



科技创新促进渔业高质量发展

2022 中国水产学会 **范夔** 学术大会

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## 一、水产绿色健康养殖新技术新模式

# 黑龙江省大龙湖春季大银鱼对后生浮游动物的摄食选择

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**摘要：**为揭示大银鱼食性转变之前的摄食偏好和关键饵料基础，我们在 2021 年春季（4-6 月）分析了黑龙江大龙湖大银鱼食性。结果表明，大银鱼春季主要以枝角类和桡足类为食。4 月初至 6 月，随着大银鱼体长的增长，偏好摄食的浮游动物体长也相应变长。与此同时，呈现出从偏好摄食桡足类向偏好摄食枝角类转变的特征。本研究首次探讨了大银鱼食性转变之前对浮游动物饵料的选择性，为大银鱼种群补充关键阶段的饵料需求提供了重要基础资料，为大银鱼种群稳定以及持续高产提供理论依据。

**关键词：**大龙湖大银鱼；食性；后生浮游动物；胃含物分析

## Feeding selection of Metazoan zooplankton by *Protosalanx chinensis* in Dalong Lake in spring

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**Abstract :** In order to explore the early feeding habits and feeding preferences of *Protosalanx chinensis* in Dalong Lake, the feeding habits of *Protosalanx chinensis* in Dalong Lake were analyzed in the spring of 2021. The results showed that the *Protosalanx chinensis* mainly fed on Cladocera and Copepods in spring. At the beginning of April to June, with the growth of the body length of *Protosalanx chinensis*, the body length of the Cladocera and copepods that preferred to feed also increased accordingly. At the same time, the preference for copepods changed to Cladocera. This study discussed for the first time the selectivity of diet for zooplankton before the change of feeding habits of *Protosalanx chinensis*, which provided important basic data for the diet demand at the critical stage of supplementing the population of *Protosalanx chinensis* and provided theoretical basis for the population stability and sustainable high yield of *Protosalanx chinensis*.

**Key words::** Dalong Lake *Protosalanx chinensis*; Food habits; Metazoan zooplankton; Analysis of gastric contents

# 不同地区稻虾综合种养系统的 微生物群落结构分析

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**摘要：**采用 Illumina Miseq 高通量测序方法，研究不同地区稻田养殖小龙虾的水体、底泥及肠道细菌群落结构，并对水体、肠道菌群与环境因子之间的关系进行了分析。结果显示，不同地区水体，底泥及小龙虾肠道微生物存在一定差异，其中水体与底泥的微生物结构更相似。武汉地区稻虾综合种养系统中水体的微生物多样性最高。不同地区养殖系统微生物的优势菌门种类没有变化，但是会改变优势菌门和优势菌属的相对丰度。

**关键词：**稻虾综合种养；水体；底泥；肠道；菌群结构；高通量测序

## Analysis of microbial community structure in rice-shrimp integrated culture system of three different areas

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**Abstract :** Environmental microbiota plays important roles in the intestinal microbiota of aquatic animals. The *Procambarus clarkii* with high commercial value has become the most important commercial species of shrimp in the world. *Procambarus clarkii* breeding is an important economic mainstay in Hubei province, China. However, information on the gut microbiota of the *Procambarus clarkii* is limited. To study the difference of bacterial community structure in the intestinal tract of *Procambarus clarkii* and the environment of rice shrimp comprehensive breeding system in different areas, and to provide a basis for improving the comprehensive breeding strategy of rice shrimp in different areas. The results showed that the diversity of the bacterial community in the water, sediment and crawfish gut of rice shrimp integrated cropping system in Wuhan area was higher than that in Yongzhou area and Shaoguan area. The results show that there are some differences among the gut of *Procambarus clarkii*, water and sediment of different regions, and the microbial structure of water bodies and sediment is more similar. The microbial diversity in the water body of rice shrimp integrated cropping system in Wuhan area is the highest, which is beneficial to the stability of the breeding system. The culture environment in different regions did not affect the core phyla of microorganisms in the culture system, but changed the relative abundance of dominant phyla and genera.

**Key words: :** integrated shrimp in rice field; water; sediment; intestine; microbial community structure; high-throughput sequencing

# 盐度、温度和光照对广西沿海 牟氏角毛藻生长的影响

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**摘要:** 结合广西沿海防城港海区水质和环境条件, 弄清影响牟氏角毛藻生长的主要理化因子, 采用单因子变量方法研究盐度、温度、光照对牟氏角毛藻生长的影响。不同环境因子对牟氏角毛藻的生长影响显著 ( $P<0.05$ ); 牟氏角毛藻在盐度 5~40‰条件下均能正常生长, 中盐度组 (20~30‰) 为牟氏角毛藻的最适生长条件; 高温培养条件下, 31°C时牟氏角毛藻达到最大藻细胞浓度; 4000Lx 为牟氏角毛藻最适生长光照强度。

**关键词:** 牟氏角毛藻; 盐度; 温度; 光照; 藻细胞密度; 生长速率

## Effects of Salinity, Temperature and Illumination on the Growth of *Chaetoceros muelleri* from the coast of Guangxi

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**Abstract:** Combining with the seawater environmental conditions in Fangchenggang sea area along the coast of Guangxi, the effects of salinity, temperature and light on the growth of *Chaetoceros muelleri* were studied by single factor method. Different environmental factors had significant effects on the growth of *Chaetoceros muelleri*. ( $P<0.05$ ). Different environmental factors had significant effects on the growth of *Chaetoceros muelleri* ( $P<0.05$ ). The medium salinity group (20-30‰) was the optimum growth condition. Under the condition of high temperature culture, the maximum cell concentration of *Chaetoceros muelleri* was reached at 31°C. The lower the temperature, the slower the growth rate, the longer the stable period, the higher the temperature, the faster the growth rate and the shorter the stable period. 4000Lx was the most suitable light intensity for the growth of *Chaetoceros muelleri*. The higher the light intensity, the longer the stability period. 20‰ salinity, 31°C temperature and 4000Lx light intensity were the best growth conditions for *Chaetoceros muelleri* in Guangxi coastal Fangchenggang sea area.

**Key words:** *Chaetoceros muelleri*; Salinity; Temperature; Light; Algal cell density; Growth rate

# 稻虾共生模式对水稻结实期根系分泌物及微生物的影响

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**摘要：**为了探明稻虾共生模式中虾对水稻生长的促进作用，本试验以红螯螯虾（*Cherax quadricarinatus*）为养殖对象，比较了稻虾共生和水稻单作两种模式下结实期水稻根系分泌物（有机酸、氨基酸和酚酸）和微生物群落结构的差异。结果显示：稻虾共生模式显著增加了结实期水稻根系苹果酸、酒石酸、马来酸、异亮氨酸、丝氨酸以及总有机酸和总氨基酸的分泌量，分别较对照组提高了 29.07%、61.84%、10.8%、136.11%、218.54%、21.50% and 12.69%。

**关键词：**红螯螯虾；稻虾共生；根系分泌物；根际微生物；结实期；

## Effects of Rice-crayfish Integrated Model on Root Exudates and Microorganisms of Rice During Grain Filling

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**Abstract:** The traditional rice-crayfish coculture systems may develop a novel sustainable agriculture by clarifying whether crayfish is serving as a stimulus for rice growth. In order to investigate this mechanism, the experiment selected *Cherax quadricarinatus* as the cultured species and compared rice root exudates (organic acids, amino acids and phenolic acids) and microbial community structure in integrated rice-crayfish farming (RSC) and rice monoculture (RMC). Gas chromatography/mass spectrometry (GC-MS) and Illumina MiSeq sequencers were adopted as the research method. The results showed that the secretion of malic acid, tartaric acid, maleic acid, isoleucine, serine, total organic acids and total amino acids in rice roots were increased significantly in coculture system during the grain filling stage, with the gap reaching at 29.07%, 61.84%, 10.8%, 136.11%, 218.54%, 21.50% and 12.69% respectively compared to the control group; The total amount of p-hydroxybenzoic acid, coumaric acid and phenolic acid decreased by 20.38%, 25.5% and 9.48%. In the hard dough stage, the abundance of *Methylomirabilota* and *Latescibacterota* were increased in integrated farming system by 101.11% and 48.86%, respectively; At the genus level, the rice-crayfish integrated model significantly increased the abundance of *Vicinamibacteria-norank* and *Latescibacterota-norank* by 22.96% and 48.23%. Correlation analysis showed that the total amount of organic acids and phenolic acids secreted by roots were negatively

**Key words:** *Cherax quadricarinatus*; Rice-crayfish Integrated model; Root exudates; Rhizospheric microorganism; Grain filling stage



# 漏斗形池塘高效循环养殖模式

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**摘要：**漏斗形池塘高效循环养殖模式（河南“168”模式），经过3年的探索和1年的升级优化，在增效降劳还是节水减排上面，均实现了显著的提升。创新点是实现了鱼粪的高效收集与资源再利用，本文重点介绍了该模式中生态循环流水养鱼、设施配套收集鱼粪、自动控制智能管理、粪污集中处理利用等关键技术，使节水节能超过50%，鱼粪分离效率达到75%以上，改变了原来全部排入沟渠、莲藕池、稻田等做法，最大限度减少对周边环境的影响。

**关键词：**漏斗形池塘；生态循环；高效养殖模式

## Funnel-type Recycled Pond Culture Model

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**Abstract :** After three years exploration and one year's optimization, funnel-type recycled pond culture model('Henan 168 model'for short) realizes significant improvement on efficiency lift, labor reduce, water saving and discharge cut-down. It is innovated that key technologies like eco-recycled flow-thru farming, feces collection by special installation, smart management by automatic control and reuse of concentrated sludge, save water and energy by up to 60% and increase sludge take-out rate to 75%. This model reuses effluent and sludge instead of discharging them all to channels of lotus and grains, which largely reduces discharge rate and protects environment. The model provides an eco-friendly and highly-efficient way to realize the requirement of green pond modification in 14th Five Year Plan.

**Key words::** Funnel-type Pond; eco-recycled; highly-efficient aquaculture model

# 三种底栖贝类在海水池塘综合养殖系统中固碳能力研究

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**摘要:** 摘要: 本研究通过现场试验方法探究了池塘虾贝综合养殖系统中文蛤、青蛤和缢蛭3种底栖贝类贝壳及软体组织碳含量随季节变动规律及年总固碳量。研究表明, 三种贝类碳含量无明显种内、种间差异, 同种贝类在不同季节碳含量无显著性差异; 固碳量与贝壳及软体组织的重量呈显著正相关, 结合经验公式计算, 相同养殖模式下年固碳量大小依次为文蛤>青蛤>缢蛭; 可通过优化文蛤与虾综合养殖模式的方法, 提升海水池塘综合固碳能力。

**关键词:** 关键词: 底栖贝类 综合养殖 碳含量 固碳能力

## Carbon sequestration capacity of three benthic shellfish in seawater pond integrated culture system

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**Abstract:** Abstract: In this study, the seasonal variation of carbon content in shells and soft tissues of three benthic shellfish, *Meretrix meretrix*, green clam and *Sinonovacula constricta*, and the total annual carbon sequestration in the pond shrimp and shellfish integrated culture system were studied. The results showed that there was no significant difference in carbon content among the three shellfish species, and there was no significant difference in carbon content of the same shellfish in different seasons; There was a significant positive correlation between carbon sequestration and the weight of shell and soft tissue. Combined with the empirical formula, the annual carbon sequestration under the same culture mode was *Meretrix meretrix* > green clam > *Sinonovacula constricta*; The comprehensive carbon sequestration capacity of seawater ponds can be improved by optimizing the comprehensive culture mode of *Meretrix meretrix* and shrimp.

**Key words:** Key words: benthic shellfish comprehensive culture carbon content carbon fixation capacity

# 基于卷积神经网络的水生生物生态物联网管理

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**摘要：**随着新兴信息技术的发展，传统的水生生物管理方法因成本高、耗时长、管理不准确等问题逐渐被新方法所取代。对这些问题进行了一系列的研究，并提出了许多解决这些问题的方法。但有些方法研究对象过于单一，不适用于其他水生生物，识别准确率普遍不高。而且有些方法研究对象过于单一，对其他水生生物的适用性较差。不高。因此，在这种情况下，提出生态系统作为架构作为数据，并使用管理空间。使用改进的卷积神经网络（CNN）模型将水生生物分类。

**关键词：** CNN、水生生物、分类、生态网络、超参数

## Convolutional Neural Network-based Ecological IoT for Management of Aquatic Organisms

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**Abstract :** With the development of emerging information technology, the traditional management methods of aquatic organisms are slowly replaced by new methods due to high cost, time-consuming, and inaccurate management. In recent years, some scholars and experts have conducted a series of studies on these problems and proposed many methods to solve these problems. However, some methods are too singular to study objects, which are not applicable to other aquatic organisms, and the accuracy of recognition is generally not high. Moreover, the research objects of some methods are too single, and the applicability to other aquatic organisms is not high. Therefore, in this case, an ecosystem is proposed as an architecture as a data, and the management space is used. The aquatic organisms were classified as a major classification method with an improved Convolutional Neural Network (CNN) model, and the model was recorded as Fish-CNN. The improved Fish-CNN model is a 2-layer structure based on the original CNN model, and the characteristics of the picture have been extracted and dropped multiple times, and the accurate classification of aquatic organisms is achieved. This study passed multiple experiments, and the optimal super parameters were selected during model training. At the learning rate of 0.0001, the training set and test set ratio were 8:1, and the final accuracy of the classification can be stable to 99% to 100%. The experiment also compares the Fish-CNN model

**Key words:** CNN, aquatic organism, classification, ecological network, super parameter

# 许氏平鲷低氧耐受能力及血液学和鳃组织学变化

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**摘要:** 本研究探明了许氏平鲷临界氧分压(Pcrit)和失去平衡点(LOE)时溶解氧含量, 分析了低氧条件下许氏平鲷血液生理指标和鳃组织的变化情况。结果表明, 结果显示, 许氏平鲷 [(88.01±5.34)g]Pcrit 和 LOE 溶解氧含量分别为(3.96±0.11) mg/L 和(2.60±0.21) mg/L。低氧使血液生理指标发生不同程度的改变, 使鳃组织出现不同程度病变情况, 相关结果为其健康养殖提供理论基础。

**关键词:** 许氏平鲷; 低氧耐受; 呼吸频率; 血液生理生化; 鳃组织结构

## Hypoxia tolerance and alternation of hematology and gill morphology in black rockfish *Sebastes schlegelii*

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**Abstract:** Dissolved oxygen is an important environmental factor affecting the survival of fish. The critical oxygen tension (Pcrit), loss of equilibrium (LOE), respiratory rate, plasma cortisol, glucose, white blood cell (WBC), red blood cell (RBC), hemoglobin (Hb), hematocrit (HCT) and the alternation of gill morphology and related parameters (lamellar length [SLL] and width [SLW], interlamellar distance [ID], perimeter), the proportion of the secondary lamellae available for gas exchange (PAGE) were determined during hypoxia to illustrate hypoxia tolerance and physiological response mechanisms in *Sebastes schlegelii* during hypoxia stress by experimental ecology and physiological method. Results showed that the value of dissolved oxygen at critical oxygen tension (Pcrit) and loss equilibrium (LOE) of black rockfish were (3.96±0.11) mg/L and (2.60±0.21) mg/L respectively, water conditions remain at temperature (15.6±0.2) °C, pH value 7.85, salinity 30.0. The PAGE and respiratory frequency increased first and then decreased, the highest value respectively obtained at Pcrit and LOE (P<0.05) throughout hypoxia stress. Meanwhile, plasma cortisol and glucose levels significantly increased, the highest values observed at LOE and Pcrit (P<0.05). In blood physiology, Hb, HCT, WBC similar results like plasma cortisol, with the highest value at LOE (P<0.05), whereas RBC remained unchanged during hypoxia stress. Besides, the SLL, ID, Perimeter of gills increased significantly during hypoxia stress

**Key words:** : *Sebastes schlegelii*; hypoxia tolerance; respiratory frequency; physiology and biochemistry; gill histology

# 池塘工程化循环流水养殖模式的创新研究

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**摘要：**近年来，池塘工程化循环水养殖模式作为一种具有高产、高效和环保等优点的生态养殖模式开始在水产业中兴起。但由于其设备和日常管理成本过高，以及自然灾害等因素，并不能为大部分养殖者的选择。本文通过对整个养殖系统进行功能分区，探索更加优化的池塘工程化循环水养殖模式，以期可以提高水体的综合利用和该模式下的养殖效益。

**关键词：**池塘工程化循环水养殖模式，功能分区，养殖效益

## Research on innovation of pond engineering circulating water aquaculture model

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Guangxi Fisheries Research Institute

**Abstract :** In recent years, pond engineering circulating water culture model has begun to rise in aquaculture as an ecological aquaculture model with the advantages of high yield, high efficiency and environmental protection. However, With the high cost of equipment and daily management, and the natural disasters, it can not be a best choice for most culturist. In this paper, through functional partition of the whole aquaculture system, a more optimized pond engineering circulating water aquaculture mode was explored, expected to improve the comprehensive utilization of water bodies and the aquaculture benefits under this mode.

**Key words: :** Pond engineering circulating water aquaculture model , Functional partition, aquaculture benefits

# 不同长茎葡萄蕨藻（*Caulerpa lentillifera*） 养殖密度对半循环水养殖凡纳滨对虾 （*Litopenaeus vannamei*）水质、生长及 饵料效率的影响

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**摘要：**本试验设置三个不同密度（2.5、5、7.5g/L）的长茎葡萄蕨藻密度作为水处理模块对凡纳滨对虾养殖用水进行处理并循环利用，不添加长茎葡萄蕨藻为对照组，每组三个平行，结果表明：实验组养殖水体的硝酸氮、亚硝酸盐、氨氮、磷酸盐、弧菌数量显著低于对照组。实验组在凡纳滨对虾存活率、绝对生长率、饵料系数方面皆有显著促进作用，7.5g/L 海藻实验组最佳，分别达到 93%、271.33%和 0.99。

**关键词：**长茎葡萄蕨藻、凡纳滨对虾、水质、生长、弧菌

## Effect of different densities *Caulerpa lentillifera* on the water quality, growth and feed efficiency of *Litopenaeus vannamei* in semi-circular aquaculture system

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**Abstract:** In this study, 4 treatments were randomly designed in triplicate tanks where shrimp was monocultured (without seaweed) as a control treatment with different seaweed density levels (2.5, 5 and 7.5 g/L) for 42 days. The results showed that the experimental group significantly reduced the concentrations of nitrate nitrogen, nitrite, ammonia nitrogen, phosphate and the quantity of *Vibrio* in the culture water. The experiment group significantly promoted the survival rate, absolute growth rate and feed efficiency of *Litopenaeus vannamei*, and the 7.5g/L seaweed experimental group was the best, reaching 93%, 271.33% and 0.99, respectively.

**Key words:** *Caulerpa lentillifera*, *Litopenaeus vannamei*, Water Quality, Growth, *Vibrio*

# 低氧和氨氮共胁迫对大口黑鲈葡萄糖代谢、氧化应激、炎症和细胞凋亡的生物学影响

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四川农业大学

**摘要：**为评估低氧和氨对大口黑鲈氧化应激和葡萄糖代谢的影响。本实验分为四组：对照、低氧、氨和低氧+氨。结果表明，低氧和氨暴露均诱导氧化应激（SOD 和 CAT 活性增加，MDA 积累）和无氧酵解（血葡萄糖、肝糖原减少，LD 积累和 LDH 活性增加）；上调抗氧化基因（SOD、CAT 和 GPx）、凋亡基因（caspase 3、8 和 9），炎症基因（IL-1 $\beta$ 和 IL-8）；诱导 GLUT1、LDH 和 MCT4 的表达增加。

**关键词：**大口黑鲈、低氧、氨、葡萄糖代谢、氧化应激、炎症、凋亡

## Combined exposure to hypoxia and ammonia aggravated biological effects on glucose metabolism, oxidative stress, inflammation and apoptosis in largemouth bass (*Micropterus salmoides*)

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**Abstract：** Hypoxia and ammonia are unavoidable environmental factors in aquaculture, and have been shown cause various adverse effects in fish. In the present study, a two-factor crossover experiment was carried out to evaluate the combined effect of hypoxia and ammonia on oxidative stress and glucose metabolism endpoints in largemouth bass. The fish were divided into four experimental groups: hypoxia and ammonia group, hypoxia group, ammonia group, and control group. The results showed that hypoxia and ammonia exposures both induced antioxidant response and oxidative stress (superoxide dismutase [SOD] and catalase [CAT] activities increased first then decreased, and malondialdehyde accumulated) and anaerobic glycolysis (increase of blood glucose, decrease of liver glycogen, accumulation of lactate, and increased lactate dehydrogenase activity). In addition, hypoxia and ammonia upregulated antioxidant enzyme genes (Cu/ZnSOD, CAT, and GPx), apoptosis genes (caspase 3, 8, 9), as well as inflammatory genes (interleukin [IL]-1 $\beta$  and IL-8) and downregulated an anti-inflammatory gene (IL-10), suggesting that apoptosis and inflammation may be related to oxidative stress. The increased expression of GLUT1, LDH, and MCT4 were induced by hypoxia and ammonia, suggesting that anaerobic glycolysis was increased. Furthermore, fish suffering from hypoxia or ammonia exposure showed some changes in gill tissues histology, and the most severe lesions of gill tissues appeared in simultaneous exposure.

**Key words：** Largemouth bass, Hypoxia, Ammonia, Glucose metabolism, Oxidative stress, Inflammation, Apoptosis

# 环氧丙烷对仿刺参抗氧化酶和免疫酶活性的影响

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**摘要:** 将经暂养的体质量 ( $5.23\pm 0.96$ ) g 的仿刺参 (*Apostichopus japonicus*) 置于 10 L 玻璃缸中, 水中环氧丙烷质量浓度为 100.00、200.00、300.00、400.00、500.00 mg/L 或 600.00 mg/L (用母液调配), 每个梯度设 3 个平行, 每个缸中 20 头幼参, 统计 24、48、72、96 h 幼参死亡率, 同时测定体腔液中超氧化物歧化酶 (SOD)、过氧化氢酶 (CAT)

**关键词:** 环氧丙烷; 仿刺参; 超氧化物歧化酶; 过氧化氢酶; 酸性磷酸酶; 碱性磷酸酶

## Effects of Propylene Epoxide on Activities of Antioxidant and Immune Related Enzymes in Sea Cucumber *Apostichopus japonicus*

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**Abstract:** 将经暂养的体质量 ( $5.23\pm 0.96$ ) g 的仿刺参 (*Apostichopus japonicus*) 置于 10 L 玻璃缸中, 水中环氧丙烷质量浓度为 100.00、200.00、300.00、400.00、500.00 mg/L 或 600.00 mg/L (用母液调配), 每个梯度设 3 个平行, 每个缸中 20 头幼参, 统计 24、48、72、96 h 幼参死亡率, 同时测定体腔液中超氧化物歧化酶 (SOD)、过氧化氢酶 (CAT)、酸性磷酸酶 (ACP) 和碱性磷酸酶 (ALP) 的活性。试验结果表明, 高质量浓度组仿刺参体腔液中抗氧化酶活性最先在 24 h 时、随后 ALP 活性在 48 h 时均显著受到诱导反应 ( $P<0.05$ ); 48 h 时各质量浓度组 CAT 活性最先极显著受到抑制 ( $P<0.01$ ), 其他 3 种酶活性在 72 h 时开始受到显著抑制, 72 h 时 CAT 活性恢复, 而高质量浓度组直到 96 h, 其他 3 种酶活性还受到显著抑制 ( $P<0.05$ )。CAT 活性受到污染物的影响最大, 但恢复也最快。除 ACP 外, 其他 3 种酶活性均表现短期毒物兴奋效应, 受到显著诱导 ( $P<0.05$ ), 长时间后活性均受到显著抑制 ( $P<0.05$ )。在环氧丙烷胁迫下仿刺参体腔液中的抗氧化酶活性受到影响时间比免疫酶短, 程度比免疫酶大。随着环氧丙烷质量浓度的增加和作用时间的延长, 不同程度的影响仿刺参体腔液中 4 种酶的活性。环氧丙烷使仿刺参致毒的机制可能是: 产生自由基的氧化胁迫, 影响消化、吸收和代谢。本研究结果可为研究环氧丙烷对海洋生物的毒理提供参考。

**Key words:** propylene epoxide; *Apostichopus japonicus*; superoxide dismutase (SOD); catalase (CAT); acid phosphatase (ACP); alkaline phosphatase (ALP)



# 小球藻在海水养殖尾水中的生长状况 及水质净化作用

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**摘要:** 为探索解决循环水养殖中氮磷较高问题, 调配两种盐度尾水。以空白作对照, 添加三种密度的小球藻, 研究其对尾水中氮磷去除情况。结果显示不同密度藻能充分利用尾水中营养盐; 不同盐度条件下, 各藻密度组对 NO<sub>3</sub>-去除效果显著; PO<sub>4</sub>-去除率与藻数目显著正相关 ( $P<0.05$ ), 实验组 TN 去除率显著高于空白组 ( $P<0.05$ ), 高密度组 TP 去除率显著高于其他组 ( $P<0.05$ ); 可将高密度组作为养殖尾水处理的适宜密度。

**关键词:** 小球藻; 海水养殖尾水; 盐度; 营养盐

## Growth status and purification effect of *Chlorella salina* in mariculture wastewater

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**Abstract:** In order to solve the problem of high nitrogen and phosphorus in recirculating aquaculture, two kinds of salinity wastewater were prepared. The nitrogen and phosphorus removal of *Chlorella salina* in wastewater was studied by adding *Chlorella salina* with three densities. The results showed that algae of different densities could make full use of nutrients in wastewater. Under different salinity conditions, the NO<sub>3</sub>- removal effect of algae density groups was significant. PO<sub>4</sub>- removal rate was significantly positively correlated with the number of algae ( $P<0.05$ ), TN removal rate of experimental group was significantly higher than that of blank group ( $P<0.05$ ), TP removal rate of high density group was significantly higher than that of other groups ( $P<0.05$ ). The high density group can be used as the suitable density for aquaculture wastewater treatment.

**Key words:** *Chlorella salina*, Mariculture wastewater, salinity, nutrients

# 草鱼-鳙-鲫零换水养殖池塘生源要素归趋特征研究

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**摘要:** 为研究零换水池塘营养盐状况, 阐明零换水机制, 以零换水池塘为实验组, 以常规池塘为对照组, 开展了为期2年的池塘生源要素收支研究。结果表明: 两组池塘生源要素的主要来源均为饲料投入, 主要输出途径均为底泥积累; 零换水池塘的生源要素积累率显著低于常规池塘 ( $P<0.05$ ), 养殖鱼类的生源要素利用率显著高于常规池塘 ( $P<0.05$ )。零换水模式能降低营养盐积累, 有效提高物质利用率, 是一种绿色高效养殖模式。

**关键词:** 草鱼; 鳙; 鲫; 零换水; 生源要素归趋

## Study on organic carbon, nitrogen and phosphorus budgets of zero-water exchange ponds of grass carp, bighead carp and crucian carp

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**Abstract:** In order to study nutrient status of zero-water exchange pond and clarify the mechanism of zero-exchange, nutrient budget of zero-water exchange pond and common pond were studied. The results showed that feed was the main input of nutrient input in the both two groups, and sediment accumulation was the main output. The nutrient accumulation of zero-water exchange pond was significantly lower than that of common pond ( $P<0.05$ ). The carbon, nitrogen and phosphorus utilization rates of zero-water exchange ponds were significantly higher than those of normal ponds ( $P<0.05$ ), which were increased by 29.49%, 21.72% and 20.65%, respectively. These results showed that the zero-water exchange mode can reduce nutrient accumulation and improve the material utilization rate effectively, which was a green and efficient aquaculture mode. Considering the nutrient emission of aquaculture in China, the zero-water exchange mode has good promotion value.

**Key words:** Ctenopharyngodon idella; Aristichthys nobilis; Carassius auratus; zero-water exchange; nutrient budget

# 欧洲鲈鱼（*Dicentrarchus labrax*）肠道微生物群和代谢对温度胁迫的响应机制

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**摘要：**在动物中，肠道微生物群对生长至关重要，这些微生物群落组成的变化可能影响生长和对环境的适应性。温度是影响动物健康生长的另一个重要因素。目前，欧洲鲈鱼幼鱼及其共生菌群对环境温度变化的适应机制尚不清楚。因此，我们评估了温度对欧洲鲈鱼幼鱼肠道菌群和代谢的影响。采用 16S rRNA 基因扩增测序和基于非靶向液相色谱串联质谱(LC-MS/MS)的代谢组学方法，研究了 10°C(T1)、15°C(T2)和 20°C(T3)。

**关键词：**欧洲鲈鱼，温度，肠道菌群，代谢

## Response mechanism of gut microbiome and metabolism of European seabass (*Dicentrarchus labrax*) to temperature stress

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**Abstract:** In animals, the gut microbiome is vital to growth, and changes in the composition of these microbial communities may affect growth and adaptability to the environment. Temperature is another important factor that influences the healthy growth of animals. To date, the mechanism by which juvenile European seabass (*Dicentrarchus labrax*) and their symbiotic flora adapt to changes in environmental temperature is not well understood. Therefore, we evaluated the effect of temperature on the gut microbiota and metabolism of European seabass juveniles. We used 16S rRNA gene amplicon sequencing and non-targeted liquid chromatography with tandem mass spectrometry (LC-MS/MS)-based metabolomics to study the gut microbes of European seabass after 60 days of rearing of water temperature at 10°C (T1), 15°C (T2) and 20°C (T3). At the phylum level, the abundance of the gut microbiota did not differ significantly among the three groups after 60 days of cultivation. At the genus level, however, the abundance of *Faecalibacterium*, *Filifactor*, *Butyricoccus*, and *Erysipelotrichaceae* UCG-006 in the intestines differed significantly among the temperature groups. Compared with T2, the relative abundance of *Filifactor* in T1 was significantly increased, while *Faecalibacterium* was significantly decreased, while the relative abundance of *Butyricoccus* and *Erysipelotrichaceae* UCG-006 in T3 was significantly increased. The LC-MS/MS analysis revealed 107 metabolites in the 10°C group and 68 metabolites in t

**Key words::** European seabass, temperature, gut microbiota, metabolism

# 上海崇明地区养殖环境微生物群落结构及水质评价

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**摘要:** 本实验采用 Illumina Miseq 高通量测序方法,基于 16S rRNA 基因的测序结果,对上海崇明岛主要水产养殖对象(中华绒螯蟹和四大家鱼)的肠道及其养殖水体、底泥和其水源环境中的微生物群落进行分析和比较,结果显示崇明岛水产养殖环境优势菌群结构与其水源环境差异较少。养殖水体各水质指标均未超标(参照《淡水池塘养殖水排放要求》(SC/T 9101—2007)淡水养殖废水排放标准值二级标准)。

**关键词:** 养殖环境; 水源环境; 水体; 底泥; 肠道; 优势菌群; 高通量测序

## Microbial community structure and water quality evaluation of pond culture environment in Chongming Island

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**Abstract:** In this experiment, the Illumina Miseq high-throughput sequencing method was used. Based on the sequencing results of the 16S rRNA gene, the intestines of the main aquaculture objects (*Eriocheir sinensis* and the four major domestic fishes) of Shanghai Chongming Island and their cultured water bodies, sediments and their water sources were analyzed. The analysis and comparison of the microbial community in the environment showed that the structure of the dominant bacterial community in the aquaculture environment of Chongming Island is less different from its water source environment. The various water quality indicators of the aquaculture water body have not exceeded the standard (refer to the "Freshwater Pond Aquaculture Water Discharge Requirements" (SC/T 9101-2007) Freshwater aquaculture wastewater discharge standard value secondary standard).

**Key words:** Culture environment; Water source environment; Water body; Sediment; intestine; Dominant flora; High-throughput sequencing

# 双碳背景下的渔光藻一体新模式

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**摘要：**中国要实现 3060“双碳”目标，不仅需要减少碳排放，还要求对人为活动排放的 CO<sub>2</sub> 通过碳捕集等固碳技术来提高吸收利用。在减少碳排放方面，通威股份有限公司致力于主推“渔光一体”。在提高碳利用方面，赐百年公司一直致力于微藻的科研、生产和销售，生产微藻 1 吨可固定二氧化碳 1.8 吨。通威-赐百年光合自养微藻项目组，将生产饲料级螺旋藻作为未来 3-5 年的阶段目标，将“渔光藻一体化”新模式作为实现路径。

**关键词：**双碳目标；渔光藻一体；新模式

## A new integrated model of fishing, light and algae under the background of double carbon

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**Abstract:** In order to achieve the 3060 "double carbon" goal, China not only needs to reduce carbon emissions, but also requires to improve the absorption and utilization of CO<sub>2</sub> emitted by human activities through carbon sequestration technologies such as carbon capture. In terms of reducing carbon emissions, Tongwei Co., Ltd. is committed to promoting the "integration of fishing and light". In terms of improving carbon utilization, CBN Co., Ltd. has been committed to the scientific research, production and sales of microalgae, producing 1 ton of microalgae and fixing 1.8 tons of carbon dioxide. TW-CBN photosynthetic autotrophic microalgae project team takes the production of feed grade Spirulina as the stage goal in the next 3-5 years, and takes the new model of "integration of fishing, light and algae" as the realization path.

**Key words::** Double carbon target; Integration of fishing, light and algae; New mode

# 斑点叉尾鮰网箱-池塘养殖 系统微生物群落变化

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**摘要:** 通过高通量测序研究了斑点叉尾鮰网箱-池塘养殖系统中微生物群落的变化。结果显示, 网箱和池塘组优势菌门相似, 分别为放线菌门、蓝藻门、变形菌门和拟杆菌门, 但两者之间存在显著差异( $P < 0.05$ )。时间和位置的变化与细菌群落的变化显著相关。综合分析表明, 网箱-池塘养殖系统中细菌群落组成的形成更多是由时间变化而非位点变化决定的。RDA 分析进一步表明水温、总溶解固体和 Secchi 深度对细菌群落的影响最大。

**关键词:** 斑点叉尾鮰, 网箱-池塘养殖系统, 微生物群落, 季节性变化

## Dynamics of the bacterial community in channel catfish cage– pond integration system

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**Abstract:** The changes in the bacterial community composition in a channel catfish nursery pond with a cage–pond integration system were investigated by sequencing of the 16S rRNA gene through Illumina MiSeq sequencing platforms. A total of 1 362 877 sequences and 1440 operational taxonomic units were obtained. Further analysis showed that the dominant phyla in the cage and pond groups were similar, including Actinobacteria, Cyanobacteria, Proteobacteria, and Bacteroidetes, although a significant difference was detected between them by ANOSIM ( $P < 0.05$ ). Temporal changes and site variation were significantly related to the variation of the bacterial community. A comprehensive analysis of the diversity and evenness of the bacterial 16S rRNA gene, redundancy analysis (RDA), and partial Mantel test showed that the bacterial community composition in a cage–pond integration system was shaped more by temporal variation than by site variation. RDA also indicated that water temperature, total dissolved solids, and Secchi depth had the largest impact on bacterial populations.

**Key words:** Channel catfish, Cage–pond integration system, bacterial community, Seasonal variation

# 普通小球藻对 $\text{NH}_4^+ - \text{N}$ 、 $\text{NO}_2^- - \text{N}$ 去除效果及 $\text{NO}_2^- - \text{N}$ 消失途径的初步研究

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**摘要:** 在水产养殖中, 氨氮 ( $\text{NH}_4^+ - \text{N}$ ) 和亚硝酸盐氮 ( $\text{NO}_2^- - \text{N}$ ) 是危害水产动物生长发育的关键因子。 $\text{NH}_4^+ - \text{N}$  和  $\text{NO}_2^- - \text{N}$  的调控决定着养殖的成败, 但目前生产中大多使用化学手段进行调控, 缺乏更为安全高效的生物调控手段。为此, 本研究以普通小球藻为研究对象, 首先筛选确定了小球藻去除水体中  $\text{NH}_4^+ - \text{N}$  和  $\text{NO}_2^- - \text{N}$  的适宜条件, 其次分析了小球藻作用下水体中  $\text{NH}_4^+ - \text{N}$  和  $\text{NO}_2^- - \text{N}$  的变化规律。

**关键词:** 普通小球藻; 氨氮; 亚硝酸盐氮; 消失途径; 亚硝酸盐还原酶

## A preliminary study on the removal effect of $\text{NH}_4^+ - \text{N}$ and $\text{NO}_2^- - \text{N}$ by *Chlorella vulgaris* and the disappearance pathway of $\text{NO}_2^- - \text{N}$

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**Abstract:** In aquaculture, ammonia nitrogen ( $\text{NH}_4^+ - \text{N}$ ) and nitrite nitrogen ( $\text{NO}_2^- - \text{N}$ ) are the key factors that harm the growth and development of aquatic animals. The regulation of  $\text{NH}_4^+ - \text{N}$  and  $\text{NO}_2^- - \text{N}$  determines the success or failure of aquaculture; to control them, however, chemical regulations are still mostly used in production, yet there is a lack of more safe and efficient biological regulation means. Therefore, in the present study, *Chlorella vulgaris* was taken as the research object. We firstly screened the suitable conditions for *C. vulgaris* to remove  $\text{NH}_4^+ - \text{N}$  and  $\text{NO}_2^- - \text{N}$  in water. Then we analyzed the change rules of ammonia nitrogen and nitrite nitrogen in water under the treatment of *C. vulgaris*. Finally, we explored the removal pathway of  $\text{NO}_2^- - \text{N}$  by *C. vulgaris*. In the first stage, *C. vulgaris* were inoculated into feed wastewater containing  $\text{NH}_4^+ - \text{N}$  and  $\text{NO}_2^- - \text{N}$ , different light intensity and density of *C. vulgaris* were set to explore the removal effect of *C. vulgaris* on  $\text{NH}_4^+ - \text{N}$  and  $\text{NO}_2^- - \text{N}$  under different conditions. In the second stage, sodium nitrite was used to configure  $\text{NO}_2^- - \text{N}$  solutions with different concentrations, and continuous aeration was used to explore the removal effect of  $\text{NO}_2^- - \text{N}$  by aeration. In the third stage, *C. vulgaris* inoculated in high-temperature sterilized feed wastewater, and the contents of  $\text{NH}_4^+ - \text{N}$ ,  $\text{NO}_2^- - \text{N}$ , nitrate nitrogen ( $\text{NO}_3^- - \text{N}$ ) and dissolved oxygen in water at different times were measured, to explore the removal effect of oxygen produced by

**Key words:** *Chlorella vulgaris*; ammonia nitrogen; nitrite nitrogen; disappear pathway; nitrite reductase

# 我国深远海大型围栏养殖发展现状与展望

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**摘要:** 深远海大型围栏养殖是我国海水养殖业结构调整和产业升级中新兴的养殖模式之一, 具有养殖面积大、鱼类活动空间大、养殖环境更近自然和养殖鱼类品质明显提升等特点。本文在介绍围网养殖发展概况、深远海养殖内涵的基础上, 重点概述我国深远海大型围栏养殖发展现状及其研究进展, 并对今后的发展方向加以展望, 为我国深远海大型围栏智能化生态养殖模式的构建提供参考。

**关键词:** 深远海养殖; 围栏养殖; 发展现状; 展望

## Development status and prospect of deep-sea large-scale fence culture in China

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**Abstract :** The deep-sea large-scale fence culture is suitable for the China's sea area which is characterized by a gentle continental shelf, and also for breeding China's various unique economic fish. It is one of the emerging aquaculture models in the structural adjustment and industrial upgrading of mariculture in China. It has the characteristics of large breeding area and activity space, closer to nature and ecology, and has broad application prospect. On the basis of introducing the development of seine culture and the connotation of deep-sea aquaculture, this paper mainly summarizes the development status and research progress of deep-sea aquaculture in China from the aspects of site selection, construction, supporting equipment research, breeding and management. Moreover, we put forward corresponding countermeasures and suggestions for the problems existing in the development of large pen breeding in the deep-sea large-scale fence culture. This article may provide a reference for the construction of intelligent ecological breeding mode of deep-sea large-scale fence culture in China.

**Key words::** Deep-sea mariculture; Fence culture; Development situation; Prospect



# 池塘吊水暂养对大口黑鲈鱼肉品质的影响

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**摘要:** 在种植苦草的清水池塘中设置 3 个平行网箱 (1\*1\*1m/40 尾/箱), 研究吊水暂养对土塘养殖的商品规格大口黑鲈 (540±30g) 品质的影响。结果显示: 肌肉硬度、脂肪酸、氨基酸含量显著提升, 脂肪酸种类增加 3 种使总脂肪酸达到 23 种; 风味氨基酸滋味活性值显著增加, 土腥味物质 2-MIB 和 GSM 含量由开始的 0.56ug/kg 和 0.54ug/kg 均降到 0.37ug/kg (第 10d)。

**关键词:** 大口黑鲈;清水池塘;暂养;改善品质

## Effects of hanging pond temporary culture on meat quality of *Micropterus salmoides*

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**Abstract:** Set up 3 parallel cages (1\*1\*1m, density of 40 fish/crate) in the clear water pond where bitter grass is planted, and study the quality of the commercial size largemouth bass (540±30g) cultivated in earthen ponds by hanging water temporary culture Impact. The results showed that the muscle hardness, fatty acid, and amino acid content of largemouth bass were significantly improved, and the number of unsaturated fatty acids increased by 3, so that the total fatty acid reached 23; Fish flavor amino acid taste activity value (TAV) significantly increased, including glutamic acid with umami taste TAV>1 (4d); and histidine with bitter taste TAV<1 (10d); The content of off-flavour compounds 2-MIB and GSM are reduced from the initial 0.56 ug/kg and 0.54 ug/kg to 0.37ug/kg (10d) .The results showed that the suspension culture significantly improved the meat quality of largemouth bass. Considering the suspension time, it is better to take 10 days.

**Key words:** : Keywords: *Micropterus salmoides*, Clear Water Pond, Temporary Raising, Quality Improvement

# 日粮中添加 EM 菌对吉富罗非鱼幼鱼生长、免疫和食欲调节的影响

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**摘要：**目前，EM 菌在水处理和农业利用方面得到了广泛的应用。本实验探究了饲料中添加 EM 菌对吉富罗非幼鱼生长、免疫和食欲调节的作用。三种不同 EM 菌拌料浓度的饲料(0 g/kg; 30g/kg; 60 克/kg) 喂养罗非鱼 90 d。结果表明，低浓度和高浓度均能促进鱼体生长；但大部分血清指标表明罗非鱼的免疫力没有明显提高；饲料中添加 EM 菌促进了肝胰腺中 npy、agrp、cck、Ghrelin 基因的表达。

**关键词：**EM 菌；生长；免疫；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:** Nowadays, effective microorganisms (EM) is wildly 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 (0 g/kg; 30 g/kg; 60 g/ 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 (npy) and agouti-related protein (agrp) in brain or cholecystokinin (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

# 养水机对刺参（*Apostichopus japonicus*）池塘理化参数和细菌丰度的影响

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**摘要:** 养水机是一套能打破温、盐跃层的新型水质改良设备,具有改善春、夏、秋季刺参养殖池塘水质和显著降低水中弧菌的良好效果,以及显著降低全年沉积物 TOM 的能力,在刺参养殖场具有较好的应用前景。

**关键词:** 水质调控; 养水机; TAN; NO<sub>2</sub><sup>-</sup>-N; 异养菌; 弧菌; 刺参

## Effects of Jet Water Mixer on physicochemical parameters and number of bacteria in the *Apostichopus japonicus* pond

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**Abstract:** Jet Water Mixer (JWM) is a set of new water quality improvement equipment. To evaluate the effects of JWM on the pond water quality improvement, we monitored eight physicochemical parameters, including temperature, salinity, pH, dissolved oxygen (DO), total ammonia nitrogen (TAN), nitrous nitrogen (NO<sub>2</sub><sup>-</sup>-N), phosphate (PO<sub>4</sub><sup>3+</sup>-P), contents of sediment organic matter (TOM), and abundance of living heterotrophic bacteria, a culturable vibrio in the ponds of Dalian Zhuanghe Sea Cucumber Farm. The results show that compared with the control group, the contents of TAN were the lowest from March to November and so were NO<sub>2</sub><sup>-</sup>-N except for June in the water, the PO<sub>4</sub><sup>3+</sup>-P content was the highest from March to August in the water and the TOM content was the lowest in the sediment in each month ( $P<0.05$ ) in JWM pond. At thermocline and halocline stage, JWM increased the DO content significantly. JWM promoted the growth of living heterotrophic bacteria and restrained the growth of Vibrio as long as 8–9 months. It is concluded that JWM can improve water quality and reduce abundance of Vibrio in the water in spring, summer and autumn significantly, and reduce TOM content in the sediment throughout the year, so it has a good application prospect in the cultivation of sea cucumbers.

**Key words:** Jet Water Mixer (JWM); Total ammonia nitrogen; NO<sub>2</sub><sup>-</sup>-N; Heterotrophic bacteria; Vibrio; Water purification; *Apostichopus japonicus* culture

# 盐度对夜光藻生长及抗氧化酶能力的影响

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**摘要:** 盐度是影响海洋藻类生长的重要因素。本研究以常见赤潮生物夜光藻 (*Noctiluca scintillans*) 为研究对象, 设置盐度梯度为 18、22、26、30、34、38、42, 测定夜光藻的生长、细胞大小、SOD、CAT 活性和 GSH 含量。结果显示, 盐度对夜光藻生长影响显著 ( $P < 0.05$ ), 当盐度 26 时, 细胞密度最高为  $3.3 \times 10^4$  个/L; 当盐度 42 时, 细胞密度最高仅有  $2.67 \times 10^3$  个/L。盐度对夜光藻细胞大小影响显著 ( $P < 0.05$ ), 当盐度 18~22 时, 夜光藻细胞直径变大, 最大为  $(914.97 \pm 25.97)$   $\mu\text{m}$ , 当盐度 38~42 时, 细胞直径变小, 最小为  $(350.94 \pm 4.66)$   $\mu\text{m}$ ; 盐度对夜光藻 SOD、CAT 活性和 GSH 含量有显著影响 ( $P < 0.05$ ), 低盐度 18 和高盐度 42 时, 夜光藻细胞内的 SOD、CAT 活性显著升高, 均高于其他盐度组。此外, 高盐度 42 时, GSH 含量显著升高 ( $P < 0.05$ ), 低盐度 18 时, GSH 含量低于其他盐度组。

**关键词:** 盐度; 夜光藻; 生长; 抗氧化酶

**Abstract :** Salinity is an important factor affecting the growth of marine algae. In this study, the common red tide organism *Noctiluca scintillans* was used as the research object, and the salinity gradient was set to 18,22,26,30,34,38 and 42. The growth, cell size, SOD, CAT activity and GSH content of *Noctiluca scintillans* were determined. The results showed that salinity had a significant effect on the growth of *Noctiluca scintillans* ( $P < 0.05$ ). When the salinity was 26, the cell density was the highest ( $3.3 \times 10^4$  cells / L). When the salinity was 42, the highest cell density was only  $2.67 \times 10^3$  cells / L. Salinity had a significant effect on the cell size of *Noctiluca scintillans* ( $P < 0.05$ ). When the salinity was 18-22, the cell diameter of *Noctiluca scintillans* increased, and the maximum was  $(914.97 \pm 25.97)$   $\mu\text{m}$ . When the salinity was 38-42, the cell diameter decreased, and the minimum was  $(350.94 \pm 4.66)$   $\mu\text{m}$ . Salinity had a significant effect on SOD, CAT activity and GSH content of *Noctiluca scintillans* ( $P < 0.05$ ). At low salinity 18 and high salinity 42, the activities of SOD and CAT in *Noctiluca scintillans* cells increased significantly, which were higher than other salinity groups. In addition, the content of GSH increased significantly at high salinity 42 ( $P < 0.05$ ), and the content of GSH was lower than that of other salinity groups at low salinity 18.

**Keywords :** salinity ; *Noctiluca scintillans* ; growth ; antioxidant enzymes

## 二、水产生物技术与遗传育种

# 母源 *gys1* 缺失对斑马鱼早期胚胎发育的影响

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**摘要：**糖原由葡萄糖结合而成，被作为能量代谢葡萄糖单位的储存库，而糖原合酶是糖原合成的限速酶。前期我们通过 CRISP/Cas9 技术构建了斑马鱼 *gys1*<sup>-/-</sup> 突变体鱼系，该突变体 F2 生长发育正常，而 F3 早期胚胎发育迟缓，48hpf 时基本死亡，但造成这一表型的原因尚不明确。斑马鱼早期胚胎发育完全依赖母源卵黄提供的营养物质，因此我们猜测 *gys1* 缺失导致母源卵黄糖原贮存减少，致使子代早期胚胎无法获得足够的营养物质而发育受阻。为了验证这一猜测，我们首先对 F2 突变体和野生型成年斑马鱼进行血糖测定，发现突变体血糖显著降低。对野生型和突变体 F2 成鱼肌肉和卵巢组织以及 F3 24hpf 胚胎中的葡萄糖代谢相关基因进行定量分析，结果显示突变体葡萄糖代谢异常。我们进一步对 F3 突变体胚胎进行糖原染色显示，突变体胚胎糖原贮存量明显减少。本研究结果表明 *gys1* 是母源卵黄糖原合成的关键基因，母源卵黄糖原对鱼类胚胎发育具有重要作用。

**关键词：***gys1*；糖原合成；胚胎体外发育；葡萄糖转运蛋白基因

## *gys1* regulates glycogen synthesis to sustain the offspring embryonic development in zebrafish

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**Abstract:** Glycogen synthase (GS) is the rate-limiting enzyme in the process of glycogen synthesis. Muscle glycogen synthase gene (*gys1*) is widely expressed in muscle, heart, brain, gonad and other tissues. Loss or overexpression of *gys1* in humans or mammals leads to neurodegenerative diseases, glycogen storage disease and other related diseases. In the previous study, we generated a *gys1* zebrafish mutant line by CRISP/Cas9 editing system. The F2 mutants showed no obvious morphological changes, were with normal development and growth, while F3 mutants delayed their embryonic development, 95% of mutants died at 48hpf. However, the reason of high mortality rate of F3 mutants is not well defined. Here we hypothesized that the defects were due to the decline of glycogen storage in the yolk, which was maternally obtained, and consequently caused the embryos not being able to obtain sufficient nutrients to maintain the embryonic development. Thus, we firstly confirmed that the blood glucose levels were significantly reduced in the F2 mutant compared to wild types. qPCR analysis showed that the expression levels of glucose transporter genes *slc2a2* and *slc2a8* were decreased in muscle of mutants, and *slc2a8* expression decreased in ovary of mutants, indicating the loss of *gys1* caused the defects of glycogen synthesis in F2 mutants. Further, we found that the glycogen of F3 mutants at 36hpf and 48hpf were significantly reduced compared to wild type siblings in the yolk by staining with PAS, indicating a declined of glycogen storage caused by the deficiency of *gys1*. qPCR analysis showed that the expression levels of genes including *g6pca.1*, *pck2*, *insb*, *gcga*, *slc2a1a*, *slc2a1b* and *slc2a2*, which involved into glucose metabolism, were increased in the F3 mutants at 24hpf. All these results demonstrated that *gys1* is a key gene for glycogen synthesis, and the maternal original glycogen has an essential role to maintain the embryonic development in zebrafish.

**Key words:** *gys1*; Glycogen synthesis; Embryo development

# 当鱼类生物学遇到新型单细胞组学技术

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**摘要：**单细胞测序技术是新兴的基因组学前沿技术，其被 *Science* 杂志选为 2018 年十大科学突破之首。近些年，单细胞测序技术也陆续应用于鱼类中以解析相关生物学难题。本次报告将主要围绕当前单细胞测序技术的重要进展，结合我们最近研发的 4 项高通量单细胞组学测序技术，讲述其在鱼类相关研究中的应用及前景。

**关键词：**单细胞测序技术，鱼类生物学

## When fish biology encounters new single cell sequencing technology

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**Abstract:** Single-cell sequencing technology is an emerging technique to study individuality of cells via using omics approaches, which was selected as “breakthrough of the year” by *Science Magazine* in 2018. Recently, single-cell sequencing technology has been applied to study how the individual fish cells change over the development stages and/or in disease conditions. Here, we will introduce the latest advances in single-cell sequencing technologies, especially the single-cell sequencing technologies we recently developed, and their applications in the basic and applied research areas of fish biology.

**Key words::** Single-cell sequencing technology, Fish biology

# 低氧胁迫对中华绒螯蟹幼蟹基因表达影响

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**摘要:** 溶解氧 (DO) 对大多数水生动物的生长和生存至关重要, 为明确低氧应激和复氧对中华绒螯蟹(*Eriocheir sinensis*)分子机制的影响。在本研究中, 通过分析缺氧信号因子, 评估中华绒螯蟹对急性缺氧应激的基本反应机制。首先, 对幼蟹进行了 0、3、6、12 和 24 小时的缺氧暴露 ( $1.0 \pm 0.2$  mg/L), 并对其进行了 1、3、6、12 和 24 小时的复氧 ( $7.0 \pm 0.2$  mg/L), 对肝胰腺、肌肉、和鳃进行了采样, 以检测基因表达。基因表达数据显示, 缺氧信号通路相关基因, 包括缺氧诱导因子-1 $\alpha/\beta$  (HIF1 $\alpha/\beta$ )、脯氨酰羟化酶、抑制缺氧诱导因子的因子和糖酵解相关因子 (HK 和 PK) 均上调, 显示 HIF 信号通路在缺氧条件下被激活。我们的研究为进一步阐明中华绒螯蟹幼蟹对急性低氧的防御和适应机制提供了参考, 并为中华绒螯蟹耐低氧性状的研究和种质优化提供理论依据。

**关键词:** 中华绒螯蟹; 低氧胁迫; HIF; 基因表达; 信号通路

## Effect of hypoxic stress on gene expression in juvenile *Eriocheir sinensis*

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**Abstract:** Dissolved oxygen (DO) is critical to the growth and survival of most aquatic animals, and to clarify the effects of hypoxic stress and reoxygenation on the molecular mechanisms of the Chinese mitten crab (*Eriocheir sinensis*). In this study, the basic response mechanisms of *Eriocheir sinensis* to acute hypoxic stress were assessed by analyzing hypoxic signaling factors. First, juvenile crabs were exposed to hypoxia ( $1.0 \pm 0.2$  mg/L) for 0, 3, 6, 12, and 24 h and reoxygenated ( $7.0 \pm 0.2$  mg/L) for 1, 3, 6, 12, and 24 h. Hepatopancreas, muscle, and gills were sampled for gene expression. Gene expression data showed that hypoxia signaling pathway-related genes, including hypoxia-inducible factor-1 $\alpha/\beta$  (HIF1 $\alpha/\beta$ ), prolyl hydroxylase, factors that inhibit hypoxia-inducible factors, and glycolysis-related factors (HK and PK) were upregulated, indicating that the HIF signaling pathway was activated under hypoxic conditions. Our study provides a reference to further elucidate the defense and adaptation mechanisms of *E. sinensis* larvae to acute hypoxia, and provides a theoretical basis for the study of hypoxia tolerance traits and germplasm optimization of *E. sinensis*.

**Key words:** *Eriocheir sinensis*; hypoxic stress; HIF; gene expression; signaling pathway



# 碱度胁迫下瓦氏雅罗鱼 AQP 基因家族的鉴定及其表达、进化分析

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**摘要:** 水通道蛋白 (aquaporin, AQP) 是小分子跨膜的特异性通道。本研究的目的是利用基因组、转录组分析来研究瓦氏雅罗鱼 AQP 基因对碱性胁迫的响应。我们在瓦氏雅罗鱼中鉴定了 20 个 AQP 基因, 并分为 4 类。在鳃和肾中, 大多数 AQP 基因在乌苏里江 (WSL) 瓦氏雅罗鱼中表达量高于达里湖 (DL) 瓦氏雅罗鱼, 并且 aqp3a-1, 3a-2, 7, 9a 在鳃中的表达高于肾和肝。在达里湖瓦氏雅罗鱼从碱水环境向淡水环境转移的过程中, aqp0a, 3a-1, 3a-2, 7, 8aa, 9a 在碱水中表达上调, 在淡水中表达下调。我们在 20 个 AQP 基因中鉴定了 1460 个 SNP 标记, CDS 区 Fst 值前 5% 的 SNP 位于 AQP3a 和 AQP11b。DL 和 WSL 瓦氏雅罗鱼 AQP3a-1 的三维结构没有显著差异, 但 DL 的瓶颈半径 (0.8Å) 大于 WSL (0.6Å)。这表明 AQP 基因参与了瓦氏雅罗鱼对碱性胁迫的反应, aqp3a-1 是关键基因。

**关键词:** AQP; 碱度; 胁迫; 表达量; SNP; 进化

## Genome-wide identification, phylogenetic analysis and expression pattern profiling of the AQP family genes in *Leuciscus waleckii*

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**Abstract:** Aquaporin (AQP) is a transmembrane-specific channel for small molecules that help in regulating homeostasis in fishes when adapts to changing environment, but its role in Amur ide challenge to alkaline stress yet reveal. Therefore, the purpose of this study was to investigate the response of AQP gene exposed to alkaline pH in Amur ide (*Leuciscus waleckii*) using genome-transcriptional assay. Based on the results, we had classified the AQPs of *L. waleckii* (LwAQPs) genome, and analyzed its transcriptional expression profile and genetic evolution under carbonate alkalinity stress. A total of 20 AQP genes had been identified in 4 categories in *L. waleckii*. The most AQP genes expression was found in the gill and kidney of *L. waleckii* from Wusuli River (WSL) than in Dali Lake (DL), whereas, the AQP3a-1, 3a-2, 7, 9a expression were found intensively higher in the gill than the kidneys and livers. The migration experiment of *L. waleckii* from DL alkaline water (carbonate alkalinity 50 mmol·L<sup>-1</sup>) to freshwater showed the expression of AQP0a, 3a-1, 3a-2, 7, 8aa, 9a were upregulated in alkaline water and downregulated in freshwater. We identified 1460 single

nucleotide polymorphism (SNP) markers in 20 AQP genes. The average value of  $F_{st}$  of SNP markers in CDS region was  $0.177 \pm 0.256$ , and the first 5% SNPs were identified at AQP3a and AQP11b. There is no significant difference in the three-dimensional structure of AQP3a-1 in DL and WSL *L. waleckii*, but the bottleneck radius of DL *L. waleckii* (0.8 Å) was bigger than that of WSL *L. waleckii* (0.6 Å). This indicated that AQP genes were involved in the response of *L. waleckii* to alkaline stress and AQP3a-1 was one of the key genes involved in regulating *L. waleckii* adaptation to alkaline environments.

**Key words:** AQP; alkalinity; stress; expression; SNP; evolution

# 罗氏沼虾 SPO11 基因克隆及其表达分析

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**摘要:** 为揭示 SPO11 基因在甲壳动物卵巢发育分子调控机制, 明确罗氏沼虾 (*Macrobrachium rosenbergii*) SPO11 基因 (MrSPO11) 的结构特征、组织分布及在不同发育时期卵巢中的表达规律, 利用 RACE 技术克隆 MsSPO11 基因的 cDNA 序列, 再用 ExPASy、SOPMA、Pfam 等软件进行生物信息学分析, 并通过实时荧光定量 PCR 检测 MsSPO11 基因在不同组织及不同发育时期卵巢中的表达情况。结果显示, MsSPO11 基因 cDNA 序列全长为 2298 bp, 其中, 5' 端非编码区 (5'-UTR) 为 457 bp, 3' 端非编码区 (3'-UTR) 为 701 bp, 开放阅读框 (ORF) 为 1140 bp, 共编码 379 个氨基酸残基。MsSPO11 蛋白分子式为 C1907H3043N523O552S9, 理论分子量为 42.42 kD, 属于稳定亲水性蛋白, 含有 Spo11 超级家族结构域。MsSPO11

**关键词:** 罗氏沼虾; SPO11 基因; 克隆; 表达分析

## Cloning and expression analysis of SPO11 gene in *Macrobrachium rosenbergii*

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**Abstract:** In order to reveal the molecular regulatory mechanism of SPO11 gene in crustacean ovarian development, and to clarify the structural characteristics, tissue distribution and expression pattern of the SPO11 gene (MrSPO11) in *Macrobrachium rosenbergii* ovary at different developmental stages, The cDNA sequence of MsSPO11 gene was cloned by RACE technology and analyzed by ExPASy, SOPMA, Pfam and other software. The expression of MsSPO11 gene in different tissues and different developmental stages of ovary was detected by real-time PCR. The results showed that the total length of MsSPO11 cDNA sequence was 2298 bp, including 457 bp of 5' -UTR, 701 bp of 3' -UTR and 1140 bp of open reading frame (ORF), encoding 379 amino acid residues. The molecular formula of MsSPO11 protein is C1907H3043N523O552S9, and the theoretical molecular weight is 42.42 kD. It is a stable hydrophilic protein and contains Spo11 super family domain. The amino acid sequence similarity between MsSPO11 and *Litopenaeus vannamei* was the highest (65.4%). Phylogenetic tree based on amino acid sequence similarity showed that MsSPO11 clustered with *Litopenaeus vannamei* and *Litopenaeus japonicus* SPO11. The expression of MsSPO11 gene was high in ovary, hepatopancreas, heart and gill, and a little in brain and muscle, but not in eye. MsSPO11 gene was expressed in four stages of ovarian development, and the relative expression level was the highest in stage I of ovarian development. The results indicated that MsSPO11 gene might be involved in ovarian development of *Macrobrachium rosenbergii*

**Key words:** *Macrobrachium rosenbergii*; SPO11 genes; Cloning; Expression analysis

# 大黄鱼多性状全基因组复合选择的研究与应用

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**摘要:** 大黄鱼是我国养殖量最大的海水鱼类, 其养殖产业的进一步发展和效益提升, 有赖于对其经济相关数量性状进行有效的遗传改良。全基因组选择是当前实现数量性状快速改良的最有效方法。近几年来, 我们针对大黄鱼肌肉 HUFA 含量、抗内脏白点病、对低鱼粉饲料适应性等性状, 分别建立基于少量主效位点计算基因组育种值的遗传选育技术, 经过反复应用验证, 证实效果良好。与此同时, 我们针对当前较严重影响养殖效果的生长、白鳃病/体表白点病/盾纤毛虫病抗性性状开展研究, 建立了包含万余个体表型与基因组序列信息的大黄鱼微单倍型数据库和基因组选择数据库, 以及基于低深度重测序的基因组选择技术, 其信息量大、选择更准确, 成本低于芯片。在此基础上, 建立了大黄鱼多性状复合基因组选育技术, 2022 年春季应用于大黄鱼育种实践。经过 7 个多月养殖比较, 选育组生长速度比对照组提高 10.7%~43.6%, 成活率为对照组 1.73~1.84 倍, 效果十分显著。

**关键词:** 大黄鱼; 多性状全基因组复合选择; 生长; 抗病; 成活率

## Study and application of genomic selection for multiple traits in large yellow croaker

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**Abstract:** Large yellow croaker is the largest amount mariculture fish in our country. The further development and improvement of its aquaculture industry depend on the effective genetic improvement of its economy related quantitative traits. Genome-wide selection is the most effective method to achieve rapid improvement of quantitative traits. In recent years, we have established the genetic selection technology based on the calculation of genomic estimated breeding value with a small number of major loci for the characteristics of muscle HUFA content, resistance to visceral white spot disease and adaptability to low fish meal diets of large yellow croaker. At the same time, we carried out research on the growth, white gill disease/*Cryptocaryon irritans*/*Paralembus digitiformis* resistance traits that seriously affect the culture effect. We established the microhaplotype database and genome selection database of large yellow croaker containing phenotypes and genome sequence information of more than 10,000 individuals, as well as the genome selection technology based on low depth resequencing, which has a large amount of information and more accurate selection. It costs less than chips. On this basis, the multi-trait complex genome breeding technology of large yellow croaker was established and applied to breeding practice in the spring of 2022. After more than 7 months of cultivation, the growth rate of the breeding group was increased by 10.7%~43.6% compared with the control group, and the survival rate was 1.73~1.84 times of the control group.

**Key words:** large yellow croaker; multi-trait genomic selection; grow; disease resistance; survival rate

# 鱼类 OXR1 基因的抗氧化作用及分子机制研究

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**摘要:** 氧化应激是鱼类对环境胁迫最常见的生理响应之一, 抗氧化基因 1 (OXR1) 在人类等哺乳动物中对神经细胞的抗氧化保护起到至关重要的作用, 但 OXR1 在鱼类中的功能仍然未知。本研究通过 CRISPR/Cas9 基因编辑技术建立斑马鱼 OXR1 基因敲除模型, 验证了 OXR1 的抗氧化作用, 初步揭示了 OXR1 在斑马鱼抗衰老和持续繁殖中扮演着重要角色。研究发现斑马鱼基因组中拥有一对 OXR1 基因, 发育早期为泛表达。在成鱼期两者均高表达于脑组织, 其次是眼和性腺组织。Oxr1a 和 oxr1b 敲除对斑马鱼衰老及持续繁殖的影响。研究提示, oxr1a 和 oxr1b 是斑马鱼抗氧化防御系统的重要成员。在氧化应激条件下, 两个基因均可通过正调控抗氧化酶相关基因的表达来参与对机体和细胞的抗氧化防御, 其介导的抗氧化作用在鱼类的抗衰老和持续繁殖中起到重要作用。

**关键词:** OXR1, 抗氧化, 衰老, 繁殖, 斑马鱼

## Antioxidation role of OXR1 Gene and Its Molecular Mechanism in Fish

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**Abstract:** The present study elucidated the temporal and spatial expression of zebrafish OXR1 genes (oxr1a and oxr1b) and their molecular response to oxidative stress. Antioxidant effects of oxr1a and oxr1b on zebrafish were studied based on CRISPR/Cas9 gene knockout model. Under oxidative stress conditions, both genes participate in antioxidant defense by regulating the expression of antioxidant enzyme-related genes. Their antioxidant effect plays an important role in the anti-aging and continuous reproduction of fish.

**Key words:** OXR1; Antioxidation; Aging; Reproduction; Zebrafish

# 比较蛋白质组学揭示了合浦珠母贝血清对大珠母贝异种移植的免疫反应

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**摘要：**珍珠贝套片移植后的早期免疫排斥反应是导致受体珍珠贝脱核和死亡的主要因素，特别是不同种间移植引起的免疫排斥反应更为严重。为了确定珍珠贝同种异体移植和异种异体移植后免疫应答的潜在机制，在同种异体移植和异种移植后的不同时间获得两组血清，并通过使用 iTRAQ 结合液相色谱 (LC) / 串联质谱 (MS) 分析来评估蛋白质组学反应。本研究共鉴定出 2127 个蛋白，其中 1148 个蛋白在数量上存在显著差异。在移植过程中，关键的蛋白质组、通路和结构域在响应不同移植而改变的蛋白质特征方面受到了不同的调控，包括信号转导机制、翻译-核糖体结构和生物发生、细胞骨架和翻译后修饰-蛋白质转换-伴随途径方面的主要变化。表明，上述对不同移植有反应的信号通路可能参与了牡蛎血清中不同移植诱导的免疫应答，并发挥重要作用。本研究结果为探索受体珍珠贝对移植套片特别是异种移植的免疫反应提供了独特的机会，并可能有助于开发珍珠养殖产业

**关键词：**珍珠贝、同种移植、异种移植、免疫排斥、比较蛋白质组学

## Comparative proteomics reveals the immune reaction of the pearl oyster *Pinctada fucata* serum to xenograft from *Pinctada maxima*

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**Abstract:** The early immune reaction after the transplantation of pearl oyster mantle piece is the main factor leading to the nucleus rejection and death of the recipient oyster, especially the immune rejection caused by transplantation between different species is more serious. To determine the mechanism underlying the immune response after transplantation of allograft (mantle grafts of *Pinctada fucata*) or xenograft (mantle grafts of *Pinctada maxima*) into a pearl oyster *Pinctada fucata*, two sets of serum were obtained at different times (6, 12, 24, 48, 96, 144 and 192 h) after allograft and xenograft transplantations and proteomic responses were evaluated by using isobaric tags for relative and absolute quantification labeling coupled with liquid chromatography (LC) / tandem mass spectrometric (MS) analysis. A total of 2127 proteins were identified in three repeated LC-MS/MS experiments with high confidence in peptide selection (FDR = 0.01). Among them, 1148 proteins were quantitatively significant different. GO, KEGG, Domain and COG analyses revealed that key groups of proteins, pathways and domains were differentially regulated during the transplantation in terms of characteristics of the proteins altered in response to different grafts, including major shifts in General function prediction only, Signal transduction mechanisms, Translation- ribosomal structure and biogenesis, Cytoskeleton and Posttranslational modification-protein turnover-chaperones pathways. It's worth noting that in KEGG enrichment analysis, ECM-receptor interaction (map04512), Focal adhesion (map04510) and PI3K-Akt signaling pathway (map04151) were the most enriched pathways for the upregulated proteins, and ribosome (map03010) was the most enriched pathways for the downregulated proteins by comparing Pm\_12h vs Pf\_12h. Interestingly, the situation was reversed in Pm\_144h vs Pf\_144h. These results indicated that the signaling pathways above, which were responsive to different grafts, may be involved in the immune response induced by different grafts in

oyster serum and play an important role. Finally, 36 proteins were selected for verification of differential expression using a parallel reaction monitoring strategy. The findings of this study provided a unique opportunity to explore the immune response of host oyster to grafted mantle pieces, particularly to xenografts, and may be helpful for creating xenograft transplantation technology for pearl culture industry.

**Key words:** The pearl oyster, Allograft transplantation, Xenograft transplantation, Immune rejection, Comparative proteomics

# 贝类三倍体育性的研究进展

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**摘要:** 由于三倍体不育, 进而可促进生长, 控制过量繁殖, 提高抗逆能力, 因此三倍体育种受到广泛重视。三倍体在高等生物中通常无法存活, 但在鱼类等低等动物中与二倍体差别不明显。通常情况下, 三倍体表现为不育, 或育性很差。但在贝类, 尤其在牡蛎中存在一定程度的育性。本文通过组织学、细胞学、转录组学和倍性等角度对国内外有关贝类三倍体育性的研究现状与成果进行综述, 并对贝类三倍体育性的分子机制研究提出展望。以期为进一步理解动物配子发生、生殖进化和多倍体育种技术的改进提供科学依据。

**关键词:** 贝类; 三倍体; 育性; 研究进展

## Research Progress on Fertility of Triploid Shellfish

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**Abstract:** Triploid breeding has received widespread attention because of the sterility of triploids, which in turn promotes growth, controls overpopulation, and improves resistance to adversity. Triploids usually do not survive in higher organisms, but do not differ significantly from diploids in lower animals such as fish. Triploids are typically found to be sterile or to have extremely low fertility. However, some degree of fertility exists in shellfish, especially in oysters. In this paper, we review the current status and achievements of domestic and international research on triploidy in shellfish from the perspectives of histology, cytology, transcriptomics and ploidy, and present an outlook on the study of molecular mechanisms of triploidy in shellfish. It is anticipated that it will offer a scientific foundation for further research into animal gametogenesis, reproductive evolution, and polyploid breeding methods.

**Key words:** shellfish ; triploid ; fertility ; research progress



# 花鲈(*Lateolabrax maculatus*)肌肉钠离子通道基因 cDNA 克隆及其生物信息学分析

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**摘要:** 为探究花鲈(*Lateolabrax maculatus*)是否存在抗 TTX 分子基础, 提取花鲈肌肉总 RNA 进行无参考基因转录组测序, 选择从 NCBI 中获得的斑马鱼、大黄鱼、金头鲷、黄鳍刺鲷、黄尾鲷、三刺鱼 6 种硬骨鱼类钠离子通道基因序列与转录组比对, 筛选出花鲈 SCN4 基因 cDNA 集合, 采用 SMART-RACE 技术克隆该基因的 cDNA 全长序列并测序。使用 CLUSTALW 进行编码蛋白序列比对。同源性和系统发育分析表明该序列为 SCN4AB, 并且与鳊鱼的 SCN4AB (XM044181956.1) 序列相似性为 92%。氨基酸序列比对结果可以看出, 花鲈的 SCN4AB 和斑马鱼以及多数无毒鱼类一致, 没有发现已知的强抗 TTX 位点。本研究成功克隆花鲈 SCN4AB 基因 cDNA 序列, 明确了 SCN4AB 的保守性及未发现已知的强抗 TTX 位点。是否存在隐秘的、还未检测的抗 TTX 位点则需要进一步实验。

**关键词:** 花鲈; 钠离子通道; 生物信息学; SMART-RACE

## Cloning and bioinformatics analysis of *Lateolabrax maculatus* muscle Voltage-gated sodium channel

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**Abstract:** To explore whether *Lateolabrax maculatus* exists anti-TTX molecular basis. Extract the *Lateolabrax maculatus* muscle total RNA, transcriptome sequencing without reference genome, then compare the transcriptome data with the sequences of six kinds teleost fish Voltage-gated sodium channel from NCBI, there are: *Danio rerio*, *Larimichthys crocea*, *Sparus aurata*, *Acanthopagrus latus*, *Seriola lalandi* and *Gasterosteus aculeatus*. SMART-RACE approach was used to obtain the full length cDNA of objective gene and sequencing. CLUSTALW was used for coding protein sequence alignment. Homology and phylogenetic analysis showed that the sequence was SCN4AB, and had a similarity with the SCN4AB sequence of *Siniperca chuatsi* (XM044181956.1). The results of amino acid sequence alignment showed that the SCN4AB of *Lateolabrax maculatus* was consistent with that of *Danio rerio* and most non-toxic fish, and no known significant anti-TTX sites were found. In this study, SCN4AB gene cDNA sequence of *Lateolabrax maculatus* was successfully cloned, SCN4AB conserved and no known significant anti-TTX site was found. Whether there are hidden, undetected anti-TTX sites needs further experiments.

**Key words:** *Lateolabrax maculatus*, Voltage-gated sodium channel, Bioinformatics, SMART-RACE

# 近缘新对虾 Cyclin G 基因的克隆及表达分析

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**摘要:** Cyclin G 作为细胞周期调控活动中的关键因子, 通过与相应的细胞周期蛋白依赖性激酶 (Cdks) 结合来调控细胞周期中的各个环节, 而近缘新对虾 (*Metapenaeus affinis*) 卵巢发育过程中存在旺盛细胞分裂活动的阶段, 关于其卵巢发育的分子机制研究依旧较少。本研究通过 SMART RACE 方法, 获得近缘新对虾 Cyclin G 基因 (MaCyclin G) 的 cDNA 序列全长。并通过实时荧光定量 PCR (real-time fluorescent quantitative PCR, qRT-PCR) 对其进行 MaCyclin G 的表达分析。MaCyclin G 基因全长 1285 bp, 开放阅读框长度为 1167 bp, 预测编码 388 个氨基酸, 分子量、等电点分别为 43.64kDa 和 8.58, 蛋白质序列包含一个周期蛋白盒结构域。同源性分析表明, MaCyclin G 蛋白序列与其他甲壳动物有着较高的同源性,

**关键词:** 近缘新对虾、Cyclin G、克隆、基因表达

## Cloning and Expression Analysis of Cyclin G Gene from *Metapenaeus affinis*

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**Abstract:** Cyclin G, as a key factor in cell cycle regulation, regulates various links in the cell cycle by combining with the corresponding cyclin dependent kinase (Cdks). There is a stage of vigorous cell division during the ovarian development of *Metapenaeus affinis*, but there is still little research on the molecular mechanism of its ovarian development. In this study, the full-length cDNA sequence of cyclin G gene in *M.affinis* (MaCyclin G) was obtained by SMART RACE method. The expression of MaCyclin G was analyzed by real-time fluorescent quantitative PCR (qRT-PCR). The total length of MaCyclin G gene was 1285 bp, the length of open reading frame was 1167 bp, encoding 388 amino acids, molecular weight and isoelectric point were 43.64kDa and 8.58, respectively. The protein sequence contains a cyclin box domain. The homology analysis showed that the MaCyclin G protein sequence had high homology with other crustaceans, and the highest homology with the *Fenneropenaeus chinensis* was 97.09%. The results of qRT-PCR analysis showed that the expression of MaCyclin G gene was the highest in muscle tissue, and the expression of MaCyclin G gene in ovaries was significantly higher than that in other ovarian development stages in the fifth stage, and the expression of MaCyclin G gene increased gradually with the development of larvae. This study provides important information for further research on gonad development regulation of *M.affinis* and other crustaceans.

**Key words:** *Metapenaeus affinis*, Cyclin G, Cloning; Gene expression

# 北部湾不同水层鱼类的黑色隐蔽伪装色

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**摘要:** 为了解南海不同水层鱼类黑色隐蔽伪装色的差异, 调查了 18 种近海鱼类的黑色隐蔽伪装色。中上层、中下层和底层鱼类黑色素细胞均背多腹少, 除大斑石鲈、翼红娘鱼和伏氏眶棘鲈外, 15 种北部湾鱼类背腹黑色素细胞数目差异显著; 中上层鱼类背腹部体色差异更明显。结果显示, 鱼类背腹部体色主要与黑色素细胞数目有关。对其背腹皮肤进行转录组测序, 分析背腹黑色素形成分布相关基因表达, 探究北部湾不同水层鱼类黑色隐蔽伪装色的形成通路

**关键词:** 隐蔽伪装色、近海中上层鱼类、近海中下层鱼类、近海底层鱼类、黑色素细胞

## Black countershading of fishes in different water layers of the Beibu Gulf

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**Abstract:** Countershading is characterized by dark dorsal body color and light abdominal body color, which is common in animals including fish. The formation of body color is mainly related to the difference in the distribution and number of pigment cells in the skin. To understand the differences of black countershading of fishes in different water layers of the South China Sea, we investigated the black countershading of four demersal fishes, six middle and lower fishes and eight bottom fishes in the South China Sea. Results: Melanocytes were more in the dorsal and less in the venter of the demersal fishes, the middle and lower fishes, and the bottom fishes. Except *Pomadasys maculatus*, *Lepidotrigla alata* and *Scolopsis vosmeri*. There were significant differences in the number of melanocytes in the dorsal and venter of the other 15 species. Compared with the middle and lower and bottom fishes, the difference of body color in the dorsal and venter of the demersal fishes was more obvious, and the number of melanocytes of the demersal fishes was more different. These results indicate that the dark color of the dorsal and venter of fish is mainly related to the number of melanocytes in the skin. Transcriptome sequencing was performed on the dorsal and venter skin to analyze the expression of genes related to the formation and distribution of dorsal and venter melanin, and to explore the formation pathway of black countershading in different water layers of fishes in the Beibu Gulf.

**Key words:** Countershading, The demersal fishes of the coastal waters, The middle and lower fishes of the coastal waters, The bottom fishes of the coastal waters, melanocytes

# 高温胁迫下黑龙江茴鱼幼鱼肝脏组织结构变化及转录组表达特征

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**摘要：**为探究急性高温胁迫下黑龙江茴鱼的响应机制，本研究在高温组（17°C）和对照组（11°C）下，分析随胁迫时间的延长黑龙江茴鱼肝脏组织结构变化及转录组表达特征。结果表明：17°C高温下，随胁迫时间的延长黑龙江茴鱼肝脏组织结构出现明显的病理损伤，于胁迫 12 h 后肝脏组织出现不同程度的核萎缩变形及空泡化现象，在胁迫 48 h 肝脏细胞损伤最为严重。转录组测序共获得 214.44 G 的有效数据，筛选到差异表达基因数（DEGs）共 9144 个，DEGs 数量随温度胁迫时间的延长呈先升高后下降的趋势。GO 功能注释显示，被注释的差异表达基因主要与代谢、催化和结合等功能有关；KEGG 富集分析表明，差异表达基因在糖酵解/糖异生、乙醛酸和二羧酸代谢、果糖和甘露糖代谢、内质网中的蛋白加工及核糖体等通路上显著富集。本试验结果为深入研究黑龙江茴鱼高温胁迫响应的分子调控机制提供基础数据。

**关键词：**黑龙江茴鱼; 高温胁迫; 肝脏; 转录组; 组织病理;

## Histological structure and transcriptome characteristics on the liver of juvenile *Thymallus arcticus grubei* under high temperature stress

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**Abstract:** In order to explore the response mechanism of *Thymallus arcticus grubei* under acute high temperature stress, this study analyzed the changes of liver tissue structure and transcriptome expression characteristics of *Thymallus arcticus grubei* with the extension of stress time under high temperature group (17 °C) and control group (11 °C). The results showed that under 17 °C high temperature, the liver tissue structure of *Thymallus arcticus grubei* showed obvious pathological damage with the extension of stress time. After 12 hours of stress, the liver tissue showed varying degrees of nuclear atrophy, deformation and vacuolization, and the liver cells were most severely damaged at 48 hours of stress. A total of 214.44G of valid data were obtained by transcriptome sequencing, and 9144 differentially expressed genes (DEGs) were screened. The number of DEGs increased first and then decreased with the extension of temperature stress time. GO function annotation showed that the annotated differentially expressed genes were mainly related to metabolism, catalysis and binding functions; KEGG enrichment analysis showed that differentially expressed genes were significantly enriched in glycolysis/gluconeogenesis, glyoxylate and dicarboxylic acid metabolism, fructose and mannose metabolism, protein processing in endoplasmic reticulum, ribosome and other pathways. The results of this experiment provide basic data for further studying the molecular regulation mechanism of the response of *Thymallus arcticus grubei* to high temperature stress.

**Key words:** : *Thymallus arcticus grubei*; High temperature stress; liver; Transcriptome; Histopathology

# 中间球海胆谷氨酸脱氢酶基因克隆及热应激对其表达影响的研究

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**摘要:** 为阐明海胆中 GDH 同源基因的序列特征及功能, 本研究中克隆并鉴定了中间球海胆 GDH (SiGDH) 的全长 cDNA 序列。结果显示, SiGDH 全长 2499 bp, 开放阅读框 (ORF) 为 1635 bp, 编码 544 个氨基酸。预测的 SiGDH 蛋白包含保守的 ELFV\_dehydrog\_N 和 ELFV\_dehydrog 结构域, 与紫球海胆 GDH 蛋白的同源性最高。通过检测 SiGDH 在中间球海胆不同组织中的相对表达量和总酶活力水平, 发现 SiGDH 在性腺中相对表达量和总酶活力水平最高。在慢性或急性热应激后, SiGDH 在中间球海胆性腺中的相对表达量和总酶活力水平均呈现不同程度的波动变化, 提示 SiGDH 可能在中间球海胆响应热应激中发挥一定的作用。本研究获得的结果有助于更好地了解和掌握不同物种中 GDH 同源基因的序列特征及其在棘皮动物响应热应激过程中的作用。

**关键词:** 谷氨酸脱氢酶; 中间球海胆; 热应激; 表达模式; 总酶活力

## Characterization of a Novel Glutamate Dehydrogenase Gene and its Response to Heat Stress in the Sea Urchin *Strongylocentrotus intermedius*

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**Abstract:** To elucidate the characteristics and functions of the GDH gene in the sea urchin, we cloned and characterized the full-length cDNA of a novel GDH homolog from *Strongylocentrotus intermedius*, herein designated SiGDH. The results showed that the full-length SiGDH gene was 2499 bp, with an open reading frame (ORF) of 1635 bp, encoding 544 amino acids. Bioinformatic analyses revealed that the predicted SiGDH protein contained the conserved ELFV\_dehydrog\_N and ELFV\_dehydrog domains and that this protein had the highest sequence identity with the GDH protein from *Strongylocentrotus purpuratus*. Tissue-specific differences in SiGDH relative expression patterns and enzyme activity levels were observed, and the highest relative expression and total enzyme activity of SiGDH were determined in the gonad. Changes in SiGDH relative expression and enzyme activity in the gonad were observed after both gradual and acute heat stress. Together, our observations help to clarify the characteristics of this GDH homolog, as well as its associations with heat resistance in echinoderms.

**Key words:** glutamate dehydrogenase, *Strongylocentrotus intermedius*, heat stress, expression pattern, enzyme activity

# C5a/C5aR 及炎性因子的表达与 GCRV 复制量的变化规律关系分析

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**摘要：**草鱼呼肠孤病毒引起的草鱼出血病制约草鱼健康养殖业的发展。以草鱼为本研究对象，利用免疫荧光技术探究 GCRV 感染草鱼后 C5a/C5aR、促炎因子与草鱼 GCRV 病毒复制量之间的变化特性。结果表明 C5a/C5aR 通路、促炎因子、GCRV 病毒载量三者随草鱼出血病程具有相似的变化规律。说明三者间在草鱼出血病中存在紧密的关联为揭示草鱼 C5a/C5aR 通路在应对 GCRV 感染炎症反应的促炎调控机制研究提供基础数据。

**关键词：**草鱼；GCRV；C5a/C5aR 通路；炎症反应；促炎调控

## **Analysis of the relationship between the expression of C5a/C5aR and inflammatory factors and the change of GCRV replication**

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**Abstract :** Grass carp hemorrhagic disease caused by grass carp reovirus reovirus restricts the development of grass carp healthy aquaculture. Taking grass carp as the research object, immunofluorescence technology was used to explore the changes between C5a/C5aR, pro-inflammatory factors and GCRV virus replication in grass carp after GCRV infection. The results showed that the C5a/C5aR pathway, pro-inflammatory factor and GCRV viral load had similar changes with the course of grass carp bleeding. The results showed that there was a close correlation between the three in grass carp haemorrhagic disease, which provided basic data for revealing the pro-inflammatory regulatory mechanism of grass carp C5a/C5aR pathway in response to GCRV infection.

**Key words::** grass carp; GCRV; C5a/C5aR pathway; Inflammation; Pro-inflammatory regulation

# 基于非靶向代谢组学的巴西龟白化病机理的研究

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**摘要:** 白化病是黑色素细胞形成或黑色素生成障碍导致的体色突变表型。巴西龟白化病发生具体原理尚不明晰。本文利用非靶向代谢组技术和酪氨酸酶活检测技术对白化突变和正常巴西龟体内代谢物以及酪氨酸酶活性表达检测。结果显示共检测出 4886 种代谢物, 395 种差异代谢物, 上调 156 种, 下调 239 种。KEGG 功能富集分析差异代谢物显著富集于 $\alpha$ -亚麻酸代谢, 核黄素代谢等通路。白化组中多巴、多巴胺、酪氨酸含量分别上调 2.69 倍、14.18 倍、6.71 倍。酪氨酸酶活性检测结果显示, 白化组酶活性显著高于正常组 ( $P<0.05$ )。本研究表明, 白化组巴西龟体内酪氨酸酶正常生成表达活性, 反应底物多巴、酪氨酸、多巴胺含量显著上升。可能有在体抑制因子抑制体内酪氨酸酶活性或其他因素致使多巴无法正常代谢为黑色素, 进而向旁路代谢。本研究初步证明巴西龟白化病发生与酪氨酸酶以及黑色素生成底物含量无关, 为揭示巴西龟白化病发生机理提供研究基础。

**关键词:** 非靶向代谢组; 酪氨酸酶; 多巴; 白化病; 巴西龟

## Study on the mechanism of albinism in red-eared sliders based on non-targeted metabolomics

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**Abstract:** Albinism is a body chromatic mutation phenotype with melanocyte formation or melanin production disorder, resulting in loss of melanin expression. The specific mechanism of the occurrence of albinism in red-eared sliders is unclear. In this paper, non-targeted metabolome technology and tyrosinase activity detection technology were used to detect metabolites and tyrosinase activity expression in albino mutation and normal individuals, and analyzed them through the MetaboAnalyst platform and SPSS and GraphPad prism software. The results showed that a total of 4886 metabolites and 395 differential metabolites were detected in the skin tissue of the red-eared sliders, of which 156 were up-regulated and 239 were down-regulated. KEGG functional enrichment analysis of differential metabolites showed that the differential metabolites were significantly enriched in  $\alpha$ -linolenic acid metabolism, riboflavin metabolism and folic acid anabolic pathway. In addition, the content of dopa in the differential metabolites related to melanin production in the albino group was increased by 2.69 times, the content of dopamine metabolite was increased by 14.18 times, the tyrosine content was increased by 6.71 times, and the content of norepinephrine was increased by 2.14 times. The expression of tyrosinase activity was detected in the skin tissues of the albino group and the normal group, and the results showed that the tyrosinase activity was significantly higher than that in the normal group ( $P<0.05$ ). This study showed that the normal production and expression activity of tyrosinase in the body of albinized red-eared sliders increased significantly, the contents of tyrosinase reaction substrates dopa and tyrosine increased significantly, and the contents of dopamine and norepinephrine of dopa metabolites increased significantly. There may be in vivo inhibitors that inhibit tyrosinase activity in vivo or other factors that prevent dopa from being metabolized normally to produce melanin, which is then metabolized in the bypass. This study preliminarily proved that the occurrence of red-

red-eared sliders albinism was not related to tyrosinase and melanin-producing substrate content, which provided a certain research basis for revealing the pathogenesis of red-eared sliders albinism.

**Key words:** non-targeted metabolomics; Tyrosinase; Dopa; Albinism; Red-eared sliders



# 虹鳟肝脏响应高温胁迫的蛋白质组学与代谢组学数据关联分析

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**摘要:** 为了筛选虹鳟慢性热应激关键蛋白质分子和应激评价指标, 更进一步阐明虹鳟高温胁迫响应机制, 对慢性热应激条件下虹鳟肝脏差异蛋白与差异代谢物的组学数据进行了整合关联分析。结果发现: 亚油酸、 $\gamma$ -亚麻酸、二十碳五烯酸、棕榈油酸、棕榈酸、油酸等代谢物分子在慢性高温胁迫后丰度显著上调; 不饱和脂肪酸合成、 $\alpha$ -亚麻酸代谢和脂肪酸降解及初级胆汁酸生物合成等通路为多组学研究视野下显著指向的代谢/信号通路。

**关键词:** 虹鳟, 高温胁迫, 蛋白质组, 代谢组, 关联分析

## Proteomic and Metabolomic Data Association Analysis of Liver Responses to Heat Stress in Rainbow trout

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**Abstract:** In order to further elucidate the response mechanism of rainbow trout to chronic heat stress and screen key protein molecules and stress evaluation indexes. An integrated analysis of the two kinds of -omics data (proteomic and metabonomics) was performed by calculating Pearson correlation coefficient of abundance of differential expression protein and different metabolite and searching the Co-pathway that shared between the two -omics data. Finally, it was found that the metabolites such as linoleic acid, oliolenic acid, eicosapentaenoic acid, palmioleic acid, palmitic acid and oleic acid had significant up-regulation in the abundance of rainbow trout liver in the chronic heat stress group. Co-pathway study has shown that pathways such as unsaturated fatty acid synthesis,  $\alpha$ -linolenic acid metabolism, fatty acid degradation, and primary bile acid biosynthesis have been significantly enriched in the two types of omics studies.

**Key words:** Rainbow trout, Heat Stress, Proteomic, Metabolomic, Association Analysis

# 金鲳( *Trachinotus ovatus* )通过 HIF-1 $\alpha$ / NF- $\kappa$ b 信号通路减轻急性氨胁迫引起的鳃氧化损伤

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**摘要:** 本次报告通过生化参数、组织学结构和 HIF-1 $\alpha$ /NF- $\kappa$ b 信号通路相关基因表达, 综合分析急性氨胁迫及毒后恢复对卵形鲳鲹幼鱼的影响, 从分子的角度阐述卵形鲳鲹氨中毒的机理以及对毒性的具体耐受性和反应。

**关键词:** 卵形鲳鲹; 生化指标; 组织学变化; 氧化应激; 炎症反应

## Gill oxidative damage caused by acute ammonia stress was reduced through the HIF-1 $\alpha$ /NF- $\kappa$ b signaling pathway in golden pompano (*Trachinotus ovatus*)

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**Abstract :** In this study, we analyzed the biochemical parameters, histological structure, and the expression of HIF-1  $\alpha$ /NF- $\kappa$  B signaling pathway related genes in juvenile golden pompano (*Pompano auratus*), and analyzed the effects of acute ammonia stress and recovery on ammonia toxicity, and explained the mechanism of ammonia toxicity in juvenile golden pompano, as well as the specific tolerance and response to ammonia toxicity from a molecular perspective.

**Key words :** Fish ; Biochemical parameters ; Histological changes ; Oxidative stress ; Inflammatory response

# 鱼类 OXR1 基因的抗氧化作用及分子机制研究

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**摘要:** 本研究以斑马鱼为模型, 确定了 OXR1 (oxr1a 和 oxr1b) 在斑马鱼中的基因表达模式及对氧化胁迫的分子响应, 通过 CRISPR/Cas9 基因编辑技术建立斑马鱼 oxr1a 和 oxr1b 基因敲除模型, 在氧化应激条件下, 两个基因均可通过正调控抗氧化酶相关基因的表达来参与对机体和细胞的抗氧化防御, 其介导的抗氧化作用在鱼类的抗衰老和持续繁殖中起到重要作用。

**关键词:** OXR1, 抗氧化, P53, 细胞凋亡, 衰老, 繁殖, 斑马鱼

## Antioxidant effect and molecular mechanism of OXR1 gene in zebrafish

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**Abstract:** The present study elucidated the temporal and spatial expression of zebrafish OXR1 genes (oxr1a and oxr1b) and their molecular response to oxidative stress. Antioxidant effects of oxr1a and oxr1b on zebrafish were studied based on CRISPR/Cas9 gene knockout model. Under oxidative stress conditions, both genes participate in antioxidant defense by regulating the expression of antioxidant enzyme-related genes. Their antioxidant effect plays an important role in the anti-aging and continuous reproduction of fish.

**Key words:** Oxidative stress; ROS, P53; oxr1a; oxr1b; antioxidant defenses; Reproduction; zebrafish

# Nxhl 通过与核仁素相互作用靶向 VE-PTP 来控制血管生成

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**摘要:** 本研究发现一个新基因 *nxhl*。敲低 *nxhl* 会导致斑马鱼的血管生成缺陷, 且 *nxhl* 对于体内和体外血管生成必不可少。另外发现敲低 *ptprb* 复制了 *nxhl* 缺失的表型, 且 *nxhl* 位于 *ptprb* 的上游, 通过与核仁蛋白 (NCL) 的相互作用靶向 VE-PTP 来调节许多极其重要的血管生成基因。本研究首次发现了一种新的 *nxhl*-NCL-VE-PTP 信号通路调节血管生成。

**关键词:** 血管生成; *Nxhl*, VE-PTP, PTPRB,核仁素

## **Nxhl controls angiogenesis by nxhl-NCL VE-PTP signaling pathway**

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**Abstract:** In this study, we discovered a novel angiogenic gene, *nxhl* (New XingHuo-like); it is known that vascular endothelial tyrosine phosphatase (VE-PTP, named *ptprb* in zebrafish) is also a novel target with great anti-angiogenic potential. However, it is unclear whether *nxhl* acts as an upstream regulator of VE-PTP in angiogenesis signaling pathways. We found that *nxhl* is a homologue of *nxb* (New XingHuo) co-expressed with key genes during embryo development. Deletion of *nxhl* causes angiogenesis defects in zebrafish. Moreover, *nxhl* is essential to mediate the effects of angiogenesis in vivo and in vitro, and *ptprb* depletion duplicates the phenotypes of *nxhl* deficiency. Importantly, *nxhl* acts upstream of *ptprb* and regulates many extremely important *ptprb*-linked angiogenic genes by targeting VE-PTP through interactions with nucleolin (NCL). For the first time, we uncovered a novel *nxhl*-NCL-VE-PTP signaling pathway in angiogenesis. The human homologue of *nxhl*, *Harbil*, inhibits metastasis of cancer cells by suppressing endothelial cells via the identical pathway to *nxhl*. In our study, we identified *nxhl* controlling angiogenesis by targeting VE-PTP through interactions with NCL, uncovering novel upstream controllers of VE-PTP. This *nxhl*-NCL-VE-PTP pathway may be a therapeutic target in the treatment of angiogenesis-dependent diseases.

**Key words:** Angiogenesis, *nxhl*, VE-PTP, *ptprb*, nucleolin, cancer

# 马氏珠母贝 PEPCK 基因序列特征及其在耐低温品系的选择印记分析

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**摘要:** 磷酸烯醇式丙酮酸羧激酶是糖异生途径的关键酶, 当动植物处于温度胁迫等不良环境条件时, 它可通过催化草酰乙酸转化为磷酸烯醇式丙酮酸, 继而生成葡萄糖以维持机体的血糖平衡, 在抗逆过程中起着重要作用。本研究鉴定了马氏珠母贝的 PEPCK 基因, 分析了低温胁迫下 PmPEPCK 表达量的变化, 筛选和比较分析了马氏珠母贝耐低温选育系 F3 和北部湾野生群体的 PmPEPCK 外显子区的 SNP 位点。

**关键词:** 马氏珠母贝; PEPCK; 低温耐受; SNP; 基因克隆

## Sequence characteristics of PEPCK gene of *Pinctada fucata martensii* and its selection in low temperature resistant line

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**Abstract:** Phosphoenolpyruvate carboxylase is a key enzyme in the gluconeogenesis pathway. When animals and plants are under adverse environmental conditions such as temperature stress, it can convert oxaloacetic acid into phosphoenolpyruvate and then generate glucose to maintain the body's blood glucose balance, and plays an important role in the process of stress resistance. In this study, PPECK gene of *Pinctada fucata martensii* was identified, the changes of PmPPECK expression under low temperature stress were analyzed, and SNP sites in the exon region of PmPPECK in Low temperature tolerant breeding line F3(R) and Beibu Gulf wild populations(W) of *Pinctada fucata martensii* were screened and compared.

**Key words::** *Pinctada fucata martensii*; PEPCK; Low temperature tolerance; SNPs; Cloning

# 盐碱胁迫对莫桑比克罗非鱼（*Oreochromis mossambicus*）TauT 基因表达的影响

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**摘要：**为研究 TauT 基因在盐碱、碱胁迫下对莫桑比克罗非鱼渗透压调控所发挥的作用，本实验扩增了 TauT 基因的 CDS 区序列，并分析该基因在 14 个组织中的表达分布特征及在盐碱、碱胁迫时，在鳃、肾、肠和脑组织中的表达水平。实验表明，TauT 基因在鱼体各组织均有表达；盐碱胁迫时，盐碱敏感组 TauT 基因的表达水平在鳃、肾、肠、脑 4 个组织中均显著低于盐碱耐受组碱胁迫时，碱敏感组在鳃、肠和脑中均显著高于碱耐受组。

**关键词：**TauT 基因；莫桑比克罗非鱼；盐碱胁迫

## Effects of saline-alkali stress on TauT Gene Expression in *Oreochromis mossambicus*

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**Abstract:** In order to study the osmoregulation of TauT gene in *Oreochromis mossambicus* under saline-alkali and alkali stress, the coding sequence (CDS) of TauT gene was amplified in this study, and the amino acid sequence and the advance structure of the encoded protein were predicted. The expression and distribution of TauT gene in liver, intestine, muscle and etc. 14 tissues were analyzed by quantitative real time PCR (qRT-PCR). Then the *Oreochromis mossambicus* were treated with salinity-alkalinity stress (salt: 25‰, alkali: 4‰) and alkalinity stress (4‰), the expression levels of TauT mRNA in gill, kidney, intestine and brain were detected by qRT-PCR in the four groups. The results of qRT-PCR showed that the gene TauT was detected in all 14 tissues examined in *Oreochromis mossambicus*. Under saline-alkali stress, the expression levels of TauT mRNA in gill, kidney, intestine and brain of saline-alkali sensitive group was significantly lower than those in the saline-alkali tolerant group. While under alkali stress, the TauT mRNA levels in the four tissues in the alkali sensitive group was higher than those in the alkali tolerant group with significant differences in gill, intestine and brain tissues ( $P < 0.05$ ), while in the kidney, the alkali sensitive group was higher than the alkali tolerant group, but the difference was not significant.

**Key words:** TauT; *Oreochromis mossambicus*; saline-alkali stress

# 基于转录组测序筛选大口黑鲈食性驯化 相关基因和 SNP 标记

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**摘要：**为了获得与大口黑鲈食性驯化相关基因和标记，本研究以大口黑鲈“优鲈 3 号”为研究对象，通过对易驯食组和不易驯食组脑和肝脏组织分别进行转录组测序，发现与食性驯化相关的差异表达基因参与昼夜节律、光传导、视黄醇代谢、类固醇生物合成、胆汁分泌和 PI3K-AKT 信号通路，RDH12 基因中 chr15-A+8322808G 位点与驯食性状存在显著关联性，为大口黑鲈食性驯化性状的分子标记辅助育种提供了候选基因和分子标记

**关键词：**大口黑鲈；驯食性状；转录组测序；差异表达基因；单核苷酸多态性

## Development of genes and SNP markers related to food domestication based on largemouth bass transcriptome

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**Abstract：** In this study, a new strain of largemouth bass, “Youlu No. 3”, was used as the research object, and transcriptome sequencing of the brain and liver tissues from domesticated group and the non-domesticated group was performed. The genes involved in food domestication regulation, such as leptin(LEP), period(PERs), rhodopsin(RHO), retinol dehydrogenase(RDHs), and bile salt export pump(BSEP) were mainly distributed in circadian rhythm, phototransduction, retinol metabolism, steroid biosynthesis, bile secretion, and PI3K-AKT signaling pathway. These pathways play an important role in environmental adaptation, visual system, digestion and metabolism, and appetite control. Furthermore, 21465 SNP markers were screened from the differentially expressed genes in the non-domesticated group and domesticated group. The SNaPshot technique was used to verify the 14 SNP markers that were randomly selected, and their association with food domestication was analyzed. Only the chr15-8322808 marker in RDH12 gene was found to be significantly associated with domestication traits ( $P < 0.05$ ), and its AA genotype was the dominant genotype in easily domesticated individuals. Overall, 3609 differentially expressed genes and one SNP marker related to food domestication traits were obtained, providing candidate genes and molecular marker for the molecular marker-assisted breeding research of domestication traits of largemouth bass.

**Key words：** largemouth bass; domestication traits; transcriptome sequencing; differentially expressed genes; single nucleotide polymorphism

# 盐碱胁迫下罗非鱼中 Dnmt1 的克隆与表达

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**摘要:** 本研究在亲本莫桑比克、荷那龙及其杂交子代“莫荷”获得了 Dnmt1 基因。Dnmt1 ORF 序列全长 4515 bp, 编码 1504 个氨基酸。对莫荷、亲本及其他动物 Dnmt1 基因的氨基酸序列进行系统发育分析, 并发现在盐碱胁迫下, Dnmt1 在肌肉、肾脏、脑和鳃的表达水平均上调, 且三种鱼的表达模式相似。表明基因 Dnmt1 在罗非鱼渗透压调控中可能发挥重要的调控功能。

**关键词:** Dnmt1, 系统发育, 盐碱胁迫, 基因表达

## Environmental induced Dnmt1 expression changes associated with salt-alkalinity adaptation in tilapia

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**Abstract:** Fishes are continuously exposed to all kinds of environmental stress such as salinity and alkalinity. In order to survive and adapt to the environment, they have developed survival strategies that have been well studied, but little is known about the gene Dnmt1 expression and function in response to osmotic stress. In this study, the Dnmt1 gene was identified and characterized in the hybrid tilapia and the parents *Oreochromis mossambicus* and *O. urolepis hornorum*. The full-length of the Dnmt1 ORF sequence was 4515 bp, encoding 1504 amino acids. Phylogenetic analysis of the amino acid sequence of gene Dnmt1 in the hybrid, its parents and other animals revealed that the Dnmt1 in the three tilapias was closely related to *Oreochromis niloticus*. The expression levels of Dnmt1 in the muscle, kidney, brain and gill were up-regulated under salt-alkalinity stress with similar expression patterns in the three fishes. Our data provide useful information for further detailed analysis of the Dnmt1 function in salt-alkalinity tolerance.

**Key words:** Dnmt1, Phylogenetic, salt-alkalinity stress, gene expression



# 基于线粒体 CO I 基因序列分析新疆 4 个河鲈野生群体的遗传现状

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**摘要:** 为了解我国新疆地区河鲈的遗传现状, 本研究基于线粒体 CO I 基因分析了新疆乌伦古河水系和喀啦额尔齐斯河共 4 个河鲈野生群体的遗传多样性, 并与欧洲群体进行了比较。结果显示新疆群体有 3 个变异位点, 定义了 4 个单倍型, Hd 为  $0.065\pm 0.022$ ,  $\pi$  为  $0.00011\pm 0.00004$ , 呈现出低水平遗传多样性。中国新疆河鲈群体和欧洲群体为不同的遗传系谱。新疆 4 个群体间变异为 1.57%, Fst 为 0.01568。

**关键词:** 河鲈; 新疆; 线粒体; 遗传结构

## Genetic status analysis of 4 wild populations of *Perca fluviatilis* in Xinjiang based on mitochondrial CO I gene sequences

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**Abstract:** In order to grasp the genetic status of *Perca fluviatilis* in Xinjiang, this study analyzed the genetic diversity of 4 *Perca fluviatilis* populations in the Wulungu River and Kalaeerqisi River in Xinjiang using mitochondrial CO I gene, and compared European populations. The results showed that the 4 populations in Xinjiang had 3 variable sites, which defined 4 haplotypes, and the haplotype diversity is  $0.065\pm 0.022$ , and the nucleotide diversity is  $0.00011\pm 0.00004$ , showing low genetic diversity. The Chinese Xinjiang and the European *Perca fluviatilis* population showed different genetic pedigrees. The four populations are estimated to have 1.57% variation among populations, and Fst is 0.01568. But the ER population and the WL population are at a moderate genetic differentiation, and the ER and WR populations are at a high genetic differentiation. Perhaps due to the blockage of the dam, genetic resources cannot be replenished, and the Kalaeerqisi River has formed an independent genetic pedigree. The results of this study provide a reference for the diversity of Xinjiang *Perca fluviatilis* populations and the development and utilization of germplasm resources.

**Key words:** *Perca fluviatilis*, Xinjiang; mitochondria; genetic structure

# 加盐对空气暴露胁迫下刀鲚幼鱼抗氧化及凋亡的影响

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**摘要:** 本文旨在研究添加盐分对空气暴露下刀鲚幼鱼存活、抗氧化能力及凋亡的影响。结果显示, 不加盐组出现了高死亡率, 抗氧化酶活性和总抗氧化能力降低, MDA 和 LPO 增加, 并且 Caspase 3 表达上调。线粒体凋亡、内质网凋亡和死亡受体凋亡相关的基因的表达在空气暴露后被激活, 空气暴露前后添加盐可以显著降低死亡率, 抑制氧化应激和细胞凋亡。添加盐将是缓解刀鲚幼鱼应激的有效方法。

**关键词:** 刀鲚, 抗氧化能力, 凋亡相关基因, 盐度, 空气暴露

## Effect of addition of salt on oxidant activity and apoptosis of *Coilia nasus* juveniles under air exposure stress

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**Abstract:** The influence of addition of salt on mitigating the stress caused by air exposure was investigated in *Coilia nasus* juveniles. The results showed that air exposure triggered high mortality; antioxidant activities and total antioxidant capacity were decreased; malondialdehyde (MDA) and lipid peroxide (LPO) were increased; and Caspase 3 expression was activated. Additionally, antioxidant activities were increased, and MDA and LPO levels were decreased. SAS could also inhibit expressions of the genes related to apoptosis. These results indicated that high mortality, oxidant stress, and apoptosis were caused by air exposure, but the addition of salt both before and after air exposure could significantly reduce mortality, inhibit oxidant stress and apoptosis. Our data demonstrated that the addition of salt both before and after air exposure would be an effective method to mitigate air exposure stress in *C. nasus* juveniles.

**Key words:** *Coilia nasus*, antioxidant capacity, apoptosis-related gene, salinity, air exposure

# 催产激素对雌性长春鳊应激生理指标的影响

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**摘要:** 研究了雌性长春鳊分别注射绒毛膜促性腺激素 (HCG)、促黄体素释放激素类似物 (LHRH-A2)、地欧酮 (DOM) 以及它们的混合制剂后, 催乳素、皮质醇及血液生化指标的变化情况。结果显示, HCG 组各项指标波动很大, 应激反应明显; DOM 组除血糖 (Glu)、乳酸和 K<sup>+</sup> 显著升高外, 其余指标变化较为平稳; LHRH-A2 组所有生化指标都相对较为平稳; 混合组除 Glu、K<sup>+</sup> 及乳酸外, 其余指标都波动较大。

**关键词:** 长春鳊; 催产激素; 应激生理指标

## Study on stress response of *Parabramis pekinensis* to different oxytocin

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**Abstract:** Changes of prolactin, cortisol and blood indices of female *Parabramis pekinensis* after injection of Human chorionic gonadotrophin (HCG), Luteinizing Hormone Releasing Hormone A2 (LHRH-A2), malediosterone (DOM) and their mixture (ALL) were compared. Results showed that, In HCG group, the indexes fluctuated greatly and the stress response was obvious. In DOM group, except glucose (Glu), lactic acid and K<sup>+</sup> increased significantly, the changes of other indexes were relatively stable. All biochemical indexes of LHRH-A2 group were relatively stable. Except Glu, K<sup>+</sup> and lactic acid, the indexes of mixed group fluctuated greatly.

**Key words:** *Parabramis pekinensis*; oxytocin; stress physiological indices

# Cyclin A 在日本沼虾卵巢发育中的 功能分析和分子表征

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**摘要:** 细胞周期蛋白 A (CycA) 是调节脊椎动物卵巢发育的关键基因。本研究从日本沼虾卵巢中克隆了 Mn-CycA 的全长 cDNA。研究发现 Mn-CycA 表达与卵巢成熟呈正相关。变态期第 25 天, Mn-CycA 在雌虾的表达量是雄虾的 3.5 倍, 这可能与卵原细胞的增殖和卵母细胞的形成有关。与对照组相比, 性腺指数有明显的变化, 证明注射双链可延缓卵巢发育周期。本研究为 Mn-CycA 参与卵巢成熟和卵子发生提供了有力证据。

**关键词:** 日本沼虾 细胞周期蛋白 A 卵巢发育 原位杂交 mRNA 表达 RNA 干扰

## Function analysis and molecular characterization of cyclin A in ovary development of oriental river prawn, *Macrobrachium nipponense*.

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**Abstract:** Cyclin A (CycA) is a key gene that regulates vertebrate ovarian development. In this study, the full-length cDNA of Mn-CycA was cloned from the ovaries of *Macrobrachium nipponense*. Studies have found that the expression of Mn-CycA is positively correlated with ovarian maturation. On the 25th day of the metamorphosis stage, the expression level of Mn-CycA in female shrimp was 3.5 times that of male shrimp, which may be related to the proliferation of oocytes and the formation of oocytes. Compared with the control group, the gonadal index has obvious changes, which proves that the double-strand injection can delay the ovarian development cycle. This study provides strong evidence for the involvement of Mn-CycA in ovarian maturation and oogenesis.

**Key words:** *Macrobrachium nipponense* Cyclin A Ovary development In situ hybridization mRNA expression RNA interference

# 组织蛋白酶 L1 在日本沼虾卵巢发育中的表达及功能分析

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**摘要：**组织蛋白酶 L 是半胱氨酸蛋白酶家族的重要成员，在昆虫及鱼类的卵巢发育中起重要作用。在本研究中，RT-PCR 结果显示，Mn-CTS L1 在雌性对虾的肝胰脏和卵巢中含量表达较高。在卵巢发育的不同阶段中，Mn-CTS L1 在肝胰脏和卵巢中的表达在卵巢成熟前达到顶峰。Mn-CTS L1 双链 rna 注射显著降低 Mn-CTS L1 表达，卵黄原蛋白表达显著增加。这些结果表明 Mn-CTS L1 在卵巢发育中起关键作用。

**关键词：**日本沼虾、组织蛋白酶 L、原位杂、RNA 干扰

## Expression and functional analysis of cathepsin L1 in ovarian development of the oriental river prawn, *Macrobrachium nipponense*

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**Abstract:** Cathepsin L is an important member of the cysteine protease family and has a central role in the development of ovaries in insects and fish. In this study, we analyzed the characteristics of the cathepsin L1 gene in the female oriental river prawn, *Macrobrachium nipponense*. The cathepsin L1 cDNA was 1173 bp in length, including a 960 bp open reading frame that encoded 319 amino acids. The cathepsin L1 gene was classified into the cathepsin L group and named Mn-CTS L1 by phylogenetic analysis. qRT-PCR analysis indicated that Mn-CTS L1 was highly expressed in the hepatopancreas and ovaries of female prawns. During the different stages of ovarian development, Mn-CTS L1 expression in the hepatopancreas and ovaries peaked before ovarian maturation. Mn-CTS L1 expression was higher at the post-larval stage of day 15 than at other stages of embryogenesis. In situ hybridization studies revealed that Mn-CTS L1 was localized in the oocyte of the ovary. Injection of Mn-CTS L1 dsRNA significantly reduced Mn-CTS L1 expression and significantly increased the expression of vitellogenin. Changes in the gonad somatic index also confirmed the inhibitory effects of Mn-CTS L1 dsRNA. These results suggest that Mn-CTS L1 has a key role in ovarian development.

**Key words:** *Macrobrachium nipponense* Cathepsin L1 Expression profile In situ hybridization RNA interference

# 低氧条件下不同生存状态日本沼虾肝胰腺的比较转录组分析

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**摘要:** 首次使用了比较转录组分析了日本沼虾在缺氧条件下不同生存状态的差异。5 通过 KEGG 富集, 在三个比较组中发现了三条与低氧密切相关的共同信号通路。相较于以往的研究, 我们发现热休克蛋白 70kda、磷酸烯醇丙酮酸羧基酶及环氧酶是全程参与了整个低氧过程。另外, 我们还发现了两个新的基因。本研究丰富了我们对低氧环境下氧化应激的认识, 为以后的研究提供了理论依据。

**关键词:** 日本沼虾, 不同生存状态, 低氧, 转录组分析, 肝胰腺

## Transcriptome analysis of hepatopancreas from different living states oriental river prawn (*Macrobrachium nipponense*) in response to hypoxia

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**Abstract:** As an important economical freshwater prawn, *Macrobrachium nipponense* has difficulty with adapting to hypoxia. In this study, comparative transcriptome analysis was used for the first time to explore the differences between different living states of *Macrobrachium nipponense* under hypoxia. A total of 94.22 Gb clean reads were obtained and assembled into 54,688 unigenes. A total of 224, 266, and 750 differently expressed genes were found in the comparison of the control and death groups, the control and moribund groups, and the control and survived groups, respectively. Three signal pathways closely related to hypoxia were found by enriching of the signal pathways in three comparison groups. In addition, much attention was focused on the differential genes in these pathways. Oxidative stress related genes, such as 70 kDa heat shock protein, phosphoenolpyruvate carboxykinase and cyclooxygenase were differentially expressed in different comparisons. After comparing with previous studies, cyclooxygenase was found to be an important hypoxia-related gene that is fully involved in the hypoxic response. Interestingly, two new genes with no Nr annotation were found in this manuscript. This manuscript will enrich our understanding of oxidative stress response to hypoxia and provide a theoretical basis for the subsequent solution of apoptosis caused by hypoxia.

**Key words:** *Macrobrachium nipponense*, Different living states, Hypoxia, Transcriptome analysis, Hepatopancreas

# Cilp 基因对斑马鱼骨骼和肌间骨发育的影响

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**摘要:** 为阐明 cilp 基因对斑马鱼骨骼和肌间骨发育的影响, 利用 RNA-FISH 证实了 cilp 在斑马鱼肌间骨、肌隔和椎骨中与成骨细胞标志基因 sp7 共表达; 利用 CRISPR/Cas9 建立 cilp 缺失突变系, 骨骼染色发现突变体肌间骨数量较野生型显著减少了 10.27% ( $P < 0.01$ ), 且尾椎骨融合及髓棘缺失; 骨发育相关基因定量分析结果显示, cilp 缺失可能通过下调成骨相关基因的表达而影响肌间骨和脊椎骨的发育。

**关键词:** cilp, CRISPR/Cas9, 肌间骨, 斑马鱼

## The Effect of cilp on the development of the skeleton and intermuscular bones in zebrafish

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**Abstract:** To elucidate the effects of cilp gene on bones and intermuscular bones development in zebrafish, RNA-FISH was used to confirm that cilp was co-expressed with osteoblast marker gene sp7 in intermuscular bones, muscular septal, and vertebrae of zebrafish; using CRISPR/Cas9 to establish a cilp deletion mutant line, bones staining showed that the number of intermuscular bones of the mutant was significantly reduced by 10.27% compared with that of the wild type ( $P < 0.01$ ), and the tail vertebra fusion and myeloid spines deletion were observed; quantitative analysis of bones development-related genes suggested that cilp deletion may affect the development of intermuscular bones and vertebra by down-regulating the expression of osteogenesis related genes.

**Key words:** cilp, CRISPR/Cas9, intermuscular bones, zebrafish

# 雌性日本沼虾五个卵巢阶段的转录组分析

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**摘要:** 本研究目的在于探究日本沼虾卵巢各期的详细转录组数据, 我们从 15 个样本中获得了 255,966 GB 的高质量转录组数据。在所选择的 105,082 个 unigene 中, 有 30,878 个被成功注释。从这些 unigene 中, 我们鉴定了 17 个差异表达基因, 并鉴定了与不同生物过程相关的三种不同的基因表达模式。我们发现组织蛋白酶富含溶酶体途径, 它们与卵黄蛋白原的水解有关。

**关键词:** 日本沼虾; 卵巢发育; 转录组

## Transcriptome analysis of five ovarian stages reveals gonad maturation in female *Macrobrachium nipponense*

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**Abstract:** The purpose of this study is to explore the detailed transcriptome data of each ovarian cycle of *Macrobrachium rosenbergii*. We obtained 255,966 Gb of high quality transcriptome data from 15 samples. Of the 105,082 unigenes that were selected, 30,878 were successfully annotated. From these unigenes, we identified 17 differentially expressed genes and identified three distinct gene expression patterns related to different biological processes. We found that cathepsins, legumains, and cystatin were enriched in the lysosome pathway, and they are related to vitellogenin hydrolysis.

**Key words:** *Macrobrachium nipponense*; ovary development; transcriptome



# RNA 干扰表明，20-羟基蜕皮激素（20E）的前体基因 Spook 对日本沼虾的蜕皮有调节作用

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**摘要：**本研究目的在于探究 Mn-Spook 基因在日本沼虾中的功能。在日本沼虾卵巢中克隆了全长 Mn-Spook 基因，与万圣节家族基因具有相同的保守结构域。通过 qRT-PCR、ISH、RNAi、ELISA 等技术系统分析了 Mn-Spook 基因在日本沼虾中的表达，分布和功能。研究结果证明 Mn-Spook 通过参与 20-羟基蜕皮激素（20E）的生产，在日本沼虾的蜕皮过程中发挥了关键作用。

**关键词：**日本沼虾，Mn-Spook，20-羟基蜕皮激素，RNA 干扰，蜕皮

## RNA interference shows that Spook, the precursor gene of 20-hydroxyecdysone (20E), regulates the molting of *Macrobrachium nipponense*

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**Abstract:** The aim of this study was to explore the function of the Mn-Spook gene, which was found in the ovary transcriptome of the Oriental river prawn (*Macrobrachium nipponense*). The Spook gene, which is the precursor gene of 20-hydroxyecdysone (20E), plays an important role in the process of molting in many arthropods, but its function in *M. nipponense* is unclear. We cloned the full-length Mn-Spook gene from the ovary of *M. nipponense* and found that it had the same conserved domains as the P450 gene of the Halloween family of genes. The MnSpook gene was highly expressed in ovary and gill tissue during the breeding period. During ovarian development, Mn-spook gene expression was highest at the nearly-ripe stage, and it also was highly expressed in the zoea developmental stage. Cellular localization analysis showed that Mn-Spook signals accumulated in the cytoplasmic membrane and nucleus of oocytes. Finally, we used RNA interference to evaluate the function of the Mn-Spook gene. Compared with the control group, in vivo injection of Mn-Spook dsRNA effectively downregulated the expression of Mn-Spook and the content of 20E. The molting frequency of *M. nipponense* in the experimental group also was significantly inhibited. These results demonstrated that the Mn-Spook gene played an important role in the molting process of *M. nipponense*.

**Key words:** *Macrobrachium nipponense*, Mn-Spook, 20E, RNA interference, Molt

# 日本沼虾 SDHB 基因的特征及鉴定

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**摘要:** SDHB 全长 54608bp, 包含 7 个内含子和 6 个外显子。全长 cDNA 序列共 1268 个碱基对, 开放阅读框 807 bp, 编码 268 个氨基酸。SDHB 在日本沼虾精巢中表达量最高, 幼虫发育到 25 天时表达量最高。注射双链后, IAG 表达降低。注射 10 天后, 日本沼虾精巢发育受到抑制, 精子减少, 说明 SDHB 促进了日本沼虾雄性发育。本研究揭示了日本沼虾中 SDHB 的功能, 为其他甲壳类动物雄性发育的研究提供了新的思路。

**关键词:** 日本沼虾, SDHB, 荧光定量分析, RNA 干扰, 雄性发育

## Identification and Characterization of the Succinate Dehydrogenase Complex Iron Sulfur Subunit B Gene in the Oriental River Prawn, *Macrobrachium nipponense*

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**Abstract:** The full-genome sequence of Mn-SDHB was 54,608 bp, including 7 introns and 6 exons. The full-length cDNA sequence was 1,268 base pairs long with an open reading frame of 807 bp, encoding for 268 amino acids. The highest expression level of Mn-SDHB in different tissues was observed in the testis, and male prawns at post-larval developmental stage 25 during different developmental stages. In situ hybridization and western-blot analysis indicated that SDHB plays essential roles in the testis development. The expressions of Mn-IAG were decreased after Mn-SDHB dsRNA injection, indicating SDHB has the positive regulatory effects on IAG in *M. nipponense*. The testis development was inhibited, and sperms were rarely observed after 10 days of injection, indicating SDHB has positive effects on the male sexual development in *M. nipponense*. This study highlights the functions of SDHB in *M. nipponense*, which provide new insights for the future studies of the male sexual development in other crustacean species.

**Key words:** *Macrobrachium nipponense*, SDHB, qPCR analysis, RNAi, male sexual development

# 高温胁迫对日本沼虾热休克蛋白基因\_省略\_达\_抗氧化酶活力及组织结构的影响

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**摘要：**为探究日本沼虾应对高温胁迫的响应机制,设置了水温对照组( $20\pm 0.5$ ) $^{\circ}\text{C}$ 和高温组( $30\pm 0.5$ ) $^{\circ}\text{C}$ ,溶氧浓度( $6.5\pm 0.5$ ) $\text{mg/L}$ ,分别在高温胁迫 0h、12h、24h、36h、48h 测定了日本沼虾肝胰腺和鳃组织中热休克蛋白 21、热休克蛋白 60、热休克同源蛋白 70-3 和热休克蛋白 90 基因的表达,相关抗氧化酶——超氧化物歧化酶、谷胱甘肽 S-转移酶、谷胱甘肽过氧化物酶和过氧化氢酶活性及组织结构变化。

**关键词：**日本沼虾 高温胁迫 热休克蛋白 抗氧化酶 组织学

## Effects of high temperature stress on heat shock protein gene expression, antioxidant enzyme activity and metabolism of *Macrobrachium nipponense* Impact of organizational structure

Shuhua Zhai、Lijuan Zhang、Hui Qiao、Wenyi Zhang、Shubo Jin、Hongtuo Fu、Yiwei Xiong、Sufei Jiang

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**Abstract :** In order to explore the response mechanism of *Macrobrachium nipponense* to high temperature stress, the water temperature control group ( $20 \pm 0.5$ )  $^{\circ}\text{C}$  and the high temperature group ( $30 \pm 0.5$ )  $^{\circ}\text{C}$  were set, and the dissolved oxygen concentration was ( $6.5 \pm 0.5$ )  $\text{mg} / \text{L}$ . the expressions of heat shock protein 21, heat shock protein 60, heat shock homologous protein 70-3 and heat shock protein 90 genes in hepatopancreas and gills of *Macrobrachium nipponense* were measured at 0h, 12h, 24h, 36h and 48h under high temperature stress, Changes of activities and tissue structure of related antioxidant enzymes - superoxide dismutase, glutathione S-transferase, glutathione peroxidase and catalase.

**Key words: :** *Macrobrachium nipponense*、High temperature stress、heat shock protein、Antioxidant enzymes、Histology

# 基于全基因组重测序开发与大口黑鲈亚种鉴定的 InDel 标记

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**摘要:** 为了建立一种与大口黑鲈种质资源鉴定相关的 PCR 方法, 本研究分别对大口黑鲈北方亚种和佛罗里达亚种进行了全基因组重测序, 总共获得了 227797 个 InDel 标记。随机挑选了 8 个 InDels (>45bp), 在 5 个大口黑鲈群体中对其 PCR 扩增产物进行琼脂糖凝胶电泳检测, 结果表明 3 个 InDels 可准确的区分大口黑鲈北方亚种、佛罗里达亚种及其 F1 代杂交种。本研究可为大口黑鲈种质鉴定以及杂交育种提供技术支持。

**关键词:** 大口黑鲈; 种质鉴定; 全基因组重测序; InDel 标记

## Development of InDel makers for identification of Largemouth bass with Whole-Genome Re-sequencing

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**Abstract:** In order to establish a PCR-based method for germplasm identification of Largemouth bass, Whole-genome Re-sequencing analysis were conducted between Northern Largemouth bass (*Micropterus salmoides*) and Florida bass (*Micropterus floridanus*). In total, 227,797 InDels were filtered obtained. 8 Indels (>45bp) were randomly selected and their PCR products were analyzed with agarose gel electrophoresis in five different populations of largemouth bass. Finally, 3 InDels could accurately distinguish the Northern Largemouth bass, Florida bass and their F1 progenies. Our study provided valuable information for the germplasm identification and hybrid breeding of Largemouth bass.

**Key words:** : Largemouth bass; germplasm identification; Whole-genome Re-sequencing; InDel maker

# 马氏珠母贝 C1q 结构域蛋白参与免疫防御过程

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**摘要：**从马氏珠母贝中鉴定出球状 C1q 结构域蛋白（PmC1qDC-1），并确定其可能参与免疫反应。对其高层结构进行了分析，对 *P. f. PmC1qDC-1* 高表达的免疫器官鳃进行荧光原位杂交。并在鳃中检测到强杂交信号。经三种典型的 PAMPs 刺激后，鳃中 PmC1qDC-1 的 mRNA 相对表达显著上调。重组蛋白 PmC1qDC-1 能够抑制细菌生长，这些结果表明 PmC1qDC-1 可以刺激马氏珠母贝发生免疫反应。

**关键词：**C1qDC;马氏珠母贝；软体动物；免疫应答

## A protein containing C1q domain from *Pinctada fucata martensii* participates in immune defense process

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**Abstract :** The globular C1q domain protein (PmC1qDC-1) was identified from *Pinctada fucata martensii*, and it was determined that it might participate in the immune response. The high-level structure of PmC1qDC-1 was analyzed, and fluorescence in situ hybridization was performed on the gills of immune organs with high expression of *P. f. martensii*. And a strong hybridization signal was detected in the gills. After stimulation by three typical PAMPs, the relative expression of PmC1qDC-1 mRNA in the gills was significantly up-regulated. The recombinant protein PmC1qDC-1 can inhibit the growth of bacteria. These results indicate that PmC1qDC-1 can stimulate the immune response of *Pinctada martensii*.

**Key words: :** C1qDC; mollusks; *P. f. martensii*; immune response

# 青虾眼柄摘除后精巢转录组比较分析

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**摘要:** 本研究通过转录组比较分析筛选摘除青虾眼柄后, 参与青虾雄性发育机制的重要基因。组织学切片观察结果显示, 青虾眼柄摘除后, 精巢的发育明显增快。转录组比较分析结果显示, 溶酶体、凋亡、糖酵解/糖异生、胰岛素信号通路是所有三组比较中均主要富集的代谢通路。通过 qPCR、原位杂交和 RNAi 等技术对 Mn-NFkB $\alpha$  基因进行功能分析, 结果表明, Mn-NFkB $\alpha$  基因对青虾精巢发育具有正调控作用。

**关键词:** 青虾、眼柄摘除、精巢、雄性发育、NFkB $\alpha$  基因

## Transcriptome profiling analysis of testis after eyestalk ablation for selection the candidate genes involved in the male sexual development in *Macrobrachium nipponense*

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**Abstract :** The eyestalk of crustacean species secretes many hormones, affected the process of reproduction, molting, metabolism of glucose and other function in crustaceans. In this study, important metabolic pathways and candidate genes involved in the male sexual development were identified through performing the transcriptome profiling analysis of testis after the ablation of eyestalk from *Macrobrachium nipponense*. The histological observations revealed that the testis development became vigorous after eyestalk ablation, indicating the hormones secreted by the eyestalk have negative effects on the testis development in *M. nipponense*. Transcriptome profiling analysis revealed that Lysosome, Apoptosis, Glycolysis/Gluconeogenesis, and Insulin signaling pathway were the main enriched metabolic pathways in all of these three comparisons, and the important genes from these metabolic pathways were also selected. The qPCR verifications of 10 DEGs from these metabolic pathways were as the same as that of RNA-seq. The qPCR, in situ hybridization and RNAi analysis of Mn-NFkB $\alpha$  revealed that NFkB $\alpha$  has the positive regulatory effected on testis development. This study provided new insights on male sexual development in *M. nipponense*, promoting the studies on male sexual development in other crustacean as well.

**Key words: :** *Macrobrachium nipponense*; Eyestalk ablation; Testis; Male sexual development; NFkB $\alpha$

# 达氏鳊血细胞的组成、发生及吞噬功能研究

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**摘要：**利用 Wright's 染色技术，对达氏鳊外周血形态特征、血细胞发生进行观察，并通过吞噬实验分析其免疫功能。结果表明，达氏鳊外周血细胞由红细胞、血栓细胞和粒细胞等组成；其单核细胞体积最大，小淋巴细胞体积最小。红细胞，粒细胞和单核细胞主要在头肾和体肾中发生；淋巴细胞主要发生在脾脏，肝脏中未发现原始血细胞。达氏鳊血细胞具有吞噬功能，粒细胞和单核细胞具有黏附能力，这与达氏鳊自身的免疫功能有关。

**关键词：**达氏鳊，血细胞，显微结构，吞噬，发生

## Observational researches on peripheral blood cells and morphogenesis of haematopoietic cells in *Huso dauricus*

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**Abstract :** The morphologic features, hematopoiesis, and immune function were analyzed by phagocytosis assays in the peripheral blood of *Huso dauricus* using Wright's stain. The results showed that the peripheral blood cells of *Huso dauricus* were composed of erythrocytes, thrombocytes, lymphocytes, monocytes and granulocytes; Its monocytes have the largest volume and average size (long diameter  $\times$  Short diameter) is  $(13.10 \pm 1.56) \mu\text{m} \times (11.10 \pm 2.45) \mu\text{m}$ . The volume of small lymphocytes was the smallest, and the average size (long diameter  $\times$  Short diameter) is  $(7.31 \pm 1.21) \mu\text{m} \times (6.07 \pm 1.35) \mu\text{m}$ . The results of the blots showed that the main haematopoietic organs in *Huso dauricus* were head kidney, body kidney and spleen. Among them, cytogenesis of erythrocytes, granulocytes and monocytes occurred mainly in the head kidney and body kidney, lymphocytes occurred mainly in the spleen, and no hematopoietic cells were found in the liver. Phagocytosis trial showed that *Huso dauricus*' blood cells have phagocytic function, and the phagocytosis rate was  $(22.84 \pm 3.21)\%$ , granulocytes and thrombocyte have adhesion ability, which are related to the immune ability of *Huso dauricus*'s own.

**Key words::** *Huso dauricus*, blood cells, Microstructure, phagocytosis, Cytogenesis

# 全转录组分析揭示 lncRNA-miRNA-mRNA 在团头鲂肌间骨生长中的作用

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**摘要:** 肌间骨存在于硬骨鱼的肌隔中, 对鱼类食用和经济价值产生不利影响。在这项研究中, 我们使用三代全长技术和全转录组, 比较分析了 1 龄和 3 龄团头鲂肌间骨的表达谱。通过 KEGG 富集分析, 我们识别了 *map2k6*、*cytc*、*lama3* 和 *thbs4b* 可能在肌间骨生长中发挥关键调节作用。通过 ceRNA 网络分析, 我们鉴定和识别的 mRNAs、lncRNAs 和 miRNAs 为深入阐明团头鲂肌间骨的生长机制提供了数据。

**关键词:** 硬骨鱼, 肌间骨, 生长, 全转录组, RNA 互作

## Genome-Wide Integrated Analysis Revealed Functions of lncRNA-miRNA-mRNA Interaction in Growth of Intermuscular Bones in *Megalobrama amblycephala*

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**Abstract:** Intermuscular bone (IB) occurs in the myosepta of teleosts. Its existence has an adverse influence on the edible and economic value of fish. In this study, we firstly used single molecular real-time sequencing (SMRT) technology to improve the draft genome annotation and full characterization of the transcriptome for *Megalobrama amblycephala*. The lncRNA, miRNA, and mRNA expression profiles in two IB growth stages (1 and 3 years old) were compared through transcriptome and degradome analyses. KEGG analysis revealed that the significantly upregulated *map2k6* and *cytc* in the MAPK/p53 signaling pathway and the significantly downregulated *lama3* and *thbs4b* in the extracellular matrix (ECM)-receptor pathway may play a key regulatory role in IB growth. Bioinformatics analysis subsequently revealed 14 competing endogenous RNA (ceRNA) pairs related to the growth of IBs, consisting of 10 lncRNAs, 7 miRNAs, and 10 mRNAs. In conclusion, our data showed that IBs had higher activity of at the cell apoptosis and lower mineralization activity in IB\_III compared to IB\_I via interaction of MAPK/p53 and ECM-receptor signaling pathways. The downregulated *zip* interacted with miR-24a-3p and lnc017705, decreased osteoblast differentiation and Ca<sup>2+</sup> deposition in the IB\_III stage. Our identified functional mRNAs, lncRNAs, and miRNAs provide a data basis for in-depth elucidation of the growth mechanism of teleost IB.

**Key words:** teleost, intermuscular bones, growth, transcriptome profiling, RNA interaction



# 利用 2b-RAD 测序开发斑点蛇头的 SNP 标记并验证 66 个 SNP

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**摘要：**本研究基于 2b-RAD 简化基因组测序，共开发了 66 个新的单核苷酸多态性(SNP)标记。结果表明，观察到的杂合度( $H_o$ )和预期杂合度( $H_e$ )分别为 0.130~0.667 和 0.112~0.502。PIC 的分布范围为 0.116~0.375。经 Bonferroni 校正后，有两个位点与 HWE 有显著偏差( $p < 0.05$ )。这些 SNP 标记将作为旨在保护斑点蛇头的遗传研究和种群评估的有用工具。

**关键词：**黄斑辣椒，SNP，2b-RAD，基因改良

## Development of SNP markers and validation 66 SNPs in blotched snakehead (*Channa maculata*) using 2b-RAD sequencing

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**Abstract:** Blotched snakehead (*Channa maculata*) is an economically important aquaculture species in China and Southeast Asia, but wild blotched snakehead resources have declined sharply in recent years because of its overexploitation and habitat destruction. Thus, it is very urgent to develop genetic markers of blotched snakehead to investigate the natural resources. In this study, a total of 66 novel single nucleotide polymorphism (SNP) markers were developed based on 2b-RAD simplified genome sequencing. The results showed that the observed heterozygosity ( $H_o$ ) and expected heterozygosity ( $H_e$ ) ranged from 0.130 to 0.667 and 0.112 to 0.502, respectively. The PIC ranged from 0.116 to 0.375. Two loci showed significant deviations from the HWE after Bonferroni correction ( $p < 0.05$ ). These SNP markers will serve as a useful tool for genetic studies and population evaluation aimed at the conservation of blotched snakehead.

**Key words:** *Channa maculata*, SNP, 2b-RAD, Genetic improvement

# 转录组学分析 mRNA 和 lncRNA 调控半滑舌鳎繁殖的分子机制

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**摘要：**半滑舌鳎是我国重要的增养殖对象，具有较高经济价值。如何提高其繁殖效率，从而提高其经济效益一直备受关注。大量研究表明，长链非编码 RNA (lncRNA) 在生殖过程中发挥着重要的调控作用。本研究通过高通量测序，检测半滑舌鳎不同卵巢发育时期 (IV 期、V 期、VI 期) 的脑、垂体和卵巢的 mRNA 和 lncRNA 水平；筛选关键基因；并通过原位杂交共定位，双荧光素酶报告实验验证 lncRNA 及其靶基因的潜在调控关系。

**关键词：**半滑舌鳎，lncRNA，mRNA，转录组，繁殖

## Intergrated lncRNA and mRNA Transcriptome Analyses of *Cynoglossus semilaevis* Reveal Genes and Pathway Potentially Involved in Reproduction

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**Abstract:** Half-smooth tongue sole (*Cynoglossus semilaevis*) is one of the most economically marine flatfish widely cultured in China. However, its reproductive dysfunctions restrict the development of the tongue sole aquaculture industry. Long non-coding RNAs (lncRNAs) have been reported to be involved in multiple biological processes included reproduction. Here, we used transcriptome sequencing to explore mRNA and lncRNA expression profiles in tongue sole to understand the molecular regulating mechanisms of tongue sole reproduction. The interactions of DE lncRNAs and mRNAs were predicted according to antisense, cis-, and trans-regulatory mechanisms. We also constructed a competing endogenous RNA (ceRNA) network through correlation analysis. It was speculated that two lncRNAs (XR\_522278.2 and XR\_522171.2) and its target genes (cyp17a1 and cyp19a1) may have an impact during tongue sole reproduction. RT-qPCR showed that two lncRNAs were mainly expressed in the ovary. Dual-fluorescence in situ hybridization showed that both XR\_522278.2 and XR\_522171.2 co-localized with their target genes cyp17a1 and cyp19a1 in the follicular cell layer. Moreover, the result of dual luciferase assay showed that lncRNA TCONS\_00082419 has a binding site with miRNA novel-m0329-3p, which could be as a molecular sponge of cyp19a1, inhibiting cyp19a1 expression. In summary, this study provides mRNA and lncRNA expression profiles to explain the molecular regulating mechanisms regulating tongue sole reproduction.

**Key words:** *Cynoglossus semilaevis*, lncRNA, mRNA, reproduction, transcriptome

# 斑马鱼 ngs 基因突变对骨骼发育的影响

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**摘要:** 为探索 ngs 对肌间刺和主轴骨骼发育的影响, 经 RNA-FISH 证实了 ngs 与成骨细胞标志基因 sp7 在肌间刺和椎骨中共表达。利用 CRISPR/Cas9 构建 ngs 缺失突变体, 胚胎发育观察显示 ngs 缺失导致脊索发育异常, 72hpf 的 ngs<sup>-/-</sup> 胚胎体长显著低于野生型; 骨骼染色表明 ngs<sup>-/-</sup> 椎骨异常融合, 肌间刺数量显著少于野生型。qPCR 结果表明 ngs 缺失可能影响骨发育相关基因的表达影响肌间刺和椎骨发育。

**关键词:** 斑马鱼; ngs; RNA-FISH; CRISPR/Cas9; 骨骼发育; 肌间刺

## Effects of ngs mutation on skeletal development in zebrafish

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**Abstract:** To explore the effect of ngs on the development of intermuscular bones (IMB) and skeleton, we confirmed that ngs was co-expressed with the osteoblast signature gene sp7 in IMB and vertebrae using RNA fluorescence in situ hybridization (RNA-FISH). we then established ngs knockout strain in zebrafish by CRISPR/Cas9 gene-editing technology, and compared the embryonic development between ngs<sup>-/-</sup> and wild-type zebrafish. The results showed that the loss function of ngs caused abnormal development of the notochord in ngs<sup>-/-</sup>, and the body length of mutants at 72hpf was significantly lower than that of the wild-type zebrafish ( $P < 2.22 \times 10^{-16}$ ). Skeletal staining showed abnormal fusion of vertebrae in ngs<sup>-/-</sup>, and the number of IMB was significantly less than that in the wild type ( $P < 0.05$ ). The results of gene expression analyses indicated that ngs deficiency might cause abnormal development in vertebrae by affecting the expression of genes related to bone development during the embryonic stage, while the number of IMB might be affected by the expression of runx2a and runx2b genes in muscle during the postembryonic developmental stage.

**Key words:** zebrafish, ngs, RNA-FISH; CRISPR/Cas9; bone development; intermuscular bones

# 基于全基因组重测序的卵形鲳鲹耐低氧性状相关 SNP 分析

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**摘要：**为了挖掘与卵形鲳鲹耐低氧性状显著相关的 SNP 位点，本研究对卵形鲳鲹养殖群体进行低氧胁迫实验，以存活时间为指标对低氧耐受和敏感的个体进行全基因组重测序。通过 GWAS 分析，筛选到了 4 个与耐缺氧性状显著相关的 SNP，在显著 SNP 位点上下游 50kb 的范围内筛选到了 16 个与耐低氧性状相关的候选基因，并在扩大群体中验证了显著 SNP 的可靠性。本研究筛选的显著 SNP 可用于卵形鲳鲹耐低氧性状的分子标记辅助育种。

**关键词：**卵形鲳鲹、耐低氧性状、全基因组关联分析（GWAS）

## SNP analysis of golden pompano (*Trachinotus ovatus*) resistance hypoxia based on re-sequencing

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**Abstract :** Hypoxia tolerance is an essential trait of golden pompano (*Trachinotus ovatus*). To excavate SNPs that are significantly related to hypoxic tolerance of *T.ovatus*, this study conducted a hypoxic stress experiment, and the Whole Genome re-sequenced the hypoxic tolerant and sensitive individuals using the survival time as an index. By GWAS, four significant SNPs were identified to be suggestively significantly associated with the hypoxia tolerance trait. In the 50 kb window surrounding the suggestive SNPs, 16 potential candidate genes affecting hypoxia tolerance trait were detected. Moreover, validation results of the screened significant loci in the large population were consistent with the results of the GWAS. This study can be used in molecular marking assistance for *T. ovatus* to hypoxia tolerance trait.

**Key words::** *Trachinotus ovatus*、hypoxia tolerance trait、Genome-wide association study

# 比较转录组学分析揭示了黄喉拟水龟的性腺发育相关基因对环境温度的反应

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**摘要:** 黄喉拟水龟表现出温度依赖性性别决定。而其性别决定/分化的机制仍然是个谜。我们转录组分析了黄喉拟水龟在性腺形成之前的温度特异性性腺和热敏感期的性腺。发现了一系列响应温度刺激的候选基因。在性发育相关基因的表达谱中发现了显著差异。还分析了其与红耳龟和西部锦龟基因表达时间过程的相似性和差异。因此, 我们的研究结果可提供基础数据来阐明黄喉拟水龟的性别决定/分化机制, 有助于了解其他 TSD 龟的这些机制。

**关键词:** 温度依赖性性别决定, 海龟, 比较转录组, RNA-seq, 性腺发育

## Comparative transcriptomic analysis reveals the gonadal development-related gene response to environmental temperature in *Mauremys mutica*

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**Abstract:** The Asian yellow pond turtle (*Mauremys mutica*) displays temperature-dependent sex determination (TSD), in which incubation temperature during embryonic development determines the sexual fate of the individual. However, the mechanism of the sex determination/differentiation of *Mauremys mutica* remains a mystery. Here, we first analyzed the temperature-specific gonadal transcriptomes of *Mauremys mutica* prior to gonad formation and gonads during the thermosensitive period. We uncovered a list of candidates that respond to temperature stimuli enriched in several categories, such as heat shock protein family members *dnajb6a*, *dnaja4*, *hspa8* and *hsp90aa1*, temperature sensor genes *mmp17* and *mmp28*, and putative novel temperature-responsive genes *tmco6*, *gria3* and *eif3f*. Notably, striking differences were identified in the expression profiles of genes underlying sexual development, such as *tex15*, *insr*, *igflr*, *cirbp*, *esr1*, *dmrt2* and *Serpinh1*. Moreover, we analyzed the similarity and divergence of the timecourse of gene expression among *Mauremys mutica* and two other reported TSD turtles (*Trachemys scripta* and *Chrysemys picta*). The shared genes revealed the common gonad-specific regulatory mechanisms existing in these three TSD turtles that initiate their sexual development. Therefore, our findings could provide basic data to elucidate the mechanisms of sex determination/differentiation of *M. mutica*, even contributing to further understanding of these mechanisms in other TSD turtles.

**Key words:** Temperature-dependent sex determination, Turtles, Comparative transcriptome, RNA-seq, Gonadal development

# 草鱼全基因组微卫星特征分析与亲子鉴定

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**摘要：**草鱼是我国重要的淡水养殖品种，开发其高多态性微卫星标记亲子鉴定平台具有重要实践意义。本研究利用已有的草鱼全基因组开发高度多态性微卫星标记。在草鱼 900Mb 基因组序列中共筛选到微卫星序列 677363 个，占全基因组长度的 1.43%。随机挑选 4~6 个碱基重复的 110 个位点设计引物，通过多态性筛选出 15 对，在 20 个家系中进行亲子鉴定验证，准确率达到 100%。

**关键词：**草鱼；全基因组；微卫星；亲子鉴定

## The analysis of microsatellite in grass carp (*Ctenopharyngodon idella*) genome and the application in parentage identification

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**Abstract:** *Ctenopharyngodon idella* is the most productive freshwater aquaculture species in China, developing molecular marker assisted breeding program for *C. idella* has important practical significance. In this study, microsatellite loci were mined based on whole genome sequences of *C. idella* and the distribution characteristics of the loci were analyzed. In the meantime, microsatellite markers with 4-6 bases repeats with high polymorphism and high accuracy of paternity test were developed. The results showed that 677363 microsatellite sequences are found in the 900Mb genome sequence of *C. idella*, accounting for 1.43% of the whole genome length. The 110 loci with 4-6 base repeats were randomly selected and primers were designed and 15 loci showed high polymorphism. These 15 loci were used to identify 20 families, all offspring matched to the correct parents successfully. In this study we analyzed the microsatellite characteristics of *C. idella*, screened out highly polymorphic microsatellite markers with 4-6 base repeats and achieving parental identification of *C. idella* by using these highly polymorphic microsatellite loci.

**Key words:** *Ctenopharyngodon idella*; genome; microsatellite; parentage identification

# 葛氏长臂虾急性高温响应基因和途径的转录组分析

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**摘要:** 葛氏长臂虾是中国东海和黄海南部的主要经济虾类之一, 目前主要来自于捕捞, 因其不耐受高温, 规模化养殖尚未成功。因此, 研究急性高温对葛氏长臂虾的影响尤为重要。本研究采用急性高温应激处理, 取三个时间点的虾肝胰腺并提取 RNA 进行转录组分析。结果表明, 急性高温显著降低了对虾的代谢能力, 但提高了对虾的免疫能力, 这可能是一种应急代谢补偿方式。本研究为研究葛氏长臂虾对急性高温反应的生理机制做出了贡献。

**关键词:** 葛氏长臂虾, 转录组, 急性高温, 代谢, 免疫

## Transcriptome analysis of acute high temperature-responsive genes and pathways in *Palaemon gravieri*

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**Abstract:** Temperature is a variable and important factor in aquaculture, and it could affect health, survival, behavior, growth and development of aquatic animals. *Palaemon gravieri* is one of the main economic shrimps in marine capture fisheries of the East China Sea and the South China Yellow Sea, but cannot tolerate high temperature lead to its large-scale farming has not yet succeeded. Therefore, it is very important to study the effects of temperature fluctuations, especially acute high temperature on *P. gravieri*. Up to now, there are few studies on the effects of acute high temperature on *P. gravieri*. In this study, *P. gravieri* were treated with acute high temperature stress, and hepatopancreas of shrimps from three time points during high temperature stress were removed under anesthesia, then RNA was extracted from hepatopancreas for transcriptome analysis. A total of 18,308 unigenes were annotated, of which 7744 were differentially expressed. Most differentially expressed genes (DEGs) basically come from several physiological and biochemical processes, such as metabolism, immunity, and stress-related process. The results indicated that acute high temperature significantly reduced the metabolic capacity of shrimp but enhanced the immune capacity, which seemed to be an emergency metabolic compensation way to resist stress. This study made contributions to the research on the physiological mechanism of *P. gravieri* response to acute high temperature.

**Key words:** *Palaemon gravieri*, Transcriptome, Acute high temperature, Metabolism, Immunity

# 斑节对虾 DMRT11E 的分子特征和功能分析

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**摘要：**DMRTs (Doublesex 和 Mab-3 相关转录因子) 作为一个高度保守的转录因子家族，参与了众多动物的性别决定和性分化。在本研究中，我们在斑节对虾中发现了一个 DM (Doublesex/ Mab-3) 域的基因，我们将其命名为 PmDMRT11E，因为它与来自不同物种的 DMRT11E 同源物有许多相似之处和系统发育上的密切关系。三维结构和氨基酸比对表明 DM 结构域的稳定性和保存性。实时 PCR 分析表明 PmDMRT11E 在睾丸中高表达，并在成熟睾丸中优先表达。

**关键词：**斑节对虾；DMRT11E；DM 域；性别分化；RNA 干扰

## Molecular characterization and functional analysis of DMRT11E in Black tiger shrimp (*Penaeus monodon*)

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**Abstract :** DMRTs (Doublesex and Mab-3-related transcription factors) are involved in sex determination and sexual differentiation in numerous animals as a highly conserved transcription factor family. In the present study, we identified a DM (Doublesex/ Mab-3)-domain gene in *Penaeus monodon*, which we named PmDMRT11E because it has many similarities to and phylogenetically close relationships with DMRT11E homologues from different species. Three-dimensional structure and amino acid alignments indicating the stability and conservation of the DM domain. Real-time PCR analysis showed that the PmDMRT11E was highly expressed in the testis, and preferentially expressed in mature testis. During embryogenesis, the expression level of PmDMRT11E was higher at the nauplius than at other periods. PmDMRT11E dsRNA injection induced a significant decrease of transcription factor Sox9 and increased ovarian marker Foxl2 expression, implying an important regulatory gene in the mechanism of male determination. Meanwhile dsDMRT11E leads to abnormal sperm development, indicating PmDMRT11E may be closely related to gonad development and spermatogenesis.

**Key words:** *Penaeus monodon*, DMRT11E, DM domain, Sexual differentiation, RNA interference



# 黄鳝高效基因组编辑技术和人工诱导雌核发育技术的建立

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**摘要:** 苗种短缺和新品种缺乏是制约黄鳝养殖业的瓶颈。黄鳝由雌到雄的性反转特性是造成苗种短缺的主要原因。我们建立了成熟的实验室条件下的黄鳝全人工繁殖技术, 进而建立了高效黄鳝基因组编辑技术和人工诱导减数和有丝分裂雌核发育技术。获得了 *dmrt1* 和 *dnd* 等基因的突变体, 发现黄鳝的初始性别分化受到原始生殖细胞数量的影响。获得了一批雌核发育黄鳝新种质, 并已经用于全基因组图谱绘制和育种实践等黄鳝遗传育种基础和应用研究。

**关键词:** 黄鳝; 性反转; 全人工繁殖; 基因组编辑; 雌核发育

## High Efficient Genome Editing and Artificial Gynogenesis in *Monopterus albus*

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**Abstract:** The shortage of seedling and new varieties are the bottleneck of rice field eel farming. The characteristic feature of sex reversal from female to male is the main reason for the shortage of seedlings. We first established maturely artificial reproduction technology in rice field eel under laboratory conditions, and then established the genome editing technology and artificial gynogenesis technology, including meiosis and mitotic gynogenesis. Mutants of *dmrt1*, *dnd* and other genes were obtained, and found that the primary sex differentiation of rice field eel was affected by the number of primordial germ cells. We also obtained some gynogenetic diploids germplasm, which have been used for the construction of genome mapping and genetic breeding research in rice field eel.

**Key words:** *Monopterus albus*; sex reversal; artificial reproduction; genome editing; gynogenesis

# 仿刺参响应灿烂弧菌胁迫差异 microRNAs 及转录组关联分析

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**摘要：**刺参是我国海水养殖的重要经济物种，目前养殖过程中面临病害频发等重大问题，而其病害发生的分子机制尚待进一步完善。本研究以灿烂弧菌为胁迫菌株，采用高通量测序技术对侵染组和健康组各 3 头刺参的体壁组织进行 miRNA 测序和转录组测序，通过生物信息学软件对 miRNAs 进行鉴定和分析，筛选差异表达 miRNAs 和差异表达 mRNAs，并构建关键 miRNA-mRNA 调控网络，为揭示刺参响应病原胁迫提供科学数据。

**关键词：**仿刺参；microRNA；灿烂弧菌；靶基因；miRNA-mRNA 调控网络

## Correlation analysis of differential microRNAs and transcriptome of *Apostichopus japonicus* in response to *Vibrio splendidus* Infection.

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**Abstract:** As an important economic species of marine aquaculture in our country, sea cucumbers (*Apostichopus japonicus*) are currently facing major problems such as frequent occurrence of diseases in the breeding process. The molecular mechanism of disease occurrence needs to be further improved. In this study, *Vibrios splendidus*, was used as the stress strain. MiRNA-seq technology and transcriptome-seq were used to sequence the body walls of healthy and diseased sea cucumbers after the stress of *V. splendidus*. The differential expression miRNAs (DEmiRNAs) and differential expression genes (DEGs) were identified and analyzed through relevant bioinformatics software and constructing the key miRNA-mRNA regulatory network, provide scientific data for revealing that sea cucumber responds to *V. splendidus* stress.

**Key words::** *Apostichopus japonicus*, microRNA, *Vibrios splendidus*, Target genes, miRNA-mRNA network

# FGFs-FGFR4 对花鲈骨骼肌细胞增殖、 分化的功能研究

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**摘要:** 骨骼肌的生长发育对鱼类躯体的生长起决定性作用。课题组前期结果显示, FGFR4 为调控生长的重要候选功能基因, 可能通过调控骨骼肌细胞增殖分化过程进而影响生长。本研究筛选了作用于花鲈肌细胞的潜在 FGFs 配体, 原核表达获得了 FGFs 重组蛋白, 并检测肌细胞标志基因的表达变化, 分析了 FGFs-FGFR4 对体外培养的骨骼肌原代细胞增殖、分化的影响。本研究为阐明 FGFs-FGFR4 对鱼类的生长调控机制奠定了基础。

**关键词:** 花鲈; FGFs-FGFR4; 骨骼肌细胞; 增殖分化

## Effects of FGFs-FGFR4 on proliferation and differentiation of skeletal muscle cells of *Lateolabrax maculatus*

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**Abstract:** The growth and development of skeletal muscle plays a decisive role in the growth of fish body. The previous results of the research group showed that FGFR4 is an important candidate functional gene for regulating growth, which may affect growth by regulating the proliferation and differentiation of skeletal muscle cells. In this study, the potential FGFs ligands acting on the muscle cells of *Lateolabrax maculatus* were screened, the recombinant FGFs protein was obtained by prokaryotic expression, the expression changes of muscle cell marker genes were detected, and the effects of FGFs-FGFR4 on the proliferation and differentiation of skeletal muscle primary cells in vitro were analyzed. This study laid a foundation for clarifying the growth regulation mechanism of FGFs-FGFR4 on fish.

**Key words:** : *Lateolabrax maculatus*; FGFs-FGFR4; Skeletal muscle cells; proliferation and differentiation

# 花鲈鳃离子细胞异质性的初步研究

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**摘要:** 鳃是硬骨鱼类最主要的渗透压调节器官之一, 鳃上皮离子细胞是核心渗透调节位点, 具有明显的异质性。本研究以广盐性花鲈为研究对象, 通过组织学揭示了鳃组织在海、淡水适应过程中的显微结构变化; 利用 qPCR、原位杂交、免疫组化等手段, 对海、淡水适应过程中的离子细胞的重要标记基因 NKA、NKCC、NHE3、CFTR 的表达量及分布特征进行检测, 鉴定出花鲈主要的海水和淡水型离子细胞, 并对 NKA 不同亚型的选择进行区分。

**关键词:** 花鲈; 鳃; 离子细胞; 原位杂交; 免疫组化

## A preliminary study on the heterogeneity of gill ionocyte of spotted sea bass (*Lateolabrax maculatus*)

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**Abstract:** Gill is one of the most important osmotic regulating organs of teleosts, and the epithelial ionocyte of the gill are the core osmotic regulating sites, which have obvious heterogeneity. In this study, the microstructural changes of gill tissues of spotted sea bass during adaptation to sea and fresh water were revealed by histology. qPCR, in situ hybridization and immunohistochemistry were used to detect the expression levels and distribution characteristics of NKA, NKCC, NHE3 and CFTR, which are important marker genes of sea and fresh water adaptation process. The main sea and fresh water ion cells of spotted sea bass were identified, and the selection of different NKA subtypes was differentiated.

**Key words:** *Lateolabrax maculatus*; gill; ionocyte; in situ hybridization; immunohistochemistry

# Keap1/Nrf2 (MafG) - GST 信号通路在牙鲆抗氧化代谢中发挥重要作用

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**摘要：** Nrf2 在牙鲆中如何发挥抗氧化作用尚不明确。本研究发现急性低氧胁迫引起牙鲆氧化因子指标（MDA、T-AOC、GSH、GST、SOD、CAT）、Nrf2 甲基化水平、Nrf2 与 GST 表达量变化。经双荧光素酶报告实验发现，Nrf2 可作为转录因子结合 GST 基因的启动子激活其表达，MafG 与 Keap1 分别是 Nrf2 的协同与拮抗因子。这表明，牙鲆通过表观遗传修饰改变与转录激活抗氧化信号通路对低氧胁迫做出响应。

**关键词：** 抗氧化信号通路，Nrf2，甲基化，转录调控

## (4) Keap1 / Nrf2 (mafG) - GST signaling pathway plays an important role in antioxidant metabolism of Japanese flounder (*Paralichthys olivaceus*)

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**Abstract:** The antioxidant role of Nrf2 in Japanese flounder (*Paralichthys olivaceus*) is not very clear. Our study found that acute hypoxia stress caused changes in oxidative factor indexes (MDA, T-AOC, GSH, GST, SOD, CAT), Nrf2 gene methylation level, Nrf2 and GST expression of Japanese flounder. As a transcription factor, Nrf2 could activated its target gene (GST) expression by combing antioxidant response element (ARE) near -980 and -852 sites in GST gene promoter using dual-luciferase reporter assay. Meanwhile, we found that MafG and Keap1 were the synergistic and antagonistic factors of Nrf2, respectively. These suggested that Japanese flounder responded to acute hypoxia stress by epigenetic modification and transcriptional activation of Keap1/Nrf2 (MafG) - GST pathway.

**Key words::** Antioxidant signaling pathway, Nrf2, methylation, transcriptional regulation

# 光照对红鳍东方鲀稚鱼摄食的影响

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**摘要:** 试验测量了红鳍东方鲀稚鱼在不同光照强度下的摄食量。结果表明, 在 400lx 时稚鱼摄食量达到最高, 随着光照强度的降低, 在 1000~400lx 时, 摄食量总体呈现上升趋势; 在 400~100lx 时, 摄食量呈现下降趋势。在 400 lx 时, 摄食率和摄食效率均随时间延长逐渐下降; 在 1000、700、100lx 时, 随着时间的延长摄食率和摄食效率均呈现出先上升后下降的趋势。

**关键词:** 光照强度; 红鳍东方鲀; 稚鱼; 摄食

## Effects of illuminances on the Feeding of Takifugu rubripes

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**Abstract:** The feeding amount of Takifugu rubripes under different illuminances were measured. The results showed that the highest feeding was observed under 400 lx, and the feeding showed an upward trend at 1 000 ~ 400 lx with the decrease of illuminance. For 400 ~ 100 lx, the feeding showed a downward trend. At 400 lx, the feeding rate and feeding efficiency decreased gradually with the time prolonging. At 1 000, 700 lx and 100 lx, feeding rate and feeding efficiency both showed a upward and then downward tendency with the extension of time.

**Key words:** illuminance; Takifugu rubripes; juvenile; feeding

# 急性低氧胁迫对黄条鰺肝脏抗氧化能力的影响

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**摘要:** 为探讨黄条鰺在急性低氧胁迫下的应激响应机制, 本实验通过药物调节水中溶解氧在  $(2\pm 0.2)$  mg/L 范围内进行低氧胁迫 0 (对照组)、2、4、6 h, 分析其肝脏中氧化应激指标变化。结果显示, 急性低氧胁迫后, 黄条鰺肝脏中总超氧化物歧化酶活性显著降低 ( $P<0.05$ ); 过氧化氢酶活性显著升高 ( $P<0.05$ ); 总抗氧化能力随时间变化呈现先下降后升高的趋势; 酸性磷酸酶和碱性磷酸酶则都呈现先升高后下降的趋势。

**关键词:** 黄条鰺; 低氧胁迫; 抗氧化酶; 代谢相关酶; 应激响应机制

## Effects of acute hypoxia stress on antioxidant capacity of liver of *Seriola lalandi*

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**Abstract:** In order to explore the stress response mechanism of *Seriola lalandi* under acute hypoxic stress, in this experiment, the changes of oxidative stress index in liver were analyzed by adjusting dissolved oxygen in water  $(2\pm 0.2)$  mg/L for 0 (control group), 2, 4 and 6 h under hypoxia stress. The results showed that the activity of total superoxide dismutase in liver of *Seriola lalandi* was significantly decreased after acute hypoxia stress ( $P<0.05$ ). Catalase activity was significantly increased ( $P<0.05$ ), and the total antioxidant capacity decreased firstly and then increased with time. Acid phosphatase and alkaline phosphatase were first rise after the fall of trends.

**Key words:** *Seriola lalandi*, Hypoxia stress, Antioxidant enzymes, Metabolism-related enzymes, Stress response mechanism

# 不同低氧条件下洛氏鲮组织及生理学研究

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**摘要:** 为探究不同低氧处理对洛氏鲮 (*Phoxinus lagowskii*) 组织及生理的影响, 采集常氧、持续低氧和昼夜循环低氧下鱼的血液、肝和鳃进行血液测定、形态观察、糖脂代谢以及相关基因表达的研究。结果显示, 不同低氧处理 10 天后, 洛氏鲮血液携氧能力增强, 鳃形态重塑, 肝细胞质空泡化, 肝脏中糖脂代谢酶及相关基因的表达发生变化。本研究为研究鱼类对不同类型低氧的响应提供了一种新的方法。

**关键词:** 洛氏鲮; 组织学; 血液参数; 酶活性; 基因表达

## Histological and physiological study of *Phoxinus lagowskii* under different hypoxia conditions

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**Abstract:** In order to explore the effects of different hypoxia treatments on the tissue and physiology of *Phoxinus lagowskii*, the blood, liver and gills of fish under normoxia, sustained hypoxia and diel-cycling hypoxia were collected for blood determination, morphological observation, glucose and lipid metabolism and related gene expression. The results showed that after 10 days of different hypoxia treatment, the oxygen carrying capacity of blood was enhanced, the morphology of gill was remodeled, the cytoplasm of liver was vacuolated, and the expression of glycolipid metabolizing enzymes and related genes in liver were changed. This study provides a new method to study the response of fish to different types of hypoxia.

**Key words:** : *Phoxinus lagowskii* ; Histology ; Blood parameters ; Enzyme activity ; Gene expression



# 低氧胁迫对瘤背石磺生理生化和免疫的影响

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**摘要:** 在潮间带这个复杂多变的环境中, 低氧是威胁海洋生物生存的一个重要因素。如今对潮间带生物在低氧胁迫下的应激机制研究极少。本文以瘤背石磺为对象探究了在不同时间低氧胁迫下血清和肝脏组织中生理生化、抗氧化酶和免疫酶活性。结果显示, 相对于对照组, 血清和肝脏中血糖、乳酸、抗氧化酶和免疫酶活性均显著升高, 且与时间呈正相关性。我们的结果将为探究低氧胁迫下潮间带动物的生理和免疫机制提供了一定的参考价值。

**关键词:** 低氧胁迫; 瘤背石磺; 潮间带; 抗氧化; 免疫

## Effects of hypoxia stress on physiology, biochemistry and immunity of tumor back brimstone

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**Abstract:** In the complex and changeable environment of the intertidal zone, hypoxia is an important factor that threatens the survival of marine life. Nowadays, there is very little research on the stress mechanism of intertidal organisms under hypoxic stress. In this study, the research on the physiological and biochemical, antioxidant enzymes and immune enzyme activities in serum and liver tissues under different periods of hypoxia stress is taken as the object. The results showed that compared with the control group, blood glucose, lactic acid, antioxidant enzymes and immune enzyme activities in serum and liver were significantly increased, and there was a positive correlation with time. Our results will provide a certain reference value for exploring the physiological and immune mechanisms of intertidal animals under hypoxia stress.

**Key words:** Hypoxia stress, *Onchidium reveesii*, Intertidal zone, Antioxidation, Immunity

# 热应激虹鳟的膳食纳米硒补充剂：对组织结构、脂质变化、非特异性免疫、热休克蛋白和抗氧化酶基因表达的影响

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**摘要：**纳米硒作为虹鳟抗热应激的自由基清除剂，将在不利的环境应激源中更加突显独特优势。因此，本研究通过添加不同水平纳米硒(0、5、10 mg/kg) 在热应激（24°C）前后不同处理时间，比较了虹鳟肝脏组织结构、脂质变化、非特异性免疫和基因表达的动态变化。结果表明，添加 5 mg/kg 纳米硒可有效缓解热应激，热应激 8 h 可作为研究虹鳟抗高温调控的“关键时间点”。本研究结果旨在为虹鳟抗热应激提供理论与实践指导。

**关键词：**虹鳟, 热应激, 纳米硒, 组织结构, 非特异性免疫, 基因表达

## Dietary Nanoselenium Supplementation for Heat-stressed Rainbow Trout: Effects on Organizational Structure, Lipid Changes, Nonspecific Immunity, Heat Shock Protein, and Antioxidant Enzyme Gene Expression

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**Abstract :** Nanoselenium shows unique protective effects against environmental heat stress in rainbow trout as a free radical scavenger. Accordingly, we investigated the effects of supplementation with different levels of Nano-Se (0, 5, and 10 mg/kg) for 9 days and before and after heat stress (24°C) for different treatment times on the dynamic changes of rainbow trout liver tissue structure, lipid changes, nonspecific immunity, and gene expression. The results showed that, under heat stress, the fish supplementation 5 mg/kg Nano-Se effectively alleviates stress damage in rainbow trout. Furthermore, stress at 24°C for 8 h can be thought of as a critical time point for the study of heat stress in rainbow trout, with significant changes in response but no serious damage. Thus, these results provide theoretical and practical guidance for protecting rainbow trout against heat stress.

**Key words: :** Rainbow trout, Heat stress, Nanoselenium, Organizational structure, Nonspecific immunity, Gene expression

# Somatostatin 1 在斑马鱼早期发育过程中表达定位及对葡萄糖刺激的表达反应

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**摘要:** 生长抑素(Somatostatin, ss)是脊椎动物生长发育调控中一种重要的多肽类激素,影响脊椎动物的生长、发育、繁殖和代谢等方面。斑马鱼(*Danio rerio*)中共有6种生长抑素基因(ss1-ss6),这些基因对斑马鱼糖代谢调控作用还鲜有报道。在本研究中,我们以最古老与保守的ss1基因为切入点,首先通过原位杂交技术发现在斑马鱼早期发育过程中,ss1在脑部、神经元及胰腺处均有表达。

**关键词:** 生长抑素, 糖代谢, 表达定位, 斑马鱼

## Somatostatin 1 expression localization and response to glucose stimulation in zebrafish during early development

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**Abstract:** Somatostatin (ss) is a type of peptides involved in the regulation of growth, metabolism, development and reproduction in vertebrate. There are six gene locis located in the fish genome, and all six genes are existed in zebrafish. However, the function of Somatostatin was rarely reported in zebrafish. Therefore, we firstly employed in situ hybridization to detect expression pattern of ss1 in the early embryonic development stage of zebrafish, and found that ss1 expressed abundantly in brain, neuron and the pancreas during all the examined developmental stage from 24hpf to 144hpf. Its persistent expression pattern in the pancreas during the early developmental stage lead us to hypothesize that ss1 may be involved into the glucose metabolism regulation. Then we exposed 5dpf zebrafish larva to different concentrations of glucose, and found that ss1 mRNA expression level was positive correlation with the concentration of glucose, and peaked at 5mg/ml exposure. This results confirmed the hypothesis that ss1 is involved into the regulation of glucose metabolism in the early developmental stage of zebrafish, and provide a preliminary insight into the function and mechanism of ss1 in the glucose homeostasis.

**Key words::** Somatostatin, Glucose metabolism, Expression localization, Zebrafish

# 深渊端足目 *Alicellagigantea* 的适应性进化和巨大化机制

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**摘要:** 深渊海沟中的 *Alicella gigantea* 的是目前已知最大的端足目。本研究以浅水端足目为背景, 对 *A.gigantea* 和 *Bathycallisoma schellenbergi* 做转录组分析, 发现这两种深渊端足目的正选择基因与饥饿反应、甘油脂代谢和减数分裂等有关。本研究还以小体型端足目为背景, 本研究还以小体型端足目为背景, 发现 *A. gigantea* 的正选择基因都与生长增殖相关, 这可能是其巨大化机制与生长和增殖有关。

**关键词:** 深渊, 端足目, *Alicella gigantea*, 巨大化, 正选择基因

## The adaptive evolution and gigantism mechanisms of the hadal "supergiant" amphipod *Alicella gigantea*

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**Abstract:** Hadal trenches are the deepest areas in the ocean, with harsh conditions such as high hydrostatic pressures and low temperature. Amphipods are common in this extreme environment, among which *Alicella gigantea* is the largest known amphipod. No studies have explored the adaptive evolution and mechanisms of "supergiant" amphipod *A. gigantea*. In this study, we conducted transcriptome analysis of *Alicella gigantea* and *Bathycallisoma schellenbergi*, and explored pathways associated with their positive selection genes. We found that the positive selection genes of *Alicella gigantea* and *Bathycallisoma Schellenbergi* were associated with response to starvation, glycerolipid metabolism and meiosis. This reflects the adaptive evolutionary strategy of hadal amphipods in hadal environment where food is scarce and pressure is high. This study also explored the mechanism of *A. gigantea* gigantism in the context of small-sized amphipods, and found that all positive selection genes of *A. gigantea* were related to growth and proliferation, which may be the cause of *A. gigantea* gigantism. This study provides a reference for exploring the mechanisms of adaptive evolution and gigantism in hadal species.

**Key words::** hadal, amphipod, *Alicella gigantea*, gigantism, positively selected gene.

# 急性缺氧条件下牙鲆肌肉中 STAT3 和 VEGF 启动子 DNA 甲基化的生化变化及免疫相关性

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**摘要:** 急性低氧会引起鱼类免疫反应, 对免疫相关基因 STAT3 和 VEGF 进行研究。原位杂交结果显示 STAT3 和 VEGF 基因在肌肉中共表达。低氧 3h 和 6h 对牙鲆肌肉有较大影响, 主要表现在两基因表达量和 LDH、ALT、AST 活性的显著上升和 ALP 活性的显著下降。进一步研究发现不同低氧条件下 STAT3 的 5'UTR 和 VEGF 启动子区甲基化水平和基因表达量呈负相关, 表明低氧可能通过改变基因的甲基化水平改变基因表达量。

**关键词:** 低氧、肌肉免疫、DNA 甲基化、生理变化、牙鲆

## Biochemical changes and immune correlates of STAT3 and VEGF promoter DNA methylation in muscle of Japanese flounder under acute hypoxia

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**Abstract:** Acute hypoxia can cause immune response in fish, and immune-related genes STAT3 and VEGF were studied. We carried out the effect of signal transducer and activator of transcription3(STAT3) and vascular endothelial growth factor(VEGF) on muscle immune of Japanese flounder (*Paralichthys olicvaceus*) during acute hypoxia stimulation ( $1.65\pm 0.28\text{mg/L O}_2$ ; 3 h, 6 h, 12 h, 24 h) and reoxygenation ( $7.30\pm 0.40\text{mg/L O}_2$ ; R12 h, R24 h, R48 h). In situ hybridization showed that STAT3 and VEGF genes were co-expressed in muscle. Hypoxia at 3h and 6h had a significant effect on the muscle of Flounder, mainly in the expression of two genes and LDH, ALP, AST activity significantly increased and ALP activity significantly decreased. Further studies found that methylation levels in STAT3's 5'UTR and VEGF promoter regions were negatively correlated with gene expression levels under different hypoxia conditions, suggesting that hypoxia may alter gene expression levels by altering gene methylation levels.

**Key words:** Hypoxia stress, Muscle immunity, DNA methylation, Biochemical changes, Japanese flounder

# kdm4aa 敲除对斑马鱼生殖和发育的影响

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**摘要:** 我们通过 CRISPR-Cas9 技术获得了 kdm4aa 基因敲除的斑马鱼品系。研究发现 kdm4aa(-/-)♀ 与 kdm4aa(-/-)♂ 成鱼交配后的胚胎 24h 内存活率仅为 21%, kdm4aa(-/-)♀ 与 WT♂、WT♀ 与 kdm4aa(-/-)♂ 成鱼交配后的胚胎 24h 内存活率分别为 30%、87.2%, 说明 kdm4aa 主要通过卵子影响胚胎发育。

**关键词:** kdm4aa; 斑马鱼; 基因敲除; RNA-seq; 发育

## Effects of kdm4aa knockout on reproduction and development of zebrafish

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**Abstract:** Lysine-specific demethylase 4A (KDM4A) specifically catalyzes demethylation of histone lysine residues, which regulates the chromatin structure and gene transcription. KDM4A was reported playing an important role in regulating growth, aging, metabolism, immunity and some other aspects in drosophila and mice, but the roles of KDM4A in fish are still unclear. There are two gene copies of KDM4A in zebrafish, namely kdm4aa and kdm4ab. We knocked out the kdm4aa gene by CRISPR-Cas9 technology in zebrafish and obtained kdm4aa knock-out (kdm4aa(-/-)) zebrafish strains. No obvious abnormalities in embryo production and fertilization was observed in kdm4aa(-/-) zebrafish, but the survival rate of the embryos was only 21% within 24h after pairing between kdm4aa(-/-)♀ and kdm4aa(-/-)♂, indicating that kdm4aa is indispensable for zebrafish embryo development. Further studies showed that the survival rates of embryos within 24h after pairing between kdm4aa(-/-)♀/WT♂ and WT♀/kdm4aa(-/-)♂ are 30% and 87.2%, respectively, indicating that kdm4aa mainly affected embryo development through ovum. In addition, compared with WT juvenile fish, the movement distance and activity of kdm4aa(-/-) juvenile fish increased. Meanwhile, RNA-seq revealed that had grate significant changes of the expression levels of many visual and mitochondria related genes in kdm4aa(-/-) juvenile fish. Taken together, this study preliminarily proved that kdm4aa is an essential element in reproduction and development of zebrafish.

**Key words:** kdm4aa, zebrafish, gene knock-out, RNA-seq, development

# 低温胁迫下斑马鱼 HDAC8 的生物学功能研究

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**摘要:** 为了研究鱼类低温胁迫下 HDAC8 的功能, 我们利用 CRISPR/Cas9 基因编辑技术获得了缺失 41 个碱基对的 *hdac8* 基因敲除的斑马鱼品系; 利用动物运动轨迹跟踪系统, 对 WT 和 *hdac8(-/-)* 幼鱼进行低温胁迫处理 (18°C) 后发现, 与常温条件下相比, WT 和 *hdac8(-/-)* 幼鱼的运动总距离、平均速度、活动性均显著性降低 ( $P<0.05$ )。低温处理条件下 *hdac8(-/-)* 幼鱼降低更为显著。

**关键词:** 关键词: HDAC8; 斑马鱼; 基因敲除; 低温

## Study on the Role of Zebrafish HDAC8 under Low Temperature Pressure

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**Abstract:** In order to explore the function of HDAC8 in fish under low temperature pressure, a Cas9 target was designed on the third exon of the zebrafish *hdac8* gene using CRISPR/Cas9 gene editing technology. And we obtained a zebrafish strain with a deletion of 41 base pairs (bp) in *hdac8*; the subcellular distribution of HDAC8 was detected by immunofluorescence technology, and the results showed that HDAC8 is distributed in both nucleus and cytoplasm; After separation of nuclear protein and cytoplasmic protein, Western Blot results further confirm that the expression of HDAC8 in the cytoplasm is higher than that in the nucleus; Behavioral tests of the 12dpf wild-type zebrafish and *hdac8(-/-)* zebrafish were performed and recorded under normal temperature (28°C) using the animal trajectory tracking system. Compared with wild-type zebrafish, the maximum acceleration of *hdac8(-/-)* zebrafish show no significant difference, but the total distance, average speed, and activity all significantly reduced ( $P<0.05$ ). In order to explore whether the *hdac8* gene is involved in regulating the biological process of zebrafish responding to low temperature pressure, wild-type zebrafish and *hdac8(-/-)* juvenile were treated under low temperature (18°C). Compared with the control temperature conditions, the total distance, average speed and activity of wild-type and *hdac8(-/-)* juvenile were significantly reduced ( $P<0.05$ ).

**Key words:** Keywords: HDAC8; zebrafish; gene knockout; low temperature

# 基于 SSR 标记的刺参不同地理群体的遗传结构分析及指纹图谱构建

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**摘要:** 为分析中、韩、俄沿海刺参种质遗传结构, 本研究采用 SSR 指纹图谱技术对中国青岛、烟台, 韩国浦项、群山、木浦, 俄罗斯的不同刺参群体进行遗传多样性分析和指纹图谱构建。结果显示, 8 个群体均具有较高的遗传多样性。构建的 DNA 指纹图谱可将所采集的 8 个群体区分开, 遗传结构分析将所研究群体分为不同组。分析表明, 不同群体的遗传结构及遗传分化情况不仅与地理位置相关, 还与刺参体色有一定的相关性。

**关键词:** 刺参; SSR 标记; 遗传多样性; 指纹图谱

## Genetic Diversity Analysis and Fingerprint Construction for Different Geographical Populations of the Sea Cucumber (*Apostichopus japonicus*) Based on SSR Markers

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**Abstract:** In order to analyze the genetic structure of sea cucumber along the coast of China, South Korea and Russia, SSR fingerprint technology was used to analyze the genetic diversity and construct the fingerprint of different sea cucumber populations in Qingdao, Yantai, Posco, Qunshan and mupu, Russia. The results showed that the eight populations had high genetic diversity. The constructed DNA fingerprint could distinguish the eight populations, and the studied populations were divided into different groups by genetic structure analysis. The analysis showed that the genetic structure and genetic differentiation of different populations were not only related to geographical location, but also related to the body color of sea cucumbers.

**Key words:** *Apostichopus japonicus*; SSR markers; Genetic diversity; Fingerprint



# 基于 19 对微卫星分子标记对两种沙鳅鱼类及其杂交群体的遗传多样性评估

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**摘要:** 中华沙鳅和宽体沙鳅是长江上游重要经济鱼类。由于人为因素等干扰其野生种群急剧下降。本研究评估两种沙鳅及杂交群体遗传多样性。结果表明: 平均多态信息含量在 0.685-0.818。平均观测杂合度在 0.779-0.887, 中华沙鳅 (♀) × 宽体沙鳅 (♂) 组最高, 宽体沙鳅最低。推荐该种杂交方式为潜在种质资源保护策略。遗传结构和 UPGMA 聚类结果显示杂交后代和母本亲缘关系更近。本研究为良种选育和保护提供宝贵资源。

**关键词:** 微卫星; 中华沙鳅; 宽体沙鳅; 杂交; 遗传多样性

## Genetic diversity evaluation of two loaches and their artificial hybrid population based on 19 polymorphic microsatellite loci

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**Abstract:** *Sinibotia superciliaris* and *S. reevesae* are two economically important loaches in the middle and upper reaches of Yangtze River. Wild populations of them have dropped sharply due to anthropogenic and environmental threats. Here, we firstly carried out artificial breeding of *S. superciliaris* and *S. reevesae*, and their hybrids. Secondly, 19 microsatellite loci were used to evaluate genetic diversity between hybrid offspring and their parents. The mean polymorphic information content among groups ranged from 0.685 to 0.818. The mean observed heterozygosity ranged from 0.779 to 0.887, and group of *S. superciliaris* ♀ × *S. reevesae* ♂ obtained the highest, while *S. reevesae* had the lowest. The high heterozygosity was helpful for protecting the genetic resources. Thus, we recommend the hybrid strategy of *S. superciliaris* ♀ × *S. reevesae* ♂ as a potential germplasm resources. Population structure and UPGMA tree indicated the close genetic relationship between the offspring and their female parent. The population genetic information supplied here will provide valuable resources for breeding, germplasm resources preservation and conservation genetics of them.

**Key words:** microsatellite; *Sinibotia superciliaris*; *Sinibotia reevesae*; hybrid; genetic diversity

# MS-222 对尖头𩾏亲鱼麻醉效果的研究

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**摘要:** 为研究 MS-222 对尖头𩾏亲鱼的麻醉效果, 本研究观测了其在不同浓度 (50、75、100、125 和 150 mg/L) MS-222 处理下的麻醉效果。结果表明, 尖头𩾏亲鱼的麻醉过程分为 6 期, 复苏过程分为 4 期; MS-222 有效麻醉浓度为 100 mg/L。随着麻醉时间增加及浓度增大, 尖头𩾏雌性亲鱼的呼吸频率成总体下降趋势。进入深度麻醉期的鱼, 当暴露时间超过 6 min 以上时, 复苏时间随着暴露时间的增加而延长。

**关键词:** 尖头𩾏; MS-222; 麻醉; 复苏; 呼吸频率

## The Anesthetic Effects of MS-222 on Brood Fish of *Rhynchocypris oxycephalus*

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**Abstract:** In order to investigate the anesthetic effects of MS-222 on brood fish of *Rhynchocypris oxycephalus*, in this paper, the behavior changes during anesthesia and resuscitation and the changes of respiratory rate during anesthesia were observed in female brood fish treated with different concentrations (50, 75, 100, 125, 150) of MS-222. At the same time, the effects of different air exposure times (0, 2, 4, 6, 8, 10 min) on recovery time and recovery rate of anesthetized fish were observed. The results showed that the anesthetic and recovery processes of female brood fish of *Rhynchocypris oxycephalus* were divided into 6 stages and 4 stages, respectively. The effective anesthetic concentration of MS-222 was 100 mg/L. The respiratory rate of female brood fish showed a decreasing trend overall, with the increasing of anesthetic time and concentration. As for the fish entering the deep anesthetic stage, the recovery time increased when the air exposure time was more than 8 min. The study proved that MS-222 has an effective effect on brood fish of *Rhynchocypris oxycephalus*.

**Key words:** *Rhynchocypris oxycephalus*; MS-222; anaesthesia; recovery; respiratory rate

# 黑鲷遗传育种进展与基因资源的挖掘和利用

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**摘要:** 测序获得黑鲷全基因组序列, 围绕生长、耐低温、耐低盐、耐低氧等经济性状开展相关研究, 对重要基因进行克隆和表达分析; 选育子四代黑鲷上周速度提高 22.6%。

**关键词:** 黑鲷; 全基因组, 遗传育种

## Progress in the breeding of black seabream and the mining and utilization of genetic resources

Zhang Zhiwei, Zhang Zhiyong, Chen Shuyi, Jia Chaofeng, Zhu Fi, Meng Dynasty, Zhang Caojin, Xu Dafeng

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**Abstract:** The whole gene sequence of black sea bream was obtained. Related researches on growth performance, low temperature resistance, low salt, low oxygen resistance, etc were conducted. cloning and expressing analysis of important gene were carried out. Compared with wild one, the growth rate of sub-four-generation black porgy increased 22.6% .

**Key words::** black seabream; whole genomics; gentic and breeding

# 低氧胁迫对花鲈鳃转录组及可变剪接事件的影响

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**摘要:** 低氧是影响鱼类生存、生长和繁殖等的重要环境胁迫因素之一。我们对低氧胁迫后不同时间点的花鲈鳃组织进行转录组测序分析。结果表明, 低氧处理后, HIF-1、糖酵解糖异生、MAPK 通路等相关基因表达显著上调, 而细胞周期、DNA 复制等相关基因显著下调。共鉴定出 4 个基因共表达模块。此外, 低氧胁迫后的差异可变剪接基因主要富集。此外, 低氧胁迫后的差异可变剪接基因主要富集在剪接体通路。

**关键词:** 花鲈; 低氧; 鳃; 转录组; 差异可变剪接

## Effects of hypoxia stress on gill transcriptome and alternative splicing events of *Lateolabrax maculatus*

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**Abstract:** Hypoxia is one of the important environmental stress factors affecting fish survival, growth, and reproduction. Transcriptome sequencing was performed on the gill tissues of spotted sea after hypoxia stress at different time points. The results showed that HIF-1, glycolysis gluconeogenesis, MAPK pathway, and other related genes were significantly up-regulated after hypoxia treatment, while cell cycle, DNA replication, and other related genes were significantly down-regulated. Four co-expression modules of vegfab, edn1, igf1, rfc4, mcm2, and mcm5 were identified as hub genes. In addition, differential alternative splicing genes were mainly enriched in the spliceosome pathway after hypoxia stress. These results provide a theoretical basis for further analysis of the molecular mechanism of response to hypoxic stress in spotted sea bass.

**Key words:** spotted sea bass, hypoxia, gill, RNA-seq, differential alternative splicing

# 南极独角雪冰鱼 GRIK1 基因抗寒功能 初步探究

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**摘要：**谷氨酸受体一直以中枢神经系统的神经递质受体被人们熟知，但近期发现一些谷氨酸受体还在外周神经扮演冷感受器的角色。南极鱼长期生活在严寒、含氧量高的南极海域，在基因组、分子、细胞等水平均发生了适应性变化，是研究鱼类适应低温的理想模型。本文通过对南极独角雪冰鱼谷氨酸受体基因 GRIK1 的研究，发现寒冷条件下，在细胞中过表达进化保守的 GRIK1 基因减少了细胞凋亡，对细胞起保护作用。

**关键词：**鱼类抗寒，谷氨酸受体基因，南极独角雪冰鱼

## Preliminary Study on Cold Resistance Function of *Chionodraco hamatus* GRIK1

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**Abstract :** Glutamate receptors have always been well known as neurotransmitter receptors in the central nervous system, but some glutamate receptors have recently been discovered to also play the role of cold receptors in the peripheral nerves. Antarctic fish live in the severely cold Antarctic waters with high oxygen content for a long time, and adaptive changes have taken place in genome, molecules, cells, etc., for which it is an ideal model for studying fish adapting to low temperature. In this paper, through the study of *Chionodraco hamatus* glutamate receptor gene GRIK1, it is found that under cold conditions, overexpression of the evolutionarily conserved GRIK1 gene in cells reduces apoptosis and protects cells.

**Key words: :** Cold resistance; Glutamate receptors; *Chionodraco hamatus*

# 嵊泗海域浮游动物数量分布与优势种

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**摘要：**通过 2016~2017 年嵊泗海域 4 个季节调查，研究了嵊泗海域浮游动物丰度时空分布和变化动力学机制及嵊泗海域浮游动物优势种的生态学特征。结果表明：嵊泗海域浮游动物生物量和丰度的季节变化明显。全年主要优势种为中华哲水蚤、真刺唇角水蚤和虫肢歪水蚤。聚集性分析表明嵊泗海域浮游动物有明显的聚集现象。

**关键词：**嵊泗海域；浮游动物数量分布；优势种

## Horizontal Distribution and Dominant Species of Zooplankton in the Shengsi Sea Area

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**Abstract :** This article discussed the Zooplankton horizontal distribution and dominant species in Shengsi Sea Area. The ecological characteristics of Zooplankton and their adaptability to the environment were also considered. Oceanographic investigation was carried out in the Shengsi Sea Area in four seasons from 2016 to 2017. It was found that the total abundance showed obviously seasonal variations. The main dominant species throughout the year were *Sinocalanus sinensis*, *Labidocera euchaeta*, *Tortanus vermiculus*. The aggregation characteristics of Zooplankton were obvious from multivariate regression analysis.

**Key words: :** Shengsi Sea Area; Horizontal Distribution; Dominant Species of Zooplankton

# 不同生长速率的黑鲷（*Acanthopagrus schlegelii*）混合组织的转录组分析

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**摘要：**本实验利用高通量测序技术对4月龄黑鲷不同生长速度个体的脑、肝脏、肌肉混合组织进行转录组测序。结果表明：共筛选出1129个上调基因、1975个下调基因，其中MYH4、IGFs、MYH6、Mb等参与肌肉生长调控的基因在小个体中呈下调趋势。在GO和KEGG富集分析中发现显著富集GO条目25条、KEGG通路39条，如代谢途径、PPAR信号通路等。本研究为进一步探究黑鲷生长发育关键分子调控机制提供理论基础。

**关键词：**黑鲷，转录组，生长发育，调控通路

## Comparative transcriptome analysis of mixed tissues of black porgy (*Acanthopagrus schlegelii*) with differing growth rates

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**Abstract :** Illumina high-throughput sequencing technology was used to perform transcriptome sequencing of mixed samples of brain, liver, and muscle tissues of 4-month-old black porgy individuals with different growth rates. The results showed that 1129 up-regulated genes and 1975 down-regulated genes were screened out. Among them, MYH4, IGFs, MYH6, Mb and other genes involved in muscle growth regulation showed a downward-regulated trend in small individuals. In the GO and KEGG enrichment analysis, it was found that 25 GO entries and 39 KEGG pathways were significantly enriched, such as metabolic pathways and PPAR signaling pathways. This study provides a theoretical basis for further exploring the key molecular regulation mechanisms of black sea bream growth and development.

**Key words: :** black porgy, transcriptome, growth and development, regulatory pathway

# 两种南极鱼 TMAO 与 TMA 含量的测定 与比较

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**摘要:** TMAO(Trimethylamineoxide)作为水生生物体内的内源性物质,同时也是稳定蛋白质结构的重要化合物, TMA (Trimethylamine)作为 TMAO 的前体物质,大量研究证明其由生物体内的微生物产生。而南极独角雪冰鱼(*Chionodraco hamatus*)与伯氏肩孔南极鱼(*Trematomus bernacchii*)作为两种广泛分布在南极的鱼类,进行这两种化合物测定以及研究分析。

**关键词:** TMAO,TMA,测定分析

## Determination and comparison of TMAO and TMA contents in two kinds of Antarctic fish

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**Abstract:** TMAO (trimethylamine oxide) is not only an endogenous substance in aquatic organisms, but also an important compound to stabilize protein structure. TMA (trimethylamine) is a precursor of TMAO. A large number of studies have proved that it is produced by microorganisms in organisms. *Chionodraco hamatus* and *Trematomus bernacchii*, as two kinds of fish widely distributed in Antarctica, were determined and analyzed

**Key words::** TMAO,TMA,determination and comprarision



# 温度、盐度和 pH 对多纹钱蝶鱼胚胎发育的影响

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**摘要:** 文章首次探究了在不同环境条件下多纹钱蝶鱼 (*Selenotoca multifasciata*) 胚胎发育的特点, 可为该鱼苗种培育适宜条件的选择和调控提供参考。实验将多纹钱蝶鱼受精卵分别置于不同温度、盐度和 pH 下孵化。试验得出多纹钱蝶鱼的最适孵化温度为 26~28°C, 最适孵化盐度为 25~32, 最适孵化 pH 为 7.0~8.2。

**关键词:** 多纹钱蝶鱼; 胚胎发育; 温度; 盐度; pH

## Effects of water temperature, salinity and pH on embryonic development of *Selenotoca multifasciata*

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**Abstract:** The characteristics of embryonic development of *Selenotoca multifasciata* under different conditions were studied for the first time, to provide a reference for the selection and regulation of suitable conditions for seedling cultivation of *S. multifasciata*. The embryos of *S. multifasciata* were incubated at different temperatures, salinities and pH. The results indicate that the optimal hatching temperature was 26–28 °C at salinity of 32. The optimal hatching pH was 7.5–8.2. The optimal hatching salinity was 25–29.

**Key words:** *Selenotoca multifasciata*; Embryonic development; Temperature; Salinity; pH

# 暴露于低频噪音下瘤背石磺（*Onchidium reveesii*）中枢神经系统的转录组分析

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**摘要：**低频噪音已成为不可忽视的海洋污染物，然而在海洋软体动物中研究较少。故本试验采用瘤背石磺为研究对象，设计不同低频噪音和不同刺激时间，测定血淋巴中的抗氧化酶活性以及对照组和噪音组中枢神经系统转录组。结果显示抗氧化酶活性与噪音频率呈正相关，与时间无相关性。在转录组学方面，根据 KEGG 分析，低频噪音主要影响信号传导、免疫和凋亡、能量代谢和神经系统等通路。本研究对低频噪音胁迫的潜在响应研究提供了有价值的参考。

**关键词：**瘤背石磺；低频噪音；转录组分析；免疫系统；氧化应激

## Transcriptome analysis of the central nervous system of sea slug (*Onchidium reveesii*) exposed to low-frequency noise

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**Abstract:** Low frequency noise has become a marine pollutant that cannot be ignored. However, it has been less studied in marine mollusks. Therefore, this experiment was designed to measure the antioxidant enzyme activity in hemolymph and the CNS transcriptome in the control and noise groups by using sea slug as the study object with different low-frequency noise and different stimulation time. The results showed a positive correlation between antioxidant enzyme activity and noise frequency, and no correlation with time. In transcriptomics, according to KEGG analysis, low frequency noise mainly affects signaling, immune and apoptotic, energy metabolism and nervous system pathways. Our results provide valuable reference material for potential response studies to low-frequency noise stress.

**Key words:** *Onchidium reveesii*; Low-frequency noise; Transcriptome analysis; Immune system; Oxidative stress

# 大口黑鲈抗缪勒试管激素(AMH)基因克隆、 表达及其在性腺发育中功能分析

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**摘要:** 大口黑鲈 AMH 基因 cDNA 序列全长 2050bp, 由 24bp5'非编码区、394bp3'非编码区和 1632bp 开放阅读框组成, 共编码 543 个氨基酸。AMH 基因在 11 个组织中均有表达, 精巢中表达量最高。在不同发育阶段雌雄鱼中, AMH 基因在精巢的表达量显著高于卵巢, 且 Western blot 结果显示 AMH 蛋白仅在精巢中表达。综上, AMH 基因在早期性别发育中起到重要的调控作用, 可能是大口黑鲈的性别决定基因。

**关键词:** 大口黑鲈; AMH; 基因克隆; 组织表达; 性腺发育

## Cloning and expression of Anti-müllerian hormone (AMH) gene in largemouth bass (*Micropterus salmoides*) and analysis of its function in gonadal development

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**Abstract:** In this study, the AMH gene of largemouth bass was cloned using RACE technology, the cDNA full-length sequence of AMH gene of largemouth bass was 2050 bp in length, including 24 bp at the 5'-UTR, 394 bp at the 3'-UTR, and a 1632 bp open reading frame (ORF) encoding 543 amino acids. AMH gene mRNA was found to be expressed in eleven tissues, with the highest expression in testis ( $P < 0.05$ ), followed by muscle. The expression of AMH gene in the gonads of male and female fish at different developmental stages was significantly higher in the testis than in the ovaries ( $P < 0.05$ ), and Western blotting showed that AMH protein was only expressed in the testis, but not in the ovaries. The expression of AMH gene in the testis increased first and then decreased, with the highest expression in the juvenile stage ( $P < 0.05$ ); The AMH gene showed an upward trend in the ovaries of female fish, and the highest expression level was in the stage of sexual maturity. The above studies indicate that the AMH gene plays an important regulatory role in early sex development, and it may be an important sex-determining gene for largemouth bass.

**Key words:** *Micropterus salmoides*, AMH, Gene Cloning, Tissue expression, Gonad development

# 虹鳟热应激相关 miRNA 靶基因功能验证

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**摘要：**前期研究发现 miR-8159-x 在虹鳟热应激和非热应激下差异表达，推测 miR-8159-x 可能对虹鳟热应激具有调控作用。为了探究 miRNA 参与虹鳟热应激的调控机制，本研究通过双荧光素酶报告系统验证了靶向关系；RT-qPCR、5-乙炔基-2'-脱氧尿苷（EdU）标记技术及流式细胞术验证了 miR-8159-x 在虹鳟肝细胞中具有调控作用。

**关键词：**虹鳟；热应激；miR-8159-x

## The mechanism of miR-8159-x involved in the regulation of heat stress of rainbow trout (*Oncorhynchus mykiss*)

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**Abstract:** Previous studies found that miR-8159-x was differentially expressed under heat stress and non-heat stress in rainbow trout, and it was speculated that miR-8159-x might play a regulatory role in heat stress in rainbow trout. In order to explore the regulation mechanism of miRNA involved in heat stress in rainbow trout, this study verified the targeting relationship through the dual luciferase reporting system. RT-qPCR, 5-acetyney-2'-deoxyuridine (EdU) labeling technique and flow cytometry confirmed the regulatory role of miR-8159-x in rainbow trout liver cells.

**Key words::** rainbow trout; heat stress; miR-8159-x

# 斑马鱼 tp53 基因上游转录 调控元件作用机制研究

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**摘要:** 实验室前期研究显示, 斑马鱼 tp53 基因上游存在与斑马鱼细胞低温驯化相关的远端调控元件。为研究该调控元件的作用机制, 将 tp53 基因上游 2.9kb 区域命名为-2.9kb, 对其进行克隆并构建双荧光素酶报告基因表达载体 pGL4.10-2.9kb-tp53 promoter, 通过双荧光素酶报告系统检测重组载体的活性, 结果显示-2.9kb 区域具有促进转录的作用。该研究为揭示斑马鱼的低温适应机制提供了新思路。

**关键词:** 斑马鱼; tp53; 转录调控; DNA 甲基化; 组蛋白修饰

## Study of Transcriptional Regulatory Elements of tp53 gene in Zebrafish

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**Abstract:** In our previous study, the expression of the tp53 gene was significantly up-regulated in zebrafish (*Danio rerio*) embryonic fibroblasts cells (ZF4 cells) cultured at 18°C for 30 days for cold acclimation, meanwhile the enrichment of H3K4me3 and H3K27ac, two putative markers for enhancer, and DNA methylation increased at the upstream region about -2.9kb from tp53. This suggests that distal regulatory elements associated with cold acclimation exist in the upstream region of tp53 in zebrafish. Thus, the -2.9kb region(1110bp) was cloned into luciferase reporter vector pGL4.10 basic to construct the pGL4.10-2.9kb-tp53 promoter vector in order to investigate the detailed mechanisms of these distal elements. Luciferase reporter plasmids were transfected into HEK293T cells, and their relative luciferase activity was measured. The results demonstrated that the -2.9kb region acts as a transcription activator for tp53. We identified an activator protein 1(AP-1) DNA recognition element (TGACTCA and TGAGTCA) in the -2.9kb region. c-jun was overexpressed in ZF4 cells, and RT-qPCR showed that the expression of tp53 increased after c-jun overexpression. The result indicated AP-1 proteins bind to the -2.9kb region and upregulate the downstream gene. Taken together, our data provide information for further understanding of the mechanism in cold acclimation in fish.

**Key words:** zebrafish; tp53; transcriptional regulation; DNA methylation; histone modification

# 斑马鱼 ZF4 细胞低温驯化中 ceRNA 相互作用关系的研究

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**摘要:** 为了研究 microRNA (miRNA) 和长链非编码 RNA (lncRNA) 在斑马鱼 ZF4 细胞低温驯化中的作用, 本研究采用转录组测序数据分析了低温驯化中差异表达的 miRNA、lncRNA、mRNA ( $p < 0.05$ 、 $|\log_2FC| > 2.5$ )。与对照相比, 分析共获得 25 个 DE-miRNA, 1019 个 DE-lncRNA 以及 3262 个 DE-mRNA。通过 GO 和 KEGG 通路富集分析, 差异基因涉及通路依次为细胞粘附、离子转运、细胞生长调控、叶酸代谢等途径。

**关键词:** 低温驯化; 斑马鱼细胞; ceRNA; 转录后调控

## Competitive endogenous RNA (ceRNA) regulation network of ceRNA during the cold acclimation in zebrafish (*Danio rerio*) ZF4 cells

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**Abstract:** To get insight into the roles of microRNA (miRNA) and long non-coding RNA (lncRNA) in the cold acclimation of zebrafish ZF4 cells, we employ transcriptome sequencing to assess the differentially expressed (DE) miRNA, lncRNA, and mRNA ( $p < 0.05$ ,  $|\log_2FC| > 2.0$ ). Compared with the control group, a total of 25 DE-miRNA, 1019 DE-lncRNA, and 3262 DE-mRNA were obtained. Through the enrichment analysis of GO and KEGG pathways, the differential genes are involved in pathways including cell adhesion, ion transport, cell growth regulation, and folate metabolism, etc. We also utilized TargetScan, miRanda as well as RNAplex to predict candidate target genes for miRNA and lncRNA., the candidate ceRNA pairs were filtered via the Spearman correlation coefficient  $> 0.5$  or  $< -0.5$ ,  $p < 0.05$ , hence 5734 ceRNA pairs were obtained with a correlation  $> 0.8$ . According to the network diagram analysis of ceRNA with Cytoscape, hub miRNAs such as dre-miR-736, dre-miR-193a-3p, and dre-miR-214 were obtained. In the light of previous research and analysis results of miRanda and ceRNA, we predicted several potential ceRNA regulatory molecule pairs such as MSTRG.3207-dre-miR-736-bbc3、MSTRG.3207-dre-miR-736-bbc3-LOC101885512 and dre-miR-LOC101885512, which may get involved in the autophagy pathway. The analysis results imply that non-coding RNAs such as miRNA and lncRNA exert an important role in post-transcriptional regulation during the cold acclimation process of ZF4 cells.

**Key words:** Keywords: cold acclimation ; zebrafish cells ; Competitive endogenous RNA (ceRNA); post-transcription regulation

# 高温胁迫对虹鳟幼鱼（*Oncorhynchus mykiss*）生化指标和 HSP47、HSP90 $\alpha$ 和 GRP78 的表达模式的影响

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**摘要:** 夏季高温是虹鳟养殖环节中最大的威胁, 高温应激很容易造成虹鳟大面积死亡或减产。本研究的目的是找出在极高的水温下, 温度敏感个体和温度耐受个体存在的差异。热应激后, 耐受组中脾和肾 SOD 活性、GSH 含量以及肾中 CAT 含量显著低于敏感组。在热应激后, 敏感组肝脏、鳃和脾脏中 hsp90 $\alpha$  和 hsp47 的表达显著高于耐受组。这些结果表明高温应力。对虹鳟 SOD、CAT 活性及 hsp90 $\alpha$ 、hsp47 表达有显著影响。

**关键词:** 虹鳟; 热应激; 热休克蛋白

## Effects of high temperature stress on biochemical indicators and expression profiles of HSP47, HSP90 $\alpha$ and GRP78 in juvenile rainbow trout (*Oncorhynchus mykiss*)

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**Abstract:** High temperature in summer is the biggest threat to rainbow trout farming, and high temperature stress can easily cause large areas of rainbow trout death or reduction in production. The purpose of this study is to find out the differences between temperature-sensitive individuals and temperature-resistance individuals at extremely high water temperatures. After heat stress, the SOD activity, GSH content of the spleen and kidney, and the content of CAT in the kidney in the resistance group were significantly lower than those in the sensitive group. After heat stress, the expression of hsp90 $\alpha$  and hsp47 in the liver, gills and spleen of the sensitive group was significantly higher than that of the resistance group. These results indicate high temperature stress. It has a significant effect on rainbow trout SOD, CAT activity and hsp90 $\alpha$  and hsp47 expression.

**Key words:** Rainbow trout; Heat stress; Heat shock protein

# 5 种大口黑鲈微卫星标记和 D-Loop 部分序列遗传变异分析

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**摘要：**本研究采用线粒体 D-Loop 部分序列和 14 个微卫星标记，对国内现有的 4 个养殖群体（台湾鲈、优鲈 1 号、优鲈 3 号、杂交群体（北方亚种♂×优鲈 3 号♀））和 1 个选育群体（北方亚种）共 165 尾个体进行群体遗传变异分析。结果显示，14 个微卫星位点均能获得有效扩增；D-Loop 部分序列中发现 23 个变异位点，23 个单倍型。

**关键词：**大口黑鲈；微卫星；D-Loop 序列；遗传变异

## Genetic variation analysis of Microsatellite markers and D-loop partial sequences in five largemouth bass species

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**Abstract:** Abstract: Partial mitochondrial D-loop sequences and 14 microsatellite markers were used in study. A total of 165 individuals from 4 cultured population (“TaiwanLu”, “YouLu 1”, “YouLu3” and “Hybrid population” (northern subspecies♂×“YouLu3”♀)) and 1 breeding population (Northern subspecies of *Micropterus salmoides*) were analyzed for genetic variation. The results showed that all the 14 microsatellite loci could be effectively amplified. There were 23 variation loci and 23 haplotypes in D-loop partial sequences. Comprehensive analysis showed that the genetic distance of Nei's and K2P was the furthest between the Northern subspecies population and “YouLu3” population. The genetic differentiation of the five largemouth bass species was obvious difference, and the genetic structure of the breeding population was relatively independent, while the genetic structure of the other cultured population was promiscuous to some extent. The results showed that there was significant genetic differentiation between cultured population and breeding population, and the breeding population had high genetic polymorphism. Our study could provide the basis for germplasm improvement and new variety breeding of largemouth bass breeding population.

**Key words:** Key words: largemouth bass, microsatellite markers, D-Loop sequences, Genetic variation



# 低温胁迫下花鲈的组织学及生理学分析

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**摘要:** 以花鲈 (*Lateolabrax japonicus*) 幼鱼 (10-20 g) 为研究对象, 从 22°C 快速降至目标温度 (4°C、8°C、10°C、16°C), 维持一段时间后采集组织样品, 进行组织染色和酶活性测定等生理学实验以及相关代谢基因表达等分子生物学实验。研究发现: 冷应激导致很多负面影响, 包括组织损伤、内环境稳态破坏和过氧化产物增加, 并最终导致花鲈生存能力下降。该研究将为花鲈在高纬度地区的养殖提供有用的信息。

**关键词:** 花鲈; 冷应激; 组织学; 生理学

## Histological and physiological analysis of *Lateolabrax japonicus* under cold stress

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**Abstract:** Taking spotted sea bass (*lateolabrax japonicus*) juveniles (10-20 g) as the research object, the temperature dropped rapidly from 22 °C to the target temperature (4 °C, 8 °C, 10 °C, 16 °C), and the tissue samples were collected after maintaining for a period of time. Physiological experiments such as tissue staining and determination of enzyme activities, as well as molecular biology experiments such as the expression of related metabolic genes. Studies have found that cold stress will bring many negative effects, including tissue damage, destruction of homeostasis and increased peroxidation products, and ultimately lead to a decline in the viability of the spotted sea bass. This research will provide useful information for the cultivation of spotted sea bass in high latitude areas.

**Key words:** *Lateolabrax japonicus*; Cold stress; Histological; Physiological

# 接触微塑料对草鱼生理、生化和转录组水平的影响

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**摘要：**微塑料（MPs）是一种广泛分布于水生环境中的污染物。在本研究中，草鱼暴露于两种浓度的MPs中21天。在肝脏消化液中检测到荧光信号，出现了肝细胞质空泡化并抑制生长。在暴露期结束后，MPs处理组的鱼表现出抗氧化系统的抑制和氧化应激的增强。然后对草鱼进行转录组分析以揭示对MPs反应的分子机制，并对引起代谢紊乱的四个基因进行了表征。

**关键词：**微塑料、生长性能、氧化应激、转录组、代谢紊乱

## The effects of exposure to microplastics on grass carp (*Ctenopharyngodon idella*) at the physiological, biochemical, and transcriptomic levels

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**Abstract:** Microplastics (MPs) are a pollutant widely distributed in the aquatic environment. In this study, grass carp was exposed to two concentrations of MPs for 21 days. A fluorescent signal was detected in the liver digestion solution, and showed liver cytoplasmic vacuolation and inhibited growth. After the end of the exposure period, fish in the MPs treatment group exhibited inhibition of the antioxidant system and enhancement oxidative stress. Then, transcriptome analysis of grass carp was performed to reveal the molecular mechanism of response to MPs, and the four genes that related to metabolic disorders were characterized.

**Key words:** : Microparticle; Growth performance; Oxidative stress; Transcriptome; metabolism disorders

# 转录组分析高密度养殖对草鱼的影响

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**摘要:** 草鱼养殖广泛, 根据二、三代转录组分析高密度养殖对草鱼的影响。PacBio 鉴定 33,773 个基因, 8,009 个 AS, 10,219 个 APAs 和 15,521 条 lncRNA。肠, 肌肉和脑中 1,235, 962 和 213 个差异基因, 富集在营养代谢和免疫功能。高密度组中编码载体蛋白基因表达和碳水化合物酶解的酶活性升高抑制生长。草鱼 MHC II 类抗原 $\alpha$ 和 $\beta$ 链的 4 种亚型被抑制, 抑制免疫功能。强调养殖中合理密度的重要性。

**关键词:** 草鱼, 高密度养殖, 转录组, 免疫功能, 代谢

## Transcriptomic analysis to elucidate the effects of high stocking density on grass carp (*Ctenopharyngodon idella*)

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**Abstract:** Grass carp (*Ctenopharyngodon idella*) is one of the most widely cultivated fishes in China. High stocking density can reportedly affect fish growth and immunity. Herein we performed PacBio long-read single-molecule real-time (SMRT) sequencing and Illumina RNA sequencing to evaluate the effects of high stocking density on grass carp transcriptome. SMRT sequencing led to the identification of 33,773 genes (14,946 known and 18,827 new genes). From the structure analysis, 8,009 genes were detected with alternative splicing events, 10,219 genes showed alternative polyadenylation sites and 15,521 long noncoding RNAs. Further, 1,235, 962, and 213 differentially expressed genes (DEGs) were identified in the intestine, muscle, and brain tissues, respectively. We performed functional enrichment analyses of DEGs, and they were identified to be significantly enriched in nutrient metabolism and immune function. The expression levels of several genes encoding apolipoproteins and activities of enzymes involved in carbohydrate enzymolysis were found to be upregulated in the high stocking density group, indicating that lipid metabolism and carbohydrate decomposition were accelerated. Besides, four isoforms of grass carp major histocompatibility complex class II antigen alpha and beta chains in the aforementioned three tissue was showed at least a 4-fold decrease. To conclude, our results emphasize the importance of maintaining reasonable density in grass carp aquaculture.

**Key words:** : *Ctenopharyngodon idella*, High stocking density, Transcriptome, Immune function, Metabolism

# 葛氏长臂虾大规格苗种人工培育技术研究

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**摘要:** 2019 和 2020 年 3~5 月, 在江苏如东分别于室内水泥池和室外土池进行葛氏长臂虾规模化大规格苗种人工育苗试验。2019 年, 海上共收集亲虾 2251 尾, 抱卵量为 2678~4876 粒/尾, 获得 I 期糠虾幼体 786.17 万尾, 获大规格苗种 ( $\geq 1\text{cm}$ ) 273.67 万尾。2020 年, 从 2019 年培育的留种亲虾中挑选 2132 尾, 抱卵量 2583~4694 粒/尾, 获大规格苗种 ( $\geq 1\text{cm}$ ) 147.61 万尾。

**关键词:** 江苏沿海; 葛氏长臂虾; 人工育苗; 大规格

## Study on artificial breeding technology of large size seedling of *Palaemon gravieri*

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**Abstract:** In order to study the breeding habits of *P. gravieri*, large-scale breeding of *P. gravieri* seedlings was realized. From March to May 2019, the shrimps were caught from the coast of Rudong, Jiangsu, and the large-scale artificial seedling breeding experiment was carried out in indoor cement ponds; from March to May 2020, the mature shrimps cultivated in the previous year were used to carry out large-scale seedling experiments in artificial earthen ponds. The water temperature is 22.5~23.5 °C and the salinity is 22~24 in the indoor artificial breeding. The seedling bait series is *Monascus-Artemia* nauplii-0.3 batch-0.5 batch. When the outdoor earthen pond raises the seedlings, the water temperature is 14.2~21.8 °C, the salinity is 20~24, the seedling bait series is fat water (natural bait), and rotifers-chilled fish and insects-0.3 batches-0.5 batches are added in sequence. In 2019, a total of 3308 Female shrimps were collected at sea, of which 2,251 survived, and each shrimps contained 2678-4876 eggs. The first stage mysis larvae were 7861700, and 2736700 large-sized seeds ( $\geq 1\text{cm}$ ) were finally cultivated. In 2020, select 2552 shrimps from the mature shrimps cultivated in the previous year, of which 2132 survived, and each shrimps contained 2583-4694 eggs, and finally 1476100 large-sized seeds ( $\geq 1\text{cm}$ ) were cultivated.

**Key words:** Jiangsu Coast; *Palaemon gravieri*; Artificial seedling; Large size

# 中华绒螯蟹羧酸酯酶基因（Es-CXE5）的克隆及其与甲基法尼酯的关联性

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**摘要:** 中华绒螯蟹 (*Eriocheir sinensis*) 是我国一种重要的经济养殖蟹类, 甲基法尼酯 (MF) 对其生理生长起着重要的调节作用。为研究羧酸酯酶 (carboxylesterase) 基因是否与中华绒螯蟹的 MF 滴度有关, 本实验从中华绒螯蟹肝胰腺组织克隆出了 CXE 基因的 cDNA 全长, 其中开放阅读框的序列长 702 bp, 编码 233 个氨基酸, 蛋白质分子量为 26.35 kDa。

**关键词:** 中华绒螯蟹; 甲基法尼酯; 羧酸酯酶; 基因表达

## Cloning of *Eriocheir sinensis* carboxylesterase gene (CXE5) and its association with farnesyl methyl

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**Abstract:** *Eriocheir sinensis* is an important economically crab in China, and methyl farnesyl (MF) plays an important role in many critical physiological processes. To explore whether the carboxylesterase gene is related to the MF titer in *E. sinensis*, the full-length cDNA of the Es-CXE5 gene from the hepatopancreas was cloned. The open reading frame (ORF) of Es-CXE5 is 702 bp, encoding 233 amino acids with a predicted protein molecular weight 26.35 kDa. Sequence analysis results show that the deduced amino acids of Es-CXE5 are conserved with other known crustaceans and insect CXEs, suggesting it belongs to the carboxylesterase family of proteins. QPCR assay were used to measure the relative expression level of genes after MF addition and ESA treatment. The results showed that Es-CXE gene expression was negatively correlated with MF titer during ovarian development. In addition, the expression of Es-CXE5 was significantly up-regulated after MF treatment and ESA surgery. To summarize, the results of this study show that the Es-CXE5 gene is related to the MF titer in *E. sinensis*.

**Key words:** *Eriocheir sinensis*, methyl farnesoate, carboxylesteras, gene expression

# 低温诱导红鳍东方鲀雄性化技术体系的建立及甲基化差异分析

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**摘要:** 本研究选用 L9(34)正交实验设计筛选低温诱导红鳍东方鲀雄性化最优组合, 并对雌、雄鱼及伪雄鱼的性腺进行全基因组甲基化测序。结果表明: (1) 雄性率最高达 75%, 最优组合: 孵化后 50 天, 13°C 处理 45 天。(2) 绘制雌雄及伪雄鱼全基因组单个碱基分辨率的甲基化图谱。(3) amhr2、pfcyp19a 基因启动子甲基化水平存在两性差异, 在雄性化中具有调控作用。本结果为指导红鳍东方鲀全雄苗种培育提供理论依据。

**关键词:** 红鳍东方鲀; 低温诱导; 雄性化; DNA 甲基化

## Establishment of a low-temperature-induced masculinization technology and methylation variation analysis in *Takifugu rubripes*

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**Abstract :** This study used an orthogonal test L9(34) design was used to select the optimal combination of low-temperature-induced masculinization in *Takifugu rubripes*, and performed comprehensive whole genome methylation sequencing of the gonads of male, female, and pseudo male. The results showed that: (1) The optimal combination was as follows: treatment starting times (days post-hatch) of 50 days; treatment temperatures of 13°C; and treatment durations of 45 days. The highest proportion of males up to 75%. (2) We constructed whole genomes methylation map at single-base resolution of gonads of male, female, and pseudo male tiger pufferfish. (3) The methylation levels of promoters of amhr2 and pfcyp19a genes were different in male and female, which had regulatory effect in masculinization. These analyses provided the theoretical basis for breeding all male population of tiger pufferfish.

**Key words:** *Takifugu rubripes*; induction of low temperature; masculinization; DNA methylation

# 生长抑素对斑马鱼骨骼增殖与分化作用的初探

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**摘要：**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* 突变鱼系。通过钙黄绿素染色发现，与 11dpf 的野生型斑马鱼幼鱼相比，*sst1*<sup>-/-</sup> 突变体斑马鱼幼鱼头部骨骼平均光密度值显著降低。推测 *sst1* 基因可能参与调控骨骼代谢，影响骨密度。我们对 42dpf 及 49dpf 的斑马鱼进行茜素红染色和定量分析，结果同样表现出 *sst1*<sup>-/-</sup> 突变体斑马鱼头部骨骼平均光密度值降低。

**关键词：**生长抑素，骨骼，内分泌，斑马鱼，骨质疏松

## Effects of somatostatin on bone proliferation and differentiation of zebrafish

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**Abstract:** a stable genetic *sst1* mutant fish line of somatostatin gene was constructed in zebrafish by CRISPR / cas9 gene editing technology. we found that the average optical density of head bones of *sst1*<sup>-/-</sup> mutant zebrafish was significantly lower than that of wild-type *Danio rerio* at 11 dpf by calcein staining. It is speculated that *sst* gene may be involved in regulating bone metabolism and affecting bone mineral density. Alizarin red staining and quantitative analysis of 42 dpf and 49 dpf zebrafish also showed that the average optical density of head bones of *sst1*<sup>-/-</sup> mutant *Danio rerio* decreased

**Key words:** Somatostatin, bone, endocrine, zebrafish, osteoporosis

# 刀鲚 RyR 基因家族鉴定及不同组织表达分析

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**摘要：**在刀鲚基因组中鉴定到 8 个 RyR 基因，通过 qPCR 的方法检测 RyR 基因在刀鲚组织的表达情况。结果显示，RyR1 在鳃和脑中均有表达，在性腺中基本不表达；RyR2 在海水组鳃组织中表达量低于淡水组，在海水组脑组织中表达量高于淡水组，在性腺的表达量并未出现差异。RyR3 基因在海水组鳃、脑、卵巢组织的表达量高于淡水组，且鳃组织中表现出极显著差异（ $P<0.01$ ），在脑和卵巢组织中表现出显著差异（ $P<0.05$ ）。

**关键词：**RyR，基因家族，刀鲚，qPCR

## Identification of RyR gene family and expression analysis in different tissues of *Coilia nasus*

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**Abstract:** We used biological information to research the RyR gene family of *Coilia nasus*. Eight RyR genes were identified in the whole genome database of *Coilia nasus*. The expression of the three subtypes of the RyR gene in the gills, brain, and gonads (ovary, testis) of *Coilia nasus* was detected by qPCR. The results showed that the RyR1 gene was expressed in the gills and brain, but was not expressed in the ovary and testis; the expression of RyR2 gene in the gill tissue of the seawater group was lower than that of the freshwater group, and the expression level of the brain tissue of the seawater group was higher. In the freshwater group, the expression levels of ovarian and testis tissues did not show any difference between the seawater group and the freshwater group; the expression level of RyR3 gene in the gill, brain, and ovarian tissues in the seawater group was higher than that in the freshwater group, and the gill tissue showed extremely significant difference ( $P<0.01$ ), showing significant difference in brain and ovarian tissues ( $P<0.05$ ).

**Key words:** RyR, Gene family, *Coilia nasus*, qPCR



# Mc1r 信号通路在红罗非鱼体色分化变异中的功能

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**摘要:** 红罗非鱼的体色分化变异已成为限制其产业化发展的瓶颈。目前 Mc1r 信号通路在鱼类色素形成中的调控机制尚不明晰。本研究中, 我们确定了红罗非鱼 mc1r 基因的序列特征、时间和时空表达特性、皮肤组织定位以及 MSH-mc1r 在红罗非鱼黑色素合成途径中的作用。

**关键词:** 红罗非鱼; mc1r 基因; 体色分化变异; 基因表达; 定位;  $\alpha$ -MSH

## The role of melanocortin 1 receptor on melanogenesis pathways in skin color differentiation of red tilapia

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**Abstract :** The skin color differentiation and variation are the main problems limiting the development of red tilapia commercial culture. The specific function and regulation mechanism of mc1r gene in fish pigmentation are still poorly understood. In this study, we investigated the mc1r sequence characteristics, expression profiles, localization and melanocortins (MSH)-mc1r role on melanogenesis pathways of red tilapia. The mc1r ORF of red tilapia is 1056 bp, corresponding to 351 amino acid, which belongs to a family of G-protein-coupled receptors. Quantitative real-time PCR demonstrated that mc1r mRNA was mainly expressed in the brain and dorsal skin tissues of PB (pink with scattered black spots) fish. The mc1r gene was found to be expressed during early development stages of red tilapia. The mc1r mRNA expressions were high in the 48 hours post-hatching (48hph), 24hph and cleavage stages. Immunofluorescence analysis revealed that Mc1r was concentrated mainly in the cytoplasm and intercellular substance of skin epidermis. Injection with caudal vein of  $\alpha$ -MSH at 2.5 mg g<sup>-1</sup> resulted in significantly higher tyrosinase activity and melanin level in the dorsal and ventral skin of red tilapia. The expression of mc1r and tyr mRNA in the skin of red tilapia increased after  $\alpha$ -MSH injection. These results suggested that mc1r plays an important role in fish melanogenesis pathway through binding to  $\alpha$ -MSH.

**Key words::** Red tilapia; melanocortin 1 receptor (mc1r); skin color differentiation and variation; gene expression; localization;  $\alpha$ -MSH

# 三种鲟鱼的全长转录组测序揭示了全基因组复制事件

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**摘要：** 鲟鱼中普遍存在全基因组加倍现象，只有少数研究分析了其全基因组加倍事件。本研究通过三代测序技术，对达氏鳇、史氏鳇和闪光鳇的血液组织进行了全长转录组测序，获得了较为精确的鲟鱼基因数据，质量明确优于已经发表的序列。找到了计算多倍体分化时间的新的方法，即通过杂合 SNP 的鉴定分析鲟鱼全基因组复制发生的时间，该方法与传统计算方法结果一致。全长转录组的鲟鱼数据，可以为鲟鱼重要功能基因挖掘和分子育种提供数据支持。

**关键词：** 鲟鱼；转录组；测序；进化；多倍化

## The full-length transcriptome sequencing of three sturgeons reveals the occurrence of whole genome duplication event

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**Abstract:** Sturgeon is one of the ancient fish species with the fossil records over 200 million years ago. However, the sturgeon genomes are rather complicated, owing to several rounds of genome polyploidizations, which makes it difficult to assemble a high quality genome so that only a few studies analyze their whole genome evolutions (WGDs). This study applied the PacBio sequencing technology to sequence the full-length transcriptomes of blood samples of octoploid *Huso dauricus*, octoploid *Acipenser schrenckii* and tetraploid *Acipenser stellatus*. A total of non-redundant 33,407 transcript assemblies of the three sturgeons were finally generated and fully annotated with different gene function databases, as well as the predictions of simple sequence repeats, transcription factors and long non-coding RNAs. Data valuation exhibited that annotations of the three transcriptomes had the higher quality than those of the previously sequenced sturgeon genomes. A phylogeny of eight typical sturgeons was constructed using the low copy genes, which illustrated that *Acipenser* and *Huso* might share a single origin. The sturgeon WGDs were parallely timed by calculating the divergence times of 2-member gene clusters and heterozygous-SNP-carried genes, which both suggested the occurrence of the WGDs later than 150 mya. The full-length transcriptome sequences were supposed to be the reliable reference data for the study of sturgeon.

**Key words:** sturgeon; transcriptome; sequencing; evolution; polyploidization

# 人工诱导星康吉鳗卵巢发育过程的 脂质代谢变化

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**摘要:** 实验使用 UPLC-MS/MS 与高通量测序技术探究了人工诱导星康吉鳗卵巢发育过程中脂质图谱与肝脏脂质代谢变化。结果表明,在星康吉鳗肝脏、肌肉、性腺和血浆中各鉴定出 68、27、63 和 212 种脂质标志物; 四种组织甘油三酯、磷脂发生了不同程度变化; 差异脂质参与了甘油磷脂代谢、亚油酸代谢等五种代谢途径; 肝脏差异表达基因 CYP2J2、ACAT1、SRD5A2 和 HSD17B3 主要参与了脂类物质的转化和代谢过程。

**关键词:** 星康吉鳗, 脂质代谢, 营养强化

## Artificially induced lipid metabolism during the ovary development of Conger myriaster

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**Abstract :** The experiment used UPLC-MS/MS and high-throughput sequencing technology to explore the lipid profile and liver lipid metabolism changes during the artificially induced ovary development of the conger eel. The results showed that 68, 27, 63 and 212 lipid markers were identified in the liver, muscle, gonads and plasma of the conger eel; the triglycerides and phospholipids of the four tissues changed to different degrees; differential lipids are involved in five metabolic pathways including glycerophospholipid metabolism and linoleic acid metabolism; the differentially expressed genes CYP2J2, ACAT1, SRD5A2 and HSD17B3 in the liver are mainly involved in the conversion and metabolism of lipids. The results of the research are of great significance for the in-depth understanding of the liver metabolism mechanism and nutritional fortification of conger eel.

**Key words: :** Conger myriaster, liver lipid metabolism, nutritional fortification

# 流水刺激下星康吉鳗激素分泌及 卵巢发育的调节与变化

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**摘要:** 本实验使用特定流水系统研究人工促熟条件下, 星康吉鳗连续游泳运动对其体内激素分泌与卵巢发育调节的影响。通过分析不同运动时长, 各组织中激素含量的变化, 发现流水刺激能够显著促进 FSH, LH 和 11-KT 等激素的合成, 抑制 E2 等激素的合成。此外, 流水刺激能够促进脑垂体 FSH 基因的表达, 有助于星康吉鳗早期的发育, 并对鱼体内激素的分泌具有调节功能。因此, 游泳运动是星康吉鳗卵巢发育过程中非常重要的环节。

**关键词:** 星康吉鳗, 流水刺激, 卵巢发育, 激素调节

## Regulation and changes of hormone secretion and ovarian development of conger eel under the stimulation of flowing water

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**Abstract:** A specific flowing water system was used to study the effects of continuous swimming of conger eel on the regulation of hormone secretion and ovarian development under artificial ripening conditions. By analyzing the changes in hormone content in various tissues for different exercise durations, it is found that water stimulation can significantly promote the synthesis of hormones such as FSH, LH and 11-KT, and inhibit the synthesis of hormones such as E2. In addition, water stimulation can promote the expression of FSH genes in the pituitary gland, contribute to the early development of the conger eel, and regulate the secretion of hormones in the fish. Therefore, swimming is a very important part of the ovarian development of conger eel.

**Key words:** conger eel, flowing water, ovarian development, hormonal regulation

# 稻鱼共生模式优化——四种体色青田田鱼生长性能、营养品质及水稻产量差异研究

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**摘要：**本实验旨在反映四种体色青田田鱼稻田适应能力差异性，探究田鱼多样化体色所对应的不同稻田适应能力，针对鱼和水稻两种主要经济产出，在青田县任庄镇采用传统生长、营养和水稻产量评价方法对四种主要养殖体色田鱼的稻田生长性能、营养价值和水稻产量做出了评价。结果表明：养殖鱼类的体色不同并不会影响水稻产量，四种体色中红黑色田鱼的稻田生长性能和营养价值最佳，为青田地区稻田环境的最适养殖体色。

**关键词：**生长性能；稻鱼共生；青田田鱼；营养成分

## Optimization of rice-fish farming system -- Study on differences in growth performance, nutritional quality and rice yield of rice-fish with four body colors in paddy fields

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**Abstract :** This experiment aims to reflect the differences of adaptability of four body colors of *Cyprinus carpio* var *qingtianensis* in paddy fields, and explore the adaptability of paddy fields corresponding to diverse body colors of *Cyprinus carpio* var *qingtianensis*. We mainly focus on two main economic outputs of fish and rice. Paddy field growth performance, nutritive value and rice yield of four main cultivated fish were evaluated by traditional growth, nutrition and rice yield evaluation methods in Renzhuang town, Qingtian County. The results showed that different body colors of cultured fish had no effect on rice yield. Among the four body colors, red and black field fish had the best growth performance and nutritional value in rice field, and were the most suitable body colors for cultivation in rice field environment in Qingtian area.

**Key words: :** growth performance; rice-fish farming system; *Cyprinus carpio* var *qingtianensis*; nutritional composition

# 虹鳟肝脏响应高温胁迫的蛋白质组学与代谢组学数据关联分析

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**摘要:** 为了筛选虹鳟慢性热应激关键蛋白质分子和应激评价指标, 更进一步阐明虹鳟高温胁迫响应机制, 对慢性热应激条件下虹鳟肝脏差异蛋白与差异代谢物的组学数据进行了整合关联分析。结果发现: 亚油酸、 $\gamma$ -亚麻酸、二十碳五烯酸、棕榈油酸、棕榈酸、油酸等代谢物分子在慢性高温胁迫后丰度显著上调; 不饱和脂肪酸合成、 $\alpha$ -亚麻酸代谢和脂肪酸降解及初级胆汁酸生物合成等通路为多组学研究视野下显著指向的代谢/信号通路。

**关键词:** 虹鳟, 高温胁迫, 蛋白质组, 代谢组, 关联分析

## Proteomic and Metabolomic Data Association Analysis of Liver Responses to Heat Stress in Rainbow trout

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**Abstract:** In order to further elucidate the response mechanism of rainbow trout to chronic heat stress and screen key protein molecules and stress evaluation indexes. An integrated analysis of the two kinds of -omics data (proteomic and metabonomics) was performed by calculating Pearson correlation coefficient of abundance of differential expression protein and different metabolite and searching the Co-pathway that shared between the two -omics data. Finally, it was found that the metabolites such as linoleic acid, oliolenic acid, eicosapentaenoic acid, palmioleic acid, palmitic acid and oleic acid had significant up-regulation in the abundance of rainbow trout liver in the chronic heat stress group. Co-pathway study has shown that pathways such as unsaturated fatty acid synthesis,  $\alpha$ -linolenic acid metabolism, fatty acid degradation, and primary bile acid biosynthesis have been significantly enriched in the two types of omics studies.

**Key words::** Rainbow trout, Heat Stress, Proteomic, Metabolomic, Association Analysis

# 云龙石斑鱼、云纹石斑鱼倍性及性腺发育分析

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**摘要:** 石斑鱼为雌雄同体, 雌性先熟的硬骨鱼类, 4至5龄即可达到性成熟, 卵巢发育完全, 在生殖季节时可分批次产卵。但是其杂交后代云龙石斑鱼至今已超过5龄, 仍未见有性成熟的迹象。为了探明云龙石斑鱼发育至5龄但仍未达到性成熟不产卵的科学问题, 本研究一方面提出或因自然杂交产生三倍体致不育的假设, 采用流式细胞仪测定DNA含量的方法来验证云龙石斑鱼是否为三倍体。另一方面通过病理学组织切片来观察不同年龄的云龙石斑鱼性腺。

**关键词:** 云龙石斑鱼; 云纹石斑鱼; 倍性分析; 性腺切片

## Analysis on ploidy and gonadal development of *Epinephelus moara*♀ and *Epinephelus moara*♀×*Epinephelus lanceolatus*♂

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**Abstract:** Grouper is a hermaphrodite, female first mature bony fish, 4 to 5 years of age can reach sexual maturity and ovarian development is complete, in the reproductive season can be divided into batches of eggs. But hybrid offspring *Epinephelus moara*♀×*Epinephelus lanceolatus*♂ has been more than 5 years old, there is still no sign of sexual maturity. In order to find out the scientific problem that hybrid F1 *E. moara*♀×*E. lanceolatus*♂ develops to the fifth instar but does not reach sexual maturity and does not spawn, on the one hand, this study put forward the hypothesis of sterility caused by triploid produced by natural hybridization, and used the method of DNA content determination by flow cytometry to verify whether hybrid F1 *E. moara*♀×*E. lanceolatus*♂ is triploid. On the other hand, the gonad development degree of Grouper of different ages was observed through pathological tissue sections. The results showed that the fluorescence value of 175 Groupers in the experimental group was  $101.3\pm 8.01$  by flow cytometry. The fluorescence value of 6 *E. moara* groupers in the control group was  $104.2\pm 9.77$ , and the ratio between them was 1.02. The results showed that no polyploid was found among the 175 hybrid F1 *E. moara*♀×*E. lanceolatus*♂, all of them were conventional diploid. At the same time observe the hybrid F1 *E. moara*♀×*E. lanceolatus*♂ of gonad slice of different ages, from the original gonads form initial stage to the age of five, find that the growth rate of primitive gonads was similar

**Key words:** *Epinephelus moara*♀×*Epinephelus lanceolatus*♂; *Epinephelus moara*♀; ploidy analysis; gonad slice

# 牛蛙脾脏响应弗氏柠檬酸杆菌胁迫的 比较蛋白质组学分析

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**摘要:** 在这项研究中, 我们在蛋白质水平研究了牛蛙感染弗氏柠檬酸杆菌后脾脏的免疫响应。通过 iTRAQ 方法, 对弗氏柠檬酸杆菌感染的牛蛙脾脏进行比较蛋白质组学分析。通过 LC-MS/MS 光谱和测序数据, 共鉴定了 2400 种蛋白质。其中, 鉴定了 316 个显著差异表达蛋白 (DEP), 其中 154 种显着上调, 162 种显着下调。

**关键词:** 蛋白质组, 牛蛙, 弗氏柠檬酸杆菌, iTRAQ

## iTRAQ-based comparative proteomic analysis of *Lithobates catesbeianus* bullfrog spleen following challenge with *Citrobacter freundii*

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**Abstract:** As a common aquaculture pathogen, *Citrobacter freundii* has resulted in inconceivable economic loss in aquaculture. In this study, we investigated the spleen immune response of *L. catesbeianus* to *C. freundii* infection at the protein level. A comparative proteomic analysis of spleens from *C. freundii*-infected *L. catesbeianus* was performed by using the isobaric tags for relative and absolute quantitation (iTRAQ) approach. A total of 2400 proteins were identified by LC-MS/MS spectra and sequencing data. In addition, 316 differentially expressed proteins (DEPs) were identified, of which 154 were significantly upregulated and 162 were significantly downregulated. Eleven DEPs that were immune-related including Kelch-like protein 22, saxiphilin, collagen type I alpha, integrin beta-3, guanine nucleotide-binding protein subunit gamma, collagen type VI alpha, GRP1-associated scaffold protein, retinoic acid-inducible gene I, laboratory of genetics and physiology 2, E3 ubiquitin-protein ligase TRIM39-like, and phospholipid scramblase 1 were selected for further study. The expression profile of these genes in the spleen at 48 h post *C. freundii*-infection showed a similar trend as the iTRAQ data. Put together, the current study is the first to report on the spleen proteome of bullfrogs (*L. catesbeianus*) and provides insight to understanding of the immune response to *C. freundii* infection.

**Key words:** comparative proteomics, bullfrog, *Citrobacter freundii*, iTRAQ



# 赤眼鳟 March 成员的克隆及功能初探

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**摘要:** March 是一类 E3 泛素连接酶, 参与多种生理功能。本研究克隆得到赤眼鳟 8 个 March 成员的 ORF 并进行生物信息学分析, 发现其均具有一个保守的 RING 结构域。系统发育树显示不同物种的同一成员分别聚为一大类, 且赤眼鳟优先与草鱼/斑马鱼聚为一支。荧光定量结果得出其在赤眼鳟各组织中均有表达, 且不同成员的表达谱差异显著。GCRV 处理赤眼鳟后各成员均出现不同程度响应提示 March 在侵染过程中发挥了重要作用。

**关键词:** 赤眼鳟; March; GCRV; 免疫

## Molecular cloning and function of the March in *Squaliobarbus curriculus*

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**Abstract:** March is a class of E3 ubiquitin ligases involved in a variety of physiological functions. In this study, ORF of 8 March members in *Squaliobarbus curriculus* were cloned and analyzed by bioinformatics, and it was found that all of them had a conserved RING domain. Phylogenetic trees showed that the same members of different species clustered into one large group, and *Squaliobarbus curriculus* preferentially clustered into one branch with grass carp/zebrafish. Fluorescence quantitative results showed that it was expressed in all tissues of red eye trout, and the expression profiles of different members were significantly different. After GCRV treatment, all members showed different degrees of response, suggesting that March played an important role in the infection process.

**Key words:** *Squaliobarbus curriculus*; March; GCRV; Immunity

# 基于 Cyt b 分析黄沙鳖、 日本鳖及其杂交子一代遗传多样性

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**摘要:** 为了解中华鳖的遗传多样性, 对 3 个群体中华鳖线粒体基因进行测序分析。实验获得 90 条序列, 25 种单倍型。碱基 A+T 含量为 61.4%, C+G 含量为 38.6%。3 个群体的单倍型多样性在 0.80-0.88 之间, 平均核苷酸差异数在 14.4-17.4 之间, 核苷酸多样性在 0.01019-0.01234 之间, 变异主要存在于群体内部。研究结果表明, 黄沙鳖群体遗传多样性较丰富, 杂交对中华鳖的遗传多样性有影响。

**关键词:** 中华鳖, 杂交育种, 遗传多样性, 线粒体 DNA

## Genetic diversity analysis of two geographical populations of *Pelodiscus sinensis* and their hybrids based on Cyt b

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**Abstract:** In order to understand the genetic diversity of *Pelodiscus sinensis*, the mitochondrial genes of the two geographical populations of *P. sinensis* and their hybrids were sequenced and analyzed. As a result, we obtained 90 sequences and 25 haplotypes. The content of base A+T was 61.4%, and the content of C+G was 38.6%. The haplotype diversity of the three populations is between 0.80-0.88. The average number of nucleotide differences is between 14.4-17.4, and the nucleotide diversity is between 0.01019-0.01234. The results of this study showed that the genetic diversity of the Huangsha population was rich, and hybridization events would impact on the genetic diversity of the *P. sinensis*.

**Key words:** *Pelodiscus sinensis*; crossbreeding; genetic diversity; mitochondria DNA

# 红鳍东方鲀幼鱼中性别分化 相关基因的表达分析

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**摘要：**本研究以孵化后 40、60 和 80d 的红鳍东方鲀幼鱼为研究对象，采用 qPCR 的方法查明了 *dmrt1*、*gsdf*、*cyp19a1a*、*foxl2* 基因在雌性和雄性幼鱼性腺中的表达规律。结果表明，*dmrt1* 和 *gsdf* 在孵化后 40、60、80d 时在 XY 性腺中的表达显著高于 XX。*Cyp19a1a* 和 *foxl2* 在 XX 性腺中表达水平显著高于 XY 个体。研究结果为深入研究性别分化相关基因在红鳍东方鲀性别分化过程中奠定基础。

**关键词：**红鳍东方鲀；幼鱼；性别分化相关基因；基因表达

## Expression Analysis of genes related to Sex differentiation in *Takifugu rubripes* larvae

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**Abstract:** In this study, the expression patterns of *dmrt1*, *gsdf*, *cyp19a1a* and *foxl2* genes in female and male gonads of juvenile *Takifugu rubripes* at 40, 60 and 80 days after hatching were investigated by qPCR method. The results showed that the expression of *dmrt1* and *gsdf* in the gonads of XY was significantly higher than that of XX at 40, 60 and 80 days after hatching. The expression levels of *Cyp19a1a* and *foxl2* in XX gonads were significantly higher than those in XY individuals. The results lay a foundation for the further study of sex differentiation-related genes in the process of sex differentiation of *T. rubripes*.

**Key words:** *Takifugu rubripes*; Larvae; Sex differentiation-related genes; Gene expression

# 鲤 gpx 基因家族的系统演化解析及 对镉暴露下的响应机制研究

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**摘要:** 谷胱甘肽过氧化物酶(Gpx)在调节细胞活性氧(ROS)稳态等方面起着重要作用。本研究发现鲤 gpx 基因家族发生了显著的扩张现象, 并分为五个亚类。本文探究了在重金属镉胁迫下, 饲料中添加不同浓度的凝结芽孢杆菌对鲤 gpx 基因表达情况的影响, 结果表明鲤不同亚类的 gpx 基因表达具有一定的差异性, 凝结芽孢杆菌在浓度为  $1.0 \times 10^7$  cfu/g 时基因的表达量更高, 推测凝结芽孢杆菌在增强机体抗氧化能力方面发挥作用。

**关键词:** 谷胱甘肽过氧化物酶; 系统进化分析; 重金属镉; 鲤; 凝结芽孢杆菌

## Phylogenetic analysis of gpx gene family and research of response mechanism to cadmium exposure in common carp(*Cyprinus carpio*)

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**Abstract:** Glutathione peroxidase (Gpx) is one of the important members of antioxidant enzymes and plays an important role in regulating cell reactive oxygen species (ROS) homeostasis. Previous studies have revealed that the gpx gene family of common carp, *Cyprinus carpio* exhibited significant expansion as compared with the diploid related species *Poropuntius huangchuchieni*. Phylogenetic analysis showed that the gpx genes of common carp were clustered into five different subclades. *Bacillus coagulans* is a probiotic that can improve the organism's immunity, that can be established based on a balanced antioxidant system. In this study, we explored the effect of the supplement of *B. coagulans* on the expression of gpx genes in the intestinal tract of common carp under the stress of heavy metal cd, and separately added different concentrations of *B. coagulans* into the feed for feeding. The results showed that *B. coagulans* could activate the expression of most genes in gpx gene family at the concentration of  $1.0 \times 10^7$  cfu/g and  $1.0 \times 10^8$  cfu/g, and the gene expression was higher at the concentration of  $1.0 \times 10^7$  cfu/g. It was speculated that *B. coagulans* played a role in enhancing the antioxidant capacity of the organism, thus effectively resisting the oxidative stress and diseases induced by reactive oxygen species.

**Key words:** : Glutathione peroxidase(Gpx); phylogenetic analysis; cd; common carp; *Bacillus coagulans*

# 杂交三倍体泥鳅及其亲本性腺发育观察及转录组学分析

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**摘要:** 以杂交三倍体泥鳅(正交  $2n \times 4n$ 、反交  $4n \times 2n$ )为实验材料, 对亲本及子代早期及成熟期性腺进行组织学及转录组学研究。结果表明: 三倍体泥鳅早期性腺分化和发生与二倍体无差别, 少数三倍体性腺能够发育成熟, 可形成少量配子。在正反交的亲本与子代之间分别筛选出 36 个和 53 个育性相关的差异表达基因。通过蛋白互作网络分析, 获得 54 个杂交三倍体泥鳅育性差的候选基因。研究结果为探讨杂交三倍体泥鳅育性分子机制提供依据。

**关键词:** 泥鳅, 杂交三倍体, 性腺发育, 转录组分析

## Histological Observation of Gonadal Development and Transcriptome analysis Of triploid hybrid loach and its parents

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**Abstract :** Hybrid triploid loaches (*Misgurnus anguillicaudatus*) were generated from natural tetraploid and diploid loaches. We studied its early and mature gonads from direct and reciprocal crosses through histological and transcriptome analyses. The results showed that the triploid offspring had inferior ability to form sperm and egg cells compared with diploid forms. 36 fertility-related genes were found to be differentially expressed between the direct cross ( $2n \times 4n$ ) progenies and their parents, while 53 fertility-related genes between the reciprocal cross ( $4n \times 2n$ ) progenies and their parents. Following protein-protein interaction network analyses, 54 differentially expressed genes, yielding candidate genes involved in the poor fertility of hybrid triploid loaches. The results of this study provide a basis for further exploring the molecular mechanism of hybrid triploid loach fertility.

**Key words::** loach,triploid hybrid,gonad development,transcriptomics

# 尼罗罗非鱼与淡水石斑鱼远缘杂交及雌核发育研究

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**摘要:** 以尼罗罗非鱼 (*Oreochromis niloticus*) 和淡水石斑鱼 (*Parachromis managuensis*) 为例, 通过胚胎发育、细胞和分子遗传学技术, 系统的研究了非洲和美洲起源的鲷鱼科不同物种间的远缘杂交和雌核发育, 结果显示两物种间的远缘杂交没有成活的子代, 而雌核发育子代都是二倍体, 且其基因纯合度高于养殖群体, 达到了快速建立纯系的目的。此外首次揭示了淡水石斑的性别决定方式为 XX/XY。

**关键词:** 淡水石斑鱼; 远缘杂交; 雌核发育; 尼罗罗非鱼

## Distant hybridization and gynogenesis between Nile tilapia *Oreochromis niloticus* and Jaguar cichlid *Parachromis managuensis*

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**Abstract:** To investigate the distant hybridization and gynogenesis between Nile tilapia *Oreochromis niloticus* and Jaguar cichlid *Parachromis managuensis*, reciprocal crossing was first performed between the two species. No offspring, however, were viable when there were these hybridizations. Gynogenesis was induced in *O. niloticus* and *P. managuensis* using ultraviolet (UV)-irradiated spermatozoa from *P. managuensis* and *O. niloticus*, respectively. The morphology during embryonic development indicated gynogenetic offspring of both *O. niloticus* and the *P. managuensis* were normal and deformed, and the results from flow cytometric analysis indicated normal fry were diploid and deformed fry were haploid. Gynogenetic *O. niloticus* and *P. managuensis* had the same DNA content and chromosome number as their species of origin, indicating that gynogenetic individuals were produced in both species. The presence of only females for both gynogenetic *P. managuensis* and *O. niloticus* was indicative of an XX genotype in the female *P. managuensis* and *O. niloticus*. Results from studies on genetic diversity indicated the average heterozygosity of the gynogenetic diploid population of *O. niloticus* were less than that of the cultured population, but the genetic homozygosity of the gynogenetic diploid population of *O. niloticus* was greater than that of the cultured population after one generation of gynogenesis, which achieved the goal of rapidly establishing genetic homozygosity.

**Key words:** *Parachromis managuensis*; Distant hybridization; Gynogenesis; *Oreochromis niloticus*.

# 转录组学分析揭示菲律宾蛤仔抗鳃弧菌的分子机制

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**摘要：**菲律宾蛤仔是我国重要的海洋经济贝类，但是近年来，菲律宾蛤仔的养殖过程受到弧菌、帕金虫等细菌病原物的侵害，这给蛤仔养殖产业带来的巨大的损失。本研究中，我们对菲律宾蛤仔进行模拟生物胁迫，实验用浓度为 107 CFU/ml 鳃弧菌进行胁迫，对胁迫后死亡率最高的第七天蛤仔进行分析，样品选取具有抗性的正常存活状态蛤仔和易感病的濒死状态蛤仔和未受处理的空白对照组，通过构建三组样品转录组文库，并在 Illumina 检测。

**关键词：**关键词：菲律宾蛤仔；转录组；鳃弧菌；分子机制

## Molecular Mechanisms Underlying Vibrio Tolerance in Manila clam Revealed by Comparative Transcriptome Profiling

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**Abstract :** The Philippine clam is an important marine economic shellfish in China. However, in recent years, the breeding process of the Philippine clam has been infested by bacterial pathogens such as Vibrio and Parkinson's, which has brought huge losses to the clam breeding industry. In this study, we conducted simulated biological stress on the Philippine clams. The experiment used the stress with a concentration of 107 CFU/ml Vibrio anguillarum. The 7th day of the highest mortality after the stress was analyzed. The samples were selected as resistant normal ones. The surviving clams and the susceptible dying clams and the untreated blank control group were constructed by constructing three sets of sample transcriptome libraries and testing them on Illumina.

**Key words: :** Ruditapes. Philippinarum; Transcriptome; Vibrio Tolerance; Molecular mechanism

# 温度升高对蛤仔免疫指标和耐干露能力的影响

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**摘要：**菲律宾蛤仔是典型的埋栖型贝类，生活在海洋与陆地过渡的潮间带区域。自然条件下，高温及干露等环境胁迫都是影响菲律宾蛤仔死亡率的因素。本研究以菲律宾蛤仔为研究对象，对蛤仔在急性高温胁迫、干露胁迫及干露后恢复期间抗氧化酶活力的变化进行检测分析。分别对两个群体蛤仔的死亡率进行了统计，并分析了其肝胰腺 CAT、SOD、T-AOC 抗氧化酶的活性变化。

**关键词：**菲律宾蛤仔，温度升高，干露，抗氧化酶

## Effect of temperature rise on immune indexes and dry dew tolerance of clams

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**Abstract:** *Ruditapes philippinarum* is a typical buried shellfish, living in the intertidal zone between sea and land. In natural conditions, high temperature, air-exposure and other environmental stresses are the factors affecting the mortality of *R. philippinarum*. In this study, we detected the activities of CAT, SOD and T-AOC in culture population clam and wild population under the condition of acute high temperature stress, air-exposure stress and recovery after air-exposure. The mortality of two populations were counted, and the activities of CAT, SOD and T-AOC antioxidant enzymes in hepatopancreas were analyzed.

**Key words:** *Ruditapes philippinarum*, high temperature, air-exposure, antioxidase



# 基于呼吸频率、鳃组织切片和抗氧化酶等多层次评估真鲷、回交鲷 F1 和黑鲷耐热性能

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**摘要:** 温度可以对鱼类的生长、发育和摄食中发挥重要作用的因子。然而, 海水鱼耐热育种缺乏系统研究是耐热性评价体系建立进展缓慢的主要原因之一。回交已被证明是水产养殖遗传改良的有效方式, 可以将改良的性状引入回交后代。在本研究中, 我们从多层次的角度分析了回交 F1 (黑鲷♀×真鲷♂) ♂×黑鲷♀、真鲷和黑鲷的耐热性及差异。温度变化显著影响鲷科鱼的生理状态, 而回交鲷 F1 可能很好的继承了黑鲷良好的耐热基因, 对热胁迫有更强适应性。

**关键词:** 热胁迫, 耐热性, 遗传改良

## The respiratory activity, histopathological sections and enzymes in a backcross progeny between *Acanthopagrus schlegelii* and *Pagrus major* subjected to thermal stress

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The respiratory activity, histopathological sections and enzymes in a backcross progeny between *Acanthopagrus schlegelii* and *Pagrus major* subjected to thermal stress

**Abstract:** Temperature factor that performs important functions in fish growth, development and feeding. Lack of systematic studies for heat-resistant breeding of seawater fish is one of the main causes of slow progress in developing heat tolerance evaluation system. Backcrossing is an effective way of genetic improvement in aquaculture, which can introduce improved traits to the backcross progeny. In this study, We analyzed thermal tolerance of Backcross F1 [Hybrid (*Acanthopagrus schlegelii*♀×*Pargus major*♂) ♂×*Acanthopagrus schlegelii*♀], *Pargus major* and *Acanthopagrus schlegelii* from a multilevel perspective. Backcross F1 may inherited more resistant to heat stress from *Acanthopagrus schlegelii* (AA).

**Key words:** heat stress, thermal tolerance, genetic improvement

# 长期高温胁迫对新吉富罗非鱼生长，基础代谢，耐低氧能力以及全基因组表达的影响

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**摘要：**鱼类是变温动物，外界水环境温度直接影响鱼类的生理活动。罗非鱼是一种重要的经济养殖鱼类，夏季高水温常造成罗非鱼食欲减退，生长速度降低。为了研究高水温下罗非鱼的生长代谢变化，提高罗非鱼的夏季养殖效率，本课题围绕高温胁迫对罗非鱼生长的分子机制开展研究。研究发现长期 36°C 高温驯化下的罗非鱼生长速度变缓，体型发生显著变化，且适应性地降低了基础代谢率，在不同温度下的基础代谢率均低于 28°C 和 32 °C 驯化的鱼。

**关键词：**高温胁迫、罗非鱼、基础代谢

## Effects of long-term high temperature stress on growth, basic metabolism, hypoxia tolerance and whole genome expression of neogifu tilapia

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**Abstract:** Fish is a variable temperature animal. The external water environment temperature directly affects the physiological activities of fish. Tilapia is an important economic cultured fish. High water temperature in summer often leads to loss of appetite and reduced growth rate of tilapia. In order to study the changes of growth and metabolism of tilapia under high water temperature and improve the breeding efficiency of tilapia in summer, this topic focused on the molecular mechanism of high temperature stress on tilapia growth. It was found that the growth rate of tilapia domesticated at 36 °C for a long time slowed down, the body shape changed significantly, and the basal metabolic rate decreased adaptively. The basal metabolic rate at different temperatures was lower than that of tilapia domesticated at 28 °C and 32 °C.

**Key words::** High temperature stress ,Tilapia , Basic metabolism

# 鲤 ITG $\alpha$ 6 基因的克隆、功能分析及其与 CyHV-3 感染的关系

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**摘要:** 当前鲤在养殖中受到 CyHV-3 的严重影响, 研究表明 ITG $\alpha$ 6 与疱疹病毒感染有关。本研究首次从鲤鱼中克隆获得了 ITG $\alpha$ 6 的两个转录本全长, 转录本一全长为 3867bp, ORF 为 3273bp, 转录本二全长为 3368bp, ORF 为 3189bp。结果表明, CcITG $\alpha$ 6 在鲤鱼组织中均有表达。在鲤受 CyHV-3 攻毒感染过程中, 转录本二可能在鲤抵抗 CyHV-3 感染的过程中有重要作用, 有待进一步证实。

**关键词:** 整合素 $\alpha$ 6 基因; 克隆; 相对表达量; CyHV-3; 鲤鱼

## Molecular Cloning and functional analysis of Common Carp (*Cyprinus carpio*) integrin $\alpha$ 6 and its correlation with the resistance to CyHV-3 virus infection

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**Abstract:** Integrin  $\alpha$ 6 (ITG $\alpha$ 6) is involved in a variety of cellular physiological responses and plays an important role in the immune response. Currently, common carp is severely affected by the virus of Cyprinid herpesvirus 3 (CyHV-3) in aquaculture. Studies have shown that ITG $\alpha$ 6 is associated with herpes virus infection. However, the role of the ITG $\alpha$ 6 in response to CyHV-3 virus infection is still unclear. In this paper, we cloned the gene of ITG $\alpha$ 6 from common carp (CcITG $\alpha$ 6) and studied its expression profile after infection of CyHV-3 virus. Two transcripts of ITG $\alpha$ 6 were cloned, named CcITG $\alpha$ 6a and CcITG $\alpha$ 6b. The full-length cDNA of CcITG $\alpha$ 6a transcript was 3867bp, the ORF was 3273b. The full-length cDNA of CcITG $\alpha$ 6b transcript was 3368bp, the ORF was 3189 bp. Two transcripts of CcITG $\alpha$ 6 both consist of four parts of the signal peptide, extracellular region, a transmembrane region, and the cytoplasmic region. And the difference between the two CcITG $\alpha$ 6 transcripts lies in the cytoplasmic region. The two CcITG $\alpha$ 6 transcripts were constitutively expressed in ten sampled tissues but displayed distinct expression patterns. After the CyHV-3 virus infection, the expression of CcITG $\alpha$ 6b in the breeding strain was significantly higher than that in the non-breeding strain at all infection stages. This result indicated that the CcITG $\alpha$ 6b might play an important role in resistance to CyHV-3 of common carp.

**Key words:** ITG $\alpha$ 6; bioinformatics analysis; relative expression; CyHV-3; common carp

# 人工养殖过程中大刺鲃间性个体的发现

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**摘要:** 我们通过对大刺鲃连续 4 年的养殖试验, 发现大刺鲃雌雄性别比例严重偏离 1:1, 雌性比例较高且个体较小。进而从形态学、解剖学和性腺组织学水平首次证明了大刺鲃在人工养殖条件下出现间性个体。通过对大刺鲃不同性腺转录组分析, 鉴定出的性别差异候选基因 *Dmrtb1/Dmrt6*, 特异性表达于精子细胞、精子、精原细胞和精母细胞中。通过单细胞转录组分析, 发现间性性腺中存在具有双向性别分化的潜力的细胞群。

**关键词:** 性别二态性; DM 结构域; *dmrtb1/dmrt6*; 间性; 单细胞 RNA 测序

## Bulk and single-cell RNA-seq reveal the sexually dimorphic expression pattern of *dmrtb1* in zig-zag eel (*Mastacembelus armatus*)

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**Abstract :** Sequential hermaphroditism, whereby the sex of one individual changes during its development, has been described in many fish species. Here, we report the characterization of intersexual differences in an aquacultural fish, the zig-zag eel (*Mastacembelus armatus*), based on 4 years of artificial breeding. A DM-domain candidate gene, *dmrtb1*, was identified from gonadal transcriptome data screening. The expression of *dmrtb1* was restricted to testis, similar to *dmrt1*, which is one of the conserved sex-determining genes in vertebrates. Interestingly, *dmrtb1* was expressed at the onset of sex change (early stage), and gradually increased in expression in the intersex gonads until the late stage of differentiation. *Dmrtb1* was also expressed in the seminiferous lobules containing cysts with germ cells. A mixed cell population from ovotestis was identified by single-cell RNA sequencing, and included mitotic fetal germ cells, meiotic prophase fetal germ cells, and gonad endothelial cells. Spermatocyte and oocyte marker genes were both enriched in the same gonadal cell population, indicating this cell population might have the potential of bisexual differentiation.

**Key words::** Sexual dimorphism, DM-domain, *dmrtb1/dmrt6*, Intersex, Single-cell RNA sequencing

# 养殖密度对达氏鳇幼鱼生长、血清生化指标和消化酶活力的影响

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**摘要:** 为了提供达氏鳇幼鱼人工养殖的基础数据, 试验随机挑选 18 d 达氏鳇幼鱼 15000 尾, 分成 5 个密度组, 每组设 3 个重复。研究在循环水养殖条件下不同养殖密度 (1100 尾/m<sup>3</sup>、1500 尾/m<sup>3</sup>、1850 尾/m<sup>3</sup>、2200 尾/m<sup>3</sup>、2600 尾/m<sup>3</sup>) 对其生长、血清生化指标和消化酶活力的影响。试验 60 d 后, 随机挑选各密度下的达氏鳇幼鱼 6 尾, 尾椎动脉采血, 测定血清生化指标; 取前、中、后肠和肝脏, 测定其消化酶活

**关键词:** 达氏鳇; 养殖密度; 生长性能; 血清生化指标; 消化酶

## Effects of Culture Density on Growth, Serum Biochemical Indices and Digestive Enzyme Activities of Juvenile *Huso dauricus*

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**Abstract:** In order to provide the basic data for the artificial culture of juvenile of *Huso dauricus*, 15000 *Huso dauricus* were randomly selected for 18 days and divided into 5 density groups with 3 replicates in each group. The effects of different stocking densities (1100, 1500, 1850, 2200 and 2600/m<sup>3</sup>) on the growth, serum biochemical indexes and digestive enzyme activities were studied. After 60 days of the experiment, 6 juvenile of *Huso dauricus* were randomly selected and blood samples were collected from the vertebral artery of the tail to determine the serum biochemical indexes; The activities of digestive enzymes in the intestine and liver were measured. The results showed that the final body length, body weight, absolute growth rate, relative growth rate and specific growth rate of juveniles *Huso dauricus* decreased first and then increased with the increase of culture density. Among them, the growth indexes of low density group (1100 /m<sup>3</sup>) were significantly higher than those of the other four density groups ( $P < 0.05$ ). With the increase of culture density, there was no significant difference in the fatness of the juveniles *Huso dauricus* ( $P > 0.05$ ), but the mortality increased significantly with the increase of culture density ( $P < 0.05$ ). In addition, the activities of alkaline phosphatase, lactate dehydrogenase, and aspartate aminotransferase in the serum of juveniles *Huso dauricus* significantly decreased with increasing farming density ( $P < 0.05$ ); The total protein and albumin conte

**Key words:** *Huso dauricus*; Culture density; Growth performance; Serum biochemical indexes; Digestive enzyme

# 对高温胁迫下吉富罗非鱼肝脏和肠道组织的转录组分析

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**摘要:** 吉富罗非鱼是中国水产养殖业中一种主要养殖品种。本实验对身长 5-7 厘米的幼吉富罗非鱼进行瞬时高温胁迫实验, 设置初始温度 23°C, 在 28°C、33°C 胁迫 24h 后分别进行取样, 对肝脏和肠道组织进行转录组测序分析, 结果如下: 23°C 与 28°C 对比, 共有 136 个基因表达量改变, 差异表达基因富集于生物膜中; 23°C 与 33°C 对比, 共有 317 个基因表达量发生改变, 总生理生化指标有较大变化, 即温度升高使罗非鱼产生了应激反应。

**关键词:** 吉富罗非鱼; 肝脏; 肠道; 转录组分析

## Transcriptome analysis of liver and intestinal tissues of GIFT tilapia under high temperature stress

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**Abstract:** GIFT tilapia is one of the main raised kinds in China's domestic tilapia farming industry. In this experiment, a transient high temperature stress experiment was performed on juvenile GIFT tilapia with a length of 5-7 cm. The initial temperature was set to 23°C, and samples were taken after stressing at 28°C and 33°C for 24 hours. Transcriptome sequencing of liver and intestinal tissues were performed and analyzed. The results are as follows: Compare 23°C with 28°C, there are 136 differential gene, of which 80 is up-regulated and 56 is down-regulated, indicating that tilapia has not been subjected to high temperature stress and the metabolic response in the body is normal. Differential gene expressions are enriched in the biofilm, and the enzyme activity and cell binding activity vary greatly. Compare 23°C with 33°C, a total of 317 gene expression levels have changed, of which 227 are up-regulated and 90 are down-regulated. The number of up-regulated genes is much greater than the number of down-regulated genes, the total physiological and biochemical indicators have changed greatly, that is, the increasing temperature causes stress response in tilapia. Differential gene expressions are enriched in cells, cell composition, and organelles, and protein processing and metabolic pathways vary greatly.

**Key words:** GIFT tilapia, Liver, Intestine, Transcriptome analysis.

# 低氧胁迫下对瘤背石磺糖酵解途径及存活的影响

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**摘要：**缺氧是潮间带贝类面临的难题之一。然而，目前的研究都集中于对生理的影响。本研究用 RACE 法克隆瘤背石磺 GLUT-1 基因，进行生物信息学和组织表达分析，并测定低氧下神经和肝胰腺组织中能量代谢相关基因的变化。结果表明，该基因 cDNA 全长 2386 bp。在低氧条件下神经和肝胰腺组织中基因 HK、PKM 和 LDH 变化量显著，说明缺氧可能影响瘤背石磺的代谢方式。本研究将对了解瘤背石磺在低氧环境中的生存机制提供参考。

**关键词：**瘤背石磺；低氧胁迫；糖酵解；能量代谢相关基因

## Glycolytic pathway regulates survival of *Onchidium reevesii* under hypoxia

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**Abstract:** Hypoxia has long been one of the challenges faced by intertidal shellfish. However, current studies have focused on the effects on physiology. Therefore, this study cloned the GLUT-1 gene of *Onchidium reevesii* using the RACE method, and performed an analysis of bioinformatics and tissue expression, and determined the changes of energy metabolism-related genes in neural and hepatopancreas tissues under hypoxic conditions. The results showed that the full-length of this gene's cDNA is 2386 bp. The amount of changes in genes HK, PKM and LDH in neural and hepatopancreatic tissues under hypoxic conditions was significant, which suggested that hypoxia may affect the metabolic pattern of *Onchidium reevesii*. This study will provide reference material for understanding the survival mechanism of *Onchidium reevesii* in hypoxic environment.

**Key words:** *Onchidium reevesii*; hypoxia; glycolysis; energy metabolism-related genes

# 利用 PCR-RFLP 方法对大口黑鲈 37 个 SNP 标记分型和特征分析

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**摘要:** 大口黑鲈 (*Micropterus salmoides*) 是我国重要经济鱼类之一。与近几十年来其产量迅速增加相反, 国内大口黑鲈遗传多样性逐渐下降。本研究通过二代测序数据 (GBS) 随机挑选出 37 个单核苷酸多态性 (SNP) 标记, 利用 PCR-RFLP 分型技术在 32 个养殖个体中进行分型, 并对所有 SNPs 进行特征分析。本研究开发的多态性 SNPs 标记可为大口黑鲈后续种质资源的合理挖掘与利用提供参考。

**关键词:** 大口黑鲈, SNP, PCR-RFLP, 种质资源

## Development and characterization of 37 SNP markers for the largemouth bass (*Micropterus salmoides*) by using PCR-RFLP method

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**Abstract:** Largemouth bass is one of the important economic fishes in China. Contrary to the rapid increase in yield in recent decades, the genetic diversity of largemouth bass in China has gradually decreased. In this study, 37 single nucleotide polymorphism (SNP) markers were randomly selected from the second generation sequencing data (GBS), and PCR-RFLP typing technique was used for typing in 32 cultured individuals, and the characteristics of all SNPs were analyzed. The main results were as follows: (1) PCR-RFLP genotyping technology could successfully classify 37 SNPs, and the genotyping results were consistent with the direct sequencing results. (2) The analysis of Cervus3.0 software showed that the effective number of alleles ( $N_e$ ), observed heterozygosity ( $H_o$ ), expected heterozygosity ( $H_e$ ) and polymorphism information content (PIC) of 37 SNPs were 1.168~1.998, 0.156~0.844, 0.146~0.507 and 0.134~0.375, respectively. Among them, two loci were low polymorphism ( $PIC < 0.25$ ), and the remaining 35 SNPs were moderate polymorphism ( $0.25 < PIC < 0.50$ ). (3) Popgene 1.32 was used to analyze the Hardy-Weinberg equilibrium and linkage disequilibrium at 37 loci. The results showed that five loci significantly deviated from the Hardy-Weinberg equilibrium ( $p < 0.05$ ), while no linkage disequilibrium existed at all loci. The polymorphic SNPs markers developed in this study can provide reference for the rational exploitation and utilization of largemouth bass germplasm resources.

**Key words:** *Micropterus salmoides*; SNP; PCR-RFLP; germplasm resources



# hepcidin 基因对斑马鱼早期造血系统的影响

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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。铁离子是血液发生的重要元素，为了研究其对造血系统发生的影响，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，发现斑马鱼外周血血清铁显著降低；血红蛋白含量也显著减少；造血相关基因在 mRNA 水平上也发生了不同的变化，揭示了 hepcidin 基因与造血功能也有着密切联系。

**关键词：**铁调素；血清铁；血红蛋白；造血系统

## Effects of hepcidin gene on the early hematopoietic system of zebrafish

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**Abstract :** Hepcidin (Hepcidin) is a cationic small molecule antimicrobial peptide specifically expressed in the liver, and it is an important hormone that regulates the iron balance in the body. Iron ion is an important element in blood production. In order to study its influence on the hematopoietic system, we used crispr/cas9 knockout technology to construct an in vivo model of zebrafish hepcidin gene deficiency, and found that zebrafish peripheral blood serum iron was significantly reduced; hemoglobin content Also significantly reduced; hematopoietic-related genes have also undergone different changes at the mRNA level, revealing that hepcidin gene is also closely related to hematopoietic function.

**Key words: :** hepcidin;Serum iron; hemoglobin; hematopoietic system

# 鳊胰腺的组织学及超显微结构

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**摘要：**利用解剖学、组织学和透射电镜技术研究了鳊胰腺大体结构、显微和超显微结构。结果发现：胰腺分布在肝、胃、幽门盲囊、前肠间系膜处，存在肉眼可见白色颗粒状胰岛，在幽门盲囊之间存在腺泡细胞。胰腺腺泡细胞呈锥状，细胞核位于膨大的基部，顶端胞质充满酶原颗粒，胰岛中存在分泌颗粒明显不同的两种内分泌细胞。

**关键词：**鳊；胰腺；组织学；超显微结构

## Studies on histochemistry and ultrastructure of the pancreas in Mandarin fish (*Siniperca chuatsi*)

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**Abstract:** The structures of the pancreas in Mandarin fish (*Siniperca chuatsi*) were studied by means of anatomy, histology and transmission electron microscopy. Results showed that the pancreas was mainly distributed on the mesentery among liver, stomach, pyloric caecum and forepart of intestines, and with white granular islets, there were exocrine cells between the pyloric caecum. The pancreatic acinar cells were cone-shaped, the nucleus was located at the expanded base of cells, and the cytoplasm in the top of cell was filled with zymogen granules. There were two kinds of endocrine cells with different secretion granules in the islet.

**Key words:** *Siniperca chuatsi*, pancreas, histochemistry, ultrastructure

# 新疆和西藏棕鲟群体的遗传多样性分析

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**摘要:** 为了解新疆和西藏棕鲟养殖群体的遗传多样性状况,了解两地棕鲟的亲缘关系和适应差异,采用全基因组重测序技术对来自西藏亚东县和新疆达坂城的两个棕鲟群体各 12 个体进行基因组重测序,对多态信息位点进行群体遗传学分析。发现两个群体的遗传多态性相似,亲缘关系相近,可能源自共同的群体。群体间选择消除分析鉴定了 21 个受到强烈选择的候选基因,其中 17 个来自西藏棕鲟群体,仅 4 个来自新疆棕鲟群体,这些基因主要与免疫相关。

**关键词:** 棕鲟; 群体遗传学; 选择消除分析; 基因组; 重测序

## Genetic diversity analysis of brown trout populations in Xinjiang and Tibet

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**Abstract:** To investigate the genetic diversity in brown trout (*Salmo trutta*) populations from Xizang and Xinjiang, provide understanding of their genetic relationship and adaptive differences. Using whole genome re-sequencing technology, 24 farmed brown trout individuals from two different farmed brown trout populations in Yadong, Tibet and Dabancheng, Xinjiang were sequenced. And population genetic analysis were applied on Single nucleotide polymorphism locus. Genetic diversity of Xizang brown trout population is slightly higher than that of Xinjiang. Population structure analyze and phylogenetic method revealed the close relation between the two population. Using selective sweep based on  $F_{ST}$  and  $\pi$ , 21 candidate genes under strong selection were obtained, 17 of which were from Tibet brown trout, while 4 candidate genes from Xinjiang brown trout. KEGG pathway analysis shows these genes belong to nervous system or immune related pathways. Xinjiang brown trout and Tibet brown trout share a common ancestral group, suggests they were introduced from the same place one after another. Disease may be the main selection factor for Tibetan brown trout.

**Key words:** Brown trout; Population genetics; Selective sweep analysis; Genome; Re-sequencing

# 湖南九肋鳖资源调查及生物学特性研究

万刚

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**摘要：**中华鳖是我国重要的特种水产经济动物，其背甲肋板为8对。在湖南沅江境内记录过一种“九肋鳖”，其肋板为9对。然而，除肋板差异外，关于九肋鳖的报道研究较少。本研究以洞庭湖甲鱼种群为研究对象，研究了九肋鳖的种群分布和生物学特性，同时收集了大量九肋鳖亲本。本研究为后续九肋鳖优势性状的挖掘提供了材料基础。

**关键词：**九肋鳖；资源调查；生物学特性；优势性状

## Resources Investigation and Biological Characteristics of the Nine Rib Turtles in Hunan

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**Abstract:** The Chinese soft-shelled turtle is an important special aquatic economic animal in China, with 8 pairs of carapace ribs. A "nine-ribbed turtle" has been recorded in Yuanjiang, Hunan, with 9 pairs of ribs. However, in addition to the difference in ribs, there are few reports and studies on the nine-ribbed turtle. This study took the Dongting Lake soft-shelled turtle population as the research object, studied the population distribution and biological characteristics of the nine-ribbed soft-shelled turtle, and collected a large number of nine-ribbed turtle parents. This study provides a material basis for the subsequent excavation of the dominant traits of the nine-ribbed soft-shelled turtle.

**Key words:** : Nine-ribbed soft-shelled turtle; resource survey; biological characteristics; dominant traits

# 斑点叉尾鮰 rrp44 基因 SNP 多态性与生长相关性关联分析

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**摘要:** 本实验选取了 8 个不同家系的 303 条斑点叉尾鮰, 筛选出 rrp44 基因的 48 个 SNP 位点, 对 SNP 位点进行分型, 并将 SNP 位点与个体不同生长性状进行关联分析。结果显示, SNP 位点 g.5514 G>C 与体长和体重显著相关。研究结论表明, 具有 CC 基因型个体的体质量比群体的平均值高 11.1%。rrp44 生长相关性 SNP 分析的结果将为斑点叉尾鮰分子标记辅助育种提供参考依据。

**关键词:** 斑点叉尾鮰; rrp44 基因; SNP; 生长性状; 关联分析

## Association between SNP polymorphism of rrp44 gene and growth of *Ictalures punctatu*

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**Abstract:** In order to explore the relationship between the single nucleotide polymorphism (SNP) of rrp44 gene and growth traits of *Ictalures punctatu*, 303 individuals from eight families were tested. The rrp44 gene of all individuals were screened by pooled DNA sequencing, and correlation analysis were conducted between the selected SNPs and different growth traits. The results showed that there were 48 SNPs in rrp44 gene, among which 1 SNP (g.5514C>G) were significantly correlated with growth traits of *Ictalures punctatu* ( $P < 0.05$ ). The conclusion indicated that genotype CC had the highest body weight, which is 11% higher than the average of the group. As a RNase, RRP44 regulated the gene expression in the process of channel catfish's growth. The analysis of its growth-related SNP provide basic knowledge for the marker-assisted breeding for channel catfish.

**Key words:** *Ictalures punctatu*, rrp44 gene, SNP, growth correlation, association analysis

# 感染才女虫虾夷扇贝外套膜组织的蛋白质组学研究

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**摘要:** 近年来, 才女虫常常侵染虾夷扇贝的养殖, 严重影响虾夷扇贝的生长和品质。为探讨虾夷扇贝应答才女虫侵染的分子机制, 本研究借助 TMT 技术, 对患病及健康扇贝外套膜进行了蛋白质组学分析。共鉴定获得 5177 个蛋白, 其中 519 个显著差异表达, 包括 317 个下调表达, 202 个上调表达。差异蛋白功能分析显示与壳形成和免疫相关的蛋白显著差异表达, KEGG 富集分析发现内质网介导的吞噬作用在虾夷扇贝抵抗才女虫病中起重要作用。

**关键词:** 虾夷扇贝; 才女虫; 蛋白质组学

## Proteomic studies on the mantle tissue of Yesso scallop (*Patinopecten yessoensis*) infected with *Polydora*

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**Abstract:** In recent years, the aquaculture of the Yesso scallop was often infected by *Polydora*, which badly affected the growth and quality of the Yesso scallop. In the present study, to explore the molecular response mechanism of the Yesso scallop to the infection of *Polydora*, proteomic analysis of the mantle tissues of the diseased and healthy Yesso scallops was carried out with TMT technique. A total of 5177 proteins were identified, of which 519 were significantly differentially expressed, including 317 down-regulated and 202 up-regulated proteins. KEGG enrichment analysis showed that endoplasmic reticulum (ER) mediated phagocytosis played an important role in the resistance of the Yesso scallop to *Polydora*.

**Key words:** Yesso scallop; *Polydora*; proteomic

# 光谱对红鳍东方鲀幼鱼视网膜结构的影响

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**摘要:** 我们以红鳍东方鲀受精卵为研究对象, 查明在相同光照强度不同光谱下的白光、红光、绿光、黄光和蓝光对由受精卵孵化的红鳍东方鲀幼鱼视网膜显微结构和超微结构的影响规律。通过组织学切片研究发现, 蓝光处理下的幼鱼的色素上皮层 (PRE) 总厚度比率显著低于绿光和黄光处理下的幼鱼。此外, 蓝光处理下的幼鱼的感光层 (PRos/is) 总厚度比率也显著低于其他光处理下的幼鱼。综上, 可以得出光谱对红鳍东方鲀的视网膜结构产生影响。

**关键词:** 红鳍东方鲀, 光谱, 视觉, 视网膜结构

## Effect of Spectrum on Retinal structure of takifugu rubripes larval

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**Abstract:** We took the fertilized eggs of takifugu rubripes as the research object to find out the effects of white light, red light, green light, yellow light and blue light under the same light intensity and different spectra on the microstructure and ultrastructure of the retina of juvenile red-finned cuttlefish hatched by fertilized eggs. Through the study of histological sections, it was found that the total thickness ratio of pigment epithelium (PRE) of young fish treated with blue light was significantly lower than that of young fish treated with green light and yellow light. In addition, the total thickness ratio of photosensitive layer (PRos/is) of juvenile fish treated with blue light was significantly lower than that of juvenile fish treated with other light. In summary, it can be concluded that the spectrum has an effect on the retinal structure of takifugu rubripes

**Key words::** takifugu rubripes, Spectral, Visual, Retinal structure

# 牡蛎高温抗性机制与育种

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**摘要：**针对牡蛎夏季大规模死亡现象，开展了高温抗性遗传机制与育种研究。以长牡蛎及其亚种福建牡蛎为对象，首先建立了心率、呼吸代谢率等生理表型测定方法；其次，利用比较基因组学发现 HSP 基因在高温抗性中发挥重要作用；进一步研究了 HSF-HSP 调控通路及其相关的调控元件；利用急性应激选择，结合上述获得的育种调控元件进行分子辅助选择，开展了 4 代高温抗性遗传选育，目前高温抗性新品系的高温抗性能力提升了 24.2%。

**关键词：**牡蛎，高温抗性，HSP, 遗传育种

## The Genetic Mechanism and Breeding for High Temperature Resistance in the Oyster

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**Abstract:** Due to the mass summer mortality for the oysters, the genetic mechanism and breeding for high temperature resistance were conducted. Using the Pacific oyster (*Crassostrea gigas gigas*) and its southern subspecies Fujian oyster (*Crassostrea gigas angulate*), the physiological methods for phenotyping such as heart rate and respiratory metabolic rate were established; Secondly, the expressional plasticity of HSP gene was found to play an important role in its high temperature resistance by means of comparative genomics; The regulatory pathway of HSF-HSP and its related regulatory elements were further identified; Four generations of high temperature resistance genetic breeding were carried out by using acute stress selection and molecular-assisted selection using the above obtained breeding regulatory elements. At present, the high temperature resistance ability of the selected oysters has been improved by 24.2%.

**Key words:** Oyster, thermal resistance, HSP, genetic breeding



# 不同壳色虾夷扇贝外套膜全基因组 DNA 甲基化分析

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**摘要:** 目前, DNA 甲基化对贝类壳色影响的研究还较为有限, 限制了壳色形成分子机制的阐明。本研究利用 WGBS 技术, 首次绘制了褐、白虾夷扇贝外套膜的全基因组甲基化图谱。褐贝的全基因组甲基化水平明显高于白贝; 筛选获得 41175 个 DMR, 其中黑色素及卟啉色素合成相关功能和通路显著富集, 且壳色相关基因的 mRNA 水平与 DNA 甲基化水平间具有一定的相关性, 表明了 DNA 甲基化在虾夷扇贝壳色形成中发挥重要的调控作用。

**关键词:** 虾夷扇贝; DNA 甲基化; WGBS; 贝壳壳色形成; 表观遗传调控

## Genome-wide DNA methylation analysis of the mantle tissues in Yesso scallops (*Patinopecten yessoensis*) with different shell colors

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**Abstract:** At present, the research on the effect of DNA methylation on shell color of shellfish is still finite, which limits the elucidation of the molecular mechanism of shell color formation. In this study, the whole genome methylation map of mantle tissue of brown and white scallop scallops (*Patinopecten yessoensis*) was drawn for the first time by using WGBS technology. The whole genome methylation level of brown scallop is significantly higher than that of white scallop; 41,175 DMRs (differentially methylated regions) were obtained after selection, in which GO functions and pathways associated with the biosynthesis of melanin and porphyrins were significantly enriched, and there was a certain correlations between mRNA expression levels and DNA methylation status in key shell colour-related genes, suggesting that DNA methylation plays an important role in shell colouration of the Yesso scallop.

**Key words:** Yesso scallop; DNA methylation; WGBS; shell colouration; epigenetic regulation

# 皱纹盘鲍（*Haliotis discus hannai*）南北方群体对高温适应的周年研究

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**摘要:** 南北方群体在福建地区周年养殖显示, 皱纹盘鲍“夏季死亡综合症”发生与5月底到11月, 死亡高峰出现在8月底到10月; 北方群体夏季累积死亡率高达85.21%, 显著高于南方群体。南方群体的耐高温指标心率ABT稳定在30.11~30.63°C, 其耐温上限可能是皱纹盘鲍夏季死亡的主要因素。南北方群体4个月的转录组差异分析结合表达趋势分析表明, 如何高效“节能”可能是皱纹盘鲍应对夏季持续高温胁迫的关键。

**关键词:** 皱纹盘鲍, 高温胁迫, 周年养殖, 转录组

## Comparison of southern and northern populations of Pacific abalone reveals the response strategy to persistent heat stress in summer

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**Abstract:** The year domestication experiment indicated that DL abalone from northern population grew faster in low-temperature seasons and JJ abalone from southern population grew faster in high-temperature seasons. The “summer mortality” occurred from late May to November, with mortality peak from the August to October. The cumulative mortality of DL abalone (85.21%) was significantly higher than that of JJ abalone (52.99%). With the extension of aquaculture duration in the south of China, the ABT values of DL abalone were increased but lower than that of JJ abalone. The ABT values of JJ abalone were stable between 30.11 °C and 30.63 °C, indicating that the upper limit of thermal tolerance might be the main factor for the higher summer mortality. Transcriptomic analysis indicated that DL abalone adopted a relatively direct and “intense” strategy in response to thermal stress, in which more genes were triggered with higher expression levels and more modulation pathways were initiated; whilst the JJ abalone was more like an “energy saver” with a much milder response to temperature changes, leaving more energy to survive. The study suggested that efficient energy conservation may be the key for the abalone to cope with the persistent thermal stress in summer.

**Key words:** Pacific abalone, Heat stress, Domestication, Transcriptome

# 鱼类信息素对大型溞诱导型防御特征的影响

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自然界中捕食者对猎物诱导型防御特征存在一定影响, 为探究捕食信息素对枝角类表型可塑性是否存在剂量效应, 本试验使用孔雀鱼 (*Poecilia reticulata*) 作为捕食者, 大型溞 (*Daphnia magna*) 作为被捕食者, 设立 0% ( $M_0$ )、10% ( $M_1$ )、50% ( $M_2$ )、100% ( $M_3$ ) 四种信息素浓度, 连续测量三代。试验结果显示, 信息素处理下大型溞体长、体高绝对长度显著减小 ( $P<0.01$ )、壳刺相对长度显著增加 ( $P<0.01$ ), 产幼数显著增加 ( $P<0.01$ ); 信息素处理下, 体型有逐代减小趋势 ( $P>0.05$ ); 连续三代个体中,  $M_3$  处理组体长、体高均最小, 壳刺相对长度最大; 信息素处理下产幼数均比对照组高, 以第三代  $M_1$  处理组最高。试验结果表明, 信息素对枝角类表型形态的影响存在剂量效应, 随着浓度的增加体型变小, 但产幼数不存在剂量效应, 只存在有或无的效应。

**关键词:** 大型溞; 孔雀鱼; 信息素浓度; 表型可塑性; 剂量效应

## Effects of fish kairomones on inducible defense characteristics of *Daphnia magna*

Predators in nature have a certain influence on the characteristics of prey induced defense. In order to explore whether there is a dose dependent response of predator kairomones on phenotypic plasticity of Cladocerans, this experiment used *Poecilia reticulata* as predator and *Daphnia magna* as prey. Four kairomones concentrations of 0 % ( $M_0$ ), 10 % ( $M_1$ ), 50 % ( $M_2$ ) and 100 % ( $M_3$ ) were set up, and three generations of continuous measurement were carried out. The results showed that the absolute length of body length and body height of *D.magna* decreased significantly ( $P<0.01$ ), the relative length of the mucrone increased significantly ( $P<0.01$ ), and the number of offspring increased significantly ( $P<0.01$ ). Under kairomones treatment, the body size showed a decreasing trend from generation to generation ( $P>0.05$ ). Among the three consecutive generations of individuals, the body length and body height of the  $M_3$  treatment group were the smallest, and the relative length of the mucrone was the largest. The number of offspring under kairomones treatment was higher than that of the control group, and the third generation  $M_1$  treatment group was the highest. The results showed that there was a dose dependent response of predator kairomones on the phenotypic morphology of Cladocerans, with the increase of concentration, the body size became smaller, but there was no dose dependent response effect on the number of offspring, and there were only on/off response.

**Keywords:** *Daphnia magna*; *Poecilia reticulata*; kairomones concentration; phenotypic plasticity; dose dependent response

### 三、水产养殖动物营养与饲料

# Somatostatin1 基因缺失斑马鱼对不同 饲养方式的代谢反应

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**摘要：**糖尿病是一个全球性的健康问题，其主要原因是食物摄入过多导致血糖水平过高。斑马鱼是研究糖尿病的理想模型。然而，高血糖模型对不同喂养方式的生理变化和分子机制尚不清楚。本实验采用斑马鱼糖尿病模型，通过 ss1 基因突变并伴有高血糖和血脂紊乱的模型，分析了长期不同的喂养方式(每天 3 次、每天 1 次、隔日 1 次)对动物生理变化和分子通路改变的影响。处理 16 周后，高摄食组 ss1 突变鱼死亡率较高，体重下降，而限制摄食组 ss1 突变鱼血糖水平得到控制，血脂功能恢复。利用转录组学方法，我们发现 SS1 突变体的肝脏代谢途径发生了显著的变化。在高摄食组中，DEGs 主要富集在胰岛素途径、丙酮酸代谢途径和糖酵解/糖异生途径中，提示突变体对高血糖的反应；而在低摄入量组中，参与脂代谢的多个途径上调和下调，表明限食改善脂代谢反应，这与突变体对甘油三酯水平的良好控制是一致的。结果显示，健康饮食有助于糖尿病的治疗。

**关键词：**糖尿病模型 血糖调节 脂代谢 转录组分析

## Metabolic responses of zebrafish with Somatostatin1 deletion to different feedings regime

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**Abstract:** Diabetes is a global health problem, which is mainly caused by high glucose levels due to excess food consumption. Zebrafish is an ideal model to study diabetes. However, the physiological alterations and molecular mechanisms of hyperglycemia model response to different feeding regimes remain unknown. Here we used a zebrafish diabetic model, which carried a somatostatin 1 (ss1) mutation with hyperglycemia and lipid disorder phenotype to analyse the effect of long-term different feeding regimes (three times a day, once a day and every other day) on physiological changes and molecular pathway alterations. After the treatment for 16 weeks, ss1 mutant fish displayed higher mortality rate, declined body weight in the high dietary intake group, while in restricted food intake groups, ss1 mutant fish displayed controlled of glucose levels and restored lipid dysfunction. Using transcriptomics, we found that significant alterations of metabolic pathways in the liver of ss1 mutants. In the high dietary intake groups, DEGs mainly enriched to insulin pathway, pyruvate metabolism and glycolysis/gluconeogenesis pathway indicated a response to hyperglycemia in mutants, while in the low dietary intake group, multiple pathways involved in lipid metabolism are up regulated and down regulated, indicating an antagonism in the lipid metabolism response to food restriction, and is consistent to the well control of triglyceride levels in the mutants. Our results suggested that healthy diet is helpful to the management of glucose control in diabetes.

**Key words:** Diabetes Models ,Blood Glucose Regulation, Lipid metabolism, Transcriptome analysis

# 上海三大水库(青草沙、陈行、金泽) 鲢、鳙肌肉营养成分差异研究

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**摘要:** 为比较上海三大水库青草沙、陈行、金泽水库优势种鲢、鳙肌肉营养成分差异, 采用常规生化分析方法和 TPA 质构分析检测了 3 个水库鲢、鳙肌肉中的水分、Ph 值、灰分、粗蛋白、粗脂肪、脂肪酸和氨基酸和硬度、弹性等指标。结果表明, 三个水库的鲢、鳙营养指标和 TPA 质构指标有显著差异。其中青草沙水库的鲢、鳙硬度指标最高, 其次是陈行、金泽水库。鲢、鳙粗脂肪金泽水库最高, 鲢、鳙粗蛋白陈行水库最高, 三个水库鲢、鳙种群均检测出 17 种常见氨基酸。综上, 陈行水库鲢、鳙肌肉品质较好, 可间接反映三大水库的水质优劣。

**关键词:** 鲢; 鳙; 脂肪酸; 氨基酸; 肌肉

## Study on the nutrient difference of silver carp and bighead muscle in three major reservoirs (Qingcaosha, Chenhang and Jinze) in Shanghai

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**Abstract:** In order to compare the nutritional differences of silver carp and bighead muscle in qingcao sand, Chenhang and Jinze reservoirs, the water, water, Ph value, ash content, crude protein, crude fat, fatty acid, amino acid, hardness and elasticity were detected in the conventional biochemical analysis and TPA structure analysis. The results showed that the nutritional indexes and TPA between the three reservoirs. Among them, the silver carp and bighead hardness index in Qingcaosha reservoir is the highest, followed by Chenhang and Jinze reservoir. The silver carp and bighead carp coarse fat fat were the highest in the Jinze reservoir, and 17 common amino acids were detected in the silver carp and bighead carp populations in the three reservoirs. To sum up, the quality of silver carp and bighead muscle in Chenhang reservoir is good, which can indirectly reflect the water quality of the three reservoirs.

**Key words::** Silver carp; bighead; fatty acid; amino acid; muscle

# 中国大鲵幼体蛋白质需求量研究

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**摘要:** 以鱼粉为主要蛋白源配制 6 种蛋白水平的实验饲料(干基): D1(43.7%)、D2(47.1%)、D3(51.3%)、D4(55.7%)、D5(59.9%)和 D6(64.4%), 饲喂初始体质量为(20.99±0.15)g 的大鲵幼体 92 d。研究表明, 以增重率、肌肉 RNA/DNA 比值、蛋白质沉积率和皮肤胶原蛋白为评价指标, 大鲵幼体饲料的最适蛋白质水平为 55.9%~58.3%(干基)。

**关键词:** 中国大鲵; 蛋白质; 体组成; RNA/DNA 比值; 消化; 抗氧化

## Dietary Protein Requirement of Juvenile Chinese Giant Salamander (*Andrias davidianus*)

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**Abstract:** In order to determine the dietary protein requirement of juvenile giant salamander, 6 isolipidic diets were formulated to contain graded levels of D1(43.7%), D2(47.1%), D3(51.3%), D4(55.7%), D5(59.9%) and D6(64.4%) crude protein(dry matter) to feed juvenile giant salamander initially weight (20.99±0.15)g for 92 days. The results showed that: With weight gain rate, muscle RNA/DNA ratio, protein deposition rate, and skin collagen content as evaluation indexes, the optimum dietary protein level of the giant salamander was 55.9%~58.3%( based on dry mater), this dietary protein level can significantly improve gastric acid secretion, the digestion and absorption, and antioxidant capacity, and increase the nutrient deposition, thus promote growth and feed conversion; While low protein level diet significantly inhibited the growth of *A. davidianus*. the giant salamander was 55.9%~58.3%( based on dry matter). this dietary protein level can significantly improve gastric acid secretion, the digestion and absorption, and antioxidant capacity, and increase the nutrient deposition, thus promote growth and feed conversion; While low protein level diet significantly inhibited the growth of *A. davidianus*.

**Key words:** *A. davidianus*; protein; body composition; RNA/DNA ratio; digestion; antioxidant

# 黄芪多糖添加对芙蓉鲤鲫鱼生长和血清生化的影响

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**摘要:** 在鲫鱼基础饲料中分别添加 0%、0.05%、0.10%、0.15% 的黄芪多糖, 开展 58 天的饲养试验, 以期明确黄芪多糖对芙蓉鲤鲫鱼生长性能及血清生化方面的影响。结果表明: 添加 0.05% 黄芪多糖显著提高了芙蓉鲤鲫鱼增重率和特定生长率 ( $P < 0.05$ ), 显著降低了饲料系数 ( $P < 0.05$ ); 其添加水平对芙蓉鲤鲫鱼血清总蛋白 (TP)、白蛋白 (ALB)、球蛋白 (GLB) 含量均无影响 ( $P > 0.05$ )。

**关键词:** 黄芪多糖; 芙蓉鲤鲫鱼; 生长性能; 血清生化;

## Effects of Astragalus Polysaccharides on Growth and Serum Biochemistry of Furong crucian carp

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**Abstract:** A series (ratio of 0%, 0.05%, 0.10%, 0.15%) of astragalus polysaccharides were added to barely-based diets and a 58 days of feeding experiment was performed to decipher the effect of astragalus polysaccharides on the growth performance and serum biochemistry of Furong crucian carp. The results showed that the addition of 0.05% astragalus polysaccharides significantly increased the weight gain rate and specific growth rate of Furong crucian carp ( $P < 0.05$ ), and significantly reduced its feed coefficient ( $P < 0.05$ ); adding different concentrations of astragalus polysaccharides to the serum of Furong crucian carp. The contents of total protein (TP), albumin (ALB) and globulin (GLB) had no significant change ( $P > 0.05$ ).

**Key words:** : Astragalus Polysaccharides; Furong crucian carp; Growth Performance; Serum biochemistry



# 饲料中碳水化合物和蛋白质水平影响光裸星虫幼稚虫的生长性能：基于 LC-MS 的代谢组学研究

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**摘要:** 为了确定饲料碳水化合物和蛋白质水平如何影响光裸星虫稚虫的生长性能并确定观察到的模式背后的机制, 配制了五种具有不同碳水化合物和蛋白质水平的等能和等脂饲料, 并将其饲喂给光裸星虫稚虫; 实验组分别称为 EG1、EG2、EG3、EG4 和 EG5。分析结果表明, EG2 中光裸星虫稚虫的生物合成能力更强。这项研究的结果增强了我们对饲料中碳水化合物和蛋白质水平对光裸星虫稚虫生长性能影响的理解。

**关键词:** 光裸星虫, 生长性能, 代谢组学, LC-MS, 碳水化合物, 蛋白质

## Dietary Carbohydrate and Protein Levels Affect the Growth Performance of Juvenile Peanut Worm (*Sipunculus nudus*): An LC-MS-Based Metabolomics Study

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**Abstract:** To determine how dietary carbohydrate and protein levels affect the growth performance of juvenile *S. nudus* and identify the mechanisms underlying observed patterns, five isoenergetic and isolipidic diets with different levels of carbohydrate and protein were formulated and fed to juvenile *S. nudus*; the experimental groups were referred to as EG1, EG2, EG3, EG4, and EG5, respectively. After 90 days of feeding, *S. nudus* had significantly lower survival rates when fed D5 compared with other diets ( $P < 0.05$ ), and the highest survival rate was observed in EG2 individuals. The weight gain rate and specific growth rate were significantly higher in EG2 compared with the other groups ( $P < 0.05$ ). Metabolomic profiling using liquid chromatography–mass spectrometry revealed 83 significantly differential metabolites (POS: 59; NEG: 24), which were identified via an in-house MS2 database. Pathway analysis indicated that the significantly different metabolites were involved in 22 metabolic pathways (POS: 9; NEG: 13). These analyses implied that the biosynthetic capabilities of juvenile *S. nudus* were greater in the EG2. The results of this research enhance our understanding of the effects of dietary carbohydrate and protein levels on the growth performance of juvenile *S. nudus*.

**Key words:** *Sipunculus nudus*, growth performance, metabolomics, LC-MS, carbohydrate, protein

# 饲料中脂肪水平对卵形鲳鲹生长性能、血清生化、脂代谢和肠道菌群的影响

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**摘要:** 制做了 5 种不同脂肪水平的等氮饲料, 饲喂卵形鲳鲹幼鱼 8 周。结果表明: 饲料中适量的脂肪水平可显著提升卵形鲳鲹的增重率、特定生长率和饲料效率, 显著影响血清生化指标; 饲料中脂肪水平显著影响谷丙转氨酶、谷草转氨酶、总脂酶、脂肪酸合成酶等酶的活性, 也显著影响肝脏 *cpt1* 和 *fas* 基因的表达; 另外适量的脂肪水平可影响肠道菌群组成, 进而调节肠道代谢; 以增重率为指标, 求得卵形鲳鲹对脂肪的最适需求量为 93.6g/kg。

**关键词:** 生长性能, 肠道菌群, 脂肪水平, 脂代谢, 卵形鲳鲹

## Effects of dietary lipid levels on growth performance, plasma biochemistry, lipid metabolism and intestinal microbiota of juvenile golden pompano (*Trachinotus ovatus*)

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**Abstract:** Five isonitrogenous diets were formulated containing five graded levels of lipid (52.0, 81.0, 112.0, 141.0 and 171.0 g/kg). The diets were fed to triplicate groups of juvenile *Trachinotus ovatus* ( $10.49 \pm 0.23$  g) for 8 weeks. Results showed that moderate lipid level in diets significantly increased weight gain rate (WGR), specific growth rate (SGR) and feed efficiency rate (FER) ( $p < .05$ ). The dietary lipid level affected plasma biochemical indexes ( $p < .05$ ). The dietary lipid level also had significant effects on enzymatic activities including alanine aminotransferase (ALT), aspartate aminotransferase (AST), total lipase (TL), fatty acid synthetase (FAS), intestinal lipase (ILPS), adipose triglyceride lipase (ATGL) and hormone-sensitive lipase (HSL) ( $p < .05$ ). The mRNA levels of hepatic fatty acid synthase (*fas*) and carnitine palmitoyl transferase I (*cpt1*) genes were significantly influenced with increasing dietary lipid levels ( $p < .05$ ). Moreover, dietary lipid level influenced microbial community to regulate metabolic capacity of intestine. The optimum dietary lipid level for the optimal growth of juvenile *Trachinotus ovatus* was 93.6 g/kg.

**Key words:** growth performance, intestinal microbiota, lipid level, lipid metabolism, *Trachinotus ovatus*

# 褐藻寡糖对卵形鲳鲹(*Trachinotus ovatus*)幼鱼生长性能、血浆指标、抗氧化能力以及促炎/抗炎细胞因子基因表达的影响

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**摘要:** 本研究以卵形鲳鲹为研究对象, 添加 0.7 和 6.0 g·kg<sup>-1</sup> 褐藻寡糖, 研究褐藻寡糖对其生长和免疫的影响。结果显示, 褐藻寡糖显著提高实验鱼生长性能, 降低饲料系数; 褐藻寡糖显著提高血浆免疫指标; 褐藻寡糖显著提高肝脏抗氧化状态, 降低丙二醛浓度; 褐藻寡糖显著降低肠道促炎细胞因子 mRNA 表达量, 显著提高抗炎细胞因子 mRNA 表达量。基于饲料成本和养殖效果考虑, 饲料中褐藻寡糖的添加量为 0.7 g·kg<sup>-1</sup>。

**关键词:** 卵形鲳鲹; 褐藻寡糖; 生长性能; 免疫; 抗氧化能力

## Effects of dietary alginate oligosaccharide on growth performance, plasma indexes, antioxidative capacity and expression of pro-/anti-inflammatory cytokine genes of juvenile *Trachinotus ovatus*

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**Abstract:** The juvenile *Trachinotus ovatus* were fed with three diets containing 0, 0.7 and 6.0 g·kg<sup>-1</sup> alginate oligosaccharide(AO) to investigate the effects of AO on growth and immunity of *T. ovatus*. The results show that AO supplementation significantly improve growth performance of fish and decrease feed conversion ratio. AO supplementation significantly improve plasma immune indexes. AO supplementation significantly improve hepatic antioxidative state and decrease the concentration of MDA. AO supplementation significantly decrease the relative expression of pro-inflammatory cytokine mRNA and increase relative expression of anti-inflammatory cytokine mRNA. After considering the feed cost and its benefit, the suitable level of AO is 0.7 g·kg<sup>-1</sup>.

**Key words:** : *Trachinotus ovatus*; Alginate oligosaccharide; Growth performance; Immunity; Antioxidative capacity

# 饲料碳水化合物水平对长江鲟幼鱼生长、 饲料利用和糖脂代谢的影响

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**摘要:** 配制碳水化合物水平分别为 6%、9%、12%、15%、18%、21% 的 6 组饲料对长江鲟幼鱼开展 8 周的养殖实验。结果表明: 鱼体增重率和饲料利用受到糖水平显著影响; 饲料中添加较高水平碳水化合物时, 鱼体己糖激酶和丙酮酸激酶基因表达显著上调, 脂肪酸合酶和乙酰 CoA 羧化酶基因表达在高水平碳水化合物实验组显著上调, 表明脂肪合成增加。根据增重率进行二次回归模型分析, 长江鲟幼鱼饲料中最适碳水化合物添加量为 18.43%

**关键词:** 长江鲟; 碳水化合物; 饲料利用; 糖脂代谢

## Effects of dietary carbohydrate levels on growth, feed utilization and glucose and lipid metabolism of juvenile *Acipenser dabryanus*

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**Abstract:** Six groups of different carbohydrate levels diets (6%, 9%, 12%, 15%, 18% and 21%) were prepared to fed juvenile *Acipenser dabryanus* for 8 weeks. The results showed that weight gain and feed utilization was significantly affected by the dietary carbohydrate levels ( $P < 0.05$ ). The results also showed that hexokinase and pyruvate kinase genes expression was significantly up-regulated in fish fed with higher dietary carbohydrate, suggesting that glycolytic pathway was significantly affected. In addition, gene expression of fatty acid synthase and acetyl CoA carboxylase was significantly up-regulated in the higher carbohydrate group, indicating fat synthesis was increased from the carbohydrate. Quadratic regression model analysis based on weight gain showed that the optimal carbohydrate supplemental level for juvenile *Acipenser dabryanus* was 18.43%.

**Key words:** *Acipenser dabryanus*; carbohydrate; feed utilization; glucose and lipid metabolism

# 复方中草药对虹鳟脾脏非特异性免疫指标及免疫相关基因表达的影响

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**摘要:** 为探讨饲料中添加不同水平的复方中草药对虹鳟(*Oncorhynchus mykiss*)脾脏非特异性免疫指标及免疫相关基因表达的影响, 在基础饲料中分别添加不同含量的复方中草药[0 g/kg (对照)、10 g/kg、20 g/kg、30 g/kg]投喂虹鳟。结果显示, 在投喂 35 d 时 20 g/kg 组能显著提高脾脏中 T-SOD、CAT 和 LZM 活性及 tlr3、myd88、il-1 $\beta$  和 ifn- $\beta$  基因的表达。

**关键词:** 虹鳟, 复方中草药, 非特异性免疫, 免疫相关基因表达

## Effects of Compound Chinese Herbal Medicine on Non-specific Immunity and Immune-related Gene Expressions in Spleen of Rainbow Trout (*Oncorhynchus mykiss*)

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**Abstract:** The aim of this study was to investigate the effects of compound Chinese herbs medicine on the non-specific immunity performance and immune-related gene expressions of rainbow trout (*Oncorhynchus mykiss*). Rainbow trout were fed a basal diet supplemented with compound Chinese herbal medicine at concentrations of 0 g/kg (control group), 10 g/kg, 20 g/kg and 30 g/kg for 35 days. The results showed that dietary compound Chinese herbal medicine significantly increased the levels of T-SOD, CAT, ACP and LZM in rainbow trout spleen at the 7th, 21st and 35th day ( $P < 0.05$ ), and the 20 g/kg supplemental groups showed the best results. Moreover, the gene expression data after 35 days of feeding indicate that dietary compound Chinese herbal medicine significantly upregulated the expression of tlr3, tlr7, myd88, il-1 $\beta$ , irf3, lgp2, il-8 and ifn- $\beta$  in the 20 g/kg supplemental group ( $P < 0.05$ ). This study is an important foundation and stepping stone in the process of optimizing the use of this compound Chinese herbal medicine on a larger scale in the aquaculture industry.

**Key words:** Rainbow trout, Compound Chinese herbal medicine, Non-specific immunity, Immune-related gene expression

# 投喂频率及投喂水平对多纹钱蝶鱼幼鱼生长及饲料利用的影响

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**摘要:** 设计不同投喂频率及投喂量对多纹钱蝶鱼进行实验。结果显示各组终末体重、增重率、特定生长率、摄食率、肥满度均随投喂频率增加先上升后降低, 不同投喂频率对摄食率、肥满度、饲料系数及蛋白质效率没有显著影响; 鱼终末体重、增重率、特定生长率、摄食率、肥满度均随投喂水平升高而升高。综合考虑鱼类生长和养殖成本, 多纹钱蝶鱼的适宜投喂频率为 2 次·d<sup>-1</sup>, 投喂水平为 6~8%, 可提高经济效益和生态效益。

**关键词:** 多纹钱蝶鱼; 投喂频率; 投喂水平; 生长; 饲料利用

## Effects of feeding frequency and feeding level on growth and feed utilization of *Selenotoca multifasciata*

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**Abstract :** In this experiment, different feeding frequency and feeding level were designed to experiment on *Selenotoca multifasciata*. The results showed that the final body weight, weight gain rate, specific growth rate, feeding rate and condition factor of each group increased first and then decreased with the increase of feeding frequency. Different feeding frequencies had no significant effect on feed rate, condition factor, feed conversion ratio and protein efficiency rate. The final body weight, weight gain rate, specific growth rate, feed rate and condition factor increased with the increase of feeding level. Considering the above fish growth and culture cost, the optimal feeding frequency was twice per day and the feeding level is 6% to 8%, which can improve the economic and ecological benefits.

**Key words: :** *Selenotoca multifasciata*; eeding frequency; feeding level; growth characteristics; feed utilization

# 芦苇替代小麦对草鱼生长性能、消化功能、免疫功能和肌肉品质的影响

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**摘要:** 本实验将芦苇按 0%、50%和 100%的比例替代小麦配置成 3 种饲料, 饲喂草鱼 42 天, 探究芦苇替代小麦后对草鱼生长性能、消化功能、免疫功能和肌肉品质的影响。结果表明: 50% 替代组和 0%组草鱼的特定生长率和饲料效率差异不显著 ( $P<0.05$ )。饲料中添加芦苇会影响草鱼肠道的消化酶活性和微生物的多样性, 可提高相关免疫因子的含量及相关基因的 mRNA 表达量, 还可以提高草鱼的肌肉品质, 改善肌肉的系水力和质构特性。

**关键词:** 芦苇, 草鱼, 生长性能, 消化功能, 免疫功能, 肌肉品质

## Effects of dietary replacement of wheat by reed on growth performance, digestive function, immune function and muscle quality of grass carp

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**Abstract:** In this experiment, a 42-day growth trial was executed to explore the effects of dietary replacement (0%, 50% and 100%) of wheat by reed on growth performance, digestive function, immune function and muscle quality of grass carp (*Ctenopharyngodon idella*). The results showed as follows: there were no significant differences in specific growth rate and feed efficiency between 50% replacement and 0% group ( $P<0.05$ ). Dietary replacement of wheat by reed can influence the intestinal digestive enzyme activities and microbial diversity of grass carp and improve the content of related immune factors and the mRNA expression of related genes; it can also improve the muscle quality of grass carp by increasing the water holding capacity and texture characteristics of muscle.

**Key words:** reed; grass carp; growth performance; digestive function; immune function; muscle quality

# 高碳水化合物饲料诱导大口黑鲈幼鱼 内质网应激和氧化应激，进而引起肠道炎症 和细胞凋亡

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**摘要：**本研究通过投喂三种不同碳水化合物浓度（7%，12%，17%）的饲料，对大口黑鲈进行了为期八周的实验，结果表明高碳水化合物日粮导致了大口黑鲈肠道氧化损伤和内质网应激，进而引起了细胞凋亡相关基因（casepase3、caspase8 和 casepas9）和促炎基因（IL-8、IL-1 $\beta$ 、TNF $\alpha$ 和 COX2）的上调，最终导致紧密连接基因的下调和肠道上皮细胞的损伤。

**关键词：**大口黑鲈、高碳水化合物日粮、氧化应激、内质网应激、凋亡、肠炎

## High carbohydrate diet induced endoplasmic reticulum stress and oxidative stress, promoted intestinal inflammation and apoptosis in juvenile largemouth bass (*Micropterus salmoides*)

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**Abstract:** This study assessed the effects of feed carbohydrate content on intestinal physical barrier and immunity in juvenile largemouth bass (*Micropterus salmoides*). Triplicate groups of juvenile fish ( $4.1 \pm 0.2$  g) were fed low (LCD, 7%), medium (MCD, 12%) and high (HCD, 17%) carbohydrate diets for eight weeks. Gut histology revealed the slight infiltration of inflammatory cells and moderate loss of mucous membrane layer in HCD group. Expression of ZO1, occluding, and claudin7 genes and epidermal growth factor receptor (EGFR) gene were significantly decreased in HCD group indicating the impairment of tight junction and epithelial cell regeneration. The results showed the significant ( $P < 0.05$ ) reduction of antioxidant capacity in HCD group compared to LCD. Furthermore, expression of intestinal ERS-related genes such as IRE1, Eif2 $\alpha$ , GRP78, CHOP $\alpha$  and CHOP $\beta$  in HCD group was significantly higher than the LCD group. In addition, HCD induced the up-regulated expression of inflammatory (IL-8, IL-1 $\beta$ , TNF $\alpha$  and COX2) and apoptosis (TRAF2, bax, casepase3, caspase8 and casepase9) related genes in fish intestine. The data generated in this study clearly demonstrated that HCD induced ERS and oxidative stress, which promoted intestinal inflammation and apoptosis in juvenile largemouth bass.

**Key words::** largemouth bass; high-carbohydrate diet; oxidative stress; endoplasmic reticulum stress; apoptosis; intestinal inflammation



# 高碳水化合物会影响代谢物的转化，并对幼年大口黑鲈的健康造成不利影响

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**摘要：**为探究不同碳水化合物水平对大口黑鲈的代谢影响， $4.0\pm 0.2\text{g}$  幼鱼被分别饲喂含有 7%、12% 和 17% 淀粉水平日粮。8 周后 17% 组增重最低。17% 组（HCD）血浆中 PA、LD、TG 和 NEFA 含量升高；肝组织空泡化，糖原和脂质积累；肝脏 PEPCK 和 LPS 的活性升高，糖原和 TG 的浓度升高。HCD 降低了 CAT、GPX 和 T-AOC 的活性。代谢组分析揭示了糖、脂代谢和抗氧化防御系统受碳水化合物水平的显著影响。

**关键词：**大口鲈鱼；碳水化合物水平；代谢物；新陈代谢，机体健康

## High carbohydrates affect the conversion of metabolites and cause adverse health of juvenile largemouth bass

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**Abstract:** To explore the metabolic differences to three carbohydrate level diets, juvenile largemouth bass (initial weight,  $4.0\pm 0.2\text{g}$ ) were fed three isonitrogenous and isoenergetic diets containing 7% (L), 12% (M) and 17% (H) cassava starch for 8 weeks. The lowest weight ( $15.75\pm 0.76\text{g}$ ) gain was observed in group H. High carbohydrate diet (HCD) caused the apparently higher the contents of pyruvate (PA), lactic acid (LD), triglyceride (TG) and free fatty acid (NEFA) in plasma. Also, HCD also gave rise to vacuolation, glycogen granule and lipid accumulation of liver tissue. Furthermore, HCD resulted more active of phosphoenolpyruvate carboxykinase (PEPCK) and lipase (LPS), higher concentration of glycogen and triglyceride (TG). Similarly, glucose and lipid genes were up-regulated with the increase of carbohydrate level, such as glycogen phosphorylase (PYG) and carnitine palmitoyl transferases (CPT1, CPT2). Hepatic antioxidant indexes revealed that HCD decreased the activities of catalase (CAT), glutathione peroxidase (GSH-PX) and total antioxidant capacity (T-AOC). UPLC-MS was performed to invest the differences of liver metabolites. Glucose metabolism, lipid metabolism, and antioxidant defense system were significantly affected by carbohydrate level in the diet. HCD raised the accumulation of carbohydrate metabolites, unsaturated fatty acids, cholesterol, and antioxidant functional substance.

**Key words:** largemouth bass; carbohydrate level; metabolites; metabolism; organism health

# 中华鳖胚胎肝脏成纤维细胞的原代培养及其 Poly I:C 刺激模型的构建

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**摘要：**本试验得到中华鳖胚胎肝脏成纤维细胞，鉴定并分析了生物学特性；之后，采用 Poly I:C 转染细胞 24 h 后。结果表明该细胞在 31 °C 和 10% 胎牛血清（FBS）培养条件下生长状况良好，细胞的生长曲线为“S”形，符合细胞增殖规律；Poly I:C 刺激该细胞 24 h 后上调了 RIG-I 和 MAVS 的蛋白表达量，上调了 RIG-I 的基因表达量并下调 m6A 和 YTHDF2 基因表达量，并引起细胞形态的变化。

**关键词：**中华鳖；原代培养；成纤维细胞；Poly I:C；干扰素

## Primary culture of embryonic fibroblast from liver of Chinese soft-shelled turtle (*Pelodiscus sinensis*) and the establishment of Poly I:C stimulation cell model

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**Abstract:** The the present study were to establish a method for isolation, culture and identification of embryonic fibroblast from liver of Chinese soft-shelled turtle (*Pelodiscus sinensis*), and to establish a model of poly I:C stimulation in vitro. The results showed that the cell grew well at 31°C and 10% fetal bovine serum (FBS) culture conditions. Poly I:C transfection upregulated the protein expression of RIG-I and MAVS, as well as the gene expression of RIG-I. The gene expression of m6A and YTHDF2 also was downregulated. In conclusion, the methods for isolation and in vitro culture of embryonic fibroblast from liver of Chinese soft-shelled turtle were successful established. The activated interferon production pathway in the fibroblast was triggered by poly I:C stimulation.

**Key words:** Chinese soft-shelled turtle; Primary culture; Fibroblast; Poly I:C; Interferon.

# 转录组与代谢组学解析花生四烯酸饲料调控雌性中华鲟子二代固醇激素合成的机制

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**摘要：**22周的养殖实验表明，添加1%的花生四烯酸有利于子二代中华鲟固醇激素的合成，但是其分子机制并不清楚。基于此，本研究拟采用转录组与脂质组学揭示其可能的调控分子机制。结果表明，脂质代谢中的性类固醇激素合成通路与内分泌系统中的卵巢固醇生成通路在花生四烯酸饲料添加组被富集。进一步通过加权共表达分析鉴定到了6个关键的节点基因。表明饲料花生四烯酸调控固醇合成的分子机制可能与促进了固醇脂代谢及固醇生成基因有关。

**关键词：**中华鲟、花生四烯酸、转录组、脂质组、固醇激素

## Transcriptome and lipidomics profiling of F2 generation female Chinese sturgeon (*Acipenser sinensis*) in response to different arachidonic acid diets

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**Abstract:** Our previous study indicated that dietary arachidonic acid (ARA) levels greater than 1% in the diets plays vital roles in the ARA deposition, metabolism, steroid and vitellogenin (Vtg) synthesis in F2 generation female Chinese sturgeon, and the regulatory mechanism remains to be elucidated. As following study (Aquaculture reports, 21, 100818), the present study was further aimed at investigating the possible mechanisms in the ovary transcriptome and serum lipidomics regarding the effects of dietary ARA promoted steroid hormone synthesis in tissues. RNA-Seq and lipidomics technology were employed to profile ovary transcriptome and serum lipidomics of these four ARA-treated diets (named as CT, LT, MT and HT, respectively), and differentially expressed genes (DEGs), key differential metabolites were identified. A total of 1018 DEGs, 853 DEGs, 2680 DEGs, 303 DEGs, 1185 DEGs and 409 were identified, respectively, from LT versus CT, MT versus CT, HT versus CT, MT to LT, HT to LT and HT to MT. Multicellular cellular developmental process, regulation of cellular process, organismal development, development process and reproduction were enriched in gene ontology between the DEGs in ARA supplemented diet group compared to un-supplemented ARA diet group. A heat map display of these DEGs expression levels showed an upward trend with the increase of dietary ARA, especially the difference was obviously between the CT and HT group. Pathway concerning steroid hormone biosynthesis and chole

**Key words:** Chinese sturgeon; arachidonic acid diets; transcriptome; lipidomics

# 酵母培养物替代鱼粉对凡纳滨对虾生长、非特异性免疫、肠道及肝胰腺组织学的影响

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**摘要：** 本实验探究酵母培养物 (YC) 替代鱼粉 (FM) 对凡纳滨对虾生长、饲料利用、非特异性免疫、肠道和肝胰腺组织学的影响。用 YC 将 FM 降低至 200、160、120 和 80 g/kg (FM20、FM16、FM12、FM8)。结果表明，FM8 组生长降低。FM12 和 FM8 组蛋白和脂肪沉积率降低。FM8 组肠绒毛长和宽减少，肝小体异常。综上，在 200 g/kg 鱼粉的饲料中，酵母培养物可替代 40 g/kg 鱼粉。

**关键词：** 凡纳滨对虾; 酵母培养物; 生长性能; 非特异性免疫力; 肠道组织学

## Effects of yeast culture substituting fish meal on growth, non-specific immunity, intestinal and hepatopancreastics histology of Pacific white shrimp, *Litopenaeus vannamei*

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**Abstract:** This study investigated the effects of yeast culture (YC) substituting fish meal (FM) on growth, feed utilization, non-specific immunity, intestinal and hepatopancreatic histology of Pacific white shrimp. In a basal diet containing 200 g/kg fish meal, YC was used to reduce FM to 200, 160, 120 and 80 g/kg (FM20, FM16, FM12, FM8), respectively, and then the four diets were fed to Pacific white shrimp for 8 weeks. The results showed that the growth of FM16 and FM12 groups was not significantly different from that of the control group, while the weight gain was decreased and feed coefficient ratio was increased in FM8 group when compared with the control ( $P < 0.05$ ). The retention of protein and lipid in FM12 and FM8 groups ( $P < 0.05$ ), and the length and width of intestinal villi in FM8 group were significantly lower those of the control ( $P < 0.05$ ). In FM8 group, the hepatic corpuscle was observed abnormal. In summary, in a white shrimp diet containing 200 g/kg fish meal, yeast culture can successfully replace 40 g/kg fish meal.

**Key words:** Pacific white shrimp; yeast culture; growth; non-specific immunity; intestinal histology

# 不同蛋白源替代鱼粉对虾料加工质量的影响

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**摘要：**本实验旨在探究棉籽浓缩蛋白（CPC）、黄粉虫（TM）和乙醇梭菌蛋白（CAP）替代鱼粉对虾料加工质量的影响。对照组鱼粉含量为 200g/kg，三种蛋白源分别替代 60g/kg 的鱼粉，采用环模制粒生产 4 种颗粒饲料。结果表明：CPC 和 CAP 降低了饲料含粉率；CPC 组、TM 组和 CAP 组的饲料硬度和容重提高，溶失率降低。综上，在鱼粉含量为 200g/kg 的饲料中替代 60g/kg 的鱼粉，三种蛋白源均可提高虾料质量。

**关键词：**棉籽浓缩蛋白；黄粉虫；乙醇梭菌蛋白；虾料；加工工艺；

## Effects of replacing fish meal with different protein sources on the processing quality of shrimp feed

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**Abstract:** The aim of this study was to evaluate the effects of replacing dietary fish meal (FM) with cottonseed protein concentrate (CPC), tenebrio molitor (TM), and Clostridium autoethanogenum protein (CAP) on the processing quality of shrimp feed. A basal diet (control) was formulated to contain 200g/kg FM, then the three protein sources were used to substitute 60g/kg of dietary fish meal in control diet, respectively, to form four diets. The diets were pelleted by hoop standard granulator. The results indicated that CPC and CAP significantly reduced the powder content ( $P<0.05$ ). Moreover, the hardness and bulk density of CPC, TM and CAP diets were significantly increased ( $P<0.05$ ), and the dissolution loss was significantly decreased ( $P<0.05$ ). In conclusion, in a shrimp diet containing 200g/kg FM, the substitution of 60g/kg fish meal with CPC, TM and CAP promoted the processing quality of feed.

**Key words:** cottonseed protein concentrate; tenebrio molitor; clostridium autoethanogenum protein; Shrimp feed; processing technology;

# 三种昆虫蛋白部分替代进口鱼粉对提升鳊鱼生长性能、肌肉营养品质及血清生化指标的研究

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**摘要：**为探究大麦虫（*Zophoas atratus* Fab）、黑水虻（*Hermetia illucens* L.）、蛹（家蚕）肽蛋白三种昆虫蛋白部分替代进口鱼粉对饲料鳊鱼的生长情况、肌肉营养品质、免疫抗病力的差异和影响，对5组鳊鱼进行了池塘架设网箱饲料养殖对比试验。结果表明，饲料中采用昆虫蛋白部分替代进口鱼粉，能提升鳊鱼机体的免疫抗病能力及营养品质，减少了对进口鱼粉的依赖，保护活饵鱼资源。

**关键词：**鳊鱼饲料；大麦虫；黑水虻；蛹肽蛋白；昆虫蛋白；替代进口鱼粉；肌肉品质；血清生化指标；增加产量；降低饲料成本；提高成活率

## Research on the Innovative Technology of Suspended Feed Insect Protein Partially Substituting Imported Fish Meal to Improve the Quality of *Siniperca chuatsi*

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**Abstract:** In order to investigate the differences and effects of partial substitution of imported fish meal by three insect proteins (*Zophoas atratus* Fab, *Hermetia illucens* L. and chrysalis peptide protein) on the growth, muscle nutritional quality and immune resistance of feed Mandarin fish. Five groups of Mandarinfish were studied in this paper. The results showed that partially replacing imported fish meal with insect protein could improve the immune and disease resistance ability and nutritional quality of mandarin fish, reduce the dependence on imported fish meal, and protect the resources of live bait fish.

**Key words:** *Siniperca chuatsi* feed; Barley; Black soldier fly; Silkworm chrysalis protein; Insect protein; Replacement of imported fish meal; Muscle quality; Serum biochemical indices; Increase production; Reduce feed cost; Increase survival rate

# 水产功能性发酵豆粕替代鱼粉 对花鲈生长性能和肠道组织结构的影响

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**摘要:** 以花鲈为研究对象, 研究水产功能性发酵豆粕部分替代鱼粉对花鲈生长性能和肠道形态结构的影响。结果表明, 使用发酵豆粕替代鱼粉, 替代比例大于 40%时花鲈生长性能显著下降。替代比例达 60%时还会显著降低花鲈的采食量、肥满度以及存活率。使用扫描电子显微镜对花鲈肠道进行观察, 随着替代比例上升, 花鲈肠绒毛越来越稀疏。综上所述, 在花鲈配合饲料中, 发酵豆粕替代鱼粉比例小于 40%, 对花鲈生长影响不显著。

**关键词:** 花鲈; 发酵豆粕; 鱼粉替代; 生长性能

## Effects of replacement of fish meal with functional fermented soybean meal on growth performance and intestinal histology of spotted seabass (*Lateolabrax japonicus*)

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**Abstract :** To evaluate the effects of replacement of fish meal (FM) with functional fermented soybean meal (FSM) in aquatic feeds on growth performance and intestinal histology of spotted seabass (*Lateolabrax japonicus*) The results showed that replacing 40% of FM with FSM did not significantly influence growth, while increasing the substitution level to 60% led to reduced growth rates ( $P < 0.05$ ). The fish received FSM60 diets showed significantly lower feed intake ( $P < 0.05$ ), condition factor ( $P < 0.05$ ) and survival rates compared with other groups ( $P < 0.05$ ). Scanning electron microscopy was used to observe the intestinal histology of spotted seabass. With the increase of substitution ratio, the space among intestinal villus between each group became larger. In conclusion, there was no adverse effect on growth performance when the rate of fish meal replaced by fermented soybean meal did not exceed 40%.

**Key words :** Japanese seabass ; Fermented soybean meal ; Fish meal replacement ; Growth performance

# 南极磷虾粉替代鱼粉以及添加牛磺酸对黄鳝雌鳝生长繁殖的影响研究

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**摘要：**为探究南极磷虾粉及牛磺酸对黄鳝生长繁殖性能的影响，分别设置 0%、20%、40%、60%、80%、100%的磷虾粉替代鱼粉以及 5mg/g 牛磺酸添加至 0%、80%、100%替代组的 9 组饲料，饲喂雌鳝 12 周。结果表明：20%磷虾粉替代对黄鳝的生长繁殖无显著影响；而添加牛磺酸不影响黄鳝的生长性能，但能显著提高其产卵量、受精率及孵化率。综上，黄鳝中南极磷虾粉的最适添加量为 20%，牛磺酸添加可提高其繁殖性能。

**关键词：**南极磷虾粉、牛磺酸、黄鳝、鱼粉替代、生长繁殖

## Effects of Antarctic krill meal instead of fish meal and supplementation with taurine on the growth and reproduction of *Monopterus Albus*

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**Abstract:** In order to explore the effects of Antarctic krill meal substitution and taurine addition on the growth and reproduction of *Monopterus Albus*, nine groups of diets were configured with Antarctic krill meal replacing 0, 20%, 40%, 60%, 80%, and 100% of fish meal, and 5mg/g taurine supplementation at 0, 80%, and 100% replacement groups. The female swamp eels were fed with the experimental diets for 12 weeks. The results showed that 20% krill meal substitution had no significant effect on the growth and reproduction of *Monopterus Albus*. The taurine addition did not influence the growth of swamp eels, but could improve their ovulation, fertilization and hatchability. In summary, the suitable substitution of Antarctic krill meal for fish meal is 20%, and the addition of taurine can improve the reproductive performance of *Monopterus Albus*.

**Key words:** Antarctic krill meal, taurine, *Monopterus Albus*, fish meal substitution, growth and reproduction



# 甲壳素及其衍生物在水产饲料中应用

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**摘要:** 随着水产品加工业的发展, 虾类水产品加工中的副产品虾壳量也逐渐增多, 虾壳内含有大量的甲壳素, 充分利用这些甲壳素可以增加经济收益, 减少环境污染。甲壳素及其衍生物有提高动物抗菌免疫、促进生长的生理功能。本文就近年来甲壳素及其衍生物在水产动物饲料中的研究做一概述, 以期甲壳素在不同的水产动物饲料中的应用提供参考。

**关键词:** 甲壳素; 壳聚糖; 水产饲料; 免疫; 生长

## Application of Chitin and its derivatives in aquatic feed

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**Abstract:** ]With the development of aquaculture processing industry, the secondary product in the aquaculture processing industry—shrimp shell waste, is increasing too. The shrimp shell waste has plenty of chitin, take advantage of it can increase the economic income and abate pollution. The chitin and its derivatives can promote animal growth and improve its immunity. The article introduced the application of chitin and its derivatives in aquatic feed in recent years, aimed to provide reference.

**Key words:** chitin; chitosan; aquatic feed; immunity; growth

# 发酵豆粕替代鱼粉对杂交鳢（*Channa argus* × *Channa maculata*）幼鱼生长、营养物质利用、肠道组织学和微生物的影响

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**摘要：**本试验旨在探究发酵豆粕替代鱼粉对杂交鳢生长和肠道健康的影响。用发酵豆粕等蛋白替代对照组 0, 50, 100, 150 和 200 g/kg 鱼粉（CON、FM30、FM25、FM20 和 FM15）。较 CON，FM25、FM20 和 FM15 生长降低。各替代组肠绒毛长及 FM20 和 FM15 宽降低，邻单胞菌属是 FM20 相对丰度最高的菌属。综上，在 350 g/kg 鱼粉的杂交鳢饲料中，发酵豆粕可替代 50 g/kg 鱼粉。

**关键词：**发酵豆粕；杂交鳢；生长性能；营养物质利用；肠道组织结构；肠道微生物

## An evaluation of replacing fish meal with fermented soybean meal in diet of hybrid snakehead (*Channa argus* × *Channa maculata*): Growth, nutrient utilization, intestinal histology and microbial community

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**Abstract:** The present study investigated the effect of fish meal (FM) replacement with fermented soybean meal (FSM) on growth, nutrition utilization, intestinal health of hybrid snakehead. Five iso-proteinic diets were formulated with FSM inclusion to decrease dietary FM from 350 g/kg (the control diet) to 300, 250, 200 and 150 g/kg, then fed to hybrid snakehead (6.5g) for 60 days. The weight gain, feed intake decreased, and feed conversion ratio increased in FM25, FM20 and FM15 groups when compared to the CON group ( $P < 0.05$ ). The apparent digestibility coefficients of dry matter and crude protein, the intestinal muscle thickness in FM20 and FM15 groups and the villus height in all FSM groups, were lower than those in the CON group ( $P < 0.05$ ). Intestinal microbiota analysis indicated that Plesiomonas was the dominant genus with the highest relative abundance in FM20 group. In summary, in a snakehead diet containing 350 g/kg FM, FSM can successfully replace 50 g/kg dietary FM.

**Key words:** Hybrid snakehead; fermented soybean meal; growth performance; nutrient utilization; intestinal histology and microbiota

# 高豆粕饲料中添加荚膜甲基球菌蛋白 (FeedKind®)对花鲈(Lateolabrax maculatus)生长、非特异免疫及肠道健康的 影响

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**摘要:** 以初体重为  $3.00 \pm 0.02$  g 的花鲈幼鱼为对象, 研究荚膜甲基球菌蛋白对豆粕引起的花鲈肠道炎症的缓解作用。分为对照组、0%、2%、4%、6%、8%FK 组, 配制成 6 种等氮等脂的实验饲料, 饲喂花鲈 56 d 后采集样品并分析。结果表明, 高豆粕饲料(35%)中添加 2-4%FK 可以显著提高花鲈的生长、非特异性免疫和消化酶活性; FK 缓解高豆粕导致的肠炎, 其机制可能是通过调节炎症因子表达和抑制有害菌群。

**关键词:** 花鲈; 荚膜甲基球菌蛋白(FeedKind®); 豆粕; 生长性能; 非特异性免疫; 肠道健康

## Effects of Methanotroph (*Methylococcus capsulatus*, Bath) Bacteria Meal (FeedKind®) supplementation in high-soybean meal diet on Growth, Non-Specific Immunity and Intestinal Health of spotted seabass (*Lateolabrax maculatus*)

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**Abstract:** This study aimed to evaluate effects of methanotroph (*Methylococcus capsulatus*, Bath) bacteria meal (FeedKind®, FK) on intestinal inflammation induced by a soybean meal-based diet in *Lateolabrax maculatus*. Six iso-nitrogenous diets were formulated with control group, 0%, 2%, 4%, 6% and 8% FK. Fish (initial body weight:  $3.00 \pm 0.02$  g) were fed by fix quantity for 56 days. Results showed that 2-4% FK supplementation improves growth performance, non-specific immunity and enzyme activities in fish fed with a high soybean meal diet (35%). FK may regulate the expression of inflammatory factors and inhibit the growth of harmful bacteria, thereby alleviating the intestinal inflammation induced by a soybean meal-based diet.

**Key words:** *Lateolabrax maculatus*; Methanotroph (*Methylococcus capsulatus*, Bath) bacteria meal (FeedKind®); Soybean meal; Growth performance; Non-specific immunity; Intestinal health

# 低鱼粉饲料中添加多酶复合物、有机酸和精油复合物、益生元对虹鳟 (*Oncorhynchus mykiss*) 生长和肠道健康的影响

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**摘要:** 本试验旨在探究低鱼粉饲料中补充复合酶 (MC)、复合有机酸和精油 (OEC)、益生元 (P) 对虹鳟生长和肠道健康的影响。正负对照 (PC、NC) 鱼粉含量为 200 和 100 g/kg。在 NC 基础上单独或联合添加 MC、OEC、P, 饲喂 56 天。NC 较 PC 组降低了增重、饲料利用和菌群的丰富度与多样性, 所有添加组均提高了生长和营养物质利用。综上, 低鱼粉饲料添加 MC、OEC、P 可提高虹鳟的生长和饲料利用。

**关键词:** 益生元; 多酶复合物; 有机酸和精油复合物; 虹鳟; 生长性能; 饲料利用

## The effect of supplementing multi-enzyme complex, organic acids-essential oils complex, prebiotics in low fish meal diet on the growth and intestinal health of rainbow trout (*Oncorhynchus mykiss*)

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**Abstract:** The present study aimed to investigate the dietary effects of multi-enzyme complex (MC), organic acid-essential oil complex (OEC), and prebiotics (P) in low fish meal feed on the growth and intestinal health of rainbow trout. The positive and negative control diets (PC, NC) were designed to contain 200 and 100 g/kg fish meal, then, the MC, OEC and P were supplemented into NC diet individually or in combination, and fed for 56 days. Compared with the PC group, the weight gain, feed utilization and the richness and diversity of microorganisms of NC group were reduced, and all the supplemented groups improved the growth and nutrition utilization. In conclusion, the supplementation of MC, OEC and P in the low fish meal diet improved the growth and nutrition utilization of rainbow trout.

**Key words:** : multi-enzyme complex; organic acids-essential oils complex; prebiotics; rainbow trout; growth; nutrient utilization

# 复方中草药对凡纳滨对虾生长性能和免疫功能的影响

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**摘要:** 为评价复方中草药在凡纳滨对虾养殖中的应用。本试验以北京爱绿生物科技有限公司生产的复方中草药——爱绿宁为添加剂, 在凡纳滨对虾饲料中分别添加 0.05%、0.075% 和 0.1% 的复方中草药, 以探究复方中草药对凡纳滨对虾生长性能和免疫功能的影响。结果表明, 饲料中添加复方中草药可以提高对虾的生长性能、免疫功能和抗氧化能力, 且以 0.1% 添加量效果最佳。

**关键词:** 复方中草药, 凡纳滨对虾, 生长性能, 免疫功能

## Effects of a compound Chinese herbal on growth performance and immune function of *Litopenaeus vannamei*

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**Abstract:** In order to evaluate the application of compound Chinese herbal medicine (CCHM) in the culture of *L. vannamei*. In this experiment, 0.05%, 0.075% and 0.1% CCHM (Ailvning, a compound Chinese herbal medicine produced by Beijing Ailv Biotechnology Co., Ltd.) were added into the feed of *L. vannamei* to explore the effects of CCHM on growth performance and immune function of *L. vannamei*. The results showed that 0.05%, 0.075% and 0.1% CCHM in feed increased the WGR and feed efficiency of shrimp. In addition, 0.05%, 0.075% and 0.1% CCHM in feed increased AKP and LYS activities in the hemolymph of shrimp. The hepatopancreas biochemical results showed that the addition of 0.05%, 0.075% and 0.1% CCHM in the feed significantly reduced the MDA content of shrimp hepatopancreas ( $P < 0.05$ ), and 0.1% CCHM group had the best effect. In conclusion, the supplementation of CCHM in the diet of *L. vannamei* can promote the growth and improve the immune function.

**Key words:** Compound Chinese herbal medicine, *Litopenaeus vannamei*, Growth performance, Immune function

# 三种益生菌发酵豆粕的营养品质研究

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**摘要:** 实验以前期筛选的乳酸乳球菌 17、酿酒酵母菌 Sa 和短小芽孢杆菌 SE5 作为菌种, 对发酵豆粕后进行感官评价和理化性质分析。结果表明各发酵组胰蛋白抑制因子几乎全部去除, 大豆抗原蛋白含量明显下降, 且活菌数量呈指数级增加, 粗蛋白质、酸溶蛋白、大豆肽和粗蛋白质消化率与发酵前相比均有显著提高 ( $P < 0.05$ ), 其中短小芽孢杆菌 SE5 发酵豆粕的大豆肽提高了 869.83%。

**关键词:** 豆粕; 固态发酵; 抗营养因子; 营养价值

## Study on nutritional quality of three probiotics fermented soybean meal

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**Abstract:** This experiment was conducted to provide a scientific basis for the industrialization of special functional fermented soybean meal feed for aquatic animals, alleviates the over-reliance on fish meal in aquatic feeds, and reduces feed costs. In this experiment, *Lactococcus lactis* 17, *Saccharomyces cerevisiae* Sa and *Bacillus pumilus* SE5 were selected as fermentation strains, and the nutritional values of the fermented soybean meals were analyzed. The results showed that the sensory state, color, viscosity and smell of all the fermentation soybean meals have been improved. The tryptic inhibitor was almost completely degraded in all fermentation groups, and the number of viable bacteria increased exponentially. The digestibility of crude protein, acid-soluble protein, soybean peptide and crude protein increased significantly in fermented soybean meal compared with the soybean meal ( $P < 0.05$ ), among which the soybean peptide of *B. pumilus* SE5 fermented soybean meal increased by 869.83%. The total amount of crude fat and free amino acids in soybean meal fermented with *L. lactis* 17 and *B. pumilus* SE5 increased, and the crude fat of soybean meal fermented with *L. lactis* 17 increased by 110.20%. It can be seen that the various indicators of *B. pumilus* SE5 fermented soybean meal are excellent, and this strain has good commercial value and can be used as a candidate strain for soybean meal fermentation for aquaculture in the future.

**Key words:** soybean meal; solid-state fermentation; ANFs; nutritional values

# 复方中草药对加州鲈生长性能和免疫功能的影响

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**摘要:** 本试验在加州鲈饲料中分别添加 0.03%、0.05%、0.075%和 0.1%的黄芪提取物、杜仲提取物等植提复方中草药, 结果表明, 饲料中添加复方中草药, 加州鲈的增重率、特定增长率、采食量均出现不同程度的提高。其中, 添加 0.075%复方中草药的加州鲈增重率较对照组增加了 9.62%。添加 0.075%复方中草药组的加州鲈总抗氧化能力较对照组提高了 71.4%, 并显著降低了肝脏丙二醛 (MDA) 含量。

**关键词:** 关键词: 复方中草药, 加州鲈, 生长性能, 免疫功能

## Effects of a compound Chinese herbal on growth performance and immune function of *Micropterus salmoides*

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**Abstract:** In the process of *Micropterus salmoides* breeding, farmers adopt excessive feeding and other methods in order to pursue yield, which leads to liver lesions and enteritis. Compound Chinese herbal medicine (CCHM) has the advantages of promoting aquatic animal growth, improving immune function and disease resistance. In this experiment, 0.03%, 0.05%, 0.075% and 0.1% CCHM were added into the feed to explore the effects of CCHM on growth performance and immune function of *Micropterus salmoides*. The results showed that the supplementation of CCHM could improve the WGR, SGR and feed intake of *Micropterus salmoides*. Among them, 0.075% CCHM in feed the WGR was increased by 9.62% compared with the control group. In addition, the supplementation of CCHM significantly increased the serum AKP activity ( $P < 0.05$ ), and had no significant difference with the serum ACP and IgM content of control group. The addition of 0.05%, 0.075% and 0.1% CCHM had a certain increase in serum complement C3 content. There was no significant difference in amylase activity among the groups adding CCHM, but lipase activity increased in different degrees, and all the groups could improve the liver A-TOC activity, among which the 0.075% CCHM test was the most significant, it was increased by 71.4% compared with the control group, and MDA content in liver was significantly decreased.

**Key words:** Compound Chinese herbal medicine, *Micropterus salmoides*, Growth performance, Immune function

# 饲料中添加羟基蛋氨酸硒对凡纳滨对虾生长性能和抗氧化能力的影响

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**摘要：**本实验旨在研究羟基蛋氨酸硒(HMSe)对凡纳滨对虾生长性能和抗氧化能力的影响。实验选用凡纳滨对虾，分别投喂5组HMSe不同添加水平的饲料。结果表明：为对虾的FBW、WGR和FE随着HMSe水平的增加先升高后下降，添加1.5mg/kg HMSe组对虾的血清GSH-Px和肝胰腺CAT活性显著高于不添加组。综上所述，在饲料中添加HMSe能够提高凡纳滨对虾的生长性能和饲料利用率。

**关键词：**凡纳滨对虾；羟基蛋氨酸硒；生长性能；抗氧化能力

## Effects of Hydroxyl Methionine Selenium Supplementation on Growth and Antioxidant Ability of Pacific White Shrimp (*Litopenaeus vannamei*)

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**Abstract :** The present study was performed to investigate the effects of hydroxyl methionine selenium (HMSe) supplementation on growth performance and antioxidant ability of *Litopenaeus vannamei*. In this experiment, *L. vannamei* with an initial body weight of  $0.90\pm 0.05$  g was fed with diets supplemented with 0, 0.375, 0.75, 1.5 and 2.25 mg/kg HMSe respectively. The results showed as follows: The final body weight (FBW, 15.03-16.11 g), weight gain (WG, 1570.1-1689.8%) and feed efficiency (FE, 1.10-1.33) of *L. vannamei* increased firstly and then decreased with the increase of dietary HMSe level in the diet. The activities of serum glutathione peroxidase (GSH-Px) and hepatopancreas catalase (CAT) in the 1.5mg/kg HMSe group were significantly higher than those in the control group. In conclusion, supplementing HMSe could improve the growth performance, feed utilization and antioxidant ability of *L. vannamei*.

**Key words: :** *Litopenaeus vannamei*; hydroxyl methionine selenium; growth performance; antioxidant ability



# 槲皮素通过调节内质网与线粒体缓解高脂饲料引起的花鲈 (*Lateolabrax maculatus*) 脂肪过度沉积

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**摘要:** 本研究旨在探究在饲料中添加槲皮素对花鲈脂肪沉积的影响及其内在机制。相比于正常脂肪饲料 (11%脂肪), 投喂高脂饲料 (17%脂肪) 显著降低花鲈的生长性能以及饲料利用效率, 提高血清与肝脏的脂肪含量, 而添加槲皮素对此有显著的改善作用。同时, 透射电镜观察与相关基因相对表达量的测定表明摄食高脂饲料抑制花鲈的肝脏线粒体生成与自噬, 并激活内质网应激, 而添加槲皮素对此有显著改善, 这可能是其发挥降脂作用的内在机制。

**关键词:** 花鲈, 脂肪沉积, 线粒体生成, 线粒体自噬, 内质网应激

## Quercetin attenuates high-fat diet induced excessive fat deposition of spotted seabass (*Lateolabrax maculatus*) through the regulatory for mitochondria and endoplasmic reticulum

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**Abstract :** This study aimed to investigate the effects of quercetin on fat deposition and the underlying mechanism. Spotted seabass were fed four test diets: normal fat diet (NFD), high-fat diet (HFD), and HFD supplemented with 0.5 or 1.0 g/kg quercetin. The results showed that HFD feeding resulted in poor growth and feed utilization while QUE treatment reversed this. The fat contents of serum and liver were increased by HFD and QUE supplementation significantly decreased fat content. Furthermore, gene expressions and ultrastructure observation showed that mitochondrial biogenesis and mitophagy were inhibited and endoplasmic reticulum stress (ERS) in the HFD group. QUE can activate the biogenesis and autophagy of mitochondria and suppress ERS, which is related to its fat-lowering effect.

**Key words: :** *Lateolabrax maculatus*, fat deposition, mitochondrial biogenesis, mitophagy, endoplasmic reticulum stress

# 饲料中添加蛹肽粉或蝇蛆粉对拟穴青蟹幼蟹生长、体组成和消化酶活性的影响

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**摘要:** 摘要: 为探讨配合饲料中分别添加蛹肽粉和蝇蛆粉对拟穴青蟹幼蟹生长性能、体成分和消化酶活性的影响, 在基础饲料中分别添加 10%的蛹肽粉和蝇蛆粉, 饲喂拟穴青蟹幼蟹 45d。结果表明: 蛹肽料组拟穴青蟹幼蟹增重率、特定生长率显著高于基础料组和蝇蛆料组 ( $P<0.05$ ), 蛹肽料组拟穴青蟹幼蟹成活率显著高于基础料组 ( $P<0.05$ ); 基础料组拟穴青蟹幼蟹水分含量显著低于蛹肽料组和蝇蛆料组 ( $P<0.05$ ), 粗蛋白含量则相反 ( $P<0.05$ )。

**关键词:** 拟穴青蟹; 蛹肽粉; 蝇蛆粉; 生长; 体成分; 消化酶活性

## Effect of diets supplemented with pupa peptide or maggot powder on growth performance, body composition, and digestive enzyme activities in green mud crab (*Scylla paramamosain*) juveniles

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**Abstract:** Abstract: In order to investigate the effect of pupa peptide powder or maggot powder on the growth performance, body composition and digestive enzyme activities of juvenile mud crab (*Scylla pseudoaculea*), the basic diet was supplemented with 10% pupa peptide powder or maggot powder to feed the juvenile mud crab for 45 days. The results showed that: weight gain rate and specific growth rate of the juvenile mud crab in pupa peptide diet group were significantly higher than those in basic diet group and maggot diet group ( $P<0.05$ ), survival rate of the juvenile mud crab in pupa peptide diet group was significantly higher than that in basic diet group ( $P<0.05$ ); Water content of the juvenile mud crab in basic diet group was significantly lower than that in pupa peptide diet group and maggot diet group ( $P<0.05$ ), crude protein content of the juvenile mud crab showed the opposite results ( $P<0.05$ ), crude lipid content of the juvenile mud crab was: basic diet group > maggot diet group > pupa peptide diet group ( $P<0.05$ ); Protease activity of the juvenile mud crab was: basic diet group < maggot diet group < pupa peptide diet group ( $P<0.05$ ), amylase activity of the juvenile mud crab was the same as protease ( $P<0.05$ ), lipase activity of the juvenile mud crab in pupa peptide diet group and maggot diet group was significantly higher than that in basic diet ( $P<0.05$ ). In conclusion, it is feasible to add pupa peptide powder or maggot powder to the diet of juvenile mud crab.

**Key words:** : Keywords: *Scylla pseudoaculea*; pupa peptide powder; maggot powder; growth performance; body composition; digestive enzyme

## 四、水产病害防治与水产品质量安全

# 养殖锦鲤锦鲤昏睡病(KSD)实验室诊断分析

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**摘要:** 本研究应用流行病学调查、病理学观察、寄生虫学观察、细菌分离鉴定、人工感染试验和分子生物学检测方法对天津地区一例养殖锦鲤病例进行了诊断与分析。结果表明: 发病锦鲤临床症状表现为头部上方颅骨软组织皱缩, 眼球凹陷。其全身主要的组织器官发生不同程度的病理变化。其中, 脾组织超微病理观察发现大量病毒粒子; 鳃丝末端细胞增生, 有融合, 鳃小片上皮细胞增生, 且其之间隙缝逐渐被上皮细胞填满, 肝细胞、肾小管上皮细胞水肿, 部分水肿至空泡化。对该病例主要组织进行镜检未见明显寄生虫, 细菌分离培养后未见单菌落。分子生物学检测结果显示鲤浮肿病毒为阳性, 鲤春病毒血症病毒、鲤疱疹病毒 II 型和锦鲤疱疹病毒均为阴性。使用该病例鳃组织悬浮液进行的人工感染试验结果表明其可引起健康锦鲤死亡, 累积死亡率为  $65\% \pm 7.07\%$ , CEV 阳性检出率为 70%。根据实验室诊断结果初步分析认为, 该养殖锦鲤死亡病例是由致病性鲤浮肿病毒感染所致。

**关键词:** 锦鲤; 锦鲤昏睡病; 鲤浮肿病毒; 实验室诊断分析

## The Laboratory diagnostic analysis on a case of (Koi Sleepy Disease, KSD) in cultured ornamental koi carp, *Cyprinus Carpio var koi*

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**Abstract:** The laboratory diagnostic analysis, including epidemiological investigation, pathological observation, parasitological observation, bacterial isolation identification, artificial infection test and molecular biology test were carried out on the case of common carp *Cyprinus Carpio var koi* suffering carp edema disease in Tianjin. The results showed that the clinical symptoms of infected carp were wrinkled around the soft tissue of the skull above the head, and the eyeballs are dented. In comparison with healthy fish, the diseased fish showed the major pathological changes in tissues and organs, including the ultra-micropathological observation of spleen tissue found a large number of viral particles; the end cell of the fission was hyperplasia, there was fusion, the epithelial cell of the crucible was grown and the gap between them was gradually filled by the epithelial cells, the epithelial cells of the kidney tube and the liver cell edema, part of the edema to the empty bubble. There were no obvious parasites in the main tissues of the case, and no monobacteria were seen after bacterial isolation and culture. Molecular biology tests showed carp edema virus (CEV) was positive, spring viremia of carp virus (SVCV), Koi herpesvirus (KHV) and Cyprinid herpesvirus II (CyHV-II) were all negative. The artificial infection test results carried out with the suspension of the gill tissue in this case showed that it could cause the death of healthy koi, with a cumulative mortality rate of  $65\% \pm 7.07\%$  and the CEV positive detection rate of 70%. According to the preliminary analysis of laboratory diagnosis results, the death of this farmed common carp is caused by the pathogenic carp edema virus infection.

**Key words:** *Cyprinus carpio var koi*; Koi sleepy disease; Carp edema virus; Laboratory diagnostic analysis

# 茶多酚改善双酚 A 诱导斑马鱼 卵巢中线粒体功能基因表达下调

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**摘要：**内分泌干扰物广泛存在于环境中，干扰生物体内分泌系统诸多环节，主要靶器官是生殖系统，导致受精下降，性腺发育和生殖行为异常。增塑剂双酚 A 是一种典型的内分泌干扰物，研究表明双酚 A 暴露会导致生殖毒性，受精异常和不育。然而，低浓度双酚 A 对生殖系统的作用机制和治疗措施尚未完全明确。本研究以斑马鱼为模型探索了雌性斑马鱼卵巢的转录组，转录组数据显示，双酚 A 暴露组线粒体 NADH 脱氢酶 (mt-Nd) 基因表达显著降低，而茶多酚共同处理组线粒体 NADH 脱氢酶基因表达显著升高。为进一步探索 mt-Nd 基因的表达模式，本研究通过 qRT-PCR 分析了 6 个 mt-Nd 基因在对照组，双酚 A 暴露组和双酚 A-茶多酚共同处理组斑马鱼卵巢不同时期的表达，结果显示 0.1mg/L 双酚 A 暴露会对斑马鱼卵巢的线粒体呼吸链产生不利影响，可能会导致生殖障碍。最后，本研究表明茶多酚对低浓度双酚 A 暴露的雌性斑马鱼卵巢线粒体功能障碍起保护作用。

**关键词：**斑马鱼，双酚 A，茶多酚，转录组，线粒体 NADH 脱氢酶

## Tea polyphenols improve down-regulation of mitochondrial functional gene expression induced by bisphenol A in zebrafish ovaries

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**Abstract:** Endocrine disrupting chemicals are widely present in the environment and interfere with many aspects of the endocrine system of organisms. The main target organ is the reproductive system, resulting in decreased fertilization, abnormal gonadal development and reproductive behavior. The plasticizer bisphenol A is a typical endocrine disrupting chemical, studies demonstrated that exposure to bisphenol A can cause reproductive toxicity, abnormal fertilization, and infertility. However, the mechanisms of low-concentration bisphenol A on the reproductive system and treatment measures have not been fully determined. In this study, we used the zebrafish as a model to explore the transcriptomic profiles of female zebrafish ovaries. The transcriptomic data revealed that mitochondrial NADH dehydrogenase (mt-Nd) genes were significantly decreased in the bisphenol A-exposed group, while the co-administration of tea polyphenols remarkably elevated the expression of mt-Nd genes. To further explore the expression pattern of the mt-Nd, we analyzed the expression of six mt-Nd genes on different days by qRT-PCR in control, bisphenol A-exposed, and bisphenol A-tea polyphenols ovaries. Here, we found that 0.1 mg/L bisphenol A exposure adversely affects the mitochondrial respiratory chain in ovaries and may lead to reproductive disorders. Finally, our study demonstrated that tea polyphenols play a protective role in ovarian mitochondrial dysfunction in low-concentration bisphenol A-exposed female zebrafish.

**Key words:** zebrafish, bisphenol A, tea polyphenols, transcriptome, mitochondrial NADH dehydrogenase

# 中华绒螯蟹(*Eriocheir sinensis*) 2个 不同类型溶菌酶(EsLys-i 和 EsLys-C) 抗菌功能研究

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**摘要:** 从中华绒螯蟹(*Eriocheir sinensis*)中克隆并鉴定了两种不同类型的溶菌酶基因(EsLys-i 和 EsLys-C)。EsLys-i 的 cDNA 全长为 1312 bp, 编码 158 个氨基酸(aa)。EsLys-C 的 cDNA 全长为 1217 bp, 编码 226 个 aa。EsLys-i 主要分布于胃和肌肉中, EsLys-C 主要分布于肝胰腺中。两种蛋白在不同程度上抑制革兰氏阴性菌性、阳性细菌和真菌的生长。rEsLys-i 与细菌结合能力较弱, rEsLys-C 结合能力极强。糖结合实验中, rEsLys-i 和 rEsLys-C 对枯草芽孢杆菌的肽聚糖(PGN)具有较强的结合活性, EsLys-C 对脂膜酸(LTA)、 $\beta$ -葡聚糖和金黄葡萄球菌的肽聚糖也有较强的结合活性。凝集实验中, EsLys-C 可引起多种细菌凝集。这些结果表明, EsLys-i 和 EsLys-C 在不同组织中发挥不同的抗菌功能, 构成了河蟹的抗菌免疫屏障

**关键词:** i 型溶菌酶; C 型溶菌酶; 中华绒螯蟹; 抗菌活性; 结合活性

## Two types of lysozymes (EsLys-i and EsLys-C) identified in Chinese mitten crab *Eriocheir sinensis* exhibit different antibacterial activities

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**Abstract:** Lysozymes are universal innate immune effector molecules from lower animals to higher animals, and play an important role in the anti-microbial infection process. However, the functional differences between different types of lysozymes in the same species need to be further clarified. We cloned and identified two different types of lysozyme genes (EsLys-i and EsLys-C) from the Chinese mitten crab (*Eriocheir sinensis*). The full-length cDNA of EsLys-i is 1312 bp, with an open reading frame of 477 bp, encoding 158 amino acids (aa). The full-length cDNA of EsLys-C is 1217 bp, the open reading frame is 681 bp, encoding 226 aa. Evolutionary analysis showed that EsLys-i was closely related to *Chionoecetes opilio* and EsLys-C was closely related to *Scylla paramamosain*. EsLys-i is mainly distributed in stomach and muscle, but EsLys-C is mainly distributed in hepatopancreas. The results of bacteriostatic experiment showed that the two proteins inhibited the growth of gram-negative bacteria (*Vibrio parahaemolyticus*, *Vibrio alginolyticus*, *Vibrio cholerae* and *Aeromonas hydrophila*), gram-positive bacteria (*Staphylococcus aureus*, *Bacillus subtilis* and *Bacillus megaterium*) and fungi (*Candida albicans* and *Pichia pastoris*) to varying degrees. Bacterial binding experiments showed that EsLys-i had weak binding ability with bacteria, while EsLys-C had strong binding ability with 10 kinds of bacteria, especially *Bacillus subtilis* and *Vibrio*. The ELISA results showed that EsLys-i and EsLys-C had strong binding activity to the peptidoglycan (PGN) of *Bacillus subtilis*, and EsLys-C also had strong binding activity to the peptidoglycan of *Staphylococcus aureus*, the lipid membrane acid (LTA) of *Bacillus subtilis* and the  $\beta$ -glucan of fungi. In the agglutination experiment, EsLys-C can cause the agglutination of bacteria. These results indicate that both EsLys-i and EsLys-C have certain antibacterial effects, and their antibacterial activities are closely related to their ability to bind specific bacterial bacteria and specific bacterial polysaccharides, suggesting that

these two lysozymes have different antibacterial functions in different tissues and play a synergistic role in the immune response to bacterial infection.

**Key words: :** Invertebrate-type lysozyme; C-type lysozyme; *Eriocheir sinensis* ; Antimicrobial activity; Binding activity.

# 小瓜虫对虹鳟组织病理变化及 TLR 信号通路基因表达影响

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**摘要：**小瓜虫病病原体为多子小瓜虫，死亡率较高，且缺乏有效的治疗手段。本研究旨在观察虹鳟感染多子小瓜虫后鳃和皮肤的组织病理学变化及虹鳟 Toll 样受体信号通路在多子小瓜虫感染后的免疫作用。结果表明，小瓜虫寄生后，皮肤表面出现大量不规则分泌物，表皮与真皮层有空隙，空隙间寄生了大小不等的小瓜虫滋养体；鳃丝受损脱落，鳃小片变形扭曲，鳃丝小骨肿胀变形；与对照组相比，处理组 TLR2 在鳃和皮肤中表达量显著升高，在脾脏中表达量显著降低( $P<0.05$ )；TLR3 基因在鳃、皮肤、脾脏和肠道中表达量显著升高( $P<0.05$ )，在肝脏和头肾中无显著性差异( $P>0.05$ )；TLR4 基因在皮肤中表达量显著升高( $P<0.05$ )，在肝脏和鳃中的表达量显著降低( $P<0.05$ )。处理组 TNF- $\alpha$  基因在鳃、皮肤和头肾中表达量显著升高( $P<0.05$ )，IL-1 $\beta$  和 IFN- $\gamma$  基因在本研究所有组织中均显著升高( $P<0.05$ )。

**关键词：**虹鳟；多子小瓜虫；组织病理；Toll 样受体(TLR)信号通路；基因表达

## Histopathological Changes and Gene Expression Dynamics of TLR Signaling Pathway in *Oncorhynchus mykiss* Infected with *Ichthyophthirius multifiliis*

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**Abstract:** The pathogen of the disease is *Ichthyophthirius multifiliis*, which has a high mortality rate and lacks effective treatment. The purpose of this study was to observe the histopathological changes of gills and skin after rainbow trout (*Oncorhynchus mykiss*) infected with small melon polyps, and the immune effect of rainbow trout Toll like receptor (TLR) signal pathway after infection with small melon polyps. The results showed that there were a lot of irregular secretions on the skin surface, and there were gaps between the epidermis and the dermis; The branchial filament is damaged and falls off, the branchial lamella is deformed and twisted, and the branchial filament bone is swollen and deformed; Compared with the control group, the expression of TLR2 in the gills and skin of the treatment group was significantly increased, and the expression in the spleen was significantly decreased ( $P<0.05$ ); The expression of TLR3 gene in gill, skin, spleen and intestine increased significantly ( $P$ ); The expression of TLR4 gene in skin was significantly increased ( $P<0.05$ ), while in liver and gill was significantly decreased ( $P<0.05$ ). Processing group TNF- $\alpha$  Gene expression in gill, skin and head kidney increased significantly ( $P<0.05$ ), IL-1 $\beta$  And IFN- $\gamma$  Genes were significantly increased in all tissues of this study ( $P<0.05$ ).

**Key words:** *Oncorhynchus mykiss*; *Ichthyophthirius multifiliis*; Histopathology; Toll-like receptor (TLR) signaling pathway; Gene expression



# 丁香酚对斑马鱼的胚胎毒性及鳔发育的影响及其机制研究

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**摘要:** 本研究以斑马鱼为研究实验材料, 用发育至 24 hpf 的斑马鱼胚胎, 在浓度梯度为 0、10、15、20、25、30 mg/L 的丁香酚中进行 96 h 的暴露实验, 结果显示, 丁香酚暴露会导致斑马鱼胚胎孵化延迟, 鳔充气率明显降低, 体长增长速度明显下降。在开口期 (120 hpf) 后鳔未充气的仔鱼因难以正常游动而摄食困难, 最终逐渐死亡, 各浓度组的累计死亡数与对照组相比明显升高, 这些形态异常程度与丁香酚浓度呈正相关。qPCR 检测调控鱼鳔发育的 Wnt- $\beta$ -catenin 信号通路中的关键基因分别在孵化期和开口期的表达水平, 结果表明, 经过丁香酚暴露, Wnt- $\beta$ -catenin 信号通路的传导被抑制, 其中 Wnt 信号通路抑制基因 *wif1* 表达显著上调, 通路内基因 *fzd3b*、*fzd6*、*ctnnb1* 和 *lef1* 表达均显著下调, 这提示丁香酚暴露导致早期斑马鱼鳔无法充气的原因可能是 Wnt- $\beta$ -catenin 信号通路传导受到了抑制。

**关键词:** 丁香酚; 斑马鱼; 鱼鳔; 充气失败; Wnt- $\beta$ -catenin 信号通路

## Eugenol exposure disrupts embryonic development and swim bladder formation in zebrafish

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**Abstract:** Eugenol is a natural phenolic essential oil extracted from cloves, that has analgesic and anesthetic effects and is widely used in fishery anesthesia. However, the environmental safety risks associated with the massive use of eugenol and its developmental toxicity during early life stages of fish have been overlooked. In this study, zebrafish (*Danio rerio*) embryos at 24 hours post-fertilization (hpf) were exposed to eugenol at concentrations of 0, 10, 15, 20, 25, or 30 mg/L for 96 h. Eugenol exposure delayed the hatching of zebrafish embryos, and reduced the body length and the inflation rate of the swim bladder. The accumulated number of dead zebrafish larvae in the eugenol-exposed groups was higher than that of the control group, and it was dose-dependent. Real-time quantitative polymerase chain reaction (qPCR) analysis showed that the Wnt/ $\beta$ -catenin signaling pathway that regulates the development of the swim bladder during the hatching and mouth-opening stages was inhibited after eugenol exposure. Specifically, the expression of *wif1*, a Wnt signaling pathway inhibitor, was significantly up-regulated, whereas the expression of *fzd3b*, *fzd6*, *ctnnb1*, and *lef1* involved in the Wnt/ $\beta$ -catenin pathway was significantly down-regulated. These results suggest that the failure of zebrafish larvae to inflate their swim bladders as a result of eugenol exposure may be caused by the inhibition of the Wnt/ $\beta$ -catenin signaling pathway. In addition, the inability to catch food due to the abnormal development of the swim bladder may be the key to the death of zebrafish larvae during the mouth-opening stage.

**Key words:** Eugenol, Zebrafish, Swim bladder, Inflation failure, Wnt/ $\beta$ -catenin signaling pathway

# 微生物分析揭示传统水产养殖 环境下克氏原螯虾（*Procambarus clarkii*）肠 道内病原体的潜在定植情况

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**摘要:** 肠道微生物群作为一个复合内分泌器官, 能够通过产生大量的生物活性分子影响生物体的健康和疾病进展。然而, 目前对水产养殖生态系统中的细菌群落的了解极为有限, 因此有必要评估环境和肠道微生物群之间的相互作用以及潜在的疾病发生风险。本研究以克氏原螯虾为例, 通过微生物分析和诊断探究环境和宿主的微生物群之间的关系。研究表明, 养殖环境中沉积物中的细菌种类大于水体, 其次是肠道; 在肠道中定植和增殖的细菌并非环境中的高丰度菌, 其在沉积物和水体中的丰度均非常低, 说明克氏原螯虾对细菌的筛选存在主动性, 环境中的一些细菌被机体特异性筛选并定植在肠道内。本研究利用四川盆地的多个真实的、传统的克氏原螯虾养殖基地的横向比较, 明确了环境和动物宿主的微生物群落之间的相互作用。结果表明, 健康的克氏原螯虾机体存在一套筛选机制, 能够通过筛选细菌种类在其肠道内定植, 从而发挥肠道菌群的作为复合内分泌器官的功能。

**关键词:** 克氏原螯虾; 环境-宿主互动; 微生物群落; 潜在病原体定植; 传统养殖模式; 微生物群分析

## Microbial analysis reveals the potential colonization of pathogens in the intestine of crayfish (*Procambarus clarkii*) in traditional aquaculture environments

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**Abstract:** The microbiota of the intestine produces a wide array of biologically active molecules and together act as a composite endocrine organ. Due to our limited understanding of bacterial communities in aquaculture ecosystems, it is necessary to evaluate the interactions between environmental and intestinal microbiota and the potential consequences of disease. This study taken the traditional *P. clarkii* culture in the Sichuan Basin as an example, and analyzed the relationships between the microbiota of the environment and host through microbial analysis and microbiological diagnosis. Our results showed that the bacterial abundance in sediment was greater than in water, followed by the intestine, and some of bacteria from the environment successfully selected to colonize the intestine. The bacterial composition in the intestines of diseased and healthy crayfish was significantly different. The bacteria that colonized and proliferated in the intestine had very low abundances in sediment and water. Two potential pathogens, *Aeromonas veronii*, and *Citrobacter freundii*, and two potential probiotics, *Lactococcus garvieae* and *Exiguobacterium undae*, were identified. Using multiple, real, and traditional *P. clarkii* aquaculture sites in the Sichuan Basin, this study revealed that the microbial communities of the environment and animal host did indeed interact. Furthermore, these results indicated that *P. clarkii* in a healthy status are capable of regulating which bacteria colonize their intestines.

**Key words::** *Procambarus clarkii*; environment-host interaction; microbial community; potential pathogen colonization; traditional cultivation pattern; microbiota analysis

# 富硒植物乳杆菌对大鳞鲃组织 镉蓄积及氧化应激的影响

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**摘要:** 为了探究富硒植物乳杆菌对镉诱导的大鳞鲃组织氧化应激的保护作用。将大鳞鲃分为 3 组, 对照组、镉组和富硒镉组。实验持续 28 d。结果显示, 富硒镉组镉浓度显著低于镉组 ( $P<0.05$ )。富硒植物乳杆菌能够显著提高镉胁迫下肾和鳃中 SOD、CAT、GPx 活性, 降低 MDA 含量 ( $P<0.05$ )。镉暴露显著降低肾脏和肝脏的 SOD、CAT、GPx、HO-1 和 Nrf2 的表达量, 富硒植物乳杆菌缓解上述指标变化。

**关键词:** 富硒植物乳杆菌; 镉; 大鳞鲃; 氧化应激; 生物积累

## Effects of feeding selenium-enriched *Lactobacillus plantarum* diets on heavy metal bioaccumulation and oxidative stress in *Luciobarbus capito* tissues under cadmium stress

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**Abstract:** To investigate the protective effect of selenium-enriched *Lactobacillus plantarum* on Cd-induced oxidative stress in the tissues of *Luciobarbus capito*. 225 *L. capito*s were divided into 3 groups, namely the control group, the Cd group, and SL + Cd group. The experiment lasted for 28 days. The results showed that the accumulation of selenium in SL + Cd was significantly higher than that in control group and Cd group ( $P<0.05$ ); the accumulation of Cd, the Cd concentration in the kidney of the Cd group was significantly higher than that in the other treatment groups ( $P<0.05$ ), The concentration of Cd in the SL+Cd was significantly lower than that in the Cd group ( $P<0.05$ ). Selenium-enriched *L. plantarum* can significantly increase the activities of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) in kidney and gill under Cd stress, and decreased the content of lipid peroxidation malondialdehyde (MDA) ( $P<0.05$ ). Cd exposure significantly decreased the relative expressions of SOD, CAT, GPx, HO-1 and Nrf2 in kidney and liver, but significantly increased the relative expression of Keap1 ( $P<0.05$ ). Compared with the Cd group, the relative expressions of SOD, CAT, GPx, HO-1 and Nrf2 in the SL+Cd group were significantly increased, the expression of Keap1 was significantly decreased ( $P<0.05$ ).

**Key words:** Se-enriched *Lactobacillus plantarum*; Cadmium; *Luciobarbus capito*; oxidative stress; Bioaccumulation

# 鳃弧菌 $\Delta$ vah1-vah4-rtxA 菌株感染花鲈能力的评估

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**摘要：**花鲈是我国重要的海水鱼养殖品种，鳃弧菌作为花鲈重要的病原菌，对花鲈养殖业的影响越来越严重。本研究通过分别对花鲈幼鱼注射弧菌野生株和鳃弧菌 $\Delta$ vah1-vah4-rtxA 减毒株，评估鳃弧菌 $\Delta$ vah1-vah4-rtxA 减毒株对花鲈的感染能力、致病能力、花鲈各组织的病理变化情况以及免疫相关基因表达量的影响，确定 vah1, vah4, rtxA 缺失对鳃弧菌感染花鲈能力的影响，并探究花鲈相应的免疫响应变化。研究结果有助于理解鳃弧菌感染花鲈的初步机制，并有望以鳃弧菌 $\Delta$ vah1-vah4-rtxA 减毒株为基础，制备针对鳃弧菌的花鲈免疫增强剂。

**关键词：**鳃弧菌; 花鲈; 减毒菌株; 细菌感染; 免疫应答

## Evaluation of the ability of *Vibrio anguillus* $\Delta$ vah1-vah4-rtxA strain to infect Chinese seabass

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**Abstract :** Chinese seabass (*Lateolabrax maculatus*) is one of the most important marine fish species in China. *Vibrio anguilli*, as an important pathogen of Chinese seabass, has a more and more serious impact on the culture of Chinese seabass. In this study, wild strain *Vibrio anguillarum* and attenuated strain  $\Delta$ vah1-vah4-rtxA were injected into Chinese seabass, to evaluate the infectivity and pathogenicity of the attenuated strain  $\Delta$ vah1-vah4-rtxA of *Vibrio anguillarum* on Chinese seabass, the pathological changes in the tissues of Chinese seabass and the expression levels of immune-related genes, the effect of vah1, vah4 and rtxA deletion on the ability of *Vibrio anguillarum* to infect Chinese seabass and the corresponding immune response of Chinese seabass were studied. The results are helpful to understand the primary mechanism of *Vibrio anguillus* infection in Chinese seabass, and may be used to prepare immune enhancer against *Vibrio anguillus* based on the attenuated *Vibrio anguillarum*  $\Delta$ vah1-vah4-rtxA strain.

**Key words::** *Lateolabrax maculatus*; *Vibrio anguillarum*; Attenuated strain; Bacterial infection; immune response

# 花鲈深海网箱养殖水体弧菌数量变动

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**摘要：**花鲈深海网箱养殖是目前主要的海水养殖模式，弧菌病是渔业养殖中常见疾病之一，目前对该病的诊断主要通过细菌学鉴定和病理观察。本研究通过设计弧菌特异性引物进行核酸扩增，一方面通过定量 PCR，调查夏天高温季节花鲈深海网箱养殖水体弧菌的数量变动规律，揭示养殖水体水温等环境条件对弧菌数量变动的的影响；另一方面，利用重组酶介导等温核酸扩增技术，结合侧向流免疫层析试纸条,建立了水产养殖弧菌致病菌的现场快速检测技术。

**关键词：**花鲈；致病性弧菌；数量变动；重组酶介导等温核酸扩增技术；快速检测

## Dynamic change of quantity of *Vibrio* in the deep-sea cage culture system of *Lateolabrax maculatus*

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**Abstract:** Sea bass (*Lateolabrax maculatus*) cultured in the deep-sea cage is the main culture mode at present. Vibriosis is one of the common diseases in culture. At present, the diagnosis of the disease is mainly through bacteriological identification and pathological observation. In this study, specific primers were designed to amplify the nucleic acid of *Vibrio*. On the one hand, quantitative PCR was used to investigate the quantity variation of *Vibrio* in deep-sea cage culture of sea bass in summer high temperature. On the other hand, combined Recombinase Aided Amplification (RAA) with lateral flow immunochromatographic test strip to establish a rapid detection technique of *Vibrio* in aquaculture.

**Key words::** *Lateolabrax maculatus*; pathogenic vibrio; RAA; rapid detection

# 溶藻弧菌 RseAB 基因缺失对花鲈致病性的研究

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**摘要：**溶藻弧菌（*Vibrio alginolyticus*）是海洋环境中的一种优势细菌，也是常见的致病菌。当温度在 25°C~35 °C 时，容易暴发流行性的弧菌病，对海水养殖产业造成重大的影响。已知 RseAB 基因跟溶藻弧菌的毒力相关联，为了解花鲈在人工感染溶藻弧菌 RseAB 缺失株之后的免疫反应能力，将 90 尾 20-30g 健康花鲈分为感染组和对照组，通过腹腔分别注射 100ul 浓度为  $5 \times 10^5 \text{CFU} \cdot \text{mL}^{-1}$  的溶藻弧菌野生菌及其缺失株和灭菌生理盐水，在注射 4, 8, 12, 24, 48h 后，取头肾、肾、肝、脾、肠、鳃、脑等病理组织做转录组测序、荧光定量、石蜡切片和定殖能力检测。初步结果显示：花鲈在感染溶藻弧菌之后，第 16h 左右 RseB 毒株注射的花鲈开始出现死亡，第 24h 左右 RseA 毒株注射的花鲈开始出现死亡，对比野生株是在第 12-16h 左右出现陆续死亡，可以发现 RseAB 敲除株较野生株的毒力均下降了。

**关键词：**溶藻弧菌；RseAB 基因；注射感染实验；花鲈

## Study on the pathogenicity of *Vibrio alginolyticus* RseAB gene deletion on Seabass

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**Abstract :** *Vibrio alginolyticus* is a dominant bacterium and a common pathogenic bacterium in Marine environment. When the temperature is 25°C~35 °C, it is easy to outbreak vibriosis, which has a great impact on the mariculture industry. RseAB gene is known to be associated with the virulence of *Vibrio alginolyticus*. In order to understand the immune response ability of seabass after artificial infection with *Vibrio alginolyticus* RseAB deletion strain, 90 healthy seabass with 20-30g were divided into infection group and control group. 100ul of *Vibrio alginolyticus* wild bacteria with a concentration of  $5 \times 10^5 \text{CFU} \cdot \text{mL}^{-1}$  and its deletion strain and sterilization saline were injected into the abdomen, respectively. After 4,8,12,24,48 h of injection, head kidney, kidney, liver, spleen, intestine, gill, brain and other pathological tissues were taken for transcriptome sequencing, fluorescence quantification, paraffin section and determination of colonizing ability. The preliminary results showed that after infection with *Vibrio alginolyticus* bacteria, the bass injected with RseB strain began to die at around 16h, and the bass injected with RseA strain began to die at around 24h. Compared with the wild strains, the virulence of the knocked out strain of RseAB decreased compared with that of wild strains.

**Key words: :** *Vibrio alginolyticus*; RseAB gene; Injection infection experiment; Flower bass

# 草鱼 IL-1 $\beta$ 蛋白诱导炎症 和干扰素抗病毒反应的功能及机制研究

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**摘要:** IL-1 $\beta$ 是人们熟知的促炎细胞因子, 近年来在哺乳动物中还发现其具有调节干扰素反应的功能。为探究草鱼 IL-1 $\beta$ 是否具备同样的功能, 我们获得了高纯度的草鱼 IL-1 $\beta$ 重组蛋白 (rCiIL-1 $\beta$ ), 体外孵育细胞后检测干扰素和炎症相关因子的表达, 验证其免疫调节功能, 并通过转录组及免疫印迹等技术探究其功能机制。结果表明, rCiIL-1 $\beta$ 能够诱导草鱼 IFN-1、IFN-2、IFN- $\gamma$ 2、ISG15 等干扰素和干扰素刺激基因以及 IL-1 $\beta$ 、IL-8、TNF- $\alpha$ 、TGF- $\beta$ 1 等炎症因子的表达, 证实其具有调节干扰素反应和炎症反应的功能。转录组分析同样揭示, rCiIL-1 $\beta$ 既能激活炎症反应, 还可能参与干扰素抗病毒反应。免疫印迹进一步发现 rCiIL-1 $\beta$ 能激活 IRF1、IRF3 和 NF- $\kappa$ B 等转录因子。共孵育结果显示, 外源 rCiIL-1 $\beta$ 可显著抑制 GCRV 在草鱼细胞中的复制。

**关键词:** 草鱼; IL-1 $\beta$ ; 炎症; 干扰素; 抗病毒免疫

## The function and mechanism of IL-1 $\beta$ induced inflammation and interferon-mediated antiviral responses in grass carp (*Ctenopharyngodon idellus*)

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**Abstract:** IL-1 $\beta$  is a well-known proinflammatory cytokine and has recently been found to regulate interferon response in mammals. To explore whether grass carp (*Ctenopharyngodon idellus*) IL-1 $\beta$  exhibits the similar function, we obtained the recombinant protein of grass carp IL-1 $\beta$  (rCiIL-1 $\beta$ ). The expressions of interferons and inflammation-related factors were detected to verify the immunodulatory functions of rCiIL-1 $\beta$  after its incubation with grass carp kidney cell in vitro, and the functional mechanism was explored by transcriptome and western blot analyses. The results showed that rCiIL-1 $\beta$  could induce the expressions of IFN-1, IFN-2, IFN- $\gamma$ 2, ISG15, IL-1 $\beta$ , IL-8, TNF- $\alpha$ , TGF- $\beta$ 1 in grass carp kidney cell, which confirmed that rCiIL-1 $\beta$  could regulate the interferon response and inflammatory response. Transcriptome analysis also suggested that rCiIL-1 $\beta$  not only induced inflammatory response, but also participated in the interferon-mediated antiviral response. Western blot further demonstrated that rCiIL-1 $\beta$  activated several transcription factors such as IRF1, IRF3 and NF- $\kappa$ B. Co-incubation experiments showed that exogenous rCiIL-1 $\beta$  significantly inhibited the replication of GCRV in grass carp kidney cell.

**Key words:** Grass carp; IL-1 $\beta$ ; Inflammatory response; Interferon; antiviral immunity



# 罗氏沼虾肝胰腺对脂多糖的免疫应答

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**摘要：**为研究 LPS 感染对罗氏沼虾肝胰腺的影响，分别对罗氏沼虾注射生理盐水和 8 $\mu$ g 的大肠杆菌 LPS，注射后分别于 0、3、6、12、24、48 h 测定了肝胰腺中免疫相关酶活性。酶活性分析表明接种 LPS 后肝胰腺的酚氧化酶（proPO）、抗氧化酶（SOD、CAT）、磷酸酶（ACP、AKP）等酶活性显著升高，MDA 含量显著升高。提示这些参数可作为注射 LPS 的罗氏沼虾肝胰腺免疫状态的敏感指标。

**关键词：**罗氏沼虾；脂多糖；免疫酶活性

## Immune response and gene expression of hepatopancreas of *Macrobrachium rosenbergii* to lipopolysaccharide

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**Abstract :** In order to study the effect of LPS infection on hepatopancreas of *Macrobrachium rosenbergii*, *Macrobrachium rosenbergii* was injected with normal saline and 8  $\mu$ g of *E. coli* LPS. The activity of immune related enzymes in hepatopancreas were measured at 0, 3, 6, 12, 24 and 48 hours after injection of *E. coli* LPS. The enzyme activity analysis showed that the activities of phenol oxidase (PO), antioxidant enzymes (SOD, cat) and phosphatase (ACP, AKP) and the content of MDA in hepatopancreas increased significantly after LPS inoculation. It is suggested that these parameters can be used as sensitive indicators of hepatopancreatic immune status of *Macrobrachium rosenbergii* injected with LPS.

**Key words: :** *Acrobrachium rosenbergii*; Lipopolysaccharide; Immune enzyme activity

# 碳酸盐碱度胁迫下大鳞副泥鳅 氨排泄相关基因的差异性表达

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**摘要:** 大鳞副泥鳅属鲤形目、鳅科、副泥鳅属, 属温水性鱼类。研究表明大鳞副泥鳅具有极强的耐受碳酸盐碱度特性, 可作为盐碱水域的增养殖鱼类, 目前 Rh 蛋白家族被认为直接参与 NH<sub>3</sub> 在鳃中的主动外排作用, 本研究克隆并分析了大鳞副泥鳅 Rh 蛋白家族 (Rhag、Rhbg、Rhcg) cDNA 序列, 对碳酸氢盐胁迫下不同浓度泥鳅 Rhag、Rhbg、Rhcg 基因的表达情况进行了研究。

**关键词:** 大鳞副泥鳅, 碳酸盐碱度, 氨排泄, Rh 基因

## Differential expression of genes related to ammonia excretion in *Paramisgurnus dabryanus* under carbonate alkalinity stress

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**Abstract:** Large scale loach is a genus of carp, loach family, loach, warm water fish. It has the characteristics of fast growth rate, strong adaptability, low disease rate, high survival rate, high fertility, easy transportation, low requirements for breeding conditions and bait, low cost of breeding, and strong tolerance to stressful environment. Studies have shown that Chinook salmon have excellent tolerance to carbonate alkalinity and can be used as an enrichment fish in saline waters. These natural advantages make them ideal experimental materials for conducting research on the evolution of saline adaptation and molecular physiological mechanisms of salinity tolerance in fish. The Rh protein family is currently thought to be directly involved in the active efflux of NH<sub>3</sub> in the gills, and among them Rhag, Rhbg, and Rhcg have been shown to have the ability to transport NH<sub>3</sub> in mammals and some fish. In this study, we cloned and analyzed the cDNA sequences of the Rh protein family (Rhag, Rhbg, and Rhcg) of *Paramisgurnus dabryanus*; the expression of Rhag, Rhbg, and Rhcg genes was investigated under different times and concentrations of bicarbonate stress in the loach.

**Key words:** : *Paramisgurnus dabryanus*; *Paramisgurnus dalin*; carbonate basicity; ammonia excretion; Rh gene

# 转录组分析为胆碱能系统在珍珠贝移植免疫中的功能提供了见解

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**摘要：**珍珠贝移植后过度的免疫反应是导致其吐核和死亡的主要因素。本研究旨在探讨胆碱能系统在珍珠贝移植免疫中的作用及分子机制。ACh 处理诱导珍珠贝血细胞中的  $\text{Ca}^{2+}$  浓度和钙调蛋白表达。获得了参与移植免疫胆碱能系统调控的通路和基因。胆碱能系统可能参与调节移植后血细胞的增殖和凋亡。这些结果为胆碱能系统调节珍珠贝移植免疫的分子机制提供了新的见解，并促进了免疫抑制剂的开发，以提高养殖珍珠的有效性。

**关键词：**胆碱能系统, 移植, 乙酰胆碱, 炎症反应, 珍珠贝

## Transcriptome analysis provides insights into the function of the cholinergic system in pearl oyster transplantation immunity

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**Abstract :** Excessive immune response of pearl oyster after transplantation is the main factor that causes its nucleus rejection and death. This study aims to explore the function and molecular mechanism of the cholinergic system in pearl oyster transplantation immunity. This transcriptomics study is the first to assess the function of the cholinergic system in pearl oyster transplantation immunity. ACh treatment induced the  $\text{Ca}^{2+}$  concentration and calmodulin expression in the hemocytes of pearl oysters. Obtained many pathways and genes involved in cholinergic system regulation of transplant immunity. The cholinergic system maybe participates in regulating the proliferation and apoptosis of the hemocytes after transplantation. These results provide new insights into the molecular mechanism of the cholinergic system in regulating the immunity of pearl oyster transplantation and facilitate the development of immunosuppressive agents to improve the effectiveness of cultured pearls.

**Key words::** cholinergic system, transplantation, acetylcholine, inflammatory response, pearl oysters

# 脂质和氨基酸：虾肝肠胞虫胞内寄生的重要物质依赖

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**摘要:** 本研究利用 4D label-free 蛋白质组和乙酰化修饰组学技术, 从蛋白水平分析虾肝肠胞虫 (EHP) 感染对凡纳滨对虾初级代谢通路的影响, 同时通过鉴定的病原蛋白信息, 初步探究病原与宿主间的相互作用关系。我们发现初级代谢缺陷的 EHP 为维持胞内寄生劫持了大量宿主的能量和代谢底物, 扰乱了宿主的能量生成以及脂质和氨基酸代谢, 蜕皮生长所需的有机物质储备不足和保幼激素的持续高水平阻滞了对虾的生长发育。

**关键词:** 虾肝肠胞虫, 凡纳滨对虾, 脂质和氨基酸代谢紊乱

## Lipid and amino acid: an important substance dependence for parasitic life of *Enterocytozoon hepatopenaei*

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**Abstract:** In this study, 4D label-free proteomics and acetylation modification omics were used to analyze the primary metabolism change of *Litopenaeus vannamei* after challenged by *Enterocytozoon hepatopenaei*, and to explore the interaction between pathogens and hosts. We found that EHP stole vast energy and metabolic substrates of host cells to maintain its intracellular parasitic life, and disrupted host energy generation, lipid and amino acid metabolism. Therefore the insufficient reserve of organic materials required for molting growth and the continuous high level of juvenile hormone hindered the growth and development of shrimp.

**Key words:** *Enterocytozoon hepatopenaei*, *Litopenaeus vannamei*, lipid and amino acid metabolism disorder

# PLGA-LrrG 荧光微球的制备及其组织分布

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**摘要:** PLGA-LrrG 为聚乳酸共聚物包裹无乳链球菌表面蛋白 LrrG 的多聚物微球疫苗抗原, 本研究采用复乳化溶剂挥发法制备了 PLGA-LrrG 荧光微球, 通过电镜扫描测定其大小及形态, 同时通过注射和灌胃两种途径研究微球在罗非鱼体内的组织分布规律。结果显示, 微球呈圆球形, 分散良好。冰冻切片显示 PLGA-LrrG 微球最早在罗非鱼脾和头肾中出现, 微球最晚到达脑。该结果为罗非鱼链球菌病口服疫苗的开发提供了数据支持。

**关键词:** PLGA; LrrG; 罗非鱼; 无乳链球菌

## Preparation of PLGA-LrrG fluorescent microspheres and tissues distribution study

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**Abstract :** PLGA-LrrG is a polymeric microsphere vaccine antigen of streptococcus agalactiae surface protein LrrG wrapped by polylactic acid copolymer. In this study, PLGA-LrrG fluorescent microspheres were prepared by solvent volatilization complex emulsification method. The size and morphology of microspheres were determined by scanning electron microscopy, and the tissue distribution of microspheres in tilapia was detected by injection and intragastric administration. The results showed that the microspheres were spherical and well dispersed. Frozen section results showed that PLGA-LrrG microspheres first appeared in the spleen and head kidney of tilapia, and reached the brain last. These results provide data support for the development of oral vaccine against streptococcus agalactiae of tilapia.

**Key words::** PLGA, LrrG, Tilapia, Streptococcus agalactiae

# 一株鳢源鳢诺卡氏菌的致病性与全基因组分析

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**摘要:** 为了解鳢诺卡氏菌在不同浓度下对鱼体的致死率与感染组织病理变化, 及基因组信息和毒力特征。攻毒实验显示不同浓度试验菌致死率在 90-100%, 攻毒鱼体皮肤溃烂、内脏肿大白色结节。病理组织分析显示结节中心呈干酪样坏死, 周围有大量细胞浸润。全基因组测序分析显示不同鳢诺卡氏菌具有较高的同源性; VFDB 数据库分析预测试验菌具有黏附侵袭、金属离子转运、信号调节、应激、分泌系统 5 类 171 个毒力因子, 与发病机制有关。

**关键词:** 鳢诺卡氏菌, 致病性, 全基因组分析, 毒力基因

## Pathogenicity and Genome Analysis of a Strain of *Nocardia Seriolae*

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**Abstract :** In order to get the mortality and infection pathological changes of fish by injecting different concentrations *N.seriolae*, as well as genomic information and toxicity characteristics. The anti-virus experiment showed that the fatality rate of different concentrations of experimental bacteria was 90-100%, and the skin of the poisonous fish festered and the internal organs were swollen with white nodules. Pathological tissue analysis showed cheese-like necrosis at the center of the nodules, surrounded by a large number of cells soaked. The Genome analysis showed that different *N.seriolae* strains had high homologousity, VFDB database analysis predicts that the experimental bacteria have 171 toxic factors in 5 categories of adhesion attack, metal ion transport, signal regulation, stress, secretion system, and are related to pathogenesis.

**Key words::** *Nocardia Seriolae*, Pathogenicity, Genome Analysis, virulence genes

# 乌鳢 IL-1RAcP 的分子特征及其 对两种病原菌感染的免疫应答分析

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**摘要:** 白细胞介素 1 受体辅助蛋白 IL-1RAcP 是参与促炎细胞因子 IL-1 信号传导的重要分子。本研究克隆了乌鳢 IL-1RAcP 基因, 初步分析了其对舒伯特气单胞菌和鳊诺卡氏菌感染及病原类似物 LTA、LPS、Poly(I:C) 和重组 IL-1 $\beta$  蛋白刺激的免疫应答。结果证实 shIL-1RAcP 既可能被病原菌诱导, 也可由病原类似物和重组 IL-1 $\beta$  蛋白诱导, 为进一步揭示鱼类 IL-1RAcP 在抗菌免疫中的作用提供了基础。

**关键词:** 乌鳢, IL-1RAcP, 舒伯特气单胞菌, 鳊诺卡氏菌, 免疫应答

## Molecular Characterization of IL-1RAcP in Snakehead (*Channa argus*) and Its Immune Response to the Infection with Two Pathogenic Bacteria

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**Abstract:** Interleukin-1 receptor accessory protein (IL-1RAcP) is an important molecule involved in the pro-inflammatory cytokine interleukin-1 (IL-1) signal transduction, which plays critical roles in the inflammation, immune response, and antimicrobial defense. To explore the mechanism of fish IL-1RAcP in immune defense against pathogen infection, in the present study, the complete open reading frame (ORF) of the IL-1RAcP gene in *Channa argus* was first cloned, and its immune response to the infection with two pathogenic bacteria (*Nocardia seriolae* or *Aeromonas schubertii*) and the stimulation with three pathogen analogues (LTA, LPS, Poly(I:C)) or recombinant IL-1 $\beta$  protein was preliminarily analyzed. The shIL-1RAcP possessed a typical structural characterization composed of three extracellular Ig-like domains, one transmembrane domain, and one intracellular Toll/IL-1 (TIR) domain. The phylogenetic tree analysis revealed that shIL-1RAcP shared the closest evolutionary relationship with IL-1RAcP protein of *Micropterus salmoides* and *Seriola lalandi*. Our results illustrated that shIL-1RAcP was constitutively expressed in all tested tissues, and its expression was induced by *Nocardia seriolae* or *Aeromonas schubertii* in the head kidney and spleen in vivo and by LTA, LPS, Poly(I:C) and recombinant IL-1 $\beta$  protein in head kidney leukocytes in vitro. In conclusion, this research provided several basic data for further revealing the mechanism of IL-1RAcP in fish species against bacterial infection.

**Key words:** *Channa argus*, IL-1RAcP, *Aeromonas schubertii*, *Nocardia seriolae*, Immune response

# 小瓜虫对虹鳟组织病理变化及 TLR 信号通路基因表达影响

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**摘要:** 小瓜虫病具有高发病率和死亡率, 威胁虹鳟的养殖。本研究观察虹鳟感染小瓜虫后, 鳃和皮肤病理学变化和 TLR 信号通路部分基因动态表达。结果表明, 感染小瓜虫的虹鳟皮肤表面有大量分泌物, 表皮与真皮间有空隙, 寄生了大量滋养体; 鳃丝脱落, 鳃小片扭曲, 上皮细胞坏死, 鳃丝小骨变形; 处理组 TLR2、TLR3、TLR4、TNF- $\alpha$ 、IL-1 $\beta$ 、IFN- $\gamma$  基因在鳃、皮肤、肝脏、头肾、脾脏和肠道中均有差异表达。

**关键词:** 虹鳟; 多子小瓜虫; 组织病理; TLR 信号通路; 基因表达

## Histopathological Changes and Gene Expression Dynamics of TLR Signaling Pathway in *Oncorhynchus mykiss* Infected with *Ichthyophthirius multifiliis*

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**Abstract:** The *Ichthyophthirius multifiliis* has high incidence and high mortality, threatening the breeding of *Oncorhynchus mykiss*. This study was to observe the pathological changes of gills and skin and the dynamic expression of some genes of TLR signal pathway after rainbow trout was infected with *I. multifiliis*. The results showed that the structure of skin and gill were seriously damaged by *I. multifiliis*. There were a large number of irregular secretions on the skin surface. There were gaps between epidermis and dermis, and the trophozoites of different sizes were parasitic in the gaps. The gill filament was damaged and shed, the gill lamellae were deformed and twisted, the epithelial cells were necrotic, and the gill filament bone was swollen and deformed. The treatment group TLR2, TLR3, TLR4, TNF- $\alpha$ , IL-1 $\beta$ , IFN- $\gamma$  gene was differentially expressed in gill, skin, liver, head kidney, spleen and intestine.

**Key words:** *Oncorhynchus mykiss*; *Ichthyophthirius multifiliis*; Histopathology; TLR signaling pathway; Gene expression



# 花鲈源杀鱼爱德华氏菌的致病性研究

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**摘要:** 杀鱼爱德华氏菌是重要的水产病原菌, 宿主范围广泛。本研究用从患病花鲈内分离的编号 18BJ136 的杀鱼爱德华氏菌, 探究其致病性。生长测试可知, 该菌具有广盐性, 但对水体 pH 值敏感。PCR 检测结果发现, 它含有九个毒力基因。酶活结果表明, 其具有多种胞外产物酶活性。人工感染试验发现, 其 LD<sub>50</sub> 为 1.0×10<sup>3</sup>cfu/g, 组织病理切片可见, 肝、脾、头肾等可见多处坏死灶, 组织内出血严重。宿主先天性免疫应答被激活。

**关键词:** 花鲈; 杀鱼爱德华氏菌; 生理生化; 致病性。

## **Edwardsiella piscicida a newly found pathogenic bacterium in spotted sea bass (*Lateolabrax maculatus*), China**

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**Abstract:** *Edwardsiella piscicida* is an important Enterobacteriaceae facultative intracellular pathogen of cultured fish spread all over the world. In this study, strain 18BJ136, isolated from diseased spotted sea bass (*Lateolabrax Maculatus*), was used to explore its pathogenicity. Results showed that it was suitable for proliferation in wide salt environment, but was sensitive to acidity or alkalinity. It was found that the 18BJ136 harbored at least nine virulence genes, such as *gadB*, *katB*, *citC*, *usp13*, *esrB*, *sodB*, *luxS*, *fimA* and *mukF*. The spot test showed it had various of extracellular enzyme activities, such as hemolysin and protease. Artificial infection experiments revealed 18BJ136 had a strong virulence to spotted sea bass, and its LD<sub>50</sub> was 1.0 × 10<sup>3</sup> cfu/g. It caused many histopathological lesions to spotted sea bass: there were different degrees of inflammation in tissues; multiple necrotic foci could be observed in liver, spleen and head kidney; and severe hemorrhage occurred in spleen and head kidney. The IL-8, TNF-α, TLR23, and HSP70 were significantly regulated revealed that it could activate the host's innate immune response. These results provided useful information for a more comprehensive understanding of *E. piscicida* infection with spotted sea bass.

**Key words::** Spotted sea bass, *Edwardsiella piscicida*, biological characteristics, pathogenicity

# 弧菌 RseABC 基因致病性功能研究

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**摘要：**弧菌疾病是水产品的主要病害，溶藻弧菌作为世界范围内近年来发现的主要海洋致病菌之一，多次引起水产品的流行性疾病，造成巨大的经济损失。为研究溶藻弧菌 RseABC 缺失后对其生物学特性的影响，该研究利用同源重组技术构建基因缺失突变株，并比较了野生株和突变株的生物学特性以及毒性的变化。结果显示，基因缺失影响菌株的生长、定植等生物学特性，在感染试验中，凡纳滨对虾的死亡时间后移，致死率明显下降。

**关键词：**同源重组；溶藻弧菌；感染试验

## Study on pathogenicity function of RseABC gene in *Vibrio*

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**Abstract:** *Vibrio* disease is the main disease of aquatic products. *Vibrio alginolyticus*, as one of the main Marine pathogens discovered in the world in recent years, has caused many epidemic diseases of aquatic products and caused huge economic losses. In order to study the effects of RseABC deletion on biological characteristics of *Vibrio alginolytica*, homologous recombination technique was used to construct gene deletion mutant strains, and the biological characteristics and toxicity of wild and mutant strains were compared. The results showed that gene deletion affected the growth, colonization and other biological characteristics of the strain. In the infection test, the time of death of *Litopenaeus vannamei* moved later, and the fatality rate decreased significantly. This study provides new data for studying the function of pathogenic genes in *Vibrio alginolyticus*.

**Key words:** Homologous recombination; *vibrio alginolyticus*; infection experiment

# 多聚磷酸钠预培养在库德毕赤酵母砷解毒中的作用

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**摘要：**砷酸盐是海水中主要的砷化合物，会被海洋生物吸收，进而影响水产品安全，危害人类健康。本研究基于多聚磷酸钠（Na<sub>5</sub>P<sub>3</sub>O<sub>10</sub>）预培养对库德毕赤酵母砷酸盐的解毒作用进行了探索。预培养后的细胞较原始细胞能够更好的适应含砷环境，同时酵母细胞在含砷培养基中产生的植物螯合肽含量增多，而谷胱甘肽含量下降。这两种物质含量的变化，证明了预培养促进了酵母细胞的砷解毒作用，脱砷率增加也表明其有应用于液态水产品脱砷的可能。

**关键词：**库德毕赤酵母；预培养；砷酸盐；多聚磷酸钠

## Effect of sodium polyphosphate preincubation on arsenic detoxification of *Pichia kudriavzevii* A16

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**Abstract:** Arsenate is the main arsenic compound in seawater, which can be absorbed into the food chain by marine organisms, thus affecting the safety of aquatic products and endangering human health. In this study, the detoxification of arsenate in *Pichia kudriavzevii* A16 was investigated based on the preincubation of sodium polyphosphate (Na<sub>5</sub>P<sub>3</sub>O<sub>10</sub>). It was found that *P. kudriavzevii* A16 cells preincubated with Na<sub>5</sub>P<sub>3</sub>O<sub>10</sub> could better adapt to the environment containing arsenic than the control cells, and the arsenic removal rate was increased compared with the control cells at the arsenate concentration of 10 mg/L. After Na<sub>5</sub>P<sub>3</sub>O<sub>10</sub> preincubation, the content of phytochelatin (PCs) was significantly increased, while the content of glutathione (GSH) was significantly decreased in the arsenic-containing medium. The changes of Na<sub>5</sub>P<sub>3</sub>O<sub>10</sub> preincubation showed that *P. kudriavzevii* A16 cells had arsenic detoxification, and the increase of detoxification rate also indicated that *P. kudriavzevii* A16 could be used for detoxification of liquid aquatic products.

**Key words:** *Pichia kudriavzevii*; preincubation; arsenate; sodium polyphosphate

# 岩藻糖对杀鱼爱德华氏菌 *uhpA* 基因缺失株生物学特性的影响

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**摘要:** 用 30 mM 的 L-岩藻糖处理爱德华氏菌野毒株和缺失株  $\Delta uhpA$ ,  $\Delta uhpA$  中 *fucP*, *fucA* 和 *fucR* 基因的 mRNA 的转录水平分别是野生株的 1.65、2.12 和 1.82 ( $P < 0.05$ ),  $\Delta uhpA$  中 *esrB*、*esrC* 等毒力基因的表达水平也有明显提高。结果表明, *uhpA* 基因可以影响岩藻糖信号调控 FusKR 系统的关键基因, 进而影响 T3SS 和其它毒力相关基因的表达。

**关键词:** 杀鱼爱德华氏菌; *uhpA*; 岩藻糖; 毒力基因

## Effect of Fucose on the biological characteristics of the *uhpA* gene mutant strain of *Edwardsiella piscicida*

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**Abstract:** The results demonstrated that the mRNA levels of gene *fucP*, *fucA* and *fucR* in  $\Delta uhpA$  were 1.65-fold, 2.12-fold and 1.82-fold upper than EIB202 ( $P < 0.05$ ) at a concentration of L-fucose of 30 mM. The results demonstrated that the mRNA levels of gene T3SS (*esrB*, *esrC*), Flagellar gene (*fliC*, *flgN*), Hemolysin gene (*EthA*, *EthB*), T6SS (*EvpB*, *EvpC*) in  $\Delta uhpA$  were 1.27-fold, 1.13-fold, 1.51-fold, 1.21-fold, 0.80-fold, 0.72-fold, 1.28-fold, 1.23-fold upper than EIB202 ( $P < 0.05$ ). The results indicate that the *uhpA* gene can affect the key genes of FusKR system regulated by fucose signal, and then affect the expression of T3SS and other virulence-related genes.

**Key words:** *Edwardsiella piscicida*; *uhpA*; Fucose; Virulent genes

# cbpD 基因对溶藻弧菌毒力的 的调控及对相关生物学特性的影响研究

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**摘要：**为研究几丁质结合蛋白(CbpD)对溶藻弧菌毒力和相关生物学特性的影响，构建溶藻弧菌 ZJ-T 的 cbpD 基因缺失突变株，比较对斑马鱼的毒性，以及毒力相关生理过程的差异。cbpD 缺失后，溶藻弧菌对斑马鱼毒力减弱，其游动能力、涌动能力和胞外蛋白酶活性均降低，但不影响生长能力、抗生素敏感性、对 H<sub>2</sub>O<sub>2</sub> 的抗性和铁离子的获取能力。cbpD 可能通过正调控溶藻弧菌的运动能力和胞外蛋白酶分泌活性而促进溶藻弧菌的毒力。

**关键词：**溶藻弧菌；cbpD；基因敲除；毒力调控；生物学特性

## Regulation of cbpD gene on the virulence of *Vibrio alginolyticus* and its influence on related biological characteristics

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**Abstract:** To study the effect of chitin-binding protein (CbpD) on the virulence and related biological characteristics of *Vibrio alginolyticus*, the knock-out mutant of cbpD in *V. alginolyticus* was constructed to compare the toxicity to zebrafish and the differences in virulence-related physiological processes. After the deletion of cbpD, *V. alginolyticus* swimming ability, surging ability and extracellular protease activity are all reduced, and its virulence to zebrafish is weakened, but the deletion does not affect the growth ability, antibiotic sensitivity, the stress response to H<sub>2</sub>O<sub>2</sub> and the uptake and utilization of iron. In conclusion, cbpD may promote the virulence of *V. alginolyticus* by positively regulating the motility and extracellular protease secretion activity of *V. alginolyticus*.

**Key words:** *Vibrio alginolyticus*; cbpD; Gene knockout; Biological characteristics; Bacterial motility

# 不同天气对青蟹池塘水质因子及微生物数目的昼夜变化影响

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**摘要:** 在不同的天气下对青蟹池塘的水质指标进行 24 h 连续监测。结果表明:晴天天气下池塘水体温度、溶解氧等呈现出典型的昼夜变化,晴天水温影响弧菌数目的主要因子,回归方程为  $YTV=-41939.511X3WT+14.754XWT+860724.811$  ( $R^2=0.73$ ,  $P<0.01$ ), COD 影响总菌数;阴雨天弧菌数目受水温和铵盐的主要影响, COD、磷酸盐、总磷影响养殖水体微生物群的主要理化因子。

**关键词:** 青蟹 水质因子 回归分析 微生物

## Effect of different weather on water quality factors and microbial number in mud crab ponds

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**Abstract:** July 24,2019 (sunny), July 29 (rainy), water temperature, DO、pH、NO<sub>3</sub>--N、NO<sub>2</sub>--N、NH<sub>4</sub>+--N、PO<sub>43</sub>--P、TP、Total Bacteria Count,Total Vibrio、COD was continuously monitored for 24 hour.In sunny days, the temperature and DO of pond water show typical diurnal changes. there is a significant correlation between Vibrio number and water temperature in sunny weather, with the regression equation being,  $YTV=-41939.511X3WT+14.754XWT+860724.811$  ( $R^2=0.73$ ,  $P<0.01$ ), There was a significant correlation between bacteria number and COD, significant correlation between  $YTBC=10016.149XCOD-25811454$  ( $R=0.644$ ,  $P<0.05$ ); a significant correlation between the number of Vibrio and water temperature, ammonium, and significant correlation between total heterotrophic number and COD, phosphate and total phosphorus Under rainy weather.Multivariate stepwise regression equation  $YTV=-7280.159XNH_4++73314.01xNO_2-$  ( $R=0.73$ , $P<0.05$ ),  $YTBC=3455045.624XPO_43--1153.217XDO-56.555$  ( $R=0.731$ ,  $P<0.05$ ), Watertemperature of sunny days is the main biological factor affecting the number of Vibrio bacteria, and COD is the main physical and chemical factor affecting the microbial community of aquaculture water; Vibrio bacteria of rainy days is mainly affected by water temperature and ammonium salt, and COD,phosphate and total phosphate affect the main physical and chemical factor of the microbial community of aquaculture water.Correlations with the other factors were not significant

**Key words::** Scylla paramamosain; water quality factors;regressive analysis;microbe

# 杀鱼爱德华氏菌 uhpA 基因缺失对其感染斑马鱼诱导细胞因子表达的差异分析

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**摘要:** 本研究测定了杀鱼爱德华氏菌 uhpA 基因缺失对诱导斑马鱼细胞因子的影响。结果显示,在整个观察期间,用野毒株和 $\Delta$ uhpA 感染的鱼显示出比用 PBS 处理的鱼中的所有细胞因子包括脾中的 IL-1 $\beta$ , TNF- $\alpha$ , INF- $\gamma$ , TGF- $\beta$ 显著升高 ( $P < 0.05$ )。在整个过程中,感染 $\Delta$ uhpA 的鱼的脾脏中 IL-1 $\beta$ , TNF- $\alpha$ , INF- $\gamma$ , TGF- $\beta$ 的基因表达水平显著高于野生株 EIB202 ( $P < 0.05$ )。

**关键词:** 杀鱼爱德华氏菌; uhpA; 斑马鱼; 细胞因子

## Analysis of cytokine expression induced by the uhpA gene deletion in *Edwardsiella piscicida* infected zebrafish

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**Abstract:** Cytokines play a very important role in the fight against pathogens in fish. We determined the effect of the absence of the uhpA gene on the induction of cytokines in zebrafish. Fish infected with EIB202 and  $\Delta$ uhpA showed significantly higher ( $P < 0.05$ ) gene expression of IL-1 $\beta$ , TNF- $\alpha$ , INF- $\gamma$ , TGF- $\beta$  in spleens than fish treated with PBS in the whole observed period. Fish infected with  $\Delta$ uhpA showed significantly higher ( $P < 0.05$ ) gene expression of IL-1 $\beta$ , TNF- $\alpha$ , INF- $\gamma$ , TGF- $\beta$  in spleen than fish treated with EIB202 in the whole observed period. In conclusion, this study successfully constructed the uhpA deletion strain of *E. piscicida*. The deletion of uhpA gene enhances its pathogenicity and changes its mode of inducing cytokine production by zebrafish. This study provides a research basis for the pathogenesis of *E. piscicida* and the prevention and control technology of Edwardsiellosis.

**Key words:** Key words: *Edwardsiella piscicida*; uhpA; Zebrafish; Cytokines

# 红鳍东方鲀 caspase 基因家族的 序列特征及表达分析

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**摘要:** 摘要: 本研究采用多序列比对、系统发育树构建等多种生物信息学方法, 对 10 个红鳍东方鲀 caspase 基因进行了系统分析。基因表达检测表明, caspase 基因在 8 个健康红鳍东方鲀组织中均有表达; 在哈氏弧菌感染后 caspase 基因呈现出不同显著表达趋势, 表明它们可能在红鳍东方鲀防御中起着不同的调控作用。实验结果为红鳍东方鲀 caspase 基因的功能研究提供了基础数据。

**关键词:** 关键词: 红鳍东方鲀; caspase; 哈氏弧菌; 基因表达

## Molecular characterization and expression analysis of caspase genes in Japanese pufferfish (*Takifugu rubripes*)

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**Abstract:** Abstract: In this study, ten caspase genes were characterized by a variety of bioinformatic methods, such as multiple sequence alignment and phylogenetic tree construction. Results showed that the expression of the caspase genes were detected in eight healthy tissues; the caspase genes showed different expression pattern following *Vibrio harveyi* infection, suggesting that they might play different roles in defense regulation of Japanese pufferfish. This study provided basic data for functional study of caspase genes in *Takifugu rubripes*.

**Key words:** Key words: *Takifugu rubripes*; caspase; *Vibrio harveyi*; gene expression



# 罗非鱼无乳链球菌 FbsA 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:** 为了研制免疫高效、操作简单的罗非鱼无乳链球菌口服疫苗, 该研究利用同源重组法构建表达无乳链球菌 FbsA 蛋白的 pNZ8148-fbsA 质粒, 获得 L.lactis NZ9000 pNZ8148-fbsA 重组乳酸菌, 使用 nisin 诱导表达并和佐剂与饲料混匀制备口服疫苗。与对照组比较, L.lactis NZ9000 pNZ8148-fbsA 的血清抗体水平显著提高, 其相对免疫保护率为 53.38%。

**关键词:** 无乳链球菌; 口服疫苗; 乳酸菌疫苗; FbsA 蛋白; 免疫; 罗非鱼

## Live recombinant *Lactococcus lactis* vaccine expressing FbsA for protection against *Streptococcus agalactiae* in tilapia

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**Abstract :** Streptococcosis is a serious disease that threatens the development of *Oreochromis niloticus* industry in China. In order to make a vaccine of *Streptococcus agalactiae* with high immune efficiency and simple operation, we constructed a recombinant plasmid pNZ8148-fbsA which could express FbsA protein of *S. agalactiae* by using homologous recombination. The recombinant plasmid was electro-transferred into *L.lactis* NZ9000. The FbsA protein was induced by nisin and tested by Western blot. *L.lactis* NZ9000 pNZ8148-fbsA were thoroughly mixed with Oral adjuvant and fish feed as oral vaccine. After immunization for 18 days, the relative immune protective (RPS) rate was obtained by intraperitoneal injection with *S.agalactiae*. The Western blot analysis showed that the molecular weight of expressed protein was 34.5 kDa, which is equal to the expected protein size. Oral immunization showed that the serum antibody of *L.lactis* NZ9000 pNZ8148-fbsA significantly higher than those of the other groups. RPS of fish from group *L.lactis* NZ9000 pNZ8148-fbsA was the highest(53.58%). This study lays a foundation for further study on oral vaccine of tilapia against *S. agalactiae* and has wide application value and prospect.

**Key words: :** *Streptococcus agalactiae*; oral vaccine; *Lactococcus lactis* vaccine; FbsA protein; immune; tilapia

# 南通地区不同来源文蛤重金属富集特征评价

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**摘要:** 测定了海捕文蛤与如东池塘养殖文蛤内脏团、足、闭壳肌、外套膜中 Zn、Pb、Cd、Hg 等 4 种重金属含量。研究表明, 文蛤中 Zn 含量最高; 养殖文蛤内脏团和足中 Zn 含量远低于海捕文蛤, 在闭壳肌中无显著性差异; 除闭壳肌外其余组织中 Cd 含量远低于海捕文蛤; 外套膜中 Pb 含量远低于海捕文蛤, 其余组织中无显著性差异; Hg 在文蛤中含量均较低。相对于自然海区, 池塘养殖环境更好, 可在一定程度上降低重金属在文蛤体内的富集。

**关键词:** 文蛤; 重金属; 富集特征; 南通地区

## Evaluation of heavy metal enrichment characteristics in *Meretrix meretrix* from different sources in Nantong area

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**Abstract:** We determined the contents of Zn, Pb, Cd and Hg in four tissues including visceral mass, foot, adductor muscle and mantle of *M. meretrix* which caught from the shallow sea and cultured in ponds in Rudong area. The result showed that, the content of Zn was the highest among the four heavy metals. The content of Zn in visceral mass and foot of *M. meretrix* cultured in ponds was much lower than which caught from the shallow sea. In adductor muscle, the mean difference was not distinct. The content of Cd in other tissues of *M. meretrix* cultured in ponds was much lower than which caught from the shallow sea, except adductor muscle. The content of Pb in mantle of *M. meretrix* cultured in ponds was much lower than which caught from the shallow sea. Among other tissues, the mean difference was not distinct. The content of Hg was low in *M. meretrix* cultured in ponds and caught from the shallow sea. Compared with natural sea areas, the pond culture environment is better, which can reduce the enrichment of heavy metals in *M. meretrix* to a certain extent.

**Key words:** *Meretrix meretrix*; heavy metals; enrichment characteristics; Nantong area

# 两类激素类似物对铜、镉胁迫后罗非鱼卵巢损伤的修复作用效果及机制的探究

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**摘要：**罗非鱼是重要的养殖鱼类之一，在广西水产品出口中有重要地位。铜和镉这两种重金属是广西重金属污染最常见的种类，且主要污染区与罗非鱼养殖区域有较大重叠。研究指出，铜、镉单一及复合暴露均会对罗非鱼卵巢发育及繁殖产生影响。本研究采用五种人工以及天然的激素类药物，注射给药，尝试修复铜、镉复合暴露导致的罗非鱼卵巢发育损伤。评价不同药物的修复效果，探明其修复机制。为罗非鱼养殖产业中重金属污染的评估、防治提供办法。

**关键词：**罗非鱼；铜；镉；卵巢；激素

## Effect and mechanism of hormone cure ovarian of tilapia under copper and cadmium stress

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**Abstract:** Tilapia is one of the critical farmed fish, which plays an essential role in exporting aquatic products in Guangxi. Copper and cadmium are the most common kinds of heavy metal pollution in Guangxi, and there is a significant overlap between the main polluted areas and tilapia culture areas. Some previous studies have pointed out that both single and combined exposure to copper and cadmium will affect tilapia's ovarian development and reproduction. In this study, five kinds of artificial and natural hormone drugs were injected to repair the ovarian development damage of tilapia caused by combined exposure to copper and cadmium to evaluate the repair effect of different drugs and explore their repair mechanism. This study provides data and theoretical support for monitoring and sustainable and healthy development of heavy metal pollution in the tilapia culture industry.

**Key words::** Tilapia,Copper,Cadmium,Ovarian,Hormone

# 罗非鱼源无乳链球菌双组份信号转导系统 SaeSR 缺失株构建及生物特性分析

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**摘要:** 为探究鱼源无乳链球菌 THN0901 双组份信号转导系统 SaeSR 基因功能, 本研究构建了基因缺失株  $\Delta$ SaeSR 及回补株 C $\Delta$ SaeSR 并进行生物学特性分析。结果如下:  $\Delta$ SaeSR 的生长能力降低, 环境胁迫方面, 其耐受高盐、高氧环境应激的能力减弱, 毒力测定其对罗非鱼的 LD50 是  $2.7 \times 10^7$  CFU, 约为野生株的 10 倍。回补株各项能力均有所恢复。结果表明, SaeSR 是无乳链球菌的毒力和环境应激的重要调控因子。

**关键词:** 无乳链球菌; 双组份信号转导系统; 基因敲除; 毒力

## Characterization and virulence of *Streptococcus agalactiae* deficient in SaeSR of the two-component system

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**Abstract:** *Streptococcus agalactiae* infection has caused huge economic losses in tilapia farms. In order to explore the function of the SaeSR in the two-component system of a highly virulence strain THN0901 isolated from tilapia in Hainan Province of China, this study constructed the gene-deleted strain  $\Delta$ SaeSR and the complement strain C $\Delta$ SaeSR, then we analyzed their biological characteristics. The results are as follows: The growth ability are reduced. In terms of environmental stress, the mutant strain's ability to tolerate high salt and high oxygen environments is weakened. In terms of virulence, the LD50 of  $\Delta$ SaeSR to tilapia is  $2.7 \times 10^7$  CFU, which is about 10 times that of the wild strain. All the abilities are restored after replenish the strain. The results show that SaeSR is one of the important regulators of the virulence and environmental stress of *Streptococcus agalactiae*.

**Key words:** *Streptococcus agalactiae*; two-component system; gene knockout; virulence

# 鳗弧菌 vah1 基因的敲除及表征

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**摘要：**前期构建鳗弧菌减毒菌株，通过感染南美白对虾来评估减毒菌株的毒力下降大小，以及通过一些生物学分析实验，对毒减菌株进行一些生物学验证其表征变化情况。

**关键词：**弧菌；缺失；溶血性

## Knockout and characterization of the vah1 gene of *Vibrio anguillarum*

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**Abstract :** The attenuated strains of *Vibrio anguilla* were constructed in the early stage, and the virulence reduction of the attenuated strains was evaluated by infection with *Penaeus vannamei*, and some biological analysis experiments were carried out to verify the characterization changes of the attenuated strains.

**Key words: :** *Vibrio*; deletion; hemolytic

# 无乳链球菌 TFJ0901-ery 冻干活疫苗的研制

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**摘要：**罗非鱼无乳链球菌严重阻碍罗非鱼养殖产业的健康发展。无乳链球菌 TFJ0901-ery 作为弱毒活疫苗具有良好的保护效果。为了促进该弱毒疫苗的应用，本研究优化了 TFJ0901-ery 冻干活疫苗的制备工艺。结果显示，保护剂 A、B 及脱脂乳粉对 TFJ0901-ery 冻干后保护率分别为 71%、52%、80%，进一步实验得出了复方保护剂的最佳配比。该结果为研制高效罗非鱼无乳链球菌弱毒疫苗提供了理论依据。

**关键词：**弱毒疫苗；冷冻干燥；无乳链球菌；尼罗罗非鱼

## Development of freeze-dried live vaccine of *Streptococcus agalactiae* TFJ0901-ery

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**Abstract :** Tilapia *Streptococcus agalactiae* seriously hinders the healthy development of tilapia aquaculture industry. *Streptococcus agalactiae* TFJ0901-ery has a good protective effect as an attenuated live vaccine. In order to promote the application of the attenuated vaccine, this study optimized the preparation process of the TFJ0901-ery freeze-dried live vaccine. The results showed that the protection rates of carbohydrate protective agent A, non-sugar protective agent B and skimmed milk powder on TFJ0901-ery after freeze-drying were 71%, 52%, and 80%, respectively. Further through the response surface design, a compound protection was obtained. The best ratio of agent. The results of this experiment provide a theoretical basis for the development of a highly effective attenuated tilapia *Streptococcus agalactiae* vaccine.

**Key words::** Attenuated vaccine; freeze-dried; *Streptococcus agalactiae*; Nile tilapia

# 甘露糖基化修饰 PEI 的罗非鱼 无乳链球菌 DNA 疫苗制备及其特性研究

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**摘要：**本文制备了一种甘露糖基化的聚乙烯亚胺为侧链的共聚物(PEI-Man), 并研究了其性能。考察其对基因的包裹能力及 PEI-Man /pDNA 复合物形态,测定其粒径及电位; 检测其细胞毒性。结果表明, PEI-Man 可以有效压缩包裹 DNA; 而 N/P=20 时形态为规则球形, 粒径为 259nm, 电位为+37mV, PEI-Man 复合物的细胞存活率均在 80%以上。因此, PEI-Man 是一种有潜力的疫苗传递载体。

**关键词：**甘露糖; 聚乙烯亚胺; 疫苗

## Preparation and characterization of *Tilapia Streptococcus agalactiae* DNA vaccine from mannosylated polyethylenimine

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**Abstract:** A mannosylated polyethylenimine side chain copolymer (PEI-MAN) was prepared and its properties were studied. The gene enveloping ability and the morphology of PEI-MAN /pDNA complex were investigated, and the particle size and potential were determined. The cytotoxicity was detected. The results showed that PEI-MAN could compress encapsulated DNA effectively. When N/P=20, the cell morphology is regular spherical, particle size is 259nm, potential is +37mV, and the cell survival rate of PEI-MAN complex is above 80%. Therefore, PEI-MAN is a potential vaccine delivery vector.

**Key words::** mannose; polyethylenimine; vaccine

# 牙鲆(*Paralichthys olivaceus*)肌肉 NF- $\kappa$ B 和 TNF $\alpha$ 启动子 DNA 甲基化与免疫指标对鳃弧菌感染的响应

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**摘要:** 鳃弧菌感染引发牙鲆肌肉免疫, 导致肌肉组织中各项免疫指标发生显著变化。qPCR、双荧光和原位杂交确定了肌肉中 NF $\kappa$ B 和 TNF $\alpha$ 的存在及 NF $\kappa$ B 对 TNF $\alpha$ 的调控作用。TNF $\alpha$ 启动子定点突变确定 NF $\kappa$ B 在 TNF $\alpha$ 上的作用位点。TNF $\alpha$ 的 DNA 甲基化水平与其表达呈负相关关系。结果表明, TNF $\alpha$ 表达受到 NF $\kappa$ B 转录和 DNA 甲基化的共同调控。

**关键词:** 鳃弧菌感染, DNA 甲基化, NF- $\kappa$ B/TNF $\alpha$ 通路, 免疫, 比目鱼

## Immune correlates of NF- $\kappa$ B and TNF $\alpha$ promoter DNA methylation in Japanese flounder (*Paralichthys olivaceus*) muscle and immune parameters change response to *Vibrio anguillarum* infection

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**Abstract:** *Vibrio anguillarum* infection induces muscle immunity of Japanese flounder (*Paralichthys olivaceus*), which results in significant changes of various immune indexes in muscle tissue. The presence of NF $\kappa$ B and TNF $\alpha$  in muscle and the regulatory effect of NF $\kappa$ B on TNF $\alpha$  were determined by q-PCR, double fluorescence and in situ hybridization. The site directed mutation experiment of TNF $\alpha$  promoter region further determined the binding site of NF $\kappa$ B on TNF $\alpha$ . The DNA methylation level of TNF $\alpha$  was negatively correlated with its gene expression. Finally, it was concluded that TNF $\alpha$  expression was jointly regulated by NF $\kappa$ B transcription and DNA methylation.

**Key words:** *Vibrio anguillarum* infection, DNA methylation, NF- $\kappa$ B-TNF $\alpha$  pathway, Immunity, Flatfish



# 春季珠海花鲈养殖区水体耐药多样性调查

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**摘要:** 本研究在春季对珠海花鲈养殖池塘水体进行了采样调查。解释了池塘养殖环境中的抗生素耐药性情况。其中四环素家族基因和可移动基因元件家族基因丰度最高。6种抗生素平板上可培养的 ARB 数量在  $3.3 \times 10^1 \sim 5.6 \times 10^4$  CFU/mL 之间。共分离出 614 株 ARB, 被鉴定为 19 个属, 其中不动杆菌 (42.3%)、假单胞菌 (25.7%)、和希瓦氏菌 (11.7%) 为优势 ARB, 变形菌门 (99.35%) 为优势门类。

**关键词:** 花鲈、养殖水环境、耐药菌、耐药基因

## Investigation on the diversity of antibiotic resistance in the water environment of Zhuhai seabass breeding area in spring

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**Abstract:** In this study, water samples were collected from 20 seabass ponds in Zhuhai in spring. The abundance and diversity of ARB and ARGs in the pond culture environment were characterized by the antibiotic plate screening method and the fluorescence quantitative technique, respectively and explained the antibiotic resistance in the pond culture environment. Among the 76 ARGs in 8 categories, 40 were detected. Tetracycline family genes and mobile gene element family genes have the highest abundance. The number of ARBs that can be cultured on the six antibiotic plates is between  $3.3 \times 10^1$  and  $5.6 \times 10^4$  CFU/ml. The average resistance rates of several antibiotics were 5.46% (Rifampicin), 2.16% (Florfenicol), 18.07% (Sulfamethoxazole x Trimethoprim), 1.43% (Ciprofloxacin), 0.16% (Enrofloxacin) and 49.15% (Erythromycin). A total of 614 ARBs were isolated, which were identified as 19 genus, Acinetobacter (42.3%), Pseudomonas (25.7%), and Shewanella (11.7%) are the dominant ARBs. Proteobacteria (99.35%) is the dominant phylum. Misuse and abuse of antibiotics is the main source of antibiotics and ARGs in the water environment. Through this study, we have a certain understanding of the antibiotic resistance of seabass farming waters, and hope that this can provide a certain theoretical basis for the occurrence of antibiotic resistance in aquaculture environments.

**Key words:** : eabass, Aquaculture water environment, Antibiotic-resistant bacteria, Antibiotic resistance genes

# 斜带石斑鱼(*Epinephelus coioides*)BAG3 基因 在病毒感染过程中的功能特征

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**摘要:** Bcl-2 相关 athanogene 3 (BAG3)是一种与 Bcl-2 相互作用并介导细胞死亡的辅伴侣蛋白。然而, 鱼类 BAG3 在病毒感染过程中的作用尚不清楚。在本研究中, 我们从斜带石斑鱼 (*Epinephelus coioides*) (EcBAG3)中鉴定了一个 BAG3 同源物, 并研究了它在病毒感染中的作用。

**关键词:** 斜带石斑鱼, BAG3, RGNNV, 炎症因子, 干扰素, 自噬

## Functional characterization of BAG3 in orange-spotted grouper (*Epinephelus coioides*) during viral infection

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**Abstract:** Bcl-2-associated athanogene 3 (BAG3) is a cochaperone protein that that interacts with Bcl-2 and mediate cell death. However, little is known about the roles of fish BAG3 during viral infection. In this study, we characterized a BAG3 homolog from orange-spotted grouper (*Epinephelus coioides*) (EcBAG3) and investigated its roles during viral infection. The EcBAG3 protein encoded 579 amino acids with typical WW, PXXP and BAG domain, which shared high identities with reported fish BAG3. Quantitative real-time PCR (qRT-PCR) analysis revealed that EcBAG3 was highly expressed in brain and heart. And the expression of EcBAG3 was significantly up-regulated after red-spotted grouper nervous necrosis virus (RGNNV) stimulation in vitro. EcBAG3 overexpression could promoted the expression of viral genes (coat protein (CP) and RNA-dependent RNA polymerase (RdRp)), which was enhanced by co-transfection with Hsp70 and Hsp22, which also up-regulated LC3 expression and down-regulated Bax and BNIP3 expression. Moreover, overexpression of EcBAG3 significantly decreased the expression levels of IRF1, IRF3, IRF7, IFP35, MX, IL-1 $\beta$  and TNF- $\alpha$ , as well as decreased the activities of NF- $\kappa$ B, ISRE and IFN-3. These data indicate that EcBAG3 can affect viral infection through modulating virus-induced cell death, regulating the expression of IFN- and inflammation-related factors, which will be helpful to further explore the immune response of fish during viral infection.

**Key words:** *Epinephelus coioides*; BAG3; RGNNV; Interferon; Inflammatory; Autophagy

# 珠三角地区池塘养殖大口黑鲈病毒病和诺卡氏菌病流行病学调查与分析

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**摘要:** 近年来, 珠三角地区养殖大口黑鲈(*Micropterus salmoides*)主要有三种病毒病: 蛙虹彩病毒(大口黑鲈虹彩病毒 Largemouth bass ranavirus, MRV)、细胞肿大虹彩病毒(传染性脾肾坏死病毒, Infectious spleen and kidney necrosis virus, ISKNV)和弹状病毒(鳃弹状病毒, *Siniperca chuatsi rhabdovi*)。

**关键词:** 大口黑鲈; 流行病学调查; 大口黑鲈虹彩病毒; 鳃弹状病毒; 鳃诺卡氏菌; qPCR

## Epidemiological investigation and analysis of viral disease and *Nocardia* disease of largemouth bass(*Micropterus salmoides*) cultured in pond in pearl River Delta

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**Abstract :** In recent years, there were three main causative virus of Cultured Largemouth bass(*Micropterus salmoides*) in Pearl River Delta region: *Siniperca* (Largemouth bass ranavirus, MRV), Infectious Spleen and kidney Necrosis virus (ISKNV), and *Siniperca Chuatsi Rhabdovirus* (SCRV); and *Nocardia seriola* (NS), belongs to actinomycetes, also caused tremendous impact. How to prevent and treat disease in has become an important problem which needs to be solved urgently. Sampling and analysis of largemouth bass in the main rearing areas of pearl River Delta were carried out, and several pathogens were detected. From June 1, 2020 to July 31, 2021, a total of 901 samples were examined, and 331 positive samples of Ranovirus belonging to iridium iridium virus (MRV) were detected, with a positive rate of 36.67%. The positive rate was 19.22% in Nanhai district and 39.48% in Shunde District. A total of 130 SCRV positive samples were detected, with a positive rate of 14.28%, among which the positive rate of seedling was 63.08% and that of cultured fish was 36.92%. Ten ISKNV positive samples were detected, all of which were mixed with MRV. A total of 69 nocardia (NS) positive samples were detected, with a positive rate of 7.66%, and 20 of them were mixed with MRV, with a positive rate of 2.22%. According to the current investigation data, the iridovirus infection of largemouth bass in pearl River Delta is mainly ranaviruses, which can be detected in normal fish, indicating that the virus can be recess

**Key words: :** Largemouth bass(*Micropterus salmoides*); Epidemiological investigation; Largemouth bass ranavirus, MRV; *Siniperca chuatsi rhabdovirus*, SCRV; *Nocardia Seriola*, NS; qPCR

# 萝卜硫素对凡纳滨对虾氨氧化损伤的保护作用

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**摘要：** 饲料中添加萝卜硫素(SFN)对凡纳滨对虾氧化损伤的影响。试验采用 4 种浓度(0、10、30、50mg/kg)的 SFN 配制，添加 SFN 的对虾肌肉中 SOD 活性显著高于对照组( $p<0.05$ )。SFN30 和 SFN50 组各组织 GPX 活性和血清过氧化氢酶 CAT 活性均高于对照组( $p<0.05$ )。SFN10、SFN30 组 SOD、CAT 基因表达高于对照组( $p<0.05$ )。综上所述，SFN 能显著降低凡纳滨对虾氧化损伤。

**关键词：** 萝卜硫素;保护作用;抗氧化能力;凡纳滨对虾 ;氨

## Protective effects of sulforaphane on oxidative damage caused by ammonia in *Litopenaeus vannamei*

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**Abstract:** Effects of dietary sulforaphane (SFN) on oxidative damage of *Litopenaeus vannamei*. Four SFN concentrations (0, 10, 30 and 50mg/kg) were used in the experiment, and the SOD activity in the muscle of shrimp supplemented with SFN was significantly higher than that in the control group ( $P < 0.05$ ). The activities of GPX in tissues and catalase CAT in serum in SFN30 and SFN50 groups were higher than those in control group ( $P < 0.05$ ). SOD and CAT gene expressions in SFN10 and SFN30 groups were higher than those in control group ( $P < 0.05$ ). In conclusion, SFN can significantly reduce the oxidative damage of *Litopenaeus vannamei*.

**Key words:** Sulforaphane; Protective effect; Antioxidant capacity; *Litopenaeus vannamei*; Ammonia

# 水生微孢子虫多样性及其在水产养殖中的影响

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**摘要:** 微孢子虫是一大类专性细胞内寄生的单细胞真核生物, 具有独特的发芽侵染方式, 可感染几乎所有动物, 包括鱼、虾、蟹、蚕、蜂、兔及生态调节因子水蚤、钩虾等。迄今报道的208个属, 1500余种微孢子虫中, 有近一半的属能感染水生动物。近年来, 由微孢子虫引起的渔业病害愈加不可忽视, 部分滤食类水生动物还可富集人畜共患微孢子虫, 危害食品及公共卫生安全。水生微孢子虫的多样性还处于被低估的状态, 丰富其研究具有重要意义。

**关键词:** 水生微孢子虫, 多样性, 水产健康养殖

## Diversity of aquatic microsporidia and its impact on aquaculture

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**Abstract:** Microsporidia is a large class of obligate intracellular parasitic single-cell eukaryotes. Germination of microsporidian is a unique infection process in the nature. It can infect almost all animals, including fish, shrimp, crab, shellfish, silkworm, bee, rabbit and ecological regulator *Daphnia* and gammarid. 208 genera and more than 1500 species of Microsporidian have been reported, in which nearly half of them can infect aquatic animals. In recent years, the fishery diseases caused by microsporidia can not be ignored. Some filter-feeding aquatic animals can even enrich zoonotic microsporidia, endangering food and public health safety. At present, the diversity of aquatic microsporidia is still underestimated, enriching its research is of great significance.

**Key words:** Aquatic Microsporidia; Diversity; Health aquaculture

# 尼罗罗非鱼缺失血清素调控免疫应答能力

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**摘要：**血清素（5-羟色胺,5-HT）作为一种被深入研究的神经递质，也在外周器官中发挥重要作用。此外，血清素系统调控免疫应答的能力已经在人和小鼠中被详细报道。然而，在硬骨鱼类中，其调控免疫应答的能力尚不清晰。在本研究中，我们针对典型硬骨鱼类——尼罗罗非鱼开展相关研究：其血清素系统的一系列关键成员及其调控免疫应答的功能均并未在淋巴器官中被鉴定到；该结果提示硬骨鱼类可能缺失了该能力。

**关键词：**尼罗罗非鱼；血清素；免疫应答

## The mediation of the serotonin system on immune response in Nile Tilapia is lost.

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**Abstract:** Serotonin [5-hydroxytryptamine (5-HT)] is largely studied as a neurotransmitter and plays an important role in many organs as a peripheral hormone. Besides, the serotonin system is high conservatism of evolution and has been identified from cnidarians to mammals. Also, the mediation of the serotonin system on the immune response has been widely reported in humans and rodents. However, the roles of the serotonin system during the immune response of teleosts remain unclear. Herein, the key members of the serotonin system were identified and their expression patterns during bacterial infection were cleared. However, these genes weren't identified in Nile Tilapia lymphoid organs or lymphocytes while conservatively existed in the brain. Furthermore, in vitro analysis indicated that the immune response of lymphocytes to LPS was not regulated by the serotonin system. The present data suggested that the mediation of the serotonin system on immune response might be lost in bony fish.

**Key words::** Nile Tilapia, serotonin, immune response

# 溶藻弧菌 T3SS *exsD* 基因敲除突变株构建及其表型特征

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**摘要：**采用 overlapPCR 技术成功构建溶藻弧菌 III 型分泌系统中的调控蛋白 ExsD 基因缺失株。研究了 *exsD* 缺失株表型特征。与野生株相比，*exsD* 的缺失  $\Delta exsD$  遗传稳定性和生长速度无显著差别，但泳动能力极显著上升，胞外蛋白酶活性、毒力、形成生物膜能力显著上升，； $\Delta exsD$  对米诺环素、庆大霉素、卡那霉素、多西环素、新霉素的敏感性从耐药变成中度敏感；实时荧光定量结果显示增加了效应蛋白 Hop 的表达。

**关键词：**溶藻弧菌；III 型分泌系统；*exsD* 基因；基因敲除；缺失株；表型特征

## Construction and Characterization of Gene *exsD* Knock-out Mutant of *Vibrio alginolyticus* Type III secretion system

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**Abstract:** Overlap PCR was used to construct the deletion strain  $\Delta exsD$ , and PCR was used to detect the genetic stability of the deletion mutant strains  $\Delta exsD$ , and the difference of growth rate, swarming motility, extracellular enzymes, drug sensitivity and virulence, crystal violet between mutant strains and wild strain were evaluated, and the change of biofilm formation was determined by confocal microscope, and the transcriptional level of T3SS effector protein Hop was analyzed by qRT-PCR. The deletion strain  $\Delta exsD$  was constructed successfully, and the *exsD*-deletion did not significantly affect the genetic stability and growth rate of *V. alginolyticus*, but the extracellular protease activity of the deleted strain  $\Delta exsD$  was significantly improved than wild strain. The ability to form biofilms of the deleted strain  $\Delta exsD$  was enhanced than the wild strain at 24h. The *exsD*-deletion resulted in a markedly increase in swarming motility; Compared with the wild strain, the sensitivity of the  $\Delta exsD$  strain to minocycline, gentamicin, kanamycin, doxycycline and neomycin changed from resistance to moderate sensitivity. The LD50 result showed that the virulence of the  $\Delta exsD$ -deficient strain is increased, which was 3.68 times compared with the wild strain. Real time fluorescence quantitative showed that compared with the wild strain, the  $\Delta exsD$  strain increased the expression of effector protein Hop.

**Key words:** *Vibrio alginolyticus*; Type III Secretion System (T3SS); *exsD* gene; gene knockout; deletion strain; characterization

# 单细胞转录组揭示硬骨鱼类 NCC 亚群特征

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**摘要:** 非特异性细胞毒性细胞(NCC)是硬骨鱼免疫系统中重要的细胞毒性白细胞。然而, NCC 的亚群还没有被报道。因此, 我们使用单细胞 RNA 测序(scRNA-seq)技术, 创建了一个完整的尼罗罗非鱼头肾白细胞图谱, 并将其分为 B 细胞、T 细胞、NCC 和单核/巨噬细胞(Mo/MΦ)四种细胞类型。同时, 通过 WGCNA 预测了 NCC 群体的调控网络, 并首将 NCC 亚群分为记忆样 NCC、成熟 NCC、未成熟 NCC 和前体 NCC。

**关键词:** 单细胞转录组 非特异性细胞毒性细胞 NCC 亚群 先天免疫系统 调控网络

## Single-cell RNA-seq reveals different subsets of non-specific cytotoxic cells in teleost

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**Abstract:** Non-specific cytotoxic cells (NCC) are important cytotoxic leukocytes in teleost immune system. However, the NCC subsets have not been clarified. Thus, we create a comprehensive cell map of ~24,062 head kidney-derived leukocytes from Nile tilapia post poly I:C stimulation using single-cell RNA sequencing (scRNA-seq). Based on cell heterogeneity and known markers, the cells were classified into four cell types including B cell, T cell, NCC and monocytes/macrophages (Mo/MΦ). In the meantime, the regulatory network of NCC population was predicted by WGCNA and four hub genes (Stbd1, VWF, PGP, and GRN) and one transcription factor (Hvxn1) were identified. To further study the differentiation of NCC, four subsets including memory-like NCC, mature NCC, immature NCC, and pre-NCC were revealed in NCC population for the first time. Our data will provide new insight into the biology of NCC and enable more accurate functional and developmental analysis of NCC in immune system of lower vertebrates

Single cell transcriptome Non-specific cytotoxic cells NCC subsets Innate immune system Regulatory network

**Key words:** Single cell transcriptome Non-specific cytotoxic cells NCC subsets Innate immune system Regulatory network



# 草鱼 NCCRP-1 和 IL-10 的表达、 抗体制备及组织病理变化

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**摘要：**制备草鱼（*Ctenopharyngodon idella*）NCCRP-1 和 IL-10 的抗血清，探讨重组 NCCRP-1 和 IL-10 免疫在草鱼抗病毒感染过程中肾脏和肠病理学变化及对 NCCRP-1 和 IL-10 表达的影响。【方法】应用 PCR 扩增技术获得草鱼 NCCRP-1 和 IL-10 开放阅读框 ORF，构建原核表达载体 pET-NCCRP 和 pET-IL10。

**关键词：**草鱼；非特异性细胞毒性细胞受体-1；白细胞介素-10；表达；多克隆抗体；组织病理学

## Expression, Antibody Preparation of NCCRP-1 and IL-10 of Grass Carp, and Histopathological Changes

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**Abstract:** To prepare antibodies against NCCRP-1 and IL-10; study the pathological changes and NCCRP-1 and IL-10 gene expression in the kidney and intestine of the recombinant NCCRP-1 and IL-10 immunized grass carp *Ctenopharyngodon idella* after they were challenged by GCRV. 【Methods】 The open reading frame (ORF) of the grass carp NCCRP-1 and IL-10 gene were acquired by PCR. Prokaryotic expression plasmids pET-NCCRP and pET-IL10 were constructed followed by recombinant protein production. Antibodies against NCCRP-1 and IL-10 were prepared respectively with the expressed proteins in rabbits. Titers of antibodies were characterized by ELISA method. Grass carp were immunized with the recombinant proteins NCCRP-1 and IL-10 respectively and challenged with GCRV GD108. Pathological sections of kidney and intestine of were performed 7 days after challenge, and the expression of NCCRP-1 and IL-10 were detected by real-time quantitative PCR and western blot. 【Result】 The ORFs of NCCRP-1 and IL-10 encoded 237 and 179 amino acids respectively. Prokaryotic expression vectors of pET-NCCRP and pET-IL10 were constructed successfully. Target fusion proteins of NCRP-1 and IL-10 were expressed in *E. coli* BL21, and the optimal expression conditions were 0.1 mmol/L IPTG at 37 °C for 4 hours and 1.0 mmol/L IPTG at 37 °C for 6 hours. Western blot results confirmed that the expressed fusion proteins were the targeted protein. The titers of antibodies against NCCRP-1 and IL-10 were 1 : 40000. After immun

**Key words:** *Ctenopharyngodon idella*; non-specific cytotoxic cell receptor protein-1 (NCCRP-1); interleukin-10 (IL-10); expression; polyclonal antibody; histopathology

# c 反应蛋白保护尼罗罗非鱼(*Oreochromis niloticus*)免受无乳链球菌感染

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**摘要:** c 反应蛋白(CRP)是一种进化高度保守的急性相反应蛋白, 广泛用于临床诊断。然而, 围绕其在硬骨鱼类免疫应答过程中的功能研究尚不完善。我们围绕尼罗罗非鱼开展相关研究: 尼罗罗非鱼 CRP 主要于肝脏合成, 并响应细菌感染; 重组 CRP 蛋白可促进巨噬细胞的吞噬活性, 并具有钙依赖的细菌凝集活性; 攻毒实验证实, CRP 可以降低组织载菌量, 并提高存活率。上述结果提示, CRP 在罗非鱼应答细菌感染过程中发挥重要作用。

**关键词:** c 反应蛋白, 尼罗罗非鱼, 无乳链球菌, 免疫反应

## CRP protects Nile tilapia (*Oreochromis niloticus*) against *Streptococcus agalactiae* infection

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**Abstract:** C-reactive protein (CRP) is an acute-phase protein that can be used as an early diagnostic marker for inflammation. Besides, CRP is an evolutionarily protein has been identified from arthropods to humans. However, the roles of CRP during immune response of Nile tilapia (*Oreochromis niloticus*) remain unclear. In this study, a CRP gene from Nile tilapia (On-CRP) was identified, and its roles during bacterial infection were investigated. On-CRP contains an open reading frame of 675 bp, encoding a peptide of 224 amino acids with the conservative pentraxin domain. On-CRP share more than 50% identical to other fish species and 30% identical to mammals. The transcriptional level of On-CRP was most abundant in liver and the On-CRP transcripts can be induced in the major immune organs following *Streptococcus agalactiae* infection. Furthermore, in vitro analysis indicated that the recombinant protein of On-CRP improved phagocytic activity of monocytes/macrophages and possessed a bacterial agglutination activity in a calcium-dependent manner. In vivo challenge experiments revealed that On-CRP could activate complement, promote of inflammation, reduce tissue bacterial burden and improve survival rate during bacterial infection. The present data lays a theoretical foundation to further explore the mechanism of CRP protects fish against pathogens.

**Key words:** CRP, Nile tilapia, *Streptococcus agalactiae*, immune response

# 通过比较溶藻弧菌 HY990 1 野生型菌株与 CobB 缺失株，研究脱乙酰基 酶 CobB 的功能

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**摘要：** CobB 是一种 NAD<sup>+</sup>依赖性赖氨酸脱乙酰酶，直接或间接调节细菌的生物学行为。CobB 对溶藻弧菌生物学功能的影响目前尚不清楚。在本研究中，我们比较了溶藻弧菌野生株和 CobB 缺失株的生物学特性，并进一步使用 RNA-seq 验证这些差异。结果表明 CobB 基因的缺失对溶藻弧菌的生长几乎没有影响，但削弱了其迁移能力和生物膜形成能力，改变了细菌细胞的形态，证实 CobB 在溶藻弧菌生物学功能中存在复杂的调控机制。

**关键词：** 溶藻弧菌；脱乙酰基酶 CobB；生物学功能；RNA-seq

## Study on the function of the deacetylation gene CobB in *Vibrio alginolyticus* based on the comparison between wild-type strain HY9901 and CobB deletion strain

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**Abstract :** Recent studies have shown that lysine acetylation has a significant effect on the pathogenicity and biological characteristics of *Vibrio alginolyticus*. CobB is a NAD<sup>+</sup>-dependent lysine deacetylase, which may be involved in complex biological functions, directly or indirectly regulating the biological behavior of bacteria. Currently, the effect of CobB on the biological function of *V. alginolyticus* is unclear. In this study, we compared the biological characteristics of wild-type *V. alginolyticus* and CobB-deleted strains, including their cell morphology, growth rate, motility, and biofilm formation ability, and further used RNA-seq to verify these differences. Physiological phenotypic results indicate that the deletion of the CobB gene had almost no effect on the growth of *V. alginolyticus* but weakened its migratory ability and biofilm formation ability and changed the morphology of bacterial cells. The RNA-seq results showed that the deleted strain had 259 differentially expressed genes compared with the wild strain, of which 78 genes were significantly up-regulated and 181 genes were significantly down-regulated. These DEGs are mainly enriched in pathways such as cell movement, membrane transport, and amino acid metabolism, and GO terms such as cell process and membrane, which can explain the above differences in physiological phenotype. These results confirmed the complex regulatory mechanism of the CobB gene in the biological functions of *V. alginolyticus*.

**Key words::** *Vibrio alginolyticus*; lysine deacetylase CobB; biological function; RNA-seq

# 瓦氏黄颡鱼头肾组织学观察与 先天性免疫屏障研究

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**摘要:** 研究用 HE 和改良 James 染色法对瓦氏黄颡鱼头肾的显微结构进行了观察, 并使用台盼蓝活体对头肾免疫屏障部位进行了定位。结果显示瓦氏黄颡鱼头肾由被膜、淋巴细胞聚集区、粒细胞聚集区、前肾间组织、网状纤维和胶原纤维组成, 胶原纤维仅在血管外周可见; 台盼蓝主要分布于血窦周围的内皮细胞和一些游离的巨噬细胞中, 且随时间延长呈递增趋势。表明: 血窦周围的内皮细胞和巨噬细胞组成了瓦氏黄颡鱼的头肾先天性免疫屏障。

**关键词:** 瓦氏黄颡鱼; 头肾; 组织结构; 免疫功能

## Histological observation and innate immune barrier study of head kidney of *Pelteobagrus vachelli*

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**Abstract :** To investigate the histological structure and immune function of head kidney of *Pelteobagrus vachelli*, we used hematoxylin-eosin (HE) staining and modified James staining to observe its microscopic structure, and applied trypan blue vital staining to locate its immune barrier site. The results show that the head kidney of *P. wallichii* consisted of capsule, lymphoid zone, granulocytic zone, anterior interrenal tissue, reticular fibers and collagen fibers, and collagen fibers were only visible at the periphery of blood vessels. Trypan blue was mainly distributed in endothelial cells around sinusoids and some free melanin macrophages, showing an increasing trend with time. Results suggest that endothelial cells of red pulps and free macrophages form the innate immune barrier of head kidney

**Key words::** *Pelteobagrus vachelli*; Head kidney; Tissue structure; Immune function

# 基于代谢组学的不同养殖模式下大西洋鲑 代谢产物的差异研究

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**摘要：**不同养殖模式下的大西洋鲑价格差异很大，由于视觉区分困难，很可能发生食品欺诈。本研究中，我们报道了利用液相质谱对来自工厂化循环水和海水网箱不同养殖模式的大西洋鲑背肌代谢物的分析。利用正交偏最小二乘判别分析(OPLS-DA)评估不同养殖模式下的大西洋鲑背肌的代谢物，并进行 KEGG 代谢途径分析。OPLS-DA 清楚地区分了大西洋鲑背肌代谢物。KEGG 代谢途径分析表明，脂代谢和氨基酸代谢与养殖模式密切相关。

**关键词：**大西洋鲑；养殖模式；代谢组学；食品欺诈

## Metabolomics analysis of Atlantic salmon (*Salmo salar* L.) in different culture modes using LC/MS

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**Abstract:** The prices of Atlantic salmon under different culture modes vary greatly, and food fraud is likely to occur due to the difficulty of visual distinction. In this study, we reported the analysis of metabolites in the dorsal muscle of Atlantic salmon from different farming modes in industrial circulating water and sea cages using liquid-phase mass spectrometry. Orthogonal Partial Least Squares Discriminant Analysis (OPLS-DA) was used to evaluate the metabolites of Atlantic salmon back muscles under different farming modes, and KEGG metabolic pathway analysis was performed. OPLS-DA clearly distinguishes the metabolites of Atlantic salmon back muscles. KEGG metabolic pathway analysis shows that lipid metabolism and amino acid metabolism are closely related to the breeding mode.

**Key words::** Atlantic salmon; culture modes; metabolomics; food fraud

# 蒸制处理对三疣梭子蟹不同组织中总镉分布的影响

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**摘要：**本研究的目的是探究三疣梭子蟹各组织中镉（Cd）的分布情况以及蒸制对 Cd 浓度水平的影响。结果表明，在生蟹中，褐肉（包括肝胰腺和性腺）是 Cd 浓度最高的部位（雌蟹湿重质量浓度  $3.6 \pm 0.05$  mg/kg，雄蟹  $3.8 \pm 0.07$  mg/kg）。蒸制 15 min 内鳃和褐肉中 Cd 浓度明显下降，然后随蒸制时间的增长而趋于稳定，经 18 min 蒸制后，各组织中的 Cd 浓度都显著下降（ $P < 0.05$ ）。

**关键词：**三疣梭子蟹；总镉；蒸制；污染；组织分布

## Effects of steaming process on the distribution of cadmium in different tissues of the *Portunus trituberculatus*

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**Abstract :** The purpose of this work was to investigate the distribution of total cadmium (Cd) in *Portunus trituberculatus* tissues and evaluate the effect of steaming practices on the Cd levels. Samples detection was performed by inductively-coupled plasma mass spectrometry (ICP-MS) . The results showed the brown meat (including hepatopancreas and gonads) was the tissue with the highest average Cd concentration ( $3.6 \pm 0.05$  mg/kg wet weight for female,  $3.8 \pm 0.07$  mg/kg wet weight for male). With the increase of steaming time, the Cd concentration based on dry weight showed different trends in different tissues. In the initial stage of steaming (15 min), the Cd was redistributed among the portunus tissues with the flow of water, the Cd concentration in the gills and brown meat decreased significantly, and then tended to be stable with the increase of steaming time. The Cd concentration in all tissues of the female and male crabs steamed for 18 min obviously declined ( $P < 0.05$ ) compared with the control group (raw crabs) , and the brown meat Cd concentration in the female crabs dropped by 47 % , while the male crabs dropped by 57 % , and the muscle As concentration was close to zero. Moreover, a large amount of the Cd was transferred to the juice produced by steaming. This research proved that steaming practices could effectively reduce the risk of Cd exposure when eating *Portunus trituberculatus*.

**Key words: :** *Portunus trituberculatus* ; total cadmium ; steaming process ; contamination ; distribution

# 中国石斑鱼病毒性神经坏死相关的大规模死亡

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**摘要：**2019年12月，在中国广东省佛山市的一个淡水养殖场，养殖的石斑鱼鱼苗发生大规模死亡。15天内累积死亡率高达45%。病鱼在大量死亡前表现出临床症状，包括游泳行为异常、食欲减退和体色变黑。在SSN-1细胞中观察到典型的以空泡化为特征感染的细胞病变效应。组织病理学检查显示，自然和实验感染的石斑鱼苗的大脑和视网膜出现空泡化和坏死。本研究是我国淡水鱼自然感染病毒的首次报道。

**关键词：**神经坏死病毒；石斑鱼；RT-PCR

## Mass Mortalities Associated with Viral Nervous Necrosis in Murray cod in China

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**Abstract:** In December 2019, a mass mortality among cultured Murray cod (*Maccullochella peelii peelii*) fry occurred on a freshwater farm located at Foshan city of Guangdong province, China. The cumulative mortality was up to 45% within 15 days. The diseased fish showed clinical signs, including abnormal swimming behaviour, loss of appetite and dark body colouration before mass mortality. Samples of brain and retina tissues were collected from affected fish and subjected to RT-PCR detection and virus isolation in cell culture. Approximately 430 bp product was detected from the brain and retina tissues and culture supernatant of betanodavirus-infected SSN-1 cells. The typical cytopathic effect of betanodavirus infection, which is characterized by vacuolation, was observed in SSN-1 cells at three days after inoculating with the tissue filtrate of diseased Murray cod fry, and the TCID<sub>50</sub> of the infected SSN-1 cells supernatant was 107.8. Histopathological examinations revealed vacuolation and necrosis in the brain and retina of naturally and experimentally infected Murray cod fry. This study is the first report of the natural infection of betanodavirus in freshwater fish in China.

**Key words:** Betanodavirus; Viral nervous necrosis; Murray cod; RT-PCR

# 鲤疱疹病毒II型编码的 microRNA (CyHV-2-KT-635)通过靶向 ORF23 调控病毒复制

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**摘要:** 据有关报道, 疱疹病毒家族能够编码和表达靶向病毒和细胞转录产物的 microRNA。在我们前期的研究发现, 一种新的 microRNA CyHV-2-KT-635 被证明可以靶向功能未知的病毒基因。本研究证明了 CyHV-2-KT-635 可靶向调控病毒基因 ORF23, 验证 ORF23 基因序列上的相关靶点, 并鉴定了 CyHV-2-KT-635 对 ORF23 表达的影响。

**关键词:** 鲤疱疹病毒II型; CyHV-2-KT-635; 核糖核苷酸还原酶; 病毒复制

## Cyprinid herpesvirus 2 encoded microRNA (CyHV-2-KT-635) regulates viral replication by targeting the ORF23

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**Abstract:** Herpesvirus family have been reported to be able to encode and express functional viral microRNAs that target both viral and cellular transcripts. With previous studies, a novel miRNA CyHV-2-KT-635 has been proved to target the viral genes with unknown functions. In this study, the target gene of CyHV-2-KT-635 regulated was proved to be the viral gene ORF23 directly, the target point on gene sequence was verified and CyHV-2-KT-635 was identified to influence the expression of ORF23. According to the bioinformatics analysis, the tRNA domain and ribosome domain in the protein sequence of ORF23 were found to share lots of homology with R2i and P53R2i, which are related to the ribonucleotide reductase small subunit in the host (transform NTP to dNTP). Within expectations, silencing of viral ORF23 or transfecting CyHV-2-KT-635 mimics in GiCF could suppress viral propagation significantly. These findings are helpful to understand the effect of virus encoded microRNA on the replication of Cyprinid herpesvirus 2.

**Key words:** Cyprinid herpesvirus 2, CyHV-2-KT-635, ribonucleotide reductase, Viral replication



# 我国养殖水产品质量安全监管现状与完善对策研究

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**摘要：**伴随着近年来水产品安全事件的发生，水产品质量安全再次引起人们的重视，养殖水产品占我国水产品产量的主要部分，在面对市场需求日益增长的情况下，如何保障养殖水产品质量安全成为了消费者关注的重要内容。本文从水产养殖的产前、产中、产后环节进行了探究，并借鉴国外主要渔业国家养殖水产品质量安全监管经验，提出对我国养殖水产品质量安全监管完善的对策，把好养殖水产品各个环节的质量安全关，从而才能保障水产品的真正安全。

**关键词：**养殖水产品；质量安全；监管；对策研究

## Research on the Current Situation and Improvement Countermeasures of the Quality and Safety Supervision of Aquatic Products in China

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**Abstract:** With the occurrence of aquatic product safety incidents in recent years, the quality and safety of aquatic products has once again attracted people's attention. Farmed aquatic products account for the main part of China's aquatic product output. How to ensure the quality of aquatic products in the face of increasing market demand Safety has become an important content of consumer concern. This article explores the pre-production, mid-production, and post-production links of aquaculture, and draws on the experience of the quality and safety supervision of aquaculture products in major foreign fisheries countries, and proposes countermeasures to improve the quality and safety supervision of aquaculture products in our country. The quality and safety of the links can ensure the real safety of aquatic products.

**Key words:** : Cultured aquatic products; quality and safety; supervision status; countermeasure research

# 乳酸菌发酵鱼制品中生物胺的研究进展

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**摘要：**发酵鱼制品可以提高低值淡水鱼的利用率，也可以赋予鱼肉较好的风味和营养价值。但在发酵生产过程中产生的生物胺对消费者具有潜在的安全威胁。乳酸菌是发酵鱼制品中最常用的发酵剂，本文对乳酸菌发酵的鱼制品的种类、发酵过程中生物胺的来源、生物胺的检测以及生物胺的控制方法等方面进行综述，以期对乳酸菌发酵鱼制品中生物胺的相关研究提供依据。

**关键词：**发酵鱼制品；生物胺；乳酸菌

## Research Progress of Biogenic Amines in Fish Products Fermented by Lactic Acid Bacteria

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**Abstract:** Fermented fish products can improve the utilization rate of low-value freshwater fish, it can also give the fish better flavor and nutritional value. However, biogenic amines produced in the process of fermentation have potential safety threats to consumers. Lactobacillus is the most commonly used fermentation agent in fermented fish products. In this paper, the types of fish products fermented by lactic acid bacteria, the source of bioamines in fermentation process, the detection of bioamines and the control methods of bioamines are reviewed in order to provide a basis for the research on bioamines in fermented fish products of lactic acid bacteria.

**Key words:** Fermented fish products; Biogenic amines; Lactic acid bacteria

# 基于改进的 QuEChERS 提取法高效液相串联质谱测定水产动物可食 性组织中甲苯咪唑及代谢产物、阿苯达唑及 代谢产物和左旋咪唑

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**摘要:** 本液相色谱-串联质谱定量方法, 基于改进的 QuEChERS 方法, 测定了团头鲂, 克氏原螯虾, 鳗鱼和乌龟肌肉中的甲苯咪唑及其代谢产物, 阿苯达唑及其代谢产物和左旋咪唑的残留量。该提取方法是, 2 克肌肉基质中加入 10 mL 乙腈, 0.8 g 硫酸镁和 0.2 g 氯化钠进行液-液分层。涡旋并离心后, 将所得液体通过 C18 和 Al-N 净化。

**关键词:** 高效液相串联质谱, 改进的 QuEChERS 法, 甲苯咪唑及代谢产物, 阿苯达唑及代谢产物, 左旋咪唑, 水产动物可食性组织

## Development of a liquid chromatography–tandem mass spectrometry method with modified QuEChERS extraction for the quantification of mebendazole and its metabolites, albendazole and its metabolites, and levamisole in edible tissues of aquatic animals

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**Abstract:** A liquid chromatography–tandem mass spectrometry quantitative method was developed for determining mebendazole and its metabolites, albendazole and its metabolites, and levamisole in muscles of bluntnose black bream, shrimp, eel and turtle based on modified QuEChERS methodology. The method included 2 g of the muscle matrix with 10 mL acetonitrile, and 0.8 g of magnesium sulphate and 0.2 g of sodium chloride for liquid-liquid partitioning. After vortex and centrifugation, the resulting liquid (5.5 mL) was purified by C18 (50 mg) and Al-N (50 mg). The limits of detection were lower than 0.3  $\mu\text{g kg}^{-1}$  and the limits of quantitation were no more than 1  $\mu\text{g kg}^{-1}$  for all analytes. The recoveries of the analytes ranged from 80.0% to 113.7% with the relative standard derivation less than 10.0%. The preparation procedure provided efficient extraction and purification that enabled a sensitive and rugged determination of target compounds.

**Key words:** liquid chromatography–tandem mass spectrometry, modified QuEChERS, mebendazole and its metabolites, albendazole and its metabolites, levamisole, edible tissues of aquatic animals

# 多子小瓜虫 $\beta$ -微管蛋白核酸疫苗的免疫保护作用研究

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**摘要:** 本研究以 $\beta$ -微管蛋白为抗原基因构建多子小瓜虫(*Ichthyophthirius multifiliis*)核酸疫苗, 首免四周后次免, 检验抗原基因表达。在 3 个月内定期测定免疫相关基因相对表达量、抗体效价、酶活及免疫球蛋白含量。42d 时攻毒并计算免疫保护率。结果表明抗原基因正常表达, 免疫相关基因相对表达量和酶活均升高, 第五周血清效价最高, 达 1280, 免疫保护率达 80%, 表明所制备核酸疫苗抗虫效果良好。

**关键词:** 多子小瓜虫; 核酸疫苗; 抗体效价

## Immunoprotective effect of *Ichthyophthirius multifiliis* $\beta$ -tubulin nucleic acid vaccine

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**Abstract:** In this study, *Ichthyophthirius multifiliis* nucleic acid vaccine was constructed with  $\beta$ -tubulin as antigen gene, and blank control group, no-load control group and immune experimental group were set up.  $\beta$ -tubulin gene expression was tested after immunization. The experiment lasted for 3 months, and the relative expression of immune-related genes, enzyme activity and immunoglobulin content were determined periodically. After immunization, toxication was challenged and the immune protection rate was calculated. The results showed that antigen genes were expressed in fish, the relative expression level of immune-related genes and the activity of immune-related enzymes were significantly up-regulated ( $P < 0.05$ ). The serum titer was the highest at the fifth week (1280), and the immune protection rate was 80%. The results showed that the nucleic acid vaccine had good resistance to *Ichthyophthirius multifiliis*.

**Key words:** *Ichthyophthirius multifiliis*; Nucleic acid vaccine; The antibody titer

# 嗜冷黄杆菌感染虹鳟脾脏的综合转录组分析

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**摘要：**嗜冷黄杆菌引起的细菌性冷水病，给鲑鳟养殖业带来巨大损失。本研究确定了虹鳟脾脏对嗜冷黄杆菌免疫反应的分子机制。结果显示 1286 个差异表达基因在 D3 和 D7 显示持续的上调或下调，与急性期反应、蛋白水解、补体级联、趋化因子和细胞因子信号传导以及细胞凋亡相关。RT-qPCR 结果证明了 TLR2、CASP-8、IL-8、IFNGR1 和其他参与 Toll 样受体信号通路的差异表达基因在感染后持续上调。

**关键词：**嗜冷黄杆菌；虹鳟；脾脏；转录组

## Integrated transcriptomic analysis in spleen of rainbow trout (*Oncorhynchus mykiss*) post *Flavobacterium psychrophilum* infection

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**Abstract :** *Flavobacterium psychrophilum* causes bacterial coldwater disease, which has led to considerable losses in salmonid aquaculture. The objective of this study was to determine the molecular mechanism of the immune response to *F. psychrophilum* in spleen of rainbow trout (*Oncorhynchus mykiss*). We investigated splenic transcriptome profiles in uninfected rainbow trout (CK) and rainbow trout at 3 (D3) and 7 (D7) days post infection with *F. psychrophilum* by RNA-seq analysis. Among of 7170 differentially expressed genes (DEGs) among three comparisons (D3vsCK, D7vsCK, D3vsD7), 1286 DEGs showed consistent up-regulation or down-regulation at D3 and D7, associated to acute phase response, proteolysis, complement cascade, chemokine and cytokine signaling, and apoptosis. TLR2, CASP-8, IL-8, IFNGR1 and other DEGs involved in Toll-like receptor signaling pathway were consistently up-regulated after infection. RT-qPCR analysis of eight DEGs confirmed the accuracy of the RNA-seq data. Our results reflected a general process from pathogen recognition to inflammatory cytokine generation, and delineated a putative Toll-like receptor signaling pathway in rainbow trout spleen following *F. psychrophilum* infection. Together, these results provide new insights into the molecular mechanism of the immune response to *F. psychrophilum* infection and are a valuable resource for future research on the immune system in rainbow trout and other salmonids.

**Key words::** *Flavobacterium psychrophilum*; rainbow trout; spleen; transcriptomic analysis

# 中华鳖 MRC2 基因克隆、表达研究

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**摘要:** 甘露糖受体 (Mannose receptor, MR) 是医学热点研究的模式识别受体, 具有启动固有免疫和适应性免疫的功能, 其常被作为靶点受体用于新型药物和疫苗的开发。本研究以中华鳖 cDNA 为模板, 克隆获得了中华鳖甘露糖受体 MRC2 的开放阅读框, 并对其组织表达谱和嗜水气单胞菌感染后表达谱进行了分析。本研究结果为进一步研究 MRC2 的抗感染功能提供了参考依据。

**关键词:** 中华鳖; 甘露糖受体; 细菌感染; 免疫机理

## Identification and Expression analysis of MRC2 of *Pelodiscus sinensis*

Zhang Hui1 Tian Yu1 Zhang Xingyue1 Wang Xiaoqing1 Hu Yazhou1

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**Abstract:** Mannose receptor, a kind of pattern recognition receptor, is a research hotspot in medicine. It has the function of initiating innate immunity and adaptive immunity. It is often used as a target receptor for the development of new drugs and vaccines. In this study, the *Pelodiscus sinensis* cDNA was used as a template to clone the open reading frame of MRC2, and the tissue expression profile and expression profile of MRC2 after *Aeromonas hydrophila* infection were analyzed. The results of this study provide a reference for further research on the anti-infective function of MRC2.

**Key words:** *Pelodiscus sinensis*; mannose receptor; bacterial infection; immune mechanism

# 草鱼源鲁氏耶尔森菌的分离鉴定与药敏特性研究

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**摘要:** 为确定草鱼中出现的以肌肉出血、鳔出血为典型症状的疾病的病原, 采用常规的细菌性病原分离鉴定方法对病原进行了鉴定和药敏特性研究。结果表明: 分离株的菌落特征和生理生化特性与鲁氏耶尔森菌相同; 16S rDNA 测序结果与鲁氏耶尔森菌同源率为 99%; 回归感染试验复制出与临床发病相似的症状; 说明该例草鱼疾病的病原为鲁氏耶尔森菌。药敏试验结果显示该菌对氨苄西林等 19 种抗菌药敏感。对青霉素等 9 种抗菌药存在耐药性。

**关键词:** 草鱼; 鲁氏耶尔森菌; 分离鉴定; 16S rDNA; 药敏试验; 肌肉出血病

## Isolation, identification and antibiotic susceptibility of *Yersinia ruckeri* in grass carp (*Ctenopharyngodon idellus*)

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**Abstract:** In order to determine the pathogen of grass carp (*Ctenopharyngodon idellus*) symptoms manifested as muscle hemorrhage, splenomegaly enteritis and swim bladder hemorrhage, bacterial separation and purification, physiological and biochemical tests, 16S rDNA detection, phylogenetic analysis and animal regression test were carried out. The results showed that the isolate was Gram-negative bacterium, the surface of the colony was smooth and round, and the color was white. The bacteria were motility, the hydrogen sulfide and V-P reaction were negative, and the glucose, fructose and maltose could be fermented. The homology of 16S rDNA amplified by PCR was 99% to *Yersinia ruckeri*. The artificial infection symptoms was consistent with the clinical case. It can be confirmed that the pathogen of the disease is *Yersinia ruckeri*. The results of drug susceptibility test showed that the bacteria were sensitive to 19 kinds of antibacterial drugs such as ampicillin, enrofloxacin and florfenicol, but not sensitive to penicillin G, oxacillin, rifampicin, vancomycin, clarithromycin, erythromycin ceftazidime, medimycin and furazolidin.

**Key words:** *Ctenopharyngodon idellus*; *Yersinia ruckeri*; Isolation and identification; 16S rDNA; Susceptibility analysis; Muscle hemorrhagic disease

# 大鳞副泥鳅(*Paramis gurnus dabryanus*)鳃和肝脏在急性空气和氨胁迫下的转录组分析

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安徽农业大学

**摘要:** 将大鳞副泥鳅(*Paramisgurnus dabryanus*)分别暴露于空气和  $\text{NH}_4\text{Cl}$  溶液中 48 h, 对其鳃和肝脏组织进行转录组分析, 共组装 92,658 个功能基因。鳃和肝脏中分别检测到 489/145 和 424/140 的差异表达基因。结果表明: 大鳞副泥鳅通过调控氨基酸代谢以应对高浓度体外和体内氨累积, 通过调控特定氨转运蛋白的表达以应对高浓度体外氨累积。研究结果将为鱼类耐氨品种选育提供理论依据。

**关键词:** 大鳞副泥鳅; 转录组; 高浓度环境氨; 体内氨累积; 氨解毒

## Transcriptomic analyses of the acute aerial and ammonia stress response in the gill and liver of large-scale loach (*Paramisgurnus dabryanus*)

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College of Animal Science and Technology, Anhui Agricultural University

**Abstract :** We performed transcriptomic analyses of the gill and liver of large-scale loach (*Paramisgurnus dabryanus*) subjected to 48 h of aerial and ammonia exposure. We obtained 47,473,424 to 56,791,496 clean reads from the aerial exposure, ammonia exposure and control groups, assembled and clustered a total of 92,658 unigenes with an average length of 909 bp and N50 of 1787 bp. Totals of 489/145 and 424/140 differentially expressed genes were detected in gill/liver of large-scale loach after aerial and ammonia exposure through comparative transcriptome analyses, respectively. In addition, totals of 43 GO terms and 266 KEGG pathways were identified. After aerial and ammonia exposure, amino acid metabolism pathways in liver of large-scale loach were significantly enriched, suggesting that large-scale loach responded to high exogenous and endogenous ammonia stress by enhancing amino acid metabolism. Besides, the expression of several ammonia transporters in gill of large-scale loach were markedly changed after 48 h of aerial exposure, suggesting that large-scale loach responded to high endogenous ammonia stress by regulating the expression of Rh glycoproteins and Aqps related genes in gill. The results will facilitate the molecular assisted breeding of ammonia resistant varieties, and will offer beneficial efforts for establishing an environmental-friendly and sustainable aquaculture industry.

**Key words: :** *Paramisgurnus dabryanus*; transcriptome; high environmental ammonia loading; endogenous ammonia accumulation; ammonia detoxification



# 三黄连合剂对副溶血弧菌致南美白对虾肝胰腺损伤的保护作用

于美玲

广西大学

**摘要：**为明确三黄连合剂对副溶血弧菌所致南美白对虾肝胰腺损伤的保护作用，首先测定副溶血弧菌对南美白对虾的半数致死浓度，建立副溶血弧菌感染模型，利用三黄连合剂进行预防和治疗。观察对虾临床症状、死亡率，检测对虾肝胰腺 AKP、ACP、ALT、AST、SOD 和 GSH-Px 活性，分析肝胰腺组织病理学变化。结果显示三黄连合剂保护率为 48.95%，提前给药可减轻肝胰腺损伤程度，对副溶血弧菌致虾肝胰腺损伤具有保护作用。

**关键词：**“三黄连”合剂 南美白对虾 副溶血弧菌 肝胰腺坏死综合征

## Protective effects of Sanhuanglian Mixture on hepatopancreas injury of *Penaeus vannamei* induced by *Vibrio parahaemolyticus*

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**Abstract:** In order to clarify the protective effect of sanhuanglian mixture on hepatopancreatic injury of *Penaeus vannamei* caused by *Vibrio parahaemolyticus*, the median lethal concentration of *Vibrio parahaemolyticus* on *Penaeus vannamei* was measured, the *Vibrio parahaemolyticus* infection model was established, and sanhuanglian mixture was used for prevention and treatment. The clinical symptoms and mortality of shrimp were observed, the activities of AKP, ACP, alt, AST, SOD and GSH PX in hepatopancreas were detected, and the histopathological changes of hepatopancreas were analyzed. The results showed that the protective rate of sanhuanglian mixture was 48.95%. Early administration could reduce the degree of hepatopancreas injury and protect shrimp hepatopancreas injury caused by *Vibrio parahaemolyticus*.

**Key words:** “San Huang Lian”mixture;*Penaeus vannamei*;*Vibrio parahaemolyticus*; Hepatopancreas Necrosis Syndrome (HPNS)

# 通过 RT-qPCR 筛选红鳍东方鲀 (Takifugu rubripes) 感染刺激隐核虫的最佳内参基因

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**摘要：**本研究以红鳍东方鲀为研究对象，对正常生理条件和感染刺激隐核虫条件下的红鳍东方鲀稳定可靠内参基因进行筛选。综合各种算法结果表明，正常生理条件下红鳍东方鲀头肾和肝脏中最稳定的内参基因为 RPL7，脾和鳃中最稳定的内参基因为 EF1A 和 B2M，脑和肌肉中最理想的内参基因分别为 ACTB 和 GAPDH。在感染组中，肌肉和鳃最稳定的内参基因分别为 EF1A 和 ACTB，肾脏和肝脏最稳定的内参基因为 RPL7 和 B2M。

**关键词：**红鳍东方鲀；内参基因；刺激隐核虫病；实时荧光定量 PCR；表达分析

## Evaluation of potential reference genes by quantitative RT-qPCR analysis of Takifugu rubripes under normal conditions and after Cryptocaryon irritans infection

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**Abstract:** In this study, the stable and reliable reference genes of Takifugu rubripes rubripes were screened under normal physiological conditions and under infection and stimulation of Cryptocaryon irritans. The results of various algorithms showed that the most stable reference genes in normal head kidney and liver were RPL7, the most stable reference genes in normal spleen and gill were EF1A and B2M, and the optimal reference genes in normal brain and muscle were ACTB and GAPDH, respectively. In the infected group, the most stable reference genes for muscle and gill were EF1A and ACTB, respectively, while the most stable reference genes for kidney and liver were RPL7 and B2M.

**Key words:** Takifugu rubripes; Housekeeping genes; Cryptocaryoniasis; Quantitative real time PCR; Expression analysis

# 海水倒灌对中国内陆咸水致病性弧菌种类的影响

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**摘要:** 由于河口从海水和河流中提供丰富的有机和无机营养, 因此河口是致病弧菌的生态位。然而, 人们对内陆咸水区这些弧菌物种的生态学知之甚少。在本研究中, 采用聚合酶链反应 (MPN-PCR) 方法研究了它们在中国浑太河中的共存情况以及与盐度和温度的关系。我们在此报告基于浑太河六项水质指标的 2 年连续监测。我们的研究表明, 海水倒灌和盐度对内河致病性弧菌的分布有着深远的影响, 这表明浑太河水用于灌溉和饮用存在潜在的健康风险。

**关键词:** 海水倒灌; 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:** The estuary is the ecological niche of pathogenic *Vibrio* spp. as it provides abundant organic and inorganic nutrients from 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 salinity and temperature in the Hun-Tai River of China were examined using the most probable number polymerase chain reaction (MPN-PCR) approach. We hereby report 2-year continuous surveillance based on six water indices of the Hun-Tai River. 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:** seawater intrusion; *Vibrio parahaemolyticus*; *Vibrio cholerae*; MLST; virulence factor

# 鱼体内溶血介导的组织损伤机制研究

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**摘要：**本实验以草鱼为研究对象，通过多染色结果发现体内溶血导致组织明显的铁沉积，组织中的丙二醛、4-羟基壬烯醛以及 ROS 含量也显著增加。同时，血清中铁离子、乳酸脱氢酶、肌酐等的含量增加。组学和体外实验表明血红蛋白介导了细胞死亡主要是铁死亡，同时结合 Znpp、FAC、NAC 等实验进行了进一步验证。综上所述，本研究首次系统探究鱼体内出血导致组织铁过载并引发组织细胞铁死亡机制，同时也为草鱼的健康养殖提供新的参考。

**关键词：**草鱼；溶血；游离血红素；铁死亡

## Mechanism of tissue injury mediated by hemolysis in fish

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**Abstract:** In this study, grass carp was used as the research model. Through multi-staining assays, the results revealed that in vivo hemolysis caused obviously iron deposition, and increased the contents of malondialdehyde, 4-hydroxynonenal and ROS in tissues. Meanwhile, hemolysis increased the content of iron, LDH and Cr in serum. RNA-seq and in vitro experiments showed that hemoglobin mainly mediated ferroptosis. In addition, the supplementary of Znpp, FAC, NAC and other experiments further verify above conclusion. Taken together, this study is the first time to systematically explore the mechanism of iron overload and ferroptosis of tissue cells caused by hemorrhage in fish, and also provides a new strategy for the healthy breeding of grass carp.

**Key words:** grass carp; hemolysis; free heme; ferroptosis

# 维氏气单胞菌 JW-4 株对鲫 的致病性及灭活疫苗免疫效果研究

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**摘要：**从典型症状病鱼中分离病原菌 JW-4，分析鉴定为维氏气单胞菌(*Aeromonas veronii*)，根据半致死量( $2 \times 10^6$  CFU/mL)设拌饲投喂浓度梯度，研究其对鲫的致病性及灭活疫苗保护作用。结果显示血清和肝脏转氨酶活性及 TNF- $\alpha$ 和 IFN- $\gamma$ 基因表达量显著升高，灭活疫苗免疫后血清中特异性 IgM 和总 IgM 含量显著增加，保护率达 75%。研究表明 JW-4 对鲫致病性强但灭活疫苗对鲫有保护效果。

**关键词：**维氏气单胞菌；致病性；灭活疫苗

## Study on pathogenicity and immunological effect of inactivated vaccine of Crucian Carp (*Carassius auratus*) by *Aeromonas veronii* JW-4

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**Abstract:** The strain JW-4 obtained from the diseased fish was selected for subsequent research, which was identified that the strain was *Aeromonas veronii*. The value of the strain(JW-4) LD<sub>50</sub> was  $2 \times 10^6$  CFU/mL. Moreover, the experimental groups with different bacterial concentrations and the control group were intended to investigate the pathogenicity and inactivated vaccine protection of crucian carp. In this study, transaminase activity in serum and liver of crucian carp treated with JW-4 increased and then gradually approached the control levels. The trend for both TNF- $\alpha$  and IFN- $\gamma$  genes expression significantly increased and then recovered. The serum injected with the inactivated vaccine exhibited significantly higher specific IgM and total IgM levels compared with the control group. The results showed that the relative immune protection rate was 75%. Overall, our data suggested that *A. veronii* JW-4 had strong pathogenicity but its inactivated vaccine had positive protective effect to crucian carp.

**Key words:** *Aeromonas veronii*; pathogenicity; inactivated vaccine

# 渔用中草药筛选的新途径

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**摘要：**中草药代替化学药物用于水产动物病害防治成为发展趋势，但采用药敏评价难以确证渔用中草药功效，导致中草药资源挖掘严重受限。本研究采用两个新途径筛选中草药：一是采用嗜热四膜虫筛选抗鱼纤毛类寄生虫中草药；二是鱼口服中草药或其单体对肠道菌群、宿主代谢及免疫水平的影响，评估中草药的效果。本研究为中草药在水产上的应用研究提供新方法途径。

**关键词：**中草药; 嗜热四膜虫; 肠道菌群; 宿主代谢; 免疫水平

## New methods of screening Chinese herbal medicine for fish disease control

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**Abstract :** Chinese herbal medicine(CHM) replacing chemical drugs for aquatic animal disease prevention and control has become a development trend, however it is difficult to confirm the efficacy of CHM by using drug sensitivity evaluation method, resulting to the serious limitation of CHM resources mining. This study used two new methods to screen CHM: one is application Tetrahymena thermophila for screen platform in vitro CHM against ciliate parasites; the other is evaluation effects of fish microbiota, metabolism and immunity levels after oral administration of CHM or its monomers .This study provides new methods for the application of Chinese herbal medicine in aquatic fish disease control.

**Key words::** Chinese herbal medicine; Tetrahymena thermophila ; metabolism; immunity level

# 一株虹鳟源枯草芽孢杆菌的分离鉴定 及生物学特性研究

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**摘要：**本研究从健康虹鳟幼鱼肠道中分离到 1 株潜在益生菌株 RT-BS07，结合 16S rRNA 基因序列分析和形态学观察结果确定菌株 RT-BS07 为枯草芽孢杆菌（*Bacillus subtilis*），具备产蛋白酶和纤维素酶能力。该菌株可有效抑制温和气单胞菌、杀鲑气单胞菌和鲁氏耶尔森氏菌等致病菌。其抗逆性能强，酸碱耐受性能良好，肠道黏附性好，对虹鳟无毒害作用，可作为虹鳟健康养殖及益生菌制剂研发源益生菌候选株。

**关键词：**虹鳟，枯草芽孢杆菌，产酶性能，抑菌特性，黏附特性

## Isolation, identification and biological characterization of a *Bacillus subtilis* strain from rainbow trout (*Oncorhynchus mykiss*)

FAN Dan

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**Abstract:** To obtain potential probiotics, one bacterial strain was isolated by comparing the enzyme production characteristics of the isolates from intestines of healthy rainbow trout (*Oncorhynchus mykiss*) juvenile and named RT-BS07. Combined with 16S rRNA gene sequence analysis, RT-BS07 strain was identified as *B. subtilis*. The strain had the enzyme production capacity of protease and cellulase. It can effectively inhibit *Aeromonas sobria*, *A. salmonicida* and *Yersinia ruckeri*, respectively. RT-BS07 strain can survive LB liquid medium at pH 2~10. The survival rate ranged from 5.7 to 93.3% when the salinity varied between 2 and 8‰ decreasing when the salinity increased. Adhesion test in vitro showed strain can adhere to anterior intestinal mucosa without destroying the integrity. Antimicrobial susceptibility test indicated that RT-BS07 strain was sensitive to 18 antimicrobial agents such as levofloxacin, ciprofloxacin, ofloxacin, streptomycin among others. These results indicated that the isolated *B. subtilis* strain RT-BS07 can be used as a candidate strain, providing strain resources for healthy aquaculture of rainbow trout and the development of probiotic preparation.

**Key words:** *Oncorhynchus mykiss*; *Bacillus subtilis*; enzyme producing capacity; antimicrobial character; adhesion character

# 中华鳖 Toll 样受体 2 和 3 的克隆、表达分析

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**摘要:** Toll 样受体是一类重要的模式识别受体, 能特异性地识别病原相关分子模式, 其在水产动物免疫中发挥重要作用。本研究克隆鉴定了中华鳖 TLR2、TLR3 的开放阅读框片段, 并对其进行生物信息学分析, 运用荧光定量 PCR 方法研究嗜水气单胞菌刺激后中华鳖肝、肾、脾、肠等免疫器官中的表达变化, 为进一步研究中华鳖 Toll 受体功能提供了基础。

**关键词:** 中华鳖, Toll 样受体, 基因克隆, 嗜水气单胞菌, mRNA 表达分析,

## MOLECULAR CLONING AND EXPRESSION ANALYSIS OF TOLL-LIKE RECEPTOR 2 and 3 GENE IN PELODISCUS SINENSIS

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**Abstract :** Toll-like receptors are important pattern recognition receptors that can specifically recognize pathogen-related molecular patterns and play vital role in aquatic animal immunity. In this study, we cloned and identified the open reading frame fragments of TLR2 and TLR3, and carried out bioinformatics analysis on them. RT-PCR was used to study the expression profiles of TLR2 and TLR3 in liver, kidney, spleen, and intestines of *Pelodiscus sinensis* after stimulation by *Aeromonas hydrophila*. The expression changes in organs provide a basis for further research on the function of Toll-like receptor in *P. sinensis*.

**Key words:** : *Pelodiscus sinensis*, Toll-like receptors, Gene clone, *Aeromonas hydrophila*, mRNA expression analysis,



# 常见市售淡水鱼肌肉中重金属含量与 安全性评价

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**摘要：**本研究对采集的湖北、广东、河南和黑龙江四省市售的 11 种常见市售淡水鱼、133 件样本，采用微波消解-电感耦合等离子体质谱仪（ICP-MS）法检测了肌肉中 Cr、Cu、As、Cd、Hg 和 Pb 6 种元素含量，并进行了安全性评价。采用单因子污染指数法和内梅罗综合污染指数法评价所检淡水鱼中 6 种重金属元素的污染状况和差异性，结果表明了目前市售养殖淡水鱼类中重金属污染风险较低。

**关键词：**淡水鱼；重金属污染；As；安全性评价；标准限量值

## Concentrations and safety evaluation of heavy metals in muscle of common commercially available freshwater fish

WU Di

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**Abstract:** In this study, 11 common commercially available freshwater fish species and 133 samples collected from four provinces of Hubei, Guangdong, Henan and Heilongjiang were tested for six elements of Cr, Cu, As, Cd, Hg and Pb in muscle by microwave ablation-inductively coupled plasma mass spectrometry (ICP-MS) and evaluated for safety. The single-factor contamination index method and the Nemero integrated contamination index method were used to evaluate the contamination status and variability of the six heavy metal elements in the freshwater fish examined, and the results indicated a low risk of heavy metal contamination in commercially available cultured freshwater fish.

**Key words:** freshwater fish; heavy metal pollution; arsenic; safety evaluation; standard limit value

# 二元系统 RstA/RstB 对病原性嗜水气单胞菌胞内存活的影响及机制

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**摘要：**比较转录组分析验证及表型研究发现，*rstA* 及二元系统 RstA/RstB 在嗜水气单胞菌抵御宿主细胞损伤维持胞内存活中发挥重要作用，其调控嗜水气单胞菌在宿主吞噬细胞中存活的机制主要是通过参与调控嗜水气单胞菌胞内抗环境压力胁迫、铁的摄取和代谢、及 VI 型分泌系统的合成。

**关键词：**嗜水气单胞菌；鱼类吞噬细胞；*rstA*；胞内存活；

## The role and mechanism of two-component system RstA/RstB on intracellular survival of Pathogenic *Aeromonas hydrophila*

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**Abstract :** *Aeromonas hydrophila* is widely distributed in freshwater, silt, human feces and other environments. It is a typical zoonotic pathogen of human, fish and livestock. It is also one of the most common pathogens in aquaculture, which once caused huge economic losses to aquaculture. Scholars have made great progress in the study of *A. hydrophila*, but its pathogenic mechanism has not been fully elucidated. Our previous studies showed that *A. hydrophila* B11 strain, a pathogenic bacterium isolated from diseased *Anguilla anguilla*, could survive in fish macrophages for at least 24 h. These results suggested that *A. hydrophila* B11 has some ability of resisting macrophage damage. This may be one of the reasons that it is difficult to control the diseases caused by this bacterium and the emergence of drug-resistant strains. However, there are only a few reports on the survival of *A. hydrophila* in phagocytes.

In this study, comparative transcriptome analysis and biological characteristics results suggested that the two-component system RstA/RstB can regulate the resistance of *A. hydrophila* to environmental stress, iron intake and metabolism, and synthesis of type VI secretion system. So RstA/RstB can help *A. hydrophila* to resist acid and ROS stress, to uptake and metabolism iron under the condition of limiting iron concentration in cells, and help the formation and assembly of VI secretion system, and ultimately affect the survival ability of *A. hydrophila* in host phagocytes.

**Key words::** *Aeromonas hydrophila*; Fish macrophages; *rstA*; Intracellular survival

# 空气暴露对大鳞副泥鳅免疫反应的影响

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**摘要:** 将大鳞副泥鳅暴露于空气后检测其血清和肝脏免疫指标变化。结果表明空气暴露显著增加了血清总蛋白、白蛋白、球蛋白和 IgM 含量, 但对溶菌酶影响均不显著。补体 C3 和 C4 均呈先升后降的变化趋势。HSP70 和 HSP90 在血清中于 48 h 升高至基础水平的 3.3 倍和 2.0 倍。血清炎症因子随着暴露时间呈先升后降的趋势; 肝脏 TNF- $\alpha$  和 IL-1 $\beta$ , IL-6 和 IL-12 在暴露 12 h 分别升至基础水平的 1.4 倍, 1.5 倍。

**关键词:** 氨累积、大鳞副泥鳅、气呼吸型鱼类、免疫抑制、氨解毒

## Effects of acute aerial exposure on immune response in large-scale loach *Paramisgurnus dabryanus*

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**Abstract:** *Paramisgurnus dabryanus* was exposed to air to evaluate the changes in serum and liver immune indicators (total protein, albumin, globulin, IgM, lysozyme, C3, C4, HSP70, HSP90, TNF- $\alpha$ , IL-1 $\beta$ , IL-6 and IL-12). The contents of serum total protein, albumin and globulin in *P. dabryanus* were significantly higher than in the control group. There were no changes in serum and hepatic lysozyme activities during the experimental period. During various period of aerial exposure, serum and hepatic C3 and C4 contents first increased slightly and then decreased. In response to 48 h of aerial exposure, the serum HSP70 and HSP90 concentrations reached maximum values that were 3.3-fold and 2.0-fold, respectively. The HSP70 and HSP90 contents in liver increased significantly after 12 h of air exposure, and then decreased rapidly to the basal level. After various periods of aerial exposure, all the measured serum inflammatory cytokines displayed a similar temporal pattern, remarkably increased at first and then decreasing. After 12 h of air exposure, the TNF- $\alpha$  and IL-1 $\beta$  contents in liver increased by 1.4-fold, IL-6 and IL-12 increased by 1.5-fold. most of the measured immune indicators declined at the later stages of the present experiment, suggesting that the immune response induced by ammonia accumulation had been mitigated. According to our results, this mitigation could be attributed to several ammonia defensive strategies in this species.

**Key words:** : ammonia accumulation, *Paramisgurnus dabryanus*, air-breathing fish, immunosuppression, ammonia detoxification

# 红细胞的抗菌活性与吞噬和呼吸爆发有关

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**摘要：**众所周知，红细胞负责气体运输。最近的报道描述了红细胞的免疫特性，因此对红细胞的功能有了新的认识。本研究中，我们使用胡子鲶的红细胞作为模型，证明红细胞具有对乳胶珠和细菌的吞噬能力。在细菌刺激下，红细胞产生对细菌有害的活性氧和一氧化氮合酶。同时，抗氧化酶的表达水平显著升高。结果表明，硬骨鱼红细胞具有吞噬能力，并产生对细菌有毒的 ROS。此外，红细胞拥有抗氧化系统，可以清除多余的 ROS，使细胞免受氧化损伤。

**关键词：**胡子鲶；抗菌活性；RBCs；活性氧；抗氧化酶；吞噬作用

## The antibacterial activity of erythrocytes from *Clarias fuscus* is associated with phagocytosis and respiratory burst generation

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**Abstract :** It is widely known that red blood cells (RBCs) are responsible for respiration and the transport of gas. However, recent reports have also described the immune properties of RBCs, therefore creating new understanding for the functionality of RBCs. In this study, we used RBCs from *Clarias fuscus* as a model and demonstrate that these cells exhibited phagocytic ability with both latex beads and bacteria. In response to bacterial stimulation, RBCs produced reactive oxygen species (ROS) and nitric oxide synthase (NOS), which are harmful to bacteria. RBCs also have an antioxidant system. Under conditions of oxidative stress, the expression levels of antioxidant enzymes, and particularly those of superoxide dismutase (SOD) increased significantly. Our results show that the erythrocytes of bony fish are phagocytic and also produce ROS which are toxic to bacteria. In addition, RBCs have an antioxidant system that removes excess ROS production to protect cells from oxidative damage.

**Key words::** *Clarias fuscus*; antibacterial activity; RBCs; ROS; antioxidant enzymes; phagocytosis

# 养殖三疣梭子蟹寄生异阿脑虫病原鉴定 和防治策略研究

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**摘要:** 自 2017 年, 浙江某养殖场的三疣梭子蟹因一种纤毛感染死亡。首先, 将分子生物学和生物信息学分析结果与显微和超微结构特征相结合, 以探明其生物学特征, 确定该虫为异阿脑虫属一未知种的纤毛虫; 另外, 通过回感实验证明该虫为引起三疣梭子蟹死亡的真正病原。为了找到有效的抗虫药物和建立安全高效的防治方法, 本研究筛选到了硫酸奎宁等, 并分别开展体外杀虫实验和养殖蟹异阿脑虫病的药物防、治实验, 并证明效果显著。

**关键词:** 三疣梭子蟹; 异阿脑虫; 奎宁; 防控

## Isolation, characterization and virulence of *Mesanoophrys* sp. (Ciliophora: Orchitophryidae) in farmed swimming crab (*Portunus trituberculatus*) and anti-parasitic effects of quinine sulfate

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**Abstract:** A disease outbreak occurred in swimming crab (*Portunus trituberculatus*) farmed in eastern China, with a mortality rate of more than 80%. To further investigate the characteristics and pathogenesis, we reported isolation, characterization and virulence of the causative agent of this disease from 10 sick crabs. The results of the morphological study confirmed that the ciliate was similar to *Mesanoophrys* ciliates and *O. stellarum* cultured in supportive media, but different from *O. stellarum* cultured in living sperm cells of starfish (*Leptasterias* spp.). Also, the growth of the ciliate did not interfere with light, which was different from *O. stellarum*. Accordingly, the ciliate was classified as genus *Mesanoophrys* and temporarily named as *Mesanoophrys* sp. In addition, experimental infection confirmed that *Mesanoophrys* sp. was the pathogen that infected farmed crabs. The anti-parasitic effects and toxicity of quinine sulfate on *Mesanoophrys* sp. were investigated. Quinine sulfate can kill *Mesanoophrys* sp. by interacting with the DNA, mitochondria and cell membrane of parasites. Also, quinine sulfate can prevent the infection of crabs and treat the *Mesanoophrys* sp. disease in aquaculture. It is possible, therefore, to combine the prevention and treatment in production, kill pathogens by drugs in the water during the high incidence of the disease and maintain a suitable environment for preventing the spread and infection of pathogens. In addition, early detection and treatment of the diseases

**Key words:** *Portunus trituberculatus*; *Mesanoophrys* sp.; Quinine sulfate; Prevention Treatment

# 一株松鼠葡萄球菌 JS-1 对鲫的致病性及其灭活疫苗保护作用研究

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**摘要:** 为探究 JS-1 对鲫的致病性及其灭活疫苗保护作用, 我们设计三种试验。结果显示, 急性毒性试验中鲫全身性出血, 96 h LD<sub>50</sub> 为  $5 \times 10^6$  cell/mL。慢性毒性试验血清中转氨酶先增加后减少, 溶菌酶显著升高; 肝脏和脾脏中 TNF- $\alpha$  和 IFN- $\gamma$  基因表达量显著升高。注射灭活疫苗后, 血清中特异性 IgM 和总 IgM 显著增加, 10 天后存活率达 83.3%。表明 JS-1 对鲫的致病性强, 其灭活疫苗可为鲫提供有效的保护。

**关键词:** 松鼠葡萄球菌; 免疫基因表达; 非特异性免疫; 灭活疫苗

## Pathogenicity and Inactivated Vaccine Protection of *Staphylococcus sciuri* JS-1 on Crucian Carp

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**Abstract:** In order to explore the pathogenicity of JS-1 on crucian carp *Carassius auratus* and the protective effect of its inactivated vaccine, we designed three kinds of experiments. Results showed that in the acute toxicity test, there was systemic hemorrhage in crucian carp, and the 96-hour LD<sub>50</sub> was  $5 \times 10^6$  cells/mL. In the chronic toxicity test, the transaminase in serum increased at first and then decreased and the activity of lysozyme was significantly increased. The expression of TNF- $\alpha$  and IFN- $\gamma$  genes in the liver and spleen of crucian carp were significantly increased than that of the control group. After injection of the inactivated vaccine, the specific IgM and total IgM in the serum immunized with inactivated vaccine were significantly higher than those in the control group, and the survival rate of crucian carp reached 83.3% on 10th day after injection. This study shows that *S. sciuri* JS-1 is highly pathogenic to crucian carp, and its inactivated vaccine can provide effective protection for crucian carp.

**Key words:** *Staphylococcus sciuri*; pathogenicity; immune gene expression; non-specific immunity; inactivated vaccine.

# 基于转录组测序分析重金属铜对黄鳝肝脏脂代谢的影响

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**摘要:** 本研究将黄鳝分别暴露于含  $\text{Cu}^{2+}$  浓度为 0、100 及 400  $\mu\text{g/L}$  的水体中 96 h, 采用转录组学测序分析了肝脏脂代谢相关基因表达的变化。结果显示, 100 和 400  $\mu\text{g/L}$  组分别有 29 和 74 个与脂代谢相关的 DEGs, GO 功和 KEGG 分析显示, 两组中与脂代谢相关的 DEGs 主要富集在 PPAR 信号通路和脂肪酸降解通路上, 且大量脂代谢降解相关基因表达上调。以上结果表明, Cu 急性暴露可对脂肪酸的沉积产生影响。

**关键词:** 黄鳝; 铜; 转录组; 脂代谢

## Transcriptome profiling provides insights for understanding the effects of copper on hepatic lipid metabolism in swamp eel

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**Abstract:** Swamp eel (*Monopterus albus*) exposed to waterborne  $\text{Cu}^{2+}$  concentrations of 0, 100, and 400  $\mu\text{g/L}$ , respectively, for 96 h, and the changes of hepatic lipid metabolism related genes were analyzed based on transcriptional analysis. 29 DEGs and 74 DEGs were related to lipid metabolism in 100 and 400 $\mu\text{g/L}$ , respectively. GO term and KEGG pathway enrichment analyses revealed that DEGs related to lipid metabolism in two  $\text{Cu}^{2+}$  group were mainly enriched in PPAR signaling and fatty acid degradation pathways. And the expressions of major genes related to fatty acid degradation were up-regulated. These results suggest that Cu toxicity affected fatty acid deposition in swamp eel, the findings provide important references for further study on the regulation mechanism of Cu-induced fish lipid metabolism disorder.

**Key words:** Swamp eel; Copper; Transcriptomics; Lipid metabolism

## 五、可持续捕捞



# 基于北斗船位数据的南海大型灯光罩网渔业研究

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**摘要：**基于北斗船位数据的渔船监测系统可通过船位特征反映渔船作业特点，为渔业资源的开发管理提供科学依据。对2018年南海外海大型灯光罩网渔业进行了分析。结果显示，北斗船位监控系统共记录来自广东、广西、海南三省区的121艘大型灯光罩网渔船的8 821 681条船位记录，平均每天每艘船406条。北斗船位监控系统记录船位信息的频次在省份间存在差异，且外海明显多于近岸。根据船位数据可判断大型灯光罩网的作业天数及位置变化。其中渔船春季主要在南沙海区作业，夏季主要在珠江口外海，秋冬季在北部湾和中、西沙海区。大型灯光罩网渔船在2018年共作业19986d，作业天数从高到低依次为春季7768d(38.87%)、秋季4738d(23.71%)、冬季4406d(22.04%)、夏季3074d(15.38%)。此外，还探讨了应用北斗船位监控系统监测大型灯光罩网渔船的优势与不足。

**关键词：**北斗渔船监测系统；船位数据；大型灯光罩网

## An investigation of large-size light falling-net fishing vessels operating in South China Sea based on Beidou VMS data

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**Abstract:** Beidou vessel monitoring system (VMS), which can be used to monitor fishing operations of the vessels, has the potential to provide scientific foundation for management of the fishery. We explored the large-size light falling-net fishery in the South China Sea based on VMS data in 2018. The Beidou VMS obtained a total of 8 821 681 records of 121 vessels from Guangdong, Guangxi and Hainan Provinces, with an average of 406 records per vessel per day. There is difference in the frequency of Beidou VMS transmission among the vessels from different provinces, and VMS signals were more frequently transmitted when a vessel was operating in the open South China Sea than when it was fishing along the coast. The vessels mainly operated fishing in the Nansha Islands in spring, off the Pearl River mouth in summer, and in the Beibu Gulf and Zhongsha and Xisha Islands waters in autumn and winter. In 2018, the vessels operated 19 986 fishing days in the South China Sea, decreasing from 7 768 d (38.87%) in spring, 4 738 d (23.71%) in autumn, 4 406 d (22.05%) in winter to 3 074 d (15.38%) in summer. Moreover, we discussed the advantages and disadvantages of Beidou VMS in monitoring the large-size light falling-net vessels. It is showed that using Beidou VMS to study the large-scale light falling-net vessel in the South China Sea can monitor their spatial distribution and dynamic changes quickly and comprehensively.

**Key words:** Beidou VMS; vessel position data; large-size light falling-net fishery; South China Sea

# 南海北部马面鲷资源利用状况研究

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**摘要:** 摘要: 限额捕捞制度的逐步实施,标志我国进入全面有序管理渔业资源的新时期。根据2009—2019年南海北部渔港渔业生产抽样调查数据,利用剩余产量模型和Kobe图分析马面鲷目前的资源利用状况。统计得出南海北部的马面鲷(Thamnaconus)的产量主要来自单拖,占总产量的65.50%。剩余产量模型分析结果显示南海北部马面鲷的最大可持续产量在73913.73~237211.25 t,平均为111772.83 t。2012年、2013年、2016年的产量超过了平均最大可持续产量,表明当年发生了过度捕捞,该鱼种的总可捕量可设为 $8 \times 10^4$  t。本研究结果可为南海北部马面鲷资源的管理和保护提供借鉴。

**关键词:** 关键词: 马面鲷; 剩余产量模型; 总可捕捞量; 南海北部

## Stock assessment of *Thamnaconus* in the northern South China Sea

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**Abstract:** Abstract: The gradual implementation of quota fishing system marks that China has entered a new period of comprehensive and orderly management of fishery resources. Based on the data of sampling survey of fishery production at fishing ports along the northern South China Sea from 2009 to 2019, the current resource utilization status of *Thamnaconus* was analyzed by using the surplus production model and Kobe plot. The production of *Thamnaconus* is mainly from otter trawler, accounting for 65.50% of the total catch. The maximum sustainable yield of *Thamnaconus* ranged from 73913.73 to 237211.25 tons, with an average of 111772.83 tons inferred by surplus production models. The catch of 2012, 2013, and 2016 was above the average MSY indicated by models that meant overfishing in the year, and therefore the current total allowable catch could be set to  $8 \times 10^4$  tons. The results of the study can provide reference for the management and protection of *Thamnaconus* in the northern South China Sea.

**Key words:** Keyword: *Thamnaconus*; surplus production model; total allowable catch; the northern South China Sea

# 拉尼娜事件前后北部湾鱼类群落结构变化研究

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**摘要:** 根据 2006、2008 年 7 月北部湾底拖网调查数据, 分析拉尼娜事件前后鱼类群落结构变化特征。结果表明, 2006 年夏季优势种为发光鲷、竹荚鱼, 2008 年夏季优势种为竹荚鱼、蓝圆鲹、发光鲷和二长棘犁齿鲷, 竹荚鱼和发光鲷为两航次共有优势种。多样性指数 ( $H'$ ) 与均匀度指数 ( $E1$ ) 在年际间差异不显著, 丰富度指数 ( $D'$ ) 差异显著。以发光鲷为代表的暖温性鱼类资源密度下降; 以竹荚鱼、蓝圆鲹为代表的暖水性鱼类资源密度升高, 并向北部湾沿岸方向转移, 北部湾沿岸站点 (C1—C22) 的各指数在拉尼娜事件发生前后具有显著性差异 ( $P<0.05$ )。聚类分析和非线性多维尺度排序结果表明, 鱼类群落空间分布较为稳定, 主要差异在海南岛西部沿岸。在捕捞压力相对稳定的情况下, 研究认为北部湾鱼类群落结构在拉尼娜事件前后存在显著的年际变化和物种更替现象。

**关键词:** 拉尼娜事件; 鱼类群落; 生物多样性; 优势种; 北部湾

## Variations in fish community structure before and after La Niña event in the Beibu Gulf

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**Abstract:** Based on the bottom trawl survey data of fishery resources in July 2006 and July 2008, variations in fish community structure before and after La Niña event in the Beibu Gulf were analyzed. In the summer of 2006, the dominant fish species are *Acropoma japonicum* and *Trachurus japonicus* while in the summer of 2008, the dominant fish species are *A. japonicum*, *Decapterus maruadsi*, *T. japonicus* and *Eynniss cardinalis*. *A. japonicum* and *T. japonicus* are the common dominant species in the two years. After the La Niña event, the density of warm-water fish resources, such as *T. japonicus* and *D. maruadsi*, increased while the density of warm-water fish resources, such as *A. japonicum*, decreased. The diversity index of the Beibu Gulf coastal sites (C1—C22) is significantly different before and after the La Niña event ( $P<0.05$ ), while the central and southern sites (S1—S30) have no significant difference ( $P>0.05$ ). The results of cluster analysis and non-metric multidimensional scale ranking show that the spatial distribution of fish communities is relatively stable, with the main differences being along the western coast of Hainan Island. In the case of relatively stable fishing pressure, this study suggests that the significant changes in fish community structure in Beibu Gulf are closely related to the La Niña event.

**Key words:** La Niña event; Community structure; Biodiversity; dominant species; Beibu gulf

# 南海扁舵鲹资源时空分布特征 及其影响因素分析

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**摘要：**扁舵鲹被认为是中国南海外海的潜在海洋资源。然而，我们对其栖息地、渔场的时空分布和对环境变化的响应知之甚少。基于渔业调查和遥感数据，我们应用地统计模型、GAM模型和HSI模型探究南海扁舵鲹分布及其与环境因素之间的关系。结果表明，南海扁舵鲹总体分布以低密度为主，高密度海域较少，具有西南—东北洄游的特征，空间布局呈片状和斑块状；影响扁舵鲹栖息地的显著环境因素在不同季节是不同的。

**关键词：**扁舵鲹；渔场；栖息地；南海；海洋环境；

## **Analysis of the spatial and temporal distribution characteristics of Auxis Thazard in the South China Sea and its influencing factors**

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**Abstract:** Frigate tuna (*Auxis thazard*) fishery is considered a potential marine resource in the open South China Sea (SCS). However, little is known about the spatial and temporal distribution of its habitat and fishing grounds and their response to environmental changes. Based on fishery surveys and remote sensing data, we applied geostatistical, GAM and HSI models to investigate the distribution of *Auxis thazard* in the South China Sea and its relationship with environmental factors. The results showed that the overall distribution of the *Auxis thazard* in the SCS was mainly low-density, with fewer high-density areas, with southwest-northeast migratory characteristics and a patchy and spatial layout; the significant environmental factors affecting the habitat of the bonito were different in different seasons.

**Key words:** *Auxis thazard*; Fishing grounds; Habitat; South China Sea; Ocean environment;

# 大食物观视角下渔业捕捞存在的问题及法律对策研究

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**摘要：**2022年3月6日，习近平总书记在出席政协农业界、社会福利和社会保障界委员联组会时提出“树立大食物观，向江河湖海要食物”。我国地域辽阔，江河湖海众多，水产品资源丰富。要树立大食物观，顺应大众饮食结构的变化趋势，更好地保障膳食营养搭配平衡，水产品作为主要的优质动物性蛋白，为促进食物供给从单一生产向多元供给发展提供重要支撑。本文从树立大食物观视角出发，具体分析渔业资源可持续捕捞面临的捕捞强度大、渔业资源枯竭及执法难度大的问题，提出加强对非法捕捞行为的监管、均衡捕捞及加大渔业执法力度的建议。为保护环境本身和人类的整体及长期利益，可持续渔业是现代渔业治理的必然要求。

**关键词：**大食物观；可持续捕捞；渔业

## Study on the problems and legal countermeasures of fishery from the perspective of big food concept

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**Abstract :** Our country has a vast territory, many rivers, lakes, and seas, and aquatic products resources rich. It is necessary to establish a big food concept, conform to the changing trend of the public diet structure, and better guarantee the balance of dietary nutrition. Aquatic products, as the main high-quality animal protein, provide important support for promoting the development of food supply from single production to multiple supplies. From the perspective of building a big food view, this paper analyzes the problems of high fishing intensity, depletion of fishery resources, and difficulty law enforcement faced by sustainable fishing of fishery resources, and puts forward suggestions on strengthening the supervision of illegal fishing behavior, balanced fishing and strengthening the law enforcement of fishery. To protect the environment itself and the overall and long-term interests of human beings, sustainable fishery is the inevitable requirement of modern fishery management.

**Key words::** Big food view; Sustainable fishing; fisheries

# 基于正交实验法的双翼型网板 水动力性能研究

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**摘要：**采用正交实验法研究展弦比、前翼板弯度以及前后翼板的水平间距对双翼型网板水动力性能的影响。通过风洞试验获取 9 块模型网板的阻力系数、升力系数，并计算得到升阻比。选取工作冲角  $30^\circ$  对应的升阻比作为考察指标，分别采用直观分析法和方差分析法对实验数据进行分析，得到优化网板参数为展弦比（2.0）、前翼板弯度（0.16）、间距比（0.35），以展弦比对网板性能的设计影响最为显著。

**关键词：**正交实验法；网板；风洞试验；水动力性能

## Research of hydrodynamic performances of double-vane otter-board with orthogonal design

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**Abstract:** Orthogonal experiment method was used to study the influence of aspect ratio, front wing plate camber and horizontal spacing of front and rear wing plates on the hydrodynamic performance of double airfoil mesh panels, the drag coefficient of 9 models board obtained through wind tunnel test, lift coefficient and the lift-drag ratio which is obtained by calculating. The lift-to-drag ratio corresponding to the working attack angle of  $30^\circ$  is selected as the inspection index, and the experimental data are analyzed by the intuitive analysis method and the variance analysis method. The conclusions drawn by the two methods are consistent, indicating that the orthogonal experimental study optimizes the screen parameters for aspect ratio (2.0), front wing plate camber (0.16), and pitch ratio (0.35). The aspect ratio is used to design the performance of the screen. The impact is the most significant.

**Key words::** orthogonal design; otter board; wind tunnel test; hydrodynamic performance

# 张网选择性捕捞生物经济效益评估

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**摘要:** 张网是海州湾小黄鱼资源的重要开发网具, 张网渔具长期的选择性捕捞会导致小黄鱼种群特征发生变化。渔获物数量和个体尺寸差异是影响小黄鱼渔业经济效益的重要因素, 为权衡渔获物数量和质量所导致的经济收益差异, 本研究通过构建生物经济模型, 模拟不同捕捞情景下小黄鱼种群特征变化和经济效益差异, 旨在得出在小黄鱼资源可持续利用基础上效益最大时的捕捞情景。本研究为海州湾张网渔业的合理开发和资源可持续利用提供理论依据。

**关键词:** 生物经济效益模型、小黄鱼、张网、选择性捕捞

## The bioeconomic assessment of stow net selective harvest

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**Abstract:** Stow net is an important fishing gear for the exploitation of small yellow croaker fishery in Haizhou Bay, China, and the long-term selective harvest of stow net effects the characteristics of small yellow croaker population. The number and individual size variation of catch are important factors that affect the economic benefits of small yellow croaker fishery. To tradeoff the economic benefits difference caused by the quantity and quality of catch, this study develops a bioeconomic model and simulates the differences of population dynamics and economic benefits of small yellow croaker under different fishing scenarios, and aims to obtain the fishing scenario that achieve maximum benefits as well as realize sustainable utilization of small yellow croaker resources. The results provide a theoretical basis for the rational development and sustainable utilization of stow net fishery in Haizhou Bay.

**Key words:** bioeconomic model, small yellow croaker, stow net, selective harvest

# 电子监控技术在海洋捕捞渔船管理中的应用

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**摘要：**随着渔业信息化和规范化快速发展，各渔业国需要更多的数据来监测和规范渔业捕捞，电子监控系统 EM（Electronic monitoring）成为人类观察员的有效替代或辅助方案，国内外已经有多个相关案例。人工智能在 EM 信息处理中发挥了重要作用，可快速提取捕捞作业信息，有利于辅助渔业企业规范化管理，为电子观察员技术应用提供技术参考。

**关键词：**电子监控；海洋捕捞；渔船管理

## Application of electronic monitoring technology in the management of marine fishing vessels

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**Abstract :** With the rapid development of fishery informatization and standardization, fishery countries need more data to monitor and regulate fishery fishing. Electronic monitoring system EM (electronic monitoring) has become an effective alternative or auxiliary scheme for human observers. There have been many relevant cases at home and abroad. Artificial intelligence plays an important role in EM information processing. It can quickly extract fishing operation information, assist fishery enterprises in standardized management, and provide technical reference for the application of electronic observer technology.

**Key words::** Electronic monitoring; Marine fishing; Fishing vessel management



# 中西太平洋鲣鱼资源的时空分布研究及不同捕捞方式的影响

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**摘要:** 用 2014-2019 年围网捕捞数据, 对中西太平洋鲣鱼自由、天然流木和人工集鱼装置鱼群 (FADs) 捕捞分析。其作业渔场主要分布于东经 135°-175°、西经 150°-180° 和北纬 0°-10°, 南纬 5°-15° 海域。自由鱼群高网次产量海域在东经 135°, 西经 160°-180°; 天然流木鱼群在东经 170°-175, 西经 180°; FADs 在西经 150°-180°。灰色关联分析表明 2019 年鱼资源状况最好。

**关键词:** 远洋渔业; 热带金枪鱼; 渔场分布; 灰色关联分析法

## Spatial and temporal distribution of Skipjack tuna fisheries in the Western and Central Pacific with the influence of different fishing methods

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**Abstract:** The purse seine fishing of Skipjack tuna *Katsuwonus pelamis* is mainly divided into fishing free school, fishing Natural-Log schools and Fishing Aggregation Devices schools. The distribution of catch and effort of Skipjack tuna purse seine fishery were investigated in the Western and Central Pacific Ocean from 2014 to 2019, considering the influence of fishing methods. The resource status was also explored by the Grey Relational Analysis method for Skipjack tuna. The results showed that the fishing grounds for Skipjack tuna in the Western and Central Pacific Ocean were mainly distributed in the sea area of 135°E -175°E and 150°W-180°W in longitude, 0°N-10°N and 5°S-15°S in latitude. The high yield per net of Skipjack tuna free schools is mainly located at 135° E and 160°-180° W. The high net yield of natural-log schools is mainly in the sea areas of 170° E -175E and 180° W. The high net yield of the FAD schools is mainly in the sea area of 150°-180° W. Grey Relational Analysis shows that the status of Skipjack tuna resources in 2019 was the best.

**Key words:** Distant-water Fisheries; Tropical tuna; Fishing Ground; Grey Relational Analysis

# 基于贝叶斯状态空间产量模型的印度洋剑鱼资源评估

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**摘要：**基于贝叶斯状态空间剩余产量模型对印度洋剑鱼的资源状况进行评估,并进行了敏感性和回顾性分析。结果表明环境承载力估计为 24 千吨。内禀增长率估计为 0.37，最大可持续产量估计为 30707t。回顾性分析表明，回顾性问题可以忽略不计，敏感性分析表明，评估结果对  $r$  先验存在一定敏感性。TAC 设置为 32000t，预测到 2028 年前仍保持健康状态。评估结果与 IOTC 现有评估结果基本一致，可以为管理决策提供建议。

**关键词：**剩余产量模型；印度洋剑鱼，敏感性分析；回顾性分析

## Stock assessment for Indian Ocean Swordfish based on Bayesian state-space production model

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**Abstract：** The resource status of Indian Ocean swordfish was assessed based on a Bayesian state-space production model, and sensitivity and retrospective analyses were conducted. The results showed that the environmental carrying capacity was estimated to be 24 kt. The intrinsic rate was estimated to be 0.37 and the maximum sustainable yield was estimated to be 30,707 t. Retrospective analysis showed that retrospective issues were negligible and sensitivity analysis showed that the assessment results were somewhat sensitive to the prior  $r$ . the TAC was set at 32,000 t and was projected to remain healthy until 2028. The assessment results are generally consistent with the existing assessment results of IOTC and can provide suggestions for management decisions.

**Key words：** surplus production model ; Indian Ocean Swordfish ; sensitivity analysis ; retrospective analysis

# 北太平洋中西部剑鱼管理策略评价

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**摘要：**剑鱼是远洋渔业重要目标渔获物和兼捕种类，本文使用 1951 年-2018 年渔获量数据，通过先验参数设置构造操作模型模拟北太平洋中西部剑鱼的种群动态和渔业动态，通过不同管理策略捕捞规则计算对数据和参数要求筛选出 9 种备选管理策略并对其管理效果进行量化分析，并对短期和长期产量进行预测。使用 Kobe 图表达管理策略实施前后资源状况变化，通过结果比对，最终确定使用根据时间序列平均值和标准误差指数来调整渔获量。

**关键词：**剑鱼；管理策略评价，敏感性分析；管理策略权衡

## Management Strategy Evaluation of Swordfish in the Western and Central North Pacific Ocean

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**Abstract :** As a highly migratory fish species. Based on stock assessment result of International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) with catch data from 1952 to 2018, we built up Operating models in which stock dynamics of swordfish in Western and Central North Pacific Ocean was defined by setting priori parameters. Nine alternative Management Procedures (DD, DD4010, CC1, SBT1, GB\_slope, ICI, ICI2, SPmod and MCD) were chosen to be tested in our simulation circulation with 48 simulations for 50 years projection of yield. Through the priors of the time series and trade-offs on management procedures, the impact on stock status with the implementation of management procedures was intuitively represented by generating Kobe plots and ICI was finally determined as the best management strategy.

**Key words: :** swordfish; management strategy evaluation; management strategy trade-off; sensitivity analysis

# 中西太平洋大眼金枪鱼渔场重心 时空分布研究

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**摘要：**摘要：中西太平洋是金枪鱼作业的主要渔场，研究该海域大眼金枪鱼的时空分布规律，为大眼金枪鱼渔情预报研究提供数据支持，并为其今后的可持续发展与管理提供科学依据。根据中西太平洋金枪鱼资源保护委员会（WCPFC）提供的 2009-2018 年中西太平洋大眼金枪鱼捕捞生产统计数据，对各年各月的大眼金枪鱼捕捞量和捕捞努力量渔获量（CPUE）进行时空统计分析，通过计算产量重心，找出渔场重心变化规律。

**关键词：**中西太平洋；大眼金枪鱼；渔场重心；时空分布

## Study on the spatial and temporal distribution of the center of gravity of bigeye tuna fisheries in the Central and Western Pacific Ocean

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**Abstract :** Abstract: The Central and Western Pacific Ocean is the main fishing ground for tuna operations, and the spatial and temporal distribution patterns of bigeye tuna in this area are studied to provide data support for bigeye tuna fishing forecast studies and provide scientific basis for its future sustainable development and management. Based on the statistical data of bigeye tuna fishing production in the Western and Central Pacific Ocean from 2009 to 2018 provided by the Western and Central Pacific Ocean Tuna Resources Conservation Commission (WCPFC), the spatial and temporal statistics of bigeye tuna catch and fishing effort catch (CPUE) in each month of each year were analyzed to find out the pattern of changes in the center of gravity of the fishery by calculating the center of gravity of production. The fluctuations of yield and average CPUE of bigeye tuna in the Central and Western Pacific Ocean were generally consistent, except for 2007; the differences between yield and CPUE of each month were small, and the high yielding months were mainly concentrated in the second half of the year; the center of gravity of the fishery was between 9°S-14°S and 153°E-157°E in all years, and the center of gravity of the fishery shifted eastward in the longitude direction in 2015 due to the influence of strong El Niño; the center of gravity of yield of each month The change of the center of gravity of production in each month shows a clockwise change pattern, with the center of gravity o

**Key words: :** Keywords: Central and Western Pacific Ocean; bigeye tuna; center of gravity of fishing grounds; spatial and temporal distribution

# 基于鱼类身体状况的种群繁殖潜力评估研究-以星康吉鳗为例

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**摘要:** 本文研究了星康吉鳗的繁殖力与产卵潜力比(SPR)。结果显示其繁殖力与体长和身体状况呈正相关, 表明其繁殖策略受体长和身体状况驱动。运用单位补充量模型检验了身体状况对SPR相关管理参考点的影响, 结果表明该种群面临过度捕捞的风险, 且鱼类状况对管理参考点的估计有很大影响。例如, 当肝指数(HSI)从0.6%上升到1.8%, F40%上升91%。此外, 使用产卵群体生物量计算F40%产生约23%的偏差。

**关键词:** 产卵潜力比, 繁殖力, 身体状况, 限捕规格, 星康吉鳗

## Accounting for the fish condition in assessing the reproductivity of a marine eel to achieve fishery sustainability

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**Abstract:** Spawning potential ratio (SPR) is a commonly used biological reference point to inform management decisions; however, the fish reproductivity may vary substantially with different body conditions, and the variability has not been well understood. Here, we examined the maturity, fecundity, and SPR of a marine eel *Conger myriaster*. The results showed that total fecundity increased with length and hepatosomatic indices (HSI), whereas relative fecundity (total fecundity/body weight) decreased with body weight, suggesting length- and condition-driven reproductive strategies. A length-structured per-recruit model was used to estimate SPR and examine the influence of HSI in resultant management decisions. Our results suggested that this stock was subject to a high risk of recruitment overfishing. Fish condition greatly influences the estimates of SPR-related reference points. For example, when HSI increased from 0.6% to 1.8%, F40% increased by 91%. In addition, using spawning stock biomass to calculate F40% could produce a bias of 23%. We highlight the need for monitoring the changes in fish fecundity and conditions in fisheries assessment, which may contribute to the robust management of data-poor fisheries.

**Key words:** SPR, fecundity, body condition, harvest restriction, *Conger myriaster*

# 热带中西太平洋海域黄鳍金枪鱼的 摄食生物学特性

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**摘要：** 对取样的 919 尾黄鳍金枪鱼叉长进行了组成和性比分析，对其中的 551 尾进行了摄食生物学研究，并使用方差分析(ANOVA)和广义线性混合模型(GLMM)分析了个体叉长、渔获水深、月相等因素对摄食的影响。结果表明：(1)样本叉长范围在 87~163cm，雌雄个体性比为 1: 1.32；(2)GLMM 拟合结果显示，生物因素(叉长和性别)、时空因素(月相的余弦和水深)对黄鳍金枪鱼的摄食强度均具有显著的影响。

**关键词：** 热带中西太平洋；黄鳍金枪鱼；摄食强度；生态位宽度；月相；水深

## Feeding Biology of Yellowfin Tuna (*Thunnus albacares*) in the Tropical Western and Central Pacific Ocean

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**Abstract:** In total, 919 yellowfin tuna individuals were sampled and the size frequency and sex ratio were analyzed. The feeding biology of 551 of yellowfin tuna were studied. The effects of fork length, fishing water depth and lunar phase on feeding biology were analyzed by analysis of variance (ANOVA) and generalized linear mixed model (GLMM). The results show that: (1) the range of fork length was 87~163cm, The sex ratio (female to male) of samples was 1:1.32. (2) The result of GLMM model fit show that biological factors (fork length and gender), spatial and temporal factors (the cosine of lunar phase and water depth) had significant effects on the feeding intensity of yellowfin tuna.

**Key words:** Tropical Western Central Pacific Ocean; *Thunnus albacares*; feeding intensity; niche breadth; lunar phase; depth

# 基于灰色系统理论的北太平洋 柔鱼渔汛特征分析及旺汛期预测

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**摘要:** 柔鱼 (*Ommastrephes bartramii*) 是大洋性经济头足类, 是我国远洋鱿钓渔船重要的捕捞对象之一。分析柔鱼渔汛特征及预测其旺汛期有助于对资源的合理开发与可持续利用。根据 2013—2017 年北太平洋柔鱼渔业生产统计数据, 以每日的单位捕捞努力量渔获量 (CPUE<sub>day</sub>) 作为资源丰度, 利用分位数的方法, 划分旺汛期; 结合灰色波形预测方法对旺汛期日期序列建立 GM (1, 1) 模型群, 对旺汛期出现的时间。

**关键词:** 柔鱼; 渔汛; 旺汛期; 灰色波形预测

## Analysis on fishing seasons characteristics of *Ommastrephes bartrami* and prediction of the main fishing season based on grey system theory

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**Abstract:** *Ommastrephes bartramii* is a kind of oceanic and economic cephalopod, which is one of the important fishing targets for ocean squid fishing vessels in China. Analyzing the characteristics of *Ommastrephes bartrami* fishing seasons and predicting the main fishing seasons are helpful for the rational development and sustainable use of resources. According to the fishing data of neon flying squid from 2013 to 2017, we use the daily unit fishing effort (CPUE<sub>day</sub>) as the resource abundance and use the quantile method to divide the main fishing seasons. The GM (1,1) model group is established for the date series of the main fishing seasons by combining the grey wave forecasting model to predict the time of the main fishing season.

**Key words:** *Ommastrephes bartrami*; fishing seasons; main fishing season; grey wave forecasting

# 西北太平洋沙丁鱼渔场变动及分布格局研究

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**摘要:** 根据 2014—2019 年统计资料, 对西北太平洋沙丁鱼渔场变动特征进行了分析。结果显示: 沙丁鱼渔场沿陆地呈带状分布。除 2015、2017 年外其他年份及各月份之间均存在空间自相关并呈现显著聚集分布模式。年间、月间沙丁鱼渔获量分布的热点区和冷点区均表现出空间集聚特征。年间渔场重心总体上往东北移动, 月间渔场重心先向东北移动, 后向西南折返。渔场年间、月间变动方向均呈西南—东北格局, 方向性、聚集性较强。

**关键词:** 沙丁鱼; 核密度分析; 空间自相关; 标准差椭圆; 渔场重心; 西北太平洋

## Distribution pattern and variation characteristics of *Sardinops sagax* fishing ground in Northwest Pacific based on spatial autocorrelation model

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**Abstract:** Based on the statistics of the light seine fishery in the Northwest China Sea from 2014 to 2019, the temporal and spatial distribution patterns, characteristics and changing trend of *Sardinops melanostictus* fishing ground in the Northwest Pacific Ocean were analyzed. The results showed that sardine fishing ground was zonal distributed along the land, and the output and fishing power decreased gradually from the fishing center to the surrounding area. There is no spatial autocorrelation in 2015 and 2017. There is spatial autocorrelation in other years and months, showing a significant aggregation distribution pattern. The spatial autocorrelation between months is stronger than that between years. The hot spots and cold spots of sardine catches showed a certain spatial concentration during the year and month. However, there were great differences in the distribution areas and areas of hot spots and cold spots in different years and months. During the years, the center of gravity of the fishing ground generally moved to the northeast, and the monthly change showed that the center of gravity first moved to the northeast, reached the northeast end and then turned back to the southwest. The sardine fishing grounds changed in the same direction in the year and month, showing a pattern of southwest to northeast, and directional and fishing ground aggregation were strong.

**Key words:** : *Sardinops melanostictus*; kernel density analysis; Spatial autocorrelation; standard deviation ellipse; barycenter of fishing ground; Northwest Pacific Ocean



# 长江下游虾类群落结构与时空变化

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**摘要：** 安庆的虾类群落生物量和丰度最高，丰富度指数（D）也最高，常熟的虾类群落生物量和丰度最低，在群落相似度上，安庆与常熟相似度最低，当涂与镇江群落相似度最高，具有一定的地理意义。秋季的群落生物量和丰度最高，丰富度指数（D）也最高，冬季的虾类群落生物量和丰度最低，在群落相似度上，冬季与夏季相似度最低，秋季与夏季群落相似度最高。群落更替指数和迁移指数显示，长江下游虾类群落的稳定性以秋季最好、冬季最差。

**关键词：** 长江下游；虾类；生物多样性；群落结构；时空变化

## Community structure and spatio-temporal changes of shrimp in the lower Reaches of the Yangtze River

xing zhao

Lower Yangtze River; Shrimp; Biodiversity; Community structure; Change of time and space

**Abstract :** Anqing had the highest shrimp community biomass and abundance, and the highest richness index (D). Changshu had the lowest shrimp community biomass and abundance. In terms of community similarity, Anqing had the lowest similarity with Changshu, and Dangtu had the highest similarity with Zhenjiang, which had certain geographical significance. The community biomass and abundance were the highest in autumn, and the richness index (D) was also the highest. The community biomass and abundance were the lowest in winter, and the community similarity was the lowest in winter and summer, and the community similarity was the highest in autumn and summer. The stability of shrimp community in the lower reaches of the Yangtze River was the best in autumn and the worst in winter.

**Key words: :** The lower reaches of the Yangtze river; Shrimp; Biodiversity; Community structure; Change of time and space

# 寄生异尖科线虫对长江刀鲚免疫系统的影响

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**摘要:** 采用 ELISA 法分别测定了空白组和寄生组长江刀鲚脾脏、头肾和血清中 7 种免疫分子的表达水平。结果发现, 长江刀鲚 7 种免疫分子因寄生异尖科线虫发生改变, 且在应对不同数量异尖科线虫寄生时会有不同的变化规律, 异尖科线虫寄生既激活了长江刀鲚免疫反应, 而且免疫反应对寄生不同数量的异尖科线虫有着相对应的免疫抵御策略。

**关键词:** 长江刀鲚; 异尖科线虫; 免疫分子; 酶联免疫测定

## The influence of Anisakis nematodes on the distribution of 7 immune molecules

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**Abstract:** To investigate the conventional levels of seven immune molecules, including TH1 cells, MIF, IL-10, TNF $\alpha$ , IgM, IgT and IgD in *Coilia nasus* and the expression caused by Anisakidae-infected. The expressions of seven immune molecules in the spleen, head kidney and serum were measured by ELISA. In conclusion, the seven immune molecules of *Coilia nasus* are changed due to Anisakidae-infected, and there will be different laws in response to the parasitism of different numbers of Anisakidae. Anisakidae-infected not only activates the immune response of *Coilia nasus*, but also has corresponding immune defense strategies against the parasitism of different numbers of Anisakidae.

**Key words:** *Coilia nasus*; Anisakidae; Immune molecules; Enzyme-linked immunoassay

# 基于中国金枪鱼远洋延绳钓渔业的 印度洋鲨鱼副渔获物的上钩死亡率研究

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**摘要:** 摘要: 金枪鱼延绳钓渔业是印度洋的主要渔业之一。本文分析了该渔业 2012 年-2019 年兼捕和丢弃的三种鲨鱼的钩挂死亡率。但该研究仅关注短期的即时死亡率, 而由于潜在的释放后死亡率, 总体死亡率可能更高。这是首次利用中国远洋金枪鱼延绳钓的观测数据来估计挂钩死亡率, 对中国金枪鱼延绳钓渔业在印度洋的管理具有重要意义。

**关键词:** 关键词: 延绳钓; 兼捕; 挂钩死亡率; 印度洋

## Hooking mortality study of shark bycatch in the Indian Ocean based on the Chinese tuna pelagic longline fishery

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**Abstract:** Abstract: The Chinese pelagic tuna longline fisheries in the Indian Ocean primarily targets bigeye tuna (*Thunnus obesus*) and albacore tuna (*Thunnus alalunga*). Pelagic sharks are an important component of this fishery, with some species, such as blue shark, silky shark, and oceanic whitetip, discarded due to management recommendations. This paper analyzes the survival status and hooking (at-haulback) mortality for the three shark species caught and discarded from 2012-2019. However, the study focuses only on short-term immediately mortality, while overall mortality may be higher due to potential post-release mortality, which is not yet known. In conclusion, although preliminary, This is the first study that Chinese pelagic tuna longline observer data in the Indian Ocean was used to estimate hooking (at-haulback) mortality, which is important for the management of Chinese tuna longline fisheries in Indian Ocean.

**Key words:** Key words: longline fishery, bycatch, hooking mortality, Indian Ocean

# 远洋渔船附着生物的群落结构 及多样性研究

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**摘要：**船体生物附着会降低船速和增加油耗,导致运营成本提高,给远洋渔业带来严重危害。本研究以南太平洋海域作业的金枪鱼延绳钓远洋渔船为研究对象,采集附着生物 12 种,优势种为茗荷 *Lepas anatifera*、白刺珊藤壶 *Creusia spinulosa pallida*( $Y=0.153, 0.288$ )。自船首至船尾附着生物覆盖率、生物量、丰度,呈先下降后上升趋势多样性指标在尾舷左侧达到最大值。

**关键词：**远洋渔船;附着生物;群落结构;多样性

## Community structure and diversity of organisms attached to distant-water fishing vessels

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**Abstract :** Vessel organism attachment can reduce vessel speed and increase fuel consumption, leading to higher operating costs and posing serious hazards to pelagic fisheries. In this study, 12 species were collected from tuna longline vessels operating in the South Pacific Ocean, and the dominant species were *Lepas anatifera* and *Creusia spinulosa pallida*( $Y=0.153, 0.288$ ). The coverage rate of adherent organisms was 0.17-95.41%, biomass was 18.33-1120 g/m<sup>2</sup> and the abundance was 11.1-77.78 ind./ m<sup>2</sup>, with a decreasing and then increasing trend(from bow to stern),

the maximum value occurring in the port bilge and the minimum value in the starboard waterline and middle; the three Shannon-Wiener, Margalef and Simpson Diversity indicators reach their maximum on the port side of the stern. The port side of the hull should be strengthened with antifouling measures to reduce bio-adhesion.

**Key words: :** deep-sea fishing vessel;Adherent organisms;Community structure;Diversity;Anti-fouling measures

# 西北太平洋秋刀鱼生长、死亡 及资源状况研究

赵长浩

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**摘要：**秋刀鱼（*Cololabis saira*）又称竹刀鱼，主要栖息于美洲和亚洲的太平洋温带和热带海域，分布在太平洋北部的温带水域，我国海洋渔业中重要的经济鱼种。目前有关太平洋北部秋刀鱼生长、死亡、资源利用状况未见报道。为对其资源状况进行科学评估及资源合理利用，本文应用 2019 年在北太平洋进行捕捞调查所获得的秋刀鱼生物学资料，使用体长频率分析法探究秋刀鱼渔获组成及生长参数；应用 Pauly 经验公式及变化体长。

**关键词：**秋刀鱼，种群组成，生长，死亡，单位补充量渔获量，资源开发利用；

## Study on growth, mortality and resource status of saury in northwest Pacific Ocean

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**Abstract:** *Cololabis saira*, also known as bamboo saira, mainly lives in the Temperate and tropical waters of the Pacific Ocean in America and Asia, and distributes in the temperate waters of the northern Pacific Ocean. It is an important economic fish species in China's Marine fishery. There are no reports about the growth, death and resource utilization of autumn saury in the north Pacific Ocean. In order to scientifically evaluate the resource status and rationally utilize the resource, this paper applied the biological data of saury autumn obtained from the fishing survey in the North Pacific Ocean in 2019 to explore the catch composition and growth parameters of saury autumn by using body length frequency analysis method. The natural death coefficient, fishing death coefficient and total death coefficient were estimated by Pauly empirical formula and catch curve method with varying body length. Based on the catch composition and biological characteristics of Autumn sawordfish, combined with the Beverton-Holt model, the resource utilization situation of autumn sawordfish in the North Pacific Ocean was evaluated according to the catch contour per unit complement and biological reference points  $F_{0.1}$  and  $F_{max}$ , and the effects of fishing opening age and fishing death coefficient on per unit complement were studied and analyzed. And put forward the relevant fishery management plan.

**Key words:** saury, population composition, growth, mortality, catch per unit complement, resource development and utilization;

# 中西太平洋长鳍金枪鱼渔场重心时空分布研究

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**摘要:** 利用统计和 K-means 聚类方法探究长鳍金枪鱼资源时间变化趋势与空间分布特征。研究发现, 长鳍金枪鱼渔场重心主要分布在  $155^{\circ}\text{E}\sim 160^{\circ}\text{W}$ 、 $15^{\circ}\text{S}\sim 30^{\circ}\text{S}$ , 12~翌年 2 月集中在北半球低纬度海域 ( $0^{\circ}\text{N}\sim 10^{\circ}\text{N}$ ), 渔场重心偏西北; 6~8 月集中在南半球低纬度海域 ( $12^{\circ}\text{S}\sim 22.5^{\circ}$ ), 渔场重心偏东南。当 SSTA 整体偏高, 渔场重心零散分布于中部海域; SSTA 相对偏低, 重心向东南与西北两侧偏移。

**关键词:** 中西太平洋; 长鳍金枪鱼; 时空分布; 渔场重心; 聚类分析

## Spatial and temporal distribution analysis of high catch fishing ground for *Thunnus alalunga* in the Western and Central Pacific

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**Abstract:** This paper was based on the world longline fishing data of *Thunnus alalunga* in the Western and Central Pacific Ocean from 2009 to 2018. Combined with the data, the monthly variation trend and spatial distribution characteristics of *Thunnus alalunga* resources were explored by using statistics and K-means clustering method. The spatial and temporal distribution of *Thunnus alalunga* fishing ground gravity center was compared and analyzed, and the relationship between the spatial and temporal distribution of fishing ground gravity center and SSTA was discussed. The results showed that the center of gravity of the fishing ground is mainly distributed in the range of  $155^{\circ}\text{E}\sim 160^{\circ}\text{W}$  and  $15^{\circ}\text{S}\sim 30^{\circ}\text{S}$  during 2009~2018. The fishing ground is mainly concentrated in the low latitude area of the northern hemisphere ( $0^{\circ}\text{N}\sim 10^{\circ}\text{N}$ ) from December to February of the next year, the center of gravity of fishing ground shifts to the northwest. And it is mainly concentrated in the low latitude area of the southern hemisphere ( $12^{\circ}\text{S}\sim 22.5^{\circ}\text{S}$ ) from June to August, the center of gravity of the fishing ground shifted to the southeast. The spatial and temporal distribution of the center of gravity of the fishing ground is significantly affected by the sea surface temperature anomaly. When the SSTA is higher, the center of gravity of the fishing ground is scattered in the central sea area, and when the SSTA is relatively lower, the center of gravity of the fishing ground shifts to the southeast and northwest.

**Key words:** Western and Central Pacific; *Thunnus alalunga*; spatial-temporal distribution; gravity of fishing ground; cluster analysis

# 基于贝叶斯动态产量模型的东、 黄海日本鲈资源评估研究

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**摘要：**随着近海底层经济鱼类的衰退，分布于东、黄海的日本鲈(*Scomber japonicas*)逐渐成为我国主要经济鱼种之一，其资源现状和开发潜力日益受到重视。加强东、黄海日本鲈的资源评估研究是其科学管理与可持续利用的前提与基础。为此，本文基于中国福建、浙江、上海、江苏、山东、河北、天津及辽宁六省二市与日本、韩国日本鲈捕捞产量以及相关文献的资源丰度指数数据，利用贝叶斯动态产量模型对日本鲈进行了资源评估研究。

**关键词：**东、黄海; 日本鲈; 资源评估; 贝叶斯动态产量模型

## Study on the stock assessment of chub mackerel (*Scomber japonicas*) in the East China Sea and Yellow Sea using a Bayesian Biomass dynamic model

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**Abstract :** With the decline of traditional demersal economic species, chub mackerel (*Scomber japonicas*) in the East China Sea and Yellow Sea is becoming one of the major commercial pelagic species in China, and its resource status and exploitation potential are receiving increasing attention. To strengthen the study on the stock assessment of chub mackerel in the East China Sea and Yellow Sea is a prerequisite for its scientific management and sustainable utilization. In this paper, a Bayesian biomass dynamics model was used to assess chub mackerel based on the catch data from six provinces and two cities in China, Japan and Korea, and the abundance index data from the references.

**Key words: :** East China Sea and Yellow Sea; *Scomber japonicas*; stock assessment; Bayesian biomass dynamics model

# 海洋生态系统在不同捕捞水平下的响应

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**摘要：**本文基于 LeMans 模型，探讨了海洋生态系统在不同捕捞水平下的响应。LeMans 模型以物种的生物学参数为基础构建一个海洋生态系统，然后将不同捕捞水平作用于该生态系统，来研究生态系统中种群生物量、体长结构以及整个生态系统结构的变化。结果表明，合理的捕捞水平下生态系统中种群的丰度达到最大，各种群的生物量也达到最高水平，而过度捕捞对海洋生态系统造成的伤害最大，严重影响了生态系统的稳健性。

**关键词：**LeMans 模型；生态系统；捕捞水平

## Response of marine ecosystem under different fishing levels

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**Abstract:** Based on LeMans model, this paper discusses the response of marine ecosystem under different fishing levels. LeMans model constructs a marine ecosystem based on the biological parameters of species, and then acts on the ecosystem with different fishing levels to study the changes of population biomass, body length structure and the structure of the whole ecosystem. The results show that under a reasonable fishing level, the abundance of populations in the ecosystem reaches the maximum, and the biomass of various groups also reaches the highest level. Overfishing causes the greatest damage to the marine ecosystem, which seriously affects the stability of the ecosystem.

**Key words:** LeMans model; Ecosystem; Fishing level



# 运用生物量动态模型的蓝枪鱼资源状况评价

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**摘要：**蓝枪鱼是金枪鱼延绳钓渔业的常见兼捕鱼种，本研究采用 ASPIC 方法对中西太平洋蓝枪鱼的资源状况进行分析。根据 ASPIC 中的不同模式设置了 6 种情景，结果显示，中西太平洋蓝枪鱼的最大可持续产量 MSY 为 19550 公吨， $B1/K=0.543$ ， $F_{msy}=0.236$ 。B2019/BMSY=1.085， $F2019/F_{msy}=1.282$ 。基于 ASPIC 模型所提供的管理参考点参数，本文建议降低当前捕捞死亡率。

**关键词：**运用生物量动态模型的蓝枪鱼资源状况评价

## Stock assessment of Blue marlin (*Makaira nigricans*) in the Indian Ocean using biomass dynamics model

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**Abstract:** Blue marlin is a common concurrent catch species in tuna longline fishery. In this study, aspic method was used to analyze the resource status of blue marlin in the central and Western Pacific. Six scenarios were set according to different models in aspic. The results showed that the maximum sustainable production MSY of blue marlin in the central and Western Pacific was 19550 metric tons,  $B1/k = 0.543$ ,  $f_{msy} = 0.236$ . B2019/BMSY=1.085,  $F2019/F_{msy}=1.282$ . Based on the management reference point parameters provided by aspic model, this paper proposes to reduce the current fishing mortality.

**Key words:** Western and Central Pacific, blue marlin, ASPIC, resource assessment

# 栖息地水温变动与柔鱼冬春生群资源丰度年际及年代际波动联系分析

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**摘要:** 柔鱼 (*Ommastrephes bartramii*) 是我国在太平洋重要的商业性捕捞种类之一。研究探究了柔鱼冬春群资源丰度年际及年代际变动与栖息地水温变动 (HTV) 的关系。研究发现, 年代际尺度上, 资源丰度在 2003-2014 年呈现下降趋势, 2014 年后上升; 而年际尺度上呈现大幅波动趋势。GAM 分析表明资源丰度的年代际变动可以通过 HTV 表征, 但仅用 HTV 不足以表征其年际变动趋势。

**关键词:** 柔鱼; 冬春生群; 年际年代际; 资源丰度; 栖息地; 水温变动

## An analysis of habitat temperature variabilities related annual and interannual abundance fluctuation of the stock of the western winter-spring cohort of *Ommastrephes bartramii*

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**Abstract:** Neon flying squid (*Ommastrephes bartramii*) is a commercially important oceanic squids in the Pacific Ocean. A comprehensive understanding of the mechanisms underlying its annual and interannual abundance variations in response to environmental and climate changes is needed to assure proper rationing and management. Based on historical Chinese Squid-jigging fisheries data from 2003 to 2020, the annual and interannual abundance variations of the stock of the western winter-spring cohort of *O. bartramii*, as well as their relationship with habitat temperature variabilities (HTV), were investigated in this study. HTV were defined as the effective principal components of the SST at its two important habitats (spawning and feeding ground) based on the principal component analysis. The Hodrick-Prescott filter analysis was used to calculate annual and interannual abundance variations and habitat temperature variations. And the generalized additive model (GAM) was used to explore at their relationships. The findings revealed that the interannual abundance of *O. bartramii* first dropped (2003–2013) and subsequently rose (after 2014), with substantial variations in annual trends. The results of GAM demonstrated that the interannual abundance trend of *O. bartramii* can be investigated by HTV. However, GAM cannot simulate its annual abundance trend well just based on habitat temperature variabilities

**Key words:** *Ommastrephes bartramii*; stock of the western winter-spring cohort; annual and interannual; abundance; habitat temperature variabilities

# 基于不同季节下太平洋金枪鱼 栖息地模型及预测结果的比较

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**摘要：**由于不同季节下栖息地指数具有差异性，在年度栖息地模型拟合程度较好的情况下，不同季节的差异性往往被忽略。本文采用2015年-2017年中西太平洋委员会公布的围网捕捞生产数据，结合NOAA提供的SST和CHL环境数据，分析不同季节下基于作业次数的栖息地指数模型构建及预测效果的影响。研究表明，中西太平洋SST与CHL最适值浓度呈相反趋势，栖息地指数模型在夏季和秋季拟合最优，在空间上具有较好的重叠性。

**关键词：**金枪鱼；栖息地模型；可持续发展；比较；异质性

## Based on different seasons the comparison the habitat suitability index model of Pacific tuna and forecast results

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**Abstract:** Due to the difference of the habitat suitability index under different seasons, when the annual habitat model fits well, the difference between different seasons is often ignored. Based on the purse seine fishery production data published by the Western and Central Pacific Commission in 2015-2017, combined with the SST and CHL environmental data provided by NOAA, and based on the number of operations in different seasons, this paper analyzes the effects of constructing the habitat index model and predicting it. The results show that the concentration of the most appropriate values of SST and CHL in the central and western Pacific is in opposite direction. The habitat suitability index model fits optimally in summer and autumn, and the proportion of summer and autumn production at  $HIS > 0.6$  is relatively high, both exceeding 50% of the total. There is better spatial overlap, while the forecast results for spring and winter are poor, in addition to spatial heterogeneity in different seasons in the habitat index model testing process, such as when  $HIS > 0.6$  in autumn,  $0.3 \leq HSI < 0.6$  in winter,  $HSI < 0.3$  in spring, the catch ratio  $> 50\%$ , whether the classification criteria are different in different seasons is still to be studied. Therefore, this study suggests that tuna HSI models in different seasons should be analyzed to obtain more accurate prediction results, so as to better understand and sustainably develop and utilize the tuna resources in the central and western Pacific.

**Key words:** tuna; the habitat suitability index; Sustainability; Comparison; heterogeneity

# 基于 LeMaRns 模型的生态系统指标体系研究—以热带太平洋中部为例

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**摘要：**基于生态系统的渔业管理（EBFM）是目前被全球普遍认可的用来加快恢复过度利用的渔业资源，阻止生态恶化，实现渔业资源可持续利用的有效管理方式。转向基于生态系统的渔业管理方式是渔业管理发展的趋势，而生态系统指标是渔业管理中有利的评价工具。本研究对 LeMaRns 模型进行了应用，并对热带太平洋中部渔业管理利用和生态系统养护提供科学参考。

**关键词：**生态系统；生态系统指标；LeMaRns 模型；热带太平洋

## Research on ecosystem index system based on lemarns model: a case study of the central tropical Pacific

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**Abstract：** Ecosystem based fisheries management ( EBFM ) is an effective management method, which is widely recognized globally to accelerate the restoration of over-utilized fishery resources, prevent ecological deterioration and achieve sustainable use of fishery resources. The shift to ecosystem based fishery management is the trend of fishery management development. Ecosystem indicators are favorable evaluation tools in fishery management. This study applies the LeMaRns model and provides a scientific reference for fishery management and ecosystem conservation in the central tropical Pacific.

**Key words：** Ecosystem; Ecosystem indicators; The LeMaRns model; Tropical Pacific

# 基于胃含物分析的东太平洋赤道海域 不同气候时期茎柔鱼食性研究

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**摘要：**为了解气候异常变化对茎柔鱼的潜在影响，该研究采用形态学鉴定结合 DNA 条形码技术鉴定东太平洋赤道海域正常时期和拉尼娜时期茎柔鱼胃含物发现，其相同的优势饵料是荧串光鱼、朗明灯鱼、翼足目和头足类。根据 Amundsen 图示法发现，茎柔鱼是广食性鱼类，表现为高表型内贡献类型。分析 Shannon 多样性指数发现，在正常时期其饵料组成多样性水平更高，且与拉尼娜时期相比具有显著差异。NMDS 分析发现，两时期的茎柔鱼饮食习惯相似。

**关键词：**茎柔鱼；胃含物分析；DNA 条形码；拉尼娜时期

## A study on the feeding habits of *Dosidicus gigas* during different climatic periods in the equatorial East Pacific Ocean based on stomach contents analysis

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**Abstract:** In order to understand the potential impact of abnormal climate changes on *Dosidicus gigas*, this research used morphological identification combined with DNA barcoding technology to identify the stomach contents of *D. gigas* in the equatorial East Pacific Ocean during different climate periods (normal period and La Niña period), and found that they have the same advantages. The baits were *Vinciguerria lucetia*, *Diogenichthys laternatus*, Pteropoda, and Cephalopod. In the La Niña period, there were also *Triphoturus mexicanus* and Hyperidea. According to the graphical method of Amundsen, *D. gigas* was a euryphagous cephalopod, which showed the high within-phenotype component. Through analyzing the Shannon diversity index, we found that the diversity level of bait composition was higher in the normal period, and there was a significant difference compared with the La Niña period. According to NMDS analysis, the diets of *D. gigas* in two periods were similar in feeding habits, however, which in the La Niña period were more extensive. This research provides an identification basis for the detailed food web construction and the study of the energy flow path of the food web in the equatorial East Pacific Ocean.

**Key words:·** *Dosidicus gigas*; stomach contents; DNA barcoding; La Niña period

# 基于 TracePro 软件仿真的秋刀鱼 LED 集鱼灯配置研究

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**摘要：**集鱼灯是秋刀鱼等光诱渔业中重要的助渔设备，节能型 LED 集鱼灯具有广阔的应用前景。

本文基于单颗 LED 集鱼灯珠光学性能，通过单颗灯珠与单块灯板光学试验，在 TracePro 软件中建立了相应的照度模型，在此基础上分析了在不同倾角下的水下照度分布，对比探究光学仿真软件与实际测量时不同情况下的照度差值分布和照度衰减情况。试验结果表明，根据 TracePro 软件建立的照度模型模拟的在不同倾角、电流下的照度值。

**关键词：**LED 集鱼灯、照度模型、安装倾角、光诱渔业

## Research on the configuration of saury LED fish-gathering lights based on TracePro software simulation

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**Abstract:** Fish-gathering lights are important fishing aids in light-trapping fishery such as saury, and energy-saving LED fish-gathering lights have broad application prospects. In this paper, based on the optical performance of a single LED fish lamp bead, through the optical test of a single lamp bead and a single light board, the corresponding illuminance model is established in the TracePro software, and on this basis, the underwater illuminance under different inclination angles is analyzed. Distribution, compare and explore the illuminance difference distribution and illuminance attenuation under different conditions between the optical simulation software and the actual measurement. The test results show that the illuminance value under different inclination angles and currents simulated by the illuminance model established by TracePro software

**Key words::** LED fish light, illuminance model, installation inclination, light lure fishery

# 基于裤式拖网法的虾拖网网囊网目 选择性试验与分析

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**摘要:** 为研究虾拖网网囊网目对主要渔获种类的选择性,于 2017 年 9 月在南海区采用裤式拖网法进行选择试验。在 SELECT 模型框架下,使用极大似然估算法,结合单网次和联合网次的的数据,同时考虑网次间差异,估算网囊对主要渔获种类的平均选择性。

**关键词:** 虾拖网, 裤式拖网法, 网囊网目, 选择性, 刀额新对虾, 黄斑蓝子鱼

## Selective experiments and analysis of codend mesh based on trouser trawl method

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**Abstract:** Selective experiments were conducted on codend to its main target species based on trouser trawl method in Sep. 2017 in the South China Sea. Based on the SELECT model, maximum likelihood method was used. Both haul-level and combined-haul level methods were used to analyse the experimental data, by considering the between-haul variation. A total of 14 hauls were successfully finished, including 4 hauls to check the fishing performance of both control codends, and 10 hauls to investigate the selective properties of the test codend. The result indicated that there was no significant system variation to the experiment, by attaching which side of the control codend. The 50% retention length (L50) of test codend to *Metapenaeus ensis* was in the range of 78.84~92.09 mm, with a mean value of 82.38 mm, the selection range (SR) was in the range of 5.01~11.32 mm, with a mean value of 6.39 mm, the relative fishing intensity (p) was in the range of 0.44~0.71, with a mean value of 0.52. The L50 of test codend to *Siganus oramin* was in the range of 59.20~76.80 mm, with mean value 71.17 mm, the SR was in the range of 5.30~16.87 mm, with a mean value of 14.20 mm, the p was in the range of 0.43~0.71, with a mean value of 0.63. The L50s of *M.ensis* from both haul-by-haul estimate and the combined-haul estimate were larger than its first maturity length (80 mm). Therefore, the tested codend could harvest *M.ensis* resources sustainably. Our trouser trawl method and the way of analyzing data could off

**Key words::** trouser trawl method; mesh size of codend; selectivity; *M. ensis*; *S. oramin*

# 舟山市普陀区灯光敷网渔具渔法调查分析

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**摘要:** 本文对浙江省舟山市普陀区灯光敷网渔具材料、结构、装配技术、操作方法、作业特点、渔期渔场等方面进行了调查分析。通过调研得出以下观点: (1)普陀区灯光敷网是 20 世纪 90 年代中后期, 为加强对东海外海的头足类及中上层鱼类资源的开发利用, 浙江渔民借鉴舟山海洋渔业公司北太平洋鱿钓的光源配置技术和台湾灯光敷网的操作方法, 进行了灯光敷网作业试验并获得成功。(2) 该种作业方式是利用渔船上的水上灯、水下灯等光源, 诱集捕鱼。

**关键词:** 灯光敷网; 渔具渔法; 渔获物

## Investigation and Analysis on fishing methods of Light left net in Putuo District

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**Abstract:** In this paper, the material, structure, assembly technology, operation method, operation characteristics and fishing grounds of Light left net for fishing gear in Putuo District of Zhejiang Province are investigated and analyzed.The following points are drawn from the survey: (1)The shape of light left net for fishing gear in Putuo District drew lessons from the Light Source configuration Technology of North Pacific squid jigging in Zhoushan Marine Fisheries Company and the operating method of Light laying net in Taiwan,to enhance the development and utilization of cephalopod and pelagic fish resources in the East overseas Sea.,in the middle and late 1990s.And the experiment of lighting netting operation was carried out and the experiment was successful.(2) This kind of operation way is to use the water lamp, the underwater lamp on the fishing boat , trap and attract fishing object into a dustpan of a net ,left them out of the water to achieve the purpose of fishing.It is the dustpan net .Therefore, it is harmless to the bottom of the sea and belongs to an environmental friendly mode of operation.(3) The shape of light left net for fishing gear in Putuo District has the characteristics of good subsidence, fast water filtration, convenient operation, stable catch accumulation and good fishing efficiency .(4)The main fishing objects of this kind of operation are: mackerel, blue scad, bamboos, Largehead hairtail Taiwan squid and other pelagic fish.According to their growth ch

**Key words::** Light left net; Fishing and fishing methods; Catch things



# 基于海表温的太平洋褶柔鱼冬生群资源评估

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**摘要：**摘要：太平洋褶柔鱼（*Todarodes pacificus*）是重要的大洋性经济头足类资源，其资源变动极易受海洋环境的影响。本研究将影响太平洋褶柔鱼种群变化的内禀自然增长率（Intrinsic natural growth rate,  $r$ ）和最大环境容纳量（Carrying capacity,  $K$ ）与海表面温度（sea surface temperature, SST）结合分别构建四种剩余产量模型。

**关键词：**关键词：太平洋褶柔鱼；海表面温度；剩余产量模型；资源评估

## An research on the stock assessment of *Todarodes pacificus* in the winter-spawning cohort of Pacific Ocean based on the factor of SST

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**Abstract:** Abstract: *Todarodes pacificus* is an important oceanic economic cephalopod resource, and its resource changes are vulnerable to the impact of the marine environment. In this study, four surplus production models (SP、S<sub>r</sub>-EDSP、S<sub>K</sub>-EDSP、S<sub>r</sub>-S<sub>K</sub>-EDSP), were constructed by combining the intrinsic natural growth rate ( $R$ ), the maximum environmental capacity ( $k$ ) and the sea surface temperature (SST) to study the changes of *Todarodes pacificus* population resources under the influence of SST. The research results show that the resource evaluation model (S<sub>r</sub>-EDSP、S<sub>K</sub>-EDSP、S<sub>r</sub>-S<sub>K</sub>-EDSP) with environmental factors added to the four surplus production models has a deviation information criterion (DIC) value smaller than that of the traditional residual production model (SP). The DIC value of the S<sub>r</sub>-S<sub>K</sub>-EDSP model is the smallest (132.6), it shows that the model has the highest accuracy. From 2007 to 2018, the fishing mortality  $F_t$  of *Todarodes pacificus* was generally lower than the fishing mortality  $F_{MSY}$ , and the maximum sustainable yield  $MSY$  was generally lower than the biomass  $B_{MSY}$  at the  $MSY$  level. At present, the resource status of *Todarodes pacificus* in the winter-spawning cohort is greatly affected by the environment, and it is necessary to pay attention to the reduction of resource biomass caused by overfishing.

**Key words :** *Todarodes pacificus*; sea surface temperature; surplus production models; stock assessment

# 马尔维纳斯群岛渔业资源状况 及渔业管理分析

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**摘要：**马尔维纳斯群岛从1987年开始发放独特的入渔许可证制度，有效的渔业管理是该地区成为世界上最重要的渔区之一。本文通过马尔维纳斯群岛渔业局1989-2019年的渔业统计年报，概述马尔维纳斯群岛海域渔业组成和发展历史，详述了鱿钓渔业在马尔维纳斯群岛海域的作业规模和渔获量变化，并阐述了马尔维纳斯群岛政府的入渔管理体系，分析马尔维纳斯群岛海域渔业管理的特点与问题，为我国远洋鱿鱼渔业的发展提供参考与借鉴。

**关键词：**马尔维纳斯群岛；渔业资源状况；管理分析

## Analysis of Fishery Resources Status and Fishery Management of Malvinas Islands

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**Abstract :** The Malvinas Islands has issued a unique fishing permit system since 1987. Effective fishery management has made the area one of the most important fishing areas in the world. This article summarizes the fishery composition and development history of the Malvinas Islands based on the 1989-2019 Fishery Statistics Annual Report of the Fisheries Bureau of the Malvinas Islands, and details the scale of operations and catches of squid fishing in the waters of the Malvinas Islands. It expounds the fishing management system of the Malvinas Islands government, analyzes the characteristics and problems of fishery management in the waters of the Malvinas Islands, and provides references and references for the development of China's offshore squid fisheries.

**Key words: :** Malvinas Islands: State of Fishery Resources: Management Analysis

# 基于 VIIRS/DNB 数据 研究新冠疫情对黄渤海灯光渔船活动的影响

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**摘要:** 为探究新冠疫情对渔业活动的影响, 本研究基于 VIIRS/DNB 数据提取了 2018 年至 2020 年每日灯光渔船点位信息数据。结果表明, 从 2019 年 12 月至 2020 年 2 月, 黄渤海灯光渔船数总体比往年同期减少了 57.3%, 其中, 中方水域降幅较大, 达 63.07%。2020 年 4 月的黄渤海灯光渔船数恢复到疫情管控前(11 月)的 88.66%。另外季节性分析发现, 中韩渔业协定区水域渔船数目变动最大, 渤海水域变动最小。

**关键词:** 新冠疫情; 夜光遥感; VIIRS/DNB; 灯光渔船; 黄渤海

## The impact of COVID-19 Pandemic on night-time light fishing vessels activities in the Yellow and Bohai Seas based on VIIRS/DNB data

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**Abstract:** VIIRS/DNB data have the unique ability to acquire nighttime lights and are widely used in fisheries activity monitoring studies. To investigate the impact of COVID-19 Pandemic on night-time light fishing vessels activities in the Yellow-Bohai Seas, the study extracts daily light fishing vessels point information from 2018 to 2020 based on VIIRS DNB data. The results show that the number of light fishing vessels has decreased by 57.3% overall from December 2019 to February 2020, with a larger decrease of 63.07% on the Chinese side, and has recovered in April to 88.66% of November. The seasonal analysis reveals that the number of lighted points have the largest change in the Sino-Korean fishery agreement waters, with a decrease of 3.36% in the autumn of 2020 compared with the same period last year; the waters of the Bohai Sea had the smallest change, with an increase of only 0.02%. The results of this study provides data support for dynamic monitoring of fishing vessels in the face of major public health events in China, and provide technical support for future fisheries management.

**Key words:** COVID-19; nighttime light remote sensing; VIIRS/DNB; fishing vessels; Yellow-Bohai Sea

# 西大西洋蓝鳍金枪鱼资源状态 及渔获量误报影响初步研究

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**摘要:** 大西洋蓝鳍金枪鱼极具经济价值, 由于缺乏合理管控, 导致西大西洋群体资源衰退严重。本研究采用 ASAP 模型对西大西洋蓝鳍金枪鱼资源状况进行初步评估, 并针对渔获量误报现象研究渔获量不确定性对于评估结果的影响。结果显示, 西大西洋蓝鳍金枪鱼资源状况不佳, 资源群体亟待养护恢复。并且, 渔获量不确定性会对评估结果造成一定影响, 建议后续评估中应深入探讨渔获量误报原因, 针对性地开展敏感性测试, 以提高评估精确性和可信度。

**关键词:** 西大西洋; 蓝鳍金枪鱼; 资源评估; 年龄结构模型; 渔获量不确定性

## Preliminary Study on the stock status of western Atlantic bluefin tuna (*Thunnus thynnus*) and impact of catch misreporting

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**Abstract:** Atlantic bluefin tuna (*Thunnus thynnus*) is a valuable tuna species. However, due to a lack of fishery management and reasonable control, its resources declined constantly, especially in the western Atlantic population. Within this research, a preliminary stock assessment was carried on the western Atlantic bluefin tuna using Age-Structured Assessment Program (ASAP), which was based on annual total catch, catch-at-age data and abundance index data from 1950 to 2015. Furthermore, considering the historical occurrence of catch misreporting phenomenon, the effects of catch uncertainty on assessment results were studied by setting different levels of observation error and statistical deviation of catch. The results showed that the stock status of western Atlantic bluefin tuna was in poor condition and necessarily proceeded the conservation and recovery. All scenario models indicated that the stock was not subject to overfishing but was suffering overfished. Compared with the base case model and other scenario models with different levels of catch uncertainty, it showed that the uncertainty had an impact on the stock assessment results. It is suggested that the reason for the historical occurrence of catch misreporting phenomenon should be further discussed in future researches. Meanwhile, sensitivity analysis should be carried out for such uncertainty to improve the accuracy and reliability of the stock assessment results.

**Key words:** Western Atlantic Ocean; *Thunnus thynnus*; Stock Assessment; Age-Structured Model; Catch Uncertainty

# 南极磷虾渔业现状与管理趋势

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**摘要：**南极磷虾渔业自 20 世纪 70 年代开始起步，年最高捕捞产量达 52.8 万吨，至今累计捕捞产量近 1000 万吨。南极磷虾渔业管理是目前最成功的渔业管理之一，近几年随着捕捞装备与捕捞技术的更新与改进，南极磷虾捕捞产量呈逐年上升趋势，但其主要捕捞区域 48 区的南极磷虾资源总产量仍能保持较好的稳定状态。究其原因，这与 CCAMLR 严格的南极磷虾渔业监管措施有较直接的关系，值得我们学习和借鉴。

**关键词：**南极磷虾，捕捞，可持续，养护措施，监督管理

## The current situation and management trend of antarctic Krill fishery

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**Abstract:** The Antarctic krill fishery started in the 1970s, with a maximum annual harvest of 528,000 tons and a cumulative harvest of nearly 10 million tons. The fishery management of Antarctic krill is one of the most successful fishery management in the world at present. In recent years, with the updating and improvement of fishing equipment and fishing technology, the fishery yield of Antarctic krill has been increasing year by year. It is evaluated that the resources of Antarctic krill in 48 major fishing areas can still maintain a good and stable state. The reason is directly related to the strict regulation measures of CCAMLR on Antarctic krill fishery, which is worth learning and referring for us.

**Key words:** Antarctic krill, fishery, sustainability, conservation measures, supervision and management

# 捕捞压力对黄海生态系统结构和功能的影响

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**摘要:** 近年来, 持续的捕捞压力导致黄海生态系统群落结构简单化和生物多样性降低。为探明导致这些变化的原因, 本研究基于黄海生态系统 OSMOSE 模型, 模拟不同的捕捞压力对黄海生态系统结构和功能的影响, 分析了生态系统对长期捕捞压力的响应。结果表明, 长期的捕捞压力导致高营养水平生物量明显下降, 同时高龄、大型个体占比和营养级水平等生态指标降低。本研究为基于生态系统的渔业管理和资源的可持续利用提供了理论依据。

**关键词:** 黄海生态系统, 捕捞压力, 生态指标, OSMOSE 模型

## Fishing impacts on the structure and function of the Yellow Sea ecosystem

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**Abstract:** The simplification of community structure and the reduction of biodiversity in the Yellow Sea ecosystem have been caused by continuous fishing pressure over the past decades. To understand the causes of these changes, our study simulates the impact of different fishing pressure on the structure and function of the Yellow Sea ecosystem based on an OSMOSE model for the Yellow Sea ecosystem, and analyzes the response of the ecosystem to long-term fishing pressure. The results indicated that the long-term fishing pressure leads to the decline of biomass for the high trophic level, and the proportion of older fish and large individuals decreased as well as the trophic level. Our research provides insights on the ecosystem-based fisheries management and sustainable utilization of fishery resources.

**Key words:** Yellow Sea ecosystem, fishing pressure, ecological indicators, OSMOSE model

# 南太平洋三种金枪鱼的营养相互关系

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**摘要：**2012年9~12月在南太平洋所罗门群岛专属经济区海域采集了120尾大眼金枪鱼，353尾黄鳍金枪鱼和307尾长鳍金枪鱼样品，用于胃含物和稳定同位素分析。结果表明三种金枪鱼摄食饵料种类包括鱼类、头足类、甲壳类等共45种。三种金枪鱼的食物组成、摄食强度、碳氮稳定同位素存在显著差异，它们之间的食物重叠系数分别为0.32、0.47和0.67，存在一定的食物竞争关系。

**关键词：**大眼金枪鱼；黄鳍金枪鱼；长鳍金枪鱼；稳定同位素；营养生态

## The trophic interactions of three tuna species in the South Pacific

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**Abstract:** From September to December 2012, 120 bigeye tuna, 353 yellowfin tuna and 307 albacore tuna were collected in the exclusive economic zone of the South Pacific Solomon Islands for stomach content and stable isotope analysis. The results showed that the three species of tuna feed for 45 species including fish, cephalopods, and crustaceans. There are significant differences in the food composition, feeding intensity, and stable carbon and nitrogen isotopic values of the three types of tuna. The food overlap coefficients between them are 0.32, 0.47 and 0.67, respectively, and there is a certain food competition relationship.

**Key words:** Thunnus obesus; Thunnus albacores; Thunnus alalunga; stable isotope; trophic ecology

# 我国印度洋金枪鱼渔业鲨鱼兼捕现状 与管理对策研究

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**摘要：**中国作为 IOTC 成员国，为履行国际条约在《野生动物保护法》《渔业法》等做出限制，但我国鲨鱼等资源养护管理仍存在公众理念未能转变、信息统计严重匮乏、野生动物保护相关法规亟待完善、管理执法体制不够健全等问题，针对存在问题提出促进转换管理者、捕捞者、消费者观念；加大信息统计力度；完善相关立法；建立统一管理协调机构，注重执法素质提升等 4 条建议。

**关键词：**中国；印度洋金枪鱼委员会；鲨鱼养护管理；问题与对策

## Study on the current situation and management countermeasures of Chinese Indian Ocean tuna fishery shark - by-catch

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**Abstract:** As a member of the IOTC, China has made restrictions in the Wildlife Protection Law and Fisheries Law in order to implement international treaties. However, there are still some problems in the conservation and management of shark resources in China, such as the failure to change the public concept, the serious lack of information statistics, the urgent need to improve the relevant laws and regulations of wildlife protection, and the incomplete management and law enforcement system. In view of the existing problems, it proposes to promote the transformation of the concepts of managers, fishermen and consumers. Increase information statistics; Improve relevant legislation; Four suggestions, such as establishing a unified management and coordination organization and paying attention to improving the quality of law enforcement.

**Key words:** China; Indian Ocean Tuna Commission; Shark conservation and management; Problems and Countermeasures



# 选择性捕捞对海水青鳉鱼 (*Oryzias melastigma*) 生物学特性的影响

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**摘要:** 持续的选择性捕捞导致了经济鱼种的生物学特征呈现低龄化、小型化和性早熟等现象。为探究捕捞如何导致这一现象产生, 本研究对海水青鳉鱼进行“捕大留小”、“捕小留大”和“随机捕捞”三种捕捞模式, 探究不同的捕捞压力和捕捞时间对实验种群生物学特征影响的差异。结果表明, 长期的“捕大留小”种群比其它捕捞模式的种群平均体长减小、性成熟提前、孵化率下降且仔鱼死亡率升高, 性成熟后捕捞比性成熟前捕捞更能减缓以上差异。

**关键词:** 海水青鳉鱼; 选择性捕捞; 生物学特征; 早期生活史

## Size-selective harvest alters biological traits change of marine medaka (*Oryzias melastigma*)

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**Abstract:** The biological traits of commercial species have changed under long-term fishing pressure, such as miniaturization, smaller size-at-age and earlier age-at-maturation. To find out how fishing causes these phenomena, in this study, we used marine medaka for a large, small, and random size-selective experiments to explore the effects of different fishing pressure and fishing time. The results showed that the mean length in large-harvested populations were significantly smaller than other populations. And they also showed earlier age-at-maturation, declining hatching rate and increasing larvae mortality. And comparing to harvest before maturation, harvest after maturation could mitigate the effects of fishing pressure to a certain extent.

**Key words:** marine medaka; size-selective harvest; biological traits; early life stages

# 北太平洋东部金枪鱼延绳钓主要渔获物种类垂直分布

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**摘要:** 掌握延绳钓渔获物的垂直分布特征有助于准确评估目标鱼种和兼捕鱼种分布, 以降低兼捕率, 为渔业管理及物种保护提供理论参考。本研究根据 2018 年 10 月至 11 月北太平洋东部我国金枪鱼延绳钓渔业数据, 分析了主要钓获鱼种的垂直分布特征, 结果显示, 北太平洋东部延绳钓渔获种类共 16 种, 其中, 大眼金枪鱼(*Thunnus obesus*)、长鳍金枪鱼(*T. alalunga*)、黄鳍金枪鱼(*T. albacares*)。

**关键词:** 北太平洋东部; 延绳钓; 兼捕; 垂直分布

## Vertical distribution of main species captured by tuna longline fishery in the eastern north Pacific

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**Abstract:** Information on the vertical distribution of pelagic species is important for the development of effective measures to mitigate bycatch. The objective of this study was to estimate depth distribution of pelagic species captured in a longline fishery and to evaluate the difference in depth distribution among species. We estimated depth distribution for 5 frequently captured species based on a Chinese longline fishing trip targeting bigeye tuna (*Thunnus obesus*) in the eastern north Pacific Ocean from October to November in 2018. The depth distribution of opah (*Lampris guttatus*) was similar with bigeye tuna. Although other 3 species of the bycatch species were found to be distributed in water depths shallower than bigeye tuna (i.e. increasing hook depths can decrease catch rates of these species), the rates of catch rates declined with increasing hook depths may be different. The depth distributions were found to be not significantly different between genders for all 5 species. There was no significant correlation between fish sizes and capture depths expect for bigeye tuna. The information derived from this study can play an important role in reducing bycatch in pelagic tuna longline fisheries in the eastern north Pacific Ocean.

**Key words:** eastern north Pacific; pelagic longline; bycatch; vertical distribution

## 六、水生生物资源养护与水域生态修复

# 空间变化对淮河干流安徽段鱼类肠道菌群影响探究

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**摘要:** 摘要:为研究淮河干流安徽段鱼类肠道菌群特征及潜在影响因素,野外采集鱼类样本进行16S rRNA高通量测序,对这些鱼类进行比较。可以看出,变形菌门(Proteobacteria)、拟杆菌门(Bacteroidetes)、厚壁菌门(Firmicutes)、酸杆菌门(Acidobacteria)和蓝菌门(Cyanobacteria)普遍存在于各类鱼类的肠道中。棒花鱼(*Abbottina rivularis*)和贝氏鲮(*Hemiculter bleekeri*)都是杂食性鱼类,但是棒花鱼生活在底层水层,贝氏鲮生活在上层水层。从肠道菌群组成上可以看出三个水域棒花鱼的肠道菌群组成相当接近,但来自中游贝氏鲮的肠道菌群与上游下游的差别较大。水层上来看底层水环境差别更小。不同水域共有ASVs差异性标志菌数量明显多余水层组。通过鱼类肠道菌群影响因素的研究,揭示不同环境对鱼类肠道菌群的影响,为鱼类资源的保护提供依据

**关键词:** 淮河安徽段; 水域; 水层; 肠道菌群

## Spatial changes on the intestinal flora of fish in Anhui section of the main stream of the Huaihe River

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**Abstract:** Abstract: In order to study the characteristics and potential influencing factors of intestinal microflora of fish in Anhui section of Huaihe River, 16S rRNA high-throughput sequencing was performed on fish samples collected in the field. It can be seen that Proteobacteria, Bacteroidetes, Firmicutes, Acidobacteria and Cyanobacteria are widely present in the intestinal tract of all kinds of fish. Flower fish (*Abbottina rivularis*) and bayesian sharpbelly (*Hemiculter bleekeri*) are omnivorous fish, but great fish live in the bottom layer, bayesian sharpbelly life in the upper layer. Can be seen from the intestinal flora composition on three waters rod flower fish intestinal flora composition very close to, but from the middle reaches of the bayesian sharpbelly intestinal fungus group a greater difference between upstream and downstream. On the water layer, the bottom water environment is even less different. The number of ASVs in different waters was obviously higher than that in the water stratum. Through the study of influencing factors of fish intestinal microflora, the influences of different environments on fish intestinal microflora were revealed, providing a basis for the protection of fish resources.

**Key words:** Anhui section of the Huai River; Waters; Aqueous layer; gut microbiota

# 盐度胁迫下曼氏无针乌贼的行为和生理响应

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**摘要:** 盐度变化会引起头足类渗透调节和免疫应答等一系列生理应激反应, 同时还会引发应激诱导的喷墨行为, 最终可能导致其因渗透失衡出现大量死亡。结合头足类苗种繁育过程中因海水盐度波动出现摄食及行为异常等问题, 本研究探究了盐度胁迫对曼氏无针乌贼行为活性、组织结构、渗透调节以及免疫应答的影响, 明确了其对盐度变化的应激反应及适应能力。结果显示, 在高盐胁迫下曼氏无针乌贼的行为活性显著增加, 且倾向于绕水槽壁游动; 与对照组相比, 高盐组肌肉、鳃和肝脏组织结构呈现较严重的损伤; 随着盐度的升高, 鳃中 NKA 酶活性先降低后升高; 33 PSU 组脑中皮质醇含量显著高于其他处理组; 盐度升高或降低均会导致鳃和肝脏中 SOD、CAT 活性显著升高, MDA 含量显著增加, LZM 活性显著降低。综合分析认为, 曼氏无针乌贼具有较好的耐低盐能力。在本研究设定的 15–33 PSU 盐度范围内, 盐度变化会引起其免疫应答和渗透调节的改变。

**关键词:** 曼氏无针乌贼; 盐度胁迫; 行为反应; 组织结构; 渗透调节; 免疫应答

## Behavioral and physiological responses of *Sepiella japonica* exposed to salinity changes

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**Abstract:** Changes in salinity may cause a series of physiological and behavioral stress responses in cephalopods, e.g. osmoregulation, immune responses, and stress-induced inking behavior, and can even lead to mass death due to osmotic stress. In the process of seedlings production of cephalopods, the behavior of broodstocks is highly affected by changes in salinity. To better understand the stress responses and the adaptability used by cephalopods to cope with salinity stress, this study investigated the effects of salinity changings on the behavioral activity, histopathology, osmoregulation and immune response of *Sepiella japonica*. The results showed that the behavioral activity of *Sepiella japonica* increased significantly under high salinity stress, and had obvious tendency to swim around the tank wall. Compared to the control group, the tissue structures of muscle, gill and liver in the high-salt groups showed more serious damage, and no significant change was found in the low-salt groups. With the increase of salinity, the activity of Na<sup>+</sup>/K<sup>+</sup>-ATPase in the gill decreased first and then increased. The cortisol in brain tissue in the 33 PSU groups was significantly higher than that of the other treatment groups. The increase or decrease of salinity could lead to the significant increase of activities of superoxide dismutase (SOD) and catalase (CAT) in gills and liver, the significant increase of content of malondialdehyde (MDA), and the significant decrease of activity of lysozyme (LZM). Based on these results, it can be concluded that the *Sepiella japonica* have good tolerance to low-salt conditions. The range of salinity used in this study (15–33 PSU) could cause immune responses and osmoregulation for *Sepiella japonica*.

**Key words:** *Sepiella japonica*; salinity stress; behavioral response; histopathology; osmoregulation; immune response

# 中街山列岛海域鱼类群落特征 及与环境因子的关系

渠遥

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**摘要:** 根据 2021 年 4 月(春季)、7 月(夏季)、10 月(秋季)和 2022 年 1 月(冬季)在中街山列岛海域进行的渔业资源和生态环境调查数据, 分析了鱼类种类组成和优势种, 采用等级聚类(Cluster)和冗余分析(RDA)研究了中街山列岛海域鱼类群落特征及其与环境因子之间的关系。结果显示, 该海域捕获的鱼类经鉴定共有 70 种, 隶属 17 目 37 科 58 属。中街山列岛海域鱼类的优势种共有 10 个, 其中龙头鱼为全年优势种。Shannon 多样性指数四季均值为 2.89, 其中夏季最高为 3.35。Margalef 物种丰富度指数四季均值为 3.23, 其中春季最高为 3.83。等级聚类分析的结果表明, 鱼类空间结构可划分为 3-4 个组群, 不同季节的组群间均存在显著差异。RDA 分析表明, 水温、盐度、水深是影响鱼类群落分布的主要环境因子。影响春季鱼类群落分布的主要因素有 Chl a、水温、水深、盐度; 夏季鱼类的分布主要受水温的影响; 秋季鱼类的分

**关键词:** 中街山列岛; 鱼类群落; 物种多样性; 优势种; 等级聚类分析; RDA 分析

## Characteristics of Fish Community and Its Relationships with Environmental Factors in the Waters of Zhongjieshan Islands

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**Abstract:** Based on the data of fishery resources and environmental factors of surveys in the waters of Zhongjieshan Islands in April (spring), July (summer) and October (autumn) in 2021 and January (winter) in 2022, the composition of fish species and dominant species were analyzed. The spatial structure of fish community and the relationship with environmental factors were studied by hierarchical clustering and redundant analysis (RDA). The results showed that 70 fish species were captured in this area, belonging to 17 orders, 37 families and 58 genera. Ten dominant species were recognized, among which the Bombay-duck (*Harpadon nehereus*) was the dominant species in all the four seasons. The average of Shannon diversity index of four seasons was 2.89, and the highest was 3.35 in summer. The Margalef species richness index averaged 3.23 in four seasons, with the highest value 3.83 in spring. The results of clustering analysis showed that the fish community could be divided into 3-4 groups, and there were significant differences among groups in different seasons. RDA ranking showed that the distribution of fish communities in the waters of Zhongjieshan Islands was mainly affected by Chl a, water temperature, water depth and salinity in spring; by water temperature in summer; by organic carbon in autumn; by organic carbon, suspended matter, pH, and phosphate in winter.

**Key words:** Zhongjieshan islands; fish communities; species diversity; dominant species; hierarchical clustering analysis; RDA analysis

# 柴油水溶性组分对褐菖鲉稚鱼行为反应和胆碱酯酶活性的影响

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**摘要：**石油类污染是我国近岸海洋环境面临的主要污染类型之一，对近岸鱼类有着较强的致毒效应。为研究柴油水溶性组分对褐菖鲉稚鱼行为反应和胆碱酯酶活性的影响，本研究以我国东海区典型的近岸岩礁性鱼类褐菖鲉为研究对象，以近岸海水石油烃浓度本底调查为参考，探讨了不同浓度船用燃料油(0#柴油水溶性组分,DWSF)对褐菖鲉稚鱼行为活跃性、探索性及捕食能力的影响，并结合鳃的组织学变化与神经传递相关酶活性变化探究了石油类污染对褐菖鲉稚鱼的毒性效应。结果表明，当海水中 DWSF 浓度增加时，褐菖鲉稚鱼的探索性与活跃性呈现先增加后减弱的趋势。当 DWSF 浓度超过四类海水标准时( $>0.30 \text{ mg}\cdot\text{L}^{-1}$ )，稚鱼的行为活跃性受到明显抑制，捕食能力显著降低；通过组织学观察发现，当 DWSF 浓度达到  $0.45 \text{ mg}\cdot\text{L}^{-1}$  时，稚鱼的鳃组织会出现明显的病变和损伤，与神经传递相关的胆碱酯酶活性受到明显抑制，死亡率显著升高。

**关键词：**褐菖鲉；行为；组织学；胆碱酯酶；死亡率

## Effects of Water-soluble Fraction of Diesel Oil on the Behavioral Responses and Cholinesterase Activity of Post-larval *Sebasticus marmoratus*

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**Abstract:** Oil pollution is one of the most predominant forms of pollution in the coastal areas of China, which has strong toxic effects on the marine fish inhabits in these areas. For fish under toxic stress, changes in behavior are one of the most obvious manifestations, which could be good indications for the marking of petroleum pollutants. With a background survey of petroleum hydrocarbon concentration in the offshore marine areas of Zhoushan, this study investigated the effects of different concentrations of marine diesel oil (0#diesel oil water-soluble fraction, DWSF) on the activeness, exploratory behavior and predation ability of *Sebasticus marmoratus*, a typical rockfish inhabits in the coastal waters of East China Sea. Furthermore, we investigated the histological changes of gill tissues and enzyme activities related to neurotransmission to reveal the mechanisms under the toxic effects of marine diesel oil for *S. marmoratus*. The results showed that with the increase of the concentration of DWSF, the exploratory behavior and activeness of the post-larval *S. marmoratus* increased first and then decreased. It was noted that the fish behavioral activity was significantly inhibited and the predation ability was obviously impaired when the concentration of DWSF exceeded the standard of inferior Class-V water quality ( $\text{DWSF} > 0.30 \text{ mg}\cdot\text{L}^{-1}$ ). It can be observed that when the concentration of DWSF reached  $0.45 \text{ mg}\cdot\text{L}^{-1}$ , the gill tissue showed obvious lesions and damages, the activity of cholinesterase related to neurotransmission was significantly inhibited and the mortality rate increased significantly. Conclusively, the marine diesel oil can induce obvious abnormal behaviors, reduce the success rate of predation, and finally, resulting an increase in mortality of post-larval *S. marmoratus*. It can be inferred that the impaired nervous and respiratory system may lead to these abnormal behaviors. In order to ensure the normal growth and development of the larvae of *S.*

marmoratus, and also other near-shore inhabiting rockfish, the concentration of DWSF in seawater should be controlled below 0.45 mg·L<sup>-1</sup>.

**Key words:** Sebasticus marmoratus; behavior; histology; cholinesterase; mortality rate



# 青海湖水系沙柳河池堰式鱼道 效果评估及问题诊断

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**摘要：**青海湖裸鲤（*Gymnocypris przewalskii*）是我国青海湖水系典型洄游性鱼种。为辅助青海湖裸鲤通过河道工程障碍到达上游产卵，7座池堰式鱼道被修建，然而建设后的鱼道过鱼效果却鲜有报道。本研究以青海湖入湖河流-沙柳河刚北渠鱼道为工程对象，在青海湖裸鲤洄游高峰期通过放鱼实验，利用射频识别技术（RFID）实时监测了刚北渠鱼道过鱼效果，获取了评估鱼道过鱼效果的指标包括尝试率、通过率，建立了尝试率的Logistic回归模型，识别了影响青海湖裸鲤尝试率的关键因素，测试了青海湖裸鲤游泳能力，采用数值模拟分析了鱼道水力学特征，结合青海湖裸鲤游泳能力和鱼道水力学特征进行了鱼道问题诊断。

**关键词：**青海湖裸鲤，池堰式鱼道，过鱼效果，诊断

## Effect Evaluation and Problem Diagnosis of Weir Fishway of Shaliu River in Qinghai Lake Basin

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**Abstract:** *Gymnocypris przewalskii* is a typical migratory fish species in Qinghai Lake. In order to assist *G.przewalskii* reach the upstream through river engineering obstacles to spawn, seven pool weir fishways were built. However, the effect of fishway crossing after construction is rarely reported. In this study, the Gangbei Channel fishway project at Shaliu River, an inflow river of the Qinghai Lake, was used to monitor the Gangbei Channel fish passage effect in real time by using radio frequency identification technology (RFID) during the peak period of the migration of *G.przewalskii*. The indicators for evaluating the fish passage effect including the attempt rate and the pass rate were obtained, and the Logistic regression model of the attempt rate was established. The key factors affecting the attempt rate of *G.przewalskii* were identified. The swimming ability of *G.przewalskii* was tested, and the hydraulic characteristics of fishway were analyzed by numerical simulation. The fishway problem was diagnosed by combining the swimming ability of *G.przewalskii* and the hydraulic characteristics of fishway.

**Key words::** *Gymnocypris przewalskii*; Pool and weir fishway; Effect of fish pass; Problem Diagnosis

# 多组学揭示船舶噪声胁迫下 杂交鲟鱼肝脏代谢的反应机制

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**摘要:** 来自船舶发动机的水下噪声会影响各种鱼类的新陈代谢和免疫系统。同时, 肝脏中的代谢途径的变化对鱼类适应不良环境非常重要。我们采用多组学联合分析的方法来研究杂交鲟对船舶噪声的适应机制。实验设置了对照组和噪声组(模拟船舶噪声: 12 小时), 并提取肝脏组织进行高通量转录组和代谢组测序。结果显示, 共检测到 588 个差异表达基因和 58 个差异代谢物。转录组和代谢组的联合分析表明, 在噪声胁迫下, 细胞凋亡和细胞运动能力加强, DNA 复制、RNA 转录和翻译以及蛋白质合成受到抑制, 脂质代谢、核苷酸代谢和维生素 D3 代谢途径也受到抑制。幸运的是, 免疫反应的启动确保了他们的正常免疫能力。此外, 由于碳水化合物和氨基酸代谢途径的上调, 生物体在噪声压力下的物质和能量需求得到了保证。

**关键词:** 杂交鲟; 船舶噪声; 转录组; 代谢组; 免疫反应; 生物合成

## MULTI-OMICS REVEALED RESPONSE MECHANISM OF LIVER METABOLISM OF HYBRID STURGEON UNDER SHIP NOISE STRESS

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**Abstract:** Underwater noise from ship engines can affect the metabolism and immune system of various fish species. Meanwhile, Changes in the metabolic pathways in liver are important for fish to adapt to adverse environments. We used a combined multi-omics analysis to investigate the adaptation mechanism of hybrid sturgeon to ship noise. A control group and a noise group (simulated ship noise: 12 h) were set up, and liver tissues were extracted for high-throughput transcriptome and metabolome sequencing. The results show that a total of 588 differentially expressed genes (DEGs) and 58 DEGs metabolites were detected. The joint analysis of transcriptome and metabolome showed that under noise stress, apoptosis and cell motility were intensified, DNA replication, RNA transcription and translation, and protein synthesis were inhibited, and lipid metabolism, nucleotide metabolism, and vitamin D3 metabolic pathways were also inhibited. Fortunately, immune responses initiation ensured their normal immunity abilities. Moreover, material and energy requirements of the organism under noise stress were guaranteed by upregulation of carbohydrate and amino acid metabolic pathways.

**Key words:** Hybrid sturgeon; Ship noise; Metabolome; Immune response; Biosynthesis

# 南海中层鱼生物学特征及西沙 海域中层鱼群落多样性研究

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**摘要:** 为了解南海中层鱼类种类组成, 为相关区域的生物多样性保护和监测工作提供科学依据。依托“南锋号”科学考察船对南海中层鱼类进行了初步调查。调查结果结合历史数据对南海中层鱼的生物学特征和西沙冷泉海域的中层鱼群落进行了初步描述。基于耳石数据对在南海分布的条带眶灯鱼 (*Diaphus brachycephalus*) 的年龄与生长进行了首次报道。同时, 对西沙群岛冷泉海域内外区域中层鱼类资源进行调查, 共采集鱼类 12 目 31 科 62 属 106 种, 以灯笼鱼目和巨口鱼目为最主要类群。通过对比冷泉内外区域种类差异, 结果表明, 冷泉内外中层鱼类群落组成差异显著, 冷泉区深层中层鱼类多样性高; 长鳍虹灯鱼 (*Bolinichthys longipes*) 和串灯鱼 (*Vinciguerria nimbara*) 等鱼类可作为区分冷泉内外的关键种群。

**关键词:** 中层鱼; 生长和年龄; 群落结构; 中国南海; 西沙海域

## Studies on the biological characteristics of mesopelagic fish in the South China Sea and the diversity of mesopelagic fish in the Xisha Island, the South China Sea

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**Abstract:** In order to understand the composition of mesopelagic fish species in the South China Sea and provide a scientific basis for biodiversity conservation and monitoring in the relevant areas. A preliminary survey of the mesopelagic fishes in the South China Sea was conducted by the R/V Nanfeng. The results of the survey combined with historical data to provide a preliminary description of the biological characteristics of the mesopelagic fishes in the South China Sea and the mesopelagic fish community in the cold seep area of Xisha Sea. The age and growth of *Diaphus brachycephalus*, distributed in the South China Sea, was reported for the first time based on otolith data. At the same time, a survey was conducted on the mesopelagic fishes in and outside the cold seep area of the Xisha Sea, and a total of 106 species in 62 genera and 31 families of 12 orders were collected, with Myctophiformes and Stomiiformes as the most dominant species. By comparing the differences between the inner and outer regions of the cold seep, the results showed that the composition of the mesopelagic fish community differed significantly between the inner and outer regions of the cold spring, and the diversity of the deep mesopelagic fish in the cold spring area was high. Fishes such as *Bolinichthys longipes* and *Vinciguerria nimbara* could be used as key populations to distinguish the inner and outer regions of the cold seep.

**Key words:** mesopelagic fish; age and growth; Community structure; South China Sea; Xisha Sea

# 6种大型海洋掠食性鱼类胃含物角质颚分类研究

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**摘要:** 为了研究大型海洋掠食性鱼类胃含物中角质颚的分类, 采集鱼类 36 个胃分析其残留角质颚的形态。采集角质颚形态侧视图和顶视图, 进行种类鉴定, 建立检索表, 提取形态系数进行聚类分析。对胃含物角质颚形态进行种类鉴定, 共发现头足类 2 目 10 科 17 种。根据角质颚形态分类检索分析, 17 种头足类角质颚形态种间差异明显。角质颚形态信息聚类分析在目级别区分效果显著。以期为大型海洋掠食性鱼类胃含物头足类分类鉴定体系奠定基础。

**关键词:** 头足类; 角质颚下颚; 大型海洋掠食性鱼类; 胃含物; 分类检索; 聚类分析

## Systematic classification on the Cephalopod beaks of stomach contents of 6 large marine predatory fishes

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**Abstract :** In order to investigate the classification effect of the Cephalopod beaks of stomach contents of 6 large marine predatory fishes, we examined a total of 36 stomachs of fishes, and analyzed cephalopod beaks morphology. Side and top views of the morphology of each lower beak were collected. Species identification of lower beak was carried out. A classification retrieval table of the beak morphology was developed. By extracting the elliptic Fourier descriptor coefficients of the beak morphology, the morphology coefficients were analyzed by clustering at the family level. The results show that a total of 17 species of cephalopods were found in 2 orders, 10 families through the species identification of beaks morphology. It through the analysis of the beak morphology of stomach contents, the morphological characteristics of beaks of 17 species of Cephalopod are obviously different among species. According to the classification retrieval of beaks morphology, lower beak of 13 species of rostrum of Teuthoidea was triangle, isosceles triangle, and lateral wall was approximately rhombus. Lower beak of 4 species of rostrum of Octopoda is developed, and lateral wall was approximately long quadrangle. The cluster analysis of morphological information of beaks was effective in distinguishing the order level. This study will lay a foundation for the classification and identification of cephalopods in the stomach of large marine predatory fish.

**Key words:** : Cephalopod; Lower Beak; Large marine predatory fishes; Stomach Contents; Classification Search; Cluster Analysis

# 根据水库自然形态特征，结合采样点 设置规范，设置了 5 个采样点（见图 1）

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**摘要：**2020年9月对蔺河电站水库进行了调查。结果显示，水库浮游植物密度为0.866 106个/L，生物量平均为1.265 mg/L；后生浮游动物密度为166个/L，平均生物量为1.7982；底栖动物的密度为113.34个/m<sup>2</sup>，生物量为40.85mg/m<sup>2</sup>；初级生产力为2.204 mg（O<sub>2</sub>）/m<sup>2</sup>·d；渔获物中有鱼类8种。该水库总鱼产力为326.50 t。

**关键词：**蔺河电站水库；渔业资源；调查；鱼产力

## Fishery resources survey and fish productivity assessment of Linhe hydropower plant reservoir

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**Abstract :** An investigation was conducted on the fishery resources and the assessment of fish productivity of Linhe hydropower plant reservoir in Shaanxi province in September 2020. The identified phytoplankton species in this reservoir belonged to 25 species or genera of 7 phyta, the abundance of the phytoplankton was 0.866x10<sup>6</sup>cells/L and the biomass was 1.265 mg/L. Metazoan zooplankton belonged to 11 species of 9 genera, its abundance was 166 ind./L and the biomass was 1.982 mg/L; the abundance and biomass of the benthic community were 113.34 ind/L and 40.85 mg/m<sup>2</sup> respectively; the primary productivity was 2.204 mg（O<sub>2</sub>）/m<sup>2</sup>·d. eight fish species was found in the catches. The assessment of the fish productivity was 326.50 t

**Key words: :** Linhe hydropower plant reservoir ; fish resources; survey; fish productivity

# 黄河鱼类保护

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**摘要:** 黄河流域分布淡水鱼类共计 147 种, 隶属于 12 目 21 科 78 属。其中黄河特有种计有 27 种, 受危物种 24 种, 分别占总数的 18.37% 和 16.32%。同中国主要江河相比, 物种多样性则处在较低水平; 但上游特有鱼类和珍稀濒危鱼类的占比很高。目前黄河鱼类多样性大幅降低, 梯级水电开发、水资源过度利用、外来物种、水域污染和过度捕捞都是威胁鱼类多样性的重要因素。

**关键词:** 可持续发展; 淡水鱼类; 中国特有种; 濒危物种

## Fish Conservation of the Yellow River

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**Abstract:** A total of 147 species, belonging to 78 genera, 21 families, and 12 orders, are distributed in the Yellow River. There are 27 endemic species to the river and 24 threatened species, accounting for 18.37% and 16.32% of the total number of freshwater fish species of the river, respectively. Moreover, species diversity varied among the upper, middle, and lower reaches of the Yellow River. Comparing to other major rivers in China, the species richness is at a lower level although the diversity at higher taxon levels is relatively high. Proportions of endemic and threatened species of the Yellow River are lower than the average level of the entire nation. However, the upper reach has large proportions of both endemic and threatened species, which should be drawn more attention for future conservation. At present, the species diversity of freshwater fish is rapidly decreasing. Our thorough field investigations may collect only 53.06% of the total species. Cascade hydropower development, over-exploitation of water resources, invasive species, water pollution, and overfishing are major threats to the fish species of the Yellow River. The main stream and tributaries may face different threat that need targeted strategies for the conservation of freshwater fishes in the future.

**Key words::** Sustainable development; Freshwater fishes; Endemic species; Threatened species

# 金属元素在东太平洋浅海长尾鲨母体和胚胎间的迁移

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**摘要:** 本研究测定了东太平洋浅海长尾鲨母体和胚胎的肌肉和肝脏组织的 12 种金属元素, 以探寻浅海长尾鲨繁殖过程中母体与胚胎间的重金属迁移规律。结果表明: 浅海长尾鲨胚胎组织中 Cr、Se、Cu 和 Mn 含量均高于母体, 而其他元素含量在母体和胚胎的同种组织间存在差异。胚胎两种组织中的 Se: Hg 摩尔比值均大于 1, 多种元素转移率与母体元素含量呈负相关关系, 推测浅海长尾鲨可能存在特定的元素调控机制。

**关键词:** 东太平洋; 浅海长尾鲨; 胚胎; 微量元素; 卵胎生

## Mechanisms of maternal transfer of heavy metals in the pelagic thresher shark (*Alopias pelagicus*) of the Eastern Pacific Ocean

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**Abstract:** Heavy metals can be accumulated by marine organisms, which pose a serious threat to their survival and reproduction. Pelagic sharks are vulnerable to overfishing due to their slow growth rates, late age-at-maturity and low fecundity. Currently, 90% of pelagic shark species are Near Threatened with an elevated risk of extinction according to IUCN Red List Criteria and the heavy metal accumulation in their bodies could have additional detrimental effects on the dynamics of their populations. In this study, the concentrations of 12 trace elements (Zn, Cu, Cr, Ni, Mn, Se, Co, Hg, Cd, Pb, As and Ba) in muscle and liver tissues of 10 pregnant pelagic thresher sharks (*Alopias pelagicus*) and their 18 embryos were analyzed. The results showed that four elements (Cu, Cr, Mn and Se) were accumulated in both tissues of the embryos. Most of the Se: Hg molar ratios in both tissues of the mother and embryos were above 1 with larger values in the embryos, which indicated that Se may have a protective role against Hg toxicity during the early life stage. Negative correlations were observed between maternal trace element concentrations and transfer rates in some elements, indicating a regulatory mechanism may exist to maintain the element contents stability in embryonic tissues. Maternal transfer as a source of trace elements in sharks should not be overlooked.

**Key words:** The Eastern Pacific Ocean; *Alopias pelagicus*; embryo; trace element; ovoviviparity

# 阿根廷滑柔鱼雌性个体生殖能量积累 及与海表面环境因子的关系

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**摘要:** 为获知雌性阿根廷滑柔鱼生殖能量积累及与栖息海域环境的关系, 采用组织能量密度测定技术和广义加性混合效应模型, 分析卵巢、输卵管和缠卵腺等组织的能量密度和能量积累变化, 及与海表温度和叶绿素 a 浓度之间的效应关系。研究表明阿根廷滑柔鱼雌性个体的生殖能量积累在繁殖产卵前期持续积累且增加显著, 海表面温度和叶绿素 a 浓度对卵巢、输卵管和缠卵腺的组织能量密度及能量积累具有显著的效应关系, 但是影响作用存在组织特殊性。

**关键词:** 阿根廷滑柔鱼; 生殖能量; 能量密度; 海洋环境; 西南大西洋

## Reproductive energy accumulation and relation to sea surface environments in female Argentinean shortfin squid, *Illex argentinus*

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**Abstract:** To better understand the female's reproductive energy accumulation and the responsive relation to living environments, we applied the technique of tissue energy density determination to determine the energy density of reproductive tissues, namely ovary, oviducts and nidamental glands, and then to estimate the tissues' energy accumulation. We also applied the generalized additive mixed-effects models to investigate the relationships between reproductive tissues' energy density, energy accumulation and sea surface oceanic variables, namely sea surface temperature (SST) and chlorophyll a concentration (Chl-a). Results indicated that during the period of sexual maturation, the ovary energy density varied significantly, but both oviducts and nidamental glands did not show significant differences in the energy density with sexual maturation. Cumulatively, the female Argentinean shortfin squid accumulates reproductive energy continuously till spawning, and the energy density and energy accumulation of the reproductive tissues are significantly correlated with SST and Chl-a, but the effects on the energy density and energy accumulation from the sea surface oceanic variables are likely tissue-specific.

**Key words:** *Illex argentinus*; Reproductive energy; Energy density; Marine environment; Southwest Atlantic



# 应用脂肪酸组成研究热带东太平洋同域中上层鲨鱼营养生态位分化

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**摘要：**热带东太平洋主要栖息有 8 种大型中上层鲨鱼，通过比较其肌肉脂肪酸组成，分析种间食性差异，营养关系及营养生态位分化。结果表明，尖吻鲭鲨营养级相对较高，大青鲨相对较低。3 种鼠鲨与 5 种真鲨存在食性差异或栖息地隔离。浅海长尾鲨与大眼长尾鲨营养生态位重叠程度较高，存在激烈的资源竞争。大青鲨与镰状真鲨生态位宽度较大，表征其对环境的可塑性较强；尖吻鲭鲨和路氏双髻鲨生态位宽度较小，表现为其食性的特化。

**关键词：**中上层鲨鱼；脂肪酸；摄食生态；同域共存；资源分配

## Trophic niche partitioning of sympatric pelagic sharks in the tropical Eastern Pacific inferred by fatty acid profiles

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**Abstract :** Species coexistence depends on how organisms utilize their environmental resources, namely trophic niche partitioning. The comparative study of interspecific trophic niches is helpful for understanding the coexistence mechanism of sympatric species. Fatty acid profiles reflect the feeding information of organisms obtaining a relative long time scale, and play an important role of revealing the trophic niche partitioning among species. There are eight pelagic shark species inhabiting in the tropical Eastern Pacific, including blue shark (*Prionace glauca*), silky shark (*Carcharhinus falciformis*), oceanic whitetip shark (*C. longimanus*), bigeye thresher shark (*Alopias superciliosus*), pelagic thresher shark (*A. pelagicus*), shortfin mako shark (*Isurus oxyrinchus*), scalloped hammerhead shark (*Sphyrna lewini*) and smooth hammerhead shark (*S. zygaena*). To study the differences of their feeding habits, nutritional relationship and trophic niche partitioning, the fatty acid profiles of shark muscle tissues were analyzed. Results showed that shortfin mako shark occupied the highest trophic level while blue shark occupied the lowest one. The trophic niche overlap of bigeye thresher shark, pelagic thresher shark and shortfin mako shark indicated their intense prey competition and the spatial segregation compared with other shark species were also detected. Bigeye thresher shark showed the most niche similarity to pelagic thresher shark, indicating they may compete for the same resources. Blu

**Key words: :** pelagic shark; fatty acid profile; feeding ecology; sympatry; trophic partitioning

# 基于多组织稳定同位素比值的 热带大西洋 4 种鲨鱼营养生态位分化

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**摘要：** 以在大西洋兼捕的大青鲨、长鳍鲨、拟锥齿鲨和尖吻鲨为对象，测定其肌肉、肝脏和血液 $\delta^{13}\text{C}$ 和 $\delta^{15}\text{N}$ 值，探讨 4 种鲨鱼营养生态位分化。结果表明：大青鲨与其他鲨鱼存在摄食隔离；尖吻鲨营养生态位宽幅最大且与拟锥齿鲨的营养生态位重叠度最高。大青鲨、拟锥齿鲨和尖吻鲨近期内无明显摄食变化，而长鳍鲨在短期内存在摄食变化。肝脏和血液整合摄食时间周期相近，其较高的代谢速率可反映相对短时间周期的摄食信息。

**关键词：** 热带大西洋；大洋性鲨鱼；组织周转；稳定同位素；摄食生态学

## Trophic niche partitioning of four pelagic shark species in the tropical Atlantic based of multi-tissue stable isotopes ratios

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**Abstract:** Stable carbon and nitrogen isotope ratios ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ , respectively) of multiple tissues with different turnover rates can provide information on the feeding, habitat utilization and trophic niche of consumers during different time periods. In this study, the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of muscle, liver and whole blood of blue sharks (*Prionace glauca*), longfin mako sharks (*Isurus paucus*), crocodile sharks (*Pseudocarcharias kamoharai*) and shortfin mako sharks (*I. oxyrinchus*) from tropical Atlantic were analyzed. The results showed similar and high trophic level of *I. oxyrinchus*, *P. kamoharai* and *P. glauca* with the lowest one of *I. paucus* due to their relatively small body size. Feeding segregation was found between *P. glauca* and other shark species because of their unique oceanic life history. The largest trophic niche width was observed for *I. oxyrinchus*, indicating its high prey diversity and ecological plasticity. Furthermore, high trophic niche overlap was found for *P. kamoharai* and *I. oxyrinchus*, implying their potential resource competition between the two species. Besides, there was no relationship observed between the differences among tissues in the  $\delta^{13}\text{C}$  or  $\delta^{15}\text{N}$  values and the body size indicated no recent diet shift. Exception was found in *I. paucus* whose differences in the  $\delta^{13}\text{C}$  or  $\delta^{15}\text{N}$  values between liver and muscle, whole blood and muscle showed significant relationship with the shark fork length, indicating its short-term diet change. Moreover, the similarity of  $\delta^{13}\text{C}$

**Key words:** tropical Atlantic; pelagic shark; tissue turnover; stable isotope; trophic ecology

# 广西红树林拟穴青蟹的主要营养来源的 稳定同位素分析

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**摘要：**通过收集广西北海、钦州、防城港的红树林区域附近的野生拟穴青蟹和潜在饵料样品，经预处理后进行碳和氮稳定同位素丰度测定，然后将测定结果输入 IsoSource 模型进行计算，得到潜在饵料分为鱼类、双壳贝类、腹足类、虾类、蟹类、小型甲壳类、多毛类、沉积物、红树、大型藻类对拟穴青蟹的营养贡献。发现沉积物的营养贡献占到 20%-30%，其余饵料类别贡献比例为 4.44%-13.7%。

**关键词：**拟穴青蟹；红树林；营养来源；稳定同位素

## The source of nutrition of the green crab in the mangrove along the coast of Guangxi

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**Abstract:** We collected the samples of green crab, *Scylla paramamosain* and potential diets from the mangrove at Beihai, Qinzhou, and Fangchenggang in Guangxi. The samples were treated and the content of stable isotope of carbon and nitrogen. The results were input to IsoSource and the contribution of potential diets were calculated. it was found that the sediment contributed 20%-30% of the nutrition of green crab. Fish, Bivalvia, Gastropoda, Shrimp, Crab, Small crustacean, Polychaete, Sediment, Mangrove, and Macrophytes contributed within the range between 4.44% to 13.7%.

**Key words:** *Scylla paramamosain*; Mangrove; Source of nutrition; Stable isotope

# 微生物制剂对白洋淀水陆交错带水体 修复模拟研究

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**摘要：**采用湖泊微流水模拟反应装置，向反应装置中定期添加不同浓度的微生物制剂（0.0，3.0，5.0，10.0，20.0mg/L），通过定期投加微生态制剂能够有效改善水陆交错带水体和底泥质量，对上覆水 CODCr、总磷和总氮的最高降解率分别为 33.57%、83.33%和 42.98%，对底泥全氮和有机碳的最高降解率分别为 31.16%和 19.53%。提高了底泥酶活性，对微生物群落结构也做出了一定的改变。

**关键词：**微生物制剂；水体修复；底泥修复；微生物群落；酶活性

## Study on indoor simulated remediation of water environment in Baiyangdian land/inland water ecotones by microecological agents

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**Abstract:** The lake micro-flow water simulation reactor was used to regularly add microbial agents with different concentrations ( 0.0, 3.0, 5.0, 10.0 and 20.0 mg / L ) to the reactor. The quality of water and sediment in the water-land ecotone could be effectively improved by regularly adding microbial agents. The maximum degradation rates of CODCr, TP and TN in overlying water were 33.57 %, 83.33 % and 42.98 %, respectively, and the maximum degradation rates of TN and TOC in sediment were 31.16 % and 19.53 %, respectively. The enzyme activity of sediment was increased, and the microbial community structure was also changed.

**Key words: :** microecological agents; water restoration; sediment restoration; microbial community; enzymatic activity

# 延绳钓渔业兼捕海鸟的现状以及对策

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**摘要：**2015年—2018年延绳钓和围网渔业中海鸟的年死亡率估计在13000—19000只之间，大约三分之二的海鸟死亡率是由北纬20°以北的延绳钓渔业造成的，大约四分之一的死亡率是由南纬30°以南的延绳钓渔业造成。目前，远洋延绳钓渔业中最有效和最可行的缓解措施是部署惊鸟绳、夜间投钩，以及增加带饵鱼钩下沉率的特定支线加重。如何在发展延绳钓渔业的同时，尽可能减少该渔业兼捕海鸟，是目前面临的重大课题。

**关键词：**延绳钓渔业；海鸟兼捕；养护措施

## The present situation and countermeasures of longline fishing and seabird catchin

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**Abstract:** Currently, the most effective and feasible mitigation measures in distant ocean longline fisheries are the deployment of bird scaring lines, night casting, and specific branch weights that increase baited hook sink rates. How to develop the longline fishery while minimizing the number of seabirds in the fishery is the biggest issue facing us. The purpose of this paper is to clarify the necessity of reducing the concurrent catching of seabirds, and to call on various fields to pay more attention to the problem of the concurrent catching of seabirds in longline fishery and to actively increase the research and improvement of the mitigation measures for seabird protection.

**Key words:** longline fishery; Sea birds bycatch; Conservation measures

# 梁子湖枝角类生物种群的衰退 与农药污染的关系研究

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**摘要：**自然水体是众多化学污染物的最终归宿地，而水体化学污染与水生生物的健康效应关系研究还鲜有报道。本研究以梁子湖为研究对象，调查了整个湖区的水质情况和浮游动植物的种群丰度，发现部分区域出现枝角类生物种群衰退现象。进一步的化学分析结果发现梁子湖部分区域枝角类生物种群衰退现象与农药的符合污染有关，并最终确认了主要致毒农药污染物，为梁子湖的污染管理提供了数据支撑。

**关键词：**梁子湖；种群衰退；化学污染物；分析化学；效应介导

## The relationship between population decline of Cladocerans in Liangzihu lake and pesticide pollution

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**Abstract:** The natural water bodies are the destinations of chemical pollutants, but the relationships between aquatic chemical pollution and health effects of aquatic organisms have been rarely studied. In this study, we examined the population density of plankton and found that in some waters of Liangzihu lake, the population of Cladocerans was declined. Furthermore, using analysis chemical methods, we found that the pollution of pesticides were responsible for the decline of Cladoceran population. Lastly, the pesticides were identified, and these data are useful for pollution management of Liangzihu lake.

**Key words:** : Liangzihu lake, population decline, chemical pollutants, analysis chemical, effect mediation

# 象山港海域不同生境类型中细菌群落多样性与结构差异分析

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**摘要：**为了解象山港海域不同生境类型中菌落组成和结构差异，本研究利用 16S rRNA 高通量测序技术评估了象山港海域的网箱养殖区、牡蛎养殖区、人工鱼礁区和天然对照区等 4 种生境类型中海水细菌的群落结构和多样性。结果表明：人工鱼礁区域具有较高的细菌丰度和多样性水平，其中网箱养殖区最低，且菌群差异较大 ( $P < 0.05$ )。人工鱼礁的投放有利于该海区细菌结构的多样性和稳定性，而近海网箱养殖活动使细菌群落结构多样性。

**关键词：**细菌；群落结构；网箱养殖；人工鱼礁

## Bacterial community structure and diversity in different habitats of Xiangshan Bay

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**Abstract:** To understand the characteristics of bacterioplankton communities in Xiangshan Bay, 16S rRNA gene high-throughput sequencing was employed in the present study to evaluate the bacterial structure and diversity in marine water samples from artificial reef area (AR), natural control area (NC), oyster culture area (OC) and cage culture area (CC) of Xiangshan Bay. Results showed that the abundance and diversity of bacterial community were higher in the AR habitat, and the lowest in the CC habitat which was found great difference in bacterial community composition ( $P < 0.05$ ). The deployment of artificial reef improved that the marine ecological environment, which was beneficial to the diversity and stability of the bacterial structure in the corresponding area, while the cage culture in offshore area caused the change of bacterial community to an unstable structure with reduced diversity.

**Key words:** bacterial; community structure; cage culture; artificial reef

# 水力停留时间和硝酸盐负荷对 2 种碳源反硝化性能的影响

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**摘要：**本研究探究了不同水力停留时间（HRT）和进水硝酸盐浓度（INC）对分别添加香蕉秆和丝瓜络的反硝化反应器（BS-DRs 和 LS-DRs）反硝化性能的影响。结果表明，BS 和 LS-DRs 最佳 HRT 分别为 20 和 24 h，BS 和 LS-DRs 的硝酸盐去除速率均随 INC 的增加而增加。此外，变形菌门、拟杆菌门和厚壁菌门在 BS 和 LS-DRs 内均被显著富集。

**关键词：**农业废弃物；水力停留时间；硝酸盐负荷；生物反硝化

## Effects of hydraulic retention time and nitrate load on denitrification performance of two carbon sources

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**Abstract:** This study investigated the effects of different hydraulic retention time (HRT) and influent nitrate concentration (INC) on the denitrification performance of denitrification reactors with banana stalk and loofah sponge (BS-DRs and LS-DRs), respectively. The results showed that the optimum HRT of BS and LS-DRs were 20 and 24 hours respectively. The nitrate removal rate of BS and LS-DRs increased with the increase of INC. In addition, Proteobacteria, Bacteroidetes and Firmicutes were significantly enriched in BS and LS-DRs.

**Key words:** Agricultural waste; Hydraulic retention time; Nitrate load; Biological denitrification



# 基于环境 DNA 技术的东海鱼类 物种多样性研究

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**摘要：**为了解东海海域主要鱼类群落的种类组成，监测和保护其多样性，本研究利用环境 DNA 技术对东海鱼类进行物种多样性分析。通过海水样本的采集、eDNA 提取、扩增和高通量测序分析，从东海 14 个站点的环境 DNA 样本中共检测出 2 纲，23 目，29 科，42 属，44 种海水鱼类，大部分种类在东海传统渔业资源调查中均有出现。

**关键词：**环境 DNA；东海；生物多样性；鱼类

## Study on fish species diversity in the East China Sea based on environmental DNA

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**Abstract:** To understand the species composition of the major fish communities in the East China Sea and to monitor and protect their diversity, this study used environmental DNA technology to analyze the species diversity of fish in the East China Sea. Through the collection of seawater samples, eDNA extraction, amplification and high-throughput sequencing analysis, a total of 44 species of marine fishes in 2 phyla, 23 orders, 29 families and 42 genera were detected, and most of the species were found in the traditional fishery resources survey in the East China Sea. Among them, the species with high relative abundance were red nose anchovy (*Thryssa kammalensis*), blue-spotted horse mackerel (*Scomberomorus niphonius*), Japanese mackerel (*Scomber japonicus*), small yellowtail (*Larimichthys polyactis*) and mullet (*Mugil cephalus*). The alpha diversity among stations was significant difference, and generally showed high biodiversity at coastal stations and high biological abundance at offshore stations. The results suggested that environmental DNA technology can quickly explore the diversity and spatial distribution of fish species in the East China Sea, as an effective supplementary to traditional fisheries resource monitoring.

**Key words:** environmental DNA; East China Sea; biodiversity; fish

# 有效微生物菌群对蟹鲈混养模式下 养殖水体菌群结构的影响

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**摘要：**为探究定期添加 EM 对蟹鲈混养养殖水质和菌群结构的影响，进行了I期（4月10号）、II期（4月20号）、III期（4月30号）和IV期（5月10号）实验监测，并通过水质理化指标、16S rRNA 基因高通量测序技术分析每个时期的水质和菌群结构。本研究表明蟹鲈混养模式下定期添加 EM 可以改善养殖水体水质，有效抑制蓝细菌，且显著优化菌群结构，具有显著的水体原位修复功能。

**关键词：**有效微生物；菌群结构；丰富度；原位修复

## Effect of Effective microorganisms (EM) on aquatic bacterial community structure under polyculture mode of *Eriocheir sinensis* and *Micropterus salmoides*

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**Abstract:** To investigate the effects of regular addition of EM on the water quality and microbial community structure in mixed culture of *Eriocheir sinensis* and *Micropterus salmoides*. Research I period (10th April), II period (20th April), III period (30th April) and IV period (10th May) experiment monitoring, and through the water quality of the physical and chemical index, 16s rDNA high-throughput sequencing technologies water and flora structure of every period are analyzed. Studies have shown that the addition EM to the mixed pond of *Eriocheir sinensis* and *Micropterus salmoides* can improve the physical and chemical properties of aquaculture water, has significant in-situ repair function of water, effectively inhibits cyanobacteria, and significantly optimizes the structure of bacterial flora.

**Key words:** Effective Microorganisms; Microbial structure; Richness; in-situ remediation

# 一株高效好氧反硝化菌 BF6 的分离鉴定及反硝化特性研究

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**摘要:** 本研究从循环水养殖系统中分离获得一株高效的好氧反硝化菌 BF6。经 16S rRNA 结合生理生化鉴定为成都假单胞菌。实验表明: 分别以亚硝酸态氮和硝酸态氮为单一氮源时, 菌株 BF6 在 12 h 的 TN 去除率分别达到 79% 和 58%。响应面法模型表明, 在 37 °C、235rpm、C/N 为 23 时, 菌株 BF6 的 TN 去除率最高 (90%)。因此, 菌株 BF6 是一株高效的好反硝化菌, 在养殖尾水处理方面具有良好的应用前景。

**关键词:** 生物脱氮; 好氧反硝化; 成都假单胞菌

## Isolation and Identification of A High-Efficiency Aerobic Denitrifying Bacterium Strain BF6 and Its Denitrification Characteristics Evaluation

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**Abstract:** An aerobic denitrifying bacterium BF6 with excellent nitrogen removal performance was isolated from biofilters of the recirculation aquaculture system. The strain BF6 was identified as *Pseudomonas chengduensis* based on physiological and biochemical characteristics and 16S rRNA. The results of experiments showed that the TN removal efficiency of strain BF6 was 79% and 58% in 12h, When nitrite and nitrate was taken as the only nitrogen source, respectively.

Response surface methodology experiment showed that the maximum removal of TN( 90%) occurred under the condition of 37°C, shaking speed 235rpm and C/N ratio of 23. This research indicated that *Pseudomonas chengduensis* strain BF6 is a highly efficient aerobic denitrifying bacteria and possesses great potential for application in aquaculture wastewater treatment.

**Key words:** Biological denitrification, Aerobic denitrification, *Pseudomonas chengduensis*

# 大洋性头足类胃和肠道中的微塑料： 以秘鲁外海茎柔鱼为例

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**摘要：**以秘鲁外海茎柔鱼胃研究对象，分析发现雌、雄个体相同组织内微塑料丰度与组成相似。每尾茎柔鱼胃中微塑料的丰度和粒径均高于肠道，单位组织质量的丰度胃低于肠道。胃和肠道中微塑料形状均以纤维为主，颜色以蓝色和黑色为主，聚合物类型主要是 Cellophane 和 Polyacrylic acid。该结果反映了秘鲁渔场水体中的微塑料分布特征，有助于探究微塑料对头足类的生态效应。

**关键词：**茎柔鱼；微塑料；胃；肠道

## Microplastics in the stomach and intestine of pelagic squid: a case study using *Dosidicus gigas* off Peru.

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**Abstract:** In this study, *D. gigas* taken from the waters off the Peruvian Exclusive Economic Zone were selected as research objects. We estimated the abundance and characteristics of MPs in the stomach and intestine of *D. gigas* and investigated the potential differences between tissues and sexes. Similar abundance and characteristics of MPs were observed in the same tissue of females and males. However, the stomach had a higher abundance of MPs by the individual and larger size than the intestine, while the MP abundance by stomach wet weight was lower than that of the intestine. The MPs were predominantly fiber-shaped, blue, or black. The most frequent polymers were high-density cellophane and polyacrylic acid. These polymers can sink into deeper water layers and are available for *D. gigas* living in these areas during the daytime. Our findings might represent the distribution pattern of MPs in the waters of the Peruvian fishing ground. This study improves our understanding of the MP contamination level in pelagic squid, and has implications for evaluating the ecological effects of MP on cephalopods.

**Key words:** *Dosidicus gigas*; microplastic; stomach; intestine

# 底播增殖菲律宾蛤仔对大型底栖动物群落营养与功能多样性的影响

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**摘要:** 为探究底播增殖菲律宾蛤仔对大型底栖动物群落功能与营养结构的影响, 本研究对莱州湾菲律宾蛤仔底播区增殖前后的大型底栖动物群落进行调查, 将其按食物来源划分为滤食功能群, 底栖碎屑食性功能群以及肉食功能群, 并基于碳、氮稳定同位素分析营养结构, 基于生物性状分析功能结构。结果显示, 大型底栖动物群落的功能与营养结构在底播前后呈现显著差异。滤食性生物向大体型转变, 食源呈现单一化。

**关键词:** 大型底栖动物, 稳定同位素, 功能性状, 底播增殖, 菲律宾蛤仔

## Trophic and functional responses of macrofaunal assemblage to bottom-based Manila clam (*Ruditapes philippinarum*) aquaculture

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**Abstract:** To assess the trophic and functional responses of macrofaunal assemblage to bottom-based Manila clam aquaculture, this study investigated the macrofaunal assemblage before and after the seeding of Manila clam from a bottom-based farm located in Laizhou Bay. The assemblages are divided into filter feeder group, detritus feeder group, and carnivore group based on animals' feeding mode. Stable isotope and biological trait were applied to analyzed trophic and functional structure, respectively. Significant differences were observed in trophic and functional structure after the seeding of Manila clam. Specifically, filter feeders turned to larger in body sizes but simplified in food sources; dominated opportunities species were observed in detritus feeders, relaying more on the biosediments from the cultured clams; Increased trophic and functional richness were found in carnivores, and high trophic level predators were also observed. Our study suggested that the the Manila clam aquaculture can benefit the trophic and functional diversity, and enhance the efficiency of resource use in macrofaunal assemblage.

**Key words:** macrofaunal assemblage, stable isotope, functional trait, bottom farming, Manila clam

# 姚江流域水质评价与污染源分析：以余姚内河水域为例

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**摘要：**采用单因子和综合水质标识指数法对 2018~2019 年丰、枯水期姚江、长冷江、湖塘江和临周江共 10 个断面的水质状况进行评价，并利用因子分析量化不同主成分中污染物的贡献率。结果表明枯水期综合水质评价优于丰水期，两时期共同超标指标为溶解氧、总氮和石油类。湖塘江综合水质评价结果最好，长冷江其次，姚江再次，临周江最差。两年度污染源结果比较分析发现余姚市开展的一系列市政建设对城市生活污水的有良好的治理效果。

**关键词：**姚江流域；水质标识指数法；因子分析；污染源

## Water quality assessment and pollution source analysis of Yaojiang River Basin: A case study of inland rivers in Yuyao City, China

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**Abstract:** To fully understand the water quality status of the Yuyao section in the Yaojiang River Basin, we utilized the single factor and comprehensive water quality identification index methods, as well as factor analysis in this study. The single factor water quality assessment results showed that the common parameters exceeding the standard in both the wet and dry seasons included dissolved oxygen and total nitrogen, which were inferior to the target water quality grade III by 1~6 grades. The comprehensive water quality order reaching the target grade III was Hutang River (87.5%), Changling River (50.0%), Yaojiang River (43.8%), and Linzhou River (37.5%). The comprehensive water quality in the dry season (90.0% standard-achieving rate) was better than that in the wet season (25.0% standard-achieving rate). These results suggested that the surface runoff might considerably impact water quality. The factor analysis results showed that the basin surveyed in 2018 was mainly polluted by urban sewage and agricultural sources, while the primary pollution source in 2019 was agricultural pollution. Integrated with comprehensive water quality assessment results, in this study, we demonstrated that series of water treatment projects carried out in Yuyao City positively impacted municipal sewage treatment.

**Key words:** Yaojiang River Basin; Water Quality Identification Index; Factor Analysis; Pollution Source

# 利用 Biolog Eco 板和 PICRUS2 方法 分析凡纳滨对虾养殖池塘末期细菌群落 的功能多样性

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**摘要:** 微生物在环境中的作用是通过群落功能来实现的, 但是人们对凡纳滨对虾池塘水体和底泥中微生物群落的功能多样性仍知之甚少。本研究中作者将高通量测序技术和 Biolog Eco 方法相结合, 研究凡纳滨对虾池塘养殖末期水体和底泥中细菌群落的结构和功能多样性, 并评价了基于 Biolog Eco 板的微生物群落实际代谢特性与基于 PICRUS2 的预测功能的相关性。

**关键词:** 凡纳滨对虾池塘; 细菌群落; 功能多样性; 高通量测序; Biolog Eco 板

## Analysis of bacterial community functional diversity in late-stage shrimp (*Litopenaeus vannamei*) ponds using Biolog EcoPlates and PICRUS2

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**Abstract :** The role of microorganisms in the environment is reflective of the function of the community; however, our understanding of the functional diversity of the bacterial microbiome found in water and sediment from shrimp ponds is currently fragmentary. This study utilized high-throughput sequencing techniques and community level physiological profiling (CLPP) methods to study the structural and functional diversity of the bacterial communities found in water samples and sediment from three intensive *Litopenaeus vannamei* culture ponds at late stage. The correlation between the presumptive functions using PICRUS2 and the actual metabolic profiles via Biolog EcoPlates was evaluated.

**Key words::** *Litopenaeus vannamei* pond, bacterial community, functional diversity, high-throughput sequencing, Biolog EcoPlates

# 基于地理条件的珠海外伶仃岛海域 海洋牧场选址适宜性分析

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**摘要：**海洋牧场选址是否适宜影响海洋牧场建设效果。本文基于地理条件考虑影响海洋牧场选址的因素，利用遥感数据研究了外伶仃岛岸线 42 年间变化情况，构建评价指标分析了拟选海域与养殖水域滩涂规划、海洋功能区划、海洋生态红线和海洋工程的符合性。结果表明，外伶仃岛岸线稳定；研究区域面积 78.68km<sup>2</sup>，最适宜、较适宜和不适宜海洋牧场建设区域的空间分布，所占面积分别为 18.21km<sup>2</sup>、14.88km<sup>2</sup>、45.59km<sup>2</sup>。

**关键词：**珠江口；外伶仃岛；海洋牧场；选址评价

## Study on Site Selection of Marine Ranching in Wailingding Island, Pearl River Estuary

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**Abstract:** Whether the location of marine ranching is suitable or not affects the construction effect of marine ranching. In this paper, based on geographical conditions, considering the factors affecting the location of marine ranching, the changes of the coastline of Wailingding Island in 42 years were studied by using remote sensing data, and the conformity of beach planning, marine functional zoning, marine ecological red line and marine engineering between the proposed sea area and aquaculture waters was analyzed by constructing evaluation indexes. The results show that the coastline of Wailingding Island is stable. The study area is 78.68km<sup>2</sup>, which is the most suitable, suitable and unsuitable area for marine ranching construction, with the area of 18.21km<sup>2</sup>, 14.88km<sup>2</sup> and 45.59km<sup>2</sup> respectively.

**Key words:** Pearl River Estuary; Wailingding Island; marine ranching; site selection evaluation



# 东太平洋赤道海域茎柔鱼(*Dosidicus gigas*)的 体型月间变化及环境效应

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**摘要:** 为了掌握茎柔鱼体型生长变化及其与栖息环境因子的效应关系, 2017年2—4月和6—8月, 在东太平洋赤道海域逐月随机采集了3 628尾茎柔鱼样本, 进行体质量、胴长的月间变化分析和胴长与海表温、叶绿素 a 浓度的效应关系研究。

**关键词:** 茎柔鱼; 体型变化; 海表温; 叶绿素 a 浓度; 东太平洋

## MONTHLY VARIATION IN BODY SIZE OF DOSIDICUS GIGAS AND ENVIRONMENTAL RESPONSES IN THE EQUATORIAL WATERS OF EASTERN PACIFIC OCEAN

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**Abstract:** The jumbo squid *Dosidicus gigas* is endemic to the eastern Pacific Ocean and plays a critical role being prey or predator, and it is an important species in the world invertebrate fishery. To understand the body size changes of *D. gigas* and the environmental responses, we randomly collected 3 628 specimens from the equatorial waters of eastern Pacific Ocean during February-April and June-August 2017.

**Key words:** *Dosidicus gigas*; size change; sea surface temperature; chlorophyll a concentration; eastern Pacific Ocean

# 河蚶（*Corbicula fluminea*）线粒体及染色体水平基因组测定分析

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**摘要：**河蚶是我国重要的淡水经济贝类。本研究应用高通量测序及辅助组装策略，分别获得了河蚶线粒体全基因组和高质量染色体水平基因组精细图谱。河蚶线粒体基因组大小 1.7Mb。基因组大小 1.52 Gb，杂合度高、重复序列多，分布在 18 条染色体上。比较基因组学分析结果显示，基因组中与免疫、繁殖相关的基因家族显著性扩张，可能与河蚶淡水环境适应性等特征相关。该工作提供的基础数据，可推动今后河蚶增殖、繁育工作。

**关键词：**河蚶；线粒体基因组；染色体水平基因组测定；PacBio；Hi-C

## Dissecting the mitochondrial genome and chromosome-level genome of the Asian Clam (*Corbicula fluminea*)

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**Abstract:** Asia clam (*Corbicula fluminea*) is a kind of important aquatic economic shellfish in China. In this study, we present a complete mitogenome and a de novo chromosome-scale genome assembly of *C. fluminea*. The mitochondrial genome size of *C. fluminea* is 17,423 bp in size, while the genome size is 1.52 GB. The *C. fluminea* genome had a relatively high repeat content (69.66%) and a high heterozygosity rate (2.41%). More than 1.51Gb (99.17%) of genomic sequences were anchored to 18 chromosomes, of which 1.40 Gb (92.81%) of genomic sequences were ordered and oriented. Compared with related species, some gene families related to immunity and reproduction showed significant expansion in *C. fluminea*. It might be related to the characteristics of freshwater environmental adaptability of *C. fluminea*. These data will be a valuable resource for a range of development and breeding studies of *C. fluminea* in future research.

**Key words:** *Corbicula fluminea*, mitogenome, chromosome-level genome sequencing, PacBio, Hi-C

# 泉吉河青海湖裸鲤自然产卵场的无人机遥测识别与定量评估

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**摘要:** 无人机测绘具有快速高效、机动灵活、成本低等特点, 成为遥感测绘领域的新兴力量, 对于分布于高原、野外作业难度大、不易达到的河流栖息地调查提供了一种便捷的方法。本研究利用无人机对青海湖入湖支流泉吉河约 60km 长的江段进行了航拍调查, 同时, 对产卵场生境特征参数进行了原位调查监测, 最终, 基于河道形态、沙洲分布、可视水深和曲折率等生境特征使用目视解译法和 AI 识别法实现了对泉吉河产卵场分布状况和规模评估。

**关键词:** 青海湖裸鲤; 无人机; 产卵场; 生境; 河道形态

## Characteristics of Spawning Habitats *Gymnocypris przewalskii* in Quanji River by UAV (unmanned aerial vehicle) Surveys

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**Abstract:** UAV surveying has become a method of field investigation due to its flexibility and convenience. Through UAV survey and field investigation, this study concluded that quanji river has 307 spawning grounds suitable for *Gymnocypris przewalskii* breeding under normal conditions, with a total area of 339,320m<sup>2</sup>. The middle reaches have the largest area (258,039m<sup>2</sup>), followed by the lower reaches (124,455m<sup>2</sup>), while the tributaries have the smallest area (5,471m<sup>2</sup>). Quanji river has many shoals that can provide potential spawning sites in flood season (the total area is 33,154,341 m<sup>2</sup>), and it is also the largest area in the middle reaches. This study can provide important basic data for the assessment and protection of natural breeding habitat of *Gymnocypris przewalskii*.

**Key words:** *Gymnocypris przewalskii*, UVA, Spawning grounds, habitat

# 莱州湾东岸大型底栖生物群落 分类与功能 beta 多样性格局及其驱动因素

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**摘要:** 本研究从分类和功能两个方面探究了莱州湾东岸大型底栖生物群落 beta 多样性及其周转和嵌套组分, 揭示了环境过滤和扩散限制两种生态学过程对其群落集合机制的影响。结果显示: (1) 莱州湾东岸大型底栖生物群落的分类与功能 beta 多样性均维持在较高水平; (2) 空间距离对大型底栖生物群落分类与功能 beta 多样性无显著影响; (3) MRM 表明, 与沉积物相关的因子是驱动大型底栖生物群落分类与功能 beta 多样性的主要因素。

**关键词:**  $\beta$ 多样性; 大型底栖无脊椎动物; 生物性状; 环境过滤

## Patterns and drivers of taxonomic and functional beta diversity of Macrobenthos Community on the eastern coast of Laizhou Bay

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**Abstract:** In this study, the beta diversity and its turnover and nestedness-resultant components of macrobenthos communities on the eastern coast of Laizhou Bay were explored from taxonomic (i.e., species composition) and functional (i.e., biological trait composition) aspects and the effects of environmental filtering and dispersal limitation on the community assembly mechanism was revealed. The results showed that: (1) both the taxonomic and functional beta diversity of macrobenthic communities on the eastern coast of Laizhou Bay were at a high level, and dominated by turnover component. (2) Spatial geographical distance had no significant effect on the taxonomic and functional beta diversity and their components of macrobenthic communities ( $P > 0.05$ , Mantel test), indicating that the impact of dispersal limitation on macrobenthic communities was limited; (3) Multiple regression on distance matrices (MRM) analysis showed that sediment-related environmental factors, namely total organic matter (TOM) and silt content, are the main factors driving the taxonomic beta diversity of macrobenthic communities, while the functional beta diversity is significantly affected by TOM. In summary, environmental filtering is the primary ecological process that driving the construction mechanism of macrobenthic communities on the eastern coast of Laizhou Bay.

**Key words:** beta diversity; macroinvertebrates; biological traits; environmental filtering

# 不同群体刀鲚的形态多样性分析

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**摘要:** 为研究刀鲚(*Coilia nasus*)种内形态特点和地理分化规律, 运用多元统计方法对刀鲚的 6 个地理群体(嵎泗海域、长江河口、长江泰州段、洪泽湖、巢湖及鄱阳湖)的 24 个形态性状指标进行形态差异性分析。研究表明, 刀鲚群体间产生了一定程度的形态差异, 且主要表现为头胸部、腹部和尾部的性状上, 但这些差异尚未达到亚种水平, 揭示了刀鲚各群体之间存在一定的关联性, 也为刀鲚资源调查以及资源保护提供了一定的理论基础。

**关键词:** 刀鲚; 形态学; 框架结构; 多元分析

## Morphological Variations Analysis of Different Geograohic Populations of *Coilia nasus*

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**Abstract :** In order to study the intraspecific morphological characteristics and geographical differentiation rules of *Coilia nasus*, the morphological differences of 24 morphological traits of six geographical populations of *Coilia nasus* (Shengsi Sea, Yangtze River Estuary, Taizhou Section of Yangtze River, Hongze Lake, Chaohu Lake and Poyang Lake) were analyzed by multivariate statistical method. The results showed that there had been a certain degree of morphological differences among the populations of *Coilia nasus* in the six waters, which were mainly manifested in the head, chest, abdomen and tail traits. However, these differences had not yet reached the subspecies level, that there was a certain correlation among the populations of *Coilia nasus*, and also providing a theoretical basis for the resource investigation and resource protection of *Coilia nasus*.

**Key words: :** *Coilia nasus*; morphology; truss network; multivariation analysis

# 江苏沿海脊尾白虾养殖池塘重金属污染及潜在生态危害评价

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**摘要：**生态环境质量评价结果表明，江苏沿海脊尾白虾养殖区池塘海水重金属铜和镉的含量均符合第一类《海水水质标准》，铅和锌的含量均符合第二类《海水水质标准》，属于清洁水平；养殖池塘沉积物重金属的含量符合第一类《海洋沉积物》标准，属于较清洁水平。潜在生态危害指数评价显示，该地区养殖池塘整体为轻微生态风险等级（RI为13.17~26.65），镉为主要污染元素，但也仅达到轻微风险等级（Eif为5.54~16.45）。

**关键词：**脊尾白虾；养殖池塘；重金属污染；潜在生态危害

## An assessment of pollution and potential ecological hazards of heavy metal in aquaculture ponds of *Exopalaemon carinicauda* Holthuis on Jiangsu coast

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**Abstract :** Based on the investigation data of heavy metals in seawater, sediment and marine organisms in aquaculture ponds of *Exopalaemon carinicauda* Holthuis at Jiangsu coast, the pollution status and the potential ecological risk of the heavy metals were studied using the index technique of single factor and Hakanson ecological risk index. The results indicated that the average concentrations of copper, lead, cadmium and zinc in seawater, sediments and organisms were 3.13, 1.02, 0.094, 28.02 ug/L,  $22.88 \times 10^{-6}$ 、 $19.93 \times 10^{-6}$ 、 $0.18 \times 10^{-6}$ ,  $140.69 \times 10^{-6}$ ,  $12.49 \times 10^{-6}$ ,  $0.50 \times 10^{-6}$ ,  $0.18 \times 10^{-6}$ ,  $28.65 \times 10^{-6}$ , respectively. The results of eco-environmental quality evaluation showed that the average concentrations of Cu and Cd in the aquatic seawater were below the first degree of Sea Water Quality Standard, while the average concentrations of Pb and Zn were below the second degree of Sea Water Quality Standard and belonged to the grade of “green”. The concentrations of four metals in the sediments of the aquatic ponds were all less than the values of the first degree of Standard for Marine Sediments Quality and belonged to the grade of “less green”. The ecological risk assessment showed that the sediments of the aquatic ponds at Jiangsu coast had the potential ecological risk at lower levels (RI were 13.17-26.65) and the most important contaminating element was Cd with a lower-level potential ecological risk (Eif were 5.54-16.45).

**Key words: :** *Exopalaemon carinicauda* Holthuis; aquaculture ponds; heavy metals pollution; potential ecological hazards

# 长江口刀鲚繁殖群体组成和繁殖性能

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**摘要:** 本研究对 144 尾长江口刀鲚繁殖群体组成和繁殖性能进行分析, 结果显示 4 月份刀鲚繁殖群体个体最大。雌性占优, 雌雄性比为 8:1。4 月份以卵巢发育至 II 期个体为主。GSI 从 4 月至 6 月随着性腺不断发育成熟而逐渐增加, 6 月份最高。所选成熟个体的繁殖力平均值为  $51073 \pm 11302$  粒。本研究结果可用于判定当前长江口刀鲚繁殖群体的整体状况, 为后期针对该物种的保护以及管理政策制定和规划调整提供基础资料和理论依据。

**关键词:** 长江口; 刀鲚; 繁殖性能; 性体指数

## Reproductive population composition and reproductive performance of *Coilia nasus* in the Yangtze Estuary

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**Abstract:** In order to find out the current reproductive population composition and reproductive performance of *Coilia nasus*, 144 fish samples were collected in the South Branch of the Yangtze Estuary. The results show that the individual size composition in April was the largest. A total of 128 females (88.9%) and 16 males (11.1%) with an overall sex ratio of 8:1 (female: male) were collected, in which females were dominant. The ovaries maturity stages for the individuals in April are mainly in phase II. GSI increased gradually with the continuous development and maturity of gonads from April to June, and reached the highest in June. The fecundity was found to vary from 29908 to 74041 eggs with an average of  $51073 \pm 11302$  eggs for the selected mature individuals. The results of this study could be used to determine the overall situation of *C. nasus* reproductive population in the Yangtze Estuary, and provide basic data and theoretical basis for later protection, management policy-making and planning adjustment for this species.

**Key words:** Yangtze Estuary; *Coilia nasus*; reproductive performance; gonadosomatic index

# 基于底拖网的南黄海水产种质资源保护区大型底栖动物生物多样性和优势种变化

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**摘要:** 为有效保护水产种质资源, 利用 2019 年 8 月—2020 年 4 月 3 个航次底拖网资料, 对南黄海 2 个水产种质资源保护区大型底栖动物进行分析。结果表明: 大型底栖动物类群组成中甲壳动物居首位, 其次鱼类, 软体动物第三。与 20th80s 相比, 原本位居前列的软体动物, 现在退居第三, 首位被甲壳动物取代, 鱼类第二; 优势种均比历史上更为丰富, 且大多为经济种; 夏季 2 个保护区之间物种多样指数具有差异显著性( $P<0.05$ )。

**关键词:** 南黄海; 底拖网大型底栖动物; 水产种质资源保护区; 物种多样性; 优势种

## Variation of biodiversity and dominant species based on trawling macrobenthos in two National Aquatic Germ-Plasm Reserves of the Southern Yellow Sea

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**Abstract:** Aquatic germplasm resources have high economic and ecological value. In order to protect aquatic germplasm resources effectively. Based on the trawling macrobenthos of three seasons from August 2019 to April 2020, the community structure and species diversity of macrobenthos in two National Aquatic Germ -Plasm Reserves of South Yellow Sea were studied. A total of 78 species of macrofauna were identified, including 30 species of crustaceans, 25 species of fishes, 12 species of mollusks, 10 species of echinoderms and 1 species of polychaete. Compared with 20th80s, molluscs, which had been in the forefront, now retreated to the third place, the first place was replaced by crustaceans and the second was fish. There was small seasonal replacement rate of dominant species in the Reserve of Chinese Shrimp and *Portunus trituberculatus*, *Oratosquilla oratoria*, *Parapenaeopsis hardwickii* were economic fishery resources. There were more economic fishery resources in the Reserve of Silver Pomfret such as *Palaemon gravieri*, *Portunus trituberculatus*, *Miichthys miiuy*, *Collichthys lucidus*, *Oratosquilla oratoria* and *Parapenaeopsis hardwickii*. The dominant species in the two Reserves were more abundant than that in 20th80s. There was significant difference between the two Reserves only in summer ( $P<0.05$ ). However, the difference disappeared in autumn, the diversity and stability of benthos community recovered, the macrobenthos communities in the two reserves could maintain a relatively stable.

**Key words:** Southern Yellow Sea; trawling macrobenthos; Aquatic germplasm resources protection area; species diversity; dominant species



# 莱州芙蓉岛人工鱼礁区大型底栖动物 营养结构特征研究

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**摘要：**为了探究投礁时长对大型底栖动物营养关系的影响，本研究应用稳定同位素技术对比分析了莱州芙蓉岛海域不同礁龄人工鱼礁区和对照区大型底栖动物及其食源的碳、氮稳定同位素组成，计算了不同区域大型底栖动物的食物基础以及消费者的营养级。结果显示：人工鱼礁的建设能使大型底栖动物更充分的利用浮游植物碳源，并且能够增加底栖动物群落营养多样性和丰富度，促进群落中较高营养级动物的增加。

**关键词：**大型底栖动物；食物关系；营养级；稳定同位素；人工鱼礁

## Study on the trophic structure of macrobenthos in artificial reef area of Furong Island, Laizhou Bay

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**Abstract:** Artificial reef is an effective practice for improving benthic habitat, benthos diversity, and resource richness, its construction effect is closely related to the construction time. In order to explore the effects of artificial reef construction time on the trophic relationship of macrobenthos, in this study, stable isotope technique was used to analyze the carbon and nitrogen stable isotope in macrobenthos and their potential food sources in an artificial reef based in Furong Island, Laizhou Bay. The trophic level of macrobenthos was also calculated. The results showed that: (1) Compared to short-age reef and control area, the macrobenthos community in the long-age reef area has higher trophic diversity, higher food source diversity, more diverse trophic niches and better stability of community structures. (2) The construction of artificial reefs could enhance the utilization of carbon sources of phytoplankton by macrobenthos. (3) Higher trophic level predators were observed in long-age reef area, which indicated that a longer food chain and more complex trophic structure in long-age reef. Our results provide basic data for the material cycle and energy flow of food web in benthic habitats, and contribute to understand the ecological effects of artificial reef construction and the trophic structure of macrobenthos communities.

**Key words:** Macrobenthos; Food relationship; Trophic level; Stable isotopes; Artificial reefs

# 饥饿对许氏平鲈行为和代谢的影响

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**摘要:** 我们调查了许氏平鲈幼鱼对不同时长食物剥夺所做出的适应, 包括行为、代谢等。本研究设置了三种不同投喂频率, 在室内进行了为期 6 周的实验, 期间内采用行为评估装置评估了实验鱼的胆量、探索性以及好斗性, 并测量了标准代谢率 (SMR)。结果发现, 经历不同时长食物剥夺实验鱼的个性行为以及标准代谢率 (SMR) 均会受到不同的影响, 并且发现实验鱼对食物剥夺所表现出的适应为短期的食物剥夺会使实验鱼表现出较为积极的个性行为。

**关键词:** 食物剥夺, 适应能力, 活动能力, 个性行为, 标准代谢率, 许氏平鲈

## Effects of food deprivation duration on the behavior and metabolism of black rockfish (*Sebastes schlegelii*)

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**Abstract:** We investigated the adaptation of juvenile *Sebastes schlegelii* to different duration of food deprivation, including behavior and metabolism. Boldness, exploration, and aggressiveness were assessed and standard metabolic rate (SMR) were measured using behavioral assessment devices during a 6-week laboratory experiment at three different food deprivation durations. The results showed that the individual behavior and standard metabolic rate (SMR) of experimental fish were affected by different duration of food deprivation, and the adaptation to short-term food deprivation led to more positive individual behavior of experimental fish.

**Key words:** food deprivation; adaptive capacity; activity ability; personality; standard metabolism rate; *Sebastes schlegelii*

# 不同发育阶段中华绒螯蟹对隐蔽物的 喜好性研究

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**摘要:** 为探究不同发育阶段中华绒螯蟹的藏匿性以及对其对隐蔽物类型的喜好性, 采用单因子实验方法, 研究了不同发育阶段中华绒螯蟹的藏匿性以及对其对泥、沙、草和石头四种隐蔽物的喜好性。研究表明, 不同发育阶段中华绒螯蟹均具有藏匿性, 且亲蟹和扣蟹白天的藏匿行为明显强于夜晚; 亲蟹最喜欢藏匿到石头里面, 其次是泥; 扣蟹对四种隐蔽物无显著喜好性; 仔蟹最喜欢躲在水草里, 其次是石头里。中华绒螯蟹不同发育阶段对隐蔽物的需求不尽相同。

**关键词:** 中华绒螯蟹; 隐蔽物; 扣蟹; 亲蟹; 仔蟹; 行为

## Preference of *Eriocheir sinensis* for concealment at different developmental stages

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**Abstract:** To explore the concealment of Chinese mitten crabs at different developmental stages and their preference for concealed objects, the single-factor experiment method was used to study the concealment of Chinese mitten crabs at different developmental stages and their preference for mud, sand, grass and stones. The results of the study showed that Chinese mitten crabs at different developmental stages are concealed, and the concealing behavior of parent crabs and button sized crabs during the day is significantly stronger than that at night; Parent crabs like to hide in stones, followed by mud; Button sized crab has no obvious preference for the four hidden objects; Juvenile crabs like hiding in grass the most, followed by rocks. *Eriocheir sinensis* has different requirements for concealed objects at different developmental stages.

**Key words::** *Eriocheir sinensis*; concealment; parent crab; button sized crab; juvenile crab; behavior

# 环境丰容对许氏平鲷空间认知能力的影响：行为和转录组学分析

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**摘要：**本研究探究了环境丰容对许氏平鲷空间认知能力的影响，并从行为和转录水平探讨了其作用机制。幼鱼经环境丰容驯养 7 周后，其游离迷宫时长显著低于对照鱼，表明丰容鱼空间认知能力较强；驯养期间丰容鱼打斗行为和群体离散均显著低于对照鱼，表明环境丰容能够影响幼鱼社群结构，降低社群压力；通过端脑转录组分析，鉴定了一系列与幼鱼应激反应、代谢和神经可塑性相关的差异表达基因，其可能介导了环境丰容对幼鱼认知能力的调控过程。

**关键词：**环境丰容，认知能力，转录组，许氏平鲷

## Environmental enrichment enhances spatial cognitive abilities of *Sebastes schlegelii*: behavioral and transcriptome analyses

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**Abstract :** This study aimed to explore the effects of environmental enrichment on the spatial cognitive abilities of black rockfish *Sebastes schlegelii* and relevant behavioral and molecular mechanisms. The results showed that environmental enrichment for seven weeks could significantly improve fish spatial learning and memory abilities (i.e., the enriched fish exited the maze faster). During the captive period, the aggressive behavior and group dispersion index of enriched fish were significantly lower than those of barren fish. Through transcriptomic analyses, a series of differentially expressed genes and pathways which may underpin the enhanced effects of enriched environment on fish spatial cognition were identified, and these genes mainly related to stress response, metabolism and neural plasticity. This study may benefit for deeply understanding the enrichment effects on fish behaviors and relevant mechanisms, and provide fundamental information for preparing released fish in stock enhancement projects.

**Key words::** environmental enrichment, cognitive abilities, transcriptome, *Sebastes schlegelii*

# 基于水声学频差技术评估镇江 长江豚类省级自然保护区渔业资源现状

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**摘要：**为准确评估江苏镇江长江豚类省级自然保护区渔业资源现状，于2020年4月和9月采用水声学方法配合网具捕捞开展鱼类资源调查，在分析200 kHz和333 kHz的鱼类回波映像数据的基础上，引入频差技术进行鱼类资源声学评估。结果表明，保护区鱼类资源密度均值为 $0.094 \pm 0.183$  尾/m<sup>2</sup>，4月和9月鱼类资源密度差异不显著( $p > 0.05$ )，在网捕采集鱼类中，中上层鱼类种群数量占比为68.46%。

**关键词：**长江豚类省级自然保护区；水声学；频差技术；资源评估；目标强度

## Assessment of fishery resources in Zhenjiang Yangtze River Dolphin Provincial Nature Reserve based on underwater acoustic frequency difference technique

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**Abstract:** In order to accurately assess the current situation of fishery resources in Zhenjiang Yangtze River Dolphin Provincial Nature Reserve, Jiangsu Province, underwater acoustic method was used in April and September 2020 to carry out fish resource survey with net fishing. Based on the analysis of fish echograms data of 200 kHz and 333 kHz, frequency difference technology was introduced for acoustic assessment of fish resources. The results showed that the average fish density in the reserve was  $0.094 \pm 0.183$  ind/m<sup>2</sup>, and there was no significant difference between April and September ( $P > 0.05$ ). The pelagic fish population accounted for 68.46% of the fish caught in the net, among which 64.93% of the total weight of the fish that the Yangtze finless porpoise likes to eat. The target strength (TS) of fish in the reserve was mainly distributed in the range of -62.5dB ~ -53.5dB. In April, the target strength was mainly concentrated in the water depth of 10 m ~ 40 m, while in September, the target strength was mainly concentrated in the water depth of 5 m ~ 50 m. The fish resources in the reserve are mainly distributed near the north branch of He Changzhou and Jiaobei Beach. The fish resources are relatively scattered in September, and the pelagic fish resources are relatively more. Underwater acoustic frequency difference technology can effectively eliminate plankton signals and background noise signals in the water environment, which is of reference significance for fishery acousti

**Key words:·** Yangtze River Dolphin Provincial Nature Reserve; hydroacoustics; frequency difference technique; resource Assessment; target strength

# 气候变化对黄海中南部斑鲈产卵场适宜性的影响

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**摘要:** 本研究根据 2014-2018 年 5-7 月黄海中南部产卵场调查数据, 结合 6 种环境因子, 基于随机森林模型构建黄海中南部斑鲈产卵场适宜性的分布模型, 并根据未来气候变化的情景, 预测该鱼种产卵场在未来的潜在分布。结果显示, 不同月份中影响斑鲈鱼卵分布的主要环境因素不同。在未来气候变化的情景下, 斑鲈的适宜产卵场将向北迁移。此外, 黄海中南部北部沿岸海域及南部远岸深水区的栖息地适宜性明显增加。

**关键词:** 气候变化; 产卵场; 黄海; 斑鲈; 随机森林

## Impacts of climate changes on the habitat suitability of spawning ground for *Konosirus punctatus* in the central and southern Yellow Sea

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**Abstract:** To comprehensively understand the changing patterns of spawning ground suitability of *Konosirus punctatus* under climate change and provide a scientific basis for the conservation of spawning grounds, surveys were conducted in the spawning grounds in the central and southern Yellow Sea from May to July in 2014-2018 using ring net. Spawning grounds distribution of *K. punctatus* were analyzed by random forest model. Six environmental variables were selected in the model, including sea surface temperature, sea surface salinity, depth, offshore distance, sea surface velocity from FVCOM (Finite-Volume Community Ocean Model) and chlorophyll-a concentration from NOAA. In addition, the potential distribution of the spawning grounds of *K. punctatus* under future climate change scenarios were also predicted. Results showed that the main environmental factors affecting the spawning grounds were different by months, and the main factors were water depth, chlorophyll-a and surface water temperature in May to July, with relative contribution of 24.49%, 28.08% and 26.26%, respectively. The suitable spawning grounds of this species will migrate northward under climate changes. Moreover, the suitability of spawning grounds in the northern coastal waters of Haizhou Bay and the deep-water areas of the southern Haizhou Bay will increase significantly. Therefore, this trend should be fully considered in the future in terms of spawning ground protection and resource development and utilization.

**Key words:** Climate change; Spawning grounds; Yellow Sea; *Konosirus punctatus*; Random Forest model

# 盐度对中华绒螯蟹交配、产卵及繁殖性能的影响研究

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**摘要：**为研究盐度对中华绒螯蟹（*Eriocheir sinensis*）交配、产卵及繁殖性能的影响，设置不同盐度梯度下亲蟹的交配、产卵及其胚胎孵化实验，分析不同盐度下亲蟹的交配率、产卵率、胚胎孵化率、性腺成熟系数（GSI）、肝胰腺指数（HSI）及繁殖性能等指标的变化。结果表明，（1）中华绒螯蟹可交配的最低盐度为1，其雌蟹的平均交配率为（5.00±1.82）%，适宜交配的盐度范围为4~21。

**关键词：**中华绒螯蟹；盐度；交配；产卵；繁殖性能

## Effects of salinity on mating, egg holding and reproductive performance of *Eriocheir sinensis*

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**Abstract:** In this study, the effects of salinity on mating, oviposition and embryonic development of Chinese mitten crab (*Eriocheir sinensis*) were studied to determine the suitable salinity range for mating, oviposition and hatching of Chinese mitten crab; At the same time, the effects of salinity on the growth and development of gonad and hepatopancreas of Chinese mitten crab parents and the fecundity of egg crabs were studied to explore the physiological mechanism of salinity on the reproductive performance of Chinese mitten crabs, so as to provide basic data for the breeding biology of Chinese mitten crabs. The mating experiment, spawning experiment and in vitro hatching experiment of embryos were set up in this study. The female and male crabs, which were temporarily raised for 7 days, were placed in water with different salinities at a ratio of 2:1 for natural mating. After mating and spawning, anatomical samples were taken, and the embryos were taken out and incubated in Petri dishes with different salinities. The mating rate, spawning rate, reproductive performance of Chinese Mitten Crab parents under different salinity were compared. The gonad index, hepatopancreas index of female crab before and after spawning, and the ratio of embryo development to different stages in vitro were also compared. The results are: (1) The lowest salinity for Chinese mitten crab to mate was 1, and the average mating rate of female was (5.00±1.82)%, and the suitable salinity range for mating was 4~21.

**Key words:** *Eriocheir sinensis*; salinity; mating; brooding; reproductive performance

# 固定化藻菌对海水养殖尾水氮磷的去除效果

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**摘要：**本文利用海藻酸钙分别包埋卵囊藻和居海噬冷菌，构建固定化的藻珠与菌珠，并用于探究在不同的氮浓度和碳浓度条件下对模拟海水养殖尾水中氮、磷的去除效果。随着氮浓度和碳浓度升高，单藻珠和藻菌珠混合组对氨氮和磷酸盐的去除效果都有提升，能够明显的增强体系对氮磷的吸收能力，过高氮浓度会抑制氮磷的吸收。碳浓度升高，对藻珠的促进效果更好，对菌珠几乎没有作用，则单藻珠对氨氮的去除效果优于混合组，磷酸盐去效果无明显差异。

**关键词：**卵囊藻；居海噬冷菌；固定化；碳浓度；氮浓度

## Removal effect of immobilized algae or bacteria beads on nitrogen and phosphorus in tail water of mariculture

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**Abstract:** In order to explore the effect of immobilized algae or bacteria beads on the removal of nutrients in the tail water of marine aquaculture, this paper uses calcium alginate to embed *Oocystis* and *Algoriphagus* sp. to construct immobilized algae beads and bacteria beads, and use them for Explore the removal effect of nitrogen and phosphorus in simulated mariculture tail water under different nitrogen and carbon concentration conditions. The results show that with the increase of nitrogen concentration and carbon concentration, the removal effect of single algal beads and bacteria beads mixed group on ammonia nitrogen and phosphate is improved; algal beads and bacteria beads mixed treatment can significantly enhance the system's treatment of nitrogen and phosphorus. When the nitrogen concentration is higher than 50mg/L, it will have an inhibitory effect on the growth of algae and affect the absorption of nitrogen and phosphorus; at a lower carbon concentration (5mg/L), the mixture of algae and bacteria beads will affect the nitrogen Phosphorus absorption effect is better, the increase of carbon concentration, the promotion effect on algae beads is better, but it has almost no effect on bacteria beads, so with the increase of carbon concentration, the removal effect of single algae beads group on ammonia nitrogen is better than mixed Group, but there is no significant difference in phosphate removal from the mixed group.

**Key words:** : *Oocystis* sp.; *Algoriphagus* sp.; Immobilized; carbon concentration; nitrogen concentration



# 舟山岛北部近岸海域鱼类种类组成及数量分布

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**摘要:** 根据 2020 年 10 月、2021 年 1 月、4 月、6 月在舟山岛北部沿岸海域鱼类调查资料, 研究了其种类组成、区系特征、数量分布及优势种等。结果为: 四季共采集鉴定出鱼类 55 种, 隶属于 12 目 30 科 49 属; 春季优势种为斑尾刺虾虎鱼, 秋季优势种为龙头鱼, 夏、冬季无优势种; 根据适温性特征, 有暖水性鱼类 31 种, 暖温性鱼类 24 种; 重量密度和尾数密度均为夏季最高, 冬季最低, 各季节渔获量分布整体表现为东南部高于西北部海域。

**关键词:** 鱼类; 种类组成; 数量分布; 舟山北部近岸

## Species composition and quantity distribution of fish in the coastal waters of northern Zhoushan Island

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**Abstract:** Based on the survey data of fish in the northern coastal waters of Zhoushan Island in October 2020, January, April and June 2021, the species composition, floristic characteristics, quantitative distribution and dominant species were studied. The results were as follows: 55 species of fish were collected and identified in four seasons, belonging to 12 orders, 30 families and 49 genera. The dominant species in spring is Shrimp Tiger, the dominant species in autumn is Tilapia, no dominant species in summer and winter. According to the characteristics of temperature adaptability, there are 31 warm water fish species and 24 warm fish species. Weight density and tail density were highest in summer and lowest in winter. The catch distribution in southeast was higher than northwest.

**Key words:** Fish. Species composition. Quantity distribution. North Coast of Zhoushan

# 舟山岛北部海域虾蟹类群落结构及其多样性研究

汪全

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**摘要：**本文基于2020-2021年春、夏、秋、冬，在舟山岛北部海域进行渔业资源底拖网调查所获得虾蟹类资料，研究调查海域的虾蟹类的种类组成、优势种、群落结构及其生物多样性等。结果表明：调查海域四季共采集并鉴定出虾蟹类25种，隶属于14科20属，其中虾类16种，蟹类9种，优势种以春季为最多。聚类分析结果，不同季节生物种类变化存在差异性，春、夏、冬三季可划分为3个群落，秋季划分为4个群落。

**关键词：**虾蟹类; 优势种; 生物多样性; 群落结构; 舟山岛北部海域

## Community Structure and Diversity of Shrimp and Crab in Northern Zhoushan Island

Wang Quan

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**Abstract:** Based on the data obtained from bottom trawl survey of fishery resources in the northern waters of Zhoushan Island in spring, summer, autumn and winter from 2020 to 2021, this paper studies the species composition, dominant species, community structure and biodiversity of shrimp and crab in the investigated waters. The results showed that 25 species of shrimp and crab were collected and identified, belonging to 14 families and 20 genera, including 16 species of shrimp and 9 species of crab. The dominant species were spring. The results of cluster analysis showed that there were differences in the changes of biological species in different seasons. Three communities could be divided in spring, summer and winter, and four communities in autumn.

**Key words:** Shrimp and crabs. Dominant species. Biodiversity. Community structure. Northern Sea Area of Zhoushan Island

# 西北太平洋春季浮游动物优势种水平分布及与影响因子的关系

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**摘要：**为探究西北太平洋浮游动物优势种分布特征及其与环境因子的关系，对 28—35N、147—154E 海域进行调查采样。共检出优势种 7 种，邦海樽、细角间哲水蚤、瘦乳点水蚤、捷氏哲水蚤、六鳍箭虫、肥胖箭虫和螺旋尖角水母，优势种分布不均匀，呈斑块状。采用 Pearson 相关分析、冗余分析等方法分析影响因子与浮游动物优势种分布的关系。我们发现，不仅非生物因子纬度，生物因素 Chl.a 也影响着西北太平洋浮游动物群落的分布。

**关键词：**西北太平洋；浮游动物；优势种；环境因子；Pearson 相关分析；冗余分析

## A study on the distribution of dominant zooplankton species and its relationship with influencing factors in the Northwest Pacific Ocean in spring

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**Abstract :** Based on the data of one month investigation in the Northwest Pacific Ocean(28° — 35°N、147° — 154°E) in March 2019 ,this paper dealt with the relationship between dominant species and their environmental factors in the Northwest Pacific Ocean .A total of 7 dominant species were observed, including *Doliolum nationalis*, *Mesocalanus tenuicornis*, *Pleuromamma gracilis*, *Calanus jashnovi*, *Sagitta hexaptera*, *Sagitta enflata*, *Eudoxoides spiralis*. The dominant species are unevenly distributed and patchy. Pearson's correlation and Redundancy analysis were used to analyze the relationship between influencing factors and the distribution of dominant zooplankton species.We found that not only abiotic latitude but also biological factor Chl.a also influenced the distribution of zooplankton communities in the Northwest Pacific Ocean.

**Key words: :** Northwest Pacific Ocean; zooplankton; dominant species; environmental factors; ; Redundancy Analysis

# 低氧胁迫对拟穴青蟹免疫抗氧化因子与 Cyclin E、Cyclin G 基因表达的影响

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**摘要：**水中的溶解氧量是衡量水质好坏的重要指标之一，也是水体净化的重要因素之一。拟穴青蟹（*Scylla paramamosain*）是我国华南地区重要的养殖水产品之一，受运输、养殖密度等各种因素的影响，拟穴青蟹所处环境中氧含量变化较大，无论是工厂化养殖还是池塘养殖，养殖水体受天气、水流、温度和养殖密度等各种因素的影响，溶解氧含量总是会发生较大的波动，水体低氧现象时有发生，对养殖生物的生长发育造成了很大的阻碍。

**关键词：**拟穴青蟹；低氧胁迫；免疫酶；抗氧化酶；细胞周期蛋白

## Effects of Hypoxia Stress on the Immune Antioxidant Factors and the Gene Expression of Cyclin E and Cyclin G in *Scylla paramamosain*

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**Abstract:** The amount of dissolved oxygen in water is one of the important indicators to measure the quality of water, and it is also one of the important factors for water purification. *Scylla paramamosain* (*Scylla paramamosain*) is one of the important aquatic products in South China. Affected by various factors such as transportation and breeding density, the oxygen content in the environment of *Scylla paramamosain* varies greatly, whether it is factoryized Cultivation is still pond culture. The aquaculture water body is affected by various factors such as weather, water flow, temperature and aquaculture density. The dissolved oxygen content will always fluctuate greatly. Hypoxia in the water body occurs from time to time, which will affect the growth and development of cultured organisms. This has greatly hindered and greatly affected the economic income of breeders. Most aquatic animals have a good ability to adapt to the fluctuation of dissolved oxygen in the water body in a short period of time, but if the dissolved oxygen remains at a very low level for a long time, it will cause irreversible damage to their body and even cause death. The main contents of this research are as follows:

(1) When organisms are under hypoxic stress, the activity of antioxidant enzymes in the body will change, breaking the original redox balance and causing oxidative stress. The level of SOD in organisms is not stable, and environmental changes will affect the synthesis of SOD. From the experimental re

**Key words::** *Scylla sinensis*; hypoxia stress; immune enzymes; antioxidant enzymes; cyclin

# 基于生物完整性指数（IBI）的 长江口综合健康状况评价

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**摘要：**生物完整性指数可以作为评估水域健康状况的重要依据。本文根据 2018 年至 2020 年在长江口水域的调查数据，对候选指标进行分布范围、判别能力及相关性分析进行筛选，将水质指标分为物理指标和化学指标，根据国家标准进行评价赋分；将生物指标分为浮游植物指标，浮游动物指标，底栖生物指标，以历史数据作为参照，以偏离程度作为评价标准，同一级指标赋予相同权重。构建了基于生物完整性指数的长江口水域综合健康状况评价体系。

**关键词：**长江口；综合评价方法；生物完整性指数；健康状况；

## Evaluation of Comprehensive Health Status of the Yangtze River Estuary Based on Index of Biological Integrity (IBI)

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**Abstract:** Index of Biological Integrity can be used as an important basis for assessing the health status of waters. Based on the survey data of the Yangtze Estuary from 2018 to 2020, the distribution range, discriminant ability and correlation analysis of the candidate indicators were screened. The water quality indicators were divided into physical indicators and chemical indicators, and the scores were evaluated according to the national standards. Biological indicators were divided into phytoplankton indicators, zooplankton indicators and benthic indicators. Historical data were taken as the reference, deviation degree was taken as the evaluation standard, and the same weight was given to the indicators at the same level. A comprehensive health status evaluation system based on Index of Biological Integrity was established.

**Key words:** The Yangtze estuary; Comprehensive evaluation method; Biological integrity index; State of health;

# 三角型人工鱼礁局部冲刷的 实验研究

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**摘要:** 由于水流和泥沙运动的影响, 布设在海底的人工鱼礁会下陷或翻滚, 影响甚至失去其应有的生态功能。因此开展人工鱼礁局部冲刷机理研究具有重要的现实意义。本研究采用水槽模型实验的方法, 开展了高度、底角及底面长度对三角型鱼礁局部冲刷影响的研究。研究结果表明, 相同高度三角型人工鱼礁周围的最大平衡冲刷深度与底角呈正相关; 相同底角鱼礁的冲刷深度随着高度的增加而增加。研究结果可为人工鱼礁的设计优化及投放提供参考。

**关键词:** 三角型人工鱼礁; 局部冲刷; 冲刷深度; 底角

## Experimental Study on Local Scour of Triangular Artificial Reef

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**Abstract:** Artificial reef is one of the key methods to restore the offshore fishery resources and ecological environment. To secure its ecological effects, it is of great significance to study the possible instability of artificial reef, like sinking and reversing caused by change of the submarine topography, water flow and sediment movement. In present study, the model experiments of the triangular artificial reefs on the mechanism of the local scour are carried out. The prototype of the triangular artificial reefs is used in Xiaoshidao National Marine Ranching in Weihai, Shandong Province. The effect of the heights, the bottom angles and the length of the bottom of the triangular artificial reefs on the on the time-scale of the scour process and the equilibrium scour depth are investigated. The results show that for the reefs with the same heights, the scour depth increases with the increasing bottom angles. For the reefs with the same bottom angles, the scour depth increases with the increasing heights. When the ratio of water depth to the height of the reef is greater than 5, the scour depth changes gently with the height of the reef. In turn, the changes are dramatic when the ratio is smaller than 5. The research results can provide references for the design optimization and deployment of artificial reefs. This proposed study will provide theoretical support and practical guidance for the optimized engineering design and construction of artificial reefs.

**Key words:** Triangular artificial reef; Local scour; Scour depth; Bottom angle

# 基于 Hurdle-GAMMs 模型研究影响 海州湾小黄鱼摄食的主要因素

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**摘要:** 根据 2011–2016 年秋季在海州湾进行的渔业资源底拖网调查数据, 构建了 Hurdle-GAMMs (两阶段广义加性混合效应模型), 研究小黄鱼摄食主要饵料生物的影响因素及其动态特征。研究表明: 体长、离岸距离和水深是影响小黄鱼摄食的关键因素, 当小黄鱼体长处于 80~100 mm 和 120~140 mm 范围内以及离岸距离 40~60 km 和水深 15~25 m 的海域时, 小黄鱼的食物组成也会发生显著变化。

**关键词:** 小黄鱼; 摄食; 广义加性混合模型; 海州湾

## Effects of environmental factors on the feeding ecology of small yellow croaker (*Larimichthys polyactis*) in Haizhou Bay based on Hurdle-GAMMs

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**Abstract:** Bottom trawl surveys in Haizhou Bay and adjacent waters and the stomach content analysis of caught fish was conducted during the autumns of 2011–2016. Based on the data collected, Hurdle-GAMMs (Hurdle-Generalized Additive Mixed Models) of the small yellow croaker in the Haizhou Bay ecosystem were built. The results showed that predator length, distance from shore, and depth of water were the most important environmental factors for feeding in small yellow croakers. When the body lengths of small yellow croakers were between 80–100 mm and 120–140 mm, their feeding habits changed significantly. In addition, areas 40–60 km offshore and at depths of 15–25 m, the food composition of small yellow croakers also changed significantly. The spatial variations of feeding in small yellow croakers were closely related to the distribution of prey species, and the variation in their feeding habits were also affected by multiple other factors. These were related to the spatial distribution of key prey species in the environment and interspecies relationships. In addition, the availability of prey could also affect the distribution of small yellow croakers and alleviate the interspecific competition in the Haizhou Bay ecosystem. The effects of various factors were also correlated with the feeding intensity in the small yellow croaker.

**Key words:** *Larimichthys polyactis*; feeding; generalized additive mixed models; Haizhou Bay

# 长江口不同刀鲚群体耳石形态 差异研究

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**摘要:** 为了研究长江口不同刀鲚群体的耳石差异性, 采集长江口南支和北支、崇明内河和浙江嵊泗共 140 尾刀鲚, 取其矢耳石, 测量其基本尺寸参数计算相应的形态指标, 并构建耳石框架模型, 对获得的形态变量进行多元统计分析。单因素方差分析结果显示除 1-2、1-6、1-3、3-6、4-5、5-6 之外其他形态变量均有显著性差异。主成分分析中前三个主成分主要显示了耳石整体轮廓特征和前端的形态特征。判别分析显示群体之间重叠度较高。

**关键词:** 长江口; 刀鲚; 耳石形态; 框架结构; 多元统计分析

## The otolith morphological variation among different populations of *Coilia nasus* in Yangtze River estuary

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**Abstract :** In order to investigate the otolith morphological difference among populations in the Yangtze River estuary, a total of 140 *Coilia nasus* were collected from South Branch and North Branch of Yangtze River estuary, Chongming Neihe and Shengsi of Zhejiang Province, and their sagittal otoliths were taken. The basic size parameters of otolith were measured and the corresponding shape indexes were calculated. The framework model of otolith was constructed and the morphological variables were analyzed by multivariate analysis. The results of one-way analysis of variance (ANOVA) showed significant differences in other morphological variables except 1-2, 1-6, 1-3, 3-6, 4-5, and 5-6. And the first three components in principal component analysis (PCA) mainly showed the overall contour features and the morphological characteristics of the front end of the otolith. The discriminant function analysis (DFA) confirmed that the overlapping degree among groups was higher, indicating a high group mixing among populations.

**Key words: :** Yangtze River estuary; *Coilia nasus*; otolith morphology; truss network; multivariate analysis



# 莱州市海域秋冬季鱼类生态位 与群落结构特征研究

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**摘要：**为了解莱州市海域鱼类生态位与群落结构特征及其季节变化趋势，对莱州市辖海域分别开展了秋季、冬季两个航次的18站位底拖网调查。结果显示：秋冬季共捕获鱼类35种，两季共有优势种为矛尾虾虎鱼；物种相似性指数显示两季种类组成为中等不相似。以50%群落聚类相似性将秋季调查站位分为3个组，冬季分为4个组。秋季白姑鱼和冬季矛尾虾虎鱼的生态位宽度最高，秋季短吻红舌鲷与鲷而冬季六丝钝尾虾虎鱼与绯鲷的重叠度最高。

**关键词：**莱州市海域；鱼类；优势种；聚类分析；生态位宽度；生态位重叠度

## Characteristics of fish niche and community structure in the autumn and winter seasons in the Laizhou city waters

ZHANG Depu

Shanghai Ocean University,

**Abstract:** In order to understand the characteristics of fish niche, community structure and seasonal variation trend in laizhou sea area, bottom trawl survey at 18 stations was carried out in autumn and winter respectively. The results showed that 35 species of fish were captured in autumn and winter, and the dominant species in both seasons was goby. The species similarity index showed that the species composition of the two seasons was medium dissimilar. The survey sites were divided into 3 groups in autumn and 4 groups in winter based on 50% community clustering similarity. The niche widths of autumn ginkgo and winter goby were the highest, autumn short-snouted red tongue sole and 鲷, and winter six-silk blunt-tailed goby and goby goby had the highest overlap.

**Key words:** : Laizhou city waters; Fish; Dominant species; Clustering analysis; Niche width; Niche overlap

# 基于稳定同位素技术的浙江南部 近海前肛鳗食性及营养级分析

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**摘要：**根据 2016 年在浙江南部近海底拖网调查采集的样品，基于稳定同位素技术对前肛鳗食性及营养级进行研究。结果：（1）局部多项式回归显示 $\delta^{13}\text{C}$ 、 $\delta^{15}\text{N}$  随个体发育呈上升趋势；（2）利用 IsoSource 计算双斑螭、口虾蛄、中华管鞭虾、其他虾类、其他蟹类和头足类 6 种可能饵料类群对不同发育阶段前肛鳗的食源贡献比例，结果显示前肛鳗随个体发育摄食高营养级饵料生物比例有所增加；（3）营养级随肛长增长而升高。

**关键词：**前肛鳗；稳定同位素；饵料贡献比例；营养级；浙江南部近海

## Feeding habits and trophic levels of *Dysomma anguillare* in the inshore waters of southern Zhejiang based on stable isotope analysis

Yang Rui

Shanghai Ocean University

**Abstract:** based on the samples collected by trawling in the offshore waters of southern Zhejiang in 2016, the feeding habits and trophic levels of *Dysomma anguillare* were studied by stable isotope technique. The results showed: (1) Local polynomial linear regression showed that the ratio of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  increased with growth. (2) IsoSource was used to calculate the contribution ratio of six prey groups to *Dysomma anguillare* at different ontogenetic stages. The results showed that the proportion of *Dysomma anguillare* feeding on high trophic level increased with its ontogeny; (3) The trophic level increased with the increase of anal length.

**Key words:** : *Dysomma anguillare*; stable isotope; proportion of prey organisms; trophic level; inshore waters of southern Zhejiang

# 江苏近岸海域游泳生物群落结构及变化

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**摘要：**为了深入了解江苏近岸海域游泳生物群落结构组成及其年间变化，于2016-2020年连续5年春、夏和秋季在江苏近岸海域开展了游泳生物调查。本实验应用多元统计分析和结构冗余度分析方法，分析了江苏近岸海域春季游泳生物群落组成、资源量、多样性、优势种和冗余度等；比较江苏近岸海域北部、中部和南部各区域游泳生物资源情况。为江苏近岸海域渔业资源管理和增殖养护提供科学准确的数据支撑。

**关键词：**江苏近岸、游泳生物、冗余度、资源量

## Community structure and changes of swimming organisms in coastal waters of Jiangsu Province

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**Abstract :** In order to deeply understand the composition and annual changes of the community structure of swimming organisms in the coastal waters of Jiangsu Province, a survey of swimming organisms was carried out in the coastal waters of Jiangsu Province in spring, summer and autumn for five consecutive years from 2016 to 2020. In this experiment, multivariate statistical analysis and structural redundancy analysis were used to analyze the composition, resources, diversity, dominant species and redundancy of swimming biological community in Jiangsu coastal waters in spring; The swimming biological resources in the northern, central and southern coastal areas of Jiangsu Province were compared. Provide scientific and accurate data support for the management, proliferation and conservation of fishery resources in Jiangsu coastal waters.

**Key words::** Jiangsu inshore, swimming organisms, redundancy, resources

# 基于碳、氮稳定同位素技术分析 浙江南部近海蓝圆鲹的摄食习性

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**摘要：**根据浙江南部近海进行的底拖网调查，应用胃含物分析法和碳氮稳定同位素分析法研究蓝圆鲹摄食习性。结果表明：浙江南部近海蓝圆鲹主要摄食鱼类、虾类、蟹类、头足类、多毛类和小型甲壳类，其中虾类的营养贡献率最高。其 $\delta^{13}\text{C}$ 值与叉长呈显著负相关，说明随着个体发育，蓝圆鲹营养来源有较大变化；蓝圆鲹其平均营养级为3.89， $\delta^{15}\text{N}$ 与叉长呈显著正相关，说明随叉长增大，蓝圆鲹倾向于摄食更高营养级的饵料。

**关键词：**胃含物分析；稳定同位素分析；摄食生态；蓝圆鲹；营养级

## Feeding habits of *Decapterus maruadsi* in the southern coastal area of Zhejiang based on carbon and nitrogen stable isotope analysis

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**Abstract:** Based on the bottom trawl survey in the southern coastal area of Zhejiang, the feeding habits of *Decapterus maruadsi* were studied by stomach content analysis and carbon and nitrogen stable isotope analysis. The results showed that *D. maruadsi* mainly fed on fish, shrimp, crabs, Cephalopod, Polychaete and small crustaceans, of which shrimp had the highest nutritional contribution rate. There was a significant negative relationship between  $\delta^{13}\text{C}$  value and fork length, indicating the variation in ultimate energy source of *D. maruadsi*; The average trophic level of *D. maruadsi* was 3.89, and a significant positive correlation was found between  $\delta^{15}\text{N}$  and fork length of *D. maruadsi*, which means that with the increase of the fork length, *D. maruadsi* tended to eat higher trophic level prey items. This study is helpful to understand the feeding ecology of *D. maruadsi*, and provide a scientific basis for its resource protection and utilization.

**Key words:** stomach content analysis; stable isotope; feeding habits; *Decapterus maruadsi*; trophic level

# 阿根廷滑柔鱼生殖投入策略的研究

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**摘要：**为获知阿根廷滑柔鱼的生殖投入策略，利用脂肪酸生物化学标志物研究分析阿根廷滑柔鱼生长发育过程中卵巢、消化腺和肌肉等组织的脂肪酸组成及变化过程。结果显示，阿根廷滑柔鱼卵巢与消化腺组织的脂肪酸组成存在显著相关性。然而在性腺发育早期和繁殖产卵期，卵巢与胴体组织之间的脂肪酸组成具有较高的相似性。结果表明阿根廷滑柔鱼的生殖投入策略为收入-资本混合型，以外源性投入为主、内源性能量转化供给为辅。

**关键词：**阿根廷滑柔鱼; 生殖投入; 脂肪酸; 头足类

## The reproductive allocation strategy of Argentinean shortfin squid, *Illex argentinus*

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**Abstract:** Life histories of organisms are frequently shaped by trade-offs between somatic growth and reproduction. Although previous studies have suggested that sources for reproduction are directly from concurrent food intake in the Argentinean short-fin squid *Illex argentinus*, referred as income breeding, recent findings indicated that its reproductive growth probably uses somatic energy (capital resource). Herein, we aimed to determine the reproductive allocation strategy of female *I. argentinus*, using fatty acids as biochemical indicators. Results indicated that the fatty acid composition in the ovaries was consistently found larger similarity with that in the digestive gland, which is a fast turnover tissue and reflects recent dietary information. During early maturation and spawning period, however, the fatty acid composition showed that the ovaries closely resembled mantle tissue, which is a slow turnover rate tissue and considered as energy reserve organ. These lines of evidence indicate that *I. argentinus* adopts a mixed income–capital breeding strategy, in which reproduction primarily relies on income resources, coupled with the involvement of storage reserves used during the early maturation and spawning period. This study presents the potential implication of fatty acids to provide insights into the breeding strategies among cephalopods, particularly for oceanic species.

**Key words:** *Illex argentinus*; Reproductive allocation; Fatty acid; Cephalopod

# 长江上游 3 个野生黑尾近红鲃 群体形态差异分析

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**摘要：**为探讨长江上游黑尾近红鲃群体间的形态差异，基于传统形态学数据和框架测量数据分析比较龙溪河、濑溪河和合江群体的形态特征。结果表明，主成分分析中各群体综合判别准确率为 84.70%，而累积贡献率为 63.98% 的 6 个主成分指标均来自鱼体的躯干部和头部。聚类分析中濑溪河与合江群体聚为一支，龙溪河群体单独聚为一支。这表明，龙溪河群体与其他两个群体形态存在较大差异。

**关键词：**黑尾近红鲃；框架测量；形态差异

## **Morphological differences of three wild *Ancherythroculter nigrocauda* in the upper Reaches of Yangtze River**

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**Abstract:** In this study, morphological characteristics of Longxi River, Laixi River and the Hejiang range of the Yangtze River were compared based on traditional morphological data and frame measurement data. The results showed that the discriminant analysis based on morphological data showed that the average correct classification ratio was 84.70%, and the six principal component with cumulative contribution rate of 63.98% were all from the trunk and head of the fish. The result of cluster analysis showed Laixi River population and Hejiang population were pooled in one clade, Longxi River population as one clade alone. These results indicated that there were great differences between the Longxi River population and the other two populations.

**Key words:** *Ancherythroculter nigrocauda*; frame measurement; morphological differences

# 气候变化对头足类渔业生物学 及渔场学影响的研究进展

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**摘要：**头足类是重要的渔业资源之一，在海洋生态系统中扮演着重要的角色，其生活史过程极易受到海洋环境变化的影响。气候能量的主要储存载体是海洋，近年来频发的气候变化事件引起海洋环境因子变动，直接或间接地改变了头足类的渔业生物学特性、渔场分布和资源丰度，对头足类的渔业生产造成影响。为此，本文总结和归纳了气候变化对头足类渔业生物学、资源丰度、渔场分布和生态学四个方面的影响，并提出了展望。

**关键词：**气候变化事件；头足类资源；渔业生物学；资源丰度；渔场分布；影响

## Review on the impact of climate change on resource of cephalopods

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**Abstract:** Cephalopod is one of the most important fishery resources which plays a significant role in marine ecosystems, its life history was easily affected by marine environmental changes. Ocean was the main storage carrier of climate energy. The changes of marine environmental factors in recent years were caused by frequent climate change events, which have directly or indirectly changed the fishery biology characteristics, abundance, distribution of fishing ground, ecology and even fishery of cephalopods. Therefore, four aspects in this paper were summarized the previous studies from fishery biology, abundance, fishery ground distribution and ecology. The results shown that the resource of cephalopods was easily affected by the occurrence of climate change events mainly through temperature and primary productivity in marine environmental factors. At present, the objectives of correlated researches were mostly concentrated on Ommastrephidae and Loliginidae, and marine temperature was mostly used to select for analysis from major marine environmental factors. In the future, long-term marine environmental data should be applied into the research for impact of climate change on other cephalopods species. The purpose of this study was to provide a theoretical basis for analyzing the impact of climate change events on cephalopod resources, and to provide scientific direction for sustainable development of cephalopod fishery under frequent climate change events in recent years.

**Key words:** climate change events; resource of cephalopods; fishery biology; resource abundance; distribution of fishing ground; impact

# 耳石微化学在鱼类洄游中的研究进展

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**摘要：**本文阐述了包括微量元素和稳定同位素在内的微化学示踪技术在还原鱼类生活史过程中水环境温度、盐度及示踪产卵场的应用进展，可知锶钙比是开展生境重建最主要的元素；锰元素可以作为低氧环境的示踪剂；碳、氧稳定同位素可还原水环境温度等。总结了各种微量元素和稳定同位素的与栖息环境的关系指标，列举了耳石碳氧同位素分馏与温度间的多种公式，探讨了多种元素含量的变化特征，为广大科研工作者深入研究鱼类生活史提供科学参考。

**关键词：**耳石；生活史；洄游鱼类；微量元素；稳定同位素

## Application progress of otolith microchemistry in fish migration

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**Abstract :** This article describes the application progress of microchemical tracer technology including trace elements and stable isotopes in the process of restoring the life history of fish in water environment temperature, salinity and trace spawning ground. It is concluded that the ratio of strontium to calcium is the most important element for the development of habitat reconstruction, the elements Mn can be used as a tracer in a low-oxygen environment and stable isotopes of carbon and oxygen can restore the temperature of the water environment. Summarizes the relationship between various trace elements and stable isotopes and the habitat environment, lists various formulas between otolith carbon and oxygen isotope fractionation and temperature. Discusses the characteristics of changes in the content of various elements for in-depth research for the majority of scientific researchers The life history of fish provides scientific.

**Key words::** Otoliths; life history; migratory fish; trace elements; stable isotopes



# 网围拆除后东太湖鱼类功能群 时空分布特征及影响因子分析

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**摘要：**通过 2019 年 4 月、7 月、10 月对网围拆除后东太湖原网围区和非养殖区鱼类资源的调查监测，分析探讨鱼类功能群的时空分布特征及其与环境因子的关系。结果表明：网围拆除后东太湖调查监测到鱼类 39 种，构建为 11 个复合功能群。原网围区与非养殖区在鱼类功能群组成、密度及环境因子相互关系上的存在差异表明了鱼类功能群对网围拆除人为干扰的响应。

**关键词：**功能群；鱼类群落；时空分布；环境因子；东太湖；网围拆除；

## **Study on the temporal variation and spatial distribution of functional groups for fish community and their interaction with environmental factors after the removal of net enclosure in East Taihu Lake, China**

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**Abstract :** Through the investigation and comparison of fish resources between the original net enclosure (ONE) and main area (MA) in East Taihu Lake after the removal of net enclosure in April, July and October, 2019, the spatial variation and temporal distribution of fish functional groups and their interaction with environmental factors were analyzed and discussed. The results showed that the fish community in East Taihu Lake recovered rapidly after the removal of the net enclosure. 39 species of fish were detected. The collected fish could be divided into 11 combined functional groups (CG). To a certain extent, the differences in composition, density of functional groups and the impact with environmental factors between the ONE and MA indicate the response of fish community to human disturbance.

**Key words :** functional groups; fish community; temporal variation; spatial distribution; environmental factors; removal of net enclosure; East Taihu Lake

# 卵石河床-青海湖裸鲤自然繁殖诱发 关键因素

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**摘要：**青海湖裸鲤，属国家二级保护动物，了解其自然繁殖河床质需求对于其自然产卵栖息地保护和资源养护等具有重要意义。本研究通过室内河床质偏好实验、人工模拟产卵场构建以及野外自然产卵场改造等方法，结合标志跟踪、Ethovision 行为追踪等技术手段，对青海湖裸鲤的底质偏好，底质诱发自然繁殖的规律和效果进行了系统地研究。结果显示，卵石河床是诱导青海湖裸鲤自然繁殖的必要条件，为生境改良、评估适宜度等提供科学依据。

**关键词：**青海湖裸鲤 卵石底质 自然繁殖 底质偏好 底质需求

## **Pebble -a key factor in the induction of Natural *Gymnocypris przewalskii* reproduction**

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**Abstract:** *Gymnocypris przewalskii*, a second class national protected animal, understanding the bed quality requirements of its natural breeding is important for the protection of its natural spawning habitat and resource conservation. In this study, the sediment preference of *Gymnocypris przewalskii* was studied by means of indoor sediment preference experiment, artificial simulated spawning site construction and field natural spawning site modification, and by means of marker tracking and Ethovision behavior tracking, the law and effect of sediment-induced natural reproduction were systematically studied. The results showed that the pebble bed was a necessary condition for inducing the natural reproduction of *Gymnocypris przewalskii*, and provided scientific basis for habitat improvement and suitability evaluation.

**Key words::** *Gymnocypris przewalskii*, pebble, natural reproduction, bed preference, bed demand

# 基于生态网络指标评价厄尔尼诺对海州湾渔业生态系统的影响

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**摘要:** 为选择合适的生态网络 (ENA) 指标解析 El Nino 现象对海州湾渔业生态系统的影响, 本研究构建了 El Nino 年和 ENSO 中性年的 Ecopath 模型, 并对 ENA 指标进行敏感性和稳健性分析。结果表明, 生态系统总流量、总初级生产、总系统非循环流量和优势度可作为最优的 ENA 指标。在 El Nino 年份海州湾生态系统的物种组成、生物量发生较大波动; 生态系统总规模缩小, 能量利用效率提高; 生态系统组织程度下降。

**关键词:** 厄尔尼诺; 生态网络指标; 食物网; Ecopath; 基于生态系统的渔业管理

## Evaluating the impacts of El Nino events on a marine bay ecosystem based on selected ecological network indicators

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**Abstract:** Understanding how ecosystems respond to El Niño is the key to the success of ecosystem-based fisheries management (EBFM). However, few studies have focussed on the ecosystems respond to this natural perturbation in China seas, and the selection of effective ecological network analyses (ENA) indicators to evaluate the ecosystem response under El Niño conditions needs to be assessed. In this study, we constructed Ecopath models for Haizhou Bay in ENSO-neutral (2013) and El Niño (2015) years. Comprehensive analyses were conducted to evaluate ENA indicators in terms of sensitivity to the ecosystem variations, robustness to the model parameters uncertainties, and statistical check. Results showed that there were obvious variations in the species composition and biomass in the Haizhou Bay ecosystem under the El Niño event. Four optimal ENA indicators were selected, including total system throughput, total primary production, total system non-cycled throughflow, and ascendancy. The indicators further showed a shrunken ecosystem size, increased energetic efficiency, and less organised ecosystem under the El Niño event. These findings enhance our understanding of ecosystem dynamics and underscore the need for precautionary management under El Niño conditions. Moreover, this work can be helpful in guiding the further selection of ENA indicators for evaluating and managing marine ecosystems during El Niño events elsewhere and thusly contribute to the implementation of EBFM.

**Key words:** : Climate variability; ENA indicators; Food web; Ecopath; Ecosystem-based fisheries management

# 东太平洋两种鲨鱼微塑料摄入丰度及特征

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**摘要：**本文研究了2019年从东太平洋采集的两种鲨鱼微塑料摄入丰度及特征，结果显示镰状真鲨（ $1.4 \pm 2.26$ ）微塑料丰度比大青鲨（ $0.57 \pm 1.27$ ）高，两种鲨鱼摄入微塑料粒径范围在120-4557 $\mu\text{m}$ 之间，大部分为纤维状（78%）且主要以蓝色为主（68%），本研究中大青鲨的微塑料摄入丰度及特征与此前相关研究报道的结果基本一致，镰状真鲨则是第一次报道，本研究进一步证实了海洋中顶级捕食者微塑料摄入的广泛性。

**关键词：**鲨鱼，微塑料，丰度，特征

## The abundance and characteristics of microplastics ingested by two shark species in the eastern Pacific Ocean

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**Abstract:** In this paper, we studied the abundance and characteristics of microplastic ingestion in two shark species collected from the eastern Pacific Ocean in 2019. The results showed that the silky shark (*Carcharhinus falciformis*) ( $1.4 \pm 2.26$ ) ingested more microplastics than in blue shark (*Prionace glauca*) ( $0.57 \pm 1.27$ ), and the MPs size ingested by both sharks ranged from 120-4557  $\mu\text{m}$ , The majority of MPs were fibrous in shape (78%), blue in color (68%). The abundance and characteristics of microplastic ingestion of *Prionace glauca* in this study are consistent with the results reported in previous studies, while *Carcharhinus falciformis* is the first one reported in this study. This research raises further confirms the extensive microplastic ingestion of top predators in the ocean.

**Key words:** Sharks, Microplastics, Abundance, Characteristics

# 温度对稀有鮡鲫镉累积过程的影响

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**摘要:** 以稀有鮡鲫为实验生物, 应用半静态双箱动力学模型模拟了室内不同温度条件下 (15°C、20°C、25°C、30°C) 重金属镉 (Cd) 的生物富集实验。结果显示不同温度条件下, 鳃的 K1 为 0.038~0.072, K2 为 0.032~0.042, BCF 为 1.18~1.71, CA<sub>max</sub> 为 11.8~17.1, B1/2 为 16~21 天; 不同温度条件下, 肝脏的 K1 为 0.055~0.197, K2 为 0.026~0.031。

**关键词:** 温度, 镉, 稀有鮡鲫, 代谢动力学

## Effect of temperature on cadmium accumulation in *Gobiocypris rarus*

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**Abstract:** In this study, *Gobiocypris rarus* was used as a model species to investigate the kinetics of uptake and elimination of Cd at different temperatures (15°C, 20°C, 25°C, 30°C). The modeling results showed that kinetic parameters of gill tissue at different temperatures K1 ranged from 0.038 to 0.072, K2 ranged from 0.032 to 0.042, BCF ranged from 1.18 to 1.71, CA<sub>max</sub> ranged from 11.8 to 17.1, B1/2 ranged from 16 to 21 days. The kinetic parameters of liver tissue at different temperatures K1 ranged from 0.055 to 0.197, K2 ranged from 0.026 to 0.031, BCF ranged from 1.96 to 6.35, CA<sub>max</sub> ranged from 19.6 to 63.5, B1/2 ranged from 22 to 27 days. The results showed that K1, BCF, CA<sub>max</sub>, B1/2 in both gill and liver tissues increased and then decreased with the increase of temperature. The kinetic parameters at 25°C were larger than those at other temperatures, but K2 did not change significantly with temperature.

**Key words:** Temperature, Cd, *Gobiocypris rarus*, Kinetics of uptake and elimination

# 环境 DNA 技术在马里亚纳海沟宏生物多样性的研究

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**摘要：** 马里亚纳海沟是地球表面最深的海沟，环境极端多样，如高压、低温及无光，拥有独特的微生物资源。采集马里亚纳海沟 6 个层位海水(50–4000 m)，建立马里亚纳海沟水样环境 DNA 宏条形码物种检测体系，对马里亚纳海沟不同深度环境 DNA(eDNA)样品的采集和高通量测序分析，阐述马里亚纳海沟主要宏生物群落的种类组成和多样性特征，结果表明：与传统调查方法相比，环境 DNA 测定灵敏性高、数据准确性高。

**关键词：** 环境 DNA (eDNA) ; 马里亚纳海沟；宏生物多样性；高通量测序

## Environmental DNA techniques for macro biodiversity studies in the Mariana Trench

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**Abstract:** The Deepest trench on earth, the Mariana Trench has an extremely diverse environment of high pressure, low temperature, and no light, with unique microbial resources. Marine water from six layers (50-4000 m) in the Mariana Trench was collected to establish an environmental DNA macro barcode species detection system. Based on the collection and high-throughput sequencing analysis of environmental DNA(eDNA) samples at different depths in the Mariana Trench, the species composition and diversity characteristics of the main macrobiomes in the Mariana Trench were described. The results showed that compared with the traditional survey methods, environmental DNA determination was more sensitive, data accuracy was higher, and cost was lower. It is suitable for macro biodiversity research in relevant sea areas.

**Key words:** : Environmental DNA (eDNA); Mariana Trench; Macrobiodiversity; High-throughput sequencing

# 北太平洋沙丁鱼（*Sardinops sagax*）体型特征对其目标强度的影响

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**摘要：**为对北太平洋沙丁鱼进行声学评估，借助 X 光影像获取了北太平洋 13 尾沙丁鱼的体型特征参数，结合基尔霍夫模型得到不同频率下目标强度。结果表明：当姿态倾角满足概率密度函数为正态分布 ( $-5^{\circ}\pm 10^{\circ}$ ) 时，38、70、120 和 200kHz 频率下平均体长 11.48cm 的沙丁鱼平均目标强度分别是-41.31、-39.82、-39.80 和-38.50dB。本研究可为日后沙丁鱼资源评估提供参考。

**关键词：**基尔霍夫模型，目标强度，北太平洋，沙丁鱼

## Influence of Morphological Parameters of Sardine (*Sardinops Sagax*) in the North Pacific Ocean on Target Strength

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**Abstract :** Target strength is an important parameter for fishery stock assessment using acoustic method. In order to develop the stock assessment of sardines (*Sardinops sagax*) in the North Pacific Ocean, the morphological parameters of 13 samples collected in this area were measured using X-ray images and the target strength at 38 kHz, 70 kHz, 120 kHz and 200 kHz was calculated by the Kirchhoff ray mode model. The results show that when the inclination angle is between  $-50^{\circ}$  and  $50^{\circ}$ , and the probability density function of sardine is normal distribution ( $-5^{\circ} \pm 10^{\circ}$ ), the average target strength at 38 kHz, 70 kHz, 120 kHz and 200 kHz were  $-41.31$  dB,  $-39.82$  dB,  $-39.80$  dB and  $-38.50$  dB, respectively. This study provides a reference for future acoustic assessment of sardines.

**Key words: :** Kirchhoff ray mode model, target strength, North Pacific Ocean, sardine

# 西北太平洋秋刀鱼营养生态学特征

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**摘要:** 根据 2018 年 7-11 月在西北太平洋海域采集的秋刀鱼样本, 采用碳、氮稳定同位素技术对其摄食生态进行研究。同位素分析结果显示,  $\delta^{13}\text{C}$  值和  $\delta^{15}\text{N}$  值在不同月份以及体长组之间均存在显著性差异 ( $P < 0.05$ ); 氮稳定同位素分析结果表明, 随着体长的增加, 秋刀鱼可以摄食更高营养级的饵料; 碳稳定同位素分析结果表明, 秋刀鱼在 7-8 月的食物来源增多, 但在其他月份食物来源保持稳定。

**关键词:** 稳定同位素、秋刀鱼、摄食生态、西北太平洋

## Trophic ecology of the Pacific saury(*cololabis saira*) in the Northwest Pacific Ocean

chloe

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**Abstract:** Carbon and nitrogen stable isotope analysis were used to study the feeding ecology of the Pacific saury collected from July to November 2018 in the Northwest Pacific Ocean. Stable isotope signatures indicated that  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of the Pacific saury differed significantly between months and size ( $P < 0.05$ ). The results of nitrogen stable isotope analysis showed that with the increase of size, the Pacific saury could take higher trophic level food items. The results of carbon stable isotope analysis showed that the food sources of the Pacific saury increased in July and August, but remained stable between other months.

**Key words:** stable isotope analysis, the Pacific saury, trophic ecology, the Northwest Pacific Ocean



# 秘鲁外海茎柔鱼脂肪酸组成的 月间差异及食性指示研究

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**摘要：**掌握茎柔鱼营养成分和食性的月间差异，对其渔业资源合理开发与利用至关重要。茎柔鱼（*Dosidicus gigas*）是我国远洋鱿钓渔业最重要的鱿鱼经济物种。本研究采用 Folch 法提取脂肪酸，以气相色谱-质谱法测定其肌肉脂肪酸构成及含量。结果显示，在同一月份不同脂肪酸组成方面，4 个月份茎柔鱼脂肪酸均以多不饱和脂肪酸为主（59.40%~60.85%），其次是饱和脂肪酸（29.18%~31.65%）。

**关键词：**茎柔鱼；脂肪酸；季节；食性

## Study on the monthly difference of fatty acid composition and dietary indicator of *Dosidicus gigas* in the offshore waters of Peru

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**Abstract:** Understanding the monthly differences in nutritional composition and feeding habits of *Dosidicus gigas* is very important for the rational development and utilization of its fishery resources. *Dosidicus gigas*, a cephalopod species unique to the East Pacific, is the most important economic species of squid in my country's pelagic squid fishing fishery. In this study, the fish caught from the offshore waters of Peru in May, June, October, and November of 2020 were used as the research object. The Folch method was used to extract fatty acids, and the composition and content of muscle fatty acids were determined by gas chromatography-mass spectrometry. Metric Multidimensional Scaling Analysis (NMDS) examines the time difference of muscle fatty acid composition in different months, uses Bray-Curtis similarity coefficient, and compares the difference in similarity analysis (ANOSIM), and combines the characteristic fatty acids to indicate the changes in the dietary habits of the fish in different months. , Aiming to explore the fatty acid composition and differences in different months of *Dosidicus gigas* off the coast of Peru. The results showed that in terms of the different fatty acid composition in the same month, the fatty acids of the fish in the four months were mainly polyunsaturated fatty acids (59.40% to 60.85%), followed by saturated fatty acids (29.18% to 31.65%), and monounsaturated fatty acids. The content is the least (8.52%~10.31%). In terms of monthly differences»

**Key words:** *Dosidicus gigas*; Fatty acid; Season; Feeding habits

# 环境因子对波吉卵囊藻和沼泽红假单胞菌藻菌体系氨氮和尿素吸收的影响

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**摘要:** 有关波吉卵囊藻和光合细菌的报道较多, 但是两者联用对氨氮和尿素的吸收机制尚不清楚。本研究采用波吉卵囊藻和沼泽红假单胞菌构建藻菌体系, 通过同位素标记法测定一定范围内不同温度、光照强度和盐度条件下波吉卵囊藻和沼泽红假单胞菌藻菌体系对氨氮和尿素的吸收速率, 相对优先系数以及体系中各组分的贡献率, 并通过正交试验确定其最适吸收条件。研究表明藻菌体系对于调控和改善对虾养殖环境有着十分重要的作用和广泛的应用前景。

**关键词:** 藻菌联合体; 波吉卵囊藻; 沼泽红假单胞菌; 氨氮; 环境因素

## Effects of environmental factors on absorption of ammonia nitrogen and urea in the algal system of *Oocystis borgei* and *Rhodopseudomonas palustris*,

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HUANG Xiang-hu  
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**Abstract:** There are many reports about *Oocystis borgei* and *Rhodopseudomonas palustris*, but the absorption mechanism of ammonia nitrogen and urea by the combination of the two is not clear. This research adopts *O.borgei* and *R.palustris* build algae bacteria system, the absorption rate of ammonia nitrogen and urea, relative priority coefficient and contribution rate of each component in the system were determined by isotope labeling method under different temperature, light intensity and salinity conditions in a certain range, and the optimum absorption condition was determined by orthogonal test. The results show that the algal bacteria system plays an important role in regulating and improving the shrimp culture environment and has a wide application prospect.

**Key words:** microalgal-bacteria consortia; *Oocystis borgei*; *Rhodopseudomonas palustris*; ammonia nitrogen; environmental factor

# 氨基酸氮稳定同位素分馏的可变性及其影响机制

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**摘要：**氨基酸稳定同位素分析已成为摄食生态学的重要研究工具。“营养”和“源”氨基酸间同位素差异可用于估算消费者 TP。但氨基酸在营养转移过程中的富集程度、不同资源关系下的 TDF 并不恒定。本文针对近些年喂养试验中单体氨基酸氮同位素分馏以及 TDF 进行计量学统计，归纳了氨基酸氮同位素分馏的生化机制以及消费者不同的饮食质量和氮排泄模式对 TDF 变异性的影响机制，以期为来 CSIA-AA 技术在摄食生态学中的应用提供参考。

**关键词：**稳定同位素、氨基酸、分馏、食物网

## Variability of stable isotope fractionation of amino acid nitrogen and its influencing mechanism

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**Abstract:** Compound-specific stable isotope analysis (CSIA) of individual amino acids (AAs) has become a powerful analytical tool in trophic ecology. The offset between the canonical trophic AA Glu and source AA Phe was used to calculate consumer TP. However, trophic fractionation of Glu and Phe and trophic discrimination factor were not effectively constant across diverse consumer-resource relationships. We utilized a comprehensive meta-analysis of controlled feeding experiments that examine individual AA trophic fractionation and TDF<sub>Glu-Phe</sub> across diverse consumer-resource relationships. We also elaborated nitrogen isotope fractionation in amino acids and the summarizing evidence for the influences of diet quality and mode of nitrogen excretion on TDF<sub>Glu-Phe</sub> value. It is expected to provide reference for the application of CSIA-AA technology in trophic ecology in the future.

**Key words:** stable isotope、amino acids、fractionation、food web

# 白洋淀生态修复工程效果研究

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**摘要：**为恢复白洋淀的渔业资源，在鲌淀内构建了“白洋淀生态修复工程”，实施了栖息生境营造、生态环境修复、水生生物分级养护等调控措施。本研究选取鲌淀区作为实验区，开展了渔业资源调查和食物网结构及营养级分析，结果显示，与对照区相比，实验区共捕获渔获物 1789 尾，总重 48734.13g，种类 19 种，对照区共捕获渔获物 1128 尾，总重 16244.41g，种类 17 种，实验区在渔业种类数、渔获量、渔获重量均比对照

**关键词：**白洋淀；渔业资源恢复；栖息地营造；水生生物养护；食物网结构；同位素

## Study on the effect of baiyangdian Ecological restoration Project

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**Abstract :** In order to restore the fishery resources of Baiyangdian, "Baiyangdian Ecological restoration Project" was constructed in the Shad warren, and the control measures such as habitat construction, ecological environment restoration, and graded conservation of aquatic organisms were carried out. A survey of fishery resources and analysis of food web structure and nutrient level was carried out in the shad chamber as the experimental area. The results showed that compared with the control area, a total of 1789 fish were caught in the experimental area with a total weight of 48734.13g and of 19 species, and 1128 fish were caught in the control area with a total weight of 16244.41g and of 17 species. The number of fish species, catch amount and catch weight in the experimental area were higher than those in the control area. The mean length, body length and body weight of fish in the experimental area were  $125.04\pm 54.97\text{mm}$ ,  $100.22\pm 44.44\text{mm}$  and  $44.02\pm 331.45\text{g}$ , respectively, while those in the control area were  $106.94\pm 35.47\text{mm}$  and  $85.79\pm 29.66\text{mm}$ , respectively. The average body weight was  $19.77\pm 82.30\text{g}$ , and the physical signs of fish in the experimental area were significantly higher than those in the control area. The health evaluation results of ABC curve showed that the experimental area was moderately disturbed,  $W=-0.0096$ , while the control area was severely disturbed,  $W=-0.0312$ . The total  $\delta^{13}\text{C}$  values of the main fishery organisms in the control area were 4.625‰, and the total  $\delta^{13}\text{C}$  values

**Key words: :** Baiyangdian, Recovery of fishery resources, Habitat creation, Aquatic conservation, Food Web structure, Isotopic Element

# 渔场沉积物中产胶原蛋白酶菌株的 筛选鉴定及发酵条件优化

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**摘要：**以环洞庭湖水系淡水湖渔场沉积物为样品，通过明胶筛选培养基进行筛选，以透明圈和菌落直径比、发酵液酶活、抗生素敏感性、溶血性、氨基酸脱羧酶和硝酸还原酶活性为指标，挑选一株产酶量高和生物安全性高的菌株。通过 16S rDNA 序列分析，鉴定该菌株为 *Exiguobacterium* 属细菌，命名为 *Exiguobacterium* sp. DJ1，并利用单因素和正交实验法对该菌株产酶发酵条件进行优化。

**关键词：**胶原蛋白酶，产胶原蛋白酶细菌，湖泊沉积物，发酵工艺

## Screening and Identification of a Collagenase-producing Strain from Sediments of Fishing Grounds and Optimization of Its Enzyme Production Conditions

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**Abstract:** A strain from the sediments of freshwater lake around Dongting Lake with high enzyme production and biosafety was selected by gelatine screening medium, and based on the ratio of transparent zone to colony diameter, enzyme activity of fermentation broth, antibiotic sensitivity, hemolytic, amino acid decarboxylase and nitrate reductase activities. by 16S rDNA sequence analysis, the strain was identified as *Exiguobacterium* and named as *Exiguobacterium* sp. DJ1 and single factor and orthogonal experiments were used to optimize the fermentation conditions.

**Key words::** Collagenase, Collagenase producing bacteria, Lake sediments, Fermentation processes

# 青海湖裸鲤自然产卵场的生境特征及 无人机遥测判别研究-以泉吉河为例

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**摘要:** 本研究以青海湖入湖河流泉吉河为例, 在平水期采用现场调查和无人机遥测的方法对青海湖裸鲤的自然产卵场分布及生境状况进行调查, 确定其产卵场生境特征参数, 建立基于无人机遥测识别产卵场的方法并进行复核验证。结果表明河道形态、沙洲分布、水深特征等特征参数可作为无人机遥测识别产卵场的判断条件, 并实现验证成功。本研究结果可为开展整个流域的青海湖裸鲤自然产卵场现状评估及保护对策制定提供技术支撑。

**关键词:** 青海湖裸鲤; 产卵场; 河道形态; 流速; 水深; 底质; 无人机

## The habitat characteristics and UAV identification of natural spawning ground of *Gymnocypris przewalskii* in tributary of Qinghai Lake -taking Quanji River as an example

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**Abstract:** Natural spawning grounds are the most critical habitat for maintaining continuation of the species, but for *Gymnocypris przewalskii* of Qinghai Lake, the natural spawning grounds are rarely studied as the tough field survey condition. Our study investigate the natural spawning ground via field survey and UAV(Unmanned Aerial Vehicle) technique to analyze the environmental characteristics and then identify the spawning grounds base on the UAV image in no ground survey area in the Quanji River. The results show that characteristic parameters such as river channel shape, sandbank distribution, and water depth characteristics can be used as judgment conditions for UAV telemetry to identify spawning grounds, and the verification is successful. The results of this study can provide technical support for the assessment of the status quo of the natural spawning grounds of Qinghai Lake naked carp and the formulation of protection countermeasures in the entire basin.

**Key words:** : *Gymnocypris przewalskii*; Spawning grounds; River morphology; Velocity; Water depth; Substrate; UAV

# 西北太平洋浮游动物桡足类体型及稳定同位素特征

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**摘要：**以 2019 年春季和秋季在西北太平洋采集的桡足类为研究对象，分析结果显示桡足类的体型大小和碳、氮稳定同位素值有显著的季节性差异。春季桡足类个体的体型参数（体长、面积、体积）均显著高于秋季，秋季 $\delta^{13}\text{C}$ 、 $\delta^{15}\text{N}$ 值显著高于春季，这可能与海表面温度的季节差异有关。两个季节的 $\delta^{15}\text{N}$ 值与三个体型参数均呈显著正相关，而 $\delta^{13}\text{C}$ 值只在春季与体型参数呈显著正相关，可能是因为秋季采样点纬度较高、覆盖海域较小。

**关键词：**浮游动物；体型参数；稳定同位素

## Body size and stable isotope characteristics of zooplankton copepods in the northwest Pacific Ocean

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**Abstract:** In this research, the copepods was sampled in the Northwest Pacific Ocean in the spring and autumn of 2019. There were significant seasonal diversity in body size and  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values. The shape parameters (body length, area and volume) of copepods in spring were significantly higher than those in autumn, and the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values in autumn were significantly higher than those in spring, which may be related to the seasonal diversity of sea surface temperature. The  $\delta^{15}\text{N}$  values in the two seasons were significantly positively correlated with three shape parameters, while the  $\delta^{13}\text{C}$  values were significantly positively correlated with shape parameters just in spring, which might be due to high latitude and narrow sea areas of the sampling sites in autumn.

**Key words:** zooplankton; shape parameters; stable isotope

# 基于卵囊藻构建藻菌体系处理 海水养殖尾水的效果及机理探究

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**摘要:** 已有研究表明藻菌协同作用处理养殖尾水, 可有效吸收水体中的多种营养元素, 对水质有较好的净化效果。卵囊藻是一种种群增长稳定, 抗逆性强的绿藻, 对水环境具有良好的调节作用。本研究从卵囊藻附生菌群中筛选有益细菌, 通过定向构建卵囊藻与附生细菌的固定化体系, 检测了其处理海水循环水养殖尾水的效果, 并探究了藻菌体系对氮元素的吸收代谢机理。研究结果为藻菌体系在海水循环水养殖尾水处理中的应用提供了参考依据。

**关键词:** 藻菌体系; 卵囊藻; 尾水处理; 氮吸收; 固定化

## Effect and mechanism of the mariculture tailwater disposal by constructing algal-bacteria system based on *Oocystis* sp.

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**Abstract:** It's known that combined action of algae and bacteria to treat the aquaculture tailwater can effectively absorb a variety of nutrients in water, and have a good purification effect on water quality. *Oocystis* sp. is a kind of green algae with stable population growth and strong resistance to stress, which has a good regulation effect on water environment. In this study, beneficial bacteria were screened from the epiphytic flora of *Oocystis* sp., and the immobilization system of *Oocystis* sp. and isolated bacterium was constructed to test its purification effect of seawater circulating aquaculture tailwater, and the absorption and metabolism mechanism of nitrogen element in the algal-bacteria system was explored. The results provide a basis for the application of algal-bacteria system in the treatment of seawater recirculating aquaculture tailwater.

**Key words:** : Algal-bacteria system; *Oocystis* sp.; Tailwater disposal; Nitrogen absorption; Immobilization



# 长江口鱼类群落粒径结构特征 及群落稳定性评估

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**摘要：**为了解长江口鱼类群落粒径结构及群落稳定状态，基于 2018 年渔业调查数据，利用粒径谱、群落稳定性模型对鱼类群落特征进行了探究，并利用营养指数法对水体质量进行了综合评价。结果表明，长江口鱼类群落以小型鱼类为主，整体处于受干扰状态；北支和南支的鱼类群落存在季节变化且群落稳定性不高，水体富营养化或对鱼类群落偏离稳定状态有重要影响。本研究探究了全面禁捕前长江口鱼类群落状态，为长江口禁渔效果评价提供前期研究。

**关键词：**鱼类群落；粒径结构；水质质量；粒径谱；群落稳定性评估模型；长江口

## Size structure and community stability assessment of fish community in the Yangtze River Estuary

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**Abstract:** Based on the fishery survey data in 2018, the size structure characteristics and community stability were studied using the size spectrum and stability assessment model to improve the understanding of fish communities in the Yangtze River Estuary. Meanwhile, the water quality of the Yangtze River Estuary was evaluated using the eutrophication index method. The results showed that the fish community was dominated by small fishes and was in a disturbed state; there were seasonal changes in fish communities of the North Branch and the South Branch, and their community stability was weak; the eutrophication may have an important influence on the deviation of the community system from the stable state. This study explored the characteristics of fish community size structure and evaluated its community stability in the Yangtze River Estuary before the implement of the fishing ban in the Yangtze River Basin, and provided a preliminary research for the effect evaluation of the fishing ban to the Yangtze River Estuary ecosystem.

**Key words:** Fish community; Size structure; Water quality; Size spectrum; Stability assessment model; the Yangtze River Estuary

# 基于文献计量对鲨类体内持久性有机污染物研究现状

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**摘要：** 鲨是海洋生态系统的重要捕食者，多处于食物网的顶端或近顶端，受到生物富集和放大作用的影响，其体内持久性有机污染物（Persistent Organic Pollutants, POPs）通常对鲨鱼的内分泌、免疫、生殖和神经系统，乃至生长发育均可能造成较大负面影响。本文汇总近二十年鲨体内 POPs 污染水平及潜在影响，以期为鲨保护生物学研究提供有益参考。

**关键词：** 持久性有机污染物；生物富集；鲨；污染水平

## Research status of persistent organic pollutants in sharks based on bibliometrics

Ren Hongye

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**Abstract:** Sharks, as the important predators in the marine ecosystem, are mostly at or near the top of the food web. And sharks are affected by biological enrichment and amplification, in which persistent organic pollutants (POPs) may cause a great negative impact on the endocrine, immunity, reproduction, nervous system and even growth and development. This paper summarizes the pollution level and potential impact of POPs in sharks in recent twenty years, in order to provide useful reference for the study of shark conservation biology.

**Key words:** persistent organic pollutants; bioconcentration; shark; pollution level

# 对日本沙丁鱼（*Sardinops melanostictus*） 的生物学和渔业方面的全球审查

郭志

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**摘要：**日本沙丁鱼是存在于东亚海域的一种重要的小型中上层鱼类。围网是用于该物种的最多的渔具。在过去的五十年里，日本沙丁鱼的渔获量呈现出不同的趋势。本文更新了1950年至2018年的渔获量趋势、种群评估和管理措施方面的信息。CMSY方法表明日本沙丁鱼处于轻微过度捕捞状态。这一结果建议对该物种进行进一步研究和管理措施。因此，本综述提出了新的研究方向，以帮助建立对这种小型中上层的合理管理。

**关键词：** CMSY, 合理管理, 日本沙丁鱼, 资源评估

## A global review on the biology and fishery aspects of the Japanese sardine, *Sardinops melanostictus* (Schlegel, 1846)

Ousmane SARR

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**Abstract:** Japanese sardine, is a significant small pelagic fish and a valuable resource. Purse seines are the main fishing gears used to catch these small pelagic species in Japan and in Korea. Japanese sardine catch showed varying trends over the last five decades. This paper updates information on the trends in catches, stock assessment methods, and management measures from 1950 to 2018 of the Japanese sardine populations globally. The current global stock assessment of this marine species is determined using the CMSY method applied on time series catch of Japanese sardine from 1950-2018. This method presented a proxy of the stock status indicating a slightly overfished state of Japanese sardines in all its regions of occurrence. Therefore, to contribute to the improvement of researches already carried on this species, this review suggests new research directions to help establish rational management of the stocks of Japanese sardines globally.

**Key words::** CMSY, Rational management, *Sardinops melanostictus*, Stock assessment

# 粤港澳大湾区近 40 年海岸线变迁的 遥感分析

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**摘要：**根据 1987-2018 年的 Landsat 影像，应用基于样本的特征提取与目视解译相结合的方法，分析了粤港澳大湾区近 40 年的海岸线变迁。研究表明：近 40 年来，粤港澳大湾区海岸线总长度不断增加，从 1987 年的 1290.6km 上升至 2018 年的 1410.6km；其中人工岸线增加 450.3km，其余岸线类型均减少，基岩岸线减少最多，为 172.2km，淤泥质岸线消失。海岸线整体表现为向海洋推进的趋势。

**关键词：**海岸线；卫星遥感；特征提取；目视解译；粤港澳大湾区

## Remote Sensing of the coastline variation of the Guangdong-Hong Kong-Macao Greater Bay Area in the past 40 years

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**Abstract :** According to Landsat satellite images from 1987 to 2018, the methods of combining feature extraction based on samples and visual interpretation were used to analyzed the coastline changes of the Guangdong-Hong Kong-Macao Greater Bay Area in the past 40 years. In the past 40 years, the total coastline length of the Guangdong-Hong Kong-Macao Greater Bay Area has been increasing, from 1290.6 km in 1987 to 1410.6 km in 2018; the artificial coastline increased by 450.3km, while the rest of the coastline types decreased. The bedrock coastline was reduced the most of 172.2km, and the silty coastline disappeared. The coastline as a whole shown a trend toward the ocean. The main reasons for the changes in the coastline were tidal flat reclamation, pond aquaculture, urban construction, land reclamation, and national policies.

**Key words: :** Coastline; Satellite remote sensing; Feature extraction; Visual interpretation; the Guangdong-Hong Kong-Macao Greater Bay Area.

# 杭州湾北部渔业资源群落结构分析

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**摘要：**根据 2016-2017 年嵊泗海域渔业资源 4 个航次的调查数据，运用 Bray-Curtis 相似性系数及多维尺度、ABC 曲线等方法，对该海域渔业资源进行物种群落结构聚集性分析。结果表明：1) 调查海域共出现渔业资源 78 种，丰度和生物量均以鱼类最高，其次为蟹类和虾类；2) 棘头梅童鱼、焦氏舌鳎、葛氏长臂虾和日本鳎为优势种；3) 群落结构稳定性分析显示春季和秋季群落结构稳定性较好，夏季和冬季受干扰较严重。

**关键词：**杭州湾；渔业资源；优势种；群落聚类

## Community structure analysis of fishery resources in northern of Hangzhou Bay

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**Abstract:** Based on the data of four seasons from 2016 to 2017 in northern of Hangzhou Bay, Bray-Curtis similarity matrix, ABC curves and other methods were used to analyze the community structure aggregation of species diversity. The results showed that: 1) 78 species of fishery importance were collected from the surveyed waters, with the highest abundance and biomass of fish, followed by crab and shrimp; 2) *Collichthys lucidus*, *Cynoglossus joyneri*, *Palaemon gravieri* and *Charybdis japonica* were the dominant species; 3) The cluster analysis of the community showed that the community structure stability in spring and autumn was better, but it was disturbed seriously in summer and winter.

**Key words:** Hangzhou Bay, fishery resources, species diversity, community structure

# 基于稳定同位素技术的 长江下游沙洲食物网结构的变化

邓艳敏

中国水产科学研究院淡水渔业研究中心

**摘要：**应用稳定性同位素技术对长江下游沙洲食物网结构进行了研究。2019年春季到冬季对沙洲水域的基础食物来源、无脊椎动物和鱼类进行采集和同位素分析。结果显示：沙洲水域消费者的碳稳定同位素比值在-34.69‰~-19.89‰，氮稳定同位素比值在5.89‰~15.84‰。浮游植物对大多数消费者的贡献有季节变化，夏季的贡献高于冬季，食源多样性水平也高于冬季。该研究结果对水生生物资源养护和水域生态修复有重要意义。

**关键词：**食物网；稳定同位素；季节变化；沙洲

## Variations of a Sandbank food web structure in the lower reaches of Yangtze River: assessed by stable isotope analysis

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**Abstract:** The structure of food web of a Sandbank in the lower reaches of the Yangtze River was studied by using stable isotope technique. Collection and isotope analysis of basic food sources, invertebrates and fish in Sandbank from spring to winter 2019. The results showed that the stable isotope ratios of carbon and nitrogen ranged from -34.69‰ to -19.89‰ and 5.89‰ to 15.84‰. The contribution of Phytoplankton to most consumers has seasonal variation, and the contribution in summer is higher than that in winter, and the level of food source diversity is also higher than that in winter. The results are of great significance for aquatic biological resource conservation and aquatic ecological restoration.

**Key words:** Food web, Stable isotope, Seasonal variations, Sandbank

# 浙江南部近海两种石首鱼摄食习性分析

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**摘要：**根据浙江南部近海底拖网调查资料，对采集的白姑鱼和黑姑鱼进行胃含物分析，研究其食物组成、摄食习性的体长变化及饵料重叠情况。结果表明，浙江南部近海白姑鱼主要摄食桡足类。黑姑鱼主要摄食鱼类和虾类。随着体长的增加，两种石首鱼的主要饵料生物均出现变化，摄食强度也随之降低。黑姑鱼的生态位宽度(3.06)高于白姑鱼(1.82)，二者间的整体饵料重叠系数为 0.22，但在部分体长组中存在较大的饵料重叠。

**关键词：**白姑鱼；黑姑鱼；胃含物分析；摄食生态；食性重叠

## Study on feeding habits of two Sciaenidae species in the southern coastal waters of Zhejiang

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Shanghai Ocean University

**Abstract :** A total of 287 stomach samples of *Pennahia argentata* and 204 stomach samples of *Atro Bucca nibe* were collected to perform analyses of the diet composition of these two species in the southern coastal waters of Zhejiang. Results showed that the prey items of *P. argentata* included 48 species, among which, Copepoda was the main prey category. *A. nibe* fed on 43 species, mainly on fish and shrimp. Obvious ontogenetic variations in the feeding habits were observed for both species. The trophic niche breadth of *A. nibe* was much wider than that of *P. argentata*, indicating that *A. nibe* had better ability and range of utilizing food resources. The overall feeding overlap value between these two species was low, while high overlap values occurred in some certain body length group combinations. The findings of this study enhanced our understanding of the trophic interaction between *P. argentata* and *A. nibe* and provided basic data for ecosystem-based fishery management.

**Key words :** *Pennahia argentata*; *Atro Bucca nibe*; stomach content analysis; feeding ecology; diet overlap

# 象山港牡蛎养殖区沉积物反硝化速率特征及其影响因素

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**摘要:** 本研究选取象山港牡蛎养殖区 7 个站位为研究对象, 在春夏秋冬四个季节分别采集沉积物样品, 测定理化指标, 用同位素配对技术研究其反硝化作用及其影响因素。结果表明, 象山港沉积物的反硝化速率变化范围为 197.86~9071.81 $\mu\text{mol}/(\text{m}^2\cdot\text{h})$ , 其中牡蛎养殖区反硝化速率显著高于对照区( $P<0.05$ ), 沉积物中的铵态氮、亚硝态氮、硝态氮、颗粒有机碳、颗粒有机氮均会对反硝化速率产生影响。

**关键词:** 象山港; 反硝化速率; 沉积物; 环境因子

## Characteristics and influencing factors of denitrification rate in sediments of oyster culture area of Xiangshan bay

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**Abstract:** In this study, seven stations in the oyster culture area of Xiangshan bay were selected as the research objects. Sediment samples were collected in spring, summer, autumn and winter, and the physical and chemical indexes were determined. The denitrification and its influencing factors were studied by isotope matching technology. The results showed that the denitrification rates varied from 197.86  $\mu\text{mol}/(\text{m}^2\cdot\text{h})$  to 9071.81  $\mu\text{mol}/(\text{m}^2\cdot\text{h})$ , and the denitrification rates in oyster culture area were significantly higher than those in control area ( $P<0.05$ ), ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, granular organic carbon and granular organic nitrogen in sediment all affect the denitrification rate.

**Key words:** Xiangshan bay; Denitrification rate; Sediment; Environmental factors



# 莱州湾芙蓉岛人工鱼礁区生态系统 能量流动及仿刺参生态容量评估

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**摘要:** 基于 2019 年莱州湾芙蓉岛人工鱼礁区渔业资源调查数据, 利用 Ecopath with Ecosim 6.6(EwE)软件构建芙蓉岛人工鱼礁区生态系统 Ecopath 模型, 系统分析了该生态系统的能量流动规律和结构特征, 估算了仿刺参(*Apostichopus japonicus*)的生态容量。结果表明芙蓉岛人工鱼礁区生态系统成熟度和稳定性较低, 食物网结构较简单, 仿刺参的生态容量为 131 t/km<sup>2</sup>。

**关键词:** 芙蓉岛; 人工鱼礁; Ecopath 模型; 生态容量

## Assessment of ecosystem energy flow and ecological capacity of *Apostichopus japonicus* in Furong Island artificial reef, Laizhou Bay

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**Abstract:** By investigating the fishery resources in Furong Island, Laizhou Bay artificial reef in 2019, the energy flow and the structure of the ecosystem were modeled and the ecological capacity of *Apostichopus japonicus* was estimated using an Ecopath model (EwE 6.6). The results showed that the Furong Island artificial reef ecosystem was under a relatively low maturity and stability level with a relatively simple food web. The ecological capacity of the *Apostichopus japonicus* estimated by the model is 131t/km<sup>2</sup>.

**Key words::** Furong Island; artificial reef; Ecopath model; ecological capacity

# 珠江口秋季鱼类群落及多样性研究

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**摘要：**根据珠江口渔业资源 2020 年枯水期调查资料，该海域枯水期鱼类资源密变化范围为 14.69~796.26 kg/km<sup>2</sup>，平均为 151.67 kg/km<sup>2</sup>。Shannon-Wiener 多样性指数为 1.00~2.59，Peilou 均匀度指数为 0.65~1.00。结果表明，调查海域鱼类个体偏小，渔获物多样性较低，群落结构较简单，空间分布上总体呈现 3 个分布带。

**关键词：**渔业资源，多样性，资源退化

## Study on fish communities and diversity in the Pearl River Estuary in autumn

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**Abstract:** According to the survey data of fishery resources in the Pearl River Estuary in 2020, the variation range of fish resource density in the dry season is 14.69 ~ 796.26 kg / km<sup>2</sup>, The average is 151.67 kg / km<sup>2</sup>. Shannon Wiener diversity index is 1.00 ~ 2.59 and peilou evenness index is 0.65 ~ 1.00. The results showed that the fish individuals were small, the diversity of catches was low, the community structure was simple, and there were three distribution zones in the spatial distribution.

**Key words::** Fishery resources, biodiversity, resource degradation

# 知鱼、识鱼、管鱼：从个性研究开始

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**摘要：**个性是指个体随着时间的推移，在不同情境下所表现出的持续一致的行为差异，普遍存在于动物界中；在种或种群水平，个性表现为行为集，即相关联行为的集合，在行为集内，每个个体有其行为类型。个性包含有5个个性轴：（1）害羞-大胆性；（2）探索-回避性；（3）活动性；（4）攻击性；（5）社交性。个性影响着鱼类的行为表现，从而影响鱼类的生命过程和产出，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。

**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 personality: implications for ecology, aquaculture and fisheries

Dong Zhang

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**Abstract:** Personality refers to consistent individual differences in behavior over time and across contexts. At population or species level, a behavioral syndrome with each individual showing a behavioral type is exhibited. Currently, behavioral syndromes in fishes are 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 behavioral performances of fish and fitness and is of great consequences to the welfare of fish, stock enhancement, fishery management and conservation. The present review summarized the research progress in fish personality, and summarized the application of fish personality in stock enhancement; information transmission, disease prevention and control; fishery resource management and protection; biological invasion prevention and control. This review aimed to provide fundamental information for the future research and application of fish personality.

**Key words:** Fish personality; aquaculture; stock enhancement; fishery resource management and conservation

# 不同比例鲢、鳙放养模式下 溇湖浮游植物群落结构的变化

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**摘要：**为了探究不同比例的鲢鳙鱼放养量对浮游植物群落结构的影响，在溇湖进行了为期 90 天的围隔实验。本实验设置了不同的鲢鳙比例和密度。共鉴定出浮游植物 6 门 44 属 79 种；实验期间藻类生物量呈现先升后降的趋势，E 组最高；物种多样性指数 ( $H'$ ) 后期 B 组最高，其他组间无显著差异；主要的环境影响因子为 T、DO。研究表明：在降低藻类生物量和提高藻类多样性方面，鲢鳙比为 3:7，放养密度为  $40\text{g}/\text{m}^3$  的 C 组的控藻效果更好。

**关键词：**鲢鳙放养模式；浮游植物；群落结构；相关性分析

## The structure of phytoplankton in different proportions of silver carp and bighead stocking mode

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**Abstract:** In order to explore the effects of different proportions of silver carp and bighead carp on phytoplankton community structure, a 90 day enclosure experiment was carried out in Gehu Lake. Different proportions and densities of silver carp and bighead carp were set up in this experiment. A total of 79 species belonging to 44 genera and 6 phyla of phytoplankton were identified; During the experiment, algal biomass increased first and then decreased, and group E was the highest; The species diversity index ( $H'$ ) was the highest in group B in the later stage, and there was no significant difference among other groups; The main environmental impact factors are T and DO. The study showed that in group C of reducing algae biomass and improving algae diversity, the ratio was 3:7 and the range density was  $40\text{g}/\text{m}^3$  was better.

**Key words:** Silver carp and bighead carp stocking mode; Phytoplankton; Community structure; Correlation analysis

# 八放珊瑚资源现状、问题与对建议

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**摘要：**开展对八放珊瑚资源保护和修复，对恢复八放珊瑚资源和重建曼氏无针乌贼产卵场具有重要的生态学和应用价值。本文对八放珊瑚的基本结构和生态特征进行了分析，总结了八放珊瑚生存环境面临的生态环境，提出了天然受精和人工移植两种珊瑚保护技术。人工移植技术作为主流手段有效恢复了珊瑚礁资源，进一步提高了珊瑚礁生态系统的生产力。

**关键词：**八放珊瑚、人工移植、保护、生态

## The current status, problems and countermeasures of Octocorallia resources

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**Abstract :** The conservation and restoration of Octocorallia resources is of great ecological and applied value to the restoration of Octocorallia resources and the reconstruction of the spawning ground of *Sepiella japonice* Sasaki. In this paper, the basic structure and ecological characteristics of Octocorallia were analyzed, the ecological environment needed for the survival of Octocorallia coral was revealed, and two kinds of coral protection technologies, natural fertilization and artificial transplantation, were proposed. As a main method, artificial transplantation can effectively restore Coral Reef Resources and further improve the productivity of coral reef ecosystem.

**Key words: :** Octocorallia、Artificial transplantation、conservation、ecology

# 乐清湾贝类群落组成及粒径谱结构特征

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**摘要：**本次共采集到贝类共计 45 种，隶属于 12 目，25 科，31 属。焦河蓝蛤为乐清湾绝对优势种；资源密度表现为夏季最高，其次为春季，秋季与冬季次之；四个季节的丰富度指数、多样性指数和均匀度指数平均为 3.26、1.61、0.45，三种多样性指数均处于较低水平；ABC 曲线显示乐清湾贝类的生物群落处于中度干扰状态；乐清湾生物量粒径谱谱型复杂，优势种控制着生物量粒径谱的峰值。

**关键词：**贝类；种类组成；资源密度；粒径谱；乐清湾

## Structure composition and particle size spectrum structure characteristics of shellfish community in Yueqing Bay

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**Abstract :** The species composition, dominance, resource biomass and density and community diversity were studied using data collected from four surveys from May 2016 to February 2017 in Yueqing Bay, Zhejiang province. The main results showed that 45 shellfish species were identified, and they belong to 12 orders, 25 families and 31 genera. The absolute dominant species were *Potamocorbula ustulata*; The resource biomass and density kept highest level in summer, winter against, followed by spring and autumn. The average values for species abundance index ( $D$ ), species diversity index ( $H'$ ) and species evenness index ( $J'$ ) were 3.26, 1.61 and 0.45, respectively, indicating the shellfish community diversity was on a low level. The ABC curve showed that shellfish community was unstable. The biomass size spectrum was complicated, which dome was controlled by dominant species. Compared with other Chinese offshore area, it was also different from others results. The slopes of NBSS ranged from -1.5539 to -0.7373, and the intercepts ranged from 16.673 to 21.597. The slope values were lower than of most other area of Chinese offshore area, and it stood for a lower circulatory efficiency of nutrients in Yueqing Bay. In addition, the intercept values inferred that the production in Yueqing Bay was higher than it.

**Key words:** shellfish; species composition; resource density; size spectra; Yueqing Bay

# 《生物多样性公约》背景下我国珊瑚礁养护 进程与改善建议

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**摘要：**珊瑚礁生态系统是《生物多样性公约》的重点保护对象。我国作为《公约》的缔约国，一直积极履行《公约》规定，从多方面采取了履约措施。本文通过梳理我国珊瑚礁养护管理的法律法规、政策文件和相关履约措施，结合海南、广西、广东三省的珊瑚礁资源变化状况，评价我国在履约方面的表现并识别存在的主要问题，并提出针对性的改善建议。

**关键词：**珊瑚礁，《生物多样性公约》，履约

## Conservation of Coral Reef Systems under Convention on Biological Diversity: Review of China's Performance and Suggestions

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**Abstract :** Aims: Coral reef system is an important protecting target under the Convention of Biological Diversity (CBD). Since its accelerated bleaching has attracted enormous attention in 1998, conservation of coral reef systems have been a significant topic in the Conference of the Parties (CoP). China, as a contracting party, has actively engaged in the conservation of coral reefs and adopted various compliance measures. To review China's performance, this article explores following questions: whether China fulfills its obligations to protect coral reef systems as prescribed under the CBD? What are the challenges for protecting coral reef systems in China by consideration of requirements of the CBD? What suggestions are there for improving compliance with the CBD?

**Method:** A comparative method is applied to identify the compliance gap under the CBD. Relevant reports at national and provincial level are investigated which shows the changes of coral reef systems in Hainan, Guangxi and Guangdong province. The law, regulations, and compliance reports of coral reef protection at national level and provincial level is also investigated.

**Results:** It finds that China has adopted many specific measures which has reversed the decline of coral reefs in general. However, there are several problems in its compliance, primarily the lack of comprehensive strategies and action plans, fragmented legislation and insufficient coordination, ineffective management in marine protected areas, unintegrated

**Key words::** coral reef, CBD

# 东莞生态园浮游植物群落结构季节变化规律 及其水质评价

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**摘要：**为研究东莞生态园浮游植物群落结构季节变化规律及其水质评价，于2019年4月、7月、9月和12月对浮游植物及水环境理化指标进行了调查分析。检出浮游植物137种，不同季节共出现优势种20种。多样性指数、均匀度指数和丰富度指数季节间均存在极其显著差异。根据综合营养状态指数结果，东莞生态园水质营养状态为中度富营养。冗余分析结果表明，透明度、TN、PO<sub>3</sub>-P和NO<sub>2</sub>-N是影响浮游植物群落变化的主要环境因子。

**关键词：**浮游植物；环境因子；水质评价

## Seasonal Variation of Phytoplankton Community Structure and Water Quality Evaluation in Dongguan Ecological Garden

Wang Yang

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**Abstract:** In order to study the seasonal changes of phytoplankton community structure and water quality evaluation in Dongguan Ecological Garden, phytoplankton and physical and chemical indicators of the water environment were investigated and analyzed in April, July, September and December 2019. The results showed that 137 species of phytoplankton were detected, and a total of 20 dominant species appeared in different seasons. The Shannon diversity index, evenness index and richness index all have extremely significant differences between seasons. According to the results of the comprehensive nutritional status index, the water quality and nutritional status of Dongguan Ecological Park is moderately eutrophic. Redundant analysis results show that transparency, TN, PO<sub>3</sub>-P and NO<sub>2</sub>-N are the main environmental factors that affect the changes of phytoplankton communities.

**Key words:** Phytoplankton; Environmental Factors; Water quality evaluation



# 千岛湖二龄鱼种网箱养殖水域水环境监测 及评价研究

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**摘要：**为了解千岛湖二龄鱼种网箱对水环境的影响，对养殖网箱内外水体进行了为期一年的采样调查。结果表明，网箱养殖区水体理化指标存在季节变化，从上游至下游呈下降趋势。浮游植物共 8 门 143 种，网箱内 7 门 122 种。网箱外水域浮游植物年均丰度和生物量均比网箱内低。研究表明千岛湖二龄鱼种网箱养殖能够对水环境起到净化与保护作用。

**关键词：**千岛湖，二龄鱼种网箱，浮游生物，环境因子

## Study on monitoring and evaluation of water environment in caged aquaculture area of second age fish species in Qiandao Lake

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**Abstract:** In order to understand the impact of second-year-old fish cages on water environment in Qiandao Lake, a one-year sampling survey was conducted inside and outside the cages. The results showed that the physical and chemical indicators of water in culture area of cages changed seasonally, and showed a downward trend from upstream to downstream. 143 species of phytoplankton from 8 phyla and 122 species from 7 phyla inside were found. The average annual abundance and biomass of phytoplankton in the water outside the cages are lower than those in the cages. Studies have shown that cage culture of second-age fish in Qiandao Lake can purify and protect the water environment.

**Key words:** Qiandao Lake, second-year-old fish cages, plankton, environmental factors

# 长江鱼类新种—三峡金线鲃

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**摘要:** 于长江三峡库区湖北省秭归县江段采集到一尾金线鲃属鱼类的全盲个体,经分类学研究确认为鱼类新种并命名为三峡金线鲃 (*Sinocyclocheilus sanxiaensis* Jiang, Li, Yang & Chang, 2019)。这一物种的发现将我国洞穴鱼类代表类群——金线鲃属鱼类已知的分布范围变大。三峡区域蕴含着大量的喀斯特地形和发达的地下水网系统,而这一物种属于典型洞穴鱼类。

**关键词:** 鲤科; 金线鲃属; 洞穴鱼类; 三峡; 长江

## A new species of fish from the Yangtze River : *Sinocyclocheilus sanxiaensis*

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**Abstract:** A blind fish from the genus *Sinocyclocheilus* (Cypriniformes: Cyprinidae) was caught in open water in the Three Gorges (Sanxia) reservoir in the mainstream of Yangtze River in Zigui County, Hubei Province, China. Which is named *Sinocyclocheilus sanxiaensis* (Jiang, Li, Yang & Chang, 2019). The discovery of this species has expanded the distribution of *Sinocyclocheilus* cavefish from around 25° N (latitude) to above 30° N. Given the Three Gorges area encompasses a vast karst landscape with abundant underground water systems, this species potentially entered the area via a subterranean river draining into the Yangtze River. The discovery of the new fish species enriches the gene bank of fish resources in the Yangtze River and has high scientific research, protection, development and utilization value.

**Key words:** Cyprinidae, *Sinocyclocheilus*, cavefish, Three Gorges, Yangtze River

# 渤海莱州湾硬骨鱼类早期资源群落结构及演变

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**摘要:** 分析阐述近 40 年莱州湾鱼类早期资源演替过程。莱州湾鱼类早期资源结构持续更替, 不同时期早期资源种类组成、资源丰度、优势种类和物种多样性水平等呈明显季节更替。相较 1980s, 早期资源已发生结构性改变, 中上层和底层小型鱼类为主体成分, 相同季节优势种更替呈明显加快趋势, 鱼卵和仔稚鱼种数和资源丰度均在 2010s 初期跌至历史低值。这些变化是捕捞-环境压力下鱼类群落内生态位错位交替和结构性渔业资源衰退体现。

**关键词:** 鱼类早期资源; 补充量; 物种多样性; 长期变化; 时间序列分析; 莱州湾

## Early life resources assemblage structure and succession to the Marine Osteichthyes in the Laizhou Bay of Bohai Sea

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**Abstract:** The recruitment characteristics and long-term trends in early life resources assemblage structure, biodiversity, and synchrony were studied. The analysis showed that early life resources assemblage structure in the Laizhou Bay changes continuously. The seasonal differences in community composition, abundance index, predominant taxa, and species diversity to eggs and larvae fish assemblage were evident. Compared with the survey result in the 1980s, the taxonomic composition and abundance of the egg and larval fish assemblage changed considerably. Small pelagic and benthopelagic taxa were the main components by relative abundance detected in the eggs and larvae fish collected across different survey periods. The dominant taxa substitution rate was significantly accelerated in recent years during the same survey season. The abundance index and taxa number of egg and larval fish assemblage had fallen to an all-time low around the early 2010s. These variations were the concrete embodiment of high turnover in fish community structure and decline of fishery resources under long-term effects of overfishing and environmental change.

**Key words:** early life resources; recruitment abundance; species diversity; long-term variation; time-series analyses; Laizhou Bay

# 烟威近岸海域鲈产卵场时空分布及其与环境因子的关系

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**摘要：**烟威近岸海域分布着鲈 *Scomber japonicas* 产卵场，然而近年来对该海域鲈产卵场的研究相对较少。本研究利用 2020 年 4-9 月烟威近岸海域开展的逐月调查而获取的鲈卵、0 龄幼体及环境数据，建立基于 Tweedie 类分布的广义加性模型(Tweedie-GAM)分析鲈卵丰度与主要环境因子的关系，并结合克里金插值绘制的鲈卵与主要生境因子时空分布图阐释烟威近岸海域鲈产卵适宜生境。

**关键词：**鲈；卵；0 龄幼体；产卵场；Tweedie-GAM 模型；环境因子；烟威近岸

## Spatio-temporal distribution of spawning grounds of chub mackerel (*Scomber japonicas*) and its relationship with environmental factors in Yantai-Weihai offshore waters and adjacent sea areas

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Yellow Sea Fisheries Research Institute

**Abstract:** There was a stable spawning ground of chub mackerel (*Scomber japonicas*) distributed in Yantai-Weihai offshore waters and adjacent sea area, which has not been paid much attention in recent years. Based on the survey data collected from the monthly field survey carried out in the Yantai-Weihai offshore waters and adjacent sea area from April to September in 2020, first, the generalized additive model (GAM) based on the Tweedie distribution was established to evaluate the effects of environmental factors on chub mackerel eggs abundance. Second, the spatio-temporal distribution pattern of chub mackerel eggs and major habitat factors was plotted in one map to interpret the optimal spawning habitat by using the Kriging interpolation method. Third, distribution and biological characteristics of age 0 chub mackerel were studied to interpret the early life history parameters of the chub mackerel. The results indicated that the spawning period of chub mackerel lasted from April to July, mainly from late May to late June. The main spawning ground of the chub mackerel covered an area from 121°30' E to 122°15' E and 37°30' to 38°00' N, according to the distribution of chub mackerel eggs. Sea surface temperature (SST), anchovy (*Engraulis japonicus*) eggs abundance (Da), ocean current velocity (OC) and sea surface salinity (SSS) were the significant factors affecting eggs abundance of chub mackerel, with deviance explained of 54.6%, 17.8%, 4.0% and 1.7%, respectively. Suitable spawning hab

**Key words:** : *Scomber japonicus*; eggs; age 0 larvae; spawning grounds; Tweedie-GAM; environmental factors; Yantai-Weihai coastal waters

# 基于转录组分析养殖黑鲷与野生黑鲷差异研究

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**摘要：**增殖放流是恢复渔业资源的重要手段，为了解放流群体与野生群体之间繁殖力、免疫力等方面的差异，选取了浙江嵊泗马鞍列岛海域黑鲷放流群体与野生群体，利用 Illumina Novaseq 6000 高通量测序平台进行了转录组分析。黑鲷放流群体与野生群体共有 3095 个差异基因，这些差异基因主要参与酶催化活性、细胞组分、代谢过程等。本研究为评估黑鲷放流群体的生长状况提供了科学依据。

**关键词：**黑鲷；转录组分析；生长发育；繁殖力

## Study on the difference between farmed *Acanthopagrus schlegelii* and wild *Acanthopagrus schlegelii* based on transcriptome analysis

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**Abstract :** Proliferation and release is an important means to restore fishery resources. In order to liberate the differences in fecundity and immunity between the current population and the wild population, the black bream release population and the wild population in the waters of the Ma'an Islands in Shengsi, Zhejiang Province were selected, and the Illumina Novaseq 6000 Qualcomm was used. Transcriptome analysis was performed on the quantitative sequencing platform. There are a total of 3095 differential genes between the released *Acanthopagrus schlegelii* population and the wild population. These differential genes are mainly involved in enzyme catalytic activity, cell components, and metabolic processes. This study provides a scientific basis for evaluating the growth status of the black sea bream release population.

**Key words: :** *Acanthopagrus schlegelii*; transcriptome analysis; growth and development; fecundity

# 马鞍列岛海洋特别保护区大黄鱼繁殖和摄食习性研究

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**摘要：**于2020年9月-2021年1月研究了马鞍列岛海洋特别保护区大黄鱼的繁殖和摄食习性。结果表明：大黄鱼的雌雄性比为3:1，雌雄个体的体长体重组成均有明显差异（ $P < 0.05$ ），性成熟系数范围为0.7-21.1，个体绝对生殖力为10.374-483.990千粒，平均164.920千粒。大黄鱼饵料种类有鱼类、十足类和端足类等共10种，优势饵料生物种类为黄鲫、龙头鱼和中国毛虾。大黄鱼平均营养级为3.97。

**关键词：**大黄鱼；繁殖；摄食；马鞍列岛海洋特别保护区

## Reproduction and feeding habits of *Larimichthys crocea* in Ma'an Special Marine Protected area

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**Abstract:** From September 2020 to January 2021, the breeding and feeding habits of *Larimichthys crocea* in the Maan Archipelago Marine Special Reserve were studied. The results showed that the female-male ratio of *Larimichthys crocea* was 3:1, the body length and weight composition of male and female individuals were significantly different ( $P < 0.05$ ), the range of sexual maturity coefficient was 0.7-21.1, and the absolute fecundity of individuals was 10.374-483.990 thousand grains. , An average of 164.920 thousand grains. There are 10 types of bait for *Larimichthys crocea*, including fish, decapod and amphipod. The dominant bait species are *Setipinna tenuifilis*, *Harpadon nehereus* and *Acetes chinensis*. The average trophic level of *Larimichthys crocea* is 3.97.

**Key words:** *Larimichthys crocea*; reproduction; feeding; Ma'an Special Marine Protected area

# 淮河安徽段秀丽白虾肠道菌群时空特征 及闸坝阻隔的影响探究

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**摘要：**利用 16SrDNA 测序技术研究了淮河安徽段秀丽白虾肠道菌群组成及受闸坝阻隔的影响。结果显示，虾菌群组成为假单胞菌属、短波单胞菌属、青枯菌属、柄杆菌属、鞘氨醇单胞菌属等。从枯水期到丰水期，随着水体交换量变大，各水域动物肠道共有菌逐渐增多，菌群相对丰度趋于均衡。因此，闸坝阻隔淮河水域连通性，在一定程度上影响底层虾类的肠道菌群组成连续性。

**关键词：**16SrDNA；肠道菌群；闸坝阻隔

## Temporal and spatial characteristics of intestinal flora of Sauvignon Blanc in Anhui section of Huaihe River and the influence of gate dam barrier

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**Abstract:** 16S rDNA sequencing technology was used to study the composition of intestinal flora and the effect of gate dam barrier of Sauvignon Blanc in Anhui section of Huaihe River. The results showed that the shrimp flora was composed of Pseudomonas, Brevundimonas, Ralstonia, Bacteroides, Sphingomonas and so on. From dry season to wet season, with the increase of water exchange, the common bacteria in the intestinal tract of animals in each water area gradually increased, and the relative abundance of flora tended to be balanced. Therefore, the gate dam blocks the connectivity of Huaihe River water area and affects the continuity of intestinal flora of bottom shrimp to a certain extent.

**Key words:** 16SrDNA; Intestinal flora; Gate dam barrier

# 基于生物学特征的瓯江口刀鲚 资源开发与保护

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**摘要：**根据 2021 年 1-10 月在瓯江口水域采集的刀鲚全长、体长和体重等生物学信息，利用体长频率分布估算生物学参数。结果表明，瓯江口刀鲚体长范围为 6.5~33.0 cm。v-B 生长方程的参数为  $L_{\infty}=37.10\text{cm}$ ， $k=0.38$  及  $t_0=-0.67$  a； $Z=2.13$ ， $M=0.86$ ， $F=1.27$ ， $E=0.596$ ，表明资源已处于过度开发状态。根据 B-H 动态综合模型，建议最适开捕体长为 24.0cm（2.1a）。

**关键词：**刀鲚；渔业生物学；生长参数；资源保护；瓯江口

## Exploitation and protection of *Coilia nasus* in Oujiang River Estuary based on biological characteristics

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**Abstract:** Based on the investigation data collected in Oujiang River Estuary from January to October 2021, the present study analyzed the biological characteristics of *Coilia nasus*, including body length, total length and body weight. The population growth and death parameters were estimated by body length frequency distribution. The results indicate that the body length of *C. nasus* in Oujiang River Estuary was 6.5~33.0 cm. The growth parameters of von Bertalanffy formula estimated by ELEFAN were  $L_{\infty}=37.10$  cm,  $k=0.38$ , and  $t_0=-0.67$  a. Total mortality coefficient ( $Z$ ), natural mortality coefficient ( $M$ ) and the fishing mortality coefficient ( $F$ ) are 2.13, 0.86 and 1.27 respectively; the exploitation rate ( $E$ ) equaled 0.596, demonstrating that the stock was subjected to over-exploited. According to the Beverton-Holt dynamic model, the minimum capture size for *C. nasus* should be 24.0 cm (age 2.1 years).

**Key words:** *Coilia nasus*; fisheries biology; growth parameters; resource protection; Oujiang River Estuary



# 诱饵式远程水下视频技术 (BRUV) 研究进展

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**摘要:** 诱饵式远程水下视频系统 (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, 已广泛应用于全球多种栖息地的资源调查与评估, 但目前其研究应用在国内尚属空白。本文根据全球 2006 年至 2020 年 3 月以来发表的与 BRUV 相关的 278 篇文献, 系统梳理了 BRUV 的研究进展并对其发展进行了展望, 本研究旨在为 BRUV 在我国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

## Research progress 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 and suitability for a variety of habitat types and water depths. 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 utilizing BRUVs published between January 2006 to March 2020 to develop a set of recommendations for the use of this technology in China, and discussed the development trend of this technology. This study provides guidelines for the use of BRUVs for non-destructive monitoring studies on fish composition, stock assessment and particularly for monitoring fish resources on marine ranches in China.

**Key words:** BRUV, Marine ranching, Fish resources monitoring, Non-destructive monitoring technology

# 我国近海乌贼产卵附着基的研究进展

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**摘要：**随着海洋自然保护区建设和人工增养殖技术研究不断推进，我国专家学者对产卵场修复、乌贼增养殖和不同产卵附着基的附卵效果进行了多方面研究。本文根据乌贼产卵繁殖习性，对我国近海乌贼产卵附着基进行总结分析，对比了天然和人工附着基的异同点，并论述了天然和人工附着基在产卵场修复和增养殖中的实际应用，最后对乌贼产卵附着基未来研究方向提出了几点思考，旨在为乌贼的生境修复、增养殖以及渔业资源的可持续发展提出合理建议。

**关键词：**乌贼；产卵附着基；生境修复；可持续发展

## Advances in studies on the ovipositing attachment substrate of cuttlefish in China's coastal waters

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**Abstract:** With the construction of marine nature reserves and the development of artificial breeding technology, many experts and scholars in China have studied the effects of oviposition site restoration, cuttlefish culture and attachment of different oviposition bases. Based on the spawning and breeding habits of Cuttlefish, this paper summarizes and analyzes the spawning substrates bases of cuttlefish in China's coastal waters, and compares the similarities and differences between natural and artificial spawning substrates bases, the practical application of natural and artificial attachment substrates in the repair and culture of spawning grounds is also discussed. Finally, some thoughts on the future research direction of the attachment substrates are put forward, the purpose of this paper is to provide reasonable suggestions for the habitat restoration, aquaculture and sustainable development of fishery resources of cuttlefish.

**Key words::** squid; spawning substrates; habitate restoration; sustainable development

# 资源养护型海洋牧场建设现状 与发展 --以浙江省为例

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**摘要：**海洋牧场作为人类获取优质蛋白的“蓝色粮仓”，被称为“第六次海水养殖浪潮”的雏形。浙江省海洋牧场建设以资源养护型为主，在改善海域生态环境及修复渔业资源过程中发挥了重要作用。本文基于浙江省资源养护型海洋牧场现状和特点，分析了海洋牧场建设中存在的突出问题，借鉴我国沿海省市海洋牧场建设成功经验，从渔业改革、转型发展和生态修复等角度提出科学建议，为推进我国养护型海洋牧场体系建设和高质量发展提供新思路。

**关键词：**海洋牧场建设；资源养护型海洋牧场；浙江省

## The current situation and development of the construction of resource-conserving marine ranches --Take Zhejiang Province as an example

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**Abstract:** As a "blue granary" for humans to obtain high-quality protein, marine pastures are known as the embryonic form of the "sixth wave of marine aquaculture". The construction of most marine pastures in Zhejiang Province is based on resource conservation, which have played an important role in improving the ecological environment of the sea and restoration of fishery resources. Based on the status and characteristics of resource-conserving marine ranches in Zhejiang Province, this paper analyzes the outstanding problems in the construction of marine ranches, draws on the successful experience of marine ranches in coastal provinces and cities in China, and puts forward scientific suggestions from the perspectives of fishery reform, transformation and development, and ecological restoration, and provides new ideas for promoting the construction and high-quality development of China's conservation-oriented marine pasture system.

**Key words::** marine pasture construction; resource conservation marine pasture; Zhejiang Province

# 全球五大金枪鱼 RFMOs 鲨鱼养护管理现存问题及应对策略研究

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**摘要：**鲨鱼养护管理是国际渔业治理的重要组成部分，自 1990 年以来，国际社会高度重视鲨鱼资源的养护和管理，目的是维持全球海洋生态系统平衡。RFMOs 历经多年发展与变革，尽管取得较大成果，提高了鲨鱼资源的可持续利用与发展水平，但仍存在一些突出问题。对此，提出建立统一的渔业管理实体组织、寻找沿海国与远洋捕捞国之间利益的最佳契合点、提高决策和实施措施的透明度、明确可持续发展目标的真正内涵来解决鲨鱼养护管理问题。

**关键词：**区域渔业管理组织；鲨鱼；养护管理；应对策略

## Research on Existing Problems and Countermeasures of Shark Conservation and Management of the World's Top Five Tuna RFMOs

Wang lei

School of Ocean Culture and Law, Shanghai Ocean University

**Abstract :** Shark conservation and management is an important part of international fishery governance. Since 1990, the international community has attached great importance to the conservation and management of shark resources, with the goal of maintaining the balance of the global marine ecosystem. RFMOs have undergone many years of development and transformation. Although they have achieved great results and improved the sustainable use and development of shark resources, there are still some outstanding problems. In this regard, it is proposed to establish a unified fishery management entity organization, find the best fit between the interests of coastal countries and ocean fishing countries, improve the transparency of decision-making and implementation measures, and clarify the true connotation of sustainable development goals to solve the problem of shark conservation and management.

**Key words: :** Regional fisheries management organizations; sharks; conservation management; response strategies

# 南江水库蓝藻应急工程治理过程中的主要生态变化研究

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**摘要：**以南江水库为例，引入生态活水控藻船助力南江水库生态修复。本研究通过在 2019 年 4 月至 12 月期间在水库设置 4 个点位，研究了控藻船运行前、运行中、以及运行后各种主要水质指标的变动情况。结果显示浮游植物优势种为硅藻门，绿藻门，蓝藻门。叶绿素 a、浮游植物生物密度、生物量均与透明度和水温呈极显著负相关，与总氮、总磷以及溶氧呈正相关关系。研究表明控藻船的使用在短期内能够造成水体中重金属含量的升高。

**关键词：**南江水库，控藻船，浮游植物，环境因子，重金属

## Study on the Main Ecological Changes of Cyanobacteria Emergency Project in Nanjiang Reservoir

Hang Ge

Shanghai Ocean University

**Abstract :** Taking Nanjiang Reservoir as an example, the introduction of ecological water control algal boat to help the ecological restoration of nanjiang reservoir. This study studied the changes of major water quality indicators before, during and after the operation of the algal control vessel by setting up four points in the reservoir from April to December 2019. The results showed that the dominant phytoplankton species were diatoms, chlorophyta and cyanophyta. Chlorophyll A, phytoplankton density and biomass were negatively correlated with transparency and water temperature, and positively correlated with total nitrogen, total phosphorus and dissolved oxygen. The study shows that the use of algal control vessel can increase the heavy metal content in water in a short term.

**Key words :** Nanjiang reservoir, algae control boat, phytoplankton, environmental factors, heavy metals

# 基于环境 DNA 技术和传统捕捞方法对淡水湖泊鱼类群落研究的比较：一套新的环境 DNA 通用 PCR 引物

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**摘要：**环境 DNA 技术可用于监测水生物种的分布，我们开发了一套新的鉴定淡水鱼类物种的 PCR 引物，用于鱼类线粒体 DNA 序列的 eDNA 监测。利用该引物检测到分布在中国江苏省太湖的 27 种鱼类；通过比较刺网和地笼的鱼类捕获数据，利用 eDNA 技术的监测结果与刺网数据相似性更高。环境 DNA 技术因其对目标生物不造成干扰和样品采集的便利等优势，可与传统的鱼类捕捞方法相结合，为鱼类分类学及其多样性保护提供技术支撑。

**关键词：**环境 DNA；PCR 引物；鱼类群落；生物多样性；传统捕捞

## Comparison of fish communities using environmental DNA metabarcoding and capture methods in a freshwater lake: a new set of universal PCR primers

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**Abstract:** Environmental DNA (eDNA) obtained directly from environmental samples can be used to evaluate the distribution of aquatic species. We developed a new set of universal PCR primers (16S 200) for eDNA metabarcoding from mitochondrial DNA sequences. Using the new 16S 200 primers, we detected the presence of 27 fish species distributed across four families in Lake Gehu, in southeastern China. Data from eDNA metabarcoding were more consistent with results from gill net capture methods than from ground cage capture. The eDNA metabarcoding is an efficient and cost-effective method that can be used in conjunction with traditional survey methods for analyzing fish communities; therefore, eDNA metabarcoding may be useful for analyzing fish communities in future studies.

**Key words::** environmental DNA; PCR primers; fish communities; biodiversity; capture methods

# 东莞生态园湿地鱼类群落结构 ——沉浮网及多网目网片渔获物比较

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**摘要:** 为了弄清东莞生态园湿地渔获物群落结构特征, 探讨沉网和浮网及不同网目渔获物组成的差异, 采用多网目单层刺网进行了调查。共采集鱼类 13 种, 海南似鲮和莫桑比克非鲫为优势种。渔获物物种组成沉浮网间差异显著。12 个网目的渔获物物种聚成 2 类。随着网目递增, 渔获物平均体长线性递增, NPUE 呈幂函数式下降。研究表明, 为了更加科学估计内陆水域鱼类群落特征, 刺网需增加 1~2 cm 网目, 且需同时放置沉浮网。

**关键词:** 东莞生态园湿地; 渔获物; 物种组成; 大小结构; 多网目刺网

## Structural attribute estimation of fish community in Dongguan ecological park wetland—Comparison of catch among multi-mesh nets and between two type of gillnet

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**Abstract:** In order to clarify the characteristics of the community structure of the catches in the wetland of Dongguan Ecological Park, and to explore the differences in the composition of sunken nets and floating nets and different nets, a multi-mesh single-layer gill net was used for investigation. A total of 13 species of fish were collected, with *Toxabramis houdemeri* and *Oreochromis mossambica* being the dominant species. The species composition of the catch differed significantly between the sinking and floating nets. The catch species of 12 nets clustered into 2 categories. As the meshes increase, the average body length of the catch increases linearly, and the NPUE decreases in a power function. Studies have shown that in order to more scientifically estimate the characteristics of fish communities in inland waters, gillnets need to be increased by 1 to 2 cm, and sink and float nets need to be placed at the same time.

**Key words:** Dongguan ecological park wetland; Catch; Species composition; Size structure; Multi-mesh gillnet

# 惠州市红树林资源调查研究

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**摘要：**利用实地探查及卫星遥感补充调查的手段，针对惠州海洋生态园范围内红树林资源现状进行了研究和评估。结果表明，惠州市海洋生态园现有红树林种类 4 目 5 科 5 属 5 种，包括蜡烛果、海榄雌、海漆、秋茄树和无瓣海桑。惠州海洋生态园内呈不同面积成片分布的 588.3 亩红树林的红树植物总生物量为 814024.64t、总固氮量为 3853.61t、总固碳量为 14911.47t。调查为保护红树林提供科学依据。

**关键词：**红树林；固碳，固氮

## Investigation of mangrove resources in Huizhou City

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**Abstract:** Using the means of field exploration and satellite remote sensing supplementary survey, the current situation of mangrove resources in Huizhou Marine Ecological Park was studied and evaluated. The results show that there are 5 species of mangrove forest in Huizhou Marine Ecological Park, including candle fruit, sea larine, sea lacquer, autumn eggplant tree and petalless sea mulberry. The total biomass of mangrove plants in Huizhou Marine Ecological Park with a distribution of different areas of 588.3 mu of mangroves is 814024.64t,the total nitrogen fixation is 3853.61tand the total carbon sequestration is 14911.47t /b115> 。 The survey provides a scientific basis for the protection of mangroves.

**Key words::** mangrove forest; Carbon fixation; Nitrogen fixation



# 基于血液转录组分析不同年龄 长江江豚的免疫适应性

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**摘要：**长江江豚终生生活在水中，易受环境污染物和病原微生物等威胁，可能会对其免疫系统产生负面影响。目前，长江江豚极度濒危，不同年龄长江江豚免疫适应能力是否存在差异？本研究分析了不同年龄长江江豚血液学和血液生化参数以及 mRNA 和 miRNA 表达谱，结果表明长江江豚的先天免疫在早期具有明显优势，而适应性免疫随着年龄增长先增强后衰退。基于以上研究，以期从免疫适应性的角度阐释长江江豚对多样生境的适应能力。

**关键词：**长江江豚，免疫变化，年龄，血液转录组

## Blood transcriptome reveals immune changes with age in the Yangtze finless porpoise

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**Abstract:** The Yangtze finless porpoise lives in water all its life and is vulnerable to environmental pollutants and pathogenic microorganisms, which may adversely affect the immune system of this endangered species. At present, the Yangtze finless porpoises are critically endangered. Is there any difference in immune changes among different ages? Here, we systematically studied the hematologic and biochemical parameters, as well as mRNAs and miRNAs profiles of old, adult, and young YFPs. These results delineate a progression from early innate immune function dominance to adaptive immune function enhancement (young to adult) and deterioration (adult to old). Based on this, we hope to explain the adaptability of Yangtze finless porpoise to diverse habitats from the perspective of immune adaptability.

**Key words:** Yangtze finless porpoise, Immune changes, Aging, Blood transcriptome

# 厦漳近海角突仿对虾数量分布 及生物学特性研究

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**摘要:** 厦漳近海调查海域角突仿对虾年平均渔获率为 234.4g/h, 春季略高于秋季。角突仿对虾数量分布呈现春季近岸站点渔获率高, 深水站点渔获率低, 秋季则呈现相反的特点。角突仿对虾春、秋季体长均值和体质量均值差异不明显 ( $P>0.05$ ); 体长 (L) 和体质量 (W) 的关系为  $W=1.644\times 10^{-5}L^{2.919}$ ; 雌雄比为 1:0.70; 雌性个体性腺成熟度以II期和III期为主; 摄食等级以 1 级最多, 2 级次之。

**关键词:** 角突仿对虾; 数量分布; 生物学特性; 厦漳近海

## Research on quantitative distribution and biological characteristic of *Parapenaopsis cornuta* in Xiamen and Zhangzhou coastal waters

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**Abstract:** The annual average catch rate of *Parapenaopsis cornuta* in the survey areas of Xiamen and Zhangzhou waters were 234.4 g/h, which one in spring were higher than autumn. The quantitative distribution of *Parapenaopsis cornuta* showed the characteristics of high catch rate at offshore sites in spring, low catch rate at deep water sites, and opposite in autumn. There was no significant difference in the mean of body length and body weight of *Parapenaopsis cornuta* in spring and autumn ( $P>0.05$ ). The relationship between body length (L) and body mass (W) was  $W=1.644\times 10^{-5}L^{2.919}$ . The gender ratio of was 1:0.70. Gonadal maturity in female individuals was mainly stage II and stage III. The highest feeding intensity level of *Parapenaopsis cornuta* was grade 1, followed by grade 2.

**Key words:** *Parapenaopsis cornuta*; quantitative distribution; biological characteristics; Xiamen and Zhangzhou coastal waters

## 七、水产品加工与综合利用

# 紫菜多糖酶的克隆表达、性质研究及应用

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**摘要:** 紫菜是世界范围内广泛养殖和食用的藻类。紫菜多糖是紫菜的主要组成部分, 被证实具有多种生理活性, 是潜在的功能食品因子。紫菜多糖酶可特异性降解紫菜多糖中的特征性结构, 是紫菜多糖研究与开发的关键工具。本研究自海洋细菌基因组中挖掘到一个与紫菜多糖利用相关的基因簇, 对其中包含的三个紫菜多糖酶进行了异源表达, 以糖组学策略阐明了酶的亚位点特异性, 并验证了紫菜多糖酶在紫菜多糖的可控降解及紫菜复合酶解中的应用可行性。

**关键词:** 紫菜; 紫菜多糖; 紫菜多糖酶; 克隆表达; 酶解

## Expression, characterization and application of porphyranases

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**Abstract:** Laver *Pyropia* sp. is one of the most cultivated and consumed marine edible algae. Porphyran is the major component of *Pyropia*, which was confirmed to have various bioactivities and is a potential functional factor. Porphyranases could specifically hydrolyze the backbone of porphyran, and it could serve as a favorable tool for degradation and investigation of porphyran. In this study, based on a porphyran-related polysaccharide utilization locus from a marine bacterial genome, three porphyranases were discovered and cloned. Using a glycomics strategy combining liquid chromatography–mass spectrometry and glycoinformatics, their subsite specificities were clarified. In addition, the feasibility of its application on controllable enzymatic hydrolysis of porphyran and the compound enzymolysis of *Pyropia* was verified.

**Key words:** *Pyropia*; porphyran; porphyranase; cloning and expression; enzymatic hydrolysis

# 一种卡拉胶特异性结合蛋白的 获取及研究

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**摘要:** 多糖特异性结合蛋白是多糖研究与开发的良好工具, 尤其可用作探针服务于多糖的原位分析。本研究以碳水化合物结合结构域 (Carbohydrate-binding module, CBM) 为切入点, 综合运用生物信息学及分子生物学技术成功挖掘得到了一个新颖的卡拉胶特异性结合蛋白。将该蛋白与绿色荧光蛋白进行融合表达, 成功构建得到首个卡拉胶特异性荧光探针, 并利用该探针实现了卡帕藻中卡拉胶的原位染色观察。本研究为卡拉胶的研究提供了良好工具。

**关键词:** 卡拉胶; 多糖结合蛋白; 碳水化合物结合结构域; 多糖探针; 原位可视化

## Discovery and characterization of a carrageenan-specific binding protein

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**Abstract:** Polysaccharide-specific binding proteins are favorable tools for the investigation and application of polysaccharides, especially in situ analysis. In this study, a novel carrageenan-specific carbohydrate-binding module (CBM) Cgk16A-CBM92 was successfully discovered by utilizing bioinformatics and molecular biology techniques. A fluorescent probe was subsequently constructed by fusing Cgk16A-CBM92 with a green fluorescent protein, based on which the in situ visualization of carrageenan in red alga *Kappaphycus alvarezii* was realized. The discovery of Cgk16A-CBM92 provided a promising tool for future investigations of carrageenan.

**Key words:** carrageenan; polysaccharide binding protein; carbohydrate-binding module; polysaccharide probe; in situ visualization

# 预糊化双醛淀粉对高温高压下海参非酶变质的抑制作用

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**摘要：**本实验研究了双醛淀粉对海参高温灭菌过程中非酶变质的抑制作用，探讨了双醛淀粉对海参体壁胶原蛋白稳定性的提高。分别配置不同浓度的预糊化双醛淀粉溶液进行交联海参。通过研究各组海参形态结构，质地，水分分布、弛豫时间和微观结构观察等，结果表明，随着交联浓度的增加(从0%到5%)，海参的质地特性，胶原纤维稳定性在逐渐提高。表明，双醛淀粉可以有效地提高海参在高温高压下的稳定性，为解决海参的非酶变质问题提供参考。

**关键词：**海参；双醛淀粉；交联；胶原蛋白；热稳定性

## Inhibitory effect of pre-gelatinized dialdehyde starch on non-enzymatic metamorphism of sea cucumber under high temperature and pressure

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**Abstract :** In this experiment, the inhibitory effect of dialdehyde starch on non-enzymatic deterioration of sea cucumber during high temperature sterilization was studied, and the improvement of stability of body wall collagen was discussed. The sea cucumber was crosslinked with different concentrations of pre-gelatinized dialdehyde starch solution. The morphological structure, texture, water distribution, relaxation time and microstructure observation of each group of sea cucumbers were studied. The results showed that with the increase of crosslinking concentration (from 0% to 5%), the texture characteristics of sea cucumbers and the stability of collagen fibers gradually improved. The results showed that dialdehyde starch can effectively improve the stability of sea cucumber under high temperature and high pressure and provide reference for solving the problem of non-enzymatic deterioration of sea cucumber.

**Key words::** sea cucumber; dialdehyde starch; cross-linking; collagen protein; thermal stability

# 不同饲料养殖雌体三疣梭子蟹 基本营养成分的比较

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**摘要:** 本研究比较了配合饲料和传统饵料养殖的雌体三疣梭子蟹不同可食部位的水分、灰分、粗脂肪、粗蛋白含量的差异。结果显示配合饲料组的体肉和肝胰腺中水分含量显著大于传统饵料组; 灰分无显著差异; 体肉粗蛋白含量显著大于传统饵料组, 肝胰腺与之相反, 性腺无显著差异; 体肉, 肝胰腺, 性腺粗脂肪含量显著高于传统饵料组。从营养成分角度来说, 配合饲料可以替代传统饵料喂养。

**关键词:** 三疣梭子蟹, 配合饲料, 传统饵料, 营养成分

## Comparison of Basic Nutritional Components of Female *Portunus trituberculatus* in Different Feeds

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**Abstract:** The objective of this study is to explore the differences in the basic nutritional components of female *Portunus trituberculatus* under different feeding modes and analyze the substitutability of two feeding conditions. Taking female *Portunus trituberculatus* as the research object, the differences in water, ash, crude fat, and crude protein content of different edible parts of female *Portunus trituberculatus* raised with compound feed and traditional bait were studied. The results showed that the water content of body meat and hepatopancreas in the compound feed group was significantly higher than that in the traditional diet group ( $P < 0.05$ ); there was no significant difference in ash content; the crude protein content of body meat in the compound feed group was significantly greater than that in the traditional diet group. On the contrary, there was no significant difference in gonads; the crude fat content of body flesh, hepatopancreas and gonads of the compound feed group was significantly higher than that of the traditional feed group. In general, the crude protein and crude fat content of the body meat and hepatopancreas of the compound feed group was significantly higher than that of the traditional feed group. From the perspective of nutritional components, compound feed can replace traditional feed feeding.

**Key words:** *Portunus trituberculatus*, compound feed, traditional bait, nutritional ingredients

# 水产品副产物中胶原蛋白提取工艺优化 及应用研究进展

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**摘要:** 本文主要针对水产品副产物中提取出的胶原蛋白的类型、来源以及应用进行了简述, 并介绍了目前胶原蛋白的提取方法(酸法、碱法、酶法、物理辅助法)。对四种方法的优缺点进行分析, 针对目前市面上胶原蛋白含量丰富需要提高提取效率的原料提出多酶复合法、酸酶复合法两种方法, 为水产原料中胶原蛋白的提取工艺优化提供一定的理论基础, 在提高提取效率的同时降低水产品副产物中营养成分对环境的污染, 使水产品资源能够得到高效利用。

**关键词:** 胶原蛋白; 水产品副产物; 提取率; 多酶复合; 酸酶复合

## Research progress on extraction process optimization and application of collagen from aquatic by-products

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**Abstract:** In this paper, the types, sources and applications of collagen extracted from aquatic by-products are briefly described, and the current methods of collagen extraction (acid, alkaline, enzymatic and physically assisted methods) are introduced. The advantages and disadvantages of the four methods are analyzed, and two methods, multi-enzyme complex method and acid-enzyme complex method, are proposed for the raw materials with rich collagen content that need to improve the extraction efficiency in the current market, so as to provide a certain theoretical basis for the optimization of the extraction process of collagen from aquatic raw materials, to improve the extraction efficiency and reduce the environmental pollution caused by the nutrients in aquatic by-products, so that the aquatic resources can be used efficiently.

**Key words:** collagen, aquatic by-products, extraction rate, multi-enzyme complex, acid enzyme complex



# 草鱼肉蒸制过程中水溶性成分的变化

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**摘要:** 以草鱼不同部位肉为研究对象, 测定了蒸制 18 min 内 ATP 及其关联化合物和游离氨基酸等指标, 并结合感官评价、味精当量值、滋味活度值和电子舌对其品质进行评价。结果表明鱼肉核苷酸蒸制 9 min 内风味较佳, 红肉和背肉中苦味氨基酸在蒸制 6 min 时显著降低, 红肉中苦味氨基酸总量远小于背肉和腹肉; 电子舌结果表明草鱼各部位肉在蒸制 6 min 和 9 min 时有差异; 整体结果表明蒸制 6-9 min 时草鱼肉品质最佳。

**关键词:** 草鱼, 蒸制, 品质

## Research on the changes of water-soluble flavor substances in grass carp during steaming

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**Abstract:** The dorsal meat, belly meat and red meat of grass carp were taken as the research object, ATP-related compounds and free amino acids were measured within 18 min of steaming, and the quality of grass carp meat was evaluated by sensory assessment, principal component analysis (PCA) based on the electronic tongue, equivalent umami concentration (EUC) and taste activity value (TAV). The results showed that the flavor presented by nucleotides in three parts of meat was better within 9 min. The bitter amino acids in dorsal meat and red meat were significantly decreased at 6 min, and the total amount of bitter amino acids in red meat was far less than that in dorsal meat and belly meat. The electronic tongue indicated that the taste differences were significantly between 6 min and 9 min. From the sensory analysis, EUC value and TAV, it can be found that the quality of grass carp meat was the best when steamed for 6-9 min. The results can provide technical support for grass carp.

**Key words:** grass carp, steaming, quality

# 中华鳖背甲脱钙工艺及其胶原蛋白结构表征的研究

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**摘要:** 为了提高中华鳖背甲胶原蛋白的提取率和产品纯度, 用盐酸对鳖甲进行脱钙研究。以脱钙率与胶原蛋白迁出率为评价指标, 考察料液比、酸浓度、脱钙时间和温度等 4 个因素对中华鳖背甲脱钙的影响, 在此基础上, 应用正交试验鳖甲钙盐的脱出工艺进行优化并且通过 SDS-PAGE、紫外吸收光谱、红外吸收光谱、氨基酸分析等技术方法分析相同提取条件下脱钙与未脱钙背甲胶原蛋白结构表征的变化。结果表明, 最佳脱钙工艺条件为: 盐酸浓度为 0.9 mol/L。

**关键词:** 中华鳖; 背甲; 脱钙; 胶原蛋白; 结构特性

## Study on Decalcification Technology of Carapace of Chinese Soft-shelled Turtle and Characterization of Collagen Structure

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**Abstract:** In order to increase the extraction rate and product purity soft-shelled turtle carapace of collagen, demineralized with hydrochloric acid turtle research. In decalcification of collagen was emigration evaluation, influences of solid-liquid ratio, acid concentration, time and temperature decalcification four factors of soft-shelled turtle carapace decalcification, on this basis, orthogonal test turtle calcium extrusion process is optimized and by SDS-PAGE, UV absorption spectrum analysis under the same extraction conditions and Characterization of demineralized collagen carapace undecalcified spectral changes, amino acid analysis, infrared absorption art methods. The optimum conditions for the decalcification: hydrochloric acid concentration of 0.9 mol/L, liquid ratio was 1: 25 (g: mL), demineralized time of 2 h, temperature 28 °C, under this condition of decalcified Reaching 65.55%, the collagen migration rate is only 4.85%. In addition, there was no significant change in the biochemical characteristics of the collagen of the turtle shell after hydrochloric acid decalcification.

**Key words::** Chinese soft-shelled turtle; carapace; decalcification; collagen; structural properties

# TG 酶催化过程中鲢肌原纤维 蛋白结构特性的变化

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**摘要：**本研究通过测定蛋白凝胶 pH、交联度、总巯基、二级结构、表面疏水性，探究了 TG 酶交联过程中（0、5、10、15、30、60 min），鲢肌原纤维蛋白结构的变化。随催化时间的增加，pH 无明显变化，表明只发生了交联作用，未发生脱酰胺反应；交联度显著提升（ $P < 0.05$ ）、总巯基显著降低（ $P < 0.05$ ）、 $\alpha$ -螺旋呈现先下降后增加的趋势， $\beta$ -折叠呈现先上升后下降的趋势，表面疏水性显著下降（ $P < 0.05$ ）。

**关键词：**转谷氨酰胺酶；鲢；肌原纤维蛋白；二级结构

## Structural characteristics of myofibrin of silver carp (*Hypophthalmichthys molitrix*) catalyzed by TG

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**Abstract:** In this study, the changes of myofibrin structure in the process of TG crosslinking (0, 5, 10, 15, 30, 60 min) were investigated by measuring the pH, crosslinking degree, total sulfhydryl group, secondary structure and surface hydrophobicity of the protein gel. With the increase of catalytic time, pH value did not change significantly, indicating that only crosslinking occurred, but no deamidation reaction occurred. Cross-linking degree was significantly increased ( $P < 0.05$ ), total sulfhydryl group was significantly decreased ( $P < 0.05$ ),  $\alpha$ -helix was firstly decreased and then increased,  $\beta$ -folding was firstly increased and then decreased, and surface hydrophobicity was significantly decreased ( $P < 0.05$ ).

**Key words:** Transglutaminase; Silver carp; Myofibrin; Secondary structure

# 海洋食品多糖分析新工具及新方法的开发-以海参岩藻聚糖为例

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**摘要:** 海洋食品多糖是海洋食品开发与利用的重要支点, 但因分析工具缺乏、分析方法落后, 其深入研究与充分开发受到制约。本研究以海参岩藻聚糖为例, 基于基因挖掘及克隆表达获取多糖分析的两类关键工具-特异性降解酶及结合蛋白, 并构建结构解析、构效关系研究、简便特异定量及原位可视化的方法。与此同时, 本课题组针对其他海洋食品多糖也进行了分析工具及方案的开发, 成果有助于进一步提升海洋食品多糖的研究与利用水平。

**关键词:** 多糖; 岩藻聚糖; 海参; 酶; 探针

## Development of Novel Analytical Tools and Methods for Marine Food Polysaccharides: A Case Study of Sea Cucumber Sulfated Fucan

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**Abstract:** Polysaccharides are critical points for the development and utilization of marine food. Nevertheless, due to the lack of analytical tools and backward analytical methods, in-depth research and full development of marine food polysaccharides are restricted. This report will present our progress on the development of analytical tools and methods for sea cucumber sulfated fucan, as an example. By gene mining, cloning and expression, two categories of key tools, i.e., specific degradation enzymes and binding proteins, were obtained. And the methods for structural analysis, structure-activity relationship investigation, rapid quantification and in situ visualization were therefore established. Meanwhile, analytical tools and methods for marine food polysaccharides including alginate, agar and carrageenan were also obtained, which would facilitate the further research and development of marine food polysaccharides.

**Key words:** Polysaccharide; Sulfated fucan; Sea cucumber; Enzyme; Probe

# 鳖源胶原蛋白的交联改性及对成纤维细胞的生长作用研究

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**摘要：**方法 以中华鳖裙边胶原蛋白为材料，用紫外辐射、N-羟基琥珀酰亚胺（EDC/NHS）和京尼平进行改性，用体外凝血指数法测定凝血效果，用 MTT 法评价细胞毒性。结论 EDC/NHS 交联的鳖源胶原具有良好的热稳定性（熔化温度 $\geq 84^{\circ}\text{C}$ ）、凝血性（BCI $< 50$ ）、高吸湿性（28~34%）和低细胞毒性（1 级），符合生物材料安全性要求，有望成为一种优良的生物医用敷料，为新型水产动物源生物医用材料研发提供科学支撑。

**关键词：**中华鳖裙边胶原蛋白，交联改性，生物医用材料

## Study on the cross-linking modification of turtle calipash collagen and its effect on the growth of fibroblasts

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**Abstract :** Method: The turtle calipash collagen was modified by ultraviolet light, N-hydroxysuccinimide (EDC/NHS) and genipin. The blood coagulation effect was measured by the baltic capesize index (BCI) method, and the cytotoxicity was evaluated by the MTT method.

Conclusion: EDC/NHS cross-linked turtle calipash collagen has good thermal stability ( $T_m \geq 84^{\circ}\text{C}$ ), good blood coagulability (BCI $< 50$ ), high hygroscopicity (28~34%) and low cytotoxicity (1 Level), so that it can meet the safety requirements of biological materials. This also means that it is expected to become an excellent biomedical dressing, which can provide scientific support for the research and development of new aquatic animal-derived biomedical materials.

**Key words::** Turtle calipash collagen, Cross-linked modification, Biomedical material

# 冷风—热风联合干燥对半干暗纹东方鲀鱼片品质变化的影响

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**摘要:** 以暗纹东方鲀为对象, 研究冷风干燥、热风干燥以及冷风—热风联合干燥对鱼肉品质的影响。结果表明, 冷风—热风联合干燥能够提高鱼肉的 pH 值, 且不易流动水含量较高。冷风干燥和联合干燥使鱼肉保持致密的结构, 热风干燥和联合干燥具有较好质构特性, 而联合干燥具有更高的蛋白质变性温度。冷风—热风联合干燥能够将冷风和热风干燥的优点进行结合, 与冷风干燥相比缩短了干燥时间, 且鱼肉的蛋白质稳定性更好, 组织结构更加致密。

**关键词:** 暗纹东方鲀; 冷风—热风联合干燥; 水分迁移; 蛋白质变化; 微观结构

## Effect of Cold and Hot Air Combined Drying Processes on Quality Changes of Semi-dry Fillets of *Takifugu obscurus*

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**Abstract:** Using *Takifugu obscurus* as raw material, it was treated by cold air drying, hot air drying and cold-hot air combined drying to investigate the effect on the quality of semi-dry fillets of *Takifugu obscurus*. Results showed that the combined drying of cold-hot air can increase the pH value of fish meat to a certain extent, the content of immobilized water in cold-hot air combined drying is higher than another two drying methods. Texture and microstructure analysis found that dense structure of fish fillets was kept during cold air drying and cold-hot air combined drying, and hot air drying and cold-hot air combined drying have good texture properties, while the cold-hot air combined drying maintained a higher protein denaturation temperature. Therefore, the combined drying of cold and hot air can combine the advantages of cold air drying and hot air drying, shorten the drying time compared with cold air drying, and the fish meat dried by cold-hot air combined drying has better protein stability and denser tissue structure now.

**Key words:** *Takifugu obscurus*; cold-hot air combined drying; moisture migration; protein changes; microstructure

# 利用 HS-SPME/GC-MS 结合电子鼻技术对不同糖鱼松挥发性风味物质进行表征

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**摘要：**无糖鱼松的成松品质优于试验组( $P < 0.05$ )，水分含量低于试验组( $P < 0.05$ )。鱼松中共检测到 64 种挥发性化合物，其中 17 种被认为是关键挥发性化合物。电子鼻的主成分分析和 GC-MS 的 PLS-DA 分析结果表明，蔗糖、葡萄糖、果糖和半乳糖样品具有相似的风味，与无糖样品的风味相差较大。通过对 BI 值、脂肪酸和关键挥发性化合物的相关性分析，结果显示美拉德反应和脂质氧化对风味的贡献很大。

**关键词：**鱼松；糖；挥发性物质；电子鼻；脂肪酸；HS-SPME/GC-MS

## Characterisation of the volatile flavour compounds of dried fish floss with different sugar using HS-SPME-GC-MS combined with electronic nose

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**Abstract:** Higher quality characteristics of dried fish floss and lower water content were observed in sugar-free fish floss treatments compared to the experimental groups ( $P < 0.05$ ). Sixty-four volatile compounds were detected in fish floss, and 17 were regarded as key volatile compounds based on the odour activity values. PCA of E-nose and PLS-DA of GC-MS ( $OVA > 1$ ) showed that sucrose, glucose, fructose and galactose samples had similar flavours, which were far away from the sugar-free one. The correlation analysis of BI values, fatty acids and key volatile compounds confirmed that Maillard reaction and lipid oxidation contributes a lot to flavour.

**Key words::** Dried fish floss; sugar; volatile compounds; electronic nose; fatty acids; HS-SPME/GC-MS

# 胶原蛋白概述及骨骼中胶原蛋白提取工艺研究

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**摘要:** 胶原蛋白大多数从哺乳动物的皮、骨、肉等部分获得的,但由于宗教信仰、疾病传播和过敏反应问题的出现,哺乳动物源胶原蛋白在使用上受到了很大的限制。在这篇综述中,阐述了胶原蛋白的不同来源及研究现状,总结了在骨骼中提取胶原蛋白的方法,包括酸法提取、碱法提取、中性盐提取、酶法提取和超声辅助提取,并讨论提取过程中会影响提取率的因素。此外,本综述还强调了胶原蛋白在各种生物医药、食品和化妆品行业的治疗潜力和重要性。

**关键词:** 胶原蛋白; 提取; 骨骼; 应用

## Collagen overview and extraction technology of collagen in bone

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**Abstract:** Collagen is mostly obtained from skin, bone and meat of mammals. However, due to religious belief, disease transmission and allergic reaction, the use of collagen from mammals is greatly limited. In this review, the different sources and research status of collagen were expounded, and the methods of extracting collagen from bone were summarized, including acid extraction, alkali extraction, neutral salt extraction, enzymatic extraction and ultrasonic-assisted extraction, and the factors affecting the extraction rate were discussed. In addition, this review also emphasizes the therapeutic potential and importance of collagen in various biomedical, food and cosmetic industries.

**Key words:** Collagen; Extract; Bones; application



# 中国毛虾多肽酶解工艺及其体外 DPP-IV 抑制活性的研究

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**摘要:** 本实验以水解度和氮回收率为指标经单因素实验及响应面设计优化酶解工艺。结果显示动物蛋白酶水解毛虾的最佳工艺为: 时间 5.1h、料液比 1:10.5g/mL、酶量 5100U/g。在此条件下酶解液实际水解度为 45.71%, 其 DPP-IV 抑制率为 44.32%, 比单因素组提高了 8.77%。故本实验不仅可以提高酶解液的水解度和 DPP-IV 抑制活性, 还为中国毛虾 DPP-4 抑制肽分离纯化及鉴定奠定基础。

**关键词:** 中国毛虾; 酶解; 响应面优化; DPP-IV 抑制; 生物活性肽

## Study on the enzymatic hydrolysis of *Acetes chinensis* polypeptide and its in vitro DPP-IV inhibitory activity

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**Abstract:** In order to improve the high-value utilization rate of low-value aquatic products, in this experiment, the DH and nitrogen recovery rate were used as indicators to optimize the enzymatic hydrolysis process through single factor experiment and response surface design. The results showed that the best process for hydrolyzing *Acetes Chinensis* with animal protease was as follows: time 5.1h, material-liquid ratio 1:10.5g/mL, enzyme amount 5100U/g. Under these conditions, the actual DH of the enzymatic hydrolysis solution was 45.71%, and its DPP-IV inhibition rate was 44.32%, which was 8.77% higher than that of the single factor group. Therefore, this experiment can not only improve the DH and DPP-IV inhibitory activity of the enzymatic hydrolysate, but also lay the foundation for the isolation, purification and identification of the *Acetes Chinensis* DPP-4 inhibitor peptide.

**Key words:** : *Acetes chinensis*; enzymatic hydrolysis; response surface optimization; DPP-IV inhibition; bioactive peptide

# 低温凝胶化及淀粉添加量对鲢鱼糜凝胶结构和化学相互作用变化的影响

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**摘要：**为探究低温凝胶化对天然马铃薯淀粉-鲢鱼糜凝胶混合物成型能力的影响，研究对直接加热和二段式加热凝胶的凝胶特性、微观结构和化学相互作用的变化进行初步探索。结果发现，低温凝胶化限制淀粉的无规则变形，影响凝胶混合物的保水特性的改变；对于直接加热处理的凝胶，淀粉糊化挤压凝胶网络，使蛋白三级结构发生变化。研究结果揭示了不同加热工艺下淀粉鱼糜凝胶物理性质的差异，为不同品质鱼糜产品的创新提供了参考。

**关键词：**鱼糜凝胶；加热方式；淀粉；物化特性

## Changes in gel structure and chemical interactions of Hypophthalmichthys molitrix surimi gels: effect of setting process and different starch addition

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**Abstract:** The research was intended to explore the impact of low-temperature setting process on the gel-forming ability of native potato starch-surimi mixtures. And the effects of direct heating process and two-step heating process coupled with different starch content on gelling properties, microstructural properties and chemical interactions of *Hypophthalmichthys molitrix* surimi were investigated. The results showed that starch incorporation into direct cooking surimi gel (CG) could significant increased breaking force and deformation ( $P < 0.05$ ). While the deformation decreased subjected with excessive starch for gels undergoing setting followed by cooking (SCG). SCG had higher whiteness, but higher cooking loss occurred on account of the denser structure and long-time heating treatment. In addition, gelatinization of SCG restricted starch swelling as shown in the scanning electron microscope images, thus reducing the improvement of water holding capacity. The results of moisture mobility (T2) and distribution varied owing to the addition of starch and changes of chemical interactions. Non-covalent bonds (non-specific associations, ionic linkages, hydrogen bonds, and hydrophobic interactions) raised with optimum starch containing in CG, whereas hydrogen bonds reduced in SCG. These results indicate the diversities of physical properties in starch-surimi gels under different heating processes, providing a reference for the innovation of surimi products with different quality.

**Key words:·** Surimi gels; heating processes; starch; phychemical properties

# 不同壳聚糖/淀粉复合膜结构 性能的比较

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**摘要：**为了探究不同壳聚糖/淀粉复合膜的性质差异性，本文选取 5 种淀粉与壳聚糖进行复合制备不同的壳聚糖/淀粉复合膜，比较其各项性能，旨在分析出壳聚糖复配的最佳淀粉种类。结果表明，壳聚糖/红薯淀粉复合膜与壳聚糖/玉米淀粉复合膜的力学性能及阻隔性能优于其他种类。并且这两种复合膜的热稳定性、表面结构较好。这表明，上述两种复合膜可作为后续壳聚糖/淀粉复合膜深入研究的材料，为复合膜其他性能的提升提供理论参考。

**关键词：**壳聚糖；玉米淀粉；红薯淀粉；复合膜；

## Comparison of structural properties of different chitosan/starch composite membranes

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**Abstract:** In order to explore the difference of properties of different chitosan/starch composite films, this paper selects 5 kinds of starch and chitosan to prepare different chitosan/starch composite films. In order to find out the best type of starch for the compound of chitosan, the properties of chitosan were compared. The results showed that the mechanical properties and barrier properties of chitosan/sweet potato starch composite membrane and chitosan/corn starch composite membrane were better than other kinds. The thermal stability and surface structure of these two composite films are better. These results indicate that the above two composite membranes can be used as materials for further study of chitosan/starch composite membranes, and provide theoretical reference for the improvement of other properties of composite membranes.

**Key words::** chitosan; corn starch; sweet potato starch; composite membrane

# 低盐预调处理对罗非鱼片冻藏稳定性的影响

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**摘要：**为揭示研究低盐预制对罗非鱼片冻藏稳定性影响，本研究分析了低盐预制罗非鱼片在冻藏过程中的保水性、质构、色泽等研究了解冻后低盐预制罗非鱼片的品质变化，并从脂肪氧化、蛋白质变性及微观结构变化探究了其变化机理。研究结果表明由于解冻后低盐预制罗非鱼片的微观组织结构的恢复能力较强其保水性、弹性及内聚性显著提高。但冻前低盐预制降低罗非鱼片的冻藏氧化稳定性，这成为低盐预调鱼片高质化加工亟需解决的问题之一。

**关键词：**低盐预制；罗非鱼片；冻藏；品质；机理

## The effect of lightly salting on the frozen storage stability of tilapia fillets

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**Abstract:** To reveal the effect of lightly salting on the frozen storage stability of tilapia fillets, the water-holding capacity, textural properties, color and other indicators were analyzed to explore the quality changes of lightly salted tilapia fillets, and mechanisms of its quality change had been studied from the aspects of lipid oxidation, protein denaturation and microstructure changes. Results showed the lightly salted tilapia fillets had higher water-holding capability, springiness and cohesiveness after thawing due to the stronger recovery ability of microstructure of them. However, lightly salting before freezing could reduce the oxidative stability of tilapia fillets during frozen storage, which has become one of the key issues that need to be resolved in the high-quality processing of lightly salted fish fillets.

**Key words:** lightly salted; tilapia fillets; frozen storage; quality; mechanisms

# 鱼源胶原蛋白改性方法及应用研究进展

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**摘要：**与哺乳动物胶原蛋白相比，鱼源胶原蛋白有相似的生物相容性且无传播疾病的风险、无宗教限制、吸收能力更强。因此，开发海洋副产品作为胶原蛋白的来源已经引起了越来越多的关注。鱼源胶原蛋白的一些特点，如熔点较低，水溶性较低，机械强度较低等使其应用范围受到了限制。本文主要综述了物理法、化学法、高分子材料共混法等改性方法及改性胶原蛋白在医疗、食品、工业等领域的应用，以期鱼源胶原蛋白的改性及应用提供理论参考。

**关键词：**鱼源胶原蛋白；胶原蛋白改性；胶原蛋白应用；研究进展

## Research progress on modification methods and application of fish collagen

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**Abstract:** Compared to mammalian collagen, fish collagen has similar biocompatibility, no risk of disease transmission, no religious restrictions, and greater absorbability. Therefore, the development of marine by-products as a source of collagen has attracted increasing attention. Some characteristics of fish collagen, such as low melting point, low water solubility and low mechanical strength, limit its application scope. The article introduced the physical, chemical, polymer material blending modification methods of fish collagen. The application of modified collagen in medical, food, industry and other fields were also reviewed, in order to provide theoretical reference for the modification and application of fish collagen.

**Key words:** fish collagen; collagen modification; application of collagen; research progress

# 水产品贮藏过程中 ATP 降解的研究进展

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**摘要：**ATP 降解是水产品死后肌肉中最重要的生化变化之一。ATP 及其关联化合物的组成比例是表征水产品的新鲜度的重要指标，通常用 K 值表征鱼类鲜度。常见的加工贮藏方式包括低温贮藏、热加工、高压处理、添加外源化合物等，需阐明这些加工贮藏方式对 ATP 关联产物的影响。本文对水产品中 ATP 及其关联化合物与水产品品质的关系、加工贮藏方式的影响进行综述，以期对 ATP 降解的控制提供参考。

**关键词：**ATP 关联产物，核苷酸，控制，加工贮藏

## The Research Progress of the Degradation of ATP during Storage

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**Abstract:** The degradation of ATP is one of the most important biochemical changes in muscles after death of aquatic products. The composition ratio of ATP and its related compounds is an important indicator to characterize the freshness of aquatic products. The K value is usually used to characterize the freshness of fish. Common processing and storage methods include low-temperature storage, thermal processing, high-pressure treatment, addition of exogenous compounds, etc. It is necessary to clarify the impact of these processing and storage methods on ATP-related products. This article reviews the relationship between ATP and its related compounds in aquatic products and the quality of aquatic products, the influence of processing and storage methods, hoping to be helpful for the control of ATP degradation.

**Key words:** ATP related compounds, nucleotides, control, the processing and storage methods

# 冷藏腌制对鱼肉品质影响研究进展

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**摘要：**鱼肉因为含有大量的水分和活性较强的酶，为微生物的生长繁殖创造条件。因此鱼肉的防腐抑菌是水产品加工的一大热点。冷藏腌制是我国传统的水产品加工方式之一，冷藏腌制还可以在贮藏过程中抑制微生物生长，延长鱼类的货架期。在腌制过程中，因渗透作用、蛋白氧化、脂质氧化等一些生化反应，鱼肉品质会发生变化。本文对冷藏腌制对鱼肉品质影响进行综述，为今后鱼类腌制技术的更新提供理论基础,并展望鱼展望鱼类腌制产品的发展方向。

**关键词：**鱼肉；冷藏腌制；品质变化

## Research Progress on Effects of Cold Curing on Fish Quality

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**Abstract:** Fish contains a lot of water and active enzymes, it creates conditions for the growth and reproduction of microorganisms. Therefore, the anti-corrosion and bacteriostasis of fish is a hot spot in aquatic products processing. Cold curing is one of the traditional processing methods of aquatic products in China. Cold curing can also inhibit microbial growth and prolong the shelf life of fish during storage. During the curing process, the quality of fish will change due to some biochemical reactions such as osmosis, protein oxidation and lipid oxidation. In this paper, the effects of cold curing on the quality of fish meat were reviewed, which provided a theoretical basis for the renewal of fish curing technology in the future, and looked forward to the development direction of fish curing products.

**Key words:** Fish meat; Cold curing; Quality change

# 表没食子儿茶素没食子酸酯对 鱼糜制品冻融稳定性的影响

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**摘要:** 本实验以冷冻白鲢鱼糜为原料, 通过研究表没食子儿茶素没食子酸酯(EGCG)对鱼糜凝胶冻融循环期间品质的影响。本研究测定了添加不同含量 EGCG (0%、0.01%、0.02%、0.03%) 并进行 0,2,4,6 次冻融循环后鱼糜凝胶的凝胶强度, TPA, 持水力以及微观结构等指标。随着 EGCG 添加量的增加, 鱼糜的凝胶强度呈先上升后下降的趋势, EGCG 添加量为 0.01% 的鱼糜凝胶的凝胶强度和持水力下降较慢。

**关键词:** 表没食子儿茶素没食子酸酯; 鱼糜凝胶; 肌原纤维蛋白; 品质

## Effect of epigallocatechin gallate on freeze-thaw stability of surimi products

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**Abstract:** In this experiment, frozen silver carp surimi was used as raw material to study the effect of epigallocatechin gallate (EGCG) on the quality of surimi gel during freeze-thaw cycle. The gel strength, TPA, water holding capacity and microstructure of surimi gel were measured after adding different contents of EGCG (0%, 0.01%, 0.02%, 0.03%) and freezing-thawing cycle for 6 times. The gel strength of surimi increased firstly and then decreased with the increase of EGCG. The gel strength and water holding capacity of surimi gel with 0.01% EGCG decreased slowly.

**Key words:** epigallocatechin gallate; surimi gel; myofibrillar protein; quality



# 仿生传感技术在水产品品质评价中的应用

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**摘要：**仿生传感技术是一种模拟人的感官特性并结合传感器阵列的响应信号和模拟识别的感官分析技术，用于对食品品质进行分析，近年来广泛应用于水产品的新鲜度评价、质量安全等各个领域。本文综述了几种常见的仿生传感技术以及近年来新兴的人机结合检测技术在水产品品质评价中的应用及研究进展，包括电子鼻、电子舌、气相色谱嗅闻技术等，并结合实际提出改进建议，以期为该技术在水产品品质评价中的应用提供参考。

**关键词：**电子鼻；电子舌；气相色谱嗅闻技术；仿生传感

## Application of bionic sensing technology in quality evaluation of aquatic products

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**Abstract:** Bionic sensing technology is a sensory analysis technology that simulates human sensory characteristics, combined with the response signal of sensor array and analog recognition. It is used to analyze food quality. In recent years, it is widely used in various fields such as freshness evaluation and quality safety of aquatic products. This paper summarizes several common bionic sensing technologies and the application and research progress of man-machine combined detection technology in aquatic product quality evaluation in recent years, including electronic nose, electronic tongue and gas chromatography sniffing technology, and puts forward improvement suggestions combined with practice, in order to provide reference for the application of this technology in aquatic product quality evaluation.

**Key words:** : electronic nose; electronic tongue; gas chromatography; olfactometry-mass spectrometry; bionic sensing

# 草鱼不同部位肌肉营养成分比较分析

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**摘要：**本研究旨在探究草鱼不同部位肉间基本营养成分差异，为确定草鱼食用品质及提高经济价值提供参考。对新鲜草鱼背肉、腹肉、红肉的四种常规营养成分进行测定。结果表明，新鲜草鱼背肉和腹肉中水分含量和灰分含量都显著高于红肉（ $P < 0.05$ ），红肉中脂肪含量显著高于背肉和腹肉（ $P < 0.01$ ），背肉的粗蛋白含量最高，且三个部位均有差异性（ $P < 0.05$ ）。营养成分含量可以作为衡量草鱼肌肉不同部位营养和品质的重要指标。

**关键词：**草鱼；肌肉；营养成分

## Comparison of Nutrient Composition of Muscles of Grass Carp, *Ctenopharyngodon idellus*

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**Abstract:** The aim of this study was to investigate the differences of basic nutrients content among different parts of grass carp and to provide references for determining the edible quality and improving the economic value of grass carp. The four major nutrients content of the dorsal meat, belly meat and red meat of fresh grass carp were studied. The results showed that the moisture content and ash content of fresh grass carp dorsal and ventral meat were significantly higher than those of red meat ( $P < 0.05$ ), the fat content of red meat was significantly higher than those of dorsal and ventral meat ( $P < 0.01$ ). The crude protein content of the back meat was the highest and differed in all three parts ( $P < 0.05$ ). The nutrient composition can be used as an important indicator of the nutrition and quality of different parts of grass carp muscle.

**Key words:** grass carp, muscle, nutrient composition, fatty acids

# 糖基小分子胶原蛋白稳定剂的 构效关系研究

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**摘要:** 海参即食类产品常温贮藏过程中会出现失稳问题, 严重阻碍了新产品开发。为解决这一问题, 本研究设计双重美拉德反应序列, 以还原糖为原型, 经改性制备出一系列有交联活性的小分子糖类衍生物, 实现了胶原蛋白的交联, 促进形成稳定的网状结构。在此基础上, 本研究从分子成环及异构化方式、还原端自由度、氢键供受体、分子主链稳定性等多个角度探究其构效关系, 优化结构, 进一步提升其稳定化海参的活性。

**关键词:** 海参; 失稳; 美拉德反应; 交联; 胶原蛋白

## Sugar based collagen stabilization agents and their structure-function relationship

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**Abstract:** Ready-to-eat sea cucumbers are prone to deteriorate during room temperature storage, which impeded the development of new sea cucumber products. In order to solve this problem, this study designed a double-Maillard reaction sequence. Using reducing sugar as prototype, a series of small sugar derivatives were prepared, and these molecules stabilized sea cucumber by collagen crosslinking. Furthermore, the structure-function relationship of these compounds was studied from the aspect of isomerization, cyclization, reducing-end degree of freedom, hydrogen bond formation, and main chain stability. Base on these results, the structure of the crosslinkers were optimized for better stabilization effect on sea cucumbers.

**Key words:** sea cucumber; deterioration; Maillard reaction; crosslinking; collagen

## 八、休闲渔业与渔文化

# 基于模糊 Kano 模型和 IPA 分析的海岛型休闲渔业服务质量研究 —— 以舟山嵊山岛为例

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**摘要：**服务质量是休闲渔业的核心要素，服务质量的好坏会直接影响休闲渔业的发展。本文从游客的角度出发，通过问卷调查的形式来获取数据，借助描述性统计法、SPSS 信度检验对调查数据进行分析和处理，并整合模糊 Kano 模型与 IPA 分析法定量与定性分析舟山嵊山岛休闲渔业的服务质量，构建舟山嵊山岛休闲渔业服务质量的 5 个维度 16 个指标体系，以确定嵊山岛休闲渔业服务质量要素提升的优先权及相应改进策略。

**关键词：**海岛休闲渔业；服务质量；Kano 模型；模糊综合评价；IPA

## Research on service quality of island-based recreational fisheries based on fuzzy kano model: Taking zhoushan shengshan island as an example

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**Abstract:** Service quality is the core element of recreational fishery, and the quality of service will directly affect the development of recreational fishery. From the perspective of tourists, this paper obtains data through questionnaire surveys, analyzes and processes the survey data with the help of descriptive statistics and SPSS reliability test, and integrates the fuzzy Kano model and IPA analysis method to quantitatively and qualitatively analyze Zhoushan Shengshan On the service quality of leisure fishery on the island, a system of 16 indicators in 5 dimensions of the service quality of leisure fishery on Shengshan Island in Zhoushan will be constructed to determine the priority and corresponding improvement strategies for improving the service quality of leisure fishery on Shengshan Island.

**Key words:** : island recreational fishing; service quality; Kano model; fuzzy comprehensive evaluation; IPA

# 中国省域休闲渔业竞争力评价 与建议

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**摘要:** [目的]发展休闲渔业是推进现代渔业建设的重要内容, 也是实施乡村振兴战略和建设海洋经济强国的重要举措。针对当前中国省域休闲渔业竞争力评价研究的空白, 且现有评价方法不能同时兼顾指标的模糊性与随机性的难题。[方法] 本研究引入竞争力概念及正态云模型方法, 通过构建中国省域休闲渔业竞争力评价指标体系, 对中国 30 个 (除西藏) 省级行政单位休闲渔业竞争力进行评价。[结果] (1) 中国省域休闲渔业竞争力整体水平不高。

**关键词:** 中国省域 休闲渔业竞争力 评价 正态云模型

## Evaluation and suggestions on competitiveness of China's provincial recreational fisheries

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**Abstract:** [Objective] The development of leisure fisheries is an important part of promoting the construction of modern fisheries, and also an important measure to implement the strategy of rural revitalization and building a strong marine economy. Considering the blank of the current research on the evaluation of the competitiveness of Chinese provincial recreational fisheries, and the existing evaluation methods cannot take into account both the ambiguity and randomness of indicators. [Methods] This study introduces the concept of competitiveness and the normal cloud model method, and evaluates the competitiveness of 30 provinces (except Tibet) of China's provincial-level administrative units for leisure fishery competitiveness by constructing a Chinese provincial leisure fishery competitiveness evaluation index system. [Results] (1) The overall level of competitiveness of China's provincial recreational fisheries is not high and the development is uneven. Two third of the provincial competitiveness is in the level I (weak) state, lacking the competitiveness of level IV (stronger) provinces; (2) Water resources area per capita, market distance index of source area and market size are common shortcomings of the competitiveness in most provincial units, and the total retail sales of social consumer goods and transportation accessibility indicators are generally highly competitive; (3) Level I and III provincial competitiveness results have less volatility, level II provincial competitiveness

**Key words:** Chinese provinces; leisure fishery competitiveness; evaluation; normal cloud model

# 京杭大运河渔文化初探

王源

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**摘要：**京杭大运河不仅哺育了沿岸人民，还孕育了灿烂的渔文化。京杭大运河在中华大地上由南向北分别流经浙江省江苏省山东省河北省天津市以及北京市。本文通过研究运河沿岸的饮食习惯、艺术创作或是渔业捕捞方法等方面，认为渔文化包罗万象。总结渔文化掇菁撷华部分并挖掘其中所蕴含的内在精神，不仅对渔业有强大的提质增效作用，也可以更好地抒发家国情怀；同时，研究并传承渔文化也是提升国家文化软实力、践行文化自信的重要内容。

**关键词：**京杭大运河、渔文化、文化自信

## Preliminary study on fishing culture in the Beijing-Hangzhou Canal

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**Abstract:** Along the Beijing-Hangzhou Grand Canal not only feed the people, also gave birth to the brilliant fishing culture. The Beijing-Hangzhou Grand Canal flows through Zhejiang, Jiangsu, Shandong, Hebei, Tianjin and Beijing from south to north. In this paper, through the study of dietary habits, artistic creation and fishing methods along the canal, fishing culture is considered to be all-inclusive. Summing up the essence of fishing culture and exploring the inherent spirit contained therein, not only has a powerful effect of improving the quality and efficiency of fishery, but also can better express the feelings of the country; At the same time, studying and inheriting fishing culture is also an important part of enhancing national cultural soft power and practicing cultural confidence.

**Key words::** the Beijing-Hangzhou Grand Canal, fishing culture, cultural confidence

# 锦鲤产业打造渔业转型升级高地， 锦鲤文化助力乡村全面振兴

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**摘要：**农业农村部已经将休闲渔业定义为五大重点支柱产业之一，观赏鱼则是休闲渔业的重要组成部分，锦鲤又是非常受欢迎的重要观赏鱼品种。现在以食用为目的的水产养殖渔业出现过剩的现象，而国家对环保的要求也越来越严格，全国渔业也面临转型升级，锦鲤作为观赏鱼是非常符合渔业转型升级方向。狠抓新旧动能转换重要契机，提托锦鲤养殖产业基础，将锦鲤文化产业与休闲渔业、旅游服务业融合开展，构建锦鲤全产业链，全力打造锦鲤文旅。

**关键词：**休闲渔业；锦鲤产业；渔业转型升级；锦鲤文化

## **Koi industry to build a highland for fishery transformation and upgrading , Koi culture to boost the overall rural revitalization**

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**Abstract:** The Ministry of Agriculture and Rural Affairs has defined recreational fishery as one of the five key pillar industries. Ornamental fish is an important part of recreational fishery, and Koi is also a very popular and important species of ornamental fish. There is now a surplus of aquaculture fishery for food, and the country's requirement for environmental protection is becoming more and more stringent. The fishery industry is also facing transformation and upgrading, Koi as ornamental fish is extremely in line with the direction. Pay close attention to the important opportunity of the transformation of new and old kinetic energy, tito Koi breeding industry foundation, integrate Koi cultural industry with recreational fishery and tourism service industry, construct the whole industrial chain of Koi and strive to create Koi cultural tourism.

**Key words::** recreational fishery; Koi industry; fishery transformation and upgrading; Koi culture



# 金鱼发展史及美学初步研究

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**摘要:** 金鱼起源于中国, 因其色彩绚丽、形态优美而深受人们喜爱。金鱼经历了漫长的演化, 由野生鲫鱼变为金鲫鱼, 再经过不同时期的家养, 逐渐形成各个品种。可以说, 金鱼的发展历程折射出人类对美学的认识过程。在这个过程中, 金鱼成为了我国古人根据对美的向往而进行人工创造的艺术杰作。本文通过研究金鱼的发展史, 从颜色、体形等方面初步分析了金鱼的美学变化, 体现出人们对金鱼观赏性的需求以及时代变迁下对美好事物与生活的追求历程。

**关键词:** 金鱼; 发展史; 美学

## A preliminary study on the development history and aesthetics of goldfish

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**Abstract:** Goldfish, also known as "golden crucian carp", originated in China. It is deeply loved by people because of its gorgeous color and beautiful shape. Goldfish has experienced a long evolution, first from silver-gray wild crucian carp to red and yellow golden crucian carp, and then after different periods of domestication, it has gradually formed various varieties of goldfish. It can be said that the development of goldfish reflects the process of human understanding of aesthetics. In this process, goldfish has become a typical representative of human changing natural species, and also an artistic masterpiece created by ancient Chinese people according to their yearning for beauty. By studying the development history of goldfish, this paper preliminarily analyzes the aesthetic changes of goldfish from color, shape and other aspects, which reflects the demand for goldfish appreciation and the pursuit of beautiful things and life under the changes of times.

**Key words:** Goldfish; Development history; Aesthetics

# 地域品牌的形成和食鱼文化的意义 ~以“佐久鲤”为例~

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**摘要：**本报告着眼于日本长野县的“佐久鲤”，揭示了当地养鲤业的发展过程及地域品牌的产生机制、食鲤文化赋予地域的社会经济作用。研究课题是①明确“佐久鲤”品牌形成的机制，②验证“佐久鲤”给当地带来的社会经济作用。

**关键词：**佐久鲤；地域品牌；食鲤文化

## The formation of regional brand and the significance of fish eating culture ~Take "SAKU carp" as an example~

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**Abstract :** This report focuses on the "Saku carp" in Nagano County, Japan, and reveals the development process of local carp industry, the generation mechanism of regional brands, and the socio-economic role of carp eating culture. The research topic is ① to clarify the formation mechanism of "SAKU carp" brand, and ② to verify the social and economic role brought by "SAKU carp" to the local area.

**Key words::** Saku carp; regional brand; fish eating culture

# 关于加强长江渔文化保护与传承的思考

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**摘要：**长江十年禁渔开启，为长江渔文化保护与传承提出重要课题。长江渔文化是长江文化的主要源头之一，而长江文化又是中华文化的重要源文化之一。面对长江十年禁渔，长江渔文化的保护与传承刻不容缓。长江渔文化不仅历史悠久、内容丰富，而且具有典型的文化多样性、历久弥新性等特征，是中国民族宝贵的精神财富和文化遗产，也是今后长江经济带永续发展的宝贵文化资源，因此及时采取措施加强长江渔文化的保护与传承是当务之急。

**关键词：**长江；十年禁渔；渔文化；保护；传承

## Discuss on strengthening the Protection and Inheritance of Fisheries Culture of the Yangtze River

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**Abstract:** The beginning of the ten-year fishing ban on the Yangtze River has raised an important issue for the protection and inheritance of fisheries culture of the Yangtze River. fisheries culture of the Yangtze River is one of the main sources of the culture of the Yangtze River, while the culture of the Yangtze River is one of the important sources of Chinese culture. In the face of the ten-year fishing ban on the Yangtze River, the protection and inheritance of fisheries culture of the Yangtze River is urgent. fisheries culture of the Yangtze River not only has a long history and is rich in content, but also has the characteristics of typical cultural diversity and lasting charms, etc. fisheries culture of the Yangtze River is the precious spiritual wealth and cultural heritage of the Chinese nation, is also a valuable cultural resource for the eternal development of the economic belt of the Yangtze River in the future. Therefore, taking measures to strengthen the protection and inheritance of fisheries culture of the Yangtze River in time. It is not only the theme of the protection of the Yangtze River, but also the important content of the inheritance and innovation of Chinese excellent traditional culture.

**Key words:** Yangtze River; 10-Year Fishing Ban; Fisheries Culture; Protection; Inheritance

# 中国渔文化的内涵初探

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**摘要：**本课题以渔文化作为研究对象，通过查阅大量文献，从物质内涵与精神内涵两方面对渔文化的内涵进行了探讨。渔文化是渔民在长期的渔业生产生活中形成的习惯、风俗、信仰、制度及其生活方式、情感、行为，具有时代性、地域性、传承性三大特点。了解渔文化的内涵对于坚定文化自信、促进渔业产业结构调整 and 我国渔业可持续健康发展具有重要意义。

**关键词：**渔文化，内涵

## On the connotation of Chinese fishing culture

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**Abstract :** This topic takes the fishing culture as the research object, through consulting a large number of documents, the connotation of the fishing culture is discussed from both the material connotation and the spiritual connotation. The culture of fishing is the habit, custom, belief, system, life style, emotion and behavior formed by the fishermen in their long-term fishery production and life. Understanding the connotation of fishery culture is of great significance for strengthening cultural self-confidence, promoting the adjustment of fishery industrial structure and sustainable and healthy development of fishery in China.

**Key words: :** Fishing culture, meaning

## 九、现代渔业设施装备与信息化

# 大尺度比对南极磷虾拖网模型 水动力性能的影响分析

刘征  
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**摘要：**渔具模型试验是渔具水动力性能研究的重要手段，试验所用准则是模型试验的核心问题。本研究以南极磷虾拖网为原型网，制作三种不同大尺度比（4、6、8）的模型网进行试验，与实物网海上实测数据进行对比，探究大尺度对南极磷虾拖网模型试验的影响；使用田内准则修正公式对模型试验结果进行修正，探究修正公式对本研究涉及的三种大尺度网具模型试验结果的影响。结果显示：（1）三种尺度模型网的试验阻力值大于实物网海上实测值，随着大尺度比的增加，模型网阻力值与实测阻力值的偏差增大；大尺度比变动对模型网网口高度没有显著性影响（ $P > 0.05$ ）。（2）试验网具的阻力系数随大尺度比的增大而增大；同一大尺度比，雷诺数越大阻力系数越小。（3）使用田内修正准则对模型试验结果进行修正后，各尺度下模型网与实物网的阻力值偏差均增大，偏差随大尺度比的增大而减小；本研究可为南极磷虾拖网模型试验大尺度比以及田内准则修正公式的选取提供参考依据。

**关键词：**田内准则；大尺度比；修正公式；模型试验；南极磷虾拖网

## Effects of large scale of Tauti's law on Antarctic krill trawl model test

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**Abstract :** The model test of fishing gear is an important means to study the hydrodynamic performance, the law used in the test and its conversion relationship are the core issues of the model test. In this study, the mid-water Antarctic krill trawl was used as the prototype net, and the Tauti's laws was used as the model test law. Three model nets with different large-scale ratios (4, 6, 8) were designed and fabricated, and the tests were carried out in the tank of the East China Sea Fisheries Research Institute. Prototype nets are tested and data collected in the South China Sea. Use the Tauti's correction law to correct the model test data, and compare the deviation between the model net of different scales before and after the correction and the experimental results of the actual physical net measured at sea. The results show that: (1) The converted resistance values of the three large-scale ratio model nets are all greater than the measured values of the physical net at sea; when the towing speed is 2.5 kn, the deviations of the converted resistance values of the 4, 6, and 8 large-scale ratio model nets from the measured resistance values are 2.90 %, 9.93% and 17.35%; (2) The change of large scale ratio has no significant effect on the net opening converted by the model net ( $P > 0.05$ ); When the drag speed is 2.5 kn, the deviations of the converted net opening and the measured net opening of the three large-scale ratio model nets of 4, 6, and 8 are 4.54%, 5.14%, and 7.96%, respectively. (3) The resistance coefficient of the test net decreases with the increase of Reynolds number; The Reynolds number of the prototype net is larger and the drag coefficient is smaller; The Reynolds number of the model net is small and the drag coefficient is large. (4) The deviation between the converted resistance and the measured resistance after the correction formula of the Tauti's laws is larger than that before the correction; When the drag speed is 2.5 kn, the deviations of the converted resistance and the measured resistance of the three large-scale ratio model nets 4, 6, and 8 after correction are 44.05%, 38.13%, and 31.73%, respectively. This study can provide a reference for the selection of large scale ratios for trawl model tests and the correction of Tauti's law.

**Key words::** Tauti's law; large scale ratio; correction formula; model test; Antarctic krill trawl

# 深远海养殖围栏内外波浪场数值模拟研究

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**摘要:** 深远海生态围栏养殖空间大、养殖环境更接近自然条件, 因此养殖鱼类品质会有显著提升, 是一种新型的水产养殖模式。然而, 这类大型养殖设施的存在会对其周围的水文环境产生一定的影响。鉴于此, 本研究采用完全非线性 Boussinesq 方程与多孔介质模型相结合, 建立了波浪作用下养殖围栏内外波浪场数值模型。并采用文献试验结果对本数值模型进行了有效性验证。在此基础上, 进一步研究了波高和波浪周期等因素对围栏内外波浪场特性的影响, 探讨了围栏内外波浪场特性对海浪参数的响应机制。研究表明, 养殖围栏的存在使其背浪侧的波高出现衰减, 波高衰减率受波浪周期影响较大, 最大波高衰减率可达 7%。同时, 较低频波浪的波高衰减区域呈辐射状趋势扩散, 而高频波浪的波高衰减区域的范围则相对较为集中。利用本模型, 还可开展海底坡度及岛礁地形影响下围栏内外波浪场研究, 为养殖围栏的选址及结构安全设计提供科学依据。

**关键词:** 养殖围栏; 波浪场; 数值模拟

## Numerical simulation of wave field inside and around an offshore aquaculture enclosure

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**Abstract:** The offshore aquaculture enclosure is a new aquaculture model with large aquaculture space and aquaculture environment closer to natural conditions. Therefore, the quality of aquaculture fish will be significantly improved. However, the existence of such large-scale aquaculture facilities will have certain effects on the surrounding hydrological environment. In view of this, a numerical model of the wave field inside and around an offshore aquaculture enclosure in waves was established by combining the fully nonlinear Boussinesq equation with the porous media model. The validity of the numerical model was verified by the experimental results of the literature. On this basis, the effects of wave height and wave period on wave field characteristics inside and around the aquaculture enclosure were further studied, and the response mechanism of the wave field to wave parameters was discussed. The results show that the existence of the aquaculture enclosure attenuates the wave height on the downstream region. The attenuation rate of the wave height is greatly affected by the wave period, and the maximum attenuation rate of the wave height can reach to 7%. At the same time, the wave height attenuation region of the lower frequency waves has a radial trend of diffusion, while the range of the wave height attenuation region of the high frequency wave is relatively concentrated. This numerical model can also be used to study the wave field inside and around the aquaculture enclosure under the influence of submarine slope and island topography, which can provide a scientific basis for the site selection and structural safety design of the aquaculture enclosure.

**Key words:** Aquaculture enclosure; Wave field; Numerical simulation



# 海带养殖筏体阻力性能研究

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**摘要:** 为了给海带养殖筏体的设计、选型以及养殖区域选址等提供数据参考, 本文以黄渤海使用的海带养殖筏为研究对象, 在主尺度为 90 m×6 m×3 m 的试验水池内进行模型试验, 研究了纵向排布时一组筏体以及延绳式排布时单根筏体在吊养海带和未吊养海带时的受力情况。研究表明: 无论纵向排布还是延绳式排布, 筏体的整体受力均随流速的增加而增大, 在相同的外界条件下, 吊养海带的养殖筏体比未吊养海带养殖筏体的受力值大 9.0%。

**关键词:** 养殖筏体; 延绳式排布; 模型试验; 阻力性能

## Hydrodynamic performance of kelp-cultured rafts

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**Abstract:** The models of kelp-cultured rafts from the Yellow Sea and Bohai Sea were taken in this study to provide references for the design and selection of kelp-cultured raft as well as the selection of the cultured location. The model test was conducted in the test tank with a main scale of 90 m × 6 m × 3 m to investigate the hydrodynamic performance of a group of rafts in the longitudinal arrangement and a single raft in the long-line arrangement with and without kelp hanging. Results show that regardless of the longitudinal or long-line arrangement of kelp-cultured rafts, the overall force of the raft increases with the increase of current velocity. The force value of conning kelp-cultured rafts is 9.0%–33.2% higher than that of unconning kelp-cultured rafts under the same external conditions. In addition, it is recommended that the length of each main cable should not exceed 50 meters.

**Key words:** kelp-cultured rafts, hydrodynamic performance, longline arrangement, model test

# 基于神经网络的中西太平洋鲣鱼渔情 预报分析

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**摘要：**掌握中西太平洋鲣鱼的资源状况变化规律，准确地预测鲣鱼的年资源量对于合理开发该物种有着极大的指导意义。随着科技的发展，机器学习领域产生了诸多神经网络模型。选用目前应用最广泛的误差反传信息前馈式 BP 神经网络。经过模型训练，利用平均相对方差(ARV)进行模型分析处理，最终选择隐含层为 8 的最优模型。采用 Grason 的权重分析，对多环境因子进行对比分析显示，得出海洋环境因素变量中海洋温度指数最高。

**关键词：**鲣鱼渔业资源；机器学习；BP 神经网络；海洋温度指数

## Prediction of bonito fishery situation in the Central and western Pacific Ocean based on neural network

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**Abstract:** It is of great guiding significance for rational exploitation of skipjack bonito in the central and western Pacific to grasp the changing rules of the resources and accurately predict the annual resources of skipjack bonito. With the development of science and technology, many neural network models have emerged in machine learning. The feed-forward BP neural network with the most widely used error information is selected. After model training, the average relative variance (ARV) was used for model analysis and processing, and the optimal model with 8 hidden layer was finally selected. Using Grason weight analysis, comparative analysis of multiple environmental factors shows that the ocean temperature index is the highest among Marine environmental factors variables.

**Key words:** Bonito fishery resources; Machine learning; BP neural network; Ocean temperature index

# 基于数值模拟的鱼类游动机理 及游泳能力影响参数研究

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**摘要：**鱼类以其高效灵活的游泳能力成为了生物学家与仿生学研究学者长期以来的重点关注对象。本文选取以尾鳍推进游泳方式的鱼类为研究对象，构建鱼体几何模型与运动计算模型，利用 CFD 方法结合动网格技术，对其游泳行为进行数值模拟，研究分析其尾鳍摆动的推进机理，并在此基础上通过改变尾拍频率、摆动幅值、鱼体体波波长及鱼体体型等参数，探究鱼类的突进运动、游泳方式及体型进化等生物学特性及规律。

**关键词：**鱼类，推进机理，游泳能力，影响参数，数值模拟

## Numerical simulation of the swimming mechanism and parameters influencing the swimming ability of fish

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**Abstract:** Fish have been the focus of biologists and bionics researchers for a long time because of their efficient and flexible swimming ability. This article selects the fish caudal fin swimming propulsion as a research object to build a fish body geometry model and a model of motion. The CFD method is used in combination with dynamic mesh technology to carry out a numerical simulation on fish swimming behavior, as well as researching and analyzing the propulsion mechanism of its caudal fin swing. The parameters of caudal fin swing frequency, swing amplitude, fish body wave wavelength, and body size are changed to investigate the biological characteristics and laws of the fish such as emergent movement, swimming pattern, and body shape evolution.

**Key words:** fish, propulsion mechanism, swimming ability, impact parameters, numerical simulation

# 电子监控系统应用在我国金枪鱼延绳钓渔业中的探索——以 WCPFC 为例

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**摘要:** 金枪鱼延绳钓渔业是我国远洋渔业的重要组成部分, 新兴的电子监控系统正在逐步被世界上各区域渔业组织所认可并存在有逐渐补充或取代渔业观察员计划的趋势。本文通过对与中国同处于中西太平洋渔业委员会管辖下的澳大利亚, 美国夏威夷与所罗门群岛三国的电子监控系统发展作为研究对象, 从资金成本、数据储存与运输、设施维护、数据处理与分析等角度进行论述分析, 希望能为中国远洋金枪鱼延绳钓渔业发展电子监控系统的发展提供参考。

**关键词:** 金枪鱼延绳钓;电子监控系统;渔业发展

## The Exploration of the Application of Electronic Monitoring System in the Tuna Longline Fisheries of China:Case Study at WCPFC

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**Abstract:** The tuna longline fisheries is an important part of China's deep-sea fishery. The emerging electronic monitoring system is gradually being recognized by various regional fisheries organizations in the world and there is a tendency to gradually supplement or replace the fishery observer program. This article uses the development of electronic monitoring systems in Australia, Hawaii, and the Solomon Islands, which are under the jurisdiction of the Western and Central Pacific Fisheries Commission with China, as the research object, from the perspectives of capital cost, data storage and transportation, facility maintenance, data processing and analysis, etc. The discussion and analysis hope to provide a reference for the development of the electronic monitoring system for the development of China's offshore tuna longline fisheries.

**Key words::** Tuna longline fisheries; electronic monitoring system; fishery development

# 基于神经网络的印度洋长鳍金枪鱼(Thunnus alalunga)时空分布与海洋环境关系研究

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**摘要:** 长鳍金枪鱼是主要的经济性金枪鱼鱼种之一, 其空间分布与环境因子存在着密切联系。利用印度洋长鳍金枪鱼生产数据和海洋环境数据, 包括海表面温度、叶绿素浓度和海表面盐度构建印度洋长鳍金枪鱼时空分布神经网络模型。以空间(经度, 纬度)、环境因子为解释变量, 局部渔获量为因变量, 变化隐含层节点数, 构建了 BP 空间分布模型, 并采用交叉验证模型稳定性, 以均方误差、平均相对方差及拟合优度作为不同模型评价标准。

**关键词:** 长鳍金枪鱼; 印度洋; 渔场预报; BP 神经网络; 时空分布

## STUDY ON THE RELATIONSHIP BETWEEN TEMPORAL-SPATIAL DISTRIBUTION OF INDIAN OCEAN ALBACORE (THUNNUS ALALUNGA) AND MARINE ENVIRONMENT BASED ON NEURAL NETWORK

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**Abstract:** Albacore (*Thunnus alalunga*) is one of the main economic tuna species, and its spatial distribution is closely related to environmental factors. In this research, BP artificial neural network method was applied, with which a neural network model was established based on the production data and environmental data of *T. alalunga* from 2012 to 2019. The output factor was the normalized fishing production data, and the input factors were spatial factors (including longitude and latitude), marine environmental factors, including sea surface temperature (SST), chlorophyll-a concentration, (chl a), and sea surface salinity (SSS), from which 18 BP neural network models were run using 10×10 cross-validation model stability, mean square error (MSE), average relative variance (ARV), and goodness of fit (R<sup>2</sup>) as the judgement of accuracy and stability of different models. Finally, Model 5-18-1 (hidden layer node 18) was chosen as the best model; its average MSE value is 0.022 32, and average ARV value is 0.511. The optimal model prediction results and the actual catch data during the same period were superimposed and compared, showing consistent results. Meanwhile, sensitivity analysis of environmental factors showed that SST significantly affected the distribution of *T. alalunga* fisheries in the Indian Ocean, with a contribution rate of 0.2. The high-precision BP neural network temporal-spatial distribution model of *T. alalunga* provides a new idea for the sustainable development and dynamism

**Key words:** Albacore tuna; Indian Ocean; fishing ground forecast; BP neural network; temporal-spatial distribution

# 方型人工鱼礁局部冲刷的数值模拟研究

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**摘要:** 人工鱼礁冲刷现象的研究对保证其发挥功能效果具有重要意义。本文基于雷诺平均的 RNGk- $\epsilon$  湍流模型, 在 FLOW-3D 建立了三维数值模型, 开展了人工鱼礁开口数和迎流角度对其冲刷特征、冲刷深度和冲刷体积影响的研究。结果表明:1.数值模拟结果与以往实验结果吻合; 2.人工鱼礁的冲刷深度和冲刷体积随开口数的减少逐渐减小; 3.迎流角改变引起人工鱼礁上游侧角处床面剪切力的变化。本研究为人工鱼礁的工程设计提供理论支持。

**关键词:** 人工鱼礁; 局部冲刷; 数值模拟; 冲刷体积; 开口数目; 迎流角度

## Numerical simulation of local scour around square artificial reef

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**Abstract :** Artificial reef is one of the key man-made constructs to restore the offshore fishery resources and the ecological environment. It found that many artificial reefs lost their stability and function due to scouring. In order to ensure the functional effect of artificial reef, it is great significance to study the instability of artificial reefs, like burying caused by scouring. The RANS equations, closed with a RNGk- $\epsilon$  turbulence model, are established for simulating stable flow field around artificial reefs. And the three-dimensional numerical model is established by FLOW-3D to study the local scour characteristics around artificial reef in steady currents. The simulation results are compared with the previous experimental results and shows good agreement. Then, the effect of the opening number and the incident angles of artificial reef on the scour characteristics, the equilibrium scour depth and maximum scour volume are investigated. The results indicate that the scour depth and scour volume decrease with the increasing opening number, and the empirical equations of the effect of the opening number of the artificial reefs on the equilibrium scour depth and maximum scour volume are proposed based on the numerical results. The bed shear stress change with the change of incident angles at the most upstream corner of the artificial reef. This study will provide theoretical support for the optimized engineering design and construction of artificial reef.

**Key words: :** artificial reef, local scour, numerical simulation, scour volume, opening number, incident angle

# 基于 BIOMOD2 组合模型 的西北太平洋秋刀鱼栖息地研究

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**摘要：**利用中国秋刀鱼渔船在西北太平洋公海海域获得的生产数据，结合海洋环境数据：SST、SSH、NPP、SSS。采用 Biomod2 组合模型对秋刀鱼渔场分布规律进行探讨研究，结果显示组合模型结果整体上优于单一模型，秋刀鱼盛渔期（7月-11月）渔场变化的时空规律呈现出由东北向西南的作业特点。Biomd2 组合模型精度检验结果显示 TSS 值大于 0.7，AUC 值大于 0.9，表明模型可以为秋刀鱼渔情预报提供参考。

**关键词：**秋刀鱼；Biomod2 组合模型；渔情预报；西北太平洋

## Study on the habitat of *Cololabis saira* in the Northwest Pacific based on the BIOMOD2 combination model

XuLingLing

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**Abstract:** Use the production data obtained by Chinese saury fishing boats in the high seas of the Northwest Pacific, combined with marine environmental data: SST, SSH, NPP, SSS. The Biomod2 combination model was used to study the distribution of *Cololabis saury* fishing grounds. The results showed that the combined model was better than the single model on the whole. The time and space regular pattern of the fishing grounds of *Cololabis saury* during the peak fishing season (July-November) showed a trend from northeast to southwest. Operating characteristics. The accuracy test results of the Biomd2 combined model show that the TSS value is greater than 0.7 and the AUC value is greater than 0.9, indicating that the model can provide a reference for the forecast of *Cololabis saira* .

**Key words::** *Cololabis saira*; Biomd2 combination model; fishing forecast; Northwest Pacific

# 虹鳟鱼群密度对网箱水动力的影响分析

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**摘要:** 网箱作为海水养殖的重要载体, 为我国海水养殖业的发展起着重要作用。网箱属于高密度集约化养殖装备, 养殖区海流、养殖鱼群密度以及网箱结构等因素的相互作用对其受力和内部水交换产生明显影响, 从而关系到网箱系统安全和养殖对象品质。本文设计长宽高分别为0.5m的方形网箱, 采用水槽试验和数值模拟方法, 研究水流作用下, 不同虹鳟鱼群密度、流速和冲角对网箱水动力的影响。研究结果可为虹鳟海水网箱养殖密度的合理配置提供参考。

**关键词:** 虹鳟; 养殖密度; 网箱水动力; 数值模拟; 物理模型试验

## Analysis of the Influence of Rainbow Trout Population Density on the Hydrodynamics of Net cage

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**Abstract:** As an important carrier of mariculture, cage plays an important role in the development of mariculture in China. The cage is a high-density intensive farming equipment, and the interaction of factors such as the current in the farming area, the stocking density and the structure of the cage has a significant impact on its stress and internal water exchange, which is related to the safety of the cage system and the quality of the cultured objects. In this paper, a square cage with length, width and height of 0.5 m was designed. The flume experiment and numerical simulation were used to study the effects of different density, flow velocity and impact angle of rainbow trout on the hydrodynamic force of the cage under the action of water flow. The results can provide reference for rational allocation of cage culture density of rainbow trout.

**Key words:** Rainbow trout; the stocking density; hydrodynamics of net cage; numerical simulation; physical model test



# 基于计算机视觉的秋刀鱼行为学检测研究

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**摘要：**秋刀鱼是我国近年来开发的远洋鱼种之一，为了研究其行为学，以 python 中的 Opencv 机器视觉库为核心，基于秋刀鱼水下图像构建其行为检测系统。通过对采集到的不同的秋刀鱼水下图像进行图像增强与形态学处理后，执行 k 均值聚类图像分割和处理，将秋刀鱼水下图像建成图像数据库用于检测其运动速度，方向以及形态特征。

**关键词：**鱼类行为学，秋刀鱼，计算机视觉，OpenCV，目标检测

## Research on behavior detection of saury based on computer vision

Rao

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**Abstract:** Saury is one of the pelagic fish species developed in China in recent years. In order to study its behavior, the behavior detection system is constructed based on the underwater image of saury with OpenCV machine vision library in Python as the core. After image enhancement and morphological processing of the collected different swordfish underwater images, K-means clustering image segmentation and processing are performed. The swordfish underwater images are built into an image database to detect their motion speed, direction and morphological characteristics.

**Key words:** fish ethology, saury, computer vision, OpenCV, target detection

# 三股绳索水动力性能研究

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**摘要:** 三股纤维绳索广泛应用于渔具、网箱等渔业装备中, 其水动力特性会对装备性能产生显著影响。本文以捻系数 3.6、公称直径 40mm 的渔用三股绳索为研究对象, 构建其数值模型, 运用雷诺平均法及  $k-\omega$  SST 湍流模型, 研究纯流作用下不同捻向、捻系数等参数对三股绳索水动力性能、流场分布的影响, 采用 3D 打印制作其物理模型, 通过水槽试验进行验证。研究结果可为渔具等装备的水动力研究提供基本参数和方法参考。

**关键词:** 三股绳索; 水动力性能; 3D 打印

## Hydrodynamic analysis of three-strand rope

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**Abstract:** Three-strand rope is widely used in fishing gear, fish cages, and other fishery equipment, and its hydrodynamic characteristics have a significant impact on equipment performance. In this study, a three-strand rope with a twist coefficient of 3.6 and a diameter of 40mm was taken as the research object. Reynolds Average Navier-Stokes method and  $K-\omega$  SST turbulence model were used to study the effects of different twist directions and twist coefficients on the hydrodynamic performance and flow field distribution of three-strand rope. Its physical model was made by 3D printing, and it was verified by a flume test. The results can provide basic parameters for hydrodynamic research of fishing gear and other equipment.

**Key words:** three-strand rope; hydrodynamic characteristics; 3D printing

# UHMWPE 裂膜纤维绳网的 耐磨性能研究

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**摘要:** UHMWPE 裂膜纤维作为一种特殊的高性能材料, 具有广阔的发展前景, 本试验用该纤维作为基体材料制成绳网和相同工艺下的传统绳网做耐磨性比较。结果: (1) 相同摩擦磨损条件下, 干湿状态下的 UHMWPE 裂膜绳索和不同结构的 UHMWPE 膜裂网都有着最高的强力保持率; (2) 随着负加载荷的提高, UHMWPE 裂膜绳索的强力保持率下降了 9.9%, 低于 UHMWPE 复丝绳索 (11.75%) 和 PE 绳索 (46.20%)

**关键词:** 关键词: UHMWPE; 裂膜纤维; 绳网; 耐磨性能

## Study on wear resistance of UHMWPE split film fiber rope net

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**Abstract:** As a special high-performance material, UHMWPE split film fiber has broad development prospects. In this experiment, the wear resistance of rope net made of this fiber as matrix material was compared with that of traditional rope net under the same process. Results: (1) Under the same friction and wear conditions, the UHMWPE film-cracked ropes and UHMWPE film-cracked nets with different structures have the highest strength retention rate; (2) With the increase of negative load, the strength retention rate of UHMWPE split film rope decreased by 9.9%, which was lower than that of UHMWPE multifilament rope (11.75%) and PE rope (46.20%).

**Key words:** Key words: UHMWPE, split fiber, rope net, wear-resisting property

# 基于 REEF3D 的深远海养殖平台水动力学高精度数值模拟研究

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**摘要:** 深远海养殖平台在复杂波浪环境下的动态响应和水动力载荷分析对其结构设计优化及安全生产具有重要意义。本研究以我国深远海养殖平台“深蓝 1 号”为对象, 利用基于流固耦合构建 REEF3D 数值水槽, 开展其在波浪环境下的非线性动态响应和水动力载荷研究, 分析波浪参数、网衣系统、框架结构垂直外柱的直径以及平台纵横比的变化对其水动力载荷、结构动态响应和最大系泊张力的影响, 可为今后深远海养殖平台的设计和优化提供科学依据。

**关键词:** 深远海养殖平台, 水动力学, 动态响应, 波浪

## A high-fidelity numerical study of the hydrodynamics of an offshore fish farm using REEF3D

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**Abstract :** The analyses of the dynamic responses and hydrodynamic loadings on the offshore aquacultural farms in waves are of great significance for structural design optimizations and safe productions. Fully considering the non-linear fluid-structure interaction, the high-fidelity open-source CFD framework REEF3D is used to build a numerical water tank (NWT), investigating the dynamic response and hydrodynamic loadings on the “ShenLan 1” in waves. Then, the effects of regular wave parameters, the net system, the thickness of the vertical outer columns of the structure, as well as the variations of the aspect ratios on the loads, responses and maximum mooring tension forces are studied. As a result of the study, the first step towards a systemic evaluation of the importance of different structural parts of an offshore fish cage for the expected responses is provided.

**Key words::** Offshore fish farm, Hydrodynamics, Dynamic response, Waves

# 基于数值计算的加筋 V 型网板 水动力性能及影响参数分析

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**摘要:** 近年来为了提高 V 型网板的结构强度与稳定性, V 型网板在设计与制作时会在传统结构的基础上加设几条较大尺度的加强筋。本文以我国近海拖网渔船配置的加筋 V 型网板为研究对象, 通过数值模拟分析, 研究加强筋对 V 型网板水动力性能的影响机理, 并通过开展动水槽试验对数值计算结构的有效性进行验证。在此基础上, 通过改变展弦比、板面折角、加强筋尺寸等参数, 研究结构参数的改变对加筋 V 型网板水动力性能的影响规律。

**关键词:** 水动力性能; 影响参数; 数值模拟; 加筋 V 型网板

## **Analysis of hydrodynamic performance and influencing parameters of reinforced V-shaped otter board based on numerical calculation**

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**Abstract:** In recent years, in order to improve the structural strength and stability of V-shaped otter board, several large-scale stiffeners will be added on the basis of traditional structure in the design and manufacture of V-shaped otter board. In this paper, the reinforced V-shaped otter board configured by offshore trawlers in China is taken as the research object. Through numerical simulation analysis, the influence mechanism of stiffeners on the hydrodynamic performance of V-shaped otterboard is studied, and the effectiveness of numerical calculation structure is verified by dynamic flume test. On this basis, the influence of structural parameters on the hydrodynamic performance of reinforced V-shaped otter board is studied by changing the aspect ratio, plate folding angle and stiffener size.

**Key words:** hydrodynamic performance ; impact parameters ; numerical simulation ; stiffened V-shaped otter board

# 利用 BP 神经网络标准化东南太平洋茎柔鱼资源丰度

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**摘要：**运用 BP 神经网络（back propagation network）模型来标准化单位捕捞努力量渔获量（catch per unit effort, CPUE, 也称名义 CPUE）。以均方误差(MSE)和平均相对变动值(ARV)为最优模型判断依据, 比较隐含层节点 3-10 的神经网络模型, 发现 6-9-1 结构为最优模型。

**关键词：**BP 神经网络; 东南太平洋; 茎柔鱼; 资源丰度

## BP neural network was used to standardize the abundance of *Dosidicus gigas* in the southeast Pacific

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**Abstract:** BP neural network (BACK Propagation Network) model was used to standardize catch per unit effort (CPUE).Based on MSE and ARV, the neural network model of hidden layer node 3-10 was compared and the 6-9-1 structure was found to be the optimal model.

**Key words::** BP neural network;Southeast Pacific;*Dosidicus gigas*;Resource abundance

## 十、渔业经济、政策与管理

# 基于大连渔业的海洋渔业标准体系建设与示范

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**摘要:** 我国是渔业大国, 水产品产量居世界首位, 其中养殖产量占全球的 70%以上, 但还不是渔业强国, 生产方式依然粗放, 出口受制于人依然存在, 究其原因是渔业标准化程度和水平不高。大连海洋大学针对现有标准体系不健全, 已有标准实用性差, 标准制定缺乏针对性和系统性等宏观管理问题开展研究, 在全国率先开展了海洋渔业标准化体系建设与示范工作。

**关键词:** 渔业标准化; 标准体系; 推广; 示范

## Construction and demonstration of Marine fishery standard system based on Dalian fishery

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**Abstract:** China is a major fishery country, the output of aquatic products ranks first in the world, among which aquaculture production accounts for more than 70% in the world, but it is not a fishery power. The production mode is still extensive and export is still controlled in world. The reason is that the degree and level of fishery standardization are below. Dalian Ocean University has carried out research on the imperfect existing standard system, the poor practicability, and the lack of targeted and systematic macro-management issues. Finally, Dalian Ocean University carry out the construction and demonstration work of the Marine fishery standardization system in China.

**Key words:** Fisheries standardization; Standards system; Generalization; demonstration



# 浙江省渔业经济发展对策研究

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**摘要：**十九大以来，渔业成为助力乡村振兴和实现共同富裕的重要抓手。作为渔业大省，浙江在渔业绿色发展、水产育种、数字渔业等方面走在全国前列，然而浙江渔业经济发展仍存在不少问题。本文通过对 2015-2019 浙江省主要渔业经济指标进行纵向比较分析，发现渔业资源、机械化水平、产业融合度、渔业安全等方面存在短板。结合浙江现代渔业运行的特点，提出了相关建议，为推动渔业经济高质量发展提供参考。

**关键词：**渔业经济；产业结构；高质量发展

## Study on the strategy about development of Zhejiang fishery economics

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**Abstract:** Since the 19th National Congress of the Communist Party of China, fishery has been the important element of Rural Revitalization and Common Prosperity. As the big fishery province, the healthy development and fishery breeding and digital fisheries of Zhejiang walk at the forefront of China, but there are some problems. Based on the main data from 2015-2019, by the vertical comparison and analysis, this paper found some problems hinder the fishery development. By analyzing the characteristic of Zhejiang fishery economy, this paper supply some proposes . The research provides a reference for strengthening fishery structural reform of supply-side reform, promoting high-quality development.

**Key words::** fishery economics; industrial structure; high-quality development

# 没有买卖就没有伤害：基于生态保护视角的“野生江鲜”购买意愿研究

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**摘要：**在长江流域水生生物资源严重衰竭，危害国家生态安全的背景下，国家实行十年禁捕政策，从捕捞生产和市场流通等供给端保护长江流域水生生物资源。市场需求端的消费者对此反应如何？是否愿意减少甚至拒绝购买“野生江鲜”以保护长江流域水生生物资源？本文基于整合的计划行为理论和规范激活理论，利用长江流域八省市的调查数据，对消费者“野生江鲜”购买意愿影响因素及其形成机制展开研究，并探明个人规范的中介作用。

**关键词：**野生渔业资源衰退；野生江鲜；购买意愿；计划行为理论；规范激活理论

## No business, no harm: Study on purchase intention of wild freshwater fish from the perspective of ecological protection

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**Abstract :** Abstract: In the context of the severe exhaustion of aquatic biological resources in the Yangtze River Basin, which endangers national ecological, the government has implemented a ten-year fishing ban policy to protect the aquatic biological resources in the Yangtze River Basin from the supply side such as fishing production and market circulation. How do consumers on the demand side of the market react to this? Are they willing to reduce or even refuse to purchase wild freshwater fish to protect the aquatic biological resources in the Yangtze River Basin? Based on the theory of planned behavior and theory of norm activation, this paper used survey data from eight provinces and cities in the Yangtze River Basin to study the influencing factors and formation mechanism of consumers' purchase intention of wild freshwater fish and explore the mediating role of personal norm. The results showed that personal norm, attitude, subjective norm, perceived behavioral control, and sense of responsibility all had significant direct impacts on purchase intention. Personal norm played mediating role between attitude, subjective norm, perceived behavioral control, sense of responsibility and purchase intention. On this basis, specific policy recommendations such as strengthening the popularization of aquatic product knowledge, raising consumers' sense of responsibility and creating a social atmosphere for ecological environment protection, were proposed.

**Key words :** fishery resource decline; wild freshwater fish; purchase intention; theory of planned behavior; theory of norm activation

# 中国头足类水产品出口贸易波动影响因素

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**摘要：**本文运用修正后的恒定市场份额模型从需求、结构和竞争力三个方面分析了2012至2019年中国头足类水产品出口波动的影响因素。研究发现：国际市场供求变化是影响中国头足类出口波动的主要因素；出口竞争力变动是中国头足类出口波动的次重要因素，但其影响效果逐渐减弱；出口结构改善对中国头足类出口增长的促进作用日益明显，但对出口增长的贡献占比仍然很小。本研究可为头足类水产品出口企业制定有针对性的出口策略提供参考借

**关键词：**CMS模型；头足类水产品；出口贸易波动；出口竞争力

## Analysis on factors affecting the fluctuation of Chinese cephalopod aquatic products export trade

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**Abstract:** This paper analyzes the influencing factors of China's cephalopod aquatic product export fluctuation from 2012 to 2019 from three aspects of demand, structure and competitiveness by using the modified CMS model. The results show that the supply and demand of the international market are the main factors affecting the fluctuation of cephalopod export in China. Export competitiveness change is the second most important factor of cephalopod export fluctuation in China, but its effect is decreasing gradually. The improvement of export structure has played an increasingly significant role in promoting the growth of cephalopod export in China, but its contribution to the growth of cephalopod export is still small. The research in this paper can provide reference for cephalopod aquatic product export enterprises to formulate targeted export strategies.

**Key words:** : CMS model; cephalopod aquatic products; fluctuation of export trade; export competitiveness

# 北太平洋柔鱼生物经济模型及管理策略探析

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**摘要：**北太平洋柔鱼是我国远洋重要的经济鱼类，本文根据 1998-2017 年我国鱿钓船在北太平洋海域捕捞的柔鱼渔获量、捕捞努力量以及相关经济数据，构建基于 Schaefer 剩余产量的生物经济模型，探讨不同管理目标下的产量及其对应的捕捞努力量，以及 1 年（短期）、5 年（中期）、10 年（长期）的经济效益和资源状况。研究表明：以 BE 为管理目标则其短期经济效益为最大，而以 MEY 为管理目标则其长期经济效益为最大。

**关键词：**柔鱼；西北太平洋；生物经济模型；鱿钓渔业

## An Analysis of the Bio-economic Model and Management Strategy of Dolphin in the North Pacific

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**Abstract:** The North Pacific Dolphin is an important economic fish in my country's oceans. Based on the catch, fishing effort, and related economic data of the squid fishing boats in the North Pacific Ocean from 1998 to 2017, this paper constructs a bioeconomy model based on Schaefer's remaining yield, and discusses the yields and their corresponding responses under different management objectives. Fishing effort, and the economic benefits and resource status of 1 year (short-term), 5 years (medium), and 10 years (long-term). The research shows that the short-term economic benefit is the greatest if BE is the management goal, and the long-term economic benefit is the greatest if MEY is the management goal.

**Key words:** Dolphin; Northwest Pacific; Bio-economic model; Squid fishing

# 中西部太平洋渔业委员会渔船 租赁机制的分析与探讨

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**摘要：**通过对中西部太平洋渔业委员会渔船租赁机制的探讨，分析了我国渔船被小岛屿发展中国家租赁的现状，针对渔船租赁存在的局限性问题，建议我国应积极推动和南太平洋岛国建立长期租赁机制，推动政府间双边合作，深化在岛国陆地投资，增加远洋渔船被租赁的机会，为我国远洋渔业企业赢得生存空间；在配额和渔船数量受限制的情况下，应探究多种合作方式，积极参与国际事务，争取合法权益。

**关键词：**中西太平洋渔业委员会；渔船租赁；小岛屿发展中国家；金枪鱼渔业

## Analysis of Western and Central Pacific Fisheries Commission Vessel Charter Mechanism

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**Abstract:** By analyzing the vessel charter mechanism of WCPFC, this article presented the current situation that the Chinese-flag tuna fishing vessels were chartered by SIDS. Aiming at the limitations of the vessel charter mechanism, it is suggested that China should actively promote the establishment of multi-year charter mechanisms with SIDS and continue to promote bilateral cooperation between SIDS governments, increase land-based investment in island countries, and thus enhance the possibility of Chinese -flag tuna fishing vessel being chartered, win the living space for China distant water enterprises. While quotas and the number of vessel are restricted, a variety of cooperation methods should be explored, actively participate in international affairs and fight for legitimate rights and interests.

**Key words:** Western and Central Pacific Fisheries Commission (WCPFC); vessel charter; Small Island Developing States (SIDS); tuna fishery

# 半咸水养殖池塘水体化学需氧量监测方法的探讨

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**摘要：**水产养殖尾水对环境的影响已引起全社会广泛关注。化学需氧量（COD）是衡量养殖水体污染程度的最常用指标，但目前我国相关监测评价体系中只包含淡水和海水，而针对半咸水养殖水体暂未有明确的监测方法。本文比较了2种标准方法的原理和局限性，建议开展盐度对半咸水养殖水体中COD测定影响的研究，明确半咸水养殖池塘水体COD监测方法，以便更全面、准确地评价水产养殖的有机物污染状况，为尾水排放政策的制定提供数据支撑。

**关键词：**化学需氧量，监测方法，半咸水养殖，盐度

## Discussion on monitoring methods of chemical oxygen demand (COD) in brackish water aquaculture ponds

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**Abstract :** The influence of aquaculture tail water on ecological environment has been widely concerned by the whole society. Chemical oxygen demand (COD) is the most commonly used index to measure the pollution degree of aquaculture water. But at present, the relevant monitoring and evaluation system in China only includes fresh water and sea water, and there is no clear monitoring method for COD in brackish aquaculture water. In this paper, the detection principle and limitations of the two existing standard methods were compared, and it was suggested to carry out the study on the influence of salinity on COD determination in brackish aquaculture water, clarify the COD monitoring method in brackish aquaculture pond, and gradually build the relevant standard system, so as to evaluate the organic pollution status of aquaculture more comprehensively and accurately. Provide data support for strengthening the formulation of policies related to tail water discharge management.

**Key words::** chemical oxygen demand, monitoring method, brackish water aquaculture, salinity

# 有限数据下秋刀鱼渔业管理策略评估

周晓杰  
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**摘要：**秋刀鱼（*Cololabis saira*）是西北太平洋主要经济种群之一，对其进行正确的资源评估和有效的管理尤为重要。本研究基于秋刀鱼的生物学参数，渔获量等有限数据，采了多种渔业管理规程(MP)对秋刀鱼进行了资源评估和管理策略评价。结果显示，时滞差分资源评估法(DD)对渔获量的不确定性响应相对较弱，适用于秋刀鱼等渔获量数据波动变化较大的渔业。而75%捕捞努力量法(curE75)更兼顾于渔业资源的开

**关键词：**有限数据渔业，秋刀鱼，资源评估，管理策略评价

## Assessment of management strategies for fallfish fisheries with limited data

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**Abstract:** *Cololabis saira* is one of the major economic stocks in the Pacific Northwest, and it is particularly important to conduct proper resource assessment and effective management of it. In this study, various fishery management protocols (MPs) were used to evaluate the resource assessment and management strategies of *Cololabis saira* based on limited data on its biological parameters and catches. The results show that the time-lagged differential resource assessment method (DD) responds relatively weakly to catch uncertainty and is suitable for fisheries with large fluctuations in catch data, such as fallfish. In contrast, the 75% fishing effort method (curE75) is more balanced for the exploitation and conservation of fishery resources.

**Key words:** Limited data fishery, saury, resource evaluation, management strategy evaluation

# 阿根廷渔业管理与政策研究

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**摘要：**阿根廷是中国的全面战略伙伴关系合作国，其海岸线延长、渔业资源丰富，与我国有着长期的过洋性渔业合作与水产品贸易往来。然而，因其国情的复杂性，中阿两国的渔业合作及发展仍面临诸多难题。本文分析了阿根廷渔业的特点，指出了阿根廷渔业所处的不利环境；描述了阿根廷渔业管理的历史沿革，归纳了其渔业管理政策对阿根廷渔业发展的贡献；梳理了国内外有关于阿根廷渔业管理的文献，为我国研究阿根廷渔业管理政策提供一定参照。

**关键词：**阿根廷；渔业管理；渔业政策

## The research on fisheries management and policy in Argentina

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**Abstract :** Argentina is a partner country of China's comprehensive strategic partnership and an important demonstration country of China's "One Belt, One Road" initiative. With its extended coastline and rich fishery resources, Argentina has a long history of transoceanic fishery cooperation and fishery products trade with China. However, due to the complexity of its national conditions, the fisheries cooperation and development between China and Argentina still face many difficulties. This paper analyzes the characteristics of Argentine fisheries and points out the unfavorable environment of Argentine fisheries; describes the history of Argentine fisheries management and summarizes the contribution of its fisheries management policies to the development of Argentine fisheries; compares the literature on Argentine fisheries management at home and abroad to provide some reference for the study of Argentine fisheries management policies in China.

**Key words::** Argentina; Fisheries Management; Fisheries Policy



# 试论水产苗种检疫体系建设的 协同发展

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**摘要：**近年来，水产苗种检疫体系受到了社会各界人士的关注，但目前水产苗种检疫还并不完善。笔者从产业发展、食品安全及经济学的角度来阐释水产苗种检疫的重要性，介绍水产苗种检疫的现状和存在的问题，并对痛点问题的解决提出了针对性的解决思路和发展建议。

**关键词：**水产苗种，检疫体系

## Discussion on the Coordinated Development of Aquatic Seeding Quarantine System Construction

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**Abstract :** In recent years, the aquatic seeding quarantine system has been concerned by people; however, the aquatic seeding quarantine system has been not perfect. The author explained the importance of aquatic seeding quarantine from the perspectives of industry development, food safety and economics; the author explains the importance of aquatic seedling quarantine, introduces the current situation and existing problems of aquatic seedling quarantine, and puts forward some targeted solutions and development suggestions.

**Key words: :** Aquatic Seeding, Quarantine System Construction

# 长江流域禁用渔具名录及其管理探讨

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**摘要:** 2018年9月26日, 国务院办公厅正式印发《关于加强长江水生生物保护工作的意见》, 明确提出要强化支撑保障、加大保护投入, 夯实长江水生生物资源保护的基础。为了强化对长江流域禁用渔具的管理, 农业农村部、公安部等明确禁用渔具名录中的渔具使用者要负刑事责任。经过研究汇总, 列入禁用渔具名录的渔具达30多种, 并对管理模式进行了探讨。

**关键词:** 长江流域; 禁用渔具; 管理

## List of prohibited fishing gear and its management in the Yangtze River Basin

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**Abstract:** On Sept. 26, 2018, the General Office of the State Council officially issued the "Guideline on Strengthening the Protection of Aquatic Organisms in the Yangtze River". China increase investment in protection and consolidate the basis for the protection of aquatic biological resources in the Yangtze River to strengthen support. In order to strengthen the management of prohibited fishing gear in the Yangtze River Basin, the Ministry of agriculture and rural areas and the Ministry of public security have made it clear that the users of fishing gear in the list of prohibited fishing gear should bear criminal responsibility. After research and summary, more than 30 kinds of fishing gear are listed in the list of prohibited fishing gear, and the management mode is discussed.

**Key words:** the Yangtze River Basin; prohibited fishing gear; management

# 基于德尔菲法（Delphi）和层次分析法（AHP）的粤桂琼三省区非法捕捞影响因素分析

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**摘要：**摘要:为探索防治粤桂琼三省区非法捕捞行为的有效方法，本文通过德尔菲法和层次分析法相结合的方式构建非法捕捞行为影响因素评价体系。求解社会因素和自然因素 2 大类计 24 种影响因素权重数值，按照权重数值大小为影响因素排序。通过实地走访调查对计算结果进行实例验证，结果表明影响程度最大的几个因素为“C4 执法力量”、“C12 暴利诱惑”、“C7 渔获市场”、“C15 文化水平”、“C9 生计需求”。

**关键词：**非法捕捞，影响因素，德尔菲法（Delphi），层次分析法（AHP），实例验证

## Analysis of the causes of illegal fishing based on Delphi and Analytic Hierarchy Process (AHP)

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**Abstract:** In order to explore an effective method to prevent and control illegal fishing behavior in Guangdong, Guangxi and Hainan provinces, this paper constructs an evaluation system for the influence factors of illegal fishing behavior by combining Delphi method and hierarchical analysis. The weights of 24 influencing factors in 2 categories, namely social factors and natural factors, were calculated and ranked according to the size of the weights. The results were verified by field visits and surveys, and the factors with the greatest influence were "C4 law enforcement force", "C12 lure of profiteering", "C7 catch market", "C15 literacy level", and "C9 livelihood needs".

**Key words:** illegal fishing, influencing factors, Delphi method, analytic hierarchy process, Instance verification

# 新发展阶段再论近海滩涂水产 养殖的权利与养殖管理变革

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**摘要：**尽管理论界对近海滩涂的水产养殖权利已做了深入的研究，但经对山东、江苏省调研发现，实践中养殖权证问题一直未能妥善解决。这一历史问题对于实现渔村振兴、高质量发展构成隐患。本文从养殖权的理论争辩出发，分析了学术界关于养殖权持续近三十年的争论，在此基础上，站在“十四五”新时期新发展阶段，提出了针对水产养殖滩涂权利与养殖证存废、变革的建议，包括对历史性权利的处置及对基于养殖权的现代化养殖生产管理制度的构建。

**关键词：**养殖权 养殖证 变革

## Re-discussion on the rights of coastal aquaculture and the reform of aquaculture management in the new development stage

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**Abstract:** Although the theoretical circles have done in-depth research on the aquaculture rights near beaches, investigations in Shandong and Jiangsu provinces have found that the issue of aquaculture licenses has not been properly resolved in practice. This historical issue poses a hidden danger to the revitalization and high-quality development of fishing villages. This article starts from the theoretical argument of aquaculture rights and analyzes the academic debates on the aquaculture rights that have lasted for nearly 30 years. On this basis, standing in the new development stage of the "14th Five-Year Plan" period, this paper proposes the right and the right to aquaculture tidal flats. Suggestions on the preservation and abolishment of breeding licenses and the reform, including the disposal of historical rights and the construction of a modern breeding production management system based on breeding rights.

**Key words::** Breeding right Breeding certificate Reform

# 长江口禁捕水域协同治理困境 及其应对

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**摘要：**长江口作为江海连接处的重要生态区、两省一市的交界区，在长江十年禁渔计划背景下，其禁捕管理工作显得极为迫切。因此长江口水域通过协同治理的方式开展禁捕工作。但存在协调领导单位缺乏法律地位、联合执法缺乏依据、协同治理缺乏保障机制等困境。为此，本文通过参与式观察法、访谈法等实证研究方法对长江口禁捕水域协同治理困境进行研究，并从建立领导协调机制、信息共享与反馈机制、功能机制等方面提出改进建议。

**关键词：**长江十年禁渔；长江口；禁捕管理；协同治理

## Difficulties and countermeasures of coordinated management of prohibited waters in the Yangtze River Estuary

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**Abstract :** As an important ecological area at the junction of the Yangtze River and the sea, the Yangtze River estuary is at the junction of two provinces and one city. Under the background of the Yangtze River's 10-year fishing ban, the management of its fishing ban is extremely urgent. Therefore, the waters of the Yangtze River estuary have been banned by means of coordinated management. However, there are dilemmas such as the lack of legal status of the coordinated leadership unit, the lack of basis for joint law enforcement, and the lack of a guarantee mechanism for coordinated governance. To this end, this paper uses empirical research methods such as participatory observation method and interview method to study the plight of coordinated governance of the Yangtze River Estuary's forbidden waters, and proposes suggestions for improvement from the establishment of leadership coordination mechanism, information sharing and feedback mechanism, and functional mechanism.

**Key words: :** Ten-year ban on fishing in the Yangtze River; the estuary of the Yangtze River; ban management; collaborative governance

# 国际渔业组织的运行机制研究

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**摘要：**国际渔业组织是以渔业发展与合作为目的，由两个或两个以上的国家或民间团体以一定协议形式而建立的机构。国际渔业组织具有一般 NGO 的属性，除此之外，它主要以渔业资源的养护和管理为目标。本文针对国际渔业组织，从整体概况、资金来源、与其他组织的关系、面临的挑战等方面对国际渔业组织的运行机制进行了研究。分析国际渔业组织的运行机制和成长经验，对于新时代人类更好地养护管理渔业资源，促进可持续发展具有重要意义。

**关键词：**国际渔业组织 运行机制

## Research on the Operation Mechanism of International Fisheries Organization

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**Abstract :** The International Fisheries Organization is an organization established by two or more countries or non-governmental organizations in a certain form of agreement for the purpose of fishery development and cooperation. The International Fisheries Organization has the attributes of a general NGO. In addition, it mainly aims at the conservation and management of fishery resources. Aiming at the International Fisheries Organization, this article studies the operating mechanism of the International Fisheries Organization in terms of its overall profile, funding sources, relations with other organizations, and challenges. Analyzing the operating mechanism and growth experience of the International Fisheries Organization is of great significance for mankind in the new era to better conserve and manage fishery resources and promote sustainable development.

**Key words::** International Fisheries Organization Operating Mechanism

# 冰岛 ITQ 制度文献综述

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**摘要：**冰岛作为世界上最早实施 ITQ 制度的国家，在 ITQ 方面的经验一再被其他国家作为渔业管理成功的案例进行研究。当前，捕捞限额制度在我国处于试点阶段，尚未全面推行，面对日益恶化的海洋渔业危机，借鉴发达渔业国家的经验，实施符合本国国情的捕捞限额制度尤为必要。本文对冰岛 ITQ 制度进行全面综述，并在此基础上，综述冰岛 ITQ 制度对中国的启示。我们应汲取冰岛 ITQ 制度的实践经验，以更好地从冰岛 ITQ 制度中获得启示。

**关键词：**冰岛；ITQ；中国；启示

## Iceland ITQ System Research Document Review

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**Abstract:** As the world's earliest implementation of the ITQ system, Iceland has been studied by other countries as a successful case of fishery management. At present, the fishing limit system is in the pilot phase in China, has not fully implemented, in the face of the increasingly deteriorating marine fishery crisis, drawing on the experience of developed fishery countries, is especially necessary. This article provides comprehensive review of the Iceland ITQ system, and on this, this paper reviews the revelation of Iceland ITQ system on China. We should draw practical experience in Iceland ITQ system to better get revelation from the Iceland ITQ system.

**Key words::** Iceland; ITQ ;China ;enlightenment

# 长江禁捕背景下江苏渔民生活 安置及转产转业问题研究

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**摘要：**长江流域实施禁止捕捞是贯彻落实习近平总书记关于“共抓大保护、不搞大开发”的重要指示，是保护长江母亲河及加强生态文明建设的重要举措，也是为全局计、为子孙谋，功在当代、利在千秋的重要决策。为贯彻落实党中央、国务院关于加强生态文明建设和共抓长江大保护的决策要求，如期完成长江流域禁捕目标任务，依据《中华人民共和国渔业法》和《江苏省渔业管理条例》等法律法规，以及国家有关部委具体工作要求，对长江干流江苏段水域全面、长期禁止渔业。

**关键词：**关键词：长江禁捕；渔民；转产转业；生活安置

## Research on the Living Settlement and Employment of Jiangsu Fishermen after Fishing Ban on the Yangtze River

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**Abstract:** The ban on fishing in the Yangtze River basin is an important implementation of General Secretary Xi Jinping's instruction on "jointly promoting great protection and not engaging in great development". It is an important measure to protect the mother river of the Yangtze River and strengthen the construction of ecological civilization. It is also an important decision for the overall situation, for future generations, and for the benefit of the present and future generations. In order to implement the decision requirements of the CPC Central Committee and the State Council on strengthening the construction of ecological civilization and jointly promoting the protection of the Yangtze River, and to complete the targets and tasks of banning fishing in the Yangtze River Basin as scheduled. In accordance with the Fisheries Law of the People's Republic of China, the Regulations of Jiangsu Province on Fishery Management and other laws and regulations, as well as the specific work requirements of relevant ministries and commissions of the state, fishing shall be banned in the waters of the Jiangsu section of the main stream of the Yangtze River. After the comprehensive and long-term ban on fishing in the Yangtze River basin, the main issues facing the government are how to change the fishing industry and how to settle the fishermen's livelihood. Fishermen are the main body of fishing. How to properly solve the livelihood of fishermen after the ban on fishing, namely, the issue of changin

**Key words:** Fishing Ban on the Yangtze River; Retreating fishermen; Employment and placement



# 渔业管理中投入和产出控制的比较研究

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**摘要：**为了减缓渔业资源衰退，世界各国提出了一系列基于“投入控制”和“产出控制”的管理措施。为此，本文通过分析投入控制与产出控制中各要素，对国际上主要渔业大国（美国、欧盟、日本等）的管理制度和措施进行综合评述，并与我国管理措施进行对比。研究表明，投入控制与产出控制具有不同的优点和局限性，我国渔业管理应采取投入和产出相结合的渔业管理制度综合发挥各种制度的优势，促进我国近海渔业的可持续发展。

**关键词：**渔业管理；投入控制；产出控制；比较研究

## Comparative Study for Input control and Output control in Fishery Management

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**Abstract:** Since the 1980s, the continuous increase of fishing catches has resulted in the decline of fishery resources. In order to alleviate this problem, a series of management measures based on "input control" and "output control" have been put forward around the world. Therefore, this article comprehensively reviews the management systems and measures of major international fishery countries (the United States, the European Union, Japan, etc.) by analyzing various elements for input control and output control, and conducts a comparative study with China to analyze long-term problems of management measures, governance effectiveness and deep-seated causes of effectiveness limited. The research results show that input control and output control have different advantages and limitations. The fishery system of any country is not a single system, but an organic combination of multiple systems. In view of the characteristics and complexity of Chinese fishery, this paper holds that China should adopt a fishery management system combining input control and output control. At present, we should focus on strengthening input management, exploring output management, making full use of the advantages of various systems, and promoting the sustainable development of offshore fishery in China.

**Key words:** Fishery management; input control ; output control; comparative study

# 水生遗传资源价值构成

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**摘要：**生物遗传资源的获取和惠益分享是《生物多样性公约》(CBD)《名古屋议定书》的重要内容，也是国家管辖范围以外区域生物多样性(BBNJ)谈判的基本问题，但生物遗传资源的概念至今尚不明确，关于其价值的研究较少。本文对水生遗传资源的概念分歧进行了分析，并在回顾和分析传统自然资源价值理论及其应用的基础上，提出了基于TEV框架的AGRs价值构成理论。这有助于澄清其概念，并为价值评估奠定良好基础。

**关键词：**水生遗传资源；概念；价值类型；价值构成

## The Valuation of Aquatic Genetic Resources: from a conceptual perspective

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**Abstract :** While access and benefit-sharing of genetic resources is a fundamental issue in the implementation of Nagoya Protocol and Convention on Biological Diversity (CBD), as well as for the negotiation in Biological Diversity of Areas Beyond National Jurisdiction (BBNJ), the very concept and value of genetic resources have not been clearly defined or demarcated. Ambiguity in such a key term may bring serious concerns in the implementation of law and negotiation. This paper analyzes the disagreements about the concept of aquatic genetic resources(AGRs), analyzes the value types of the AGRS and proposes a value framework of AGRs based on the TEV framework in natural resources theory by reviewing and analyzing the theory of traditional natural resource value and its application. AGRS value composition framwork is help for the clarification of its concept and valuation.

**Key words::** aquatic genetic resources; concept; value types; value composition

# 生计资本视角下长江流域禁捕 补偿政策效应评估

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**摘要：**本文从生计资本的总量、结构和流动性三个方面的变化对长江禁捕补偿政策效应进行评估，结果表明，禁捕补偿政策的实施对渔户生计资本的影响表现为生计资本存量的提升、生计资本结构的优化及渔民群体生计资本差距的缩小，且不同地区间政策效应存在异质性。禁捕补偿政策的实施在一定程度上促进了退捕渔户的生计可持续性，渔户生计的“内卷化”，退捕地区的社会和谐稳定及渔户生计资本阶层的重新固化仍是十年禁渔需要持续关注的问题。

**关键词：**长江禁捕；生计资本指数；耦合协调度；流动性

## EFFECT EVALUATION OF ECOLOGICAL COMPENSATION POLICY IN THE YANGTZE RIVER FROM THE PERSPECTIVE OF LIVELIHOOD CAPITAL OF FISHERMEN

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**Abstract:** The ecological compensation policy in the Yangtze River has great significance to realize the green and sustainable development of the Yangtze River economic belt. Taking the retired fishermen in Anhui, Jiangsu and Hubei Province as research objects and basing on the sustainable livelihood analysis framework, this paper constructs an evaluation index system for the livelihood capital of the retired fishermen, and from the changes of total amount, structure and mobility before and after retiring to evaluate the policy effect on livelihood capital before and after the implementation of the policy. The results indicate that: (1) The effect of the policy on the livelihood capital is mainly reflected in three aspects: the improvement of capital index, the optimization of capital structure the narrowing of capital gap. (2) There is heterogeneity in policy effects among different regions. In general, the implementation of the ecological compensation policy in the Yangtze River has promoted the sustainability of the livelihood of retired fishermen, but the "involution" of the retired fishing households, the social harmony and stability of retired areas and the new round stratum solidification of the livelihood capital are still issues that need continuous attention in the ten-year fishing ban.

**Key words:·** fishing ban policy in the Yangtze River; livelihood capital index; coupling coordination degree; mobility

# 我国水污染防治的政策工具研究——基于 1984-2020年政策文本的量化分析

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**摘要：**“十三五”规划以来，我国的生态文明建设取得了显著成效，但环境问题仍然很严重，水污染防治作为生态文明建设的重要内容之一，需要在“十四五”期间进一步推进和加强。以1984年以来我国水污染防治政策文本为研究对象，基于水污染防治政策工具的基本类型，结合水污染防治政策治理过程、政策发文时间以及政策行动者三个维度，构建分析框架。通过对水污染防治政策文献的收集、整理、编码和量化分析，发现我国水污染防治政策体系较为完善。

**关键词：**水污染防治；环境政策；政策工具

## Research of Policy Tools for Water Pollution Prevention and Control in China ——A Quantitative Analysis Based on Policy Text (1984-2020)

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**Abstract:** Since the "13th Five-Year" Plan, China's ecological civilization construction has achieved remarkable results, but environmental problems are still serious. As one of the important contents of ecological civilization construction, water pollution prevention and control need to be further promoted and strengthened during the "14th Five-Year" Plan period. Constructe an analysis framework by taking China's water environment policy texts as the research object since 1984, which is based on the basic types of water environment policy tools and combines the three dimensions of water pollution policy governance process, policy issuance time and policy actors. Through the collection, sorting, coding and quantitative analysis of water pollution prevention and control policy documents, it is found that China's water pollution prevention and control policy system is relatively comprehensive. However, there are problems such as the imbalance in the use of policy tools, the weak governance links in the whole process of policy tools and the monotonous structure of the actors of policy tools. In the future, it is necessary to adjust the use proportion of flexible and rigid policy tools, strengthen the supply of the whole-process governance tools of water pollution control policies, promote the diverse participation of water pollution control policy actors, and improve existing policy tools and expand new ones.

**Key words::** Water pollution control; Environmental policy; Policy tool



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