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RESEARCH ARTICLE

Optimization of Crustacean Cultivation Biotechnology Using Biofloc Technology (BFT)

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ABSTRACT

The article presents the results of an experimental study aimed at optimizing the biotechnology of cultivation of the Australian redclaw crayfish (*Cherax quadricarinatus*) using Biofloc Technology (BFT). Over a 21-day period, crustaceans were maintained in a BFT system at an average temperature of 27.3 °C, while dissolved oxygen concentration averaged 8.7 mg/L. The average body weight of crayfish increased from 13.97 g to 17.81 g; the average daily weight gain amounted to 0.18 g/day, which is comparable to the productivity achieved under pond culture conditions. The obtained data substantiate the prospects of applying biofloc technology for the commercial cultivation of tropical crustaceans in regions with climatic limitations for traditional crayfish cultivation.

INTRODUCTION

Global aquaculture has demonstrated stable positive growth over recent decades. According to the latest data of the Food and Agriculture Organization of the United Nations (FAO), presented in The State of World Fisheries and Aquaculture (SOFIA) 2024 report, aquaculture production in 2022 equaled, and subsequently exceeded, the volume of industrial fisheries production for the first time in history. Total aquatic animal production in 2022 reached 185.4 million tons. Of this amount, aquaculture accounted for 94.4 million tons, representing 51% of global aquatic organism production. As noted by FAO experts, this trend confirms the potential of aquaculture to meet the growing global demand for aquatic food products, whereas catches of wild species have remained relatively stable since the late 1980s [2].

Crustaceans constitute a significant share of commercial aquaculture production. In the Russian Federation, the commercial crustacean cultivation sector is characterized by gradual increases in production volumes and expansion of the species composition of cultivated organisms. Freshwater crustacean species are predominantly cultivated in Russian aquaculture facilities. Over the past decade, particular interest has been directed toward tropical species characterized by high growth rates and favorable commercial qualities. Among such species is the Australian redclaw crayfish (*Cherax quadricarinatus*), which, due to its rapid growth rate, disease resistance, and tolerance to relatively high stocking densities, is considered a promising species for industrial aquaculture.

In modern crustacean aquaculture, one of the most widespread and technologically justified approaches is the combined cultivation method. This technology involves division of the production cycle into two principal stages. During the first stage, juveniles (larvae and postlarvae) are reared in recirculating aquaculture systems (RAS). During the second stage, after juveniles reach a certain body weight, they are transferred to open water bodies, namely ponds. It is under pond culture conditions that aquatic organisms attain marketable size. The pond cultivation stage is characterized by lower operational costs compared with RAS, since the natural food base

partially substitutes expensive compound feeds, while large water areas provide sufficient space for growth. However, despite its economic accessibility and the possibility of utilizing natural food resources, pond cultivation is associated with several significant disadvantages, primarily determined by climatic factors. The optimal temperature range for crustacean growth and development in the Russian Federation is 25–30 °C. Taking into account the aquaculture zoning of the territory, pond cultivation of crustaceans requiring elevated temperatures is possible only in southern regions belonging to fishery zones 5, 6, and 7 [6].

It should also be noted that under RAS conditions, certain difficulties arise during the early developmental stages of aquatic organisms. The principal issue is the accumulation of ammonia and nitrites generated as a result of the metabolic activity of aquatic organisms and decomposition of feed residues. In global aquaculture practice, Biofloc Technology (BFT) is employed to address this complex of problems. The primary function of BFT consists in converting metabolic waste products of aquatic organisms into protein-rich biomass. Microbial aggregates (flocs) not only utilize ammonia and nitrites, thereby maintaining optimal water quality without water exchange, but also serve as a high-energy nutritional source, making it possible to reduce the use of compound feeds [1,3].

The aim of the present study was to substantiate and experimentally evaluate the application of Biofloc Technology (BFT) for crustacean cultivation.

MATERIALS AND METHODS

Biofloc Technology (BFT) is an innovative solution in industrial aquaculture aimed at increasing the productivity of aquatic organisms and improving the environmental sustainability of production. Its principle is based on the management of microbial communities in the aquatic environment: stimulation of heterotrophic bacterial growth ensures the biotransformation of inorganic nitrogen compounds (ammonia, nitrites, and nitrates) into microbial biomass. This process is initiated through the introduction of an organic carbon source, resulting in the formation of bioflocs—aggregates composed of bacteria, protozoa, detritus, and suspended particles (Figure 1). Bioflocs possess high nutritional value, containing proteins, lipids, and enzymes, and serve as an additional natural food source for cultivated organisms, thereby reducing feed conversion ratios and decreasing the load on water exchange systems [5,7].

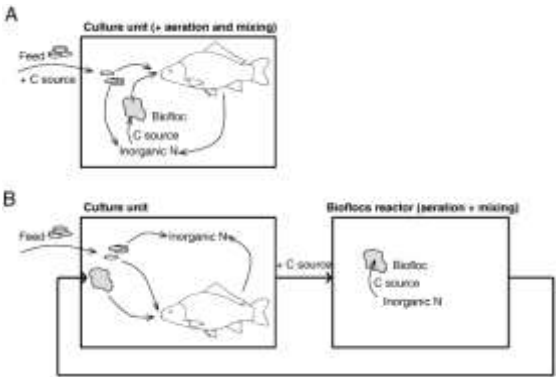

Figure 1 — Integration Schemes of Biofloc Technology (BFT) in an Aquaculture System

The present study evaluates the feasibility of cultivating the Australian redclaw crayfish (*Cherax quadricarinatus*) under Biofloc Technology (BFT) conditions. The experimental system was established in an aquarium with a working volume of 210 L. The formation of the microbial community was achieved through the combined introduction of three components:

– a probiotic preparation at a dosage of 1 g per 100 L of water, corresponding to 2.1 g for the total system volume; prior to introduction into the aquarium, the probiotic was preliminarily resuspended in water to ensure uniform inoculation;

– a feed substrate represented by a starter compound feed for shrimp in the amount of 5 g;

– as well as a source of exogenous carbon, namely beet molasses, with a dry matter content of 43% and pH ranging from 6.5 to 8.5 (Figure 2).

Figure 2 — Components of Biofloc Technology (BFT)

The probiotic strain *Bacillus velezensis* was used in the study. This probiotic strain enhances the immune status of aquatic organisms and restores beneficial microflora. The application of *Bacillus velezensis* contributes to organic feed production by eliminating the use of antibiotics. In addition, this probiotic strain participates in fermentation processes, thereby promoting more efficient nutrient assimilation by aquatic organisms and increasing protein bioavailability [4].

The object of the study was the Australian redclaw crayfish, *Cherax quadricarinatus*. This species represents a promising aquaculture organism. It is characterized by a rapid growth rate; under optimal conditions, individuals reach marketable body weight within 7–9 months of life. The advantages of cultivating *C. quadricarinatus* include omnivorous feeding behavior, high tolerance to fluctuations in water quality parameters, the ability to tolerate low dissolved oxygen concentrations, as well as the possibility of cultivation at high stocking densities [8]. At the beginning of the experiment, the Australian redclaw crayfish were 2 months old; the experimental group consisted of 5 females and 5 males (Figure 3).

Figure 3 — Experimental Specimens of *Cherax quadricarinatus*

Preliminary holding was carried out in a standard aquarium. Starter compound feed for shrimp was used. Initial morphometric data, including body weight and body length at the beginning of the experiment, are presented in Table 1.

Table 1 — Morphometric Measurements at the Beginning of the Experiment

No.	Sex	Body weight, g	Body length, mm
1	♂	9.0	63
2	♂	15.5	75
3	♂	15.6	73
4	♀	16.0	74
5	♀	14.3	75

6	♂	10.1	65
7	♀	13.2	72
8	♂	15.7	76
9	♀	16.0	76
10	♀	14.3	70

The average body weight of the crustaceans used in the experiment was 13.97 g, while the average ichthyological length was 71.9 mm. The water quality parameters of water in the BFT system remained within the normal range and corresponded to optimal conditions for the cultivation of tropical crustaceans. Measurements of all water quality parameters were conducted daily. Averaged values for the entire experimental period are presented in Table 2.

Table 2 — Water Quality Parameters in the Biofloc System

No.	Parameter	Value
1	Temperature, °C	27.3
2	O_2, mg/L	8.7
3	pH	7.6
4	NH_3/ NH_4, mg/L	0.0
5	NO_2, mg/L	0.0

RESULTS AND DISCUSSION

Over the 21-day cultivation period of the Australian redclaw crayfish in the BFT system, the average body weight increased from 13.97 g to 17.81 g. Absolute weight gain amounted to 3.84 g, while the average daily weight gain reached 0.18 g/day (Table 3).

Table 3 — Biological Performance Parameters of the Australian Redclaw Crayfish at the Beginning and End of the Experiment

Parameters	Beginning of the experiment	End of the experiment
Average body weight, g	13.97	17.81
Total weight gain over 21 days, g	3.84	
Average daily weight gain over 21 days, g/day	0.18	

To analyze these data, information from published studies on the cultivation of *Cherax quadricarinatus* in ponds and recirculating aquaculture systems (RAS) should be considered. Under the climatic conditions of the Astrakhan Region, which are among the most favorable in Russia for the cultivation of thermophilic aquatic organisms, the growing season for cultivation of *C. quadricarinatus* in open ponds lasts only 3–5 months, after which overwintering in tanks with regulated temperature conditions becomes mandatory. Under intensive cultivation technology in tropical and subtropical regions, the average daily growth rate of juvenile individuals (within the body weight range of 10–30 g) generally varies between 0.10 and 0.20 g/day [6].

The obtained average daily growth rate of 0.18 g/day corresponds to the productivity level observed under pond culture conditions, since this parameter falls within the range characteristic of pond cultivation productivity during the optimal warm period and even slightly exceeds the lower boundary of this range (0.10–0.20 g/day). The efficiency of biofloc technology should be emphasized, since the result was achieved not in a pond with a natural food resource, but in an experimental biofloc system where a consistently high temperature (27.3 °C) and high water quality (zero concentrations of ammonium and nitrites) were maintained, conditions that are difficult to achieve in pond systems without continuous water exchange. In addition, the obtained results demonstrate economic feasibility, since the achieved growth was obtained without the use of expensive water treatment systems, with a reduced proportion of commercial compound feeds and without costs associated with water replacement, indicating the economic potential of the proposed technology.

CONCLUSION

The developed experimental system based on Biofloc Technology (BFT) ensured stable hydrochemical conditions over a 21-day period without water replacement. Temperature was maintained at 27.3 °C, dissolved oxygen concentration reached 8.7 mg/L, while ammonium and nitrite concentrations remained at zero levels. This confirms the high efficiency of BFT for water purification during the cultivation of tropical crustaceans.

During the experimental period, the average body weight of the Australian redclaw crayfish (*Cherax quadricarinatus*) increased from 13.97 g to 17.81 g, while the average daily weight gain amounted to 0.18 g/day. This parameter corresponds to the productivity level of pond cultivation under optimal climatic conditions. These findings indicate that biofloc technology may be considered a promising alternative to traditional cultivation methods.

The obtained results demonstrate the feasibility of further investigation of biofloc technology for the commercial cultivation of *Cherax quadricarinatus* under controlled climatic conditions, which is particularly relevant for regions where traditional pond-based crayfish culture is impossible due to low temperatures.

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