A Study on Artemia Culture System and Its Application

Wanying Zhang *, Yicheng Wu, Ziting Zhang,Yumei Huang
Tianjin University of Science and Technology, Tianjin, China
*E-mail: *3123559440@qq.com*

Abstract

Aimed at the shortcomings of the low efficiency and high cost of Artemia culture, this paper proposes a high-density Artemia culture system based on the Internet of Things technology. The system detects and controls the breeding environment through sensors and actuators, and uses a cloud platform to analyze and process the collected data. Automation control and remote monitoring of the system reduce the cost of breeding and human resource. The system's Internet of Things technology provides scientific basis and decision support for Artemia culture.

Keywords: the Internet of things, intelligent control, artemia, high density culture

1. Introduction

The "14th Five-Year Plan" emphasizes the importance of the fishery sector in implementing new development concepts, expanding food sources, and increasing farmers' income. It also proposes the use of science and technology to promote the high-quality development of the fishery industry. Currently, China's aquaculture and seedling industries are world leaders (as shown in Fig1).

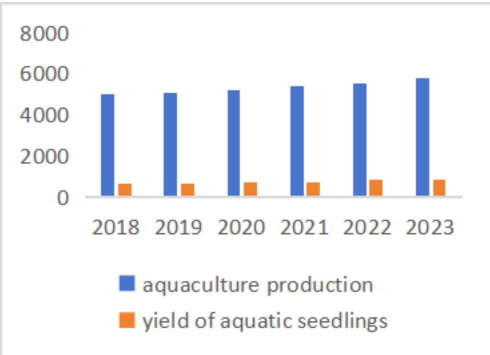

Fig. 1 Production of aquaculture and seed industry

The quality of feed for aquatic seedlings is a key factor in determining the quality of aquatic products. Artemia, with its high protein content and short growth cycle, is widely used as feed in marine aquaculture breeding. Studies indicate that about 90% of artemia eggs come from inland salt lakes. However, these salt lakes are at risk of drying up due to climate change. As the global aquaculture industry continues to expand, the demand for artemia is rising, yet its natural resources are becoming increasingly scarce. Currently, indoor artemia breeding requires frequent manual monitoring and feeding, which is time-consuming and labor-intensive, making large-scale breeding challenging. Therefore, industrialized high-density artemia culture holds significant economic potential. By integrating intelligent artemia breeding systems with Internet of Things technology, breeding efficiency can be greatly improved, costs reduced, and the quality of the final product enhanced.

The structure of this article is as follows: Section 2 presents related research on the growth conditions of artemia. Section 3 describes the overall design, as well as the detection and control modules of the system. Section 4 highlights the advantages of this design compared to traditional artemia breeding methods. Finally, Section 5 provides a summary of the main findings of the paper.

2. Study On Artemia Growth Conditions

Artemia is widely used in aquaculture as a feed for fish, shrimp, and crab larvae due to its rich nutritional value in early developmental stages. To efficiently culture artemia, achieve high hatching rates, and ensure optimal growth during the guarantee period, it is crucial to study the factors influencing its growth.

The growth and survival of artemia result from the combined effects of temperature and salinity. This study focuses on the American Great Salt Lake artemia. Through extensive experiments, it was found that when temperature is constant, artemia's growth length is positively correlated with salinity—higher salinity leads to greater growth. Conversely, when salinity is constant, survival time is negatively correlated with temperature; higher temperatures shorten the survival time of artemia. The results indicate that the optimal growth and survival conditions for artemia occur at 28°C and 20 ‰ salinity. Notably, at a temperature of 24°C, salinity does not significantly affect artemia hatching.[1]

Further studies have revealed that, in addition to temperature and salinity, other environmental factors also play a crucial role in the growth and development of artemia. For example, light intensity influences artemia's photosynthesis and biological rhythms. While appropriate light supports growth and reproduction, excessive or insufficient light inhibits development.[2] Dissolved oxygen is another key factor, as Artemia requires adequate oxygen for respiration and metabolism. Low oxygen levels can result in stunted growth or even mortality. Additionally, the pH level of the water affects artemia's nutrient absorption and enzyme activity.

Maintaining an optimal pH range ensures proper enzyme function and supports normal growth.

3. System Design

3.1. Overall system architecture

The high-density aquaculture system for artemia uses Internet of Things technology to detect and control the growth environment of brine worms. It can be divided into four parts: perception layer, network layer, platform layer, and application layer. Among them, the perception layer detects the environment through sensors and execution pumps; The network layer is implemented by IoT gateways and communication controllers for centralized data collection and transmission; The platform layer is the OneNET cloud platform, which conducts data mining and computation to optimize the incubation plan; The application layer consists of computer, mobile APP, and PAD (both computer and PAD are web versions). Users can monitor the breeding situation in real time and remotely control and manage the breeding environment through these three media.(as shown in Fig2)

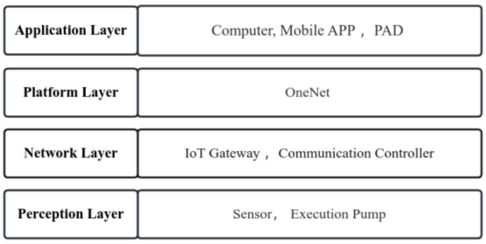

Fig. 2 Overall architecture diagram

3.2. System hardware design

The hardware equipment used in the high-density aquaculture system for brine worms based on Internet of Things technology mainly includes two parts: sensors and actuators. In terms of sensors, it mainly includes temperature sensors, salinity sensors, pH sensors, turbidity sensors, light sensors, dissolved oxygen sensors, etc., to ensure comprehensive monitoring of the aquaculture environment. The actuators include peristaltic pumps, circulation pumps, heaters, quantitative pumps, air pumps, and lighting control equipment. (as shown in Fig3)

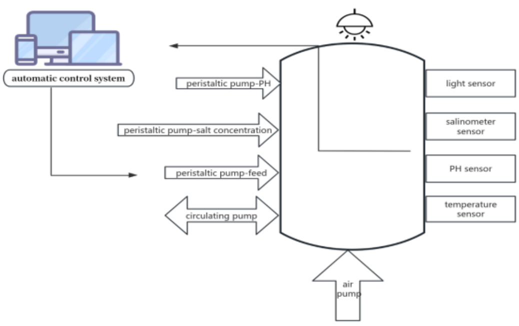

Fig. 3 System Hardware Design Diagram

(1) Water environment monitoring

In the process of brine worm cultivation, environmental conditions are the most important influencing factor on its growth. Different environmental conditions can cause changes in the growth rate of brine worms, and some species of brine worms require specific environmental conditions for growth and reproduction. The following provides a detailed explanation of the core technical principles of water environment monitoring.

Water salinity detection module: The working principle of the salinity sensor is to indirectly measure the salinity of saltwater by measuring the ion concentration in the saltwater using conductivity. That is, when the concentration of salt ions in the water increases, the conductivity also increases.

Water display module: In order to facilitate users to quickly understand the relevant information of the aquaculture environment, the system adopts the USART serial port screen as the water display module (as shown in Fig4). This display screen can display real-time water information such as temperature, light intensity, salinity, pH, etc., helping users accurately analyze and process data.

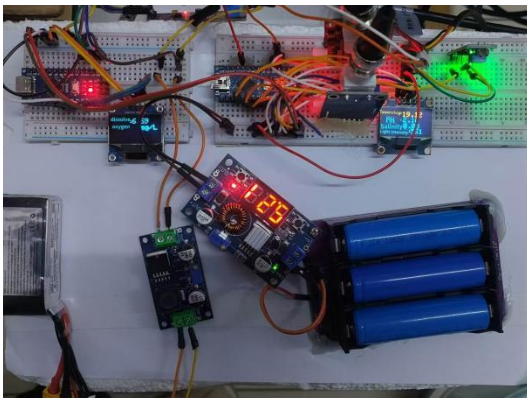

Fig. 4 Water display module

Water dissolved oxygen module [3]: The core technical principle of water dissolved oxygen sensors is fluorescence method, which involves the interaction between dissolved oxygen and fluorescent substances, resulting in a change in fluorescence intensity. When the concentration of dissolved oxygen increases, the fluorescence intensity decreases, and vice versa, it increases. Based on this characteristic, dissolved oxygen sensors can accurately determine the concentration of dissolved oxygen in water by measuring changes in fluorescence intensity.

Water pH detection module: The working principle of the pH sensor is based on the relative voltage between the signal electrode and the reference electrode to measure the pH value of the solution. When the pH value of the solution is 7 (neutral), the theoretical output voltage of the reference electrode is 0. As the acidity or alkalinity of the solution changes, the output voltage will correspondingly undergo positive or negative changes..(as shown in Fig5)

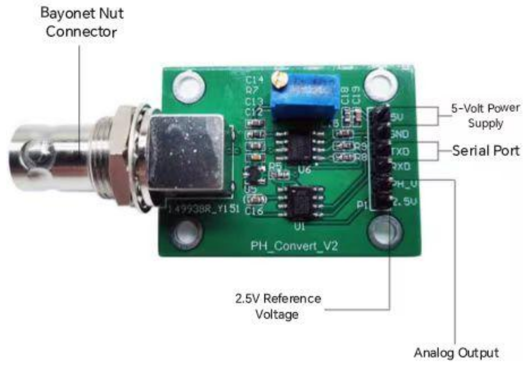

Fig. 5 Water pH detection module

(2) Water environment control

This system controls the water content, feed, temperature, light intensity, and dissolved oxygen in the water environment through a series of actuators. As shown in Fig6.

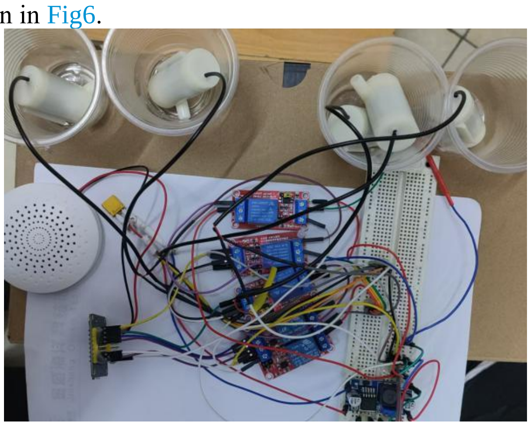

Fig. 6 Water control module

3.3. *Intelligent decision and control module*

The high-density breeding system for brine worms based on Internet of Things technology is designed with automatic water change, temperature control, feeding, oxygenation, and lighting functions in the brine worm breeding environment. Breeding users can monitor the breeding environment in real time through media such as PC and mobile APP.[4] In addition, the addition of voice assistants allows aquaculture users to issue commands to the system through voice, enabling them to regulate the environment of brine shrimp farming. (As shown in Fig7)

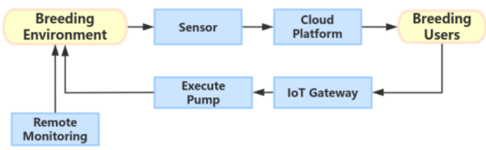

Fig. 7 Schematic diagram of the system operation

The various levels of the system cooperate with each other and work together. The system is equipped with advanced intelligent devices and sensors to monitor various parameters of the breeding environment in real time, and transmit the data to the platform backend for analysis and processing. The platform integrates, analyzes, and mines the collected data through big data management and analysis technology, providing real-time breeding data for breeding users; Through the Internet of Things gateway, the breeding environment can be intelligently controlled, achieving precise control over breeding environment, feed feeding, water quality testing, and other aspects, to meet the growth needs of brine worms to the greatest extent possible. At the same time, this system supports remote monitoring and remote operation functions, making it convenient for breeding users to control and manage the breeding environment anytime and anywhere. The overall schematic diagram of the system is shown in Fig8.

Fig. 8 Overall schematic diagram of the system

4. System Test

A high-density Artemia breeding platform based on Internet of Things technology integrates intelligent systems, data management, and aquaculture production. Through demand analysis and market research, the technical plan for the Artemia intelligent breeding platform was developed, encompassing the platform's basic structure, functional modules, and data processing flow. Following the overall system design, each functional module undergoes testing, which is primarily divided into two parts: the monitoring node test and the data transmission node test.

4.1. *Monitoring node test*

During the testing period, key environmental parameters such as dissolved oxygen, pH, water temperature, and salinity were successfully detected, and corresponding values were accurately obtained. Although there was a slight time lag when uploading data to the web end due to the influence of network transmission speed, the lag was exiguous and had negligible impact on the overall system performance and data accuracy.[4] The display module operated stably without any abnormalities and was able to display important information such as temperature, light intensity, and humidity at any time according to user needs, which providing great convenience for system debugging and daily management. Additionally, the USART serial port screen equipped with the system had excellent data processing capabilities, allowing for rapid and accurate processing of various data, so that fishermen and professional technicians could analyze the data timely and accurately, thereby making scientific and reasonable breeding decisions.

4.2. Data transfer node test

As a crucial hub connecting monitoring nodes and the cloud platform, the data transfer node is responsible for vital data transmission and command interaction tasks. In this system, the data transfer node employs Node MCU to achieve A/D conversion signal acquisition, the design that ensures the accuracy of data collection and lays a solid foundation for subsequent precise control. For data transmission, the system selects Wi-Fi for wireless transmission, enabling stable and efficient transmission of collected data to the network for storage. This ensures the timeliness and integrity of the data while also providing strong support for data processing and analysis on the cloud platform. Through rigorous testing of the data transfer node, it is ensured that it can stably and reliably achieve bidirectional data transmission during system operation, effectively guaranteeing the normal operation of the entire aquaculture platform.

5. Contrastive Analysis

Traditional Artemia aquaculture techniques mostly rely on existing salt pans and mudflat resources, which have the merit of certain cost advantages and relatively simple operations. However, this model faces numerous challenges, with significant impacts from uncertain factors such as climate and seasons, leading to large fluctuations in production and difficulties in ensuring stable Artemia quality. For instance, extreme weather conditions like heavy rainfall and drought can damage the growth environment of artemia, trigger pests and diseases, and severely affect both the yield and quality of artemia.

In comparison, the high-density Artemia aquaculture system designed by us demonstrates significant advantages. Equipped with precision sensors and advanced controllers, the system enables full-process and multi-dimensional precise monitoring and control of various parameters in the artemia aquaculture environment. From precise regulation of the aquaculture environment to delivery feed scientifically, and real-time water quality monitoring, every aspect is managed with fine precision, greatly enhancing the stability of Artemia production and quality.

6. Summery And Prospect

This project has developed a high-density Artemia aquaculture system relying on modern Internet of Things (IOT) technology, providing a novel platform for artemia aquaculture. Additionally, the system innovates in the application of artificial intelligence, the integrated use of detection equipment, and the overall aquaculture mode of artemia, promoting the overall transformation and upgrading of the industry. In the future, the high-density Artemia aquaculture system based on IOT technology will leverage its advanced technological advantages to propel the aquaculture industry towards intelligence and sustainable development.

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Authors Introduction

Ms. Wanying Zhang

She studied at Tianjin University of Science and Technology in 2022 and is currently a bachelor student in Marine Academy. She expects to receive a bachelor's degree in 2026.

Ms. Yicheng Wu

She is currently studying in Tianjin University of Science and Technology, she has mastered the knowledge of marine resources development and application, protein extraction and content determination.

Ms. Ziting Zhang

She was admitted to Tianjin University of Science and Technology in China in 2022 and is currently an undergraduate student in the School of Oceanography and Environment at Tianjin University of Science and Technology

Ms. Yumei Huang

She studied at Tianjin University of Science and Technology in 2021.She is now the first major in her faculty and is expected to receive her Bachelor's degree in 2025.