Study of the use of compound feeds in the cultivation of koi carp Cyprinus carpio haematopterus

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Abstract. The object of study – koi carp (Cyprinus carpio haematopterus). The aim of this work was the analysis of piscicultural-biological results of growing koi in 2 variants of feed – Coppens and Tetra. During the experiment to determine the water resistance of the granules of the feed, it was established the time of complete dissolution of the feed in the aqueous medium. The leader of the resistance to water was feed Coppens. Feed German company Tetra showed faster solubility than the Dutch product. Fish-breeding and biological indicators of koi carp also had differences in experimental cultivation. The leader in terms of the increase in linear and weight growth was again the feed Coppens (absolute growth was 6.72 g, the average daily increase – 0.22 g). Feed Tetra showed relatively lower results of growth of the studied fish (absolute increase – 5.15 g; average daily increase – 0.17 g). Mass of fish that were fed with Coppens feed has increased by 156%, Tetra – 116%.

1. Introduction
Among the large range of tasks of fisheries research, a special place is occupied by the organization of rational fish feeding, since it determines the effectiveness of the fish-breeding process as a whole [1, 2].

The main issue in the development of aquaculture is the ability to organize a full-fledged feeding of fish at all stages of cultivation. In the conditions of industrial fish farming, with the complete absence of a natural food base, there is a need for careful balancing of the composition of artificial diets [3, 4].

Fish feeding in industrial aquaculture is the most important technological element [5, 6]. The quality of compound feeds, their composition, and the peculiarities of feeding technology significantly affect the most important fish-breeding and biological indicators – fish survival during the growing period, growth rate, physiological state and health [7, 8].

When rearing juveniles for both reproduction and commercial production, there is a need to provide biologically complete feed, which, first of all, must be adequate to the physiological needs of the developing organism, guaranteeing good growth and survival, the formation of adaptive properties and physiological and immunological status [9, 10].

Thus, feed plays a dominant role in aquaculture technologies, and it is necessary to determine the correct strategy for their use in the production of fish products.

The purpose of this work was to analyze the fish-breeding and biological results of growing koi carp using 2 variants of mixed feeds.

The goal defined the solution of the following tasks:
• to analyze the hydrochemical parameters of fish-breeding pools when using the studied compound feeds;
• test feed granul. examine their physical properties;
• evaluate the size parameters of koi carp when using two versions of granular feed;
• analyze some physiological parameters of koi carp.

2. Material and research methods

Studies on the comparative evaluation of compound feeds were carried out in the "Kagalnik" aqua-complex at the research and expedition base of the Federal Research Center Southern Scientific Center of the Russian Academy of Sciences.

The object of the study is the koi carp (*Cyprinus carpio haematopterus*).

The fish were grown in square pools measuring 2×2 meters at a maintained water level of 35-40 cm, the time of full water exchange was 20-25 minutes.

The number of fish in the pools during the experiment was 15 pieces per pool. The fish were fed with sturgeon feed Coppens Supreme-10 (Holland) and Tetra (Germany). Koi carp were fed by hand, in equal portions, four times a day.

The feeding rate is 1.0% of the total weight of fish per day. The feeding rate is due to the feedability of the fish feed, with an increase in the daily feeding rate, the uneaten feed remained. Several feedings were skipped to take blood samples and measure the weight and length of the fish.

The food was stored in a cool, dry place, protected from direct sunlight and pests.

To determine the water resistance, the granul. of the experimental feed variants were lowered into containers with water, and the time of complete dissolution of the granul. at a temperature of 20°C was determined.

The effectiveness of the tested feeds was evaluated by the indicators of absolute and average daily growth, average daily growth rate and mass accumulation coefficient. The functional state of the fish was assessed by a number of physiological indicators.

The analysis of the physiological state of the fish was carried out after their adaptation to the growing conditions. Blood was obtained from the caudal vein using a syringe. The physiological state of the individuals was assessed by the content of serum protein in the blood, the rate of erythrocyte sedimentation, and hematocrit.

The results of the experiment were processed using the generally accepted methods of biological statistics using the Excel computer program.

3. Results and discussion

Every living organism during its life is inseparably connected with the environment that surrounds it and has a direct impact on physiological indicators. The most important role for the life of hydrobionts is played by biochemical adaptation, which ensures the stability of the microenvironment conditions. In other words, the adaptation of an organism to a certain environment indicates the adaptation of all its organ systems and metabolism as a whole.

During the experiment, the water temperature ranged from 20.4°C to 21.5°C, the dissolved oxygen content in the water did not fall below 6.5-7 mg/l with an average value of 7.5 mg/l (~ 85-90% saturation) during the entire growing period.

One of the most important indicators of the use of granular feed in the cultivation of fish in industrial conditions is their effect on the hydrochemical composition, primarily on the content of biogenic elements. Throughout the experiment, the content of biogenic elements in fish-breeding pools was regularly monitored; the average values during the experiment are shown in table 1.
Table 1. Content of biogenic elements in fish-breeding basins.

| Feed   | Phosphates | Nitrites | Nitrates |
|--------|------------|----------|----------|
|        | C, mg/dm³ | C, mg/dm³ | C, mg/dm³ | C, mg/dm³ | C, mg/dm³ |
| Coppens| 11         | 39       | 0.069    | 0.21     | 44        | 201       |
| Tetra  | 12         | 40       | 0.067    | 0.22     | 45        | 198       |

The amount of biogenic elements in fish-breeding plants is mainly influenced by the biological filtration systems used in fish farming, the density of fish planting, and the amount of daily replacement water. However, all other things being equal, the use of certain batches of mixed feed for growing fish can have an extremely negative impact on the quality of water, including the content of biogenic elements.

The total content of biogenic elements in the fish-breeding system was within the standard values throughout the entire study period.

Due to the significant influence of the physical properties of granules on the pollution of the aquatic environment during the cultivation of fish by industrial methods, the water resistance of feed granules evaluated.

Within 5 minutes after the start of the experiment, the Tetra feed variant was significantly different from the Coppens variant. The granules of the feed were strongly swollen, and when mixed, a suspension was formed from the dissolved particles of the feed. After 14 minutes, more than half of the volume of granules dissolved in water to form a rich cloudy suspension, while the variant with the Coppens compound feed for this period of time showed the most resistant to erosion result. After 30 minutes, the Tetra compound feed swelled and partially dissolved, while the second compound feed did not have such a tendency, almost completely retained the appearance of the granules, did not create a suspension in the water.

The increase in the mass of fish per unit of time is the most important indicator that characterizes the quality of the feed used. Data on linear and weight growth are given in table 2, 3.

Table 2. Indicators of linear growth of koi carp

|                    | Coppens | Tetra  |
|--------------------|---------|--------|
| At the beginning of | 5.69±0.22 | 6.9±0.28 |
| the experiment, cm |         |        |
| At the end of the   | 7.14±0.23 | 7.9±0.32 |
| experiment, cm      |         |        |
| AD                  |         |        |
| AC                  | 6.65±0.23 | 6.97±0.26 |
| AB                  | 7.44±0.32 | 7.72±0.27 |
|                     | 9.0±0.29 | 9.74±1.05 |

Table 3. Indicators of weight growth of koi carp

| Parameters                        | Coppens | Tetra  |
|----------------------------------|---------|--------|
| Start weight, g                  | 4.3±0.46 | 4.5±0.34 |
| Final weight, g                  | 11±1.02 | 9.7±1.13 |
| Absolute increase, g             | 6.72    | 5.15   |
| Average daily growth, g/day      | 0.22    | 0.17   |
| Average daily growth rate, %     | 3.2     | 2.57   |
| Mass accumulation coefficient, units. | 0.06 | 0.048 |
| Fulton fatness coefficient, units | 3.02    | 2.9    |

The leader in terms of the increase in linear and weight growth was again Coppens compound feed (the absolute increase was 6.72 g; the average daily increase was 0.22 g). When using Tetra compound feed, lower results of the growth of the studied fish were obtained (absolute growth – 5.15 g; average
daily growth-0.17 g). The weight of fish that fed on Coppens increased by 156%, and Tetra - by 116%. This result can be explained by the high content of proteins, fats and a better balance of Coppens feed.

In order to obtain comprehensive results that characterize the effectiveness of cultivation, during the experiment on the comparative evaluation of granular feed, the fish-breeding parameters were supplemented with studies of the physiological parameters of fish (hematocrit, erythrocyte sedimentation rate, protein content in the blood) in order to assess the overall physiological state of the experimental fish (table 4).

Table 4. Physiological blood parameters of koi carp

| Variants of experiments | Hematocrit, % | ESR, mm / h | Protein, g/% |
|-------------------------|--------------|-------------|--------------|
| Coppens                 | 26.4±3.2     | 7.5±0.8     | 2.86±0.8     |
| Tetra                   | 29.9±2.2     | 8.9±1.2     | 1.84±0.9     |

The results of the analysis of some physiological parameters of fish blood showed a satisfactory condition of individuals in the experimental versions. However, in the variant with the use of Tetra compound feed, a lower protein content in the blood was observed, as well as an increase in the rate of erythrocyte sedimentation, which may indicate a weakening of the physiological status of the farmed fish.

Thus, throughout the experiment, the hydrochemical composition in the fish-breeding pools remained within the standard values. When conducting an experiment to determine the water resistance of granules of the studied compound feeds, the time of complete dissolution of the feed in an aqueous environment was established. The leader in water resistance was the Coppens compound feed. The compound feed of the German company Tetra showed faster solubility than the Dutch product. Fish-breeding and biological indicators of koi carp during experimental cultivation also had differences. The leader in terms of the increase in linear and weight growth was again Coppens compound feed (the absolute increase was 6.72 g; the average daily increase was 0.22 g). Tetra compound feed showed comparatively lower results of the growth of the studied fish (absolute growth-5.15 g; average daily growth-0.17 g). The weight of fish that fed on Coppens increased by 156%, and Tetra - by 116%. This result can be explained by the high content of protein and fat in the Coppens feed. Summing up the results of the experiment, it should be noted that both recipes of compound feed proved to be quite good, but the German compound feed Tetra is somewhat inferior to the Dutch Coppens. Therefore, with different prices for mixed feed and its different production qualities, it is extremely important for a fish breeder to make the right choice and stop at mixed feed, which will ultimately be more economically feasible.

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