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Original article

FEEDING SPECIFICS OF THE AUSTRALIAN RED CLAW CRAYFISH *CHERAX QUADRICARINATUS* (VON MARTENS, 1868) IN AQUACULTURE

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Abstract

Background. The selection of optimal feed formulations is a primary factor determining the efficiency and sustainability of aquaculture. The Australian Red Claw Crayfish, *Cherax quadricarinatus* (von Martens, 1868), known for its high growth rates and tolerance to water quality parameters, is a popular aquaculture species worldwide. However, the development of specialized feeds for this species remains insufficiently addressed. In practice, prepared feeds for other crustaceans or for sturgeon are commonly used for its cultivation. In natural habitats, the diet of this crayfish consists primarily of macrophytes (up to 87.5%) and detritus (42.8%), with the proportion of the plant component increasing with body size. The omnivorous feeding type creates opportunities for finding cheaper protein sources compared to fishmeal. Analysis of scientific research has shown that black soldier fly larvae and yellow mealworm can be used as alternatives to fishmeal in feeds for the Australian crayfish. Among plant-based raw materials, soybean, rapeseed, and peanut meal are unsuitable components. The specific feeding behavior of the Red Claw Crayfish necessitates sufficient stabilization and binding of feed pellets. Furthermore, the shape of the feed pellets must be considered, with the prism shape being the most preferable. Developing feed formulations that account for the biological specifics of the Red Claw Crayfish will enhance the efficiency of its aquaculture and reduce costs for farmers.

Purpose. To identify the main dietary characteristics and nutritional requirements of the Australian red claw crayfish *Cherax quadricarinatus* in order to develop feed formulations that ensure high farming efficiency and economic sustainability in aquaculture.

Materials and methods. A comparative – analytical approach was applied in this study. The information base was formed through the analysis of more than 150 scientific publications from both domestic and international sources. Literature searches were conducted in databases such as eLibrary, ScienceDirect, ResearchGate, Google Scholar, Wiley, and others, using keywords in both Russian and English.

Results. The analysis revealed that *Cherax quadricarinatus* is capable of effectively digesting both plant- and animal-based dietary components. Protein was identified as the primary limiting nutrient, with an optimal content for juveniles ranging between 30-33%. As an alternative to fish meal – the most expensive component of aquafeeds – promising protein sources include black soldier fly larvae, yellow mealworms, poultry by-products, and microbial protein DREAMFEED. The species' specific feeding behavior necessitates high water stability and mechanical strength of feed pellets, as well as adjustment of their shape and size according to crayfish age; prismatic pellets are considered optimal. Experimental studies of both domestic and international feed formulations demonstrated that the use of alternative protein sources and locally available raw materials can reduce feed costs without compromising growth rates or survival.

Conclusion. The efficiency of *Cherax quadricarinatus* aquaculture is largely determined by the quality and nutritional balance of the feed. The biological features of this species, including its versatile digestive system and ability to process a wide range of organic substances, provide a basis for the development of diets using alternative protein sources. Diets that maintain an optimal balance of proteins, lipids, carbohydrates, vitamins, and minerals contribute to enhanced productivity, survival, and profitability of aquaculture farms. The improvement of feed formulations and manufacturing technologies aimed at increasing water stability and adapting pellet size to different developmental stages represents a key direction for the further advancement of *Cherax quadricarinatus* aquaculture.

Keywords: Red Claw Crayfish; *Cherax quadricarinatus*; feeds; aquaculture; feed formulations; feed additives; probiotics

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Научная статья

ОСОБЕННОСТИ КОРМЛЕНИЯ АВСТРАЛИЙСКОГО КРАСНОКЛЕШНЕВОГО РАКА *CHERAX QUADRICARINATUS* (VON MARTENS, 1868) ПРИ ВЫРАЩИВАНИИ В АКВАКУЛЬТУРЕ

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Аннотация

Обоснование. Подбор оптимальных рецептур кормов является основным фактором, который определяет эффективность выращивания и устойчивость аквакультуры. Австралийский красноклешневый рак *Cherax quadricarinatus* (von Martens 1868), обладая высокими темпами роста и толерантностью к показателям качества воды, является популярным объектом аквакультуры во всем мире. Тем не менее, вопрос разработки специализированных кормов не полностью раскрыт. В практике выращивания этого вида используют готовые корма для других ракообразных, либо для осетровых рыб. В естественных местах обитания основой пищи раков составляют макрофиты (до 87,5%) и детрит (42,8%), причем с увеличением размера тела увеличивается доля растительного компонента в питании красноклешневых раков. Всеядный тип питания создает возможность для поиска более дешевых источников белка по сравнению с рыбной мукой. Анализ научных исследований показал, что в качестве альтернативы рыбной муке в кормах для австралийского рака возможно использование личинок черной львинки и желтого мучного червя. Среди растительного сырья неподходящими компонентами являются соевая, рапсовая и арахисовая мука. Особенность пищевого поведения красноклешневого рака обуславливает необходимость в достаточной стабилизации и закреплении кормовых гранул. Кроме того, необходимо учитывать форму гранул корма, среди которых наиболее предпочтительной формой является призма. Создание кормовых рецептур с учетом особенностей красноклешневого рака позволит повысить эффективность аквакультуры этого объекта и снизит затраты фермеров.

Цель. Определить основные особенности питания и кормовых потребностей австралийского красноклешневого рака *Cherax quadricarinatus* с целью разработки рационов, обеспечивающих высокую эффективность выращивания и экономическую устойчивость аквакультуры.

Материалы и методы. В исследовании применялся сравнительно-аналитический метод. Информационная база была сформирована на основе анализа более 150 научных публикаций, представленных в отечественных и зарубежных источниках. Поиск литературы осуществлялся в базах eLibrary, ScienceDirect, ResearchGate, Google Scholar, Wiley и других с использованием ключевых слов на русском и английском языках.

Результаты. Анализ показал, что австралийский красноклешневый рак способен эффективно усваивать как растительные, так и животные компоненты рациона. Основным лимитирующим элементом питания является белок, оптимальное содержание которого для молоди составляет 30-33%. В качестве альтернативы рыбной муке, являющейся наиболее дорогостоящим компонентом, перспективно использование белков из личинок черной львинки, желтого мучного червя, субпродуктов птицы и микробного белка. Отмечено, что особенности пищевого поведения данного вида требуют высокой водоустойчивости и механической прочности гранул, а также подбора их формы и размера в зависимости от возраста раков. Экспериментальные исследования отечественных и зарубежных рецептур показали, что использование альтернативных источников белка и местного сырья позволяет снизить себестоимость кормов без ухудшения показателей роста и выживаемости особей.

Заключение. Эффективность выращивания австралийского красноклешневого рака в аквакультуре определяется качеством и сбалансированностью кормов. Биологические особенности вида, включая универсальность пищеварительной системы и способность переваривать широкий спектр органических веществ, создают возможности для разработки рационов на основе альтернативных источников белка. Рационы, обеспечивающие оптимальное соотношение белков, жиров, углеводов, витаминов и минералов, способствуют повышению продуктивности, выживаемости и рентабельности хозяйств. Совершенствование рецептур и технологии производства комбикормов, направленное на повышение водоустойчивости и адаптацию гранул к разным возрастным группам, является важным направлением для дальнейшего развития аквакультуры *Cherax quadricarinatus*.

Ключевые слова: красноклешневый рак; *Cherax quadricarinatus*; корма; аквакультура; рецептуры корма; кормовые добавки; пробиотики.

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Introduction

The success of cultivating aquaculture species depends on feeding quality. Diet selection should be based on the biological characteristics of the species, age category, etc. The experience of feeding the Australian Red Claw Crayfish is based on diets specialized for other crustacean species, such as *Litopenaeus vannamei*, *Penaeus monodon*, and *Macrobrachium rosenbergii* [1]. In some cases, artificial feeds created for sturgeon are used for feeding Red Claw Crayfish. Despite good growth rates with such feeding, the development of specialized artificial feeds for this species is required.

Fig. 1. Appearance of a male *Cherax quadricarinatus*

Fig. 2. Appearance of a female *Cherax quadricarinatus*

The Australian Red Claw Crayfish *Cherax quadricarinatus* (von Martens, 1868) (Fig. 1) offers several advantages for aquaculture: high growth rates, tolerance to deteriorating water quality [1, 2], and an attractive appearance. From a consumer perspective, this species is also of interest due to its high yield of tender meat [3], constituting 30% of body weight [2]. The Australian Red Claw Crayfish is a tropical species, with an autochthonous range covering Northern Queensland, Australia. This species is cultivated in many countries worldwide, including Argentina, Mexico, Spain, the USA, Southeast Asia, and Central/South America [2], among others.

Enterprises specializing in the commercial cultivation of the Australian Red Claw Crayfish that lack their own broodstock must spend a substantial portion of their financial resources on purchasing juveniles. With this approach, it is important to ensure high survival rates of the aquaculture stock to achieve maximum possible profit. Research results have shown that diet type significantly influences the survival and growth rates of *C. quadricarinatus* [4]. When cultivated in ponds, crayfish consume natural food organisms; however, for production intensification, the additional introduction of artificial feeds is required. These feeds must account for all biological needs of the species and possess high water stability [2].

Objective

The object of the study is the Australian red claw crayfish *Cherax quadricarinatus* cultivated under aquaculture conditions, as well as its feeding characteristics and nutritional requirements that determine the effectiveness of formulated feed development and application for this species.

Materials and methods

A comparative-analytical method was applied during the research. The information base was formed through the analysis of data from open scientific publications. Literature searches were conducted in abstract and information databases, including eLibrary, the Russian State Library, ScienceDirect, ResearchGate, Google Scholar, National MedLine, the Wiley Online Library, and others. The following key terms were used as search queries: «*Cherax quadricarinatus*», «Australian red claw crayfish», «red claw crayfish», «aquaculture», «crustaceans», «feed», «diet» - both individually and in various combinations. No temporal restrictions were set during the search to cover the most representative body of publications. In total, over 150 literature sources were analyzed during the study.

Feeding Type

Analysis of the digestive tract contents of juvenile Australian Red Claw Crayfish (body size less than 28.7 mm) from natural water bodies showed that macrophytes constituted a significant portion of the food bolus (87.5%), with detritus content being second (12.1%). As crayfish grow, the quantity of food particles in the digestive system changes. In individuals with a body size greater than 56 mm, the content of macrophytes decreases (to 57.2%), while detritus consumption increases (to 42.8%) [5].

In the digestive system of juvenile Red Claw Crayfish, enzymes play a significant role. The activity of proteases – enzymes that break down proteins, including trypsin, astacin, exopeptidase, and aminopeptidase – is most pronounced [6, 7]. However, their activity and concentration change depending on age and diet. Ontogenetic changes in *C. quadricarinatus* lead to high activity of general proteases in juveniles, which decreases with growth [8].

The entire genus *Cherax* possesses a large number of carbohydrase enzymes: amylase, cellulase, endo-β1,4-glucanase, β-glucosidase, laminarinase, lichenase, xylanase, endochitinase, and N-acetyl-β-D-glucosaminidase, which ensure the breakdown of starch, oligosaccharides, and other carbohydrates. The activity of cellulase indicates that dietary cellulose is assimilated and can serve as an energy source at all free-living stages, as this enzyme is present at all growth stages and can be synthesized by the organism of the Australian Red Claw Crayfish itself [8]. It is important to note that cellulase activity was observed in the smallest crayfish even before first feeding, indicating an ability to use plant material as food from the moment yolk absorption is completed. The cellulase enzymes of the Red Claw Crayfish demonstrate broad substrate specificity, hydrolyzing polysaccharides containing β-1,4 and mixed β-1,4 and β-1,3 glycosidic bonds, but showing a preference for soluble substrates [9]. The diversity of digestive enzymes (proteases, carbohydrases, and lipases) confirms the ability of Red Claw Crayfish to successfully digest various types of food [10]. Thus, the enzymatic system of *C. quadricarinatus* is universal and plastic: high protease activity ensures the assimilation of protein substrates, the presence of cellulases and other carbohydrases allows for the effective use of plant-based carbohydrate sources, and a developed lipase system promotes lipid assimilation. The presence of such an enzymatic apparatus allows for the creation of feed formulations characterized by greater availability and lower overall production costs.

Nutrient Requirements of Australian Red Claw Crayfish in Feed Composition

The most limiting element at any growth stage of the Australian crayfish is protein, which is simultaneously the most expensive component of compound feeds in aquaculture. The protein content in the diet of aquaculture species influences the cost of compound feeds, which can account for up to 70% of all expenses on an aquaculture farm. Regarding the Australian Red Claw Crayfish, it is reported that for juveniles weighing 1 g, a sufficient level of crude protein is 31%, while for early juveniles weighing 0.022 g, 33% crude protein is necessary [11]. It has been established that for juveniles aged from 9 to 19 weeks, the rational use of feeds with a protein content of 30% is recommended [12].

Among the essential amino acids, lysine and threonine determine the growth success of Australian Red Claw Crayfish [10] because they cannot be synthesized in the body and must be supplied through feed. The addition of 0.4% threonine to the diet significantly increases crayfish growth rates ($P < 0.05$), feed digestibility, enhances antioxidant status, and stabilizes intestinal microbiota [13].

Lipids also play an important role in the functioning of the Australian Red Claw Crayfish organism, and the requirement for these substances must be considered in artificial feeds. They provide the organism with energy and essential fatty acids, sterols, phospholipids, and fat-soluble vitamins necessary for proper physiological functioning and maintaining the biological structure and functions of cell membranes. Soybean oil has been proposed as a lipid source. Experiments have shown that when soybean oil was included in artificial feeds at 40 g/kg dry matter and 60 g/kg dry matter, the growth rate of juvenile crayfish was significantly higher than at 20 g/kg, 80 g/kg, and 100 g/kg dry matter ($P < 0.05$). It was established that the optimal lipid level in the diet of *C. quadricarinatus* is 9.67% [14].

Features of Juvenile Feeding in Aquaculture

A peculiarity of the feeding behavior of the Australian Red Claw Crayfish is the slow consumption of feed particles and the performance of a series of manipulations with them (transfer between pereiopods), which necessitates sufficient stabilization and binding of feed particles. Furthermore, the shape of the feed particles also matters for feeding success. In a study by Cheng S. et al., it was shown that the most preferable pellet shape is a prism compared to a column, granule, or tablet [4]. Existing scientific recommendations regarding the feeding of juvenile Red Claw Crayfish can be summarized in several theses:

- Supplemental feeding should begin after the yolk sac disappears;
- Feed should be provided twice a day (morning and evening);
- The size and shape of the feed particle must be suitable for holding by the pereiopods [4].

Testing of experimental feed formulations demonstrated good growth and survival indicators for juvenile Red Claw Crayfish with an average weight of 0.024 g on a diet consisting of 85% feed mixture + 14% *Artemia* + 1% spirulina powder. Additionally, it was shown that feeding with *Artemia* could improve trypsin activity in juvenile Australian Red Claw Crayfish and thus promote their growth [4].

Some juvenile crayfish cultivation technologies involve the use of natural feeds. In a study by Muhammad Safir, Akbar Marzuki Tahya, and Hikmah Asdin, crayfish growth rates were analyzed when fed carrots, golden snails, earthworms, and anchovies. The obtained results indicate the high effectiveness of a diet consisting of the worms *Lumbricus rubellus*. The daily growth increment with such feeding was 0.69% (compared to 0.40%, 0.43%, and 0.13% with other diets) [15].

Alternative Protein Sources for Feeds

In most artificial feed formulations for aquaculture, fishmeal is used as the protein source [16] in amounts of 20-50% [1]. This component is expensive [17], which increases feed costs and raises the production cost of commercial Australian Red Claw Crayfish products. The omnivorous feeding type, as well as the effective enzymatic system in the gastrointestinal tract of *C. quadricarinatus*, allows for the use of alternative protein sources of plant origin. The success of this approach has been proven in feeding the crustaceans *Eriocheir sinensis*, *Pacifastacus leniusculus*, *Macrobrachium nipponense*, and *L. vannamei*.

In many aquaculture sectors, researchers are conducting work on selecting alternative protein sources [18]. The selection of alternative protein sources from plant raw materials requires careful analysis of their impact on the crayfish organism. In an experiment by Dunwei Qian, it was shown that the introduction of soybean meal into the crayfish diet adversely affects the organism's condition. An increase in malondialdehyde levels and a decrease in acid phosphatase were recorded. Peanut meal is also an unsuitable replacement for fishmeal for Red Claw Crayfish, as it leads to high activity of glutathione peroxidase, alanine aminotransferase, aspartate aminotransferase, and reduced lipase activity. When rapeseed meal is introduced into the diet, detachment of the peritrophic membrane and lower lipase activity are recorded [1].

Insect meal is recognized as a promising replacement for fishmeal [19], particularly meal from black soldier fly larvae [20]. The use of yellow mealworm meal is possible, which increases superoxide dismutase activity and reduces malondialdehyde content in the crayfish hepatopancreas [11]. The use of poultry by-product meal as an inexpensive alternative to fishmeal is also being considered. During experimental feeding of juvenile Red Claw Crayfish (average weight 13.0±0.03 g), no differences in growth indicators were found between a diet based on fishmeal and one based on poultry by-product meal and plant components [21].

Exogenous enzymes are often present in feeds for aquaculture species [22]. These proteins contribute to improved digestibility of complex polymeric compounds, better feed utilization, energy conversion, and reduced nutrient loss [23]. In the work of E.S. García Martínez et al., the growth rates of juvenile Red Claw Crayfish (average weight 1.5 g) were analyzed upon the introduction of a multi-enzyme extract obtained from waste of the Argentine shrimp *Pleoticus muelleri* into the diet. The feed base consisted of plant (65%) and animal (25%) components. After feeding the crayfish for 90 days, it was established that the introduction of exoenzymes significantly modulates the animals' digestive enzymes. For example, the activity of endogenous digestive peptidases increased, and a tendency for increased lipase activity was shown. The experimental group recorded lipid accumulation in the hepatopancreas and increased glycogen in the muscles [23].

Reducing the production cost of pond-cultivated products is possible by making feeds cheaper through the omission of vitamin and mineral additives. In a study by Yuka Kobayashi et al., weight gain indicators of juvenile *C. quadricarinatus* (average weight 15.7±1.0 g) were analyzed on a diet with added premixes (control) and without added premixes (experimental). After 105 days of cultivation in ponds (pond area 0.02 ha) at a density of 3.2 ind./m², no statistical differences (P>0.05) were found in the feed conversion ratios for the groups of juveniles receiving different diets [24].

Compound Feed Components for *Cherax quadricarinatus*

To develop cost-effective diets, it is necessary to understand how farmed organisms utilize energy. Energy from non-protein sources (lipids, carbohydrates) must be supplied in the diet in sufficient quantity relative to the protein level so that protein is used for tissue synthesis, as it is considered the most expensive major component of crustacean diets. If the ratio of non-protein energy to protein in the diet is insufficient, then dietary protein may be catabolized and used as an energy source for maintaining vital functions, rather than for somatic growth.

A balance of basic nutrients determines the optimal composition of feeds for the Australian Red Claw Crayfish: protein, fat, and mineral components, as well as carbohydrates and vitamins. The growth rate and protein content directly depend on the content of protein components in the feed; sources such as fishmeal, meat-and-bone meal, shrimp meal, and crab meal are used for this purpose. In turn, fat components provide essential fatty acids; the presence of lipids supports the growth process, and the presence of carbohydrates in the crustacean diet is used as an energy source. Mineral components and vitamins are aimed at maintaining normal body function and increasing overall survival.

Examples of Feed Formulations.
Australian FRDC Project (92/119) Compound Feeds

In the mid-1990s, large-scale research was conducted in Australia to determine optimal diets for cultivating *C. quadricarinatus*. During the FRDC project (92/119) under the direction of C.M. Jones and I.M. Ruscoe, six different diets were tested – five pelleted compound feeds and one "natural" diet (a mixture of whole rice, lupin seeds, and raw potatoes) in pond cage and laboratory aquarium conditions. The feed compositions varied significantly in protein content: from 18 to 42%. The diets included commercial crayfish feeds, shrimp feed (*Penaeus monodon*), fish feed, and a specially developed "reference diet" for Red Claw Crayfish, which included fishmeal (21%), meat-and-bone meal, soybean meal, cottonseed cake, cereals, amino acid supplements (lysine, methionine, threonine), and a vitamin-mineral premix.

The cultivation results showed that all feeds provided satisfactory growth: over 5 months, crayfish weight increased from 10 to 25-65 g, with individual specimens reaching over 100 g. The highest efficiency was noted for one of the commercial crayfish compound feeds – the average weight at harvest was 45.8 g, which was significantly higher ($p < 0.01$) than when using the other diets (31.3-38.5 g). Meanwhile, the "natural" diet demonstrated the worst results, despite its high caloric content.

Escapes and predators complicated survival in the trials, which prevented a reliable assessment of the diet's influence on this indicator. Nevertheless, the obtained data confirmed that a complex of factors could determine formulating diets with high protein content does not always guarantee better results, and feed efficiency. The conclusions of the 1996 research formed the basis for industrial feed production.

Compound Feed with DREAMFEED Additive

Formulations of compound feeds for *C. quadricarinatus* have now been developed and are in use, in which part of the fishmeal is replaced with the microbial protein DREAMFEED to reduce costs. This is a concentrate of microbial protein from an inactivated cell culture of *Methylococcus capsulatus* (strain GBS-15), grown on methane. Its chemical composition is characterized by high crude protein content (70-80%), lipids (9-14%), ash (6-10%), and low moisture. Trials of compound feeds with the DREAMFEED additive were conducted in two stages: on juveniles (with 20% additive content) and on adults (with 15% additive content). The percentage composition of components in the control and experimental types of compound feeds is presented in Table 1.

Table 1.

Formulation of control and experimental compound feeds for *Cherax quadricarinatus*

Components, %	Control	Feed with DREAMFEED – Juveniles	Feed with DREAMFEED – Adults
Fishmeal	72	52	57
Wheat Gluten	15	15	15
Blood Meal	3	3	3
Premix	1	1	1
Grape Pomace Meal	1	1	1
Krill Meal	5	5	5
DREAMFEED	-	20	15
Fish Oil	3	3	3

According to the research by Ponomorev S., the compound feeds with microbial protein DREAMFEED did not differ from the control feed in organoleptic characteristics; differences were manifested in the higher nutritional value of the compound feed with the DREAMFEED additive, where protein content reached 67% and lipids about 10%, as well as in its greater water stability. Over the first two months, the weight gain in the group with the additive was 11.57% higher compared to the control. The average daily gain was 3.87% versus 3.69% in the control group, and the mass accumulation coefficient was also higher (5.6% vs. 5.3%). Furthermore, weight distribution within the population was more uniform: the control group had more individuals with low weight (2-3 g and 3-6 g), whereas the experimental group had a larger proportion in the heavier size classes (7-10 g). However, juvenile survival remained approximately the same in both groups (69-70%), which is associated with the high frequency of molting and the vulnerability it causes [25].

In the second stage of the experiment, when crayfish were cultivated for another three months, the differences in results were less pronounced. The absolute weight gain was 25.49 g in the experimental group and 24.83 g in the control, meaning the difference in favor of the feed with the additive was only 2.66%. The average daily gain also differed insignificantly (1.38% vs. 1.44%). However, a significant advantage of the experimental feed was the higher survival of adults – 100% against 94% in the control group [25].

Compound Feed by «KazNRI of Processing and Food Industry» LLP

In Kazakhstan, a specialized production compound feed for the Australian Red Claw Crayfish based on locally produced ingredients was developed for the first time. «KazNRI of Processing and Food Industry» LLP carried out its creation and testing in 2021-2023 in recirculating aquaculture systems (RAS). The imported feed "Aller Aqua" (Denmark), traditionally used in aquaculture, was used as a control in the experiments [26].

The composition of the compound feed changed during the refinement of the formulation. The basis was formed by fishmeal (10-25%), meat-and-bone meal (10-15%), corn gluten (5-15%), wheat (14-25%), soybean meal (up to 12%), feed yeast (10-18%), vegetable oils (soybean and rapeseed), as well as mineral and vitamin additives (monocalcium phosphate, premixes, lecithin, betaine, flavorings). The feed was balanced in protein (38-41%), fat (8-12%), and mineral substance content, corresponding to the physiological needs of crayfish.

In 2021, for juveniles, the average daily weight gain was 0.17 g with a feed conversion ratio (FCR) of 1.5 and a survival rate of 74%, while the control feed indicators were slightly higher (0.19 g, 1.2, and 78%, respectively). In 2022, for marketable specimens, weight gain reached 12.3 g over 30 days with a survival rate of 93%, which was comparable to the results with "Aller Aqua". In 2023, high survival rates (94-95%) were observed with similar values for weight gain and feed conversion ratios. Thus, the differences between the experimental and control groups were statistically insignificant.

The developed Kazakh specialized compound feed has a balanced composition, is well assimilated by crayfish, and provides satisfactory growth and survival indicators comparable to imported feeds. Its main advantage is a significantly lower cost due to the use of local raw materials, making it economically viable for the industrial cultivation of *C. quadricarinatus*. The use of local formulations contributes to reducing the cost of aquaculture products and developing import-substituting technologies in the republic.

Feeds by Ridley Agri Products Pty Company

In feeds for *C. quadricarinatus* produced by Ridley Agri Products Pty Company, plant proteins are primarily used – cereals, legumes, and oilseed crops, completely excluding fishmeal, which allows for a significant reduction in production costs. However, research into their effectiveness has revealed a number of serious limitations directly affecting cultivation outcomes.

The key problem was the low water stability of the pellets. Experiments showed that standard industrial pellets with a diameter of 4.5 mm retain their structure in water for no more than 10-15 minutes before beginning to disintegrate. The second important limitation was the uniform pellet size. The industry produces only feed with a pellet diameter of 4.5 mm; juveniles and grow-out individuals cannot efficiently consume such large particles. As a result of studying feeding responses, it was noted that feeds with a fully plant-based composition have reduced attractiveness for crayfish [27].

Within the research of Thobejane T. R., attempts were made to improve feed efficiency; the greatest effect was achieved by introducing binding additives, particularly alginate at a dosage of 4.4% of dry mass [27]. This modification increased pellet water stability: 24 hours after immersion in water, the pellets retained their structure, and the level of dry matter loss decreased to 16.2%, which is significantly better compared to 23.8% for the standard feed. It was established that a three-level scheme is optimal: pellets with a diameter of 1.0 mm for juveniles weighing 5-8 g, 2.0 mm for grow-out individuals weighing 15-25 g, and 3.0 mm for adult crayfish weighing 35-50 g. This approach significantly improved feed utilization efficiency and reduced its losses.

Results

The study established that the Australian red claw crayfish *Cherax quadricarinatus* exhibits high dietary plasticity and can efficiently utilize feeds of various origins. The key factor determining the growth rate and development of juveniles is the protein level in the diet, which should be maintained at approximately 30–33%. The species' feeding behavior necessitates optimization of the physical properties of feed pellets, including high water stability and the adjustment of pellet shape and size according to the developmental stage of the animals. Experimental evaluation of domestic and international feed formulations demonstrated that the use of alternative protein sources and locally available raw materials can reduce feed costs without compromising growth performance and survival rates.

Conclusion

The analysis of the feeding specifics of the Australian Red Claw Crayfish has shown that the efficiency of aquaculture cultivation of this species is largely determined by the composition and quality of feeds. The biological characteristics of the species, including an omnivorous feeding type, a broad spectrum of enzymes, and the ability to assimilate both animal and plant components, create opportunities for developing diverse and economically accessible diets. At the same time, unbalanced feeding or the use of unsuitable ingredients leads to slowed growth, reduced survival, and increased production costs. Diets for the Australian Red Claw Crayfish must ensure a balance of proteins, fats, carbohydrates, vitamins, and minerals. The use of alternative components, such as microbial and plant proteins, allows for a reduction in feed costs; however, it requires consideration of their impact on crayfish growth and survival. Improving feed formulations and compound feed technology, including enhancing water stability and adapting pellet sizes for different age groups, is an important condition for increasing the efficiency of *Cherax quadricarinatus* aquaculture.

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Ethical statement. This article does not contain any studies which require ethics committee approval.

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