Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(5): 755 – 767 (2021)
www.ejabf.journals.ekb.eg

Composition and Abundance of Macrobenthos, using two sampling methods, in El Rayah El Tawfiky, River Nile, Egypt

Reda E. Bendary [1*], Shaimaa M. Ibrahim[1], Hosam E. El Saied[2], Gamal M. El Shabrawy[1], Mohamed Abd El Mordy[3], Magdy T. Khalil[3]

1- Hydrobiology Laboratory, Department of Freshwater and Lakes, National Institute of Oceanography and Fisheries, NIOF, Cairo, Egypt.

2- Genetics and Genetic Engineering Laboratory, Department of Aquaculture, National Institute of Oceanography and Fisheries, Cairo, Egypt.

3- Department of Zoology, Faculty of Science, Ain Shams University, Cairo, Egypt.

[*] **Corresponding Author: om_redahady@hotmail.com**

ARTICLE INFO

Article History:
Received: Nov. 5, 2021
Accepted: Nov. 19, 2021
Online: Nov. 25, 2021

Keywords:
Macrobenthos,
Ekman Grab,
Macrophyte sweep netting,
El Rayah El Tawfiky.

ABSTRACT

During the period extending from spring 2014 till winter 2015, macrobenthic invertebrates were collected from El Rayah El Tawfiky using two sampling methods; Ekman grab and macrophyte sweep netting. To address the composition, distribution and abundance of the species under study, thirty nine species were recorded, representing the sampling methods (20,505 and 3557 individuals/m^2respectively). Macrobenthic invertebrates collected belong to three phyla; namely, Arthropoda, Annelida and Mollusca. Significant differences were detected in community composition, distribution and abundance of macrobenthos. Those differences were attributed to the varieties of the sampling methods, the seasons and the sites as well. In samples collected by a grap, the dominance of Annelida species was observed, while the Arthropoda species prevailed in samples collected by macrophytes. The highest density was detected at stations VI and V in a grap and macrophyte sampling, respectively. Adversely, its lowest was determined at station VII with respect to both sampling methods. For the grap sampling, spring was the best season, whereas summer was the most preferred for macrophyte sampling. Results showed that the study area suffers from several sources of pollution, and the tolerant species such as *Chironomidae larva* and *Limnodrilus udekemianus* were the most dominant. Hence, a regular monitoring program is recommended to allow the detection of any future changes.

INTRODUCTION

Irrigation in Egypt depends mainly on the River Nile through a system of main canals and rayahs, secondary canals, third order and meskas **(Radwan & El-Sadek, 2008)**. These irrigation canals are widespread along the area of the Nile Delta and canals run towards the Mediterranean coastal plain and discharge their water either into the northern lakes or the sea **(Elewa, 2010)**. Similar to the role of the River Nile, the

Indexed in Scopus ELSEVIER DOAJ IUCAT

irrigation canals and rayahs are purposed for drinking, irrigation, navigation and fishing. El-Rayah El-Tawfiky is a channel with a length of about 180 km. It arises from Damietta branch of the River Nile in El Kanater city and extends towards the northeastern area of El Mansoura city and then branch into two sub- channels

Macrobenthic play an important role in aquatic community; some of which are mineralization, mixing of sediment and flux of oxygen into sediment, cycling of organic matter and assessing the quality of inland water **(George *et al*., 2009)**. The distribution of macrobenthos fauna is determind through a number of factors, such as physical nature of the substratum, depth, nutritive content, degree of stability and the oxygen content of water body **(Lydeard *et al*., 2004).**

Aquatic macrophytes act as a significant habitat for invertebrates. utilize them directly as a food source **(Gregg & Rose, 1982, 1985)** shelter from predators **(Harrod, 1964)** spawning and attachment sites **(Keast, 1984)** and indirectly upon the periphyton growing on the surface of macrophytes **(Higler, 1975)**. A direct relationship was found between the quantity and richness of aquatic macrophytes and that its associated fauna **(Hynes, 1970)**. Moreover, seasonal growth of aquatic macrophytes act as an important factor influencing the abundance of invertebrate diversity **(Hargeby, 1990)**.
Due to the importance of rayahs as a water source of drinking and irrigation, the present study aimed to investigate the species composition of macrobenthic invertebretes, their abundance, and distribution in El Rayah El Tawfiky using two sampling methods, by Ekman Grab and macrophyte sweep netting.

MATERIALS AND METHODS

Study Area

El-Rayah El-Tawfiky (Figure 1) is a channel with length of about 180 km. It arises from Damietta branch of the River Nile in El Kanater city and extends towards northeastern of El Mansoura city and then branched into two sub- channels. Seven stations were selected along El-Rayah to represent all types of habitats in this ecosystem (Tables 1), starting from El-Kanater El-khairia city (T1, 30°11'46.58" N-31° 7'55.98" E) to Manzalah city (T7 , 31°09'49.9 N - 31° 7'55.98" E) .

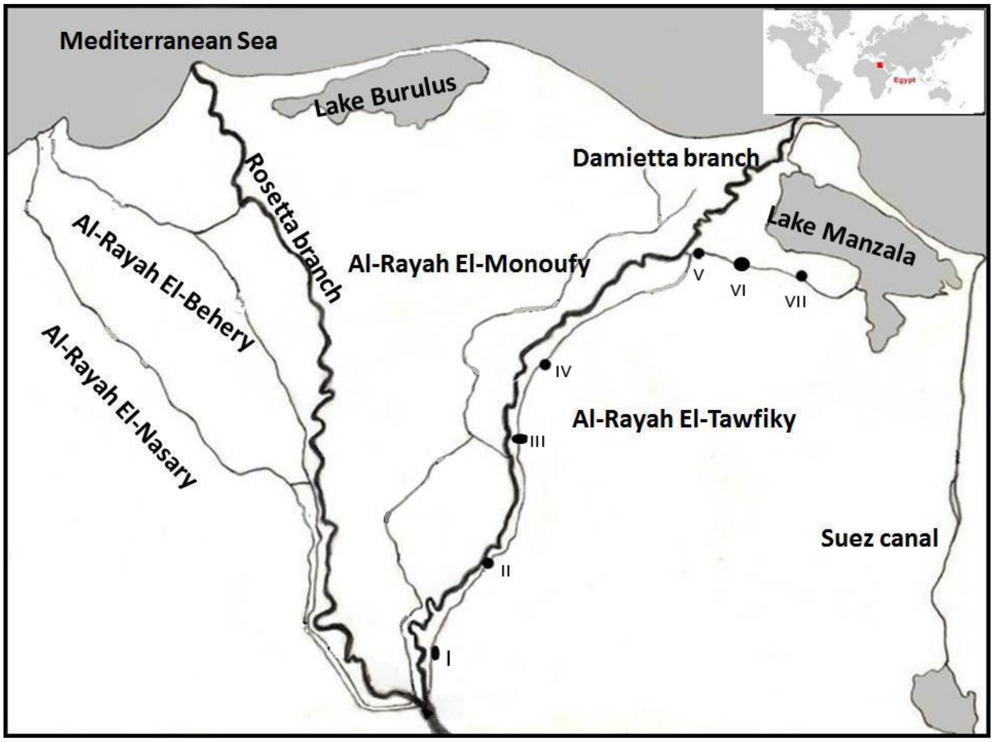

Fig. 1. A map of the River Nile Delta showing the sampling sites in El-Rayah El-Tawfiky

Table 1. Stations of El-Rayah El-Tawfiky and their description

SiteNo	Name	Latitude	Longitude	Distance*	Description
I	El Kanater	30°11'46.58"	31° 7'55.98"	1-1.5 Km	After railway station of El Kanater El Khairia
II	Banha	30°28'24.0"	31°12'1.04"	40 Km	In the Front side of Banha Water plants
III	Met gamer	30°41'35.3"	31°16'50.2"	70 Km	Between agricultural and residential regions
IV	Agga	30°54'23.12"	31°16'51.88"	100 Km	There are agricultural and residential regions at the two banks
V	Mansoura	31°04'02.84"	31°25'02.13"	130 Km	Before bifurcation of El-Rayah
VI	Dekerness	31° 5'38.65"	31°37'37.77"	155 Km	Between residential region in the west side and agricultural region in the east
VII	El-Manzalah	31°09'49.9"	31°56'09.5"	185 Km	End of El Rayah

*from El-Kanater City

Collection and analysis of macro invertebrate samples

The sampling program was within a national project funded by the NIOF for studying the environmental conditions and fisheries of the Nile River Rayahs (El-Nassery, El-Monofiy, El-Tawfiky and El-Behery). Freshwater macrobenthic invertebrate samples were seasonally collected from spring 2014 to winter 2015.

Macrobenthos samples were collected from all sites during the study period. Samples were collected using Ekman grab sampler with an opening area of 225 cm2. Three grab samples were taken from each site from the upper layer of the bottom sediments. The samples were immediately washed to remove any attached sediments or mud and sieved through 500 µm mesh diameter net. Samples were then stored in polyethylene jars, labeled withtheir relevant date and mixed with 10% neutral formaldehyde solution. In the laboratory, the samples were washed and sieved again through 0.5 mm mesh diameter net. Benthic animals were sorted to their genera or species using a zoom stereo microscope. Every species was kept in a glass bottle with 7% formalin for identification.

The macrophytes within a 0.125 m^2 quadrate were cut, thoroughly shaken, and washed in a 500 µm mesh sweep net to dislodge the associated macroinvertebrates. The macroinvertebrates (>500 µm) were separated from the substrate using 500 µm mesh sieves, followed by hand-picking, and were stored in plastic jars with 7% formalin solution before identification. Invertebrates were identified at species level where possible.

RESULTS AND DISCUSSION

The composition and abundance of macrobenthic invertebrates of El-Rayah El-Tawfiky were investigated with respect to the two sampling methods, Ekman Grab and macrophyte sweep netting . Samples included 39 species and were represented by 20,505 and 3557 individuals/m^2, respectively affiliating to three phyla; Arthropoda, Annelida and Mollusca. The grab samples produced 28 identified taxa, whereas the macrophytes identified 30. **Fishar and William (2006)** demonstrated that “the grab” is the least effective sampling method for obtaining a realistic list of taxa present at a site. 12 taxa were exclusive to the macrophytes including 9 species of Arthropoda (*Hydroptilidae larva*, *Cloenon* sp., *Baetis* sp., *Lepidoptera larva*, *Hydroptilidae larva*, *Caridina nilotica*, *Gammarus* sp., *Mesovelia vittigera*, and *Hyphoporus* sp.) and 3 species of Mollusca (*Lymnaea natalensis*, *Succinea cleopatra*, and *Mutela rostrata*). On the other hand, 8 taxa was exclusive to the grab samples including 3 species of Arthropoda (*Enallagma* sp., *Procambarus clarkii*, and *Trithemis* sp.) 1 species of Mollusca, *Viviparus contectus*, and 4 species of Annelida (*Allolobophora caliginosa*, *Limnatis nilotica*, *Branchiura sowerbyi*, *and Barbronia assiuti*) (Table 2).

Table 2. Community of macrobenthic invertebrates (ind./m^2) at the different stations along El-Rayah El-Tawfiky

	Stations															
Species	I		II		III		IV		V		VI		VII		Average	
Arthropoda	M	G	M	G	M	G	M	G	M	G	M	G	M	G	M	G
Chironomidae larva	551	19	322	94	0	2438	208	169	852	44	202	163	0	13	305.0	419.6
Chironomidae pupa	16	0	131	44	0	56	20	25	123	19	12	0	0	0	43.1	20.5
***Micronecta* sp.**	2	0	14	6	0	25	0	0	3	0	2	3506	0	0	3.0	505.3
***Ischnura* sp.**	23	0	79	19	0	0	3	0	24	0	36	0	3	0	24.0	2.7
Hydroptilidae larva	25	0	15	0	0	0	13	0	2	0	0	0	0	0	7.9	0.0
***Caenis* sp.**	3	0	14	13	0	50	2	0	41	0	32	6	0	0	13.1	9.9
***Cloenon* sp.**	0	0	2	0	0	0	0	0	11	0	29	0	0	0	6.0	0.0
***Baetis* sp.**	4	0	20	0	0	0	12	0	16	0	35	0	0	0	12.4	0.0
Lepidoptera larva	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0.7	0.0
Hydroptilidae larva	0	0	8	0	0	0	0	0	1	0	0	0	3	0	1.7	0.0
***Coanagrion* sp.**	0	19	0	575	0	13	1	38	1	188	0	75	0	0	0.3	129.5
Caridina nilotica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0.1	0.0
***Gammarus* sp.**	0	0	0	0	0	0	0	0	7	0	2	0	0	0	1.3	0.0
Mesovelia vittigera	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0.1	0.0
***Philopotamus* sp.**	0	0	0	0	0	0	0	0	6	0	0	0	0	13	0.9	1.9
***Hyphoporus* sp.**	0	0	6	0	0	0	0	0	1	0	1	0	0	0	1.1	0.0
***Enallagma* sp.**	0	0	0	6	0	0	0	6	0	6	0	0	0	0	0.0	2.6
Procambarus clarkii	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0.0	0.9
***Trithemis* sp.**	0	0	0	0	0	13	0	6	0	0	0	0	0	6	0.0	3.6
Total Arthropoda	624	38	615	763	0	2594	259	243	1090	256	352	3750	6	32	420.9	1096
Mollusca																
Theodoxus niloticus	27	13	4	0	0	113	6	19	66	19	1	19	0	0	14.9	26.1
Gabbiella senaariensis	0	0	2	0	0	281	0	0	0	69	0	6	2	0	0.6	50.9
Viviparus contectus	0	0	0	0	0	13	0	13	0	0	0	19	0	19	0.0	9.1
Lanistes carinatus	4	13	0	0	0	0	0	0	0	0	0	0	0	0	0.6	1.9
Cleopatra bulimoides	5	13	0	0	0	181	0	88	0	0	0	25	0	6	0.7	44.7
Physa acuta	0	0	27	0	0	0	0	0	0	0	1	0	5	6	4.7	0.9
Bulinus truncatus	3	0	6	0	0	6	0	0	4	31	6	0	0	0	2.7	5.3
Melanoides tuberculata	0	0	1	31	0	0	0	19	2	13	0	13	0	0	0.4	10.9
Lymnaea natalensis	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.1	0.0
Pila ovate	0	0	0	0	0	0	0	0	0	0	0	6	0	31	0.0	5.3
Succinea cleopatra	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0.4	0.0
Corbicula fluminalis	0	0	1	0	0	219	0	25	0	0	0	19	0	6	0.1	38.4
Mutela rostrata	0	0	0	38	0	6	0	0	0	6	0	0	0	0	0.0	7.1
***Calatura* sp**	13	0	0	0	0	13	0	0	0	6	0	13	0	0	1.9	4.6
Total Mollusca	52	39	41	69	0	832	6	164	72	144	9	120	10	68	27	205
Annelida																
Limnodrilus	15	1894	381	900	0	88	0	1344	0	2331	0	3869	2	394	56.9	1546

udekemianus																
Helobdella conifer	0	88	0	25	0	44	0	0	0	6	0	0	23	6	3.3	24.1
Allolobophora caliginosa	0	0	0	0	0	0	0	0	0	13	0	0	0	6	0.0	2.7
Limnatis nilotica	0	44	0	6	0	13	0	0	0	0	0	0	0	0	0.0	9.0
Branchiura sowerbyi	0	19	0	0	0	0	0	0	0	19	0	44	0	6	0.0	12.6
Barbronia assiuti	0	44	0	6	0	181	0	0	0	6	0	0	0	0	0.0	33.9
Total Annelida	15	2088	381	937	0	326	0	1344	0	2376	0	3913	25	412	60	1628
Total ind./m2	691	2165	1037	1769	0	3752	265	1751	1162	2775	361	7783	41	511	3557	20505
Total species/m2	12	10	18	14	0	18	8	11	18	15	14	14	7	12		

G (Grab sapmles), M (macrophyte sweep netting samples)

In samples collected by Ekman Grab (Fig. 2), Annelida constituted the highest density (11,395 ind./m^2) despite being represented by only 6 species and estimated by 56% of the total individuals. Arthropoda recorded the second highest density (7675 ind./m^2) and were manifested as 37% of the total individuals in El-Rayah El-Tawfiky. Mollusca constituted the highest species number and the lowest density (1436 ind./m^2). They are represented by 12 species. *Limnodrilus udekemianus* is the most dominant species being 95 % of the total Annelida with an average of 1546 ind./m^2. The dominance of *L. udekedmianus* may be attributed to either the soft muddy substratum which is suitable for oligochaetes **(Fishar, 1995)**, or to their ability to adapt to various habitats and the tolerance to oxygen depletion accompanied with excess decomposable organic matter **(Rashid & Pandit, 2014)**. **Nassif (2012)** mentioned that the variation in temperature was not determined as a factor limit distribution of *L. udekedmianus*. The distribution of *L. udekedmianus* was mostly confined to summer and early autumn in Lake Nasser due to the increase of sediment organic carbon **(EI-Tantawy *et al*., 2003)**. Furthermore, **Abdel Salam and Tanida (2013)** reported that the oligochaetes are truly cosmopolitan and widely distributed among different habitats. The present result agrees with those of **Bendary (2013)** and **El-Damhogy *et al*. (2017)**.

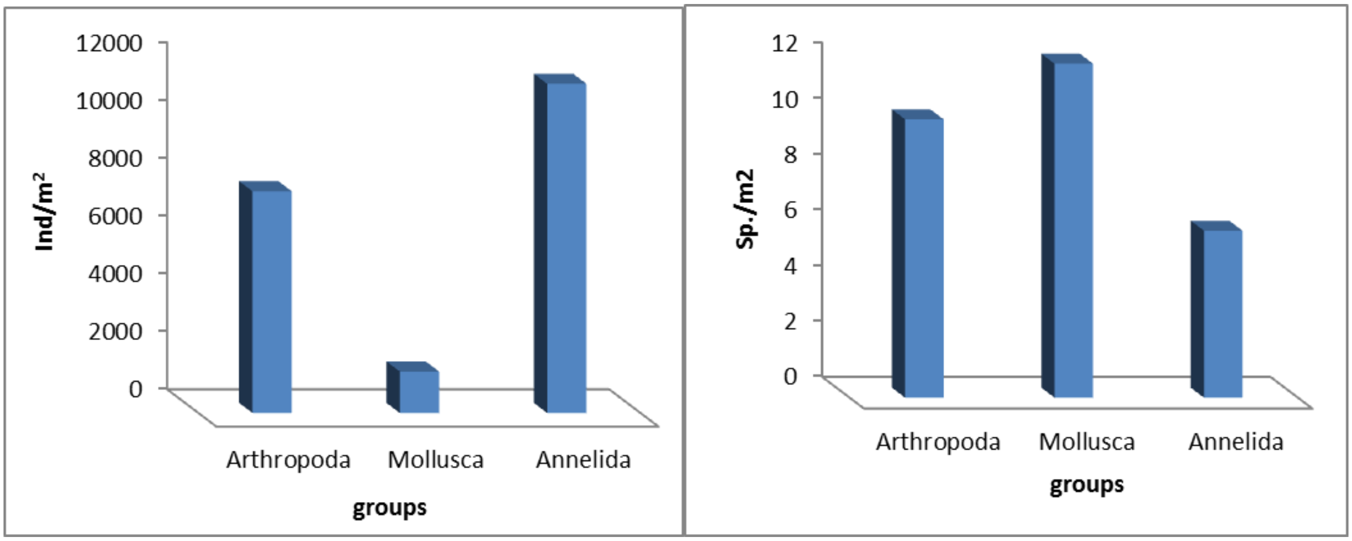

Fig. 2. Macrobenthic invertebrates sampled by Ekman Grab (a) No. of individuals/m^2 and (b) No. of species/m^2 at the different stations in El-Rayah El-Tawfiky

In samples collected by macrophyte sweep netting (Fig. 3), Arthropoda constituted the highest species number and density (2946 ind./m^2). 16 species of Arthropoda were recorded with an estimation value of 83% of the total individuals (Table 1 & Fig. 2). While, Annelida was represented by 3 species and recorded the second highest density (421 ind./m^2) forming 12% of the total individuals in El-Rayah El-Tawfiky. In addition,11 species of Mollusca were detected (190 ind./m^2), constituting 5% of the total individuals in this area. *Chironomidae larva* was the most dominant species being 72 % of the total Arthropoda with an average of 305 ind./m^2. This result coincides with that of **Bendary and Ibrahim, (2021**). Additionally, **Stahl (1986)** mentioned that these larvae are wide spread and abundant in all kinds of inland lakes. Similarly, **Wirth and Stone (1968)** stated that Chironomus larvae are most abundant in lakes, ponds and streams favored by growth of aquatic plants. Chironomidae and Oligochaeta are generally the most successful aquatic macroinvertebrate taxa and they inhabit all freshwater bodies, including polluted and eutrophic waters **(van der Berg, 1999; Mackie, 2001)**. One of the main reasons for the great abundance of Chironomidae is that they exhibit all types of feeding behaviour and food preference **(Nilsson, 1997)**.

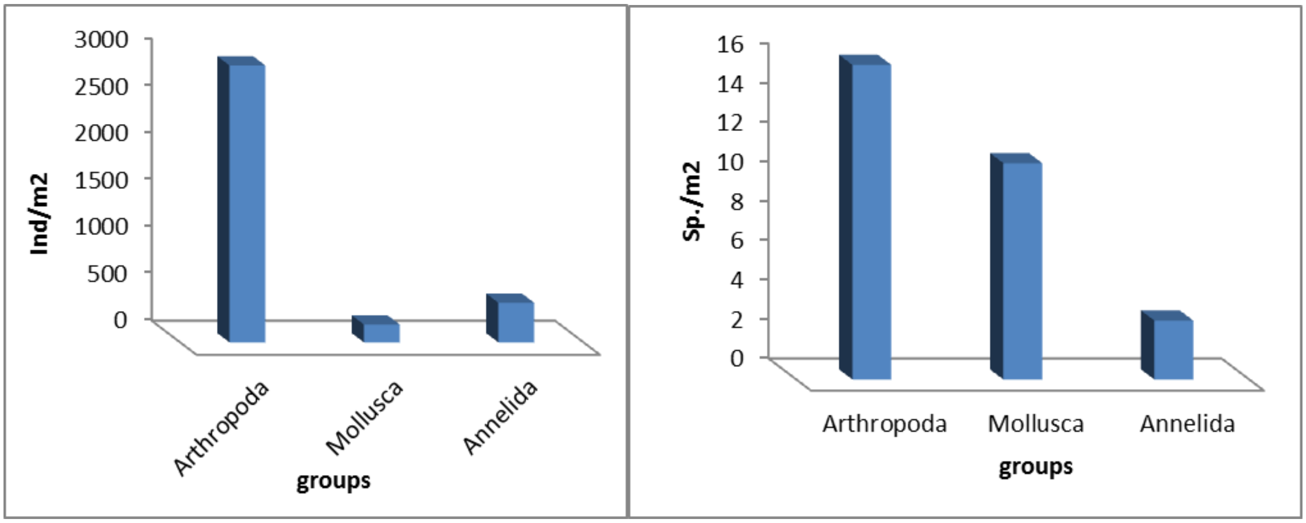

Fig. 3. Macrobenthic invertebrates sampled by macrophyte (a) No. of individuals/m^2 and (b) No. of species/m^2 at the different stations in El-Rayah El-Tawfiky

The distribution of macrobenthic invertebrates in El-Rayah El-Tawfiky varies greatly with respect to stations. For grab samples, it was observed that, the highest density was detected at station VI (14 species and 7783 individuals/m^2) due to the flourishing of *Micronecta* sp. and *Limnodrilus udekemianus*. Contrarily, station VII showed the lowest abundance of macrobenthic fauna (12 species and 512 individuals/m^2). While, in samples collected by macrophyte, the highest density and diversity were found at stations V (18 species and 1162 ind./m^2),from which El-Rayah El-Tawfiky is divided into sub-main branches at the Mansoura city, and hence, a decrease of water current velocity appears in consequence. In this respect, **Franklin *et al*., (2008)** considered flow velocity as the main controlling factor of macrophyte colonisation, establishment and persistence in the rivers. Once communities are established, both the abundance and diversity of macrophytes are stimulated at low to medium velocities, and growth is diminished at higher velocities and therefore the macroinvertebrate biodiversity increases. On the other hand, stations VII recorded the lowest abundance and species number of macrobenthic fauna (7 species and 41 ind./m^2). No live fauna was found at station III (Table 2).

The community structure of macrobenthos in the grap samples showed that, station III had the highest richness value (SR = 2.1) as well as the highest diversity (H´ = 1.45). At station I, the number of species was fairly high, noting that only one specific species (*Limnodrilus udekemianus*) formed more than 87% of the total number of individuals in this station. Therefore, the minimum species diversity (H´ = 0.62) and the minimum evenness (E = 0.27) at this station was primarily due to the uneven distribution of individuals among the species (Tables 3). On the other hand, for the macrophyte samples,station II had the highest richness value (SR = 2.45) as well as the highest diversity (H´ = 1.71). while, station VI exhibited the lowest value of richness (SR = 1.25) and diversity (H´ = 0.87). Low diversity at station VI probably reflect the pollution effluents of water treatment and electrical power plants established at this station (Table 4).

Table 3. Population density (total individuals/m^2), total species/m^2, species richness (SR), equitability (E) and diversity index (H') of macrobenthic invertebrates sampled by Ekman Grab in El-Rayah El-Tawfiky

	Stations						
	I	II	III	IV	V	VI	VII
Total ind./m^2	2166	1769	3753	1752	2776	7783	512
Total species/m^2	10	14	18	11	15	14	12
(SR)	1.2	1.7	2.1	1.3	1.8	1.5	1.8
(E)	0.27	0.51	0.50	0.40	0.28	0.36	0.42
(H')	0.62	1.35	1.45	0.96	0.76	0.96	1.04

Table 4. Population density (total individuals/m^2), total species/m^2, species richness (SR), equitability (E) and diversity index (H') of macrobenthic invertebrates sampled by macrophyte in El-Rayah El-Tawfiky

	Stations						
	I	II	III	IV	V	VI	VII
Total ind./m^2	691	1037	0	265	1162	361	41
Total species/m^2	13	18	0	8	18	14	7
(SR)	1.84	2.45	0.00	1.25	2.41	2.21	1.62
(E)	0.37	0.59	0.00	0.42	0.37	0.58	0.74
(H')	0.95	1.71	0.00	0.87	1.07	1.52	1.45

Seasonal changes associated with the abundance of macrobenthos differed according to sampling methods. For grap samples, the highest values were recorded in the season of spring, while their lowest values were detected in autumn. This finding concurs with that of **Fishar and William (2006)**, who recommended May and June as the preferred period for grab sampling. For macrophytes, the highest abundance are generally found in summer, while the lowest values are recorded in winter (with no macrophyte samples collected in spring). **Fishar and William (2006)** reported that, the critical factor with macrophyte sampling is the presence of good macrophyte beds in the period that extends from May to September (Fig. 4).

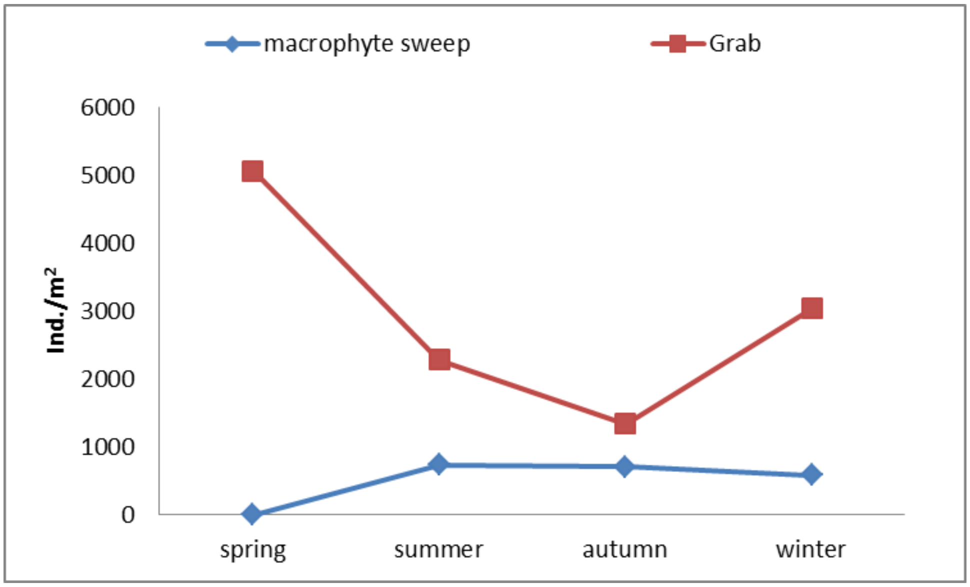

Fig. 4. Seasonal variation in macrobenthic invertebrate density sampled by Ekman Grab and macrophyte sweep observed in El-Rayah El-Tawfiky

Ind/m^2 = individuals/m^2

The similarity index (Fig. *) for grap samples showed that, a strong relation existed between stations II and IV (S = 99.5%). Approximately, similar results were also obtained between stations I and II , and IV and V (S = 87.6 – 89.8 %). It was observed that, stations VI & VII revealed the lowest similarity compared to the other stations (Fig. 5).

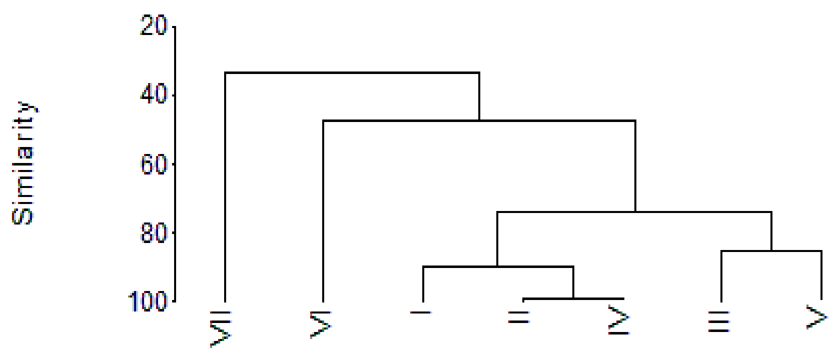

Fig. 5. Similarity between the different stations in El-Rayah El-Tawfiky for grap samples

The similarity index (Fig. *) for macrophytes showed that, a strong relation existed between stations II and V (S = 94.3%). Similarly, it was obtained between stations IV and VI (S = 84 %). Notably, station VII revealed the lowest similarity compared to the other stations .Alternatively, compared to all other stations, station III was determined dissimilar (S = 0%), as a result of the absence of live fauna (Fig. 6).

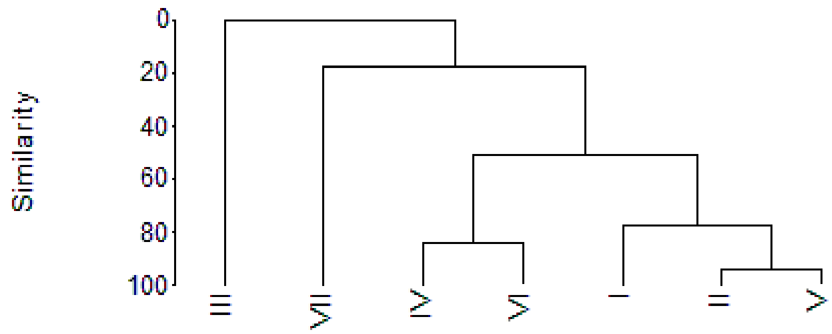

Fig. 6. Similarity between the different stations in El-Rayah El-Tawfiky for macrophyte sweep samples.

CONCLUSION

El-Rayah El-Tawfiky is a source of water supply for drinking, irrigation and fishing. The present data indicate thatthe significant differences detected in community composition, distribution and abundance of macrobenthos are attributed to the difference in the sampling methods, seasons and sites. In comparison, Annelida species flourished in samples collected by grap, whilst Arthropoda species prevailed in samples collected by macrophyte. The highest density was observed at stations VI and V in grap and macrophyte samples, respectively, while the lowest values were observed at stations VII with reference to the two sampling methods. Remarkably, spring is the recommended season for grab sampling, while summer is the best for macrophyte sampling. Results indicate that the study area suffers from several sources of pollution, whereas the tolerant species dominated the community as *Chironomidae larva* and *Limnodrilus udekemianus*. Therefore, the implementation of a biomonitoring strategy is recommended to identify risks facing biodiversity, and hence, detect future changes in El-Rayah El-Tawfiky.

REFERENCES

Abdel Salam, K. H. and Tanida, K. (2013). Diversity and spatio-temporal distribution of macro-invertebrates communities in spring flows of Tsuya Stream, Gifu prefecture, central Japan. Egypt. J. Aquat. Res. 39: 39-50.

Bendary, R.E.E. (2013). Ecological studies on macrobenthic invertebrates associated with macrophytes in River Nile, Egypt. M.Sc. Thesis, Zool. Dept. Fac. Sci., Ain shams Univ., 207pp.

Bendary, R.E. and Ibrahim, SH. M. (2021). Diversity and Density of Macrobenthic Invertebrates Associated with Macrophytes in the El-Rayah El-Nasery and El-Rayah El-

Behery, Nile River, Egypt. Egyptian Journal of Aquatic Biology & Fisheries. Vol. 25(5): 511 – 526

EI-Tantawy, A.; Bishai, R. M.; Abdel-Latif, A.; Samaan, A. A. and Iskaros, I. A. (2003). Species Composition and Seasonal Population Dynamics of the Benthic Fauna in Khor Kalabsha, Lake Nasser, Egypt. Egypt J. Aqua. Bio. Fisiu, 4, 2U-240.

El-Damhogy K.A.; Fishar M. R.; Hesham R.A. Mola and Shreif A. M.M. El-Naggar (2017). The relationship between macrobenthic invertebrates and those associated with Plants (Myirophyllum spicatum) in River Nile at Qanater region, Egypt. J. Egypt. Acad. Soc. Environ. Develop., 18 (1): 21-32.

Elewa, H. H. (2010). Potentialities of Water Resources Pollution of the Nile River Delta, Egypt. The Open Hydrology Journal, 4: 1-13.

Fishar, M. R. A. (1995). Studies on bottom fauna in Lake Nasser, Egypt (Ph. D. thesis). Suez Canal Univ., Egypt.

Fishar, M. R. and Williams, W. P. (2006). A feasibility study to monitor the macroinvertebrate diversity of the River Nile using three sampling methods. Hydrobiol. 556: 137-147.

Franklin, P.; Dunbar, M. and Whitehead, P. (2008). Flow controls on lowland river macrophytes: a review. Sci. Total Environ. 400: 369–378.

George, A.D.I.; G.F.N. Abowei and E.R. Daka (2009). Benthic macroinvertebrates fauna and physic- chemical parameters in Okpoka creek sediments, Niger Delta, Nigeria. Int. J. Anim. Vet. Adv., 1: 59-65.

Gregg, W. W. and Rose, F. L. (1982). The effect of aquatic macrophytes on the stream microenvironment. Aquatic Botany 14:309-324.

Hargeby, A. (1990). Macrophyte associated invertebrates and the effect of habitat permanence. Oikos,vol. 57, no. 3: 338-346.

Harrod, J. J. (1964). The distribution of invertebrates on submerged aquatic plants in a chalk stream. Journal of Animal Ecology 33: 335-348.

Higler, L. W. G. (1975). Analysis of macrofauna community on Stratiotes vegetation. Verhand-lungen der international Vereinigung fur Theoretische und Andewand Limnologie 19: 2773-2777.

Hynes, H. B. N. (1970). The diversity of macroinvertebrates and macrophyte communities in Ponds. Freshwater Biology, vol.18, no.1: 87-104.

Keast, A. (1984). The introduced aquatic macrophytes, macroinvertebrate associations and water levels in a lowland Tasmanian river. Hydrobiologia, 321:219-233

Lydeard, c.; R.H. Cowei; W. F. Ponder; A. E. Bogan and P. Bouchet (2004). The global decline of nonmarine Molluskus. Bioscience, 54: 321-330.

Mackie, G.L. (2001). Applied Aquatic Ecosystem Concepts. Kendall/ Hunt Publishing Company, 744 pp.

Nassif, M. G. (2012). Ecological studies on invertebrates of Ismailia Canal, Egypt. M. Sc. Thesis, Fac. Sci., Ain Shams Univ., Egypt.

Nilsson A. ed. (1997). Aquatic Insects of North Europe 2. Appolo Books. Stenstrup, 440 pp.

Radwan, M. and El-Sadek, A. (2008). Water Quality Assessment of Irrigation and Drainage Canals in Upper Egypt, Proc. Twelfth Int. Conf. on Water Technology (IWTC12), Alexandria, Egypt: 1239-1251.

Rashid, R. and Pandit, A. K. (2014). Macroinvertebrates (oligochaetes) as indicators of pollution: a review. J. Ecol. Nat. Environ. 6 (4): 140-144.

Stahl, J. B. (1986). A six year study of abundance and voltinism of Chironomidae (Diptera) in an Illinois cooling reservoir. Hydrobiologia, 134: 67-79.

van der Berg, M.S. (1999). Charophyte Colonization in Shallow Lakes. Processes, Ecological Effects and Implications for Lake Management. Thesis Vrije Universiteit Amsterdam. Drukkerij. Deventer, 138 pp.

Wirth, W.W. and Stone, A. (1968). Aquatic Diptera, P.372-482 in R.L. Usinger (ed.), aquatic insects of California. Univ. Calif. P.R. Los Angeles.