Verh. Internat. Verein. Limnol.	24	2519–2522	Stuttgart, September 1991

Impact of juvenile cyprinid fish predation on the food availability and zooplankton community

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Introduction

In freshwater pelagic systems predators limit prey populations. Several studies suggest that at the top of the food web piscivores can have a strong, negative impact on planktivores (STEWART et al. 1981, VAN DENSEN 1985). At the next level in the food web planktivores have a major impact on the size structure and species composition of zooplankton communities (HRBAČEK 1962, HALL et al. 1976, VIJVERBERG & RICHTER 1982).

The effects of food web manipulations on phytoplankton dynamics are not always evident (DORAZIO et al. 1987). Starvation and/or predation may eliminate any possibility of grazer control of algal populations (MCQUEEN & POST 1988). Since copepods dominate the zooplankton in Lake Balaton during summer (ZÁNKAI & PONYI 1986) and exhibit much lower grazing rates than *Daphnia*-dominated assemblages in other lakes, we decided to determine experimentally if the zooplankton in eutrophic Lake Balaton were capable of controlling phytoplankton biomass in the offshore region of the lake.

Material and methods

Two circular, polyethylene enclosures (3 m in diameter, depth 2.2 m) open to the sediments and atmosphere were installed in the shore zone of the mesotrophic basin of Lake Balaton in the summer of 1988. (The design of the enclosures was described in TÁTRAI & ISTVÁNOVICS 1986.) Changes in the phytoplankton structure and biomass were followed from integrated samples preserved with LUGOL's solution and enumerated using UTERMÖHL's method. Zooplankton samples were taken similarly with a surface-mud tube sampler 12 cm in diameter. About 10 l of water were filtered through a 50 μm net.

One of the enclosures contained no fish (CE). On the 6th day of the study 10 underyearling bream (*Abramis brama* L.) were put into the other enclosure (FE) in densities corresponding to 4.5 g wet weight · m^{-2} (min–max: 0.3–4.3 g wet wt). One week later the fish density was increased by the introduction of a further four fish (min–max: 1.7–13.2 g wet wt). Thus, the final fish stocking corresponded to 2 fish · m^{-2} or to 7.3 g · m^{-2}, i.e. half of the maximum quantified by echo-sounding during summer in the offshore region of Lake Balaton (PAULOVITS pers. comm.).

Results and discussion

The population dynamics of algae showed four distinct phases of growth in FE that are comparable

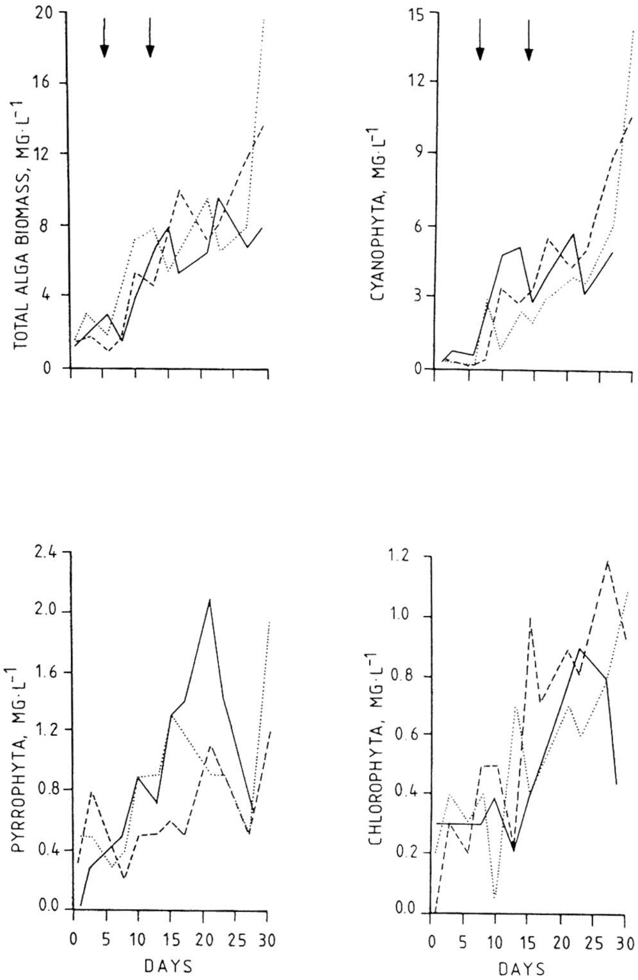

Fig. 1. The biomass of dominant phytoplankton genera for the fish (· · · ·) and control (——) enclosures and for Lake Balaton (- - - - -). The arrows indicate stocking of the enclosure with fish.

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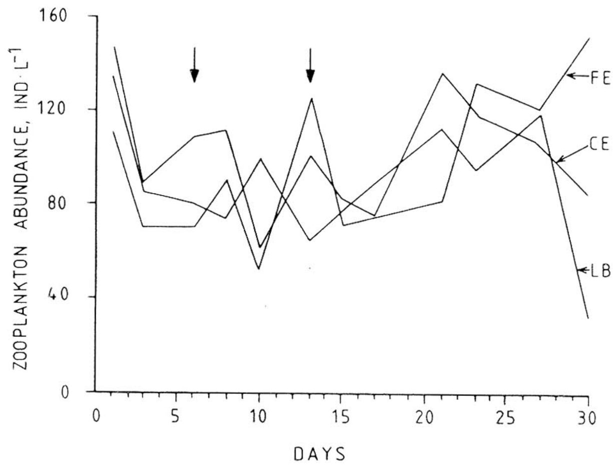

Fig. 2. Total zooplankton numbers for the fish (FE) and control (CE) enclosures and for the lake (LB).

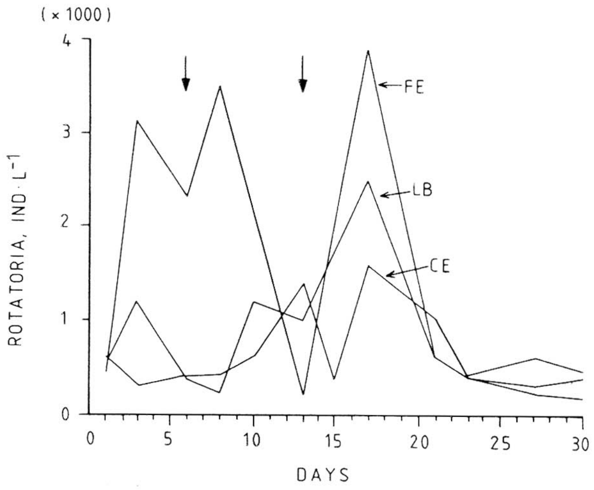

Fig. 3. Rotifer numbers for the enclosures and for the lake (symbols as in Fig. 2).

to those observed in the natural system, i.e. in Lake Balaton (LB). Increasing algal growth, except the CE, usually occurred before the zooplankton, especially copepods, *Eudiaptomus gracilis* and *Mesocyclops leuckarti*, became dominant and were attributed to the intense proliferation of the blue-green alga (*Gomphospheria lacustris*) (Fig. 1). Although the biomass fo good quality phytoplankton fluctuated throughout the study, it was consistently greater in LB and CE than in FE.

Statistical analyses showed that although cladocerans, mainly the larger *Daphnia birgeri lacustris*, were relatively more abundanat during most of the experimental period both in CE and LB, but the difference in total zooplankton abundance showing maximum by the last week of the study in FE was not significant (F-test, $P = 0.58$) (Fig. 2). *Eudiaptomus*, the largest herbivore copepods in the community, like total zooplankton numbers, tended to be more abundant in FE toward the end of the experiment, although the overall difference was not significant (F-test, $P = 0.34$ for CE, $P = 0.26$ for LB). In addition to the herbivores, the predaceous copepods, *Cyclops vicinus, Mesocyclops leuckarti*, were as abundant as other groups of crustaceans exhibiting no significant density differences among treatments ($P = 0.27$ for CE and $P = 0.64$ for LB). Rotifers, being represented mainly by *Keratella cochlearis*, the smallest herbivores, were significantly more abundant in FE than in CE ($P = 0.023$) and in LB ($P = 0.084$) although the difference was slight at the beginning and at the end of the study (Fig. 3).

Differences in phytoplankton biomass between treatments were examined statistically. The objective here was to determine whether differences in food availability for the crustaceans existed between enclosures. During the experiment total phytoplankton biomass was not greater in FE than in CE ($P = 0.97$) and in LB ($P = 0.60$). However, at the two final data the biomass of the phytoplankton was greater in FE than in CE ($P = 0.027$).

Mostly the less edible blue-greens dominated in both enclosures and their biomass in CE significantly exceeded that of in FE ($P = 0.046$). These large, *Aphanizomenon, Gomphospheria*, species might interfere with the collection of smaller cells, biomass of that being by an order magnitude lower, and consequently reduce grazing rate of crustaceans. Taxonomic differences appeared to be the greatest by the last week of the experiment when there was greater amount of edible chlorophytes in FE and fewer greens and diatoms in CE. In addition, CE by this time contained less and FE more filamentous blue-greens, unedible diatoms and dinoflagellates, mainly *Ceratium*.

Whether these differences in food quality and quantity had effects on crustaceans abundance and vica versa, regression analyses linking phytoplankton and zooplankton biomass were performed. Zooplankton grazing pressure was unimportant in the development of phytoplankton blooms in FE. Net increase in phytoplankton biomass especially that of cyanophytes, increased markedly as a function of zooplankton numbers in FE ($P = 0.009$) revealing substantial avoidance of these cells (Fig. 4). Diaptomids, up to the density of 50 ind $\cdot$ l^{-1}, were not able to control the growth of algae. However, the relationship between phytoplankton and zooplankton biomass was

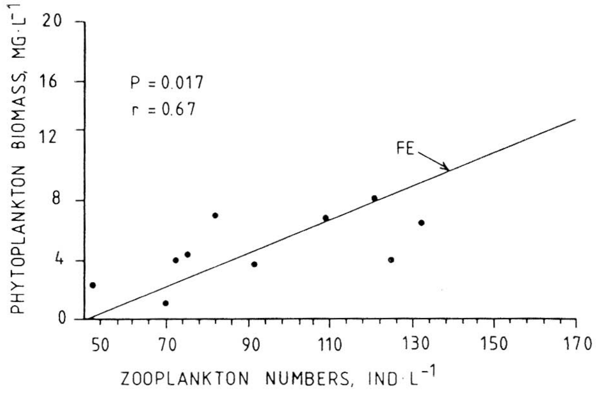

Fig. 4. The relationship between zooplankton numbers and phytoplankton biomass for the fish enclosure (FE).

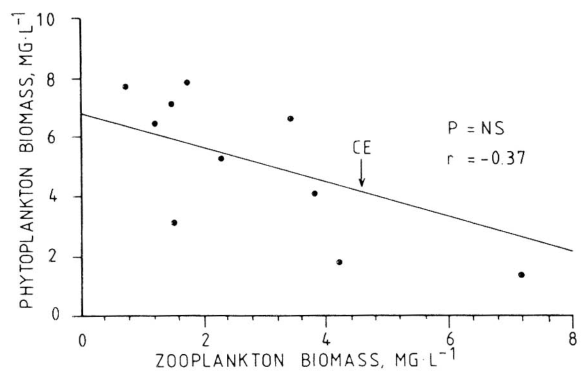

Fig. 5. Reduction in biomass of phytoplankton with increases in zooplankton biomass in the control enclosure (CE).

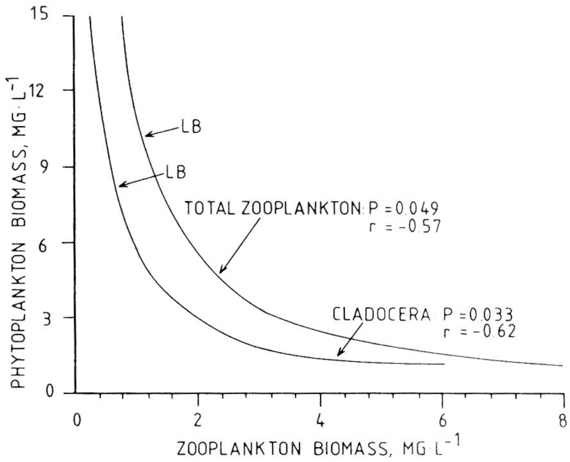

Fig. 6. Reduction in phytoplankton biomass with increases in Cladocera and total zooplankton biomass in Lake Balaton (LB).

negative but not significant (P = 0.11) (Fig. 5). Zooplankton grazing pressure proved to be more important in LB. There was a multiplicative negative but significant relationship between the biomass of total zooplankton and cladoceran biomass and the phytoplankton biomass (P = 0.049 and P = 0.033, respectively) (Fig. 6).

In eutrophic lakes the top-down effects remain strong at the top of the food web but diminishing further down, eventually producing little effect on algal grazer relationship (McQueen & Post 1988). We agree that the relative importance of the control of pelagic food web varies with lake trophic status hence the copepods were not able to control algal biomass effectively neither in the lake nor in the fish free enclosure. Copepods dominate the crustacean plankton in Lake Balaton during summer (Zánkai & Ponyi 1986) and exhibit much lower grazing rates than *Daphnia*-dominated assemblage in other lakes. We believe that the variations among laks derives just from differences in species composition and from relative abundance of organisms at adjacent trophic levels.

Because of the copepods dominance, underyearling bream fed mainly on them as shown by other investigations as well (Ponyi & Zarok 1984) and is consistent with the observed but not predicted diet investigated by Winfield & Townsend (1988). It follows from this that top-down manipulation of Lake Balaton's food web (young bream – zooplankton – phytoplankton) probably has little effect on the phytoplankton biomass.

Acknowledgements

This work was financed partly by the AKA-project of the Hungarian Academy of Sciences. I. Tatrai gratefully acknowledges the grant provided by the Organizing Commitee to visit the SIL Conference.

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