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COMPARATIVE ASSESSMENT OF FISH-BIOLOGICAL AND MORPHO-PHYSIOLOGICAL CHARACTERISTICS OF TWO FORMS OF TROUT REARED UNDER THE CONDITIONS OF AQUACULTURE IN AZERBAIJAN

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Abstract. Conclusions of the fish-breeding-biological, morphometric parameters, morphophysiological indicators, as well as the chemical composition of the body of juveniles of the rainbow (*Oncorhynchus mykiss* Walbaum, 1792) and amber trout (*Oncorhynchus mykiss* Walbaum) in the process of their rearing by the pool method were given in the article. The research material was implemented in between December-June 2021-2022 years at the "AZFOREL fish farm" which is located in the village of Seyfali, Shamkir region of the Republic of Azerbaijan. Growing conditions for the two groups of trout (rainbow and amber) were the same. After the juveniles reached a 70 gram weight, the fish-breeding-biological and morphometric parameters were determined in the studied fish. A comparative assessment of the quality of grown objects was carried out using the obtained data on morphometric parameters, morphophysiological indicators and biochemical analyzes of the fish body.

It is determined that experimental rainbow trout fish (71.50 g) have the highest average weight at the end of the rearing period, which turned out to be higher by an average of 3.71 g, or 5.2% compared to experimental amber trout fish. When comparing the results obtained by the indices, the following draws attention: in the rainbow trout, such indicators as the index of the heart, liver, and, importantly, the gonads, turned out to be significantly higher, which allows us to say that the maturation of germ cells in representatives of the rainbow trout is possible earlier compared to amber.

A biochemical analysis of the body composition showed that as a result of rearing the experimental fish in a fish farm under the same conditions of keeping and feeding, the body of the rainbow trout, compared to the amber trout, had a higher nitrogen content by 0.30 p.p., and as a result, a higher protein content by 2.3 p.p. This indicates a better assimilation of feed proteins, as well as its distribution and synthesis in the body of farmed fish. An increase in calcium in the muscles of rainbow trout by 0.03 p.p. was also noted, which is a very important indicator in the life of fish.

Keywords: *rainbow trout, amber trout, fish-biological and morphophysiological indicators, chemical composition of the body.*

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1. Introduction

Modern world trout farming is a highly profitable, steadily developing industry with controlled or partially controlled methods of rearing and growing trout of all age

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groups, with a complete transition to complete granular feed, with economically and technologically safe farming (Novozhenin, 2010).

Rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) is one of the most common objects of world aquaculture and is intensively cultivated in many countries of the world due to its fish-breeding qualities: it adapts well to artificial conditions and assimilates artificial feed, and also has a high growth rate at a significant density implantation.

The history of trout farming in Azerbaijan for commercial purposes dates back to 1977, when a trout fish farm was built for the first time in the Sheki region, and 10,000 rainbow trout fry from the Konakovo fish farm of the Russian Federation were initially brought to stock the pools.

At present, aquaculture is intensively developing in Azerbaijan, and in recent years a number of modern fish farms have been built and are operating, where the latest achievements of world aquaculture, including trout breeding, are being introduced. One of such farms in Azerbaijan is "AZFOREL fish farm", which is located in the village of Seyfali, Shamkir region, and was built in 2017, has been operating since 2018. Initially, fertilized eggs of more than 10 forms of rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) were brought to this farm from other countries, but then, on the basis of grown planting material, their own repair, breeding and production school was formed on this farm. The fish breeding use of the spawners of the production school of trout formed on this farm began from the end of 2020. They receive sexual products, grow planting material and marketable fish from their own spawners grown on the farm. In this regard, the study of the fish-breeding quality of the resulting implanting material, marketable fish and spawners, as well as the feasibility of their rearing on this farm is relevant and of great practical importance.

The task of our research was to study the fish-breeding biological and morphophysiological parameters, as well as the chemical composition of the body of juveniles and adults of the rainbow and amber trout in the process of their rearing by the pool method.

2. Materials and methods

The research material was implemented in between December-June 2021-2022 years at the "AZFOREL fish farm" of the Republic of Azerbaijan. The objects of study were 2 forms of trout: rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) and amber trout (*Oncorhynchus mykiss* Walbaum). During the experiments, mature male and female individuals were pre-marked and grouped. Their length (L), weight (P), fullness coefficient (Fulton), productivity and sexual maturity factor of the fries and spawners used in the experiment were determined according to the rules adopted in ichthyology and were determined (Pravdin, 1966; Moiseev *et al*., 1981; Najafov *et al*., 2019). Mature spawns were obtained from sexually mature spawners by the "milking method" (Figure 1).

In order to specify the number of roe in the options and to calculate the total productivity, 1 gram of roe was taken from each roe used and fixed in 4% formalin solution after determining the number of roe grains. Fertilization of roe was carried out by the "dry" method according to the accepted methodology (Guliyev, 2006; Emre & Kürüm, 2007; Grigoryev & Sedova, 2008; Mamedov *et al*., 2016) (Figure 2). The quality of sperm taken from male was initially assessed visually, and the sperm activity

in the samples was determined on a 5-point scale, magnified 200 times with the assistance of the Karl Zeiss Axio Imager M2 binoculars in accordance with the obtained methodology (Persov, 1953).

Fig. 1. Obtaining mature roe from rainbow trout by the "milking method"

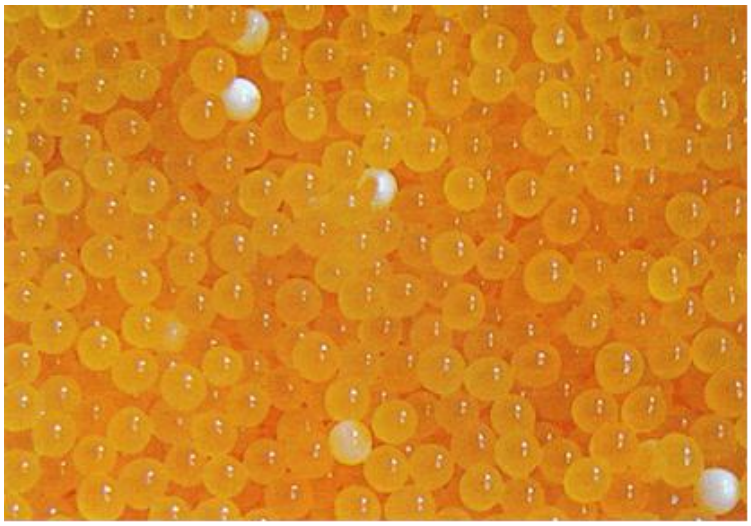

Fig 2. Fertilized rainbow trout roe

The obtained one-day-old larvae from rainbow and amber trout with an average weight of 0.1 g were initially placed in 2 identical plastic pools (3.5m x 0.9m x 0.5m). The initial stocking density of experimental fish in the pools was 10,000 fish/pool, and as they grew, the stocking density in each pool was halved. When growing in plastic pools, artesian water was used with an average temperature of 16-17^{0}C.

For feeding experimental fish in both variants, dry granulated food of the SKRETTING brand with granule sizes of 1.0-1.5 mm was used. The daily rate of dry feed varied from 2 to 6%, depending on the water temperature and the increase in fish biomass, and averaged 3.0% over the growing period.

After the juveniles reached a 10 gram sample, the experimental subjects were transplanted into 2 concrete pools (9.0m x 1.5m x 1.0m). The stocking density of

experimental fish in the pools was 2000 fish/pool. When growing in concrete pools, river water is used, flowing by gravity from the Shamkir reservoir. In these pools, experimental fish were grown up to 70 gram sample. When growing in concrete pools, the water temperature ranged from 15 to 18^0C. For feeding experimental fish in both variants, dry granulated food of the SKRETTING brand with granule sizes of 1.5-2.0 and 3.0 mm was used. The daily feed intake averaged 3.0%.

Growing conditions for the two groups of trout (rainbow and amber) were the same. During the entire growing period, the hydrochemical parameters of the aquatic environment were monitored (Instructions, 1985).

After the juveniles reached a 70 gram weight, the fish-breeding-biological and morphometric parameters were determined in the studied fish. Morphometric studies were carried out according to the methods generally accepted in ichthyology (Pravdin, 1966). For research at the beginning and end of rearing, one group of the same age rainbow and amber trout was formed (n=15). The daily increase in body weight of reared fish was determined by the formula of G.G.Vinberg (1956):

$$SGR. = \left[10^{\frac{1}{t}(\lg W_t - \lg W_0)} - 1 \right] \times 100,$$

where
SGR - (specific growth rate) – daily gain, %;
W_0 - average sample of fish at the beginning of feeding, q;
W_t - average sample of fish at the end of feeding, q;
t - period of fish rearing, days.

A comparative assessment of the quality of grown objects was carried out using the obtained data on morphometric parameters, morphophysiological indicators, and biochemical analyzes of the fish body (Ivanov, 1963; Limansky *et al*., 1986; Sklyarov *et al*., 1984; Sklyarov, 2008).

Indices of the internal organs of fish (I, %) were calculated using the formula:

$$I = x / y \cdot 100 \ (\%),$$

where
I – relative mass of an organ, %;
x – organ weight, r;
y – total body weight of fish, gr.

The total number of studied individuals from 2 experimental groups was 30 specimens.

The amount of protein, fat, dry matter, as well as some microelements in the body of grown fish (7 pieces each) was determined according to the generally accepted method, together with the staff of the Institute for Scientific Control of Veterinary Drugs.

The results obtained were group-averaged and compared by Student's t-test (Lakin, 1980).

3. Results and discussion

Hydrochemical indicators of water. When growing larvae, fry and juveniles of experimental fish, the hydrochemical regime of the aquatic environment was monitored daily. The average daily water temperature, the content of oxygen dissolved in water, the active reaction of the medium (pH), total mineralization, concentrations of ammonium, nitrate and nitrite nitrogen, as well as some heavy metals were determined. The saturation of water with oxygen during the period of rearing experimental fish ranged from 8.5 to 10.5 mg/l, averaging 9.5 mg/l. The active reaction of the medium (pH) shifted from slightly alkaline (8.2) to neutral (7.0). The concentration of nitrite nitrogen (NO_2) did not increase to critical values and did not exceed 0.1 mg/l throughout the entire operation phase of the pools. The maximum concentrations of nitrate and ammonium nitrogen were 0.7-0.8 mg/l and 0.2 mg/l, respectively. Thus, the indicators of water quality during the entire experimental period were within the optimal values.

Fish-breeding-biological and morphometric indicators of experimental fish.

Fish-breeding and biological indicators of experimental fish were determined by the results of their rearing in concrete pools up to 70 grams. With this weight, juveniles of rainbow and amber trout clearly differed from each other in external signs and actively consumed artificial mixed feed. The results of rearing experimental fish are presented in table 1.

The data presented in table 1 show that experimental rainbow trout fish (71.50 g) have the highest average weight at the end of the rearing period, which turned out to be higher by an average of 3.71 g, or 5.2% compared to experimental amber trout fish. Accordingly, the average daily body weight gain in rainbow trout turned out to be higher compared to amber trout by 0.08 g/day.

The analysis of morphometric indicators also shows that at the end of the growing period, the morphometric of rainbow trout is higher than that of amber trout. Given the fact that the conditions for keeping and feeding experimental fish were absolutely the same for experimental fish of both groups, it can be argued that from a fish breeding point of view, rainbow trout is a more valuable object for breeding in this fish farm.

Morphophysiological characteristics of experimental fish.

The value of the method of morphophysiological indicators lies in the fact that it makes it possible to judge the biological originality of the studied objects, that is, on the basis of individual morphological features, an assessment of the variability of certain indicators is carried out.

The selection of indicators suitable as morphophysiological indicators is determined based on the tasks set and the possibilities available to the researcher. So, to obtain a preliminary picture of the state of the population, one can limit oneself to only a few of the most effective, labor-intensive and most studied indicators: body weight and length, weight of the most important internal organs (heart, liver, digestive tract, spleen, etc.). However, the main advantage of the method of morphophysiological indicators is the use of the simplest indicators, which, in the presence of ichthyological material, can be obtained in large quantities and without much difficulty.

Since rainbow trout and its subspecies (form) amber trout are grown on the fish farm, the quality of the planting material obtained from them is very relevant and

requires deep consideration. The results of morphophysiological studies are presented in table 2.

Table 1. Fish-breeding-biological and morphometric parameters of rainbow and amber trout when grown in the pool method

№	Indicators	Trout	
		rainbow (n=15)	amber (n=15)
1	Total number of implanted fish, specimen/pool	2000	2000
2	Average weight of experimental fish at the beginning of the experiment, g	10,50±1,30	10,30±1,48
3	Average weight of experimental fish at the end of the experiment, g	71,50±4,28	67,79±3,95
4	Average daily gain, g	0,78	0,70
5	Final mass of fish, g	71,50±4,28	67,79±3,95
6	Length of the whole fish, cm	12,21±2,54	11,0±3,00
7	Body length, cm	11,00±0,90	9,47±0,80
8	Torso length, cm	9,0±0,30	7,8±0,35
9	Head length, cm	3,95±0,31	3,78±0,32
10	Maximum body height, cm	4,52±0,51	4,34±0,52
11	Smallest body height, cm	1,41±0,07	1,4±0,09
12	Caudal peduncle length, cm	2,4 ±0,63	2,35±0,06
13	Snout length, cm	0,65±0,11	0,62±0,10
14	Eye diameter, cm	0,88±0,02	0,86±0,018

Analyzing the data in table 3, we can say with confidence that the representatives of the rainbow and amber trout selected for research were almost the same in terms of total weight (no significant differences were noted between these indicators in the two groups). When comparing the results obtained by the indices, the following draws attention: in the rainbow trout, such indicators as the index of the heart, liver, and, importantly, the gonads, turned out to be significantly higher, which allows us to say that the maturation of germ cells in representatives of the rainbow trout is possible earlier compared to amber.

Table 2. Morphophysiological characteristics of experimental fish

№	Indicators	rainbow (n=15)	amber (n=15)
		M ± m	M ± m
1	Weight of fish, g	71,50±4,28	67,79±3,95
2	Heart index, %	0,172±0,06***	0,141±0,04
3	Liver index, %	2,850±0,67***	1,290±0,23
4	Kidney index, %	0,580±0,17	0,470±0,10
5	Spleen index, %	0,345±0,19***	0,412±0,17
6	Gonad index, %	0,118±0,007***	0,015±0,008
7	Stomach index, %	4,080±0,75	4,075±0,55

Remarks: * – P>0,05; ** – P>0,01; *** – P>0,001.

In turn, a significant increase in the spleen index was noted in amber trout, which is presumably due to an increase in the production of blood cells in this fish (as is known, the spleen in fish is the main hematopoietic organ) in response to the indicators of the environment in which the fish is kept.

As a result of the research, it can be argued that the most important indices, other things being equal, were higher in rainbow trout. This indicates its prospects for cultivation from a fish breeding point of view compared to amber trout.

Biochemical studies of experimental fish. One of the most important indicators of the quality of planting material for any fish species is their ability to accumulate nutrients in the body (Sklyarov, 2008; Najafov *et al*., 2019).

Live juveniles of amber and rainbow trout of the same age and size were selected for biochemical studies. The research results are presented in table 3.

Table 3. Biochemical composition of the body of juvenile experimental fish

№	Indicators	Trout	
		rainbow	amber
1	Surface moisture, %	64,5	66,15
2	Dry matter, %	32,4	30,80
3	Protein, %	22,15	19,82
4	N, %	3,50	3,20
5	P_2O_5, %	0,8	0,74
6	Ca, %	0,102	0,072
7	Cu, mg/kg	0,939	1,095
8	Zn, mg/kg	6,64	5,50

A biochemical analysis of the body composition showed that as a result of rearing the experimental fish in a fish farm under the same conditions of keeping and feeding, the body of the rainbow trout, compared to the amber trout, had a higher nitrogen content by 0.30 p.p., and as a result, a higher protein content by 2.3 p.p. This indicates a better assimilation of feed proteins, as well as its distribution and synthesis in the body of farmed fish. An increase in calcium in the muscles of rainbow trout by 0.03 p.p. was also noted which is a very important indicator in the life of fish, since it is the calcium contained in the bones that is a reserve for those physiological processes in which the need for it increases. Calcium is necessary for the formation of fibrin during blood clotting, it affects the colloidal state of protoplasm, maintains the osmotic pressure of the blood, and is also necessary for maintaining the normal activity of the cardiovascular system of fish. Other indicators in the control and experimental groups were approximately the same, except for the content of zinc ions, which can be absorbed through the skin of fish directly from the water.

4. Conclusion

In the course of biochemical studies with fish stock of rainbow and amber trout, it was found that rainbow trout is the most valuable in terms of nutrients and of high quality in physiological terms.

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