocropping (RM) and rice-fish co-culture (RF) group. The 20th and 60th day after carp was stocked, sampling and analysis were compared with different depths (0-2cm, 2-10cm, 10-20cm) about soil nutrients and bacterial community characteristics. The results showed that with the increase of soil depth, soil nutrients and microbial biomass showed a fluctuating downward trend. In the early stage (20 d), the pH, available phosphorus and total phosphorus contents of RF were significantly higher than RM ($P<0.05$). In the late stage (60 d), the available phosphorus, available K and microbial biomass phosphorus content of RF was significantly higher than that of RM ($P<0.05$). The results of high-throughput sequencing showed that RF and RM treatments had significant differences in the abundance of Acidbacteria, Firmicutes, Proteobacteria, and *Bacillus*. The results showed that rice carp co-culture improved soil acidity and nutrient status, and affected the distribution of some soil flora.

Key words: Rice-fish co-culture, soil nutrient status, *Cyprinus carpio*, bacterial community structure

草鱼和大口黑鲈养殖系统生源要素(C、N、P)

归趋比较研究

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摘要: 当前, 尾水处理已成为水产养殖业可持续发展的“卡脖子”问题, 摸清不同养殖模式富营养物归趋则是处理养殖尾水的前提。本研究通过室内实验, 分析了典型植食性鱼类—草鱼和典型肉食性鱼类—大口黑鲈养殖系统的碳(C)、氮(N)、磷(P)归趋, 结果显示: 草鱼可吸收利用投喂饲料中 22.8%的 C、50.9%的 N 和 14.34%的 P, 大口黑鲈吸收利用 17.85%的 C、30.4%的 N 和 4.87%的 P, 其余生源要素均排放到养殖环境中。结果表明, 养殖草鱼的环境负荷低于大口黑鲈。实验结果可为两种鱼类尾水处理系统设计、优化提供参考。

关键词: 草鱼、大口黑鲈、生源要素、归趋

Comparative study on the fate of biogenic elements (C, N, P) of grass carp and largemouth bass aquaculturesystem

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Abstract: The aquaculture wastewater treatment has become the bottle-neck for the sustainable development of aquaculture. It is a prerequisite to understand the fate of eutrophic nutrients in different breeding modes. This study analyzed the carbon (C), nitrogen (N), and phosphorus (P) fate of the typical herbivorous fish-grass carp and the typical carnivorous fish-largemouth bass culture system through indoor experiments. The results showed that grass carp could absorb and utilize 22.8% of C, 50.9% of N and 14.34% of P in the input feed, largemouth bass could absorb and utilize 17.85% of C, 30.4% of N and 4.87% of P. The rest of the input biogenic elements were discharged into the environment. It indicated that the environmental load of grass carp was lower than the largemouth bass. These results could provide references for the design and optimization of grass carp and largemouth bass aquaculture wastewater treatment systems.

Key words: Grass carp, largemouth bass, biogenic elements, fate

台风浪作用下深水重力式网箱失效概率分析

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摘要: 随着经济的发展, 人们对海产品需求日益增加, 海水养殖逐渐走向深远海, 而离岸距离越大, 海况变化愈剧烈, 深水网箱作为海水养殖的主体设备, 其遭受破坏的可能性越大。台风浪是近海区域养殖网箱结构破坏的主要因素, 开展深水网箱在不同台风浪下失效概率的研究是养殖网箱保险产品开发、设计的基础。本文以珠海市桂山岛附近海域深水网箱作为典型案例, 计算了不同重现期下台风浪作用下深水网箱锚绳、网衣、浮架的水动力响应, 并且使用蒙特卡洛模拟法计算得到锚绳、网衣、浮架在不同重现期下的失效概率。同时, 从深水网箱风险程度大小和建造成本高低的角度出发, 得到了桂山岛不同代表点海域网箱不同构件的最佳尺寸。

关键词: 重力式深水网箱; 受灾破坏; 失效概率; 数值模拟; 蒙特卡洛模拟法

Analysis of failure probability of gravity net cage under typhoon

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Abstract: With the development of the economy, people's demand for seafood is increasing, and marine aquaculture is gradually moving towards the deep sea. The greater the distance from the shore, the more drastic the changes in sea conditions. As the main equipment of marine aquaculture, the possibility of damage to deep-water cages is greater. Typhoon waves are the main cause of damage to the structure of aquaculture cages in offshore areas. Research on the failure probability of deep-water cages under different typhoon waves is the basis for the development and design of insurance products for aquaculture cages. In this paper, the deep-water cages in the sea near Guishan Island in Zhuhai City are taken as a typical case. The hydrodynamic response of the anchor ropes, nets, and buoys of the deep-water cages under the action of typhoons and waves in different recurrence periods is calculated, and calculated by Monte Carlo simulation method. The failure probability of anchor rope, net clothing, and floating frame under different recurrence periods. At the same time, from the perspective of the degree of risk of deep-water cages and the level of construction costs, the best sizes of different components of the cages in different representative sea areas of Guishan Island were obtained.

Key words: Gravity net cage, Disaster damage, Probability of failure, Numerical simulation, Monte Carlo simulation

月桂酸单甘酯对尖吻鲈肝脏组织形态和肠道 消化酶活性的影响

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摘要: 月桂酸单甘酯 (Glycerol monolaurate, GML) 是一种天然存在于椰子油、棕榈油的单甘油酯, 常作为功能性中短链脂肪酸应用于畜禽肉质改善、肠道健康、病害防控等方面, 在水产中的应用尚不多见。本文以平均体质量 (442.727±54.423) g, 平均体长 (28.438±1.493) cm 的尖吻鲈 (*Lates calcarifer*) 为实验对象, 分析了不同浓度 (0 g/kg、1 g/kg、2 g/kg、4 g/kg) 月桂酸单甘酯 (GML) 对其肝脏组织学结构和肠道消化酶活性的影响。结果显示, 与对照组相比, 2 g/kg 实验组中 GML 肝细胞平均直径、平均面积显著 ($P<0.05$) 低于其他组, 空泡化现象得到明显缓解; 肠道淀粉酶 (AMS)、脂肪酶 (LPS)、胰蛋白酶 (PR) 活性显著 ($P<0.05$) 高于其他组。结果表明, 拌喂 GML 对尖吻鲈无不利影响, 并可增强其肠道消化能力, 减少肝脏空泡化现象, 提高其健康水平。本实验条件下, 最适添加量为 2 g/kg。

关键词: 月桂酸单甘酯; 尖吻鲈; 肝脏组织学; 肠道消化酶

Effects of Glycerol Monolaurate on Hepatic Histology, and Intestinal Digestive Enzyme of *Lates calcarifer*

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Abstract: Glycerol monolaurate (GML), a 1-monoglyceride of lauric acid, exists naturally in coconut oil and palmetto oil, was applied as a functional short-chain fatty acid to improved livestock muscle quality, intestinal health and disease prevention, and had not been reported in aquaculture. This study was to investigate the effect of (0 g/kg, 1g/kg, 2 g/kg and 4 g/kg) GML on liver histological structure and intestinal digestive enzyme activities of *Lates calcarifer* with an average weight of 442.727±54.423 g and body length of 28.438±1.493 cm. The result showed that, compared with the control, the group of 2 g/kg GML could significantly improve the average area, diameter of liver cells, the vacuolation of hepatocytes was relieved obviously ($P<0.05$). In *L. calcarifer* intestinal, the PR, LPS, AMS activities in 2 g/kg GML group were significantly higher than those in the other groups ($P<0.05$). The result showed that feeding with GML had no adverse effects on *L. calcarifer*, and could enhance the ability of digestive, reduce the vacuolation of hepatocytes, improve their health. To sum up, the optimal dietary GML level was estimated to be 2 g/kg.

Key words: GML, *Lates calcarifer*, liver histological structure, intestinal digestive enzyme

球等鞭金藻 (*Isochrysis galbana*) 对氟苯尼考

胁迫的响应研究

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摘要: 球等鞭金藻常用作水产鱼类、软体动物和甲壳类动物养殖育苗中的开口饵料。本研究以养殖过程中常用且在环境中被大量检测到的抗生素氟苯尼考为研究对象, 分析在不同浓度氟苯尼考(为 0、0.001、0.01、0.1、1.0、10、20 和 50 mg/L)暴露 72 h 后, 球等鞭金藻细胞的生物量、叶绿素、类胡萝卜素、抗氧化系统、脂肪酸含量的变化以及球等鞭金藻对氟苯尼考的生物富集能力。本研究探究了水产养殖环境中抗生素残留的生态风险, 为利用微藻进行含抗生素养殖废水处理技术的探究提供理论依据。

关键词: 氟苯尼考; 球等鞭金藻; 光合作用; 脂肪酸;

Study on the response of florfenicol on microalgae *Isochrysis galbana*

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Abstract: Marine microalgae *Isochrysis galbana* was widely used as the bait at the early larval stage of fish, mollusks and crustaceans in aquaculture. In the present study, florfenicol, an antibiotic commonly used in aquaculture and frequently detected in aquatic environment, was selected as the research object. Florfenicol at the concentration of 0.001, 0.01, 0.1, 1.0, 10, 20 and 50 mg/L exposed *Isochrysis galbana* for 72h, and algal growth, photosynthetic pigments contents, fatty acids and the bioaccumulation of florfenicol were determined. The present study highlighted the potential risk of antibiotic residues in aquatic environment on algae, which provided theoretical support for the antibiotics contained aquaculture wastewater treatment using microalgae.

Key words: Florfenicol, *Isochrysis galbana*, Photosynthesis, Fatty acid

稻虾共作模式对稻田土壤细菌群落的影响

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摘要: 为研究水稻-红螯螯虾共作模式对土壤细菌群落的影响, 本研究采用 16S rRNA 高通量测序手段对比研究引入红螯螯虾前后的稻田土壤细菌群落组成。结果表明: 稻田优势菌门均为变形菌门 (Proteobacteria)、绿弯菌门 (Chloroflexi)、酸杆菌门 (Acidobacteria)、硝化螺旋菌门 (Nitrospirae) 和拟杆菌门 (Bacteroidetes) 5 类, 主要优势菌属均为 *Anaerolineaceae_uncultured*、*Thermodesulfovibrionia_norank*、*Subgroup_6_norank*、*SBR1031_norank*、*Sva0485_norank*、*Gemmatimonadaceae_uncultured*、*MBNT15_norank*、*Latescibacteria_norank* 和 *RBG-16-58-14* 这 9 类。引入红螯螯虾后, 优势菌门属的相对丰度相较引入前有所变化, 但变化程度皆未达到显著水平。水稻-红螯螯虾共作模式带来的短期影响更明显地体现在低丰度种类上。初步探索了水稻-红螯螯虾共作体系对土壤细菌群落造成的短期影响。

关键词: 稻虾共作; 土壤微生物; 16S rRNA; 红螯螯虾

Effects of rice-crayfish farming model on soil bacterial communities in paddy fields

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Abstract: In order to study the effect of rice-*Cherax quadricarinatus* culture model on the soil bacterial community, this study compares soil bacterial community composition in paddy field before and after farmed *Cherax quadricarinatus* by 16S rRNA high-throughput sequencing technology. The results showed that: the dominant bacterial phyla are Proteobacteria, Chloroflexi, Acidobacteria, Nitrospirae, and Bacteroidetes. The main genus is *Anaerolineaceae_uncultured*, *Thermosulfovibrionia_norank*, *Subgroup_6_norank*, *SBR1031_norank*, *Sva0485_norank*, *Gemmatimonadaceae_uncultured*, *MBNT15_norank*, *Latescibacteria_norank*, and *RBG-16-58-14*. After farming *Cherax quadricarinatus*, the relative abundance of the major phyla and genus has changed, but the degree of change has not reached a significant level. The short-term effects of the rice-*Cherax quadricarinatus* culture model are more prominently reflected in low-abundance species. The short-term effects of the rice-*Cherax quadricarinatus* co-cultivation system on the soil bacterial community can be initially explored.

Key words: rice-crayfish farming, 16S rRNA, soil microorganism, *Cherax quadricarinatus*

大口黑鲈仔鱼转食期间肝脏基因和肠道微生物的协同调控

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摘要: 近年来, 大口黑鲈已成为我国最常见的水产养殖品种之一, 但其转食成活率低一直是制约大口黑鲈产业化发展的瓶颈。了解大口黑鲈仔鱼转食过程中肝脏代谢和肠道菌群的变化, 有助于设计更好的转食策略, 提高仔鱼存活率。本研究采用高通量测序方法分析了转食前、中和后三个时期(孵化后 15、30、45 天)。转录组结果显示, 转食前与氨基酸代谢有关基因表达相对较高, 转食后脂肪酸代谢有关基因表达相对较高。肠道菌群在转食前阶段占优势的变形菌门(相对丰度 56.32%), 在转食后被厚壁菌门(相对丰度 62.81%)所取代。转食中期肠道三种重要的消化酶(胰蛋白酶、脂肪酶和淀粉酶)显著降低; 并且肝脏中免疫通路基因也是如此。总的来说, 这些发现表明, 大口黑鲈转食会引起肝脏代谢和肠道微生物群落的变化, 这提高了我们对大口黑鲈转食期间应对食物变化的适应能力的认识。

关键词: 大口黑鲈、转食、仔鱼、转录组、肠道微生物、肠道消化酶

Co-modulation of liver genes and intestinal microbiome of largemouth bass larvae (*Micropterus salmoides*) during weaning

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Abstract: In recent years, largemouth bass have become one of the most commonly aquaculture species in China, however, its low survival rate during larval weaning has always been a bottleneck that has restricted industrial development. Understanding the changes in liver metabolism and intestinal microflora during the weaning of largemouth bass larvae can help to design better weaning strategies and improve survival. In this study, liver mRNA and intestinal microflora 16S rRNA genes were analyzed using high-throughput sequencing at the pre, mid, and post weaning stages (15, 30, 45 days post hatching). The transcriptome results revealed that the genes with increased expression were related to amino acid metabolism in the pre-weaning stage, but they were related to fatty acid metabolism in the post-weaning stage. A similar phenomenon was observed in the intestinal microflora where the dominant microbe Proteobacteria (relative abundance 56.32%) in the pre-weaning stage was gradually replaced by Firmicutes (relative abundance 62.81%) by the post-weaning stage. In addition, the three most important digestive enzymes (trypsin, lipase, and amylase) in the intestine were significantly decreased during the mid-weaning stage ($P < 0.05$), which was also true for some genes crucial to immune pathways in the liver. Overall, these findings showed that weaning in largemouth bass can cause changes in liver metabolism and intestinal microbial communities, which has improved our understanding of fish adaptation to changes in food sources during weaning.

Keywords: Largemouth bass; weaning; larvae; transcriptome; intestinal microbes; intestinal digestive enzyme

大口黑鲈 leptin A 基因的组织表达及其对急性低氧胁迫的响应

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摘要: 瘦素(leptin)是一种重要的激素, 参与调节动物的摄食、繁殖和能量消耗, 其可以通过抑制食欲和促进能量代谢的方式维持机体能量稳态。大多数鱼类具有双重瘦素基因。在本研究中, 利用 PCR 技术克隆了大口黑鲈 leptin A 基因的编码区, 其开放阅读框(ORF)为 486 bp, 编码 161 个氨基酸蛋白。通过与其他物种进行同源性比对, 发现鲈形目的 leptin 基因的保守型较高, 一致性高达 91.46%, 在大口黑鲈 leptin A 中几乎不存在基因特异性突变位点, 而且大口黑鲈 leptin A 氨基酸序列与鳊同源性最高(92.59%), 与花鲈(89.51%)、布氏鲮(87.04%)、斜带石斑鱼(83.87%)的同源性次之。组织分布结果显示, leptin A 基因在肝脏中的表达量最高, 在心、头肾、脑、中肾、肠、脾、鳃、肌肉和性腺中的表达量均较低。此外, 对大口黑鲈进行不同程度急性低氧胁迫[重度低氧(1.2±0.2)mg/L 和 中度低氧(3.5±0.2)mg/L], 发现低氧初期时严重低氧组中度低氧组的 leptin A 的表达量都升高, 显著高于对照组 Leptin A 的表达。这表明急性低氧能够诱导大口黑鲈 leptin A 在肝脏中的表达。综上所述, 大口黑鲈 leptin A 基因与鳊 leptin A 基因的同源性最高, leptin A 主要在大口黑鲈肝脏中显著表达, 急性低氧胁迫能显著诱导 leptin A 的表达。

关键词: 大口黑鲈; 瘦素; 基因克隆; 基因表达; 低氧胁迫

温度和盐度对中间球海胆胚胎发育早期进程 联合效应分析

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摘要: 为了探讨高温和低盐对中间球海胆(*Strongylocentrotus intermedius*)早期胚胎发育进程的影响, 本文利用中心复合设计(CCD)和响应曲面分析法(RSM), 开展不同温度(12~26 °C)和盐度(22~34)对中间球海胆胚胎发育早期进程的联合效应研究。结果显示, 在实验设定的温度和盐度范围内, 随着温度的升高, 中间球海胆早期胚胎发育时间呈现出先缩短后延长的趋势; 随着盐度的降低, 中间球海胆胚胎发育早期时间延长。温度一次项系数的绝对值均大于盐度的一次项系数; 温盐的联合效应对中间球海胆胚胎发育早期进程的影响不显著($P>0.05$)。实验建立的二细胞期、八细胞期、十六细胞期、囊胚期、上浮期和四腕幼虫期发育进程模型方程决定系数分别为 0.9576、0.9508、0.9689、0.9932、0.9681 和 0.9763。模型优化和验证试验得出, 温度 20.47 °C 和盐度 31.46 时, 中间球海胆二细胞期、八细胞期、十六细胞期、囊胚期、上浮期、四腕幼虫期的发育时间最短, 分别为 1.28 h、2.07 h、3.31 h、4.14 h、11.28 h 和 47.31 h。研究结果表明高温和低盐会延长中间球海胆早期胚胎发育时间, 本结论将为中间球海胆人工繁育提供一定的理论依据。
关键词: 中间球海胆; 早期胚胎发育; 温度; 盐度; 联合效应

Interactive effect of temperature and salinity on early embryo development process of sea urchin (*Strongylocentrotus intermedius*)

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Abstract: Based on the fertilized eggs and larva of *Strongylocentrotus intermedius*, the effects of high temperature and low salinity on the early embryonic development of the *S. intermedius* were discussed, and the tolerance of larvae at various stages to temperature and salinity were studied. Central Composite Design (CCD) and Response Surface Methodology (RSM) were used to study the interactive effect of temperatures (12~26 °C) and salinity (22~34) on the early embryonic development process of *S. intermedius*. The results showed that the early embryonic development time of *S. intermedius* shortening first and then lengthening with temperature increasing. With salinity decreasing, the early embryo development of *S. intermedius* prolonged. The absolute value of the linear coefficient of temperature was greater than the linear coefficient of salinity. The combined effect of temperature and salinity has no significant effect ($P>0.05$) on the early embryonic development of *S. intermedius*. The model equation of the 2-cell, 8-cell, 16-cell, blastula, floating, and four-arm pluteus larvae towards temperature and salinity were established, with the coefficients of determination (R^2) being 0.9576, 0.9508, 0.9689, 0.9932, 0.9681 and 0.9763, respectively. At a temperature of 20.47 °C and a salinity of 31.46, the development time of the 2-cell, 8-cell, 16-cell, blastula, floating, and four-arm pluteus larvae of *S. intermedius* was the shortest, which were 1.28h, 2.07h, 3.31h, 4.14h, 11.28 h and 47.31h. The results indicated that high temperature and low salinity will prolong the early embryonic development process of *S. intermedius*. The findings aim to provide a certain theoretical basis for the artificial breeding of *S. intermedius*.

Key words: sea urchin (*Strongylocentrotus intermedius*); early embryo development; temperature; salinity; interactive effect

稻田和池塘养殖小龙虾肠道菌群、免疫酶活及肌肉氨基酸比较分析

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Rice-shrimp culture: a better intestinal microbiota, immune enzymatic activities and muscle relish of crayfish (*Procambarus clarkii*) in Sichuan Province

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Abstract: Intestinal microbiota play an important role in the intestinal immunity and nutrient absorption, even muscle nutritional components, and the composition and function were affected by environment. In this study, the intestinal microbiota and immune enzyme, nutritional flavor of muscle of crayfish in rice field and pond cultivation model were compared in summer and autumn. Results of shannon-diversity and Chao 1 index of intestinal microbiota based on 16S sequencing analysis showed that the diversity and abundance in autumn were higher than in summer. And the diversity and abundance of intestinal microbiota of different model in the same season were different. Four dominant phyla (relative abundance >5% at least in one sample) of the intestinal microbiota were *Bacteroidetes*, *Firmicutes*, *Proteobacteria* and *Tenericutes*. From summer to autumn, the intestinal immune enzyme activity of crayfish in both models showed a decreasing trend. In summer, the activity of catalase and alkaline phosphatase of crayfish cultured in the pond were significantly higher than that in rice field ($P < 0.05$). In autumn, the activity of catalase and lysozyme of crayfish cultured in rice field were significantly higher than that in pond ($P < 0.05$). The content of umami and sweetish amino acids of muscle were higher in rice field than in pond, and the percentage of glutamic acid and alanine was significantly higher in rice field than in pond ($P < 0.05$). Thus, rice field model can make crayfish a more stable intestinal environment, a better intestinal immune enzyme activity and muscular flavor.

Key words: Intestinal microbiota, cultivation model, immune enzyme, amino acid, *Procambarus clarkii*

不同种类饵料会影响鲤鱼消化和免疫能力：通过酶活性测定和转录组测序

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Different diets can affect the digestion and immunity of common carp (*Cyprinus carpio*) according to enzyme activity assay and transcriptome sequencing

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Abstract: rice field. Common carp is a typical omnivorous fish. They can generally prey on both plant and animal diets in rice paddy mode. In this research, the common carp were randomly divided into three groups: animal diet group (group AD), plant diet group (group PD) and mixed diet group (group MD). Growth index, enzyme activity (digestive and immune), and transcriptome profile were performed to evaluate the effect of different diets on carp health. The results showed that the final weight of common carp is lesser than initial weight and the activity of trypsin and lipase were the highest in animal diet group. On the contrary, the body weight loss and α -amylase activity were the highest in the plant diet group. The mixed diet group had the highest the acid phosphatase (ACP) and alkaline phosphatase (AKP) activity in liver. "Protein digestion and absorption", "bile secretion", "hematopoietic cell lineage" and "intestinal immune network for IgA production" pathways belonging to the digestive and immune systems had significant enrichment between common carp fed a single type of diet and a mixed diet. These results indicate that rice-fish system is more conducive to common carp health, certainly, it is better for economic benefits if providing additional diet for fish.

Key words: Ecological aquaculture, Diets, Digestion, Immunity, mRNA sequencing

不同种类饵料会影响鲤鱼肠道微生物和免疫能力

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Effects of different diets on the intestinal microbiota and immunity of common carp (*Cyprinus carpio*)

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Abstract: Aims: An 8-week trial was performed to evaluate the differences in the intestinal microbiota and immune function of common carp (*Cyprinus carpio*)-fed different diets. Methods and Results: The fish were randomly divided into three groups with three replicates and were fed earthworms (group A), earthworms + duckweed (group M) or duckweed (group P) respectively. The diversity and dominant microbiota of the intestinal bacteria were detected by denaturing gradient gel electrophoresis, and the abundance of dominant bacteria was quantified by qPCR. Additionally, the activities of some nonspecific immune enzymes and antioxidant enzymes were determined. The results showed that higher diversity and abundance of intestinal microbiota were observed in group M and group P ($P < 0.05$). Based on the intestinal microbiota, *Cetobacterium* was only detected in the intestines of common carp in group A, and *Bacillus* was identified in groups M and P. Additionally, a higher abundance of Bacteroidetes and Firmicutes was also found in the intestine in group P than in group A ($P < 0.05$). Interestingly, the higher activities of immune enzymes were detected in intestine of common carp in group M, such as acid phosphatase, phosphatase (AKP), lysozyme, total antioxidant capacity, superoxide dismutase, catalase, glutathione peroxidase. In addition, the lower level of metabolites were also detected, such as nitric oxide and malondialdehyde. Conclusions: Our results indicate that the intestinal microbiota and intestinal immunity of common carp were affected by diet. Meanwhile, the results show that a mixed diet can promote and improve the immune function of the omnivorous carp intestine, which suggests that paddy fields might be more suitable for the intestinal health and animal welfare of omnivorous fishes because they contain plant and animal diets. Significance and Impact of the Study: As an ecological aquaculture strategy, the rice-fish mode has attracted attention among farmers, researchers and even consumers, especially for the cultivation of common carp in paddy fields. In paddy fields, fish can eat plant- and animal-based diets. However, it is not clear whether common carp feeding on a mixed diet in paddy fields have better intestinal health. This experiment is one of only a few studies performed from the perspective of intestinal micro-organisms and immunity to successfully study the effects of different natural diets on adult common carp. This study also provides a theoretical basis for healthy breeding of common carp in paddy fields.

Keywords: Common carp, diets, immunity, intestinal microbiota, rice-fish mode.

盐度骤变对金钱鱼幼鱼鳃线粒体丰富细胞形态结构的影响

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摘要: 本论文研究了盐度骤变对金钱鱼 (*Scatophagus argus*) 幼鱼鳃线粒体丰富细胞 (mitochondria-rich cells, MRCs) 的形态结构变化, 采用显微镜技术研究盐度骤降 (20‰投入 5‰), 盐度骤升 (20‰投入 35‰), 胁迫不同时间后 MRCs 的形态结构变化。观察结果: 低盐胁迫 3h MRCs 长径 $9.517 \pm 1.390 \mu\text{m}$ 和短径 $7.150 \pm 1.448 \mu\text{m}$ 与对照组长径 $7.317 \pm 0.986 \mu\text{m}$ 和短径 $5.067 \pm 0.467 \mu\text{m}$ 显著增大 ($P < 0.05$), 胁迫 6h MRCs 数量增加。分化出两种类型的 MRCs: I 型 MRCs, 椭圆形, 胞核形状不规则, 内脊发达, 顶端开口处于关闭状态或开放状态; II 型 MRCs, 圆形, 胞核规则呈圆形, 具有多个顶端开口。线粒体呈 a 型和 b 型, a 型着色较浅, 呈短粗状; b 型着色较深, 呈小的颗粒状。结果表明: 盐度骤变金钱鱼幼鱼会产生应答反应机制, 通过 MRCs 体积、数量、形状结构, 以及线粒体的形状结构变化, 共同维持内环境稳定。

关键词: 金钱鱼; 鳃; 线粒体丰富细胞; 组织结构; 超微结构

Effects of abrupt salinity change on Morphology and structure of mitochondria-rich cells in *Scatophagus argus*

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Abstract: The present paper studies the abrupt salinity change on Morphology and structure of MRCs in *Scatophagus argus*, The salinity sag (20‰ into 5‰) and salinity surge (20‰ into 35‰) were studied by microscope technology. At different time compare the morphologic structural change of the MRCs. Observation results: The long diameter $9.517 \pm 1.390 \mu\text{m}$ and short diameter $7.150 \pm 1.448 \mu\text{m}$ of MRCs were significantly larger from the control group long diameter $7.317 \pm 0.986 \mu\text{m}$ and short diameter $5.067 \pm 0.467 \mu\text{m}$ ($P < 0.05$). The number increased significantly after 6h of stress. Show the two types of MRCs: Type I, oval, The nuclei are irregularly shaped, The inner ridge is well developed and the apex opening is closed or open; Type II, roundness, The nuclei are regular and round with multiple apex openings. The mitochondria are of type A and B, Type A is lighter in color, short and stout, Type B has a darker coloration, small and granular. Results t: A sudden change in salinity occurs, They through MRCs volume, number, shape and structure, as well as mitochondrial shape and structure changes, Adjust osmotic pressure balance together to maintain the stability of the internal environment.

Key words: *Scatophagus argus*, gill, mitochondria-rich cells, organization struct, ultrastructure

不同光照度对红鳍东方鲀 (*Takifugu rubripes*) 幼鱼生长、消化免疫及氧化应激的影响研究

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摘要: 为了更准确的获知不同光照度对红鳍东方鲀幼鱼时期影响规律。本研究采用新型 LED 全光谱灯具作为实验光源, 设置 4 种不同光照强度 (50、250、500、750mW/m²) 对 30 日龄红鳍东方鲀 (0.03 ± 0.01g) 生长、消化免疫及氧化应激等方面进行为期 35 天的实验研究。结果表明, 750 mW/m² 光照度下最终体重显著增加, 达到 1.1±0.005 g, 四组幼鱼全长在实验结束时无显著差异。在 250mw /m² 条件下, 幼鱼的消化酶活性 (AKP、ACP 和 PPS) 显著高于其他各组。在实验结束时, 50 mW/m² 处理导致幼鱼代谢酶 (ALT、AST 和 LDH) 活性水平下调。高光照强度 (750 mW/m²) 引起红鳍东方鲀幼鱼应激反应, SOD 活性波动较大, T-AOC 活性被抑制。综合而言, 250-500 mW/m² 较适合作为红鳍东方鲀早期幼鱼养殖和健康生长的光照度环境。

关键词: 光照度、红鳍东方鲀、生长性能、消化免疫、氧化应激

Effects of different illumination intensity on growth, digestive metabolic enzymes, and oxidative stress responses of juvenile *Takifugu rubripes*

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Abstract: In order to know more accurately the effect of different illumination intensity on juvenile *Takifugu rubripes* (0.03 ± 0.01g). In the current study, juveniles were reared under four light illuminations intensities: 50 , 250 , 500 and 750 mW/m². The results showed that After 35 days, the use of 750 mW/m² light illuminations intensity led to a significant increased in final body weight that reached 1.1±0.005 g, and the total length of juveniles under four groups had no significantly differences at the end of research. The activities of digestive enzymes (AKP, ACP, and PPS) of *Takifugu rubripes* juveniles in 250 mW/m² was significantly higher than those in other groups. 50 mW/m² treatment resulted in down-regulation of metabolic enzyme (ALT, AST, and LDH) activities levels at 35 days. High light intensity (750 mW/m²) resulted in a stress response characterized by T-AOC activity were inhibited and the activities of SOD was obvious fluctuation during the experiment. On the whole, our results suggested that 250-500 mW/m² was most suitable for early stage of *Takifugu rubripes* farming and health growth.

Key words: Illumination intensity, *Takifugu rubripes*, growth performance, digestive enzyme, oxidative stress

火山石和细菌屋对锦鲤养殖池水质净化效果的对比研究

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摘要: 为了比较火山石和细菌屋 2 种生物滤材对锦鲤养殖池的水质净化效果, 分别设置火山石组、细菌屋组、空白对照组, 在水泥池中, 对同一亲本繁育的锦鲤苗种开展了为期 7 周的循环水过滤养殖试验。试验结果显示, 火山石比表面积 $[(14.12\pm 0.37) \text{ m}^2/\text{g}]$, 高于细菌屋 $[(7.83\pm 0.39) \text{ m}^2/\text{g}]$; 自试验第 2 周开启循环过滤系统后, 火山石组和细菌屋组水体化学需氧量 (COD)、氨氮含量逐渐下降, 最终趋于平稳, 并显著低于对照组 ($P < 0.05$); 火山石组和细菌屋组水体硝化细菌数量显著高于对照组 ($P < 0.05$), 其中火山石组最高。试验说明, 火山石更有利于硝化细菌的生长繁殖, 是较好的锦鲤养殖池生物滤材。

关键词: 火山石; 细菌屋; 锦鲤; 水质; 生物滤材

Comparative study on purification effect of volcanic stone and bacteria house on water quality of *Cyprinus carpio* culture

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Abstract: In order to study the purification effect of volcanic stone and bacteria house on the water quality of *Cyprinus carpio* culture. Volcanic stone group, bacterial house group and blank control group were set in this study, and the koi seedlings bred by the same parent were subjected to circulating water filtration culture. The results showed that the specific surface area of volcanic rocks is higher than that of bacteria houses. After opened the circulating filtration system in the second week, the contents of COD and ammonia nitrogen tend to decrease first and then stability in the water of volcanic rock group and bacterial house group ($p < 0.05$), of which was significantly lower than that of the control group. The number of nitrifying bacteria in the volcanic group and the bacterial house group were significantly higher than that in the control group ($p < 0.05$), and the volcanic group was the highest. Because volcanic stone is a natural filter material, rich in mineral elements, and has a high specific surface area, it is more conducive to the growth and reproduction of nitrifying bacteria. Therefore, it is more suitable to select volcanic stone as a biological filter material.

Key Words: Volcanic stone, bacteria house, *cyprinus carpio*, water quality

水流作用下沉降式网箱受力特性研究

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摘要: 为了给沉降式网箱的设计、选型以及养殖区域选址等提供数据参考, 本文以东海水产研究所设计的沉降式网箱为研究对象, 在主尺度为90 m×6 m×3 m的试验水池内进行模型试验, 研究了网箱在浮、沉两种状态时的阻力性能。结果显示: 网箱箱体的浮态和沉态的整体受力均随流速的增加而增大, 在相同的外界条件下, 沉态比浮态的总受力值大8.3%-24.1%, 因箱体采用铜合金网衣结构, 使得箱体本身自重较大, 建议使用大于250mm管径的双浮管结构或者采用250mm的三浮管结构以增加框架的整体浮力。

关键词: 沉降式网箱; 模型试验; 阻力性能

Research on the mechanical Characteristics of settling cage under the action of water flow

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Abstract: In order to provide data reference for the design and selection of settling cage and the selection of breeding area, this paper takes the settling cage designed by the East China Sea Fisheries Research Institute as the research object, in the main size of 90 m×6 m×3 m of the test tank model test, study the cage in float, sink two states of resistance performance. The result shows: the box body of the float and sink states overall stress increases with the increase of flow velocity, under the condition of the same outside, heavy state is greater than the total stress value of the float state of structure is 8.3% - 24.1%, because of the case with copper alloy net structure, makes the body itself weight is bigger, it is recommended to use more than 250 mm diameter double or three floating structure with 250 mm floating structure to increase the overall framework of buoyancy.

Key words: Settling cage, model test, resistance performance

深远海养殖用聚甲醛网片制备及性能研究

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摘要: 为了开发新型高性能深远海养殖用网衣材料, 本实验以渔用聚甲醛单丝为原料, 采用经编和绞捻两种织网工艺, 制备了渔用聚甲醛网片材料, 并研究了聚甲醛网片的制备工艺及渔用性能。结果表明: 制作聚甲醛绞捻网片时, 20股聚甲醛网线的最佳捻度为20捻/米。对于聚甲醛经编网片, 最佳热定型温度为130度。45纱与270纱的聚甲醛经编网片的网目断裂强力分别为699.2N和3759.3N。

关键词: 聚甲醛; 深远海养殖; 绞捻网片; 经编网片; 渔用材料

Study on Preparation and properties of polyoxymethylene mesh for high sea farming

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Abstract: In order to develop a new type of high-performance net material for high sea farming, the monofilament of polyoxymethylene (POM) was used as raw material in this study, adopting warp knitting and twisting netting technology. And the preparation technology and fishing performance of POM mesh were studied. The results showed that the optimum twist of 20 strand POM netting twine made for twisting netting is 20 twists/m. For POM warp knitted mesh, the best heat setting temperature is 130 °C. The POM mesh breaking strength of 45 yarn and 270 yarn is 699.2N and 3759.3N, respectively.

Key words: Polyoxymethylene, high sea farming, twisting netting, warp knitted mesh, fishery materials

芡实生态塘在南美白对虾养殖中的净化作用分析

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摘要: 本研究开展了芡实生态塘对滨海滩涂南美白对虾养殖的净化效果分析。9 个南美白对虾养殖池塘 (0.6 公顷) 随机分成 3 个不同处理组: 对虾单养组 (SM), 对虾-芡实养殖组 (SE) 和对虾-芡实-尾水养殖组 (SET)。研究结果显示, 芡实种植 (SE 和 SET) 可显著降低池塘中污染物含量 ($P<0.05$)。芡实种植 (SE 和 SET) 可显著提高南美白对虾成活率和最终产量 ($P<0.05$)。经济效益结果表明, 芡实种植组利润 (SE 20653.0 USD \cdot ha $^{-1}$, SET 21431.3 USD \cdot ha $^{-1}$) 约为 SM 组 (14290.0 USD \cdot ha $^{-1}$) 的 1.45-1.50 倍。与 SM 和 SE 组相比, SET 组可减少尾水排放约 2666.6m 3 。因此, 芡实种植组, 尤其是对虾-芡实-尾水组采用的养殖模式是一种适宜于滩涂南美白对虾养殖池塘的节水、可持续的养殖模式。

关键词: 生态塘; 芡实; 南美白对虾; 水质; 经济效益

Purification effect of ecological ponds of *Euryale ferox* Salisb on shrimp aquaculture

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Abstract: This study was conducted to explore the in-situ and ex-situ purification effect of ecological ponds of *Euryale ferox* Salisb on shrimp aquaculture in the tidal flat ponds. Nine 0.60 ha tidal flat ponds were divided into three groups randomly, (1) shrimp monoculture group, SM; (2) shrimp + *E. ferox* group, SE; (3) shrimp + *E. ferox* + tailwater group, SET. Results showed that most main water quality parameters in aquaponics groups (SE and SET) were significant lower than those in SM group ($P<0.05$). All water quality parameters demonstrated significant increased after tailwater input (95 days) in SET group. The shrimp production and survival rates in the aquaponics groups (SE and SET) were significant higher than those in SM group ($P<0.05$). The profits of aquaponics groups (SE 20653.0 USD \cdot ha $^{-1}$, SET 21431.3 USD \cdot ha $^{-1}$) were approximately 1.45 to 1.50 times higher than that of the SM group (14290.0 USD \cdot ha $^{-1}$). The SET group also saved source water of 2666.6 m 3 by using tailwater of shrimp aquaculture. Thus, the aquaponics model, especially the shrimp + *E. ferox* + tailwater system, is a water saving and sustainable development model that fits well with the conditions of shrimp ponds in the coastal tidal flats.

Key words: Ecological pond, *Euryale ferox* Salisb, shrimp, water quality, economic

进水方式对圆形养殖池自清洗性能的影响

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摘要: 养殖池自清洗是指通过调节池内水流设置,使等污物自动聚集至池中心排出的过程。本文通过物理模型试验研究进水方式(布设距离、射流角度、射流管数量)对圆形养殖池自清洗性能的影响。试验中通过比较不同工况下池内污物完全排出所消耗时间,评价养殖池的自清洗性能。试验结果表明:(1)双管工况下:进水管布设距离分别为0、1/4、1/2半径时,入射角度在60度、45度、30度时集污耗时最短。(2)单管工况下:进水管布设距离分别为0时任何角度均不能将污物完全排除,布设距离为1/4、1/2半径时,入射角度在45度、0度时集污耗时最短。双管工况集污耗时均短于单管工况,双管工况下随着布设距离的增大最短集污耗时逐渐减小。本文研究成果可以为工厂化循环水圆形养殖池设置进水方式提供参考。

关键词: 进水方式; 自清洗; 水动力特性; 集污效果

Influence of water inlet mode on self-cleaning performance of circular culture pond

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Abstract: The self-cleaning of the aquaculture tank is primarily achieved by adjusting the flow settings in the tank to concentrate the wastes to the water outlet in the center. In this research, the influence of inlet water setting (distance, jetting orientation, pipe number) on the self-cleaning performance of circular aquaculture tank was investigated through laboratory physical model test. In the experiment, the self-cleaning performance of the aquaculture tank was evaluated by comparing the consumption time of the process of concentrating wastes in the tank under different setting conditions. The results show that: (1) Double-pipe condition: when the inlet pipe is set at a distance of 0 1/4radius 1/2radius, the consumption time is the shortest with the jetting orientation of 60° 45° 30°. (2) Single pipe condition: when the inlet pipe is close to the pool wall, it cannot completely discharge the sewage; when the inlet pipe is set at a distance of 1/4radius and 1/2radius, the consumption time is the shortest with the jetting orientation of 45° and 0°. The fouling collection time in the double-pipe condition is shorter than that in the single-pipe condition, and the shortest fouling collection time decreases gradually with the increase of the layout distance in the double-pipe condition. The research results of this paper can provide reference for the water inlet setting of circular aquaculture ponds for circulating water in the factory.

Key words: Water-inlet setting, self-cleaning, hydrodynamic characteristics, waste concentration

淡水池塘养殖尾水处理的研究

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摘要: 养殖尾水污染是我国现在面临的重要问题, 本研究构建了尾水处理系统, 通过净化淡水池塘养殖尾水以期减少环境污染。本系统中尾水依次流经沉淀池自然沉淀去除悬浮物, 随后经过过滤坝拦截大颗粒污染物, 再经曝气池增氧为后续微生物处理池提供充足的溶氧以供有益菌进行生化反应去除氨氮等污染物、最后经水生植物净化池进一步吸收氮、磷。经过 30 天采样检测, 结果显示该系统对总磷 (TP)、氨氮 (NH₄⁺-N)、亚硝态氮(NO₂⁻-N)和化学需氧量 (COD_{Mn}) 的平均去除率为 53.15%、58.07%、15.24%和 54.99%, 本系统对淡水池塘养殖尾水具有显著净化效果, 对推进水产绿色发展具有重要意义。

关键词: 尾水处理; 淡水养殖; 净化效果

Study on tail water treatment of freshwater pond culture

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Abstract: The water pollution of aquaculture tailwater is an important problem in China. In this study, the tailwater treatment system was constructed to purify the tailwater of freshwater pond in order to reduce environmental pollution. This system of tail water, in turn, flows through the sedimentation tank to remove suspended solids naturally, and then filtered dam intercepts large particulate pollutants, then through aeration tank increasing oxygen and providing plenty of dissolved oxygen for subsequent microbial processing pool in order to offer beneficial bacteria oxygen for biochemical reactions to remove ammonia nitrogen pollutants, finally the aquatic plant purification pool further absorbed nitrogen and phosphorus. After 30 days of sampling and testing, the results showed that the average removal rates of total phosphorus (TP), ammonia nitrogen (NH₄⁺-N), nitrite nitrogen (NO₂⁻-N) and Chemical oxygen demand (COD_{Mn}) were 53.15%, 58.07%, 15.24% and 54.99%. This system has a remarkable purifying effect on the tail water of freshwater pond culture, which is great significance for promoting the ecological development of aquaculture.

Key words: Tail water treatment, freshwater aquaculture, purification effect

大力发展休闲渔业 助推产业精准扶贫

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摘要: 随着国民经济与城乡居民收入水平提高,休闲渔业已成为人们休闲、度假、娱乐的重要方式,是渔(农)民脱贫致富的重要途径。近年来,麒麟区利用优越的地理环境大力发展休闲渔业,把休闲渔业融入到产业扶贫。本文从产业精准扶贫政策、休闲渔业发展方式、提升服务质量,规范市场行为三个方面分析了休闲渔业助推产业精准扶贫新模式,为产业融合发展和乡村振兴战略提供新举措。

关键词: 休闲渔业;精准扶贫

Energetically developing recreational fishery to boost industrial integration development

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Abstract: With the rapid growth of the national economy and the increase in the income level of urban and rural residents, recreational fishery has gradually become an important place for people's leisure, vacation and entertainment, and it has also become one of the important ways for fishery (farmers) to get rid of poverty and become rich. In recent years, Qilin District advantage of favorable geographical environment to develop recreational fishing, recreational fishing to the integration of poor industry. This article analyzes the new model of industrial precision poverty alleviation by industrial precision poverty alleviation policies, recreational fishery development methods, improving service quality, and standardizing market behavior, and provides new measures for industrial integration development and rural revitalization strategies.

不同成分培养基底栖动物生物量及其水质评价

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摘要: 采用 4 种不同成分的营养物质的培养基对底栖动物的密度及生物量进行分析, 同时对水质中营养盐进行研究。结果表明: 培养基中底栖动物主要有 3 种底栖动物, 为摇蚊幼虫(Chironomid)、水丝蚓(Limnodrilus hoffmeisteri)与螺狮(Bellamya quadrata)。生长季中密度的比较, 糖蜜>腐植酸>培养基>对照组。对照组中 NO₂-N 的含量最高, 对照组中营养物质较少。底栖动物数量上呈水丝蚓>摇蚊幼虫>螺狮。不同底栖动物之间相关性不明显, 营养盐对摇蚊幼虫及水丝蚓相关性较大, TP 对底栖动物的营养大于 TN。底栖动物是虾蟹生长的饵料, 通过对比对日后虾蟹生长提供科学依据。

关键词: 培养基; 底栖动物; 群落结构; 水质评价

Biomass and water quality evaluation of basal-dwelling animals cultured with different components

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Abstract: The density and biomass of benthic animals were analyzed by using four nutrient medium with different components, and the nutrient salts in water quality were also studied. The results show that: There are three main benthic species in the culture medium, namely Chironomid larvae, Limnodrilus hoffmeisteri and Bellamya quadrata. The density of molasses > humic acid > medium > control group. The content of NO₂-N was the highest in the control group, and the nutrient substances in the control group were few. The number of benthic animals is the water silk worm > midge larva > snail lion. No significant correlation between different benthic animals. There was a negative correlation between nutrient salt and larva of midge and water worm, the nutrition of TP is greater than that of TN. Benthic animals are the bait for the growth of shrimp and crabs. The comparison provides scientific basis for the growth of shrimp and crabs in the future.

Key words: Culture medium, benthonic animal, community structure, water quality evaluation

基于 ecopath 模型的稻鱼共作系统生态机制探讨及优化

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摘要: 稻渔共作系统历史悠久, 被列为“全球重要农业遗产系统”, 研究该系统生态机制, 有助于发展新型可持续农业。本研究采用生态路径模型(一种可对研究对象进行全面定量评价的生态系统方法)对稻鱼生态系统的结构和功能进行了研究, 进而发掘其生态价值。本研究以单种稻田为对照生态系统(RM), 以放养鲤鱼的稻田为实验生态系统(RF)。结果表明, 放养鲤鱼系统的能量传递路径增加了 78.69%, RF 系统的能量传递效率相比 RM 系统提高 67.86%。RF 生态系统的连接度指数(CI)、Finn's cycle Index (FCI)、冗余值等均高于 RM 生态系统, 说明 RF 生态系统具有更高的成熟度和稳定性。为进一步提高稻鱼系统的能量利用效率并减少系统的碎屑积累, 可将稻鱼生态系统鲤鱼放养密度增加至 34.850 g·m⁻²。总体而言, 稻渔共作可增加系统能量传递路径, 提高系统能量利用效率, 提高系统的稳定性和成熟度, 是一种可持续的农业模式。

关键词: 稻鱼共作; ecopath; 生态机制

Application of ecopath model to assess the mechanism of rice-fish co-culture system

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Abstract: Rice-fish coculture ecosystem has a long history and has been designated a “globally important agricultural heritage system”. Recognizing the ecological mechanism of this ecosystem comprehensively and quantitatively may help people develop novel sustainable agriculture. The existing studies mainly focus on the perspectives of the nutrient concentration, biological community structure, yield and profit of this system, while deeper understanding of this system at the ecosystem level is still scarce and therefore limit its application. This study investigated the structure and function of two different ecosystems of rice and common carp (*Cyprinus carpio*) using Ecopath model, which is an ecosystem approach and can assess the ecosystem comprehensively and quantitatively. Two treatments were designed, including the control ecosystem (without common carp, RM) and the treatment ecosystem (with common carp, RF). 17 and 18 functional groups were incorporated into models of these two ecosystems. Results showed that the cladocera and copepod had strong effects on the ecosystem in both the keystone index and mixed trophic impacts (MTI) analysis. Most of the total system throughput (TST) of the two ecosystems was distributed in trophic level I and II. RF ecosystem had the higher energy transfer efficiency, which were 67.86% higher than RM ecosystem. RF ecosystem showed higher value of Connectance Index (CI), Finn's cycling index (FCI), overhead (O), redundancy (R), O/D and R/D than those of RM ecosystem, indicating greater maturity and stability for RF ecosystem. Overall, the coculture with common carp could improve the energy utilization efficiency, maturity and stability of the rice field ecosystems, representing a sustainable agriculture practices. To achieve higher energy utilization efficiency and less detritus accumulation of the ecosystem, more common carp (34.850 g·m⁻²) could be adopted in the rice-fish coculture ecosystem.

Key words: Rice-fish co-culture, ecopath model, mechanism

除氮型改性凹凸棒土、火山石及复合外源微生物净水效果机理

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摘要: 为探讨材料在污水处理中的净化机理, 进行了生物与净化材料联合强化净水试验。选择除氮型改性凹凸棒土(Al@TCAP)和火山石作为净化材料, 组合外源微生物包括芽孢杆菌属(*Bacillus* sp.)和活性污泥。用扫描电子显微镜分析纯化材料的表面特性, 酶联免疫吸附法测定肝酶活性, 并对材料周围水样进行 16s rRNA 及其 ITS 组检测。48h 时, 净化液和三种外源微生物对总氮、总磷和锰化学需氧量的去除率分别为 46.91%、50.93%和 65.08%。火山石组、Al@TCAP 组和外源微生物组的碱性磷酸酶活性均呈上升趋势, 有机磷水解酶、脱氢酶和微生物亚硝酸盐还原酶活性分别在 36-48 h、6-24 h 和 36-48 h 升高。研究表明, Al@TCAP 的微生物负荷能力较弱, 主要归因于吸附作用。火山石有足够的容量负载改善水质的微生物。Al@TCAP 和外源微生物促进了浮霉菌的生长和反硝化反应。曲霉属的生长提高了磷的净化效果。

关键词: 净化材料; 外源微生物; 水质净化; 微生物酶活; 宏基因组

Effective mechanism of water purification for nitrogen-modified attapulgite, volcanic rock, and combined exogenous microorganisms

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Abstract: To explore the purification mechanism of materials in wastewater treatment, water purification and its enhancement by combining organisms and purification materials were tested. Nitrogen removal-type modified attapulgite (Al@TCAP) and volcanic rock were selected as the purification materials, while the combined exogenous microorganisms included a mix of *Bacillus* sp. and activated sludge. The superficial characteristics of the purification materials were analyzed via a scanning electron microscope, the hepatic enzyme activities were assessed using the enzyme-linked immunosorbent assay method, and metagenome (16srRNA and ITS) on the water samples around the material. At 48 h, the removal rates of total nitrogen, total phosphorous, and Mn chemical oxygen demand in the purified materials plus the three exogenous microorganisms were 46.91%, 50.93%, and 65.08%, respectively. The alkaline phosphatase activity increased for all times tested in the volcanic rock, Al@TCAP, and exogenous microorganism groups, while the organophosphorus hydrolase, dehydrogenase, and microbial nitrite reductase activities increased at 36-48, 6-24, and 36-48 h respectively. However, the tested activities only increased in the combination groups at 48 h. The study demonstrates that Al@TCAP exhibits a weak microbial loading capacity, and the Al@TCAP removal is primarily attributed to adsorption. Volcanic rock has enough capacity to load microorganisms that improve water quality. The growth of Planctomycetes and the denitrification reaction was promoted by Al@TCAP and the exogenous microorganisms. The growth of the genus *Aspergillus* enhanced the phosphorous purification effect.

Key words: Purification materials, exogenous microorganisms, water purification, microbial enzyme activity, metagenome

稻虾共作模式中不同投饲率对稻虾生长及氮磷利用的影响

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摘要: 为优化稻虾种养模式的资源配置, 研究了稻虾种养模式中小龙虾的投饲率对水稻、小龙虾生长及氮、磷利用率的影响。结果显示: 当投饲率为6%时, 小龙虾增重率和特定生长率最高, 但是饲料利用率有所下降; 随着投饲率的增加, 水稻产量有提高的趋势, 但是差异均不显著 ($P>0.05$); 稻虾种养系统中, 随着投饲率增加, 系统中小龙虾对氮、磷利用率呈现提高的趋势, 但是水稻对系统中氮、磷的利用率出现下降的趋势。由此说明, 不同投饲率对虾的生长影响较大, 适当提高投饲率可以增加小龙虾产量, 进而提高系统的氮、磷利用率。

关键词: 水稻; 克氏原螯虾; 投饲率; 氮磷收支

Effects of crayfish feeding rate on rice growth, crayfish growth, and budgets of nitrogen and phosphorus in the rice-crayfish system

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Abstract: In order to optimize the allocation of resources, the effects of feeding rate of crayfish (*Procambarus clarikia*) on the growth and nitrogen and phosphorus utilization of rice and crayfish were studied. The results showed that when the feeding rate was 6%, the weight gain rate and specific growth rate were the highest, but the feed utilization rate decreased. With the increase of feeding rate, the yield of rice tended to increase, but the difference was not significant ($P>0.05$). In the rice-crayfish culture system, with the increase of feeding rate, the utilization rate of nitrogen and phosphorus of rice and crayfish in the system showed an increasing trend, but that of nitrogen and phosphorus in rice showed a decreasing trend. Therefore, the growth of crayfish with different feeding rates has a greater impact, and appropriate increase of feeding rates can increase the yield of crayfish, and thus improve the nitrogen and phosphorus utilization rate of the system.

Key words: Rice, *Procambarus clarikia*, feeding rate, nitrogen and phosphorus utilization

养殖环境中抗生素及 pH 值对生物质炭填料生物膜微生物群落及系统脱氮性能的影响

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摘要：人工湿地作为一种绿色可持续的水产养殖方式，近年来受到越来越高的关注，被认为是水产养殖未来的一种重要的发展方向。填料作为人工湿地的重要组成部分，对人工湿地的运行效率起到至关重要的作用。生物质炭膜架是一种新型填料，由于其较高的单位比表面积，其净化污水能力较强。通过研究不同外界环境因素对生物质炭膜架除污能力以及对生物质炭膜架上附着的生物膜微生物群落结构的影响，为以后实际应用提供参考依据。本文通过对 pH 进行梯度设置（6.5、7.5 和 8.5）；以及添加氟苯尼考（6mg/L）和土霉素（20mg/L）模拟实际生产过程中所遇到的使用渔药后的环境条件，分别分析不同外界因素对生物质炭填料降氨氮效率及生物膜微生物群落结构的影响，实验温度为 28 ~ 31 °C。研究表明：（1）在 6.5~8.5 范围内，生物质炭填料降氨氮效果随着 pH 值的升高越来越强，但均低于对照组（0.323mg/（L·h）），pH6.5、7.5、8.5 组的降氨氮速率分别约为 0.247、0.249、0.305mg/（L·h）。随着 pH 升高，各组生物质炭填料生物膜上的微生物群落中，硝化螺旋杆菌相对含量上升。（2）添加抗生素实验组与对照组相比，降氨氮能力均出现显著下降，其中对照组降氨氮速率约为 0.323mg/（L·h），而土霉素、氟苯尼考组降氨氮速率分别约为 0.172、0.172mg/（L·h）。此外，添加抗生素的两组生物质炭填料生物膜上的微生物群落中，硝化螺旋杆菌相对含量变化不大，但是绿弯菌相对含量下降，放线菌相对含量上升。综上所述，pH 值、土霉素和氟苯尼考均对生物质炭填料生物膜群落结构丰富度和多样性产生了影响；pH 值对硝化螺旋杆菌的相对含量影响较大，其中 pH 为 6.5 和 7.5 时对生物质炭填料降氨氮效果有显著抑制作用，pH 为 8.5 时更有利于生物质炭填料去除氨氮；土霉素与氟苯尼考对生物质炭填料生物膜上微生物群落中的绿弯菌，放线菌的相对含量影响较大，对其降氨氮效果亦有显著抑制作用。因此在弱碱性水质、控制抗生素使用量的情况下生物质炭填料能够发挥最大降氨氮效用。

关键词：生物质炭膜架；pH 值；抗生素；微生物群落结构；填料；人工湿地

Effects of antibiotics and pH values on microbial communities and systematic denitrification performance of biomass carbon packing biofilms in culture environment

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Abstract: As a green and sustainable way of aquaculture, constructed wetland has attracted more and more attention in recent years and is regarded as an important development direction of aquaculture in the future. As an important component of constructed wetland, packing plays a vital role in the operation efficiency of constructed wetland. Biomass carbon membrane frame is a new

type of filler, because of its high specific surface area, its purification capacity is strong. By studying the influence of different environmental factors on the decontamination ability and the microbial community structure of biofilm attached to the biogenic carbon membrane shelf, this paper provides a reference for future practical application. In this paper, pH gradients were set (6.5, 7.5 and 8.5). In addition, the environmental conditions after the use of fishing drugs were simulated with the addition of florphenicol (6mg/L) and oxytetracycline (20mg/L) in the actual production process, and the effects of different external factors on the ammonia-nitrogen lowering efficiency of biomass carbon filler and the microbial community structure of biofilm were analyzed respectively. The experimental temperature was 28 ~ 31 °C. The results showed that: (1) within the range of 6.5~8.5, the ammonia-nitrogen lowering effect of biomass charcoal packing became stronger and stronger with the increase of pH value, but all of them were lower than the control group (0.323mg/ (L·h)). The ammonia-nitrogen lowering rates of pH6.5, 7.5 and 8.5 groups were about 0.247, 0.249 and 0.305mg/ (L·h), respectively. With the increase of pH, the relative content of Nitrospira increased in the microbial community of biomass charcoal packing biofilm in each group. (2) Compared with the control group, the ammonia-nitrogen lowering capacity of the experimental group with antibiotics was significantly decreased, in which the ammonia-nitrogen lowering rate of the control group was about 0.323mg/ (L·h), while that of the oxytetracycline and flufenicol groups was about 0.172 and 0.172mg/ (L·h), respectively. In addition, in the microbial communities of the two groups of biomass charcoal packing biofilms with antibiotics, there was little change in the relative content of Nitrospira, but the relative content of *C. greeningii* decreased while that of actinomycetes increased. In conclusion, pH value, oxytetracycline and florphenicol all affected the structural richness and diversity of biogenic carbon filler biofilms. PH value has a great influence on the relative content of Nitrospira. When pH is 6.5 and 7.5, it has a significant inhibitory effect on ammonia nitrogen removal effect of biomass carbon filler. When pH is 8.5, it is more conducive to ammonia nitrogen removal effect of biomass carbon filler. Oxytetracycline and florphenicol had a great influence on the relative content of *C. greenbergii* and actinomycetes in the microbial community on the biomass carbon packing biofilm, and had a significant inhibitory effect on the ammonia-nitrogen lowering effect. Therefore, under the condition of weak alkaline water quality and controlling the use of antibiotics, biomass carbon filler can exert the maximum effect of reducing ammonia nitrogen.

Key words: Biomass carbon membrane frame, pH value, antibiotics, microbial community structure, fillers, constructed wetlands

投喂频率对绿鳍马面鲈幼鱼生长、生理指标及肝脏 hsp70 基因表达丰度的影响

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摘要: 为探究投喂频率对绿鳍马面鲈 (*Thamnaconus septentrionalis*) 幼鱼生长、生理指标及肝脏 hsp70 基因表达丰度的影响, 实验设计了 5 个投喂频率, 分别为 1、2、3、4 和 5 次/d (分别简称 F1、F2、F3、F4 和 F5), 每个处理组设计 3 个平行, 每个缸养殖 30 尾鱼 (6.47±0.56 g)。实验期间水温在 17-26℃, 盐度 30-31, pH6.8-7.6, 溶解氧≥5mg/L, 养殖周期为 30 d。研究结果表明: 不同投喂频率对绿鳍马面鲈幼鱼的生长、体成分、消化酶和抗氧化酶活性均有影响。随着投喂频率的增加, 绿鳍马面鲈幼鱼的摄食和生长均呈现上升趋势, F5 组数值最大, 摄食率 3.95%, 增重率 347.19%, 特定生长率 5.07%/d, 特定生长率和增重率超过 F1 组数值的两倍。F1 组的肥满度为 1.79 g/cm³ 显著低于其他 4 组(P<0.05), 肝体比逐渐升高, F4 和 F5 组的肝体比显著高于其他 3 组(P<0.05)。增加投喂频率, 实验鱼体的粗蛋白含量呈先升高后降低的趋势, F2 最高为 59.82%, 粗脂肪含量呈逐渐升高的趋势, F5 组最高为 31.23%。胰蛋白酶活性随着投喂频率增加呈现先降低后增加的趋势, F3 组活性最低, 37.48U/ug prot; 脂肪酶活性逐渐升高, F5 组最高, 2.67 U/g prot; 淀粉酶活性不受投喂频率的影响(P>0.05)。过氧化氢酶、超氧化物歧化酶活性和丙二醛含量均在 F5 组最高, 分别为 14.71 U/mg prot、250.32 U/mg prot 和 2.73 nmol/mg。肝脏中 hsp70 基因的相对表达量不受投喂频率的影响(P>0.05)。基于绿鳍马面鲈幼鱼的生长性能和生理效应的综合考虑, 其最适投喂频率为 3 次/d。

关键词: 投喂频率; 绿鳍马面鲈; 生长性能; 生理指标

Effects of feeding frequency on the growth, physiology and expression abundance of *hsp70* mRNA in juvenile *Thamnaconus septentrionalis*

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Abstract: Effects of five different feeding frequencies on the growth performance, physiological index and hepatic heat shock protein 70 (hsp70) gene expression levels of *Thamnaconus septentrionalis* juvenile (body weight:6.47±0.56g) were studied. The experiment designed 5 feeding frequencies, namely 1, 2, 3, 4, and 5 times/d (referred to as F1, F2, F3, F4, and F5 respectively), and each treatment group was designed with 3 parallels, and each tank was cultured 30 fish. The experimental period was 30 days and water temperature range was 17-26℃, the salinity was 30-31, the pH was 6.8-7.6, and the dissolved oxygen was ≥ 5 mg/L. Results showed that under different feeding frequency conditions, the growth, body composition, digestive enzymes and antioxidant enzyme activities of the juvenile were affected. With the increase of feeding frequency, the feeding and growth of *Thamnaconus septentrionalis* showed an upward trend. The F5 group had the largest value, with a feeding rate of 3.95%, a weight gain rate of 347.19%, a specific growth rate of 5.07%/d. The specific growth rate and weight gain rate of the F5 group exceeded twice the value of the F1 group. The condition factor of F1 group was 1.79g/cm³ significantly lower than the other 4 groups (P<0.05), the hepatosomatic index gradually increased, and the F4 and F5 groups was significantly higher than the other 3 groups (P<0.05). Increasing the feeding frequency, the crude protein content of the experimental fish showed a trend of first increasing and then decreasing, F2 was the highest, 59.82%, and the crude fat content showed a gradually increasing trend, F5 was the highest, 31.23%. Trypsin activity showed a trend of first decreasing and then increasing with the increase of feeding frequency.

The F3 group had the lowest activity, 37.48U/ug prot; lipase activity gradually increased, and the F5 group was the highest, 2.67U/g prot; amylase activity was not affected by feeding frequency ($P>0.05$). Catalase, superoxide dismutase activity and the content of malondialdehyde were the highest in F5 group, which were 14.71U/mg prot, 250.32U/mg prot and 2.73nmol/mg, respectively. The relative expression levels of hsp70 gene in liver is not affected by feeding frequency ($P>0.05$). Based on the comprehensive consideration of the growth performance and physiological index of the *Thamnaconus septentrionalis*, the optimal feeding frequency is 3 times/d.

Key words: Feeding frequencies, *Thamnaconus septentrionalis*, growth performance, physiological index

三种益生元对两种海水鱼的作用效果研究

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摘要: 本研究探索了三种益生元: 低聚果糖 (FOS)、菊粉 (Inulin) 和甘露寡糖 (MOS) 分别以 1%, 1% 和 0.3% 的浓度拌料投喂 4 周后对珍珠龙胆石斑鱼和卵形鲳鲹的生长、血清非特异性免疫、免疫基因表达及抗应激的作用效果。结果发现: 在珍珠龙胆石斑鱼中, FOS、Inulin 以及 MOS 都不能显著提升其生长性能 ($P>0.05$)。空气暴露胁迫后 MOS 组的成活率显著高于对照组, FOS 组显著低于对照组。在卵形鲳鲹中, MOS 具有显著的促生长作用 ($P<0.05$); 哈氏弧菌攻毒胁迫结果表明, 三种益生元都显著降低了卵形鲳鲹受哈氏弧菌侵染时的死亡率 ($P<0.05$)。在两种鱼中, 三种益生元添加组的血清非特异性免疫指标及免疫相关基因表达实验结果都既有相似性, 又呈现一定程度的差异性。

关键词: 益生元; 低聚果糖; 菊粉; 甘露寡糖; 珍珠龙胆石斑鱼; 卵形鲳鲹

Effects of three prebiotics on two marine fishes

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Abstract: This study investigated the effects of fructooligosaccharide (FOS), inulin and mannose oligosaccharide (MOS) (supplemented for 4 weeks at 1%, 1%, 0.3%, respectively) on growth, serum biochemical parameters, expression of immune genes and the anti-stress ability of hybrid grouper (*Epinephelus lanceolatus* ♂ × *Epinephelus fuscoguttatus* ♀) and *Trachinotus ovatus*. Results indicated that: In hybrid grouper, none of the three prebiotics showed any growth promoting effects. However, after air exposure, MOS group had significantly lower mortality rate than control group. In *T. ovatus*, MOS showed significant growth promoting effects. Challenge test with *V. Harvey* revealed that all three prebiotics could significantly decrease the death rate of infected fish. Three prebiotics had different effects on serum biochemical parameters and immuned gene expressions.

Key words: Prebiotic, fructooligosaccharide, inulin, mannose oligosaccharide, hybrid grouper, *Trachinotus ovatus*

领域二

水产生物技术与遗传育种

基于转录组分析发掘泥鳅低温、低氧适应相关 基因及信号通路

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为探究泥鳅低温、低氧适应机制, 本研究对常温常氧(NN)、低温常氧(CN)、常温低氧(NH)、低温低氧(CH)胁迫条件下泥鳅肝脏进行 RNA-seq 分析。RNA-seq 共产生 33.5Gb 有效数据和 82402 条 Unigene。与 NN 相比, CN、NH、CH 分别得到 DEGs 208、138 和 396 个, 且分别有 116、77 和 202 条基因在 KEGG 数据库得到注释, 并分别富集在 81、62 和 111 条信号通路中, 如“系统性红斑狼疮”、“HIF-1 信号通路”、“cGMP-PKG 信号通路”、“胰岛素信号转导通路”、“细胞凋亡”、等根据 GO 功能分类和 KEGG 信号通路分析筛选出了大量与泥鳅生长代谢、疾病和免疫和相关的候选基因或蛋白, 如胰岛素样生长因子结合蛋白(IGFBP)、ADP-核糖基化因子 4 (ARF4)、转铁蛋白(TRF)和 MHC I 类抗原(MHCI)等, 以及一批预测蛋白。低温胁迫与低氧胁迫筛选出的候选基因各不相同, 其中 ARF4 在 CH 和 NH 共同表达下调, TRF 在 CH 和 CN 共同表达上调, MHC I 在 CH 和 CN 共同表达下调。本研究结果丰富了泥鳅的基因资源, 可为泥鳅的遗传育种和抗逆研究提供基础数据。

关键词: 泥鳅; 低温低氧胁迫; 转录组分析; 差异基因; 信号通路

Identification of genes and signal pathways related to cold and hypoxia adaptation in *Misgurnus anguillicaudatus* based on transcriptome analysis

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Abstract: In the present study, livers of *Misgurnus anguillicaudatus* under normal temperature and normal oxygen (NN), cold stress and normal oxygen (CN), normal temperature and hypoxia stress (NH), cold and hypoxia stress (CH) were analyzed by RNA-seq to explore the mechanism of cold and hypoxia tolerance of *Misgurnus anguillicaudatus*. RNA-seq produced 33.5Gb of clean data and 82,402 Unigene. Compared with NN, 208, 138 and 396 DEGs were obtained respectively from CN, NH and CH, 116, 77 and 202 genes were annotated in KEGG database and respectively enriched in 81, 62 and 111 signal pathways, such as “systemic lupus erythematosus”, “HIF-1 signal pathway”, “cGMP-PKG signal pathway”, “Insulin signal transduction pathway”, “cell apoptosis”. According to GO and KEGG analysis, a large number of candidate genes or proteins related to growth and metabolism, disease and immunity of *Misgurnus anguillicaudatus* were screened, such as insulin-like growth factor binding protein (IGFBP), ADP ribosylation factor 4 (ARF4), transferrin (TRF), MHC class I antigen (MHCI) and hypothetical proteins. The candidate genes related to cold and hypoxia stress were different. The expression of ARF4 was down-regulated in CH and NH, the expression of TRF was up-regulated in CH and CN, while the expression of MHCI was down-regulated in CH and CN. The results of this study enrich the gene resources of *Misgurnus anguillicaudatus*, and provide basic data for the genetic breeding and stress resistance research of *Misgurnus anguillicaudatus*.

Key words: *Misgurnus anguillicaudatus*, transcriptome analysis, cold and hypoxia stress, DEGs, signal pathway

泥鳅新品系选育研究进展

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摘要: 为了选育生长快、抗逆强、肉质佳的泥鳅新品种, 本研究通过群体选育、杂交、雌核发育、多倍体诱导等育种方法构建了 5 个泥鳅新品系并进行经济性状及生物学特征比较分析。结果显示 2 个杂交品系性腺不育且在生长、肉品质(营养成分、风味、滋味)有显著和一定程度的提升, 且 SSR 及 *CO I* 基因遗传多样性显著提高; 泥鳅雌核发育品系在生长上有显著提升; 同源、异源四倍体品系生长上显著高于二倍体父母本。该研究为泥鳅新品种选育提供理论指导并奠定了群体基础, 具有较高的理论价值与重要的生产意义。

关键词: 泥鳅; 新品系; 选育; 经济性状分析

Breeding progress of new loach strains

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Abstract: Aiming on breeding new loach varieties which grow fast, adapt to cold and hypoxic environment, offer tasty muscle meat, in the present study, five new loach strains are established through breeding methods such as group selection, hybridization, gynogenesis, polyploid induction, and economic traits and biological characteristics of them were compared and analyzed. Results showed that both of the two hybrid strains were Infertile, and increased significantly in growth and made improvement in nutrients, flavor and taste in a certain degree, and showed significant genetic diversity of SSR and *CO I* gene. The growth of gynogenesis loach strain showed significant improvement. The growth of both autotetraploid and allotetraploid loach strains were significantly faster than those of diploid parents. This study provided theoretical guidance and based groups for loach breeding, showed high theoretical value and important production significance.

Key words: Loach, new strain, selective breeding, economic characters analysis

达氏鲟 *Elovl4*、*Elovl5* 和 *Elovl7* 克隆、组织分布以及饥饿对其表达的影响

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摘要: 为研究长链脂肪酸延长酶 (Elovl) 作用机制, 实验根据前期达氏鲟转录组测序获得的 unigene 序列为基础, 得到 *Elovl4*、*Elovl5* 和 *Elovl7* CDS 区序列, 并分析了三个基因在各组织及饥饿胁迫下的表达情况。结果显示, 达氏鲟 *Elovl4*、*Elovl5* 和 *Elovl7* 编码区为 753、885 和 846 bp, 分别编码 250、294 和 281 个氨基酸。达氏鲟 *Elovl4*、*Elovl5* 和 *Elovl7* 氨基酸序列与斑点雀鳊 Elovl 具有较高的同源性; 达氏鲟 *Elovl4* 在卵巢和眼中表达最高; *Elovl5* 在肌肉中的表达最高 ($P<0.05$); *Elovl7* 在卵巢中表达最高 ($P<0.05$)。在饥饿条件下, *Elovl4*、*Elovl5* 和 *Elovl7* 在肝脏中的表达量均显著下调 ($P<0.05$); 饥饿 3d 时, *Elovl4*、*Elovl5* 和 *Elovl7* 在胃中的表达量显著降低 ($P<0.05$); 饥饿 7d 时, 脑和肌肉中 *Elovl4*、*Elovl5* 和 *Elovl7* 的表达量显著高于其他各组 ($P<0.05$)。这说明 *Elovl4*、*Elovl5* 和 *Elovl7* 在达氏鲟营养调控过程中发挥的作用可能存在差异, 其具体作用机制需要进一步研究。

关键词: 达氏鲟; 长链脂肪酸延长酶; 组织表达; 饥饿胁迫

Molecular cloning, tissue distribution of *Elovl4*, *Elovl5* and *Elovl7* from *Acipenser dabryanus*

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Abstract: Long-chain polyunsaturated fatty acids (LC-PUFAs) are essential for numerous critical biological processes, and elongases of very long chain fatty acids are the rate-limiting enzyme for LC-PUFAs synthesis. The CDS of *Elovl4*, *Elovl5* and *Elovl7* were cloned from the unigene database by full-length transcriptome sequencing of *A. dabryanus*. Results showed that the open reading frames (ORF) of *Elovl4*, *Elovl5* and *Elovl7* were 753, 885 and 846 bp which encoded 250, 294 and 281-residue peptide, respectively. Phylogenetic analysis showed that the *Elovl4*, *Elovl5* and *Elovl7* clustered with *Lepisosteus oculatus*. The highest *Elovl4* level is in the ovary and eye; the highest *Elovl5* level is in muscle and the highest *Elovl7* is in ovary ($P<0.05$). Starvation significantly decreased the expression of liver *Elovl4*, *Elovl5* and *Elovl7* ($P<0.05$). Stomach *Elovl4*, *Elovl5* and *Elovl7* were significantly reduced at day 3 ($P<0.05$); The highest expression levels of *Elovl4*, *Elovl5* and *Elovl7* in brain and muscle were at day 7 ($P<0.05$). These findings suggest that *Elovl4*, *Elovl5* and *Elovl7* may play certain roles in the nutritional regulation of *A. dabryanus*, and the specific mechanisms need further investigation.

Key words: *Acipenser dabryanus*; Elovl; Tissue expression; Starvation

通过分子克隆、表达模式和原位杂交对日本沼 虾一个 SoxE 族基因的功能分析

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摘要: 本文从日本沼虾 (*Macrobrachium nipponense*) 中克隆了一个 Sox 基因的全长 cDNA 序列, 并将其命名为 *MnSoxE1*。 *MnSoxE1* 的全长 cDNA 为 1748 bp, 由 110 bp 的 5'UTR, 105 bp 的 3'UTR 和 1533 bp 的 ORF 组成, 编码 510 个氨基酸。保守结构域显示, *MnSoxE1* 基因与南美白对虾的 SoxE 基因具有非常高的相似性属于 SoxE 亚族。在胚胎发育过程中, *MnSoxE1* 主要在原肠胚期表达, 变态后第 25 天可以区分出雌雄时, *MnSoxE1* 基因在雄性中的表达水平明显高于雌性, 这表明 *MnSoxE1* 可能在促进早期生殖细胞分化以及性腺尤其是雄性的分化发育中发挥作用。进一步的原位杂交定位分析表明, *MnSoxE1* 主要位于卵母细胞和精母细胞中尤其是在精巢支持细胞中。这些结果表明, *MnSoxE1* 可能参与日本沼虾的性腺分化和发育, 特别是精巢的发育。

关键词: 日本沼虾; SoxE; 时空表达; 原位杂交

Functional analysis of a SoxE gene in the oriental freshwater prawn, *Macrobrachium nipponense* by molecular cloning, expression pattern analysis, and in situ hybridization

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Abstract: In this study, a full-length cDNA sequence of SoxE (subgroup E within the Sox family of transcription factors) was cloned from *Macrobrachium nipponense* and named *MnSoxE1*. Conserved domains showed that *MnSoxE1* belongs to the SoxE subgroup. During embryonic development, *MnSoxE1* was mainly expressed in the gastrula stage and significantly higher than that in females on post-larval day 25, showing that *MnSoxE1* may play a role in promoting early development and gonadal differentiation, especially for males. Further in situ hybridization analysis revealed that *MnSoxE1* was mainly located in oocytes and spermatocytes, especially in sertoli cells. These results indicate that *MnSoxE1* is involved in gonadal differentiation and development in *M. nipponense*, especially testis development.

Key words: *Macrobrachium nipponense*, SoxE, Temporal and spatial expression, In situ hybridization

日本沼虾 *Fem1b* 的分子克隆及表达分析

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摘要: 雌性化-1 同源基因 b (*Fem1b*) 是雄性发育所必需的基因之一, 在隐杆线虫的性别决定中起着重要作用。本研究从日本沼虾的不同组织和不同发育阶段克隆了 *Fem1b* 全长 cDNA。实时定量逆转录聚合酶链反应 (RT-qPCR) 显示 *MnFem1b* 基因在所有被研究的组织中均有表达, 其中以睾丸表达水平最高。结果表明, *MnFem1b* 基因可能在雄性沼虾表型发育过程中起重要作用。所有被调查组织中的表达水平均表现出一定的性二型性, 雄性的表达水平高于雌性 ($P < 0.05$)。 *MnFem1b* 在睾丸中表达最高。 *MnFem1b* 在不同组织中的表达表明, *MnFem1b* 在日本沼虾内具有多种生物学功能。

关键词: 日本沼虾; 雌性化-1 同源物 b (*Fem1b*); RT-qPCR; 后幼虫

Molecular cloning and expression analysis of *Fem1b* from oriental river prawn *Macrobrachium nipponense*

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Abstract: Feminization-1 homolog b (*Fem1b*) is one of the genes essential for male development and play central roles in sex determination of *Caenorhabditis elegans*. In this study, we cloned and characterized the full-length *Fem1b* cDNA from the freshwater prawn *Macrobrachium nipponense* (*MnFem1b*) in different tissues and at different developmental stages. Real-time quantitative reverse polymerase chain reaction (RT-qPCR) showed that the *MnFem1b* gene was expressed in all investigated tissues, with the highest expression level found in the testes. The results revealed that the *MnFem1b* gene might play roles in aspects of development of the male prawn phenotype. The expression levels in all investigated tissues showed a certain degree of sexually dimorphism, the expression levels in males were significantly higher than those in females ($P < 0.05$). Notably, the highest expression of *MnFem1b* was found in the testes. The expression of *MnFem1b* in different tissues indicates that it plays multiple biological functions in *M. nipponense*.

Key words: *Macrobrachium nipponense*; Feminization-1 homolog b (*Fem1b*); RT-qPCR; Post-larval

鲍的杂交育种及杂种优势利用

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摘要: 鲍是我国重要的海水经济养殖贝类, 年产值位列福建省水产养殖种类之首, 杂交是国内外鲍遗传改良的重要途径。针对耐高温和国内缺乏大规格鲍这两个产业瓶颈问题, 我们构建了鲍远缘杂交育种技术体系, 相继培育出两个国家级鲍鱼新品种, 并在产业上得到较好的推广应用。在破译多个鲍全基因组序列信息的基础上, 综合多组学技术, 初步验证与鲍耐高温杂种优势相关的重要基因和调控网络, 解析杂种优势形成的分子机制。本研究对鲍耐高温育种和杂交育种具有重要的借鉴意义。

关键词: 鲍; 耐高温; 杂种优势

Heterosis and hybridization on abalone: experimental evidence and its application on abalone industry

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Abstract: Abalone is an economically important shellfish species in China and ranks in the first place for all the aquatic animals in Fujian Province based on the output value. Hybridization plays an important role in sustainable development for abalone aquaculture industry. Some specific hybrids show positive heterosis for growth and thermal resistance abilities and two hybrids were conferred for "new species certificate" by Ministry of Agriculture and now are large-scale cultured in China. Furthermore, multi-omics methods were used to verify high temperature resistant ability related genes and regulatory network and the molecular mechanism of heterosis on abalone. The results would be beneficial to enrich the theory and concept on heterosis, guide the breeding practices of high temperature resistant traits and hybridization methods.

Key words: abalone; thermal resistance; heterosis

黑鲷真鲷杂交子代 F2 早期生长与温度效应的 转录组分析

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摘要: 为了探究温度效应对黑鲷真鲷 (*Acanthopagrus schlegelii* ♀ × *Pagrus major* ♂) 杂交子代 F2 早期生长的影响, 利用转录组测序比较了保温与常温培育条件下个体生长的功能基因差异。结果发现大量差异表达基因 GO 功能与跨膜转运活性、离子通道活性及钙离子结合等相关; KEGG 分析主要富集于与细胞生长、发育相关的 MAPK 信号通路。本研究首次报道了 *A. schlegelii* × *P. major* 杂交子代 F2 温度效应转录组, 将为其生长调控基因研究提供基础依据。

关键词: 杂交子代 F2; 温度效应; 转录组; 差异基因

Transcriptome profiles of F2 hybrid (*Acanthopagrus schlegelii* ♀ × *Pagrus major* ♂) reveal temperature effects on individual early growth

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Abstract: To research the temperature effects on the early growth of F2 hybrids (*Acanthopagrus schlegelii* ♀ × *Pagrus major* ♂), transcriptome sequencing were preformed to compare the differentially expressed genes (DEGs) between the warming groups and the normal temperature conditions groups of larvae. The results showed that lots of the DEGs were involved in transmembrane transport activity, ion channel activity and calcium ion binding, and these genes were enriched to the MAPK signaling pathway that mainly related to cell growth and development. This is the first report from the *A. schlegelii* × *P. major* hybrid F2 transcriptome about temperature effects and provides an important foundational data for studying its growth molecular mechanisms.

Key words: hybrid F2, temperature effect, transcriptome, differentially expressed genes

Met 基因在甲基法尼酯介导中华绒螯蟹卵黄合成中作用

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摘要: 为了探究 JH/MF 信号通路是否保守存在于甲壳类动物中, 本实验采用了 RACE 技术克隆了中华绒螯蟹 *Met* 基因, QPCR 技术进行相对定量分析。结果表明 *Met* 基因属于 bHLH-PAS 家族转录因子蛋白, 该种转录因子在昆虫中被认为是保幼激素 JH 的主要受体蛋白。QPCR 结果表明 *Met* 基因在中华绒螯蟹卵巢发育二期时表达量显著增加, 在体外, 体内和去眼柄实验中 *Met* 基因相对表达量在肝胰腺组织中显著性升高, 而在卵巢中无明显变化。本实验结果揭示了 *Met* 基因可能是作为 MF 受体而参与甲基法尼酯介导的中华绒螯蟹卵黄合成, 且 JH/MF 信号通路可能是保守存在于甲壳类动物中。

关键词: 中华绒螯蟹; 甲基法尼酯; Methoprene-tolerant; 基因表达; 卵黄合成

Potential role of Methoprene-tolerant (*Met*) in methyl farnesoate-mediated vitellogenesis in the Chinese mitten crab (*Eriocheir sinensis*)

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Abstract: To explore whether JH/MF signaling is conserved in crustaceans. We used RACE technology to cloned Methoprene-tolerant (*Met*) from *Eriocheir sinensis*. QPCR technology was applied to relative quantification of genes. Results showed that *Met* belongs to the basic helix-loop-helix (bHLH)-Per-Arnt-Sim (PAS) family of nuclear transcriptional regulators and is a leading candidate receptor for juvenile hormone (JH III) in insects. The QPCR results showed that *Met* expression in the hepatopancreas increased significantly in stage II during the ovary development of *E. sinensis*. *In vitro*, *in vivo* and in eyestalk ablation experiments results shows *Met* expression both increased significantly, but not in the ovary. Our results indicate that *Met* may act as a receptor for MF in MF-mediated vitellogenesis in *E. sinensis*, and the JH/MF signaling pathway is potentially conserved in crustaceans.

Key words: *Eriocheir sinensis*; Methyl farnesoate; Methoprene-tolerant; Gene expression; vitellogenesis.

长江鲟 MHC I α , II α , II β 和 II 的多态性及表达分析

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摘要: 主要组织相容性复合体(MHC)是将外来抗原呈递给 T 淋巴细胞过程中的关键免疫因子。本研究从濒危物种长江鲟中鉴定出了三种 MHC 分子, 即 MHC I、MHC II α , II β 和变异链 II。组织分布结果显示, MHC 和 II 在各种组织中广泛表达。在病原菌侵染下, MHC 和 II 显著上调表达, 表明 MHC 在免疫应答中的潜在作用。在不同的个体中, MHC II 具有高度多态性, 而 MHC I 更保守。在 MHC II 的肽结合区(PBR), 非同义替换的频率明显高于同义替换的频率, 这说明了 PBR 区阳性选择的存在。研究结果表明 MHC 在病原微生物感染中存在重要的作用, 且本研究中发现的大量等位基因将有助于应用于长江鲟的遗传管理和分子标记辅助选择育种计划。

关键词: 长江鲟; MHC I; MHC II; 免疫应答; 多态性

Molecular polymorphism and expression of MHC I α , II α , II β and II invariant chain in the critically endangered Dabry's sturgeon (*Acipenser dabryanus*)

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Abstract: In this study, three MHC genes, namely, MHC I α , II α , II β and the II invariant chain (II), were identified and characterized in the critically endangered *Acipenser dabryanus*. A tissue distribution study showed that the MHC and II transcripts were widely expressed in various tissues. Challenge of *A. dabryanus* with a pathogenic bacterium *in vivo* resulted in significant upregulation of both MHC and II expression. MHC II α and II β were highly polymorphic in different individual. The ratio of non-synonymous substitution occurred at a significantly higher frequency than synonymous substitution in PBR of MHC II α and II β , demonstrating the existence of positive selection at peptide-binding sites. Our study suggested potential roles of the MHC chains in immune response to pathogen microbial infection, and the numerous alleles identified in this study will help further genetic management and molecular marker-assisted selective breeding programmes in *A. dabryanus*.

Key words: *Acipenser dabryanus*; Major histocompatibility complex class I; Major histocompatibility complex class II; Immune response; Molecular polymorphism

盐度胁迫对凡纳滨对虾水通道蛋白基因表达的影响

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摘要: 为探讨凡纳滨对虾(*Litopenaeus vannamei*)水通道蛋白基因(Aquaporin, AQP)在盐度胁迫过程中的渗透调节作用, 实验设置了低盐度(10)和高盐度(50)2个急性盐度梯度, 以盐度30为对照组, 分别于0h、2h、4h、8h、12h、24h取肝胰腺、鳃、肠、肌肉等组织, 进行转录组分析及qPCR检测。结果表明, 凡纳滨对虾转录组中发现了AQP3、AQP4和AQP11共3个水通道蛋白基因序列, qPCR检测发现AQP3和AQP11在肠和肌肉里表达量最高, 其他组织中表达量较低; AQP4在肝胰腺中表达量最高, 鳃中次之。急性盐度胁迫下, 对照组AQP3、AQP11以及AQP4在鳃中的表达量均高于盐度10和50组, 而AQP4在肝胰腺中的表达量则相反; 低盐、高盐胁迫下AQP3和AQP4在鳃中的表达量显著降低($P<0.05$); 低盐胁迫下AQP4在肝胰腺的表达量逐渐增加, 在12h、24h显著增加($P<0.05$), 在高盐胁迫下, 其表达量在2h显著增加($P<0.05$), 而后无明显变化; AQP11的表达量在低盐和高盐胁迫下均逐渐降低, 在12h后趋于稳定, 且较AQP3和AQP4在鳃中的表达变化缓慢。结果说明, AQP3、AQP4和AQP11的表达水平因组织、盐度和盐度胁迫时间的不同而异, 说明3个基因在凡纳滨对虾渗透压调节中均具有重要作用。

关键词: 水通道蛋白; 渗透调节; 盐度胁迫; 凡纳滨对虾; qPCR

Effect of salinity stress on gene expression of aquaporin in *Litopenaeus vannamei*

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Abstract: In order to explore the osmotic regulation of the aquaporin gene (Aquaporin, AQP) of *Litopenaeus vannamei* in the process of salinity stress, the experiment set up two acute salinities: low salinity (10) and high salinity (50). Gradients and salinity in the control group (30), hepatopancreas, gills, intestines, muscles and other tissues were taken at 0h, 2h, 4h, 8h, 12h, and 24h, respectively, for transcriptome analysis and qPCR detection. The results showed that three aquaporin gene sequences, AQP3, AQP4, and AQP11, were found in the transcriptome of *Litopenaeus vannamei*. The qPCR detection revealed that AQP3 and AQP11 were expressed in the intestines and muscles with the highest expression levels, and the expression levels in other tissues were low. AQP4 has the highest expression in hepatopancreas, followed by gills. Under acute salinity stress, the expression levels of AQP3, AQP11 and AQP4 in the gills under 30 salinity are higher than 10 and 50 salinity, while the expression level of AQP4 in hepatopancreas is the opposite; under low-salt and high-salt stress, the expression of AQP3 and AQP4 in the gills was significantly reduced ($P<0.05$). The expression of AQP4 in the hepatopancreas gradually increased under low-salt stress, and significantly increased at 12 and 24h ($P<0.05$). Under high-salt stress, expression level of AQP4 increased significantly at 2h ($P<0.05$), and then there was no significant change. Expression of AQP11 gradually decreased under both low-salt and high-salt stress, and stabilized after 12h, and compared with the expression of AQP3 and AQP4 in the gills slow. The results show that the expression levels of AQP3, AQP4 and AQP11 vary with tissue, salinity and stress time, indicating that the three genes all play a very important role in the regulation of osmotic pressure in *Litopenaeus vannamei*.

Keywords: Aquaporin; Osmotic adjustment; Salinity stress; *Litopenaeus vannamei*; qPCR

中间球海胆 *Caspase-10* 的分子特性、表达规律 与体外干扰验证

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摘要: 为明确中间球海胆 *Caspase-10* 基因序列及表达特征, 研究其在是否参与免疫应答, 利用 cDNA 末端快速扩增 (RACE) 技术获得中间球海胆 *Caspase-10* 基因的全长 cDNA, 分析了其在中间球海胆不同组织和不同发育阶段的表达情况, 并采用 siRNA 进行体外干扰实验。结果表明: ①中间球海胆 *Caspase-10* 全长 cDNA 包含 3107 个碱基对 (bp), 开放阅读框长度 2064 bp。其预测分子质量为 254.7 kDa, 理论等电点为 4.85。该蛋白质保守结构域包括两个 DED 域和一个 CASc 域。②*Caspase-10* 编码蛋白在中间球海胆的体腔细胞中表达量最高, 而在肠道中表达量最低。在不同发育阶段表达量测定结果显示, *Caspase-10* 基因在 8 细胞时期表达量最高, 在原肠胚时期表达量最低。③特异性 siRNA 干扰 *Caspase-10* 的结果表明, 在转染 48 h 时 *Caspase-3* 表达在肠和体腔细胞中显著降低, *Caspase-10* 的下游靶基因是 *Caspase-3*。④*Caspase-10* 干扰后体腔液中免疫酶 SOD, CAT, POD 和 GSH-PX 活性水平降低。这些研究结果将为探索 *Caspase-10* 基因调控机制以及筛选优秀抗病海胆家族提供了理论实验基础。

关键词: 中间球海胆; *Caspase-10*; 基因克隆; siRNA

Molecular cloning, expression profile and in vitro interference of the *Caspase-10* gene in the sea urchin (*Strongylocentrotus intermedius*)

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Abstract: In order to identify and characterize the *Caspase-10*, study whether it is involved in the immune response, we used database data mining and rapid amplification of cDNA ends (RACE) to identify the full-length sequence of the *Caspase-10* gene and analyzed its expression profile in different tissues, during different developmental stages of *Strongylocentrotus intermedius* and use siRNA for in vitro interference experiments. The full-length cDNA of *Caspase-10* contains 3107 base pairs (bp), with a putative open reading frame of 2064 bp. The predicted molecular mass is 254.7 kDa and its theoretical isoelectric point (pI) is 4.85. The protein contains conserved motifs, including two death effector domains (DED) and a cysteine aspartate-specific catalytic (CASc) domain. The tissue distribution of *Caspase-10* showed that its highest expression was in the coelomocyte tissues, whereas its lowest expression was in the intestines of *S. intermedius*. Time-course expression measurements at different developmental stages indicated the highest expression of *Caspase-10* occurred in the eight-cells stage, and its lowest expression occurred in the gastrula stage. Knock-down of *Caspase-10* by specific small interfering RNA (siRNA) revealed that *Caspase-3* expression was significantly depressed in the intestines and coelomocyte tissue at 48 h post transfection, indicating that the downstream target gene of *Caspase-10* is *Caspase-3*. Before and after *Caspase-10* interference, our results showed that SOD, CAT, ACP, AKP, POD and GSH-PX activity levels had decreased. These data provide a theoretical experimental basis for exploring the mechanism of action of the *Caspase-10* genes and the screening of excellent disease-resistant sea urchin families.

Key words: *Strongylocentrotus intermedius*; *Caspase-10*; Gene cloning; siRNA

母源因子 *boule* 在光棘球海胆性腺中的表达与定位

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摘要: 为了鉴定光棘球海胆生殖细胞标记基因, 本实验利用基因克隆、荧光定量 PCR 以及切片原位杂交等技术研究了 *boule* 基因的分子特征以及其在光棘球海胆中四个发育时期 (I 期 - IV 期) 的动态表达模式及定位。结果表明: 光棘球海胆 *boule* cDNA 序列全长为 1788 bp。荧光定量 PCR 结果表明, *boule* 为母源因子, 在整个胚胎发育时期均有表达。*boule* 在精巢表达量最高。在卵巢中, *boule* 的表达量随着卵母细胞的成熟而逐渐升高, 在成熟期 (Stage IV) 达到最高; 在精巢中, *boule* 的表达量仅在生长期 (Stage II) 以及成熟前期 (Stage III) 有较高表达。切片原位杂交结果表明, *boule* 基因在光棘球海胆精巢的生殖细胞中特异表达。综上所述, 光棘球海胆 *boule* 基因是雄性生殖细胞标记基因, 本研究为海胆雄性生殖细胞发育相关的研究奠定了基础。

关键词: 光棘球海胆; *boule*; 生殖细胞; 精子发生

Expression and cellular localization of maternal factor *boule* in gonad of sea urchin

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Abstract: In order to identify the germ cell marker genes of *Mesocentrotus nudus*, the molecular characteristics, dynamic expression patterns and location of *boule* gene during the four stages of sea urchin's development (Stage I - Stage IV) were elucidated by means of gene cloning, Real-time quantitative PCR (RT-qPCR) PCR and in situ hybridization in sections. The results show the full length of *boule* cDNA sequence was obtained at 1788bp. Real-time quantitative PCR (RT-qPCR) analysis revealed that *boule* is a maternal factor, which is expressed throughout the embryonic development. The expression of *boule* was highest in the testis. In ovary, with the maturation of oocytes, the expression of *boule* increased gradually until Stage IV reached the maximum level. In testis, the expression of *boule* was higher only at Stage II and Stage III. Section in situ hybridization results showed that *boule* gene expresses specifically in male germ cells. In conclusion, *boule* gene of sea urchin is a marker gene of male germ cells and this study lays a foundation for the study of male germ cell development of sea urchin.

Key words: sea urchin, *boule*, germ cell, spermatogenesis

2 种底栖硅藻生物膜对中间球海胆家系的附着效果

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摘要: 为研究底栖硅藻对中间球海胆(*Strongylocentrotus intermedius*)选育家系的附着效果, 使用2种纯种底栖硅藻(BD3和BD9)对选育7代的32个中间球海胆家系幼体进行附着, 测量了不同硅藻附着下, 不同家系的变态率、壳径和成活率, 并检验了硅藻种类、家系及二者的交互作用对海胆壳径、变态率和成活率的影响。结果表明, 底栖硅藻种类与海胆家系的交互作用对壳径、变态率和成活率均有显著影响($P<0.05$)。BD3硅藻组的海胆在壳径、变态率和成活率上相对于BD9均表现出极显著优势($P<0.01$), 不同家系之间的变态率和壳径无显著差异, 但变态率差异显著($P<0.05$)。本研究表明, 底栖硅藻种类对于海胆幼体成活率和壳径有显著影响, 家系选择有潜力用于改良海胆的变态率。

关键词: 中间球海胆, 家系, 底栖硅藻, 变态率, 成活率, 生长

The effect of the benthic diatom on the attachment of families of the sea urchin *Strongylocentrotus intermedius*

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Abstract: In order to investigate the effect of the benthic diatom on the attachment of families of the sea urchin *Strongylocentrotus intermedius*, two species of purebred benthic diatom (BD3 and BD9) were used to induce attachment of the 7th generation families of *S. intermedius*. The abnormal rate, test diameter and survival rate were measured. The effects of family, diatom and their interactive effect on abnormal rate, test diameter and survival rate were examined. The results showed that the species of benthic diatoms and the interaction between species and sea urchin families had significant effects on test diameter, metamorphosis rate and survival rate ($P<0.05$). Compared with BD9, BD3 diatom group showed significant advantages in shell diameter, metamorphosis rate and survival rate ($P<0.01$). There was no significant difference in the metamorphosis rate and test diameter among families, but the metamorphosis rate was significantly different ($P<0.05$). This study showed that the species of benthic diatoms had a significant effect on the survival rate and shell diameter of the sea urchin, and family selection has a potential in improving the metamorphosis rate.

Keywords: Sea urchin, benthic diatom, family, metamorphosis rate, interaction

虾夷扇贝不同外套膜区域的组织学和转录组学分析

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摘要: 由于贝壳独特的物理和生物学特性, 贝壳形成的分子机制研究一直是软体动物的热点问题。虾夷扇贝 (*patinopecten yessoensis*) 是一种古老的双壳贝类, 具有重要的经济价值和进化地位, 其壳色呈现多态性。本研究首次对负责不同壳层形成的虾夷扇贝不同外套膜区域进行了组织学和转录组学差异分析, 以期对贝壳和壳色的形成机制研究提供更多线索。组织学研究表明, 边缘膜和中央膜在显微结构组成上存在较大差异, 这与它们的功能密切相关。转录组学分析发现, 与生物矿化有关的 GO 功能在不同外套膜区域中显著富集, 可能分别参与不同壳层的形成, 表明不同外套膜区域在贝壳形成中发挥的分子功能不同。黑色素形成通路是边缘膜和中央膜差异基因中最显著富集的通路, 控制黑色素的形成, 表明其在贝壳色素沉着中发挥重要的作用。酪氨酸酶基因 (*Tyr*) 是黑色素形成通路的关键和限速基因, 在中央膜中表达水平非常高, 而通路中的上游调控基因主要在边缘膜中上调表达, 表明两个外套膜区域在壳色形成中的分子功能不同。

关键词: 虾夷扇贝, 外套膜组织, 贝壳形成, 壳色, 黑色素形成

Histological and transcriptomics analysis among different mantle regions of the Yesso scallop (*Patinopecten yessoensis*)

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Abstract: The molecular mechanisms of shell formation and pigmentation are issues of great interest in molluscan studies due to the unique physical and biological properties of shells. The Yesso scallop, *Patinopecten yessoensis*, is one of the most important maricultural bivalves in Asian countries, and its shell color shows polymorphism. To gain more information about the underlying mechanisms of shell formation and pigmentation, this study presents the first analyses of histological and transcriptional differences between different mantle regions of the Yesso scallop, which are thought to be responsible for the formation of different shell layers. The results showed major microstructural differences between the edge and central mantles, which were closely associated with their functions. Different biomineralization-related GO functions, which might participate in the formation of different shell layers, were significantly enriched in the different mantle regions, indicating the different molecular functions of the two mantle regions in shell formation. The melanogenesis pathway, which controls melanin biosynthesis, was the most significantly enriched pathway in the DEGs between the two mantle regions, indicating its important role in shell pigmentation. *Tyr*, the key and rate-limiting gene in melanogenesis, was expressed at a remarkably high level in the central mantle, while the upstream regulatory genes included in melanogenesis were mainly upregulated in the edge mantle, suggesting the different molecular functions of the two mantle regions in shell pigmentation.

Key words: Yesso scallop; mantle tissue; shell formation; pigmentation; melanogenesis

斑马鱼 *Bmp7b* 突变品系的建立和表型分析

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摘要: 骨形态发生蛋白-7 (Bone morphogenetic protein 7, *Bmp7*) 是转化生长因子 TGF- β 家族中的一员, 在正常黑色素细胞中明显表达, 但高度表达会诱导黑色素瘤的发生、促进和转移。目前关于 *Bmp7b* 基因在鱼类皮肤色素上的分子调控机制的研究较少, 故本实验探讨了 *Bmp7b* 基因在斑马鱼 (*Danio rerio*) 皮肤色素发生发育过程中的调控作用: (1) 通过 CPISPR/Cas9 基因编辑技术构建了缺失 49bp 的斑马鱼 *Bmp7b* 基因缺失品系; (2) 基于形态学和组织学方法, 发现自 10 天起突变体与野生型斑马鱼体色已经有差异, 以及随着体型增长这两种类型体色差异日益明显。以及 HE 染色结果表明斑马鱼突变体的皮肤的色素细胞多于野生型; (3) 为了进一步了解 *Bmp7b* 基因在斑马鱼上的分子调控机制, 进行了转录组测序并结合实时荧光定量, 分析结果表明缺失 *Bmp7b* 会影响相关色素基因的表达。

关键词: 皮肤色素; 斑马鱼; 组学分析; 基因功能

Establishment and Phenotype Analysis of Zebrafish *Bmp7b*

Mutant Strain

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Abstract: Bone morphogenetic protein 7 (*Bmp7*) is a member of the transforming growth factor TGF- β family. It is obviously expressed in normal melanocytes, but its high expression can induce the occurrence of melanoma and promote metastasis. At present, there are few studies on the molecular regulation mechanism of *Bmp7b* gene on fish skin pigments. Therefore, this experiment explored the regulatory role of *Bmp7b* gene in the development of zebrafish (*Danio rerio*) skin pigments: (1) Through CPISPR/Cas9 Gene editing technology constructed a zebrafish *Bmp7b* gene deletion strain with a 49bp deletion; (2) Based on morphological and histological methods, it was found that the body color of the mutant and wild-type zebrafish had been different since 10 days, and this was as the body size increased. The difference in body color between the two types is becoming increasingly obvious. And the results of HE staining showed that the skin of zebrafish mutants had more pigment cells than the wild type; (3) In order to further understand the molecular regulation mechanism of *Bmp7b* gene on zebrafish, transcriptome sequencing and real-time fluorescence quantification were performed. The analysis results showed the deletion of *Bmp7b* will affect the expression of related pigment genes.

Keywords: skin pigment, zebrafish, omics analysis, gene function

红壳色文蛤各选育世代遗传变异的微卫星分析

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摘要: 文蛤作为一种高产的海洋经济贝类, 在进行群体选育工作时, 因繁殖成功率存在差异, 易导致遗传多样性的下降。本研究通过 15 个 SSR 标记, 对江苏红壳色文蛤 5 个连续选育世代的遗传多样性水平进行了评估。结果表明: 连续选育 5 代后, 期望杂合度($H_e=0.642-0.680$)和等位基因数($N_a=6.2-7.9$)均未出现明显的降低。江苏红壳色文蛤原种(SR)与各选育世代(F_1-F_5)的等位基因差异主要是由于选育过程中的零星基因缺失所造成的。 F_{st} 值和 AMOVA 分析结果表明: 各选育世代与江苏红壳色文蛤原种群体无显著差异 ($P>0.05$)。人工选育试验并未对红壳色文蛤各选育世代的遗传多样性和群体遗传结构造成不良影响。这项研究对红壳色文蛤各选育世代的遗传多样性水平进行了深入分析, 并能够更好地了解现有育种试验有效保持后代群体遗传变异水平的方法。

关键词: 文蛤; 遗传变异; 选育世代; 红壳色; 微卫星标记

Genetic variation in successive mass selected generations of *Meretrix meretrix* with red shell color based on SSR markers

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Abstract: The *Meretrix meretrix* is one of the highly fecund marine aquaculture species and has a large variance in reproductive success, these characteristics can result in loss of genetic diversity especially when conducting mass selection. In the current study, we investigated the level of genetic diversity over five successive mass-selected generations in the red shell strain of *Meretrix meretrix* from Jiangsu assessed by 15 SSR markers. The results showed that the genetic variation over five generations were maintained since no detectable depression of expected heterozygosity ($H_e=0.642-0.680$), number of alleles ($N_a=6.2-7.9$). The difference in alleles between the stock population from Jiangsu with red shell color (SR) and five mass selective generations (F_1-F_5) could be mainly due to the loss during selection process. F_{st} values and AMOVA analysis indicated unremarkable differentiation ($P>0.05$) within each generation including SR. There was no deleterious effect on genetic diversity and population structure for mass selected generations imposed by our artificial breeding practice. This study will provide an insight into the level of genetic diversity within mass-selected red shell line and enable a better understanding of how efficient current breeding practices keep maintaining genetic variation.

Key words: *Meretrix meretrix*; genetic variation; selected generations; red shell strain; SSR markers

文蛤 CDK1 基因 SNP 多态性与生长相关性关联分析

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摘要: 为探索细胞周期依赖性蛋白激酶 1 (CDK1) 基因单核苷酸多态性 (SNP) 与文蛤生长性状的相关性, 本实验选取了江苏红壳色文蛤原种及其选育子代等 7 个群体, 通过直接测序法对其 CDK1 基因外显子区域进行了 SNP 位点筛查, 并将 SNP 位点与个体不同生长性状 (壳长、壳宽、壳高、粒重) 进行关联分析。结果显示, CDK1 基因的外显子上存在 15 个 SNP 位点, 其中有 6 个 SNP 位点与生长性状显著相关 ($P < 0.05$), 其中 4 个 SNP 位点为非同义突变 (272C>T; 356G>A; 536A>G; 713G>A)。亦对 6 个生长相关性 SNP 位点进行了连锁不平衡分析, 构建出 4 种单倍型与文蛤生长性状显著相关 ($P < 0.05$)。研究结论表明, CDK1 基因作为在文蛤生长发育过程中具有重要调控作用的基因, 其生长相关性 SNP 分析结果将为文蛤分子标记辅助育种提供重要数据。

关键词: 文蛤; CDK1 基因; SNP; 生长性状; 关联分析

Association between SNP polymorphism of *CDK1* gene and growth of *Meretrix meretrix*

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Abstract: In order to explore the relationship between the single nucleotide polymorphism (SNP) of cyclin dependent kinases 1 (CDK1) gene and growth traits of *Meretrix meretrix*, 7 populations including the initial broodstocks with red shell color from Jiangsu and its offsprings were chosen as study subjects, the SNP loci in exon region of CDK1 gene of all individuals were screened by direct sequencing, and correlation analysis were conducted between the selected SNP loci and different growth traits (shell length, shell width, shell height, body weight). The results showed that there were 15 SNP loci in the exons of CDK1 gene, which found that 6 SNP loci were significantly correlated with growth traits ($P < 0.05$), among the 6 SNP loci, 4 SNP loci were non-synonymous mutations (272C>T, 356G>A, 536A>G, 713G>A). Linkage disequilibrium analysis was also used to research 6 growth-related SNP loci, 4 haplotypes were significantly correlated with the growth traits of *Meretrix meretrix* ($P < 0.05$). The conclusion indicated that the CDK1 gene was regarded as the growth candidate function gene, the analysis results of its growth-related SNP loci will provide important data for the reliable molecular markers for *Meretrix meretrix* breeding.

Key words: *Meretrix meretrix*, CDK1 gene, SNP, growth correlation, association analysis

紫菜类胡萝卜素代谢对失水胁迫的响应

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摘要: 研究及栽培表明, 条斑紫菜失水后经复水处理仍可恢复自身的光合活性, 进行正常的新陈代谢。实验从类胡萝卜素代谢途径出发, 以空白组为对照, 设置了 30%、60%、90% 三个失水组以及失水 90% 后 30min 的复水组, 对基因表达量、类胡萝卜素成分、过氧化物含量变化以及光合活性四个层面进行分析, 探究了类胡萝卜素代谢对失水胁迫的响应机制。结果显示, 八氢番茄红素合酶 (PSY)、八氢番茄红素脱氢酶 (PDS)、番茄红素环化酶 (LCYB、LCYE) 以及类胡萝卜素羟化酶 (CYP97B) 这 5 个基因均对失水以及复水有响应; 玉米黄素、 α -胡萝卜素和 β -胡萝卜素表现出相似的变化趋势, 而叶黄素在失水 90% 时含量显著升高; 超氧阴离子 (O_2^-)、过氧化氢 (H_2O_2) 以及 MDA (丙二醛) 三种过氧化物中只有 O_2^- 在 60% 时显著上升, 其余两种类型过氧化物含量不变甚至降低; Yield、rETR (max)、qp 三个光合活性数值都反映出失水光合活性下降, 复水后上升的共同趋势。结果表明紫菜在长期的进化过程中已经产生了各种机制, 适应了短期失水的过程。且失水 60% 可能是紫菜失水生理及其适应机制的一个转折点。

关键词: 紫菜; 逆境适应; 类胡萝卜素; 代谢途径

Response of Carotenoid metabolism to water loss stress in

yezoen

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Abstract: Studies and cultivation showed that *Neopyropia yezoensis* can restore its photosynthetic activity and normal metabolism after water loss-rehydration. The present study set undehydrated as control and the 30%, 60%, 90% water-loss group and rehydrated 30 min after 90% water-loss as a rehydration group. The gene expression, carotenoids composition, peroxide content and photosynthetic activity were determined to discern the mechanism employed by *Pyropia* to cope with desiccation. The results showed PSY、PDS、LCYB、LCYE and CYP97B are in response to dehydration and rehydration. The content of zeaxanthin、 α -carotene and β -carotene showed similar patterns but lutein. The content of O_2^- increased significantly when water-loss reached 60% but H_2O_2 and MDA has no significant variation. Yield、rETR (max) and qp showed that the photosynthetic activity decreased during dehydration and increased when rehydration. These data showed that *Neopyropia yezoensis* can adapt to temporary water loss in the long course of evolution and loss of 60% of water is a turning point.

Key words: *Pyropia*; stress adaption; carotenoid; metabolic pathways;

长吻鮠单核苷酸多态性标记与生长性状关联分析

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摘要: 本研究以 115 尾长吻鮠为研究材料, 运用 57 个单核苷酸多态性标记(SNPs)位点与生长相关性状进行关联分析。结果显示, 有 11 个 SNPs 位点与生长性状显著相关, 其中有 3 个 SNPs(Cluster-65_137265, Cluster-65_111833, Cluster-65_137642)位点对所测量的 4 个生长性状均有显著性影响($P<0.05$); 3 个 SNPs(Cluster-65_120392, Cluster-65_19647, Cluster-65_5592_0)位点对体质量、全长和体长有显著性影响($P<0.05$); Cluster-65_110382 对全长、体长和头高有显著性影响($P<0.05$); Cluster-65_19497 和 Cluster-24304_1 对全长和体长有显著性影响($P<0.05$); Cluster-65_130153 对体长和头高有显著性影响($P<0.05$); Cluster-65_105077 对体质量和全长有显著性影响($P<0.05$)。对与生长相关的 11 个 SNPs 位点进行多态性检测, 平均观测杂合度和平均期望杂合度分别为 0.490 和 0.426, 平均多态信息含量为 0.326。本研究为长吻鮠的遗传改良和选择育种提供了基础资料。

关键词: 长吻鮠; SNP; 生长性状; 关联分析

Correlation analysis of SNP markers and growth traits of *Leiocassis longirostris*

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Abstract: In this study, the correlation analysis of 57 SNP markers and growth-related traits in *Leiocassis longirostris* were analyzed using 115 samples with the same growth conditions. The results showed that 11 loci were related to the growth-related traits. Among them, 3 (cluster-65_137265, cluster-65_111833, cluster-65_137642) loci had significant influence on the growth-related traits (body weight, total length, body length and head height) ($P<0.05$). Cluster-65_120392, cluster-65_19647, and cluster-65_5592_0 had significant influence on body weight, total length and body length ($P<0.05$). Cluster-65_110382 had significant influence on the total length, body length and head height ($P<0.05$). Cluster-65_19497 and cluster-24304_1 had significant influence on the total length and body length ($P<0.05$). Cluster-65_130153 had significant influence on body length and head height ($P<0.05$). Cluster-65_105077 has a significant effect on body weight and total length ($P<0.05$). We also estimated that the genetic diversity parameters for 11 loci. The mean observed heterozygosity, expected heterozygosity, and polymorphism information content (PIC) were 0.490, 0.426 and 0.326. This study provides basic data for the genetic improvement and selective breeding of the *L. longirostris*.

Key words: *Leiocassis longirostris*; SNP markers; growth-related traits; correlation analysis

花鲈肝转录组及 alpha-1 抗胰蛋白酶表达分析

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摘要: 我们提取了花鲈肝脏总的 RNA 并构建了 cDNA 文库进行高通量测序。共获得原始碱基数 5.5G, 对数据进行拼接和聚类最后得到 20743 条 unigene, 其平均长度为 1255bp, N50 为 1867bp。肝和其他五种组织 (胃、脾、精巢、脑和鳃) 的转录组比较结果发现, 在肝脏中存在一些高表达基因, 如载脂蛋白 A1、白细胞衍生趋化因子 2、纤维蛋白原、血清转铁蛋白, 和一些特异表达的基因, 如玻连蛋白、血管生成素、葡糖-6-磷酸酶、尿苷磷酸化酶 2、和 alpha-1 抗胰蛋白酶。本文对肝中特异表达的 alpha-1 抗胰蛋白酶(AAT)进行了重点分析。我们克隆了 AAT 基因的全长序列, 包括完整的编码区(1230bp)和外显子-内含子结构(4 个外显子和 3 个内含子)。AAT 基因编码了 409 个氨基酸, 前 20 个氨基酸为信号肽, 中间 50-406 个氨基酸为丝氨酸蛋白酶抑制剂 (serpin) 结构域。通过定量 PCR 进一步表明, AAT 主要在鳃中表达, 而在胃、肝、脑、脾、精巢中几乎不表达。系统进化分析表明花鲈 AAT 被归类到硬骨鱼类的子群中, 与点带石斑鱼 (*Epinephelus coioides*) 有着较高的同源性。预测的花鲈 AAT 蛋白三级结构与斑马鱼 (*Danio rerio*)、中华鳖 (*Pelodiscus sinensis*)、青海龟 *Chelonia mydas*、人 (*Homo sapiens*) 高度相似, 表明 A1A 蛋白在脊椎动物进化过程中非常保守。

关键词: 花鲈; 肝; alpha-1 抗胰蛋白酶

Transcriptom profiling of the liver from *Lateolabrax maculatus* and expression analysis of alpha-1-antitrypsin

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Abstract: We extracted total RNA from the liver of *Lateolabrax maculatus* and constructed a cDNA library for high-throughput sequencing. A total of 5.5G raw data was obtained, and spliced and clustered to obtain 20743 unigenes with an average length of 1255bp and N50 of 1867bp. The transcriptome comparison of liver with other five tissues (stomach, spleen, testis, brain, and gill) showed that there are some highly expressed genes in the liver, such as apolipoprotein A1, leukocyte cell-derived chemotaxin-2, fibrinogen beta chain, and serotransferrin, and some specifically expressed genes, such as vitronectin, angiogenin, glucose-6-phosphatase, uridine phosphorylase 2, and alpha-1-antitrypsin. This article focuses on the analysis of alpha-1 antitrypsin (AAT) specifically expressed in the liver. We cloned the full-length sequence of the AAT gene, including the complete coding region (1230bp) and the exon-intron structure (4 exons and 3 introns). The AAT gene encodes 409 amino acids, the first 20 amino acids are signal peptides, and the middle 50-406 amino acids are the serpin domain. Quantitative real-time PCR further showed that AAT was mainly expressed in the gills, but barely expressed in the stomach, liver, brain, spleen and testis. Phylogenetic analysis shows that AAT of *Lateolabrax maculatus* is classified into a subgroup of bony fishes and has high homology with *Epinephelus coioides*. The predicted tertiary structure of AAT protein in *Lateolabrax maculatus* is highly similar to *Danio rerio*, *Pelodiscus sinensis*, *Chelonia mydas*, and *Homo sapiens*, indicating that A1A protein is very conserved in vertebrate evolution.

Key words: *Lateolabrax maculatus*; liver; alpha-1-antitrypsin

鳊 *lect2* 基因的分子和功能表征

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摘要: 鳊(*Siniperca chuatsi*)是一种重要的经济鱼类, 病毒和细菌性疾病严重影响鳊的人工饲养。作为肉食性鱼类, 人工饲料驯化也是提高鳊养殖规模的一个重要方法。因此免疫学和消化生理学的研究对鳊的产业化具有重要意义。在本研究中, 我们基于二代和三代测序技术分析鳊白细胞衍生趋化因子 2 (*Sc-lect2*)基因。 *Sc-lect2* 基因主要表达在肝脏中, 在鳃、皮肤、肌肉、肾、头肾、脑、胃和肠中几乎不表达。当鳊被脾肾感染性坏死病毒、脂多糖、和聚肌苷-聚胞苷酸感染时, 与未感染组相比 *Sc-lect2* 表达分别显著升高约 40、17 和 7 倍。我们也发现当鳊被人工饲料驯养后 *Sc-lect2* 升高约 8 倍。这些结果表明鳊肝脏不仅能消化食物也能表达特异性免疫基因, 饮食的改变也能造成 *Sc-lect2* 基因的差异表达。另外, miR-145-3p 能够通过靶向 *Sc-lect2* 的编码区来抑制 *Sc-lect2* 基因的表达。启动子区域中的一个 CpG 岛显示出高水平的甲基化, 表明高甲基化不会影响肝脏中 *Sc-lect2* 基因的表达。

关键词: 鳊; 肝脏; 白细胞衍生趋化因子 2; miR-145-3p; DNA 甲基化

Molecular and functional characterization of the *lect2* gene from *Siniperca chuatsi*

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Abstract: Mandarin fish (*Siniperca chuatsi*) is an important economic fish in China. Viral and bacterial diseases seriously affect the artificial culture of *S. chuatsi*. As a carnivorous fish, artificial feed domestication is also an important means to improve the scale of *S. chuatsi* culture. Therefore, the study of immunology and digestive physiology is very important to the industrial development of *S. chuatsi*. In this work, we analyzed the expression and function of the *S. chuatsi* leukocyte cell-derived chemotaxin 2 (*Sc-lect2*) gene on a basis of next generation and single-molecule long-read sequencing. *Sc-lect2* was mainly expressed in the liver but barely expressed in the gill, skin, muscle, kidney, head kidney, brain, stomach, and intestine. When the fish were infected with infectious spleen and kidney necrosis virus and challenged with lipopolysaccharide and polyinosinic-polycytidylic acid, *Sc-lect2* expression significantly increased by about 40, 17, and 7-fold, respectively, compared with unstimulated samples. We also found that *Sc-lect2* increases by approximately 8-fold after the fish are fed an artificial diet. These results show that mandarin fish liver can not only digest food but also express specific immune genes. Changes in the diet can cause the differential expression of *Sc-lect2* genes. Interestingly, miR-145-3p could inhibit *Sc-lect2* gene expression by targeting its coding sequence region. One CpG island in the promoter region showed a high level of methylation, suggesting that high methylation does not affect *Sc-lect2* gene expression in the liver.

Keywords: *Siniperca chuatsi*; liver; leukocyte cell-derived chemotaxin 2; miR-145-3p; DNA methylation.

鳞头犬牙南极鱼 *leptin* 基因的克隆及表达分析

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摘要: 为探究 *leptin* 基因在鳞头犬牙南极鱼 (*Dissostichus mawsoni*) 适应南极极端低温环境中的作用, 本研究从 *D.mawsoni* 卵巢组织中克隆获得了一个 *leptin* 基因 (*lepb*)。序列分析表明, *lepb* 基因的开放阅读框(ORF)为 396 bp, 编码 132 个氨基酸, 含有两个特征性的半胱氨酸残基参与二硫键的形成, 分子质量为 14.39 kD, 理论等电点为 5.14, 不稳定系数为 40.22, 亲水性系数为 -0.218, 为亲水性蛋白, 无信号肽和跨膜结构域, 在细胞质和细胞核中均可表达。同源性比对及进化树分析发现, *lepb* 基因与伯氏肩孔南极鱼 (*Trematomus bernacchii*) 亲缘关系最近, 相似度为 84.4%。组织表达分析表明, *lepb* 基因在卵巢表达最高, 脑部表达次之。研究结果为进一步探索 *lepb* 基因在极地鱼类适应低温中的分子功能与作用机制奠定了一定的理论基础。

关键词: 鳞头犬牙南极鱼; *leptin*; 基因克隆; 细胞定位; 组织表达

Cloning, identification and expression analysis of leptin gene in Antarctic toothfish *Dissostichus mawsoni*

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Abstract: To investigate the role of leptin gene in the adaptation of Antarctic toothfish *Dissostichus mawsoni* in the extreme low temperature in Antarctica. In this study, a leptin gene (*lepb*) was cloned in ovary by RT-PCR. Sequence analysis showed that the ORF of *lepb* gene was 396 bp, encoding 132 amino acids, including two characteristic cysteine residues involved in the formation of disulfide bonds with a molecular weight of 14.29 kD, a theoretical isoelectric point of 5.14, an instability coefficient of 40.22 and an average hydrophilic number of -0.218. Protein prediction results showed that LEPB protein is a hydrophilic protein with no signal peptide and transmembrane domain, which can be detected in both cytoplasm and nucleus by immunofluorescence analysis. Homology comparison and phylogenetic tree analysis showed that *lepb* gene is closely related to *Trematomus bernacchii*. Tissue expression analysis showed that *lepb* gene was most expressed in ovary, followed by brain. The results lay the foundation for dissecting the molecular mechanism of *lepb* gene involved in polar fish response to cold stress.

Key words: Antarctic toothfish, leptin, cloning, cell localization, tissue expression

牙鲆 CRH 基因组织特异性表达及其启动子甲基化转录调控机制研究

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摘要: 促肾上腺皮质激素释放激素 CRH 参与多种生理过程, 如昼夜节律运动和焦虑样行为。在鱼类中 CRH 主要表达于尾部神经分泌系统 (CNSS), 在肌肉和下丘脑中表达水平较低。本研究中我们首先研究了牙鲆不同组织中 CRH mRNA 的表达模式。其次我们发现牙鲆在白天中几乎不活动, 与之对应的是 CRH mRNA 在中午时间表达最高。最后研究 DNA 甲基化是否参与了 CRH 基因的组织特异性表达。在 CRH 基因近端启动子中, 肌肉、下丘脑和 CNSS 中几乎没有发现甲基化, 但是在 CRH 远端启动子中检测到不同的甲基化。CNSS 甲基化率为 63%, 下丘脑和肌肉甲基化率分别为 85%和 96%。总之, 本研究结果表明远端启动子甲基化可能参与了牙鲆 CRH 表达的转录调控。

关键词: 牙鲆; 促肾上腺皮质激素释放激素; 启动子甲基化; 转录调节

Expression of corticotropin releasing hormone in olive flounder (*Paralichthys olivaceus*) and its transcriptional regulation by promoter methylation

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Abstract: Corticotropin-releasing hormone (CRH) has been implicated in multiple physiological processes, such as circadian rhythms and anxiety-like behavior. In teleost fishes, CRH is predominantly expressed in the caudal neurosecretory system (CNSS), a much low level in muscle and hypothalamus. In this study, firstly, we investigated the expression pattern of CRH mRNA in different tissues of olive flounder (*Paralichthys olivaceus*). Secondly, we found that flounder exhibited low locomotor activity in the daytime, concomitant with the highest CRH mRNA expression in CNSS at noon. Thirdly, we examined whether epigenetic regulation through DNA methylation are involved in tissue-specific expression of CRH mRNA. In the proximal promoter, almost no methylation was detected in the muscle, hypothalamus and CNSS. However, different methylation was detected in the distal promoter of CRH. The methylation was 63% in CNSS, while that in hypothalamus and muscle was 85% and 96%, respectively. Collectively, our data provide the evidence that distal promoter methylation involved in transcriptional regulation of CRH expression in flounder.

Key words: olive flounder; CRH; promoter methylation; transcriptional regulation

基于代谢组学解析眼斑星丽鱼白化形成机理

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摘要: 眼斑星丽鱼又名地图鱼是重要的观赏鱼类, 有白化和黑地图鱼等品种, 但目前其白化形成机理尚不清楚。本研究对白化和黑地图鱼皮肤、眼球壁中黑色素分布及皮肤结构进行了组织学分析, 基于 UHPLC-Q-TOF MS 技术对皮肤进行了非靶向代谢组学分析。结果表明: (1) 皮肤和眼球壁均有黑色素分布, 但白化的数量少, 且黑色素小体数量少, 分布集中。(2) 多元统计模型显示白化和黑地图鱼总体代谢组显著分离, 表明二者皮肤可能具有不同的代谢特征; 共鉴定出 25 种显著差异代谢物, 主要以氨基酸类衍生物和脂类为主; 显著差异代谢物层次聚类分析显示白化和黑地图鱼分别聚类在同一簇, 具有相似的表达模式; 进一步的 KEGG 通路分析显示氨基酸生物合成和 ABC 转运蛋白等通路发生显著变化。地图鱼白化形成与黑色素相关, 黑色素是氨基酸类衍生物, 其合成涉及物质转运, 本研究结果为地图鱼白化发生机制研究提供了新见解。
关键词: 地图鱼; 白化; 黑色素; 代谢组学; 氨基酸

Mechanism of albinism for *Astronotus ocellatus* based on metabolomics

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Abstract: Map fish (*Astronotus ocellatus*) is an important ornamental fish, including albino and common breed. However, researches on the mechanism of albinism are scarce at present. Here, we detected the distribution of melanin in the skin and eye by histology analysis and Untargeted Metabolomics of skin based on UHPLC-Q-TOF MS. The results showed that melanin was detected in both, but the quantity in albino was rare. Meanwhile, albino had fewer melanosomes and concentrated distribution in melanocytes. Multivariate statistical model showed that the metabolites were significantly separated, indicating that the both skin may have diverse metabolic characteristics. A total of 25 differential metabolites were identified, mainly including amino acid derivatives and lipid. Hierarchical cluster analysis showed that the both were grouped in the same cluster respectively. KEGG pathway showed significant changes in amino acid biosynthesis and ABC transporter pathway. Melanin, an amino acid derivatives, contributes to the formation of albinism, and its synthesis involves substance transport. This study provides a new insight into the mechanism of albinism in *Astronotus ocellatus*.

Key words: *Astronotus ocellatus*, albinism, melanin, metabolomics, amino acid

异源精子诱导兰州鲇雌核发育的遗传纯度和性别决定机制分析

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摘要: 雌核发育作为可持续渔业的重要手段之一, 广泛应用于养殖新品种的开发、纯系及单性群体的建立以及性别决定机制的探究等方面, 为兰州鲇这一黄河经济鱼类所面临的种质资源濒危和退化的困境。本研究利用紫外线失活的黄颡鱼精液诱导兰州鲇(减数分裂)雌核发育, 并筛选精子遗传失活和冷休克处理条件, 利用微卫星标记分析兰州鲇雌核发育后代的遗传纯度, 通过性腺组织切片得到雌核发育后代雌雄比探究兰州鲇性别决定机制。结果表明, 最佳诱导条件为以 107 uw/cm³ 紫外线照射 30 min 的黄颡鱼精子与兰州鲇卵子受精 6 min 后, 在 4-6°C 下冷休克处理 25 min; 微卫星分子标记证成功鉴定雌核发育后代遗传组成的准确性; 通过性腺组织学观察确定其性别比例, 雌核发育群体后代均为 100%雌性个体, 极大程度上支持兰州鲇的性别决定机制为 XX/XY 型。本研究利用灭活的异源精子在兰州鲇中首次成功获得雌核发育个体, 为兰州鲇这一濒危经济鱼类的纯系建立及性别控制育种提供了依据。

关键词: 兰州鲇; 雌核发育; 遗传纯度分析; 性别控制机制

Analysis of genetic purity and sex determination mechanisms of gynogenetic individuals induced by heterogenous sperm in *Silurus lanzhouensis*

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Abstract: Gynogenesis as one of the important factors in the sustainability of fisheries. The process can be used to provide a shortcut for the genetic improvement of the endangered and degraded germplasm resources of the economically important Yellow River fish *Silurus lanzhouensis*. In this study, ultraviolet-inactivated *Pelteobagrus fulvidraco* sperm was used to induce gynogenesis in *S. lanzhouensis* (meiosis) through cold shock, and the best conditions for sperm genetic inactivation and cold shock treatment were selected. Using microsatellite markers and gonadal histology, the genetic purity and sex determination mechanism of gynogenetic offspring of *S. lanzhouensis* were analyzed. The results showed that the best induction was obtained when the sperm of *P. fulvidraco* and the eggs of *S. lanzhouensis* were fertilized for 6 min with 107 uw/cm³ ultraviolet irradiation for 30 min and then treated with cold shock at 4-6°C for 25 min. Microsatellite molecular markers proved that the genotype of the offspring obtained with gynogenesis was consistent with the maternal genotype. The sex ratio was determined through gonad histological observation, and the offspring of the gynogenetic group were all 100% female individuals, which greatly supports the sex determination mechanism of *S. lanzhouensis* as the XX/XY type. This study used inactivated heterologous sperm to successfully obtain gynogenetic individuals of *S. lanzhouensis* for the first time, providing a basis for the establishment of a pure line of these endangered fish and for sex-controlled breeding of *S. lanzhouensis*.

Keywords: *Silurus lanzhouensis* · gynogenesis · genetic purity analysis · sex control mechanism

虹鳟肝细胞系的建立与鉴定

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摘要:鱼类细胞培养技术是一种被广泛应用于病毒学、环境毒理学、细胞生物学、基因组学以及遗传学等方面研究的重要研究手段。本研究通过不同的分离方法和培养条件探索虹鳟鱼肝细胞的原代培养,以建立稳定的虹鳟鱼肝细胞原代培养模型。细胞分离后用0.4%台盼蓝染色检测细胞存活率,并通过CCK-8检测细胞活力;同时在倒置显微镜下观察长期培养过程中肝细胞的形态变化。结果表明:组织块分离法并不适用于虹鳟鱼肝细胞分离,在培养过程中未见细胞从组织块中迁出,而胰蛋白酶消化法获得良好稳定的分离效果,经0.25%胰蛋白酶消化25 min,每克肝重可收集细胞数量达到 1.8×10^8 个,平均细胞存活率达到95%;不同培养基和不同血清浓度均会影响细胞贴壁以及生长,结果显示细胞在含15% FBS的DMEM培养基生长效果明显优于MEM、M199以及L15培养基;

关键词:虹鳟;肝细胞;胰蛋白酶;原代培养

Establishment and Characterization of hepatocyte from

Oncorhynchus mykiss

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Abstract: As powerful tool, fish cell lines have been widely used in virology, environmental toxicology, cell biology, genomics and genetics. In order to establish a stable primary culture model of hepatocytes in *Oncorhynchus mykiss*, 2 different isolation methods (tissue culture and pancreatin digestion) and culture conditions of primary hepatocytes culture were compared in the present study. The survival rate was tested with 0.4% trypan blue exclusion and the viability was assessed with CCK-8; As well as the morphological changes of cells in long-term culture were also observed under inverted microscope. The results showed that the separation of tissue blocks was not suitable for rainbow trout liver cells, and no cells were removed from the tissue blocks in the culture process. However, the trypsin digestion method obtained a good and stable separation effect. The liver tissue digested by 0.4% trypsin for 25 min yielded 1.8×10^8 cell /g (liver weight) and the viability was 95%. Both culture medium and concentration of serum influenced the attachment and proliferation of the hepatocytes. and the growth effect of DMEM medium containing 15% FBS was significantly better than that of MEM, M199 and L15.

Key words: *Oncorhynchus mykiss*; Hepatocytes; Trypsin; Primary culture

利用比较转录组技术鉴定斑点叉尾鲷白化病 相关候选基因

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摘要: 本研究对白化型和野生型斑点叉尾鲷皮肤组织进行比较转录组研究, 结果显示: 在白化型和野生型的皮肤组织中获得 1106 个差异表达基因, 其中 530 个上调, 576 个下调。总共鉴定了 30,813 个可变剪接(AS)事件。AS 事件主要分布在 15090 个基因中, 平均每个基因包含 2.04 个 AS 事件。差异表达主要集中在黑色素生成、黑色素小体生物合成、黑色素小体转运和酪氨酸代谢等生物途径, 显著性差异表达基因包括 *mart1*、*cdk2*、*pmel17*、*tyr*、*tyrp1*、*adh*、*hgd* 和 *tyrl*, 主要在黑色素的生成、与色素沉着相关的几个生物学过程中显著过表达。白化样本中酪氨酸代谢途径中所有基因的表达水平均显著提高。此外, 还发现了斑点叉尾鲷 *hps4* 基因突变到至斑点叉尾鲷白化的可能机制, 其突变后主要影响酪氨酸代谢途径中基因表达的调控。本研究结果为进一步了解斑点叉尾鲷白化病的发病机制提供了理论基础。

关键词: 斑点叉尾鲷; 白化; *hps4*; 黑色素; 转录组测序

Use of comparative transcriptome analysis to identify candidate genes related to albinism in channel catfish (*Ictalurus punctatus*)

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Abstract: Transcriptome profiles of albino and wild type catfish were generated using next generation high-throughput RNA sequencing technology and compared. A total of 1106 differentially expressed genes were obtained, of which 530 were up-regulated and 576 were down-regulated in the skin tissue of albino catfish relative to wild type catfish. In total, 30,813 alternative splicing (AS) events were identified. These AS events were distributed in 15,090 genes with an average of 2.04 AS events per gene. We identified and compared a large proportion of transcripts encoding genes involved in regulation of melanogenesis, melanosome biogenesis, melanosome transport, and the tyrosine metabolism pathway in the catfish skin transcriptome dataset. Further analysis revealed that differentially expressed genes, including *mart1*, *cdk2*, *pmel17*, *tyr*, *tyrp1*, *adh*, *hgd* and *tyrl*, were significantly overrepresented in the melanogenesis pathway and in several biological processes associated with pigmentation. The albino catfish skin samples exhibited significantly increased expression levels of all candidate genes in the tyrosine metabolism pathway. We also identified a possible mechanism for the mutation of the catfish *Hps4* gene, which affects regulation of expression of genes in the tyrosine metabolism pathway.

Key words: Catfish, Albinism, *hps4*, Melanin, RNA sequencing

不同地域刺参群体微进化分析

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摘要: 为了探明黄渤海海域刺参与俄罗斯刺参的遗传进化特点, 采用基因组重测序的方法探究黄渤海海域及俄罗斯的 8 个群体(平岛、旅顺、西小磨、黄龙尾、蛇蛸岛、山东、俄罗斯, 中俄杂交刺参)共 215 只刺参的微进化特征。结果显示:(1)高通量测序共获得 2180.6G 数据, 平均覆盖深度为 11.99, 近 1/3 的 SNP 和 INDel 集中在基因编码区;(2)主成分和群体结构分析中, 俄罗斯群体均为单独聚类, 8 个地理群体可划分为 2 个亚群: 中国亚群和俄罗斯亚群, 俄罗斯亚群存在两个分化方向;(3)系统发育结果显示, 8 个刺参种群基本各自聚类, 部分群体之间存在个体混杂, 其中俄罗斯群体基因最为纯净, 亲缘关系热图中, 俄罗斯刺参和中俄杂交刺参亲缘关系最近, 当位点间的相关系数 r^2 衰减到 0.2 时, 中俄杂交刺参衰减距离为 1.992kb, 较其他群体刺参衰减最慢, 推测是由于较其他群体, 中俄杂交刺参基因组处在成种后逐渐进入遗传稳态期过程中;(4)在选择清除分析 99% 阈值处, 中俄杂交刺参和俄罗斯刺参的比值最大, F_{st} 值为 0.1344766, P_i 值为 1.16691, 表明两个群体之间分化水平最高;(5)进行刺参棘刺数 GWAS 分析, 筛选出 50 个高质量 SNP 位点, 验证后得到可用于分子育种的 KASP 标记。这为刺参的环境适应性研究和遗传育种工作奠定基础。

关键词: 刺参; 不同地理种群; 微进化; GWAS

Microevolution analysis of sea cucumber (*Apostichopus japonicus*) populations in different regions

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Abstract: In order to explore the genetic evolution characteristics of *stichopus japonicus* in the Yellow Sea and Bo Sea, the study uses the method of genome resequencing to explore the microevolutionary characteristics of a total of 215 sea cucumbers in 8 groups (Pingdao, Lushun, Xixiaomo, Huanglongwei, Zijiao Island, Shandong, Russia, Sino-Russian hybrid sea cucumber), combined with the geographical environment of the sea cucumber population. The results shows: (1) High-throughput sequencing obtained 2180.6G data, with an average coverage depth of 11.99, and nearly 1/3 of SNPs and INdels were concentrated in the gene coding region; (2) In the principal component and group structure analysis, the Russian group always clusters separately, the 8 geographic groups can be divided into 2 subgroups: the Chinese subgroup and the Russian subgroup. There are two directions of differentiation within the Russian subgroup; (3) The phylogenetic results showed that the 8 sea cucumber populations basically clustered separately, and there were individual intermingling among some populations, among which the Russian population had the purest genes. In the kinship heat map, Russian sea cucumbers and Sino-Russian hybrid sea cucumbers are closely related. When the correlation coefficient r^2 between the sites attenuates to 0.2, the attenuation distance of Chinese-Russian hybrid sea cucumbers is 1.992 kb, which attenuates more slowly than other populations. It is speculated that the genome of the Chinese-Russian hybrid sea cucumber is in the process of gradually entering the genetic steady-state phase after seeding, compared with other populations; (4) At the 99% threshold of selective clearance analysis, the population with the largest ratio is Russian and Sino-Russian hybrid sea cucumbers, with F_{st} value of 0.1344766 and P_i value of 1.16691, indicating the highest level of differentiation between the two groups; (5) Carry out GWAS analysis of the number of spines in sea cucumbers, and screen out 50 high-quality SNP loci. After verification, a KASP marker for molecular breeding was obtained.

Keywords: sea cucumber, different geographic populations, Microevolution, GWAS

虾夷扇贝、栉孔扇贝对高温低氧耐受性研究

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摘要: 近年来, 随着夏季高温, 导致虾夷扇贝出现大量死亡, 环境变化占主要因素。本研究以虾夷扇贝 (*Mizuhopecten yessoensis*)、栉孔扇贝 (*Azumapecten farreri*) 为研究对象。旨在比较分析两个物种对高温、低氧的耐受性。将在 15℃, 8±0.5mg/L 暂养一周的扇贝分组放入高温组 (22、25℃), 低氧组 (2、4、6mg/L), 高温低氧联合组 (25℃, 2mg/L) 的实验水槽中。36h 后取扇贝的鳃组织、内脏囊、体腔液, 后期进行鳃组织切片观察, 扇贝耗氧率、排氨率和相关免疫酶测定。结果显示: 随温度、氧含量的升高, 两种扇贝的鳃丝宽度和丝间隔均增大, 联合组虾夷扇贝最大鳃丝宽度 102mm, 丝间隔 74.984mm 大于栉孔扇贝鳃丝宽度 68.47mm, 丝间隔 60.55mm, 差异不显著 (P>0.05)。在高温、低氧胁迫下, 两种扇贝耗氧率和排氨率趋势一样, 均在 25℃ 最高 (P<0.05), 其中栉孔扇贝的耗氧率 (3.5~15.02) 显著高于虾夷扇贝 (2.94~6.29) (P<0.05), 排氨率反之; 联合组数据比较分析, 栉孔扇贝的耗氧率(3.45)、排氨率(0.75)均小于虾夷扇贝(3.5,3.9)。高温、低氧胁迫下, 两种扇贝的内脏囊和体腔细胞中相关免疫酶活力变化趋势一样, 但两种扇贝免疫酶活力数值不同。例如 T-AOC 活力虾夷扇贝 (22.12~27.78mM) 中上升趋势显著大于栉孔扇贝(0.015~0.019mM) (P<0.05), 但栉孔扇贝体腔细胞中 T-AOC、MDA 呈下降趋势 25℃ (0.0072Mm) 最低, 2mg/L(0.0074Mm)最低。虾夷扇贝内脏囊和体腔细胞中的 SOD 均随温度的升高和含氧量的降低均呈上升趋势, 栉孔扇贝反之。联合组中, 栉孔扇贝的 T-AOC (0.157mM) 含量均显著低于虾夷扇贝 (27.78mMt) (P<0.05)。推测由于栉孔扇贝是广温性贝类, 对温度的应激能力较冷水性的虾夷扇贝弱。研究可为探究贝类高温、低氧耐受性提供理论基础, 为后续贝类抗逆新品系的选育提供参考。

关键词: 虾夷扇贝; 栉孔扇贝; 高温; 低氧; 内脏囊; 体腔液; 相关免疫酶活力

Study on Tolerance of *Mizuhopecten yessoensis* and *Azumapecten farreri* to High Temperature and Hypoxia

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Abstract: In order to Compare and analyze the tolerance of two species to high temperature and hypoxia. *Mizuhopecten yessoensis* and *Azumapecten farreri* are the research objects. Gill section, Physiological and biochemical indicators. total antioxidant capacity (T-AOC), superoxide dismutase (SOD), catalase (CAT), and malondialdehyde (MDA) in the visceral sac and body cavity cells of the two kinds of scollop. With the hightempter hypoxia stress, The two tissues of differents collop have different expressions trends. This study can provide a theoretical basis for exploring the tolerance of scollop to high temperature and hypoxia, provide a reference for the subsequent breeding of new scollop resistant strains.

Key words: *Mizuhopecten yessoensis*; *Azumapecten*; Hightempter; Hypoxia; Visceral sac. Body cavity cells

基因芯片在凡纳滨对虾病原诊断中的应用

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摘要: 基因芯片出现于 20 世纪 90 年代, 采用反向斑点杂交原理在探针上做生物素类的标记, 经过反应之后通过显色程度判断核酸分子杂交情况, 以此得出样品中靶基因的含量。水产养殖病原体包括细菌、真菌、病毒和寄生虫, 每年爆发疾病的概率在 50% 以上, 造成 20% 左右的损失。凡纳滨对虾 1988 年由中国科学院海洋研究所从美国引进, 江苏连云港市南美白对虾养殖发展迅猛, 已经成为全国较大的南美白对虾养殖区域。本研究经过核酸快速提取, 芯片上特异的基因探针能够对待检虾样品进行病原体定性和半定量检测, 基因芯片反应可在 15 分钟内完成, 肉眼直接判读结果。目前能够对凡纳滨对虾肝肠胞虫、急性肝胰腺坏死、皮下及造血组织坏死病、血虹彩病毒、杆状病毒、肝胰腺细小病毒进行快速检测。

关键词: 基因芯片; 凡纳滨对虾; 病原诊断

The application of gene chip technology in the etiological diagnosis of *Litopenaeus vannamei*

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Abstract: The gene chip appeared in the 1990s using reverse dot blot(RDB) technology to mark the biotin on the probe to obtain the content of target genes in the sample with judging the hybridization of nucleic acid molecules by the degree of color development after the reaction. Aquaculture pathogens include bacteria, fungi, viruses and parasites, and the probability of disease outbreaks is more than 50% per year, resulting in about 20% loss. *L. vannamei* was introduced from the United States by the Institute of Oceanology of the Chinese Academy of Sciences in 1988. The culture of *L. vannamei* in Lianyungang City, Jiangsu Province has developed rapidly and become a larger culture area of *L. vannamei* in China. The research can be used to detect the pathogen qualitatively and semi-quantitatively through the specific gene probe on the chip after rapid extraction of nucleic acid. The gene chip reaction can be completed in 15 minutes and the results can be interpreted directly by the naked eye. At present, the rapid detection of *L. vannamei* Enterocytozoon hepatopenaei, acute hepatopancreatic necrosis disease, infectious hypodermal and haematopoietic necrosis virus (IHHNV), *Penaeus irido virus*, baculovirus and hepatopancreatic parvovirus can be carried out.

Key words: gene chip; *Litopenaeus vannamei*; etiological diagnosis

光棘球海胆 *piwi* 基因的克隆及表达分析

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摘要: *piwi* 基因是影响海胆生殖细胞发育的重要因子。光棘球海胆(*Mesocentrotus nudus*)是我国主要的海胆养殖品种。本研究以光棘球海胆为研究对象, 利用转录组数据, 通过同源比对筛选得到 *piwi* 基因片段, 并利用 cDNA 末端快速扩增技术(Rapid Amplification of cDNA ends, RACE) 获得光棘球海胆 *piwi* 基因的全长 cDNA 序列。*piwi* 序列全长为 3004bp, 该序列 5'非编码区长 116bp, 3'非编码区长 233bp, 开放阅读框(Open Reading Frame, ORF)共 2655bp, 编码 884 个氨基酸。具有保守的 PIWI 和 PAZ 结构域, 相对分子量为 99473.18, 理论等电点为 9.57。同源性及系统进化分析显示光棘球海胆 *piwi* 蛋白序列与紫球海胆 *seawi* 蛋白序高度保守。(同源性 90.50%)。实时荧光定量 PCR 检测发现 *piwi* 基因在光棘球海胆的性腺各时期及肠和管足中均有表达, 在肠中表达量最高。在胚胎表达情况中, 结果表明 *piwi* 基因为母源因子, 在受精卵就检测到大量信号, 且在整个胚胎发育中均有表达。母源的表达随着胚胎的发育到八胞期母源表达降低, 之后持续上升稳定表达。在性腺表达中, 雄性逐渐升高, 随后稳定表达。在性腺与组织对比的表达中, 雌雄性腺差异表达, 在肠中大量表达。性腺组织切片 RNA 原位杂交结果表明, *piwi* 仅在光棘球海胆性腺组织中的生殖细胞中特异表达。本研究为海胆生殖细胞发生过程中 *piwi* 的功能及相关研究提供了基础。

关键词: 光棘球海胆; *piwi*; 生殖细胞

Cloning and expression analysis of *piwi* gene of *Mesocentrotus nudus*

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Abstract: *Piwi* gene is an important factor affecting the development of sea urchin germ cells. *Strongylocentrotus nudus*(*Mesocentrotus nudus*) is the main sea urchin breed in our country. In this study, *Strongylocentrotus nudus* was taken as the research object, the *piwi* gene fragment was screened by homology comparison using transcriptome data, and the full-length cDNA sequence of the *piwi* gene of *echinocentrotus nudus* was obtained using rapid amplification of cDNA ends (RACE). *Piwi* sequence has a total length of 3004bp, the 5' non-coding region is 116bp, the 3' non-coding region is 233bp, and the ORF is 2655bp, encoding 884 amino acids. It has conserved PIWI and PAZ domains with a relative molecular weight of 99473.18 and a theoretical isoelectric point of 9.57. Homology and phylogenetic analysis showed that the *piwi* protein sequence of *Strongylocentrotus nudus* and *seawi* protein sequence of *Strongylocentrotus nudus* were highly conserved. (homology 90.50%). Real-time fluorescence quantitative PCR detection found that *piwi* gene was expressed in gonad, intestine and tubular foot of *Strongylocentrotus nudus*, with the highest expression in intestine. In the case of embryo expression, the results show that *piwi* gene is a maternal factor, and a large number of signals are detected in fertilized eggs and expressed throughout embryo development. The expression of maternal source decreased with the development of embryo to octuple stage, and then increased steadily. In gonad expression, male gradually increased and then expressed stably. In the contrast expression between gonad and tissue, the male and female gonads are differentially expressed and expressed in large quantities in intestine. RNA in situ hybridization of gonad tissue sections showed that *piwi* was only specifically expressed in germ cells in gonad tissue of *Strongylocentrotus nudus*. This study provides a basis for *piwi* function and related research in the process of urchin germ cell generation.

Key words: *Meconocrotus nudus*; *piwi*; Germ cells

利用 DIA/SWATH 分析虹鳟肝脏响应慢性热应激的蛋白质组学

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摘要: 夏季高温严重制约了虹鳟 (*Oncorhynchus mykiss*) 养殖业的发展, 了解虹鳟对慢性热应激反应的调控机制有助于制定缓解热应激的措施。在本研究中, 非特异性免疫参数的变化表明虹鳟在 24°C 下遭受了强烈的应激反应, 同时应激防御系统和免疫系统被激活。本研究在热应激 (24°C) 和对照 (18°C) 条件下, 利用 DIA/SWATH 对肝脏蛋白质组进行分析, 共鉴定出 390 个差异表达蛋白 (DEPs; $q\text{-value} < 0.05$, $FC > 1.5$), 其中 175 个上调, 225 个下调。许多与热休克蛋白 (HSPs)、代谢蛋白和免疫蛋白相关。Gene Ontology (GO) 富集分析表明, 热应激下一些与调节细胞稳态、代谢、适应性应激和刺激相关的蛋白被高度诱导。Kyoto Encyclopedia of Genes and Genomes (KEGG) 富集分析表明代谢途径、内质网蛋白质加工、PPAR 信号以及补体和凝血级联是机体参与热应激调控的主要途径。蛋白质互作 (PPI) 网络预测 HSP90b1 和 C3 可能协同保护热应激下细胞膜的完整性。本研究结果有助于制定缓解虹鳟热应激的策略。

关键词: 虹鳟; 热应激; DIA/SWATH; 肝脏蛋白质组; 蛋白质互作网络

Proteome analysis of rainbow trout (*Oncorhynchus mykiss*) liver responses to chronic heat stress using DIA/SWATH

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Abstract: Aquaculture of rainbow trout (*Oncorhynchus mykiss*) is severely hampered by high temperatures in summer, and understanding the regulatory mechanisms controlling responses to chronic heat stress may assist the development of measures to relieve heat stress. In the present study, biochemical parameters revealed a strong stress response in rainbow trout at 24°C, including activation of stress defence and immune systems. Liver proteome analysis under heat stress (24°C) and control (18°C) conditions using DIA/SWATH identified 390 differentially expressed proteins (DEPs; $q\text{-value} < 0.05$, fold change > 1.5), among which 175 and 225 were up- and down-regulated, respectively. Many were related to heat shock proteins (HSPs), metabolism and immunity. Gene Ontology (GO) analysis showed that some DEPs induced at high temperature were involved in regulating cell homeostasis, metabolism, adaptive stress and stimulation. Kyoto Encyclopedia of Genes and Genomes (KEGG) analysis identified metabolic pathways, protein processing in endoplasmic reticulum, PPAR signalling, and complement and coagulation cascades. Protein-protein interaction (PPI) network analysis indicated that HSP90b1 and C3 may cooperative to protect cell membrane integrity under heat stress. Our findings may assist the development of strategies to relieve heat stress in rainbow trout.

Keywords: rainbow trout; heat stress; DIA/SWATH; liver proteome; PPI network

金沙江攀枝花段岩原鲤微卫星分子标记的筛选及遗传多样性分析

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摘要: 采用 RDA-seq (Restriction-site associated DNA sequencing) 测序技术, 以 2017~2019 年采集的金沙江攀枝花段岩原鲤 (*Procypris rabaudi*) 为材料, 共筛选出 15 个多态性微卫星标记。利用这 15 对多态性引物对该江段岩原鲤种群的遗传多样性进行分析, 数据显示: 15 对多态性微卫星引物的等位基因数为 2~6 个, 平均等位基因数为 3.4 个, 平均期望杂合度为 0.552, 平均观测杂合度为 0.562, 其中引物 Prora098 和 Prora102 显著偏离哈迪温伯格平衡 ($P < 0.05$)。结果表明该江段岩原鲤种群的遗传多样性水平略低。筛选的微卫星标记将在岩原鲤的遗传背景分析和生物种质资源保护等研究中发挥重要作用。

关键词: 岩原鲤; 微卫星分子标记; 遗传多样性; 金沙江

Development and screening of microsatellite molecular marker and genetic diversity analysis for *Procypris rabaudi* in the Panzihua Section of Jinsha River

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Abstract: In recent years, due to the construction of hydroelectric projects, overfishing and other human activities, the resource of *Procypris rabaudi* in Panzihua section of Jinsha River declined seriously. In this study, we screened 15 polymorphic microsatellite markers of *P. rabaudi* by RDA-seq (restriction-site associated DNA sequencing) technology, which collected from 2017 to 2019 in Panzihua section of Jinsha River. Using these polymorphic microsatellite markers, we analyzed the genetic diversity of the population of *P. rabaudi* collected from this section of the river. The data showed that the loci of alleles ranging from 2 to 12 with an average of 3.4 per locus, the average observed heterozygosity (H_o) was 0.552, and the average expected heterozygosity (H_e) was 0.562. The markers of prora098 and prora102 significantly deviated from Hardy-Weinberg equilibrium ($P < 0.05$). These results showed that the genetic diversity of *P. rabaudi* population was slightly low. The selected microsatellite markers will play an important role in genetic background analysis and biological germplasm protection of *P. rabaudi*.

Key words: *Procypris rabaudi*, microsatellite molecular marker, genetic diversity, Jinsha River

草鱼 miRNA-21 在抗 GCRV 中的功能初探

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摘要: MicroRNAs(miRNAs)是长度约 21-24 个核苷酸的非编码 RNA, 主要通过与其靶基因 3'端非翻译区(3'UTR)结合而抑制靶基因翻译或降解靶基因等方式形成复杂的调控网络来调控生物体的各项生命活动。本研究利用高通量技术对 GCRV 攻毒前后的草鱼头肾组织进行比较分析, 经比较分析筛选出了 32 个表达量差异显著的 miRNAs, 其中 29 个为下调表达 miRNA、3 个为上调表达 miRNA。结合 miRNA 的定量验证结果, 我们选取了表达量高且攻毒前后表达差异显著的上调表达分子 miR-21 进行功能研究。本研究利用病毒侵染及 miRNA 的过表达等操作研究其免疫功能, 结果发现过表达 miR-21 会显著延缓 GCRV 引起的细胞病变, 提示 miR-21 在草鱼抗 GCRV 中发挥潜在重要作用。

关键词: 草鱼; GCRV; miRNA-21; 免疫

A preliminary study on the function of grass carp miRNA-21 in anti-GCRV

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Abstract: MicroRNAs (miRNAs) is a non-coding RNA, with a length of about 21-24 nucleotides, mainly through binding to the 3' untranslated region (3'UTR) of the target gene to inhibit the translation of the target gene or to degrade the target gene to form a complex regulatory network to regulate various life activities of the organism. In this study, high-throughput technique was used to compare and analyze the head kidney tissues of grass carp before and after GCRV challenge. 32 miRNAs, with significant differences were screened by comparative analysis, of which 29 were down-regulated miRNA and 3 were up-regulated miRNA. Combined with the quantitative verification results of miRNA, we selected the up-regulated expression molecule miR-21 with high expression and significant difference before and after challenge to study the function. In this study, virus infection and overexpression of miRNA were used to study the immune function of grass carp. The results showed that overexpression of miR-21 significantly delayed the cytopathic effect induced by GCRV, suggesting that miR-21 plays a potential important role in anti-GCRV of grass carp.

Key words: Grass carp; GCRV; miRNA-21; Immunity

中间球海胆 *PPAR γ* 的分子特性、表达规律与体内干扰验证

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摘要: 过氧化物酶体增殖物激活受体 γ (*PPAR γ*) 在脂肪细胞分化中起重要的调节作用。为了解 *PPAR γ* 在中间球海胆中的作用, 本研究使用了 RACE 技术获得了完整的编码 *PPAR γ* 的全长 cDNA 序列, 并分析了其在中间球海胆的不同发育阶段以及不同组织中的表达。*PPAR γ* 的全长 cDNA 包含 2286bp, 推定的开放阅读框为 1755 bp, 编码 584 个氨基酸。预测的分子质量为 67.27 kDa, 其理论等电点为 10.07。该蛋白质包含保守的基序, 包括 RRM 结构域。*PPAR γ* 在中间球海胆不同组织中表达量最高的是性腺, 最低的是管足; 不同发育时期中表达量最高的是受精卵时期, 最低的是 32 细胞时期。siRNA 特异性抑制 *PPAR γ* 表达 48 小时后, *UCP2* 在性腺和肠中的表达明显降低, 证明 *UCP2* 是 *PPAR γ* 的下游靶基因。测定干扰前后性腺中脂肪酸含量, C18:2(trans, n-6) 和 C20:3(n-6) 水平显著降低。这些表明 *PPAR γ* 在脂肪酸合成代谢中发挥作用, 且 *PPAR γ* 和 *UCP2* 具有正向的调节作用, 研究有助于解析中间球海胆的脂肪酸合成途径和调节机制。

关键词: 中间球海胆; *PPAR γ* ; 基因克隆; siRNA

Molecular cloning, expression, characterization and in-vivo interference verification of *PPAR γ* in the sea urchin (*Strongylocentrotus intermedius*)

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Abstract: Peroxisome proliferator activated receptor gamma (*PPAR γ*) plays important regulatory roles in adipocyte differentiation, to understand the function of *PPAR γ* in *S. intermedius*, we used the rapid amplification of cDNA ends (RACE) to obtain the full-length cDNA sequence encoding *PPAR γ* and analyzed its expression profile during different developmental stages, and in different tissues of *Strongylocentrotus intermedius*. The full-length cDNA of *PPAR γ* contains 2286 base pairs (bp), with a putative open reading frame of 1755 bp, encoding a polypeptide of 584 amino acid (AA) residues. The predicted molecular mass is 67.27 kDa and its theoretical isoelectric point (pI) is 10.07. The protein contains conserved motifs, including an RRM domain. The tissue distribution of *PPAR γ* showed that its highest expression was in the gonads, whereas the weakest expression was in the tube feet of *S. intermedius*. Time-course expression measurements at different developmental stages showed the highest expression of *PPAR γ* occurred in the eggs, and the weakest expression occurred in the 32 cells stage. Knock-down of *PPAR γ* by specific siRNA revealed that *UCP2* expression was significantly depressed in the gonads and intestines at 48 h post transfection, indicating that the downstream target gene of *PPAR γ* is *UCP2*, suggesting *PPAR γ* and *UCP2* have positive regulatory effects. When we examined changes in fatty acid levels in the gonads, before and after *PPAR γ* interference, our results showed that 48 h of siRNA, C18:2(trans, n-6) and C20:3(n-6) levels had decreased. Taken together, these results suggest a role for *PPAR γ* in fatty acid anabolism, *PPAR γ* and *UCP2* have positive regulatory effects, which helps us understand fatty acid synthesis pathways and regulatory mechanisms of *S. intermedius*.

Keywords: *Strongylocentrotus intermedius*; *PPAR γ* ; Gene cloning; siRNA

中华鳖 SOX 转录因子的鉴定与功能分析

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摘要: SOX 转录因子在生物发育过程中起重要作用。已在许多物种中鉴定到 Sox 基因, 然而中华鳖基因组中 Sox 基因的定位和功能分析尚未阐明。中华鳖基因组中含有 17 个 Sox 基因, 根据系统发育关系将其分为 7 组。本研究对 Sox 基因结构和蛋白质结构域分析表明, 同一系统发育组中 Sox 基因的外显子、内含子数和结构域相对保守, 但不同组之间存在差异。Sox 基因的两性异型表达分析表明, Sox8 和 Sox9 在精巢中表达上调, 而 Sox3、Sox7、Sox11 和 Sox13 在卵巢中表达上调。SOX 转录因子与其靶基因关联网络分析表明, Sox3、Sox9 和 gata4 呈负相关, Sox11、Sox7 与 gata4 呈负相关。Sox8、Sox9 与 gata4 呈正相关。综上所述, 本研究基因组范围内鉴定和分析 Sox 基因家族有助于进一步揭示 Sox 基因在中华鳖发育的作用。

关键词: 中华鳖, 转录因子, SOX 基因, 性别分化, 转录组测序

Identification and functional analysis of SOX transcription factors in the genome of the Chinese soft-shell turtle (*Pelodiscus sinensis*)

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Abstract: SOX transcription factors play an irreplaceable role in biological developmental processes. Sox genes have been identified in a wide variety of species; however, their identification and functional analysis in the genome of the Chinese soft-shell turtle (*Pelodiscus sinensis*) have not been performed. In the present study, the Chinese soft-shell turtle genome was found to contain 17 Sox genes, which were categorized into seven groups according to their phylogenetic relationships. Gene structure and protein motif analysis of the Sox genes showed that within the same phylogenetic group, their exon-intron number and motif structure of the Sox family were relatively conserved, but diverged in the comparison between different groups. Sexual dimorphism expression analysis for the Sox genes displayed that Sox8 and Sox9 were upregulated in the testis, while Sox3, Sox7, Sox11, and Sox13 were upregulated in the ovary. A correlation network analysis of SOX transcription factors with their target genes analysis showed that Sox3 correlated negatively with Sox9 and gata4. Sox11 and Sox7 correlated negatively with gata4. Sox8 and Sox9 correlated positively with gata4. Therefore, the genome-wide identification and functional analysis of the Sox gene family will be useful to further reveal the functions of Sox genes in the Chinese soft-shell turtle.

Key Words: Chinese soft-shell turtle; transcription factor; Sox gene; Sex differentiation; RNA-seq

低温压力下斑马鱼细胞中 DNMT1 作用研究

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摘要:为了探究低温压力下斑马鱼细胞中 DNA 甲基转移酶 DNMT1 的作用, 本实验以 28℃ 常规培养的斑马鱼 ZF4 细胞作为对照组, 低温 18℃ 培养的 ZF4 细胞作为实验组, qRT-PCR 检测低温压力下斑马鱼 ZF4 细胞中 DNMT1 的表达变化。构建 pLKO.1-DNMT1-shRNA 重组质粒, 在斑马鱼 ZF4 细胞中敲降 DNMT1, 随后细胞经 18℃ 低温处理 3 天, 台盼蓝染色法检测 ZF4 细胞存活率, Western Blot 检测 DNA 损伤水平。克隆斑马鱼 DNMT1 cDNA 并将其克隆到 pLVX-IRES-Neo 载体构建了 FLAG-DNMT1 融合蛋白过表达载体。随后 pLVX-IRES-Neo-FLAG-DNMT1 转染 ZF4 细胞, 18℃ 低温刺激 3 天后台盼蓝染色法检测 ZF4 细胞存活率并对其 DNA 损伤水平进行检测。结果显示: 低温压力下 ZF4 细胞中 DNMT1 表达量增加。在低温压力下, 与对照组相比, 敲降 DNMT1 会导致 DNA 损伤增加, 细胞存活率降低; 过表达 DNMT1 可以减少 DNA 损伤, 提高 ZF4 细胞的存活率。本实验初步证明, 斑马鱼 DNMT1 在低温压力下可以抑制 DNA 的损伤水平, 提高 ZF4 细胞的存活率并对 ZF4 细胞起到了一定的保护作用。

关键词:DNMT1; 低温; 斑马鱼 ZF4 细胞; DNA 损伤

Study on the role of DNMT1 in zebrafish cells under low temperature pressure

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Abstract: To explore the role of DNA methyltransferase DNMT1 in zebrafish cells under low temperature pressure, ZF4 cells were shifted from 28℃ to 18℃ for cold treatment and qRT-PCR was used to detect the expression changes of DNMT1 in zebrafish ZF4 cells. The recombinant plasmid pLKO.1-DNMT1-shRNA was constructed and DNMT1 was knocked down in zebrafish ZF4 cells. Then the cells were treated at a low temperature of 18℃ for 3 days, and the survival rate of ZF4 cells was detected by trypan blue staining and the DNA damage was detected by Western Blot. The zebrafish DNMT1 cDNA was cloned and then it was cloned into the pLVX-IRES-Neo vector to construct a FLAG-DNMT1 fusion protein overexpression vector. pLVX-IRES-Neo-FLAG-DNMT1 was transfected into ZF4 cells, and the DNA damage and the survival rate of ZF4 cells were detected after a 3-day cold exposure at 18℃. The results showed that under low temperature pressure, DNMT1 expression was up-regulated in ZF4 cells. Under low temperature pressure, knocking down DNMT1 could cause DNA damage and reduce cell survival rate compared with the control group; while overexpression of DNMT1 could improve the survival rate of ZF4 cells and reduce DNA damage. This experiment preliminarily proved that under low temperature pressure, zebrafish DNMT1 could inhibit the level of DNA damage, improve the survival rate of ZF4 cells and protect ZF4 cells.

Keywords: DNMT1; low temperature; zebrafish ZF4 cells; DNA damage

罗非鱼作为清洁鱼防控刺激隐核虫感染的研究

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摘要: 罗非鱼具有广盐性和杂食性的特点。为了探究罗非鱼是否可以作为清洁鱼防控刺激隐核虫感染, 本研究优化了红罗非鱼的海水驯化方法; 检测了红罗非鱼清除水中包囊的速率; 并应用红罗非鱼与卵形鲳鲹混养的方式 (13尾和19尾红罗非鱼/m²), 评估红罗非鱼作为清洁鱼对卵形鲳鲹感染了刺激隐核虫后的保护效果。实验结果显示, 红罗非鱼在12‰海水中暂养2d后, 以6‰/2d逐渐增加养殖水盐度, 驯化至28‰盐度的存活率为100%。红罗非鱼清除包囊的速率与水体中包囊的数量呈正相关, 速率高达207.60个包囊/小时。在混养实验中, 经过二次重复感染后, 13尾/m²组和19尾/m²组中卵形鲳鲹的载虫量相对于对照组分别减少了46.60%和93.57%, 其相对保护率分别为84.44%和100%。但经过三次重复感染后, 实验组的保护效果与对照组相比不显著。实验结果说明了红罗非鱼可以通过清除包囊从而降低刺激隐核虫对鱼体的二次感染, 但红罗非鱼清除包囊的稳定性还需要进一步研究。

关键词: 刺激隐核虫; 红罗非鱼; 混养; 生物防控

Use of tilapia as a scavenger to control *Cryptocaryon irritans* infestations

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Abstract: Tilapia has the characteristics of euryhaline and omnivorous. To explore whether tilapia could be used as scavenger to control the infection of *Cryptocaryon irritans*, this study optimized the method for red tilapia to acclimatized seawater. The rate of consumed tomonts of red tilapia was measured. Moreover, the polyculture of red tilapia (13 and 19 red tilapias /m²) and pompano were used to evaluate the protect effect of red tilapia as a scavenger against *C. irritans* infection. The results showed that after red tilapia was cultured in 12‰ seawater for 2d, the salinity was gradually increased at 6‰/ 2d, and the survival rate of red tilapia was 100% when acclimatized to 28‰ salinity. There was a positive correlation between consumed-tomonts rate and the number of tomonts, and the rate was up to 207.6 tomonts/h. Additionally, after the second repeated infection of *C. irritans*, the parasite abundance on pompano in the 13 fish /m² group and the 19 fish/m² group were decreased by 46.60% and 93.57%, respectively, compared with the control group, and the relative protection rates were 84.44% and 100%, respectively. The difference, however, was no significant between experimental group and control group after the third repeated infection. It implied that the second repeated infection could be controlled by co-cultured with red tilapia, but the ability of eliminating tomonts could be further studied.

Key words: *Cryptocaryon irritans*, Red tilapia, Polyculture, Biocontrol

锦鲤 microRNA-137 系统进化、靶基因预测及表达分析

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摘要: 为探究 miR-137 与锦鲤体色形成的关系, 本实验对鱼类 miR-137 前体序列进行比对, 构建 ML 系统进化树, 并分析其在体色发生阶段和不同组织中的相对表达水平。随后对其靶基因进行预测, 并对预测的靶基因进行 GO 和 KEGG 分析。最后利用荧光素酶实验验证 miR-137-3p 与靶基因的靶向关系, 并分析 miR-137 与靶基因 mRNA 的表达变化。结果显示 pre-miR-137 在鱼类中具有较高的保守性, GO 和 KEGG 分析表明多个靶基因富集在色素细胞分化、色素沉积等通路。QPCR 显示 miR-137-3p 在锦鲤 11dph 表达量最高, 随后显著降低 ($P<0.05$), 在皮肤、鳍条中较高表达, 白色组织表达量显著高于红色组织 ($P<0.05$)。双荧光报告载体结果显示 miR-137-3p 结合 *mitfa* 3'-UTR, 抑制其表达, 但对 *sprb* 无显著抑制作用。本研究显示 miR-137 与锦鲤体色形成具有一定的相关性, 为 miR-137 在锦鲤体色形成中的作用提供基础数据。

关键词: 锦鲤; miRNA-137; 进化; 表达; 靶基因; 体色

Evolution, target gene prediction and expression analysis of microRNA-137 in Japanese ornamental carp

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Abstract: In order to explore the role of miR-137 in the color formation of koi, the precursor sequences of miR-137 were aligned and constructed phylogenetic tree by ML, qPCR was used to analyze the relative expression levels of miR-137, target genes were predicted. The target genes of miR-137-3p were analyzed by GO, KEGG analysis. The relationship between miR-137-3p and target genes was verified by luciferase assay, and changes in mRNA expression were detected by qPCR. The results was pre-miR-137 was conserved in fish, GO and KEGG analysis showed multiple target genes were enriched in pigment-related pathways. The expression of miR-137-3p climbed the peak on 11 dph and decreased in the following stages ($P<0.05$). The skin and fins of white tissues had a higher expression than that of the red tissues. Dual-fluorescent reporter vector results was miR-137-3p combined with *mitfa* 3'-UTR inhibited its expression, but had no significant inhibitory effect on *sprb*. This study shows that miR-137 may affect the body color of Koi, which provides data for the role of miR-137 in body color of Koi.

Key words: *Cyprinus carpio* L.; miRNA-137; evolution; expression; target gene; body color

日本海神蛤 *Panopea japonica* 繁殖生物学研究

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摘要: 日本海神蛤 *Panopea japonica* 是象拔蚌的一种, 为探究日本海神蛤规模化人工苗种繁育的可行性, 在国内首次开展了日本海神蛤繁殖生物学研究。结果表明: ①日本海神蛤繁殖周期共分为5期, 分别为休止期、增殖期、生长期、成熟期和排放期, 5月和10月为繁殖盛期; ②日本海神蛤生物学零度为 -1°C , 有效积温约为 $356^{\circ}\text{C}\cdot\text{d}$; ③日本海神蛤单次产卵量为(300-500)万粒/个, 卵径为75-85 μm 。春季人工将水温升至 $18.6-19^{\circ}\text{C}$, 经过60 d的培育, 日本海神蛤平均壳长可达到 $(4.94\pm 0.93)\text{mm}$, 平均苗种产量为2 695粒/ m^3 。秋季自然水温 $17.4-13.2^{\circ}\text{C}$ 条件下, 日本海神蛤幼虫相对春季生长发育较慢, 经过148 d的培育, 稚贝平均壳长可达 $(2.88\pm 0.47)\text{mm}$, 平均苗种产量为6 666粒/ m^3 , 再经室外池塘中间育成后, 可培育平均壳长 $(13.22\pm 2.39)\text{mm}$ 幼贝。比较发现在我国北方秋季可培育出适于底播养殖的大规格苗种, 且培育成本较低。本研究为日本海神蛤苗种繁育、高效养殖及资源修复提供了科学依据。

关键词: 日本海神蛤; 繁殖周期; 生物学零度; 有效积温; 人工繁殖; 生长发育

A study on reproductive biology of the geoduck clam(*Panopea japonica*)

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Abstract: Geoduck, *Panopea japonica*, a kind of large marine mollusk. In order to test the feasibility of large scale artificial breeding of geoduck clam *P. japonica*, this study for the first time performed reproductive biology of the geoduck clam *P. japonica*. The results showed :①The reproductive cycle of *P. japonica* can be divided into five stages, which are the rest period, the proliferation period, the growth period, the maturity period and the spawning period. *P. japonica* has two breeding periods, May and October.②The biological zeros point (BZP) of gonadal development of *P. japonica* is -1°C , the effective accumulative temperature (EAT) of it is about $356^{\circ}\text{C}\cdot\text{d}$. ③For *P. japonica*, a single spawning amount is $(3\times 10^6) - (5\times 10^6)$ eggs/female and an egg diameter is 75-85 μm . In the spring, artificially raise the water temperature to $18.6-19^{\circ}\text{C}$, after cultivation for 60 days, the average shell length of the juveniles reached $(4.94\pm 0.93)\text{mm}$. The average unit production of the spring season was 2 695 spat/ m^3 . In autumn, when the water temperature was from 17.4°C to 13.2°C , the development of larval *P. japonica* was relatively slow and after cultivation for 148 days, the average shell length of the juveniles reached $(2.88\pm 0.47)\text{mm}$ and the unit production was 6 666 spats/ m^3 , then the spat could reach $(13.22\pm 2.39)\text{mm}$ when be transferred to the outside pool for cultivation. In comparison, large size seed for cultivation in the sea bottom could be produced with low cost in Autumn in northern China. This study lay a scientific basis for larval breeding, high-efficient cultivation and resource restoration of *P. japonica* in China.

Key words: *Panopea japonica*; reproductive cycle; BZP;EAT; artificial breeding; growth

石首鱼染色体的研究

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摘要: 石首鱼科鱼类是我国重要的渔业资源类群之一, 该科系统发生在形态水平和分子水平的研究较多, 但染色体总体研究水平较低。我们利用多种染色方法以及FISH比较分析了黄姑鱼、双棘原黄姑鱼、厦门白姑鱼(又名鮟状黄姑鱼)、眼斑拟石首鱼、棘头梅童鱼和大黄鱼等六种石首鱼科鱼类的核型特征, 得到2个有趣的发现。一是, 石首鱼核型宏观结构虽然稳定, 但rDNA位点(特别是5S rDNA)位点存在较大的种间变异; 二是, 棘头梅童鱼具有多性染色体系统($X_1X_1X_2X_2/X_1X_2Y$)。利用三色FISH进一步分析棘头梅童鱼染色体发现, Chr.1为 X_1 , 其中分布5S rDNA、18SrDNA和臂间端粒。结合GWAS定位和Hi-C互作确定Chr.7为 X_2 。另外, 我们利用双末端序列比对开发了一套大黄鱼染色体特异标记, 实现大黄鱼染色体的准确识别, 以及基因组与染色体研究的信息互通。

关键词: 石首鱼; 染色体; 荧光原位杂交; 性染色体; 染色体识别

棘头梅童鱼性别特异性标记的开发与验证

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摘要: 棘头梅童鱼是一种广泛分布于我国沿海的经济鱼类, 其具有特殊的多性染色体系统 $X_1X_1X_2X_2/X_1X_2Y$, 并在生长过程中表现出性别的二态性。但依靠传统方法通常难以鉴定幼体的生理性别与遗传性别。此外, 现有研究普遍认为棘头梅童鱼在我国沿海呈南北分化格局。在本课题组的前期研究中已开发了适用于宁德、九龙江等南部群体的性别分子标记, 但该标记并不适用于舟山等北部群体。因此, 本研究基于舟山群体的全基因组重测序原数据, 分析并获得了 13,228,765 个 SNP 和 6,825,306 个 INDEL, 再与宁德群体的重测序原数据合并后, 从一号染色体找出了舟山、宁德群体共有的 221,206 个 SNP 和 244,901 个 INDEL。通过对雌雄重测序序列的比较分析, 开发出一个舟山、温州等北部群体适用的性别 DNA 标记和一个舟山、宁德等南北群体通用的性别 DNA 标记。该研究结果为进一步研究棘头梅童鱼性别分化机制和性染色体进化机制提供了重要工具。

关键词: 棘头梅童鱼; 性别特异标记; 遗传性别鉴定; 全基因组重测序

Development and Verification of sex-specific markers of spinyhead croaker (*Collichthys lucidus*)

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Abstract: *Spinyhead croaker* is a commercially fish widely distributed in China, exhibiting sexual dimorphism in growth, and being of a special multiple sex system $X_1X_1X_2X_2/X_1X_2Y$. It is difficult to identify the biological sex and genetic sex by traditional methods. Existing studies believe that there is a north-south differentiation pattern in China. In previous research, we have developed a gender marker that is applicable to southern populations (ND, JLJ), but not applicable to northern populations (ZS). In this study, 13,228,765 SNPs and 6,825,306 INDELs were obtained based on the whole-genome resequencing data of ZS population. After merging with the resequencing data of ND population, 221,206 SNPs and 244,901 INDELs were found from Chr. 1 of ZS and ND. After comparative analysis of resequencing sequences, a gender DNA marker suitable for ZS, WZ and other northern groups and a gender DNA marker common in ZS, ND and other northern and southern groups were developed. This study provides an tool for the study of sexual differentiation mechanism and sex chromosome evolution mechanism in spinyhead croaker.

Key words: *Collichthys lucidus*, Sex-specific marker, Whole Genome Resequencing

通过分析黄鳝性腺 DNA 甲基化和基因表达水平变化鉴定参与其性别转换的重要基因

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摘要: 黄鳝是我国重要的名优经济水产动物之一, 同时也是一种雌性先熟型雌雄同体鱼类。目前, 黄鳝性别转换的分子机制仍不清楚。研究黄鳝性别转换的分子机制不仅有重要的经济意义, 还可以丰富鱼类性别决定与分化的机制。本研究初步分析了 DNA 甲基化水平在黄鳝卵巢和精巢中变化, 以及结合转录组分析结果筛选参与黄鳝性别转换的重要基因。筛选到 1718 个存在启动子区域甲基化水平差异显著的基因, 以及发现 11479 个差异表达的转录本。整合分析 DNA 甲基化和转录组测序结果, 共发现 901 个基因在甲基化水平和表达水平同时存在差异, 其中 457 个基因的表达水平与启动子区域的甲基化水平呈负相关。我们发现 *piwi1*、*tdrd1*、*nanos2*、*sox30*、*stra6*、*mei1*、*meioc*、*dnmt3a* 等与性腺分化和发育相关基因的启动子区域甲基化水平在精巢中下降, 而其表达量在精巢中上升。本研究为后续研究黄鳝性别转换的分子机制提供了参考基因。**关键词:** 黄鳝; 性别转换; DNA 甲基化; 转录组测序

Identification of key genes involving sex change of rice field eel (*Monopterus albus*) by integrating analysis of DNA methylation and mRNA expression profiles of gonads

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Abstract: The rice field eel (*Monopterus albus*), a protogynous hermaphroditic Synbranchiform species, is one of the most economically valuable freshwater fishes in China. Because of its molecular mechanism of sexual change remaining largely unclear, studies on sexual change of the rice field eel will benefit artificial culture, and provide opportunities for understanding sex determination and differentiation in fish. In this study, whole-genome DNA methylation of ovary and testis was analyzed in the rice field eel. We also investigated the gene expression profiles of ovary and testis using RNA-seq, so as to investigate effects of methylation alterations on gene expression. A total of 1718 genes methylated differentially in the gene promoter region, and 11479 differentially expressed genes were identified. Both promoter methylation and expression changes were observed for 901 genes with 457 genes showing a negative correlation between DNA methylation status and expression level. We found a decreased methylation and an increased expression of *piwi1*, *tdrd1*, *nanos2*, *sox30*, *stra6*, *mei1*, *meioc* and *dnmt3a* in testis, which are involved in gonadal differentiation and development. This study would provide basic information for gene expression epigenetically regulating by methylation changes in the process of sexual reversal in the rice field eel.

Key words: *Monopterus albus*, Sexual change, DNA methylation, RNA-seq

橘色双冠丽鱼 Mitf1、Mitf2 基因的克隆与表达分析

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摘要: 为探究 Mitf (Microphthalmia-associated transcription factor, Mitf) 基因在橘色双冠丽鱼体色褪黑过程中的调控作用, 采用 RACE 技术克隆了橘色双冠丽鱼 Mitf1、Mitf2 基因 cDNA 序列全长, 并利用 qRT-PCR 技术检测其在橘色双冠丽鱼胚胎不同发育时期、体色褪黑不同时期和各个组织中的表达规律。获得橘色双冠丽鱼 Mitf 基因两个突变体序列...

关键词: 橘色双冠丽鱼; Mitf 基因; 克隆; 表达

Cloning and expression of Mitf1、Mitf2 gene in *Amphilophus citrinellus*

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Abstract: In order to explore the regulatory role of the Mitf (Microphthalmia-associated transcription factor, Mitf) gene during body color variation in *Amphilophus citrinellus*, the full-length cDNA sequence of the *Amphilophus citrinellus* Mitf1 and Mitf2 genes were cloned using rapid amplification of cDNA ends (RACE). And using qRT-PCR technology to detect its expression in the different developmental stages of *Amphilophus citrinellus* embryos, different stages of body color variation and various tissues. Two mutant sequences of *Amphilophus citrinellus* mitf gene were obtained.....

Key words: *Amphilophus citrinellus*, Mitf gene, Cloning, Expression analysis

低温胁迫下黑鲷肝脏转录组测序分析

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摘要: 黑鲷 (*Acanthopagrus schlegelii*) 是我国沿海养殖的重要海水经济鱼类, 但是室外越冬的问题限制着黑鲷养殖业的发展, 而目前对黑鲷的低温调节的分子机制研究较少。因此, 本研究通过对经过 15 °C(对照组)、10 °C 和 5 °C 低温胁迫 12 h 的黑鲷肝脏进行转录组测序, 共获得 19465 个基因, 筛选到 2900 个差异表达基因 (DEGs), 其中上调基因为 1096 个, 下调基因为 1804 个。对这些 DEGs 进行富集分析, 发现与对照组相比, 10 °C 与 5 °C 组均显著富集在生物生物学过程中的细胞过程、代谢过程和单组织过程, 细胞组分中的细胞、细胞组分和细胞器以及分子功能中的粘和催化活性等生物学 GO 簇。通过 KEGG 富集分析发现, 与对照组相比, 10 °C 组在免疫通路、昼夜节律以及细胞循环富集最显著, 而 5 °C 组以转录与翻译、蛋白质合成与降解和昼夜节律富集最显著。本研究为进一步揭示黑鲷耐低温分子调控机制提供了数据支持和理论依据。

关键词: 黑鲷; 肝脏; 低温胁迫; 转录组; 差异表达基因

Transcriptome Study of Liver of black porgy (*Acanthopagrus schlegelii*) under Low-Temperature Stress

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Abstract: Black porgy (*Acanthopagrus schlegelii*) is an important marine economic fish cultivated along the coast in China. However, the problem of outdoor overwintering restricts the development of black porgy aquaculture. At present, there is little research on the low temperature response mechanism of black porgy. Therefore, the liver of black porgy (*Acanthopagrus schlegelii*) was transcriptome sequencing after has been subjected to low temperature stress of 15 °C (control group), 10 °C and 5 °C for 12 h. A total of 19,465 genes were obtained and 2900 differentially expressed genes (DEGs) were screened. The DEGs included 1096 genes were up-regulated and 1804 genes were down-regulated. In the enrichment analysis of DEGs, compared to 15 °C group, the 10 °C and 5 °C groups were significantly enriched in the biological process's cellular process, metabolic process, and single-organism process; as well as the cells, cell part and organelle in the cellular component; and binding and catalytic activity in molecular functions. Through the KEGG enrichment analysis, compared to control group, the DEGs in the 10 °C group was the most significant enrichment in the immune pathway, circadian rhythm and cell cycle, while 5 °C group was enriched in transcription and translation, protein compose and degradation and circadian rhythm enrichment are the most significant. This study provides data support and theoretical basis for further revealing the molecular regulation mechanism of low temperature tolerance of black porgy.

Key Words: Black porgy, Liver, low temperature stress, Transcriptome, Differentially expressed genes

笠贝 (*Lottia goshimai*) 背腹轴调控基因表达模式的初步研究

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摘要: BMP 信号通路在多数两侧对称动物中参与调控背腹轴的形成, 然而软体动物 BMP 信号通路及其在背腹轴形成中的功能尚缺乏深入研究。本文以腹足纲软体动物笠贝 (*Lottia goshimai*) 为对象, 选择可能参与背腹轴形成的 BMP 信号通路基因(如 Tolloid、Gremlin 等), 利用整装原位杂交技术研究了其在胚胎早期发育过程中的时空表达规律。结果显示, 这些基因在表达起始时间上存在显著差异, 提示笠贝背腹轴形成可能分为两个涉及不同调控网络的发育阶段; 另外, 发现基因的表达多聚集在不同的细胞团中, 范围存在明显的差别, 提示在背腹轴形成过程中可能存在多个功能各异的细胞群体。这些结果为进一步了解软体动物 BMP 信号通路的功能以及构建背腹轴的调控网络提供了重要参考。

关键词: 笠贝; BMP; 背腹轴; 发育

Expression patterns of dorsal-ventral patterning genes in the gastropod mollusc *Lottia goshimai*

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Abstract: Generally, bone morphogenetic protein (BMP) signaling regulates the dorsoventral (DV) patterning of bilaterian animals. However, the knowledge of BMP signaling in molluscan DV patterning remains limited. Here, we cloned the components of BMP pathway (Tolloid, Gremlin etc.) in the gastropod *Lottia goshimai* and investigated their temporal-spatial expression patterns during DV patterning. Our results showed that there were evident differences in the initiation expression time of these genes, indicating that the DV patterning of *L. goshimai* may be divided into two stages involving varied regulatory networks. In addition, the expression of these genes were mainly detected in distinct cell masses, suggesting the existence of multiple cell populations that may have different roles during DV patterning. These results add to the knowledge of the functions of BMP signaling pathway in molluscan DV patterning.

Key words: *Lottia goshimai*, BMP signaling pathway, Dorsal-ventral patterning, development

红罗非鱼体色变异与调控研究

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摘要: 一些环境因素的改变对红罗非鱼的体色产生影响。饲料中额外添加酪氨酸和胱氨酸显著影响红罗非鱼皮肤黑色素含量、酪氨酸酶活力、酪氨酸酶基因和 *slc7a11* 基因的 mRNA 表达; 随着越冬温度的升高, 血液和肌肉中 *tyr* mRNA 的表达量升高, 切片显微结构发现, 红罗非鱼背部皮肤的黑色素细胞数量减少; 光周期对红罗非鱼的黑色素形成和生长都有影响; 背景光线的变化影响红罗非鱼的体色及相关基因的表达。为研究红罗非鱼的体色变异和调控因素, 开展了 3 种不同体色红罗非鱼的转录组分析, 筛选到 148 个差异表达的基因, 获得了 158 个显著差异表达的 miRNA, 进行了 miRNA-mRNA 调控网络关联分析, 鉴定出 miR-138-5p 和 miR-722 这 2 个显著差异表达的 miRNA 在调控体色中起重要作用。克隆得到 *slc7a11* 基因 3 个亚型的 cDNA 序列, 证明 *slc7a11* 通过黑色素通道在红罗非鱼体色变异上发挥重要作用。

关键词: 红罗非鱼; 体色; 转录组; 基因; miRNA; 环境因子

The studies of color variation and its regulation in red tilapia

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Abstract: Some environmental changes influenced body color of red tilapia. The extra dietary tyrosine and cystine significantly affected the melanin content, tyrosinase activity, the expression of *tyrosinase* (*tyr*) mRNA and *slc7a11* mRNA in red tilapia. When temperature increased during overwintering, the blood and muscle *tyr* mRNA expression increased and melanocytes number in fish dorsal skin decreased by slice microstructure observation. The photoperiod had an impact on melanogenesis and growth of red tilapia, and changes in background color affected the apparent body color and expression of the related genes. In order to research on the color variation and its regulation, we conducted transcriptomic analysis on three color varieties of red tilapia. One hundred and forty-eight significantly differentially expressed unigenes and 158 significantly differentially expressed miRNAs were obtained. The two significantly differentially expressed miRNAs (miR-138-5p and miR-722) were predicted to play important roles in color regulation by miRNA-mRNA regulatory network analysis. Three complete cDNA sequences of *slc7a11* were successfully isolated from red tilapia and it is demonstrated that *slc7a11* played an important role in skin color formation and differentiation of red tilapia through the melanogenesis pathway.

Key words: red tilapia; body color; transcriptome; gene; miRNA; environmental factors

不同群体间弓背青鲮角膜厚度的比较

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摘要: 为了获知不同光照强度的弓背青鲮(*Oryzias curvinotus*)群体角膜厚度的差异, 本实验综合弓背青鲮 Kera 基因(ocKera)的时空表达数据、氨基酸序列和角膜切片数据, 探讨了弓背青鲮湛江高桥和海南三亚群体在不同光照条件下, Kera 在基因型和角膜表型上的差异。胚胎发育过程中 ocKera mRNA 丰度在囊胚期至体节期最低, 发眼期呈现明显上调, 并在出膜前达到显著性水平($P<0.05$); ocKera 在成体眼睛中表达量极显著高于其他组织($P<0.001$), 且雌性高于雄性、视网膜高于角膜($P<0.05$)。Kera 序列比对揭示出亮氨酸重复结构域(LRRNT domain)内存在多个非同义置换, 其中第 77 号残基的 P(CCA)/S(TCA)置换在低纬度的三亚群体样本中均为 S 纯合型。而弓背青鲮的三亚群体的角膜相比于高桥群体较厚($P<0.05$)。本研究发​​现弓背青鲮群体间角膜存在显著的表型差异, 且发育关键基因 ocKera 呈现基因型分化, 为更深入开展眼睛发育的研究以及鱼类疾病模型的开发利用提供了参考。

关键词: 弓背青鲮; 角膜; Kera; 组织表达

Comparison of corneal thickness of *Oryzias curvinotus* among different populations

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Abstract: Keratocan play a crucial role in the normal function in vertebrates. The aims of this study were to identify the sequence information of the Kera and the comparison between populations in the *Oryzias curvinotus*. In this study, we demonstrated the existence of Kera in the eyes and embryonic development of each stage in *Oryzias curvinotus* using quantitative real-time PCR (qRT-PCR). ocKera gene sequence alignment reveals that there are multiple non-synonymous substitutions in the LRRNT domain, of which the P(CCA)/S(TCA) of residue 77 is substituted in the sample of Sanya population at low latitudes both are S homozygous. Correspondingly, the cornea and stromal portion of the Sanya population were thicker than the Gaoqiao population. This study found that there are significant phenotypic differences in the cornea of the *Oryzias curvinotus* populations, and the developmental key genes show genotype differentiation, which provides a reference for further research on eye development and the development and utilization of fish disease models.

Key words: *Oryzias curvinotus*; Kera; cornea; tissue expression

B 族维生素对海洋细菌生物被膜形成及厚壳贻贝幼虫变态的影响

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摘要: 为探究 B 族维生素对海洋生物被膜形成及海洋贝类幼虫变态的影响, 本研究以对厚壳贻贝幼虫变态有诱导活性的海假交替单胞菌为研究对象, 调查其在生物被膜形成过程中添加 VB7 和 VB12 与否, 对贻贝幼虫变态发育的影响。另外, 对 VB7 和 VB12 直接诱导效果进行了检验。结果显示, 0.02 mM VB7 和 VB12 处理后的海假交替单胞菌生物被膜对幼虫附着变态的诱导作用最为显著。进一步发现, VB7 和 VB12 处理后生物被膜细菌密度、膜厚度以及胞外多糖、蛋白、脂类均显著增加。同时, 0.02 mM 浓度下 VB7 和 VB12 的诱导效果最强。综上, VB7 和 VB12 通过改变海洋细菌生物被膜的生物学特性进而调控厚壳贻贝幼虫变态发育。

关键词: B 族维生素; 海假交替单胞菌; 厚壳贻贝; 生物被膜; 变态

Effects of B vitamins on biofilm formation and larval metamorphosis of the mussel *Mytilus coruscus*

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Abstract: To explore the induction activity of B vitamins on the metamorphosis of marine mollusks larvae, VB7 and VB12 were used to investigate its impact on biofilm formation of *Pseudoalteromonas marina*, which had the induction activity on the metamorphosis of *Mytilus coruscus* larvae. The direct induction activity of VB7 and VB12 on larval metamorphosis was also detected. Results showed that the biofilm of *P. marina*, which formed in 0.02 mM VB7 or VB12, had the most significant induction effects on larval metamorphosis. The biofilm bacterial density, thickness, extracellular polymeric substances (EPS) such as polysaccharides, proteins, and lipids were increased significantly after VB7 or VB12 treatment. Besides, the concentration of VB7 or VB12 at 0.02 mM had the best direct induction effects. In summary, VB7 and VB12 can promote the larval metamorphosis of *M. coruscus* via changing the biofilm EPS composition.

Keywords: B vitamins, *Pseudoalteromonas marina*, *Mytilus coruscus*, biofilms, larval metamorphosis

基于 GBS 技术的黄渤海区域牙鲆遗传特征分析

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摘要: 基于下一代 GBS 测序技术, 利用 SNP 标记对锦州凌海、大连旅顺、大连长海、丹东东港和秦皇岛北戴河的牙鲆群体进行了遗传特征分析。共获得 5292854 个 SNP 标记, 5 个群体的观测杂合度 (H_o) 和期望杂合度 (H_e) 分别为 0.2016~0.2195 和 0.1723~0.2018, 遗传分化指数 F_{st} 值 0.067749~0.12734。本研究发现 5 个群体的观测杂合度均大于期望杂合度, 表明该海域的牙鲆野生群体的遗传多样性未降低。遗传分化指数结合系统进化分析, 发现东港群体与其他群体的遗传距离较远, 表明东港群体相对更加独立; 北戴河群体与旅顺群体趋于聚在一起, 表明两群体之间有较强的基因交流。研究结果有助于了解黄渤海区域野生牙鲆的遗传多样性水平, 为增殖放流等工作提供依据。

关键词: 牙鲆; GBS; SNP; 遗传多样性; 种群结构; 黄渤海

Analysis of Genetic Diversity of the Flounder (*Paralichthys olivaceus*) from Yellow Sea and Bohai Sea areas using GBS

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Abstract: The genetic diversity and population structure of the Flounder (*P. olivaceus*) populations (i.e. Linghai population (LH), Lushun population (LS), Changhai population (CH), Donggang population (DG), and Beidaihe population (BD)) were tested by Genotyping-by-Sequencing Technology. A total of high quality 5292854 SNP sites were obtained. The mean observed heterozygosity (H_o) was from 0.2016 to 0.2195, the mean expected heterozygosity (H_e) was from 0.1723 to 0.2018, and the average pairwise inbreeding coefficient F_{is} ranges from 0.067749 to 0.12734. For each population, the H_o was higher than that of the H_e , indicating high variation exists in the five populations from Yellow Sea and Bohai Sea areas. According to the F-statistic (F_{st}) among populations and phylogenetic analysis, the DG population was found to have a higher genetic differentiation and lower gene flow; extensive gene exchange might occur among the BD population and LS population. These results will contribute to the knowledge of the genetic characteristics of wild *P. olivaceus* from Yellow Sea and Bohai Sea areas and provide scientific basic data for the scientific development of the flounder breeding and releasing in China.

Key words: *Paralichthys olivaceus*; GBS; SNP; genetic diversity; population structure; Yellow Sea and Bohai Sea

社群等级因素对许氏平鲷幼鱼行为、生长及相 关调控激素的影响

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摘要: 为揭示鱼群内生长离散的发生机制, 本实验研究了养殖环境下社群等级对许氏平鲷幼鱼生长、摄食行为及相关调控激素的影响, 探究了群体内幼鱼个体间的社会交互行为模式, 分析了养殖环境中鱼群生长离散发生机制。结果表明, 社群等级因素并未对鱼群内小规格幼鱼的生长产生明显抑制作用。鱼群内的初始规格结构对于鱼群整体的生长离散变化有着显著影响, 统一规格组内的幼鱼体重变异系数(CV_w)随时间呈显著增加趋势, 而混合格组内的CV_w则呈现先降低后稳定的变化规律, 表现出群落结构的异质稳定性。行为学观察发现, 投饵期间, 鱼群内表现出明显的等级化摄食现象, 小规格幼鱼主要通过“偷食”策略获取饵料, 并未发现等级化摄食现象对小规格幼鱼有明显的摄食抑制。统一规格组内小规格个体间的攻击行为明显高于混合格组, 各处理组内相同规格个体之间发生打斗的频率均高于不同规格个体间的打斗频率。规格差异较大的鱼群内小规格幼鱼体内皮质醇水平要显著低于统一规格组, 鱼群内的竞争压力更小。实验结果表明, 人工育苗环境下许氏平鲷幼鱼生长离散的发生更可能是由个体间竞争能力的差异所引发, 而非社群等级因素的作用结果。在实际育苗生产过程中应努力实现鱼群规格结构的最佳化, 以获得最佳的育苗生产效益。

关键词: 社群等级; 规格组成; 生长; 攻击行为; 内分泌

Effects of size distribution on social interactions and growth of juvenile black rockfish (*Sebastes schlegelii*)

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Abstract: To better understand the relationship between size grading and growth variation in cultured juvenile black rockfish (*Sebastes schlegelii*) we studied how size heterogeneity affected their growth performance (body weight, SGR, CVW), social interactions (feeding position, aggressive behavior) and endocrine responses (cortisol, growth hormone, 5-hydroxytryptamine). We demonstrated that the growth variation in juvenile black rockfish seems to be a consequence of intensive competition between similar-sized individuals rather than growth suppression of smaller in a size-related dominance hierarchy. Thus a size-grading practice where rearing groups retain an acceptable level of size heterogeneity that limits competition and cannibalism would produce the overall best result in terms of growth and survival.

Key words: Social hierarchy; Size distribution, Growth, Aggressive behaviour, Endocrine

利用高通量测序技术探究卵形鲳鲹仔鱼对温度胁迫的转录响应

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摘要: 为了研究温度胁迫下卵形鲳鲹仔鱼的分子响应变化, 我们利用 RNA-Seq 技术对不同水温处理下 (24°C、28°C 和 32°C) 的卵形鲳鲹仔鱼进行转录组测序。结果显示, 共获得 501,367,768 个 clean reads, 94,144 个 unigenes 和 5828 个差异表达基因。GO 分析和 KEGG 分析表明, 大量差异表达基因与代谢过程、蛋白质合成和营养物质消化吸收等过程有关。高温组中的差异表达基因在蛋白质消化吸收、脂肪消化吸收、淀粉和蔗糖代谢、维生素消化吸收、谷胱甘肽代谢等通路中富集程度最高。与鱼类骨骼发育相关的 *shh*、*sox9a*、*col1a1*、*col2a1* 和 *ocn* 基因受不同温度胁迫的影响显著。本研究结果为理解卵形鲳鲹仔鱼对温度胁迫的响应模式提供了基础, 并对卵形鲳鲹的苗种繁育和养殖提供了重要支持。

关键词: 转录响应; 温度胁迫; 卵形鲳鲹

Transcriptional response of golden pompano *Trachinotus ovatus* larvae to temperature

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Abstract: In order to investigate the molecular response pattern of golden pompano *Trachinotus ovatus* larvae under temperature stress, transcriptome sequencing was performed in three temperature-treated groups (24 °C, 28 °C and 32 °C). A total of 501367768 clean reads, 94144 unigenes and 5828 differentially expressed genes (DEGs) were obtained. Gene ontology (GO) analysis and Kyoto encyclopedia of genes and genomes (KEGG) analysis showed that a large number of differentially expressed genes were related to metabolic processes, protein synthesis and nutrient digestion and absorption. The DEGs were most highly enriched into the pathways including protein digestion and absorption, fat digestion and absorption, starch and sucrose metabolism, vitamin digestion and absorption, glutathione metabolism. The results of this study provide important support for understanding mechanism of the response to high temperature in *Trachinotus ovatus*.

Key words: Transcriptional response; temperature stress; *Trachinotus ovatus*

基于 2b-RAD 技术的泥鳅 SNP 标记的开发和鉴定

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摘要:泥鳅是亚洲特有的经济鱼类。近几年由于过度捕捞和生境破坏, 自然群体的数目急剧下降, 但分子标记的缺乏限制了其种质资源保护和分子辅助育种。本研究通过 2b-RAD 测序获得候选 SNP 位点信息, 随机选择其中 70 个候选 SNP 位点进行验证, 其中 14 个 SNP 标记有效, 将其应用于 40 个群体中进行 SNaPshot 检测, 观测杂合度 H_o 和期望杂合度 H_e 的分布范围分别是 0.029 到 0.675 和 0.095 到 0.447, 其中 3 个 SNP 标记偏离 Hardy-Weinberg 平衡 ($P < 0.05$)。泥鳅 SNP 标记的筛选和鉴定可为今后的群体遗传研究和自然资源保护提供有效信息。

关键词: 泥鳅; 2b-RAD 测序; SNP; SNaPshot

Development and characterization of SNP markers based on 2b-RAD Sequencing in *Misgurnus anguillicaudatus*

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Abstract: Dojo loach *Misgurnus anguillicaudatus* is an endemic freshwater species to Asia. In recent years, natural populations have declined dramatically because of over-exploitation and habitat destruction. The effective conservation and molecular-aided selection of *M. anguillicaudatus* have been limited without sufficient molecular markers. In this study, 70 novel single nucleotide polymorphisms (SNPs) were screened based on 2b-RAD sequencing database, and 14 SNP markers were developed and characterized by genotyping 40 individuals using SNaPshot method. The observed heterozygosity (H_o) ranged from 0.079 to 0.675, while the expected heterozygosity (H_e) varied from 0.095 to 0.447. Among these SNPs, 3 loci were found to deviate significantly from the Hardy-Weinberg equilibrium after Bonferroni correction ($p < 0.05$). The first set of SNP markers developed from *M. anguillicaudatus* will provide valuable information in further population genetic analysis and natural resource conservation.

Keywords: *Misgurnus anguillicaudatus*, 2b-RAD sequencing, Single nucleotide polymorphism (SNP), SNaPshot

弓背青鲮早期胚胎色素细胞发育观察及色素 相关基因表达规律分析

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摘要: 体表色素具有保护鱼类免受紫外线辐照伤害等重要功能。依照自然选择理论, 不同群体的体色形成过程受到环境光照等的选择作用可能发生遗传分化。为了检验这一假说, 本研究以相同条件下人工繁育的弓背青鲮不同纬度群体(饶平、高桥、三亚)后代(F6)为材料。使用荧光倒置显微镜观察早期胚胎的黑色素细胞和虹彩色素细胞进行观察统计, 并利用实时荧光定量PCR分析对色素细胞发生相关基因(黑色素形成的限速酶基因 *tyr*、虹彩色素细胞相关基因 *alk*、转录因子 *sox10* 和 *pax3*) 在高桥群体后代早期发育过程中的表达, 验证显微观察结果.....

关键词: 弓背青鲮; 色素细胞发生; 早期胚胎; 群体分化

Observation on the development of pigment cells and analysis of the expression of pigment related genes in the early embryo of *Oryzias curvinotus*

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Abstract: The pigments have lots of function such as protecting fish from radiation and changing their for courtship. According to the theory of natural selection, the process of formation of pigments of different groups may genetically differentiated due to the selection effect of environment light and so on. *Oryzias curvinotus* has strong fertility, short generation cycle, early sensitivity to water quality and environmental changes, and wide adaptability to salinity. They used to live in the layer water, which is widely distributed in Guangdong coastal areas and is expected to be developed as a model species for monitoring coastal water environment in China. To test the above hypothesis, in this study, different latitudes groups (Rao Ping, Gao Qiao, San Ya) of *Oryzias curvinotus* were bred under the same conditions, which progenies (F6) were used as materials. The Melanin and iridescent pigment cells of embryo were observed by fluorescence inverted microscope, in addition, the expression of four main genes (*tyr*、*alk*、*sox10*、*pax3*), in the early development of the offspring of Gao Qiao population was analyzed by real-time fluorescence quantitative PCR, and the observation results were verified.....

Key words: *Oryzias curvinotus*; pigment cells; embryo; genetic differentiation;

多组学联合探究皱纹盘鲍生长性状的调控机制

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摘要: 为了探究皱纹盘鲍生长性状的调控机制, 以便在育种过程中更好应用, 本实验利用转录组、miRNA组、蛋白组等组学手段研究了影响皱纹盘鲍生长性状的关键基因和分子通路, 同时进一步分析了候选基因 BMP7 和 hdh-miR-1984 的表达规律、作用关系及其调控生长的分子机理。本试验获得了 Myophilin、MyHC、GDF8、BMP7、hdh-miR-1984 等一些关键基因与 miRNAs, MAPK、TGF- β 等关键的分子通路, 发现 BMP7 和 hdh-miR-1984 广泛分布于皱纹盘鲍不同组织中, 揭示了 hdh-miR-1984 可能通过抑制靶标基因 BMP7 对皱纹盘鲍生长进行负向调控。本研究为利用现代生物技术培育速长的鲍新品种提供了重要参考依据。

关键词: 皱纹盘鲍; 生长性状; 组学; 调控机制; BMP7; hdh-miR-1984

Multi-omics analysis on the Growth Traits and Regulatory Mechanisms in the Pacific abalone, *Haliotis discus hannai*

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Abstract: In order to understand the regulatory mechanism of the growth traits of Pacific abalone, this study analyzed the key genes and molecular pathways that affect the growth traits of *H. discus hannai* by using multi-omics methods. In addition, the expression, interactions and molecular mechanisms of the candidate genes BMP7 and hdh-miR-1984 was also conducted. We identified some key genes (Myophilin, MyHC, GDF8, BMP7, hdh-miR-1984) and several molecular pathways (MAPK, TGF- β signaling pathways), which are strongly associated with growth traits. BMP7 and hdh-miR-1984 are found to be widely distributed in different tissues of the abalone. Moreover, we revealed that hdh-miR-1984 may negatively regulated the growth of *H. discus hannai* by targeting to BMP7. This study provides an important reference for the use of modern biotechnology to breed fast-growing abalone new variety.

Key words: Pacific abalone; growth; omics; regulatory mechanism; BMP7; hdh-miR-1984

基于 18sRNA 序列对广东地区壳状珊瑚藻遗传多样性分析

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摘要: 珊瑚藻科 (Corallinaceae) 海藻属于红藻门 (Rhodophyta) 真红藻亚纲 (Florideae) 珊瑚藻目 (Corallinales)。本研究以 18sRNA 序列作为壳状珊瑚藻的分子标记, 分析壳状珊瑚藻的遗传多样性。基于 18sRNA 序列(389bp)分析结果:T、C、A 和 G 碱基的平均含量分别为 29.0%、23.4%、27.8%、19.8%,A+T 的含量(56.8%)明显高于 C+G 的含量(43.2%)。本研究对广东地区的壳状珊瑚藻形态和分子数据进行了补充, 为壳状珊瑚藻的分子标记鉴定提供参考依据。

关键词: 壳状珊瑚藻; 18sRNA; 遗传多样性

Genetic Diversity Analysis of crustose coralline algae in Guangdong Based on 18sRNA sequence

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Abstract: Crustose Coralline algae (CCA) belong to the Rhodophyta subclass Florideae and Corallinales. In this study, 18sRNA sequence was used as molecular marker to analyze the genetic diversity of the crustose coralline algae in the Guangdong area. The results of 18sRNA sequences (389 bp) showed that the average contents of T, C, A and G were 29.0%, 23.4%, 27.8% and 19.8%, respectively, and the content of A+T (56.8%) was significantly higher than that of C+G (43.2%). This study complements the morphological and molecular data of CCA, which provides a reference for molecular marker identification of CCA.

Key words: crustose coralline, 18sRNA, genetic diversity

3 种南极鱼头肾组织样本 TMT 标记定量常规 蛋白质组学比较分析

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摘要: 南极冰鱼 *Chionodraco hamatus* (CH) 缺乏血红蛋白, 是研究寒冷和富氧水适应性的理想模型, *Notothenia coriiceps* (NC) 和 *Trematomus bernacchii* (TB) 是两种带有红细胞的南极鱼。在这里, 我们使用涉及 TMT 标记和 LC-MS/MS 的整合方法来揭示 CH 的头部肾脏整个蛋白质组与 TB 和 NC 相比的动态变化的量化。我们鉴定了 5896 个蛋白质, 其中定量了 4735 个蛋白质, 372 个差异表达蛋白质, 其中 164 个蛋白质被上调, 而 208 个蛋白质被下调 (倍数变化 > 1.5 或 < 0.67, Pvalue < 0.05)。基于 KEGG 通路分析的不同蛋白质的功能分组揭示了白血鱼和红血鱼在红细胞生成, 血红素生物生成, B 细胞生成和血小板细胞发育方面的显著差异。CH 的造血过程显示出明显的红细胞生成相关蛋白下调趋势, 但是巨核细胞生成相关蛋白和淋巴细胞生成相关蛋白在冰鱼头肾脏中明显上调。本文研究数据不仅为三种南极鱼头肾蛋白质组的研究提供了数据支持, 同时为进一步探索南极冰鱼的免疫功能和造血作用提供了重要的参考。

关键词: 南极冰鱼; 红细胞生成; 免疫; 头肾; TMT

TMT-based quantitative proteomic analysis of total kidney proteins in three Antarctic fish species

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Abstract: Antarctic icefish *Chionodraco hamatus* (CH) lack of hemoglobin is an ideal model for studying cold and oxygen-rich water adaptation, *Notothenia coriiceps* (NC) and *Trematomus bernacchii* (TB) are two kinds of Antarctic fish with red blood cells. Here, we use an integrated approach involving TMT labeling and LC-MS/MS to reveal the quantifies dynamic changes of the whole proteome of head kidney of CH comparing to TB and NC. We identified 5896 proteins, among which 4735 proteins were quantified and 372 proteins were differently expressed of which 164 proteins were up-regulated and 208 proteins were down-regulated (a fold change of > 1.5 or < 0.67, Pvalue < 0.05). Functional grouping of the different proteins based on the KEGG pathway analyses revealed significant differences in erythropoiesis, haeme biogenesis, B cell generation and platelet cell development between the white and red-blooded fish. The haematopoietic process in CH showed a clear trend of downregulation of erythropoiesis related proteins, however megakaryopoiesis related proteins and lymphopoiesis related proteins were significantly up-regulated in the icefish head kidney. The research data in this paper not only provide important references for further research, exploration on the immunity and hematopoiesis of Antarctic icefish, but also provide some data analysis for the research on three kinds of Antarctic fish kidney proteins.

Keywords: *Chionodraco hamatus*; erythropoiesis; immunity; kidney; TMT

不同鱼粉蛋白水平饲料下斑节对虾体重与存活率的遗传参数估计

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摘要: 将 36 各家系的共计 5400 尾斑节对虾在两种鱼粉蛋白水平饲料下混养 56 天, 以分析体重和生存性状的遗传参数。结果表明, 饲料 A 组和饲料 B 组斑节对虾的体重和存活率的遗传力分别为 0.53 ± 0.12 和 0.39 ± 0.09 , 属于高遗传力。估计的遗传力和转化存活率分别为 0.46 ± 0.10 和 0.32 , 显示出较高的遗传力水平。饲料 A 组和饲料 B 组之间的遗传相关性较高 ($0.84-0.92$), 且 G×E 方差分量与加性遗传方差分量之比小于 0.5, G×E 的影响不显著。结果表明, 在饲料鱼粉蛋白质水平为 10%-30% 的范围内, 无需为不同的饲料条件建立不同的育种系。

关键词: 斑节对虾; 鱼粉; 遗传力; 基因环境互作

Genetic Evaluation of Body Weight and Survival of Black Tiger Shrimp (*Penaeus monodon*) fed on Different Dietary Levels of Fish Meal Protein

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Abstract: In this study, 5400 *Penaeus monodon* from 36 families were mixed cultured with two kinds of different dietary levels of fish meal protein (Diet A and Diet B) for 56 days to analyze the genetic parameters of body weight and survival traits. The results showed that the heritability of *P. monodon* in Diet A and Diet B group was 0.53 ± 0.12 and 0.39 ± 0.09 , respectively, which belonged to high heritability. The estimated heritability of body weight and transformed survival were 0.46 ± 0.10 and 0.32 , respectively, which showed high heritability level. There was a high genetic correlation ($0.84-0.92$) between Diet A and Diet B groups, and the ratio of G×E variance component to additive genetic variance component was less than 0.5, and the effect of G×E was not significant. The results showed that it was not necessary to establish different breeding lines for different feed conditions in the range of 10% - 30% protein level of feed fish meal.

Key words: *Penaeus monodon*, Fish meal, Heritability, G×E interaction

凤鲚染色体核型研究

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摘要: 为了解凤鲚 (*Coilia mystus*) 染色体数量和核型结构, 以上海市临港近岸的 1~2 龄性成熟凤鲚为材料, 采用鳃丝细胞进行短期离体培养方法制备染色体标本, 对凤鲚染色体核型进行了研究。结果表明, 凤鲚雌雄染色体数量存在差异, 雌性染色体数目为 $2n=47$, 雄性染色体数目为 $2n=48$, 核型公式为 $2n(\text{♀})=47t$ 、 $2n(\text{♂})=48t$; 雌性染色体臂数 (NF) =47, 雄性 NF=48。雄性凤鲚染色体相对长度范围为 $(2.66\pm 0.27) \sim (5.54\pm 0.25)$, 而雌性凤鲚染色体相对长度范围为 $(2.83\pm 0.32) \sim (5.70\pm 0.38)$, 雌雄凤鲚的染色体相对长度不存在显著差异 ($P>0.05$), 各相邻两对染色体之间相对长度无明显差异 ($P>0.05$)。凤鲚存在性染色体, 其性染色体类型为 ZO/ZZ 型。

关键词: 凤鲚; 染色体; 核型; 性染色体

The karyotype of *Coilia mystus*

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Abstract: In order to understand *Coilia mystus* chromosome number and karyotype, this study collected silk of sexually mature individuals with the age of 1 to 2 years old, from Shanghai Lingang inshore as the materials. The *C. mystus* chromosome karyotype was studied through the operation process of colchicine pre-treatment, hypotonic, fixed, dissociation, thermal and dyeing. The results showed that chromosome from the male and female *C. mystus* are different, the female *C. mystus* was 47 chromosomes in the diploid and the karyotype formula was $2n=47t$, and the male *C. mystus* was 48 chromosomes in the diploid and the karyotype formula was $2n=48t$. The female chromosome number of arms (NF) was 47, and that of male was 48. The relative length of the male *C. mystus* chromosome with the range 2.66 ± 0.27 to 5.54 ± 0.25 , while the relative length of the female *C. mystus* chromosome with the range of 2.83 ± 0.32 to 5.70 ± 0.38 . A significant difference ($P > 0.05$) relative length of chromosome male *C. mystus* does not exist, no significant difference ($P > 0.05$) until the relative length of each two adjacent pairs of chromosomes. There is a sex chromosome of *C. mystus*, and its sex chromosome formula was ZO/ZZ.

Key words: *Coilia mystus*; chromosome; karyotype; sexual chromosome

通过基因组和转录组测序相结合的方法鉴定

西藏双足类高原适应候选基因

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摘要: 湖沼勾虾分布在以青藏高原隆起闻名的西藏地区。因此, 它被认为是研究高原适应机制的一种模式生物。在本研究中, 我们对西藏湖泊勾虾进行全基因组和全长转录组测序, 并通过转录组比较分析, 一起解析西藏湖泊勾虾高原适应机制。西藏湖泊勾虾的全基因组草图为 5.07GB, N50 为 2,578bp。西藏湖泊勾虾全长转录组中共包含 8858 个基因, 平均基因长度为 1811bp。通过与 *G. pisinnus* 进行转录组比较分析, 西藏湖泊勾虾中有 2,672 个上调的差异表达基因和 2,881 个下调的差异表达基因。此外, 氧化磷酸化、核糖体、细胞能量稳态、糖酵解和糖异生等代谢途径被预测在高原适应中起重要作用。综上所述, 本研究为了解青藏高原湖泊的高原适应性提供了基因组学基础, 为进一步开展青藏高原其他栖息水生物种的生物学和生态学研究奠定了基础。

关键词: *Gammarus lacustris*; *Gammarus pisinnus*; 全基因组测序; 全长转录组; 比较转录组; 高原适应

Identification of Candidate Genes for the Plateau Adaptation of a Tibetan Amphipod, *Gammarus lacustris*, Through Integration of Genome and Transcriptome Sequencing

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Abstract: The amphipod *Gammarus lacustris* is considered as a good model for investigating stress adaptations of the plateau. Here, we sequenced the whole-genome and full-length transcriptome of *G. lacustris*, and compared the transcriptome results with its counterpart *Gammarus pisinnus* from a nearby plain. Our main goal was to provide a genomic resource for investigation of genetic mechanisms, by which *G. lacustris* adapted to living on the plateau. The final draft genome assembly of *G. lacustris* was 5.07 Gb with an N50 of 2,578 bp. A total of 8,858 unigenes were predicted in the full-length transcriptome of *G. lacustris*, with an average gene length of 1,811 bp. Compared with the *G. pisinnus* transcriptome, 2,672 differentially expressed genes (DEGs) were up-regulated and 2,881 DEGs were down-regulated in the *G. lacustris* transcriptome. Along with these critical DEGs, several enriched metabolic pathways, such as oxidative phosphorylation, ribosome, cell energy homeostasis, glycolysis and gluconeogenesis, were predicted to play essential roles in the plateau adaptation.

Key words: *Gammarus lacustris*, *Gammarus pisinnus*, whole-genome sequencing, full-length transcriptome, comparative transcriptome, plateau adaptation

不同碳氮比对生物絮团形成及对日本沼虾生长、抗氧化酶和消化酶的影响

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摘要: 本文设置 5 个不同实验组[对照组(不做任何添加), 碳氮比 10 组(C/N10)、碳氮比 15 组(C/N15)、碳氮比 20 组(C/N20)、碳氮比 25 组(C/N25)], 每组设三个重复;将初始体重(0.25±0.03) g 的日本沼虾 (*Macrobrachium nipponense*) 置于不同碳氮比的玻璃缸(30 cm×40 cm×100 cm)中, 进行 50d 的饲养实验。研究结果表明, 随着碳氮比升高, 生物絮团含量有上升趋势。C/N20 的氨氮和亚硝酸氮浓度在整个养殖期间都维持在较低水平, C/N20 的增重率、抗氧化酶及消化酶活性显著高于对照组。这些结果表明, 当碳氮比达到 20 时能有效产生生物絮团,降低水体氨氮和亚硝酸氮浓度并显著提高日本沼虾的生长性能、肠道消化酶活性和肝胰腺抗氧化酶活性。

关键词: 日本沼虾; 碳氮比 (C/N); 生物絮团; 抗氧化酶; 消化酶

Effects of bioflocs on growth, digestive enzymes and antioxidant enzymes of *Macrobrachium nipponense*

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Abstract: In this paper, five different experimental groups were set up [control group (no carbon source added), carbon-nitrogen ratio 10 (C/N10), carbon-nitrogen ratio 15 (C/N15), carbon-nitrogen ratio 20 (C/N20) and carbon-nitrogen ratio 25 (C/N25)] with three replicates per group. The original weight (0.25±0.03 g) of *Macrobrachium nipponense* were cultured in a glass jar (30 cm×40 cm×100 cm) for 50 days. The results showed that the content of bio-flocs increased with the increase of C/N ratio. The concentration of ammonia nitrogen and nitrite nitrogen in C/N20 maintained at a low level during the whole culture period. The weight gain rate, antioxidant enzyme and digestive enzyme activities of C/N20 were significantly higher than those of the control group. The results suggested that bio-flocs can be effectively produced when the C/N ratio is 20 under the culture condition, and the concentration of ammonia nitrogen and nitrite nitrogen in the water environment was able to be reduced greatly. In addition, the growth performance, intestinal digestive enzyme activity and hepatopancreatic antioxidant enzyme activity of *Macrobrachium nipponense* can be significantly improved.

Key words: *Macrobrachium nipponense*, C:N ratio, Biofloc, Antioxidant enzyme, Digestive enzyme

湖栖鳍虾虎鱼(*Gobiopterus lacustris*)皮肤和眼

睛转录组比较分析

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摘要: 湖栖鳍虾虎鱼(*Gobiopterus lacustris*)是一种对盐度适应性强、易于实验室饲养的小型鱼类。其体表几乎透明, 肉眼可见机体组织器官, 是理想的模式生物和环境指示物种。为探究湖栖鳍虾虎鱼体色透明的成因, 本文对湖栖鳍虾虎鱼的皮肤和眼睛进行了转录组比较分析。测序原始数据经 *de novo* 拼接组装共获得 103 686 个单基因 (unigene), N50 和平均长度分别为 1 456bp 和 2 490bp。在 NR、NT、SwissProt、PFAM、KOG、GO 及 KEGG 数据库中对上述 unigenes 进行注释, 分别有 57 380、37 343、51 277、47 020、47 555 和 25 604 个 unigenes 获得注释.....

关键词: 湖栖鳍虾虎鱼; RNA-Seq; 色素形成; 体色

Comparative analysis of skin and eye transcriptome in the lacustrine goby (*Gobiopterus lacustris*)

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Abstract: *Gobiopterus lacustris* is a kind of small fish with strong adaptability to salinity and easy to raise in laboratory. It is an ideal model organism and environmental indicator species, whose body is transparent and its organs can be seen by naked eyes. In order to explore the cause of the transparent body color of Lake fin goby, the transcriptome analysis of skin and eye of *Gobiopterus lacustris* was carried out. A total of 103 686 unigenes were obtained by *de novo* splicing. The N50 and average length were 1 456 bp and 2 490 bp, respectively. In NR, NT, Swissprot, Pfam, KOG, GO and KEGG databases, 57 380, 37 343, 51 277, 47 020, 47 555 and 25 604 unigenes were annotated respectively.....

Keywords: *Gobiopterus lacustris*; RNA-Seq; pigment formation; body color

Bmp10 对斑马鱼心脏发育的影响

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摘要: 在脊椎动物中, 心脏是第一个形成的器官。*bmp10* 是心脏 BMP 家族成员, 在调节心脏发育中起着关键作用。本研究利用 CRISPR/Cas9 技术获得 *bmp10* 缺失斑马鱼。统计观察发现 *bmp10*^{-/-} 斑马鱼在 6-10 周会出现心包水肿, 鳃部及腹部渗血, 并且伴有严重的鳞片突起, 最终死亡。本研究首先分别对 *bmp10*^{-/-}、*bmp10*^{+/-} 和 WT 斑马鱼的心脏进行石蜡切片和 HE 染色, 发现 *bmp10*^{-/-} 斑马鱼心脏体积和细胞体积相对增大, 且结构疏松。进一步通过转录组测序, 对差异基因进行 GO 和 KEGG 富集分析, 结果显示 *bmp10*^{-/-} 斑马鱼心脏与 *bmp10*^{+/-} 和 WT 相比, 在细胞增殖和凋亡及心脏收缩相关通路上存在较大差异。对心脏组织进行 TUNEL 染色观察, 发现 *bmp10*^{-/-} 斑马鱼心脏的细胞有明显的凋亡信号。综上所述, *bmp10* 基因的缺失会对斑马鱼心脏发育产生不良影响, 导致心脏肥大, 产生致死性影响。

关键词: *bmp10*; 心脏发育; CRISPR/Cas9; 细胞增殖; 凋亡

Effect of BMP10 on heart development of zebrafish

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Abstract: In vertebrates, the heart is the first organ to form. *Bmp10* is a member of the BMP family of the heart and plays a key role in regulating the development of the heart. In this study, CRISPR/Cas9 technology was used to obtain *bmp10* deletion zebrafish. According to statistical observation, *bmp10*^{-/-} zebrafish will have pericardial edema, blood oozing from gills and abdomen, and severe scaly protrusions, which will eventually lead to death. First, HE staining on the hearts of *bmp10*^{-/-}, *bmp10*^{+/-} and WT zebrafish indicated that the size of heart and cell of *bmp10*^{-/-} zebrafish were relatively increased and the structure was sparse. By transcriptome sequencing, GO and KEGG results showed that *bmp10*^{-/-} zebrafish heart have significant differences in cell proliferation and apoptosis and heart contraction-related pathways compared with *bmp10*^{+/-} and WT. TUNEL staining proved that the *bmp10*^{-/-} zebrafish heart cells had significant apoptotic signals. In summary, the deletion of *bmp10* gene has an adverse effect on the heart development of zebrafish, leading to cardiac hypertrophy and fatal effects.

Key words: *bmp10*, Cardiac development, CRISPR/Cas9, Cell proliferation, Apoptosis

草鱼 IL-22 生物活性及 IL-22 阳性细胞的特性研究

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摘要: 白细胞介素-22 在调节感染性病原体的炎症清除中起重要作用。鱼类中已发现 IL-22 同源物, 但其功能和产生 IL-22 的来源尚未完全阐明。本研究在草鱼中鉴定出一个 IL-22 同源物, 并对其生物活性进行了研究。草鱼 IL-22 在组织中有组成性表达, 以鳃和后肠最高。草鱼感染柱状黄杆菌和呼肠孤病毒后, IL-22 在脾脏上调, LPS 和 IL-34 刺激下的头肾和脾原代白细胞中 IL-22 也上调。相反, 它被 Th2 细胞因子如 IL-4/13B 和 IL-10 下调。细菌产生的重组 IL-22 对原代头肾白细胞和 CIK 细胞中炎性细胞因子和 STAT3 的表达有促进作用。在草鱼感染柱状黄杆菌 24h 后, 使用单克隆抗体 GC3-22, 经共聚焦显微镜观察到在其后肠和头肾中诱导产生了 IL-22 阳性细胞。我们的数据表明, IL-22 在调节黏膜和全身免疫系统对抗细菌和病毒感染方面起着重要作用。

关键词: 白细胞介素 22; 白细胞介素 22 产生细胞; 细胞因子; 生物活性; 草鱼

中华绒螯蟹实时荧光定量 PCR 内参基因的筛选

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摘要: 为了筛选不同组织及鳃弧菌感染下中华绒螯蟹中表达最稳定的内参基因。本研究应用 qRT-PCR 技术测定了 10 种候选内参基因的表达量, 并采用三种分析方法 geNorm、BestKeeper、NormFinder 对结果分析。结果表明: 不同组织中, 候选内参基因稳定性顺序由高到低为: *EF-2>EF-1 α >GAPDH>PGM2>UBE> β -actin>HSP90>GST> α -TUB>AK*; 鳃弧菌感染下, 候选内参基因稳定性顺序为 *AK>GAPDH>EF-1 α >UBE> α -TUB> β -actin>EF-2>GST>PGM2>HSP90*。本研究为今后中华绒螯蟹不同组织及鳃弧菌感染条件下相关基因研究提供重要依据。

关键词: 中华绒螯蟹; 内参基因; qRT-PCR; 表达稳定性

Screening of reference genes for qRT-PCR amplification in *Eriocheir sinensis*

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Abstract: In order to screened the most stable reference gene in different tissues and infected with *Vibrio anguillarum* in *Eriocheir sinensis*. In this study, qRT-PCR technique was used to determine the expression of 10 reference genes, and three analytical methods were used to analyze the results: geNorm, BestKeeper and NormFinder. The results showed that the stability order of candidate reference genes in different tissues was as follows: *EF-2>EF-1 α >GAPDH>PGM2>UBE> β -actin>HSP90>GST> α -TUB>AK*; under *Vibrio anguillarum* infection, the sequence of candidate reference genes stability was *AK > GAPDH> EF-1 α > UBE> α -TUB> β -actin> EF-2>GST> PGM2> HSP90*. This study provided an important basis for the study of related genes in different tissues of *Eriocheir sinensis* and *Vibrio anguillarum* infection in the future.

Key words: *Eriocheir sinensis*; reference gene; qRT-PCR; expression stability

草鱼 *SIDT2* 基因克隆及免疫功能研究

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摘要: 为研究 *SIDT2*(systemic RNA interference deficient-1 (SID1) transmembrane family, member 2) 介导的病毒跨膜转运作用及其诱导 RLR 受体抗病毒免疫机制, 该研究获得了 3180 bp 的草鱼 (*Ctenopharyngodon idella*) *SIDT2* (*CiSIDT2*) cDNA 全长, 其编码 825 个氨基酸。表达量检测结果显示脾脏 *CiSIDT2* 的表达量显著高于其它组织 ($P<0.05$); Poly I:C 和 GCRV 刺激后脾脏 *CiSIDT2* mRNA 表达水平总体下调。草鱼卵巢细胞中 *CiSIDT2* 过表达后该基因表达水平显著上调 ($P<0.05$), 且 GCRV 感染 12 h 和 24 h 时 *LGP2*、*IRF3*、*IRF7* 和 *Mx* 表达均上调。研究结果为深入探究 *CiSIDT2* 功能提供了基础。

关键词: 草鱼; *SIDT2*; 病毒跨膜转运; RLR 受体; 抗病毒免疫

Cloning and immune function study of *SIDT2* from grass carp (*Ctenopharyngodon idellus*)

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Abstract: To investigate the function of viral transmembrane transport mediated by *SIDT2* (systemic RNA interference deficient-1 (SID1) transmembrane family, member 2) and its mechanism of inducing RLR receptor antiviral immunity. The study obtained the full-length cDNA sequence of *CiSIDT2*, which is 3180 bp in length and encodes a protein of 825 amino acid residues. The result of expression level detection showed that the expression of *CiSIDT2* was the highest in the spleen, and significantly higher than those in other detected tissues ($P<0.05$). The stimulation of fish with Poly I:C and GCRV resulted in down-regulation expression of *CiSIDT2* in the spleen. The overexpression of *CiSIDT2* in the grass carp ovary (GCO) line resulted in the significantly up-regulated of *CiSIDT2* mRNA level ($P<0.05$), and we also found that the expression levels of *LGP2*, *IRF3*, *IRF7* and *Mx* were all up-regulated at 12 and 24 h after GCRV stimulation. The results provide a basis for further function study of *CiSIDT2*.

Key words: *Ctenopharyngodon idellus*, *SIDT2*, viral transmembrane transport, RLR receptor, antiviral immunity

三种鲹科鱼类线粒体全基因组序列进化及系统发育分析

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摘要: 鲹科鱼类是具有重要生态和经济意义的海水鱼类。本研究对完整的三种鲹科鱼类（长吻丝鲹，聚缘圆鲹和吉达副叶鲹）的线粒体全基因组进行了测序，分析与鲹科家族的其他 29 个已测序物种进行了比较研究。这三种鱼类线粒体全基因组的长度在 16530~16610 bp 之间，基因组的结构和基因排列顺序与其它硬骨鱼类一致，均包括 13 个蛋白质编码基因、22 个 tRNA 基因、2 个 rRNA 基因(12SrRNA 和 16SrRNA)和一个非编码区(控制区)。22 个 tRNA 基因中，只有 tRNA-ser (GCT)存在没有折叠成典型的三叶草二级结构，缺少可识别的 DHU 臂。13 个蛋白编码序列的 ka/ks 值都低于 1，表明它们都受到纯化选择。同时，利用 13 个蛋白编码基因基于最大似然法和贝叶斯法对 32 种鲹科鱼类进行了系统发育分析和分歧时间估算。

关键词: 鲹科；线粒体基因组；系统发育分析；分歧时间

Complete Mitogenomes of Three Carangidae (Perciformes)

Fishes: Genome Description and Phylogenetic Considerations

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Abstract: Carangidae are ecologically and economically important marine fish. The complete mitogenomes of three Carangidae species (*Alectis indicus*, *Decapterus tabl*, and *Alepes djedaba*) were sequenced, characterized, and compared with 29 other species of the family Carangidae in this study. The length of the three mitogenomes ranged from 16,530 to 16,610 bp, and the structures included 2 rRNA genes (12S rRNA and 16S rRNA), 1 control region (a non-coding region), 13 protein-coding genes, and 22 tRNA genes. Among the 22 tRNA genes, only tRNA-Ser (GCT) was not folded into a typical cloverleaf secondary structure and had no recognizable DHU stem. The phylogenetic tree based on PCGs sequences of mitogenomes using maximum likelihood and Bayesian inference analyses showed that three clades were divided corresponding to the subfamilies Caranginae, Naucratinae, and Trachinotinae. The monophyly of each superfamily was generally well supported. The divergence time analyses showed that Carangidae evolved during three geological periods, the Cretaceous, Paleogene, and Neogene. *A. indicus* began to differentiate from other species about 27.20 million years ago (Mya) in the early Miocene, while *D. tabl* (21.25 Mya) and *A. djedaba* (14.67 Mya) differentiated in the middle Oligocene.

Key words: Carangidae; comparative characterization; mitochondrial genome; phylogeneny

红鳍笛鲷视蛋白基因家族分析

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摘要: 视蛋白是具有七个跨膜结构域的 G 蛋白耦联受体超家族 (G protein-coupled receptors, GPCR) 中的一个家族, 根据其是否直接参与视觉成像可分视觉视蛋白和非视觉视蛋白两大类。在鱼类生长发育和进化中, 视蛋白在视觉图像形成和生物钟昼夜节律等非图像形成功能调节方面起着至关重要的作用。红鳍笛鲷在我国主要产于东海南部和南海, 是南海重要经济鱼类之一。为研究红鳍笛鲷视蛋白基因存在和表达情况, 我们进行了红鳍笛鲷基因组测序及组织样本转录组测序。本研究从红鳍笛鲷基因组鉴定得到 32 个视蛋白基因。运用生物信息学方法, 对红鳍笛鲷视蛋白基因家族的系统进化关系、基因结构、保守基序、保守结构域以及在不同组织中基因的表达水平进行分析.....

关键词: 红鳍笛鲷; 视蛋白; 基因家族; 生物信息学; 基因表达

Gene family analysis of opsin in *Lutjanus erythropterus*

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Abstract: Opsins are one of the G protein-coupled receptor (GPCR) families with seven transmembrane domains. According to whether it directly participates in visual imaging, it can be divided into two categories: visual opsin and non visual opsin. In the development and evolution of fish, opsins plays an important role in the visual image formation and regulation of non-image-forming functions such as circadian rhythm. *Lutjanus erythropterus* is one of the most important economic fish in the South China Sea, which is mainly produced in the southern part of the East China Sea and the South China Sea. To study the presence and expression of opsin genes in *Lutjanus erythropterus*, genome sequencing and tissue transcriptome sequencing were performed. In this study, 32 opsin genes were identified from the genome of the *Lutjanus erythropterus*. The phylogenetic relationship, gene structure, conserved motif, conserved domain and gene expression level in different tissues were analyzed by bioinformatics methods.....

Key words: *Lutjanus erythropterus*; opsin; gene families; bioinformatics; gene expression

棘头梅童鱼 Sox 基因家族的全基因组鉴定及基于转录组的表达谱分析

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摘要: Sox 基因是编码 HMG-box (high-mobility group) 的一类转录因子, 在启动和维持各种发育过程中发挥关键作用, 如性别决定和分化。在本研究中, 基于同源性的 HMG-box 分析, 在棘头梅童鱼 *Collichthys lucidus* (Richardson, 1844) 基因组中鉴定出 26 个 Sox 基因。转录组结果显示, 当体长为 2.74 ± 0.24 cm 时, Sox 基因在性腺中的表达开始出现性别差异。同时, 卵巢中有 2 个 Sox 基因 (*Sox11b* 和 *Sox19*) 表达上调, 12 个 Sox 基因表达下调, 在精巢中有 6 个 Sox 基因表达暂时上调。此后, 在卵巢和精巢中, Sox 基因的表达谱变化幅度相对较小。在成体雌雄性腺中, Sox 基因的表达有很大差异, 而体细胞组织差异较小。这些结果为进一步解释 Sox 基因在棘头梅童鱼和硬骨鱼性别决定和分化过程中的作用提供了线索。

关键词: 棘头梅童鱼; Sox 基因; 基因表达; 性别分化; 转录组

Genome-Wide Identification and Transcriptome-Based Expression Profiling of the Sox Gene Family in the spinyhead croaker (*Collichthys lucidus*)

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Abstract: Sox genes encode transcription factors with an HMG (high-mobility group) box, playing critical roles in initiation and maintenance of a variety of development processes, such as sex determination and differentiation. In the present study, we identified 26 Sox genes in the genome of spinyhead croaker *Collichthys lucidus* (Richardson, 1844) with homology-based analysis of HMG-box. The transcriptome-based expression profiles revealed that the expression of Sox gene in gonads began to differ between sexes when the body length was 2.74 ± 0.24 cm. At that time, two Sox gene (*Sox11b* and *Sox19*) were up-regulated strongly accompanied by the down-regulation of twelve Sox genes in ovary, and six Sox genes were temporarily up-regulated in testis. Afterwards, the expression profile of Sox genes changed only in a small amplitude in both ovary and testis. For the tissue of adult, huge differences were observed in expression profile of Sox genes between ovary and testis, as well as small differences in somatic tissues between sexes. These results provided clues for further deciphering the role of Sox genes in the process of sex determination and differentiation in spinyhead croaker and other teleost.

Key words: *Collichthys lucidus*, Sox gene, gene expression, sex differentiation, transcriptome

草鱼 *PepT2* 基因克隆及表达分析

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摘要: 为研究草鱼(*Ctenopharyngodon idellus*)*PepT2*基因结构及表达特性, 本研究采用cDNA末端快速扩增(rapid-amplification of cDNA ends, RACE)技术克隆得到草鱼*PepT2*基因的cDNA全长, 命名为*CiPepT2*。该基因全长2733 bp, 其中5'非编码区82 bp, 3'非编码区482 bp, 开放阅读框(open reading frame, ORF) 2196 bp, 编码722个氨基酸, 相对分子质量80.32 kDa, 理论等电点6.01。多序列比对和系统进化树结果显示, *CiPepT2*基因与斑马鱼、大黄鱼和青鳉*PepT2*同源性较高, 与斑马鱼同源蛋白的相似度最高, 为86.65%。荧光定量PCR结果显示, *CiPepT2*在肠道中表达量最高, 其次是肾脏。草鱼*PepT2*氨基酸序列具有高度保守区域, 该基因在肠道、肾脏中具有较高表达量, 提示*PepT2*参与营养物质的吸收, 以及药物的转运。

关键词: 草鱼; *PepT2*; 基因克隆; 组织表达

Cloning and expression analysis of *PepT2* gene in *Ctenopharyngodon idellus*

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Abstract: In order to study the gene structure and expression characteristics of *PepT2* in grass carp (*Ctenopharyngodon idellus*), the full-length cDNA sequence of *PEPT2* gene was cloned by rapid amplification of cDNA ends technique (RACE), named *Cipept2*. The total length of the *Cipept2* gene is 2733 bp, including a 82 bp 5' terminal untranslated region, a 2196 bp open reading frame (ORF) 482 bp and a 3' terminal untranslated region, encoded 722 amino acids, the predicted molecular weight of *Cipept2* was 80.32 kDa and theoretical isoelectric point was 6.01. The results of multiple sequence alignment and phylogenetic tree showed that *CiPepT2* gene had high homology with *PepT2* of *Danio rerio*, *Larimichthys crocea* and *Oryzias latipes*, and the similarity with zebrafish homologous protein was the highest (86.65%). The results of qPCR showed that the expression of *CiPepT2* was the highest in intestine, followed by kidney. The amino acid sequence of *CiPepT2* was highly conserved, and its gene was highly expressed in intestine and kidney, suggesting that *PepT2* is involved in nutrient absorption and drug transport.

Keywords: *Ctenopharyngodon idellus*, *PepT2*, gene cloning, tissue expression

双斑蟳 (*Charybdis bimaculata*) 线粒体基因组

测序和系统发育分析

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摘要: 本研究中, 对双斑蟳 (*Charybdis bimaculata*) 的线粒体基因组进行了测序和注释。此线粒体基因组长度为 15,441 bp, 包含 37 个经典的真核生物线粒体区域 (13 个典型的蛋白质编码基因 (PCG), 22 个 tRNA 基因, 2 个 rRNA 基因) 和一个非编码调控区。大多数 PCGs 的起始密码子为 ATA, ATG 和 ATT, 少数为 GTG。除了 Cob 以不完整密码子 (T--) 为终止密码子, 其余 12 个蛋白质编码基因的终止密码子为 TAA 和 TAG。基于 13 个蛋白质编码基因的系统进化树分析, 结果显示双斑蟳与锈斑蟳和善泳蟳的亲缘关系较近。

关键词: 双斑蟳; 线粒体基因组; 进化分析

Characterization of the complete mitochondrial genome sequence of *Charybdis bimaculata* and phylogenetic analysis

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Abstract: In this study, the complete mitogenome of *Charybdis bimaculata* was sequenced and annotated. The mitogenome is 15,441 bp in length, containing 37 classical eukaryotic mitochondrial regions (13 typical protein-coding genes (PCGs), 22 tRNA genes, two rRNA genes) and a non-coding control region. Most of the genes are initiated with ATA, ATG, and ATT, though GTG is also used as initiation codon. Twelve PCGs stop with complete termination codon TAA and TAG, while Cob uses incomplete codon (T--). The phylogenetic relationships based on 13 PCGs show that *C. bimaculata* clusters closest to *C. fariata* and *C. natator*.

Keywords: *Charybdis bimaculata*, Complete mitochondrial genome, Phylogenetic analysis

草鱼补体调节因子 I 的表达特性及功能初探

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摘要: 为探明补体调节因子 I (CFI) 在草鱼抗 GCRV 免疫应答及补体激活途径中的作用, 本实验通过 qPCR 和 Western blot 技术检测草鱼 CFI 在健康组织中及 GCRV 刺激后在肝脏中的表达特性, 结果显示草鱼 CFI 在测定的 8 个组织 (肝、脾、肾、头肾、肠、鳃、肌肉和皮肤) 中均有表达, 其中在肝脏中的表达水平最高。感染 GCRV 后, 草鱼 CFI 在肝脏中的表达量呈现总体下调的趋势, 表明经 GCRV 刺激后, 机体将更多的 CFI 用于裂解 C3b 或 C4b, 从而防止草鱼补体系统的过度激活。通过构建草鱼 CFI 重组蛋白并将其与草鱼血清进行孵育, 经 rCFI 处理后血清中的 C3b 浓度明显降低, 证明 CFI 可通过负调控 C3b 来抑制补体系统激活。本研究首次证明了 CFI 在草鱼中通过降解 C3b 负调控补体激活, 并可能在机体免疫防御病毒感染中发挥重要作用。

关键词: 草鱼; 草鱼呼肠孤病毒 (GCRV); 补体调节因子 I; 病毒感染; 补体激活

Preliminary study on the expression characteristics and functions of complement regulator I in *Ctenopharyngodon idella*

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Abstract: To explore the role of CFI in anti-GCRV immune response and complement activation pathway in *Ctenopharyngodon idella* (*C. idella*), the mRNAs and proteins of *C. idella* CFI detected by qPCR and Western blot were expressed in tested tissues (liver, spleen, kidney, head kidney, intestine, gill, muscle and skin), with the highest expression level in liver. After GCRV infection, the mRNA and protein expression levels of CFI in the liver detected by qPCR and Western blot showed a downward overall tendency, indicating that more CFI were used to lyse C3b or C4b, and inhibited the activation of complement system after GCRV stimulation in *C. idella*. By constructing recombinant *C. idella* CFI protein and incubating it with *C. idella* serum, rCFI inhibited complement activation and degraded C3b in serum, indicating that *C. idella* CFI negatively regulates complement activation via degradation C3b. These results provide the first evidence to indicate that CFI in *C. idella* negatively regulates complement activation via degradation C3b, and probably plays a role in host immune defense against virus infection.

Key words: *Ctenopharyngodon idella*, GCRV, CFI, virus infection, complement activation

西北太平洋秋刀鱼耳石微量元素

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摘要: 根据我国远洋渔船 2014 年在西北太平洋海域生产期间采集的秋刀鱼样本, 应用激光剥蚀(LA)-ICPMS 技术分析了 24 枚秋刀鱼耳石的微量元素组成及其分布特性。结果表明: 秋刀鱼耳石主要有 47 种微量元素, 含量前 10 位的元素分别为钙 Ca、锶 Sr、钠 Na、铁 Fe、镁 Mg、钡 Ba、锌 Zn、钛 Ti、锰 Mn、铬 Cr。方差分析表明, (1)不同性别间秋刀鱼的 Ba、Zn 存在显著差异; (2)不同孵化群体的个体中 Mg、Fe 存在显著性差异; (3)不同耳石部位的 Fe、Ba、Mn 存在显著性差异; (4)不同性成熟度秋刀鱼的 Mn、Ti、Na、Mg 存在显著性差异。研究表明, 耳石中的微量元素 Fe 较适用于研究秋刀鱼的群体划分、洄游史的追溯等。

关键词: 秋刀鱼; 耳石; 微量元素; 西北太平洋

Trace elements of otolith from Northwestern Pacific saury

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Abstract: Otolith is a calcareous deposit in the inner ear of fish, and can provide a basis for reconstructing the life history and environmental parameters of fish. In this paper, the trace element composition and distribution characteristics of 24 saury otoliths were analyzed using laser ablation (LA)-ICPMS technology based on the saury samples collected by our ocean-going fishing boats in the Northwest Pacific Ocean in 2014. The results show that saury otolith mainly has 47 trace elements, and the top 10 elements are calcium Ca, strontium Sr, sodium Na, iron Fe, magnesium Mg, barium Ba, zinc Zn, titanium Ti, manganese Mn, chromium Cr. Variance analysis showed that (1)there were significant differences in Ba and Zn of saury among different genders; (2)among individuals in different hatching groups, Mg, Except for Fe; (3)there are no significant differences in Fe, Ba, and Mn at different otolith sites; (4)there are significant differences in Mn, Ti, Na, Mg of saury of different sexual maturity. Studies have shown that the trace element Fe in otolith is more suitable for studying the grouping of saury and the tracing of migration history.

Key words: saury; otolith; trace elements; Northwest Pacific

高温对尼罗罗非鱼早期性逆转作用的影响及相关基因的表达分析

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摘要: 为探究高温处理对尼罗罗非鱼早期性逆转的影响及相关基因的表达分析。本研究通过 RT-PCR 检测 *dmrt1* 和 *cyp19a1a* 两种基因的表达情况, 从而建立了鉴定发育早期高温雌性 (*cyp19a1a*) 和高温伪雄性 (*dmrt1*) 的表型性别方法。此外, 我们利用此方法鉴定了温度处理条件下的罗非鱼 (受精后 25、35、180 天) 表型性别, 并分析了性别分化相关基因 (*dmrt1*、*gsdf*、*amh*、*cyp19a1a*、*foxl2*、*foxl3*、*kdm6bb*) 的表达变化。结果显示, 这些基因在罗非鱼性腺中的表达具有明显的性别二态性, 并且其表达模式随罗非鱼的性逆转而改变, 伪雄鱼的雄性发育相关基因 *dmrt1*、*gsdf* 和 *amh* 高表达, 而雌性发育相关基因 *cyp19a1a*、*foxl2* 和 *foxl3* 低表达。本研究发现在发育早期, 高温伪雄性罗非鱼的性别发育相关基因表达模式与高温雄性更相似, 从而为揭示温度性别决定的分子调控机制奠定了基础。

关键词: 尼罗罗非鱼; 高温; 性逆转; 发育早期; 表型性别; 表达分析

The effect of high temperature on the early sexual reversal of Nile tilapia (*Oreochromis niloticus*) and the expression analysis of related genes

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Abstract: To explore the effect of high temperature treatment on the early sexual reversal of Nile tilapia and the expression analysis of related genes. RT-PCR was used to detect the expression of *dmrt1* and *cyp19a1a* genes, thereby we established a method to identify the phenotypic sex in early development. Besides, we used this method to identify the phenotypic sex of temperature-treated tilapia (25, 35, and 180 days after fertilization), and analyzed the expression changes of genes related to sex differentiation (*dmrt1*, *gsdf*, *amh*, *cyp19a1a*, *foxl2*, *foxl3*, *kdm6bb*). The results showed that the expression of these genes of tilapia was sex dimorphism, and their expression patterns change follow the sex reversal of tilapia. The male development-related genes of pseudo-male like *dmrt1*, *gsdf* and *amh* are highly expressed. The female development-related genes *cyp19a1a*, *foxl2* and *foxl3* were low expressed. This study show that the expression patterns of sex-related genes of high-temperature pseudo-male tilapia were more similar to those of high-temperature males, which laid the foundation for revealing the molecular mechanism of temperature sex determination.

Keywords: Nile tilapia, high temperature, sex reversal, early development, phenotypic sex, expression analysis

西氏鲍性别决定区域的定位以及分子标记的开发

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摘要: 西氏鲍是我国鲍类养殖的重要品种, 然而, 目前对于该物种性别决定的分子基础知之甚少。因此, 我们在西氏鲍上使用基因组重测序鉴定了性别相关的基因组片段以及分子标记。通过重测序和进一步处理, 共获得 6,159,941 个高质量 SNPs 和 4,778,050 个 indels。其中 1737 个 SNPs 和 179 个 indels 检测出具有性别二态性。根据性别二态 SNPs 的分布, 在 4 号染色体上鉴定出与性别相关的一个主要片段 (23.20 Mb), 该结果与全基因组关联分析 (GWAS) 的结果一致。另外, 根据雄性特异性缺失 rs4391834 (14 bp), 开发了西氏鲍遗传性别的诊断标记 (XMSP-15)。这些结果可用于进一步研究西氏鲍性别决定和性别控制育种的分子机制。

关键词: 西氏鲍; 性别决定; 分子标记; 基因组重测序

Mapping and marker identification for sex-determining in the abalone, *Haliotis sieboldii*

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Abstract: *Haliotis sieboldii* is an economically important mollusk. However, little is currently known on the molecular basis of sex determination in the species. Therefore, we identified the sex-linked genomic segment and markers with genome resequencing in *H. sieboldii*. A total of 6,159,941 high quality SNPs and 4,778,050 indels were obtained with resequencing and further processing. Among them, 1737 SNPs and 179 indels were detected as sexually dimorphic. According to distribution of sexually dimorphic SNPs, a major segment on Chr. 4 (~23.20 Mb) were identified as sex-linked, consistent to the results of genome-wide association analysis (GWAS). In addition, a diagnostic marker (XMSP-15) for genetic sex of *H. sieboldii* was developed according to the male-specific deletion rs4391834 (14 bp). These results were useful in further researches on the molecular mechanism of sex determination and sex-control breeding in *H. sieboldii*.

Key words: *Haliotis sieboldii*, Sex determination locus, Sex DNA marker, Genome re-sequencing

赤眼鲮 I 型干扰素及受体基因序列结构及组织分布差异

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摘要: 为探索赤眼鲮 I 型干扰素(Interferon, *IFN*)及其受体(class II cytokine receptor family 5, *CRFB5*)的免疫功能, 本研究利用 cDNA 末端快速扩增(RACE)技术获得了赤眼鲮 *IFN1*、*IFN2* 和 *CRFB5* 基因(分别命名为 *ScIFN1*、*ScIFN2* 和 *ScCRFB5*), *ScIFN1*、*ScIFN2* 和 *ScCRFB5* 基因的 cDNA 全长分别为 540、549 和 1 542bp, 分别编码 180、183 和 383 个氨基酸。*ScIFN1* 和 *ScIFN2* 均含一个信号肽和一个保守的 IFab_d 功能域。而 *ScCRFB5* 则含三个结构域, 分别为 Tissue_fac、Interfer_bind 和一个跨膜结构域。基因组织分布结果显示, *ScIFN1*、*ScIFN2* 和 *ScCRFB5* 三个基因的表达量均在鳃中最高, 而分布最低的组织分别为脑、皮肤和脾脏, 且 *ScIFN1* 和 *ScCRFB5* 基因的组织分布基本一致。

关键词: 赤眼鲮; I 型干扰素; 受体; 基因结构; 组织分布

Sequence structure and difference in tissue distribution of type I interferon and class II cytokine receptor family 5 of Barbel chub (*Squaliobarbus curriculus*)

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Abstract: To investigate the immune function of *IFN1*, *IFN2* and *CRFB5* in barbel chub (*Squaliobarbus curriculus*) (*ScIFN1*, *ScIFN2* and *ScCRFB5*), this study obtained the full-length cDNA sequences of *ScIFN1*, *ScIFN2* and *ScCRFB5* which were 540, 549 and 1 542 bp in length and encoded proteins of 180, 183 and 383 amino acid residues, respectively. Both *ScIFN1* and *ScIFN2* contained a signal peptide and a conserved IFab_d domain, and the *ScCRFB5* contained conserved domains for Tissue_fac, Interfer_bind and Transmembrane region. The expression levels of three genes of *ScIFN1*, *ScIFN2* and *ScCRFB5* were shown to be the highest in the gills among the tissues analyzed, with the lowest level detected in the brain, skin and spleen, respectively. And the tissue distributions of the *ScIFN1* and *ScCRFB5* were basically the same.

Key words: *Squaliobarbus curriculus*, type I interferon, *CRFB5*, sequence structure, tissue distribution

转录组揭示代谢失衡，免疫紊乱和细胞凋亡在克氏原螯虾高温应激处理下的重要作用

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摘要: 温度的变化会影响甲壳动物的正常生长和代谢, 甚至引起细菌性疾病。目前, 我们尚未完全了解甲壳动物在高温条件下潜在的抗逆分子反应机理。因此, 在这项研究中, 我们使用 RNA 测序技术鉴定了克氏原螯虾转录组, 并进行了高温组和常温对照组之间的比较。组装和注释后.....

关键词: 克氏原螯虾, 高温, Illumina 测序, DEGs, 分子机理

Transcriptome reveals the important role of metabolic imbalances, immune disorders and apoptosis in the treatment of *Procambarus clarkii* at super high temperature

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Abstract: Changes in temperature can affect crustaceans normal growth and metabolism and even cause bacterial disease. Currently, the potential anti-reverse molecular reaction mechanism of crustaceans during high-temperature conditions has not yet been fully understood. Therefore, in this study, we characterised the transcriptome of *Procambarus clarkii* using RNA sequencing and performed a comparison between high-temperature-treated samples and controls. After assembly and annotation.....

Key words: *Procambarus clarkii*, high temperature, Illumina sequencing, DEGs, molecular mechanism

缺失 *scx* 基因的功能会造成斑马鱼肌间骨的矿化严重缺失

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摘要: 肌间骨是由肌腱间的肌腱骨化而来, 仅存在低等真骨鱼类中。肌间骨的存在影响了消费者对经济鱼类的食用及水产品的加工, 降低了经济鱼类的经济价值。目前关于肌间骨的分子调控机制尚不清楚。*Scx* 基因是与肌腱发育相关的, 且在肌间骨发育时期的表达是呈上升趋势的。*scx* 是基础的 helix-loop-helix (bHLH) 的转录因子, 作为肌腱的标记基因在肌腱细胞分化和成熟发挥重要的作用。*Scx* 基因在斑马鱼里有两个亚型, *scxa* 与 *scxb*。本文运用 *crispr-cas9* 方法构建 *scxa* 与 *scxb* 基因的斑马鱼突变品系, 结果表明 *scxa-1*^{-/-} 突变体既有明显的肋骨矿化与数量缺失, 且在肌间骨数量上有显著的减少, 接近 70%。成年的斑马鱼的肌间骨是有序地排列在背部和尾部的, 而 *scxa* 突变体仅有少量的肌间骨排列在尾部。尽管 *scxa-1*^{-/-} 斑马鱼具有肋骨缺陷, 但突变体是像野生成年鱼一样可育的, *scxb*^{-/-} 的斑马鱼与野生鱼具有相同数量的肌间骨和相同的骨骼表型, 这表明 *scxa* 在肌间骨发育中具有关键作用。为了进一步阐明 *scxa* 在肌间骨发育过程中的分子调控机制, *scxa-1*^{-/-} (无肌间骨) 与 *scxa-1*^{+/+} (有肌间骨) 的背部组织样品进行了比较转录组分析并通过 qPCR 验证了关键基因的表达。本研究为 *scxa* 基因在肌间骨发育的调控机制的方面提供了一个新的研究方向。

关键词: 肌间骨 *Scx* CRISPR-Cas9 表型 基因表达

Loss of scleraxis leads to distinct reduction of mineralized intermuscular bone in zebrafish

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Abstract: Intermuscular bones (IBs) are ossified from tendons and only occur in lower teleosts. Positive association between the regulation of scleraxis gene (*scx*) and tendon development gave us reasons to speculate that the *scx* gene may play a potential role in regulating the development of IBs. The *scxa*^{-/-} and *scxb*^{-/-} zebrafish were generated through CRISPR-Cas9 technology to study the role of *scx* in the IB and rib development. The results showed a significant reduction of the number of IBs in adult *scxa-1*^{-/-} zebrafish, with almost 70% reduction (15–25 IBs) compared to the wild type *scxa-1*^{+/+} zebrafish (76–80 IBs). In the *scxa-1*^{+/+} adults, IBs were observed in both dorsal and tail segments; however, in *scxa-1*^{-/-} fish IBs were observed only in the tail segment (none in the dorsal segment). Although *scxa-1*^{-/-} zebrafish had rib defects, the mutants were viable and fertile as adult fish. The *scxb*^{-/-} zebrafish had the same number of IBs and same skeletal phenotype as the wild-type fish. This suggests that only *scxa* has a crucial role in the IB development. To further clarify the molecular mechanism by which *scxa* affects the IB development, we conducted comparative transcriptome analysis of dorsal tissue samples of *scxa-1*^{+/+} (with IBs) and *scxa-1*^{-/-} (without IBs), and further verified the expression of key genes via qPCR. This is the first study to identify a gene that controls the amount of IBs in fish, and it provides a new sight into the effects of *scxa* on the molecular mechanism of IB development in fish.

Keywords: Intermuscular bone *Scx* CRISPR-Cas9 Phenotype Gene expression

日本沼虾精巢代谢组和转录组在不同温度和光照时间下的变化分析

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摘要: 为了日本沼虾产业的持续发展, 需进一步了解其雄性分化机制。温度和光照等环境因素对日本沼虾性腺发育有显著影响。本研究在于通过对精巢代谢组和转录组在不同温度和光照时间下的变化分析, 确定参与日本沼虾雄性分化和发育的关键基因和代谢产物, 共鉴定出 268 个不同的代谢产物和 11832 个差异表达基因。根据代谢组和转录组分析, 甘油磷脂和鞘磷脂代谢对日本沼虾雄性分化和发育有显著影响。根据 DEGs 的 KEGG 富集分析, 预测氧化磷酸化、糖酵解/糖质新生、HIF-1 信号通路等可促进日本沼虾雄性分化和发育。qPCR 和原位杂交显示, SDHB、PDE1、HSDL1、CYP81F2、SRSF 和 SNRNP40 基因有差异表达, 提示其在本沼虾雄性分化和发育中发挥作用。

关键词: 日本沼虾; 代谢组和转录组; 精巢; 组织学观察; 性别分化和发育

Analysis of testis metabolome and transcriptome from the orientalriver prawn (*Macrobrachium nipponense*) in response to different temperatures and illumination times

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Abstract: For the development of *Macrobrachium nipponense* industry, the mechanism of male sexual differentiation of *Macrobrachium nipponense* needs to be further understood. Environmental factors, especially temperature and illumination, have dramatic effects on gonadal development. The aim of the present study was to identify key genes and metabolites involved in the male sexual differentiation and development of *M. nipponense*. A total of 268 differentially abundant metabolites and 11,832 differentially expressed genes (DEGs) were identified. According to the KEGG enrichment analysis of DEGs, oxidative phosphorylation, glycolysis/gluconeogenesis, the HIF-1 signaling pathway were predicted to promote male differentiation and development. Quantitative polymerase chain reaction analysis and in situ hybridization showed that the SDHB, PDE1, HSDL1, CYP81F2, SRSF, and SNRNP40 genes were differentially expressed, suggesting roles in the male sexual differentiation and development of *M. nipponense*.

Key words: *Macrobrachium nipponense*, Metabolomes and transcriptome, Testis, Sexual differentiation

虹鳟感染传染性造血器官坏死病病毒脾脏的 免疫应答转录组分析

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摘要：虹鳟是一种重要的冷水性经济鱼类，广泛分布于我国冷温性水域。*IHN*V感染虹鳟有着极高的致死率并且会给养殖产业带来巨大的经济损失。然而，有关虹鳟抗病毒免疫的分子机制尚不清楚。因此，本研究通过RNA-Seq技术对虹鳟感染*IHN*V脾脏转录组进行了分析。共获得9144个显著差异表达基因（ $FDR < 0.05$ 且 $|\log_2FC| > 1$ ），包含3274个上调和5870个下调基因，其中参与免疫反应的几个关键基因有*TLR2*、*TLR3*、*MyD88*、*STAT1*、*IL-6*、*CD40*。GO分析显示，主要的生物功能有细胞过程、细胞和催化活性。基于KEGG分析，虹鳟免疫反应相关的几个重要通路有Toll样受体通路、RIG-I样受体通路、NOD样受体通路、TNF信号通路和T细胞信号通路。最后，随机筛选出12个差异基因进行qRT-PCR验证。该研究结果为后续虹鳟抗*IHN*V的研究提供了基础数据。

关键词：*IHN*V；虹鳟；转录组；脾脏；免疫反应

Transcriptome analysis of the spleen immune response of rainbow trout (*Oncorhynchus mykiss*) infected with infectious hematopoietic necrosis virus

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Abstract: Rainbow trout is an important cold-water economic fish, widely distributed in China. *IHN*V infection of rainbow trout has a high mortality rate and can cause significant economic losses to the farming industry. However, the molecular mechanisms underlying the antiviral immunity of rainbow trout are unclear. Therefore, the transcriptome of the spleen of rainbow trout infected with *IHN*V was analyzed by RNA-Seq technology in this study. A total of 9144 significantly differentially expressed genes ($FDR < 0.05$ and $|\log_2FC| > 1$) were obtained, including 3274 up-regulated and 5870 down-regulated genes, of which several key genes involved in immune response were *TLR2*, *TLR3*, *MyD88*, *STAT1*, *IL-6*, and *CD40*. GO analysis showed that the main biological functions are cellular processes, cell and catalytic activity. Based on KEGG analysis, several important pathways associated with the immune response in rainbow trout are Toll-like receptor pathway, RIG-I-like receptor pathway, NOD-like receptor pathway, TNF signaling pathway, and T-cell signaling pathway. Finally, 12 differential genes were randomly selected for qRT-PCR validation. The results of this study provide basic data for subsequent studies on *IHN*V resistance in rainbow trout.

Key words: *IHN*V, rainbow trout, transcriptome, spleen, immune response

斑节对虾 TRIM-Like 通过调节细胞自噬来抑制病毒复制

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摘要: 本研究首次从斑节对虾中克隆并鉴定了一种 TRIM-Like 基因, 并将其命名为 PmTRIM-Like。当对虾受到白斑综合征病毒 (WSSV) 的刺激后, PmTRIM-Like 的 mRNA 和蛋白质水平呈显著的上调表达。敲低 PmTRIM-Like 导致 WSSV 病毒的含量显著增加, 对虾存活率降低。过表达 PmTRIM-Like 后会有效减少病毒含量, 提高对虾存活率。Pull-down 和体外泛素化实验结果表明 PmTRIM-Like 重组蛋白能与 WSSV 的衣壳蛋白 VP28、VP26 和 VP24 相互作用, 并使其泛素化。WSSV 或者雷帕霉素刺激对虾后, 肠道组织细胞自噬水平显著增加。同时结果表明细胞自噬能的发生帮助对虾清除 WSSV 感染。而当敲低 PmTRIM-Like 后, WSSV 和雷帕霉素刺激刺激却不能显著提高自噬水平。本研究结果显示 PmTRIM-Like 能靶向并且泛素化病毒衣壳蛋白, 调节细胞自噬, 从而帮助对虾清除 WSSV 病毒。

关键词: PmTRIM-Like; 细胞自噬; 泛素化; 斑节对虾; WSSV

TRIM-Like restrict WSSV replication through positive regulation autophagy in *penaeus monodon*

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Abstract: The TRIM-Like gene was first cloned and identified from *Penaeus monodon*, and was named as PmTRIM-Like. The mRNA and protein expression levels of PmTRIM-Like are significantly up-regulated by WSSV infection. Knockdown of PmTRIM-Like significantly increased the content of WSSV virus and decreased the survival rate of shrimp. Overexpression of PmTRIM-Like effectively reduced the content of WSSV virus and increased the survival rate of shrimp. Pull-down and in vitro ubiquitination experiments showed that recombinant PmTRIM-Like protein can interact with and ubiquitinate the capsid proteins VP28, VP26 and VP24 of WSSV., the autophagy level of intestinal tissue increased significantly after stimulated by WSSV or rapamycin. Meanwhile, the results show that the occurrence of autophagy can help the shrimp clear the WSSV infection. However, WSSV and rapamycin stimulation failed to increase the level of autophagy in PmTRIM-Like silenced shrimp. These results indicated that PmTRIM-Like can target and ubiquitinate viral capsid proteins of WSSV, regulate cell autophagy, and help shrimp eliminate WSSV virus.

Key words: PmTRIM-Like, autophagy, ubiquitination, *Penaeus monodon*, WSSV

香港牡蛎、近江牡蛎及其杂交子系统比较研究

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摘要: 香港牡蛎和近江牡蛎都是我国华南地区的原生河口种, 但近江牡蛎在我国北方也有分布, 而香港牡蛎仅仅分布在南方地区。由于肉质偏黄, 近江牡蛎的销量和产量连年下降, 但其在生长和耐高盐方面有显著优势; 而肉质发白、闭壳肌肉质佳和口感好的香港牡蛎在南方广受欢迎, 但其在抗病力、应激能力和分布范围方面有很大缺陷。所以, 这两种牡蛎杂交可能是降低各自劣势和提高遗传性能的一种方法。我们首次对香港牡蛎和近江牡蛎杂交 F₁ 及其子代进行系统研究, 以期获得一个有优良性状的新品系。根据实验结果, 发现杂交 HA 在两个不同的地点一直有显著的杂交优势, 预示着它在不同的环境条件下都有生长优势; 实验结果也证明了杂交子 HA 比两个纯种拥有更好的盐度耐受能力。杂交 F₂ 发生了性状分离, 但相对于两个纯种, 其仍有显著的生长优势。这些结果为进一步的选育耐高盐、生长快的杂交新品种奠定了基础。

关键词: 香港牡蛎; 近江牡蛎; F₁; F₂; 生长性状;

A systematic comparative study on *C. hongkongensis*, *C. ariakensis* and their hybrids

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Abstract: *C. hongkongensis* and *C. ariakensis* are native estuarine species in southern China, and *C. ariakensis* is also distributed in northern China, while *C. hongkongensis* is endemic to southern china. The production and sales volume of *C. ariakensis* is gradually decreasing because of its yellow flesh color, but it has advantages in growth and suitability for higher salinity environments, while *C. hongkongensis* is popular because of its white flesh color, high-quality adductor muscle, and delicious taste but has disadvantages in disease resistance, stress tolerance and distribution areas. Hence, interspecific hybridization between these two species may be a good method to minimize the disadvantages of each species and is potentially useful for the genetic improvement of these two important aquaculture species. Here, we present the first report of a systematic comparative study on the two native sympatric oysters of southern China, *C. hongkongensis* and *C. ariakensis*, and their hybrid and hybrid generation, in order to obtain a new variety with excellent characters. According to the results, HA always exhibited positive heterosis at both sites, indicating that it had growth advantages regardless of different environmental conditions; Our trials also demonstrated that HA had a greater salinity tolerance than the two pure species. Character separation occurs in hybrid F₂, and its growth traits still have significant advantages over the two pure species. These results laid a foundation for further breeding of new hybrid varieties with high salt tolerance and fast growth.

Keywords: *Crassostrea hongkongensis*, *Crassostrea ariakensis*, F₁, F₂, growth traits

整合分析 circRNA-miRNA-mRNA ceRNA 网络对虹鳟 (*Oncorhynchus mykiss*) 肝脏响应热应激的调控机制

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摘要: 随着全球变暖的加剧, 虹鳟受到不同程度的热刺激。热应激可通过降低免疫应答而引起病理症状或疾病, 从而导致大规模死亡。因此, 高温严重制约了虹鳟养殖业的发展。了解虹鳟在热胁迫下的分子调控机制有助于开发缓解症状的方法。我们对高温胁迫(24℃)和对照条件(18℃)下虹鳟的肝脏组织进行了全转录组分析, 以识别 circRNA、miRNA 和 mRNA。非特异性免疫参数的变化表明, 在 24℃时虹鳟鱼产生了强烈的应激反应。分别共从 6 个文库中鉴定出 324 个 DEcircRNAs、105 个 DEmiRNAs 和 1885 个 DEmRNAs, 构建了 ceRNA 调控网络。从 ceRNA 调控网络中识别了 301 个 circRNA-miRNA 和 51 个 miRNA-mRNA 负相关对。预测了 3 对调控相关对: novel_circ_003889/novel-m0674-3p/hsp90ab1、novel_circ_002325/miR-18-y/HSPA13 和 novel_circ_002446/novel-m0556-3p/hsp70。一些参与代谢过程、生物调节和响应刺激的基因在高温下被高度诱导。几个参与热应激的重要途径被鉴定, 如内质网蛋白质加工, 雌激素信号通路, 和 HIF-1 信号通路。这些结果扩展了我们对热应激反应的分子机制的理解, 并为缓解热应激的策略的发展提供了新的见解。

关键词: 虹鳟; 热应激; 转录组; ceRNA 网络

Integrated analysis of the responses of a circRNA-miRNA-mRNA ceRNA network to heat stress in rainbow trout (*Oncorhynchus mykiss*) liver

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Abstract: With the intensification of global warming, rainbow trout suffer from varying degrees of thermal stimulation. Heat stress may cause pathological symptoms or diseases by reducing the immune response, which then leads to mass mortality; thus high temperatures severely restrict the development of aquaculture. Understanding the molecular regulatory mechanisms of rainbow trout under heat stress is useful to develop approaches to relieve symptoms. We performed multiple transcriptomic analyses of liver tissues from rainbow trout under heat stress (24 °C) and control conditions (18 °C) to identify circRNAs, miRNAs and mRNAs. Changes in nonspecific immune parameters revealed that a strong stress response was caused in rainbow trout at 24 °C. A total of 324 DEcircRNAs, 105 DEmiRNAs, and 1885 DEmRNAs were identified from six libraries, and a ceRNA regulatory network was constructed. A total of 301 circRNA-miRNA and 51 miRNA-mRNA negative correlation pairs were identified from the ceRNA regulatory network, and three regulatory correlation pairs were predicted: novel_circ_003889 - novel-m0674-3p - hsp90ab1, novel_circ_002325 - miR-18-y - HSPA13 and novel_circ_002446 - novel-m0556-3p - hsp70. Some genes involved in metabolic processes, biological regulation or response to stimulus were highly induced at high temperatures. Several important pathways involved in heat stress were characterized, such as protein processing in the ER, the estrogen signaling pathway, and the HIF-1 signaling pathway. These results extend our understanding of the molecular mechanisms of the heat stress response and provide novel insight for the development of strategies that relieve heat stress.

Keywords: rainbow trout; heat stress; transcriptome; ceRNA network

饲料中添加EM菌对幼年吉富罗非鱼生长免疫和食欲调节的影响

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摘要: EM菌广泛应用于水质改良和农业生产中,许多水产养殖实验证明EM菌对鱼类有积极的作用。本实验检测了饲料中添加EM菌对幼年吉富罗非鱼的生长、免疫和调节食欲都有一定的作用。三种不同浓度EM菌拌料投喂(0g/kg; 30g/kg; 60g/kg)饲养罗非鱼90天。结果表明,低浓度和高浓度的EM菌拌料均能促进鱼类生长,然而,大多数血清指标表明罗非鱼的免疫水平提升不明显。EM菌拌料投喂可显著提高脑中神经肽Y(*npv*)和次鼠色蛋白相关蛋白(*agrp*)以及肝胰腺中胆囊收缩素(*cck*)和胃饥饿素(*Ghrelin*)的mRNA的表达。研究表明,基因表达的结果表明了拌料投喂EM菌对鱼类生长和罗非鱼养殖有积极影响,这为养殖生产提供了信息。

关键词: 益生菌; 经济增长; 免疫力; 食欲调节; 罗非鱼

Effects of supplemental effective microorganisms in feed on the growth, immunity, and appetite regulation in juvenile GIFT tilapia

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Abstract: Effective microorganisms (EM) is widely employed in water improvement and agricultural utilization. Many experiments in aquaculture have proved that EM takes positive effects on fish. Naturally, the present experiment evaluated the influence of supplemental EM in feed on tilapia, which contains the growth, immunity, and appetite regulating of juvenile GIFT tilapia. Three different EM-concentration diets (0g/kg; 30g/kg; 60g/kg) were fed to tilapia for 90 days. The results showed that Low and High concentration could promote fish grow. However, most of the serum indicators suggested the little improvement of the immunity in tilapia. The neuropeptide Y (*npv*) and agouti-related protein (*agrp*) in brain or cholecystokin (*cck*) and Ghrelin in hepatopancreas mRNA expression were significantly improved by EM diets. According to the study, fish growth indicated the results of gene expression, thus adding EM to diets suggested positive effects on tilapia culture. The study provided information to aquaculture production.

Key words: probiotics; growth; immunity; appetite regulation; tilapia

草鱼 C5、C5a 和 C5aR 及相关细胞因子的组织表达特性分析

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摘要: 为探究草鱼(*Ctenopharyngodon idellus*) C5、C5a 和 C5aR 的免疫效应, 本研究利用 qPCR 和 Western blot 检测了草鱼 C5、C5a 和 C5aR 与三种细胞因子 (F2、IL-8、IFN- γ) 在健康组织及感染 GCRV 时的表达特性。qPCR 检测结果显示, 健康草鱼的 7 个组织 (肝脏、脾脏、头肾、体肾、肠、肌肉、鳃) 中, C5/C5a 和 F2 在肝脏表达量最高; C5aR 在脾脏表达量最高; IL-8 和 IFN- γ 分别在肠道和鳃表达量最高。草鱼感染 GCRV 后, 肝脏中 C5/C5a、F2、IL-8 和 IFN- γ 的表达量先显著上调再显著下调 ($P < 0.05$), C5aR 表达量整体趋于稳定; Western blot 结果显示, 肝脏中 C5/C5a、C5aR、F2、IL-8 和 IFN- γ 的蛋白表达量逐渐上升, 呈现相似的变化趋势。上述结果表明, 草鱼 C5、C5a 和 C5aR 在抗 GCRV 感染过程中具有一定的免疫效应。

关键词: 草鱼; 草鱼呼肠孤病毒 (GCRV); 补体 5; 过敏性毒素 C5a; 补体受体 5

Analysis of tissue expression characteristics of C5, C5a, C5aR and related cytokines in grass carp (*Ctenopharyngodon idellus*)

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Abstract: To explore the immune effects of C5, C5a and C5aR in *Ctenopharyngodon idella* (*C. idella*), the expression characteristics of C5, C5a and C5aR and three cytokines (F2, IL-8, IFN- γ) in healthy tissues and GCRV infected *C. idella* were detected by qPCR and Western blot. The results of qPCR detection showed that among the seven tissues of healthy *C. idella* (liver, spleen, head kidney, body kidney, intestine, muscle, gill), the expression of C5/C5a and F2 was the highest in liver, the highest expression of C5aR in spleen, and the highest expression of IL-8 and IFN- γ in intestine and gill. After GCRV infection, the expressions of C5/C5a, F2, IL-8 and IFN- γ in the liver were significantly up-regulated and then significantly down-regulated, and the expression of C5aR tended to be stable as a whole. Western blot results showed that the protein expressions of C5/C5a, C5aR, F2, IL-8 and IFN- γ in the liver increased gradually, showing a similar trend. These results suggest that C5, C5a and C5aR of *C. idella* have certain immune effects in the process of anti-GCRV infection.

Key words: *Ctenopharyngodon Idella*, GCRV, C5, C5a, C5aR

IHNV 感染对虹鳟头肾组织转录组变化分析

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摘要: 为了探究传染性造血器官坏死病病毒(IHNV)对虹鳟 (*Oncorhynchus mykiss*) 头肾组织相关免疫基因的变化影响, 本研究利用 Illumina HiSeq4000 高通量测序平台对感染 IHNV 的虹鳟头肾组织进行转录组测序, 筛选差异表达基因, 并用 GO 和 KEGG 数据库进行分析。结果显示, 共筛选出 7486 条差异基因, 其中上调 2223 条, 下调 5263 条。GO 功能注释结果显示, 差异表达基因编码蛋白主要与代谢、免疫、炎症以及调控途径等相关; KEGG 通路富集分析表明, 差异表达基因主要富集在 Toll 样受体信号通路、Jak-STAT 信号通路、RIG-I 样受体信号通路、NOD 样受体信号通路、PI3K-Akt 信号通路、IL-17 信号通路、TNF 信号通路。随机筛选出与抗病毒免疫相关的 12 个关键基因进行 RT-PCR 验证, 实验结果与转录谱结果一致, 证实了转录组测序结果的可靠性。本研究获得了 IHNV 感染虹鳟后头肾组织中免疫相关基因的表达信息, 为深入探究鱼类 IHNV 致病机理奠定了基础。

关键词: 虹鳟; IHNV; 转录组; KEGG; 差异基因

Analysis of transcriptome changes of head kidney of rainbow trout (*Oncorhynchus mykiss*) with IHNV infection

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Abstract: In order to investigate the influence of Infectious Hematopoietic Necrosis Virus (IHNV) on the changes of immune-related genes in IHNV-infected rainbow trout (*Oncorhynchus mykiss*) renal tissue, this study used Illumina HiSeq4000 high-throughput sequencing platform to conduct transcriptome sequencing on IHNV-infected rainbow trout renal tissue, screen the differentially expressed genes, and analyze them with GO and KEGG databases. The results showed that a total of 7486 differentially expressed genes were screened, among which 2223 genes were up-regulated and 5263 genes were down-regulated. GO function annotation results showed that the differentially expressed gene encoding proteins were mainly related to metabolism, immunity, inflammation and regulatory pathways. Enrichment analysis of KEGG pathway showed that differentially expressed genes were mainly concentrated in Toll-like receptor signaling pathway, Jak-STAK signaling pathway, RIG-I-like receptor signaling pathway, NOD-like receptor signaling pathway, PI3K-Akt signaling pathway, IL-17 signaling pathway, and TNF signaling pathway. Twelve key genes related to antiviral immunity were randomly selected for RT-PCR verification, and the experimental results were consistent with the results of transcriptional spectrum, which confirmed the reliability of transcriptomic sequencing results. In this study, the expression information of immune-related genes in the backkidney tissues of rainbow trout infected with IHNV was obtained, which laid a foundation for further exploring the pathogenesis of IHNV in fish.

Key words: rainbow trout, IHNV, the transcriptome, KEGG, differences in gene

盐度胁迫下斑尾刺虾虎鱼鳃的转录组测序与组装 注释

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摘要: 为了探究盐度胁迫下的斑尾刺虾虎鱼的耐盐性适应机制, 我们利用 RNA-Seq 技术对不同盐度胁迫下斑尾刺虾虎鱼的 mRNA 进行表达量测序。本研究设置 0 psu、15 psu(对照)、30 psu 和 45 psu 四种水域环境进行盐度胁迫实验。与对照组相比, 3 个实验组共筛选出 572 个差异表达基因。此外, 我们对差异表达基因进行基因本体论(GO)和京都基因和基因组百科全书(KEGG)功能富集分析。绑定, 代谢过程和细胞过程等功能被 GO 显著富集, KEGG 则显著富集在信号转导, 新陈代谢, 消化和内分泌系统等信号通路。最后, 随机选取 8 个差异表达基因进行实时荧光定量 PCR (qRT-PCR)验证实验, 结果表明, qRT-PCR 的基因表达量与转录组测序结果基本一致, 这证明了本研究数据的可靠性。

关键词: 斑尾刺虾虎鱼; RNA 测序; 盐度胁迫; 差异表达基因;

Gill Transcriptome Sequencing and De Novo Annotation of *Acanthogobius ommaturus* in Response to Salinity Stress

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Abstract: In order to understand the mechanism of adaptation to salinity stress, RNA-seq was used to compare the transcriptome responses of *Acanthogobius ommaturus* to the changes of salinity. Four salinity gradients, 0 psu, 15 psu (control), 30 psu and 45 psu were set to conduct the experiment. Compared with the gene expression profile of the control group, 572 differentially expressed genes (DEGs) were screened. Additionally, among these DEGs, Gene Ontology (GO) analysis indicated that binding, metabolic processes and cellular processes were significantly enriched. Kyoto Encyclopedia of Genes and Genomes (KEGG) pathways analysis were significantly enriched in signal transduction, metabolism, digestive and endocrine systems. Eight DEGs were randomly selected for further validation by quantitative real-time PCR (qRT-PCR) and the results were consistent with the RNA-seq data.

Key words: *Acanthogobius ommaturus*; RNA-seq; salinity stress; differentially expressed genes (DEGs)

低频声波对瘤背石磺的生化应激反应

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摘要: 伴随着经济全球化的发展, 水上运输业也迎来了爆发式的增长, 相应的海洋噪声污染对海洋生物的生长发育产生了极大的影响。本研究探究了低频声波对瘤背石磺 (*Onchidium reevesii*) 的生理生化的影响。实验是在一个长 3m, 宽 60cm, 高 50cm 的箱体中进行, 分别用频率为 10Hz、40Hz、70Hz、100Hz、130Hz、160Hz、190Hz、220Hz、250Hz、280Hz、310Hz 的声波刺激 1h、6h、12h、24h, 每个处理组 9 只瘤背石磺。在低频声波的影响下瘤背石磺表现出远离声波源的行为, 但无任何规律。对采集的血液进行总超氧化物歧化酶 (SOD)、过氧化氢酶 (CAT)、丙二醛 (MDA)、甘油三酯 (TG)、葡萄糖 (Glu)、白蛋白 (ALB) 测定, 结果显示在频率 280Hz, 刺激 6h 时以上生化指标数值明显较高。对血液和神经节组织中的 *Hsp70* 进行 qPCR 和免疫组化的结果进一步验证了这一结果。本研究对评估海洋噪声对海洋生物的生命活动的影响提供参考资料。

关键词: 海洋噪声; 瘤背石磺; 低频声波; 生化应激; 免疫组化

Biochemical stress response of *Onchidium reevesii* after exposure to low-frequency sound waves

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Abstract: Along with the development of economic globalization, the water transportation industry has also witnessed explosive growth, and the corresponding marine noise pollution has greatly affected the growth and development of marine organisms. This study investigated the effect of low-frequency acoustic waves on the physiology and biochemistry of *Onchidium reevesii*. The experiments were conducted in a chamber 3 m long, 60 cm wide, and 50 cm high, and were stimulated with acoustic waves at frequencies of 10Hz, 40Hz, 70Hz, 100Hz, 130Hz, 160Hz, 190Hz, 220Hz, 250Hz, 280Hz, and 310Hz for 1h, 6h, 12h, and 24h, respectively, with nine samples per treatment group. Under the influence of low-frequency sound waves *Onchidium reevesii* exhibited behavior away from the source of the sound waves, but without any pattern. SOD, CAT, MDA, TG, Glu and ALB were measured in the collected blood, and the results showed that the values of the above biochemical indicators were significantly higher when stimulated at a frequency of 280Hz for 6h. This result was further validated by qPCR and IHC of *Hsp70* in blood and ganglion tissues. This study provides a reference for assessing the impact of ocean noise on the life activities of marine organisms.

Keywords: ocean noise, *Onchidium reevesii*, low-frequency acoustic waves, biochemical stress, IHC

斑马鱼细胞冷应激下氧化损伤的分子机制探究

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摘要: 冷应激是鱼类生活史中常见的现象, 也是水产养殖业面临的重要威胁之一, 目前关于鱼类冷应激的耐受机制研究并不完善。为进一步探究鱼类冷应激耐受相关的分子机制, 以斑马鱼 ZF4 细胞为研究材料, 通过与常温 (28°C) 比较探究不同冷应激条件下 (13°C、18°C) 细胞的氧化损伤和调节过程。结果表明: 冷应激下细胞聚集成团状, 增殖速度下降, 凋亡明显。通过对氧化应激途径研究发现冷应激下 ROS 含量增加, 还原型谷胱甘肽 (GSH)、谷胱甘肽还原酶 (GR)、超氧化物歧化酶 (SOD) 酶活水平改变, 线粒体凋亡途径被激活, caspase 活化, 氧化应激失衡引起氧化损伤。轻度氧化应激时, 机体清除多余的活性氧自由基并维持平衡; 而过度氧化应激时则引起氧化损伤进而触发细胞凋亡。通过对斑马鱼细胞冷应激下氧化损伤的机制探究, 为鱼类低温适应的分子机制研究奠定基础。

关键词: 冷应激; ZF4 细胞; 氧化损伤; 线粒体; 凋亡

Molecular mechanism of oxidative damage in zebrafish cells under cold stress

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Abstract: Cold stress is a common phenomenon in fish life, and it is also one of the important threats to the aquaculture industry. However, the research on the mechanism of cold stress is not well revealed at present. In order to further explore the molecular mechanism related to cold stress in fish, using ZF4 cells as the research material to explore the oxidative damage and regulation process of cells under different cold stress conditions (13°C, 18°C) by comparing with normal temperature (28°C). The results showed that under cold stress the cells aggregated into clusters, the proliferation rate decreased and the apoptosis was obvious. Through the study of oxidative stress pathway, it was found that ROS level increased, the activity levels of glutathione (GSH) and glutathione reductase (GR) and superoxide dismutase (SOD) enzyme changed, mitochondrial pathway and caspase activated, resulting in oxidative stress imbalance causes oxidative damage. During mild oxidative stress, the body removes excess reactive oxygen species and maintains balance. When excessive oxidative stress occurs, it causes oxidative damage and apoptosis. By studying the mechanism of oxidative damage of ZF4 under cold stress, it lays a foundation for the study of molecular mechanisms of fish adaptation to low temperature in the future.

Key words: cold stress, ZF4 cells, oxidative damage, mitochondria, apoptosis

褐牙鲆变态过程中促肾上腺皮质激素释放激素和尾加压素 I 的动态表达与调控

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摘要: 促肾上腺皮质激素释放激素 (CRH) 和尾加压素 I (UI) 被认为是适应性生理的关键因素。为了了解甲状腺激素 (T_3) 对变态过程中硬骨鱼 CRH 和 UI 的调节作用, 我们研究了褐牙鲆 (*Paralichthys olivaceus*) 变态过程中 CRH 和 UI 基因的表达模式以及对 T_3 的反应。头部的 CRH 和 UI mRNA 表达在变态期间保持较低水平并在变态后急剧增加至峰值, 但在尾部逐渐增加。将 22 日龄仔鱼暴露于外源 T_3 和 TU (T_3 的合成抑制剂), 结果表明 T_3 负反馈调节 CRH 和 UI。此外, 还确定了甲状腺激素受体 (TRs) mRNA 的表达水平。结果表明 $TR\alpha A$, $TR\alpha B$ 和 $TR\beta$ mRNA 的表达在 8 小时均升高, 而 T_3 对 CRH 和 UI mRNA 的上调可能与 $TR\alpha A$ 和 $TR\beta$ 有关。总体而言, 我们的发现首次描述了褐牙鲆变态过程中 CRH 和 UI mRNA 的表达模式以及 T_3 通过 $TR\alpha A$ 和 $TR\beta$ 的反馈调节作用。

关键词: 促肾上腺皮质激素释放激素, 尾加压素 I, 甲状腺激素, 变态, 牙鲆

Dynamic expression and regulation of corticotropin-releasing hormone and urotensin I during metamorphosis of olive flounder *Paralichthys olivaceus*

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Abstract: Corticotropin-releasing hormone (CRH) and Urotensin I (UI) are considered as key players of adaptive physiology. To understand the regulatory role of 3,5,3'-triiodothyronine (T_3) on CRH and UI in teleosts during metamorphosis, we investigated the expression patterns of CRH and UI genes, and their response to T_3 during metamorphosis of olive flounder, *Paralichthys olivaceus*. CRH and UI mRNA expression remained a lower level during metamorphosis and sharply increased to a maximum after metamorphosis in the head, but gradually increased during and after metamorphosis in the caudal. Exposure of 22 DAH larvae to exogenous T_3 and thiourea (TU)-a synthetic inhibitor of T_3 , results revealed that T_3 regulated CRH and UI mRNA with negative feedback. Furthermore, the expression levels of thyroid hormone receptors (TRs) mRNA were also determined. Results indicated that $TR\alpha A$, $TR\alpha B$ and $TR\beta$ mRNA expression was elevated with increasing concentrations after 8 h, and the up-regulatory effect of T_3 on CRH and UI mRNA might be related to $TR\alpha A$ and $TR\beta$. Overall, our findings described for the first time the expression patterns of CRH and UI mRNA and the feedback-regulatory role of T_3 through $TR\alpha A$ and $TR\beta$ during metamorphosis in *Paralichthys olivaceus*.

Key words: Corticotropin-releasing hormone, Urotensin I, Thyroid hormone, Metamorphosis, Flounder

福瑞鲤胚胎发育阶段特异性 microRNA, lncRNA 和 mRNA 的鉴定和分析

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摘要: 鲤鱼 (*Cyprinus carpio*) 品种繁多, 是世界上的重要经济鱼类。同时鲤鱼被认为是斑马鱼外的另一种脊椎模式动物。然而, 对于鲤鱼胚胎发育各期 microRNA (miRNA) 和 lncRNA 的系统研究还未见报道。本研究首次鉴定和分析了鲤胚胎发育 6 个主要阶段 (卵裂期, 囊胚期, 原肠胚, 器官形成期, 孵化期和孵化后 24h) 的 miRNA 和 lncRNA-mRNA 表达谱。分别建立了 18 个 miRNA 和 lncRNA 文库 (每个阶段 3 个重复)。共鉴定出 2565 个 miRNAs, 204 个差异表达 miRNAs 中有 68 个与阶段特异性 miRNAs 重叠, 其中 15 个已知 miRNAs 可能在胚胎发生中发挥关键作用。同时鉴定出 51,979 个 lncRNAs, 筛选出了表达丰度前 10 位以及阶段特异性的 lncRNAs 和 mRNAs。鉴定了显著差异表达的 lncRNAs 和 mRNAs, 还研究了两种 lncRNA (*lncrps25* 和 *malat1*) 和两种 mRNA (*mitf* 和 *肌钙蛋白 T*) 的协同调控网络。GO 和 KEGG 分析确定了大量和胚胎发育相关的信号通路。研究结果为非编码 RNA 在胚胎发育中的作用提供了新的视角, 并将促进非编码 RNA 介导的鱼胚胎发育机制的理解。

关键词: MicroRNAs; lncRNA; mRNA; 胚胎发育; 阶段特异性表达; 鲤

The stage-specific microRNAs, lncRNAs and mRNAs identification and analysis during embryonic development of common carp, *Cyprinus carpio*

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Abstract: The *Cyprinus carpio* is a most economical importance fish with over hundred strains and varieties in the world and it is also considered an alternative vertebrate fish model. However, systemic times-series research on the microRNAs and lncRNAs during embryonic development of *C. carpio* has not been reported yet. This study provides the first microRNAs and lncRNA-mRNA expression profiles during six main embryonic development stages (2 hours post-fertilization hpf, 6 hpf, 12 hpf, 20 hpf, 64 hpf and 1 day post-hatching). A total of 2565 miRNAs were identified. 68 of 204 DEMs (differentially expressed microRNAs) were overlapped with stage-specific miRNAs, in which 15 were known miRNAs and seemed to play a key role in embryogenesis. For lncRNAs, a total of 51,979 lncRNAs were identified. We screened the top 10 abundance and stage-specific lncRNAs and mRNAs. We identified significant DE-lncRNAs and DE-mRNAs. Additionally, the lncRNA-mRNA co-regulated network analysis of two lncRNAs (*lncrps25* and *malat1*) and two mRNAs (*mitf* and *troponin T*) were investigated. GO and KEGG analysis identified numerous signaling pathways. Our results provide new insight into the role of non-coding RNAs, and would advance the understanding of non-coding RNAs-mediated mechanisms in embryonic development of fish.

Key words: MicroRNAs, lncRNA; mRNA; embryonic development; stage-specific expression; common carp (*Cyprinus carpio*)

基于生物标记法的通州湾养殖水域海蜇食性分析

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摘要: 海蜇 (*Rhopilema esculentum*) 是大型浮游动物。本实验用脂肪酸生物标记法和碳氮稳定同位素技术研究了江苏南通养殖海蜇的食性及营养级。结果表明: 对江苏南通养殖海蜇共检测出 29 种脂肪酸。特征脂肪酸 C20:1+C22:1 和 C20:4n6 的存在, 指示了其植食性桡足类以及底栖生物的摄食。DHA 和 EPA 的含量最高, 表明浮游动物和硅藻是海蜇两种最重要的食物来源。此外, 海蜇的 DHA/EPA 的值为 $0.78 < 1$, 这说明海蜇的营养级较低。经研究发现, 海蜇伞径长与 $\delta^{13}C$ 和 $\delta^{15}N$ 的相关性并不显著 ($P > 0.05$), 说明随着成体海蜇的生长, 其营养级没有发生明显的变化。

关键词: 海蜇; 脂肪酸; 同位素; 食性; 通州湾

Analysis of Feeding Habits of Cultured Jellyfish (*Rhopilema esculentum*) in Tongzhou Bay Based on the Biomarker Techniques

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Abstract: Jellyfish (*Rhopilema esculentum*) are large zooplankton. The results of this study show that the energy flow of the jellyfish is a major contributor to the energy flow in the marine ecosystem. The results showed that a total of 29 fatty acids were detected in jellyfish cultured in Nantong, Jiangsu Province. The presence of the characteristic fatty acids C20:1+C22:1 and C20:4n6 indicated the feeding of phytophagous copepods and benthic organisms, with the highest concentrations of DHA and EPA, indicating that zooplankton and diatoms are the two most important food sources of jellyfish. In addition, the DHA/EPA value of $0.78 < 1$ for jellyfish indicated a low trophic level. It was found that the correlation between jellyfish umbrella diameter length and $\delta^{13}C$ and $\delta^{15}N$ was not significant ($P > 0.05$), indicating that no significant changes in trophic level occurred as the adult jellyfish grew.

Key words: *Rhopilema esculentum*, fatty acid, isotope, Tongzhou Bay, feeding habits

通过全基因组关联分析鉴定参与马氏珠母贝

黄色珍珠层形成的 SNPs

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摘要: 养殖珍珠颜色是评估珍珠质量的重要指标, 其颜色主要受供体贝的影响, 并且与供体贝的珍珠层颜色一致。为了了解珍珠层颜色的遗传基础, 本研究利用全基因组关联分析, 对 647 只马氏珠母贝 (*Pinctada fucata martensii*) 的珍珠层颜色进行了研究。基于混合线性模型关联分析, 发现 14 号染色体上的一个基因组区域包含 110 个与珍珠层颜色显著相关的单核苷酸多态性 (SNP) 基因座。通过基因注释进一步确定了与颜色相关的候选基因 LDLR, 该基因据报道是参与类胡萝卜素转运的重要因子。在另一个群体中的进一步分析确定了该基因中新的与珍珠层颜色相关的 SNP。这些重要的 SNP 和候选基因将为马氏珠母贝分子标记辅助育种提供参考。

关键词: GWAS; 珍珠层颜色; SNP; 马氏珠母贝; 类胡萝卜素; LDLR

Identification of SNPs involved in the formation of the yellow nacre of *Pinctada fucata martensii* by whole-genome association analysis

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Abstract: The color of cultured pearls is an important indicator for evaluating the quality of pearls. Its color is mainly affected by the donor pearl oysters and is consistent with the nacre color of the donor. In this study, a genome-wide association study of 647 pearl oysters (*Pinctada fucata martensii*) was conducted to understand the genetic basis of nacre color. After association Analysis based on mixed linear model, one genomic region on chromosome 14 that included 110 single-nucleotide polymorphisms (SNPs) was identified as significantly associated with nacre color. The color-related candidate gene LDLR, was further identified by gene annotation, which is reported to be an important factor involved in carotenoid transport. Further analysis in another population identified a new SNP in this gene associated with nacre color. These important SNP loci and candidate genes will provide reference for molecular marker-assisted breeding of *P. f. martensii*.

Key words: GWAS; nacre color; SNP; *Pinctada fucata martensii*; carotenoids; LDLR

克氏原螯虾胚胎发育的研究进展与离体孵化 新技术

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摘要: 克氏原螯虾(*Procambarus clarkii*)是世界上分布最广、养殖最普遍的淡水螯虾。该虾肉味鲜美、营养丰富, 深受国内外市场欢迎, 消费量巨大。克氏原螯虾具有广阔的产业化前景, 然而苗种供应不足的问题一直制约着克氏原螯虾产业的可持续发展。因此, 规模化的人工繁殖是克氏原螯虾产业化的起点和突破口。本文概述了克氏原螯虾胚胎发育的形态结构变化、生化组成及营养代谢、酶活研究、分子和组学研究以及生态因子对克氏原螯虾胚胎发育的影响; 通过对克氏原螯虾离体孵化和离体受精卵胚胎运输的实验研究以兹解决虾苗规模化生产的问题。

关键词: 克氏原螯虾; 胚胎发育; 离体孵化; 甲壳动物

Research progress in embryonic development and in vitro incubation in red swamp crayfish *Procambarus clarkii*

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Abstract: *Procambarus clarkii* is the most widely distributed and widely farmed freshwater crayfish in the world. The delicious and nutrient-rich meat of this species made it welcomed by domestic and foreign markets with huge consumption. Therefore, large-scale artificial reproduction is becoming the start-point and breakthrough of the industrialization of *P. clarkii*. In this article, the morphological structure, biochemical composition, nutritional metabolism, enzyme activity, molecular and omics-study of embryonic development as well as the effects of ecological factors were reviewed. The research progress in the incubation in vitro in *P. clarkii* was overviewed as well. Finally, In order to solve the problem of mass production of shrimp larvae, the experiments of in vitro hatching and embryo transport of in vitro fertilized eggs of *P. clarkii* were carried out.

Key words: *Procambarus clarkii*; embryonic development; in vitro incubation; crustacean

棘头梅童鱼性别决定遗传基础的初步研究

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摘要: 性别决定机制是鱼类遗传育种学与繁殖生物学的研究热点。要深入理解鱼类性别决定相关知识, 尚需拓展研究对象, 特别是仍然空缺的多性染色体鱼类。棘头梅童鱼 (*Collichthys lucidus*) 是我国重要的海洋经济鱼类, 是石首鱼中目前已知唯一具有多性染色体系统的物种。课题组前期通过荧光染色、本种基因组原位杂交 (Self-GISH) 和多色荧光原位杂交 (M-FISH) 首次报道了棘头梅童鱼的多性染色体系统 ($X_1X_1X_2X_2/X_1X_2Y$), 雌性核型为 $2n=48t$, $NF=48$, 雄性核型为 $2n=46t+1sm$, $NF=48$ 。FISH 结果显示, X_1 染色体和 Y 染色体富含重复序列, 均检测出 18S 和 5S rDNA 和 (CAG) n 信号, X_1 上还特异分布臂间端粒和 (CAT) n 信号。为了进一步解析棘头梅童鱼性染色体的发生与进化, 我们结合 Illumina、PacBio 和 Hi-C 测序技术构建了染色体级别的参考基因组, 大小为 877.4 Mb, contigs N50 长度 1.10 Mb, scaffold N50 长度为 35.92 Mb, 染色体的挂载率为 96.86%。基于参考基因组, 我们进一步对棘头梅童鱼的性别决定区域 (SDR) 进行了定位与表征。SDR 被定位于 Chr. 1 的 4.3 Mb~4.9 Mb (0.6Mb 区间) 和 Chr. 7 的 26.8 Mb~28.7 Mb (1.9 Mb)。Chr. 1 前 23 Mb 基因组结构被发现与常染色体有较大区别, 各类重复序列含量均高于常染色体, 蛋白编码序列含量较低, 雌雄平均测序深度比约为常染色体的 1.5 倍。Chr. 1 的后 20 Mb 和 Chr. 7 未见明显区别于常染色体的特征。Chr. 1 SDR 的重复序列除 TR 外, 其余重复序列, 尤其是 LINE 和 LTR 含量高于常染色体; 但蛋白编码序列含量和测序深度却与常染色体更为接近。Chr. 7 SDR 的 TR 含量与 Chr. 1 SDR 相当, 而 LTR 含量高于常染色体, 除此之外, 未发现其他明显区别于常染色体的特征。在 Chr. 7 上发现一个 68 bp Y 特异缺失, 我们在此基础上开发了棘头梅童鱼性别分子标记。该标记适用于宁德和厦门样品, 但不适用于舟山样品。结合参考基因组, 性腺转录组和 SNP 注释结果, 最终筛查得 7 个候选雄性决定基因, 5 个候选雌性决定基因。在 SDR 中未发现其他物种中已经报道的性别决定基因。本探究结果为理解融合染色体对于性别决定区域和性别决定机制的影响奠定了基础, 同时也为后续进一步探究棘头梅童鱼性别决定基因提供了线索。

关键词: 棘头梅童鱼; 性染色体; 参考基因组; 性别决定区域

恒温高温调节对赤点石斑鱼幼鱼的生长、性腺发育以及 *gnrh*, *fshβ* 和 *lhβ* 基因表达的影响

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摘要: 以孵化后 120 到 420 日龄的赤点石斑鱼幼鱼为研究对象, 对照组为自然水温饲养, 实验组为 26 °C 恒温饲养, 比较两组中鱼的体长、体重、性腺指数(GSI)、性腺发育频率变化以及 *gnrh*、*fshβ* 和 *lhβ* 基因表达的差异。结果表明, 在 360、390 和 420 日龄的个体中, 实验组 GSI 显著高于对照组 ($P < 0.05$)。实验结束时, 对照组中未检测到卵黄形成期卵母细胞的个体, 但实验组在 330、360 和 390 日龄的幼鱼中确认出现了卵黄成熟期卵母细胞的个体。脑垂体中 *fshβ* 表达在 360、390 和 420 日龄, *lhβ* 在 390 和 420 日龄时, 实验组均显著高于对照组 ($P < 0.05$)。研究表明, 26 °C 恒温调节不仅能促进赤点石斑鱼幼鱼 GSI 的增加, 同时也能显著提高脑垂体中 *fshβ* 和 *lhβ* 基因含量, 从而加速性腺发育成熟。

关键词: 赤点石斑鱼; 高温; 生长; 性腺发育; *gnrh*; *fshβ*; *lhβ*

Effects of regulation with constant high water temperature on growth, gonadal development, as well as *gnrh*, *fshβ* and *lhβ* gene expression in the juvenile red spotted grouper *Epinephelus akaara*

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Abstract: The juvenile red spotted grouper from 120 to 420 days post hatching (dph) was used as target species. The fish in control group were fed under natural water temperature, and in experimental group they were fed with the constant water temperature at 26 °C. The gonadosomatic index (GSI), gonadal development frequency, as well as *gnrh*, *fshβ* and *lhβ* gene were measured, calculated, and compared between two groups. The results showed that at 360, 390, and 420 dph, the GSI in the experimental group was significantly higher than in the control group ($P < 0.05$). At the end of the trial, the vitellogenic oocytes were not detected in the control group. However, the vitellogenic oocytes were detected at 330, 360, and 390 dph in the experimental group. The *fshβ* gene levels at 360, 390 and 420 dph, and *lhβ* gene levels at 390 and 420 dph in the experimental group were significantly higher than in the control group ($P < 0.05$). These results suggest that the regulation of constant water temperature at 26 °C may not only promote the increase of GSI, but also significantly improve the *fshβ* and *lhβ* gene levels, and then accelerate the maturation for gonadal development in the juvenile red spotted grouper.

Key words: *Epinephelus akaara*; high water temperature; growth; gonadal development; *gnrh*; *fshβ*; *lhβ*

罗非鱼耐寒性能研究进展

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摘要: 罗非鱼是源自非洲的一种具有高经济价值的热带鱼, 其肉质鲜美, 营养价值高, 但却对低温十分敏感, 而处于越冬期的罗非鱼, 可能会无法忍低温, 导致该鱼的大量死亡进而造成损失。但目前罗非鱼低温致死的分子机制尚未可知。近年来, 国内外对罗非鱼耐寒性能进行了一些研究并取得一定的进展, 但罗非鱼安全越冬问题是长期困扰我国罗非鱼产业的主要技术问题, 罗非鱼耐寒新品种的选育对我国罗非鱼产业化发展具有重大的现实意义。然而, 我国罗非鱼品种选育的技术水平、种质资源利用率和新品种选育效率等方面与发达国家相比还有较大差距, 罗非鱼良种化率低, 不能满足渔业生产和市场发展的需求, 良种对渔业生产增长的贡献率低于发达国家近 50% 的水平。目前对于罗非鱼抗寒机制的研究主要集中在对罗非鱼体内抗冻蛋白以及相关耐寒的基因型等方面。

关键词: 罗非鱼, 耐寒性, 应激反应, 基因, 信号通路

Research progress on cold tolerance of Tilapia

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Abstract: Tilapia is derived from an African tropical fish with high economic value, its meat is delicious, high nutritional value, but it is sensitive to low temperature, while the overwintering tilapia may not be able to stand low temperature. resulting in a large number of deaths of the fish and resulting in losses. But the tilapia molecular mechanism of low temperature to death is not known. In recent years, domestic and foreign some research was conducted on the performance of tilapia hardy and made some progress, but tilapia safety overwintering problem is the main technical problem in tilapia industry in China for a long time, tilapia breeding of new varieties of hardy tilapia industrialization in China's development is of great practical significance. However, compared with developed countries, China still lags far behind in terms of the technical level of tilapia variety breeding, germplasm resource utilization and new variety breeding efficiency. tilapia entire hectareage rate is low, can't meet the needs of fishery production and market development, improved variety of fishery production, the contribution rate of growth is lower than the developed countries nearly 50% of the level. At present, tilapia of cold resistance mechanism research focuses on the tilapia fish antifreeze proteins in the body as well as the related cold-resistant genes, etc.

Keywords: Tilapia, cold tolerance, stress response, gene, signaling pathway

miR-30d 通过 Psen1/Notch2 信号通路调节南极 独角雪冰鱼的血管发育

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摘要: 南极冰鱼是目前已知的唯一缺乏血红蛋白和功能红细胞的脊椎动物, 其心血管系统呈补偿性增生。脊椎动物血管系统的发育受许多不同的转录因子、信号蛋白和 microRNA 的调控。已知 miRNAs 在转录后水平和转录水平上调控靶基因的表达。本研究通过 Western blotting 以及双荧光素酶和 EGFP 报告基因检测研究 miR-30d 介导的 Psen1 和 Notch2 的表达。机制上, Psen1 和 Notch2 在 miR-30d 的作用下协同调控血管发育。综上所述, 我们认为 miR-30d 是在 *C.hamatus* 发育过程中通过下调 Notch 信号通路中 Notch2 和 Psen1 的表达来调控血管发育的新型分子因子。

关键词: 南极冰鱼; miR-30d; 血管; Notch2; Psen1; 信号通路

miR-30d regulates vascular development via psen1/Notch2 pathway in *Chionodraco hamatus*

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Abstract: The Antarctic ice fish is the only vertebrate known to lack hemoglobin and functional red blood cells, and its cardiovascular system shows compensatory hyperplasia. The development of the vascular system in vertebrates is regulated by many different transcription factors, signaling proteins and microRNAs. The miRNAs are known to regulate the expression of their target genes at the post-transcriptional level and transcriptional level. In this study, western blotting as well as dual luciferase and EGFP reporter assays were employed to investigate the expression of Psen1 and Notch2 mediated by miR-30d. Mechanistically, Psen1 and Notch2 synergistically regulated vascular development under the action of miR-30d. In conclusion, we suggest that miR-30d is a novel molecular factor that regulates vascular development during the development of *C. hamatus* by down-regulating the expression of Notch2 and Psen1 in the Notch signaling pathway.

Key words: *Chionodraco hamatus*, miR-30d, vascular, Notch2, Psen1, signaling pathway

KDM4A 在斑马鱼 ZF4 细胞低温应激下的作用研究

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摘要: 为了探讨组蛋白赖氨酸特异性去甲基酶 4A (KDM4A) 在斑马鱼(*Danio rerio*) 胚胎成纤维细胞 (ZF4) 低温应激下的作用, 本研究在 ZF4 细胞中过表达斑马鱼 KDM4A (*kdm4aa* 和 *kdm4ab*), 检测自噬相关基因 *becn1* 和 *Map1lc3* 的表达, 用台盼蓝染色检测低温压力(18℃)下过表达 KDM4A 对 ZF4 细胞的自噬和存活率的影响。结果显示: (1) 过表达 *kdm4aa* 的 ZF4 细胞中 Beclin1 和 LC3 在 mRNA 和蛋白水平表达量均显著下调, 而过表达 *kdm4ab* 变化不显著。(2) 过表达 *kdm4aa* 的 ZF4 细胞在低温处理 1d 后存活率显著下降, 而过表达 *kdm4ab* 无明显变化。(3) 用自噬抑制剂 Bafilomycin A1 抑制自噬后, 能逆转 *kdm4aa* 过表达导致的低温下存活率下降。综上, 在低温应激下过表达 *kdm4aa* 基因通过下调自噬使细胞死亡增加。本实验为细胞在环境压力下表观遗传与自噬的作用机制研究奠定了基础。

关键词: KDM4A; ZF4 细胞; 自噬; 低温; Bafilomycin A1

Study on the effect of KDM4A on zebrafish ZF4 cells under low temperature stress

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Abstract: To investigate the effect of histone lysine specific demethylase 4A (KDM4A) on zebrafish embryonic fibroblast cells (ZF4) under low temperature stress, *KDM4A* (*kdm4aa* and *kdm4ab*) was overexpressed in ZF4 cells. The expression of autophagy related genes *becn1* and *Map1lc3* was detected. Trypan blue staining was used to detect the effect of KDM4A overexpression under low temperature pressure (18℃) on autophagy and survival rate of ZF4 cells. The results showed that: (1) mRNA and protein levels of Beclin1 and LC3 in ZF4 cells were significantly down-regulated by *kdm4aa* overexpression, but not by *kdm4ab* overexpression. (2) The survival rate of ZF4 cells overexpressing *kdm4aa*, but not *kdm4ab*, decreased significantly after 1d treatment at low temperature. (3) Pretreatment with autophagy inhibitor Bafilomycin A1 reversed the decrease of survival rate caused by *kdm4aa* overexpression under cold stress. In summary, under low temperature stress, *kdm4aa* overexpression in ZF4 cells increases cell death by down-regulating autophagy. This experiment laid a foundation for the study of the mechanism of epigenetics and autophagy in cells under environmental pressure.

Keywords: KDM4A; ZF4 cell; autophagy; low temperature; Bafilomycin A1

溶藻弧菌胁迫下厚壳贻贝的 miRNA-mRNA 调控网络：基于 miRNAome 和 transcriptome 测序

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摘要: 贻贝已发展成为研究软体动物环境胁迫应答机制的模式物种。本研究构建了溶藻弧菌胁迫前后厚壳贻贝的 small RNA 和 mRNA 文库, 并进行了深度测序。基于生物信息学手段分析了胁迫前后差异表达的 miRNAs 和 mRNAs, 并构建了 miRNA-gene-pathway 调控网络。在该网络中, 一些典型的免疫相关信号通路包括 toll 样受体信号通路, TGF- β 信号通路, 过氧化物酶体信号通路, 吞噬体信号通路等与特定的 miRNAs 和基因相互连接作用。TLR 信号通路中, 一些 TLR 受体基因包括 TLR1、TLR2、TLR4 和 TLR6, 及下游基因 IRAK1, TRAF6, MAPKs 和 IL-17 受到 novel_miR_11, novel_miR_145, novel_miR_196, novel_miR_5, novel_miR_163 和 novel_miR_217 等 miRNAs 调控。相关结果揭示了贻贝响应细菌胁迫时复杂的 miRNA-mRNA 调控网络, 为深入阐释软体动物先天免疫应答机制提供一个新方向。

关键词: 厚壳贻贝; miRNAome ; mRNAome

Integrated analysis of miRNAome and transcriptome reveals miRNA-mRNA network regulation in *Vibrio alginolyticus* infected thick shell mussel *Mytilus coruscus*

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Abstract: The *Mytilus coruscus* has developed into a model species for studying the interaction between molluscs and environmental stimuli. Herein, miRNA and mRNA libraries with or without *V. alginolyticus* challenge were constructed and sequenced, differentially expressed miRNAs and genes were analyzed by bioinformatics. A regulatory network was constructed, some traditional immune-related signaling pathways such as TLR, TGF-beta, peroxisome, and phagosome signaling pathway were linked to specific miRNAs and genes. Further, interactional relationship between miRNAs and TLR pathway was dissected, which the results predicted that TLRs and TLR-associated genes including TLR1, TLR2, TLR4, TLR6, IRAK1, TRAF6, MAPKs, and IL-17 were negatively regulated by novel_miR_11, novel_miR_145, novel_miR_196, novel_miR_5, novel_miR_163 and novel_miR_217. The integrated analysis with mRNA and miRNA sequenced data exhibited a sophisticated miRNA-mRNA network in *M. coruscus* in response to *V. alginolyticus* challenge, which shed a new light on the underlying mechanism of molluscs innate immune response.

Keywords: *Mytilus coruscus*; miRNAome; transcriptome

Hepcidin 对斑马鱼铁稳态的影响及胚胎发育的表观遗传研究

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摘要: 铁调素(Hepcidin)是肝脏特异性表达的一种阳离子小分子抗菌肽, 是调节体内铁平衡的重要激素。为了研究该基因对铁代谢的影响, 我们利用 *crispr/cas9* 敲除技术构建了斑马鱼 *hepcidin* 基因缺乏的体内模型, 发现 *hep*^{-/-} 肝脏颜色明显变浅; 通过切片的普鲁士蓝染色发现肝脏出现铁过载的现象; 且 *ferroportin* (膜铁输出蛋白) 作为 *hepcidin* 的受体显著性上调, 二者作用方式值得进一步探索。随着代际的增长, 胚胎死亡率大幅度增加, 也许与胚胎发育相关的基因被沉默有关。

关键词: 铁稳态; 铁调素; 铁输出蛋白; 表观遗传; 早期发育

Effect of Hepcidin on iron homeostasis of zebrafish and epigenetic study on embryonic development

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Abstract: Hepcidin is a cationic small molecule antimicrobial peptide specifically expressed in the liver and is an important hormone regulating iron balance in the body. In order to study the effect of this gene on iron metabolism, we used CRISPR/Cas9 knockout technology to construct the in vivo model of hepcidin gene deficiency in zebrafish, and found that *hep*^{-/-} liver became significantly lighter in color. The phenomenon of iron overload in liver was found by Prussian blue staining of sections. Moreover, *Ferroportin* is significantly up-regulated as the receptor of hepcidin, and the mode of action of the two is worthy of further exploration. There has been a significant increase in embryonic mortality with intergenerational growth, perhaps related to the silencing of genes associated with embryonic development.

Key words: iron homeostasis; hepcidin; ferroportin; early development

牡蛎四倍体新技术及产业应用和三倍体研究

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摘要: 通过贝类细胞工程技术, 我们研发了一个牡蛎四倍体诱导新技术, 在国内三大养殖种类 (长牡蛎、福建牡蛎和香港牡蛎) 中取得成功, 获得了四倍体群体并自繁成功; 随后采用二倍体×四倍体杂交方式在企业进行了生产性应用, 获得了良好结果。香港牡蛎倍性、环境及其相互作用对生长相关性状的影响研究显示, 相对于二倍体, 香港牡蛎三倍体的幼虫期和成贝期在生长、全重和存活方面有显著优势, 总体重性状上存在基于不同地点和倍性的明显差异, 但在地点与倍性间没有明显的相互作用。同时, 对香港牡蛎二倍体和三倍体的生化和营养成分的比较研究显示, 在繁殖期, 三倍体各组织的糖原含量显著性高于二倍体; 两者糖原合成酶和磷酸化酶的 qPCR 分析显示, 两个基因的表达模式与两者的糖原含量变化模式相对应; 特别的是在繁殖期和非繁殖期, 三倍体的四种必需脂肪酸明显高于二倍体; 而且, 三倍体的两类不饱和脂肪酸比例也明显高于二倍体。因此, 三倍体的的营养价值和味道品质高于二倍体。

关键词: 牡蛎; 四倍体; 产业应用; 三倍体研究

A new technique of tetraploid oyster, successful application and triploid oyster studies

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Abstract: We developed a new inducement technique of tetraploid oyster using cell engineering technology. Successful applications were made in three primary species of oysters, and then the self-breeding of tetraploid oysters was accordingly conducted. Fruitful all-triploidy seed production trials were carried out in commercial hatcheries. The first study of the effects of ploidy, site and their interaction on the grow-out traits was presented of *C. hongkongensis* reaching market size, and the clear advantage of triploid *C. hongkongensis* over diploids was confirmed at larvae and grow-out stages in terms of growth, whole weight and survival rate. Additionally, there were significant differences in whole weight based on both site and ploidy, but no significant interactions between site and ploidy were observed. The comparison of the biochemical composition and nutritional quality was made between diploid and triploid *C. hongkongensis*. Results showed that in the reproductive season, the glycogen content was significantly higher in triploids than in diploids, and in both diploid and triploid oysters, quantitative real-time PCR analysis of the glycogen synthesis gene (ChGS) and glycogen phosphorylase gene (ChGP) showed that the gene expression patterns matched the pattern of variation in glycogen content. Surprisingly, in both the reproductive and the non-reproductive phases, significantly higher percentages of four essential fatty acids were observed in triploids than in diploids. Additionally, the ratio of n-3/n-6 polyunsaturated fatty acids (PUFAs) was much higher in triploids than that in diploids. Overall, the triploid Hong Kong oyster has a better nutritional value and taste than the diploid in terms of glycogen content, protein quality and fatty acid content.

Key words: oysters, tetraploidy, commercial trial, triploid studies

日本沼虾卵巢发育阶段的比较代谢组学分析

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摘要: 在这项研究中, 我们系统地分析了日本沼虾五个不同卵巢发育阶段的 15 个样本, 以了解有关代谢产物如何随着生殖过程发生变化。89 种代谢产物和 14 种代谢途径在不同阶段有显著差异。据推测, N-乙酰基-N-甲酰基-5-甲氧基尿嘧啶、抗坏血酸、果糖-2,6-二磷酸、皮质酮和其他代谢物受激素调节, 与卵巢发育密切相关。采用定量聚合酶链式反应技术, 将植物次生代谢物生物合成途径中的基因变化与代谢物联系起来。我们发现 TCA 循环可能是雌性生殖期小型化的原因, 而通过水产养殖营养控制脂肪酸含量可能是调控成熟的外源性工具。本研究为日本沼虾卵巢发育提供了系统、全面的代谢组学分析, 为解决性成熟问题奠定了基础。

关键词: 性成熟; 能量代谢; 胆固醇代谢; 营养需求; 脂肪酸代谢; 表达验证

Comparative metabolomics analysis of ovarian developmental stages in *Macrobrachium nipponense*

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Abstract: In this study, we systematically analyzed 15 samples from five different ovarian developmental stages in *M. nipponense* to learn more about how metabolites change over reproduction. 89 metabolites and 14 pathways were significantly different across stages. It is hypothesized that N-acetyl-N-formyl-5-methoxykynurenamine, ascorbate, fructose-2,6-bisphosphate, corticosterone and other metabolites that significantly differed by stage are regulated by hormones and are closely related to ovarian development. Quantitative polymerase chain reaction was used to correlate gene changes to metabolites in the pathway for biosynthesis of plant secondary metabolites. We found that the TCA cycle rate may be the cause of female miniaturization during the reproductive period, and that the control of fatty acid content via aquaculture nutrition may be an exogenous tool for regulatory control of maturation. This study provides a systematic and comprehensive metabolomics analysis of ovarian development in *M. nipponense* and lays a foundation for addressing the problem of rapid sexual maturity.

Keywords: Sexual maturity, Energy metabolism, Cholesterol metabolism, Nutritional requirement, Fatty acid metabolism, Expression verification

基于 microRNAs 和 mRNAs 差异表达综合分析 的日本沼虾生殖相关 miRNAs 和基因的筛选

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摘要: 本研究中, 我们分析了雌性日本沼虾在繁殖期和非繁殖季节的眼柄 (E) 和脑神经节 (B) 的 micro RNA-seq 数据。在繁殖期与非繁殖期的眼柄和脑神经节组织中, 分别鉴定出 393 和 189 个差异表达的 miRNAs。富集分析表明, 差异表达 miRNA 靶基因主要参与“代谢过程”和“结合”, 并与“神经激素调节”和“光感受器活性”信号通路相关。从 miRNA-mRNA 差异表达的相互作用网络中选择了四对差异表达 miRNA 及其相应的目标注释基因。这四对基因在卵巢不同发育时期的表达分析表明, 它们在卵巢成熟过程中具有潜在的调控作用。

关键词: 日本沼虾; 综合分析; microRNAs; mRNAs; 生殖

Integrated analysis of differentially expressed microRNAs and mRNAs to screen miRNAs and genes related to reproduction in *Macrobrachium nipponense*

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Abstract: In this study, we characterized micro (mi) RNA-seq data of the eyestalk (E) and cerebral ganglia (B) of female *M. nipponense* during breeding and non-breeding seasons. A total of 393 and 189 differentially expressed miRNAs were identified in BSE vs. NBSE and BSB vs. NBSB, respectively. Enrichment analysis showed that DE miRNA target genes were mainly involved in ‘metabolic process’ and ‘binding’, and were associated with ‘neurohormonal regulation’ and ‘photoreceptor activity’ signaling pathways. Four pairs of DE miRNAs and their corresponding target annotated genes were selected from the DE miRNA-mRNA interaction network. Gene expression analysis of these four pairs in different ovary development stages showed their potential regulatory roles in ovary maturation.

Key words: *Macrobrachium nipponense*, Integrated analysis, microRNAs, mRNAs, Reproduction

不同光谱下罗非鱼幼鱼生长、应激和免疫响应

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摘要: 为了探究光谱对罗非鱼生长、应激和免疫的影响, 为罗非鱼工厂化养殖的光谱选择提供理论依据, 本实验比较了不同光谱(红,LDR;黄,LDY;蓝,LDB;绿,LDG;白,LDW)对吉富罗非鱼幼鱼的生长、应激和非特异性免疫等指标的影响。结果显示, 不同光谱对罗非鱼幼鱼的摄食和生长、应激反应及免疫性能有显著性影响。LDY 和 LDR 组幼鱼摄食率最高、生长最快, LDG 组最低(P<0.05)。LDY 组实验鱼血清溶菌酶活力显著高于其它 5 组(P<0.05); LDR 组实验鱼胃蛋白酶和淀粉酶活力均显著高于其它光谱组(P<0.05)。LDG 组罗非鱼幼鱼血浆中皮质醇浓度以及碱性磷酸酶活力显著高于其它光谱组(P<0.05)。本研究表明, 红、黄光对吉富罗非鱼幼鱼的生长具有积极影响, 而绿光使罗非鱼产生应急响应, 不利于其生长。因此, 在工厂化养殖生产中建议使用红、黄光照环境以提高罗非鱼福利水平和生产效率。

关键词: 罗非鱼; LED 光谱; 生长; 应激; 免疫

Growth, stress and immune responses of juvenile tilapia (*Oreochromis niloticus*) exposed to different light spectra

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Abstract: Juvenile GIFT tilapia (*Oreochromis niloticus*), 49.2±3.2 g, were exposed to different light spectra, including red (LDR), yellow(LDY), blue(LDB), green(LDG) and white(LDW) to investigate the effects of light spectra on growth, stress and immunity of juvenile tilapia. The results showed that light spectra had significantly different effects on the growth, stress and immunity of juvenile tilapia. The juvenile GIFT tilapia exposed to LDY and LDR exhibited higher feeding rate and body weight gain than those in other light colors, followed by LDB, LDW and LDG, with significant differences among all different light spectra groups(P<0.05). Activities of protease and amylase in the stomach of juvenile GIFT tilapia of LDR group were significantly higher than the other groups(P<0.05). The alkaline phosphatase activity and cortisol concentration in the plasma of juvenile GIFT tilapia in LDG group were significantly higher than those in other groups (P<0.05). And lysozyme activity in the serum of juvenile GIFT tilapia in LDY group was significantly higher than that in other groups (P<0.05). The findings above indicated that LDY and LDR had a positive effect on growth of juvenile GIFT tilapia, but the LDG induced a stress response in juvenile tilapia and had negative effect on fish growth. Therefore, the red and yellow light was recommended in the industrial culture of juvenile tilapia to improve fish welfare and productivity.

Key words: *Oreochromis niloticus*, LED light spectra, growth, stress, immunity

通过单细胞 RNA 测序分析斑马鱼 EVL 相关的 关键基因和通路

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摘要: 为了探究 EVL 在斑马鱼胚胎发育中相关功能, 本文通过对 4 小时的斑马鱼胚胎单细胞 RNA 测序分析, 计算出了斑马鱼中 EVL 更多的 marker 基因。我们利用 GO 和 KEGG 数据库对 marker 基因做了生物功能和相关通路的富集分析。此外, 本研究还针对计算出的 marker 基因构建了蛋白-蛋白相互作用网络(PPI), 对 EVL 标记的目标基因通过实时定量 PCR 计算了表达量。通过 GO 和 KEGG 富集分析发现 EVL marker 基因主要与细胞紧密连接、角蛋白纤维细胞骨架形成、节点信号通路、细胞间质发展等通路相关。我们通过与恒河猴胚胎单细胞 RNA 测序分析对比发现, EVL 的 marker 基因并没有在恒河猴某一组织发生特异性表达, EVL 有可能是鱼类特异进化的。同时, 斑马鱼 EVL 的 marker 基因 *krt4*、*krt8*、*grhl3*、*pou5f3* 与其他动物如恒河猴、小鼠等的同源基因相比发生了正选择, 也从侧面说明了 EVL 在进化上的保守性。

关键词: 包膜层; 斑马鱼; 单细胞 RNA 测序; 胚胎发育; qPCR

Analysis of key genes and pathways associated with the EVL by single-cell RNA sequencing in zebrafish

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Abstract: To explore the related functions of EVL in zebrafish embryo development, more marker genes of EVL in zebrafish were calculated by single-cell RNA sequencing. GO and KEGG database were used to do the accumulation analysis of biological functions and related pathways of marker genes. In addition, this study also constructed a protein-protein interaction network (PPI) for the marker genes, selected out EVL labeled genes through comprehensive analysis, and calculated the expression quantity of these genes through qPCR. We found that EVL marker gene was mainly related to cell tight connection, keratin filament, node signaling pathway and other pathways by GO and KEGG enrichment analysis. By comparing with rhesus monkey 16-cell, morula and blastocyst embryonic single-cell RNA sequencing analysis, we found that marker gene of EVL was not specifically expressed in a rhesus monkey tissue, and EVL may have evolved specifically in fish. At the same time, zebrafish EVL marker genes *KRT4*, *KRT8*, *Grhl3* and *Pou5F3* were positively selected compared with the homologous genes of other animals such as rhesus monkeys and mice, which also indicated the conservatism of EVL in evolution from the side.

Keywords: EVL; zebrafish; single-cell RNA sequencing; Embryonic development; qPCR

花鲈 I 型 IFN α 的克隆和免疫刺激下的功能分析

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摘要: 为研究花鲈 I 型干扰素 (LmIFN α) 在先天免疫中的作用, 本研究获得了花鲈 LmIFN α cDNA 全长、重组表达蛋白、病毒和细菌刺激下 LmIFN α 表达变化及其对下游基因的调控作用。研究表明, 在病毒和细菌感染中, LmIFN α 可能通过调控 Mx, ISG15 等下游基因发挥保护作用。

关键词: 花鲈; 干扰素; 全长 cDNA; 先天免疫

Molecular cloning and functional analysis of Type I IFN α of *Lateolabrax maculatus* under immune stimulation

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Abstract: In order to study the role of interferon type I (LmIFN α) in innate immunity of *Lateolabrax maculatus*, we obtained the full length of LmIFN α cDNA, the LmIFN α recombinant protein, the expression changes of LmIFN α stimulated by virus and bacteria, and the regulation of LmIFN α on downstream genes. The results indicate that LmIFN α may play a protective role in viral and bacterial infection by regulating downstream genes such as MX and ISG15.

Key words: *Lateolabrax maculatus*; Interferon; Complete cDNA; Innate immunity

相手蟹科物种线粒体基因组比较分析及其系统发育意义

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摘要: 线粒体基因组全序列为更好地理解基因重排、分子进化和系统发育提供了重要信息。本研究首次测定了多疣相手蟹 (*Episesarma lafondii*) 和尤默尔拟相手蟹 (*Parasesarma eumolpe*) 的线粒体基因组全序列。本文对这两个物种的基因组特征进行了描述, 并与其它 9 种相手蟹进行了比较分析。Ka/Ks 比值分析表明, 13 个蛋白编码基因都受到纯化选择。与典型甲壳动物线粒体基因组相比, 两种相手蟹的 tRNA-His 和 tRNA-Gln 基因都发生了易位, 并认为串联重复-随机丢失是最有可能导致该重排现象发生的模型。系统发育分析表明, 相手蟹科所有物种都归为一个类群, 并支持了酋妇蟹总科、沙蟹总科和方蟹总科的多系性。发生重排的区域 G1(Q 与 I 之间的间隙) 和 G2(I 与 M 之间的间隙) 的长度随着物种进化呈不断退化的趋势, 表明重排区域可以为相手蟹科系统发育提供线索。这些结果将有助于更好地理解相手蟹线粒体基因组进化, 并为短尾目的系统发育研究提供新的思路。

关键词: 相手蟹; 线粒体基因组; 基因重排; 系统发育分析

Comparative mitochondrial genome analysis of Sesarmidae and its phylogenetic implications

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Abstract: Complete mitochondrial genome (mitogenome) provides important information for better understanding of gene rearrangement, molecular evolution and phylogenetic analysis. In this study, we sequenced the complete mitogenomes of *Episesarma lafondii* and *Parasesarma eumolpe* for the first time. The features of these two mitogenomes were described and compared with the other nine Sesarmidae crabs. The Ka/Ks ratio analysis shows that all 13 PCGs are under purifying selection. The tRNA-His and tRNA-Gln genes in two sesarmid crabs appeared to be translocated with respect to the gene arrangement in ancestral crustaceans, and tandem duplication/random loss model is determined as most likely to explain the observed gene rearrangements. Phylogenetic analyses show that all Sesarmidae species are placed into one group, and the polyphyly of Eriphioidea, Ocypodoidea, and Grapsoidea is well supported. The lengths of G1 (the gap between Q and I) and G2 (the gap between I and M) show a degenerating trend with the evolution process, which indicates that the gaps in the rearranged region can provide clues for the phylogeny of Sesarmidae crabs. These results will help to better understand the genomic evolution within Sesaemidae and provide insights into the phylogenetic studies of Brachyura.

Key words: Sesarmid crab; Mitogenome; Gene rearrangement; Phylogenetic analysis

刀鲚 *PPAR γ* 基因的 cDNA 克隆及其应激应答

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摘要: 旨在研究刀鲚(*Coilia nasus*)过氧化物酶体增殖物激活受体 γ (peroxisome proliferator activated receptor, PPAR γ)基因的应激调控表达,克隆并获得了刀鲚 PPAR γ 基因的 cDNA 全长。刀鲚 PPAR γ 基因的 cDNA 全长 1951 bp,开放阅读框 1470 bp,预测编码 489 个氨基酸。刀鲚 PPAR γ 包括 4 个功能结构域,即 A/B 区, DNA 结合区(DNA binding domain, DBD 区),铰链区,配体结合区(ligand binding domain, LBD 区)。运用(real time quantitative PCR, RT-qPCR)检测刀鲚 PPAR γ 基因在不同组织、运输胁迫和胚胎发育时期的表达。结果显示,刀鲚 PPAR γ 在各组织中均有表达,其中在肝中表达量最高,在脑、肠、心脏、肾、头肾、肌肉中相对高表达,在鳃和脾中微量表达。运输胁迫过程中,PPAR γ 基因表达显著上调($P < 0.05$),在 4 h 达到峰值,随后显著降低,但仍高于对照组。PPAR γ 在胚胎发育时期各时期均表达,其中在受精卵时期高表达,随后表达量急剧降低,并在此后的时期一直处于较低的表达水平。PPAR γ 基因在应激过程中发挥重要作用,也是胚胎发育过程中重要的基因。本研究为刀鲚的人工繁育和应激调控提供了理论基础。

关键词: 刀鲚;PPAR γ ;应激应答;运输应激;胚胎表达;

Cloning and stress response of PPAR γ gene in *Coilia nasus*

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Abstract: In order to study the stress regulated expression of peroxisome proliferator activated receptor (PPAR γ) gene in *Coilia nasus*, full length cDNA of PPAR γ gene was cloned and obtained. Full length cDNA of the gene was 1951 bp, with an open reading frame of 1470 bp, encoding 489 amino acids. PPAR γ consisted of four functional domains: A / B domain, DNA binding domain (DBD), hinge domain and ligand binding domain (LBD). The results of RT q-PCR showed that PPAR γ was expressed in all tissues of *Coilia nasus*, with the highest expression in liver, relatively high expression in brain, intestine, heart, kidney, head kidney and muscle, and trace expression in gill and spleen. PPAR γ was significantly up-regulated during transport stress ($P < 0.05$), peaked at 4 h, and then decreased significantly, but still higher than control. PPAR γ was expressed in all stages of embryonic development, which was highly expressed in fertilized egg stage, then decreased sharply, and remained at a low level in following period. PPAR γ gene played an important role in the process of stress and was an important gene in embryonic development. This study provided a theoretical basis for artificial breeding and stress regulation of *Coilia nasus*.

Key words: *Coilia nasus*, PPAR γ , stress response, transport stress, embryonic expression

通过代谢组学研究欧洲舌齿鲈幼鱼生长发育 对温度的响应机制

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摘要: 本文主要通过代谢组学, 对 10 °C、15 °C、20 °C 温度条件下养殖 60 天后, 将 10 和 15 °C 调温到 20 °C 再养殖 62 天后的欧洲舌齿鲈的肝脏组织进行分析, 来解析温度调控欧洲舌齿鲈生长发育的响应机制。研究结果表明: 20 °C 条件下欧鲈生长最快, 15 °C 次之, 10 °C 最慢; 10 °C 和 15 °C 温度胁迫后的欧洲舌齿鲈发生了部分补偿生长。我们筛选到的主要肝脏标志代谢物包括: L-胱氨酸、牛磺胆酸、UDP-葡萄糖、左旋甲状腺素。涉及的主要代谢通路包括: 酪氨酸代谢通路、色氨酸代谢通路、牛磺酸代谢通路和胆汁分泌通路等。结果表明, 温度可诱导欧洲舌齿鲈能量相关代谢通路发生显著变化, 促使鱼体发生补偿生长效应。本研究结果可为欧洲舌齿鲈的高效养殖提供理论基础和技术指导。

关键词: 代谢组学; 欧鲈舌齿鲈; 温度胁迫; 肝脏; 补偿生长

Metabolomics analysis of temperature in responding on the growth and development of juvenile European seabass (*Dicentrarchus labrax*)

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Abstract: In our study, the liver of European seabass (*Dicentrarchus labrax*) cultured at 10 °C, 15 °C and 20 °C for 60 days and then cultured at 10 and 15 °C to 20 °C for 62 days were analyzed by metabolomics to analyze the mechanism of temperature regulation on the growth and development of it. The results showed that the growth speed of European seabass from high to low was group of 20 °C, 15 °C and 10 °C. Fish cultured after 62 days at 20 °C, the European seabass grew partially after temperature stress at 10 °C and 15 °C. Differentially expressed metabolites identified including L-cysteine, taurocholic acid, UDP-glucose and L-thyroxine were mainly belong to metabolic pathways like tyrosine metabolic pathway, tryptophan metabolic pathway, taurine metabolic pathway and bile secretion pathway. Our work show that temperature could active significantly the energy-related metabolic pathways and of the compensatory growth effect of European seabass. Our research can provide theoretical basis and technical guidance for efficiently culturing European seabass.

Keywords: Metabolomics, *Dicentrarchus labrax*, Temperature stress, Liver, Compensatory growth

织锦巴非蛤橘色斧足中色素物质的分离与鉴定

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摘要: 织锦巴非蛤斧足的颜色存在显著差异, 从白到黄, 深浅不一。与白色斧足相比, 织锦巴非蛤橘色斧足中的类胡萝卜素含量更高, 但具体类胡萝卜素的种类以及是否存在其他的色素物质尚不清楚。本研究首先用丙酮萃取织锦巴非蛤橘色斧足中的色素, 再利用液质联用仪对提取的色素进行检测, 共检测出 47 种化学物质, 有 13 种脂类、9 种萜类、9 种有机酸、7 种氨基酸及其衍生物类、2 种视黄醇和其它 7 种物质, 其中 β -doradecin (3'-hydroxy-3,4-diketo- β -carotene) 是斧足主要呈色物质。本次研究将有助于解析织锦巴非蛤斧足中色素沉积的分子机理, 为选育高品质的织锦巴非蛤奠定基础。

关键词: 织锦巴非蛤; 斧足; 类胡萝卜素; 成分分析; β -doradecin

Isolation and identification of pigment substances in orange feet of *Paphia textile*

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Abstract: *Paphia textile* is an economically important shellfish cultured in south-eastern of China. Feet, as the main edible part of *P. textile*, varies in colour from white to orange. Previous studies have suggested that the orange feet of *P. textile* contain higher carotenoids than the white one, but which kinds of carotenoid are not known. The pigment identified in this study will facilitate the further analysis of its underlying molecular mechanism, and the breeding of *P. textile* with high carotenoid content. The pigments were extracted from orange feet of *P. textile* by acetone extraction method, and then extracted pigments were detected by liquid chromatography-mass spectrometry (LC-MS). Moreover, the MS analysis was carried out by the electrospray ionization (ESI) source in the positive (ESI+) and negative (ESI-) ion mode. A total of 47 substances were detected, including 9 terpenoids, 7 amino acids and peptides, 13 lipids, 9 organic acids, 2 types of vitamin A and 7 other substances. Furthermore, β -doradecin (3'-hydroxy-3,4-diketo- β -carotene) was identified the main pigment in feet. This is the first report of β -doradecin in bivalves, a type of carotenoid, in the feet of *P. textile*.

Key words: *Paphia textile*, Feet, Carotenoid, Composition analysis, β -doradecin

整合代谢组和转录组分析揭示热应激影响大菱鲆的脂代谢

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摘要: 为了阐释热应激对大菱鲆脂代谢的影响, 我们将大菱鲆在不同温度刺激的肾脏转录组数据和代谢组数据进行了关联分析。分别鉴定出差异常表达的基因和代谢物, 并通过 KEGG 通路分析富集到与脂代谢相关的 7 条通路(固醇激素生物合成、初级胆汁酸生物合成、甘油磷脂代谢、亚油酸代谢、鞘磷脂代谢、甘油磷脂代谢和不饱和脂肪酸生物合成)。对这 7 条通路中差异表达的基因和代谢物进行关联分析后, 根据相关性系数选取了最具代表性的 6 个基因(*lpcat2*、*Etnk1*、*TAZ*、*SCP2*、*ch25hl*、*gpd1l*)和 5 个代谢物(胞二磷胆碱、UPD -6-磺喹啉、二羟丙酮、牛磺酸、邻磷胆碱)。研究发现, 这些差异基因和代谢物在热应激下通过不同程度的上调或下调, 在维持脂质稳态和细胞膜流动性方面发挥重要作用。研究结果为理解热胁迫下鱼类脂代谢的调控作用提供了新的线索。

关键词: 大菱鲆; 代谢组; 转录组; 热应激; 脂质代谢

Integrated metabolome and transcriptome analyses reveal the effects of thermal stress on lipid metabolism in *Scophthalmus maximus*

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Abstract: To gain insights into the influence of heat stress on lipid metabolism in turbot, we analyzed the correlations between data obtained by transcriptome sequencing and metabolome sequencing of the kidney under different temperature stimuli. We identified the differentially expressed genes and metabolites, which were found to be enriched in seven pathways (steroid hormone biosynthesis, primary bile acid biosynthesis, glycerophospholipid metabolism, linoleic acid metabolism, sphingolipid metabolism, glycerolipid metabolism and biosynthesis of unsaturated fatty acids) associated with lipid metabolism, according to KEGG pathway analysis. After correlation analysis, the most representative genes (*lpcat2*, *Etnk1*, *TAZ*, *SCP2*, *ch25hl* and *gpd1l*) and metabolites (citicoline, UPD-6-sulfoquinovose, dihydroxyacetone, taurine and o-phosphocholine) were selected according to their correlation coefficients. These differential genes and metabolites play an important role in maintaining lipid homeostasis and cell membrane fluidity by up-regulating or down-regulating in different degrees under heat stress. The results provide a new clue for understanding the regulation of fish lipid metabolism under heat stress.

Key words: *Scophthalmus maximus*; metabolome; transcriptome; heat stress; lipid metabolism

大口黑鲈北方亚种群体和“优鲈 1 号”群体及其正反杂交子代的遗传和生长性能比较

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摘要:为解决国内养殖的大口黑鲈 (*Micropterus salmoides*) 群体遗传多样性下降问题,以引进的大口黑鲈北方亚种群体 (N) 和大口黑鲈“优鲈 1 号” (G) 为亲本,通过自交和正反杂交获得 4 个大口黑鲈子代群体 (N、G、NG 和 GN),并对其进行遗传多样性分析和生长性能比较。结果显示,12 对微卫星引物在 120 尾样本中共扩增到 126 个等位基因,N、G、NG 和 GN 群体的期望杂合度 (H_e) 分别为 0.491、0.454、0.553 和 0.519,观测杂合度 (H_o) 分别为 0.519、0.480、0.729 和 0.664,多态信息含量 (PIC) 分别为 0.407、0.412、0.454 和 0.425。结果表明,NG 和 GN 群体的遗传多样性均高于 N 和 G 群体,NG 群体的遗传多样性最高。生长对比发现,GN 群体的绝对生长率 (AGR) 和特定生长率 (SGR) 均高于其他群体。研究结果可为大口黑鲈良种培育和遗传改良提供科学依据。

关键词: 大口黑鲈;杂交;微卫星;遗传多样性;生长性能

Comparison analysis of genetic diversity and growth traits among “Youlu No.1” and their reciprocal hybrids of northern *Micropterus salmoides*

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Abstract: In order to improve the decreasing genetic diversity of *Micropterus salmoides* in China, four populations (N、G、NG and GN) were obtained through crossing between an imported northern *Micropterus salmoides* group from America and “Youlu No.1 ” to analyze the genetic diversity and growth performance. Results showed that a total of 126 alleles were amplified from 120 samples with 12 pairs of microsatellite primers. The average expected heterozygosity of the four populations N, G, NG and GN was 0.491, 0.454, 0.553 and 0.519, respectively; the average observed heterozygosity of N, G, NG and GN was 0.519, 0.480, 0.729 and 0.664, respectively; and the average polymorphic information content values were 0.407, 0.412, 0.454 and 0.425, respectively. These results indicated that the genetic diversities of NG and GN were higher than those of N and G, and the absolute growth rate (AGR) and specific growth rate (SGR) of GN were significant higher than others. The study will provide valuable information to improve the genetic breeding of *Micropterus salmoides*.

Key words : northern *Micropterus salmoides*; hybridization; SSR; genetic diversity; growth performance

吉富罗非鱼 *TRIM35* 基因的克隆及功能初探

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摘要: 为揭示 *TRIM35* 在吉富罗非鱼 (*Oreochromis niloticus*) 免疫应答中的作用, 本实验对克隆获得的 *OnTRIM35* cDNA 序列进行生物信息学分析并初步分析其在固有免疫通路中的作用。*OnTRIM35* 可编码 503 个氨基酸, 与其它鱼类同源性达 60% 以上, 与人同源性为 27%。预测蛋白结构具有高度保守的 RING、B-Box 和 SPRY 结构域。*OnTRIM35* 在脾脏和心脏中表达量最高。此外, 体内感染无乳链球菌、LPS 和 Poly(I:C) 后, *OnTRIM35* 表达量显著变化。亚细胞定位表明 *OnTRIM35* 分布在细胞质中。在 293T 细胞系中, TRAF3 可显著增强 *OnTRIM35* 依赖的核因子 κ B (Nuclear factor- κ B, NF- κ B) 活性, IRF7 对 *OnTRIM35* 依赖的 NF- κ B 活性无显著影响。免疫共沉淀显示 *OnTRIM35* 与 IRF7 无相互作用。由此推测, *OnTRIM35* 可能参与了 NF- κ B 信号通路的正调控。

关键词: TRIM35、吉富罗非鱼、表达谱、先天免疫、NF- κ B 活性

Molecular characterization and functional analysis of *TRIM35* in GIFT strain Nile tilapia (*Oreochromis niloticus*)

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Abstract: In order to GIFT strain Nile tilapia (*Oreochromis niloticus*), the cloned *OnTRIM35* cDNA sequence was analyzed by bioinformatics and its role in the innate immune pathway was analyzed. *OnTRIM35* encoded a polypeptide of 503 amino acids, which showed 60% and 27% homology with other fishes and human (*Homo sapiens*). Protein structure prediction indicated that *OnTRIM35* contained RING, B-Box and SPRY domain. The highest expression level of *OnTRIM35* was detected in the spleen and heart. In addition, after infection with *Streptococcus agalactiae*, LPS and Poly(I:C), the transcripts of *OnTRIM35* was significantly changed in all tested tissues. Subcellular localization showed that *OnTRIM35* was distributed in the cytoplasm. After co-transfection with *OnTRAF3*, the *OnTRIM35*-dependent nuclear factor- κ B (NF- κ B) activity was significantly increased ($p < 0.05$). *OnIRF7* had no effect on *OnTRIM35*-induced NF- κ B activation. Co-immunoprecipitation (Co-IP) assays did not show the interaction between *OnTRIM35* and IRF7. Taken together, we speculated that *OnTRIM35* plays an important role in the innate immune response.

Key words: TRIM35, GIFT strain Nile tilapia, Expression profile, Innate immunity, NF- κ B activity

日本沼虾 DNA 聚合酶 zeta 催化亚基潜在新功能的鉴定：克隆、qPCR、原位杂交和 RNAi 分析

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摘要: 本研究旨在分析日本沼虾(*Macrobrachium nipponense*, Mn-Rev3)DNA 聚合酶 Zeta 催化亚基(Rev3)的功能。Mn-Rev3cDNA 序列全长 6832bp, 开放阅读框 6102bp, 编码 2033 个氨基酸。在发育过程中, Mn-Rev3 在幼虫第 15 天表达最高, 在幼虫后第 1 天(PL1)至第 15 天相对较高, 表明 Mn-Rev3 在促进日本沼虾变态和性腺分化发育中起重要作用。在精细胞、精母细胞和精子中检测到较强的 Mn-Rev3 信号。这一结果表明, Rev3 促进了日本沼虾的整个精巢发育, 尤其是精子的发育。注射 Mn-Rev3 双链 RNA 后, Mn-胰岛素样雄激素(Mn-IAG)的表达水平和睾酮含量与 Mn-Rev3 的表达模式一致, 表明 Rev3 对日本沼虾的雄性分化和发育有积极的促进作用。

关键词: 日本沼虾; Rev3; 性腺分化; RNAi

Identification of potentially novel functions of DNA polymerase zeta catalytic subunit in oriental river prawn, *Macrobrachium nipponense*: cloning, qPCR, in situ hybridization and RNAi analysis

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Abstract: The goal of this study was to analyze the functions of DNA polymerase zeta catalytic subunit (Rev3) in the oriental river prawn *Macrobrachium nipponense* (Mn-Rev3). The full length of Mn-Rev3 cDNA sequence was 6832 base pairs (bp) with an open reading frame of 6102 bp encoding 2033 amino acids. During development, expression of Mn-Rev3 was highest on larval day 15 and relatively high from post-larval day 1 (PL1) to PL15, indicating that it played essential roles in promoting metamorphosis and gonad differentiation and development in *M. nipponense*. Strong Mn-Rev3 signals were detected in spermatids, spermatocytes, and sperm in the testes. This result indicated that Rev3 promoted whole testis development, and especially sperm development. The expression level of Mn-insulin-like androgenic gland hormone (Mn-IAG) and the content of testosterone showed the same expression pattern as that of Mn-Rev3 after injection of double-stranded RNA of Mn-Rev3, which indicated that Rev3 had positive effects on male sexual differentiation and development in *M. nipponense*.

Key words: *Macrobrachium nipponense*, Rev3, Sexual differentiation, RNAi

深渊钩虾微量元素的分析

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摘要: 端足目是深海生物的重要组成部分, 在深海系统中发挥着关键作用。为了探究深渊区域不同钩虾体内元素含量的差异, 以及其长期在高压低温环境下体内微量元素的改变。针对来自新不列颠海沟 (*Alicella gigantean*), 马里亚纳海沟 (*Hirondellea gigas*) 和玛索海沟 (*Scopelocheirus schellenbergi*) 三种钩虾样品, 本研究采用微波消解电感耦合等离子体质谱法 (ICP-MS) 测定了 *A. gigantean*、*H. gigas* 和 *S. schellenbergi* 的骨骼、腿部肌肉和肠道组织样品中元素 V, Cr, Mn, Fe, Co, Ni, Se, Mo, Ag and Cd 的含量, 对三种钩虾的元素进行显著性差异分析, 并找浅海端足目作对照。结果表明深渊微量元素含量明显高于浅海生物的微量元素的含量, Mn 和 Se 元素在骨骼、肌肉和肠道中的含量都比较高, 而且这两种元素都与生长发育有密切的联系。推测这种差异可能是端足目钩虾长期适应深渊环境有关。本研究在国内首次使用微波消解法对三种钩虾内脏和腿部中的常量元素和微量元素进行测定分析, 有效探究了三种钩虾体内元素的差异, 为后续通过体内组织元素分析深渊钩虾适应低氧环境的生理差异比较提供了依据。

关键词: 端足目; 深渊; 微量元素; 元素分析

Analysis of trace elements of abyssal Amphipods

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Abstract: Amphipods were regarded as a key factor in deep ocean ecosystem due to their important impacts on the hadal environment. In order to explore the differences of the contents of elements in different amphipods in the abyss region and the changes of trace elements in their bodies under the long-term environment of high pressure and low temperature. we collected three amphipods species sampled *Alicella gigantean*, *Scopelocheirus schellenbergi* and *Hirondellea gigas* from three sampling sites including New Briton Trench, Mariana Trench and Marceau Trench. We detected trace elements (V, Cr, Mn, Fe, Co, Ni, Se, Mo, Ag and Cd) of the three hadal amphipod by using inductively coupled plasma mass spectrometry (ICP-MS) method. The significant difference of the elements of three kinds of amphipods was analyzed, and the shallow sea amphipods was compared. Results showed that trace elements accumulation is greater in the abysmal sea than in the shallow sea in shrimp from all areas, the content of Mn and Se is relatively high in exoskeleton, leg muscle and gut and both Mn and Se are closely related to growth and development. These results might be related to long-term adaptation of amphipod in the hadal environment. Our study firstly unfolded element concentrations of the three amphipod. And the results will provide some scientific basis for the physiological difference comparison studies between hadal amphipod through tissue element analysis.

Key Words: amphipod, hadal zone, trace elements, element analysis.

瓦氏黄颡鱼在鮰爱德华氏菌感染下的肝脏蛋白组学分析

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摘要: 鮰爱德华氏菌可以引起鲶形鱼类的主要疾病肠道败血症。本论文以瓦氏黄颡鱼为研究对象, 运用 iTRAQ 技术在鮰爱德华氏菌感染 24 小时后探究该鱼肝脏组织蛋白质水平的免疫应答反应。结果显示: 在 2608 个总蛋白中共发现 819 个差异表达蛋白, 包括 6 个上调蛋白和 813 个下调蛋白, GO 富集分析表明, “Complement activation, alternative pathway”和“Complement activation, classical pathway”被显著富集($P < 0.05$), KEGG 富集分析表明, “antigen processing and presentation”和“bacterial secretion system”被显著富集, 表明这些生物学过程在鮰爱德华氏菌感染后发挥重要的作用; 最后, 本论文运用荧光定量 PCR 检测了免疫相关的 6 个上调蛋白和 10 个下调蛋白, 发现其验证结果与 iTRAQ 定量结果一致。这是首次瓦氏黄颡鱼应对鮰爱德华氏菌感染的蛋白质组学研究, 其结果有助于我们了瓦氏黄颡鱼肝脏的防御机制。

关键词: 瓦氏黄颡鱼; 肝脏; 蛋白质组学; iTRAQ; 鮰爱德华氏菌

iTRAQ analysis of liver immune-related proteins from darkbarbel catfish (*Pelteobagrus vachelli*) infected with *Edwardsiella ictaluri*

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Abstract: *Edwardsiella ictaluri* causes enteric septicemia of catfish (ESC), a major disease occurring in these siluriform fish. This study aimed to determine the liver immune response to *E. ictaluri* after 24 h at the protein level in darkbarbel catfish. A total of 819 differentially expressed proteins were reliably quantified in 2608 proteins using iTRAQ technology, including 6 up-regulated proteins and 813 down-regulated proteins. GO enrichment analysis indicated that the “complement activation, alternative pathway” and “complement activation, classical pathway” were significantly enriched. KEGG enrichment analysis indicated the “antigen processing and presentation” and “bacterial secretion system” were significantly enriched. The real-time PCR verification results of 6 up-regulated proteins and 10 immune-related down-regulated proteins are consistent with iTRAQ results. This is the first report detailing the proteome response in the darkbarbel catfish liver during *E. ictaluri* infection and markedly contributes to our understanding of the defense mechanisms in the livers of darkbarbel catfish.

Key words: Darkbarbel catfish, Liver, Proteomics, iTRAQ, *Edwardsiella ictaluri*

4 种河鲀全基因组微卫星分布特征分析研究

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摘要: 本研究利用 MISA 软件对 4 种河鲀全基因组中的微卫星进行筛选并分析。结果如下: 在红鳍东方鲀 *Takifugu rubripes* (391.49 Mb)、菊黄东方鲀 *Takifugu flavidus* (366.29 Mb)、双斑东方鲀 *Takifugu bimaculatus* (371.68 Mb) 及黑青斑河鲀 *Tetraodon nigroviridis* (342.40 Mb) 全基因组中, 分别筛选出 142 885 个、135 009 个、147 549 个和 179 703 个完整型微卫星。微卫星总长度分别占基因组序列总长度的 0.73%、0.73%、0.84% 和 1.06%。在 1~6 不同碱基重复类型完整型微卫星中, 4 种河鲀的 6 种碱基类型数目排序是一致的。均是单碱基重复数目最多, 然后依次是二碱基、三碱基、四碱基、五碱基和六碱基。东方鲀属 3 种河鲀基因组微卫星分布特征极为相似, 分析红鳍东方鲀和双斑东方鲀的遗传距离可能更为接近。鲀属黑青斑河鲀与其他 3 种东方鲀属河鲀在微卫星总数、微卫星相对丰度和密度、部分碱基类型数目及类别方面和东方鲀属差距较大。这可能与两属鱼类地理分布及进行滑动复制的碱基组成有关。推测东方鲀属和鲀属基因组可能具有独特的进化机制。

关键词: 河鲀, 基因组, 微卫星, 特征分析

Analysis of Distribution Characteristics of Microsatellites in the Four Genomes of Puffer Fish

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Abstract: In this study, MISA software was used to screen and analyze the microsatellites in the four genomes of puffer fish. The results were as follows: in the genome of *Takifugu rubripes* (391.49 Mb), *Takifugu flavidus* (366.29 Mb), *Takifugu bimaculatus* (371.68 Mb) and *Tetraodon nigroviridis* (342.40 Mb), 142 885, 135 009, 147549 and 179 703 perfect microsatellites were screened, respectively. The total lengths of the microsatellites were, respectively, accounting for 0.73%, 0.73%, 0.84% and 1.06% of the total length of the genome sequence. Among the complete microsatellites with 1~6 different base repeat types, the orders of 6 base types from four species of puffer fish were the same. Each has the largest number of mononucleotide repeats, followed by dinucleotide repeats, trinucleotide repeats, tetranucleotide repeats, pentanucleotide repeats, and hexanucleotide repeats. The distribution characteristics of the microsatellites from the three species of *Takifugu* were very similar. The genetic distances of *Takifugu rubripes* and *Takifugu bimaculatus* might be closer. There were big gaps in the total number of microsatellites, the relative frequency and density of microsatellites, the number and type of partial microsatellites types in the four species, which might be related to the geographical distribution of two genus and the base composition of sliding replication. It was speculated that the genomes of *Takifugu* and *Tetraodon* might have unique evolutionary mechanisms.

Key words: Puffer fish, Genome, Microsatellite, Characteristics

日本沼虾缺氧和复氧条件下 MnGPx-3 和 MnGPx-4 的分子克隆，表达和原位杂交分析

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摘要: 谷胱甘肽过氧化物酶(GPx)作为一种抗氧化剂, 在活性氧(ROS)诱导损伤中起重要作用。研究 GPxs 与日本沼虾的相关性是因为日本沼虾对缺氧的耐受性较差。根据谷胱甘肽过氧化物酶命名系统, 这两个亚型分别被命名为 MnGPx-3 和 MnGPx-4。在本研究中, 我们分析了日本沼虾中两个 GPxs 的表达对环境氧气变化的应答。MnGPx-3 和 MnGPx-4 的表达水平表明两者对缺氧都有强烈的反应。原位杂交结果表明 GPx 基因是由分泌细胞表达和释放的, 并对缺氧产生反应。然而, 在鳃组织中, GPxs 位于血细胞中, 这表明它们在不同的组织或器官中执行不同的功能。本研究为了解日本沼虾在缺氧条件下的氧化应激反应提供了基础。

关键词: 日本沼虾; 低氧; 复氧; mRNA 表达; 原位杂交

Molecular cloning, expression, and in situ hybridization analysis of MnGPx-3 and MnGPx4 from oriental river prawn, *Macrobrachium nipponense*, in response to hypoxia and reoxygenation

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Abstract: Glutathione peroxidase (GPx) has been the focus of increased research because of its important role as an antioxidant and in reactive oxygen species (ROS) induced damage repair. Studies on GPxs have relevance with *Macrobrachium nipponense* because it has poor tolerance to hypoxia in *M. nipponense*. The two subunits named as MnGPx-3 and MnGPx-4 according to the glutathione peroxidase nomenclature system. In this study, we analyzed the expression of two GPxs in *M. nipponense* in response to changes in environmental oxygen. Expression levels of MnGPx-3 and MnGPx-4 indicated that both have strong responses to hypoxia. In situ hybridization showed that GPx gene is expressed and released by secretory cells and released response to hypoxia in the gill tissue, however, GPxs are located in blood cells, suggesting that they perform different functions in different tissues or organs. This study provides a basis for understanding the oxidative stress response in *M. nipponense* under hypoxia.

Key words: *Macrobrachium nipponense*, hypoxia, reoxygenation, mRNA expression, in situ hybridization

盐度对缢蛏稚贝生长、Na⁺/K⁺-ATPase 及能量代谢相关酶活性的影响

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摘要: 盐度是影响海水贝类生长和存活的重要因素之一。本实验以缢蛏(*Sinonovacula constricta*)稚贝为研究对象, 在 15ppt、20ppt、25ppt、30ppt、35ppt 五个盐度条件下进行 40 天的养殖实验, 测定其生长、Na⁺/K⁺-ATPase(NKA)以及己糖激酶(HK)、丙酮酸激酶(PK)、琥珀酸脱氢酶(SDH)三种能量代谢相关酶的活性。结果显示, 15ppt 组日均体重增长量显著高于其他盐度组($p<0.05$), 分别为 20ppt、25ppt、30ppt、35ppt 组的 1.35、1.79、1.93、2.75 倍。30ppt 组 NKA 活性显著高于其他组($p<0.05$), 15ppt、20ppt、25ppt、35ppt 四组之间无显著差异($p>0.05$); 25ppt 和 30ppt 组 HK、PK、SDH 活性显著高于其他组($p<0.05$), 15ppt、20ppt、35ppt 三组之间三种酶活性无显著性差异($p>0.05$)。研究表明, 盐度对缢蛏稚贝的生长表现及渗透压调节和体内能量代谢相关途径影响显著, 研究结果为揭示贝类对盐度的适应性机制提供了一定的参考。

关键词: 缢蛏; 稚贝; 生长; Na⁺/K⁺-ATPase; 能量代谢

Effects of salinity on growth, Na⁺/K⁺-ATPase activity and enzyme activity related to energy metabolism in juvenile razor clam

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Abstract: Salinity is one of the important factors affecting the growth and survival of seawater shellfish. This experiment selected juvenile razor clam *Sinonovacula constricta* as the research object. The juveniles were cultured for 40 days under five salinity conditions of 15ppt, 20ppt, 25ppt, 30ppt, and 35ppt. The results showed that the average daily weight gain in 15ppt group was significantly higher than that of the other groups ($p<0.05$), which was 1.35, 1.79, 1.93, and 2.75 times in the 20ppt, 25ppt, 30ppt, and 35ppt groups, respectively. The NKA activity in the 30ppt group was significantly higher than that of the other groups ($p<0.05$). The HK, PK, and SDH activities in the 25ppt and 30ppt groups were significantly higher than those of the other groups ($P<0.05$).

Key words: *Sinonovacula constricta*, juvenile shellfish, growth, Na⁺/K⁺-ATPase, energy metabolism

西伯利亚鲟神经介素 U 鉴定及食欲调控作用研究

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摘要: 神经介素 U (NMU) 在摄食行为调控中扮演着重要的角色。为了明确西伯利亚鲟 NMU 的食欲调控作用, 以便在品种选育和养殖过程中应用, 本研究采用实时荧光定量法检测了 *nmu* 在西伯利亚鲟幼鱼中枢和外周组织中的表达模式, 以及在脑和胃肠道中 *nmu* 对不同饲喂策略的响应模式。西伯利亚鲟 *nmu* 基因编码区包括 154 个氨基酸, 其广泛分布于中枢和外周, 尤其在端脑和下丘脑表达丰富。在摄食前后试验中, 下丘脑 *nmu* 基因在摄食后 1 小时和 3 小时的表达量显著降低; 在禁食试验中, 当禁食 1 天时下丘脑 *nmu* 基因表达显著升高, 而禁食 3-17 天时下丘脑 *nmu* 基因表达显著降低。由上可知, 西伯利亚鲟 *nmu* 基因可能具有双向调节摄食行为的独特作用, *nmu* 基因可能作为厌食欲因子参与短期摄食调控, 在长期摄食调控中发挥增食欲作用。

关键词: 神经介素 U; 鲟鱼; 下丘脑; 食欲; 表达模式

The identification of Neuromedin U and role in appetite regulation of Siberian sturgeon (*Acipenser baerii*)

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Abstract: Neuromedin U plays an important role in the regulation of feeding behavior. To investigate Siberian sturgeon *nmu* appetite regulation function, so that applications in variety breeding and breeding process, this research used real-time fluorescence quantitative method to detect *nmu* expression pattern in Siberian sturgeon central and peripheral tissues, response pattern of *nmu* in brain and gastrointestinal to different feeding strategies. Siberian sturgeon *nmu* gene coding region contains 154 amino acids. *Nmu* gene is widely distributed in the central and peripheral regions, especially in the telencephalon and hypothalamus. In the hypothalamus, *nmu* mRNA expression decreased significantly 1 hour and 3 hours after feeding, significantly increased when fasting for 1 day but significantly decreased when fasting for 3-17 days. These results suggest that Siberian sturgeon *nmu* gene may have a unique bidirectional role in the regulation of feeding behavior, that is, as orexigenic factor in short term and anorexigenic factor in long term.

Key words: Neuromedin U, Sturgeon, hypothalamus, appetite, expression pattern

提高基因组预测准确性及降低成本的策略：以大西洋鲑为例

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摘要：本研究以 1481 条大西洋鲑为对象，对鳃损伤（GD）和阿米巴负荷（AL）两个抗病性状进行基因组预测准确性评估。通过 10 次重复 5 倍交叉验证比较了 BLUP、GBLUP、BayesR、多性状 GBLUP（MTGBLUP）和 GFBLUP 方法预测准确性，其中 GFBLUP 方法特征标记通过 GWAS 先验策略进行筛选。另外，本研究分别利用连锁不平衡（LD）程度（0.05-0.95）降低 SNP 标记密度和减少家系内全同胞数量（5-30）来降低基因选择成本。结果表明，所有方法预测准确性都高于基于系谱信息的 BLUP 方法；MTGBLUP 方法获得最高的预测准确性，相比于 GBLUP，GD 和 AL 预测准确性分别提高了 4.2% 和 1.2%；相比于 GBLUP 方法，BayesR 准确性无差别，而 GFBLUP 并未提高预测准确性且偏差较大。另外，SNP 标记密度降低至 1000，参考群体规模减少约 110 头，就足以获得与整个数据集相似的准确性。本研究结果对基因组选择在水产动物上的应用具有重要意义。

关键词：大西洋鲑；抗病性状；基因组选择；方法；降低成本

Strategies to improve the accuracy of genome prediction and reduce costs: a case study in Atlantic salmon

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Abstract: This study investigated the efficiency of genomic prediction for two disease resistance traits (Gill damage (GD) and Amoebic load (AL)) in 1481 Atlantic salmon. We compared the prediction accuracy obtained from BLUP, GBLUP, BayesR, multi-trait GBLUP (MTGBLUP) and GFBLUP with GWAS prior information through 10 replicates of 5-fold cross-validation. Moreover, SNP marker with linkage disequilibrium (LD) pruning (0.05-0.95) and reduce the size of full sibling family (5-30) were performed to reduce the cost of genomic selection. The results showed that the methods with marker information produced more accurate predictions than the pedigree-based BLUP method. MTGBLUP obtained the highest prediction accuracy, and for GD and AL, MTGBLUP produced 4.2% and 1.2%, respectively, higher accuracy than GBLUP. BayesR performed comparably to GBLUP and GFBLUP with larger bias did not yield higher accuracy than GBLUP. In addition, the SNP marker density reduced to ~1000 and the reference population size reduced by ~110, were sufficient to obtain accuracies similar to those obtained using the whole dataset. Our result is meaningful for the application of genome selection in aquaculture.

Key words: Atlantic salmon, disease resistance traits, genomic selection, methods, reduce costs

基于线粒体 D-loop 序列的不同群体刀鲚遗传多样性研究

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摘要: 将线粒体 DNA *D-loop* 部分基因序列作为分子标记, 研究四个地理群体 (辽河 LH、大洋河 DYH、鸭绿江 YLJ、太湖 TH) 刀鲚 (*Coilia nasus*) 的遗传多样性。结果显示: 相较于 TH 群体, 辽宁沿海三个刀鲚群体其遗传多样性明显更为饱满, 尤以 YLJ 群体最为丰富, 间接证明辽宁沿海地区比较适宜刀鲚种群生长; 另外, YLJ 刀鲚样本证明曾存在扩张种群的迹象; 四个不同地理群体之间尚未进行分化。通过 NJ 和 MP 法建立分子系统发育树的结果也验证了四个不同地理群体间的刀鲚并未进行分化这一结论。

关键词: 刀鲚; 线粒体 DNA; D-loop; 遗传多样性; 分子遗传标记

Genetic diversity of *Coilia nasus* in different groups based on mitochondrial D-loop sequences

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Abstract: Partial gene sequences of mitochondrial DNA *D-loop* were used as molecular markers to study the genetic diversity of *Coilia nasus* in four geographical populations (Liaohe LH, Dayanghe DYH, Yalujiang YLJ, And Taihu TH). The results showed that, compared with the TH population, the genetic diversity of the three *Coilia nasus* populations in the coastal areas of Liaoning province was significantly more abundant, especially YLJ population, which indirectly proved that the *Coilia nasus* population was more suitable for growth in the coastal areas of Liaoning province. In addition, samples of YLJ *Coilia nasus* proved the existence of signs of expanding population. There is no differentiation between the four different geographic groups. The establishment of molecular phylogenetic trees by NJ and MP also verified the conclusion that *Coilia nasus* did not differentiate among four different geographical populations.

Key words: *Coilia nasus*, mitochondrial DNA, *D-loop*, genetic diversity, molecular marker

基于脂质组学对中间球海胆脂类代谢的初步研究

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摘要: 中间球海胆性腺中含有丰富的高不饱和脂肪酸 (PUFA), 是其主要营养物质。为了更详细地阐明海胆不同 PUFA 丰度的积累与其生物合成的相关性, 研究采用非靶向的、高分辨率的脂质组学方法来分析性腺中与 PUFA 合成代谢相关的差异脂质。依据 PUFA 含量不同 (共检测出 11 种 PUFA, 占总脂肪酸含量的 54.13% 以上), 将待测中间球海胆进行划分为 PUFA 高、中、低三组; 通过脂质组学分析, 不同组别海胆共鉴定出 1552 个脂质分子, 隶属于 36 个脂质类别; 筛选出其显著差异的脂质分子, 采用正交偏最小二乘判别分析方法对脂质分子图谱进行分析, 结果表明雌性性腺中主要脂质为磷脂酰胆碱, 雄性性腺的主要脂质为甘油三酸酯, 磷脂酰胆碱 (42:11) 可用作区分高 PUFA 丰度的潜在标志物。本研究首次对中间球海胆的不同脂质丰度的脂质组学进行了比较分析, 丰富了水产品的脂质库, 并为进一步研究提供了更可靠和完善的理论基础。

关键词: 中间球海胆; 脂质组学分析; 多不饱和脂肪酸; 脂质丰度

Comparative lipidomics profiling of the sea urchin, *Strongylocentrotus intermedius*

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Abstract: *Strongylocentrotus intermedius* is an edible sea urchin and well-known for its nutritional value, such as a high content of polyunsaturated fatty acids (PUFAs). We carried out an untargeted, high-resolution lipidomics approach to highlight gonad lipids, which allowed for a more detailed and complete interpretation of the biological correlates of PUFA biosynthesis and accumulation of PUFAs with different abundances among sea urchins. We detected 11 types of PUFAs, which represented > 54.13% of the total fatty acid content. A total of 1552 lipid molecular species belonging to 36 lipid classes were identified. Lipidomics profiles were analyzed by orthogonal partial least squares discriminant analysis and distinguished the PUFA abundances in both sexes of sea urchins. The significant differences in lipid molecules were highlighted and the major lipid classes identified were phosphatidylcholine (PC [19 species]) among females and triglycerides (TG [11 species]) among males. PC (42:11) may be used as a potential marker for distinguishing high levels of PUFAs. For the first time, lipidomics profiling of lipid abundances in *S. intermedius* was demonstrated. These data enrich the lipid profile library of aquatic products and provide a more reliable and refined theoretical basis for further research.

Keywords: *Strongylocentrotus intermedius*; lipidomics profiling; polyunsaturated fatty acids; lipid abundance

不同地域刺参胶原蛋白含量及一般营养成分比较

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摘要: 为探讨不同地域刺参胶原蛋白含量及营养成分的差异, 研究于 2019 年 5 月至 7 月测定了黄渤海野生和养殖刺参的胶原蛋白、水分、粗蛋白、灰分、粗脂肪、总糖及氨基酸和脂肪酸的含量。结果显示, 养殖刺参(营城子、黑石礁和瓦房店海域)的胶原蛋白质量分数极显著高于野生刺参(旅顺、蚬蛸岛和西霞口海域) ($P < 0.01$); 养殖刺参的粗蛋白质量分数极显著高于野生刺参 ($P < 0.01$); 野生刺参的灰分质量分数极显著高于养殖刺参 ($P < 0.01$)。野生刺参与养殖刺参的粗脂肪、总糖含量差异不显著 ($P > 0.05$)。各地域氨基酸组成相似; 脂肪酸含量差异较大, 其中营城子刺参的 DHA 与 EPA 含量极显著高于其它群体 ($P < 0.01$)。综合各项数据, 养殖刺参的品质优于野生刺参, 营城子池塘养殖刺参的品质优于瓦房店池塘养殖刺参及黑石礁室内养殖刺参, 黄渤海刺参的营养成分差异不显著。研究结果为刺参不同地域、不同养殖方式的营养情况提供参考。

关键词: 刺参; 营养成分; 胶原蛋白; 品质

Comparison of collagen content and general nutritional components of sea cucumber (*Stichopus japonicus*) from different regions

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Abstract: In order to explore the differences of collagen content and nutritional components of *Stichopus japonicus* in different regions, the contents of collagen, water, crude protein, ash, crude fat, total sugar, amino acid and fatty acid of wild and cultured *S. japonicus* were determined from May to July in 2019. The results showed that the collagen content of cultured *S. japonicus* (Yingchengzi, Heishijiao and Wafangdian sea areas) was significantly higher than wild *stichopus japonicus* (Lvshun, Bashaodao and Xixiakou sea area) ($P < 0.01$); the crude protein content of cultured *S. japonicus* was significantly higher than wild *S. japonicus* ($P < 0.01$); the ash content of wild *S. japonicus* was significantly higher than cultured *S. japonicus* ($P < 0.01$). There was no significant difference in crude fat and total sugar content between wild *S. japonicus* and cultured *S. japonicus* ($P > 0.05$). The amino acid composition of different regions was similar, the content of fatty acids varies greatly, and the content of DHA and EPA of *S. japonicus* in Yingchengzi was significantly higher than other groups ($P < 0.01$). According to the data, the quality of cultivated *S. japonicus* is better than wild *S. japonicus*. The quality of *S. japonicus* cultivated in Yingchengzi pond is better than that in Wafangdian pond and Heishijiao indoor culture. There is no significant difference in nutrient composition of *S. japonicus* between the Yellow Sea and the Bohai Sea. The results provide a reference for the nutritional status of *S. japonicus* in different regions and different culture methods.

Keywords: *Stichopus japonicus*; Nutrition; Collagen; Quality

低氧胁迫下瓦氏黄颡鱼肌肉的多组学联合分析

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摘要: 在水生生态系统中, 常见的高密度、浅池塘水产养殖过程中, 高养殖密度以及高营养输入导致增殖的浮游动植物引发水华, 使得水体溶解氧含量低且不稳定, 成为鱼类养殖的一个巨大威胁。目前低氧胁迫研究已经成为鱼类生理学的热点之一, 本文以瓦氏黄颡鱼为研究对象, 运用测序技术对低氧胁迫前后(溶氧 0.7 mg/L; 4h)肌肉的转录组、miRNA组、蛋白质组、代谢组进行联合和对比研究, 结果显示: 为了维持正常的生理活动, 瓦氏黄颡鱼针对低氧胁迫表现出急性反应, 包括增强分解代谢途径以产生更多能量, 减少生物合成途径以减少能量消耗, 以及由需氧代谢向无氧代谢的转变; 此外, 低氧胁迫可导致细胞线粒体功能损伤、激活炎症小体和细胞凋亡引起瓦氏黄颡鱼肌肉功能障碍, 并且我们推测炎症小体激活和线粒体功能障碍形成恶性循环, 更进一步促进细胞凋亡。本文期望在分子水平上系统地阐明鱼类应对低氧胁迫的分子调控机制, 也为今后开展鱼类耐低氧新品种选育提供一定的理论依据。

关键词: 转录组; miRNA组; 蛋白质组学; 代谢组; 低氧; 瓦氏黄颡鱼

Integrated application of multi-omics strategies provides insights into the environmental hypoxia response in *Pelteobagrus vachelli* muscles

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Abstract: Aquatic ecosystems are increasingly stressed due to nutrient enrichment, pollutants, and global warming, which have seriously depleted oxygen concentrations. Here, we used a multi-omics approach to identify several hypoxia-associated miRNAs, mRNAs, proteins, and metabolites involved in diverse biological pathways in the muscles of *Pelteobagrus vachelli*. According to our data of integrated analysis, to maintain normal physical activity, fishes exhibit an acute reaction to acute hypoxia, including activation of catabolic pathways to generate more energy, reduction of biosynthesis to decrease energy consumption, and shifting from aerobic to anaerobic metabolic contributions. Also we found that hypoxia induced muscle dysfunction by impairing mitochondrial function, activating inflammasomes, and apoptosis. Further, inflammatory body activation and mitochondrial dysfunction can form a vicious circle. Our findings contribute meaningful insights into the molecular mechanisms of hypoxia, and the methods and study design can be utilized across different fish species.

Key words: Transcriptome; miRNAome; Proteome; Metabolome; Hypoxia; *Pelteobagrus vachelli*

lncRNA 作为转录因子介导 *dmrt* 基因调控半滑舌鲷性别决定与分化的功能初探

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摘要: 为了研究长链非编码 RNA (Long non-coding RNA, lncRNA) 在鱼类性别决定与分化中的调控作用, 本研究对半滑舌鲷性别分化前后的雌鱼、雄鱼和伪雄的性腺进行了全转录组分析。结果显示在半滑舌鲷的性腺中鉴定到 13,383 个 lncRNAs, 1,081 个 circRNAs 和 823 个 miRNAs, 它们与半滑舌鲷性别相关基因的表达具有相关性。其中 lncRNA DMRT2-AS 与 XLOC_024163 在性别分化后的雄鱼和伪雄鱼中高表达, 通过 RACE 克隆获得上述 lncRNA 全长序列, 通过 RT-qPCR 以及共表达实验验证了它们对半滑舌鲷性别分化关键基因 *dmrt2*、*dmrt1* 的表达具有调控作用。上述研究表明 lncRNA 在鱼类性别决定和分化中具有调控作用, 进一步揭示了表观遗传调控脊椎动物性别决定与分化的复杂机制。

关键词: 表观遗传; 长链非编码 RNA; 性别决定与分化; 性腺; qPCR

A study on the Function of lncRNA as Transcription Factor Regulate *dmrt* Gene in Sex Determination and Differentiation of Chinese Tongue

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Abstract: Long non-coding RNAs (lncRNAs) plays important roles in various biological processes. In this study, we analysed the whole transcriptome sequencing of Chinese tongue gonad from normal male, female and pseudo-male fishes. A total of 13383 lncRNAs, 1081 circRNAs and 823 miRNAs were found, they are correlated with the expression of sex-related genes in fish. we cloned and characterized DMRT2-AS and XLOC_024163, which were highly expression in male and pseudo-male fish after sex differentiation. In vitro experiments and bioinformatics predictions showed that they promoted the expression of *dmrt2* and *dmrt1* at the transcriptional level. These results suggest lncRNA plays a regulatory role in sex determination and differentiation of fish and reveal epigenetics regulates the complex mechanism of vertebrate sex determination and differentiation.

Key words: Long non-coding RNA, Sex determination and differentiation, gonad, qPCR

基于 DNA 甲基化和转录组水平揭示吉富罗非鱼抗无乳链球菌病的遗传调控机制

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摘要: 为阐明吉富罗非鱼的抗病机制, 本文采用全基因组 DNA 甲基化和转录组测序技术检测了抗病家系和易感病家系感染无乳链球菌 5h 后脾脏组织的差异。结果显示, 共鉴定得到 10177 个甲基化差异位点 (DMGs) 和 2374 个差异表达基因 (DEGs), 联合分析发现有 337 个重叠的 DEGs 和 DMGs, 其中启动子 DMGs 与 DEGs 的重叠基因有 82 个。整合甲基化与表达验证结果, 发现 4 个免疫相关基因(Arnt2、Nhr38、Pcdh10、Ccdc158)的表观遗传机制在吉富罗非鱼病抗无乳链球菌感染过程中发挥了重要作用。本文首次绘制了罗非鱼脾脏甲基化图谱, 从 DNA 甲基化水平揭示了罗非鱼抗无乳链球菌病的遗传调控机制, 获得了抗病相关的甲基化位点和基因, 为下一步分子标记辅助罗非鱼抗病育种奠定了基础。

关键词: 吉富罗非鱼; 无乳链球菌; 全基因组甲基化测序; 转录组测序; 表观遗传调控

Genome-Wide DNA Methylation and RNA Analysis Reveal Potential Mechanism of Resistance to *Streptococcus agalactiae* in GIFT Strain of Nile Tilapia (*Oreochromis niloticus*)

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Abstract: To clarify the resistance mechanism of GIFT tilapia, we carry out genome-wide DNA methylation and transcriptome profiles in spleen of resistant and susceptible GIFT at 5h post infection with *S. agalactiae*. A total of 10,177 differentially methylated regions and 2374 differentially expressed genes (DEGs) were identified in the two groups. Integrated analysis showed 337 overlapping DEGs and DMGs and 82 overlapping DEGs and differentially methylated region promoters. By integrating promoter DNA methylation with gene expression, we revealed four immune-related genes (Arnt2, Nhr38, Pcdh10, and Ccdc158) as key factors in epigenetic mechanisms contributing to pathogen resistance. Our study provided systematic methylome maps to explore the epigenetic mechanism and reveal the methylation loci of pathogen resistance and identified methylation-regulated genes that are potentially involved in defense against pathogens.

Key word: GIFT Strain of Nile Tilapia, *Streptococcus agalactiae*, whole genome bisulfite Sequencing, RNA-Seq, epigenetic regulation

黑鲟基因资源的挖掘与遗传育种进展

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摘要: 测序获得黑鲟基因组总长度为 688.08 Mb, Scffold N50 长度达到 7.64 Mb, 共注释出 19,465 个基因。通过对黑鲟性转变过程中差异化表达基因的分析, 发现 *dmrt1*、*amh*、*amhr2*、*piwil2*、*sox9*、*sox30* 和 *gsdf* 这组基因可能与黑鲟的精巢发育和功能维持有关, 其中 *dmrt1* 基因可能是启动黑鲟性转变的关键基因。前人的实验结果显示, *jnk1*、*vasa*、*wnt4*、*figla* 和 *foxl2* 这组雌性性别决定标志基因与黑鲟卵巢的发育和功能维持有关。这些基因在黑鲟从雄性向雌性转化的过程中起到重要作用。对生长性状相关基因 *IGFBP-2*、*Calmodulin* 进行了克隆和组织表达分析。综合运用群体选育、家系选育结合杂交育种方法, 选择生长速度和耐低温为目标性状培育获得黑鲟新品系, 开展池塘生态化绿色养殖、室内循环水养殖、海水池塘工程化养殖等多种养殖模式示范。

关键词: 黑鲟; 基因资源; 遗传育种

The development gene resources and genetic breeding for black sea bream *Acanthopagrus schlegelii*

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Abstract: The whole genome length of the black sea bream was 688.08 Mb and the length of Scffold N50 reached 7.64 Mb. A total of 19,465 genes were annotated. Through the analysis of the differentially expressed genes during the sex transition of black sea bream, it was found that *dmrt1*, *amh*, *amhr2*, *piwil2*, *sox9*, *sox30*, and *gsdf* may be related to the testis development and function maintenance for black sea bream, and the *dmrt1* gene may be the active key gene for black sea bream during sexual transformation.. Previous experiments showed that the female sex determination marker genes *jnk1*, *vasa*, *wnt4*, *figla* and *foxl2* are related to the development and maintenance of the ovaries of black sea bream. These genes play an important role in the transformation of black sea bream from male to female. Growth traits related genes such as *IGFBP-2* and *Calmodulin* were also Cloned and tissue expression analyzed. Group breeding, family breeding combined with hybrid breeding methods were used in black sea bream breeding. Growth speed and low temperature tolerance were selected as the target traits to breed new black sea bream strain. Pond ecological green breeding, indoor circulating aquaculture, seawater pond engineering aquaculture, etc. Demonstration of breeding mode were also carried out for black sea bream.

Keyword: black sea bream; gene resource; genetic and breeding

虹鳟感染 IHNV 后肠道免疫调控的转录组分析

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摘要: 传染性造血器官坏死病病毒 (IHNV) 是鲑科鱼类中研究较多的一种病毒。目前, 对虹鳟 (*Oncorhynchus mykiss*) 感染 IHNV 后肠道的转录组研究较少, 所以本研究基于 RNA-seq 技术对虹鳟感染 IHNV 病毒的肠道组织进行了转录组分析。结果显示, 在 $FDR < 0.05$ 且 $|\log_2FC| > 1$ 的条件下筛选出 3081 个差异基因, 其包括很多重要的免疫基因, 如 *IL17F*、*IL6*、*TLR3*、*CXCL10*、*NOD1*、*TNF1*, 其中 1494 个基因表达上调, 1587 个基因表达下调。GO 分析表明细胞活化、免疫效应过程、生物粘附是机体主要参与免疫调控的过程。KEGG 富集分析表明差异基因主要富集在 Toll 样受体信号通路、NOD 样受体信号通路、NF-KB 信号通路、IL-17 信号转导通路、趋化因子信号通路等免疫相关通路。随机筛选 15 个差异基因进行 qRT-PCR 验证, 证明了转录组测序结果的可靠性。本研究在 mRNA 水平上分析了虹鳟肠道组织抗 IHNV 的免疫调控机制, 为虹鳟抗 IHNV 的研究提供理论基础。

关键词: 虹鳟; IHNV; RNA-seq; 信号通路; 差异基因

Transcriptome analysis of intestinal immune regulation in rainbow trout (*Oncorhynchus mykiss*) infected with IHNV

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Abstract: Infectious haematopoietic necrosis virus (IHNV) is a well-studied virus of salmonid fishes. At present, there are few studies on the transcriptome of the intestine of rainbow trout (*Oncorhynchus mykiss*) infected with IHNV. Therefore, this study was based on RNA-seq technology to analyze the transcriptome of the intestinal tissue of rainbow trout infected with IHNV. The results showed that 3081 differential genes were screened under the conditions of $FDR < 0.05$ and $|\log_2FC| > 1$, including many important immune genes, such as *IL17F*, *IL6*, *TLR3*, *CXCL10*, *NOD1*, *TNF1*, and 1494 genes were upregulated, 1587 genes were down-regulated. GO analysis showed that cell activation, immune effect process, and bioadhesion are the main processes that the body participates in immune regulation. KEGG enrichment analysis showed that differential genes were mainly enriched in immune-related pathways such as Toll-like receptor signaling pathway, NOD-like receptor signaling pathway, NF-KB signaling pathway, IL-17 signaling pathway, and chemokine signaling pathway. Fifteen differential genes were randomly selected for qRT-PCR verification, which proved the reliability of the transcriptome sequencing results. This study analyzed the immune regulation mechanism of rainbow trout against IHNV at the mRNA level, and provided a theoretical basis for the research on rainbow trout against IHNV.

Keywords: rainbow trout, IHNV, RNA-seq, signal pathway, differential gene

基于全基因组 RAD 测序筛选鉴定大鲵性别特异标记

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摘要: 中国大鲵是一种濒危物种, 人工繁育技术的突破为对其保护提供一条有效途径。然而, 目前对大鲵性别鉴定及其决定机制仍然不清楚。4 雌 4 雄大鲵个体开展了 RAD 测序, 获得 134.4Gb 的数据, 934M 的读长。将组装的数据与相反性别的 RAD 数据进行比对, 分别获得 19097 与 17994 个雌性与雄性特异候选序列。再将雌性候选序列与雄性基因组 (不完全) 数据进行比对, 最终获得 308 个雌性特异候选序列。随机选取 100 个进行 PCR 验证, 初步获得 4 个雌性特异候选序列, 扩大样本验证后 4 个序列均为雌性个体特有序列。为了验证标记, 我们将前期高温与性激素处理的大鲵个体, 进行 PCR 验证, 高温诱导组获得 3 个雌转雄反转个体, 雌激素诱导组获得 13 个雄转雌个体。大鲵性别特异标记的获得为后续性别决定机制以及大鲵保护奠定基础。

关键词: 大鲵; RAD 测序; 雌性特异标记; 性别鉴定; 性反转

Genome-wide RAD sequencing to identify a sex-specific marker in Chinese giant salamander *Andrias davidianus*

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Abstract: Chinese giant salamander *Andrias davidianus* is an endangered species. The success of artificial breeding provides a useful way to protect this species. However, the method to identify the sex and mechanism of sex determination were unclear. Four male and four female specimens were subjected to RAD sequencing, which generated 934,072,989 reads containing approximately 134.4 Gb of sequences. The first round of comparison of the assembled sequence against the opposite sex raw reads revealed 19,097 female and 17,994 male unmatched sequences. Subsequently, 19,097 female sequences were subjected to a BLAST search against male genomic data, which revealed 308 sequences unmapped to the male genome. One hundred of these were randomly selected and validated by PCR in five male and five female specimens, and four putative sex-specific sequences were produced. Further validation was performed and exhibited the expected specific bands in another 24 females and 24 males. To apply the sex specific marker, three specimens reversed from genetic female to physiological male were found in a group exposed to elevated temperature, and 13 individuals reversed from genetic male to physiological female were obtained in a 17 β -estradiol exposed group. This is the first report of a sex-specific marker in *A. davidianus* and may have potential for elucidation of its sex determination mechanism and, hence, its conservation.

Keywords: *Andrias davidianus*, RAD-seq, Female-specific marker, Sex identification, Sex reversal

尼罗罗非鱼性别特异分子标记的多态性研究

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摘要: 尼罗罗非鱼 LG22 上标记 Marker-5 与性别决定主效基因 amhy 连锁, 已用于不同品系遗传性别鉴定。Marker-5 可分别特异性扩增 X 和 Y 染色体 1422 和 982bp 的片段。然而, Marker-5 多态性尚未评估。本研究利用 Marker-5 对海南养殖场的尼罗罗非鱼进行基因型鉴定, 发现了 Marker-5 的多态性和特异性扩增模式。本研究有助于 Marker-5 在养殖尼罗罗非鱼性别控制育种中的应用。

关键词: 遗传全雄罗非鱼; 性别控制; 性别连锁标记; 异二聚体; 性别逆转

Polymorphism in a sex-linked DNA marker located on LG22 in Nile tilapia (*Oreochromis niloticus*)

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Abstract: Marker-5, which is linked to the major sex-determination gene amhy on LG22, has been used for sex genotyping of various strains of Nile tilapia. Marker-5 specifically amplifies fragments of approximately 1422 and 982 bp of the X and Y chromosomes, respectively. However, Marker-5 polymorphism has not been evaluated. Herein, Marker-5 was used to identify the genotypes of a Nile tilapia strain from a breeding farm in Hainan, China. Understanding the polymorphism and specific amplification pattern of Marker-5 is useful for its utilization in sex-controlled breeding in farmed Nile tilapia.

Key words: Genetically male tilapia; sex control; sex linked marker; heterodimer; sex reversal

Somatostatin 1 基因突变斑马鱼仔鱼转录组分析

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摘要: 生长抑素 (Somatostatin, SST) 是一类神经激素多肽, 对脊椎动物的生长和代谢起着关键的调控作用。在斑马鱼 (*Danio rerio*) 和其它鱼类中, 生长抑素由 6 个基因编码 (*sst1-sst6*), *sst1* 存在于所有脊椎动物中, 并且在进化上最为保守。本研究利用 CRISPR/Cas9 基因编辑技术在斑马鱼中构建了可稳定遗传的生长抑素基因 *sst1* 突变体鱼系。通过比较 6 dpf (days postfertilization, dpf) 的 *sst1*^{-/-} 突变体和野生型仔鱼转录组, 发现 *sst1*^{-/-} 突变体相关生化过程和信号通路发生了显著变化。相比野生型, *sst1*^{-/-} 突变体仔鱼中有 354 个基因显著上调, 504 个基因显著下调。结果表明, *sst1*^{-/-} 突变体蛋白质生物合成和代谢过程更加活跃。本研究结果为进一步挖掘生长抑素基因家族的潜在功能奠定基础。

关键词: Somatostatin1; 斑马鱼; 代谢; 蛋白质合成

Transcriptome sequencing analysis of somatostatin 1 gene mutation in zebrafish larvae

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Abstract: Somatostatin (SST), is a kind of neurohormone with key roles in regulating growth and metabolism in all vertebrates. In zebrafish and other fishes, SST peptides are encoded by six genes, *sst1* exists in all vertebrates and is the most evolutionarily conservative. Here, we explored *sst* functions through a transcriptomic comparison of 6 days post fertilization (dpf) zebrafish *sst1*^{-/-} mutants generated by CRISPR/Cas9 gene-editing technology and their wild type counterparts. We found that several biological processes and biochemical pathways modified in *sst1*^{-/-} zebrafish. The mutant had 354 significantly up-regulated and 504 significantly down-regulated genes. The results provide a foundation for further exploring the potential functions of the somatostatin gene family.

Key words: Somatostatin1; zebrafish; metabolism; protein biosynthesis

罗氏沼虾性别相关 miRNA 的挖掘

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摘要: 为挖掘与罗氏沼虾性别相关的 miRNA, 探讨 miRNA 调控其性别分化的分子机制, 本研究对正常雌虾、超雌虾和雄虾的性腺组织进行 small RNA-seq 分析。共计获得 5.93G 数据和 28,458-165,878 个 miRNA, 检测到的 miRNA 均为本研究新发现的。采用 DESeq2 软件进行差异 miRNA 分析, 三个比较组 ZW vs ZZ、WW vs ZZ、WW vs ZW 中, 筛选到 34 个、34 个和 16 个差异表达的 miRNA ($q < 0.05$), 分别预测到 12,859、12,807 和 9,376 个靶基因。整合课题组前期 RNA-seq 数据, 共鉴定到 12 个重要的性别相关的候选基因和 13 个 miRNA, 其中雌性特异性表达基因 IR、雄性特异性表达基因 male reproductive-related protein 和 male reproductive-related protein B 及其对应的 miRNA novel_49、miRNA novel_30 和 novel_2、miRNA novel_19 是重要的性别相关的候选基因和 miRNA。本研究为后续 miRNA 介导的罗氏沼虾性别分化调控机制研究奠定了理论基础。

关键词: 罗氏沼虾; 性别; miRNA; small RNA-seq

Unraveling the sex-related miRNA of giant freshwater, *Macrobrachium rosenbergii*

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Abstract: To unravel sex-related miRNA and further explore the molecular mechanism of miRNA-mediated sex differentiation, we conducted small RNA-seq analysis of female (ZW), super female (WW), and male (ZZ) individuals in *M. rosenbergii*. A total of 5.93 G data was obtained, the number of identified miRNA was ranged from 28,458 to 165,878, which were novel predicted by miREvo and mirdeep2. Amongst, 34, 34, and 16 differentially expressed miRNAs were identified by DESeq2 in ZW vs ZZ, WW vs ZZ, WW vs ZW, respectively. And 12,859, 12,807, and 9,376 target genes were correspondingly predicted. Integrated analysis of differentially expressed miRNA and mRNA, a total of 12 important sex-related candidate genes and 13 miRNAs were identified. Subsequently, female-specific gene including IR, as well as male-specific genes including male reproductive-related protein and male reproductive-related protein B, and miRNA novel_49, miRNA novel_30 and novel_2, miRNA novel_19 were the key sex-related candidates and miRNAs, respectively.

Key words: *Macrobrachium rosenbergii*, sex, miRNA, small RNA-seq

优质鲤龙科 13 号新品种选育技术研究及应用

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摘要: 对同塘培育的优质鲤 F3 及其双亲(大头鲤和黑龙江鲤)的形态特征指标(体质量、体长、体高、须长等)和肌肉品质指标(氨基酸、肌内脂肪、脂肪酸、肌肉剪切力等)等进行测定和比较。通过对形态特征和肌肉品质指标的相关性分析, 结合亲本个体间遗传距离, 形成了集亲本形态、肉质和亲缘关系相结合的优质鲤综合选育技术。应用此技术再进行 2 代繁殖亲本筛选获得了 F5, 其肉质性能已稳定, 定名为“优质鲤龙科 13 号”。与其双亲(大头鲤和黑龙江鲤)相比, 优质鲤具有肉质优、生长速度快、成活率高等特性, 特别是肌肉品质方面, 优质鲤肌内脂肪含量高于双亲 20%, EPA、DHA 和粗脂肪高于双亲 11.90-21.11%, 肌肉剪切力小于双亲 10%。该选育新种有望成为中国首个以肉质为选育指标的鲤新品种。

关键词: 优质鲤龙科 13 号; 大头鲤; 黑龙江鲤; 肌内脂肪

Study and application on the selective breeding technique of a new variety named “high-quality carp (Cyprinus carpio L.) Longke No.13”

Abstract: The morphological characteristic indexes (body weight, body length, body height, beard length, etc.) and muscle quality indexes (amino acids, intramuscular fat, fatty acids, muscle shear force, etc.) of the high-quality carp (*Cyprinus carpio* L.) F3 and its parents (big head carp and Heilongjiang carp) were measured. Through the correlation analysis of morphological characteristics and muscle quality indicators, combined with the genetic distance between individuals of parents, a comprehensive breeding technique of high-quality carp that combines parental morphology, meat quality and genetic relationships has been established. Applying this technique to screen the breeding parents for 2 generations to obtain F5, its meat quality performance has been stable, named "high-quality carp Longke No. 13". Compared with its parents (big head carp and Heilongjiang carp), high-quality carp has the characteristics of superior meat quality, fast growth, and high survival rate. Especially in terms of muscle quality, the intramuscular fat content of high-quality carp is 20% higher than that of its parents, the EPA, DHA and crude fat are 11.90-21.11% higher than the parents, and the muscle shear force is 10% lower than the parents. This new variety of breeding is expected to become the first new carp breed with meat quality as the breeding objective in China.

Key words: high-quality carp (*Cyprinus carpio* L.) Longke No. 13; big head carp; Heilongjiang carp; intramuscular fat

Kr-h1 基因在甲基法尼酯介导中华绒螯蟹卵黄合成中作用

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摘要: 为了探究 JH/MF 信号通路是否保守存在于甲壳类动物中。本实验采用了 RACE 技术克隆了中华绒螯蟹 *Kr-h1* 基因, QPCR 技术进行相对定量分析。结果表明 *Kr-h1* 含有七个保守存在于昆虫 *Kr-h1* 基因中的锌指结构域。QPCR 结果表明 *Kr-h1* 基因的相对表达量在中华绒螯蟹卵巢发育二期时表达量显著增加; 组织表达谱结果表明: *Kr-h1* 基因在肝胰腺中表达量显著高于其他组织。在体外, 体内和去眼柄实验中, *Kr-h1* 基因的相对表达量在肝胰腺组织中显著性升高, 而在卵巢中无明显变化。结合之前的研究报道: *Met* 基因在中华绒螯蟹中执行着 MF 受体的角色, 本实验结果揭示了 *Kr-h1* 基因可能是通过响应 *Met* 基因途径而参与甲基法尼酯介导的中华绒螯蟹卵黄合成, 且 JH/MF 信号通路可能是保守存在于甲壳类动物中。

关键词: 中华绒螯蟹; 甲基法尼酯; Kruppel homolog 1; 基因表达

Effects of methyl farnesoate on Kruppel homolog 1 (*Kr-h1*) during vitellogenesis in the Chinese mitten crab (*Eriocheir sinensis*)

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Abstract: To explore whether JH/MF signaling is conserved in crustaceans. We used RACE technology to cloned Kruppel homolog 1 from *Eriocheir sinensis*. QPCR technology was applied to relative quantification of genes. Results showed that *Kr-h1* contains seven zinc finger motifs commonly conserved in other crustaceans. The QPCR results showed that *Kr-h1* expression in the hepatopancreas increased significantly in stage II. Tissue expression profile results show that the expression of *Kr-h1* gene in hepatopancreas is significantly higher than other tissues. In vitro, in vivo and in eyestalk ablation experiments results shows the relative expression of *Kr-h1* gene are both significantly increased in hepatopancreas tissues, but not in the ovary. Combining with previous research reports: *Met* plays the potential role of MF receptor in Chinese mitten crabs, notably, *Kr-h1* may be involved in MF-mediated vitellogenesis via response to Es-Met in *E. sinensis*, and the JH/MF signaling pathway is potentially conserved in crustaceans.

Key words: *Eriocheir sinensis*; Methyl farnesoate; Kruppel homolog 1; Gene expression.

高盐和氨氮胁迫对凡纳滨对虾免疫应答、氨耐受性的独立及综合影响

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摘要: 本实验中, 经过 30 天的长期高盐 (36 and 44) 胁迫后, 我们探讨了在 48 (0 h、6 h、12 h、24 h、48 h) 内氨氮暴露下高盐和氨氮胁迫 (15mg/L) 对凡纳滨对虾能量代谢、免疫应答、抗氧化能力和氨代谢的独立和联合作用。检测葡萄糖和乳酸的水平(LD); 酸性磷酸酶(ACP)、碱性磷酸酶(AKP)、过氧化氢酶(CAT)、总超氧化物歧化酶活力 (T-SOD)、总抗氧化能力(T-AOC)以及热休克蛋白 70(HSP 70)、酚氧化酶(PO)、免疫缺陷基因(IMD)、精氨酸激酶(AK)、硫氧还蛋白(TRX)、谷氨酰胺合成酶(GDH)和谷氨酸脱氢酶(GS)等基因的表达水平。结果表明, 在所有处理组中, 血淋巴中葡萄糖的水平升高并且无氧代谢加强导致各处理组中肌肉的乳酸水平显著升高($p < 0.05$)。联合的胁迫减弱了对虾的非特异性免疫反应, 从而降低了 AKP 和 ACP 的活性, 并在胁迫结束时降低了 PO, IMD 和 AK 基因的表达水平。此外, 对虾通过抗氧化防御系统中 T-AOC, T-SOD 和 CAT 以及 HSP70 和 TRX 来减少氧化损伤, 而暴露在不同盐度的氨氮处理下, 抗氧化体系的活性差异很大。在高盐处理组的肝胰腺中, 氨代谢相关基因 GDH 和 GS 的表达水平先显著上升, 然后下降 ($p < 0.05$)。研究说明, 高盐度和氨的变化超出耐受范围会显著影响糖代谢、非特异性免疫、抗氧化和氨代谢, 并且这两个因素的协同作用较弱。

关键词: 凡纳滨对虾; 高盐胁迫; 氨氮胁迫; 代谢; 抗氧化; 免疫

Individual and combined effects of high salinity and ammonia-N on the immune response and resistance to ammonia stress Pacific white shrimp *Litopenaeus vannamei*

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Abstract: In this study, after 30 days of long-term high salinity stress (36‰ and 44‰), we explored the individual and combined effects of high salinity and ammonia-N stress (15mg/L ammonia-N) on the energy metabolism, immune response, oxidation resistance, and ammonia metabolism of *Litopenaeus vannamei* during the following 48 h ammonia exposure. The levels of glucose and lactic acid (LD), activities of acid phosphatase (ACP), alkaline phosphatase (AKP), catalase (CAT), total superoxide dismutase (T-SOD), and total antioxidant capacity (T-AOC), and mRNA expression levels of heat shock protein70 (HSP70), phenol oxidase (PO), immune deficiency (IMD), arginine kinase (AK), thioredoxin (TRX), glutamine synthetase (GS), and glutamate dehydrogenase (GDH) were measured. The result showed the increased glucose levels in the hemolymph and accelerated anaerobic metabolism with higher lactate levels in the muscle in all treatment groups. The combined stressor treatments depressed the non-specific immune responses of shrimp with the decreasing activities of AKP and ACP, and expression levels of PO, IMD, and AK genes at the end of the exposure. In addition, the *L. vannamei* employ antioxidant defense system through T-AOC, T-SOD and CAT enzymes, and HSP70 and TRX proteins to reduce oxidant damage, while confused activities of antioxidant systems were observed when exposed to ammonia-N with different high salinity stress. Furthermore, the expression levels of ammonia metabolism related genes GDH and GS were significantly up-regulated and then declined in high salinity treatment groups in hepatopancreas. The study revealed that variations in high salinity and ammonia beyond the optimal range significantly influence the glycometabolism, non-specific immune, antioxidation, and ammonia metabolism, and these two factors can have weak synergic effects.

Key words: *Litopenaeus vannamei*, high-salinity stress, ammonia-N stress, metabolism; antioxidant; immune.

基于 mtDNA D-loop 区的祁连山裸鲤遗传多样性和分类学地位

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摘要: 为了分析祁连山裸鲤的遗传多样性和分类学地位, 对来自黑河和疏勒河流域的 50 尾祁连山裸鲤和 25 尾青海湖裸鲤的线粒体 DNA D-loop 区进行了测序。对这些样本进行了遗传多样性和序列差异分析, 以及对基因库上下载的另一个亲和的花斑裸鲤 (*G. eckloni*) 的 25 个同源序列进行了分析。结果显示, 祁连山裸鲤疏勒河种群 (*G. chilianensis*) 的单倍型多样性 ($Hd=0.963$) 和核苷酸多样性 ($Pi=0.00414$) 均低于其他种群, 表明祁连山裸鲤疏勒河种群 (*G. chilianensis*) 的遗传多样性水平较低, 可作为优先保护对象; 祁连山裸鲤黑河和疏勒河种群的 (*G. chilianensis*) 遗传距离为 0.0013, 祁连山裸鲤黑河种群和疏勒河种群与花斑裸鲤遗传距离分别为 0.0148 和 0.0141, 与青海湖裸鲤遗传距离分别为 0.0143 和 0.0137。系统进化树显示, 祁连山裸鲤 (*G. chilianensis*) 与青海湖裸鲤 (*G. przewalskii*) 和花斑裸鲤 (*G. eckloni*) 的亲缘关系较远, 因此, 祁连山裸鲤 (*G. chilianensis*) 可看作裸鲤的一个独立物种。

关键词: 祁连山裸鲤; D-Loop; 遗传多样性; 分类学地位

Genetic diversity and taxonomic status of *Gymnocypris chilianensis* based on the mitochondrial DNA D-loop region

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Abstract: To analyse the genetic diversity and taxonomic status of *Gymnocypris chilianensis*, D-loop region of the mitochondrial DNA was sequenced in 50 individuals of *G. chilianensis* obtained from two geographic locations (Heihe River and Shule River) and 25 individuals of *G. przewalskii*. These samples were analyzed for genetic diversity and sequence divergence, and 25 homologous sequences of another affinity *G. eckloni* downloaded from GenBank were analyzed. The results revealed that *G. chilianensis* of the Shule River showed lower haplotype diversity ($Hd = 0.963$) as well as nucleotide diversity ($Pi = 0.00414$) than the other populations, indicating that *G. chilianensis* of the Shule River should be protected preferentially due to its lower level of genetic diversity. The study also demonstrated the genetic distance of *G. chilianensis* in both Heihe River and Shule River was 0.0013, and the genetic distances between the aforementioned two populations and the *G. przewalskii* were 0.0143 and 0.0137, respectively. The genetic distances between the two *G. chilianensis* populations and the *G. eckloni* were 0.0148 and 0.0141, respectively. The NJ phylogenetic trees showed that *G. chilianensis* had further genetic distance with *G. eckloni* and *G. przewalskii*. Therefore, *G. chilianensis* could be considered as an independent species of *Gymnocypris*.

Keywords: *Gymnocypris chilianensis*, D-loop, genetic diversity, taxonomic status

全长转录组和小 RNA 测序揭示棘头梅童鱼性别相关分子调控网络

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摘要: 性别分化机制是鱼类繁殖生物学的研究热点。棘头梅童鱼是我国重要经济鱼类, 其性别相关机制尚未清楚。本研究利用三代测序获得棘头梅童鱼的全长转录组信息, 通过小 RNA 测序鉴定性别相关 miRNA, 结合全长转录组信息预测 miRNA 的靶基因, 初步解析其性别相关 RNA 调控网络.....

关键词: 棘头梅童鱼; 性别分化; 全长转录组; 小 RNA 测序; miRNA; 调控网络

Integrated full-length transcriptome and small RNA sequencing approaches reveal sex-related RNAs in *Collichthys lucidus*

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Abstract: Sex differentiation mechanism is one of the important topics in fish reproductive biology. *Collichthys lucidus* (C.lucidus) is an important economic fish in China, and its sex-related mechanism remains unclear. Here we performed long-read sequencing to obtain full-length transcriptome in C.lucidus. Moreover, gender-related miRNAs were identified by small RNA sequencing. Target genes of the sex-related miRNAs were predicted by combining full-length transcriptome information, and the sex-related RNA regulatory networks were preliminarily established.....

Key words: *Collichthys lucidus*, Gender differentiation, Full-length transcriptome, Small RNA sequencing, miRNAs, Regulatory networks

全基因组关联分析可以提高石斑鱼氨氮耐受性状基因组选择的准确性

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摘要: 为了培育高氨氮耐受性状的石斑鱼,本研究基于 600 条斜带石斑鱼 (*Epinephelus coioides*) 基因组重测序得到的三百多万单核苷酸多态性 (single nucleotide polymorphism; SNP) 位点, 进行基因组选择 (genomic selection, GS)。遗传力估计为 0.36 ± 0.12 。四种方法 BayesA, BayesB, BayesC 和 rrBLUP 进行 GS 预测准确性比较得出 BayesB 更适用于本研究。随后, 基于全基因组关联分析 (genome-wide association study, GWAS) 的有效 SNP 位点和随机选择位点预测准确性比较得出前者预测的准确性可达 100%, 比后者预测的准确性高的多。这些结果表明, GS 适用于石斑鱼氨氮耐受性状的选育, 且前期的 GWAS 分析有助于提高 GS 的准确性。本研究为后续石斑鱼及其他水产动物育种提供参考。

关键词: 斜带石斑鱼; 基因组选择; 全基因组关联分析; 单核苷酸多态性; 氨氮耐受

Genome-wide association study can improve genomic selection for ammonia tolerance in orange-spotted grouper (*Epinephelus coioides*)

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Abstract: To breed groupers with high tolerance to environmental ammonia, genomic selection (GS) was performed based on 600 orange-spotted groupers (*Epinephelus coioides*) were genotyping by whole-genome resequencing, and over 3 million single nucleotide polymorphisms (SNPs) were identified. A moderate heritability of 0.36 ± 0.12 was estimated. Four methods, BayesA, BayesB, BayesC, and rrBLUP, were employed for GS. It seems that BayesB more fitted than others. Then, the predictive accuracies of genome-wide association study (GWAS) informative SNPs and randomly selected SNPs were compared. The accuracies of former reached 100%, which are more higher than later'. These results suggest GWAS can improve the cost-efficiency of GS, and GS is suitable for the trait of ammonia tolerance and offers guidance for grouper breeding in the future.

Key words: orange-spotted grouper, *Epinephelus coioides*, genomic selection (GS), genome-wide association study (GWAS), single nucleotide polymorphism (SNP), ammonia tolerance

水体酸化在转录水平上对中华绒螯蟹鳃和卵巢的影响

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摘要: 目前, 由于二氧化碳浓度增加而导致的水体酸化, 给水生生物带来了一系列严重的影响。为了评估水体酸化对甲壳类动物的影响, 本研究对水体酸化环境下, 河蟹的鳃和卵巢组织进行了分析。组织学与卵母细胞透明液的结果表明水体酸化显著推迟了河蟹卵母细胞的成熟。此外, 对酸化处理过的河蟹鳃和卵巢组织进行转录组分析, 与对照组对比, 分别获得了 5,471 个和 485 个差异表达基因, 其聚类分析揭示了与酸化应急有关的通路, 其中包括 PI3K-Akt 信号通路、Chemokine 信号通路、细胞凋亡与 toll 样受体信号通路。荧光定量 PCR 验证了部分与免疫和卵巢成熟相关的基因在酸化组织中的表达情况, 其中包括 Cathepsin A、HSP70、HSP90、cyclin B 和 Fem-1 等。本研究为中华绒螯蟹对酸化环境的分子应激机制的研究提供了一定的基础。

关键词: 水体酸化; 中华绒螯蟹; 免疫反应; 卵母细胞成熟

Transcriptional response to acidification in the gills and ovaries of the Chinese mitten crab, *Eriocheir sinensis*

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Abstract: Nowadays, due to increasing carbon dioxide released, water acidification poses a series of serious impacts on aquatic organisms. To evaluate the effects of water acidification on crustaceans, we focused on the gills and ovaries of the Chinese mitten crab *Eriocheir sinensis*. Based on histological and oocyte transparent liquid observation, we found the acidified environment significantly delayed the ovarian maturation of *E. sinensis*. Moreover, RNA-seq was applied to obtain gene expression profile from the crab's gills and ovaries in response to acidified environment for half a month. Compared with control groups, 5,471 differentially expressed genes (DEGs) were identified in acidified gills and 485 DEGs were identified in acidified ovaries, respectively. Enrichment analyses indicated the DEGs and pathways in response to the acidified environment, such as PI3K-Akt signaling pathway, Chemokine signaling pathway, apoptosis and toll-like receptor signaling pathway. Some DEGs involved in immune response (ALF, Cathepsin A, HSP70, HSP90 and catalase) and ovarian maturation (Cyclin B, Fem-1a, Fem-1b, Fem-1c) are selected to validate the Illumina sequencing results by qRT-PCR. This comparative transcriptome provides valuable molecular information on the mechanisms of the Chinese mitten crab responding to acidified environment.

Key words: water acidification, Chinese mitten crab, immune response, oocyte maturation

比较转录组学研究鳙脊椎畸形性状

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摘要: 鱼类体型畸形是水产养殖业面临的重大难题之一, 关于养殖鱼类体型畸形的遗传因素研究十分有限。本研究以雌核发育鳙畸形个体和正常个体为研究对象, 取其肌肉和脊椎组织进行比较转录组分析。分别从肌肉和脊椎组织转录组获得 43,923 和 44,416 个 unigenes。在肌肉组织中没有差异表达基因, 在脊椎骨组织中发现 20 个与脊椎畸形相关的差异表达基因, 例如低密度脂蛋白相关蛋白 2 (*Irp2*), 骨形态发生蛋白 2B (*bmp2b*) 和胶原蛋白 α -1 (IV) (*col4a1*)。在脊椎转录组中发现了 12 条潜在与骨骼畸形相关的通路, 这些通路主要参与生长、发育、细胞骨架和能量代谢, 如 MAPK 信号通路、细胞骨架调节和 TGF β 信号通路等。本研究的结果有助于了解鱼类体型形成的遗传机制, 也为鳙体型选育和骨骼发育研究提供潜在候选基因。

关键词: 体型畸形; 转录组; 肌肉; 脊椎; 候选基因

Comparative transcriptome analyses and identification of candidate genes involved in vertebral abnormality of bighead carp *Hypophthalmichthys nobilis*

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Abstract: Body deformity occurs both in wild and farmed fishes, which is one of the most challenging problems for aquaculture industry. In this study, we performed muscles and vertebrae transcriptome analyses in body deformity and normality of bighead carp *Hypophthalmichthys nobilis* (from one meiotic gynogenesis family) using RNA-Seq. A total of 43,923 and 44,416 unigenes were generated in muscles and vertebrae, respectively. No differentially expressed gene (DEG) was found in transcriptome data of muscles. Totally, 20 candidate DEGs were identified in transcriptome data of vertebrae, such as low-density lipoprotein-related protein 2 (*Irp2*), bone morphogenetic protein 2B (*bmp2b*) and collagen α -1(IV) (*col4a1*). 12 potential pathways were also identified in vertebrae transcriptome data, which were mainly involved in development, growth, cytoskeleton and energy metabolism, such as MAPK signaling pathway, regulation of actin cytoskeleton and TGF- β signaling pathway. Results of this study will be informative for the understanding of genetic mechanisms for body shape formation and also provide potential candidate genes for selection program involved in body shape and skeleton morphology in bighead carp.

Keywords: body deformity, transcriptome, muscles, vertebrae, candidate genes

尼罗罗非鱼 TLR13 可识别链球菌 23sRNA 并通过 myd88 进行信号转导

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摘要: 为揭示 TLR13a 和 TLR13b 在尼罗罗非鱼 (*Oreochromis niloticus*) 免疫应答中的作用, 本实验对克隆获得的 *OnTLR13a* 和 *TLR13b* cDNA 序列进行生物信息学分析并初步分析其在固有免疫通路中的作用。两个基因的预测蛋白结构具有高度保守的 LRR、TIR 结构域。*OnTLR13a* 和 *TLR13b* 分别在脾脏和血液中表达量最高。此外, 体内感染无乳链球菌后, 两个基因的表达量在肠和鳃中显著升高。在 293T 细胞系中, TLR13a 可显著增强 *OnMyd88* 依赖的核因子κB (Nuclear factor-κB, NF-κB) 活性, *OnTLR13b* 则对 *OnMyd88* 依赖的 NF-κB 活性有显著的抑制作用。免疫共沉淀显示 *OnTLR13a* 和 *OnTLR13b* 均可与 *OnMyd88* 相互作用。Pull-down 结果表明, *OnTLR13a* 和 *OnTLR13b* 均可与无乳链球菌 (*Streptococcus agalactiae*) 的 23s rRNA 结合。由此推测, *OnTLR13a* 和 *TLR13b* 可识别无乳链球菌, 并通过 *myd88* 进行信号转导。

关键词: TLR13、尼罗罗非鱼、表达谱、先天免疫、NF-κB 活性

Nile tilapia TLR13 can recognize Streptococcus 23S RNA and conduct signal transduction through MyD88

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Abstract: In order to elucidate the function of *OnTLR13a* and *OnTLR13b* in immune response of Nile tilapia (*Oreochromis niloticus*), the cloned *OnTLR13a* and *OnTLR13b* cDNA and genome sequence was analyzed and its role in the innate immune pathway was analyzed. that *OnTLR13a* and *OnTLR13b* contained the conserved domains of TLRs, including LRR domain and TIR domain. The highest expression level of *OnTLR13a* and *OnTLR13b* was detected in the spleen and blood in healthy fish. In addition, after infection with *Streptococcus agalactiae*, the transcript of *OnTLR13a* and *OnTLR13b* was significantly increased in the intestine and gill. After cotransfection with *OnTLR13a*, the *OnMyd88*-dependent nuclear factor-κB (NF-κB) activity was significantly increased ($p < 0.05$). However, *OnTLR13b* significantly impaired *MyD88*-dependent NF-κB activation. Co-IP assays showed that both *OnTLR13a* and *OnTLR13b* could interact with *OnMyd88*. RNA Pull down showed that *OnTLR13a* and *OnTLR13b* could combine the 23s rRNA of *S. agalactiae*. Taken together, we speculated that Nile tilapia TLR13 can recognize *Streptococcus* 23S RNA and conduct signal transduction through *MyD88*.

Key words: TRIM35, Nile tilapia, Expression profile, Innate immunity, NF-κB activity, *Streptococcus agalactiae*

斑马鱼 ZF4 细胞冷适应中 dre-miR-183-5p 的作用研究

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摘要: MicroRNA(miRNA)在生物冷适应中具有重要的作用。目前已有研究植物冷适应相关 miRNA 及其作用,然而 miRNA 在鱼类冷适应过程中的作用尚不明确。本课题主要研究斑马鱼(*Danio rerio*)胚胎成纤维细胞(ZF4 细胞)冷适应过程中 dre-miR-183-5p 的作用:对照组于 28℃培养,实验组于 18℃培养 30 天,通过 RT-qPCR 分析 dre-miR-183-5p 的表达变化。对 28℃培养的 ZF4 细胞分别转染 miRNA minics 或 miRNA inhibitor 后转移至 18℃培养,通过台盼蓝拒染法等方法,研究过表达和抑制 dre-miR-183-5p 后,ZF4 细胞在低温压力下的生存状态。实验结果显示,ZF4 细胞低温处理 30 天后 dre-miR-183-5p 表达量显著上调;在 ZF4 细胞中过表达 dre-miR-183-5p 能够显著降低低温压力下的细胞死亡;在 ZF4 细胞中抑制 dre-miR-183-5p 的表达能够显著增加低温压力下的细胞死亡。实验结果显示 ZF4 细胞中 dre-miR-183-5p 能够在低温压力下起保护作用,本研究为进一步探究 dre-miR-183-5p 在 ZF4 细胞冷适应调控中的作用机制奠定了基础。

关键词: miRNA; 斑马鱼胚胎成纤维细胞; 冷适应

The role of dre-miR-183-5p in cold acclimation of zebrafish ZF4 cells

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Abstract: MicroRNA(miRNA) plays a critical role in cold acclimation process. Present studies have found relative miRNAs and their functions in plant cold acclimation, while the role of miRNA in cold acclimation process of fish remains unclear. The present study was conducted to investigate the effect of dre-miR-183-5p during cold acclimation process of zebrafish (*Danio rerio*) embryonic fibroblast cells (ZF4 cells). We used 28℃-cultured cells and 18℃-cultured cells(30 days) to analyze miRNA variation during cold acclimation of ZF4 cells by RT-qPCR. We transfected and cell viability was assessed by trypan blue exclusion. Experiment results showed that after 30 days' cold pressure, the expression level of dre-miR-183-5p in ZF4 cells was significantly up-regulated; over-expression of miR-183-5p in ZF4 cells could significantly reduce cell death under cold pressure. Inhibition of dre-miR-183-5p in ZF4 cells could significantly increase cell death under cold pressure. This study foreshadowed the protection function of dre-miR-183-5p for ZF4 cells under cold pressure and laid a solid foundation for further study of the regulation mechanisms of dre-miR-183-5p during cold acclimation of ZF4 cells.

Key words: miRNA, zebrafish embryonic fibroblast cells; cold acclimation

鲤抗疱疹病毒 (CyHV-3) 新品种选育与性状验证

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摘要: 鲤疱疹病毒病(Cyprinid herpesvirus 3, CyHV-3)是近些年来在主要鲤养殖国家爆发的一种疾病, 该病具有高度传染性, 药物治疗效果甚微, 发病率和死亡率可高达 90%-100%, 给产业造成了巨大的经济损失, 因此, 开展鲤抗疱疹病毒遗传基础与机制、新品种选育对鲤产业健康、稳定发展具有重要作用。我们围绕鲤疱疹病毒病, 开展了系统的基础研究, 明确不同种鲤及同种鲤个体间存在遗传差异及其抗病机制;通过比较不同镜鲤群体遗传变异, 建立基础选育群, 利用候选基因法和全基因组关联分析筛选性状相关标记并开展分子辅助育种, 目前已选育到 F4, 抗病性能已达稳定。2018-2019 年度对抗病镜鲤生长及抗病性能进行了生产小试和生产性对比试验, 结果表明抗病镜鲤 F4 生长速度快、抗病性强。

关键词: 镜鲤; 疱疹病毒; 成活率; 选育

Breeding and character verification of a new variety of common carp resistant to Cyprinid herpesvirus 3 (CyHV-3)

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Abstract: In recent years, Cyprinid herpesvirus 3 is a disease that has broken out in major common carp culture countries. The disease is highly contagious and has little effect on drug treatment. Its morbidity and mortality could reach 90% -100%, which caused huge economic losses to the fisheries. Therefore, the study on the genetic basis and mechanism of resistance to CyHV-3 and the breeding of new varieties of common carp is important for the healthy and stable development of the carp fisheries. We have carried out systematic basic research on common carp CyHV-3 disease. Based on the statistical data of infection of common carp, it is clear that there have been significant difference in resistance between carp species and individuals in same population. By comparing the genetic variation of different mirror carp populations, a basic breeding group was established. Trait-related markers were screened and molecular assisted breeding was carried out. Now we have bred to F4. The growth and disease resistance performance of the disease-resistant mirror carp was carried out in 2018-2019. The results showed that the disease-resistant mirror carp F4 has the characteristics of fast growth and strong disease resistance.

Key words: Common carp, Cyprinid herpesvirus 3, survival rate, breeding

盐度对金钱鱼幼鱼存活、生长和抗氧化系统的影响

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摘要: 设置 6 个盐度梯度养殖金钱鱼 (*Scatophagus argus*) 幼鱼 60 d, 统计存活及生长情况, 测定各盐度下幼鱼肝脏、鳃、肌肉组织中超氧化物歧化酶(SOD)、过氧化氢酶(CAT)、谷胱甘肽过氧化物酶(GPx)、谷胱甘肽 S-转移酶(GST)活力, 以及谷胱甘肽(GSH)和丙二醛(MDA)含量, 探讨盐度对其存活、生长和不同组织抗氧化状态的影响。结果表明, 存活率在 0~35 盐度范围内无显著差异($P>0.05$)。终末体长体重和增重率均在盐度为 5 时达到最大, 盐度 35 时最小。盐度 5 的特定生长率显著高于其他盐度组($P<0.05$)。基于特定生长率的二次回归模型拟合, 获得最佳养殖盐度为 7.5。淡水和盐度 35 组肝脏中 SOD 与 CAT 活力显著高于其他各组($P<0.05$), MDA 含量也较高。研究揭示, 金钱鱼幼鱼在 0~35 盐度范围内存活率高, 且在低盐环境中生长较快; 淡水和高盐环境使其体内产生氧化应激, 此时肝脏中 SOD 和 CAT 活力较高, MDA 含量累积, 抗氧化水平达到新的平衡。

关键词: 盐度; 金钱鱼; 存活; 生长; 抗氧化酶

Effects of salinity on survival, growth and antioxidant defense system of *Scatophagus argus*

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Abstract: In order to study the effects of salinity on the survival, growth and antioxidant status of juvenile *Scatophagus argus*, juveniles were exposed to different salinities for 60 days, the survival rate and growth status were counted. The activities of SOD, CAT, GPx, GST, and the contents of GSH, MDA in liver, gill and muscle tissues were determined. The results showed that the survival rate was no significant differences in the salinity range of 0~35($P>0.05$). When the salinity was 5, the final body length, body weight and weight gain rate reached the maximum, and the specific growth rate was significantly higher than other groups($P<0.05$). The optimal breeding salinity was 7.5 obtained by the quadratic regression model fitting based on the specific growth rate. The activities of SOD and CAT in the liver of fresh water and salinity 35 group were significantly higher than other groups($P<0.05$), and the content of MDA in liver was also higher. The results showed that the survival rate of *Scatophagus argus* juveniles was high in the salinity range of 0~35, juveniles grew slower in the hypertonic environment. The fresh water and hypertonic environment caused oxidative stress, the activities of SOD and CAT in liver were higher to resist oxidative stress, and MDA content accumulated, the antioxidant level reached a new balance.

Key words: salinity; *Scatophagus argus*; survival; growth; antioxidant enzymes

全基因组关联分析揭示鳙头部尺寸相关基因组区域和候选基因

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摘要: 为了探究鳙头部大小的遗传调控机制, 本研究利用全基因组关联分析 (GWAS) 方法, 以 776 个体和 9285 个 SNP 标记, 定位了头长、头高和头宽的基因组区域, 共获得与这些头部性状相关的 11 个显著性关联 SNP 和 12 个关联 SNP, 其中 4 个 SNP 为 3 个性状所共有; 这些 SNP 主要分布在 16 号染色体, 少数分布在 3 号和 21 号染色体。基于这些关联 SNP 查询鳙基因组, 获得一批遗传通路的候选基因, 例如 *cc2b*, *prdm1b*, *fndc5b*, *lbr*, *bmp8a*, *ATP6v1cb*, 其主要功能与骨骼发育、细胞增殖和脂肪代谢等调控功能有关。本研究定位和发掘的相关基因, 为揭示鱼类头部形态发育与尺寸调控机制以及选育快速生长且头部较大的鳙养殖品系提供了有用的遗传资源。

关键词: 头部尺寸; GWAS; 鳙; 骨骼发育; 细胞增殖; 候选基因

Genome-wide association study reveals genomic regions and candidate genes associated with head size in bighead carp *Hypophthalmichthys nobilis*

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Abstract: In order to study the genetic mechanism underlying head-size regulation in bighead carp (*Hypophthalmichthys nobilis*), in this study, using genome-wide association study (GWAS), we identify genomic regions associated with head length, head width and head height in a population of 776 individuals with 9285 SNP markers. GWAS detected eleven significant and twelve suggestive SNPs, which were mainly located on LG16 and four of these SNPs were commonly shared among head-size traits. Genes potentially involved in bone development, cell proliferation and lipid metabolism, such as *cc2b*, *prdm1b*, *fndc5b*, *lbr*, *bmp8a* and *ATP6v1cb*, were identified based on surrounding SNPs of the genomic regions. This study shed lights on understanding genetic architecture of head-size traits in fish and provided valuable genetic resources and candidate genes for genetic improvement towards a fast-growing bighead carp variety with bigger head.

Key words: head size, GWAS, bighead carp, bone development, cell proliferation, candidate genes

中华鳖性腺 miRNAs 和 lncRNAs 筛选及 ceRNA 网络的构建

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摘要: 为了进一步了解 MicroRNAs(miRNAs)和长非编码 RNA(lncRNAs)在生殖中的作用, 本研究采用转录组测序分析了中华鳖性腺差异表达(different expressed, DE)miRNAs、mRNA 和 lncRNAs。共筛选获得 miRNAs 10 446 个, mRNA 20 414 个, lncRNAs 28 500 个, 其中, 包括 DE miRNAs 633 个, DE mRNA 11 319 个, DE lncRNAs 10 495 个。通过基因本体论 (Gene Ontology, GO) 功能注释及京都基因与基因组百科全书 (Kyoto Encyclopedia of Genes and Genomes, KEGG) 通路富集分析, 发现了差异转录本主要参与中华鳖性别分化和性腺发育等相关的信号通路。随后, 运用生物信息学构建了内源性 lncRNAs-miRNAs-mRNA 网络。此外, 通过 qRT-PCR 验证了 miRNAs 和 lncRNAs 测序结果的准确性。本研究为更好地认识中华鳖卵巢和精巢中 miRNAs 和 lncRNAs 的作用提供基础。

关键词: 中华鳖; 性腺; miRNA; lncRNA; ceRNA

Genome-wide identification and comparison of differentially expressed profiles of miRNAs and lncRNAs with associated ceRNA networks in the gonads of Chinese soft-shelled turtle, *Pelodiscus sinensis*

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Abstract: In order to further understand the role of MicroRNAs(miRNAs) and long non-coding RNA(lncRNAs) in reproduction, this study has applied RNA-seq to analyze the different expressed (DE)miRNAs, mRNA and lncRNAs from the gonad of *Pelodiscus sinensis*. We identified 10 446 mature miRNAs, 20 414 mRNA and 28 500 lncRNAs, including 633DE miRNAs, 11 319 DE mRNA, and 10 495 DE lncRNAs. Through GO functional annotation and KEGG pathway enrichment analysis, we found the differential transcripts, which are mainly involved in sexual differentiation and signaling pathways of gonadal development in the *Pelodiscus sinensis*. Subsequently, We further constructed complete endogenous lncRNA-miRNA-mRNA networks using bioinformatics. In addition, qRT-PCR was used to verify the accuracy of the sequencing analysis of miRNAs and lncRNAs. This study provides a basis for a better understanding of the roles of miRNAs and lncRNAs in the ovaries and testes of the *Pelodiscus sinensis*.

Keywords: *Pelodiscus sinensis*, gonad, miRNAs, lncRNAs, ceRNA

鲢 EST-SSR 标记的开发及其与生长性状关联性分析

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摘要: 研究采用 Illumina 高通量测序技术对鲢 (*Hypophthalmichthys molitrix*) 卵组织进行转录组测序分析, 筛选多态 EST-SSR 标记并与生长性状进行关联性分析。研究结果显示: (1) 测序组装总 Unigene 77129 个, SSR 共 24458 个, 占所测 EST 数据的 31.7%。鲢包含 SSR 的 EST 序列主要有二碱基、三碱基、四碱基和五碱基组成。二碱基中, AC 含量最丰富; (2) 随机挑选 175 条 EST 序列设计 SSR 引物, 筛选出多态 EST-SSR 标记 36 个, Blast 结果显示有 10 条已知基因功能; (3) 全同胞家系检测结果显示有两个标记与生长性状相关。SCE26 与体长和体重相关 ($P < 0.05$), SCE65 与肥满度显著相关 ($P < 0.05$)。研究结果将为鲢的分子标记辅助育种的应用提供基础理论指导。

关键词: 鲢; EST-SSR; 分子标记; 家系; 生长性状

Development of EST-SSR markers and analysis of growth trait in silver carp

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Abstracts: Silver carp is one of important breeding fish in China. It is necessary to study the growth traits markers for accelerate the molecular marker-assisted breeding techniques. The simple sequence repeat (SSR) from the transcriptome of egg in silver carp were characterized by high-throughput Illumina sequencing, and genotypes associated with growth traits were analyzed. The main results are shown as follows: (1) 77129 unigenes were detected by assembly, about 31.7% of 24458 ESTs contain repeat motifs of various types (dinucleotide, trinucleotide, tetranucleotide and pentanucleotide) and lengths with AC being the most abundant dinucleotides one. (2) 175 EST-SSR primers were random characterized and 36 polymorphic EST-SSR were developed in silver carp. The results of Blast indicated that 10 EST-SSR genes are known. (3) The results showed that two loci were significantly correlated with growth traits in full-sibling family in silver carp. One locus SCE26 was significantly ($P < 0.05$) correlated with body length and body weight, and SCE65 was significantly ($P < 0.05$) correlated with condition factor. This study will provide theoretical basis and technical methods for the development of the marker-assisted breeding system in silver carp.

Keywords: *Hypophthalmichthys molitrix*, EST-SSR, molecular marker, family, growth traits

西北太平洋海域的日本囊对虾两个邻域隐种的精细群体遗传结构

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摘要: 日本囊对虾 (*Marsupenaeus japonicus*) 自然分布广泛, 大部分为异域分布, 在南中国海北部 (从广东惠来至广西北海) 呈同域分布。为了探究西北太平洋海域的日本囊对虾两个邻域隐种的精细遗传结构, 本研究利用简化基因组和比较转录组技术建立其系统发生关系。实验结果支持日本囊对虾两个高度分化的进化单元 (类型 I 和类型 II)。厦门群体和北海群体的迁移率和近交系数低于其他群体, 这可能与台湾海峡和琼州海峡的历史海陆变迁和复杂洋流相关。根据直系同源基因的同义替换率 (ds) 峰值估算两个邻域隐种的分化时间大概在 0.26 ~ 0.69 百万年。选择性杂交实验表明两个邻域隐种存在一定程度上的生殖隔离, 这支持生物学物种概念。日本囊对虾两个邻域隐种间的诸多差异提示了分别建立两个邻域隐种的遗传数据库, 重新评估两个邻域隐种的环境适应性, 研发特有的前沿育种技术的必要性。

关键词: 日本囊对虾; 隐种; 简化基因组; 比较转录组; 杂交实验

Fine-Scale population genetic structure and parapatric cryptic species of kuruma shrimp (*Marsupenaeus japonicus*), along the northwestern pacific coast of China

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Abstract: The kuruma shrimp (*Marsupenaeus japonicus*) includes two cryptic species, which are distributed mostly allopatrically but co-occur in the northern South China Sea (from Huilai to Beihai). To obtain a better understanding of the parapatric diversification of these two varieties in the northwestern Pacific region, we used genotyping-by-sequencing (GBS) and comparative transcriptomics to establish their phylogenetic relationships. The results supported two highly diverged evolutionary lineages of kuruma shrimp (var. I and II). The migration rates and inbreeding coefficients of XM and BH were much lower than those of the other populations, which might be related to the land-sea changes and complex ocean currents in the Taiwan Strait and Qiongzhou Strait. According to the peak of synonymous rates, the divergence time between two cryptic species was about 0.26~0.69 Mya. Choice and no-choice interbreeding experiments provided support for the biological species concept, by showing the existence of reproductive isolation or incompatibility. In view of these differences between the two *Marsupenaeus* species, it is essential and urgent to establish a genetic database for each and reevaluate their ecological suitable conditions in order to improve species-specific culturing techniques.

Key words: *Marsupenaeus japonicus*; cryptic species; genotyping-by-sequencing; comparative transcriptomics; interbreeding experiments

基于转录组分析鉴定脊尾白虾响应低氧-复氧胁迫的关键基因

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摘要: 低氧是虾类常见的应激源之一, 目前对脊尾白虾在低氧-复氧下的分子调控机制知之甚少。在本研究中, 我们对脊尾白虾在低氧 0h、3h、6h 和复氧 1h、8h 的肝胰腺组织进行了转录组测序, 共获得了 93227 个基因; 其中 4315 个基因被鉴定为差异表达基因。KEGG 富集分析显示所有差异基因显著富集在真核生物核糖体发生, 凋亡, 长寿调节途径, MAPK 信号通路和内质网蛋白质加工。此外, 通过 WGCNA 将表达量 (RPKM) ≥ 1 的 20203 个基因划分为 20 个模块, 确定了 3 个与低氧-复氧正相关的特异性模块, 并对特异性模块进行了 GO 和 KEGG 富集分析。根据模块内连通性鉴定了三个核心基因: RREB1 (ras-响应元件结合蛋白), UBE1 (泛素激活酶 E1) 和一个未知基因。本研究结果将有助于进一步阐明脊尾白虾应对低氧的调控机制。

关键词: 脊尾白虾; 低氧和复氧; 转录组测序; WGCNA

Hub genes of *Exopalaemon carinicauda* in responses to hypoxia and reoxygenation were identified by transcriptome analysis

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Abstract: Hypoxia is a common stressor to shrimp, however, the molecular mechanisms of hypoxia and reoxygenation adaptation of the ridgetail white prawn, *Exopalaemon carinicauda* is little to know. In this study, transcriptomic sequencing was performed on the hepatopancreas tissue of ridgetail white prawn at hypoxia for 0h, 3h, 6h and reoxygenation for 1h, 8h. A total of 93227 genes were obtained, of which 4315 genes were identified differentially expressed genes (DEGs) responding to hypoxia and reoxygenation. KEGG analyses showed that all DEGs were mainly enriched in ribosome biogenesis in eukaryotes, apoptosis, longevity regulating pathway, MAPK signaling pathway and protein processing in endoplasmic reticulum. In addition, 20203 genes with the RPKM values ≥ 1 were parsed into 20 modules via weighted gene co-expression network (WGCNA), 3 specific modules of which positively related with hypoxia and reoxygenation were identified, and GO and KEGG enrichment analysis was performed for specific modules. Three hub genes were identified based on connectivity: RREB1 (ras-responsive element-binding protein 1-like), UBE1 (ubiquitin-activating enzyme E1) and an unknown gene. Our study may help to further elucidate the hypoxia tolerance mechanism of *E. carinicauda*.

Key words: *E. carinicauda*, hypoxia and reoxygenation, RNA-seq, WGCNA

虹鳟体色相关基因 *mitfa* 的克隆及在不同发育阶段和组织的表达分析

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摘要: 小眼畸形相关转录因子(*mitf*)在动物体色形成过程中发挥重要的作用。本研究采用 RACE 技术首次获得了虹鳟 *mitfa* 基因的 cDNA 全长序列, 同时利用 qRT-PCR 分析了野生型虹鳟(虹鳟)与黄色突变型虹鳟(金鳟)体色发生不同时期、相同时期和不同组织中 *mitfa* 基因的表达差异。结果获得 cDNA 全长序列 2700 bp, 其中 ORF1212 bp。qRT-PCR 分析表明, *mitfa* 基因在虹鳟与金鳟胚胎及出膜后均有不同程度的表达, 均在胚胎前期的表达较高且显著高于其他各时期($P<0.05$); 在虹鳟与金鳟相同时期的差异表达结果显示, 受精期、16 细胞期、桑葚期、囊胚期、体节期、心跳期、3 days post hatch (dph)、5dph、7dph、10dph、1month (M)和 12M 的差异极显著($P<0.01$); *mitfa* 基因在 12 月龄虹鳟和金鳟各组织中也均有表达, 其中分别在背部皮肤的表达量最高且显著高于其他各组织($P<0.05$)。以上结果表明 *mitfa* 基因的表达与虹鳟体色变异密切相关, 可为虹鳟体色变异分子调控机制研究及其体色遗传改良提供基础资料。

关键词: 虹鳟; 体色; *mitfa* 基因; 克隆; 表达分析

Cloning and Expression of *mitfa* Gene of the Different Stages and Tissues in Rainbow Trout (*Oncorhynchus mykiss*)

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Abstract: Microphthalmia associated transcription factor (*mitf*) plays an important role in the formation of animal body colour. We obtained the full-length sequence of *mitfa* gene of rainbow trout for the first time by RACE technique, and qRT-PCR was used to investigate the different expression level of *mitfa* in different and same stages and various tissues. The full-length of *mitfa* was 2700 bp which contained 1212 bp ORF. qRT-PCR analysis revealed that *mitfa* was expressed at different levels in various stages of embryos and post hatch, and in the early of embryonic stages had higher expression and significantly higher than other periods ($P<0.05$). Moreover, the differential expression analysis of *mitfa* gene showed that wild-type and yellow mutant rainbow trout of the fertilized-stage, 16-cell, multi-cell, blastula, somites, heartbeating, 3 days post hatch (3dph), 5dph, 7dph, 10dph, 1 month (1M) and 12M had extremely significant differences ($P<0.01$). *mitfa* gene was also expressed in all tissues in wild-type and yellow mutant rainbow trout of 12 months old, the expression level in the dorsal skin was the highest ($P<0.05$). The above results indicated that the expression of *mitfa* gene was closely related to rainbow trout body colour variation, which can provide basic data for the molecular regulation mechanism of body colour variation and the genetic improvement of body colour in rainbow trout.

Key words: Rainbow trout, Body colour, *mitfa* gene, Cloning, Expression analysis

Tlx1 基因突变导致的先天无脾降低了斑马鱼 对嗜水气单胞菌抵抗力

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摘要: 在哺乳动物中, *tlx1* 基因在早期脾脏发育调控中起着关键作用。但是 *tlx1* 在非哺乳动物物种, 特别是鱼类中的功能尚未报道。在本研究中, 我们证明了 *tlx1* 在斑马鱼受精后 52 小时(hpf)就在脾原基中表达。通过 CRISPR/Cas9 建立了 *tlx1*^{-/-} 纯合突变斑马鱼模型, 以阐明 *tlx1* 在斑马鱼脾脏发育中的作用。在 *tlx1*^{-/-} 背景中, 表达 *tlx1* 的细胞在 52 hpf 的脾原基中持续存在, 但在 53 hpf 后不再被检测到, 表明早期脾脏发育受到阻断。此外, *tlx1* 突变导致了斑马鱼的先天性无脾而无其他明显缺陷。在嗜水气单胞菌感染实验中先天无脾斑马鱼存活率明显低于野生型斑马鱼。在注射嗜水气单胞菌疫苗后 *b7r* 和 *ccr2* 在先天无脾斑马鱼中的表达降低, 表明单核细胞吞噬系统功能部分受损。此外, 与野生型斑马鱼相比, 先天性无脾鱼中 *MHCII/IgM* 的表达明显降低。

关键词: *tlx1*; 先天无脾; 嗜水气单胞菌; 抗病力

Congenital asplenia due to a *tlx1* mutation reduces resistance to *Aeromonas hydrophila* infection in zebrafish

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Abstract: It is documented that *tlx1* plays critical roles in the regulation of early spleen developmental in mammalian species. However, there is no direct evidence supporting the functions of *tlx1* in non-mammalian species, especially in fish. In this study, we demonstrated that *tlx1* is expressed in the splenic primordia as early as 52 hours post-fertilization (hpf) in zebrafish. A *tlx1*^{-/-} homozygous mutant line was generated via CRISPR/Cas9 to elucidate the roles of *tlx1* in spleen development in zebrafish. In the *tlx1*^{-/-} background, *tlx1*^{-/-} cells persisted in the splenic primordia until 52 hpf but were no longer detectable after 53 hpf, suggesting perturbation of early spleen development. The zebrafish also exhibited congenital asplenia caused by the *tlx1* mutation. The survival rate of asplenic zebrafish infected with *Aeromonas hydrophila* was significantly lower than that of wild-type zebrafish. In asplenic zebrafish, the mononuclear phagocyte system was partially impaired. Furthermore, the expression of *MHCII/IgM* was significantly reduced in the congenitally asplenic fish.

Key words: *tlx1*, congenital asplenia, *A. hydrophila*, disease resistance

鲤鱼 sPLA2-IIIs 磷脂酶活性研究

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摘要: 为测定鲤鱼 sPLA2-IIIs 的磷脂酶活性, 通过构建重组质粒 MBP-PLA2g3a1、MBP-PLA2g3b1、MBP-PLA2g3c1 进行原核表达, 经蛋白纯化系统获得重组蛋白, 采用偶联脂氧合酶法测定重组蛋白的磷脂酶活性。结果显示三者比活力为 7.68、3.97、1.83 U· μmol^{-1} ; 最适 pH 为 7.5、7、8; 22~30℃ 内, 磷脂酶活性无明显差异; Ca^{2+} 明显提升磷脂酶活性, K_d 值为 15.3、28.8、13.6 $\mu\text{mol}\cdot\text{L}^{-1}$; 米氏方程参数 V_m 为 2.2、2.58、1.99 $\mu\text{mol}\cdot\text{L}^{-1}\cdot\text{min}^{-1}$, K_m 为 31.9、50.53、41.71 $\mu\text{mol}\cdot\text{L}^{-1}$ 。

关键词: 鲤鱼; sPLA2-IIIs; 重组蛋白; 磷脂酶活性

Research on the activity of sPLA2 - III s phospholipase in *Cyprinus carpio*

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Abstract: In order to determine the phospholipase activity of *Cyprinus carpio* sPLA2-IIIs, the recombinant plasmids MBP-pla2g3a1、MBP-pla2g3b1、MBP-pla2g3c1 were constructed for prokaryotic expression. The recombinant protein was obtained by protein purification system, and the phospholipase activity of the recombinant protein was determined by coupled lipoygenase method. The results showed that the specific activities of the three compounds were 7.68、3.97、1.83 U· μmol^{-1} ; the optimum pH was 7.5、7、8; there was no significant difference in the activity of phospholipase from 22 to 30 °C; Ca^{2+} significantly increased the activity of phospholipase, with K_d of 15.3, 28.8 and 13.6 $\mu\text{mol}\cdot\text{L}^{-1}$; Parameters of Mie equation V_m were 2.2、2.58 and 1.99 $\mu\text{mol}\cdot\text{L}^{-1}\cdot\text{min}^{-1}$, and k_m were 31.9、50.53、41.71 $\mu\text{mol}\cdot\text{L}^{-1}$.

Key words: *Cyprinus carpio*, sPLA2-IIIs, Recombinant protein, Phospholipase activity

南美白对虾 *krüppel* 转录因子在对虾免疫应答 中对血蓝蛋白小亚基基因转录的负调控研究

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摘要: 血蓝蛋白是一种多功能的呼吸糖蛋白, 同是具有多种免疫学功能。但是, 其转录调控机制仍然鲜为人知。因此, 本研究利用 DNA pull-down 和 LC-MS/MS 技术筛选发现 Krüppel 转录因子(PvKrüppel)可能参与南美白对虾血蓝蛋白(PvHMCs)的转录调控。为此, 利用突变以及 EMSA 分析证实 PvKrüppel 可以与 PvHMCs 核心启动子结合。此外, 在对虾应对脂多糖(LPS), 溶血性弧菌和白斑综合症病毒(WSSV)等的免疫应答过程中, PvKrüppel 和 PvHMCs 的转录水平呈负相关。并且, PvKrüppel 的过表达显著降低了 PvHMCs 的启动子活性, 而 RNA 干扰或脂多糖(LPS)刺激引起的 PvKrüppel 表达降低导致 PvHMCs 转录水平显著增加。综上所述, 我们目前的研究有助于了解对虾对病原体免疫反应期间 PvKrüppel 对 PvHMCs 转录调控的机制。

关键词: krüppel; 转录调控; 血蓝蛋白; 凡纳滨对虾

The *krüppel*-like factor of *Penaeus vannamei* negatively regulates transcription of the small subunit hemocyanin gene as part of shrimp immune response

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Abstract: Hemocyanin is a multifunctional respiratory glycoprotein, which has also been implicated in other biological functions in shrimp. However, its transcription regulation mechanism is still rarely known about. Here, Krüppel-like factor (designated PvKrüppel), a zinc finger transcription factor homolog in *Penaeus vannamei*, was identified among the putative transcription factors by DNA pull-down and LC-MS/MS. Mutational analysis and electrophoretic mobility shift assay (EMSA) confirmed that PvKrüppel could bind to the KLF motif on the core promoter region of PvHMCs. Moreover, in response to lipopolysaccharide (LPS), *Vibrio parahaemolyticus* and white spot syndrome virus (WSSV) challenge, transcript levels of PvKrüppel and PvHMCs were negatively correlated. Furthermore, overexpression of PvKrüppel significantly reduced the promoter activity of PvHMCs, while PvKrüppel knockdown by RNA interference or lipopolysaccharides (LPS) stimulation resulted in a significant increase in the transcript level of PvHMCs. Taken together, our present study provides mechanistic insights into the transcriptional regulation of PvHMCs by PvKrüppel during shrimp immune response to pathogens.

Key words: Krüppel-like factor, Transcriptional regulation, Hemocyanin, *Penaeus vannamei*

花鲈垂体和下丘脑中生物钟基因在三种光周期下的表达节律分析

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摘要: 文章研究了三种光周期条件下(16L:8D、12L:12D 和 8L:16D), 七个重要生物钟基因 Bmal2、Npas4、Per2、Cry1、Cry1a、Cry2 及 Timeless 在花鲈垂体和下丘脑中的表达节律。研究结果表明, 相同基因在垂体和下丘脑两种组织中的昼夜节律不同, 长光照或者短光照处理会改变或使之失去昼夜节律。

关键词: 花鲈; 光周期; 昼夜节律

Circadian rhythmicity of clock genes in pituitary and hypothalamus of spotted sea perch (*Lateolabrax maculatus*) under three photoperiod conditions

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Abstract: In this study, seven important clock genes Bmal2、Npas4、Per2、Cry1、Cry1a、Cry2、Timeless were detected in the pituitary and hypothalamus of *Lateolabrax maculatus* under three photoperiod conditions: 16L:8D , 8L:16D and 12L:12D. The results show that the circadian rhythms of the same gene in pituitary and hypothalamus are different. Long day (16L:8D) or short day (8L:16D) can change the circadian rhythm and some genes lose circadian rhythms.

Key words: *Lateolabrax maculatus*; Photoperiod; Circadian rhythmicity

基于转录组学研究氨氮胁迫和恢复对刀鲚稚鱼和幼鱼的不同影响

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摘要: 为研究氨氮胁迫和恢复对刀鲚稚鱼和幼鱼的不同影响, 本实验基于转录组测序研究比较了刀鲚稚鱼和幼鱼在氨氮胁迫和恢复中发挥重要作用的基因的表达趋势。分别在稚鱼和幼鱼中筛选到了 831 和 952 个差异基因。趋势分析表明与嘌呤代谢、免疫、炎症、表观遗传修饰以及神经传导相关的基因在稚鱼和幼鱼中存在不同的表达趋势。此外, 运用荧光定量 PCR 检测了与嘌呤代谢相关基因 *XDH* 以及表观遗传修饰相关基因 *DNMT1*、*DNMT3A*、*DNMT3B* 的表达, 结果表明这些基因出现了不同的表达趋势。*TNF- α* 、*ILF-2*、*ILF-3* 表达的升高以及 LZM、AKP、ACP 活性的增强表明氨氮胁迫下的稚鱼和幼鱼均引起了炎症, 免疫力下降。相比于稚鱼, 幼鱼在氨氮胁迫下神经传导功能受到了影响。清水恢复减弱了氨氮对幼鱼神经传导的影响。但是, 清水恢复并未减弱炎症和提升免疫力。由此可见, 氨氮胁迫后立即换水恢复后的稚鱼和幼鱼仍存在炎症和免疫下降的风险。本研究探讨了氨氮胁迫和恢复对刀鲚稚鱼和幼鱼的不同影响, 为日后提升刀鲚氨氮耐性奠定基础。

关键词: 转录组, 氨氮胁迫和恢复, 刀鲚稚鱼和幼鱼, 嘌呤代谢, 表观遗传修饰

Transcriptomic analysis reveals different responses to ammonia stress and subsequent recovery between *Coilia nasus* larvae and juveniles

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Abstract: Transcriptomic analysis of *Coilia nasus* larvae and juveniles treated with ammonia stress and subsequent recovery in freshwater were performed. 831 and 952 DEGs were identified in *C. nasus* larvae and juveniles, respectively. Transcriptomic analysis revealed that genes associated with purine metabolism, immune, inflammation, epigenetic modification, and nerve conduction presented different expression trends between *C. nasus* larvae and juveniles. Other genes related to purine metabolism (*XDH*) and epigenetic modifications (*DNMT1*, *DNMT3A*, and *DNMT3B*) detected by RT-qPCR also displayed different expression trends. These results indicated that ammonia detoxify strategies and gene regulation patterns were different in *C. nasus* larvae and juveniles. Higher *TNF- α* , *ILF-2*, and *ILF-3* expression and reduced LZM, AKP, and ACP activities suggested that inflammation and declined immunity were triggered by ammonia stress. Additionally, nervous conduction was severely affected under ammonia stress in *C. nasus* juveniles. Furthermore, recovery in freshwater had positive effects on nervous conduction. However, it was worth noting that reduced immunity and inflammation were still existed after recovery in freshwater. In conclusion, our study would be beneficial to reveal the different responses to ammonia stress between larvae and juveniles.

Keywords: Transcriptomic analysis, ammonia stress and recovery, *Coilia nasus* larvae and juveniles, purine metabolism, epigenetic modifications

雌核发育棕点石斑鱼的遗传连锁图谱构建及其生长相关 QTLs 的定位

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摘要: 棕点石斑鱼 (*Epinephelus fuscoguttatus*) 是石斑鱼杂交育种中最重要的母本之一。其生长性状的改良对石斑鱼产业具有积极影响。本实验, 使用雌核发育 F1 棕点石斑鱼家系构建遗传图谱, 并对生长相关 QTLs 进行定位。该遗传图谱共包含 10106 个 SNP 标记, 24 个连锁群, 长度为 15435.61cM, 标记间平均遗传距离为 1.53cM。在 8 个连锁群上检测到 76 个与生长性状相关的 QTLs, 这些 QTLs 解释表型变异的比例于 9.4~14.5% 之间。本研究开发的生长相关 QTLs 有助于棕点石斑鱼分子辅助育种工作, 对于石斑鱼生长相关遗传改良具有重要意义。

关键词: 棕点石斑鱼; 雌核发育; 遗传图谱; 数量性状位点 (QTL); 生长

Construction of genetic map and QTLs analysis of Growth-Related traits in Gynogenetic Brown-Marbled Grouper (*Epinephelus fuscoguttatus*)

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Abstract: Brown-Marbled grouper, *Epinephelus fuscoguttatus*. is one of the most important female parents in grouper cross-breeing. The improvement of its growth is essential for the grouper industry. In the studies, the meiotic gynogenetic population of brown-marbled is applied to construction of genetic maps and the location of growth-related QTLs. The genetic maps included 10,106 SNPs in 24 linkage groups, spanned 15,435.61 cM with a average genetic distance of 1.53cM. According to the genetic map, 76 QTLs related to growth traits were detected in 8 linkage groups, and the proportion of phenotypic variation explained by these QTLs ranged from 9.4 to 14.5%. The QTLs detected in the research promote the improvement of molecular selection breeding of brown marbled grouper and provide improtant genetic resources to the improvement of growth traits in grouper.

Key words: *Epinephelus fuscoguttatus*, Gynogenetic, genetic map, quantitative trait locus (QTL), growth-related trait

全雌黄姑鱼的规模化培育

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摘要: 黄姑鱼是我国重要的海水经济鱼类, 在养殖实践中发现, 黄姑鱼的雌鱼比雄鱼生长快, 所以培育全雌黄姑鱼苗种能够提高养殖效益。本研究建立了异源精子(条石鲷精子)诱导黄姑鱼雌核发育的方法, 并进一步利用雌核发育苗种培育了伪雄鱼。首先, 筛选出条石鲷精子紫外灭活的适宜剂量为 45 mJ/cm^2 ; 并且, 筛选到适合黄姑鱼卵雌核发育的冷休克起始时间(授精后 2min)、冷休克温度和持续时间 ($2.5\sim 3.5^\circ\text{C}$ 下冷休克处理 8min)。采用外部形态、流式细胞仪、组织切片及微卫星的方法对黄姑鱼雌核发育后代进行了鉴定, 证明所诱导的黄姑鱼为雌核发育苗种。进一步利用不同浓度的 17α -甲睾酮 (MT) 对 25 日龄的雌核发育黄姑鱼进行浸浴处理, 每日 2 小时, 连续处理 60 天, 能够 100% 诱导性逆转。通过伪雄鱼和雌鱼交配, 规模化生产全雌鱼。

关键词: 黄姑鱼, 雌核发育, 伪雄鱼, 性别控制

Mass production of all female yellow drum (*Nibea albiflora*) for its aquaculture

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Abstract: Yellow drum (*Nibea albiflora*) is one of the most important species for commercial fisheries and a promising candidate for aquaculture in China. This fish exhibits significant sexually dimorphic growth and the efficiency and profitability of its aquaculture could be maximized by all-female production. Consequently, we developed an effective protocol to induce meiotic gynogenesis and further produced sex-reversed fish (neo-males) using gynogenetic fish. Spermatozoa from rock bream (*Oplegnathus fasciatus*) were used and the optimal UV-irradiation dose for genetically inactivating the spermatozoa was observed at a UV dose of 45 mJ/cm^2 . The critical parameters for preventing extrusion of the second polar body were optimized, and the best yield of gynogens was obtained with a cold-shock at 4°C for a period of 8 min, initiated 2 min after fertilization. Flow cytometry and microsatellite analyses demonstrated that our protocol successfully obtained 100% gynogenetic individuals. Then, immersion treatments with 17α -methyltestosterone (MT) were applied to gynogenetic yellow drum to induce phenotypic sex reversal fish. Gynogenetic yellow drum at an undifferentiated sex stage (total length, $1.63 \pm 0.16 \text{ cm}$) were immersed in 17α -methyltestosterone (17α -MT) for 2 h/day from 30–90 dph (60 days), producing 100% neo-males. Furthermore, crossing of gynogenetic sex-reversed males with normal females produced 100% females, demonstrating the potential efficiency of this protocol for reversing the sex of yellow drum and establishing large-scale production of all-female populations in yellow drum.

Key words: *Nibea albiflora*, gynogenesis, neo-males, sex control

基于转录组的鲢低氧胁迫下差异表达基因的 筛选

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摘要: 鲢是我国四大家鱼之一, 耐低氧能力差, 易引起浮头, 泛塘等现象, 造成大面积死亡。为了探究鲢低氧胁迫相关基因, 选用正常氧浓度(6.45 mg/L DO)、浮头(0.76 mg/L DO)、半窒息(0.58 mg/L DO)和窒息(0.53 mg/L DO)鳃组织为实验材料, 进行Illumina Hiseq™ 2000测序, 对测序数据进行拼接、注释并筛选低氧胁迫下的差异表达基因。结果显示, 测序共获得157505条unigenes, 平均长度为2394bp, N50为2734bp。浮头与常氧时相比, 得到989个差异表达基因, 其中上调544个, 下调445个; 半窒息与浮头时相比较共252个差异表达基因, 其中上调145个, 下调107个; 窒息与半窒息时相比筛选到差异表达基因84个, 其中上调47个, 下调37个。KEGG富集分析表明, 注释的95153条Unigenes主要与5个生化途径相关, 包括细胞过程、环境信息处理、遗传信息处理、代谢和有机系统。经实时荧光定量PCR验证差异表达最显著的10个基因, 其基因表达特征与转录组数据一致。该研究为鲢低氧胁迫下鳃的分子响应提供了基础数据和理论依据。

关键词: 鲢; 转录组; 低氧胁迫; 差异表达基因

Screening of differentially expressed genes of silver carp under hypoxia stress based on transcriptomics

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Abstract: The silver carp is one of the four common carp in China, with poor hypoxic tolerance, which is easy to cause floating head and pan-pond, etc., causing large area of death. Illumina Hiseq™2000 sequencing was performed on normal oxygen concentration, floating head, semi-asphyxia and asphyxia in the gills to explore the genes related to hypoxia stress of the silver carp. The sequencing data were splice, annotated and the different-expressed genes were screened under hypoxia stress. The results showed that 157505 unigenes were obtained, with an average length of 2394bp and 2734bp for N50. A total of 989 differentially expressed genes were found in the floating head, among which 544 genes were up-regulated and 445 genes were down-regulated. There were a total of 252 differentially expressed genes, among which 145 were up-regulated and 107 were down-regulated. Eighty four differentially expressed genes were screened during asphyxia and semi-asphyxia, among which 47 were up-regulated and 37 were down-regulated. KEGG enrichment analysis showed that the 95,153 Unigenes annotated were mainly related to 5 biochemical pathways, including cellular process, environmental information processing, genetic information processing, metabolism and organic system. The ten most significantly differentially expressed genes were verified by real-time fluorescence quantitative PCR, and their gene expression characteristics were consistent with transcriptome data. This study provides basic data and theoretical basis for molecular response of gills under hypoxia stress of silver carp.

Key words: silver carp, transcriptomics, under hypoxia stress, differentially expressed genes

尼罗罗非鱼与奥利亚罗非鱼的正、反交后代中线粒体 DNA 遗传方式的不同

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摘要: 奥尼罗非鱼 (奥利亚罗非鱼 ♂ × 尼罗罗非鱼 ♀) 是中国国内罗非鱼养殖业中一种主要养殖品种, 而尼奥罗非鱼 (尼罗罗非鱼 ♂ × 奥利亚罗非鱼 ♀) 则是一种研究杂交基因重组的优良实验鱼种。本文中分别对尼罗罗非鱼、奥利亚罗非鱼、奥尼罗非鱼、尼奥罗非鱼进行了 DNA 提取及线粒体 DNA 测序, 通过 Blast 进行比对, 发现奥尼罗非鱼线粒体基因组与其母本尼罗罗非鱼的相似度为 92.88%, 与其父本奥利亚罗非鱼的相似度为 99.86%, 证明奥尼罗非鱼中存在父系线粒体 DNA 遗传。而在尼奥罗非鱼中, 所有的线粒体基因组都与其母本尼罗罗非鱼 100% 相似, 不存在父系线粒体 DNA 遗传。我们的研究揭示了相同两个物种间不同的杂交方式会导致线粒体 DNA 的遗传方式出现不同。

关键词: 杂交罗非鱼; 线粒体 DNA; 父系遗传; 母系遗传

The Difference of Mitochondria DNA Inheritance Behavior Between Orthogonal and Backcrossed Offspring of *Oreochromis niloticus* and *Oreochromis aureus*

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Abstract: The hybrid of *Oreochromis niloticus* (♀) × *Oreochromis aureus* (♂) was one of the main raised kind in China's domestic tilapia farming industry, and the hybrid of *Oreochromis niloticus* (♂) × *Oreochromis aureus* (♀) is a good experimental fish species for studying hybrid gene recombination. We sequenced the mtDNA of *Oreochromis niloticus*, *Oreochromis aureus*, the hybrid of *Oreochromis niloticus* (♀) × *Oreochromis aureus* (♂) and the hybrid of *Oreochromis niloticus* (♂) × *Oreochromis aureus* (♀), used Blast to aligned the 4 sequences, and found the mtDNA of hybrid of *Oreochromis niloticus* (♀) × *Oreochromis aureus* (♂) had 92.88% identical with maternal mt genome, and 99.86% identical with paternal mt genome, implied that there was paternal mtDNA inheritance. All the hybrid of *Oreochromis niloticus* (♂) × *Oreochromis aureus* (♀) had 100% identical mt genome with their female parent, and no sign of paternal mtDNA inheritance. Our research revealed that different hybridization patterns between the same two species can lead to different inheritance patterns of mitochondrial DNA.

Key words: Hybrid tilapia, mitochondria DNA, Paternal Inheritance, Maternal Inheritance.

中国7种罗非鱼遗传结构和遗传多样性分析

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摘要: 利用线粒体控制区 (D-loop 区) 的全序列, 对尼罗罗非鱼 *Oreochromis niloticus* (NL)、奥利亚罗非鱼 *O. aureus* (AR)、莫桑比克罗非鱼 *O. mossambicus* (MS)、吉富罗非鱼 (GIFT) 和 3 种红罗非鱼 [中国台湾 (TW)、以色列 (IL)、马来西亚 (MY)] 进行遗传结构和遗传多样性分析。序列总长 867bp, 包含了 146 个变异位点和 32 个单倍型。遗传多样性表明: 7 个群体具有很高的遗传多样性 (0.234-0.952) 和核苷酸多样性 (0-0.060)。成对遗传分化系数(Fst)分析显示, MY 与 IL 间遗传分化不显著 ($P>0.05$), 其余群体间均呈极显著遗传分化 ($P<0.01$)。分子方差分析表明, 群体间遗传变异极显著 ($P<0.01$), 占总变异的 63.57%。结果表明, 7 种罗非鱼遗传多样性丰富, 具备较高的生态适应和选育的潜力。

关键词: 罗非鱼; D-loop; 遗传结构; 遗传多样性;

Genetic structure and genetic diversity analysis of seven tilapia species from China

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Abstract: We examined the population genetic structure and genetic diversity of the seven tilapia species, containing *Oreochromis aureus* (AR), *O. niloticus* (NL), *O. mossambicus* (MS), GIFT and three red tilapia varieties [China Taiwan (TW), Israel (IL), and Malaysia (MY)]. Fragments of 867 bp were sequenced and a total of 146 polymorphic sites were detected, which defined 32 haplotypes. The genetic diversity showed that seven populations had high genetic diversity (0.234-0.952) and nucleotide diversity (0-0.060). F-st value showed that there was extremely significant genetic differentiation between the other populations ($P<0.01$), except MY and IL ($P>0.05$). AMOVA showed that the genetic variation among seven populations was extremely significant ($P<0.01$), contained 63.57% of total variance. The results showed that seven tilapia species had strong adaptive capacity and breeding potential due to its high genetic diversity.

Key words: tilapia, D-loop, genetic structure, genetic diversity

不同浓度白藜芦醇对罗非鱼幼鱼血液转录组的影响

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摘要: 尼罗罗非鱼作为浮床时经常咬伤虎杖根, 白藜芦醇主要积累在虎杖根中。在本研究中, 我们测定了 RES 给药对 GIFT 患者血液转录反应的影响。随着 RES 浓度的增加, 133 个、155 个和 123 个基因被检测为显著差异表达基因。3 组和 4 组中有 3 个和 95 个共同显著的 deg 富集。结果显示相同的表达模式: 细胞色素 c 亚型 X2、含 A1 亚基的 katanin p60 ATP 酶 X1、质膜钙转运 ATP 酶 1 样和 GTP 结合蛋白 A 样在 0.1g/kg RES 组表达最高, 而 NADH 脱氢酶铁硫蛋白 2 线粒体、ATP 合成酶亚单位 β 、线粒体、ATP 合成酶亚单位 α 、线粒体样、ATP 合成酶亚单位 α 、线粒体和 ATP 依赖的 Clp 蛋白酶蛋白水解亚基, 补充 RES 后, 线粒体呈剂量依赖性表达。0.05, 0.1g/kg RES 组血 Ca^{2+} -ATP 酶活性、丙二醛、谷胱甘肽和 ATP 含量均显著高于对照组。我们的研究表明, 补充 RES 可能通过线粒体能量合成和/或呼吸链来提高对代谢功能障碍的抵抗力。

关键词: 白藜芦醇, 吉特罗非鱼, RNA 测序

Transcriptome analysis of juvenile tilapia (*Oreochromis niloticus*) blood, fed with different concentrations of resveratrol

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Abstract: *Oreochromis niloticus* often bites the root of *Polygonum cuspidatum* when it is used as a floating bed, and resveratrol is mainly accumulated in the root of *P. cuspidatum*. In this study, we determined the effects of RES administration on blood transcriptomic response in GIFT. With increasing RES concentration, 133, 155, and 123 genes were detected as significant differentially expressed genes. Three and 95 shared significant DEGs were found to be enriched among the three and four groups respectively. The results revealed the same expression pattern: cytochrome c isoform X2, katanin p60 ATPase-containing subunit A1 isoform X1, plasma membrane calcium-transporting ATPase 1-like and GTP-binding protein A-like showed the highest expression in the 0.1 g/kg RES group, while NADH dehydrogenase iron-sulfur protein 2 mitochondrial, ATP synthase subunit beta, mitochondrial, ATP synthase subunit alpha, mitochondrial-like, ATP synthase subunit alpha, mitochondrial and ATP-dependent Clp protease proteolytic subunit, mitochondrial revealed a dose-dependent expression following RES supplementation. Blood Ca^{2+} -ATPase activity, and malondialdehyde, glutathione, and ATP content were significantly increased in the 0.05, 0.1 g/kg RES group when compared with the controls. Our study demonstrated that RES supplementation might improve the resistance to metabolism dysfunction via mitochondrial energy synthesis and/or the respiratory chain.

Key words: resveratrol, GIFT tilapia, RNA sequencing

中华鳖 MHC II α 基因 cDNA 的克隆及组织表达分析

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摘要: 为了探究中华鳖(*Pelodiscus sinensis*)的主要组织相容性复合体(MHC)的结构和功能,本研究利用 RACE 技术成功克隆获得中华鳖 MHC II α 基因的 cDNA 全长序列,其长度为 1296 bp,开放阅读框(ORF)807 bp,共编码 268 个氨基酸,分为信号肽序列,II 类组织相容性抗原 α 结构域,IGc1 结构域及跨膜结构域 4 个功能结构域。荧光定量 PCR 结果分析表明 MHC II α mRNA 在中华鳖 8 个组织中均有表达,在脾、心、肝及肠组织中表达水平较高,在肌肉组织中表达量最低。感染嗜水气单胞菌(*Aeromonas hydrophila*)12h 后,中华鳖 MHC II α mRNA 在肝和肠组织中显著上调表达;感染 1 天时在脾组织中显著上调表达;感染 1 天及 5 天时在肾组织中显著上调表达,以上研究表明中华鳖 MHC II α 基因参与了中华鳖免疫反应。

关键词: 中华鳖; MHC II α ; 序列分析; 基因表达

Cloning and expression analysis of MHC II α cDNA in *Pelodiscus Sinensis*

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Abstract: To study the structure and function of MHC in *Pelodiscus sinensis*, we obtained the fulllength cDNA of MHC II α by RACE-PCR technology. This sequence was 1296 bp, including an ORF region of 807 bp. The peptide encoded MHC II α gene could be divided into four parts, including signal peptide, MHC II alpha domain, IGc1 domain and transmembrane region. In all 8 tissues, the highest expression level of MHC II α gene was observed in spleen、heart、liver and intestine, while the minimum level in muscle using qRT-PCR. Meanwhile, MHC II α mRNA expression levels were significantly up-regulated in liver and intestine (after 12 hours), spleen (on 1st day) and kidney (on 1st and 5th day) after being infected with *Aeromonas hydrophila*, and the liver, spleen, intestine and kidney are closely related to immunity, which indicates that this gene has important effects on immune response.

Key words: *Pelodiscus sinensis*; MHC II α ; sequence analysis; gene expression

中华鳖皮肤色素沉着相关miRNA-mRNA联合分析

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摘要: 为研究中华鳖 (*Pelodiscus sinensis*) 不同体色色素沉着差异, 本实验选清溪乌鳖和洞庭鳖为实验对象, 采用mRNA和miRNA测序比较了清溪乌鳖(WBF)和洞庭鳖(DTF)腹部皮肤色素沉着差异。结果显示: mRNA测序共发现了25,077个基因, 其中共1,772个基因(包括1,079个上调的基因和693个下调的基因)呈现不同的表达模式。MiRNA测序鉴定了1,071个新miRNA。此外, 319个miRNA差异表达, 包括187个上调和132个下调的miRNA。对差异表达的miRNA和mRNA进行联合分析, 结果显示, miR-383-3p和miR-138-5p可能参与中华鳖色素沉着并分别靶向调控*Tyr*和*Gpmnb*的转录表达。本研究结果将为进一步研究中华鳖色素沉着机理提供重要线索。

关键词: 中华鳖; 体色; microRNA; 转录组测序; 黑色素生成

Comprehensive analysis of miRNA-mRNA related to skin pigmentation of Chinese soft-shelled turtle

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Abstract: In order to study the differences in pigmentation of different body colors in Chinese soft-shelled turtle (*Pelodiscus sinensis*), the Qingxi soft-shelled turtle Dongting soft-shelled turtle as experimental subjects. MRNA and miRNA sequencing were used to compare Qingxi soft-shelled turtle (WBF) and Dongting turtle (DTF) abdomen skin pigmentation characteristics. The results showed that mRNA sequencing revealed a total of 25,077 genes, of which a total of 1,772 genes (including 1,079 up-regulated genes and 693 down-regulated genes) showed different expression patterns. MiRNA sequencing identified 1,071 new miRNAs. In addition, 319 miRNAs were differentially expressed, including 187 up-regulated and 132 down-regulated miRNAs. The combined analysis of differentially expressed miRNA and mRNA showed that miR-383-3p and miR-138-5p may be involved in the pigmentation of soft-shelled turtle and target the transcriptional expression of *Tyr* and *Gpmnb*, respectively. The results of this study will provide important clues for further research on the pigmentation mechanism of Chinese soft-shelled turtle.

Keywords: *Pelodiscus sinensis*, body color, microRNA, transcriptome sequencing, melanogenesis.

滇池高背鲫基因组 DNA 的扩增及在 SSR 分析中的验证

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摘要: 为了构建滇池高背鲫全基因组 DNA 扩增方法, 使用内切酶酶切初孵仔鱼的基因组 DNA, 酶切片段连接寡核苷酸接头, 根据酶切位点序列与接头序列设计引物, 采用 PCR 法扩增酶切片段, 增加基因组 DNA 的数量。使用 *Taq* I 内切酶酶切滇池高背鲫基因组 DNA, 酶切片段连接寡核苷酸接头后 PCR 扩增, 获得扩增产物集中于 250~1500 bp。以扩增的滇池高背鲫基因组 DNA 为模板, PCR 扩增基因组中的微卫星位点 (SSR), 获得预期的扩增片段, 电泳图谱与对照组 (未扩增的基因组 DNA 为 PCR 模板) 无差异。本实验构建了滇池高背鲫基因组 DNA 的扩增方法, 并可用于 SSR 分析中, 为滇池高背鲫及其他鱼类大规模遗传分析提供了技术支撑。

关键词: 滇池高背鲫; 基因组 DNA; PCR; 微卫星; 内切酶

Increase of genomic DNA with the verification by SSR analysis in Dianchi carp *Carassius auratus*

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Abstract: In order to establish a method for increasing the genomic DNA in Dianchi carp *Carassius auratus*, firstly the genomic DNA of Dianchi carp larva fish was digested by endonuclease. Subsequently, the DNA fragments were linked with specific oligonucleotide adaptors and were amplified by PCR using the primers that were designed from the sequences of endonuclease recognition sites and the adaptors. As a result, the genomic DNA was increased. The genomic DNA was digested by *Taq* I endonuclease. After PCR for the genomic DNA fragments, the length of the major DNA fragments ranged from 250 bp to 1500 bp. The increased genomic DNA was used as the PCR template for microsatellite loci (SSR) amplification, and the expected PCR product was obtained. Furthermore, when compared to the control (the native genomic DNA was used for PCR), the electrophoresis patterns were similar between the experiment and control groups. The present study developed a method for increasing Dianchi carp genomic DNA by PCR, which can be applied in SSR analysis that supports the massive genetic analysis in Dianchi carp and other fish species.

Keywords: Dianchi carp *Carassius auratus*, genomic DNA, PCR, microsatellite, endonuclease

低氧-复氧胁迫对鲢抗氧化酶活性的影响

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摘要: 为探究低氧-复氧胁迫对鲢抗氧化酶活性影响, 在溶解氧 2.5mg/L 下对体重 (100±10) g 的鲢低氧胁迫 3h、6h、12h 和 24h 及复氧 24h, 采集血清、心脏和肝脏, 测定总抗氧化能力(T-AOC)、过氧化物酶 (CAT)、超氧化物歧化酶 (SOD) 和谷胱甘肽过氧化物酶 (GPX) 活性。结果显示: 随胁迫时间增加, 血清中 GPX 活性升高, T-AOC、CAT 和 SOD 活性先升高后降低, 在低氧胁迫 3h 显著高于正常水平 (P<0.05); 心脏中 T-AOC、CAT 活性先降低再升高后降低, 在低氧胁迫 24h 显著低于正常水平 (P<0.05), 而 SOD 和 GPX 活性呈现相反趋势; 肝脏中 T-AOC、SOD 和 GPX 活性先降低后升高, 在低氧胁迫 6h 显著低于正常水平 (P<0.05)。复氧 24h, 血清中 T-AOC、CAT 和 SOD 活性恢复正常水平, GPX 活性高于正常水平; 心脏中 T-AOC 和 CAT 活性恢复正常水平; SOD 和 GPX 活性高于正常水平; 肝脏中 4 种酶活性恢复正常水平。结果说明: 持续低氧胁迫能够使鲢血清、心脏和肝脏中抗氧化酶发生显著变化, 但复氧 24h 后, 均能较好地消除低氧胁迫造成的影响。

关键词: 白鲢 低氧胁迫 氧化应激 抗氧化物酶

Effects of hypoxia reoxygenation stress on antioxidant enzyme activities in silver carp

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Abstract: To explore the effect of hypoxia-reoxygenation stress on silver carp antioxidant enzyme activity. Under the 2.5mg/L dissolved oxygen, the weight (100±10)g silver carp was hypoxia stress for 3h, 6h, 12h and 24h and reoxygenation 24h. Serum, heart and liver were collected to determine the T-AOC, CAT, SOD and GPX activities. With the increase of stress time, serum GPX increased, T-AOC, CAT, SOD first increased and then decreased, significantly higher than normal at 3h (P<0.05), cardiac T-AOC, CAT first decreased, then increased and then decreased, significantly lower than normal at 24h (P<0.05), while SOD and GPX showed the opposite trend. Liver T-AOC, SOD and GPX first decreased and then increased, and were significantly lower than normal at 6h (P<0.05). After 24 h of reoxygenation, serum T-AOC, CAT and SOD returned to normal, GPX was higher than normal; cardiac T-AOC and CAT returned to normal; SOD and GPX activity were higher than normal; liver four enzyme activities returned to normal. The results show that continuous hypoxia stress can significantly change the antioxidant enzymes in silver carp serum, heart and liver, after 24 h of reoxygenation, the effects caused by hypoxia stress can be eliminated.

Keywords: silver carp, hypoxia stress, oxidative stress, antioxidant enzyme

光照强度对条斑紫菜种苗生长的影响

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摘要: 光照强度是条斑紫菜种苗(贝壳丝状体)生长的重要因素。目前关于种苗最适光强的报道有较大出入, 且育苗技术人员对光强的认知有较大差异, 因此不同光强对条斑紫菜种苗生长影响的研究有较大的生产指导意义。本文采用全光谱培养灯对条斑紫菜 Y-9101 种苗在 1.3- 25 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 五个梯度的光强下接种至文蛤壳并在 16 $^{\circ}\text{C}$ 培养 10 周, 利用光学与电子显微镜、色差计与叶绿素荧光仪等技术手段, 定期测量藻落密度、横向与纵向生长速率、色差及光合活性。结果显示在 150 Ind/cm^3 相同接种条件下, 18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 光强下种苗萌发的藻落密度最大, 为 6.5 Ind/cm^2 贝壳; 6.3 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 光强下种苗横向平均生长速率最高, 达 2.9 $\text{mm}^2/\text{周}$; 25 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 光强下种苗纵向平均生长速率为 8.9 $\mu\text{m}/\text{周}$, 6.3- 18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 的纵向平均生长速率一致, 均为 7.3 $\mu\text{m}/\text{周}$; 6.3 - 18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 光强下, 藻落颜色趋于一致, 呈黑色, 但 25 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 下偏浅黄, 其实际量子效率、最大光化学量子产量和非光化学猝灭等光合活性参数低于前者。综上, 在 6.3-18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ 的光强范围内, 条斑紫菜种苗的藻落密度、横向与纵向生长速率较高, 藻体生长较好, 过高光强抑制了种苗生长, 光强过低种苗生长缓慢。

关键词: 光照强度、条斑紫菜、贝壳丝状体、生长速率

The effect of Light intensity on the growth of *Pyropia yezoensis* seedlings

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Abstract: Light intensity is an important factor for the growth of *Pyropia yezoensis* seedlings(conchocelis). The current reports and the seedling technology on the optimal light intensity for seedlings were quite different. Study of the influence of different light intensity will promote seedlings production remarkably. *P. yezoensis* Y-9101 was seedled and cultured at 16 $^{\circ}\text{C}$ until 10 weeks under full-spectrum conditions, and the light intensity was designed five degrees arranged from 1.3 to 25 $\mu\text{mol}/\text{m}^2\cdot\text{s}$. The density of algae germinated from seedlings under 18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ was the highest, which was 6.5 Ind/cm^2 . Under 6.3 $\mu\text{mol}/\text{m}^2\cdot\text{s}$, the average horizontal growth rate was the highest, reaching 2.9 mm^2/w . Under 25 $\mu\text{mol}/\text{m}^2\cdot\text{s}$, the average vertical growth rate of seedlings was 8.9 $\mu\text{m}/\text{w}$, and the average vertical growth rate of 6.3-18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$ was consistent, both at 7.3 $\mu\text{m}/\text{w}$. Under 6.3-18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$, the color of algae colonies tends to be the same and appears black, but under 25 $\mu\text{mol}/\text{m}^2\cdot\text{s}$, the algae was slightly yellowish. Its photosynthetic activity parameters such as Yield, Fv/F0 and NPQ were lower than the former. In 6.3-18.8 $\mu\text{mol}/\text{m}^2\cdot\text{s}$, the algae density, horizontal and vertical growth rate were higher. High light intensity inhibited the growth of seedlings, grew slowly at lower light intensity.

Keywords: Light intensity, *Pyropia yezoensis*, conchocelis, activity, growth rate

脊尾白虾 UCHL5 的基因克隆及其在卵巢发育中的功能研究

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摘要: 为了研究 UCHL5(ubiquitin carboxyl-terminal hydrolase isozyme L5)在脊尾白虾(*Exopalaemon carinicauda*)卵巢发育中的作用, 本研究克隆了脊尾白虾 UCHL5 全长 cDNA, 并对其在脊尾白虾不同组织和不同卵巢发育时期的表达情况进行了分析, 在此基础上构建了 pET32a-UCHL5 原核表达载体, 进行了诱导表达研究。结果表明, UCHL5 cDNA 全长 1 440 bp, 编码 329 个氨基酸, 预测蛋白质分子质量为 37.57 kDa, 理论等电点为 5.51。系统进化树分析表明, 脊尾白虾与同为甲壳纲的凡纳滨对虾、拟穴青蟹和三疣梭子蟹聚为一支。荧光定量结果显示, UCHL5 在鳃中的表达量最高, 其次是卵巢, 均显著高于其它组织; 在卵巢发育过程中 UCHL5 的表达呈现先上升后下降的趋势, 在 O5 期急剧下降到最低水平。通过原核表达得到的重组蛋白约为 52.00 kDa, 与预期大小一致。本研究结果显示 UCHL5 可能在脊尾白虾卵巢发育过程中起着重要作用, 为进一步研究甲壳动物卵巢发育的分子机制奠定了基础。

关键词: 脊尾白虾; UCHL5 基因; 卵巢; qPCR; 原核表达

Molecular cloning of the UCHL5 and its functional analysis during ovarian development of *Exopalaemon carinicauda*

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Abstract: In our study, for a better understanding of the role regarding UCHL5 in the development of ovarian in white prawn(*Exopalaemon carinicauda*), the full length cDNA of UCHL5 was identified and characterized by using an approach which combines the data of transcriptome and RACE. The expression profile of UCHL5 in different development stages of the ovary and various tissues were determined by real-time quantitative PCR. pET32a-UCHL5 prokaryotic expression recombinant plasmid was constructed, and induction expression was carried out. The homology and phylogenetic analysis showed that the deduced amino acid sequence of UCHL5 shared high homology in different species and the highest conservation with *Penaeus vannamei*. Real-time quantitative PCR results indicated that expression quantity of UCHL5 gene was the highest in gill tissue in *E.carinicauda*, and followed by ovary. The expression of UCHL5 gene in the ovaries of different ovarian development stages varies up and down. Fusion protein UCHL5 obtained through prokaryotic expression was 52.00 kDa. It is concluded that UCHL5 might play an important role in ovarian development of *E.carinicauda*.

Key words: *Exopalaemon carinicauda*; UCHL5 gene; ovary; qPCR; prokaryotic expression

基于形态学和分子鉴定的布氏鲳鲹/卵形鲳鲹 分类研究

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摘要: 金鲳鱼肉质细嫩、鲜美可口, 为我国南方沿海名贵海产经济鱼类之一。然而, 国内对金鲳鱼的命名一直存在分歧, 根据形态和部分骨骼特征被认为是两个独立的物种: 布氏鲳鲹 (*Trachinotus blochii*) 和卵形鲳鲹 (*T. ovatus*)。本研究利用形态学和 DNA 条形码技术 (COI、cytb) 对海南、广东和福建的 4 金鲳养殖群体各 30 尾鱼进行分类鉴定形态学结果表明, 海南三亚群体与广东湛江群体形态上更为相似, 与海南澄迈群体在形态上有少量差异, 但这个三个群体与福建漳州群体在形态上都差异较大; DNA 条形码分析结果表明, 四个金鲳养殖群体的平均遗传距离小于 0.02 (COI: 平均遗传距离为 0.00311; cytb: 平均遗传距离为 0.00285)。虽然福建漳州群体与其他三个群体在形态上差异较大, 但还未达到种间差异的水平, 我国现有养殖的金鲳鱼为同一物种。

关键词: 布氏鲳鲹; 卵形鲳鲹; COI; cytb ; 形态学

Classification of *Trachinotus blochii* and *T. ovatus* Based on Morphology and Molecular Identification

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Abstract: The golden pompano is tender and delicious. It is one of the valuable marine economic fishes along the coast of southern China. However, there have always been differences in the naming of golden pompano in China. According to the morphology and some skeletal characteristics, they are considered to be two separate species: *Trachinotus blochii* and *T. ovatus*. In this study, morphology and DNA barcoding technology (COI, cytb) were used to classify and identify 30 fish in each of the 4 golden pompano breeding populations in Hainan, Guangdong and Fujian. The morphological results showed that the Hainan Sanya population and the Guangdong Zhanjiang population are more similar in morphology, There is a small difference in morphology from the Chengmai population in Hainan, but these three populations are quite different from the Zhangzhou population in Fujian; DNA barcode analysis results show that the average genetic distance of the four golden pompano breeding populations is less than 0.02 (COI : The average genetic distance is 0.00311; cytb: The average genetic distance is 0.00285). Although the Zhangzhou population in Fujian is quite different from the other three populations in morphology, it has not yet reached the level of inter-species differences. The existing farming in China is the same species of golden pompano.

Key words: *Trachinotus blochii*, *Trachinotus ovatus*, COI, cytb, morphology

领域三

水产养殖动物营养与饲料

野生芦苇作为渔饲料源的应用前景

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摘要: 洞庭湖区是我国重要的芦苇产区, 芦苇种植面积达 130 万亩, 占全国总面积的 13.3%, 年产干芦苇 120 万吨。芦苇是作为制浆造纸的重要原料, 也用于编席、制框、中药等方面, 同时也可作为青储饲料在牛、羊等反刍动物饲养中有较好的效果。但因芦苇造纸纸质较差、污染严重, 国家提出洞庭湖生态经济区和长江经济带开发建设战略, 造纸等产业全面禁止, 湖区芦苇因未得到有效利用, 成为严重污染水域生态环境的重要因子, 是困扰政府亟待解决的难题。本团队 3 年来对芦苇生长发育及营养价值、芦苇青贮工艺技术与营养成分保留、芦苇渔用饲料配制与饲养鱼类作用及机理等进行了实验研究。结果表明: 芦苇具有较好的营养价值, 年可刈割 3-4 次, 年亩产最高可达 4t; 通过控制温度、湿度和 pH 值等环境因子、钝化或去除拮抗因子等技术对芦苇茎叶进行青储发酵, 生产出全成份保留较好的饲料源料; 按照不同比例添加芦苇制成配合饲料, 饲喂翘嘴鲌、青鱼、黄颡鱼、异育银鲫、青鲫、草鱼、团头鲂等鱼类, 其适宜添加量为 5-30%, 且草食性鱼类>杂食性鱼类>肉食性鱼类; 添加适量的芦苇可以提高鱼体的抗氧化能力、免疫功能和肌肉品质, 但添加量过高会降低鱼体的消化吸收能力。综上所述, 野生芦苇作为渔饲料源前景广阔, 仅洞庭湖区每年可为渔业提供优质饲料源 200 万吨以上, 新增产值 40 亿元, 并有助于改善洞庭湖的生态环境。

关键字: 洞庭湖区; 芦苇; 渔用饲料源; 应用前景

Application prospect of wild reed as fish feed ingredient

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Abstract: The reed (*Phragmites australis*) in Dongting Lake area is one of the most important reed producing area in China. This area is more than 867 km², accounting for 13.3% of the total area in China. The annual production of dried reeds is about 1.2 million tons. As an important raw material for papermaking, it is also used for making mats, frames, traditional Chinese medicine and so on. As a green storage feed, it has a good effect in the feed of cattle, sheep and other ruminant animals. However, due to the poor paper quality and serious pollution of reed papermaking, the state proposed the development and construction strategy of Dongting Lake Ecological economic zone and Yangtze River Economic zone. Reed papermaking will be completely prohibited in Dongting Lake area. Because of the lack of effective utilization for reed, reed has become an important factor which seriously polluted water ecological environment. It is also a difficult problem to be solved for the government. Our team has studied the fish feed ingredient of reeds for 3 years. We studied the growth and the nutrition value of reeds, the feed silage technology and nutrients retention, and the effect on freshwater fishes fed on reed compound feed. The results showed that the nutritional value of reed is good. Reed can be cut three to four times every year, the annual yield can reach to 4 tons per 666.7m². By controlling environmental factors such as temperature, humidity and pH, passivating and removing anti-nutritive factors, the fish feed ingredient of reed stem and leaf can be produced. The appropriate supplements of reed in the feed of topmouth culter, black carp, yellow catfish, gibel carp, *Carassius auratus indigenticus* Yang, grass carp and blunt snout bream were 5-30%. About the appropriate supplements, it was highest in herbivorous fish, was lowest in carnivorous fish, and it was in the middle in omnivorous fish. The antioxidant capacity, immune function and muscle quality of fish can be improved by adding proper amount of reed, but the digestive capacity of fish will be inhibited by adding excessive reed. In conclusion, wild reed has a broad prospect in fish feed ingredient. We can obtain more than 2 million tons of high-quality fish feed ingredient, which can increase 4 billion yuan of output value in Dongting Lake area every year. In addition, it is helpful to improve the ecological environment.

Keyord: Dongting Lake area; reed; fish feed ingredient; application prospect

功能性饲料添加剂在大菱鲆低鱼粉配合饲料中的应用评价

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摘要: 为评价功能性饲料添加剂在大菱鲆低鱼粉配合饲料中的应用效果, 设计 1 个正对照组 (鱼粉含量 50%, D1), 1 个负对照组 (鱼粉含量 30%, D2), 在低鱼粉基础上分别添加 1% 酶解鱼溶浆 (D3), 0.02% 肉桂醛 (D4), 1% 酶解鱼溶浆+0.02% 肉桂醛 (D5), 养殖周期 8 周。结果表明: 以增重率为评价指标, 饲料中添加 1% 酶解鱼溶浆 (30% 鱼粉) 可显著促进大菱鲆幼鱼生长性能, 但 1% 酶解鱼溶浆和 0.02% 的肉桂醛二者配伍效果不佳, 其相互作用机理还有待于进一步研究。

关键词: 大菱鲆; 酶解鱼溶浆; 肉桂醛; 生长; TOR

Evaluation of feed additives in low fish meal diet for juvenile turbot (*Scophthalmus maximus*)

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Abstract: The study was carried out to examine and optimize the feed additives in low fish meal diets for juvenile turbot (*Scophthalmus maximus*). A 50%, 30% fishmeal diets was considered as a positive and negative control group, respectively. which adding 1% stickwater hydrolysate, 0.02% cinnamic aldehyde, 1% stickwater hydrolysate and 0.02% cinnamic aldehyde in a diet with low fishmeal(30%). It can be concluded that the supplementation of 1% stickwater hydrolysate can significantly enhance the growth performance of turbot. However, the combination of stickwater hydrolysate and cinnamic aldehyde showed no better effect, the mechanism of their interaction needs further study.

Key words: *Scophthalmus maximus* L.; stickwater hydrolysate; cinnamic aldehyde; growth; TOR

日粮维生素 D₃ 对中华绒螯蟹大眼幼体生长、抗氧化能力、免疫和蜕壳的影响

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摘要: 为了研究维生素 D₃ (VD₃) 对中华绒螯蟹大眼幼体生长、抗氧化能力、免疫和蜕壳的影响, 本实验配制了六种不同 VD₃ 水平的等氮等能饲料 (0、3000、6000、9000、12000 和 36000 IU/kg), 分别饲喂大眼幼体 (7.52±0.10 mg) 23 天。结果表明, 饲料中添加 3000 和 6000 IU/kg VD₃ 能显著提高幼体增重率、特定生长率、存活率和蜕壳频率。基于生长指标的折线分析结果表明, 大眼幼体对 VD₃ 的最适需求量为 4825-5918 IU/kg。同对照组相比, 12000 和 36000 IU/kg VD₃ 组幼体的酸性磷酸酶活性显著提高, 3000 和 6000 IU/kg 组的碱性磷酸酶活性和谷胱甘肽过氧化物酶活性显著提高, 并且丙二醛含量显著降低, 6000 和 9000 IU/kg 组大眼幼体超氧化物歧化酶活性和总抗氧化能力均显著提高。9000 IU/kg 组幼体在 120 h 盐度胁迫后的存活率最高, 并且该组大眼幼体抗脂多糖因子、溶菌酶和髓系分化因子 88 的基因表达量均显著高于对照组。本研究表明, 日粮中 3000-9000 IU/kg 维生素 D₃ 水平可以提中华绒螯蟹大眼幼体的生长、存活率、免疫力、蜕壳频率和抗胁迫能力。

关键词: 中华绒螯蟹; 维生素 D₃; 盐度胁迫; 免疫能力; 蜕壳

Effects of dietary vitamin D₃ on growth, antioxidant capacity, immunity and molting of *Eriocheir sinensis* larvae

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Abstract: This study investigates the effects of vitamin D₃ (VD₃) on growth performance, antioxidant capacity, immunity and molting of larval *Eriocheir sinensis*. A total of 6,000 larvae (7.52 ± 0.10 mg) were fed with six isonitrogenous and isolipidic diets with different levels of dietary VD₃ (0, 3000, 6000, 9000, 12000 and 36000 IU/kg) respectively for 23 days. Weight gain, specific growth rate, survival rate and molting frequency significantly increased in crabs fed 3000 and 6000 IU/kg VD₃ compared to the control. Broken-line analysis of these indices against dietary VD₃ levels indicates that the optimal VD₃ requirement for juvenile crabs is 4825-5918 IU/kg. The ACP activity of the crabs fed 12000 and 36000 IU/kg VD₃, the activities of AKP and GSH-px of crabs fed 3000 and 6000 IU/kg VD₃, the SOD activity and T-AOC of crab fed 6000 and 9000 IU/kg VD₃ were significantly higher than the control, while the MDA content was lower than the control. Crabs fed 9000 IU/kg showed the highest survival after 120 h of salinity stress, and the relative mRNA expressions of *anti-lipoplysaccharide factor*, *lysozyme* and *myeloid differentiation factor 88* were higher than the control. This study suggests that 3000-9000 IU/kg dietary vitamin D₃ can improve growth, survival, immunity, stress resistance and molting frequency in *E. sinensis* larvae.

Key words: *Eriocheir sinensis*; Vitamin D₃; Salinity stress; Immunity; Molting

紫苏叶促进大鲵生长并改善部分生理功能

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摘要: 为研究紫苏叶添加在大鲵日粮中的生物学效果, 配制 4 组不同紫苏叶含量的等氮等脂试验饲料: D0(0)、D1(1%)、D2(2%)、D3(3%), 饲喂初始体质量为(54.23±0.26)g 的大鲵 105d。结果显示: ①大鲵生长指标均在 D2 组达到最优。②D2 组大鲵肌肉粗蛋白含量最优。③紫苏叶添加能显著提高大鲵胃肠功能, 各类消化酶活性在紫苏叶添加后得到显著提高, 肠道屏障功能在 D2 组最佳。④当紫苏叶添加量为 2%时, 肝脏和肠道抗氧化能力显著提高。⑤紫苏叶添加能改善免疫及肝功能。⑥D2 组的高密度脂蛋白胆固醇、低密度脂蛋白胆固醇指标最佳。研究表明, 日粮中添加 2%紫苏叶在改善大鲵生长性能、胃肠肝功能等方面的综合效果最佳。

关键词: 中国大鲵; 紫苏叶; 生长; 胃肠功能; 肝功能; 免疫; 脂质代谢

Perilla leaves can promote the growth of *Andrias davidianus* and improve some physiological functions

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Abstract: In order to study the effect of adding perilla leaves in the diet of *Andrias Davidianus*, four isonitrogenous and isolipidic diets with graded levels of perilla leaves were formulated: D0 (0), D1 (1%), D2 (2%) and D3 (3%). *A. davidianus* with an initial weight of (54.23±0.26) g were fed for 105d. The results showed that ① The growth indicators were all optimized in D2. ② The crude protein content of muscle in D2 was the highest. ③The addition of perilla leaves could significantly improve gastrointestinal function. The activities of various digestive enzymes were significantly increased after the addition of perilla leaves. Intestinal barrier function were the best in D2. ④ When the addition level of perilla leaves was 2%, the antioxidant capacity of liver and intestine increased significantly. ⑤ The addition of perilla leaves could improve immunity and liver function. ⑥ The indexes of high-density lipoprotein cholesterol and low-density lipoprotein cholesterol in D2 were the best. To sum up, the addition of 2% perilla leaves have the best comprehensive effect on improving growth performance, improving gastrointestinal and liver function, and so on of *A. davidianus*.

Key words: *Andrias davidianus*; Perilla leaves; Growth performance; Gastrointestinal function; Liver function; Immunity; Lipid metabolism

鱼源植物乳杆菌 HS-07 胞外多糖对鲤益生作用的研究

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摘要: 为探究植物乳杆菌 HS-07 胞外多糖(EPS-07)对鲤免疫、抗氧化及抗嗜水气单胞菌感染能力的影响, 本研究设置对照组(灌喂无菌生理盐水)和处理组(分别灌喂 250、500、1000 $\mu\text{g}/\text{mL}$ 浓度的 EPS-07), 1 次/天, 连续灌喂 7 天, 随后腹腔注射嗜水气单胞菌进行感染试验。结果表明: 鲤头肾细胞与 EPS-07 共同培养后, 其增殖能力、吞噬活性, 上清液中 NO 的含量, 促炎细胞因子(TNF- α 、IL-1 β 和 IL-6)和抗炎细胞因子(IL-10 和 TGF- β)的表达均显著增强($P < 0.05$); EPS-07 处理组血清中 NO 的含量、促炎细胞因子和抗炎细胞因子的表达显著增强($P < 0.05$); EPS-07 处理组的肝胰腺中总抗氧化能力(T-AOC)和谷胱甘肽(GSH)含量, 以及超氧化物歧化酶(T-SOD)、谷胱甘肽过氧化物酶(GSH-Px)和过氧化氢酶(CAT)的活性均显著高于对照组($P < 0.05$), 但丙二醛(MDA)的含量显著降低 ($P < 0.05$); 嗜水气单胞菌感染后, EPS-07 能抑制 NO 的大量释放, 上调抗炎细胞因子的表达, 下调促炎细胞因子的表达, 维持机体稳态。综上所述: EPS-07 在细胞和宿主水平均能提高机体免疫力, 增强鲤抗氧化和抗细菌感染能力。

关键词: 乳酸菌胞外多糖; 鲤; 免疫; 抗氧化活性; 抗感染能力

The probiotic effect of *Lactobacillus plantarum* HS-07 exopolysaccharide in *Cyprinus carpio*

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Abstract: To explore the effects of the oral administration of exopolysaccharides from *Lactobacillus plantarum* HS-07 (EPS-07) on the immunity, antioxidation and resistance against *Aeromonas hydrophila* in *Cyprinus carpio*, in this experiment, the control group was fed with sterile saline, and the treatment group was fed with different concentrations of EPS-07 (250, 500, 1000 $\mu\text{g} / \text{mL}$), once a day, for 7 consecutive days, followed by intraperitoneal injection of *A. hydrophila*. The EPS-07 were co-cultured with the head kidney cells of the *Cyprinus carpio*, the proliferation ability, phagocytic activity, NO content and the expression of pro-inflammatory cytokines (TNF- α , IL-1 β and IL-6) and anti-inflammatory cytokines (IL-10 and TGF- β) were significantly increased ($P < 0.05$); The content of NO and the expression of pro-inflammatory cytokines and anti-inflammatory cytokines in serum of EPS-07 treatment group were significantly increased ($P < 0.05$); The contents of T-AOC and GSH, and the activities of T-SOD, GSH-Px and CAT in hepatopancreas of EPS-07 treatment group were significantly higher than those of control group ($P < 0.05$), but the content of MDA decreased in a concentration-dependent manner. After *A. hydrophila* infection, EPS-07 could inhibit the release of NO, up regulate the expression of anti-inflammatory cytokines and down regulate the expression of pro-inflammatory cytokines and maintain homeostasis in vivo. To sum up, EPS-07 can improve the immunity of the body at the cellular and host levels, and enhance the antioxidant and antibacterial infection abilities of *Cyprinus carpio*.

Key words: *Lactobacillus* exopolysaccharide; *Cyprinus carpio*; immunity; antioxidant activity; anti-infection ability

饲料中不同蛋白质水平对三个不同生长阶段克氏原螯虾生长、饲料利用和抗氧化能力的影响

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摘要: 本实验制定了7种不同蛋白水平的饲料喂养三个不同生长阶段的克氏原螯虾八周。结果发现, 随着饲料中蛋白质水平的增加, 三个不同生长阶段的小龙虾的增重率呈现先升高后稳定的趋势, 而饲料转化率和蛋白质效率比则呈现先下降后稳定的相反趋势。当饲料中蛋白水平达到40%时, 第一生长阶段的小龙虾肝胰腺中超氧化物歧化酶(SOD)活性和酚氧化酶(PO)活性均达到最大值。而对于第三生长阶段的小龙虾, 用蛋白水平最高的饲料处理后, 小龙虾肝胰腺中SOD活性和PO活性最低。存活率、*sod*转录水平和*propo*转录水平的变化趋势与对应生长阶段小龙虾SOD活性和PO活性的变化趋势相似。根据这些发现, 结合特定增长率折线模型, 确定初始体重为0.026 g、1.04 g和5.06 g的小龙虾饲料中最佳蛋白水平分别为40.33%、35.88%和30.56%。

关键词: 克氏原螯虾; 饲料蛋白水平; 生长性能; 抗氧化能力

Effects of dietary protein levels on growth performance, body composition and antioxidant capacity of red swamp crayfish (*Procambarus clarkii*) at three different growth stages

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Abstract: With the increase in dietary protein levels, weight gain rate of crayfish was first increased and then stabilized in the three different growth stages, while the feed conversion ratio and protein efficiency ratio showed an opposite trend of first decrease and then stability. Survival rate, *sod* transcriptional level, and *propo* transcriptional level followed a pattern similar to the change in SOD activity and PO activity of crayfish in the corresponding growth stage. Based on these findings and a broken-line model of specific growth rate, 40.33%, 35.88%, and 30.56% were determined to be the optimal diet protein levels for the crayfish with initial body weight of 0.026 g, 1.04 g, and 5.06 g, respectively.

Key words: *Procambarus clarkia*, dietary protein level, growth performance, antioxidant capacity

肌醇对中华绒螯蟹生长性能、体组成、抗氧化能力、非特异性免疫力和脂肪代谢的影响

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摘要: 试验共设计 6 组等氮等脂 (肌醇的添加水平为 0, 204, 406, 810, 1650 和 3211 mg/kg) 的试验饲料, 饲喂中华绒螯蟹幼蟹 8 周。试验结果表明, 饲料中添加 1650 mg/kg 的肌醇显著提高幼蟹的末体重、增重率和特定生长率 ($P < 0.05$)。与未添加肌醇组相比, 饲料中添加肌醇显著降低了全蟹总脂含量和肝胰腺中甘油三酯含量 ($P < 0.05$)。此外, 饲料中添加肌醇可以提高幼蟹的抗氧化能力和非特异性免疫力。实时荧光定量 PCR 结果分析表明, 饲料肌醇抑制了脂肪合成相关基因的表达, 促进了脂肪转运相关基因的表达, 从而降低了肝胰腺甘油三酯的含量。本研究表明, 饲料肌醇可促进中华绒螯蟹的生长、抗氧化能力和非特异性免疫力, 同时对脂肪代谢具有调节作用。

关键词: 肌醇; 生长性能; 非特异免疫力; 脂肪代谢; 中华绒螯蟹

Effects of *myo*-inositol on growth performance, body composition, antioxidant status, nonspecific immunity and lipid metabolism of juvenile Chinese mitten crab (*Eriocheir sinensis*)

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Abstract: Crabs was fed with six diets supplemented with graded levels of *myo*-inositol (MI) (0, 204, 406, 810, 1650, and 3211 mg/kg) for 8 weeks. The crabs fed with diets containing 1650 mg/kg MI had significantly higher final body weight, weight gain and specific growth rate than those fed 0, 204, 406 and 810 mg/kg MI ($P < 0.05$). The crabs fed with diets containing 1650 and 3211 mg/kg MI had significantly lower total lipid content in the whole body and triglyceride contents in hepatopancreas than those fed diets without supplemented MI ($P < 0.05$). Moreover, dietary MI supplementation could improve antioxidant capacity and nonspecific immunity of crabs. Results of real-time quantitative PCR revealed that dietary MI reduced hepatic triglyceride accumulation probably through inhibiting lipid synthesis related genes and promoting lipid export related genes at the transcriptional level. These results indicate that dietary MI could improve growth, antioxidant capacity and nonspecific immunity and regulate lipid metabolism of *Eriocheir sinensis*.

Key words: *Myo*-inositol, growth, nonspecific immunity, lipid metabolism, *Eriocheir sinensis*

Lactococcus lactis Z-2 不同处理方式对鲤益生作用的研究

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摘要: 为探究乳酸乳球菌 Z-2 (*Lactococcus lactis* Z-2) 不同处理方式对鲤的益生作用, 本文将 *L. lactis* Z-2 的不同处理方式[活细菌上清液的混合物 (LCS)、无细菌培养上清液 (CS)、活细菌 (LC)、热灭活 (HK)、超声破碎 (UB) 和胞外多糖(EPS-2)]对鲤[(42.35 ± 0.76) g]进行为期 7 天的灌胃处理。我们发现, 不同处理方式的 *L. lactis* Z-2 均能显著提高血清中 NO 的合成量、促炎细胞因子(TNF- α 、IL-1 β 、IL-6) 和抗炎细胞因子(IL-10 和 TGF- β)的蛋白水平、AKP 活性和肝胰腺中抗氧化能力(T-AOC、SOD、CAT、GSH), 并显著降低 MDA 水平($P < 0.05$)。此外, 大多数处理组还能显著上调血清中 LZM 的活性和肝胰脏中 GSH-Px 的活性($P < 0.05$)。上述结果表明, 不同处理方式的 *L. lactis* Z-2 均具有免疫调节和抗氧化作用, 其可作为一种安全有效的饲料添加剂应用于水产养殖。

关键词: 鲤; 乳酸菌; 不同处理方式; 免疫应答; 抗氧化活性

Effects of the different treatments of *Lactococcus lactis* Z-2 on the probiotic performance in *Cyprinus carpio* L.

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Abstract: To investigate the effects of the oral administration of different treatments of *L. lactis* Z-2 (mixture of live cells and supernatant, LCS; cell-free culture supernatant, CS; live cells, LC; heat-killed cells, HK, ultrasonic broken of cells, UB; exopolysaccharides of CS, EPS-2) on the probiotic performance in *Cyprinus carpio*, the fish [(42.35 ± 0.76) g] were administered with the different treatments of *L. lactis* Z-2 for 7 days. *In vivo* results revealed that the different treatments of *L. lactis* Z-2 significantly enhanced NO production, protein levels of pro-inflammatory cytokines (TNF- α , IL-1 β , IL-6) and anti-inflammatory cytokines (IL-10, TGF- β), AKP activity, the antioxidant content (T-AOC, SOD, CAT, GSH), and reduced the level of MDA compared to that observed in the negative group ($P < 0.05$). In addition, most of the treatment groups also significantly promoted the activities of LZM in serum and GSH-Px in hepatopancreas ($P < 0.05$). Therefore, the results suggested the different treatments of *L. lactis* Z-2 has immunomodulatory, and antioxidant effects on common carp, and can provide a theoretical basis for the rational use of potential probiotics, and solve the problems encountered in the use of LAB in microecological preparations.

Key words: *Cyprinus carpio* L., *Lactococcus lactis*, Different treatments, Immune response, Antioxidant activity

大豆抗原蛋白对中华绒螯蟹生长性能和肠道健康的影响及其改善对策

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摘要: 作为豆粕中含量高、热稳定性强的抗营养因子, 大豆抗原蛋白对甲壳动物的肠道健康和生长性能的影响却鲜有研究。本研究首先探究了大豆球蛋白对中华绒螯蟹(*Eriocheir sinensis*)幼蟹生长和肠道健康的影响, 结果显示大豆球蛋白抑制幼蟹生长, 损伤幼蟹肠道围食膜和菌群结构。通过一系列营养干预实验发现, 饲料中在添加 0.1%的氮—乙酰半胱氨酸基础上, 1%-2%的丁酸钠能够显著改善幼蟹的生长和肠道健康。紧接着对丁酸钠处理组幼蟹肠道进行微生物的体外分离和定向筛选, 得到了三株潜在益生菌。将益生菌添加到含有大豆球蛋白的饲料里进行活体实验发现, 短小芽孢杆菌 Z98 能通过提高幼蟹对大豆球蛋白的利用和改善肠道微生态平衡, 最终提高幼蟹的生长表现。本研究结果为合理利用植物蛋白源和科学配置中华绒螯蟹饲料提供了参考。

关键词: 中华绒螯蟹; 大豆球蛋白; 肠道菌群; 围食膜; 益生菌

Effect of soybean antigen proteins on growth performance and intestinal health of Chinese mitten crab (*Eriocheir sinensis*) and regulation strategy

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Abstract: Soybean antigenic proteins are anti-nutritional factors with high content and strong thermal stability in soybean meal, but their effects on the intestinal health and growth performance of crustaceans are rarely studied. Firstly, this study explored the effects of glycinin on the growth and intestinal health of juvenile Chinese mitten crab (*Eriocheir sinensis*). The results showed that glycinin inhibited the growth of juvenile crabs and damaged the intestinal peritrophic membrane and microbiota of crabs. Through a series of nutrition intervention experiments, it was found that on the basis of adding 0.1% N-acetylcysteine to the diets, 1%-2% sodium butyrate can significantly improve the growth and intestinal health of juvenile crabs. Then the intestines of crabs in the sodium butyrate treatment group were isolated and screened in vitro to obtain three potential probiotics. In vivo experiments by adding probiotics to the diet contained glycinin, it was found that *Bacillus pumilus* Z98 can improve the growth performance of young crabs by improving the utilization of glycinin by juvenile crabs and improving the intestinal microecological balance. The results in this study can provide a new insight to the efficient use of plant protein sources in diet of aquatic animal.

Key words: *Eriocheir sinensis*; glycinin; intestinal microbiota; peritrophic membrane; probiotics

锌转运体 ZIP3 和 ZIP8 启动子的功能分析及其对 MTF1 和 RREB1 在调控锌代谢中的不同响应

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摘要: ZIP (锌调控转运蛋白, 铁调控转运蛋白) 家族在机体锌平衡中发挥着重要作用。本研究鉴定了淡水硬骨鱼中 ZIP 家族的两个成员 ZIP3 和 ZIP8 的启动子区域, 并对其启动子区域上的金属响应转录因子 1(MTF-1)和 Ras 响应元件结合蛋白 1(RREB1)的结合序列进行了表征。

关键词: 鱼; 锌稳态; ZIP 转运体; 转录调控; 锌的毒性

Functional Analysis of Two Zinc (Zn) Transporters (*ZIP3* and *ZIP8*) Promoters and Their Distinct Response to *MTF1* and *RREB1* in the Regulation of Zn Metabolism

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Abstract: *ZIP* (zinc-regulated transporters, iron-regulated transporter-like protein) family plays an important role in organism Zn balance. This research identified the promoter regions of *ZIP3* and *ZIP8*, two members of *ZIP* family, from a freshwater teleost yellow catfish *Pelteobagrus fulvidraco*, characterized the binding sequences of the metal-responsive transcription factor-1 (*MTF-1*) and Ras responsive element binding protein 1 (*RREB1*) on their promoter regions.

Key words: fish; Zn homeostasis; *ZIP* transporter; transcriptional regulation; Zn toxicity

饥饿对矛尾复鰕虎鱼肠道形态、酶活和脂代谢基因表达的影响

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摘要: 为探索饥饿胁迫对矛尾复鰕虎鱼肠道健康与能量代谢机能的影响, 本实验分析了不同饥饿时长下(0、3、7、14 d)矛尾复鰕虎鱼肠道结构、酶活等形态与生理特征, 评估脂代谢相关基因表达的变化。结果显示, 随饥饿延长, 矛尾复鰕虎鱼肠道的总长、长度系数逐渐降低。肠内淀粉酶和脂肪酶活性显著下降, 而蛋白酶活性变化不大。饥饿7天后, 肠道出现部分脱落、局部空泡、绒毛间隙增大、微绒毛缩短等现象。饥饿期间, 肠内 *scd1* 基因的表达逐步下调, 参与脂肪分解与氧化的 *lpl*、*cpt1* 及负责脂肪酸转运的 *fatp1* 的 mRNA 持续上升, 而转录因子 *ppary* 也降低。本研究为深入解析饥饿状态矛尾复鰕虎鱼的营养代谢特征与分子调控机制, 制定经济高效的鱼类养殖策略提供理论和实践参考。

关键词: 饥饿; 矛尾复鰕虎鱼; 肠道; 形态; 消化酶; 脂代谢

Effect of starvation on intestinal morphology, enzyme activity and expressions of lipid metabolism genes in *Synechogobius hasta*

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Abstract: To explore the effect of starvation on intestinal health and energy metabolic function in *Synechogobius hasta*, fish starved for 0, 3, 7 and 14 days were sampled for examining histological and physiological traits in the intestine, as well as lipid metabolism-related gene expression. The results showed that intestinal length and Intestine length index were decreased steadily in starved *S. hasta*, in agreement with the reduced trends of amylase and lipase activities in the intestine. The exfoliated villus cells, increased vacuoles, widened cell interstices and shortened microvilli were present in the intestine of starved *S. hasta* after 7 days of starvation. Starvation weakened intestinal lipid deposition by up-regulating gene expression involved in lipolysis and fatty acid transport. These findings provide preliminary data for studies regarding metabolic traits and regulatory mechanism of *S. hasta* in fasting status.

Key words: Starvation, *Synechogobius hasta*, intestine, morphology, digestive enzyme, lipid metabolis

不同开口饵料对美洲鲥幼苗生长的影响

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摘要: 鱼苗开口饵料是鱼苗育种的关键环节, 也是目前美洲鲥鱼苗大规模繁殖制约因素之一。试验选取了常见的轮虫、商品粉料、蛋黄及小球藻, 并首创发酵蛋黄作为美洲鲥鱼幼苗的开口饵料, 结果显示, 以轮虫和商品粉料投喂美洲鲥幼苗效果最为理想, 发酵蛋黄能有效解决蛋黄坏水问题。

关键词: 美洲鲥; 幼苗; 开口饵料; 死亡率; 生长

The effect of different diets on the juvenile fish of American shad (*Alosa sapidissima*)

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Abstract: The juvenile fish diets is the key link of fry breeding, and it is also one of the restrictive factors of large-scale propagation of American shad(*Alosa sapidissima*) fry breeding. In this experiment, the rotifer, commercial powder, yolk and *Chlorella* were selected, and the fermented yolk was the first time used as the juvenile fish diets of American shad. The results showed that the best effect was to feed American shad with rotifer and commercial powder, and fermented yolk can effectively solve the problem of water pollution caused by yolk.

Keywords: American shad(*Alosa sapidissima*), juvenile fish, diets, mortality, growth

配合饲料和冰鱼对单养中华绒螯蟹生长、蛋白代谢及其基因表达的影响

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摘要: 为研究配合饲料和冰鱼投喂对中华绒螯蟹(*Eriocheir sinensis*)生长及其作用机理的影响,旨在完善中华绒螯蟹的饲料配方和精准投喂的目的。研究表明:在成活率(SR)上配合饲料投喂组要显著高于冰鱼投喂组($P<0.05$),而在终质量(FBW)和增重率(WGR)上冰鱼投喂组却显著高于配合饲料投喂组($P<0.05$);在蛋白质代谢相关酶活性上,配合饲料投喂组谷草转氨酶(AST)和谷丙转氨酶(ALT)水平相对升高,雌蟹该2个指标在两组中均差异显著($P<0.05$),而雌蟹琥珀酸脱氢酶(SDH)水平相对降低,显著低于冰鱼投喂组($P<0.05$);在蛋白代谢基因表达方面,TOR、eIF4G和Rag A/B三个基因在两种饲料投喂下表达量差异显著,配合饲料投喂组相较于冰鱼投喂组显著上调($P<0.05$),而Akt表达量相较于冰鱼投喂组显著下调($P<0.05$)。上述结果表明,配合饲料对中华绒螯蟹生长有着较好的作用,而且还可以提高其蛋白代谢能力。

关键词: 中华绒螯蟹; 生长; 蛋白代谢; 基因表达; 单体养殖

The effect of growth, protein metabolism and gene expression on *Eriocheir sinensis* with formula feed and frozen fish under monomer culture

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Abstract: In order to study the effects of formula feed and frozen fish on the growth and mechanism of *Eriocheir sinensis*. Studies had shown that the SR of the formula feed group was significantly higher than the other group, while the FBW and WGR of the frozen fish group were significantly higher than the other group; In protein metabolism-related enzyme activities, the levels of AST and ALT in the formula feed group were relatively increased, and the two indices of female crabs were significantly differences in the two groups, while the level of SDH in female crabs was relatively lower, respectively. In addition, the expression levels of TOR, eIF4G and Rag A/B genes were significantly differences under the two groups, respectively; while the Akt expression was significantly lower than the other group. The above results indicated that the formula feed had a good effect on the growth of Chinese mitten crabs, and could also improve their protein metabolism.

Keyword: *Eriocheir sinensis*; growth; protein metabolism; gene expression; monomer culture

饲料中添加地衣芽孢杆菌对黄河鲤生长性能、肠道组织形态、肠道菌群以及抗感染能力的影响

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摘要: 本试验的目的是评估在饲料中添加地衣芽孢杆菌后, 鲤鱼的生长性能, 肠道形态, 肠道菌群和对嗜水气单胞菌的抗感染活性的影响。试验组鲤的终末体重、增重率和特定生长率均显著高于对照组。相比对照组, 试验组的肠道绒毛显著增长, C组的肠绒毛长度高于A组和B组。肠道微生物分析显示, 与对照组相比, 处理组的厚壁菌门的丰度显著增加, 拟杆菌门的丰度显著降低。嗜水气单胞菌攻毒试验结果表明, 饲料中添加地衣芽孢杆菌能显著提高鲤的抗感染能力。试验结果表明, 添加地衣芽孢杆菌可以提高黄河鲤的生长性能、肠绒毛长度和肠道菌群。因此, 地衣芽孢杆菌是可作为促进水产养殖业可持续发展的潜在益生菌。

关键词: 地衣芽孢杆菌; 黄河鲤; 生长性能; 肠道组织形态; 肠道菌群; 抗感染能力

Effects of dietary *Bacillus licheniformis* on growth performance, intestinal morphology, intestinal microbiome and disease resistance in common carp (*Cyprinus carpio* L.)

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Abstract: The objective of this study was to evaluate the growth performance, intestinal morphology, intestinal flora, and anti-infection activity against *Aeromonas hydrophila* in common carp upon adding *Bacillus licheniformis* to the feed. The final body weight, weight gain rate, and specific growth rate of common carp in groups A, B, and C were significantly higher than those in the control group. The intestinal villi of the experimental groups increased significantly compared with that in the control group, and the villi in group C were longer than those in groups A and B. The intestinal flora analysis showed that, compared with that in the control group, the richness of phylum, *Firmicutes* in the treatment group significantly increased, and that of *Bacteroides* significantly decreased. The results of the *A. hydrophila* challenge experiment showed that adding *B. licheniformis* to the feed could significantly improve the anti-infection ability of common carp. We conclude that *B. licheniformis* addition improved the growth performance, length of intestinal villi, and intestinal flora in common carp. Therefore, *B. licheniformis* is a potential strain for use as a probiotic for facilitating sustainable development of the aquaculture industry.

Keywords: *Bacillus licheniformis*; Common carp; Growth performance; Intestinal morphology; Intestinal flora; Anti-infection

饲料磷对中华绒螯蟹幼蟹生长、体成分、抗氧化能力及脂肪代谢的影响

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摘要: 本试验研究了饲料磷 (P) 对中华绒螯蟹幼蟹 (*Eriocheir sinensis*) 生长、体成分、抗氧化能力和脂肪代谢的影响。实验配制 (有效磷含量 0.20%, 0.44%, 0.99%, 1.37%, 1.75% 和 2.01%) 六种饲料, 饲喂幼蟹 ($0.38 \pm 0.01\text{g}$) 56 天。结果表明: 饲料磷显著影响幼蟹增重率、特定生长率以及肝胰腺抗氧化能力。全蟹、肝胰腺和肌肉的脂肪含量随饲料中磷水平的增加而降低。实时荧光定量结果表明, 饲料磷可能是通过抑制脂肪合成相关的基因并促进脂肪转运相关的基因来减少肝胰腺脂肪积累。本研究表明, 适宜饲料磷水平能提高中华绒螯蟹幼蟹的生长, 抗氧化能力并减少肝胰腺脂肪的积累, 建议饲料的有效磷含量为 1.16%-1.51%。

关键词: 磷; 生长; 体成分; 抗氧化能力; 脂肪代谢; 中华绒螯蟹

Effect of dietary phosphorus on growth performance, body composition, antioxidant activities and lipid metabolism of juvenile Chinese mitten crab (*Eriocheir sinensis*)

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Abstract: This study investigated the effects of dietary phosphorus (P) on growth, body composition, antioxidant activities and lipid metabolism of juvenile Chinese mitten crab (*Eriocheir sinensis*). Six diets containing available P levels at 0.20%, 0.44%, 0.99%, 1.37%, 1.75% and 2.01% were prepared and fed to juvenile *E. sinensis* ($0.38 \pm 0.01\text{ g}$) for 56 days. The weight gain and specific growth rate were markedly affected by dietary P. Dietary P significantly affected the hepatopancreatic antioxidant capacity. With the increase of dietary available P levels, the lipid contents of whole-body, hepatopancreas and muscle significantly decreased. The results of RT-RCP showed that dietary P reduced hepatopancreas lipid accumulation might be produced through suppressing the genes related to lipid synthesis and promoting the genes related to lipid transport. This study demonstrates that optimum dietary P could enhance growth, antioxidant capacity and reduce hepatopancreatic lipid accumulation in juvenile *E. sinensis* and the range of available P in the diet is suggested to be 1.16%–1.51%.

Key words: Phosphorus; Growth performance; Body composition; Antioxidant activities; Lipid metabolism; *Eriocheir sinensis*.

添加皇竹草粉对草鱼稚鱼生长、抗氧化和肠道非特异免疫基因表达的影响

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摘要: 为探讨饲料中添加皇竹草粉对草鱼稚鱼生长、抗氧化和肠道非特异免疫基因表达的影响, 配制3组分别含0%、10%和20%皇竹草粉的等氮等能纯化饲料, 饲喂草鱼稚鱼(28.51±0.04 g) 8周。结果显示, 饲料中添加10%和20%皇竹草粉显著提高草鱼稚鱼的增重率和成活率($P<0.05$), 同时显著提高肝脏的3-羟酰辅酶A脱氢酶和细胞色素C氧化酶的活性($P<0.05$), 以及血清中补体C3和C4的含量($P<0.05$); 20%皇竹草粉组草鱼血清和肝脏中的超氧化物歧化酶的活性相比对照组草鱼显著降低($P<0.05$); 10%和20%皇竹草粉组的草鱼肠道绒毛结构完整, 上皮细胞细胞核整齐排列在细胞基部; 饲料中添加10%和20%皇竹草粉后, 肠道免疫基因(Toll样受体22, 髓样分化因子, 干扰素1, 干扰素调节因子3, 干扰素调节因子7, 抗病毒蛋白1, IFN- β 启动子刺激物1)mRNA水平显著上调, 肠道促炎细胞因子(肿瘤坏死因子 α 和白细胞介素1 β)mRNA水平显著下调。以上结果表明, 饲料中添加一定量的皇竹草粉提高了草鱼稚鱼的生长, 以及非特异性免疫和抗氧化能力。

关键词: 草鱼; 皇竹草; 生长性能; 抗氧化; 免疫基因

Effects of adding *Pennisetum sinense Roxb* powder to feed on growth, antioxidant and intestinal non-specific immune gene expression of juvenile grass carp (*Ctenopharyngodon idella*)

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Abstract: Prepare 3 groups of feeds containing 0%, 10% and 20% *Pennisetum sinense Roxb* powder. After 8 weeks, the addition of 10% and 20% *Pennisetum sinense Roxb* powder significantly increased the weight gain and survival rate of grass carp ($P<0.05$), and significantly improved the antioxidant capacity in serum and liver ($P<0.05$). The serum complement C3 and C4 content ($P<0.05$), intestinal immune genes and pro-inflammatory cytokine mRNA levels were significantly up-regulated, and pro-inflammatory cytokine mRNA levels were significantly down-regulated. It shows that adding a certain amount of *Pennisetum sinense Roxb* powder improves the growth, non-specific immunity and antioxidant capacity of grass carp.

Key words: grass carp, *Pennisetum sinense Roxb*, growth performance, anti-oxidation, immune gene

饲料磷脂对中华绒螯蟹生长性能、体组成、抗氧化能力和脂肪代谢的影响

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摘要: 本文旨在研究不同磷脂对中华绒螯蟹生长性能、体组成、抗氧化能力和脂肪代谢的影响。试验共设计了 7 组等氮 (35%) 等脂 (8%) 饲料, 包括 1 组对照组 (不含磷脂) 和 6 组试验组 (分别添加 1% 或 3% 水平的大豆卵磷脂、蛋黄卵磷脂或磷虾油), 饲喂中华绒螯蟹幼蟹 (0.26 ± 0.01 g) 8 周。结果表明, 饲料中添加磷脂显著提高了中华绒螯蟹幼蟹的增重率、特定生长率和蜕皮频率, 其中添加 3% 的磷虾油具有最好的促生长效果。磷脂添加组幼蟹肝胰腺中超氧化物歧化酶和过氧化氢酶活性显著增加, 而丙二醛的含量显著减少。饲料中添加磷脂显著降低了全蟹脂肪含量, 肝胰腺脂肪含量和甘油三酯的含量。实时荧光定量 PCR 结果显示, 饲料磷脂通过抑制脂肪的合成和脂质的转运, 从而降低了肝胰腺脂肪的含量。本研究表明, 磷虾油是一种优质的磷脂源, 饲料中添加 3% 水平的磷虾油可更好的改善中华绒螯蟹幼蟹的生长性能, 提高机体的抗氧化能力, 促进脂肪的利用。

关键词: 抗氧化能力; 中华绒螯蟹; 磷虾油; 脂肪代谢; 磷脂

Influence of dietary phospholipid on growth performance, body composition, antioxidant capacity and lipid metabolism of Chinese mitten crab, *Eriocheir sinensis*

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Abstract: This study determines the effects of level and source of dietary phospholipid (PL) on growth performance, body composition, antioxidant capacity and lipid metabolism in juvenile Chinese mitten crab, *Eriocheir sinensis*. One control diet (PL-devoid) and six test diets containing three PL types (soybean lecithin, egg yolk lecithin, and krill oil) at two levels (1% and 3%) each were formulated to feed *E. sinensis* juveniles (0.26 ± 0.01 g) for 8 weeks. Final body weight, specific growth rate, weight gain and molting frequency significantly increased in the PL supplementation groups, and the crabs fed 3% krill oil showed the best growth performance. The total lipid of whole body was significantly lower in the PL supplementation groups than that in the control. With PL supplementation, the specific activities of superoxide dismutase and catalase in the hepatopancreas markedly increased, while malondialdehyde decreased. In addition, total lipid and triglyceride contents in the hepatopancreas significantly decreased in the PL supplementation groups. Real-time quantitative PCR revealed that dietary PL reduced hepatic lipid accumulation through inhibiting lipid synthesis and promoting lipid export at the transcriptional level. This study indicates that krill oil is an excellent PL and the diet with 3% PL can improve growth performance, increase antioxidant capacity and promote lipid utilization for juvenile *E. sinensis*.

Keywords: Antioxidant capacity, *Eriocheir sinensis*, Krill oil, Lipid metabolism, Phospholipid

Lactococcus lactis Z-2 胞外多糖对鲤益生作用的 研究

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摘要: 为研究乳酸乳球菌 Z-2 胞外多糖(exopolysaccharides from *Lactococcus lactis* Z-2, EPS-2)对鲤的益生作用, 本文将提取并纯化的 EPS-2(250、500 和 1 000 $\mu\text{g}/\text{mL}$)对鲤进行体外和体内处理。体外结果表明, EPS-2 能显著增强鲤头肾细胞的增殖能力和吞噬活性($P < 0.05$), 并提高 NO、促炎细胞因子(TNF- α 、IL-1 β 和 IL-6)和抗炎细胞因子(IL-10 和 TGF- β)的合成量($P < 0.05$)。随后, 用 EPS-2 对鲤连续灌喂 7 天处理, 可以观察到血清中 NO、促炎细胞因子(TNF- α 、IL-1 β 和 IL-6)和抗炎细胞因子(IL-10 和 TGF- β)、LZM 和 AKP 活性, 以及肝胰腺中抗氧化能力(T-AOC、SOD、CAT、GSH-Px、GSH)均有显著提高($P < 0.05$)。这些结果表明, EPS-2 在体内和体外均具备提高鲤的非特异性免疫和抗氧化活性的能力, 可作为一种安全有效的添加剂应用于水产养殖中。

关键词: 鲤; 乳酸菌; 胞外多糖; 免疫应答; 抗氧化活性

Effects of an exopolysaccharide from *Lactococcus lactis* Z-2 on the probiotic performance in *Cyprinus carpio* L.

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Abstract: To investigate the effects of the oral administration of exopolysaccharides from *Lactococcus lactis* Z-2 (EPS-2) on the probiotic performance in *Cyprinus carpio*, the purified EPS-2 (250, 500 and 1 000 $\mu\text{g}/\text{mL}$) were used to common carp *in vitro* and *in vivo* treatment. *In vitro* tests showed that EPS-2 could significantly enhance the proliferation and phagocytosis activities ($P < 0.05$) as well as induce the production of nitric oxide (NO), pro-inflammatory cytokines (TNF- α , IL-1 β , IL-6), and anti-inflammatory cytokines (IL-10, TGF- β) ($P < 0.05$) in head kidney cells. When the fish were gavaged with three different concentrations of EPS-2 (250, 500 and 1000 $\mu\text{g}/\text{mL}$) for 7 days, and EPS-2 supplementation significantly up-regulated the NO production, protein levels of pro-inflammatory cytokines (TNF- α , IL-1 β , IL-6) and anti-inflammatory cytokines (IL-10, TGF- β), activities of LZM and AKP, and levels of antioxidant molecules (T-AOC, SOD, CAT, GSH-Px, GSH) compared to those in the negative group ($P < 0.05$). Therefore, the results suggested that EPS-2 could enhance the non-specific immunity and antioxidant activities of the *Cyprinus carpio in vitro* and *in vivo*, and could be used as a safe and effective feed additive in aquaculture.

Key words: *Cyprinus carpio* L, *Lactococcus lactis*, Exopolysaccharide, Immune response, Antioxidant activity

紫苏饼在大鲵配合饲料中的应用评价

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摘要：为研究紫苏饼在大鲵配合饲料中应用效果，以配合饲料为对照组，在其基础上分别添加 5.0%的紫苏饼(PC)和发酵紫苏饼(FPC)（在预实验中所得 5%效果最优），配制成 3 种等氮等脂的试验饲料，饲喂初始均重（54.14±0.17）g 的大鲵。结果显示：PC 和 FPC 组大鲵 FBW、WGR 和 SGR 均显著高于对照组（ $P<0.05$ ）；肝脏和肠道总超氧化物歧化酶和血浆丙二醛含量均在 FPC 组最优，肝脏和肠道总抗氧化能力分别在 FPC 和 PC 组出现最大值；胃蛋白酶.....及血浆二胺氧化酶、D-乳酸和内毒素含量均在 FPC 组最优。综上所述，PC 和 FPC 均能显著提高大鲵的生长。在抗氧化、免疫、消化吸收、及肠道屏障等方面发酵紫苏饼更好。

关键词：大鲵；紫苏饼；生长；免疫；胃肠功能

Evaluation on the application of perilla cake in the compound feed feed of *Andrias davidianus*

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Abstract: In order to study the effect of perilla cake in the compound feed of giant salamanders, the compound feed was used as the control group, and on the basis of it, 5.0% perilla cake and fermented perilla cake were added (5% in the preliminary experiment was the best), formulated into 3 kinds of test feeds with equal nitrogen and fat, and fed with giant salamanders with an initial average weight of (54.14±0.17) g. The results showed that the FBW, WGR and SGR of the salamander in the perilla cake group and the fermented perilla cake group were significantly higher than those in the control group ($P<0.05$); the contents of T-SOD and MDA in the liver and intestine were the best in the fermented perilla cake group , The liver and intestinal T-AOC showed the highest value in the fermented perilla cake and perilla cake group respectively; pepsin, and DAO, D-LA and ET content Both are the best in the fermented perilla cake group. In summary, both the perilla cake and the fermented perilla cake can improve the growth performance of the giant salamander. Fermented perilla cake is better in terms of antioxidant, immunity, digestion and absorption, and intestinal barrier.

Keywords: *Andrias davidianus*; perilla cake; growth; immunity; gastrointestinal function

中国大鲵幼体脂肪需求量研究

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摘要: 为评定大鲵幼体脂肪需求量, 以大豆油为主要脂肪源配制 6 种脂肪水平 (干物质基础) 的等氮 (粗蛋白 57%): L1 (5.02%)、L2 (8.96%)、L3 (12.90%)、L4 (16.21%)、L5 (19.46%)、L6 (22.80%) 的实验饲料, 饲喂初始体重 (34.20±0.27g) 的大鲵幼体 105 天。结果表明: 饲料脂肪水平对大鲵增重率 (WGR) 有显著影响 ($P<0.05$), L4 组较 L6 组增加了 217.2%。大鲵肌肉 RNA/DNA 比值、皮肤胶原蛋白含量、肠道蛋白酶、脂肪酶、Na⁺-K⁺-ATP 酶和超氧化物歧化酶 (SOD) 活性均在 L4 组达到最高, 饲料系数和肝脏丙二醛 (MDA) 则在该组达到最低.....以增重率、脂肪沉积率、脂肪酶活性和皮肤胶原蛋白含量为评价指标, 通过二次回归方程分析可得最适脂肪水平为 13.3%-17.5% (干样基础)。该添加水平最有利于增加大鲵幼体消化吸收能力、生长性能并提高机体抗氧化能力。

关键词: 大鲵幼体; 脂肪; 生长性能; 体成分; 抗氧化

Study on lipid requirements of juvenile Chinese giant salamanders (*Andrias davidianus*)

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Abstract: In order to assess the lipid requirements of juvenile giant salamander, soybean oil is used as the main fat source to prepare 6 kinds of lipid levels (dry matter) of isonitrogen (crude protein 57%): L1 (5.02%), L2 (8.96%), L3 (12.90%), L4 (16.21%), L5 (19.46%), L6 (22.80%) experimental feed, fed with initial weight (34.20±0.27g) giant salamander larvae for 105 days. The results showed that the feed lipid level had a significant effect on the weight gain rate (WGR) of giant salamander ($P<0.05$), and the L4 group increased by 217.2% compared with the L6 group. The muscle RNA/DNA ratio, skin collagen content, intestinal protease, lipase, Na⁺-K⁺-ATPase and superoxide dismutase (SOD) activities reached the highest in the L4 group, and the feed coefficient and liver malondialdehyde (MDA) reached the lowest in this group.....With weight gain rate, fat deposition rate, lipase activity and skin collagen content as evaluation indexes, the optimal fat level can be obtained by quadratic regression equation analysis as 13.3%-17.5% (dry sample). The addition level was most beneficial to increase the digestion and absorption capacity, growth performance and antioxidant capacity of juvenile Chinese giant salamanders.

Keywords: *Andrias davidianus*; fat; growth performance; body composition; antioxidant

中华绒螯蟹雌蟹育肥阶段合适磷脂源的筛选

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摘要: 本试验制备了三组实验饲料(基础饲料添加2.5%大豆磷脂、蛋黄磷脂或磷虾油)和一组对照组饲料(基础饲料), 饲喂中华绒螯蟹雌蟹(95.23±4.43 g) 10周。结果发现饲料磷脂添加组均促进了雌蟹肝胰脏和卵巢中脂质的积累, 且磷虾油组效果显著高于其他两组。饲料中添加磷虾油显著地促进了磷脂酰胆碱、磷脂酰乙醇胺等极性脂和n-3高不饱和脂肪酸的沉积, 极大地提高了中华绒螯蟹可食用部位(卵巢、肝胰脏和肌肉)的营养价值。摄食添加磷脂饲料的中华绒螯蟹雌蟹, 肝胰脏中的丙二醛含量显著降低, 超氧化物歧化酶、过氧化氢酶和谷胱甘肽过氧化物酶的活性显著增高, 且在这三种磷脂源中, 磷虾油的抗氧化效果最好。此外, 磷虾油对雌蟹卵黄形成的促进作用比其它磷脂源更显著。因此, 磷虾油可能是一种较好的磷脂源, 可用于中华绒螯蟹雌蟹育肥饲料中。

关键词: 中华绒螯蟹; 脂肪酸; 磷虾油; 生殖激素; 血清生化

Selecting suitable phospholipid source for female *Eriocheir sinensis* in pre-reproductive phase

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Abstract: Three experimental diets (the basal diet plus 2.5% soybean lecithin, 2.5% egg yolk lecithin or 2.5% krill oil) and one control diet were formulated to feed female *Eriocheir sinensis* (95.23 ± 4.43 g) for 10 weeks. The dietary phospholipid (PL) promoted the accumulation of lipids in the hepatopancreas and ovary of female *E. sinensis*, and krill oil more effectively boosted lipid deposition in the hepatopancreas and ovaries than soybean lecithin and egg yolk lecithin. Krill oil greatly improved the nutritional value of the edible parts (e.g., ovaries, hepatopancreas and muscle) of female *E. sinensis* by efficiently promoting polar lipids and n-3 highly unsaturated fatty acid deposition. The female *E. sinensis* fed diets with PL supplement had a lower content of malondialdehyde and higher specific activities of superoxide dismutase, catalase and glutathione peroxidase in the hepatopancreas, and krill oil exhibited the best antioxidant effect among three different PL sources. In addition, krill oil more effectively promoted vitellogenesis of female *E. sinensis* than other PL sources. Therefore, krill oil might be an excellent PL source, and could be used in the diet of *E. sinensis* in the pre-reproductive phase.

Keywords: Chinese mitten crab, Fatty acids, Krill oil, Reproductive hormones, Serum biochemistry

湖南稻区不同规格克氏原螯虾的肌肉营养成分分析与评价

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摘要: 为了科学评价克氏原螯虾的品质特性, 通过对八月份湖南稻区养殖的 0-10g (A₁)、10-20g (A₂)、20-30g (A₃) 和 30-50g (A₄) 四种不同规格的克氏原螯虾腹部肌肉含肉率、肝体比、常规成分和质构特性进行分析评价。结果显示: 不同规格的克氏原螯虾肝体比无显著差异 ($P > 0.05$); A₁ 组的出肉率、水分、粗蛋白和粗灰分含量均为最高, 分别为 16.42%、78.56%、86.07%、6.59%, 随着规格增大有下降趋势, 粗脂肪则随着规格的增大显著性升高 ($P < 0.05$); A₁ 组肌肉的弹性和内聚力最大, A₄ 组肌肉硬度、胶粘性、咀嚼性均最大, 且咀嚼性与其它三组差异极其显著 ($P < 0.01$)。

关键词: 湖南稻区; 克氏原螯虾; 常规成分; 质构特性; 营养评价;

Analysis and Evaluation on Nutritional Components in Muscle of the different sizes of *Procambarus clarkii* in Rice Area of Hunan Province

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Abstract: The research aimed to scientifically evaluate the quality characteristics of *Procambarus clarkii*. The meat content, liver-body ratio, texture properties and conventional components of four different sizes of *Procambarus clarkii*(0-10g(A₁), 10-20g(A₂), 20-30g(A₃), and 30-50g(A₄)) cultured in rice area of Hunan Province were analyzed and evaluated. The results showed that the liver-body ratio was no significant difference at different sizes($P > 0.05$). The contents of flesh, moisture, crude protein and crude ash in group A₁ were the highest, which were 16.42 %, 78.56 %, 86.07 % and 6.59 %, respectively, which have a downward trend with the increase of specifications, while the crude fat increased significantly($P < 0.05$). The elasticity and cohesion in group A₁ were the highest. The hardness, adhesiveness and chewiness in group A₄ were the highest, and the chewiness was significantly different from the other three groups ($P < 0.01$).

Key words: Rice area of Hunan Province, *Procambarus clarkii*, conventional components, texture properties, nutrition evaluation

外源牛磺酸影响卵形鲳鲹的生长和牛磺酸的合成调节

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摘要: 为研究饲料牛磺酸水平对卵形鲳鲹的生长、抗氧化和牛磺酸合成调节的影响, 选取初始体重 81.0 ± 0.5 g 的健康卵形鲳鲹 750 尾, 随机分为 5 个处理组, 分别投喂含 1.3、4.4、7.4、10.5 和 12.7 g kg^{-1} 牛磺酸的饲料, 养殖试验为期 60d。结果显示: 1) 添加外源牛磺酸显著提高了卵形鲳鲹增重率 WGR 和特定生长率 SGR ($P < 0.05$); 2) 添加外源牛磺酸显著提高全鱼粗蛋白和粗脂肪的含量; 3) 添加牛磺酸显著降低血清中丙二醛 MDA 含量, 显著提高总抗氧化能力 T-AOC、超氧化物歧化酶 SOD、过氧化氢酶 CAT 和谷胱甘肽过氧化物酶 GSH-PX 活性 ($P < 0.05$); 4) 添加牛磺酸显著提高各组织的牛磺酸含量, 降低牛磺酸合成酶胱硫醚 β 合酶 CBS、胱硫醚 γ 裂合酶 CSE、半胱氨酸双加氧酶 CDO、半胱氨酸亚磺酸脱羧酶 CSAD 和半胱胺双加氧酶 ADO 的酶活性和基因表达量 ($P < 0.05$)。以 SGR 为评价指标, 经多项式回归分析, 卵形鲳鲹饲料中牛磺酸的适宜添加量为 10 g kg^{-1} 。

关键词: 卵形鲳鲹; 牛磺酸; 生长性能; 基因表达

Dietary taurine intake affects growth and taurine synthesis regulation in golden pompano, *Trachinotus ovatus*

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Abstract: The purpose of this study was to investigate the effect of varying dietary taurine levels on the growth, antioxidant capacity and taurine synthesis regulation of *Trachinotus ovatus*. A total of 750 golden pompano ($81 \pm 0.50 \text{ g}$) were randomly divided into 5 groups, taurine concentrations of 1.3, 4.4, 7.4, 10.5 and 12.7 g kg^{-1} were added to the basic feed. The results showed: 1) The addition of exogenous taurine significantly increased WGR and SGR ($P < 0.05$); 2) Exogenous taurine significantly increased the content of crude protein and crude fat in whole fish; 3) The addition of taurine significantly reduced the content of MDA and increased T-AOC, SOD, CAT and GSH-PX activity ($P < 0.05$); 4) The addition of taurine significantly increased the content of tissue taurine, and decreased the enzyme activity and gene expression of e CBS, CSE, CDO, CSAD and ADO ($P < 0.05$). Based on SGR as the evaluation index, the appropriate addition amount of taurine in the feed of *T. ovatus* is 10 g kg^{-1} .

Key words: *Trachinotus ovatus*, taurine, growth performance, gene expression

棕、白两色卤虫卵比较形态测量学研究

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摘要: 卤虫卵色泽是评价卤虫卵来源和品质的重要表征之一, 为探究同一产地卤虫卵不同色泽形成的原因及其形态特征差异。本研究采用形态学测量方法研究了采自巴里坤湖、越南、旧金山湾的卤虫卵, 其棕、白两色卵的未去壳卵径、去壳卵径、卵壳厚度、亚壳层厚度等测量学特征。结果显示越南、旧金山卤虫棕、白色卵未去壳卵径 ($P>0.05$)、去壳卵径 ($P>0.05$) 差异不显著; 巴里坤湖棕、白色卵去壳卵径差异不显著 ($P>0.05$), 未去壳卵径差异显著 ($P<0.05$); 巴里坤湖卤虫棕、白卵壳各亚壳层厚度统计分析显示 OMCL (包括外膜、皮层) 差异不显著 ($P>0.05$), 泡层 ($P<0.05$) 差异显著, 第一胚膜 EC1 ($P>0.05$) 差异不显著。这表明对于两性卤虫 (越南、旧金山) 卵色泽可能是一种遗传性状, 而对于孤雌卤虫, 其休眠卵卵壳泡层厚度可能是同一种群卵壳厚度不同的原因, 种群内遗传差异造成的卵壳厚度和泡层正铁红素沉积量可能是影响卵壳色泽的原因。

关键词: 卤虫卵; 色泽; 形态学测量法; 亚壳层

Biometrical Comparison of the brown and white cysts of Artemia

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Abstract: The cysts color of Artemia is one of the important characters to evaluate its origin and quality. In this study, the untreated cyst diameter, decapsulated cyst diameter, chorion thickness and subshell thickness of the brown and white cyst of Artemia collected from Barkol Hu, Vietnam and San Francisco Bay were measured by morphological methods. The results showed that there were no significant differences in the diameters of untreated cyst and decapsulated cyst ($P>0.05$) between brown and white cysts from Vietnam and San Francisco Bay. There were no significant differences in the diameters of decapsulated cyst ($P>0.05$), but show significant differences in the diameter of untreated cyst between brown and white cysts from Barkol Hu ($P<0.05$). There were no difference of thickness of the OMCL Layer and EC1 layer of the brown and white cysts shells of Artemia from Barkol Hu ($P>0.05$), but the AL layer was significant different ($P<0.05$). These suggests that cysts color may be a genetic trait in bisexual Artemia (Vietnam, San Francisco), but in parthenogenetic Artemia, the thickness of the follicular layer of the dormant egg shell may be the reason for the difference in the thickness of the egg shell of the same population, the egg shell thickness and the amount of Ferritin deposited in the follicular layer may be the reasons that affect the egg shell color.

Key words: the cysts of Artemia, color, measured by morphological methods, subshell thickness

不同饵料、水温对口虾蛄肌肉和卵巢营养成分的影响

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摘要: 选用当年养殖口虾蛄为研究对象, 在设施相同条件下, 研究了在自然水温和加温条件下投喂冰鲜杂鱼、蛤蜊肉对口虾蛄常规生化成分和脂肪酸组成的影响。结果显示: (1) 在自然水温条件下, 不同饵料对口虾蛄常规生化成分的影响趋势相近; (2) 水温对口虾蛄常规生化成分的影响差异较大, 粗蛋白含量在肌肉中影响不显著 ($P > 0.05$), 在卵巢中则影响显著 ($P < 0.05$); (3) 蛤蜊肉和冰鲜杂鱼对口虾蛄肌肉脂肪酸含量的变化趋势相同, ΣSFA 和 $\Sigma MUFA$ 均随着实验进行逐渐上升, 其中 $\Sigma MUFA$ 的上升幅度更为明显 ($P < 0.05$); (4) ΣSFA 和 $\Sigma MUFA$ 在口虾蛄水温实验中差异不显著 ($P > 0.05$), EPA 与 DHA 之和在常温组中稳步上升, 在加热组中则呈下降趋势。

关键词: 口虾蛄; 饵料; 温度; 肌肉; 卵巢; 脂肪酸

Effects of Different Diets and Water Temperatures on nutritional components of *Oratosquilla oratoria*

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Abstract: In order to compare the effects of different diet and water temperature on the nutritional components in muscles and ovarian of *Oratosquilla oratoria* during the overwintering period, 600 individuals were used for this study to investigate the effects of two kind foods under two different temperature named natural and heated on the biochemical composition and fatty acid composition under the same condition. The results were as follows: (1) The common changing trends of biochemical components in muscles and ovarian was similar under the natural water temperature; (2) There was great difference among the effects of water temperature on biochemical components in muscles and ovarian, and the content of crude protein was change exquisitely, it had no significant influence on muscles, but showed significant influence on ovarian; (3) The changes of fatty acid contents of different diets on muscles showed the same trend, the ΣSFA and $\Sigma MUFA$ kept and increasing trend throughout the whole process, and $\Sigma MUFA$ was increased more significantly; (4) ΣSFA and $\Sigma MUFA$ had not significant difference among the experiments of water temperature in muscles, the EPA+DHA of muscles increased steadily in normal water temperature and showed the downtrend in heated water temperature.

Key words: *Oratosquilla oratoria*; Diets; Water Temperatures; Muscle; Ovarian; Fatty acid

黄颡鱼锌稳态 SLC30A/ZnTs 家族中 6 个基因的特征、mRNA 表达及其对饲料纳米氧化锌的响应

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摘要: 锌转运蛋白 SLC30A/ZnTs 在 Zn 稳态中发挥的重要作用。本研究对黄颡鱼 ZnT 家族的 6 个成员 ZnT2、ZnT4、ZnT6、ZnT8、ZnT9 和 ZnT10 进行克隆和鉴定, 并确定其表达模式。探究了饲料纳米氧化锌(ZnO NPs)的添加对黄颡鱼脾脏、肾脏、肌肉和鳃等组织中锌含量以及 ZnT mRNA 表达的影响。

关键词: SLC30A/ZnTs; 分子特征; 纳米氧化锌; 锌稳态; 黄颡鱼

Six members of SLC30A/ZnTs family related with the control of zinc homeostasis: Characterization, mRNA expression and their responses to dietary ZnO nanoparticles in yellow catfish

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Abstract: Zn transport proteins, SLC30A/ZnTs play important roles in the control of Zn homeostasis. The present study was conducted to clone and characterize six members (ZnT2, ZnT4, ZnT6, ZnT8, ZnT9 and ZnT10) of ZnT family and determine their expression patterns from yellow catfish *Pelteobagrus fulvidraco*. The influences of zinc oxide nanoparticles (ZnO NPs) in the diets on their mRNA expression and zinc content were determined in several tissues, such as spleen, kidney, muscle and gill of yellow catfish.

Keywords: SLC30A/ZnTs, Molecular characterization, ZnO NPs, Zn homeostasis, *Pelteobagrus fulvidraco*,

月桂酸单甘油酯对花鲈脂质代谢的影响

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摘要: 为评价月桂酸单甘油酯 (Glycerol monolaurate, GML) 对花鲈 (*Lateolabrax maculatus*) 脂质代谢的影响, 通过基础饲料拌喂 0 mg·kg⁻¹ (对照组)、1 000 mg·kg⁻¹ (低剂量组)、2 000 mg·kg⁻¹ (中剂量组) 和 4 000 mg·kg⁻¹ (高剂量组) 的 GML, 养殖花鲈 8 周。结果显示: 1) 低剂量和中剂量组的腹脂率、肝体均显著低于高剂量组 ($P<0.05$); 2) 低剂量和中剂量组的血清甘油三酯、总胆固醇、低密度脂蛋白胆固醇浓度活性均低于高剂量组 ($P<0.05$); 3) 中剂量组肝脏中超氧化物歧化酶、谷胱甘肽过氧化物酶活性和还原型谷胱甘肽浓度显著高于其他组 ($P<0.05$); 4) 中剂量组肝脏脂蛋白脂酶活性显著升高, 且脂质沉积明显减少 ($P<0.05$)。综上, 饲料中添加 2 000 mg·kg⁻¹ GML 能够显著改善花鲈脂质代谢。

关键词: GML; 花鲈; 脂质代谢; 脂肪肝

Effects of glycerol monolaurate on lipid metabolism of *Lateolabrax maculatus*

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Abstract: We evaluated the effect of Glycerol monolaurate (GML) on the lipid metabolism with four diets containing 0 mg·kg⁻¹ (control group), 1000 mg·kg⁻¹ (low-dose group), 2000 mg·kg⁻¹ (medium-dose group) and 4000 mg·kg⁻¹ (high-dose group) GML fed the *Lateolabrax maculatus* for eight weeks. Results showed that: 1) The intraperitoneal fat ratio (IPF) and the hepatosomatic index (HIS) in low-dose and medium-dose groups were lower than the high-dose groups ($P<0.05$). 2) The triglyceride (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C) contents in low-dose and medium-dose groups were lower than the high-dose groups ($P<0.05$). 3) The activities of superoxide dismutase (SOD), glutathione peroxidase (GSH-Px) and the contents of glutathione (GSH) increased in medium-dose groups ($P<0.05$). 4) The lipoprotein lipase (LPL) activities in medium-dose group were significantly higher than those of the other groups and the lipid deposition decreased in liver of the GML supplementation groups significantly ($P<0.05$). In summary, the dietary supplementation with 2000 mg·kg⁻¹ GML can significantly improve the lipid metabolism of the *L. maculatus*.

Key words: Glycerol monolaurate, *Lateolabrax maculatus*, Lipid metabolism, Fatty liver

桑叶粉添加对养殖草鱼的功能影响分析

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摘要: 在草鱼基础饲料中分别添加 0%、5%、10%、15% 和 20% 的桑叶粉, 开展 67 天的饲养试验, 以期明确桑叶粉对草鱼生长、肉质及免疫等方面的功能影响。研究发现草鱼饲料中添加桑叶粉会显著影响草鱼的生长性能, 其添加水平与增重率、特定生长率呈负相关。添加桑叶粉能显著降低脏体比和肝体比。随着桑叶粉添加水平的提高, 草鱼肌肉粗蛋白含量显著提高, 肌肉脂肪含量显著降低; 熟肉率提高, 肉质改善; 草鱼的抗氧化能力提高。研究结果为草鱼养殖过程中合理利用桑叶粉提供了参考。

关键词: 桑叶粉; 草鱼; 生长; 肉质; 免疫

Functional effect analysis of the addition of mulberry leaf powder on cultured grass carp (*Ctenopharyngodon idellus*)

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Abstract: A series (ratio of 0%、5%、10%、15% and 20%) of mulberry leaf powder were added to barley-based diets and a 67 days of feeding experiment was performed to decipher the functional effect of mulberry leaf powder on the growth, meat quality and immune function of grass carp (*Ctenopharyngodon idellus*). We found that the adding of mulberry leaf powder significantly affect the growth performance of grass carp, and the levels of mulberry leaf powder added were significantly negative correlated with the weight gain and the specific growth rate. The addition of mulberry leaf powder also leads to significantly lower of viscerosomatic index and hepatosomatic index. Following the up-regulation of levels of mulberry leaf powder, the crude protein content of muscle was significantly increased, whilst the muscle fat content decreased, cooking percentage increased and the meat quality and antioxidative ability improved. The results obtained from this study provided a reference for the reasonable utilization of mulberry leaf in the culture of grass carp.

Key words: mulberry leaf powder, grass carp; growth; meat quality; immune

甘氨酸对南美白对虾生长、消化和生理生化的影响

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摘要: 本实验采用单因素实验设计来研究饲料中添加甘氨酸对南美白对虾生长、消化和生理生化指标的影响。设计 2%、2.4%、2.8%、3.2%、3.6%、4% 六个甘氨酸添加水平。选取 720 尾初始体重为 $4.2 \pm 0.4\text{g}$ 的南美白对虾随机分为 6 组, 每组三个重复, 每天两次饱食投喂, 实验期为 49d。结果表明: 甘氨酸对南美白对虾的生长有促进作用。与对照组 (2% 水平) 相比, 随着甘氨酸添加水平的增加, 显著提高了南美白对虾的增重率, 降低了饵料系数, 且在 3.6% 添加水平下达到最大值 ($P < 0.05$)。饲料甘氨酸水平显著影响了体蛋白含量、血清 AKP 及血清 MDA 以及消化酶活性 ($P < 0.05$)。肝胰腺淀粉酶、胰蛋白酶、脂肪酶活性在 3.6% 甘氨酸添加水平时达到最大值 ($P < 0.05$)。在本实验条件下, 当甘氨酸添加量为 3.6% 时, 对南美白对虾最有利。

关键词: 甘氨酸; 生长; 生理生化; 消化酶; 南美白对虾

Effects of glycine on growth, digestion, physiological and biochemical index of *Penaeus vannamei*

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Abstract: A single factor experiment was designed to study the effects of glycine on growth, digestion, physiological and biochemical index of *Penaeus vannamei*. Six glycine levels were designed: 2%, 2.4%, 2.8%, 3.2%, 3.6% and 4%. 720 *Penaeus vannamei* with initial weight of $4.2 \pm 0.4\text{g}$ were randomly divided into 6 groups with three replicates in each group. Shrimp were fed twice daily to apparent satiation. The feeding trial last for 49d. The results showed that glycine could promote the growth of *Penaeus vannamei*. Compared with the control group (2% level), with the increase of glycine level, the weight gain rate of *Penaeus vannamei* was significantly increased, the feed coefficient was decreased, and reached the maximum at 3.6% level ($P < 0.05$). Dietary glycine levels significantly affected body protein content, serum AKP, serum MDA and digestive enzyme activities. The activities of amylase, trypsin and lipase in hepatopancreas reached the maximum at 3.6% glycine level ($P < 0.05$). Under the experimental conditions, when the amount of glycine was 3.6%, it was the most beneficial to *Penaeus vannamei*.

Key words: Glycine; Growth; Physiology and biochemistry; Digestive enzymes; *Penaeus vannamei*

饲料添加 T-2 毒素对中华绒螯蟹幼蟹生长和免疫功能的影响

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摘要: 本研究旨在探究饲料添加 T-2 毒素对中华绒螯蟹幼蟹生长性能和免疫功能的影响。试验选取幼蟹 (2 ± 0.05) g 700 只, 随机分为 4 组, 分别投喂 4 种不同的饲料, 即在基础饲料中添加 0 (对照组)、0.6 (T1)、2.5 (T2) 和 5.0 (T3) mg/kg 的 T-2 毒素, 试验期 8 周。结果表明: 饲料添加 T-2 毒素显著降低幼蟹的体增重和特定生长率, 且存活率显著下降。血液免疫结果显示 T-2 毒素导致总血细胞数 (THC)、呼吸爆发和酚氧化酶 (PO) 活性均显著下降。此外, T-2 毒素导致肝胰腺丙二醛 (MDA) 含量显著升高, 超氧化物歧化酶 (T-SOD) 和谷胱甘肽过氧化物酶 (GSH-Px) 活性、总抗氧化能力水平 (T-AOC) 和 *CncC*-mRNA 的表达量均显著下降。组织学结果显示 T-2 毒素诱导了肝胰腺结构的损伤, 肝胰腺小管基膜发生脱离。综上, 饲料污染 T-2 毒素会对中华绒螯蟹幼蟹的生长性能和免疫功能造成负面影响, 并损害肝胰腺健康。

关键词: T-2 毒素; 中华绒螯蟹; 生长; 免疫毒性; 氧化应激; 凋亡

T-2 toxin in the diet suppresses growth and induces immunotoxicity in juvenile Chinese mitten crab (*Eriocheir sinensis*)

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Abstract: In the present study, the crab juveniles were fed with diets containing four levels of T-2 toxin: 0 (control), 0.6 (T1), 2.5 (T2) and 5.0 (T3) mg/kg diet for 8 weeks to evaluate its impact on the Chinese mitten crab (*Eriocheir sinensis*). The crabs fed the T-2 toxin diets had significantly lower weight gain, specific growth rate and survival. The total hemocyte count, respiratory burst, phenoloxidase in the haemolymph of crabs fed T-2 toxins were significantly lower than those in the control. Oxidative stress occurred in all the treatment groups as indicated by lower activities of total superoxide dismutase, glutathione peroxidase, total antioxidant capacity and mRNA expression of *CncC* and higher malondialdehyde content. Dietary T-2 toxin damaged the hepatopancreas structure, especially the detached basal membrane of hepatopancreatic tubules. This study indicates that dietary T-2 toxin can reduce growth performance, deteriorate health status and cause hepatopancreas dysfunction in crabs.

Key words: T-2 toxin; *Eriocheir sinensis*; growth; immunotoxicity; oxidative stress; apoptosis.

饲料锌水平对中华绒螯蟹幼蟹生长性能、抗氧化能力及非特异性免疫力的影响

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摘要: 为探究饲料锌对中华绒螯蟹生长性能, 抗氧化能力和免疫力的影响, 本试验在基础饲料中分别添加 0 (对照), 25、50、100、200 和 400 mg/kg 的锌 (七水合硫酸锌), 饲喂幼蟹 (0.40±0.01 g) 56 天。结果发现: 与对照组相比, 100 mg/kg 锌可以显著提高幼蟹的增重率、特定生长率、肝胰腺锌含量以及血清的碱性磷酸酶和酸性磷酸酶的活性。另外, 当饲料中添加 200 mg/kg 锌时, 肝胰腺的锌含量以及肝胰腺的铜锌超氧化物歧化酶和谷胱甘肽过氧化物酶活性显著提高。对增重率的回归分析表明, 饲料锌的最适添加量为 101.1 mg/kg。这项研究表明, 100-200 mg/kg 的饲料锌可以显著改善幼蟹的生长性能, 抗氧化能力和非特异性免疫力。

关键词: 锌; 生长性能; 抗氧化; 免疫; 中华绒螯蟹

Effects of dietary Zn on growth, antioxidant capacity, and immunity in juvenile Chinese mitten crab *Eriocheir sinensis*

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Abstract: This study investigates the effects of dietary Zn on the growth, antioxidant capacity and immunity of juvenile Chinese mitten crab. Zn was supplemented respectively at 0 (control), 25, 50, 100, 200 and 400 mg kg⁻¹ to feed the crabs (0.40 ± 0.01 g) for 56 days. The weight gain, specific growth rate, Zn in the hepatopancreas, the activities of serum alkaline phosphatase and acid phosphatase were significantly increased in the Zn100 group compared with other groups. Moreover, Zn accumulation in the hepatopancreas reached a saturation in the Zn200 group, and the copper-zinc superoxidase and glutathione peroxidase in the hepatopancreas were significantly increased. The broken-line regression analysis on weight gain showed that the optimal dietary Zn level is 101.1 mg kg⁻¹ in the diet. This study demonstrates that dietary Zn supplement of 100-200 mg kg⁻¹ can significantly improve growth performance, antioxidant capacity and nonspecific immunity of juvenile crabs.

Key words: Zinc; growth performance; antioxidant capacity; immunity; *Eriocheir sinensis*

饲料中不同类型添加剂对 T-2 毒素引起的中华绒螯蟹幼蟹毒性效应的缓解作用研究

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摘要: 试验研究了 N-乙酰半胱氨酸 (NAC)、姜黄素和酵母细胞壁三类添加剂对 T-2 毒性效应的缓解作用, 分别在含有 T-2 毒素的中华绒螯蟹幼蟹饲料中添加两种浓度的添加剂 (0.05% NAC, 0.1% NAC, 0.5%姜黄素, 1.0%姜黄素, 1%细胞壁, 2%细胞壁), 饲喂中华绒螯蟹幼蟹 8 周。试验结果表明, 饲料 T-2 毒素显著抑制幼蟹的生长, 对免疫功能造成负面影响, 并且损害肝胰腺健康。与 T-2 组相比, 饲料中添加 0.1%的 NAC 显著提高幼蟹的生长和存活, 同时显著增加肝胰腺谷胱甘肽的含量和 γ -谷氨酰半胱氨酸合成酶的活性; 添加 0.5%的姜黄素能够显著提高幼蟹生长和存活率, 同时提高 CncC 基因的表达量和总抗氧化能力; 1%和 2%细胞壁均能够显著提高幼蟹生长, 但 2%添加量能有效提高幼蟹的存活率。通过转录表达分析和酶活检测, 结果发现姜黄素可通过诱导抗氧化转录因子 CncC 基因的表达, 提高幼蟹抗氧化酶系统的活动; NAC 可通过促进还原性谷胱甘肽的合成提高非酶和酶系统抗氧化能力; 酵母细胞壁可物理吸附降低毒性效应, 改善幼蟹的生长状况。

关键词: T-2 毒素; 中华绒螯蟹; N-乙酰半胱氨酸; 姜黄素; 酵母细胞壁; 生长; 抗氧化

Mitigative effects of different additives on growth inhibition and oxidative damage induced by T-2 toxin in juvenile Chinese mitten crabs (*Eriocheir sinensis*)

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Abstract: This study was conducted to investigate the mitigative effects of different additives (N-acetylcysteine (NAC), curcumin, and yeast cell walls) on the adverse effects of T-2 in juvenile Chinese mitten crabs (*Eriocheir sinensis*). Juvenile crabs were fed diets with T-2 toxin and different additives for 8 weeks. T-2 toxin in the diet significantly inhibited the growth of the crabs and impaired the immunological function and hepatopancreas health of the crabs. However, 0.1% dietary NAC, 0.5% curcumin and 2% yeast cell walls could significantly mitigate the impairment of T-2 toxin and improve the growth of crabs. Dietary NAC increased the glutathione content and the activities of γ -glutamylcysteine synthase, while dietary curcumin increased the mRNA expression of CncC and total antioxidant capacity. These results indicated that curcumin could increase the activity of antioxidant enzyme system by inducing the expression of the transcriptional factor CncC. NAC would promote the synthesis of reductive glutathione which would increase both non-enzyme and enzyme antioxidant system capacity. The cell walls can effectively reduce the toxicity effect of T-2 by adsorption or physical adhesion.

Key words: T-2 toxin, *Eriocheir sinensis*, N-acetylcysteine, curcumin, yeast cell walls, growth

饲料脂肪水平对血鹦鹉鱼吸收虾青素效果、生长性能和血清生化指标的影响

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摘要: 为探讨血鹦鹉鱼增色期饲料脂肪水平对其吸收虾青素的效果、生长性能及血清生化指标的影响。选取初始体重为 (28.84±4.84) g 的血鹦鹉鱼 540 尾, 随机分为 6 组, 每组设 3 个重复, 每个重复 30 尾鱼, 分别饲喂豆油添加水平为 0 (对照组)、3%、6%、9%、12%、15% (实测脂肪水平分别为 2.93%、5.90%、8.89%、11.91%、14.94%、17.92%) 的 6 种等氮试验饲料, 均含 4% 的虾青素, 试验期 60d.....

关键词: 血鹦鹉鱼; 饲料脂肪水平; 体色; 血清生化指标; 生长性能

Effects of Dietary Lipid Level on Astaxanthin Absorbtion, Growth Performance and Serum Biochemical Indices of Blood Parrot Fish

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Abstract: This study was conducted to study the effects of dietary lipid level on astaxanthin absorption effect, growth performance and serum biochemical indexes of blood parrot fish. A total of 540 blood parrot fish with the average body weight of (28.84±4.84) g were randomly divided into 6 groups with 3 replicates per group and 30 fish per replicate. Fish in the 6 groups were fed experimental diets containing 0 (control)、3%、6%、9%、12%、15% (measured lipid levels were 2.93%、5.90%、8.89%、11.91%、14.94%、17.92% respectively) for 60 days, respectively.....

Key words: Blood parrot fish; Feed fat level; Body color; Serum biochemical indexes; The growth performance

螺旋藻粉是中国鲎一种有益的饲料添加剂

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摘要: 为满足市场对鲎试剂需求, 成鲎暂养和取血以及鲎工厂化养殖技术亟待升级。为了探究螺旋藻粉作为人工饲料成分对鲎的作用, 本研究通过 4 周养殖实验调查螺旋藻粉对中国鲎成鲎生长性能、血液生化指标以及非特异性免疫酶活性的影响, 发现螺旋藻粉对中国鲎生理变化具有稳定和促进作用。

关键词: 中国鲎; 螺旋藻粉; 生长性能; 血浆生化; 非特异性免疫酶

Spirulina platensis powder is an applicable feed additive for Chinese horseshoe crab *Tachypleus tridentatus*

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Abstract: Given the requirement of *Tachypleus* amebocyte lysate, the technology of temporary rearing, hemolymph collection and industrial aquaculture need to be promoted. To evaluate the function of *Spirulina platensis* powder in artificial feed, the effects within four weeks of *S. platensis* powder on growth performance, hemolymph biochemical parameter, and non-specific immune enzymes were investigated. *S. platensis* powder not only had physiological stimulative effects and increased the growth performance, but also stabilized the hemolymph biochemical parameters and non-specific immune enzymes.

Key words: *Tachypleus tridentatus*, *Spirulina platensis* powder, growth performance, hemolymph biochemistry, non-specific immune enzyme

黄颡鱼中七种硒蛋白基因鉴定及其对饮食硒水平的表达分析

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摘要: 本研究对黄颡鱼各组织中的七个硒蛋白(包括 GPX1, GPX3, GPX4, SELENOW, SELENOP, TXNRD2 和 TXNRD3) cDNA 进行了鉴定, 探讨饮食中硒添加对它们的调控。它们在心脏, 肝脏, 大脑, 脾脏, 头肾, 背肌, 肠系膜脂肪, 前肠和鳃等九种组织中广泛表达, 显示出组织特异性的表达模式。饮食中硒的添加影响了黄颡鱼脾脏, 肾脏, 睾丸和脑组织中七个基因的表达。综上所述, 我们的研究证明了七种硒蛋白的表征, 表达和调控, 这加深了我们对鱼类硒和硒蛋白的生物学功能的了解。

关键词: 黄颡鱼; 硒蛋白; 膳食硒; 脂质代谢; 分子表征

Characterization and expression analysis of seven selenoprotein genes in yellow catfish *Pelteobagrus fulvidraco* to dietary selenium levels

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Abstract: The present study characterized seven selenoproteins, consisting of the GPX1, GPX3, GPX4, SELENOW, SELENOP, TXNRD2 and TXNRD3 cDNAs in various tissues of yellow catfish, explored their regulation to dietary Se addition. They were widely expressed in nine tissues, including heart, liver, brain, spleen, head kidney, dorsal muscle, mesenteric fat, anterior intestine and gill, but showed tissue-dependent expression patterns. Dietary Se addition affected the expression of the seven genes in spleen, kidney, testis and brain tissues of yellow catfish. Taken together, our study demonstrated the characterization, expression and regulation of seven selenoproteins, which increased our understanding of the biological functions of Se and selenoproteins in fish.

Key words: *Pelteobagrus fulvidraco*; Selenoprotein; dietary selenium; lipid metabolism; Molecular characterization

脂肪水平对卵形鲳鲹幼鱼生长性能、脂肪代谢相关酶活和基因表达以及肠道菌群的影响

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摘要: 制做了5种脂肪水平(5.2%、8.1%、11.2%、14.1%和17.1%)的等氮饲料, 饲喂初始重量为(8.80±0.10)g的卵形鲳鲹(*Trachinotus ovatus*)幼鱼8周。研究表明: 饲料中适量的脂肪水平显著提高了卵形鲳鲹的增重率(WGR)、特定生长率(SGR)和饲料效率(FER)($P < 0.05$)。饲料中脂肪水平对酶活性有显著影响, 包括谷丙转氨酶(ALT)、谷草转氨酶(AST)、碱性磷酸酶(ALT)、总脂肪酶(TL)、脂肪酸合成酶(FAS)和激素敏感性脂肪酶(HSL)($P < 0.05$)。肝脏中肉碱棕榈酰转移酶 I(CPT1)mRNA的表达水平随饲料中脂肪水平的增加而显著升高, 而脂肪酸合成酶(FAS)mRNA的表达先升高后降低($P < 0.05$)。此外, 饲料中脂肪水平也影响微生物群落组成, 改变肠道菌群中厚壁菌群与拟杆菌门的比例, 调节肠道代谢能力。

关键词: 卵形鲳鲹; 脂肪水平; 生长性能; 脂肪代谢; 肠道菌群;

Effects of dietary lipid levels on growth performance, enzymatic activities and gene expression associated with lipid metabolism and intestinal microflora of juvenile golden pompano (*Trachinotus ovatus*)

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Abstract: Five isonitrogenous diets were formulated containing five graded levels of lipid (5.2%, 8.1%, 11.2%, 14.1% and 17.1%). The diets were fed to triplicate groups of juvenile golden pompano (initial body weight: 10.49 ± 0.23 g) for 8 weeks. The study indicated that moderate lipid level in diets significantly increased gain rate (WGR), specific growth rate (SGR) and feed efficiency rate (FER) of golden pompano ($P < 0.05$). The dietary lipid level had significantly effects on enzymatic activities including alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALT), total lipase (TL), fatty acid synthetase (FAS) and hormone-sensitive lipase (HSL) ($P < 0.05$). The relative level of hepatic carnitine palmitoyl transferase I (cpt1) mRNA increased significantly with increasing dietary lipid levels, while the expression of hepatic fatty acid synthase (fas) mRNA increased first and then decreased significantly ($P < 0.05$). Moreover, dietary lipid level influenced microbial community composition and changed the Firmicutes to Bacteroidetes ratio of intestinal microflora to regulate metabolic capacity of intestine.

Key words: Golden pompano, Lipid level, Growth performance, Lipid metabolism, Intestinal microflora

高脂饲料中添加 VE 对珍珠龙胆石斑鱼生长、脂代谢及免疫的影响

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摘要: 本试验旨在探究高脂饲料中添加 VE 对珍珠龙胆石斑鱼幼鱼生长、脂代谢及免疫的影响。在基础配方中分别添加 0 (对照), 0.01%, 0.02%, 0.03%, 0.04%, 0.05% 的 α -生育酚, 配制 6 组等氮等脂的高脂 (15.36%) 试验饲料。每处理设 3 重复, 每重复 30 尾鱼 (10.20 ± 0.02 g), 养殖期 8 周。结果显示, 1) 与对照组相比, 高脂饲料中添加 VE 不影响石斑鱼的生长性能和形态学指标, 但与 0.02%, 0.03% 两组相比高剂量 VE 组显著降低了其增重率和特定生长率。2) 在高脂饲料中添加一定量的 VE 可以显著提高石斑鱼血清高密度脂蛋白含量, 显著降低血清低密度脂蛋白、极低密度脂蛋白、胆固醇、含量及肝脏脂肪酸合成酶的活力和甘油三酯含量。3) 高脂饲料中添加 VE 可以缓解高脂引起的肝脂肪异常沉积, 同时显著提高鱼体的非特异免疫功能。4) 与对照组相比, VE 的添加显著上调了肝脏抗炎因子 TGF- β 和 IL10 基因的表达, 显著下调促炎因子 IL8 和 IL6 基因的表达。综上, 高脂饲料中加入适量 VE 可以促进石斑鱼脂肪代谢、提高抗氧化能力和免疫力, 我们推测 VE 可能是通过提高抗氧化能力来缓解机体脂质过氧化以提高自身免疫力。
关键词: 石斑鱼; VE; 生长性能; 脂代谢; 免疫

Effects of vitamin E on growth, lipid metabolism and immunity for hybrid grouper ($\text{♀ Epinephelus fuscoguttatus} \times \text{♂ E. lanceolatu}$) in high-lipid diet

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Abstract: The experiment was conducted to investigate the effects of vitamin E on growth, lipid metabolism and immunity for hybrid grouper ($\text{♀ Epinephelus fuscoguttatus} \times \text{♂ E. lanceolatu}$) in high-lipid diet. Six groups of isonitrogenous and isolipidic high-lipid (15.36%) experimental feeds were prepared by adding 0 (control), 0.01%, 0.02%, 0.03%, 0.04%, 0.05% α -tocopherol respectively in the basic formula. Each treatment consisted of 3 replicates and 30 fish (10.20 ± 0.02 g) for 8 weeks. The results showed that: 1) compared with the control group, the growth performance and morphological indexes of grouper were not affected by the addition of VE in high-lipid diet, but the WGR and SGR in high VE dose group were significantly decreased compared with 0.02% and 0.03% groups. 2) Adding a certain amount of VE in high-lipid diet could significantly increase the content of serum high-density lipoprotein, and significantly reduce the content of serum low-density lipoprotein, very low-density lipoprotein, cholesterol, liver fatty acid synthase activity and triglyceride content. 3) Adding VE to high-lipid diet can alleviate the abnormal deposition of liver lipid caused by high-lipid diet, and significantly improve the non-specific immune function of fish. 4) Compared with the control group, VE significantly increased the expression of liver anti-inflammatory factors TGF- β and IL10, and significantly decreased the expression of proinflammatory factors IL8 and IL6. In conclusion, adding appropriate amount of VE into high-lipid diet can promote lipid metabolism, improve antioxidant capacity and immunity of grouper. We speculate that VE may alleviate lipid peroxidation by improving antioxidant capacity to improve immunity.

Key words: grouper; VE; growth performance, lipid metabolism; immunity

发酵桑叶对草鱼生长性能及脂代谢的影响

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摘要: 为探究发酵桑叶对草鱼生长性能及脂代谢的影响, 试验通过在草鱼基础饲料中分别添加5%、10%、15%的发酵桑叶为实验组, 以不添加发酵桑叶为对照组, 饲喂平均体重为 854 ± 71 g的草鱼63天。每组设3个重复, 每个重复投放30尾草鱼。结果表明: 添加不同水平发酵桑叶对草鱼的增重率(WGR)、特定生长率(SGR)、饲料系数(FCR)均无显著影响($P > 0.05$)。各试验组草鱼的肝体指数(HSI)以及血清中总胆固醇(CHO)、甘油三酯(TG)、游离脂肪酸(NEFA)含量均显著低于对照组($P < 0.05$)。qPCR结果发现脂肪分解关键基因激素敏感酯酶(HSL)以及脂蛋白脂酶(LPL)的基因表达量均显著上调($P < 0.05$)。由此可见, 饲料中添加一定量的发酵桑叶, 不影响草鱼的生长性能, 且能有效调节脂代谢。

关键词: 草鱼; 发酵桑叶; 生长性能; 脂代谢

Effects of fermented mulberry leaves on growth performance and lipid metabolism of *Ctenopharyngodon idellus*

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Abstract: In order to explore the effects of fermented mulberry leaves on the growth performance and lipid metabolism of *Ctenopharyngodon idellus*. In the present study, We added 5%, 10%, and 15% fermented mulberry leaves to the basic feed of *Ctenopharyngodon idellus* as the experimental group, and fed no fermented mulberry leaves as the control, and fed *Ctenopharyngodon idellus* with the weight of 854 ± 71 g for 63 days. There were 3 repetitions for each group, and 30 grass carp for each repetition. The results showed that the addition of different levels of fermented mulberry leaves had no significant effect on the Weight gain rate(WGR), specific growth rate (SGR) and feed coefficient (FCR) of grass carp ($P > 0.05$). The liver body index (HSI), serum total cholesterol (CHO), triglyceride (TG), and free fatty acid (NEFA) contents of each experimental group of grass carp were significantly lower than control group ($P < 0.05$). qPCR results showed that the expression of hormone-sensitive esterase (HSL) and lipoprotein lipase (LPL) genes, the key genes for lipolysis, were significantly up-regulated($P < 0.05$). It can be seen that adding a certain amount of fermented mulberry leaves to the feed has no influence on the growth performance of *Ctenopharyngodon idellus* and can effectively regulate lipid metabolism.

Key words: *Ctenopharyngodon idellus*., fermented mulberry, Growth performance, lipid metabolism

低鱼粉饲料中添加适量的酶解肠膜蛋白粉对珍珠龙胆石斑鱼的生长性能、肠道菌群以及肠道氨基酸和小肽转运载体表达的影响

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摘要: 配制含有 0% (EH0), 3% (EH3), 6% (EH6), 9% (EH9) 和 12% (EH12) 的酶解肠膜蛋白粉 (EH) 的 5 种等氮等脂的低鱼粉饲料。将珍珠龙胆石斑鱼幼鱼随机分到 15 个玻璃钢桶中, 每天投喂试验饲料两次, 持续 56 天。结果显示, EH3 组的增重率和特定生长率与 EH0 组无显著差异。EH3 组后肠的 CAT1, CAT2, LAAT1, PAT1, SNAT3, EAAT1, B⁰⁺AT 和 PepT1 的表达量显著高于 EH0 组。EH6 组前肠的 CAT1, CAT2, LAAT1 和 SNAT3, 中肠的 PAT1, B⁰⁺AT3 和 B⁰⁺AT, 以及前肠和中肠的 EAAT1 和 PepT1 的表达量显著高于 EH0 组, EH6 组肠道菌群香农指数显著高于其他各组。这些结果表明, 低鱼粉饲料中添加 3% 的 EH 对珍珠龙胆石斑鱼的生长性能无显著影响, 后肠氨基酸和小肽转运载体的表达显著提高, 6% 的 EH 可以改变肠道菌群的多样性, 并显著改善前肠和中肠的氨基酸和小肽转运载体的表达。

关键词: 酶解肠膜蛋白粉; 生长性能; 肠道菌群; 氨基酸转运载体; 小肽转运载体

Effects of adding suitable amount of enzyme-digested hydrolyzed porcine mucosa in low fish meal dietary on growth, intestinal microbiota, and the transporters expressions of peptide and amino acid located in the intestine for hybrid grouper (*Epinephelus fuscoguttatus* ♀ × *E. lanceolatus* ♂)

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Abstract: Five iso-nitrogenous and iso-lipidic low-fish-meal experiment diets were formulated to contain enzyme-digested hydrolyzed porcine mucosa (EH) 0%(EH0), 3% (EH3), 6% (EH6), 9% (EH9) and 12% (EH12). The hybrid groupers were randomly divided into 15 fiberglass tanks and fed with the experimental diets twice daily for 56 days. The results showed that weight gain rate and specific growth rate of EH3 group were not significantly different with EH0 group. The expressions of CAT1, CAT2, LAAT1, PAT1, SNAT3, EAAT1, B⁰⁺AT and PepT1 of DI in EH3 group were significantly greater than those in EH0 group. The expressions of CAT1, CAT2, LAAT1 and SNAT3 of PI, and PAT1, B⁰⁺AT3 and B⁰⁺AT of MI, and EAAT1 and PepT1 of PI and MI in EH6 group were significantly higher than those in EH0 group. The Shannon in EH6 group was significantly higher than that in other groups. These results revealed that, adding 3% EH in diet were significantly improved the expressions of amino acid and peptide transporters in DI, the growth performance of hybrid grouper was not significantly affected by the feed. Adding 6% EH can change the diversity of intestinal bacterial communities, and significantly improve the expressions of amino acid and peptide transporters in PI and MI.

Key words: enzyme-digested hydrolyzed porcine mucosa, growth performance, intestinal microbiota, amino acid transporters, peptide transporter

饲料浮萍水平对黄金锦鲤形体及体色的影响

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摘要:以黄金锦鲤 *Cyprinus carpio* [初重 (52.99 ± 1.95) g] 为研究对象, 研究浮萍 *Lemna minor* 对黄金锦鲤形体及体色的影响。在饲料中分别添加 0%、3%、6%、9%、13%、14% 的浮萍, 相应替代同等水平的菜粕, 制成 6 组等氮 (粗蛋白: 38.5%–38.6%) 等能 (12.2 MJ/kg) 饲料, 分别记为对照组 D1、D2、D3、D4、D5、D6。将 540 尾健康的黄金锦鲤随机分成 6 组 (为每组 3 个平行, 每个平行 30 尾鱼), 养殖时间 8 周。形体指标的结果表明, D4 组与 D6 组的体长/提高表现最为理想, 显著低于其他各组 ($P < 0.05$), 空壳率 (DOR) 与肥满度 (CF) 均以 D6 组显著高于其他组 ($P < 0.05$); 色素指标结果显示, 体表白度值 (L^*) 随养殖时间的增长呈现下降的趋势, 黄度值 (b^*) 在养殖第四周时显著高于其他阶段 ($P < 0.05$), 体表各组织总类胡萝卜素含量高低顺序为背鳍 > 皮肤 > 鳞片 > 肌肉, 且各组织总类胡萝卜素含量随紫背浮萍添加量提高呈上升趋势, D6 组显著高于其他组 ($P < 0.05$)。研究表明: 本试验条件下, 饲料浮萍添加水平在 14% 时, 有利于黄金锦鲤体型趋于美观, 达到体表增色的效果。

关键词: 浮萍; 黄金锦鲤; 形体指标; 总类胡萝卜素

Effects of Different Duckweed Levels on physique indices and pigment indices of *Koi* carp

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Abstract: To evaluate the effects of different Duckweed Levels on physique indices and pigment indices of *Koi* carp [initial average weight of (52.99 ± 1.95 g)], six isonitrogenous (38.5%–38.6% CP, crude protein) and isocaloric (12.2 MJ/kg) diets were formulated containing 0% (control), 3%, 6%, 9%, 13%, 14% Duckweed, named as D1, D2, D3, D4, D5, D6, by replacing corresponding rapeseed meal, respectively. Each diet was randomly fed to triplicate groups of 30 fish per cage for 8 weeks. The results of morphology index showed that body L/T values of fish in D4 and D6 group were the more ideal and significantly lower than those of fish in other groups ($P < 0.05$), while DOR and CF values of fish in D6 group were significantly higher than fish in other groups ($P < 0.05$). The results of the pigment index showed that whiteness value (L^*) of surface presented a decreasing trend in the total trial stages period, while yellow value (b^*) at 4th week was significantly higher than those at other trial stages ($P < 0.05$). In addition, total carotenoid content of dorsal fin, surface, scale, muscle presented a increasing trend with increasing Duckweed levels, and reached the highest value in the D6 group, and total carotenoid content was distributed in order as follow: dorsal fin, surface, scale, muscle. Results in this present study indicate that under the experimental conditions, according to the morphology index and body-color, appropriate duckweed supplemental level is 14%.

Key words: Duckweed; *Koi* carp; Physique indices; Pigment indices

豆粕替代鱼粉及添加柠檬酸钠对南美白对虾生长和免疫的影响

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摘要: 采用 3*3 双因素实验研究豆粕替代鱼粉蛋白 (20%、30%、40%) 以及柠檬酸钠 (0、0.3%、0.6%) 对南美白对虾生长和免疫的影响。配置 9 种等氮等能饲料, 依次记为 20/0、20/0.3、20/0.6、30/0、30/0.3、30/0.6、40/0、40/0.3、40/0.6。结果表明, 双因素的交互作用显著影响了对虾的增重率、饵料系数, 血清中 MDA 含量、ACP、AKP 及 SOD 活性, 肠道和肝胰脏的胰蛋白酶、脂肪酶及淀粉酶活性。30/0.3 试验组增重率和体蛋白含量显著高于其他组 ($P<0.05$); 与 20% 替代水平相比, 30% 和 40% 替代水平组血清 MDA 含量上升、SOD 活性下降 ($P>0.05$), 而随着柠檬酸钠水平的增加, 血清 MDA 含量呈下降趋势、血清 SOD 活性和 AKP 活性则逐渐升高 ($P>0.05$)。添加柠檬酸显著提高了肝胰脏和肠道淀粉酶、胰蛋白酶及脂肪酶活性 ($P<0.05$)。在本实验条件下, 30/0.3 组合最有利于南美白对虾的生长以及肠道健康。

关键词: 南美白对虾; 柠檬酸钠; 生长; 免疫; 消化酶

Effects of soybean meal substitution and sodium citrate on growth and immunity of *Penaeus vannamei*

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Abstract: A 3*3 two-factor experiment were conducted to study the effects of replacing fish meal protein by soybean meal (20%, 30%, 40%) and dietary sodium citrate levels (0, 0.3%, 0.6%) on growth and immunity of *Penaeus vannamei*. Nine isonitrogenous and isoenergetic diets were formulated, denoting as 20/0, 20/0.3, 20/0.6, 30/0, 30/0.3, 30/0.6, 40/0, 40/0.3 and 40/0.6 respectively. The results showed that the interaction of the two factors significantly affected the weight gain rate, feed coefficient, MDA content, ACP and AKP activity, SOD activity, trypsin activity, lipase activity and amylase activity of *Penaeus vannamei*. The weight gain rate and protein content of 30/0.3 group were significantly higher than those in other groups ($P < 0.05$). Compared with 20% replacement level, the serum MDA content and SOD activity in the 30% and 40% replacement levels increased and decreased respectively ($P > 0.05$), while with the increase of sodium citrate level, the serum MDA content showed a downward trend, while the serum SOD activity and AKP activity gradually increased ($P > 0.05$). The addition of citric acid significantly increased the activities of amylase, trypsin and lipase in the liver, pancreas and intestines ($P < 0.05$).

Keywords: *Penaeus vannamei*; Sodium Citrate; growth; immunity; digestive enzymes

肌醇对缓解尼罗罗非鱼高碳水化合物饮食不良反作用

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摘要: 本研究旨在探讨日粮添加肌醇(MI)对缓解尼罗罗非鱼(*Oreochromis niloticus*)高碳水化合物饮食不良反作用的影响。饲料中分别添加两个碳水化合物水平(NC: 30%和 HC: 45%)和三个 MI 浓度(0、400 和 1200mg/kg 饲料)。经过 8 周的投喂, 结果表明, 长期 HC 饮食对尼罗罗非鱼的生长状况和肝脏健康有明显的不良影响。但在日粮中添加外源性 MI 可以显著改善鱼的生长性能, 提高鱼的粗蛋白含量。日粮外源性 MI 的添加不仅促进了肝脏中脂质分解和运输, 而且还改变了葡萄糖代谢模式, 促进葡萄糖向磷酸戊糖途径代谢产生大量 NADPH, 并且增强肝脏的抗氧化性能, 防止脂肪肝的形成, 有效缓解高糖饲料的不良影响, 提高鱼类对碳水化合物的利用率。

关键词: 尼罗罗非鱼; 肌醇; 碳水化合物; 脂肪合成; 脂肪分解

Effect of dietary *myo*-inositol on alleviating the adverse effects of high carbohydrates diet in Nile tilapia (*Oreochromis niloticus*)

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Abstract: This study was conducted to investigate the effect of dietary *myo*-inositol (MI) on alleviating the adverse effects of high carbohydrate diet in Nile tilapia (*Oreochromis niloticus*). Six different diets were prepared with two carbohydrate levels (NC: 30% and HC: 45%) and three MI concentrations (0, 400 and 1200 mg/kg diet). After a 8-week feeding trail, the results showed that long-term HC diet had adverse effects on the growth and liver health of *O.niloticus*. Dietary MI could significantly improve the growth performance and increase the crude protein content of fish. The addition of MI could not only promote the lipid decomposition and transport in the liver, but also change the glucose metabolism mode. Moreover, it would increase the activity of pentose phosphate pathway to produce a large amount of NADPH which would help enhance the antioxidant performance of liver to prevent the formation of fatty liver.

甲烷细菌蛋白替代鱼粉对杂交鳢生长性能的影响及其可追溯研究

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摘要: 本试验旨在研究甲烷蛋白替代鱼粉对杂交鳢生长性能的影响以及可追溯性, 探讨甲烷蛋白替代杂交鳢饲料中鱼粉的适宜替代比例及其可追溯应用。试验以含 55%鱼粉的饲料为基础饲料, 分别在其基础上添加 0%、10%、20%、30%甲烷蛋白, 等量替代基础饲料中的鱼粉, 配制 4 种等氮等脂的试验饲料, 并分别记为 MBP0%、MBP10%、MBP20%、MBP30%组, 在池塘网箱 (2m×2m×2m) 中饲喂 4 组杂交鳢 (初始均重 193.31g) 6 周。结果表明: 随着甲烷蛋白替代鱼粉比例的升高, 饲料系数逐渐升高, MBP30%组显著高于基础组 ($P<0.05$); 蛋白质效率、特定生长率逐渐降低逐渐降低, MBP30%组显著低于基础组 ($P<0.05$)。肌肉中 $\delta^{13}\text{C}$ 值随着甲烷蛋白替代鱼粉比例的升高呈显著下降趋势 ($P<0.05$)。由此得出, 甲烷蛋白等量替代饲料中 20% 鱼粉, 对杂交鳢的生长性能无显著不利影响, 但过高的替代比例会影响杂交鳢的生长; 肌肉中的 $\delta^{13}\text{C}$ 值可以作为产品可追溯标记。综合各项指标, 建议甲烷蛋白在杂交鳢饲料中替代鱼粉的比例不宜超过 20%。

关键词: 甲烷细菌蛋白; 杂交鳢; 生长性能; 可追溯; $\delta^{13}\text{C}$ 值

Effects of fish meal replacement by methane-utilising bacteria protein meal on growth performance of *Ophiocephalus argus* and its traceability

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Abstract: The study was conducted to evaluate effects of fish meal replacement by methane-utilising bacteria protein meal(MBP) on growth performance of *Ophiocephalus argus* and its traceability, and investigate the optimal dietary substitute proportion of MBP in replacing fish meal for *Ophiocephalus argus* and the application of traceability. Four isonitrogenous and isolipidic diets were formulated by replacing 0%, 10%, 20% and 30% equivalent for fish meal (the addition of fish meal in the basal diet was 55%) with MBP, and named groups MBP0%, MBP10%, MBP20% and MBP30%, respectively. The experiment lasted for 6 weeks in pond cages (2m × 2m × 2m) (initial weight 193.31 g). The results showed that, with the increase of replacement proportion of fish meal by MBP, the FCR showed an increasing trend, and the group MBP30% was significantly higher than group MBP0% ($P<0.05$). The feed conversion ratio (FCR) and specific growth rate(SGR) decreased with the increase of replacement proportion of fish meal by MBP, and the group MBP30% was significantly lower than group MBP0% ($P<0.05$). The $\delta^{13}\text{C}$ value in muscle decreased significantly as the replacement proportion increased ($P<0.05$). Overall, it is recommended that the equivalent replacement proportion of fish meal by MBP in *Ophiocephalus argus* diets should not be above 20%, the $\delta^{13}\text{C}$ value in muscle can be used as a traceable mark of the product.

Keywords: methane-utilising bacteria protein meal(MBP); *Ophiocephalus argus*; growth performance; traceability; $\delta^{13}\text{C}$ value

肠膜蛋白替代鱼粉后对杂交鳢幼鱼生长、肝脏和肠道组织结构的影响

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摘要: 本文旨在研究肠膜蛋白粉替代鱼粉对杂交鳢幼鱼生长、肝脏和肠道组织结构的影响, 试验以含 25%鱼粉的饲料为基础饲料, 分别在基础饲料的基础上添加 0%、3%、6%、9%肠膜蛋白, 同时减少相应量的鱼粉。用四种饲料养殖杂交鳢幼鱼 11 周。结果显示: 随着肠膜蛋白添加量的增加, 饲料系数呈先下降后上升的趋势, S2 组的饲料系数最低, 为 0.93, 显著低于对照组 ($P < 0.05$)。随着肠膜蛋白添加量的增加, 特定生长率、增重率呈先升高后降低的趋势; 当肠膜蛋白添加量为 3% 时, 特定生长率和增重率最高, 分别为 2.82%、674.52%, 显著高于对照组 ($P < 0.05$)。肠膜蛋白替代鱼粉后对杂交鳢幼鱼的形体指标和肝脏组织结构无显著影响。随着肠膜蛋白添加量的增加, 绒毛皱襞高度呈先降低后上升的趋势, S3、S4 组的绒毛皱襞高度明显高于 S1 组。各试验组肠道组织结构均较完整, 表现为皱襞致密, 肌层发达。研究结果表明, 一定量的肠膜蛋白对杂交鳢幼鱼形体和肝脏健康无负面影响, 同时可促进杂交鳢幼鱼的生长, 改善肠道健康, 修护损伤组织。其在杂交鳢幼鱼饲料中的建议添加量为 3%-9%, 以增重率为评价指标, 经折线模型拟合回归方程后得出, 杂交鳢幼鱼配合饲料中肠膜蛋白粉的最适添加比例为 2.84%。

关键词: 肠膜蛋白, 鱼粉, 杂交鳢, 肠道组织

Effects of intestinal membrane proteins replacing fish meal on the growth, liver and intestinal histology of juveniles of *Ophiocephalus argus*

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Abstract: The aim of this study was to investigate the effects of intestinal protein powder instead of fish meal on the growth, liver and intestinal histology of juveniles of *Ophiocephalus argus*. The base feed containing 25% fish meal. Add 0%, 3%, 6%, 9% of intestinal membrane protein to the base feed, and reduce the corresponding amount of fishmeal. Fish were feed 4 groups for 11 weeks in cages. The results showed that with the increase of intestinal membrane protein, the feed coefficient decreased first and then increased. The feed coefficient of S2 group was the lowest, 0.93, which was significantly lower than that of the control group ($P < 0.05$). With the increase of intestinal membrane protein, the specific growth rate and weight gain rate increased first and then decreased. When the intestinal membrane protein was added in the feed 3%, the specific growth rate and weight gain rate were significantly higher than the control group ($P < 0.05$). The replacement of fish meal by intestinal membrane protein had no significant effect on the body shape and liver tissue structure of juveniles. With the increase of intestinal membrane protein content, the villus height decreased first and then increased. The villus height of S3 and S4 groups were higher than that in control group, the difference was not significant; The intestinal tissue structure of each experimental group was relatively complete, showing that the folds were intact and dense, and the intestinal muscle layer was developed. Studies have shown that a certain amount of intestinal membrane protein has no negative impact on the shape and liver health of juveniles, and can promote the growth of juveniles, improve intestinal health, and repair damaged tissues. The recommended addition amount in the feed of juvenile of *Ophiocephalus argus* is 3%-9%. Based on the weight gain rate, The optimal addition ratio of intestinal membrane protein is 2.84%.

Keywords: Intestinal membrane protein, fish meal, *Ophiocephalus argus*, intestinal histology

不同组合藻粉替代鱼粉对鲤鱼生长、体组成和体色的影响

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摘要: 为探究不同组合藻粉替代鱼粉对鲤鱼生长、体组成和体色的影响, 实验设计以基础配方 S1 (6%鱼粉) 作为对照组, 用等量的裂殖壶藻粉、裂殖壶藻粉+螺旋藻、裂殖壶藻粉+小球藻完全替代基础配方 S1 鱼粉, 分别记作 S2、S3、S4, 投喂初始规格为 (228.98±0.46) g/尾的鲤鱼, 网箱养殖 90 天。结果表明: 与 S1 鱼粉组相比, 各试验组增重率、特定增长率显著降低 ($P<0.05$), 饲料系数显著升高 ($P<0.05$), 而成活率没有明显变化 ($P>0.05$); 各试验组间肝体比、脏体比与 S1 鱼粉组相比有所升高, 肥满度降低, 但差异不显著 ($P>0.05$), 其中裂殖壶藻添加组性腺指数有所升高; 各试验组间肝体比、脏体比与 S1 鱼粉组相比有所升高, 肥满度降低, 但差异不显著 ($P>0.05$); 鱼粉组 S1 各试验组的背部和尾鳍的 L 值有所降低, 即亮度有所降低, 而尾鳍 b 值升高 (偏蓝)。各试验组脂肪含量升高, DHA 含量明显增加, 而粗蛋白、氨基酸、脂肪酸等没有显著影响。研究表明, 当不同组合藻粉替代 6% 鱼粉时, 会显著降低鲤鱼的生长性能, 提高饲料系数, 增加高背部、尾鳍亮度, 提升肌肉脂肪和 DHA 含量。

关键词: 鲤鱼; 裂殖壶藻; 螺旋藻; 小球藻; 生长

Effects of different combinations of microalgae meals instead of fishmeal on the growth, body composition and body color of carp (*Cyprinus carpio*)

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Abstract: A 90-day feeding experiment was conducted to investigate the effects of different combinations of microalgae meals instead of fishmeal on the growth, body composition and body color of carp (*Cyprinus carpio*) [initial body weight (228.98±0.46 g)]. The basic formula S1 fish meal was completely replaced by the same amount of Schizochytrium, Schizochytrium + Spirulina, Schizochytrium + Chlorella, which were recorded as S2, S3 and S4 respectively. The results showed that compared with S1 fish meal group, the weight gain rate and specific growth rate of all experimental groups decreased significantly ($P<0.05$), and the feed coefficient increased significantly ($P<0.05$), but the survival rate did not change significantly ($P>0.05$). Compared with S1 fishmeal group, the liver-body ratio and viscera-body ratio of each experimental group increased, but the lipidness decreased, but the difference was not significant ($P>0.05$). Compared with S1 fishmeal group, the liver-body ratio and viscera-body ratio of each experimental group increased, but the lipidness decreased, but the difference was not significant ($P>0.05$). In fishmeal group, the L value of back and caudal fin of S1 experimental groups decreased, that is, the brightness decreased, while the b value of caudal fin increased. The lipid content and DHA content of each experimental group increased significantly, but the crude protein, amino acids and lipidty acids had no significant effect. The results showed that when different combinations of algae meal replaced 6% fish meal, it would significantly reduce the growth performance of carp, improve the feed coefficient, increase the brightness of high back and caudal fin, and increase the content of muscle lipid and DHA.

Key words: *Cyprinus carpio*; *Schizochytrium*; *Spirulina*; *Chlorella*; growth

紫苏油等 3 种油脂在大鲵日粮中的应用

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摘要: 为研究紫苏油、鱼油和大豆油为大鲵饲料脂肪源的可行性, 配制 3 组分别添加 3%紫苏油(PSO)、鱼油(FO)和大豆油(SO)的等氮等脂试验饲料, 饲喂初始体质量为(75.20±1.18)g 的中国大鲵 98 天。结果表明: 各组大鲵的生长性能无显著差异, 而 PSO 组大鲵肌肉粗脂肪含量显著降低, 粗蛋白质含量显著升高。肌肉中亚油酸、EPA 和 DHA、 α -亚麻酸的含量分别在 SO、FO 和 PSO 组出现最大值。PSO 组饲料可显著提高大鲵肝脏总超氧化物歧化酶和肉碱脂酰转移酶-1 及血浆免疫球蛋白 M 含量, 并显著降低大鲵肝脏丙二醛及血浆碱性磷酸酶、谷草转氨酶活性。综上所述, 推荐使用紫苏油, 其能提高大鲵肌肉品质、增强机体抗氧化、免疫能力, 促进脂质代谢。

关键词: 中国大鲵; 紫苏油; 肌肉品质; 免疫; 脂质代谢

Application of Perilla oil, Fish oil or soybean oil in the diet of *Andrias davidianus* production

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Abstract: A 98 days feeding trial was conducted to determine the feasibility of adding perilla oil, fish oil or soybean oil as the lipid source in the feed of *Andrias Davidianus*. Three isonitrogenous and isolipidic diets were formulated by adding 3% soybean oil(SO), fish oil(FO) and perilla seed oil(PSO) respectively. The results showed that there was no difference in the growth performance of three groups. But in PSO, the crude lipid of muscle was lower than others. Crude protein of muscle was higher than others. In muscle, linoleic acid levels were maximized in SO, EPA and DHA levels were the highest in FO, α -linoleic acid reached the highest in PSO. Compared with others, the feed in PSO can improve total antioxidant capacity both in liver and intestinal tract, also it can improve total superoxide dismutase, carnitiny transferase-1 as well as the content of plasma immunoglobulin M. Moreover, the feed in PSO reduced hepatic malondialdehyde as well as plasma alkaline phosphatase and the activity of aspartate transaminase decreased obviously. To sum up, it is recommended to use Perilla oil can invigorate muscle quality, enhance antioxidant capacity, boost immunity, promote lipid metabolism.

Key words: *Andrias davidianus*; perilla oil; muscle quality; immunity; lipid metabolism

日粮蛋氨酸硒亚慢性暴露对克氏原螯虾生殖性能的影响

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摘要: 本研究的目的是探究投喂不同水平的日粮蛋氨酸硒 60 天后对克氏原螯虾生长性能和生殖的影响。结果表明, 高浓度蛋氨酸硒日粮 (10.02、30.27 和 59.76 $\mu\text{g Se/g}$) 导致雌性和雄性克氏原螯虾头胸甲长和体重显著下降。值得关注的是, 硒在卵巢的积累高于其他组织。研究发现, 克氏原螯虾摄食 10.02 $\mu\text{g Se/g}$ 的日粮显著性地提高其产卵率和促进更加同步的产卵; 并通过上调 *cdc2* 和 *vtg* 的 mRNA 的表达, 显著提高雌性克氏原螯虾血淋巴中 E2 和 VTG 的浓度。综上所述, 本研究结果表明硒在卵巢中蓄积最高, 其通过干预生殖系统中 *cdc2* 和 *vtg* 的表达影响生殖性能。在生长上观察到最低可见负面效应浓度 (LOAEL) 为 10.02 $\mu\text{g Se/g}$, 所以在饲料添加 Se 应该控制在此范围以内。

关键词: 蛋氨酸硒; 生殖性能; 蓄积; 生长; 克氏原螯虾

Effect of sub-chronic dietary L-selenomethionine exposure on reproductive performance of Red Swamp Crayfish, (*Procambarus clarkii*)

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Abstract: This study is aimed to investigate the effect of SeMet on growth performance and reproductive system after crayfish were fed with graded levels of dietary SeMet for 60 days. Crayfish treated with the high levels of SeMet (10.02, 30.27 and 59.76 $\mu\text{g Se/g}$) exhibited decreasing FW and CL in both male and female. Interestingly, Se accumulation was higher in ovary than in other tissues. Results showed that dietary Se concentration of 10.02 $\mu\text{g Se/g}$ significantly improved the spawning rate, promoted the synchronized spawning, and up-regulated the expressions of mRNA of *cdc2* and vitellogenin, with significantly increased E2 and VTG concentrations in hemolymph of female crayfish. In conclusion, the results of this study indicated that the Se had maximum accumulation in ovary, affecting the reproductive capacity by intervening the expression of *cdc2* and vitellogenin in the reproductive system. The LOAEL to induce FW was observed in crayfish fed with 10.02 $\mu\text{g Se/g}$ diet, so the addition of Se in the feed should be within 10.02 $\mu\text{g Se/g}$.

Key words: L-selenomethionine, Reproduction, Accumulation, Growth performance, *Procambarus clarkia*

固相微萃取-气质联用法测定鱼肉中土臭味素和 2-甲基异茨醇

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摘要 采用顶空固相微萃取法, 建立了以顺式-十氢-1-萘酚为内标物, 气相色谱质谱法测定鱼肉中土臭味素和 2-甲基异茨醇定性定量测定方法。考察了鱼肉中土臭味素和 2-甲基异茨醇提取和定量方法, 优化了顶空固相微萃取条件, 并通过实际样品的测定考察方法的适应性。结果表明, 在 0.1 μg/L~10 μg/L 范围内, 土臭味素和 2-甲基异茨醇峰面积与内标物峰面积的比值均与质量浓度的比值呈良好的线性关系, 相关系数 $r^2 > 0.999$, 检出限分别为 0.018 μg/kg、0.023 μg/kg, 定量限分别为 0.059 μg/kg、0.076 μg/kg, 3 个浓度梯度添加平均回收率分别在 68.67%~80.30%、62.67%~83.40%之间, 相对标准偏差分别在 2.35%~6.53%、3.16%~6.80%之间, 该方法灵敏度高、重复性好, 可用于批量鱼肉样品中土臭味素和 2-甲基异茨醇的定量测定。

关键词 顶空固相微萃取; 气相色谱质谱法; 鱼肉; 土臭味素; 2-甲基异茨醇

Determination of geosmin and 2-methylisoborneol in Fish Muscle by Gas Chromatography-Mass Spectrometry

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Abstract Geosmin and 2-methylisoborneol are semi-volatile off-flavor compounds with similar chemical structures that are produced by certain species of actinomycetes, fungi and blue-green algae. These off-flavor compounds tend to bio-accumulate within fish flesh dependent on the concentration of the compound in the water supply, water temperature, fat content and mass of fish, and other abiotic and biotic factors. It is of great necessary to develop an accurate test method of geosmin and 2-methylisoborneol in fish muscle for quality improvement of aquaculture products. A novel qualitative and quantitative determination method for determination of geosmin and 2-methylisoborneol in fish meat using cis-decahydro-1-naphthol as internal standard substance and headspace solid-phase microextraction coupled with gas chromatography-mass spectrometry was established. The method of extraction and quantification of geosmin and 2-methylisoborneol in fish meat was investigated, the conditions of headspace solid phase microextraction were optimized, and the adaptability of the method was investigated through the measurement of actual samples. The results show that in the range of 0.1 μg / L ~ 10 μg / L, the ratio of the peak area of geosmin and 2-methylisoborneol to the peak area of the internal standard has a good linear relationship with the ratio of the mass concentration. The correlation coefficient $r^2 > 0.999$, the detection limits were 0.018 μg/kg and 0.023 μg/kg, the limits of quantification were 0.059 μg/kg and 0.076 μg/kg, respectively, and the average recovery of the three concentration gradients was 68.67% ~ 80.30% , 62.67% ~ 83.40%, the relative standard deviations are between 2.35% ~ 6.53%, 3.16% ~ 6.80%. The geosmin content of actual culture fish samples, such as *Carassius auratus*, *Channa argus*, *Tilapia*, Grass carp, *Aristichthys nobilis*, *Cyprinus carpio* and *Megalobrama amblycephala*, were 0.306±0.012 μg/kg, 0.213±0.009 μg/kg, 0.187±0.008 μg/kg, 0.305±0.007 μg/kg, 0.204±0.007 μg/kg, 0.179±0.008 μg/kg and 0.232±0.005 μg/kg, and the 2-methylisoborneol of those actual culture fish samples were 0.353±0.019 μg/kg, 0.344±0.015 μg/kg, 0.255±0.010 μg/kg, 0.531±0.028 μg/kg, 0.257±0.006 μg/kg, 0.222±0.009 μg/kg and 0.350±0.016 μg/kg. This method has high sensitivity and good repeatability, and can be used for determination of geosmin and 2-methylisoborneol.

Key words headspace solid-phase microextraction; gas chromatography-mass spectrometry; fish muscle; geosmin; 2-methylisoborneol

Deep transcriptome analysis reveals the molecular mechanism of lipid deposition caused by dietary fish oil replacement by plant oils in liver of spotted sea bass (*Lateolabrax maculatus*)

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Abstract: A 150-day feeding experiment was conducted to investigate the effects of diets with different lipid sources on growth performance and lipid deposition in spotted sea bass (*Lateolabrax maculatus*), including FO (fish oil), TO (tea seed oil), PO (perilla oil) and SO (soybean oil). Four experimental diets were formulated with four different lipid sources and used for the feeding experiment. The results indicated that there were no significant differences in BWI, SGR, FCR and SR among the four groups. However, HSI and VSI in TO and PO groups were significantly higher than that in FO group. The results of Oil red O staining showed that a large number of lipid droplets were found in liver tissue of TO, PO and SO groups, which confirmed increased lipid deposition caused by the plant oils. To further characterize the molecular mechanism of lipid deposition, transcriptome analysis of liver tissue were carried out. As a results, a total of 61, 32 and 103 differentially expressed genes (DEGs) were identified in FO vs. TO, in FO vs. PO and FO vs. SO, respectively. These DEGs were enriched in several pathways closely associated with lipid metabolism. More specifically, their biological functions were implicated in fatty acid and steroids synthesis, which could be responsible for lipid deposition caused by TO, PO and SO. Our study would provide the comprehensive view of the molecular mechanism of lipid deposition in spotted sea bass and serve as a valuable reference for future studies.

Keywords: lipid deposition, spotted sea bass, plant oils, RNA-Seq

抑制肉碱合成损伤尼罗罗非鱼对高脂饲料的代谢适应

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摘要: 鱼类高脂饲料 (HFD) 的摄入, 往往会引起机体代谢稳态的失衡, 给鱼类生长等带来不良影响。为了探究 L-肉碱和相关的线粒体 FAO 在鱼类适应 HCD 摄入中的调节作用, 尼罗罗非鱼分别饲喂 HFD (13%脂肪)、HFD+MD (肉碱合成抑制剂, 米屈肼; 每天 1000mg/kg 鱼体重) 和正常脂肪饲料 NFD (7%脂肪) 8 周。结果发现, HFD 组罗非鱼肝脏中游离肉碱的含量和线粒体 FAO 的活性均显著升高, 而血清 TG 和全鱼总脂含量与 NFD 组水平近似。HFD+MD 组罗非鱼组织中肉碱含量和 FAO 效率显著低于 HFD 组罗非鱼; 然而, 血清中 FFA 和 TG 的浓度, 以及全身总脂和肝脏 TG 的含量, 均明显高于 HFD 组罗非鱼。此外, HFD 组罗非鱼上调肝脏中与 FAO 过程、脂转运和脂肪水解相关基因的表达。然而, HFD+MD 组罗非鱼的脂水解和脂转运相关基因的表达明显降低, 而脂肪合成相关基因的表达显著增加。这些结果表明, 组织中肉碱内源性缺乏而引起的线粒体 FAO 活性降低, 会损伤罗非鱼对 HFD 摄入的脂代谢适应性。本实验证明了 L-肉碱及其相关的线粒体 FAO 活性在鱼类应对 HFD 摄入的适应中发挥重要调节作用; 也揭示了内源性 L-肉碱浓度和线粒体 FAO 活性可能是 HFD 在水产养殖应用中重要的代谢调节点。

关键词: 适应性; L-肉碱; 高脂饲料; 脂肪沉积; 尼罗罗非鱼

Inhibited carnitine synthesis impairs adaptation to high-fat diet in Nile tilapia (*Oreochromis niloticus*)

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Abstract: High-fat diet (HFD) caused some adverse effects in farmed fish, thus the adaptation to HFD in fish is an important research topic. This study was conducted to examine the roles of carnitine and its related mitochondrial fatty acid β -oxidation (FAO) in the adaptation to HFD in Nile tilapia. Nile tilapias were fed with HFD (13%), HFD+mildronate (HFD+MD, inhibitor of carnitine synthesis, 1000 mg/kg body per day) or a normal fat diet (NFD, 7%) for eight weeks. After the feeding trail, the fish fed with HFD showed higher hepatic free carnitine content and FAO activities, and similar levels of serum triglyceride (TG) and whole body fat. However, the HFD+MD-fed fish remarkably decreased carnitine content and FAO efficiency in tissues than those in the HFD-fed fish, and increased contents of serum free fatty acids (FFA) and TG, whole body fat and hepatic TG. Moreover, the HFD-fed fish upregulated the expressions of the genes associated to FAO, lipid transport and lipolysis. Nevertheless, the fish fed with HFD+MD showed lower transcriptional levels of the genes related to lipolysis and lipid transport, and higher lipogenesis genes. These results indicate that the adaptive changes in the fish fed with HFD were eliminated by dietary MD supplementation, and show that carnitine and its related FAO activity play important roles in the adaptation to HFD in fish. This study illustrates that in the practical usage of HFD in aquaculture, the endogenous carnitine concentration and mitochondrial FAO activities should be important checkpoints.

Key words: adaptation, L-carnitine, high-fat diet, lipid deposition, Nile tilapia

两种养殖模式红螯螯虾肌肉营养及质构比较

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摘要: 为了比较池塘和稻虾共生养殖模式下红螯螯虾肌肉的主要营养成分及质构特性, 两种养殖模式分别采集 3 批样品进行相关指标检测。经统计分析: 两种养殖模式下红螯螯虾肌肉的粗蛋白、脂肪、水份、部分氨基酸和脂肪酸含量存在显著差异, 池塘养殖模式下红螯螯虾肌肉中的含量均高于稻虾共生养殖模式。两种养殖模式下红螯螯虾肌肉质构无显著差异; 品质评价显示, 相对于池塘养殖模式, 稻田养殖模式的化学评分(CS)、氨基酸评分(AAS)、必须氨基酸指数(EAAI)值均与标准蛋白组成更接近, 两种养殖模式的致动脉粥样化指数(AI)、血栓形成指数(TI)、多烯指数(PI)值均无显著性差异; 综合比较, 池塘养殖模式下红螯螯虾肌肉的主要营养成分含量更高, 而稻虾共生养殖模式下红螯螯虾肌肉品质更好。

关键词: 养殖模式; 红螯螯虾; 氨基酸; 脂肪酸; 质构

Comparison of nutritional and texture of *Cherax quadricarinatus* muscle in two culture patterns

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ABSTRACT: In order to compare the main nutrients and texture characteristics of *Cherax quadricarinatus* cultured in ponds and in rice-shrimp symbiosis, Three batches of samples were collected and analysed in every kinds of culture modes. The statistics show that there were significant differences of *Cherax quadricarinatus* between two kinds of culture modes in crude protein and fat, water content, some amino acids and fatty acids, the contents of *Cherax quadricarinatus* in pond culture mode were higher than that in rice-shrimp symbiosis. No significant differences in texture parameters of *Cherax quadricarinatus* between two kinds of culture modes; The quality evaluation shows the values of CS, AAS and EAAI in rice-shrimp symbiosis were more similar to those of standard protein compared with pond culture mode, and there were no significant differences in AI, TI and PI of *Cherax quadricarinatus* between the two modes; By comprehensive comparison, the muscle of *Cherax quadricarinatus* in pond culture mode had higher content of main nutrients, but the muscle quality of *Cherax quadricarinatus* in rice-shrimp symbiosis was better.

Keywords: culture pattern, *cherax quadricarinatus*, amino acid, fatty acid, texture

菜籽油替代饲料鱼油对大黄鱼生长、抗氧化能力和炎症反应的影响

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摘要: 本研究进行了 12 周的养殖实验以评估菜籽油替代饲料鱼油对大黄鱼 (36.02 ± 0.58 g) 生长性能、抗氧化能力和炎症反应的影响。对照组饲料含 6.5% 鱼油, 命名为 FO, 在对照组基础上, 用菜籽油分别替代 50% 和 100% 鱼油, 分别命名为 FR 和 RO。结果表明, RO 组特定生长率显著降低, 肌肉和肝脏粗脂肪含量显著增加。RO 组肝脏总抗氧化能力及超氧化物歧化酶 1 和 2、谷胱甘肽过氧化物酶和核因子 E2 相关因子 2 的表达量显著降低。饲料菜籽油显著降低了肝脏精氨酸酶 I 和白介素 10 的表达量, 而增加了肿瘤坏死因子 α 、白介素 1 β 、Toll 样受体 22 和髓样分化因子 88 的表达量。总之, 饲料高水平菜籽油会抑制大黄鱼生长和肝脏抗氧化能力, 并引发炎症反应。

关键词: 大黄鱼; 鱼油; 菜籽油; 脂质沉积; 抗氧化; 炎症

Effects of replacement of dietary fish oil by rapeseed oil on growth performance, anti-oxidative capacity and inflammatory response in large yellow croaker *Larimichthys crocea*

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Abstract: A 12-week feeding trial was conducted to evaluate the effects of replacement of dietary fish oil by rapeseed oil on the growth, anti-oxidative capacity and inflammatory responses of large yellow croaker *Larimichthys crocea* (initial body weight: 36.02 ± 0.58 g). The control diet was designed to contain 6.5% of fish oil, and named as FO. Based on it, the fish oil was 50% and 100% replaced by rapeseed oil to make the other two diets (FR and RO, respectively). Results showed that the specific growth rate was significantly reduced, and the crude lipid contents in muscle and liver were significantly increased in the RO group. The total anti-oxidative capacity and expressions of superoxide dismutase 1 and 2, glutathion peroxidase and nuclear factor erythroid 2-related factor 2 in liver of fish fed RO were significantly lower. Dietary rapeseed oil significantly decreased expressions of arginase I and interleukin 10, and increased expressions of TNF α , interleukin 1 β , toll-like receptor 22 and myeloid differentiation factor 88 in liver. In conclusion, high dietary rapeseed oil could suppress growth performance and liver anti-oxidative capacity, and induce inflammation of large yellow croaker.

Key words: Large yellow croaker, Fish oil, Rapeseed oil, Lipid deposition, Anti-oxidation, Inflammation

吉非罗齐激活 PPAR α 缓解高糖饲料诱导的尼罗罗非鱼脂肪累积

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摘要: 碳水化合物价格低廉因其能够发挥节约蛋白的效应在水产饲料中广泛应用。然而, 饲料中高水平的碳水化合物能够导致养殖鱼类脂肪蓄积, 并引发代谢综合征。在鱼类中, 提高脂肪分解代谢是否能够缓解高糖饲料引起的不良效应研究尚不清楚。过氧化物酶体增殖物激活受体 α (PPAR α) 是哺乳动物和鱼类中公认的脂肪分解代谢关键调控因子。本研究中, 通过在饲料中添加 PPAR α 激活剂吉非罗齐, 旨在探讨 PPAR α 激活对高糖诱导脂肪蓄积的缓解效应。初始体重为 (3.03 \pm 0.11 g) 的尼罗罗非鱼 270 尾, 随机分成 3 组, 每组 3 个重复。分别投喂 NC (30% 玉米淀粉), HC (45% 玉米淀粉) 和 HCG (45% 玉米淀粉, 0.25% 吉非罗齐) 三组饲料, 养殖周期 8 周。结果显示: 高糖组显著降低尼罗罗非鱼生长性能和饲料利用率。HC 组的肝体比、腹脂率、脂肪含量和脂肪合成相关基因表达均显著升高。组织切片显示肝脏脂肪过度蓄积, 同时血清 ALT、AST 和 MDA 含量显著升高 ($P < 0.05$)。此外结果还显示, 吉非罗齐通过去磷酸化激活 PPAR α , 并提高其转录和翻译水平。PPAR α 激活后上调脂肪分解相关基因表达, 提高抗氧化和抗炎能力。综上所述: 高糖饲料引起脂肪蓄积, 并损坏肝脏健康; 而吉非罗齐通过激活 PPAR α 缓解高糖饲料引起的不良效应。

关键词: 尼罗罗非鱼, 高糖饲料, 吉非罗齐, PPAR α 激活, 脂肪蓄积, 肝脏损伤

Gemfibrozil attenuates high-carbohydrate induced lipid deposition in Nile tilapia (*Oreochromis niloticus*) through activation of PPAR α

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Abstract: High levels of relatively cheap carbohydrates are widely used in aquatic feed production for their protein saving effect. However, high carbohydrate diets lead to severe lipid accumulation in tissues of farmed fish, and induce metabolic disturbances. In fish, whether enhancing lipid catabolism can alleviate the adverse effects caused by high carbohydrate is not clear. Peroxisome proliferator-activated receptor- α (PPAR α) has been recognized as a master regulator of lipid catabolism in mammals and fish. In the present study, the alleviation effect of PPAR α activation on lipid accumulation caused by high carbohydrate diet was investigated by adding PPAR α activator gemfibrozil. Nile tilapia (*Oreochromis niloticus*) with initial mean weight (3.03 \pm 0.11) g were randomly divided into 3 treatment groups with two hundred and seventy fish in each of triplicate. Fish were fed three diets, which were NC diet (30% Corn starch), HC diet (45% Corn starch) and HCG diet (45% Corn starch, 0.25% gemfibrozil) for eight weeks. The results showed that high carbohydrate remarkably decreased growth performance and feed utilization of Nile tilapia. HSI, MFI, lipid content and gene expression of lipogenesis were significantly ($P < 0.05$) higher in the HC group. Histology results also suggested excessive lipid accumulation in the liver of HC group, and increased of ALT, AST and MDA indication of liver damage and oxidation stress. The results indicated that high carbohydrate diet induced excessive lipid accumulation and impaired the health of fish. Our results also showed that, PPAR α was activated by gemfibrozil and was verified in fish by decreased phosphorylation of PPAR α and increased PPAR α mRNA and protein expression. Moreover, PPAR α activation significantly increased the gene expression of lipolysis, antioxidant and anti-inflammatory ability of fish. Taken together, gemfibrozil attenuates high-carbohydrate induced lipid deposition in Nile tilapia through activation of PPAR α .

Keywords: Nile tilapia, High carbohydrate diet, Gemfibrozil, Activation of PPAR α , Lipid accumulation, liver damage

浓缩脱酚棉籽蛋白替代鱼粉对斑节对虾抗逆性能的影响

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摘要: 本实验用浓缩脱酚棉籽蛋白替代鱼粉, 探究了此植物蛋白是否对斑节对虾的非特异性免疫指标构成影响, 以及盐度胁迫后它们的非特异性免疫指标的变化。本实验测定肝胰脏中四种非特异性免疫指标。研究结果显示, 用浓缩脱酚棉籽蛋白替代鱼粉对斑节对虾肝胰脏的热休克蛋白-70 (HSP70), Na-K-ATP 酶 (Na-K-ATPase), 皮质醇 (Cortisol) 含量有显著性影响, 且替代组 DietB 的表达量显著高于对照组 DietA。

关键词: 浓缩脱酚棉籽蛋白、鱼粉、斑节对虾、盐度胁迫、非特异免疫

Effects of concentrated dephenolic cottonseed protein instead of fish meal on immune indexes of *Penaeus monodon*

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Abstract: In this experiment, concentrated dephenolic cottonseed protein was used to replace fish meal, and it was explored whether this plant protein has an impact on the non-specific immune indicators of *Penaeus monodon* and the changes in their non-specific immune indicators after salinity stress. This experiment measures four non-specific immune indexes in the Hepatopancreas, and the results show that. Substituting concentrated dephenolic cottonseed protein for fish meal has a significant effect on the heat shock protein-70, Na-K-ATPase and Cortisol content in the Hepatopancreas of *Penaeus monodon*. and the expression of DietB in the replacement group was significantly higher than DietA in the control group.

Key words: Concentrated dephenol cottonseed protein、Fish meal、*Penaeus monodon*、Salinity stress、Non-specific immunity

领域四

水产病害防治与水产品质量安全

重金属污染物汞和镉对毛蚶的生理毒性研究

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摘要: 海洋重金属污染威胁着海域生物和人类的健康。本研究以天津渤海湾代表性种类-毛蚶为试验对象, 研究了重金属汞 (Hg^{2+}) 和镉 (Cd^{2+}) 对毛蚶的急性、慢性毒性, 研究了毛蚶对两种重金属的富集和释放效应, 以及毛蚶在重金属暴露下的鳃和肝脏组织的毒性损伤。结果表明, Hg^{2+} 对毛蚶的 96h 半致死浓度为 6.46 mg/L; 在暴露第 7 天时 Hg^{2+} 在毛蚶的鳃和内脏团中达到含量峰值, 随后下降; 暴露于 Hg^{2+} 下 7 天的毛蚶鳃组织出现明显的肿胀现象, 20 天的毛蚶内脏团组织出现细胞消融现象。 Cd^{2+} 对毛蚶 96h 半致死浓度为 7.07 mg/L; 且 Cd^{2+} 在毛蚶鳃和内脏团中的富集量随暴露时间的延长而升高; 暴露于 Cd^{2+} 下 7d 和 20d 的毛蚶鳃和内脏团组织出现了类似的肿胀和消融现象。

关键词: 重金属; 毛蚶; 生理毒性; 半致死浓度; 组织切片

Study on the Physiological Toxicity of Heavy metal pollutants mercury and cadmium on *Scapharca subcrenata*

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Abstract: Marine heavy metal pollution threatens the health of marine organisms and humans. In this study, *Scapharca subcrenata* was exposed to heavy metals mercury (Hg^{2+}) and cadmium (Cd^{2+}) to study their toxic effects on *Scapharca subcrenata* and the enrichment and release effects of *Scapharca subcrenata* towards the two heavy metals were studied. The 96-h half-lethal concentration was 6.46 mg/L; Hg^{2+} peaked in the gills and visceral tissues of *Scapharca subcrenata* on the 7 day of exposure, and then decreased; The gill tissue of *Scapharca subcrenata* exposed to Hg^{2+} for 7 days showed obvious swelling phenomenon, and its visceral tissue exposed to Hg^{2+} for 20 days showed obvious cell ablation phenomenon. The half-lethal concentration of Cd^{2+} to *Scapharca subcrenata* was 7.07 mg/L; the concentration of Cd^{2+} in the gills and visceral tissues increased with the prolonged exposure time; The gills and visceral masses of *Scapharca subcrenata* exposed to the two heavy metals for 7 days and 20 days showed similar swelling and cell ablation phenomenon to those exposed to Hg^{2+} .

Key words: GnRH, CNS, ovarian maturation, *Penaeus monodon*, immunocytochemistry, qPCR

基于 UPLC / Q-TOF MS 的刺参腐皮综合征的代谢组学分析

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摘要: 为探究腐皮综合征 (SUS) 刺参与正常刺参之间的差异, 并了解其发病机理, 检测了刺参体腔液中超氧化物歧化酶 (SOD), 过氧化氢酶 (CAT), 酸性磷酸酶 (AKP), 碱性磷酸酶 (ACP) 的活性以及丙二醛 (MDA) 和还原型谷胱甘肽 (GSH) 的含量, 运用超高效液相色谱和 Q-TOF 质谱仪评估其体壁中的代谢产物。研究结果表明, 相较于正常刺参, SUS 刺参体腔液中 AKP 和 ACP 的活性以及 MDA 和 GSH 的水平显著升高 ($P < 0.01$), 但 SOD 和 CAT 的活性显著降低 ($P < 0.05$)。通过代谢组学分析, 发现腺苷, 胆碱, 甜菜碱醛, 棕榈酸和牛磺酸等代谢产物上调, 而 2-氧己二酸, 邻氨基苯甲酸, 硫代醚酰胺-PC, 胆固醇 3-硫酸盐和戊二酸下调 ($VIP > 1$, $P < 0.1$)。KEGG 富集结果表明, 富集的通路主要与能量代谢, 免疫和渗透调节有关。研究反映了腐皮综合征刺参与正常刺参酶活性及代谢组学之间的差异。研究结果表明, 腐皮综合征对刺参的能量代谢和渗透调节产生了影响, 为刺参腐皮综合征的进一步研究提供了数据参考。

关键词: 刺参; 腐皮综合征; 代谢组; 差异代谢物

Metabolomics analysis for skin ulceration syndrome of *Apostichopus japonicus* based on UPLC/Q-TOF MS

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Abstract: Skin ulceration syndrome (SUS) is the main diseases affected the development of sea cucumber (*Apostichopus japonicus*) culture industries. To better observe the changes in the sea cucumber *A. japonicus* with skin ulceration syndrome (SUS) and understand the pathogenesis of the disease, activities of superoxide dismutase (SOD), catalase (CAT), and level of malondialdehyde (MDA) in coelomic fluid were detected using the Assay Kit and metabolites in the body wall were assessed using ultra-performance liquid chromatography and Q-TOF mass spectrometry. The results indicated that level of MDA was increased during SUS compared with healthy individuals ($P < 0.01$), but activities of SOD and CAT were reduced ($P < 0.05$). In metabolomics analysis, metabolites, such as adenosine, choline, betaine aldehyde, palmitic acid, and taurine, were found to be upregulated and 2-oxoadipic acid, anthranilic acid (vitamin L1), thioetheramide-PC, cholesterol-3-sulfate, and pentadecanoic acid were downregulated ($VIP > 1$ and $P < 0.1$). Pathway enrichment analysis indicated most enrichment of KEGG pathways were mainly related to energy metabolism, immunity and osmoregulation such as ABC transporters, glycine, serine and threonine metabolism, tryptophan metabolism and neuroactive ligand-receptor interaction. Our study reflected the difference in enzyme activity and metabolites between *A. japonicus* with SUS and those without, which will provide reference data for investigating SUS.

Keywords: *Apostichopus japonicus*; skin ulceration syndrome; metabolome; differential metabolites

拟穴青蟹 p53 基因克隆与功能分析

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摘要: p53 是一个重要的抑癌基因, 在细胞周期、DNA 修复、凋亡和衰老过程中起着重要作用。本实验采用 RACE 技术从拟穴青蟹中克隆了 p53 基因。该基因全长为 1687 bp, 5' 编码区为 42 bp, 3' 编码区为 262 bp, 开放阅读框为 1383 bp, 编码 460 个氨基酸。p53 蛋白分子量为 51.59kDa, 等电点为 5.49。Blastx 分析发现拟穴青蟹 p53 与其它物种 p53 氨基酸序列具有较高的同源性。通过 SMART 软件预测 p53 蛋白含有 N 端的转录活化结构域和中间的 DNA 结合结构域。p53 在所有组织中均有表达, 其中在胰腺和血细胞中表达量最高, 在肌肉中表达量最低。副溶血弧菌感染后, 导致拟穴青蟹丙二醛含量升高和 DNA 损伤, p53 基因在应激后 6h, 12h, 24h 和 48h 表达量逐渐升高。RNA 干扰 p53 基因后, 副溶血弧菌感染后, 拟穴青蟹死亡率和 DNA 损伤显著升高。以上结果表明拟穴青蟹 p53 在副溶血弧菌感染过程中发挥重要作用。

关键词: 拟穴青蟹; p53; 细菌感染; RNA 干扰

The role of tumor suppressor protein p53 in the mud crab (*Scylla paramamosain*) after *Vibrio parahaemolyticus* infection

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Abstract: The tumor suppressor gene p53 is a transcription factor, playing an important role in cell cycles, genetic stability, DNA repair and apoptosis. A p53 gene was obtained from the mud crab. The full-length cDNA of p53 was 1687 bp, including a 42 bp of 5' untranslated region (UTR), a 1687 bp of open reading frame (ORF), and a 262 bp 3' UTR with a poly (A) tail. The ORF sequence encoded a polypeptide of 460 amino acids with an estimated molecular mass of 51.591kDa and a predicted isoelectric point (pI) of 5.49. Amino acid sequence analysis suggested that showed that Sp-p53 protein contained a DNA-binding and a tetramerization domain and located at amino acid. The deduced amino acid sequences of Sp-p53 showed high similarities to counterparts of other species. Quantitative real-time PCR analysis revealed that the Sp-p53 mRNA was distributed abundantly in mud crab. MDA content and DNA damage significantly increased after *Vibrio parahaemolyticus* infection. Sp-p53 transcriptions in hepatopancreas were significantly up-regulated after *Vibrio parahaemolyticus* infection. After knockdown of the Sp-p53 level, the mortality of mud crabs and DNA damage significantly increased after *Vibrio parahaemolyticus* infection. These results suggested that Sp-p53 played an important role in response to *Vibrio parahaemolyticus* infection

Key words: *Scylla paramamosain*, p53, *Vibrio parahaemolyticus* infection, RNAi

三种益生元对两种海水鱼的作用效果研究

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摘要: 本研究探索了三种益生元: 低聚果糖 (FOS)、菊粉 (Inulin) 和甘露寡糖 (MOS) 分别以 1%, 1% 和 0.3% 的浓度拌料投喂 4 周后对珍珠龙胆石斑鱼和卵形鲳鲹的生长、血清非特异性免疫、免疫基因表达及抗应激的作用效果。结果发现: 在珍珠龙胆石斑鱼中, FOS、Inulin 以及 MOS 都不能显著提升其生长性能 ($P>0.05$)。空气暴露胁迫后 MOS 组的成活率显著高于对照组, FOS 组显著低于对照组。在卵形鲳鲹中, MOS 具有显著的促生长作用 ($P<0.05$); 哈氏弧菌攻毒胁迫结果表明, 三种益生元都显著降低了卵形鲳鲹受哈氏弧菌感染时的死亡率 ($P<0.05$)。在两种鱼中, 三种益生元添加组的血清非特异性免疫指标及免疫相关基因表达实验结果都既有相似性, 又呈现一定程度的差异性。

关键词: 益生元; 低聚果糖; 菊粉; 甘露寡糖; 珍珠龙胆石斑鱼; 卵形鲳鲹

Effects of three prebiotics on two marine fishes

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Abstract: This study investigated the effects of fructooligosaccharide (FOS), inulin and mannose oligosaccharide (MOS) (supplemented for 4 weeks at 1%, 1%, 0.3%, respectively) on growth, serum biochemical parameters, expression of immune genes and the anti-stress ability of hybrid grouper (*Epinephelus lanceolatus* ♂ × *Epinephelus fuscoguttatus* ♀) and *Trachinotus ovatus*. Results indicated that: In hybrid grouper, none of the three prebiotics showed any growth promoting effects. However, after air exposure, MOS group had significantly lower mortality rate than control group. In *T. ovatus*, MOS showed significant growth promoting effects. Challenge test with *V. Harvey* revealed that all three prebiotics could significantly decrease the death rate of infected fish. Three prebiotics had different effects on serum biochemical parameters and immuned gene expressions.

Key words: Prebiotic, fructooligosaccharide, inulin, mannose oligosaccharide, hybrid grouper, *Trachinotus ovatus*

鱼类鳊鱼诺卡氏菌 RTFQ-LAMP 检测方法的建立

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摘要: 鳊鱼诺卡氏菌(*Nocardia seriolae*)是鱼类诺卡氏菌病的主要病原菌之一。本研究对已报道的鳊鱼诺卡氏菌 ZJ0503 全基因组数据进行比对分析, 筛选获得种内保守、种间变异的特异性基因组片段, 并设计 4 条引物, 利用 SYBR Green I 核酸荧光染料, 建立鳊鱼诺卡氏菌实时荧光定量环介导等温扩增技术检测方法。优化了 RTFQ-LAMP 反应条件, 所有试剂在 64℃ 下孵育 60min, 结果表明, RTFQ-LAMP 法的灵敏度为 1.23×10³cfu/ml(每次反应 16.8cfu), 比 Real-time PCR 法高 10 倍。RTFQ-LAMP 方法也被有效地应用于病鱼样品中鳊鱼诺卡氏菌的检测, 可能有助于鱼类诺卡氏菌病的监测和早期诊断。

关键词: 鳊鱼诺卡氏菌; 基因组片段; RTFQ-LAMP; 检测方法; 特异性

Establishment of ARTFQ-LAMP Method for Detection of *Nocardia seriolae*

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Abstract: *Nocardia seriolae* is one of the main pathogens of fish nocardiosis. In this study, the specific genome fragments with intraspecific conservation and interspecific variation were screened by comparing and analyzing the whole genomes of *N. seriolae* ZJ0503, and four primers were designed to establish a Real-time fluorescence Loop-Mediated Isothermal Amplification (RTFQ-LAMP) method using SYBR Green I as nucleic acid dye for the rapid and sensitive detection of *N. seriolae*, and conditions for RTFQ-LAMP were optimized as incubating all the reagents for 60 min at 64°C. Results showed the sensitivity of the RTFQ-LAMP assay was 1.23×10^3 CFU/ml (1.23 CFU per reaction) and 10-fold higher than that of Real-time PCR. The RTFQ-LAMP method was also effectively applied to detect *N. seriolae* in diseased fish samples, and it may potentially facilitate the surveillance and early diagnosis of fish nocardiosis.

Key words: *Nocardia seriolae*, Genome fragment, RTFQ-LAMP, Detection method, Specificity

一例黄颡鱼腹水性脓肿病的病理学研究

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摘要: 黄颡鱼是我国的特种水产经济动物, 年产量超 50 万吨。2020 年 8 月, 在四川崇州市暴发一起以皮肤脓肿、充血和腹水为主要特征的黄颡鱼疾病, 病死率高达 30%。本研究利用病理学方法观察黄颡鱼腹水性脓肿病的病理损伤特征以分析该病的发生原因。大体病理检查显示患病鱼颌部、肛门充血, 鳍条基部瘀血、脓肿, 皮肤点状出血、溃疡, 肝脏、脾脏和肾脏等内脏器官充血肿大, 并伴随“绿肝”症。组织病理学研究表明该病的损伤靶器官为肝、脾、肾、心等, 肝脏主要表现为肝细胞水肿、坏死, 肝脏血管内细胞浸润; 脾脏网状纤维坏死; 肾间质结节样病变, 肾小管肿大坏死及蛋白管型; 心脏表现为坏死型心肌炎、心膜炎; 此外, 患病鱼伴有鳃小片增生、融合, 胰腺细胞坏死等症状。根据病理学结果表明该病是一起以炎症为主的多器官坏死性疾病, 无明显细菌等微生物检出, 推测为某种病毒或其它微生物引发的生物性疾病。

关键词: 黄颡鱼; 腹水; 脓肿; 病理学研究; 炎症

Pathological study and diagnosis of ascitic abscess disease of yellow catfish (*Pelteobagrus fulvidraco*)

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Abstract: Yellow catfish is a special aquatic economic animal in China and annual production exceed 500,000 tons. In August 2020, a disease with skin abscess, congestion and ascites of yellow catfish broke out in Chongzhou, Sichuan Province, case fatality rate was as high as 30%. In this study, pathological features of ascitic abscess of yellow catfish were observed to analyze the causes of the disease. Gross pathological examination showed jaw and anal congestion, fin base blood stasis, abscess, skin dotted bleeding, ulcer, visceral organs such as liver, spleen and kidney shows hyperemia swelling, with green liver. The histopathological studies showed liver, spleen, kidney, heart were the target organs. The liver was mainly characterized by edema and necrosis of hepatocytes and intravascular cell infiltration; The spleen showed necrosis of reticular fibers; Renal interstitial nodular lesions, tubules enlargement and necrosis; The manifestations of the heart were necrotic myocarditis and pericarditis. In addition, the fish was accompanied by gill hyperplasia, fusion, and pancreatic cell necrosis. According to the pathological results, this disease is a multi-organ necrotizing inflammation disease without obvious bacteria detection, which is presumed to be a biological disease caused by some virus or other microorganisms.

Key words: yellow catfish, ascites, abscess, Pathological study, inflammation

凡纳滨对虾传染性皮下及造血组织坏死病毒 (IHHNV) 可视化环介导等温扩增(LAMP)技术方法的优化与应用

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摘要: 传染性皮下及造血组织坏死病毒 (IHHNV) 作为对虾疾病的主要病原之一, 能够感染多种对虾, 对幼虾危害尤其明显, 死亡率虽然不高, 但可以引起对虾生长缓慢, 造成巨大的经济损失, 严重影响对虾养殖业持续健康发展。本文根据 IHHNV 病毒基因的保守序列, 采用 Primer Explorer V4 软件设计 6 条 LAMP 特异性引物组合, 建立了一种以环介导等温核酸扩增技术 (loop-mediated isotherm amplification, LAMP) 为基础的快速检测 IHHNV 的方法。对本研究的 LAMP 检测方法的敏感性和特异性进行分析, 并将其灵敏度与实时荧光定量 PCR、普通 PCR 检测方法进行比较。结果显示: LAMP 检测方法在 63℃ 恒温条件 60 min 内完成反应, 阳性结果出现可视化的绿色, 阴性结果颜色不发生变化; LAMP 方法的最低检出限为 10.3 copies/μL, 灵敏度与荧光实时定量 PCR 相当, 较常规 PCR 高。结果表明建立的 LAMP 方法适合于对虾 IHHNV 的现场快速检测。

关键词: 传染性皮下及造血组织坏死病毒; 环介导等温扩增; 快速检测; 对虾

连续给药后恩诺沙星及其代谢产物在石斑鱼体内的残留消除研究

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摘要: 在 28℃ 的水温条件下, 按 30 mg/kg.b.w 恩诺沙星对石斑鱼进行连续 5 d 灌胃给药实验, 用高效液相色谱-串联质谱法测定石斑鱼血浆、肌肉和肝脏中恩诺沙星及其代谢产物环丙沙星的含量。结果显示: 恩诺沙星在血浆、肝脏和肌肉中很快达到最大值, 峰时间分别为第五天给药结束的 3 h、第五天给药结束的 3 h 和第四天给药结束的 3 h, 浓度分别为 24.5 mg/kg (血浆)、13 mg/kg (肝脏) 和 8.2 mg/kg (肌肉), 血浆中的恩诺沙星在第五天给药结束后的 24 h 明显下降, 肝脏中的恩诺沙星在第五天给药结束后的 24h 明显下降; 肌肉在第四天结束给药后到 25d 之间呈现下降趋势; 恩诺沙星的代谢产物环丙沙星在第五天给药结束的 3 h、第五天给药结束的 3 h 和第四天给药结束的 3 h 达到峰值, 达到峰值时的浓度分别为 0.276 mg/kg (血浆)、0.738 mg/kg (肝脏) 和 0.11 mg/kg (肌肉), 说明只有少量的恩诺沙星代谢成环丙沙星。根据本研究的数据, 建议休药期不得低于 31 天。本实验研究, 在连续给药的情况下, 掌握恩诺沙星及其代谢产物环丙沙星在石斑鱼体内的代谢残留情况, 为科学合理地使用恩诺沙星防治石斑鱼的细菌性疾病提供理论依据, 也为水产养殖上指导恩诺沙星科学用药提供借鉴。

关键词: 恩诺沙星; 环丙沙星; 石斑鱼; 药物残留; 休药期

稻虾综合种养模式之克氏原螯虾重金属的富集特征及安全性评估

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摘要: 在湖北监利县“双水双绿”科研示范基地采集克氏原螯虾, 测定克氏原螯虾不同组织 (肝胰腺、壳、鳃和肌肉) 中 6 种重金属含量, 分析稻虾综合种养模式下克氏原螯虾重金属的富集特征及安全性评估。研究表明, 克氏原螯虾不同组织中汞 (Hg)、铅 (Pb)、铜 (Cu) 和铬 (Cr) 均未超过甲壳类水产品安全国家标准污染物限量。砷 (As) 和镉 (Cd) 在肝胰腺中蓄积最高, 其次是在鳃和壳中, 肌肉中含量最低。除了肝胰腺外, 其他组织中 As 和 Cd 均未超标。从 4 月到 11 月, 总 As 在不同组织中均出现上升趋势, Cd 在肝胰腺中也出现上升趋势, 而在其他组织中出现下降趋势。根据 HQ 非致癌暴露风险评估, 小龙虾肌肉内各类重金属的风险值均小于 1, 说明小龙虾肌肉内重金属不存在明显食用健康风险。

关键词: 稻虾综合种养; 克氏原螯虾; 重金属; As; Cd

Enrichment characteristics and safety assessment of heavy metals in *Procambarus clarkii* in the rice-fish coculture system

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Abstract: The *Procambarus clarkii* were collected from the "Shuangshui Shuanglu" scientific research demonstration base in Jianli County, Hubei Province. 6 heavy metals were detected in different tissues (hepatopancreas, exoskeletons, gills, muscles) for analysis of the enrichment characteristics and assessment of food safety under the rice-crayfish coculture system. Studies have shown that the mercury (Hg), lead (Pb), copper (Cu) and chromium (Cr) in different tissues of crayfish did not exceed the national standard pollutant limit for the safety of crustacean aquatic products. The order of arsenic (As) and cadmium (Cd) accumulation in different tissues was hepatopancreas > gills > exoskeletons > muscle. Except for hepatopancreas, As and Cd in other tissues did not exceed the standard. From April to November, total As showed an upward trend in different tissues. Cd in hepatopancreas also showed an upward trend, while a downward trend was found in other tissues. According to the HQ non-carcinogenic exposure risk assessment, the risk value of various heavy metals in the muscle of crayfish is less than 1, indicating that there is no obvious health risk for heavy metals in the muscle of crayfish.

Key words: rice-fish coculture system, *Procambarus clarkii*, heavy metal, As, Cd

线纹海马源溶藻弧菌的分离、鉴定及药敏分析

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摘要: 为确定深圳某海马养殖基地线纹海马(*Hippocampus erectus*)突发性死亡病因, 本研究从患病死亡线纹海马病灶组织分离到一株优势菌 SZVA20190621, 随后对分离菌形态特征、生理生化特性、回归感染、16S rRNA 基因进化及药物敏感性进行研究。结果显示, 该菌葡萄糖产气、甘露醇、覃糖、蔗糖、氧化酶活性和 MR 等生理生化鉴定为阳性; 与 NCBI 上溶藻弧菌(*Vibrio alginolyticus*) KT986151 具有 98.16% 同源性; 回归感染实验表明菌株 SZVA20190621 对线纹海马具有强致病性, LD₅₀ 为 3.73×10⁵CFU/mL; 综上结果, 鉴定该菌为致病性溶藻弧菌。药敏结果显示, 该菌株耐受头孢唑林, 头孢噻吩, 哌拉西林, 大观霉素, 阿米卡星, 克拉霉素, 克林霉素及呋喃妥因耐药; 对氨曲南, 头孢西丁, 头孢呋辛, 头孢曲松, 卡那霉素, 红霉素中度敏感; 对头孢他啶, 复方新诺明, 氯霉素等 17 种抗生素高度敏感。本研究为线纹海马养殖中溶藻弧菌病的防控提供一定的参考依据。

关键词 线纹海马, 溶藻弧菌, 16S r RNA, 药敏试验

Isolation and Identification of Pathogenic *Vibrio alginolyticus* Isolated from *Hippocampus erectus*

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Abstract: In order to determine the cause of *Hippocampus erectus* suddenly death, this study isolated a Gram-negative bacteria SZVA20190621 from the diseased part of it, and then studied the morphological characteristics, physiological and biochemical characteristics, Regression infection, 16S rRNA gene evolution and drug sensitivity. The results showed that the strain produced glucose, mannitol, sucrose, oxidase activity and MR test were positive for physiological and biochemical identification; had 98.16% homology with *Vibrio alginolyticus* KT986151 on NCBI; Regression infection test showed that the strain SZVA20190621 was pathogenic to *Hippocampus erectus*, and its LD₅₀ was 3.73×10⁵ CFU/mL. In summary, the strain was identified as a pathogenic *Vibrio alginolyticus*. The results of drug susceptibility test showed that the strain was resistant to cefazolin, cefalotin, piperacillin, spectinomycin, amikacin, clarithromycin, clindamycin and furadantin; moderately sensitive to aztreonam, ceftazidime, cefotaxime, ceftriaxone, kanamycin and erythromycin; highly sensitive to 17 different antibiotics such as ceftazidime, cefotaxime and chloramphenicol. This study will provide some reference basis for the prevention and control of disease induced by *Vibrio alginolyticus* in *Hippocampus erectus* culture

Key words: *Hippocampus erectus*, *Vibrio alginolyticus*, 16S rRNA, Susceptibility test

洪湖碘泡虫单管半巢式 PCR 检测方法的建立及应用

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摘要: 异育银鲫 (*Carassius auratus gibelio* Bloch) 因感染洪湖碘泡虫 (*Myxobolus honghuensis*) 引起的“喉孢子虫病”常会导致池塘养殖苗种和成鱼大量死亡。为建立一种高效的检测方法, 本研究基于洪湖碘泡虫 18S rDNA 基因序列设计两组特异性引物, 建立了单管半巢式 PCR 检测方法, 并对该方法的特异性、灵敏度及临床应用分别进行了验证。结果显示, 只有洪湖碘泡虫扩增为阳性; 最低检测灵敏度极限为 4.2copy/μL; 对疫区养殖池塘健康异育银鲫的卵巢、肾脏及脾脏组织样品检测发现洪湖碘泡虫阳性率分别为 40%、32%和 8%。因此, 本研究所建立的检测方法特异性强、灵敏度高, 可应用于洪湖碘泡虫的早期快速检测。

关键词: 异育银鲫; 洪湖碘泡虫; PCR; 喉孢子虫病

Development a single-tube, semi-nested PCR method for the detection of *Myxobolus honghuensis* (Myxoporea: Bivalvulida)

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Abstract: In *Carassius auratus gibelio* Bloch, infection with *Myxobolus honghuensis* often leads to the death of both seedling species and adult fish in ponds. In order to establishment an efficient detection method, in this study, two groups of specific primers were designed based on the 18S rDNA gene sequence of *Myxobolus honghuensis*, and a single-tube half-nest PCR detection method was established. The specificity, sensitivity and clinical application of the method were verified respectively. The results showed that only *Myxobolus honghuensis* was amplified to be positive. The minimum detection sensitivity limit is 4.2copy/μL; The positive rate of ovary, kidney and spleen was found to be 40%, 32% and 8% in the healthy *Carassius auratus gibelio* Bloch in the breeding pond in the epidemic area. Therefore, the detection method established in this study has strong specificity and high sensitivity, and can be applied to the early and rapid detection of *Myxobolus honghuensis*.

Key words: *Carassius auratus gibelio* Bloch; *Myxobolus honghuensis*; PCR; myxozoan disease

赖氨酸琥珀酰化修饰在鱼类致病性溶藻弧菌代谢及毒力因子中的重要作用

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摘要: 许多研究表明, 赖氨酸琥珀酰化是原核和真核细胞中普遍存在的一种重要的翻译后修饰 (PTM), 与诸多重要的细胞过程调节有关。溶藻弧菌是引起水产养殖动物病害的一种常见病原菌。本研究采用 LC-MS/MS 亲和富集的方法, 首次报道了溶藻弧菌 671 个蛋白 2082 个赖氨酸琥珀酰化位点的鉴定, 并与我们前期研究中溶藻弧菌的赖氨酸乙酰化进行了比较.....

关键词: 溶藻弧菌; 赖氨酸琥珀酰化及乙酰化; 毒力因子

Succinylome analysis reveals the important roles of lysine succinylation on metabolism and virulence in fish pathogenic *Vibrio alginolyticus*

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Abstract: Many studies have shown that lysine succinylation has a major post-translational modification (PTM) widespread in prokaryotic and eukaryotic cells, and is associated with the regulation of many important cellular processes. *Vibrio alginolyticus* is a common aquaculture pathogen that causes diseases of aquaculture animals. Here we used the affinity enrichment method with LC-MS/MS, first.....

Key Words: *Vibrio alginolyticus*, lysine succinylation and acetylation, virulence factors

花鲈哈维弧菌甲醛灭活疫苗的初步研制

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摘要: 哈维弧菌病严重影响花鲈的健康养殖, 为预防该病, 本研究进行了花鲈哈维弧菌甲醛灭活疫苗试制。将 9 株不同分型的哈维弧菌进行筛选, 筛选出 3 株毒株, 其中毒株 1、2 为强毒株。将毒株 1、2 制成甲醛灭活疫苗, 免疫两周后, 用 3 株毒株分别进行攻毒。经毒株 1 疫苗免疫的花鲈, 对毒株 1、3 分别有 51%和 50%的相对保护效果, 对毒株 2 的相对保护效果为 3%; 经毒株 2 疫苗免疫的花鲈对毒株 2、3 分别有 52%和 60%的相对保护效果, 对毒株 1 的相对保护效果为 37%。当注射疫苗浓度为 9.6×10^7 cfu/g 时, 免疫效果最佳。研究结果表明感染花鲈的哈维弧菌有多个型, 部分菌株间交叉免疫保护效果较差, 需采用二价疫苗方可达到良好的免疫效果。

关键词: 花鲈; 哈维弧菌; 交叉保护; 二价疫苗

Preliminary development of *Vibrio harveyi* formalin-killed vaccine in *Lateolabrax maculatus*

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Abstract: *Vibrio harveyi* is an important pathogenic bacteria of sea bass (*Lateolabrax maculatus*) that can cause vibriosis extensively. In the present study, the inactivated vaccine was prepared to further prevent the vibriosis. Three strains of *V. harveyi* were screened from 9 serotypes, named strain 1, 2, and 3. Thereinto, strain 1 and 2 were virulent strains and used for inactivation by formaldehyde to prepare vaccine. After two weeks, the three strains of *V. harveyi* were used to challenge the immune bass respectively. We found that the relative percent survival (RPS) of bass which accepted strain 1 vaccine were 51% and 50% against strain 1 and 3, whereas was only 3% against strain 2. The RPS of bass which accepted strain 2 vaccine were 52% and 60% against strain 2 and 3, respectively, whereas was 37% against strain 1. The optimal concentration of inactivated vaccine was 9.6×10^7 CFU/g. The results showed that sea bass infected by multifarious serotypes of *V. harveyi*, and the protecting effect of cross immunity was weak. To sum up, It is necessary to progress the bivalent vaccine to achieve better immune effect.

Key words: *Lateolabrax maculatus*; *Vibrio harveyi*; cross protection; combined vaccine

健康与五月瘟患病克氏原螯虾肠道菌群结构和多样性分析

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摘要: 在克氏原螯虾养殖过程中, 5月份通常是病害发生的高峰期, 被称为“五月瘟”。为研究健康与患病克氏原螯虾肠道菌群结构和多样性的差异, 实验采集健康和患病克氏原螯虾样品, 通过 Illumina 高通量测序技术测定肠道菌群组成, 并利用 Alpha 和 Beta 多样性分析样品中微生物的多样性。结果显示, 病害的发生伴随着肠道菌群结构的显著变化, 而多样性无显著差异。与健康克氏原螯虾肠道菌群相比, 患病克氏原螯虾肠道中变形菌门丰度显著增加, 厚壁菌门和软壁菌门丰度降低。通过 LEfSe 分析差异菌属发现, 潜在病原菌气单胞菌属的丰度在感染后显著上升。

关键词: 克氏原螯虾; 五月瘟; 肠道菌群; 菌群结构; 生物多样性

Analysis on the structure and diversity of intestinal flora of *Procambarus clarkii* in health and May plague

Abstract: In the course of *procambarus clarkii* cultivation, may is usually the peak of disease occurrence, which is called "May plague". To investigate the differences in intestinal flora structure and diversity between healthy and diseased *procambarus clarkii*, samples of healthy and diseased *procambarus clarkii* were collected, intestinal flora composition was determined by Illumina high-throughput sequencing technology, and microbial diversity in the samples was analyzed using Alpha and Beta diversity. The results showed that the occurrence of disease was accompanied by significant changes in intestinal flora structure, but there was no significant difference in diversity. Compared with the intestinal flora of healthy *Procambarus clarkii*, the abundance of proteobacteria in the intestinal tract of diseased *procambarus clarkii* was significantly increased, while the abundance of firmicutes and firmicutes was decreased. LEfSe analysis of the differential bacteria found that the abundance of the potential pathogenic bacteria *Aeromonas* increased significantly after infection.

Key words: *Procambarus clarkii*; intestinal flora; microflora structure; biodiversity; May plague

红笛鲷 IL-6 基因的鉴定、表达分析及其对哈维氏弧菌 OmpW DNA 疫苗的免疫效果

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摘要: 白细胞介素6 (IL-6) 是一种多效性细胞因子, 在调节机体抵抗病原体感染的先天性和适应性免疫应答中起着重要作用。在本研究中, 我们分析了一个IL-6同源物 (Ls-IL6), 并对其进行了鉴定。预测的Ls-IL6蛋白具有典型的IL-6家族基序, 与硬骨鱼IL-6s具有高度同源性, 在不同组织中广泛表达, 在头肾、脾脏和胸腺中表达最高。在体内, Ls-IL6的转录水平在哈维氏弧菌感染后显著上调。此外, 成功构建了哈维氏弧菌OmpW与Ls-IL6基因的DNA质粒, 并将其应用于鱼类体内, 研究了Ls-IL6的保护作用。与pcDNA-IL6-OmpW组相比, 注射pcDNA-IL6-OmpW组抗哈维氏弧菌特异性抗体水平升高。感染哈维氏弧菌后, 接种pcDNA-IL6-OmpW的鱼的相对存活率 (76%) 高于pcDNA-OmpW免疫的鱼 (60%)。结果表明, Ls-IL6参与了哈维氏弧菌感染的免疫应答, 具有成为哈维氏弧菌DNA疫苗佐剂的潜力。

关键词 IL6, 红笛鲷, 哈维氏弧菌, Omp W, 佐剂

An IL-6 gene in humphead snapper (*Lutjanus sanguineus*): Identification, expression analysis and its adjuvant effects on *Vibrio harveyi* OmpW DNA vaccine

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Abstract: Interleukin 6 (IL-6) is a pleiotropic cytokine that plays important role in mediating the innate and adaptive immune responses against pathogen infection. In this study, an IL-6 homolog (Ls-IL6) was identified and characterized from humphead snapper, *Lutjanus sanguineus*. The predicted Ls-IL6 protein had typical motif of IL-6 family and shared high identities to teleost IL-6s. Ls-IL6 extensively expressed in various tissues, and the highest expression of Ls-IL6 was detected in head kidney, spleen and thymus. In vivo, the transcript levels of Ls-IL6 were significantly up-regulated in response to *Vibrio harveyi* infection. Moreover, the DNA plasmid containing the OmpW of *V. harveyi* together with the gene encoding Ls-IL6 were successfully constructed and administered to fish, the protective efficacy of Ls-IL6 was investigated. Compared with the pcDNA-OmpW group, the level of specific antibodies against *V. harveyi* increased in pcDNA-IL6-OmpW injected group. After *V. harveyi* infection, the pcDNA-IL6-OmpW vaccinated fish showed higher relative percent survival (76%) than the relative survival of fish immunized with pcDNA-OmpW (60%). These results indicated that Ls-IL6 was involved in immune response against *V. harveyi* infection and could be applied as a promising adjuvant for DNA vaccines against *V. harveyi*.

Key words: IL-6, *Lutjanus sanguineus*, *Vibrio harveyi*, Omp W, Adjuvant

基于核酸适配体的水产疫病高效防控技术体系的研究与应用

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探究水产疫病病原的侵染机制, 进而研发出可以快速便捷检测病原的诊断技术、研发高效抗病药物, 对于控制水产疫病病原的感染、降低损失至关重要。指数富集的配基系统进化技术(SELEX)是一类新型的生物文库技术。由SELEX技术筛选得到的新型分子探针核酸适配体, 具有高特异性和高亲和力识别结合靶标、易于化学合成和修饰等诸多优点, 目前已发展成为一种备受关注的新型检测和治疗工具。目前, 我们已经针对多种水产疫病病原, 包括SGIV、GNNV、STIV、GCRV和LMBV等, 筛选获得高特异性的分子探针核酸适配体^[1]。基于适配体识别疫病病原具有高特异性和亲和性的特点, 我们首次研发出操作简便, 可以快速准确诊断病毒感染的Apt-ELISA、AFMP技术和“桂海纳-水产病害现场快速检测试剂盒系列产品”, 为丰富和提高各领域的检测技术提供了新方法和新思路。

目前大多数水产病毒性病害尚无市场化的有效抗病毒药物, 因此亟需开拓新的思路研发高效抗病毒药物, 用于水产养殖动物病毒病的防控治疗。我国拥有非常丰富的药用植物资源, 从中寻找具有显著抗病毒、抗菌作用的天然活性成分, 研究水产用中草药制剂, 是实现水产绿色、高质化生态养殖的重要发展方向。传统的药理实验筛选方法, 存在耗时、劳动强度大、需要使用大量实验动物等诸多缺点。因此, 我们首次基于核酸适配体开发出高通量抗病毒药物筛选技术(Aptamer-based high-throughput screening methods of Medicine against virus, AHTS)^[2]。AHTS技术能够用于抗病毒中草药的高通量快速筛选, 在水产疫病防治领域应用前景广阔。其次, 根据AHTS技术初筛结果, 我们系统开展了药用植物抗水产病害的功能成分研究, 筛选出一批抗病效果显著的药用植物及其活性化合物成分, 并且系统阐明有效成分作用靶标及作用机制^[3]。综上所述, 我们着力开展了基于核酸适配体的水产疫病高效防控技术体系研究, 在探究病原侵染机制的基础上, 以水产养殖病害发生早期检测和有效防控为目标, 着力开展病害快速检测技术产品研发和药用植物源制剂的研制, 为我国水产养殖业的健康可持续发展提供科技支撑。

关键词: 病毒性疫病病原; 核酸适配体; 快速检测技术; 抗病毒药物的高通量筛选技术; 抗病毒机制

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硫酸铜防治卵形鲳鲹淀粉卵涡鞭虫病的研究

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摘要：为在生产上更科学地使用硫酸铜防治淀粉卵涡鞭虫病，我们用卵形鲳鲹作为动物模型研究了硫酸铜对淀粉卵涡鞭虫生活史各个阶段的有效驱杀浓度和作用时间，并评估其对卵形鲳鲹幼鱼的安全浓度范围。结果显示，卵形鲳鲹幼鱼对硫酸铜的耐受性强，安全浓度为小于 43.06 mg/L。用 3.13、0.78、0.20 mg/L 硫酸铜分别药浴处理 10、30、60 min 可 100.00% 驱杀孢子(dinospore)；用 4、2、1、0.5 mg/L 硫酸铜分别药浴浸泡鱼体 2、2、4、8 h 可 100.00% 清除鱼体上的营养体(trophont)；而包囊(tomont)对硫酸铜的耐受性强，用 100 mg/L 的硫酸铜连续浸泡，仍有 90.00% 以上的包囊能继续分裂。治疗试验显示，在 0.2、0.4 mg/L 硫酸铜中连续药浴 10 d，对患病鱼的相对保护率分别为 80.00% 和 90.00%，表明使用低浓度硫酸铜连续药浴效果显著。

关键词：卵形鲳鲹；淀粉卵涡鞭虫；硫酸铜；防治

The prevention and treatment of Amyloodiniosis in golden pompano (*Trachinotus ovatus*) by copper sulfate

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Abstract: In order to use copper sulfate scientifically to prevent and treat the disease caused by parasite *Amyloodinium ocellatum* in farmed fish, we used the golden pompano (*Trachinotus ovatus*) as an animal model to study the effective concentration and time of copper sulfate dealing with each stage of the *A. ocellatum*, and evaluate safety concentration of copper sulfate on juvenile golden pompano. The results showed that the juvenile golden pompano has a good tolerance to copper sulfate, and its safety concentration was less than 43.06 mg/L. The effective concentration of copper sulfate to kill fully dinospores within 10, 30, 60 min were 3.13, 0.78, 0.20 mg/L and making the trophonts detaches from the host within 2, 2, 4, 8 h were 4, 2, 1, 0.5 mg/L, respectively. However, tomonts will be highly resistant to copper sulfate, as its cell can divide and incubate with concentration of 100 mg/L copper sulfate solution. The treatment trial indicated that if diseased fish were immersed continuously with copper sulfate solution at concentration of 0.2, 0.4 mg/L, relative percentage survival (RPS) of fish will reach to 80.00% and 90.00% respectively. The results showed that the use of copper sulfate solution at low-concentration to immerse ill fish can be effective to prevent the infection of *A. ocellatum* to golden pompano.

Keywords: *Trachinotus ovatus*; *Amyloodinium ocellatum*; copper sulfate; treatment

福建东山湾贝类养殖区有毒藻丰度对贻贝中麻痹性贝类毒素富集风险

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摘要: 为探讨贻贝中麻痹性贝类毒素的积累与产毒藻的相关性, 于 2017 年 5 月~2018 年 4 月期间, 在福建省贝类主要养殖区东山湾设立 4 个采样点, 逐月采集浮游植物、海底沉积物和贻贝样品, 进行有毒藻类甄别和麻痹性贝类毒素分析。结果发现: 1) 东山湾贝类养殖区的有毒藻的丰度均较低; 2) 东山湾贻贝中麻痹性贝类毒素含量较低, 毒素成分为 GTX1&4 和 GTX5, 且检出率存在明显的季节性; 3) 东山湾贻贝中麻痹性贝类毒素检出率与其生长周期成正相关。

关键词: 麻痹性贝类毒素; 东山湾; 贻贝

Risk of enrichment of paralytic shellfish poisoning in mussels by abundance of toxin-producing algae in shellfish culture area of Dongshan Bay, Fujian

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Abstract: To investigate the correlation between the accumulation of paralytic shellfish toxins in mussels and the toxin-producing algae, four sampling sites were set up in Dongshan Bay, Fujian, collection of phytoplankton, seabed sediment and mussel samples on a monthly basis for toxic algae screening and paralytic shellfish toxin analysis from May 2017 to April 2018. The results showed that: 1) the abundance of toxic algae in the shellfish culture area of Dongshan Bay was at a low level; 2) the content of paralytic shellfish poisoning in mussels was low, and the toxin profiles were mainly GTX1&4 and GTX5, and the detection rate has obvious seasonality. 3) the detection rate of paralytic shellfish poisoning in mussels was positively correlated with its growth cycle.

Key words: mussels; paralytic shellfish poisoning; Dongshan Bay

环境胁迫对塔玛亚历山大藻产麻痹性贝类毒素能力的影响研究

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摘要: 为探究环境胁迫对塔玛亚历山大藻产麻痹性贝类毒素(Paralytic shellfish poisoning, PSP)的能力的影响, 本文选取典型产麻痹性贝类毒素藻类——塔玛亚历山大藻作为研究对象, 通过改变空间效应、盐度和营养素浓度对塔玛亚历山大藻进行培养, 分析不同培养条件下塔玛亚历山大藻产麻痹性贝类毒素的能力。结果表明, 具有高 PSP 毒性的有害藻华易发生于盐度高、空间充足、氮磷浓度相对较低的富营养化海洋环境中。

关键词: 塔玛亚历山大藻; 麻痹性贝类毒素; 产毒能力;

Effects of environmental stress on paralytic shellfish toxin production of *Alexandrium tamarense*

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Abstract: The aim of this study was to investigate the effect of environmental stress on the production of paralytic shellfish poisoning in *Alexandrium tamarense*. In this paper, *Alexandrium tamarense*, a typical paralytic shellfish toxin producing alga, was selected as the research object. By changing the spatial effect, salinity and nutrient concentration, the ability of *Alexandrium tamarense* to produce paralytic shellfish toxin under different culture conditions was analyzed. The results showed that harmful algal blooms with high PSP toxicity were prone to occur in eutrophic marine environment with high salinity, sufficient space and relatively low nitrogen and phosphorus concentrations.

Keywords: *Alexandrium tamarense*; paralytic shellfish toxin; toxigenic capacity;

氨和空气暴露对大鳞副泥鳅肝脏抗氧化能力的影响

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摘要: 将大鳞副泥鳅(*Paramisgurnus dabryanus*)分别暴露于 30 mmol/L NH₄Cl 溶液和空气中, 以评价氨和空气暴露对其肝脏抗氧化能力的影响。结果显示, 氨暴露并未引起大鳞副泥鳅肝脏 SOD 活性的显著变化, 仅空气暴露 12 h 后, 大鳞副泥鳅肝脏 SOD 活性显著高于对照组。氨和空气暴露均显著降低了大鳞副泥鳅肝脏 CAT 活性且在暴露 72 h 后升高。MDA 及 LPO 含量在氨和空气暴露组中均呈现先显著上升后下降的趋势。氨和空气暴露对大鳞副泥鳅肝脏 GST 活性、GSH 含量和 T-AOC 活性无显著影响, 但 GSH-Px 活性均明显降低, AChE 活性均显著上升。研究结果说明, 在氨和空气暴露的初期, 大鳞副泥鳅体内出现了明显的氧化反应; 而在暴露一段时间后, 体内的氧化反应受到了明显的抑制。然而, 大鳞副泥鳅肝脏中 SOD、CAT、GST 及 GSH-Px 等抗氧化酶系统并未被成功激活。这可能是由于大鳞副泥鳅的氨耐受机制被激活, 降低了体内的氨毒性从而抑制了体内的氧化反应。

关键词: 大鳞副泥鳅; 氨累积; 空气暴露; 抗氧化能力; 氨耐受

Effects of ammonia and aerial exposure on hepatic antioxidant capacity of *Paramisgurnus dabryanus*

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Abstract: The *Paramisgurnus dabryanus* were exposed to 30 mmol/L NH₄Cl solution and air to evaluate the effects of exogenous and endogenous ammonia accumulation on hepatic antioxidant capacity of this species. During various periods of ammonia exposure, hepatic SOD activity fluctuated slightly, but there were no significant difference with the control group. After 12 h of air exposure, the SOD activities were notably higher than control group. Both ammonia and aerial exposure induced markedly decreased in CAT activities. The MDA and LPO contents first increased and then fall after ammonia and air exposure. The hepatic GST activities, GSH contents and T-AOC were unaffected by various of ammonia and aerial exposure, while the GSH-Px activities significantly decreased and the AChE activities markedly increased. Our results indicated that the obvious oxidation reactions occurred during early stage of ammonia and aerial exposure in *P. dabryanus*, while this reaction was inhibited after a period of exposure. However, the antioxidant enzymes system (e.g. SOD, CAT, GST and GSH-Px) in *P. dabryanus* were not activated successfully. According to our previous studies, we speculated that the ammonia defensive strategies in *P. dabryanus* were activated effectively and detoxified the body ammonia so that to avoid the oxidative damage.

Key words: *Paramisgurnus dabryanus*; ammonia accumulation; aerial exposure; antioxidant; ammonia tolerance

尼罗罗非鱼 ICAM-1 基因克隆及其 mRNA 表达分析

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摘要: ICAM-1 是介导细胞识别、粘附的重要粘附分子, 参与细胞的信号转导与活化、炎症反应和免疫应答等一系列重要生理病理过程。本研究克隆鉴定了尼罗罗非鱼 ICAM-1 cDNA 全长(命名为 On-ICAM-1), 并对该基因进行生物信息学分析, 运用荧光定量 PCR 方法对无乳链球菌刺激后 On-ICAM-1 mRNA 在各组织中的表达模式进行了研究。结果显示, 该基因 ORF 为 1059 bp, 编码 352 个氨基酸, 分子质量为 38.8 kDa, 等电点为 5.55。On-ICAM-1 序列与美妊丽鱼、布氏朴丽鱼和三湖慈鲷相似性较高, 分别为 89.80%、88.10% 和 71.02%。氨基酸序列的比对结果表明, ICAM-1 在慈鲷科其他鱼类中高度保守。On-ICAM-1 基因在健康尼罗罗非鱼的 10 种组织中均有表达, 在胸腺组织中的表达量最高, 其次是鳃、肠道和皮肤, 在头肾组织的表达量最低。经无乳链球菌 (*Streptococcus agalactiae*) 刺激后, On-ICAM-1 基因在鳃、肠道、脾、脑、胸腺中显著下调, 且呈时序性表达。鳃、脾均在 12 h 表达量最低, 肠道、脑、胸腺也在 12 h 时表达量下调, 且都在 24 h 开始上调。该研究表明, On-ICAM-1 表达可以被无乳链球菌诱导, 参与尼罗罗非鱼的免疫应答过程。

关键词: 尼罗罗非鱼, ICAM-1, 基因克隆, mRNA 表达分析, 无乳链球菌

Molecular Cloning and mRNA Expression Analysis of ICAM-1 Gene in Nile Tilapia (*Oreochromis niloticus*)

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Abstract: ICAM-1 is an important adhesion molecule mediating cell recognition and adhesion, and it is involved in a series of important physiological and pathological processes including cell signal transduction and activation, inflammatory response and immune response. The full length of ICAM-1 cDNA of Nile Tilapia (named On-ICAM-1) was cloned and identified in this study. The bioinformatics analysis of this gene was carried out, and the expression pattern of On-ICAM-1 mRNA in various tissues after the stimulation of *Streptococcus agalactiae* was studied by using fluorescence quantitative PCR method. The results showed that the ORF was 1059 bp, encoded 352 amino acids, with a molecular weight of 38.8 kDa and a theoretical pI of 5.55. The sequence of On-ICAM-1 was similar to that of *Astatotilapia calliptera*, *Haplochromis burtoni* and *Pundamilia nyererei* in 89.80%, 88.10% and 71.02%. Amino acid sequence alignment showed that ICAM-1 was highly conserved in other cichlid fishes. Moreover, the mRNA expression levels in different tissues were analyzed by real time quantitative PCR, it was found that the expression of On-ICAM-1 could be detected in all the examined tissues and the highest expression level was in the thymus, with lower level detected in gill, intestine, skin, and the lowest level was detected in head kidney. Under *Streptococcus agalactiae* stimulation, the expression of On-ICAM-1 gene was significantly down-regulated in gill, intestine, spleen, brain and thymus, and the expression was temporal. The expression levels in gill and spleen were the lowest at 12 h, and decreased expressions in intestine, brain and thymus at 12 h, all of which were upregulated at 24h. This study showed that On-ICAM-1 expression could be induced by *Streptococcus agalactiae* and was involved in the immune response of Nile tilapia.

Key words: Nile tilapia, ICAM-1, Gene clone, mRNA expression analysis, *Streptococcus agalactiae*

不同鱼源鮰诺卡氏菌生物学特征分析

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摘要: 鮰诺卡氏菌是一种革兰氏阳性好氧菌, 易引起鱼类尤其鲈形目结节病发生。比较不同鱼源鮰诺卡氏菌的生物学特征, 为进一步制定相应的防御与治疗措施提供可靠的科学依据。对 9 株不同年份不同地区患结节病不同淡水鱼品种中分离的鮰诺卡氏菌进行 16S rRNA 和看家基因 *secA1* 序列比对, 以及运用限制性片段长度多样性比较菌株间的同源性; 通过人工注射感染比较菌株对加州鲈的致病性; 采用微量二倍稀释法测试菌株对常用药物的敏感性。结果显示, 不同鱼源鮰诺卡氏菌的基因型相似, 聚为一簇; 致病力无显著差异; 不同菌株对磺胺类药物和氨苄西林耐药, 对其他药物较敏感。不同鱼源鮰诺卡氏菌的生物学特征基本相似, 提示引起淡水鱼结节病的的鮰诺卡氏菌为同一流行株, 该结果有助于进一步开展鮰诺卡氏菌的致病机制和防控技术研究。

关键词: 鮰诺卡氏菌; 基因型; 致病性; 药物敏感性

Comparison of biological characteristics of *Nocardia seriolae* isoalted from different fishes

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Abstract: *Nocardia seriolae* is a gram-positive aerobic bacterium that may cause sarcoidosis in fish, especially Perciformes. In order to compare the biological characteristics of *N. seriolae* from different fishes, 16S rRNA and housekeeping gene *secA1* were sequenced. PCR-RFLP was performed to analyze the homology of different origins. Challenge assays was conducted to compare the pathogenicity of 9 strains in *Micropterus salmoides* and susceptibilities of commonly used antimicrobial agents were also determined. The results showed that the genotype of *N. seriolae* from different origins were similar and clustered into one group. There were no significant differences in pathogenicity. All the strains were resistant to sulfonamides and ampicillin. The results implied similar genotype of *N. seriolae* was prevalent in freshwater fish. It helps to further study on the pathogenic mechanism, prevention and control of *N. seriolae*.

Key words: *Nocardia seriolae*, genotype, pathogenicity, antimicrobial susceptibility

哈维氏弧菌 Flge 亚单位疫苗及添加壳寡糖佐剂对石斑鱼免疫效果研究

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摘要: 哈维氏弧菌(*Vibrio harveyi*)是多种海水动物的常见致病菌,对石斑鱼的养殖产业造成巨大经济损失,疫苗的研制是预防弧菌病的有效手段。FlgE 蛋白是细菌鞭毛构组成成分之一,具有强的免疫刺激性,可诱使机体产生强烈的免疫应答。然而,关于哈维氏弧菌 Flge 蛋白在作为鱼类中疫苗的特性和作用的报道较少。本研究对哈维氏弧菌的 Flge 编码区进行克隆和序列分析,构建表达载体 pET28a-Flge 后转入表达菌株大肠杆菌 BL21,对表达重组菌株进行表达条件优化及 Western Blot 鉴定。将具有佐剂活性的壳寡糖和油佐剂修饰 Flge 亚单位疫苗,通过以珍珠龙胆石斑鱼为动物模型动物实验评估了疫苗的免疫效果。其研究成果将应用到石斑鱼海水养殖中,提高养殖对象的成活率和扩大水产养殖规模,为石斑鱼抗弧菌病提供安全有效的选择。

关键词: 珍珠龙胆石斑鱼; Flge; 哈维氏弧菌; 免疫保护; 佐剂

Identification and immunoprotective analysis of a *Vibrio harveyi* Flge subunit vaccine and chitosan oligosaccharide adjuvant on grouper

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Abstract: *Vibrio Harveyi* is a common pathogenic bacterium in a variety of Marine animals, which causes great economic loss to grouper breeding. The development of vaccine is an effective means to prevent *Vibrio* disease. FlgE protein has strong immune stimulation and can induce the body to produce a strong immune response. However, little has been reported on the properties and effects of *Vibrio harveyi* Flge protein as a vaccine in fish. In this study, the flGE coding region of *Vibrio harveyi* was cloned and sequence analyzed. The expression vector PET28A-FLGE was constructed and transferred into the expression strain *E. coli* BL21. The expression conditions of the recombinant strain were optimized and identified by Western Blot. Chitosan oligosaccharide and oil adjuvant modified Flge subunit vaccine were used to evaluate the immune effect of the vaccine by using pearl gentiana grouper as animal model. The research results will be applied to grouper mariculture to improve the survival rate of breeding objects and expand the scale of aquaculture, so as to provide a safe and effective choice for grouper resistance to vibrio.

Key words: Pear gentian grouper ; Flge; Immune protection; Inactivated vaccine of *V. harveyi*

表达 EGFP 标记分子修饰 IPNV VP2 蛋白重组无抗乳酸菌的构建及免疫应答分析

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摘要: 为了获取安全高效的 IPNV 口服疫苗, 利用乳酸菌作为呈递抗原的活菌载体, 融合表达 IPNV VP2 蛋白以及虹鳟趋化因子 CK6 蛋白, 并利用增强型绿色荧光蛋白 EGFP 代替乳酸菌载体中的抗生素抗性基因构建重组乳酸菌 pPG^{ΔCm}-612-CK6-VP2EGFP/*L.casei* 393。结果显示, 重组干酪乳杆菌具有遗传稳定性, 并能够在虹鳟肠道内定植。免疫后的虹鳟脾脏和肠道细胞因子水平均有上调, 并且产生具有中和活性的 IPNV 特异性 IgM 和皮肤粘液 IgT。MTT 法检测抗原刺激下的受免虹鳟脾淋巴细胞显著增殖 ($p < 0.01$), 免疫后对虹鳟进行攻毒, 虹鳟肝胰脏组织中的病毒载量显著低于对照组 ($p < 0.01$)。本研究成果构建了非抗性标记的食品安全级的重组干酪乳杆菌系统 pPG^{ΔCm}-612-CK6-VP2EGFP/*L.casei* 393, 能够诱导 IPNV 特异性抗原 VP2 蛋白更快、更准确地呈递至肠道上皮细胞, 使机体产生更强的体液免疫应答, 有效抵御 IPNV 的感染, 为研发高效安全的 IPNV 口服疫苗提供理论基础和科学根据。

关键词: 口服活载体;趋化因子;黏附素;免疫应答;黏膜免疫

Construction and immune response analysis of recombinant IPNV VP2 protein modified by expressing EGFP marker molecules without anti-lactic acid bacteria

Abstract: In order to obtain safe and efficient IPNV oral vaccine, we use lactic acid bacteria as a live bacteria vector for antigen presentation, fusion express IPNV VP2 protein and rainbow trout chemokine CK6 protein, and use enhanced green fluorescent protein EGFP to replace the antibiotic resistance gene to construct recombinant pPG^{ΔCm}-612-CK6-VP2EGFP/*L.casei* 393. The results showed that the recombinant *Lactobacillus casei* had genetic stability and could colonize the intestines of rainbow trout. After immunization, cytokine levels of rainbow trout spleen and intestine were up-regulated, and IPNV-specific IgM and skin mucus IgT with neutralizing activity were produced. The proliferation of spleen lymphocytes was detected by MTT assay ($p < 0.01$), and the viral load in liver and pancreas of rainbow trout was significantly lower than that of the control groups ($P < 0.01$). This research constructs the free of antibiotic resistance marker level of food safety system pPG^{ΔCm}-612-CK6-VP2EGFP/*L.casei* 393, which can induce IPNV specific antigen VP2 protein faster and more accurate presentation to the intestinal epithelial cells, make the body produce stronger humoral immune response, effectively resist IPNV infection. This study provide efficient and safe IPNV oral vaccines, theoretical foundation and scientific basis.

Key words: Oral live carrier, chemokine, adhesin, immune response, mucosal immunity

黄柏及小檗碱对棕点石斑鱼非酒精性脂肪肝病改善作用的研究

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摘要: 本实验研究了黄柏及其主要生物碱小檗碱对棕点石斑鱼非酒精性脂肪肝病(NAFLD)的改善效果, 连续投喂4周高脂饲料建立棕点石斑鱼NAFLD模型后, 继续分三组投喂含高脂、黄柏(高脂+1%黄柏)和小檗碱(高脂+0.005%小檗碱)的饲料8周, 对肝脏组织进行H.E染色和油红O染色分析, 并测定其血清脂肪代谢和抗氧化相关生化指标。结果表明连续高脂投喂4周后, 肝脏细胞发生严重变性, 肝细胞内存在大量脂滴, 指标发生显著变化, 表明成功建立了非酒精性脂肪肝病模型。治疗8周后, 饲料中添加的1%黄柏和0.005%小檗碱显著降低因脂肪肝病引起的ALT、AST、TG、TCHO和LDL-C水平升高($P < 0.05$), 同时与高脂对照组相比, 肝细胞脂肪变性程度也有一定程度的改善。

关键词: 黄柏; 小檗碱; 非酒精性脂肪肝病; 棕点石斑鱼

Effects of Phellodendri Chinensis Cortex and Berberine on nonalcoholic fatty liver disease in *Epinephelus fuscoguttatus*

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Abstract: This study investigated the effect of Phellodendri Chinensis Cortex and its main alkaloid Berberine on the nonalcoholic fatty liver disease (NAFLD) of *Epinephelus fuscoguttatus* (*E. fuscoguttatus*). After establishing the *E. fuscoguttatus* NAFLD model by 4 weeks of continuous feeding of high-fat diet (HFD) the NAFLD groupers were fed three diet(HFD, HFD+1% P, HFD+0.005% BBR) for 8 weeks, respectively. Then the liver tissues were sampled and stained with H&E and Oil Red O. The plasma biochemical parameters (such as lipid metabolism related and antioxidant related) were also measured. The results showed that after 4 weeks of HFD, *E. fuscoguttatus* liver cells were severely degenerated, and there were a large number of lipid droplets in the liver cells. The serum indexes were also significantly changed, indicating that the NAFLD model was successfully established. After 8 weeks of treatment, 1% Phellodendron and 0.005 % BBR supplementation significantly reduced the increase in ALT, AST, TG, TCHO and LDL-C levels caused by NAFLD ($P < 0.05$), and fatty degeneration of liver cells was also alleviated to a certain degree.

Key words: Phellodendri Chinensis Cortex, Berberine, NAFLD, *Epinephelus fuscoguttatus*

花鲈源维氏气单胞菌分离鉴定及耐药性分析

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摘要: 为探究广东省珠海市养殖花鲈突发性死亡病因, 对患病花鲈进行病原分离、鉴定及致病性分析, 旨在防治花鲈维氏气单胞菌病提供参考。从患病花鲈病灶中分离到一株优势菌 18BJ181, 经 Vitek 2 生理生化分析、16S rRNA 和 *gyrB* 基因序列鉴定该菌株为维氏气单胞菌。人工回归感染实验结果显示分离菌能引起花鲈死亡, 半数致死量 (LD₅₀) 为 8.5×10⁵cfu/g。组织病理结果显示脾脏和肾脏是感染较为严重的靶器官, 脾脏、肾脏、肝脏和心脏出现不同程度的变性和坏死。16 种药敏实验结果表明, 18BJ181 对氯霉素等 10 种药物具有较高敏感性。

关键词: 维氏气单胞菌; 花鲈; 致病性; 药敏实验

Identification and drug sensitivity of *Aeromonas veronii* from diseased *Lateolabrax maculatus*

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Abstract: In order to study the causes of acute death of the *Lateolabrax maculatus* in Zhuhai, Guangdong Province. The pathogen isolation, identification, and pathogenicity study of the diseased *L. maculatus* were conducted, aiming to provide a reference for the prevention and treatment of *Aeromonas veronii* infection of the *L. maculatus*. A dominant strain, 18BJ181, was isolated from the diseased *L. maculatus* and identified as *A. veronii* by Vitek 2 Compact, 16S rRNA, and *gyrB* gene sequence analysis. The results of artificial regression infection showed that the isolated strain 18BJ181 could cause the death of the *L. maculatus*, and the median lethal dose (LD₅₀) was 8.5×10⁵cfu/g. Histopathological results showed that the spleen and kidney were the target organs with severe infection, and showed different degrees of degeneration and necrosis. The results of 16 drug sensitivity experiments showed that 18BJ181 was highly sensitive to 10 drugs such as chloramphenicol.

Key words: *Aeromonas veronii*, *Lateolabrax maculatus*, pathogenicity, antimicrobial susceptibility test

镉对日本沼虾抗氧化以及免疫性能的影响

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摘要: 由于工业的飞速发展、农业农药的滥用以及人口的不断增加, 大量污染物排入水中, 这些污染物中主要包括各种重金属, 而在这些重金属中镉是毒性最大的污染物之一。本研究通过在水中添加不同浓度的镉, 测定镉对日本沼虾血清中 MDA, SOD, CAT, POD, PO, ACP, AKP, GOT, GPT 和血蓝蛋白含量、肝胰腺中 MT, HSP60, SOD, TLR3, TNF, Caspase1 基因表达水平以及对鳃和肝胰腺的组织学影响。研究表明, 重金属镉对日本沼虾 96h 半致死浓度为 0.03 mg/L, 低浓度镉可以诱导日本沼虾氧化应激的发生, 对免疫系统具有激活作用, 但是高浓度镉对日本沼虾抗氧化防御系统具有抑制作用, 导致日本沼虾产生氧化损伤和细胞凋亡, 免疫系统受到抑制甚至损伤, 同时对日本沼虾鳃和肝胰腺具有损伤作用。

关键词: 镉; 日本沼虾; 抗氧化; 非特异性免疫

Effects of cadmium on antioxidation and immunity of

Macrobrachium nipponense

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Abstract: Due to the rapid development of industry, the abuse of agricultural pesticides and the continuous growth of population, a large number of pollutants are discharged into the water, including a variety of heavy metals, while cadmium is one of the most toxic pollutants. In this study, different concentrations of cadmium were added to water to determine the effects of cadmium on the contents of MDA, SOD, CAT, POD, PO, ACP, AKP, GOT, GPT and hemocyanin, expression level of MT, HSP60, SOD, TLR3, TNF, Caspase1 gene in hepatopancreas, histology of gill and hepatopancreas in *Macrobrachium nipponense*. The results showed that the 96 h LC₅₀ of cadmium to *M. nipponense* was 0.03 mg/L. Low concentration of cadmium could induce oxidative stress and activate the immune system of *M. nipponense*. However, high concentration of cadmium could inhibit the antioxidant defense system of *M. nipponense*, resulting in oxidative damage and apoptosis of *M. nipponense*, and the immune system was inhibited or even damaged. It can also damage the gill and hepatopancreas of *M. nipponense*.

Key words: cadmium, *Macrobrachium nipponense*, antioxidation, non-specific immunity

厚朴酚对嗜水气单胞菌感染异育银鲫的抗氧化因子及抗炎 *TLR-5/MyD88* 通路基因表达的影响

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摘要: 为了评价厚朴酚 (Magnolol) 在养殖鱼类感染嗜水气单胞菌 (*Aeromonas hydrophila*) 病的防治效果, 本研究在构建异育银鲫 (*Carassius auratus gibelio*) 感染病原菌模型的基础上, 分析厚朴酚不同浓度处理下鱼体血液生化指标、肝脏抗氧化因子和炎症相关基因表达的变化。研究表明: 厚朴酚能减少嗜水气单胞菌感染引起的异育银鲫死亡, 降低异育银鲫肝脏的氧化损伤, 下调机体炎症相关基因的表达。

关键词: 厚朴酚; 氧化损伤; 炎症; 嗜水气单胞菌; 异育银鲫

Effects of magnolol on antioxidant factors and anti-inflammation *TLR-5/MyD88* pathway gene expression of *Carassius auratus gibelio* infected with *Aeromonas hydrophila*

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Abstract: In order to evaluate the effect of magnolol on the treatment of *Aeromonas hydrophila* infection, this study applied different concentrations of magnolol to treat *Carassius auratus gibelio* infection model. The effect of magnolol on the intervention of *Aeromonas hydrophila* infection was analyzed from the blood biochemical index, the aspects of liver antioxidant performance and inflammation related gene expression. Studies have shown that magnolol can reduce the death of *Carassius auratus gibelio* caused by *Aeromonas hydrophila* infection, reduce the oxidative damage of *Carassius auratus gibelio* liver, and down-regulate the expression of inflammation-related genes in the body.

Key words: magnolol; oxidative damage; inflammation; *Aeromonas hydrophila*; *Carassius auratus gibelio*

罗非鱼 CD226 亚家族及其配体的克隆鉴定与功能研究

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摘要: CD226 亚家族成员 CD226 和 CD96 具有共同配体 Necl5, 它们之间的相互作用在 T 细胞增殖与活化中具有重要作用。本研究从尼罗罗非鱼中成功克隆 CD226、CD96 以及 Necl5 分子。qPCR 分析发现它们主要在免疫组织中高表达, 经多种病原刺激物刺激后在脾脏、头肾、胸腺等免疫组织和头肾淋巴细胞中均上调表达, 表明该家族成员参与了机体抵御病原的免疫应答过程。亚细胞定位结果发现 CD226 和 CD96 与其共同配体 Necl5 均为典型细胞膜分布, 且均能发生共定位, 表明它们具有潜在互作的可能。接着, 我们通过酵母双杂交实验进一步验证了 CD226 和 CD96 与其共同配体 Necl5 的相互作用, 提示它们之间的相互作用机制在尼罗罗非鱼中保守存在。这些实验结果, 将为我们进一步探究 CD226 和 CD96 与其共同配体 Necl5 之间的调控机制与功能奠定基础。

关键词: CD226; CD96; Necl5; 无乳链球菌; 酵母双杂交

Cloning, Identification and Function Study of Nile Tilapia CD226 Subfamily and Its Ligand

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Abstract: The interaction of CD226 subfamily members (CD226 and CD96) with their ligand Necl5 is involved in T cell activation and proliferation. In this study, CD226, CD96 and Necl5 were cloned from Nile tilapia, and the expression of them were analyzed by qPCR in healthy tissues and stimulated by various pathogenic stimuli in the spleen, thymus and other immune tissues and head kidneys lymphocytes. The results of subcellular localization showed that CD226, CD96 and Necl5 were all membrane-distributed and shared common localization. Yeast two-hybrid experiment results showed that CD226 and CD96 interact with their common ligand Necl5. These findings indicate that CD226 and CD96 are critical to the immune response during pathogens infection, and the interaction mechanism of CD226 and CD96 with Necl5 is conserved in Nile tilapia.

Key words: CD226, CD96, Necl5, *Streptococcus agalactiae*, yeast two-hybrid

溶藻弧菌 PepA 蛋白原核表达载体的构建及其乙酰化鉴定

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摘要: 旨在构建溶藻弧菌 HY9901 PepA 蛋白的原核表达载体、优化其表达条件, 并分析该蛋白是否存在乙酰化调控。首先设计特异性引物经 PCR 克隆 *pepA* 基因, 构建表达载体 pET-28a-PepA 并将其转入大肠杆菌 BL21 (DE3), 然后用 SDS-PAGE 和 Western blot 分析蛋白的表达及乙酰化情况。结果显示, 表达菌株可以正确表达重组蛋白 (60.7 kD), 其最佳表达条件为: 体积分数为 0.1% 的 IPTG, 37°C 诱导 5 h; Western blot 结果表明, PepA 蛋白是乙酰化蛋白, 且在体外不存在去乙酰化。

关键词: 溶藻弧菌; PepA 蛋白; 表达条件优化; 乙酰化

Construction of Prokaryotic Expression Vector of PepA Protein of *Vibrio alginolyticus* and Identification of Its Acetylation

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Abstract: The purpose of this study is to construct a prokaryotic expression vector of PepA protein in *Vibrio alginolyticus* HY9901, to optimize its expression conditions, and to analyze whether or not it is regulated by protein acetylation. Firstly, the *pepA* gene was cloned via PCR, and an expression vector pET-28a-PepA was constructed and transferred it into *Escherichia coli* BL21 (DE3). Then, the protein expression and acetylation were analyzed by SDS-PAGE and Western blot. The recombinant expression strain correctly expressed the recombinant protein (60.7 kD), and its optimal expression conditions was, induced for 5 h at 37°C by IPTG with a volume fraction of 0.1%. Western blot results showed that PepA protein was acetylated protein, and there was no deacetylation in vitro.

Key words: *Vibrio alginolyticus*, PepA protein, optimal expression condition, acetylation

苯并芘急性暴露对泥蚶的毒性影响：组织学变化、氧化压力、神经毒性和 DNA 去甲基化

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摘要: 本研究系统评价了急性苯并芘 (Bap) 暴露下泥蚶的组织病理学变化, 以及诱导产生的氧化压力、神经毒性及 DNA 甲基化水平变化, 旨在探究苯并芘对海洋底栖经济贝类的毒性效应和内在机制。结果表明: 10 和 100 $\mu\text{g/L}$ Bap 暴露 96h 后, 泥蚶鳃组织形态结构出现明显异常, 表现为鳃丝肿胀、充血和断裂。抗氧化酶包括 SOD、CAT、POD 和 GST 的酶活性, MDA 和 8-OHdG 的水平显著上升, 代表氧化压力和 DNA 损伤的存在。神经递质酶 AChE 和 ChAT 活性降低表明 Bap 对泥蚶产生神经毒性。此外, DNA 甲基化水平显著降低。关联性分析表明, DNA 甲基化和某些抗氧化酶活呈负相关而与神经递质酶呈正相关。结论: 苯并芘暴露下, 泥蚶可能通过 DNA 去甲基化来诱导抗氧化酶基因表达, 从而提高抗氧化酶活性来对抗苯并芘毒性。

关键词: 泥蚶; 组织病理学; 氧化压力; 神经毒性; DNA 甲基化

Effects of acute benzo[a]pyrene exposure on blood clam *Tegillarca granosa*: Histological changes, oxidative stress, neurotoxicity and DNA hypomethylation

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Abstract: The blood clam, *Tegillarca granosa*, is an economical bivalve species in China. Herein, we employed multiple biomarkers to investigate the effects of benzo[a]pyrene (Bap) exposure on blood clams. Acute Bap exposure can induce significant morphological abnormalities in gills. Meanwhile, the oxidative stress was significantly elevated as manifested by the increase of lipid peroxidation level, 8-hydroxy-2'-deoxyguanosine content, and the antioxidants activities of superoxide dismutase, catalase, peroxidase and glutathione-s-transferase. The neurotoxicity was also strengthened by Bap toxicity manifested as inhibited acetylcholinesterase and choline acetyltransferase activities. In addition, a significant DNA hypomethylation was observed in Bap exposed blood clams. The correlation analysis showed that the global DNA methylation was negatively correlated with antioxidants activities, but positively correlated choline enzymes activities.

Key words: *Tegillarca granosa*, histopathology, oxidative stress, neurotoxicity, global DNA methylation

脂多糖(LPS)与克氏原螯虾血淋巴黏附性的影响

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摘要: 脂多糖 (LPS) 是革兰氏阴性菌外膜的两亲性糖脂, 与感染时的毒性和免疫原性有关。本研究采用不同浓度的 LPS (0、5mg/L、10mg/L、15mg/L、20mg/L) 对克氏原螯虾进行腹部肌肉注射, 进行为期两天(48h)的实验室养殖实验。测定了注射 LPS 后对克氏原螯虾酸性磷酸酶(ACP)、碱性磷酸酶 (AKP)、酚氧化酶 (PO)、过氧化物酶 (POD)、溶菌酶 (LZM)、血蓝蛋白、细胞密度、吞噬活性、血清凝集素和血淋巴黏附性的影响。AKP、ACP、PO、POD、LZM、血蓝蛋白、血清凝集素及血淋巴黏附性呈现先上升后下降的趋势, 而细胞密度和吞噬活性则呈现逐渐下降的趋势。因此, 克氏原螯虾的血淋巴黏附性会受到细菌含量的影响, 随着环境的变化, 克氏原螯虾的产量也会受到影响。

关键词: LPS; 克氏原螯虾; 血淋巴黏附性

Effects of lipopolysaccharide (LPS) on haemolymph adhesion of *Procambarus clarkii*

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Abstract: Lipopolysaccharide(LPS) is an amphiphilic glycolipid in the outer membrane of Gram-negative bacteria, which is related to the toxicity and immunogenicity of infection. In this study, different concentrations of LPS (0, 5 mg/L, 10 mg/L, 15 mg/L, 20 mg/L) were injected into the abdominal muscles of *Procambarus clarkii*. The experiment lasted for two days (48h). The study aims to measure the effects of LPS injection on *Procambarus clarkii*, such as acid phosphatase (ACP), alkaline phosphatase (AKP), phenol oxidase (PO), peroxidase (POD), lysozyme (LZM), hemocyanin, cell density, phagocytic activity, serum lectin and hemolymph adhesion. AKP, ACP, PO, POD, LZM, hemocyanin, serum lectin and hemolymph adhesiveness increased at first and then decreased, while cell density and phagocytic activity decreased gradually. Therefore, the haemolymph adhesion of *Procambarus clarkii* will be affected by bacterial content, otherwise, the yield of *Procambarus clarkii* will be affected with the change of environment.

Key words: LPS, *Procambarus clarkii*, hemolymph adhesion

阳澄湖原产及“洗澡”中华绒螯蟹元素与形态的差异性研究

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摘要: 为了有效确认阳澄湖原产中华绒螯蟹(*Eriocheir sinensis*)及非阳澄湖“洗澡蟹”是否有显著的不同并探寻鉴别途径, 本研究分别通过矿质元素与几何形态分析法, 比较研究了后者在阳澄湖中人为“洗澡”式养殖1个月始末时, 其与同期阳澄湖原产蟹的微化学和形态学特征的差异性。基于第三步足Na、Mg等11种矿质元素含量进行微化学积累类型的逐步判别分析, “洗澡蟹”的判别准确率可达100%。基于所建立的35个地标点系统来进行背甲的形态分析, 相对扭曲得分的逐步判别分析结果显示: “洗澡蟹”养殖前后阳澄湖原产蟹与非阳澄湖产蟹背甲形态差异均极其显著, 判别准确率亦可达100%。本研究首次量化证实, 非阳澄湖产中华绒螯蟹即使在阳澄湖“洗澡”式养殖1个月, 其第三步足矿质元素积累类型与背甲形态仍无法与原产蟹趋同。这些差异性具有鉴别阳澄湖原产和“洗澡蟹”的应用潜力。

关键词: 中华绒螯蟹; 阳澄湖; “洗澡蟹”; 几何形态分析; 矿质元素

Study on elemental and morphological differences between originated and “bathed” *Eriocheir sinensis* of the Yangcheng Lake

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Abstract: To confirm difference between originated and “bathed” Chinese mitten crabs *Eriocheir sinensis* of the Yangcheng Lake, multi-mineral element and landmark-based geometric morphometric analyses were used to comparatively study the corresponding characteristics of the native and one-month bathing cultured crabs in Yangcheng Lake. The patterns of 11 mineral elements in the third pereopod of the two types of *E. sinensis* crab were significantly different, and the stepwise discriminant analysis reached 100% accuracy. Similarly, the carapace morphology characterized by a 35-landmark point system were significantly different each other, and 100% accuracies could be obtained with stepwise discriminant analysis for the originated and “bathed” crabs. This study quantified and revealed, for the first time, the difference between originated and one-month bathed crabs in the Yangcheng Lake, i.e., one-month bathing culture was unable to converge the element profiles between the ecdemic and native crabs. The aforementioned differences have strong application potentials for effectively distinguishing “bathed” individuals from the Yangcheng Lake originated *E. sinensis* crabs.

Key words: Chinese mitten crab *Eriocheir sinensis*; Yangcheng Lake; “Bathed” crab; Geometric morphometric analysis; mineral element

尼罗罗非鱼 Galectin-4 基因的原核表达及诱导条件优化

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摘要: 研究尼罗罗非鱼 (*Oreochromis niloticus*) Galectin-4 基因 (记作 OnGal-4) 的原核表达, 为大量获取尼罗罗非鱼 Galectin-4 蛋白 (OnGal-4) 和后续功能研究奠定基础。根据 NCBI 上公布的尼罗罗非鱼 Galectin-4 基因序列 (Genbank: XM-019345120) 设计引物, 构建原核表达载体, 诱导 Galectin-4 重组蛋白 (rOnGal-4) 在 BL21 原核表达系统中表达, 并优化其诱导条件。

关键词: 尼罗罗非鱼; Galectin-4; 基因克隆; 原核表达; 条件优化

Prokaryotic Expression and Optimization of Galectin4 Gene from Nile Tilapia (*Oreochromis niloticus*)

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Abstract: To study the optimization conditions for prokaryotic expression of the Nile tilapia (*Oreochromis niloticus*) OnGal-4 gene, and perform functional studies of Galectin-4. A pair of primers were designed based on the tilapia Galectin-4 gene sequence (Genbank:XM-019345120), and to expression plasmid (pGEX-4T-OnGal-4) was produced. The Galectin-4 recombinant clone was induced to express rOnGal4 in BL21 cells and the expression conditions were optimized.

Key words: *Oreochromis niloticus*; Galectin-4; gene clone; prokaryotic expression; condition optimization

团头鲂内凝集素蛋白对巨噬细胞免疫调节作用的新见解

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摘要: 为了阐明鱼类内凝集素蛋白对巨噬细胞的免疫调控作用机制, 以便在鱼类病害防治和抗病新品种的选育中更好的应用, 本实验利用去内毒素的重组团头鲂内凝集素蛋白处理原代团头鲂头肾巨噬细胞, 提取总 RNA 后进行比较数字表达谱测序(Digital Gene Expression Profiling, DGE)。DGE 结果分析表明, 测序质量较好, 蛋白处理组与对照组相比共存在 1247 个差异表达基因, 其中上调表达 482 个, 下调表达 765 个。对关键差异表达基因用实时荧光定量 PCR(qPCR)进行验证, 其基因表达水平与表达谱的趋势一致。

关键词: 团头鲂; 内凝集素蛋白; 数字表达谱测序; 巨噬细胞; 免疫调节

Novel insights into the immune regulatory effects of *Megalobrama Amblycephala* intelectin on macrophages

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Abstract: In order to clarify lectin proteins in the fish immune regulation mechanism of macrophage, so that the fish disease prevention and control and better application in the breeding of disease-resistant varieties, this experiment used to endotoxin restructuring *Megalobrama amblycephala* processing the original generation of megalobrama amblycephala lectin proteins in the head kidney macrophages, compares Digital Expression after extracting total RNA sequencing (Digital Gene Expression Profiling, the DGE). DGE analysis of results showed that the sequencing quality was good. There were 1247, differentially expressed genes in the protein treatment group compared with the control group, among which 482 genes were up-regulated and 765 genes were down-regulated. The key differentially expressed genes were verified by real-time fluorescence quantitative PCR(qPCR), and the gene expression level was consistent with the trend of the expression spectrum.

Key words: *Megalobrama amblycephala*; intelectin; Digital Gene Expression Profiling; macrophages; immune regulatory

高淀粉饲料对加州鲈肝脏的影响

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摘要: 为了探究高淀粉饲料对加州鲈 (*Micropterus salmoides*) 肝脏的影响, 本实验采用小麦 α 淀粉作为淀粉来源配制等氮饲料, 实验组淀粉含量为 22%, 对照组为 0%。利用两种饲料投喂初始体重为 (7.06 \pm 1.30 g)的加州鲈, 经 45 天喂养之后, 分别采集加州鲈血液和肝脏, 进行血液生理生化检测和 H&E、PAS 和油红 O 染色观察。结果显示, 实验组肝脏肿大, 发白, 边缘钝化, 质地易碎, 同时肝体比显著高于对照组 ($P<0.05$)。血液生理生化检测显示, 实验组血糖、谷丙转氨酶 (ALT)、谷草转氨酶 (AST)均显著高于对照组 ($P<0.05$)。H&E 染色观察发现, 实验组肝细胞肿胀, 细胞核偏移, 细胞与细胞间界限模糊, 出现严重的空泡变性。PAS 和油红 O 染色显示, 实验组糖原含量有所增加, 且可见大量的橘红色脂滴。本研究证实, 高淀粉饲料, 能够对加州鲈肝脏组织结构产生明显的影响, 糖原、脂肪含量显著上升, 进而导致加州鲈肝脏损伤。

关键词: 高淀粉饲料; 加州鲈; 肝脏; 组织病理学观察

The effects of high starch feeds on the liver of largemouth bass (*Micropterus salmoides*)

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Abstract: To investigate the effects of high starch feeds on the liver of largemouth bass (*Micropterus salmoides*), isonitrogenous feeds were prepared using wheat α -starch as the starch source, with 22% starch content in the experimental group and 0% in the control group. After 45 days of feeding, blood and liver of largemouth bass were collected for blood physiology and biochemistry tests and observation of H&E, PAS, and oil red O staining, respectively. The results showed that the livers of the experimental group were swollen, white, with blunted edges and brittle texture, while the liver body ratio was significantly higher than that of the control group ($P<0.05$). The blood physiological and biochemical tests showed that the blood glucose, alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were significantly higher in the experimental group than in the control group ($P<0.05$). H&E staining showed that the hepatocytes in the experimental group were swollen, the nuclei were shifted, the boundaries between cells were blurred, and there was severe vacuolar degeneration. A large number of orange lipid droplets were visible. This study confirms that high starch feeds, which are capable of significantly affecting the structure of largemouth bass liver, significantly increase glycogen and fat content, which in turn leads to liver damage in largemouth bass.

Key words: High starch feeds, *Micropterus salmoides*, liver, histopathological observation

溶藻弧菌 T3SS 调控缺失株影响药敏性及其作为减毒活疫苗对斑马鱼有显著保护

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摘要: 溶藻弧菌的毒力机制 III 型分泌系统(T3SS)与其致病性密切相关。本研究以 T3SS 上的一个调控基因 *tyeA* 作为研究对象, 从溶藻弧 HY9901 克隆得到 *tyeA* 基因序列长度为 285bp。利用 Overlap PCR 和同源重组的两种技术在溶藻弧菌上敲除了 T3SS 的基因 *tyeA*, 得到了无抗生素标记的溶藻弧菌 HY9901 基因无痕缺失、突变株, 并对其进行了生物学表型分析; 通过对斑马鱼的半数致死实验发现 *tyeA* 的缺失使溶藻弧菌 HY9901 的毒力下降了约 40 倍。将 $\Delta tyeA$ 作为减毒活疫苗肌肉注射免疫斑马鱼, 发现其对溶藻弧菌相对免疫保护率达 71.2%, qPCR 分析表明 $\Delta tyeA$ 免疫斑马鱼后能增强鱼体免疫基因的表达, qRT-PCR 分析 T3SS 相关基因的转录水平。

关键词: 溶藻弧菌; 减毒活疫苗; 三型分泌系统; *tyeA*; 调控因子

A T3SS Regulator Mutant of *Vibrio alginolyticus* Affects Antibiotic Susceptibilities and Provides Significant Protection to *Danio rerio* as a Live Attenuated Vaccine

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Abstract: The virulence mechanism of *V. alginolyticus*, the Type III secretion system (T3SS), is closely related to its pathogenicity. In this study, the T3SS gene *tyeA* was cloned from *V. alginolyticus* wild-type strain HY9901. The mutant strain HY9901 $\Delta tyeA$ was constructed by Overlap-PCR and homologous recombination techniques. Following vaccination with the mutant strain, zebrafish had significantly higher survival than controls following infection with the wild-type HY9901 (71.2% relative percent survival; RPS). Analysis of immune gene expression by qPCR showed that vaccination with HY9901 $\Delta tyeA$ increased the expression in zebrafish. This study provides evidence of protective efficacy of a live attenuated vaccine targeting the T3SS of *V. alginolyticus* which may be facilitated by up-regulated pro-inflammatory and immunoglobulin-related genes, qRT-PCR was employed to analyze the transcription levels of T3SS-related genes.

Keywords: *Vibrio alginolyticus*, live attenuated vaccine, type III secretory system, *tyeA*, regulator

褶纹冠蚌 JNK 对 Nrf2/ARE/NQO1 通路的调控

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摘要: C-Jun 氨基末端激酶 (JNK) 是丝裂原活化蛋白激酶 (MAPK) 的家族成员之一, 对细胞分化、环境应激和炎症反应等生理过程具有调控作用。Nrf2-ARE 是重要的抗氧化通路, 可以增强组织抗氧化能力, 保护机体免受损伤。醌氧化还原酶 NQO1 是生物体内一种重要的 II 相解毒酶, 通过去电子还原反应参与机体内外源物质代谢过程。为了探究 JNK 对 Nrf2/ARE/NQO1 通路是否有调控作用, 本研究首先克隆出褶纹冠蚌的 JNK 基因及其下游靶基因 NQO1, 并对其进行鉴定和功能分析; 然后结合小干扰 RNA 和荧光定量 PCR 技术, 发现褶纹冠蚌 JNK 对 Nrf2 具有负调控作用。凝胶亲和实验表明 Nrf2 蛋白在体外能与 NQO1 启动子结合。双荧光素酶报告结果表明 Nrf2 对 NQO1 启动子具有转录调控作用。

关键词: 褶纹冠蚌; JNK; NQO1; Nrf2-ARE; 转录调控

The regulation of Nrf2/ARE/NQO1 pathway by JNK in *Cristaria plicata*

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Abstract: c-Jun N-terminal kinase (JNK) is one of the members of the mitogen-activated protein kinase (MAPK) family. It regulates physiological processes such as cell growth and differentiation, environmental stress and inflammatory response. Nrf2-ARE is an important antioxidant pathway, which can enhance the antioxidant capacity of tissues and protect the body from oxidative damage. NQO1 is an important II detoxification enzymes. It participates in the metabolism process of internal and external source substances by deelectron reduction reaction. In order to explore whether JNK mediates the regulation of Nrf2/ARE/NQO1 pathway. In this paper, first, we cloned the JNK gene and NQO1 gene of *Cristaria plicata*, and performed identification and functional analysis on them. Then combined with siRNA and qPCR technology, it was found that JNK negatively regulates Nrf2. Finally, Electrophoretic Mobility Shift Assays showed that Nrf2 protein can bind to NQO1 promoter in vitro. Dual-luciferase reporting assay showed that Nrf2 had transcriptional regulation effect on the NQO1 promoter.

Key words: *Cristaria plicata*, JNK, NQO1, Nrf2-ARE, Transcriptional regulation

石斑鱼 BAG5 的鉴定及其在病毒感染中的作用

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摘要: BAG5 (Bcl-2-associated athanogene 5)是一种可以与 Bcl-2 结合并促进细胞存活的分子伴侣。本研究中, 我们鉴定了斜带石斑鱼 (*Epinephelus coioides*) 基因 (*Ec-BAG5*) 的同源物, 并研究了 *Ec-BAG5* 在病毒感染中的作用。*Ec-BAG5* 蛋白编码 468 个氨基酸, 具有 4 个 BAG 结构域。进化树分析表明, *Ec-BAG5* 与鱼类的 BAG5 聚为一支。实时荧光定量 PCR 分析表明, *Ec-BAG5* 在外周血淋巴细胞 (PBL) 中表达最高。在赤点石斑鱼神经坏死病毒 (RGNNV) 或脂多糖 (LPS) 刺激后, *Ec-BAG5* 转录水平显着提高。此外, 体外过表达 *Ec-BAG5* 可以促进 RGNNV 病毒诱导的自噬, 并且抑制病毒外壳蛋白 (CP) 和 RNA 依赖性 RNA 聚合酶 (RdRp) 的表达。这些数据表明, *Ec-BAG5* 可以影响病毒感染, 这为更好地了解病毒感染的免疫反应提供了有用的信息。

关键词: 斜带石斑鱼; BAG5; 赤点石斑鱼神经坏死病毒; 自噬

The identification of grouper BAG5 and its roles during virus infection

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Abstract: Bcl-2-associated athanogene 5 (BAG5) is a kind of molecular chaperone that can bind to the Bcl-2 and promotes cell survival. In this study, we characterized a BAG5 homolog from orange-spotted grouper (*Epinephelus coioides*) gene (*Ec-BAG5*) and investigated its roles during viral infection. The *Ec-BAG5* protein encoded 468 amino acids with 4 BAG domain. Phylogenetic tree analysis revealed that *Ec-BAG5* was clustered with fish BAG5. qRT-PCR analysis revealed that *Ec-BAG5* was highest expressed in the peripheral blood lymphocyte(PBL). The *Ec-BAG5* transcripts were significantly up-regulated after red-spotted grouper nervous necrosis virus (RGNNV) or Lipopolysaccharide(LPS) stimulation *in vitro*. Furthermore, *Ec-BAG5* overexpression could promoted RGNNV induced-autophagy, but suppressed the expression of coat protein (CP) and RNA-dependent RNA polymerase (RdRp). These data indicate that *Ec-BAG5* can affect viral infection, which provide useful information to better understand the immune response against viral infection.

Key words: *Epinephelus coioides*; BAG5; RGNNV; Autophagy

多子小瓜虫侵染草鱼和光倒刺鲃转录组分析

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摘要: 草鱼是中国重要的淡水养殖鱼类, 但在网箱和清水中养殖的草鱼深受多子小瓜虫危害。与此同时, 同池饲养的光倒刺鲃却不易感染多子小瓜虫。为了进一步研究两种鱼类对多子小瓜虫的抗性机制, 分别取小瓜虫感染前后的草鱼和光倒刺鲃的鳃、皮肤、肝、脾和肾进行转录组测序分析。KEGG 富集分析后加权共表达网络分析 (WGCNA) 鉴定的 25 个关键免疫基因属于 9 个免疫途径 (Toll 样受体信号通路, p53 信号通路, 细胞因子-细胞因子-受体相互作用, 吞噬体, RIG-I 样受体信号通路, mTOR 信号通路, 胞吞作用, 细胞凋亡和补体凝血级联通路)。多子小瓜虫感染诱导草鱼产生了比光倒刺鲃更严重的炎症反应。值得关注的是多子小瓜虫感染后的光倒刺鲃鳃组织中 C3 基因表达量显著上调, 草鱼鳃组织中 C3 基因无显著上调。荧光原位杂交显示感染组光倒刺鲃 C3 基因在鳃弓、鳃丝和鳃小片大量阳性表达, 草鱼仅在鳃弓有少量表达。

关键词: 多子小瓜虫; 草鱼; 光倒刺鲃; 转录组学; 荧光原位杂交; 补体成分 C3

Transcriptomic analysis of grass carp and *Spinibarbus hollandi* in response to the infection of *Ichthyophthirius multifiliis*

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Abstract: Grass carp is one of the most valuable freshwater fishes in China, but the grass carp and other freshwater fishes were subjected to *Ichthyophthirius multifiliis*. However, the *Spinibarbus hollandi* breed in the same tank are not susceptible to *I. multifiliis*. To further investigate their resistance mechanism, the gill, skin, liver, spleen and kidney of the infected and the uninfected groups of the two fishes were sampled for transcriptomic analysis. KEGG enrichment analysis and WGCNA identify 25 key immune DEGs belonging to 9 immune pathways (Toll-like receptor signaling pathway, p53 signaling pathway, cytokine-cytokine-receptor interaction, phagosome and RIG-I-like receptor signaling pathway, mTOR signaling pathway, endocytosis, apoptosis and complement coagulation cascade pathway). These results demonstrated that the *I. multifiliis* induced grass carp to produce a severer inflammatory response than *S. hollandi*. It is worth noting that the expression of C3 gene in the gill of the *S. hollandi* was significantly up-regulated after being infected by *I. multifiliis*. Fluorescence in situ hybridization showed that the C3 gene of the infected *S. hollandi* was positively expressed in the gill arch, gill filament and secondary lamella, which only expressed a small amount in the gill arch of the grass carp.

Key words: *Ichthyophthirius multifiliis*, Grass carp, *Spinibarbus hollandi*, Transcriptomics, Fluorescence in situ hybridization, Complement component C3

草鱼体表粘液分泌的调控及机制

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摘要: 为探究草鱼(*Ctenopharyngodon idella*)体表粘液的分泌调控机制, 试验选取一组健康草鱼分别内服维生素 C500mg/Kg、应激宁(复方中药) 5 g/Kg15d 和外用硫酸铜 1 mg/L 和五倍子 2 mg/L 药物 5d, 进行多子小瓜虫 (*Ichthyophthirius multifiliis*)感染的预防试验, 另一组健康草鱼感染多子小瓜虫后分别用上述药物内服或外用 5d 的治疗试验, 分别测定两组草鱼皮肤粘液中的酸性磷酸酶、碱性磷酸酶、溶菌酶活性以及皮肤中 Muc5B 的表达量。结果表明预防组粘液中的酶活上升, 除五倍子预防后粘液中的 Muc5B 基因表达量下降外, 其余各组较健康对照均上升。治疗组中除硫酸铜和五倍子用后粘液中的溶菌酶活性下降, 其余酶活及 Muc5B 基因表达量均上升。结果表明维生素 C 内服治疗和预防效果最好。上述药物通过基因调控草鱼体表粘液的分泌及相关的酶活, 增强抗多子小瓜虫的免疫能力。

关键词: 草鱼; 粘液; 基因表达; 小瓜虫

Mechanism and Regulation of Surface Mucus Secretion in *Ctenopharyngodon idellus*

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Abstract: To explore the secretion regulation mechanism of *Ctenopharyngodon idella*'s body surface mucus, the test selects a group of healthy *Ctenopharyngodon idella*, an internal medicine of vitamin C500mg/Kg, 5 g/Kg15d and externally applied copper sulfate 1 mg/L and 2 mg/L chingall drug 5d to carry out the prevention test of *Ichthyophthirius Multifiliis* infection. The interpretation godon idella of a healthy *Ctenopharyngodon idella* infected with *Ichthyophthirius Multifiliis* was treated by the aforementioned drug internal and external 5D test, and the activity of acid phosphatase, alkaline phosphatase, lysozyme and the expression level of Muc5B in the skin mucus of the two groups of *Ctenopharyngodon idella* was determined respectively. The results showed that the enzyme activity in the mucus of the prevention group increased, except that the expression of Muc5B gene in the mucus decreased after the prevention of gallnut, the expression of Muc5B gene in the mucus increased in all the other groups compared with the healthy control group. In the treatment group, the lysozyme activity in the mucus decreased after the removal of copper sulfate and galla gallus, while the activity of other enzymes and the expression of Muc5B gene increased. The results showed that vitamin C had the best therapeutic and preventive effect. The above drugs genetically regulate the secretion of body surface mucus and related enzyme activity of *Ctenopharyngodon idella*, thus enhancing the immunity of *Ichthyophthirius Multifiliis*.

Key words: *Ctenopharyngodon idella*, Mucus, Gene expression, *Ichthyophthirius multifiliis*

中华草龟腐皮裂甲病病原的分离鉴定和组织病理学研究

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摘要: 中华草龟腹甲腐皮裂甲病典型的临床症状为腹甲角质层干裂、骨质层发黑, 病龟精神状态均表现呆滞、不爱爬动。病理解剖结果表现为肝脏发黑, 肺部发白, 肠道无内容物, 有腹水, 内脏团伴均有恶臭味。组织病理观察显示, 多数病龟密质骨发生裂解坏死为主, 骨髓腔浸润大量的嗜酸性粒细胞, 同时内脏组织均有炎症特征。进一步从病龟腹甲、肝脏、肺分离获得 5 株菌株, 经细菌形态学观察、生理生化试验、16S rDNA 基因序列以及系统发育分析等鉴定为嗜水气单胞菌, 人工回感染试验得到和自然发病龟的临床症状一致, 并且在回感中华草龟脏器中再分离到相同的菌株。结果表明中华草龟腐皮裂甲病的病原菌是嗜水气单胞菌, 药敏试验结果表明该菌对头孢类、庆大霉素、阿米卡星、卡那霉素、喹诺酮类抗菌药物高度敏感, 对青霉素类、四环素抗菌类药物有耐药性, 以上高度敏感药物可作为对该病的临床防治首选。

关键词: 中华草龟;嗜水气单胞菌;腐皮;裂甲;病原学;病理学

Isolation, Identification of the Pathogens and Histopathological Study of the cracked carapace disease in Chinese Pond Turtle *Chinemys reevesiis*

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Abstract: The typical clinical symptoms of Chinese Pond Turtle ventral nail rot and skin split onychomysis are cracked ventral horny layer and black bone layer. The sick turtle is sluggish and unmoving. The result of pathological anatomy is that the liver becomes dark, the lungs become white, there is no food in the intestine, there is ascites, and the internal organs emit an odor. Histopathological observation showed that the dense bone of most diseased turtles mainly lysed and necrosed, the bone marrow cavity was infiltrated with a large number of eosinophils, and the visceral tissue had inflammation characteristics. Five bacterial strains were isolated from the carapace, liver and lung of the turtle. The same strain was extracted from the carapace, liver and lung of the Chinese Pond Turtle in the artificial infection test. 16S rDNA gene sequence alignment, and phylogenetic analysis identified 5 strains as *Aeromonas hydrophila*. The results show that the pathogen of the Chinese Pond Turtle rot skin schizont disease is *Aeromonas hydrophila*. Drug susceptibility test results show that this bacterium is highly sensitive to cephalosporins, gentamicin, amikacin, kanamycin, and quinolone antibacterials, while it is resistant to penicillins and tetracyclines. The above highly sensitive drugs can be the first choice for clinical prevention and treatment of the disease.

Key words: *Chinemys reevesiis*; *Aeromonas hydrophila*; Skin rot; Ripped carapace; Etiology; Pathology

鲤 IL-17A/F1a 和 IL-17A/F1b 分子克隆和生物信息学分析

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摘要: 哺乳动物白细胞介素-17A (IL-17A) 和 IL-17F 具有较高氨基酸序列相似性, 生物学活性也较为相似, 是一类标志性的炎症细胞因子, 由 Th17 细胞分泌。在硬骨鱼中, IL-17A 和 IL-17F 的同义基因 IL-17A/F 已被克隆鉴定, 但对其功能研究较少。本研究通过分子克隆获得了鲤 IL-17A/F1a 和 IL-17A/F1b 基因序列, 并通过生物信息学分析, 结果显示鲤 IL-17A/F1a 和 IL-17A/F1b 的基因开放阅读框 (ORF) 长均为 480 bp, 编码由 159 个氨基酸组成的蛋白质。预测的 IL-17A/F1a 蛋白分子量为 17.6 kDa, 等电点 (PI) 为 7.62; IL-17A/F1b 蛋白分子量为 17.7 kDa, 等电点 (PI) 为 8.25。分析发现, 鲤 IL-17A/F1a 和 IL-17A/F1b 氨基酸序列 N 末端存在信号肽, 推测均为分泌蛋白。氨基酸序列比对结果显示, 鲤 IL-17A/F1a 和 IL-17A/F1b 分子与其他鲤科鱼类同源序列的一致性较高 (48%-92%), 并存在 5 个位置保守的半胱氨酸残基位点; 系统进化分析结果显示, 硬骨鱼类 IL-17A/F 在系统进化树上聚为一簇。以上结果为进一步研究 IL-17A/F1a 和 IL-17A/F1b 的功能及作用机制提供了理论依据。

关键词: 鲤; IL-17A/F1; IL-17A/F1b; 分子克隆; 序列特征

GCRV 096 VP6 蛋白及其对不同基因型 GCRV 在 CIK 细胞中复制的影响

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摘要: 草鱼呼肠孤病毒 (GCRV) 是草鱼出血病的病原。已知 GCRV 有四种基因型, 不同 GCRV 基因型间存在着很大的差异。本研究分析了不同 GCRV 分离株 VP6 蛋白的多样性, 并对 GCRV 096 VP6 蛋白对不同基因型 GCRV 在 CIK 细胞中复制的影响进行了研究。研究表明, GCRV 096 (基因型 I 型) VP6 蛋白与 GCRV GD108 (基因型 III 型) VP6 蛋白同源性很低, 蛋白互作位点预测中, 发现极少的保守位点。本研究表达并纯化了 GCRV 096 VP6 蛋白, 制备了其抗血清并进行鉴定。将纯化的 VP6 蛋白或抗血清添加到 CIK 细胞的培养基中可抑制细胞中 GCRV 096 的复制。然而, 在相同条件下, CIK 细胞中 GCRV GD108 (基因型 III 型) 的复制不受影响。总而言之, 研究结果表明了 VP6 蛋白和 VP6 抗血清不能在抗 GCRV 感染中产生交叉保护作用, 这可能与 GCRV 基因型间的差异有关。在开发有效的 GCRV 疫苗和其它抗草鱼出血病防治方法时, 必须考虑 GCRV 基因型的多样性。此外, 生物信息学分析表明 VP6 蛋白可能在 GCRV 感染过程中发挥作用。本研究为草鱼出血病的预防和 GCRV 发病机制的深入研究奠定了基础。

关键词: 草鱼呼肠孤病毒 (GCRV); VP6 蛋白; 复制; 功能分析

GCRV 096 VP6 protein and its impacts on GCRV replication with different genotypes in CIK cells

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Abstract: Grass carp reovirus (GCRV) is the causative agent of grass carp hemorrhagic disease. There are four known genotypes of GCRV and strains of different GCRV genotypes differ greatly. In this study, the diversity of the protein VP6 from different GCRV stains and the effect of genotype GCRV 096 on replication was investigated in CIK cells. Our results showed that the VP6 protein of GCRV 096 (genotype I) exhibited limited homology to that of GCRV GD108 (genotype III), with few residues conserved in predicted protein-protein interaction domains. GCRV 096 VP6 protein was expressed and purified and an antiserum against it was characterized. Addition of purified VP6 protein or antiserum to culture media of CIK cells inhibited the replication of GCRV 096 in these cells. In contrast, replication of GCRV GD108 (genotype III) was not affected in CIK cells under the same condition. Overall, our results indicated that the protein VP6 and VP6 antiserum did not provide cross-protection against GCRV strains and this can be attributed to differences among GCRV genotypes. It will be important to consider multiple GCRV genotypes in the development of effective GCRV vaccines and other therapies against grass carp hemorrhagic disease. In addition, bioinformatics analysis also suggested that the protein VP6 may have a role in the process of GCRV infection. This study lays the foundation for the prevention of grass carp hemorrhagic disease and further detailed studies on the pathogenesis of GCRV.

Key words: Grass carp reovirus (GCRV), Protein VP6, Replication, Functional analysis

红鳍东方鲀及欧鲈感染刺激隐核虫的转录组学分析

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摘要: 本文主要对红鳍东方鲀和欧鲈感染刺激隐核虫的鳃组织进行转录组学分析。通过结合 GO 和 KEGG 等生物信息分析方法, 我们发现 Toll 样受体、MAPK、C 型凝集素受体和 NOD 样受体等免疫相关信号通路在两种鱼的感染组中都显著上调表达。而在红鳍东方鲀鳃组织中, *AP-1*、*P38*、*IL-1β*、*HSP90* 和 *PLA* 显著上调表达, 在欧鲈的鳃组织中, *P38* 和 *PLA* 显著下调表达。综上所述, 我们推测 Toll 样受体、MAPK、C 型凝集素受体信号通路和 *AP-1*、*P38*、*IL-1β*、*HSP90* 和 *PLA* 等基因在两种鱼抗刺激隐核虫感染的过程中, 可能起着重要的免疫保护作用。这为我们进一步了解刺激隐核虫的感染机制, 并为该病害防控提供新的思路做好铺垫。

关键词: 刺激隐核虫; 红鳍东方鲀; 欧鲈; 转录组学; 感染机制

Transcriptome analysis of *Takifugu rubripes* and *Dicentrarchus labrax* after *Cryptocaryon irritans* infection

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Abstract: We analyzed the gills of *T. rubripes* and *D. labrax* after *C. irritans* infection by transcriptome to select differentially expressed genes (DEGs). Combined with GO and KEGG bioinformatics analysis methods and we found Immune-related pathways included Toll-like receptors, MAPK, C-type lectin receptor, and NOD-like receptor signaling pathways were significantly enriched pathways in the gills tissue of both fishes. The *AP-1*, *P38*, *IL-1β*, *HSP90*, and *PLA* were significantly up-regulated DEGs in *T. rubripes*, but *P38* and *PLA* were significantly down-regulated in *D. labrax*. Therefore, we guessed that toll-like receptor, MAPK, C-type lectin receptor signaling pathway and *AP-1*, *P38*, *IL-1β*, *HSP90* and *PLA* could play an important role in these two fish against *C. irritans* infection. Our work could provide a new theoretical basis for further understanding the mechanism of fish against *C. irritans* infection, and provide a novel technical support for preventing this disease.

Keywords: *Cryptocaryon irritans*, *Takifugu rubripes*, *Dicentrarchus labrax*, Transcriptome, mechanism of infection

罗非鱼源无乳链球菌(*Streptococcus agalactiae*) 新型 AI-2 信号分子受体 RbsB 蛋白结晶生长 研究

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摘要: 为了开展无乳链球菌(*Streptococcus agalactiae*)核糖结合蛋白(Ribose binding protein B, RbsB)结构功能的研究, 本实验根据已知无乳链球菌 ZQ0910 全基因组序列设计相关引物。采用 PCR 方法扩增其 *RbsB* 基因,随后将该基因定向克隆到原核表达载体 pGEX-6p-1 中,在大肠杆菌 BL21(DE3)感受态细胞中进行 IPTG 诱导表达;并对 RbsB 蛋白二级和三级结构进行预测;采用 NeXtal Tubes JCSG Core Suite 结晶试剂盒筛选蛋白结晶条件。

关键词:无乳链球菌; RbsB 蛋白; 蛋白纯化; 结晶化

Crystal growth of novel AI-2 signaling molecule receptor RBSB Protein from *Streptococcus agalactiae*

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Abstract: To understand the structural function of the RbsB (Ribose binding protein B, RbsB) protein in *Streptococcus agalactiae*, we designed primers according to the related genes registered on GenBank, and amplified the RbsB gene of the strain by PCR. The gene was directionally cloned into the prokaryotic expression vector pGEX-6p-1. In addition, we carried out IPTG-induced expression in *E. coli* BL21 (DE3) competent cells, predicted the secondary tertiary structure of RbsB protein, and screened the protein crystallization conditions in the NeXtal Tubes JCSG Core Suite crystallization kit.

Key words: *Streptococcus agalactiae*; RbsB protein; protein purification; crystallization

褶纹冠蚌硫氧还蛋白基因及启动子的克隆与功能分析

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摘要: Nrf2/ARE 抗氧化系统是调控多种抗氧化酶转录表达的关键内源性抗氧化应激通路, 可调节内源及外环境引发的氧化应激, 减少机体损伤。硫氧还蛋白是生物体调节体内氧化还原系统的一种重要蛋白质, 是 Nrf2-ARE 下游重要的靶基因之一。本研究从褶纹冠蚌中克隆得到硫氧还蛋白基因 (CpTrx) 的 cDNA 全长。荧光定量结果表明该基因在血细胞、肝胰腺、鳃、外套膜、闭壳肌中均有表达, 鳃中表达量最高。微囊藻毒素 (MC) 刺激后, CpTrx 在肾脏、鳃中的表达量显著上调; 分别敲降褶纹冠蚌 Nrf2 和 Keap1a 基因后, 在肾脏和鳃中, CpTrx 基因的表达量在 Nrf2 敲降组显著下调, 而在 Keap1a 敲降组显著上调。采用染色体步移法, 克隆得到 CpTrx 的启动子序列, 序列分析结果显示启动子序列具有多种转录因子结合位点。凝胶迁移率实验 (EMSA) 表明 Mafk 蛋白可以与 CpTrx 启动子结合, 推测褶纹冠蚌可通过 Nrf2/keap1a/Mafk 途径活化 Trx 基因, 来消减微囊藻毒素造成的氧化损伤。

关键词: 褶纹冠蚌; Thioredoxin; 微囊藻毒素; 启动子; Nrf2/ARE 信号通路

Cloning and functional analysis of thioredoxin gene and promoter from *Cristaria plicata*

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Abstract: Nrf2/ARE antioxidant system is the key endogenous anti-oxidative stress pathway for the transcription and expression of a variety of antioxidant enzymes, which can regulate the oxidative stress caused by the endogenous and external environment and reduce organism damage. Thioredoxin is not only an important protein regulating the redox system in vivo, but also is one of the important downstream target genes of NRF2-ARE. In this study, thioredoxin gene cDNA (CpTrx) was cloned from *Cristaria plicata*. The results of qRT-PCR revealed that CpTRX mRNA was constitutively expressed in tissues, and the highest expression level was in gills. After microcystin challenge, the expression levels of CpTrx were significantly increased in kidney and gills. Knock down Nrf2 and Keap1a genes of *C. plicata*, under the stimulation of microcystin, the expression of Trx gene in kidney and gills was down-regulated in the Nrf2 knock-down group, while Keap1a knockdown group showed significantly up-regulated. Chromosome walking method was used to clone the CpTrx promoter sequence. Its sequence analysis showed that the promoter had multiple transcription factor binding sites. Gel mobility experiment (EMSA) verified that the Mafk protein of *C. plicata* can bind to the TRX promoter. It is speculated that the Trx gene can be activated through the Nrf2/keap1a/Mafk pathway in *C. plicata* to reduce the oxidative damage of microcystin.

Key words: *Cristaria plicata*, Thioredoxin, Microcystin, Promoter, Nrf2/ARE pathway

对虾养殖场底泥中副溶血弧菌的质粒多样性及其与细菌毒力之间的关系

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摘要: 为了阐明副溶血弧菌引起的急性肝胰腺坏死病 (AHPND) 相关质粒在对虾养殖环境中的遗传多样性, 从中国五个省的虾场收集的 100 个底泥样品, 共从 100 个样品中分离出 15 株副溶血弧菌, 其中 13 株含有一到两个质粒, 随后进行攻毒实验发现菌株毒性有显著差异, 仅 *pirAB* 阳性菌株会产生 AHPND 症状, 死亡率为 100%。对质粒组成进行分析发现, 大部分质粒的遗传组成与质粒 *pVP2HP* 相似。研究结果表明, 在引起 AHPND 的副溶血弧菌的质粒中经常发生遗传交换和重组。这项研究增强了我们对引起 AHPND 的副溶血弧菌质粒遗传多样性的理解, 也为质粒之间的遗传信息交换提供了新的见解。

关键词: 质粒多样性; 虾; 副溶血弧菌; AHPND

Plasmid diversity of *Vibrio parahaemolyticus* in the sediment of shrimp farm and its association with the bacterial virulence towards shrimp

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Abstract: To elucidate the genetic diversity of Acute hepatopancreatic necrosis disease (AHPND) caused by *Vibrio parahaemolyticus* associated plasmid in the environment of shrimp farm, 100 sediments samples in shrimp farms from five provinces were collected in China. In total, 15 *V. parahaemolyticus* strains were isolated from 100 samples, of which 13 harbored one or two plasmids. *V. parahaemolyticus* strains were selected for challenge tests which exhibited a remarkable difference in terms of virulence towards shrimp. Only *V. parahaemolyticus* strain process *pirAB*-positive plasmid cause the symptoms of AHPND and 100% mortalities. Majority of plasmids were constituted by the part of the genetic component from plasmid *pVP2HP*. In summary, results indicated that genetic exchange and recombination frequently occurred in the plasmids of AHPND-causing *V. parahaemolyticus*. This study enhanced our understanding of the genetic diversity of plasmids in AHPND-causing *V. parahaemolyticus*, which provided new insights into the genetic exchange among the plasmid.

Keywords: plasmid diversity, evolution, shrimp, *Vibrio parahaemolyticus*, AHPND

蜕皮激素通过 Hippo-YAP 通路抑制中华绒螯蟹血淋巴细胞的增殖

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摘要: Hippo-YAP 通路在高等动物造血过程中发挥重要作用。本研究运用流式细胞术等生物学技术手段研究了蜕皮激素和 Hippo-YAP 通路在中华绒螯蟹造血过程中的调控作用。发现随着蜕皮激素注射含量的升高, 中华绒螯蟹血淋巴细胞中 EdU 阳性细胞的比例和处于 S 期的细胞比例显著降低; 当 Hippo 通路被抑制后, 血淋巴细胞中 EdU 阳性细胞的比例和处于 S 期的细胞比例均显著升高。进一步分析发现, 注射蜕皮激素后, MST 在血淋巴细胞中的磷酸化水平升高, YAP 从血淋巴细胞的细胞核转移到细胞质, 且 YAP 的磷酸化水平升高, 说明蜕皮激素可通过 MST 激活 Hippo-YAP 通路。以上结果表明, 蜕皮激素可通过激活 Hippo-YAP 通路抑制中华绒螯蟹血淋巴细胞的增殖。

关键词: 蜕皮激素; Hippo-YAP 通路; 血淋巴细胞增殖; 中华绒螯蟹

Ecdysone inhibited the proliferation of haemocytes by regulating Hippo-YAP pathway in Chinese mitten crab *Eriocheir sinensis*

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Abstract: Hippo-YAP pathway plays an important role in the hematopoiesis of mammals. In this study, the biological techniques including flow cytometry were performed to explore the regulation of ecdysone and Hippo-YAP pathway in the hematopoiesis of Chinese mitten crab. The proportion of EdU-positive cells and proportion of haemocytes in S phase were significantly down-regulated with the increase of ecdysone concentration injection, which were contrary to the results of inhibiting the Hippo pathway. After injection of ecdysone, the phosphorylation level of MST in haemocytes was increased, and YAP transferred from the nucleus of the hemolymph to the cytoplasm and the phosphorylation level of YAP was increased, indicating that ecdysone could activate the Hippo-YAP pathway by regulating MST. These results indicated that ecdysone was able to inhibit the proliferation of haemocytes by activating Hippo-YAP pathway.

Key words: ecdysone, Hippo-YAP pathway, proliferation of haemocytes, *Eriocheir sinensis*

尼罗罗非鱼 Galectin-related protein B 基因的原核表达与条件优化

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摘要: Galectin-related protein B 是一种缺乏半乳糖苷结合活性的半乳糖凝集素相关蛋白 B, 本研究基于 NCBI 公布的尼罗罗非鱼(*Oreochromis niloticus*) Galectin-related protein B 基因序列设计带酶切位点引物, 构建原核表达载体 pET-28a-GRP B, 将重组质粒导入大肠杆菌, 诱导重组质粒的蛋白表达, 并对蛋白表达条件进行优化。结果显示在 28℃ 条件下, IPTG 浓度为 0.20.mmol/L, 诱导 6h 时, 诱导重组蛋白的效果最佳。经 Western-blot 免疫印迹显示, 纯化后的重组蛋白能特异的与带 HIS 标签的单抗结合, 条带单一, 进一步证明该重组蛋白为 Galectin-related protein B 蛋白, 为后续研究罗非鱼抗体制备和蛋白的功能研究奠定了基础。

Prokaryotic Expression and Condition Optimization of Galectin-related protein B Gene in Nile Tilapia

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Abstract: Galectin-related protein B is a galactose lectin-related protein B which lacks galactoside binding activity. In this study, primers with restriction site were designed based on the Galectin-related protein B gene sequence of Nile tilapia (*Oreochromis niloticus*) published by NCBI, and the prokaryotic expression vector pET-28a-GRP B, was constructed. The recombinant plasmid was introduced into E. coli to induce the expression of the recombinant plasmid protein. The factors affecting the expression of the protein were optimized. The results showed that the concentration of the recombinant protein reached a maximum under the induced time of 6h, the induced temperature of 28 °C and concentration of IPTG of 0.20.mmol/L. Western-blot blotting showed that the purified recombinant protein could specifically bind to the monoclonal antibody with HIS tag and had a single band, which further proved that the recombinant protein was Galectin-related protein B protein, which laid a foundation for the follow-up study of antibody preparation and protein function of the *O.niloticus*.

Key words: *Oreochromis niloticus*, lectin-associated protein B, prokaryotic expression, condition optimization

罗非鱼无乳链球菌 Sip-pgk 融合蛋白乳酸菌口服疫苗制备及其免疫效果的研究

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摘要: 目前链球菌病是危害罗非鱼养殖的重要细菌性疾病。为研究安全有效、绿色环保的病害防治技术, 该研究构建表达无乳链球菌 Sip-pgk 融合蛋白的 pNZ8148-*sip-pgk* 质粒, 通过电转化乳酸乳球菌 NZ9000 中获得 *L.lactis* NZ9000 pNZ8148-*sip-pgk* 重组乳酸菌, 诱导表达 Western blot 鉴定, 制备 Sip-pgk 融合蛋白乳酸菌口服疫苗。将该口服疫苗通过灌胃免疫罗非鱼, ELISA 检测血清特异性抗体, 在灌胃免疫结束后的第 18 天腹腔注射无乳链球菌攻毒。结果显示, 与所有对照组比较 Sip-pgk 融合蛋白乳酸菌口服疫苗能够显著提高罗非鱼的血清抗体水平和抵抗无乳链球菌感染能力, Sip-pgk 融合蛋白乳酸菌口服疫苗的相对免疫保护率最高为 45.56%。该研究为研发安全有效的口服罗非鱼疫苗提供了实验基础。

关键词: 无乳链球菌; 乳酸菌疫苗; 融合蛋白; 免疫; 罗非鱼

The Preparation of *Lactococcus lactis* vaccine expressing *sip-pgk* fusion protein of *Streptococcus agalactiae* isolated from tilapia and immunogenicity analysis

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Abstract: Streptococcosis is a serious bacterial disease that threatens the cultivation of tilapia. In order to make a vaccine of fish disease prevention and control technology, we constructed a recombinant plasmid pNZ8148-*sip-pgk* which could express Sip-pgk fusion protein of *S. agalactiae*. The recombinant plasmid was electro-transferred into *L.lactis* NZ9000, expression of Sip-pgk fusion protein induced by nisin and tested by Western blot. Tilapia was vaccinated orally by gavage with of the recombinant *L.lactis* NZ9000 pNZ8148-*sip-pgk*, the ELISA was used to test the change of serum antibody. The results showed that oral Sip-pgk fusion protein *L.lactis* vaccine could significantly improve the serum antibody level and resistance to *L.lactis* infection in tilapia. The RPS of the oral Sip-pgk fusion protein *L.lactis* vaccine was 45.56%, which was the highest of all experimental groups. This study provides an experimental basis for the development of a safe and effective oral tilapia vaccine.

Key words: GnRH, *Streptococcus agalactiae*, *Lactococcus lactis* vaccine, fusion protein, immune, tilapia

北部湾养殖牡蛎体内异养细菌数量及其耐药性研究

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摘要: 为了探究北部湾养殖香港牡蛎(*Crassostrea hongkongensis*)的体内异养细菌(Heterotrophic bacteria)和弧菌(*Vibrio*)数量及其耐药情况变化, 对不同死亡率养殖区域牡蛎体内异养细菌分离培养统计、采用纸片扩散法(Kirby-Bauer 法) 等方法研究细菌的数量及耐药状况。结果表明: 高死亡率养殖区异养细菌($8.6 \pm 0.4 \times 10^6$ cfu·g⁻¹)和弧菌($9.5 \pm 0.4 \times 10^5$ cfu·g⁻¹)数量较高, 中死亡率养殖区异养细菌($6.9 \pm 0.2 \times 10^6$ cfu·g⁻¹)和弧菌($4.5 \pm 0.6 \times 10^5$ cfu·g⁻¹)数量次之, 低死亡率养殖区异养细菌($3.3 \pm 0.1 \times 10^6$ cfu·g⁻¹)和弧菌($2.5 \pm 0.6 \times 10^5$ cfu·g⁻¹)数量最低。耐药细菌主要为革兰氏阴性菌, 对β-内酰胺类(青霉素)、糖肽类(万古霉素)耐药率较高; 对四环素类(四环素、多西环素)的耐药率次之; 对氨基糖苷类(链霉素、庆大霉素、妥布霉素、新霉素)、大环内酯类(红霉素)、喹诺酮类(诺氟沙星、环丙沙星、氧氟沙星、恩诺沙星)耐药率较低。高死亡率牡蛎体内多重耐药菌占 79.7%; 中死亡率牡蛎体内多重耐药菌占 66.2%; 在低死亡率牡蛎体内多重耐药菌占 58.4%。异养细菌数量与死亡率呈正相关, 相关系数为 0.99。

关键词: 香港牡蛎; 异养细菌; 耐药率; 多重耐药菌; 弧菌

The number and antibiotic resistance of heterotrophic bacteria in *Crassostrea hongkongensis* in Beibu Gulf

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Abstract: In order to explore the quantity of heterotrophic bacteria and *Vibrio* spp. of *Crassostrea hongkongensis* in farming zones with different mortality rate. Heterotrophic bacteria in oysters were isolated and numbered. Antibiotic resistance profiles of the isolated strains were investigated by a disk diffusion method (Kirby-Bauer method). The results showed that the highest number of heterotrophic bacteria ($8.6 \pm 0.4 \times 10^6$ cfu·g⁻¹) and *Vibrio* ($9.5 \pm 0.4 \times 10^5$ cfu·g⁻¹) occurred in the farming zones with high mortality. The medium number of heterotrophic bacteria ($6.9 \pm 0.2 \times 10^6$ cfu·g⁻¹) and *Vibrio* ($4.5 \pm 0.6 \times 10^5$ cfu·g⁻¹) occurred in the farming zones with moderate mortality. Heterotrophic bacteria ($3.3 \pm 0.1 \times 10^6$ cfu·g⁻¹) and *Vibrio* ($2.5 \pm 0.6 \times 10^5$ cfu·g⁻¹) are least abundant in low mortality culture areas. The antibiotic-resistant bacteria are mainly gram-negative bacteria, with a high resistance rate to β-lactams (penicillin) and glycopeptides (vancomycin). The antibiotic resistant rate of tetracycline (tetracycline, doxycycline) is the second. The antibiotic resistance rates of aminoglycosides (streptomycin, gentamicin, tobramycin, neomycin) and macrolidene (erythromycin) to quinolones (norfloxacin, ciprofloxacin, ofloxacin, enoxacin) are lower. Multi-antibiotic resistant bacteria accounted for 79.7% in high mortality oysters; Multi-antibiotic resistant bacteria accounted for 66.2% in medium mortality oysters; In low mortality oysters multi-antibiotic resistant bacteria accounted for 58.4%. The number of heterotrophic bacteria is positively correlated with mortality, and the correlation coefficient is 0.99.

Key words: *Crassostrea hongkongensis*, Heterotrophic bacteria, Antibiotic resistance rate, Multi-antibiotic resistant bacteria, *Vibrio*

鱼类类结节病原舒伯特气单胞菌的致病机制研究

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摘要: 2009 年以来, 舒伯特气单胞菌病在养殖鱼类(鳢、大口黑鲈、罗非鱼)中暴发, 给我国水产养殖业造成了严重的经济损失。该病的典型症状为肾脏、肝脏、脾脏等器官肿大, 形成点状白色类结节结构。为了深入的了解该病的致病机理, 本实验采用同源重组的方法分别对其病原菌舒伯特气单胞菌的 IV 型菌毛、鞭毛和过氧化氢酶三个毒力基因进行敲除, 结果发现: 与野生株相比较, 三种基因缺失株生化特性和在 BHI 培养基中的生长速度均无显著差异。杂交鳢浸泡感染实验发现, IV 型菌毛和鞭毛敲除后对鱼体的粘附能力下降, 毒力有显著降低; 过氧化氢酶敲除株毒力有极显著降低。本研究探讨了三种毒力基因在舒伯特气单胞菌致病过程中的作用, 为鱼类舒伯特气单胞菌的防控提供理论支撑。

关键词: 舒伯特气单胞菌; IV 型菌毛; 鞭毛; 过氧化氢酶; 致病机制

Study on pathogenic mechanism of *Aeromonas schubertii*, a pathogen of fish sarcoidosis

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Abstract: Since 2009, an acute epidemic disease of *Aeromonas schubertii* infection in freshwater cultured fish (Snakehead, Largemouth Bass and Tilapia) has been outbreak in China. The main gross clinical symptom of diseased fish showed multiple organs exhibited varying degrees of enlargement, white necrotic foci were observed on the surface of the liver, spleen and kidney. To investigate the pathogenic mechanism of *A. schubertii*, type IV pili, flagellum and catalase gene deletion mutant strains of *A. schubertii* were constructed through insertional mutagenesis, and their virulence-associated phenotypes and pathogenicity were tested, respectively. Compared with the wild-type (WT) strain, the proliferation of three mutant strains were not changed, but fish challenged by immersion resulted in reduced cumulative mortality of three mutant strains compared with the WT strain. These results indicated that the type IV pili, flagellum and catalase are essential for *A. schubertii* pathogenicity.

Key words: *Aeromonas schubertii*, type IV pili, flagellum, catalase, pathogenesis

尼罗罗非鱼肝脏凝集素对细菌感染免疫应答的影响

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摘要: C型凝集素(ctl)在先天性和适应性免疫上起着重要作用。参与多种生理过程,包括细胞-细胞粘附、病原体免疫应答和细胞凋亡。去唾液酸糖蛋白受体(Asialoglycoprotein receptor, ASGPR)又称肝凝集素(hepatic lectin)ctl的一员,是第一个被发现的动物凝集素,但有关它的信息在硬骨鱼类中仍然相当有限。在本研究中,我们鉴定了尼罗罗非鱼肝脏凝集素(On-hl)。Onhl编码一种典型的Ca²⁺依赖性碳水化合物结合蛋白,主要以组织特异性方式在肝脏中表达。

关键词: C型凝集素; 肝凝集素; 尼罗罗非鱼; 细菌凝集; 免疫系统

Characterization of The hepatic lectin from Nile tilapia (*Oreochromis niloticus*) participated in immune response against bacterial infection

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Abstract: C-type lectins (CTLs) plays important roles in innate and adaptive immunity, CTLs participated in a variety of physiological processes including cell-cell adhesion, immune response to pathogens and apoptosis. Asialoglycoprotein receptor (ASGPR), also known as hepatic lectin, a member of CTLs, was the first animal lectin identified, yet information regarding it remains rather limited in teleost. In this study, we identified a putative protein in zebrafish, named as the zebrafish hepatic lectin (Onhl). The zh1 encoded atypical Ca²⁺ dependent carbohydrate-binding protein, and was mainly expressed in the liver in a tissue specific fashion.

Key words: C-type lectins, hepatic lectin, Nile tilapia, Bacterial agglutination, Immune system

尼罗罗非鱼 CD209 基因的克隆、表达及功能鉴定

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摘要: CD209 是一种模式识别受体, 在动物的先天免疫的启动和适应性免疫的激活中起着重要的作用。为了揭示尼罗罗非鱼的 CD209 的分子结构, 表达特性和初步了解其免疫功能, 本研究利用聚合酶链式反应(PCR)获得尼罗罗非鱼 *Oreochromis niloticus* CD209 的开放阅读框片段(Open Reading Frame, ORF), 命名为 *OnCD209*。

关键词: 尼罗罗非鱼; CD209; 荧光定量 PCR; 亚细胞定位; NF-κB

Cloning, Expression and Functional Identification of CD209 gene in *Oreochromis niloticus*

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Abstract: CD209 is a pattern recognition receptor that plays an important role in priming innate immunity and activating adaptive immunity in animals. To further understand the molecular structure, expression characteristics and preliminary understand its immune function of CD209 in Nile tilapia, the Open Reading Frame (ORF) of *Oreochromis niloticus* CD209 (*OnCD209*) was obtained.

Key Word: *Oreochromis niloticus*, qRT-PCR, Gene cloning, Subcellular localization, NF-κB

CyHV-2 感染的异育银鲫尾鳍细胞中病毒 miRNAs、mRNA 和蛋白的联合分析

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摘要: 为更好研究 CyHV-2 复制过程中病毒基因的表达情况以及初步探究病毒 miRNA 可能调控的病毒靶基因。我们重点研究 CyHV-2 感染 GiCF 细胞中 mRNA、蛋白和病毒 miRNA 表达谱。结果表明在 96hpi vs 48hpi, 156 个病毒基因都有表达, 其中 7 个基因显著上调, 28 个基因显著下调。但是翻译成功并检测到的只有 78 个病毒蛋白, 包括大量与病毒装配相关的膜蛋白和衣壳蛋白。最后, 分析得到的 10 个病毒 miRNAs (2 个 novel-miRNAs), 通过 qRT-PCR 验证 novel-miRNA CyHV-2-KT-635 靶向病毒基因(*orf19, orf23, orf118, orf121, orf127*), WB 进一步验证对 *orf121* 蛋白的表达有调控作用。

关键词: CyHV-2; 异育银鲫尾鳍细胞系; miRNA; mRNA; 蛋白

Integrated analysis of viral miRNAs、mRNA and protein in the caudal fin cells of *C. auratus gibelio* with cyprinid herpesvirus 2 infection

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Abstract: To better study the expression of virus gene during CyHV-2 replication and preliminary explore the viral targets which may modulated by viral miRNA. We focus on mRNA, protein, and viral miRNA expression profiles in GiCF cells infected with CyHV-2. The results revealed that 156 virus genes were differentially expressed during the infection, 7 viral genes were significantly up-regulated and 28 were significantly down-regulated at 96 hpi (hours post infection) vs 48hpi. 7 genes were significantly down-regulated and 28 genes were significantly up-regulated, but only 78 viral proteins, including a large number of membrane proteins and capsid proteins associated with the viral assembly, were successfully translated and detected. Finally, 10 miRNAs (contains 2 novel miRNAs) were obtained, CyHV-2 genes (*orf19, orf23, orf118, orf121, orf127*) targeted by the novel miRNA CyHV-2-KT-635 were predicted and validated by qRT-PCR, and the regulation of CyHV-2-KT-635 on *orf121* protein expression was verified by WB.

Key words: Cyprinid Herpesvirus 2, GiCF cells, miRNAs, mRNA, protein

长牡蛎 CgIL-17-5 诱导细胞因子表达的分子机制

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摘要: 白介素 17 (IL-17) 是一类经典的促炎细胞因子, 在高等动物免疫防御、组织修复、自身免疫性疾病、炎症性疾病中发挥重要作用。本研究分析了长牡蛎 CgIL-17-5 的结构特征, 研究了其作为促炎因子诱导下游细胞因子表达的功能。CgIL-17-5 含有一个典型的 IL-17 结构域。三维结构分析表明, CgIL-17-5 与人的 IL-17 结构相似, 均含有四个紧密折叠的 α 螺旋。在 LPS 刺激 24 h 后, 鳃中 CgIL-17-5 mRNA 表达量显著上升。注射重组 CgIL-17-5 后, 长牡蛎血淋巴细胞中 CgJNK、CgERK 和 CgP38 激酶的磷酸化水平升高, 转录因子 CgAP-1 和 CgRel 转位入核, CgIL-17-1 等细胞因子的 mRNA 表达量显著升高。研究结果表明, CgIL-17-5 作为一种促炎因子通过激活 MAPK 通路促进转录因子转位入核, 进而促进细胞因子表达, 在长牡蛎免疫应答中发挥重要作用。

关键词: 长牡蛎; 白介素 17; MAPK; AP-1; Rel

The mechanism of CgIL-17-5 in regulating the expression of cytokines in the Pacific oyster *Crassostrea gigas*

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Abstract: Interleukin-17 (IL-17) is a classic pro-inflammatory cytokine that plays an important role in the immune defense, tissue repair, autoimmune disease and the pathogenesis of inflammatory disease of vertebrates. In the present study, the sequence feature of CgIL-17-5 from oyster *Crassostrea gigas* and its function as a pro-inflammatory factor in inducing the expression of downstream cytokines was investigated. There is a typical IL-17 domain and four tightly folded alpha helixes identified in CgIL-17-5. The expression level of CgIL-17-5 mRNA was significantly increased at 24 h after LPS stimulation. After the injection of rCgIL-17-5, the phosphorylation of CgJNK, CgERK and CgP38 kinase the translocation of the transcription factors CgAP-1 and CgRel into the nucleus of haemocytes were induced, and the expression level of CgIL-17-1 mRNA was significantly enhanced. All the results collectively suggest that CgIL-17-5 activates the MAPK pathway to regulate the nuclear translocation of AP-1 and Rel and to eventually promote the production of cytokines, which acts as a pro-inflammatory cytokine to be involved in the immune response of oysters.

Key words: Interleukin 17; *Crassostrea gigas*; MAPK; AP-1; Rel

西白令海夏季狭鳕肝脏异尖线虫感染特性

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摘要: 为探究狭鳕 (*Gadus chalcogrammus*) 肝脏内寄生虫的寄生特性, 对2018年夏季采自西白令海域狭鳕肝脏内的异尖线虫 (*Anisakis* sp.) 进行收集统计, 并探究其感染强度对狭鳕生长造成的影响。结果显示, 狭鳕肝脏感染异尖线虫的感染率较高且感染强度较大, 60尾狭鳕样本中共发现异尖线虫864条, 93%的狭鳕肝脏被感染; 异尖线虫感染强度随寄主体长、肝重的增加而增加, 寄主肥满度与感染异尖线虫的强度不显著相关。研究结果为掌握狭鳕肝脏寄生虫的感染特性提供了基础信息, 为进一步研究北太平洋重要鱼种与寄生虫之间的寄生关系提供了科学参考。

关键词: 狭鳕; 肝脏; 异尖线虫; 寄生虫

Parasitic characteristics of *Anisakis* in the liver of *Gadus chalcogrammus* in the Western Bering Sea during summer

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Abstract: In order to investigate the parasitic characteristics of parasites in the Walleye pollock liver, the *Anisakis* sp. in the pollock liver in the western Bering Sea in the summer of 2018 were collected and counted, and the effect of the infection intensity on the growth of pollock was investigated. The results showed that a total of 60 pollock samples were dissected, and 864 *Anisakis* sp. were detected. *Anisakis* sp. were found in the livers of 93% of the pollock. The intensity of the parasite infection increased with the increase of host body length and liver weight. The fatness decreases with the increase of the intensity of the parasite infection, and the parasite has an adverse effect on the growth of the host fish. This study provides basic information for characteristics of walleye pollock liver parasites, and provides a scientific reference for further studying the parasitic relationship of important fish species in the North Pacific Ocean.

Key words: *Gadus chalcogramma*, liver, *Anisakis* sp., parasite

长牡蛎 cGAS 和 STING 对类干扰素合成的调控作用

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摘要: 干扰素系统在机体抗病毒免疫应答中发挥重要作用, 已有研究表明无脊椎动物中存在类干扰素系统。前期工作证实长牡蛎类干扰素 CgIFNLP 参与抗病毒免疫应答。本研究鉴定了长牡蛎中类 cGAS (CgcGAS) 和 STING (CgSTING) 基因, 二者蛋白序列均具有相对保守的结构特征。通过原核表达获得重组蛋白 (rCgcGAS 和 rCgSTING), 发现二者均可识别并结合病毒核酸。干扰素调节因子 (IRF) 是干扰素系统重要的调节分子, 本研究鉴定了长牡蛎类 IRF 分子 CgIRF8, 免疫荧光实验表明, 其主要分布于血淋巴细胞的细胞质, CgIRF8 响应 poly (I:C) 刺激并发生明显的核转移。利用 RNA 干扰实验分别敲低 CgcGAS 和 CgSTING 的表达, 结果显示二者的低表达均显著性抑制了 CgIRF8 的核转移, 并且抑制 CgIFNLP 及其下游干扰素刺激基因 (ISG) 的表达。因此推测长牡蛎 CgcGAS 和 CgSTING 均可响应病毒刺激, 并激活 CgIRFs 转位入核介导类干扰素 CgIFNLP 的表达。

关键词: 长牡蛎; 类干扰素系统; cGAS; STING; 抗病毒免疫

Regulation of CgcGAS and CgSTING on the expression of CgIFNLP in *Crassostrea gigas*

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Abstract: Interferon system plays a vital role in antiviral defence, previous researches have revealed the existence of interferon system in invertebrates. Recently, we identified an interferon-like protein CgIFNLP in *Crassostrea gigas*, which was demonstrated to activate the antiviral immune response. Here, the cyclic GMP-AMP synthase (CgcGAS) and stimulator of interferon gene (CgSTING) were also identified from *C. gigas*, and their predicted protein showed conserved structural features with the homologs in vertebrate. The rCgcGAS and rCgSTING could recognize the viral nucleic acid. The IRF family members are renowned for their involvement in the regulation of IFN responses. The CgIRF8 was identified in *C. gigas*, which responded to Poly (I:C) stimulation and transferred from cytoplasm to nucleus. Knockdown of CgcGAS or CgSTING suppressed expression levels of CgIFNLP and CgIRFs and the nuclear translocation of CgIRF8 after Poly (I:C) stimulation. Conclusively, both CgcGAS and CgSTING could recognize the viral nucleic acid, and activate the nuclear translocation of CgIRFs to mediate the expression of CgIFNLP.

Key words: *Crassostrea gigas*, interferon-like system, cGAS; STING, antiviral immunity

HPLC 法在线衍生测定中华绒螯蟹中 17 种氨基酸含量

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摘要:建立了中华绒螯蟹中 17 种氨基酸同时测定的反相高效液相色谱法。该方法以 DTDPA、OPA 和 FMOC 为柱前衍生化试剂。以 $\text{Na}_2\text{B}_4\text{O}_7$ 、 Na_2HPO_4 缓冲液、甲醇为流动相, 在线衍生进样、梯度洗脱, 紫外检测器检测, 外标法定量。结果表明: 17 种氨基酸在 25ng/mL~5000ng/mL 的范围内呈良好的线性关系, 其 R^2 在 0.9973~1.0000 之间。其检测限为 3.00ng/mL~7.50ng/mL; 在 2.30mg/g、4.60mg/g、6.90mg/g 三个加标浓度下的平均加标回收率在 82.6%~119.6%, RSD 为 0.91%~7.39%。该方法操作简便且定性可靠、定量准确, 实现了同时对中华绒螯蟹中氨基酸的准确定量。

关键词: 高效液相色谱法; DTDPA; OPA; FMOC; 柱前在线衍生化; 17 种氨基酸含量

Determination of 17 Amino Acids in *Eriocheir Sinensis* by HPLC on Line Derivatization

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Abstract: A RP-HPLC method was developed for the simultaneous determination of 17 amino acids in *Eriocheir sinensis*. DTDPA, OPA and FMOC were used as pre column derivatization reagents. Using $\text{Na}_2\text{B}_4\text{O}_7$, Na_2HPO_4 buffer and methanol as mobile phase, on-line derivatization injection, gradient elution, UV detector detection, external standard method quantitative. The results showed that there was a good linear relationship in the range of 25 ng / ml ~ 5 000 ng / ml for 17 amino acids, and their R^2 was between 0.9973 ~ 1.0000. The detection limit was 3.00ng/ml ~ 7.50ng/ml; the average recoveries were 82.6% ~ 119.6% with RSD of 0.91% ~ 7.39% at the three spiked concentrations of 2.30mg/g, 4.60mg/g and 6.90mg/g. The method is simple, reliable and accurate, and can be used for the simultaneous determination of amino acids in *Eriocheir sinensis*.

Key words: high performance liquid chromatography, 3,3'-2-thio-2-propionic acid, phthalaldehyde, 9-fluorene methyl chloroformate, pre column on-line derivatization, 17 amino acid

长牡蛎 E3 泛素连接酶 CgCHIP-like 泛素化调控血淋巴细胞的增殖和分化

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摘要: E3 泛素连接酶是泛素蛋白酶体系统的关键组成部分。本研究首次从长牡蛎 *Crassostrea gigas* 中克隆并鉴定一种 U-box 型 E3 连接酶, 命名为 CgCHIP-like。免疫共沉淀实验显示 CgCHIP-like 能够结合并泛素化修饰造血转录因子 CgRunx。泛素化修饰后, CgRunx 的表达水平显著性下调。相反地, CgCHIP-like 被干扰后, CgRunx 的 mRNA 和蛋白质表达水平均显著性上调, 颗粒细胞的分子标记 CgAATase 的表达水平显著升高, 而透明细胞的分子标记 CgCD9 的表达水平降低。同时, 颗粒细胞占总血淋巴细胞的比例及 EdU 阳性细胞比例显著增加, 而透明细胞的比例显著降低。上述结果表明, E3 泛素连接酶 CgCHIP-like 通过负向调控造血转录因子 CgRunx 的表达从而抑制颗粒细胞的增殖和透明细胞的分化, 揭示了泛素蛋白酶体系统在长牡蛎造血作用中发挥重要作用。

关键词: E3 泛素连接酶; 造血作用; 长牡蛎

E3 ubiquitin ligase CgCHIP-like regulates haemocyte proliferation and differentiation via ubiquitination of CgRunx in oyster *Crassostrea gigas*

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Abstract: E3 ubiquitin ligases are the critical components of the ubiquitin proteasome system. In the present study, a typical U-box E3 ubiquitin ligase CHIP-like (designated CgCHIP-like) was identified from oyster *Crassostrea gigas*. CgCHIP-like was found to directly bind, ubiquitinate and degrade CgRunx *in vitro*. After CgCHIP-like was knocked down by RNAi, the expression levels of CgRunx mRNA and protein were significantly up-regulated. Meanwhile, the expression of granulocyte specific marker CgAATase in haemocytes was promoted, whereas the expression of agranulocyte specific marker CgCD9 was inhibited. Accordingly, the percentage of granulocytes in total haemocytes was increased, while the percentage of agranulocytes was decreased. The EdU positive signals in granulocytes were significantly increased after CgCHIP-like was knocked down, which was consistent with the increase of granulocyte number. These results indicated that CgCHIP-like play important roles in the regulation of oyster haematopoiesis by inhibiting the proliferation of granulocytes and differentiation of agranulocytes.

Key words: Haematopoiesis, Ubiquitination, *Crassostrea gigas*

BBH 在异育银鲫体内三种主要组织中富集水平的比较研究

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摘要: 盐酸小檗碱(BBH), 一种具有生物活性的植物生物碱, 显示了对不同病毒的潜在抗病毒作用。本文报道了 BBH 在鲫鱼体内的药代动力学。在水温(20±2)°C下, 取供体量(90g±20g)的异育银鲫胃内灌胃 BBH, 剂量分别为 50mg/kg、30mg/kg 或 10mg/kg。分别在给药后 1、1.5、4、6、8、12、24、48 和 72 小时取样。我们报道了在鲫鱼体内 BBH 的药代动力学数据显示, 口服给药后 BBH 的快速吸收、合适的血浆半衰期和剂量依赖性药物暴露特性。口服 50mg/kg BBH 时肝胰脏中的最高药物浓度约为肾脏的 1.143 倍, 约为血液的 4.21 倍。这些发现阐明了用 BBH 治疗银鲫鲤疱疹病毒感染的新方法。

关键词: 异育银鲫鱼; 鲤疱疹病毒; BBH; 药代动力学

Comparative Study of BBH enrichment levels in three main tissues of *Carassius auratus gibelio*

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Abstract: Berberine hydrochloride (BBH), a bioactive plant-derived alkaloid, demonstrated potential antiviral actions against different viruses. Here, we report the pharmacokinetics of BBH in Crucian carp. At water temperature (20±2) °C, *carassius auratus gibelio* with donor mass (90g±20g) was given BBH in the stomach by tube at doses of 50mg/kg, 30mg/kg or 10mg/kg. Samples were taken at 1,1.5, 4,6,8,12,24,48 and 72 hours after administration. We report that pharmacokinetic data of BBH in Crucian carp reveals its rapid absorption, suitable plasma half-life, and dose-dependent drug exposure properties following oral administration. The highest drug concentration of BBH in hepatopancreatine at 50mg/kg was about 1.143 times that of the kidney and about 4.21 times that of the blood. These findings shed light on repurposing BBH to treat *Cyprinus herpes virus* infections in silver crucian carp.

Key words: *Carassius auratus gibelio*, *Cyprinus herpes virus*, BBH, Pharmacokinetics

罗非鱼无乳链球菌纤维二糖-磷酸转移酶系统 EII 酶复合体对其毒力的影响

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摘要: 为阐明纤维二糖磷酸转移酶系统 (cel-PTS) 的 EII 酶复合体在无乳链球菌毒力调控中的作用, 采用同源重组的方法, 构建了强毒菌株 THN0901 和弱毒菌株 TFJ0901 的 *cel-EII* 基因缺失株。结果表明, THN0901 和 TFJ0901 基因缺失株的纤维二糖代谢和生物膜形成能力显著降低 ($P < 0.01$), 对罗非鱼脑细胞的粘附能力和体内外混合竞争能力增强。与其野生株相比, TFJ0901 的 *cel-EII* 缺失株其毒力和组织病理学损伤明显增强, PTS 系统的 *manA* 和 *ascA/C*、双组份系统的 *ciaR* 和 *dltR* 以及 *pavA*、*bca* 和 *spb1* 等毒力基因表达显著上调, 而 THN0901 的 *cel-EII* 缺失株上述基因则下调。综上所述, EII 酶复合体负调控 TFJ0901 的毒力, 而对 THN0901 的毒力无明显影响。

关键词: 无乳链球菌; EII 酶复合体; 生物学特性; 毒力调控

The influence of enzyme EII of cellobiose-phosphotransferase system on virulence of *Streptococcus agalactiae* in tilapia

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Abstract: To elucidate the role of EII complexes of cellobiose-phosphotransferase systems (cel-PTS) in the virulence regulation of *S. agalactiae*, Δ cel-EII mutant in high-virulence strain THN0901 and low-virulence strain TFJ0901 were constructed by homologous recombination. The results showed that after the deletion of cel-EII complexes, the biological characteristics in THN0901 and TFJ0901 were consistent, including the cellobiose metabolism and biofilm formation ability were significantly reduced ($P < 0.01$), and the adhesion ability to tilapia brain cells and mixed competition ability in vitro and in vivo were enhanced. The virulence and histopathological lesions caused by Δ cel-EII-TFJ0901 were significant enhanced relative to that of TFJ0901. Furthermore, the expression level of *manA* and *ascA/C* of PTS, *ciaR* and *dltR* of two-component signal transduction system (TCS), and *pavA*, *bca* and *spb1* of virulence genes of Δ cel-EII-TFJ0901 were significant upregulated compared with TFJ0901 ($P < 0.01$), whereas that of Δ cel-EII-THN0901 were significant downregulated ($P < 0.01$) or downregulated compared with THN0901. Taken together, cel-EII complexes may negative regulation the virulence of TFJ0901 by regulating the expression of the virulence-related genes, but the negative regulation mechanism of the above-mentioned cel-EII complex has no obvious effect on the virulence of THN0901.

Keywords: *Streptococcus agalactiae*; EII complexes; biological characteristics; virulence regulation

哈维氏弧菌 *glyA* 基因的克隆及原核表达分析

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摘要: 哈维氏弧菌 (*Vibrio harveyi*) 广泛存在于海洋环境, 近几年高密度养殖使它成为海水鱼致病甚至死亡的原因之一。本实验对哈维氏弧菌 ZJ0603 株中 *glyA* (MT364338) 基因进行克隆及原核表达分析。首先, 应用 PCR 技术获得哈维氏弧菌菌株 ZJ0603 的 *glyA* 基因, 随后将 *glyA* 基因与表达载体 pET-28a 连接构建重组质粒 pET-28a-*glyA*, 并成功构建 BL21-pET-28a-*glyA* 重组菌株, 测序后选取正确的菌株用 IPTG 诱导并对重组蛋白进行 Western blot 分析鉴定, 结果表明成功获得了 SHMT 重组蛋白。最后用控制变量法对表达条件优化后发现, IPTG 最佳诱导时间、浓度以及温度分别为 4 h、0.4 mmol/L 和 37 °C。

关键词: 哈维氏弧菌; *glyA* 基因; 原核表达; 条件优化

Cloning and Prokaryotic Expression Analysis of *glyA* Gene of *Vibrio harveyi*

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Abstract: *Vibrio harveyi* (*Vibrio harveyi*) is widespread in the marine environment. In recent years, high-density aquaculture has made it one of the causes of disease and even death of marine fish. In this experiment, the *glyA* (MT364338) gene in *Vibrio harveyi* ZJ0603 strain was cloned and analyzed for prokaryotic expression. First, the *glyA* gene of *Vibrio harveyi* strain ZJ0603 was obtained by PCR technology, and then the *glyA* gene and the expression vector pET-28a were connected to construct the recombinant plasmid pET-28a-*glyA*, and the BL21-pET-28a-*glyA* recombinant strain was successfully constructed. After sequencing, the correct strain was induced with IPTG and the recombinant protein was analyzed and identified by Western blot. The results showed that the SHMT recombinant protein was successfully obtained. Finally, after optimizing the expression conditions using the controlled variable method, it was found that the optimal induction time, concentration and temperature of IPTG were 4 h, 0.4 mmol/L and 37 °C.

Keywords: *Vibrio harveyi*, *glyA* gene, prokaryotic expression, optimization of conditions

黄颡鱼和斑点叉尾鮰体表溃烂症微生物鉴定

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摘要: 由于细菌繁殖速度快、可独立于寄主生存在水环境中, 因此, 细菌性疾病是困扰我国渔业经济发展的重要原因。2020 年 6 月, 我们在中洋公司广东的养殖场中发现养殖的黄颡鱼 (*Tachysurus fulvidraco*) 和斑点叉尾鮰 (*Ictalurus punctatus*) 游动缓慢、体表出血、溃烂, 并且池中大量鱼有类似症状。我们对病鱼的伤口进行了解剖取样, 提取了其中的微生物 DNA, 测序, 同时对这些微生物进行分离培养, 确定本次发病的主要致病菌。结果表明, 两种鱼伤口处的微生物群落组成有显著差异, 黄颡鱼中气单胞菌 (*Aeromonas*)、弧菌 (*Vibrio*) 较多, 而斑点叉尾鮰主要为变形杆菌 (*Proteus*)、库尔特氏菌 (*Kurthia*)。本研究可为未来我国水产养殖过程中, 对鱼类细菌性疾病的快速鉴定和预防提供一定的数据支持。

关键词: 气单胞菌; 鱼类细菌性疾病; 斑点叉尾鮰; 溃疡; 黄颡鱼

Microbial identification of skin ulceration disease of Yellow catfish and Channel catfish

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Abstract: Bacteria grow fast and can live in the water environment without host. Therefore, bacterial disease is an important reason to restrict the development of fishery economy in China. In June 2020, we found that the Yellow catfish (*Tachysurus fulvidraco*) and Channel catfish (*Ictalurus punctatus*) swimming slow, hemorrhage and ulceration in Zhongyang Group. And large Numbers of fish in ponds have similar symptoms. We dissected the wounds of the infected fish, extracted the microbial DNA, and sequenced it. Meanwhile, we isolated and cultured these microbes to identify the main pathogenic bacteria. The results showed that there were significant differences in the microbial community in the wounds of the two fish. There were more *Aeromonas* and *Vibrio* in the Yellow catfish, while the Channel catfish were mainly *Proteus* and *Kurthia*. This study can provide data for the identification and prevention of fish bacterial diseases in the process of aquaculture in the future.

Key words: *Aeromonas*, Bacterial disease of fish, Channel catfish, hemorrhage, Yellow catfish

水体入侵对中国内陆咸水水体致病性弧菌种类的影响

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摘要: 河口为海水和河流提供了丰富的有机和无机营养。然而, 对这些弧菌在内陆微咸水区的生态状况知之甚少。本研究采用最可能数聚合酶链反应 (MPN-PCR) 方法, 研究了它们在中国浑太河中的共现情况及其与主要环境约束 (盐度和温度) 的关系。结果表明, 21.9%的水样检出致病性弧菌。特别是霍乱弧菌、副溶血性弧菌和创伤弧菌分别在10份 (10.4%)、20份 (20.85%) 和2份 (2.08%) 样本中分离到。副溶血弧菌 tdh 基因均为阴性, trh 基因阳性率为10%。多位点序列分型 (MLST) 将浑太河副溶血弧菌分为12个序列型。对12株霍乱弧菌分离株进行了6个毒力基因和第7次大流行岛 I、II 的PCR检测, 发现3种基因型。我们的研究结果显示, 海水入侵和盐度对内河致病性弧菌的分布有着深刻的影响, 这表明浑太河用于灌溉和饮用的水域存在潜在的健康风险。

关键词: 海水入侵; 副溶血性弧菌; 霍乱弧菌; MLST; 毒力因子

The Impact of Water Intrusion on Pathogenic Vibrio Species to Inland Brackish Waters of China

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Abstract: Estuaries provide rich organic and inorganic nutrients for seawater and rivers. However, little is known about the ecology of these Vibrio species in the inland brackish water area. In this study, their co-occurrence and relationships to key environmental constraints (salinity and temperature) in the Hun-Tai River of China were examined using the most probable number polymerase chain reaction (MPN-PCR) approach. The results showed that Pathogenic Vibrio spp. were detected in 21.9% of the water samples. In particular, *V. cholerae*, *V. parahaemolyticus*, and *V. vulnificus* were isolated in 10 (10.4%), 20 (20.85%), and 2 (2.08%) samples, respectively. All *V. parahaemolyticus* strains were tdh gene negative, 10% were positive for the trh gene. Multi-locus sequence typing (MLST) divided *V. parahaemolyticus* strains into 12 sequence types (STs) for the Hun-Tai River. The PCR assay for detecting six virulence genes and Vibrio seventh pandemic island I and II revealed three genotypes in 12 *V. cholerae* isolates. The results of our study showed that seawater intrusion and salinity have profound effects on the distribution of pathogenic Vibrio spp. in the inland river, suggesting a potential health risk associated with the waters of the Hun-Tai River used for irrigation and drinking.

Key words: GnRH, CNS, ovarian maturation, *Penaeus monodon*, immunocytochemistry, qPCR

基于代谢组学技术研究硫酸铜对水霉病的抑制作用

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摘要: 水霉病的病原体主要是水霉菌, 寄生在鱼体的伤口和鱼卵上的一种常见疾病, 尤其在春季和夏季初期会给养殖鱼类造成巨大的损失。硫酸铜经证明能够有效的减少鱼体感染水霉病, 为进一步了解硫酸铜抑制水霉的作用机制, 本研究采用液相色谱-质谱联用技术(LC-MS)比较了水霉标准菌株(ATCC 200013)在硫酸铜处理条件下和对照组代谢产物的差异。结果显示硫酸铜处理后氨基酸、脂类和碳水化合物含量显著下降。同时, 有 5 个代谢途径受到影响, 包括氨基酸生物合成、柠檬酸循环、糖酵解/糖异生、尿循环和色氨酸代谢。改变的代谢产物和代谢途径主要与能量的产生、蛋白质的合成和代谢有关。这些结果从代谢组学的角度深入探讨硫酸铜抑制水霉的机制提供了理论依据, 也为水霉病的防治提供了参考。

关键词: 水霉菌; 代谢组学; 硫酸铜; LC-MS

Analysis of the *Saprolegnia Parasite* Metabolome Following Treatment with Copper Sulphate

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Abstract: Saprolegniasis, a damaging disease arising from *Saprolegnia oomycetes*, causes enormous losses in many farmed fish. Copper sulphate can reduce infections effectively. Herein, the metabolome of two groups of *Saprolegnia* ATCC200013TM with copper sulfate treatment and the controls were compared through liquid chromatography-mass spectrometry (LC-MS). Results revealed the marked down-regulation of amino acids, lipids and carbohydrates after treatment with copper sulphate. Moreover, there were 5 metabolic pathways that were affected including biosynthesis of amino acids, citrate cycle, glycolysis/gluconeogenesis, urine cycle and tryptophan metabolism. The altered metabolites and pathways were mainly related to the production of energy, protein synthesis and metabolism. The results provide insights into the mechanism from the perspective of metabolome, provide a theoretical basis for further investigation of the mechanism of copper sulfate inhibited the *Saprolegnia* and a reference for the prevention and control of *Saprolegnia*.

Keywords: Saprolegniasis, Metabolomics, Copper sulphate, LC-MS

养殖胡子鲶杀鱼爱德华氏菌的分离鉴定

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摘要: 爱德华氏菌是一类水生动物的重要病原菌, 导致全球水产养殖业严重经济损失。从广东省湛江市患溃疡病的养殖胡子鲶中分离到一株致病菌, 回归感染实验证实分离菌株为胡子鲶的病原菌, 半数致死量 (LD₅₀) 为 3.25×10^4 CFU/g。通过形态学观察生理生化鉴定、16S rDNA 序列测定以及多位点序列分析 (MLSA), 鉴定该病原菌为杀鱼爱德华氏菌 (*Edwardsiella piscicida*)。药物敏感性实验结果显示, 该菌对所测试的 38 种药物中的头孢曲松、诺氟沙星等药物表现敏感; 对四环素等耐药。研究为防治该病暴发提供了理论依据。

关键词: 胡子鲶; 杀鱼爱德华氏菌; 分离鉴定

Isolation and Identification of *Edwardsiella piscicida* from cultured *Clarias fuscus*

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Abstract: *Edwardsiella* is an important pathogen of aquatic animals and will cause serious economic losses to the global aquaculture industry. A pathogenic bacterium was isolated from a cultured *Clarias fuscus* with ulcer disease in Zhanjiang City, Guangdong Province. Regression infection test confirmed that the isolated strain is the pathogen of *Clarias fuscus* and the median lethal dose (LD₅₀) is 3.25×10^4 CFU/g. Through morphological observation, physiological and biochemical identification, combined 16S rDNA sequencing and Multi-locus Sequence Analysis (MLSA), identified as this pathogen as *Edwardsiella piscicida*. Drug sensitivity experimental results showed that the bacteria was sensitive to drugs such as ceftriaxone and ofloxacin among 38 drugs tested. Resistance to tetracycline and so on. This study provides a theoretical basis for the prevention and treatment of this disease outbreak.

Keyword: *Clarias fuscus*, *Edwardsiella piscicida*, Isolation and Identification

尼罗罗非鱼 *Crtam* 基因的克隆鉴定与 mRNA 表达分析

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摘要: *Crtam* 作为 NK 细胞和 CD8⁺T 细胞的活化标志物, 在哺乳动物中已证实参与多种免疫途径, 但在罗非鱼中的作用未知。本研究克隆鉴定了尼罗罗非鱼 *Crtam* cDNA 全长(命名为 *On-Crtam*), 并对该基因进行生物信息学分析, 运用荧光定量 PCR 方法对无乳链球菌刺激后 *On-Crtam* mRNA 在各免疫组织及器官中的表达模式进行了研究。结果显示, *Crtam* 在鱼类进化过程中较保守。*On-Crtam* 在健康尼罗罗非鱼各组织及器官中均有表达。经 poly I:C 病毒类似物和灭活无乳链球菌刺激后, *On-Crtam* 的表达量在免疫组织及器官中表现为极显著上调。该研究表明 *On-Crtam* 基因可能在无乳链球菌和 poly I:C 病毒类似物等病原入侵宿主过程中发挥重要作用。

关键词: 尼罗罗非鱼; *Crtam*; 无乳链球菌; 克隆; 表达分析

Clone identification and mRNA expression analysis of *Crtam* gene in Nile Tilapia

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Abstract: *Crtam*, as an activation marker of NK cells and CD8⁺T cells, has been shown to be involved in various immune pathways in mammals, but its role in tilapia remains unknown. In this study, the full-length *Crtam* cDNA of Nile tilapia (named *On-Crtam*) was cloned and identified, bioinformatics analysis of the gene was performed, and the expression pattern of *On-Crtam* mRNA in various tissue species after stimulation by *Streptococcus agalactis* was studied by fluorescence quantitative PCR. The results showed that *Crtam* is more conservative in the evolution of fish. *On-Crtam* was expressed in all tissues and organs of healthy Nile tilapia. After the stimulation of poly I:C virus analogs and inactivated *Streptococcus agalactis*, the expression level of *On-Crtam* was significantly up-regulated in immune tissues and organs. This study shows that the *On-Crtam* gene may play an important role in the invasion of host pathogens such as *Streptococcus agalactiae* and poly I: C virus analogs.

Keywords: Nile tilapia, *Crtam*, *Streptococcus agalactiae*, Cloning, Expression analysis

贝类 p62 参与 Nrf2/Keap1 通路消减微囊藻毒性的分子机制研究

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摘要: 蓝藻水华产生的微囊藻毒素 (MC) 严重影响了贝类的生存。贝类可以通过直接的摄食活动将 MC 快速地富集在体内通过产生活性氧簇 (ROS) 引起贝类机体氧化系统失衡, 以致细胞损伤。已知 ROS 可通过多条信号途径诱导细胞产生自噬和激活 Nrf2/Keap1 途径以缓解氧化损伤。首先, 本实验室发现褶纹冠蚌在 MC 的胁迫下, Nrf2、Keap1 基因和下游抗氧化酶基因的表达均上调, 其蛋白活性也均上调。其次, 克隆了褶纹冠蚌 p62 和 LC3, 发现 MC 攻击模型和 CpNrf2 敲降模型中 Cpp62 和 CpLC3 的表达发生改变, 并且 MC 攻击模型产生自噬小体, 构建的自噬抑制剂 (3-MA) 和自噬激活剂 (Rap) 贝类模型中 CpNrf2 和下游抗氧化酶基因表达、蛋白活性均发生变化。最后, 克隆了 Cpp62 基因启动子, 发现 Cpp62 启动子与 CpNrf2 蛋白在体外亲和性较好, Cpp62 对 NQO1 启动子、CpNrf2 对 Cpp62 启动子都具有调控作用。明确了 p62 与 Nrf2/Keap1 通路的之间的联系以及 p62/Keap1-Nrf2 通路介导细胞自噬调控贝类氧化应激消减 MC 毒性的先天免疫功能。这将有助于了解自噬参与贝类氧化应激的调控机制。

关键词: 贝类; 微囊藻毒素; Nrf2/Keap1; 自噬

Molecular mechanism of shellfish p62 involved in Nrf2 / Keap1 pathway to reduce Microcystis toxicity

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Abstract: Microcystins (MC) produced by cyanobacteria blooms seriously affect the survival of shellfish. Shellfish can accumulate MC rapidly in the body through direct feeding activities, and the imbalance of oxidation system caused by the production of reactive oxygen species (ROS) leads to cell damage. ROS can induce cells to produce autophagy and activate Nrf2 / Keap1 pathway to alleviate oxidative damage. Firstly, we found that the expression of CpNrf2, CpKeap1a and downstream antioxidant enzyme genes were up-regulated, and the activity of these protein were also up-regulated. Secondly, the sequence of Cpp62 and CpLC3 were cloned. Compared with MC group, the expression of Cpp62 were down-regulated, which of CpLC3 were up-regulated, and the MC attack model produced autophagosomes. Finally, the Cpp62 gene promoter was cloned, and Cpp62 promoter has a good affinity with CpNrf2 protein in vitro. In addition, Cpp62 and CpNrf2 protein can regulated NQO1 and Cpp62 promoter, respectively.

Key word: Shellfish, Microcystins, Nrf2/Keap1, autophagy

大西洋鲑感染杀鲑气单胞菌后 MicroRNA 筛选及功能分析

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摘要: MicroRNA(miRNAs)是内源性的非编码 RNA, 其可以通过与靶基因结合, 调控基因转录后表达。目前已知 miRNA 在发育、癌症、细胞分化、细胞增殖与凋亡、脂肪代谢等方面发挥重要作用。然而, 有关大西洋鲑中 miRNA 功能的研究还知之甚少。本文共设置实验组三个: 即感染杀鲑气单胞菌的高浓度感染组 (3.06×10^8 CFU/mL)、低浓度感染组 (3.06×10^5 CFU/mL) 和对照组 (100 μ L PBS 缓冲液), 并提取三个组别中鱼的鳃组织进行高通量测序。通过结合 GO 注释和 KEGG 分析等方法, 我们共鉴定到 242 种 miRNAs, 676 种 novel miRNAs。根据 \log_2 fold change >1 及 q values < 0.01, 我们对 38845 种 miRNAs 进行了靶基因预测, 发现显著差异表达的 miR-146a、miR-21、miR-143 和 miR-novel_142 的靶基因主要富集在 ErbB 信号通路、mTOR 信号通路和 Jak-STAT 等免疫相关的信号通路中。因此, 我们推测这些 microRNAs 可作为潜在研究的指示因子, 并以此为基础, 为深入解析大西洋鲑抵抗杀鲑气单胞菌的病害防控提供理论指导。

关键词: microRNA; 大西洋鲑; 杀鲑气单胞菌

Functional analysis of MicroRNA in Atlantic salmon immuno-resistant against *Aeromonas salmonicida* infection

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Abstract: MicroRNA (miRNAs) are endogenous non-coding RNA that could regulate target genes expression by binding to 3'UTRs. MiRNAs play a vital role in physical development, cancer, apoptosis and lipid metabolism. However, the function of miRNA in response to Atlantic salmon against *A. salmonicida* infection remains unknown. In this study, we challenged Atlantic salmon at high dose infection (3.06×10^8 CFU/mL), low dose infection (3.06×10^5 CFU/mL), and PBS (100 μ L). We extracted the gill tissues for high-throughput sequencing. Then we obtained 242 known miRNAs and 676 novel miRNAs through gene ontology and KEGG rich analysis. We found the target gene of miR-146a、miR-21、miR-143 and miR-novel_142 were involved in the immune response, such as ErbB signaling pathway, mTOR signaling pathway and Jak-STAT signaling pathway. Overall, our results suggest that these miRNAs could as indicators of potential research to provide theoretical guidance for analysis Atlantic salmon immuno-resistant against *A. salmonicida* infection.

Key words: miRNA, Atlantic salmon, *Aeromonas salmonicida*

蒸制对栉孔扇贝不同部位镉分布的影响

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摘要: 为探究栉孔扇贝不同部位的镉含量水平并评价蒸制处理对扇贝中镉分布的影响, 本研究对栉孔扇贝样品进行不同时长的蒸制处理, 以未经蒸制的扇贝作为对照组, 将处理完成的扇贝样品解剖为肌肉、性腺、鳃、外套膜和内脏五部分并收集蒸制过程中产生的蒸出液。通过电感耦合等离子体质谱法 (Inductively Coupled Plasma Mass Spectrometry, ICP-MS) 对样品进行检测。结果发现, 内脏是栉孔扇贝镉富集的主要组织, 其浓度达到 27.12 ± 0.86 mg/kg (湿重), 是其余组织镉浓度的十倍以上, 该部位含量超过扇贝软组织中镉总量的 85%。栉孔扇贝的质量损失和水分损失都主要发生在蒸制初期 (0-3 min), 在该阶段, 部分镉自扇贝内脏迁出到鳃和性腺中, 作短暂停留后转移至蒸出液。经过 15 min 蒸制后, 内脏、肌肉和外套膜中的镉含量显著降低 ($p < 0.05$), 由扇贝组织转移至蒸出液的镉超过总量的 21%。该研究表明, 蒸制可有效降低扇贝食用的镉暴露风险, 去除扇贝内脏和蒸出液也是提高扇贝食用安全性的有效方法。

关键词: 栉孔扇贝; 镉; 蒸制; 加热; 重金属; 电感耦合等离子体质谱法

Effect of Steaming on Organ Distribution of Cadmium in *Chlamys farreri*

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Abstract: The objective of this study was to investigate the organ distribution of cadmium (Cd) in *Chlamys farreri* (*C. farreri*) and evaluate the effect of steaming practices on the Cd levels in different tissues. Viscera was tissue with the highest Cd concentration (27.12 ± 0.86 mg/kg wet weight) in the raw scallops, and contributed more than 85% to Cd content of the whole scallop soft tissues. Both weight and moisture loss process of scallop tissues mainly occurred in the heating stage within 3 min. A part of Cd migrated from the viscera to the gill and gonad in the initial stage of steaming (3 min), and finally transferred to the juice after a short stay. A large amount of Cd (21%) migrated from the soft tissue of scallops into the juice, and making juice the part with the second highest content of Cd element. Avoiding the consumption of scallop viscera and juice, and removing the viscera before cooking or preparing deep-processed products are both considered effective measures to reduce the risk of exposure to Cd contamination of scallops.

Key words: *Chlamys farreri*, cadmium, steaming, heating, heavy metal, ICP-MS

HPS 通过抑制 Hsp70 抗水生呼肠孤病毒的研究

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摘要: 我们前期的研究发现, Hsp70 在草鱼呼肠孤病毒 (GCRV) 感染的细胞中显著上调, 并在促进 GCRV 感染中起积极作用。HPS 是一种植物来源的膳食类黄酮, 它通过抑制热休克因子 (HSF) 的活化来抑制应激诱导的 Hsp70 在动物细胞中的表达。本研究发现, GCRV104 感染诱导了 Hsp70 的表达, HPS 可以抑制 Hsp70 的表达并减少病毒蛋白的表达和子代病毒的产生, 热激处理可以减弱 HPS 对 Hsp70 表达的这些抑制作用, 表明 Hsp70 参与了 HPS 介导的抗病毒作用。此外, 我们发现病毒双链 RNA (dsRNA) 与 Hsp70 共定位, 提示 Hsp70 可能在病毒复制和转录复合体 (RTC) 的构成中发挥作用。这些发现为在水产养殖中对抗水生呼肠孤病毒感染的新绿色抗病毒药物开发提供了启示。

关键词: HPS; GCRV104; Hsp70; dsRNA; 抗病毒

HPS serves as a promising antiviral reagent against aquareovirus infection that involves the inhibition of *Hsp70*

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Abstract: We have previously shown that *Hsp70* is significantly up-regulated in grass carp (*Ctenopharyngodon Idella*) reovirus (GCRV) infected cells, and *Hsp70* plays a positive role in facilitating GCRV infection. Plant-derived HPS, a major dietary flavonoid, was known to repress the expression of stress-induced Hsp70 in animal cells by inhibiting the activation of HSF factor. Here, we found that GCRV104 infection induced the expression of *Hsp70*, and inhibiting *Hsp70* expression with HPS reduced viral protein expression and progeny virus production. Notably, these inhibitory effects on GCRV104 infection can be weakened by heat shock treatment, indicating the specific involvement of *Hsp70* in HPS-mediated antiviral effect. Furthermore, the viral double-stranded RNA (dsRNA) was found to colocalize with *Hsp70*, suggesting *Hsp70* might play a role in the constitution of viral replication and transcription complex (RTC) that could be mitigated by HPS. Our study supported the idea that *Hsp70* is an indispensable host cytokine required for the efficient replication of GCRV104, and the fact that inhibition of Hsp70 by HPS significantly reduced GCRV104 replication shed light on an alternative environmental-friendly antiviral strategy against aquareovirus infection in aquaculture.

Keywords: HPS, GCRV104, *Hsp70*, dsRNA, Antiviral

海水养殖源副溶血弧菌耐药性流行特征分析

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摘要: 环境抗菌药物耐药性 (AMR) 因其对人类健康的巨大危害而受到越来越多的关注。为了解我国东南沿海养殖地区副溶血弧菌的流行特征及对抗菌药物的耐药现状, 本研究分离鉴定得到 114 株海水养殖源副溶血弧菌。采用琼脂稀释法测定 114 株副溶血弧菌对 13 种常用抗生素的最小抑菌浓度 (MIC), 结果表明: 分离株表现出对链霉素 (78.9%)、氨苄西林 (64.9%) 和庆大霉素 (53.5%) 的高耐药率。60.5% 的副溶血弧菌呈多重耐药性, 其中氨苄西林-庆大霉素-红霉素-链霉素为主要耐药谱型。但是, 本研究中副溶血弧菌的耐药表型和基因型存在着不一致的情况: 所有的红霉素耐药菌株和部分环丙沙星耐药菌株和庆大霉素耐药菌株中并未检测到相应的耐药基因。脉冲场凝胶电泳 (PFGE) 分子分型将 114 株副溶血弧菌分为 92 个不同的谱型, 其中仅 17 组由两个或多个分离株组成, 由此推测, 多重耐药副溶血弧菌由一个特定的副溶血弧菌克隆传播的可能性很小。实验表明, 需要在海水养殖场上谨慎使用抗菌剂, 以控制耐药性副溶血弧菌的传播。

关键词: 副溶血弧菌; 抗药性; PFGE; 食品安全; 海水养殖场

Analysis on Antimicrobial resistance and epidemic characteristics of *Vibrio parahaemolyticus* from mariculture

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Abstract: Environmental antimicrobial resistance (AMR) has drawn increasing attention due to its great risk to human health. The aim of this study was to investigate AMR and genotyping of *Vibrio parahaemolyticus* isolates (n = 114) recovered from shrimp mariculture environment in China. There were obvious disparities between the antimicrobial resistance phenotypes and genotypes among the *V. parahaemolyticus* isolates in these present findings. Among these 92 groups, 17 groups consisted of two or more isolates through the cluster analysis of genetic profiles from the PFGE typing. These data suggest that the dissemination of multidrug-resistant *V. parahaemolyticus* strains was unlikely to be the spread of a specific *V. parahaemolyticus* clone.

Key words: *Vibrio parahaemolyticus*, Antimicrobial resistance, PFGE, Food safety, Mariculture farms

日本囊对虾抗脂多糖因子 D 的抗副溶血弧菌活性的鉴定分析

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摘要: 抗脂多糖因子属于抗菌肽家族, 已被证实对细菌、真菌及一些病毒具有抑制活性。在本研究中于日本囊对虾中鉴定了一种 D 组抗脂多糖因子 MjALF-D。在脂多糖和副溶血弧菌的刺激下, 其表达水平在鳃和胃中均明显表达上调。此外, rMjALF-D 能抑制副溶血性弧菌的生长; 通过扫描电镜及透射电镜观察, rMjALF-D 能破坏细菌膜并导致胞内内容物外泄; rMjALF-D 能够与细菌及基因组 DNA 结合, 并对其蛋白表达产生一定的影响。这些结果表明 rMjALF-D 具有对副溶血性弧菌的抗菌活性, 并可能参与日本囊对虾的先天免疫应答。

关键词: 日本囊对虾; 抗脂多糖因子; 先天免疫; 抗菌活性; 副溶血弧菌

Identification and analysis of a group D anti-lipopolysaccharide factor (ALF) from kuruma prawn (*Marsupenaeus japonicus*) with antibacterial activity against *Vibrio parahaemolyticus*

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Abstract: Anti-lipopolysaccharide factor (ALF), which belongs to the antimicrobial peptide (AMP) family, has been demonstrated to be active against bacteria, fungi and some viruses. In the present study, a new ALF of group D(MjALF-D) from *Marsupenaeus japonicus* was detected. MjALF-D expression was universally upregulated in both the gill and stomach after challenge by LPS and *Vibrio parahaemolyticus*. Moreover, rMjALF-D can inhibit the growth of *V. parahaemolyticus*. rMjALF-D could destroy the bacterial membrane and lead to cytoplasmic leakage investigated by SEM and TEM. Furthermore, rMjALF-D showed distinct binding after direct incubation with bacteria influenced its protein expression. Together, these results indicated that rMjALF-D possessed the antibacterial activity against *V. parahaemolyticus* and the potential involvement in the innate immune response of *M. japonicus*.

Key words: *Marsupenaeus japonicus*, Anti-lipopolysaccharide factor, Innate immunity, Antibacterial activity, *Vibrio parahaemolyticus*

草鱼 IgM⁺ B 淋巴细胞与浆细胞的比较鉴定及分化调控

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摘要: 在抗原刺激下, 初始 B 淋巴细胞可分化为浆细胞, 合成和分泌抗体以执行机体的体液免疫应答。鱼类 IgM⁺ B 细胞是 B 细胞的主要类型, 在非粘膜免疫器官和组织中占总 B 细胞的 70% 以上, 对其研究是揭示鱼类适应性免疫的关键。我们发现草鱼存在两类 IgM⁺ B 细胞亚群: IgM⁺ 淋巴细胞 (IgM⁺ Lym) 和 IgM⁺ 髓样细胞 (IgM⁺ Mye)。通过表型及功能分析, IgM⁺ Lym 被鉴定为初始 B 细胞, 而 IgM⁺ Mye 被鉴定为浆细胞, 且重组 CD40L 和 IL-21 能够诱导 IgM⁺ Mye 的生成和 IgM 的分泌。此外, 我们发现壳聚糖能够诱导草鱼 IgM⁺ B 细胞分化为低表达膜型 IgM 的淋巴细胞亚群 (IgM^{lo} Lym), 通过表型及功能分析, IgM^{lo} Lym 被鉴定为浆细胞样细胞。这些结果表明, 草鱼 B 淋巴细胞可分化为不同类群的浆细胞, 其免疫功能尚待深入解析。这是首次在我国大宗淡水鱼中比较鉴定了 B 淋巴细胞和浆细胞, 研究结果将为草鱼疫苗、佐剂和免疫增强剂的研发奠定基础。

关键词: B 淋巴细胞; 浆细胞; IgM; 草鱼

The identification and regulation of IgM⁺ plasma cells from B lymphocytes in grass carp

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Abstract: Under the stimulation of antigens, naïve B lymphocytes can differentiate into plasma cells, which can synthesize and secrete antibodies to execute the humoral immune responses. As the main B cell type in fish, IgM⁺ B cells account for more than 70% B cells in non-mucosal immune organs and tissues. Thus, the study of IgM⁺ B cells is the key to reveal the adaptive immunity of fish. We discovered two IgM⁺ B cell subsets in grass carp: IgM⁺ lymphocytes (IgM⁺ Lym) and IgM⁺ myeloid cells (IgM⁺ Mye). Through phenotypic and functional analysis, these two subsets were identified as naïve B cells and plasma cells (PCs), respectively. Moreover, recombinant CD40L and IL-21 could induce the PC generation and IgM secretion. Furthermore, we found that chitosan could induce the generation of a Lym subset with low membrane IgM (IgM^{lo} Lym), which were identified as PC-like cells. These results indicated that grass carp B lymphocytes can differentiate into different PC subsets, the immune function of which needs further study. This is the first time we identified B Lym and PCs in staple freshwater fish in China. The results will lay the foundation for the development of vaccines, adjuvants and immunostimulants for grass carp.

Key words: B lymphocyte, plasma cell, IgM, grass carp

珍珠龙胆石斑鱼注射壳寡糖作为免疫增强剂 对哈维氏弧菌的免疫效果

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摘要: 壳寡糖(COS)是一种有效的免疫刺激剂, 在水产养殖中具有一定抵抗病原体的作用。在本研究中, 我们评价了 COS 提高珍珠龙胆石斑鱼免疫力的效果和抵御哈维氏弧菌的能力。结果表明, 注射 COS 能显著提高血清中过氧化氢酶、溶菌酶、超氧化物歧化酶和总蛋白的活性。实验石斑鱼注射 COS 35 天后攻毒哈维氏弧菌, 实验组相对存活率较对照组显著提高。实验对象在注射 8 或 10 mg/ml 浓度的 COS 达到最佳免疫效果。结果表明, COS 对珍珠龙胆石斑鱼的特异性和非特异性免疫均有增强作用, 是一种有效的免疫增强剂。

关键词: 哈维氏弧菌; 壳寡糖; 免疫增强剂; 珍珠龙胆石斑鱼

The effect of chitosan oligosaccharide as an immune enhancer against *Vibrio harveyi* in pearl gentian grouper (♀ *Epinephelus fuscoguttatus* × ♂ *Epinephelus lanceolatus*)

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Abstract: Chitosan oligosaccharide (COS) is an effective immunostimulant and provide some extent protection against pathogens in aquaculture. In this study, we evaluated the effects of COS on enhancing immunity of pearl gentian grouper and providing the protection against *Vibrio harveyi*. The results showed COS injection significantly enhanced antibody titers, the activities of catalase, lysozyme, superoxide dismutase and total serum protein. The experimental groupers were challenged with *V. harveyi* at 35 days post-injection, and the relative percent survival (RPS) significantly increased in experimental groups compared with that in control group. Furthermore, the optimal immunity effect was observed with injection of COS at concentration of 8 or 10 mg/ml. The results indicated COS was an effective immune enhancer against *V. harveyi* by enhancing both specific and nonspecific immunity in pearl gentian grouper.

Keywords: *Vibrio harveyi*, chitosan oligosaccharide, immune enhancer, pearl gentian grouper

克氏原螯虾自噬相关基因的克隆及表达分析

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摘要: 本研究克隆得到了克氏原螯虾(*Procambarus clarkii*)的部分自噬相关基因 Beclin1、自噬相关基因-2 (Autophagy-related protein 2, ATG2) 和自噬相关蛋白半胱氨酸蛋白酶前体酶 (Cysteine proteinase preproenzyme, CYP) 的全长 cDNA 序列, 并利用 qPCR 技术对上述基因进行了研究, 同时检测了上述基因在克氏原螯虾不同组织的相对表达量。主要结果如下: (1) Beclin1 基因全长 2880bp, 5'UTR 为 175 bp, 3'UTR 为 1238bp, ORF 为 1467 bp, 编码 488 个氨基酸, Beclin1 基因主要在肌肉中表达, 在血细胞中表达丰度最低。(2) ATG2 基因全长为 9966bp, 5'UTR 为 582 bp, 3'UTR 为 2817bp, ORF 为 6567 bp, 编码 2188 个氨基酸, ATG2 基因主要在肝胰腺、胃中表达, 在肌肉中表达丰度最低。(3) CYP 基因全长 2136bp, 5'UTR 为 111 bp, 3'UTR 为 1071bp, ORF 为 954bp, 编码 317 个氨基酸, CYP 基因主要在肠和肌肉中表达显著。经过对上述基因在各个组织表达量的比较, 为进一步探究病毒感染克氏原螯虾体内的自噬机制奠定了基础。

关键词: 克氏原螯虾; 基因克隆; 自噬

Cloning and expression analysis of autophagy related genes in *Procambarus clarkii*

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Abstract : In this study, Beclin1, Autophagy-related gene-2(ATG2) and Cysteine proteinase preproenzyme of autophagy-related protein of *Procambarus clarkii* were cloned and the full-length cDNA sequences were obtained. QPCR technology was used to study the above genes, and the relative expression levels of these genes in different tissues of *Procambarus clarkii* were also detected. The results as follow: (1) Beclin1 gene is 2880bp in length, with a 5'UTR of 175bp, a 3'UTR of 1238bp, and an ORF of 1467bp, encoding 488 amino acids. Beclin1 gene was mainly expressed in muscle and has the lowest expression abundance in blood cells. (2) ATG2 gene is 9966bp in length, with a 582 bp in 5'UTR, 2817bp in 3'UTR and 6567 bp in ORF, encoding 2,188 amino acids. ATG2 gene was mainly expressed in hepatopancreas and stomach, and has the lowest expression abundance in muscle. (3) CYP gene is 2136bp in length, with a 5'UTR of 111 bp, a 3'UTR of 1071bp, and an ORF of 954bp, encoding 317 amino acids. CYP gene was significantly expressed mainly in intestine and muscle. The comparison of the expression levels of these genes in different tissues laid a foundation for further study of the autophagy mechanism in the virus infected *procambarus clarkii*.

Key words: *procambarus clarkii*, Gene clone, Autophagy

气相分子吸收光谱法测定渔业水质中氨氮的含量

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摘要: 本文优化了样品贮运条件及前处理步骤, 建立了气相分子吸收光谱仪测定渔业水质中氨氮的方法。样品采集于棕色玻璃瓶中, 调节 pH 至 1~3, 采样运输时间小于 6 小时, 可常温运输。样品摇匀后不过滤, 直接上机检测, 外标法定量。结果发现: 氨氮在 0.1~2.0 mg·L⁻¹ 范围内线性良好, 相关系数>0.9999。检出限为 0.003 mg·L⁻¹, 检测下限为 0.013 mg·L⁻¹。

关键词: 气相分子吸收光谱法; 氨氮; 渔业水质; 水产品安全

Determination of ammonia nitrogen in aquaculture water by gas phase molecular absorption spectrometry

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Abstract: This paper optimized the sample storage conditions and pretreatment steps, and establishes a method to determine the ammonia nitrogen of fishery water quality by gas phase molecular absorption spectrometer. The samples are collected in brown glass bottles, the pH value is adjusted to 1 to 3, and they can be transported at room temperature when the sampling transportation time is expected to less than 6 hours. After shaking and not filtering, it is directly tested on the machine and quantified by external standard method. The results showed that ammonia nitrogen was linear within the range of 0.1 ~ 2.0 mg·L⁻¹, and its correlation coefficient was >0.9999. The detection limit was 0.003 mg·L⁻¹, and the lower detection limit was 0.013 mg·L⁻¹.

Key words: gas phase molecular absorption spectroscopy, ammonia nitrogen, fishery water quality, aquatic product safety

文蛤脂肪代谢通路对弧菌感染的响应特征

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摘要: 文蛤 (*Meretrix petechialis*) 是一种重要的海洋经济贝类, 近年来由于弧菌感染引起的夏季大规模死亡时有发生, 严重威胁文蛤养殖业的发展。转录组研究发现, 弧菌感染会引起文蛤脂肪代谢通路的变化。我们进一步分析了感染后脂肪代谢通路关键基因和酶活的变化规律, 发现甘油三酯在感染后的合成相对于分解显著减少, 其含量也呈下降趋势; 感染后脂肪酸从头合成增加, 游离脂肪酸含量也随之增加; 而脂肪酸 β 氧化途径的关键基因在感染后没有发生显著的变化。上述结果揭示了弧菌感染早期脂肪代谢对弧菌感染的响应过程, 为文蛤抗病品种培育提供理论参考。

关键词: 文蛤; 弧菌; 能量代谢; 脂肪代谢

The response characteristics of lipid metabolism pathway to *Vibrio* infection in the clam *Meretrix petechialis*

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Abstract: The clam *Meretrix petechialis* is an important marine commercial shellfish. In recent years, mass mortality of clams occurs frequently in summer due to *Vibrio* infection seriously threatening the development of *M. petechialis* aquaculture. The transcriptome research found *Vibrio* infection could induce changes of lipid metabolism pathway in *M. petechialis*. We further analyzed the variation patterns of key genes and activity of enzymes in lipid metabolism pathway after infection and found the synthesis of triglycerides was significantly reduced compared to decomposition, and the triglycerides content also showed a downward trend. De novo synthesis of fatty acid increased and the free fatty acids content also increased after infection. The key genes of fatty acid β -oxidation pathway showed no significant changes after infection. These results above revealed the response process of lipid metabolism to *Vibrio* infection and provide theoretical support for the breeding of *Vibrio*-resistant varieties in the clam *M. petechialis*.

Key words: *Meretrix petechialis*, *Vibrio*, energy metabolism, lipid metabolism

单次给药下恩诺沙星及其代谢产物在石斑鱼体内的残留消除研究

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摘要: 本研究按 150 mg/kg·bw 恩诺沙星剂量对小嶝石斑鱼进行单次灌胃给药实验, 采用高效液相色谱-串联质谱法测定石斑鱼血浆、肝脏和肌肉中恩诺沙星及其代谢产物环丙沙星的含量水平。结果显示, 恩诺沙星在血浆、肝脏和肌肉中较快的达到最大值, 达到峰值的时间分别是给药后 60、40 和 60 min, 浓度分别为 9.85 mg/kg、4.93 mg/kg 和 3.57 mg/kg, 随后出现明显的下降趋势。恩诺沙星的代谢产物环丙沙星在给药后 60 min 在血浆、肝脏和肌肉中都达到峰值, 峰值浓度为 0.122 mg/kg、0.574 mg/kg 和 0.032 mg/kg。研究表明仅有少量的恩诺沙星代谢为环丙沙星。在本实验条件下, 建议休药期不少于 23 d。本研究掌握了恩诺沙星及其代谢产物环丙沙星在小嶝石斑鱼体内的残留消除规律, 为石斑鱼养殖业提供合理的休药期和给药方案。

关键词: 恩诺沙星; 环丙沙星; 石斑鱼; 药物残留; 休药期

牙鲆(*Paralichthys olivaceus*)6 种血清免疫指标的比较分析

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摘要: 为评价遗传背景、体重、黑化、运输应激等对牙鲆(*Paralichthys olivaceus*)血清免疫指标的影响, 本实验以引进的“鲆优 2 号”抗病牙鲆和普通牙鲆为实验材料, 通过肉眼区分无眼侧有无黑化, 在不同生长阶段采集样本, 采样前有无施行包装运输等手段, 将研究对象分成 7 个实验组, 分别测定溶菌酶活力(LYS)、酸性磷酸酶活力(ACP)、超氧化物歧化酶活力(SOD)、免疫球蛋白 M 含量(Ig M)、补体 3 含量(C3)和补体 4(C4)含量等 6 种免疫学指标, 并对测定数据进行比较分析。

关键词: 牙鲆; 遗传背景; 体重; 黑化; 运输应激; 免疫指标

Comparative analysis in 6 immune indexes of *Paralichthys olivaceus*

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Abstract: In order to evaluate the influence of genetic background, body weight, hypermelanosis and transportation stress on the serum immune indexes of *Paralichthys olivaceus*, the subjects were divided into 7 experimental groups, according to blind-side with hypermelanosis or not, different growth stages, and sampling with transportation stress or not, from the resistant flounder and common flounder which were used as experimental materials. Lysozyme (LYS) activity, acid phosphatase (ACP) activity, superoxide dismutase (SOD) activity, immunoglobulin M (IgM) content, complement C3 content, C4 content were measured and compared separately of the above groups.

Key words: *Paralichthys olivaceus*, genetic background, body weight, hypermelanosis, transportation stress, immune indexes

患红斑病、恢复期及健康中间球海胆肠道微生物群落结构和多样性分析

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摘要: 为探索患红斑病、恢复期及健康中间球海胆 (*Strongylocentrotus intermedius*) 肠道微生物群落结构和多样性差异, 采集患病、健康和恢复期样品, 通过 Illumina 高通量测序技术测定样品海胆的肠道及内容物微生物组成, 并评估微生物多样性。结果表明, 患病海胆肠道组织和内容物中的差异 OTU 的比例分别从 33.3% 和 29.5% 下降至 26.3% 和 21.2%, 表明肠道菌群和肠道内容物菌群的相对平衡出现变化; 健康、患病和恢复状态的海胆肠道组织和肠道内容物中分别存在相对丰度有显著差异的 OTU 109 和 192 个; 患病海胆肠道组织和肠道内容物中微生物种类和多样性均增加, 而处于病后恢复期的海胆肠道中微生物种类较患病海胆降低; 患病海胆肠道组织中弧菌属 *Vibrio* 和假单胞菌属 *Pseudomonas* 的丰度是健康海胆的 288.4 倍和 10.3 倍, 肠道内容物中检测到健康海胆中未检出或丰度极低的噬纤维菌属 *Cytophaga*、阿德杆菌属 *Adhaeribacter* 和链球菌属 *Streptococcus*, 这些菌属是海胆红斑病的潜在致病菌; 健康海胆肠道组织中嗜盐单胞菌属 *Halomonas* 是患病海胆的 13.6 倍, 有望作为候选益生菌用于海胆红斑病的防控。

关键词: 中间球海胆; 红斑病; 肠道微生物

Analysis of gut bacterial communities and diversity in spotting diseased, recovering and healthy sea urchin *Strongylocentrotus intermedius*

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Abstract: to investigate the differences in gut bacterial communities and diversity among spotting diseased, recovering and healthy sea urchin *Strongylocentrotus intermedius*, diseased, recovering and healthy sea urchin were sampled, and their gut bacterial communities were examined by Illumina high-throughput sequencing. Gut bacterial diversity were also analyzed. The results show that, proportions of the abundances of operational taxonomic units (OTUs) differential between gut tissue and gut digesta in diseased sea urchins reduced from 33.3% and 29.5% to 26.3% and 21.2%, indicating the change in microbiota balance between gut tissue and gut digesta. In gut tissue or gut digesta, there was 109 or 192 significantly abundance differential OTUs among healthy, diseased and recovered sea urchins, respectively. Both the species and diversity were increased in the diseased sea urchins, but reduced in the recovered ones. The abundance of *Vibrio* and *Pseudomonas* in gut tissue of the diseased sea urchins were 288.4 and 10.3 times that of the healthy ones. *Cytophaga*, *Adhaeribacter* and *Streptococcus* were detected in gut digesta of diseased sea urchins, however, they were rare in healthy sea urchins. These genus might be the potential pathogens causing spotting disease. The abundance of *Halomonas* in gut tissue of healthy sea urchins is 13.6 times the diseased ones, suggested that it could be the potential probiotics used in resisting spotting disease.

Keywords: *Strongylocentrotus intermedius*, spotting disease, gut microbiota

鲢鱼淀不同基质附着细菌群落结构特征及功能分析

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摘要: 旨在了解湖泊生态系统中微生物群落组成及其在生态系统中的功能和作用, 以期提高湖泊生态系统的自我净化能力。基于高通量测序技术与 PICRUSt 功能预测, 分析了鲢鱼淀芦苇、棕榈片、人工水草、网片四种不同基质附着细菌的群落结构组成以及功能多样性。结果表明, 鲢鱼淀四种基质附着细菌群落组成丰富, 共检测出 38 门、91 纲、183 目、338 科和 646 属。通过对 α -多样性分析发现四种基质附着细菌多样性大小依次为芦苇基质>棕榈片基质>人工水草基质>网片基质, 丰富度依次为棕榈片基质>芦苇基质>网片基质>人工水草基质。进行 PCoA 分析和聚类分析, 发现棕榈片基质与芦苇基质的附着细菌群落较为相似, 而网片基质与人工水草基质较为相似。采用 PICRUSt 进行菌群功能预测分析, 表明主要的 COG 功能共涉及 22 个功能基因家族, 表现出功能上的丰富性。研究表明, 生态修复中天然芦苇的自我净化能力最强, 棕榈片是三种人工基质中的最理想修复材料。

关键词: 附着细菌; 生物膜; 高通量测序; PICRUSt 功能预测

Diversity and function prediction of bacterial community attached to different substrates in ShiHou lake

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Abstract: Aimed at understanding of lake ecosystems in the microbial community composition and its function and role, and in the ecological system in order to improve the ability of self purification of lake ecosystem. The results showed that the four kinds of bacteria attached to ShiHou lake stroma had rich community composition, a total of 38 phylums, 91 classes, 183 orders, 338 families and 646 genera were detected. Through α -diversity analysis, it was found that the diversity of bacteria attached to the four substrates was reed substrates > palm piece substrates > artificial aquatic mat substrates > meshes substrates, The richness was palm piece substrates > reed substrates > meshes substrates > artificial aquatic mat substrates. PCoA analysis and cluster analysis were performed, It was found that the bacterial communities attached to the stroma of palm slice were similar to that of reed, the mesh substrate is similar to the artificial aquatic grass substrate. PICRUSt was used to predict and analyze the function of flora, which showed that the main COG function involved 22 functional gene families, showing the richness of function. Studies have shown that ecological restoration of natural reed strongest self purification capacity, palm is the most ideal repair material of three kinds of artificial matrix.

Keywords: Adherent bacteria, Biological film, High-throughput sequencing, PICRUSt function predicts

患溃疡病的大口黑鲈病原分离与鉴定

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摘要: 为探明安徽某养殖场大口黑鲈 (*Micropterus salmoides*) 溃疡病的致病病原, 对其进行了病毒和细菌的分离与鉴定。从患病大口黑鲈肝脏中分离出 6 株优势菌株, 经 16S rRNA 基因序列测序比对和生理生化鉴定, 6 株菌株均为维氏气单胞菌 (*Aeromonas veronii*)。药敏结果显示 6 株菌对恩诺沙星、氧氟沙星、诺氟沙星、氟苯尼考、甲氧苄氨嘧啶、复方新诺明、四环素均敏感。从肝脏、脾和体肾的混合液中进行弹状病毒、虹彩病毒、细胞肿大病毒和神经坏死病毒的检测, 结果虹彩病毒得到阳性结果, 扩增得到的主要衣壳蛋白基因序列与已知的大口黑鲈溃疡综合征病毒基因序列 (GenBank 号: GU256635.1) 相似性为 99.8%。实验结果表明, 患病大口黑鲈存在细菌和病毒的混合感染, 该结果将为大口黑鲈疾病的防控和治疗提供参考依据。

关键词: 加州鲈; 虹彩病毒; 维氏气单胞菌; 药敏试验

Isolation and Identification of the Pathogen of *Micropterus salmoides* Suffering from Canker

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Abstract: To investigate the causative agent of *Micropterus salmoides* canker in Anhui, the virus and bacteria were isolated and identified. Six dominant bacterium strains were isolated from the liver of diseased *Micropterus salmoides*. After 16S rRNA gene sequence alignment and physiological and biochemical identification, the six bacterium strains were all *Aeromonas veronii*. Drug sensitivity results showed that the six strains were all sensitive to enrofloxacin, ofloxacin, norfloxacin, florfenicol, trimethoprim, compound trimethoprim and tetracycline. *Rhabdovirus*, *Iridovirus*, *Cytomegalovirus* and *Neuronecrosis virus* were tested from the mixture of liver, spleen, and kidney. The result was a positive result for the *Iridovirus*. The amplified sequence of the main capsid protein show the highest similarity(99.8%) with the corresponding sequence of *Micropterus salmoides* ulcer syndrome virus (GenBank number: GU256635.1). Our results show that there is a mixed infection of bacteria and viruses in the diseased *Micropterus salmoides*. This results will provide a reference for the prevention, control and treatment of *Micropterus salmoides* disease.

Key words: *Micropterus salmoides*, *Iridovirus*, *Aeromonas Wilsonii*, Drug sensitivity test

池塘慢性气泡病的发生机理及其衍生后遗症的危害

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摘要: 水温形成的养殖水体上下分层非常普遍且明显。晴天上表水层藻类光合作用产生的氧气, 与池底有机物处于缺氧还原环境下脱氮产生的氮气, 在上下水层不能进行交流的情况下, 经常处于过饱和的现象。生存在这样水体的鱼类, 不论鱼苗还是成鱼阶段的大鱼, 过饱和和游离气体将不可避免地进入其体内, 患上气泡病。相对于鱼苗气泡病的急性发病症状, 患上气泡病的成鱼不会有明显症状, 称作慢性气泡病。目前人们对慢性气泡病产生机理了解不多或存在认识误区, 任其发展, 气泡病常常成为继发病原性疾病的诱因, 也是滥用药的入口。我们应充分认识慢性气泡病发生机理, 采取科学有效措施, 消除气体过饱和的现象。

关键词: 慢性气泡病; 水温上下分层; 氮气; 后遗症; 滥施药; 上下水层交流

The mechanism of chronic gas bubble disease in ponds and the harm of its derived sequelae

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Abstract: The stratification of aquaculture water caused by water temperature is very common and obvious. Without mixing of upper and lower water, the oxygen produced by the photosynthesis of the algae in the surface water on sunny days and the nitrogen produced by the denitrification of the organic matter at the bottom of the ponds in the anoxic environment are often supersaturated. Fish that live in such water body, regardless of fry or adult fish, will suffer from air bubble disease because the supersaturated free gas will inevitably enter their bodies. Compared with the acute symptoms of the air bubble disease in the fry, the adult fish suffering from air bubble disease will not have obvious symptoms, thus it is called chronic air bubble disease. To date, there is a lack of knowledge or even misunderstanding about the mechanism of chronic bubble disease. Without intervention, the air bubble disease often becomes the cause of secondary pathogenic diseases, and also leads to drug abuse. Therefore we should fully understand the mechanism of chronic air bubble disease, take scientific and effective measures to eliminate the phenomenon of gas oversaturation.

Key words: chronic air bubble disease, stratification by water temperature, nitrogen, sequelae, drug abuse, mixing of upper and lower water

加强水生动物疫病防控工作的思考

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摘要: 针对水生动物疫病危害日益严重的现实, 水产养殖业应切实加强水生动物疫病防控工作。要增强风险意识, 防患于未然; 要完善水生动物疫情监测体系; 要把握传染病发生规律, 科学防控; 要运用科技手段, 提升疫情防控科技含量; 要加强培训, 提高从业人员素质。

关键词: 水生动物; 疫病防控工作; 水生动物疫情监测体系

Thoughts on strengthening the prevention and control of aquatic animal diseases

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Abstract: In view of the fact that aquatic animal diseases are becoming more and more serious, aquaculture industry should strengthen the prevention and control of aquatic animal diseases. It is necessary to enhance the awareness of risk and prevent the disease in the bud; to improve the monitoring system of aquatic animal epidemic situation; to grasp the occurrence law of infectious diseases and scientific prevention and control; to use scientific and technological means to improve the scientific and technological content of epidemic prevention and control; to strengthen training and improve the quality of employees.

Key words: aquatic, epidemic prevention and control, monitoring system of aquatic animal epidemic situation

日本鳗鲡 IRF1 的功能研究及结构分析

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摘要: 干扰素调节因子 (Interferon regulatory factor, IRFs) 是调控机体抗病毒免疫反应, 细胞生长、分化和凋亡必不可少的转录因子。IRF 可结合于干扰素 (Interferon, IFN) 和干扰素刺激基因启动子区域, 进而调控其转录表达。本研究从日本鳗鲡中获得了 IRF1 (AjIRF1), 并对其进行了结构与功能分析。AjIRF1 的开放阅读框全长 804 bp, 编码 267 个氨基酸 (aa), 其中包含一个保守的 N 端 DNA 结合结构域 (DBD)。序列比对显示 AjIRF1 的 DBD 中存在六个高度保守的色氨酸 (W) 残基。荧光定量 PCR 结果显示, Poly I:C 刺激或爱德华氏菌感染可显著诱导日本鳗鲡各组织中 AjIRF1 上调表达。本研究利用荧光素酶分析了 AjIRF1 对 I 型 IFN 启动子的调控作用, 结果显示过表达 AjIRF1 可显著上调 AjIFN2 启动子活性, W46A, R82A, S87A 突变可显著抑制 AjIFN2 启动子的激活。亚细胞定位结果显示 AjIRF1 定位于细胞核中, 其入核能力由位于 DBD 内的双簇 NLS 和位于 DBD 下游的单簇 NLS 共同调节。本研究为进一步解析硬骨鱼 IRF1 的调控机制的提供了重要信息。

关键词: IRF1; 核定位信号; 启动子激活; 日本鳗鲡

Functional characterization and structural basis of Japanese eel IRF1

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Abstract: Interferon regulatory factors (IRFs) are a family of transcription factors that play important roles in host antiviral defense and regulation of cell growth, proliferation, and apoptosis. Members of IRF family can recognize and bind to the interferon-stimulated response element (ISRE) within the promoter region of target gene, such as interferon and interferon-stimulated genes, thus regulating its expression. In the present study, we report the functional and structural analysis of IRF1 from Japanese eel (AjIRF1). The open reading frame of AjIRF1 was 804 bp in length, encoding a protein of 267 amino acids (aa). Structural analysis showed that AjIRF1 contains an N-terminal DBD domain, which processes six conserved tryptophans. Expression of AjIRF1 was significantly upregulated in all examined tissues / organs, including head kidney, spleen, liver, skin, gill and intestine, after challenged with poly I:C or *Edwardsiella tarda*. Luciferase assays were performed to evaluate the effects of AjIRF1 on IFN promoter activation. Overexpression of AjIRF1 led to a significant increase of AjIFN2 promoter activity, and W46A, R82A, S87A mutations individually or in combination strongly abolished AjIFN2 reporter activation. Subcellular localization analysis showed that AjIRF1 is a nuclear-localized protein and its nucleus import ability is cooperatively regulated by a bipartite NLS located in the DBD and a monopartite NLS located downstream of the DBD.

Keywords: IRF1, nuclear localization signal, promoter activation, Japanese eel, *Anguilla japonica*

淡水养殖鱼类主要病原菌多样性分析

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摘要: 为了探究细菌毒力因子的多样性, 本文选取了对长三角地区大宗淡水养殖鱼类危害较大的气单胞菌属和假单胞菌属病原菌进行研究。研究表明: 气单胞菌属细菌能分泌溶血素、气溶素和肠毒素等多种毒力因子; 假单胞菌属细菌的毒力因子有铁吸收调节蛋白 Fur、T3SS 效应蛋白基因 ExoU、ExoS、ExoT、ExoY 等。同时本论文也对由此引发的水产品质量问题进行了阐述。

关键词: 气单胞菌属; 假单胞菌属; 毒力因子; 水产品品质

Diversity analysis of main pathogenic bacteria in freshwater Fish

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Abstract: In order to explore the diversity of bacterial virulence factors, the pathogenic bacteria of *Aeromonas* and *Pseudomonas*, which are harmful to the bulk freshwater fish in the Yangtze River Delta, were selected in this paper. The results showed that *aeromonas* bacteria could secrete a variety of virulence factors such as hemolysin, aerysin and enterotoxin. The virulence factors of *pseudomonas* bacteria include the ferric uptake regulator protein Fur, T3SS effector protein gene ExoU, ExoS, ExoT, ExoY, etc. At the same time, the quality problems of aquatic products caused by this are also described in this paper.

Key words: *Aeromonas Pseudomonas*, Virulence factor, Aquatic product quality

TLR/NF- κ B 通路在三角帆蚌抗菌免疫中的作用

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摘要: TLR/NF- κ B 信号通路在机体先天性免疫中承担着重要的功能。本研究克隆出三角帆蚌 2 种 TLR(简称 HcToll9, 10)以及 2 种 NF- κ B 基因(简称 HcP65, P105)。荧光定量 PCR 结果表明 HcToll9, 10 与 HcP65, P105 在三角帆蚌各个组织中均有表达, 且 LPS, PGN 和 PolyI:C 刺激可诱导它们表达上调。敲降 HcToll9 可下调 HcP65, P105 和下游靶基因溶菌酶(Lysozyme), 抗菌肽(Theromacin), 乳清酸蛋白(whey acidic protein, WAP), 2 种脂多糖结合蛋白/杀菌通透性增加蛋白(LBP/BPI 1, 2)的表达。同样, 敲降 HcP65, P105 也明显导致 Lys, Ther, WAP, LBP/BPI 1, 2 的表达下调。重组 HcToll9, 10 蛋白在体外可结合革兰氏阳性细菌和革兰氏阴性细菌及 LPS, PGN 和 PolyI:C。双荧光素酶报告结果表明 HcToll9, 10 都可以明显激活 NF- κ B 报告基因, 这些结果初步表明 HcTLR/NF- κ B 信号通路参与了三角帆蚌的抗菌免疫应答。亚细胞定位结果显示: HcToll9, 10 融合蛋白的绿色荧光主要广泛分布在细胞质和细胞膜附近。

关键词: 三角帆蚌; TLR/NF- κ B 信号通路; TLR; NF- κ B

Role of TLR/NF- κ B pathway in antibacterial immunity of *Hyriopsis cumingii*

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Abstract: The TLR/NF- κ B signaling pathway plays an important role in innate immunity. Two TLR (HcToll9, 10) and two NF- κ B genes (HcP65, P105) were cloned from *Hyriopsis cumingii*. qPCR results showed that HcToll9, 10, HcP65, P105 were expressed in all tissues of *H. cumingii*, and LPS, PGN, PolyI:C stimulation could induce upregulation of their expressions. After knocked down of HcToll9, the expression of HcP65, P105 and downstream target genes Lysozyme, Theromacin, whey acid protein (WAP), and LBP/BPI 1,2 were significantly reduced. Similarly, after knocked down of HcP65 and P105, the expressions of Lys, Ther, WAP, LBP/BPI 1 and 2 were also significantly down-regulated. Recombinant HcToll9, 10 proteins could bind to Gram-positive and Gram-negative bacteria in vitro as well as LPS, PGN and PolyI:C. Dual luciferase reporting assay showed that both HcToll9 and 10 could significantly activated the NF- κ B reporter gene. Collectively, these results preliminarily indicated that the HcTLR/NF- κ B signaling pathway was involved in the antibacterial immune response of *H. cumingii*. Subcellular localization showed that the HcToll9 and 10 fusion proteins was mainly distributed in the cytoplasm and near the cell membrane.

Key words: *Hyriopsis cumingii*, TLR/NF- κ B pathway, TLR, NF- κ B

TNFRs 介导的细胞凋亡/坏死信号途径在溶珊瑚弧菌诱导香港牡蛎幼贝大规模死亡过程中的分子应答机制

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摘要: 溶珊瑚弧菌可以感染香港牡蛎, 并能够引起成贝血液细胞大量的凋亡和坏死, 而幼贝则引起大规模死亡。为了阐述牡蛎在溶珊瑚弧菌感染下的分子应答机制, 我们采用转录组分析技术, 通过采集溶珊瑚弧菌感染后的血液(成贝)或者幼贝样本, 进行转录组测序分析, 发现TNFRs介导的细胞凋亡/坏死信号途径相关基因高度表达, 并通过定量验证了TNF40、TNF10L、TNFR27、EDAR、TRAF2、TRAF3、Caspase3/7/8/10、Jun和NF- κ B等部分基因的变化, 发现它们在成贝血液中显著表达上调; 但是在幼贝中, 凋亡途径下游的基因如Caspase3/7/8/10等表达没有多大的变化, 而且这些基因编码蛋白的酶活也受到了抑制。通过这些结果, 我们可以初步确定, TNFRs介导的细胞凋亡/坏死信号途径参与了宿主的免疫应答, 成贝可能通过凋亡途径活化机制, 顺利清除入侵的病原体而使得个体存活下来, 而幼贝则可能凋亡途径受阻、坏死信号途径活化而导致组织坏死和个体死亡。

关键词: 溶珊瑚弧菌; 香港牡蛎; 凋亡; 坏死

The molecular response mechanisms of TNFRs-mediated apoptosis/necrosis signaling pathway in *Vibrio coralliilyticus* induced the massive mortality of oyster (*Crassostrea hongkongensis*) larva

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Abstract: *Vibrio coralliilyticus* could cause the adult oyster *Crassostrea hongkongensis* hemocytes to apoptosis and necrosis, and cause the larva to massive mortality. To shed light on the molecular response mechanism of oyster under *V. coralliilyticus* infection, we used transcriptome sequencing analysis and other relevant techniques to analyze the oyster hemocytes or larval oyster after *V. coralliilyticus* challenge, the results revealed that TNFRs-mediated apoptosis/necrosis signaling pathway were riched. Quantitative validation results illustrated that with exposure to *V. coralliilyticus*, the expression of TNF40、TNF10L、TNFR27、EDAR、TRAF2、TRAF3、Caspase3/7/8/10、Jun、NF- κ B were all significantly up-regulated in the adult oyster. But in the larval oyster, the expression of Caspase3/7/8/10 were not up-regulated which indicate the apoptosis signal passway mabe inhibited. Further more, control the the adult, the enzyme activity of Caspase3/8 in the larval oyster were inhibited also. According to these results, there were preliminary demonstrated that the expression of TNFRs-mediated apoptosis/necrosis signaling pathway related genes were activated after *V. coralliilyticus* challenge, we supposed that the adult maybe survived by removing pathogens through activate apoptosis pathway, while the larva may be blocked in apoptotic pathway and over-activated by necrotic pathway, which caused the tissues to necrosis and death.

Key words: *Vibrio coralliilyticus*, *Crassostrea hongkongensis*, apoptosis, necrosis

凝结芽孢杆菌和牛至油调节大菱鲆肠道微生物与免疫的作用机制

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摘要: 为了解益生菌和植物提取物在大菱鲆养殖中的作用, 本研究以凝结芽孢杆菌(*Bacillus coagulans*) (P组)和牛至油(O组)作为饲料添加剂, 研究30d内其对大菱鲆幼鱼生长、免疫、肠道组织形态和菌群结构的影响, 并分析杀鲑气单胞菌(*Aeromonas salmonicida*)引起疥疮病的发病率。结果表明, O组和P组SGR显著高于对照组($P < 0.05$), 疥疮病发病率显著低于对照组($P < 0.05$), 免疫基因(IL-1 β , TNF- α , MHC-I, IFIH1)表达水平20d全部上调。O组和P组肠道菌群多样性显著增加, 其中, O组肠道中有益菌属的丰度提高, 它们与免疫代谢途径相关; P组梭菌(*Clostridium*)和多尔氏菌(*Dorea*)等潜在病原菌降低。O组和P组肠道绒毛数量、高度和肌层厚度增加, 大菱鲆的消化吸收能力显著提升。综上所述, 添加凝结芽孢杆菌或牛至油均能不同程度提高大菱鲆的免疫应答, 优化肠道菌群构成, 多样性增加, 改善肠道组织结构, 从而改善大菱鲆的生长性能。

关键词: 益生菌; 植物提取物; 大菱鲆; 肠道菌群; 免疫应答; 组织形态

The effects of probiotics and plant-derivatives on intestinal microbiota and immunity in turbot (*Scophthalmus maximus*)

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Abstract: To understand the effects of probiotics and plant derivatives in turbot *Scophthalmus maximus*, in this study, *Bacillus coagulans* (P group) and oregano oil (O group) were used as feed additives for turbot juveniles. The growth performance, immunity, intestinal microbiota and morphology, and furunculosis incidence were evaluated of 30 days. The results showed that the specific growth rate of turbot in the O and P groups was significantly higher than the control group ($P < 0.05$). The furunculosis incidence was significantly lower than the control group ($P < 0.05$). The expression levels of selected genes (IL-1 β , TNF- α , MHC-I, IFIH1) were up-regulated in O and P groups on the day of 20. The intestinal microbiota diversity was improved in O and P groups. The abundance of beneficial bacteria was increased in O group, which were correlated with immune related metabolic pathways. Meanwhile, the potential pathogens like *Clostridium* and *Dorea* were decrease in P group. Moreover, the villi, villus height and muscularis thickness of intestine were significantly increased in O and P group, which may enhance digestive and absorption ability of turbot. In conclusion, the administration of *Bacillus coagulans* or oregano oil could promote growth performance of turbot by enhancing immune response, optimizing structure and diversity of intestinal microbiota, and improving intestinal morphology.

Key words: probiotics, plant derivatives, *Scophthalmus maximus*, Intestinal microbiota, Immune response, histomorphometry

鲤疱疹病毒 II 型 ORF66 截短蛋白原核表达和多克隆抗体制备

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摘要: 鲤疱疹病毒 II 型 (Cyprinid herpesvirus 2, CyHV-2) 可导致疱疹病毒性造血器官坏死症 (Herpesviral haematopoietic necrosis, HVHN), 对病毒基因编码蛋白的体外表达与抗体制备研究有望为临床免疫学检测提供依据。研究 CyHV-2 病毒 ORF66 基因编码蛋白的可能功能, 制备特异性良好、效价较高的 rORF66 蛋白多克隆抗体。为进一步开展鲤疱疹病毒 II 型的研究提供材料, 同时构建一种鲤疱疹病毒 II 型的免疫学检测方法。分析了 CyHV-2 ORF66 基因编码蛋白的抗原表位, 根据 ORF66 基因序列设计了一对特异性引物, 构建了 ORF66 截短基因的原核表达质粒 pET28a-tORF66, 转化至 BL21 感受态细胞后利用 IPTG (Isopropyl-beta-D-thiogalactopyranoside) 37 °C 诱导蛋白表达, 8mol/L 尿素溶解重组蛋白后免疫 6 周龄小鼠, 制备鼠抗 tORF66 多克隆抗体。经 Western-Blot 检测显示, 抗体能够识别感染的 GICF 细胞中鲤疱疹病毒 II 型, 效价较高, 特异性较好。ORF66 特异性抗体的制备为构建新的鲤疱疹病毒 II 型的免疫学检测方法和 研究 ORF66 的生物学特性奠定了基础。

关键词: 鲤疱疹病毒 II 型; ORF66 截短蛋白; 多克隆抗体; 原核表达

Prokaryotic expression and polyclonal antibody preparation of orf66 truncated protein of CyHV-2

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Abstract: Cyprinid herpesvirus 2 can cause the necrosis of hematopoietic organs in *Carassius auratus*. The analysis of its gene-encoding protein virus-encoded gene expression in vitro and antibody preparation are expected to provide a basis for clinical immunological detection. To study the possible function of orf66 ORF66 gene- encoding protein of cyhv-2 virus, and to this study aims to prepare the specific and high titer rrf66 ORF66 protein polyclonal antibody. In order to provide materials for further study of carp herpesvirus type II, , and to construct develop an immunological detection method of for carp cyprinid herpesvirus type II. The epitopes of the protein encoded by cyhv-2 orf66 gene were analyzed. A pair of specific primers were designed according to the orf66 gene sequence, and the prokaryotic expression plasmid pet28a-torf66 of orf66 truncated gene was constructed. After transformation into BL21 cells, the expression of the protein was induced by IPTG (isopropyl beta-D-thiogalactopyranoside) at 37 °C and purified, and the 6-week-old mice were immunized with 8 mol / L urea to dissolve the recombinant protein. Western-blot analysis showed that the antibody could recognize CyHV-2 in the infected GICF cells with high titer and good specificity. By expression and purification of ORF66 in *E. coli*, we are able to generate specific polyclonal antibody against ORF66, and provide a specific It provides a better technical route for the construction of immunological detection method of for carp cyprinid herpesvirus type II.

Keywords: CyHV-2, ORF6 truncated protein, Polyclonal antibody, Prokaryotic expression

基于溶氧参数的南美白对虾养殖技术研究

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摘要: 为了提高南美白对虾的养殖效益, 南美白对虾的密集养殖在中国逐渐推广起来。但是也带来一些问题, 因为南美白对虾的养殖密度过大, 很容易导致虾塘的溶氧降低, 从而造成藻类的大量死亡, 出现“倒藻”现象, 导致南美白对虾的死亡, 对养殖户造成巨大的财产损失。现在通过观测虾塘溶氧参数, 可以提前发现虾塘水体的异常, 对养殖户提前进行预警, 提高对虾的养殖成功率, 增加南美白对虾的经济效益。

关键词: 南美白对虾; 溶氧参数; 养殖技术

*Research on culture technology of *Penaeus vannamei* based on dissolved oxygen parameters*

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Abstract: In order to improve the farming efficiency of *Penaeus vannamei*, intensive culture of *Penaeus vannamei* has been gradually promoted in China. However, it also brings some problems. Because the cultivation density of *Penaeus vannamei* is too high, it is easy to reduce the dissolved oxygen in shrimp ponds, resulting in a large number of deaths of algae, and the phenomenon of "algae inversion", leading to the death of *Penaeus*. The households caused huge property losses. Now by observing the dissolved oxygen parameters of shrimp ponds, it is possible to detect abnormalities in the water bodies of shrimp ponds in advance, give early warning to farmers, increase the success rate of shrimp breeding, and increase the economic benefits of *Penaeus vannamei*.

Key words: *Penaeus vannamei*, dissolved oxygen, culture technology

海水中刺激隐核虫幼虫定量检测方法的建立

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摘要: 为快速进行自然水体中刺激隐核虫幼虫数量的检测。我们根据刺激隐核虫 18S rRNA 基因保守序列设计 8 对引物, 筛选出一对特异性好、扩增效率高的定量引物。并将人工混有一定已知数目刺激隐核虫幼虫的海水样品抽滤浓缩, 提取幼虫 DNA, 以此为模板进行实时荧光定量聚合酶链式反应 (qPCR), 获取不同幼虫添加数对数所对应的扩增荧光阈值 (CT 值)。所建方法中幼虫添加数对数与 CT 值呈良好线性关系, 其线性方程为 $Y = -2.8826x + 24.395$, $R^2 = 0.9969$ 。该方法重复性良好, 最低检测量为 5-10 个幼虫 (1L 海水)。本研究建立的刺激隐核虫幼虫检测方法, 可准确、迅速的计算未知海水样本中幼虫数量, 为该寄生虫病的防控提供了技术支持。

关键词: 刺激隐核虫; qPCR; 检测方法

Establishment of a quantitative detection method for theronts of *Cryptocaryon irritans* in seawate

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Abstract: To quickly detect the number of theronts of *Cryptocaryon irritans* in natural water. We designed 8 pairs of primers based on the conservative sequence of the 18S rRNA gene of *C. irritans*, and selected a pair of quantitative primers with good specificity and high amplification efficiency. The artificially mixed seawater sample with a certain number of theront was suction filtered and concentrated, and the theront DNA was extracted, which was used as a template for real-time fluorescent quantitative polymerase chain reaction (qPCR) to obtain the logarithm of the addition of different theront Corresponding amplification fluorescence threshold (CT value). In the method, the logarithm of larval addition has a good linear relationship with CT value, and the linear equation is $Y = -2.8826x + 24.395$, $R^2 = 0.9969$. The method has good repeatability, and the minimum detection number of *C. irritans* is 5~10 (1L seawater). The detection method of *C. irritans* established in this research can accurately and quickly calculate the number of theronts in unknown samples, which provides technical support for the prevention and control of the parasitic disease.

Key words: *Cryptocaryon irritans*, qPCR, detection method

嗜水气单胞菌感染洞庭青鲫肾脏转录组分析

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摘要: 洞庭青鲫 (*Carassius auratus* var. *dongting*) 是湖南省洞庭湖地区选育的鲫鱼地方新品种(系), 具有生长速度快、抗逆性强、肉质好等优良特性。在本研究中采用高通量测序平台 (IlluminaHiSeq-2500 和 PacBio) 分别对嗜水气单胞菌处理后的洞庭青鲫肾脏组织开展转录组测序, 并进行生物信息学分析, 包括 GO、KEGG、表达差异基因分析等。结果显示, 全长转录组测序共获得 Polished consensus 序列 81584, 平均长度为 3675bp, 使用 CD-HIT 最终得到非冗余转录本序列 62799 条, Q30 达到 85%。将 Unigenes 分别在 Nr、KEGG、GO 等数据库进行序列比对及功能注释, 共注释了 56804 条; 预测得到转录因子 2755 个, 隶属于 60 个转录因子家族, 其中, C2H2 锌指蛋白家族的基因数目最多。嗜水气单胞菌感染下基因表达谱结果进行分析, 感染组和对照组存在着显著差异, 差异基因达到 15868 个, 其中上调基因 7757 个, 下调基因 8111 个。差异表达基因按 GO 功能分类, 共分为细胞组分、分子功能及生物学过程 3 类, 包括 58 个功能组。将差异表达基因归属于 248 条代谢通路, 分为 6 类 KEGG 途径: 细胞进程、遗传信息处理、细胞过程、疾病、环境信息和先天性免疫系统。本研究建立了洞庭青鲫嗜水气单胞菌胁迫肾脏转录组数据库, 为洞庭青鲫嗜水气单胞菌胁迫分子机理研究提供了参考数据。

关键字: 洞庭青鲫; 嗜水气单胞菌; 转录组分析

Transcriptome analysis of kidney from *Carassius auratus* var. *dongting* infected by *Aeromonas hydrophila*

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Abstract: *Carassius auratus* var. *dongting* selected and bred in Dongting Lake, Hunan Province, is a new breed of *C. auratus* with excellent characteristics such as fast growth rate, strong resistance and good meat qualification. In this study, the IlluminaHiSeq-2500 and PacBio platform was used to sequence the transcriptome of kidneys from *C. auratus* var. *dongting* after *Aeromonas hydrophila* treatments, through bioinformatics analysis, including GO, KEGG and differential gene expression analysis, etc. The main results obtained were as follows: the total number of Polished consensus obtained by assembly was 81584, the average length was 3675 bp and the Q30 was reached 85%. Sequence alignment and function annotation of Unigenes was conducted in Nr, KEGG, and GO databases. A total of 56804 clusters were obtained, A total of 2755 transcription factors were detected by transcription factor analysis, with the C2H2 Zn finger protein family having the highest number of genes. Through the analysis of gene expression profiles under *A. hydrophila* treatment, there were significant differences between control group and experiment group. the difference was the largest; 15868 genes, of which 7757 were up-regulated and 8111 were down-regulated. According to GO function classification, Differential expression genes were distributed in three kinds of cell components, molecular functions, and biological processes, including 58 functional groups. Further, Differential expression genes were classified into 248 metabolic pathways and six KEGG pathways: metabolic pathway, genetic information processing, cellular processes, environmental information, diseases and organismal Systems. In this study, we established a database of renal transcriptional groups in *C. auratus* var. *dongting* under *A. hydrophila* infected, which provides abundant data for the study of molecular mechanisms of *C. auratus* var. *dongting* resistance to *A. hydrophila* infection.

Keyord: *Carassius auratus* var. *dongting*, *Aeromonas hydrophila*, Transcriptome analysis

维氏气单胞菌灭活疫苗发酵培养基的优化

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摘要: 为培养优质的鲫鱼维氏气单胞菌灭活疫苗菌液, 通过单因素试验对鲫鱼维氏气单胞菌灭活疫苗发酵培养基的氮源、碳源、硫酸盐和磷酸盐成分进行了筛选, 采用响应面试验法对培养基各主要成分的用量进行了优化组合, 并经过验证试验绘制出了维氏气单胞菌在优化培养基条件下的7 L发酵罐生长曲线。结果表明: 维氏气单胞菌最适发酵培养基配方组成及用量: 胰蛋白胨 10.6 g/L, 葡萄糖 5.0 g/L, 牛肉膏 3.0 g/L, 磷酸二氢钾 2.0 g/L, 硫酸镁 0.2 g/L, 氯化钠 5.0 g/L。在优化发酵培养基下, 发酵可得到维氏气单胞菌活菌数 5.94×10^9 CFU/mL, 比基础培养基增幅达到 43.13%, 7升发酵罐发酵培养 10 h, 活菌数达到最大 8.85×10^9 CFU/mL。研究表明, 通过对发酵培养基的优化, 可以获得更高产量维氏气单胞菌发酵菌液, 本研究数据为今后维氏气单胞菌灭活疫苗规模化发酵培养提供了参考依据。

关键词: 维氏气单胞菌; 培养基优化; 单因素试验; 响应面分析

Optimization of fermentation medium for *Aeromonas veronii* inactivated vaccine

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Abstract: The nitrogen source, carbon source, sulfate source and phosphate source were screened in culture medium of *Aeromonas veronii* inactivated vaccine in a single-factor test, and different ingredients of the medium were optimized in an response surface methodology experiment, with a verification test of growth of the bacterium in a 7 L fermentor. It was found that the best fermentation of *Aeromonas veronii* was observed under the conditions of tryptone as nitrogen source, glucose as carbon source, $MgSO_4$ as sulfate source, KH_2PO_4 as phosphate source, at a dose of tryptone 10.6 g/L, beef extract 5.0 g/L, glucose 5.0 g/L, $MgSO_4$ 0.2g/L, KH_2PO_4 2.0 g/L, and NaCl 5.0 g/L. Under the optimized fermentation medium, the number of viable bacterial was 5.94×10^9 CFU/mL, which was an increase of 43.13% compared with the basic medium. The fermentation kinetics analysis revealed that the stain had the maximal number of viable bacterial was 8.85×10^9 CFU/mL in 10 h culture, indicating that a high yield of *Aeromonas veronii* fermentation broth is obtained by the optimized fermentation medium, The data of this study will provides a reference for the large-scale fermentation and cultivation of the *Aeromonas veronii* inactivated vaccine in the future.

Key words: *Aeromonas veronii*, medium optimization, single factor test, response surface methodology

维氏气单胞菌重组外膜蛋白 OmpA II 的抗原性及其对异育银鲫的免疫效果

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摘要: 为探究维氏气单胞菌重组外膜蛋白 OmpA II (rOmpA II) 的抗原性及其免疫效果, 本本通过基因检测、克隆表达、免疫印迹和鱼体免疫等方法开展研究。结果表明 *ompA II* 基因广泛存在于维氏气单胞菌和嗜水气单胞菌中 (52/58, 90%)。维氏气单胞菌 GZ09007 的 *ompA II* 基因开放阅读框为 999bp, 编码 332 aa, 蛋白分子量大小为 35kDa, 等电点 (pI) 为 4.91。rOmpA II 的兔抗血清能够识别维氏气单胞菌和嗜水气单胞菌约 36kDa 的外膜蛋白 Omps; 维氏气单胞菌 GZ09007 外膜蛋白 Omps 的兔抗血清能够识别 rOmpA II。腹腔注射 rOmpA II (含 ISA763A 佐剂) 免疫异育银鲫, 血清超氧化物酶 (SOD) 活性和溶菌酶活性 (LSZ) 均在第 14 天达到最高。受免疫鲫鱼能有效抵抗维氏气单胞菌和嗜水气单胞菌感染, 相对保护率 (RPS) 分别达到 79% 和 68%。结果表明, 维氏气单胞菌 rOmpA II 具有良好的抗原性, 能作为气单胞菌基因工程亚单位疫苗进一步研究开发。

关键词: 维氏气单胞菌; 嗜水气单胞菌; 重组蛋白 OmpA II; 抗原性; 免疫效果

Antigenicity and Immune effect of *Aeromonas veronii* Recombinant OmpA II in *Carassius auratus gibelio*

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Abstract: The Antigenicity and immune efficacy of recombinant protein OmpA II of *A.veronii*GZ09007 were assessed through gene detection, cloning expression, western blotting and immunologic test in *Carassius auratus gibelio*. The result showed that *ompA II* gene is common in *A.veronii* and *A.hydrophila* (52/58,90%). Cloning and sequencing of *ompA II* revealed that it contains an open reading frame (ORF) of 999 nucleotides encoding 332 aa with molecular mass 35kDa and isoelectric point (pI) 4.91. Western blotting suggested that the Omps with molecular masses 36kDa in *A.veronii* and *A.hydrophila* were recognized by rabbit antiserum of rOmpA II as well as rOmpA II was recognized by rabbit antiserum of *A.veronii*GZ09007 Omps. *Carassius auratus gibelio* was immunized by rOmpA II-ISA763A adjuvant. The serum superoxidase activity and lysozyme activity were significantly enhanced on the 14d post-vaccination. The relative percent survival (RPS) after challenged by *A.veronii*GZ09007 and *A.hydrophila* YK090901 was 79% and 68% on 30d, respectively. These results indicate that the recombinant protein OmpA II of *A.veronii* has positive antigenicity and is a subunit vaccine candidate against motile aeromonad septicemia (MAS).

Key words: *Aeromonas veronii*; *A.hydrophila*; Recombinant OmpA II; Antigenicity; Immune effect

基于 $\text{Fe}_3\text{O}_4@\text{SiO}_2$ 磁提取 DNA 的副溶血弧菌检测研究

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摘要: 副溶血性弧菌(*Vibrio parahaemolyticus*, VP)是一种食源性致病菌, 危害人类健康, 严重时危及生命。传统的副溶血性弧菌检测方法需要增菌、分离、培养等复杂步骤, 检测时间长。本研究开发了一种 $\text{Fe}_3\text{O}_4@\text{SiO}_2$ 磁提取 DNA 与 qPCR 相结合的 VP 检测方法。我们通过碱性共沉淀法制备了 Fe_3O_4 , 通过水解正硅酸四乙酯对 Fe_3O_4 进行硅修饰得到了 $\text{Fe}_3\text{O}_4@\text{SiO}_2$ 。 $\text{Fe}_3\text{O}_4@\text{SiO}_2$ 呈球状且表面光滑, 其粒径分布在 70-150nm。本研究优化了材料制备和核酸提取的条件, 通过紫外吸收和凝胶电泳检测 DNA 的提取效果。最佳条件为 pH=5 且正硅酸乙酯添加量为 1ml, 此时 DNA 的提取率为 81.3%, 将提取的核酸应用于 qPCR 且准确的检出了虾样本中的副溶血性弧菌。本方法将 VP 的检测时间由传统方法的 7 天缩短至 1 天, 为有关部门进行快速检测提供了新的方法。

关键词: 磁性纳米材料; 副溶血性弧菌; 实时荧光 PCR; 核酸提取

Be based on $\text{Fe}_3\text{O}_4@\text{SiO}_2$ Detection of *Vibrio parahaemolyticus* by magnetic extraction of DNA

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Abstract: *Vibrio parahaemolyticus* (VP) is a food-borne pathogen, which is harmful to human health and life-threatening in severe cases. Traditional detection methods for VP require complicated steps such as enrichment, isolation, and cultivation, and the detection time is long. This research developed a VP detection method combining $\text{Fe}_3\text{O}_4@\text{SiO}_2$ magnetic DNA extraction with qPCR. We prepared Fe_3O_4 by alkaline co-precipitation method, and modified Fe_3O_4 with silicon by hydrolyzing tetraethyl orthosilicate to obtain $\text{Fe}_3\text{O}_4@\text{SiO}_2$. $\text{Fe}_3\text{O}_4@\text{SiO}_2$ is spherical and has a smooth surface, and its particle size distribution is 70-150nm. In this study, the conditions of material preparation and nucleic acid extraction were optimized, and the DNA extraction effect was detected by UV absorption and gel electrophoresis. The optimum conditions were pH = 5 and the amount of TEOS was 1ml. The extraction rate of DNA was 81.3%. The extracted nucleic acid was applied to qPCR and *Vibrio parahaemolyticus* in shrimp samples was detected accurately. This method shortens the detection time of VP from 7 days in the traditional method to 1 day, and provides a new method for relevant departments to conduct rapid detection.

Key words: Magnetic nanomaterials, *Vibrio parahaemolyticus*, qPCR, nucleic acid extraction

天津早春大规格草鱼鱼种患病病原分离鉴定 及药敏试验

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摘要: 为了鉴定天津某池塘养殖发病死亡的草鱼病原, 本研究通过临床解剖观察、镜检寄生虫、细菌分离鉴定、药敏实验、GCRV 病毒检测等方式对其进行分析鉴定。结果显示, 患病鱼主要症状为体表红肿、出血、溃疡, 鳃丝粘液增多、烂鳃; 现场镜检排除寄生虫感染; 取发病草鱼肝脾肾混合样, 直接提取核酸检测 GCRV, 结果未检出; 从患病鱼的肾脏分离出 1 株细菌, 命名为 C1, 经生化鉴定、16s rRNA 和 gyrB 基因序列分析, 分离菌 C1 与嗜水气单胞菌聚为一支, 同源性均在 99%以上; 用 C1 菌株人工感染健康草鱼, 人工感染的草鱼出现与自然发病鱼相似的症状, 并从人工感染的草鱼中分离出菌落形态相同的细菌, 初步证明 C1 是引起草鱼患病的病原; 药敏实验显示, 在使用的 14 种药物中, 对阿莫西林、磺胺异恶唑、链霉素耐药, 对氟苯尼考、多西环素等敏感, 为今后草鱼气单胞菌病临床用药提供参考依据。

关键词: 草鱼; 气单胞菌; 病原; 鉴定

Isolation and identification of pathogen and drug sensitivity test of grass carp fingerling in early spring of Tianjin

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Abstract: In order to identify the pathogens of grass carps that died of disease in aquaculture ponds of Ning He district in Tianjin, this study analyzed and identified them through clinical anatomical observation, parasitic infection by microscope, bacterial isolation and culture, biochemical identification, drug sensitivity test, GCRV virus detection and other methods. The results showed that the main symptoms of the diseased fish were redness, swelling, bleeding, ulcer, increased mucus in the gill and rotten gills; Microscopic examination ruled out parasitic infections; The mixed samples of liver, spleen and kidney of grass carp were taken, and the nucleic acid was directly extracted to detect GCRV, but the results were not detected; A strain of bacteria was isolated from the pathogenic grass carp and named C1. After biochemical identification, 16S rRNA and gyrB gene sequence analysis, the isolated bacteria C1 and *Aeromonas hydrophila* converged into one branch, and the homology was more than 99%; We used C1 strain to infect the grass carps, The infected grass carps caused symptoms similar to those of naturally occurring, and isolated the same bacteria from infected grass carps. It can be confirmed that C1 was the pathogen causing disease; The results of drug sensitivity test showed that among the 14 antibiotics, it was resistant to amoxicillin, sulfamethoxazole, streptomycin, and sensitive to florfenicol, doxycycline, etc. The drug sensitivity test results provided a reference for clinical drug use of *Aeromonas spp.*

Key Words : grass carp, *Aeromonas spp.*, pathogen, identification

血鸚鵡肠道微生态与细菌性肠炎病关系研究

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摘要: 为了阐明细菌性肠炎病对血鸚鵡肠道微生态的影响。分别取健康血鸚鵡, 患细菌性肠炎病血鸚鵡和用诺氟沙星治愈后的血鸚鵡的肠道内容物和肠道组织, 用 Illumina HiSeq2500 进行高通量测序, 同时进行代谢组学和微生物多样性分析。结果显示: 健康组和治愈组肠道内容物代谢产物, 患病组和治愈组肠道组织的代谢产物差异性最为明显, 两组之间差异代谢物数量分别为 326 和 335。筛选出标志性差异代谢物分别为丙酸、DL-乳酸盐、肌酸酐、乙酰甘氨酸和琥珀酸盐。微生物多样性分析结果显示, 厚壁菌门 (Firmicutes), 拟杆菌门 (Bacteroidetes) 和放线菌门 (actinobacteria) 在健康组、患病组和治愈组均为优势菌群, 总和占到总体数量的 90%。患病组肠道内的拟杆菌属 (Bacteroidetes)、变形菌属 (Proteobacteria) 细菌丰度显著高于健康组和治愈组。研究表明细菌性肠炎病对血鸚鵡肠道微生物及其代谢产物有显著影响。

关键词: 血鸚鵡, 肠道菌群, 细菌性肠炎病, 高通量测序, 代谢组学

A study on the relationship between intestinal microecology and bacterial enteritis disease of blood parrot cichlid

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Abstract: In order to elucidate the effect of bacterial enteritis disease on intestinal microecology of blood parrot. Intestinal contents and intestinal tissues of healthy blood parrots, blood parrots with bacterial enteritis, and blood parrots treated with norfloxacin were collected, respectively, and high-throughput sequencing was performed using Illumina HiSeq2500, together with metabolomics and microbial diversity analysis. The results showed that the differences of intestinal contents metabolites between the healthy group and the cure group were the most obvious, and the differences of metabolites between the two groups were 326 and 335. The marker metabolites were propionic acid, DL-lactate, creatinine, acetylglycine and succinate. The results of microbial diversity analysis showed that Firmicutes, Bacteroidetes and Actinobacteria were the dominant bacteria in the healthy group, the sick group and the cured group, accounting for 90% of the total number. The abundance of Bacteroidetes and Proteobacteria in the intestinal tract of the diseased group was significantly higher than that of the healthy group and the cured group. The results showed that bacterial enteritis had a significant effect on the intestinal microorganisms and metabolites of blood parrots.

Key words: blood parrot cichlid, Intestinal flora, bacterial enteritis disease, high-throughput sequencing, metabolomics

斑节对虾促性腺激素释放激素的免疫定位及 调控机制初探

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摘要: 为了获知促性腺激素释放激素(GnRH)调控机制, 以便在繁育中更好应用, 本实验利用免疫组化方法研究了 GnRH 在斑节对虾卵巢发育五个时期(II 至 VI 期)中在神经系统及卵巢中的免疫定位和分布, 以及在肝胰腺及卵巢中 GnRH 信号通路相关的调控因素 c-Jun 及卵黄蛋白原的表达规律。

关键词: GnRH; 神经系统; 卵巢; 斑节对虾; 免疫组化; 卵黄蛋白原; qPCR

The identification and distribution of gonadotropin releasing hormone in the central nervous system and ovary of each stages in *Penaeus monodon*

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Abstract: Gonadotropin-releasing hormone (GnRH) plays important roles in reproduction. In the present study, we demonstrated the existence of GnRH-like peptides in the central nervous system (CNS) and ovary of each stage in *Penaeus monodon* using immunocytochemistry and quantitative real-time PCR of c-jun and vitellogenin expression quantity. The immunoreactivity (ir) of GnRH was detected in the of medium-sized neurons located in deutocerebrum, both medium-sized and large-sized neurons in thoracic ganglia and abdominal ganglion.

Key words: GnRH, CNS, ovarian maturation, *Penaeus monodon*, immunocytochemistry, qPCR

铜和镉复合暴露对吉富罗非鱼的生长以及卵巢发育的影响初探

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摘要: 铜(Cu^{2+})和镉(Cd^{2+})是两广地区重金属污染的主要元素, 在罗非鱼主要养殖区域的水体中广泛存在, 当水体中的铜和镉含量过高时, 就会对鱼类的生长繁殖产生不利的影响。本研究以吉富罗非鱼雌鱼(37.4 ± 8.7)g为研究对象, 以鱼体全长、体长、体重为主要检测指标, 探讨不同浓度铜和镉复合暴露 30d 和 60d 对吉富罗非鱼生长指标的影响; 以血清中促性腺激素释放激素(GnRH)、促性腺激素(GtH)、雌二醇(E2)的含量以及性腺指数(GSI 值)为主要检测指标, 探讨不同浓度铜和镉复合暴露 30d 和 60d 对吉富罗非鱼卵巢发育的影响。本研究将为深入了解在铜和镉复合暴露中吉富罗非鱼卵巢发育的分子机制提供基础参考数据。

关键词: 重金属; 铜; 镉; 吉富罗非鱼; 生长指标; 卵巢

Effects of copper and cadmium combined exposure on growth indices and ovarian development of GIFT tilapia (*Oreochromis niloticus*)

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Abstract: Copper (Cu^{2+}) and cadmium (Cd^{2+}) are the main elements of heavy metal pollution in Guangdong and Guangxi in China. They are widely found in the water bodies in the main tilapia breeding areas. When the content of copper and cadmium in the water bodies is too high, it will have adverse effects on the growth and reproduction of fish. In this study, the female GIFT tilapia (37.4 ± 8.7)g was used as the research object, and the total length, body length and body weight of the fish were used as the main detection indicators to explore the influence of different concentrations of copper and cadmium combined exposure for 30d and 60d on the growth indicators of the GIFT tilapia.

The contents of gonadotropin-releasing hormone (GnRH), gonadotropin (GtH), estradiol (E2) and gonadal index (GSI) in serum were used as the main indicators to investigate the effects of different concentrations of copper and cadmium combined exposure on the ovarian development of GIFT tilapia at 30d and 60d. This study will provide basic reference data for a deeper understanding of the molecular mechanisms of ovarian development in GIFT tilapia exposed to copper and cadmium.

Key words: Heavy metals, Copper, Cadmium, GIFT tilapia, Growth index, ovary

热应激损伤鲟鱼消化系统：重点关注肠道生理功能和微生物群体

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摘要: 热应激是水生环境中广泛存在的应激源。水生动物的生理和代谢功能极易受到热应激的影响, 尤其是胃肠道功能。为探讨热应激对胃肠道的潜在影响, 研究了鲟鱼胃肠道的结构和功能以及肠道菌群的响应特性。我们分别将鲟鱼置于 20℃, 24℃和 28℃进行 12 天的处理。在高温组, 鲟鱼出现胃肠道出现系统性损伤, 其中瓣肠有严重肠炎, 瓣肠内消化酶(糜蛋白酶、淀粉酶和脂肪酶)和抗氧化酶(POD)的活性普遍降低。热应激导致鲟鱼瓣肠热耐受(*Hsp70* 和 *Grp75*)和损伤修复能力(*Tgf-β*)受到抑制。PICRUSt 分析预测热应激会影响肠道微生物群(细菌和真菌)的消化吸收功能, 如抑制氨基酸的运输和能量的产生。结果表明, 热应激可能直接影响鲟鱼胃肠道的消化吸收功能并导致鲟鱼肠道嗜热病原菌丰度爆发性增加。本研究结果为水生变温动物, 特别是冷水鱼类面对热应激的潜在风险提供了新的见解。

关键词: 热应激; 鲟鱼; 肠道; 消化和吸收功能; 微生物

Heat Stress damages the Digestive System of Sturgeon: Focus on Intestinal Physiological Function and Microbiota

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Abstract: Heat stress, a widely existing stress source in aquatic environment. The physiological and metabolic functions of aquatic animals are easily affected by heat stress, especially the function of gastrointestinal tract. To investigate the potential effects of heat stress on the gastrointestinal tract, the structure and function of the gastrointestinal tract and the response characteristics of the intestinal microflora in sturgeon were studied. Sturgeon were treated at 20 °C, 24 °C and 28 °C for 12 days. In heat stress group, systemic damage was observed in the gastrointestinal tract of sturgeon, with severe enteritis in the valve intestine. Activities of digestive enzymes (chymotrypsin, alpha amylase and lipase) and antioxidant enzymes in valve intestine(POD) generally reduced. Heat stress resulted in inhibition of thermal tolerance(*Hsp70* and *Grp75*) and damage repair ability(*Tgf-β*) in sturgeon valve intestine. PICRUSt analysis predicted that heat stress would affect the digestion and absorption functions of intestinal microbiota(bacteria and fungi), such as inhibition of amino acid transport and energy production. Our findings suggested that indicated that heat stress may directly affect the digestion and absorption functions of sturgeon gastrointestinal tract, and lead to the explosive increase of the abundance of thermophilic pathogens in sturgeon intestinal tract. The results of present study provide new insights into the potential risks of heat stress in aquatic poikilotherm, particularly in cold water fish.

Key words: Heat stress, sturgeon, intestinal, digestion and absorption function, microbiota

恩诺沙星在加州鲈体内的药动学与残留消除规律研究

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摘要: 本实验旨在研究单次口服恩诺沙星(ENF)后, ENF及其代谢产物环丙沙星(CIP)在加州鲈体内的药动学和组织残留消除规律。在28条件下, 加州鲈以20mg/kg单剂量口服恩诺沙星后, 采用高效液相色谱法测定给药后不同时间点血浆、肝脏、肌肉及与其自然相连的皮肤中ENF及CIP的药物含量。WinNolin药动学软件对药物浓度-时间数据进行分析。结果表明: 口服给药后, ENF在血浆中达峰时间为0.60 h, 峰浓度为10.99 ug/mL, 消除半衰期($T_{1/2\beta}$)为90.79 h, 药-时曲线下面积(AUC)为1185.73 ug h/mL。恩诺沙星在加州鲈肝脏和肌肉及皮肤中消除缓慢, $T_{1/2\beta}$ 分别为124.73 h和115.14 h。为保证食品安全, 建议休药期为24 d。

关键词: 恩诺沙星; 加州鲈; 药物代谢动力学; 组织残留; 休药期

Pharmacokinetics and tissue residues of enrofloxacin in the largemouth bass (*Micropterus salmoides*) after oral administration

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Abstract: The study was carried out to evaluate the pharmacokinetic disposition of enrofloxacin (ENF) with a single dose of 20 mg/kg after oral administration in largemouth bass (*Micropterus salmoides*) at 28°C. The concentrations of ENF and of its metabolite ciprofloxacin (CIP) in plasma, liver, and muscle plus skin in natural proportions were determined using HPLC. The concentration-time data for ENF in plasma were best described by a two-compartment open model. After oral administration, the maximum ENF concentration (C_{max}) of 10.99 $\mu\text{g/ml}$ was obtained at 0.60 hr. the elimination half-life ($T_{1/2\beta}$) of the drug was 90.79 hr. The estimates of area under the plasma concentration-time curve (AUC) was 1,185.73 $\mu\text{g hr/ml}$. ENF residues were slowly depleted from the liver and muscle plus skin of largemouth bass with the $T_{1/2\beta}$ of 124.73 and 115.14 h, respectively. To ensure food safety, it is recommended that the drug withdrawal period is 24 days.

Key words: enrofloxacin, largemouth bass, pharmacokinetics, tissue residues, withdrawal time

传染性造血器官坏死病毒环介导等温扩增检测方法建立和初步应用

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摘要: 本试验建立了一套反转录环介导等温扩增方法(reverse transcription loop-mediated isothermal amplification, RT-LAMP), 用于实验室及现场检测鲑鳟鱼传染性造血器官坏死病毒(infectious haematopoietic necrosis virus, IHNV)。针对 IHNV 的核蛋白(nucleoprotein, N)基因设计特异性引物, 以 IHNV 基因组 RNA 为模板, 在反转录酶及 Bst DNA 聚合酶的作用下进行反转录 LAMP, 结果阳性样本表现为荧光绿色, 阴性样本仍为红棕色。反应条件优化结果表明最适反应温度为 64 °C; 特异性试验表明仅 IHNV 发生特异性扩增, 而 SVCV、HRV、VHSV 和 H2O 均不发生反应; 敏感性试验表明该 LAMP 方法可检出浓度为 $1.0 \times 10^{-4} \mu\text{g}/\mu\text{L}$ 的 IHNV 核酸。本研究所建立的 IHNV 反转录 LAMP 检测法成本低、操作简单、反应迅速、不依赖专门的仪器, 同时具有较高的灵敏度和特异性, 适合 IHNV 的现场检测和大批量样品的检疫。

关键词: 传染性造血器官坏死病毒; 鲑鳟鱼; 环介导等温扩增; 核蛋白基因

Establishment and application of loop-mediated isothermal amplification for detection of IHNV

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Abstract: A reverse transcription loop-mediated isothermal amplification method for detection of trout infectious haematopoietic necrosis virus (IHNV) in laboratory and field was established in this study. A set of specific primers were designed based on the IHNV N gene sequence. IHNV RNA was used as a template for RT-LAMP in a reaction mixture containing reverse transcriptase and Bst DNA polymerase. Positive samples exhibited a fluorescent green color whereas negative samples exhibited a reddish brown color. The optimum temperature for the reaction was 64 °C. Specific tests shown that the method was capable to detect the IHNV with no cross action with SVCV, HRV, VHSV and H2O. Sensitivity test showed that the method could detect $1.0 \times 10^{-4} \mu\text{g}/\mu\text{L}$ IHNV RNA. In summary, the method established in this study was suitable for field detection of IHNV and convenient perform quarantine of mass samples with high specificity and sensitivity, rapidity, simple, low cost, and without relying on any special equipment.

Key words: infectious hematopoietic necrosis virus, trout, loop-mediated isothermal amplification, N gene

患白内障黑斑蛙病原分离鉴定与药敏检测

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摘要: 为探明安徽舒城地区某养殖场患病黑斑蛙 (*Pelophylax nigromaculatus*) 的致病病原, 对病蛙进行了细菌分离、鉴定和药敏检测。从典型患病黑斑蛙的肝脏、眼睛、脊柱和脑中分离出 4 株优势菌株, 经 16S rRNA 基因序列、系统发育分析和氨基糖苷酶基因检测, 结果表明, 4 株菌株均为脑膜炎败血伊丽莎白菌 (*Elizabethkingia meningoseptica*)。药敏检测结果显示 4 株分离株仅对酰胺醇类中的氟苯尼考敏感, 对香豆素类中的新生霉素、大环内酯类中的红霉素和利福霉素类中的利福平等三种抗生素中度敏感, 对多种抗生素耐药。实验结果将为黑斑蛙细菌病防治提供参考依据。

关键词: 黑斑蛙; 脑膜炎败血伊丽莎白菌; 16S rRNA; 药敏试验

Isolation, identification and drug sensitivity detection of the pathogen of *Pelophylax nigromaculatus* with cataract

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Abstract: To ascertain the pathogen of the diseased *Pelophylax nigromaculatus* in a farm in Shucheng area, Anhui Province, the bacteria were isolated, identified and tested for drug sensitivity. Four dominant strains were isolated from the liver, eyes, spine and brain of a typical diseased *Pelophylax nigromaculatus*. After sequencing 16S rRNA gene sequence, phylogenetic analysis and aminoglycosidase gene detection, results showed that all four strains were *Elizabethkingia meningoseptica*. The results of drug sensitivity test showed that the four isolates were only sensitive to florfenicol in amido alcohols, and to novobiocin in coumarins, erythromycin and rifamycins in macrolides rifampin is moderately sensitive to the three antibiotics and resistant to many antibiotics. Our results will provide a reference for the prevention and treatment of bacterial diseases of the *Pelophylax nigromaculatus*.

Key words: *Pelophylax nigromaculatus*, *Elizabeth meningitis*, 16S rRNA, Drug sensitivity test

一种防控刺激隐核虫病杀虫涂料研发

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摘要: 刺激隐核虫病是海水鱼类的常发寄生虫病。前期研究发现, 附着于铜片上的刺激隐核虫会被杀灭。根据刺激隐核虫生物学特性, 体外生活阶段的包囊会附着于池子底部的特点, 本研究将一种铜合金颗粒添加到鱼池涂料中, 涂于鱼池底部以期杀灭附着于池底的刺激隐核虫。利用人工发病的卵形鲳鲹比较涂料中添加不同大小和比例的铜合金颗粒的防控效果, 研究发现铜合金颗粒大小接近纳米级时, 其对刺激隐核虫杀灭效果显著增强, 添加了适当比例的铜合金颗粒涂料, 对病鱼的保护率可达 100%。体外试验结果显示, 包囊前体接触涂料 3 小时后开始出现破裂, 6 小时后死亡率达 100%, 包囊接触涂料 24 小时后死亡率达 100%。检测水体和石斑鱼血清(养殖 3 个月)的 Cu^{2+} 浓度结果显示, 对照池和涂料池浸泡 5、15 和 30 天的海水中 Cu^{2+} 浓度分别为 1.23 ± 0.23 、 1.21 ± 0.22 、 1.41 ± 0.58 和 $1.23 \pm 0.18 \mu\text{mol/L}$, 血清 Cu^{2+} 浓度分为 12.45 ± 3.80 和 $13.57 \pm 4.90 \mu\text{mol/L}$, 对照池和涂料池水体和鱼血清的 Cu^{2+} 浓度无显著差异。研究表明研发的杀虫涂料可有效防控刺激隐核虫病, 释放的 Cu^{2+} 符合养殖水质要求, 本研究对工厂养殖中刺激隐核虫病防控提供了安全有效的策略。

关键词: 刺激隐核虫; 铜合金颗粒; 涂料; 防控

Development of an antiparasitic paint for prevention and control of *Cryptocaryon irritans*

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Abstract: Previous studies have found copper alloy sheets can kill with *Cryptocaryon irritans* effectively. According to the biological characteristics of *C. irritans*, the tomonts adheres to the hard surface on the bottom of seawater. In this study, a copper alloy particle was added to the fishpond paint and applied to the fishpond in order to control outbreak of cryptocaryoniasis. The effect of different sizes and proportions of copper alloy were comparing by treating the infected *Trachinotus ovatus*. The results showed that the antiparasitic effect significantly enhanced when the size was close to nanometer scale, and the protection rate up to 100% with an appropriate proportion. In vitro, the mortality rate of protomonts and tomonts up to 100% over 6 h and 24 h contact with the paint, respectively. Results of Cu^{2+} concentration in water and fish serum showed no significant difference in control pool and paint pool. Studies have shown that the antiparasitic paint can effectively prevent and control *C. irritans* and did not lead to excessive heavy metal levels in the culture seawater. This study provides a safe and effective strategy for control cryptocaryoniasis in factory aquaculture.

Key words: *Cryptocaryon irritans*, copper alloy particle, paint, control

池塘养殖模式下氟苯尼考及其代谢产物在斑点叉尾鮰体内及养殖环境中残留代谢及迁移行为

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摘要:为解决目前在实际大池塘养殖模式下, 氟苯尼考 (FF) 在斑点叉尾鮰 (*Letaurus punetaus*, 以下简称鮰) 体内及养殖环境中的残留降解规律及风险评估的研究匮乏的问题, 本研究采用 HPLC-MS/MS 法探究了 FF 及其代谢产物氟苯尼考胺 (FFA) 在鮰体内及养殖环境中的组织分布及药物残留消除规律, 并初步探究药物在鮰和养殖环境中的迁移行为。结果显示, 不同剂量组药物浓度在生物样品和环境样品中的总体变化规律基本一致, 呈现出先升高后下降的总体趋势, 但达峰时间略有差异。药物达峰浓度与剂量高低成正相关。研究认为, FF 在鮰体内及养殖环境中主要以原型的方式代谢消除, 且 FF 消除速率远高于 FFA, 建议实际生产中, 不同剂量条件下休药期分别设为 161、230 及 345 度日。

关键词: 斑点叉尾鮰; 氟苯尼考; 氟苯尼考胺; 残留消除; 组织分布; 迁移; 高效液相色谱-串联质谱法; 池塘养殖

Elimination and migration of florfenicol and its metabolic residues in *Letaurus punetaus* and aquaculture environment under pond conditions

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Abstract: At present, there are less research of drug residues on the effect of florfenicol (FF) in *Letaurus Punetaus* were carried out under the actual large pond farming model, moreover, studies on the elimination and risk assessment of FF residues in aquaculture environment were also scarce. In order to solve the problem, the elimination and migration of FF and its metabolic florfenicol amine (FFA) in *Letaurus Punetaus* and aquaculture environment under pond conditions were investigated by HPLC-MS/MS. The results showed that the change rules of drug concentration in biological and environmental samples were generally the same in different dosage groups, presenting a general trend of increasing firstly and then decreasing with the slightly different peak time. The peak concentration of the drug was positively correlated with the dose level. In this study, it was evident that FF drug was eliminated as the original type and the elimination rate of FF was higher than that of FFA. Therefore, the withdrawal period should be 161、230、345 days under different drug doses in actual production.

Key words: *Letaurus punetaus*, florfenicol, florfenicol amine, elimination, tissue distribution, migration, high performance liquid chromatography-tandem mass spectrometry, pond conditions

浸泡接种后鱼类各器官的 IgM 表达、分泌及各 粘膜相关淋巴组织和器官关系研究

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摘要: 浸泡接种后, 鱼类粘膜相关淋巴组织会被诱导产生局部粘膜免疫反应, 同时也会引起其它器官的免疫反应。在本实验中发现, 连续两次浸泡 1.5×10^7 CFU/mL 的哈维氏弧菌灭活疫苗后, 粘液抗体滴度达峰时间要早于血清抗体, 显示了粘膜相关淋巴组织产生了局部粘膜免疫反应, 远远早于系统免疫反应。在器官产生反应中, 脾脏、头肾的 IgM mRNA 表达强度最高, 显示了系统免疫的重要性和中枢地位, 当然鳃淋巴组织表达强度也很高, 显然在浸泡接种后, 粘膜免疫也很重要。而从各器官的 IgM mRNA 表达强度随时间变化的趋势看, 后肠、肝脏、脾脏基本处于同一趋势, 显示了相当密切的关系, 可以基本推断有一个内部的后肠-肝脏-脾脏的免疫分子机制的存在。实验也显示连续两次浸泡 1.5×10^7 CFU/mL 的哈维氏弧菌灭活疫苗后, 鲫鱼和石斑鱼的相对保护率 (RPS) 变化趋势基本相同, 但其最高 44.4% 小于石斑鱼的 47.4%。

关键词: 浸泡接种; 粘膜免疫; 后肠-肝脏-脾脏的免疫分子机制; IgM

Study on IgM Expression, Secretion and Relationship between Mucosal Related Lymphatic Tissues and Organs of Fish after immersion vaccination

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Abstract: After immersion vaccination, fish mucosa-associated lymphoid tissue will be induced to produce local mucosal immune response, and it will also cause immune response crosstalk with internal organs. In this experiment, it was found that after immersing 1.5×10^7 CFU/mL inactivated *Vibrio harveyi* vaccine twice in succession, the peak time of mucus antibody titer was earlier than that of serum antibody, which indicated that local mucosal immune response was produced in mucosa-associated lymphoid tissue, far earlier than systemic immune response. In the organ reaction, the IgM mRNA expression intensity of spleen and head kidney is the highest, which shows the importance and central position of systemic immunity. Of course, the expression intensity of gill lymphoid tissue is also very high. Obviously, mucosal immunity is also very important after soaking and inoculation. However, from the trend of IgM mRNA expression intensity in various organs changing with time, the hindgut, liver and spleen are basically in the same trend, showing a very close relationship, which can basically infer the existence of an internal immune molecular mechanism of hindgut-liver-spleen. The experiment also showed that after soaking 1.5×10^7 CFU/mL inactivated *Vibrio harveyi* vaccine twice in succession, the change trend of relative protection rate (RPS) of crucian carp and grouper was basically the same, but its highest 44.4% was lower than that of grouper's 47.4%.

Key words: immersion vaccination, Mucosal immunity, Immune molecular mechanism of hindgut-liver-spleen, IgM

领域五

海洋渔业资源养护与可持续利用

基于线粒体标记的小裸胸鳝遗传同质性分析

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摘要: 小裸胸鳝中国被误鉴定为网纹裸胸鳝, 由于其特殊的生境、昼伏夜出、具有一定的攻击性, 导致样品采集具有一定的难度, 目前尚未见有关于其群体遗传学的研究。在近海渔业资源呈现衰退的大趋势下, 有必要对小裸胸鳝的遗传特征进行研究, 有待于后续的资源保护。本研究在小裸胸鳝的中国分布区内采集 6 个地理群体, 首次采用线粒体 CR 片段对其遗传特征进行研究, 结果显示小裸胸鳝具有非常高的遗传多样性, 群体间无遗传分化现象。中国横跨不同维度的海岸线和多样而复杂的近岸流、充足的饵料等这些生活史特征和环境异质性促进了小裸胸鳝种群快速增长, 积累较多的基因突变和丰富的遗传多样性。小裸胸鳝在更新世晚期发生过群体扩张事件, 塑造了各自的遗传特征。较长的浮游期(PLD)能保证柳叶鳃幼体有效的避开各种物理障碍, 有机会随着洋流输送到中国沿海各海域, 寻求适合生存的环境定居, 与来自其他地方的补充群体进行基因交流。

关键词: 基因流; 遗传特征; 遗传结构; 珊瑚礁鱼类

Genetic homogeneity detectable in the sedentary moray eel *Gymnothorax minor* based on mitochondrial DNA analysis

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Abstract: On the basis of traditional morphological classification, *Gymnothorax minor* has been misidentified as *Gymnothorax reticularis* in China. Because of the special ecological habits and aggressiveness of this species, little research has been performed on its population genetics. Given the general decline in offshore fishery resources, it is necessary to study the genetic characteristics of *G. minor* in order to protect this resource. In the present study, six different geographical populations of *G. minor* were collected from their distribution areas in China, and their genetic signatures were investigated for the first time based on the control region fragments. The results showed that *G. minor* had a very high degree of genetic diversity, and there was no genetic differentiation between these populations. However, the genetic analysis failed to reject panmixia among geographic populations of this species. The life-history characteristics of *G. minor* and the heterogeneity of its habitat promote the rapid growth of its populations, resulting in gene mutation accumulation and rich genetic diversity. *G. minor* experienced a population expansion event during the late Pleistocene, which shaped its various genetic signatures. The prolonged pelagic larval duration (PLD) of this species ensures that its leptocephali effectively avoid various physical obstacles and have the opportunity to follow ocean currents to various coastal areas of China.

Key words: Genetic flow, Genetic signature, Genetic structure, Pelagic larval duration, Reef fish

东海中南部龙头鱼(Harpadon nehereus)的营养可塑性探讨

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摘要: 本研究根据 2018 年 11 月和 2019 年 4 月在东海中南部进行的 2 个航次底拖网调查采集的生物样品(龙头鱼及其潜在食源)的稳定同位素比值, 分析了龙头鱼营养级和摄食习性的特征。结果显示, (1) 秋季龙头鱼的 $\delta^{13}\text{C}$ 介于 -18.6‰ ~ -16.0‰ , $\delta^{15}\text{N}$ 值介于 10.7‰ ~ 14.0‰ ; 春季龙头鱼的 $\delta^{13}\text{C}$ 介于 -20.2‰ ~ -16.7‰ , $\delta^{15}\text{N}$ 值介于 8.5‰ ~ 13.2‰ , 其稳定同位素比值表现出显著的季节差异, 且 $\delta^{15}\text{N}$ 与体长显著正相关。(2) 秋季龙头鱼营养级介于 3.1 ~ 4.1 , 春季龙头鱼营养级介于 2.6 ~ 3.9 , 相近体长的龙头鱼营养级波动大(0.5 ~ 1), 且随体长的增长逐渐升高。(3) 不同季节的龙头鱼摄食习性表现出一致的变化规律, 即随着体长的增加, 龙头鱼对浮游动物的摄入逐渐下降而对鱼类的摄入逐渐增长, 然后逐渐趋于稳定。同时, 不同类型的饵料生物对龙头鱼的贡献率也存在季节性差异。本研究证实了龙头鱼在不同体长和不同季节间的营养可塑性, 探讨了可能造成该物种资源现状的营养生态学方面的原因, 对该物种资源动态的研究以及东海渔业资源的可持续利用具有重要意义。

关键词: 龙头鱼; 稳定同位素; 营养级; 食性; 营养可塑性

Research on the trophic plasticity of Bombay duck (Harpadon nehereus) in south-central East China Sea

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Abstract: The stable isotope ratios of the samples (include Bombay duck and their potential food organisms) collected from the bottom trawl surveys of two voyages in south-central East China Sea in November 2018 and April 2019 were used to analyze the trophic level (TL) and feeding habits of the Bombay duck. The results showed that: (1) In the autumn of 2018 and the spring of 2019, the range of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ ratios of Bombay duck are -18.6‰ ~ -16.0‰ , -20.2‰ ~ -16.7‰ and 10.7‰ ~ 14.0‰ , 8.5‰ ~ 13.2‰ . Stable isotope ratios are significantly different in different seasons, and $\delta^{15}\text{N}$ is significantly positively correlated with body length. (2) The TL of Bombay duck in autumn ranged from 3.1 to 4.1, while in spring ranged from 2.6 to 3.9. The TL increases with the increase of body length and shows a greatly fluctuates among similar body length. (3) The feeding characteristics of the Bombay duck are as follows: with the increase of body length, the contribution rate of zooplankton to the Bombay duck continues to decrease while the contribution rate of the fish increase. And there are seasonal differences in the contribution rate of different items of food organisms to the Bombay duck.

Key words: Bombay duck, stable isotope, trophic level, feeding habits, trophic plasticity

东山湾增殖放流种类—黄鳍棘鲷遗传多样性现状初探

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摘要: 黄鳍棘鲷是东山湾内重要的捕捞种类和增殖放流种类, 随着增殖放流的逐年开展, 有必要对其遗传多样性现状进行研究。结果显示所有黄鳍棘鲷群体呈现高的遗传多样性现状, 这主要与其繁殖习性和生长速度有关, 能保证其在自然海域中有大量的补充群体。现如今的群体已经与历史群体产生分化, 遗传结构已经发生了变化, 大量历史单倍型丢失。本研究研究结果可为渔业管理部门提供参考, 制定专门针对黄鳍棘鲷的管理措施和保育政策, 尤其是黄鳍棘鲷是一种雌雄同体雄性先熟的种类, 若以高龄鱼作为主要捕捞对象, 不利于其繁殖保护和资源的增长, 在渔业生产中应限制捕捞高龄鱼。

关键词: 东山湾; 遗传多样性; 增殖放流; 资源衰退; 黄鳍棘鲷

Preliminary Study on the Genetic Diversity of *Acanthopagrus latus*—an Enhancement Species in Dongshan Bay

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Abstract: Yellowfin seabream is an important enhancement species in Dongshan Bay that is also frequently captured. Due to yearly progress in enhancement and release, it is necessary to study the current status of the genetic diversity of yellowfin seabream in Dongshan Bay. The results show that all yellowfin seabream populations have high genetic diversity, which is mainly related to its breeding habits and growth rate, and this ensures a large recruitment stock in the natural seas. The current population has differentiated from the historical population due to a change in genetic structure, and many historical haplotypes have been lost. The results of this study provide a reference for fishery management departments to formulate management measures and conservation policies specifically for yellowfin seabream. In particular, yellowfin seabream is a hermaphroditic and protandrous species. Targeting an older age group as the main fishing subject is not conducive to its breeding protection and resource growth, and therefore, fishing of an older age group should be restricted in fishery production.

Key words: Dongshan Bay, Genetic diversity, Stock enhancement, Resource decline, Yellowfin seabream

稳定同位素和脂肪酸标记法揭示了夏季南极磷虾食性的相似性

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摘要: 南极磷虾(*Euphausia Superba*)作为环南极分布的物种,以其重要的商业价值和生态作用在南极生态系统占据重要地位。本文以脂肪酸和同位素标记物(“营养动力学的二维方法”)探讨了南极磷虾在斯科舍海和南极印度洋扇区中心海域夏季的食性及营养动态。通过对 2017 年在两处海域收集的磷虾样本进行分析研究,结果表明,基于非参数多元方差分析(PERMANOVA),稳定同位素和脂肪酸组成在两个区域未发现性别上的差异和地理性的差异。非度量多维尺度法(NMDS)及主成分分析(PCA)结果同样揭示了磷虾在两个区域相似的食性及营养特征。

关键词: 南极磷虾; 脂肪酸; 同位素; 食性

Stable isotope and fatty acid profiles reflect similar trophic dynamics of Antarctic krill (*Euphausia Superba*) in the different sectors of Antarctic Ocean during summer

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Abstract: Antarctic krill (*Euphausia Superba*, hereafter krill) is a circumpolar distributed species, to explore the trophic dynamics of krill in the Scotia Sea and in the southern part of the Cooperation Sea during summer, stable isotope and fatty acid analyses were used as the biomarkers to evaluate the food supply and nutrition condition. The $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotopes showed closely composition between regions. The dominated marker FAs in term of percentage composition were 16:0, 18:1n9, EPA, and DHA in both areas. No significant differences were found from the stable isotope and fatty acid profiles between sexes and areas statistically. In addition, similar dietary pattern of krill was found between two areas, either reflected by the trophic niche of stable isotope, or principle component analysis of the fatty acids.

Key words: *Euphausia Superba*, Antarctic, fatty acid, stable isotope

近20年南海四带笛鲷(*Lutjanus kasmira*)种群特征的长期变化

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摘要: 根据 1998–2018 年于我国南海珊瑚礁海域以手钓及流刺网采集的四带笛鲷(*Lutjanus kasmira*)的生物学数据, 对其群体结构、初次性成熟体长、摄食强度及肥满度等种群特征的年际变化进行了研究。结果表明: 四带笛鲷的体长范围逐渐缩小, 平均体长、最大体长及优势体长组均呈减小趋势; 2013–2018 年四带笛鲷体长结构与 1998–1999 年差异极显著; 雌鱼所占比例逐渐升高; 低摄食等级个体占比不断升高, 平均摄食等级逐渐降低; 胃含物含有未消化的鸡骨和鸡肉残余; 肥满度持续减小, 雌性、雄性和全部群体 2016–2018 年的肥满度极显著低于 1998–1999 年; 肥满度雌雄及季节间的差异不显著, 但与平均摄食等级呈显著正相关关系。四带笛鲷种群特征演变表明, 其生境恶化, 种群健康和食物供给受到威胁。为促进珊瑚礁鱼类种群恢复, 建议及时采取措施保护其资源, 改善栖息地质量

关键词: 四带笛鲷; 珊瑚礁鱼类; 生物学特征; 肥满度

Long-term variations in the population characteristics of Blue-striped snapper *Lutjanus kasmira* in the South China Sea during recent 20 years

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Abstract: Based on the biological data of *Lutjanus kasmira* collected by hand fishing and gill nets in the coral reefs of the South China Sea from 1998 to 2018, the inter-annual variations in population characteristics such as population structure, first maturity lengths, feeding intensity and fitness were studied. The results showed that: The body length ranges, average body and maximum body length of *L. kasmira* reduced gradually, and the dominant body length groups were smaller. The difference of body length between 2013–2018 and 1998–1999 was extremely significant. From 1998 to 2018, the proportion of females increased gradually. The proportion of individuals with low feeding intensity increased continuously, and the proportion of individuals with high feeding intensity decreased significantly, and the average feeding intensity gradually decreased. In the stomach, some undigested chicken bone and chicken residue were found, indicating that the human activities in the reef area have directly penetrated into the material circulation of the population. The fitness continued to decrease from 1998 to 2018, and the fitness of the female, male and unsex populations during 2016 to 2018 was significantly lower than that during 1998 to 1999. The fitness was not significantly different between male and female and seasons, but it significantly positively correlated with the average feeding intensity. The long-term changes of the population characteristics of *L. kasmira* indicated that the population may be in poor health, and its habitats and supply of prey have been deteriorated. To promote the recovery of reef fish stocks, it is recommended to take timely measures to protect their resources and improve habitat quality.

Key words: *Lutjanus kasmira*, coral reef fish, biological characteristics, body condition

浙江南部近海夏季鱼类群落结构关键种及稳定性分析

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摘要: 根据 2016-2019 年浙江南部近海夏季渔业调查数据, 利用多元统计分析筛选鱼类群落结构典型种和分歧种, 利用 ABC 曲线探究关键种对群落结构稳定性的影响。研究发现: (1) 组内相似性累积贡献率达到 80%, 且在所有组内出现率超过 50% 的鱼类中, 带鱼是四个年度均出现的物种, 没有两、三个年度共有的种类; (2) 组间差异性累积贡献率达到 80%, 且在所有组内出现率超过 50% 的鱼类中, 带鱼、黑姑鱼是四个年度均出现的物种, 刺鲳、镰鲳、小黄鱼是两个年度出现的种类; (3) 夏季鱼类群落结构稳定性较差 ($W < 0$), 带鱼经去除实验发现会进一步加剧群落结构的不稳定性。综合群落结构特征, 推测带鱼为浙江南部近海夏季鱼类群落结构的关键种, 对群落结构稳定性具有较大影响。

关键词: 浙江南部近海; 鱼类群落; 稳定性; 关键种

Key species and Stability analysis of summer fish community structure offshore water of southern Zhejiang

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Abstract: According to the bottom-trawl survey offshore water of southern Zhejiang from 2016 to 2019, the typical species and different species of fish community structure were screened by multivariate statistical analysis, and the influence of key species on the stability of community structure was explored by ABC curve. The results showed that : (1) among the fish with 80% similarity accumulation contribution rate and over 50% occurrence rate in all groups, hairband fish was a species that appeared in all four years, and there was no species Shared in two or three years. (2) The cumulative contribution rate of difference between groups reached 80%, and among the fish with the occurrence rate of over 50% in all groups, *Trichiurus lepturus* and *Argyrosomus nibe* were the species that appeared in all four years, *Psenopsis anomala*, *Pampus argenteus* and *Larimichthys polyactis* were the species that appeared in both years. (3) The stability of the community structure was poor in summer ($W < 0$), and the removal of *Trichiurus lepturus* was found to further aggravate the instability of the community structure. Based on the characteristics of the community structure, it is speculated that *Trichiurus lepturus* is the key species of the summer fish community structure in the southern coastal waters of Zhejiang province, which has great influence on the stability of the community structure.

Key words: offshore water of southern Zhejiang; fish community; stability; keystone species

空间尺度选择对长江口刀鲚 (*Coilia nasus*) 分布预测的影响

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摘要: 河口区域是一个淡水-咸淡水-咸水过渡的复杂环境, 海洋环境要素在较小的空间范围具有剧烈的变化。长江口作为我国最大的河口, 是多种重要物种的产卵场、索饵场和洄游通道。为进一步了解空间尺度选择对于物种分布的影响, 本文以长江口刀鲚 (*Coilia nasus*) 为研究对象, 使用二阶广义加性模型 (GAM), 对比了五种空间尺度下物种分布模式对于环境变化的响应。结果显示: (1) 在不同空间尺度下, 3'×3'的 Chla 与 Depth 的预测值的均值比其它空间尺度显著要低, 5'×5'的 Sal 的预测值均值高于其它空间尺度; (2) 在丰度上, 3'×3'的均值比其它尺度要低, 但分布模式十分相似。因此建议今后的研究需要评估空间尺度的潜在影响。

关键词: 长江口; 环境因子; 空间尺度; 刀鲚 (*Coilia nasus*); 分布预测

The influence of spatial scale selection on the prediction of *Coilia Nasus* distribution in Yangtze River estuary

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Abstract: The estuarine area is a complex environment with a transition from fresh water to brackish water, and the Marine environmental elements change dramatically in a small space. As the largest estuary in China, the Yangtze River estuary (YRE) is the spawning ground, feeding ground and migration channel for many important species. In order to further understand the influence of spatial scale selection on species distribution, this paper takes *Coilia Nasus* as the research object, and uses two-step Generalized additive models (GAM) to compare the response of five spatial scales species distribution patterns to environmental changes. The results show that: (1) under different spatial scales, the mean predicted values of Chla and Depth of 3'×3' are significantly lower than those of other spatial scales, and the mean predicted values of Sal of 5'×5' are higher than those of other spatial scales. (2) In abundance, the mean value of 3'×3' is lower than other scales, but the distribution pattern is very similar. It is therefore suggested that future research needs to assess the potential impact of spatial scales.

Key words: the Yangtze river estuary, environmental factors, Space scale, *Coilia nasus*, spatial distribution

基于蒙特卡罗方法的集鱼灯海面照度分布研究

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摘要: 集鱼灯照度分布计算和模拟是灯光渔船集鱼灯合理布置的重要手段。本研究利用环境变量中的风速和相对湿度数据, 基于米氏理论得出大气消光系数, 建立了蒙特卡罗模型, 并利用该方法计算了集鱼灯海面照度分布。蒙特卡罗方法相比于其他集鱼灯照度计算方法具有如下优势: 1、考虑了大气消光系数及不同波长的衰减特性, 具有更高的精确性; 2、能对船底阴影部分的照度分布进行较好的计算。模型验证表明: 通过实测值与理论值线性回归分析 ($R^2=0.9935$) 和相对均方根误差计算 ($RMSE=0.0084$), 表明实测值与理论值有很好的对应关系。研究结果还表明: 在相同前提下, 相对湿度和风速越高照度衰减越快。

关键词: 照度分布; 米氏理论; 集鱼灯; 蒙特卡罗

Research on Illumination Distribution of Fishing Lamp on Sea Surface Based on Monte Carlo Method

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Abstract: The calculation and simulation of the illuminance distribution of the fishing lamp play an important role for the rational arrangement of the fishing lamp of the fishing vessel. This study uses data of the wind speed and relative humidity in environmental variables to obtain the atmospheric extinction coefficient based on Mie theory, establishes a Monte Carlo model, and uses this method to calculate the illuminance distribution on the sea surface of the fishing lamp. The Monte Carlo method has the following advantages compared with other fishing light illumination calculation methods: 1. It takes into account the atmospheric extinction coefficient and the attenuation characteristics of different wavelengths, and has higher accuracy; 2. It can measure the illuminance distribution of the shadow part of the bottom of the fishing vessel. Model verification shows that the linear regression analysis between the measured value and the theoretical value ($R^2=0.9935$) and the calculation of the relative root mean square error (RRMSE=0.0084) results show that the measured value and the theoretical value have a good corresponding relationship. The research results also show that under the same premise, the higher the relative humidity and wind speed, the faster the illuminance attenuation.

Key words: Illumination distribution, Mie theory, Fish Lights, Monte Carlo

江苏潮间带大型底栖动物群落组成及多样性研究

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摘要: 为了研究江苏潮间带大型底栖动物群落的组成和多样性情况, 于2019年5月、8月和10月在江苏沿海潮间带进行了涵盖3个季节10个断面的大型底栖动物的采样调查。调查结果表明, 共调查发现潮间带生物10门103种, 以环节动物、软体动物和甲壳动物为主。各季节的优势种为泥螺(*Bullacta exarata*)、四角蛤蜊(*Mactra veneriformis*)、宽身大眼蟹(*Macrophthalmus dilatatum*)、浅古铜吻沙蚕(*Glycera subaenea*)、加州齿吻沙蚕(*Nephtys californiensis*)、纽虫(*Glycera chirorilizuka*)、鸭嘴海豆芽(*Lingula anatina*)、海豆芽(*Lingula Bruguire*)、长吻沙蚕(*Glycera chirorilizuka*)和琥珀刺沙蚕(*Neanthes succinea*)。年平均密度121.60 ind·m⁻², 年平均生物量197.09 g·m⁻²。调查断面Shannon-Wiener(*H'*)多样性指数平均值为3.16, Margalef丰富度指数(*d*)平均值为2.35, Peilou均匀度指数(*J*)平均值为0.85。聚类分析和多维尺度分析可将十个断面分为三个群, 江苏北部积汪和东连岛划分为一群, 中部滨海、竹港、条子泥北和射阳电厂为一群, 南部东元、连兴港、新港和梁垛河为一群。由此更加直观的显现群落不同季节和潮带的梯度变化。江苏北部大型底栖动物种类、多样性、生物密度和生物量高于江苏中南部。江苏潮间带大型底栖动物总体上生物物种丰富度一般, 个体分布比较均匀, 多样性指数级别较高。

关键词: 江苏潮间带; 群落组成; 季节变化; 多样性;

Study on the composition and diversity of macrozoobenthos community in the intertidal zone of Jiangsu.

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Abstract: In order to study the composition and diversity of macrobenthos communities in the intertidal zone of Jiangsu, sampling surveys of macrobenthos covering 10 sections in 3 seasons were carried out in the coastal intertidal zone of Jiangsu in May, August and October 2019. The survey results showed that a total of 103 species of 10 intertidal organisms were found, mainly link animals, mollusks and crustaceans. The dominant species in each season were *Bullacta exarata*, *Mactra veneriformis*, *Macrophthalmus dilatatum*, *glycora subaenea*, *Nephtys californiensis*, *glycora chirorilizuka*, *lingula anatina*, *lingula bruguire*, *Glycera Chirorilizuka* and *Neanthes succinea*. The annual average density is 121.60 ind·m⁻², and the annual average biomass is 197.09 g·m⁻². The average of Shannon-Wiener (*H'*) diversity index in the survey section was 3.16, the average of Margalef richness index (*d*) was 2.35, and the average of Peilou evenness index (*J*) was 0.85. Cluster analysis and multi-dimensional scale analysis can divide the ten sections into three groups. Several sections in northern, southern and central Jiangsu are divided into groups. Therefore, the gradient change of the community in different seasons and tidal zones can be visualized more intuitively. The species, diversity, biological density and biomass of macrobenthos in northern Jiangsu are higher than those in central and southern Jiangsu. The macrobenthos in Jiangsu's intertidal zone are generally rich in biological species, with relatively uniform distribution of individuals and a high level of diversity index.

Keywords: Jiangsu intertidal zone; community composition ; diversity; seasonal variation

2019 年海州湾海域中国明对虾增殖放流效果评估

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摘要: 2019 年江苏省在海州湾海域共放流中国明对虾苗种约 3.8 亿尾, 放流后开展了三个航次的海上跟踪调查和社会调查。本研究通过对放流后捕获的中国明对虾数量、生物学测定结果, 结合渔船生产捕获数量综合分析, 开展中国明对虾增殖放流效果评估。结果表明: 2019 年海州湾海域中国明对虾产量为 100t, 其中放流中国对虾产量 95t、产值 1700 万元、投入产出比为 1:6, 回捕率 0.43%。通过多年的增殖放流, 海州湾海域中国明对虾增殖放流效果显现, 捕捞渔民收入增加, 促进了渔区社会稳定, 经济效益、社会效益和生态效益显著。

关键词: 中国明对虾; 增殖放流; 效果评估; 回捕率;

The Evaluation on the Releasing of Chinese shrimp (*Fenneropenaeus chinensis*) in Laoshan Bay

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Abstract: In 2019, a total of about 380 million larvae of Chinese shrimp were released into the Haizhou Bay. After the release, three voyages of marine tracking and social surveys were carried out. In this study, the number and biological measurement results of the Chinese shrimp caught after release, combined with the comprehensive analysis of the number of catches produced by fishing vessels, were used to evaluate the effect of Chinese shrimp proliferation and release. The results showed that the output of Chinese shrimp in the Haizhou Bay in 2019 was 100 tons, of which the output of Chinese shrimp was 95 tons, the output value was 17 million yuan, the input-output ratio was 1:6, and the catch rate was 0.43%. Through years of proliferation and release, the effect of the proliferation and release of Chinese shrimp in the Haizhou Bay has become apparent, and the income of fishermen has increased, which has promoted social stability in the fishing area, and has significant economic, social and ecological benefits.

Key words: Chinese shrimp, stock enhancement, evaluation, recapture rate

江苏近海曼氏无针乌贼增殖放流背景下的资源现状

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摘要: 为修复江苏近海曼氏无针乌贼(*Sepiella maindroni*)资源, 2013-2019年江苏近海实施了规模化放流, 累计增殖放流受精卵 895×10^4 粒, 2019年5月、8月和10月在江苏大面和重要渔业水域开展了本底调查和跟踪调查, 对比放流前后曼氏无针乌贼的资源情况。结果表明, 2019年本底调查(春季)曼氏无针乌贼出现频率为10%, 出现在两沙保护区; 2019年夏季大面跟踪调查曼氏无针乌贼的出现频率为26%, 主要出现在吕泗渔场; 2019年秋季跟踪调查曼氏无针乌贼的出现频率为20.00%, 出现在海洲湾渔场和吕泗渔场。2019年跟踪调查(夏季和秋季)捕获的曼氏无针乌贼与本底调查(春季)相比, 不管是重量密度、数量密度、资源量还是资源密度, 均存在显著性差异, 前者明显高于后者, 在区域分布上具有从吕泗渔场近岸向外、向南北扩散的趋势。根据2019年大面调查数据, 春季江苏近岸海域曼氏无针乌贼本底资源量为3.63 t, 夏季、秋季跟踪监测捕获的曼氏无针乌贼资源量分别为69 t和91 t, 放流后捕获的曼氏无针乌贼资源量远高于本底, 并且是理论放流数量产生的资源量1.71倍和2.26倍。从理论估算到实际调查均显示, 曼氏无针乌贼增殖放流给海域增加了资源量, 并且补充了一定数量的性成熟个体, 切合实际地起到修复江苏近岸海域曼氏无针乌贼资源的效果, 直接或间接地为当地渔业增加经济效益。最后, 针对资源现状提出开展曼氏无针乌贼放流标记和合理利用资源的建议。

关键词: 江苏近海; 曼氏无针乌贼; 增殖放流; 资源现状

Status of *Sepiella maindroni* resources after enhancement release in Jiangsu coastal water

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Abstract: In order to restore the *Sepiella maindroni* resources in the coastal water of Jiangsu Province, the large-scale release had been carried out from 2013 to 2019. A total of 895×10^4 ind. fertilized eggs were released, and the background survey and follow-up monitoring survey were carried out in 2019. In order to compared the resources of *Sepiella maindroni* before and after releasing. The results show that, the resources of *Sepiella maindroni* were significant improved after releasing, and spread from the nearshore of Lvsi fishing ground to the South and North. In spring, the background resources of *Sepiella maindroni* in the coastal waters of Jiangsu were 3.63 t. The follow-up monitoring survey resources were 69 t and 91 t in Summer and Autumn. Finally, we put forward the suggestions about improving the effect of releasing *Sepiella maindroni* and using the resources reasonably according to the research.

Key words: Jiangsu coastal water, *Sepiella maindroni*, enhancement release, resources

舟山近海捕捞压力对鱼类种群动态变化的定量影响研究

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摘要: 舟山渔场是我国最重要的渔场之一, 受到捕捞压力持续增加的影响, 近海渔业资源严重衰退。量化捕捞压力是渔业资源管理的前提, 当前的捕捞压力监测大都基于渔船产量、捕捞努力量统计, 很难反映渔船捕捞活动时空动态变化的客观事实。本文结合近几年的舟山近海大部分渔船的北斗卫星监测数据(船速、航向), 以及渔业资源科学调查数据, 量化捕捞压力对舟山近海三种鱼类种群(小黄鱼、龙头鱼、矛尾虾虎鱼)的影响, 结合鱼类的生活史, 建立影响不同种群鱼类动态变化对捕捞压力和环境因子参数的响应模型, 为渔业资源的管理提供一定的参考和依据。

关键词: 舟山近海; 鱼类种群; 捕捞压力; 北斗卫星监测;

The quantitative study on influence of fishing pressure on fish population dynamics in Zhoushan offshore Seas

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Abstract: Zhoushan fishing ground is the most important fishing grounds in China, similar with other offshore areas, it is heavily influenced by increase of fishing effort. The fisheries were declined and exhausted recently. The quantitative analysis of fishing effort is precondition for EBFM. Current fishing effort were generally collected from fisheries catch, fishing vessel statistic survey by fishermen. These data hardly characterize the real condition of the spatial-temporal dynamics of fishing effort. Based on Beidou navigation system, the fishing vessel speed, direction were currently available for later study. In combination with fisheries-independent survey, we could quantify the fishing pressure in spatial and temporal scales, and their influence on three most important fish populations (*Larimichthys polyactis*, *Harpadon nehereus*, *Chaeturichthys stigmatias*). According to their life stages, we constructed the response model between population of each species and fishing pressure and environment, and this may be valuable for fisheries management.

Keywords: Zhoushan offshore; fish population; fishing pressure; Beidou Navigation

基于 CiteSpace 的南极磷虾主题文献分析

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摘要: 南极磷虾渔业已成为中国远洋渔业发展的重点关注对象之一, 逐渐成为学术界研究热点。为掌握南极磷虾相关文献产出情况和趋势, 采用 CiteSpace 可视化分析工具, 以 web of science™ 核心合集收录的文献为数据来源, 通过设计检索式, 截至 2020 年 7 月 21 日, 得到高度相关文献 1 527 篇。通过对南极磷虾研究领域的论文发文量、文献学科分布和关键词的可视化聚类分析, 研究发现: 有关南极磷虾的学术研究越来越多, 学者从资源、环境、政治等多个角度来进行了相关研究, 发表文献数量和施引文献数量整体均呈现增长趋势。近年来, 南极磷虾产业技术研究新兴热点有很多, 特别是基于南极磷虾为原料开发的水产养殖饲料、虾粉中蛋白质的提取、南极磷虾粗油提纯、南极磷虾油中虾青素含量的测定等的主题文献数量增长迅速。通过分析南极磷虾主题的研究热点以及研究趋势, 以期了解中国南极磷虾主题研究的现状及发展, 为推动未来南极磷虾开发及相关研究提供参考依据。

关键词: 南极磷虾; CiteSpace; web of science™ 核心合集; 南极磷虾油

Literature analysis of Antarctic krill based on CiteSpace

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Abstract: Antarctic krill fishery has become one of the focuses of the development of China's pelagic fishery, and has gradually become a research hotspot in the academic community. CiteSpace visual analysis tool was used to comprehensively grasp the output and trend of Antarctic krill related literature. Based on the core collection of web of science, through the design of retrieval formula, by July 21, 2020, 1 527 highly related literatures were obtained. Through the visual cluster analysis of the number of papers published, the distribution of literature disciplines and key words in the research field of Antarctic krill, it was found that the number of published literature and the number of citation literature were increasing as a whole. It showed that there were more and more academic researches on Antarctic krill, and scholars have carried out relevant research from the perspectives of resources, environment, politics and so on. In recent years, there were many new hotspots in Antarctic krill industry. There has been a rapid increase in the number of subject literature on aquaculture feed developed from Antarctic krill, protein extraction from Antarctic krill powder, purification of crude krill oil, determination of astaxanthin content in krill oil. By analyzing the research hotspots and trends, the current situation and development of Antarctic krill theme research in China, it can provide reference for promoting the development of Antarctic krill in the future.

Key words: Antarctic krill, CiteSpace, web of science™ core collection, krill oil

基于生态类群的舟山近海仔稚鱼数量时空动态变化及与环境因子的关系

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摘要: 仔稚鱼是鱼类资源进行补充和可持续利用的基础, 但影响其亲体选择繁殖环境的影响因素尚不清楚。本文根据在 2019 年 3 月、4 月、7 月、11 月在舟山近海海域开展的 4 个航次的仔稚鱼生态调查, 对舟山近海仔稚鱼群落结构(种类组成、优势种数量)的动态变化进行了研究, 探讨了仔稚鱼群落的季节变化和对环境变化的响应。结合温盐数据, 探讨控制仔稚鱼分布数量的物理因素, 并建立一个生态预测系统。结果显示仔稚鱼丰度的季节变化比较大, 仔稚鱼集中分布于 30°N~31°N、水深 10~20 m 的近岸河口区。近岸河口型仔稚鱼在温度(13.5-16°C)和盐度(14-17)范围内出现。近海型仔稚鱼在温度(20-23°C)和盐度(30-35)范围内出现。回归分析表明, 温度和盐度的组合是仔稚鱼出现的重要预测因子。模型预测结果显示: 近岸型仔稚鱼在近岸出现的概率为 0.65-0.95, 在近海出现的概率为 0.26-0.60; 近海型仔稚鱼在近岸出现的概率为 0.12-0.34, 在近海出现的概率为 0.32-0.54。本研究揭示了仔稚鱼丰度的时空分布特征和环境因子之间的关系, 为舟山近海产卵场保护区、资源量化管理等措施提供科学依据。

关键词: 仔稚鱼; 生态类群; 季节变化; 环境因子

Spatiotemporal dynamics of fish larvae in Zhoushan archipelago waters based on ecological groups and its relationship with environmental factors

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Abstract: Fish larvae are the basis of fish resources for replenishment and sustainable utilization, but the influencing factors of parental selection and breeding environment are not clear. In this paper, the dynamic changes of community structure (species composition and number of dominant species) of fish larvae in Zhoushan archipelago waters were studied based on the ecological surveys of fish larvae carried out in Zhoushan archipelago waters in March, April, July and November, 2019, and the seasonal changes of fish larvae communities and their responses to environmental changes were discussed. Combined with temperature and salinity data, the physical factors controlling the distribution of fish larvae were discussed, and an ecological prediction system was established. The results showed that the seasonal variation of fish larvae abundance was relatively large, and the fish larvae were mainly distributed in the coastal estuary of 30° N ~ 31° N and water depth of 10 ~ 20 m. The fish larvae of estuarine type fish appeared in the range of temperature (13.5-16 °C) and salinity (14-17). The fish larvae of offshore type appeared in the range of temperature (20-23 °C) and salinity (30-35). Regression analysis showed that the combination of temperature and salinity was a significant predictor of the emergence of fish larvae. The prediction results show that the occurrence probability of inshore fish larvae is 0.65-0.95 and 0.26-0.60 respectively; the occurrence probability of offshore fish larvae is 0.12-0.26 and 0.32-0.54 respectively. This study revealed the relationship between the spatial and temporal distribution characteristics of fish larvae abundance and environmental factors, and provided a scientific basis for the protection area of Zhoushan offshore spawning ground and the quantitative management of resources.

Key words: fish larvae; ecological groups; seasonal changes; environmental factors

毛里塔尼亚海域沙丁鱼和圆沙丁鱼耳石微量元素分析

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摘要: 本研究主要通过对毛里塔尼亚海域沙丁鱼和圆沙丁鱼耳石九种主要耳石边缘微量元素(Na、Mg、Cu、Mn)含量与Ca比值的比较,并结合环境因子对沙丁鱼和圆沙丁鱼的生活史进行研究。结果发现沙丁鱼耳石微量元素Na:Ca与海表面温度有显著差异($P=0.006$),Fe:Ca与海盐度有显著差异($P=0.043$),其他七种元素均无显著差异。圆沙丁鱼耳石微量元素Fe:Ca与海表面温度有显著差异($P=0.045$),Mg:Ca与海盐度有显著差异($P=0.013$),其他七种元素均无显著性差异。本研究认为沙丁鱼耳石微量元素Na、Fe,圆沙丁鱼耳石微量元素Fe、Mg与海表面温度和盐度有密切关系,对耳石微量元素的分析有利于对沙丁鱼栖息环境的研究,对沙丁鱼生活史的研究有重要意义。

关键词: 毛里塔尼亚; 沙丁鱼; 圆沙丁鱼; 耳石

Trace element analysis of otolith of Sardines and round sardines in Mauritanian waters

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Abstract: In this study, the concentrations of trace elements (Na, Mg, Cu, Mn) and Ca ratios of the nine main otolith edge trace elements of sardines and round sardines in the sea area of Mauritania were compared, and the life history of sardines and round sardines was studied by combining environmental factors. The result shows that the trace element Na:Ca was significantly different from sea surface temperature ($P=0.006$), Fe:Ca and sea salinity were significantly different ($P=0.043$). There was no significant difference among the other seven elements; There were significant differences between Fe:Ca and sea surface temperature ($P=0.045$), Mg:Ca and sea salinity ($P=0.013$), and no significant differences between the other seven elements. In this study, the trace elements of otolith such as Na and Fe and Fe and Mg are closely related to sea surface temperature and salinity. The analysis of trace elements of otolith is conducive to the study of the habitat environment of sardine, and is of great significance to the study of the life history of sardines.

Key words: Mauritania, sardine, round sardine, otolith

基于长度频率的北部湾大头白姑鱼种群参数估算

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摘要: 基于 2006-2018 年北部湾大头白姑鱼 (*Pennahia macrocephalus*) 生物学数据, 通过长度贝叶斯生物量法 (Length-based Bayesian biomass estimator, LBB) 估算大头白姑鱼的渐进体长 (L_{inf})、相对自然死亡率 (M/k)、相对捕捞死亡率 (F/k)、最适开捕体长 (L_{c_opt}) 和开发率 (E)。结果表明, 2006-2018 年北部湾大头白姑鱼的平均渐进体长为 262mm, 最适平均开捕体长为 156mm, 相对死亡率 M/k 、 F/k 和 Z/k 分别为 1.44、9.28、10.71。大头白姑鱼开捕体长呈上升趋势, 而渐进体长呈下降趋势。目前大头白姑鱼开发率较高, 开发率为 0.63, 已处于过度开发状态。研究结果丰富和完善了大头白姑鱼的基础生物学资料, 可为大头白姑鱼资源的科学管理提供技术支撑。

关键词: 数据缺乏; LBB; 长度频率; 种群参数; 大头白姑鱼; 北部湾

Based on the length-frequency method to estimate fish population parameters of *Pennahia macrocephalus* in the Beibu Gulf

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Abstract: Based on the biological data of *Pennahia macrocephalus* collected in the Beibu Gulf from 2006 to 2018, the asymptotic body length (L_{inf}), relative natural mortality (M/k), relative fishing mortality (F/k), optimal body length-at-first-capture (L_{c_opt}) and exploitation rate (E) of *P. Macrocephalus* were estimated by the Length-based Bayesian biomass Estimator (LBB). Results showed that the average asymptotic body length and optimal body length-at-first-capture were 262 mm and 156 mm, and the relative mortality rates of M/k , F/k , and Z/k were 1.44, 9.28, and 10.71, respectively. The optimal body length-at-first-capture of *P. Macrocephalus* showed an increasing trend while the asymptotic body length showed a decreasing trend. At present, the exploitation rate of *P. Macrocephalus* is relatively high, with 0.63. The results enrich and improve the basic biological data of the species, and provide scientific and technical support for the fishery management of the species.

Key words: data-poor method; LBB; length frequency; population parameter; *Pennahia macrocephalus*; Beibu Gulf

中国沿海沙带鱼遗传多样性和种群结构研究

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摘要: 沙带鱼是一种重要的海洋经济鱼类, 广泛分布于印度-西太平洋的热带沿海。目前有关这一物种的遗传学研究很少。因此, 本研究在前人成功开发的 13 个微卫星标记的基础上, 利用 2019 年从中国大陆沿海 6 个地点采集的 172 个样品首次评估了沙带鱼的种群结构和遗传多样性。6 个群体中等位基因数为 10.3-14.0, 观测杂合度 0.76-0.83, 期望杂合度 0.85-0.86, 遗传多样性较高。分子方差分析(AMOVA)表明, 99% 以上的遗传变异发生在个体间, 与地理区域无关。STRUCTURE 分析显示所有种群都由两个聚类组成, 表明沙带鱼较高的迁移能力导致了广泛的基因流动。该研究对遗传改良、保护与管理以及资源可持续利用具有一定的实践与理论价值。

关键词: 沙带鱼; 微卫星; 遗传多样性; 种群结构

Genetic diversity and population structure of cutlassfish (*Lepturacanthus savala*) along the coast of mainland China

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Abstract: Cutlassfish (*Lepturacanthus savala*) is a commercially important fish species that is distributed in the tropical coastal area throughout the Indo-West Pacific and Indian Oceans. However, there have been few genetic studies on this species. Therefore, based on thirteen microsatellite markers that have been successfully developed by predecessors, the objective of this study is to assess the genetic diversity and structure of *L. savala* for the first time, using 172 individuals collected from six locations along the coast of mainland China during 2019. The average number of alleles among the six populations ranged from 10.3 to 14.0. The observed and expected heterozygosity ranged from 0.76 to 0.83 and from 0.85 to 0.86, respectively, which showed that the all population exhibited the high level of genetic diversity. Analysis of molecular variance (AMOVA) showed that more than 99% of genetic variation was maintained within individual components with no relation to geographic area. The results of STRUCTURE suggested that all populations were admixtures of two clusters, which could be explained only by the high migratory ability of *L. savala* resulting in extensive gene flow. Such study is both practical and theoretical value for genetic improvement, conservation, management and sustainable resource utilization.

Key words: *Lepturacanthus savala*, microsatellite, genetic diversity, population structure

PAR 对南沙鸢乌贼 CPUE 的影响机制研究

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摘要: 根据 2018 年和 2019 年灯光罩网渔船在南沙附近 111 - 117°E、8 - 14°N 海域的鸢乌贼产量数据, 结合光合有效辐射 (PAR) 遥感数据。采用广义加性模型 (GAMs), 研究 PAR 与单位捕捞努力量渔获量 (CPUE) 的关系。研究表明: 南沙附近海域 PAR 随着时间变化呈现出双峰型, 4 月、10 月分别达到峰值; PAR 随空间变化不大。GAMs 模型分析时空因素与 PAR 之间关系, 月份对于 PAR 变化的解析率 (74.30%) 最大。GAMs 模型分析 PAR 与不同方式处理的 CPUE 之间关系, 当 PAR 大于 48.5 mol·m⁻²·d⁻¹ 时, CPUE 与之正相关; PAR 对于 ln(CPUE+1) 的解析率 (25.50%) 更高。当 PAR 值明显高于或低于同期水平时, CPUE 值也高于或低于同期水平。研究期间海域发生了弱厄尔尼诺现象, 2019 年 CPUE 春季高产期较 2018 年提前一个月, 2019 年 8—12 月 CPUE 明显低于 2018 年同期, 厄尔尼诺现象可能对于 CPUE 有影响。研究 PAR 与 CPUE 之间的关系有助于寻找渔场以及进行渔业资源评估, 对于未来的鸢乌贼渔业资源管理也有一定的参考意义。

关键词: 鸢乌贼; 遥感; 广义加性模型; 厄尔尼诺; 异常气候; 渔业资源管理

Effect of photosynthetic effective radiation on CPUE of The purpleback flying squid in nansha Area

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Abstract: According to the yield data of the purpleback flying squid (*Sthenoteuthis oualaniensis*) in the sea area of 111-117°E and 8-14°N near Nansha Islands in 2018 and 2019. Combined with PAR marine environment data obtained by remote sensing. This study used GAMs to describe the relationships between CPUE and PAR. The study found that the monthly changes of PAR show double peak in research area, that is the peak appear in April and October. PAR does not change much with space. The GAMs model analyzes the relationship between time and space factors and PAR, and finds that the monthly desorption rate (74.30%) to the change of PAR is the largest. The GAMs model analyzes the relationship between CPUE and PAR processed in different methods, and found that when PAR is greater than 48.5 mol·m⁻²·d⁻¹, CPUE is positively correlated with it; the desorption rate (25.50%) of PAR to ln(CPUE+1) higher. During the study period, there was a weak El Niño phenomenon, and the spring high yield period of CPUE in 2019 was one month earlier than that in 2018. The CPUE from August to December 2019 was significantly lower than the same period in 2018. The El Niño phenomenon may have an impact on CPUE. When the PAR is significantly higher or lower than the same period, the CPUE is also higher or lower than the same period. The study of the relationship between PAR and CPUE is helpful to find fishing grounds and conduct fishery resource assessment, and it is also of certain reference significance for the future management of the purpleback flying squid fishery resources.

Key words: *Sthenoteuthis oualaniensis*; Remote Sensing; GAMs; El Niño; Abnormal Climate; Fishery Resources Management

基于形态学特征和 DNA 条形码对中国沿海银口天竺鲷属(*Jaydia*)分类研究

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摘要: 本研究结合形态特征比较与 DNA 条形码技术对 *Jaydia* 属分类鉴定问题进行梳理。2014—2019 年间于南海北部沿海采集 101 尾银口天竺鲷属鱼类标本, 经形态学特征鉴定为: 横带银口天竺鲷; 印度洋银口天竺鲷; 白边银口天竺鲷; 黑边银口天竺鲷; 史密斯银口天竺鲷; 斑鳍银口天竺鲷; 黑鳃银口天竺鲷。研究发现 *Apogon arafurae* 并不是 *J. truncata* 同种异名, 学名应更正为 *Jaydia poeciloptera*。结合 NJ 树分析发现, 史密斯银口天竺鲷和黑鳃银口天竺鲷均出现错误鉴定, 认为 GenBank 上传的序列(MH085808、JQ681491)存在误鉴, 实为黑鳃银口天竺鲷。

关键词: 银口天竺鲷属; 形态学; COI 基因; 分类学

CLASSIFICATION AND IDENTIFICATION OF CARDINALFISH (AOGONIDAE: JAYDIA) IN COASTAL CHINA BASED ON MORPHOLOGICAL CHARACTERISTICS AND DNA BARCODE

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Abstract: Classification and identification of *Jaydia* in coastal China were organized through morphological characteristics and DNA barcode. One hundred and one specimens of *Jaydia* were collected in the South China Sea from 2014 to 2019 and were identified as *J. striata*, *J. striatodes*, *J. novaeguineae*, *J. truncata*, *J. smithi*, *J. carinatus* and *J. poeciloptera*. *Apogon arafurae* is not a synonym of *J. truncata* and its valid name should be corrected to *J. poeciloptera*. NJ tree shows that interspecific genetic distance of *J. striata*, *J. smithi*, and *J. truncata* of K2P were greater than 2% and the sequences of MH085808, JQ681491 in GenBank may be *J. poeciloptera*.

Key words: *Jaydia*, morphology, COI gene, taxonomy

基于计算机视觉的头足类角质颚特征研究：形态学测量

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摘要: 角质颚形态被广泛应用于头足类种类鉴定与种群判别, 基于游标卡尺的手动径向测量是获取角质颚形态参数最常用的方法。本文提出一种利用计算机视觉提取角质颚形态参数的方法, 首先通过 MATLAB 编程提取角质颚特征点及空间坐标, 然后计算特征点间的空间距离, 最后将提取的角质颚形态学参数值与手动径向测量的结果进行比较。研究表明: 两种方法所得头足类角质颚形态学参数的算术平均值接近且相对误差和绝对误差都较小, 说明两种方法的测量结果准确, 偏离真值较少; 但由标准差和离散系数可看出, 计算机视觉提取的角质颚形态学参数结果离散程度更低精密度更高。计算机视觉不仅为头足类角质颚参数测量提供了一种快速、准确方法, 同时还大幅促进角质颚形态学参数在头足类种群判别与种类鉴定等领域的广泛应用。

关键词: 角质颚; 形态参数; 计算机视觉; 手动测量

Morphological study of cephalopod beak based on computer vision : Morphological parameter measurement

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Abstract: Beak morphology is widely used in cephalopod species identification and population discrimination. This paper presents a method to extract the morphological parameters of beak by computer vision. Firstly, the feature points and spatial coordinates of beak are extracted by MATLAB programming, and then the spatial distance between the feature points is calculated. Finally, the extracted morphological parameters of beak are compared with the results of manual radial measurement. The arithmetic mean value of the morphological parameters of cephalopod beak obtained by the two methods is close and the relative error and absolute error are small, which shows that the measurement results of the two methods are accurate and less deviated from the true value; however, from the standard deviation and the discrete coefficient, it can be seen that the results of the morphological parameters of beak extracted by computer vision are more aggregated, and the dispersion degree is lower and the precision is higher.

Key words: beak, morphological parameters, computer vision, manual measurement

俄罗斯渔业发展现状

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摘要: 俄罗斯幅员辽阔, 海岸线漫长, 渔业资源极为丰富, 若能合理并高效地开发利用将在其国民经济中占据重要地位, 但就现状而言发展并不乐观。本文基于俄罗斯统计年鉴, 以苏联解体作为主要时间节点, 对多年来俄罗斯渔业经济数据进行汇总, 从渔业资源、经济贸易、从业人员三个围度, 对俄罗斯渔业经济发展历史、现状进行分析, 并对其未来渔业发展及中俄渔业合作进行了探讨。

关键词: 俄罗斯; 渔业经济; 渔业合作

The Current Situation of Fishery Economic in Russia

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Abstract: Russia has vast territory, long coastline and abundant fishery resources, which will occupy an essential position in its national economy, but development is not optimistic in the current situation if it can be developed and utilized reasonably and efficiently. This paper, based on the Russian Statistical Yearbooks, with the disintegration of the Soviet Union as the turning point, summarized and analyzed some data from the fishery resources, economic trade and labor force. The overall decline of the Russian fishery economy explained and discussed, and suggestions made for its fishery development and Sino-Russian fishery cooperation with China.

Key words: Russia; Fishery economy; Fishery cooperation

金枪鱼延绳钓力学性能研究进展

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摘要: 文章总结了国内外金枪鱼延绳钓力学性能由最初的海上实测到动水槽模型试验再到数值模拟研究的相关研究方法与成果。结果显示: 1) 进行小尺度延绳钓模型试验, 目的是验证特定情况下数值模拟分析的准确性; 2) 根据数值模拟和实测结果确定了延绳钓干线垂直阻力系数 (CN90) 为 1.12 和附加质量系数 (Cm) 为 3。建议今后对延绳钓力学性能研究为: 1) 研究渔具材料刚度、阻尼对数值模拟精度的影响; 2) 对于渔具与海流、渔船、绞机和渔获物之间的相互作用机理进行深入的数值模拟研究。

关键词: 延绳钓; 力学性能; 海上实测; 模型试验; 数值模拟

A review of tuncgline gear mechanical property

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Abstract: This paper summarizes relevant research methods and progress on the mechanical property of tuna longline gear, including the initial measurement at sea, the model test in the flume tank, and the numerical simulation. Results showed that: 1) the model test of longline could only be carried out on a small scale in order to verify the accuracy of numerical simulation analysis under specific circumstances; 2) the vertical drag coefficient (CN90) and the additional mass coefficient (Cm) were determined to be 1.12 and 3. This paper suggested that in the future research on longline gear mechanical property: 1) the effects of the stiffness and damping of fishing gear materials on the numerical simulation accuracy should be studied; 2) the interaction among the fishing gear, current, fishing boat, line hauler and catches should be simulated numerically further.

Key words: longline; mechanical property; measurement at sea; model test; numerical simulation

北太平洋小型中上层鱼类资源对气候-海洋变化的响应研究进展

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摘要: 小型中上层鱼类是北太平洋海域重要的渔业资源, 其资源年间波动显著, 且受气候-海洋变化的影响。本文围绕秋刀鱼(*Coloabis saira*)、鲹鱼(*Katsuwonus pelamis*)等6种主要的小型中上层鱼类, 回顾了厄尔尼诺-南方涛动(ENSO)、太平洋年代际振荡(PDO)等关键气候-海洋指数的特点及对鱼类栖息地环境和资源变动的影响。概括了气候-海洋变化对小型中上层鱼类的洄游分布和资源丰度的直接影响过程, 以及对亲体繁殖产卵、仔稚体成活率和资源量波动间接的滞后影响过程。建议: (1)添加种群动态过程、捕捞方式系数、自然死亡率等参数构建生物量动态模型, 揭示气候-海洋变化对渔业资源量的影响过程; (2)基于物理海洋模型及空间耦合水动力学模型研究大尺度海流、中尺度涡旋对小型中上层鱼类影响。

关键词: 小型中上层鱼类; 气候-海洋指数; 栖息地变化; 资源丰度

Review on the response of small pelagic fish resource in the North Pacific to climate-ocean changes

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Abstract: Small pelagic fishes are important fishery resource in the Pacific. Their resources fluctuate significantly from year to year and are affected by climate-ocean changes. In this paper, the characteristics of the key climate-oceanic index such as ENSO, PDO and its influence on the changes of the habitat environment and resources of fish were reviewed, focusing on six main small pelagic fishes, including saury(*Coloabis saira*), skipjack (*Katsuwonus pelamis*) and so on. The climate-oceanic changes is direct influence on migration distribution and resource abundance of small pelagic fishes and indirect delayed influence on parental reproduction and spawning, larvae and juvenile survival rate, resource fluctuation were summarized. Suggestions: (1)A biomass dynamic model was constructed by adding parameters such as population dynamic process, fishing mode coefficient and natural mortality rate to reveal the influence process of climate-ocean change on fishery resource quantity; (2)The effects of large-scale ocean currents and mesoscale vortex on small pelagic fish were studied based on physical ocean models and spatially coupled hydrodynamics models.

Key words: small pelagic fish, climate-oceanic index, habitat change, resource abundance

南海北部带鱼资源利用状况研究

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摘要: 根据 2008—2018 年南海北部渔港抽样调查数据, 采用主成分分析和因子分析, 从南海北部带鱼的 21 个捕捞努力量时间序列中提取出了捕捞努力量综合指数, 应用剩余产量模型估算了种群管理参数, 并采用 Kobe 图判断了当前南海北部带鱼资源的利用状况。结果表明, 南海北部带鱼的主要产量来自刺网和双拖, 分别占总产量的 46.21% 和 21.47%。Kobe 图显示, 2014 年和 2016 年南海北部带鱼捕捞过度, 种群生存受到严重威胁, 2017 年实施休渔新政后, 资源利用压力得到缓解, 没有发生过度捕捞。目前南海北部带鱼最大可持续产量在 165306.27~218032.62t, 平均为 190620.52t。总可捕捞量为 178696.61t。该研究结果可为南海北部带鱼的资源管理提供参考。

关键词: 带鱼; 捕捞努力量; 剩余产量模型; 总可捕捞量

Research on the utilization of *Trichiurus lepturus* in the northern South China Sea

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Abstract: According to the sampling survey data at fishing ports in the northern South China Sea from 2008 to 2018, an index of fishing effort was calculated from 21 fishing effort time series of *Trichiurus lepturus* by using principal component analysis and factor analysis. Population management parameters were estimated by surplus production models and exploitation status of *Trichiurus lepturus* was assessed by Kobe plot. The results showed that the catch of gill netting and twin-tow accounted for 46.21% and 21.47% of the total catch of *Trichiurus lepturus* in the northern South China Sea. Kobe's plot showed that *Trichiurus lepturus* was overfished in 2014 and 2016, but recovered since new closed season executed in 2017. The maximum sustainable yield of *Trichiurus lepturus* in the northern South China Sea was 165306.27 to 218032.62 tons, with an average of 190620.52 tons. The total available catch (TAC) was 178696.61 tons. The results of this study may provide reference for the management of *Trichiurus lepturus* in the northern South China Sea.

Keyword: *Trichiurus lepturus*, fishing effort, surplus production models, total allowable catch

浙江沿岸中国毛虾的资源分布与季节变化

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摘要: 中国毛虾是浙江虾类中产量最高的种类, 然而近年来浙江省中国毛虾产量却不断下降, 为了解浙江沿岸中国毛虾的渔场分布和资源变动规律, 更好的指导生产实践和服务渔业管理, 本研究利用 2018 年 9 艘毛虾作业样本船渔捞日志分析了浙江沿岸中国毛虾的主要作业渔场及其资源的季节变化。结果表明, 浙江沿岸中国毛虾渔场主要分布在舟山渔场南部、鱼山渔场南部以及温台渔场北部的禁渔区线附近。产量呈双峰分布, 上半年产量明显低于下半年产量。上、下半年 CPUE 也存在显著差异, 上半年 CPUE 以 2 月最高为 1877kg/天, 下半年 9 月份 CPUE 最高为 4927kg/天, 随后 CPUE 逐渐下降。高产渔区主要分布在浙江南部的温州近海和鱼山渔场南部以及温台渔场北部的禁渔区线附近海域, 其海域 CPUE 超过 5t/天。

关键词: 中国毛虾; 浙江沿岸; 渔捞日志; 渔场分布

The distribution and seasonal changes of *Acetes chinensis* in Zhejiang coastal waters

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Abstract: The *Acetes chinensis* are the highest species of shrimp production in Zhejiang. However, the production in Zhejiang Province has been declining in recent years. In this research, 9 sample boats of shrimp operations are analyzed to understand the spatial and temporal changes of *Acetes chinensis* in Zhejiang coastal waters. The results show that The *Acetes chinensis* fishing grounds are mainly distributed in the southern part of Zhoushan and Yushan fishing ground, and the northern part of Wentai fishing ground. The output showed a bimodal distribution. There are also significant differences in CPUE between the first half of the year and the second half of the year. the CPUE peaked at 1877kg/day in February, while the highest CPUE in September was 4927kg/day. The high-yield fishing areas are mainly distributed in the coastal waters of Wenzhou, Yushan fishing grounds and northern Wentai fishing grounds which exceeds 5t/day.

Key words: *Acetes chinensis*, Zhejiang coastal waters, fishing log, fishing ground

东南太平洋智利竹筴鱼渔场时空分析与资源丰度的预测

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摘要: 根据 2011—2018 年 4—8 月我国东南太平洋智利竹筴鱼(*Trachurus murphyi*) 大型拖网渔捞数据和海表面温度 (Sea Surface Temperature, SST)、海表面盐度(Sea Surface Salinity, SSS)、叶绿素 a 浓度(chlorophyll concentration, Chl-a)和海表面温度异常值 (sea surface temperature anomaly,SSTA)数据, 分析智利竹筴鱼集群重心的时空变化及其与海洋环境之间的关系。结果表明, 随着月份的增长, 集群重心呈现西南-东北移动趋势。SSTA 指数升高时, 集群重心呈现向西北偏移趋势, SSTA 指数降低时, 呈现向东南偏移趋势。4—5 月, 验证固定集群重心范围内的实际产量与总产量的比值分别为 82%、79%。6 月、7 月和 8 月智利竹筴鱼密度降低, 占比分别为 60%、56%、48%。

关键词: 智利竹筴鱼; 东南太平洋; 集群重心; 海洋环境

Spatial and temporal analysis of Chilean jack mackerel fishing ground and its resource abundance prediction in the Southeast Pacific

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Abstract: Based on the fishing data of Chilean jack mackerel (*Trachurus murphyi*) obtained by Chinese large trawling fleets in the southeastern Pacific Ocean from April to August of 2011—2018, combined with the data of Sea Surface Temperature (SST), Sea Surface Salinity (SSS), chlorophyll concentration (Chl-a) and sea surface temperature anomaly (SSTA), this paper analyzes the temporal and spatial changes of the center of gravity of Chilean jack mackerel (*Trachurus murphyi*) clusters and its relationship with the marine environment. The results show that as the month grows, the center of gravity of the cluster is moving from the southwest to the northeast. When the sea surface temperature anomaly rises, the cluster's center of gravity shifts to the northwest, and when the sea surface temperature anomaly decreases, the cluster's center of gravity shifts to the southeast. In April and May, it was verified that the ratio of actual output to total output within the fixed cluster's center of gravity was 82%, 79%, respectively. The density of Chilean jack mackerel decreased in June, July and August, accounting for 60%, 56% and 48% of the fish respectively.

Key words: Chilean jack mackerel; the Southeast Pacific Ocean; cluster center of gravity; the marine environment

南海圆舵鲹栖息地影响因素分析

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摘要: 根据 2013—2019 年南海区灯光罩网调查数据, 结合遥感获得的海表温度 (SST)、海面高度 (SSH)、叶绿素 a 浓度 (CHLA) 数据, 采用栖息地适应性指数模型原理, 以标准化后的单位捕捞努力量渔获量 (CPUE) 作为栖息地质量高低的指标, 建立 CPUE 与海洋环境建立模型, 分析不同环境因子对圆舵鲹栖息地的影响及栖息地对海洋环境变化的适应性。结果表明, 南海圆舵鲹渔场各因子的最适值分别为 SST 28.6 °C, SSH 81.0 cm, CHLA 0.11 mg/m³。对不同海洋环境因子赋予不同的权重系数分别与 CPUE 建立适应性指数模型, 各模型 R² 均大于 0.8, 模型解释度较好。采用最小二乘法原则对模型权重系数进行分析, SST 的系数为 0.26, SSH 系数为 0.52, CHLA 的系数为 0.22, SSH 对栖息地的影响最大。采用 2019 年调查数据对模型进行验证, 模型准确度均超过 75%, 模型预测准确。

关键词: 圆舵鲹; 南海; 海洋环境; 权重系数

Analysis of habitat influencing factors of *Auxis rochei* in south China sea

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Abstract: According to south China sea light cover web survey data in 2013-2019, combined with remote sensing of sea surface temperature (SST), sea surface height (SSH) and concentration of chlorophyll a (CHLA) data, using principle of habitat suitable index model in a standardized unit of catch per unite effect (CPUE) as indicators of habitat quality. The results showed that the optimum values of each factor in *Auxis rochei* fishery in the south China sea were SST 28.6 °C, SSH 81.0 cm and CHLA 0.11 mg/m³, respectively. Different weights were assigned to different Marine environment factors to establish the adaptability index model with the CPUE, and the R² of each model was greater than 0.8, with good model interpretation. The least square method was used to analyze the weight coefficient of the model. The coefficient of SST was 0.26, the coefficient of SSH was 0.52, and the coefficient of CHLA was 0.22. SSH had the greatest impact on habitat. The 2019 survey data were used to verify the model, and the model accuracy was more than 75%, and the model prediction was accurate.

Key words: *Auxis rochei*, south China sea, marine environment, weight coefficient

2016和2020年夏季舟山临近海域浮游动物群落的年际变化及影响因素

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摘要: 根据2016、2020年夏季舟山近海海域浮游动物的数据,对舟山近海浮游生物的群落结构(种类组成、优势种数量)的夏季年际动态变化进行了研究。利用典范对应分析(CCA)研究浮游动物丰度差异、年际动态变化及与环境因子的关系,探讨2016-2020年夏季舟山近海海域浮游动物年际动态变化的因素。结果表明:2016年和2020年夏季分别鉴定浮游动物106种和93种,2016年浮游动物优势种为:小拟哲水蚤(*Paracalanus parvus*)、肥胖箭虫(*Sagitta enflata*)、微刺哲水蚤(*Canthocalanus pauper*),2020年浮游动物优势种为:双生水母(*Diphyes chamissonis*)、长尾类溞状幼体(*Macrura zoea*)、尖刺唇角水蚤(*Labidocera acuta*)、中型莹虾(*Lucifer intermedius*)、拿卡箭虫(*Sagitta nagae*)。两年夏季的浮游动物群落结构发生了显著变化。2016和2020年的表层温度(SST)都呈现舟山近海低,外海高的趋势,2020年的表层盐度(SSS)也呈现出近海低,外海高的趋势。表层叶绿素呈现近海高,外海低的趋势。通过CCA分析发现2016和2020年浮游动物优势种有显著的差异,差异贡献种分别为小拟哲水蚤和双生水母(贡献率都大于10%)。温度、盐度是影响浮游动物空间分布的主要因素。

关键词: 浮游动物; 年际变化; 群落结构; 环境因子

Interannual changes and influencing factors of zooplankton communities in the waters adjacent to Zhoushan in the summer of 2016 and 2020

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Abstract: According to the data of zooplankton in the coastal waters of Zhoushan in the summer of 2016 and 2020, The summer interannual dynamic changes of the plankton community structure (species composition, number of dominant species) in the coastal waters of Zhoushan were studied. Using Canonical Correspondence Analysis (CCA) to study the differences in zooplankton abundance, interannual dynamic changes and their relationship with environmental factors, To explore the factors of the interannual dynamic changes of zooplankton in the coastal waters of Zhoushan during the summer of 2016-2020. The results showed that 106 species and 93 species of zooplankton were identified in the summer of 2016 and 2020, respectively, The dominant species of zooplankton in 2016 are: *Paracalanus parvus*, *Sagitta enflata*, *Canthocalanus pauper*. The dominant species of zooplankton in 2020 are: *Diphyes chamissonis*, *Macrura zoea*, *Labidocera acuta*, *Lucifer intermedius*, *Sagitta nagae*. The zooplankton community structure has changed significantly in the summer of two years. The sea surface temperature (SST) in 2016 and 2020 both show a trend of low offshore Zhoushan and high offshore, The sea surface (SSS) in 2020 also shows a trend of low offshore and high offshore, The sea surface chlorophyll presents a trend of high offshore and low offshore. CCA analysis found significant differences in the dominant species of zooplankton in 2016 and 2020, The different contributing species are *Pseudosylla* and *Gemini* (the contribution rate is greater than 10%), Temperature and salinity are the main factors affecting the spatial distribution of zooplankton.

Keywords: zooplankton; interannual variability; community structure; environmental factors

诱饵式远程水下视频技术 (BRUV)

研究综述

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摘要: 诱饵式远程水下视频技术 (BRUV) 是一种用于记录鱼类相对丰度和物种行为的监测技术, 具有无破坏性、成本低且易于复制、适用范围广等优点, 但其研究应用目前在国内尚属空白。本文梳理了全球 2006 年至 2020 年 3 月以来发表的与 BRUV 相关的 278 篇文献, 从文献发表年份、国家分布、栖息地类型、部署水深等多个方面分析了 BRUV 的研究进展。分析结果建议 BRUV 采用前向视角结构得到更大的视野; BRUV 调查时饵料采用类沙丁鱼的油性鱼类, 有利于对肉食性鱼类的诱集; BRUV 使用前, 需试验性地定量其部署时间, 通常底层 BRUV 60 分钟的部署时间已足够; BRUV 记录期间, 所见到的某一个物种的个体最大数量 (MaxN) 的计数是表征物种相对丰度广泛使用的度量指标。本研究旨在为 BRUV 在我国无破坏性海洋生物调查技术的发展以及在海洋牧场鱼类资源监测中的应用提供支持。

关键词: BRUV, 海洋牧场, 鱼类资源监测, 无破坏性监测技术

Review of baited remote underwater video (BRUV) technology

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Abstract: Baited remote underwater video (BRUV) is a monitoring method used to record the relative abundance of fish species and their behavior. The benefits of using BRUVs have been well documented; and include their non-destructive nature, ease of replication etc. Although BRUVs have been widely used around the world for over 20 years, no such studies have been undertaken in China. This study reviewed 278 scientific documents relating to BRUVs published between January 2006 to March 2020. Data on the year of publication, country/continent of the lead author, habitat types, depth etc. For use in China, we recommend that BRUVs use i) forward-facing camera to maximize the field of view, ii) oily fish such as clupeids (sardines and pilchards) as bait to attract carnivorous fish. Before using BRUVs a pilot study should be conducted to determine quantitatively (e.g. using accumulation curve) the deployment time needed. Generally, a time of 60 minutes is sufficient for benthic BRUVs. MaxN, i.e. the maximum number of individuals observed of a species in a single frame of a video, is a widely accepted metric characterizing the relative abundance of species.

Keywords: BRUV, Marine ranching, Fish resources monitoring, Non-destructive monitoring technology

标志放流技术在旗鱼研究中的应用

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摘要: 旗鱼是高度洄游的顶端掠食性鱼类, 在海洋中上层生态系统的食物网中扮演着重要的角色, 同时在延绳钓渔业的兼捕渔获物中占据的比例较大, 研究其渔业生态学信息具有重要意义。标志放流是将特定标记标志在鱼体上后将其放流, 基于重捕个体或标志回传信息对其深入分析。通过对旗鱼的标志放流可以获取该物种的渔业生物学和生态学信息, 并对其关键生活史展开研究。本文介绍了旗鱼的生物学信息, 对标志放流技术在旗鱼渔业生态学中的应用进行了归纳, 并基于标志放流技术详细地对旗鱼的分布模式、运动及洄游模式、栖息地指数和渔业应用等方面进行了总结, 旨在为标志放流技术获取更多的旗鱼数据提供科学依据, 更好地进行渔业管理。

关键词: 旗鱼; 标志放流; 渔业生物学; 渔业生态学

Application of tagging and recovery technology in billfish research

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Abstract: Billfish, a highly migratory apex predatory fish, plays an important role in the food web of the the pelagic ecosystem of the ocean. At the same time, it accounts for a large proportion of the bycatch in the longline fishery. Research on its fishery Ecological information is of great significance. Tagging and recover is to mark a specific sign on the fish body and release it, and analyze it in depth based on the recaptured individual or the return information of the tagging. The fishery biology and ecology information of this species can be obtained by tagging billfish, and the key life history can be studied. This article introduces the biological information of billfish, summarizes the application of the marker release technology in the ecology of billfish fishery, and based on the tagging and recover, details the distribution pattern, movement and migration pattern, habitat index and the fishery application and other aspects are summarized. The purpose is to provide a scientific basis for the acquisition of more billfish data from tagging and recover technology and better fishery management.

Key words: billfish, tagging and recover, fishery biology, fishery ecology

基于 Ecopath 模型的西沙群岛七连屿海域生态系统模型构建和分析

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摘要: 为了解南海西沙群岛七连屿海域生态系统的结构和功能现状, 基于 2019 年渔业资源和生态环境的综合调查数据, 构建七连屿珊瑚礁海域生态系统的生态通道(Ecopath)模型, 并分析了该系统的能量流动及系统的总体特征。结果显示, 七连屿珊瑚礁海域生态系统各功能群营养级范围为 1.00~3.81。生态系统以牧食食物链为主要能流通道, 能量直接来源于初级生产者占比 53%。生态系统各营养级平均转化效率为 15.06%, 其中来自碎屑和初级生产者的能流转化效率分别为 14.45%和 15.50%。关键种分析表明, 珊瑚功能群为七连屿珊瑚礁海域生态系统的核心种。系统总初级生产量/总呼吸量为 2.98; 系统连接指数和系统杂食性指数分别为 0.35 和 0.18。

关键词: 七连屿; Ecopath 模型; 结构与功能; 生态系统特征

Construction and analysis of ecosystem structure of coral reef of Qilianyu Island in the Xisha Islands based on Ecopath model

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Abstract: Based on data collected from fishery resources and ecological environmental surveys conducted in coral reef of Qilian Islet of Xisha Islands of South China Sea in 2019, the Ecopath model about coral reef of Qilian Islet was constructed to analyze the energy flow pattern and overall characteristic of the ecosystem for reveal the structure and function of the coral reef ecosystem. The trophic levels of the functional groups were range from 1.00 to 3.81. Primary productivity was dominating the energy flow of ecosystem, and the proportion of the total flow originated from primary productivity was 53%. The total energy transfer efficiency was 15.06%, with the mean transfer efficiency of 14.45% and 15.50% from detritus and primary productivity within the ecosystem, respectively. The keystone Index analysis indicated that the functional group of Coral was considered as key specie in the ecosystem. Overall, the ratio of total primary productivity to total respectively was 2.98, And the connectance index and system omnivory index were 0.35 and 0.18, respectively.

Key words: Qilianyu Island; Ecopath model; structure and junction; ecosystem characteristic

基于SWOT的渔业资源资产负债表编制分析

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摘要: 探索编制自然资源资产负债表是生态文明体制改革的基础性制度建设, 渔业资源资产负债表作为自然资源资产负债表的重要组成部分, 更是渔业资源资产核算的一项基础内容。核查渔业资源开发利用状况, 既是厘清渔业资源资产“家底”的必然要求, 也是实现渔业资源绿色发展的必要手段。目前国内学者对于渔业资源资产负债表的编制研究却少有涉足, 处于相对空白状态, 其重要性尚未形成普遍共识。本文从SWOT分析法入手, 分析编制渔业资源资产负债表的可行性, 重要性, 考量渔业资源资产负债表编制的优势(S)、劣势(W)、机会(O)、挑战(T), 从管理体制机制、数据统计、专业技能培养、财政保障、实际应用性等视角探讨渔业资源资产负债表编制过程中可能存在的问题。在此基础上, 提出了符合我国国情的渔业资源资产负债表编制的可行性建议, 以期对渔业资源资产负债表的编制给出新的启示。

关键词: SWOT分析; 渔业资源; 资产负债表;

Analysis of fishery resources balance sheet based on SWOT

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Abstract: Exploring the compilation of natural resources balance sheet is the basic system construction of ecological civilization system reform, and fishery resources balance sheet is a basic content. It is not only helpful to grasp the current status of fishery resources, but also conducive to the development of fishery resources. Domestic scholars have little research on the compilation of the balance sheet of fishery resources, and its importance has not yet reached a general consensus. Starting from SWOT analysis, this paper analyzes the feasibility and importance of compiling the balance sheet of fishery resources, and discusses the possible problems in the compilation process. On this basis, the paper puts forward feasible suggestions in order to give enlightenment.

Key Words: SWOT analysis; fishery resources; balance sheet

基于 GAM 和 GWR 的中西太平洋金枪鱼围网鲣环境模型对比研究

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摘要: 中西太平洋围网鲣的单位捕捞渔获量(CPUE)和环境因子之间存在着大量的空间变化, 影响围网鲣的环境因子有很多, 仅仅依靠单因素来预报渔情是不够的。本文以中西太平洋 2010~2019 年围网鲣随附鱼群的月平均 CPUE 为因变量, 海表面温度 (SST)、盐度 (SSS)、不同水层的温度和盐度, 混合层深度 (MLD)、海表面高度异常 (SLA) 以及叶绿素浓度 (Chl-a) 为解释变量建立 GWR (geographically weighted regression) 模型。同时采用 GAM (generalized additive model) 分析各环境因子对金枪鱼围网鲣 CPUE 非线性作用。两种模型都显示中西太平洋围网鲣的 CPUE 与海洋环境因子之间存在空间非平稳性。对比分析两种模型的差异, 有利于更好的研究环境因子对鱼类的影响。

关键词: 围网鲣; 单位捕捞渔获量(CPUE); 地理加权回归(GWR); GAM; 中西太平洋

A comparative study of environmental models based on GAM and GWR model in the Western and Central Pacific Ocean and skipjack tuna

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Abstract: There are substantial spatial variations in relationship between CPUE and environmental factors in the Western and Central Pacific Ocean. There are many environmental factors that affect the skipjack, and it is not enough to rely on only one factor to predict the fishing situation. In this paper, the monthly average skipjack CPUE of the purse seine in the Western and Central Pacific Ocean from 2010 to 2019 is taken as the dependent variable, and sea surface temperature (SST), salinity (SSS), the temperature and salinity of different water layers, mixed layer depth(MLD), sea level anomaly(SLA) and chlorophyll concentration (Chl-a) are taken as the explanatory variables to establish a geographically weighted regression (GWR) model. Meanwhile, the generalized additive model (GAM) is used to analyze the nonlinear effects of environmental factors on CPUE of skipjack tuna catches by purse seine. Both models show that there are spatial nonstationary between skipjack CPUE and Marine environmental factors in the Western and Central Pacific Ocean. Comparative analysis of the differences between the two models is conducive to better study of the impact of environmental factors on fishery.

Key words: Skipjack, catch-per-unit-effort(CPUE), geographically weighted regression(GWR), generalized additive model(GAM), Western and Central Pacific Ocean(WCPO)

基于生态视角的海洋渔业资源负债核算研究

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摘要: 编制自然资源资产负债表是生态文明体制改革的基础性要求, 是摸清自然资源资产负债家底状况的主要手段。渔业资源作为我国自然资源的重要组成部分, 其资产负债表编制是探索自然资源管理体制改革的一项基本内容, 而负债问题恰是资产负债表编制的重点和难点。文章以海洋渔业资源为研究对象, 包括海洋渔业资源负债的确认、核算及列报三部分内容, 基于理论视角阐释海洋渔业资源负债确认的理论契合点、假设及逻辑, 从资源利用上线层面探讨其负债核算的总体思路、框架与主要方法, 并从渔业权维度尝试性设计海洋渔业资源资产存量表、负债核算表以及资产负债表等表式。可能贡献: (1) 厘清海洋渔业资源、社会生产活动与海洋生态环境之间的关系; (2) 利用资产负债表工具摸清海洋渔业资源资产负债状况; (3) 以期为海洋渔业绿色可持续发展和自然资源管理体制改革提供技术支持。

关键词: 生态文明; 海洋渔业资源; 负债问题; 资产负债表

Research on the liability of marine fishery resources based on the ecological perspective

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Abstract: Compiling the natural resources balance sheet is a basic requirement in ecological civilization institution reform. It is also the main method to find out the conditions of natural resources assets and liabilities. As an important part of natural resources in China, compiling marine fishery balance sheet is a critical content about natural resources management system reform. While its liability research is the essential and difficult issues on marine fishery resources balance sheet. This paper takes marine fishery resources as the research object, including the recognition, accounting and presentation of marine fishery resources liabilities. From the theoretical perspective, it explained theoretical contract points, hypothesis and logic of marine fishery resources liability recognition. Based on upper limit of resource utilization, it discussed general thoughts, framework and main liability accounting methods. Then from the fishery right dimension, it tentatively designed the tables of asset inventory statement, liability accounting statement and balance sheet of marine fishery resources. Possible contributions:(1) to clarify the relationship among marine fishery resources, social productive activities and marine ecological environment;(2) to use balance sheet tools to find out the conditions of marine fishery resources assets and liabilities;(3) to provide support for marine fishery green and sustainable development and natural resource management system reform.

Key words: ecological civilization, marine fishery resources, liability problem, balance sheet

梨形环棱螺扰动作用对池塘沉积物中氮转化的影响

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摘要: 为探究梨形环棱螺扰动作用对池塘沉积物中氮转化的影响, 旨在为实际应用梨形环棱螺缓解池塘沉积物中氮素堆积提供一定的参考, 本研究选用梨形环棱螺作为研究对象, 开展室内模拟实验, 结合氮赋存形态、硝化反硝化强度以及胞外酶活性等内容, 探究不同放养密度梨形环棱螺对沉积物中氮素转化的影响.....

关键词: 梨形环棱螺; 扰动作用; 沉积物; 硝化反硝化强度; 氮赋存形态; 胞外酶活性;

Effect of the Bioturbation Derived from Pear-shaped ringed edge snail (*Bellamya purificata*) on nitrogen conversion in pond sediments

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Abstract: In order to investigate the effect of pear-shaped ringed snail perturbation on nitrogen conversion in pond sediments and to provide a reference for practical applications to alleviate the accumulation of nitrogen in pond sediments, this study investigated the effect of different stocking densities of snails on nitrogen conversion in sediments by indoor simulation experiments, combined with nitrogen transport patterns, nitrification denitrification intensity and extracellular enzyme activity.

Key words: Pear-shaped ringed snail; perturbation; sedimentation; nitrification denitrification intensity; nitrogen transport patterns; extracellular enzyme activity.

流场底面效应对底拖网网板水动力性能的影响分析

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摘要: 随着我国渔业的不断发展, 渔具的改良和稳定已然是我们需要优先考虑和需要解决的问题, 而网板作为是拖网作业系统中重要的属具之一, 其水动力性能的优劣直接决定了拖网网口的扩张程度, 进而影响其渔获效率和经济效益。该研究以典型底拖网网板结构——矩形曲面网板为研究对象, 利用数值模拟方法研究其在贴近底面 2cm 与 5cm 时的水动力性能, 以及在这两种距离下不同的冲角 (5°、10°、15°、20°、25°、30°、35°、40°、45°、50°)、的水动力性能, 分析与地面不同距离, 不同的冲角时矩形曲面网板水动力性能的变化, 对比两种方法的结果, 实现矩形曲面网板周围流场可视化。结果显示: (1) 在来流速度为 1m/s 时两种不同高度的矩形曲面网板的阻力系数在 0°到 50°范围内都随着冲角的增大而持续增大; 而升力系数也都随着冲角的逐渐增大, 呈现先增加后减小的趋势, 并在 35°左右时达到最大值; 同样升阻比也都是随着冲角的逐渐增大, 呈现先增加后减小的趋势, 但是不同的是前者在 10°左右时达到最大值而后者大概在 8°左右时达到最大值。(2) 离地面越近其阻力系数、升力系数及升阻比越大。本研究结果对底拖网网板结构与优化具有参考价值。

关键词: 底拖网网板、数值模拟、水动力性能

Analysis of hydrodynamic performance of bottom surface effect of flow field on bottom trawl plate

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Abstract: with the continuous development of Chinese fishery, fishing has been improved and stability we need to prioritize and need to solve problems, and the screen as is one of important tools in trawling system, its hydrodynamic performance fit and unfit quality directly determines the degree of expansion of the trawl front-end ports, which affect the catch efficiency and economic benefits. The study in a typical bottom trawl sheet structure - rectangular surface mesh plate as the research object, by using numerical simulation method to study the when close to the bottom 2 cm and 5 cm of hydrodynamic performance, and in both distance under different Angle of attack (5°, 10°, 15°, 20°, 25°, 30°, 35°, 40°, 45°, 50°), the hydrodynamic performance, analysis of different distance with the ground, different Angle of attack of the rectangular surface mesh the change of hydrodynamic performance, comparing the results of two methods, realize the rectangular surface flow field visualization around the screen. The results show that :(1) when the incoming flow velocity was 1m/s, the drag coefficient of two rectangular curved panels with different heights increased continuously with the increase of impact Angle in the range of 0° to 50°. The lift coefficient also increases gradually with the impact Angle, showing a trend of first increasing and then decreasing, and reaches its maximum value at about 35°. Similarly, the lift-drag ratio increases first and then decreases with the gradual increase of the impact Angle, but the difference is that the former reaches its maximum value at about 10° and the latter reaches its maximum value at about 8°. (2) The closer it is to the ground, the greater its drag coefficient, lift coefficient and lift-drag ratio are. The results of this study have reference value for the structural design and optimization of bottom trawl net.

Keywords: bottom trawl plate, numerical simulation, hydrodynamic performance

拖网用三股绳索水动力性能研究: 基于数值模拟与 3D 打印的模型试验

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摘要: 三股绳索广泛应用于拖网等网具系统, 其水动力特性会对网具的性能(包括扩张能力、网具阻力、拖曳速度、燃料消耗)产生显著的影响。本研究对捻系数为 3.6、公称直径为 80mm 的不同捻向的三股绳索进行了水动力分析。在数值模拟中, 使用有限体积法求解雷诺平均纳维-斯托克斯方程, 采用 k- ϵ EARSM 模型模拟湍流。试验测量了两种捻向的绳索在不同冲角(0°、10°、20°、30°、40°、50°、60°、70°、80°、90°)下的升力与阻力, 研究了该绳索的水动力系数与雷诺数的关系, 并通过 3D 打印的方法建立绳索模型进行水槽试验验证。研究结果表明, 相较于捻向为 S 的三股绳索, Z 捻向的三股绳索具有更高的升力系数与更低的阻力系数。研究结果可为拖网等网具的设计提供理论依据。

关键词: 三股绳索; 数值模拟; 水槽试验; 3D 打印

Study on hydrodynamic performance of three-stranded ropes used in trawls: Based on numerical simulation and 3D printing model test

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Abstract: Three-stranded ropes are widely used in fishing gear such as trawls. The hydrodynamic performance of ropes has a significant impact on the performance of trawls, including their expansion, drag, towing speed, and fuel consumption. In this study, we investigate the hydrodynamic performance of three-stranded ropes with a twist factor of 3.6 and a diameter of 80mm. In the numerical simulation, the finite volume method was used to solve the Reynolds averaged Navier-Stokes equation, and the turbulence flow is simulated using the k- ϵ EARSM model. The lift and drag of ropes in two twist directions at different angles of attack (0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, and 90°) were measured. The lift and drag coefficients of the rope were calculated for different Reynolds numbers, and a flume tank experiment was used to validate the accuracy of numerical simulation, in which the rope model was made by 3D printing. According to the results, the three-stranded rope with the Z twist direction has a higher lift coefficient and a lower drag coefficient compared with the ropes with the twist direction of S. The research results can provide a theoretical basis for the design of trawls and other fishing gear.

Key words: Three-stranded Rope; Numerical Simulation; Flume Tank Experiment; 3D Printing

舟山群岛东侧海域春秋季节主要甲壳类空间生态位分析

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摘要: 为进一步了解舟山群岛东侧海域甲壳类种群的资源现状, 文章根据 2018 年 4 月(春季)、10 月(秋季)在该海域进行的拖网调查数据, 运用相对重要性指数对该海域甲壳类优势度进行计测, 基于 Shannon 指数及 Pianka 公式对主要甲壳类的生态位宽度及重叠进行分析, 并结合种间竞争系数与冗余分析(RDA)对生态位分化进行研究。结果表明: (1)主要甲壳类物种($IRI>100$)春季 11 种、秋季 15 种, 其中优势种($IRI>1000$)春季 4 种, 秋季 5 种。(2)春秋季节主要甲壳类生态位宽度值范围分别为: 0.13~2.54、1.32~2.42, 生态位宽度值季节差异较大。(3)春季绵蟹(*Dromia dehaani*)与日本英雄蟹(*Achaeus japonicus*)、秋季须赤虾(*Metapenaeopsis barbata*)与东海红虾(*Plesionika izumiae*)的空间生态位重叠值最高, 表明种对间空间资源序列上的同域性最强, 物种对空间资源的利用趋于一致。(4)春秋季节主要甲壳类空间生态位重叠显著($Q_{ik}>0.6$)的种对所占比例均较低, 总体上该海域主要甲壳类种间竞争关系较弱, 生态位分化较明显。结合种间竞争系数与冗余分析(RDA)结果可进一步解释物种的种间关系及生态位分化情况。

关键词: 主要甲壳类; 生态位宽度; 生态位重叠; 生态位分化; 种间竞争系数

Analysis of the spatial niche of major crustacean species in the waters east of Zhoushan Islands in spring and autumn

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Abstract: In order to understand the resource status of crustacean populations in the waters east of Zhoushan Islands, based on data of trawl survey of the area in April (spring) and October (autumn) in 2018, the index of relative importance was used to measure the dominance of crustaceans in the waters, using Shannon index and Pianka formula to analyze the niche breadth and overlap of major crustacean species, combining interspecific competition coefficient and redundancy analysis (RDA) to study niche differentiation. The results showed that: (1) There were 11 and 15 of major crustacean species ($IRI>100$) in spring and autumn respectively, among which 4 were dominant species ($IRI>1000$) in spring and 5 in autumn. (2) The niche breadth of major crustacean species in spring and autumn are: 0.13~2.54, 1.32~2.42, niche breadth differ greatly between the two seasons. (3) The spatial niche overlap between *Dromia dehaani* and *Achaeus japonicus* in spring, *Metapenaeopsis barbata* and *Plesionika izumiae* in autumn were highest, indicating that the spatial homology was high and the species' use of the spatial resources tends to be consistent.(4) The proportion of species pairs with significant spatial niche overlap ($Q_{ik}>0.6$) was low in spring and autumn, in general, the competition among major crustacean species was weak and niche differentiation was obvious. Combining interspecific competition coefficient and redundancy analysis (RDA) results, we can further explain the inter-species relationship and niche differentiation of species.

Key words: major crustacean species; niche breadth; niche overlap; niche differentiation; interspecific competition coefficient

厦漳近海游泳动物群落结构特征初步研究

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摘要: 根据 2018 年 10 月 (秋季) 和 2019 年 4 月 (春季) 在福建厦门和漳州近海拖网定点调查资料, 分析该海域游泳动物的种类组成、数量分布、优势种及群落多样性特征。结果显示, 调查海域共有游泳动物 204 种, 隶属于 23 目 82 科 141 属, 其中鱼类种类最多, 有 131 种, 甲壳类次之, 有 64 种, 头足类 9 种; 游泳动物优势种春季为哈氏仿对虾 (*Parapenaeopsis hardwickii*)、二长棘鲷 (*Parargyrops edita*)、鹰爪虾 (*Trachypenaeus curvirostris*); 秋季为哈氏仿对虾、大头白姑鱼 (*Argyrosomus macrocephalus*)、矛形梭子蟹 (*Portunus hastatoide*) 和红星梭子蟹 (*Portunus sanguinolentus*); 春、秋季质量资源密度分别为为 239.1 kg·km⁻² 和 261.7 kg·km⁻²; 春、秋季数量资源密度分别为为 24943 ind·km⁻² 和 38384 ind·km⁻²; 游泳动物群落 Shannon-Wiener 多样性指数春季略高于秋季, 平均值为 2.342。

关键词: 游泳动物; 种类组成; 资源密度; 群落结构; 厦漳近海

Research on characteristics of community structure of nekton in Xiamen and Zhangzhou coastal waters

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Abstract: Based on the data of fisheries resource survey from Xiamen and Zhangzhou coastal waters in Fujian in October (autumn) 2018 and April (spring) 2019, species composition, quantitative distribution, dominant species and community biodiversity characteristic of the nekton were analyzed. The results showed that there were 204 kinds of nekton in Xiamen and Zhangzhou coastal waters, belonging 23 orders, 82 families and 141 genera, including 131 fishes, 64 crustaceans and 9 cephalopods; there were 3 kinds of dominant species such as *Parapenaeopsis hardwickii*, *Parargyrops edita*, *Trachypenaeus curvirostris* in spring and 4 kinds of dominant species such as *Parapenaeopsis hardwickii*, *Argyrosomus macrocephalus*, *Portunus hastatoide*, *Portunus sanguinolentus* in autumn; the stock density in weight in spring and autumn were 239.1 kg·km⁻² and 261.7 kg·km⁻², respectively, and the stock density in quantity in two seasons were 24943 ind·km⁻² and 38384 ind·km⁻², respectively; the Shannon-Wiener biodiversity index of nekton in spring was higher than the one in autumn, and the average was 2.342.

Key words: Nekton, Species composition, Stock density, Community structure, Xiamen and Zhangzhou coastal waters

基于捕食者 CPUE 权重的浙江南部近海龙头鱼摄食习性分析

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摘要: 根据 2019 年 3 月至 11 月浙江南部近海底拖网调查所获 750 尾龙头鱼样本, 采用胃含物分析法, 结合该海域各调查站位龙头鱼的 CPUE, 研究了龙头鱼的食物组成、摄食强度及其随季节和体长变化的情况。结果表明, 龙头鱼摄食的饵料生物有 40 余种, 以鱼类(IRI%=82.29%)和虾类(IRI%=15.77%)为主。优势饵料种类为七星底灯鱼、细条天竺鲷、龙头鱼和中国毛虾等。龙头鱼各季节摄食的饵料类群存在一定差异, 春、秋季摄食的鱼类相对重要性指数百分比(IRI%)超过了 85%, 夏、冬季, 还摄食了一定比例的虾类。龙头鱼摄食强度在春季和秋季较高, 冬季最低。不同体长组龙头鱼食物组成差异明显, 随着体长增加, 饵料中鱼类比例逐渐升高, 虾类比例降低。该海域龙头鱼同类相残现象主要发生在较大体长组内。

关键词: 龙头鱼; 摄食习性; 加权平均; 胃含物分析; 浙江南部近海

Study on feeding habits of Bombay duck (*Harpadon nehereus*) in the offshore waters of southern Zhejiang based on predator CPUE weighting

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Abstract: Based on the fishery resources survey in the offshore waters of southern Zhejiang, a total of 750 stomach samples of Bombay duck (*Harpadon nehereus*) were collected from March to November 2019. Combined with the CPUE difference of *H. nehereus*, the diet composition, feeding intensity, seasonal variation and ontogenetic shift of *H. nehereus* were examined. The results showed that the prey items of *H. nehereus* included 11 groups and more than 40 prey species, fishes (IRI%=82.29%) and shrimps (IRI%=15.77%) as the dominant prey categories. The dominant prey species were *Benthosema pterotum*, *Apogon lineantus*, *H. nehereus* and *Acetes chinensis*. The fish was the most important prey group in all seasons, with higher than 85% for IRI% in spring and autumn, meanwhile, the proportion of shrimp consumed by *H. nehereus* in summer and winter higher than that in other seasons. Feeding intensity of *H. nehereus* was higher in spring and autumn, and the lowest in winter. With the increase of *H. nehereus*'s body length, the main prey items of *H. nehereus* transferred from small size items to big size items, meanwhile, the predation ability of *H. nehereus* is greatly enhanced, the phenomenon of cannibalism mainly occurred in the larger group.

Key words: *Harpadon nehereus*, feeding habit, weighting average, stomach content analysis, the offshore waters of southern Zhejiang

包含零值的渔业计数数据建模与比较——以浙江南部近海黄鲫（*Setipinna taty*）为例

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摘要: 为有效使用包含零值的渔业计数数据, 本文以 2017-2019 年浙江南部近海黄鲫资源为例, 选取水温、水深和盐度等环境因子, 基于 Tweedie 分布的广义加性模型、两阶段广义加性模型、Ad Hoc 和广义加性混合模型进行建模与比较。研究结果显示, 黄鲫各季节资源密度大小依次为春季>夏季>冬季>秋季, 各站点所占零值比例较高; 与其他模型相比, Two-stage GAM 模型的偏差解释率较高, GAM1 为 19.6%, GAM2 为 60.4%。交叉验证结果显示, Two-stage GAM 模型的性能评估最佳, 其 R^2 值最高, 平均绝对误差最低, 均方根误差相对较小。研究发现春季和秋季浙江南部近海黄鲫资源密度在水温 21°C、18°C 左右最高, 资源密度在 20m 左右水深达到最高; 空间分布上, 黄鲫资源密度的高值大多分布在 28°N 以南的近岸海域。在今后研究中还应针对不同采样零值比例进行模型的拟合和比较, 并纳入更多关键解释变量, 以期更准确地找出适合分析包含零值计数数据的模型, 为养护渔业资源提供参考借鉴。

关键词: 黄鲫; 零值计数数据; 广义加性模型; 资源分布

Modeling and Comparison of Fishery Counting Data Containing Zero Values : A Case Study of *Setipinna taty* in the south inshore of Zhejiang

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Abstract: In order to effectively use the fishery counting data with zero value, this paper used the generalized additive model of Tweedie GAM, two-stage GAM, Ad Hoc and GAMM model with the environmental factors such as water temperature, water depth and salinity to establish and compare models based on the *Setipinna taty* resources in the south inshore of Zhejiang Province from 2017 to 2019. The results showed that the abundance of *Setipinna taty* was spring > summer > winter > autumn, and the proportion of zero value of each station was higher; compared with other models, the two-stage GAM model has a higher bias interpretation rate, which is 19.6% for GAM1 and 60.4% for GAM2. The cross validation results show that the performance evaluation of two-stage GAM model is the best, with the highest R^2 value, the lowest MAE and the relatively small RMSE. The results showed that the highest abundance of *Setipinna taty* was found in water temperature of 21 °C and 18 °C in spring and autumn, and reached the highest value in water depth of about 20 m; in spatial distribution, the high value of abundance of *Setipinna taty* was mostly distributed in the coastal waters south of 28 °N. In the future research, we should also fit and compare the models for different sampling zero value ratios, and include more key explanatory variables, so as to find out more accurate models that are suitable for the analysis of zero value counting data, and provide reference for the conservation of fishery resources.

Key words: *Setipinna taty*, zero value counting data, generalized additive model, resource distribution

东海浮游植物群落结构变迁与环境因子的相关研究

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摘要: 通过近年东海的浮游植物群落结构及环境基本要素研究, 结合东海海洋环境基本要素(水温、营养盐含量及其结构、COD、悬浮物浓度)的变化, 阐明东海浮游植物群落结构与环境因子之间的关系。研究表明, 春季浮游植物的优势种主要由虹彩圆筛藻、琼氏圆筛藻和中肋骨条藻组成, 夏季的主要优势种为中肋骨条藻。冗余分析结果显示, 冗余度分析结果显示, 活性磷酸盐、pH、无机氮是东海研究海域浮游植物群落结构和分布的重要环境因子。

关键词: 东海; 浮游植物; 环境因子

Correlation between phytoplankton community structure and environmental factors in the East China Sea

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Abstract: Based on the study of phytoplankton community structure and environmental elements in the East China Sea in recent years, the relationship between phytoplankton community structure and environmental factors in the East China Sea was clarified in combination with the changes of the basic elements of the marine environment in the East China Sea, including water temperature, nutrient content and its structure, COD and suspended matter concentration. The results showed that the dominant species of phytoplankton in spring were mainly composed of *Coscinodiscus oculus-iridis*, *Coscinodiscus jonesianus* and *Skeletonema costatum*, while the dominant species in summer was *Skeletonema costatum*. The results of redundancy analysis showed that active phosphate, pH and inorganic nitrogen were important environmental factors for phytoplankton community structure and distribution in the East China Sea.

Keywords: phytoplankton community; environmental factors; East China Sea

基于 COI 的南海灯笼鱼物种鉴定初探

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摘要: 利用线粒体 COI 部分序列对采自南海的灯笼鱼种类进行鉴定, 以获得南海灯笼鱼科的物种组成。所获得的序列通过与 NCBI 和 BOLD systems 数据库比对来确定种类, 通过 K2P 遗传距离、系统发育树对物种划界。实验一共获得 254 条 COI 序列, 可归类于 4 个亚科, 14 个属, 39 个种。种间遗传距离为 19.25%(±0.016%), 种内遗传距离为 0.41%(±0.054%), 种间遗传距离平均为种类遗传距离的 47 倍。结果显示, 虹灯鱼 sp. (*Bolinichthys* sp.) 与同属的其他物种有明显差异, 显示其可能为隐秘种。标灯鱼 sp. (*Symbolophorus* sp.) 与已获得的标灯鱼属的其他物种种间距离较大, 但由于标灯鱼属物种序列不全, 其是否为隐秘种还有待验证。瓦氏角灯鱼 (*Ceratoscopelus warmingii*) 可分为 2 个群体, 并且与其他海域的同一物种有明显差别, 主要体现在第 2、3 密码子的 GC 含量差异。本研究验证了 COI 在灯笼鱼鉴定的有效性, 为南海灯笼鱼资源的保护和利用提供了基础信息。

关键词: 灯笼鱼; 鱼类鉴定; 分子鉴定; 物种界定; COI 基因

Preliminary study of species identification for Myctophidae of the South China Sea based on COI

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Abstract: This study aims to identify the species composing of Myctophidae in the South China Sea with the utilization of part of the mitochondria cytochrome oxidase I (COI) sequence. The sequences then were used to compare with two databases, NCBI and BOLD systems. Besides, we compared the different methods of species identification like K2P genetic distance, phylogenetic tree, and other species delimitation methods. The result showed that the 254 samples could be classified into 39 species and 14 genera, belonging to 4 subfamilies. The average value of intraspecific genetic distance was 0.41% (±0.054%), while interspecific distance value was 19.25% (±0.016%). The relationship between interspecific and intraspecific distance is 47 times. In this result, *Bolinichthys* sp. of this study did not similar to either one of *Bolinichthys*, indicated that it might be a cryptic species. *Symbolophorus* sp. was segregated with other species, whether it was a cryptic species still need further study. The individuals of *Ceratoscopelus warmingii* were separated into 2 main groups, which could distinguish from the same kind of other ocean. The diversity of those sequences was determined by the GC content of the 2nd and 3rd codon positions. This study verified the effectiveness of COI in Myctophidae identification, providing the basis information to protect and utilize the recourse of Myctophidae in the South China Sea.

Key words: Myctophidae, fish identification, molecular identification, species delimitation, COI gene

三疣梭子蟹对笼壶渔具的行为反应

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摘要: 近年来, 东海地区蟹笼渔业的增加给三疣梭子蟹资源造成了巨大的压力, 因此, 采取适当的放生措施来捕获合格大小的蟹是十分必要的。任何笼壶渔具的设计都与捕捞对象的行为有关, 研究三疣梭子蟹的行为习性, 对改善笼壶渔具选择性至关重要。本文通过观察三疣梭子蟹在靠近、进入蟹笼、笼内行为和逃逸行为, 结果发现: 三疣梭子蟹逃逸成功率与逃逸口的高度并没有显著的关系, 逃逸口的高度只会增加其逃跑的难度, 只要三疣梭子蟹的甲厚小于逃逸口的宽度, 均可逃逸成功。本实验将对笼壶渔具的优化提供指导。

关键词: 三疣梭子蟹; 蟹笼; 逃逸口; 行为反应

Behavior of portunus trituberculatus in response to Crab pots

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Abstract: An increase in the crab pot fishery in the East China Sea has caused great pressure on swimming crab portunus trituberculatus resources. It is essential to implement suitable measures to release sublegal-sized crabs to increase the number of recruits for legal-sized crabs. One of the measures considered is the installation of escape vents on crab pots. The design of any crab pots is related to the behavior of the target, and studying the behavior of Portunus trituberculatus is crucial to improve the selection of cage fishing gear. This paper observed the behavior and escape behavior of portunus trituberculatus in the approach, entering the cage. The results showed that there was no significant relationship between the success rate of escape and the height of the escape port. The height of the escape port only increased the difficulty of escape. As long as the crab thickness was less than the width of the escape port, the successful escape could be achieved. The experiment will provide guidance for the optimization of crab pots.

Key words: Portunus trituberculatus; Crab pots; Escape vents; Behavior response

基于观察员数据的印度洋金枪鱼延绳钓渔业 剑鱼丰度指标比较的初步结果

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摘要: 在金枪鱼延绳钓渔业中一般使用两种方式来计算单位捕捞努力量的渔获量 (CPUE, Catch Per Unit Effort), 即每千钩渔获量的尾数和每千钩渔获量的重量。针对具体的鱼种选取合适的 CPUE 对资源评估和管理具有重要意义。本研究基于 2013-2018 年中国印度洋金枪鱼延绳钓渔业的剑鱼观察员数据, 运用广义加性模型 (generalized additive model, GAM), 比较 CPUE_n (尾数/千钩) 和 CPUE_w (重量/千钩) 两种指标的差异。结果显示: 1) CPUE_n 的解释率为 26.5%, 高于 CPUE_w 的 22.4%, 且 CPUE_n 模型 AIC 值更小; 2) 雌雄受影响环境因子存在差异, 雌性偏好海表面叶绿素, 雄性偏好海表面高度; 3) 两种 CPUE 年间趋势相似, 其中 2014-2016 年 CPUE_w 整体大于 CPUE_n, 雌性自 2016 年后整体大于雄性。因此在使用商业延绳钓渔业数据表达丰度状态时, 需考虑不同 CPUE 计算方法的差异。

关键词: 剑鱼; 延绳钓渔业; 丰度指标; 印度洋; CPUE 标准化

Preliminary research of comparison on swordfish abundance indicators in Indian Ocean tuna longline fisheries based on observer data

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Abstract: In tuna longline fisheries, two methods, the number of catch per thousand hooks and the weight, are generally used to calculate the catch per unit effort (CPUE). Choosing an appropriate CPUE is of great significance to resource assessment and management for specific fish species. Comparison CPUE in number and weight were obtained for the swordfish (*Xiphias gladius* L.) using generalized additive modeling procedures based on observer data from the Chinese tuna longline fleet in the Indian Ocean over the period 2012-2018. The corresponding methods were CPUE_n (Number/thousand hooks) and CPUE_w (Weight/thousand hooks), respectively. The results showed that: 1) The explanation rate of CPUE_n is 26.5%, which is higher than 22.4% of CPUE_w, and the AIC value of CPUE_n model is smaller. 2) Sex differs in the significance of different environmental factors. Females prefer sea surface chlorophyll, while males sea surface height. 3) The difference in trends between the two CPUE years is relatively small. In 2014-2016, CPUE_w is larger than CPUE_n, and females are larger than males since 2016. In summary, when using commercial longline fishery data to express the abundance status, it is necessary to consider the differences in abundance indicators.

Key words: Swordfish, Longline fishery, Abundance indicators, Indian Ocean, Standardized CPUE

基于集成学习的大西洋热带海域黄鳍金枪鱼 渔情预报方法研究

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摘要: 利用 2016—2019 年中国渔业企业在大西洋热带海域(17°20'S-15°20'N; 52°23'W-2°30'E)13 艘延绳钓作业渔船黄鳍金枪鱼 (*Thunnus albacares*) 的渔业数据, 结合海表面风速、叶绿素 a 浓度、涡动能以及 0-500m 水层的垂直温度和盐度等海洋环境数据, 以天为时间分辨率, 0.25°×0.25° 为空间分辨率, 利用朴素贝叶斯、KNN、随机森林、GLMNET、决策树、逻辑斯蒂回归、支持向量机、梯度提升决策树、隐狄利克雷分配 (Latent Dirichlet Allocation, LDA) 和 stacking 集成模型分别对黄鳍金枪鱼渔场进行预测, 结果显示对黄鳍金枪鱼渔场预测准确率 (ACC) 分别为 61%、61%、67%、67%、66%、63%、65%、64%、63%、68%; 其 ROC 曲线下面积 (AUC) 分别为 0.65、0.67、0.73、0.63、0.68、0.68、0.69、0.69、0.68、0.72, 预测准确率较传统的机器学习方法均有所提高。建议使用 stacking 集成对大西洋热带海域黄鳍金枪鱼渔场进行预测。

关键词: 黄鳍金枪鱼; 渔情预报; 集成模型; 大西洋

Research on Fishery forecast models of Yellowfin Tuna based on ensemble learning in Atlantic tropical waters

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Abstract: Using 13 longline fishing vessels for *Thunnus albacares* in the tropical Atlantic Ocean (17°20'S-15°20'N; 52°23'W-2°30'E) from 2016 to 2019 by Chinese fishery companies fishery data, combined with sea surface wind speed, chlorophyll a concentration, eddy kinetic energy, and 0-500m water layer vertical temperature and salinity and other marine environment data, with day as the time resolution and 0.25°×0.25° as the spatial resolution Rate, using Naive Bayes, KNN, Random Forest, Decision Tree, Logistic Regression, glmnet, Support Vector Machine, Gradient Boosting Decision Tree, Latent Dirichlet Allocation (LDA) and Stacking Integrated Models The tuna fishing grounds were predicted, and the results showed that the accuracy rates (ACC) of the yellowfin tuna fishing grounds were 61%, 61%, 67%,67%,66%, 63%, 65%, 64%, 63%, 68% respectively; its ROC curve The area under (AUC) is 0.65, 0.67, 0.73, 0.63,0.68, 0.68, 0.69, 0.69, 0.68, 0.72, respectively, and the prediction accuracy is improved compared with traditional machine learning methods. It is recommended to use stacking integration to predict yellowfin tuna fishing grounds in the tropical Atlantic Ocean.

Key words : *Thunnus albacares*; Fishery forecast; Ensemble learning; Atlantic

基于环境因子的东海马鲛鱼(*Scomberomorus Niphonius*)资源量评估

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摘要: 东海马鲛鱼 (*Scomberomorus Niphonius*) 种群动态易受海洋环境条件的影响, 在其资源评估和管理中需要考虑海洋环境条件的作用。假设马鲛鱼产卵场最适海表温 10~19°C (Suitable SST, SUT) 范围会影响种群环境容纳量 (K), 构建三种基于环境因子的剩余产量模型 (Environmentally Dependent Surplus Production, EDSP), 利用贝叶斯估计模型参数, 结果为从 1994 年到 2015 年, 马鲛鱼的捕捞死亡率远低于目标死亡率 (F_{tar}) 和 MSY 水平捕捞死亡率 (F_{MSY}), 种群资源量高于 MSY 水平资源量 (B_{MSY})。东海马鲛鱼没有被过度捕捞或未发生过度捕捞, 基于 EDSP 模型中的管理参考点更为保守, 建议日后东海马鲛鱼的种群评估和管理应考虑产卵场环境条件。

关键词: 马鲛鱼; 剩余产量模型; 产卵场环境因子; 东海

Resource assessment of *Scomberomorus Niphonius* dependent environmental factors in the East China Sea

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Abstract: Marine environmental variable is one of the important factors affecting fishery resources and fishing ground for pelagic fishes. Stock dynamics of mackerel are greatly affected by environmental conditions, therefore, environmental factors need to be considered in assessment and management. We assumed that the temporal variability of spawning ground with favorable sea surface temperature of 10-19°C (SUT) affected the carrying capacity (K). In this study, three types of environmentally dependent surplus production (EDSP) model were used to evaluate the population dynamics of *S. niphonius*. Using Bayesian to estimate the model parameters, the results show that the fishing mortality rates of *S. niphonius* from 1994 to 2015 were much lower than the target and MSY fishing mortality (F_{tar} and F_{MSY}), and stock biomass was higher than B_{MSY} , suggesting that mackerel was not overfished or undergoing overfishing. The management reference points in the EDSP model for *S. niphonius* were more conservative than those in the conventional model. It is recommended that the future assessment and management of mackerel in the East China Sea should take into account the spawning environment conditions.

Key words: *Scomberomorus Niphonius*; stock assessment; surplus production model; environmental factors; East China Sea

南海北部渔业资源密度的表底差异及多类相关因素的重要性分析

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摘要: 为研究低纬度近岸海区恒定温跃层外上下水层间(表层混合层、底层冷水层)的渔业生物声学密度差异及其对多类非生物因子的敏感性差异, 利用渔业声学技术对南海北部近海区域进行走航调查, 并计算调查区域内表层 20m、底层 20m 的声学积分值之差(NASC 底层 - NASC 表层), 然后利用 XGBoost、随机森林对南海北部 41 种非生物因子与表层、底层的声学积分值差异分别进行理化因子敏感性分析, 并整合 XGBoost、随机森林计算各项特征的敏感性分值(或贡献率), 根据分值及其他属性将非生物因子进行敏感性分类、分级。结果表明: 南海北部渔业资源的底-表密度差异平均值 62.62 m²/n.mi², 负值区域范围明显少于正值区域, 负值区域多分布于海南岛周边, 其余区域绝大部分为正值区域(底部资源密度高于表层资源密度); 41 种潜在影响因素中以温度(包括底层 2m 处温度、表-底温度差以及表层 2m 处温度)、水深为主, 其中三种温度因素占 41.22%, 第二级特征以磷酸盐(P-20m、P-d1020)等受人类活动影响较直接的一些营养物质为主。另外, XGBoost、随机森林建模效果优于线性回归分析, R² 值相对后者高出 0.4; 样本量增大过程中, 出现建模效果波动, 可适当增加样本数量, 以便获得稳定的建模效果。总之, 温度因素是影响南海北部渔业资源表底差异的最主要相关因素, 水深因素次之, 其中部分衍生的动态特征具有不可忽视的敏感性; XGBoost、随机森林的综合方法可高效分析多种非生物因子的敏感性关系。

关键词: 非生物因子, 敏感性, XGBoost, 随机森林, 渔业声学, NASC, 恒定温跃层

The difference of the fishery resource density between bottom layer and surface layer and the analysis of multiple types of related factor importances in the Northern South China Sea

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Abstract: The offshore of the Northern South China Sea is considered as the traditional fishing ground, owing to its good climate that offers a conducive habitat for the marine life, a spawning site, and place for fattening and farming of fish. However, fishery resources have increasingly become small and of reduced quality, this could be related to probability distribution characteristics, environmental factors and overfishing. Although previous studies have determined the roles of most influential factors on fishery resource density, analysis with multiple ensemble methods for 41 potential factors in a multitude of water conditions can still present novel insight. In order to study the difference of fishery bioacoustic density between upper and lower water layers (surface mixing layer and bottom cold water layer) outside the permanent thermocline in the coastal sea area of low latitude, as well as

its sensitivity difference to a variety of abiotic factors, the fishery acoustic technology was used to conduct the navigation survey in the offshore area of the northern South China Sea. We calculate the difference between the acoustic integral values (NASC bottom layer - NASC surface layer). Then use XGBoost and random forest to analyze the characteristic importance of 41 abiotic factors and Bottom-Surface acoustic integral values in the northern South China Sea. Finally, the importance score series (or contribution rates) calculated by two methods are integrate into one series, and the feature factors are classified and graded according to the scores and other attributes. The results show that the average value of the bottom-surface difference in the northern part of the South China Sea is 62.62 m²/n.mi². The negative area is significantly less than the positive area, and the negative area is mostly distributed around Hainan Island. The bottom resource density of most areas is higher than the surface resource density. Among the 41 potential influencing factors, temperature (including BT, DT, ST) and water depth (WD) are the main ones, of which three temperature factors account for 41.22%. The second level is characterized by phosphate (P-20m, P-d1020) and other nutrients that are more likely to be directly affected by human activities. In addition, the XGBoost and random forest modeling effects are better than the linear regression analysis, and the R² value is 0.4 higher than the latter. In the process of increasing the sample size, the modeling effect fluctuates, and the sample size can be appropriately increased to obtain a stable modeling effect. In summary, the integrated approach of XGBoost and random forests can efficiently analyze the importance of complex feature combinations. The temperature factor is the most important factor affecting the difference of Bottom-surface fishery resource density in the northern South China Sea, followed by the water depth factor. Some of the derived dynamic features have important importance that cannot be ignored.

Key words: abiotic factors, sensitivity, XGBoost, Random Forest, fishery acoustics, NASC, permanent thermocline

粤西海域产卵场时空分布的遥感研究

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摘要: 根据 2014-2015 年 4-6 月份南海北部粤西海域产卵场调查资料, 结合遥感卫星海表温度 (Sea Surface Temperature, SST)、海表盐度 (Sea Surface Salinity, SSS) 和基于海底地形数字高程模型 (Digital Elevation Model, DEM) 数据获得的水深 (Depth) 数据, 基于一元非线性回归建立各环境因子的适应性指数模型, 分别采用最大值法 (Maximum Model, MAXM)、最小值法 (Minimum Model, MINM)、算术平均值法 (Arithmetic Mean Model, AMM)、几何平均值法 (Geometric Mean Model, GMM) 建立栖息地指数模型 (Habitat Suitability Index, HSI), 用调查数据对模型精度进行验证。结果表明, 基于鱼卵密度同各环境因子在不同月份建立适应性指数 (Suitability Index, SI) 模型的拟合曲线均呈现单峰分布。应用 GMM 法和 MINM 法分别对 4、5 月份和 6 月份的鱼卵密度建立的 HSI 模型准确性最高。HSI 高值区域主要分布在雷州半岛东部一带海域。模型的准确率均超过 60% 且 HSI 的分布趋势与产卵场鱼卵密度的分布趋势相似, 表明基于 GMM 法和 MINM 法构建的栖息地指数模型能够较好预测粤西海域产卵场。

关键词: 产卵场、栖息地指数模型、遥感、粤西海域

Spatiotemporal distribution of spawning grounds in the western Guangdong waters Based on remote sensing

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Abstract: According to the survey data of spawning grounds in the northern South China Sea from April to June 2014, combined with the sea surface temperature (SST), sea surface salinity (SSS) and depth data obtained from digital elevation model (DEM) data, the adaptive index models of various environmental factors were established based on the univariate nonlinear regression. The habitat suitability index (HSI) was established by using maximum model (MAXM), minimum model (MINM), arithmetic mean model (AMM) and geometric mean model (GMM), and the accuracy of the model was verified with the survey data. The results showed that the fitting curves of Suitability index (SI) model based on egg density and environmental factors in different months presented unimodal distribution. The results showed that GMM method and MINM method had the highest accuracy for fish egg density in April, May and June, respectively. The high HSI values are mainly distributed in the east of Leizhou Peninsula. The accuracy of the models was more than 60%, and the distribution trend of HSI was similar to that of egg density in spawning grounds, which indicated that habitat Suitability model based on GMM and MINM could better predict spawning grounds in western Guangdong Sea.

Key words: spawning grounds, habitat Suitability model, remote sensing, western Guangdong waters

基于耳石元素的黄海南部和东海海域小黄鱼产卵场亲鱼回归分析

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摘要: 海洋鱼类在产卵场间的回归性研究是鱼类不同地理群体时空连通性的重要内容。本文通过 LA-ICP-MS 耳石元素指纹分析技术对黄海南部和东海小黄鱼产卵场亲鱼回归性进行了分析研究。在近海四个产卵场分别于 2019 年和 2020 年春季 (4-6 月) 采集了小黄鱼幼鱼和 1 龄亲鱼。对小黄鱼幼鱼耳石核心区域微量元素分析, 结果表明 Sr:Ca、Ba:Ca、Mg:Ca 是有效区分各地理群体的元素指纹, 总体判别成功率为 77.4%。对成鱼耳石核心区域元素的分析结果显示, 小黄鱼各产卵场亲鱼有较强的回归性, 回归率为 41.4%-53.1%, 同时小黄鱼各产卵场间亲鱼也存在一定的交流, 这种交流往往仅限于临近产卵场。

关键词: 小黄鱼; 耳石元素; 回归; 连通性

Regression analysis of broodstock of small yellow croaker spawning ground based on otolith elements in the southern and eastern seas of the Yellow Sea

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Abstract: Research on the regression of marine fish between spawning grounds is an important part of the temporal and spatial connectivity of different geographic groups of fish. In this paper, the regression analysis of broodstock of small yellow croaker spawning ground in the southern Yellow Sea and the East China Sea was carried out by LA-ICP-MS otolith element fingerprint analysis technology. Small yellow croaker juveniles and 1 year old broodstock were collected in the spring of 2019 and 2020 (April-June) at four spawning grounds in the coastal waters. The analysis of trace elements in the core area of otoliths in small yellow croaker juveniles showed that Sr:Ca, Ba:Ca, and Mg:Ca are the element fingerprints that effectively distinguish each geographic group, and the overall discrimination success rate is 77.4%. The analysis results of the elements in the core area of adult otoliths showed that the broodstock of small yellow croaker spawning grounds have strong regressivity, with a regression rate of 41.4%-53.1%. At the same time, the broodstock of small yellow croaker spawning grounds also have certain exchanges. Species communication is often limited to nearby spawning grounds.

Key words: small yellow croaker, otolith elements, regression, connectivity

南海北部陆架区二长棘犁齿鲷资源密度的时空变化特征

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摘要: 南海北部陆架区受过度捕捞的影响, 渔业资源密度时空变动明显。文章根据 2014-2015 年对南海北部陆架区 4 个航次的渔业资源调查数据, 统计分析二长棘犁齿鲷 (*Evynnis cardinalis*) 资源密度的时空变化特征。结果显示南海北部陆架区二长棘犁齿鲷的出现频率存在明显的季节差异, 夏季最高, 春季最低。平均生物量和尾数资源密度均存在显著的季节差异, 生物量资源密度秋季最高, 尾数资源密度春季最高。汕头断面年平均生物量和尾数资源密度最高, 达到 41.6 kg·km⁻² 和 1021 ind·km⁻², 湛江断面最低, 仅为 7.2 kg·km⁻² 和 165 ind·km⁻², 聚类分析显示阳江断面和汕头断面的资源密度季节分布相似性较高。统计分析表明 40m 水层站位的年平均生物量资源密度最高, 达到 56.9 kg·km⁻²; 30m 水深站位的年平均尾数资源密度最高, 为 1084 ind·km⁻²。二长棘犁齿鲷资源密度随水深变化呈现显著差异, 即在浅水区和深水区资源密度较低, 中间水层资源密度较高。

关键字: 南海北部陆架区, 二长棘犁齿鲷, 资源密度, 时空变化

Tempo-spatial distribution of *Evynnis cardinalis* in northern continental shelf of South China sea

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Abstract: The northern continental shelf of South China Sea is affected by over fishing, and the fishery resources density has obviously tempo-spatial distribution. Based on the data collected by fishery survey in 2014-2015, this paper given a analysis to the temporal and spatial variation characteristics of the resource density of *Evynnis cardinalis* in the northern continental shelf of South China Sea. The results indicates that there are obvious seasonal variations in the occurrence frequency of *Evynnis cardinalis* in the northern continental shelf of South China Sea, the highest in summer and lowest in spring. There is significant seasonal difference in average resource density for biomass and number, average resource density for biomass reached the highest in autumn, but average resource density for number reached the highest in spring. The highest annual average resource density for biomass and number in Shantou section were 41.6 kg·km⁻² and 1021 ind·km⁻², the lowest values in Zhanjiang section were only 7.2 kg·km⁻² and 165 ind·km⁻², cluster analysis showed that the seasonal distribution of the resource density was more similar between Yangjiang section and the Shantou section. Statistical analysis suggested that the highest annual average resources density for biomass in the 40m layer is 56.9 kg·km⁻²; the highest annual average resources density for number in the 30m layer is 1084 ind·km⁻². The resource density of *Evynnis cardinalis* was varies obviously with water depth, that is the lower resource density occurred in shallow water and deep water, respectively the resource density of intermediate water layers are higher.

Key words: northern continental shelf of South China sea, *Evynnis cardinalis*, resource density, tempo-spatial variation

北太平洋浮游生物宽频声散射特征分析

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摘要: 北太平洋浮游生物分布广泛, 声学方法作为现代渔业资源调查的重要手段, 在浮游生物调查中应用日益广泛。本文根据 2019 年“淞航”号科学调查船搭载的 SIMRAD EK80 宽频带科学鱼探仪在北太平洋获取的声学走航调查数据, 借助 ESP3 V1.4.1 后处理软件分析调查海域浮游生物声散射特征。研究发现: (1) 随着换能器频率的升高, 各水层后向散射强度或是直接呈现出上升态势, 或是在短暂下降后上升; (2) 在 20-40 m 水层, 各站点后向散射强度之和为 -54.31 dB, 随水深增加散射强度分别减小至 -55.57 dB、-56.14 dB、-57.16 dB、-58.50 dB、-60.28 dB、-61.61 dB、-61.41 dB、-60.06 dB, 表明北太平洋浮游生物主要分布于 20-40 m 水层; (3) 黑潮对浮游生物分布影响较大, 位于黑潮附近的站点散射强度高于其他站点。

关键词: 北太平洋; 浮游生物; 散射强度; 渔业声学

Broadband Acoustic Scattering characteristics of plankton in the North Pacific Ocean

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Abstract: As an important means of modern fishery resources survey, acoustic method has been widely used in plankton survey in the North Pacific Ocean. Based on acoustic navigation survey data of the North Pacific Ocean obtained by broadband scientific fish finder SIMRAD EK80 on the research vessel *Songhang* in 2019, the acoustic scattering characteristics of plankton in the surveyed waters were analyzed with post-processing software ESP3 V1.4.1. The results show that: (1) with the increase of frequency, the backscattering strength of each water layer either directly presents an increasing trend or starts to increase after a short decrease. (2) In the 20-40 m layer, the sum of backscattering strength of each station is -54.31 dB. With the increase of depth, the scattering strength decreases respectively to -55.57 dB, -56.14 dB, -57.16 dB, -58.50 dB, -60.28 dB, -61.61 dB, -61.41 dB and -60.06 dB, indicating that the plankton in the North Pacific Ocean is mainly distributed in the 20-40 m layer. (3) Kuroshio has a great influence on the distribution of plankton, and the backscattering strength of stations located near kuroshio is higher than that of others.

Key words: North Pacific Ocean, plankton, backscattering strength, fishery acoustic

南黄海和东海小黄鱼繁殖策略差异分析

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摘要: 本研究以 2019 年至 2020 年南黄海和东海渔业捕捞小黄鱼为样品, 对南黄海和东海两群体小黄鱼的形态、卵巢(精巢)发育、繁殖力和肌肉性腺脂肪蛋白质含量等进行了分析。结果表明: 1、两群体形态差异明显, 主成分分析散点图可以将两群体明显分离 2、南黄海群体的繁殖力明显高于东海 3、未成熟的小黄鱼脂肪含量较低, 脂肪含量较高, 成熟个体则相反 4、在一个生殖周期内, 东海群体长体重优势组均大于南黄海。总结两群体繁殖力、繁殖时间等繁殖策略的差异, 并结合其形态和能量分配上的差异对造成两群体繁殖策略差异的原因进行探讨。

关键词: 南黄海和东海; 小黄鱼; 繁殖策略; 繁殖力; 生殖能量分配

Analysis of Differences in Reproduction Strategies of Small Yellow Croaker in the South Yellow Sea and East China Sea

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Abstract: This study used small yellow croaker fishing in the South Yellow Sea and East China Sea as samples from 2019 to 2020, and analyzed the morphology, ovarian (testis) development, fecundity, and muscle gonadal fat protein content of small yellow croaker in the South Yellow Sea and East China Sea. The results show that :1. The morphology of the two groups is significantly different, and the principal component analysis scatter diagram can clearly separate the two groups. 2. The fecundity of the South Yellow Sea population is significantly higher than that of the East China Sea. 3. The immature yellow croaker has lower fat content and higher fat content The opposite is true for mature individuals. 4. In one reproductive cycle, the dominant group of body length and weight in the East China Sea is larger than that in the South Yellow Sea. Summarize the differences in reproductive strategies of the two groups in terms of fecundity and reproductive time, and discuss the reasons for the differences in reproductive strategies between the two groups in combination with their differences in morphology and energy distribution.

Key words: South Yellow Sea and East China Sea; small yellow croaker; reproduction strategy; fecundity; reproductive energy distribution

浙江省远洋渔业发展有关问题探讨

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摘要:浙江省重视远洋渔业的发展,从1985年发展远洋渔业至今,远洋事业已发展的相对成熟。浙江省远洋鱼业的数量和规模持续扩大,作业区域和作业方式积极拓展,并发展成以浙江舟山为中心的浙江省远洋渔业重点产业体系聚集。本文结合浙江省远洋渔业的发展现状、着重分析了发展过程中面对的阻碍,针对性地提出了提升远洋渔船装备水平,保障生产安全、加强人才队伍建设,培养综合性人才、创新体制机制,提升发展和管理水平、政府和企业干预,积极拓展国内水产品销售市场和积极参与国际渔业竞争与合作,发展过洋性渔业等一系列合理化的对策建议,这对远洋渔业的可持续发展具有重要的现实参考意义。

关键词:远洋渔业、可持续发展、影响因素、解决对策

Discussion on the development of pelagic fishery in Zhejiang Province

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Abstract: Zhejiang province attaches great importance to the development of pelagic fishery. Since 1985, the development of pelagic fishery has been relatively mature. The number and scale of offshore fishery in Zhejiang province continued to expand, and the operation area and operation mode were actively expanded, and developed into a Zhejiang Province offshore fishery key industrial system cluster centered on Zhoushan, Zhejiang Province. Based on the current situation of the development of offshore fishery in Zhejiang Province, this paper mainly analyzes the obstacles in the development process, and puts forward some suggestions, such as improving the equipment level of offshore fishing vessels, ensuring the production safety, strengthening the construction of talent team, cultivating comprehensive talents, innovating the system and mechanism, improving the development and management level, and government and enterprise intervention, A series of reasonable countermeasures and suggestions, such as actively expanding domestic aquatic product sales market, actively participating in international fishery competition and cooperation, and developing offshore fishery, are of great practical reference significance for the sustainable development of pelagic fishery.

Key words: Pelagic fishery; sustainable development ; influence factor ; Solutions

不同类型厄尔尼诺事件对中西太平洋围网鲣 栖息地影响

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摘要: 鲣 (*Katsuwonus pelamis*) 主要分布于中西太平洋海域, 渔场分布受海洋环境因子影响。基于中国大陆地区渔船在中西太平洋围网鲣渔捞日志数据点位信息和环境因子数据, 利用最大熵模型 (MaxEnt) 模型对中部型强厄尔尼诺年和东部型超强厄尔尼诺年鲣潜在栖息地适宜性进行预测。结果表明: 受试者工作特征曲线(ROC)获得的各月 AUC 均值达 0.9 以上, MaxEnt 模型预测准确度较高。温度和海表面高度异常的变化是造成中西太平洋围网鲣栖息地分布差异的主要原因。鲣栖息地与不同类型厄尔尼诺事件显著相关, 随着异常气候事件的不同而发生变化。

关键词: 鲣; 最大熵模型; 环境因子; 中西太平洋; 潜在栖息地

Effects of different types of El Nino events on habitat of purse-seine skipjack tuna in the Western and Central Pacific Ocean

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Abstract: Skipjack tuna, *Katsuwonus pelamis*, is widely distributed in the western and central Pacific Ocean, and its fishing grounds are susceptible to marine environmental factors. We evaluated the potential habitat distribution of Skipjack tuna in the western and central Pacific Ocean of the strong El Nino with MaxEnt model based on the logbook data from mainland China and the oceanographic environmental data. The results show that: The operating characteristic curve (ROC) is higher than 0.9, so that MaxEnt model was proved to be accurate and reliable. The changes of sea surface temperature and sea level anomaly are the main causes of the potential habitat distribution and difference. The habitat of skipjack tuna is significantly related to different types of El Nino events, and changes with different abnormal climate events.

Key words: *Katsuwonus pelamis*, maximum entropy model, environmental factors, Western and Central Pacific Ocean, potential habitat

基于最大熵模型的中西太平洋围网鲣栖息地适宜性分析

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摘要: 鲣 (*Katsuwonus pelamis*) 主要分布于中西太平洋海域, 渔场分布受海洋环境因子影响。基于中国大陆地区渔船在中西太平洋围网鲣渔捞日志数据点位信息和环境因子数据, 利用最大熵模型 (MaxEnt) 模型对 2015 年 9 月-2016 年 2 月鲣栖息地适宜性进行评价。用 Arcgis 软件制作鲣栖息地渔场分布图。结果表明: 受试者工作特征曲线(ROC)获得的各月 AUC 均值达 0.9 以上, MaxEnt 模型预测准确度较高。T50 (Sea temperature at 50m depth)、SLA(Sea Level Anomaly)、SST(Sea Surface Temperature)为影响鲣潜在栖息地分布的重要因子, 累计贡献率达到 71.9%, 表明温度是影响鲣生存的主要因子。温度和海表面高度异常的变化是造成中西太平洋围网鲣栖息地分布差异的主要原因。

关键词: 鲣; 最大熵模型; 环境因子; 中西太平洋; 潜在栖息地

Analysis of habitat distribution of purse-seine skipjack tuna in the Western and Central Pacific Ocean using maximum entropy model

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Abstract: Skipjack tuna, *Katsuwonus pelamis*, is widely distributed in the western and central Pacific Ocean, and its fishing grounds are susceptible to marine environmental factors. We evaluated the potential habitat distribution of Skipjack tuna in the western and central Pacific Ocean in September 2015 to February 2016 with MaxEnt model based on the logbook data from mainland China and the oceanographic environmental data. Using Arcgis to make a fishing grounds map of Skipjack tuna. The results show that: The operating characteristic curve (ROC) is higher than 0.9, so that MaxEnt model was proved to be accurate and reliable. Sea temperature at 50m depth, Sea Level Anomaly, and Sea Surface Temperature, are important factors affecting the distribution of Skipjack tuna potential habitat, with a cumulative contribution rate of 71.9%. Temperature is the main factor affecting the survival of Skipjack tuna. The changes of sea surface temperature and sea level anomaly are the main causes of the potential habitat distribution and difference.

Key words: *Katsuwonus pelamis*, maximum entropy model, environmental factors, Western and Central Pacific Ocean, potential habitat

基于脂肪酸标记法的西印度洋四种顶级捕食者营养生态位研究

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摘要: 本研究调查了 2016 年 12 月至 2017 年 4 月西印度洋海域的四种大型顶级捕食者 (大眼金枪鱼、太平洋蓝枪鱼、条纹四鳍旗鱼、黄鳍金枪鱼) 的营养生态位。我们利用肌肉组织中脂肪酸组成情况以及空间分布情况, 从摄食行为和栖息地两个方面来研究它们的摄食策略。其中, 大眼金枪鱼、太平洋蓝枪鱼以及条纹四鳍旗鱼的脂肪酸组成重叠最为明显, 黄鳍金枪鱼与其他三种捕食者之间存在着显著差异。空间重叠分析表明, 物种之间存在高度的空间重叠, 但是这种重叠并没有使物种间产生负面竞争。总体而言, 这四种顶级捕食者均为典型的机会性肉食动物, 不选择性地捕食常见猎物, 宽阔的生态位以及西印度洋沿岸海域丰富的生物资源可以减少其种间竞争。

关键词: 营养生态位; 西印度洋; 脂肪酸; 顶级捕食者; 资源重叠

Trophic niches of four top predators in the Western Indian Ocean inferred by fatty acids

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Abstract: This study examined the trophic ecology of four top predators sampled in the Western Indian Ocean from December 2016 to April 2017. We investigated their feeding strategies in terms of foraging behavior and habitat use by comparing fatty acid profiles in muscle tissue and spatial distributions. Among them, the fatty acid composition overlap appeared strongest between big eye tuna, Indo-Pacific blue marlin and striped marlin, and there were significant differences between yellowfin tuna and other three predators. Spatial overlap analysis shows that there is high spatial overlap among them, but does not cause negative competition. Cumulatively, our results suggest that these four top predators are opportunistic carnivores, unselectively foraging on common prey items, and that a wide niche and abundant resources in the coastal waters of the Western Indian Ocean can reduce inter-species competition".

Keywords: trophic niche, Western Indian Ocean, fatty acid, top predator, resource overlap

V型网板的水动力性能影响参数分析

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摘要: 网板是提供拖网网衣张力的主要属具。V型网板有利于在保证有足够的扩张力和坚固性的同时大大提高网板操作稳定性。为研究小型拖网渔船网板的水动力性能, 通过数值模拟的方法, 在其他参数一定的情况下, 采用控制变量法控制V型网板的展弦比, 折角以及冲角的单一变化, 研究其对拖网网板水动力性能的影响规律。数值计算结果表明: 基本模型最佳升阻比出现在冲角为 10° 左右。展弦比 $\lambda=0.6$ 时升阻比最大为3.5, $\lambda=0.75$ 时升阻比最小为2.6。折角 $d=175^\circ$ 和 $d=180^\circ$ 两组网板模型最佳升阻比最高, 为4.7左右。流场分析显示以上情况和网板附近漩涡的出现和消失以及漩涡出现的位置有关。

关键词: V型网板 水动力性能 参数 数值模拟

Analysis of parameters affecting hydrodynamic performance of V-shaped mesh plate

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Abstract: The otter board is the main appliance to provide tension of trawl net. The V-shaped otter board can ensure enough tension and firmness, and greatly improve the operation stability of the otter board. In order to study the hydrodynamic performance of small trawler, the single change of aspect ratio, fold angle and attack angle of V-shaped otter board was controlled by numerical simulation method, and the influence of V-shaped otter board on hydrodynamic performance was studied. The numerical results show that the optimal lift drag ratio appears at the angle of attack of about 10° . When aspect ratio $\lambda = 0.6$, the maximum lift drag ratio is 3.5, and the minimum lift drag ratio is 2.6 when $\lambda = 0.75$. The best lift drag ratio of the two groups of mesh models with break angle $d = 175^\circ$ and $d = 180^\circ$ is about 4.7. The flow field analysis shows that the above situation is related to the appearance and disappearance of the vortex near the otter board and the position of the vortex.

Key words: numerical simulation hydrodynamic performance V-shaped otter board ratio

基于 LBB 方法的南沙群岛珊瑚礁鱼类资源评估

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摘要: 为了评估珊瑚礁鱼类资源量水平和开发现状, 利用一种基于体长数据的贝叶斯生物量评估方法 (LBB) 对南沙群岛三个主要岛礁 (永暑礁、美济礁和渚碧礁) 的 10 种优势珊瑚礁鱼类数据进行了分析。评估结果显示, 黑缘尾九棘鲈、尾纹九棘鲈、驼背笛鲷、金带齿颌鲷、犬牙锥齿鲷和横带唇鱼资源量水平 (B/B_{SMY}) 在 0.16-0.45 之间, 处于过度捕捞状态; 蜂巢石斑鱼和三带副绯鲤资源量水平分别为 0.98 和 1.1, 处于完全开发状态; 而黑边角鳞鲷和四带笛鲷资源量水平分别为 2.5 和 1.3, 处于未完全开发状态。该研究可为南海珊瑚礁鱼类资源养护提供科学依据。

关键词: 南沙群岛; 珊瑚礁鱼类; LBB 方法; 过度捕捞

Stock assessment for coral reef fishes from Nansha Islands, South China Sea, based on length-based Bayesian biomass (LBB) estimation method

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Abstract: We applied a newly developed length-based Bayesian biomass (LBB) estimation method to assess ten dominate coral reef fishes from three main reefs (Yongshu Reef, Zhubi Reef, and Meiji Reef) of Nansha Islands. Results showed relative biomass levels (B/B_{SMY}) of *Cephalopholis spiloparaea*, *Cephalopholis urodeta*, *Lutjanus gibbus*, *Gnathodentex aureolineatus*, *Pentapodus caninus*, and *Cheilinus fasciatus* were between 0.16 and 0.45, suggesting the overfishing status; the relative biomass levels of *Epinephelus merra* and *Parupeneus trifasciatus* were 0.98 and 1.1, respectively, indicating they were fully exploited; the relative biomass levels of *Lutjanus kasmira* and *Melichthys vidua* were 1.3 and 2.5, respectively, indicating good conditions. The assessment results can provide an overview of the current exploitation status of coral reef fisheries in Nansha Islands, and relative biomass levels of specific fish stocks.

Key words: Nansha Islands, coral reef fishes, LBB method, overfishing

氨基酸对铜绿微囊藻生长及叶绿素荧光参数的影响

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摘要: 本文以 6 种氨基酸——天门冬氨酸、丝氨酸、精氨酸、谷氨酸、丙氨酸和甘氨酸为唯一氮源, 在实验室条件下模拟自然水体氨基酸浓度 (12、25、50、75、100 $\mu\text{mol/L}$) 对铜绿微囊藻细胞数量、叶绿素含量及相关叶绿素荧光参数的动态变化。结果表明: 无氮对照组测定的指标均显著低于各氨基酸试验组 ($p<0.01$); 随着氨基酸浓度的升高, 6 种氨基酸均能促进铜绿微囊藻的生长及相关叶绿素荧光参数的提高, 并在氨基酸浓度为 100 $\mu\text{mol/L}$ 时达到最高值; 随着培养时间的增加, 除谷氨酸波动明显外, 其余各氨基酸试验组测定的指标整体均呈先上升后下降的趋势, 其反应的结果基本符合延滞期、对数生长期、稳定期的规律。研究表明, 不同浓度、种类的氨基酸对铜绿微囊藻生长及叶绿素荧光参数均表现出有利特征, 且氨基酸的作用程度依次为天门冬氨酸 > 丝氨酸 > 精氨酸 > 谷氨酸 > 丙氨酸 > 甘氨酸。

关键词: 铜绿微囊藻; 氨基酸; 细胞密度; 叶绿素荧光参数;

Effects of Amino acids on growth and chlorophyll fluorescence parameters of *Microcystis aeruginosa*

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Abstract: In this paper, six kinds of amino acids—aspartic acid, serine, arginine, glutamic acid, alanine and glycine were used as sole nitrogen sources to simulate the dynamic changes of cell number, chlorophyll content and related chlorophyll fluorescence parameters of *Microcystis aeruginosa* at the concentration of 12, 25, 50, 75, 100 $\mu\text{mol/L}$. The results showed that the indexes of nitrogen-free control group were significantly lower than those of all amino acid groups ($p<0.01$). With the increase of amino acid concentration, all six amino acids could promote the growth and chlorophyll fluorescence parameters of *Microcystis aeruginosa*, and reached the highest value when the amino acid concentration was 100 $\mu\text{mol/L}$. With the increase of culture time, except for the obvious fluctuation of glutamic acid, the indexes of other amino acid test groups increased at first and then decreased, and the results were basically consistent with the rules of lag period, logarithmic growth period and stable period. The results showed that different concentrations and kinds of amino acids showed favorable characteristics on the growth and chlorophyll fluorescence parameters of *Microcystis aeruginosa*, and the effect degree of amino acids was aspartic acid > serine > arginine > glutamic acid > alanine > glycine.

Keywords: *Microcystis aeruginosa*; amino acid; cell density; chlorophyll fluorescence parameter

海南东南部海域春季鳶乌贼 CPUE 与海洋环境关系

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摘要: 通过对 2016 年 4 至 5 月海南岛东南海域的鳶乌贼渔获、温盐密以及海平面高度异常(SSHA)数据进行分析, 探讨海南岛东南部海域鳶乌贼单位努力渔获量(CPUE)与海水温度、SSHA 和涡流等海洋环境关系。结果表明, 所调查海域温跃层上界深度高于 50 m 的站点 CPUE 较高, 低于 50 m 的站点 CPUE 较低。在海表面温度(SST)范围为 27 至 30 °C 的海域鳶乌贼 CPUE 较高, 25 至 27 °C 的海域鳶乌贼 CPUE 较低。此外, 调查海域的纬度范围不同, 鳶乌贼适宜 SST 范围有差异。在 SSHA 为-0.05 至 0.05 m 的海域, 鳶乌贼 CPUE 较高。反气旋漩涡边缘部分的站点 CPUE 较高, 而漩涡内部的站点 CPUE 较低。以上表明, 海水温度、SSHA 和涡流等环境因子对鳶乌贼 CPUE 有重要影响。

关键词: 鳶乌贼; CPUE; 温跃层; SST; SSHA; 漩涡

Relationship between CPUE of *Sthenoteuthis oualaniensis* and environmental factors in the southeast water of Hainan in spring

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Abstract: The relationship between the CPUE of *S.oualaniensis* and sea water temperature, SSHA and eddy in the southeast sea area of Hainan island is discussed by analyzing the date of *S.oualaniensis*, the date of CTD and the date of SSHA in the southeast sea area of Hainan island from April to May 2016. Results showed that the CPUE of sites with upper bound depth of thermocline above 50 m is higher and the CPUE of the sites with upper bound depth of thermocline below 50 m is lower in the investigative sea area. In the sea area with the range of the SST from 27 to 30 °C, the CPUE of *S.oualaniensis* is higher and in the sea area with the range of the SST from 25 to 27 °C, the CPUE of *S.oualaniensis* is lower. In addition, the suitable range of SST is different in the different range of the latitudes of the investigative sea area. In the sea area with the SSHA between -0.05 and 0.05 m, the CPUE of *S.oualaniensis* is higher. The CPUE of the site at the edge of the anticyclone eddy is higher, while the CPUE of the site inside the eddy is lower. The above showed that sea water temperature, SSHA and eddy have a important impact on the CPUE of *S.oualaniensis*.

Key words: *Sthenoteuthis oualaniensis*; CPUE; thermocline; SST; SSHA; eddy

马鞍列岛东部海域小黄鱼 (*Larimichthys polyactis*) 分布特征和生境选择初探

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摘要: 对不同生活史阶段鱼类生境选择的全面认知是进行资源保护及海洋牧场目标种选择和增殖的前提。基于 2016-2017 年马鞍列岛东部海域的底拖网调查数据, 本文结合相对重要性指数和 GIS 空间分析, 对捕获的共计 3496 inds 小黄鱼 (*Larimichthys polyactis*) 样品进行了体长、年龄、性别、性成熟度及饵料组成等生物学特征参数的统计分析和可视化。结果显示马鞍列岛小黄鱼群体存在较强的季节变化和空间分布规律: 夏季小黄鱼平均资源密度和幼鱼密度显著高于其他季节 ($p < 0.05$); 岛礁区域幼鱼密度高于外围海域, 而成鱼密度则相反。研究揭示, 马鞍列岛独特的生境格局 (繁多的岛礁、规模化的人工生境) 为不同生活史阶段的小黄鱼提供了良好的索饵、繁殖、栖息和避敌场所。

关键词: 小黄鱼; 生境选择; 分布规律; 空间分析

Distribution characteristics and habitat selection of small yellow croaker (*Larimichthys polyactis*) in the eastern of Ma'an Islands

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Abstract: Systematic recognition of fish habitat selection is the premise of effective resource protection and target species selection and proliferation in marine ranching. Based on the bottom trawl in 2016-2017 in the eastern waters of Ma'an islands, the biological characteristics of 3496 *Larimichthys polyactis*, including body length, age, sex, sexual maturity and the food composition, were analyzed and visualized by relative importance index and GIS spatial analysis. The results show the seasonal and spatial distribution patterns of small yellow croaker off Ma'an Archipelago: The density of small yellow croaker in summer was significantly higher than in other seasons and the density of juveniles in summer was significantly higher than in other seasons ($p < 0.05$). The density of juveniles in reef area was higher than in the periphery area, and the adults were reversed. Above all, the specific habitat pattern created by islands and large scale artificial habitats off Ma'an Islands provide suitable habitats for small yellow croaker for feeding, breeding and sheltering in different life stages.

Key words: *Larimichthys polyactis*, habitat selection, distribution patterns, spatial analysis

基于双频识别声呐监测调查的辽东湾北部近海大型水母沙蜇丰度和分布的研究

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摘要: 近些年, 国际上声学技术已经被应用到大型水母的监测调查和行为规律研究中, 展现出了良好的观测效果和应用前景。2017年7月18日和8月18日, 本研究通过双频识别声呐(DIDSON)在辽东湾对伞径16-81cm的大型水母沙蜇开展丰度和分布的监测调查, 并同步开展传统网具的监测调查, 将网具与声呐同步监测调查的结果相比对, 验证双频识别声呐技术在大型水母沙蜇监测调查中的效果。调查结果显示, 比起传统的网具调查, 双频识别声呐更加精准的监测调查到调查海区沙蜇的丰度, 并观测到沙蜇分布的主要水层。证明双频识别声呐可以适用于浅海大型水母沙蜇的监测调查工作。

关键词: 双频识别声呐; 辽东湾; 沙蜇; 丰度; 分布

The quantification of abundance and distribution of giant jellyfish *Nemopilema nomurai* in inshore waters of the northern Liaodong Bay with a Dual-frequency Identification Sonar(DIDSON)

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Abstract: In recent years, acoustic technology has been used to investigate the stock and behavior of giant jellyfish in the world. These technologies have demonstrated favourable monitoring capabilities and the potential for their application in both resource assessment and the kinematics of the giant jellyfish. We used a dual-frequency identification sonar (DIDSON) to determine quantification of abundance and distribution of giant jellyfish *Nemopilema nomurai* individual medusae of 16–81 cm bell diameter in inshore waters of the northern Liaodong Bay in July 18 and August 18, 2017, and the jellyfish drift net samples were conducted for 1 hour for comparison at the same time. Compared with the traditional network survey, the DIDSON can more accurately observe the abundance of jellyfish in the survey area and the main water layer of jellyfish distribution. The results suggested that it is effective to monitor the giant jellyfish by using DIDSON in inshore waters of Liaodong Bay.

Key words: DIDSON; Liaodong Bay; *Nemopilema nomurai*; Abundance; distribution

中西太平洋长鳍金枪鱼渔情预报研究

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摘要: 主要介绍了影响长鳍金枪鱼渔场变动的海表面温度、海表面盐度、海表面高度、叶绿素 a 浓度、温跃层、海流等主要环境因子, 以及栖息地适宜指数模型、广义可加模型、分位数回归模型、支持向量机方法、人工神经网络模型等的模型应用与研究现状, 对其渔场中应用的优缺点进行了分析, 根据存在的问题提出了建议, 希望可以为瓦努阿图海域长鳍金枪鱼渔场的分析和研究提供参考。

关键词: 长鳍金枪鱼; 渔场; 环境因子; 渔情预报

Forecasting Albacore Fishery Status in Central-west Pacific Ocean

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Abstract: This article mainly focuses on the dynamics of sea surface temperature of albacore tuna fishing ground, sea surface salinity, sea surface height, chlorophyll a concentration, thermocline, a main environmental factor such as current, and suitable habitat index model, generalized additive model, quantile regression model, support vector machine method and artificial neural network model and other models application and research status quo, analyzes the advantages and disadvantages of its application in fisheries. Based on the existing problems, some suggestions are put forward in the hope of providing reference for the analysis and research of albacore tuna fishery in Vanuatu sea.

Keywords: Thunnus alalunga, Fisheries, Environmental factors, Fishery forecast

黄海南部辐射沙脊群小黄鱼早期生活史

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摘要: 小黄鱼 (*Larimichthys polyactis*) 是中、日、韩三国管辖海域重要经济种, 其产卵场位于我国南黄海近海。由于小黄鱼为位居我国捕捞前列的单品种产量, 加之其在高强度捕捞压力下突出的生存能力, 我国常将其列为渔业资源研究模式种。本文通过长周期捕捞调查和耳石微化学的研究来揭示黄海南部辐射沙脊群小黄鱼早期运输机制。辐射沙脊群区域不同发育阶段的小黄鱼幼鱼的 Sr/Ca 值, 从离核心 15-20 μm 处 (约 5 日龄) 和在离核心约 400 μm 处 (约 35 日龄), Sr/Ca 比值会发生明显的格局转变。该区域小黄鱼资源的补充时间规律: 平均见苗时间为 5 月 9 日, 大量苗发日平均时间为 5 月 16 日, 苗发结束期平均时间为 9 月 12 日。4 月上旬到 5 月上旬小黄鱼 Sr/Ca 比变化客观反映出营浮游生活的小黄鱼仔鱼对沙脊群水动力场的一种环境适应策略。综合捕捞调查和耳石微化学的分析可以推测, 辐射沙脊群海域小黄鱼幼鱼的扩散方式可能为: 孵化后约从 4 月上旬至 5 月上旬小黄鱼在辐射沙脊群区域分散漂流, 此后聚集于辐射沙脊群至 6 月下旬, 再开始向外侧迁出。

关键词: 资源补充物候学, 耳石微化学, 生境转变, 运输机制, Sr/Ca, 小黄鱼

Early life history of the small yellow croaker (*Larimichthys polyactis*) in sandy ridges of the South Yellow Sea

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Abstract: Early life history of the small yellow croaker *Larimichthys polyactis* was studied using otolith microchemistry of juvenile fish and a recruitment survey in the sandy ridges of the South Yellow Sea. Otolith Sr/Ca ratio regime shifted markedly at the age of 5-7 days (early April) and 37-41 days (around early May). Subsequently, the Sr/Ca ratio was almost constant until late June, indicating an aggregation of *L. polyactis* juveniles in the relatively stable habitat of the sandy ridges, which was supported by a recruitment survey that showed a rapid increase in the number of juveniles in the same area between early May and the end of June. Variations in the Sr/Ca ratio between early April and early May might reflect a habitat adaptive strategy of *L. polyactis* in the pelagic stage to hydrodynamic processes of the sandy ridges. Based on the aforementioned habitat shifts and recruitment phenology, it was hypothesised that *L. polyactis* juveniles disperse between early April and early May, inhabit sandy ridges to feed, and migrate offshore in late June.

Keywords: Recruitment phenology, otolith microchemistry, habitat shifts, dispersal pattern, Sr/Ca ratio, *Larimichthys polyactis*

时空和环境因素对南海鸢乌贼 CPUE 的影响

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摘要: 鸢乌贼是南海海洋生态系统中营养级较高的重要物种, 具有较大的渔业开发潜力。在气候和环境变化日益加剧的情况下, 了解鸢乌贼时空分布和丰度的本质和变化因素具有重要的科学性和社会经济价值。利用广义加性模型方法分析了环境因素和 CPUE 之间的关系。本研究结果表明, 南海鸢乌贼个体较小, 且没有大型群个体。生物学特征表明南海鸢乌贼属于正异速生长类型, 且寿命相对于其他海域的个体较短。本研究样本仅代表南海的成年鸢乌贼, Logistic 生长方程最适合描述其生长模式。CPUE 较高的海域主要分布在 10°~11°N。在 GAMs 分析中, SST 是最重要的影响因素, 最适 GAM 模型的解释偏差为 67.9%。SST 范围在 27~28 °C、Chl-*a* > 0.18 μg/l 和 SSHA 范围在 -0.05 - 0.05 m 的条件下, 南海鸢乌贼 CPUE 较高。在充分了解南海鸢乌贼特性和栖息状况的前提下, 对南海鸢乌贼资源的管理和可持续开发具有重要作用。

关键词: 鸢乌贼; 南海; 广义加性模型; 单位努力渔获量

Spatio-temporal and environmental impact on CPUE of purpleback flying squid in the South China Sea

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Abstract: The purpleback flying squid (Ommastrephidae: *Sthenoteuthis oualaniensis*) is an important species dynamic in higher trophic level of regional marine ecosystem in the South China Sea (SCS), where the species is believed potential in fishery development. Accordingly, under the scheme of increasingly rapid climatic and environmental changes, understanding the nature and importance of various factors determining the spatial and temporal distribution and abundance of purpleback flying squid in the SCS is of great scientific and socio-economic interests. Using GAM (generalized additive models) methods, we analyzed the relationship between available environmental factors and catch per unit effort (CPUE) data. This study showed that the individuals of *S. oualaniensis* were small and there were no giant form individuals in the SCS. The biological characteristics indicate that *S. oualaniensis* belongs to the type of positive allometric growth in the SCS, and the lifespan was shorter compared to those in other seas. The sample in our study only represented the adult *S. oualaniensis* in the SCS, and the Logistic growth equation was most suitable to describe its growth pattern. In our study, the sea areas with higher CPUE were mainly distributed in 10° - 11°N. The sea surface temperature (SST) was the most important factors in GAM analysis and the deviance explained by the best fitting GAM model was 67.9%. The results of our study show that CPUE was higher when SST was in the range of 27 - 28°C, chlorophyll-*a* concentration (Chl-*a*) > 0.18 μg/l, and sea surface height anomaly (SSHA) was in the range of -0.05 - 0.05 m. Under the premise of fully understanding the biological characteristics and habitat status of *S. oualaniensis* in the SCS, it plays an important role in the management of this resource and sustainable fisheries.

Keyword: *Sthenoteuthis oualaniensis*; South China Sea; generalized additive model (GAM); CPUE

南海北部带鱼群体结构及生长、死亡和性成熟参数估计

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摘要: 根据2014—2015年南海北部底拖网渔业调查数据, 对带鱼的群体结构及生长、死亡和性成熟参数等进行了研究。结果表明: 1)带鱼肛长频率分布为单峰型, 优势肛长组为160~190 mm, 雌雄个体的肛长组成无显著差异($P>0.05$); 2) 4个季度雌雄比与1: 1均有显著差异 ($P<0.05$); 性成熟度以II期为主; 最小性成熟肛长为113 mm, 50%性成熟肛长 (L_{50}) 为241.5 mm; 3) 电子体长频率分析法评估的带鱼渐近肛长为585 mm, 生长系数为 $0.2 a^{-1}$, 总死亡系数为1.172, 自然死亡系数0.475, 开发率为0.59。虽然带鱼当前仍处于过度捕捞状态, 但是个体平均肛长有恢复迹象。

关键词: 带鱼; 群体结构; 生长; 死亡; 南海北部

Population structure of *Trichiurus japonicus* in the northern South China Sea, and parameters for its growth, mortality and maturity

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Abstract: The fisheries biology characters of *Trichiurus japonicus*, including population structure, sex ratio, gonad maturity, and parameters for its growth, mortality, were analyzed based on the data collected during 2014–2015. Results show that the dominant anal length groups are 160~190 mm and there is no significant difference in the composition of anal length between females and males ($P> 0.05$). There is significant difference from 1:1 ($P< 0.05$) of the ratios of females to males in four quarters. Their grade of gonadal maturity is mainly in level two, and the minimum maturity length is 113 mm, and the estimated anal length at 50% sexual maturity (L_{50}) is 241.5 mm. The estimated asymptotic anal length (L_{∞}) and growth parameter (K) calculated by Electronic Length Frequency Analysis I (ELEFAN I) are 585 mm and $0.20 a^{-1}$, respectively. The estimated total mortality coefficient (Z) and natural mortality coefficient (M) are 1.172 and 0.475, respectively. Although the exploitation rate of 0.59 indicates that this resources are in over development state, the average anal length of the individuals show signs of recovery.

Key words: *Trichiurus japonicus*, population structure, growth, mortality, northern South China Sea

象山县小黄鱼刺网渔具渔法调查分析

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摘要: 本文主要对宁波象山县高塘乡的小黄鱼刺网的渔具结构、装配技术、主捕对象、经济效益、存在问题等进行调查,得出结论如下:(1)象山县高塘乡小黄鱼刺网属于定置单片刺网。(2)该网具主捕对象为小黄鱼,其优势规格为40~60g,符合浙江省最小可捕过渡性规格(体重30g),兼捕少量的鳗鱼、方头鱼,对海底、环境无害,因此为环境友好型网具,可以进行适当的推广使用。(3)小黄鱼有一定的渔汛期,该作业不可能在每年的8月1日~翌年的5月1日均有产量,宜根据实际情况,建议适当发展兼作渔船,以提高渔民的经济收入。(4)建议政府对各种作业方式进行划区域生产,以减少各种作业方式在生产过程中的纠纷。

关键词: 小黄鱼;刺网;兼捕渔船

Investigation and Analysis on Fishing Gear of Yellow Croaker Gill Net in Xiangshan County

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Absrtact: this paper mainly investigates1 the fishing gear structure, assembly technology, main target, economic benefit and existing problems of the small yellow croaker gill net in Gaotang Township, Xiangshan County, Ningbo, and draws the following conclusions :(1) the small yellow croaker gill net in Gaotang Township, Xiangshan County belongs to the fixed monolithic gill net. (2) The main target of the net is small yellow croaker, its dominant specification is 40~60 g, conforms to the minimum catchable transitional specification of Zhejiang Province (weight 30 g), and catches a small amount of eel and square head fish, which is harmless to the sea floor and environment, so it is an environment-friendly net, so it can be used appropriately. (3) Small yellow croaker has a certain fishing season, the operation can not be in every Both August 1 of the year ~ May 1 of the following year yield, it is appropriate to recommend the appropriate development of concurrent fishing vessels according to

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南海北部近海蓝圆鲹的渔业生物学特征研究

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摘要: 根据 2014-2017 年南海北部底拖网调查中蓝圆鲹 (*Decapterus maruadsi*) 的生物学数据, 对南海北部蓝圆鲹群体的体长与体质量、性腺成熟度、摄食等级等生物学特征的组成与季节变化进行初步研究。结果显示, 南海北部蓝圆鲹体长范围 78-248mm, 平均体长 146mm, 优势体长为 121-150mm; 体质量范围 7.9-290g, 平均体质量 52g, 优势体质量为 21-60g; 雌雄个体体长间存在显著性差异 ($P < 0.05$)。生长参数 $b = 3.1312$, 接近等速生长。雌雄性比 1.5: 1。性腺成熟度以 II 期为主, 各月份均有性成熟的个体, 冬、春季节性成熟个体都超过 50%, 为主要繁殖季节。雌性初次性成熟体长为 170.9mm, 摄食等级以 2 级为主, 随着体长的增加, 摄食水平有升高的趋势。

关键词: 蓝圆鲹; 南海北部; 渔业生物学

Biological characteristics of *Decapterus maruadsi* in the northern South China Sea

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Abstract: Based on the biological data from the bottom trawl surveys in the northern South China Sea from 2014 to 2017, we evaluated the compositional and seasonal changes of the biological characteristics such as body length and weight, gonadal maturity, and feeding stage of the *Decapterus Maruadsi*. The results showed that the body length ranged from 78-248mm, the average was 146mm, and the dominant body length group ranged from 121-150mm; The body weight ranged from 7.9-290g, the average was 52g, and the dominant body weight group range from 21-60g. There were significant differences in body length between male and female individuals ($P < 0.05$). The growth parameter $b = 3.1312$, close to the constant growth rate. The sex ratio is 1.5:1. Gonad maturity is a priority to II period, each season has the sexual maturity individuals, winter and spring seasonal mature individuals are more than 50%, as the main breeding season. The body length at the first maturity of the female individual is 170.9mm, and the feeding stage is mainly level 2. With the increase of body length, the feeding stage tends to increase.

Key words: *Decapterus maruadsi*; northern South China Sea; fishery biology

基于环境 DNA 的大黄鱼和小黄鱼资源分布研究

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摘要: 物种分布监测和生物量评估对于渔业管理和资源养护至关重要。大黄鱼 (*Larimichthys crocea*) 和小黄鱼 (*Larimichthys polyactis*) 曾是我国的重要经济鱼种。但是由于过度捕捞和生境恶化, 大黄鱼资源严重枯竭, 捕捞压力转移至小黄鱼。由于传统渔业资源调查有诸多限制, 本研究采用环境 DNA 方法, 设计并使用大黄鱼和小黄鱼的特异性引物和 TaqMan 探针, 对东海区 (覆盖面积 190,467 km², 44 站位, 171 个不同水深样品) 大黄鱼和小黄鱼的空间分布和相对生物量进行了监测。其中, 在 29 个站位 (66%) 检测到 96 个 (56%) 大黄鱼阳性样本, 在 14 个站位 (28%) 检测 28 个 (16%) 小黄鱼阳性样品。在水平分布上, 大黄鱼和小黄鱼在各站位之间有显著性差异 ($p < 0.05$), 显示出大小黄鱼均有很强的生境选择性; 在垂直分布方面, 大黄鱼和小黄鱼的环境 DNA 浓度在不同水层的分布不同, 其中, 小黄鱼在表层、中层和底层水体中有显著性差异, 中层水体中的小黄鱼浓度显著高于底层水体中的浓度 ($p < 0.05$), 而表层和中层无显著性差异, 大黄鱼环境 DNA 浓度在各水层间无显著差异。研究发现大黄鱼和小黄鱼的产卵场均有从近岸产卵场扩展至近海产卵场的现象, 推测可能是对环境压力 (近岸污染和气候变化) 和捕捞压力的响应。在各种环境变量中, 深度和温度均与环境 DNA 的存在与否和浓度显著相关 ($P < 0.05$), 是大小黄鱼空间分布预测的重要环境因子。本研究证实了环境 DNA 方法在重要海水鱼类资源大规模监测方面的优越性, 同时也提示垂直采样对于不同生态习性物种监测的必要性, 本研究将有助于今后海洋渔业资源的长期监测和评估。

关键词: 环境 DNA, 大黄鱼 (*Larimichthys crocea*), 小黄鱼 (*Larimichthys polyactis*), 资源分布

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LBB 方法对黄渤海八种常见鱼类的评估

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摘要: 本文运用基于体长的贝叶斯生物量公式 (LBB 方法) 对山东沿海的八种常见的和具有商业价值的海洋鱼类进行了评估。这些种类分别是日本鲭、褐鲳鲷、大泷六线鱼、赤鼻棱鲷、大头鳕、黄鲫、多鳞鱈和黄鲛鳕。LBB 是一种运用体长频率数据对渔业资源进行评估的简单、有效的方法。山东沿海毗邻黄渤海,是中国重要的渔场,在 2018 年黄鲛鳕、日本鲭和大头鳕的产量分别达到 57200, 21100 和 1330 吨。在本研究中,除了多鳞鱈的其它 7 种鱼,现存生物量和未开发生物量的比值 (B/B0) 小于评估生物量与未开发生物量的比值。

关键词: 黄渤海; LBB 方法; 过度捕捞; 种群评估; 渔业资源

Stock Assessment Using LBB Method for Eight Fish Species From the Bohai and Yellow Seas

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Abstract: Eight common and commercially important marine fishes from coastal and offshore areas of Shandong Province, China, were assessed using the “Length-based Bayesian Biomass” estimator (LBB) method. These species were *Scomber japonicus* (chub mackerel), *Sebastiscus marmoratus* (false kelpfish), *Hexagrammos otakii* (fat greenling), *Thryssa kammalensis* (kammal thryssa), *Gadus macrocephalus* (Pacific cod), *Setipinna taty* (scaly hairfin anchovy), *Sillago sihama* (silver sillago), and *Lophius litulon* (yellow goosefish). LBB is a new and powerful, yet simple, approach to evaluate a fisheries’ status using length and frequency data. Shandong Province’s coastal areas, adjacent to the Yellow and Bohai Seas, are an important fishing ground of China, where the 2018 catch of three of these species, yellow goosefish, chub mackerel, and Pacific cod, yielded up to 57,200, 21,100, and 1330 tons, respectively.

Key words: Bohai and Yellow Seas, LBB method, overfishing, stock assessment, fishery resources

毛里塔尼亚海域日本鲭时空分布与海洋环境的关系

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摘要: 根据 2017 年 9 月至 12 月在毛里塔尼亚海域 112 个站点的调查数据, 研究日本鲭的时空分布规律, 并采用分位数回归的方法建立其 CPUE 与叶绿素 *a* 浓度、海表面温度、海表面盐度的关系模型, 结合 GAM 模型评价环境因子的影响程度。结果表明: (1) 海表面温度对日本鲭 CPUE 的影响最显著; (2) 各站点 CPUE 预测值与实测值间皆无显著性差异; (3) IHI 模型对 CPUE 具有良好的预测效果; (4) IHI 分布较高的海域为 17°25'W-17°45'W, 20°15'N-20°45'N。

关键词: 日本鲭; 时空分布; 海洋环境; 分位数回归; 栖息地综合指数

Relationship between spatiotemporal distribution of chub mackerel and marine environment variables in the waters near Mauritania

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Abstract: From data collected on 112 sites in waters near Mauritania from September to December in 2017, the relationship model based on Quantile Regression method was established using 78% randomly selected sites between CPUE of chub mackerel and environmental factor such as chlorophyll-*a* concentration, sea surface temperature and sea surface salinity, then use General Additive Model to evaluate the impact of environmental factors to CPUE. The results showed that: (1) the most significant environmental factors affecting CPUE of chub mackerel was sea surface temperature; (2) there were no significant differences between the predicted CPUE and the nominal CPUE of all sites; (3) the IHI model had good predictive ability on CPUE of chub mackerel; (4) the higher IHI were defined in the area of 17°25'W - 17°45'W and 20°15' N - 20°45' N.

Key words: chub mackerel, spatiotemporal distribution, marine environment, integrated habitat index, quantile regression

北部湾斑鳍白姑鱼渔业生物学研究

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摘要: 通过2008-2009年和2018-2019年在北部湾海域沿岸北海和东方渔港采集斑鳍白姑鱼样品, 根据测量所得的生物学数据, 利用体长频率分析法分析斑鳍白姑鱼(*Pennahia pawak*)种群生长、死亡参数和开发率等的变化, 以评估两个时期北部湾斑鳍白姑鱼的开发利用状况。结果显示, 2008-2009年和2018-2019年两个时段北部湾斑鳍白姑鱼优势体长分别为11~17cm和10~15cm, 平均体长由14.83cm减小到12.59cm; 优势体重分别为30~100g和10~80g, 平均体重由85.88g降低至52.91g, 2018-2019年的平均体长、平均体重较2008-2009年分别下降了15.1%和38.4%。两个时段异速生长因子 b 分别为2.84和3.00, 表明斑鳍白姑鱼趋向匀速生长。生长参数 K 分别为0.39和0.32; 总死亡系数分别为1.39和1.17, 自然死亡系数分别为0.98和0.90, 捕捞死亡系数分别为0.41和0.28, 估算的开发率分别为0.29和0.24。综上, 北部湾斑鳍白姑鱼呈小型化明显, 目前该资源呈轻度开发状态。

关键词: 斑鳍白姑鱼; 北部湾; 生长参数; 死亡参数

Study on fishery biology of *Pennahia pawak* in Beibu Gulf

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Abstract: The samples of *Pennahia pawak* (*P. pawak*) were collected at the Behai and Dongfang fishing ports in the coast of Beibu Gulf from 2008 to 2009 and 2018 to 2019. Samples were measured for biological data. Length frequency analysis (ELEFAN) technique was used to analyze the growth, mortality parameters and exploitation rate to assess the resource utilization status in the two periods. The results indicated that the dominant standard length (SL) was 11~17cm and 10~15cm, with the SL decreasing from 14.83 cm to 12.59 cm in the two periods. The dominant body mass (BM) were 30~100g and 10~80 g, with the BM decreasing from 85.88 g to 52.91 g. The average of SL and BM in 2018-2019 decreased by 15.1% and 38.4% respectively compared with 2008-2009. The allometric parameter b in the two periods was 2.84 and 3.00, *P. pawak* tended to isometric growth. L_{∞} (asymptote length) declined 8.7 % from 24.15 cm to 22.05 cm while L_c (first catchable size) declined 18.1 % from 12.56 cm to 10.29 cm. The growth parameter K decreased from 0.39 to 0.32. The total mortality coefficient decreased from 1.39 to 1.17. The natural mortality coefficient of the *P. Pawak* was 0.98 and 0.90. The fishing mortality coefficients was 0.41 and 0.28. The exploitation rate decreased from 0.29 to 0.24, respectively. The population structure of *P. pawak* in the Beibu Gulf showed a tendency to miniaturize and it was not over-exploited.

Key words: *Pennahia pawak*; the Beibu Gulf; growth parameter; mortality parameter

基于线粒体 NADH 脱氢酶 2 太平洋褶柔鱼种群遗传结构分析

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摘要: 太平洋褶柔鱼(*Todarodes pacificus*)为生活在暖温带的海洋性头足类物种, 年资源量保持逐年增长趋势。当前基于太平洋褶柔鱼种群遗传结构的研究主要集中于形态学层面上, 有关于分子生物学方面的研究较少。本试验对太平洋褶柔鱼种群遗传结构展开的研究是以线粒体 NADH 脱氢酶 2 (ND2) 分子标记为基础, 取东海海域和日本海海域的 65 尾太平洋褶柔鱼为样本, 通过对样本的 ND2 序列进行扩增, 并分析得到 33 个多态性位点。分析三个样本群体的遗传多样性显示, 三个群体的遗传多样性均处于较低的水平, 其中区域 2 的遗传多样性水平略高于区域 1 和 3。通过对 F_{st} 和基因流(Nm)的分析得出, 这三个群体没有出现显著的遗传变异, 同时, 产生的遗传变异几乎全部来自于群体内。通过对核苷酸不配对分布分析并经过 Fajima's D 和 Fu's F_s 中性检验结果可以推断出, 太平洋褶柔鱼种群在近期经历过种群扩张, 且扩张时间约为 2.83 万年前。通过构建分子进化树发现, 三个群体之间没有出现明显地理谱系的分化。

关键词: 太平洋褶柔鱼; ND2; 种群遗传多样性; 种群扩张

Genetic structure analysis of the *Todarodes pacificus* population based on mitochondrial NADH dehydrogenase 2

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Abstract: *Todarodes pacificus* is a Marine cephalopod species living in warm temperate zones. According to the investigation, it is found that the *Todarodes pacificus* is a potential species for fishery development, and the annual resource quantity keeps increasing year by year. At present, studies on genetic structure of *Todarodes pacificus* population are mainly focused on morphology, and there are few studies on molecular biology. Based on mitochondrial NADH dehydrogenase 2 (ND2) molecular markers, 65 *Todarodes pacificus* were sampled from the east China sea and the sea of Japan. The ND2 sequence of the samples was amplified, and 33 polymorphic loci were obtained through analysis. The analysis of genetic diversity of the three sample populations showed that the genetic diversity of the three populations was at a low level, and the genetic diversity of region 2 was slightly higher than that of region 1 and 3. Based on the analysis of F_{st} and gene flow (Nm), no significant genetic variation was found in these three populations, and almost all genetic variation was generated within the population. By analyzing the unpaired distribution of nucleotides and passing the Fajima's D and Fu's F_s neutral test results, it can be inferred that the Pacific pleura population experienced population expansion recently, and the expansion time was about 28,300 years ago. The results of building molecular evolutionary tree show that there is no obvious geographical lineage differentiation among the three populations.

Key words: *Todarodes pacificus*; ND2; Population genetic structure; Population expansion

中国近海海洋渔业资源现状评价

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摘要: 海洋渔业资源是地球生物资源的重要组成部分, 在粮食安全、经济生产和社会发展方面都占有重要作用。本文基于 1950 年以来我国近海的渔业统计数据, 结合渔获物平均营养级(MTL)、海洋营养级指数(MTI)和渔业均衡指数(FIB), 对我国近海渔业资源的开发状况进行了分析评价。结果表明: (1) 自 1951 年以来, 虽然我国近海捕捞产量有了较大的增长, 但是产量的增加依靠的是捕捞力量的增加, CPUE 基本上呈现连年下降的趋势; (2) MTL 呈现先降低后增长的趋势, 1950—1988 年期间以 0.12/10 a 的速度降低, 1989—2016 年以 0.04/10 a 的速度升高, 总的来说处于下降趋势; (3) FIB 总体上呈上升趋势, 而 MTI 总体呈下降趋势, 同时结合 MTL 的变化趋势可以得出, 被开发的渔业生态系统发生了地理性扩张。这表明, 中国近海渔业的地理性扩张明显, 渔获物组成向低营养级改变。

关键词: 海洋渔业资源; 平均营养级; 海洋营养级指数; 渔业均衡指数; 中国近海

The evaluation of current status of China's offshore marine fishery resources

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Abstract: Marine fishery resources are an important part of the earth's living resources, and play an important role in food security, economic production and social development. Based on the statistical data of China's offshore fisheries since 1950, combined with the average trophic level (MTL), the regional trophic level index (MTI) and the fishery in balance index (FIB), this paper analyzes and evaluates the development status of China's offshore fishery resources. The results show that: (1) The China's offshore fishing output has increased, but it depends on the increase of fishing power, and CPUE has basically shown a downward trend in successive years since 1951; (2) MTL shows a trend of first decreasing and then increasing, with a rate of 0.12/decade from 1950 to 1988 and 0.04/decade from 1989 to 2016; (3) FIB showed an upward trend, while MTI showed a downward trend. At the same time, combined with the relative downward trend of MTL, it can be concluded that the developed fishery ecosystem has undergone geographical expansion. The research shows that the geographical expansion of China's offshore fisheries is obvious, and the catch composition changes to low trophic level.

Key words: marine fishery resource, mean trophic level, marine trophic index, fishing in balance index, offshore China

舟山群外海域春秋季节鱼类群落结构及生物多样性

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摘要: 2018年4月和10月在舟山群岛外海域进行的渔业资源调查, 研究表明: (1)该海域鱼类有106种, 隶属于12目47科80属; (2)春季优势种为黄鲛鰵、日本红娘鱼和细条天竺鲷, 秋季优势种为细条天竺鲷和日本发光鲷; (3)鱼类生物多样性指数值是秋季大于春季, 春、秋季均匀度指数(J')对比多样性指数(H')和丰富度指数(D)都较小; (4)春季在35%的相似水平上分为3个群落, 秋季在45%相似水平上分为2个群落; (5)ABC曲线表明, 舟山群岛外海域的春季鱼类群落结构可能处于未受干扰状态, 秋季鱼类群落结构可能处于严重干扰状态。

关键词: 种类组成; 相对重要性指数; 群落结构; 生物多样性

Fish community structure and biodiversity in the offshore waters of Zhoushan islands in spring and autumn

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Abstract: A survey of fishery resources conducted in the waters off Zhoushan Islands in April and October 2018 shows that: (1) There are 106 species of fish in this sea area, belonging to 12 orders, 47 families and 80 genera; (2) Spring advantage The species are yellow anglefish, Japanese red fish and thin striped snapper. The dominant species in autumn are thin striped snapper and Japanese luminescent snapper; (3) The fish biodiversity index value is greater in autumn than in spring, and the uniformity index of spring and autumn (J') The contrast diversity index (H') and richness index (D) are both small; (4) In spring, it is divided into 3 communities at a similar level of 35%, and in autumn, it is divided into 2 communities at a similar level of 45%; (5) The ABC curve shows that the fish community structure in the waters off Zhoushan Islands may be undisturbed in spring, and the fish community structure in autumn may be severely disturbed.

Key words: species composition; relative importance index; community structure; biodiversity

不同发育阶段的斑马鱼光谱敏感性差异研究

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摘要: 本试验旨在探讨斑马鱼 (*Danio rerio*) 在不同发育阶段的光谱敏感性差异。试验中, 分别记录了 10 dpf、20 dpf、30 dpf 的斑马鱼幼鱼和斑马鱼成鱼在不同波长不同强度 LED 光刺激下的视网膜电图 (ERG), 分析了各发育阶段的斑马鱼的光谱敏感性。结果显示: 随着年龄的增长, 斑马鱼对所有波长的敏感度均有增加, 且对中波 (460–550 nm) 和长波 (550–620 nm) 刺激的敏感度增加更为明显; 不同年龄段的斑马鱼均表现出对紫外光和可见光的敏感性, 且对紫外光的敏感峰值均为 365 nm 左右; 不同年龄段的斑马鱼对可见光的光谱敏感性差异明显, 10 dpf 的斑马鱼幼鱼敏感峰值为 550 nm, 20 dpf 和 30 dpf 的斑马鱼幼鱼敏感峰值则为 500 nm, 且发现一个 550 nm 的次波峰, 斑马鱼成鱼敏感峰值为 500 nm。该研究结果表明斑马鱼在发育过程中不同类型的视细胞数量及占总视细胞数的比例发生变化, 视杆细胞逐渐参与影响斑马鱼的光谱敏感性。

关键词: 斑马鱼; 视网膜电图; 刺激时间间隔; 光谱敏感性

Research on Spectral Sensitivity Differences of Zebrafish at Different Developmental Stages

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Abstract: The research was to investigate the spectral sensitivity differences of zebrafish at different developmental stages. In the experiment, the electroretinograms(ERG) of 10 dpf zebrafish larvae, 20 dpf zebrafish larvae, 30 dpf zebrafish larvae and adult zebrafish were recorded under LED light stimulus with different wavelengths and intensities. The spectral sensitivity of zebrafish at different developmental stages were analyzed. The results showed that the sensitivity of zebrafish to all wavelengths increased with age, and the sensitivity to middle-wavelength stimulus range (460-550 nm) and long-wavelength stimulus range (550-620 nm) increased more significantly. Zebrafish at different ages showed sensitivity to ultraviolet and visible light, and the peak value of sensitivity to ultraviolet light was about 365 nm. Zebrafish at different ages showed significant differences in spectral sensitivity to visible light. The 10 dpf group had a sensitivity peak of 550 nm. The 20 dpf group and 30 dpf group had a sensitivity peak of 500 nm, and a second peak of 550 nm was found. The sensitivity peak of adult zebrafish was 500 nm. The results indicated that the number of different types of visual cells and their proportion in the total number of visual cells changed during the development of zebrafish, and rod cells gradually affected the spectral sensitivity of zebrafish.

Key Words: Zebrafish (*Danio rerio*); electroretinogram(ERG); stimulus interval; spectral sensitivity

领域六

水生生物资源养护利用及水域生态修复

钱塘江七里泷大坝下江段鱼类资源现状

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摘要:于2015年-2018年在钱塘江七里泷大坝下4个江段按季度开展鱼类多样性调查。共发现鱼类83种,隶属于13目25科59属;桐庐、富阳、一桥和六桥分别采集到鱼类63种、58种、25种和32种。聚类分析显示桐庐-富阳江段鱼类群落为一类群;一桥-六桥江段鱼类群落为一类群,SIMPER分析桐庐-富阳江段群落组成平均相似度为45.41%,一桥-六桥江段群落组成平均相似度为50.87%,桐庐-富阳江段和一桥-六桥江段平均相异度为80.88%。桐庐-富阳江段优势种为似鳊、银鮡、鲫和光泽黄颡鱼;一桥-六桥江段优势种为鲢、鳙、刀鲚和鲫。多样性指数显示富阳江段生鱼类物多样性最高,桐庐次之,六桥、一桥生物多样性较低。丰度/生物量比较(ABC)曲线显示,一桥、六桥受干扰程度较低,桐庐、富阳江段鱼类群落受到干扰。针对钱塘江七里泷大坝下鱼类多样性现状,建议加强流域水质监管,建立种质资源保护区,开展渔业资源动态监测等方式以保护钱塘江下游渔业资源。

关键词:钱塘江七里泷大坝下;群落结构;多样性;

Current situation of fish resources in Qililong Dam section of Qiantang River

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Abstract: A quarterly survey on fish diversity was carried out in four river sections under Qililong dam in the Qiantang River from 2015 to 2018. A total of 83 species of fish were found, belonging to 59 genera, 25 families and 13 orders. In Tonglu, Fuyang, Yiqiao and Liuqiao, 63 species, 58 species, 25 species and 32 species were collected respectively. Cluster analysis showed that the fish community in Tonglu-Fuyang section was a group. The fish community in the Yiqiao-Liuqiao section is a taxa, and the average similarity of community composition in the Yiqiao-Liuqiao section is 45.41%, the average similarity of community composition in the Yiqiao-Liuqiao section is 50.87%, and the average facies difference between the Yiqiao-Liuqiao section and the Tonglu-Fuyang section is 80.88%. The dominant species in Tonglu-Fuyang River section are *Pseudobrama simoni*, *Squalidus argentatus*, *Carassius auratus* and *Pelteobagrus nitidus*. The dominant species of *Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis*, *Coilia nasus* and *Carassius auratus* in the section of Yiqiao-Liuqiao. The diversity index showed that the fish diversity in Fuyang section was the highest, followed by That in Tonglu, and the biodiversity in Liuqiao and Yiqiao was lower. The abundance/biomass comparison (ABC) curve showed that the disturbance degree of the Yiqiao and the Liuqiao was relatively low, and the fish communities in Tonglu and Fuyang sections were disturbed. In view of the current situation of fish diversity under Qililong dam in Qiantang River, it is suggested to strengthen the supervision of water quality in the basin, establish germplasm resources protection zone and carry out dynamic monitoring of fishery resources to protect the fishery resources in the lower reaches of Qiantang River.

Key words: Qiantang River Under the Qililong Dam, Community structure

沙柳河青海湖裸鲤早期资源发生量及时空分布

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摘要: 为掌握青海湖裸鲤资源补充状况, 本研究于 2019 年对沙柳河开展了青海湖裸鲤早期资源丰度时空变化特征的调查研究。调查发现, 鱼卵自 6 月初出现, 到 6 月底至 7 月初达到高峰, 随后逐渐下降。鱼苗自 7 月初呈波动式上升, 8 月到达高峰。估算沙柳河鱼卵径流量为 8.12×10^6 粒, 鱼苗径流量为 44.15×10^6 尾。卵苗空间分布为从河口往上丰度依次递减, 断面水平分布为右岸 > 左岸 > 中心。昼夜间鱼卵丰度存在显著差异 ($P < 0.05$); 昼夜间鱼苗丰度存在极显著性差异 ($P < 0.01$)。卵苗漂流高峰期均集中在夜间。鱼卵丰度和流速呈显著正相关 ($P < 0.05$), 鱼苗丰度和流速呈极显著正相关 ($P < 0.01$), 鱼苗丰度和水温呈极显著正相关 ($P < 0.01$)。本研究首次报道了沙柳河青海湖裸鲤早期资源现状, 补充了该水域青海湖裸鲤早期资源资料的空缺。

关键词: 青海湖裸鲤; 早期资源; 资源量补充; 时空变化; 环境因子; 沙柳河

The occurrence amount and spatial and temporal distribution of early resources of *Gprzewalskii przewalskii* in Shaliu River

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Abstract: This study investigated the distribution and abundance of eggs and fries of *Gprzewalskii przewalskii* in Qinghai lake of Shalu river. The eggs were found in early June and peaked in July then gradually decline through middle of August. The fry's fluctuations were observed in early July, peaked in August. Eggs runoff in Shaliu river is estimated at 8.12×10^6 while the fries is 44.15×10^6 . The spatial distribution of egg seedlings was declining successively from the mouth of the river and the horizontal distribution of the section was higher on the west bank followed by the east bank and then on the center. There was a significant difference in egg abundance between day and night ($P < 0.05$). The abundance of fry was significantly different between day and night ($P < 0.01$). The peak of egg drift is concentrated at night. There was a significant positive correlation between the abundance of fish eggs and the flow velocity ($P < 0.05$), a very significant positive correlation between the abundance and the flow velocity of fish fry ($P < 0.01$), and an extremely significant positive correlation between the abundance and the water temperature of fish fry ($P < 0.01$). This study was the first of its kind to be conducted on the status of *Gprzewalskii przewalskii* in Qinghai lake of Shalu river.

Key words: *Gprzewalskii przewalskii*, Early resources, Replenishment of resources, Spatial and temporal variation of abundance, Environmental factors; Shaliu river

临港海上风电场水域鱼类群落结构及其与环境因子的关系

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摘要: 为探明工程建设后临港海上风电场水域鱼类群落结构特征, 本研究利用多元统计和冗余分析 (RDA) 等方法对该水域鱼类群落结构及其与环境因子的关系进行分析。春、秋季共获得 28 种鱼类, 隶属 6 目 15 科 26 属; 鲈形目鱼类所占比例最高 (57.14%), 其中以虾虎鱼科鱼类最多 (21.43%)。鱼类组成以海洋性、暖温性、底层鱼类为主。多样性分析和 ABC 曲线表明, 调查水域鱼类群落结构处于受干扰状态。T-检验显示, 风电场区鱼类的丰度、生物量、丰富度指数 (D)、均匀度指数 (J') 和多样性指数 (H') 均与邻近水域无显著性差异, 风电场对该水域鱼类群落结构无明显影响。等级聚类和非度量多维排序 (NMDS) 表明, 临港海上风电场及邻近水域鱼类群落分为春季和秋季 2 个组群。相似性检验 (ANOSIM) 显示 2 个组群差异极显著 ($R=0.726$, $P<0.01$), 群落结构的季节更替明显。RDA 表明鱼类群落结构受溶氧、温度、深度和盐度的综合影响, 不同环境因子对不同生活史阶段优势种的影响作用不同。

关键词: 临港; 海上风电场; 种类组成; 群落结构; 环境因子

Fish community structure and its relationships with environmental factors in offshore wind farm of Lingang

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Abstract: In order to illustrate fish community structure in offshore wind farm (OWF) of Lingang and its adjacent waters, multivariate statistics and redundancy analysis (RDA) were used to analyze the fish community structure and its relationships with environmental factors. The results showed that 28 species belonging to 6 orders, 15 families and 26 genera were identified. Perciformes (57.14%) had the highest percentage, among which the most species in Gobiidae (21.43%). The diversity analysis and ABC curve showed that the fish community structure in these waters was disturbed. T-test showed that the abundance, biomass, D, J' and H' in the OWF were not significantly different with the adjacent waters, and the OWF had no significant impact on the fish community structure in these waters. Cluster and non-metric multidimensional scaling (NMDS) indicated that fish community in the OWF of Lingang could be clustered into two groups, which were spring and autumn assemblages. ANOSIM analysis indicated that there were significant differences in community structure between these two groups ($R=0.726$, $P<0.01$), and the seasonal alternation of fish community structure is obvious. RDA showed that the fish community structure was affected by dissolved oxygen, temperature, depth and salinity, and different environmental factors showed different effects on dominant species during different life cycle stages.

Key words: Lingang, offshore wind farm (OWF), species composition, community structure, environmental factors

食物缓解海洋微塑料对双壳贝类的生理影响

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摘要: 为了获知被摄食生物对海洋污染物微塑料带来的生理效应的影响, 同时了解微塑料与各营养级生物的互动以及产生的生态效应, 本实验通过对厚壳贻贝的能量收支, 消化系统消化酶和抗氧化酶的研究, 发现暴露于微藻后的微塑料被表面修饰, 微藻与微塑料的共同暴露缓解了微塑料对厚壳贻贝的生理影响, 这为水环境生态修复提供了新思路。

关键词: 微塑料; 被摄食者; 厚壳贻贝; 能量收支; 生理效应

Physiological effects of plastic particles on mussels are mediated by food presence

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Abstract: Physiological effects of marine microplastics could be affected by the predator and microplastic might interact with different trophic organisms and lead to ecological effect. We focused on the energy budget, digestive and antioxidant enzymes of the digestive system of mussels *Mytilus coruscus* under the independent/mixture exposure of microplastic and microalgae. The results showed that microplastic particles were surface modified after exposure to microalgae and presence of food mediated the physiological effects on mussels caused by microplastics. This study provides a new idea for ecological restoration of marine environment.

Key words: Microplastic, predator, mussel, *Mytilus coruscus*, energy budget, physiological effects

基于层次分析法南海伏季休渔期秩序评估初探

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摘要: 采用德尔菲法从 33 个伏季休渔影响指标中筛选得到 28 个影响伏季休渔秩序因素的指标, 基于层次分析法分析、计算各评价指标的权重值, 根据伏季休渔期对南海区部分渔港、渔政走访调查及海上巡航等数据进行实例验证, 综合评价各项指标对南海伏休秩序的影响程度。结果显示渔政执法经费、执法装备等指标对目前南海伏休秩序具有关键性影响, 渔民的休渔期补贴、三无渔船休渔期间的违规捕捞及越南渔船的侵渔对南海伏季休渔秩序具有较大影响。本研究在一定程度上揭示了各评价指标对南海伏季休渔秩序的影响程度, 可为规范我国南海伏季休渔秩序, 完善伏季休渔制度提供一定的参考。

关键词: 南海; 伏季休渔; 层次分析法; 秩序评估

Preliminary analysis of the order assessment of the summer fishing moratorium in the South China Sea based on Analytic hierarchy process

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Abstract: By using Delphi method, 28 factors affecting the order of summer fishing closure season were selected from 33 indexes. Based on the analytic hierarchy process (AHP), the weight value of each evaluation index was calculated. According to the data of some fishing ports, fishing administration visits and cruises in the South China Sea during the summer fishing closure season, the influence of each index on the fishing closure order was comprehensively evaluated. The results show that the fishery administration law enforcement funds, equipments and other indicators have a key impact on the current summer fishing closure order in the South China Sea. Fishermen's subsidies during the fishing moratorium, illegal fishing of vessels without certification and the invasion fishing of Vietnamese fishing vessels have a great impact on the order. To some extent, this study reveals the impact of each evaluation index on the summer fishing closure order, which can provide some reference for standardizing the order and improving the summer fishing closure system in the South China Sea.

Key words: South China Sea, summer fishing moratorium, Analytic hierarchy process, order assessment

2015—2018年珠江口近岸海域鱼类群落结构及其稳定性

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摘要: 生态网络稳健性是群落稳定性的重要研究内容。本研究依据底拖网调查的鱼类群落数据, 利用鱼类的捕食与被捕食的关系分别构建了4个年份的生态网络, 并分析了网络的拓补性质。结果表明: ①网络应对随机扰动(如捕捞、环境突变)的能力较强, 符合河口生境多变特征; ②网络稳健性呈逐年弱化之趋势, 且该趋势基本未受到种类数量变化的影响; ③网络能流效率较高, 种间关系分布较均匀。

关键词: 鱼类; 群落结构; 稳定性; 稳健性; 生态网络; 食物网; 珠江口

Structure and stability of the fish community in the Pearl River Estuary coastal waters from 2015 to 2018

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Abstract: The Robustness can elucidate the degree of community stability, which is essential to better understand the community structure and ecosystem functioning. Using the fish data of bottom trawl samplings, we established the annual ecological networks based on the feeding relationship between the fish species. Characters of the networks were summarized as follows: ① all the networks had high resistance of the networks on random disturbances (such as fishing and environmental change). It also a sign for the drastic environmental variations of estuaries habitat; ② the annual species richness varied significantly, and the degrading of network robustness regardless of species richness; ③ the networks had the high rates of energy flow and comparatively even distribution of fish species relations.

Keywords: fish, community structure, stability, robustness, ecological networks, food web, Pearl River estuary

长江口中华绒螯蟹亲蟹的适宜生境研究

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摘要: 采用视频记录分析法和六分室盐度选择装置研究了中华绒螯蟹亲蟹的行为反应, 结果表明: 半咸水会刺激亲蟹的运动活力及其它相关行为增强, 亲蟹在低盐胁迫后腹部开合反应增强, 而在高盐胁迫后表现出封闭反应。在盐度 0-21 范围内, 雌性亲蟹在各盐度分室中出现的次数随着盐度的升高而增加; 在盐度 7-28 范围内, 在各盐度分室中停留的时间随着盐度的升高逐渐降低, 盐度是影响雌性亲蟹栖息分布的重要因子。资源调查和标记跟踪研究表明: 长江口中华绒螯蟹产卵水域主要分布在九段沙南部、北槽深水航道和横沙浅滩至崇明浅滩水域。产卵期的适宜水温为 8-11 °C、盐度为 6-14。中华绒螯蟹抱卵期主要分布在横沙浅滩东部水域和横沙浅滩南部深水航道水域。胚胎发育期间栖息水深为 11 m、孵化高峰期栖息水深为 6 m 左右。抱卵蟹适宜盐度为 5-15、流速为 0.6-1.2 m/s、透明度小于 16 cm。研究结果为亲蟹生境修复和资源保护提供了参考依据。

关键词: 中华绒螯蟹; 行为生态; 适宜生境; 生态修复

Study on the suitable habitat of the broodstock of *Eriocheir sinensis* in the Yangtze Estuary

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Abstract: The behavioral responses of Chinese mitten crab *Eriocheir sinensis* broodstock were studied. The results showed that brackish water could stimulate the activity and other related behaviors of broodstock crabs, broodstock crabs increase their abdominal opening and closing response after low-salt stress, but show closing response after high-salt stress. Female Chinese mitten crab *sinensis* broodstock occurred in the salinity chambers more and more frequently with the increase of salinity at a range 0-21. Salinity is an important factor affecting the habitat distribution of female broodstock crabs. The spawning waters of *E. sinensis* in the Yangtze River estuary are mainly distributed in the south of Jiuduansha Wetland, Deep Water Channel of the north channel and the area between Hengsha Shoal and Chongming Shoal. The appropriate temperature (°C) and salinity of female spawning were separately 8-11 and 6-14. Ovigerous *E. sinensis* mainly distributed in the east of Hengsha Shoal and the waters in Deep Water Channel which located in the south of Hengsha Shoal. During the embryogenesis, *E. sinensis* mainly inhabited depth of 11 m. While in the peak time of hatching, the ovigerous *E. sinensis* mainly inhabited depth 6 m. The ovigerous *E. sinensis* preferred habitats with salinity 5-15, flow velocity 0.6-1.2 m/s and transparency below 16 cm.

Key words: *Eriocheir sinensis*, behavior ecology, suitable habitat, ecological restoration

基于指数随机图模型 (ERGMs) 的嘉陵江中游 上石盘支流鱼类群落分析

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摘要: 人类活动 (诸如城市化、工业化、大坝建设以及过度捕捞等) 会造成水体环境改变, 并进一步引起栖息在该水域的鱼类群落变化, 例如性早熟, 个体小型化、群落结构单一化等现象。但由于鱼类群落中个体相互依存, 在统计分析中违反了数据的独立性, 鱼类群落结构对环境变化的诸多现象并未经过任何统计检验。指数随机图模型是社会学分析中常用且有效的网络分析模型。本研究利用该模型探究了嘉陵江中游段上石盘支流的鱼类群落对坝闸建设的响应模式。调查期间 (2015-2017 年) 上石盘支流共采集到 5975 尾标本, 隶属 6 属、共 39 种。群落 Shannon-weiner 多样性指数和 Simpson 多样性指数分别为 2.23 和 0.83。经 ERGMs 模型检验分析, 建坝前后鱼类性成熟年龄、个体大小、生活水层等适应性策略发生显著性改变; 建坝后性成熟年龄小、小个体和底层鱼类在群落中更占优势。

关键词: 适应性策略; 指数随机图模型; 鱼类群落; 小型化; 网络分析

Fish assemblage status of Sanshipan Stretch, Jialing River, verified by exponential random graph models (ERGMs)

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Abstract: Fish assemblage are sensitive to river environmental changes induced by anthropogenic activities, such as urbanization, industrialization, dam construction, and overfishing, which potentially lead to the biota's early maturation, miniaturization, simple community structure with few species. However, most of the changes were descriptive, and not subject to any statistical testing, for violating the fundamental assumption of independent data. This study used a network analysis, the exponential random graph models (ERGMs) to explore the adaptive strategy changes of fish assemblage of the Shangshipan stretch, the middle reaches of the Jialing River. A total number of 5975 fish specimens, representing 39 species of 6 families, were collected from 2015 to 2017. Shannon diversity index and Simpson diversity index were 2.23 and 0.83, respectively. Sexual maturity age, miniaturization and living layers were significantly changed of the fish assemblage after construction of the dam. Fish species with earlier sexual maturity age, smaller body length, and living in bottom layer had been proved more superior. The study was a preliminary practice of application of ERGMs in fish assemblage analysis, and proved useful in illustrating the characteristics of fish assemblage and conducting fish diversity protection in aquatic ecosystems.

Keywords: adaptive strategy, exponential random graph models (ERGMs), fish assemblage, miniaturization, network analysis

高温对中间球海胆行为和生长的跨代影响

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摘要: 本文研究了亲本效应对经历长时间升温适应的中间球海胆子代的适合度相关行为和生长的跨代影响。研究发现, 长期高温环境下的中间球海胆后代的适合度相关行为(翻正行为、遮蔽行为、觅食行为和亚里士多德提灯反应)没有受到跨代影响。长期高温环境对海胆后代的壳厚也没有受到跨代效应的影响。父母长期经历高温环境下的海胆后代的性腺重量存在消极的滞留效应。有趣的是, 中间球海胆的一些体尺对升温环境的适应体现出了明显的父本效应(壳压、亚里士多德提灯的长度、壳高和壳高/壳径)。这些结果表明, 随着海胆的生长, 父本效应逐渐占主导地位。

关键词: 海胆; 海洋变暖; 跨代效应; 行为; 生长

Transgenerational effects of ocean warming on fitness behaviors and growth of the sea urchin *Strongylocentrotus intermedius*

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Abstract: The present study investigated the transgenerational effects of fitness related behaviors and growth of the sea urchin *Strongylocentrotus intermedius* whose parents were exposed to long term high temperature. In the present study, *Strongylocentrotus intermedius* exposed to long term high temperature showed no transgenerational effects on related fitness behaviors (righting behavior, covering behavior, foraging behavior and Aristotle's lantern reflex). There was no transgenerational effect on test thickness of offspring sea urchins whose parents exposed to long term high temperature. Negative transgenerational effects were found in gonad weight of offspring sea urchins whose parents were exposed to long term temperature. Interestingly, significant differences in paternal effect on crushing force, lantern length, test height and test height/test diameter were found. These findings indicate that as sea urchin grows, the effect of paternal effect gradually dominates.

Keywords: Sea urchin, ocean warming, transgenerational effect, behavior, growth

水库生态牧场绿色发展模式与技术对策的思考

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摘要: 水库渔业是我国淡水渔业的重要组成部分, 在保障优质水产品供给、维持生态平衡、促进渔民增收等方面发挥着重要作用。近年来, 随着资源与环境约束日益加大, 水库渔业发展方式亟需转型升级。文中分析了水库渔业发展现状及面临的问题, 探讨了水库生态牧场发展的理论基础、绿色模式和技术方法, 最后提出了三点建议: (1) 加强水库本底调查, 制定生态牧场发展规划; (2) 坚持绿色发展理念, 发挥水库多种功能; (3) 强化科技支撑作用, 重视技术培训推广。

关键词: 水库生态系统; 生态渔业; 增殖放流; 渔业资源管理; 水域生态牧场

Thinking on Green Development Models and Technical Countermeasures of Reservoir Ecological Ranching

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Abstract: Reservoir fishery is an important component of freshwater fishery in China. It plays a critical role in ensuring the supply of high-quality aquatic products, maintaining ecological balance, and promoting fishermen's income. In recent years, with the increasing restriction of resources and environment, the development model of reservoir fishery needs to be transformed and upgraded. In this paper, we analyze the current situation of reservoir fishery development, the problems and challenges it faces, and summarize the theoretical basis of ecological fishery development. We put forward four types of green fishery models and corresponding technical approaches as well as relevant suggestions, from the aspect of basic investigation, planning and layout, standard formulation, multi-functioning, and scientific supports.

Key words: reservoirs ecosystem, ecological fishery, stocking enhancement, fishery resources management, aquatic ecological pastures

珠江下游两种土著鱼类的育幼场和生长

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摘要: 幼鱼数量决定着繁殖补充群体的大小, 高质量的育幼场决定幼鱼的生长和存活率, 了解鱼类育幼场和生长是保证鱼类补充成功的基础。广东鲂和鮰是珠江下游重要经济鱼类。本研究在珠江下游肇庆江段和珠江三角洲九江连续5年(2015-2019)用地笼采集幼鱼, 采样时间每年从7月至次年的1月。在肇庆和九江分别采到3373 and 4096条鮰幼鱼, 97.0%和80.5%的个体都是当年幼鱼。分别在肇庆和九江采集63和853条广东鲂幼鱼, 大部分都是1岁幼鱼(98.4%和86.1%)。广东鲂幼鱼微耳石核心由原基、模糊区和摄食轮组成, 日轮在摄食轮后出现, 宽度随着生长增加, 在第40轮左右达到最高此后下降, 轮纹清晰度逐渐增加在幼鱼阶段最清晰, 体长与日龄的关系为 $y=4.60+0.47x$ 。7-8月群体的生长率在肇庆和九江具有明显差异, 可能跟两个江段的径流量相关; 11月群体的生长率没有明显差异。这个研究说明了珠江下游和三角洲是鮰鱼的重要育幼场, 珠江三角洲是广东鲂的重要育幼场, 为珠江渔业管理提供基础数据。

关键词: 幼鱼; 育幼场; 耳石微结构; 生长; 珠江

The nursery grounds and growth of two endemic fish juveniles in the lower Pearl River

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Abstract: *Megalobrama terminalis* and *Cirrhinu molitorella* are economically important and endemic fish species in the Pearl River. Using benthic fyke nets, juvenile fish were sampled monthly from June to January for five consecutive years in the Pearl River Delta (PRD) and the lower Pearl River. 3373 and 4096 *C. molitorella* were respectively collected at the PRD and Zhaoqing, mainly composed age-0 juveniles. 835 and 63 *M. terminalis* were respectively collected at the PRD and Zhaoqing, mainly composed age-1 juveniles. Both species occurred throughout the sampling time, except *M. terminalis* juveniles appeared in July and August at Zhaoqing. Daily increments in the lapillus of *M. terminalis* formed following a black band, which corresponded to the first feeding. Increment widths increased until 40 days. Increment contrast was the strongest during the juvenile stage. The growth rate of *C. molitorella* was higher at the PRD than the river habitat for the July-August cohort but not for the November cohort. The results firstly described otolith microstructure and growth of *M. terminalis*, suggest that *C. molitorella* used the PRD and the lower West River as nursery grounds and *M. terminalis* used the PRD as nursery ground. These results provided baseline for ensuring successful recruitment of juveniles.

Keywords: juveniles, nursery ground, otolith microstructure, growth rate, Pearl River

海南海草床微生物群落特征及水产养殖主要污染物对泰来草细菌群落的影响

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摘要: 本文发现海南长圯港海草床的海水与海草叶表、海草根际与根表、海水与表层沉积物的细菌群落之间存在动态交换的现象; 而且细菌群落的物种丰富度、 α 生物多样性、群落结构与组成均与海草种类有关。确定泰来草叶表与根表核心细菌群落。泰来草细菌群落对水产养殖排放主要污染物饲料浸出液的响应较大, 但是对硝基呋喃类抗生素和病原菌哈维氏弧菌的胁迫具有较高的耐受性。从微生物角度揭示了泰来草细菌群落可以在一定程度上缓解养殖废水对近岸海洋环境的不良影响。为科学评估海草床的环境适应性和生态学价值奠定基础。

关键词: 海草微生物组; 水产养殖; 扩增子测序; 海南

Microbial community characteristics in seagrass beds in Hainan and the effects of important aquaculture effluents on the bacterial community of *Thalassia hemprichii*

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Abstract: In this paper, it is found that there exists dynamic exchange between the seawater and the seagrass leaf surface, root surface and the root surface, and the bacterial community between the sea water and the surface sediment in Changpi bay, Hainan. Moreover, the species richness, biodiversity, community structure and composition of the bacterial community were all related to the species of seagrass. To determine the core bacterial communities on the leaf surface and root surface of *Thalassia hemprichii*. The bacterial community of *Thalassia hemprichii* was more responsive to the feed leaching solution of the main pollutant discharged from aquaculture, but had higher tolerance to the stress of nitrofurantoin antibiotics and pathogenic bacterium *Vibrio parvulus*. From the point of view of microorganism, it was revealed that the bacterial community of *Thalassia hemprichii* could alleviate to some extent the adverse effects of aquaculture wastewater on the nearshore Marine environment. It lays a foundation for scientific evaluation of the environmental adaptability and ecological value of seagrass beds.

Key words: Seagrass microbiome, Aquaculture effluents, Amplicon sequencing, Hainan

铜绿微囊藻在溶藻细菌侧孢短芽孢杆菌作用下的转录分析

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摘要: 本研究旨在探讨溶藻细菌对有害藻类进行溶藻作用的分子机制。将铜绿微囊藻与侧孢短芽孢杆菌 BL-zj 共培养, 以单独培养的铜绿微囊藻作为对照, 进行转录组的测定与分析。转录结果共鉴定出 1706 个差异表达基因, 其中大部分差异表达基因涉及碳水化合物代谢、能量代谢和氨基酸代谢。在与侧孢短芽孢杆菌 BL-zj 共培养时, 铜绿微囊藻光合作用和氧化磷酸化的表达受到了严重的抑制, 但脂肪酸合成相关基因的表达增加。此外, 抗氧化酶 2-Cys 过氧化物酶的表达增加。结果表明侧孢短芽孢杆菌 BL-zj 通过攻击铜绿微囊藻的光合系统 I 和氧化磷酸化复合物 I, 阻断铜绿微囊藻的电子传输, 影响其能量获取, 使铜绿微囊藻产生氧化损伤, 藻细胞膜脂质过氧化, 进而导致藻类死亡。

关键词: 溶藻细菌; 侧孢短芽孢杆菌; 铜绿微囊藻; 氧化磷酸化; 光合作用; 转录组

Transcriptional Analysis of *Microcystis aeruginosa* under Algicidal Bacteria *Brevibacillus laterosporus*

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Abstract: The current study investigates the molecular mechanism of algicidal bacteria to harmful algal. The *Microcystis aeruginosa* was co-cultured with *Brevibacillus laterosporus* BL-zj, and an analysis was carried out that compared the transcriptome of *M. aeruginosa* grown separately. A total of 1706 DEGs were identified, and most DEGs were involved in carbohydrate metabolism, energy metabolism and amino acid metabolism. At co-cultured with *B. laterosporus*, severe inhibited changes in the expression levels of several pathways were observed, which were related to photosynthesis and oxidative phosphorylation, but the expression of fatty acid synthesis related genes were increase. In addition, the expression of the antioxidant enzymes 2-Cys peroxiredoxin was increase. These implied that *B. laterosporus* attacks PSI and complex I of *M. aeruginosa*, blocking electron transport and affecting energy acquisition, produces oxidative damage cause algal cell membrane lipid peroxidation, leading to algal death.

Key words: Algicidal bacteria, *Brevibacillus laterosporus*, *Microcystis aeruginosa*, Oxidative phosphorylation, Photosynthesis, Transcriptome

我国渔业限额捕捞发展的若干思考

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摘要: 捕捞限额制度是我国《渔业法》规定的一项新的捕捞渔业管理制度,其实质是一种总可捕量限制制度。开展渔业资源限额捕捞,是对中央有关精神和工作部署的具体贯彻落实,也是提升渔业资源管理能力、实施渔业资源总量控制制度的重要措施。本文总结了日本、美国、冰岛、新西兰等国外典型渔业国家限额捕捞模式与发展趋势,梳理了我国浙江、山东、辽宁、福建、广东、广西六个省(自治区)海洋渔业限额捕捞试点情况和江河渔业限额捕捞发展情况,从渔业资源可持续发展、生态文明建设、新一轮科技革命三个维度分析了我国渔业限额捕捞发展机遇,同时面临总许可渔获量尚难以精确定、新技术充分应用尚需时日、限额捕捞制度认知不到位三个层面的挑战,提出我国渔业限额捕捞发展重点是要强化渔业资源总量控制、赋能渔船管理机制创新、技术赋能限额捕捞管理、加强限额捕捞法制建设、强化退捕渔民安置保障。

关键词: 限额捕捞; 渔业管理模式; 总许可渔获量; 技术赋能; 可持续发展

Some thoughts on the development of the fishery catch quotas in China

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Abstract: The new policy of Fisheries Law is a restrictive system about capacity of the fishing essentially. Carrying out catch quotas work, not only implements the central government 's spirit and work arrangements, but is a important measure to improve management ability and execute control system in fishery resource. This article summarizes the catch quota models and development trends of typical foreign fishery countries such as Japan, the United States, Iceland, and New Zealand, and sorts out many catch quota pilots in the six provinces of Zhejiang, Shandong, Liaoning, Fujian, Guangdong and Guangxi, also analyzes the development opportunities in China from the three dimensions of sustainable development of fishery resources, ecological civilization construction and scientific and technological revolution. At the same time, it is difficult to accurately determine the total allowable catch amount ,fully apply new technologies and recognition of the catch quota system. It is proposed that the matter of China's fishery catch quota development is to strengthen the total control of fishery resources, empower the innovation of vessel management, improve technology enabling catch quota management, perfect Fisheries catch quota Law and guarantee social resettlement of fishermen.

Key words: catch quota, fishery management model, the total allowable catch amount, technology enabling ,the sustainable development

基于脂肪酸标志法和分子技术的小黄鱼食性研究

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摘要: 小黄鱼 (*Larimichthys polyactis*) 是吕泗渔场重要的经济鱼种, 为了解其营养价值和食性, 测定吕泗渔场不同体长小黄鱼脂肪酸组成和胃容物 DNA 序列, 基于脂肪酸标志法和分子技术进行食源和摄食分析。结果显示, 小黄鱼 PUFA/SFA、n-3/n-6 在常见水产鱼类中较高, n-3/n-6 与体长呈显著正相关 ($P < 0.05$)。体长 < 70 mm 时植物食源贡献较高 ($P < 0.05$), 体长 ≥ 120 mm 时植物食源显著减少 ($P < 0.05$)。随着体长增加, 胃容物中甲壳类生物比例逐渐减少, 鱼类比例明显增加。研究表明, 小黄鱼营养价值较高, 大个体鱼油营养价值更高。随着体长增加植物食源减少, 肉食食源增加, 出现明显的食性转变。

关键词: 脂肪酸; DNA; 食性; 营养价值; 吕泗渔场

Research on feeding habits of *Larimichthys polyactis* based on fatty acid biomarkers method and molecular technology

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Abstract: *Larimichthys polyactis* is an important economic fish species in the Lüsi fishing ground. In order to explore *Larimichthys polyactis*' nutritional value and feeding habits, we analyzed fatty acid composition and stomach content DNA sequence of different body lengths. Food source and food intake analysis were based on fatty acid biomarkers method and molecular technology. The results showed that PUFA/SFA and n-3/n-6 of *L. polyactis* was higher than those found in common aquatic fish. The n-3/n-6 of *L. polyactis* had a significantly positive correlation with body length ($P < 0.05$). *L. polyactis* had a higher herbivorous diet when the body length was less than 70 mm ($P < 0.05$), and a significant decrease in herbivorous diet when the body length was greater than or equal to 120 mm ($P < 0.05$). As body length increased, the proportion of crustaceans in the stomach content gradually decreased, and the proportion of fish increased significantly. The research indicated that the nutritional values of *L. polyactis* was very high; the larger individuals' fish oil of *L. polyactis* had a higher nutritional value. As the body length increased, the herbivorous diet decreased and carnivorous diet increased, it had significant changes in feeding habits.

Key words: fatty acid, DNA, feeding habits, nutritional value, Lüsi fishing ground

珠江浮游细菌群落的空间变异：土地利用和理化因子的影响

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摘要：河流生态系统对人类和环境健康至关重要，浮游细菌在生物地球化学循环中发挥着重要作用。揭示浮游细菌群落的空间模式与环境因素的关系，对于了解微生物变异和其功能维护的过程是重要的。然而，我们对浮游细菌群落、物理化学因素和土地利用之间的相互关系，特别是在受密集人类活动影响的大河中，理解仍然相对贫乏。对此，我们基于 16S rRNA 高通量测序技术，于 2018 年 7 月对珠江三大支流北江、西江和珠江的浮游细菌群落进行了调查。结果表明，变形菌门(Proteobacteria)、放线菌门(Actinobacteria)、蓝藻菌门(Cyanobacteria)和浮霉菌门(Planctomycetes)的丰度最高，分别占总丰度的 33.75%、22.15%、11.65%和 10.48%。三支支流浮游细菌群落在组成、结构、多样性和预测功能剖面等方面存在显著差异.....

关键词：浮游细菌；空间变化；土地使用；理化因子；珠江

Spatial Variation in Bacterioplankton Communities in the Pearl River, South China: Impacts of Land Use and Physicochemical Factors

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Abstract: River ecosystems are critical for human and environmental health, with bacterioplankton playing a vital role in biogeochemical cycles. Unveiling the spatial patterns of bacterioplankton communities in relation to environmental factors is important for understanding the processes of microbial variation and functional maintenance. However, our understanding of the correlations among bacterioplankton communities, physicochemical factors, and land use, especially in large rivers affected by intensive anthropogenic activities, remains relatively poor. Here, we investigated the bacterioplankton communities in July 2018 in three main tributaries of the Pearl River, i.e., Beijiang, Xijiang, and Pearl River Delta, based on 16S rRNA high-throughput sequencing. Results showed that the most dominant phyla, Proteobacteria, Actinobacteria, Cyanobacteria, and Planctomycetes accounted for 33.75%, 22.15%, 11.65%, and 10.48% of the total abundance, respectively. The bacterioplankton communities showed remarkable differences among the three tributaries in terms of composition, structure, diversity, and predictive functional profiles.....

Key words: bacterioplankton, spatial variation, land use, physicochemical factors, Pearl River

基于组合物种分布模型的菲律宾蛤仔适宜底播增殖区评价

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摘要: 目标种类的增殖区选址与评价是进行物种底播增殖的前提。本文依据 2017 年 4 个季度的山东荣成天鹅湖菲律宾蛤仔和环境调查数据, 利用组合物种分布模型 (Ensemble model), 对菲律宾蛤仔的潜在适宜增殖区进行了预测评价, 并根据生境适宜指数大小对其增殖区的适宜性等级进行了分类。结果表明: 各单一算法模型的预测性能存在差异, 组合物种分布模型优于任何单一算法模型。底质相关变量 (有机质和粒径) 对菲律宾蛤仔的生境适宜性贡献最大。随着生境适宜性指数的增加, 菲律宾蛤仔的平均壳长和生物量逐渐增大。山东荣成天鹅湖菲律宾蛤仔的适宜、次适宜和一般适宜增殖面积分别为 7.69%、9.03% 和 11.80%。组合物种分布模型是评估菲律宾蛤仔底播增殖区适宜性的有力工具, 也可用于其他相似物种的适宜性评价。

关键词: 生境适宜性; 菲律宾蛤仔; 物种分布模型; 贝类养殖; biomod2

Evaluation of suitable area for the proliferation of *Ruditapes philippinarum* in Swan Lake by ensemble species distribution model

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Abstract: Suitable site selection and evaluation for target species is the premise of proliferation. Based on the survey data of *Ruditapes philippinarum* and environmental factors in Swan Lake, Rongcheng, Shandong province, in four seasons of 2017, the potential suitable areas for the proliferation of *R. philippinarum* were predicted by using the ensemble model. And the grade of the suitability for proliferation area was classified according to the values of habitat suitability index (HSI). Results showed that the predictive performances of single-algorithm models were different, and the ensemble model performed better than any individual modelling technique according to performance metrics. The substrate-related variables (organic matters and grain size) contributed the best at predicting habitat suitability of *R. philippinarum*. Both the biomass and average shell-length of *R. philippinarum* increased with increasing the values of HSI. The predicted suitable, secondary suitable, and general suitable habitat for *R. philippinarum* accounted for 7.69%, 9.03% and 11.80% of the total area of Swan Lake, respectively. This ensemble-modelling approach could be a useful tool to identify suitable aquaculture sites for *R. philippinarum* farming, and can also be used to evaluate the suitability of the similar species.

Keywords: Habitat suitability, *Ruditapes philippinarum*, Species distribution models, Bivalves aquaculture, biomod2

不同营养条件下狐尾藻的生长和养分吸收及其在东海封闭海域的潜在生态服务功能

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摘要: 本研究调查了不同营养条件下狐尾藻的生长和养分吸收, 并评价了其对金山封闭海域生态系统服务功能的影响。狐尾藻在不同营养条件下对溶解态无机碳、氮和磷的吸收率分别为 1.30~1.62、0.040~0.453 和 0.003~0.027 mg/(g·d)。产氧速率和固碳效率分别为 154.30 和 1.25 mg/(g DW·h)。与开放海域相比, 狐尾藻生长区的 NH₄⁺-N、NO₃⁻-N、NO₂⁻-N 和 PO₄³⁻-P 平均去除率分别为 43.05%、97.03%、64.26%和 59.24%。2018 年 11 月, 通过收获活动从封闭海域分别去除了 12,936.87、1,289.97 和 114.81 kg 的碳、氮和磷。

关键词: 狐尾藻; 生态系统服务; 固碳效率

Growth and nutrient uptake of *Myriophyllum spicatum* under different nutrient conditions and its potential ecosystem services in an enclosed sea area in the East China Sea

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Abstract: We investigated the growth and nutrient uptake of *Myriophyllum spicatum* under different nutrient conditions and evaluated its implications for ecosystem services in an enclosed area of Jinshan. The dissolved inorganic carbon and nitrogen, and phosphorus uptake rates were 1.30-1.62, 0.040-0.453, and 0.003-0.027 mg/(g·day), respectively, under different nutrient conditions. The O₂-production and carbon-sequestration efficiencies in the field were 154.30 and 1.25 mg/(g DW·h), respectively. The average removal efficiencies of NH₄⁺-N, NO₃⁻-N, NO₂⁻-N, and PO₄³⁻-P were 43.05%, 97.03%, 64.26%, and 59.24%, respectively, in *M. spicatum*-cultivated areas compared with in the open sea. Harvesting of *M. spicatum* removed 12,936.87, 1,289.97 and 114.81 kg of carbon, nitrogen, and phosphorus, respectively, from seawater in Jinshan in Nov, 2018.

Keywords: *Myriophyllum spicatum*, Ecosystem service, Carbon sequestration efficiency

秋季苦草对白洋淀水环境生态的影响

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摘要:以开放水域作为对照组,通过分析高目围隔内水域架设苦草后,7月至11月白洋淀水体溶氧变化,营养盐变化和浮游生物群落的组成,探索苦草对白洋淀水环境生态产生的影响。结果表明:溶氧含量在9月份有明显下降;从9月份开始总氮总磷含量上升,硝氮含量下降,亚硝氮含量上升;随着时间推移,浮游动物呈增长趋势,浮游植物呈减少趋势。综上所述,苦草在9月进入衰败开始释放营养盐,释放氧气能力开始减弱,对白洋淀水体的修复能力减弱,建议适当人工打捞避免产生消极影响。

关键词:苦草;白洋淀;营养盐;浮游生物

Effect of *Vallisneria* on water environment ecology of Baiyangdian Lake in autumn

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Abstract: Taking the open water area as the control group, this experiment sets *Vallisneria* in semi enclosed water to explore the effects of *Vallisneria* on water environment ecology of Baiyangdian Lake by analyzing the changes of dissolved oxygen, nutrients and the composition of plankton community from July to November. The results were as follows: the dissolved oxygen content decreased significantly in September; since September, the contents of TN and TP increased, NO₃ decreased and NO₂ increased; zooplankton showed an increasing trend, while phytoplankton showed a decreasing trend. To sum up, *Vallisneria* entered into decline in September and began to release nutrients, the ability to release oxygen began to weaken, and the ability to repair the water quality of Baiyangdian Lake was weakened. It is suggested that appropriate artificial salvage should be carried out to avoid negative effects.

Key word: *Vallisneria*, Baiyangdian Lake, nutrients, plankton

基于单电极式心电图法的许氏平鮎听觉特性研究

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摘要: 许氏平鮎 (*Sebastes schlegelii*) 是我国北方近海典型的岩礁性鱼类, 经济价值高。近年来, 随着我国音响驯化型海洋牧场建设的不断发展, 许氏平鮎作为北方海洋牧场增养殖的优势鱼种, 关于其听觉特性的研究亟需开展。本研究使用心电图法 (ECG) 测量了许氏平鮎的听觉阈值, 绘制并分析其听力图及听觉特性。结果表明: 分别以声刺激频率为 60、100、200、300、500、700、1000 Hz 的正弦波纯音, 对 20 尾体长为 (8.1 ± 1.3) cm, 体重为 (10.2 ± 2.4) g 许氏平鮎的听觉阈值进行测定, 20 尾许氏平鮎均记录到声刺激诱发心率信号。许氏平鮎在 60~1000 Hz 频率范围内, 许氏平鮎听觉阈值均小于 123 dB, 最敏感频率为 300 Hz, 听觉阈值为 105 ± 1.5 dB。许氏平鮎对 60~200 Hz 的低频音较敏感, 300 Hz~1000 Hz 声音敏感度较弱。本研究结果可为今后我国在音响驯化型海洋牧场建设中, 运用水声学方法驯化和控制放流鱼类以及对主要鱼类资源动态进行科学管理提供理论依据, 同时可对使用 ECG 法对其它鱼类开展听觉基础研究提供参考。

关键词: 许氏平鮎; 海洋牧场; ECG 法; 听觉阈值

Study on auditory characteristics of *Sebastes schlegelii* based on single electrode ECG

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Abstract: *Sebastes schlegelii* is a typical rocky fish off the coast of northern my country, with high economic value. In recent years, with the continuous development of my country's acoustic domesticated marine pastures, *Sebastes schlegelii* as the dominant fish species for aquaculture in northern marine pastures, needs to be researched on its auditory characteristics. In this study, the ECG method was used to measure *Sebastes schlegelii* hearing threshold, and to draw and analyze the audiogram and hearing characteristics. The results show that: pure sounds with sine wave frequencies of 60, 100, 200, 300, 500, 700, and 1000 Hz, respectively, with a length of (8.1 ± 1.3) cm and a body weight of (10.2 ± 2.4) g Hearing threshold of *Sebastes schlegelii* was measured, and heart rate signals induced by acoustic stimulation were recorded in 20 tails of *Sebastes schlegelii*. *Sebastes schlegelii* hearing threshold is less than 123 dB in the frequency range of 60~1000 Hz, the most sensitive frequency is 300 Hz, and the hearing threshold is 105 ± 1.5 dB. *Sebastes schlegelii* is more sensitive to low-frequency sounds of 60-200 Hz, and the sound sensitivity of 300 Hz~1000 Hz is weaker. The results of this research can provide a theoretical basis for the domestic use of hydroacoustic methods to domesticate and control the release of fish and the scientific management of the dynamics of major fish resources in the construction of acoustic domesticated marine pastures in the future. At the same time, it can also use the ECG method to other fish. Provide a reference for basic hearing research.

Key words: *Sebastes schlegelii*, marine pastures, electrocardiography, hearing threshold

基于生态系统的渔业管理-以加拿大西海岸为例

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摘要: 本研究通过构建加拿大西海岸基于 End-to-End 的生态系统模型 (OSMOSE-BC), 探究了多种典型渔业种群基于生态系统的生物学参考点 (ecosystem-based biological reference points, EBRP), 模拟并评估了渔业生态系统对不同气候变化、渔业活动以及捕捞控制策略等的响应过程和途径, 研究结果为加拿大西海岸建立基于生态系统的渔业管理提供了必要的基础。

关键词: 渔业管理; 捕捞控制策略; 生态系统模型; 种群评估; 生物学参考点; 气候变化

Ecosystem-based Fisheries Management in the marine ecosystem off western Canada supported by End-to-End model

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Abstract: We constructed an end-to-end ecosystem model with OSMOSE platform for the marine ecosystem off western Canada. With this model (OSMOSE-BC), we first developed ecosystem-based biological reference points for a set of species like Pacific Herring, Pacific Cod and Lingcod. We also simulated multiple scenarios with different levels of fishing activities, climate forcing, as well as harvest control rules in order to reveal the ecosystem response of BC ecosystem to multiple stressors. With the simulations of ecosystem models, the present studies provided useful guidelines for investigating ecosystem effects of climate forcing and for evaluating ecosystem-level fisheries management strategies in an increasingly changing world. These studies will also guide the adaptation of fisheries management strategies in the face of climate change.

Key words: Fisheries management, harvest control rules, ecosystem modelling, stock assessment, biological references points, climate change

长江湖口段四大家鱼卵资源及其产卵场分布

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摘要: 为了解长江湖口段四大家鱼卵的资源现状和产卵场位置与产卵规模, 本研究于 2019 年 4 月 19 日至 8 月 5 日利用浮游生物网对湖口江段进行逐日调查。本研究采集到的受精卵瞬时发育时期共九期, 结合水流情况, 推算出四大家鱼产卵场分布于湖口江州、武穴龙坪和黄冈蕪州三个江段附近, 产卵规模分别为 0.49×10^8 ind、 0.68×10^8 ind 和 0.38×10^8 ind。1 号断面的鱼卵平均日丰度为 1.52 ind/1000m³, 显著高于 2 号(0.88 ind/1000m³)和 3 号断面(0.43 ind/1000m³)。运用 P 检验分析表明, 四大家鱼卵日丰度与流量日上涨率呈极显著正相关($P < 0.01$), 与水位日上涨率和流速呈显著正相关($P < 0.05$)。时隔 50 余年, 本研究再次报道了长江中下游衔接水域四大家鱼产卵场位置与产卵规模, 为四大家鱼资源保护提供基础资料。

关键词: 湖口江段; 四大家鱼; 产卵场; 时空分布; 长江中下游

Four major Chinese carps eggs Resources and Spawning grounds distribution at Hukou section of the Yangtze River

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Abstract: In order to understand the resources and the spawning grounds location and size of the four major Chinese carps in Hukou section of the Yangtze River. The study conducted From April 19 to August 5, 2019, were investigated daily by plankton net. The collected fertilized eggs had 9 periods of instantaneous development. Combined with the water flow, it was inferred that the spawning grounds location were in the vicinity of Hukou Jiangzhou, Wuxue Longping and Huanggang Qizhou, it could be inferred that the size were 0.49×10^8 ind, 0.68×10^8 ind and 0.38×10^8 ind. The average density of fish eggs in sect.1 was 1.52 ind/1000m³, which was significantly higher than sect.2 (0.88 ind/1000m³) and sect.3 (0.43 ind/1000m³). The P test showed that the four major Chinese carps eggs abundance was extremely significant positively correlated with the daily increase rate of water flow ($P < 0.01$), and daily increase rate of water level and the water flow significantly positively correlated ($P < 0.05$). Over 50 years, this study once again reported the location and spawning scale of the fish in the middle and lower reaches of the Yangtze River, which can provide basic information for the protection of the four major fish.

Key words: Hukou section of the Yangtze River; four major Chinese carps; spawning ground; temporal and spatial distribution; the middle and lower reaches of Yangtze River

长江口凤鲚早期资源的时空分布特征

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摘要: 为掌握凤鲚 (*Coilia mystus*) 早期资源在长江口的时空分布特征, 于 2019 年 5 月-10 月在长江口沿岸水域设置 10 个调查站点对凤鲚的仔、稚鱼及其环境因子进行逐月采样, 研究了凤鲚在长江口的繁殖时间及早期个体分布情况, 并利用 GAM 模型 (generalized additive models) 拟合了生态模型。结果表明: 5-10 月是长江口凤鲚的繁殖期, 其中 5 月-8 月份为繁殖盛期。长江口北支的东旺沙-北八淤-启隆乡沿岸水域为凤鲚仔稚鱼在不同月份的主要分布水域, 为长江口凤鲚的重要育幼场。GAM 分析得出最优模型为 $\log(A+0.01)=\epsilon+s(\text{Sal})+s(\text{Tur})$, 凤鲚仔稚鱼适宜的盐度范围为 6-10, 最适浊度约 251.2 NTU。

关键词: 凤鲚; 仔稚鱼; 时空分布; 长江口

Spatial and temporal distribution of *Coilia mystus* in the Yangtze Estuary

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Abstract: In order to understand the temporal and spatial distribution characteristics of *C. mystus* in the Yangtze Estuary, ten survey stations were set up in the Yangtze Estuary from May to October, 2019 to collect the larvae, juveniles and environmental factors of *C. mystus*. The breeding time and early individual distribution of *C. mystus* in the Yangtze Estuary were studied, and the ecological model was fitted by using the generalized additive models (GAM). The results showed that: May to October is the breeding period of *C. mystus* in the Yangtze Estuary, and may to August is the peak breeding period. The coastal waters of Dongwangsha- Beibayao-Qilongxiang in the North Branch of the Yangtze Estuary are the main distribution areas of *C. mystus* larvae and juveniles in different months, which is an important nursery for *C. mystus* in the Yangtze Estuary. GAM analysis showed that the optimal model was $\log(A + 0.01) = \epsilon + s(\text{SAL}) + s(\text{TUR})$, the suitable salinity range of *C. mystus* larvae and juveniles is 6 ~ 10, and the optimum turbidity is about 251.2 NTU.

Key words: *Coilia mystus*, larvae and juveniles, temporal and spatial distribution, Yangtze Estuary

长江口凤鲚繁殖群体个体繁殖力和繁殖频率研究

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摘要:为了更好地保护和利用长江口凤鲚资源, 以及为政府制定长江口凤鲚资源管理措施提供科学依据, 对2018年和2019年凤鲚繁殖群体个体生殖力和繁殖频率进行了研究, 结果表明个体绝对繁殖力F为1305~7840粒, 个体相对繁殖力FL为105~637粒/cm, 个体相对繁殖力FW为169~960粒/g。凤鲚卵径平均值为 $0.69\pm 0.05\text{mm}$ 。凤鲚为不分批产卵类型, 在解剖镜下观察凤鲚繁殖群体卵巢切片并记录统计, 结果表明其2018年5月、6月和7月繁殖频率分别为0.23、0.27和0.30。2019年5月和8月繁殖频率分别为0.23和0.30。

关键词: 长江口; 凤鲚; 个体繁殖力; 繁殖频率

Study on the individual fecundity and spawning frequency of *Coilia mystus* breeding population in the Yangtze River Estuary

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Abstract: In order to better protect and utilize the *Coilia mystus* resources in the Yangtze River Estuary, and provide a scientific basis for the government to formulate management measures for *Coilia mystus* resources in the Yangtze River estuary. The individual fecundity and spawning frequency of the breeding population of *Coilia mystus* in 2018 and 2019 were studied. The result shows that the individual absolute fecundity(F) varied from 1305 to 7840 eggs, and the individual relative fecundities(FL)and(FW) ranged from 105 to 637 eggs·cm⁻¹ and 169 to 960 eggs·g⁻¹.The mean±SD diameter of egg is $0.69\pm 0.05\text{mm}$. *Coilia mystus* does not spawn multiple times in a year. The result shows that its spawning frequency in May, June and July 2018 were 0.23, 0.27 and 0.30. The spawning frequency in May and August 2019 were 0.23 and 0.30.

Key words: Yangtze River Estuary, *Coilia mystus*, individual fecundity, spawning frequency

池塘河蟹养殖对水环境的影响及养殖容量估算

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摘要: 为了评价河蟹整个养殖周期对水环境的影响以及估算河蟹养殖容量, 于 2019 年 5~11 月在上海某水产养殖专业合作社选取了 4 个典型河蟹养殖池塘以及水源进行了一个养殖周期内 4 个阶段的水质监测, 并采用两种模型对养殖容量和最佳养殖密度进行估算。结果表明: (1) 水源组主要超标项目为 TN 和 TP, 最大超标幅度分别为 470.44%和 28.50%; 池塘组主要是 TN、TP 和 COD_{Mn} 超标, 最大超标幅度分别为 412.00%、122.76%和 74.48% (2) 养殖初期超标指标数最多, 超标倍数也最高, 是水质最差的阶段; 养殖末期水体中所有指标均低于初期, 尤其是 TP 已优于地表水Ⅲ类水标准 (3) 以磷排放标准估算, T1、T2、T3 和 T4 实际养殖量仅为合理养殖量的 55%左右, 4 个池塘均可大量增养, 增养比例为 60%~99%; (4) 以氮排放标准估算, T1、T2、T3 和 T4 实际养殖量仅为理论养殖容量的 65%~83%左右, 4 个池塘均可适量增养, 增养比例为 19%~54%。故综合两种估算结果, 该养殖实验池塘还可进行增养, 增养后的养殖容量可达 2004~2681 kg/hm², 养殖密度达 10229~13296 只/hm²。

关键词: 河蟹; 池塘; 生态养殖; 水环境; 养殖容量

Effect of ecological culture of crab on water environment and its aquaculture capacity assessment

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Abstract: In this paper, the water quality of four crab culture ponds and the water quality of the water source of ponds were monitored from May to November in 2019 to evaluate the impact of the whole culture cycle on water environment. Based on the nitrogen and phosphorus load and tail water discharge standard, two models were used to estimate the aquaculture capacity and optimal breeding density. The results showed that: (1) TN and TP were the main over standard items in water source group, and TN, TP and COD_{Mn} in pond group were mainly over standard; (2) In the early stage of aquaculture, the number of over standard indexes was the most, and the times of exceeding standard were the highest, which was the worst stage of water quality; (3) According to the estimation of phosphorus emission standard, the culture density of four crab culture ponds is 12012 ~ 16770 tail/hm², and the nitrogen emission standard is estimated to be 9406 ~ 12547 tail/hm². Therefore, the crab culture capacity of the experimental pond is 2004 ~ 2681 kg/hm², and the breeding density is 10229 ~ 13296 tail/hm².

Key words: crab, pond, Eco-culture, water environment, carrying capacity

长春市石头口门水库水源地污染治理及水域生态修复观察

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摘要: 石头口门水库是拦截饮马河干流形成的大型人工水域, 位于吉林省东部。2005 年 11 月 13 日, 吉化双苯厂爆炸引起松花江干流水质严重污染, 作为长春市水源地的石头口门水库的污染防治工作势在必行。通过采取房屋拆迁、划界立标、工矿企业搬迁、排污口治理、垃圾清理、处理及在石头口门水库水位变化区和入河口种植芦苇 2000 公顷, 睡莲 30 公顷湿地等措施, 全面改善水源环境状况、增加城市供水量、改善生态环境、增加供水收入及芦苇销售收入。

关键词: 长春; 石头口门水库; 水源地; 污染治理; 水域生态修复

Water source pollution control of Shitoukoumen Reservoir in Changchun City and water ecological restoration observation

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Abstract: *Shitoukoumen reservoir*, located in the east of Jilin Province, is a large artificial water area formed by intercepting the main stream of Yinma River. On November 13, 2005, the explosion of Jilin Chemical bisbenzene plant caused serious water pollution in the main stream of Songhua River. Through the measures of house demolition, demarcation and marking, relocation of industrial and mining enterprises, sewage outlet treatment, garbage cleaning and treatment, planting 2000 hectares of reed and 30 hectares of water lily wetland in Shitoukoumen reservoir water level change area and river mouth, the water source environment condition, urban water supply quantity, ecological environment, water supply income and reed sales revenue were comprehensively improved.

Key words: Changchun, *Shitoukoumen reservoir*, water source, pollution control, water ecological restoration

内蒙古四水库浮游动物群落结构特征及鱼产力估算

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摘要: 2018年分别对内蒙古自治区达林台水库、白音花水库、山湾子水库以及打虎石水库进行了浮游动物群落结构研究及鱼产力估算, 其中打虎石水库采样月份为5、7、9月, 其余三水库为5月和9月。四水库浮游动物分别鉴定出21、22、25和39个种属, 种类上看四个水库均是轮虫占优势。浮游动物密度分别为3090.10 ind./L、4522.93 ind./L、4760.25 ind./L和1924.54 ind./L; 生物量分别为4.10 mg/L、7.67 mg/L、1.87 mg/L和1.34 mg/L。达林台水库浮游动物提供的鱼产力为39.17 kg/hm², 白音花水库为98.53 kg/hm², 山湾子水库为9.64 kg/hm², 打虎石水库为100.50 kg/hm²。由四水库浮游动物的Margalef指数(d)、Shannon-Wiener指数(H)、Pielou指数(J)显示, 四个水库污染程度均属于轻—中污染类型。结合四水库浮游植物提供鱼产力, 白音花水库和山湾子水库实际产鱼与估算值相差较小, 达林台水库和打虎石水库还有一定的饵料利用空间, 可以适当调整鲢鳙的放养比例, 防止水库进一步污染, 同时增大鱼类产量。

关键词: 内蒙古水库; 浮游动物; 群落结构; 鱼产力;

Zooplankton community structure characteristics and fish productivity estimation in four reservoirs of Inner Mongolia

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Abstract: In 2018, researches on zooplankton community structure and fish productivity were carried out on Dalintai Reservoir, Baiyinhua Reservoir, Shanwanzi Reservoir, and Dahushi Reservoir in Inner Mongolia Autonomous Region. The sampling months of Dahushi Reservoir were May, July, and September. The remaining three reservoirs were in May and September. There were 21, 22, 25 and 39 species of zooplankton in the four reservoirs, In terms of species, all four reservoirs were dominated by rotifers. The zooplankton densities were 3090.10 ind./L, 4522.93 ind./L, 4760.25 ind./L and 1924.54 ind./L; the biomass was 4.10 mg/L, 7.67 mg/L, 1.87 mg/L and 1.34 mg/L, respectively. The fish productivity provided by zooplankton in Dalintai Reservoir was 39.17 kg/hm², Baiyinhua Reservoir was 98.53 kg/hm², Shanwanzi Reservoir was 9.64 kg/hm², and Dahushi Reservoir was 100.50 kg/hm². According to the Margalef index (d), Shannon Wiener index (H) and Pielou index (J) of zooplankton in the four reservoirs, the pollution degree of the four reservoirs all belong to the light-medium pollution type. Combining the phytoplankton provided by the four reservoirs to provide fish productivity, the actual fish production of Baiyinhua Reservoir and Shanwanzi Reservoir was relatively small from the estimated value. Dalintai Reservoir and Dahushi Reservoir still have a certain amount of food utilization space, and silver carp and bighead carp can be adjusted appropriately. The stocking ratio of the plant can prevent further pollution of the reservoir and increase fish production.

Key words: Inner Mongolia reservoir, zooplankton, community structure, fish product

铜对背角无齿蚌幼蚌的组织损伤效应研究

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摘要: 铜(Cu)是我国淡水渔业生态环境中污染形势最为严峻的重金属。背角无齿蚌(*Anodonta woodiana*)作为“淡水贝类观察”研究体系的专用指示生物, 非常有潜力开发为渔业环境研究用模式动物。根据 Cu 对幼蚌 96 h-EC50(3.4 mg/L)和我国渔业水质标准(GB11607-89)中 Cu 限量(0.01 mg/L)设定了 5 个浓度梯度(2.0、1.0、0.1、0.01 和 0.005 mg/L), 并进行 24、48、72 和 96 h 的急性暴露及组织切片观察, 以探究 Cu 对幼蚌鳃、消化腺、外套膜和斧足等的组织水平毒性损伤效应。结果显示: 0.005 mg/L 的 Cu 对幼蚌没有产生明显的组织损伤。其余暴露组随着 Cu 浓度的升高和暴露时间的增加, 幼蚌上述 4 种组织的损伤程度不断加重。经过 96 h 暴露, 鳃在 0.01 mg/L 暴露组开始出现色素细胞显著增加, 细胞发生空泡化的现象。在 0.1 mg/L 暴露组鳃开始出现巨噬细胞增多、纤毛脱落。在 2.0 mg/L 暴露组, 鳃开始出现细胞坏死、鳃丝萎缩、结缔组织糜烂等情况。外套膜在 0.01 mg/L 暴露组会出现色素细胞和巨噬细胞显著增加。在 2.0 mg/L 暴露组其可出现上皮层损伤。斧足在 0.01 mg/L 暴露组可观察到粘液细胞变形。在 0.1 mg/L 暴露组则可出现细胞空泡化及上皮层损伤。消化腺从 0.1 mg/L 暴露组开始, 可出现小管上皮细胞变形和结缔组织萎缩。总体来看, 背角无齿蚌幼蚌的鳃对 Cu 组织损伤毒性最为敏感, 适宜用作淡水渔业生态环境 Cu 污染监测和毒性评价的靶器官。

关键词: 背角无齿蚌; 铜; 组织切片; 毒性效应

Effects of copper on tissular damage of *Anodonta woodiana*

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Abstract : Copper (Cu) is the most significantly polluted heavy metal in freshwater fishery eco-environment in China. *Anodonta woodiana*, as a special bioindicator of Freshwater Mussel Watch system, has great potential to be developed as a model animal for fishery environment assessment. Five concentration gradients (2.0, 1.0, 0.1, 0.01 and 0.005 mg/L) were set according to the 96 h-EC50 (3.4 mg/L) and the Cu limit (0.01 mg/L) in China's Fisheries Water Quality Standard (GB11607-89) in order to explore the tissular toxic effects of Cu on the main tissues (i.e., gill, digestive gland, mantle and foot) of juvenile mussels. The results showed that 0.005 mg/L Cu did not cause obvious tissue damage to the juveniles. With the increase of Cu concentration and exposure time, the damage degree of the tissues was aggravated. After 96 hours of exposure, the gills in the 0.01 mg/L exposed group began to have a significant increase in pigment cells and vacuolization of the cells. In the 0.1 mg/L group, macrophages began to increase and cilia fell off. In the 2.0 mg/L group, cell necrosis, gill filament atrophy, connective tissue erosion began to appear; The mantle showed a significant increase in pigment cells and macrophages in the 0.01 mg/L group, and the epithelial layer was damaged in the 2.0 mg/L group; The mucous cell deformation of the foot began to occur in the 0.01 mg/L group, and cell vacuolation and epithelial damage occurred in the 0.1 mg/L group; Digestive glands began to show tubular epithelial cell deformation and connective tissue atrophy from the 0.1 mg/L group. The results showed that the gills of *A. woodiana* were the most sensitive to tissular Cu toxicity, and could be used as a target tissue for Cu pollution monitoring and toxicity assessment of freshwater fishery ecological environment.

Key words: *Anodonta woodiana*, copper, tissue section, toxicological effect

不同修复模式下的营养盐和浮游植物变化

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摘要: 为了打赢“碧水”保卫战, 提升水域景观质量, 对金山城市沙滩富营养化水体采用了以贝类养殖为核心和以穗花狐尾藻构建水下森林为核心的两种生态修复模式。自2018年7月至次年6月对该水域营养盐水平及相关环境因子进行监测, 依据季节变化采集浮游植物, 为比较两种修复模式和综合评价修复效果提供理论依据。结果表明: 藻类修复区仅5、6月呈中度富营养化, 其他10个月均为贫营养化; 贝类修复区8个月时间呈贫营养化, 4个月呈中度或轻度富营养化, 两种模式均能有效修复水体, 穗花狐尾藻修复模式对去除营养盐效果更好。浮游植物调查结果显示: 蓝藻门、绿藻门和硅藻门是浮游植物的主要组成, 除4月份外, 贝类修复区浮游植物丰度均大于藻类修复区, 但浮游植物多样性指数和均匀度指数均小于藻类修复区, 藻类修复区生态系统更稳定。

关键词: 生态修复; 浮游植物; 营养盐; 修复策略

Nutrient and phytoplankton changes under different ecological restoration modes

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Abstract: In order to win the battle of "clean water" and improve the water landscape quality, two ecological restoration models were adopted for eutrophication water body of Jinshan City Beach, with shellfish cultivation as the kernel and the construction of *Myriophyllum spicatum* underwater forest as the kernel. From July 2018 to June 2019, nutrient levels and related environmental factors in the water area were monitored, and phytoplankton were collected according to seasonal changes, providing a theoretical basis for comparing the two restoration models and comprehensively evaluating the restoration effect. The results showed that the *Myriophyllum spicatum* restoration zone presented moderate eutrophication only in 5 and 6 months, and the other 10 months were poor eutrophication. The restoration area of shellfish presented poor eutrophication for 8 months, and moderate or light eutrophication for 4 months. Both modes were effective in restoring water bodies, and the restoration mode of *Myriophyllum spicatum* was more effective in removing nutrients. The results of phytoplankton survey showed that Cyanophyta, Chlorophyta and bacillariophyta were the main components of phytoplankton. Except in April, phytoplankton abundance in shellfish restoration area was higher than that in *Myriophyllum spicatum* restoration area, but phytoplankton diversity index and evenness index were lower than that in *Myriophyllum spicatum* restoration area, and the ecosystem of *Myriophyllum spicatum* restoration area was more stable.

Key words: ecological restoration, phytoplankton, nutrient, ecological restoration strategy

东太湖鱼类群落结构及其与水环境因子的关系

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摘要: 基于2019年4月、7月和10月的调查数据, 用多元统计分析方法研究了围网拆除后东太湖鱼类群落结构的变化, 及其与主要环境因子的关系。共调查到鱼类4目10科31属39种, 其中鲤形目鱼类占69.23%。按不同生态类型东太湖鱼类主要为定居性鱼类、中上层鱼类以及肉食性和杂食性鱼类。优势种为鲫 (*Carassius auratus*)、大鳍鱮 (*Acheilognathus macropterus*) 和鳊 (*Hemiculter leucisculus*) 等。单因子相似性分析 (ANOSIM) 和相似性百分比分析 (SIMPER) 表明, 4月和10月的鱼类群落物种组成差异显著, 平均相异性为59.41%。丰度/生物量曲线 (ABC) 分析表明, 东太湖鱼类群落结构处于中度干扰状态。冗余分析 (RDA) 表明, 总磷对主要鱼类变化的解释量为21.0%, 是重要的解释因子 (蒙特卡罗检验 $P=0.036$)。目前, 总磷 (TP)、pH、溶解氧 (DO) 等是影响东太湖鱼类群落的主要环境因子。

关键词: 东太湖; 鱼类群落; 多元统计; 环境因子; 冗余分析

Fish community structure and its relationship with water environmental variables in the East Taihu Lake

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Abstract: The fish community structure and its relationship with the environment were studied by multivariate analysis using the data collected from the field surveys in April, July and October, 2019. In total, 39 species were collected, belonging to 31 genera, 10 families, and 4 orders. Cypriniformes had the largest number of species, accounting for 69.23% of all captured species. Sedentary fish species, upper fish species and carnivore and omnivore fish species were the most frequent of the ecological groups, habitat types, and feeding functional groups respectively. *Carassius auratus*, *Acheilognathus macropterus*, and *Hemiculter leucisculus* were the dominant species. ANOSIM and SIMPER analysis revealed that the fish species composition varied significantly between April and October, and the average dissimilarity was up to 59.41%. Abundance-biomass curves of fish community indicated that the community was moderately disturbed. 21.0% of the variation in composition of fish community was explained by TP in the RDA analysis, which suggested TP was the main explanatory factor (Monte Carlo test $P=0.036$). TP, pH and DO were key environmental variables for temporal variation of the fish community structure in the East Taihu Lake.

Key words: East Taihu Lake, fish community, multivariate, environmental variables, RDA analysis

内蒙古四水库浮游植物群落结构特征及鱼产力估算

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摘要: 为探究内蒙古自治区达林台水库、白音花水库、山湾子水库以及打虎石水库浮游植物的种类组成、密度、生物量等群落结构特征, 并通过浮游植物多样性指数对水体营养状况评价和水库鱼产力进行估算, 于2018年对其浮游植物进行了调查分析。四水库浮游植物分别有52、68、57和57个种属, 平均生物量分别为13.62 mg/L、5.82 mg/L、11.97 mg/L和3.11 mg/L。由浮游植物提供的鱼产力分别为达林台水库78.04 kg/hm², 白音花水库44.87 kg/hm², 山湾子水库47.90 kg/hm², 打虎石水库139.95 kg/hm²。通过Shannon-Wiener多样性指数 H' 、Pielou均匀度指数 J 、Margalef丰富度指数 d , 判断出四个水库污染程度均属于轻—中污染类型。结合四水库浮游动物提供鱼产力, 白音花水库和山湾子水库实际产鱼与估算值相差较小, 达林台水库和打虎石水库还有一定的饵料利用空间, 可以适当调整鲢鳙的放养比例, 防止水库进一步污染, 同时增大鱼类产量。

关键词: 浮游植物; 群落结构; 鱼产力

Community structure characteristics of phytoplankton and estimation of fish productivity in four reservoirs of Inner Mongolia

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Abstract: In order to explore the phytoplankton community structure characteristics such as species composition, density and biomass of Dalintai Reservoir, Baiyinhua Reservoir, Shanwanzi Reservoir, and Dahushi Reservoir in Inner Mongolia Autonomous Region, and to evaluate the water nutrition status and estimate the fish productivity of the reservoir by using the phytoplankton diversity index, the phytoplankton were investigated and analyzed in 2018. In the four reservoirs, 52, 68, 57 and 57 species/genera of phytoplankton were identified, the biomasses were 13.62 mg/L, 5.82 mg/L, 11.97 mg/L and 3.11 mg/L, respectively. The fish productivity provided by phytoplankton in Dalintai Reservoir was 78.04 kg/hm², Baiyinhua Reservoir was 44.87 kg/hm², Shanwanzi Reservoir was 47.90 kg/hm², and Dahushi Reservoir was 139.95 kg/hm², respectively. The pollution degree of the four reservoirs all belong to the light-medium pollution type according to Shannon Wiener diversity index H' , Pielou evenness index J and Margalef richness index d . Combining the zooplankton provided by the four reservoirs to provide fish productivity, the actual fish production of Baiyinhua Reservoir and Shanwanzi Reservoir is relatively small from the estimated value. Dalintai Reservoir and Dahushi Reservoir still have a certain amount of food utilization space, and silver carp and bighead carp can be adjusted appropriately. The stocking ratio of the plant can prevent further pollution of the reservoir and increase fish production.

Key words: phytoplankton, community structure, fish productivity

鲌鲢淀鱼类群落特征及生物完整性评价

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摘要: 鱼类群落及生物完整性指数 (F-IBI) 被广泛应用于河湖健康评价, 可为水域生态修复和保护提供重要科学依据。本研究于 2018 年 10 月至 2019 年 7 月在白洋淀区的典型草型湖泊鲌鲢淀开展鱼类群落采样, 以鱼类完整性指数评价体系综合评价鱼类群落组成特征和水域健康状况。调查共发现鱼类 30 种, 隶属 4 目 10 科, 其中鲤科鱼类物种数最多, 共 21 种, 占鱼类总物种数目的 70%。F-IBI 评价结果表明, 在鲌鲢淀的采样站点中, 鱼类生物完整性评为“好~优”等级共有 3 个点; 评价为“好”等级共有 3 个点; 评价为“一般~好”等级共有 4 个点; 评价为“一般”等级共有 5 个点; 评价为“差~一般”等级共有 8 个点; 评价为“差”等级共有 3 个点; 其中没有点位被评价为“优”和“极差”等级。总体上, 春季和秋季呈现“一般~好”, 夏季呈现“差~一般”。过度捕捞、水质污染和极端气候等是白洋淀鱼类群落历史变化的重要因素, 建议在湖泊生态修复的同时, 通过划定禁渔区和延长禁渔期等方式, 加强对鱼类资源保护和可持续利用。

关键词: 鱼类完整性指数; ABC 曲线; 健康评价; 白洋淀

Fish communities characteristics and Index of Biotic Integrity (IBI) Assessment in Shihoudian Lake

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Abstract: Fish index of biotic integrity (F-IBI) is widely used in health assessment of rivers and lakes, which is of great significance for regional ecological restoration and protection. From October 2018 to July 2019, the fish community was sampled in the experimental area of typical grassy lake named 'Shihoudian Lake' in Baiyangdian Lake. Water health status was evaluated by F-IBI. A total of 30 species of fish belonging to 4 orders and 10 families were found. Cyprinidae has 21 species, accounting for 70% of the total number of fish species. The evaluation results showed that there were 3 sampling sites in the "good to excellent"; there were 3 sites in the evaluation as "good"; there were 4 sites in the evaluation as "general to good"; there were 5 sites in the evaluation of "general"; there were 8 sites in the evaluation of "poor to general"; there were 3 sites in the evaluation as "poor"; among them, no site was evaluated as "excellent" and "very poor". Overall, the autumn showed "general to good", the spring and autumn showed "general to good", and the summer showed "poor to general". Overfishing, water pollution and extreme climate are important factors for the historical changes of Baiyangdian fish communities. It is suggested to strengthen the protection and sustainable use of fish resources by delimiting restricted fishing areas and extending the restricted fishing period while restoring lake ecology.

Key words: fish-index of biotic integrity; abundance-biomass curves; health assessment; Baiyangdian Lake

急性降温对野生大眼鳊的游泳能力的影响

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摘要: 采用自制鱼类游泳能力及代谢测定装置, 测定了4个温度(20、24、28和32℃)下沉水野生大眼鳊(体长 11.81 ± 2.21 cm, 26.4 ± 6.28 g)的游泳参数及流速变化对耗氧率的影响, 并分析了不同游泳速度下的游泳行为。大眼鳊的临界流速和偏好游泳速度随着温度的变化呈近似线性的递增趋势($P < 0.05$)。4个温度下的相对感应流速分别为(1.16±0.07)、(0.94±0.06)、(0.86±0.07)和(0.70±0.09)BL/s; 相对偏好游泳速度分别为(1.86±0.04)、(2.23±0.35)、(2.65±0.28)和(2.74±0.33)BL/s; 相对临界流速分别为(2.58±0.32)、(3.31±0.41)、(4.31±0.52)和(5.22±0.48)BL/s。根据不同温度及流速下耗氧率的变化情况, 采用非线性拟合得到4个温度梯度下耗氧率与游泳速度关系的非线性函数模型($P < 0.05$)。模型表明耗氧率随流速的增大而增加, 且温度越高耗氧率随游泳速度的变化越显著。研究表明: 急性降温对大眼鳊幼鱼游泳特性具有显著的作用, 并且对其行为产生胁迫。本实验为沉水典型鱼类运动生理生态的适应机制提供基础数据支持。

关键词: 大眼鳊; 水温; 感应流速; 临界流速; 活动代谢

Effects of acute temperature Declining on swimming performance of *Siniperca knerii* Garman

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Abstract: In this study, the fish swimming ability and metabolism apparatus was used to study the swimming parameters and oxygen consumption rate under four temperature gradients of *Siniperca knerii* Garman (11.81 ± 2.21 cm, 26.4 ± 6.28 g) from Yuanshui River. The swimming behavior of *Siniperca knerii* Garman in different swimming speeds was also analyzed. The results showed an approximately linear increasing trend of The critical swimming speed and preferred swimming speed of the fish with the change of temperature ($P < 0.05$). The relative induced velocities of the fish at four temperatures were (1.16±0.07), (0.94±0.06), (0.86±0.07) and (0.70±0.09)BL/s. The preferred swimming speed were (1.86±0.04), (2.23±0.35), (2.65±0.28) and (2.74±0.33) BL/s. The Relative critical speed were (2.58±0.32), (3.31±0.41), (4.31±0.52) and (5.22±0.48) BL/s. According to the change of oxygen consumption rate at different temperature and flow rate, the nonlinear function models of the relationship between oxygen consumption rate and swimming speed under four temperature gradients were obtained by using nonlinear fitting ($P < 0.05$). The models showed that the oxygen consumption rate increased with the increase of swimming speed, and the higher the temperature was, the more significant the oxygen consumption rate changed with swimming speed. The observed results suggested that acute hypothermia had significant effect on the swimming characteristics of juvenile *Siniperca knerii* Garman. the behavioral stress was induced. This experiment provided basic data support for the adaptive mechanism of sports physiology and ecology of typical fishes in Yuanshui River.

Key words: *Siniperca knerii* Garman; water temperature; Induced velocity; critical speed; activity metabolism

浅海贝类养殖对大型底栖动物群落结构和功能多样性的影响

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摘要: 本研究通过收集中国近岸 12 处不同贝类养殖区的底栖生态环境调查数据和文献资料, 经数据标准化处理, 利用多样性指数与生物性状分析方法, 研究了浅海贝类养殖方式及规模对大型底栖动物群落结构和功能多样性的影响。结果表明: 养殖密度是影响大型底栖动物物种多样性最重要的指标。随养殖密度的增加, 大型底栖动物物种数和功能冗余度锐减, 但底栖生态系统仍然能够保持功能丰度, 说明减少的生物主要为冗余种。贝类养殖使一些原本数量较少的物种丰度增加, 这些物种的增加使底栖动物群落中物种和功能的分布更加均匀。另一方面, 大型底栖动物功能性状的分布与养殖方式密切相关。贝类笼养区分布有更多的小型机会主义种; 贝类吊绳区更容易吸引肉食性捕食者; 贝类底播区由于底播贝类的存在, 滤食性状显著增加。分析认为, 近海贝类养殖密度与其对浅海生态系统的生物可利用性是影响大型底栖动物群落结构和功能多样性的主要因素。

关键词: 大型底栖动物, 贝类养殖, 生物性状分析, 功能多样性

Ecological impacts of shallow bivalve culture on compositional and functional diversity of macrofaunal assemblages

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Abstract: The present study collected the macrofauna assemblage data of 12 bivalve farms along China coast from previous studies and investigation. Diversity indices and biological trait analysis were applied to assess the impacts of coastal bivalve culture on taxonomic and functional diversity of macrofaunal assemblages. Our results illustrated that density is the most important factors impacting diversity indices. The increased density of cultured bivalve sharply reduced the abundance and functional redundancy but the system can still maintain the functional richness, suggesting that these animals were mainly on redundant group. Moreover, increased density of cultured bivalve attracted less abundant species and contributed to more balanced distribution of taxa and functional traits. Additionally, functional trait composition of macrofauna assemblage is strongly related to the culture methods. Small sized opportunistic deposit feeders were likely to appear in cage farms, carnivorous predators were more attracted by rope farm. As the introduction of culture bivalves, filter feeders dominate bottom farm. Our results suggest that the density and the bioavailability of the cultured bivalve are the most important factors impacting the structure and function of macrofaunal assemblages.

Keywords: Macrofaunal assemblages, bivalve culture, biological trait analysis, functional diversity

在太子河流域的水生生物群落检验中度干扰假说

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摘要: 人类活动强度对生物多样性的影响一直以来是生态研究的热点问题。中度干扰假说预测: 在中等强度的人类干扰下物种会维持更高的生物多样性。本研究以太子河流域着生藻类、大型底栖动物和鱼类群落为研究对象, 将水环境因子作为反映人类干扰的指标。通过典范对应分析筛选影响各生物群落的环境驱动因子, 运用多项式拟合曲线验证生物与环境之间是否具有单峰响应关系。典范对应分析结果表明, 水温和总磷是各群落的共同驱动因子, 且与各群落生物多样性的拟合结果均呈单峰型, 证实水生生态系统中确实存在中度干扰现象。研究结果可进一步支持和检验中度干扰假说, 同时, 为人类在流域上进行生物多样性的恢复和保护工作提供科学依据。

关键词: 太子河流域; 生物群落; 典范对应分析; 单峰型; 中度干扰假说

The verification of the intermediate disturbance hypothesis on the Aquatic Community of the Taizi River Basin

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Abstract: The impact of human activity intensity on biodiversity has always been a hot issue in ecological research. The intermediate disturbance hypothesis predicts that species will maintain higher biodiversity under moderate human disturbance. In this study, the algae, macrobenthos and fish communities in the Taizi River Basin are the research objects, and the water environment factors are used as indicators to reflect human disturbance. The canonical correspondence analysis is used to screen the environmental driving factors affecting each biological community, and a polynomial fitting curve is used to verify whether there is a unimodal response relationship between organisms and the environment. The canonical correspondence analysis results show that water temperature and total phosphorus are the common driving factors of each community, and the fitting results with the biodiversity of each community are unimodal, confirming that there is indeed a moderate disturbance in the aquatic ecosystem. The research results can further support and test IDH, and at the same time, provide a scientific basis for humans to restore and protect biodiversity in the watershed.

Keywords: Taizi River Basin, biological community, canonical correspondence analysis, unimodal, intermediate disturbance hypothesis

大汶河水生态环境健康状况与土地利用相关性分析

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摘要: 为了解大汶河水生态环境现状以及河岸带土地利用类型对其影响, 基于 2017 年 4 月大汶河流域水生态调查数据, 采用主成分分析 (principal component analysis, PCA) 和相关分析 (correlation analysis, CA) 方法对流域地形、水文、水环境因子、主要水生生物因子和栖息地质量五个方面共 19 个候选指标进行筛选和优化, 构建了大汶河生态系统健康评价多指标体系并用于大汶河水生态健康评价。结果表明: 水环境因子和水生生物类型指标在健康评价指标体系中所占权重较大; 大汶河水生态系统健康状况评价结果主要以一般和较差为主, 分别占总采样点的 58.33% 和 20.83%, 仅瀛汶河上段、大汶河南支上段和大汶河干流下段部分断面处于健康或亚健康水平; 城镇村及工矿用地、耕地和交通用地与大汶河生态健康综合指数呈负相关, 是该流域水生态系统受到破坏的主要因素。

关键词: 大汶河; 水生态健康; 指标; 主成分分析; 土地利用

Studies on correlation between ecosystem health conditions and land usage in Dawen River Basin

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Abstract: In order to understand the current situation of water ecological environment of Dawen River and the influence of land use type on it, we conducted water ecological environment monitoring in the this River Basin based on the water ecology survey data of Dawen River basin in April 2017. Principal component analysis (PCA) and correlation analysis (CA) were used to screen and optimize a total of 19 candidate indicators in five aspects of watershed topography, hydrology, water environment factors, major aquatic biological factors and habitat quality. By analyzing weight coefficient of these evaluation indicators, a multi-indicator system for river ecosystem health assessment in the Dawen River Basin was constructed to evaluate the river conditions. The results showed that water environmental factors and aquatic organisms had a large weight in the health evaluation index system. The health status of the water ecosystem in the Dawen River Basin was dominated by general and poor, accounting for 58.33% or 20.83% of the total sampling points respectively. The upper section of the Yingwen River and southern tributaries of Dawen River, and the lower section of the main stream of the Dawen River were at excellent or good level. Urban village, industrial and mining land, farmland and traffic land were negatively correlated with the water ecological health comprehensive index of Dawen River, which was the main factor for the destruction of the ecosystem of the river basin.

Key words: Dawen River basin; water ecological health; indicators; principal component analysis; land use.

社群等级形成过程中许氏平鲷好斗行为、皮质醇和大脑单胺类神经递质的变化

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摘要: 许氏平鲷(*Sebastes schlegelii*)具有较强的领域性。在高密度养殖条件下, 许氏平鲷幼鱼经常表现出频繁的好斗互动, 这将导致其机体损伤、生长离散程度增大等动物福利问题的出现。本研究分析了在社群等级形成过程中(短期好斗互动至长期好斗互动)许氏平鲷生长状况、好斗行为、皮质醇和大脑单胺类神经递质含量的变化。结果表明, 饱食投喂条件下, 处于劣势等级幼鱼的皮质醇和 5-羟色胺的含量均显著增加, 并且好斗行为受到明显抑制, 但其生长与优势等级个体相比并未出现显著差异。皮质醇引起的脑单胺类神经递质变化程度, 可作为预测许氏平鲷幼鱼好斗行为的潜在指标。推测脑单胺类神经递质可能参与了鱼类好斗行为的调控。

关键词: 好斗互动; 好斗性; 皮质醇; 单胺类神经递质; 社群等级; 许氏平鲷

Changes in aggressive behavior, cortisol and brain monoamines during the formation of social hierarchy in black rockfish (*Sebastes schlegelii*)

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Abstract: Black rockfish (*Sebastes schlegelii*) are naturally solitary animals. Under a high stocking density in aquaculture, juvenile black rockfish frequently show aggressive interactions, resulting in welfare issues (e.g., body injury). This study examines the changes in the growth performance, aggression, cortisol level, brain serotonergic activity, and brain dopamine activity during the process of social hierarchical formation in black rockfish (short-term aggressive interactions to long-term aggressive interactions). Ultimately, our results suggest that subordinate hierarchy inhibits aggression but does not impact growth in black rockfish. The cortisol-induced change in brain monoaminergic activity could be a potential indicator to predict aggressive behavior in black rockfish in captivity with an obvious social hierarchy.

Key words: Aggressive interactions, Aggression, Cortisol, Monoamines, Social hierarchy, Black rockfish

长江下游苏通段刀鲚产卵场的发现

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摘要: 为了解长江下游苏通江段刀鲚(*Coilia nasus*)早期资源的时空分布特征, 本研究于2018-2020年5至8月在刀鲚繁殖高峰期对该江段进行早期资源调查, 调查期间共采集到刀鲚受精卵646枚, 分析表明, 1、2、5和8号断面为刀鲚产卵场推测位置, 其平均密度和采集到刀鲚受精卵的频次均显著高于其它采集断面 ($P<0.05$); 5和6月份各断面采集到的刀鲚受精卵数量均高于其它月份; 各断面刀鲚受精卵平均密度分布为: 北岸($1.42 \text{ ind}/100 \text{ m}^3$)>南岸($0.87 \text{ ind}/100 \text{ m}^3$)>江心($0.69 \text{ ind}/100 \text{ m}^3$)。在温度 $21.1\text{-}25.3^\circ\text{C}$ 、溶氧 $6.8\text{-}7.41\text{mg/L}$ 范围内采集到刀鲚受精卵的密度较高。可见, 长江苏通江段5、6月份为刀鲚产卵高峰期, 1、2、5和8号断面为刀鲚的潜在产卵场, 研究结果可为刀鲚产卵场的保护提供科学依据。

关键词: 苏通段; 鱼类早期生活史; 刀鲚产卵场; 时空分布

The discovery spawning grounds of *Coilia nasus* in Sutong section of the Lower Reaches of the Yangtze River

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Abstract: In order to understand the early resources of *C. nasus* in the Sutong section of the lower Reaches of the Yangtze River, this study was conducted on investigation of *C. nasus* during the peak season of its propagation from May 2018 to August 2020. A total of 646 *C. nasus* eggs were collected, analysis showed that section 1, 2, 5 and 8 were the presumed positions of *C. nasus* at the birth place; The number of *C. nasus* eggs collected in each section were higher in May and June compared to other months. Among the 13 sections that were collected, the average density and frequency of *C. nasus* eggs in sections 1, 2, 5 and 8 were significantly higher than that in other sections ($P<0.05$). The average density distribution of *C. nasus* eggs in each section was: north bank ($1.42 \text{ ind}/100\text{m}^3$) > south bank ($0.87 \text{ ind}/100\text{m}^3$) > middle of the river ($0.69 \text{ ind}/100\text{m}^3$). The density of *C. nasus* eggs were relatively high in the temperature range of $21.1\text{-}25.3^\circ\text{C}$ and dissolved oxygen $6.8\text{-}7.41\text{mg/L}$. Thus, the Sutong section of the Yangtze River is the peak section for seasonal *C. nasus* spawning in May and June, and sections 1, 2, 5 and 8 are the potential spawning grounds for *C. nasus*. The results for the *C. nasus* spawning ground protection putting forward effective method and scientific basis.

Key words: Sutong Section, ELHF, Spawning grounds of *C. nasus*, Temporal distribution

基于线粒体 16S rRNA 和 COI 序列的江苏启 东海域四种贝类的遗传多样性分析

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摘要: 为了解江苏启东海域贝类的遗传多样性背景, 本研究采集启东海域主要的四种贝类, 即日本镜蛤 (*Dosinia japonica*)、四角蛤蜊 (*Mactra veneriformis*)、西施舌 (*Coelomacra antiquata*) 和中国蛤蜊 (*Mactra chinensis*), 对其线粒体 16S rRNA 和 COI 基因片段进行 PCR 扩增和测序, 并进行遗传多样性分析。结果显示: 西施舌和四角蛤蜊的遗传多样性处于一个相对较高的水平, 而日本镜蛤和中国蛤蜊的遗传多样性水平相对较低; 且同一物种 COI 基因的变异程度一般高于 16SrRNA 基因。研究结果可为江苏启东四种贝类种质资源的管理、保护和监测提供参考。

关键词: 日本镜蛤; 四角蛤蜊; 西施舌; 中国蛤蜊; 遗传多样性; 16S rRNA; COI

Genetic Diversity of Four Shellfishes in Sea area of Qidong, Jiangsu Province Based on mitochondrial 16S rRNA and COI Sequences

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Abstract: The mitochondrial 16S ribosomal RNA (16S rRNA) and cytochrome oxidase subunit I (COI) gene sequences of four shellfishes, i.e., *Dosinia japonica*, *Mactra veneriformis*, *Coelomacra antiquate*, and *Mactra chinensis*, were amplified, sequenced, and analyzed to investigate the genetic diversity background of shellfishes in sea area of Qidong, Jiangsu Province. The results show that the genetic diversity of *C. antiquata* and *M. veneriformis* was at a relatively high level, while the genetic diversity of *D. japonica* and *M. chinensis* was relatively low. For the same species, the degree of COI gene variation was generally higher than that of 16SrRNA. The results will be helpful for the germplasm resources protection and detection of four shellfishes in Qidong, Jiangsu Province.

Key words: *Dosinia japonica*, *Mactra veneriformis*, *Coelomacra antiquate*, *Mactra chinensis*, Genetic diversity, Mitochondrial 16S rRNA and COI

润扬大桥水下噪声特征及其对水生生物的潜在影响初探

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摘要: 于2019年4月在长江镇江段润扬大桥运营时进行桥梁周边水域水下噪声特征测量, 计算不同点位水下噪声平均声压级 (Sound pressure level, SPL), 并进行带宽 20 Hz-20 kHz 的噪声频谱分析。结果表明: 润扬大桥运营时周边水下噪声以低频为主 (< 200 Hz), 主频率峰值范围为 20-2000 Hz。桥梁下方水下噪声平均声压级为 117.96 ± 3.25 dB, 大桥共振噪声被同频声场覆盖, 主频率不明显。当船舶通过时噪声增益较为明显, 能量集中于低频 (1 kHz 以下) 部分, 声压级集中在 120 dB-130 dB, 将背景噪声 (2000 m 处) 平均声压级提高了约 7-17 dB。基于该水域可能存在的水生生物及其听阈特性评价水下噪声对其产生的潜在影响, 为长江水生生物生态保护提供理论基础。

关键词: 润扬大桥; 水下噪声; 频谱特性; 听觉影响

The characteristics of underwater noise of Runyang Bridge and its potential impact on aquatic organisms

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Abstract: The underwater noise characteristics around the Runyang Bridge in zhenjiang section of the Yangtze River were measured in April 2019, the average sound pressure level (SPL) of underwater noise at different sites were calculated, and the noise spectrum of bandwidth of 20 HZ-20 kHz was analyzed. The results show that the underwater noise around Runyang Bridge is mainly low frequency (below 200 Hz), and the peak frequency is 20-2000 Hz. The average sound pressure level of underwater noise under the bridge is 117.96 ± 3.25 dB. The resonance noise of the bridge is covered by the same frequency sound field, and the main frequency is not obvious. However, in the reverberation sound field, ship noise is more obvious, the energy is concentrated in the low frequency (below 1 kHz), and the sound pressure level is concentrated at 120 dB-130 dB, which increases the average sound pressure level of background noise (at 2000 m) by about 7-17 dB. Based on the possible aquatic organisms in the water area and their hearing threshold characteristics, the potential impact of underwater noise on them is evaluated, which provides a theoretical basis for the ecological protection of aquatic organisms in the Yangtze River.

Key words: Runyang Bridge, underwater noise, frequency spectrum characteristics, auditory effects

框架型人工鱼礁流场效应的数值模拟研究

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摘要: 为了对比分析框架型人工鱼礁在海中的流场效应差异, 本文采用计算流体动力学技术, 对 3 种层数、12 种不同开口比的框架型人工鱼礁在流速 0.5m/s 的开放海域的条件下进行了数值模拟, 并对流场中垂面与左右开口正中间平面上的上升流相对高度与相对面积、背涡流相对长度与相对面积和漩涡产生情况进行对比。结果表明: 流场的上升流相对高度与开口比呈线性相关, 并随高度增加、框架层数减少而降低, 两种评价方式区别不大; 流场的上升流相对面积随礁体高度的增加、框架层数的减少而降低; 流场的背涡流相对长度与相对面积皆在开口比大于等于 4/7 后处于稳定值, 在中垂面上的取值明显要比另一种方式的取值要大; 流场的漩涡区域在开口比大于 2/5 后不明显, 框架内部的漩涡情况随框架层数的改变、礁体高度的改变不明显, 框架顶部迎流侧的第一个漩涡规模明显小于第二个漩涡规模。

关键词: 框架型人工鱼礁; 流场效应; 数值模拟; 相对高度; 相对面积; 相对长度; 漩涡区域

Numerical simulation study of flow field effects on framework-type artificial reefs

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Abstract: As an important index to evaluate artificial reefs, the flow field effect of Ara has been widely concerned by academia. In order to compare and analyze the difference of flow field effect of frame type artificial reefs in the ocean, computational fluid dynamics (CFD) technology was used to simulate three layers of 12 different openings of artificial reefs under the condition of 0.5m/s open sea. The results show that: the relative height of upwelling has a linear correlation with the opening ratio, and decreases with the increase of height and the decrease of the number of frame layers; the relative area of upwelling decreases with the increase of reef height and the decrease of frame layers; when the opening ratio is greater than or equal to 4 / 7, the relative length and area of reflux are stable. The results show that the vorticity on the middle vertical plane is significantly larger than that of other methods; when the opening ratio is greater than 2 / 5, the vortex area is not obvious; with the change of the number of frame layers and reef height, the vortex inside the frame is not obvious, and the scale of the first vortex on the upstream side of the top of the frame is obviously smaller than that of the second vortex.

Key words: Frame-type artificial reefs, Current field effects, Numerical simulation, Relative height,Relative area,Relative length,Vortex area

鱼类行为个性：理论与实践

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摘要：个性指的是个体随着时间的推移，在不同的背景下所表现出的持续性行为差异，普遍存在于动物界中。行为是系列行为、生理、生活史表型特性的集合，即行为集，包含有 5 个个性轴：（1）谨慎-勇敢性；（2）开拓-逃避性；（3）活动性；（4）攻击性；（5）社会性。个性影响着鱼类的行为表现，对鱼类自身福利，水产增、养殖，渔业管理等都具有十分重要的意义。本报告简要介绍了鱼类个性和鱼类个性在水产增、养殖，信息传递及鱼病防控，渔业资源管理及保护，物种入侵防治等方面的应用，并对存在的问题进行了分析，展望了今后的研究方向，旨在为今后鱼类个性的研究及应用提供参考。

关键词：鱼类个性；水产养殖；增殖放流；渔业资源管理及保护

Fish behavioral personality: implications for ecology, aquaculture and stocking enhancement

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Abstract: Personality refers to consistent individual differences in behavior, in time and/or across contexts, for both human and non-human animals. Current knowledge of behavioral syndromes in fishes is reviewed with respect to five main axes of animal personality: (1) shyness–boldness, (2) exploration–avoidance, (3) activity, (4) aggressiveness and (5) sociability. Personality affects the behavior performances of fish and is of great consequences to the welfare of fish, stock enhancement, fishery development and conservation. The present paper briefly reviewed the research progress in fish behavioral personality, and summarized the application of the personality on stock enhancement; information transmission, disease prevention and control; fishery resource management and protection; biological invasion prevention and control. This review aimed to provide referential information for the future research and application of fish personality.

Key words: Fish behavioral personality, aquaculture, stock enhancement, fishery resource conservation

基于细胞色素 B(Cyt b)基因对翘嘴鲌不同群体遗传多样性分析

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摘要: 以淀山湖(DSH)、太湖(TH)、长荡湖(CD)和长江(CJ)四个水域共 211 尾翘嘴鲌为研究对象, 对线粒体 DNA 细胞色素 b 基因进行序列测序分析以研究四个种群翘嘴鲌的遗传多样性。结果显示, Cyt b 基因序列长度为 1088bp, 其中碱基含量 A+T 为 55%, G+C 为 45%。共检测到 258 个多态位点, 占核苷酸总数的 23.71%。四个群体 211 个样本中得到 46 个单倍型。单倍型多样性为 0.849-0.946, 核苷酸多样性为 0.0083-0.174, 整体遗传多样性较高。四个种群种间遗传距离 0.52-1.52, 太湖群体和淀山湖群体的种间遗传距离最大。DnaSP 分析四个地理的翘嘴鲌群体间的遗传分化指数范围为 0.197-0.646, 基因流值范围为 0.152-1.019, 其中长江与淀山湖群体的基因流值最小, 长江与长荡湖群体的基因流值最大, 变异来源主要来源于群体间。基于 NJ 法构建的系统进化树结果显示, 4 个群体翘嘴鲌存在地理区分, 但并不明显。

关键词: 翘嘴鲌; 线粒体 DNA; 细胞色素 b 基因; 遗传多样性

Genetic Diversity Analysis of *culter alburnus* Basilewsky Different Populations Based on Cytochrome B (Cyt b) Gene

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Abstract: In the study, based on the PCR amplification and sequencing of the mtDNA Cyt b genes in the population of the four groups. A sequence of 1088 bp, Analysis shows, The A+T was 55%, G+C 45%, 258 polymorphic sites, 211 samples obtained 46 haplotypes. The haplotype diversity was 0.849-0.946, of the four groups, the lowest haplotypes was Dianshan Lake, and Taihu Lake is the highest. Nucleotide diversity at 0.0083-0.174, the genetic diversity of the whole population is abundant. The interspecific genetic distance of four populations was 0.52-1.52, Taihu Lake population and Dianshan Lake population was 1.52. DnaSP analyzing the range of genetic differentiation index is 0.197-0.646, and the range of gene flow value is 0.152-1.019. The source of variation mainly comes from intergroup. 211 Cyt b gene sequences construction Neighbour-joining(NJ) phylogenetic tree shows that four geographic groups have geographical distinctions, but not very obvious.

Key words: *culter alburnus* Basilewsky, Cytochrome b gene, mitochondria DNA, genetic diversity

上海市徐汇区城市河流浮游动物的季节性变化及其与环境因子的关系

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摘要: 探究河道水体中浮游动物群落分布的变化及影响因素对河道水体生物多样性的维持和水生生态系统保护具有非常重要的意义。本研究于 2017 年 9 月至 2018 年 8 月对上海徐汇区代表性的城市河道进行了环境因子和浮游动物群落结构的周年调查, 共采集到浮游动物 32 种, 其中轮虫 25 种, 桡足类 4 种, 枝角类 3 种。全年浮游动物优势种 12 种, 包括轮虫 10 种, 桡足类 1 种, 枝角类 1 种。不同季节环境因子差异显著, 浮游动物种数、丰度和生物量均为夏季最高, 冬季最低。浮游动物的典范对应分析 (CCA) 显示, 氮磷比、叶绿素 a 浓度和溶解氧是影响该水体浮游动物群落差异的显著环境因子。运用水质理化因子、多样性指数及浮游动物优势种进行水质污染水平评价, 判断该河流水质状况属于中污型。调查结果可为上海市城市河道生态环境保护提供理论支撑。

关键词: 城市河道; 浮游动物; 季节变化; 环境因子; 典范对应分析

Seasonal variation of zooplankton in urban rivers and its relationship with environmental factors in Xuhui District, Shanghai

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Abstract: It is very important to explore the changes and influencing factors of zooplankton community distribution in river water bodies to maintain the biodiversity of river water bodies and protect aquatic ecosystems. From September 2017 to August 2018, environmental factors and zooplankton community structure were investigated in the representative urban river channel of Xuhui District, Shanghai. During this survey, we collected 32 species of zooplankton, including 25 species of rotifers, 4 species of copepods, and 3 species of cladocerans. There are 12 dominant species of zooplankton throughout the year, including 10 species of rotifers, and 1 species in each of Copepoda and Cladocera. The environmental factors vary significantly in different seasons. The zooplankton species, abundance and biomass are highest in summer and lowest in winter. The canonical correspondence analysis (CCA) of zooplankton showed that the ratio of nitrogen to phosphorus, chlorophyll a concentration and dissolved oxygen are significant environmental factors that affect the differences of zooplankton communities in this water body. By using water quality physical and chemical factors, diversity index and dominant zooplankton species to evaluate the water pollution level, we concluded that the water quality of the river belongs to the middle pollution type. These results can provide theoretical support for urban river ecological protection in Shanghai.

Keywords: urban river, zooplankton, seasonal variation, canonical correspondence analysis, environmental factor

环境丰容对许氏平鲷行为、生长和应激反应的影响

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摘要: 本研究通过室内受控实验, 探究了环境丰容对许氏平鲷(*Sebastes schlegelii*) 幼鱼攻击行为、生长、压力水平、脑部单胺类神经递质活动及应激反应的影响。结果显示: 幼鱼经环境丰容驯养 8 周后, 中水平构件丰容 SM 组和高水平构件丰容 SH 组幼鱼终末体重、特定生长率、增重率和饵料转化效率显著低于其余 5 组(即低水平植株丰容 PL 组、中水平植株丰容 PM 组、高水平植株丰容 PH 组、低水平构件丰容 SL 组和空白对照 C 组); PL 组幼鱼皮质醇水平最高, 而 SM 组和 SH 组最低, 同时 C 组幼鱼皮质醇水平显著高于 PM 组、PH 组和 SL 组; 脑部 5-羟色胺能系统活动和攻击行为频率变化趋势与皮质醇相似。急性刺激后, 各组幼鱼皮质醇水平均于应激后 0.5 小时达到峰值, PM 组、PH 组和 SL 组于 1 小时, PL 组和 C 组于 3 小时, SM 组和 SH 组于 6 小时恢复基础皮质醇水平; SH 组幼鱼皮质醇水平峰值显著高于其余各组。攻击行为与基础皮质醇水平、5-羟色胺能系统活动、生长指标显著相关, 基础皮质醇水平与应激皮质醇峰值、应激恢复时间显著相关。本研究结果为水产养殖苗种健康培育和增殖放流苗种行为驯化提供了新思路。

关键词: 许氏平鲷; 环境丰容; 攻击行为; 生长; 应激反应

Effects of environmental enrichment on the behavior, growth and stress response of *Sebastes schlegelii*

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Abstract: The effects of environmental enrichment on the aggressive behavior, growth performance, stress level, brain monoaminergic activity and stress response of juvenile *Sebastes schlegelii* were studied with experimental ecology methods. The results showed that after rearing for eight weeks, the final body weight, specific growth rate, weight gain and food conversion efficiency of juveniles from SM and SH groups were significantly lower than the other treatments (i.e., PL, PM, PH, SL and C groups). PL juveniles had significantly higher, while SM and SH juveniles had significantly lower cortisol levels. The cortisol levels of C fish were significantly higher than those of either PM, PH or SL juveniles. The changing trends of brain serotonergic system activity and aggressive behavior were similar to that of cortisol levels. The PM, PH and SL fish recovered to basal stress levels at 1 h, the C and PL fish recovered at 3 h, and the SM and SH fish recovered at 6 h after the stress. The peak cortisol levels of SH fish were significantly higher than the other groups. Strong correlations among behavioral and physiological parameters were observed. This research may provide useful information for aquaculture and stock enhancement.

Key words: *Sebastes schlegelii*, environmental enrichment, aggression, growth, stress response

两株水源细菌对克氏原螯虾养殖水体净化效果研究

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摘要:为探究甲基营养型 BMF04 芽孢杆菌和带鱼-4 芽孢杆菌对克氏原螯虾养殖水体的净化效果, 将其分别接种在克氏原螯虾养殖水体中, 以接两株芽孢杆菌和两株菌 1: 1 混合为处理组, 不接菌为对照组。定期检测水体嗜水气单胞菌、芽孢杆菌增殖的数量以及水体氨氮、亚硝酸盐的质量浓度, 结果表明: BMF04 芽孢杆菌组和 1: 1 混合组水体嗜水气单胞菌数量、氨氮和亚硝酸盐含量显著低于对照组 ($P<0.05$); 带鱼-4 芽孢杆菌组氨氮含量显著降低 ($P<0.05$), 而亚硝酸盐含量显著升高 ($P<0.05$); 综上, 甲基营养型 BMF04 芽孢杆菌和带鱼-4 芽孢杆菌都具有一定抑菌和净化水质的作用。

关键词: 微生物制剂; 克氏原螯虾; 水体净化; 抑菌作用

Purification of culture water of *Procambarus clarkii* by two water source bacteria

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Abstract: In order to explore the purification of culture water of *Procambarus clarkii* by methyl trophic Bacillus BMF04 and Bacillus hairtail-4, they were inoculated in the water, and two strains of Bacillus and two strains 1:1 were mixed as the treatment group, and the no bacteria were taken as the control group. The number of aqueous gas monocytes and Bacillus hydrophilus and the mass concentration of ammonia nitrogen and nitrite in the water were regularly measured. The results showed that the number, ammonia nitrogen and nitrite content of Bacillus aqueous gasophilic bacteria in the BMF04 and 1:1 mixed group were significantly lower than those in the control group; The ammonia nitrogen content in the group Bacillus hairtail-4 decreased significantly and the nitrite content increased significantly. In summary, the methyl trophic Bacillus BMF04 and Bacillus hairtail-4 have certain antibacterial and purifying water quality.

Key words: Microbial preparations, *Procambarus clarkii*, Water purification, Bacterial inhibition

长江靖江段近岸鱼类群落多样性

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摘要: 基于 2017 年长江下游靖江段的鱼类群落调查数据, 应用生物多样性分析和多元性分析, 研究了长江靖江段鱼类群落结构特征及时空变化。本次调查鱼类共计 71 种, 隶属于 10 目 20 科 53 属, 此次调查主要以鲤科(38 种, 53.52%)鱼类为主, 其中小型鱼类(42 种, 59.15%)居多, 且多为优势种, 如贝氏鲮。本研究还以 4 种鱼类多样性指数评估了长江下游靖江段的鱼类多样性, 其中 Simpson 指数(C)、Shannon 指数(H')和 Margalef 丰富度指数(D)最大值均分布在春、夏季; 4 号样点的 Simpson 指数(C)、Shannon 指数(H')和 Evenness 均匀度指数(E)均高于其他样点, 但其 Margalef 丰富度指数(D)均低于其他样点。结果表明, 长江靖江段鱼类资源丰富, 鱼类群落较稳定, 但鱼类群落具有小型化趋势。

关键词: 鱼类多样性; 群落结构; 靖江段; 小型化

The diversity of fish community near the Jingjiang section of Yangtze River

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Abstract: Based on the 2017 survey data of the fish community in Jingjiang section of the lower Reaches of the Yangtze River, the structural characteristics and seasonal changes of the fish community in jingjiang Section of the Lower Reaches of the Yangtze River were studied by using biodiversity analysis and pluralism analysis., the survey fish a total of 71 species belonging to 53 genera and 10 orders, 20 families, this survey mainly cyprinidae fish (38, 53.52%), in which small fish (42, 59.15%), and as the dominant species, such as *Hemiculter bleekeri*. In this study, four fish diversity indexes were used to evaluate the fish diversity in the Jingjiang section of the lower reaches of the Yangtze River. Among them, the Simpson index (C), Shannon index (H') and Margalef richness index (D) had their maximum values in spring and summer. The Simpson index (C), Shannon index (H') and Evenness Evenness Evenness index (E) of Sample Point 4 were all higher than other sample points, but its Margalef richness index (D) was all lower than other sample points. The results show that the fish resources in Jingjiang section of the Yangtze River are abundant and the fish community is relatively stable, but the fish community has the tendency of miniaturization.

Key words: Fish diversity, Community structure, Jingjiang section, miniaturization

水体富营养化生态修复理论基础的探讨

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摘要: 水体富营养化生态修复的理论基础是过量营养物质输入后, 通过人为操纵生态系统优化食物网, 将过量的部分移出该生态系统。传统理论认为随着食物链的延长, 各营养级生产量是逐渐减少, 而且近似以 10:1 的比例减少 (Lindeman, 1942; Odum, 1988)。据此推论, 营养物质沿食物链传递过程中, 食物链越长, 能量转化效率越低, 营养物质流失在水中的越多, 因而选择短食物链为主流的尤其是以水生植物直接吸收营养物质的生态修复具有最大效率, 这也是我国大水面生态修复普遍关注增殖滤食性的鲢鳙, 以及严重污染水体中食用无土栽培植物 (生态浮岛) 的理论基础。本文将传统的食物链理论, 放到时空的多维空间中, 建立了含时滞和庇护所的食物链模型。通过对该模型的时间序列分析得出, 在稳定的生态系统中, 如果输入的物质和能量持续稳定足够的时间, 可以实现营养物质的输入等于输出的理想生态修复的效果。但全球富营养化生态修复 40 多年的实践中, 都没有稳定实现该状态。原因一方面是食物链上、下级的捕食和逃避关系没有受到控制, 使二者现存量波动剧烈, 降低了食物链能量流动的效率; 另一方面是人们对能量流入和流出的统计时间跨度还太短, 统计范围还不全面。本文通过含庇护所的食物链模型, 强调了庇护所以对食物链上、下级关系的调节作用, 即对食物网能量流动的保障作用, 并分析认为庇护所可以概括为奇数营养级和偶数营养级 2 种类型的庇护所, 并对二者的时空分布做了初步探讨。

关键词: 食物网; 生产量; 现存量; 庇护所; 富营养化

The theoretical foundation of ecological restoration for aquatic eutrophication

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Abstract: The productivity of each trophic level along any food chain were believed to decrease step by step, ratio of each level to the next around 10:1 (Lindeman, 1942; Odum, 1988). This paper disputes it by analyzing food chains in the view of dynamics, and proposes that the ratio might be 1:1 when each trophic level get the sustainable maximum productivity, meanwhile the biomass of higher trophic level might be bigger than the lower such as the biomass of zooplankton are bigger than those of phytoplankton in some oligotrophic and mesotrophic lakes and reservoirs (He ZH, 1987). The paper also discusses ecological refuges of all trophic levels from the view of maintaining their sustainable maximum productivities (SMPs) and classifies all the refuges into 2 opposite types, odd trophic level refuge and even trophic level refuge.

Keywords: Food web, production, standing biomass, refuge, eutrophication

长江中游江段浮游生物群落结构及其与环境因子的关系

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摘要: 为了解长江中游江段浮游生物群落结构及其与环境因子之间的关系,于2019年7月、10月,2020年1月、5月进行4次采样调查。结果显示,共鉴定出浮游植物6门76属117种,其中硅藻门种类数最多(43.59%),其次是绿藻门(29.91%);浮游动物44属74种,以轮虫(48.65%)和原生动物(20.27%)为主。浮游生物优势种主要包括:假鱼腥藻(*Pseudanabaena sp.*)、变异直链藻(*Melosira varians*)、小环藻(*Cyclotella sp.*)、无节幼体(*Nauplius*)、长额象鼻溞(*Bosmina longirostris*)、哲水蚤幼体(*Calanoida larva*)。浮游植物年平均密度及生物量分别为 5.3×10^5 cells/L、1.54 mg/L;浮游动物年平均密度及生物量分别为69.61 ind./L、0.61 mg/L。根据生物多样性评价,初步得出长江中游江段浮游生物群落结构较稳定,且水质状况呈轻度污染-中度污染型。冗余分析表明,TP、TN和NH₃-N是浮游植物群落分布的主要影响因子;TP、NH₃-N、COD_{Mn}是浮游动物群落分布的主要影响因子。

关键词: 长江中游;浮游生物;群落结构;时空分布;环境因子

Spatial and temporal distribution of plankton community structure and its relationship with environmental factors in the middle Reaches of the Yangtze River

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Abstract: In evaluate the relationship between plankton community structure and environmental factors in the middle reaches of the Yangtze River, 4 sampling surveys were conducted in July and October 2019, and January and May 2020. The results showed that a total of 117 species of phytoplankton in 6 phyla and 76 genera were identified, with the most abundant species of Bacillariophyta (43.59%), followed by Chlorophyta (29.91%); the zooplankton had 44 genera and 74 species, dominated by Rotifer (48.65%) and Protozoa (20.27%). The dominant species of plankton mainly include: *Pseudanabaena sp.*, *Melosira varians*, *Cyclotella sp.*, *Nauplius*, *Bosmina longirostris*. The mean density and biomass of phytoplankton were 5.3×10^5 cells/L and 1.54 mg/L, the mean density and biomass of zooplankton were 69.61 ind./L and 0.61 mg/L. According to the evaluation of biodiversity, the plankton community structure in the middle reaches of the Yangtze River is preliminarily found to be relatively stable, and the water quality is slightly polluted to moderately polluted. Redundancy analysis shows that TP, TN and NH₃-N are the main factors affecting the distribution of phytoplankton community; TP, NH₃-N and COD_{Mn} are the major factors affecting the distribution of zooplankton community.

Keywords: the middle reaches of the Yangtze River; plankton; community structure; temporal and spatial distribution; environmental factors

流速对光棘球海胆摄食行为和生长的影响

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摘要: 海胆在海藻床生态系统结构和功能调控中发挥重要作用。深入理解流速对海胆摄食和生长的影响具有重要的生态学研究价值。我们研究了长时间(49天)不同流速(2 cm/s, 10 cm/s 和 20 cm/s)对光棘球海胆幼胆(壳径 20 mm)摄食行为、摄食量和生长的影响, 以评估流速对海胆的生长的影响, 及其影响的摄食行为为基础。实验结果表明, 长时间流速显著影响光棘球海胆的生长, 2 cm/s 下海胆的壳径和体重要显著大于 10 和 20 cm/s, 在实验开始后的第 2 周和第 3 周, 2 cm/s 下海胆的体重和壳径已显著高于 20 cm/s, 但各流速下的存活未受到影响。流速显著影响光棘球海胆的摄食量 ($P < 0.0001$) 和觅食行为 (10 cm/s, $P = 0.05$; 20 cm/s, $P = 0.004$), 但其口器咬合行为未被流速显著影响 ($P = 0.113$)。管足附着时间在 10 cm/s 和 20 cm/s ($P < 0.001$ 和 $P < 0.001$) 下显著长于其在 2 cm/s。同样的, 相较于 2 cm/s ($P = 0.02$) 和 10 cm/s ($P = 0.03$), 20 cm/s 的流速显著削弱了光棘球海胆的翻正行为。综上, 海胆管足活动影响觅食行为(而非摄食行为), 进而降低其摄食量和生长; 流速为 2–10 cm/s 的海区更适合光棘球海胆的野外生存和底播增殖。

关键词: 光棘球海胆; 流速; 生长; 摄食; 行为

Effects of long-term different flow velocity exposed on feeding, growth and behavior of the sea urchin *Mesocentrotus nudus*

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Abstract: Sea urchins play an important role in the regulation of the structure and function of kelp bed ecosystems. A better understanding of the effects of flow velocity on the feeding behavior and growth of sea urchins has an important ecological value. We studied the effects of different flow velocities (2 cm/s, 10 cm/s, and 20 cm/s) on the survival, growth, feeding and behaviors of the sea urchin *Mesocentrotus nudus* over a long period (49 days) to improve the stock enhancement of sea urchins. The results showed that the long-term experience of flow velocity significantly affected the growth of *M. nudus* (test diameter ~20 mm) and that test diameter and body weight of the sea urchin increased significantly slower with the increase of flow velocity, but the survival was not affected. Significant differences in body weight and test diameter of sea urchins were observed in the 2nd and 3rd week after the experiment started. The long-term unidirectional water flow significantly affected food intake ($P < 0.0001$) and foraging behavior of *M. nudus*, which are the main factors affecting the growth of sea urchins. However, chewing behavior was not significantly affected by the flow velocity ($P = 0.113$). Water flow significantly affected righting behavior and adhesion behavior of *M. nudus*. Adhesion behavior may be an important factor affecting foraging of sea urchins. Therefore, the sea area with a perennial flow velocity of 2–10 cm/s is suitable for the survival and stock enhancement of sea urchins.

Key Words: *Mesocentrotus nudus*; flow velocity; growth; feeding; behavior

盐度对威氏海链藻生长和生化组分的影响

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摘要 为了研究威氏海链藻(*Thalassiosira weissflogii*)在不同盐度条件下的生长和生化组分的变化。采用血球计数板、热乙醇提取法、尼罗红染色法、苯酚硫酸法和考马斯亮蓝法, 分别测定威氏海链藻的生物量、叶绿素 a 和类胡萝卜素、中性脂、总糖和蛋白质含量。培养至第八天达到稳定生长期, 盐度 5 生长速度显著低于其他组 ($P < 0.05$)。第四天时, 各盐度下威氏海链藻的叶绿素 a 含量达到最大 (3.4814 $\mu\text{g}/\text{mL}$, 15 psu)。第八天时类胡萝卜素含量达到最大 (2.3549 $\mu\text{g}/\text{mL}$, 15 psu)。各组总糖和中性脂第八天达到最大 (123 $\mu\text{g}/\text{mL}$, 15 psu), 各组蛋白含量第六天达到最大 (142.9 $\mu\text{g}/\text{mL}$, 35 psu)。盐度 5 藻细胞生长速度最慢, 盐度 15 最有利于藻细胞叶绿素 a 和类胡萝卜素、总糖的合成, 盐度 35 和盐度 30 分别最有利于藻细胞蛋白和中性脂的积累。

关键词: 威氏海链藻; 生长; 生化组分

Effects of salinity on the growth and biochemical components of microalgae *Thalassiosira weissflogii*

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Abstract: To study the growth and biochemical changes of *Thalassiosira Weissflogii* under different salinity conditions. The biomass, chlorophyll a and Carotenoid, neutral lipid, total sugar and protein of *Thalassiosira Weissflogii* were tested by blood cell counting plate, hot ethanol extraction method, Nile red staining method, phenol sulfuric acid method and Coomassie bright blue method at different salinity. On the 8th day it reached a stable growth period. The growth rate of salinity 5 was significantly lower than other groups ($P < 0.05$). On the 4th day, chlorophyll a content reached the maximum in all salinity groups (3.4814 g/mL, 15 psu). At the 8th day, the Carotenoid content reached the maximum (2.3549 g/mL, 15 psu). The total sugars and neutral lipids of each group reached the maximum on the 8th day (123 g/mL, 15 psu), and the protein content of each group reached the maximum on the sixth day (142.9 g/mL, 35 psu). The growth rate was the slowest at salinity 5. And the synthesis of chlorophyll a, Carotenoids, and total sugars was most favorable at salinity 15. The salinity 35 and 30 were most favorable for the accumulation of protein and neutral lipid respectively.

Key words: *Thalassiosira Weissflogii*; growth; biochemical changes

不同附着基对长茎葡萄蕨藻生长和附着效果的影响

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摘要:【目的】探索不同附着基质对长茎葡萄蕨藻 (*Caulerpa lentillifera*) 直立枝生长及藻体附着效果的影响。【方法】采用单因素方法, 以垂直沙埋、水平沙埋、塑料网网夹、尼龙网网夹及无附着基 (对照组) 五种附着方式进行实验, 探究长茎葡萄蕨藻的生长、附着能力、光合特性参数及营养含量的变化。【结果】垂直沙埋处理下藻体的新生直立枝鲜重、质量长度比及球状小枝的直径与其他各组相比最优 ($P < 0.05$), 分别为 0.3133 g、0.0866 g/mm 和 1.67 mm, 是对照组的 7.38、9.62、1.67 倍; 水平沙埋与对照组相比对藻体附着能力有显著性增强 ($P < 0.05$), 假根数为 26, 长度为 30.77 mm 及 0.5660 g 附着砂砾干重; 水平沙埋与垂直沙埋处理后的藻体其可溶性糖含量显著降低 ($P < 0.05$), 网夹处理后没有显著性差异 ($P > 0.05$)。垂直沙埋处理对藻体总蛋白含量有显著促进作用 ($P < 0.05$)。【结论】藻体垂直附着在砂砾地质其直立枝生长最佳, 水平沙埋处理藻体附着更牢固。

关键词: 长茎葡萄蕨藻; 附着基; 生长; 附着能力; 营养成分

Effect of different substrates on growth and attachment effect of *Caulerpa lentillifera*

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Abstract: 【Objective】 explore the effects of different substrates on the growth of fronds and the attachment effect of *Caulerpa lentillifera*. 【Method】 the single factor method was adopted to study the growth, adhesion capacity, photosynthetic characteristics and the change of nutrient content of *Caulerpa lentillifera* in four attachment modes: buried in sand vertically, buried in sand horizontally, cultured with plastic net, cultured with nylon net, and no attachment (control). 【Result】 Compared with other treatments, the fresh weight, the ratio of fresh weight to length and the diameter of spherical ramuli of the regenerated fronds were the best in vertical sand burial treatment ($P < 0.05$), which were 0.3133 g, 0.0866 g / mm and 1.67 mm, respectively, and they were 7.38, 9.62 and 1.67 times of the control group. Compared with the control group, horizontal sand burial significantly enhanced the adhesion capacity of algae ($P < 0.05$), and the number of false roots was 26, and the length was 30.77mm and the dry weight of sand grains was 0.5660 g. The content of soluble sugar in the alga was significantly decreased after horizontal sand burial and vertical sand burial ($P < 0.05$), but there was no significant difference if cultured with plastic and nylon net ($P > 0.05$). Vertical sand burial had significant promoting effect on the content of total protein ($P < 0.05$). 【Conclusion】 The vertical attachment of algae in sandy soil was shown to be the best for algae's growth, and the attachment effect was the best in horizontal sand burial.

Key words: *Caulerpa lentillifera*, substrates, growth, attachment effect, nutrient content

西江中下游草鱼年龄与生长特征研究

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摘要: 为了解西江中下游草鱼种群的年龄和生长情况, 于2019年7-12月对草鱼种群展开调查。结果显示, 草鱼种群个体体长范围为138~555mm, 平均体长为 361.13 ± 100.29 mm, 体重范围为46.20-3361.55g, 平均体重为 1092.71 ± 755.27 g。该江段草鱼年龄结构为1~4龄, 优势年龄组为3龄, 占个体数量的39.78%。草鱼体长(L)与鳞径(R)呈显著线性关系($L=43.6366R+0.8307$), 与体重(W)呈显著幂函数关系($W=2.4654 \times 10^{-5}L^{2.956}$)。Von Bertalanffy生长方程模型参数为 $L_{\infty}=1097.787$, $k=0.1281$, $t_0=-0.5142$, $W_{\infty}=23966.58$, 其生长特征指数 $\phi=5.1885$, 生长拐点年龄为7.95。与历史资料相比, 西江中下游草鱼种群个体大小和生长性能均有所下降, 建议加强草鱼资源和栖息地的保护。

关键词: 草鱼; 年龄; 生长; 西江中下游

Age and growth characteristics of *Ctenopharyngodon idellus* in the middle and lower reaches of the Xijiang River

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Abstract: In order to find out the population structure and growth of Grass Carp (*Ctenopharyngodon idellus*) in the middle and lower reaches of the Xijiang River, investigations on Grass Carp population were carried out from July to December 2019. The results showed that the standard length of Grass Carp in this section ranged from 138 mm to 555 mm with the average length of 361.13 ± 100.29 mm, and the body weight range from 46.20g to 3361.55g with the average body weight of 1092.71 ± 755.27 g. The age of Grass Carp in this section ranged from 1 to 4, and the dominant age groups was 3, accounting for 39.78% of the total individuals. The standard length (L) had a significant linear relation with scale length (R) ($L=43.6366R+0.8307$), and had a significant power function relation with body weight (W) ($W=2.4654 \times 10^{-5}L^{2.956}$). The growth of Grass Carp could be described by Von Bertalanffy growth model, where $L_{\infty}=1097.787$, $k=0.1281$, $t_0=-0.5142$, $W_{\infty}=23966.58$. The index of length growth performance (ϕ) of Grass Carp was 5.1885, and the growth inflection age was 7.95. Compared with the previous data, the individual size and growth performance of Grass Carp population in the middle and lower reaches of the Xijiang River all showed a decline tendency. Conservation of the population and habitat of the species should be prioritized.

Key words: *Ctenopharyngodon idellus*; age; growth; the middle and lower reaches of the Xijiang River

基于微卫星标记对钱塘江上游黄尾鲌增殖放流效果评估

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摘要:本研究采用11对微卫星引物,利用微卫星亲子鉴定技术,对钱塘江上游放流的黄尾鲌进行增殖放流效果评估。研究结果显示,33尾繁殖亲本和105尾回捕群体中共检出等位基因数为95个,平均等位基因数为8.64,单个位点等位基因数(N_A)为6~18;观测杂合度(H_o)为0.493~0.899,平均观测杂合度为0.708;期望杂合度(H_e)为0.544~0.923,平均期望杂合度为0.739;多态信息含量(PIC)为0.493~0.914,平均多态信息含量为0.703,除了引物XD19以外,其他微卫星位点PIC>0.5,均表现为高度多态性。表明11对微卫星引物多样性较高,可用于亲子鉴定。通过Cervus软件分析,11座位累计非亲权排除率(combined non-exclusion probability, CEP)达到99.99998%;在回捕的105尾黄尾鲌个体中,5尾回捕黄尾鲌个体确认为我们放流的子代,回捕率为4.76%。综合分析表明,钱塘江增殖放流的黄尾鲌具有较好资源恢复效果。

关键词:黄尾鲌;增殖放流;效果评估;分子标记

Effect of stock enhancement of *Xenocypris davidi* in the upper reaches of Qiangjiang River base on molecular makers

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Abstract: The stock enhancement of *Xenocypris davidi* in the upper reaches of Qiangjiang River were evaluated by the parentage relationship technology using 11 polymorphic microsatellite loci. We collected 33 breeding parents and 105 recaptured individuals. The number of different alleles (N_A) the mean observed (H_o) and expected heterozygosity (H_e) were 6~18, 0.493~0.899, 0.544~0.923, respectively, and their corresponding mean values were 8.64, 0.708 and 0.739. The polymorphic information content(PIC) per locus ranged from 0.493 to 0.914 with the mean value of 0.703. In addition to the primer XD19, other microsatellite loci PIC > 0.5 are all highly polymorphic, which proved 11 pairs of microsatellite primers as an effective tool for parentage identification. The combined non-exclusion probability (CEP) of 11 loci was 99.99998% by Cervus software. Five individuals were confirmed to be released. The return capture rate of the offspring is 4.76%. So our results suggested that the stock enhancement of *Xenocypris davidi* in Qiangjiang River had produced a good resource recovery effect.

Keywords: *Xenocypris davidi* stock enhancement effect evaluation molecular makers

长江河口区南支水域富营养化现状及其理化驱动研究

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摘要: 为了解长江河口区南支水域营养状况时空变化及其理化驱动因子, 于 2019 年冬、春、夏、秋四季对该水域水温、溶解氧、总氨氮、亚硝酸盐氮、硝酸盐氮、无机氮、可溶性活性磷酸盐、总氮、总磷、化学需氧量及叶绿素 a 等水质因子进行采样调查, 运用富营养化指数法、营养状态质量指数法和潜在性富营养化评价法对该水域富营养化水平进行分析, 采用主成分分析法 (PCA) 初步确定影响该水域富营养化状况的主要驱动因子。结果表明: (1) 调查水域水质因子时空分布季节变化显著; (2) 营养状态质量指数法与富营养化指数法评价的结果基本一致: 调查水域处于重度富营养化水平; (3) 潜在性富营养化评价法分析结果是水域富营养化程度高, 表现为磷限制, 在夏季磷的限制程度进一步加剧; (4) 主成分分析结果初步明确影响调查水域富营养化状况的主要驱动因子是硝酸盐氮。

关键词: 长江河口区; 富营养化; 主成分分析

Analysis of Eutrophication and Driving Physicochemical Factors in Southern Branch in Yangtze Estuary

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Abstract: The spatial-temporal distribution and variations of eutrophication in southern branch in Yangtze Estuary were analyzed by eutrophication index, nutritional quality index and potential eutrophication based on the investigation data including temperature, dissolved oxygen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, dissolved inorganic nitrogen, reactive phosphate, total nitrogen, total phosphate, chemical oxygen demand, and chlorophyll-a on four cruises in 2019. And principal component analysis (PCA) was carried out to evaluate driving physicochemical factors of the eutrophication. The results showed that (1) there were significant seasonal differences in spatial-temporal distribution of water factors; (2) the results of EI and NQI were nearly consistent indicating that the quality has been reached an extremely high level of eutrophication; (3) the potential eutrophication analysis revealed that the investigated area can be characterized by phosphate-limiting moderate-level nutrient, and the level was further enhanced in summer; (4) the driving physicochemical factors determined by PCA was nitrate nitrogen which would impact the eutrophication of the investigated area.

Key words: Yangtze Estuary; eutrophication; principal component analysis

珠江口资源变动及海洋牧场效果分析

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摘要: 长期的过度捕捞致使近海渔业资源日益枯竭, 海洋生物栖息地退化, 生态荒漠化趋势日益严重。人工鱼礁是一种设置在海中的水下构筑物, 鱼礁的建设在国际上已有上百年的历史, 人工鱼礁的建设投放, 对海域渔业资源的空间分布具有显著的影响。根据珠江口外伶仃海域人工鱼礁调查, 共有游泳生物 71 种, 隶属 8 目 34 科 46 属, 礁区鱼类所占比例由 2006 年的 39.13% 上升至 2016 年的 63.89%, 甲壳类则由 60.87% 降至 30.56%, 可知人工鱼礁的投放更多的吸引鱼类的聚集。对比区生态能质高于礁区, 说明礁区生物群落结构更加多样化, 投礁对生态系统稳定性和多样性具有一定的改善和促进作用。针对人工鱼礁的调查研究, 对地区综合开发利用和海洋管理政策的制定具有重要意义。

关键词: 人工鱼礁; 生物群落; 生态能质

Resource change and effect analysis of Marine ranching in Pearl River Estuary

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Abstract: Long-term overfishing has led to the depletion of offshore fishery resources and the increasing trend of ecological desertification. Artificial reef is a kind of underwater structure located in the sea, which has a history of hundreds of years in the world, it's construction has a significant influence on the spatial distribution of fishery resources. According to the survey of the Pearl River Estuary, there are 71 species belonging to 46 genera, 34 families and 8 families. The proportion of fish rose from 39.13% in 2006 to 63.89% in 2016, while crustaceans decreased from 60.87% to 30.56%, artificial reef is more attractive to fish. The eco-energy quality of the contrast area is higher than that of the reef area, which indicates that the reef community structure is more diversified, and reef throwing has a certain improvement and promotion effect on the stability and diversity of the ecosystem. The investigation of artificial reefs is of great significance to the formulation of regional comprehensive development and utilization and Marine management policies.

Key words: Artificial reef, Biological communities, ECO-EXERGY

波吉卵囊藻对铜绿微囊藻的化感作用研究

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摘要:波吉卵囊藻(*Oocystis borgei*)是一种能够维持水体稳定的有益绿藻。本研究采取混合培养法,探究其与有害蓝藻铜绿微囊藻(*Microcystis aeruginosa*)之间的竞争关系,同时采用滤液培养的方法研究波吉卵囊藻对铜绿微囊藻的化感作用。结果表明:波吉卵囊藻能有效抑制铜绿微囊藻的生长($p < 0.05$),而铜绿微囊藻对波吉卵囊藻的抑制效果较差。在波吉卵囊藻滤液胁迫下,铜绿微囊藻生长受到显著抑制($p < 0.05$),叶绿素 a 停止积累,其 SOD 活性先上升再下降,MDA 含量持续增加,透射电镜结果显示,细胞超微结构完全损坏,可以推断,波吉卵囊藻胁迫下使铜绿微囊藻产生过量的氧自由基,破坏其细胞膜、抗氧化酶系统和光合系统,从而抑制其生长。

关键词: 化感作用; 铜绿微囊藻; 波吉卵囊藻; 抗氧化酶

Allelopathic effect of the *Oocystis borgei* on *Microcystis aeruginosa*

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Abstracts: *Oocystis borgei* is a beneficial green alga that can maintain water stability. In this study, a co-culture method was used to explore the competition between *O. borgei* and *Microcystis aeruginosa* (a harmful cyanobacteria), and the filtrate culture method was used to study the allelopathy of *O. borgei* on *M. aeruginosa*. The results showed that *O. borgei* could effectively inhibit the growth of *M. aeruginosa* ($p < 0.05$), while *M. aeruginosa* had a lesser inhibitory effect on *O. borgei*. Under the stress of *O. borgei* filtrate, the growth of *M. aeruginosa* was significantly inhibited ($p < 0.05$) and chlorophyll a content stopped accumulating, simultaneously with its SOD activity increased first and then decreased, and the MDA content continuously increased. Combined with the ultrastructure of the cells completely destroyed under transmission electron microscope (TEM), it can be inferred that *O. borgei* can cause *M. aeruginosa* to produce excessive oxygen free radicals, destroy its cell membrane, antioxidant enzyme system and photosynthetic system, thereby inhibiting its growth.

Key words: Allelopathic effect, *Microcystis aeruginosa*, *Oocystis borgei*, Antioxidant enzyme

生态系大小决定长江干流的鱼类食物链长度

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摘要: 食物链长度是衡量复杂食物网的重要指标, 其变化决定着群落结构和生态系统功能。目前, 对长江流域鱼类食物链长度的研究尚未开展, 人们对长江流域食物链长度以及影响食物链长度的关键驱动因素尚不清楚。因此, 我们利用稳定同位素技术对长江干流不同江段的鱼类食物链长度进行了研究。研究表明, 长江干流不同江段食物链长度变化较大, 平均值为 4.09, 变化范围为 3.69 至 4.31, 其中三峡水库上游段的食物链长度最短, 库区中下游的食物链长度最长, 长江中游的食物链长度介于两者之间, 三峡库区不同江段的食物链长度差异大于长江中游。回归分析和模型选择结果表明, 资源可利用性和生态系统规模分别与食物链长度呈显著线性关系, 生态系统规模可以解释长江干流 75% 的食物链长度变化。总体而言, 长江流域食物链长度主要受生态系统规模和资源可利用性的影响, 其中生态系统规模对食物链长度起着关键作用。同时, 我们推测三峡大坝的建设通过增加生态系统大小来增长了原有河段的食物链长度。

关键词: 食物链长度; 长江; 稳定同位素; 生态系统大小; 驱动因素

The size of ecosystem determines food chain length of the main stream in the Yangtze River

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Abstract: Food chain length (FCL) is an important measure of food web complexity and its change determines the community structure and ecosystem function. At present, the research on the food chain length in the Yangtze River Basin has not been carried out, and the key driving factors affecting the food chain length in the Yangtze River Basin are still unclear. Therefore, we used stable isotope technology to study the FCL of fish in different reaches of the Yangtze River. The results show that FCL varied widely among the studied area with a mean of 4.09 (range 3.69-4.31), and the upstream section of the Three Gorges reservoir has the shortest FCL, the middle and lower reaches of the reservoir area have the longest FCL, the FCL in the middle reaches of the Yangtze River lies between them, and the difference of FCL between different river sections in the Three Gorges Reservoir area is greater than that in the middle reaches of the Yangtze River. The results of regression analysis and model-selection results indicated that resource availability and ecosystem size have significant linear relationship with FCL respectively, ecosystem size can explain 75 % of the FCL variation. Overall, FCL in the Yangtze River Basin is mainly controlled by ecosystem size and resources availability, in which ecosystem size plays a key role in FCL. At the same time, we speculate that the construction of the Three Gorges Dam increases the length of the food chain of the original river.

Keywords: food chain length, Yangtze River, stable isotope, the size of ecosystem, driving factor

不同氮磷比 (NO₃-N: PO₄-P) 对异枝江蕨生长及生化组分的影响

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摘要: 探究异枝江蕨 (*Gracilaria bailinae*) 生长的最适氮磷比 (NO₃-N: PO₄-P), 为异枝江蕨的规模化人工养殖提供理论依据和指导。以 NaNO₃ 为氮源, KH₂PO₄ 为磷源, 在不同氮 (0、100、400、800、1600 μmol/L)、磷 (10、20、40 μmol/L) 浓度梯度下, 室内培养异枝江蕨 12d, 测定其特定生长率、可溶性糖含量、可溶性蛋白含量、MDA 含量及 T-SOD 活性。【结果】氮磷比为 40: 1 时最适合藻体生长; 氮浓度为 1600 μmol/L, 磷浓度为 40 μmol/L 时, 藻体的特定生长率最大 (2.9493±0.1855%·d⁻¹), 可溶性糖含量最低 (8.2353±0.1246 mg·ml⁻¹), 可溶性蛋白含量最高 (0.1177±0.0116 mg·ml⁻¹), MDA 含量最低 (12.6244±0.4203 nmol·g⁻¹), T-SOD 活性最高 (459.8393±2.8027 U·g⁻¹)。【结论】最适氮磷比为 40: 1, 且氮浓度为 1600 μmol/L、磷浓度为 40 μmol/L 时, 异枝江蕨特定生长率最大; 氮磷比为 40: 1 时, 可溶性糖含量最低, 可溶性蛋白含量最高, MDA 含量最低, T-SOD 活性最高。

关键词: 异枝江蕨; 氮磷比; 特定生长率; 生化组分

Effects of Different Nitrogen and phosphorus ratios (NO₃-N: PO₄-P) on Growth and Biochemical components in *Gracilaria Bailinae*

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Abstract: To investigate the optimal Nitrogen and phosphorus ratio (NO₃-N: PO₄-P) in *Gracilaria bailinae*, providing theoretical basis and guidance for large-scale artificial breeding in *Gracilaria bailinae*. NaNO₃ was used as nitrogen source and KH₂PO₄ as phosphorus source. With different concentrations of nitrogen (0, 100, 400, 800, 1600 mol/L) and phosphorus (10, 20, 40 mol/L), 12 d growth rate, soluble sugar content, soluble protein content, MDA content and T-SOD activity were measured. When the ratio of N/P was 40:1, it was most suitable for algal growth. When nitrogen concentration was 1600 mol/L and phosphorus concentration was 40 mol/L, the specific growth rate of alga was the highest (2.9493±0.1855 %·d⁻¹) and soluble sugar content was the lowest (8.2353±0.1246 mg·ml⁻¹). Soluble protein content was the highest (0.1177±0.0116 mg·ml⁻¹), MDA content was the lowest (12.6244±0.4203 nmol·g⁻¹). T-SOD activity was the highest (459.8393±2.8027 U·g⁻¹). The optimum nitrogen and phosphorus ratio was 40:1, and the nitrogen concentration was 1600 mol/L, and the phosphorus concentration was 40 mol/L. The specific growth rate of *Gracilaria gracilaria* was highest. When N/P ratio was 40:1, the soluble sugar content was the lowest, soluble protein content was the highest, MDA content was the lowest, and T-SOD activity was the highest.

Keywords: *Gracilaria bailinae*, Nitrogen and phosphorus ratio, SGR, Biochemical components

赣江发现溯河洄游型刀鲚及其生态保护意义

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摘要: 基于鱼类江海洄游与否的电子探针耳石锶和钙微化学判别手段, 对 2020 年 5 月采于赣江炉子窑江段的 21 尾刀鲚进行了洄游履历的重建及生态表型的判别。研究发现, 16 尾为典型的溯河洄游型长颌鲚。其占总刀鲚标本的数量比达 76%, 远高于迄今鄱阳湖及其通湖水系所报道的相关比率。赣江中存在洄游型刀鲚的产卵场, 推测位于采样点到赣江新干航电枢纽江段间的水域。上述结果首次确证了赣江中溯河洄游型刀鲚的存在, 并体现出了在长江生态大保护及 10 年禁渔的国策下, 赣江水域洄游型刀鲚资源量和栖息地有恢复向好的趋势。宜尽快开展赣江下游相关类群分布区和产卵场等及潜在人类活动威胁的全面调查, 以便抢救性保护该水域的刀鲚资源及其关键栖息地。

关键词: 赣江; 刀鲚; 耳石微化学; 溯河洄游; 鄱阳湖; 保护

Discovery of Anadromous *Coilia nasus* in Ganjiang River and its Significance on Ecological Conservation

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Abstract: A confirmatory study on the discovery of anadromous *Coilia nasus* was conducted with 21 fish sampled in May at the Luziyao section of the Ganjiang River in Jiangxi Province by means of the diadromous identification approach of otolith strontium and calcium microchemistry. The results indicated that there were 16 individuals of anadromous-long supermaxilla ecomorphotype in the sampled fish, accounting for as high as 76%, which is far higher than those reported ratios in literatures so far for *C. nasus* around the Poyang Lake and its tributaries. Spawning site in the Ganjiang River may locate in the lower reaches of the Ganjiang River between our sampling site and the dam of Xingan Navigation Power Junction Project. The present study firstly confirmed the existence of anadromous *C. nasus* in the Ganjiang River, and provided objective evidence on the recovery tendency of resource and habitat for this fish under the national policies of ecological protection and 10-year ban on all commercial fishing for the Yangtze River. Further studies are urgently needed to exactly locate the distributing areas and spawning sites, and clarify the potential impacts from human activities for this fish, in order to rescue protection its resources and key habitats in the Ganjiang River.

Key words: *Coilia nasus*, Ganjiang River, otolith microchemistry, anadromy; ecological Conservation

岷江鱼类资源调查与分析

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摘要: 岷江系长江重要组成部分, 为了解岷江鱼类资源现状, 2017年~2019年对岷江鱼类种类组成、优势种和多样性指数进行了分析。结果显示, 共采集到鱼类72种, 隶属于4目、14科、53属, 包含了1种国家级保护鱼类胭脂鱼、4种四川省级保护鱼类、16种长江上游特有鱼类以及4种入侵鱼类。渔获物统计分析, 岷江上游以齐口裂腹鱼、重口裂腹鱼、黄石爬鮡和青石爬鮡等喜急流的鱼类为主, 中下游以福建纹胸鮡、白缘鮡、切尾拟鲿等适应缓流或静水环境的鱼类为优势种群; 鱼类多样性指数、丰富度指数以及均匀度指数表明岷江鱼类多样性较差且随河流梯度向下而递增的趋势。研究结果显示岷江鱼类种类数减少、经济鱼类小型化, 呈现衰退趋势。

关键词: 岷江; 鱼类资源; 多样性

Investigation and analysis of fish resources in Minjiang River

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Abstract: Minjiang River is the important part of the Yangtze River. The species composition, dominant species and diversity index were analyzed to understand the current status of fish resources in Minjiang River from 2017 to 2019. A total of 72 species were identified inside 5 orders, 14 families, and 53 genera. Among these species, *Myxocyprinus asiaticus* was enlisted as a protected species in China, 4 species were enlisted as protected species in Sichuan Province, 16 species were endemic to the upper Yangtze River and 4 species were non-native fish in Minjiang River. The statistics of catches showed that the fish assemblages in the upper of Minjiang River were predominated by lotic species, such as *Schizothorax prenanti*, *Schizothorax (Racoma) davidi*, *Euchiloglanis kishinouyei* and *Euchiloglanis davidi*. In contrast, the fish assemblages in the middle and lower reaches were mainly dominated by lentic species, such as *Glyptothorax fokiensis*, *Liobagrus marginatus* and *Pseudobagrus truncatus*. The Shannon-Wiener index, Pielou evenness index and Margalef species richness index indicated the fish species diversity were poor and presented significant longitudinal changes in Minjiang River. The investigation showed the reduced number of species and the miniaturization of economic fish stocks, which indicated the recession of fish resources in Minjiang River.

Key words: Minjiang River; fish resource; diversity

海水养殖区的水质评价与分析

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摘要: 随着海洋养殖业的迅速发展, 水环境质量已成为制约水产养殖业发展的主要因素。本研究采用主成分分析法 (PCA) 对池塘养殖和网箱养殖的水质状况、时空变化及驱动因素进行分析。结果表明, 影响池塘养殖的主要因素是盐度、溶解氧和 ARGs。对于网箱养殖区来说, 主要的驱动因子是叶绿素 a、盐度和溶解氧。主成分综合得分表明, 池塘和养殖区污染最重的月份分别出现在 8 月和 11 月。池塘养殖区的水质主要受池塘水量的影响, 而养殖活动和季节是网箱养殖的主要因素。养殖活动可能不是 ARGs 高丰度的主要原因, 人类活动是造成海洋养殖区污染的主要原因。ARGs 作为一种新的污染物, 其治理仍需高度重视, 以防进一步污染环境。

关键词: 水质评价、主成分分析、抗性基因、海水养殖

Evaluation and Analysis of Water Quality of Marine Aquaculture Area

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Abstract: With the rapid development of marine aquaculture, the water quality of aquatic environment was regarded as the main limiting factor. In present study, principal component analysis (PCA) was used to analyze the water quality state, spatial-temporal changes, and the driving factors analysis in pond and cage aquaculture areas. The results showed that the main driving factors are salinity, dissolved oxygen and ARGs in pond aquaculture area. For the cage aquaculture area, the main driving factors are chlorophyll a, salinity and dissolved oxygen. As the comprehensive scores of the principal components indicated that the heaviest polluted month in pond and aquaculture area was appeared in August and November, respectively. The water quality of the pond aquaculture area is mainly affected by the volume of the pond water, while aquaculture activities and season are the main factors for cage aquaculture. Aquaculture activities may not be the main attribution for the high abundance of ARGs, and human activities are the main contribution for the pollution of marine aquaculture areas. ARGs as the new pollutant, the elimination still needs to be highly valued in case of the further pollution to the environment.

Key words: water quality assessment, principal component analysis, antibiotic resistance genes, marine aquaculture

LC-MS代谢组学研究剑尾鱼肝脏对微塑料的生理反应

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摘要: 微塑料是水生环境中的新型污染物,为了探究微塑料对水生动物的影响,本实验采用 LC-MS 代谢组学的方法研究了 5 μm 微塑料对剑尾鱼肝脏代谢的影响。暴露浓度分别为 0(对照组), 1×10^6 粒/升和 1×10^7 粒/升, 每组设置 3 个平行, 暴露时间为 72 小时。结果显示, 与对照组相比, 微塑料浓度为 1×10^6 粒/升的剑尾鱼肝脏中共筛选出 6 种显著变化的代谢物, 其中 1 种代谢物含量上升, 5 种代谢物含量下降, 共涉及 7 条代谢通路。 1×10^7 粒/升浓度组的剑尾鱼肝脏中共筛选出 8 种显著变化的代谢物, 其中 6 种代谢物含量上升, 2 种代谢物含量下降, 共涉及 12 条代谢通路, 其中有 6 条受到影响的代谢通路与 1×10^6 组重叠, 分别是: 氨基糖和核苷酸糖代谢、 β -丙氨酸代谢、硫代谢、谷胱甘肽代谢、半乳糖代谢、ABC 转运体。根据筛选出的差异代谢物的生理功能及涉及的代谢通路显示, 短期暴露于高于环境中微塑料浓度会影响鱼肝脏的糖代谢和脂代谢, 引起肝脏氧化应激, 影响细胞稳态、物质转运和凋亡, 产生神经毒性。

关键词: 剑尾鱼; 微塑料; 肝脏; 代谢组学

Study on the physiological response of *Xiphophorus helleri* liver to microplastics by LC-MS Metabonomics

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Abstract: Microplastics is a new type of pollutants in aquatic environments. In order to explore the impact of microplastics on aquatic organisms, this experiment used LC-MS metabolomics to study the effect of microplastics with a diameter of 5 μm on the liver metabolism of swordtail fish. The exposure concentrations were 0 (control group), 1×10^6 particles/L and 1×10^7 Particles/L, 3 parallels were set for each group, and the exposure time was 72 hours. The results showed that compared with the control group, 6 kinds of metabolites were significantly changed in group 1×10^6 particles/L, among them, 1 metabolite increased and 5 decreased significantly, 7 metabolic pathways were involved; 8 kinds of metabolites were significantly changed in group 1×10^7 particles/L, among them, 6 metabolite increased and 2 decreased significantly, 12 metabolic pathways were involved. 6 of the affected metabolic pathways overlap with the 1×10^6 particles/L, they are amino sugar and nucleotide sugar metabolism, beta-alanine metabolism, sulfur metabolism, glutathione metabolism, galactose metabolism and ABC transporters. According to the physiological functions of the differential metabolites selected and the metabolic pathways involved, short-term exposure higher than the microplastics concentration in the environment will affect the carbohydrate and lipid metabolism of fish liver, cause liver oxidative stress, affect cell homeostasis, substance transport and apoptosis, and cause neurotoxicity.

Key words: Swordtail fish (*Xiphophorus helleri*), Microplastics, metabolomics, Liver

中国淡水渔业与水生生物多样性保护的发展 历程及其启示

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摘要: 中国是渔业大国, 其中内陆渔业产量(含养殖和捕捞)约占全球内陆产量的一半。中国同时也是世界上水生生物多样性最为丰富的国家之一, 其中内陆鱼类种类数约占全球的 10%。长期的过度捕捞和不合理的养殖发展对中国内陆水生生物多样性带来了严重不利影响。本文系统回顾了自中华人民共和国建国 70 年以来, 中国内陆渔业从以捕捞为主、养捕并重再到保护为主的发展历程, 阐述了其主要做法。并系统梳理了当前以生态文明建设为总基调的前提下, 中国在内陆水生生物多样性保护方面所做出的各种努力。以及仍然可能存在的一些关键问题, 包括渔业发展与水生生物多样性保护的矛盾仍然客观存在, 保护优先前提下渔业发展与资源合理利用, 水生态系统保护和发展目标的科学设定等。本研究可为世界各国协调内陆水域渔业发展和水生生物多样性保护提供借鉴。

关键词: 水产养殖; 捕捞渔业; 濒危鱼类; 渔业管理; 休渔, 淡水生态区

Inland fisheries development versus aquatic biodiversity conservation in China and its global implications

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Abstract: China is unique among nations on account of its rich aquatic biodiversity (1443 inland fish species comprising 10% of those worldwide), status as the world's largest producer (50%) of inland fish, and recent history of significant disruption of natural ecosystems. Ecological Civilization, a policy increasingly advocated in China since 2015, provides a strong platform to protect aquatic ecosystems and restore biodiversity in inland waters. We reviewed processes, policies, and outcomes related to inland fisheries and aquatic biodiversity during the 70 years since the establishment of the People's Republic of China (PRC). Particular focus was on recent transformations in inland fisheries development and protection of inland aquatic biodiversity (IAB) under the goals of Ecological Civilization. We describe how Chinese inland fisheries have undergone three transformative historical phases, i) rapid development, ii) over-exploitation, and iii) vigorous protection. A series of newly introduced policies and programs hold promise for rehabilitating IAB. Global implications are considered by comparison with many of the world's major river basins. We highlight the challenge of balancing fisheries development with biodiversity conservation; avoiding incidental adverse effects on conservation; rationalizing development under protection; eliminating gaps between protected areas, averting extinction and restoring endangered species; and integrating protection in managing watershed ecosystems. In the context of the global decline in freshwater biodiversity, the 70 years of fisheries development and biodiversity conservation in Chinese inland waters serve as a leading example for global IAB.

Key words: Aquaculture, capture fisheries, endangered fish, fishery management, fishing moratorium, freshwater ecoregion

山美水库渔业生态修复的初步研究

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摘要: 2002年被列为泉州市的重要饮用水源地后,山美水库库区内养鱼网箱被彻底清除,四周绿化补种,改善库区植被,改变传统渔业发展理念,开展“以渔治水,以渔养水”的保水渔业。库区水质良好,与2003年相比,2016年库区水质NH₄-N和TN分别下降了64.0%和55.8%;从库区上游到大坝7个站点水样NO₂-N、NO₃-N、NH₄-N、TN、COD和TP含量与库外东美站点相比,分别下降了83.9%、16.1%、90.5%、42.6%、27.0%和28.7%,其中NO₂-N、NH₄-N、TN、COD和TP差异显著(p<0.05)。叶绿素a含量从库外东美站位经库区上游的高平、土楼至库区下游的大坝急剧下降,到水库渔业主要区域的杜潭、大湾、九都、井角和大坝下降了67.2%,差异显著(p<0.05)。库区鱼类生长迅速,鳊鱼Von Bertalanffy生长方程为: $L_t=107.2167 \times [1-e^{-0.1349(t+0.1561)}]$, $W_t=22095.9566 \times [1-e^{-0.1349(t+0.1561)}]^2.9132$, 翘嘴红鲌Von Bertalanffy生长方程为: $L_t=120.5981 \times [1-e^{-0.0913(t+1.09)}]$, $W_t=21.9368 \times [1-e^{-0.0913(t+1.09)}]^2.825$; 水库鱼产量逐年上升,平均年渔产量441.0t,渔获物中鲢鱼产量占28%,鳊鱼产量占66.3%,翘嘴鲌、鲤、鲫等占4.90%,沼虾占0.76%。库区生态系统稳定,有浮游植物7门共69种,平均数量436.88×10⁴个/L,生物量为2.98 mg/L;浮游动物39种,平均数量350.48个/L,生物量为3.98 mg/L,库区内现有鱼类10科37种。山美水库保水渔业的实践科学合理地开发了库区渔业生长和水源地的有效保护。

关键词: 山美水库 水质 水生生物 生态修复

Preliminary Studies on Fishery Ecological Restoration in ShanMei Reservoir

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Abstract: Since Shanmei Reservoir was ratified as an important source of drinking water in Quanzhou City, the fish cages were completely cleared up. A large of trees was replanted to improve reservoir vegetation. Traditional fisheries was change to develop aquatic environmental protection oriented fishery, what was called "Fishery regulation waters ,and fishery protection waters ". The water quality was good in shanmei reservoir. Comparison with 2003, the NH₄-N and TN were decreased by 64% and 55.8% in 2016, respectively. Comparison with the outside reservoir ,the NO₂-N、NO₃-N、NH₄-N、TN、COD and TP of 7 sites in reservoir were decreased by 83.9%, 16.1%, 90.5%, 42.6%, 27% and 28.7%, respectively, which there were significant difference of NO₂-N, NH₄-N, TN, COD and TP (p<0.05). There was a sudden drop in Chlorophyll-a from outside to inside of reservoir. Comparison with Dongmei stance outside of reservoir, Chlorophyll-a descend 67.2% than that of major reservoir fisheries regional (include Dutang, Dawang, Jiudu, Jingjiao and Daba) (p<0.05). Fish in reservoir growde rapidly. Von Bertalanffy growth equation of *Aristichthys nobilis* was $L_t=107.2167 \times [1-e^{-0.1349(t+0.1561)}]$, and $W_t=22095.9566 \times [1-e^{-0.1349(t+0.1561)}]^3$. Von Bertalanffy growth equation of *Erythroculter Itishaeformis* (Bleaker) was $L_t=120.5981 \times [1-e^{-0.0913(t+1.09)}]$, $W_t=21.9368 \times [1-e^{-0.0913(t+1.09)}]^2.825$. The average annual catch fish, was 441.0t from 2003 to 2012, which the carp) was accounted for 28.1%, 66.3%, 0.7%, and 4.9%, respectively. Reservoir ecosystem was stable. There were 7 families and 69 genera of phytoplankton in shanmei reservoir, which species abundance was 436.88×10⁴ ind·L⁻¹ and biomass was 2.98 mg·L⁻¹. There was 39 species of zooplankton which species was 350.48 ind·L⁻¹ and biomass was 3.98 mg·L⁻¹. There were 10 families 37 species of fish composition. The reservoir fishery was sciencely developed ,and water source was effectivly protectde in shanmei reservoir.

Keyword: Shanmei reservoir; Water quality; Aquatic organisms ; Ecological restoration

酸碱度、盐度和温度对海蜇耗氧率和排氨率的影响

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摘要: 海蜇是我国沿海常见的一种经济价值较高的水母, 探究其耗氧率 (Oxygen consumption rate, OCR) 和排氨率 (Ammonia excretion rate, AER) 受环境因子的变化机制奠定其生物学基础研究的主要问题。为此, 本研究通过测定不同酸碱度 (pH)、盐度和温度的对照试验组, 分析海蜇幼蜇和成蜇的 OCR 和 AER 的变化机制。结果表明, 海蜇的 AER 和 OCR 随 pH 的增加呈现先增大后减小的趋势 ($P < 0.05$), 幼蜇和成蜇的代谢率分别在 pH=7 和 pH=7.5 时达最大值, 且收缩次数最多。不同 pH 条件下海蜇氧氮比值为 0.742~3.646, 平均值为 1.871。海蜇的 AER 和 OCR 随盐度的增加呈现先增后减的趋势 ($P < 0.05$), 分别在盐度为 25 和 20 时达到峰值。海蜇在盐度为 20~25 时收缩力最强。海蜇的 O:N 为 0.916~2.032, 平均值为 1.245。温度对海蜇影响显著 ($P < 0.05$), 随着温度升高, 不同规格海蜇的 OCR 随之增加; AER 先增大后减小, 25℃ 达到峰值。海蜇在 21℃ 时运动和进食最快, 温度低于 3℃ 或高于 35℃ 海蜇停止运动。幼蜇排泄 Q_{10} 为 0.767~4.362, 呼吸 Q_{10} 为 1.299~2.201; 成蜇排泄 Q_{10} 为 -0.617~4.147, 呼吸 Q_{10} 为 0.714~2.519。不同温度条件下海蜇的 O:N 比值在 0.505~2.035, 平均值为 1.062。本研究中不同条件下海蜇 O:N 的平均值为 1.392, 说明海蜇主要以蛋白质代谢为主。

关键词: 海蜇 (*Rhopilema esculenta*) ; 耗氧率和排氨率; pH; 盐度; 温度

The effect of pH, salinity and temperature on the oxygen consumption rate and ammonia excretion rate of *Rhopilema esculenta*

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Abstract: *Rhopilema esculenta* is a common jellyfish with high economic value in the coastal areas of our country. As the main problem, the study of the mechanism of changes in oxygen consumption rate (OCR) and ammonia excretion rate (AER) affected by environmental factors has laid its biological foundation. In that case, this study analyzed the change mechanism of OCR and AER of juvenile and adult *rhopilema esculenta* by measuring control test groups with different pH, salinity and temperature. The results showed that the AER and OCR of *rhopilema esculenta* increased first and then decreased with the increase of pH ($P < 0.05$). The metabolic rate of juvenile and adult *rhopilema esculenta* reaches the maximum at pH=7 and pH=7.5, and the number of contractions is the largest. The oxygen-nitrogen ratio of *Rhopilema esculenta* under different pH conditions is 0.742~3.646, with an average value of 1.871. The AER and OCR of *rhopilema esculenta* showed a trend of increasing firstly and then decreasing with the increase in salinity ($P < 0.05$), reaching their maximum when the salinity is 25 and 20, respectively. *Rhopilema esculenta* has the strongest contraction force when the salinity is 20-25. The O:N of *rhopilema esculenta* is 0.916~2.032, with an average value of 1.245. Temperature has a significant effect on *rhopilema esculenta* ($P < 0.05$). As the temperature increases, the OCR of *rhopilema esculenta* of different size increases; AER first increases and then decreases, reaching a peak at 25℃. The *rhopilema esculenta* moves and eats fastest at 21℃, which stops moving when the temperature is lower than 3℃ or higher than 35℃. The excretion Q_{10} of juvenile *rhopilema esculenta* is 0.767~4.362, the respiratory Q_{10} is 1.299~2.201; the excretion Q_{10} of adult *rhopilema esculenta* is -0.617~4.147, and the respiratory Q_{10} is 0.714~2.519. The O:N ratio of *rhopilema esculenta* under different temperature conditions is 0.505~2.035, with an average value of 1.062. In this study, the average value of O:N of *rhopilema esculenta* under different conditions was 1.392, indicating that *rhopilema esculenta* is mainly protein metabolism.

Key words: *Rhopilema esculenta*, oxygen consumption rate (OCR) and ammonia excretion rate (AER), pH; salinity, temperature

石臼湖鱼类群落结构现状及其季节变化

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摘要: 本研究于2017年1月-2018年3月采用多目刺网和地笼在石臼湖采集渔获物, 调查了石臼湖的鱼类群落结构及其季节变化情况。共调查到鱼类36种, 隶属于6目7科28属, 其中鲤科鱼类最多, 占总物种数的69.4%; 鱼类物种组成以定居性、杂食性、中上层鱼类为主, 小型鱼类达25种, 占总物种数的69.44%。似鳊(*Toxabramis swinhonis*)、湖鲢(*Coilia nasus*)和鲫(*Carassius auratus*)为石臼湖鱼类全年优势种, 在季节上, 除全年优势种外, 还有春季的麦穗鱼(*Pseudorasbora parva*)、夏季的翘嘴鲌(*Culter alburnus*)和鳊(*Hemiculter leucisculus*)、秋季的似鳊(*Pseudobrama simoni*)、冬季的贝氏鳊(*Hemiculter bleekeri*)。鱼类相对密度、相对生物量有较大的季节变化, 但其变化趋势一致, 均为冬季>春季>秋季>夏季。Margalef丰富度指数 R 的变动范围为2.28~3.17, 基于个体数量的Shannon-Wiener多样性指数 H'_N 、Pielou均匀度指数 J'_N 变动范围分别为1.24~2.14、0.14~0.34, 基于生物量的Shannon-Wiener多样性指数 H'_W 、Pielou均匀度指数 J'_W 变动范围分别为1.64~2.51、0.21~0.49。与历史记录相比, 石臼湖鱼类资源有较明显的衰退, 存在较为严重的物种单一化与资源小型化问题, 原因可能与人类活动不断加剧, 对湖泊生态环境造成严重干扰有关, 因此, 建议减少人类活动干扰来保护鱼类多样性。

关键词: 石臼湖; 通江湖泊; 鱼类群落结构; 季节变化

The structure and spatial-temporal variation of fish community in Shijiu Lake

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Abstract: In this study, multi-mesh gill and cage nets were used to collect fish in Shijiu Lake from January 2017 to March 2018, and the fish community structure and seasonal changes in Shijiu Lake were investigated. A total of 36 species of fish belonging to 28 genera, 7 families and 6 orders were investigated, of which Cyprinidae was the most, accounting for 69.4% of the total species. The fish species were mainly sedentary, omnivore and upper, with 25 small fishes accounting for 69.44% of the total species. *Toxabramis swinhonis*, *Coilia nasus* and *Carassius auratus*, were the dominant species of Shijiu Lake fishes throughout the year. On the season, except for dominant species throughout the year, there were *Pseudorasbora parva* in spring, *Culter alburnus* and *Hemiculter leucisculus* in summer, *Pseudobrama simoni* in autumn and *Hemiculter bleekeri* in winter. The relative density and biomass of fish showed great seasonal variation, but the variation trend was the same: winter > spring > autumn > summer. The variation range of Shannon-Wiener diversity index H'_N and Pielou evenness index J'_N based on individual number is 1.24~2.14 and 0.14~0.34 respectively. The variation range of Shannon-Wiener diversity index H'_W and Pielou evenness index J'_W based on biomass is 1.64~2.51 and 0.21~0.49 respectively. The variation range of Margalef species richness index R was 2.28~3.17. The variation range of Shannon-Wiener diversity index H'_N and Pielou evenness index J'_N based on individual number was 1.24~2.14 and 0.14~0.34 respectively. The variation range of Shannon-Wiener diversity index H'_W and Pielou evenness index J'_W based on biomass was 1.64~2.51 and 0.21~0.49 respectively. Compared with the historical records, the fish resources in Shijiu Lake are obviously declining, and there are serious problems of species simplification and resource miniaturization, which may be related to the serious disturbance of lake ecological environment caused by the continuous intensification of human activities. Therefore, it is suggested to reduce the disturbance of human activities to protect fish diversity.

Key words: Shijiu Lake, Yangtze-connected lake, fish community structure, spatial difference, seasonal variation

拟穴青蟹对天然饵料中稳定性同位素富集效应的初步研究

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摘要: 稳定性同位素分析技术用于确定饵料组成和营养, 已经成为生态学中营养来源研究的重要手段。但要使用这一手段进行研究, 就必须获得青蟹对不同饵料中稳定性同位素的富集效应数据。本实验研究穴青蟹对不同天然饵料中稳定性同位素富集效应。采用室内可控条件下对拟穴青蟹从幼蟹开始投喂从红树林和邻近滩涂收集的6种天然饵料犬牙珠虾虎鱼(*Acentrogobius caninus*)、李氏鲮(*Callionymus richardsoni*)、须赤虾(*Metapenaeopsis barbata*)、杂色蛤(*Ruditapes philippinarum*)、多齿围沙蚕(*Perinereis nuntia*)、双齿围沙蚕(*Perinereis aibuhitensis*)养殖66天。试验结束后对青蟹进行称重, 然后每只青蟹作为一个单独样品, 进行预处理后存保持测。采用稳定性同位素质谱仪测定碳和氮稳定性同位素含量。杂色蛤、双齿围沙蚕和须赤虾对青蟹的养殖效果比较好。不同饵料的氮稳定性同位素¹⁵N和碳稳定性同位素¹³C含量均显著比初始青蟹高, 青蟹摄食不同饵料后体内氮稳定性同位素¹⁵N和碳稳定性同位素¹³C含量显著提高, 表明青蟹的确从摄食的饵料中吸收和同化了大量营养元素。但从对¹⁵N和¹³C的富集效应来看, 与已有的¹³C偏差1‰至2‰和¹⁵N富集3‰至4‰作为判断直接捕食者与食物的差值标准有一定差别。导致这一现象的主要原因可能是由于实验后期水温较低, 导致青蟹生长慢和营养元素同化效率低。

关键词: 拟穴青蟹; 稳定同位素; 天然饵料; 营养; 富集效应

A preliminary study on the enrichment of stable isotope from natural diets by mud crab, *Scylla paramamosain*

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Abstract: Trace to the source of dietary composition and nutrition by stable isotope analyzing has become an important tool in nutrition sources study in ecology. To apply this technology to study the dietary resources of mud crab, *Scylla paramamosain*, essential data of enrichment of stable isotope from natural diets by mud crab must be provided. In the present experiment, the enrichment of stable isotope from natural diets by mud crab was investigated. Controlled aquariums were used to conduct this experiment and six natural diets (*Acentrogobius caninus*, *Callionymus richardsoni*, *Metapenaeopsis barbata*, *Ruditapes philippinarum*, *Perinereis nuntia*, *Perinereis aibuhitensis*) inhabit nearly to the mangrove and adjacent intertidal zone were provided to the crabs for 66 days. And then the crabs were weighed and sampled individually. Samples and diets and crabs were treated and measured to achieve the stable isotope contents of ¹³C and ¹⁵N. performance of the growth of crabs fed on *R. philippinarum*, *P. aibuhitensis*, and *M. barbata* were better than those fed on fish and *P. nuntia*. The contents of stable isotope ¹³C and ¹⁵N of six natural diets were obviously higher than initial crab. Compare to the initial crabs, the contents of stable isotope ¹³C and ¹⁵N of final crabs exhibited significant increase. It indicated that the crabs absorbed and assimilated an amount of organic C and N from ingested diets. However, the enrichment effects of ¹⁵N and ¹³C were still lower than the judgement baselines of direct predator and prey, they were 1‰~2‰ for ¹³C and 3‰~4‰ for ¹⁵N respectively. This appearance may be attributed to the low growth rates of crab and low nutritional regenerations caused by lower temperature in the experiment.

Keywords: *Scylla paramamosain*, stable isotope, natural diets, nutrition; enrichment effects

不同采样设计对长江口海洋环境监测效果影响的评价

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摘要: 长江口作为我国生物多样性最丰富的河口, 海洋环境对研究水生生物种群分布和数量变化的影响都十分重要。但在目前该水域的综合监测调查中, 多数监测项目缺少站点优化设计的过程。为评价不同采样设计对长江口海洋环境监测结果的影响, 本研究使用基于普通克里金法 (Ordinary Kriging, OK) 插值了不同海洋环境要素的空间分布, 比较了定点采样 (Stationary Sampling, SS)、简单随机采样 (Simple Random Sampling, SRS) 和分层随机采样 (Stratified Random Sampling, StRS) 三种监测站点设计对长江口中华鲟自然保护区及周边水域的水温、盐度、溶解氧及化学需氧量 (COD) 等要素的采样效果, 结果显示: 1) 各环境要素插值结果与调查值相近, 普通克里金插值能够较好的模拟出研究区域的“真实”海洋环境状况; 2) 三种采样设计的平均采样效果 (Design Effect, DE) 为: 分层随机采样 > 定点采样 > 简单随机采样; 3) 三种采样设计在水温、盐度和溶解氧数据中分层随机采样效果最好, COD 中的采样效果差别较小。长江口水域的环境要素中, 盐度存在明显的空间分布特征, 因此在今后的综合性调查监测中, 建议优先采用分层随机采样的方法, 以同时满足所有要素的监测需要。

关键词: 长江口; 海洋环境监测; 采样调查设计

Evaluation of the Effect of Different Sampling Designs on Marine Environmental Monitoring in the Yangtze River Estuary

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Abstract: As the estuaries with the richest biodiversity in China, marine environment is very important to study the effects of the population distribution and quantity changes of aquatic organisms in the Yangtze River Estuary. However, in the current comprehensive monitoring survey of the Yangtze River Estuary, there is a lack of optimization process in the design of monitoring stations. In order to evaluate the impact of different sampling designs on the monitoring results of marine environment in the Yangtze River Estuary, the Ordinary Kriging (OK) was used to interpolate the spatial distribution of different marine environmental factors. And sampling effects of Stationary Sampling (SS), Simple Random Sampling (SRS) and Stratified Random Sampling (StRS) on water temperature, salinity, dissolved oxygen and chemical oxygen demand (COD) of the Yangtze River Estuary were compared. The results show that: 1) the environmental factors of interpolation results similar to survey value, OK can better simulate the research area of the "true" Marine environmental conditions; 2) the average Design Effect (DE) of the three sampling designs is as follows: StRS > SS > SRS; 3) the sampling effect of the three sampling designs in COD has little difference, and the StRS is the best among the water temperature, DO and salinity. Salinity has obvious spatial distribution characteristics in the Yangtze River Estuary. In order to meet the monitoring needs of all factors, it is recommended to use StRS in the future comprehensive investigation and monitoring.

Key words: Yangtze River Estuary, Marine environmental monitoring, Sampling design

禁渔前南京长江江豚省级自然保护区渔获物组成及其多样性

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摘要: 生物群落组成是水生生态系统的重要指标, 鱼类和虾类又是江豚重要的饵料来源。根据2018年6月、7月、9月、11月-12月以及2019年1月在南京长江江豚省级自然保护区对干流新济洲江段和江心洲江段开展的5次渔业资源调查, 分析了禁渔前保护区内渔获物组成及鱼类多样性指数。结果显示, 5次渔业调查期共采集并记录渔获物64种, 其中鱼类59种、甲壳类5种。丰富度指数(R)冬季比夏季高; 多样性指数(H')并无季节性差异。

关键词: 长江; 种类组成; 多样性指数; 渔获物

Composition and diversity of catches of Nanjing Finless Porpoise Provincial Natural Reserve before fishing off

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Abstract: Community composition is an important indicator of aquatic ecosystem. Fish and shrimp are important food sources of finless porpoise. According to 5 fishery resource surveys conducted in the Xinjizhou and Jiangxinzhou river sections in Finless porpoise Nature Reserve of Nanjing Yangtze Provincial in June, July, September, November-December of 2018 and January of 2019, we analyzed the catches composition and fish diversity indices before fishing ban. We collected 64 species, including 59 fish species and 5 crustacean species. The richness index (R) in winter was higher than in summer, and there was no seasonal difference in diversity index (H').

Key words: the Yangtze River, species composition, biodiversity index, catches

我国近岸海藻场分布及区系划分

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摘要: 为探明我国近岸潮下带海藻场资源分布现状, 本文以 2018-2019 年全国沿海重点海藻场调查数据为基础, 对海藻场分布特征进行了分析探讨, 并依据水温、优势藻种属性对我国近岸海藻场进行区系划分。结果表明, 我国近岸潮下带海藻场优势种中以马尾藻属 (*Sargassum*) 分布最广, 全国沿岸均有以其为优势种形成的海藻场, 裙带菜属 (*Undaria*) 及海带属 (*Laminaria*) 次之, 其海藻场仅分布在辽宁省及山东省近岸; 我国近岸潮下带海藻场平均生物量为 7.29kg/m², 平均覆盖度为 41.25%, 由北向南, 优势藻种株高、湿重随纬度降低逐渐减少, 海藻场分布水深由北向南逐渐递减, 海南省近岸海藻场水深约 6m 以下; 结合海藻场水温特征、优势藻种温度属性及其分布特征, 可将我国近岸潮下带海藻场类型具体划分为温带温水型海藻场、亚热带暖水型海藻场及热带暖水型海藻场。

关键词: 海藻场, 潮下带, 分布特征, 区系划分, 优势种

Distribution and flora division of key seaweed beds in the coastal subtidal zone of China

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Abstract: In order to ascertain the current distribution of seaweed beds resources in the coastal subtidal zone of China. Based on the survey data of key seaweed beds in coastal regions of China from 2018 to 2019, this article analyzed and discussed the distribution characteristics of seaweed beds. And according to the water temperature and the attributes of dominant species, the coastal seaweed beds in China were classified into the flora. The result shows that, *Sargassum* is the most widely distributed among the dominant species in coastal subtidal seaweed beds in China. There are seaweed beds formed by it as the dominant species along the coast of the country. Followed by *Undaria* and *Laminaria*, its seaweed beds are only distributed near the coast of Liaoning Province and Shandong Province. The average biomass of the seaweed beds in the coastal subtidal zone of China is 7.29kg/m², and the average coverage is 41.25%. From north to south, the height and wet weight of dominant species gradually decreases with decreasing latitude. The water depth of the seaweed beds distribution gradually decreases from north to south, and the water depth of the coastal seaweed beds in Hainan Province is below 6m. Combining the water temperature characteristics of seaweed beds, the temperature attributes of dominant species and their distribution characteristics, the types of coastal subtidal seaweed beds in China can be specifically divided into temperate warm water seaweed beds, subtropical warm water seaweed beds, and tropical warm water seaweed beds.

Key words: Seaweed beds, subtidal zone, distribution characteristics, flora division, dominant species

雌二醇和双酚 A 对雄性斑马鱼的脂质沉积、炎症和抗氧化反应具有浓度依赖效应

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摘要: 环境雌激素是重要的污染物, 广泛分布在自然水环境中。本工作通过对雄斑马鱼的生长、性腺发育、脂质组成和代谢、炎症和抗氧化能力等方面的指标检测, 探究不同浓度的环境雌激素雌二醇 (E2) 和双酚 A (BPA), 对斑马鱼的脂代谢、炎症和抗氧化能力的干扰效应。结果显示, 低浓度的 E2 (200 ng/L) 和 BPA (100 mg/L) 处理组与高浓度 E2 (2000 ng/L) 和 BPA (2000 mg/L) 相比较, 前者具有更高的脂合成和积累能力, 而后者则诱发鱼体的炎症和抗氧化反应。BPA 与 E2 相比较, BPA 可更大程度地损害雄鱼的性腺发育, 同时引发严重的脂质过氧化。本研究表明 E2 和 BPA 对雄斑马鱼的毒理影响具有浓度依赖效应, 主要表现为低浓度的环境雌激素显著诱发鱼体脂质沉积, 而高浓度组则引发明显的炎症和抗氧化反应。

关键词: 抗氧化反应; 浓度依赖毒理效应; 环境雌激素类化合物; 炎症; 脂质沉积; 斑马鱼

Concentration-dependent effects of 17 β -estradiol and bisphenol A on lipid deposition, inflammation and antioxidant response in male zebrafish (*Danio rerio*)

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Abstract: Environmental estrogenic compounds are important pollutants, which are widely distributed in natural water bodies. This study investigated the effects of 17 β -estradiol (E2) and bisphenol A (BPA) at low and high concentrations on lipid deposition, inflammation and antioxidant response in male zebrafish. Notably, zebrafish exposed to low concentrations of E2 (200 ng/L) and BPA (100 mg/L) had higher lipid synthesis and deposition compared to high concentrations (2000 ng/L and 2000 mg/L, respectively). However, the high concentrations of E2 and BPA increased inflammation and antioxidant response. Furthermore, BPA caused greater damage to fish gonad development and more severe lipid peroxidation compared to E2. Overall, the results suggest that the toxic effects of E2 and BPA on zebrafish are concentration-dependent such that, the relative low concentrations used induced lipid deposition, whereas the high ones caused adverse effects on inflammation and antioxidant response.

Key words: antioxidant response, concentration-dependent toxicity, environmental estrogenic compounds, inflammation, lipid deposition, zebrafish

孔雀鱼生长、抗氧化防御及同位素组成对微塑料的综合应答

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摘要: 微塑料(MPs)污染成为研究热点,但很少有研究综合多级指标来评估生物体对MPs的应答。在这里,我们将孔雀鱼暴露于MPs 28天。我们发现,孔雀鱼鳃中MPs的积累量高于肠道。MPs对孔雀鱼生长无明显影响,但显著抑制肥满度。孔雀鱼内脏出现氧化应激。Na⁺/K⁺-ATP活性下降,MPs可能干扰鳃的渗透平衡。MPs降低了碳氮比(C:N)和同位素 $\delta^{13}\text{C}$ 值,但对同位素 $\delta^{15}\text{N}$ 无明显影响。最终,通过综合生物标记响应指数(IBR),我们发现过氧化氢酶活性MPs的响应最高,MPs的风险以浓度梯度的方式加剧。这些发现表明,应该采用多元IBR方法来量化MPs对水生生物的影响,特别是对鱼类的影响。

关键词: 微塑料; 氧化应激; 稳定同位素; IBR

Integrated response of growth, antioxidant defense and isotopic composition to microplastics in juvenile guppy (*Poecilia reticulata*)

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Abstract: Microplastics (MPs) pollution becomes a research hotspot, but few have integrated multi-level indicators to assess response to MPs of organisms. Here we exposed guppy (*Poecilia reticulata*) to MPs with two concentrations for 28 days. We found that higher accumulation of MPs appeared in guppy gill than that in gut. MPs had no obvious effect on guppy growth but significantly inhibited the condition factor. Oxidative stress presented in guppy viscera with activated antioxidants. The decline of Na⁺/K⁺-ATP activity in guppy indicated that MPs might interfere with the osmotic balance of gills. MPs reduced body molar ratio of C:N and $\delta^{13}\text{C}$ value, but no apparent impact on $\delta^{15}\text{N}$. It Eventually, through integrated biomarkers response index (IBR) of guppy, we found that catalase activity was the highest index in response to MPs, and the response of growth performance to MPs was lower than that of oxidative stress and element alteration. Risks of MPs aggravated in a concentration-dependent manner. These findings suggested that multi-level IBR approach should be adopted to quantify effects of MPs on aquatic organisms, especially on fish.

Key words: Microparticle; Oxidative stress; Stable isotope; IBR

斑点雀鳊对环境因子耐受性研究

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摘要: 外来物种雀鳊对水域生态系统有着极大的威胁并可能产生严重的社会影响。为探究斑点雀鳊对主要环境因子的耐受性, 研究了不同温度、盐度、酸碱度和干旱胁迫下斑点雀鳊幼鱼的死亡率。实验结果表明, 斑点雀鳊幼鱼对水体温度的耐受范围是 6.5-41.3℃, 高低温的半致死温度分别是 38℃ 和 8.4℃.....

关键词: 斑点雀鳊; 环境因子; 耐受性; 半致死浓度

Study on Tolerance of Spotted Gar to Environmental Factors

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Abstract: The alien species gar poses a great threat to the water ecosystem and may have serious social impacts. In order to explore the tolerance of spotted gar to major environmental factors, the mortality of spotted gar juveniles under different temperature, salinity, pH and drought stress was studied. The experimental results showed that the tolerance range of spotted gar juveniles to water temperature is 6.5-41.3℃, and the half lethal temperature of high and low temperature were 38℃ and 8.4℃, respectively.....

曝气扰动下微囊藻水华浓度和营养盐水平对藻类光合作用的影响

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摘要:已有研究发现曝气扰动可以促进合适浓度的微囊藻水华中出现绿藻、硅/甲藻的生长,为进一步获得适宜的初始微囊藻水华浓度及营养盐浓度对微囊藻水华中藻类演替的影响,在玻璃温室中,研究了曝气扰动条件下不同的初始微囊藻水华浓度和营养盐添加对藻类光合作用的影响.....

关键词:曝气扰动;微囊藻水华;营养盐;硅藻

Effects of *Microcystis* bloom concentration and nutrient levels on algae photosynthesis under aeration disturbance.

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Abstract: In order to further clarify the effect of *Microcystis* concentration and nutrient levels on the algal community structure, an experiment on the photosynthetic activity of different concentrations and nutrient levels of *Microcystis* blooms under aeration disturbance was carried out in a greenhouse, which was based on former study that aeration disturbance can promote the growth of green algae and diatom/dinoflagellate from *Microcystis* blooms of some appropriate concentration.....

Key word: aeration disturbance, *Microcystis* blooms, nutrients, diatom

领域七

濒危水生野生动物保护

基于耳石微化学和群体遗传学的长江中下游 刀鲚洄游生态学研究

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摘要: 刀鲚是一种名贵鱼类。近几十年来长江流域其资源量严重下降, 然而仍缺乏对其生态表型、群体结构的足够了解。本研究首先利用电子探针技术, 分析了长江口、长江镇江段、鄱阳湖的刀鲚群体耳石微化学特征, 反演了其生活史履历。长江口刀鲚可以分为两种生活史模式, 即长期淡水依存型群体(LF)和短期淡水依存型群体(SF)。LF型与镇江段、鄱阳湖刀鲚生活史模式相似, 而SF型的性腺已经达到成熟阶段, 表明其产卵场应该位于近长江口的位置。之后, 用激光烧蚀等离子质谱技术, 分析了耳石核心多元素特征; 同时, 用微卫星遗传标记, 分析了长江口LF型及SF型两个洄游型刀鲚群体与鄱阳湖洄游型群体(PYCN)、淡水定居型群体(PYCB)的遗传结构。SF型与LF, PYCN, PYCB的耳石核心元素特征截然不同, 并具有显著的遗传差异; LF型的耳石核心元素特征与PYCN, PYCB相似, 显示LF型与PYCN、PYCB均为鄱阳湖中孵化的个体, 遗传分析显示LF型与PYCN具有遗传同质性, 耳石与遗传证据均表明了LF与PYCN具有关联性。鄱阳湖中的PYCB与PYCN具有极显著的遗传差异和微弱的基因流, 显示鄱阳湖中洄游与定居型之间具有某种生殖隔离的机制。这可能是不同生态表型适应不同生活环境的结果, 也保证了不同生态表型间的稳定性。

关键词: 刀鲚; 耳石微化学; 微卫星; 群体结构; 洄游生态学

Study on the migration ecology of *Coilia nasus* in the middle and lower reaches of the Yangtze River based on otolith microchemistry and population genetics

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Abstract: The *Coilia nasus* is a highly valuable fish in China. During recent decades the fish resources in the Yangtze River have declined dramatically. However, we still lack adequate information of ecomorphotypes and population structure for conservation. Firstly, we used the electron probe microanalysis to analyze the microchemical signal for reconstructing life history of *C. nasus* from the Yangtze River Estuary (YRE), Zhenjiang Section (ZJ), and Poyang Lake (PY). Those fish can be divided into two different types, i.e., long-term (LF) and short-term (SF) freshwater dependency types. Life history of LF is similar to those of *C. nasus* from ZJ and PY. The gonads of SF have reached mature stages, indicating that its spawning site is close to the YRE. Then, we used laser ablation inductively coupled plasma mass spectrometer to analyze the multi-element characteristics of the otolith cores, and microsatellite genetic marker to explore the spatial and genetic population structure of LF, SF, anadromous *C. nasus* (PYCN) and the freshwater resident *C. brachygnathus* (PYCB) from PY, respectively. The otolith and microsatellite shown a separation between SF and other three populations, and the otolith signal of LF were similar to that of PYCN and PYCB, indicating that all LF, PYCN and PYCB are possibly hatched in the Poyang Lake. In addition, genetic analysis showed that LF and PYCN were genetically homogenous, indicating a connectivity of LF and PYCN. However, the significant genetic differences and weak gene flow between PYCN and PYCB which co-existed in PY shown that there was a reproductive isolation between them. It may be a mechanism for adaptability and stability of *C. nasus* ecomorphotypes.

Key words: *Coilia nasus*; Otolith microchemistry; Microsatellites; Population structure; migration ecology

青海湖裸鲤游泳能力及鱼梯过鱼效果

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摘要: 本研究采用递增流速法对青海湖裸鲤(*Gymnocypris przewalskii*)野生洄游群体和人工养殖 1、2 龄群体的临界游泳速度进行测试, 采用固定流速法和人工模拟鱼梯对野生群体克流能力评估。结果发现: 野生洄游组的绝对临界游泳速度(U_{crit})略高于养殖 1 龄组($P>0.05$); 显著低于养殖 2 龄组($P<0.01$)。养殖 1 龄组、养殖 2 龄组和野生洄游组的相对临界游泳速度(U_{crit}')随体长和年龄的增加呈下降趋势($P<0.01$)。野生洄游组雄鱼的 U_{crit}' 显著高于雌鱼($P<0.01$), 养殖 1 龄组和养殖 2 龄组中不同性别间无显著差异($P>0.05$)。青海湖裸鲤的持续游泳时间与流速呈显著负相关($P<0.01$)。本研究初次评估了青海湖裸鲤的游泳能力及鱼梯通过效果, 以为鱼梯设计优化及青海湖裸鲤洄游群体保护提供技术支持。

关键词: 青海湖裸鲤; 临界游泳速度; 洄游障碍; 鱼梯

The swimming ability of *Gymnocypris przewalskii* and passing effect of fish ladder

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Abstract: Increasing velocity method was adopted to test critical swimming speed of *Gymnocypris przewalskii* wild migratory group and artificial breeding groups the age of 1, 2 in this study, and then by the method of fixed velocity, swimming endurance of *G. przewalskii* was tested, lastly we simulated three-stage fish ladder, calculated and analysed efficiency of fish. The results showed that: The absolute critical swimming speed (U_{crit}) of the wild migration group was slightly higher than that of the 1-age cultured group ($P>0.05$), and lower than that of the 2-age cultured group ($P<0.01$) significantly. The relative critical swimming speed (U_{crit}') of the 1-age cultured group, the 2-age cultured group and the wild migration group showed a decreasing trend with the increase of body length and age ($P<0.01$). The U_{crit}' of male in the wild migratory group was significantly higher than that of female ($P>0.01$), which showed no significant difference between different sex in the 1-age cultured group and the 2-age cultured group ($P<0.01$). In this study, the swimming ability of *G. przewalskii* and the capacity in passing fish ladder were evaluated firstly, which could provide technical support for the design and optimization of fish ladder and the protection of migratory population of *G. przewalskii* in the future.

Key words: *Gymnocypris przewalskii*; Critical swimming speed; migration obstacles, fish ladders

青海湖裸鲤野生亲体自然繁殖的底质需求

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摘要: 本研究通过标志跟踪、视频监控等方法在人工模拟产卵环境和野外自然产卵场对青海湖裸鲤的底质行为偏好性进行了观测。研究表明: 青海湖裸鲤亲体在多种底质环境测试中, 纯卵石底质繁殖效果最佳; 当亲鱼处于卵石、卵石加砂、砂三种不同底质的环境时, 显著偏好停留在纯卵石底质中, 其次为砂质, 最次为卵石加砂底质。而且, 这种栖息偏好无性别差异和昼夜差异。此外, 其繁殖偏好体现于卵石底质的产卵量及受精率要显著高于砂质和卵石加砂底质。经验证, 以上人工产卵环境的行为偏好性与自然产卵场中的体现一致。基于纯卵石河床质上青海湖裸鲤产前持续性游泳并多次重复产卵的事实, 推断卵石底质是诱发自然繁殖发生的主要原因, 本结果可为青海湖裸鲤仿自然繁殖的人工产卵场营造技术提供参考, 也为产卵场保护积累了基础资料。

关键词: 青海湖裸鲤 野生亲体 栖息偏好 繁殖偏好

The bottom quality demand of natural reproduction of wild parent of *Gymnocypris przewalskii* in Qinghai Lake

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Abstract: In this study, the behavior preference of *Gymnocypris przewalskii* was observed in artificial spawning environment and natural spawning ground in the wild by means of marker tracking and video monitoring. The results showed that: the pure pebble substrate had the best reproduction effect in the various sediment environment tests of *Gymnocypris przewalskii*; when the parent fish were in the environment of pebble, pebble with sand and sand, the parent fish preferred to stay in the pure pebble sediment, followed by sand and gravel, and then the gravel and sand sediment. In addition, the fecundity and fertilization rate of pebble sediment were significantly higher than those of Sandy and sandy gravel. After verification, the behavior preference of artificial spawning environment is consistent with that in natural spawning site. Based on the fact that *Gymnocypris przewalskii* continuously swam and laid eggs repeatedly on the pure pebble bed material, it is inferred that the pebble sediment is the main reason for inducing the natural reproduction. The results can provide reference for the artificial spawning ground construction technology of Qinghai Lake *Gymnocypris przewalskii* and accumulate basic data for the protection of the spawning ground.

Key words: *Gymnocypris przewalskii*, Wild parent, Habitat preference, Breeding preference

基于转录组筛选长江鲟营养研究最佳内参基因

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摘要: 为了荧光定量 PCR (qRT-PCR) 在长江鲟 (*Acipenser dabryanus*) 营养研究中的更好应用, 本实验基于转录组筛选长江鲟营养研究的最佳内参基因。转录组测序获得 unigene 179199 个, 筛选到符合条件的内参基因 9 个, 分别是 mPEPCK, Tc1Tase, β -actin, EF2Kase, Mcl1, hH3.3, EF1- α , ttxnip 和 CF2。GAPDH, β -tubulin, B2M, SDHA, HPRT1 和 18s rRNA 也被视为候选内参基因。候选内参基因在餐后的表达稳定性为 EF1- α >hH3.3>CF2> β -actin>18srRNA>B2M>HPRT1>GAPDH>mPEPCK> β -tubulin>Mcl1>SDHA>EF2Kase>ttxnip>Tc1Tase, 禁食复投喂中的稳定性为 EF1- α > β -actin>hH3.3>CF2>HPRT1>B2M>mPEPCK>18srRNA>SDHA> β -tubulin>GAPDH>Mcl-1>EF2Kase>ttxnip>Tc1Tase, 转食过程中的稳定性为 β -actin>GAPDH>EF1- α >CF2>hH3.3>B2M>18srRNA>HPRT1> β -tubulin>Mcl-1>mPEPCK>EF2Kase>Tc1Tase>SDHA>Txnip。加权分析表明, 长江鲟营养研究候选内参基因稳定性为 EF1 α > β -actin>hH3.3>CF2>B2M>18srRNA>HPRT1>GAPDH>mPEPCK> β -tubulin>Mcl1>SDHA>EF2Kase>ttxnip>Tc1Tase。综上, 推荐 EF1 α 和 β -actin 作为 qRT-PCR 在长江鲟营养研究中运用时的内参基因。

关键词: 长江鲟, 营养研究, 荧光定量, 内参基因

Screening suitable reference genes for nutrition studies of the Yangtze sturgeon based on the transcriptome

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Abstract: For better application of qRT-PCR in nutrition research of the Yangtze sturgeon (*Acipenser dabryanus*), this study screened the reference genes for the Yangtze sturgeon based on transcriptome. Transcriptome sequencing obtained 179,199 unigenes, and 9 qualified reference genes were screened, namely mPEPCK, Tc1Tase, β -actin, EF2Kase, Mcl1, hH3.3, EF1- α , ttxnip and CF2. GAPDH, β -tubulin, B2M, SDHA, HPRT1 and 18s rRNA are also considered as candidate reference genes. The expression stability of candidate reference genes is EF1- α >hH3.3>CF2> β -actin>18srRNA>B2M>HPRT1>GAPDH>mPEPCK> β -tubulin>Mcl1>SDHA>EF2Kase>ttxnip>Tc1Tase after a meal, EF1- α > β -actin>hH3.3>CF2>HPRT1>B2M>mPEPCK>18srRNA>SDHA> β -tubulin>GAPDH>Mcl-1>EF2Kase>ttxnip>Tc1Tase in fasting re-feeding, and β -actin>GAPDH>EF1- α >CF2>hH3.3>B2M>18srRNA>HPRT1> β -tubulin>Mcl-1>mPEPCK>EF2Kase>Tc1Tase>SDHA>Txnip during weaning. Weighted analysis showed that the stability of the candidate reference genes was EF1 α > β -actin>hH3.3>CF2>B2M>18srRNA>HPRT1>GAPDH>mPEPCK> β -tubulin>Mcl1>SDHA>EF2Kase>ttxnip>Tc1Tase. In summary, EF1 α and β -actin are recommended as reference genes when qRT-PCR is used in the nutrition research of Yangtze sturgeon.

Key words: Yangtze sturgeon, nutrition research, qRT-PCR, reference gene

银白鱼人工繁殖受精卵附着介质筛选

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摘要: 银白鱼作为仅存于滇池的土著鱼种, 曾是滇池的主要的经济鱼类, 上世纪八十年代后随着城市工业化快速发展, 滇池水质受到严重的污染, 水生态平衡受到破坏, 导致种群数量急剧下降, 目前滇池中现存量极低。2017年, 昆明市水产科学研究所率先独立开展银白鱼人工繁殖及孵化试验, 为了提高银白鱼在人工繁殖过程中的孵化率, 筛选出最利于受精卵孵化的附着介质, 以便为今后开展银白鱼人工繁殖和孵化工作提供有力支撑。通过选取4种受精卵附着介质: 纱窗网、棕片、砾石、瓦片, 观察估算受精率、孵化率, 并记录孵化温度、孵化时长等数据。结果表明, 人工繁殖受精率能够保证在90%左右, 孵化率由高到低的排序为: 纱窗网(64.78%) > 棕片(46.67%) > 砾石(20.00%) > 瓦片(15.45%)。故选择纱窗网作为银白鱼人工繁殖工作中受精卵附着介质, 并前做好消毒工作, 是可取的。

关键词: 滇池; 银白鱼; 人工繁殖; 孵化率

Selection of attachment media for fertilized eggs in artificial reproduction of *Anabarilius alburnops*

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Abstract: As the only indigenous fish species in Dianchi Lake, *Anabarilius alburnops* was once the main economic fish in Dianchi Lake. With the rapid development of urban industrialization After the 1980s, the water quality of Dianchi Lake was seriously polluted, and the water ecological balance was destroyed, leading to a sharp decline in the population. At present, the stock in Dianchi Lake is extremely low. In 2017, Kunming Fisheries Research Institute took the lead in independently carrying out artificial reproduction test and hatching test of *Anabarilius alburnops*. In order to improve the hatching rate of *Anabarilius alburnops* in the process of artificial reproduction, the adhesive medium most conducive to fertilized egg hatching was screened out, so as to provide strong support for future artificial reproduction and hatching work of *Anabarilius alburnops*. Four kinds of fertilized eggs adhesion media were selected: screen mesh, palm slices, gravel and tile. The fertilization rate and hatching rate were observed and estimated, and the incubation temperature and incubation time were recorded. The results showed that the fertilization rate of artificial propagation was about 90%. The order of hatching rate from high to low was as follows: screen mesh (64.78%) > palm slices (46.67%) > gravel (20.00%) > tile (15.45%). Therefore, it is advisable to select the screen mesh as the attachment medium of fertilized eggs in the artificial propagation of *Anabarilius alburnops*, and do a good job of disinfection before.

Key words: Dianchi, *Anabarilius alburnops*, artificial reproduction, hatchability

长江刀鲚生殖洄游过程中血清能量代谢的变化

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摘要: 为了解长江刀鲚(*Coilia nasus*)生殖洄游过程中能量代谢的变化, 本研究对崇明、镇江、安庆段长江刀鲚血清生化参数及游离脂肪酸含量进行分析。研究结果显示, 相比于崇明水域, 镇江水域长江刀鲚血清总蛋白含量和甘油三酯含量显著降低($P<0.05$), 游离脂肪酸含量显著升高($P<0.05$), 葡萄糖含量、总胆固醇和低密度脂蛋白胆固醇含量在整个洄游过程均无显著性变化; 安庆水域长江刀鲚性腺从Ⅱ期发育到Ⅳ期过程, 血清中葡萄糖、总蛋白、游离脂肪酸、总胆固醇、高密度脂蛋白胆固醇和低密度脂蛋白胆固醇含量均无显著性差异; 甘油三酯含量从Ⅲ期到Ⅳ期显著性升高($P<0.05$)。本研究表明, 长江刀鲚生殖洄游过程中可维持稳定的能量代谢水平, 并以糖原和脂肪作为代谢能源, 且主要供能物质是脂肪。

关键词: 长江刀鲚; 生殖洄游; 血糖; 能量代谢

Changes of serum energy metabolism index in *Coilia nasus* during spawning migration

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Abstract: In order to understand the changes in the energy metabolism of *Coilia nasus* in the Yangtze River during the spawning migration, this study analyzed the biochemical parameters and the content of free fatty acids in the serum of *C. nasus* in Chongming, Zhenjiang and Anqing sections. Results show that compared with chongming waters of the Yangtze *C. nasus*, which migrates to zhenjiang, the total protein content and triglyceride content of *C. nasus* serum significantly decreased ($P<0.05$), the free fatty acid content significantly increased ($P<0.05$), and the glucose content, total cholesterol and low-density lipoprotein cholesterol showed no significant difference in the whole migration process. As the gonads developed from stage II to IV in Anqing, serum glucose, total protein, free fatty acids, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol levels had no significant difference; Triglyceride levels from stage III to IV have significantly increased ($P < 0.05$). This study indicated that the *C. nasus* could maintain a stable level of energy metabolism during the whole migration process, and took glycogen and fat as metabolic energy, and the main energy-supplying substance was fat.

Key words: *Coilia nasus*, spawning migration, serum glucose, Energy metabolism

新疆克孜勒河厚唇裂腹鱼人工繁殖、胚胎发育和早期仔鱼发育研究

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摘要: 2019年4~5月通过厚唇裂腹鱼 *Schizothorax irregularis* 人工繁殖试验, 催产厚唇裂腹鱼亲鱼35组, 获受精卵20.7万粒, 获水花鱼苗14.12万尾; 厚唇裂腹鱼的繁殖期在新疆南疆地区主要集中在4月下旬至5月中旬, 水温(17.14±0.01)℃的条件下, 其胚胎发育过程经历胚盘、卵裂、囊胚、原肠胚、神经胚、器官形成和出膜7个阶段; 早期仔鱼发育分为眼球色素出现期、体色素出现期、鳔充气期和卵黄囊完全吸收期这4个时期, 出膜后432h, 卵黄囊完全吸收, 仔鱼全长为(21.51±0.75)mm。本研究通过对厚唇裂腹鱼进行人工繁殖试验, 了解厚唇裂腹鱼的胚胎和早期仔鱼发育特征, 为其资源保护提供科学依据。

关键词: 克孜勒河; 厚唇裂腹鱼; 人工繁殖; 胚胎发育; 早期仔鱼发育

Study on the artificial propagation technology, embryonic and early larval development of *Schizothorax irregularis* in the Kizil River in Xinjiang

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Abstract: In April to May 2019, through artificial propagation test of *Schizothorax irregularis* we obtained 35 pair spawning fish, 20.7 million eggs and 14.12 million fries. Spawning season of *S. irregularis* was mainly range from late of April to middle of May in the Southern Xinjiang, Under the condition of water temperature of (17.14±0.01)℃ the embryonic development process experienced seven stages: embryo disc, cleavage, blastocyst, gastrula, neuroembryo, organ formation and membrane formation; , the fertilized eggs were hatched for 147h and 31min. The development of the early larvae was divided into four stages: eye pigmentation increasing period, body pigmentation increasing period, air bladder inflated period, yolk sac absorbed completely. After 432 h, the yolk sac was completely absorbed, and the total length of the larva was (21.51±0.75) mm. In this study, the artificial reproduction experiment was conducted on *Schizothorax irregularis* so as to understand the developmental characteristics of embryos and early larvae of *Schizothorax irregularis* and provide scientific basis for resource protection.

Key words: The Kizil River, *Schizothorax irregularis*, Artificial propagation, Embryonic development, Early larval development

新疆克孜尔河斯氏高原鳅繁殖生物学研究

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摘要: 2018年于新疆克孜尔河拜城县黑英山乡河段采集30尾斯氏高原鳅 *Triplophysa stoliczkae*, 对其繁殖生物学进行研究, 结果表明: 性成熟时雄鱼胸鳍略尖且变厚; 雌鱼胸鳍钝圆。性成熟雄鱼体色较深, 背部斑纹呈马鞍型, 分界明显; 雌鱼胸鳍上无明显变化体色较淡, 身体长形, 背部斑纹分界明显。除5条未辨性别外, 雌雄鱼性比为1:1.08(N=25)。最小性成熟年龄均为2龄, 雌性最小性成熟个体体长46.19 mm, 体质量10.20 g; 雄性最小性成熟个体体长49.55 mm, 体质量11.60 g。观察鱼类性腺及卵径分布图得知, 属于一次产卵类型。其绝对繁殖力为2362±1066粒, 相对繁殖力301±112粒/g。绝对繁殖力与体长关系式: $F=0.0003 L^{3.9486}$ ($R^2=0.9008$), 绝对繁殖力与体重关系式: $F=169.38 W-518.21$ ($R^2=0.9223$); 相对繁殖力与体长关系式: $F=0.0011 L^{3.1094}$ ($R^2=0.914$), 相对繁殖力与体重关系式: $F=19.441+16.603 W$ ($R^2=0.8023$)。

关键词: 克孜尔河; 斯氏高原鳅; 繁殖生物学; 性比; 繁殖力

Study on the Reproductive Biology of the *Triplophysa stoliczkae* in the Kezier River in Xinjiang

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Abstract: In 2018, 30 *Triplophysa stoliczkae* were collected from Heiyingshan Township, Baicheng County, Kizil River, Xinjiang, and their reproductive biology was studied. The results showed that the pectoral fin of male fish was slightly pointed and thickened, while that of female fish was blunt and round. The body color of the sexually mature male fish is deep, and the dorsal markings are saddle shaped, and the boundary is obvious; there is no obvious change on the pectoral fin of the female fish, the body color is lighter, the body is long, and the boundary of the back stripes is obvious. The sex ratio of male to female was 1:1.08 (n=25), except for 5 unidentified fish. The minimum age of sexual maturity was 2 years old. The female was 46.19 mm in length and 10.20 g in weight; the male was 49.55 mm in length and 11.60 g in weight. According to the distribution of gonad and egg diameter, it belongs to the type of one-time spawning. The absolute fecundity was 2362±1066 grains and the relative fecundity was 301±112 grains/g. The relationship between absolute fecundity and body length: $F=0.0003 L^{3.9486}$ ($R^2=0.9008$), absolute fecundity and body weight: $F=169.38 W-518.21$ ($R^2=0.9223$); relative fecundity and body length: $F=0.0011 L^{3.1094}$ ($R^2=0.914$), relative fecundity and body weight: $F=19.441+16.603 W$ ($R^2=0.8023$).

Key words: Kizil River, *Triplophysa stoliczkae*, Reproductive biology, Sex ratio, Fecundity

热带气旋影响下嵊泗贻贝养殖海域 风浪特征与分布模型

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摘要: 为满足嵊泗海洋牧场建设和环境监测工作的需要, 本文利用 2000~2018 年中国气象局提供的热带气旋路径资料、风场和海浪环境因子的实测与遥感数据, 分析热带气旋对嵊泗海洋牧场海域风浪的变动规律, 建立风浪联合分布概率模型。结果表明, 影响浙江沿海热带气旋的移动路径有 4 种类型, 7~9 月是浙江沿海热带气旋盛行期。年累积气旋能量呈波动状态, 月累积气旋能量逐月增加, 8 月达到峰值。热带气旋影响范围内, 嵊泗海洋牧场平均风速达 24.59 m/s。热带气旋中心与嵊泗马鞍列岛海域间平均距离和对应的风速和有效波高均值具有显著线性关系。嵊泗海洋牧场海域在热带气旋活动过程中导致的极值风速与有效波高分布符合 Gumbel 联合概率分布模型。嵊泗海洋牧场自 2000 年后经历最强热带气旋“梅花”产生的风浪重现期是 11.20 年。鉴于 2020 年及往后 1~2 年间已达“梅花”强度级别的热带气旋重现期, 本文提出嵊泗海洋牧场海域近几年急需对热带气旋灾害做足预警减灾准备。

关键词: 台风; 海洋牧场; 浮筏养殖; 渔业互助险; 厄尔尼诺

Characteristics and distribution model of wind and wave in Shengsi mussel culture area under the impacts of tropical cyclones

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Abstract: The paths of tropical cyclones could be divided into four types. High frequency of tropical cyclones were found between July and September. The annual accumulated cyclone energy (ACE) was slight variations, with ACE peaking in August. The average wind speed of Shengsi marine ranching was 24.59 meters per second during tropical cyclones' impacts. There was a significant linear relationship between the mean distance of tropical cyclone center and study area and wind speed and significant wave height, respectively. The extreme wind speed and significant wave height distribution caused by the tropical cyclone in Shengsi marine ranching conforms to the Gumbel joint probability distribution model. Since 2000, Shengsi marine ranching experienced the strongest tropical cyclone is Muifa. According to the wind speed and significant wave height joint cumulative probability model calculation, the wind wave recurrence period of Muifa is 11.20 years with sever intensity. In view of the tropical cyclone recurrence period of Muifa intensity in 2020 and the next 1-2 years, this paper points out that it is urgent to prepare for tropical cyclone disaster in Shengsi marine ranching in recent years.

Key words: typhoon; marine ranching; raft culture; fishery mutual insurance; El nino

基于线粒体 D-loop 控制区序列分析新疆额尔齐斯河北极茴鱼种群遗传多样性分析

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摘要: 本研究采用线粒体 DNA (mtDNA) D-loop 控制区为分子标记, 对分布于新疆额尔齐斯河 10 个地理群体共 161 个样本, 北极茴鱼 D-loop 控制区序列长度为 1 072 bp。共检测到 13 个变异位点和 17 个单倍型; 单倍型多样性为 0.477~0.848, 核苷酸多样性为 0.00089~0.00288; 上游群体 (喀拉额尔齐斯河、卡伊尔特河) 以克兰河为界不与下游群体有共享单倍型; 上游群体与下游群体间 N_m 为 0.67474, 基因流动存在障碍, 根据分子方差分析 (AMOVA) 显示遗传变异主要来源于种群间, 群体间呈高度遗传分化水平 ($F_{st} = 0.53334$, $P < 0.05$); 中性检验 Tajima's D 值与 Fu's F_s 值结果均不显著; 不配对分布显示 SSD、 H_{ir} 值均偏离种群扩张模型, 表明种群没有经历过扩张现象。基于以上研究结果, 推测北极茴鱼单倍型分布与地理群体间形成明显的对应关系可能是由于地理隔离导致短时间内种群间基因交流减少造成的, 并且与北极茴鱼有限的扩散行为与很强的繁殖洄游特性以及对生境的选择要求较高相关。

关键词: 北极茴鱼; D-loop 控制区; 遗传分化; 系统进化

Analysis of Genetic Diversity of *Thymallus arcticus arcticus* (Pallas) Populations From the Irtysh River Based on D-loop Sequence

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Abstract: In this study, a total of 161 samples of Arctic grayling D-loop sequence length was 1 072 bp in the 10 geographical groups. There are 13 mutation sites and 17 haplotypes, and the haplotype diversity was from 0.477 to 0.848, and the nucleotide diversity was from 0.00089 to 0.00288. The research also indicates that the upstream bounded by Kelan don't share haplotypes with the downstream, and the N_m is 0.67474, and there are many obstacles for gene flow. According to the AMOVA, the genetic variation mainly comes from among populations, and there is a high level of genetic differentiation among populations ($F_{st} = 0.53334$, $P < 0.05$). The results of Tajima's D value and Fu's F_s value are not significant. And unpaired distribution shows that both the SSD and H_{ir} values deviate from the population expansion model. It is speculated that the obvious correspondence between the haplotype distribution of Arctic grayling and geographic populations may be caused by the decrease in gene exchanges between populations due to geographical isolation in a short period of time, and It has a higher correlation with the limited spreading behavior and strong reproductive migration characteristics and higher requirements for habitat selection.

Key words: *Thymallus arcticus arcticus* (Pallas), D-loop control, genetic differentiation phylogenetics

不同材质的人工鱼巢对中臀拟鲮 孵化效果的影响

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摘要: 为比较不同人工鱼巢对中臀拟鲮孵化效果的影响, 2017年6-7月在相同水温条件下开展了中臀拟鲮受精卵对不同材质的人工鱼巢的附着率、孵化时间、孵化率的对比实验。实验分别选用四种不同材质的人工鱼巢, 分别为棕榈片鱼巢、人工草皮鱼巢、瓦片鱼巢、塑料网片鱼巢放置于水泥池中开展相同水温条件下中臀拟鲮受精卵孵化效果对比实验。结果表明:在20-21.5℃水温条件下, 中臀拟鲮受精卵附着率依次为塑料网片>棕榈片>人工草皮>瓦片, 孵化率依次为棕榈片>塑料网片>瓦片>人工草皮, 棕榈片孵化时间最短, 人工草皮孵化时间最长。结果分析发现, 中臀拟鲮受精卵孵化材质选用棕榈片鱼巢的孵化效果相对较为理想。

关键词: 中臀拟鲮; 人工鱼巢; 孵化效果

Effects of artificial fish nests with different materials on hatching effect of Dianchi lake bullhead

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Abstract: to compare the effects of different artificial fish nests on the hatching effect of Dianchi lake bullhead, a comparative experiment on the adhesive rate, hatching time and hatching rate of artificial fish nests with different materials was carried out under the same water temperature from June to July, 2017. 4 kinds of artificial fish nests with different materials were selected, such as palm slice fish nest, artificial grass fish nest, tile fish nest and plastic net fish nest, respectively. They were placed in the cement pool to carry out the comparative experiment on hatching effect of Dianchi lake bullhead fertilized eggs under the same water temperature condition. The results showed that: under the water temperature of 20-21.5 °C, the adhesive rate of fertilized eggs from high to low was as follows: plastic net > palm slice > artificial grass > tile, and the hatching rate from high to low was as follows: palm slice > plastic net > tile > artificial grass. The hatching time of palm slice was the shortest and the hatching time of artificial grass was the longest. The results showed that the hatching effect of palm slice fish nest was relatively ideal.

Key words: Dianchi lake bullhead, Artificial fish nest, hatching effect

大银鱼不同发育时期的转录组分析

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摘要: 为探讨大银鱼不同发育时期肠道组织基因表达变化, 利用高通量测序技术对大银鱼内源性营养期、混合营养期和外源性营养期等不同发育时期的肠道组织进行 RNA-Seq 分析。共筛选到 9561 个差异基因, 其中 5605 个上调基因, 3956 个下调基因。Gene Ontology (GO) 功能聚类分析表明, 差异基因主要富集在膜、结合和细胞过程生物学通路中, 且上调基因主要富集在发育过程和催化活性, 以利于细胞的分化发育。KEGG 功能富集分析结果表明, 差异基因主要富集在光传导、氮代谢、蛋白质消化与吸收、视黄醇的新陈代谢和味觉转导通路中, 表明大银鱼的感光系统和消化系统在发育过程中起重要作用。本文通过全面分析大银鱼不同发育时期肠道组织基因表达变化, 为深入了解大银鱼肠道组织发育调控分子机理和相关功能基因提供了重要的基因数据资源。

关键词: 大银鱼, 转录组分析, 差异表达基因, 消化系统

Transcriptome analysis of *Protosalanx chinensis* at different developmental stages

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Abstract: To better understand the gene expression changes of different developmental stages in *Protosalanx chinensis*, transcriptome sequencing and gene expression analysis were adopted to investigate differentially expressed genes by using RNA sequencing approach. A total of 9561 differential genes were identified, including 5605 up-regulated genes and 3956 down-regulated genes. The Gene Ontology classification showed that, the differentially expressed genes were mostly enriched in the biological pathways of membrane, binding and cell process, and the up-regulated genes were mostly enriched in the development process and catalytic activity, which was beneficial to the differentiation and development of cells. KEGG pathway analysis revealed that the differential genes were mostly enriched in light conduction, nitrogen metabolism, protein digestion and absorption, retinol metabolism and taste transduction pathway, indicating that the photosensitive system and digestive system play an important role in the development of *Protosalanx chinensis*. In this study, through a comprehensive analysis of the changes of gene expression in intestinal tissue of *Protosalanx chinensis* at different developmental stages. It provides important genetic data resources for in-depth understanding of the molecular mechanism of intestinal tissue development regulation and related functional genes.

Key words: *Protosalanx chinensis*, transcriptome analysis, differentially expressed genes, digestive system

鲟鱼实验养殖自动投饲系统的设计与试验

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摘要: 为了提高鲟鱼养殖实验中投饲的定时、定量精度, 简化投饲步骤, 精细化控制水流与喂食、排污的配合, 减少饲料浪费, 降低研究人员的劳动强度。本实验利用新型 PLC, 螺旋杆送料机构, 减速电机, 自制撒料盘, 液位传感器, 自制水流发生器, 电动阀, 自制虹吸动态排污装置, 设计制作了一套鲟鱼实验养殖自动投饲系统。该投饲系统包括自动喂食系统, 自动排污系统及水水流调控系统三个子系统。进行了实验鱼的养殖及设备性能测试, 结果表明: 改系统子系统间可通过简易 PLC 来进行相互的配合, 可模拟人工养殖实验的方式, 自动进行喂食前水流调控及自动投饲后的自动排污步骤, 其中投饲机投饲能力 0.3kg/min, 投饲量误差在 ± 0.6 以内, 撒料均匀度高。

关键词: 水产养殖; 设备; 投饲机; 自动投饲; 自动排污系统; 实验养殖; PLC

Design and Experiment of Automatic Feeding System for Sturgeon Experimental Breeding

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Abstract: In order to improve the accurate of timing and quantitative in sturgeon breeding experiments, simplify feeding steps, finely control the coordination of water flow, feeding, and sewage, reduce feed waste and the labor intensity of researchers. In this experiment, a new type of PLC, auger feeding mechanism, geared motor, self-made sprinkler, water level sensor, self-made water flow generator, electric valve, self-made siphon dynamic sewage discharge device, designed and produced a set of automatic feeding system for sturgeon experimental breeding. The feeding system includes three subsystems: an automatic feeding system, an automatic sewage system and a water flow control system. The experimental fish breeding and equipment performance tests showed that the system subsystems can cooperate with each other through a simple PLC, which can simulate the way of artificial breeding experiments, and automatically adjust the water flow before feeding and automatic after feeding. In the sewage discharge step, the feeding capacity of the feeding machine is 0.3kg/min, the feeding amount error is within ± 0.6 , and the feeding uniformity is high. It can achieve the purpose of refined experimental breeding, eliminating the repeated labor of researchers in breeding experiments.

Key words: Aquaculture; equipment; feeding machine; automatic feeding; automatic sewage system; experimental breeding; PLC

中臀拟鲢仿生态自然繁殖方法研究

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摘要: 中臀拟鲢是云南土著鱼, IUCN 红色名录 2008 年已将其评估为极危(CR), 为保护其资源, 探索研究仿生态繁殖方法, 开展了中臀拟鲢仿生态自然繁殖研究。根据中臀拟鲢的生物学特性, 人为地建造适合中臀拟鲢生长发育的模拟自然的生态环境, 再加上科学饲养管理, 促使中臀拟鲢自然繁殖。运用仿生态自然繁殖可以起到保护中臀拟鲢、保护云南土著鱼的作用。2017 年 6 月先后开展中臀拟鲢仿生态繁殖 2 批, 繁殖亲鱼 60 组, 产卵雌鱼 55 尾, 5 尾未产卵; 共计产卵 8250 粒, 受精卵 7600 粒, 平均受精率 92.1%; 孵出鱼苗 4400 尾, 平均孵化率 70.6%。仿生态繁殖取得较好效果。

关键词: 中臀拟鲢; 仿生态; 繁殖方法

Study on natural breeding methods in imitation of ecology of Dianchi lake bullhead

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Abstract: Dianchi Lake Bullhead is an indigenous fish in Yunnan province. It has been assessed as critically endangered (CR) in the RED list of IUCN in 2008. In order to protect its resources, explore and study methods of imitation of ecology and carry out the study on natural breeding of Dianchi Lake Bullhead. According to the biological characteristics of Dianchi Lake bullhead, a simulated natural ecological environment suitable for the growth and development of Dianchi Lake bullhead was artificially constructed, and scientific breeding management was also carried out to promote the natural breeding of Dianchi Lake bullhead. The use of ecological-like natural breeding can protect Dianchi Lake Bullhead and yunnan indigenous fish. In June 2017, two batches of Dianchi Lake Bullhead ecologically simulated breeding were carried out, and 60 parent fish groups were bred. There were 55 spawning females and 5 non-spawning females. A total of 8,250 eggs were laid and 7,600 were fertilized, with an average fertilization rate of 92.1%. 4400 fry were hatched, with an average hatching rate of 70.6%. Good results have been obtained in imitating ecologic breeding.

Key words: Dianchi lake bullhead, imitation of ecology, breeding methods

秦岭山区大鲵保护策略分析——基于水域生态测评方法

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摘要: 中国大鲵 (*Andrias davidianus*) 是我国特有物种, 也是濒危动物, 十分珍稀, 尽管如此, 人为捕猎大鲵现象仍然时有发生, 对大鲵栖息地环境的破坏也屡禁不止, 因此对野生大鲵的资源保护工作刻不容缓。秦岭山区是我国大鲵最大的自然适生地, 然而, 在保护策略方面, 之前的举措, 如对遗传背景不清的大鲵大规模放生, 可能会扰乱野生种群基因, 带来生态风险, 对大鲵野生物种的保护产生负面影响。本文对秦岭山区大鲵保护现状进行了生态学野外调研, 主张不应盲目放流大鲵, 而应当控制规模, 考虑生态容纳量, 如大鲵生存所需的隐蔽场所、食物资源以及繁殖洞穴等因子。还应对野生大鲵进行标记, 确认其遗传背景, 建立背景清晰, 身体健康的当地养殖种群, 再将成年后代放归自然。

关键词: 秦岭山区; 中国大鲵; 生态分析; 保护

Analysis on protection strategy of giant salamander in Qinling mountain area—based on assessment method of water area ecology

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Abstract: Chinese giant salamander (*Andrias davidianus*) is an endemic species and endangered animal in China. The resource protection of wild *Andrias davidianus* cannot be delayed. Qinling mountain area is the largest natural habitat for *Andrias davidianus* in China. However, in terms of conservation strategies, previous measures, such as releasing giant salamander with unclear genetic background, may disrupt the gene of wild population, bring ecological risk, and have a negative impact on the protection of wild giant salamander species. In this paper, the present situation of giant salamander protection in Qinling mountain area was investigated. It was suggested that the giant salamander should not be released blindly, but the scale should be controlled and the ecological capacity should be considered. The wild giant salamander should also be labeled to confirm its genetic background, establish a local breeding population with clear background and healthy body, and then release the adult offspring to nature.

Key words: Qinling mountain area, Chinese giant salamander, Ecological analysis, Protection

不同地理种群叶尔羌高原鳅形态差异分析

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摘要: 为探究不同地理种群叶尔羌高原鳅形态差异及适应分化, 进一步保护塔里木河特有鱼类资源。采用传统形态学与框架形态学方法, 对叶尔羌高原鳅塔里木河 (TH)、叶尔羌河 (YH) 及和田河 (HH) 3 个地理种群 11 个传统可量性状和 22 个框架可量性状进行多元统计分析。结果显示: 三个不同地理种群叶尔羌高原鳅所有可量性状中, 除胸鳍起点到吻端外, 其它形态特征均存在显著差异 ($P < 0.05$); 前三个主成分贡献率分别为 49.169%、7.470%、5.548%, 累计贡献率达 62.188%; 构建判别方程并进行交互验证, 综合判别率为 92.375%, 识别度较高; 聚类分析与主成分分析结果一致, 叶尔羌河群体与塔里木河群体先汇为一支, 最后与和田河群体汇为一支。研究表明: 不同地理种群的叶尔羌高原鳅形态差异较为明显, 生长趋势不同, 这与栖息水域环境、饵料结构等密切相关, 可能存在一定的适应和进化。

关键词: 叶尔羌高原鳅; 传统形态学; 框架形态学; 多元统计分析

Analysis of morphological differences among different geographic populations of *Triplophysa yarkandensis*

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Abstract: In order to explore the morphological differences and adaptive differentiation among different geographic populations of *Triplophysa yarkandensis*, protect the endemic fish resources of Tarim River. Using traditional morphological and frame morphological methods, the multivariate statistical analysis was carried out on 11 traditional quantitative traits and 22 frame quantitative traits of the Tarim River (TH), Yarkand River (YH) and Hotan River (HH) populations of the *Triplophysa yarkandensis*. The results showed that there were significant differences in all the quantitative traits except from the pectoral fin origin to the rostral end in the three different geographic populations of *Triplophysa yarkandensis* ($P < 0.05$). The contribution rate of the first three principal components is 49.169%, 7.470% and 5.548% respectively, with a cumulative contribution rate of 62.188%. The discriminant equation was constructed and the comprehensive discriminant rate was 92.375%, indicating a high recognition rate. Cluster analysis and principal component analysis show that the YH and TH converge to one group at first, and finally to the HH population. The research indicated that there were obvious morphological differences among different geographic populations, which were closely related to the environment and feed structure, and there might be some adaptation and evolution.

Key words: *Triplophysa yarkandensis*; Traditional morphology; Frame morphology; Multivariate statistical analysis

船舶噪声对葛洲坝下至梅子溪江段 鱼类资源分布的影响

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摘要: 为了研究噪声对鱼类资源分布的影响, 以便更好的保护长江水生生物, 本实验利用 C55 型水听器对葛洲坝下-梅子溪江段的船舶噪声进行录制并记录声压级, 采用 DT-X 型鱼探仪对江段内鱼类资源分布进行追踪探测。结果发现: 在葛洲坝下-梅子溪江段, 船舶噪声主要分布在葛洲坝下至喜长江大桥江段, 该江段是来往船舶通行的主要地区, 最大声压级可达 164.99dB, 鱼类资源的分布随噪声声压级的增大呈减少趋势; 在临江坪地区和隔流堤左岸, 少有船舶通航, 噪声相对较小, 鱼类资源分布显著增多。鱼类资源分布与船舶噪声呈显著负相关关系 ($P<0.01$)。本研究初步评估了噪声对鱼类资源分布的影响, 以期为后续保护区的规划及环境评估提供技术支持。

关键词: 船舶噪声, 鱼类资源分布, 噪声影响

The influence of ship noise on the distribution of fish resources in Gezhoubaxia to Meizixi section

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Abstract: In order to study the impact of noise on the distribution of fish resources, so as to better protect the aquatic life of the Yangtze River, a C55 hydrophone was used to record the sound pressure level of ship noise in the Gezhouba-Meizixi section, DT-X type fish finder tracks was used to detect the distribution of fish resources in the river section. The results showed that: In the Gezhouba-Meizixi section, ship noise is mainly distributed from the Gezhouba section to the Xichang River Bridge section. This section is the main area for ships to pass, and the maximum sound pressure level can reach 164.99dB. With the increase of noise sound pressure level, there is a decreasing trend in the distribution of fish resource; there are few ships passed Linjiangping area and the left bank of the dike, the noise is relatively small, the distribution of fish resources is more. The distribution of fish resources has a significant negative correlation with ship noise ($P<0.01$). This study initially assessed the impact of noise on the distribution of fish resources, with a view to providing technical support for the subsequent planning and environmental assessment of the protected area.

Key words: ship noise, fish resource distribution, influence of noise

基于线粒体 DNA12S rRNA 基因序列分析 黑龙江流域杂色杜父鱼种群遗传多样性

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摘要: 本研究采用线粒体 DNA (mtDNA) 12S rRNA 基因为分子标记, 对黑龙江 4 个水域 10 个地理群体的杂色杜父鱼(*Cottus poecilopus*)共 66 个样本进行遗传多样性研究。获得 12S rRNA 基因有效序列长度为 788 bp, 总体为高单倍型多样性 (0.903) 低核苷酸多样性 (0.01506), 单倍型多样性中鸭绿江(0.667)>黑龙江水域(0.445)>松花江水域(0.310)>图们江水域(0.000); 10 个地理群体中单倍型的分布与地理位置形成了较为明显的关系, 特有单倍型占单倍型总数的 77.78%; 分子方差分析 (AMOVA) 显示遗传变异主要来源于种群之间, 群体间呈高度遗传分化水平 ($F_{st} = 0.82405$, $P < 0.01$); 中性检验 (Tajima's D 、Fu's F_s) 和核苷酸不配对 (SSD、 H_{ir}) 结果不显著, 表明种群未发生过扩张。以上研究证实 10 个群体间的基因流动存在障碍, 水域系统的隔离及同一河流中各地点水文情势不同等生态屏障是导致杂色杜父鱼生殖隔离的主要原因。

关键词: 杂色杜父鱼; 12S rRNA 控制区; 分子标记; 遗传多样性

Analysis of Genetic Diversity of *Cottus poecilopus* Population in Heilongjiang River Basin Based on mtDNA 12S rRNA Gene Sequence

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Abstract: Using 66 samples of *Cottus poecilopus* distributed in 4 waters of the upper reaches of Heilongjiang. The effective sequence length of the 12S rRNA gene obtained was 788 bp, the overall haplotype diversity (0.903) and the oligonucleotide diversity (0.01506), the distribution of haplotypes in 10 geographic groups has a clear relationship with geographical location. The unique haplotypes account for 77.78% of the total haplotypes; AMOVA shows that the genetic variation is mainly derived from Among populations, a high level of genetic differentiation between populations ($F_{st} = 0.82405$, $P < 0.01$); neutral test (Tajima's D , Fu's F_s) and nucleotide mismatch (SSD, H_{ir}) results were not significant, indicating that the population did not occur Over-expansion. There are obstacles in the gene flow between 10 groups of *C. poecilopus*. It is speculated that the isolation between water systems and the different hydrological in the same river cause the reproductive isolation of *C. poecilopus*.

Key words: *Cottus poecilopus*, 12S rRNA controlled region, molecular markers, genetic diversity

南海砗磲人工繁育中培技术 体系构建及其应用

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摘要: 砗磲是一种热带海洋贝类, 是一种战略生物资源, 它是珊瑚礁生态系统中主要框架物种, 对于维持珊瑚礁生物多样性、生态系统稳定起到积极关键作用。我们突破了砗磲人工规模化繁育技术、中间育成技术, 在我国南沙群岛、西沙群岛、蜈支洲岛开展了底播增殖工作。发明了“无应激法植入虫黄藻技术”将国际上不足 1% 的变态率提高至 30% 以上, 填补了国际空白。在此基础上, 开展了砗磲遗传育种工作, 进行了砗磲的定向选育、家系构建、个体间杂交、群体杂交、种间杂交、属间杂交等育种工作, 培育出蓝紫色外套膜新品系 1 个, 杂交新品系 1 个。本研究为砗磲繁育养殖及其新品种培育工作奠定了实践基础。

关键词: 砗磲; 人工繁育; 中间培育; 底播增殖

Construction and Application of Artificial Breeding and Culture Technology System for giant clam in South China Sea

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Abstract: Giant clam is a strategic biological resource as a tropical marine shellfish, which is the main frame species in coral reef ecosystem and plays a positive role in maintaining coral reef biodiversity and ecosystem stability. We have broken through the artificial breeding technology, grow-out breeding technology. On this basis, the bottom seeding and multiplication work was carried out in Nansha Islands, Xisha Islands and Puzhizhou Island, and the core culture area was constructed. In the world, we took the lead in carrying out the genetic and breeding work, such as directional breeding, pedigree construction, interindividual hybridization, population hybridization, interspecific hybridization, intergeneric hybridization and so on. Two strains of giant clams were cultured, it provided a base on genetic breeding for giant clams.

Key words: Giant clam; Artificial breeding; Grow-out satge; Bottom propagation

保山裂腹鱼人工繁殖试验

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摘要: 为积累和丰富保山裂腹鱼人工繁殖生物学资料, 保护保山裂腹鱼种质资源及扩大其种群数量, 进而开展规模化人工养殖及增殖放流开发研究, 用促黄体素释放激素 A2 (LRH-A2)、注射用绒毛膜促性素 (HCG) 对 3 组 (3 雌 3 雄) 进行保山裂腹鱼进行人工催产授精, 分别获卵 3320、8650、7240 粒, 受精率分别为 81.5%、75.6%、85.8%。利用木质孵化框在圆形流水池孵化, 分别经 175h、172h、161h 孵化出膜。人工繁殖试验获得成功。

关键词: 保山裂腹鱼; 授精; 孵化

Study on Artificial Propagation of *Schizothorax(Racoma) yunnanensis paoshanensis* Tsao

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Abstract: The aim of this paper is accumulate the biological data of artificial reproduction of *Schizothorax(Racoma) yunnanensis paoshanensis* Tsao, for carried out a development research about scaled artificial culture and the enhancement and release, and protect the resources. We injected Luteinizing Hormone(LH) to release hormone A2 (LRH- A2) and Chorionic Gonadotrophin (HCG) to three groups (3 females and 3 males). The spermatovums we got were 3320,8650 and 7240, respectively. The fertilization rates were 81.5%, 75.6% and 85.8%. Wooden hatchery frame was used to incubate in a circular water pool. Through 175 h, 172h, 161h, respectively, fry began to hatch. The artificial reproduction test was successful.

Key words: *Schizothorax(Racoma) yunnanensis paoshanensis* Tsao; Artificial propagation; Incubate

马苏大麻哈鱼的人工繁育与保护建议

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摘要: 马苏大麻哈鱼 (*Oncorhynchus masou*), 属鲑科 (Salmonidae)、大麻哈鱼属 (*Oncorhynchus*), 在我国仅分布于图们江、绥芬河以及台湾部分地区。近年来, 由于栖息地环境的破坏和无节制的捕捞行为, 导致其种群数量急剧下降, 新修订的《国家重点保护野生动物名录》已将其提升为国家二级。为早日实现马苏大麻哈鱼的规模化养殖, 同时更好地开展野外种群恢复工作, 本文连续五年采集陆封型马苏大麻哈鱼的雌雄亲鱼 (数量配比为 5:3), 通过干法受精后进行孵化。结果表明, 每年可获得总卵数约 30 万粒, 受精率 90.5%, 积温 200°C·d 左右发眼 (平均发眼率 83%), 350-390°C·d 出苗 (平均出苗率 81%), 苗种成活率 78%, 最终可培育出苗种约 14.2 万尾。人工繁育试验的顺利开展为马苏大麻哈鱼的种群恢复提供了有力保障, 随着渔政执法力量的加强和公众保护意识的提升, 马苏大麻哈鱼的保护效果也不断彰显, 野生种群的生存困境和捕获压力得到了有效缓解。

关键词: 马苏大麻哈鱼, 人工繁育, 种群恢复, 资源保护

Artificial breeding and resource protection of *Oncorhynchus masou*

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Abstract: *Oncorhynchus masou* is one species of Salmonidae and *Oncorhynchus*, which distributes in Tumen River, Suifen River and some areas of Taiwan in China. In recent years, due to the destruction of habitat environment and uncontrolled fishing behavior, the number of its population had declined sharply and it also had been upgraded to the level II in the national key protected wildlife list. In order to realize the large-scale cultivation of *Oncorhynchus masou* and recover the wild populations, this paper collected the landlocked parent fish (the male and female ratio was 3:5) for five years. The results indicated that the total number of eggs was approximately 300000, the fertilization rate, the eyed rate, the emergence rate and the survival rate was 90.5%, 83%, 81% and 78% respectively. Finally, 142000 individuals could be gained. This is a strong guarantee for the population recovery and with the improvement of fishery law enforcement and public protection consciousness, the survival predicament and capture pressure of wild resources of *Oncorhynchus masou* have been effectively alleviated.

Key words: *Oncorhynchus masou*, artificial breeding, population recovery, resource protection

拟赤梢鱼早期性腺发育和 *dmrt1* 基因克隆及表达分析

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摘要: 为阐明拟赤梢鱼(*Pseudaspius leptocephalus*)早期性腺发育规律, 本研究对其性腺发育过程进行组织切片观察, 并克隆拟赤梢鱼 *dmrt1* 基因全长 cDNA 序列, 探究 *dmrt1* 基因在性腺早期发育过程中的表达模式。*dmrt1* 基因是 DMRT 基因家族成员, 是参与性别控制、性别分化的调控基因之一。结果显示: 拟赤梢鱼卵巢分化早于精巢, 于 45dph 出现卵巢腔, 卵巢开始分化; 65dph 出现精细小管, 精巢分化。拟赤梢鱼 *dmrt1* 基因 cDNA 全长 1743bp, 编码 292 个氨基酸, 含 DMRT 家族保守的 DM 域。*dmrt1* 基因在性腺发育各时期均有表达, 25dph 和 55dph 时表达量升高, 且 160dph 以后表达量显著高于 75dph 之前, *dmrt1* 基因在精巢中的表达水平显著高于卵巢及其他组织。*dmrt1* 基因在拟赤梢鱼性腺发育过程中参与精巢分化及其发育的功能调节。

关键词: 拟赤梢鱼; 性腺分化; *dmrt1*; 克隆; 基因表达

Early gonadal development, cloning and expression characterization of *dmrt1* from *Pseudaspius leptocephalus*

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Abstract: To clarify the early gonadal development of *Pseudaspius leptocephalus*. In this study, we observed the gonadal development of *Pseudaspius leptocephalus* in tissue sections, cloned the full-length cDNA of *dmrt1* gene, and explored its expression pattern in the early gonadal development. The *dmrt1* gene was a member of the DMRT family and was one of the regulatory genes involved in sex control and sex differentiation. The results showed that: the ovary differentiation of *Pseudaspius leptocephalus* was earlier than the testis, at 45 dph, the ovarian cavity appeared and marked the beginning of ovary differentiation; at 65 dph, the vas efferens appeared and the testis differentiated. The cDNA of *dmrt1* gene of *Pseudaspius leptocephalus* was 1743 bp, encoding 292 amino acids, which contained the conserved DM domain of DMRT family. The *dmrt1* was expressed in all stages of gonadal development, and expression level in the testis was significantly higher than ovary and other tissues; the expression level increased at 25dph and 55dph, nevertheless, after 160dph was significantly higher than before 75dph. The *dmrt1* was involved in the testis differentiation and development in *Pseudaspius leptocephalus* during the gonadal development.

Key words: *Pseudaspius leptocephalus*; gonadal differentiation; *dmrt1*; clone; gene expression

西藏雅鲁藏布江下游墨脱江段墨脱 新光唇鱼年龄组成与生长特性

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摘要: 于2017年4月-10月、2018年4月-10月, 于雅鲁藏布江墨脱江段采集墨脱新光唇鱼 (*Barbodes hexagonlepis*) 223尾, 其中202尾使用微耳石作为主要鉴定材料对其进行年龄鉴别, 分析其生长特征。通过对比发现, 与鳞片、鳃盖骨相比, 微耳石更适合做为墨脱新光唇鱼的年龄鉴定材料。所采样本的年龄范围为1-10、12、14、15龄, 其中优势年龄组为6龄组, 占总样本的30.6%。雌、雄个体生长无显著性差异, 样本体长分布范围为77.0mm~591.0mm, 平均体长为(290.6±94.6)mm, 体重分布范围为8.4g~3586.3g, 平均体重为(611.2±554.4)g。耳石长轴半径与体长的直线关系式: $L=0.2959R_L-65.118$ ($R^2=0.9353$, $n=202$)。体长与体重的关系式: $W=2\times 10^{-5}L^{3.0259}$ ($R^2=0.988$, $n=202$), 选用 von Bertalanffy 方程描述墨脱新光唇鱼生长特性, 生长方程: $L_t=989.04[1-e^{-0.074(t+0.652)}]$, $W_t=24194.49[1-e^{-0.074(t+0.652)}]^{3.0259}$; 生长速度方程: $dL/dt=73.19e^{-0.074(t+0.652)}$, $dW/dt=73210.1e^{-0.074(t+0.652)}(1-e^{-0.074(t+0.652)})^{2.0259}$; 生长加速度方程: $d^2L/dt^2=-5.42e^{-0.074(t+0.652)}$, $d^2W/dt^2=400.89e^{-0.074(t+0.652)}(1-e^{-0.074(t+0.652)})^{1.0259}(3.0341e^{-(0.074(t+0.652))}-1)$ 。墨脱新光唇鱼拐点年龄为14.4龄, 对应的体长、体重为 $L_t=561.77$ mm, $W_t=3498.97$ g。墨脱新光唇鱼为缓慢生长鱼类, 调查发现雅鲁藏布江下游墨脱江段墨脱新光唇鱼资源量正在衰退, 需加强保护力度。

关键词: 墨脱新光唇鱼 (*Barbodes hexagonlepis*); 年龄; 生长; 雅鲁藏布江

AGE AND GROWTH OF BARBODES HEXAGONLEPIS IN YARLUNG ZANGBO RIVER OF TIBET

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Abstract: To study age composition and growth characteristics of *Barbodes hexagonlepis*, 223 specimens were collected from Yarlung Zangbo River of Motuo County reach from April to October 2017 and April to October 2018. Otolith could be used for estimating the age efficiently. Compared with scales and gill cover bones, micro-otoliths are more suitable as age identification materials for *B. hexagonlepis*. There were ten age groups of collected samples, and the most individuals was 6 year-old accounting for about 37.07% of total samples. The relationship growth showed nosignificant between females and males. The sample body length range is 77.0mm~468.0mm, and the average body length is (281.2±86.3) mm The body weight distribution ranged from 8.4g~2282.5g with an average of (542.8±422.8g) g. The straight line relationship between the radius of Otolith long axis and body length was $L=0.3194R_L-91.595$ ($R^2=0.9384$, $n=188$). The relationship between body length and body weight was $W=2\times 10^{-5}L^{3.0341}$ ($R^2=0.9948$, $n=188$). The growth pattern of *B. hexagonlepis* was formulated by Von Bertalanffy growth function as follow: $L_t=837.94[1-e^{-0.074(t+0.512)}]$, $W_t=11771.59[1-e^{-0.074(t+0.512)}]^{3.0341}$, The growth rate equation was $dL/dt=62.01e^{-0.074(t+0.512)}$, $dW/dt=2642.99e^{-0.074(t+0.512)}(1-e^{-0.074(t+0.512)})^{2.0341}$, The Growth acceleration equation was $d^2L/dt^2=-4.59e^{-0.074(t+0.512)}$, $d^2W/dt^2=195.58e^{-0.074(t+0.512)}(1-e^{-0.074(t+0.512)})^{1.0341}(3.0341e^{-(0.074(t+0.512))}-1)$. The age at the in-flexion point of body weight growth was 14.49 years, in which total length and body weight were 561.77 mm and 3498.97 g. As a slow-growing fish, *B. hexagonlepis* are found to be declining in the lower reaches of the The lower reaches of the Yarlung Zangbo river and need to be protected.

Key words: *Barbodes hexagonlepis*; Age; Growth; Yarlung Zangbo River

水生野生动物濒危机制及保护方式探究

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摘要: 水生野生动物资源具有很高的生态、科研、医学、经济和文化等价值。保护和合理利用水生野生动物资源, 对于维持生态平衡、拯救濒危物种、开展科学研究、发展经济、改善和丰富人民物质和文化生活, 以及促进国际交流与合作, 都具有重大意义。基于此, 分析我国水生野生动物的濒危机制, 进而提出一些切实可行的水生野生动物资源保护方式。

关键词: 水生野生动物; 濒危机制; 保护

Research on the endangered mechanism and protection of aquatic wildlife

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Abstract: Aquatic wildlife resources have high ecological, scientific, medical, economic and cultural values. The protection and rational utilization of aquatic wildlife resources is of great significance for maintaining ecological balance, saving endangered species, carrying out scientific research, developing economy, improving and enriching people's material and cultural life, and promoting international exchange and cooperation. Based on this, this paper analyzes the endangered mechanism of aquatic wildlife in China, and then puts forward some practical ways to protect aquatic wildlife resources.

Key words: aquatic wildlife, endangered mechanism, protection

北京地区瓦氏雅罗鱼资源现状和物种恢复研究

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摘要: 瓦氏雅罗鱼作为北京土著鱼类, 是北京市二级保护鱼类, 也是本地物种恢复的重点对象。但是, 近年来相关单位在北京地区野外实地调查期间未曾采集到瓦氏雅罗鱼标本, 其资源现状堪忧。基于此, 介绍北京地区瓦氏雅罗鱼资源现状、保护学意义, 以及为保护瓦氏雅罗鱼所做的物种恢复探索工作。

关键词: 瓦氏雅罗鱼; 资源现状; 物种恢复

Research on the resource status and species restoration of *Leuciscus waleckii* in Beijing

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Abstract: As an indigenous fish in Beijing, *Leuciscus waleckii* is a secondary protected fish and a key target for local species restoration. However, in recent years, the relevant scientific research institutions have not collected any samples of *Leuciscus waleckii* during the field investigation in Beijing area, so the resource status is worrying. Based on this, this research introduces the current situation of the resources, the significance of conservation science, and the exploration of species restoration for the protection of *Leuciscus waleckii* in Beijing.

Key words: *Leuciscus waleckii*, resource status, species restoration

领域八

水产品加工与综合利用

10 种植物精油对腐生葡萄球菌抑制效果比较 及肉桂精油抑菌机制分析

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摘要: 为研究 10 种植物精油对腐生葡萄球菌的抑菌效果, 本实验通过抑菌圈与微量肉汤稀释法确定 10 种植物精油对菌体的最小抑菌浓度 (minimum inhibitory concentration, MIC) 与最小杀菌浓度 (minimum bactericidal concentration, MBC), 筛选作用效果最佳的植物精油, 进一步分析其对腐生葡萄球菌作用机制。结果显示, 肉桂精油对腐生葡萄球菌的作用效果最佳, 其抑菌圈直径为 (24.10±2.55) mm, MIC 与 MBC 均为 1 mg/mL。腐生葡萄球菌经 MIC 与 2 MIC 肉桂精油处理后, 其在 5 h 时生长被完全抑制。肉桂精油对腐生葡萄球菌的细胞膜完整性破坏作用明显, 使菌体胞外介质中的 AKP 活力增加, 导致核酸与蛋白质外泄, 对菌体细胞壁与细胞膜的完整性和代谢系统产生一定影响, 其作用效果与质量浓度正相关。腐生葡萄球菌经肉桂精油处理后, 菌体表面出现明显皱缩, 表面不再致密, 并出现溶解与黏聚现象, 部分菌体破裂, 且有内容物溢出, 使其外膜脱落, 最终导致菌体死亡。综上所述, 肉桂精油对腐生葡萄球菌作用效果显著, 其可通过破坏菌体细胞壁与细胞膜, 抑制生物膜形成实现其抑菌效果。

关键词: 植物精油; 肉桂精油; 腐生葡萄球菌; 抑菌机制; 生物膜

Effects of 10 Plant Essential Oils and Antimicrobial Mechanism of Cinnamon Essential Oil against *Staphylococcus saprophyticus*

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Abstract: In order to study the effects of 10 plant essential oils on *Staphylococcus saprophyticus*, minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of 10 plant essential oils against *Staphylococcus saprophyticus* were determined by the method of bacteriostatic circle and broth dilution. The most effective one could be screened out and the effects on antimicrobial mechanism and biofilm formation of *Staphylococcus saprophyticus* were further analyzed. The results showed that cinnamon essential oil had the best effect on *Staphylococcus saprophyticus*. The diameter of inhibition zone was 24.10±2.55 mm, Both MIC and MBC of cinnamon essential oil were 1 mg/mL. After being treated with MIC and 2 MIC cinnamon essential oil, the growth of *Staphylococcus saprophyticus* was completely inhibited at 5 h. Cinnamon essential oil could destroy the cell membrane integrity of *Staphylococcus saprophyticus*, increase the activity of AKP in the extracellular medium of *Staphylococcus saprophyticus*, lead to the leakage of nucleic acid and protein, affect the integrity and metabolism system of cell wall and membrane. The effect was positively related to the mass concentration of cinnamon essential oil. After treatment with oregano essential oil, the surface of *Staphylococcus saprophyticus* was obviously shrunk, the surface was no longer dense, then it appeared the dissolution and cohesion of bacteria, some of the bacteria were broken and some of the contents were overflowed, the outer membrane was fall off, and led to the death of bacteria finally. In conclusion, cinnamon essential oil has the significant effect on *Staphylococcus saprophyticus*. It can achieve its bacteriostatic effect by destroying cell wall and cell membrane, inhibiting the formation of biofilm.

Key words: plant essential oil; Cinnamon essential oil; *Staphylococcus saprophyticus*; antimicrobial mechanism; biofilm

卡拉胶寡糖对凡纳滨对虾冻融过程中脂质、蛋白质氧化及水分迁移变化影响

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摘要: 研究了卡拉胶寡糖对凡纳滨对虾 (*Litopenaeus vannamei*) 在反复冻融循环中脂质、蛋白质氧化和水分迁移变化影响。分别使用无菌蒸馏水(CK)、三聚磷酸钠(ST)与卡拉胶低聚糖(CO)对凡纳滨对虾予以浸渍处理, 随后进行不同冻融循环的各项指标分析研究。通过脂肪含量、硫代巴比妥酸值(TBARS)、游离脂肪酸(FFA)含量和过氧化值(PV)评价其冻融期间的脂质氧化, 由羰基含量、巯基含量(SH)、表面疏水性、十二烷基硫酸钠-聚丙烯酰胺凝胶电泳(SDS-PAGE)评价其冻融期间的蛋白质氧化变性, 采用低场核磁共振(LF-NMR)分析其冻融期间的水分迁移。由差示扫描量热法(DSC)和动态流变学分析了其蛋白质的理化性质变化。其中, 由DSC、动态流变学与SDS-PAGE结果表明, 卡拉胶寡糖对凡纳滨对虾冻融期间的肌球蛋白和肌浆蛋白结构有明显的保护作用。与CK组和ST组比较。卡拉胶寡糖处理能抑制凡纳滨对虾冻融期间的TBARS、PV、FFA含量、表面疏水性与羰基含量升高, 保持其较高的脂肪、总巯基与不可移动水含量, 对样品中脂质和蛋白质的变化有较好控制作用。因此, 在凡纳滨对虾的加工过程中, 卡拉胶低聚糖可作为替代的低温保护剂。

关键词: 南美白对虾; 卡拉胶寡糖; 冻融循环; 脂肪氧化; 蛋白质氧化; 水分迁移

Effects of carrageenan oligosaccharide on lipid, protein oxidative changes and moisture migration of *Litopenaeus vannamei* during freeze-thaw cycles

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Abstract: The effects of carrageenan oligosaccharide on lipid, protein oxidative changes and moisture migration of Pacific white shrimp (*Litopenaeus vannamei*) were evaluated respectively during repeated F-T cycles. Distilled water (CK), sodium tripolyphosphate (ST) and carrageenan oligosaccharides (CO) were subjected to samples with different F-T cycles. Lipid oxidation was evaluated by lipid content, thiobarbituric acid-reactive substances (TBARS) value, free fatty acids (FFA) content and peroxide value (PV), protein oxidative denaturation and degradation were evaluated by carbonyl content, sulfhydryl content (SH), surface hydrophobicity, sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) and Low field nuclear magnetic resonance (LF-NMR) was used to reflect moisture migration. Differential Scanning Calorimeter (DSC) and dynamic rheology were also conducted to analyze the physicochemical properties changes in protein. The results of DSC, dynamic rheology and SDS-PAGE showed that carrageenan oligosaccharide could protect the structure of myosin and sarcoplasmic protein significantly. When compared with CK and ST groups. carrageenan oligosaccharide was more effective in controlling the changes of lipid and protein in samples during F-T cycles with lower contents of TBARS, PV, FFA, surface hydrophobicity, carbonyl and higher contents of lipid, SH and immobilized water. Therefore, carrageenan oligosaccharides as the alternative cryoprotectant might be employed during processing of *Litopenaeus vannamei*.

Key words: *Litopenaeus vannamei*; Carrageenan oligosaccharides; Freeze-thaw cycles; Lipid oxidation; Protein oxidation; Moisture migration

四种贝壳粉、珍珠粉和乌贼骨粉的成分分析及结构比对

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摘要: 本文以贝壳中的花蛤壳、淡水蚌壳、扇贝壳和牡蛎壳为原料制备贝壳粉, 同时和珍珠粉、乌贼骨粉在成分和结构上进行分析。采用氨基酸自动分析仪、电感耦合等离子体质谱、傅里叶红外光谱法、SEM 对其氨基酸、矿物元素进行分析和结构表征。结果显示六种粉体的主要成分均为文石型碳酸钙, 其在贝壳粉和珍珠粉的含量在 95% 以上, 而乌贼骨粉含量为 77.5%。乌贼骨粉的蛋白质和氨基酸含量为 16.18%、21.549g/100g, 显著高于贝壳粉和珍珠粉。珍珠粉和蚌壳粉氨基酸含量略高于其他三种贝壳粉, 分别为 2.208g/100g 和 2.443g/100g。贝壳粉和珍珠粉的矿物元素中, Ca 含量均在 33.29% 以上, Na、Mg、K、Fe、Al、Cr、Mn、Cu、Zn、Se、Cd、Hg、Pb 的含量可能与其生长的水环境有关, 其中 Fe 含量可能与贝壳粉颜色有关。乌贼骨粉的 Ca 含量也高达 24.26%, 其他微量元素中 Zn 的含量最高。六种粉体粒度分布在 1~100 μ m 之间。花蛤粉具有交错叠片结构, 蚌壳粉和珍珠粉具有棱柱结构。牡蛎壳粉和扇贝壳粉呈叶片状结构, 使其具有天然多孔结构, 而乌贼骨粉含有独特的气室结构。

关键词: 贝壳粉; 成分分析; 碳酸钙; 珍珠粉; 元素分析; 红外光谱

Composition analysis and structure comparison of four kinds of shell powder pearl powder and cuttlefish bone powder

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Abstract: Shell powder was prepared from clam shell, clam shell, scallop shell and oyster shell, and its composition and structure were analyzed with pearl powder and cuttlefish bone powder. The amino acids and mineral elements were analyzed and characterized by automatic amino acid analyzer, inductively coupled plasma mass spectrometry (ICP-MS), Fourier infrared spectroscopy (FTIR) and SEM. The results showed that the main components of the six powders were aragonite calcium carbonate, and the content of shell powder and pearl powder was more than 95%, while the content of cuttlefish bone powder was 77.5%. The protein and amino acid content of cuttlefish bone meal were 16.18% and 21.549g/100g, which were significantly higher than shell meal and pearl meal. The amino acid content of pearl powder and clam shell powder was slightly higher than that of the other three shell powders, which were 2.208g/100g and 2.443g/100g respectively. In the mineral elements of shell powder and pearl powder, the content of Ca is above 33.29%. The content of Na, Mg, K, Fe, Al, Cr, Mn, Cu, Zn, Se, Cd, Hg and Pb may be related to the water environment in which they grow, and the content of Fe may be related to the color of shell powder. The content of Ca in cuttlefish bone meal was up to 24.26%, and the content of Zn in other trace elements was the highest. The particle size of the six powders ranged from 1 to 100 m. Clam powder has staggered laminated structure and clam shell powder and pearl powder have prismatic structure. Oyster shell powder and scallop shell powder have leaf-like structure, which makes them have natural porous structure, while cuttlefish bone powder has unique air chamber structure.

Key words: Shell powder; Component analysis; Calcium carbonate; Pearl powder; Elemental analysis; Infrared spectrum

罗非鱼皮蛋白多肽-Fe²⁺结合物的制备及性质分析

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摘要: 以罗非鱼皮为原料, 探究罗非鱼皮蛋白多肽-Fe²⁺结合物的制备工艺, 研究多肽及肽-Fe²⁺结合物的性质特点。结果表明, 罗非鱼皮蛋白经胰蛋白酶水解 2 h 后得到的多肽 (tilapia skin protein peptides, TSPP), 其 Fe²⁺结合率最高; TSPP 与 Fe²⁺最佳的结合条件为: pH 5、37 °C、90 min; TSPP 结合 Fe²⁺后, 其内源性荧光强度下降, 紫外的特征性吸收带出现红移, 肽链中的氨基、羰基、羧基可能是 Fe²⁺的结合位点; TSPP 中的 Fe²⁺结合活性肽, 其分子量大约在 500-3000 Da 之间, 且肽链富含 Asp、Glu、Gly、Arg 及 Pro 等氨基酸; TSPP 结合 Fe²⁺前后, 其抗氧化能力无显著性变化; TSPP 的抗氧化能力明显低于谷胱甘肽; 但其 Fe²⁺结合活性明显高于谷胱甘肽。结果显示, TSPP 具有良好的 Fe²⁺结合活性, 有望发展为新型的铁离子膳食补充剂。

关键词: 罗非鱼皮蛋白; 肽-Fe²⁺结合物; 结合条件; 结构特征; 生物活性

Preparation and characterization of peptide-Fe²⁺ complexes from tilapia skin protein

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Abstract: In this research, tilapia skin protein was used as raw material to study the preparation conditions of Fe²⁺ chelating peptide, and analyzed the characteristics of peptide and peptide Fe²⁺ complex. The results showed that the peptides from trypsin 2 h hydrolysate(TSPP) have the highest Fe²⁺ chelating rate; The best chelating conditions are pH 5, 37 °C, 90 min ; After TSPP chelating Fe²⁺, its intrinsic fluorescence intensity decreased, and the characteristic absorption band of UV showed slightly redshifted, -NH, C=O and -COOH of the peptide may be the Fe²⁺ chelating sites; Fe²⁺ chelating peptide from TSPP was about 500-3000 Da, and rich in Asp, Glu, Gly, Arg and pro; The antioxidant capacity of TSPP had no significant change before and after chelating Fe²⁺; Although the antioxidant capacity of TSPP was significantly lower than glutathione, the Fe²⁺ chelating activity of TSPP was significantly higher than glutathione. The results showed that TSPP had excellent Fe²⁺ chelating activity and was expected to develop into a new type of iron dietary supplement.

Key words: tilapia skin protein; peptide-Fe²⁺ complexes; chelating conditions; structure characteristics; biological activity

南极磷虾管束干燥特性与品质分析

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摘要: 本实验研究南极磷虾管束干燥过程中温度对产品品质的影响, 以期为高效、高品质南极磷虾粉加工提供优化工艺及参数。设置 110℃、120℃、130℃、140℃、150℃ 5 组干燥温度, 以南极磷虾料温、水分含量、干燥速率为干燥特性指标, 检测干燥过程中南极磷虾粗蛋白、粗脂肪、虾青素和色泽变化等营养指标。结果显示: 干燥温度越高, 物料达到干燥终点(水分含量 10%为干燥终点)所用时间越短, 温度每升高 10℃, 缩短 10-20min; 干燥过程中物料水分>60%时, 各组营养含量变化差异不大; 随着物料水分继续下降, 料温上升明显, 当料温>60℃, 营养含量变化极其显著(P<0.01)。实验得出结论: 采用管束干燥加工南极磷虾粉, 物料水分>60%同时料温<60℃时, 可采用>130℃的干燥温度以提高干燥效率; 物料水分<60%或料温>60℃时, 宜采用<120℃的干燥温度, 以获得较高品质的南极磷虾粉。

关键词: 南极磷虾; 管束干燥系统; 干燥特性; 营养品质

The drying characteristics and nutritional quality of Antarctic krill processed by tube bundle dryer

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Abstract: The effect of temperature on Antarctic krill product quality during the tube bundle drying process was studied in order to provide optimum technology and parameters for the processing of high efficiency and high-quality Antarctic krill powder. Drying temperatures were set at 110 ° C, 120 ° C, 130 ° C, 140 ° C and 150 ° C, and temperatures, water content and drying rate of Antarctic krill were used as drying characteristics to detect the protein, fat, astaxanthin and color changes of Antarctic krill during drying. The results showed that the higher the drying temperature was, the shorter the time it took to reach the drying end point (10% water content as the drying end point), and time was shortened 10-20 min for every 10 ° C increase. When material water content > 60%, there was little difference in nutrient content among each group. As water content continued to decline, material temperature increased significantly. When material temperature >60 ° C, nutrient content change was extremely significant(P<0.01). The results showed that drying temperature >130 ° C could be used to improve drying efficiency when material water content >60% and temperature <60 ° C; when material water content <60% or temperature > 60 ° C, drying temperature <120 ° C should be adopted to obtain higher quality Antarctic krill powder.

Key words: Antarctic krill, bundle drying system, drying characteristics, nutritional quality

纳米纤维素及其聚合物的多功能应用

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摘要: 纤维素是世界上最丰富、可再生和可循环利用的多糖。绿色环保、来源丰富、合成工艺简单等特点, 在一定条件下能形成手性向列液晶结构, 具有独特的光学性质并呈现出结构色的特性。纤维素是由非晶区和晶区组成。而纤维素纳米晶体(CNCs)是从纤维素结晶区中提取的。纤维素纳米晶体最大的特点是它可以作为纳米材料合成有着特殊性能(吸附性、抑菌性、溶解性和机械性等)的聚合物。本文综述了几种天然高分子和合成高分子在各自的聚合物基体中使用 CNCs 作为增强剂进行改性的研究进展。这些高分子的聚合物在生物医药、废水处理、可控药物递送和农业化合物的改良方面有很大的应用前景。CNCs 的巨大活性被成功地用于提高各自聚合物的力学性能和拓宽其应用领域。

关键词: 纳米纤维素; 高分子聚合物; 功能

Multifunctional applications of nanocellulose and its polymers

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Abstract: Cellulose is the most abundant, renewable and recyclable polysaccharide in the world. It is environmentally friendly, rich in sources, and simple in synthesis process. It can form a chiral nematic liquid crystal structure under certain conditions, has unique optical properties and exhibits structural color characteristics. Cellulose is composed of amorphous regions and crystalline regions. The cellulose nanocrystals (CNCs) are extracted from the cellulose crystallization area. The biggest feature of cellulose nanocrystals is that they can be used as nanomaterials to synthesize polymers with special properties (adsorption, antibacterial, solubility and mechanical properties, etc.). This article reviews the research progress of several natural polymers and synthetic polymers using CNCs as reinforcing agents in their respective polymer matrixes. These high-molecular polymers have great application prospects in biomedicine, wastewater treatment, controlled drug delivery, and the improvement of agricultural compounds. The huge activity of CNCs has been successfully used to improve the mechanical properties of their respective polymers and broaden their application fields.

Keywords: nanocellulose; polymer; function

低温等离子技术在食品工业中的应用研究和展望

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摘要: 本篇主要阐述了低温等离子体技术的发展现状、放电方式、诊断及活性成分表征, 综述了低温等离子体技术处理对食品主要品质指标以及对食品中微生物灭活的研究进展, 为低温等离子体技术调控食品品质提供重要理论参考和新的技术手段, 为该技术的工程化应用提供理论支撑。

关键字: 低温等离子体; 食品加工; 食品灭菌; 展望

Application research and Prospect of low temperature plasma technology in food industry

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Abstract: This paper mainly describes the development status, discharge mode, diagnosis and characterization of active components of low temperature plasma technology, summarizes the research progress of low temperature plasma technology on the main quality indicators of food and the inactivation of microorganisms in food, provides important theoretical reference and new technical means for the regulation of food quality by low temperature plasma technology, and provides the engineering of this technology. Application provides theoretical support.

Key words: Low temperature plasma; food processing; food sterilization; Prospect

不同处理条件对上海熏鱼风味的影响

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摘要: 为了去除草鱼的鱼腥味, 提高草鱼的商业价值, 本文研究了不同处理条件(油爆温度、白糖与酱油的比例、还原糖类型)对上海熏鱼风味的影响。通过气相色谱-质谱联用仪对上海熏鱼风味进行分析和鉴定。研究表明, 在 170°C 的条件下对草鱼进行油爆, 其挥发性风味物质达到最多, 为 96 种。当浸渍液中白糖与酱油的比例为 1.5:1 时, 上海熏鱼的感官评定结果最高, 且关键性风味物质为 1-辛烯-3-醇, 2,4-癸二烯醛, 芳樟醇。把白糖替换成果糖、葡萄糖、乳糖后, 糖和酱油在最佳比例的情况下, 浸渍液中糖的类型为葡萄糖时, 上海熏鱼中的关键性风味物质最多, 并且对整体风味起到改善作用的风味物质也有所增加。本研究为改善上海熏鱼风味提供了理论支持。

关键词: 草鱼; 上海熏鱼; 风味; 白糖; 酱油

Effects of different treatment conditions on the flavor of Shanghai smoked fish

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Abstract: In order to remove the fishy smell of grass carp, improve the commercial value of grass carp, this paper studies the different processing conditions (the ratio of sugar and soy sauce, oil temperature and reducing sugar type) the influence of the fish flavor of Shanghai by gas chromatography/mass spectrometry analysis and identification of the Shanghai fish flavor. The results showed that under the condition of 170 °C to oil of grass carp, its volatile flavour compounds, most of 96 when the sugar and soy sauce in the soaking solution ratio of 1.5:1, the sensory evaluation is highest, and the key flavor compounds for 1-octene -3-ol, 2,4 -decadienal, linalool. Have replaced the white sugar to lactose, fructose and glucose, sugar and soy sauce in proportion to the best of conditions, the type of sugar in the soaking solution of glucose, the content of the key flavor compounds is highest, and to improve the overall flavor of flavor substances also increased. This study provides a theoretical support to improve the flavor of Shanghai smoked fish.

Key words: grass carp, Shanghai smoked fish, flavor, white sugar, soy sauce

包埋法固定化酶的研究进展

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摘要: 酶是一种高效的、具有选择特异性的生物催化剂, 在食品、造纸、医药、废水处理等方面具有广泛的应用。然而, 游离酶存在不稳定、易失活、回收率低等缺陷, 为了改进游离酶的种种缺点, 可采用包埋法固定化酶的技术提高酶的固定化效率以及回收率。壳聚糖是一种生物聚合物, 具有无毒性、抗菌性等优点, 且其含有丰富的氨基和羟基, 可对壳聚糖进行改性提高包埋效率。本文将通过以壳聚糖为载体材料包埋酶在食品中的应用做简要介绍和分析。

关键词: 酶; 催化剂; 包埋; 壳聚糖

Research progress of immobilized enzyme by embedding method

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Abstract: Enzyme is a kind of efficient and selective biological catalyst, in such aspects as food, paper, pharmaceutical, wastewater has extensive application, however, the free enzyme has some defects, such as unstable, easy deactivation, low recovery rate, in order to improve the flaws of free enzyme, we can adopt the embedding method of immobilized enzyme technology to improve efficiency of immobilized enzyme and the recovery. Chitosan is a kind of biological polymer, has the advantages of non-toxic, antimicrobial properties, and it contains rich amino and hydroxyl groups, can be modified to improve the embedding efficiency of chitosan. In this article, we will through embedding enzyme with chitosan as carrier material application in the food do a brief introduction and analysis.

Key words: enzyme, catalyst, embedding, chitosan

鱼露发酵过程中的风味变化

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摘要: 为了本研究采用固相微萃取-气相色谱-质谱测定了鱼露在发酵过程中的风味物质变化。随着发酵时间的增加, 风味化合物醛类、酮类、含氮化合物、醇类、酯类、碳氢化合物的含量均有所增加, 而酸类物质有所减少。整体来说, 关键性风味物质 (ROAV \geq 1) 有明显的增加。发酵时间不同, 鱼露中风味物质的含量有明显变化。通过研究鱼露在发酵过程中风味物质的变化, 可有效改善鱼露的品质, 提高经济效益。

关键词: 鱼露; 风味; ROAV; 发酵

Flavor changes during fish sauce fermentation

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Abstract: To this research adopts the solid-phase microextraction and gas chromatography-mass spectrometry determination of fish sauce flavor substance in the fermentation process. Changes with the increase of fermentation time, flavor compounds such as aldehydes, ketones, nitrogen compounds, alcohol, ester and hydrocarbons has increased, however, the acids has decreased. Overall, the key flavor substances (ROAV \geq 1) significantly increase with the fermentation time. By studying the content of flavor substance in fish sauce, which can effectively improve the quality of fish sauce and the economic benefits.

Key words: fish sauce, flavor, ROAV, fermentation

海藻糖对水产品的抗冻保鲜性应用研究进展

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摘要: 水产品是我国主要的动物性食品之一, 由于水产品极易腐败, 冷冻储藏是水产品的主要的运输与保藏手段。然而, 冷冻储藏虽然能有效的延长水产品的保存期, 但长期的冷藏会对水产品的品质造成影响。所以在水产品冷冻储藏时, 需要通过技术手段来提高水产品的抗冻性, 以此来防止水产品的品质的下降。海藻糖作为一种天然多糖, 无毒无害, 其本身具有良好的物理化学性质, 并且是一种优秀的抗冻剂, 能够使冻藏时候形成的冰晶形态不破坏细胞结构, 并延缓水产品蛋白质的变性, 维持水产品的营养与口感, 使水产品在冻藏时依然能保持较好的品质。本文总结目前海藻糖在水产品抗冻保鲜性的研究进展与应用成果, 对未来海藻糖在水产品抗冻性的应用进行了展望, 以期对未来水产品的抗冻性研究提供指导。

关键词: 海藻糖; 保鲜; 水产品; 抗冻性

Research progress on application of trehalose in antifreeze preservation of aquatic products

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Abstract: Aquatic products are one of the main animal foods in our country. Since aquatic products are extremely perishable, frozen storage is the main means of transportation and preservation of aquatic products. However, although frozen storage can effectively extend the shelf life of aquatic products, long-term refrigeration will affect the quality of aquatic products. Therefore, when aquatic products are frozen and stored, technical means are needed to improve the frost resistance of aquatic products to prevent the quality of aquatic products from degrading. As a natural polysaccharide, trehalose is non-toxic and harmless. It has good physical and chemical properties and is an excellent antifreeze. It can make the ice crystals formed during freezing storage do not damage the cell structure and delay aquatic products. The denaturation of protein maintains the nutrition and taste of aquatic products, so that aquatic products can still maintain good quality when frozen. This article summarizes the current research progress and application results of trehalose in the antifreeze preservation of aquatic products, and prospects the application of trehalose in the antifreeze of aquatic products in the future, hoping to provide guidance for future research on the antifreeze of aquatic products.

Key words: Trehalose, preservation, aquatic products, frost resistance

鲣鱼产品的开发与利用

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摘要: 鲣鱼是金枪鱼重要的种类之一, 营养价值丰富, 具有较高的经济价值, 占全球金枪鱼捕捞量的一半以上。但鲣鱼又属于低值鱼, 其肉酸涩、腥味大、口感不佳并且暗色肉比例高, 长期以来没有得到很好的开发利用。目前, 如何对鲣鱼进行开发, 探究符合中国人饮食习惯、营养丰富的具有高附加值的利用技术以及开发相关产品, 是目前研究的重点。本文将阐述鲣鱼的基本特点和开发现状, 从适合中国口味的加工工艺、罐头产品、鲣鱼预制加工品、副产品的精细加工等方向进行分析, 为鲣鱼的产品开发与高效利用, 提高鲣鱼产业的发展提供一定的思路和想法

关键词: 鲣鱼; 金枪鱼; 加工利用; 产品开发;

Development and utilization of *Katsuwonus Pelamis*

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Abstract: *Katsuwonus Pelamis* is one of the important species of tuna, with rich nutritional value and high economic value, accounting for more than half of the global tuna catch. However, *Katsuwonus Pelamis* is also a low-value fish. Its meat is sour and astringent, has a big fishy taste, has a poor taste and has a high proportion of dark meat, which has not been well developed for a long time. As a result, how to develop *Katsuwonus Pelamis*, explore nutrient-rich and high-value-added utilization technologies and develop related products in line with Chinese dietary habits, are the focus of current research. Here, we will adjust the basic characteristics and development status of *Katsuwonus Pelamis*, analyze the processing technology suitable for Chinese taste, canned products, *Katsuwonus Pelamis* outstanding processed products, and fine processing of by-products, so as to improve the development and efficient use of *Katsuwonus Pelamis* products. Provide certain ideas and ideas for the development of *Katsuwonus Pelamis* industry

Key words: *Katsuwonus Pelamis*, Tuna, processing and utilization, product development

鲜度指示剂在水产品新鲜度检测中的研究进展

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摘要: 新鲜度是水产品重要的质量指标之一, 传统的新鲜度检测方法大多繁琐、费时费力, 建立快速便捷的检测方法具有重要的现实意义和学术价值。鲜度指示剂操作简单、检测快速、成本低, 近年来被广泛研究应用于水产品新鲜度的检测。本文在简要阐述传统和新型新鲜度检测方法的基础上, 综述了鲜度指示剂在水产品新鲜度检测上的应用, 着重介绍了基于天然提取物的指示剂的最新进展。对现有研究成果进行总结, 指出了研究中依然存在的问题并对未来的研究方向进行展望以及提出合理性研究建议, 旨在为今后更深入的食品新鲜度指示剂技术研究提供借鉴和参考。

关键词: 水产品; 新鲜度; 鲜度指示剂; 指示标签; 指示膜

Research progress of freshness indicator in freshness detection of aquatic products

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Abstract: Freshness is an important indicator to judge the quality of aquatic products. The traditional freshness detection methods are mostly cumbersome, time-consuming and laborious. It is of great practical significance and academic value to establish fast and convenient detection methods. The freshness indicator is simple to operate, fast to detect, and low in cost. In recent years, it has been widely studied and applied to the freshness of aquatic products. Based on a brief description of traditional and new freshness detection methods, this article reviews the application of freshness indicators in the detection of freshness of aquatic products, and focuses on the latest developments of indicators based on natural extracts. Summarize the existing research results, point out the problems that still exist in the research, and prospect the future research direction and put forward reasonable research suggestions, aiming to provide reference and reference for the future in-depth research on food freshness indicator technology.

Key words: Aquatic products; freshness; freshness indicator; indicator label; indicator film

发酵后鲢鱼的风味分析

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摘要: 以鲢鱼肉为原料, 乳酸菌为发酵剂, 通过顶空固相微萃取与气质联用(HS-SPME-GC-MS)技术确定发酵后的鲢鱼的关键风味物质。发酵条件控制为乳酸菌的添加量为 0.8%, 发酵时间为 6h, 发酵温度为 28℃, 检测出发酵后的鲢鱼的关键风味物质主要有壬醛、苯甲醛、1-辛烯-3-醇、乙酸乙酯、乙酸异戊酯和 2-戊基呋喃, 因此得出这些关键风味物质造就了发酵后的鲢鱼特有的风味。

关键词: 鲢鱼; 乳酸菌; 风味物质; 检测

Analysis of the flavor of Silver carp after fermentation

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Abstract: The key flavoring substances of silver carp were determined by headspace solid phase microextraction (HS-SPME-GC-MS) with lactic acid bacteria as starter. Fermentation conditions of control for the adding amount of 0.8%, lactic acid bacteria fermentation time is 6h, fermentation temperature 28℃, the key to detect after fermentation of silver carp flavor substances mainly nonyl aldehyde, benzene, formaldehyde, 1-octene-3-alcohol, ethyl acetate, isoamyl acetate and 2-amyl furan, therefore it is concluded that these key flavor substances produced after fermentation of silver carp unique flavor.

Key words: Silver carp; Lactic acid bacteria; Flavoring substances; detection

复合抗冻剂配方优化及对冻藏黑鱼鱼片的影响

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摘要: 以失水率, Ca^{2+} -ATPase 活性测定和感官评定为指标探究复合抗冻剂对不同处理组黑鱼鱼片品质的影响。结果表明, $-20\text{ }^{\circ}\text{C}$ 条件下, 抗冻剂按照 3% 山梨醇 + 25% 海藻糖 + 0.5% 多聚磷酸盐条件复配之后, Ca^{2+} -ATPase 活性能够达到 90%, 较对照组 (不添加抗冻剂) 增加 55% 左右。被抗冻剂处理过的黑鱼片在冻藏过程中的失水率明显低于对照组。将加入复合抗冻剂的样品于 $-20\text{ }^{\circ}\text{C}$ 冻藏 25 天, 其颜色接近于鱼肉的原有颜色, 鱼肉有黑鱼固有气味, 对照组为暗红色, 肉质松软, 有滴水。复合抗冻剂有效抑制了黑鱼鱼片的冷冻变性。

关键词: 黑鱼鱼片; 抗冻剂; 冷冻变性; 海藻糖

Optimization of compound antifreeze formulation and its effect on frozen snakehead fillets

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Abstract: Using water loss, Ca^{2+} -ATPase activity and sensory quality as indicators to explore the effect of compound antifreeze on the quality of snakehead fillets in different treatment groups. The results showed that under the condition of $-20\text{ }^{\circ}\text{C}$ and 3% sorbitol + 25% trehalose + 0.5% polyphosphate antifreeze formulation, the activity of Ca^{2+} -ATPase reached 90%, which was increased by about 55% than that of the control group (without addition of antifreeze). The water loss rate of snakehead fillets treated with antifreeze during freezing storage was significantly lower than that of the control group. The frozen sample with the compound antifreeze agent was stored at $-20\text{ }^{\circ}\text{C}$ for 25 days, and its color was close to the original color of fish. The meat had the inherent smell of snakehead. The control group was dark red with soft meat and dripping water. The compound antifreeze effectively inhibited the frozen denaturation of snakehead fillets.

Key words: Snakehead fillets, antifreeze, frozen denaturation, trehalose

海藻糖-蔗糖-多聚磷酸盐复合抗冻剂对 冷冻白鲢鱼糜抗冻效果的影响

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摘要: 淡水中的白鲢鱼是制作鱼糜的优质原料, 添加抗冻剂是防止白鲢鱼糜冷冻变性最有效的方法。以盐溶性蛋白含量、持水性、凝胶强度为指标, 通过 $L_9(3^4)$ 正交试验优化海藻糖-蔗糖-多聚磷酸盐复合抗冻剂配方, 并将其与传统商业抗冻剂(4%蔗糖+4%山梨糖醇)进行对比。-18℃条件下冻藏 24 周, 结果表明, 复合抗冻剂的最优配方为: 海藻糖 10%, 蔗糖 3%, 多聚磷酸盐 1%。新型复合抗冻剂的持水性和凝胶强度优于传统商业抗冻剂, 盐溶性蛋白含量的降低得到了很好的抑制。新的复合抗冻剂能达到理想的抗冻效果。

关键词: 鱼糜; 复合抗冻剂; 海藻糖

The effect of trehalose-sucrose-polyphosphate compound antifreeze on the antifreeze effect of frozen silver carp surimi

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Abstract: Silver carp is a high-quality raw material for making surimi in freshwater fish and adding antifreeze is the most effective way to prevent frozen denaturation of silver carp surimi. Taking salt-soluble protein content, water holding capacity, and gel strength as indicators, the formula of trehalose-sucrose-polyphosphate compound antifreeze was optimized by $L_9(3^4)$ orthogonal test, and it was compared with traditional commercial antifreeze (4 % sucrose + 4% sorbitol) for comparison. Frozen storage at -18℃ for 24 weeks, the results showed that the optimal formula of the compound antifreeze was: trehalose 10%, sucrose 3%, and polyphosphate 1%. The water holding capacity and gel strength of the new compound antifreeze were better than traditional commercial antifreeze, and the decrease in salt-soluble protein content was well suppressed. The new compound antifreeze could achieve the ideal antifreeze effect.

Key words: Surimi, compound antifreeze, trehalose

不同类型乳剂对植物油与肌原纤维蛋白乳化复合凝胶的结构特性的影响

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摘要: 肌原纤维蛋白的凝胶特性金枪鱼鱼肉的品质有决定性影响。通过将低商业价值的鱼类或加工过程的下脚料与其他物质混合以获得重组肌原纤维蛋白产品可能会引起鱼类肌原纤维蛋白功能特性的改变, 从而提高其食用性或改变其感官品质。研究发现: 乳剂类型对复合凝胶的结构特性有很大影响。MP 做乳剂的复合凝胶的 G' 大于吐温 80 做乳剂的复合凝胶的 G' ; MP 乳化复合凝胶的凝胶强度也大于吐温 80 乳化复合凝胶的凝胶强度, MP 乳化的复合凝胶的持水力与吐温 80 乳化的复合凝胶持水力没有显著性差异, 但是都大于未添加乳化油脂的复合凝胶, 表明乳剂的添加确实增强了复合凝胶的凝胶强度和持水力; 凝胶电泳结果显示做乳剂的 MP 并未参与到凝胶的三维网络结构中。

关键词: 肌原纤维蛋白; 复合凝胶; 乳化

Effects of different emulsion types on the structural characteristics of emulsified composite gel of vegetable oil and myofibrillar protein

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Abstract: The gel properties of myofibrillar protein have a decisive effect on the quality of tuna fish. To obtain recombinant myofibrillar protein products by mixing low commercial value fish or processing waste with other substances may cause changes in functional characteristics of fish myofibrillar protein, thus improving its edible quality or changing its sensory quality. It is found that the emulsion type has a great influence on the structural properties of the composite gel. The G' of the composite gel of MP emulsion is larger than that of Twain 80 composite gel G' ; MP gel composite gel also has stronger gel strength than that of Twain 80 emulsion composite gel, and the water holding capacity of MP emulsified composite gel has no significant difference from that of Twain 80 emulsified composite gel, but it is greater than that of the composite gel without emulsified grease, indicating that the emulsion is added exactly. The gel strength and water holding capacity of the composite gel were enhanced. Gel electrophoresis showed that the MP of the emulsion did not participate in the three-dimensional network structure of the gel.

Key words: myofibrillar protein, composite gel, emulsification.

酶解凡纳滨对虾虾头制备小分子活性肽的研究

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摘要: 以 α -淀粉酶抑制活性为指标, 筛选酶解凡纳滨对虾虾头的最佳条件, 得到小分子活性肽制品。通过响应面方法学与 Box-Behnken 设计结合得到最佳酶解条件: 酶浓度为 6.2% (w/w), 液固比为 15ml/g, 时间为 5h, 温度为 50℃, pH 为值 7.0。此条件下得到的酶解物的 α -淀粉酶抑制率为 45.2%。运用 PITC 柱前衍生氨基酸分析法对酶解液进行氨基酸组成分析。酶解液中含有较多的 Gln、Asn、Arg、Pro、Ile 和 Phe 等氨基酸, 而 His、Ala 和 Lys 的含量很少。在氨基酸比评价中, Trp、Ile、Met、Tyr + Phe 和 Thr 都超过了 1。此外, 必需氨基酸含量为 278 mg/g, 这表明虾壳废弃物酶解物比推荐的标准蛋白质 (FAO / WHO) 具有更高的营养价值。

关键词: 酶解; 凡纳滨对虾虾头; 活性肽; α -淀粉酶抑制率; PITC 柱前衍生

Preparation of small molecular active peptides from shrimp head of *Litopenaeus vannamei* by Enzymatic hydrolysis

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Abstract: Using α -amylase inhibitory activity as the index, the optimal conditions for enzymatic hydrolysis of shrimp head of *Litopenaeus vannamei* were screened to obtain small molecular active peptide products. Response surface methodology and box Behnken design were combined to obtain the optimal conditions: enzyme concentration of 6.2% (w / W), liquid-solid ratio of 15 ml / g, time of 5 h, temperature of 50 °C, pH of 7.0. Under this condition, the α - amylase inhibition rate of the hydrolysate was 45.2%. The amino acid composition of enzymatic hydrolysate was analyzed by PITC pre column derivatization amino acid analysis method. There were more Gln, ASN, Arg, pro, ile and Phe in the hydrolysate, while his, ALA and Lys were less. In the evaluation of amino acid score, Trp, ile, met, Tyr + Phe and thr all exceeded 1. In addition, the content of essential amino acids was 278 mg / g, which indicated that the enzymatic hydrolysate of shrimp shell waste had higher nutritional value than the recommended standard protein (FAO / who).

Key words: enzymatic hydrolysis, shrimp head of *Litopenaeus vannamei*, active peptide, α -amylase inhibition rate, pre column derivation of PITC

鱼油微胶囊制备工艺及其性质表征

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摘要: 本研究以鱼油为芯材, 魔芋葡聚糖复配麦芽糊精为壁材, 采用喷雾干燥法制备鱼油微胶囊。在单因素试验基础上以鱼油包埋率为指标, 通过响应面法优化鱼油微胶囊的制备工艺; 进一步对最优条件下所得的鱼油微胶囊的水分含量、溶解性、堆积密度、休止角及微观结构进行了表征。结果表明: 在魔芋葡聚糖/麦芽糊精复配比为 1:1、固形物含量为 15%、芯壁比为 1:1.3、进风温度为 85 °C 时, 鱼油微胶囊包埋率可达到 96.88%; 在此条件下得到的鱼油微胶囊水分含量为 1.85%、溶解性为 49.68%、堆积密度为 0.695g/cm³、休止角为 34.58°, 微观结构表征显示其颗粒细小均匀、近球形、表面致密、无裂缝。研究结果可为鱼油微胶囊的研制提供理论指导。

关键词: 鱼油; 魔芋葡聚糖; 麦芽糊精; 微胶囊

Preparation and characterization of fish oil microcapsules

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Abstract: In this study, fish oil was used as core material, konjac glucomannan combined with maltodextrin as wall material, and fish oil microcapsule was prepared by spray drying. On the basis of single factor experiment, the preparation process of fish oil microcapsules was optimized by response surface methodology with the embedding rate of fish oil as the index. Furthermore, the water content, solubility, bulk density, repose angle and microstructure of fish oil microcapsules under the optimal conditions were characterized. The results showed that when the ratio of konjac dextrin / maltodextrin was 1:1, the solid content was 15%, the core wall ratio was 1:1.3, and the inlet air temperature was 85 °C, the embedding rate of fish oil microcapsules could reach 96.88%. Under these conditions, the water content of fish oil microcapsules was 1.85%, the solubility was 49.68%, the bulk density was 0.695g/cm³, and the angle of repose was 34.58°. The microstructure characterization showed that the particles were fine and uniform, nearly spherical, compact surface and no cracks. The results can provide theoretical guidance for the development of fish oil microcapsules.

Key words: fish oil, konjac dextran, maltodextrin, microcapsule

中国毛虾抗氧化多肽制备的研究

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摘要: 通过对清除超氧阴离子自由基、DPPH 自由基和羟基自由基能力做检测, 筛选制备中国毛虾抗氧化多肽的水解条件, 得到高效的抗氧化多肽制品。结果表明: 胰蛋白酶、中性蛋白酶复合, 酶解中国毛虾 6h 后得多肽的抗氧化能力最强, 超氧阴离子自由基的清除率达到 10.8%, DPPH 自由基的清除率达到 75.1%, 羟基自由基的清除率达到 88.2%。经超滤分离, 分子量范围在 5~10ku 的多肽表现出较强的清除三种自由基的能力。对其进行 tricine-SDS-PAGE 电泳, 结果显示电泳图谱上出现了三个条带。

关键词: 抗氧化; 中国毛虾; 酶解; 超滤; tricine-SDS-PAGE 电泳

Preparation of antioxidant polypeptides from *Penaeus Chinensis*

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Abstract: By testing the ability of scavenging superoxide anion radical, DPPH radical and hydroxyl radical, the hydrolysis conditions of antioxidant polypeptide were screened to obtain high-efficiency antioxidant peptide products. The results showed that the antioxidant activity of the peptides was the strongest after 6 hours of enzymatic hydrolysis with trypsin and neutral protease. The scavenging rates of superoxide anion radical, DPPH radical and hydroxyl radical were 10.8%, 75.1% and 88.2%, respectively. After ultrafiltration, the peptides with molecular weight ranging from 5 to 10 Ku showed strong ability to scavenge three kinds of free radicals. The results of Tricine SDS PAGE electrophoresis showed that there were three bands in the electrophoretic map.

Key words: antioxidation, Chinese hairy shrimp, enzymolysis, ultrafiltration, tricine - SDS - PAGE electrophoresis

菲律宾蛤仔营养品质的季节性变化分析

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摘要: 菲律宾蛤仔, 是一种重要的经济贝类在中国。因产卵期及温度盐度等环境因素的影响, 市场上只在每年的三月至十月销售红岛蛤蜊(菲律宾蛤仔), 且每个时期所销售的蛤蜊品质会有一些的差异。为了阐明红岛蛤蜊营养品质的季节性变化, 本研究分析了红岛蛤蜊从三月至九月的 15 种基本营养指标。但从评价技术角度分析, 蛤蜊理化品质评价体系还不完善, 不同的指标之间存在冗余。本研究采用相关性分析、主成分分析以及聚类分析等多种化学计量学方法结合对指标进行筛选。结果表明, 根据 ANOVA 结果, 观察到红岛蛤蜊的营养品质的季节性存在显著差异 ($P < 0.05$)。七个月中菲律宾蛤仔的 15 个评价指标的变异系数值为 1.67%–43.47%。CA 结果表明, 某些指标在一定范围内相互关联。用 PCA 获得了特征值 > 1 的四个主要成分, 累积贡献达到 92.11%。最终, 使用 SCA 筛选了四个基本品质评价指标。

关键词: 菲律宾蛤仔; 评价指标; 季节性变化; 化学计量学

Evaluation indicators of *Ruditapes philippinarum* nutritional quality

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Abstract: Seasonal variations have a significant effect on their nutritional quality for *Ruditapes philippinarum*. This study, the seasonal influence on the nutritional quality of *R. philippinarum* was explored and comprehensive data were obtained. And, over a period of seven months, fifteen nutritional quality evaluation indicators were analyzed, and the most important evaluation indicators were determined by analysis of variance (ANOVA), correlation analysis (CA), principal component analysis (PCA), and system cluster analysis (SCA). The nutritional quality showed significant differences across the seven months ($P < 0.05$). The coefficient of variation values for the fifteen evaluation indicators were 1.67%–43.47%. The CA results revealed that some indicators were correlated to each other within a certain range. Four principle components with eigen-values of > 1 were extracted by PCA, and a cumulative contribution of 92.11% was achieved. Based on the above results, four characteristic indicators quality were obtained by SCA.

Key words: *Ruditapes philippinarum*; evaluation indicator; seasonal variation; chemometric evaluation

南极磷虾羧甲基壳聚糖对罗氏沼虾的保鲜效果

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摘要: 本文旨在研究南极磷虾羧甲基壳聚糖对罗氏沼虾的保鲜效果。采用实验室自制的南极磷虾羧甲基壳聚糖为保鲜剂, 以不同浓度 (0.5%、1.0%、1.5%) 的羧甲基壳聚糖对罗氏沼虾进行涂膜处理, 在 $4\pm 1^{\circ}\text{C}$ 条件下保鲜 7d。采用 TVB-N (挥发性盐基氮) 值、TBA (硫代巴比妥酸) 值、菌落总数、K 值等指标来评价罗氏沼虾在保鲜期间的品质变化。结果表明: 在贮藏到第 7d 时, 1%处理组的 TVB-N 值显著低于其他实验组 ($P<0.05$), 为 $20.31\text{mg}/100\text{g}$; 1%处理组的 TBA 值最低, 为 0.84 ($P<0.05$); 三种不同浓度羧甲基壳聚糖处理组之间的菌落总数无显著性差异 ($P>0.05$); 1%处理组的 K 值在贮藏第 7d 时为 30.73% , 比对照组的 K 值小了 17.41% 。不同浓度羧甲基壳聚糖对罗氏沼虾的保鲜品质均有效果, 其中 1%处理组保鲜效果最好, 可延长罗氏沼虾货架期 4d。

关键词: 南极磷虾; 羧甲基壳聚糖; 罗氏沼虾; 保鲜

The fresh-keeping effect of Antarctic krill carboxymethyl chitosan on *Macrobrachium rosenbergii*

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Abstract: The purpose of this study was to study the preservation effect of carboxymethyl chitosan of Antarctic krill on *Macrobrachium rosenbergii*. The carboxymethyl chitosan of Antarctic krill made in the laboratory was used as the preservative, and the carboxymethyl chitosan of different concentrations (0.5%, 1.0%, 1.5%) was used to coat the *Macrobrachium rosenbergii*, which kept fresh for 7 days at $4\pm 1^{\circ}\text{C}$. The quality changes of *Macrobrachium rosenbergii* during the fresh-keeping period were evaluated by TVB-N value, TBA value, total number of colonies and K value. The results showed that: the value of TVB-N in the 1% treatment group was significantly lower than that in the other groups ($P<0.05$) at the 7th day of storage, which was $20.31\text{mg}/100\text{g}$. TBA value in 1% treatment group was the lowest, which was 0.84 ($P<0.05$). There was no significant difference in the total number of bacterial colonies among the three groups treated with carboxymethyl chitosan at different concentrations ($P>0.05$). The K value in the 1% treatment group was 30.73% at the 7th day of storage, which was 17.41% lower than that in the control group. Carboxymethyl chitosan at different concentrations has good effect on the fresh-keeping quality of *Macrobrachium rosenbergii*, among which 1% treatment group has the best fresh-keeping effect, which can extend the shelf life of *Macrobrachium rosenbergii* for 4d.

Key words: Antarctic krill, carboxymethyl chitosan, *Macrobrachium rosenbergii*, preservation

活性氧 (ROS) 参与蚕豆促使草鱼肌肉硬度增加的调控机制初探

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摘要: 肌肉硬度是消费者接受鱼类的一个重要质量特征, 且硬度越高的鱼更易加工成优质产品。为了探究淡水鱼肌肉硬度的可能调控机制, 选用了脆肉鲩(草鱼摄食蚕豆后肌肉硬度增加)作为生物模型。前期研究发现, 蚕豆提升草鱼肌肉硬度后, 调节肌肉代谢与生化组成的活性氧(ROS)相关的 25 个蛋白质表达也发生改变。本实验针对草鱼在摄食蚕豆过程中各组织 ROS 的含量、生成、消除以及肌肉的质构进行了检测, 以期探究 ROS 与肌肉硬度之间可能存在的线性关系以及在过程中各组织之间可能存在的关联。并在确定了线性关系以及 ROS 主要产生场所是线粒体后, 主要围绕 ROS 通过线粒体参与的细胞凋亡途径促使肌肉纤维细胞分化调控草鱼肌肉硬度增加这一可能的分子机制, 对 ROS 调控草鱼肌肉硬度进行探讨。

关键词: ROS; 肌肉硬度; 草鱼; 蚕豆 ; 线粒体; 细胞凋亡

The Reactive oxygen species (ROS) participates in the regulatory mechanism of faba bean increasing muscle hardness of grass carp

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Abstract: Muscle hardness is an important quality feature of fish accepted by consumers, and the fish with higher hardness are more likely to be processed into high-quality products. In order to explore the possible regulation mechanism of muscle hardness of freshwater fish, crispy grass carp (grass carp increased muscle hardness after eating faba bean) was selected as the biological model. Previous studies found that feeding faba bean enhanced the muscle hardness of grass carp, the expression of 25 proteins related to reactive oxygen species (ROS), which regulates muscle metabolism and biochemical composition, also changed. In this experiment, the content, production, elimination of ROS in various tissues and muscle texture of grass carp were detected in the process of eating faba bean, in order to explore the possible linear relationship between ROS and muscle hardness and the possible correlation between tissues in the process. After determining the linear relationship and the main production site of ROS is mitochondria, the possible molecular mechanism that ROS promotes muscle fiber cell differentiation through mitochondrial apoptosis pathway and regulates the muscle hardness of grass carp was discussed.

Key words: ROS; muscle hardness; grass carp; faba bean; mitochondria; apoptosis

冷冻鱼糜的研究现状及进展

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摘要: 近年来, 冷冻鱼糜制品越来越受消费者的喜爱, 我国也成为冷冻鱼糜生产大国。本文首先介绍了冷冻鱼糜的起源、原料的选取、加工工艺及在国内外的的发展情况。其次文章探讨了冷冻鱼糜的现有储藏方法, 抗冻剂的使用(低聚糖、酶类等)及其他延长保藏期(改善解冻方式、提高持水性等)来保持鱼糜品质的方法。最后, 文章就现有的冷冻鱼糜的贮藏情况进行了分析, 对未来冷冻鱼糜的发展前景做出了展望。

关键词: 冷冻鱼糜; 贮藏; 抗冻剂; 品质

Research status and progress of frozen surimi

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Abstract: In recent years, frozen surimi products have become more and more popular among consumers, and China has also become a major producer of frozen surimi. This article first introduces the origin of frozen surimi, selection of raw materials, processing technology and development at home and abroad. Secondly, the article discusses the existing storage methods of frozen surimi, the use of antifreeze agents (oligosaccharides, enzymes, etc.) and other methods of extending the storage period (improving thawing methods, increasing water retention, etc.) to maintain the quality of surimi. Finally, the article analyzes the current storage situation of frozen surimi, and makes a prospect for the future development of frozen surimi.

Key words: frozen surimi, storage, antifreeze, quality

不同金枪鱼种梯度解冻过程 NAD 与 ATP 的变化与品质的关系

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摘要: 对不同金枪鱼种: 大目金枪鱼、蓝鳍金枪鱼、黄鳍金枪鱼进行梯度解冻研究, 不同金枪鱼种从 -60°C 转移至 -6°C 冰箱中贮藏后流水解冻, 分析其咀嚼性、汁液损失、NAD、ATP、pH 值、K 值的变化。结果表明大目金枪鱼、黄鳍金枪鱼、蓝鳍金枪鱼当 NAD 降解至 $0.25\mu\text{mol/g}$ 左右、ATP 降解到 $2.50\mu\text{mol/g}$ 左右时, 既能保证鲜度 K 值在一级鲜度范围内, 又能缓解解冻过程中鱼肉的收缩、减缓 pH 值的降低、降低汁液流失。流水解冻前在 -6°C 保藏一定时间可有效减少金枪鱼解冻后的汁液损失, 减缓鱼肉收缩和 pH 降低。

关键词: 金枪鱼; 解冻梯度; 解冻; 品质特性

Relationship between NAD and ATP Changes and Quality during Gradient Thawing of Different Tuna Species

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Abstract: Different species of tuna, including macroorder tuna, bluefin tuna, and yellowfin tuna, were studied for razor thawing. After different species of tuna were transferred from -60°C to -6°C for storage, water thawing was conducted to analyze the changes of their chewability, juice loss, NAD, ATP, pH value and K value. The results showed that when NAD was degraded to about 0.25 mol/g and ATP to about 2.50 mol/g , large-order tuna, yellowfin tuna and bluefin tuna could not only ensure that the freshness K value was within the first-order freshness range, but also alleviate the shrinkage of fish during thawing, the decrease of pH value and the loss of juice. Storage at -6°C for a certain time before thawing can effectively reduce the loss of juice after thawing of tuna, and slow down the shrinkage and pH reduction of fish.

Key words: tuna, thaw gradient, thawing, quality

不同海水鱼种梯度解冻过程 NAD 与 ATP 的变化与品质的关系

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摘要: 对不同海水鱼种: 鳕鱼、三文鱼、沙丁鱼进行梯度解冻研究, 不同海水鱼从 -18°C 转移至 -6°C 冰箱保藏后再流水解冻, 分析鱼肉解冻过程中 NAD、ATP 降解与 pH 值以及滴沥损失的关系, 并与直接流水解冻的鱼肉进行比较。结果表明: 三种鱼直接经流水解冻后的滴沥损失分别为鳕鱼 5.89%、三文鱼 11.58%、沙丁鱼 5.97%; 而 -6°C 保藏一段时间后再流水解冻, 滴沥损失显著下降。冻藏水产品中 NAD 与 ATP 的分解随原料品种各异。三文鱼较其他两种鱼经 -6°C 保藏后流水解冻, 能显著降低滴沥损失、延缓 pH 降低。鳕鱼、沙丁鱼冻藏后流水解冻与直接流水解冻差异不显著, 现有梯度解冻工艺和 NAD 作为鲜度指标更只用于高鲜度的冻藏金枪鱼。

关键词: 鳕鱼; 三文鱼; 沙丁鱼; 解冻梯度; 品质特性

The relationship between NAD and ATP Changes and Quality during Gradient Thawing of Different Marine Fishes

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Abstract: Gradient thawing study was carried out for different seawater fish species: cod, salmon and sardines. Different seawater fish were transferred from -18°C to -6°C for refrigerator storage before being thawed by running water. The relationship between NAD, ATP degradation, pH value and drip loss in the fish thawing process was analyzed, and compared with fish thawed directly by running water. The results showed that the drip loss of cod, salmon and sardine were 5.89%, 11.58% and 5.97% respectively. When stored at -6°C for a period of time and then thawed, drip loss decreased significantly. The decomposition of NAD and ATP in frozen aquatic products varies with the variety of raw materials. Compared with other two kinds of fish, salmon thawed after being stored at -6°C can significantly reduce drip loss and delay pH reduction. There is no significant difference between thawing water and direct thawing water after frozen storage of cod and sardines. The existing gradient thawing process and NAD as freshness indexes are only used for frozen tuna with high freshness

Key words: cod, salmon, sardine, thaw gradient, quality

不同金枪鱼种梯度解冻过程 NAD 与 ATP 的变化与品质的关系

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摘要: 对不同金枪鱼种: 大目金枪鱼、蓝鳍金枪鱼、黄鳍金枪鱼进行梯度解冻研究, 不同金枪鱼种从 -60°C 转移至 -6°C 冰箱中贮藏后流水解冻, 分析其咀嚼性、汁液损失、NAD、ATP、pH 值、K 值的变化。结果表明大目金枪鱼、黄鳍金枪鱼、蓝鳍金枪鱼当 NAD 降解至 $0.25\mu\text{mol/g}$ 左右、ATP 降解到 $2.50\mu\text{mol/g}$ 左右时, 既能保证鲜度 K 值在一级鲜度范围内, 又能缓解解冻过程中鱼肉的收缩、减缓 pH 值的降低、降低汁液流失。流水解冻前在 -6°C 保藏一定时间可有效减少金枪鱼解冻后的汁液损失, 减缓鱼肉收缩和 pH 降低。

关键词: 金枪鱼; 解冻梯度; 解冻; 品质特性

Relationship between NAD and ATP Changes and Quality during Gradient Thawing of Different Tuna Species

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Abstract: Different species of tuna, including macroorder tuna, bluefin tuna, and yellowfin tuna, were studied for razor thawing. After different species of tuna were transferred from -60°C to -6°C for storage, water thawing was conducted to analyze the changes of their chewability, juice loss, NAD, ATP, pH value and K value. The results showed that when NAD was degraded to about 0.25 mol/g and ATP to about 2.50 mol/g , large-order tuna, yellowfin tuna and bluefin tuna could not only ensure that the freshness K value was within the first-order freshness range, but also alleviate the shrinkage of fish during thawing, the decrease of pH value and the loss of juice. Storage at -6°C for a certain time before thawing can effectively reduce the loss of juice after thawing of tuna, and slow down the shrinkage and pH reduction of fish.

Key words: tuna, thaw gradient, thawing, quality

冷冻大黄鱼梯度解冻工艺的研究

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摘要: 大黄鱼在较高鲜度下冻结后流水解冻, 易导致鱼肉收缩、滴沥损失升高、品质降低。将鱼肉在 -60°C 保藏后取出转移至 -12°C 、 -9°C 、 -6°C 、 -3°C 、 0°C 冰箱中保藏相应时间再流水解冻, 在大黄鱼梯度解冻工艺中寻找 NAD 与 ATP 降解最佳平衡点处贮藏时间-温度组合。研究表明: -6°C 贮藏 18h 后流水解冻的鱼肉样品品质与直接流水解冻在 $P < 0.05$ 水平上有显著性差异, 贮藏终点时菌落总数为 $2.79 \lg\text{cfu/g}$, 且能较好地保持鱼肉的持水力、质构等品质。

关键词: 大黄鱼; 梯度解冻; 品质特性

Gradient Thawing Process of Farmed *Pseudosciaena crocea* and Quality Evaluation

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Abstract: The water thawing of farmed *Pseudosciaena crocea* after freezing under high freshness easily leads to the shrinkage of fish, the increase of drip loss and the decrease of quality. Fish meat was stored at -60°C , then taken out and transferred to the refrigerator at -12°C , -9°C , -6°C , -3°C and 0°C for the corresponding time and then thawed in water. In the gradient thawing process of farmed *Pseudosciaena crocea*, the storage time and temperature combination at the optimal equilibrium point of NAD and ATP degradation was searched. The results showed that the quality of fish samples thawed by running water after -6°C storage for 18h was significantly different from that thawed by direct running water at $P < 0.05$ level. The total number of bacterial colonies at the end point of storage was $2.79 \lg\text{Cfu/g}$, and the quality of water holding capacity and texture of fish could be better maintained.

Key words: *Pseudosciaena crocea*, thaw gradient, quality

射频解冻罗非鱼片工艺的研究

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摘要: 为了探究批量解冻罗非鱼片的最优工艺, 本文对比了静水和射频解冻两种工艺, 射频解冻中, 通过调整极板间距 (10/12/14cm)、功率 (600/800/1000W)、模式 (批量/连续) 设置不同的工艺, 将样品从-20℃解冻到-4℃左右。得出以下结论: 静水和射频解冻都能在较短时间内达到解冻目的, 时间从 3.6 分钟到 9 分钟不等; 从红外热像图上来看, 射频解冻均匀性优于静水解冻, 当中心温度达到解冻终温-4℃时, 射频解冻后样品边缘的最高温度为 6.3℃, 而静水解冻后样品边缘最高温度则达到 18.2℃; 射频解冻中设置功率为 800W、极板间距为 12cm 的工艺能使解冻后的样品有较好的均匀性; 与静水解冻相比, 射频解冻后的样品解冻损失率低、温度分布均匀、感官评定得分高。经开启传送带的连续射频解冻后的样品品质与批量解冻无较大差异。

关键词: 罗非鱼; 静水解冻; 射频解冻; 解冻均匀性; 品质特性

Radio frequency Tempering of Tilapia Fillet and Quality Evaluation

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Abstract: In order to find optimal processing conditions of a bulk of tilapia fillets, RF tempering with various power setting (600/800/1000 W), electrode gap setting (10/12/14 cm), different modes (batch/continuous) and water tempering experiments of tilapia fillets were conducted for comparison. The samples were tempered from -20℃ to -4℃. The following conclusions are drawn: tempering time were in a range of 3.6~9min. Based on the infrared picture of the fish fillets after tempering, temperature uniformity by RF were relatively good, with the maximum temperature of 6.3℃. Meanwhile, the maximum temperature went up to 18.2℃ for water tempering when the lowest temperature was kept at -4℃ at the center. The optimal process of radio frequency thawing is the continuous mode with 800 W and 12 cm electrode gap which generated the best tempering uniformity. Compared with water tempering, RF tempering produced a lower drip loss, a much uniform temperature distribution, a higher sensory sensory within the samples. No significant influence was detected between the batch and continuous mode of RF tempered fish fillets.

Key words: tilapia, tempering, radio frequency, temperature uniformity, quality evaluation

养殖大黄鱼梯度解冻中 ATP 与 NAD 的变化

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摘要: 将-60℃冻藏的大黄鱼转移至-12℃至 0℃的冰箱中梯度保藏相应时间再流水解冻, 分析大黄鱼 ATP 及 NAD 的变化。研究表明: 在-6℃保藏 15h 后流水解冻的鱼肉 NAD 含量为 0.25μmol/g、ATP 含量为 2.20μmol/g。直接流水解冻后鱼肉 NAD 含量为 0.45μmol/g、ATP 含量为 2.58μmol/g。当 NAD 降解至 0.25μmol/g 左右, ATP 降解至 2.20μmol/g 左右时, 既能降低滴沥损失、缓解鱼肉收缩, 又能保证 K 值在一级鲜度(20%)范围内, 此梯度解冻工艺可提高大黄鱼流水解冻的品质。

关键词: 大黄鱼; NAD; ATP; 解冻梯度; 品质特性

Changes of ATP and NAD in Gradient Thawing of Farmed *Pseudosciaena crocea*

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Abstract: The frozen farmed *Pseudosciaena crocea* stored at -60℃ was transferred to the refrigerator at -12℃ to 0℃ for a gradient preservation time and then thawed by flowing water to analyze the changes of ATP and NAD of farmed *Pseudosciaena crocea*. The results showed that the NAD content and ATP content of fish thawed from running water were 0.25 mol/g and 2.20 mol/g after being stored at -6℃ for 15h. The NAD content and ATP content of fish were 0.45 mol/g and 2.58 mol/g after thawing in direct running water. When the decomposition of NAD was to 0.25 mol/g as well as the degradation of ATP was to 2.20 mol/g, water thawing optimization had abilities to ease the shrinkage of farmed *Pseudosciaena crocea* and reduce drip loss, as well as ensured the K value less than 20%. This gradient thawing process could improve the quality of thawing water of farmed *Pseudosciaena crocea*.

Key words: *Pseudosciaena crocea*, NAD, ATP, thaw gradient, quality

海参皂苷 Holothurin A 和 Echinaside A 对肥胖小鼠尿酸代谢的影响

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摘要: Holothurin A (HA)和 Echinaside A (EA)是海参中含量较高的两种皂苷, 本研究通过 db/db 小鼠高脂喂食建立高尿酸血症模型, 分析了 HA 和 EA 对高尿酸血症模型小鼠尿酸、尿酸代谢相关酶活性及相关转运体 mRNA 表达的影响。将 db/db 小鼠按体重随机分成 3 组, 分别是模型组、HA 组、EA 组, 每组 8 只, C57/BL6 小鼠为对照组。研究表明, 喂养 14 天后, 海参皂苷 HA 与 EA 均可显著降低血清尿酸水平, 分别降低了 18.1%和 12.7%; 经光学显微镜观察肾脏组织结构, HA 与 EA 均可改善模型组肾小球的病理变化, 这两组的肝脏黄嘌呤氧化酶和腺苷脱氨酶的活性均升高, 肾脏代谢相关转运体 GLUT9、URAT1、OAT1 mRNA、OCTs、OCTNs mRNA 表达均升高。海参皂苷 HA 和 EA 通过调控尿酸代谢相关酶活及转运体 mRNA 表达可以明显改善高尿酸血症。

关键词: 海参皂苷; 尿酸代谢; 嘌呤代谢; 高尿酸血症; 肥胖

The effects of Holothurin A and Echinaside A from sea cucumber on uric acid metabolism

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Abstract: Holothurin A (HA) and Echinaside A (EA) are two major saponins in sea cucumbers. In the present study, high fat-induced hyperuricemia db/db mice model was established to study the effects of HA and EA on uric acid metabolism, moreover, the mechanism was further illustrated by determining the uric acid metabolism-related enzyme activity and the mRNA expression of transporters. The db/db mice were randomly divided into 3 groups (n=8), including model group, HA group, and EA group. Results showed that dietary intervention with HA and EA for 14 days significantly reduced the serum uric acid level by 18.1% and 12.7%, respectively. Furthermore, both HA and EA alleviated the pathological changes of glomeruli compared to the model group. The activities of hepatic xanthine oxidase (XOD) and adenosine deaminase (ADA) were increased, and the mRNA expression of transporters, including GLUT9, URAT1, OAT1 mRNA, OCTs and OCTNs, were significantly elevated after administration with HA and EA. HA and EA could significantly alleviate hyperuricemia by regulating the activity of uric acid metabolism-related enzymes and the mRNA expression of transporters.

Keywords: sea cucumber saponin, uric acid metabolism, purine metabolism, hyperuricemia, obesity

膳食补充海参神经酰胺和脑苷脂减轻果糖诱导的大鼠胰岛素抵抗

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摘要: 内源性神经酰胺抑制许多组织中的胰岛素信号转导, 然而饮食中外源性神经酰胺和脑苷脂对胰岛素抵抗的影响尚不清楚。本研究探讨了海参神经酰胺和脑苷脂对高果糖诱导的 Sprague-Dawley 大鼠的胰岛素抵抗作用。结果表明, 喂食大鼠神经酰胺和脑苷脂可显著改善葡萄糖耐量, 降低空腹血清葡萄糖、胰岛素和糖化血红蛋白的水平, 并减轻胰岛素抵抗伴随的高血压。喂食神经酰胺的大鼠肌糖原含量比喂食脑苷脂更高, 脑苷脂组的肝糖原含量则明显高于神经酰胺组。进一步研究表明脑苷脂主要通过抑制肝细胞内糖异生, 促进糖原合成和激活肝脏组织中的 IRS / PI3K / Akt 胰岛素信号转导通路来减轻胰岛素抵抗, 而神经酰胺主要是促进肌糖原合成和肌肉组织中胰岛素信号转导来减轻胰岛素抵抗。

关键词: 胰岛素抵抗, 炎症, 神经酰胺, 脑苷脂, 海参

Dietary supplementation with sea cucumber-derived ceramides and glucosylceramides alleviates insulin resistance in fructose-induced rats

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Abstract: Endogenous ceramides are considered to be implicated in the development of insulin resistance. However, the effects of dietary exogenous ceramides and glucosylceramides on insulin resistance are unclear. A model of fructose-induced male Sprague-Dawley rats was used to investigate the comparative effects of ceramides and glucosylceramides from sea cucumber on insulin resistance. Results showed that both supplementation with ceramides and glucosylceramides diet significantly improved glucose tolerance, reduced the levels of circulating glucose, insulin and glycosylated hemoglobin, as well as alleviated the accompanied hypertension. The rats administrated with ceramides exhibited higher glycogen content in skeletal muscle compared with glucosylceramides-treated group, whereas the hepatic glycogen content was significantly higher in glucosylceramides group compared with ceramides. A further mechanistic study revealed that glucosylceramides achieved the alleviation of insulin resistance mainly through the inhibition of gluconeogenesis, the promotion of glycogen synthesis and insulin signal transduction by activating IRS/PI3K/Akt signaling pathway in hepatic tissue, meanwhile, ceramides ameliorated insulin resistance mainly due to the promotion of glycogen synthesis and insulin signal transduction in skeletal muscle tissue.

Keywords: insulin resistance, inflammation, ceramides, glucosylceramides, sea cucumber

大黄鱼鱼糜在冻藏过程中流变及凝胶特性

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摘要: 大黄鱼是我国重要的经济鱼类, 本实验利用流变仪研究不同冻藏温度和冻藏时间对大黄鱼鱼糜流变及凝胶特性的影响。结果表明, 大黄鱼鱼糜存在剪切变稀的现象, 即粘度随剪切速率的增加而减小; 鱼糜的 G' 和 G'' 随着剪切频率的增加而升高。鱼糜的凝胶过程经历了 3 个阶段: 第一阶段在 40℃ 之前, 第二阶段出现在 40-50℃, 第三阶段在 50℃ 以后, 蛋白开始形成最终凝胶。随着冻藏温度的升高和冻藏时间的延长, 鱼糜的 G' 和 G'' 减小, 粘弹性下降, 损耗角正切($\tan\delta$) 增大, 流动性增加。本研究对大黄鱼鱼糜的实际生产应用具有重要参考意义。

关键词: 大黄鱼; 鱼糜; 冻藏; 流变; 凝胶

Rheological and gel properties of large yellow croaker surimi during frozen storage

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Abstract: Large yellow croaker is an important economic fish in my country. In this experiment, a rheometer was used to study the effects of different freezing storage temperatures and freezing times on the rheology and gel properties of large yellow croaker surimi. The results showed that there was a phenomenon of shear thinning in the surimi, that is, the viscosity decreases with the increase of the shear rate; the G' and G'' of the surimi increase with the increase of the shear frequency. The gel process of surimi had gone through three stages: the first stage was before 40℃, the second stage appeared at 40-50℃, and the third stage after 50℃, the protein began to form the final gel. With the increase of frozen storage temperature and the extension of frozen storage time, the G' and G'' of surimi decreased, the viscoelasticity decreased, the loss tangent ($\tan\delta$) increased, and the fluidity increased. This research has important reference significance for the actual production and application of large yellow croaker surimi.

Key words: large yellow croaker; surimi; frozen storage; rheology; gel

金针菇多糖复合茶多酚冰衣对冻藏金枪鱼品质影响的研究

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摘要: 为研究金针菇多糖复合茶多酚对水产品的保鲜效果, 本文以金枪鱼为研究对象, 对其-18℃冻藏过程中的感官评定、色泽、高铁肌红蛋白含量、TVBN、持水力等变化进行了研究。结果表明, 2g/L的金针菇多糖复合6g/L的茶多酚冰衣保鲜效果最好, 对冻藏期间金枪鱼颜色的稳定性具有正向协同作用, 抑制了肌红蛋白中二价铁的氧化, 有效保持了感官和质构特性。在贮藏2个月后, 金枪鱼的色泽开始迅速下降, 蛋白质变性较严重。本研究为金枪鱼保鲜技术的进步提供一定借鉴和参考。

关键词: 金针菇多糖; 茶多酚; 冰衣; 金枪鱼; 冻藏

Study on the effect of flammulina velutipes polysaccharide and tea polyphenol ice coating on the quality of frozen tuna

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Abstract: In order to study the preservation effect of flammulina polysaccharide combined with tea polyphenols on aquatic products, this paper took tuna as the research object, and studied the changes of sensory evaluation, color, content of ferric myoglobin, TVBN and water holding capacity during the freezing process of -18℃. The results showed that the tea polyphenols ice coating preservation effect of 2g/L flammulina polysaccharide combined with 6g/L was the best, which had a positive synergistic effect on the color stability of tuna during frozen storage, inhibited the oxidation of ferric divalent in myoglobin, and effectively maintained the sensory and structural properties. After 2 months of storage, the tuna's color began to decline rapidly and protein denaturation was more serious. This study provides some references for the advancement of tuna preservation technology.

Key words: flammulina velutipes polysaccharide; tea polyphenol; ice glaze; tuna; frozen storage

秘鲁鱿鱼须冷冻调理食品的 加工工艺及品质研究

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摘要: 鱿鱼具有高蛋白、低脂肪和低胆固醇等突出特点, 秘鲁鱿鱼更是资源量丰富。但在目前鱿鱼的加工产业中, 少部分鱿鱼须会被利用起来, 这造成了严重的资源浪费。以秘鲁鱿鱼为原料, 对鱿鱼须冷冻调理食品的加工工艺及品质进行研究。结果表明, 添加 3.5% 的质量分数为 2% 的多聚磷酸盐溶液作为保水剂, 质量比为 0.8:1 的辣椒粉和五香粉进行腌制, 辅以 15% 玉米淀粉、0.3% 白砂糖、0.7% 食盐, 160℃ 下油炸 3min 得到的产品最佳。此工艺参数下, 产品的感官评定得分较高, 持水力、脆性较好, 色泽金黄、质地均匀、口感适中。

关键词: 秘鲁鱿鱼须; 冷冻调理食品; 感官评定

Study on the processing technology and quality of Peruvian squid beard frozen prepared food

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Abstract: Squid has outstanding characteristics such as high protein, low fat and low cholesterol. Peruvian squid is rich in resources. However, in the current squid processing industry, a small part of the squid whiskers will be used, which causes a serious waste of resources. Using Peruvian squid as raw material, the processing technology and quality of squid beard frozen prepared food were studied. The results showed that 3.5% polyphosphate solution with a mass fraction of 2% was added as a water-retaining agent, chili powder and five-spice powder with a mass ratio of 0.8:1 were added for pickling, supplemented by 15% corn starch, 0.3% white sugar, The best product was obtained with 0.7% salt and fried at 160℃ for 3min. Under this process parameter, the product had a high sensory evaluation score, good water holding capacity, good brittleness, golden color, uniform texture, and moderate taste.

Key words: peruvian squid whiskers; frozen prepared food; sensory evaluation

微酸性电解水冰对罗非鱼片杀菌效果的影响

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摘要: 本研究探讨了微酸性电解水冰对罗非鱼片杀菌效果的影响, 对比分析了微酸性电解水冰与自来水冰贮藏罗非鱼片的感官评价、TVBN、K值和菌落总数的变化。结果表明, 在0℃的环境下, 与自来水冰贮藏的罗非鱼片相比, 微酸性电解水冰能够抑制贮藏过程中菌落总数的增加和TVBN值的生长, 延长其货架期2-3天, 有效保持了罗非鱼片的品质。而相比于pH为6.0的微酸性电解水, pH为5.5的微酸性电解水更能有效地杀灭细菌, 减缓细菌增殖, 未来可与其他保鲜技术复合来提高水产品的保鲜技术。

关键词: 微酸性电解水冰; 杀菌; 罗非鱼片

Effect of slightly acidic electrolyzed water ice on the sterilization effect of tilapia fillets

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Abstract: This study explored the influence of slightly acidic electrolyzed water ice on the sterilization effect of tilapia fillets, and compared and analyzed the sensory evaluation, TVBN, K value and the changes of the total number of colonies of tilapia fillets stored in slightly acidic electrolyzed water ice and tap water ice. The results showed that compared with tilapia fillets stored in tap water, slightly acidic electrolyzed water ice could inhibit the increase in the total number of colonies and the increase in TVBN value during storage, and extend its shelf life by 2-3 days and effectively maintain the quality of tilapia fillets. Compared with the slightly acidic electrolyzed water with a pH of 6.0, the slightly acidic electrolyzed water with a pH of 5.5 was more effective in killing bacteria and slowing down the proliferation of bacteria. In the future, it can be combined with other fresh-keeping technologies to improve the fresh-keeping technology of aquatic products.

Key words: slightly acidic electrolyzed water ice; sterilization; tilapia fillets

新型“海洋磷脂牛奶”制备工艺的研究

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摘要: 为了提高牛奶的营养价值研发新型复配牛奶, 本研究利用酶解和乙醇浸提法相结合探究扇贝生殖腺中海洋磷脂的提取工艺, 从而进行磷脂牛奶复配工艺的研究。通过单因素及响应面试验设计确定最佳酶解工艺, 并对提取后的海洋磷脂采用高效液相色谱法进行组分定性分析, 最后将海洋磷脂与液态纯牛奶进行复配, 对其稳定性及感官属性进行评价。实验结果显示, 木瓜蛋白酶酶解温度 60 °C、酶解时间 2 h、料液比 1:1.5 为最佳酶解条件, 此条件下海洋磷脂的最高提取率为 78.93 %。将含脂量为 1.2 g /100ml 的牛奶与 75 mg /100 ml 的磷脂复配, 得到的新产品的感官属性、海洋磷脂的乳化性和稳定性最佳。

关键词: 扇贝生殖腺, 海洋磷脂, 提取工艺, 牛奶

Study on the preparation process of new type "marine phospholipid milk"

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Abstract: In order to improve the nutritional value of milk and develop a new type of compound milk, this study used a combination of enzymatic hydrolysis and ethanol extraction to explore the extraction process of marine phospholipids in the scallop gonads, so as to study the phospholipid milk compound process. The optimal enzymatic hydrolysis process was determined through single factor and response surface test design, and the extracted marine phospholipids were qualitatively analyzed by high performance liquid chromatography. Finally, the marine phospholipids were compounded with liquid pure milk to ensure their stability and sensory attributes were evaluated. The experimental results showed that papain enzymatic hydrolysis temperature of 60 °C, enzymatic hydrolysis time of 2 h, and material-to-liquid ratio of 1:1.5 were the best enzymatic hydrolysis conditions. Under these conditions, the highest extraction rate of marine phospholipids was 78.93%. Combining milk with a fat content of 1.2 g/100ml and 75 mg/100 ml of phospholipids, the new product obtained had the best sensory properties, emulsification and stability of marine phospholipids.

Key words: scallop gonad, marine phospholipids, extraction process, milk

琼枝麒麟菜营养成分分析与评价

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摘要 : 为评价琼枝麒麟菜 (*Eucheuma gelatinae*) 的营养价值, 提高其综合应用价值。通过对琼枝麒麟菜基本营养成分、氨基酸、脂肪酸以及矿物元素测定, 对其营养价值进行评价。结果表明: 琼枝麒麟菜的水分、灰分、粗纤维、粗脂肪、粗蛋白以及总碳水化合物的质量分数分别为 12.03%、10.63%、5.03%、0.25%、3.73% 和 73.36%; 含有 17 种氨基酸, 其中包括 8 种必需氨基酸, 第一限制性氨基酸为色氨酸; 含有 10 种脂肪酸, 包括具有重要生理功能的花生四烯酸、二十二碳五烯酸以及二十二碳六烯酸; 琼枝麒麟菜富含钠 (Na)、镁 (Mg)、钙 (Ca)、铁 (Fe)、锌 (Zn)、铜 (Cu)。研究表明琼枝麒麟菜具有较高的营养保健价值和应用开发前景。

关键词: 琼枝麒麟菜; 营养成分; 品质评价; 氨基酸; 矿物元素

Nutritional analysis and quality evaluation of *Eucheuma gelatinae*

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Abstract: In order to evaluate the nutritional value of *Eucheuma gelatinae* and improve its comprehensive application value. In this experiment, the nutritional value of *Eucheuma gelatinae* were evaluated by the determination of its basic nutrients, amino acids, fatty acids and mineral elements. The mass fractions of water, ash, crude fiber, crude fat, crude protein and total carbohydrate of *Eucheuma gelatinae* were 12.03%, 10.63%, 5.03%, 0.25%, 3.73% and 73.36%, respectively. It contains 17 amino acids, including 8 essential amino acids, the first limiting amino acid is tryptophan. Ten kinds of fatty acids were found which included arachidonic acid, eicosapentaenoic acid and docosahexaenoic acid with important physiological functions. Na, Mg, Ca, Fe, Zn and Cu were rich in *Eucheuma gelatinae*. The findings indicated that *Eucheuma gelatinae* has high nutritional value and application development prospects.

Key words: *Eucheuma gelatinae*; nutritional composition; quality evaluation; amino acid; mineral elements

虾青素提取及抗氧化性的研究

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摘要: 为有效提高虾青素的提取率及虾壳废弃物的综合利用, 本文以罗氏沼虾、南美白对虾及南极磷虾为原料, 利用有机溶剂浸提法通过单因素试验比较了三种虾壳中虾青素的提取效果和提取量, 并对南极磷虾虾壳中虾青素提取工艺参数进行正交优化。以 VC 作为对照, 探索了三种虾壳中虾青素的抗氧化能力。结果表明, 罗氏沼虾、南美白对虾及南极磷虾在以二氯甲烷为提取液, 提取温度为 30℃, 提取时间为 2h, 料液比分别为 1:20、1:30、1:30 g/mL 条件下可得到最大提取量, 南极磷虾虾壳中的虾青素的提取量显著高于南美白对虾及罗氏沼虾虾壳中的虾青素。通过正交试验得出, 南极磷虾虾壳中提取虾青素的最佳条件为料液比 1:30g/mL, 提取温度 30℃, 提取时间 2.5 h, 此条件下虾青素的提取量明显提高, 达到为 246.99 μg/g。通过抗氧化实验研究发现, 三种虾壳中的虾青素均具有较好的抗氧化活性, 以罗氏沼虾虾壳中虾青素最佳。

关键词: 南极磷虾; 罗氏沼虾; 南美白对虾; 虾青素; 抗氧化性

The study on the extraction and antioxidant properties of astaxanthin

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Abstract: To effectively improve the extraction yield of astaxanthin and shrimp shell waste comprehensive utilization, this article with *Macrobrachium rosenbergii* and *Penaeus vanname*, *Euphausia superba* as raw material, using organic solvent extraction by single factor experiment, comparison of the three kinds of shrimp shell effect and extracting astaxanthin extraction in quantity, and for extracting astaxanthin from the Antarctic krill shrimp shell process parameters on the orthogonal optimization. The antioxidant capacity of astaxanthin in three kinds of shrimp shells was investigated by taking VC as the control. Results indicate that the *Macrobrachium rosenbergii*, *Penaeus vanname* and *Euphausia superba* in dichloromethane as extract, extract the temperature of 30 °C, extracting time for 2 h, material liquid ratio of 1:20 respectively, 1:30, 1:30g/mL could obtain maximum extraction conditions, the *Euphausia superba* shrimp shells had a significantly higher amount of the extraction of astaxanthin in *Penaeus vanname* and *Macrobrachium rosenbergii* shrimp shell of astaxanthin. Orthogonal experiments showed that the optimal conditions for the extraction of astaxanthin from the shell of *Euphausia superba* were the ratio of solid to liquid 1:30g/mL, the extraction temperature 30℃, and the extraction time 2.5hm, the extraction amount of astaxanthin was significantly increased to 246.99 g/g. The antioxidant activity of astaxanthin in the shell of three kinds of shrimp was found, and astaxanthin in the shell of *Macrobrachium rosenbergii* was the best.

Key words: *Euphausia superba*, *Macrobrachium rosenbergii*, *Penaeus vanname*, Astaxanthin, anti-oxidation

海参甾醇在小鼠体内的消化吸收和代谢特性

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摘要: 海参甾醇在改善机体糖脂代谢紊乱及炎症方面发挥显著功效, 但其消化吸收特性不明。本研究通过灌胃和尾静脉注射实验探究了海参甾醇两种单体 (SS1 和 SS2) 在小鼠体内的消化吸收与代谢特性。灌胃实验结果显示, SS1 的血清吸收峰值在 3h, SS2 的吸收峰值在 4h, 浓度分别为 20.14 $\mu\text{g}/\text{mL}$ 和 13.32 $\mu\text{g}/\text{mL}$ 。海参甾醇 SS1 在小肠内的吸收速度要快于 SS2, 这可能与 SS2 中的 C-24 亚甲基结构有关。代谢动力学研究结果显示, 按照 0.05mg/kg BW 剂量尾静脉注射海参甾醇后, 血清中两种甾醇在 1h 左右恢复至初始水平, 其中海参甾醇 SS1 在血清中的浓度由最初的 47.9 $\mu\text{g}/\text{mL}$ 降低至 5.8 $\mu\text{g}/\text{mL}$, 海参甾醇 SS2 由 34.5 $\mu\text{g}/\text{mL}$ 降低至 2.8 $\mu\text{g}/\text{mL}$ 。尾静脉注射甾醇 0-3 小时小鼠经尿液排泄的量最高, 9 小时几乎排泄完全。海参甾醇主要在肝脏、胆囊、肾上腺、胰腺等器官蓄积, 与胆固醇类似。本文明确了海参甾醇在小鼠体内消化吸收特性, 阐明了两种海参甾醇在小鼠血清中的消减规律, 为海参甾醇类保健食品及药物的研发提供了理论依据。

关键词: 海参甾醇; 消化吸收; 代谢

Digestion, absorption and metabolism of sea cucumber sterol in mice

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Abstract: Sea cucumber sterol plays a significant role in improving the disorder of glucose and lipid metabolism as well as inflammation, but its digestion and absorption characteristics are unknown. In this study, the digestion, absorption and metabolism of sea cucumber sterols (SS1 and SS2) in mice were studied by intragastric administration and tail vein injection. Results showed that SS1 and SS2 reached the peak at 3h (20.14 $\mu\text{g}/\text{mL}$) and 4h (13.32 $\mu\text{g}/\text{mL}$), respectively, after intragastric administration. The absorption rate of SS1 was faster than that of SS2, which might be due to the C-24 methylene in SS2. The serum concentration of SS1 and SS2 was reduced to the lowest level (SS1 from 47.9 to 5.8 $\mu\text{g}/\text{mL}$, SS2 from 34.5 to 2.8 $\mu\text{g}/\text{mL}$) after tail vein injection with sterol at a dose of 0.05 mg/kg BW for 1h. The excretion of sterols in the urine was highest at 0-3 h and almost completely excreted at 9 h. Sea cucumber sterol was mainly accumulated in liver, gallbladder, adrenal gland, pancreas, which was similar to cholesterol. These findings might provide a theoretical basis for the research and development of functional foods and medicines associated with sea cucumber sterols.

Key words: Sea cucumber sterol; digestion and absorption; metabolism

太阳能热泵联合干燥系统设计与试验研究

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摘要: 为有效利用能源、提高水产品干燥品质, 设计了太阳能热泵联合干燥系统, 该系统由太阳能干燥室、热泵机组、进回风风道、卷帘等组成。以海带为研究对象, 在干燥空气温度为 40°C, 流速为 0.85m/s 条件下, 进行了纯太阳能干燥, 纯热泵干燥, 以及太阳能热泵联合干燥海带试验。结果表明三种干燥方式干燥海带耗时分别为 5h, 6h 和 3h。联合干燥比纯热泵干燥收缩率低 2.05%, 色差低 5.57NBS, 略高于纯太阳能干燥。联合干燥海带的复水率最高, 为 75.11%。太阳能热泵联合干燥海带品质最佳, 干燥速率是纯热泵干燥的 2 倍, 能耗降低 50%, 具有较好的应用前景。

关键词: 太阳能干燥; 热泵干燥; 联合干燥; 海带; 干燥品质

Design and experiment of drying kelp with solar and heat pump combined drying system

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Abstract: In order to effectively use energy and improve the drying quality of aquatic products, a solar heat pump combined drying system is designed. The system consists of a solar drying room, a heat pump unit, air inlet and return air ducts, and rolling curtains. Taking kelp as the research object, under the conditions of dry air temperature of 40°C and wind speed 0.85m/s, pure solar drying, pure heat pump drying, and solar heat pump combined drying kelp experiments were carried out. The results showed that the three drying methods took 5h, 6h and 3h to dry kelp. Combined drying has a 2.05% lower shrinkage rate than pure heat pump drying and a 5.57NBS lower color difference, which is slightly higher than pure solar drying. The rehydration rate of joint dried kelp is the highest, at 75.11%. The solar heat pump combined with dried kelp has the best quality, the drying rate is twice that of pure heat pump drying, and the energy consumption is reduced by 50%, which has a good application prospect.

Keywords: solar drying, Heat pump drying, Joint drying, kelp, Dry quality

不同盐度暂养对草鱼、青鱼肌肉品质的影响

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摘要: 为探究不同盐度暂养对草鱼、青鱼肌肉品质的影响, 设置盐度为 0、5.0、7.5 的 3 个水体, 对草鱼、青鱼暂养 48 h。检测肌肉常规营养成分、氨基酸含量、脂肪酸含量、挥发性物质和质构指标, 结果表明: 在盐度 7.5 时, 可以使草鱼肌肉失水率显著下降, 提升草鱼呈味氨基酸含量; 改善草鱼、青鱼肌肉脂肪酸组成, 降低肌肉中的腥味物质含量, 提高草鱼肌肉质构特性; 在盐度 5 时可改善青鱼肌肉质构特性。

关键词: 草鱼; 青鱼; 暂养; 盐度; 肌肉品质

Effects of temporary culture with different salinity on muscle quality of Grass carp and Black carp

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Abstract: In order to explore the effects of different salinity on the muscle quality of grass carp and black carp, three water bodies with salinity of 0, 5.0, 7.5 were set up to temporarily culture grass carp and black carp for 48 hours. The routine nutritional composition, amino acid content, fatty acid content, volatile matter and texture index of grass carp and black carp muscle were tested. The results showed that the water loss rate of grass carp muscle was significantly decreased and the flavor amino acid content of grass carp was increased at 7.5 salinity. It can improve the fatty acid composition of grass carp and black carp muscle, reduce the fishy smell substance content in muscle, improve the texture properties of grass carp muscle, and at salinity 5 can improve the texture properties of grass carp muscle .

Key words: Grass carp; Black carp; Salinity; Short-term culture; Muscle quality

草鱼冷藏过程中品质变化的研究

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摘要: 为了研究草鱼死后的品质变化, 以草鱼(*Ctenopharyngodon idellus*)背肉为研究对象, 研究了草鱼在 4°C 贮藏 192 h 后 pH、质地、乳酸、ATP 相关化合物、K 值、游离氨基酸(FAA)含量的变化, 同时进行了感官评价和电子舌实验。结果表明: 硬度和咀嚼性变化趋势一致, 在 24 h 达到最大, 弹性、内聚性及回复性均随时间的延长而降低。pH 与乳酸含量和硬度密切相关。pH 呈先降低后升高的趋势, 在 24 h 达到最大值。乳酸含量则先增加后减少。在整个贮藏过程中, 鲜甜味游离氨基酸的总含量逐渐减少, 而苦味游离氨基酸的总含量则逐渐增加。IMP 含量整体呈减少趋势, 而 Hx、HxR 含量逐渐增加。在整个贮藏过程中, K 值一直在增加, K 值的变化情况表明, 草鱼死后常温贮藏 48 h 内可保持较高鲜度。生熟草鱼感官评估则与 K 值相反, 感官评分逐渐降低。总的来说, 草鱼死后 4°C 贮藏时在 4-8 h 食用效果较好, 并应在 6 天内尽快食用。本研究将丰富鱼类死后品质变化的基础理论, 为水产品的贮运保鲜提供参考。

关键词: 草鱼; 游离氨基酸; ATP 及其关联化合物; K 值, 感官评价

Study on Quality Changes of Grass Carp during Cold Storage

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Abstract: In order to study the quality changes of grass carp during cold storage, the changes in the pH, texture, lactic acid, ATP-related compounds, K value, free amino acids (FAA) contents in the dorsal meat of grass carp stored at 4°C for 192 hr were measured. Sensory and electronic tongue assessment were also performed. The results showed a consistent trend in the hardness and chewiness, and reached its maximum at 24 h and then decreased, while springiness, cohesiveness, and resilience of grass carp decreased with the extension of storage time. pH were closely correlated with the lactic acid content and hardness. pH showed a trend of decreasing first and then increasing, and it reached its maximum at 24 h. The content of lactic acid increased initially and then decreased. The total amount of fresh sweet amino acids gradually decreased during the postmortem process, while the opposite occurred with the bitter amino acids. The content of IMP decreased on the whole, while the content of Hx and HxR increased gradually. The K value remained increased throughout the storage. The change in K value indicated that grass carp could maintain high freshness after storage for 48 h at 4°C. Sensory assessment followed the opposite trend, which decreased throughout the storage. Overall, we recommend that grass carp should be consumed within 6 days when stored at 4°C, it has better edible effect in 4-8h after death. This study will enrich the basic theory of postmortem variation of fish and provide support for the quality change of aquatic products.

Key words: Grass carp, Free amino acids, ATP-related compounds, K-value, Sensory assessment

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暂养密度对越冬暂养中华绒螯蟹 (*Eriocheir sinensis*) 的死亡率、生理状态和营养成分的影响

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摘要: 为探究池塘循环水网箱养殖中中华绒螯蟹的最佳越冬暂养密度和时间, 分析了不同暂养密度中华绒螯蟹的死亡率、生理状况和营养成分随时间的变化。结果表明, 越冬暂养时间小于90d时, 最佳暂养密度为21.88 kg/m²左右, 而越冬暂养时间较长(90d以上)的暂养密度以15.63 kg/m²为宜。消化酶活性、抗氧化状态和 *HSP70* 基因表达随暂养时间的延长而波动。此外, 可食组织中 PUFA/SFA 比值上升, C20: 4 和 C20: 5 水平升高, 表明中华绒螯蟹的食用品质得到了改善。本研究结果为中华绒螯蟹的越冬暂养提供了参考标准。

关键词: 中华绒螯蟹; 暂养密度; 死亡率; 脂肪酸; 抗氧化状态

Effect of stocking density on mortality rate, physiological status and nutrient contents of Chinese mitten crab *Eriocheir sinensis* during overwintering cultivation

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Abstract: Aiming to find the optimal stocking density and time for overwintering rearing *E. sinensis* using net cages embedded in a circulating pond aquaculture, we analyzed the death rate, physiological status, and nutrient contents of *E. sinensis* at different stocking densities over time periods. Our findings suggested that the optimal stocking density is around 21.88 kg/m² in case of overwintering cultivation less than 90 days; while a medium density of 15.63 kg/m² is more suitable for longer term overwintering cultivation (more than 90 days). the activity of digestive enzymes, antioxidant status, or gene expression of *hsp70* were fluctuant over rearing time. Moreover, a rising ratio of PUFA/SFA, as well as increased levels of C20:4 and C20:5 in edible tissues after 105-days overwintering cultivation, suggesting an improved eating quality of *E. sinensis*. Our results provide a reference standard for the overwintering cultivation of *E. sinensis*.

Keywords: *Eriocheir sinensis*, Stocking density, Death rate, Fatty acids, Antioxidant status

非热加工技术在食品工业中的应用与展望

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摘要: 食品的非热加工不仅能够保证食品的营养及新鲜品质, 也能保证其安全性。本文将简要介绍如超声波技术, 超高压技术和辐照技术为代表的非热加工技术的原理以及食品工业中的研究进展, 并对食品非热加工技术进行展望。

关键词: 非热加工技术; 食品工业; 综述

Application and Prospect of Non-thermal Processing Technology in Food Industry

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Abstract: Non-thermal processing of food can not only ensure the nutritional and fresh quality of food, but also its safety. This article will briefly introduce the principles of non-thermal processing technologies such as ultrasonic technology, ultra-high pressure technology and irradiation technology, as well as research progress in the food industry, and look forward to non-thermal processing technologies for food.

Keywords: non-thermal processing technology; food industry; review

南美白对虾贮藏期间品质变化建模: Arrhenius 模型和 Random Forest 模型对比

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摘要: 为了研究南美白对虾在 4、-3、-20 °C 贮藏条件下的品质变化, 本文对感官、pH、质构(硬度、弹性、胶着性和咀嚼性)、TBA、巯基和 Ca²⁺-ATPase 活性和菌落总数进行了测定, 选择了 Random Forest 模型与 Arrhenius 模型进行对比来评估这些指标的品质变化并构建货架期模型。在不同温度下, pH, TBA 和 TVC 随着贮藏时间的延长而增加, 其他指标均呈下降趋势。与 Arrhenius 模型相比, Random Forest 模型的各项品质指标的相对误差均低于 10%, r² 接近 1, 均方根误差大多低于 0.1, 这意味着品质指标在随机森林模型中拟合度更好。因此, 具有较高预测精度的随机森林模型对预测南美白对虾品质变化起到重要作用, 这为水产品的货架期模型提供了一个具有可行性的模型。

关键词: 南美白对虾; 劣变; Arrhenius 模型; Random Forest 模型

Modeling Quality Changes in Pacific White Shrimp (*Litopenaeus vannamei*) During Storage: Comparison of the Arrhenius Model and Random Forest Model

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Abstract: To investigate the quality changes of Pacific white shrimp stored at 4, -3 and -20 °C, indicators including sensory assessment, pH, texture (hardness, springiness, gumminess, chewiness), thiobarbituric acid (TBA), total sulfhydryl content, Ca²⁺-ATPase activity and total viable counts (TVC) were studied in this work. The Random Forest model was chosen to estimate the quality changes of these indicators in comparison with the Arrhenius model. During different temperatures, pH, TBA and TVC increased with the extension of storage time, while the other indicators decreased. Compared with the Arrhenius model, the relative errors of quality indicators of the Random Forest model were below 10%, r² was close to 1, and root mean square error was mostly below 0.1, which meant a better fitting property for these indicators. Thus, the Random Forest model with higher prediction accuracy is a hopeful method for predicting the changes in the quality of Pacific white shrimp.

Keywords: Pacific white shrimp; Deterioration; Arrhenius model; Random Forest model

海珍品冰-低温热泵干燥控制系统设计与试验

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摘要: 为提升海珍干品品质, 降低人力成本, 设计了基于西门子 S7-300 PLC 的冰-低温热泵干燥控制系统。干燥过程中冰、低温干燥箱温度、湿度和风速等参数通过传感器由数据采集模块采集, 根据海珍品干燥工艺设计了参数控制程序和人机界面, PLC 将控制信号发送给电磁阀和风机变频器, 自动控制干燥过程中温、湿度等环境参数。为验证控制系统性能, 以南美白对虾为研究对象, 干燥过程中冰、低温干燥箱温度分别经过 0.3h 和 0.5h 达到稳态, 稳态后温差分别为 0.7℃ 和 1℃, 波动范围较小。此外, 相对于带皮对虾, 低温干燥去皮对虾可节省 7% 的时间。试验结果表明, 干燥过程中该控制系统运行稳定, 控制精度高, 能够在海珍品干燥过程中取得良好的控制效果。

关键字: 冰-低温热泵; 控制系统; PLC; 人机界面; 南美白对虾

Design and Test of Drying Control System for Seafood Freezing Point and Low Temperature Heat Pump

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Abstract: In order to improve the quality of dried seafood and reduce labor costs, a freezing point and low temperature heat pump drying control system based on Siemens S7-300 PLC was designed. The temperature, humidity and wind speed of the freezing point temperature drying oven and low temperature drying oven are collected by the data acquisition module through sensors. The parameters control program and human machine interface are designed according to the seafood drying process. The control signal is sent by the PLC to the solenoid valve and the fan inverter to adjust the drying environment parameters, which realizes the automatic control of temperature and humidity during the drying process. In order to verify the performance of the drying control system, a drying test of prawns (*Penaeus vannamei*) was carried out. During the drying process, the temperature of freezing point temperature drying oven reached a steady state after 0.3h, and that of low temperature drying oven reached a steady state after 0.5h. After the steady state, the temperature difference of freezing point temperature drying oven was 0.7 °C, and that of low temperature drying oven was 1 °C. The fluctuation range was little. In addition, compared to the prawns without peeled, low temperature drying of peeled prawns could save 7% of the time. The test results showed that the freezing point and low temperature heat pump drying control system runs stably. The control precision of the control system was high. And the control effect of this system was good during the drying process of seafood.

Keywords: freezing point and low temperature heat pump; control system; PLC; human machine interface; prawns (*Penaeus vannamei*)

不同盐度暂养对鲤鱼、鲫鱼肌肉品质的影响

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摘要: 以鲤鱼、鲫鱼为研究对象, 研究其在盐度 0、5.0、7.5 的水体中暂养 48 h 后的肌肉品质变化, 为改善鲤鱼、鲫鱼肌肉品质提供理论参考。暂养结束后通过营养成分分析, 质构分析和检测氨基酸、脂肪酸、挥发性化合物含量等方法检测肌肉品质, 结果表明: 在盐度为 5 和 7.5 时, 可以使鲤鱼、鲫鱼肌肉呈香味氨基酸含量提高; 使鲤鱼肌肉硬度减小、粘性增加, 使鲫鱼肌肉弹性、粘性和咀嚼性增加; 改善鲤鱼、鲫鱼肌肉脂肪酸组成。

关键词: 鲤鱼; 鲫鱼; 盐度; 肌肉品质; 营养成分

Effects of temporary culture with different salinity on muscle quality of *Cyprinus carpio* and *Carassius auratus*

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Abstract: Taking *Cyprinus carpio* and *Carassius auratus* as the research object, the muscle quality changes of *Cyprinus carpio* and *Carassius auratus* were studied after 48 h of temporary cultivation in salinity 0, 5.0 and 7.5, which provided theoretical reference for improving muscle quality of carp and crucian carp. The results showed that when the salinity was 5 and 7.5, the flavor of carp and crucian carp could be increased; the hardness and viscosity of carp muscle were decreased, and the elasticity, viscosity and chewiness of crucian carp muscle were increased; the muscle elasticity, viscosity and chewiness of crucian carp muscle were improved when the salinity was 5 and 7.5 Fatty acid composition of muscle of fish and crucian carp.

Key words: *Cyprinus carpio*; *Carassius auratus*; Salinity; muscle quality; nutritional ingredient

金针菇多糖对大黄鱼微冻储藏期间品质变化的影响

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摘要: 为研究金针菇多糖 (polysaccharide from *Flammulina velutipes*, FVP) 对大黄鱼在微冻储藏期间肌原纤维蛋白质性质的影响, 试验分别选用 0.03 g/L、0.06 g/L 与 0.09 g/L FVP 浸渍处理样品, 以无菌水处理为对照组, 分析微冻贮藏期间样品的感官指标、总巯基含量、Ca²⁺-ATPase 活性以及蛋白流变学性质。结果得出, FVP 可有效抑制整鱼 TVB-N 值上升和感官值的下降, 减缓整鱼及鱼片在冻藏过程中总巯基含量、Ca²⁺-ATPase 活性下降。此外 FVP 还能够延缓大黄鱼因腐败而产生的蛋白凝胶能力的减弱。在本试验选取的多糖浓度范围内, 0.09 g/L FVP 处理组保鲜效果较强。该研究结果可为 FVP 用于水产品贮运保鲜提供理论参考。

关键词: 金针菇多糖; 大黄鱼; 微冻; 水分迁移; 品质

Effects of polysaccharide from *Flammulina velutipes* on the quality of large yellow croaker (*Pseudosciaena crocea*) during superchilled storage

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Abstract: In order to investigate the effects of polysaccharide from *Flammulina velutipes*(FVP) treatment on the myofibrillar proteins from large yellow croaker during superchilled storage, the fish were treated with 0.03 g/L, 0.06 g/L and 0.09 g/L FVP respectively, and that of sterile water treatment was used as control group. The sensory evaluation, TVB-N value, total sulfhydryl content, Ca²⁺-ATPase activity and protein rheological properties of the samples during storage were analyzed. The results showed that FVP could effectively inhibit the increase of TVB-N value and the decrease of sensory value of fish, slow down the decrease of total mercapto content and Ca²⁺-ATPase activity of fish. In addition, FVP can retard the weakening of the protein gel produced by the spoilage of large yellow croaker. In the range of polysaccharide concentration in this experiment, FVP treatment group of 0.09 g/L had the strongest fresh-keeping effect. The research can provide a theoretical reference for FVP in the storage and transportation of aquatic products.

Keywords: polysaccharide from *Flammulina velutipes*(FVP); *Pseudosciaena crocea*; superchilled storage; water migration; quality

不同添加物对不漂洗大黄鱼鱼糜凝胶品质的影响

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摘要: 以不漂洗大黄鱼鱼糜为对象, 添加 4 组添加物, 分别为占鱼糜重量 6%淀粉+0.5%碳酸氢钠、6%淀粉+0.5%焦磷酸按、6%大豆分离蛋白 (Soybean protein isolate, SPI) +0.5%碳酸氢钠以及 6%大豆分离蛋白+0.5%焦磷酸钠。并对其凝胶强度、硬度、持水性、蒸煮损失、白度、pH、水分迁移变化以及动态流变学特性等进行测定。结果表明: 与不漂洗对照组 (ck)相比, 加入添加物 4 组均在不同程度增强了其凝胶强度、TPA、保水能力、动态流变学特性 G'等, 其中加入淀粉与焦磷酸钠组的凝胶强度达到最大值, 为 358.65 (g.cm), 淀粉与碳酸氢钠组改善凝胶硬度最为显著 (p<0.05); 但加入 4 组添加物后均在一定程度上降低了凝胶的白度。综合各指标得出: 相比于大豆分离蛋白, 添加淀粉可以更好地改善不漂洗大黄鱼鱼糜的凝胶特性与保水能力, 而加入碳酸氢钠与焦磷酸钠均可提高凝胶保水能力, 且作用效果相当。

关键词: 大黄鱼鱼糜; 淀粉; 大豆分离蛋白; 碱性保水剂

Effects of different additives on the quality characteristics of non-rinsed large yellow croaker surimi

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Abstract: Taking the non-rinsing large yellow croaker surimi as the research object, 4 groups of additives were added, namely 6% starch + 0.5% sodium bicarbonate, 6% starch + 0.5% pyrophosphate, 6% soybean protein isolate (Soybean Protein isolate, SPI) + 0.5% sodium bicarbonate and 6% soy protein isolate + 0.5% sodium pyrophosphate. And its gel strength, hardness, water holding capacity, cooking loss, whiteness, pH, water migration changes and dynamic rheological properties were measured. The results showed that: compared with the non-rinsing control group (ck), the addition of additives in the 4 groups all enhanced their gel strength, TPA, water retention capacity, dynamic rheological properties G', etc. to varying degrees, in which starch and pyrophosphate were added. The gel strength of the sodium group reached the maximum value of 358.65 (g.cm), and the starch and sodium bicarbonate group improved the gel hardness most significantly (p<0.05); but after adding the 4 groups of additives, it decreased to a certain extent The whiteness of the gel. Comprehensive indicators show that compared with soy protein isolate, adding starch can better improve the gel properties and water retention capacity of non-rinsed large yellow croaker surimi, while adding sodium bicarbonate and sodium pyrophosphate can improve the water retention capacity of the gel, And the effect is equivalent.

Key words: large yellow croaker surimi; starch; soy protein isolate; alkaline water retention agent

EPA/DHA-PS 对 A β 诱导的原代海马神经元神经毒性及小胶质细胞清除 A β 的影响

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摘要: 阿尔兹海默症 (AD) 是一种年龄依赖的、渐进性神经退行性疾病。前期研究结果表明, 富含 n-3 多不饱和脂肪酸的甘油磷脂, 特别是磷脂酰丝氨酸 (PS), 在预防和改善 AD 方面具有显著效果。但是, EPA-PS 与 DHA-PS 对 AD 的改善作用是否存在差异未被报道。本研究以 A β 损伤的原代海马神经元及小胶质细胞 (BV2) 为模型, 比较研究了 EPA-PS 与 DHA-PS 对 A β 神经毒性的改善作用, 并探究了 EPA-PS 与 DHA-PS 对 BV2 吞噬 A β 的影响。结果显示 EPA/DHA-PS 可以通过抑制 PI3K/Akt 信号转导通路和细胞凋亡通路显著改善 A β 诱导的海马神经元损伤, 且 EPA-PS 与 DHA-PS 的效果无显著差异。此外, EPA/DHA-PS 均可提高小胶质细胞吞噬 A β 的能力, DHA-PS 效果优于 EPA-PS。本研究为预防和治疗阿尔兹海默症提供膳食指导并为相关功能食品的开发提供参考。

关键词: 阿尔兹海默症; β -淀粉样蛋白; EPA/DHA-磷脂酰丝氨酸

Effects of EPA/DHA-PS on primary hippocampal neuronal neurotoxicity induced by A β and microglial clearance of A β

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Abstract: Alzheimer disease (AD), is an age-dependent, progressive neurodegenerative disease. The results of previous studies have shown that phospholipids enriched with n-3 polyunsaturated fatty acids, especially phosphatidylserine (PS), have significant effects in preventing and improving AD. However, whether there is a difference between EPA-PS and DHA-PS in improving AD has not been reported. In the present study, primary hippocampal neurons and mouse microglia BV2 as experimental cells were used to study the effects of EPA-PS and DHA-PS on A β -induced primary hippocampal neuronal neurotoxicity as well as on the microglial clearance of A β . Results found that EPA-PS and DHA-PS equally protected A β -induced hippocampal neurons from toxic damage by inhibiting PI3K/Akt signal transduction pathway and apoptosis pathway. Moreover, DHA-PS was superior to EPA-PS in enhancing the ability of microglia to clear A β . This research might provide dietary guidance for the prevention of Alzheimer's disease as well as the reference for the development of related functional foods.

Key words: Alzheimer's disease β -amyloid; EPA/DHA-PS

鱼血浆、鳃代谢组学样品处理优化

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摘要: 采用高效液相色谱-飞行时间质谱联用技术 (UPLC/Q-TOF-MS), 对鱼类代谢组学中血浆、鳃样品的前处理方法进行了考察和优化, 为研究鱼类受水环境胁迫代谢组学奠定了基础。通过考察不同溶剂系统的有机试剂、有机试剂用量、萃取温度、样品冻融循环次数, 对血浆、鳃中蛋白质去除程度以及代谢物提取效果的影响, 确定了采用预冷甲醇沉淀蛋白法; 进一步对预冷甲醇沉淀蛋白法进行了优化, 确定了血浆和鳃样品分别使用 4 倍、5 倍体积用量的预冷甲醇, 可以达到最佳的提取效果。并且实验结果表明, 样品经不同次数的冻融循环后, 不引起统计学上的差异。利用质量控制样本 (QC) 进行方法学考察, 结果表明, 本方法的仪器精密度、方法精密度和样本稳定性均良好。

关键词: 代谢组学; 样品前处理; 血浆; 鳃; UPLC/Q-TOF-MS

Sample treatment optimization for fish plasma and gill metabolomics

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Abstract: The pretreatment methods of plasma and gill samples in fish metabolomics were investigated and optimized by high performance liquid chromatography-time-of-flight mass spectrometry (UPLC/Q-TOF-MS), which laid a foundation for the study of fish metabolomics under water environment stress. The effects of different solvent systems on the degree of protein removal in plasma and gill and the extraction effect of metabolites were investigated, including the amount of organic reagent, extraction temperature and freeze-thaw cycle times of samples. The method of pre-cooled methanol precipitation protein was determined. Furthermore, the pre-cooled methanol precipitation protein method was further optimized, and it was determined that the pre-cooled methanol with 4 times volume and 5 times volume was used for plasma and gill samples, respectively, to achieve the best extraction effect. The experimental results show that there is no statistical difference between the samples after different freeze-thaw cycles. The results show that the instrument precision, method precision and sample stability of this method are good.

Key words: metabolomics, sample treatment, plasma, gill, UPLC/Q-TOF-MS

大黄鱼肝脏的生化组成及评价

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摘要:近年来我国大黄鱼产量不断增加, 进而在加工大黄鱼的过程中产生了大量的鱼副产物(如肝脏等), 为了提高鱼副产物的利用率, 获得更高的价值, 对大黄鱼肝的生化组成进行了详细的分析与评价, 以期为接下来营养和功能性产品的开发提供依据。结果表明, 大黄鱼肝中水分含量较鱼肉低, 为 45.71%, 蛋白质含量为 8.25%, 脂肪含量为 37.97%。且大黄鱼肝中含有丰富的氨基酸, 脂肪酸的测定结果也较为理想, 不饱和脂肪酸含量多达 62.63%, 其中 EPA 和 DHA 占 9.42%。与此同时, 大黄鱼肝还富含磷脂、维生素以及微量元素。且重金属元素(如汞, 砷, 镉等)含量均低于中国鱼类重金属限量标准。在其挥发性风味成分的测定结果中也分析出形成鱼肝风味的关键成分, 为醛、酮和醇类化合物。

关键词: 大黄鱼肝; 脂肪酸与氨基酸; 挥发性成分; 微量元素; 营养成分

Biochemical composition and evaluation of the liver of large yellow croaker

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Abstract: During the processing of the large yellow croaker, the further utilization of the by-products (e.g., the liver) generated in the processing process can provide opportunities for value addition and increase profitability, promoting the sustainable use of raw materials. Therefore, we have studied the detailed nutritional composition of the large yellow croaker liver (LYCL), which ultimately helps in the development of nutritional and functional products. The results showed that the LYCL has a lower moisture content (45.71%) than fish meat, 8.25% protein, and 37.97% fats. In addition, LYCL contained the full range of amino acids. Unsaturated fatty acids accounted for 62.63%, of which EPA and DHA account for 9.42%. It was rich in phospholipids, vitamins and trace elements. Heavy metal elements such as Hg, As, Cd were lower than the heavy metal limit standards for fish in China. Aldehydes, ketones and alcohols in the liver have the greatest impact on odor.

Key words: Large yellow croaker liver, amino acids and fatty acid, volatile components, trace elements, nutritional evaluation

不同加热方式对罗非鱼片品质的影响

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摘要: 为探究不同加热方式对罗非鱼品质影响, 以生鱼肉为对照, 实验研究了汽蒸、水煮、空气炸 3 种加热方式对其色差、加工损失率、pH 值、质构、基本营养成分、脂肪氧化、脂肪酸组成含量、挥发性物质组成的影响。结果表明, 汽蒸对鱼肉 pH 值影响较小; 水煮热加工损失率最小, 脂肪氧化程度较大; 空气炸处理热加工损失率最大, 灰分、粗蛋白、粗脂肪相对含量升高, 颜色变化更加明显, 硬度、咀嚼性增加。加热后鱼肉饱和脂肪酸 (SFA) 含量增加, 单不饱和脂肪酸 (MUFA) 含量减少, 多不饱和脂肪酸 (PUFA) 含量增加。在对照、汽蒸、水煮、空气炸鱼肉中分别检测出 38、44、44、47 种挥发性物质, 主要有醛类、醇类和烷烃类物质。不同热加工方式对罗非鱼肉颜色、风味、营养成分等品质具有一定影响, 可为罗非鱼的热加工提供一定的理论指导。

关键词: 罗非鱼; 热处理; 色差; 质构; 营养成分; 脂肪酸; 风味; GC-MS

Effects of different heating methods on the quality of tilapia fillet (*Oreochromis niloticus*)

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Abstract: In order to explore the influence of different heating methods on tilapia quality, the effects of steaming, boiling and air-frying on color difference, processing loss rate, pH value, texture, basic nutrients, fat oxidation, fatty acid composition content and volatile substance composition were experimentally studied by taking raw fish as the control. The results showed that steaming had little effect on the pH value of fish. The loss rate is the lowest in boiling and the degree of fat oxidation is larger. In the air-frying treatment, the loss rate of heat processing was the highest, the relative contents of ash, crude protein and crude fat increased, the color changes were more obvious, and the hardness and chewability increased. After heating, the content of saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) in fish were increased. 38, 44, 44 and 47 kinds of volatile substances, mainly aldehydes, alcohols and alkanes, were detected in the control, steaming, boiling and air-frying fish meat, respectively. Different thermal processing methods have a certain influence on the color, flavor, nutrition and other qualities of tilapia fish, which can provide certain theoretical guidance for the thermal processing of tilapia fish.

Key words: tilapia; thermal processing; color difference; texture; nutritional content; fatty acid; flavor; GC-MS

定量测定虾剥壳效果及其在剥壳过程中的应用

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摘要: 为了定量分析虾的剥壳效果, 以质构仪为基础并通过标准化分开壳肉所需总功来测量虾剥壳所需功。结果表明, 所建立的单位功在定量测量虾的剥壳效果方面是有效的并且与脱壳面积和虾的大小无关。1、2、3节虾身的剥壳功分别为 8.36, 7.90, 和 8.02 mJ/g, 无显著差异。对虾身而言, 冷冻 4 h (4.07 mJ/g) 和冰盐泥 8 h (5.11 mJ/g) 处理后, 以及对尾巴冷冻 8 h (19.28 mJ/g) 后, 所需剥壳功显著降低。与鲜虾对照相比, 冷冻/冰盐泥预处理后的虾显示出更大的壳肉间隙。这种定量分析虾的剥壳效果和剥壳性能的方法可能有助于优化虾的剥壳过程。

关键词: 虾可剥性; 定量方法; 质构仪; 冷冻预处理; 冰盐预处理

A quantitative method to analysis shrimp peelability and its application in the shrimp peeling process

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Abstract To quantitatively analyze shrimp peelability, the peeling work was measured using a texture analyzer by normalizing the total peeling work to separate the shell and shrimp muscle. The results showed the developed method of normalized peeling work was valid in accessing the peelability of shrimp and was independent of the shell removal area and shrimp size; no significant difference was observed for abdominal segments (AS) 1, 2, and 3 with peeling work 8.36, 7.90, and 8.02 mJ/g, respectively. Furthermore, the peeling work decreased after 4 h of freezing (4.07 mJ/g) and 8 h of ice-slurry (5.11 mJ/g) pre-treatment for AS, and after 8 h of freezing (19.28 mJ/g) for tail segments. Moreover, as compared to raw shrimps, frozen/ice-slurry pre-treated shrimps displayed larger shell-loosening gaps. The quantitative analysis method for measuring the peeling efficiency and peeling performance of shrimps could be useful to optimize the shrimps peeling.

Keywords: shrimp peelability; quantitative method; texture analyzer; frozen pre-treatment; ice-slurry pre-treatment.

微胶囊化丁香酚乳剂对养殖日本鲈鱼冷藏过程中品质的影响

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摘要: 本研究探讨含微胶囊化丁香酚乳剂的海藻酸钠-亚麻籽胶涂膜保鲜对 4℃ 冷藏过程中养殖日本鲈鱼的品质影响, 主要集中于微生物、理化、风味和感官评价等指标。研究表明, 含 0.15% 微胶囊化丁香酚乳剂的涂膜保鲜可以显著抑制菌落总数、假单胞菌、产 H₂S 菌和嗜冷菌的增长, 同时, 可以显著抑制 TMA、TVB-N、ATP 相关化合物和游离氨基酸的积累。利用 SPME-GC/MS 分离鉴定出 29 种挥发性风味化合物, 含微胶囊化丁香酚乳剂涂膜保鲜处理的养殖日本鲈鱼中 1-辛烯-3-醇、1-戊烯-3-醇、己醛、庚醛、壬醛、癸醛、(E)-2-辛烯醛和 2,3-戊二酮等与鱼腥味相关化合物相对含量较低。MRI 结果显示, 含微胶囊化丁香酚乳剂涂膜保鲜可以更有效地延缓水的迁移。根据感官评价结果, 涂膜保鲜可以更好的保持冷藏条件下养殖日本鲈鱼的感官品质。

关键词: 日本鲈鱼; 冷藏; 微胶囊化丁香酚乳剂; 挥发性风味化合物

Effects of microencapsulated eugenol emulsions on microbiological, chemical and organoleptic qualities of farmed Japanese sea bass (*Lateolabrax japonicus*) during cold storage

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Abstract: The objective of this study was to investigate the effect of sodium alginate (SA) and flaxseed gum (FG) active coatings containing microencapsulated eugenol emulsions on microbiological, physicochemical, flavor and organoleptic evaluation of farmed Japanese sea bass samples during 16 days storage at 4 °C. Results showed that SA-FG coatings combining with 0.15 % eugenol emulsions could significantly lower total viable count, *Pseudomonas* spp., H₂S-producing bacteria and psychrophilic counts, and reduce the productions of off-flavor compounds including the trimethylamine, total volatile basic nitrogen and ATP-related compounds, and accumulation of free amino acids. 29 volatile compounds were identified by SPME-GC/MS during cold storage and the coating treated sea bass samples significantly lowered the relative content of fishy flavor compounds, such as 1-octen-3-ol, 1-penten-3-ol, hexanal, heptanal, nonanal, decanal, (E)-2-octenal and 2,3-pentanedione. Further, SA-FG coatings containing eugenol could more efficiently retard the water migration by magnetic resonance imaging results, and maintained quality of sea bass during storage at 4 °C according to organoleptic evaluation results.

Key words: Japanese sea bass; cold storage; microencapsulated eugenol emulsions; volatile components

南极磷虾船载加工技术与装备研究进展

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摘要: 介绍了南极磷虾产业发展现状,船载加工技术与装备研究背景、国内外研究现状及存在的问题。并针对南极磷虾船载加工技术与装备落后、产品品质不稳定等主要问题,结合南极磷虾酶活性强、氟含量高的特性,开展了南极磷虾脱壳加工技术与装备、虾糜加工技术与装备、虾粉加工工艺及关键装备等研究,形成了南极磷虾船载虾肉与虾粉加工工艺,研发了磷虾船载脱壳加工、虾糜制取、快速蒸煮等关键装备,为实现南极磷虾船载加工技术与装备的国产化奠定了基础。

关键词: 南极磷虾; 船载加工; 脱壳; 虾糜; 虾粉; 蒸煮; 装备

Research Progress in Shipboard Processing Technology and Equipment for Antarctic Krill

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Abstract: The development status of Antarctic Krill Industry, research background ,research status and existing problems of shipboard processing technology and equipment are introduced. Aiming at the key problems of Antarctic Krill shipboard processing, such as backward technology and equipment, unstable product quality, combined with the characteristics such as high activity of enzyme and high content of fluorine, the techniques and equipment such as Shucking , Minced shrimpe and Shrimp powder for Antarctic Krill Shipboard Processing were researched. The Shipboard processing technology of Shrimp powder was formed,the key equipment such as Krill Shucking,Minced shrimpe and rapid cooking were developed, which laid a foundation for the localization of Krill Shipboard processing technology and equipment.

Key words: Antarctic Krill; shipboard processing; Shucking; Shrimp mince; shrimp powder; cooking; Equipment

二十二碳六烯酸羧化的虾青素酯对帕金森小鼠行为缺陷的改善作用优于非酯化虾青素

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摘要: 非酯化虾青素 (astaxanthin, AST) 对帕金森病 (Parkinson's disease, PD) 具有改善作用。值得注意的是, 二十二碳六烯酸羧化的虾青素酯 (Docosahexaenoic acid-acylated astaxanthin ester, DHA-AST) 在海产品中广泛分布。然而, DHA-AST 对帕金森病的影响, 及其与非酯化 AST 或非酯化 AST 与 DHA 复配 (DHA+AST) 的差异尚不清楚。本研究采用 1-甲基-4-苯基-1,2,3,6-四氢吡啶 (MPTP) 诱导的 PD 小鼠, 观察 DHA-AST、AST 和 DHA+AST 对帕金森病的影响。结果表明, DHA-AST 对 MPTP 诱导的小鼠帕金森病具有显著改善作用, 且显著优于非酯化 AST 和 DHA+AST。机制研究表明, 三种虾青素补充剂都能抑制小鼠脑内氧化应激。重要的是, DHA-AST 通过线粒体介导的以及 JNK/P38MAPK 介导的途径抑制多巴胺能神经元凋亡, 且其作用在三种补充剂中最佳。DHA-AST 在改善 PD 小鼠行为缺陷方面优于非酯化 AST, 这与细胞凋亡相关而与氧化应激无关。本研究为神经退行性疾病的防治提供膳食指导, 为相关功能性食品的开发提供理论参考。

关键词: 虾青素; 二十二碳六烯酸羧化虾青素酯; 帕金森病; 细胞凋亡; 氧化应激

DHA-acylated astaxanthin ester exerted superior effects to non-esterified astaxanthin in preventing behavioral deficits coupled with apoptosis rather than oxidative stress in MPTP-induced mice with Parkinson's disease

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Abstract: Non-esterified astaxanthin (AST) has been reported to exhibit protective effect on Parkinson's disease (PD). Notably, DHA-acylated astaxanthin ester (DHA-AST) is widely distributed in the seafood. However, it is unclear that the effect of DHA-AST on PD, and the differences from DHA-AST, non-esterified AST and the recombination of non-esterified AST (AST) with DHA (DHA+AST). In the present study, the PD mice induced by 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP) were employed to investigate the effects of DHA-AST, AST and DHA+AST on Parkinson's disease. Results showed that DHA-AST exerted significant effects on alleviating PD development by the rotarod test in MPTP-induced mice, which was better than AST and DHA+AST. Further mechanical research indicated that all three kinds of astaxanthin supplements could inhibit the oxidative stress in brain. It was noted that DHA-AST had the best effects to suppress the apoptosis of dopaminergic neurons via mitochondria-mediated pathway and JNK and P38 MAPK pathway in brains among the three treated groups. DHA-AST exerted superior effects to AST in preventing behavioral deficits coupled with apoptosis rather than oxidative stress, which might provide a reference for the prevention and treatment of neurodegenerative diseases.

Keywords: Astaxanthin; Docosahexaenoic Acid-Acylated Astaxanthin; Parkinson's disease; apoptosis; oxidative stress

罗非鱼鱼糜自然发酵过程中微生物群落结构对其品质形成的影响研究

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摘要: 本文采用 16S rRNA 高通量测序技术研究罗非鱼鱼糜自然发酵过程中微生物群落演替规律, 结果显示 Firmicutes 和 Proteobacteria 为整个发酵过程主要微生物菌门, *Lactococcus* 是罗非鱼发酵鱼糜中最主要的属, 其次是 *Pediococcus*。罗非鱼发酵鱼糜品质指标分析显示, 随着发酵时间的增加, 凝胶强度、白度、硬度和菌落总数逐渐增加, 而 pH、粘性、弹性、咀嚼性和内聚性与发酵初始相比有所下降。利用 Pearson 和 PCA 等统计学分析方法分析核心微生物菌属与鱼糜品质的相关性, 结果显示 *Lactococcus*、*Pediococcus*、*Enterococcus*、*Enterobacter*、*Citrobacter* 等产酸菌属的增加与发酵鱼糜 pH 的下降, 以及凝胶强度、白度、硬度等关键鱼糜品质指标的改善呈显著正相关性。

关键词: 发酵鱼糜; 微生物菌群; 罗非鱼; 品质; 高通量测序

Effect of microbial community on the quality formation of naturally fermented tilapia surimi during fermentation

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Abstract: In this study, 16S rRNA high-throughput sequencing was used to study the succession of microbial communities during the natural fermentation of tilapia surimi. The results showed that Firmicutes and Proteobacteria were the main microbial phyla in the whole fermentation process, and *Lactococcus* was the most important genus in the fermented tilapia surimi, followed by *Pediococcus*. The quality index analysis of fermented tilapia surimi showed that with the increase of fermentation time, the gel strength, whiteness, hardness and total plate count significantly increased, while the pH, adhesiveness, springiness, chewiness and cohesiveness decreased compared with that before fermentation. The correlation between core microbial genera and quality indexes was analyzed using Pearson and PCA. The increase of acid-producing bacteria such as *Lactococcus*, *Pediococcus*, *Enterococcus*, *Enterobacter*, *Citrobacter*, was positively correlated with the decrease of pH value, as well as the improvement of key quality indexes of fermented surimi such as gel strength, whiteness and hardness.

Key words: Fermented surimi; microbial community; tilapia; quality; high-throughput sequencing

水产品中挥发性风味物质的提取及分析

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摘要: 水产品因其营养丰富一直以来都是消费者青睐的产品, 而评价水产品品质的关键是对其挥发性风味物质进行分析鉴定。本文简述了水产品中挥发性风味物质主要的种类, 以及目前国内外研究者们利用电子鼻、气相色谱-质谱联用法、气相色谱-质谱-嗅闻法及气味检测技术结合智能技术等分析方法对挥发性风味物质进行鉴定。样品前处理过程, 主要介绍了蒸馏法、固相萃取整体捕集剂法、固相微萃取法、溶剂辅助蒸发法等, 并且分析了水产品中挥发性物质的鉴定的发展方向, 为对水产品挥发性风味物质的研究提供参考。

关键词: 水产品; 挥发性风味物质; 提取; 检测

Methods of extraction and detection of volatile flavoring substances in aquatic products

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Abstract: Aquatic products have always been favored by consumers because of their rich nutrition, and the key to evaluate the quality of aquatic products is to analyze and identify their volatile flavor substances. This paper briefly describes the main types of volatile flavor compounds in aquatic products, and the researchers at home and abroad and utilize electronic nose, gas chromatography-mass spectrometry, gas chromatography-mass-spectrometry-olfactory and odor detection technology combined with intelligent technology such as analysis method for identification of volatile flavor compounds and combined with the sample preparation process, mainly focus on distillation overall capture agent, solid phase extraction, solid phase microextraction, auxiliary solvent evaporation method, etc. The development direction of the identification of volatile compounds in aquatic products is analyzed, which provides reference for the study of volatile flavor substances in aquatic products.

Key words: aquatic product; volatile flavor compounds; extraction; detection

上海熏鱼的风味形成机理及制品改良

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摘要: 以大口黑鲈 (*Micropterus salmoides*) 替代草鱼 (*Ctenopharyngodon idellus*) 制作上海熏鱼, 采用单因素试验设计和正交试验设计改良上海熏鱼的加工工艺, 即油爆时间 6min, 油爆后浸渍液中酱油: 白砂糖 4: 3 (即鱼块质量的 20%:15%), 油爆后浸渍时间 16min。采用顶空固相微萃取气相色谱-质谱法分别测定油爆后鲈鱼、用不含香辛料的油爆后浸渍液处理的上海熏鱼及上海熏鱼成品中的挥发性风味活性物质的变化, 三种样品中的挥发性化合物分别为 37、47、55 种。经气相色谱-质谱的定性定量分析, 醛酮类、醇类、烃类、芳香类和含氮含硫类物质是上海熏鱼的主要风味化合物。高温油爆过程中发生的美拉德反应、热降解、脂肪酸氧化有助于去除鱼腥味, 形成上海熏鱼的特色风味。浸渍和油爆是提高鱼肉制品品质的优良加工工艺。

关键词: 大口黑鲈; 感官评定; 顶空固相微萃取-气质联用; 挥发性化合物; 上海熏鱼改良

Flavor formation mechanism and product improvement of Shanghai style bloated fish

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Abstract: Using largemouth bass as an alternative to grass carp and processing Shanghai style bloated fish. In order to improve the processing technology of Shanghai style bloated fish, single-factor test design and orthogonal test were adopted, that was frying 6min, soy sauce: white sugar 4:3 (fish quality 20%:15%) in the soaking liquid after frying and soaking 16min. Headspace solid phase micro-extraction gas chromatography-mass spectrometry was used to analyze the changes of volatile flavor active substances in deep-fried largemouth bass, Shanghai style bloated fish (no spices in the soaking liquid) and Shanghai style bloated fish final product. The volatile compounds in three samples were 37, 47 and 55, respectively. Aldehydes, ketones, alcohols, hydrocarbons, aromatic and nitrogen, sulfur-containing substances were the main flavor compounds of Shanghai style bloated fish by qualitative and quantitative analysis of gas chromatography-mass spectrometry. The Maillard reaction, thermal degradation and fatty acid oxidation happened in the deep-frying process helped to reduce fishy smell and form the characteristic flavor of Shanghai style bloated fish. Soaking and deep-frying were excellent processing methods to improve the quality of fish products.

Key words: *Micropterus salmoides*, sensory evaluation, headspace solid phase micro-extraction gas chromatography-mass spectrometry, volatile flavor compounds, process method improvement of Shanghai style bloated fish

褐藻胶特异性分子探针的获取与应用

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摘要: 褐藻胶是褐藻门生物的主要多糖, 同时也是一种具有重要商业价值的海洋多糖, 被广泛应用于食品、化妆品、医药等领域。特异性分子探针是开展相应多糖特异性检测、高通量分析及原位可视化研究的重要工具。本研究从课题组前期分离鉴定的一株海洋细菌新种 *Wenyingshuangia fucanilytica* CZ1127^T 的基因组出发, 通过生物信息学分析, 挖掘得到一条由两个碳水化合物结合结构域组成的基因序列 *abp*, 对其进行异源表达并系统研究了表达蛋白 ABP_Wf 的结合特性。结果表明, ABP_Wf 对褐藻胶具有结合能力, 而对果胶、硫酸软骨素等含有糖醛酸结构的多糖以及海带淀粉、海藻岩藻聚糖硫酸酯等褐藻来源的多糖均不具有结合能力, 表明 ABP_Wf 特异性结合褐藻胶。利用生物膜干涉技术研究了 ABP_Wf 对褐藻胶的结合动力学常数, K_a 和 K_D 值分别为 $1.94 \times 10^3 \text{ M}^{-1}\text{s}^{-1}$ 和 $1.16 \times 10^{-6} \text{ M}$ 。以 ABP_Wf 及其荧光融合蛋白为探针, 实现了褐藻胶的高通量半定量分析及原位特异性可视化观察。ABP_Wf 的获取为褐藻胶的研究提供了良好工具。

关键词: 褐藻胶; 多糖结合蛋白; 碳水化合物结合结构域; 探针

The discovery and application of a specific molecular probe for alginate

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Abstract: Alginate is the main polysaccharide of the *Phaeophyta*. And it is a commercially important polysaccharide widely applied in food, cosmetics and pharmaceutical industries. Specific molecular probes are important tools for the specific detection, high-throughput analysis, and *in situ* visualization of responding polysaccharide. In the present study, a novel alginate-binding protein ABP_Wf, consisting of two carbohydrate-binding modules, was cloned from a marine bacterium *Wenyingshuangia fucanilytica* CZ1127^T, and heterologously expressed in *Escherichia coli*. ABP_Wf exhibited a binding capacity to alginate, and the K_a and K_D were $1.94 \times 10^3 \text{ M}^{-1}\text{s}^{-1}$ and $1.16 \times 10^{-6} \text{ M}$. While ABP_Wf could not bind to other polyuronic acids including pectin, chondroitin sulfates, dermatan sulfate, hyaluronic acid and heparin, or to other predominant polysaccharide components in brown algae, *i.e.*, laminarin and fucoidans, which indicated that ABP_Wf binds specifically to alginate. Besides, the potentials of ABP_Wf and its fluorescent fusion protein in the semi-quantitative detection and the *in situ* visualization of alginate were evaluated, which implied that ABP_Wf could be served as a promising tool for investigating alginate.

Key words: Alginate, polysaccharide-binding protein, carbohydrate-binding module, prob

领域九

休闲渔业与渔文化

对七彩神仙鱼大脑的转录组分析以确定在亲代养育期间调节“乳汁”分泌的基因

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摘要: 亲代养育在哺乳动物中很常见, 它能给后代提供牛奶, 牛奶是一种富含多种营养和非营养因素的物质, 对发育中的新生儿的生存至关重要。一种亚马逊慈鲷——七彩神仙鱼有一种不寻常的行为: 自由游动的鱼苗在孵化一个月后会啄食父母的皮肤黏液供其生长发育, 这与哺乳动物的哺乳行为非常相似。然而, 关于七彩神仙鱼分泌“乳汁”的机制和相关基因却知之甚少。为了在分子水平上探索七彩神仙鱼啄食亲代皮肤黏液的独特行为, 我们利用雌七彩神仙鱼在泌乳和非泌乳期间的脑组织进行了转录组测序。通过对脑转录组的分析, 比较七彩神仙鱼泌乳和非泌乳期间共得到 86 个差异表达基因, 其中上调基因 71 个, 下调基因 15 个。通过功能富集分析, 得到 20 个代谢通路如雌激素信号通路、炎症、促性腺激素信号通路、神经营养信号通路、Jak-STAT 信号通路, 吞噬作用等。参与这些通路的差异表达基因有 PRKCD、H1-5、EDNRB、LAPTM、FOXB、OTX2、NRIF2、SOX1 和 HBE, 可能在亲代养育过程中对七彩神仙鱼分泌乳汁发挥重要作用。

关键词: 七彩神仙鱼; 转录组; 脑; 亲代抚育

Transcriptome analysis of discus fish (*Symphysodon aequifasciata*) brain to identify genes that regulate 'milk' secretion during parental care

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Abstract: Parental care is common in mammals and allows offspring to obtain milk, a substance rich in a range of nutritional and non-nutritional factors crucial to the survival of a developing newborn. The discus fish *Symphysodon* spp., an Amazonian cichlid, have an unusual behavior: Free-swimming fry bite the skin mucus of their parents' for growth and development after hatching for a month. This is similar to the breastfeeding behavior of mammals. However, little is known about the mechanism by which discus secrete 'milk' and the related genes involved. In order to explore the unique behavior of discus fry feeding on parental skin mucus at the molecular level, transcriptome sequencing was performed using the brain tissues of female discus during parental and non-parental periods. By analyzing the brain transcriptome, a total of 86 differentially expressed genes were obtained by comparing parental with non-parental discus including 71 up-regulated genes and 15 down-regulated genes. Through functional enrichment analysis, 20 metabolic pathways were obtained, e.g., estrogen signaling pathways, inflammatory mediator regulation of TRP channels, vascular smooth muscle contraction, GnRH signaling pathway, neurotrophic signaling pathway, NOD-like receptor signaling pathway, Jak-STAT signaling pathway, Fc gamma R-mediated phagocytosis, serotonergic synapses, autophagy-animal and cytokin-cytokine receptor interaction. The differentially expressed genes, e.g., PRKCD, H1-5, EDNRB, LAPTM, FOXB, OTX2, NRIF2, SOX1 and HBE, involved in these pathways might play important roles in upstream regulation of discus 'milk' secretion during parental care.

Keywords: Discus fish; Transcriptomic; Skin mucus; Brain; Parental care.

血鹦鹳温室工程化循环水养殖系统构建与应用研究

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摘要: 为提升血鹦鹳 (*Cichlasoma citrinellum* ♂ × *Cichlasoma synspilum* ♀) 的养殖效益, 降低能耗, 构建了血鹦鹳工程化养殖系统 (A 棚)。该系统以传统温棚养殖系统为对照组 (B 棚), 通过将各养殖池交叉串联, 配置集中输水管道和多层级“物理+生物过滤”等处理设施。通过比较在不同养殖模式下, 血鹦鹳养殖出产的品级、养殖成本及效益, 探讨血鹦鹳工程化养殖系统的养殖性能及效果。结果显示: A 棚养殖的成活率为 96.6%, 比 B 棚高 1.06%; 参照国家标准-观赏鱼分级规则血鹦鹳鱼 (GB/T 30946-2014), A 棚出产 AAA 级、AA 级和 A 级血鹦鹳的比例分别为 19.70%、35.78% 和 29.64%, 分别比 B 棚高 4.1%、3.07% 和 1.87%; A 棚出产返黑现象血鹦鹳和 B 级血鹦鹳所占的比例分别为 13.19%、1.69%, 分别比 B 棚低 2.23%、6.81%。结果表明: 该工程化养殖系统能够提高血鹦鹳的成活率和优级品的产出率, 提高养殖效益。

关键词: 血鹦鹳; 设施化循环水养殖系统; 品级; 养殖效益

Effect of engineering and recirculating aquaculture system with greenhouse for blood parrot fish (*Cichlasoma citrinellum* ♂ × *Cichlasoma synspilum* ♀)

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Abstract: To improve the culture effects and reduce the farming cost, a engineering aquaculture system for *Cichlasoma citrinellum* ♂ × *Cichlasoma synspilum* ♀ was upgraded to construct the enclosed recirculating aquaculture system by adding the unit such as hot water pipeline and multi level water treatment facilities. Comparative experiments on aquaculture were carried out with a duration of 90 d. The result showed that survival rate of experimental group was 96.6%, which was better than the control group. According to the ornamental fish grading rules-blood parrot cichlid (GB/T 30946-2014), the rations of blood parrot grades of AAA, AA and A in the treatment group were 19.70%, 35.78% and 29.64%, respectively, which were 4.1%, 3.07% and 1.87% more than the control group; the rations of blood parrot grades of B and returning to black were 13.19% and 1.69%, which were 2.23% and 6.81% less than the control group. This study demonstrated that the constructed engineering and recirculating aquaculture system is an economically feasible system with the advantages of high efficiency, energy saving and emission reduction.

Keywords: blood parrot fish; engineering and recirculating aquaculture system; grading rules; breeding benefit

浅谈观赏鱼文化传承与发展

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摘要: 观赏鱼, 色彩鲜艳、姿态优雅、美妙动人。近年来, 随着人们物质生活水平的不断提高, 人们对精神生活的要求也在提高, 更要求精神生活充裕, 发展型和享受型的精神生活方式消费需求出现了日益增长的趋势。不论是发展中国家还是发达国家, 现代世界各国都在兴起观赏鱼热, 使观赏渔业成为现代渔业经济发展新的增长点。经济的迅猛发展带来了人们精神文化生活水平的提高, 为满足人们的精神享受, 从文化深度和艺术高度两个维度上, 观赏鱼文化应运而生。观赏鱼文化潜移默化地影响着全世界的价值取向、文化艺术、审美观念、民族风俗、社会风尚等, 是人类在社会历史实践过程中所创造的又一类物质财富和精神财富。

关键词: 观赏鱼; 精神生活; 观赏鱼文化

On the inheritance and development of ornamental fish culture

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Abstract: Ornamental fish, which are colorful, elegant and beautiful. In recent years, with the continuous improvement of people's material living standard, people's requirement for spiritual life is also increasing, and the spiritual life is more abundant. There is a growing trend of consumption demand for developing and enjoying spiritual lifestyle. Whether in developing countries or in developed countries, ornamental fish fever is rising all over the world, ornamental fishery has become a new growth point of modern fishery economy. The rapid development of economy has brought about the improvement of people's spiritual and cultural living standard. In order to satisfy people's spiritual enjoyment, ornamental fish culture come into being from two dimensions of cultural depth and artistic height. Ornamental fish culture subtly influence the value orientation, culture and art, aesthetic concept, ethnic custom and social fashion, etc. of the world. It is another kind of material wealth and spiritual wealth created by human beings in the process of social and historical practice.

Key words: ornamental fish, spiritual life, ornamental fish culture

文旅融合背景下象山海洋渔文化旅游发展研究

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摘要: 当今社会, 文旅融合发展是新形势下旅游产业的必然选择, 目前中国旅游正从单一的观光游到文化休闲游的转换中, 要想留住游客的心, 必须深度挖掘地域文化, 建立文化体验感, 将文化融入到旅游中, 丰富游客的精神世界, 达到“文”与“游”的高度融合。象山县地处宁波市东南部, 渔文化历史悠久, 有“中国渔文化之乡”之称, 渔文化资源丰富。本文通过分析象山渔文化旅游的发展现状, 指出象山渔文化旅游发展中存在的问题并提出解决策略。

关键词: 文旅融合 渔文化 文化旅游

Research on the development of Xiangshan fishery culture tourism under the background of cultural tourism integration

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Abstract: In today's society, the integration of culture and tourism is the inevitable choice of tourism industry under the new situation. At present, China's tourism is changing from a single sightseeing tour to a cultural leisure tourism. In order to retain the hearts of tourists, it is necessary to deeply explore regional culture, establish a sense of cultural experience, integrate culture into tourism, enrich the spiritual world of tourists, and achieve the high integration of "culture" and "tourism". Xiangshan County, located in the southeast of Ningbo City, has a long history of fishing culture, known as the "hometown of Chinese fishing culture", and is rich in fishery cultural resources. This paper analyzes the development status of Xiangshan fishing culture tourism, points out the problems existing in the development of Xiangshan fishing culture tourism and puts forward the solutions.

Key words: Cultural tourism integration, fishery culture and cultural tourism

读诗寻味品鲈鱼

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摘要: 我国渔文化历史悠久, 鱼在历史的演变中逐渐渗透入人们生活的方方面面, 成为生产劳动和艺术创造的重要对象, 从而形成了丰富多彩的渔文化, 成为中国优秀文化的组成部分。我国是一个诗的国度, 有着丰富灿烂的诗词瑰宝, 其中与“鱼”相关的有千余首, 传承着中华民族的独特精神。鲈鱼以其鲜美的口感和诗意化的意象多次出现在古诗词中, 被文人墨客赞美咏叹, 形成了令人回味无穷的“鲈鱼文化”。本文通过搜集解读相关古诗词, 探讨渔文化之精美以及对当今渔业发展的推动作用, 感受古人之于鱼的酒食雅趣和风流韵味。

关键词: 鲈鱼; 古诗词; 渔文化; 咏鱼诗; 鲈鱼文化; 渔业

Reading poems, looking for flavor and tasting perch

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Abstract: Fishing culture has a long history in China. Fish has gradually penetrated into all aspects of people's life in the historical evolution, and has become an important object of production, labor and artistic creation, thus forming a rich and colorful fishing culture, and becoming an integral part of China's excellent culture. China is a nation of poems with rich and splendid poetic treasures, among which there are more than one thousand poems related to "fish", inheriting the unique spirit of the Chinese nation. Perch, with its delicious taste and poetic image, has appeared in ancient poetry for many times. It has been praised and chanted by literati, forming the "perch culture" with endless aftertaste. Through collecting and interpreting relevant ancient poetry, this paper discusses the delicacy of fish culture and its promotion to the current fishery development, and feels the elegance and romantic taste of ancient fish.

Key words: perch, ancient poetry, fishing culture, poems praising fish, perch culture, fishery industry

浙江省渔业科技发展特点及其展望

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摘要: 渔业科技是我国建设渔业强国的重要突破点和关键着力点, 渔业科技的进步是渔业实现产业生态化、可持续发展的必经之路。浙江省是我国的传统农业大省, 渔业科技的进步必然会极大的推动浙江省渔业产业结构的深化调整。为了深化浙江省渔业科技创新的发展, 以便更好地助力浙江省渔业经济的建设, 本文通过调研渔业相关资料以及文献, 综述了浙江省渔业科技发展的历程, 采用对比分析法和统计分析法纵向比较了一段时期内浙江省渔业科技的发展现状, 概括了浙江省渔业科技发展以恢复渔业资源、培育优秀品种、促进渔业经济发展和提高渔民人均收入的主要特点, 在此基础上提出浙江省渔业科技发展要更侧重于渔业科技人才的培养、加强渔业科技体系的创新建设、以重点科技进行优种良种的培育以及加快渔业科技信息化的建设。本文对浙江省加快渔业科技发展的道路和方式提供了参考。

关键词: 浙江省; 渔业科技; 发展特点; 展望

Characteristics and prospect of fishery science and technology development in Zhejiang Province

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Abstract: The progress of fishery science and technology is the only way to realize the ecological and sustainable development of fishery industry, also the breakthrough point for China to become a powerful fishery country. The progress of fishery science and technology will promote the growth of fishery economy. In order to boost the construction of fishery economy in Zhejiang province, Zhejiang province was reviewed in this paper the development of fishery science and technology, the longitudinal comparison with the method of statistical analysis of Zhejiang province fishery science and technology development present situation, summarized the characteristics of fishery development in Zhejiang province, pointed out that the development of fishery science and technology of Zhejiang province must pay attention to training in fishery talents, accelerate the construction of fishery science and technology information.

Key words: Zhejiang Province; Fishery science and technology; Development characteristics; Looking forward

“互联网+”背景下休闲渔业创新发展的模式与策略研究—以广东省休闲渔业为例

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摘要: 近年来, 休闲渔业作为一种新型业态正蓬勃发展, 不断开拓传统渔业的内涵, 将渔业与休闲娱乐、观赏旅游、生态创新、文化传承、科学普及、餐饮美食等有机结合, 提供满足社会大众休闲需求的产品和服务, 逐步实现一二三产业融合发展的形态。随着互联网时代的来临, 休闲渔业也势必会通过网络助力, 探寻出新的发展道路。本文基于“互联网+”的时代背景下, 重点以广东省休闲渔业发展为例, 通过概念阐述、现状分析和创新提升策略等对休闲渔业与多产业协调融合的发展模式及策略进行了探讨。

关键词: 休闲渔业; 产业融合; 大数据; O2O 模式; 渔文化

Research on the mode and strategy of innovation and development of recreational fishery under the background of “Internet +” —Take Guangdong Province's recreational fishery as an example

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Abstract: In recent years, as a new type of business, recreational fishery has been developing vigorously and constantly exploring the connotation of traditional fishery, which organically combines fishery with recreational entertainment, ornamental tourism, ecological innovation, cultural heritage, scientific popularization, catering and food, etc, to provide products that meet the leisure needs of the public And services, and gradually realize the form of one-two-three industry integrated development. With the advent of the Internet age, recreational fishery will inevitably find new development paths through the help of the Internet. Based on the “Internet+” era, this paper focuses on the development of recreational fishery in Guangdong Province as an example, and discusses the development mode and strategy of the harmonious integration between recreational fishery and multi-industry through concept elaboration, current situation analysis and innovation promotion strategy.

Key words: recreational fishery, industry convergence, Big data, O2O mode, Fishing culture

供给侧结构性改革背景下休闲渔业标准体系的构建

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摘要: 休闲渔业是现代渔业五大产业之一,同时也是推进渔业转型升级的有效途径。它充分利用了渔村、渔文化资源,促进了渔业的提质增效,带动了渔民转产增收,为供给侧结构性改革提供了新途径、新动能。当前我国渔业发展已经进入到供给侧结构性改革的关键时期,迫切需要对休闲渔业的各环节进行规范提升以得到进一步发展。本文阐述了休闲渔业及其标准化的基本内涵,分析了休闲渔业标准化在国内外的发展现状,从产品、管理、服务和评价四个维度初步构建休闲渔业标准体系,总结提出休闲渔业标准体系落地实施的工作建议。

关键词: 供给侧结构性改革; 休闲渔业; 标准体系; 产业融合

Establishment of standard system for recreational fishery base on supply-side structural reforms

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Abstract: The recreational fishery is one of the five major branches for the modern fishery industry, and as an effective way to transform and restructure the fishery industry. It has effectively activated fishing villages and cultural resources, promoted the improvement of the quality and efficiency of the fishery industry, boosted fishermen's income and increased production, and provided new ways and new drivers for supply-side structural reforms. The recreational fisheries in China has currently stepped into the phase of adjustment and improvement, all the key elements about recreational fishery are in dire need of regulation and direction for further development. This paper expounds the basic connotation of recreational fishery and its standardization and analyzes the development status of recreational fishery standardization at home and abroad. At the same time, the paper puts preliminarily constructs the standard system of recreational fishery from the four dimensions such as product, management, service and evaluation, and puts forward the suggestions for the implementation of recreational fishery standard system.

Key words: supply-side structural reforms ; recreational fishery ; standard system ; industrial convergence

唐诗“观鱼”意象中的假隐与真隐

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摘要: 唐诗中的“观鱼”意象常与隐逸之风有着密切联系, 其中不仅有心无杂念的“真隐”, 更有表达复杂心绪的“假隐”, 两种隐逸类型与“观鱼”意象交织呈现, 反映出其背后具有的深刻的历史、文化内涵。

关键词: 唐诗; “观鱼”意象; 隐逸

False concealment and true concealment in the image of "watching fish" in Tang Poetry

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Abstract: The image of "watching fish" in Tang poetry is often closely related to the intention of seclusion, in which there is not only the "true seclusion" with no distracting thoughts, but also the "false seclusion" with complex mood. The two types of seclusion and the image of "watching fish" are interwoven, reflecting the profound historical and cultural connotation behind them.

Key words: Tang Poetry, The image of "watching fish", Seclusion

海岛型休闲渔业游客满意度研究——以舟山东极岛为例

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摘要: 以东极岛为例, 构建了海岛型休闲渔业游客感知因子指标体系, 包括岛上基础设施、资源环境、文化体验、服务质量等四大层面共 18 个因子。运用单因素方差分析, 研究了各因子对游客满意度的影响关系, 运用 IPA 分析模型得出目前东极岛需要继续保持的项目主要有景观特色、生态环境、当地居民热情友好程度, 需要重点改善交通的通达性、公共设施水平等方面。东极岛可以通过升级基础设施、筑造景观特色品牌、强化文化体验等措施, 提高游客的满意度, 同时促进海岛型休闲渔业的可持续发展。

关键词: 海岛型休闲渔业; 游客满意度; IPA 法; 东极岛

Research on tourist satisfaction of island leisure fishery ——Take Zhoushan Dongji Island as an example

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Abstract: Taking the Dongji Island as an example, an island-type leisure fishery tourist perception factor index system was constructed, including 18 factors in four major aspects, including the island's infrastructure, resources and environment, cultural experience, and service quality. Through the single factor analysis of variance, the relationship between the factors affecting tourist satisfaction was studied, and the IPA analysis model was used to conclude that the current projects that need to be maintained on the Dongji Island mainly include landscape features, ecological environment, and the enthusiasm and friendliness of the local residents. It is necessary to focus on improving transportation accessibility, public facilities, etc. The Dongji Island can improve tourist satisfaction through measures such as upgrading infrastructure, building landscape brand, and strengthening cultural experience, while promoting the sustainable development of island-type recreational fisheries.

Key words: Island-type recreational fishery, tourist satisfaction, IPA analysis model, the Dongji Island

不同生长速率七彩神仙鱼肠道菌群差异分析

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摘要: 七彩神仙鱼 (*Symphysodon haraldi*) 是一种具有重要经济价值和观赏价值的鱼类。同一批次鱼苗在相同饲养条件下个体之间生长速率存在显著差异, 这种差异会直接影响七彩神仙鱼养殖的经济效益。肠道菌群在鱼类营养代谢和生长发育中起着重要作用。目前, 关于肠道菌群与生长速率之间关系的研究还较少。本研究比较分析了来自同一生产批次在相同培育条件下不同生长速度七彩神仙鱼幼鱼 (40 日龄) 和成鱼 (270 日龄) 肠道菌群之间的差异性。结果表明, 生长缓慢组七彩神仙鱼幼鱼和成鱼肠道菌群 OTU 均高于生长快速组, 但生长快速组和生长缓慢组七彩神仙鱼幼鱼和成鱼 α 、 β 群落多样性及功能预测的差异不显著。对于 40 日龄七彩神仙鱼, 生长缓慢组幼鱼肠道内邻单胞菌属含量相对较高, 而生长快速幼鱼肠道内乳球菌属和芽孢杆菌属含量相对较高。对于 270 日龄七彩神仙鱼, 生长缓慢组成鱼肠道内肠球菌属含量相对较高, 而生长快速组成鱼肠道中乳球菌和梭菌属含量相对较高。尽管生长快速组和生长缓慢组七彩神仙鱼幼鱼和成鱼 α 、 β 群落多样性及潜在功能差异不显著, 但上述肠道菌种类丰度的差异可能是导致七彩神仙鱼长速率不同的重要原因。

关键词: 七彩神仙鱼; 肠道菌群; 生长差异

Comparative analysis of intestinal microbiota of discus fish (*Symphysodon haraldi*) with different growth rates

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Abstract: Discus fish (*Symphysodon haraldi*) is an important ornamental fish. There are significant individual growth differences in the same batch of fry under the same feeding conditions and such differences can greatly influence the efficiency and profitability of discus farming. Gut microbiota plays an important role in fish nutrition metabolism and growth. Studies on the relationship between intestinal microbiota and growth rates are scarce to the present. Here, we investigated the community diversity and function of intestinal microbiota of juvenile and adult discus from the same parents but with different growth speeds under the same culture conditions. The results showed that, for 40 (juvenile) and 270 (adult) days post-hatch (DPH) discus, the OTUs of bacterial community of the slow-growing discus were both higher than those of the fast-growing fish. No significant differences in Alpha, Beta community diversity and functional potential between fast-growing and slow-growing juvenile or adult discus were observed. For 40 DPH, however, relatively higher content of *Plesiomonas* was observed in the guts of juvenile slow-growing discus while relatively higher levels of *Lactococcus* and *Bacillus* were found in the guts of juvenile fast-growing discus. For 270 DPH, relatively higher content of *Enterococcus* was observed in the guts of adult slow-growing discus but relatively higher levels of *Lactococcus* and *Clostridium* were found in the guts of adult fast-growing discus. The difference in the abundance of the above-mentioned intestinal bacteria may be an important reason for the different growth rate of the discus.

Key words: *Symphysodon haraldi*; Intestinal microbiota; Growth difference

产业融合背景下浙江海洋休闲渔业发展研究

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摘要: 海洋休闲渔业作为渔业产业中的新兴力量,对渔业产业发展有着巨大的推动作用。浙江省作为海洋经济发展示范区,休闲渔业的发展成为当前海洋渔业资源调整的一项重要任务。文章从浙江省“海洋经济”建设的大背景下,结合本省发展海洋休闲渔业的优劣势进行分析,探究其发展海洋休闲渔业的机遇与挑战,融合浙江滨海自身经济发展特色,加强政府对发展本省海洋休闲渔业的扶持引导力度,优化海洋生产结构布局,以生态文明建设为前提,共同促进浙江省海洋经济示范区和海洋休闲渔业健康持续发展。

关键词: 海洋休闲渔业; 产业融合; 海洋经济;

Research on the Development of Zhejiang Marine Leisure Fisheries under the Background of Industrial Integration

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Abstract: As a new force in fishery industry, marine leisure fishery plays a great role in promoting the development of fishery industry. As a demonstration area of marine economic development, the development of leisure fishery has become an important task in the adjustment of marine fishery resources. This paper analyzes the advantages and disadvantages of the development of marine leisure fishery in Zhejiang Province, explores its opportunities and challenges, integrates the characteristics of Zhejiang Binhai's own economic development, strengthens the government's support and guidance for the development of marine leisure fishery in Zhejiang Province, optimizes the layout of marine production structure, and promotes the healthy and sustainable development of Zhejiang marine economic demonstration area and marine leisure fishery on the premise of ecological civilization construction.

Key words: Marine leisure fisheries, Industrial integration, marine economy

领域十

现代渔业设施装备

进径比对双通道方形圆弧角内流场影响的数值研究

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摘要: 为研究进径比(参数 C/B , 射流孔位置到养殖池壁的水平距离 C 与养殖池短边边长 B 之比)对双管入流模式下双通道方形圆弧角养殖池系统内流场特性的影响, 基于计算流体动力学仿真技术, 应用 Fluent 前处理软件 Gemetry 构建三维数值计算模型, 采用 RNG $k-\epsilon$ 湍流模型模拟循环水养殖池内流场。结果表明: 优化进径比可有效改善养殖池系统内平均流速($a=0.05, P<0.0001$)、提高能量有效利用率。研究表明, 进径比参数 C/B 在 0.02-0.04 区间有利于双通道方形圆弧角养殖池系统获得最佳水动力条件。本研究为工厂化循环水养殖进水管的布设位置提供理论参考。

关键词: 矩形圆弧角养殖池, 进径比, 计算流体动力学, 水动力特性

Numerical study on the influence of the relative inflow distance on the flow field characteristics in square arc angle aquaculture tank

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Abstract: In order to study the influence of the relative inflow distance (parameter C/B , C is the horizontal distance from inlet to sidewall, B is the width of the rectangular tank) on the flow field characteristics of the double-drain square arc angle aquaculture tank system under the pattern of single-inlet pipe, this paper, based on CFD simulation technology, applied Fluent pre-processing software Gemetry to construct a three-dimensional numerical calculation model and RNG $k-\epsilon$ turbulence model to simulate the flow field in a recirculating aquaculture tank system. The results indicate that the average velocity ($a=0.05, P<0.0001$) in the aquaculture tank system and the effective energy utilization rate could be effectively improved by adjusting the relative inflow distance. The findings indicated that when the parameter C/B is between 0.02 and 0.04, it is conducive to obtaining the optimal hydrodynamic conditions in the double-drain square arc angle aquaculture tank system, which provides a theoretical basis for the layout of the industrial recirculating aquaculture inlet pipe.

Key words: aquaculture tank, relative inflow distance, CFD, flow field characteristics

离心式滩涂贝类播苗装置播苗过程仿真与参数优化

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摘要: 针对目前我国滩涂贝类养殖无专用播苗装备, 人工播散不均匀、效率低、劳动强度大、人力成本高等问题, 根据播苗作业规范和贝苗的生物、物理学特性, 设计了一种离心式滩涂贝类播苗装置。以菲律宾蛤仔苗为研究对象, 基于播苗过程的受力和运动分析, 建立播苗过程的动力学模型; 运用 Design-Expert 软件进行贝苗播撒影响因素正交实验设计和中心组合曲面响应设计。完成了播苗过程离散元仿真, 建立并解析了分布变异系数与叶轮盘叶片个数、叶轮盘转速及播苗装置行进速度的关系模型, 并对播苗作业参数进行了优化。结果表明, 叶片个数对分布变异系数的影响最显著, 且叶片个数与叶轮盘转速对分布变异系数具有明显的交互影响; 回归分析和优化可知, 当叶片个数为 6、转速为 800rpm、行进速度为 1.02m/s 时, 分布变异系数达到最小值 7.13%; 实测值与模型理论值的平均相对误差为 10.25%。

关键词: 贝类播苗装置; 离心叶轮盘; 动力学模型; 离散元仿真; 参数优化; 分布变异系数

Simulation and Parameter Optimization of Centrifugal Spat Spreader for Tidal-Flat Shellfish Culture

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Abstract: No customized spat spreaders are widely applied in shellfish culture, artificial seeding is uneven, low efficiency, high labor intensity and labor costs. A centrifugal spat spreader was designed according to the specifications of spat seedling operations and the biological, physical characteristics of spat. A dynamic model of the spat's movement on the centrifugal plate was established through force and kinetic analysis. With orthogonal test design and central composite design in Design-Expert, the spat spreading process was simulated with EDEM based on a discrete element model. A regression equation of the relationship between variation coefficient of spats' distribution and spreader forwarding speed, blade number and impeller disk rotating speed was obtained, and the most significant factor influence on the variation coefficient of spat distribution was blade number. The influence of the interaction between blade number and impeller disk rotating speed on variation coefficient was significant. It is found out after regression analysis and optimization that the variation coefficient decreased to the minimum of 7.13% when blade number was 6, forwarding speed was 1.02 m/s and impeller disk rotating speed was 800rpm. The validation experiment showed that the average relative error between the measurements and the predictions was 10.25%.

Key words: Spat spreader; Centrifugal impeller disc; Dynamics model; Discrete element simulation; Parameter optimization; Coefficient of variation

基于有限元非线性显示动力学的深水网箱结构强度及破坏性评估

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摘要: 为了减小强台风高海况环境的结构失效风险, 本文分析了系泊及波浪过度及长期交变载荷的深水网箱破坏, 主要考虑规则波的弯曲受力、不规则波的扭转受力及振动疲劳, 研究结果为网箱结构优化设计提供指导。通过网箱浮架的二通斜管、工字架及管材的压缩测试及有限元瞬态、模态动力学可得: 浮架均布 8 点扭转 1m、4 点扭转 5m 时发生剪切断裂; Z 方向浮架强度约为 X 方向的 1/5; 最大变形主要发生在工字架管孔两端; 浮管及护栏的失效波高分别为 5m、1.1m; 浮架发生扭转和剪切比弯曲变形更易发生破坏。增加系泊和工字架的数量同时减小主浮管焊接、突变及联接区域的标准尺寸比等方法, 能够有效提高网箱浮架在长期波浪和系泊条件的极限承载能力和疲劳可靠性。

关键词: 深水网箱; 有限元模型; 非线性力学; 结构强度破坏; 三维显示动力学

The display dynamics evaluation for structural strength and failure of offshore fish cage based on FEM non-linear analysis

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Abstract: In order to reduce the structural failure risk from extreme sea conditions, this work analyses the yielded phenomenon of offshore fish cage under excessive or long-term wave and mooring loads. The research is divided into 3 stages: The bending force of regular wave, the torsional force of irregular wave, followed by the vibration fatigue of fish cage. The results provide principle guidelines for the optimized structural design of fish cage. The mechanical properties of the floating pipe, cap and connection tube are measured, while the Finite Element Model (FEM) of transient and modal is implemented. When the fish cage floating collar is twisted 1m of 8 points type and 5m of 4 points type, the float is sheared. The structural strength in Z-vertical direction is 1/5 of the X-horizontal direction's. The maximum deformation is mainly on the two ends of cap and pipes. The guardrail's critical failure point is at a wave height of 1.1m, while the respective height for the floating pipe is 5m. The floating collar can be damaged easily when there is torsion or shear deformation by mooring and wave loads. Increasing the number of mooring points and cap and, as well as reducing the standard size ratio of welding points, structural mutation points and connection areas, can improve the ultimate bearing capacity and fatigue reliability of floating collar in long-term wave and mooring conditions.

Key words: Offshore fish cage, Finite element model, Non-linear mechanics, Structural strength failure, 3-D display dynamics

中国海域主要作业渔具丢弃率分布

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摘要: 通过问卷调查的形式, 调查我国沿海主要作业方式渔船的海上渔具丢弃情况, 结合 ArcMap 10.3 绘图软件分析并展示渔具丢弃高发渔区。发现我国拖网渔船和刺网渔船的网衣丢弃率相对较高, 张网渔船的网衣丢弃率相对较低, 渤海、黄海、东海和南海海域均存在网衣高丢弃渔区, 且主要集中分布在靠近大陆或岛礁附近的渔区。拖网高丢弃海区主要分布在 21°-21°30'N, 111°30'-123°E 附近 (100-150 g/kg); 20°30'-22°N, 110°-114°E 附近 (>200 g/kg)。刺网高丢弃海区主要分布在 26°30'-31°N, 121°-124°30'E 附近 (50-100 g/kg) 和 9°30'-10°30'N, 114°-115°30'E 附近 (>200 g/kg)。张网高丢弃海区主要分布在 31°-32°30'N, 122°-122°30'E; 31°-32°30'N, 124°-124°30'E 和 31°-32°N, 125°-125°30'E 附近 (15-20 g/kg) 和 33°-33°30'N, 121°30'-122°30'E 和 33°30'-34°N, 121°30'-122°30'E 附近 (>20 g/kg)。

关键词: 丢弃率; 丢弃高发渔区; 拖网; 刺网; 张网

The fishing gear lost and abandoned rate of main fishing gears in waters near China

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Abstract: In the form of questionnaire surveys, the quantity of lost and abandoned fishing gear from the main fishing operation methods in waters near China was investigated. Using ArcMap 10.3 mapping software, the lost and abandoned rate of fishing gear in waters near China was analyzed and displayed. In China, trawlers and gillnetters have a relatively high net lost and abandoned rates, and trap fishing vessels have a relatively low net lost and abandoned rate. Bohai Sea, Yellow Sea, East China Sea and South China Sea, all are the high net lost and abandoned fishing areas. The high net lost and abandoned fishing zones are mainly close to the mainland or islands and reefs. The high lost and abandoned rates areas of trawls are mainly distributed in the areas of 21°-21°30'N, 111°30'-123°E (100 - 150 g/kg) and 20°30'-22°N, 110°-114°E (> 200 g/kg). The area with high net lost and abandoned rate of gillnetters are mainly distributed in the areas of 26°30'-31°N, 121°-124°30'E (50 - 100 g/kg) and 9°30'-10°30'N, 114°-115°30'E (>200 g/kg). The area with high net loss rate of stow netter are mainly distributed in the areas of 31°-32°30'N, 122°-122°30'E; 31°-32°30'N, 124°-124°30'E and 31°-32°N, 125°-125°30'E (15 - 20 g/kg) and 33°-33°30'N, 121°30'-122°30'E and 33°30'-34°N, 121°30'-122°30'E (> 20 g/kg).

Keywords: lost and abandoned rate, high lost rate fishing areas, trawl, gillnet, trap

通过代谢组学研究欧洲舌齿鲈肉质对温度的响应影响

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摘要: 本文主要通代谢组学技术, 对工厂化循环水系统中, 三种不同养殖温度(10 °C、15 °C和20 °C)条件下欧鲈(*Dicentrarchus labrax*)的肌肉组织进行代谢组学分析。结合主成分分析(PCA)和正交偏最小二乘判别分析(OPLS-DA)和KEGG等方法, 我们研究发现: 在脂质代谢、糖代谢、三羧酸循环、尿素循环、烟酸和烟酰胺代谢通路中的氨基酸、脂类和核苷酸等代谢物的水平发生了差异表达。在10 °C的养殖温度条件下, 欧鲈幼鱼肌肉中的 β -NMN、NAD⁺、UDPG、琥珀酸和L-瓜氨酸等代谢物的水平显著上调。但烟酸、GPC、(\pm)17-HDHA、(\pm)15-HEPE、 γ -亚麻酸和L-丝氨酸的水平下调, 在15 °C的养殖温度条件下, 肌醇含量出现显著下调。综上所述, 我们推测鉴定到的这些重要差异代谢物, 可能是在不同温度条件下, 影响鱼肉品质的重要物质。本实验结果可为工厂化循环水养殖温度调控策略及高效养殖欧洲舌齿鲈提供理论基础及技术指导。

关键词: 温度; 代谢组学; 鱼肉品质; 欧洲舌齿鲈

Metabolomics investigation of temperature effects on flesh quality in sea bass (*Dicentrarchus labrax*)

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Abstract: Our work was mainly used metabolomics to analyze the muscle tissues of sea bass (*Dicentrarchus Labrax*) under three different culture temperatures (10 °C, 15 °C and 20 °C) in the industrial recirculation aquaculture system. Combined with principal component analysis (PCA) and orthogonal partial least-squares discriminant analysis (OPLS-DA) and KEGG method, our research found that the levels of metabolites such as amino acids, lipids and nucleotides in lipid metabolism, glucose metabolism, tricarboxylic acid cycle, urea cycle, nicotinate and nicotinamide metabolism pathways have significantly changed under different culture temperature conditions. At 10 °C group, the levels of metabolites such as β -NMN, NAD⁺, UDPG, succinic acid and L-citrulline in the muscles of juvenile sea bass were increased significantly. However, the levels of nicotinic acid, GPC, (\pm)17-HDHA, (\pm)15-HEPE, γ -linolenic acid and L-serine were down-regulated significantly. At 15 °C group, the content of inositol was significantly down-regulated. In summary, we speculate that these important differential metabolites identified may be important substances that affect the fish quality under different temperature conditions. Our study could provide theoretical basis and technical guidance by controlling temperature to improve production of sea bass in industrial recirculating aquaculture system.

Key words: Temperature; metabolomics; flesh quality; *Dicentrarchus labrax*

光照颜色对虹鳟行为反应、血浆皮质醇和生化指标的影响

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摘要: 光照是影响鱼类行为、生理以及生长的主要环境因子之一。为研究光照颜色对虹鳟行为反应、血浆皮质醇、血液生化指标的影响, 本研究根据鱼类行为学研究方法, 分别将白、红、黄、蓝、绿五种光照颜色灯带铺设在室内试验水槽中央底部, 将虹鳟放置在水槽同一侧, 观察虹鳟在水槽中穿越灯带尾次数及行为反应; 根据行为生理学研究方法, 分析比较在不同光照颜色下虹鳟血浆皮质醇、总蛋白(TP)、白蛋白(ALB)、甘油三酯(TG)、总胆固醇(TC)、谷草转氨酶(AST)、谷丙转氨酶(ALT)的含量差异。结果显示, 五种光照颜色下虹鳟穿越灯带尾次数均低于对照组, 其中虹鳟对黄光和白光有一定的趋避反应, 且黄光的趋避效果最强; 黄光条件下血浆皮质醇浓度显著高于对照组和其余四种光照颜色($P < 0.05$), TP、ALB、TG、TC、AST、ALT均具有显著差异($P < 0.05$)。研究结果可为虹鳟的深远海网箱养殖光照补充和捕捞技术研究提供参考。

关键词: 虹鳟; 光照颜色; 鱼类行为; 血浆皮质醇; 生化指标

Effects of light colors on behavior response, plasma cortisol and biochemical indexes of rainbow trout *Onchorynchus mykiss*

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Abstract: In order to study the effect of light color on behavior response, plasma cortisol and blood biochemical indexes of rainbow trout (*Onchorynchus mykiss*), the light bands of white, red, yellow, blue and green, were respectively laid at the bottom of the central tank, and rainbow trout were placed on the same side of the tank to observe the times and behavior response of rainbow trout crossing the light band in the tank. The contents of plasma cortisol, total protein (TP), albumin (ALB), triglyceride (TG), total cholesterol (TC), aspartame aminotransferase (AST) and alanine aminotransferase (ALT) in rainbow trout under different light colors were analyzed and compared. The results showed that the times of rainbow trout passing through the lamp tail under five light colors were all lower than those in the control group, among which rainbow trout had a certain negative effect on the yellow light and white light, and the yellow light had the strongest effect. Plasma cortisol concentration in yellow light was significantly higher than that in the control group and the other four light colors ($P < 0.05$). TP, ALB, TG, TC, AST and ALT all showed significant differences ($P < 0.05$).

Key words: *Onchorynchus mykiss*; light color; fish behavior; plasma cortisol; biochemical index

鱼类固定轨迹运动对方形圆弧角养殖池流动速度影响的数值模拟研究

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摘要: 为研究养殖鱼类运动对方形圆弧角养殖池系统流场速度的影响, 基于计算流体力学仿真(CFD)技术建立了方形圆弧角养殖池及鱼类模型, 该数值模型应用于模拟循环水养殖池内流场; 采用多重参考系法(MRF)模拟鱼类在固定轨迹下的运动。并对有鱼和无鱼工况下养殖池流场速度及特性进行对比分析。结果表明: 鱼类逆流运动对方形圆弧角养殖池流场速度有较大影响, 鱼类逆流游泳运动明显降低养殖池内流速。在鱼类个体体积相同的情况下, 随鱼群个体数量增加对流场影响更加明显。该研究可为不同放养密度的养殖池进水管的进水流速设置提供理论依据。

关键词: 计算流体力学; 流场; 结构优化; 方形圆弧角养殖池

Numerical simulation of the Influence of fish moving along a fixed trajectory on velocity in square arc angle aquaculture tank

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Abstract: In order to the influence of fish movement on the water velocity in the square arc angle aquaculture tank, tank model and a fish model are established based on Computational Fluid Dynamics (CFD). The numerical model is applied to simulate the flow field in the tank; Multi-Reference Frame (MRF) is used to simulate the movement of fish under a circular trajectory. Compare and analyze the flow field velocity of the tank with and without fish. The results show that the rheotaxis of fish has a greater impact on the velocity of the square arc angle aquaculture tank. At the same size of each fish, the impact on the flow field becomes more obvious as the number of fish increases. This study provides a theoretical basis for the setting of the inlet velocity of tanks with different concentrations of fish.

Key words: computational fluid dynamics; flow field; structural optimization; the square arc angle aquaculture tank

菲律宾蛤仔苗种离散元仿真参数标定与排苗验证

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摘要: 为校准菲律宾蛤仔排苗仿真设计中蛤仔接触模型, 该文测量了蛤仔大苗(15-20mm)基本物理参数(尺寸、质量、体积等), 利用3D扫描技术建立蛤苗轮廓模型, 基于EDEM软件构建蛤苗离散元仿真模型。通过压缩、斜面滑移、碰撞仿真试验并对比物理试验, 标定得到蛤苗杨氏模量为 $1.53 \times 10^8 \text{Pa}$; 蛤苗与有机玻璃、不锈钢间静滑动摩擦系数为0.31、0.23; 蛤苗间、蛤苗与有机玻璃和不锈钢表面弹性恢复系数分别为0.32、0.48、0.32; 通过蛤苗堆积响应面仿真试验, 以蛤苗休止角实测值为优化目标, 得出接触材料为有机玻璃时, 蛤苗间滚动摩擦系数、静滑动摩擦系数以及蛤苗与有机玻璃间滚动摩擦系数组合为0.17、1.12、0.20; 接触材料为不锈钢时, 蛤苗间滚动摩擦系数、静滑动摩擦系数以及蛤苗与不锈钢间滚动摩擦系数组合为0.33、1.25、0.34; 选取蛤仔排苗器进行验证试验, 结果表明排苗轮各转速下, 播苗变异系数实际值与仿真值间误差均小于5.0%。研究结果为蛤仔机械化播苗设备研发提供了重要设计依据。

关键字: 菲律宾蛤仔苗种; 机械化播苗; 离散仿真模型; 接触参数; 标定; 排苗器

Calibration of DEM parameters for juvenile manila clam (*Ruditapes philippinarum*) and verification of seeding

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Abstract: In order to calibrate the parameters of juvenile manila clam simulation contacting model in the design of juvenile clam seeding. The basic physical parameters of juvenile clam (size, mass, volume, etc.) were measured. The juvenile clam DEM model was established based on EDEM software and 3D scanning. Combined with the result of physics and simulation experiment (compression, slope sliding, colliding) of clam contacting with PMMA (polymethyl methacrylate) and stainless steel, the calibration results show that the young's modulus of juvenile clam is $1.53 \times 10^8 \text{Pa}$; The coefficient of static friction: clam-PMMA (0.31), clam-stainless steel (0.23); The restitution coefficient: clam-clam (0.32), clam-PMMA (0.48), clam-stainless steel (0.32). The results of angle of repose from central composite design experiment show that the better interaction parameters was selected for represent clam-PMMA: coefficient rolling friction(0.17), coefficient static friction(1.12), coefficient rolling friction(0.20); The parameters of clam-stainless steel: coefficient rolling friction(0.33), coefficient static friction(1.25), coefficient rolling friction(0.34); The results of verification test to juvenile clam seeding device with difference rotational speeds show that the error between the actual and simulated value is less than 5.0%; The results may adequately be used to design clam scale mechanics of clam in seeding.

Key words: juvenile manila clam; mechanical seeding; DEM simulation model; interaction parameters; calibration; clam seeding discharger

池塘工程化循环水养殖模式下饲料添加 EM 菌对大口黑鲈生长及生理指标的影响

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摘要: 本文以大口黑鲈为研究对象, 对大口黑鲈的池塘工程化循环水养殖系统发展与应用以及 EM 菌应用于水产养殖方面的可行性进行了综述, 总结了 EM 菌在水产动物方面的作用机理与效果, 并以此作为研究依据, 设计了在大口黑鲈饲料中添加 EM 菌以研究对其生长和生理指标的影响。结果表明饲料添加 EM 菌提高了大口黑鲈幼鱼的终末体重、特定生长率与增重率。对大口黑鲈部分肝脏抗氧化酶指标与肠道消化酶指标进行了检测, 结果表明, EM 菌添加组大口黑鲈肝脏 SOD、CAT 活性与 GSH 含量在整个养殖周期均有所提高。

关键词: 大口黑鲈; EM 菌; 池塘工程化循环水养殖; 生长; 生理指标

Effects of Feeding Effective Microorganisms on the Growth and Physiological Indexes of *Micropterus salmoides* under the In-pond raceway system

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Abstract : This article takes *Micropterus salmoides* as the research object , summarizes the development and application of the In-pond raceway system, and the feasibility of applying EM bacteria in aquaculture. The mechanism and effect of EM bacteria on aquatic animals are summarized. By using result above as research basis, the research of adding EM bacteria to the feed of *Micropterus salmoides* was designed to study the effect on its growth and physiological indicators. The results showed that the addition of EM bacteria in the feed increased the terminal body weight , specific growth rate and weight gain rate of *Micropterus salmoides* juveniles. The liver antioxidant enzymes and intestinal digestive enzymes of three samples of *Micropterus salmoides* were tested. The results showed that the activity of SOD and CAT and GSH content of *Micropterus salmoides* in the EM group were increased compared with the control group during the entire breeding cycle.

Keywords: *Micropterus salmoides*; In-pond raceway system; Growth; Physiological index

半潜式养殖平台内部及周围流场特性研究

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摘要: 半潜式养殖平台内部和周围流速分布对于鱼类的生存具有重要影响。为了分析养殖平台内外流速的分布规律, 本文建立了基于多孔介质与刚性壁面相结合的数值计算模型。选择 SST k- ω 湍流模型来描述流动, 并采用有限体积法对流体域和多孔介质域进行离散求解。网衣和主框架分别采用多孔介质和刚性壁面进行模拟。通过与物理模型试验结果对比可知: 数值计算结果与试验测得结果相吻合, 满足计算精度。针对养殖平台有无网衣对流场的影响分析可知, 网衣对流速的衰减起到至关重要的作用。此外, 在养殖平台壁面附近有涡的产生。当涡脱落的频率与平台结构固有频率一致时, 会发生共振, 导致结构破坏, 这一现象值得进一步分析和研究。

关键词: 半潜式养殖平台; 流场; 多孔介质; k- ω 湍流模型

Investigation on the characteristics of flow field inside and around the semi-submersible aquaculture platforms

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Abstract: The distribution of flow velocities inside and around semi-submersible aquaculture platforms has an important impact on marine fish survival. To analyze the flow field inside and outside the aquaculture platform, a numerical method based on the combination of porous media and rigid walls is developed and applied in this study. The SST k- ω turbulence model was chosen to describe the flow, and the finite volume method was used to discretize the fluid domain and porous media domain. The fish nets and the main frame are simulated using porous media and rigid walls, respectively. The comparison of the simulated and tested values shows that the numerical calculation results agree with the tested values and meet the calculation accuracy. For the analysis of the effect of the aquaculture platform with or without fish nets on the flow field, it can be concluded that the fish net plays a crucial role in the attenuation of the flow velocity. In addition, vortices are generated near the walls of the aquaculture platform. When the frequency of vortex shedding is consistent with the inherent frequency of the platform structure, resonance will occur and lead to structural damage. The phenomenon worthy of further analysis and research.

Key words: Semi-submersible aquaculture platform, flow field, porous media, k- ω turbulence model

循环水养殖系统中 BFT 生物滤器水处理功能的转换研究

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摘要: 为了提高循环水产养殖系统 (recirculating aquaculture systems, RAS) 的水处理效率, 本研究基于生物絮团技术 (biofloc technology, BFT) 将两个异养型 BFT 生物滤器 (R1 和 R2) 作为 RAS 唯一种类的水处理装置。结果, R1 和 R2 具有同时控制总氨氮、亚硝酸盐、硝酸盐、活性磷酸盐和碱度的水处理效果, 获得反硝化菌、聚磷菌, 反硝化、聚糖菌、氨氧化菌和亚硝酸盐氧化菌等相关功能微生物。停止碳源的添加可以快速地将 R1 转换为硝化型 BFT 生物滤器。在水处理效果转换后的 R1 中, 上述功能细菌仍然为优势菌属, 碳源的缺乏使硝酸盐出水浓度持续上升, 活性磷酸盐在第 40h 后开始升高, 但是获得了稳定的亚硝酸盐去除效果。研究表明, RAS 采用 BFT 生物滤器实现了氮、磷的同步去除, 碳源控制可以转换 BFT 生物滤器的水处理功能。

关键词: 循环水养殖系统; 生物絮团技术; 反硝化; 硝化; 水处理

Study on a RAS using BFT biofilters with a conversion from denitrifying to nitrifying water-treatment efficiencies

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Abstract: A recirculating aquaculture systems (RAS) used two reactors (R1 and R2) based on biofloc technology (BFT) as the water-treatment biofilters. During RAS operation using heterotrophic BFT biofilters, R1 and R2 simultaneously controlled total ammonium nitrogen, nitrite (NO_2^- -N), nitrate (NO_3^- -N), soluble reactive phosphate (SRP), and alkalinity, with relevant functional microbes including denitrifying bacteria (DNB), phosphorus accumulating organisms (PAOs), denitrifying PAOs (DNPAOs), glycogen accumulating organisms, ammonia oxidizing bacteria, and nitrite oxidizing bacteria. Stopping carbohydrate addition was able to quickly convert R1 into a nitrifying BFT biofilter with increasing NO_3^- -N and SRP in the effluent, and stable NO_2^- -N removal efficiency and above functional microbes. It indicated that this novel RAS using BFT biofilters achieved simultaneous nitrogen and phosphate removal, and that the convertible water-treatment efficiencies of BFT biofilters could be controlled by carbohydrate addition.

Key words: recirculating aquaculture system, biofloc technology, denitrification, nitrification, water-treatment

基于 ANSYS/LS – DYNA 滚刀式紫菜刈割装置的动力学仿真

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摘要: 为解决紫菜收割环节仍然停留在手工以及简陋机械作业阶段, 劳动强度大, 生产效率低下等问题。设计了一种紫菜刈割船, 其集起帘、切割、收集和酸化处理等功能于一体的紫菜刈割船, 包括起帘装置、滚刀式切割装置、酸化处理装置、导向架、收集箱以及液压驱动装置。为避免收割时紫菜的漏割和重割, 对滚刀式切割装置的螺旋刀辊刀刃进行了运动轨迹分析; 分析了切割时紫菜的受力情况; 基于 ANSYS /LS-DYNA 建立滚刀式切割装置与紫菜叶状体的刚柔耦合模型, 进行采收过程仿真, 以分析不同的刀具延伸长度和刀具倾角对紫菜所受切割力的影响。结果表明, 漏割区域面积较小可以忽略; 切断间距和留茬长度随着刀刃数量的增加而减小, 当刀刃数量为 3 时, 装置工作效率最高; 剪切应力和拉伸应力与旋转角成比例, 当旋转角变小时, 紫菜被切断的比例增加, 反之拉断比例增加; 仿真得到滚刀最佳刀具延伸长度和刀具倾角组合为 55°, 13mm。本研究为机械化紫菜采收机的相关设计提供理论依据。

关键词: 紫菜; 滚刀式切割装置; 刚柔耦合模型; 动力学仿真

Dynamic simulation of hob-type laver cutting device based on ANSYS/LS-DYNA

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Abstract: the laver harvesting process is still by manual and simple mechanical operation stage, with high labor strength and low production efficiency. In order to solve the problems, a laver mowing boat is designed, for curtain lifting, cutting, collecting and acidizing treatment. The laver cutting boat integrated a curtain lifting device, a hob-type cutting device, an acid treatment device, a guide frame, a collection box and a hydraulic drive device. To avoid missing and repeat cutting of laver during harvesting, the trajectory of the spiral knife roller blade of the hob-type cutting device and the stress condition of laver were analyzed respectively; the hob-type cutting was established based on ANSYS/LS-DYNA, and the rigid-flexible coupling model of the laver fronds are used to simulate harvesting process. To analyze the influence of different knives extension lengths and knives inclination angles on the cutting force of laver. The results showed that the missing cut area was small and could be ignored; the cutting distance and stubble length decreased with the increase of the number of blades. When the number of blades was 3, working efficiency was highest; shear stress and tensile stress is proportional with the rotation angle. When the rotation angle became smaller, the cut proportion was increased, on the contrary the proportion of pulling and breaking increases. The optimal combination of hob extension length and cutter inclination angle is 55°, 13mm respectively. This research provides a theoretical basis for the related design of mechanized laver harvester.

Keywords: laver; hob-type cutting device; rigid-flexible coupling model; dynamic simulation

我国新型牡蛎采收装备研发状况

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摘要: 针对我国沿海传统牡蛎养殖方式效率低、人力消耗大的现状, 项目组根据不同地域的牡蛎养殖模式研制多种机械化采收设备。对山东沿海的垂绳牡蛎养殖模式, 研制纵向双拖拽轮牵引采收装备; 对福建沿海的横绳牡蛎养殖模式, 研制并列拖拽轮隔板输送采收装备; 对广西地区短垂绳十字梁养殖筏架, 研制动力拖曳导架分段式采收平台。新型牡蛎采收设备的应用极大提升牡蛎采收作业的工作效率、降低人力成本, 可缓解渔业生产劳动力不足的状况。

关键词: 牡蛎; 机械化采收; 养殖模式

Research and development status of new oyster harvesting equipment in my country

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Abstract: Aiming at the current situation of low efficiency and high labor consumption in traditional oyster farming methods along the coast of China, The project team developed a variety of mechanized harvesting equipment based on oyster farming models in different regions. The project team developed a longitudinal double drag wheel traction harvesting equipment to adapt to the mode of raising oysters by hanging ropes in coastal areas of Shandong; developed a parallel drag wheel partition conveying and harvesting equipment to adapt to this mode of raising oysters by horizontal ropes in coast areas of Fujian; developed a segmented harvesting platform with a powered towed guide frame to adapt to this mode of raising oysters by short vertical rope cross beam breeding raft in coast areas of Guangxi. The application of new oyster harvesting equipment greatly improves the efficiency of oyster harvesting operations and alleviates the shortage of labor in fishery production.

Key words: Oyster, Mechanized harvest, Farming mode

波浪作用下单点系泊多体网箱水动力响应数值模拟研究

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摘要: 随着渔业养殖逐渐向深海转移, 能够承受恶劣海况的养殖设施愈发重要。与传统的 HDPE 重力式网箱相比, 多体船型浮式网箱具有许多优点。配置着单点系泊系统, 船型的特殊结构型式可以显著降低网箱受到的由船首传递来的波浪载荷。在这项研究中, 建立了数值模型来研究波浪作用下单点系泊船型浮式网箱的水动力响应。文中建立了三种分别具有两个, 三个和四个框架的多体网箱的不同数值模型并进行了计算, 以探究具有不同框架数量的船型浮式网箱在水动力响应方面的差异。比较了同一个多体网箱中不同框架之间以及不同波浪工况之间框架运动响应的差异。此外, 还分析了同一多体网箱不同位置的铰接力的差异。

关键词: 浮式网箱; 单点系泊系统; 数值模拟; 水动力响应

Numerical simulation of hydrodynamic responses of a Multi-body fish cage with single-point mooring system in waves

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Abstract: As fish farming gradually migrates to the deep sea, farming facilities that can withstand harsh sea conditions become more important. Compared with traditional high density polyethylene gravity cages, a multi-body ship type floating net cage has numerous advantages. Combined with a single-point mooring system, the special structural form of the ship type can greatly reduce the wave load transmitted from the bow. In this study, a numerical model is established to study the hydrodynamic responses of a single-point moored ship type floating net cage in waves. Three different numerical models of the net cage with two, three and four frames were established and calculated to find the difference in the motion and mooring force responses between the ship type floating net cages with different numbers of frames. The difference in the motion responses between different frames of the same net cage and between different wave conditions were compared. The difference in the hinge joint force between hinges at different positions of the same net cage is also analyzed.

Key words: Floating net cage; Single-point mooring system; Numerical simulation; Hydrodynamic responses

我国玻璃钢渔船规范技术要求研究

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摘要: 为提高玻璃钢渔船技术标准的适用性, 建立科学完善的设计、建造、检验技术标准体系, 从制度上保证玻璃钢渔船的建造质量, 根据玻璃纤维树脂的材料特性, 从玻璃钢渔船特点和标准现状出发, 分析了国内外玻璃钢渔船原材料、成型工艺、力学性能等关键技术指标, 结合实船技术性能检测结果进行对比验证, 得出适合我国玻璃钢渔船实际使用需求的技术标准。本研究可全面保障玻璃钢渔船技术性能和经济性能, 为我国玻璃钢渔船建造技术提供依据。

关键词: 玻璃钢; 渔船; 规范; 技术要求

Research on technical standards of FRP fishing vessels

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Abstract: In order to improve the applicability of the technical standards for FRP fishing vessels, establish a scientific and perfect technical standard system for design, construction and inspection, and ensure the construction quality of FRP fishing boats, this paper analyzes the raw materials, molding technology, structural performance of FRP fishing boats at home and abroad according to the material characteristics of glass fiber resin and the characteristics and standards of FRP fishing vessels Key technical indicators, combined with the actual ship technical performance test results for comparative verification, to obtain the technical standards suitable for the actual use of FRP fishing vessels in China. This research can provide a basis for improving the construction technology of FRP fishing vessels in China, and comprehensively guarantee the technical performance and comprehensive economic performance of FRP fishing vessels.

Key words: glass fiber reinforced plast; fishing boat; standard; technical requirement

领域十一

渔业信息化与新兴技术应用

基于个体的西北太平洋柔鱼冬春生群早期生活史阶段生态模型的构建

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摘要: 为了了解西北太平洋柔鱼冬春生群早期生活史阶段的情况, 在掌握其生物特征的基础上, 对生长、死亡等早期生物过程进行参数化, 利用物理模型模拟生成北太平洋三维物理场, 采用拉格朗日质点追踪的方法把物理模型和生物模型相耦合, 对基于个体的西北太平洋柔鱼冬春生群早期生活史阶段生态模型进行了构建。

关键词: 基于个体模型; 柔鱼; 冬春生群; 早期生活史

Construction of an individual-based ecological model on the early life history stage of the winter-spring cohort of *Ommastrephes bartramii* in the Northwest Pacific Ocean

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Abstract: Born in order to understand the early life history stage of the winter-spring cohort of *Ommastrephes bartramii* in the Northwest Pacific Ocean, in its biological characteristics, on the basis of the early biological process parameters, such as growth, death, North Pacific generated by physical model to simulate the three dimensional physical fields, adopt the method of Lagrange particle tracking the physical model and biological model coupling, build to an individual-based ecological model on the early life history stage of the winter-spring cohort of *Ommastrephes bartramii* in the Northwest Pacific Ocean.

Key words: individual-based model, *Ommastrephes bartramii*, the winter-spring cohort, early life history

渔业专题电子海图信息融合关键技术研究

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摘要: 为推进海洋渔业信息化的发展, 实现海洋地理空间、海况气象、渔获、渔业生产和渔业船舶等综合信息的融合共享与应用。本文基于 IHO S-57 电子海图国际标准及相关附加层规范, 通过分析中国远洋渔业数据库的结构特点, 提出了有关渔业专题物标与属性的扩展编码规则, 研究了渔业专题异构数据的融合技术和方法。

关键字: 海洋渔业; 电子海图; IHO S-57 标准; 信息融合

Research on key technologies for fishery thematic electronic nautical chart information fusion

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Abstract: In order to promote the development of marine fishery information, and realize fusion sharing and application of marine geospatial, sea state meteorology, catch, fishery production, fishery vessels and other comprehensive information. In this paper, based on IHO S-57 international standards of electronic chart and related additional layer specifications, and by analyzing the structural characteristics of the China's Distant-water Fisheries Database, expanded coding rules for fishery thematic biomarkers and attributes are proposed, and the fusion techniques and methods of heterogeneous fishery thematic data are studied.

Keywords: marine fishery, electronic chart, IHO S-57 standard, information fusion

浙江省渔业科技进步贡献率研究

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摘要: 浙江是渔业经济大省,始终走在渔业经济发展的前列,渔业科技推动渔业经济发展。渔业科技的进步助力浙江从传统小农渔业升级为现代化渔业。本文运用 Cobb-Douglas 生产函数法构建浙江省渔业科技进步贡献率的测算模型。利用浙江省渔业相关生产数据,对 2000-2018 年浙江省渔业各要素增长率及贡献率和科技进步贡献率进行测算,并对不同时期的平均贡献率水平进行对比分析。结果表明:浙江省渔业经济主要依靠物质投入增长和科技进步来带动,不同时期科技进步贡献率差异明显,波幅较大,2000-2018 年平均科技进步贡献率仅为 58.97%。针对浙江省渔业科技进步贡献率较低且不稳定的现状,提出加大科技投入,打造渔业科技人才队伍,发展渔业科技信息化建设,建立浙江省渔业科技成果转化机制和转变渔业经济增长方式。

关键词: 海洋渔业; 科技进步; 贡献率; 浙江省

Research of Zhejiang ocean fisheries scientific technological progress contribution rate

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Abstract: Zhejiang is fishery economy big province, Always in the forefront of fishery economic development, Fishery science and technology promotes fishery economy development. Advances in fishery science and technology helped Zhejiang upgrade from traditional smallholder fishery to modern fishery. This paper used Cobb-Douglas production function method to build Zhejiang fishery scientific and technological progress contribution rate calculation model. Based on production data of Zhejiang fishery, this paper calculated the growth rates and contribution rates of each elements and scientific and technological progress contribution rates of Zhejiang fishery from 2000 to 2018, then made comparison among the contribution rates of each period. The results showed that the growth of Zhejiang fishery economy mainly depended on material inputs and scientific and technological progress, while the scientific and technological progress contribution. rates appeared rather differently at various periods and fluctuated greatly, and the average rate from 2000 to 2018 was only 58.97%. In view of the scientific and technological progress contribution rate of Zhejiang fishery was low and volatile, it was proposed to increase technology investment, culture fisheries scientific and technological personnel, develop fisheries science and technology information, establish mechanisms for scientific and technological achievements transformation of Zhejiang fishery and transform economic growth mode.

Key words: fishery, scientific and technological progress, contribution rate, Zhejiang province

基于渔船轨迹的阿根廷滑柔鱼捕捞强度空间分析

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摘要: 大洋性柔鱼类最具有重要开发利用的价值, 本文利用 2017 年 7 月到 2018 年 5 月的 AIS 数据对阿根廷滑柔鱼的捕捞渔船行为进行研究。统计了研究区域数据的整体特征, 包括航速、航向。绘制渔船空间捕捞强度图, 研究渔船在研究区域的捕捞强度时空分布分布。并在此基础上用空间相关性分析方法对渔船捕捞空间行为进行分析。结果表明: 1、阿根廷滑柔鱼拖网捕捞渔船速度分布呈明显的双峰分布, 其中低速捕捞, 高速航行或寻找鱼群。2、在研究区域(经度 66°W~55°W, 纬度 55°)内, 有三片高强度捕捞区域。

关键字: 阿根廷滑柔鱼、AIS 数据, 捕捞强度、空间分布

Spatial Analysis of Fishing Intensity of Argentine *Illex argentinus* Based on Fishing Vessel Track

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Abstract: Oceanic mussels have the most important development and utilization value. This article uses AIS data from July 2017 to May 2018 to study the fishing behavior of Argentine *Illex argentinus*. Statistics of the overall characteristics of the data, including speed and course. Draw a spatial fishing intensity map of fishing vessels, and study the distribution of fishing intensity in space and time in the study area. Statistics study the overall characteristics of regional data, including speed and course.

Keywords: Argentine soft fish, AIS data, fishing intensity, spatial distribution

基于栖息地指数的阿拉伯海鲈鱼渔情预报模型构建

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摘要: 为了更好地了解和可持续开发利用阿拉伯海鲈鱼资源, 采用 2016—2017 年 1 月、2 月、11 月、12 月、主渔汛期我国公海围网渔船在阿拉伯海的鲈鱼(*Scomber australasicus*)生产数据, 结合海表温度(sea surface temperature, SST)、混合层厚度(mixed-layer thickness, MLT)、海面高度异常(sea level anomaly, SLA)、叶绿素 a 浓度(chlorophyll-a concentration, CHL)环境数据, 分别构建了以渔获量(Fish catch, FC)和作业次数(Fishing times, FT)为基础的栖息地指数(habitat suitability index, HSI)模型: FC-HSI 模型、FT-HSI 模型。在 HSI>0.6 的海域, 2016—2017 年实际渔获产量占比平均分别为 76.25 %和 80.03 %。利用 2018 年的实际生产数据对模型进行预报准确度的验证, 得到在 HSI 大于 0.6 的海域, 实际渔获产量占比平均分别为 45.68 %和 50.15 %, FT-HSI 模型的预报结果优于 FC-HSI 模型。结果表明, 基于 SST、MLT、SLA、CHL 的 FT-HSI 模型能够较好的预测阿拉伯海鲈鱼中心渔场。

关键词: 栖息地指数模型, 阿拉伯海, 澳洲鲈, 渔情预报

Forecasting fishing ground of mackerel (*Scomber australasicus*) in the Arabian Sea according to habitat suitability index

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Abstract: In order to better understand and sustainably develop and utilize the mackerel resources in the Arabian Sea, using the Chinese light purse seine production data of mackerel (*Scomber australasicus*) during the main fishing season (January, February, October and November) from 2016 to 2017 on the high sea of Arabian Sea, and the environmental data of sea surface temperature (SST), sea level anomaly (SLA), mixed-layer thickness (MLT), chlorophyll-a concentration (CHL), we established the habitat suitability index (HSI) models, FC-HSI model and FT-HSI model respectively. In the sea area with HSI greater than 0.6, the actual catch in 2016 and 2017 accounted for 76.25 % and 80.03 % respectively. Using the actual production data in 2018 to verify the prediction accuracy of FC-HSI model and FT-HSI model, it is found that in the sea area with HSI greater than 0.6, the actual catches accounted for 45.68 % and 50.15 % respectively which means that the prediction result of FT-HSI model is slightly better than that of FC-HSI model. This study indicates that the FT-HSI model based on SST, MLT, SLA, and CHL can better predict the central fishing ground of mackerel in the Arabian Sea.

Key words: habitat suitability index; Arabian Sea; *Scomber australasicus*; fishery forecast

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夜间灯光遥感在西北太平洋秋刀鱼渔业中的应用

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摘要: 基于新兴的夜间灯光遥感技术, 本研究利用秋刀鱼灯光渔船识别模型提取了 2018 年西北太平洋的秋刀鱼渔船, 并分析了灯光遥感数据在秋刀鱼渔船监测、渔场指导、核心渔区探测以及渔场与环境变动的关系等方面的应用前景, 旨在扩展灯光遥感图像在渔业领域的应用。

关键词: 秋刀鱼; 灯光遥感; DNB; 渔船识别; 渔场监测; 西北太平洋

The application of night light remote sensing in the fishery of *Cololabis saira* in Northwest Pacific

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Abstract: Based on the emerging night light remote sensing technology, this study extracts the saury fishing boats with the VBD model in the Northwest Pacific in 2018, and analyzes the application prospects of light remote sensing data in saury fishing boat monitor, fishing ground guidance, core fishing area detection, and the relationship between fishing grounds and environmental changes. This study aims to expand the application of light remote sensing images in the fishery field.

Key words: *Cololabis saira*, night light remote sensing, DNB, fishing boats detection, fishing grounds monitor, northwest Pacific

太平洋年代际涛动对秘鲁外海茎柔鱼栖息地变动的影响评估研究

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摘要: 茎柔鱼广泛分布于东南太平洋海域, 是我国重要的远洋捕捞对象之一。利用海表面温度 (SST) 和海表面高度距平 (SSHA) 两个关键环境因子, 计算 1950-2015 年 1-12 月秘鲁外海茎柔鱼栖息地适宜性指数 (HSI)。结果显示, 1950-2015 年 PDO 呈现冷、暖、冷 3 个位相变化, 其中 PDO 冷位相内的 SST 距平 (SSTA) 和 SSHA 值明显低于 PDO 暖位相。交相关分析表明, PDO 指数与 SSTA 和 SSHA 均呈显著正相关, 而 HSI 值与 PDO 指数、SSTA 和 SSHA 均呈显著负相关。PDO 位于冷位相时, 茎柔鱼渔场内水温变冷, 海面高度下降, 适宜的 SST 和 SSHA 范围增加, 因此茎柔鱼有利的栖息地面积增大; 而 PDO 位于暖位相时, 水温增暖, 海面高度上升, 适宜的 SST 和 SSHA 范围缩减, 导致茎柔鱼适宜的栖息地面积缩小。

关键词: 茎柔鱼; 栖息地适宜性; 太平洋年代际涛动; 秘鲁

Assessment of the impact of Pacific Decadal Oscillation on habitat variability of *Dosidicus gigas* off Peru

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Abstract: *Dosidicus gigas* is an important fishing target by Chinese squid-jigging fisheries, which is widely distributed in the southeastern Pacific Ocean. We calculated the habitat suitability index (HSI) on the fishing ground of *D. gigas* off Peru from January to December during 1950 to 2015 based on sea surface temperature (SST) and the anomalies of sea surface height (SSHA). The results suggested PDO showed cold, warm and cold phases from 1950 to 2015. The anomalies of SST (SSTA) and SSHA during the cold PDO were significantly lower than those during the warm PDO. The cross-correlation analysis suggested both the SSTA and the SSHA were significantly positively correlated with the PDO index. However, the HSI values were significantly negatively correlated with the PDO index, SSTA and SSHA. During the cold PDO, the water temperature became cold, and the SSH decreased, these changes led to enlarged areas of suitable SST and SSHA for *D. gigas*, therefore, the favorable habitats largely increased. However, during the warm PDO, the water temperature became warm, the SSH elevated, whereas the ranges of suitable SST and SSHA contracted, all these changes resulted in the decrease of the suitable habitat of *D. gigas*.

Key words: *Dosidicus gigas*, habitat suitability, Pacific Decadal Oscillation, Peru

湖南省常见鱼类 DNA 条形码数据库的构建及 鱼类资源状况评估

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摘要: 随着测序技术的发展, 基于环境 DNA 的宏条形码 (meta-barcoding) 技术也逐步运用到渔业资源调查中。宏条形码技术不仅具有省时高效等特点, 还能为传统形态学鉴定方法提供补充及校正。为了构建针对湖南省渔业资源的宏条形码技术, 本研究搜集目前已报道淡水鱼类的特异性引物并在湖南省内搜集的样品进行扩增以期构建湖南省特异的条形码库。结果显示, *COI* 基因、*RHO* 基因以及 16S rDNA 对湖南省鱼类有较好的扩增效果, 目前已获 74 种鱼类的序列, 共 555 条。为了验证数据库的效果, 通过对毛里湖采集的环境 DNA 样品验证发现, 数据库对湖区内常见鱼类有较好的注释效果。本研究构建的数据库, 不仅能够对湖南省鱼类资源调查评估提供技术和数据支持, 还利于特色鱼类的保护及隐存种质资源的挖掘。

关键词: 鱼类鉴定; DNA 条形码; 数据库; 湖南省鱼类;

Construction of DNA barcoding database of meta-barcoding fishes in Hunan province and evaluation of fish resource status

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Abstract: With sequencing technology development, the meta-barcoding technology based on eDNA is gradually applied to fishery resource surveys. As a supplement and correction tool for traditional morphological identification methods, meta-barcoding technology has high efficiency and time-efficient characteristics. To construct a macro-barcoding technology for fishery resources in Hunan Province, we collected the specific primers of freshwater fishes that were reported and amplified the samples collected in Hunan Province due to constructing a Hunan-specific barcode library. The results showed that *COI* gene, *RHO* gene, and 16S rDNA had a good amplification effect, and sequences of 74 species of fish were obtained, including 555 sequences. To verify the effects of the database, we collected eDNA samples from Maoli Lake. It was found that the database has a better annotation effect on common fish in the lake. The database obtained in this study can provide technical and data support for fish resources survey and evaluation in Hunan Province and benefit for protecting characteristic fish and the excavation of hidden germplasm resources.

Key words: Fish identification, DNA barcoding, Database, Hunan ichthyofauna

基于 LSTM 深度学习网络远洋船舶分类

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摘要: 船舶自动识别系统 (AIS, automatic identification system) 为渔业资源和渔船捕捞活动管理和研究提供了可能。现有文献多基于已知渔船类型进行研究, 但大洋中更多的的船舶渔船我们不知道类型。因此明确渔船类型是开展 AIS 应用前提。本文搜集整理 3067 艘已知类型船舶信息 (其中渔船分 4 类, 有 1831 艘; 非渔船 3 类, 共有 1236 艘), 基于 2017-2018 年 AIS 数据, 三层双向长短期记忆网络 (BiLSTM, Bidirectional Long Short-Term Memory), 首先构建渔船/非渔船分类识别模型, 提取渔船信息。然后对 4 种渔船构建分类识别模型。模型结果表明。渔船/非渔船的 LSTM 模型的训练数据分类平均准确率是 99.6%, 平均精确率是 99.8%, 平均灵敏度为 99.5%, 平均算 Kappa 系数为 0.992, F1 分数为 0.997, AUC 为 0.996。验证数据集分类平均准确率是 93.6%, 平均精确率是 95.6%, 平均灵敏度为 93.8%, 平均算 Kappa 系数为 0.867, F1 分数为 0.947, AUC 为 0.936。渔船分类模型训练数据集分类平均准确率是 99%, 平均精确率是 99.3%, 平均灵敏度为 99%, 平均算 Kappa 系数为 0.967, F1 分数为 0.991, AUC 为 0.98。验证数据集分类平均准确率是 97%, 平均精确率是 97.6%, 平均灵敏度为 97.4%, 平均算 Kappa 系数为 0.895, F1 分数为 0.975, AUC 为 0.942。

关键词: AIS 数据; 船舶类型分类; 双向长短期记忆网络

Classification of ocean-going ships based on LSTM deep learning network

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Abstract: The automatic identification system (AIS) provides the possibility for the management and research of fishery resources and fishing activities. The existing literature is mostly based on the known types of fishing vessels, but we do not know the types of more vessels in the ocean. Therefore, clarifying the type of fishing vessel is a prerequisite for the application of AIS. This paper collects and sorts out the information of 3067 known types of ships (including 4 types of fishing boats, 1831 ships; 3 types of non-fishing ships, 1236 ships in total), based on 2017-2018 AIS data, three-layer bidirectional long short-term memory network (BiLSTM, Bidirectional Long Short-Term Memory), first build a fishing vessel/non-fishing vessel classification and recognition model to extract fishing vessel information. Then build classification and recognition models for 4 kinds of fishing boats. The model results show that. The average accuracy of training data classification of the fishing boat/non-fishing boat LSTM model is 99.6%, the average accuracy is 99.8%, the average sensitivity is 99.5%, the average Kappa coefficient is 0.992, the F1 score is 0.997, and the AUC is 0.996. The average accuracy rate of the validation data set classification is 93.6%, the average accuracy rate is 95.6%, the average sensitivity is 93.8%, the average Kappa coefficient is 0.867, the F1 score is 0.947, and the AUC is 0.936. The average accuracy rate of fishing vessel classification model training data set classification is 99%, the average accuracy rate is 99.3%, the average sensitivity is 99%, the average Kappa coefficient is 0.967, the F1 score is 0.991, and the AUC is 0.98. The average accuracy rate of the validation data set classification is 97%, the average accuracy rate is 97.6%, the average sensitivity is 97.4%, the average Kappa coefficient is 0.895, the F1 score is 0.975, and the AUC is 0.942.

Key words: AIS data; Classification of ship types; Bidirectional Long Short-Term Memory

基于 DEA 模型的浙江渔业科技生产效率实证分析

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摘要: 渔业发展的根本出路在于科技, 科技创新能力与科技创新活动的生产效率息息相关。科技生产效率从抽象的生产过程出发, 具体反映科技资源的配置状况, 全面考虑了科技投入与经济产出的相互关系。依靠科技的力量转变渔业经济增长方式是未来浙江渔业发展的重点。运用数据包络分析 DEA 模型对浙江渔业科技生产效率进行了实证分析, 研究结果表明: 浙江渔业在技术创新进程中的高投入问题比较突出, 总体没有达到规模有效水平; 渔业纯科技效率波动较大, 总体没有呈现一个明显的增长态势; 从 2012 年以后, 综合效率稳步上升, 渔业技术创新投入产出结构调整收到了一定成效, 技术创新的投入产出比率更趋向于合理。

关键词: 浙江省; 渔业科技; DEA 模型; 生产效率

Empirical analysis of fishery science and technology production efficiency in Zhejiang Province Based on DEA

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Abstract: The fundamental way out for fishery development lies in science and technology, which is closely related to the production efficiency of scientific and technological innovation activities. From the abstract production process, scientific and technological production efficiency reflects the allocation of scientific and technological resources, and comprehensively considers the relationship between scientific and technological input and economic output. Relying on the power of science and technology to change the mode of fishery economic growth is the focus of Zhejiang fishery development in the future. Data envelopment analysis (DEA) model is used to analyze the production efficiency of fishery science and technology in Zhejiang Province. The results show that: the high investment problem of Zhejiang fishery in the process of technological innovation is relatively prominent, and the overall efficiency has not reached the scale effective level; the pure scientific and technological efficiency of fishery fluctuates greatly, and there is no obvious growth trend on the whole; since 2012, the comprehensive efficiency has increased steadily, The adjustment of input-output structure of fishery technology innovation has achieved certain results. The input-output ratio tends to be more reasonable.

Key words: Zhejiang Province, fishery science and technology, DEA model, production efficiency

气候变化与日本鳀越冬栖息地特征的关系

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摘要: 利用统计模型以单位捕捞努力渔获量(CPUE)为响应变量, 海表温度 (SST)、叶绿素-a、盐度、经向纬向海流和水深为环境变量。盐度锋与冬季日本鳀分布有密切关系。CPUE 与 SST 呈显著正相关, 与 Niño1+2 均呈显著负相关。海温上升导致栖息地向北迁移并在本世纪末相对丰度增加。

关键词: 日本鳀; 栖息地特征; 盐度锋; 机器学习; 气候变化

Relationship between climate change and habitat characteristics of wintering Japanese anchovy (*Engraulis japonicus*)

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Abstract: The models were fitted with the catch per unit effort (CPUE) as the response variable and environmental variables as covariates. The salinity front highlights a strong relationship with Japanese anchovy. The relationship between CPUE and SST showed a significant positive correlation, both indicated a significant negative correlation with Niño 1+2. The rising temperatures will result in the northward habitat shift and the increasing relative abundance by the end of the century.

Key word: japanese anchovy; habitat characteristics; salinity front; machine learning; climate change

华南沿海牡蛎体内病毒多样性及群落结构研究

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摘要: 病毒是一种普遍存在于所有环境中的生命体, 且高度丰富。贝类作为滤食性动物, 是海洋环境中病毒的重要存储库。本文主要研究中国华南沿海等多地牡蛎体内的病毒群落结构规律和生态学特征, 利用宏病毒组分析技术, 分别使用参考病毒基因组库和 *de novo* 组装的病毒基因组库进行比对, 发现牡蛎体内的病毒群落不同建库方式、不同物种和不同取样组织的分组下具有显著差异, 但两种基因库的多样性结果保持一致。将群落结构数据与 AMG 代谢功能进行关联分析, 显示出了显著的一致性。这项研究展现了牡蛎体内的病毒群落结构特征, 并为研究牡蛎体内的微生物群落提供了新的视角。

关键词: 牡蛎; 宏病毒组; 病毒群落结构

Viral diversity and community structure of oyster in South China Coast

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Abstract: Virus is a kind of living organism that exists in all environments with high abundance. Shellfish, as filter-feeding animals, are important reservoirs of viruses in the marine environment. This paper mainly studies the virus community structure and ecological characteristics of oysters in many places along the coast of South China, by using the virome analysis technology, the reference virus genome library and the virus genome library assembled by *de novo* were respectively used to compare. It is found that the virus community in oyster has significant differences under different library building methods, different species and different sampling tissues, but the diversity results of the two gene library are consistent. The association analysis of the community structure and AMG metabolism showed a significant consistency. This study shows the structure of virus community in oyster and provides a new perspective for the study of microbial community in oyster.

Key words: oyster, virome, viral community structure

基于卷积神经网络的西北太平洋柔鱼渔场预报模型构建

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摘要: 传统渔场预报模型的构建方法需要人工进行环境特征的提取, 为了更智能、充分利用环境数据里蕴含的空间特征信息, 提高西北太平洋柔鱼渔场预报模型的精确度, 拓宽构建渔场预报模型的新思路, 本研究利用 2000 - 2014 年西北太平洋柔鱼生产数据、海洋表面温度数据 (Sea Surface Temperature, SST) 以及渔场的时空信息, 基于深度学习原理, 构建了卷积神经网络的柔鱼渔场预报模型.....

关键词: 渔场预报; 卷积神经网络; 西北太平洋; 柔鱼

Construction of fishing ground forecast model of *Ommastrephes bartramii* in Northwest Pacific based on Convolutional Neural Network

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Abstract: The traditional fishery forecast methods of neon flying squid (*Ommastrephes bartramii*) have several shortcomings such as low temporal resolutions and low spatial resolution, and they requires manual extraction of environmental characteristics. Different from traditional fishery forecast methods, the extraction of environmental features is automatically completed by computer. In order to take full advantage of the spatial feature information contained in environmental data, improve the accuracy and practicability of fishery forecast in Pacific Northwest, as well as explore new methods to build a fishery forecast model, this research build a fishing ground forecast model of *Ommastrephes bartramii* in Northwest Pacific based on Convolutional Neural Network.....

Keywords: fishing ground forecast; CNN; Northwest Pacific; *Ommastrephes bartramii*

基于声学表达的大口黑鲈摄食行为特征分析

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摘要: 本实验通过声像同步方法对大口黑鲈摄食行为进行监测, 初步分析了其声谱特征, 旨在建立以大口黑鲈为代表的养殖鱼类摄食声学特征相关模型, 为声学投饲的开发提供理论基础。结果表明: 鱼类摄食行为过程中具有可识别的声学特征。大口黑鲈摄食的频谱范围约为 120Hz-1200Hz, 最大信噪比约为 1.37dB, 摄食声单脉冲宽度约为 0.01s。

关键词: 水产养殖; 摄食行为; 水声信号; 声谱特征

Analysis of feeding behavior characteristics of largemouth bass based on acoustic expression

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Abstract: in this experiment, the feeding behavior of *Micropterus salmoides* was monitored by Underwater acoustic image synchronization method, and its acoustic spectrum characteristics were preliminarily analyzed in order to establish a model related to the acoustic characteristics of farmed fish represented by *Micropterus salmoides*, to provide a theoretical basis for the development of Acoustic feeding machine. The results show that there are identifiable acoustic characteristics in the process of fish feeding behavior. The frequency range of feeding is about 120Hz, the maximum signal-to-noise ratio is about 1.37, and the single pulse signal of feeding sound is about 0.01s.

Key words : aquaculture; feeding behavior; Underwater acoustic signal; Sound spectrum characteristics

基于环境 DNA 的长江口渔业资源季节变化与评估

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摘要: 在过去的几年中, 环境 DNA (eDNA) 技术已被用于监视海洋生物群落。研究表明, 环境 DNA 技术可以作为渔业资源监测的有效手段。本研究通过环境 DNA 技术分析了长江口鱼类资源的季节性变化。在 2019 年的四个季度里, 总共从长江口收集了 103 个水样本, 分别为 2 月 20 个、5 月 28 个、8 月 28 个和 11 月 27 个。我们的研究成功地监测了长江口的渔业资源, 也发现了明显的季度性差异。结果显示, 2019 年共鉴定出 59 种 (2 月 20 种, 5 月 16 种, 8 月 5 种, 11 月 45 种), 四个季节的鱼类种类差异很大.....

关键词: 长江口; 环境 DNA; 海洋鱼类; 季节变动; 鱼类评估

Seasonal Variation and Assessment of Fish Resources in the Yangtze Estuary Based on Environmental DNA

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Abstract: In the past few years, environmental DNA (eDNA) techniques have been used to monitor marine communities. Research indicates that eDNA is an effective tool for monitoring fishery resources. This study analyzed the seasonal variations in fish resources in the Yangtze Estuary, China, using eDNA. A total of 103 water samples were collected from the Yangtze Estuary across the four seasons in 2019—27 samples in February, 20 in May, 28 in August and 28 in November. Our research successfully detected the fishery resources of the Yangtze Estuary. We found significant differences according to the season. The results showed that 59 species were identified in 2019 (20 in February, 16 in May, 5 in August and 45 in November) and fish species varied widely over the four seasons.....

Key words: Yangtze Estuary; environmental DNA; marine fish; seasonal variation; fish assessment

基于渔船轨迹数据的中西太平洋金枪鱼围网 渔船捕捞行为空间分析

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摘要: 为了明确中西太平洋金枪鱼围网渔船捕捞努力量时空变化和渔船捕捞强度, 为渔业资源管理提供支撑。本研究基于 2017 年 7 月到 2018 年 5 月全球 130 条金枪鱼围网渔船卫星自动识别系统 (Automatic Identification System, AIS) 数据, 开展中西太平洋金枪鱼围网渔船捕捞活动空间分析, 采用数据挖掘方法识别金枪鱼围网渔船作业状态, 挖掘捕捞强度空间特征以及热点区域的分布, 分析渔船捕捞行为空间特征。

关键词: 金枪鱼围网; AIS 数据; 捕捞努力强度; 空间特征

Spatial analysis of the fishing behavior of tuna purse seine vessels in the Western and Central Pacific Ocean based on vessel trajectory data

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Abstract: In order to clarify the temporal and spatial changes of the tuna purse seine fishing effort and fishing intensity of the Western and Central Pacific Ocean, and provide support for fishery resource management. This study is based on the data of 130 tuna purse seine vessels (Automatic Identification System, AIS) data from July 2017 to May 2018. It conducts a spatial analysis of tuna purse seine fishing activities in the Western and Central Pacific Ocean and uses data mining methods to identify tuna. The operating status of purse seine fishing vessels, the spatial characteristics of digging fishing intensity and the distribution of hot spots, and the analysis of the spatial characteristics of fishing behavior of fishing vessels.

Key words: Tuna purse seine, AIS data, fishing effort intensity, spatial characteristics

领域十二

渔业经济、政策与管理

远洋渔业水产品精深加工业高质量发展研究 ——以舟山国家远洋渔业基地为例

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摘要：国家高度重视农产品精深加工业发展。探索水产品精深加工产业高质量发展，是贯彻落实党的十九大提出的“乡村振兴战略”的重要举措。远洋渔业水产品精深加工是延长远洋渔业产业链、提升价值链、优化供应链、构建利益链的关键环节，是推进渔业供给侧结构性改革、加快渔业渔村现代化的重要支撑力量。本文总结舟山国家远洋渔业基地建设取得成效的基础上，分析远洋渔业水产品加工企业转型精深加工存在的困难，从实施乡村振兴战略、共建“一带一路”倡议、供给侧结构性改革、舟山国家战略叠加四个维度探讨舟山国家远洋渔业基地建设面临机遇，梳理了国内外农（水）产品精深加工的先进发展模式和发展趋势，提出推进远洋渔业水产品精深加工产业高质量发展需要打造“创新人才+营销团队+资金保障+政策扶持”四位一体招商引资才联动新模式，最大程度吸释政策红利。

关键词：远洋渔业水产品；精深加工；舟山国家远洋渔业基地

Research on high-quality development of deep-sea fishery and aquatic products processing industry: A case from Zhoushan National Ocean Fishery Base

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Abstract: The state attaches great importance to the development of the intensive processing industry of agricultural products. Exploring the high-quality development of the deep-processing industry of aquatic products is an important measure to implement the "Rural Revitalization Strategy" proposed by the 19th National Congress of the Communist Party of China. The deep processing of deep-sea fishery products is a key link in extending the deep-sea fishery industry chain, enhancing the value chain, optimizing the supply chain, and building the profit chain. It is an important supporting force for advancing the structural reform of the fishery supply side and accelerating the modernization of fishery villages. This article summarizes the achievements in the construction of the Zhoushan National Ocean Fishery Base and analyzes the difficulties in the transformation of deep-sea fishery and aquatic product processing enterprises. From the four dimensions of implementing the rural revitalization strategy, co-constructing the "Belt and Road" initiative, supply-side structural reform, and Zhoushan's national strategy stacking, it discusses the opportunities for the construction of Zhoushan's national offshore fishery base, it summarizes the domestic and foreign agricultural (aquatic) product intensive processing Advanced development model and development trend and it proposes that to promote the high-quality development of deep-sea fishery and aquatic product processing industry, it is necessary to create a four-in-one new model of "innovative talents + marketing team + capital guarantee + policy support" to attract talents to maximize the absorption of policy dividends.

Key words: deep-sea fishery products; refined and deep processing; Zhoushan National Ocean Fishery B

我国水产品供给与消费平衡及结构问题研究

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摘要: 在梳理水产品供给与消费结构研究问题的基础上, 基于我国水产品供需现实, 构建以统计当量为基准单位的水产品供给与消费测算平衡模型。结果表明, 2010-2019年, 我国水产品年均供给量为6916.41万吨, 其中国内供应部分占比86.66%, 食用水产品进口占比5.43%, 进口鱼粉等非食用水产品占比7.92%; 水产品年均消费量为5812.83万吨, 其中居民食用消费占比44.18%, 水产品出口占比5.90%, 养殖业消耗鱼粉占比26.15%, 其他加工品消耗占比9.53%; 年均水产品损耗减重及误差等1082.59万吨, 占年均供应量的15.17%。通过总供给与总消费的平衡及结构分析, 发现我国居民食用水产品占比较低, 以鲜活为主的消费方式大量浪费水产蛋白资源, 属于“资源浪费型”消费方式; 我国水产品生产供应量仍不能完全满足居民平衡膳食的营养需求, 渔业部门仍需探讨和完善“优化水产品供应结构、增加生产供应量”的政策措施。

关键词: 水产品供给; 水产品消费; 供求平衡; 消费结构; 供给结构

Research on the balance and structure of aquatic products supply and consumption in China

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Abstract: On the basis of sorting out the research problems of aquatic product supply and consumption structure, based on the reality of China's aquatic product supply and consumption, this paper constructs a balance model of aquatic product supply and consumption based on statistical equivalent. The results showed that from 2010 to 2019, the annual average supply of aquatic products in China was 69 million tons, of which the domestic supply accounted for 86.66%, the import of edible aquatic products accounted for 5.43%, and the import of fish meal and other non-edible aquatic products accounted for 7.92%. The average annual consumption of aquatic products was 58 million tons, including 44.18% of residents' consumption, 5.90% of export of aquatic products, and 26.15% of aquaculture consumption, and other products accounted for 9.53%. The average annual loss was 10 million tons, accounting for 15.17% of the average annual supply. Through the analysis, it is found that the proportion of aquatic products consumed by residents is relatively low, which belongs to the "resource waste type" consumption mode. The production and supply of aquatic products still can not fully meet the nutritional needs of residents for balanced diet.

Key words: Aquatic product supply, aquatic product consumption, balance of supply and demand, consumption structure, supply structure

非法生产、进口和出口水产苗种的法律责任及其完善

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摘要:为促进我国水产养殖业和水产品贸易的发展,文章梳理我国关于生产、进口和出口水产苗种的法律规定,分析对非法生产、进口和出口水产苗种进行处罚的原因和力度,并提出建议。研究表明:水产苗种是重要的渔业资源,具有自身特点和内在规律,我国以法律形式对生产、进口和出口水产苗种进行规定;我国对非法生产、进口和出口水产苗种进行处罚的法律规定较宽泛,建议以法律形式完善水产苗种检疫体系、完善水产苗种许可制度以及规定从轻或减轻处罚条款。

关键词:渔业法;水产苗种;水产养殖;水产品贸易;处罚

Legal Liability and Improvement of Illegal Production, Import and Export of Aquatic Seeds

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Abstract: In order to promote the development of China's aquaculture industry and aquatic products trade, the article reviews China's laws and regulations on the production, import and export of aquatic seed, analyzes the reasons and intensity of penalties for illegal production, import and export of aquatic seed, and makes recommendations. The research results show that aquatic seed is an important fishery resource with its own characteristics and inherent laws. China regulates the production, import, and export of aquatic seed in legal form; China penalizes illegal production, import, and export of aquatic seed. The legal provisions are relatively broad, and it is recommended that the aquatic seed quarantine system, the aquatic seed licensing system, and the provision of lighter or lighter penalties be improved in legal form.

Key words: Fisheries law, Aquatic products breeding, Aquaculture, Aquatic products trade, Punish

完善渔业法规：明确破坏生态平衡捕捞行为的 法律责任

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摘要：随着渔业资源的不断减少，人们使用破坏生态环境的手段进行捕捞以追求经济利益最大化。当前《中华人民共和国渔业法》对该种行为规定规定的较为模糊，为解决因破坏生态环境极其生态平衡的非规范化捕捞所造成的对生态系统严重影响问题，全国人民代表大会须及时对《中华人民共和国渔业法》进行修改。通过梳理渔业法对破坏生态平衡的捕捞方式方法的法律责任问题，明确破坏生态平衡捕捞行为及其应当承担的法律责任，从而加强对捕捞行为的法律规制，保护生态环境。

关键词：中华人民共和国渔业法；渔业资源；生态平衡；捕捞方式；法律责任

Improve fishery laws and regulations: make clear the legal responsibility of fishing behaviors that destroy ecological balance

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Abstract: With the decrease of fishery resources, people use the means of destroying the ecological environment to catch in order to pursue the maximization of economic benefits. At present, the provisions of the Fisheries Law of the People's Republic of China on this kind of behavior are relatively vague. In order to solve the serious impact on the ecosystem caused by non-standardized fishing that damages the ecological environment and the ecological balance, the National People's Congress must amend the Fisheries Law of the People's Republic of China in a timely manner. By sorting out the legal liability of fishing methods and methods that destroy the ecological balance in the fishery law, the behaviors of destroying the ecological balance and the legal liability they should bear are more determined. Further strengthen the legal regulation of fishing behavior, achieve the purpose of protecting the ecological environment.

Key words: The Fisheries Law of the People's Republic of China ,fishery resources,ecological balance ,fishing methods ,the legal responsibility

渔业法规影响渔业船舶适航行为的法律责任分析

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摘要:近年来,随着渔业及捕捞业规模的不断扩大,经济逐渐发展的同时渔业船舶事故发生的频率也在逐年增加。为了保障我国渔船管理制度的稳定推进,必须要增加渔业船舶的适航性。本文从《中华人民共和国渔业法》增设规制影响渔业船舶适航行为的必要性出发,减少不适航船舶下水作业而导致水上事故,并保障渔业船舶检验制度的发展。阐述增设规制影响渔业船舶适航行为的可行性,从实践依据和立法依据进行分析增设影响渔业船舶适航行为法律责任的有利条件,最后梳理渔业船舶适航的设备、人员和证书等构成要件,并针对增设渔业船舶适航行为的法律责任提出相应的设计。

关键词: 中华人民共和国渔业法; 渔业船舶; 船舶适航; 法律责任; 捕捞业

On the Legal Liability of Fishery Law to Affect the Navigation of Fishery Vessels

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Abstract: In recent years, with the continuous expansion of fishery and fishery industry, the frequency of fishery ship accidents has been increasing year by year with the gradual development of economy. In order to ensure the steady advancement of China's fishing vessel management system, the seaworthiness of fishing vessels must be increased. This paper starts from the necessity of adding regulations to affect the seaworthiness behavior of fishery ships in the Fisheries Law of the People's Republic of China, to reduce water accidents caused by unseaworthy ships in launching operations, and to ensure the development of fishery ship inspection system. Feasibility and the effect of additional regulation of fishing vessel seaworthy behavior, from the legislation and practice bases to analyze the effect of adding fishing vessel seaworthy behavior legal responsibility of favorable conditions, finally comb fishing vessel seaworthy certificate of equipment, personnel, and constitutive requirements, and aim at increasing the number of fishing vessel seaworthy behavior legal responsibility put forward the corresponding design.

Key words: The Fisheries Law of the People's Republic of China; Fishery vessels; Seaworthiness of the ship; Legal liability; Fishing industry

完善渔业行政许可法律体系与督查机制研究

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摘要: 行政许可既关乎公共利益的维护, 又兼顾私人利益的保障, 能够有效调节社会关系, 规范行业行为。渔业行政许可同样是在渔业开发行政管理中的重要行政手段。渔业行政许可在渔业资源的保护、渔业生产者合法权益的保障, 以及渔业生产发展的促进方面扮演重要的角色, 因此正确理解与适用, 并不断完善渔业行政许可具有重要的现实意义。探究渔业行政许可在现实中存在主要问题是实践易生矛盾, 渔业行政许可法律体系不完善; 行业缺乏自律, 渔业行政许可管理比较僵硬; 监督检查不健全, 渔业行政许可制度亟需修订完善。因此, 完善渔业行政许可法律体系与督查机制必须细化渔业分类, 完善渔业行政许可法律体系; 加强行业的自主灵活性, 与政府相关部门强制手段形成互补; 严格监督检查, 完善渔业行政许可的法律法规制度。**关键词:** 渔业资源; 行政许可; 渔业行政许可; 渔业管理

On Perfecting the Legal System and Supervision Mechanism of Fishery Administrative License

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Abstract: Administrative licensing not only concerns the maintenance of public interests, but also gives consideration to the protection of private interests. It can effectively regulate social relations and regulate industrial behaviors. And fishery administrative license is also an important administrative means in fishery development administration. Fishery administrative license plays an important role in the protection of fishery resources, the protection of fishery producers' legitimate rights and interests, and the promotion of fishery production development. Therefore, it is of great practical significance to correctly understand and apply fishery administrative license and constantly improve fishery administrative license. The main problems of exploring fishery administrative license in reality are the contradiction of practice, and the legal system of fishery administrative license is not perfect. The industry lacks self-discipline and fishery administrative license management is relatively rigid. Supervision and inspection are not perfect, and the fishery administrative licensing system needs to be revised and improved. Therefore, to perfect the fishery administrative licensing legal system and supervision mechanism must refine fishery classification and perfect the fishery administrative licensing legal system; Strengthen the industry's autonomy and flexibility, and form a complementary coercive means with relevant government departments; We will strictly supervise and inspect and improve the laws and regulations governing fishery administrative licensing.

Key words: Fishery resources; Administrative license; Fishery administrative licensing; Fisheries management

国家管辖范围外渔业法律制度研究

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摘要: 国家管辖范围外 (ABNJ) 渔业法律制度随着海域划界变迁和捕鱼能力的提升, 经历了显著的变化, 形成了由分散到集中再到分散的制度模式。通过梳理 ABNJ 渔业法律制度, 大体分为: 国际性渔业法律制度、区域性渔业法律制度和个别渔业法律制度。经研究发现, 这些制度存在渔业资源分配不公、渔业资源养护变革阻碍大、渔业组织监管与国际合作机制不完善和渔业执法制度缺乏体系等问题。对此, 建议设立以渔业资源养护义务履行量与兼顾发展中国家的分配制度, 加强区域渔业组织对渔业资源养护的主导和贸易措施的调控力度, 完善渔业组织的监管制度和国际合作制度, 并建立一套统一有效的渔业执法体系, 促进海洋渔业资源的可持续发展。

关键词: 国家管辖范围外 (ABNJ); 渔业资源分配; 渔业资源养护; 渔业组织监管

Research on Legal System of Fishery Areas Beyond National Jurisdiction

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Abstract: The fishery legal system areas beyond national jurisdiction (ABNJ) has undergone significant changes with the changes of maritime boundary demarcation and the enhancement of fishing capacity, forming a system model from scattered to centralized and then to scattered. Through combing ABNJ fishery legal system, it can be divided into international fishery legal system, regional fishery legal system and individual fishery legal system. Studies have found that these systems have problems such as unfair distribution of fishery resources, great obstacles to the conservation and reform of fishery resources, imperfect supervision and international cooperation mechanisms of fishery organizations, and lack of systems for fishery law enforcement. To this end, it is suggested to establish a distribution system that takes into account both the fulfillment of fishery resources conservation obligations and the consideration of developing countries, to strengthen the control of regional fishery organizations on fishery resources conservation and trade measures, to improve the supervision system and international cooperation system of fishery organizations, and to establish a unified and effective fishery law enforcement system to promote the sustainable development of marine fishery resources.

Key words: Outside national jurisdiction (ABNJ), Distribution of fishery resources, Conservation of fishery resources, Fishery Organization Supervision

我国渔业法与刑法的法条衔接问题研究

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摘要: 中华人民共和国渔业法与刑法分属不同的法律部门, 但研究具体条文内容会发现两法部分领域规范交叉重合, 导致不同地区在司法实践中对破坏渔业资源的违法行为法律适用不同, 渔业法与刑法的相关法条产生适用冲突。因此, 以渔业法与刑法的法条衔接与冲突为解决思路, 在渔业法中进行实质性刑事立法、修正或废除渔业法中宣示性附属刑法条款, 以及出台涉及“情节严重”的相关司法解释, 将有利于渔业法与刑法在执法与维权实践中的良性互动发展。

关键词: 法条衔接; 法条冲突; 渔业法; 附属刑法; 没收

On the Connection between Fishery Law and Criminal Law in China

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Abstract: The fishery law and the criminal law belong to different legal departments, but the legal provisions between them are overlapping in some areas. These overlapping legal provisions will lead to the conflict of application between fishery law and criminal law in judicial practice, when different laws are applied by different regions to destruction of fishery resources. Thus, the connection and conflict of the legal provisions between fishery law and criminal law should be taken into consideration. Substantive criminal legislation or abolition of the declaratory subsidiary penal provisions, as well as the relevant judicial interpretation of serious circumstances, should be issued in the fisheries act, which will be conducive to the benign development of the two laws.

Key words: law cohesion; conflict of law; fisheries law; the accessory criminal law; confiscated

论渔业法之未取得或违反船网工具指标造船 违法行为的法律责任

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摘要: 船舶是渔业生产、水上运输的重要工具,我国对渔业船舶借助船网工具控制指标管理模式达到对渔船数量和功率数控制的“双控”管理,但实践中碍于很多因素还存在未取得或违反船网工具指标造船的现象,这一行为对水域交通安全、渔业生产安全、渔业资源保护 3 个方面都存在安全隐患。文章主要梳理现行法律法规对这一行为的规定并简要分析其法律责任,建议在处罚幅度中增加处罚下限。

关键词: 船网工具指标;非法造船;法律责任;渔业船舶;捕捞许可

On the Legal Liability of the Illegal Act of Shipbuilding without Obtaining or Violating the Fishing Vessel and Net Devices Quota in the Fishery Law

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Abstract: Vessel is an important tool of fishery production and water transportation. In China, fishery vessel's management adopts a control quota system for the vessel and net devices, to achieve the number and power number of fishing vessels control of the "double control" management. However, in practice, the phenomenon of building vessels without obtaining or violating Fishing Vessel and Net Devices Quota still exists,which will cause hazard to the water traffic safety, fishery production safety and fishery resources protection. This paper mainly combed the provision of the existing laws and regulations about this behavior and briefly analyzed its legal liability, and suggested to add the lower limit of punishment in the penalty range.

Key words: Fishing Vessel and Net Devices Quota, Illegal Shipbuilding,Legal responsibility,Fishing vessel,Fishing license

论渔业法之没收处罚

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摘要: 新的《中华人民共和国渔业法》(以下简称《渔业法》)草案增加了部分应追究法律责任的违法行为,从整体看,渔业法处罚中涉及没收处罚的条款占据了相当大的比例。正确理解并适用没收处罚的重要性不言而喻。本文简要分析了《渔业法》中没收处罚的概念、没收处罚的成立条件和实施情况,发现没收处罚的实施还是存在一些值得注意的问题,包括没收标的范围不够明确、情节轻重的认定标准难以达成统一、与刑法的衔接不够流畅、执法主体众多且权责不明、没收物的后续处理存在问题等。针对这些问题,笔者分析认为造成这些问题的原因有法律条文对没收的表述界定模糊,处罚条款对没收的情节认定缺少具体表述,缺乏有效司法衔接机制,执法权限划分不明确,法律规定缺乏可操作性等,并且提出相关建议,希望可以对《渔业法》中没收处罚的实施提供一些参考。

关键词: 渔业法; 没收处罚; 实施; 标的范围; 裁量; 问题与对策

On the punishment of confiscation in fishery law

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Abstract: The new draft Fisheries Law of the People's Republic of China (hereinafter referred to as "Fisheries Law ") adds some illegal acts that should be investigated for legal liability. On the whole, the provisions of fishery law penalties involving confiscation penalties account for a considerable proportion. The importance of correctly understanding and applying confiscation penalties is self-evident. This paper briefly analyzes the concept of confiscation punishment in the Fisheries Law, the conditions for the establishment and implementation of confiscation punishment, and finds that there are still some problems to be paid attention to in the implementation of confiscation punishment, including the lack of clarity in the scope of confiscation punishment, the difficulty of unifying the criteria for determining the seriousness of the circumstances, the lack of smooth connection with criminal law, the large number of law enforcement subjects and unclear powers and responsibilities, and the problems in the follow-up treatment of confiscated objects. In view of these problems, the author analyzes that the reasons for these problems include the vague definition of confiscation in legal provisions, the lack of specific expression of the circumstances of confiscation in punishment provisions, the lack of effective judicial convergence mechanism, the unclear division of law enforcement authority, the lack of maneuverability of legal provisions, and puts forward some suggestions.

Key words: fishery Law; confiscation penalty; implementation; Scope of subject matter; discretion; problems and countermeasures

论渔业执法之当场处罚

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摘要: 在渔业行政执法活动中, 当场处罚是渔业执法机关行使制裁权的重要方式之一, 但对于渔业 执法当场处罚制度的理解和认识尚存争议。文章在明确当场处罚的含义、原则和种类的基础上, 分析渔业当场处罚的适用条件及相关程序的规定。并进一步探讨《中华人民共和国渔业法》及其 相关涉渔执法法律、法规和规章中有关当场处罚的问题, 分析渔业执法当场处罚制度与实践需求不匹配的情形与原因, 最后对于发现的问题提出完善证据制度、明确法定依据、明确当场处罚的执法人员数、明确渔业当场处罚的标准、完善渔业当场处罚的监督体系等建议。

关键词: 渔业执法; 当场处罚; 行政处罚法; 农业行政处罚程序规定; 行政裁量

On the spot punishment of fishery law enforcement

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Abstract: In fishery administrative law enforcement activities, on-the-spot punishment is one of the important ways for fishery law enforcement agencies to exercise their sanction rights, but there is still controversy on the understanding of on-the-spot punishment system in fishery law enforcement. On the basis of clarifying the meaning, principles and types of on-the-spot punishment, this paper analyzes the applicable conditions and relevant procedures of on-the-spot punishment in fisheries. Furthermore, this paper probes into the problem of on-the-spot punishment in Fisheries Law of the People's Republic of China and its related laws, regulations and rules concerning fishery law enforcement, analyzes the situation and reasons of the mismatch between the on-the-spot punishment system of fishery law enforcement and the practical needs, and finally puts forward some suggestions on perfecting the evidence system, clarifying the legal basis, the number of law enforcement officers who are punished on the spot, clarifying the standard of fishery on-the-spot punishment and perfecting the supervision system of fishery on-the-spot punishment.

Key words: Fishery law enforcement, Punishment on the spot, Administrative punishment law, Provisions on agricultural administrative punishment procedures, Administrative discretion

论涉嫌渔业犯罪案件的移送

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摘要: 2001 年国务院颁布实施了《行政执法机关移送涉嫌犯罪案件的规定》，该法规的出台是为了保证行政执法机关能够及时地向公安机关移送涉嫌犯罪的案件。这一行政法规对渔业行政执法部门也同样适用。涉嫌渔业犯罪行政执法与刑事司法之间的衔接相当重要，实践中“以罚代刑”仍然是衔接中最普遍的问题，该法规的出台并没有很好的有效的解决这一问题。本文将对涉嫌渔业犯罪案件的移送所存在的问题以及如何去解决提出合理化建议。

关键词: 渔业犯罪；渔业行政机关；案件移送；行政处罚

On the transfer of suspected Fisheries Crime cases

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Abstract: In 2001, the State Council promulgated and implemented the provisions on the transfer of suspected Criminal cases by Administrative Law Enforcement organs. The purpose of this regulation is to ensure that administrative law enforcement agencies can transfer suspected criminal cases to public security organs in a timely manner. This administrative regulation is also applicable to fisheries administrative law enforcement departments. The connection between administrative law enforcement and criminal justice of suspected fishery crime is very important. In practice, "replacing punishment with punishment" is still the most common problem in connection, and the promulgation of this law has not solved this problem very effectively. This paper will put forward reasonable suggestions on the problems existing in the transfer of suspected fishery crimes and how to solve them.

Key words: Fishery crime, Fishery administrative organ, Transfer of cases, administrative penalty

论渔业法之为违法捕捞提供便利活动行为的 法律责任

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摘要:近年来随着人们对水产品需求也越来越大,人们逐渐加大对水产品的开发,违法捕捞活动逐年增多,并且在实践中为违法捕捞提供便利活动的行为也越发猖獗,由于立法的缺失,这种行为并没有受到法律的规制,行为人也逃避了应承担的法律责任,行走在法律的边缘,加剧损害渔业捕捞秩序,严重破坏水产品资源可持续发展。本文分析了为违法捕捞提供便利活动的行为,介绍了增加为违法捕捞提供便利活动行为的法律责任的必要性,分析了增加为违法捕捞提供便利活动行为的法律责任的可行性,提出了增加为违法捕捞提供便利活动行为的法律责任的构成要素以及立法建议。

关键词: 渔业法; 违法捕捞; 便利活动; 法律责任

On the legal liability of Fisheries Law in providing convenient activities for illegal fishing

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Abstract:In recent years, with the increasing demand for aquatic products, people have gradually increased the development of aquatic products, illegal fishing activities have increased year by year, and the behavior of providing facilities for illegal fishing in practice has become more and more rampant. Due to the lack of legislation, this kind of behavior has not been regulated by the law, and the actor has evaded the legal responsibility and walked on the edge of the law. It harms the order of fishery and fishing and seriously destroys the sustainable development of aquatic products resources. This paper analyzes the behavior of providing convenient activities for illegal fishing, introduces the necessity of increasing the legal liability for providing convenient activities for illegal fishing, and analyzes the necessity of increasing the legal liability for providing convenient activities for illegal fishing. The feasibility of increasing legal liability for facilitating activities in cases of illegal fishing is presented, together with elements for increasing legal liability for facilitating activities in cases of illegal fishing, as well as legislative recommendations.

Keyword : Fisheries law; Illegal fishing; Facilitation activities; Legal liability.

渔业法之情节严重研究

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摘要: 为了维护渔业生产秩序的和谐稳定, 实现渔业资源的可持续发展, 我国渔业法对诸多不当行为予以规制。但由于渔业法对“情节严重”的表述具有一定的模糊性, 未能明显阐明立法者本意, 不少渔业行政执法人员对此感到难以认定和把握, 为了稳妥起见只追究较轻的责任, 如此不利于法的实施。因此, 明确情节严重的认定标准具有重要的理论和实践意义。针对认定标准不明确、行政裁量空间过大、部分执法人员处罚结果不够合理的问题, 在考虑我国当前国情的基础上, 建议在立法上出台相关的司法解释, 行政机关制定完善的行政裁量基准, 并辅以司法机关审查作为补充, 多元规范“情节严重”的理解与认定。

关键词: 渔业法; 情节严重; 不确定法律概念; 行政裁量; 司法审查

A study on serious situation of fishery law

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Abstract: In order to maintain the harmony and stability of fishery production order and realize the sustainable development of fishery resources, China's fishery law regulates many improper behaviors. However, due to the vagueness of the expression of "serious circumstances" in the fishery law and the failure to clearly clarify the intention of the legislators, many fishery administrative law enforcement personnel find it difficult to identify and grasp this, and only pursue relatively light responsibilities for safety, which is not conducive to the implementation of the law. Therefore, it is of great theoretical and practical significance to clarify the criterion for determining the seriousness of the case. According to standards are not clear, administrative discretion space is too large, unreasonable part of the law enforcement of the penalty, on the basis of considering China's current national conditions, Suggestions on the legislation introduced relevant judicial explanation, the administrative organ for administrative discretion should be made as benchmark, supplemented by the judiciary review as a supplement, multiple specifications "serious" understanding and recognition.

Key words: fishery law, serious uncertainty, legal concept, administrative discretion, judicial review

渔业法之取证措施研究

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摘要: 取证措施在渔业执法实务过程中往往容易被忽视, 取证行为不规范也是亟待解决的一个问题。取证是执法过程中的重要环节, 也是调查渔业行政违法行为的必要措施, 渔业执法部门在作出相应的行政处罚之前必定会对案件进行调查取证。规范取证措施是使证据合法有效的的重要途径, 本文通过对渔业法中的取证措施进行研究, 选取了常见的渔业行政执法过程中的取证措施问题, 逐一分析该问题的成因, 在现有的法律制度下寻找解决问题的方法和对策, 给出相应建议, 达到规范渔业行政执法过程中的取证措施的目的。促进我国渔业执法实务发展, 有利于建设高效的渔业执法体制, 提高渔业执法效率。

关键词: 渔业执法; 取证措施; 行政强制; 执法体制

Research on Evidence Collection Measures of Fishery Law

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Abstract: Evidence collection measures in fishery law enforcement practice is often be ignored, evidence collection behavior is not standard, that problem is urgent to be solved. Evidence collection is an important link in the process of law enforcement, and it is a necessary measure to investigate illegal fishery acts. Before making corresponding administrative penalty, the enforcement departments will certainly conduct investigation and evidence collection. Specification forensics measures is the important way that make evidence legal and valid, this article study the fishery law of evidence collection measures, selection the common problems in the process of fishery law enforcement, analyze the cause of the problem, under the existing legal system to find the methods and countermeasures to solve the problem, and gives corresponding Suggestions, for the purpose of standardizing evidence collection measures. To promote the development of fishery law enforcement in China, to improve the construction of efficient that fishery law enforcement system and the improvement of fishery law enforcement efficiency.

Key words: Fishery law enforcement ; Evidence collection measures; Compulsory administrative; Law enforcement system

论渔业法之对影响渔业船舶适航行为的法律责任

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摘要: 渔船管理是渔业产业管理的重要内容,而船舶适航性是渔船正常运行的重要保证。我国现阶段渔业产业中出现的船舶事故频发,其中很多是不适航导致的。文章从我国渔业监管现状出发,结合《渔业法》及其相关法律对影响船舶适航行为法律责任的相关规定,分析违法行为构成要件,发现依然存在处罚手段单一、处罚力度不够等问题,针对存在的原因,从完善对相关违法行为的认定,加强行政监管,丰富处罚方式,提高行政处罚标准等措施出发提出完善建议,从而减少渔业安全事故,推动我国渔业健康发展。

关键词: 船舶适航; 违法行为; 构成要件分析; 船舶安全; 渔业法

On the Legal Liability of Fishery Law to the Behavior Affecting the Seaworthiness of Fishery Ships

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Abstract: Fishing vessel management is an important part of fishery industry management, and ship seaworthiness is an important guarantee for the normal operation of fishing vessels. At present, there are frequent ship accidents in China's fishery industry, many of which are caused by unseaworthiness. Based on the current situation of China's fishery supervision, combined with the relevant provisions of the Fisheries Law on the legal liability for acts affecting the seaworthiness of ships, this paper analyzed the elements of illegal acts, and found that there were still problems such as single means of punishment and insufficient punishment. In view of the existing reasons, from improving the identification of relevant illegal acts, strengthening administrative supervision, enriching punishment methods, and improving administrative punishment in order to reduce the accidents of fishery safety and promote the healthy development of fishery in China, some suggestions were put forward.

Key words: Seaworthiness of ship, illegal act, Analysis of constitutive requirements

论渔业法之渔业水域污染事故法律责任

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摘要: 优质的的渔业水域环境是我国渔业可持续发展的重要保障,目前,我国渔业水域环境面临着较为严峻的污染问题,污染事故时有发生,严重影响了渔业的持续稳定发展。为了保护渔业水域环境、防治渔业水域污染事故,我国在《中华人民共和国渔业法》、《中华人民共和国水污染防治法》、《中华人民共和国海洋环境保护法》等法律中均规定了相关内容,基本形成了渔业水域污染事故的法律规制模式,但仍然存在许多法律问题,如法律规定缺乏实施细则,可行性较低;相关定义模糊不清;事故损害调查方式不够合理等。在此背景下,本文分析了目前渔业水域污染事故对应的民事法律责任、行政法律责任和刑事法律责任,并提出相应的完善建议,为渔业水域污染事故的处理和归责提供参考。

关键词: 渔业法、渔业水域污染事故、法律责任

The Legal Responsibility of Pollution Accidents in Fishing Waters under Fishery Law

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Abstract: Excellent water environment for fishery is an important guarantee of sustainable development of fishery in China. Currently the water environment for fishery in China is faced with severe pollution, with pollution accidents happening from time to time, seriously impacting the sustainable and stable development of fishery. In order to protect the water environment and prevent pollution accidents in water for fishery, relevant content is stipulated in laws of China, including Law of the People's Republic of China on Fishery, Law of the People's Republic of China on Water Pollution Prevention and Law of the People's Republic of China on Sea Environment Protection. Laws and regulations on water pollution accidents for fishery are basically developed, but many legal issues still exist, including lack of detailed rules for implementation of laws and regulations, low feasibility, ambiguous definitions, and unreasonable investigation method of accident damages. Under such a context, the article analyzes the civil law responsibilities, administrative legal responsibilities and criminal responsibilities for water pollution accidents of fishery, and puts forward corresponding suggestions, so as to provide reference for handling such accidents and identifying responsibilities.

Keywords: Fishery law, Pollution Accident in Fishery Waters, legal Responsibility

中国海洋捕捞小型渔业的定义、问题及对策

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摘要: 小型渔业治理问题是全球范围内可持续渔业发展的热点之一。小型渔业是否能治理好, 不仅体现一国的渔业治理水平, 更能反映该国渔业资源利用是否具有可持续发展的潜力。本文首先利用文献分析的方法, 对国内外小型渔业的发展阶段、定义特征进行了总结。尽管目前没有统一的定义, 但其内涵和主流观点呈现阶段性特征。其次, 对小型渔业国内外的主要问题、治理理论及应用进展进行了回顾和比较。最后, 基于以上总结, 指出目前我国对小型渔业的关注度不够、治理理论缺乏、实践经验不足的现状。因此, 我国应加快对小型渔业治理制度的探索、增强渔业执法队伍建设和提升执法能力、促进渔民合作组织的培育。

关键词: 海洋捕捞; 小型渔业; 治理; 渔业执法; 渔民合作组织

The Definition, Problems and Solutions in China's Capture Small-scale fisheries

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Abstract: The governance of small-scale fisheries (SSF) has been one of the hottest issues around the world. Small-scale fisheries that have good governance can reflect a state governance capability, which mirrors the country's potential for sustainable utilization of fishery resources. The paper used the bibliometric analysis method to discuss the stage characteristics of SSF. Reviewing and comparing the theories and cases of the application of governance. On this basis, lacking attention, insufficient foundation theories, and practical experience will be pointed out by retrospection of the problems of China. Therefore, China should accelerate process the exploration of the small-scale fishery governance system, strengthen the construction of fishery law enforcement teams, and enhance the ability of law enforcement, meanwhile promote the cultivation of fishermen's cooperative organizations.

Keywords: Capture fishery, small-scale fishery, governance, law enforcement of fishery, fishermen's organizations

从美国金枪鱼案分析单边生态标签措施合法性

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摘要: 为了解美国单边海豚安全标签措施合法化关键和渔业影响, 文章结合美国金枪鱼案件中该措施的修改历史和是否构成“任意或不合理歧视”的裁决结果, 研究了 2018 年 WTO 通过完善不同海域用不同捕捞方法造成海豚伤亡的风险评估和匹配分析方法, 确立合法监管区分例外标准来判定 TBT 第 2.1 条“不低于待遇”要求。

关键词: 美国金枪鱼案; TBT 第 2.1 条; 单边生态标签措施; “海豚安全”标签; 渔业资源养护

Analyses on the Legality of unilateral Eco-labeling measures in the light of the U.S.-Tuna Case

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Abstract: This paper analyzed the history of the amendment to the U.S. dolphin-safe labeling measures and examined how a unilateral labeling measure would constitute arbitrary or unreasonable discrimination of Article 2.1 of the TBT Agreement in the U.S.-Tuna case. The World Trade Organization in 2018 established the exception standard of the legitimate regulatory distinction test to determine the ‘no less favorable’ requirement of Article 2.1. The use of unilateral eco-labeling measures to promote the conservation of fisheries resources are likely to precipitate international trade disputes, against the efforts of multilateral cooperation to conserve the global fisheries resources.

Key words: the U.S.-Tuna case; Article 2.1 of TBT Agreement; unilateral eco-labeling measures; the dolphin-safe label ; fishery resources conservation

中国渔业的要素投入、规模报酬与技术效率分析——基于随机前沿模型的全要素生产率分析

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摘要: 近年来, 中国不断加大渔业科技投入, 但中国渔业技术效率表现如何, 渔业要素投入结构是否合理, 一直是我们关注的问题。本文运用 CD 随机前沿生产函数, 对 2012—2019 年全国 29 个省的 232 组面板数据, 对渔业要素投入结构和渔业技术效率进行分析。结果显示: (1) 中国渔业从业人员、渔业养殖面积、机动渔船功率水平、鱼苗投入要素弹性呈现递增的趋势, 但除鱼苗外, 要素投入贡献份额都为负, 要素投入过量; (2) 中国渔业规模报酬较低, 渔业科技要素投入不足; (3) 中国渔业技术效率呈递增的趋势, 沿海地区的技术效率大于内陆地区。研究表明: 渔业技术效率低和要素投入协同存在相关性, 要素结构配置不合理是技术效率低的主要原因, 要素投入协同才能促进生产效率提高。

关键词: 中国渔业; 技术效率; 随机前沿分析; 全要素生产率

Factor inputs, returns to scale and technical efficiency analysis of Chinese fisheries -- A total factor productivity analysis based on stochastic Frontier Model

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Abstract: In recent years, China has been increasing the input of fishery technology, but the performance of China's fishery technology efficiency and whether the structure of fishery factor input is reasonable have been concerned. In this paper, CD stochastic frontier production function was used to analyze the structure of fishery factor input and fishery technical efficiency through 232 sets of panel data from 29 provinces from 2012 to 2019. The results showed: (1) The elastic of labour, aquaculture area, the vessel power and fish fry showed a trend of increase, but in addition to the fish fry, the contribution of inputs are negative; (2) The utility of returns to scale has not yet been realized, and the input of fishery technology factors is insufficient; (3) The fishery technical efficiency shows an increasing trend. The technical efficiency of coastal areas is greater than that of inland areas. Research shows that low technical efficiency of fishery is correlated with factor input synergy, and unreasonable factor allocation is the main reason for low technical efficiency, so factor input synergy can promote the improvement of production efficiency.

Key words: Chinese fishery; Technical efficiency; Stochastic frontier analysis; Total factor productivity

基于 Nvivo 分析的我国围填海政策发展变迁的 质性研究

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摘要: 围填海政策是生态文明政策的重要组成部分, 新出台的围填海政策起到了一定的成效的同时, 也发现了一系列问题。本文基于扎根理论, 运用 Nvivo 11 软件对我国历史上的围填海政策进行质性分析, 梳理了我国围填海政策的发展变迁, 围绕着政策目标和政策措施两个节点, 来探究我国围填海政策的变迁规律集中在管控措施、管控权利和针对性三个方面, 揭示其变迁的驱动因素为政策决策者、过去的经验、国际背景以及社会公众的反馈, 从而对我国未来围填海政策的发展方向提出建议, 以期对我国整个海洋环境保护事业做出贡献。

关键词: 围填海政策; 质性分析; 海洋环境保护

Qualitative research on development and change of reclamation policy in China based on Nvivo analysis

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Abstract: The reclamation policy is an important part of the ecological civilization policy. While the new reclamation policy has achieved certain results, a series of problems have also been discovered. Based on the grounded theory, this paper uses NVivo 11 software to conduct a qualitative analysis of China's reclamation policy in history, sorts out the development and changes of China's reclamation policy, and explores China's reclamation around the two nodes of policy objectives and policy measures. The law of change in maritime policy focuses on three aspects: control measures, control rights and pertinence, revealing that the driving factors of its changes are policy decision makers, past experience, international background, and public feedback, so as to inform China's future reclamation policies. It puts forward suggestions on the development direction of China, with a view to making contributions to China's entire marine environmental protection.

Key words: the reclamation policy, qualitative research, marine environmental protection

我国水产品质量安全法律规制研究

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摘要：近年来，水产品行业迅猛发展，质量安全问题不容忽视。本文从法律保障角度分析，指出我国水产品质量安全法律体系存在的问题和原因，提出完善思路，即建立健全水产品质量安全法律体系，发挥政府主导作用，发挥社会监督作用，以期从法律规制角度为水产品质量安全提供思路，促进我国水产品行业良性发展。

关键词：水产品质量安全；管理体系；法律保障

Research on the legal regulations of aquatic product quality and safety in China

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Abstract: In recent years, with the rapid development of aquatic products industry, the quality and safety issues cannot be ignored. This article analyzes from the perspective of legal protection, points out the problems and causes of the legal system of aquatic product quality and safety in China, and puts forward the improvement ideas, that is to establish and improve the legal system of aquatic product quality and safety, play the leading role of the government, and play the role of social supervision, in order to provide ideas for the quality and safety of aquatic products from the perspective of legal regulation, and promote the healthy development of China's aquatic products industry.

Key words: quality and safety of aquatic products; management system; legal guarantee

泉吉河青海湖裸鲤自然产卵场的生境特征

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摘要: 2018-2019年采用江底采卵、现场断面测量及无人机遥测的方法对青海湖入湖支流泉吉河全流域进行调查, 选取了10个典型的青海湖裸鲤产卵场与5个非产卵场进行生境特征测量, 主要包括江段形态(江宽、面积大小等)、流速、水深、底质(类型和粒径)、水温等。结果表明: 青海湖裸鲤产卵场往往流速较缓, 水深较浅, 具有深潭。产卵场江段流速均值为0.33m/s(范围0.01-0.95m/s), 非产卵场江段流速均值较高, 为0.63m/s(范围0.13-1.06m/s); 产卵场江段平均水深为21.6cm(范围3-80cm), 非产卵场江段平均水深较深, 为33.5cm(范围8-70cm); 产卵场江段与非产卵场江段底质的区别主要为卵石大小: 非产卵场卵石平均粒径为18cm, 产卵场卵石平均粒径为7cm。本研究初步获得了青海湖裸鲤自然产卵场生境特征参数, 为青海湖裸鲤自然产卵场评估及人工产卵场的构建提供基础数据及理论。

关键词: 青海湖裸鲤; 产卵场; 非产卵场; 生境特征

Habitat characteristics of natural reproduction of naked carp in Qinghai Lake of Quanji River

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Abstract: 2018-2019, using a recently collected eggs, cross section measurement on site and uav remote sensing method of the water flowing into the lake of qinghai lake river gee whole basin investigation, selected the 10 typical qinghai lake naked carp spawning grounds and five measurement of spawning habitat characteristics, mainly including Jiang Duan form, flow velocity, water depth, bottom, water temperature, etc. The results showed that the spawning ground of naked carp in Qinghai Lake tended to have slow flow rate, shallow water and deep pools. The average flow velocity of the river section in the spawning field was 0.33m/s (0.01-0.95m/s), and the average flow velocity of the river section in the non-spawning field was higher, 0.63m/s (0.13-1.06m/s). The average water depth of the river section in the spawning field was 21.6cm (3-80cm), and the average water depth of the river section in the non-spawning field was 33.5cm (8-70cm). The difference between the sediment of the spawning river section and the non-spawning river section is mainly the pebble size: the average pebble diameter of the non-spawning river section is 18cm and the average pebble diameter of the spawning river section is 7cm. In this study, the habitat parameters of natural spawning grounds of naked carp in Qinghai Lake were obtained, providing basic data and theories for the evaluation of natural spawning grounds and the construction of artificial spawning grounds for naked carp in Qinghai Lake.

Key words: *Gymnocypris przewalskii*; Spawning grounds; The spawning grounds; Habitat characteristics

海州湾紫菜养殖空间格局变化及其驱动因子相关性分析

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摘要: 海州湾紫菜养殖作为连云港重要的农业产业,其养殖规模的动态监测和产业发展内在驱动力分析对紫菜产业的发展规划以及整片海域的生态环境评估有着重要作用。以海州湾 2004-2018 年冬春两季时相 Landsat 系列遥感影像为基础数据源,通过面向对象分类特征算法提取紫菜养殖区的时空动态变化状况和近岸人工开发信息,结合紫菜产业近期的统计资料和促进保障政策,探索紫菜产业发展的空间格局变化以及驱动因子分析。

关键词: 海州湾; 紫菜养殖区; 空间分异; 驱动因子;相关性分析

Correlation analysis of spatial pattern change and driving factors of laver cultivation in Haizhou Bay

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Abstract: Laver cultivation in Haizhou Bay is an important agricultural industry in Lianyungang. The dynamic monitoring of its cultivation scale and the analysis of the internal driving force of industrial development play an important role in the development planning of seaweed industry and the ecological environment assessment of the whole sea area. Using the Landsat series of remote sensing images in the winter and spring of 2004-2018 in Haizhou Bay as the basic data source, extract the spatiotemporal changes and artificial development information of the laver cultivation area through the face-to-object classification feature algorithm, combined with the industry's recent statistics and promotion guarantee policies will explore the spatial pattern of the development of the laver industry and the analysis of driving factors.

Key words: Haizhou Bay, laver cultivation area, spatial differentiation, driving factors, correlation analysis

我国引入 TAC 制度的研究进展初探

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摘要: 长期的过度捕捞引发了渔业资源破坏、生态系统失衡等诸多环境问题, 一系列出台的渔业管理措施都没能从根本上解决资源枯竭问题, 渔业资源危机愈发严重。文章以 TAC 为阐述对象, 简要分析了我国试行 TAC 试点前后的实际效果; 加以 PEST 分析法评估我国实施 TAC 的外部环境并提出发展对策。结论表明: 我国试点地区虽取得一定成果但当前仍以投入控制为主要措施, 实行产出和投入控制相结合才是国际渔业管理的趋势和目标。

关键词: 渔业资源; TAC 制度; PEST 分析; 建议对策;

A preliminary study on the introduction of TAC system in China

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Abstract: Long term overfishing has caused many environmental problems, such as the destruction of fishery resources and the imbalance of ecosystem. A series of fishery management measures have failed to fundamentally solve the problem of resource depletion, and the crisis of fishery resources is becoming more and more serious. Taking TAC as an example, this paper briefly analyzes the actual effect before and after the trial implementation of TAC in China, evaluates the external environment of TAC implementation by PEST analysis method and puts forward development countermeasures. The conclusion shows that although some achievements have been made in China's pilot areas, input control is still the main measure, and the combination of output and input control is the trend and goal of international fisheries management.

Key words: fishery resources; TAC system; PEST analysis; suggested countermeasures;