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ORIGINAL ARTICLE

The use of sorption feed supplement in the young fish feeding

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The purpose of the research is to study the effect of feeding an active coal feed supplement (ACFS) on biological fish-breeding indicators of young fish grown in closed water supply plants. The experiment was conducted in the conditions of a sturgeon farm in the Krasnodar territory. The object of the research was juvenile ship sturgeon *Acipenser nudiventris* Lovetsky, 1828. The traditional technology of keeping and feeding sturgeon fish with combined starter feeds in closed-cycle plants was used in the experiments. The physical and chemical properties of water and the content of chemical and toxic substances in sturgeon feed were analyzed. We studied the influence of feeding with ACFS on biological fish-breeding parameters, growth rate, survival rate, feed spending, nutrient products, and the coefficient of the fatness of sturgeon juveniles. We also checked the influence of active coal feed supplements on the development of muscle tissue, the chemical body composition of young fish, and its heavy metals content. We established that all water indicators in the closed water supply system were stable during the experiment and met the existing requirements. We registered that the use of ACFS in feeding young sturgeon fish contributes to an increase in their weight by 5.3-10.2%, the fatness coefficient – by 1.7-7.5% and a reduction in feed-cost products – by 5.0-8.9%. The use of ACFS has a positive effect on the development of muscle tissue, increasing its protein content by 0.41 - 0.42%, fat-by 0.16-0.32%, and reduces the content of heavy metals in the body of young sturgeon by 1.5-2.0 times.
Keywords: young sturgeon, compound feed, heavy metals, sorbent, fish mass, fatness coefficient.

Introduction

The Russian Federation has a state policy on priority development of fisheries in inland waters (Asanov, 2015, Sklyarov, 2015). Sturgeon production in the Krasnodar region has increased 12 times over the last five years and reached 250 tons per year. However, the industry needs to be developed, and economic and production indicators are reduced for several reasons (Sklyarov, 2015). Sturgeons are fish species with biological and economic importance, and most of them are endangered, vulnerable, or rare due to their large size, late sexual maturity, long period between spawning and longevity (Hung, 2017; Hao, 2018; Jafari, 2018).
Considering individual sectors of aquaculture, we note that, along with traditional technologies for growing commercial fish, the most important place is occupied by intensive forms of fish farming, in which the organization questions of full-fledged feeding is of paramount importance (2015; Wang, 2016; Roy, 2018). Improving the fish farming industry's efficiency The interest of scientists and practitioners in using new feed supplements, biologically active substances, including sorbents in the cultivation of fish, has been significantly increasing in recent years. The mechanism of their action is pervasive, and, as many scientific experiments show, these new dietary supplements can be effective in a variety of animal husbandry industries, including fish farming. Moreover, it is impossible to use compound feeds that meet all the requirements for safety indicators (Bakaneva, 2013; Yuan, 2019.; Pshatsiyeva, 2019).
The purpose of the research was to study the effect of feeding an active coal feed supplement (ACFS) on biological fish-breeding indicators of young fish grown in closed water supply plants.

Materials and methods

The experiments were carried out in sturgeon farm "Infoservice" LLC of the Krasnodar territory in fish-breeding pools of 4 m^3 size with a stocking density of 18 pcs/m^2. The water level in the pools was 0.5 m. the object of research was juvenile ship sturgeon *Acipenser nudiventris* Lovetsky, 1828. The traditional technology of keeping and feeding sturgeon fish with combined starter feeds in closed-cycle plants in the experiments was used. The experiments were done according to the "Methodological guide for the study of fish nutrition" (1974) and M. A. Shcherbina (1983). The fish feeding experiment was conducted according to the scheme presented in Table 1. The duration of the second experiment was 40 days.

Table 1. Scheme of research and production experience (n=100).

Groups	Feeding characteristics
1	Basic diet (BD)
2	BD + 0.1% ACFS by feed weight
3	BD +0.2% ACFS by feed weight
4	BD + 0.5% ACFS by feed weight

Juveniles in the first (control) group obtained standard farm compound feed. The main diet was supplemented with the studied active coal feed supplement (ACFS) in the corresponding percentages with feed in the experimental groups. Feeding was carried out five times a day with granulated feed mixtures.

Active coal feed supplement (ACFS) was produced in LLC scientific and technical Center "Himinvest," located in Nizhny Novgorod. The supplement is prepared from active charcoal with coniferous extract in an amount of at least 20% of the main mass. ACFS is intended to protect animals from the influence of feed and environmental toxicants, produce environmentally friendly products, and be sources of biologically active substances for the animal organism. Feed for juvenile fish contained 13.19 MJ of metabolic energy, 55.0% crude protein, 18.0% crude fat, 0.9% crude fiber, 2.2% lysine, 0.7% methionine, 1.1% methionine + cystine, 2.0% calcium, 1.7% phosphorus. Keeping conditions in all groups of fish were the same and corresponded to the technology of fish breeding. Young sturgeon fish weighing and body length measuring were carried out individually on electronic scales at the beginning and the end of the experimental period. The gross and average daily increments were determined by periods. The fish's length was measured from the top of the snout to the abrupt end of the caudal fin's longest blade when the fish was horizontal. Preservation (survival) was determined as a percentage of the surviving fish to the dead.

The fatness coefficient was determined as the ratio of mass to body length: according to Fulton's formula (1) (fatness formula)

$$K = P\times 100 / L3(1),(P / L3)100$$

where P is the mass of the fish (g), and L is the body's length (cm).

Feed was fed manually. Accounting for the amount of feed consumed was individually for each group, according to the amount of the given feed and the leftover feed. Leftover feed was collected from containers by hand with a net, dried, and the mass was determined. The difference between the amount of introduced and uneaten feed was used to calculate the feed intake amount (Sklyarov et al., 1984). Morphometric analysis of muscle tissue development was performed at the end of the experiment on six specimens from each group. The chemical composition of the fish body was determined using generally accepted methods of complete zootechnical analysis.

Results and discussion

During the research and production experiment, the water temperature in closed water supply plants was maintained at +17±1,0 0C. The optimal values of the hydrogen ion exponent for growing sturgeon fish ranged within the limits of 7.0-8.0. During the research and production experiment, the pH of the water was 7.6.

All water indicators in the closed water supply plant during the scientific and economic experiment were stable and met the requirements of industry standard 15.312.87. " Nature protection. Hydrosphere. Water for fish farms. General requirements and rules" for the cultivation of sturgeon juveniles.

The main fish-breeding indicators for growing juvenile ship sturgeons are presented in Table 2.

Table 2. Main fish-breeding indicators for growing sturgeon juveniles (n=100).

Indicators	Group			
	1	**2**	**3**	4
Average fish weight, g:				
initial	220.0±2.3	220.0±1.7	220±2	220±2
final	360.3±4.1	379.3±4.0**	396.9±4.3***	396.0±4.8***
% of control	100.0	105.3	110.2	109.9
Growth rate (average daily growth), g	3.5	4.0	4.4	4.4
Survival rate, %	100	100	100	100
For 1 kg of growth it was spent:				
feed, kg	1.79	1.70	1.62	1.63
% of control	100.0	95.0	90.5	91.1

Note: Here and further in the tables:*P<0.05;* * P<0.01; ***P<0.001 according to the t-criterion compared with the control.

The initial mass of fish when they were put in the pools was the same. However, there were significant differences at the end of the growing period. The final weight of the ship sturgeon increased significantly in the second group by 5.3% (P<0.01), in the third – by 10.2%(P<0.001), in the fourth-by 9.9%(P<0.001).

Feed consumption in all groups was 251.2 g per 1 fish for the entire experiment period and was the same because the feeding was normalized. However, feed costs per 1 kg of live weight gain were lower in the experimental group.

We noted a decrease in feed costs per 1 kg of growth in the second group (by 5.0%), in the third (by 9.5%), and in the fourth (by 8.9%), compared to the control. The fatness coefficient of juvenile fish calculated by Fulton is shown in Table 3.

The Fulton's fatness coefficient of sturgeon juveniles was higher in the second group of juveniles by 1.7%, in the third – by 7.5%, and in the fourth – by 3.3% compared to the control group. The obtained results allow us to conclude that using an active coal feed supplement (ACFS) in the feeding of ship sturgeon yearlings in a closed water supply system helps to increase its productivity.

Table 3. Fatness coefficient of juvenile fish.

Indicators	Group			
	1	2	3	4
Fish length, cm	24.7±0.29	25.0±0.40	24.9±0.20	25.2±0.24
Fatness by Fulton	2.39	2.43	2.57	2.47
As % of the control	100.0	101.7	107.5	103.3

At the end of the experimental period, a morphometric analysis of fish with a mass equal to the group's average was performed (Table 4).

We established that in feeding young sturgeon fish with ACFS as part of full-fledged compound feeds, there is a tendency to increase the mass of fish carcasses by 0.5-1.1%. There is a significant increase in the mass of fish muscle tissue – in the second group by 2.2 abs.%, in the third-by 3.5 abs.%, in the fourth-by 3.8 abs. % (in all experimental groups P<0.001)

The weight of fish can increase due to the accumulation of reserve nutrients. When conducting scientific and economic experiments to study various feed additives' effectiveness, it is crucial to establish the relationship between the fatness coefficient and the protein and fat content in their body.

Table 4. The results of morphometric analysis of juvenile fish (n=6).

Indicators	Group			
	1	2	3	4
Fish weight, g	359.7±6.2	397.8±6.0***	395.1±5.2***	396.0±4.3***
Weight of gutted carcass (with head and fins), g	325.2±5.4	364.0±4.7**	360.7±5.4**	360.0±7.3*
% of the initial mass	90.4	91.5	91.3	90.9
Weight, g: head and fins, g	116.4±3.0	127.0±3.2	122.3±2.6	124.2±2.2*
% of weight of gutted carcass	35.8	34.9	33.9	34.5
skin	40.7±0.5	41.1±0.4	42.2±0.3	41.4±0.3
% of weight of gutted carcass	12.5	11.3	11.7	11.5
cartilaginous tissue	29.9±0.3	32.8±0.5**	32.1±0.6*	30.6±0.7
% of weight of gutted carcass	9.2	9.0	8.9	8.5
muscle tissue	136.3±3.3	160.5±2.2***	163.8±2.1***	163.1±2.0***
% of weight of gutted carcass	41.9	44.1	45.0	45.3

In the composition of fish tissues, the most important are proteins, fats, water, and some minerals, particularly phosphorus and calcium. The fish body's chemical composition was studied to justify the effectiveness of using an active coal feed supplement when growing young ship sturgeon in closed water supply plants (Table 5).

Table 5. Chemical composition of the body of juvenile fish (n=6).

Indicators	Group			
	1	2	3	4
Moisture, %	83.06±0.18	82.39±0.07	82.42±0.17	82.45±0.10
Protein, %	10.94±0.15	11.26±0.05	11.36±0.04*	11.35±0.07*
Fat, %	3.94±0.05	4.26±0.08*	4.14±0.04*	4.10±0.03*
Ash, %	2.07±0.03	2.1±0.04	2.09±0.01	2.1±0.05
Calcium, g/kg	4.55±0.07	4.94±0.35	4.57±0.05	4.56±0.07
Phosphorus, g/kg	3.37±0.11	3.44±0.11	3.45±0.11	3.41±0.05

According to the analysis of juveniles' chemical body composition, a significant increase in protein content in the fish body third group – 0.42 abs.%, the fourth group - 0.41 abs.% (P<0.05) was established. In all experimental groups, the mass fraction of fat increased significantly (P<0.05), which is consistent with the data on an increase in fish mass and Fulton's fatness coefficient: in the second group – by 0.32 abs.%, in the third – by 0.20 abs.%, in the fourth – by 0.16 abs.%. There was a positive trend towards a decrease in the moisture content in the body of fish of the experimental groups and an increase in the ash, calcium, and phosphorus content, but based on these data, it can be said that ACFS does not remove minerals from the body. Data on the content of heavy metals in the homogenate of juvenile ship sturgeon bodies are presented in Table 6.

Table 6. Content of heavy metals in the ship sturgeon body homogenate (mg/kg, n=6).

Indicators	Group			
	1	2	3	4
Dosage of ACFS	-	0.1	0.2	0.5
Cadmium (MPC 0.2)	0.03±0.001	0.02±0.001***	0.01±0.001***	0.01±0.001***
Mercury (MPC 0.5)	0.20±0.001	0.17±0.006	0.11±0.005**	0.10±0.001***
Lead (MPC 1.0)	0.05±0.004	0.05±0.002	0.02±0.001***	0.02±0.006***

The feeding with ACFS sorbent significantly reduces the content of heavy metals in young sturgeon bodies by 1.5-2.5 times (P<0.001 in the third and fourth groups). Thus, the use of ACFS sorbent in mixed feeds for young sturgeons has a positive effect on fish meat productivity and quality. We found that at a certain level of heavy metal content in the feed, feeding with ACFS significantly reduces the residual quantity of cadmium, mercury, and lead in the body of fish (Chernyshov, 2017).

Conclusion

We concluded that the application of ACFS in the feeding of young sturgeons contributes to growth intensity, coefficient of fatness, reducing feed cost of production, increasing muscular tissue mass and improving its chemical composition, and reducing heavy metals' content in the body of young sturgeon by 1.5-2.0 times.

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