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Cultivation of Australian red-clawed crayfish, *Cherax quadricarinatus* as a new object of aquaculture in industrial conditions of fish farms in Kazakhstan

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ABSTRACT

This study explores the cultivation of *Cherax quadricarinatus* (Australian red-clawed crayfish) under industrial aquaculture conditions in fish farms across Kazakhstan. The primary goal is to support the diversification of aquaculture by introducing new, adaptable species. Researchers evaluated the growth performance and adaptability of the species under controlled environments. Cultivation methods were tested for both juvenile and market-size specimens. During the juvenile rearing phase, optimal water quality parameters were maintained: temperatures between 25–28 °C, and pH, dissolved oxygen, NO_2, NO_3, and NH_4 levels remained within the normative thresholds required for this species under intensive aquaculture conditions. For optimal growth, juveniles should be reared starting from a weight of 2.5–3.0 g, with the use of high-quality feed rich in protein and essential nutrients. Once crayfish reach an average weight of 6.9 g, it becomes economically feasible to transition to feeds with reduced nutrient density, provided the feed contains no less than 41.4% crude protein, 9.4% crude fat, and 1.2% crude fiber. During the cultivation of market-size specimens of Australian red-clawed crayfish (*C. quadricarinatus*), water temperatures were maintained between 25–27 °C. The pH (hydrogen index) ranged from 7.9 to 8.2, while dissolved oxygen levels varied from 5.7 to 7.4 mg dm^{-3}. Biogenic compounds remained within acceptable limits throughout the rearing process. Over the course of eight months, crayfish reared from an initial weight of 4.2 g reached an average marketable weight of 95.0 g. The findings from juvenile and commercial cultivation under industrial aquaculture conditions in Kazakhstan demonstrate that *C. quadricarinatus* adapts well and grows effectively in local fish farms. From an economic standpoint, the breeding of this species—similar to trends observed in other countries—proves to be profitable for Kazakhstan as well.

Based on the research outcomes, calculations of economic efficiency were performed, and the profitability of industrial cultivation technologies for Australian red-clawed crayfish in Kazakhstan's fish farms was evaluated. The technologies developed show moderate profitability according to net profit indicators, with strong potential for increased returns upon full-scale implementation in the future. The implementation of such studies in the fish farms of Kazakhstan not only broadens the range of aquaculture products produced in the country but also promotes the development of technologies for non-traditional aquaculture species. This, in turn, supports economic growth in the fish farming sector, even in the absence of direct access to the sea.

Keywords: *Cherax quadricarinatus*, Industrial aquaculture, Juveniles, Marketable products, Recirculating aquaculture systems (RAS), Environmental sustainability, Economic efficiency, Kazakhstan.

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INTRODUCTION

Aquaculture plays a vital role in global food security, particularly in regions without direct access to marine environments. Kazakhstan, despite being landlocked, possesses over 48,000 hectares of water resources suitable for aquaculture development. At present, the country's aquaculture sector primarily focuses on conventional species such as carp and trout. However, this limited diversity has led to challenges including market oversaturation, reduced profitability, and a heightened risk of disease outbreaks. To overcome these limitations, the diversification of aquaculture species is essential—especially through the introduction of economically viable and high-value species. One such candidate is *Cherax quadricarinatus*, commonly known as the Australian red-clawed crayfish. Over the past two decades, this tropical crayfish species has demonstrated strong potential in aquaculture systems across tropical and subtropical regions. *C. quadricarinatus* is characterized by rapid growth, adaptability to various rearing environments, and resistance to many common aquatic diseases. Under optimal conditions—specifically water temperatures between 25–30 °C—it can reach marketable size (over 50 grams) in less than six months. Moreover, studies have shown that this species can be cultivated successfully in any region where water temperatures do not fall below 10 °C (López 2021), making it a promising species for Kazakhstan's climate and aquaculture systems. In Southern Kazakhstan, the average annual temperature is approximately 25 °C, which aligns well with the biological requirements of *C. quadricarinatus*. Under natural conditions, cultivation of this species in outdoor pond systems is feasible during the summer months. However, for year-round, full-cycle production, the implementation of industrial aquaculture technologies—particularly recirculating aquaculture systems (RAS)—is recommended. Currently, crustacean farming in Kazakhstan is underdeveloped. Most crayfish are harvested from natural water bodies, with minimal cultivation taking place under aquaculture conditions. In 2022, crustaceans accounted for less than 0.5% of total aquaculture production in Kazakhstan. By contrast, according to the Food and Agriculture Organization (FAO), global crustacean production reached approximately 9.7 million tons in 2021, valued at over $30 billion. The global crustacean market was estimated at $50.4 billion in 2022 and is projected to grow to $71.5 billion by 2030, at an average annual growth rate of 4.5% between 2024 and 2030. This significant disparity highlights the need for Kazakhstan to reconsider its aquaculture strategies, especially in diversifying into high-value crustacean species. *C. quadricarinatus* offers several ecological and economic advantages: it requires less protein in its diet compared to shrimp and other carnivorous species, resulting in a lower feed conversion ratio. Additionally, it produces less nitrogen waste, making it a more environmentally sustainable aquaculture candidate (Wang 2022). However, the introduction of *C. quadricarinatus* into aquaculture in Kazakhstan presents several challenges. The first major issue is the absence of biotechnological regulations and the lack of locally produced, nutritionally balanced, specialized artificial feeds suitable for industrial-scale cultivation. Secondly, there is limited knowledge and experience in managing diseases such as White Spot Disease (WSD), a highly contagious pathogen that can be fatal to *C. quadricarinatus* and other crustaceans. From an economic standpoint, the initial investment required for heating systems—necessary to maintain optimal water temperatures during harsh winters that can reach -30 °C—is considerable. However, the use of renewable energy sources such as biogas could reduce these heating costs by up to 40%, improving economic feasibility. Kazakhstan's geographic location offers strategic access to major high-demand markets, including China, Russia, and member states of the Eurasian Economic Union, creating significant potential for export. From a social perspective, the expansion of crayfish aquaculture could generate both direct and indirect employment opportunities, particularly in rural areas. With approximately 43% of Kazakhstan's population residing in rural communities, this sector holds promise for enhancing livelihoods and supporting socio-economic development across the country. Studies conducted in countries such as China, Australia, and Mexico have demonstrated that the success of aquaculture projects often depends on three key factors: the adaptability of the species, the development of cost-effective cultivation technologies, and the establishment of well-integrated supply chains. Building on these insights, the present study aims to enhance understanding of the cultivation of *C. quadricarinatus* in Kazakhstan. Specifically, the research investigates the feasibility of rearing both juvenile and market-size crayfish under industrial conditions within a single calendar year, while maintaining high growth and survival rates. In addition, the study evaluates the economic viability of industrial aquaculture technologies for this species in the context of Kazakhstani fish farms. This research holds significance at the national, regional, and international levels. Nationally, it has the potential to increase the contribution of aquaculture to Kazakhstan's agricultural sector, which currently accounts for only 1.2% of total production, according to the Kazakhstan Bureau of Statistics (2023). Regionally, the successful introduction of a non-native yet ecologically safe species like the Australian red-clawed crayfish could serve as a model for sustainable aquaculture in other Central Asian countries. Internationally, this study contributes to the broader body of knowledge on crustacean aquaculture, particularly in regions where such practices remain underdeveloped. As such, it may pave the way for advancements in cultivation methods and support the global expansion of the aquaculture industry. Over the past two decades, the global aquaculture industry has increasingly embraced the diversification of farmed species, with a particular emphasis on economically valuable crustaceans. According to the Food and Agriculture Organization (FAO, 2023), crustaceans accounted for 15% of global aquaculture production in 2022, a significant rise from 8% in 2000. This growth is largely attributed to the introduction of sustainable and adaptable species such as *C. quadricarinatus*, which is now commercially farmed in over 20 countries (López 2021). A number of studies have explored the biological characteristics of *C. quadricarinatus*. Medley (2020) reports that the species thrives in water temperatures ranging from 25–28 °C and tolerates salinity levels between 0–5 ppt, achieving an average weight gain of 5–7 grams per month under optimal conditions. Additionally, its resistance to common crustacean diseases has been noted: *C. quadricarinatus* shows up to 80% greater resistance to Tarda Syndrome (TS) compared to *Litopenaeus vannamei* (whiteleg shrimp), according to Cheng (2021) and Mohammed & Al-Gawhari (2024). These traits—rapid growth, environmental adaptability, and strong disease resistance—make *C. quadricarinatus* a promising species for cultivation in regions with limited aquaculture infrastructure. The success of countries such as China and Mexico in cultivating *C. quadricarinatus* serves as a practical model for other regions. Liu (2020) reports that crayfish farms in Guangdong Province, China, achieved production rates of up to 8 tons per hectare per year, resulting in economic returns approximately 40% higher than those from traditional shrimp farming. In Mexico, the adoption of integrated aquaponic systems led to a 70% reduction in water usage, highlighting the potential for sustainable intensification (Gonzalez 2022; Winarno *et al.* 2022). These outcomes demonstrate the species' strong potential for resource optimization in both traditional and innovative farming systems. From an environmental sustainability perspective, *C. quadricarinatus* holds notable advantages over many other aquaculture species. Its relatively low dietary protein requirement (25–30%) and favorable feed conversion ratio (FCR) of 1.6 contribute to cost efficiency and reduced environmental impact. A comparative analysis by Wang (2022) and Yamamoto (2021) shows that nitrogen output from *C. quadricarinatus* is 50% lower than that of shrimp and 65% lower than carnivorous fish species. Additionally, its ability to thrive on plant-based feed significantly reduces dependence on wild-caught fish for fishmeal production, helping to alleviate pressure on marine ecosystems. However, the challenges of introducing non-native species into new ecosystems cannot be overlooked. Karataev (2023) cautions that the potential introduction of *C. quadricarinatus* into Kazakhstan's rivers may disrupt the ecological balance, threatening native species such as the Siberian eel. Consequently, there is a clear need for closed aquaculture systems with multi-level environmental controls to prevent unintended ecological impacts (Ivanov 2022). From a technological standpoint, advancements are necessary to adapt farming practices to Kazakhstan's cold climate. For instance, Smith (2021) demonstrated that combining solar heating with effective insulation can reduce winter energy costs by up to 35%, highlighting a promising approach to improving the economic and environmental sustainability of crayfish farming under harsh conditions. In addition, the experience of Southern Russia in utilizing biogas from agricultural waste demonstrates a low-cost and sustainable method of generating energy for aquaculture systems (Petrov 2023; Arifin *et al.* 2023). This is particularly relevant for regions like Kazakhstan, where energy costs pose a major challenge to year-round crayfish cultivation, especially in colder climates. Economic studies emphasize that the profitability of *C. quadricarinatus* farming is strongly influenced by production scale. Simulations conducted by the World Bank (2023) suggest that aquaculture farms producing over 5 tons annually can achieve a return on investment (ROI) of 25–30% within three years. This projection is especially compelling in Kazakhstan, where the average bank interest rate stands at 14% (Kazakhstan Statistical Bureau 2023), making aquaculture a more attractive investment alternative. From a social perspective, the expansion of *C. quadricarinatus* farming holds the potential to become a powerful catalyst for rural development. According to the Asian Development Bank (2022), a single 10-hectare crayfish farm can generate up to 50 seasonal jobs, helping to alleviate unemployment in economically underdeveloped regions such as South Kazakhstan. Moreover, the development of technical skills among the rural population ensures long-term sustainability and resilience of aquaculture projects (Kazakhstan National Census 2021). Research on the cultivation of *C. quadricarinatus* under industrial aquaculture conditions in Kazakhstan is both timely and unique. The introduction of breeding and cultivation technologies for this non-traditional species has the potential to significantly expand the range of aquaculture products in the country. Beyond its economic implications, this initiative can contribute to strengthening the social and economic foundation of Kazakhstan's fishery sector and, more broadly, enhance the overall development of the agricultural industry.

MATERIALS AND METHODS

This study on the rearing of juvenile Australian red-clawed crayfish (*C. quadricarinatus*) was conducted under industrial aquaculture conditions at Kaz Organic Product LLP, located in the Almaty region of Kazakhstan. The experimental period lasted four months and began when the crayfish were 42 days post-hatching. The cultivation process was carried out in two stages, each lasting 60 days. During the first stage, juveniles were reared in glass aquaria at a stocking density of 100 individuals per square meter. In the second stage, the juveniles were transferred to larger pools with a reduced stocking density of 40 individuals per square meter. The experimental population consisted of fry from three different breeding lines, imported from a fish farm in China, with an initial average weight of 0.3 ± 0.12 g. Water quality parameters were assessed using standard methods widely accepted in hydrochemistry (Alekin 1970; State Water Quality Control 2003). A comprehensive analysis of biogenic elements and pH was conducted using express testing kits produced by "Sera" (Germany). To evaluate the influence of abiotic environmental factors on crayfish growth and development, daily monitoring (twice a day) of water temperature and dissolved oxygen was performed using the "MARK-302 M" dissolved oxygen analyzer. Throughout the experiment, hydrochemical conditions in the tanks remained stable and within optimal ranges for *C. quadricarinatus* cultivation. Water temperature varied between 26–28 °C, dissolved oxygen levels ranged from 5.0 to 6.5 mg O_2 L^{-1}, and pH was maintained between 7.5 and 8.0. Nitrite concentrations (NO_2^-) ranged from 0 to 0.25–0.5 mg L^{-1}, nitrate concentrations (NO_3^-) remained below 0.7 mg L^{-1}, and ammonium (NH_4^+) was not detected. The juveniles of *C. quadricarinatus* were manually fed throughout the cultivation process. During the initial stage in aquaria, feeding included a combination of chironomid larvae, minced fish, and commercial starter feeds produced by "Aller Aqua," with crude protein content ranging from 64% to 54%. The feed types were selected based on pellet sizes appropriate for growth stages (0, 1, 2, and 3 g). The daily feed ration was maintained at 10% of the total biomass of the juvenile crayfish. To enrich the juveniles' diet with plant-based supplements, oak leaves and assorted vegetables were placed in the tanks. In the second stage of rearing (pool culture), the crayfish were fed a formulated diet developed by Kaz Organic Product LLP, containing 41.4% protein, 9.4% crude fat, and 1.2% fiber. This shift to a less protein-dense diet corresponded with the increased body mass and metabolic stability of the crayfish during this stage. The experiment for cultivating market-size specimens of Australian red-clawed crayfish was conducted under industrial conditions at the S. Seifullin Kazakh Agrotechnical University (KATU) facility in Astana, Kazakhstan. The cultivation period lasted eight months and was carried out in a specially designed, multi-tiered recirculating aquaculture systems (RAS) for crustaceans. The CWSU system featured shallow-depth tanks with a large bottom surface area, optimized for benthic species like *C. quadricarinatus*. Each tank had a capacity of 220 liters, and a total of six tanks were used for the experiment. Cultivation was conducted in a single rearing stage, beginning with individuals at an initial mean weight of 4.2 g. The stocking density was maintained at 50 individuals per square meter. The crayfish used in this study were imported from a commercial aquaculture farm in China.

Water quality monitoring and analytical methods

Hydrochemical water parameters—including temperature, pH, and dissolved oxygen—were measured daily using a HARIBA U50 multiparameter sensor. Additionally, a comprehensive water quality analysis was performed once every seven days to assess the concentrations of key biogenic elements: nitrite (NO_2^-), nitrate (NO_3^-), and ammonium (NH_4^+). Throughout the study, the water quality in all tanks remained stable and within the optimal ranges recommended for the cultivation of *C. quadricarinatus*. Recorded values included: Water temperature: 25.0–27.0 °C; Dissolved oxygen: 5.7–7.4 mg O_2 L^{-1}; pH: 7.9–8.2; NO_2^-: 0.01–0.2 mg L^{-1}; NO_3^-: 0.5–2.5 mg L^{-1}; NH_4^+: Not detected.

During the cultivation period, crayfish were fed a varied diet composed of both plant- and animal-based feeds. The primary commercial feeds included Aller Aqua and Tetra Wafer Mix. Supplemental feeds consisted of lettuce leaves, California worms, eggshells, oak bark, and Javanese moss (a type of aquatic algae). This diverse diet aimed to meet the nutritional needs of both juvenile and market-sized crayfish across all stages of development. The cultivation practices adhered to guidelines and procedures recommended in established regulatory and technological literature, including works by Borisov *et al.* (2013), Hofstetter (2008), Zhigin *et al.* (2017), and

Arystangalieva (2017). These sources provided foundational knowledge for implementing effective rearing strategies under industrial aquaculture conditions. To evaluate the growth performance of *C. quadricarinatus*, both control and final assessments were conducted. Crayfish were weighed at regular intervals using digital scales with a precision of ± 0.1 g. Survival rates were calculated by daily mortality monitoring, expressed as a percentage of the initial population in each treatment group. Weekly clinical observations were carried out to detect signs of disease or stress, such as pallor, lethargy, or gill necrosis. Growth parameters—including absolute weight gain, total biomass, and productivity—were calculated using standard aquaculture metrics. Data were analyzed using biostatistical methods outlined by Lakin (1980). Statistical and economic analyses were carried out using Microsoft Excel 8.0 and referenced methodologies from Brigham & Ehrhardt (2007), Osipov (2017), Damodaran (2004), and Kovaleva (2004).

RESULTS

The cultivation of juvenile *Cherax quadricarinatus* was carried out under controlled industrial aquaculture conditions at the Kaz Organic Product LLP fish farm (Republic of Kazakhstan). At the first stage of the experiment, juveniles aged 42 days post-hatching with an average initial weight of 0.3 g were stocked into three identical recirculating aquaria (180 L each) equipped with mechanical and biological water purification systems. Stocking density was maintained at 100 individuals m^{-2}. The water temperature was kept between 26–28 °C, and all key hydrochemical parameters met the regulatory standards for closed water supply systems (CWSU). Crayfish were fed “Aller Aqua” feed formulated for juvenile sturgeon, containing 64% crude protein, at a daily rate of 10% of total biomass. After 60 days of cultivation, the following results were obtained: Final average weight: 6.6 g; Average daily weight gain: 0.11 g day^{-1}; Survival rate: 84%; Feed conversion ratio (FCR): 1.0. To evaluate the impact of stocking density on juvenile crayfish development, the findings from Kazakhstan were compared with similar studies conducted in the Russian Federation. The referenced study was carried out in the aquarium laboratory for invertebrate mariculture at the FGBNU “VNIRO” (Moscow). In the Russian experiment, juveniles derived from a single female, aged 45 days post-hatching, were used. A total of 162 crayfish with an initial mean weight of 0.24–0.26 g were distributed across three aquaria (180 L each) at varying stocking densities of 80, 120, and 160 individuals m^{-2}. The experimental period lasted 60 days. Water temperature was automatically maintained between 27.1–29.0 °C, and water quality parameters complied with the RAS norms (Zhigin 2011). Feeding was performed using “TetraWafer Mix” (Tetra, Germany), an ornamental fish and crustacean diet, at 10% of the live biomass per day. The impact of different stocking densities—80, 100, 120, and 160 individuals m^{-2}—on the growth and survival of juvenile *C. quadricarinatus* was evaluated under controlled conditions. The best overall performance was observed at a stocking density of 100 individuals m^{-2}, where the maximum average final weight (6.9 g), absolute growth (6.6 g), average daily weight gain (0.11 g day^{-1}), and survival rate (84%) were recorded. At a lower density of 80 individuals m^{-2}, all key performance indicators were slightly lower, with reductions of 2.78 g in final weight, 2.73 g in absolute growth, 0.041 g in daily gain, and 9% in survival rate compared to the 100 pcs. m^{-2} group. At a lower density of 80 individuals m^{-2}, all key performance indicators were slightly lower, with reductions of 2.78 g in final weight, 2.73 g in absolute growth, 0.041 g in daily gain, and 9% in survival rate compared to the 100 pcs. m^{-2} group. Conversely, increasing the density to 120 and 160 individuals m^{-2} resulted in a notable decline in growth and survival, likely due to intensified competition for feed and space, as well as potential deterioration in water quality from increased biomass. Feed conversion ratios (FCRs) also varied with stocking density and feed type. The lowest FCR (1.0) was recorded at 100 pcs. m^{-2}, suggesting optimal feed quality, palatability, and nutrient absorption. At 80 pcs. m^{-2}, the FCR was slightly higher at 1.06. Substantially less efficient feed utilization was observed at higher densities: 120 pcs. m^{-2}: FCR = 1.60; 160 pcs. m^{-2}: FCR = 1.69. This further emphasizes the negative impact of overstocking on feed performance. Regarding weight uniformity, the coefficients of variation (CV) in body mass were 100 pcs. m^{-2}: 17.1%; 80 pcs. m^{-2}: 17.48%; 120 pcs. m^{-2}: 9.25%; 160 pcs. m^{-2}: 14.34%. Although lower CVs were observed at higher densities (indicating more uniform size), they were accompanied by significantly poorer overall growth and feed efficiency. Considering all growth, survival, and feed utilization metrics, the optimal stocking density for juvenile *C. quadricarinatus* in recirculating aquaculture systems is 100 individuals m^{-2}. At this density, crayfish demonstrate strong growth, high survival, and efficient feed utilization. To support these outcomes, diets with a crude protein content of 40% or higher are recommended during juvenile development stages to ensure proper nutritional intake. Following the juvenile rearing stage in aquaria, the crayfish were transferred to breeding pools for further growth.

Table 1. Comparative Data of juvenile Australian red-clawed crayfish rearing results as a Function of Stocking Density.

	Data of Arystangalieva V.A. (2017) RF	
	(	
Period of experiment (days)		
Number of individuals in the tank (pcs.)		
Survival rate (pcs.; %)		
Average weight (g): initial,		
final		
	2.81 ± 0.26 б	0.35 б
Absolute weight gain (g)		
Total biomass (g): initial,		
final		
Absolute biomass gain (g)		
Specific growth rate		
Average daily gain (g)		
Coefficient of variation by weight (%): initial,		
(		
Feed inputs, g g^{-1} biomass growth		
(		

Due to the high cost of commercial starter feeds typically used in crustacean aquaculture, the next stage of the study focused on evaluating the use of domestically produced feeds manufactured by Kaz Organic Product LLP. This phase aimed to assess the feasibility of cost-effective, locally sourced diets while maintaining growth and survival performance under industrial conditions.

Table 2. Composition of feed for juvenile Australian red-clawed crayfish produced by Kaz Organic Product LLP.

Indicator	Value
Crude protein (%)	41.4
Crude fat (%)	9.4
Fibre (%)	1.2

It should be noted that the use of locally produced artificial feed for rearing *C. quadricarinatus* can significantly contribute to the reduction of production costs in industrial aquaculture. The results of this second-stage cultivation—conducted in pools using locally produced feed—are summarized in Table 3. As shown in Table 3, the second stage of rearing juvenile *C. quadricarinatus* in fish-breeding pools using domestically produced feed from Kaz Organic Product LLP yielded promising, though slightly reduced, performance indicators compared to the first stage. The feed conversion ratio (FCR) increased to 1.9, while the final average weight reached 20.8 g, with an average daily gain of 0.23 g. The survival rate during this stage was 68%, and the productivity was calculated at 565.8 g m^{-2}. A key factor contributing to the reduced survival rate was increased cannibalism, which is typically more pronounced during later stages of juvenile development. Nevertheless, the biological parameters of the crayfish remained within acceptable ranges and were consistent with the findings of previous studies conducted under similar rearing conditions (Borisov *et al.* 2013; Zhigin *et al.* 2017; Arystangalieva 2017; Liu 2020; Medley 2020; López 2021). Following the juvenile phase, further studies were conducted on the cultivation of marketable-sized specimens under industrial conditions at the Seifullin Kazakh Agrotechnical University (KATU NAO). Rearing began with crayfish weighing 4.2 g, cultivated in a specialized multi-tier recirculating aquaculture systems (RAS) designed for crustaceans, with a stocking density of 50 individuals m^{-2}.

Table 3. Results of rearing juvenile *Cherax quadricarinatus* in fishponds.

Indicator	Unit	Value
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 gain	g	0.23
Survival rate	%	68
Mass accumulation ratio	units	0.0425
Specific growth rate	% day^{-1}	1.842
Feeding ratio	units	1.9
Productivity	g m^{-2}	565.8

The experiment was carried out over an eight-month period, with monthly control samplings to monitor growth dynamics. Feeding was carried out using "Aller Aqua" sturgeon feed and Tetra Wafer Mix, supplemented with natural additives such as lettuce leaves, Californian worms, eggshells, oak bark, and algae (*Javanese moss*) to enrich the crayfish diet. Throughout the experiment, water quality remained stable and within optimal parameters: temperatures ranged from 25–27 °C, pH levels were between 7.9–8.2, and dissolved oxygen concentrations varied from 5.7–7.4 mg dm^{-3}.
The results of cultivating commercial-size *C. quadricarinatus* in the RAS tanks are presented in Table 4.

Table 4. Rearing results of marketable *C. quadricarinatus* in recirculating aquaculture systems (RAS).

Indicator	Value
Initial weight of juveniles (g)	4.2 ± 0.5
Growing period, days	240
Final weight of crayfish (g)	95.0 ± 7.9
Absolute weight gain (g)	90.8
Average daily gain (g)	0.378
Relative gain (%)	2162
Mass accumulation coefficient (units)	0.1262
Specific growth rate (% day^{-1})	1.30
Daily ration (% of body weight)	1.5-2
Feeding coefficient (units)	0.9-1.2
Survival rate (%)	72

As shown in Table 4, the growth performance of *C. quadricarinatus* reared under industrial conditions over an eight-month period demonstrated high productivity.
The values of absolute weight gain, average daily weight gain, and relative weight gain were 90.8 g, 0.378 g day^{-1}, and 2162%, respectively. The survival rate of the crayfish during this period was 72%. The feed conversion ratio (FCR) for the artificial feeds used ("Aller Aqua" and "Tetra Wafer Mix") ranged from 0.9 to 1.2, indicating good feed efficiency. In addition, the mass accumulation factor was calculated at 0.1262, and the specific growth rate (SGR) reached 1.30% per day, both of which confirm strong growth performance. The dynamics of monthly growth in the tanks of the specialized multi-tier recirculating aquaculture systems (RAS) at S. Seifullin Kazakh Agrotechnical University (KATU) are presented in Table 5.
Thus, the results of the study demonstrate that under proper aquaculture conditions, rearing *C. quadricarinatus* from the egg stage to juvenile or marketable size within one calendar year is achievable, provided that all necessary biotechnical protocols are followed. The experiments conducted at Kaz Organic Product LLP and S. Seifullin Kazakh Agrotechnical University (KATU) confirm the practical feasibility of producing both seed stock and market-ready crayfish under industrial aquaculture conditions in Kazakhstan. In addition to biological assessments, the study also included an economic analysis aimed at evaluating the profitability of industrial crayfish farming technologies in Kazakhstan. The findings revealed that the implementation of these technologies presents a viable commercial opportunity.

Table 5. Monthly growth dynamics of *Cherax quadricarinatus* in RAS conditions.

Indicator	Value
Initial weight (g)	4.2 ± 0.5
Weight average after one month of rearing (g)	14.8 ± 1.6
Absolute gain for the first month (g)	10.6
Average daily gain (g)	0.353
Relative gain (%)	252
Weight of young fish after 2 months (g)	25.3 ± 2.4
Absolute gain for the second month (g)	10.5
Average daily gain (g)	0.35
Relative gain (%)	71
Weight of crayfish after 3 months (g)	39.8 ± 3.8
Absolute gain for the third month (g)	14.5
Average daily gain (g)	0.483
Relative gain (%)	57
Cancer weight in 4 months (g)	54 ± 5.3
Absolute gain in fourth month (g)	14.2
Average daily gain (g)	0.473
Relative gain (%)	36
Daily ration (%) of body weight	3 - 7
Feeding coefficient	0.8-1.2
Cancer weight in 5 months (g)	67 ± 6.2
Absolute gain in the fifth month (g)	13
Average daily gain (g)	0.433
Relative gain (%)	24
Daily ration (%) of body weight	3 - 5
Feeding coefficient	0.9-1.2
Cancer weight in 6 months (g)	77 ± 6.8
Absolute gain in the sixth month (g)	10
Average daily gain (g)	0.333
Relative gain (%)	15
Daily ration (%) of body weight	2-3
Feeding coefficient	0.9-1.2
Cancer weight in 7 months (g)	86 ± 7.3
Absolute gain in the seventh month (g)	9
Average daily gain (g)	0.3
Relative gain (%)	12
Daily ration (%) of body weight	2-3
Feed coefficient	0.9-1.2
Final average weight in 8 months (g)	95.0 ± 7.9
Absolute gain in the eighth month of rearing (g)	9
Average daily gain (g)	0.3
Relative gain (%)	9.5
Daily ration (%) of body weight	1.5-2
Feed coefficient	0.9-1.2
Overall survical rate (%)	72

Fig. 1. illustrates the project payback schedule for Australian red-clawed crayfish cultivated in recirculating aquaculture systems (RAS) at Kaz Organic Product LLP, highlighting the financial return timeline based on production costs, operating expenses, and expected revenue streams.

As shown in Figs. 1 and 2, the developed technologies for cultivating Australian red-clawed crayfish under industrial conditions at fish farms in Kazakhstan demonstrate moderate profitability based on net profitability indicators. In the first case, net profitability was -22.5%, while in the second case, it reached 13.7%. Despite the initial negative figure, the implementation of the project is expected to become profitable in the future, with the discounted payback period estimated at 60 months (5 years) for both scenarios.

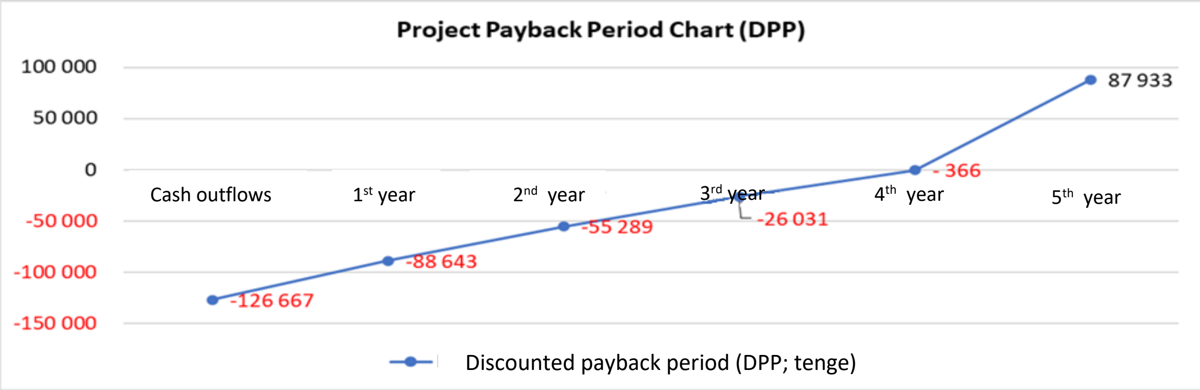

Fig. 1. Project payback schedule for Australian Red-Clawed Crayfish cultivation in RAS at Kaz Organic Product LLP.

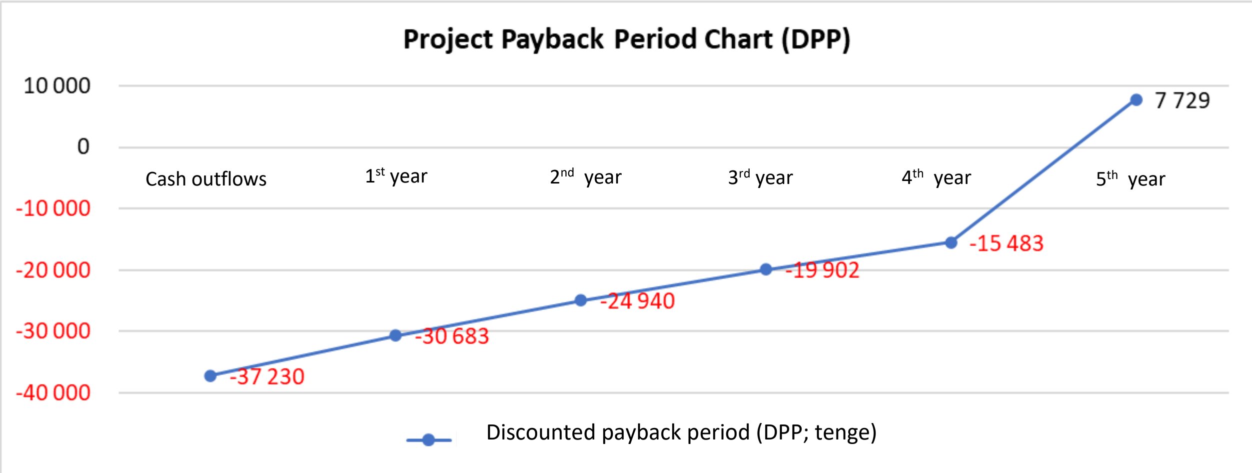

Fig. 2. presents the payback schedule for the project focused on the cultivation of Australian red-clawed crayfish at the S. Seifullin Kazakh Agro Technical University (KATU).

For the project conducted at Kaz Organic Product LLP, the financial indicators are as follows:
Net Present Value (NPV): 87,933.2 KZT > 0; Profitability Index (PI): 1.7 > 1; Internal Rate of Return (IRR): 34.22%, compared to the real discount rate of 14%. The project reaches payback by the end of the 5th year.
The Return on Sales (ROS) at project completion is 35.2%. For the project at the S. Seifulin KATU NAO site, the financial metrics include: NPV: 7,729.1 KZT > 0; PI: 1.2 > 1; IRR: 20.05%, against a discount rate of 14%. The project is financially viable and achieves payback. The ROS is 24.3%. These results confirm that the recommended cultivation technologies for juvenile and market-sized Australian red-clawed crayfish under industrial conditions at Kazakhstan fish farms are profitable and suitable for implementation. In conclusion, large-scale cultivation of *C. quadricarinatus* in Kazakhstan's industrial fish farms has strong potential to significantly boost the development of the country's aquaculture sector.

CONCLUSION

The study of the cultivation features of *Cherax quadricarinatus* under industrial fish farm conditions in Kazakhstan has demonstrated its effectiveness as a promising new aquaculture species. This advancement is expected to contribute significantly not only to the growth of the fish farming sector but also to the broader economic development of the country. Key advantages of this species include its relatively short rearing periods—juveniles can be grown within 3 months, and market-size crayfish within 8 months—along with a low feed conversion ratio and compatibility with closed water supply systems. These characteristics make *C. quadricarinatus* a sustainable and cost-efficient option for diversifying Kazakhstan's aquaculture industry. The results of this study provide a strong scientific foundation to guide future policy and strategic development, positioning Kazakhstan as a regional hub for industrialized crustacean breeding across Central Asia.

REFERENCES

Alekin O A 1970, Fundamentals of hydrochemistry, Л., 444 p.

Arifin, Y, Putra, W, Maslikhah, Tongli, B & Sholeh, M 2023, The impact of green supply chain management on the economic performance of SMEs, considering environmental conditions. *Economic Annals-XXI*, 205: 34-38, DOI: https://doi.org/10.21003/ea.V205-03.

Arystangalieva, VA 2017, Development of Technology for the Cultivation of Juvenile Australian Red-Clawed Crayfish (*Cherax quadricarinatus*) in a Closed Water Supply System [Author's abstract of the dissertation for the degree of Candidate of Agricultural Sciences, Specialty 06.04.01]. Moscow, 132 p.

Asian Development Bank 2022, *Rural employment generation through aquaculture: Central Asian perspectives.* Manila: ADB Publications.

Lakin, GF 1980, Biometrics. Moscow: Vysshaya Shkola, 293 p.

Brigham, Y & Erhardt, M 2007, Analyzing Financial Statements. In E. A. Dorofeev (Ed.), Financial Management: Theory and Practice (10th ed., 131 p.), St. Petersburg: Peter. 960 p. ISBN 5-94723-537-4.

Borisov, RR, Kovacheva, NP, Akimova, MY & Parshin-Chudin, AV 2013, Biology and Cultivation of Australian Red-Clawed Crayfish *Cherax quadricarinatus* (Von Martens, 1898). Moscow: VNIRO Publishing House, 47 p.

Cheng, W 2021, Comparative analysis of protein requirements in decapod crustaceans. *Aquaculture Nutrition*, 27: 1120-1135.

Damodaran, A 2004, Investment Valuation: Tools and Techniques for Determining the Value of Any Asset (2nd ed., trans. from English). Moscow: Alpina Business Books, 1323 p. ISBN 5961400247.

FAO 2023, *The state of world fisheries and aquaculture 2023*. Rome: Food and Agriculture Organization.

Flegel, T 2020, Emerging viral threats in crustacean aquaculture: A review. *Journal of Invertebrate Pathology*, 173: 107372.

Global Aquaculture Alliance 2023, *Market trends in crustacean farming: 2023 global report*. Portsmouth: GAA.

Gonzalez, R 2022, Water-efficient systems in Mexican aquaculture. *Aquacultural Engineering*, 98: 102245.

Hofstatter, KV 2008, Shrimp and Crayfish in the Aquarium. Moscow, 118 p.

Ivanov, S 2022, Renewable energy integration in Russian aquaculture. *Sustainable Aquaculture Journal,* 15: 45-59.

Jones, A 2020, Food security strategies for landlocked nations. *Global Food Policy*, 8: 22-37.

Karatayev, M 2023, *Ecological risks of non-native species in Central Asia*. Almaty: Kazakh Ecological Institute.

Kazakhstan Fisheries Committee 2022, *Annual report on aquaculture production 2022*, Nur-Sultan: Ministry of Agriculture.

Kazakhstan Ministry of Agriculture 2023, *National aquaculture development strategy 2023-2030*. Nur-Sultan: Government Press.

Kazakhstan National Census 2021, *Demographic and socioeconomic indicators*. Nur-Sultan: National Statistics Office.

Kazakhstan Statistical Bureau 2023, *Economic contribution of agriculture 2023.* Nur-Sultan: KAZSTAT.

Kazhydromet 2023, *Climatic atlas of Southern Kazakhstan.* Almaty: Meteorological Service.

Kovalev, AM (Ed.) 2004, Financial management: Textbook. Moscow: INFRA-M, 283 p. ISBN 5160009701.

Liu, X 2020, Intensive farming of *Cherax quadricarinatus* in China. *Aquaculture Research*, 51: 3241-3252.

López, C 2021, Biological adaptability of Cherax quadricarinatus. *Journal of Crustacean Biology*, 41: 78-89.

Medley, P 2020, Growth optimization of tropical crustaceans. *Aquaculture International*, 28: 1897-1910.

Mohammed, A & Al-Gawhari, J 2024, Bioavailability enhancement techniques, and in vitro - in vivo evaluation of rosuvastatin calcium - cyclodextrin inclusion complex nanofibers. *Procedia Environmental Science, Engineering and Management*, 11: 117-134.

Osipov YS (Ed.) 2004–2017, Profitability, In Great Russian Encyclopedia (Vols. 1-35). Moscow: Great Russian Encyclopedia Publishing, Moscow, Russia.

Petrov, A 2023, Biogas applications in cold-climate aquaculture. *Energy for Sustainable Development*, 72: 231-240.

Smith, J 2021, Thermal management in continental climates. *Aquacultural Engineering*, 94: 102189.

State Control of Water Quality 2003, Reference book of the technical committee on standardization. Moscow: IPK Publishing House of Standards, 775 p.

Wang, Y 2022, Nitrogen footprint reduction in crustacean farming. *Environmental Aquaculture*, 19: 550-565.

Winarno, ST, Harijani, WS, Soetriono, Susanto, A, Kurniawan, DT & Winarno, DRR 2022, Economic and environmental analysis of establishing coffee agrotourism in East Java, Indonesia. *Economic Annals-XXI*, 196: 29-34, DOI: https://doi.org/10.21003/ea.V196-03.

World Bank 2023, *Export potential of Central Asian aquaculture*. Washington, DC: World Bank Group.

Yamamoto, K 2021, Waste management in shrimp vs. crayfish farming. *Marine Pollution Bulletin*, 168: 112432.

Zhigin, AV, Borisov, RR, Kovacheva, NP, Zagorskaya, DS & Arystangalieva, VA 2017, Growing Australian Red-Clawed crayfish in a circulating installation. Fish Farming, (1), 56–61.

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