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CARP FISH REARING IN AUTOCHTHONOUS MIXED POLYCULTURE (*CYPRINUS CARPIO*, L., *ARISTICHTHYS NOBILIS* RICH. AND *CTENOPHARYNGODON IDELLA* VAL.)

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Abstract

NIKOLOVA, L., L. HADJINIKOLOVA, K. DOCHIN, D. TERZIYSKI, R. ATANASOVA, A. STOEVA, G. GROZEV and E. PASKALEVA, 2008. Carp fish rearing in autochthonous mixed polyculture (*Cyprinus carpio*, L., *Aristichthys nobilis* Rich. and *Ctenopharyngodon idella* Val.). *Bulg. J. Agric. Sci.,* 14: 139-144

For the needs of organic fish farming at the Institute of Fisheries and Aquaculture-Plovdiv, the levels of natural fish productivity of carp fish, reared in polyculture, based on a natural nutritive basis (an "autochthonous polyculture") have been investigated. The experiment has been carried out in five fish ponds with a total area of 1.47 ha (two fish ponds – with 3000 kg.ha^{-1} of organic manure applied), three fish ponds (no organic manure applied). Before supplying with water, 300 kg.ha^{-1} of quicklime has been applied, and during the vegetation period – an additional quantity of 150 kg.ha^{-1}. The quantity of the organic manure and quicklime used has been conformed to the requirements for organic fish farming. The polyculture structure has been the following: one-year old carp - 500 pcs.ha^{-1}; one-year old bighead carp - 300 pcs.ha^{-1} and two-years old grass carp - 100 pcs.ha^{-1}, with an average single fish weight (ASFW) in the fish-stocking of ponds, respectively – 0.071; 0.034 and 0.578 kg. During the vegetation period the quality of water has been within the technological standards. The ponds have ensured a good natural nutritive basis. From the experimental ponds max 645 kg.ha^{-1} of yield and 545 kg.ha^{-1} of gain have been obtained, when organic manure has been applied and max 537 kg.ha^{-1} of yield and 437 kg.ha^{-1} of gain, when no organic manure has been applied. The maximum carp gain has reached up to 241 kg.ha^{-1} (final ASFW of 0.555 kg); of the bighead carp – 200 kg.ha^{-1} (final ASFW of 0.699 kg); of the grass carp – 124 kg.ha^{-1} (final ASFW of 1.837 kg). At the conditions of the experiment, the two-summer old grass carp has exercised a reducing effect upon macrophytes growth.

Key words: organic fish farming; natural fish production; fish pond; organic manure; polyculture
Abbrevitions: ASFW – average single fish weight; K_{1+} - two-summer old carp; T_{1+} - two-summer old bighead carp; A_{2+} - three-summer old grass carp

Introduction

During organic aquaculture organization, it has been recommended to introduce the polyculture everywhere it has been possible. The polyculture has not been anything new for the European fish farming practice, however, the objective laws of polyculture fish breeding established at the higher levels of intensification

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have not always been valid at conditions approaching the intensive ones (Bondarenko, 1997).

The polyculture structure formation has been determined by the conditions in the fish-ponds. The inclusion of the grass carp has been explained by the level of ponds overgrowing and most of all by the degree of intensification of production. The fish of one species have been introduced by using extensive technologies, mainly. The grass carp has supported not only ponds melioration but the direct carp nutrition, as well (Bojadzhiev, 1970), and its influence has been connected with the age of the fish utilized.

For the needs of organic fish farming, we have set the purpose to make a complex investigation of ponds ecosystem and to establish the levels of fish productivity, when rearing fish in an autochthonous mixed polyculture (carp (*Cyprinus carpio* L.), bighead carp (*Aristichthys nobilis* Rich.) and grass carp (*Ctenopharyngodon idella* Val.)).

Materials and Methods

The investigation has been carried out at the Institute of Fisheries and Aquaculture-Plovdiv, within the framework of the project "Investigation of the Possibilities for Biological Production Introduction into the Warm Water Fish Farming at the Conditions of Bulgaria" (2004-2006), financed by the NCAS. For the purposes of the experiment, five carp ponds have been used, with a total area of 1.47 ha, divided into two groups: 1 group (two fish ponds) – in which organic manure has been applied (3000 kg.ha^{-1}of cattle manure); II group (three fish ponds) – in which no organic manure has been applied. Before flooding the experimental ponds from the two groups with water, 300 kg.ha^{-1} of quicklime each has been used. During the vegetation period, 150 kg.ha^{-1} have been additionally applied. The quantity of organic manure and quicklime applied has been in conformation with the requirements of organic fish farming standards.

For the purposes of the experiment, polyculture based on the natural nutritive basis of the pond has been formed – "autochthonous polyculture" (Privezencev, 1991). One and the same structure of autochthonous mixed polyculture has been used in all experimental ponds: one-year old carp - 500 pcs.ha^{-1}; one-year old bighead carp - 300 pcs.ha^{-1} and two-years old grass carp - 100 pcs.ha^{-1}. The average weight of the carp in the fish-stocking of ponds has been 0.071; of the bighead carp - 0.034 and of the grass carp - 0.578 kg.

In order to trace the ecosystem parameters of the experimental ponds during the vegetation period (May – October) investigations have been carried out upon the quality of the water and of the natural nutritive basis. The samples for the physical and chemical investigations of water have been taken once per week to measure: temperature (t^0C), oxygen dissolved in water (O_2, mg.l^{-1}; O_2,%) and through a 14 days' interval to determine: oxidability and biogenic elements level. The temperature and the oxygen dissolved in water have been measured by using a microprocessor oxymeter, OXI 96 type; the hydrogen index – by means of pH meter, MV 88 type; the permanganate oxidability – by using the analytical method (Bulgarian State Standard (BSS) – 3413-77); ammonium nitrogen (mg.l^{-1}) – spectrophotometrically by Nessler' reagent (BSS 3587-79, synchronized by ISO); nitrate nitrogen (mg.l^{-1}) spectrophotometrically; phosphate phosphorus (mg.l^{-1}) – spectrophotometrically by molybden reagent (BSS 7210-838). For investigating the sanitary and hygienic parameters of water samples have been taken once per month. The following has been recorded: the total microbial count (microbial number), by Koch' method; coliform test (by Ganchev' medium) – by using standard methods (Kapreljan et al., 1990). As regards the hydrobiological investigations, the samples have been taken through a 14 days' interval. The growth of phytoplankton and zooplankton has been determined by recording the numbers, biomass and the species composition: measuring of chlorophyll a colorimetrically at λ= 750-665 nm (ISO-1/1980; ISO-5667-2/1991); benthos – by determining the total biomass; ponds overgrowing – in % of the total area.

In order to determine the fish health status at the moment of fish-stocking during the vegetation period and during fishing, prophylactic check-ups have been

done, by using methods, generally accepted in ichthyopathology. At the end of the vegetation period, the main fish productive indices have been reported by using routine for the fish farming methods.

Results and Discussion

Table 1 presents the parameters characterizing experimental ponds ecosystem during the vegetation period. The water qualitative indices, in general, have been within the technological standards and have ensured a favorable medium for fish farming. As regards water supply with biogenic elements it can be seen that the level of phosphorus in the experimental ponds has been below the optimum. The ratio between the biogenes has been close to the optimum but this has been due to the lower level of phosphates.

The sanitary and hygienic parameters have shown that the water in the ponds has a high quality and corresponds to the requirements for the quality of water used for fish farming. In the ponds, in which organic manure has been applied, the total microorganisms count has varied within 700 and 370 000 cm^{-3}, and in the ponds, in which no organic manure has been applied – 700–200 000 cm^{-3}. The values of water coliform test have varied within 1 and 0.01, and coliform test increase of 0.001 has been registered only once, in one of the ponds, at the end of the vegetation. The phytoplankton growth has established favorable trophic conditions for the zooplankton organ-

Table 1

Physical and chemical, sanitary and hygienic and hydro-biological parameters of experimental ponds (average seasonal values; coliform test limiting values)

Parameters	Ponds, №				
	Manured		Without manure		
	1	2	3	4	5
Pond area, ha	0.26	0.38	0.18	0.38	0.27
Physicochemical and sanitary-hygienic qualities of water					
Temperature, °C	21.2	21.7	21	21.8	20.9
O_2, $mg.l^{-1}$	8.15	9.25	6.27	8.95	9.25
O_2, %	90	102	69	100	104
pH	8.12	8.35	7.85	8.46	8.1
$N(NH_4)$`, $mg.l^{-1}$	0.09	0.125	0.05	0.145	0.062
$N(NO_3)$`, $mg.l^{-1}$	1.81	2.24	1.23	2.17	1.55
N-total, $mg.l^{-1}$	1.897	2.361	1.276	2.311	1.615
NH_3, $mg.l^{-1}$	0.06	0.015	0.002	0.016	0.006
$P\text{-}PO_4$ $mg.l^{-1}$	0.328	0.262	0.208	0.236	0.227
Oxidability, $mg.l^{-1}$	13.42	11.4	10.54	18.24	11.98
Total number of microorganisms, cm^{-3}	116100	62333	7900	4118	63616
Coli-titer, cm^{-3}	0.001-1			0.01-1	
Hydro-biological parameters					
Phytoplankton, $mg.l^{-1}$	1.585	1.109	1.097	1.355	1.213
Chlorophyll a, $mg.l^{-1}$	145.51	109.28	53.15	190.02	93.34
Zooplankton, $g.m^{-3}$	2.606	0.843	0.84	1.175	0.913
Zoobentos, $g.m^{-2}$	44.16	22.96	31.2	11.6	11.4
Macrophyte, % of pond area	1	1	29	0	13

isms and the fish species bred, the green algae having grown predominantly. The average seasonal biomass in the ponds has varied within 1.097 mg.1^{-1} and 1.585 mg.1^{-1}, having in mind that in the ponds where organic manure has been applied it has been at an average of 10% higher as compared to the ponds with no organic manure. Concerning chlorophyll a content in the phytoplankton, the difference between the two groups has been preserved at a similar (13.5%) level.

During the vegetation period, 35 species of zooplankton have been recorded in total, of which 19 species of Rotatoria, 12 species of Cladocera and 4 forms of Copepoda. From May till the beginning of July it has been the Copepoda and Cladocera that predominated, which has determined the higher biomass during that period. During the next summer months the biomass in most of the ponds has been below 1 g.m^{-3}, which has been a result of zooplankters predominance from the group of Rotatoria. No stable difference has been observed of the index between the ponds of the two groups. In general, the ponds rank as regards the average seasonal growth of zooplankton coincides with the rank s regards the growth of phytoplankton. The difference as regards the most productive ponds from the two groups has been more than two times higher in favor of the ponds, in which organic manure has been applied. As a whole, the average seasonal biomass of zooplankton has been by 76.7% higher in the ponds, in which organic manure has been applied, as compared to the ponds without organic manure application.

The species composition of zoobentos in the ponds studied has been predominantly hyronomidic, olygochetes being observed in separate samples only. All experimental ponds have shown a very high supply with bentos organisms at the beginning of summer (May – June), which ensure a good nutritive basis for the carp at the beginning of the vegetation period. The difference according to this index between the ponds from the two groups has been 85.6% in favor of the ponds with organic manure application.

During the period of the experiment, different species of submerged and semi-submerged vegetation have grown (*Trapa natans*, *Lemna minor*, *Potamogeton* sp., *Ceratophyllum demersum*, *Mougeotia* sp., *Typha* sp., *Sparganium erectum*, etc.). The degree of ponds overgrowing has varied within wide limits, from completely clean ponds and ponds having an insufficient waterside hard vegetation, to ponds with significant sections of water vegetation during separate vegetation periods.

At the experimental conditions, the fish have been in a good health condition, with a high percent of vitality. The limit values obtained for the total fish productivity at the experimental conditions have been presented on Table 2. The total fish gain (kg.ha^{-1}) in the experimental ponds has varied within 325 kg to 545 kg. The results obtained have been close to the indicated by Kourzhil and Adamek (2003) average levels of freshwater fish productivity – 450 kg.ha^{-1}, registered in Czechia at extensive and semi-extensive conditions.The highest and the lowest levels have been observed in organic manure ponds. The levels of the total fish gain in the ponds without organic manure has been from 410 to 437 kg.ha^{-1}. The difference between the maximum increase levels among the separate groups has amounted to 19.8%.

The carp gain has reached 241 kg.ha^{-1} (at the highest fish weight at the end of the vegetation period). The difference between the best of the ponds with no organic manure application and the best of the ponds with organic manure application has been 26.6% in favor of the latter. The bighead carp gain has been 200 kg.ha^{-1} at a final ASFW of 0.699 kg. The organic manure application has affected positively upon the growth of the fish of this species. The difference between the groups as regards the increase maximum levels has amounted to 23.5%. The highest gain of the grass carp in the ponds with total fish productivity limit values has amounted to 101 kg.ha^{-1} at a final ASFW of 1.756 kg. The maximum increase levels have been reached in the pond with average fish productive levels of 124 kg.ha^{-1} (with a final ASFW of 1.837 kg). At experimental conditions, the two-summer old grass carp has influenced considerably upon the pond overgrowing. The greater part of the experimental ponds in the basis has been apt to overgrowing. In the technological diagrams applied, at the

Table 2

Limits of total fish productivity in growing one-year old carp and bighead carp and two-years old grass carp in polyculture, based on a natural nutritive basis

Parameters	Manured		Without manure	
	Ponds, № ***			
	1*	2**	3*	4**
Yield, kg.ha^{-1}				
Total (Without *C. gibelio*)	626	402	515	495
Total	645	428	537	516
K_{1+}	278	157	212	224
T_{1+}	210	164	147	162
A_{2+}	138	81	156	109
Carassius gibelio	19	26	22	21
Gain, kg.ha^{-1}				
Total (Without *C. gibelio*)	526	299	415	389
Total	545	325	437	410
K_{1+}	241	124	177	188
T_{1+}	200	153	137	153
A_2+	85	22	101	48
Carassius gibelio	19	26	22	21
Final Weight, kg				
K_{1+}	0.555	0.318	0.439	0.475
T_{1+}	0.699	0.548	0.491	0.539
A_{2+}	1.385	0.808	1.756	1.122
Survival, %				
K_{1+}	100	98.9	96.7	94.2
T_{1+}	100	100	100	100
A_{2+}	100	100	88.9	97.4

* The maximum total fish yield and gain

** The minimum total fish yield and gain

*** It corresponds to the enumeration in Table 1

beginning of the vegetation period, the overgrowing has been at its usual levels but still at the beginning of June, the ponds, in practice, have got rid of the vegetation, in a period when the maximum development of macrophytes can be observed.

Conclusion

The quality of the water and the natural nutritive basis in the experimental ponds can ensure good conditions for the fish species grown. When growing one-year old carp and bighead carp and two-year old grass carp in polyculture, based on a natural nutritive basis only, an yield of 645 kg.ha^{-1} and an gain of 545 kg.ha^{-1} can be obtained, when applying organic manure and up to an yield of 537 kg.ha^{-1} and an gain of 437 kg.ha^{-1} without organic manure application. The maximum carp gain has reached 241 kg.ha^{-1} (final ASFW of 0.555 kg); the bighead carp – 200 kg.ha^{-1} (final ASFW of 0.699 kg); the grass carp – 124 kg.ha^{-1}

(final ASFW of 1.837 kg). At the experimental conditions, the two-summer old grass carp has exerted a reducing effect upon macrophytes growth.

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