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# SHORT TERM VARIATIONS OF ZOOPLANKTON COMMUNITY IN THE WEST NAUBARIA CANAL, ALEXANDRIA, EGYPT

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## ABSTRACT

The variations of zooplankton structure and abundance were studied at short time intervals in the northern part of the West Naubaria Canal, near the sea side, based on weekly sampling from May 2002 to May 2003 .The community represented high species richness (120 species), and relatively low population density ( annual average 31340 organisms/m.$^3$). Freshwater forms were the major representatives (68 species) of the community, including the sea side station. However, several marine species were reported inside the canal at a long distance from the sea. The community structure showed wide weekly variations (4-29 species), while between stations the differences were small. Relative to salinity in the canal, diversity index sustained the highest value (annual average 1.8) at the sea side station (St. 1) with surface salinity 11.1 PSU compared to the values reported at the other stations (annual averages 1.5-1.7) with average salinity was 8.7, 7.6 and 6 PSU at stations 2, 3 & 4 respectively. The diversity index experienced also clear temporal variations at all stations, parallel to those of standing crop and number of species. The zooplankton abundance showed wide changes on both scales of time and space, with an annual average of 34.4, 17.1, 33.2 and 40.6 x $10^3$ organisms /m$^3$at station 1-1V respectively, and weekly values varying from a minimum of 150 organisms /m$^3$ to a maximum of 797.7 x $10^3$ organisms /m$^3$.

Despite of salinity differences, copepods, mainly their nauplii larvae were the absolute predominant component at all stations representing a very stable fraction of zooplankton forming 66.1%-77.9%, while different patterns of co-dominance were observed at different stations relative to salinity variations.

## INTRODUCTION

The West Naubaria Canal was constructed to collect agricultural drainage water from the cultivated land around south and south west of Alexandria. Along the study area, its depth varied between 1.5-2 meters and its width is about 20 m. In 1986, it was connected to the Mediterranean Sea at the kilometer 21 of Alexandria – Matrouh Highway. The drainage water is loaded by high amounts of nutrients as well as industrial and domestic wastes. The canal is connected at certain part with Omum Drain which discharges great amount of different types of waste water to Max Bay. The rate of water exchange between the canal and the open sea and the volume of discharged waste water often interact with complex dynamics on a wide range of spatial and temporal scales, and fluctuations in ecological parameters can be quite complex. These features are expected to impact the structure and abundance of zooplankton community inside the canal and the sea area surrounding its opening.

No studies are so far known to be carried out on the physico-chemical and biological characters of the West Naubaria Canal since it was connected to the Sea, except that of Gharib and Dorgham (2003) on the phytoplankton. The present study is considered as the first comprehensive survey of zooplankton composition and abundance, based on short term intervals of samples collection.

## MATERIALS AND METHODS

Zooplankton samples were collected weekly for one year from May 2002 to May 2003 at four stations in the northern part of the West Naubaria Canal. The study area extended for about 2 km between the sea shore and the Highway of Alexandria – Matrouh (Fig.1). Vertical hauls were done from bottom to surface at each station, using a plankton net of 55 µ. The samples were preserved immediately after collection in 4 % neutralized formalin. Concurrent samples were collected for ecological studies, including temperature, salinity, dissolved oxygen, nutrient salts ($NO_2$, $NO_3$, $NH_4$, $PO_4$, and $SiO_4$), Secchi depth and Chl a. but they will be considered in a separate paper.

Identification of zooplankton species was performed following the keys of Rose (1933), Tregouboff and Rose (1957), Edmondson (1959), Hutchinson (1967), Dussart (1969), Marshall (1969), Bradford (1972) and Malt (1983). The standing stock was estimated from the average count of three aliquots, 5 ml each and expressed as number of individuals per cubic meter.

Species diversity was determined following Shannon and Weaver (1963) and the number of species was considered as an index of species richness. Correlation coefficient between zooplankton abundance and some environmental factors were also calculated according to Moore and Shirely (1972).

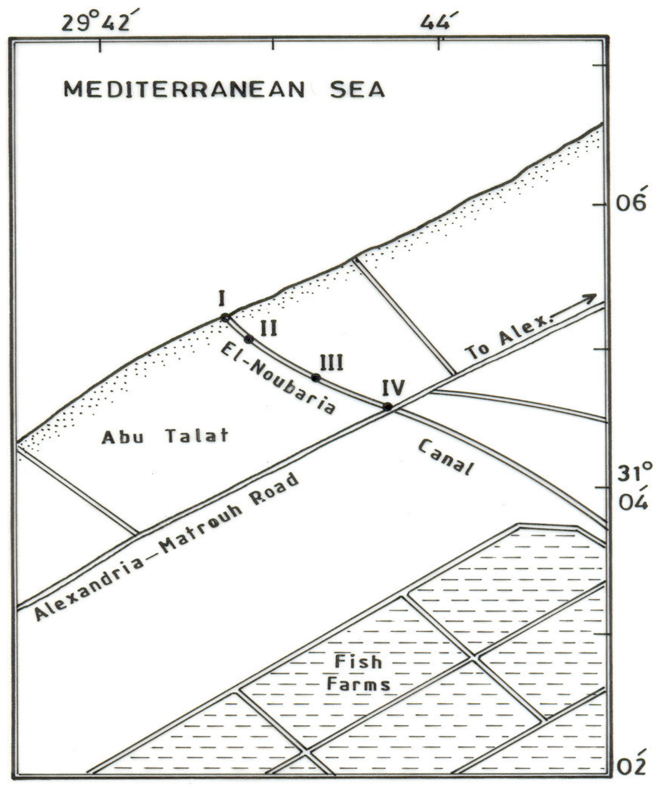


**Fig.1. The map showing El-Naubaria Canal and the sampling stations.**

## RESULTS AND DISCUSSION

The West Naubaria Canal is characterized by its changeable environmental conditions due to two main factors, namely: the discharged waste water of different types reacheing the canal from the surrounding area, and seawater which enters the canal and causes variation of its salinity along relatively long distance from the sea shore.

The water temperature ranged between 19.5-29°C (Table 1).The vertical profile of salinity indicates a pronounced difference between surface and bottom water, the surface water had low salinity, varying between 2.9 - <15 PSU while the near bottom water demonstrated higher salinity (5- 30.5 PSU). This indicates the dominance of a brackish water current seaward all the year round and the penetration of seawater into the canal for a considerably long distance from the seashore through the subsurface layer.

Dissolved oxygen content showed little variations and always near the critical levels (3-4.9 mg/l) for the living organisms (Stachowitzsch and Avcin, 1988). Regardless of being originated from agricultural drainage waters, the canal sometimes suffered from deficient nutrients like $NO_2$, $NH_4$, and $PO_4$, while in other times reached pronouncedly high concentrations. However, $NO_3$ and $SiO_4$ were extremely high all the year. The canal water was mostly highly transparent, whereas the Secchi depth readings in many occasions reached to the bottom. The phytoplankton biomass (0.36-2.56 µg/l) did not indicate high primary production. This may be related either to the stress of zooplankton grazing or to the wide variations of environmental conditions in general and N/P ratio in particular.

Zooplankton community in the West Naubaria Canal was rich in species numbers (120 species) (Table 2), perhaps due to the effect of mixing of both freshwater and marine species. The majority of species were freshwater forms (68 spp.) and the rest (52 spp.) were euryhaline marine forms. Several marine forms were observed at different parts of the canal. By number of species, rotifers were the most abundant (31 species), followed by copepods (22 species), tintinnids (18 species) and freshwater ciliates (16 species).

**Table1: Ranges and averages of ecological parameters in West Naubaria Canal (2002-2003)**

| Parameter | Min. | Max. | Average |
|---|---|---|---|
| Temperature (°C ) | 19.5 | 29 | 25.4 |
| Salinity (PSU) | 2.9 | 30.5 | 6.03 |
| DO (mg/l) | 3.0 | 4.9 | 3.95 |
| PH | 7.5 | 8.54 | 8.08 |
| Secchi depth (cm) | 100 | 230 | 153 |
| Chl a (µg/l) | 0.36 | 2.56 | 0.91 |
| $NO_3$ (µM/l) | 9.51 | 81.13 | 48.93 |
| $NO_2$ (µM/l) | 0 | 2.32 | 0.98 |
| $NH_4$ (µM/l) | 0 | 99.5 | 3.14 |
| $PO_4$ (µM/l) | 0 | 1.86 | 0.36 |
| $SiO_4$ (µM/l) | 16.1 | 196.6 | 153.5 |
| N/P | 40 | 1145 | 236 |

**Table 2: Zooplankton species recorded in the southern part of the West Naubaria Canal (May 2002-May 2003).**

| | |
|---|---|
| **PROTOZOA:** | **FORAMINIFERA** |
| **A- CILIOPHORA** | *Adelosina elegans* |
| *Amphileptus claparedei Stein* * | *Ammonia beccarii Linne* |
| *Bursaridium sp.* * | *Cibicides refulgens Montfort* |
| *Disematostoma sp.* * | *Eponides repandus Fichtel & Mole* |
| *Epistylis sp.* * | *Globigerina bulloides d'Orb.* |
| *Euplotes sp.* * | *Globigerina Inflata d'Orb.* |
| *Oxytricha fallax Stein* * | *Globorotalia truncatuloides d'Orb.* |
| *Paramecium sp.* * | *Loxostomum plaitum Carsey* |
| *Strombidium sp.* * | *Quinqueloculina seminulum Linnaeus* |
| *Strongylidium sp.* * | *Quinqueloculina striata d'Orb.* |
| *Trachelius sp.* * | *Spirillina vivipara Ehren.* |
| *Trichodina sp.* * | Spiroloculina limbata d'Orb. |
| *Vasicola ciliata Tatem* * | Textularia sp. |
| **TINTINNIDS** | **CNIDARIA** |
| *Codonellopsis morchella Cleve* | Medusae of Obelia sp. |
| *Epiplocylis undella Ost. & Schm.* | **ROTIFERA** |
| *Eutintinnus fraknoi Daday* | *Anuraeopsis fissa Gosse* * |
| *Eutintinnus lusus -undae Entz* | *Ascomorpha saltans Beauchamp* * |
| *Favella adriatica Imhof.&Bdt.* | *Asplenchna priodonta Gosse* * |
| *Favella azorica Cleve* | *Brachionus angularis Gosse* * |
| *Favella composita Jorg.* | *Brachionus bidentata* * |
| *Favella ehrenbergi Clap.& Lahm.* | *Brachionus calyciflorus Pallas* * |
| *Favella markusovszkyi Dad.* | *Brachionus caudatus Barrios & Daday** |
| *Helicostomella subulata Ehr.* | *Brachionus plicatilis O.F.Muller* * |
| *Metacylis mereschkowskii Kof & Campb.* | *Brachionus urceolaris O.F.Muller* * |
| *Rhabdonella elegans Jorg.* | *Cephalodella gibba Ehren.* * |
| *Rhabdonella spiralis Lachm.* | *Colurella adriatica Ehr.* * |
| *Tintinnopsis beroidea Stein* | *Filinia terminalis* * |
| *Tintinnopsis compressa Dad.* | *Keratella cochlearis Gosse* * |
| *Tintinnopsis lata Meun.* | *Keratella quadrata O.F.Muller* * |
| *Tintinnopsis nordguisti Leprotin* | *Keratella valga Ehr.* * |
| *Tintinnopsis vosmaeri Dad.* | *Lecane depressa* * |
| **B- RHIZOPODA** | *Lecane luna O.F.Muller* * |
| *Arcella discoides Ehr.* * | *Lepadella patella O.F.Muller* * |
| *Centropyxis constricta Ehr.* * | *Macrochaetus collinsi* * |
| *Centropyxis ecornis Ehr.* * | *Monostyla bulla Gosse* * |
| *Difflugia lebes Penard* * | *Monostyla closterocerca Schmarda* * |

**Table 2- Continued.**

| | |
|---|---|
| *Monostyla quadridentata Ehr.* * | *Euterpina acutifrons Dana* |
| *Polyarthra vulgaris Carlin* * | *Halicyclops magniceps Lilljeborg* * |
| *Proales daphnicola Thompson* * | Horsiella bravicornis Vass Dauwe * |
| *Pseudoharringia similis* * | *Mesochra sp.* * |
| *Synchata oblonga Ehr.* * | *Microsetella rosea Dana* |
| *Synchaeta okai Sudzuki* * | *Nitocera lacustris Schmank.* * |
| *Synchaeta grimpei Remane* * | *Oithona nana Giesbr.* |
| *Synchaeta pectinata Ehr.* * | *Onychocamptus mohammed Kewitsch* * |
| *Trichocerca longiseta Schrank* * | *Paracalanus parvus Claus.* |
| *Trichocerca marina Daday* | *Schizopera clandestina Klie.* * |
| **NEMATODA** | **CLADOCERA** |
| *Achromadora sp.* * | *Alona intermedia Sars* * |
| *Aphelenchoides sp.* * | *Lynceus bukobensis Weltner* * |
| *Dorylaimus sp.* * | *Moina micrura Kruz* * |
| *Rhabdolaimus sp.* * | *Podon polyphemoides Leuckart* |
| *Trilobus sp.* * | **OSTRACODA** |
| **Polychaetes** | *Candona subgibba Sars* * |
| *Chaetogaster sp.* * | *Cypria obesa Sharpe* * |
| **COPEPODS** | *Cypria pellucida Sars* * |
| *Acanthocyclops americanus Marsh* * | **LARVACEAE** |
| *Acartia clausi Giesbr.* | *Oikopleura dioica Fol* |
| *Acartia grani Sars* | **CHAETOGNATHA** |
| *Acartia latisetosa Kricz.* | *Sagitta friderici R.Z.* |
| *Cannula perplexa Scott* * | **AMPHIPODA** |
| *Calocalanus pavo Dana* | *Corophium sp.* |
| *Canthocamptus gracilis Sars* * | *Gammarus sp.* |
| *Centropages kroyeri Giesbr.* | **ISOPODA** |
| *Clausocalanus arcuicornis Dana* | *Apseudes sp.* |
| *Corycaeus clausi Dahl.* | **PTEROPODA** |
| *Corycaeus speciosus Dana* | *Limacina inflata d'Orb* |
| *Ergasilus sieboldi Nordmann* * | |

* = Freshwater forms

Throughout the canal, the species richness decreased gradually from 106 species at the sea side station (St.1) to 88 species at the farthest one (St.4) inside the canal. Such pattern coincided with the decrease of salinity in the same direction. This agrees with the observation of Kingston *et al* (1983) who reported that diversity would be higher when two different communities mix together. Despite of the limited spatial variation, pronounced temporal differences were observed in number of species along the canal, whereas 4-29 species appeared weekly at each station. The temporal variation in the number of species is related to the seasonal succession in the community structure as well as to the growth pattern of different species. It appears that the variation in number of species influenced the diversity index which had wide weekly variations at each station, and also between stations every week (Fig.2). However, the annual average diversity index, similar to the number of species, decreased also with salinity decrease off the sea side in the canal, reflecting the effective contribution of the marine species in this context at the sea side station. This is clearly shown from the high significant correlation between the species richness and diversity index (r= 0.51525-0.5826, p=0.001) at the four stations.

The canal zooplankton showed two different periods of production, the first from 24 May to 30 August 2002, characterized by high standing crop with weekly average varying between 49.4 x $10^3$ and 291.5 x $10^3$ organisms/$m^3$, while the second period, from 6 September 2002 to 28 May 2003, had markedly low weekly population density (4.6 – 20.9)x$10^3$ organisms/$m^3$). Except the pronouncedly low value at station 2 (17.1x$10^3$ org./$m^3$), the abundance of zooplankton sustained approximately close annual average counts (34.4 -33.2) x$10^3$ org./$m^3$) at stations 1 & 3 and relatively higher one at station 4 (40.6x$10^3$ org./$m^3$). The surface low salinity current was usually directed towards the sea and reversed subsurface current of seawater occurs towards the canal. Therefore, station 2 can be considered as a mixing area of the two currents, causing continuous change of salinity, and consequently affect the standing crop at this station. On the other hand, zooplankton crop demonstrated wide weekly variations at all stations (Fig.3). The maximum abundance of zooplankton during late spring and summer may be attributed to favorable conditions, such as higher temperature, stable water conditions and abundance of food. Kiorboe and Nielsen (1994) noted that blooms of diatoms were always due to chain forming (spring phase) or small centric (summer phase) diatoms. The latter were probably too small (<10um) to be significantly grazed by adult copepods, which were the main component of zooplankton stock most of the year. This agrees with Gharib and Dorgham (2003) who concluded that diatoms play the major role in phytoplankton production during these two seasons. However, copepods showed some preference for food other than phytoplankton such as microzooplankton, other suspended material, detritus, or a combination of all, as indicated by Christou and Moraitou-Apostopoulou (1995). Rotifers contributed frequently significant role at stations 2, 3 and 4 during the period from December to May, but less so at station 1 (Fig. 4), which was strongly influenced by the seawater. This indicates the extreme flexibility of copepods present in this study area in adapting to a fluctuating environment at all stations.

Freshwater ciliates showed temporal active contribution to the zooplankton stock, particularly from January to May 2003, with the highest relative abundance at station 4 .The medusae of cnidarian *Obelia* sp. contributed sometimes significant role up to 40% of the total zooplankton at first station, while it decreased far from the sea inside the canal

The distribution of key species showed different patterns, as they were more clearly controlled by salinity levels. Copepod nauplii which represent the main prey item for fish larvae were the most abundant component of zooplankton throughout the canal (66.1-77.9%) with increasing relative abundance at seaside. The higher density of copepods at sea side station may be attributed to the contribution of both freshwater and marine species. This is in agreement with Peter *et al* (2003) who in south Florida straits hypothesized that elevated abundance of copepod nauplii would be present in convergent frontal zones resulting from aggregation of adult and larval copepods in presence of relatively higher food (Chlorophyll a) concentration. Boyd and Smith (1983) reported increased abundance of copepod nauplii in areas of mixing associated with upwelling off the coasts. Lamellibranch veligers demonstrated also active contribution at all stations but with decreasing order, in contrast to copepod nauplii. Meroplankton has been hypothesized to utilize near shore circulation to enhance recruitment success via larval transport to habitats favorable for growth in coastal regions (Bjorkstedt and Roughgarden, 1997).

It seems that the decreasing and increasing order of relative abundance for both types of larvae were related to their affinity to salinity distribution along the canal. This is indicated from the increasing significance of the correlation coefficient value ( r ) between salinity and copepod nauplii and vice versa for Lamellibranch veligers, as we go far from the sea (Table 3).

Copepodites, Polychaete larvae, *Acartia clausi*, *Oithona nana* and *Synchaeta okai* were restricted to stations 1 and / or 2, which had higher salinity, while *Brachionus plicatilis, Anureopsis fissa* and cirriped larvae are dominated at the inner part of the canal, with lower salinity. Raymont (1983) mentioned that *Acartia clausi* and *Oithona nana* make up most of zooplankton numbers in many temperate marine environments and Polycheate larvae typically dominated in many estuaries. The marked seasonal increase in the density of *Synchaeta* spp. in estuarine and coastal waters may be due to their rapid parthenogenetic reproduction under favorable conditions, while the sudden decline in numbers may have resulted from a switch to the production of resting eggs in response to high population densities (Hernoth, 1983).

According to the frequency of species dominance with time, zooplankton in West Naubaria Canal could be divided into four categories, the first includes the persistent species which predominated during most of the study period such as *Nitocera lacustris, Halicyclops magniceps, Euterpina acutifrons, Acartia clausi, Acanthocyclops americanus, Achromadora* spp.*, Monostyla bulla, Colurella adriatica* and *Brachionus plicatilis.* The second category was represented by species that were intermittently dominanted throughout the year as *Dorylaimus* sp*., Synchaeta oblonga, Proales daphnicola, Brachionus calyciflorus, Ammonia beccarii, Adelosina elegans, Oxytricha fallax.* The third category includes species which dominated during certain period like *Bursaridium* sp.*, Tichodina* sp.*, Favella ehrenbergii, Schizopera clandestina, Paracalanus parvus, Oithona nana, Cannula perplexa, Synchaeta okai,* and *Onychocamptus mohammed.* There were other species which flourished occasionally (Fig. 5).

As shown in table 4, several of the dominant species, either marine or freshwater demonstrated different tolerance ranges to salinity variations. The marine copepod *Oithona nana*, as well as the freshwater rotifers, *Synchaeta okai* and *S. oblonga*, can withstand the widest salinity variations (6.0-30.7 and 4-30.7 PSU respectively). Other marine copepods such as *Acartia clausi, Paracalanus parvus, Acartia grani and Euterpina acutifrons* were able to tolerate the drop of salinity to 3.5 PSU. This is in agreement with Raymont(1983) and Paffenhofer (1993). The freshwater copepods *Halicyclops magniceps, Acanthocyclops americanus* and *Nitocera lacustris* extend their tolerance to 21.8-26 PSU and in the meantime,the rotifer *Brachionus plicatilis* was recorded at salinity up to 26 PSU.On the other hand, some species could not tolerate high salinity and were restricted to the area with relatively low salinity (14.8 PSU), like *Onychocamptus mohammed* ,*Oxytricha 7fallax*, *Asplanchna priodonta, Brachionus calyciflorus, Monostyla bulla*, *Monostyla closterocerca* and *Colurella adriatica*.

From the above observations, it was noticed that various changes in environmental conditions especially salinity which was continuously variable over short time scale, can severely affect the structure of coastal zooplankton communities.

**Table 3. Correlation coefficient between dominant zooplankton components and environmental factors as independent variables, (2002-2003).**

| Parameter | I | II | III | IV | P | n |
|---|---|---|---|---|---|---|
| S‰ # Nauplii | -0.29166 | -0.3592 | -0.37806 | -0.46362 | 0.1 | 48 |
| S‰ # Copepodides | --------- | 0.28696 | -0.32459 | -0.35758 | 0.1 | 48 |
| S‰ # Lamel. vel. | –0.26601 | -------- | -0.30994 | -0.46287 | 0.1 | 48 |
| DO # Nauplii | --------- | -0.36419 | --------- | 0.4294 | 0.05-0.1 | 24 |
| DO # Copepodites | -0.45178 | -------- | -0.3656 | --------- | 0.05-0.1 | 24 |
| DO # Lamel. vel. | –0.49577 | -0.57402 | -0.38973 | --------- | 0.05-0.1 | 24 |
| Chl. # Zoop. | –0.2955 | -0.354 | -0.31309 | -0.2985 | 0.05-0.1 | 30 |

S‰: salinity. **DO:** dissolved oxygen **Chl.:** Chlorophyll-a

**Table 4. Salinity range of the dominant zooplankton species**

| Species | S%o | Species | S‰ |
|---|---|---|---|
| *Trichodina sp.* | 4.8-26.1 | *Halicyclops magniceps* | 2.9-25.9 |
| *Favella ehrenbergii* | 5.7-14.8 | *Acanthocyclops americanus* | 4.0-21.8 |
| *Oithona nana* | 6.0-30.7 | *Nitocera lacustris* | 4.1-26.0 |
| *Obelia* spp. | 3.1-30.7 | *Brachionus plicatilis* | 3.1-26.0 |
| *Synchaeta okai* | 3.1-30.7 | *Onychocamptus mohammed* | 3.8-9.5 |
| *Synchaeta oblonga* | 4.0-30.7 | *Oxytricha fallax* | 3.1-11.9 |
| *Acartia clausi* | 3.5-26.1 | *Asplanchna priodonta* | 8.9-11.8 |
| *Achromadora* sp. | 4.3-26.1 | *Brachionus calyciflorus* | 3.5-9.5 |
| *Paracalanus parvus* | 5.4-19.4 | *Monostyla bulla* | 3.3-8.9 |
| *Acartia granii* | 18.7 | *Monostyla closterocerca* | 6.5-14.8 |
| *Euterpina acutifrons* | 3.5-21.8 | *Colurella adriatica* | 3.1-14.8 |

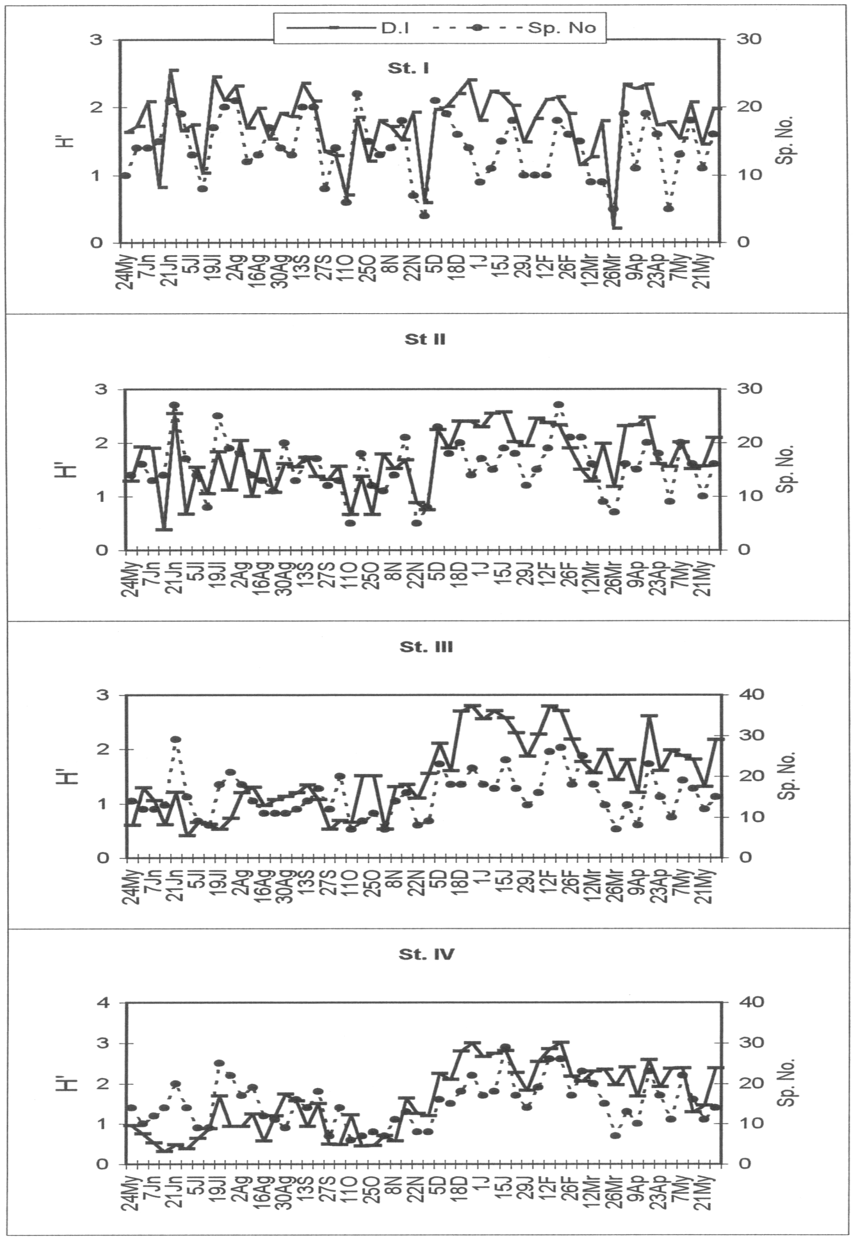


**Fig. 2. Weekly diversity index (H') and species number of zooplankton at different stations in West Naubaria Canal.**

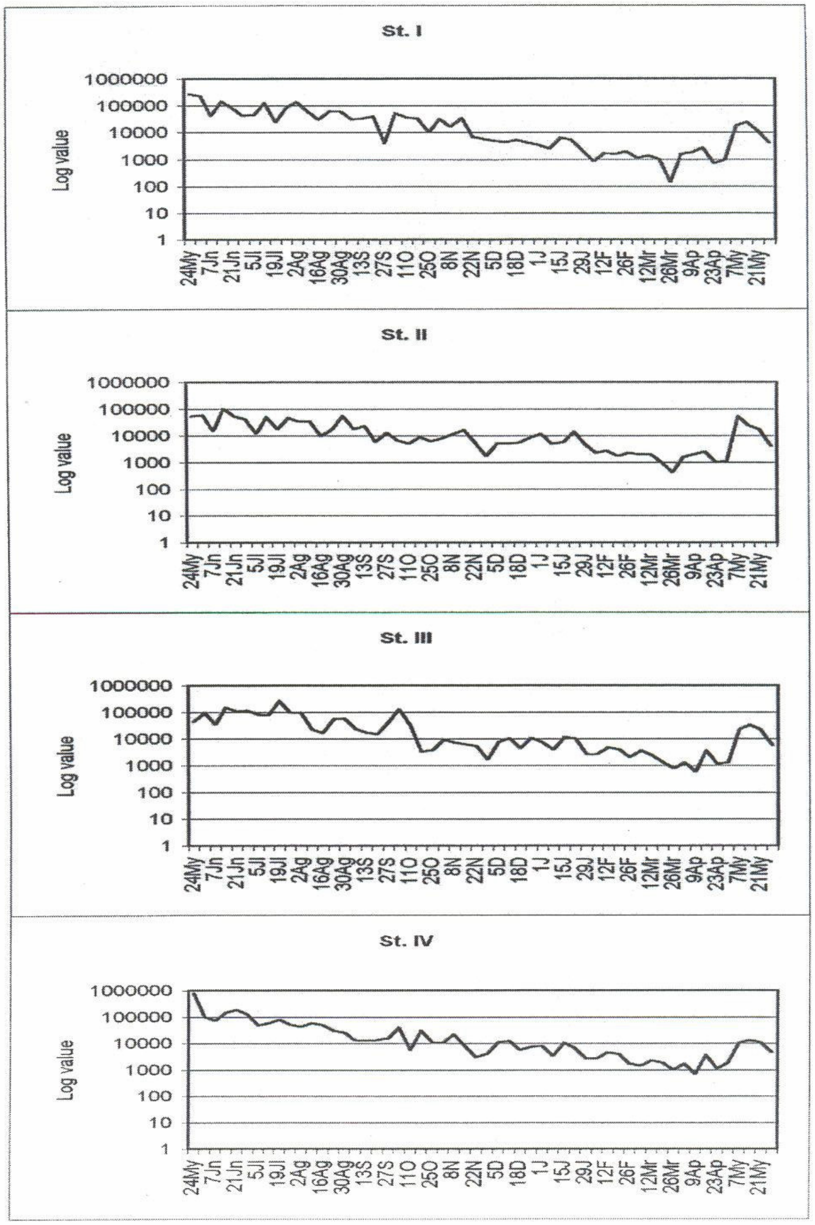


**Fig. 3. Weekly count of total zooplankton (Organisms/m^3) at different stations in West Naubaria Canal.**

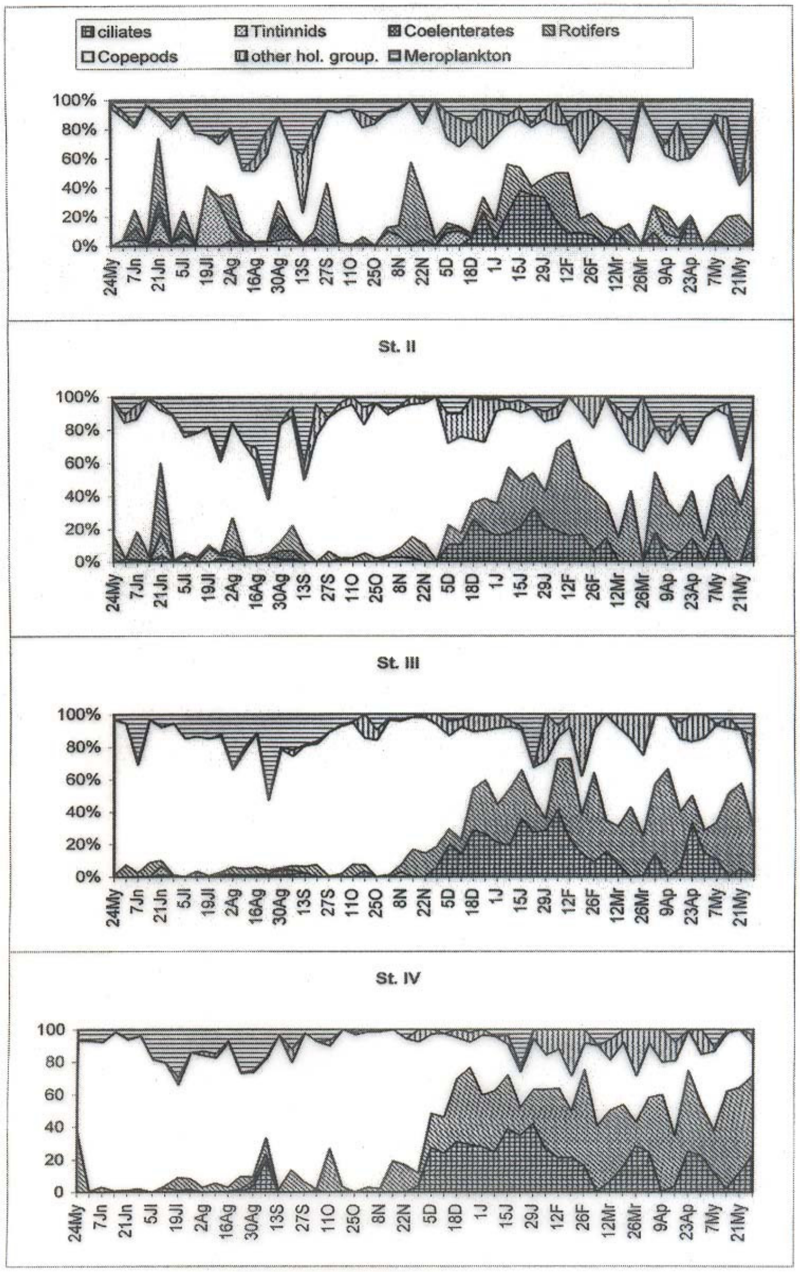


**Fig. 4. Weekly relative abundance (%) of different zooplankton groups at the sampled stations in West Naubaria Canal.**

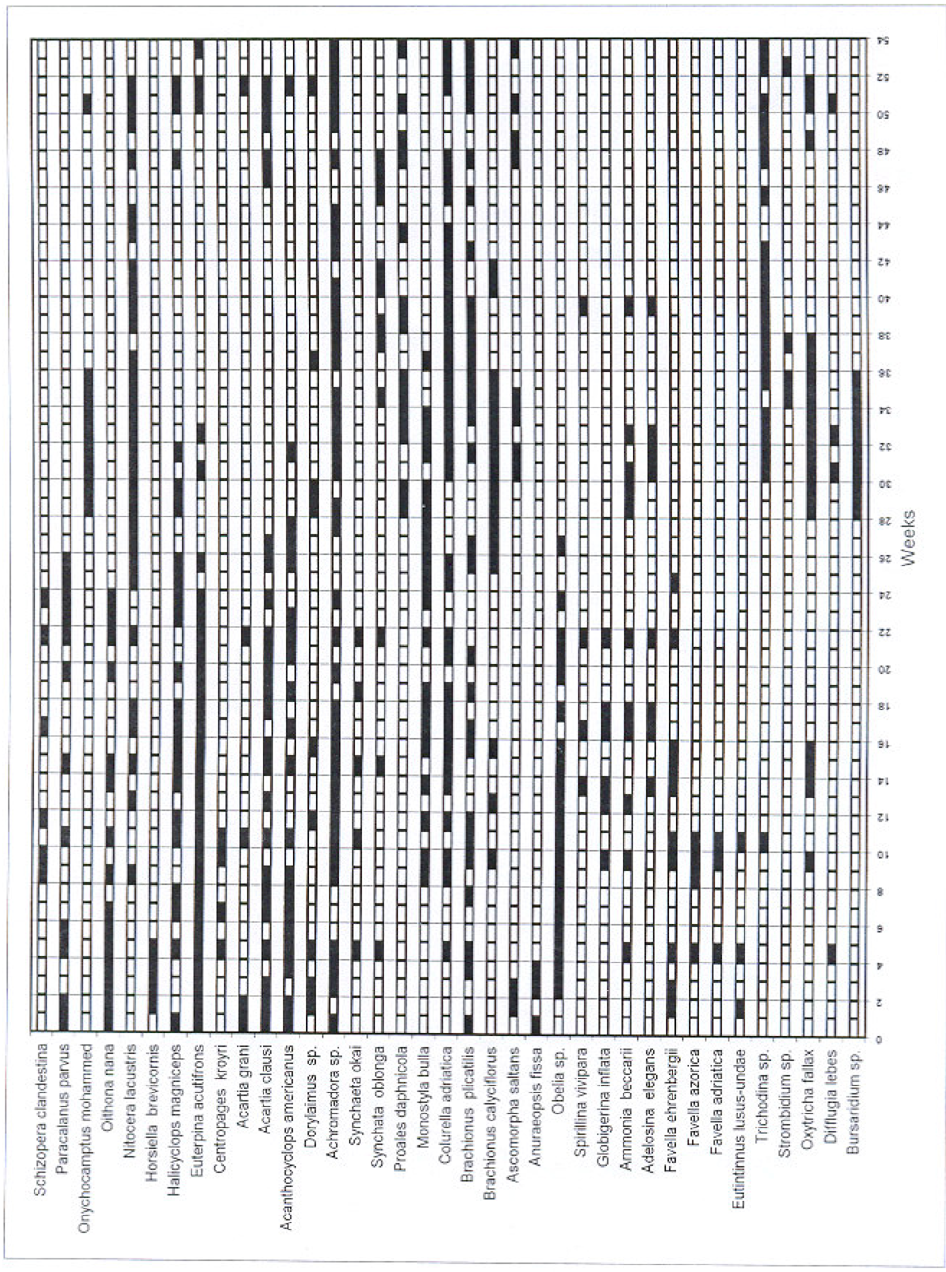


Fig. 5- The frequency of dominance of species with time in West Naubaria Canal

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