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Possibilities of Implementation of Polyculture for Optimization of Industrial Sturgeon Aquaculture on the Basis of Closed Water Supply Facilities.

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ABSTRACT

The aim of the research was to analyze the results of 10 months observations in laboratory conditions (as close to production as possible) on the basis of the operating experimental small-size module of closed water supply facility (CWSF) during industrial commercial rearing of sterlet and carp in monoculture and in conditions of joint maintenance (joint stocking, polyculture) in common reservoirs. An increase in the mass fraction of carp, associated with an increase in its individual mass and ichthyomass, during maintenance in the polyculture with sterlet in common reservoirs for maintenance of hydrobionts leads to inhibition of growth of the latter due to the aggravation of food competition between the objects.

Keywords: sterlet, carp, polyculture, closed water supply facilities (CWSF), hydrochemical regime, individual mass.

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INTRODUCTION

Implementation of the concept of a complex optimization of industrial aquaculture for field-valuable species of hydrobionts (primarily sturgeons and their hybrid forms) based on facilities with a closed cycle of water supply (CWSF) presupposes a wide range of possible engineering-technical (design) and technological (biotechnical) solutions that provide the most effective management of the fish industry [1-9].

Among the most promising directions in the realization of the concept of the complex optimization of industrial aquaculture of sturgeon on the basis of CWSF, where, according to the authors, it is necessary to conduct scientific research, are the following:

1. Study of the possibilities and further ways to optimize the conditions of the maintenance (including, in particular, the stocking density) of the object that ensure the maximum safety of females [10];

2. Development of the most optimal and adapted (with respect to the appropriate conditions of the maintenance) formulations and recipes for combined feed, as well as the study of the possibilities and ways of further optimization of the feeding regimes of the object [10, 11];

3. Study of the possibilities and ways of implementation of polyculture and mixed stocking into the technological production scheme [12].

Implementation of polyculture in the technological scheme of production on the basis of CWSF implies the possibility of simultaneous joint maintenance (joint stocking) within the same production area of two species of hydrobionts (as the main and additional objects).

Depending on the requirements for the conditions of the maintenance (water temperature, hydrological, hydrochemical and gas regimes) and some features of the biology of objects (primarily the food relations of the latter: predator-prey relationship; the nature of food needs and the level of tension of food competition between objects), in the discussed issue it would be perfectly permissible to consider both the variant of joint maintenance (joint stocking) of objects in common reservoirs, and the possibility of their spatial isolation (in individual reservoirs connected to each other, or within the same reservoir, divided into sectors by means of mesh partitions) [8, 13].

The aim of the research was to analyze the results of 10 months observations in laboratory conditions (as close to production as possible) on the basis of the operating experimental small-size module of CWSF during industrial commercial rearing of sterlet and carp in monoculture and in conditions of joint maintenance (joint stocking, polyculture) in common reservoirs.

METHODOLOGY OF RESEARCH

Characteristics of some conditions for the maintenance of objects during the study are presented in Table-1

During the study, control over the change in size-weight (linear-mass) characteristics, indices of viability (survival) of objects, and also water temperature and hydrochemical regimes was implemented.

The water temperature regime throughout the study was relatively stable and was within the physiological optimum (thermo-preferendum) both for sturgeon and carp. The temperature range was: 21.73°C average, with a minimum value of 17.00°C and a maximum value of 27.00°C.

Hydrochemical data in general make it possible to characterize the quality of the circulating water throughout the whole study as satisfactory, and it has in common with the corresponding information of some authors on the industrial commodity rearing of hydrobionts (in particular, sturgeon) on the basis of other operating systems of closed water supply (Table 2).

Nevertheless, for the hydrochemical regime a slightly alkaline reaction of the medium (pH) was typical during the entire study on the background of a relatively stable increase in the level of compounds containing

the ammonium group (NH_4^+/NH_3) and some fluctuations of the level of compounds including the nitro group (NO_2^- и NO_3^-).

Table 1: Conditions for the maintenance of research objects on the basis of CWSF in monoculture and in multicultural environment

Indicators		Characteristic
Base		operating experimental small-sized module of CWSF on the basis of the business incubator of KubSU (Krasnodar)
Water treatment node (purification of circulating water)	mechanical	sand-gravel high-pressure filter
	biological	biological purification filter, separated by incomplete partitions into compartments that make up the aerated and non-aerated (denitrification) sections
	antibacterial treatment and aeration	aerated distribution compartment of a biological filter with surface UV lamps; aeration in containers for maintenance of hydrobionts
Scheme of recirculation (water rotation)		all elements are assembled into a single ring of recirculation (water rotation), with an autonomous water supply and spillway of containers for maintenance of hydrobionts
Multiplicity of water rotation (per hour) in containers for maintenance of hydrobionts		1.0
Duration of the study, days		298
Object of study		sterlet (*Acipenser ruthenus*), carp (*Cyprinus carpio*)
Production combined feed (crude protein / crude fat)		Assortment Agro (Russia): “Carp growth” 38/9; “Sturgeon growth” 44/12. Aquarex (Russia): “Carp” 34/8; “Sturgeon”
Multiplicity of feeding, times per day.		10–12

Table 2: The quality of circulating water for some hydrochemical indicators in different sampling sites

Indicators of quality of circulating water	Sampling sites	
	At the output of the filter of biological treatment	Before entering the filter of biological treatment
NH_4^+/NH_3, mg/l (min–max)	0.30 (0.00–1.00)	0.63 (0.00–5.00)
NO_2^-, mg/l (min–max)	0.18 (0.00–0.75)	0.19 (0.00–0.75)
NO_3^-, mg/l (min–max)	11.81 (0.00–50.00)	13.62 (0.00–50.00)
pH, units (min–max)	7.97 (7.50–8.22)	7.97 (7.50–8.22)

Throughout the study, the objects in all variants of the experiments in the series were kept under conditions of relatively sparse stocking. So, the density of stocking (at the maintenance both in monoculture and under conditions of joint stocking (polyculture)) did not exceed: for starlet – 17.95 kg/m^2; for carp – 7.45 kg/m^2. The total ichthyomass of the objects per unit of fish-breeding area, while keeping in conditions of joint stocking (polyculture), did not exceed 19.70 kg/m^2.

During the study, the objects actually received mixtures consisting of specialized (sturgeon and carp) combined feeds, respectively, with different contents of the main components (first of all, crude protein and crude fat). Therefore, during each of the experiments in the series, the weight of the given daily feeds was summed, the total mass of the given crude protein and crude fat was determined, and the percentage of the corresponding components in the given mixture was calculated. Since the calculated daily values of the percentage of crude protein and crude fat were slightly (insignificantly) different, at the end of each of the experiments in the series the average values of the percentage of the corresponding components during the entire experiment were determined.

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The calculation of the indicators characterizing the efficiency of feed costs (the degree of useful utilization of mixed fodders) for the size-weight (linear-mass) growth of objects, in each of the experiments in the series was based on the total weight of the given mixtures of combined feed for the entire experiment. In those variants of the experiments in the series where the objects were kept in a joint stocking (polyculture) environment, taking into account the low selectivity in consuming the used mixed fodders (as was determined visually in a series of trial feedings) for both objects, a calculation of the corresponding indices was made based on the total gain of their ichthyomass for the entire time of each experiment.

RESULTS

A comparison of the indicators characterizing the survival of the objects revealed the superiority of the latter in those variants of the experiments in the series where the objects were kept under conditions of joint stocking (polyculture).

Some comparative results of industrial commodity rearing of objects on the basis of CWSF in monoculture and in conditions of joint stocking (polyculture) are presented in table 3.

Table 3: Some comparative results of industrial commodity rearing of sterlet (*Acipenser ruthenus*) and carp (*Cyprinus carpio*) on the basis of CWSF in monoculture and in conditions of joint maintenance (joint stocking, polyculture)

Features of the maintenance		monoculture		joint maintenance (joint stocking, polyculture)			
Duration of the study, days		108		73		105	
Object		carp	sterlet	carp	sterlet	carp	sterlet
Age category	at the beginning of the experiment	0+	3	0	3	1	3+
	at the end of the experiment	0+	3	1	3+	1	3+
Mortality per day, %		0.061	0.026	0.000	0.000	0.000	0.000
Average weight M±m, kg	initial	0.011 ±0.004	1.207 ±0.32	0.535 ±0.03	1.490 ±0.06	0.546 ±0.05	1.476 ±0.05
	final	0.333 ±0.005	1.491 ±0.11	0.640 ±0.02	1.571 ±0.07	1.000 ±0.07	1.429 ±0.05
Content of the main components in combined feed, %	crude protein	41.821	44.478	45.003		40.508	
	crude fat	10.709	14.083	12.001		10.028	
Coefficient of feed costs (C_{FC})		1.113	2.457	2.893		1.516	
Coefficient (index) of mass accumulation (C_M)		0.013	0.002	0.002	0.001	0.005	-0.0003

Note: 0+ – young fish of the current year; 1 – yearlings; 3 – three-year-olds; 3+ – four-year-olds.

As one of the possible causes of 100% survival of both sterlet and carp in the respective variants of the experiments one can assume an improvement in the sanitary state of the reservoirs due to the decrease in the remains of uneaten feed and possibly sturgeon excrement due to food utilization by carp, significantly exceeding sterlet on a spectrum of nutrition (due to omnivorousness) and to the level of the search activity connected with extraction of food.

In addition, it should be noted that for the rearing of sterlet during maintenance in monoculture, a mixture of fodders with a slightly larger total percentage of crude fat (14.083% at 44.478% crude protein) was used as for the groups maintained in conditions of joint stocking (polyculture) with carp (12.001% and 10.028% of crude fat at 45.003% and 40.508% of crude protein, respectively). The latter, in terms of CWSF, could also affect on the increase in mortality, increasing the risk of accumulation of excess fat in the body of the object, thereby contributing to the deterioration of its physiological state and the weakening of resistance to the possible negative influence of a number of environmental factors, taking into account the hydrochemical picture during the study, as well as the potential hazard of toxic effects of nitrogen-containing metabolites and their mineralization products (especially if they accumulate in recycled water) [6, 7, 12].

The main indicators characterizing the intensity of mass accumulation in carp maintained in monoculture were much higher than those for carp maintained in conditions of joint stocking (polyculture).

The intensity of mass accumulation in sterlet in all the variants of the experiments in the series differed insignificantly and was somewhat lower in those cases where the object was kept in conditions of joint stocking (polyculture) with carp.

It should be also noted that during maintenance in conditions of joint stocking (polyculture) the intensity of mass accumulation in sterlet was slightly higher in those variants of the experiments in the series, where the ichthyomass (and, correspondingly, the stocking density) of sterlet was 7-12 times higher than the corresponding values, determined for carp. At the same time, the average individual weight of sterlet in this group exceeded the average individual carp weight by 2-3 times. In those variations of the series, where ratios of ichthyomass (and stocking density) of sterlet and carp were about 1:1, some losses of the average individual weight of the sterlet were noted on the background of rapid growth of carp. If at the beginning of the experiment the average individual weight of sterlet was 3 times higher than the average individual carp weight, then by the end of the experiment this difference decreased almost twice.

Comparative analysis of the indicators characterizing the efficiency of feed costs for size-weight (linear-mass) growth, revealed a higher degree of useful utilization of feed for growth of the individual mass in experiments where the objects were kept in monoculture. In addition, during maintenance of the objects in the conditions of joint stocking (polyculture), there was also a slight decrease in the values of the feed cost factor (C_{FC}) for growth in objects in those groups where mixtures of combined feeds with a lower total percentage of crude fat were used (with some correction on the above-mentioned influence of the ratio of the values of ichthyomass and the density of stocking on the growth of objects in these groups), which in general agrees with the information on this issue, previously published by the authors [7].

CONCLUSION

As a result of the study, it was determined that the maintenance of sterlet and carp under conditions of joint stocking (polyculture) in common reservoirs for the maintenance of hydrobionts is accompanied by a decrease in mortality of both objects. An increase in the mass fraction of carp, associated with an increase in its individual weight and ichthyomass (and, correspondingly, the density of stocking per unit of production area), during maintenance in a joint stocking (polyculture) with sterlet in common reservoirs for maintenance of hydrobionts, leads to inhibition of growth of the latter due to the aggravation of food competition between the objects.

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