Chapter 6
Zooplankton and Zoobenthos

ZOOPLANKTON

THE MAIN CHANNEL

Zooplankton organisms form an important link in aquatic food chains, since they are therefore secondary producers. It is necessary to study zooplankton in detail to elucidate the dominant species, their seasonal, horizontal and vertical distribution; and also the relationship among zooplankton distribution, chlorophyll *a* and transparency of water in the Lake. In other words, it is important to complete the general picture of the Lake productivity.

Species diversity. Many investigators studied the zooplankton of Lake Nasser and its khors since its early filling (Samaan 1971; Rzóska 1974; Samaan & Gaber 1976, 1981; Zaghloul 1985; Guerguess 1986a and b; Abdel-Mageed 1992, 1995; Mohamed, I. 1993k; Mohamed, M. 1993c and g; Iskaros 1993; Habib 1995b, 1996b, 1997 and 1998c; Shehata *et al*. 1998a and b; El-Shabrawy, 1998). Most of these studies were carried out for limited periods and localities. Studies on zooplankton in the main channel, which extended for four seasons, are those of Zaghloul (1985), Abdel-Mageed (1995), Shehata, S. *et al.* (1998a and b), even though based on the examination of a limited number of samples from various depths. However, such studies may give an idea about the diversity, density, standing crop and distribution of zooplankton in the Lake and its succession during various periods. The total number of species recorded in Lake Nasser by various investigators is 79 spp., belonging to four major groups: Protozoa (8 families and 10 spp.), Platyhelminthes (1 family and 1 sp.), Rotifera (16 families and 48 spp.) and Arthropoda (9 families and 21 spp.) (Table 65) in addition to minor groups of rare occurrence such as free living nematodes, chironomid larvae, fish eggs and larvae. Zaghloul (1985) recorded 28 species (4 protozoans, 10 rotifers, 9 copepods and 5 cladocerans). Abdel-Mageed (1992) working in Khor El-Ramla, listed 36 species (26 rotifers, 7 cladocerans and 3 copepods). In his study at Khor Kalabsha, Iskaros (1993) recorded 42 species (29 rotifers, 7 cladocerans, 5 copepods and one species of ostracods). Abdel-Mageed (1995), in his study at 10 localities along the main channel during 1993 and 1994 listed 54 species (36 rotifers, 8 cladocerans, 3 copepods, 6 protozoans and one turbellarian species in addition to the minor groups (Table 65). The 36 rotifer species recorded by Abdel-Mageed (1995) and Shehata, S. *et al.* (1998a) belong to 20 genera and 16 families, the genera *Keratella* (72% of total rotifers) and *Brachionus* (18.53% of total rotifers) were dominant, constituting 90 % of the total rotifer number, a finding which agrees with that of previous authors (Zaghloul 1985, Abdel-Mageed 1992, Iskaros 1993). The highest number of zooplankton species was that of Rotifera (48 species out of 80 species – Table 65) which may be attributed to the high alkalinity of Lake Nasser which favours the occurrence of rotifers. Train (1979) pointed out that rotifers prefer alkaline waters. Thus Abdel-Mageed (1995) found a positive correlation between rotifers density and alkalinity.

The differences between species diversity, composition, density and standing crop, given by various authors may be attributed to differences in methodology, number of samples examined and inclusion or exclusion of littoral species. However, the species pattern of Lake Nasser recorded by various investigators, since its early filling gives a good indication of the dynamic balance of the communities as previously mentioned by MacLachlan (1974).

Density. The density of zooplankton in the Lake was studied by different authors (Samaan 1971, Samaan & Gaber 1977 and 1981, Ateato 1985, Zaghloul 1985, Abdel-Mageed 1995, Habib 1995b, 1997 and 1998c, El-Shabrawy, 1998). The results of these studies indicate that Lake Nasser is very rich in zooplankton (Table 66). It seems that figures given by these authors from 1979 to 1995 are comparable except for those of Ateato (1985) who gave higher figures (215,504 ind./m^3). However, figures as high as 733,99/ind./m^3 were recorded in autumn at Tushka at 0-10m depth (Abdel-Mageed 1995).

Studies by various investigators indicate that the zooplankton community of Lake Nasser is dominated by copepods, rotifers and cladocerans (Zaghloul 1985, Abdel-Mageed 1992, 1995, Iskaros 1993, Habib 1995b). Habib (1995b) studied the density and distribution of zooplankton at 6 localities in February 1994 and her results showed that copepods mainly nauplii are dominant (68.5%) followed by cladocerans (18.9%), and rotifers 12.8 % (Tables 67 and 68 and Fig. 88). In 1993/1994 Abdel-Mageed (1995) found that copepods (62.39%), rotifers (29.54%) and cladocerans (7.55%) constituted 99.48% of the total zooplankton of the Lake. The highest density of copepods was recorded in autumn (75, 312 ind./m^3) due to the dominance of larvae (53,695 ind/ .m^3) which feed mainly on phytoplankton flourishing in autumn in the Lake (Abdel Monem 1995). The average number of rotifers was 22,219 ind./m^3 decreasing with increasing depth. Rotifers are dominant in spring when copepod density is low and the oxygen content is high and the temperature is low. Thus, the predation effect of most copepods on rotifers is low in spring (Hutchinson 1967). Furthermore, Galati (1978) pointed out that rotifers prefer cold water. In addition Abdel-Mageed (1995) found that rotifers in Lake Nasser were positively related to dissolved oxygen, thus confirming the observation of Herzig (1989) who pointed out that population development of rotifers is limited by the effect of oxygen concentration. Abdel-Mageed (1995) found that *Keratella cochlearis* density increased with increasing oxygen content.

Table 65 **List of zooplankton species recorded from Lake Nasser by different authors. [Plates 9-13]**

Taxa and Species	1981	1989/90	1989/90	1993/94
	1 Zaghloul (1985)	2 Abdel-Mageed 1992	3 Iskaros 1993	4 Abdel-Mageed 1995
PROTOZOA				
Ciliophora				
Holophryidae				
Lacrymaria olor Müller, 1773*	-	-	-	+
Microregma auduboni Smith	+	-	-	-
Didniidae				
Acropisthium mutabile Perty, 1850*	-	-	-	+
Epistylidae				
Epistylis bimarginata Nenninger, 1880*	-	-	-	+
Euplotidae				
Euplotes patella Müller, 1786*	-	-	-	+
Tintinnidae				
Tintinnopsis cincta Claparéde & Lachmann	+	-	-	-
Strobilidiidae				
Strobilidium gyrans Stokes	+	-	-	-
Rhizopoda				
Sarcomastigophora				
Arcellidae				
Arcella discoides Ehrenberg, 1832*	-	-	-	+
Centropyxidae				
Centropyxis aculeata (Ehrenberg, 1882)*	-	-	-	+
PLATYHELMINITHES				
Turbellaria				
Dalyelliidae				
Microdalyellia sp. *	-	-	-	+

ROTIFERA (ROTATORIA)

Philodinidae				
Rotaria citrina (Ehrenberg, 1932)*	-	-	-	+
Brachionidae				
Brachionus patulus Müller, 1786	-	+	-	+
B. falcatus Zacharias, 1898	-	+	+	+
B. plicatilis (Müller, 1786)	-	+	-	+
B. calyciflorus (Pallas, 1766)	+	+	+	+
B. caudatus (Barrois & Daday, 1894)	+	+	+	+
B.angularis (Gosse, 1851)	+	+	+	+
Keratella cochlearis (Gosse, 1851)	+	+	+	+
K. procurva (Thorpe, 1891)	-	+	-	+
K. tropica (Apstein, 1907)	+	+	+	+
K. quadrata Müller, 1786	-	-	+	-
Anuraeopsis fissa (Gosse, 1851)	-	+	+	+
Platyias patulus Müller, 1788	-	+	+	-
Euchlanidae				
Euchlanis dilatata (Ehrenberg, 1832)	-	+	+	+
Collurellidae				
Lepadella patella (Müller, 1773)	-	+	+	+
L. ovalis (Müller, 1786)	-	-	+	+
Colurella adriatica (Carlin, 1939)	-	+	-	-
C. obtusa (Gosse, 1851)	-	-	+	-
Lecanidae				
Lecane luna (Müller, 1776)	+	+	+	+
L. depressa (Bryce, 1891)	-	-	+	+
Monostyla elachis (Harring & Mers, 1913)*	-	-	-	+
M. bulla (Gosse, 1886)	+	+	+	+
M. lunaris (Ehrenberg, 1882)	-	-	-	+
M. closterocerca Schmarda	-	-	+	-
Notommatidae				
Cephalobdella catellina (Müller, 1786)	-	+	+	+
Scaridium longicaudum (Müller, 1786)	-	+	+	-
Trichocercidae				
Trichocerca similis (Wierzejski, 1893)	-	+	-	+
T. longiseta **Schrank**	+	-	+	-
T. chattoni (Beauchamp, 1907)*	-	-	-	+
T. collaris (Rousselet, 1892)*	-	-	-	+
T. pusilla (Lauterbon, 1898)*	-	-	-	+
T. porcellus Gosse, 1851	-	-	+	-
T. stylata (Gosse, 1851)*	-	-	-	+
Trichotria tetractis (Ehrenberg, 1843)	-	+	-	-
Synchaetidae				
Polyarthra vulgaris (Carlin, 1943)	-	+	-	+
Polyarthra sp.	-	-	+	-

Asplanchnidae				
Asplanchna priodonta (Gosse, 1861)	+	+	+	+
Dicranophoridae				
Pedipartia sp.*	-	-	-	+
Gastropodidae				
Ascomorpha ecaudis (Perty, 1850)*	-	-	-	+
Collothecidae				
Collotheca balatonica (Varga, 1936*)*	-	-	+	+
Testudinellidae				
Testudinella patina (Hermann, 1783)	-	-	+	+
Pompholyx complanata (Gosse, 1851)	-	-	+	+
Conochilidae				
Conochilus hippocrepis (Schank, 1830)	-	-	+	+
Conochiloides sp.	-	-	+	-
Hexarthridae				
Hexarthra mira (Hudson, 1871)	-	+	+	+
Polyarthra vulgaris Carlin	-	+	-	-
Filiniidae				
Filina longiseta *(*Ehrenberg, 1834*)*	+	+	+	+
F. opoliensis (Zaocharias, 1898)	-	+	+	+
ARTHROPODA				
Crustacea				
Branchipoda				
Cladocera				
Sididae	+	+	+	+
Diaphanosoma excisum Sars, 1855				
Daphnidae				
Daphnia longispina Müller, 1785	-	-	-	+
D. barbata Weltner, 1898	+	+	+	-
Ceriodaphnia cornuta Sars, 1885	+	+	+	+
Bosminidae				
Bosmina longirostris *(*Müller, 1776*)*	+	+	+	+
Macrothricidae				
Macrothrix spinosa King, 1853	-	+	-	+
hyidoridae				
Alona intermedia Sars, 1862	-	+	-	+
A. affinis Leydig	+	-	+	-
A. quadrangularis *(*Müller, 1785)	-	+	-	+
Chydorus sphaericus (Müller, 1776)	-	-	+	+
Maxillopoda				
Copepoda				
Cyclopoida	+	+	+	+
Thermocyclops hyalinus (Ehrenberg, 1880)	+	+	+	+
Mesocyclops leuckarti (Claus, 1857)	+	-	-	-
Cyclops vernalis Fischer	+	-	-	-

Acanthocyclops americanus Marsh	+	-	-	-
Halicyclops magniceps Lilljeborg				
Ergasilidae				
Ergasilus sieboldi Nordmann	+	-	+	-
Calanoida				
Diaptomidae				
Thermodiaptomus galebi (Barrois, 1891)	-	+	+	+
Diaptomus wierzejskii Richard	+	-	-	-
D. minutus Lilljeborg	+	-	-	-
D. marshianus M.S.Wilson	+	-	-	-
Ostracoda				
Cypris sp.	-	-	+	-
34 Families	**27**	**36**	**42**	**54**

(1) Zaghloul 1985 (main channel), (2) Abdel-Mageed 1992 (Khor El Ramla), (3) Iskaros 1993 (Khor Kalabsha), (4) Abdel-Mageed 1995 (Main channel). * Recorded for the first time in Lake Nasser.

Cladocera attain their maximum abundance in summer due to the flourishing of *Diaphanosoma excisum* and *Ceriodaphnia cornauta* which prefer warm water (Abdel-Mageed 1995). The latter author recorded the highest zooplankton density (733,991 ind./m^3) during 1993/1994 at Tushka in autumn at 0 - 10 m depth, and the minimum (5,500 ind./m^3) at the surface water near the High Dam in spring.

Lake Nasser is very rich in zooplankton. Habib (1995b) recorded the maximum number (562,100 ind./m^3) at 5-m depth at Abu Simbel in February, 1994 (Table 62). It is clear that the southern region of the Lake is richer in zooplankton than the northern. The total number of zooplankton at Korosko, Tushka, and Abu Simbel were 294,800; 233,900 and 562,900 ind. /m^3 respectively, while at El Ramla, Kalabsha and Allaqi, the average total numbers were only 52,900, 156,400 and 154,800 ind. /m^3 respectively (Table 67). The vertical distribution of zooplankton in Lake Nasser shows that at Abu Simbel high numbers of zooplankton were recorded at all depths (Table 68).

Samaan (1971) estimated the zooplankton standing crop in the upper 10 meters during March 1970 from three localities, viz., El-Ramla, El-Madiq and Khor Singari, which amounted to 21,807, 20,037 and 45,534 ind./m^3 respectively (Table 69). The results suggest that khors are richer in zooplankton, being nearly twice as from the main channel (Table 69). The latter author pointed out that near the southern end of the Lake colonies of *Volvox* spp., Cladocera (mainly *Daphnia* spp.) and Copepoda (mainly *Cyclops* spp.) formed numerically 49.1, 34.2 and 16.7% respectively; while in the northern part of the Lake Cladocera and Copepoda constituted 57.1 and 42.9% respectively. In the middle third of the Lake the picture was different, as

Cladocera, Copepoda and *Volvox** spp. comprised numerically 42.6, 43.6 and 13.8% respectively. So, it seems that species density and diversity differ from one locality to another. At the early stage of filling of Lake Nasser very dense populations of *Volvox** colonies appeared in the plankton, later in Lake Nubia, but these flagellates almost disappeared in 1974 (Entz, 1980b). A similar aspect on the development of *Volvox* could be observed often in other African lakes (e.g. Lake Volta, Beadle, 1974). However, *Volvox globator* is still occurring in the Lake as it is recorded by Zaghloul (1985), and in the southern region of the Lake in 1990 by Mohamed, I. (1993j) (Fig. 92).

***Table* 66 Average annual density of zooplankton in Lake Nasser.**

	Average density of zooplankton (ind. /m^3)	Author	
Northern and Southern regions			
	43,593	Samaan and Gaber	(1976)
	79,925	Gaber	(1981)
	84,660	Zaghloul	(1985)
	215,504	Ateato	(1985)
	66,000	Mohamed, I.	(1993j)
	75,224	Abdel-Mageed	(1995)
Northern region			
	52,900 - 156,400	Habib	(1995b)
Southern region			
	233,900 - 562,100	Habib	(1995b)

Seasonal distribution. Bowers (1979) and Moss (1980) pointed out that zooplankton density does not always correlate with phytoplankton; it depends mainly on the species diversity of phytoplankton. In 1976, zooplankton were more abundant in March than in August (Fig. 89, Latif 1984a). In March, zooplankton were more abundant in the region from El-Madiq to Tushka; while Adindan showed the lowest values. In August, the northern region had values less than those from the southern region. Tushka and Abu Simbel showed the maximum values, while at Adindan zooplankton were much less abundant (Fig. 89). Copepods, particularly their nauplii, are the most dominant groups, followed by Cladocera and Rotifera.

In April 1986, Mohamed, M. (1993c) studied the distribution of zooplankton at six stations along the main channel and his results (Fig. 90) showed that Copepda were the most dominant group, forming numerically 70.4%, followed by Cladocera (25.5%), and Rotifera which were rarely (4.1%) recorded. *Diaptomus* spp. were an important constituent of zooplankton as they formed numerically 43%, followed by *Cyclops* sp. and *Daphnia* sp. (16 and 15% respectively) (Fig. 89). *Asplanchna* sp. was the main rotifer species in the 6 stations (2.5%). It seems that zooplankton population is rich in number of individuals, although represented by few species only (Fig. 92).

* *Volvox globator* is classified by some authors (Soliman 1996) with Protozoa as a member of Phylum Sarcomastigophora (Class Phytomastigophora, Order Volvocida). Other authors (Zaghloul 1985), however include it with phytoplankton (Class: Chlorophyceae order Volvocales)

Table 67 **Distribution of zooplankton and percent of the different groups to 20 m depth during February 1994 (Habib 1995b).**

Location	Cladocera (ind./l)	%	Copepoda (ind./l)	%	Rotifera (ind./l)	%	Total zooplankton (ind./l)
Northern region							
El Ramla	9.6	18.3	40.8	77.6	2.5	4.8	52.9
Kalabsha	38.0	24.3	107.4	68.7	11.0	7.0	156.4
Allaqi	33.5	21.9	110.9	71.6	10.4	6.7	154.8
Southern region							
Korosko	55.8	18.9	226.7	76.9	12.3	4.2	294.8
Tushka	30.1	12.9	153.3	65.5	50.5	21.6	233.9
Abu Simbel	96.3	17.1	283.9	50.5	181.9	32.4	562.1
Average	43.9	18.9	153.8	68.5	44.7	12.8	242.4

[For stations refer to Fig. 4].

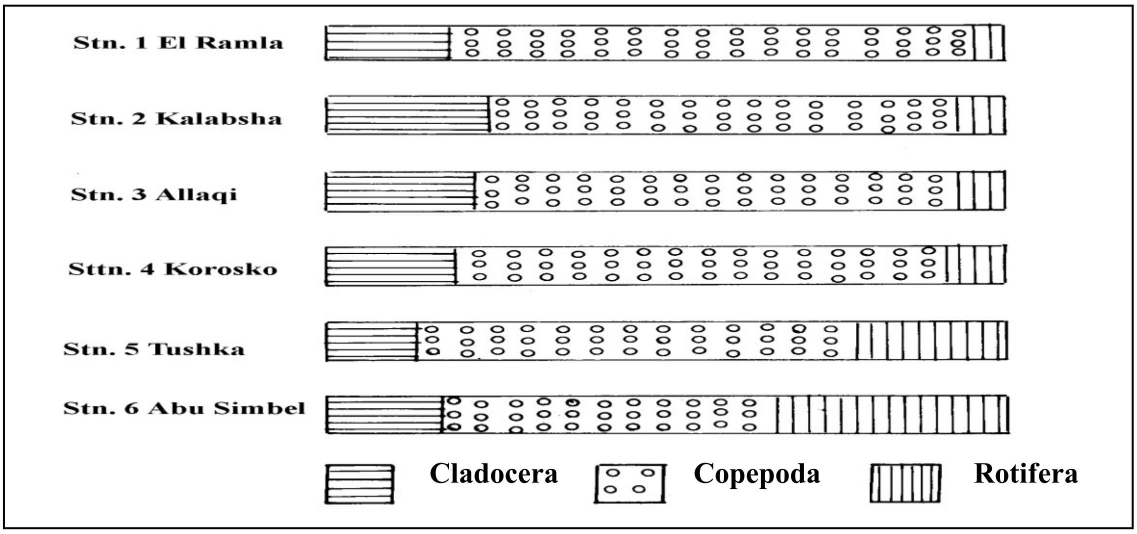

Fig. 88 **Percentage of zooplankton groups in Lake Nasser (Habib 1995b) [**For stations refer to Fig. 4**].**

Table 68 **Vertical distribution of zooplankton (ind./l) at various depths at six stations along the main channel of Lake Nasser (Habib 1995b).**

Location	0	5	10	15	20 (m)
Northern region					
El-Ramla	9.6	15.6	14.4	10.9	2.1
Kalabsha	19.2	29.7	28.3	34.6	44.6
Allaqi	8.7	54.9	40.8	26.7	23.7
Southern region					
Korosko	72.9	90.9	66.0	33.1	31.9
Tushka	41.0	64.8	50.5	36.5	41.1
Abu Simbel	120.2	135.8	96.1	75.2	134.8

[For stations refer to Fig. 4].

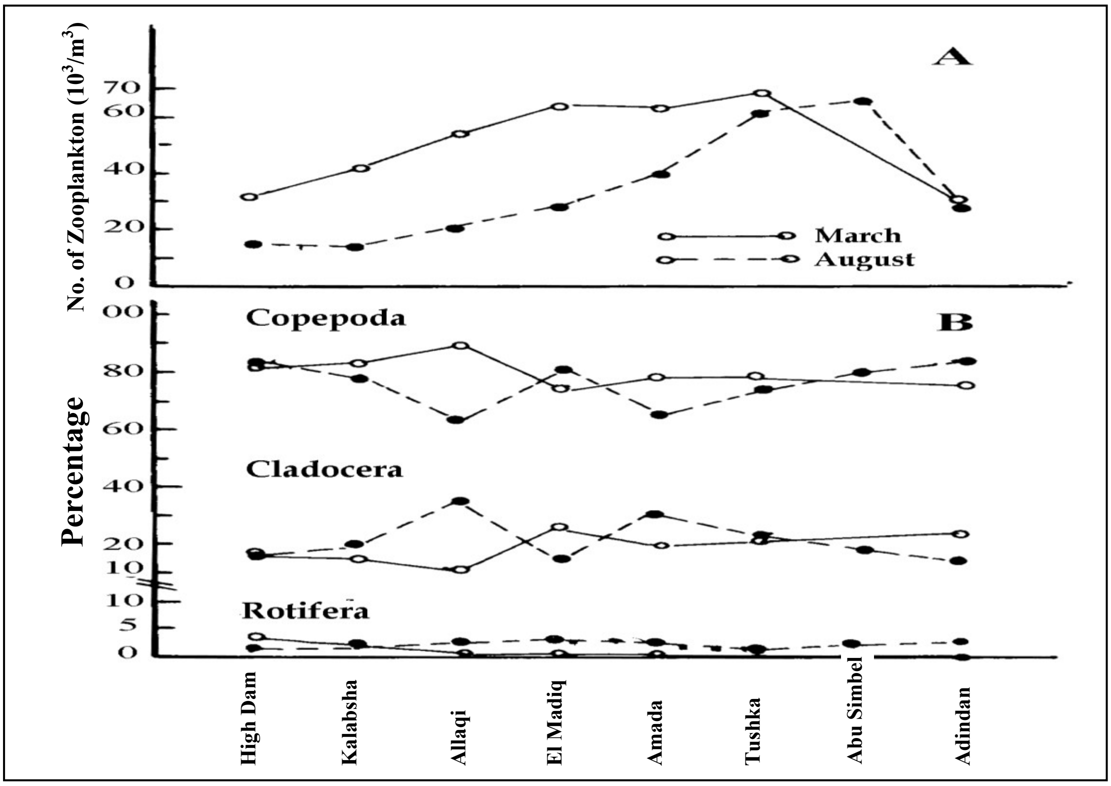

Fig. 89 **Zooplankton at different stations along the main channel of Lake Nasser in March and August 1967 A: number of zooplankton ($10^3/m^3$), B: percentage of Copepoda, Cladocera and Rotifera (Latif 1984b).**

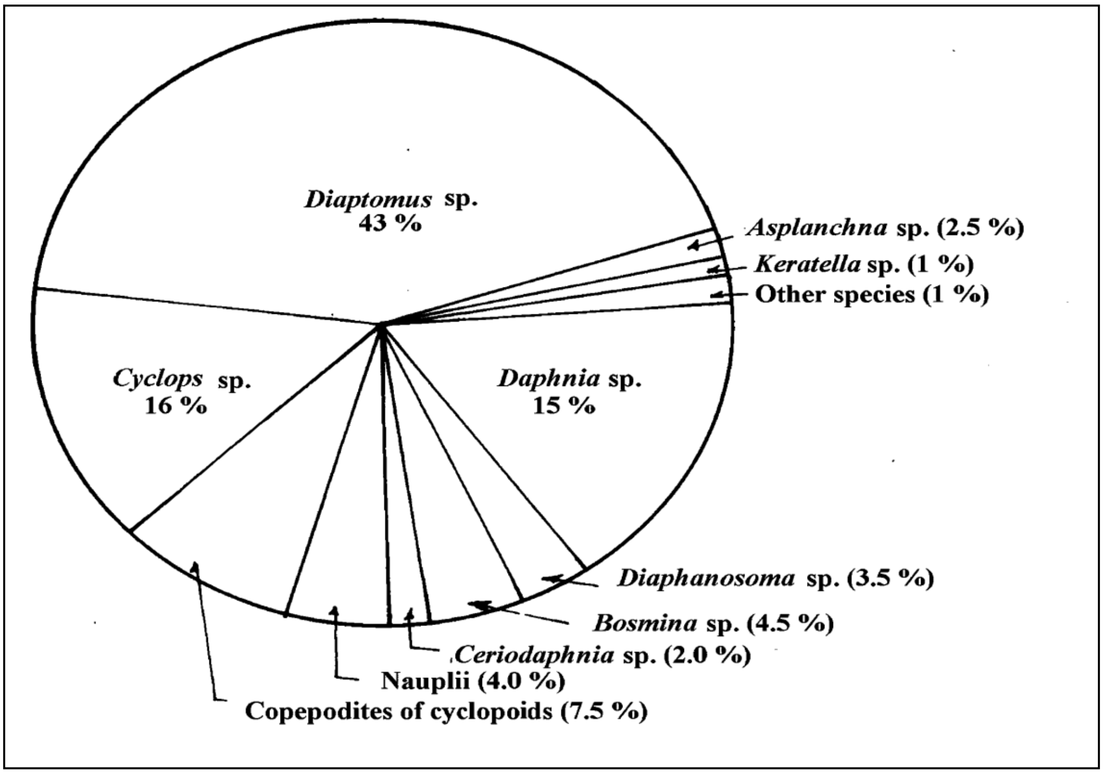

Fig. 90 **Percentage of zooplankton species in Lake Nasser recorded in April 1986 (Mohamed, M. 1993c).**

Table 69 **Number of zooplankton (ind./m³) at different localities of Lake Nasser (Samaan 1971).**

Zooplankton	Locality		
	El Ramla	El-Madiq	Khor Singari
Copepoda			
Calanoida	510	3150	900
Cyclopoida	8850	8151	11490
Copepod nauplii	8349	7449	23499
Cladocera			
Sida sp.	549	798	7800
Bosmina sp.	449	300	898
Daphnia sp.	---	---	150
Rotifera			
Keratella sp.	2100	2790	699
Brachionus sp.	600	399	198
Standing Crop (ind. /m³)	21,807	20,307	45,534

Abdel-Mageed (1995) studied the seasonal variation of zooplankton during 1993/94 at 10 stations along the main channel and found that the flood water period (autumn) was marked by very high population density (average, 99,803 ind./m³) due to the increase of copepods. The remaining seasons exhibited a variety of overlapping patterns, showing no statistically significant difference. Lower densities were recorded in winter, spring and summer being 68,899, 68,816 and 63,318 ind./m³ respectively. The seasonality of zooplankton showed variable patterns at each station.

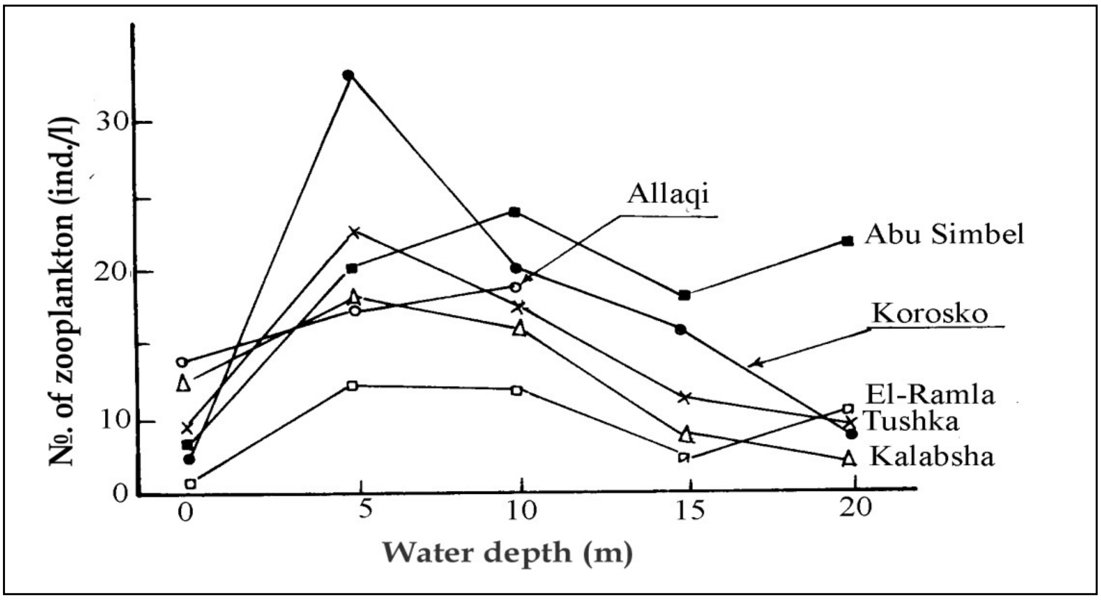

Fig. 91 **Vertical distribution of zooplankton in Lake Nasser (Mohamed, M. 1993c).**

□ **El Ramla (Stn.1)** ∆ **Kalabsha (Stn. 2)**
o **Allaqi (Stn. 3)** ● **Korosko (Stn. 4)**
x **Tushka (Stn. 5)** ■ **Abu Simbel (Stn. 6)**

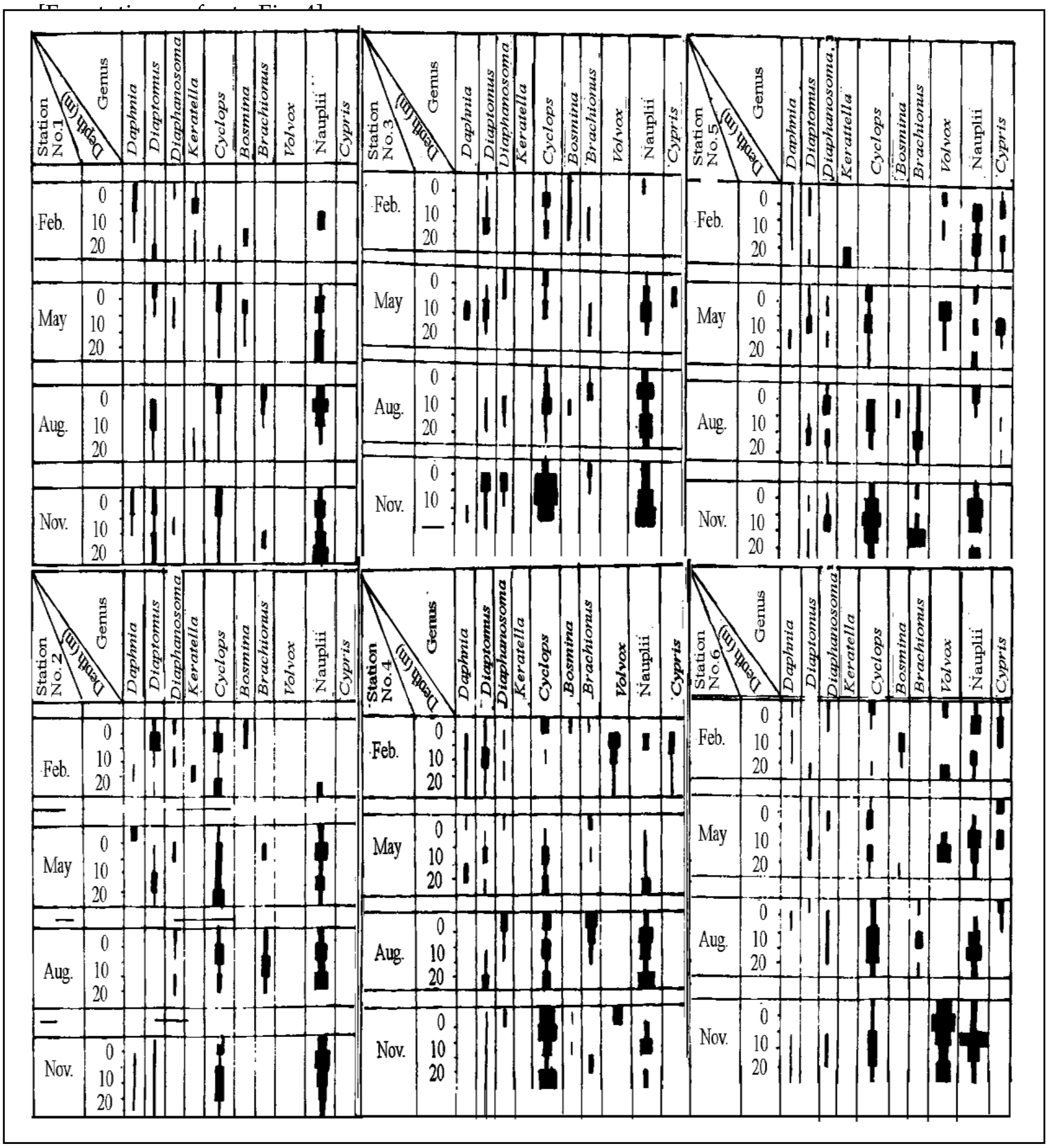

Fig. 92 **Seasonal variations of vertical distribution of zooplankton at stations 1-6 along the main channel of Lake Nasser in 1990 (Mohamed, I. 1993j). Scale bar = 10 ind. / ml** [For stations refer to Fig. 4].

Vertical and monthly distribution. The vertical distribution shows that the zooplankton were much more abundant at 5 and 10 m depth compared with other depths (Fig. 90). The relationship among the number of zooplankton per litre, mean value of chlorophyll *a* (mg/m^3) and transparency indicate that the highest mean value of chlorophyll *a* concentration was 9.1 mg/m^3 at station 4 (Korsoko) and the lowest one was 2.9 mg/m^3 at station 1 (El Ramla) (Fig. 96).

In 1990, Mohamed, I. (1993j) studied the seasonal variations of vertical distribution of zooplankton at 6 localities in the main channel of Lake Nasser, his results are shown in Fig. 92. The results indicated that in February 1990 the highest values were recorded for nauplii at stations 5, 6; for *Volvox* spp. at stations 4, 6; for *Cyclops* spp. at stations 2, 3; for *Diaptomus* spp. at stations 2, 3 and 4; for *Bosmina* spp. at stations 2 and 3; for *Keratella* spp. at station 1 and for *Daphnia* spp. at stations 1, 4 and 5 (Fig. 93). In May 1990, the highest values for nauplii, *Volvox* spp., *Cyclops* spp., *Diaptomus* spp., *Diaphanosoma* and *Daphnia* spp. were recorded at stations 1-4 and 6; 2, 1, 4, 5, 6; 6, 4, 2; 3 and 2, 3, 4 (Fig. 93). In August 1990, the highest values of nauplii were recorded in all stations, *Cyclops* spp. at stations 6, 3 and 4; *Brachionus* spp. at stations 4, 5 and 2; *Diaphanosoma* spp. at stations 5 and 4; *Diaptomus* spp. at St. 1 (Fig. 93). In November 1990, the highest values of nauplii were recorded in all stations, *Cyclops* spp. at stations 3, 4 and 5; *Diaptomus* spp. at stations 1, 2, 3 and 4 and *Daphnia* spp. at stations 1 and 2 (Fig. 94).

Thus, zooplankton organisms were abundant in August and relatively poor in February and May. *Cyclops* spp. and nauplii were the main components of zooplankton in August and November throughout the main channel of Lake Nasser. *Diaptomus* spp. were distributed throughout the Lake in February and May, however their numbers were not high. *Keratella* spp. and *Cypris* spp. were not found in all stations in May and November, and *Volvox* spp. were not recorded in August (Mohamed, I. 1993j). The results indicate that zooplankton organisms were more abundant in the southern 3 stations than in the northern 3 stations. *Cypris* spp. and *Volvox* spp. , were recorded only in the southern region (Mohamed, I. 1993j).

Abdel-Mageed (1995) studied the seasonal and vertical distribution of zooplankton at depths from surface to 20 m during 1993/1994. The statistical analysis for zooplankton densities at various depths showed high significant differences with higher densities at 0 m and 0-10 m depth (average 31,943 ind./m^3) and decreasing densities with increasing depth. The annual average number recorded was 75,224 ind./m^3 which decreased with increasing depth, being 119,768, 73,962 and 31, 943 ind./m^3 at 0, 0-10 and 10-20 m depth respectively. This may be attributed to the richness of the upper water layers of Lake Nasser (till about 8 m) with phytoplankton, bacteria and detritus (Habib & Aruga 1988) which constitute the main food items of zooplankton. The high densities of zooplankton organisms recorded in the middle and southern regions of the Lake (Abdel-Mageed 1995) were parallel with the rich phytoplankton densities recorded in the same regions during the same period (Abdel-Monem 1995).

Habib (1995b) investigated the vertical distribution of zooplankton at 6 stations along the main channel of Lake Nasser in February 1994 (Table 68 and Fig. 95). It is obvious that the number of zooplankton organisms was much higher at 5 m depth, than at other depths in almost all stations, except at Abu Simbel where the maximum number of organisms was observed at 20 m depth

(Fig. 95). It is noteworthy that the southern region of the Lake, particularly Abu Simbel station, is very rich in zooplankton at all depths (Table 68 and Fig. 95). The relationships between zooplankton distribution, chlorophyll *a* concentration and transparency along the main channel of Lake Nasser and at all 6 stations, are illustrated in Fig. 96 (Mohamed, M. 1993c). It is obvious that there is a high correlation between the number of zooplankton individuals/l and the concentration of chlorophyll *a* (Fig. 96).

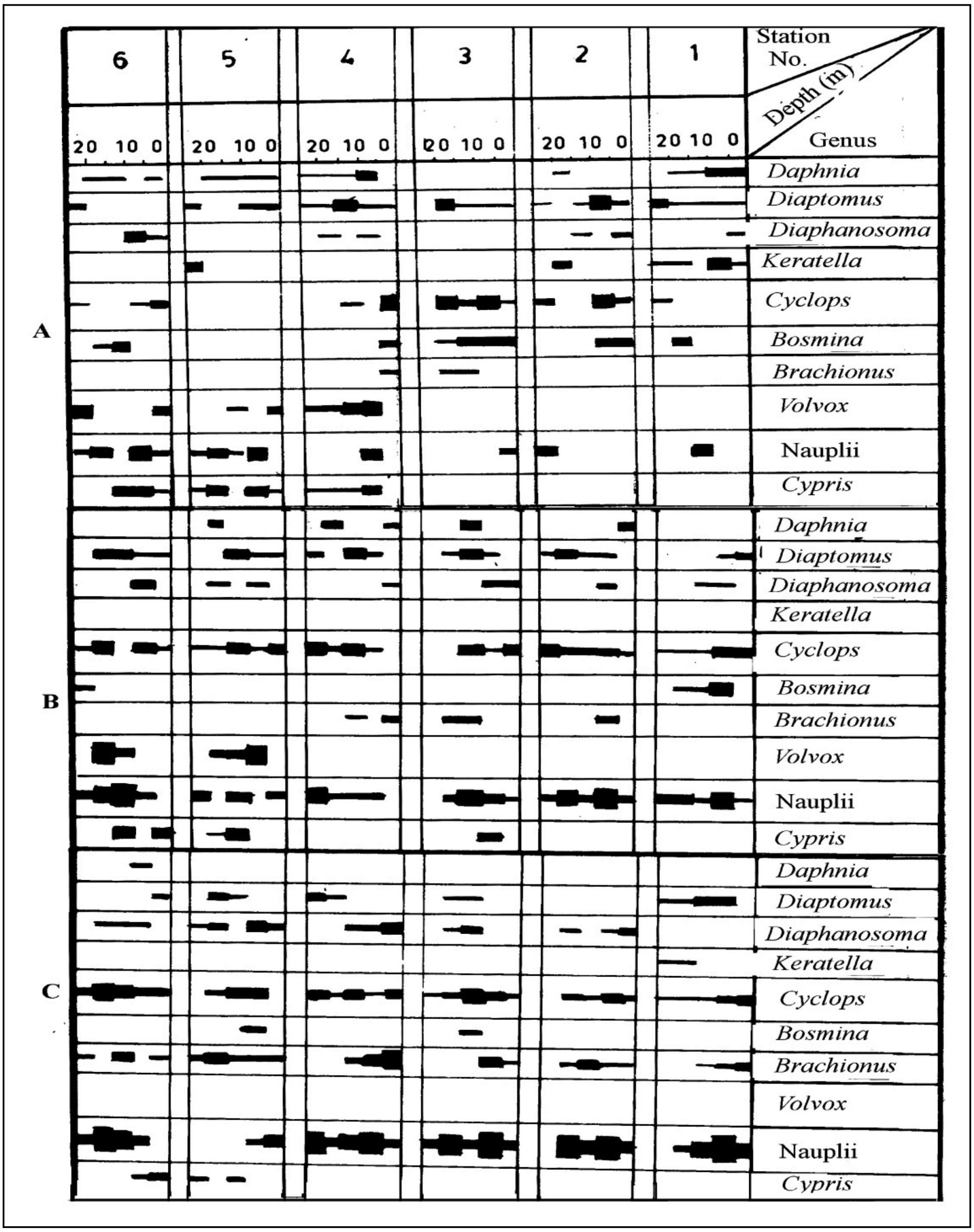

Fig. 93 **Vertical distribution of zooplankton in the main channel of Lake Nasser during A: February, B: May and C: August 1990 (Mohamed, I. 1993j). Scale bar 10 individuals/ml [**For stations refer to Fig. 4**].**

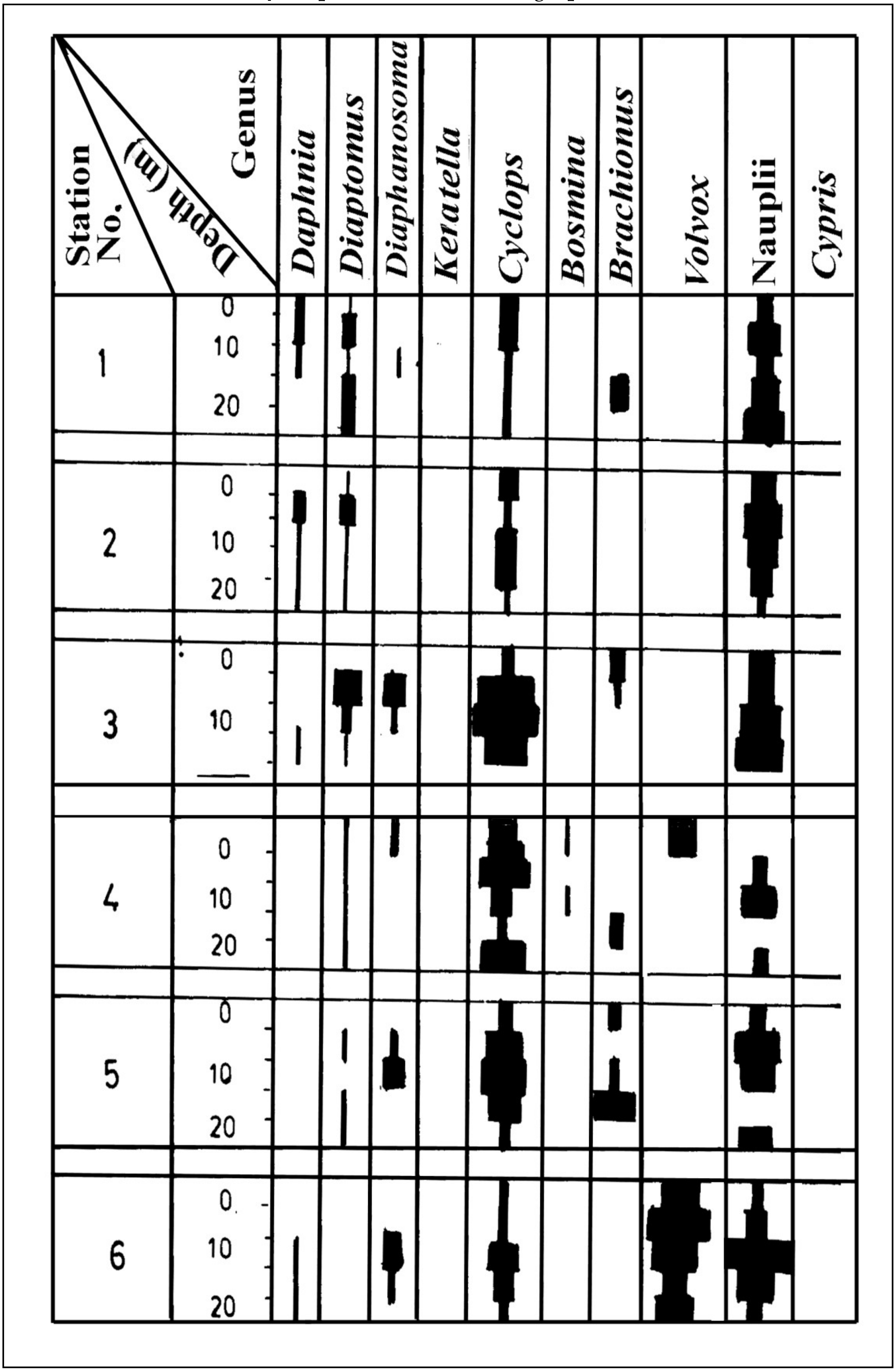

Fig. 94 **Vertical distribution of zooplankton in the main channel of Lake Nasser in November 1990 (Mohamed, I. 1993j) Scale bar = 10 individuals/ ml**. [For stations refer to Fig. 4**]**.

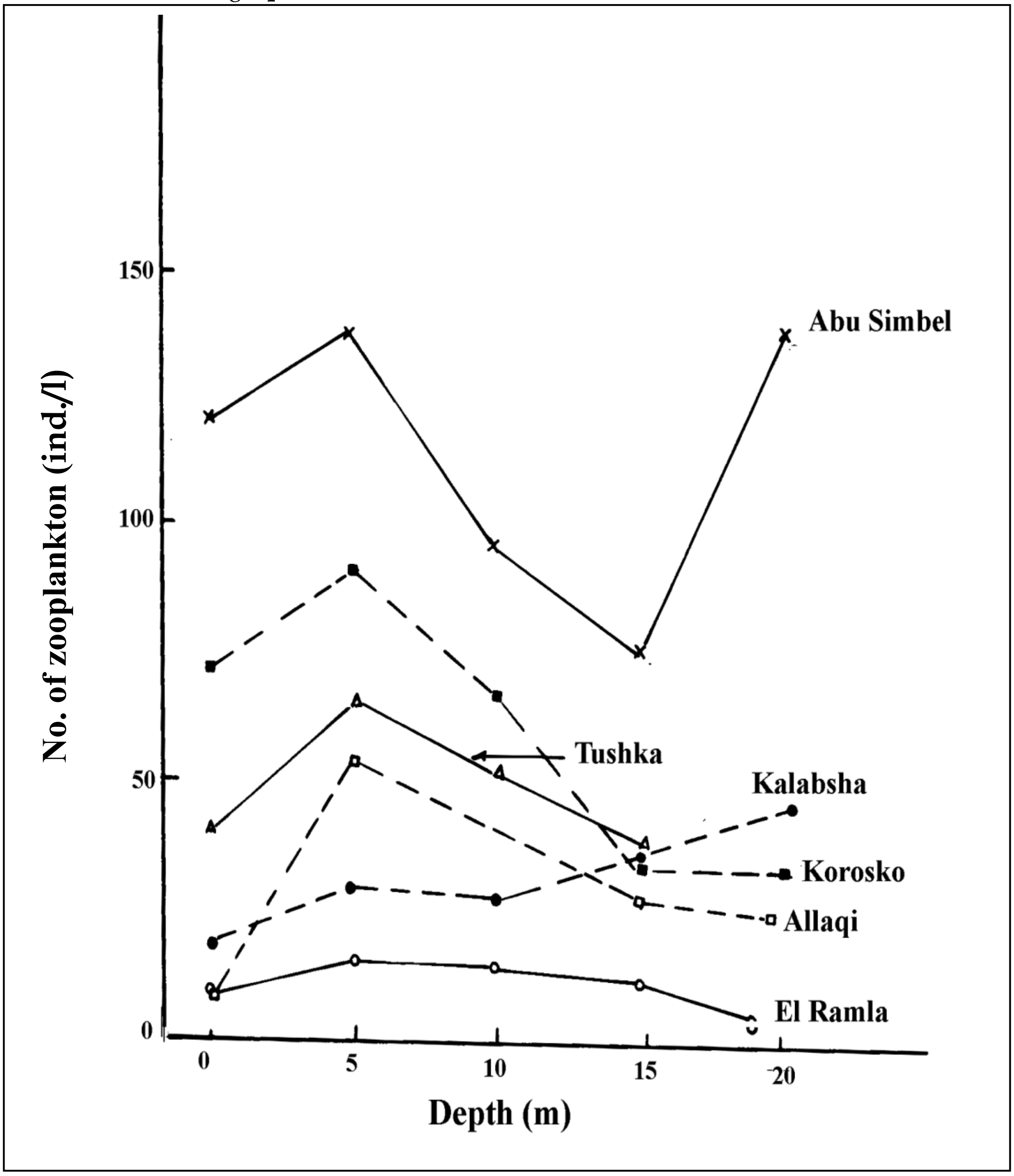

Fig. 95 **Vertical distribution of zooplankton in Lake Nasser (Habib 1995b). [**For stations refer to Fig. 4**].**

Table 70 **Regional and seasonal changes of zooplankton biomass (mg/m^3) in Lake Nasser (July-December, 1990) [Mohamed, M. 1993g]**

Weight (mg/m^3)	Region	Season

	Northern Stns. 1,2 and 3	Southern Stns. 4, 5 and 6	Hot season (July - Sept)	Cold season (Dec. - Jan.)
Wet	50 - 980	210 - 1940	50 - 480	190 - 1940
Dry	11 - 148	28 - 196	11 - 69	24 - 196

[For stations refer to Fig. 4]

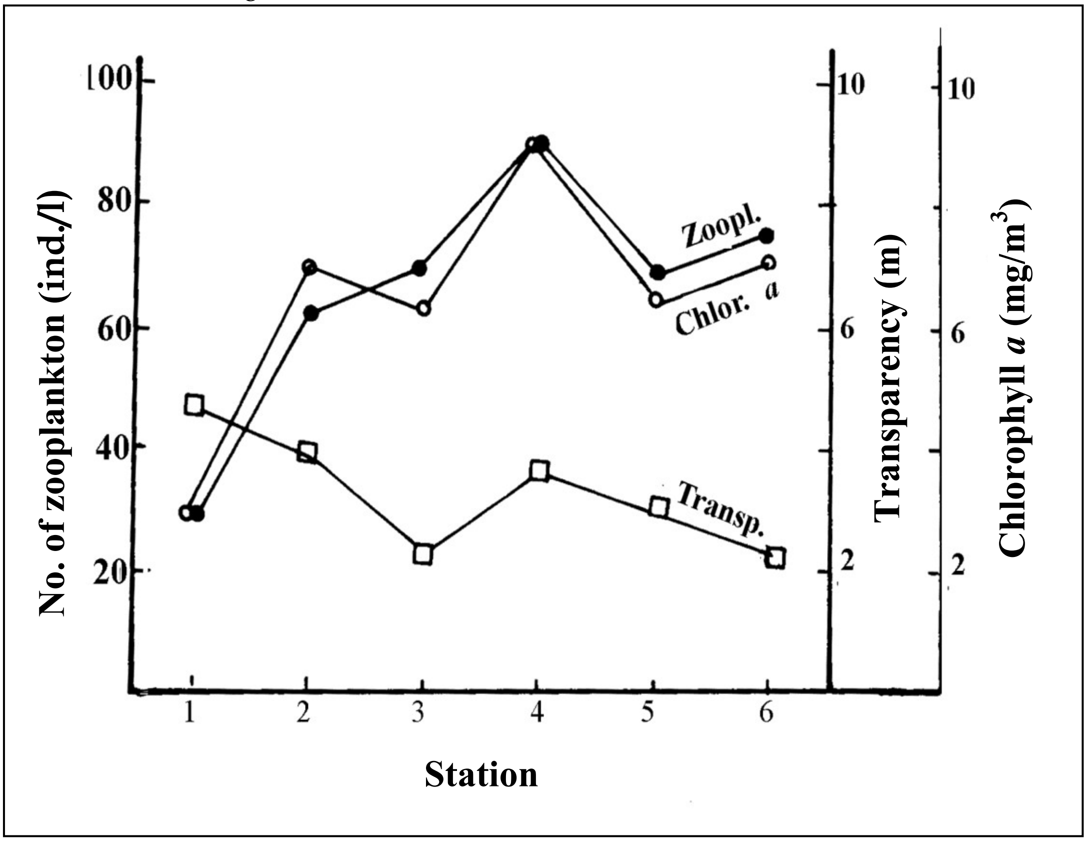

Fig. 96 **Relationship between zooplankton distribution (•), chlorophyll *a* (○) and transparency (□) at 6 stations in Lake Nasser (Mohamed, M. 1993c)** [For stations refer to Fig. 4].

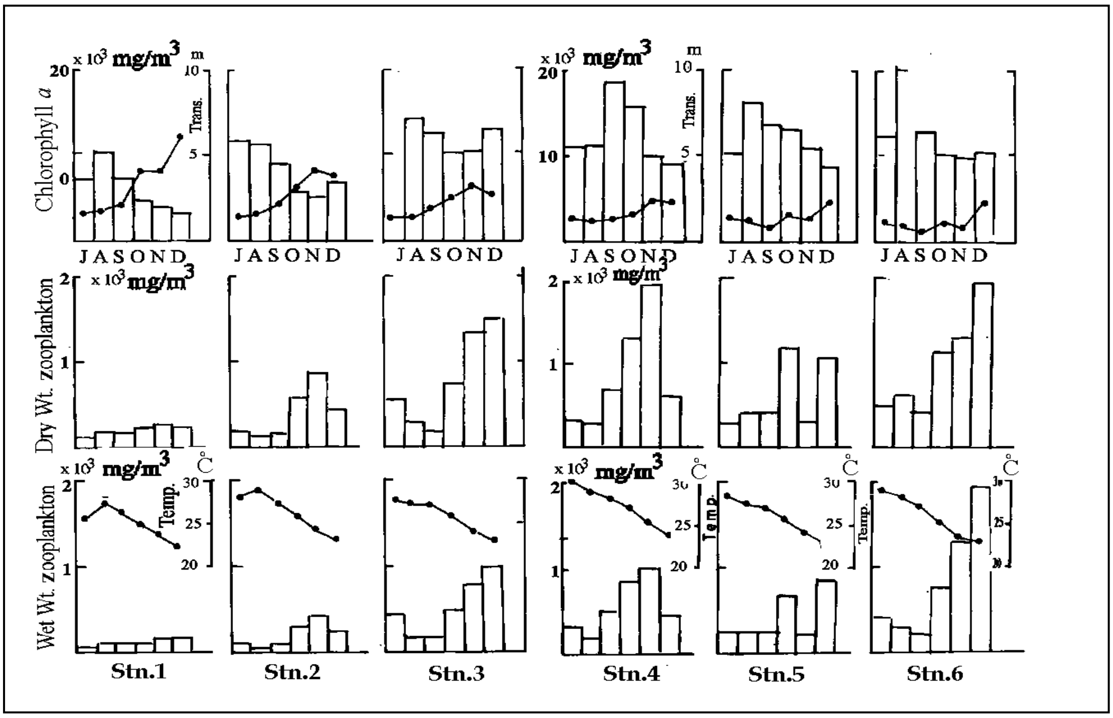

Fig. 97 **Monthly changes of transparency, water temperature, chlorophyll *a* concentration and wet and dry weights of zooplankton in the main channel at stations 1-6 (Mohamed, M. 1993g) [**For stations refer to Fig. 4**].**

Biomass. The horizontal distribution of zooplankton biomass along the main channel was studied in 1991 and 1990 by Mohamed, M. (1992, 1993g) [Tables 71 and Fig. 97]. The highest values (wet and dry weight) were recorded from the southern region (Stn. 5) in January, while the lowest values were recorded at stations 1 and 2 in the northern region during the hot season. The monthly changes of transparency, water temperature, chlorophyll *a* concentration, wet and dry weights at stations 1-6 from July to December 1990 (Fig. 97) indicate that:

1. The southern region is richer in zooplankton than the northern region which may be attributed to the high productivity of phytoplankton being the essential food for zooplankton.

2. High zooplankton density was recorded during the cold season, low density during the hot season (Tables 70 and 71).

3. At station 3 both wet and dry weights showed, more or less, a stable state, which may be due to that this station (Allaqi) is located in a shallow intermediate region between the southern and northern regions.

Table 71 **Distribution of total biomass of zooplankton (mg/m^3) during January to June 1991 at different localities of the main channel of Lake Nasser (Mohamed, M. 1992).**

Site	Jan.		Feb.		March		April		May		June	
	W.W*	D.W**	W.W*	D.W**	W.W*	D.W**	W.W*	D.W**	W.W*	D.W**	W.W*	D.W**
El Ramla 1	180	21.4	80	12.1	90	13.9	120	20.6	300	49.7	160	10.3
Kalabsha 2	170	21.0	190	24.5	510	52.9	160	27.0	220	30.9	120	6.1
Allaqi 3	250	41.5	320	40.3	630	65.6	280	58.4	680	75.6	520	40.1
Korosko 4	770	118.6	960	140.5	430	49.3	240	31.3	410	49.0	330	22.7
Tushka 5	1500	240.8	430	81.6	350	45.3	270	30.6	480	33.7	590	36.0
Abu Simbel 6	570	52.9	610	85.5	460	56.0	310	52.0	390	35.3	750	47.9

[For stations refer to Fig. 4] * Wet weight, ** Dry weight.

THE KHORS

Species diversity. Iskaros (1993) investigated the distribution and seasonal variation of zooplankton in Khor Kalabsha in relation to the dominant prevailing environmental conditions. The latter author identified 40 species belonging to Copepoda, Cladocera and Rotifera, and estimated the average annual density of zooplankton in Khor Kalabsha as 71,245 ind./m^3 during October 1989 to September 1990. It seems that zooplankton population is rich in the number of individuals in the Khor, but is represented by 11 genera.

Distribution. Abdel-Mageed (1992) studied the zooplankton at Khor El Ramla, and pointed out that the littoral zone of the khor has a sustainable standing stock of zooplankton all the year round with a minimum in summer and a maximum in winter (Table 72).

Table 72 **Seasonal variations of the standing stock of zooplankton in Khor El Ramla (Abdel-Mageed 1992).**

Zooplankton Standing stock (ind./m^3)	Summer	Autumn	Winter	Spring
	84,765	128,782	157,439	154,521

The overall picture of littoral zooplankton indicates that zooplankton density is minimum in summer (84,765 ind./m^3) increases in autumn with an average of 128,782 ind. /m^3, and almost get doubled in winter and spring with an average of 157,439 and 154,521 ind./m^3 respectively. It is worth mentioning that the highest standing stock is recorded from the depth of 5 m, with an annual average of 85,537 ind./m,^{3} the lowest density from the depth of 20 m, being 15,294 ind. /m^3.

Habib (1996b) studied the distribution and density of zooplankton at 5 stations to 10 m depth at Khor El Ramla in February, 1994 (Figs. 98 and 99) and found that Cladocera, Copepoda and Rotifera are the major zooplankton with an average percentage of 21.6 (15.3- 33.4); 33.6 (12.8-41.8) and 44.8% (24.8-71.9%) (Table 73). Copepods are the most dominant group at 2 stations followed by rotifers and cladocerans at one station. For the other stations, rotifers dominated other groups. The vertical distribution of zooplankton shows that zooplankton were most abundant at 10 m depth, except at stations 3 and 5.

Table 73 **Average density of zooplankton and percentage of different groups to 10 m depth during February 1994 in Khor El Ramla (Habib 1996b).**

Group	Ind./l	Percentage %

Rotifera	192.1	44.8
Copepoda	101.1	33.6
Cladocera	66.8	21.6
Total	360.0	100

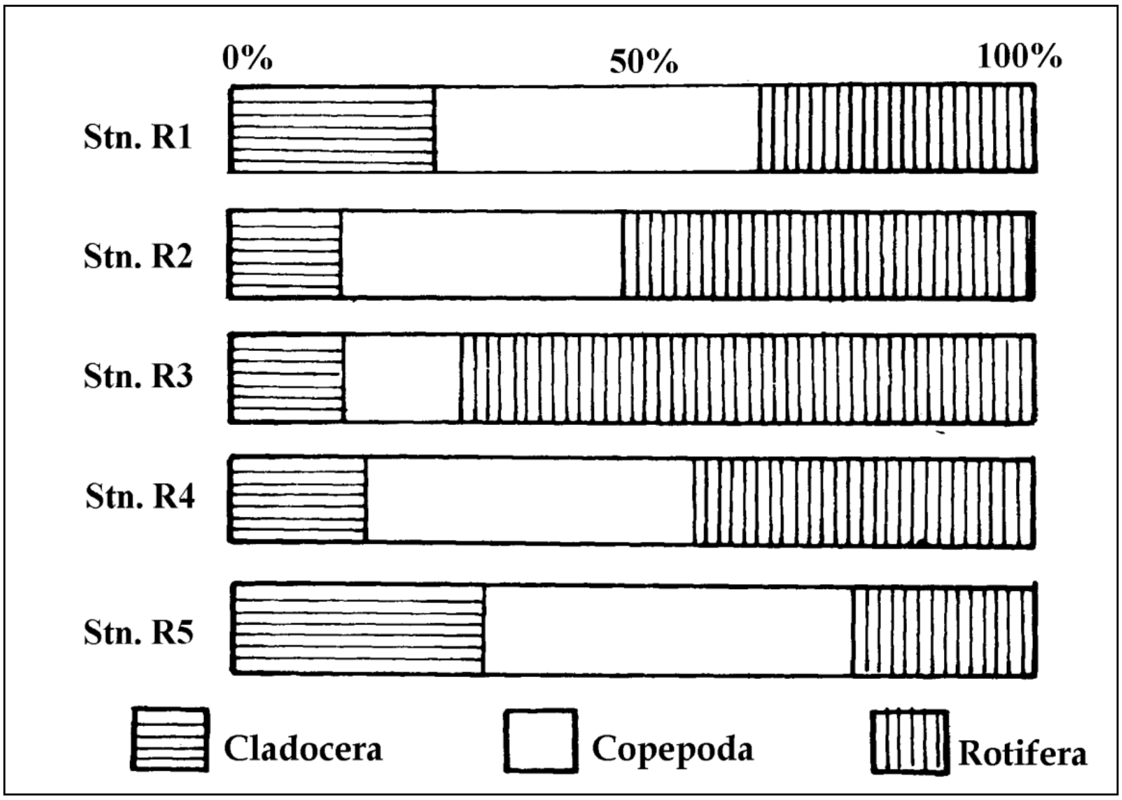

Fig. 98 **Percentage of zooplankton groups in Khor El Ramla (Habib 1996b).**

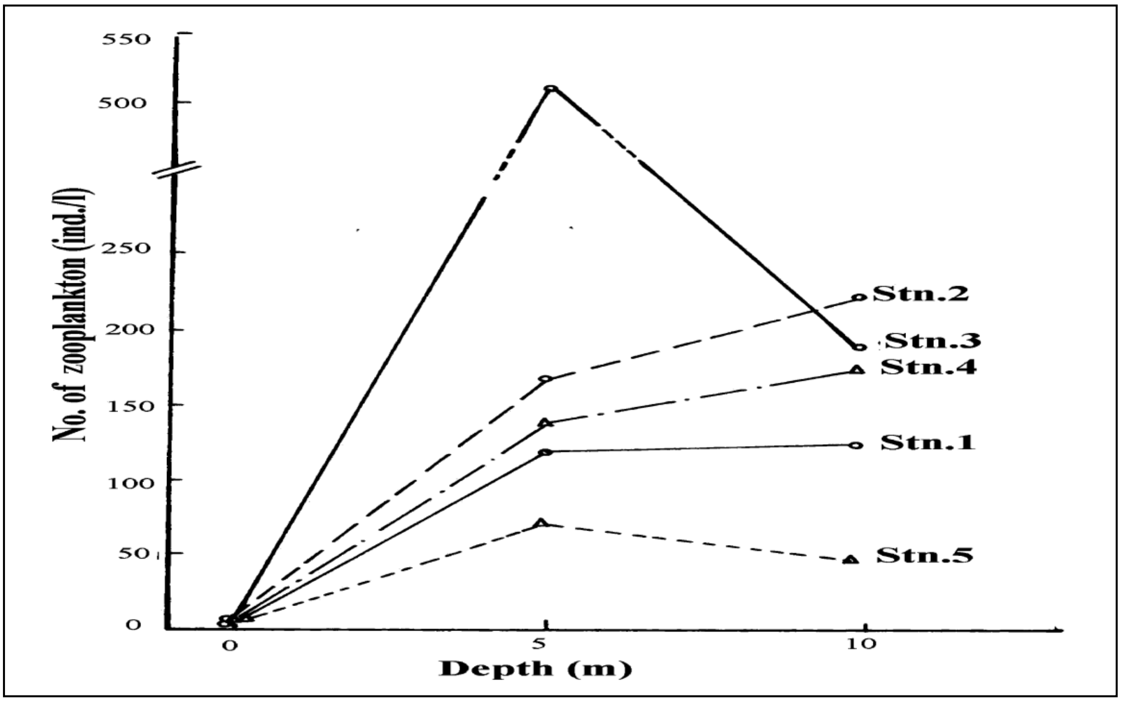

Fig. 99 **Vertical distribution of zooplankton in Khor El Ramla (Habib 1996b) [**For stations refer to Fig. 81**].**

ZOOBENTHOS

The different groups of benthos serve as an important food for various fish species in Lake Nasser (Latif 1974a; Iskaros 1988, 1993). These authors found that chironomid larvae form the major food items for *Mormyrus kannume*, *M. caschive* and *Chrysichthys auratus* throughout the different seasons. *Synodontis schall* and *S. serratus* feed mainly on gastropods, *Bulinus truncatus* and *Physa acuta*. Furthermore, they report that nymphs of Odonata and Ephemeroptera, larvae of Trichoptera, Corixidae are also infrequently recorded in the guts of the above 5 fish species. *Hydrocynus* spp., particularly *H. forskalii*, subsist mainly on insect larvae in winter (Iskaros 1993).

Species diversity. The first survey on bottom fauna in Lake Nasser was carried out by Entz (1978), who mentioned a gradual change in the components of benthos with the development of the Lake, particularly molluscs and oligochaetes. Latif *et al*. (1979) studied the distribution of benthic fauna of both Lake Nasser and Lake Nubia (only in the main channel) in March and July 1979 respectively and found that the major components of benthic fauna in Lake Nasser were the oligochaetes, while that of Lake Nubia were composed mainly of molluscs. Elewa (1987b) recorded 14 species. Detailed investigations were carried out by Iskaros (1988, 1993) on the distribution and seasonal variations of benthic organisms in Lake Nasser and adjacent waters (Aswan Reservoir and the River Nile) in relation to the prevailing environmental conditions and identified 40 species related to the aquatic Insecta, Mollusca, Annelida and Platyhelminthes. Fishar (1995) recorded 39 species of zoobenthos, 19 species previously recorded by Iskaros (1993) were not included in Fishar's (1995) list, and recorded 14 species for the first time (Table 74). In a survey of zoobenthos during 1996 (SECSF, 1996) only 19 species were recorded, which were previously known by other investigators. The total number of benthic invertebrate species recorded in Lake Nasser by various investigators is 59 species belonging to 4 major groups: Cnidaria (Coelentrata) (2 classes and 2 spp.), Arthropoda (2 classes and 33 spp.), Annelida (2 classes and 5 spp.) and Mollusca (2 classes and 19 spp.) in addition to larvae, pupae, nymphs and adult insects.

Density and biomass. Iskaros (1988) pointed out that the average annual number and biomass of bottom fauna recorded for Lake Nasser as a whole during 1986-1987 amounted to 2,659 ind./m^2 and 13.1 g fresh weight/m^2 (GFW), at the littoral zone, and 288 ind./m^2 and 1.9 g fresh weight/m^2 at the profundal zone. These values were much lower than those recorded for Khor Kalabsha during 1989-1990, by the same author, where the standing crop of bottom fauna reached 10,292 ind./m^2 and 33.9 g fresh weight/m^2 at the littoral zone and 908 ind./$m^2$and 4.0 g fresh weight/m^2 at the profundal zone (Iskaros, 1993). Thus khors seem to be richer in benthic fauna than the main channel.

Fishar (1995) studied the distribution of bottom fauna in Lake Nasser main channel in 1993 as well as the eastern and western sides and pointed out that the standing crop of bottom fauna for Lake Nasser as a whole averaged 823 ind./m^2/year, weighing 4.776 g fresh weight/m^2/year. The bottom fauna showed a high population density (PD)[x**] in Amada section, where 1236 ind./m^2/year weighing 7.04 g fresh weight/m^2/year were recorded. This value decreased gradually towards the northern and southern sections. The lowest population density was recorded at the southernmost locality (Adindan section) with an average value of 331 ind./m^2/year weighing 1.672 g fresh weight/m^2/year (Fig. 100). In the main channel stations, the population density and biomass (BM) of total bottom fauna remained low, attaining average values of 556 ind./m^2/year, and 3.192 g fresh weight/m^2. The highest values (1027 and 887 ind./m^2/year) were recorded at the eastern and western stations respectively (Fig. 100 - Fishar 1995).

A reverse picture was observed on the biomass values. Thus, the biomass values of bottom fauna in the western side of the lake were higher than those recorded in the eastern one. This increase in the biomass was associated with the increase of Mollusca at stations of Dihmit, Mariya and El-Madiq, and heavy crustaceans in Amada and annelids at Dihmit stations (Fishar 1995). Table 75 shows the results of Absolute Importance Value (AIV)[*] and Relative Importance Value (RIV)[**] of the total bottom fauna in Lake Nasser. Amada section occupies the first rank on the AIV scale, where a value of 19.65 was recorded, followed by Mariya section. While, the lowest AIV was found at El Madiq section followed by Tushka section and at last in the upstream section.

Species diversity, density and biomass

In Lake Nasser, aquatic insects, molluscs and annelids are important organisms as food for fishes and their diversity, density and biomass are as follows:

1. Aquatic insects are the most important organisms among the benthic fauna community in Lake Nasser. They form 77.8%, with an average 2072 larvae/m^2 and constitute by weight 16.1% (average 8.0 g fresh weight/m^2) of the total

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[*]Absolute Importance Value Index (A I V) = Log (PDxBMxAF) [Ghabbour and Shakir 1980]

AF = Absolute frequency = Number of occurrences of a taxon in the sampling unit

[x**] PD = Population density BM = Biomass (g fresh weight)

RF= Relative frequency = number of occurrences of taxon to the total occurrences of all taxa in the sampling unit

[**] Relative Importance Value Index (R I V) = % PD + % BM + % RF[Ghabbour and Shakir 1980]

benthos at littoral areas. At the profundal zone, these values decrease to 196 insect/m^2 and 0.4 g fresh weight/m^2 of the biomass. Their maximum distribution is recorded at the northern and middle sectors in winter and autumn (Iskaros 1988).

The aquatic insects recorded in Lake Nasser include 5 orders: Diptera (mainly chironomid larvae and pupae), Odonata (nymphs), Ephemeroptera, Trichoptera and Hemiptera (adult Corixidae). Wirth & Stone (1968) pointed out that chironomid larvae appear more abundant in shallow waters favoured by heavy growth of aquatic plants. In the littoral areas of Lake Nasser during 1986-1987, insect larvae formed numerically about 92.1% of the total insects (average 1909 larvae/m^2) and 40.0% of their biomass (average 3.2 g fresh weight/m^2). Entz (1978) pointed out that during the early years of impoundment, chironomids developed in enormous numbers in shallow freshwater areas of Lake Nasser, huge swarms of chironomids may occur within few years, probably due to the progressive inundation of the cultured river valley rich with soil. Iskaros (1988) mentioned that, at the profundal zone, the average counts of insects decreased to 196 larvae/m^2.

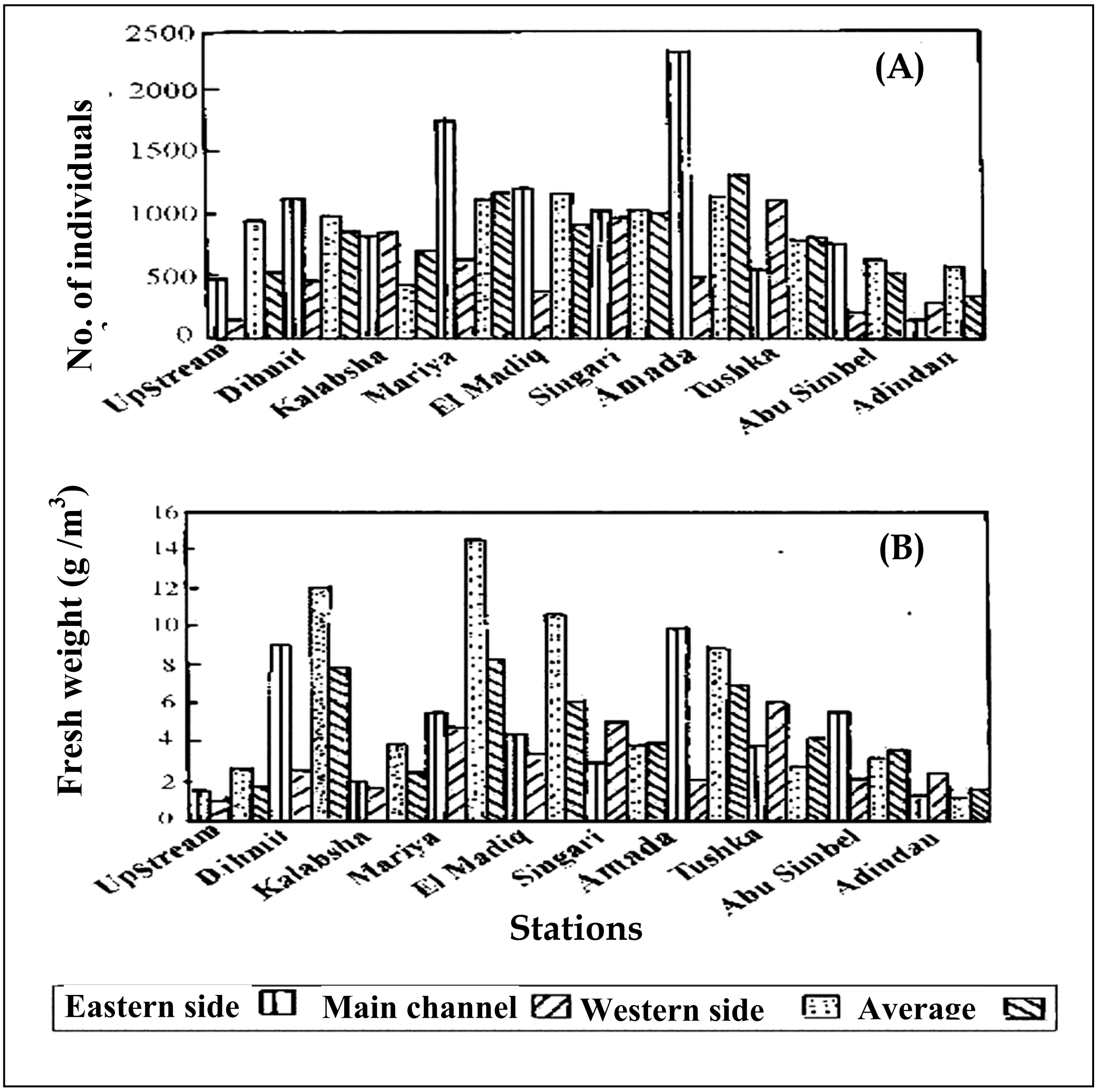

Fig. 100 **Distribution of A: population density, and B: biomass of total bottom fauna in different localities of Lake Nasser (Fishar 1995) [**For stations refer to Fig. 15**].**

Table 74 **Checklist of benthic invertebrates recorded in Lake Nasser by different authors (+ = Present, - = Not recorded).[Plates 14-16]**

Taxa and species	Elewa (1987b)	Iskaros (1988 & 1993)	Fishar (1995)
Phylum : Cnidaria			
Class : Hydrozoa			
Hydra vulgaris Pallas, 1766	-	-	+
Phylum : Bryozoa			
Class : Phyleclolaemata			
Fredericella sultana (Blumenbach, 1779)	-	-	+
Phylum : Arthropoda			
Class : Insecta			
Ablabesmyia sp.	-	+	+
Caenis sp.	-	-	+
Chironomus sp.	-	+	+
Circotopus sp.	-	+	+
Clinotanpus sp.	+	+	-
Coelotanpus sp.	-	+	+
Conchopelopia sp.	-	+	-
Cryptochironomus sp.	+	+	+
Dicrotendipes modestus	-	+	-
Einfeldina sp.	-	+	-
Enallagma sp.	-	-	+
Gomphus sp.	-	+	-
Ischnura sp.	-	-	+
Libellula sp.	-	+	-
Microchironomus sp.	-	+	-
Micronecta plicata	-	-	+
Microtendipes sp.	+	+	+
Neurocordula sp.	-	-	+
Nilodorum sp.	-	+	+
Pelopia sp.	-	+	-
Plathemis sp.	-	-	+
Polypedilum sp.	-	+	+
Perithemis sp.	-	+	+
Procladius sp.	+	+	+
Pseudoagrion niloticus	-	+	-
Tanpus sp.	-	+	-
Dytiscide sp.	-	-	+
Tanytarsus sp.	+	+	+
Hydrovatus sp.	-	-	+
Larvae of Trichoptera	+	+	+
Pupae of Chironomidae	-	-	-
Nymphs of Ephemeroptera	-	+	-
Adult of Corixidae	-	+	-
Class : Crustacea			
Cardina nilotica (P. Roux, 1833)	-	-	+
Chlamydotheca unispinosa Baird, 1862	-	-	+
Potamonautes niloticus (H. Milne Edwards)	-	-	-
Stenocypris malcolmsoni Baired, 1862	-	-	+

Phylum : Annelida			
Class : Oligochaeta			
***Branchiura sowerbyi* Beddard, 1892**	+	+	+
***Limnodrilus hoffmeisteri* Claparéde, 1862**	+	+	+
***Limnodrilus udekemianus* Claparéde, 1862**	+	+	+
***Pristina* sp.**	-	-	+
Class : Hirudinea			
***Helobdella conifera* (Moore, 1933)**	-	+	+
Phylum: Mollusca			
Class : Gastropoda			
***Bellamya unicolor* (Olivier, 1804)**	-	+	-
***Biomphalaria alexandrina* (Ehrenberg, 1831)**	-	+	-
***Bulinus truncatus* (Audouin, 1827)**	+	+	+
***Bulinus forskalii* (Ehrenberg, 1831)**	-	+	-
***Cleopatra bulimoides* (Olivier, 1804)**	-	+	+
***Gabbiella senaariensis* (Kuster, 1852)**	-	+	-
***Helisoma duryi* (Wetherbg, 1879)**	-	+	-
***Lanistes carinatus* (Olivier, 1804)**	-	+	-
***Lymnaea natalensis* Krauss, 1848**	-	+	-
***Melanoides tuberculata* (Müller, 1774)**	+	+	+
***Physa acuta* Darparnaud, 1805**	+	+	+
***Pila ovata* (Olivier, 1804)**	-	+	-
***Segmentorbis angustus* (Jickeli, 1874)**	-	+	-
***Theodoxus niloticus* (Reeve, 1856)**	-	+	-
***Valvata nilotica* Jickeli, 1874**	+	+	+
***Gyraulus ehrenbergi* (Beck, 1837)**	-	-	+
Class : Bivalvia			
***Corbicula consobrina* (Cailliaud, 1827)[1]**	+	-	+
***Pisidium pirothi* Jickeli, 1881**	+	-	+
***Eupera ferruginea* (Krauss, 1848)[2]**	-	-	+
Total = 63 species	**15**	**43**	**39**

1- Misidentified by the author (Fishar 1995) as *C. fluminalis*

2- Misidentified by the author (Fishar 1995) as *Sphaerium simili*

In Lake Nasser, chironomid larvae belong to 3 subfamilies, viz. Chironominae (8 species), Tanypodinae (6 species) and Orthocladiinae (one species). According to their relative abundance, they constituted 76.1, 23.8 and 0.1% respectively of the total number of chironomid larvae (Iskaros 1988). The dominance of Chironominae in reservoirs is probably related to their tolerance to reduced oxygen concentration and their ability to exploit newly flooded terrestrial vegetation (Rosenberg *et al*. 1984).

Furthermore, the distribution of Odonata nymphs in Lake Nasser was confined to the littoral areas (Iskaros 1988). Their average annual number amounted to 70 nymphs/m^2, constituting numerically about 3.4% of the total insects. Nevertheless, their biomass increased to 55% of their weight (average 4.4 g fresh weight/m^2). This is attributed to the large size of anisopteran nymphs. Iskaros (1988) pointed out that Ephemeroptera nymphs, Trichoptera larvae and Corixidae were scarcely recorded at the littoral areas.

2. Molluscs. In Lake Nasser, Mollusca represent the second important bottom dwellers inhabiting the littoral areas. They form about 11.9 and 9.2% by numbers and weight respectively (the average number 317 ind./m^2 and the average weight 1.2 g fresh weight/m^2) (Iskaros 1988). They appear in maximum numbers at the northern region, particularly in spring and summer. On the other hand, their occurrence is very rare (average annual number 3 ind./m^2) at the profundal zone (Iskaros 1988).

It seems that water temperature controls the distribution of molluscs in Lake Nasser. Iskaros (1993) regarded that their numbers inhabiting the littoral areas of Khor Kalabsha increased gradually throughout winter and spring, reaching their peaks in May and/or June. This is mainly due to the increased fecundity of individuals along with the increase of water temperature. The latter author found that late winter and spring were the most productive periods for *Physa acuta* and *Bulinus truncatus*, while a sharp drop in their numbers took place when water temperature exceeded 27.5 °C. The gastropod *Valvata nilotica* appeared at the littoral areas of Khor Kalabsha during spring and summer, showing a persistence in June and August and disappearing mostly throughout autumn and winter. In the profundal areas, this gastropod occurred mainly in winter and spring and became rare in summer and autumn. This indicates a downward migration of this species during the cold season, but the development of the thermocline during the summer forced it to return for an upward migration in the well-oxygenated layer.

The Lake's old bed was inhabited by a very dense population of bivalves. During the stagnation period, with the formation of the Lake, these bivalves died and disappeared. Starting from 1973, mussels and oligochaetes resettled in the shallow inlet water of the khors due to the continuous favourable oxygen conditions (Entz 1976).

3. Annelids (Oligochaetes). Oligochaetes represent the third important component among the benthic community at the littoral zone of Lake Nasser. They form numerically about 10.2 % (average 270 ind./m^2)and 29.8% of their biomass (average 3.9 g fresh weight/m^2). On the other hand, oligochaetes rank second in importance at the profundal zone where they form numerically about 30.5% of the total fauna (average 88 ind./m^2) and 73.7% of its biomass (average 1.4 g fresh weight/m^2). Their maximum distribution appears at the northern sector of the Lake, particularly in summer of 1986 (Iskaros 1988). The prevalence of oligochaetes in the littoral zone of Khor Kalabsha during October 1989-September 1990 was confined to spring and summer, and disappeared in autumn and winter (Iskaros 1993). At the profundal zone of Khor Kalabsha, oligochaetes were more abundant throughout most of the year, indicating that the variation of water temperature is not a determining factor for seasonal distribution. The factor of prey-predator interactions may have a controlling effect on the distribution of oligochaetes. Iskaros (1988 and 1993) reported an inverse relation between the abundance of chironomid larvae and oligochaetes, which are mainly consumed by the high density of such chironomid larvae. The predation of chironomids on oligochates was emphasized by Loden (1974), who found setae of oligochaete species in the gut contents of 13 species belonging to Chironominae and Tanypodinae.

Table 75 **Absolute importance value (AIV)* and relative importance value (RIV)** of bottom fauna in different localities of Lake Nasser during 1993 (Fishar 1995).**

Taxa and species	Upstream		Dihmit		Kalabsha		Mariya		El Madiq		Singari		Amada		Tushka		Abu Simbel		Adindan	
	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV
Phylum : CNIDARIA																				
Class : Hydrozoa																				
Hydra vulgaris	-	-	-	-	0.830	8.980	-0.030	2.210	-	-	-	-	0.670	2.660	0.480	5.170	-	-	-	-
Phylum: BRYOZOA																				
Fredericella sultana	0.080	5.080	-0.570	2.840	1.690	13.710	2.310	7.500	-0.300	2.560	-	-	-0.330	2.330	-1.700	3.700	-	-	-	-
Phylum : ARTHROPODA																				
Class : Insecta	3.170	34.790	3.970	41.830	3.990	66.920	4.620	54.890	4.880	81.620	4.380	54.920	5.040	70.280	3.110	22.670	4.370	84.810	3.060	44.510
Ablabesmyia sp.	1.770	5.010	3.060	83.260	0.500	2.890	1.630	11.850	2.240	16.140	2.610	48.190	1.180	5.970	-0.870	6.620	1.680	21.290	0.750	23.860
Caenis sp.	-	-	-0.400	8.620	-	-	1.720	12.720	1.760	11.030	-	-	-	-	-	-	-	-	-	-
Chironomus sp	-	-	-	-	-	-	0.160	2.200	-	-	-	-	-	-	-	-	-	-	-	-
Circotopus sp.	-	-	-	-	-	-	-	-	-	-	0.320	5.170	-0.520	2.480	-	-	-	-	-	-
Coelotonypus sp.	1.340	30.820	-	-	-	-	1.930	19.370	-1.000	2.470	0.430	6.160	-0.300	2.630	-	-	-	-	0.390	11.010
Cryptochironomus sp.	-	-	-1.480	3.010	-	-	-1.000	2.510	1.840	12.120	-1.180	3.050	-0.400	2.560	-	-	-	-	0.780	28.510
Enallagma sp.	-	-	-	-	-0.004	5.080	0.430	5.030	-	-	-	-	2.770	42.260	-	-	-	-	-	-
Ischnura sp.	0.750	22.290	-	-	0.110	6.400	0.200	4.390	-0.700	2.700	-	-	-	-	-	-	-	-	-	-
Micronecta plicata	-	-	1.040	13.600	-	-	-	-	-	-	-	-	0.570	9.730	0.920	26.140	-	-	-	-
Microtendipes sp.	-	-	-	-	3.020	71.150	1.450	10.310	2.680	23.670	2.210	25.330	1.100	5.650	2.460	101.89	3.120	65.370	0.780	23.400
Neurocordula sp.	-	-	0.170	8.620	-	-	-	-	-	-	-	-	0.760	8.590	-	-	-	-	-	-
Nilodorum sp.	-0.870	5.690	1.670	22.890	2.920	18.850	3.730	93.300	2.230	17.840	2.180	24.400	3.420	55.870	1.570	51.660	0.170	5.120	0.380	19.230
Plathemis sp.	-	-	-	-	-	-	-	-	-	-	1.010	11.750	0.480	8.760	-	-	-	-	-	-
Polypedilum sp.	-	-	2.120	35.180	-	-	2.300	21.930	3.210	61.630	2.970	46.530	2.080	12.290	-	-	-	-	0.760	22.420
Prithemis sp.	-	-	-	-	-0.370	4.660	-	-	2.340	56.110	0.600	8.200	-	-	-	-	0.790	14.090	-	-
Procladius sp.	1.220	26.330	2.480	50.440	3.330	101.11	3.200	47.470	2.300	17.120	2.080	22.110	2.680	19.110	1.470	37.930	2.620	36.670	0.000	12.440
Tanytarsus sp.	1.940	77.790	1.160	16.390	-	-	-0.770	3.180	1.090	7.430	2.390	29.490	2.080	11.970	-	-	3.340	81.570	2.250	92.430

Cont. *Table 75*

Larvae of Trichoptera	-	-	-	-	-	-	-0.173	3.160	1.220	7.500	-1.780	3.240	-	-	-	-	-	-	0.220	12.740
Pupae of chironomidae	0.270	15.130	-0.050	5.840	-0.880	3.860	1.110	8.680	1.390	9.110	1.470	13.360	1.900	11.140	-	-	0.370	6.830	-	-
Class : Crustacea	2.570	26.100	3.830	31.450	2.250	14.640	2.670	11.580	2.320	11.030	3.090	18.460	4.780	49.870	2.110	14.940	2.270	14.870	1.880	18.370
Cardina nilotica	-	-	2.830	90.150	-	-	0.440	39.700	-	-	-	-	4.170	122.880	-	-	0.490	64.490	-	-
Chlamydotheca unispiosa	1.800	88.800	2.990	82.750	1.930	152.530	1.690	62.570	1.487	80.550	2.590	118.340	3.110	58.500	198.000	182.040	1.760	125.020	1.520	115.680
Stenocypris malcolmsoni	2.100	121.800	2.050	39.390	0.540	61.630	1.950	83.170	1.900	127.970	2.210	93.020	2.710	33.710	-0.080	31.750	0.120	25.640	0.860	46.380
Phylum : ANNELIDA	4.190	85.350	4.620	66.850	4.490	91.920	4.780	55.460	4.830	75.460	5.200	127.370	5.70	67.410	5.270	154.230	4.240	72.400	4.180	120.350
Class : Oligochaeta																				
Branchiura sowerbyi	1.110	13.520	2.650	31.780	-	-	2.690	28.560	2.740	26.630	2.010	12.290	2.900	24.090	3.060	26.780	2.550	42.320	-	-
Limnodrilus hoffmeisteri	3.070	63.140	3.350	65.060	2.810	39.980	2.160	16.130	4.520	147.910	4.520	98.740	3.940	60.520	4.480	93.850	2.900	59.090	2.170	39.480
Limnodrilus udedkemianus	3.620	112.325	3.640	71.010	4.080	133.740	3.790	72.700	2.670	24.740	4.460	91.810	4.240	83.530	4.610	106.430	3.660	115.450	3.950	164.250
Pristina sp.	1.810	31.520	3.040	49.960	2.620	42.140	4.130	101.620	1.910	18.250	2.740	24.430	2.770	28.270	1.420	14.300	0.640	5.830	1.250	16.280
Class Hirudinea																				
Helobdella conifera	1.420	15.400	1.320	10.080	1.610	14.680	-0.300	2.900	0.930	7.930	-	-	-	-	-	-	-	-	-	-
Phylum : MOLLUSCA	3.880	74.300	4.590	84.850	3.410	39.950	5.200	95.430	4.370	54.980	3.570	26.510	4.420	33.880	3.740	40.680	3.820	58.200	3.240	52.770
Class : Gastropoda																				
Bulinus truncatus	1.030	12.670	3.380	60.230	-	-	4.020	49.890	2.770	61.410	-	-	1.440	11.950	-	-	-0.400	5.910	-	-
Cleopatra bulimoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.390	36.480	-	-
Melanooides tuberculata	2.220	55.680	-	-	1.570	30.290	3.120	26.560	3.540	99.110	2.680	102.890	2.980	61.070	2.130	41.420	2.730	83.950	1.660	43.850
Physa acuta	0.880	4.380	2.230	19.790	0.240	12.220	3.750	-	0.120	6.740	-	-	1.100	14.240	-1.000	7.300	-	-	-	-
Valvata nilotica	3.490	139.040	4.180	130.800	3.100	145.710	4.120	71.140	2.400	35.480	0.300	13.950	3.590	82.740	1.830	34.780	2.130	34.790	2.710	123.880
Gyraulus ehrenbergi	-	-	0.780	5.470	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class : Bivalvia																				
Pisidium pirothi	1.000	5.070	-	-	0.080	10.170	-	-	1.260	16.410	2.650	99.090	2.890	48.680	3.390	140.650	2.420	57.280	1.830	56.260
Eupera ferruginea	0.060	6.230	-	-	0.085	20.670	-	-	-	-	-	-	-	-	-	-	0.480	5.830	-	-
Total	13.89	225.62	14.66	227.82	16.66	236.12	19.04	227.07	16.10	241.89	16.24	227.26	19.65	226.43	13.01	241.39	14.70	230.28	12.36	236.00

[For stations refer to Fig. 12]. * and ** For abbreviations refer to p. 208.

Entz (1976) was the only author who recorded the oligochaete *Tublifex* sp. in Lake Nasser which was estimated to be 60,000 ton. However, it seems that Entz's identification was erroneous as *Tubifex* sp. was mistaken for the oligochaete annelid *Branchiura sowerbyi* (personal communication with Prof. S. Gabbour)which was abundant in the Lake and was recorded by other authors (Table 74).*Tubifex* is known to be a boreal species and does not exist in Africa.

Oligochaetes were the only benthic forms inhabiting the profundal zone in Lake Nasser in summer, indicating their tolerance to low oxygen level. This observation confirms the findings of Eggleton (1931) in certain Michigan lakes who reported the disappearance of most benthos except *Tubifix* sp. with the development of summer stratification. This supports the view that *Tubifex* sp. previously recorded by Entz (1976) never existed in Lake Nasser, otherwise it would remain even at low oxygen concentrations.

Seasonal distribution. Fishar (1995) studied the seasonal variations of population density and biomass of the total bottom fauna in different localities of Lake Nasser (Fig. 101) and his results may be summarized as follows:

1. Winter. Numerically winter was the least productive season of the Lake's benthos producing an average of 610 ind./m^2. Pronounced variations in the population density between the sides were observed. The western side represented the most productive site producing an average of 876 ind./m^2. Also, the highest biomass value (5.014 g fresh weight/m^2) was recorded in the western side, while the biomass values were very low in the eastern side and the main channel, with average values together representing about 79 % of the biomass recorded in the western side.

2. Spring. The density of benthic organisms gained an increase, of 33.55 % of the value of the preceding season. The eastern side was the richest one (1038 ind./m^2). The population density showed a sharp increase in the main channel, and the standing crop was 3.9 times that during winter. Population density slightly increased in the western side with an average of 991 ind./m^2 Fig. 101). The average biomass of the main channel and the two sides proved to be richer than during winter. The highest average biomass (7.868 g fresh weight/m^2) was recorded in the western side (Fig. 101).

3. Summer. The average population density decreased to 804 ind./m^2 for the entire Lake. The highest value was recorded in the eastern side (960 ind./m^2). The standing crop in the main channel (774 ind./m^2) nearly equals that of the preceding season. At the western side the population density was 678 ind./m^2 being nearly 68.64% that of spring. Comparing the biomasses recorded in summer in the eastern side and the main channel with their corresponding values recorded in spring, reveals a sharp contrast.

Meanwhile, the biomass in the western side remained the same in spring and summer (Fig. 101).

4. Autumn. Numerically this season is the most productive one for the entire Lake, producing an average of 1013 ind./m^2. Pronounced variations were observed in the population density of both sides. The highest density (1460 ind./m^2) occurred in the eastern side, while the lowest average value (536 ind./m^2) was recorded in the main channel. Biomass values of benthic organisms showed a remarkable decrease than those observed in summer. Meanwhile, the biomass recorded in the western side was still higher than the values in the eastern side or in the main channel.

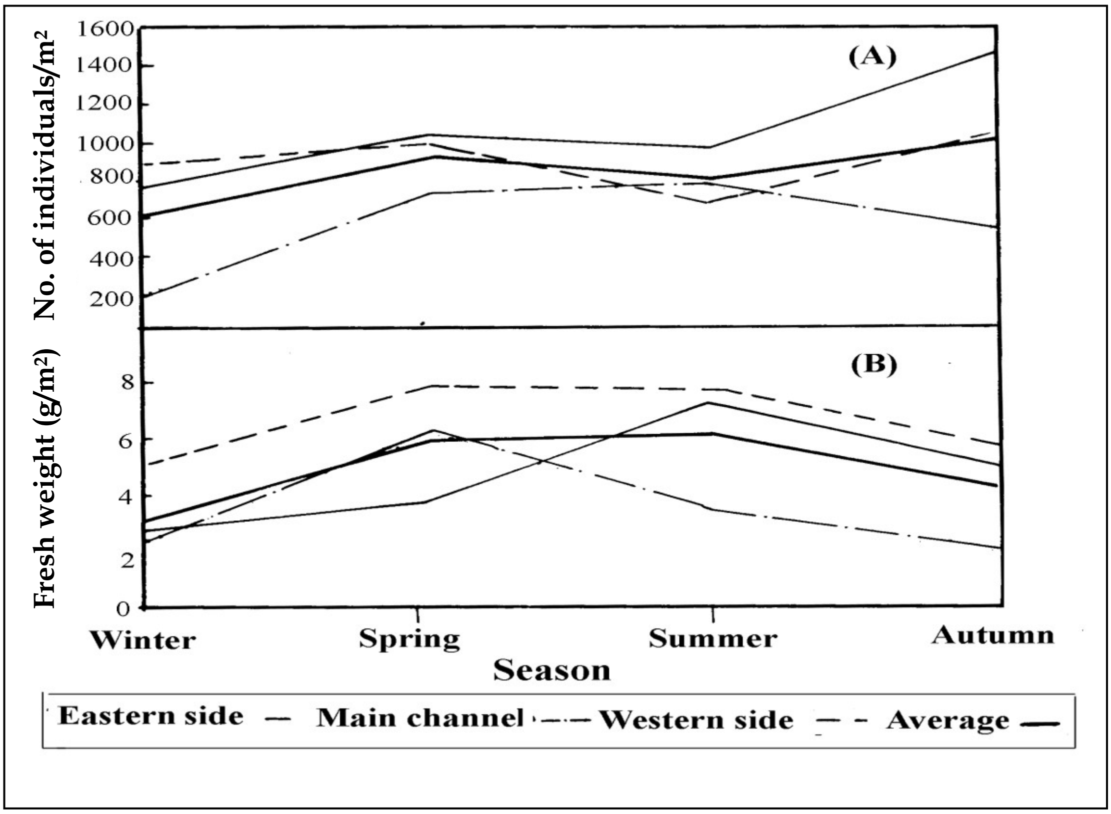

Fig. 101 **Seasonal variations of A: population density, and B: biomass of total bottom fauna in different localities of Lake Nasser during 1993 (Fishar 1995)** **[**For localities refer to Fig. 15**].**

The seasonal variations of absolute importance value (AIV) and relative importance value (RIV) of bottom fauna of Lake Nasser in 1993 show slight variations between different seasons (Table 76). Furthermore, the results show a slight increase in AIV value during spring for the total benthic groups. RIV also showed its highest value (223.29) in spring (Table 76).

Community composition. In Lake Nasser benthic organisms are rich and diversified. They are represented by 5 major groups, namely, Annelida (oligochaetes), Arthropoda (Insecta and Crustacea), Mollusca, Cnidaria

(Hydrozoa) and Bryozoa. Fishar (1995) mentioned that annelids and insects were the most common groups contributing 38.68 and 31.86% to the total benthic organisms (Fig. 102). Annelids are much heavier than the other components. They contributed 40.29% of the total biomass, followed by molluscs, which formed 36.16% of the total biomass. The percentages of biomass values were different from one side to other. Molluscs occupied the first position in both the eastern side stations (43.34%) and the western ones (47.74%), while annelids occupied the first position (90.40%) of the total benthic biomass in the main channel stations (Fig. 102). On the other hand, Bryozoa and Hydrozoa were less in population density and biomass, where 1.33 and 0.84% represented the population density of Bryozoa and Hydrozoa respectively, and 0.31 and 0.04% represented the respective percentages of biomasses. The distribution and seasonal variations of various benthic groups in the surveyed localities of Lake Nasser are shown in the Figs. 102-115.

In a complex natural environment, such as Lake Nasser, where several factors operate simultaneously, it is not easy to generalize and designate any one factor as being more important than the other. The biological processes taking place in the bottom of the Lake being the end result of the interactions of organisms present with the surrounding environment. Several abiotic and biotic factors are regarded as important in structuring stream macroinvertebrate communities, e.g. flow (Edington 1968), substratum (Reice 1980), allochthonous matter (Cummins & Klug 1979), temperature (Vannote & Sweeney 1980), chemistry (Sutcliffe & Hildrew 1989), predation (Allan 1983), and competition (Hart 1983).

The composition of benthic fauna has long been considered a good indicator of water quality because, unlike planktonic organisms, they form relatively stable communities in the sediments, which integrate change over long time intervals and reflect characteristics of both sediment and the water column (Aboul-Ezz 1984). The benthic fauna in Lake Nasser is rich and diversified. The general list includes, as mentioned before, 9 groups. It should be mentioned that the presence of certain species such as *Hydra vulgaris* is a bioindicator that Lake Nasser is unpolluted.

Successional Changes of Zoobenthos

Maclachlan (1974) pointed out that in a newly created lake the successional changes occur over a period of the order of ten to twenty years. Fishar (1995) identified three periods in the formation of the zoobenthos in Lake Nasser.

1. The first stage covered the early years of impoundment(1965-1969) where a mass of Chironomidae and Oligochaeta occurred in the littoral areas (Entz 1976) and the freshwater crab *Potamonautes niloticus* (Latif 1984a) were recorded.

Table 76 **Seasonal variations of absolute importance value (A I V) and relative importance value (R I V) of bottom fauna of Lake Nasser during 1993 (Fishar 1995).**

Taxa and Species	Winter		Spring		Summer		Autumn	
	AIV	RIV	AIV	RIV	AIV	RIV	AIV	RIV
Phylum : CNIDARIA								
Class : Hydrozoa								
Hydra vulgaris	0.030	4.410	0.330	2.660	-	-	0.080	3.610
Phylum : BRYOZOA								
Class : Phyleclolaemata								
Fredericella sultana	1.120	8.320	0.520	2.450	1.380	5.020	0.120	3.990
Phylum : ARTHROPODA								
Class : Insecta	3.910	51.010	4.570	59.080	3.900	36.010	4.510	62.86
Ablabesmyia sp.	2.060	10.000	2.330	8.510	2.100	9.340	1.50	7.71
Caenis sp.	0.880	3.600	1.000	3.370	-1.180	1.940	0.300	1.93
Chironomus sp.	-1.097	1.940	-	-	-	-	-	-
Circotopus sp.	-	-	-0.400	2.050	-	-	-1.480	1.59
Coelotanypus sp.	1.020	5.190	-	-	0.860	4.370	0.150	2.1
Cryptochironomus sp.	1.870	4.150	0.130	2.340	-0.700	3.500	0.560	3.76
Enallagma sp.	0.301	2.290	1.550	4.990	-0.880	1.850	0.990	4.13
Ischnura sp.	-1.220	3.380	0.390	4.120	-1.180	1.820	-1.480	1.59
Micromecta plicata	-	-	0.870	4.350	0.200	3.830	-1.430	1.590
Microtendipes sp.	1.810	9.500	2.540	10.890	2.160	9.340	2.750	11.87
*Neurocordul*a sp.	0.156	3.280	-	-	-	-	-	-
Nilodorum sp.	2.340	12.840	2.050	7.200	1.260	5.300	3.590	27.38
Plathemis sp.	0.176	3.350	0.120	2.210	-	-	-	-
Polypedilum sp.	1.880	8.900	2.880	14.780	1.080	6.150	2.450	10.19
Perithemis sp.	-	-	1.780	8.680	-0.250	2.060	0.360	3.55
Procladius sp.	1.400	6.450	2.990	14.200	2.970	17.690	2.500	10.12
Tanytarsus sp.	1.760	9.490	2.090	7.440	1.490	5.430	2.180	7.74
Larvae of Trichoptera	0.080	4.030	-0.480	1.960	-	-	0.030	2.050
Pupae of Chironomidae	0.505	4.530	-0.880	1.910	1.320	6.690	1.340	4.97
Class : Crustacea	3.590	38.180	2.820	13.900	2.320	12.650	3.910	32.580
Cardina nilotica	3.070	30.020	-	-	-	-	2.720	13.560
Chlamydotheca unispinosa	1.960	10.150	2.460	10.810	1.600	7.780	2.940	14.900
Stenocypris malcolmsoni	-0.160	6.060	1.860	8.160	1.640	8.200	2.760	12.490
Phylum : ANNELIDA	4.570	99.350	5.020	91.810	4.960	90.320	4.560	63.89
Class Oligochaeta								
Branchiura sowerbyi	2.790	17.670	3.080	14.500	2.020	6.850	1.000	4.16
Limnodrilus hoffmeisteri	3.190	24.040	4.480	52.180	3.520	21.780	3.590	25
Limnodrilus udekemianus	4.085	58.680	3.880	28.380	4.360	47.940	3.920	33.45
Pristina sp.	2.120	12.800	1.850	9.790	3.790	27.070	2.330	11.74
Class Hirudinea								
Helobdella conifera	-0.330	2.270	1.320	35.260	-	-	1.030	4.21
Phylum : MOLLUSCA	2.990	22.870	4.450	53.400	4.790	79.300	4.150	55.110
Class : Gastropoda								
Bulinus truncatus	0.030	3.850	3.230	24.450	2.570	10.800	2.680	18.660
Cleopatra bulimoides	-	-	-	-	-	-	0.570	4.240
Melanoides tuberculata	1.190	7.500	2.600	14.750	3.090	17.510	2.580	13.590
Physa acuta	-0.480	2.120	0.970	4.990	2.890	14.790	1.640	5.490
Valvata nilotica	2.340	12.050	3.030	13.880	4.090	37.050	3.200	18.050
Gyraulus ehrenbergi	-	-	-	-	-0.570	1.980	-	-
Class : Bivalvia								
Pisidium pirothi	0.750	3.700	2.330	8.620	2.790	11.990	2.230	7.960
Eupera ferruginea	0.160	3.280	-	-	-1.180	1.820	-1.000	1.740
Total	17.21	224.14	17.71	223.29	17.35	223.30	17.33	222.04

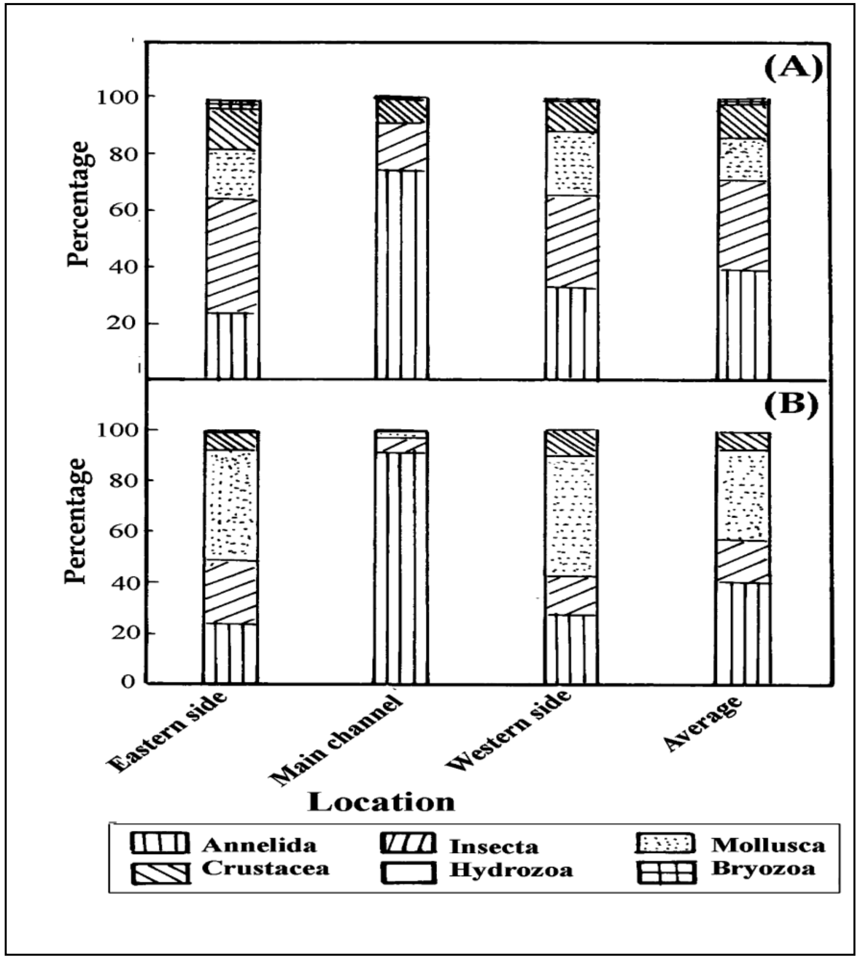

Fig. 102 **Percentage composition of A: population density, and B: biomass of benthic groups in Lake Nasser (Fishar 1995) [**For localities refer to Fig. 15**].**

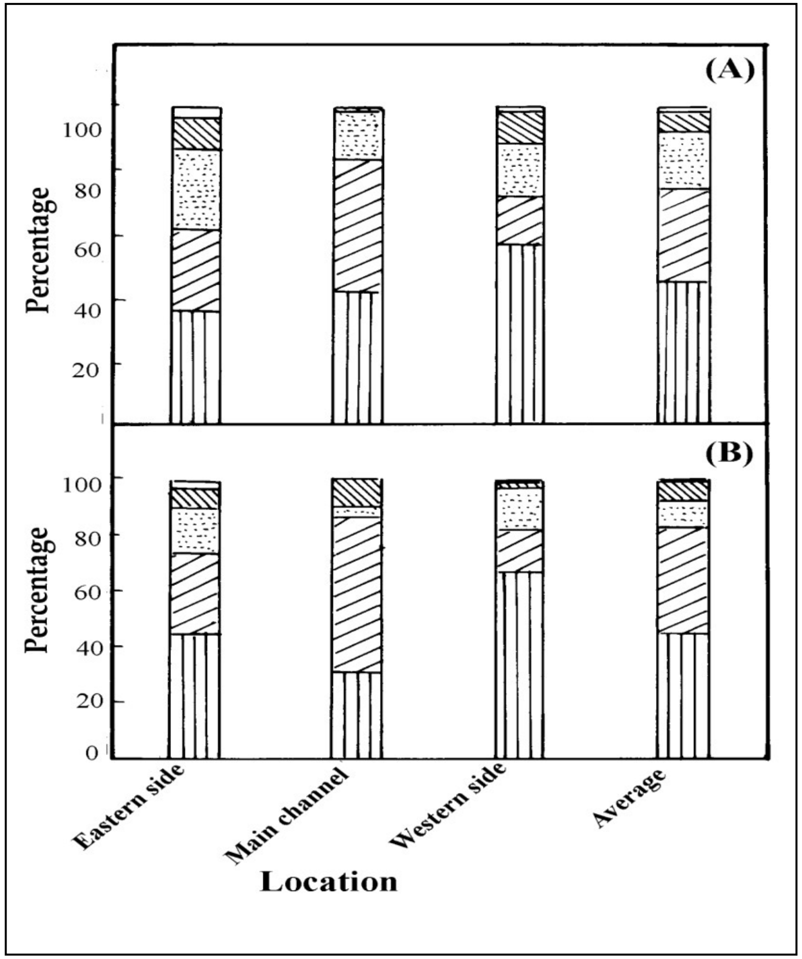

Fig. 103 **Percentage composition of A: population density, and B: biomass of Annelida in Lake Nasser (Fishar 1995) [**For localities refer to Fig. 15**].**

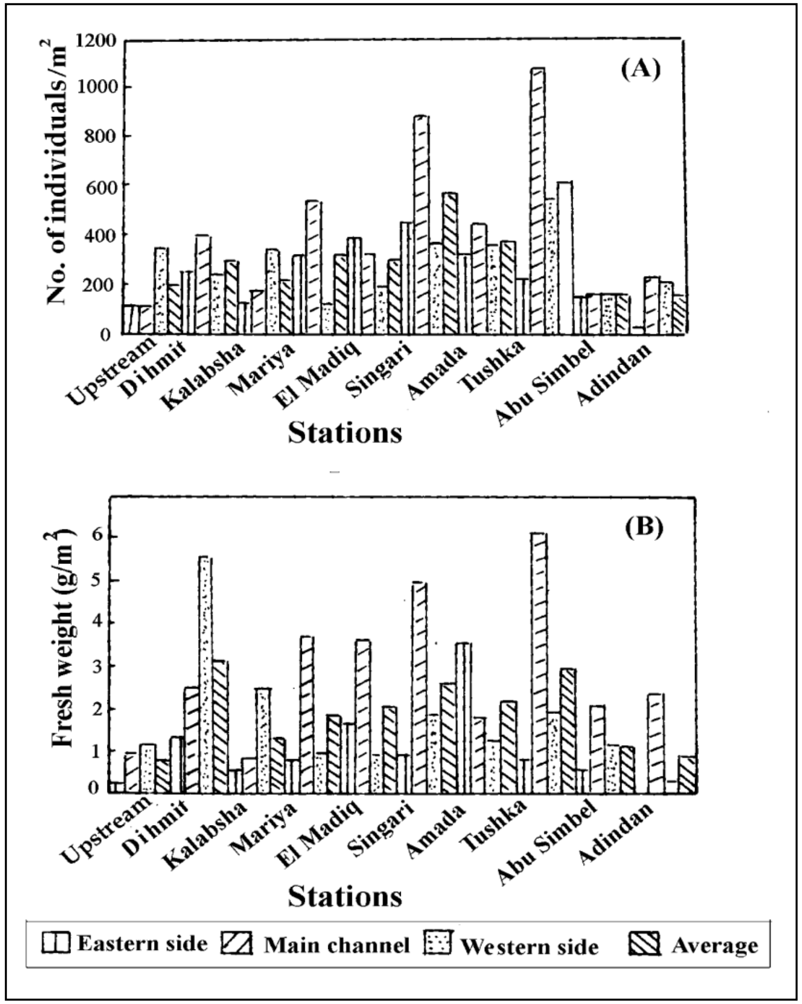

Fig. 104 **Distribution of A: population density, and B: biomass of Annelida at different localities of Lake Nasser. (Fishar 1995) [**For stations refer to Fig. 15**].**

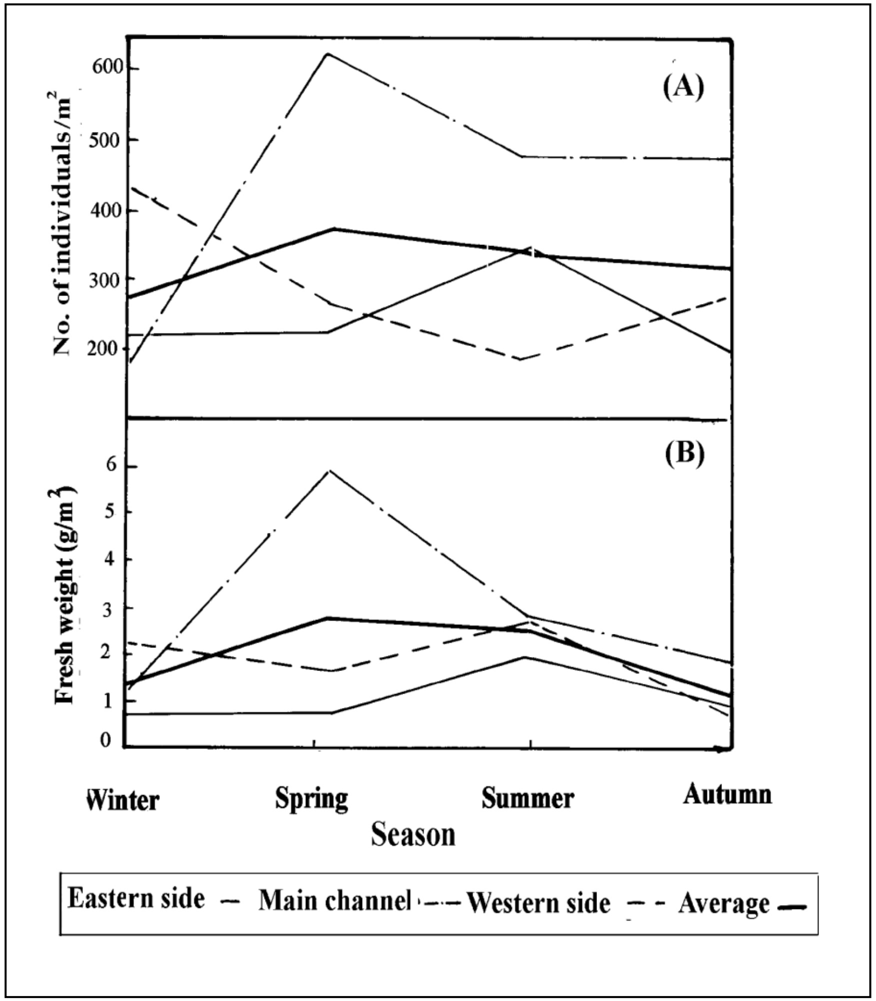

Fig. 105 **Seasonal variations of A: population density, and B: biomass of Annelida at different localities of Lake Nasser during 1993 (Fishar 1995) [**For stations refer to Fig. 15**].**

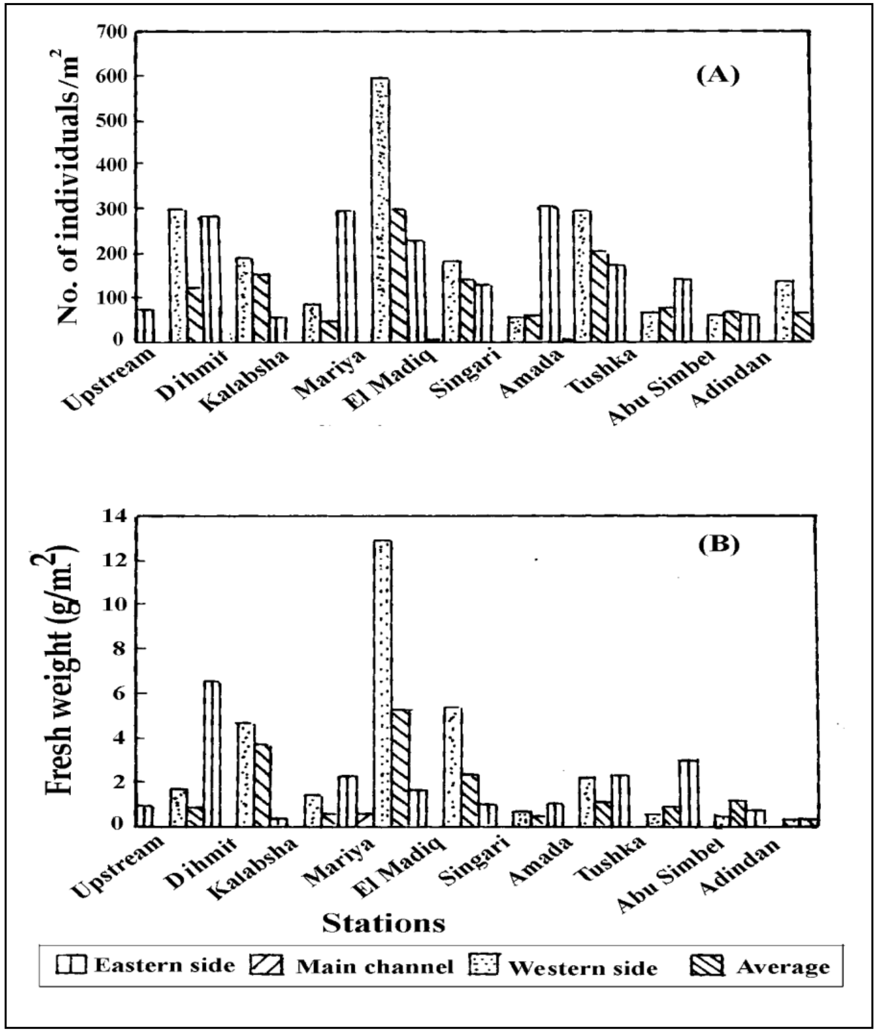

Fig. 106 **Distribution of A: population density, and B: biomass of Mollusca in different localities in Lake Nasser (Fishar 1995)** [For localities refer to Fig. 15]

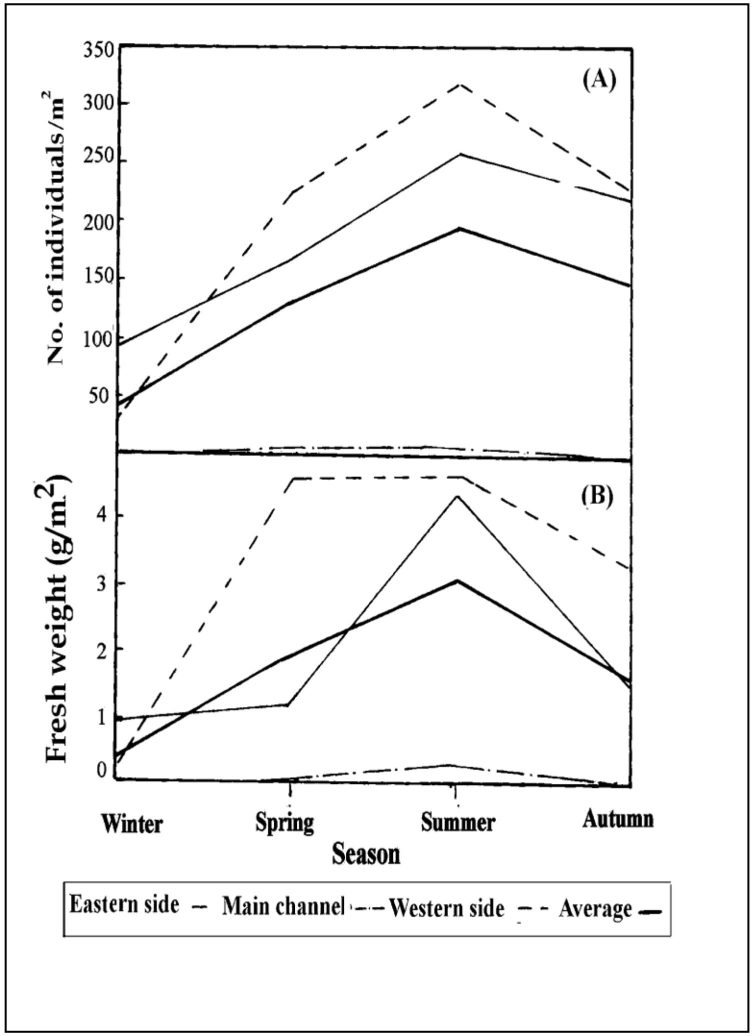

Fig. 107 **Seasonal variations of A: population density, and B: biomass of Mollusca in different localities of Lake Nasser during 1993 (Fishar 1995)** [For localities refer to Fig. 15].

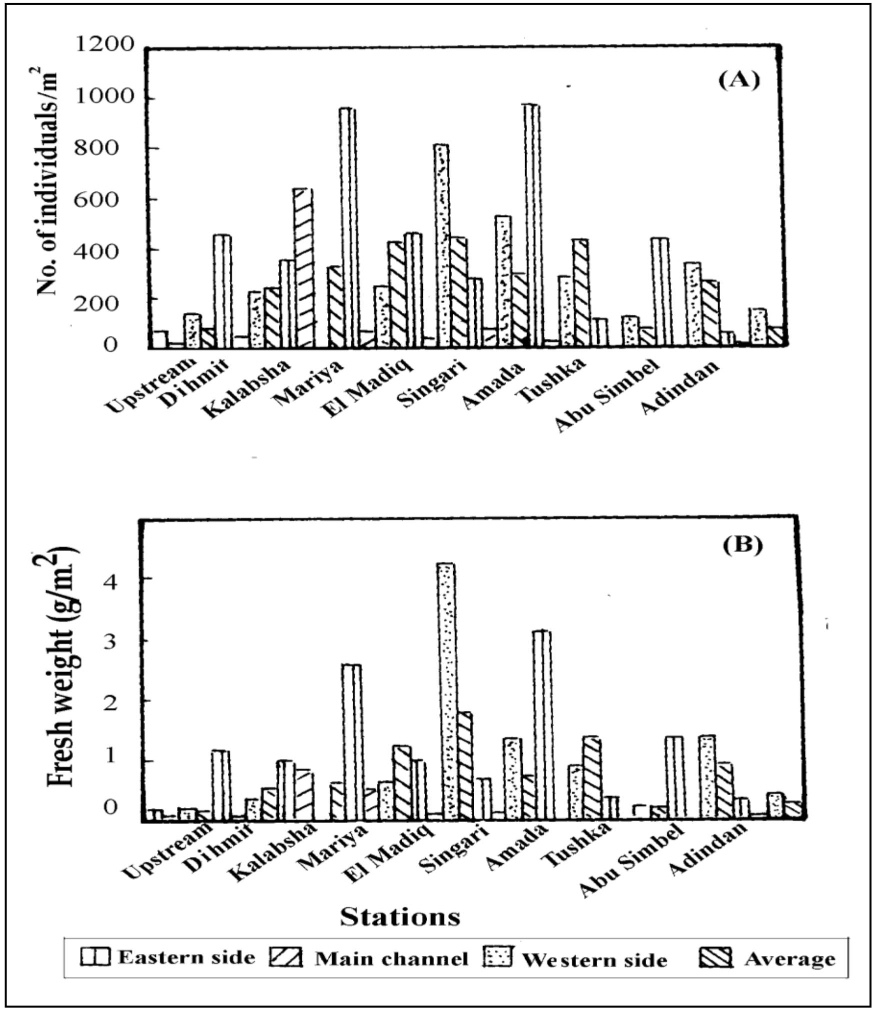

Fig. 108 **Distribution of A: population density, and B: biomass of Insecta recorded in different localities of Lake Nasser (Fishar 1995)** [For localities refer to Fig. 15].

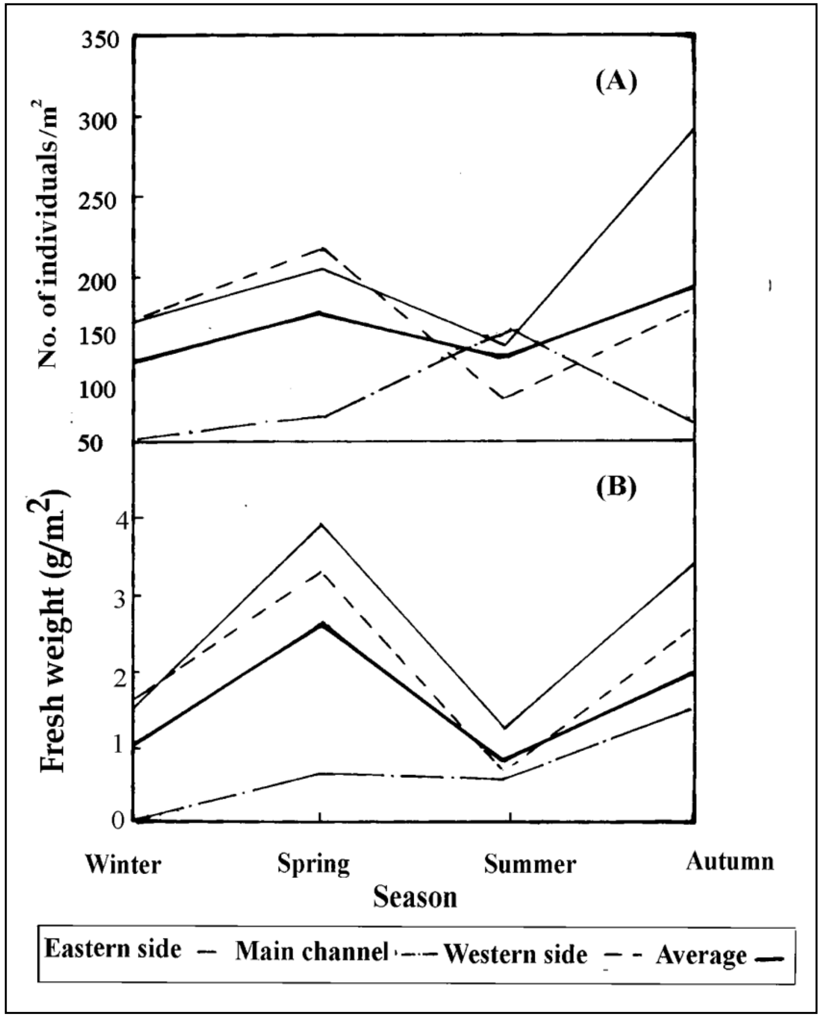

Fig. 109 **Seasonal variations of A: population density, and B: biomass of total Insecta in different localities of Lake Nasser (Fishar, 1995)** [For localities refer to Fig. 15].

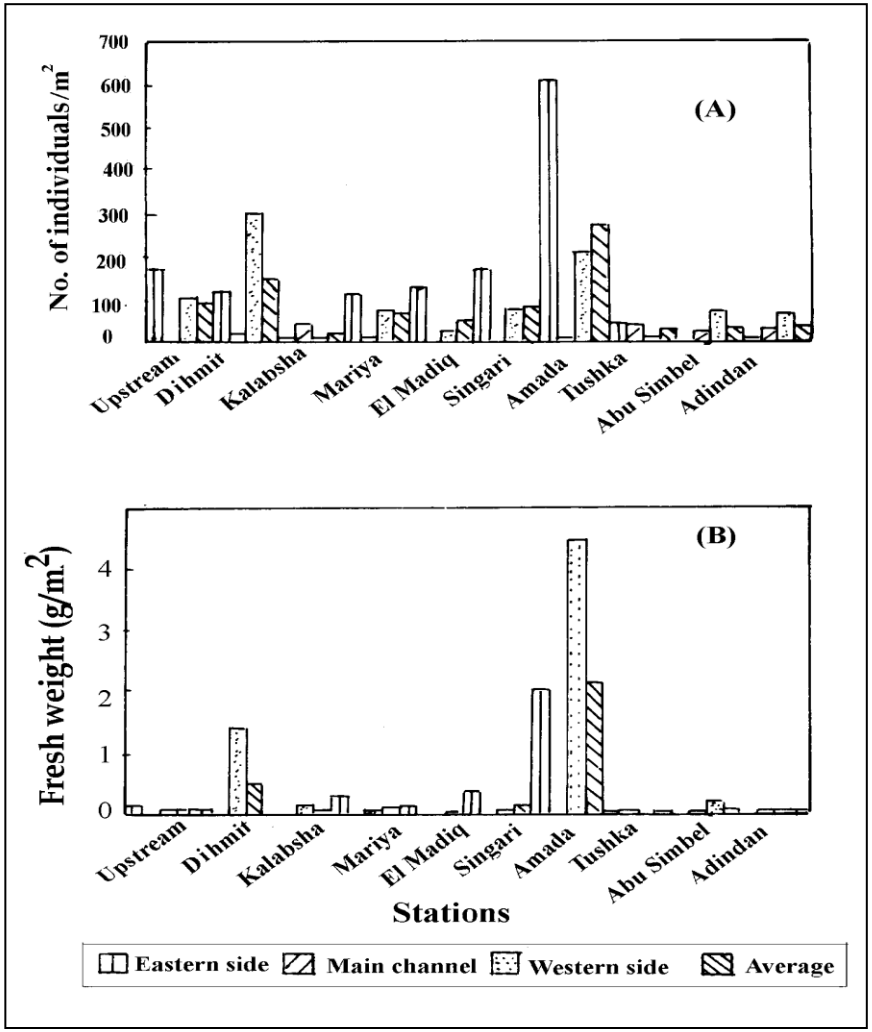

Fig. 110 **Distribution of A: population density, and B: biomass of Crustacea in different localities in Lake Nasser (Fishar 1995) [**For localities refer to Fig. 15**].**

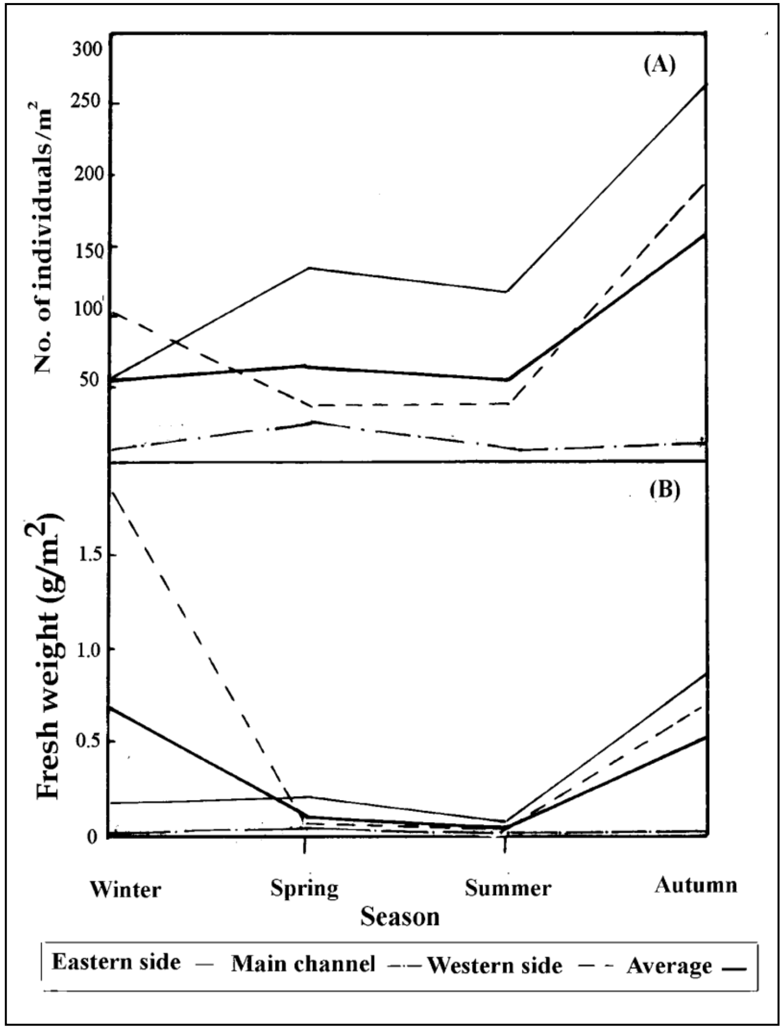

Fig. 111 **Seasonal variations of A: population density, and B: biomass of Crustacea in different localities of Lake Nasser during 1993 (Fishar 1995) [**For localities refer to Fig. 15**].**

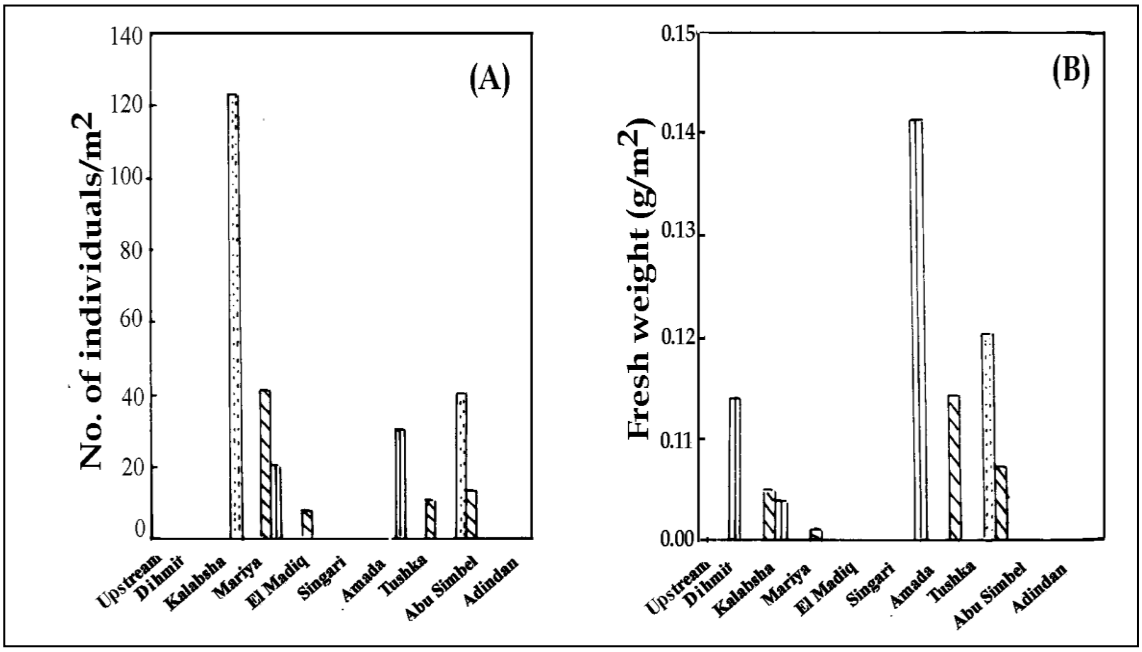

Fig. 112 **Distribution of A: population density, and B: biomass of *Hydra vulgaris* at different sites of Lake Nasser (Fishar 1995) [**For stations refer to Fig. 15**].**

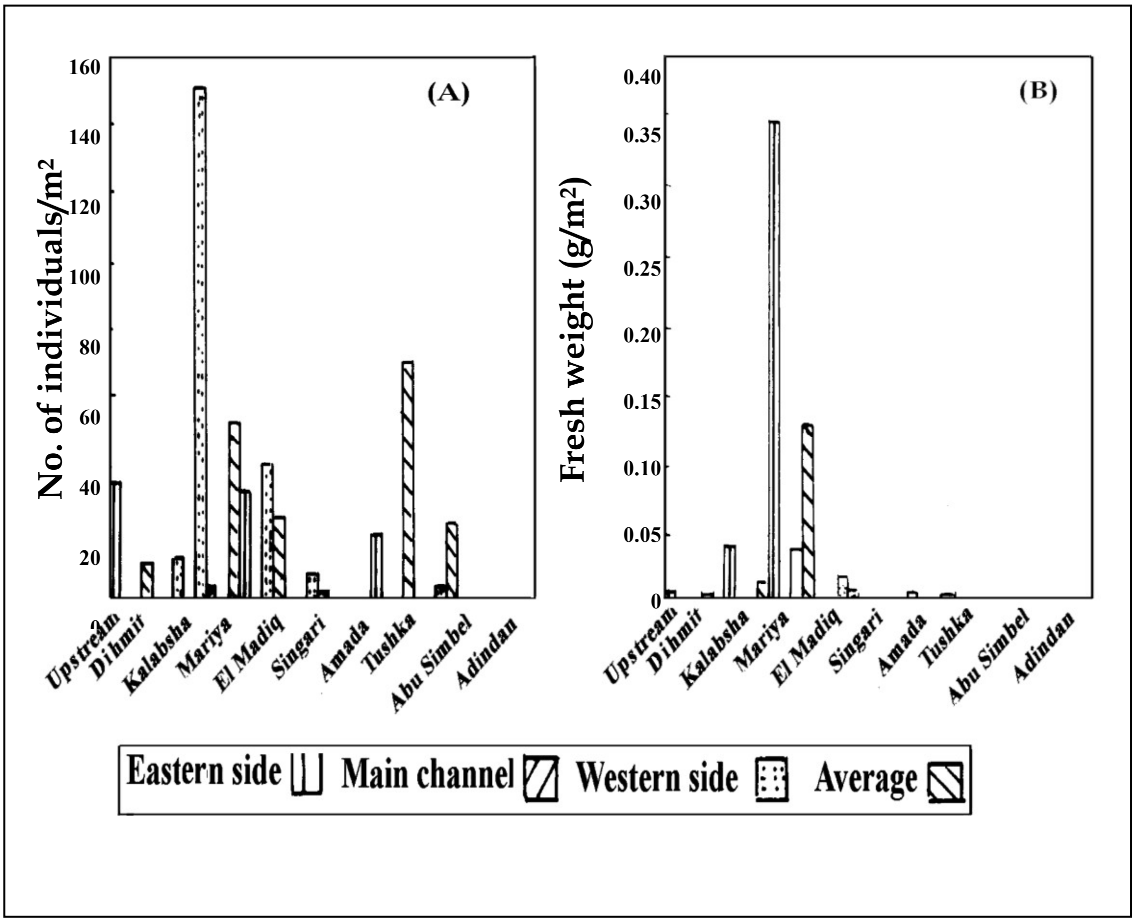

Fig. 113 **Distribution of A: population density, and B: biomass of *Fredericella sultana* at different localities of Lake Nasser (Fishar 1995) [**For stations refer to Fig. 15**].**

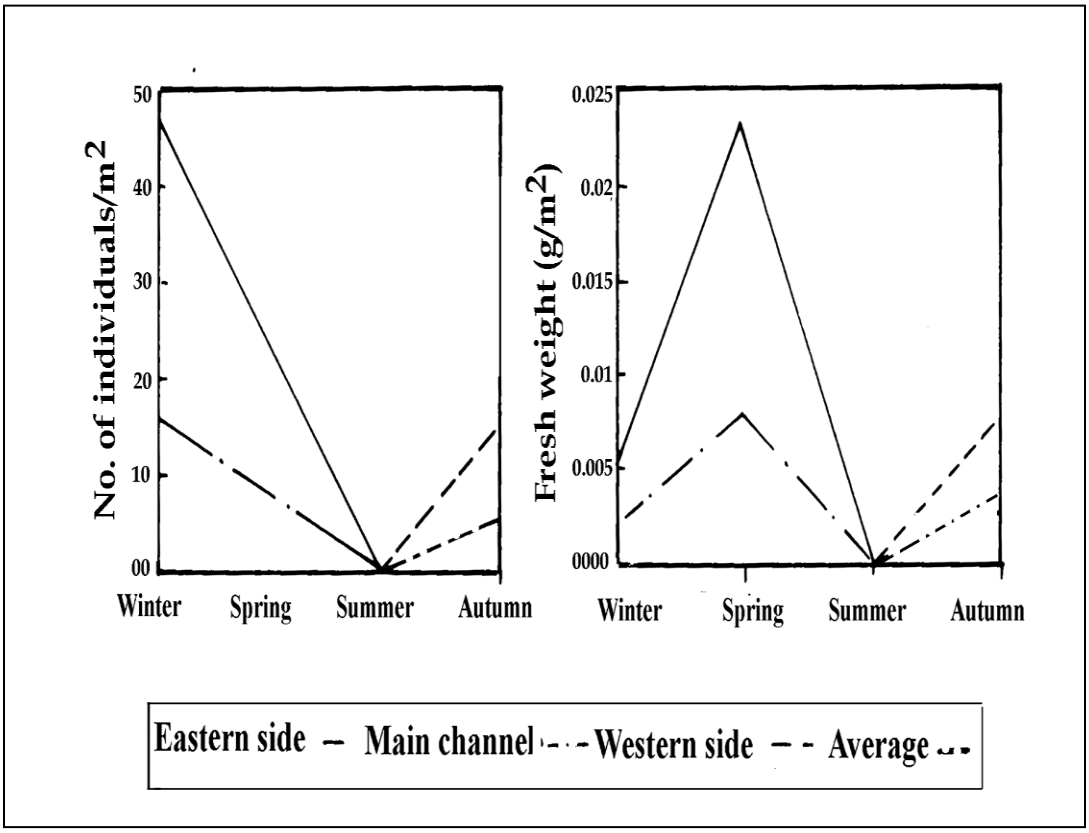

Fig. 114 **Seasonal variations of A: population density, and B: biomass of *Hydra vulgaris* in Lake Nasser during 1993 (Fishar 1995) [**For stations refer to Fig. 15**].**

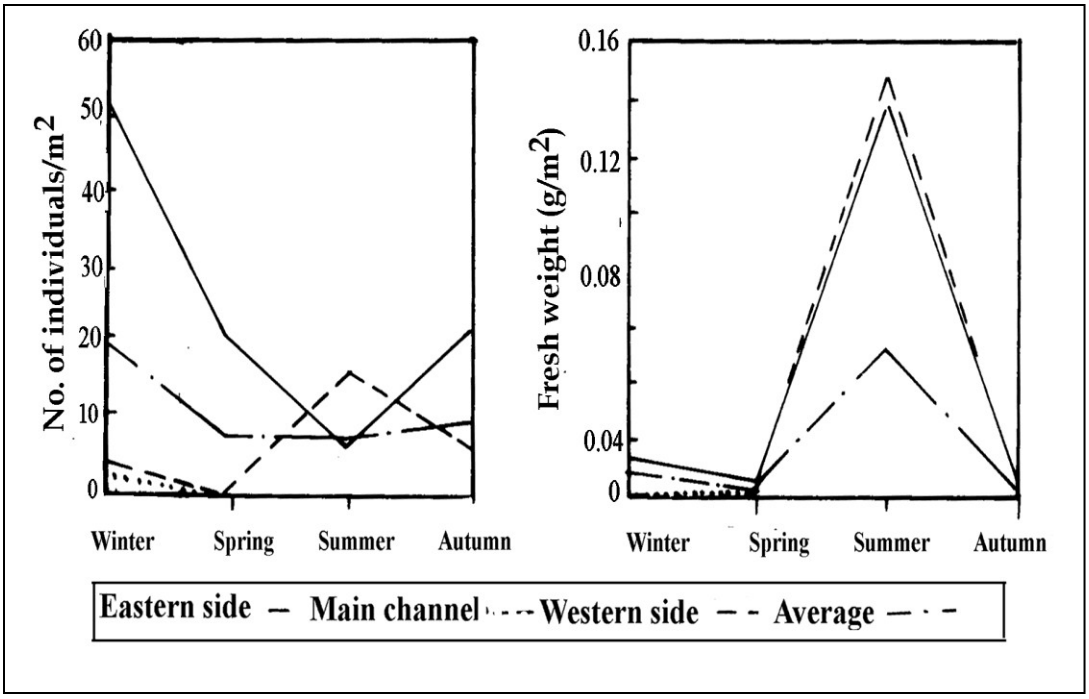

Fig. 115 **Seasonal variations of A: population density, and B: biomass of *Fredericella sultana* in Lake Nasser during 1993 (Fishar 1995) [**For stations refer to Fig. 15**].**

In the meantime, all bivalves already existing in the old river bed died during the stagnation period because of lack of oxygen (Entz 1976).

2.The second stage began with the final formation of the Lake and ended with the ending of the major African drought (1988). During this stage, about 30 benthic species were recorded (Anon. 1979, Elewa 1987b and Iskaros 1988); some previously recorded species such as *Potamonautes niloticus* disappeared.

3.The third stage extended from 1989 to 1993. In spite of the decline in the number of insects during this stage, the number of species constituted the benthic invertebrate community, further increased to 59 species, belonging to 4 Phyla.

CONCLUSIONS

Lake Nasser is very rich in **zooplankton,** including 79 species belonging to 4 major groups, with an annual density ranging from 233,900 to 562,100 ind./m^3 in the southern region of Lake Nasser and from 52,900 to 156,400 ind./m^3 in the northern region. The southern region of Lake Nasser is richer in zooplankton than the northern. From July to December 1990, the zooplankton wet weight ranged from 210 to 1940 and from 50 to 980 mg/m,^{3} collected from the southern and northern regions respectively. The highest number of zooplankton organisms (562,100 ind./m^3) was recorded at Abu Simbel in the southern region. The great abundance of zooplankton organisms in the southern region is attributed to high productivity of phytoplankton, since there is a high positive correlation between the number of zooplankton organisms and concentration of chlorophyll *a.*

The major zooplanktonic groups in Lake Nasser are Copepoda, Cladocera and Rotifera. There are variations in the percentage composition of the major planktonic species seasonally and regionally. Zooplankton numbers are more abundant at 5 to 10 m depth than at any other depth, except at Kalabsha station, where the highest number of zooplankton organisms was recorded at 15 m depth. There is a parallelism in number of zooplankton and mean value of chlorophyll *a* concentrations. Areas with high chlorophyll *a* concentrations (e.g. Korosko region) contain the highest number of zooplankton individuals (90 ind./l), as compared with the other areas as in Khor El Ramla (29 ind./l) corresponding to chlorophyll *a* values 9.1 and 2.9 mg/m^3.

High zooplankton density was recorded during the cold season (winter); while the lowest one was found during the hot season (summer). In winter, copepods, mainly nauplii, are most abundant (68.5%), followed by cladocerans (18.9%) and rotifers (12.7%).

Khors are richer in zooplankton density than the main channel, being nearly twice as that of the latter. In khors at least 34 zooplankton species were recorded, mainly copepods, cladocerans and rotifers. The littoral zone of khors has a sustainable standing stock of zooplankton all year round, with a maximum in winter and a minimum in summer, increasing in autumn and almost doubled in winter and spring. The highest standing crop is recorded at 5 m depth, and the lowest one at 20 m depth.

From the various studies on **benthic fauna** of Lake Nasser (Entz 1976, Latif 1984, Elewa 1987, Iskaros 1988, 1993, Fishar 1995) it is concluded that :

The number of recorded species is 59 belonging to 4 major groups and 9 classes, dominated by insects (29 species), followed by molluscs (19 species); oligochaete annelids and crustaceans each 4 species; and Hirudinea, Hydrozoa and Bryozoa each represented by one species. While Iskaros (1988, 1993) recorded 40 species, Fishar (1995) found 37 species. Nineteen species previously recorded by Iskaros (1988, 1993) were not included in Fishar's (1995) list of benthic fauna. The latter author recorded 13 species for the first time (Table 74).

Annelids and insects constitute the most common benthos with an average of 38.7 and 31.9% of all benthos. As to the total biomass, molluscs constitute the highest biomass in both the eastern (43.3%) and western sides (47.7%) of the Lake. Oligochaete annelids, however rank first (90.4%) in the main channel. Hydrozoans and bryozoans are the lowest in biomass. The littoral zone is richer in number and biomass of zoobenthos, than in the main channel which harbours much less benthos either in number or biomas. The eastern side of the Lake is richer in benthos, both number and biomass, than the western side. Molluscs, in this region, constitute the highest biomass. Khors (both littoral and profoundal zones) are richer in benthos than the main channel.

Amada station (200 km south from the High Dam) is the richest area in its benthos, compared with both northern and southern regions. The most productive season for benthos is autumn, followed by spring and summer; winter is characterized by the low number and biomass of benthos.

Certain species which were previously recorded during the early stages of Lake Nasser i.e. *Potamonautes niloticus,* was recorded by Latif (1984b) but was not recorded in subsequent studies (Entz 1976, Iskaros 1988,1993, Fishar 1995).

A comparison between the benthic fauna of the Lake recorded by Iskaros (1993) and Fishar (1995) is given in Table 77.

Table 77 **Comparison between the benthic fauna (number, biomass) of Lake Nasser recorded by Iskaros (1993) and Fishar (1995).**

	Iskaros (1993)			Fishar (1995)		
No. of species	**40 (15 spp. are not recorded by Fishar)**			**39 (10 spp. are not recorded by Iskaros)**		
Locality and Density	**Lake Nasser**	**No. (ind./m²)**	**Biomass (g/m²)**	**Lake Nasser**	**No. (ind./m²)**	**Biomass (g/m²)**
	Littoral	2659	13.1	**Amada**	1326	7.040
	Profoundal	288	1.9	**Adindan**	331	1.672
	Khor Kalashaba			**Main channel**	556	3.192
	Littoral	10292	33.9	**Eastern side**	1027	lower
	Profoundal	908	4.0	**Western side**	887	higher
				Average	823	4.776

Seasonal variations in number of organisms in Lake Nasser (ind./m^2).

Site	Winter	Spring	Summer	Autumn
Western side	876	991	678	--
Eastern side	--	1038	960	1460
Main channel	--	2379	774	536
Average	610	815	804	1013

(--) not recorded