

IMPORTANCE OF PROTOZOA AS FOOD TO ZOOPLANKTON AND SOME FISH SPECIES IN LAKE QAROUN, EGYPT

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Key words: Protozoa, food, zooplankton, fish, Lake Qaroun, Egypt

ABSTRACT

The relationship between the protozoan organisms and zooplankton in addition to fish predation of Lake Qaroun were hereby studied. An experiment was conducted in the aquatic laboratory of Shakshouk Station–Fayoum close to Lake Qaroun using cylindrical fiberglass enclosures of 1000 liters capacity that were filled with water pumped from 0.5m depth of Lake Qaroun. The numbers and net population growth and production of the dominant protozoan organisms in absence and presence of small and large- sized zooplankton as well as two native fishes namely, *Mugil cephalus* and *Tilapia zillii* were described. The average air and water temperatures were 27.7 ± 2.1 and 22.6 ± 1.1 °C (mean \pm SD) respectively. PH values ranged from 7.39 to 8.00 (7.74 ± 0.13 , mean \pm SD) while ammonium ranged from $64.39 \mu\text{g l}^{-1}$ to 1.05mg ml^{-1} during the experiment. At the start, the protozoan organisms, constituted numerically 48.12% of total zooplankton organisms that dominated by three species; *Tintinnopsis kofoidi*, *Helicostomella subulata*, and *Euplotes vannus*. In the presence of the small-sized organisms (SS), the total protozoan number was decreased. In the presence of small and large sized organisms (SLS) the protozoan number returned to the control level. The impact of the fishes was more pronounce in presence of *M. cephalus* than *T. zilli* compared to the control enclosure. Protozoan organisms were observed in the gut contents of *M. cephalus* and *T. zilli*, representing 14.29% and 4.69% respectively. The net population growth (NPG) was higher in control, (2.15 day^{-1}) followed by SLS (2.10 day^{-1}). NPGR of *T. kofoidi* was the highest especially in presence of the SLS

(1.18 day⁻¹), while its lowest level was recorded in presence of *M. cephalus* (0.63 day⁻¹).

INTRODUCTION

Recent investigations have shown that processes within the planktonic web are of great significance for limnetic ecosystems. Protozoan organisms represent a dominant component of the microzooplankton in marine waters (Pierce and Turner, 1992). These organisms are a considerable food source for zooplankton in addition to some fishes (Rajas de Mendiola, 1974; Berk *et al.*, 1977; Robertson, 1983; Sanders, 1987). The protozoan community represents an important regulatory component of the ecosystem, enabling it to respond quickly to perturbations and thus ensuring its stability. They are free-swimming planktonic organisms occurring in marine, estuarine and freshwater environments where they feed predominantly on unicellular microplankton (Laval-Peuto and Brownlee, 1986). Tintinnid ciliate protozoans constitute a major fraction, by number of many microzooplankton communities (Heinbokel and Beers, 1979; Beers *et al.* 1980). Qualitative analyses have shown that tintinnids feed mainly on bacteria (Hollibaugh *et al.*, 1980), dinoflagellates (Stoecker *et al.*, 1981) and smaller tintinnids (Blackbourn, 1974).

However, the general importance of protozoans as a food source for rotifers and copepods that constitute a major component of planktonic habitats, has seldom been evaluated in Qaroun Lake. Mechanisms governing fluctuations in protozoan ciliate populations of Lake Qaroun remain unclear. The present work aims to reveal the relationship between these organisms and the small- and large-sized zooplankton in addition to fish predation. Furthermore, determination of the net population growth of the dominant protozoan organisms in the absence and presence of the small- and large- sized zooplankton in addition to two native fishes (*Mugil cephalus* and *Tilapia zilli*) in Lake Qaroun might clarify the importance of such protozoans as food for these organisms.

MATERIAL AND METHODS

An experiment was conducted in the aquatic laboratory of Shakshouk Station –Fayoum, close to Lake Qaroun during April

1998, and continued for seven days (the community started to decrease in number after six days). Five cylindrical fiberglass enclosures of 1000 liters capacity each, were filled with water pumped from 0.5m depth of Lake Qaroun. The steps of the experiment are shown in table (1).

Table (1): The different treatments during the experiment

Enclosures	Treatments	Contents
Control	Filtration with 55µm-mesh net	Protozoa
SS	Filtration with 100µm-mesh net	Protozoa and small sized zooplankton (nauplius larvae and rotifers)
SLS	Lake water without treatment	Protozoa and small-and large-sized zooplankton (rotifers, nauplius larvae, copepodites and adult stage of copepods)
<i>M. cephalus</i>	Lake water without treatment and 12 fishes of the same size category	Protozoa, small- and large-sized zooplankton and <i>Mugil cephalus</i>
<i>T. zilli</i>	Lake water without treatment and 12 fishes of the same size category	Protozoa, small- and large-sized zooplankton and <i>Tilapia zilli</i>

Twenty liters were daily filtered from each enclosure using 20µm-mesh net. The filtered organisms were preserved in 4% neutral formalin, and then identified according to Tuffrau (1960), Bick (1972) and Harrison and Corliss (1991).

The water pH and temperature were measured by digital Orion pH meter (model 201) in the enclosures directly. Concentration of ammonium (NH₄) was measured according to standard methods of American Public Health Association (APHA, 1980). The gut contents of the fishes were also analyzed.

Population growth rates (r) of the dominant protozoan species were calculated from the changes in abundance (per day) by Gauld's equation (1951), assuming exponential growth $r = \ln \{N(t) / N(0)\} / t$, where $N(0)$ and $N(t)$ are the mean number of ciliates at the start and the end of the experiment respectively, and "t" is the duration time of the experiment.

RESULTS AND DISCUSSION

Physicochemical parameters

Both air and water temperatures were nearly constant during the time course of the experiment, with average of 27.7 ± 2.1 and $22.6 \pm 1.1^\circ\text{C}$ (mean \pm SD) respectively. The pH values ranged from 7.39 to 8.00 (7.74 ± 0.13 , mean \pm SD). The variation was narrow in the first three days then stabilized.

Ammonium ranged from $64.39 \mu\text{g l}^{-1}$ to 1.05mg l^{-1} during the experiment. The maximum values were recorded during the last day (seventh day) of the experiment, especially in the fish enclosures (Fig. 1). These increases may be due to: (1) regeneration of ammonium by protozoan and zooplankton organisms. In this respect, Korstad (1983) studied nutrient regeneration by zooplankton in Southern Lake Huron (USA), and found that zooplankton regenerate $23.28 \mu\text{g N (mg dry wt)}^{-1} \text{day}^{-1}$. Moreover, Janik (1989) measured the rates of ammonium released by the natural zooplankton assemblages in Lake Castle (California), and found that zooplankton provided $30.7 \mu\text{g N (mg dry wt)}^{-1} \text{day}^{-1}$. (2) accumulation of the dead organisms. Protozoans are usually short-lived (1-2 days) (Buskey *et al.*, 1993). Rotifers can persist from 1-7 days, while copepods persist for a matter of days or weeks according to the instar (Payne, 1986). (3) the fish faeces may also responsible for the increase of ammonium in fish enclosures.

Analysis of organisms

A. In the control enclosure:

At the start of the experiment, the lake protozoan organisms represented numerically 48.12% of total zooplankton organisms and were dominated by three species; namely *Tintinnopsis kofoidi*, *Helicostomella subulata*, and *Euplotes vannus*. Copepods form 39.20% (of the total zooplankton number) and dominated by the juvenile stages of *Paracartia latesetosa*. It was followed by rotifers (7.51%) that dominated by *Brachionus plicatilis* (forming about 98% of the total rotifer number). These results are nearly similar to those reported by Khalifa (1994) and Mageed (1998) in Lake Qaroun.

The total number of protozoan organisms increased gradually up to the fifth day; thereafter it increased dramatically on the sixth day, and then started to decrease on the last day (Fig. 2A). This decrease may be due to the increase of ammonium concentration during this period.

B-In presence of the small-sized organisms (SS)

The increases in total protozoan number as well as the most dominant protozoan species were lower than control in SS enclosure. The number of *H. subulata* was increased after the fifth day only (Fig. 1B). Such decrease in protozoan organisms was concomitant with the increase in rotifers and copepods (Fig 7). This means that both rotifers and nauplius larvae have some regulatory effect on the protozoan organisms. In this respect, Arndt (1991) revealed that, ciliates should be a common part of the food of most rotifer species. Gilbert and Jack (1991) had also found that, in the absence of edible algal food, rotifers might extensively prey ciliates in natural plankton communities, ingesting 25 to 50 individuals daily. Taniguchi and Kawakami (1985) have cultivated the tintinnid *Favella taraikaensis* and the rotifer *Synchaeta vorax* with *Prorocentrum* as the only source of food. They found competition between tintinnids and rotifers. Ingrid *et al* (1996) stated that the early stages of copepods might compete for food with ciliates, so it can decrease ciliates indirectly.

C-In presence of small and large sized organisms (SLS)

The total protozoan number was similar to the control over the time course of the experiment. However, the number of *T. kojoidi* decreased in presence of SLS than in the control; whereas for *H. subulata* the reverse was reported. For *E. vannus*, the number decreased gradually up to the third day and increased again during the fourth day where it reached its maximum number. Thereafter, its number returned to the control level up to the seventh day

Burns and Schallenberg (1996) and Wickham (1998) considered protozoans as important food for copepods, whereas Ingrid *et al* (1996) and Merrell & Stoecker (1998) found that one should expect an ontogenetic shift from strong competition with ciliates in early life history stages of copepods to weaker competition in adult stages. Copepods, the main predators of tintinnids, may also consume rotifers (Egloff, 1988; Pinel-Alloul, 1995 and Lam-Hoai *et al*, 1997). The feeding of copepods on rotifers decreased predation of Protozoa by copepods in presence of rotifers.

D In presence of Fishes

The impact of the fishes on protozoa was more pronounced in presence of *M. cephalus* than *T. zilli* compared with the control

enclosure (Figs 3 & 4). The number of protozoan organisms decreased in presence of these fishes with similar trends for the three protozoan species. The presence of these planktivorous fish leads to decrease in macrozooplankton population. Thus, the small zooplankton has increased and fed on the protozoan organisms or compete with them on food.

Analysis of gut contents of *M. cephalus* revealed that adult copepods are the main item in the gut (representing 36.74% of total zooplankton number in the gut). They were followed by rotifers and nauplius larvae. Protozoan organisms were also observed in the gut content of *M. cephalus* (Table 2). They represented 14.29% of the gut content. These results are in agreement with Zimann *et al.* (1975) who stated that, copepods were found to be the most important food items in the gut content of grey mullet in the Haif Bay region. For *T. zilli*; rotifers, nauplius larvae and adult copepods represented 37.5%, 26.56% and 25% of the gut contents respectively, while protozoans represented only 4.69%. In this concern, Shabrawy and Fishar (1999) revealed that, nauplius larvae and adult *Paracartia latisetosa* were the most important food items in the gut content of mullet of Lake Qaroun. The decrease in protozoa in the gut contents of the species may be due to the very fast digestion of protozoa.

Net population growth rates (NPGR, $r \text{ day}^{-1}$):

Several methods have been used to measure population growth rate of ciliates, including extrapolations (Leakey *et al.* 1992), frequency of dividing cells (Heinbokel, 1987), and incubation of size-fractionated water samples (Gilron and Lynn, 1989). The later method was applied in the present investigation since it is convenient for use in multispecies assemblages. This approach has assumed that all potential ciliate predators are removed by filtration. However, several predators of the same size of ciliates may pass through the filters (Doland, 1991). The net growth rates estimated by this method should therefore be considered conservative (Verity, 1986).

Total net population growth rate of protozoan organisms during the experiment was higher in control (2.15 day^{-1}) followed by SLS enclosure (2.1 day^{-1}). NPGR increased to the maximum value in the sixth day (Fig. 9).

NPGR of *T. kofoidi* was the highest especially in presence of the SLS (1.18 day^{-1}), while its lowest was recorded in presence of *M. cephalus* (0.63 day^{-1}). For *H. subulata*, the net population growth rate was higher in presence of the SLS than the control, while it decreased

in presence of fishes especially *M. cephalus*. Net population growth rate for *E. vannus* was the lowest. (0.47 day^{-1}) in the presence of *T. zilli*. The growth rates of *E. vannus* was negatively influenced by *M. cephalus* (-0.39 day^{-1}).

Net protozoans growth rates of total dominant protozoan organisms ranged from 0.38 to 2.15 day^{-1} . They were nearly similar to those reported by Schiewer *et al* (1990) (1.9 day^{-1}). Furthermore, Nielsen and Kiorboe (1994) stated that the true planktonic bacterivorous ciliates $<15 \mu\text{m}$ have relatively low growth rates ($\sim 0.5 \text{ day}^{-1}$). Ingrid *et al.* (1996) found that the rotifers have some regulatory effect on the protozoan organisms. They also found that the high specific growth rate for ciliates imply high ability to rapidly increase population size. Ciliates are able to grow 2-20 times faster than copepods under optimal conditions, but they are controlled through predation of copepods on them. (Nielsen and Kiorboe, 1991).

In conclusion, protozoa are important food item for the small-sized and with a lesser extent to large-sized zooplankton. They can also be consumed by the two studied fishes especially *M. cephalus* so that the production of protozoa can be used in feeding of more transplanted *Mugil* fry in the lake.

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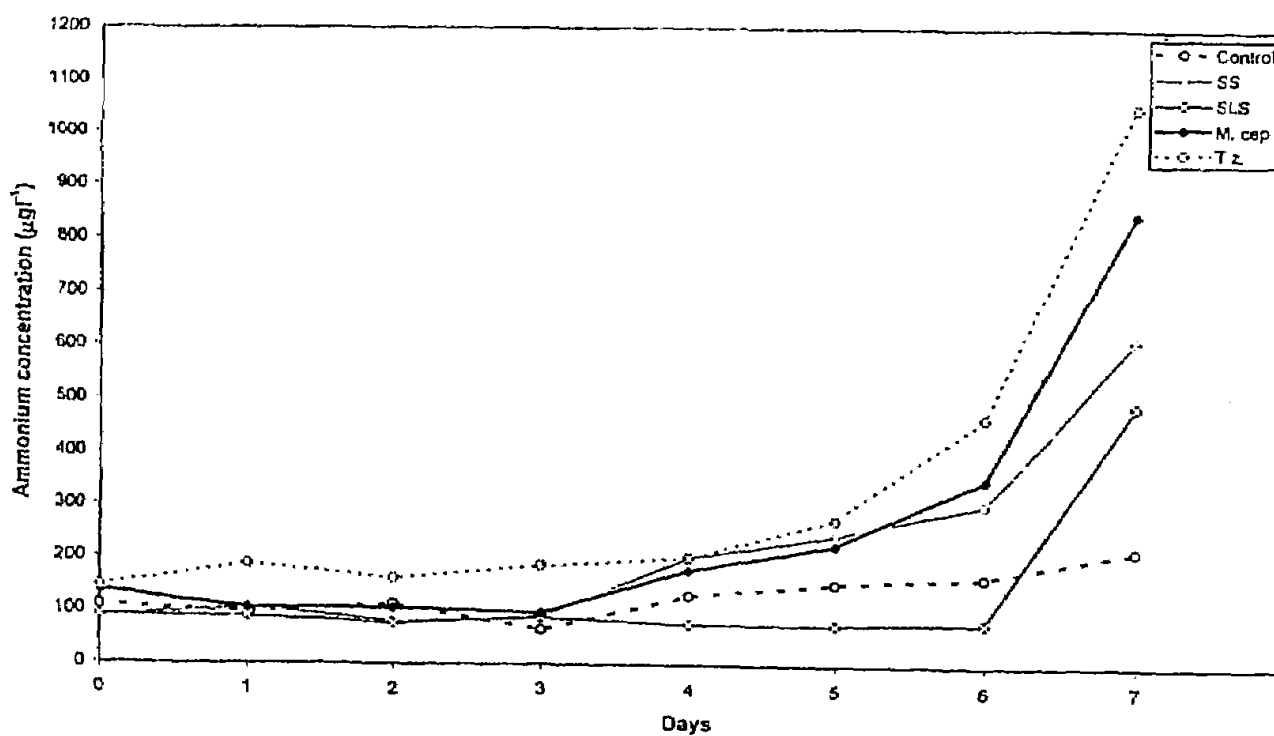
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Table (2): Gut contents of *Mugil cephalus* and *Tilapia zilli* of the experiment

	<i>Mugil cephalus</i>	<i>Tilapia zilli</i>
Protozoa	14.29%	4.69%
Rotifera	19.39%	37.5%
Nauplius larvae	36.74%	26.56%
Copepodite stages	11.23%	6.25%
Adults of copepods	18.37%	25%

Fig. (1): Ammonium concentration ($\mu\text{g l}^{-1}$) in the different enclosures over 7 days

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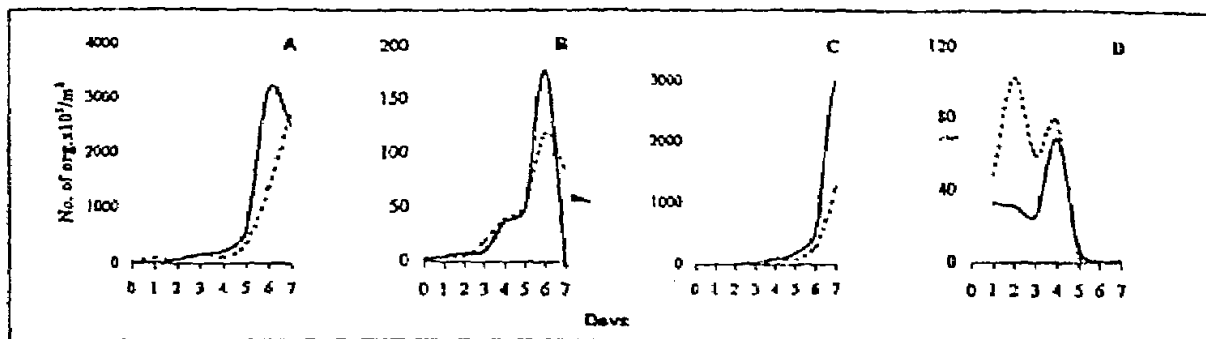


Fig. (2): Comparison of the mean numbers, $n=3$ (organisms/ m^3) of A: total protozoan organisms, B: *Halicostomella subulata*, C: *Tintinnopsis kofoidi* and D: *Euplotus vannus* in control (continued line) and small-bodied enclosures (dashed line)

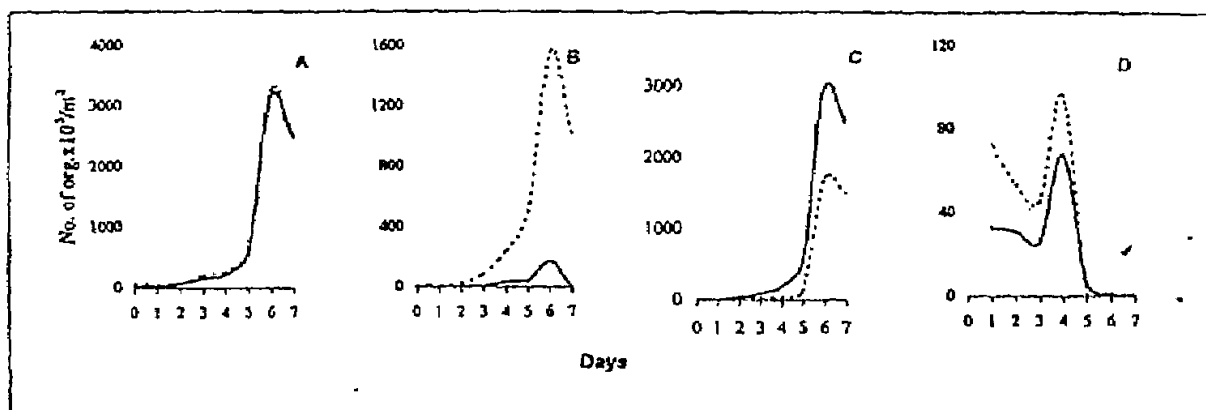


Fig. (3): Comparison of the mean numbers, $n=3$ (organisms/ m^3) of A: total protozoan organisms, B: *Halicostomella subulata*, C: *Tintinnopsis kofoidi* and D: *Euplotus vannus* in control (continued line) and small and large-bodied enclosures (dashed line)

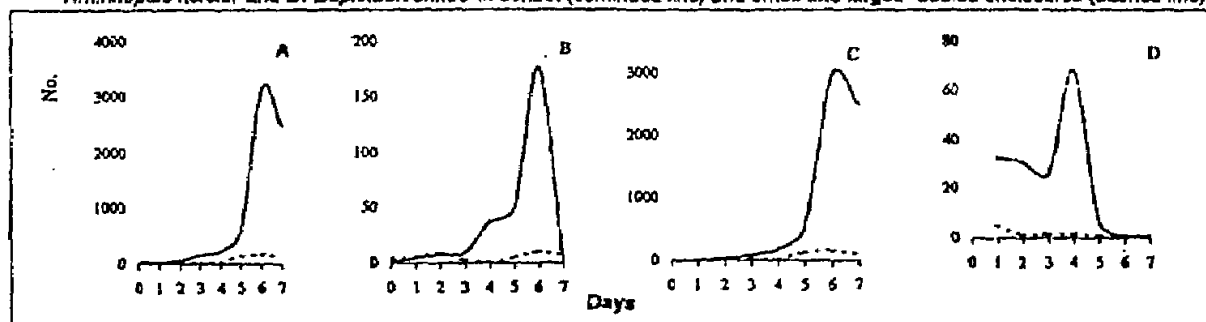


Fig. (4): Comparison of the mean numbers, $n=3$ (organisms/ m^3) of A: total protozoan organisms, B: *Halicostomella subulata*, C: *Tintinnopsis kofoidi* and D: *Euplotus vannus* in control (continued line) and *Mugil cephalus* enclosures (dashed line)

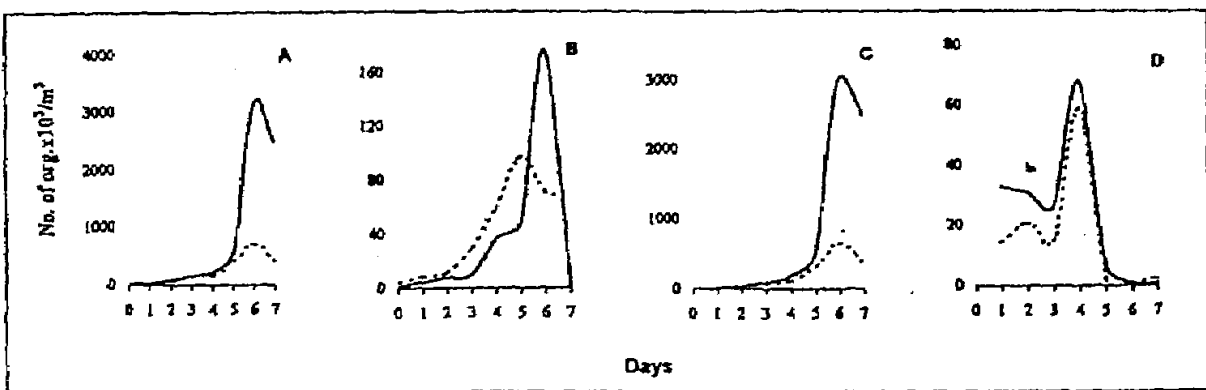


Fig. (5): Comparison of the mean numbers, $n=3$ (organisms/ m^3) of A: total protozoan organisms, B: *Halicostomella subulata*, C: *Tintinnopsis kofoidi* and D: *Euplotus vannus* in control (continued line) and *Tilapia zillii* enclosures (dashed line)

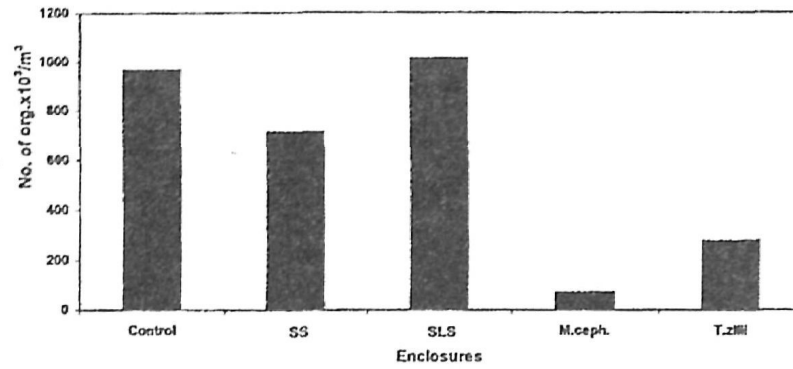


Fig.(6): Average number of the common protozoan organisms (org./m³) in the different enclosures

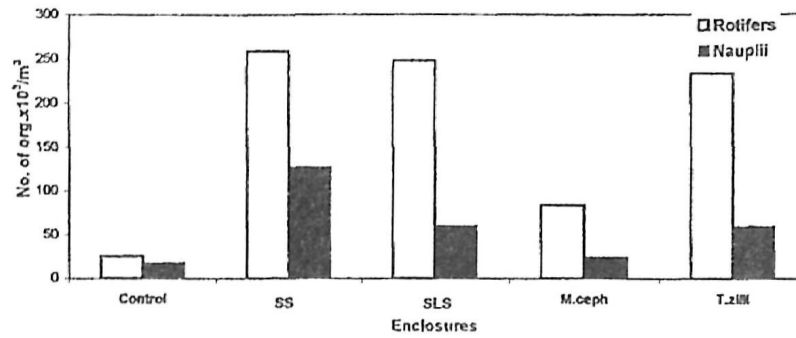


Fig.(7): Average number of the common small-sized zooplankton (org./m³) in the different enclosures

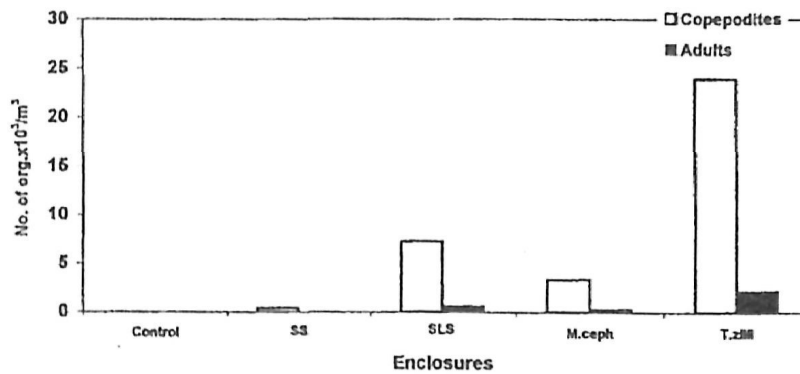


Fig.(8): Average number of the common large-sized zooplankton (org./m³) in the different enclosures.

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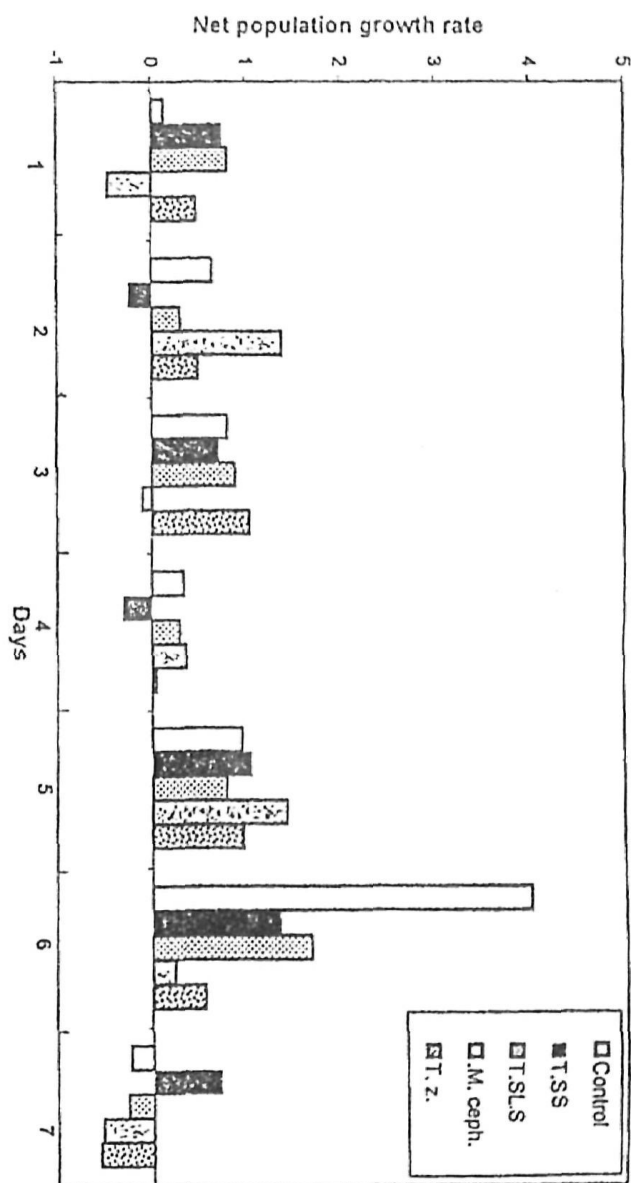


Fig. (9): Net population growth rate of total protozoan organisms in different enclosures over 7 days