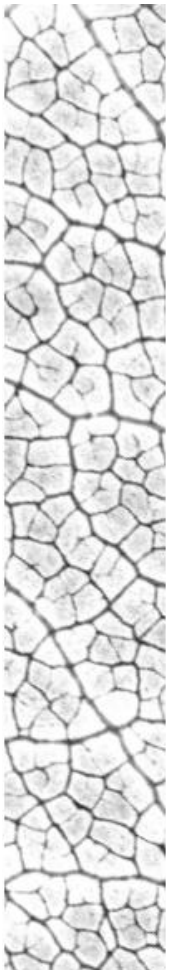

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Use of domestic starter feeds for culturing clarid catfish and tilapia

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Abstract
The article presents the results of scientific research on testing domestic starter feed for larvae of clarid catfish and tilapia when cultured in cages installed in ponds and basins with natural thermal regime in the conditions of the fish farm of "HalykBalyk" LLP (Almaty region). The data of comparative analysis of fish-rearing and biological indicators of fish larvae during the experiment are presented. Feed ratios for starter mixed feeds were determined, which amounted to 0.93 units for clarid catfish and 1.3 units for Nile tilapia.

Keywords: nile tilapia, clarid catfish, artificial starter feeds, recipes, fish-rearing and biological indicators, feed ratio

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INTRODUCTION

Currently, Kazakhstan is actively developing commercial fish rearing and according to the state program for the development of the agro-industrial complex of the Republic of Kazakhstan in 2017-2021, it is expected to receive 5 thousand tons of fish per year due to commercial fish rearing, and in general, the possibility of aquaculture - up to 50 thousand tons per year (State program for the development of the agro-industrial complex of the Republic of Kazakhstan for 2017-2021). Therefore, the need for high-quality domestic feed for valuable fish species cultured in aquaculture is increasing several times. One of the most promising objects for commercial culturing in the Almaty region (Kazakhstan) is tilapia and clarid catfish, since this region has a large number of geothermal sources that are suitable for hydrochemical indicators for culturing these types of fish. The use of geothermal sources allows fish to activate metabolic processes, increase the growth rate and accelerate the timing of puberty, which can significantly increase the efficiency of industrial fish rearing. Also, the economic effect of culturing fish directly depends on the quality of feed and its cost. Therefore, despite the fact that there are currently imported starter feeds for clarid catfish and tilapia, the issue of providing domestic complete starter feeds to fish farms in Kazakhstan is still quite relevant, and the availability of total mixed rations that meet the production requirements is the main condition for the success of fish culturing. Kazakhstan has previously developed production mixed feed for tilapia two-year-olds, which showed good results when conducting experiments (Zharkenov et al. 2017). Of particular interest is the development of starter mixed feed based on the analysis of the food needs of these fish and their integration into the practice of fish rearing, which will increase the efficiency of rearing juvenile tilapia and clarid catfish and expand the possibilities of culturing these objects in the aquaculture of Kazakhstan. Currently, there are no recipes for starter mixed feeds for clarid catfish and tilapia, developed in Kazakhstan, which would be used for their industrial rearing and, today, fisheries enterprises in Kazakhstan provide their needs for starter mixed feeds mainly due to imported mixed feeds.

OBJECTS OF RESEARCH

African clarid catfish, or marble clarid catfish, or Nile clarias (*Clarias gariepinus*) - found throughout Africa, including reservoirs of the Sahara, in the Jordan river basin, in South and South-East Asia. However, the habitat has now expanded very much. In the 90's, it was

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imported for culturing in China, Indonesia, Brazil, Thailand, and the Philippines. In Europe, it is common in fish farms in Germany, Belgium, Poland, Hungary, and other countries. The African catfish has a large flattened head with four pairs of long whiskers and a brusque body compressed laterally near the tail. The large mouth has many small and sharp teeth (the teeth of clarias are the same as those of its European relative). The scales on the body are completely absent, and the color of the body depends on the quality and color of the water in the habitat, but usually resembles a marble color of greenish shades (Podushka 2011, Vlasov 2012).

The clarid catfish has additional air breathing, which allows to live for a long time without water or in muddy water. Functionally, this is a real lung, whose task is to be included in the work when the fish is out of water. Thanks to this organ, catfish can crawl from one reservoir to another, and do without water for up to forty hours. This is one of the advantages of catfish, as it gives it exceptional endurance during long transportations.

The African catfish is omnivorous, feeding on small fish, amphibians, mollusks and various underwater inhabitants of rivers. The clarid catfish is smaller than its European counterpart (it reaches only one hundred and seventy centimeters in length and weighs up to sixty kilograms). The average life span of a clarid catfish is about eight years. Meat from catfish has a white color, has a delicate and juicy taste, so it is valued quite highly. The African catfish is unpretentious, adapts quickly to various conditions and has a unique resistance to oxygen deficiency. Due to the factors listed above, clarias is extremely resilient, which makes it possible to culture these fish in high density conditions (for example, in some farm fish farms, the number of fish can reach eight hundred kilograms of live weight per cubic meter of water) (Peteri et al. 2015, Podushka 2011, Slapoguzova et al. 2011).

A significant factor in favor of catfish rearing is the fact that they multiply elementary and are absolutely unpretentious in food, which significantly affects the level of production costs. In addition, the African catfish is absolutely not demanding on water quality, while demonstrating the highest resistance to various diseases. Production fish farms start with a capacity of twenty tons of products per year and above (up to one hundred tons). The optimal temperature for keeping rearing stock is 25°C. Although this temperature differs from that found in natural habitats, it is most acceptable for artificial rearing.

Clarid catfish does not pose a sanitary-epidemiological and environmental hazard. First, this species has been bred for many generations in industrial fish farms without contact with other aquatic organisms, which could be intermediate hosts of parasites, including those dangerous to humans, so the probability of accidental importation of such parasites is practically excluded. Secondly, because of its heat-loving nature, the clarid catfish will inevitably die in winter if it accidentally enters natural reservoirs, and will not be able to have a negative impact on the local fish fauna. This fish effectively uses feed, the cost of which, as a rule, is 0.8-1.2 kg per 1 kg of products (Fattolakhi 2008, Romanova et al. 2017).

Nile tilapia (*Oreochromis niloticus*) from the genus *Oreochromis*. The native range of the Nile tilapia covers tropical and subtropical regions of North-Eastern, Central and Western Africa and the Middle East. It is widely distributed in the basins of the Nile and Niger rivers, in lakes Tanganyika, Baringo, Kreiter, Kivu, Rudolph, Tana, and is found in the Yarkon river (Israel). It is introduced into reservoirs of many countries of the world, including such countries and regions as South Africa, Asia, South-East Asia, Latin America, and the United States. The maximum body length is 60 cm, the maximum weight is 4.3 kg, and the maximum life span is 9 years. The laterally compressed body is covered with cycloid scales. During the spawning period, the mating color appears, especially pronounced in males. The back and sides become light orange, and the abdomen is orange-red; a red-orange spot appears on the lower jaw. The ventral, dorsal, and anal fins become reddish, and numerous black stripes appear on the caudal fin (Tetdoyev 2009). Polyphagus, the main food is macrophytes, but the diet includes phytoplankton, green (*Chlorophyta*) and blue-green algae (*Cyanobacteria*), diatoms *(Diatomeae*, or *Bacillariophyceae*), larvae of aerial insects, aquatic insects and fish eggs. There is a seasonal change in the food spectrum. It can serve as a biological meliorator that controls the number of malarial mosquitoes. It reaches puberty at the age of 4-5 months. Spawning takes place at a temperature above 24°C. Fecundity - from 100 to 1500 eggs, depending on the size of the females. Caviar develops in the female's mouth for 3-4 days. The larvae also stay in the female's mouth or near her head for 1-2 weeks until the yolk sac is completely absorbed. At this time, the female does not feed. Even after switching to an active diet, they can hide in the mouth or under the operculum of the female when in danger. In those parts of the range where the temperature in the winter months falls below the optimum, spawning stops. In tropical areas, spawning continues all year round (Mukhramova 2016, Zobova 2004).

In the presence of optimal conditions, tilapia spawning takes place regularly (an interval of 45-60 days), which makes it possible to obtain offspring all year round in recirculating aquaculture system. Tilapia are good eaters of both plant and animal feed, while easily adapting to feeding with artificial feeds, as well as getting used to the time and place of feeding. At the same time, under favorable conditions, the average daily increase is 3-5 grams. The entire growing cycle from the larva to the

commercial product is 160-180 days (Tetdoyev 2009, Zobova 2004, Effective technologies for growing commercial tilapia in industrial conditions of fish farms in Kazakhstan 2019). Therefore, having valuable biological and economic qualities, such as rapid growth, high tolerance to environmental conditions, year-round spawning, and resistance too many diseases make tilapia a promising object of industrial fish rearing in Kazakhstan.

MATERIAL AND METHODS

Experiments on testing artificial starter mixed feed were conducted in cages and basins with natural thermal conditions at the experimental section of the fish farm of “Halyk balyk” LLP (Almaty region, VI zone of pond fish rearing). The larvae of the clarid catfish and the Nile tilapia were used as material for research. Analytical determination of hydrochemical indicators was carried out in accordance with generally accepted methods, scheme of O.A. Alekin was used for water classification (Alekin 1970).

To assess the influence of abiotic environmental factors, the dynamics of temperature and oxygen regimes were monitored daily - 2 times a day, and the level of the hydrogen index in the pond - 1 time a day. The water temperature, pH of the medium, and oxygen content were measured using the Consort thermo-oximeter.(Ande et al 2017)

When culturing larvae of clarid catfish and tilapia, foreign regulatory and technological literature was used (Kozlov and Abramovich 1991, Kozlov et al. 2006, Orlova and Lyubomirov 2016, Ponomarev et al. 2002, Tamash et al. 1985).

For culturing tilapia larvae, cages made of sieves installed in the pond were used. When accounting larvae that are reared in cages, we used the volumetric counting method. To assess the effectiveness of culturing tilapia and clarid catfish, the method of expert assessments was used. Determination of fish-rearing and biological indicators of fish that make up the primary database was performed using methods adopted in fish rearing (Kozlov et al. 2006, Collection of normative and technological documentation for commercial fisheries 1986).

Fish feeding was performed manually, in equal portions, 10 times a day. During the experiment, the hydrochemical regime in cages and basins was optimal. Once every 10 days, control searches were conducted. Based on their results, the growth rate of juvenile fish was determined and the daily feeding ration was calculated.

The development of recipes for tilapia and clarid catfish larvae was carried out in the laboratory of grain products and mixed feed technology in “Kazakh Research Institute of processing and food industry” LLP (“KazRI PFI” LLP). Experimental batches of mixed feed were developed at the PetFood KZ plant, which is located in the Almaty region. Mixed feed is produced by extrusion. The feed quality indicators are determined on the FOSS device (NIRS TMDA 1650 IR analyzer). Quality indicators in the obtained formulations were evaluated by the level of fat, protein, fiber, nitrogen-free extractives (NFE), caloric content, energy-protein ratio, and the quantitative content of amino acids determined by the calculation method using reference materials.

Table 1. Fish feed size

Group No.	Diameter, mm	Fish weight, g
1	Up to 0.2 - grit	Up to 0.1
2	0.2 – 0.4 – grit	0.1-0.3
3	0.4 -0.6 – grit	0.3-1.0
4	0.6 -1.0 – grit	1-2

RESEARCH RESULTS

When developing mixed feed for clarid catfish and tilapia, nutritional features were taken into account, as well as recipes for feeds enriched with all the necessary nutrients, vitamins and minerals, taking into account the physiological needs of fish in industrial culture.

The physical and mechanical properties of extruded starter feeds were determined by the following parameters: density, water resistance, crumbling, granule density, and water absorption coefficient. Mixed feed, both in the laboratory and in the experiment conditions, was poorly immersed in water and eaten by fish from the water column.

Dry starter feed is produced in the form of grits and granules of different sizes. As the fish moves from one size group to another, the size of the grits and granules being fed changes. A grit size of 0.2-1.0 mm is used for feeding juveniles weighing up to 2 g (**Table 1**).

Development of improved recipes for starter feed for fish (clarid catfish, tilapia) and modes of technology for their production by extrusion was carried out as follows. The recipes were corrected, the mixing of the components was carried out strictly according to the developed recipe, the grinding of the components was carried out in two stages - crushing and grinding to 0.1 mm of grits. When working out production modes, the moisture content of the extruded fish feed mixture, the extrusion temperature of the feed mixture, the extrusion pressure, and the temperature of the fat applied to the feed granules were set. Then the granules were cooled, the feed was packed, and the granules were ground to a grit (0.2 – 0.5 – 1 mm), sifted, marked for storage.

The ratio of ingredients used in the formulation of recipes creates a full-fledged biological complex that allows to balance the mixed feed in terms of metabolic energy, protein, limiting amino acids, individual vitamins and minerals. All recipes for nutritional value meet the requirements for starter feeds.

Table 2. Physical, chemical and technological properties of mixed feed for tilapia and clarid catfish

Indicators	Content	
	Clarid catfish	Tilapia
Mass fraction of moisture, %	8.43	9.51
Protein content, %	53.5	44.1
Fat content, %	11.4	10.28
Cellulose content, %	0.66	1.94
Ash, %	8.9	9.0
Linoleic acid, %	1.68	2.17
NFE, %	13.56	21.14
Lysine, %	4.36	3.33
Methionine, %	1.08	0.85
Methionine + cystine, %	1.71	1.42
Tryptophan, %	0.77	0.57
Sugar, %	0.34	1.2
Starch, %	3.99	5.84
Phosphorus, %	1.35	1.27
Calcium, %	1.97	2.0
Internal energy, kcal/100g//MJ/kg	487.34// 20.39	472.3// 19.76
Exchange energy, kcal/100g//MJ/kg	409.36//17.12	396.73//16.59

Table 3. Data on hydrochemical indicators of water

Indicators	Unit	Value
pH value	-	7.30
Permanganate oxidizability	mg O/dm^3	4.1
Ammonium nitrogen	mg/dm^3	0.02
Nitrites	mg/dm^3	0.082
Nitrates	mg/dm^3	0.31
Phosphorus	mg/dm^3	0.01
Iron	mg/dm^3	0.04
Silicon	mg/dm^3	2.53
Hardness	mg-eq/dm^3	5.6
Hydrocarbonates	mg/dm^3	317
Sulfates	mg/dm^3	110
Chlorides	mg/dm^3	26.9
Calcium	mg/dm^3	59.3
Magnesium	mg/dm^3	32.5
Sodium	mg/dm^3	40.3
Potassium	mg/dm^3	3.9
Mineralization	mg/dm^3	590
Copper	mg/dm^3	0.008

Table 2 shows the physical, chemical and technological properties of mixed feed for tilapia and clarid catfish.

Before conducting the experiments, water samples were taken for hydrochemical analysis. The results are presented in **Table 3**.

According to research data, the water from the water-supply channel of "Halyk Balyk" LLP is neutral in terms of the reaction of the water medium (the pH value is 7.30), the amount of organic substances is low (the value of permanganate oxidizability is characterized by values of 4.1 O/dm^3). The content of biogenic elements in water is within optimal limits. Ammonium nitrogen and iron were found in the amount of 0.02-0.04 mg/dm^3, phosphorus-0.010 mg/dm^3.

The nitrite concentration is 0.082 mg/dm^3. Nitrate nitrogen is found in an amount of 0.31 mg/dm^3. According to the number of dissolved salts, water belongs to fresh water with a mineralization of 590 mg /dm^3. According to the ratio of ions, it belongs to the hydrocarbonate-calcium class. By technical properties - moderately hard, the total hardness is 5.6 mg-eq/dm^3. The copper content is 0.008 μg/dm^3 (8.7 MPC for fishery reservoirs). According to the research results, the water from the water-supply channel of "Halyk Balyk" LLP meets the regulatory requirements for fishing reservoirs.

Table 4. Dynamics of hydrochemical indicators of water

Month	Decade	Value of indicator					
		in basins			in cages		
		t, °C	pH	mg O_2/l*	t, °C	pH	mg O_2/l*
June	III	23.7	7.5	7.2	24.1	7.8	7.4
July	I	25.2	7.4	7.4	25.6	7.6	7.1
	II	26.4	7.7	7.6	26.7	7.7	7.3
	III	26.8	8.2	7.8	26.9	8.0	6.7
August	I	25.7	7.6	7.1	25.6	7.8	6.2
	II	25.1	8.1	7.3	24.8	8.0	7.5
	III	23.6	7.8	7.7	23.4	8.2	7.6
September	I	22.3	8.0	7.6	22.6	8.1	7.5
	II	21.2	7.9	7.5	21.3	8.0	7.6

Note - *Values of oxygen content in water in the morning

Table 5. Fish-rearing and biological indicators of clarid catfish juvenile when feeding with various starter artificial feeds

Indicators	Values	
Type of feed	"KazRI PFI" LLP	"AllerAqua"
Variants	I	II
Rearing period, days	30	30
Planting density, thousand pcs/m^3	10000	10000
Initial weight, mg	1.5±0.1	1.6±0.1
Final weight, mg	1635±52.1	1708±59.4
Absolute growth gain, mg	1633.5	1706.4
Average daily growth gain, mg	54.45	56.88
The survival rate of juveniles, %	73	76
Feed ratio, units	0.93	0.87

During the entire growing season, hydrochemical indicators in fish tanks were systematically monitored. The dynamics of temperature, oxygen conditions and values of the hydrogen index (pH) in basins and cages is shown in **Table 4**.

Analysis of the data showed that the basins were characterized by fluctuations in the values of the hydrogen index in the range of 7.4-8.1; in ponds (cages), the pH values changed in the range of 7.6–8.2. These hydrochemical water indicators were generally optimal for culturing tilapia and clarid catfish in industrial conditions.

Juvenile of clarid catfish. Clarid catfish planting material of "Halyk Bank" LLP was grown in direct-flow basins on water with a natural thermal regime.

To determine the effectiveness of the impact of starter artificial feeds on fish-rearing and biological indicators of clarid catfish juveniles, 2 feeds were used: domestic, developed by "Kazakh Research Institute of processing and food industry" LLP for clarid catfish juveniles (variant I) and foreign trout "AllerAqua" (variant II). The larval planting density was 10 thousand pcs/m^3. The experiment was performed for 30 days in two repetitions.

Comparative results of rearing clarid catfish juveniles using different starter artificial feeds are presented in **Table 5**.

The larvae of the clarid catfish began to be fed with artificial starter feeds after switching to an active diet. As the results showed, satisfactory results were obtained in

Table 6. Fish-rearing and biological indicators of tilapia juveniles using various starter artificial feeds

Indicators	Values	
Type of feed	**"KazRI PFI" LLP**	**"AllerAqua"**
Variants	I	II
Rearing period, days	30	30
Planting density, pcs/m^3	1000	1000
Initial weight, g (x±m)	1.14±0.1	1.17±0.1
Final weight, g (x±m)	5.6±0.12	5.9±0.13
Absolute growth gain, g	4.46	4.73
Average daily growth gain, g	0.14	0.15
The survival rate, %	87	89
Feed ratio, units	1.3	1.15

both versions of the experiment. The absolute and average daily growth gain values in both variants differed slightly: by 72.9 mg and 2.43 mg, respectively. Survival rate values were within the standard values and differed slightly by 3%. The feed of "KazRI PFI" LLP proved to be good, so the difference in the feed ratio from the imported "AllerAqua" was 0.04 units.

Describing the starter domestic feed developed specifically for clarid catfish juveniles, can be said that it is not inferior in quality to the imported "AllerAqua". And since the cost of domestic feed is much lower than imported it will be quite competitive and therefore recommended for use in the Republic of Kazakhstan.

Tilapia juveniles. Tilapia planting material was grown in cages installed in the fry pond of the "HalykBalyk" LLP.

To assess the effectiveness of the impact of artificial starter feeds for tilapia juveniles, 2 starter artificial feeds were also used: the domestic one developed by "KazRI PFI" LLP specifically for tilapia (variant I) and the foreign one "AllerAqua" (variant II). The experiment was performed for 30 days in two repetitions.

The results of rearing tilapia in cages using various starter artificial feeds are presented in **Table 6**.

As the results of the experiment showed, satisfactory results were obtained in all variants. The absolute and average daily growth gain values in the variants differed slightly from the imported ones ("AllerAqua"): by 0.27 mg and by 0.01 mg, respectively. Survival rate values were also normative and varied slightly by 2%. The difference of the feed ratio was 0.15 units.

Based on the results obtained, it can be concluded that the domestic starter feed developed for tilapia juveniles is not inferior in quality to the imported "AllerAqua" and is recommended for use in production conditions.

CONCLUSION

As a result of the experiments, the following conclusions were made. The developed starter mixed feeds have high water resistance, and they swell quite well, as a result of which they are easier to eat by fish. The developed experimental batches of starter feed for juvenile fish had a crumb rate of no more than 2.2% for all variants. Based on the considered technological indicators, it can be noted that the new domestic starter feed for fish is a good technological product that meets the requirements of regulatory and technical documentation.

According to the developed recipes, starter mixed feeds for fish larvae (clarid catfish and tilapia) were developed by extrusion, which are well-loose grits with a moisture of no more than 10%, from dark to light brown.

Physical, chemical and technological properties of mixed feeds were determined for:

- starter for clarid catfish - moisture 8.43%, protein content - 53.5%, fat content -11.4%, cellulose - 0.66%, ash content - 8.9%, linoleic acid - 1.68%, lysine - 4.36%, methionine + cysteine - 1.71%, phosphorus - 1.35%, calcium - 1.97%, exchange energy - 409.36 kcal/100g;

- starter for tilapia - moisture 9.51%, protein content -44.1%, fat content - 10.28%, cellulose - 1.94%, ash content - 9.0%, linoleic acid - 2.17%, lysine - 3.33%, methionine + cysteine - 1.42%, phosphorus - 1.27%, calcium - 2.0%, exchange energy - 396.73 kcal/100g.

The accepted ratio of components in the recipe creates a full-fledged biological complex that allows to balance the feed for metabolic energy, protein, limiting amino acids, individual vitamins and minerals.

When conducting production tests on the effectiveness of using starter feed and assimilation on larvae of clarid catfish and tilapia at the experimental site of "Halyk Balyk" LLP, it was revealed that the starter feed was well eaten by fish, almost without waste and crumbling, corresponded in size, had a high feed ratio (clarid catfish - 0.93 units, tilapia - 1.3 units), and the fish survival rate was normative (clarid catfish 73%, tilapia - 87%).

Thus, the developed recipes for artificial cost-effective starter feed for clarid catfish and tilapia have been tested for the effectiveness of their use in the fish farm of "Halyk Balyk" LLP, have shown good results and can be recommended for implementation in fish farms in the Almaty region. The use of domestic improved starter feed with a lower cost than imported feed can enable domestic fish farms to produce a sufficiently large number of fish products with a low cost.

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