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INNOVATIVE DIRECTIONS OF THE BIOTECHNOLOGY OF GROWING *CHERAX QUADRICARINATUS* IN THE AQUACULTURE OF UKRAINE

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INTRODUCTION

World aquaculture is actively developing, steadily increasing its share in the total production of hydrobionts. Today, more than 48% of consumed fish products are grown in aquaculture. In the area of consumption, the range of delicate species of hydrobionts (including crustaceans) is expanding[1].

Aquaculture of crustaceans is one of the main sources of valuable food protein, which cannot be replaced by other animal or vegetable proteins due to its properties[2].

The statistics of The Food and Agriculture Organization (FAO) mention 45 species of crustaceans as a separate object of aquaculture: shrimp (*Caridea*) – 26; crabs (*Brachyura*) – 9; river crayfish (*Astacoidea*, *Parastacoidea*) – 7; lobsters (*Achelata*) – 3. In the total volume of crustacean aquaculture, crayfish occupy 10%, crabs – 15%, and the main volume falls on shrimp – 75%[3].

The production of products that ensures maximum profit is determined, firstly, by the development of aquaculture as an element of the primary sector of the country's economy and, secondly, by the high technological level of cultivation of hydrobionts on an industrial scale.

Over the past twenty years, the Australian red-clawed crayfish *Cherax quadricarinatus* (von Martens, 1868) has been introduced to many countries and successful aquaculture sectors of this species have been established[4].

At the moment, in Ukraine, there is a lot of information on the methods of growing the Australian red-clawed crayfish *Cherax quadricarinatus* (von Martens, 1868) only at the amateur, experimental level, without standards of breeding and maintenance technology. Market analysis showed a complete

[1] Haubrock P.J., Oficialdegui F.J., Zeng Y., Patoka J., Yeo D.C.J., Kouba A. The redclaw crayfish: A prominent aquaculture species with invasive potential in tropical and subtropical biodiversity hotspots. *Reviews in Aquaculture.* 2021. № 13(3). P. 1488–1530.

[2] Boyd C.E., McNevin A.A., Davis R.P. The contribution of fisheries and aquaculture to the global protein supply. *Food Security.* 2022. № 14. P. 805–827.

[3] FAO. World Food and Agriculture – Statistical Yearbook 2022. Rome.

[4] Patoka J., Wardiatno Y., Mashar A., Wowor D., Jerikho R., Takdir M., Purnamasari L., Petrtyl M., Kalous L., Kouba A., Blaha M. Redclaw crayfish, *Cherax quadricarinatus* (von Martens, 1868), widespread throughout Indonesia. *BioInvasions Records.* 2018. № 7(2). P. 185–189.

lack of marketable *Cherax quadricarinatus*. At the same time, the large number of proposals for the sale of fry of this hydrobiont suggests the establishment of breeding methods and the complete absence of the technology for growing a commercial product[5].

On a large scale, the cultivation of red-clawed crayfish requires knowledge of biological characteristics, mastering the biotechnological process of reproduction, research into the breeding and economic features of this species with the development of modern, progressive biotechnological schemes and standards for controlled conditions.

1. Australian red-clawed crayfish is a new object of freshwater crustacean aquaculture in Ukraine

Aquaculture of crustaceans has been developing for many years in countries with tropical and subtropical climates, while industrial cultivation of these hydrobionts occupies an insignificant place in temperate latitudes[6].

The Australian red-clawed crayfish *Cherax quadricarinatus* (von Martens, 1868) (Fig. 1) appeared relatively recently on the territory of Ukraine as an object of aquaculture and aquarium science.

Fig. 1. Australian red-clawed crayfish *Cherax quadricarinatus* (von Martens, 1868), ♂ (photo by authors)

Biological classification: type – *Arthropoda*; subtype – *Crustacea*; class – *Malacostraca*; series – *Decapoda*; family – *Parastacidae*; genus – *Cherax*;

[5] Hrynevych N.E., Zharchynska V.S., Svitelskyi M.M., Khomiak O.A., Sliusarenko A.O. Promising object of aquaculture of crustaceans *Cherax quadricarinatus* (von Martens, 1868): biology, technology (review). *Aquatic bioresources and aquaculture*. 2022. № 1. P. 47–62.

[6] Nanda P.K., Das A.K., Dandapat P., Dhar P., Bandyopadhyay S., Dib A.L., Lorenzo J.M., Gagaoua M. Nutritional aspects, flavour profile and health benefits of crab meat based novel food products and valorisation of processing waste to wealth: A review. *Trends in Food Science & Technology*. 2021. № 112. P. 252–267.

species – *Cherax quadricarinatus*. The first description and scientific species name was given in 1868 by the German zoologist Karl Eduard von Martens[7].

The natural range of distribution includes the northern territories of Australia, northwestern Queensland, the southern part of Papua New Guinea, as well as New Zealand, where red-clawed crayfish inhabit floodplains, small freshwater rivers, lakes and streams. They live under stones, tree trunks, sometimes in burrows. *Cherax quadricarinatus* is a fairly large representative of the river crayfish of the Australian continent. The body length reaches 20-25 cm. The weight of males is 500 g, and females – 400 g. In sexually mature males, a peculiar bright red flat growth is clearly visible on the outer part of the claw. It is because of this feature that the species got its name[8].

The species *Cherax quadricarinatus* was first introduced to the general public in the late 1980s, in south-east Queensland, as a promising new target for commercial aquaculture and a potential source of income for farmers.

Today, China is the largest supplier of *Cherax quadricarinatus* products in the world market (more than 70%). As an aquaculture species, red claw crab has been introduced to Argentina, Barbados, Guatemala, Malaysia, Mauritius, Mexico, New Caledonia, Samoa, Uruguay, Belize, Indonesia, Morocco, Panama and Spain. The main countries that grow Australian red-clawed crayfish in commercial volumes are Indonesia, Israel, Spain and the USA. Marketable crayfish are grown both in monoculture and in polyculture together with non-predatory fish species (*Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis*, *Ctenopharyngodon idella*)[9].

The Australian red claw crab *Cherax quadricarinatus* (von Martens, 1868) dominates crustaceans in terms of biological, ecological and commercial properties in freshwater aquaculture. *Cherax quadricarinatus* is an optimal species for cultivation due to a number of characteristics: a relatively simple life cycle, unpretentiousness to the conditions of maintenance, high resistance, the ability to consume a wide range of feeds. This species is quite capable of competing with freshwater shrimp *(Macrobrachium rosenbergii)*, which is in good demand. In addition, the works of[10] confirm the high degree of profitability and significant potential of industrial crayfish farming.

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[7] Crandall K.A., Grave S.D. An updated classification of the freshwater crayfishes (*Decapoda: Astacidea*) of the world, with a complete species list. *Journal of Crustacean Biology*. 2017. № 37(5). P. 615–653.

[8] Naranjo J., Vargas-Mendieta M., Hernandez-Llamas A., Mercier L. Dynamics of commercial size interval populations of female redclaw crayfish *(Cherax quadricarinatus)* reared in gravel-lined ponds: A stochastic approach. *Aquaculture*. 2017. № 484. P. 82–89.

[9] Tacon A.G.J., Metian M. Fish matters: importance of aquatic foods in human nutrition and global food supply. *Reviews in Fisheries Science*. 2013. № 21(1). P. 22–38.

[10] Zheng-Bin T., Saadiah I., Chaiw-Yee T. Comparative study on the nutritional content and physical attributes of giant freshwater prawn *(Macrobrachium rosenbergii)* and redclaw crayfish *(Cherax quadricarinatus)* meats. Preprint (Version 1) 2022.

Cherax quadricarinatus has a significant yield in terms of meat yield, which is about 30% of body weight and compares favorably with other commercially valuable crustaceans. The composition of *Cherax quadricarinatus* meat: water – 81.0%, proteins – 16.46%, fats – 0.16%, fiber – 0.1%, ash – 1.42%, etc. – 0.86%.

As a delicacy, decapod crustaceans are traditionally valued on the domestic and world markets. The attractiveness of this direction is also related to the waste-free production technology of crustacean products, which is due to the presence of chitin, melanin and chitosan in the carapaces of crayfish, which have found their wide application in humane medicine and in animal husbandry[11].

2. Peculiarities of the external structure and biological characteristics of the Australian red-clawed crayfish

Cultivation of any kind of hydrobionts involves studying the external structure and biological features[12].

The body of *Cherax quadricarinatus* is divided into two parts: cephalothorax and abdomen. The cephalothorax is externally unsegmented, covered with a chitinized carapace. Abdomen consists of movably connected six segments and telson; the latter has the shape of a plate, carries the anus and forms a fin together with the last pair of abdominal limbs. The front part of the cephalothoracic shield is elongated into a long, pointed, wedge-shaped rostrum. Complex faceted eyes are located on the sides of the base of the rostrum, on the movable outgrowths of the head are stalks. There is an arcuate groove on the carapace – sutura cervicalis. It separates the main part of the cephalothorax from the chest. From this groove, along the thoracic part of the carapace, there are two gill-cardiac grooves (suturae branchiocardiales), which limit the area where the heart is located. Lateral parts of the head of the thoracic shield are branchiostegites form gill cavities in which pinnate gills are located[13].

The mobility of the abdominal segments relative to each other is explained by the fact that there is only a thin and soft chitinous cuticle between them, while the dorsal and ventral parts of the segments themselves are limited by chitinous plates that form the exoskeleton. The abdomen almost does not bend on the dorsal side, while on the ventral side it bends under the cephalothorax, which happens, for example, during swimming of crayfish. This depends in part on the fact that the dorsal plates (tergites) of the exoskeleton of the

[11] Jones C.M., Valverde C. Development of mass production hatchery technology for the red claw crayfish *Cherax quadricarinatus*. *Freshwater Crayfish.* 2020. № 25(1). P. 1–6.

[12] Arias A., Torralba-Burrial A. (2021). First record of the redclaw crayfish *Cherax quadricarinatus* (von Martens, 1868) on the Iberian Peninsula. *Limnetica.* 2021. № 40. P. 33–42.

[13] Kawai T., Policar T., Kouba A. Gill morphology and formulae of European Astacidae. *Freshwater Crayfish.* 2021. № 26(2). P. 127–137.

abdominal segments are wide, while the ventral plates (sternites) are narrow, with spaces between them bounded externally by an elastic chitinous cuticle. The relative width of the abdomen in relation to the cephalothorax is different in males and females. In males, the abdomen is narrower, in females – wider[14].

The ventral part of the Australian red-clawed crayfish is represented by limbs. In front of the rostrum is the first pair of small antennules, in its distal part each antennule carries two flagellar appendages. From them, a second pair of bundles is articulated, characterized by a long cord-like appendage. On the ventral side of the cephalothorax, there is a mouth opening surrounded by oral limbs that serve to hold and grind food. The number of limbs is six pairs (one pair of upper jaws, or mandibles, two pairs of lower jaws, or maxillae, and three pairs of mandibles)[15].

Five pairs of walking legs (thoracopods) are attached to the thoracic part of the cephalothorax, which perform the function of locomotion. And besides, the first three pairs bear claws, the last two lack them. The external genital openings of the female are located on the main joint of the third pair of walking legs. In males, they are located on the first (proximal) joint of the fifth pair of walking legs. Small bifurcated limbs (pleopods) typical for crustaceans are observed on the abdomen. The sixth pair of abdominal legs (uropods) is flattened in the dorsoventral direction and together with the limbless telson forms a fin.

Regarding the structure of the two front pairs of abdominal limbs, males and females differ sharply from each other. In males, they are modified into a copulatory apparatus, well developed and bent forward under the posterior part of the cephalothorax. The sexual dimorphism of males of the Australian red-clawed crayfish is also manifested in the form of a red growth from the outer part of the first pair of walking legs (claws).

In females, the first pair of abdominal legs is underdeveloped, in the form of a small appendage. The second pair has the bifurcated structure usual for pleopods. With the onset of puberty, developing eggs or hatched young can often be found on the abdominal legs of females. Females show concern for offspring[16].

The color of the chitin cover is from dark green to light blue, due to the presence of pigments.

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[14] Norshida I., Mohd Nasir MSA, Khaleel A.G., Sallehuddin A.S., Syed Idrus S.N., Istiqomah I., Venmathi Maran B.A., Ahmad S.K. First wild record of Australian redclaw crayfish *Cherax quadricarinatus* (von Martens, 1868) in the East Coast of Peninsular Malaysia. *BioInvasions Records.* 2021. № 10(2). P. 360–368.

[15] Cheng S., Wei Y., Jia Y., Li F., Chi M., Liu S., Zheng J., Wang D. A study on primary diets for juveniles of red claw crayfish *Cherax quadricarinatus*. *Aquaculture Research.* 2020. № 52(5). P. 2138–2145.

[16] Rigg D.P., Courtney R.L., Jones C.M., Seymour J.E. Morphology and weight-length relationships for the first six instars of *Cherax quadricarinatus* (von Martens, 1868). *Freshwater Crayfish.* 2021. № 26(1). P. 9–16.

The presence of a rigid exoskeleton causes the rapid growth of crayfish, unlike vertebrates. Growth is accompanied by periodic moulting[17].

Moulting individuals have soft coats. The composition of the chitinous coating of crayfish: 48% $CaCO_3$; 6.8% $Ca_3(PO_4)_2$; 40.6% of organic substances, 4.6% – small amounts of Mg, Al, Fe salts. In this period of their life, crayfish are completely defenseless, therefore, they hide in shelters of various types[18].

The study of the features of the external structure of the Australian red-clawed crayfish is necessary for a better understanding and further development of an effective resource-saving biotechnology for the reproduction and cultivation of this species in the conditions of freshwater aquaculture.

3. Ontogeny and critical periods of development of *Cherax quadricarinatus*

Despite the increase in production, aquaculture of crustaceans is associated with the risks of their ontogenesis. Existing morphological and ethological features of individuals must be taken into account for the biotechnology of cultivation.

A solid exoskeleton is one of the key features of arthropods, which contributed to their widespread distribution in the aquatic environment. It has a cuticular origin, performs protective and supporting functions. The cuticle of crustaceans consists of four layers: epi-, exo– and endocuticle, mineralized with calcium carbonate, and an inner membrane layer. The exoskeleton of crustaceans is a complex structure that is characterized by unique biomechanical resistance to stretching and mechanical impact. Despite the advantages, external covers have a significant drawback, this is the growth of *Crustacea* which is possible only as a result of ecdysis, which consists of 4 stages: proecdysis, ecdysis, metecdysis, anecdysis[19].

In higher crustaceans, ecdysis is controlled by the endocrine system. In particular, these are Y-organs located in the second maxillary segment and X-organs located near the eyes (or in the eye stalk). The glandular cells of the Y-organ produce the molting hormone – ecdysone, which also stimulates metabolic processes and body growth. In addition, the Y-organ produces a hormone that stimulates the development of the gonads. The neurosecretory

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[18] Ghanawi J., Saoud I. P. Molting, reproductive biology, and hatchery management of redclaw crayfish *Cherax quadricarinatus* (von Martens 1868). *Aquaculture.* 2012. № 358–359. P. 183–195.

[19] Neelima H., Srinivasa R.B., Ramachandra R.P. Crustacean molting: regulation and effects of environmental toxicants. *Journal of Marine Science: Research & Development.* 2017. № 7(5). P. 236.

cells forming the X-organ produce the neurohormone MIH (Moult inhibiting hormone), this is an ecdysone antagonist that inhibits the molting process[20].

Cyclic changes associated with ecdysis occur not only in the outer integuments, they also affect the anatomy, biochemistry, and physiology of other systems. Ecdysis in crayfish does not occur during the period of sexual mating, spawning and bearing of offspring. Females usually molt before mating and after dropping the crustaceans from the pleopods. The molting process of the Australian red-clawed crayfish, depending on the age, takes a different time from 5 min. up to 24 hours Hardening of the new exoskeleton takes place within 6-10 days.

Ecdysis is preceded by the formation of new integuments, the removal of nutrients from the old cuticle, and its exfoliation. At the same time, the shell of the gills, esophagus, eyes and organs of the digestive system is renewed[21].

During ecdysis, the size of the individual increases due to water absorption in the digestive system and osmotic transport in the gills. This leads to a multiple increase in hemolymph pressure and ensures the straightening of new covers. For most species of decapod crustaceans, the hardening of the integuments is associated with the process of their calcification. The ways in which calcium is used mainly depend on the way of life of hydrobionts. Freshwater crustaceans store calcium in their tissues. Thus, they have a reservoir of calcium ions available immediately after moulting.

In this case, complete mineralization of the new cuticle includes remobilization of accumulated calcium. *Cherax quadricarinatus* store calcium ions, after molting, to calcify parts of the new exoskeleton. They are mainly stored in the form of amorphous calcium carbonate (ACC) for each previous moult in a pair of gastroliths synthesized in the stomach wall[22].

The ecdysis of the Australian red-clawed crayfish has periods: 1) the crayfish begins to «scratch» in order to make a hole in the old shell; 2) air and water enter through the hole under the shell; 3) the crayfish gets rid of the old chitinous cover by lying on its side, pulling the carapace first from the cephalothorax, and then freeing the abdomen with a leap.

After molting, the old exoskeleton remains almost intact. During ecdysis, crayfish can lose limbs and sometimes die. Often, crayfish cannot extract some part of the body, most often the claw, from the outer shell. Then they discard the limb and leave it in the old shell. The loss of limbs reflects the

[20] Daubnerová I., Žitňan D. Ecdysis triggering hormone. *Handbook of Hormones (Second Edition).* 2021. № 2. P. 829–831.

[21] Nhut T.M., Mykles D.L., Elizur A., Ventura T. Ecdysis triggering hormone modulates molt behaviour in the redclaw crayfish *Cherax quadricarinatus*, providing a mechanistic evidence for conserved function in molt regulation across Pancrustacea. *General and Comparative Endocrinology*. 2020. № 298(1). P. 113556.

[22] Fasya A.H. Study of the relationship pattern of ecdysis with age of freshwater lobster *Cherax quadricarinatus* aged 76 days. *Contributions of Central Research Institute for Agriculture.* 2021. № 15(3). P. 78–82.

inherent ability of decapods to autotomy a protective mechanism that helps escape from predators. Therefore, there are often individuals with one claw or two, but different in size.

A number of factors affect the ecdysis of the Australian red-clawed crayfish, namely: age, sex, environmental temperature, nutrition. In young individuals, this happens more often, about 1-2 times a week. After moulting, the new cuticle remains soft and elastic, adults moult less often, once every 1–2 months[23].

Behavior, ecdysis in young and adult decapod crustaceans and the dynamics of food consumption are closely related. The available data allow us to distinguish general patterns for *Cherax quadricarinatus*: feed consumption reaches a maximum in the middle and in the first half of the molting cycle; during the period of proecdysis, there is a decrease in feed consumption; during ecdysis, and in adults before and after it, the individual does not feed; at the end of late metecdysis, with the hardening of the integuments, there is a sharp increase in feed consumption. The share of fodder objects with high calcium content is increasing.

In addition, soft covers after molting lead to a significant decrease in the protection of individuals, which, especially in aquaculture conditions, is one of the main reasons for the occurrence and exacerbation of intraspecific cannibalism[24].

Cannibalism can be avoided by synchronization of ecdysis and isolation of molting individuals.

4. Analysis of innovative directions of *Cherax quadricarinatus* cultivation biotechnology

Aquaculture of *Cherax quadricarinatus* in the world is mostly carried out extensive pond systems, but interest in the development of more intensive methods is growing.

Cultivation of red claw crayfish in Ukraine is at the stage of improvement and has its own characteristics. This is primarily due to the cold winter season.

That is why the cultivation of these arthropods in our country takes place in two stages: cultivation in artificial conditions (recirculation systems, aquariums) and growing to marketable mass in reservoirs for fish farming with a depth of 1 to 2.5 meters and a surface area of 0.05 to 0.5 ha.

Domestic aqua farmers are working on the technology of growing Australian crayfish exclusively in artificial conditions. The conditions for growing *Cherax quadricarinatus*, except for the temperature of the water

[23] Zharchynska V.S., Hrynevych N.E. Improvement of crustacean rearing technology using the example of *Cherax quadricarinatus. Scientific Bulletin of the LNUVMB named after S.Z. Gzhitskyi.* 2022. № 24(96). P. 16–23.

[24] Calvo N.S., Stumpf L., Sacristan H.J. Energetic reserves and digestive enzyme activities in juveniles of the red claw crayfish *Cherax quadricarinatus* nearby the point-of-no-return. *Aquaculture.* 2013. № 416–417. P. 85–91.

environment, are similar to those for long-toed crayfish (*Pontastacus leptodactylus*).

The process of growing crayfish on an industrial scale should include the following stages: formation of a brood stock, reproduction, incubation of roe, rearing of young and adult (marketable) individuals[25].

The growth rate of *Cherax quadricarinatus* is influenced by the factors of abiotic (water temperature, hydrogen index, hardness, dissolved oxygen content, illumination) and biotic (planting density, intensity of reproduction, individual characteristics of individuals) environment[26].

Environmental temperature during crustacean culture is an integral component of the organism's physiological ability to consume and convert resources, such as food, into growth, reproduction, and survival. Australian red claw crayfish can tolerate a wide range of temperatures from 16 to 32°C. *Cherax quadricarinatus* grows best at a temperature of 20 to 34°C. The optimum temperature is 27°C. When creating conditions for reproduction, the water temperature should be 28°C. A temperature below 10°C and above 36°C is lethal for the species and a limiting factor during cultivation[27].

The hydrogen indicator is within 6.5-8.5 pH units. Hardness is from 5 to 20 mg-equiv./dm^3. As the hardness of the water increases, the color of these arthropods becomes more saturated and bright. In sufficiently soft water, the color of their chitinous shell acquires a light brown shade with a blue sheen. The content of oxygen dissolved in water is 6-7 mg/dm^3. Illumination is 14/10 (day – 14 hours; night – 10 hours).

Australian crayfish usually reach puberty between 6 and 12 months of age. To stimulate the simultaneous production of offspring, males and females are placed separately for 7-10 days, temperature – 17-18°C, illumination 10 (day)/14 (night). Then gradually raise the temperature by 1-2°C per day to the optimum. and illumination 14 (day)/10 (night) and sex ratio at the rate of 2-3 females to 1 male.

After mating, the female Australian crayfish begins to form eggs under her abdomen, which she then hatches for 8-9 weeks (primarily this depends on the water temperature). Each adult female is able to bring 3-5 clutches of 300 to 800 eggs. Spawning in Australian crayfish occurs three times a year, and the survival rate of young is about 60%. Under optimal conditions, crayfish grow

[25] Honcharova O., Sekiou O., Kutishchev P. Physiological and biochemical aspects of adaptation-compensatory processes of hydrobionts under the effect of technological factors. *Fisheries science of Ukraine.* 2021. № 4(58). P. 101–114.

[26] Grynevych N.E., Zharchynska V.S., Shariga V.S. The value of abiotic factors during the cultivation *Cherax quadricarinatus. Book of abstracts of the I International Scientific and Technical Conference «Water quality: biomedical, technological, agro-industrial and environmental aspects»* (Ternopil, 20–21 May 2021). Ternopil, 2021. P. 74–75.

[27] Thompson K.R., Muzinic L.A., Yancey D.H., Webster C.D., Rouse D.B., Xiong Y. Growth, processing measurements, tail meat yield, and tail meat proximate composition of male and female Australian red claw crayfish, *Cherax quadricarinatus*, stocked into earthen ponds. *Journal of Applied Aquaculture.* 2004. № 16(3/4). P. 117–129.

rapidly and can reach commercial size (approximately 50-100 g) within 5-6 months[28].

The young grow quickly, but unevenly, so from time to time they need to be sorted by size. The size groups formed as a result of sorting must be kept in different aquariums or pools and the weaker ones must be constantly culled. Reasons for uneven growth of individuals include: competition for food (dominant individuals eat more food than weaker ones); aggressive interaction of crayfish (damage to limbs during «fights»); chemicals secreted by larger individuals that inhibit the growth of smaller crayfish. A change in the size of red-clawed crayfish can have a negative effect on smaller individuals due to hierarchical dominance.

Cannibalism is the main fundamental difference from which all the following technological features of crustacean cultivation follow. If the main factors limiting the density of planting, and therefore the productivity in artificial fish farming, can be the oxygen regime and the level of accumulation of organic substances released, then when keeping crustaceans, the problem of cannibalism comes to the fore and ultimately determines the biomass[29].

To increase survival and growth rate during cultivation of the Australian red-clawed crayfish *Cherax quadricarinatus* (von Martens, 1868) in aquaculture conditions, special attention should be paid to the organization of the bottom area and the availability of shelter. The need for shelter is explained by providing individuals with the absence of exposure to stress factors and the space in which they are until the normal recovery of the body.

Containers for growing crustaceans and shelters in them must have a special design and meet certain requirements: provide the necessary specific surface area of the shelter, sufficient and uniform water exchange, free removal of sediment that accumulates both inside the shelter and at the bottom of the rearing pool[30].

Studies[31] have demonstrated the effectiveness of various materials that provide a habitat for juveniles and adults: microtubes, polypropylene mesh bags, artificial macrophytes, PVC pipes of various sizes. During cultivation in industrial conditions, shelter should be provided to crayfish at the rate of 3 cells per 1 speciman.

[28] Calvo N.S., Tropea C., Anger K., Lopez-Greco L.S. Starvation resistance in juvenile freshwater crayfish. *Aquatic Biology.* 2012. № 16. P. 287–297.

[29] Dyudyaeva O.A, Bekh V.V. Food security of domestic aquaculture products as a guaranteed prerequisite for entering foreign markets. *Aquatic bioresources and aquaculture.* 2020. № 1. P. 44–60.

[30] Stumpf L., Sarmiento Cárdenas P.N., Timpanaro S., López Greco L. Feasibility of compensatory growth in early juveniles of «red claw» crayfish *Cherax quadricarinatus* under high density conditions. *Aquaculture.* 2019. № 510. P. 302–310.

[31] Takahashi K., Nagayama T. Shelter preference in the Marmorkrebs (marbledcrayfish). *Behaviour.* 2016. № 153(15). P. 1913–1930.

Providing feed accounts for 70% of the operating costs in aquaculture. Feed efficiency is a critical factor for aquaculture worldwide.

A significant number of studies on the nutrition of red claw crayfish of different age groups have been published. Young crayfish must be provided with a variety of food, which includes detritus, animal (zooplankton, tubers, fish, shrimps) and plant (chara) components. The generally accepted structure of the diet of crayfish is 70% plant and 30% animal food.

With age, the need for red-clawed crayfish in proteins decreases. Juveniles need from 31 to 34% of protein, individuals weighing more than 50 g need 25.6%. Lipids are also an important component of the diet that affects the growth, development and health of crayfish. Unlike protein, the need for lipids does not change with age. Carbohydrates perform an energy function, participate in the formation of steroids and fatty acids, and also contribute to the accumulation of glycogen and chitin synthesis. A mandatory element of feeding should be the leaves of the common oak *Quercus robur* (Linnaeus, 1758) in unlimited quantities. Due to the presence of tannins in them, they serve as natural antibiotics for crayfish[32].

Given the geography of distribution of Australian red claw crayfish, considerable attention must be paid to quarantine and preventive measures. Disease prevention of *Cherax quadricarinatus* consists in: creating optimal sanitary and hygienic conditions during cultivation; compliance with the biotechnological requirements of growing (planting density, ensuring adequate feeding); ensuring the optimal hydrochemical regime; preventing the spread of infectious diseases (ichthyopathological supervision of the transportation of live crayfish); preventive quarantine; preventive culling, isolation of patients and disposal of dead individuals; preventive disinfection and disinfestation[33].

Therefore, working out the basic biotechnological principles and creating a resource-saving technology for reproduction of *Cherax quadricarinatus* in artificial conditions on the territory of our country are quite relevant. Investments in crustacean aquaculture, provided the latest technologies are implemented, can pay off within the first two years.

CONCLUSIONS

The development of aquaculture of Australian red claw crayfish *Cherax quadricarinatus* is possible only with scientific justification and use of «best

[32] Hou S., Li J., Zhang Y., Huang J., Wu X., & Cheng Y. Effects of fish meal replacement with protein mixtures on growth, gonad development and amino acid composition of pre-adult red swamp crayfish, *Procambarus clarkii* (Girard, 1852) (*Decapoda, Cambaridae*). *Crustaceana.* 2021. № 94(10). P. 1161–1186.

[33] Saoud I.P., Ghanawi J, Thompson K.R, Webster C.D. A review of the culture and diseases of redclaw crayfish *Cherax quadricarinatus* (von Martens 1868). *Journal of the World Aquaculture Society.* 2013. № 44. P. 1–29.

practices», which in the future provide for increased efficiency, profit and further expansion of the crustacean industry on the territory of Ukraine.

SUMMARY

In the conditions of the modern development of the world fishery, the production of hydrobionts shows a steady tendency to decrease in volume, which determines the prospects of breeding hydrobionts, including crustaceans, in artificial conditions. The great demand on the world market for edible species of crustaceans, as well as the deterioration of the ecological conditions of water bodies, led to a decrease in their natural reserves. Aquaculture of crustaceans is a relatively new direction, which has good prospects both from the ecological and food points of view, including in our country. Crustaceans are a valuable source of protein. For the maximum effect of growing tropical species of crayfish, namely – *Cherax quadricarinatus*, it is necessary to know the peculiarities of morphology, critical periods of ontogenesis, peculiarities of cultivation. Studying the best practices for growing decapod crayfish will contribute to the development of technological schemes for growing introduced species in artificial conditions for the maximum resource-saving effect. In the case of crayfish cultivation using industrial aquaculture methods, it is necessary to reduce the use of clean water as much as possible, to obtain ecologically clean products in the shortest possible time.

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