

Research Progress on Feeding Behavior of Prawn Based on Passive Acoustics

Nanqing Huang

College of Nanjing University of Finance & Economics, Nanjing, China

ABSTRACT

Passive acoustic monitoring (PAM) technology can obtain the sound information of aquatic organisms without causing disturbance or damage to aquatic organisms, and use the information for various ecological research and aquaculture activities management. With the continuous improvement and progress of prawn culture technology, the density of prawn culture continues to increase, but the problems such as low feed utilization rate and deteriorating water quality seriously restrict the rapid development of prawn culture. The use of passive acoustic monitoring technology can realize intelligent automatic feeding, improve feed utilization and alleviate water quality deterioration. This paper mainly describes the feeding process of prawn and its influencing factors, summarizes the research progress and application of passive acoustic monitoring technology in the acoustic signal of prawn feeding in recent years, analyzes the advantages and disadvantages of passive acoustic monitoring technology, and puts forward the future development trend in view of the existing problems, in order to provide a reference for the automatic feeding system to become intelligent.

KEYWORDS

Passive acoustic monitoring technology; Prawn; Ingestion; Sound signal

1. INTRODUCTION

Passive acoustic monitoring (PAM) technology collects and records the acoustic signals of animals in the environment by installing sound sensors (hydrophones) in the environment. This technique mainly studies sound interactions in the environment and is widely used in remote observation of Marine mammals . PAM technology uses the radiated noise of underwater target, and then detects, identifies, locates and tracks the target. The collected signal mainly contains the characteristics of the detected target, and these characteristics express the behavior of the target. In recent years, PAM technology has been used in shrimp ponds to control feed, which can detect the sound signal characteristics generated by shrimp when feeding feed. Due to the slow feed intake rate of prawns, the feeding situation of prawns is estimated mainly by observing the residual feed amount on the feed tray. However, the muddy and complicated water environment in the shrimp pond and the benthic nature of prawns make it difficult for aquaculture personnel to accurately judge the feeding situation and growth state of prawns by direct observation or watching videos, and the phenomenon of overfeeding or underfeeding often occurs. There are various technologies available to monitor the movements of aquatic animals, but these techniques can face considerable challenges in observing prawns' feeding behavior in the field. PAM technology can utilize hydrophones in complex shrimp

The sound signal in the feeding feed of prawn is obtained in the pond environment, and the feed demand of prawn is calculated by a specific algorithm, so as to improve the utilization rate of feed . At present, PAM technology has been one of the main technologies to study crustacean behavior.

Researchers will use PAM technology to study the sounds made by different types of crustaceans and identify the characteristics of the sounds .

Prawn farming is a rapidly growing industry. Prawn meat is delicious and nutritious, and it has become one of the important aquaculture varieties, providing a large amount of high-quality protein for the aquatic product market. 2022

The cultured output of prawn is 5.74 million tons , which is a kind of breeding species with high economic value. Feeding management of shrimp in aquaculture is a complex process, and scientific feeding of feed will be affected by many factors, such as water quality and environment, shrimp activity range, weather, etc. . Improper feeding will lead to low utilization rate of feed, deterioration of water quality and other problems. PAM technology can be applied to a wide range of feeding environmental conditions to assess the feeding behavior of prawn. Some scholars use PAM technology to understand the feeding behavior of prawn and help farmers solve problems such as low feed utilization rate and deteriorating water quality, so as to achieve better feed utilization rate and sustainable development .

This study outlines the process of shrimp feeding and the factors that influence shrimp feeding behavior, providing a detailed discussion of the progress and application of PAM technology in monitoring shrimp feeding vocalization signals, summarizing the challenges faced by the technology's development, and proposing future trends, in order to provide reference for the application and promotion of PAM technology in shrimp farming.

Shrimp are benthic omnivorous animals, and the feeding behavior of shrimp is completed through a chain of reactions of appetite, stimulation, searching, swallowing, satiation, and hunger . The storage capacity of the shrimp digestive system is very limited, and it needs to continuously feed on small amounts of feed. The feeding behavior of shrimp is influenced by olfactory and gustatory senses, with olfactory receptors being the first antennae and gustatory receptors being the appendages and legs near the mouth. Shrimp mainly rely on chemical information to locate the bottom of the shrimp pond food, and when searching for food, they use the first three pairs of walking legs to search for food. When they find food, they immediately use the walking legs to hold the food and then bring it to the mouth. Shrimp can directly swallow small particles of food, and they can hold large particles of food with the third maxilliped and then tear and cut it for ingestion .

The type and quality of feed will affect shrimp feeding, growth, and feed coefficient . Inappropriately replacing plant protein with animal protein, an unreasonable amino acid composition structure, low calcium content, and the absence of trace elements in the feed will cause shrimp to absorb nutrients insu Hamilton et al. discovered that lobsters emit clicks by using a stirring system located at the base of their antennae in similar environments. Crustaceans not only emit sounds in territorial behavior, sexual behavior, and social behavior, but also in other activities. The PAM (Passive Acoustic Monitoring) technology detection report for shrimp behavior reported that the "frying" sound was first produced in the fishing area of the Gulf of Mexico in the *Litopenaeus setiferus* species. The video and hydrophone synchronized recordings and analyses of the *Penaeus monodon* and *Litopenaeus vannamei* confirmed that the "clack" sound was emitted when the lower jaws collided and scraped against each other, mainly related to the calcification of the lower jaw, which can be more effective in tearing food.

2. ORGANIZATION OF THE TEXT

Sound frequency. Hunt et al. found that the pulse signal frequency generated by the *Litopenaeus vannamei* during growth was mainly between 2-8 kHz, which was related to feeding, and its sound waveform had certain regularities. Zhang Lizhen et al. studied the characteristics and regularities of the feeding-related sound signals of the *Litopenaeus vannamei*, and found that the sound signals before and after feeding were distinctly different. The feeding frequency range was approximately

(5-15) kHz after feeding duration. The sound of shrimp feeding would present short bursts of pulses. The single sound pulse duration of *Litopenaeus vannamei* feeding granular feed of different body lengths was different, reflecting the randomness of shrimp feeding behavior. Peixoto et al. found that the results of the sound duration in two experiments were consistent, around 2.7 ms; but Silva et al. found that the sound duration of different specifications of *Litopenaeus vannamei* in the artificial breeding process was around 4.7 ms. There was a significant difference between them, which may be caused by the experimental environment, feed type, and shrimp specifications, etc.

Different textures and specifications of feed will lead to certain differences in the sound intensity produced by shrimp when feeding. With the increase of hardness of feed, shrimp will decompose feed by increasing the number of biting times, and the sound intensity generated by feeding will also increase. Different textures and sizes of feed affect the bite force exerted by the lower jaw when cutting feed particles, thus affecting the acoustic signature generated during feeding. The hardness and moisture of feed will affect the characteristics of feeding sound signal. Compared with puffed feed, the stability and physical durability of pellet feed are lower. Soares et al. found that when *Litopenaeus vannamei* with different body length fed pellet feed and expanded feed, the feeding frequency and feeding sound intensity of *Litopenaeus Vannamei* with larger body length were higher than those of *Litopenaeus Vannamei* with smaller body length. Peixoto et al. also studied the feeding of granular feed and puffed feed for *Litopenaeus vnanaeus*, and the results showed that the sound intensity of puffed feed was higher than that of pellet feed, while the peak frequency of pellet feed was higher than that of puffed feed. Peixoto et al. found that the length of pellet feed was related to the feeding times of prawn, which affected the vocal times of a single feed, and there was a significant correlation between feed consumption and the acoustic energy generated by each particle size of pellet feed. However, the pellet feed used in the breeding of *Litopenaeus vannamei* abroad is not fully applicable to the situation in China. Cao Zhengliang et al. found that there were significant differences in the acoustic signal characteristics when *Penaeus vannamei* fed silkworm and pellets with different particle sizes, and the frequency generated when feeding pellets with different particle sizes was similar. Wang Xiuxiu found that when *Penaeus vannamei* ate four kinds of feed with different textures (pellet feed, silkworm, squid and shrimp shell), the sound signal features were different and the frequency range was similar, but there were obvious differences between the peak frequency and the main peak frequency.

3. LITERATURE REFERENCES

At present, researchers at home and abroad use PAM technology to correct.

In this study, we determined that the characteristics of vocal signals are different when shrimp feed on different feeds, and effectively evaluated the feeding behavior and feeding frequency of shrimp. These studies are helpful to provide a reference for feeding shrimp in aquaculture. PAM technology can be used to predict feed consumption, so as to improve feed utilization, which also lays a foundation for the study of PAM technology in the feeding behavior of shrimp. From the perspective of domestic and foreign research, most of them focus on pellet feed with different particle sizes, and the pellet feed eaten by *Litopenaeus vannamei* at different growth stages in actual breeding will be different. Therefore, future research should focus on in-depth exploration of how the differences in the intake of different types of feed by *Litopenaeus vannamei* are reflected in the changes of acoustic signal characteristics.

Stocking density is one of the important factors affecting the acoustic parameters of feeding activities. High stocking density leads to interference between shrimp during feeding, making the feeding sound chaotic. Reis et al. showed that feeding acoustic signals of shrimp can be collected under different aquaculture environments, feeding conditions, and stocking densities. Costa et al. found that the behavior of *Penaeus vannamei* shrimp in different stocking densities would show obvious differences,

and as the stocking density increased, the growth environment of the shrimp in the pond changed, leading to a decline in growth and survival rate, which are related to living space.

The number of feeding sounds emitted by shrimp increases significantly as the stocking density increases, and this trend shows a gradual progression from the lowest density to the highest density. Currently, research on shrimp feeding sounds has all been conducted in laboratories, and the stocking density in different ponds may vary. Therefore, in future research, it is necessary to further determine the changes in sound energy and feeding volume of shrimp at different stocking densities, as well as the feeding sounds of shrimp in different aquaculture environments. Moreover, PAM technology has not been widely applied to study the impact of stocking density on shrimp feeding behavior, and by using PAM technology, it is possible to better understand the feeding sounds of shrimp at different stocking densities, which can help to estimate the population density of shrimp in muddy ponds.

The biting force of the maxilliped of different-sized shrimp will differ, and the maxilliped will continue to mature and develop as the shrimp grows, resulting in significant differences in the feeding sounds of shrimp. Hamilton et al. studied the acoustic signal features of feeding sounds in different sizes and stocking densities of the Pacific white shrimp, and found that the number of feeding times increased as the size of the shrimp increased. Moreover, the larger shrimp had a higher overall "click" sound. Other studies have shown that the size of the shrimp has a certain influence on the acoustic parameters of feeding activities, for example, the juvenile shrimp (0.04 g) showed higher peak frequency and lower energy in the frequency band compared with the larvae or juveniles or adults (1-12 g). Silva et al. found no significant differences in the acoustic signal features of the three different-sized Pacific white shrimp through research, but the feeding behavior of the larger shrimp was much faster than that of the smaller shrimp, and the feeding frequency and intensity were stable. Cao Zhengliang et al. found that the feeding sound signals of the Pacific white shrimp with different body lengths (2-3 cm, 4 The passive acoustic feeding system (AQ1 Systems) developed in Australia is a recently developed and applied feed control system based on acoustic sensors in shrimp farming, which uses PAM technology to control feeding frequency and feeding amount. Bador et al. conducted trials with the acoustic control system in different ponds and with different shrimp species by monitoring the feeding behavior of shrimp in real time to dynamically adjust feeding strategies, and compared it with the traditional feeding method. The ponds using the acoustic control system showed higher feed conversion rates and significantly improved growth rates of shrimp, with average yields increased by 25% to 30% for all species. Napaumpaipom.

Study on the Application of Precision Aquaculture Monitoring (PAM) Technology in *Penaeus monodon* Cultivation: A Review.

The study compared the application effects of three different feeding management techniques (manual feeding, automatic timed feeding device, and AQ1 system) in intensive *P. monodon* farming, and found that the feed conversion rate was lower with the AQ1 system, the survival rate and yield of *P. monodon* were higher, and the water quality was improved. In addition to the feeding method, the automatic feeding system can also increase the frequency of daily feeding and the input of daily feed. Ullman et al. compared the application effects of different feeding strategies in *P. monodon* pond farming, and the results showed that using the AQ1 system can optimize the feeding strategy, achieve high economic benefits in a shorter cultivation cycle, and the feeding amount using the AQ1 system can reach 160 kg / (hm²·d), the feeding amount increased significantly again. The AQ1 system has more obvious advantages than other feeding technologies, with better growth performance, feed conversion rate, yield, and economic benefits than manual feeding. Reis et al. improved the automatic timed feeding device and the AQ1 system to improve the growth performance and yield of *P. monodon* by setting four feeding strategies, three fixed feeding treatments used the automatic timed feeding device, one demand-based treatment used the AQ1 system, using the AQ1 system can significantly improve the growth performance and yield of *P. monodon*, and using the AQ1 system in feed management is an important way to achieve precise feeding and improve aquaculture

efficiency; at the same time, this study provides valuable reference for the future improvement and development of feed automation technology.

4. SUMMARY

Although the research on acoustic feeding systems has achieved certain results, there are still some limitations. The AQ1 system is affected by external noise, which increases the difficulty of extracting and analyzing acoustic signals. The system is expensive, and the installation and maintenance of the equipment are complex, which increases the cost of long-term maintenance. In addition, the acoustic signals of different aquatic organisms are significantly different, which makes it difficult for the system to precisely monitor the There are also differences in feeding behavior among shrimp at different growth stages, so the PAM technology's ability to identify and monitor is not sufficient to meet the needs of different situations. So far, the PAM technology has achieved significant results in the experimental environment, but its application and promotion in actual aquaculture still face many challenges. Many farmers have insufficient awareness of PAM technology and hold skeptical attitudes. In actual application, it is necessary to fully utilize the advantages of PAM technology and overcome its limitations, and continuously promote and popularize it.

PAM technology has been constantly developed in the study and application of shrimp, and this technology has greatly improved the management and utilization efficiency of feed . In the past 20 years, significant achievements have been made in the research of intelligent feeding technology in aquaculture, which has become one of the main research trends . PAM technology can monitor shrimp feeding behavior and can be combined with automatic feeding systems to achieve feeding on demand, avoiding overfeeding, and improving feed utilization rate. PAM technology can not only be used for feed management, but also by monitoring shrimp acoustic activity to determine the shrimp's health status and abnormal behavior. With the progress of wireless communication technology and artificial intelligence, PAM technology is developing towards intelligent and efficient direction . The development of real-time monitoring and warning systems is an important trend in the application of PAM technology in shrimp farming, real-time transmission and analysis of acoustic data can further accurately grasp the shrimp farming situation. By combining PAM technology with artificial intelligence, researchers can develop more precise models for signal processing and analysis, and extract more effective information more efficiently. The related equipment of PAM technology will gradually become smaller and portable, which will make PAM technology easier to deploy and use in the breeding environment, and reduce breeding costs. Data sharing and open platform are important directions to promote the development of PAM technology, by establishing an open data platform, researchers can more conveniently access and utilize global acoustic data resources. These trends not only promote the application of PAM technology in shrimp research, but also provide important technical support for shrimp farming. With the further development and improvement of the technology,PAM technology will promote the scientific and technological progress and sustainable development of the shrimp farming industry .

PAM technology plays an important role in the development of prawn culture. At present, the acoustic research on prawn feeding is in the initial stage in China, and it is necessary to further understand and recognize the acoustic information of prawn feeding behavior and other behaviors. PAM technology is used as an alternative method to monitor shrimp feeding activities, so as to realize real-time on-demand feeding, and the automatic feeding system is transformed from mechanization to intelligence. However, there are still some challenges in the application of this technology in actual production, and further research is needed. Such as whether there is a difference in feeding different types of feed, the changes in sound intensity and food intake of shrimp with different stocking density during feeding, and the feeding sound mechanism of stocking density in different farming environments, etc. According to the characteristics of the feeding sound signal of shrimp at different growth stages, the

feeding sound was applied in aquaculture to realize automatic feeding, reduce the impact of over-feeding on the environment, and promote the sustainable development of shrimp culture.

REFERENCES

- [1] HAMILTON S, SILVA J F, PEREIRA - NEVE A, et al. Sound production mechanism in the Brazilian spiny lobsters (Family Palinuridae) [J]. *Zoomorphology*, 2019, 138(4):475-482.
- [2] BOHNENSTIEHL D R, LILLIS A, EGGLESTON D B. The curious acoustic behavior of estuarine snapping shrimp: temporal patterns of snapping shrimp sound in sub-tidal oyster reef habitat [J]. *PLoS ONE*, 2016, 11(1): e0143691.
- [3] POPPER A N, SALMON M, HORCH K W. Acoustic detection and communication by decapod crustaceans [J]. *Journal of comparative physiology A, Sensory, neural, and behavioral physiology*, 2001, 187(2):83-89.
- [4] REIS J, PEIXOTO S, SOARES R, et al. Passive acoustic monitoring as a tool to assess feed response and growth of shrimp in ponds and research systems [J]. *Aquaculture*, 2022, 546:737326.
- [5] SILVA J F, HAMILTON S, ROCHA J V, et al. Acoustic characterization of feeding activity of *Litopenaeus vannamei* in captivity [J]. *Aquaculture*, 2019, 501:76-81.
- [6] HUNT M J, WINSOR H, ALEXANDER C G. Feeding by penaeid prawns: the role of the anterior mouthparts [J]. *Journal of Experimental Marine Biology and Ecology*, 1992, 160 (1):33-46.
- [7] PEIXOTO S, SOARES R, ALLEN DAVIS D. An acoustic based approach to evaluate the effect of different diet lengths on feeding behavior of *Litopenaeus vannamei* [J]. *Aquacultural Engineering*, 2020, 91:102114.