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Zooplankton community at fish fry collection sites along the Mediterranean coast of Egypt

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Abstract

The abundance and diversity of zooplankton community were studied during the period from February 2005 to February 2006 at six sites. Every site was represented by one station, where fish fry of marine origin were collected along the Mediterranean coast of Egypt. Water quality was also considered. Chosen stations are heavily perturbed by land drainage discharge, high nutrient levels, abundant zooplankton, and a low diversity index. Kassara station is characterized by its highest density of zooplankton (427.7 X10^3 ind/m^3), the lowest diversity index, presumably reflecting a combination of the high nutrient loading of this system, high dissolved oxygen, and the low salinity of water. On the other hand Soffara station was affected much less by drain water, so it has the lowest zooplankton abundance (27.7 X10^3 ind/m^3) combined with high salinity. Variable zooplankton peaks were detected between different investigated stations. Although the density of the total zooplankton community reached its maximum value during spring at Naubaria and El-Mex stations; it was the highest during summer at Maadia station, and during winter 2006 at the other three stations. The most numerically important group was the rotifers which formed 10 to 88% of the total average zooplankton, dominated by *Brachionus* spp. especially *Brachionus plicatilis* which formed approximately from 10% to 74% to the total average rotifers at the studied stations. Copepods, of which 48% to 91% were nauplii stages contributed from 6% to 51% to the total average number of zooplankton at the six stations. The dominant copepod species was *Oithona nana*. During some months copepod nauplii were the single representative of copepods at one station or more. The meroplanktonic stages of molluscs, polychaetes and cirripedes were also important taxa. *Brachionus plicatilis* (48.1%) and copepod nauplii (11.3%) were the dominant zooplankton taxa, and form the main zooplankton food supply of fish fry at these sites.

Keywords: Zooplankton, diversity, community composition, fish fry, Mediterranean coast.

1. Introduction

In Egypt, fish fry collection sites are mainly distributed on Delta coast of the Mediterranean, especially at the outlets of the major agriculture drainage canals, branches of the River Nile and the connecting canals of lagoons and lakes to the Mediterranean Sea (Saleh, 2008). The functional roles of estuaries and coastal lagoons to fish have been extensively investigated worldwide, in temperate, subtropical and tropical areas (Potter *et al*., 1990; Blaber, 1997and 2000; Whitfield, 1999; Elliott and Hemingway, 2002, Nordlie, 2003 and Jezierska *et a*l., 2008), with a particular focus on their nursery function.

One of the most important influences for the survival of fish fry and population dynamics is the food availability in areas defined by mesoscale hydrographic structures (Last, 1980; Iles and Sinclair, 1982) and the ability to consume it, at the critical time and place (Taivo and Murray, 1981). Zooplanktonic organisms represent the main source of food for fish fry and juvenile marine pelagic fish (Cushing, 1990; Moreno and Castro, 1995; Mercier, *et al*., 2004 and El-Ghobashy, 2009).

The densities of zooplankton communities in temperate coastal areas and estuaries undergo marked seasonal changes, usually peaking in summer but also occasionally in spring or autumn (Kennish, 1990).The most abundant groups of zooplankton in such areas are copepods, rotifers, protozoans and meroplanktonic stages of benthic invertebrates (Ambler *et al*., 1985). Smaller developmental stages of zooplankton such as copepod nauplii constitute an important component diet for larval fishes (Hunter, 1981 and Turner, 1982).

Relatively few studies were done on the seasonal changes of the zooplankton communities of the Egyptian coastal area (Abdel –Aziz, 2000 a & b, 2001, 2002 and 2005; Abdel-Aziz and Dorgham, 1999 & 2002; Zakaria, 2007 and El-Ghobashy, 2009).

The aim of the present study is to provide information on the abundance and the diversity of zooplankton community at fish fry collection sites along the Mediterranean coast of Egypt. Also, it contributes to some extent the knowledge of the shallow zooplankton structure in Mediterranean Sea.

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2. Material and methods

2.1. Sites of collection

Six stations were studied along the Mediterranean coast of Egypt, one station per site (Figure 1).All stations receive huge amounts of agriculture drainage water, from different sources and with different quantities.

Naubaria station (S1), receives its water from the West Naubaria Canal which was constructed to collect agricultural drainage water from the cultivated land around south and south west of Alexandria City, as well as industrial and domestic wastes. El Mex station (S2) receives a heavy load of waste waters (7 X10^9 m^3/year), both directly from industrial outfalls (El-Umum Drain) and indirectly from Lake Maryout via El-Mex Pumping Station (Mahmoud *et al*., 2005). Maadia station (S3) is situated at Boughaz El Maadia between Lake Edku and Abu Qir Bay. This station is exposed to continuous exchange of marine and freshwater from Lake Edku which receives regularly huge amounts of agricultural drainage water (Abdel-Aziz, 2000b). Rosetta station (S4), lies at Rosetta mouth of the River Nile, influenced by freshwater discharges from Lake Edku at the western side and Rosetta Branch of the River Nile at the eastern side. Kassara station (S5), is greatly affected by Kassara Drain which receives agricultural drainage water from the cultivated land of Dakahlia Governorate, also industrial wastes of sugar factories. Soffara station (S6), is located where the Damietta Branch of the River Nile pours its freshwater into the Mediterranean, and also is affected by drainage water from Lake Manzalah.

2.2. Zooplankton sampling and data analysis

Zooplankton samples were collected during most months between February 2005 and February 2006 from each station. Zooplankton samples were collected by filtering 40 liters of seawater at every station (average depth 1.5-2m.) using 55 µm mesh conical net with a mouth diameter of 0.34 m and a length of 0.7 m. Samples were preserved in seawater- buffered 5% formalin solution. The identification of zooplankton organisms was done according to Rose (1933), Tregouboff and Rose (1957) and Edmondson *et al*., (1959). Aliquots for counts were taken from the total sample adjusted to 100 ml. The standing crop of zooplankton community was calculated and expressed in number per cubic meter. Various environmental parameters (Table 1) were measured at each station at the time of zooplankton sampling. Taxonomic diversity of the zooplankton community was calculated with the Shannon-Weaver Index (*H'*) (Shannon & Weaver, 1949), $H' = - \sum^{s}_{i=1} fi \, \mathrm{Log}_2 fi$ where *fi* is the frequency of the *i* species.

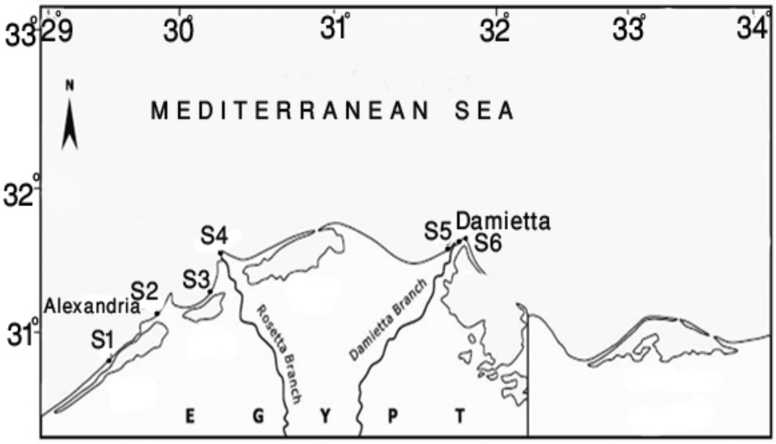

Figure1: The study area and the sampling stations.

Table 1: The variation range of different parameters at the surface water of the sampling.

stations, February 2005-February 2006 (Anon, 2007)						
Stations	S1	S2	S3	S4	S5	S6
Temperature (ºC)	17- 31	15.5-32	16-32.5	16-32.5	17-33	17-33
pH	7.55 -8.64	7.2 - 8.89	7.25 - 8.43	6.75 - 8.73	7.45- 8.4	7.45 - 8.57
Salinity ‰	6.93 - 13.61	3.06 - 10.97	7.57- 30.95	9.92- 17.26	2.86-3.1	31.38 - 37.89
Dissolved oxygen (ml/L)	8.48 - 8.82	3.59 - 8.16	5.22 - 10.45	7.51 - 11.43	7.18- 11.43	7.7- 10.12
NH4 (µmol/L)	3.9-75.85	5.35-76.8	0.66-45.85	1.2-22.4	9.3-29.35	0.78-11.9
PO4 (µmol/L)	0.03-1.92	2-26.21	0.9-4.25	0.35-5.7	1.7-6.4	0.3-2.25
SiO4 (µmol/L)	63.6-192.3	72.45-206.9	4.5- 76.5	9.23-41.5	56.4-159.7	3.48-11.9
NO2 (µmol/L)	1.03-3.88	0.25- 15.53	0.43-9.06	0.45-12.48	1.4- 8.25	0.33- 2.5
NO3 (µmol/L)	68.27-175.95	0.51-67.26	1.93-49.34	1.69-64.4	1.6-28.56	2.5-24.3
Phytoplankton(X10^3unit/L)	30.6-115.2	9.1-543.1	79.2-1597	23.7-1101.2	82.4-2277.6	17.4-320.4

3. Results

3.1. Zooplankton abundance

The results showed that the abundance of zooplankton was much higher in Kassara station (S5) with an annual mean value of 427.7 X10^3 ind/m^3, while the lowest density was recorded in Soffara station (S6) with annual mean value 27.7 X10^{3}ind/ m^3. In the other stations it ranged between 30.4 X10^3 and 77.3 X10^3 ind/m^3 (Table 2). The zooplankton community at El-Naubaria station (S1) showed one prominent peak during spring (April, 268.9 X10^3 ind/m^3) (Figure 2).At El-Mex station (S2), zooplankton peaked up at one period during spring (March, 133.3 X10^3 ind/m^3 – April 139.2 X10^3 ind/m^3). Zooplankton at Maadia station (S3) showed three peaks of developments: the first period was recorded during summer months (maximum peak during July, 59.4 X10^3 ind/m^3), the second period at the end of autumn (November, 25.4 X10^3 ind/m^3) and the third in winter (February, 2006, 49.4 X10^3 ind/m^3). In Rosetta station (S4), zooplankton peaked up at two periods: one in summer (July, 168.4 X10^3 ind/m^3) and the second during winter (February 2006, 185 X10^3 ind/m^3). In S5, zooplankton peaked up also at two periods: the smallest one during autumn (October, 347.4 X10^3 ind/m^3) and the maximum one during winter (February 2006, 1424.8 X10^3 ind/m^3). At S6, two equal peaks (49.6X10^{3}ind/m^3)were recorded: the first during autumn (October) and the second during winter (February, 06) (Figure 2). The maximum abundance of zooplankton paralleled that of rotifers and copepods or one of them.

Table 2: Mean values of the Shannon- Weaver Index H', the number of zooplankton taxa and total abundance /m3 at the sampling stations.

	S1	S2	S3	S4	S5	S6
Shannon- Weaver Index	2.81	2.45	2.78	2.8	1.55	2.71
Number of species	58	56	67	63	65	58
Total zooplankton (ind/ m3)	43406	46981	30411	77305	427666	27661

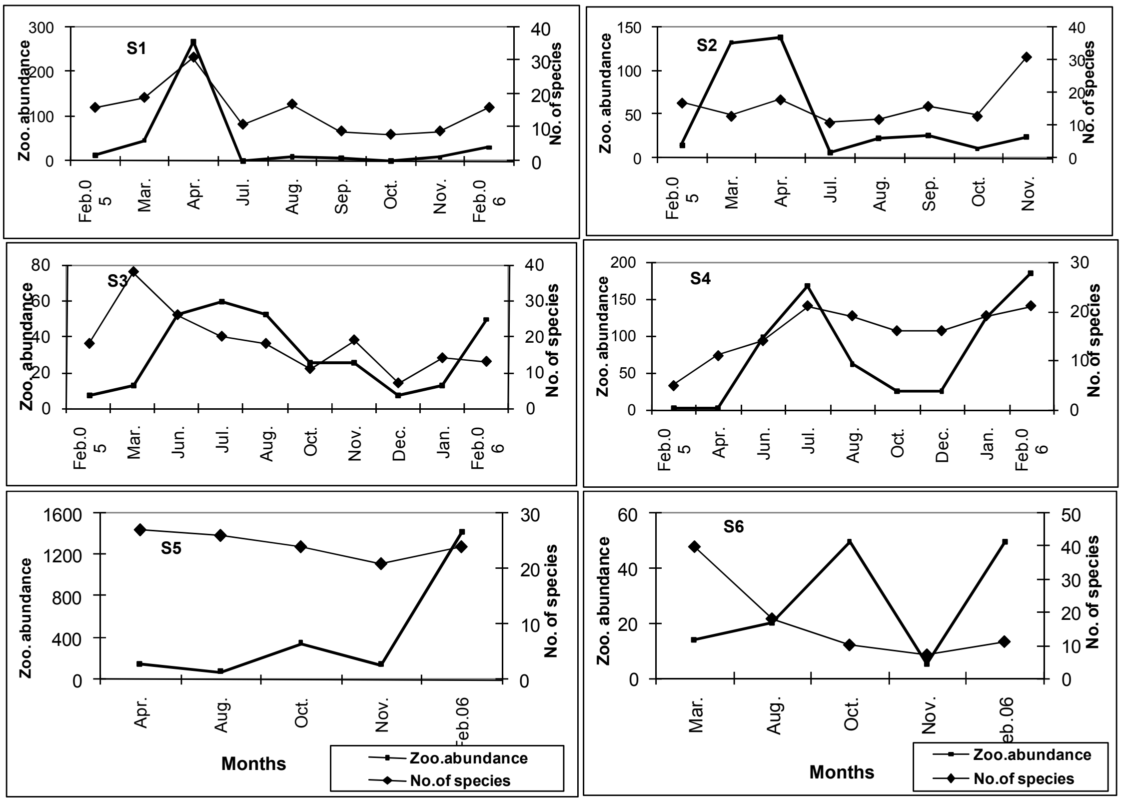

Figure2: Seasonal variations of zooplankton abundance (×10^3 ind/m^3) and number of species at the sampling stations.

3.2. Major components of zooplankton

Rotifers (36 species), were predominant throughout this study, since it contributed about 70% of the total zooplankton community. They showed spatially several peaks during the study period; during spring at S1 and S2, during autumn at S3, during summer at S4 and during winter at S5 and S6 which reflect the temporal abundances of different dominant species (Figure 3). The main rotifer species were *Brachionus plicatilis, B. urceolaris, B. angularis, B. calyciflopus, Keratella quadrata* and *Ascomorpha saltans* (Table 3). *Brachionus plicatilis* lonely comprised 48.1% of the total zooplankton at the studied stations. It was much more abundant at S2 and S5 (69.9% and 74.3% of the total rotifers respectively), much less at S4 (44.4%) and on the other stations it formed a percentage ranged from 9.7% to 21.2% of its total abundance. Peaked during spring at S1 and S2, during summer at S4 and during winter at S5 (Figure 4). *B. angularis* was the most abundant rotifer species at S3 peaked during autumn, and *Keratella quadrata* at S6 peaked during winter (February 2006).

Copepods (26 species) were the second dominant group averaged 16% of the total zooplankton community. Copepods were more abundant at S4 and S5 (24.6 X10^3 and 26.5 X10^{3}ind/m^3) (Figure 3). The main species were *Oithona nana, Euterpina acutifrons, Halicyclops magniceps* and *Acartia clausi* (Table 3).The marine species, *Oithona nana* was the dominant copepod species at all stations except S1 and S2 (Figure 4). The maximum density of this species was observed during summer (August) at S4 and S5 (6.2 X10^3 and 14.6 X10^3 ind/ m^3 respectively) and during autumn (October) at S3 and S6 (10.6 X10^3 and 5.1 X10^3 ind/ m^3 respectively).The fresh water species, *Halicyclops magniceps* was relatively more abundant at S2 and S5 (mean values 1074 and 2996 ind/ m^3). *Acartia clausi* was much more abundant at S1 (mean value =386 ind/ m^3). *Euterpina acutifrons* frequently occurred at all stations with its maximum (1119 ind/ m^3) at S6. Copepod nauplii, with annual mean and maximum densities of 12327 and 20106 ind/ m^3 respectively, were the most abundant copepods contributing 71.6%to its total numbers (Table 3).

The relative abundance of nauplii and olders (copepodite stages + adults of copepods) revealed that nauplii were represented by high percentage to total copepods most times at the different stations. During some months the nauplii were the single representative of copepods (Figure 5).

Although protozoans were highly diversified (53 species), their abundance was relatively low at the studied stations compared to the total abundance of zooplankton (except at S4 where these invertebrates represented 19.2% to the total zooplankton community at this station). The maximum abundance of protozoans was recorded during spring (March) at S1 & S6 and (April) at S2; during winter (February, 2006) at S3 and S4 and at the end of autumn (November) at S5 (Figure3). No species strongly dominated throughout the six stations, but there were one or two species which occasionally flourished at every station.

The meroplankton during this study was mainly composed of polychaete larvae, cirriped larvae and Lamellibranch veligers. Their abundance was relatively low over the study period compared to the total abundance of zooplankton (except in June when these larvae represented 68.7% and 74.1% of the total zooplankton community at S3 and S4 respectively).

Table3: Mean year abundances of the different taxonomic groups of the zooplankton community at the sampling stations (* means marine species).

Taxonomic groups	S1	S2	S3	S4	S5	S6
Protozoa						
Acineria sp.	0	20	0	0	0	0
Amphileptus claparedei	0	0	0	0	381	0
Arcella discoids	0	0	1	111	223	42
Branchioecetes sp.	135	0	0	0	0	0
Bursaridium sp.	389	937	0	0	0	0
Carchesium sp.	0	0	64	0	0	0
Centropyxis aculeata	35	522	0	0	0	0
C. constricta	34	443	0	0	0	0
C. ecornis	16	227	0	0	0	0
Cranotheridium sp.	0	301	0	0	0	0
Cyclograma sp.	0	318	0	0	0	0
Difflugia lebes	135	482	0	0	0	0
Disematostoma butschlii	112	63	0	1	0	0
Endosphaera sp.	0	0	0	555	0	0
Euplotes sp.	1	675	0	1080	1370	21
Glaucoma scintillans	96	179	0	0	0	0
Lionotus fasciola	0	20	0	0	0	0
Oxytricha fallax	393	238	0	793	13583	42
Paramecium caudatum	167	681	0	0	223	0
Platyophrya sp.	0	80	0	0	0	0
Spirozona sp.	0	0	0	0	95	0
Stombidium sp.	32	40	29	0	0	0

Table 3. continue

Taxonomic groups	S1	S2	S3	S4	S5	S6
Strongylidium sp.	0	0	0	0	191	21
Tetrahymena sp.	0	578	0	0	0	0
Trachelophyllum sp.	32	0	0	0	0	0
Trichodina sp.	0	79	0	0	160	0
Vorticella sp.	16	757	0	6000	0	0
*Eutintinnus lusus undae**	0	0	0	0	32	0
*E. nordguistii**	0	0	58	0	0	0
*Favella adriatica**	0	0	0	88	0	0
*F. azorica**	0	0	331	199	0	21
*F. Composita**	0	0	129	110	63	0
*F. Ehrenbergii**	0	0	489	353	95	889
*F. markuzviskii**	0	0	0	0	127	0
*F. Serrata**	1143	0	774	3155	0	0
*Helicostomella subulata**	0	0	230	0	0	0
*Metacylis mediterranea**	0	0	0	286	32	32
*Tintinnopsis beroidea**	0	0	29	0	95	106
*T. buetschlii**	0	0	73	0	0	0
*T. Campanula**	0	0	1968	666	0	0
*T. cylinderica**	0	0	0	0	539	603
*T. nordguistii**	0	0	302	242	190	477
*T. tubulosa**	0	0	0	0	1	32
*T. Vosmarii**	0	0	14	0	0	0
*Adelosina elegans**	0	0	1	333	0	0
Ammonia beccarii	1	60	1146	665	0	32
*Cycloforina contorta**	0	0	137	0	0	0
*Globigerina bulloides**	1	0	137	222	0	0
*G. inflata**	0	0	355	0	0	0
*Loxostomum plaitum**	0	0	50	0	0	0
Nonion sp*.	0	0	1	0	0	0
*Quinqueloculina striata**	0	0	152	1	0	0
*Spirilina vivipara**	0	0	341	0	0	32
Cnidaria						
Obelia spp.	0	0	0	0	32	32
Rotifera						
Anuraeopsis fissa	48	0	0	0	413	1
Ascomorpha saltans	2511	1527	0	2353	7259	106
Asplanchna priodonta	564	0	14	749	2268	0
Brachionus angularis	1	377	979	774	6303	383
B. budapestinensis	0	40	86	0	0	0
B. calyciflorus	0	1647	345	1146	18256	381
*B. plicatilis**	3627	20158	302	8444	280879	998
B. urceolaris	2857	1448	0	661	8709	320
Cephalodella gibba	1448	0	0	0	0	0
Chromogaster ovalis	0	0	0	0	1682	0
Colurella adriatica	952	238	0	0	0	0
Eothinia elongata	739	198	14	44	762	0
Filinia longiseta	0	853	57	0	572	0
Keratella cochlearis	80	556	116	132	0	127
K. hiemalis	0	0	450	0	0	0
K. serrulata	0	0	1	0	0	0
K. quadrata	0	0	14	0	5440	6720
K. valga	0	99	29	0	1022	0
Lecane luna	112	0	0	0	0	0
L epadella ovalis	0	0	0	0	0	0
L . patella	333	99	0	0	0	0
Macrochaetus collinsi	1446	0	0	0	0	0
Monostyla bulla	121	79	0	0	0	0
M. closterocerca	179	317	0	0	0	0
M. lunaris	128	298	0	0	0	0
M. quadridentata	1	0	0	0	0	0
Notholca sp.	0	20	0	0	0	0
Polyarthra vulgaris	0	0	389	0	2930	1
Proales decipiens	0	0	0	1222	0	0
Pseudoharringia similis	56	0	0	0	0	0
Synchaeta oblonga	111	99	86	199	0	0

Table 3. continue

Taxonomic groups	S1	S2	S3	S4	S5	S6
S. okai	0	0	100	22	63	32
S. pectinata	0	0	32	0	160	0
Trichocerca cylinderica	81	0	0	0	0	0
T. marina	0	40	0	0	540	0
Triplochlanis plicata	1125	297	0	1	508	0
Metamorphosis of rotifers	626	456	101	3259	40022	320
Nematoda						
Achromadora sp.	355	62	14	3906	384	127
Anaplectus sp.	0	0	0	111	127	0
Aphanolaimus sp.	404	0	58	44	95	0
Aphelenchoides sp.	694	188	145	889	733	85
Dorylaimus sp.	421	397	245	709	830	244
Polychaeta						
*Eulalia virides**	370	0	0	0	0	0
Polychaete sp.*	1	20	0	0	0	106
Spionid larvae	1578	79	6080	2627	1305	190
Trochophore larvae	81	0	0	0	320	0
Oligochaeta						
Chaetogaster sp.	0	0	0	1	1	0
Oligochaete spp.	323	0	0	0	0	0
Copepoda						
Acanthocyclops americanus	0	678	0	0	1209	1119
*Acartia clausi**	386	0	158	243	0	32
*A. discaudata**	0	0	0	1	0	0
*A. latistosae**	0	0	0	111	0	0
Cannula perplexa	0	0	0	222	0	0
Canthocamptus gracilis	242	0	0	333	160	0
C. pygmaeus	48	278	14	66	63	149
Caligus rapax	0	0	1	0	0	0
*Centropages kroyeri**	0	0	0	0	0	85
*Clytemnestra scutellata**	0	0	1	0	0	0
Cyclops vernalis	0	0	0	0	254	330
Diacyclops odessanus	0	0	0	0	0	42
*Eucalanus attenuatus**	0	0	0	0	0	85
*Euterpina acutifrons**	304	80	937	508	286	1119
Halicyclops magniceps	0	1074	14	0	2996	490
Mesochra sp.	0	0	0	111	0	21
Metis sp.	0	0	0	0	0	21
Moraria brevipes	0	0	0	0	0	42
Nitocra lacustris	0	0	0	0	0	64
*Oithona nana**	0	99	2722	1391	2920	1694
*O. Plumifera**	0	0	432	111	95	984
*Oncea venusea**	0	0	0	1	0	0
Onychocamptus mohammed	1	0	0	266	0	85
Paracalanus parvus	0	0	0	0	32	381
Schizopera clandestina	0	0	0	0	0	21
Thermocyclops neglectus	0	0	0	0	0	21
Nauplii stages	14328	7665	7281	20106	17901	6678
Copepodite stages	519	437	548	1087	571	551
Cladocera						
Macrothrix laticornis	0	0	1	0	0	0
Moina micrura	0	298	0	0	762	0
*Podon polyphemoids**	0	0	14	22	0	0
Ostracoda						
Eucypris sp.	0	0	158	0	382	21
Cirripedia						
Cirriped larvae*	1163	0	1182	9593	222	794
Decapoda						
Shrimp sp.*	0	0	0	1	32	1
*Portunus puper** (zoea)	0	0	1	0	0	0
Amphipoda						
Corophium acutum	0	0	1	1	32	0
Elasmopus pectinicrus	0	0	0	111	32	21
Gammarus aequicauda	0	20	87	333	32	64
Hyperia latissima	0	0	1	1	0	0

Table 3. continue

Taxonomic groups	S1	S2	S3	S4	S5	S6
Parathemisto oblivia	0	0	1	0	0	0
Mollusca						
Gastropod veliger*	0	0	0	0	0	21
Lamellibranch veliger*	1984	20	346	508	637	202
Larvaceae						
*Oikopleura dioica**	0	0	14	22	1	0
Aquatic insecta						
Chironomus larvae	320	40	0	1	0	0
Fish eggs	0	0	29	2	32	0

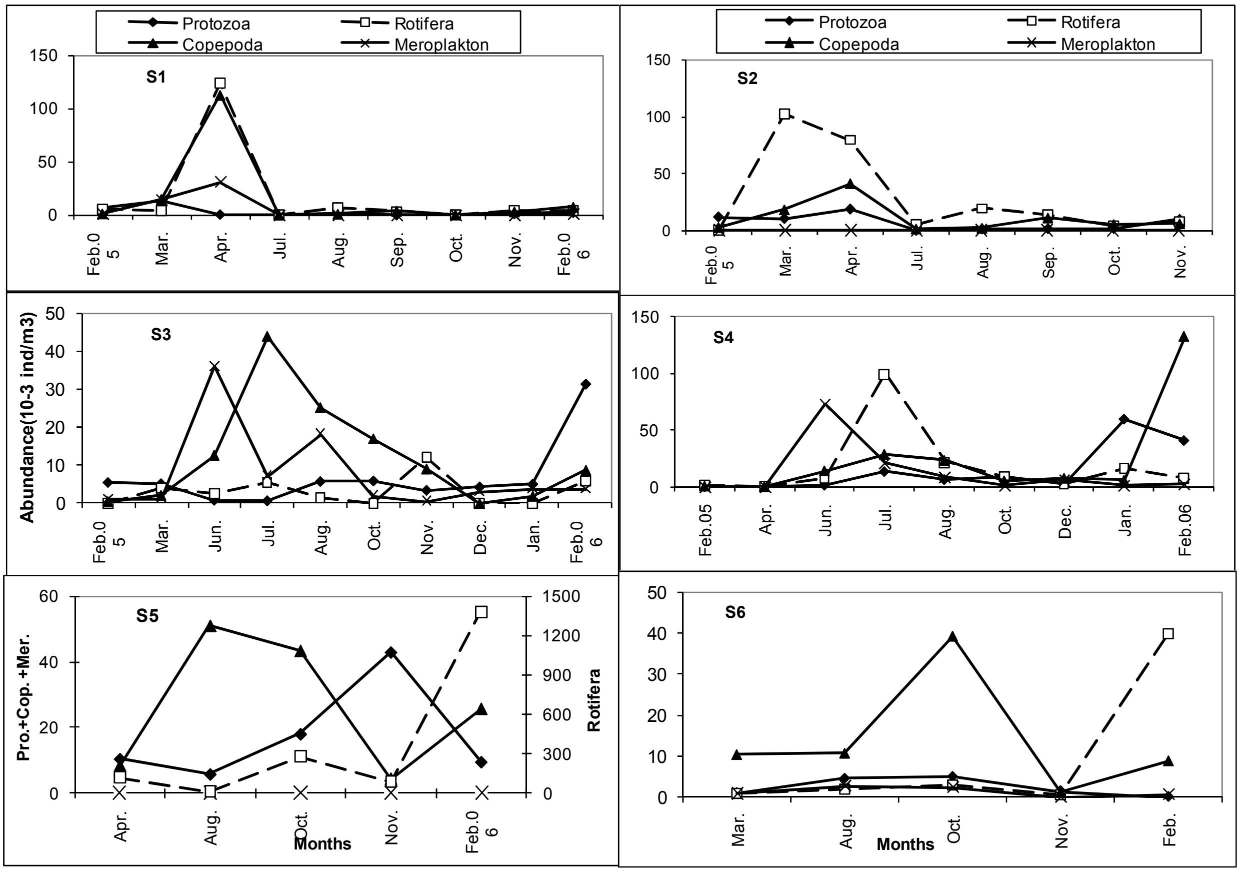

Figure 3: Seasonal variations of the abundance (×10^3 ind/ m^3) of the main zooplankton groups and meroplankton.

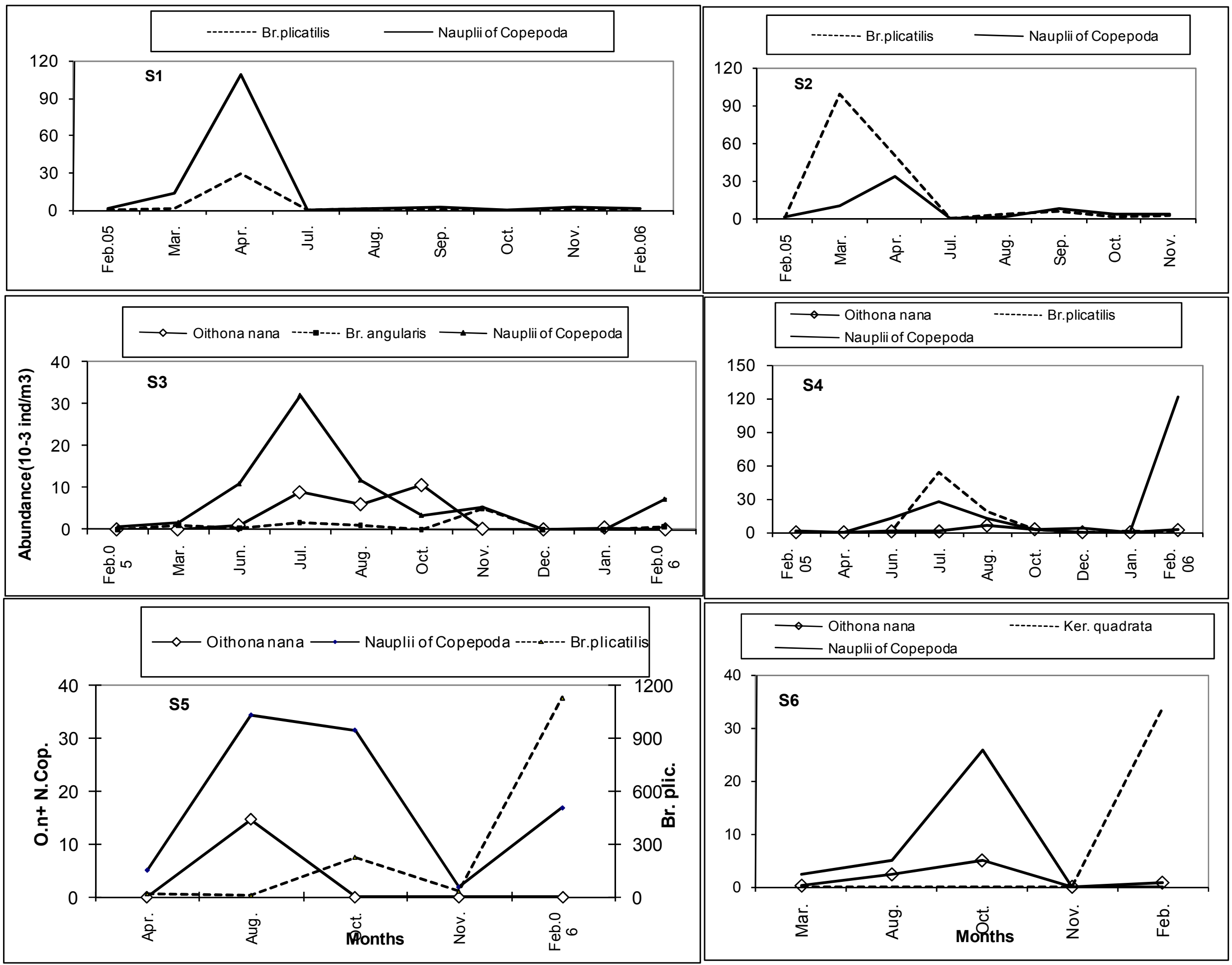

Figure 4: Seasonal variations of the abundance ($\times10^3$ ind /m^3) of the most abundant rotifers and copepods at the sampling stations.

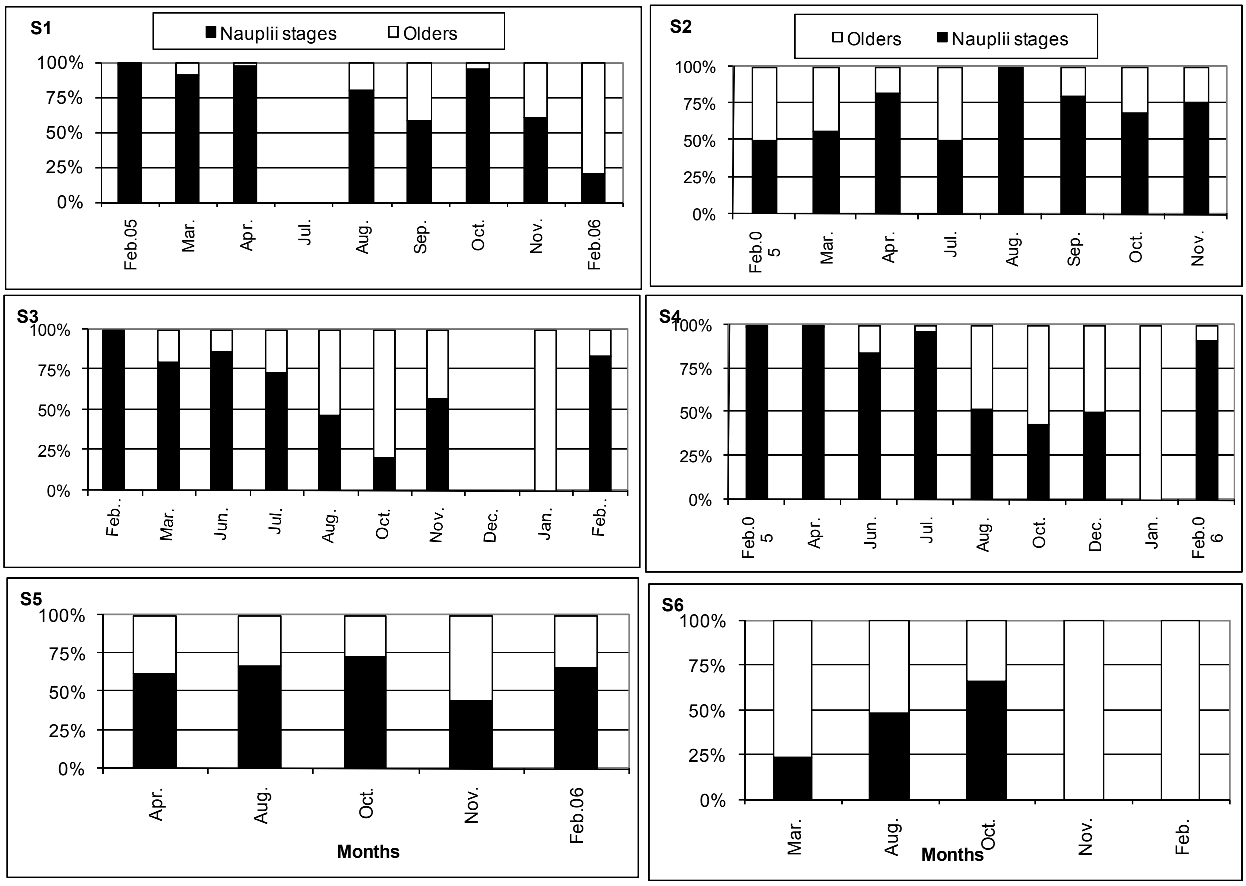

Figure 5: Relative abundance of Nauplii and Olders to total Copepoda at the sampling stations.

3.3. Zooplankton diversity

Although small differences in the species diversity (58 – 67 species) were observed between the stations (Table 2), the monthly pattern showed pronounced variations (Figure 2). The highest diversity was reported in March (38 and 40 species) at S3 and S6 respectively and the minimum during February (5 species) at S4, also during November and December (7 species) at S6 and S3 respectively.

The diversity index of zooplankton community was much lower in S5 (mean annual value = 1.55 bits/ind) than in S1and S4 (mean annual value = 2.8 bits/ind for each), while the mean annual values at the other three stations ranged between 2.45 (S2) and 2.78 & 2.71 at S3 and S6 respectively (Table 2). The Shannon – Weaver Index H' values varied from maximum values >3 recorded during November (3.02 bits/ind) at S2, and during March (3.1 bits/ ind) at S6. The minimum value <1 was noticed during February 06 (0.88 bits/ind) at S5 (Figure 6). Values between 2.5 and 3 bits/ind were only recorded during August (2.56 bits/ind), February 06 (2.62 bits/ind) at S1, March (2.86 bits/ind) at S3 and December (2.53 bits/ind) at S4. The values >1and <2.5 bits/ind were the common and recorded during most times of investigation.

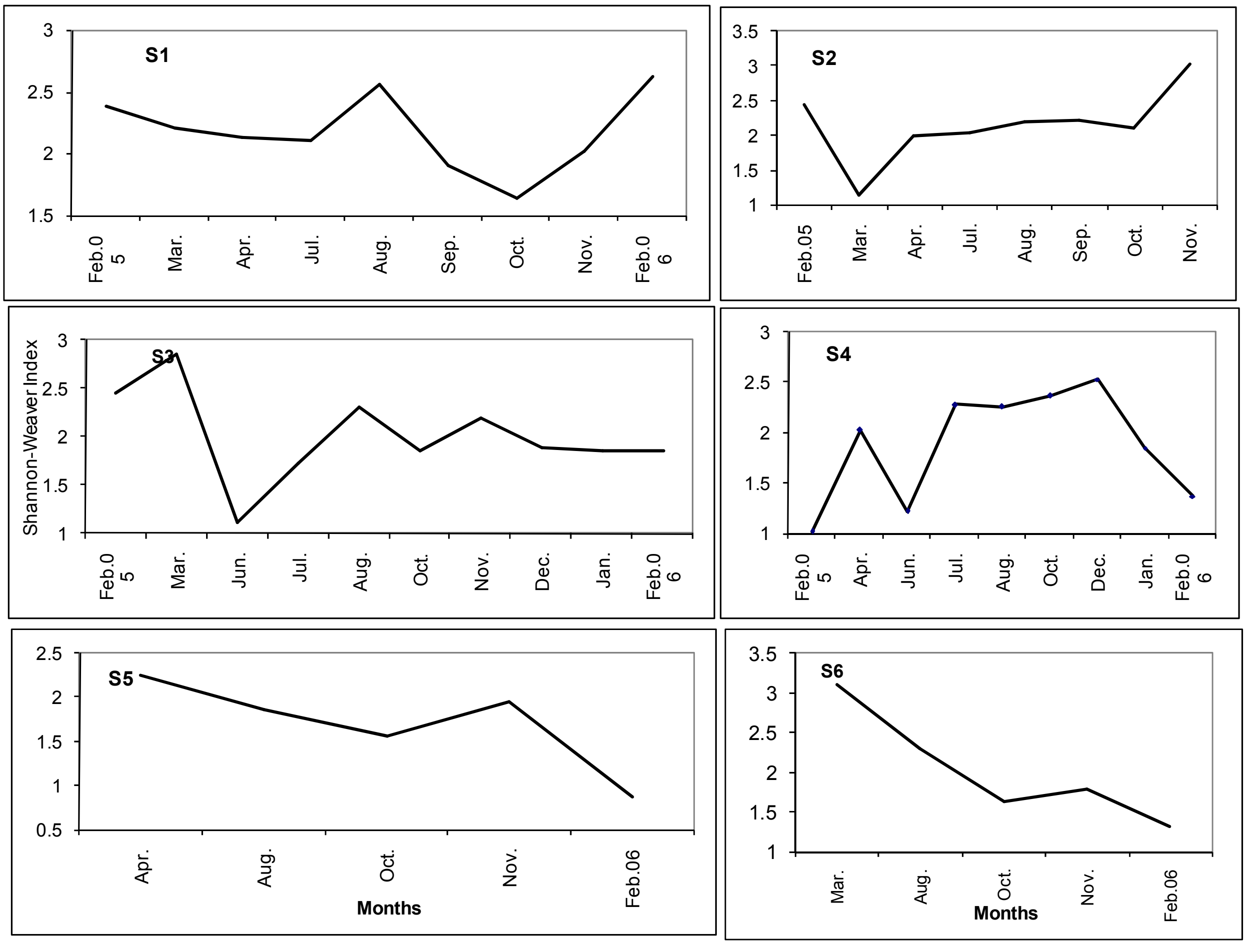

Figure 6. Seasonal variations of Shanon - Weaver Index H` of the zooplankton community at the sampling stations.

4. Discussion

The results discriminate two categories of stations. Station S5 has the most abundant zooplankton (427.7 X10^3 ind/m^3), highest proportion of rotifers (88.3 %), and the lowest diversity index (1.55 bits/ind). There are a leader species (*B. Plicatilis*) and many other species shared the dominancy with high counts of various taxonomic groups; reflecting a combination of the high nutrient loading of this system, the low salinity of water (2.86- 3.1 ppt) and the highest phytoplankton density (848.3 X10^3 unit/L). At the other stations zooplankton densities were less abundant (26.7 X10^3– 77.3 X10^3 ind/m^3), the diversity index was higher (2.45- 2.81 bits/ind), combined with higher salinity (up to 37.9 ppt) and lower density of phytoplankton (66.7 X10^3 – 539.9 X10^3 unit/L). According to Levinton (1982), the low value of diversity index is related to the disturbance of the environment. Based on the present records zooplankton community is characterized by low diversity index most times of investigation, which indicated non equilibrium of the population in the studied area. Margalef (1980) reported that the low diversity index (1- 2.5 bits/ind) is the common for the coastal zooplankton.

Concerning the water quality, according to Anon (2007) and Shakweer *et al.* (2008) all stations are well oxygenated (5.22 – 11.43 ml/L), except a low value 3.59 ml/L was recorded at S2 during September, corresponding to the high ranges recorded in the Mediterranean Sea (Psyllidou- Giouranovits *et al*., 1997; Vukadin *et al.*, 1996). The values are also much higher than the minimum oxygen concentration needed for upon the survival of living organisms (4 mg/L) (Stachowitzsch and Avcin, 1988) and the survival of copepods (2 mg/L) (Roman *et al*., 1993).Thus this parameter is not the cause of the difference in the zooplankton structure in the studied stations.

The differences in the abundance of zooplankton observed in the stations are probably due to ecological factors, such as perturbed conditions by pollution and anthropogenic inputs. Many studies on the coastal Mediterranean Sea have shown great changes in the abundance and diversity of communities in polluted environments (Gaudy, 1972 and Siokou – Frangou, 1996). Seasonal fluctuations of zooplankton abundance is a common feature as observed by Siokou-Frangou and Papathanassiou, 1991.

Ammonia detected at the areas of study with high concentrations (0.66- 76.8 µmol/L) and it reached 49.2 and 76.8 µmol/L at S2 during September and November 2005 respectively, may be due to agriculture wastewater discharge with high rates (Shakweer *et al*., 2008).Vanloon and Duffy (2000) mentioned that the use of ammonium containing fertilizer (ammonium sulphate, ammonium nitrate, urea and ammonia itself) is a source of ammonium ion in water. In an aerobic environment nitrification takes place and nitrate is the end product which is essential for marine primary production. Nitrogen nitrates compounds comprised more than 50% of the nitrogen compounds at the investigated area (Shakweer *et al*., 2008). On the other hand, pH in the studied stations was favorable in all cases for the process of nitrification where it ranged between 6.75 and 8.4. In this concern, Vanloon and Duffy (2000) pointed out that the optimum pH for nitrification lies between 6.5 and 8 and the reaction rate decreases significantly when the pH is below 6.0. High pH values during autumn (7.2 -8) can be attributed to the phytoplankton bloom where CO_2 is consumed with higher rates for photosynthesis.

Dissolved phosphates with an average from 0.03 – 6.4 µmol/L is more or less of normal concentration indicating a low risk of toxic phytoplankton occurrence at the investigated areas.

There were significant differences in phytoplankton density between the different stations, where mean phytoplankton density was very high at S5 (848.3 X10^3 unit/L) decreased to 539.9 X10^3 and 329.2 X10^3unit/L at S3 and S4 respectively. On the other hand S1and S6 showed the lowest phytoplankton density (66.7 X10^3 and 98.5 X10^3 unit/L), these values are considered high when compared with coastal Egyptian waters (Zaghloul, 1994; Shams El Din and Dorgham, 2007; Madkour *et al.*, 2007 and Hussein, 2008). The Mediterranean Sea is generally considered to be a poor productive oligotrophic sea (Jacques and Treguer, 1986), except in some coastal bays and ports where nutritional anthropic inputs may favor the growth of phytoplankton and zooplankton.

The seasonal changes in the zooplankton community showed increases of zooplankton densities between spring at S1 and S2, and summer at S3 and S4 in accompanying with water temperature increased, paralleling with the situations in many temperate coastal waters and estuaries (Wooldridge and Bailey, 1982; Mallin, 1991; Gaughan and Potter, 1995), Also the zooplankton community increased during winter at S3- S6 when salinity and temperature were at their lowest values.

The maximum density of zooplankton (i.e. 1425 X10^3 ind/m^3) recorded in February at S5 and mean annual density for the studied area (i.e.108.9 X10^3 ind/m^3) are higher than that recorded in other estuaries and coastal Egyptian waters, 40.7 X10^3 ind/m^3 in Eastern Harbor (Abdel-Aziz, 2004), 82 X10^3 ind/m^3in Damietta Harbor (El- Ghobashy *et al.*, 2006). The maximum peak was detected in S1 during April and remained for a further one or two months as at S2 and S3. This is contradicted with many temperate coastal areas where the annual peak is well defined, in spring, summer, or autumn (Kennish, 1990) and agreed with Gaughan and Potter, 1995). The persistence of high densities of zooplankton at S2 and S3 for a longer period may be related to the stability of the water mass of this system between spring and summer.

The major components of zooplankton in the studied area were rotifers, copepods, protozoans and larval stages of molluscs, cirripedes and polychaetes, as they are in other shallow, temperate estuaries and coastal waters (Roman *et al*., 1983; Ambler *et al*., 1985; Gaughan and Potter, 1994). Cladocerans are considered rare in the studied area contrasting with the situation in many other coastal waters (Grindley, 1981; Williams and Collins, 1986), and agreed with Gaughan and Potter, 1994 and Abo-Taleb, 2009).

Rotifers dominated the zooplankton in the studied stations since they constitute 69.7 % of the total average zooplankton. *Brachionus* species were common of which *Brachionus plicatilis* was the most abundant, averaged 48.1 % to the total zooplankton and 69 % of the total rotifers. *Brachionus plicatilis* is a typical brackish water form which detected in most areas of the world (Townsend, 1984; Ambler *et al*., 1985; Gaughan and Potter, 1994) and is common in several Egyptian coastal waters (Aboul- Ezz, 1994; Soliman and Gharib, 1998; Abdel-Aziz, 2001; and Abdel-Aziz and Dorgham, 2001). The peak of abundance of *Brachionus plicatilis* was variable in different stations according to the environmental conditions at each station. The marked seasonal increases in the density of *Brachionus plicatilis* may be due to rapid parthenogenetic reproduction under favorable conditions, while the decline in numbers may due to the switch to the production of resting eggs in response to high population densities (Gilbert, 1974). *Brachionus plicatilis* is an important prey for marine fish fry at first feeding (Mercier, *et al*., 2004).

Copepoda was the second group in order of abundance, *Oithona nana* was the most abundant copepod in the studied area. Gallienne and Robins (2001) considered *Oithona* as the most important copepod in the world's oceans. Gaudy (1971) reported that this cyclopoid occurs in brackish and polluted waters and its density in the sea near urban waste varies with the pollution as observed by Patriti, 1972, in Marseille area. *Oithona nana* is a euryhaline species (3-37 ppt in the present study) and eurythermal (16- 33 ºC in the present study) with a wide ecological tolerance (Lampitt and Gamble, 1982). This species is considered as perennial occurring most times of the year with 2 -3 peaks in Egyptian Mediterranean waters (Abdel-Aziz, 2004). Although it is generally considered to be rare in pelagic areas, Krsinic (1995) reported the absolute dominance of *Oithona nana* in pelagic zones in northern Adriatic Sea during 1989 to 1992, when there was heavy pollution by large mucous aggregates. So, the proliferation of *Oithona nana* in most stations of the studied area may result from human activities and pollution of nutrient enrichment due to eutrophication.

Oithona nana was the dominant copepod species in S3 – S6 throughout the year with small seasonal variations at each station. This proliferation according to Lampitt and Gamble (1982), may be due to the capacity of *Oithona nana*, which differs from that of the other common copepods, to consume a wide range of food –particle sizes and to have a low metabolic rate, suggesting that these adaptations constitute the strategy whereby *Oithona nana* maintains its population levels throughout the year. It is not excluded that the seasonal succession of *Oithona nana* is driven by the abundance of algae as a source of food and thus this succession would be considered as allogenic. In this case, the term periodicity should be used (Reynolds, 1982).

Oithona species is broadly omnivorous, feed upon a variety of phytoplankton but primarily on ciliates and heterotrophic protozooplankton, dinoflagellates (Nakamura and Turner, 1997), rather than to chlorophyll. Thus, the ability of this copepod to exploit the lower portion of the food size spectrum, which is more coupled to the microbial loop than to phytoplankton blooms, may contribute to *Oithona* species ability to maintain in almost –continuously stable population. *Oithona nana* like its congener *Oithona similes* has low respiration rates (Nakamura and Turner, 1997). Low respiration coupled with infrequent intermittent movement (Hwang and Turner, 1995) might result in energy savings that can be channeled into reproduction.

Copepod nauplii dominated the copepod in the studied stations (71.6% to its counts). The high density of copepod nauplii (annual average 12327 org./m^3) may be attributed to the contribution of both freshwater and marine species. This is in agreement with Boyed and Smith (1983) who reported increased abundance of copepod nauplii in areas of mixing associated with upwelling off the coasts, and Peter *et al.* (2003) in south Florida straits hypothesized that elevated abundance of copepod nauplii would be present in convergent frontal zones resulting from aggregation of adults and larval copepods in the presence of relatively high food concentration. Makino and Ban (2000) reported that water temperature causes more rapid development and higher egg production and increased food density causes more rapid development, larger body size and high egg production. All these factors are available in the studied area. The presence of copepod nauplii and copepodides as persistent component of zooplankton indicates the continuous reproduction of copepods all the year round. The bulk of these nauplii and copepodides are produced by the dominant species as *Oithona nana* and *Euterpina acutifrons*.

Most studies of larval fish feeding documented that copepod nauplii and *Oithona* are important prey of fish larvae (Lough and Mountain, 1996; Conway *et al*., 1998; Fortier *et al*., 1995; Fortier and Villeneuve, 1996; Hillgruber *et al*., 1995; Ringuettle *et al*., 2002 and Turner, 2004).

Bivalve; lamillibranch veligers, cirriped and polychaete larvae dominated the meroplankton in the studied stations as like many coastal waters (Gaughan and Potter, 1995; Abdel –Aziz, 2004, El-Tohamy, 2005 and Abo- Taleb, 2009). During the present study, the meroplanktonic forms found in low density at all stations except at S3 and S4 especially during June. This may be due to the fact that the bottom of the other

4 stations is unsuitable for the settlement of the majority of the benthic fauna, but the bottom of S3 and S4 is sandy- muddy suitable for cirriped larvae mainly belonging to barnacles encrusting the cement blocks protecting the channel banks at S3 and also those which may be found in the fouling community on the fishing boats anchoring in large numbers in the two stations (Abdel-Aziz, 2000 b).

The available data from General Authority for Fish Resources Development during 2005 – 2006, indicated that S5 and S6 had the maximum abundance of fish fry (annual average about 22X10^6 *Mugil capito* fry and 5 X10^6 *Mugil cephalus* fry at the two stations), beside other types of fish fry, against about 1.8 X10^6 *Mugil capito* fry and one million *Mugil cephalus* fry in the other four stations. On the other hand, El –Ghobashy (2009), found that collection of *Mugil cephalus* fry (20% of the catch) usually occurred during summer and autumn months of 2007-2008 at S6 for *Liza ramada* and *L. aurata* (41%) during late autumn and winter, and for *Sparus auratus* fry (17%) during winter. This agreed with the peaks of abundance of copepods and rotifers at this station. Also, he concluded that out of 116 zooplankton species recorded in the water during collecting fry, only 28 items were found in the guts of the seven fish species fry studied with different feeding strategies. In addition to nauplii larvae and copepodides which were the most preferable food for all fish fry he studied; *Brachionus plicatilis* and *B. urceolaris* for *Mugil cephalus*; *Oithona nana* and *Euterpina acutifrons* for *Liza ramada, L. aurata, Sparus auratus* and *Dicentrarcus labrax*. Also meroplanktonic forms (Cirripedia and Mollusca) for *Liza ramada* ; Thus this may be the reason for decreasing of meroplankton at S3 and S4 in winter and spring after their high densities in summer months.

5. Conclusion

Fish fry collection sites in Egyptian Mediterranean waters are characterized by their high density of zooplankton with more than one peak differed in timing from one site to another. These peaks may extend for more than one month which leads to the abundance of food for fish fry for a longer time. The dominant zooplankton groups are rotifers and small copepods especially *Brachionus plicatilis, Oithona nana* and nauplius larvae. S5 and S6 had the maximum abundance of fish fry although S5 had the maximum density of zooplankton is characterized by high density of rotifers as well as its highest diversity of copepods (19 species) which may give a good chance to fish species fry to select its preferable food items.

The hydrodynamic and geomorphologic position, the unbalance in nutrients distribution and the concentrations of the different water discharges may interfere in the level of the production of each site.

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مجتمع العوالق الحيوانية فى مناطق تجمع زريعة الأسماك
على طول الساحل المصرى للبحر المتوسط

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اهتم البحث بدراسة وفرة وتنوع العوالق الحيوانيه خلال الفتره من فبراير 2005 الى فبراير 2006 فى ست مواقع. كل موقع ممثل بمحطه حيث تجمع زريعة الأسماك ذات الأصل البحرى على طول الساحل المصرى للبحر المتوسط . تميزت هذه المحطات بزيادة تركيز الأملاح المغذيه نتيجه للصرف الزراعى وبالتالى زيادة كثافة العوالق النباتيه والحيوانيه وانخفاض التنوع البيولوجى.

تميزت محطة الكساره بأعلى كثافه للعوالق الحيوانيه والانخفاض الشديد للتنوع البيولوجى مما يعكس ارتباطها بكثافة الأملاح المغذيه وارتفاع قيم الأكسجين المذاب وانخفاض الملوحه. ومن ناحيه أخرى كانت أقل كثافه للعوالق الحيوانيه ممثله فى محطة الصفاره التى بدت أقل تأثرا بالصرف الزراعى حيث تميزت هذه المحطه بارتفاع الملوحه.

تميزت منطقة البحث باختلاف مواسم أعلى انتاجيه لكل محطه فبالرغم من ارتفاع كثافه العوالق الحيوانيه خلال الربيع فى النوباريه والمكس كانت أعلى كثافه لها خلال الصيف فى المعديه وخلال الشتاء فى المحطات الثلاث الأخرى. وبالنسبه للمجموعات الرئيسيه فكانت ممثله بالعجليات الدواره التى سادت بأنواع البراكيونس تلتها مجموعة مجدافيات الأرجل التى سادت بالاطوار اليرقيه ونوعى الأويثونا نا نا والاوتربينا اكيوتيفرونس. أيضا يرقات الأنواع المؤقته من العوالق الحيوانيه كان لها دور فعال. أما بالنسبه لمجموعة الأوليات فكانت نسبتها أقل ورغم تنوعها الكبير الا أن كل محطه تميزت بالظهور الفجائى لنوع أو نوعين بكثافه عالية لمده قصيره.

مثلت العجليات الدواره من نوع البراكيونس بليكاتلس نسبة 48.1 % والأطوار اليرقيه لمجدافيات الأرجل بنسبة 11.3 % من مجموع العوالق الحيوانيه وكانت من أهم غذاء ليرقات الأسماك الموجوده فى منطقة الدراسه.