Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 24(4): 165 – 179 (2020)
www.ejabf.journals.ekb.eg

Distribution and abundance patterns of freshwater zooplanktons at different water habitats of Bahr Shebeen Nilotic Canal, Egypt

Sherin K. Sheir *, Gamalat Y. Osman, Abd Elhafez R. Abd Elhafez, Azza H. Mohamad
Department of Zoology, Faculty of Sciences, Menoufia University, Shebeen El-Koom, Egypt.

*Corresponding Author: sherin.sheir@yahoo.com

ARTICLE INFO

Article History:
Received: May 19, 2020
Accepted: June 12, 2020
Online: June 16, 2020

Keywords:
Zooplankton;
Diversity;
Environmental conditions;
Richness; indices

ABSTRACT

Zooplanktons are cosmopolitan organisms and impacted by environmental factors. So, freshwater zooplanktons were surveyed in three different sites at Menoufia governorate, Egypt from March 2017 till February 2018. Zooplanktons were collected monthly in order to evaluate the changes of its diversity and population density in the light of some environmental conditions. Three sites were selected at Bahr Shebeen Nitoltic canal, two of them were at Shebeen El-Koom city and the third was at Menouf city. Physico-chemical parameters values varied according to the season or the site. Nineteen species belong to 6 phyla, Protozoa, Cnidaria, Platyhelminthes, Nematoda, Rotifera and Arthropoda were recorded. The total number of collected zooplanktons showed differences in population density between sites. The highest percentage of individuals (89.52%) was recorded at the least polluted site with heavy metals concentrations, followed by (8.75 and 1.73 %) of the other sites. Classes Turbellaria, Monogonota and Crustacea were considered as abundant. However, Ciliophora, Hydrozoa, Secernentea, Bdelloidea and Insecta were common species. Insect larvae and copepods recorded the highest densities at the least polluted site (*P* = 0.04, ANOVA). Shannon diversity index, richness and evenness indices recorded the highest values at the least polluted site, followed by the other sites. It can be concluded that zooplanktons community structure and density efficiently responded to inter-specific variations of habitats with special reference to pollution type and less to environmental factors.

INTRODUCTION

Freshwater has many important values in human life, such as industrial purposes, power generation, role in the continuation of life, agriculture and domestic purposes like drinking, cooking, bathing and washing. Hence, water quality is a very important issue that should be studied.

Zooplanktons are a diverse group of heterotrophic organisms that consume phytoplankton, regenerate nutrients via their metabolism, and transfer energy to higher trophic levels (Steinberg and Condon, 2009). Freshwater zooplanktons are used as a bioindicator for the physical, chemical and biological processes in freshwater ecosystems, integrity of water besides forming an important link in the food chain. Zooplankton populations are considered bioindicators of eutrophication, as they are related to environmental conditions, responding more rapidly to changes than fishes and are easier to identify than phytoplanktons (Sládecek, 1983; Murugan *et al*., 1998). Changes in zooplankton community composition can affect the degree of up and down regulations of phytoplankton communities, influence the amount of nutrient availability, processing, and determine the capacity of aquatic ecosystems to uptake carbon dioxide (Brucet *et al*., 2010).

Zooplankton communities usually vary in composition as certain species which were highly sensitive to changes in temperature, nutrient cycling, and environmental fluctuations (Primo *et al*., 2015). Jeppesen *et al*. (2011) demonstrated that zooplankton richness inversely relate to amounts of phosphorus, which associated with eutrophic processes especially cladocerans which were sensitive to increased phosphorus. Some biotic and abiotic parameters, such as temperature, habitat differences, the presence or absence of fish and macrophytes, may affect the richness and composition of zooplankton species (Kaya *et al*., 2010).

The present work aimed to study freshwater zooplanktons, their population density, biodiversity indices and relationships with each other’s under the shade of environmental factors from different locations in Menoufia governorate, Egypt.

MATERIALS AND METHODS

The investigated sites

Freshwater zooplanktons at three sites in Menoufia governorate were selected for investigation. Sampling were monthly at the three sites and were collected during one year (March, 2017 till February, 2018, Fig. 1).

Site #1 was located in Bahr Shebeen El-Koom, Milig branch (coordinates between 30°34'50.3"N and 31°01'00.1"E), opposite to a River Conservative Police station, near to cars wash area. It is 1.5 meters depth and 22 meters width with substrate mainly formed of mud. The vegetation of this site composed of *Cinnamomum camphora, Atropa belladonna*, *Ceratophyllum demersum*, *Arundo donax* , several genera of Poaceae family.

Site #2 was located in Bahr Shebeen El-Koom, Tanta branch (coordinates between 30°34'51.1"N and 31°00'55.9"E) under a bridge and construction of a coffee shop was running during the period of investigation. The depth was 1 meter and the width was 6 meters, the sides were cemented and the substrate was formed mainly of silt. In this site, the vegetation were *Ceratophyllum demersum* and many genera of Poaceae family

Site #3 was located in Gezay village, Menouf city (8 km, coordinates between 30°27'26.8"N and 30°50'59.0"E) and surrounded by cultivated lands. The substrate of this site was composed mainly of mud and sand. This site is rich in water plant. It is 1.5 meters depth and 10 meters width. This site was characterized by no visible pollutants (non-point source of pollution). The vegetation of this site was similar to site one. Vegetations of the three sites were identified depending on personal communication with Professor Dr. Zaki Tork (Botany Department, Faculty of Science, Menoufia University).

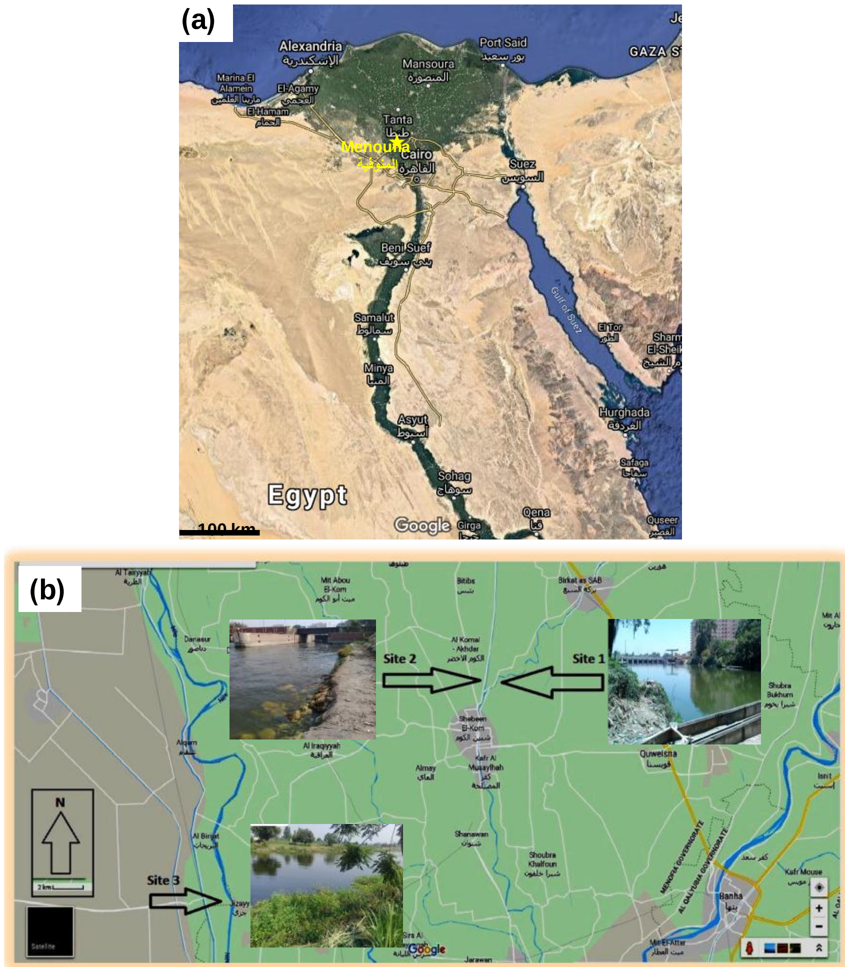

Fig. 1: (a) A map of Egypt with Menoufia governorate location (star) and **(b)** A satellite map and photographs of the three investigated sites **(**after Google.com/maps).

Samples collection and preservation

Sampling of specimens was carried out every month from each site at the time period from 9:30 to 11:30 am. About 3 litres of water column were collected from each site every month for freshwater zooplanktons investigation. The samples were transferred to lab after collection in labelled plastic buckets then preserved in collecting glass jars. Collected samples were examined and identified then preserved in 70% ethanol (Steedman, 1976).

Samples separation and counting

Collected water samples were shaken gently several times for few seconds prior to sampling in order to disperse specimens through the sample. Then, triplicate sub-samples (10 ml) were transferred into a petri dish to be examined under a binocular research microscope. The average number of the total individuals was calculated as mean of the triplicate sub-samples for quantitative purpose. The population density was calculated as the total number of individuals per 1 litre of collected water. For the evaluation of population density, zooplanktons were classified into three categories as rare (1-9 individuals L^{-1}), common (10-99 individuals L^{-1}) and abundant ($100 \geq$ individuals L^{-1}).

Identification of zooplanktons

The collected zooplanktons were identified according to Patterson (1992), personal communication with Professor Mansour Galal, Zoology Department, Faculty of Science, Menoufia University (protozoans), Campbell (1983 and 1987, hydrozoans), Kepner (1931, turebellarians), Tarjan *et al*. (1977, nematodes), Voigt (1956, rotifers), Guigley (1977, insect larvae/nymphs), Lai *et al*. (1979, copepods), Salem (1987, crustaceans), and Ahlstrom (1940; 1943) and Enaceanu (1967, zooplanktons).

Physico-Chemical parameters

Physico-Chemical parameters of water samples were measured monthly every sampling occasion. Water temperature (°C) and pH were evaluated by a regular thermometer and Ion Meter (Model 6500, China), respectively. Electrical conductivity (µmhos cm^{-1}) was measured using CON 6000 (model No. EPA-30IDAN-9, Eutech Instruments, Singapore), total chlorines (mg L^{-1}) was measured by Mi 404 (Romania). NaCl (‰) and TDS (mg L^{-1}) were measured by (Mi 306, Romania). Metal concentrations were measured in the three investigated sites according to Sheir et al., (2018).

Community structure analysis

Relative abundance

Relative abundance was calculated according to Simpson (1949) as the following formula: RA = ni/N X 100, where: ni is total number of individuals of species and N is total number of individuals of all the species.

Species richness

Species richness was calculated according to Menhinick (1964) as the following formula: $d = S/\sqrt{N}$, where: S is the number of species and N is total number of all species

Diversity Index (H)

Diversity Index was calculated according to Shannon and Wiener (1949) as the following formula: $H' = -\Sigma\, [ni/N] \ln [ni/N]$, where: ni is the number of individuals in each species, N equals the total number of individuals in the sample, and Σ equals the total number of species in the sample.

Evenness index

Evenness index was calculated according to Pielou (1966) as the following formula: $e = H'/\log S$, where: H is diversity index and S is number of species

Index of similarity

Index of similarity was calculated according to Sorensen (1948) as the following formula: S (%) = (2C / A+B) X 100, where, A is number of species in one study site, B is number of species in another study site and C number of species common to both study sites.

The ratio of crustaceans to rotifers abundances

The ratio of crustaceans/rotifers abundance was calculated according to Haberman and Haldna (2014) as the following formula: N_{Crust}/N_{Rot}, where, N_{Crust} is the abundance of crustaceans and N_{Rot} is the abundance of rotifers.

Statistical analysis

The data of the present study were analysed using Statgraphics v18 software (centurion). Data were expressed as mean ± SE. Data were analysed using one way analysis of variance (ANOVA) using LSD as a post-hoc test under the effect of site, time and phyla. Where ANOVA could not be applied, a nonparametric ranking test was used (Kruskal – Wallis) when $P \leq 0.05$.

RESULTS

Environmental factors affecting freshwater zooplanktons

The mean values of physico-chemical parameters of the water in the three sites were measured throughout the period of investigation. The temperature recorded the highest degrees at summer (29.89°C, site 1) and the lowest at winter (18 °C, site 3). However, NaCl (%) ranged between 2.07 (site 3) in winter and 0.6 (site 1) in summer. Also, the total dissolved solids and electric conductivity were the maximum (site 3) at winter (569.78 mg L^{-1} and1140 μmhos cm^{-1}, respectively) and the minimum (site 1) at summer (161.46 mg L^{-1} and 324.24 μmhos cm^{-1}, respectively). The values of pH were highest at autumn (8.31, site 3) and were lowest at spring (7.55, site 3). Total chlorines values ranged between 0.85 mg L^{-1} (site 3) in autumn and 0.35 mg L^{-1} (site 1) in winter. NaCl (%), electric conductivity and total dissolved solids were significantly higher in site 3 than 1 and 2 (Kruskal-Wallis, $P = 0.02$, Fig. 2).

Freshwater zooplanktons

In the present study, six zooplankton phyla were recorded; Protozoa, Coelentrata, Platyhelminthes, Nematoda, Rotifera and Arthropoda. Overall phylum Protozoa was represented in this study by one class Ciliophora which was represented by 3 genera, *Paramecium* sp. (family: Parameciidae), *Vorticella* sp. (family: Vorticellidae) and *Vagnicola* sp. (family: Vaginicolidae. Phylum Cnidaria was represented by one class, Hydrozoa which was represented by 2 genera *Hydra viridis* and *Hydra vulgaris* and all belong to family Hydridae. Phylum Platyhelminthes was represented in this study by one class, Turbellaria which was represented by 1 genus, *Stenostomum* sp. (family: Stenostomidae). Phylum Nematoda was represented by one class, Secernentea which was represented by 1 genus, *Pratylenchus* sp. (family: Pratylenchidae). Phylum Rotifera was represented by 2 classes, Bdelloidea as 1 geneus, *Rotaria neptunia* (family: Philodinidae). The other class was Monogononta and was represented by 3 genera, *Brachionus calyciflorus*, *B. plicatilis* and *Keratella tropica* and all belong to family, Brachionidae. Phylum Arthropoda was represented by 2 classes Crustacea and Insecta. The former was represented by 4 genera, *Simocephalus vetulus* (family Daphniidae), *Chydorus sphaericus* (family Chydoridae), *Cypridopsis* sp. belongs to family Cyprididae, *Mesocyclops* sp. adults and copepodite stages belong to family Cyclopoida. The later class was represented by insect larvae and nymphs like Chironomidae larvae belong to family Chironomidae, *Culex* larvae belongs to family Culicidae, *Lethocerus niloticus* nymphs belongs to family Belostomatidae, *Lestidae* sp. nymphs belongs to family Lestidae and *Ephemeroptera* nymphs belongs to family Ephemeridae.

The total number of collected zooplanktons showed differences in numerical population density of the selected sites. Site #3 recorded the highest percentage (89.52%)

followed by site #1 (8.75 %) and finally site #2 (1.73 %) of the total collected zooplankton count. Site #1 recorded the highest population densities of the collected zooplankton samples in winter (6666.64 Indv L^{-1} $Season^{-1}$) and the lowest population densities in spring (3799.97 Indv L^{-1} $Season^{-1}$). While, Site #2 recorded the highest population densities of the collected zooplankton samples in winter and spring (1366.64 and 1366.63 Indv L^{-1} $Season^{-1}$, respectively) and the lowest population densities in autumn (266.66 Indv L^{-1} $Season^{-1}$). Finally, site #3 recorded the highest population densities of the collected zooplankton samples in summer (75166.60 Indv L^{-1} $Season^{-1}$) and the lowest population densities in spring (12466.60 Indv L^{-1} $Season^{-1}$, Table 1).

Protozoa and Rotifera were significantly higher than the rest of the phyla at site #1 (P = 0.001, ANOVA). However in sites #2 and #3, only Rotifera was significantly higher than the other phyla (P = 0.0002, Kurskal-Wallis/ ANOVA). There no significant difference between phyla of the three sites in summer ($P \geq 0.07$, ANOVA). Spring did not show any significant difference in phyla densities at all sites. Phylum Protozoa recorded the highest density in site #1 (P = 0.04, Kurskal-Wallis) and Rotifera and Arthropoda on site #3 (P = 0.03, ANOVA/Kurskal-Wallis) during summer. In autumn, only rotifers showed significant increase at site #3 (P = 0.05, Kurskal-Wallis). However, in winter, site #3 had the maximum density of nematods, rotifers and arthropods (P = 0.03, Kurskal-Wallis/ ANOVA, Table 1). Arthropods classes showed no significant difference in population density between seasons in sites #1 and 3 (P > 0.05). However, in site #2, cladocerans recorded significant increase in winter and spring (P = 0.02, Kurskal-Wallis) but not the rest of classes. Insect larvae/nymphs were the highest in winter, copepod in spring at site 3 significantly (P = 0.04, ANOVA). On the other hand, cladocera and ostracods did not show significant difference between sites in specific seasons.

Community structure analysis of zooplanktons

Community structure analysis of zooplanktons showed that Shannon diversity index (H) and index of richness (d) indices were maximum at site #3 (1.93 and 74.26) followed by site #1 (1.48 and 23.21) then site #2 (1.23 and 10.32), respectively. Index of similarity (S) between the investigated sites was as follows: sites #1 and 2 was 100 %, sites #1 and 3 was 50 % and finally, #2 and 3 was 61 %. Relative abundance (RA) of Protozoa was highest in site 1 (42.6%), Cnidaria, Platyhelminthes, Nematoda and Rotifera at site 3 (0.92, 2.18, 1.05, 84.42 %, respectively), Arthropoda at site 2 (11.30 %). Evenness index showed highest values of Protozoa at site 1 (0.97), Platyhelminthes and Rotifera at site 3 (0.05 and 1.94, respectively). However, the rest of investigated phyla did not show a specific pattern. The ratio of crustaceans to rotifers abundance also was highest in site #1 followed by site #2 then site #3, respectively (0.20, 0.18 and 0.13, respectively, Table 2).

In the current work, total population densities of zooplanktons` classes were classified into rare, common and abundant. So, classes' Ciliophora, Hydrozoa, Secernentea, Bdelloidea and Insecta were classified as common individuals. While, classes Turbellaria, Monogonota and Crustacea were categorized as abundant.

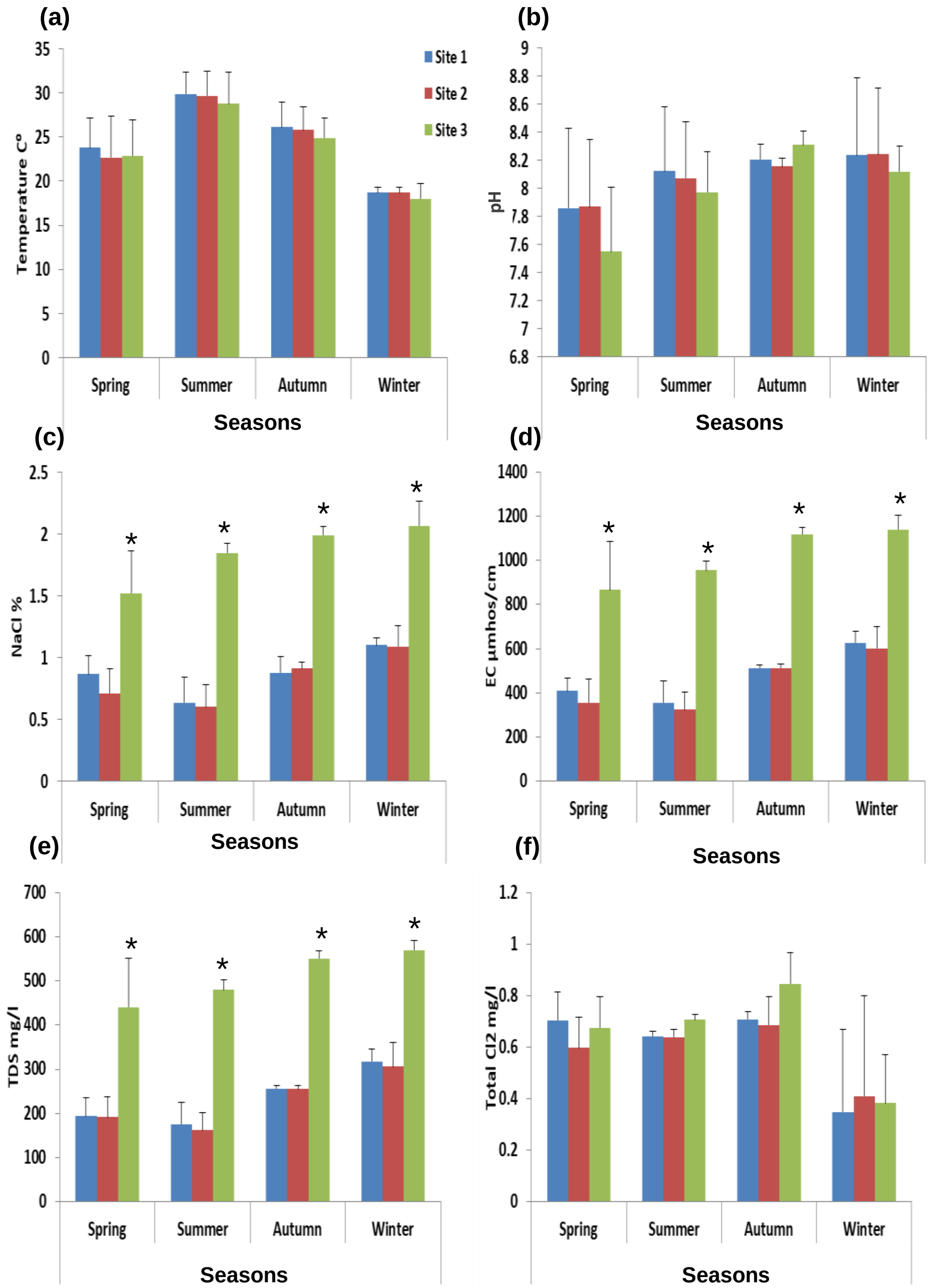

Fig. 2: Seasonal variations of environmental factors at the three selected sites during the period of investigation. **(a)** Temperature; **(b)** pH; **(c)** NaCl; **(d)** EC; **(e)** TDS and **(f)** Total $Cl_{2.}$ * represents significant difference between site three the other two sites, when $P \leq 0.05$, Kruskal wallis.

Table 1: Seasonal variations of zooplanktons` population density from selected sites during the period of investigation

Sites	Seasons	Protozoa	Cnidaria	Platyhelminthes	Nematoda	Rotifera	Arthropoda	Average Ind./L/ season	Average Ind./L/ year
		Phyla							
One	Spring	1566.66±294.60	ND	ND	ND	1399.99 ± 171.05	833.32±47.57	3799.97	19399.87
	Summer	1599.99±467.06#	ND	ND	ND	2633.32±128.13	99.99±4.35	4333.30	
	Autumn	99.99±19.24	ND	133.33±44.44	100±33.33	3533.32±714.22$	733.31±29.82	4599.95	
	Winter	4899.99±812.62$	ND	ND	ND	1533.33±155.55	233.32±11.20	6666.64	
Two	Spring	466.66±155.55	ND	ND	ND	733.32±48.43	166.65±7.62	1366.63	3833.25
	Summer	33.33±11.11	ND	ND	ND	766.66±207.57$	33.33±2.77	833.32	
	Autumn	ND	ND	ND	ND	233.33±61.86	33.33±2.77	266.66	
	Winter	499.99±134.71	ND	ND	ND	666.66±189.86	199.99±8.70	1366.64	
Three	Spring	266.66±58.79	ND	233.33±61.86	66.66±11.11	7199.99±1071.51	4699.96±114.82	12466.60	198521.90
	Summer	ND	1833.32±337.92	2555.56±743.51	ND	60277.74±4602.99$#	10499.98±387.20#	75166.60	
	Autumn	ND	ND	555.56±185.18	333.33±64.14	53111.04±6688.94#	5222.20±356.24	59222.13	
	Winter	111.11±37.03	ND	999.99±279.62	1666.66±279.62#	46999.94±4129.58#	1888.87±53.77#	51666.57	

Note, n = 9 replicates and data were expressed as mean ± SE. ND, not detected. $ and # represent significant difference between seasons and sites population density of zooplanktons, respectively when $P \leq 0.05$, ANOVA/Kruskal-Wallis.

Table 2: Community structure indices of freshwater zooplanktons from selected sites during the period of investigation

Indices						
Relative abundance (%)						
Sites	**Protozoa**	**Cnidaria**	**Platyhelm.**	**Nematoda**	**Rotifera**	**Arhtropoda**
One	42.09	0	0.69	0.52	46.91	9.79
Two	26.08	0	0	0	62.62	11.30
Three	0.19	0.92	2.18	1.05	84.42	11.24
Evenness						
	Protozoa	**Cnidaria**	**Platyhelm.**	**Nematoda**	**Rotifera**	**Arhtropoda**
One	0.97	0	0.02	0.02	1.08	0.23
Two	0.60	0	0	0	1.44	0.26
Three	0.004	0	0.05	0.02	1.94	0.26
	Shannon	**Sp. richness**	**Similarity (%)**	**$N_{crust.}/N_{rot.}$**		
One	1.48	23.21	(1,2) 100	0.21		
Two	1.23	10.32	(1,3) 50	0.18		
Three	1.93	74.26	(2,3) 61	0.13		

Note, *n* = 12 replicates and data were expressed as means.

DISCUSSION

This study is one of the rare works on freshwater zooplankton` diversity in relation to some environmental conditions at certain sites in Menoufia governorate, Egypt. This research revealed two important facets; the first one was that zooplanktons were a good tool in evaluation of water habitats of any size. The second was human activities can severely influence the biological status of the water body.

During this study, site #3 showed high electrical conductivity, salinity and TDS of the water. This result was in accordance with El-Shimy and Obuid-Allah (1992), who noticed that high conductivity and low water current may play a role in increasing the richness of freshwater fauna (invertebrates) in the Nile, Assiut, Egypt. These factors made that site richer in zooplankton numbers than the other two sites because increased conductivity means more salts and metals for organisms to use in food and biological process. Also, low current system means better microhabitat for zooplanktons to live in.

The present investigation revealed that the highest density of zooplanktons was recorded in winter at sites #1 and #2. This finding was in harmony with Gulati (1978) who regarded temperature as the main factor controlling the growth and composition of zooplanktons. In addition, winter was favorable season for zooplankton to reproduce and increase in density at the lentic ecosystem (Sheir, 2018). During this study, Arthropoda was the third population density in sites #1 and #2 (after Protozoa and Rotifera) and the second (after Rotifera) on site #3 of the collected zooplanktons during spring and summer seasons. Manickam *et al*. (2015) outlined similar results and attributed that to temperature and availability of favorable food such as bacteria and suspended detritus where most of planktonic arthropods are filter feeders. Copepods and insect larvae were the highest at winter/spring at site #3, in the current work. Waya *et al*. (2017) discussed the high abundance in rainfall seasons because this is the entrance time of the nutrients to Lake Victoria, Tanzania through rainfall and runoff of water of agricultural lands.

During this study site three recorded the highest population density and diversity than the other two sites with two species of phylum Cnidaria and six genera belong to phylum Arthropoda. Abd El-Hameed (2012) studied freshwater invertebrates at nine sites in Assiut governorate, and documented that the better site recorded highest and various invertebrate species rather than the others. Khalifa *et al*. (2015) confirmed that the higher the number of richness the better the quality of the site, and this was the case in the present study as site three was the highest value in species richness. Sheir (2018) also studied freshwater zooplankton at Bahr Shebeen Nilotic canal and found that variation of zooplankton communities was the highest at only one site making it the richest studied site in zooplankton. Also, site #3 was characterized with the least metal concentrations' as reported by Sheir *et al*. (2018). The recorded copepod species were belonged to cyclopoids in the present study. This was in accordance with Waya *et al*. (2017), who reported 75% of the collected copepod was cyclopoids as it can escape its predatory fishes and have several feeding habits (herbivores/carnivores/omnivores). During this investigation, the number of insect larvae/nymphs was high while no adults were found in the three sites. Eutrophication as a result of different types of pollution could result in dominance of small species and disappearance of adult species (El-Serehy and El-Rahman, 1999). Protozoa was the second largest group of zooplanktons in sites #1 and #2 after rotifers during the present study. It recorded the maximum value at site #1 followed by site #2. Similar results were obtained by Emam (2006), George (2012), and Khalifa and Bendary (2016). They concluded that, Protozoa are pollution tolerant group of zooplanktons and attained its highest density at the polluted area. Also, Patterson (1992) emphasized on that the richest ecosystems of protozoans were the largest water bodies, which was the case at site #1. Sites #1 and #2 were higher in heavy metal pollution than site #3 as described by Sheir *et al*. (2018). In addition, lee and Park (2002) explained that presence of pollutants can cause decreased light permeability and productivity and this may lead to scarcity of food for zooplanktons. This can reduce the number of zooplanktons in the water habitat. Also, Yi *et al*. (2011) mentioned that species diversity and density decrease as pollutants increase. In the present investigation, Cnidaria (hydrozoas) achieved its maximum density only at spring at site 3. It could be a result of asexual reproduction of hydrozoans during the spring season (Kaliszewicz and Lipin´

ska, 2013). Food supply and competition are the main factors regulating population density of organisms at any ecosystem. Hydrozoa follow a predatory lifestyle which will be supported by the presence of several types of insect larvae, nymphs, small crustaceans and suitable submerged plants as a microhabitat in site three. Platyhelminthes was represented by only one genus, *Stenostomum* sp. in all sites especially at site #3, which were characterized by slow water current (lentic). The substrate of the freshwater system should have stones and plants as a hard habitat for them (Reynoldson, 1981). Turbillarins favourite preys are insect larvae, which is a characteristic of the #3 site in the current work (Davies and Reynoldson, 1971). Also, Müller and Faubel (1993) explained the presence of *Stenostomum* sp. as a common genus inhabiting most of the lentic freshwater environments of Europe. Nematodes showed extensive density at site #3 at the present work. Ristau and Traunspurger (2011) mentioned that oligo and mesotrophic lakes supported the largest number of nematodes. However, the recorded genus was *Pratylenchus*, which is a plant parasite and may come from the agricultural fields around site 3 area through leaching. In addition, a relationship between nematodes and organic matters (particulate or dissolved) has been approved (Hoss *et al*., 2001). Rotifers density dominated the other five phyla (Protozoa, Coelentrata Platyhelminthes, Nematoda and Arthropoda) at all sites and reached to 81% of the total collected zooplanktons. Allan (1976) attributed rotifers high density to their parthenogenetic reproductive pattern and short developmental rates under favorable conditions in most freshwater systems. Similar results were obtained by Aboul-Ezz *et al*. (1996) who found that, rotifers were the highest phylum numerically accounting 82% of the total zooplanktons in Rosetta Branch. In addition, Khalifa and Bendary (2016) reported that rotifers formed the main component of zooplanktons of El-Rayah El-Menoufy of Bahr Shebeen Nilotic Canal and attributed this to the eutrophic status of those sites. In addition, rotifers longevity was longer at high population densities because of the expression of Mn-superoxide dismutase enzyme (Yoshinaga *et al*. 2003). The highest density of phylum Rotifera and Arthropoda was recorded at site #3 at the period of investigation. This result was in accordance with Aboul Ezz *et al*. (1996), who mentioned that rotifers and crustaceans always aggregate in the sites characterized by high nutritional plants, organic matters and/or detritus.

In the present work, site #3 was the highest in biodiversity indices and rich vegetation and surrounded by cultivated lands. Lougheed and Chow-Fraser (2002) discussed the effect of vegetation of the water body on the biotic indices and they found a positive relationship between vegetated sites and species richness, abundance and Shannon indices of zooplanktons. The trophic state of the water body can greatly affect the organisms` density and biological indices as in the present study. Site #3 surpassed the other two sites in all biotic indices as it recorded the best abiotic factors and less pollution. However, sites #1 and #2 dominated the indices of some phyla which are tolerant to increased concentrations of metals (pollution). Ristau and Traunspurger (2011) mentioned the increase in species density, Shannon, richness and evenness indices in the oligo and mesotrophic lakes. They explained this patterns as some species could tolerate different degrees of nutrient levels of the water. Also, they mentioned the distribution of some species were dependent on the water movement (lentic/lotic). Shannon diversity index of the current work ranged between 1.23 and 1.93. According to Haberman and Haldna (2014), they reported when diversity index values were 1-2, the water body was considered as mesotrophic and will contain small sized filter feeders (rotifers and cladocerans). That is coinciding with the present data, where site #3 had the highest value of Shannon diversity index and highest populations of zooplanktons (rotifers and arthropods). They also pointed out the important role of rotifers as a prey for cyclopoid copepods by applying the ratio of crustacean to rotifer abundance index for assessment of the water biodiversity.

CONCLUSION

In conclusion, zooplankton community structure and density efficiently responded to inter-specific variations of habitats. They responded well to some environmental factors, such as TDS, electric conductivity and salinity. Metals pollution played a role in zooplankton distribution and diversity. Community structure indices were a good tool of evaluation of zooplankton diversity of a water habitat.

REFERENCES

Abd El-Hameed, F. A. (2012). Taxonomical and Ecological Studies on Freshwater Benthic Invertebrates at Assiut Governorate, Egypt. PhD Thesis, University of Assiut.

Aboul Ezz; S. M.; Salem, S. A.; Samman, A. A.; Latif, A. F. and Soliman, A. M. (1996). distribution of rotifers in the Rosseta Nile Branch (Egypt). J. Egypt. Ger. Soc. Zool., 20(D): 85-123.

Ahlstrom, E. H. (1940). A Revision of the Rotatorinan Genera *Brachionus* and *Platyias* with Descritions of One New, Species and Two New Varieties. Pull. Am. Mus. Nat. Hist., **77**(3): 143-184.

Ahlstrom, E. H. (1943). A Revision of the Rotatorian Genus *Keratella* with Descriptions of Three New Species and Five New Varieties. Pull. Am. Mus. Nat. Hist**.,** 80(12): 411-457.

Allan, J. D. (1976). Life History Patterns in Zooplankton. Am. Nat., 110: 165–180.

Brucet, S.; Boix, D.; Quintana, X. D.; Jensen, E.; Nathansen, L. W.; Trochine, C. and Jeppesena, E. (2010). Factors influencing zooplankton size structure at contrasting temperatures in coastal shallow lakes: implications for effects of climate change. Limnol. Oceanogr., 55(4): 1697-1711.

Campbell, R. D. (1983). Identifying *hydra* species. In: "*Hydra* Research Methods" Lenhoff, H. M. (Eds.). Plenum press, New York, pp. 19-28.

Campbell, R. D. (1987). A new species of *Hydra* (Cnidaria: Hydrozoa) from North America with comments on species clusters within the genus. Zool. J. Linnean. Soc., 91(3): 253-263.

Davies, R. W. and Reynoldson, T. B. (1971). The incidence and intensity of predation on lake-d welling triclads in the field. J. Anim. Ecol., 40: 191-214.

El-Serehy, H. A. and El-Rahman, N. S. (1999). Zooplankton ecosystem at the Egyptian natural Protectorates of the Gulf of Aqaba, Red Sea. J. Egypt. Ger. Soc. Zool., 30: 67-81.

El-Shimy, N. A. and Obuid-Allah, A. H. (1992). A survey of some freshwater invertebrates in the Nile at Assiut, Egypt. J. Egypt. Ger. Soc. Zool., **7**: 363-376.

Emam, W. (2006). Preliminary study on the impact of water pollution in El-Rahawy drain dumping in Rosetta Nile branch on zooplankton and benthic invertebrates. M.Sc. Thesis, University of Ain Shams.

Enaceanu, V. (1967). Da zooplankton der donau. In: "limnoogie der donau" Liepolt, R. E. (Ed.), Schweizerbart's che verlagsbuchh and lung; Stuttgart, Germany Quoted from Winner, pp. 180-197.

George, M. N. (2012). Ecological studies on aquatic invertebrates of Ismalia Canal, Egypt. MSc Thesis, University of Ain Shams.

Guigley, M. (1977). Invertebrates of Streams and Rivers, A Key to Identification. London, Beccles and Colchester.

Gulati, R. D. (1978). The ecology of common planktonic crustacea of the freshwaters in the Netherlands. Hydrobiologia, 59(2): 101-112.

Haberman, J. and Haldna, M. (2014). Indices of zooplankton community as valuable tools in assessing the trophic state and water quality of eutrophic lakes: long term study of Lake Võrtsjärv. J. Limnol., 73(2): 263-273.

Hoss, S.; Bergtold, M.; Haitzer, M.; Traunspurger, W. and Steinberg, C. E. W. (2001). Refractory dissolved organic matter can in Fluence the reproduction of *Caenorhabditis elegans* (Nematoda). Freshw. Biol., 46: 1–10.

https://www.google.com/maps/place/Minuf,+Madinet+Menuf,+Menuf,+Menofia+Governorate/@30.5209687,31.0129134,12z/data=!4m5!3m4!1s0x14587e662f9e048d:0x75267884cf57bb9b!8m2!3d30.4641487!4d30.9358018;at15/4/2018(11:30pm).

Jeppesen, E.; Nõges, P.; Davidson, T. A.; Haberman, J.; Nõges, T.; Blank, K. and Johansson, L. S. (2011). Zooplankton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). Hydrobiologia, 676(1): 279–297.

Kaliszewicz, A. and Lipin´ska, A. (2013). Environmental condition related reproductive strategies and sex ratio in hydras. Acta Zool., 94: 177–183.

Kaya, M.; Fontaneto, D.; Segers, H. and Altındağ, A. (2010). Temperature and salinity as interacting drivers of species richness of planktonic rotifers in Turkish continental waters. J. Limnol., 69: 297-304.

Kepner, W. A. and Carter, J. (1931). Ten well-defined new species of Stenostomum. Zool. Anz., 93: 108–123.

Khalifa, N. and Bendary, R. E. (2016). Composition and biodiversity of zooplankton and macrobenthic populations in El-Rayah El-Menoufy, Egypt. Internat. J. App. Environ. Sci., 11(2): 683-700.

Khalifa, N.; El-Damhogy, k. A.; Fishar, M. R.; Nasef, A. M. and Hegab, M. H. (2015). Using zooplankton in some environmental biotic indices to assess water quality of Lake Nasser, Egypt. Internat. J. Fish. Aquat. Stud., 2(4): 281-289.

Lai, H. C.; Fernando, C. H. and Mamaril, A. (1979). The freshwater calanoida (copepoda) of the Philippines. Crustaceana**,** 37(3): 225-240.

Lee, C.R. and Park, C. (2002). Long-term variation of zooplankton composition and abundance in Asan Bay, Korea: is it influence of dyke construction? The Yellow Sea., 1: 9-18.

Lougheed, V.L. and Chow-Fraser, P. (2002). Development and use of a zooplankton index of wetland quality in the Laurentian Great Lakes basin. Ecol. Appl., 12(2): 474-486.

Manickam, N.; Bhavan, P. S.; Santhanam, P.; Muralisankar, T.; Srinivasan, V.; Vijayadevan, K. and Bhuvaneswari, R. (2015). Biodiversity of freshwater zooplankton community and physicochemical parameters of Barur Lake, Krishnagiri District, Tamilnadu, India. Malaya. J. Biosci., 2(1): 1-12.

Müller, D. and Faubel, A. (1993). The 'Turbellaria' of the River Elbe Estuary. A faunistic analysis of oligohaline and limnic areas. Arch. für Hydrobiol. Suppl., 75: 363–396.

Murugan, N.; Murugavel, P. and Kodarkar, M. S. (1998). Cladocera: The biology, Classification, Identification and Ecology. Indian Association of Aquatic Biologists (IAAB), Hyderabad.

Patterson, D. J. (1992). Free-living Freshwater Protozoa. A Color Guide. MANSON Publishing, UNSW Press Sydney, New York.

Pielou, E. G. (1966). The measurement of diversity in different types of biological collections. J. Theor. Biol., 13: 131–144.

Primo, A.; Kimmel, D.; Marques, S.; Martinho, F.; Azeiteiro, U. and Pardal, M. (2015). Zooplankton community responses to regional-scale weather variability: a synoptic climatology approach. Clim. Res., 62(3): 189–198.

Reynoldson, T. B. (1981). The ecology of the Turbellaria with special reference to the freshwater triclads. Hydrobiologia**,** 84: 87-90.

Ristau, K. and Traunspurger, W. (2011). Relation between nematode communities and trophic state in southern Swedish lakes. Hydrobiologia**,** 663: 121–133.

Salem, A. H. (1987). Ecological and biological studies on freshwater Crustaceans. PhD Thesis, University of Assiut**.**

Shannon, C.E. and Wiener, W. (1949). The mathematical theory of communication. Urbana, Illinois University Press.

Sheir, S. K. (2018). Diversity of zooplankton communities at Bahr Shebeen Nilotic canal, El-Menoufia, Egypt: environmental fluctuations or chemical pollution effects? Egypt. J. Zool., 69: 175-190.

Sheir, S. K.; Osman, G. Y.; Mohamad, A. H. and Abd Elhafez, A. R. (2018). Spatial and temporal effects on freshwater benthic invertebrates` diversity in some localities of Menoufia governorate, Egypt. Egypt. J. Zool., 70: 191- 208.

Simpson, E. H. (1949). Measurement of diversity. Nature, 163: 688.

Sládecek, V. (1983). Rotifers as indicators of water quality. Hydrobiologia**,** 100: 169–201.

Sorensen, T. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation of Danish commons. K Danske Vidensk Selsk Biol. Skr., 5: 1–34.

Steedman, H. R. (1976). Zooplankton fixation and preservation. UNESCO, Monogr. Oceanogr. Methodol., 4: 350.

Steinberg, D. K. and Condon, R. H. (2009). Zooplankton of the York River. J. Coast. Res., 10057: 66-79.

Tarjan, A. C.; Esser, R. P. and Chang, S. L. (1977). An illustrated key to nematodes found in fresh water. J. Water Poll. Cont. Fed., 49(11): 2318-2337.

Voigt, M. (1956). Rotatoria. Die Radertiere Mitteleuropas. Gebruder Borntraeger, Berlin.

Waya, R. K.; Limbu, S. M.; Ngupula, G. W.; Mwita, C. J. and Mgaya, Y. D. (2017). Temporal patterns in phytoplankton, zooplankton and fish composition, abundance and biomass in Shirati Bay, Lake Victoria, Tanzania. Lakes Reserv., 22: 19-42.
Yi, X.; Kim, E.; Jo, H-J.; Han, T. and Jung, J. (2011). A Comparative study on toxicity identification of industrial effluents using *Daphnia magna*. Bull. Environ. Contam. Toxicol., 87: 319-323.
Yoshinaga, T.; Kaneko, G.; Kinoshita, S.; Tsukamoto, K. and Watabe, S. (2003). The molecular mechanisms of life history alterations in a rotifer: a novel approach in population dynamics. Comp. Biochem. Physiol. B. Biochem. Molec. Biol., 136: 715–722.

ARABIC SUMMARY

أنماط توزيع ووفرة العوالق الحيوانية في المياه العذبة من بيئات مائيه مختلفة في قناة بحر شبين النيلية، مصر

شيرين خليفة شعير، جمالات يوسف عثمان، عبد الحافظ رجب عبد الحافظ و عزة حسن محمد

قسم علم الحيوان ، كلية العلوم ، جامعة المنوفية ، شبين الكوم ، المنوفية ، مصر

تنتشر العوالق الحيوانية عالمياً وتوجد تقريبا في جميع البيئات المائيه العذبة وتتاثر كثيرا بالعوامل البيئية. لهاذا تمت دراسة العوالق الحيوانية بالمياه العذبة في ثلاثة مواقع في أماكن مختلفة في محافظة المنوفية، مصر خلال الفترة من مارس، ٢٠١٧ وحتى فبراير، ٢٠١٨ .تم تجميع عينات شهرية من أجل تقييم التغير الذي يطرأ علي تنوعها و كثافتها العددية في ضوء بعض الظروف البيئية. ولقد تم إختيار ثلاثة مواقع علي قناة بحر شبين النيلية من أجل هذه الدراسة، اثنان يقعان في مدينة شبين الكوم بينما يقع الموقع الثالث بالقرب من مدينة منوف. وقد أظهرت النتائج ان قيم العوامل البيئية تختلف علي حسب الموسم و الموقع. تم تسجيل تسعة عشرة نوعا تنتمي الي ستة شعب و هي الاوليات، الجوفمعويات، الديدان المفلطحة، الديدان الاسطوانية، العجليات و المفصليات. وقد اختلف العدد الإجمالي للعوالق الحيوانية التي تم جمعها من موقع الي اخر، حيث سجل الموقع الثالث أعلى نسبة افراد بلغت (٨٩.٥٢ ٪) يليه موقع الاول بنسبة (٨.٧٥ ٪) وأخيرا الموقع الثاني بنسبة (١.٧٣ ٪) من إجمالي العوالق الحيوانية تبعا لتركيز المعادن الثقيلة في كل موقع من الادني للاعلي علي التوالي. وسجل كل من مؤشر تنوع شانون، ومؤشر الهيمنة، والثراء ومؤشر تساوي التوزيع الحد الأقصى في الموقع الثالث يليه الموقع الأول ثم الموقع الثاني. ومثلت كل من طوائف وحيدة المنسل، القشريات ثم التربيللاريا العوالق الوفيرة. وتمثلت الطوائف الشائعة في الهدبيات، الهيدروزوا، يرقات الحشرات، بيديلويديا و سيسيرنينتيا. ويمكن استخلاص ان التركيب المجتمعي و كثافة العوالق الحيوانية تكيفت بكفائة للتغيرات الداخلية بين البيئات وقليلا مع الظروف البيئية للمواقع المختلفة بالاضافة الي نوع التلوث.