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The Effects of Grass Carp on Aquatic Plants, Plankton and Benthos in Ponds

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ABSTRACT

The effects of the grass carp (*Ctenopharyngodon idella* Val.) on aquatic plant biomass, water quality, phytoplankton, chlorophyll *a*, zooplankton and benthic fauna were investigated between May and September 2000 in earthen ponds at Ciftteler-Sakaryabasi Aquaculture and Research Station. Four earthen ponds with an area of 100 m^2 were used and one of them was selected as control. The other ponds were stocked at rates of 200, 400 and 600 fish per ha in May. The survival rate of harvested grass carp was 100% in September and the highest weight gain of 428 g occurred at the minimum stocking rate. *Cladophora* and *Zygnema* species of aquatic plants were consumed in June by grass carp; however, *Chara* was eliminated completely by August. At the end of the stocking period, *Phragmites* was the only plant not consumed by the grass carp. Plant biomass increased 1.4 times in the pond without grass carp but was decreased 2.5 times in the ponds stocked with 200 and 400 grass carp per ha and 4 times in the pond stocked with 600 grass carp per ha. The lowest values of nitrite-nitrogen, nitrate-nitrogen, and total phosphate were measured in the pond without grass carp ($p < 0.05$). The highest values of phytoplankton, zooplankton, benthic fauna abundance and chlorophyll *a* were found in the ponds with fish ($p < 0.05$).

Key words: Ctenopharyngodon idella, water quality, phytoplankton, zooplankton, earthen pond.

INTRODUCTION

Excessive growth of aquatic plants in ponds, lakes, rivers and irrigation and drainage systems can be managed with grass carp. Biological weed control by grass carp is preferred because of its ability to control a wide variety of submersed and floating vegetation (Riemer 1984). The benefits of using grass carp for plant control include longevity of the method, constant feeding activity against the growing weeds, low long-term

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costs, and the potential for conversion of weed biomass to fish protein (Baran and Secer 1979, Sutton and Vandiver 1986). However, the possible effects of grass carp on the ecosystem are complex and depend upon the stocking rate, size of fish stocked, macrophyte abundance, size of the system, and complexity of the ecosystem (Opuszynski and Shireman 1995).

The introduction of grass carp for the control of aquatic plants and as a source of food in Turkey was verified by State Water Works in 1972 (Altınayar et al. 1994). This study was designed to obtain more field information on the effects of grass carp in different stocking rates in a pond environment and to measure the indirect impacts of biological reduction of vegetation on water quality, phytoplankton, zooplankton, and benthic fauna.

MATERIAL AND METHODS

Research was conducted in four earthen ponds in the Cifteler-Sakaryabasi Aquaculture and Research Station of Agricultural Faculty, Ankara University between May 15 and September 15, 2000. The area and the depth of each pond were 100 m^2 and 1 m, respectively. One pond not stocked with fish was selected as the control (C). The others were stocked with 200 (P1), 400 (P2) and 600 (P3) grass carp per ha in May 15, 2000 (Table 1) as indicated by Santha et al. (1991). The grass carp stocked were >195 mm in length and not subject to predation (Lembi et al. 1978). The variations of stocked fish length and weight among ponds were insignificant ($p > 0.05$).The fish were harvested September 15, 2000 and their final lengths and weights determined.

Samples of aquatic plants, benthos, and water were collected monthly from each pond. Water samples were collected with a Ruttner sampler from two points, near to the inlet and the outlet of each pond. Water temperature, dissolved oxygen, pH were measured *in situ*. Total hardness and calcium hardness were determined titrimetrically. Nitrate-N, nitrite-N, ammonia-N, and orthophosphate were determined by spectrophotometric methods (APHA 1975).

Aquatic plant samples were collected along transect lines from each pond with a pulling hook that sampled an area 0.2 m^2. The samples were labelled in nylon bags and plants were identified under stereomicroscope (Prescott 1973, Casper and Krausch 1980, 1981). Plants were allowed to drain for 30 min, and then dried for 24 h in an oven set at 105 C for determination of dry weights. Percent vegetation coverage of each pond was estimated visually and the biomass of plants was calculated as g dry weight per m^2 for each pond (Lembi et al. 1978).

Identification of phytoplankton and an estimation of abundance were conducted on water samples collected 0.5 m in depth near the inlet and the outlet of the ponds (Lembi et al. 1978). Ten ml of the water were sedimented after preservation with Lugol solution in counting chambers and counted under inverted microscope (Lund et al. 1958). Phytoplankton was identified under binocular microscope (Huber-Pestallozzi 1942, 1950, Lind and Brook 1980, Komarek and Fott 1983, Popovski and Pfiester 1990). Chlorophyll *a* concentration was determined spectrophotometrically after filtration of water samples through Whatman GF/C filter paper and extracted with acetone (Strickland and Parsons 1972).

Zooplankton abundance was estimated from the water samples, which were taken as for phytoplankton analyses. Water samples were preserved with a 4% formaldehyde solution and were settled in graduated cylinders, enumerated in counting chamber (Edmondson 1959). Zooplankton was identified under binocular microscope (Edmondson 1959, Koste 1978).

Benthos samples were collected with an Ekman dredge (15 cm by 15 cm) from the inlet and the outlet of the ponds, and the samples were washed through a series of sieves that varied between 210 to 3360 micron mesh. The organisms were preserved in 4% formaldehyde solution. Benthic fauna abundance was estimated as individual per m^2 and identified under a stereoscopic microscope (Edmondson 1959, Macan 1975, Koste 1978).

The counted values of phytoplankton, zooplankton and benthos were normalized using square root transformation. Repeated measures analyses and Duncan multiple range test were computed to evaluate the differences in terms of all parameters. Statistical analyses were carried out using Minitab and Mstat programmes for Windows.

RESULTS AND DISCUSSION

During the study, the survival rate of the grass carp was 100%. The initial and final weight and length of grass carp were given in Table 1. In this study, fish weight increased 2 to 3.7 times in 5 months. Grass carp were stocked to the ponds at 23 to 26.6 cm total length. Lembi et al. (1978) indicated that vegetation control by grass carp is excellent when using fish longer than 190 to 195 mm. Fish at the lowest stocking rate exhibited the highest weight gain. Kilgen and Smitherman (1971) reported that the average weight gain of grass carp stocked at 50 fish per hectare had been significantly higher than those stocked at rates of 100, 200 and 400 per ha.

TABLE 1. MEASUREMENTS FOR TOTAL LENGTH AND BODY WEIGHT OF GRASS CARP STOCKED IN PONDS WITH A SURFACE AREA OF 100 M^2. THE FISH WERE STOCKED MAY 15 AND REMOVED IN SEPTEMBER 15, 2000.

	Initial		Final	
Stocking rate, fish/100 m^2	Total length (cm) mean ± S.E.	Body weight (g) mean ± S.E.	Total length (cm) mean ± S.E.	Body weight (g) mean ± S.E.
2	25.8 ± 1.8	205.0 ± 20.1	36.5 ± 0.5	633 ± 16
4	23.0 ± 0.5	169.3 ± 13.6	35.3 ± 2	595 ± 13
6	26.6 ± 1.5	243.6 ± 25.0	33.0 ± 1	410 ± 25

The results of Repeated measures analyses showed that the differences between all parameters except zooplankton were statistically significant at 1% level while the differences of zooplankton abundance was at 5% level (Tables 2, 3 and 4). At the beginning of the study in May, the variations of aquatic plant biomass, water quality parameters, chlorophyll *a*, phytoplankton and benthic fauna abundance among ponds were found to be insignificant ($p > 0.05$).

In May, *Chara* sp. *Chladophora* sp., *Zygnema* sp. were identified in the ponds. *Phragmites australis* (Cavanilles) Trinius *et* Steudel, *Mentha* sp., *Nasturtium* sp., *Polygonum* sp., *Sagittaria* sp. were present at the edges of the ponds (Table 5). The vegetation biomass ranged from 95 ± 8 (P3) to 119 ± 6 (P1) dry weight g per m^2 in May (Table 2). In the control pond, plant biomass increased during the experiment and the pond was covered completely when the experiment was terminated.

In June, *Zygnema* sp. and *Cladophora* sp. were eliminated from the P1, P2, and P3 ponds and in July the coverage of *Chara* sp. was reduced. In August and September, only *Phragmites australis* remained in the ponds. By September, *Phragmites australis* had increased in plant biomass 2.5 times in P1 and P2, and 4 times in P3 in comparison to May.

During the study, all vegetation except *Phragmites* was removed by grass carp in P1, P2 and P3 ponds. Mitzner (1978) reported that the vascular plants and *Chara* had been eliminated in earthen ponds within 40 days of introduction of grass carp. In this study, grass carp were smaller than 36.5 cm and did not consume *Phragmites*. Plant selection varies with size, as larger fishes will eat plants that are hard tissue plants or plants too large for small fishes to consume (Opuszynski and Shireman 1995). For the control of rooted plants, such as *Phragmites*, stocking of large grass carp must be taken into the consideration.

In May and September, the lowest values of the water temperature of 20 ± 0.5 C were measured and the highest value (25.5 ± 0.1 C) was measured in August (Figure 1). Zonneveld and Von Zon stated that for an effective weed control, water temperature must be above 18 C (Opuszynski and Shireman 1995). Mean dissolved oxygen and pH values were determined as 7.8 ± 0.1 mg/l and 7.5 ± 0.2, respectively. Mean total hardness and Ca hardness were found as 31.6 ± 1.9 FH° (316 mg $CaCO_3$/l) and 113.6 ± 10.8 mg $CaCO_3$/l, respectively.

Ammonium nitrogen values were higher in control pond in June and July while these values were higher in P1 and P3 ponds than the others in August and September. In this study, the lowest nitrate-nitrogen, nitrite-nitrogen and total phosphate concentration were measured in the control pond (Table 4). Although an important part of the nutrients in vegetation was retained in grass carp after consumption, the concentrations of nitrate-nitrogen and total phosphate in ponds with grass carp were higher than the control pond (Lembi et al. 1978, Chapman et al. 1987, Kirkagac and Pulatsu 2001a). In the control pond, nutrients might be used by dense plant and periphyton biomass. In this pond, nitrate concentration and total phosphate concentration decreased 3.4 and 2.9 times, respectively. But in the ponds with grass carp nitrate-nitrogen and total phosphate decreased 1.1 and 1.4 times, respectively. Shireman and Smith (1983) reported that the nutrients and phytoplankton numbers increased in a lake after stocking grass carp. Water quality parameters may increase over the short term but will return to prestocking levels in subsequent years (Shireman et al. 1985). Although nutrients were richer in the ponds with grass carp than the control pond, nutrients reduced during the study. These might be because of the changes in phytoplankton, periphyton biomass or *Phragmites*, which couldn't be consumed completely by grass carp.

Phytoplankton belonging to seven classes was identified in the ponds (Table 5). Mean phytoplankton numbers varied between 240752 ± 5350 and 245570 ± 11232 individual/l in May. The phytoplankton abundance increased 8 times in ponds with grass carp, the lowest value was found in the control pond (Table 3). Bacillariophyceae was dominant in all ponds (Figure 2). In May, pennate diatoms and Chlorococcales were dominant. In August, the members of Cyanophyceae were increased in all ponds. Diatoms were higher in the control pond than the other ponds. Most of the pennate diatoms in the control pond were epiphytic species and mixed to pond water. The phytoplankton composition of the ponds with grass carp was similar. Elimination of vegetation by grass carp in the ponds caused a rise in phytoplankton

TABLE 2. THE BIOMASS OF AQUATIC PLANTS AND THE CONCENTRATION OF CHLOROPHYLL *A* (N = 2) (MEAN ± SE) IN PONDS.[1,2]

		Number of grass carp per 100 m^2				
	Months	0	2	4	6	F
Aquatic plants (g dry weight/m^2)	May	110.3 ± 5.9 a	118.8 ± 5.5 a	101.9 ± 10.0 a	95.4 ± 7.9 a	11.39**
	June	132.3 ± 7.5 a	108.3 ± 3.9 b	91.4 ± 8.1 b	60.8 ± 5.5 c	
	July	147.2 ± 11.6 a	61.4 ± 1.8 b	49.9 ± 4.8 bc	33.2 ± 3.9 c	
	August	149.1 ± 5.3 a	45.7 ± 6.3 b	36.1 ± 2.3 b	24.0 ± 2.1 b	
	September	150.0 ± 13.0 a	47.1 ± 5.7 b	39.8 ± 4.1 bc	23.4 ± 4.0 c	
Chlorophyll *a* (mg/m^3)	May	2.55 ± 0.15 a	2.20 ± 0.1 a	2.65 ± 0.15 a	2.45 ± 0.05 a	86.76**
	June	2.18 ± 0.47 c	6.68 ± 0.06 b	6.09 ± 0.8 b	7.83 ± 0.02 a	
	July	1.57 ± 0.04 d	9.15 ± 0.25 a	7.25 ± 0.06 b	5.75 ± 0.65 c	
	August	2.99 ± 0.03 c	10.69 ± 0.51 a	11.25 ± 0.25 a	5.73 ± 0.05 b	
	September	3.35 ± 0.05 d	17.55 ± 0.35 b	20.85 ± 0.55 a	6.56 ± 0.13 c	

[1]Means with the different letters in the same line are significantly different ($p < 0.05$).
[2]**($p < 0.01$).

TABLE 3. ABUNDANCE OF PHYTOPLANKTON, ZOOPLANKTON, AND BENTHIC FAUNA (N = 2) (MEAN ± SE) IN PONDS.[1,2]

	Months	Number of grass carp per 100 m^2				F
		0	2	4	6	
Phytoplankton (individual/l)	May	240752 ± 5350 a	243618 ± 4650 a	255019 ± 12484 a	245570 ± 11232 a	270.69**
	June	39233 ± 7134 c	857782 ± 19626 b	877390 ± 32100 b	1346401 ± 65983 a	
	July	94516 ± 12484 b	1294685 ± 7133 a	1225136 ± 16050 a	1226919 ± 10700 a	
	August	324562 ± 7134 c	1378500 ± 8917 a	1367801 ± 16050 a	841723 ± 32100 b	
	September	602758 ± 28536 d	2239840 ± 17834 b	3044115 ± 19616 a	1080688 ± 14266 c	
Zooplankton (individual/l)	May	130 ± 8 ab	122 ± 20 bc	105 ± 10 c	150 ± 20 a	2.87*
	June	76 ± 6 c	92 ± 4 bc	112 ± 3 b	139 ± 9 a	
	July	105 ± 2 c	128 ± 4 bc	149 ± 6 b	186 ± 5 a	
	August	114 ± 3 c	131 ± 2 bc	144 ± 4 b	187 ± 6 a	
	September	143 ± 3 b	171 ± 4 a	182 ± 15 a	197 ± 11 a	
Benthic fauna (individual/m^2)	May	882 ± 127 a	897 ± 127 a	823 ± 310 a	902 ± 120 a	5.04**
	June	913 ± 31 c	1189 ± 139 bc	1398 ± 70 b	2028 ± 72 a	
	July	955 ± 35 c	1363 ± 106 b	1652 ± 56 b	2225 ± 75 a	
	August	996 ± 64 c	1615 ± 65 b	2079 ± 20 b	2652 ± 152 a	
	September	963 ± 158 c	2145 ± 209 b	2491 ± 111 ab	3057 ± 207 a	

[1]Means with the different letters in the same line are significantly different ($p < 0.05$).
[2]**($p < 0.01$), *($p < 0.05$).

TABLE 4. THE CONCENTRATIONS OF AMMONIUM-NITROGEN, NITRITE-NITROGEN, NITRATE-NITROGEN AND TOTAL PHOSPHATE (N = 2) (MEAN ± SE) IN PONDS.[1,2]

Months	NH_3-N (mg/l)				F
	C	P1	P2	P3	
May	0.053 ± 0.003 a	0.053 ± 0.001 a	0.050 ± 0.002 a	0.050 ± 0.001 a	190.4**
June	0.071 ± 0.001 a	0.051 ± 0.001 b	0.059 ± 0.001 b	0.038 ± 0.001 c	
July	0.125 ± 0.005 a	0.053 ± 0.002 c	0.064 ± 0.002 b	0.016 ± 0.001 d	
August	0.074 ± 0.002 b	0.088 ± 0.002 a	0.062 ± 0.003 c	0.073 ± 0.003 b	
September	0.061 ± 0.004 c	0.063 ± 0.001 c	0.077 ± 0.002 b	0.131 ± 0.003 a	
	NO_2-N (mg/l)				
May	0.019 ± 0.002 a	0.021 ± 0.002 a	0.023 ± 0.002 a	0.021 ± 0.002 a	60.2**
June	0.021 ± 0.002 d	0.063 ± 0.004 a	0.035 ± 0.003 c	0.040 ± 0.001 b	
July	0.014 ± 0.002 d	0.094 ± 0.002 a	0.021 ± 0.001 c	0.045 ± 0.002 b	
August	0.019 ± 0.020 c	0.030 ± 0.002 b	0.029 ± 0.002 b	0.039 ± 0.001 a	
September	0.033 ± 0.002 a	0.032 ± 0.002 a	0.031 ± 0.002 a	0.036 ± 0.002 a	
	NO_3-N (mg/l)				
May	0.544 ± 0.004 a	0.545 ± 0.006 a	0.539 ± 0.002 a	0.531 ± 0.004 a	1288.3**
June	0.483 ± 0.003 c	0.592 ± 0.003 b	0.606 ± 0.003 a	0.485 ± 0.004 c	
July	0.172 ± 0.002 d	0.295 ± 0.003 c	0.606 ± 0.002 a	0.367 ± 0.002 b	
August	0.162 ± 0.002 c	0.686 ± 0.003 a	0.656 ± 0.003 b	0.683 ± 0.003 a	
September	0.159 ± 0.003 c	0.394 ± 0.002 a	0.351 ± 0.003 b	0.395 ± 0.002 a	
	TP (mg/l)				
May	0.192 ± 0.001 a	0.197 ± 0.001 a	0.189 ± 0.001 a	0.190 ± 0.001 a	118.7**
June	0.115 ± 0.001 b	0.111 ± 0.001 b	0.112 ± 0.004 b	0.138 ± 0.015 a	
July	0.099 ± 0.001 b	0.139 ± 0.001 a	0.100 ± 0.001 b	0.134 ± 0.001 a	
August	0.086 ± 0.001 c	0.263 ± 0.003 a	0.190 ± 0.001 b	0.193 ± 0.001 b	
September	0.067 ± 0.001 d	0.114 ± 0.001 b	0.084 ± 0.002 c	0.202 ± 0.001 a	

[1]Means with the different letters in the same line are significantly different ($p < 0.05$).
[2]**($p < 0.01$).

Table 5. A list of phytoplankton, zooplankton, benthic fauna, and aquatic plants found in ponds.

Phytoplankton
BACILLARIOPHYCEAE
Achnanthes brevipes Ag.
Amphora ovalis Kütz.
Caloneis ventricosa (Ehr.) Meister
Cocconeis placentula Ehr.
Cyclotella sp.
C. Meneghiniana Kütz.
Cymbella asparea (Ehr.) Cleve
C. cistula Hemp.
C. hybrida Grun.
Cymatopleura solea (Breb.) W. Smith
Epithemia turgida (Ehr.) Kütz.
Fragilaria construens (Ehr.) Grun.
Gomphonema intricatum Kütz.
Gyrosigma acuminatum (Kütz.) Rahb.
Melosira granulata (Ehr.) Ralfs
Navicula cryptocephala Kütz.
N. cuspitata Kütz.
Nitzschia littoralis Grun.
N. palea (Kütz.) W. Smith
N. scalaris (Ehr.) W. Smith
N. sigmoidea (Ehr.) W. Smith
Pinnularia viridis (Nitszch.) Ehr.
Rhicosphaenia curvata (Kütz.) Grun.
Surirella linearis W. Smith
Synedra acus Kütz.
S. capitata Ehr.
S. ulna (Nitzsch.) Ehr.
CHLOROPHYCEAE
Ankistrodesmus gracilis (Reinsch.) Kors.
Ankyra Judayi (G. M. Smith) Fott
Botryococcus braunii Kütz.
Closterium aciculare T. West
Coelastrum microporum Naeg.
Cosmarium depressum (Naeg.) Lund.
C. Turpinii Breb.
Crucigenia tetrapedia (Kirch.)West *et* West
Dictyosphaerium pulchellum Wood
Monoraphidium circinale (Nyg.) Nyg.
Oocystis parva West *et* West
Pandorina morum Bory
Pediastrum boryanum (Turp.) Menegh.
P. duplex Meyen
Scenedesmus acuminatus (Lagerh.) Chod.
S. acutus Meyen
S. magnus Meyen
Schroederia setigera (Schröd.) Lemm.
Sphaerocystis schroeteri Chod.
Tetraedron caudatum (Corda) Hansg.
T. minimum (A. Braun) Hansg.
CHRYSOPHYCEAE
Dinobryon sertularia Ehr.
CRYPTOPHYCEAE
Cryptomonas marssonnii Skuja
Rhodomonas lacustris Pascher *et* Ruttner
CYANOPHYCEAE
Anabaena affinis Lemm.
A. spiroides Klebahn
Gloeocapsa turgida (Kütz.) Hollerbach
Merismopedia tenuissima Lemm.
Microcystis incerta Lemm.
Oscillatoria tenuis Ag.
DINOPHYCEAE
Peridinium bipes (Müll.) Ehr.
P. inconspicuum Lemm.
EUGLENOPHYCEAE
Euglena sp.
Phacus Lemmermannii (Swir.) Skvortzow
Trachelomonas volvocina Ehr.

Zooplankton
ROTIFERA
Cephalodella gibba Ehr.
Cephalodella sp.
Colurella adriatica Ehr.
Euchlanis dilatata Ehr.
Lecane luna (O.F.M.)
Lepadella ovalis (O.F.M.)
Microcoides robustus (Glascott)
Monommata longiseta (O.F.M.)
Monostyla sp.
Polyarthra dolichoptera Idels.
Scaridium longicaudum (O. F. M.)
Squatinella rostrum (Schmarda)
Testudinella sp.
Trichotria pocillum (O.F.M.)
CLADOCERA
Alona rectangula Sars.
Bosmina longirostris (O.F.M.)
Simocephalus sp.
COPEPODA
Cyclops sp.
Nauplius

Benthic Fauna
GASTROPODA
Planorbis sp.
Lymnaea sp.
Napaeus sp.
DIPTERA
Chironomidae

Aquatic Plants
CHLOROPHYCEAE
Chara sp.
Cladophora sp.
Zygnema sp.
SPERMATOPHYTA
Mentha spicata L.
Nasturtium sp.
Phragmites australis (Cavanilles) Trinius *et* Steudel
Polygonum sp.
Sagittaria sp.

growth. Richard and Small (1984) indicated that mean phytoplankton abundance had increased in all cases with macrophyte reduction and most sharply with complete elimination. But in the control pond, macrophytes inhibited the growth of phytoplankton. The inhibition of phytoplankton growth among dense macrophytes is likely related to competition for light and nutrients (Wetzel 1983).

Chlorophyll *a* concentrations varied between 2.2 ± 0.1 and 2.7 ± 0.2 mg/m^3 in May (Table 2). In June, July, August and September, the lowest values of chlorophyll *a,* as phytoplank-

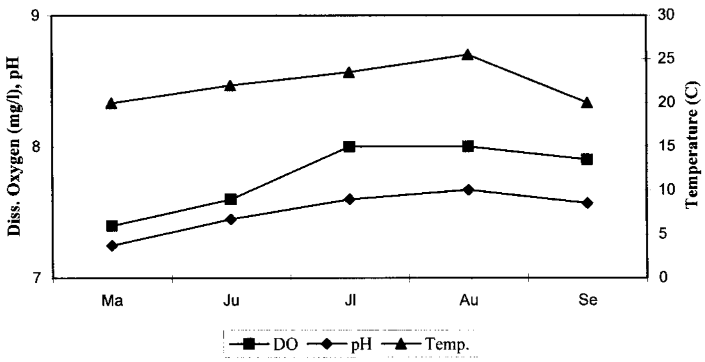

Figure 1. Mean water temperature, dissolved oxygen and pH values in ponds by months.

ton numbers, were found in the control pond and the highest value (20.9 mg/m^3) was measured in P2 pond in September. These differences were found to be significant ($p < 0.05$). It was reported that in a reservoir, chlorophyll *a* concentration had not been affected after grass carp had been stocked for biological control (Cooke et al. 1986). Lembi et al. (1978), indicated that chlorophyll *a* concentration had increased in the ponds with grass carp in comparison to the control pond. Grass carp in the ponds consumed macrophytes and encouraged phytoplankton growth so chlorophyll *a* concentration increased. The lowest mean values of phytoplankton number and chlorophyll *a* were found in P3 among ponds with grass carp. This might be explained with the highest biomass of zooplankton and benthic fauna in P3.

In the study, 14 species from Rotifera, 3 species from Cladocera and 1 genus from Copepoda were identified (Table 5). At the beginning of the study, 9 species from Rotifera, 3 species of Cladocera as *Simocephalus* sp., *Alona rectangula* and *Bosmina longirostris*, 1 species from Copepoda were found. The number of Rotifera species decreased until September. In September, the number of Rotifera species increased again. *Simocephalus* sp. was not observed after May. The lowest zooplankton abundance was estimated in the control pond while the highest value was found in P3 pond (Table 3). In general, zooplankton abundance increased during the experiment in all ponds. Rotifera was dominant in zooplankton community (Figure 3). Copepoda decreased in June. In July and August, only Rotifera members were found in the control pond. Subjected to the gradual decrease or elimination of the vegetation, all ponds with carp shifted toward zooplankton assembledges of increased mean abundance, dominated by fewer species of small suspension-feeders (primarily rotifers) (Richard et al. 1985). Kirkagac and Pulatsü

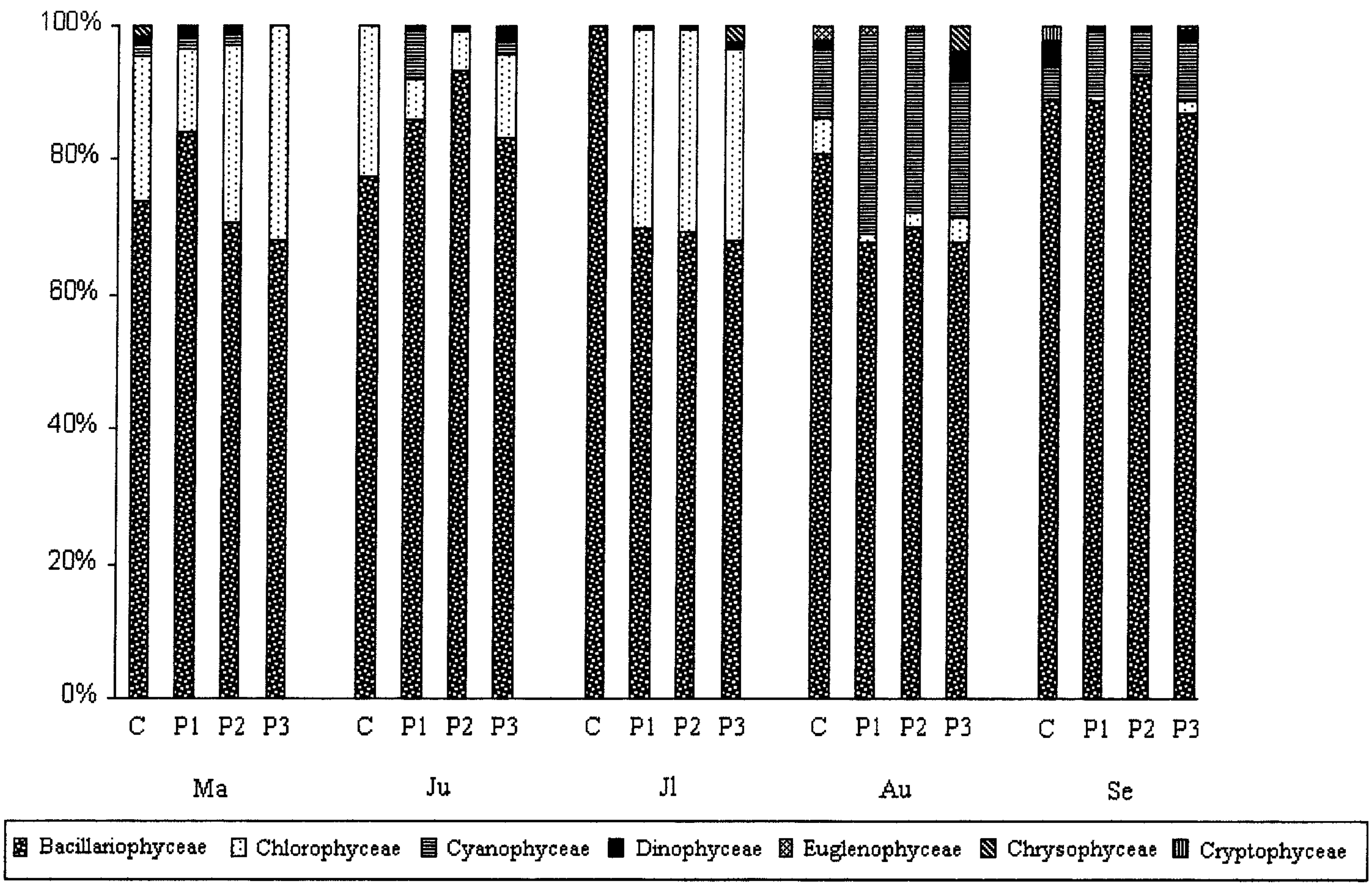

Figure 2. Phytoplankton composition in ponds by months.

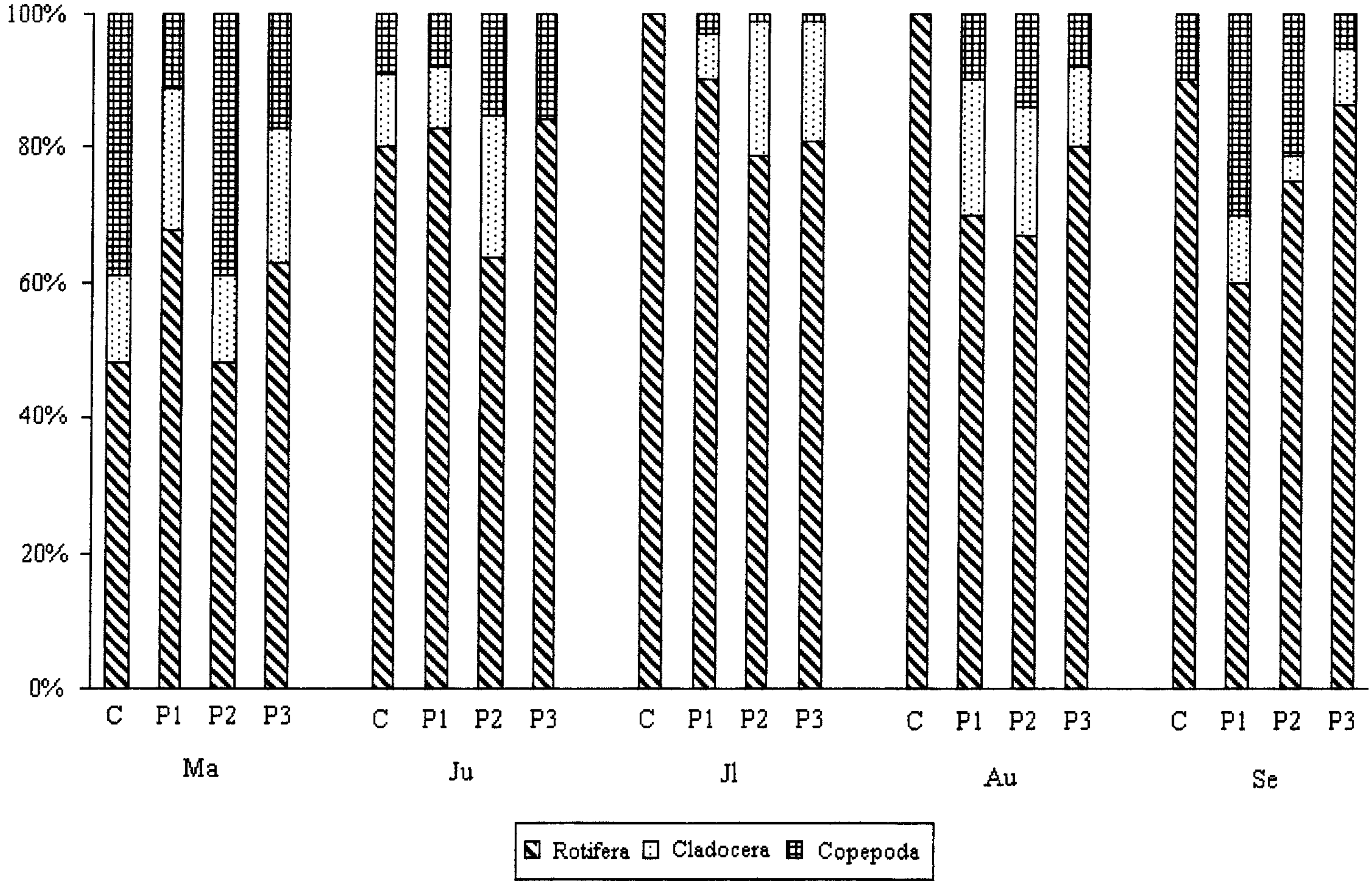

Figure 3. Zooplankton composition in ponds by months.

(2001b), reported that *Diaphanosoma* and *Ceriodaphnia* from cladocerans had been found before stocking grass carp in an irrigation reservoir, then *Bosmina longirostris* and Rotifera composed 75% of zooplankton composition and took place of big cladocerans. In this study, zooplankton composition was similar in all ponds because grass carp was bigger than the size to consume zooplankton directly as reported by Van Dyke and Sutton (1977). There were no differences in species numbers of zooplankton between control and the ponds with grass carp. During the experiment the differences in species numbers affected from seasonal succession. In ponds with grass carp zooplankton abundance was affected from increasing nutrients and phytoplankton after elimination of vegetation by grass carp.

The benthic fauna community consisted of members belonging to the orders of Gastropoda and Diptera (Table 5). During the study, benthic fauna abundance was lowest in the control pond but the highest value was estimated in P3 pond ($p < 0.05$), however, benthic fauna abundance increased in all ponds (Table 3). The members of Gastropoda were dominant with Diptera comprising 5 to 30% of the benthic community. Benthic fauna abundance was increased 2 to 3 times in ponds with grass carp in comparison to the control pond. The elimination of the vegetation by grass carp caused an increase in benthic fauna growth (Bain 1993).

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