Prospects for growing Australian red claw crayfish (*Cherax quadricarinatus*) in the industrial conditions of Kazakhstani fish farms

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Abstract. The prospects for the development of aquaculture in Kazakhstan through the application of industrial technologies are indisputable, with an imperative to expand the range of cultivated species. Of particular interest within the Republic of Kazakhstan's aquaculture context is the Australian red claw crayfish (*Cherax quadricarinatus*). This study marks the pioneering effort to cultivate *C. quadricarinatus* under industrial conditions within Kazakhstani fish farms. This article presents the results of industrial cultivation endeavors for *C. quadricarinatus* planting material. Various biotechnical methods were employed, including recirculating water supply installations, aquaria, pools, and trays. These methods were tested using both natural water sources and water from artesian wells. The cultivation systems encompassed both direct-flow water supply and forced water circulation facilitated by pumps. The study shows the dynamic trends in absolute and average daily growth, as well as survival rates of *C. quadricarinatus* juveniles and fingerlings within these proposed conditions. Growth rate evaluation was based on criteria such as mass accumulation coefficients, specific growth rates, and survival rates. Additionally, the study explores the feasibility of employing diverse types of feed - both of animal and plant origin, based on coefficients related to artificial feed. Finally, the study puts forth theoretical and practical foundations for applying biotechnical standards to the cultivation of *C. quadricarinatus* planting material, specifically tailored for entrepreneurs within the Republic of Kazakhstan.

Key Words: juveniles, fingerlings, recirculating aquaculture systems (RAS), mass accumulation coefficient.

Introduction. The most relevant and economically attractive segment of aquaculture in Kazakhstan centers around the production of freshwater tropical species. Particularly noteworthy for reproduction and cultivation within the industrial confines of Kazakhstani fish farms is the Australian red claw crayfish (*Cherax quadricarinatus*). The principal bottleneck hindering the advancement of crayfish production in Kazakhstan is the absence of established biotechnological standards and of a well-balanced artificial feed regimen (Scientific and Production Center for Fisheries LLP 2021).

C. quadricarinatus is a novel focal point within Kazakhstani crustacean aquaculture. It's worth resides in its accelerated growth rate and its comparatively undemanding requirements for breeding conditions. An encouraging factor for *C. quadricarinatus* is its non-invasiveness, rendering it well-suited for artificial breeding and amenable to specific temperature conditions (Scientific and Production Center for Fisheries LLP 2021). The species exhibits resilience in varying temperature parameters, with an optimal range of 23-31°C for growth and development, and 25-30°C for cultivation (Meade et al 2002). Temperatures plummeting below 10°C and surging beyond 36°C prove lethal to the species (Lawrence & Jones 2002), whereas juveniles face critical thresholds below 20°C and above 32-34°C (King 1994).

The species shows versatility in its dietary preferences, encompassing an array of feed options, both of animal and plant origin. *C. quadricarinatus* holds notable dietary and gustatory value, boasting elevated nutritional qualities. Notably, its meat content (comprising 30% of body weight) surpasses analogous indicators of long-clawed crayfish by 15-20% (Lagutkina & Ponomarev 2010a). Furthermore, males demonstrate remarkable growth rates, thereby accentuating a viable avenue to enhance species profitability by fostering a male-dominated population (Salnikov & Sukhanova 1998). Thanks to its inherent biological traits and palatable characteristics, the species has exhibited promise in the realm of commercial breeding.

Prevalent tropical and heat-enduring *C. quadricarinatus* production countries include China, Indonesia, Israel, Morocco, Panama, Spain, and the USA (FAO 2024). Beyond borders, methodologies for cultivating *C. quadricarinatus* have been pioneered, spanning pond-based systems and industrial contexts within fish farms (Lagutkina et al 2019; Lagutkina & Ponomarev 2012; Borisov et al 2013; Kiselev et al 1995; Kiselev 1999; Zhigin et al 2017). In 2021, a groundbreaking endeavor was undertaken as part of the project "Development and implementation of industrial technologies for cultivating promising fish farming species and invertebrate aquatic organisms in fish hatcheries." This initiative aimed to pioneer effective biotechnical methodologies for the industrial-scale cultivation of planting material for *C. quadricarinatus* within the primary fish farms of Kazakhstan.

The core objective of this research was to evaluate the feasibility of artificially cultivating planting material for *C. quadricarinatus* within the industrial environs of fish farms situated in the Republic of Kazakhstan.

Material and Method. The research was carried out in 2021 in accordance with the project work program at the basic fish farms located in the Almaty region: in "Kapshagay Spawning and Growing Farm – 1973" LLP, where the Australian red-claw crayfish was grown in a closed water supply system using water from an artesian well; in "Halyk Balyk" LLP - in Yeisk-type trays, the water source was a storage pond and in "Kaz Organik Product" LLP - the research object was grown in a closed water supply system using water from a natural source (Kapshagay Reservoir). The focal subjects of investigation encompassed juveniles and fingerlings of the Australian red claw crayfish.

The developmental work concerning technological methods for the industrial cultivation of *C. quadricarinatus* planting material unfolded across multiple contexts. These included recirculating water supply installations, aquaria, pools, and trays. In this pursuit, water sourcing exhibited variability, either drawn from natural reservoirs or tapped through artesian wells. Water provision for fish tanks occurred through two distinct mechanisms: gravity flow (direct flow) or facilitated by forced water supply employing pumps. To evaluate the impact of abiotic environmental factors on the cultivation of *C. quadricarinatus*, monitoring of temperature, oxygen levels, and pH was undertaken. Water temperature and oxygen content were measured with the MARK-302E analyzer. The quantification of biogenic elements and the determination of the hydrogen ion concentration (pH) were conducted using rapid tests provided by Sera (Germany). For the assessment of water quality, established hydrochemical methodologies were applied, according to the guidelines for the chemical analysis of surface waters (Gidrometeoizdat 1997; Alekin et al 1993). Biological indicators of *C. quadricarinatus* were ascertained in accordance with aquaculture norms (Lagutkina & Ponomarev 2010b). The growth patterns of juvenile and fingerling crayfish were discerned by means of controlled sampling. For an in-depth assessment of crayfish growth, key metrics such as the mass accumulation coefficient (Cm) and the specific growth rate (SGR) were used (Kupinsky 2007; Shcherbina & Gamygin 2006).

The specific growth rate of the studied specimen was calculated using the formula (Kupinsky 2007):

$$A\ (\%) = [(m_к/m_о)^{1/t}-1]*100$$

Where:
$m_к$, $m_о$ - final and initial weight of fish;
t – duration of the experiment, days.

For a more accurate determination of the growth rate, the coefficient of mass accumulation was calculated (Shcherbina & Gamygin 2006):

$$К_м = (М_к^{1/3}-М_о^{1/3})*3/t$$

Where:
$К_м$ - – general production coefficient of growth rate;
$М_к$ and $М_о$ – final and initial weight of fish, g;
t – time of rearing, days.

The absolute growth was calculated using the formula:

$$P_{аб}= m_к - m_о$$

Where:
$m_к$, $m_о$ – fish weight at the end and beginning of the experiment.

The average daily gain ($P_{ср.сут}$) was calculated using the formula:

$$P_{ср.сут.} = (m_к - m_о)/\Delta t$$

Where:
Δt – growing period, days.

An assortment of feed variants was used for nourishing *C. quadricarinatus*. The quantum of feed and the feeding frequency were meticulously calculated, accounting for *C. quadricarinatus*'s physiological state as well as fluctuations in temperature and oxygen regimes. The daily feeding allocation for *C. quadricarinatus* was determined based on the findings of controlled sampling and was additionally influenced by international practices (Lagutkina et al 2016; Lagutkina 2017; Zagorsky et al 2016). Throughout the cultivation of *C. quadricarinatus* planting material in industrial settings, reference was made to foreign regulatory and technological literature (Zagorsky et al 2016; Lagutkina & Ponomarev 2008; Zhigin 2002; Zhigin 2011; Hofstatter 2008; Kovacheva 2006; Nguyen & Kryuchkov 2014; Jones 1990; FAO 2020; Holthuis 1986; Medley et al 1993; King 1993; Romero 1997; Jones 1995; Arystangaliyeva 2017). The data amassed underwent rigorous processing through the utilization of biological statistical methods (Lakin 1990). Mathematical and statistical analysis of the gathered results was performed using software "Microsoft Excel 8.0".

Results. Research on the development of industrial technologies for growing Australian red claw crayfish in the conditions of basic fish farms was carried out according to the developed scheme (Table 1).

Table 1

Scheme for conducting research on industrial technologies for growing planting material of the *Cherax quadricarinatus*

Location	*Technology cultivation*	*Water use*	*Water supply*	*Water temperature*
"Kapshagai fish farm - 1973" LLP	In RAS	Artesian water	By gravity	Use of water heating
"Halyk Balyk" LLP	In trays of the Yeysk type	Storage pond water	By gravity, direct flow	Natural thermal regime of pond water
"Kaz Organik Product" LLP	In aquaria, pools of RAS systems	Water from the Kapshagai reservoir	Forcibly, with pumps	Partial water heating

During the period of industrial rearing of juvenile *C. quadricarinatus*, feeding was carried out with various artificial extruded feeds, as well as feeds of plant origin. Feeding data for *C. quadricarinatus* are presented in Table 2.

Table 2

Feeding data for *Cherax quadricarinatus*

Name	*Eatability*	*Note*
Artificial feed "Aller Aqua"	Excellent	Feeding of ARCC* juveniles was carried out according to the calculated daily feeding ration.
Lettuce leaves	Satisfactory	Lettuce leaves were dipped into fish tanks fixed on aluminum wire.
Cabbage	Medium	The eatability was low compared to lettuce leaves.
Cucumbers	Excellent	The crustaceans willingly ate cucumbers, which were cut into slices, strung on a wire and placed at the bottom.
Eggshell	Excellent	Eggshells were ground in a mortar, and then evenly distributed in places where the crayfish were located. Eggshells have been used to replenish calcium and allow for easy molting.
Oak leaves	Medium	Before introducing oak leaves into the fish tank, they must first be steamed.

ARCC* – Australian red claw crayfish

Based on the data shown in the Table 2, it can be concluded that *C. quadricarinatus* are tolerant of a variety of feeds.

Cultivation of juvenile C. quadricarinatus in "Kapshagai fish farm-1973" LLP. Cultivation of Australian red claw crayfish was carried out in a mini-RAS located in the incubation shop of the farm (Figure 1).

Figure 1. Mini RAS in the incubation shop of "Kapshagai fis farm-1973" LLP.

The RAS system consists of six fish tanks 3 m x 0.5 m x 0.4 m in size, with a total water volume of 6 m^3. The water coming from the pools is cleaned in a sand filter with a capacity of 3 m^3 $hour^{-1}$. A 1 m^3 tank is used as a biofilter. A similar sedimentation tank is also provided for sedimentation. Using RAS to grow *C. quadricarinatus*, the pools are maintained at a constant optimum temperature by installing an instantaneous water heater with a flow sensor and a temperature sensor. The water source for RAS is water flowing by gravity from an artesian well, which previously undergoes forced degassing and aeration. Chemical indicators of water from an artesian well are presented in Table 3.

The water's dissolved salt content categorizes it as freshwater, exhibiting a mineralization level of 151 mg dm^{-3}, belonging to the bicarbonate-sodium classification. In terms of technical attributes, the water is soft, boasting a total hardness of 0.88 mg-eq dm^{-3}. The hydrochemical analysis indicates that biogenic element concentrations in the water fall within optimal thresholds. Notably, nitrate nitrogen is the dominant element, reaching a level of 1.76 mg dm^{-3}. Overall, the artesian water sourced from "Kapshagai fish farm-1973" LLP is deemed suitable for crayfish cultivation.

Table 3

General hydrochemical indicators of water from an artesian well in "Kapshagai fish farm-1973" LLP

Indicators	*Measurement*	*Values*
Hydrogen index (pH)	units	7.2
Carbon dioxide	mg dm^{-3}	38.3
Permanganate oxidizability	mg O dm^{-3}	3.52
Ammonia nitrogen	mg dm^{-3}	0.06
Nitrite nitrogen	mg dm^{-3}	0.008
Nitrate nitrogen	mg dm^{-3}	1.76
Phosphorus	mg dm^{-3}	0.004
Iron	mg dm^{-3}	0.02
Silicon	mg dm^{-3}	5.40
Rigidity	mg-eq dm^{-3}	0.88
Bicarbonates	mg dm^{-3}	86.6
Sulfates	mg dm^{-3}	9.6
Chlorides	mg dm^{-3}	10.6
Calcium	mg dm^{-3}	12.0
Magnesium	mg dm^{-3}	2.7
Sodium	mg dm^{-3}	28.1
Potassium	mg dm^{-3}	1.2
Mineralization	mg dm^{-3}	151

Juveniles of the *C. quadricarinatus* were procured from "KazOrganik Product" LLP and introduced to "Kapshagai fish farm-1973" LLP. Transportation of *C. quadricarinatus* was executed in foam thermoboxes, cushioned by damp fabric material, yielding successful results. The stocking density amounted to 90 juveniles per thermobox. Upon introduction to the pools, the water level was maintained at 20 cm. PVC-U pipes, each measuring 30 mm in diameter and cut into 15 cm segments, served as shelter for the juvenile crayfish.

Before placing the crustaceans in the pools, the farm carried out a grading of the imported juvenile Australian red-claw crayfish. Prior to their release into the pools, an evaluation of the imported *C. quadricarinatus* was conducted on the farm. The grading assessment yielded an average crayfish weight of 10.0 g. The juveniles were provided with "AllerAqua" artificial feed, supplemented by lettuce, cabbage, and cucumbers as additional plant-based nourishment. During the 60 days of observation, it was noted that cabbage leaves were scarcely consumed, while lettuce leaves were consumed only when slightly decomposed; fresh cucumbers were actively consumed. However, a consistent reliance on vegetable-based nutrition wasn't feasible due to *C. quadricarinatus* 's requirement for protein-rich sustenance. To support the comprehensive development of *C. quadricarinatus* exoskeletons following molting, finely crushed eggshells were introduced to the pool substrates to enhance water calcium levels. Additionally, to infuse the water with beneficial tannins, essential for the well-being of *C. quadricarinatus*, dry oak branches with leaves were placed within the water.

Throughout the rearing phase of juvenile *C. quadricarinatus*, daily assessment of key hydrochemical indicators within the RAS pool system was conducted. Notably, the temperature and oxygen content of the water were monitored. The results of the hydrochemical monitoring, conducted at "Kapshagai fish farm-1973" LLP, are detailed in Table 4.

As a result of the monitoring, the values of water temperature in the RAS during rearing of juveniles were within the optimal limits for the *C. quadricarinatus* (24.2-26.3°C) and they are based on the technological standards for growing Australian red claw crayfish (ARCC). At the same time, the content of dissolved oxygen was maintained at the proper level and did not go beyond the range of 6.9-8.1 mg O L^{-1}. In general, the hydrochemical indicators during the cultivation of ARCC in RAS in the "Kapshagai fish farm-1973" LLP were within the normal range for ARCC (Borisov et al 2013; Kiselev et al 1995; Kiselev 1999; Zhigin et al 2017).

Table 4
Dynamics of key hydrochemical indicators in RAS water at "Kapshagai fish farm-1973" LLP

Month	*Decade*	*t, °C*	*mg O_2 L^{-1}*
July	I	24.2	7.1
	II	25.6	6.9
	III	25.8	7.2
August	I	26.3	7.4
	II	25.7	7.8
	III	25.4	8.1
September	I	25.2	7.9

The first molt of crayfish occurred on the third day of being in the mini-RAS system. An increase in molts was observed after the 20th day of keeping *C. quadricarinatus* juveniles in the RAS system. At the same time, the main part of the lines took place at night with a minimum level of illumination. Molts took place mainly outside the shelters, in the corners of the pools. The results of growing ARCC planting material in RAS under the conditions of "Kapshagai fish farm-1973" LLP are shown in Table 5.

Table 5
The results of growing planting material *Cherax quadricarinatus* under conditions "Kapshagai fish farm - 1973" LLP

Indicators	*Values*
Growing period, days	60
Planting density, pcs m^{-2}	40
Initial weight, g	10.0±0.22
Final weight, g	16.7±0.72
Absolute weight gain, g	6.7
Average daily weight gain, g	0.11
Relative weight gain, %	67
Feed ratio, units	1.1
Survival rate, %	91
Mass accumulation coefficient, units	0.02
Specific growth rate, % day^{-1}	0.86

According to the research results, during 60 days of growing in the RAS system, the values of the absolute, average daily and relative weight gain of ARCC fingerlings were 6.7 g, 0.11 g and 67%, respectively, with a high survival rate, of 91%. The coefficient of mass accumulation was equal to 0.02 units, and the specific growth rate of fingerlings was 0.86% day^{-1}. The feed ratio of artificial feed "Aller Aqua" was 1.1 units. Studies have shown (Scientific and Production Center for Fisheries LLP 2021) hat in RAS using water from a heated artesian well, it is possible to grow high-quality material of juvenile *C. quadricarinatus*.

Cultivation of juvenile C. quadricarinatus in "Halyk Balyk" LLP. Juvenile *C. quadricarinatus* were grown in Yeisk-type trays located in the incubation facility of the farm (Figure 2).

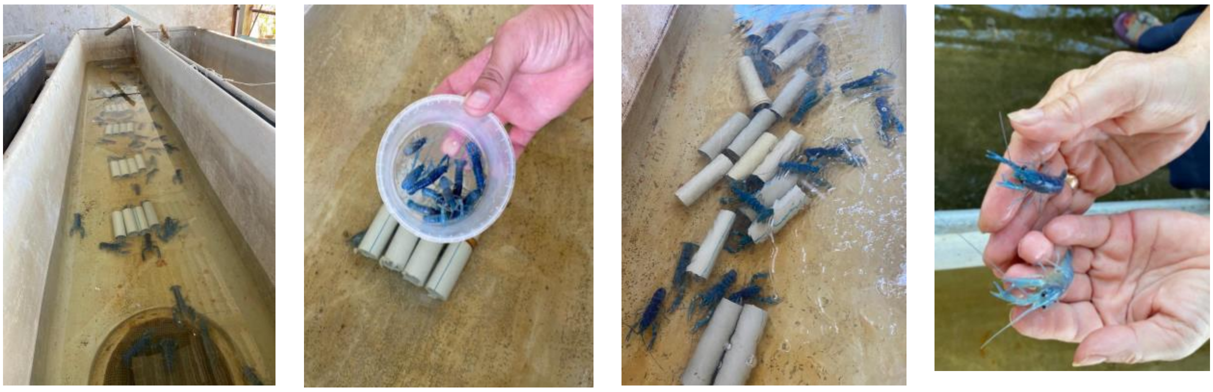

Figure 2. Juvenile *Cherax quadricarinatus* in Yeisk-type trays at “Halyk Balyk” LLP.

The supply of water to the incubation facility within “Halyk Balyk” LLP was performed through gravitational means, sourced from the storage pond. This water originates from the Lavar River and is conveyed through a dedicated water supply channel. Juvenile *C. quadricarinatus*, housed in fish-breeding plastic bags, were transported from “KazOrganik Product” LLP, for a spanning journey of 2 hours. The survival rate of the crustaceans remained at 100% throughout the transportation process. Upon release from the bags, juveniles were acclimatized to the tray conditions over a 20-minute period, with the tray water temperature maintained at +26°C. Post grading assessment, the juvenile *C. quadricarinatus* displayed mass values ranging from 1.6 to 2 g, with an average weight of 1.8 g. Plastic tubes measuring 15 to 20 cm in length and up to 5 cm in diameter, were used to accommodate the crustaceans.

Within the confines of “Halyk Balyk” LLP, juvenile *C. quadricarinatus* were cultivated utilizing pond water characterized by its inherent thermal variability. The quality of the pond water at “Halyk Balyk” LLP conforms to the stipulated criteria for fishery reservoirs and is deemed suitable for fostering aquatic organisms (Gidrometeoizdat 1997; Alekin et al 1993). The temperature dynamics of the pond water within the trays during the crustacean growth phase are presented in Table 6.

Table 6

Temperature regime dynamics in trays at “Halyk Balyk” LLP

Month	*Decade*	*Temperature values (t^0C)*	
		Limits	*Median*
July	I	23.7-27.9	25.8
	II	24.5-28.8	26.7
	III	25.8-28.9	27.3
August	I	26.2-28.8	27.5
	II	25.7-27.6	26.7
	III	24.5-25.9	25.2
September	I	22.1-23.3	22.7

It can be seen from the data that the temperature of pond water during the rearing period of juvenile *C. quadricarinatus* was within the optimal range (Borisov et al 2013; Kiselev et al 1995; Kiselev 1999; Zhigin et al 2017). Fluctuations in the average values of water temperature were: in July from 25.8°C to 27.3°C; in August from 25.2°C to 27.5°C; in the first ten days of September, on average, up to 22.7°C. The water exchange in the trays was in the range of 9-10 L min^{-1}. The oxygen content in the water did not fall below 7 mg L^{-1}.

Cultivation of juvenile *C. quadricarinatus* in the conditions of "Halyk Balyk" LLP was carried out in two stages. The duration of each stage was 30 days. *C. quadricarinatus* were fed 3 times a day. For feeding, artificial granulated feed "Aller Aqua" was used, as well as plant feed (vegetables). Trays were cleaned before each feeding. The results of rearing juvenile *C. quadricarinatus* at stage I in trays at "Halyk Balyk" LLP are presented in Table 7.

Table 7

Results of cultivation of juvenile *Cherax quadricarinatus* at stage I in trays

Indicators	*Values*
Growing period, days	30
Planting density, pcs m^{-2}	50
Initial weight, g	1.8±0.2
Final weight, g	7.2±0.7
Absolute weight gain, g	5.4
Average daily weight gain, g	0.18
Relative weight gain, %	300
Feed ratio, units	0.98
Survival rate, %	93
Mass accumulation coefficient, units	0.072
Specific growth rate, % day^{-1}	4.62

Following a 30-day cultivation period at stage I within the trays, the juvenile crustaceans exhibited notable growth metrics. The absolute, average daily, and relative weight gains measured 5.4 g, 0.18 g, and 300%, respectively. Concurrently, their survival rate stood at a commendable 93%. The crustaceans demonstrated robust acclimatization to artificial sustenance, readily consuming vegetables, especially cucumbers. Efforts to gauge juvenile growth efficacy involved computation of the mass accumulation coefficient and the specific growth rate, which yielded values of 0.072 units and 4.62% per day, respectively. Additionally, the feed coefficient for the "Aller Aqua" artificial feed recorded 0.98 units. With the progression to stage II, involving *C. quadricarinatus* fingerlings within the trays at "Halyk Balyk" LLP, the results are detailed in Table 8.

Table 8

Results of fingerling *Cherax quadricarinatus* rearing at stage II in trays at "Halyk Balyk" LLP

Indicators	*Values*
Growing period, days	30
Planting density, pcs m^{-2}	50
Initial weight, g	7.2±0.7
Final weight, g	14.7±0.18
Absolute weight gain, g	7.5
Average daily weight gain, g	0.25
Relative weight gain, %	104
Feed ratio, units	0.99
Survival rate, %	90
Mass accumulation coefficient, units	0.051
Specific growth rate, % day^{-1}	2.38

After a 30-day growth period in stage II within the trays, the fingerling crustaceans exhibited distinct developmental parameters. The absolute, average daily, and relative weight gains reached 7.5 g, 0.25 g, and 104%, respectively, coupled with a commendable survival rate of 90%. Calculations of the mass accumulation coefficient and specific growth rate yielded figures of 0.051 units and 2.38% per day, respectively. The feed ratio for the "Aller Aqua" artificial feed was recorded 0.99 units. Interestingly, it was observed that under identical keeping conditions, a more robust growth pattern was evident in stage I juveniles. This observation is substantiated by the relative growth and specific growth rate values, which were notably higher during this period, reflecting a

196% increase in relative growth and an enhancement of 0.021% per day in specific growth rate. The study effectively underscores the successful cultivation of juvenile *C. quadricarinatus* within the southern region of Kazakhstan, specifically within the VI fish breeding zone, utilizing pond water characterized by its natural thermal variability during the summer season.

Cultivation of juvenile C. quadricarinatus in "KazOrganik Product" LLP. *C. quadricarinatus* stock was reared within aquaria and pools of RAS systems, as depicted in Figures 3 and 4.

Figure 3. Aquarium site of RAS system.

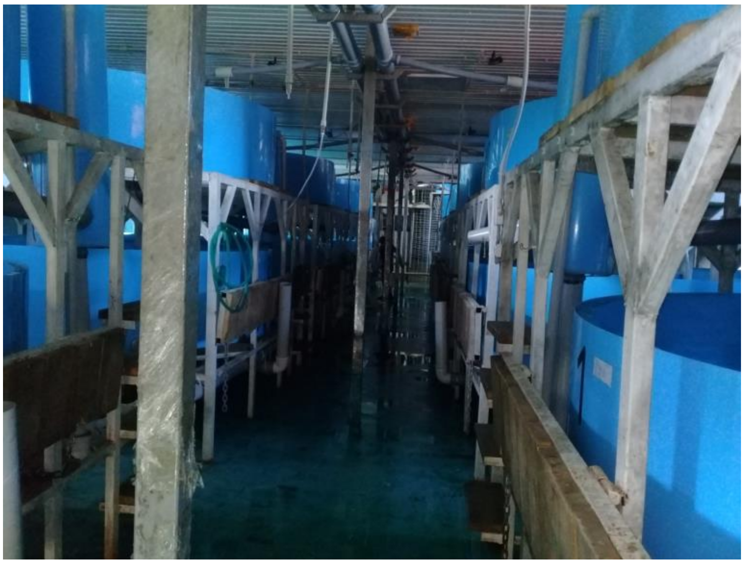

Figure 4. Basin section of RAS system.

Discussion. The cultivation process of juvenile *C. quadricarinatus* transpired across two distinct stages, with each stage spanning over a duration of 60 days. During stage I, juvenile *C. quadricarinatus* were reared in the aquaria housed within the first RAS. These aquaria were systematically grouped into racks, structured with 4 tiers, each containing 2 aquaria, thereby resulting in a total of 8 aquaria per rack. Of these, the upper three tiers served the primary purpose of cultivating crayfish, while the lower-tier aquaria functioned as a crucial water purification unit. In this regard, these lower-tier aquaria were furnished with both a sump compartment and a dedicated bio-load compartment, specifically designed to facilitate the biological treatment of circulating water. Subsequently, during stage II, the growth of crayfish juveniles continued within the pools of the second RAS system. These pools were outfitted with an independent, closed-loop water supply system, comprising a cassette sump housing a floating load biofilter, a dedicated pump, and a well-integrated communication network. The mechanism of water renewal for both RAS systems hinged on the supply of heated water sourced from the water treatment plant. Furthermore, aeration of the water within both the aquaria and pools was systematically administered via diffusers, facilitated through the overarching air supply and distribution system integrated into the RAS framework.

In the context of "Kaz Organik Product" LLP, the water supply mechanism was marked by a forced approach, achieved through the pumping of water from the Kapshagay reservoir subsequent to preliminary water treatment measures. The treated water underwent a dual process of ozonation and UV treatment before being introduced into the fish tanks. As evaluated against hydrochemical indicators, the water sourced from the Kapshagai reservoir, following the requisite treatment regimen implemented on the farm, broadly adhered to the prerequisites for fostering the growth of *C. quadricarinatus*. Throughout the research period, these hydrochemical attributes consistently aligned with the optimal standards (Borisov et al 2013; Kiselev et al 1995; Kiselev 1999; Zhigin et al 2017). Notably, fluctuations in water temperature were noted within the range of 24.5 to 26.1°C, while the pH levels exhibited variation within 6.9 to 7.5 units. The oxygen content within the water exhibited variability within the range of 7 to 8 mg dm^{-3}.

Shelters (tubes) made of polygal from 15 to 20 cm in size were installed in aquaria and pools to avoid cannibalism during molting of crayfish. In the process of research, it was noted that the surface of shelters for crayfish placed in aquaria is intensively overgrown with a biological film, which begins to perform the function of water purification. During the growing process, aquaria and pools were regularly cleaned. The frequency of cleaning may vary depending on the hydrochemical regime.

To determine the growth rate of *C. quadricarinatus* juveniles, control catches were carried out. According to the results of the control catches, the daily diet of *C. quadricarinatus* was calculated. The crustaceans were fed manually: at stage I, in aquaria, up to 5 times a day; at stage II, in pools, up to 3 times. The basis of the diet of juvenile *C. quadricarinatus* at the first stage was artificial feed "Aller Aqua"; the daily dose of feed was up to 10% of the mass of crustaceans. Oak leaves and vegetables were laid out as a vegetable feed additive. The results of growing juvenile *C. quadricarinatus* in aquaria at stage I at "Kaz Organik Product" LLP are presented in Table 9.

Table 9

Results of rearing juvenile *Cherax quadricarinatus* in aquaria at stage I in "Kaz Organik Product" LLP

Indicators	*Values*
Growing period, days	60
Planting density, pcs m^{-2}	100
Initial weight, g	0.3±0.12
Final weight, g	6.9±0.71
Absolute weight gain, g	6.6
Average daily weight gain, g	0.11
Relative weight gain, %	2200
Survival rate, %	84
Feed ratio, units	1.2

According to the research results, during 60 days at the first stage of rearing in aquariums, the absolute and average daily weight gains of fingerlings were 6.6 g and 0.11 g, respectively, with a survival rate of 84%. It was noted that the maximum growth rate can be observed in early juveniles, as indicated by the relative growth rate of 2200%, then the growth rate of the crustaceans begins to slow down. The feed coefficient of the artificial feed "Aller Aqua" was 1.2 units. Then, at the age of two months, juvenile *C. quadricarinatus* from aquariums were transplanted for further rearing into tanks of the RAS system.

Due to the high cost of imported artificial starter feeds used in industrial aquaculture for feeding crustaceans, the possibility of feeding *C. quadricarinatus* juveniles with feeds produced by Kaz Organik Product LLP was studied. Specialists of "Kaz Organik Product" LLP developed food for crayfish, which included the following ingredients: rice, wheat, starch, peas, fish bone meal, meat and bone meal, alfalfa meal, minced fish, blood meal, premix, fritox, thermox, chalk feed, salt. During the period of growing *C. quadricarinatus* fingerlings in basins, feeding of the crustaceans at the second stage was carried out with granulated feed manufactured at "Kaz Organik Product" LLP, at the ratio of 3% of the weight of the crayfish. The results of growing ARCC fingerlings in the basins of the RAS system at "Kaz Organik Product" LLP at stage II are presented in Table 10.

Table 10

Results of growing *Cherax quadricarinatus* fingerlings in the basin at stage II

Indicators	*Values*
Growing period, days	60
Planting density, pcs m^{-2}	40
Initial weight, g	6.9± 0.72
Final weight, g	20.8± 2.54
Absolute weight gain, g	13.9
Average daily weight gain, g	0.23
Relative weight gain, %	201
Survival rate, %	68
Feed ratio, units	1.9
Mass accumulation coefficient, units	0.0425
Specific growth rate, % day^{-1}	1.842

The findings of the research conducted over a 60-day period at stage II within the RAS system's pools yielded distinct developmental results for the *C. quadricarinatus* fingerlings. The absolute, average daily, and relative weight gains were recorded at 13.9 g, 0.23 g, and 201%, respectively, accompanied by a survival rate of 68%. Calculated values for the mass accumulation coefficient and specific growth rate for the fingerlings were 0.0425 units and 1.842% per day, respectively. The feed coefficient for the in-house artificial feed, produced within the feed facility of "KazOrganikProduct" LLP, was determined as 1.9 units. The research results have effectively demonstrated the efficacy of cultivating juvenile *C. quadricarinatus* within aquaria and pools integrated into RAS systems, utilizing water sourced from the natural reservoir (Kapshagai reservoir) with partial heating.

Conclusions. As a result of the research conducted at the basic fish farms of the Almaty region, effective biotechnical methods for growing *C. quadricarinatus* seedlings in closed water supply systems, pools, Yeisk-type trays and aquariums using different types of water were developed for the first time. Specimens captured from natural sources were used (Kapshagay reservoir, storage pond, water from an artesian well and a water supply system). The research results showed a real possibility of effective cultivation of *C. quadricarinatus* juveniles in industrial conditions of fish farms in Kazakhstan. This crayfish is a promising object of aquaculture, primarily for the southern regions of the Republic of Kazakhstan, where it can be cultivated using water from natural sources, without heating in the summer. According to the research results, it was found that *C. quadricarinatus* exhibits tolerance to a variety of feeds. The crayfish readily consumes both artificial and plant feeds. Biotechnical methods of growing red-clawed crayfish as an object for warm-water aquaculture in Kazakhstan are easy to use and accessible to fish farmers under recommended cultivation conditions. In the future, the proposed biotechnological methods will be implemented at industrial fish farms in the republic.

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Conflicts of interest. The authors declare no conflict of interest.

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