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SOME PARAMETERS OF THE FISHPONDS ECOSYSTEM FOR REARING CARP IN AUTOCHTHONOUS MONOCULTURE

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Abstract

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The study was conducted at the Institute of Fisheries and Aquaculture- Plovdiv. Two groups of the ponds with different structure of fish stocking were set: I group: K_1 - 500 pcs.ha^{-1}; K_0 - 15 000 pcs.ha^{-1}; II group: K_1 - 500 pcs.ha^{-1}; K_0 - 30 000 pcs. ha^{-1}. In all ponds fish was reared in autochthonous (based only on developing in ponds natural food) mixed monoculture. To stimulate the development of natural food base in all ponds in the beginning of the vegetation period was applied cattle manure in quantity 3 000 kg.ha^{-1}. In addition, 450 kg.ha^{-1} of quicklime was used. Quantities of used fertilizer and lime complied with the requirements of organic aquaculture standards. Throughout the entire vegetation period was carried out monitoring hydrochemical, hydrophysical, hydrobiological parameters of the experimental ponds. In this study the chlorophyll-a was not credible indicator for phytoplankton biomass. Macrophyte density is a factor influencing not only the different parameters of aquatic ecosystem, but affecting the nature of interactions between them and therefore should be definitely considered in aquatic ecosystems research. Considering only average macrophytes density levels is not enough, as in similar average macrophytes density levels the impact of the developed macrophytes is changing depending on different development trends over time, and reached maximum macrophyte density levels in the pond.

Key words: aquatic ecosystems; organic fish farming; natural fish food, hydrobiological parameters

*Abbreviation*s: K_0- 0-**year old** carp; K_1 – one-**year old** carp; Pr-water column transparency; Bf- phytoplankton biomass; Bz – zooplankton biomass; Bb-zoobenthos biomass; Hl- content of chlorophyll-a in the phytoplankton; Om- **macrophyte density level**

Introduction

Currently, the scientific research in Europe is focused on improving the efficiency of production systems and the quality of produced fish by achieving higher levels of environmental consistency (Varadi et al., 2010). In this regard, the Common Strategy for Sustainable Development of European Aquaculture has emphasized the importance of pond fish farming (Varadi, 2009). Extensive pond fish aquaculture corresponds to the greatest degree with the requirement for environmental consistency (IFOAM/IAMB, 2010). Extensive carp farming is ideal for organizing organic production. Currently in Bulgaria, there is an acute shortage of scientific research concerning the issues extensive and low-intensity hydrobionts farming in general and organic aquaculture in particular. However, many important conditions are available for development of organic aquaculture in our country. Organizing a well-functioning fish farming ecosystem is a complex task. The main concern, especially in organizing organic production is to provide optimal environmental conditions consistent with the biological and physiological needs of fish (Kovacheva et al., 1995; Marković et al., 2009; Talbot, 1993, etc.). The nature of the complex mechanisms occurring in aquatic ecosystems requires sufficient knowledge necessary for technology development. In this regard, our goal is to investigate some parameters of the ecosystem of the fish pond and relationships between them, rearing common carp in mixed autochthonous monoculture.

Material and Methods

The study was conducted at the Fisheries and Aquaculture Institute – Plovdiv, within the research task "Study of the Pro-

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ductive Qualities of Common Carp Fingerlings Rearing in a Low Degree of Production Intensification", included in a research project funded by the Bulgarian Agricultural Academy. Five carp ponds with a total area of 1.8 ha were used. The ponds were stocked in the first decade of June. Two groups with different structure of fish stocking were set: I group (I/1; I/2; I/3): K_1 – 500 pcs.ha^{-1}; K_0 – 15 000 pcs.ha^{-1}; II group (II/1; II/2): K_1 – 500 pcs.ha^{-1}; K_0 – 30 000 pcs.ha^{-1}. In all ponds fish was reared in autochthonous (based only on developing in ponds natural food) mixed monoculture. To stimulate the development of natural food base in all ponds in the beginning of the vegetation period was applied cattle manure in quantity 3 000 kg.ha^{-1}. In addition, 300 kg.ha^{-1} of quicklime was used, and during the vegetation period additional 150 kg.ha^{-1}. Quantities of used fertilizer and lime were in compliance with the requirements of organic aquaculture standards.

Throughout the vegetation period (from the first decade of June to late September) was carried out monitoring hydrochemical, hydrophysical, hydrobiological parameters of the experimental ponds. Water sampling for physicochemical tests was performed once a week, and the hydrobiological sampling – in 14-day intervals. Routine methods were applied for the study: water column transparency of was measured with Secchi disk (cm); phytoplankton biomass (mg.l^{-1}) – according to Laugaste (1974); zooplankton biomass (g.m^{-3}) – according to size-weight Prikryl method (1980); content of chlorophyll-a in the phytoplankton (μg.l^{-1}) – colorimetrically at λ 750-665 nm (ISO-1/1980; ISO-5667-2/1991).; zoobenthos biomass (g.m^{-2}) – according to Zhadin (1956). The **macrophyte** density level is determined visually in % of the pond area. To establish links between the studied parameters were calculated Spearman rank correlations (r_s) and their levels of **significance** (Lakin, 1990).

Results and Discussion

Our study shows that fishponds are complex ecosystems in which are present considerable dynamics of the environmental parameters within the season, and between the separate ponds for the same period (Table 1; Figure 1).

Average water temperature values ranged between 22 and 23°C, as there is no significant difference in this indicator between separate ponds. The same applies to the water pH. Differences that are more significant are found in the content of oxygen, as the lower average values are recorded in ponds with higher levels of macrophyte density. Aquatic plants affect the ecosystem of the water reservoirs (Dudley et al., 2001;

Table 1
Average, minimum and maximum values of the separate parameters in experimental ponds

Parameters		Group / pond				
		I / 1	I / 2	I / 3	II / 1	II / 2
Temperature, ° C	min	14.00	14.80	15.00	14.90	13.80
	max	27.10	27.80	27.50	27.40	27.20
	average	22.50	23.00	23.00	22.00	22.50
pH	min	7.37	7.71	7.76	7.56	7.61
	max	8.29	8.44	8.55	8.22	8.03
	average	7.69	8.03	8.16	7.87	7.89
O_2, mg.l^{-1}	min	2.00	4.40	6.60	3.60	3.40
	max	7.70	14.50	14.30	12.10	10.90
	average	4.30	8.90	10.00	8.60	6.90
Om, %	min	2	1	1	0	30
	max	100	45	16	20	50
	average	47.0	17.7	7.1	7.2	41.7
Pr, cm	min	35	15	19	12	31
	max	70	70	70	70	70
	average	44.90	30.40	32.0	26.30	44.20
Bf, mg. l^{-1}	min	0.033	0.111	0.152	0.082	0.069
	max	1.068	1.192	4.048	1.268	0.876
	average	0.311	0.659	1.497	0.688	0.387
Hl, μg.l^{-1}	min	2.31	10.88	17.76	11.10	6.30
	max	65.03	303.40	229.40	82.22	38.06
	average	22.39	77.09	100.85	34.07	21.11
Bz, g.m^{-3}	min	0.012	0.140	0.015	0.025	0.019
	max	6.177	4.655	1.253	5.624	2.224
	average	2.825	1.426	0.359	2.034	0.410
Bb, g.m-^{2}	min	0	0	0	0	0
	max	3.56	4.2	19.84	26.12	6.56
	average	1.10	1.10	2.60	8.05	2.40

Abdel-Tawwab, 2006, etc.). In our study, in terms of impact on the macrophyte density level on studied parameters the results are not unambiguous. For all the ponds, we established a negative correlation between Om/Pr and Om/Bz. In four of the five studied ponds the Om/Bb relation is negative (as two ponds it is significant), and positive Om/Bf and Om/Hl (Table 2).

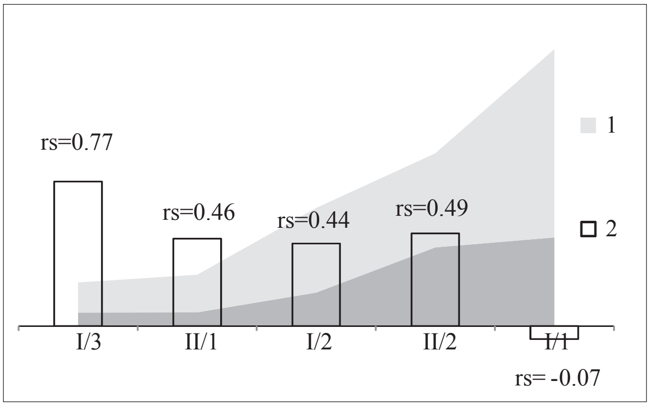

Fig. 2. Rank correlations between average levels of the overgrowing for the period and the phytoplankton biomass (1. maximum overgrowing levels in each pond; 2. average levels for all period)

The analysis of the results of different groups and ponds shows that the Group I in the pond with the highest level of development of aquatic macrophytes (I/1) is where the average vegetation reached 47% of the maximum 100% at the end of vegetation period. The **macrophyte** density levels influenced negatively all studied parameters (Table 2), as the most considerable impact is established on Bb and Bz, while for Bf this ratio is low. Such credible negative impact of increased level of **macrophyte** density on the level of chlorophyll and the amount of phyto- and zooplankton was established by Abdel-Tawwab (2006). Petr (2000), explaining the complex relations between aquatic plants and different groups of organisms in water reservoirs, noted that aquatic macrophytes provide refuge for zooplankton and thus larger zooplankters control small phytoplankton, preventing negative changes in the structure of phytoplankton communities. The author indicates that macrophytes are useful for benthic organisms by providing protection from animals that eat them on one hand and, and on the second, providing the benthos with organic matter.

Our study established negative effects of **macrophyte** density on the benthos, which is preserved in ponds with both more significantly and less developed macrophytes. In pond I/2, with average Om of 17.7%, where maximum levels have

Table 2
Rank Correlation coefficients (r_s)

Variable	Group/pond	Bf	Hl	Bz	Bb	Om
Pr	I/1	0.05	-0.23	0.67	0.66	-0.67
	I/2	-0.14	-0.46	0.09	0.12	-0.04
	I/3	-0.93**	-0.87**	0.19	0.32	-0.78*
	II/1	-0.62	-0.27	-0.38	0.02	-0.45
	II/2	-0.69*	0.12	0.35	0.13	-0.35
Bf	I/1		0.45	0.29	0.12	-0.07
	I/2		0.22	-0.69	-0.08	0.44
	I/3		0.90**	-0.05	0.25	0.77*
	II/1		0.13	0	-0.35	0.46
	II/2		0.12	0.09	-0.08	0.49
Hl	I/1			0.31	0.18	-0.09
	I/2			0.36	-0.47	0.38
	I/3			-0.26	0.25	0.87**
	II/1			-0.14	0.13	0.20
	II/2			0.31	0.07	0.32
Bz	I/1				0.66	-0.77*
	I/2				0	-0.38
	I/3				0.78*	-0.17
	II/1				0.63	-0.53
	II/2				0.74*	-0.53
Bb	I/1					-0.63
	I/2					-0.72*
	I/3					0.08
	II/1					-0.79*
	II/2					-0.61

* - (P<0.05); **- (P<0.01)

not exceeded 45% relations Om/Bf and Om/Hl are positive, while Om/Bb are highly negative (Table 2). When vegetation is poorly developed (I/3), and maximum levels do not exceed 16%, it has a significant positive impact on phytoplankton communities, as it is especially highlighted in regard with chlorophyll-a. In pond I/3 relations between Om and Pr is negative, an interesting thing in this case is the relation between transparency and the phytoplankton development, suggesting that the lowest water transparency is determined by the phytoplankton development.

Examining the relation between the chlorophyll-a content in phytoplankton biomass and its mass, Marisol and Catalan (2000) found a correlation ratio equal to 0.66, indicating that the relation between the parameters has changed both within seasons and depending on the taxonomic composition of phytoplankton. Diana et al. (1991) in their study established a close relationship (r = - 0.82) between Secchi transparency and the amount of chlorophyll-a in phytoplankton, and therefore consider transparency for reliable enough indicator for chlorophyll presence. In our study, however, in only one pond the Pr/Hl relation is significant.

In the Group II ponds, pond II/2 stands out with higher **macrophyte** density levels stands, but unlike the pond I/1, which has similar average Om, there are significant amounts of macrophytes recorded from beginning to end of the season, with peak values of the indicator not exceeding 50%. Comparing the two ponds, it appears that unlike the pond I/1, II/2 established a positive correlation Om/Bf and Om/Hl, as regarding the development of zooplankton and zoobenthos, the relation remains negative. Significant negative relationship between the measured depths according to Secchi and Bf is established in the pond. On the contrary, the dependence of the measured Secchi depth is positively associated with the Bz. Our results indicate that **macrophyte** density is a factor influencing on one hand various indicators of fish pond ecosystem, and on the other hand, has an impact on the nature of interactions between other environmental factors, such as the impact of **macrophyte** density is not unambiguous, but changes its strength and direction depending on the nature of the macrophytes development.

Macrophytes are an important part of water bodies (Bamidele and Nyamali, 2008) and affect the completely aquatic ecosystem (Dudley et al., 2001; Abdel-Tawwab, 2006, etc.). Petr (2000) noted that aquatic plants could have both positive and negative effects. Aquatic plants directly affect the water reservoir through the water saturation with oxygen and conversion of poisonous ammonia into useful nitrate; indirectly through the implementation of recirculation of nutrients, facilitating relations between water and air, thereby affecting the benthos and plankton, and hence fish.

Figure 2 shows change in the nature of the impact of macrophytes on the food base zooplankters, which in turn provide food for common carp in autochthonous monoculture. Usually, in terms of **macrophyte** density, the recommendations are limited to not exceeding certain levels of macrophytes in the pond, but our study demonstrated that in addition to observing average **macrophyte** density levels, the dynamics of macrophytes development should also be considered.

In ponds with similar average for vegetation period aquatic macrophyte density levels, but with registered different seasonal dynamics, the relation between the Om and the phytoplankton development differ not only in strength but also on the direction: - At high Om from the outset (II/2): Om/Bf - $r_s = 0.492$; Om/Hl - $r_s = 0.317$; - Late in the season development of pond overgrowing (I/1): Om/Bf - $r_s = - 0.067$; Om/Hl - $r_s = - 0.092$. In ponds with lower Om (less than 50 % vegetation density by aquatic macrophytes), this factor does not affect negatively the phytoplankton development. On the contrary, the relation is positive. The higher the level of **macrophyte** density is, the lower is water transparency, but if for ponds with lower **macrophyte** density it is connected to the positive effect of macrophytes on the phytoplankton growth, for considerably overgrown ponds the reduced water transparency is not associated with better phytoplankton development, but with other factors not included in this analysis.

In ponds with higher Om (up to 100% of the area covered with macrophytes), this factor affects negatively all studied indicators forming the nutritional basis of common carp. Relation Pr/Bf and Pr/Hl for the pond with higher Om (I/1) (average – 47%; max – 100%) is weaker compared to the pond with a lower Om (I/2 – average – 17.7%; max – 45%) where the relevant coefficients of correlation are rs = - 0.138 and rs = - 0.463.

The relationship between the Bf and Bz is also associated with the macrophytes level in ponds. So in a very overgrown ponds the relation between phytoplankton and zooplankton biomass was positive, while in less developed it is negative (Table 2). With the exception of the pond I/2 in all other ponds was established positive correlation between Bb and Bz, as in the pond I/3 the correlation is significant. The established relation from on one hand could be associated with a unilateral response to zooplankton and zoobenthos communities of the factors influencing them and the other it could be result of nutrient interactions carp -zooplankton and carp-zoobenthos. In this regard, of interest would be a study of the relations between these parameters and the biomass of fish that is reared in the ponds.

Conclusions

Fishponds are complex ecosystems in which are present considerable dynamics of the environmental parameters both

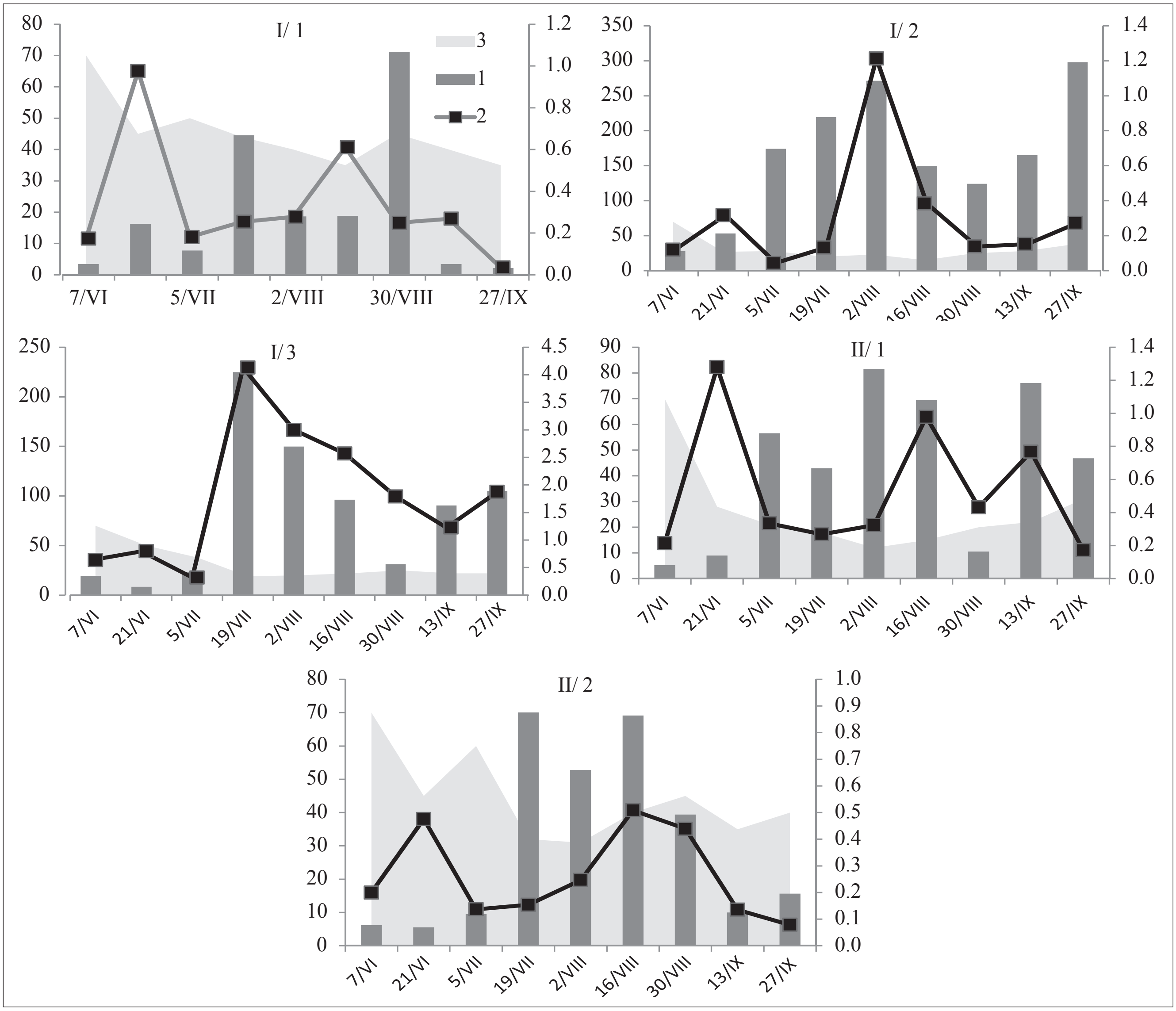

Fig. 1. Dynamics of the phytoplankton biomass (1) , chlorophyll-a (2) and the water column transparency (3) in the experimental ponds (I/1;I/2;I/3;II/1;II/2)

within the vegetation season, and between the separate ponds in the same period. In our study the chlorophyll-a was not credible indicator for phytoplankton biomass. Macrophyte density is a factor impacting not only the different parameters of aquatic ecosystem, but affecting the nature of interactions between them and therefore should be definitely considered in aquatic ecosystems research. The impact of macrophytes density factor changes its strength and direction in ponds with different nature of macrophytes development during the vegetation period. Considering only average macrophytes density levels is not enough, as in similar average macrophytes density levels the impact of the developed macrophytes is changing depending on different development trends over time, and reached maximum macrophyte density levels in the pond.

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