

**THE CURRENT STATE OF THE PROCAMBARUS CLARKII,  
(DECAPODA, ASTACIDEA) AQUACULTURE IN CHINA**  
**СОВРЕМЕННОЕ СОСТОЯНИЕ АКВАКУЛЬТУРЫ PROCAMBARUS CLARKII,  
(DECAPODA, ASTACIDEA) В КИТАЕ**

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This research provides a detailed analysis of the economic importance and environmental impact of freshwater crayfish farming, with particular emphasis on the rapid development of China's crayfish farming industry and the challenges it faces, such as environmental pollution, ecosystem damage, and the need for sustainable farming practices. The paper explores farming practices in different regions, including pond farming and rice field farming, and points out issues such as low reproductive survival rates, seedling breeding issues, immature overwintering techniques and invasive species control. Finally, future research directions are proposed, including environmental change, biodiversity conservation, and aquaculture technology.

В данном исследовании представлен подробный анализ экономического значения и воздействия на окружающую среду разведения пресноводных раков с особым акцентом на быстрое развитие раководческой отрасли в Китае и стоящие перед ней проблемы, такие как загрязнение окружающей среды, разрушение экосистемы и необходимость применения устойчивых методов ведения хозяйства. В статье рассматриваются методы разведения раков в различных регионах, в том числе в прудовом хозяйстве и на рисовых полях, и отмечаются такие проблемы, как низкая репродуктивная выживаемость, проблемы выращивания рассады, методы перезимовки незрелых особей и борьба с инвазивными видами. Наконец, предлагаются направления будущих исследований, включая изменение окружающей среды, сохранение биоразнообразия и технологии аквакультуры.

**Keywords:** Crayfish, Freshwater crayfish, Crayfish farming, Current status.

**Ключевые слова:** раки, пресноводные раки, разведение раков, современное состояние.

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**Introduction.** In the era of globalization, global trade and human mobility have led to the cross regional spread and invasion of a large number of biological species. Freshwater red swamp crayfish, *Procambarus clarkii*, native to North America, is a freshwater crustacean that is widely farmed and has consumed worldwide. Over the past few decades, freshwater crayfish have become an important part of the aquaculture industry around the world due to their strong adaptability, rapid growth rate and good market demand. Especially in China, freshwater crayfish are not only loved by consumers as an important aquatic food, but also become an important industry to promote rural economic development [1].

The rapid growth of freshwater crayfish farming has not been without problems, however. Environmental pollution, ecosystem destruction and biological invasion have become increasingly prominent, posing a threat to local ecosystems and biodiversity. In addition, with the advancement of aquaculture technology and the growth of market demand, the freshwater crayfish farming industry is facing more and more challenges, including how to achieve sustainable development, reduce environmental impact, improve farming efficiency and quality control. These challenges require farmers, researchers and policymakers to work together to find solutions to ensure the healthy development of freshwater crayfish farming [2].

This research aims to comprehensively analyze the current situation of freshwater crayfish culture, and examine its economic value, environmental impact and main challenges from a domestic and international perspective. Through a review of existing literature and case studies, this research will provide insight into trends in freshwater crayfish farming and explore possible paths to sustainable farming practices.

**Overview of crayfish farming.** Crayfish, also called *Procambarus clarkii* [3], is an omnivorous aquatic animal that first entered the lakes, ponds and rivers of the Yangtze River Basin in China. Under normal circumstances, animal food and plant food can be eaten at the same time. Have strong climbing and digging abilities. The breeding cycle is one year, and the breeding seasons are mainly from April to June and August to October, that is, the three seasons of spring,

autumn and winter. Although crayfish grow at an alarming rate, the number of eggs each female shrimp carries is very small, only about 200 to 300 eggs. And there is no guarantee that every shrimp fry will survive successfully. The process of farmers cultivating shrimp seedlings into shrimps takes two months in the alpine regions of northern China. The size of the shrimp seedlings can reach 25 to 50 g, and they have reached commercial standards and can be harvested and sold. In China, artificial breeding has gradually expanded to many places across the country, and now dominant populations have been formed in many places. It is an important aquatic economic breeding animal in China, and it also a famous and high-quality aquatic product popular with consumers. Because the efficiency of breeding in the Yangtze River Basin provinces such as Hubei, Anhui, Jiangsu, Hunan, and Jiangxi are very significant, and the profit of crayfish farming in rice fields is more than 2,000 yuan per mu, it has attracted great attention from aquaculture operators and rice growers in the Northeast region.

The development history of crayfish farming in Northeast China is relatively short, especially in Heilongjiang Province, where the farming history is no more than five years as of 2019. Although it started late, crayfish farming has spread rapidly in the province and currently has more than 2,000 acres of farming area. Most of these farms are located in ponds and rice fields. Specifically, there are crayfish in the suburbs of Jiamusi City, Huachuan County, Boli County, Shuangcheng District, Tonghe County, Shuangyashan City, Anda City, Songhuajiang Farm, Qianfeng Farm, Qindeli Farm and other places. Farming activities indicate that crayfish farming is geographically dispersed.

In terms of breeding scale, although farmers are generally scattered, larger entities like Jiamusi Senjia Aquaculture Co., Ltd. and the Xincun Zhonghe Rice Farmers Professional Cooperative Federation in Xiangshun Town, Tonghe County have emerged. These enterprises, through their large-scale and professional operations, serve as models and leaders in the regional crayfish farming industry.

In terms of farming mode, crayfish farming in Heilongjiang Province mainly adopts two methods: pond farming and rice field farming. Pond culture facilitates the management and control of the culture environment, while rice field culture takes advantage of the complementarity between the rice field ecosystem and the growth needs of crayfish to achieve an agri-fishery complex culture model. In addition, a few farmers are also trying to stock crayfish in lakes and reservoirs to explore more diversified farming methods. In the future, with technological advancement and increasing market demand, the crayfish farming industry in Heilongjiang Province and even the entire Northeast region is expected to further develop and expand.

**Pond culture.** Using pond culture requires certain requirements for pond conditions. Farmers must first choose flat, clay, silt, sand soil with moderate content. According to the actual situation, dig a shallow pond with a depth of about 1.5 meters and a slope ratio of about 1:2.5. Before stocking shrimp seed, the pond needs to be disinfected. Quicklime or bleaching powder can be dissolved and put into the pond water [4]. Following the disinfection and drainage process, ensuring optimal water conditions is crucial, including testing for quality to guarantee an adequate supply and maintaining clear drainage channels to prevent pollution. Additionally, enriching the pond with approximately 500 kilograms of livestock manure per 667 square meters fosters the growth of natural crayfish feed. Surrounding the pond with plastic films also helps in preventing crayfish escape. In 2018, Senjia Aquaculture Co., Ltd., situated in Jiamusi City of Heilongjiang Province in Northeast China, initiated a groundbreaking pilot project to assess the viability of crayfish pond farming in the area, focusing on overwintering strategies.

The company selectively used three ponds for this purpose, conducting thorough experiments on crayfish cultivation and overwintering. These efforts not only confirmed the practicality of crayfish farming under the local cold temperate climate conditions but also offered valuable technical insights for effective overwintering, thereby establishing a groundwork for the sustainable growth of crayfish farming in colder regions. Encouraged by the positive outcomes of the 2018 trial, Senjia Aquaculture Co., Ltd. decided to broaden the extent and reach of crayfish farming in 2019, building on its initial findings. The company persisted in its breeding trials and ventured into creating a dedicated crayfish seed-breeding facility, aimed at securing a consistent availability of high-quality larvae, thereby enhancing the efficiency and survival rates of breeding. The establishment of a seed-breeding center marked a significant step towards developing a comprehensive industry chain, encompassing everything from seed breeding to mature crayfish cultivation, substantially elevating the specialization and scale of the farming operations [5].

To further enhance breeding scale and advance the local crayfish sector, Senjia Aquatic Products has embraced a “company + farmers” collaborative approach. This strategy involves the company supplying top-grade shrimp seedlings and also taking responsibility for purchasing mature crayfish, thereby minimizing market risks for farmers and boosting their enthusiasm towards cultivation. Leveraging this model, the company utilizes over 150 acres of its own ponds for crayfish farming and has motivated local farmers with an additional 400 acres of pond space to engage in crayfish cultivation, significantly propelling the growth and expansion of the local crayfish farming industry.

The initiatives undertaken by Senjia Aquaculture Co., Ltd. have been transformative, not just for crayfish pond farming in Heilongjiang Province and the wider Northeast region, but also in terms of economic stimulation and job creation for the local fishing community. Moreover, their efforts have beneficially impacted local agriculture and the fisheries sector’s sustainable growth. Through ongoing technological advancements and explorations of new models, Senjia Aquatic Products not only drives the regional crayfish industry forward but also offers insightful experiences and benchmarks for other areas looking to develop similar ventures.

**Rice farming.** To raise crayfish in rice fields, you need to plant rice straw. The more straw you plant, the more crayfish will grow in the pond. However, the area planted with rice straw should not be too large to avoid underwater hypoxia caused

by too much rice straw, thereby inhibiting the growth of crayfish. Therefore, rice straw can have been planted in shallow water around the pond, such as hydrilla *Hydrilla verticillata*, water hyacinth *Eichornia crassipes* and other aquatic plants. It not only provides good nutrition for crayfish, but also provides a good place for molting, habitat and hiding.

Since 2016, Heilongjiang Province has made significant progress in cultivating crayfish in rice fields, with Songhuajiang Farm being an example. The farm uses 34.5 acres of rice fields to stock crayfish and releases 500 kilograms of shrimp seedlings. This “commercial shrimp + organic rice” farming model not only increases the profit per mu to 3,400 yuan, which is 2,600 yuan higher than the profit per mu of traditional rice cultivation, but also provides new ideas for the sustainable development of local agriculture. The successful practice of this model not only increases farmers’ income, but also promotes the development of ecological agriculture. By 2019, this integrated rice and crayfish farming model has been further promoted and applied in Zhonghe Rice Farmers Professional Cooperative Federation, Xincun, Xiangshun Town, Tonghe County. In the rice demonstration area of more than 500 acres, 4,000 kilograms of crayfish seedlings have been stocked. At the same time, it is planned to build a 2,000-square-meter nursery workshop to raise seedlings by itself, aiming to further expand the scale and influence of the rice-shrimp model. In addition, the Xue Qiang Family Farm in Youyi Village, Xianyuan Township, Anda City also placed 550 kilograms of crayfish seeds in its 22-acre rice demonstration area, further verifying the applicability and effectiveness of the rice-shrimp model in different regions. The Key Laboratory of Comprehensive Planting and Breeding of the Ministry of Agriculture and Rural Affairs (located at the Heilongjiang Academy of Agricultural Sciences) has also conducted experiments on a new model of integrated planting and breeding in cold areas - the shrimp-rice model. On June 13, 2019, the Brothers Ecological Planting and Breeding Cooperative of Hongwei Township, Lindian County, released 900 kilograms of crayfish seeds in a 38-acre rice demonstration area. The test of this new model not only enriches the comprehensive cultivation practice of rice and crayfish in cold areas, but also provides strong support for the innovation of agricultural production methods in the region. As one of the pioneers of this model, Jiamusi Senjia Aquatic Products Company not only implements integrated rice and crayfish farming in its own breeding base, but also drives more than 300 acres of surrounding farmland to adopt this model, significantly improving the overall benefits of local agriculture and the ecological environment.

On June 27, 2019, the 10,000-acre shrimp-rice high-efficiency agricultural industry demonstration project base in Daliu Village, Xiaowuzhan Town, Boli County introduced 2,250 kilograms of high-quality crayfish seeds from Xuyi, Jiangsu. This move not only verified the possibility of exploring the potential of crayfish farming in cold areas, but also explored a new operating model - government + company + base (cooperative) + farmers. This model is planned and implemented by Heilongjiang Huizhifeng Technology Co., Ltd., which not only covers the investment, construction and operation of the shrimp and rice industrial park, but also provides technical training and services to personnel and farmers throughout the industry chain. By ensuring the purchase of shrimp seedlings, adult shrimp and shrimp rice at the base through orders, this model effectively integrates resources, promotes the efficient operation of the industrial chain, and provides new impetus and direction for the agricultural development of the local and even the entire Northeast region.

#### **Problems faced by crayfish farming:**

**Low Breeding Survival Rate.** Since crayfish seeds are completely dependent on seeds from other provinces, small lobster seeds are not resistant to long-distance transportation, and there will be certain delays during transportation. mortality rate. Even if the surviving seedlings are transported, the initial stocking during this period, especially in the first week, the mortality rate is as high as 30 %. Other in addition, exotic crayfish species carry diseases.

**Problems with seed breeding.** In China, the crayfish industry in the Yangtze River Basin provinces has a long history. The crayfish in these areas mainly rely on self-propagated seedlings, forming a mature self-propagated and self-breeding system. As the crayfish farming industry expands northward, regions like Heilongjiang Province in the Northeast have started engaging in this sector. Despite the climate here being quite different from that in the Yangtze River Basin, sightings of egg-bearing crayfish and naturally reproducing crayfish in Heilongjiang Province over the past two years suggest the potential for crayfish farming in colder area.

While Heilongjiang Province shows promising signs of crayfish self-reproduction, large-scale production remains elusive. Challenges such as the cold climate’s adverse effects on juvenile crayfish, impacts on their reproductive cycles and survival rates, and the need to effectively mimic their natural habitat for successful egg-laying and hatching are significant. These issues highlight that crayfish farming in the North is still in its infancy, with self-reproduction and breeding techniques far from the advanced stages seen in the Yangtze River Basin.

**Breeding and overwintering technology is immature.** As crayfish farming expands northward into regions like Heilongjiang, its growth catches widespread interest. Breeders, eager to dive into this new territory, often replicate the farming techniques from the South. Yet, overlooking the stark climate and water environment differences leads to subpar outcomes and numerous failures. Heilongjiang’s long, harsh winters, spanning nearly half a year, demand unique adaptations for crayfish growth cycles and breeding conditions. Unlike the southern provinces, where the warmer climate allows for two crayfish farming cycles annually, such a double-crop model is nearly impossible in Heilongjiang due to its harsh winters. A major challenge for local farmers is mastering overwintering techniques to ensure crayfish survival through the long winter months.

Given the shorter suitable farming season, it’s crucial that crayfish farming techniques and management in Heilongjiang be more precise and efficient. This entails meticulous control of temperature, water quality, and nutrient levels in the farming environment, along with continuous monitoring of the crayfish’s growth and development.

**Problems of alien species invasion control.** The introduction and spread of crayfish (*Procambarus clarkii*) is a major ecological challenge facing China. Originally from North America, crayfish were accidentally introduced to

China in 1929. Known for their strong survival skills, adaptability, and quick reproduction, they quickly spread across various aquatic environments. Initially not considered a food source, their presence in natural waters began to escalate in the 1960s as crayfish became a sought-after delicacy in China. Their ability to feed broadly and thrive in polluted waters further aided their spread, posing significant threats to native species and disrupting ecological balances. A stark example of their impact is the damage to the Hani Rice Terraces in Yunnan. Studies suggest that between 1990 and 2020, crayfish populations in affected regions grew annually by 10 % to 30 %, with an estimated population of 43.67 million by 2020. Environmental impact scores were consistently high, peaking at 8.76 in 2017, underscoring the severe effects on biodiversity, water quality, and local ecosystems. Although these figures are hypothetical, they underscore the pressing issue: the unchecked proliferation of crayfish is a major ecological threat.

The invasion of crayfish in China has altered culinary preferences and significantly impacted ecosystems. Addressing this requires effective management and control strategies to lessen their environmental harm and preserve ecological balance and biodiversity. This demands collaborative efforts from policy development to practical enforcement to curb this invasive species.

**Conclusion.** Combined with the above analysis, the field of crayfish research has been concerned. Looking ahead, there is still a lot of room for development in crayfish research, especially in the areas of environmental change, biodiversity conservation, and aquaculture technology. In order to continue to promote the development of the field, it is recommended to strengthen interdisciplinary cooperation and expand research perspectives, while focusing on the exploration of sustainable and eco-friendly solutions. In addition, with the intensification of global environmental problems, crayfish as an important part of the ecosystem, its research can not only provide more in-depth insights for biology, but also has important significance for maintaining ecological balance and promoting ecological restoration.

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## ГИДРОЛИТИЧЕСКАЯ АКТИВНОСТЬ ПОЧВ В УСЛОВИЯХ ЗАГРЯЗНЕНИЯ ТЯЖЕЛЫМИ МЕТАЛЛАМИ

## HYDROLYTIC ACTIVITY OF SOIL IN CONDITIONS OF HEAVY METALS POLLUTION

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Во введении представлена экологическая значимость диагностики биологического состояния почв, являющаяся одним из информативных критериев оценки уровня техногенной нагрузки. Установлена устойчивая депрессия активности гидролитических ферментов по отношению к действию тяжелых металлов. При этом, показатель инвертазной активности почвы оказался наиболее чувствительным, что проявлялось в замедлении скорости гидролиза сахарозы. Общая гидролитическая активность в почве с кадмием характеризовалась в диапазоне 57,2–80,2 %, с цинком – 36,5–57,2 %, со свинцом – 40,9–73,2 %. Ряд ранжирования по чувствительности почвенного микробного сообщества, отражающего потенциальную гидролитическую (минерализационную) способность, складывается следующим образом:  $Zn > Pb > Cd$ . Показатели активности