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Community structure of crusteacean Zooplankton in the River Nile at Esna Barrages, Upper Egypt.

Ahmad H. Obuid-Allah[1], Ahmed S. Moustafa[2], Wafaa A. Mohammad[3], El-Amier H. M. Hussien[2]* and Azza M. Gaber[2]

1- Zoology Department, Faculty of Science, Assiut University, Egypt.
2- Zoology Department, Faculty of Science, South Valley University, Qena, Egypt
3- Zoology Department, Faculty of Science, New Valley University, Egypt

*Corresponding author: elameer.hussien@sci.svu.edu.eg

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ABSTRACT

Zooplanktons are major components in the trophic dynamics of freshwater ecosystems. The present study was carried out on the River Nile at Esna barrages, Upper Egypt which located between 25°19'03.5"N and 32°33'19.5"E. Samples were collected from six sites up and down stream of the barrage during one year extended from October 2018 till September 2019. The study revealed that the total number of zooplankton community collected was (36367 indv/m^3). The collected zooplankton could be assigned to three different groups (Cladocera, Copepoda, and Ostracoda) which included 37 species belonging to 27 genera that fall in 10 families. The highest value of total abundance of zooplankton was recorded during winter and the lowest value was recorded during summer. The total density of zooplankton community was recorded at site 1 which is located upstream (9396 indv/m^3), while the lowest value was recorded at site 4 (downstream) (4186 indv/m^3). Cladocera was the dominant group; it represented about 87.5% of the total density followed by Copepoda and Ostracoda. Taxa richness reached the highest peak value (29 taxa) at upstream, while the highest peak value was (25 taxa) at downstream. Shannon- wiener's diversity index ranged between (2.06) and (2.33) at upstream while it ranged between (1.95) and (2.45) at downstream.

INTRODUCTION

The new Esna barrage was constructed on the River Nile in 1995 and equipped with a hydropower station. The distance between the new Esna barrage, which is located downstream the old barrage, is 1.1 km. Moffat *et al*. (1990) and Gray (1992) reported that the construction of barrages on a River leads to change the hydraulic regime of that River by increasing water depths and reducing velocities in areas of developed backwater curves.

The word plankton is being initial authored by Victor Henson in 1887 to assign the heterogeneous gathering of suspended microscopic materials, minute organisms and debris in water that move by the helping of winds, currents and tides (Pavan *et al*., 2017). Zooplankton is considered as the major components in the trophic dynamics of freshwater ecosystems. They occupy an intermediate position in the food chain and indicate the environmental status (Fishar *et al*., 2019).

Zooplankton plays a vital role in matter and energy flow in most river ecosystems and it is essential in maintaining their balance. Zooplanktons are good indicator for future fisheries health, where they transfer primary productivity to fish and other consumers (Dejen *et al*., 2004 and Davies *et al*., 2009).

Zooplankton species composition changes from one area to another within the same geographical areas (Jonathan *et al*., 2000). Zooplankton species composition varies from one season to another influenced by the physico-chemical and biological factors (Perumal *et al*., 2009). Within given water body, mostly of certain zooplankton species may be found in certain areas and may be less or absent in another areas (Kapusta, 2013). Ezekiel *et al*. (2011) reported that dominance of certain zooplankton species due to naturally varying flows of water and sediment in aquatic systems.

Previous studies on various aspects of zooplankton were carried out in the River Nile by many authors and authorities. However, to the best of the present authors` knowledge, the present study is the first one that focuses on survey of crustacean zooplankton community in the River Nile at Esna barrages, Upper Egypt.

MATERIALS AND METHODS

Description of the Study Area:

The present study was carried out at the new Esna barrage, Upper-Egypt which is located 1.1 km downstream the old barrages. The barrage lies between 25°19'03.5''N latitude and 32°33'19.5''E longitude. Six different locations were randomly chosen; three sites (Sites 1-3) located after the old barrages (Upstream) and the other three sites (Sites4- 6) located after the new barrages (Downstream) (Fig. 1). The latitude and longitude coordinates of sampling stations were recorded using the survey vessel's Garmin, Global Positioning System (GPS) unit navigation system (Table 1).

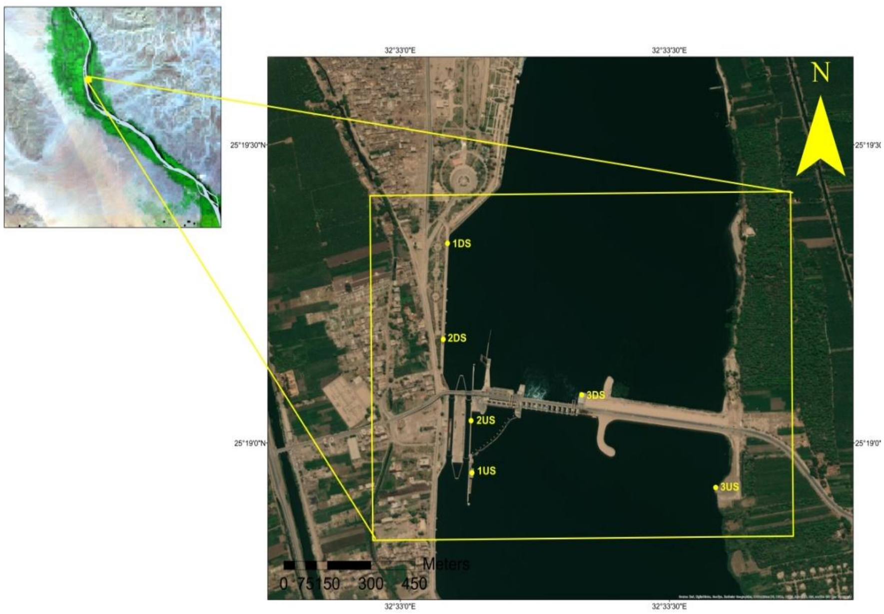

Fig. 1: A map of the River Nile at Upper Egypt, showing the locations of studied sites. Sites 1- 3 U.S. represent upstream while sites 1- 3 D.S. represent downstream.

Table 1: The coordinates and localities of sampling locations at upstream and downstream of the Esna barrages on the Nile River.

Sample sites	GPS coordinates
Site 1 upstream east	25°18'57.74"N 32°33'7.94"E
Site 2 upstream east	25°19'2.24"N 32°33'8.15"E
Site 3 upstream west	25°18'55.47"N 32°33'35.28"E
Site 4 downstream east	25°19'10.75"N 32°33'5.00"E
Site 5 downstream east	25°19'20.07"N 32°33'5.49"E
Site 6 downstream west	25°19'4.96"N 32°33'21.02"E

Zooplankton sampling:

Plankton net was used to collect samples; cone-shaped net is made of nylon cloth with about 153 micron mesh size which permits water to pass through but is fine enough to filter out organisms. Minute plankton is collected and can be observed in the removable, clear conical tube (50 ml.) at the end of the net. A sturdy stainless steel ring and harness keep the mouth of the net open while it is being pulled through the water. It has a (12.7cm) diameter mouth, and is (38cm) long. The zooplankton samples were stored in plastic bottles containing 95% ethanol. The bottles were kept and transported to the laboratory, Department of Zoology, Faculty of Science, South Valley University, Qena.

Identification of zooplankton:

The collected zooplankton species were identified according to different keys: To identify Cladocera, the following keys were used: Brooks (1959) and Obuid-Allah (2001). Copepoda were identified according to Wilson and Yeatman (1959) and Obuid-Allah (2001). Ostracoda were identified according to Fangary (2003).

Samples treatment:

The dominance structure of species was calculated according to Engelmann`s classification (Engelmann, 1978) as subrecedent (below 1.3%), recedent (1.3-3.9%), subdominant (4-12.4%), dominant (12.5-39.9%), eudominant (40-100%). Shannon wiener diversity index (H`) was calculated to show zooplankton diversity within the collected community by using shannon-wiener equation: $H^{`} = -\Sigma pi\ (\ln pi)$, where pi is the proportion of individuals belonging to the i^{th} species. Zooplankton richness of the community was calculated.

Statistical analysis:

Analysis of Variance on SPSS software package (SYSTAT statistical program, version 23) was used to test the present data. In the case of significant differences, the Multiple Range Comparisons (Least Significant Difference; LSD) was selected from the Post Hoc window on the same statistical package to detect the distinct variances between means.

RESULTS

A total number of 36367 indv/m^3 of different taxa of zooplankton were collected from six different sites located at Esna barrages. The collected zooplankton taxa belong to 3 main groups: (21 taxa of Cladocera, 13 taxa of Copepoda and 3 taxa of Ostracoda). Taxa collected were assigned in 28 genera and 35 species that fall in 10 families. In addition to Copepodite stage and Nauplius stage. The identified families included the following: Six families belonging to Cladocera: Bosminidae, Daphniidae, Ilyocryptidae, Macrothricidae, Chydoridae, Sididae. Three families belonging to Copepoda: Diaptomidae, Cyclopidae, Miraciidae. One family belongs to Ostracoda:Cyprididae. These families varied in their numbers and frequencies of occurrence according to the site. The most abundant family was Chydoridae, which represented the highest number during the whole period of study (19826 indv/m^3) and embraced most of zooplankton taxa (13 species), but the lowest number was represented by Family Sididae (26 indv/m^3), which embraced one species in the same period of study Table (2).

Table 2: The identified species from the six investigated sites during the period of investigation.

Division	Family	Species
Cladocera	Family: Bosminidae	*Bosmina longirostris*
	Family: Daphniidae	*Simocephalus expinosus*
		Simocephalus vetulus
		Ceriodaphnia reticulata
		Daphnia longispina
	Family: Ilyocryptidae	*Ilyocryptus sordidus*
	Family: Macrothricidae	*Macrothrix laticornis*
	Family: Chydoridae	*Alona bukobensis a*
		Alona bukobensis b
		Alona bukobensis c
		Alona rectangular
		Alona sp.
		Camptocercus australis
		Leydigia quadrangularis
		Oxyurella sp.
		Chydorus sphaericus
		Disparalona rostrata.
		Pleuroxus aduncus
		Pleuroxus letourneuxi
		Dunhevedia crassa
	Family: Sididae	*Diaphanosoma birgei*
Copepoda	1-Order: Calanoida	*Thermodiaptomus galebi*
	Family: Diaptomidae	
	2-Order: Cyclopoida	*Mesocyclops ogunnus*
	Family: Cyclopidae	*Thermocyclops consimilis*
		Thermocyclops neglectus
		Tropocyclops confinis
		Macrocyclops albidus
		Microcylops varicans
		Microcylops linjanticus
		Ectocyclops phaleratus
		Afrocyclops gibsoni
	3-Order: Harpacticoida	*Shizopera nilotica*
	Family: Miraciidae	
Ostracoda	Family: Cyprididae	*Cypridopsis vidua*
		Potamocypris variegate
		Candona sp.

Cladocera was the most abundant group of zooplankton in all investigated sites constituting (31806 indv/m^3) followed by Copepoda (4228 indv/m^3) and Ostracoda (333 indv/m^3) (Fig.2). Considering the number of each taxa of zooplankton collected from all sites, it was observed that the maximum number was collected from *Disparalona rostrata* (9652 indv/$m^{3,}$ constituting 26.54% of the total number), while *Daphnia longispina*, *Alona* sp. *Oxyurella s*p. were the least species in number since (4 indv/m^3 for each one, constituting 0.01% from the total number) (Table 3).

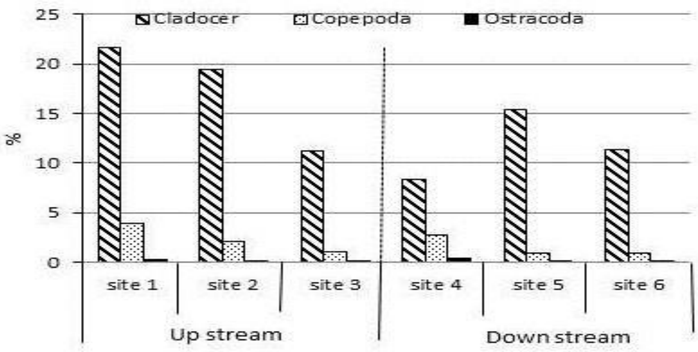

Fig. 2: The abundance of the collected zooplankton (indv/m^3) in the upstream and downstream sites.

Table 3: Total number and percentage of zooplankton taxa collected from all investigated sites during the period of investigation.

Taxa	**Site**							
	Site 1 indv/m^3	**Site 2** indv/m^3	**Site 3** indv/m^3	**Site 4** indv/m^3	**Site 5** indv/m^3	**Site 6** indv/m^3	**Total**	**%**
Cladocera								
Bosmina longirostris	1864	952	117	318	311	218	3780	10.39
Simocephalus expinosus	321	133	0	164	116	9	743	2.04
Simocephalus vetulus	33	46	13	16	42	13	163	0.45
Ceriodaphnia reticulate	962	449	143	746	908	1299	4507	12.39
Daphnia longispina	0	0	0	0	0	4	4	0.01
Ilyocryptus sordidus	176	182	216	126	68	119	887	2.44
Macrothrix laticornis	21	54	0	151	1580	63	1869	5.14
***Alona bukobensis* a**	13	95	389	0	53	27	577	1.59
***Alona bukobensis* b**	7	17	92	19	0	20	155	0.43
***Alona bukobensis* c**	423	742	447	39	44	82	1777	4.89
Alona rectangular	51	9	66	0	0	0	126	0.35
***Alona* sp.**	0	4	0	0	0	0	4	0.01
Camptocercus australis	63	39	127	20	27	15	291	0.8
Leydigia quadrangularis	0	0	0	7	0	0	7	0.02
***Oxyurella* sp.**	4	0	0	0	0	0	4	0.01
Chydorus sphaericus	1974	926	1637	506	1358	523	6924	19.04
Disparalona rostrata.	1866	3362	826	922	1102	1574	9652	26.54
Pleuroxus aduncus	0	7	0	0	0	13	20	0.05
Pleuroxus letourneuxi	0	0	0	0	0	13	13	0.04
Dunhevedia crassa	91	46	0	0	13	127	277	0.76
Diaphanosoma birgei	4	13	0	0	0	9	26	0.07
Copepoda								
Thermodiaptomus galebi	224	171	20	175	102	110	802	2.21
Mesocyclops ogunnus	446	166	176	422	133	128	1471	4.04
Thermocyclops consimilis	125	127	13	51	45	28	389	1.07
Thermocyclops neglectus	0	4	0	7	9	0	20	0.05
Tropocyclops confinis	38	24	9	40	13	0	124	0.34
Macrocyclops albidus	13	0	0	13	0	0	26	0.07
Microcylops varicans	48	38	31	13	0	24	154	0.42
Microcylops linjanticus	231	49	22	103	18	0	423	1.16
Ectocyclops phaleratus	0	0	0	0	13	0	13	0.04
Afrocyclops gibsoni	53	0	8	0	0	0	61	0.17
Shizopera nilotica	105	46	22	53	0	31	257	0.71
Copepodite stage	136	126	55	110	11	28	466	1.28
Nauplius stage	0	4	18	0	0	0	22	0.06
Ostracoda								
Cypridopsis vidua	54	24	8	158	7	13	264	0.73
Potamocypris variegate	43	0	0	7	4	0	54	0.15
***Candona* sp.**	7	4	0	0	0	4	15	0.04
Total	**9396**	**7859**	**4455**	**4186**	**5977**	**4494**	**36367**	

Concerning monthly fluctuations abundance of zooplankton in all investigated sites, it was found that the maximal number was collected during March (7125 indv/m^3 specimens, constituting 19.59% from the total number), while, the lowest number of the populations was collected during May, (617 indv/m^3, consisting 1.70% from the total number). The most favorable locality was site 1 since the maximum number of specimens was collected reached (9396 indv/m^3, constituting 25.84 % of the overall total number), whereas site 4 was the least favorable one, (4186 indv/m^3 and constituting 11.51% of the overall total number). (Table 4).

Table 4: Total number of zooplankton taxa collected from all investigated sites during the period of investigation.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
Site 1	173	1207	1934	642	1310	2382	402	169	29	398	465	285	**9396 25.84**
Site 2	234	825	1184	673	1490	2360	146	303	121	21	146	356	**7859 21.61**
Site 3	216	880	969	260	1221	497	0	11	105	81	22	193	**4455 12.25**
Site 4	200	518	567	132	933	353	245	78	521	156	188	295	**4186 11.51**
Site 5	134	154	873	665	443	869	1843	56	665	87	43	145	**5977 16.44**
Site 6	111	205	81	194	751	664	662	0	921	101	48	756	**4494 12.36**
Total	1068	3789	5608	2566	6148	7125	3298	617	2362	844	912	2030	**36367**
%	2.94	10.42	15.42	7.06	16.91	19.59	9.07	1.70	6.49	2.32	2.51	5.58	**100**

Regarding seasonal fluctuations of all six sites, it could be noticed that the maximal number was collected during winter (14322 indv/m^3, constituting 41.84 % from the total number), and the minimal number was collected during summer (4118 indv/m^3, constituting 12.03 % from the total number) (Fig.3).

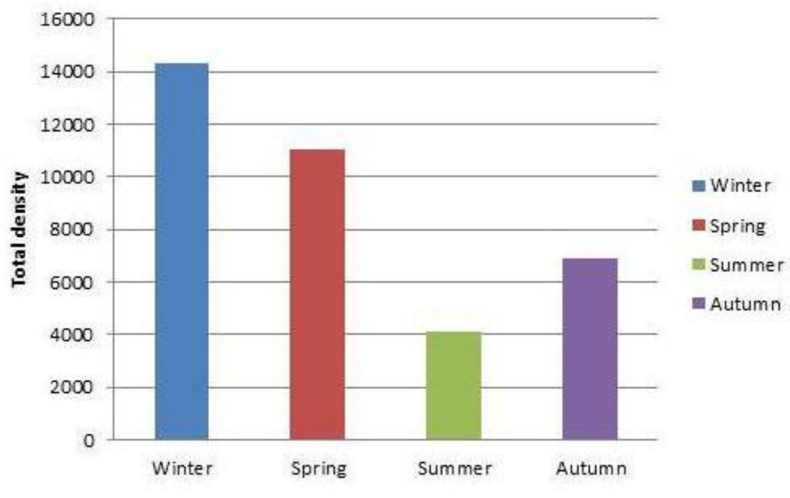

Fig. 3: Seasonal abundance of total density of zooplankton during the period of study.

In monthly fluctuations; the dominance structure of the collected species showed that there were 3 eudominant species, the Eudominant zooplankton taxa were: *Ceriodaphnia reticulata* (43.98%), *Chydorus sphaericus* (43.06%) and *Mesocyclops ogunnus* (40.74%). The dominant species were 9 taxa: *Bosmina longirostris* (39.35%), *Disparalona rostrata* (32.41%), *Ilyocryptus sordidus* (29.63%), *Alona* *bukobensis c* (20.37%), *Thermodiaptomus galebi* (20.37%), Copepodite stage (16.67%) *Thermocyclops consimilis* (15.28%), *Simocephalus expinosus* (12.5%) and *Shizopera nilotica* (12.50%). The subdominant species were 10 species*: Microcylops linjanticus* (11.11%), *Simocephalus vetulus* (9.72%), *Camptocercus australis* (8.80%), *Macrothrix laticornis* (7.41%), *Cypridopsis vidua* (7.41%), *Tropocyclops confinis* (6.94%), *Microcylops varicans* (6.48%), *Alona bukobensis a* (5.56%), *Alona bukobensis b* (5.09%). There were 4 recedent taxa: *Dunhevedia crassa* (3.70%), *Alona rectangular* (2.78%), *Potamocypris variegate* (2.78%), Nauplius stage (2%), *Thermocyclops neglectus (*1.39%*)* and *Fabaeformiscandona holzkampfi* (1.39%) (Table 5).

Table 5: The frequency, the percentage (F ,%) and the dominancy of the zooplankton taxa at upstream and downstream sites during the period of investigation.

Taxa	Site								
	Site1	Site2	Site3	Site4	Site5	Site6	Total		
	F	F	F	F	F	F	F	%	Dominancy
Cladocera									
Bosmina longirostris	24	19	4	11	14	13	85	39.35	Dominant
Simocephalus expinosus	9	8	0	6	3	1	27	12.5	Dominant
Simocephalus vetulus	6	7	1	2	4	1	21	9.72	Subdominant
Ceriodaphnia reticulata	23	18	8	16	14	16	95	43.98	Eudominant
Daphnia longispina	0	0	0	0	0	1	1	0.46	Subrecedent
Ilyocryptus sordidus	14	11	8	10	9	12	64	29.63	Dominant
Macrothrix laticornis	3	2	0	5	2	4	16	7.41	Subdominant
Alona bukobensis a	1	5	4	0	1	1	12	5.56	Subdominant
Alona bukobensis b	1	2	4	3	0	1	11	5.09	Subdominant
Alona bukobensis c	12	8	11	4	3	6	44	20.37	Dominant
Alona rectangular	3	1	2	0	0	0	6	2.78	Recedent
Alona sp.	0	1	0	0	0	0	1	0.46	Subrecedent
Camptocercus australis	3	5	6	1	1	3	19	8.80	Subdominant
Leydigia quadrangularis	0	0	0	1	0	0	0	0.46	Subrecedent
Oxyurella sp.	1	0	0	0	0	0	1	0.46	Subrecedent
Chydorus sphaericus	19	14	16	16	15	13	93	43.06	Eudominant
Disparalona rostrata.	13	13	11	12	9	12	70	32.41	Dominant
Pleuroxus aduncus	0	1	0	0	0	1	2	0.93	Subrecedent
Pleuroxus letourneuxi	0	0	0	0	0	1	1	0.46	Subrecedent
Dunhevedia crassa	4	2	0	0	1	1	8	3.70	Recedent
Diaphanosoma birgei	1	1	0	0	0	0	2	0.93	Subrecedent
Copepoda									
Thermodiaptomus galebi	12	9	2	7	8	6	44	20.37	Dominant
Mesocyclops ogunnus	22	13	11	18	13	11	88	40.74	Eudominant
Thermocyclops consimilis	8	10	1	5	5	4	33	15.28	Dominant
Thermocyclops neglectus	0	1	0	1	1	0	3	1.39	Recedent
Tropocyclops confinis	5	3	1	5	1	0	15	6.94	Subdominant
Macrocyclops albidus	1	0	0	1	0	0	2	0.93	Subrecedent
Microcylops varicans	4	3	2	1	0	4	14	6.48	Subdominant
Microcylops linjanticus	9	5	2	5	3	0	24	11.11	Subdominant
Ectocyclops phaleratus	0	0	0	0	1	0	1	0.46	Subrecedent
Afrocyclops gibsoni	1	0	1	0	0	0	2	0.93	Subrecedent
Shizopera nilotica	11	5	3	5	0	3	27	12.50	Dominant
Copepodite stage	9	9	4	8	2	4	36	16.67	Dominant
Nauplius stage	1	2	1	0	0	0	4	1.85	Recedent
Ostracoda									
Cypridopsis vidua	5	3	1	4	1	2	16	7.41	Subdominant
Potamocypris variegata	4	0	0	1	1	0	6	2.78	Recedent
Candona sp.	1	1	0	0	0	1	3	1.39	Recedent

Taxa Richness and Shannon diversity index.

In upstream sites, the highest value for Shannon- wiener's diversity index were recorded in sites 1, 2, while the lowest value was recorded in site 3. In downstream sites the highest value of Shannon- wiener's diversity index was recorded in site 4 and the lowest was in site 6. The taxa richness at downstream sites were usually lower than upstream sites (Fig. 4).

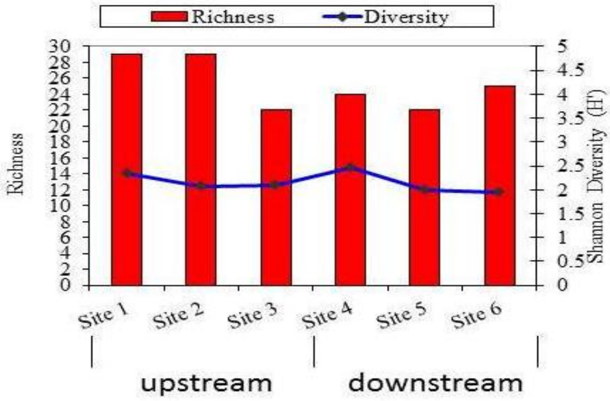

Fig. 4: Taxa richness and Shannon diversity of the total zooplankton in the up and downstream sites during the period of investigation.

DISCUSSION

In the present study, thirty seven zooplankton taxa had been recorded at six investigated sites (upstream and downstream) during the period of investigation. They were represented, by common freshwater crustacean groups, Cladocera (21 taxa), Copepoda (13 taxa), and Ostracoda (3 taxa).

The study indicated that, the total density of crustacean zooplankton showed the highest peak during winter and lowest peak during summer. This result agrees with Mohammad (2016) who studied zooplankton inhabiting the River Nile at Assiut, Egypt and concluded that zooplankton attained the highest total average density during winter and the minimum value was at summer. The high abundance recorded during winter may be due to that low temperature is unfavorable for predation. Previous studies indicated increase of predation by planktivorous fish during summer months compared to spring (De Stasio, 1991; Flik and Ringelberg, 1993).

Cladocera was the most dominant group; its total density was represented by 87.5%. This result agrees with that recorded in the Nile water by mohammad (2008), Mohammad *et al*., (2016) and Abdel hady (2013). The present study showed that the highest peak density of Cladocera was noticed during winter, while the lowest peak was during summer. The increase in the density of Cladocera in winter could be due to the increased oxygen content of the water because of decreased temperature and increased water movement. This result agrees with Zaghloul (1985), who illustrated that the limnoplanktonic forms of Cladocera require high oxygen concentration. Green (1962) indicated flourishing of Cladocera during low temperature seasons and most of large cladoceran species don't produce in warm months but can produce in winter-spring. Fakayode (2005) estimated that dissolved oxygen is very crucial for survival of aquatic organisms and it is also used to evaluate the degree of freshness of Alaro River, Nigeria. El-Bassat (2002) mentioned that, temperature plays a major role in the distribution of Cladocera and most cladoceran species prefer low temperature. Fishar *et al*. (2019) reported that in El-Rayah El-Behery, the highest population density of Cladocera was recorded in winter while the lowest population density was observed during summer.

The decrease in density of Cladocera during summer may explain that high temperature is an unfavorable for Cladocera. Abd El-Karim (1999) and Bedair (2006) mentioned that, the decreasing in the density of Cladocera populations during summer may due to flourish of blue green algae and dinoflagellates which lead to the inhibition of Cladocera filtering rate. Helal (1981) demonstrated that summer and autumn were apparently the period of the paucity of the cladocerans.

Ceriodaphnia reticulata was the eudominant species in cladoceran group during the period of investigation, this result is in agreement with Mohmoud (1995) who reported that *Ceriodaphnia reticulata* was an abundant species, constituted 23.5% of the total number. Obuid- Allah (1990a) made a survey of freshwater Cladocera at 11 districts including 25 sites in Egypt and estimated that *Ceriodaphnia reticulata* was accessory species.

The present work indicated that the total density of zooplankton was recorded at sites located upstream of the old barrages on the River Nile. It was (21710 Indv/m^3) constituting 59.70% of the total zooplankton at both streams. However, the total density of zooplankton recorded at sites located downstream of the old barrages on the River Nile was (14657 Indv/m^3) constituting 40.30% of the total zooplankton at both streams. These differences in zooplankton community between upstream and downstream pointed to the impacts of the new Esna barrages construction. Previous studies conducted by Poiner and Kennedy (1984) revealed that a further effect of dredging may be that the disturbance of sediments, releases sufficient organic materials to enhance the species diversity and population density of organisms outside the immediate zone of deposition of suspended material.

The mean value of Shannon diversity index (H) recorded slight fluctuations among different studied sites during the period of investigation. In the upstream the value of index (H) ranged from (2.33) in site 1 to (2.06) in site2. On the opposite side, the value of index (H) at downstream increased from (2.45) in site 4 to (1.95) in site 6. In comparing upstream and downstream, the values of index (H) were (2.17) & (2.13); respectively. Kerkhoff (2010) reported that typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4.

From the above mentioned results, it was concluded that the diversity from the studied upstream sites is much higher than from the sites located downstream. This result is an expected one and mostly due to the effect of the barrage since the presence of the barrage makes the conditions of the upstream looks like a lake condition which helps many organisms to flourish and make true associations. Attayed and Bozelli (1998) reported that changes in zooplankton diversity are known to be significant indicators of environmental disturbance.

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