MELIORATIVE EFFECT OF GRASS CARP (*CTENOPHARYNGODON IDELLA*) IN CONTROLLING AQUATIC MACROPHYTES IN THE TISZA VALLEY

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*Maletin, S., Djukić, N., Stojanović, S., Ivanc, A., Žderić, M., Matić, A., Andrić, B., Radak, Lj. and Miljanović, B. (1994): Meliorative effect of grass carp (**Ctenopharyngodon idella**) in controlling aquatic macrophytes in the Tisza valley. - Tiscia 28, 41-45.*

Abstract. Effect of biomanipulation with grass carp monoculture was studied to suppress macrophytes overgrowth under controlled conditions during vegetation period of 1993. The experiment was performed in two separate basins of 0.15 ha each. A hundred specimens of 3-5 years of age and approximately 4 kg individual body weight on the average were stocked in each basin. A favourable meliorative effect coinciding with a significant increase in ichthyomass and satisfactory condition and general physiological status of fish was obtained when abundance and coverage of aquatic (*Polygonum amphibium* and *Spirodela polyrrhyza*) and semiaquatic vegetation (*Phragmites australis, Typha latifolia* and *T. angustifolia*) varied and supplementary feeding with fresh biomass of *Ceratophyllum demersum* (95%) and *Potamogeton pusillus* (5%) was regularly supplied. Also, selection in nourishment taking into consideration the presence of stands of various phytocenoses was evident.

Keywords: herbivorous fish, aquatic weeds, biomanipulation, food selection.

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Introduction

The control of macrophyte overabundance by biomanipulation with grass carp in an extended part of its distribution area has shown great meliorative potential of this exotic herbivorous fish. In many situations, the grass carp offers a very attractive alternative weed control in comparison to mechanical removal, herbicide application or water level manipulation. Also, the control of overgrowth of aquatic vegetation by grass carp introducing is less expensive and lasts considerably longer than other methods (Rotman, 1977; van Zoon, 1979). In that way, detrimental effects of an excessive primary production on navigation, drainage, recreation, and other purposes of water bodies may be efficiently made less (Opuszynski, 1972, 1979; van Zoon, 1974, 1977). Due to a favourable stock of grass carp, beside other facts mentioned above, an outcome is also the conversion of nonutilized portion of macrophyte production into highly edible proteins (van Zoon, 1977, 1982).

Efficiency of biomanipulation by fish community in process of suppression the development of primary and partly of secondary production has been discussed recently. Mestrov et al. (1972) reviewed that not only phytophagous fish can wholly solve the problem of lake sanation, but, also mechanical elimination of sediment is necessary. In the past decade there was a great number of papers dealing with this hypothesis and positive and negative arguments on the possibilities of biomanipulation in regulation of water, namely, most frequent lake ecosystems (Carpenter et al., 1985; Zalewski et al., 1990; Brönmark and Weisner, 1992; De Melo et al., 1992; Carpenter and Kitchell, 1992). In this paper therefore the results on the efficiency of meliorative role of grass carp in controlling aquatic weeds are presented from the valley of lower part of river Tisza.

Methods

The experiment was performed in two separate basins of a 0.15 ha each to evaluate the efficiency of the meliorative effect of grass carp upon the control of number, coverage and diversity of aquatic vegetation. The stock included 100 specimens for each of average individual weight of 4 kg and of 3-5 years of age.

Phytocenological investigations of the aquatic macrophytes were performed by the method of Braun-Blanquet. Plant names were presented according to Flora Srbije (Josifovic, 1970-1986), while only certain cases after Soó (1964-1985).

Also, length and body weight growth, intensity and preference in relation to diet, as well as condition status according to the fattening coefficient.

General physiological status of fish was estimated on the basis of the hematological status. Number of erythrocytes and leukocytes were counted in haemocytometer, according to Kekic and Ivanc (1982). Hemoglobin concentration was estimated using haemoglobincyanide method, and hematocrit was determined by micromethod. From those values mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were calculated. Differential blood count was determined on blood smears stained by Pappenheim method (Heckner, 1975).

In addition to the biological investigations, also abiotic factors, such as temperature, pH and oxygen regime were measured.

Results and discussion

On June 3 at the beginning of the experiment, the experimental units A and B were overgrown with macrophyte to various extent. Dominants of the basin A were *Typha latifolia* and *Polygonum lapatifolium*, while *Phragmites austrális, Typha latifolia, Typha angustifolia* and *Polygonum amphibium* of the basin B. Also, *Spirodela polyrrhyza* was observed in either unit. Total covering in the basin A was 30-40 %, and in basin B 80 %, respectively.

In such conditions, grass carp specimens of total ichthyomass of 400 kg were stocked. In June, total coverage was reduced by approximately 10 %. At the same time, varying overgrowth of macrophytes affected variation of growth rate of total fish weight (Tab. 1).

Table 1. Body weight and length growth and coefficients of fattening.

Date	m	l	Q_F	Q_C
Basin A				
3.6.	400	612	1.74	1.57
18.6.	433	617	1.84	1.66
1.7.	430	624	1.77	1.61
16.7.	486	637	1.88	1.67
3.8.	469	638	1.80	1.64
18.8.	452	657	1.59	1.29
16.9.	446	657	1.57	1.41
Basin B				
3.6.	400	611	1.75	1.59
18.6.	509	641	1.93	1.74
1.7.	550	663	1.89	1.71
16.7.	690	663	2.36	2.01
3.8.	650	682	2.05	1.73
18.8.	620	687	1.91	1.76
16.9.	581	704	1.66	1.50

m = total fish biomass (kg); l = individual standard length (mm); coefficients of fattenig: Q_F = Fulton index; Q_C = Clark index.

After first two weeks total weight of stocked fish in the basins A and B were 433 and 509 kg, respectively. Such a variation was primarily due to larger resource in the basin B. The fattening coefficient in this period was found to increase in both fish groups pointing to optimum diet in the first third of the experiment.

In the following months, after a period of adaptation, grass carp diet was even more intensive affecting total ichthyomass. After four weeks, this difference amounted to 120 kg. In both basins, a drastic reduction in overgrowth was observed, namely in July only the macrophyte *Polygonum lapatifolium* was recorded in the basin A while total coverage in basin B was 40-50 % where *Phragmites australis* and species of the genus *Typha* dominated. Therefore, in July 1, fresh plant material consisting of *Ceratophyllum demersum* (95 %) and *Potamogeton pusillus* (5 %) was added in three equal portions (total of 10 kg) per experimental unit. In the next days, offered quantity of added fresh biomass of aquatic plants became greater and varied in relation to its consumption (Tab. 2). In July, grass carp in the basin A and basin B consumed 955 and 435 kg additional biomass of plant food, respectively. Such a difference was due to different supply of original components. In that period total ichthyomass again increased up to 486 (basin A) and 690 (basin B). Also, an increase was recorded in fattening, in particular in specimens from the area B. These coefficients reached the maximum in the middle of July, in both fish groups.

Table 2. Daily dynamics of consumption of additional fresh microphytes biomass (kg).

	July		August	
Day	A	B	A	B
1	-	-	55	30
2	-	-	55	-
3	10	10	55	35
4	-	-	55	35
5	-	-	55	-
6	-	-	55	-
7	-	-	58	30
8	-	-	55	-
9	20	-	50	20
10	25		55	-
11	-	-	55	-
12	15	15	-	30
13	20	20	55	-
14	50	-	50	20
15	-	-	60	-
16	30	30	55	15
17	40	40	45	-
18	-	-	45	30
19	30	30	45	-
20	30	30	45	-
21	30	50		
22	50	50		
23	110	30		
24	150	-		
25	110	30		
26	60	50		
27	60	-		
28	-	50		
29	60	-		
30	55	-		
Totoal	955	435	903	215

Similar situation was observed in August, namely the presence of *Polygonum lapatifolium* was recorded in basin A while addition of a portion containing *Ceratophyllum* and *Potamogeton* together with daily control continued up to 20 August. Total coverage in basin B was reduced to 35 % where species observed in July dominated. Total plant weight of macrophytes was reduced to app. 10 % in basin B until the end of experiment. The mass was composed of *Phragmites australis* and dried *Typha latifolia* and *T. angustifolia* specimens. Also in this case, greater consumption was recorded in basin A (903 kg) than in basin B (215 kg). Total amount of available food, in particular that originated from the experimental units, however, was reduced considerably resulting in ichthyomass decrease. Therefore, in the middle of August, total fish mass was 452 kg and 620 kg in basins A and B, respectively. Biomass decrease reflected also in reduced values of fattening coefficient approaching the initial status.

At the end of the experiment on 16 September when the addition of fresh mass of aquatic plants was stopped and when poverty of vegetation was evident, again decrease in total ichthyomass to 446 kg (basin A) and 581 kg (basin B) were recorded due to starvation.

In the study of meliorative effect of grass carp upon the control of excessive growth of macrophyte vegetation, particular attention has been paid to the preference to individual plant species. Permanent presence of *Polygonum* species was recorded characterized by stable numbers and coverage during entire experiment. The analysis of the intestinal content of grass carp showed certain selectivity in diet under the given conditions. Analyzed specimens were found to consume additional fresh plants (*Ceratophyllum* and *Potamogeton*) only when all the original vegetation available, primarily *Typha* species, were consumed.

General physiological condition of fish was followed on the basis of hematological status fortnightly during the entire experiment. The results obtained show that the number of erythrocytes, hemoglobin concentration, hematocrit, MCV, MCH, MCHC, leukocyte count and differential blood count of grass carp ranged within expected values (Ivanova, 1983) in both experimental areas (Tab. 3 and 4). Decreased values of erythrocyte count recorded in basin A at the end of the experiment, however, were primarily the result of meager diet in that period. Fluctuation in the number of leukocytes which resulted in high standard deviation should be explained by a normal seasonal changes noted also in other fish species (Ivanc et al., 1985).

Table 3. Erythrogram of grass carp under different nutritional conditions (mean and standard deviation).

	Basin A	Basin B
No. of individuals	17	17
RBC count	2.063E+12 2.806E+11	2.183E+12 4.413E+12
Hemoglobin concentration (g/l)	79.94 7.74	81.90 16.50
Hct. (l/l)	0.403 0.061	0.414 0.100
MCV (fl)	196.89 31.79	189.37 28.31
MCH (pg/l)	39.09 3.44	37.58 3.14
MCHC (gHb/l Erc)	202.01 26.20	200.26 12.55

The basic physico-chemical parameters ranged within expected values (e.g. water temperature 19-24 °C and pH 7.40-9.03; Tab. 5). Oxygen regime values were in most cases satisfactory except in certain periods when deviations were recorded. For example, extremely high oxygen concentration and saturation were recorded at the beginning of the experiment while decrease in these parameters and therefore their optimum values may be in great part attributed to the meliorative role of grass carp. Only periodically, greater decrease in oxygen amount, as well as in saturation during September (basin A) and in June (basin B) were noted.

Table 4. Differential blood count of grass carp under different nutritional conditions (mean and standard deviation).

	Basin A	Basin B
No. of individuals	17	17
WBC count	2.791E+10 1.295E+10	3.103E+10 1.171E+09
IBN	0.011 0.014	0.024 0.024
Neutrophils		
Nonsegmented	0.245 0.201	0.206 0.125
Segmented	0.018 0.017	0.024 0.022
Pseudoeosinophil	0.384 0.192	0.452 0.166
Lymphocytes	0.315 0.193	0.256 0.148
Monocytes	0.027 0.034	0.038 0.044

On the basis of results obtained, the meliorative abilities of grass carp under high stock density may be evaluated very satisfactory. At optimum temperature, oxygen regime and pH values, grass carp consumed very intensively the present macrophyte while its deficit effected the consumption at additional portion of fresh plant mass showing some selectivity to certain species of aquatic vegetation. Similar results on the control of aquatic plants were reviewed by Gajdusek and Lusk (1982) in Czechoslovak waters, Riemens (1982) in Holland, Mugridge et al. (1982) in South England channels, and Gharably et al. (1982) in irrigation and drainage channels in Egypt. Promising effects of biomanipulation with fish are also emphasized by Gophen (1990) who speaks about a significant role of grass carp in nutrient transfer (mostly P) from the sediment through macrophyte. Unfavourable climatic conditions, primarily low temperature, low stock density, poor water quality during overwintering have been cited as main limiting factors (Müller, 1982).

The physico-chemical parameters have shown to be satisfactory in biomanipulation by grass carp to control macrophyte aquatic vegetation. Extremely dense stock and relatively old experimental specimens affected high consumption of present and added amounts of food and also a slower growth pointing to application of some other combination of stock in planning the directions in the control of the aquatic vegetation. Present results show undoubtedly that this biomanipulation should be introduced in the control mentioned taking into account its positive and negative aspects.

Table 5. Physico-chemical parameters of water.

Date	t (°C)	pH	O_2	Sat. (%)
Basin A				
3.6.	24	8.20	18.6	218
18.6.	21	7.50	6.1	68
1.7.	21	9.03	10.2	114
16.7.	21	7.70	9.7	108
3.8.	24	8.42	11.2	132
18.8.	24	8.42	11.5	135
16.9.	20	7.83	3.6	39
Basin B				
3.6.	24	8.10	19.2	225
18.6.	22	7.60	3.5	40
1.7.	21	8.37	9.0	100
16.7.	21	7.40	6.5	72
3.8.	24	8.16	8.6	101
18.8.	24	7.85	9.5	117
16.9.	19	8.44	7.8	83

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