Productivity of Sharp-Tooth Catfish Depending on Feeding Methods

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Abstract—The automatic adaptive feeder for fish feeding in recirculation plants has been developed and tested. It was found that the use of this feeder allowed to increase the yield of fry per 1 m³ by 35% and 13.6%; the yield of fingerling – by 45.9% and 18.5%; in the final period of cultivation – by 52.3% and 21.9% in comparison with hand-feeding and traditional auto-feeding without the adaptation function of the auto-feeder. Accordingly, using an automatic adaptive feeder, it was possible to obtain by 71.7 kg and 37.6 kg more fish per 1 m³ of recirculating aquaculture system (RAS) during one production cycle than using the existing technology. It helps to make an additional clear profit from the sale of products for 6,702 rubles 88 kopecks from 1 m³ of RAS in comparison with hand-feeding and 3,503 rubles 09 kopecks in comparison with automatic feeding without the adaptation system.

Keywords—recycling plants for fish farming, RAS, fish automatic feeding, automatic feeder for fish, feeding behavior of fish, sharp-tooth catfish

I. INTRODUCTION

It is well known that the live weight gains of animals (including aquatic organisms) by 60-65% depends on full feeding and optimal feeding regime [1-10]. Therefore, the intensification of sectors of the national economy (including aquaculture) is not possible without the use of complete feeds on the basis of scientifically developed standards and without the use of automatic equipment for optimal dosing and distribution of feed [11]. Proper feeding of fish is also affecting the ecology of water bodies and recirculation systems, and human health.

Most feeders available on the market are designed for pre-programmed distribution of feed, as a rule, for no more than a week. At the same time, this equipment is not able to take into account the weather dependence the feed intake of fish and the chemical composition of the aqueous environment. Such "automatic" feeding requires constant monitoring of feed intake by specialists and periodic adjustment of automatic feeders. Otherwise, such auto-feeding can lead to clogging of the plant with feed and intoxication of fish with the products of their decomposition. Therefore, if the possibility of constant control for feed intake is absent, experts adjust feeding according to minimum standards to prevent mass fish mortality in the RAS, and this leads to a waste of feed according to some data up to 5% [2, 3] for the growing period. In addition, this approach does not allow eliminating the so-called "human factor" completely, which leads to the irregularity of fish feeding over time and other violations. At the same time, such irregularity may lead to significant losses in productivity. Thus, cannibalism is often observed in the cultivation of predatory fish species with dense holding in the RAS. This phenomenon is mainly due to irregular feeding, which leads to the fact that at the beginning of the growing period with a similar live weight of fish, some individuals feed more often than others and some significant differences in the speed of their growth arise inevitably. Subsequently, when some individuals grow bigger than others significantly such irregular feeding time during the day leads to the aggressive behavior of larger fish against smaller. As a result, fish viability may be only 20-40% in the fry period. Especially similar phenomena are expressed in case of hand-feeding during the working day and a break in feeding during the night period.

The group of authors created a technology that takes into account water redox potential, the presence and quantity of ozone in the water, temperature, pH, and oxygen quantity. However, it is necessary to take into account some specificity in the cultivation of different species of fish and the use of different technologies. For example, it is known from ethological studies that the appetite of the sharp-tooth catfish depends on the dynamics of atmospheric pressure significantly. Therefore, when the factors that increase the appetite of fish (for example, the dynamics of atmospheric pressure and the increased period of time between feedings) interfere with each other, a phenomenon of cannibalism arises that may lead to the fact that the production will not be profitable [12].

II. EXPERIMENTAL

A computer program for the analysis and inspection of chemical composition (ammonium nitrogen, nitrite ions, nitrate ions, oxygen), water temperature and atmospheric

pressure dynamics with the function of controlling electrical equipment to maintain the necessary parameters of feeding and keeping in the RAS has been developed by us. The team of authors created an automatic feeder, compatible with this software as well. It allowed developing a complex of the equipment for the fish-farming organizations on control of farming parameters and feeding of fishes and other aquatic organisms.

Practical value of the created complex is expressed in a more rational use of available feed; improve of the viability of aquatic organisms in the RAS, including a significant reduction of mass fish mortality due to operating troubles of various systems and mechanisms of the RAS; increase of average daily gains of fish live weight; decrease of the negative influence of "human factor" when feeding.

To check the efficiency of this equipment, the zootechnical experiments on the sharp-tooth catfish farming was conducted in the RAS of the FSBEI of HE Belgorod SAU. The object of the study was the process of automatic feeding of sharp-tooth catfish using the interactive weather adaptive automatic feeder for fish with numerical control developed by us. The subject of the study is the optimization of feeding regimes for sharp-tooth catfish in the RAS by means of an innovative automatic adaptive feeder.

Three groups of sharp-tooth catfish fry at the age of 21 days, 373 individuals in each group, were selected based on analogues for the zootechnical experiment. The first group received feed according to the technology of hand-feeding using in Belgorod SAU. The second group was fed with the use of auto feeders without sensors on pre-programmed modes of feeding. The third group received feed with the use of the auto-feeder developed by us using the mode of automatic adaptation to changing conditions of the fish habitat and their ethology. All other conditions were the same for all groups and in accordance with scientifically sound standards. The assessment of fish productivity was carried out on the basis of live weight gain per 1 m³ of the RAS basin, absolute gross live weight gain, average daily growth during the growing period, fish viability, economic indicators.

III. RESULTS AND DISCUSSION

Table I shows the productivity of sharp-tooth catfish fry, depending on the method of feeding.

The data of Table I indicate that the yield of sharp-tooth catfish in the live weight per 1 m³ of the third group was the highest and exceeded the corresponding indicator of the first and second groups in fry – by 35.7% and 13.6%. This was due to an increase in the viability of fish in the third group compared to the first and second in fry – by 18.9% and 6.9% respectively.

The average daily growth in live weight among fish of the third group increased as well in comparison with the first and second groups in fry – by 6.4% and 4.7% respectively in groups.

The productivity of sharp-tooth catfish fingerling depending on the used feeding method is presented in Table II.

TABLE I. PRODUCTIVITY OF SHARP-TOOTH CATFISH FRY DEPENDING ON THE USED METHOD OF FEEDING

Indicators	Fry group 1	Fry group 2	Fry group 3
Holding density at the beginning of the period	373	373	373
Holding density at the end of the period	255	299	325
Weaning duration, days.	40	40	40
Initial weight, g	0.70	0.70	0.70
Final weight, g	28.06	28.50	29.82
Fish yield in live weight, kg/m³	7.143	8.531	9.694
Viability, %	68.2	80.2	87.1

[a.] All data in Table 2 are valid p<0.01

TABLE II. PRODUCTIVITY OF SHARP-TOOTH CATFISH FINGERLING DEPENDING ON THE USED FEEDING METHOD

Indicators	Fingerling group 1	Fingerling group 2	Fingerling group 3
Holding density at the beginning of the period	255	299	325
Holding density at the end of the period	235	282	316
Weaning duration, days.	50	50	50
Initial weight, g	28.06	28.50	29.82
Final weight, g	172.10	176.10	186.30
Fish yield in live weight, kg/m³	40.391	49.709	58.929
Viability, %	92.2	94.3	97.3

[b.] All data in Table 3 are valid p<0.01

The data of Table II indicate that the yield of sharp-tooth catfish in live weight per 1 m³ of the third group was the highest and exceeded the corresponding indicator of the first and second groups in fingerling – by 45.9% and 18.5% respectively in the groups. This happened due to the increase of fish viability in the third group compared to the first and second in fingerling – by 5.1% and 3.0%, respectively.

The average daily growth in fish live weight of the third group increased as well in comparison with the first and second groups in fingerling by 8.6% and 6.1 respectively in the groups.

The productivity of sharp-tooth catfish in the final growing period, depending on the used feeding method is presented in Table III.

The data of Table III indicate that the yield of sharp-tooth catfish in live weight per 1 m³ of the third group was the highest and exceeded the corresponding indicator of the first and second groups in harvestable fattened fish – by 52.3% and 21.9%, respectively in the groups. This happened due to the increase in fish viability in the third group compared to the first and second in harvestable fish – by 3.0% and 1.6%, respectively.

The average daily growth in live weight of fish of the third group increased as well in comparison with the first and second groups in harvestable fattened fish – by 10.1% and 7.6%, respectively in groups.

TABLE III.   THE PRODUCTIVITY OF SHARP-TOOTH CATFISH IN THE FINAL GROWING PERIOD, DEPENDING ON THE USED FEEDING METHOD

Indicators	Harvestable fish group 1	Harvestable fish group 2	Harvestable fish group 3
Holding density at the beginning of the period	235	282	316
Holding density at the end of the period	225	274	313
Weaning duration, days.	50	50	50
Initial weight, g	172.10	176.10	186.30
Final weight, g	610.00	624.12	668.32
Fish yield in live weight, kg/m³	137.151	171.241	208.863
Viability, %	95.8	97.2	98.8

c. All data in Table 3 are valid p<0.01

Analysis of the conducted studies shows that the fish mortality was greatest in the fry of the first group, receiving feed in hand mode (31.8%), especially at the end of the fry period, when the difference in the live weight of particular individuals reached a critical value, at which larger individuals could eat the smallest. This happened mainly as a result of irregular feeding of fish, in which the maximum difference in weight among individuals of the same group was observed. In the case of more regular feeding with the use of auto feeders, the fish mortality in the second group was 19.8%. However, cannibalism took place in individuals of the second group as well, since the automatic feeding did not take into account the ethological features of fish eating behavior. When using an adaptive feeder, allowing feed the fish more regularly, taking into account their eating behavior, the fish mortality in the fry period was minimal – 12.9%.

A similar situation has been created in other periods of farming. Thus, fish mortality of the third group among fingerling was 2.7%, which is 3% and 5.1% less than in fish of the second and first groups, in the final period of farming, these indicators were in fish of the first group – 4.12%, in fish of the second group – 2.8%, and in the third group – 1.2%. Certainly, it is very difficult to eliminate cannibalism totally because the difference in speed growth of fish is observed not only in dependence on feeding and food behavior, but from other factors as well.

Using an automatic adaptive feeder, it was possible to obtain by 71.7 kg and 37.6 kg more fish per 1 m³ of RAS during one production cycle than using the existing technology.

Economic indicators of the adaptive feeders use in sharp-tooth catfish farming in the RAS are presented in Table IV.

The data of Table IV indicate that as a result of the use of the product developed by us, the net cost of commercial products in the third group was reduced by 0.7% and 0.4%, respectively, compared with the first and second groups.

TABLE IV.   ECONOMIC INDICATORS OF THE ADAPTIVE FEEDERS USE IN SHARP-TOOTH CATFISH FARMING IN THE RAS

Indicators	First group	Second group	Third group
Fish yield in live weight, kg/m³	137.151	171.241	208.863
The cost of 1 kg of harvestable fish	184	184	184
Gross income from the sale of fish per 1 m³ of RAS, rub.	25235.77	31508.41	38430.71
Received additional funds from the sale of fish per 1 m³ of the RAS, rub.	0	6272.63	13194.93
Received marketable products additionally, kg/m³	0	34.090	71.712
Net cost of 1 kg of harvestable fish, rub.	91.21	90.93	90.53
Net cost of additionally received commercial products per 1 m³ of the RAS, rub.	0	3099.84	6492.05
Net profit from the sale of additionally received commercial products per 1 m³ of the RAS, rub.	0	3172.79	6702.88

13194.93 rubles and 6922.3 rubles were additionally gained as well from the sale of products of the third group (in the farming of which the product developed by us was used) in comparison to the first and second groups, and the net profit from the sale of additional products at the same time amounted to 6702.88 rubles per 1 m³ of the installation volume.

IV.   CONCLUSION

The developed auto-feeder was used in sharp-tooth catfish farming in the installation with a closed water supply system. During the study it was found that the yield of sharp-tooth catfish in live weight per 1 m3 of the third group was the highest and exceeded the corresponding indicator of the first and second groups in fry – by 35.7% and 13.6%; in fingerling – by 45.9% and 18.5%; in harvestable fattened fish – by 52.3% and 21.9%, respectively in groups. This happened due to the increase in the fish viability in the third group compared to the first and second in fry – by 18.9% and 6.9%; in fingerling – by 5.1% and 3.0% and in harvestable fish – by 3.0% and 1.6%, respectively.

The average daily growth in live weight of fish of the third group increased as well in comparison to the first and second groups in fry – by 6.4% and 4.7%; in fingerling – by 8.6% and 6.1%; in harvestable fattened fish – by 10.1% and 7.6%, respectively in groups.

In our opinion, it is connected with the automation of the feeding process for fish of the second and third groups. It is known that sharp-tooth catfish is a predatory fish, so some deviations in time of feeding in hand mode, associated with the "human factor" contributed to the aggressive behavior of fish, which reduced their viability and productivity.

Using an automatic adaptive feeder, it was possible to obtain by 71.7 kg and 37.6 kg more fish per 1 m³ of RAS during one production cycle than using the existing technology. It helps to make an additional clear profit from

the sale of products for 6,702 rubles 88 kopecks from 1 m³ of RAS in comparison with hand-feeding and 3,503 rubles 09 kopecks in comparison with automatic feeding without the adaptation system.

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