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POPULATION DENSITIES OF ADULT NERITIC CALANOID COPEPODS AND THEIR RESPONSE TO VARIOUS ENVIRONMENTAL FACTORS IN PORT-FOUAD WATERS (MEDITERRANEAN SEA) , PORT – SAID PROVINCE EGYPT.

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Abstract

This work was carried out in order to investigate and evaluate the population densities of adult neritic calanoid copepods and their response to various environmental factors in Port-Found waters (Mediterranean Sea) Egypt. It was found that minimum and maximum calanoid densities were obtained in winter and summer, respectively. Twelve species were collected during this study, they belong to six genera and six families. From all the collected species only three of them dominated all other calanoid samples and constituted 86% of the total collected calanoids, viz, cntropagus kroyeri, Paracalamus parvus and Clausocalamus aruicornis which they belonging to Centropagidae , paracalanidae and pseudocalanidae, respectively ,so they are considered important as biomass builders . It was found that water temperature, salinity, transparency and dissolved oxygen were the main factors controlling the occurrence and population densities of calanoid species. While pH has a minor effect . Data analysis showed that values of all ecological indices fluctuated among different seasons, so the ecosystem of the studied area was unstable .

Introduction

The copepods occupy the first importance in a marine plankton catch , they constituting more than 90% of the catch . It has been said that the copepods doubtless outnumber all other multicellular animals in the world totalled together. Special attention has been paid to the copepods as they are important in the general economy of the Sea . The calanoids has the maximum number of copepod species (Santhanam and Srinivasan , 1994).

Few studies were done before 1965 , on the marine plankton of the Egyptian Mediterranean coast particularly in the eastern part . Gurney (1927) gave some notes on the distribution and occurrence of planktonic Crustscea in the reports of the Cambridge Expedition to the Suez canal . The seasonal qualitative and quantitative variations of the total plankton population in Alexandria region were studied by Dowidar (1965). El Maghraby and Halim (1965). El Maghraby (1965) examined copepod populations along the Egyptian Mediterranean coast .Hussein (1977) studied the composition , distribution and biomass of the total zooplankton with special reference to copepods along the Egyptian Mediterranean coast . Nour El –Din (1987) gave special reference to pelagic copepods and its occurrence along the Egyptian coasts. Amer, (1999) studied the exchange of water and zooplankton between lake Manzalah and Mediterranean see through Boughaz El-Gamil with appendix of copepods .

The present work was designed to study the population densities of adult neritic calanoid copepods and their response to

various environmental factors in Port-Fouad waters (Mediterranean sea) , Port-Said, Egypt .

Material And Methods

The area investigated included the neritic zone of Port-Fouad waters (Mediterranean sea). Five sites were selected for the present study . Five environmental factors were considered here ,viz , water temperature , transparency ,dissolved oxygen ,salinity and pH (hydrogen ion concentration). Water temperature was measured by ordinary thermometer . Transparency of water column was determined by black and white enamel coated secchi disc with a diameter of 25 cm . Dissolved oxygen was obtained by oxygen meter (YSI.M.54). Salinity was determined by using the gravimetric method according to American Public Health Association (1985). Hydrogen ion concentration (pH) was obtained by a digital pH meter (Model 211) .

Samples of the adult neritic calanoid copepods were collected monthly during the period from September 1999 to August 2000 using a plankton net of mesh size 325 um and with 40 cm mouth diameter and 50 cm length of filtering cone . Samples from all sites were taken by filtering 50 liters from each site through the plankton net . All zooplankton caches were preserved in 4% neutralized formalin solution . Each sample was concentrated to a suitable volume (120-200ml) for 48 hours in covered cylinders to ensure complete settlement , and siphoning of the surplus water of. At the laboratory the whole sample was examined in a large petri dish and larger

organisms such as fish larvae were removed. For identification the individual was placed on a glass slide immersed in glycerol and dissecting by aid of two fine pins. For counting , three subsamples (each 1 ml volume) were taken from each sample and emptied into 1 ml rafter counting cell for enumeration and identification of calanoids under a binocular research microscope (X 160). The total number of calanoids present in m^3 of water sample can be calculated using the following formula :

$$N = n \times \frac{v}{V} 1000$$ (Santhanam and Srinivasan, 1994)

Where N: Total number of calanoids/ m^3 of water filtered.

n: Mean number of calanoids in 1 ml of plankton sample .

v: Volume of plankton concentrate (ml).

V: Volume of total water filtered (m^3) .

Calanoid species were identified using the following.

Harding and Smith (1960); Mori (1964); Gonzalez and Bowman (1965); Neunes (1965); Verheye and Dumont (1984) and Santhanam & Srinivasan (1994).

Data analysis:

Species richness was calculated according to the following equation: D= (S –1) Ln N (Margalf, 1968)

Where S: number of species. N: number of individuals in the samples.

Shannon index was calculated by the following equation.

$$H = 3.3219 (\log N - \frac{1}{N} \sum ni \log ni)$$ (Pielou, 1977)

Where N: Total number of individuals of all species.

ni: Number of individuals of a species .

Evenness index was calculated by the following formula:

E=H/S (Pielou, 1966). Where H: Shannon index.

S: Number of species.

Results

The adult calanoid populations were collected during the present work included 12 species belong to 6 genera and 6 families namely: Centropagidae, Paracalanidae, Pseudocalanidae, Acartidae, Pontellidae, and Eucalanidae (Table 1). The percentage frequencies of their annual means were 39.3,36, 17.5, 4.5, 2.1 and 0.6,respectively (Fig.1)

From all the collected calanoid species only three were considered important as biomass builders, these were *Centropages kroyeri, Paracalanus parvus* and *Clausocalanus arcuicornis*.The percentage frequencies of their annual means were 35,34.7 and 16.3%, respectively .While those of the other recorded species were 3.7,3.2,1.8,1.3,1.3,1.2,0.6,0.6,and 0.3% for *Centropages violaceus ,Acartia negligens, Labidocera wallastoni, Acartia latisetosa , Paracalanus aculeatus, Clausocalanus furcatus, Mecynocera clausi, Centropages typicus* and *Labidocera brunescens,* respectively (Fig2).

The total population denisty of the calanoid copepods varied between minimal value during November (222 individuals /m^3) and maximal one in August (5017 individuals /m^3). Their total annual

count one was 1599 individuals /m^3 (Fig. 3). Concerning the differential count of the present important calanoids, it was found that the approximate mean number of *Centropages kroyeri* 559 individuals /m^3 and nearly is equal that of *Paracalanus parvus* (555 individuals /m^3), but exceeded the denisty of *Clausocalanuus arcuicornis* (260 individuals /m^3).The population denisty of *Centropages kroyeri* recorded during the present study ranged between 4 and 2160 organisms/ m^3 during December and August , respectively, while it was absent in November, those of *Paracalanus parvus* varied from 8 to 2195 individuals /m^3 during January and August , respectively,but was absent during November also , while those of *Clausocalanuus arcuicornis* ranged between 8 and 988 organisms / m^3 during February and September, respectively , and was absent in March . *Acartia latisetosa* and *Mecynocera clausi* were considered as winter species as their maximal denisties were 83 and 33 organisms/ m^3 during this season, respectively, while *Paracalanus aculeatus* was considered as autumn species with density of 85 organisms / m^3. The minimal denisity of *Centropages violaceus was* recorded in spring (29 individuals /m^3), while maximal one recorded during summer (215 individuals /m^3), its annual count was 61 individuals /m^3 , it was absent during autumn and winter. *Centropages typicus* was collected in February and during summer months, with maximal denisty in July (48 individuals /m^3),its annual mean denisity was 9 individuals /m^3 . *Clausocalanus furcatus* was recorded during summer, autumn and spring months except March, with maximal and minimal denisties in

summer and spring being 40 and 14 individuals /m^3 respectively, while that during autumn it was 21 individuals/m^3 , its mean annual count was 19 individuals /m^3 . The denisty of *Labidocera brunescens* was lower than all the previously mentioned species. It was recorded during summer months and May also with mean annual density amounted to 5 individuals /m^3 .

Taking the total denisties of each calanoida species in the present study, it could be possible to divide Calanoida into three mean groups; most common, frequent and rare ones. The most common calanoids included the following species: *Centropages kroyeri*, *Paracalanus parvus* and *Clausocalanus arcuicornis*, their denisties were 559, 555 and 260 individuals /m^3 ,respectively. The frequent calanoids were found to be less in their denisities as compared with the most common and they included: *Centropages violaceus* and *Acartia negligens* where their denisties were 61 and 51 individuals /m^3 ,respectively. On the other hand, the rare calanoid, declined from 51 to 5 individuals /m^3 and were represented by *Labidocera wallastoni, Paracalanus aculeatus, Acartia latisetosa, Clausocalanus furcatus, Centropages typicus, Mecynocera clausi* and *Labidocera brunescens.*

With regard to table (2), it appeared that the highest water temperature was recorded in August with a mean of 28 .1c^o, while the mean of the lowest one was 14 c^o during January. The mean water temperature decreased from 24.5 c^o in September to 14 c^o during January, but increased to 28.1 c^o in August the mean water temperature during autumn and spring did not differ greatly being

21.8 and 23 c^{o} ,respectively ,while the lowest mean one was recorded in winter, but the highest one was in summer being 14.9 and 27.6 c^{o} ,respectively. Salinity showed higher levels during summer (38.1‰) than other seasons ,while the lowest one occurred in winter with a mean of 33.7 ‰ . It increased from 36.1‰ in September to37.4‰ during October, after that it decreased to reach the lowest value being 33‰ in January. Another increase occurred from January to show the highest mean in August being 38.2‰. With regard to transparency, the maximal value of secchi disc reading (287 cm) was obtained in June, while the minimal one (110 cm) was recorded during December. Concerning the seasonal variations, the highest transparency being 285 cm in summer, while the lowest one (144.3cm) showed during winter. Generally the pH of the studied area tends to be alkalinize, it ranged between a minimal

mean Value of 8.0 (about 50% of the data the pH was 8.0)and maximal one of 8.3 in January. The mean values of dissolved oxygen ranged between 4.0 to 6.9 ml O_2 /L during May and January, respectively .Concerning seasonal variations ,spring was the season of the lowest mean value(4.3ml O_2 /L), while winter was the season of the highest one (6.5 ml O_2/L).

There was a parallel decrease for the total calanoids with the temperature from September to November and from December to January. On the other hand , a parallel increase (with temperature) was obtained from February to April and from May to Augest .

Species diversity

In the investigated area 12 species of calanoid copepods were identified. Regarding the seasonal variations of the species diversity, the highest richness value (1.1) occurred in winter (8 species), while the lowest one (0.7) was recorded in summer.

On the other hand , the highest Shannon and evenness indices (2.8 and 0.40, respectively), occurred in summer , while the lowest Shannon index (1.3) and evenness one (0.19)were recorded during autumn (Table 3).

Discussion

The calanoid copepod communities in the investigated area were dominated by three species, viz. *Centropages kroyeri*, *Paracalanus parvus* and *Clausocalanus arcuicornis* in all months during the present work except November for the first and second mentioned species and March for the third one, they constituting, on the mean, of 86% of the total collected individuals. The remaining percentage was formed by *Centropages violaceus* (3.7%), *Acartia negligens* (3.2%) *Labidocera wallastoni* (1.8%), *Acartia latisetosa* (1.3%), *Paracalanus aculeatus* (1.3%), *Clausocalanus furcatus* (1.2%) *Centropages typicus* (0.6%), *Mecynocera clausi* (0.6%) and *Labidocera brunescens*(0.3%). The annual mean population density of total calanoids in the studied area amounted to 1599 individuals/m^3.

The variations of the species composition of calanoids were mostly due to fluctuations in the ecological conditions.

The maximal value of various calanoids was recorded in summer, where high temperature, transparency and salinity but relatively low dissolved oxygen, while the lowest one was
obtained during winter, where low temperature, transparency and salinity, but high dissolved oxygen.Temperature is one of the most important factors that influences all chemical, physical and biological processes (Welch, 1952), so it determine distribution of the species in various niches (Pace *et al.*, 1952 and kobayashi *et al.*, 1998). Also salinity is one of the important factors that affects faunal composition, distribution and diversity of zooplankton populations in aquatic ecosystems (Greenwood and Hurlbert, 1993, Wollheim and Lovvorn, 1995 and williams, 1998).It is generally noticed that the water temperature and salinity were the main factors controlling the occurrence of calanoids.

Although the mean water temperature during autumn and spring did not differ greatly there were variation of the total number calanoid individuals during these two season this showed that the effect of temperature may be interacted with some other environmental factors (Por, 1972, Goldman and Heron. 1983, Adrian and Deneke, 1996, Dumount and Segers, 1996) . The dissolved oxygen in the water is the one of the most important factors involved in the metabolic activity in any aquatic system, it serves as an indicator of the water conditions (Maccrimman and kelso,1970, and Huet, 1973). The relationship between diversity and dissolved oxygen in the present study found to be similar to Hakkari (1978) and Arndt (1988). The relatively low

value of dissolved oxygen in summer is due to high temperature and salinity.

During winter high values of dissolved oxygen were recorded. This due to low temperature which decrease the activity of many animals, then decrease the rate of oxygen consumption this agrees with Welch (1952) and Ruttner (1968), *Acartia latisetosa*, *Acartia negligens* and *Mecynocera clausi* seemed to be as winter species, where they exhibited the highest densities in this cold, low salinity and transparency with high value of dissolved oxygen season. While *Centropages typicus*, *Centropages violaceus* and *Labidocera brunescens* occurred in summer with the highest densities in this warm , high salinity and transparency with relatively low value of dissolved oxygen season . This confirm the results of Aleem and Samaan (1969); Hofmann (1975) and Omori and Ikeda (1984), whom stated that the response of zooplankton populations to the changes of temperature varies with different species. The presence of *Acartia* sp. in winter during this work is in contrast with Lee and Mcalice (1979) and Jeffries (1962) whom reported that *Acartia* sp. scarce in the cold season in temperate area and reach their maximum abundance when temperature became high, but Woodmansee (1958) showed that they generally occur all year round in tropical areas.

The collection of *Clausocalanus furcatus* during all seasons except winter and *Labidocera wallastoni* during winter and spring, although the high ranges between water temperatures, salinities, sacchi disc readings and the values of dissolved oxygen in the

mentioned seasons, this confirmed with williams (1998) who said that the influences of environmental variables such as temperature, salinity, transparency....etc, on diversity of species in most aquatic ecosystems are difficult to distinguish among their effects due to intercorrellated between them. *Paracalanus aculeatus* was collected in autumn only, this refers to its migration from studied area to another as a result of the effect of some ecological factors such as trophic conditions, competitions and predation. This agrees with Gilbert (1988) and Gulati (1982).

The pH of investigated water lie on the alkaline side, and it was relatively constant. Then it has a minor effect (Michael.1984). The calanoid abundance is positively correlated with water transparency (Hart, 1986,1987,1990). This is in agreement with the present results. The fluctuation of all ecological indices showed that the ecosystem of the studied area was unstable.

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Table 1. Monthly variations of the total adult calanoid copepods (individuals /m^3) recorded during the period from September 1999 to August 2000 in Port-Fouad waters (Mediterranean Sea), Egypt.

Months & Seasons Families & Species	Sept.	Oct.	Nov.	Autumn	Dec.	Jan.	Feb.	Winter	Mar.	Apr.	May	Spring	June	July	Aug.	Summer	Total	Mean	Frequency %
Fam. Acartidae	0	0	68	23	172	288	271	244	42	20	0	21	0	0	0	0	862	72	4.5
A.latisetosa	0	0	0	0	32	126	90	83	0	0	0	0	0	0	0	0	249	21	1.3
A.negligens	0	0	68	23	140	162	181	161	42	20	0	21	0	0	0	0	613	51	3.2
Fam.Centropagidae	630	265	0	298	4	10	85	33	383	1037	337	585	1308	1419	2374	1600	7552	629	39.3
C.kroyeri	630	265	0	298	4	10	69	28	383	1005	281	556	796	1110	2160	1355	6713	559	35
C.typicus	0	0	0	0	0	0	16	5	0	0	0	0	32	48	11	30	107	9	0.6
C.violaceus	0	0	0	0	0	0	0	0	0	32	56	29	180	261	203	215	732	61	3.7
Fam.Pseudocalanidae	1003	27	50	360	246	95	8	116	0	140	182	108	651	508	432	530	3342	279	17.5
Cl.arcuicornis	988	12	18	339	246	95	8	116	0	118	163	94	603	466	402	490	3119	260	16.3
Cl.furcatus	15	15	32	21	0	0	0	0	0	22	19	14	48	42	30	40	223	19	1.2
Fam.Eucalalanidae	0	0	18	6	24	44	26	33	0	0	0	0	0	0	0	0	117	10	0.6
M.clausi	0	0	18	6	24	44	26	33	0	0	0	0	0	0	0	0	117	10	0.6
Fam.Pontellidae	0	0	0	0	62	66	74	67	65	61	21	49	12	18	16	15	392	33	2.1
L.brunescens	0	0	0	0	0	0	0	0	0	0	13	4	12	18	16	15	56	5	0.3
L.wallastoni	0	0	0	0	62	66	74	67	65	61	8	45	0	0	0	0	336	28	1.8
Fam.Paracalanidae	792	155	86	115	20	8	15	15	395	912	327	545	815	1195	2195	1402	6915	576	36.0
P.aculeatus	108	62	86	85	0	0	0	0	0	0	0	0	0	0	0	0	256	21	1.3
P.parvus	684	93	0	30	20	8	15	15	395	912	327	545	815	1195	2195	1402	6659	555	34.7
Total	2424	447	222	802	533	511	479	508	885	2170	867	1308	2486	3140	5017	3547	19180	1599	100

Fam.=Family , A.=Acartia , C.=Centropages , Cl=Clausocalanus , M.=Mecynocera , L.=Labidocera ,P.=Paracalanus

Table 2. Monthly and seasonal variations of the total adult Calanoida (individuals /m^3) and physico-chemical parameters in Port-Fouad waters (Mediterranean sea) recorded during the period from September 1999 to August 2000.

Parameters Months & Seasons	Water temperature	Salinity ‰	Sacchi disc readings (cm)	Dissolved Oxygen (mg O_2/L)	pH	Total Calanoida (individuals/m^3)
September	24.5	36.1	275	4.6	8.0	2424
October	23.3	37.4	266	5.5	8.0	447
November	17.5	37.0	190	6.7	8.1	222
Autumn	21.8	36.8	243.7	5.6	8.0	802
December	14.8	34.2	110	6.4	8.1	533
January	14.0	33.0	133	6.9	8.3	511
February	16.0	33.8	190	5.3	8.1	479
Winter	14.9	33.7	144.3	6.5	8.2	508
March	19.1	36.0	268	4.8	8.0	885
April	24.0	38.0	278	4.1	8.0	2170
May	26.1	38.0	195	4.0	8.0	867
Spring	23.0	37.3	247	4.3	8.0	1308
June	27.0	38.1	287	5.1	8.2	2486
July	27.8	38.1	205	5.0	8.1	3140
August	28.1	38.2	165	4.2	8.0	5017
Summer	27.6	38.1	285.7	4.8	8.1	3547

Table 3. Total number of calanoid species and diversity indices recorded in Port-Fouad waters in the different seasons during the period from September 1999 to August 2000 .

Seasons	No.of species	Richness	Shannon	Evenness
Autumn	7	0.9	1.3	0.19
Winter	8	1.1	2.6	0.33
Spring	8	1.0	1.8	0.23
Summer	7	0.7	2.8	0.40

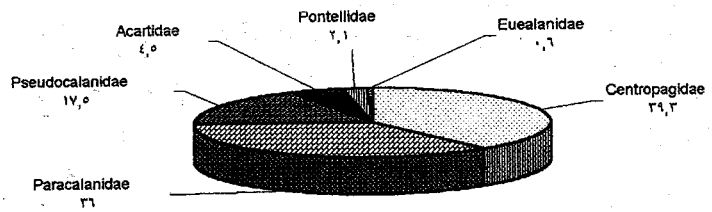

Figure 1. The frequency of calanoid families collected during the period from September 1999 to August 2000 in Port-Fouad water.

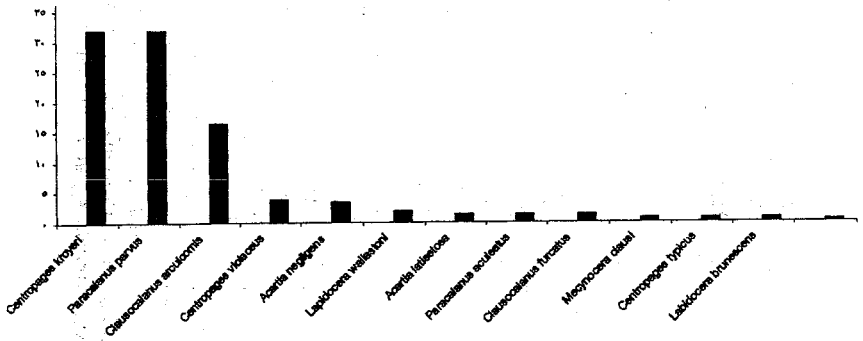

Figure 2. The frequency of calanoid species collected during the period from September 1999 to August 2000 in Port-Fouad waters

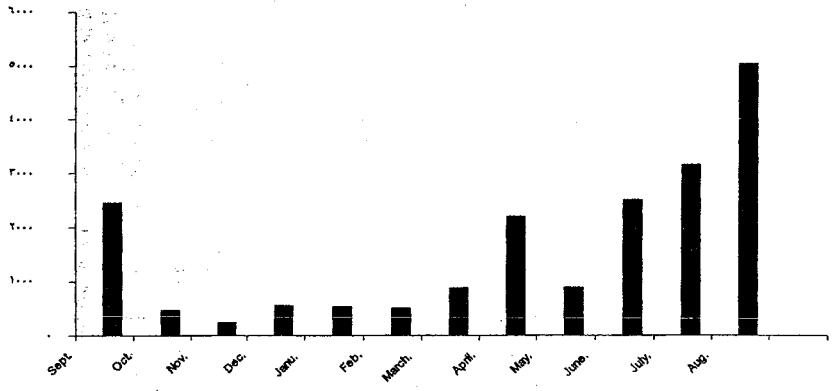

Figure 3. Monthly variations of the total calanoids (ind./m^3) recorded during the period from September 1999 to August 2000 in Port-Fouad waters.

الكثافة العددية لمجتمعات الأطوار البالغة لمجدافية الأرجل (كالانويد) ومدي استجابتها للعوامل البيئية المختلفة في المياه الشاطئية ببور فؤاد (البحر الأبيض المتوسط) محافظة بور سعيد ـــ مصر .

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الملخص العربي

أجريـــت هذه الدراسة لتقدير الكثافة العددية لمجتمعات الأطوار البالغة لمجدافية الأرجل (كـــالانويد) ومـــدي استجابتها للعوامل البيئية المختلفة في المياه الشاطئية ببور فؤاد (البحر الأبيض المتوسط) محافظة بور سعيد ـــ مصر .

تم تجمـــيع اثني عشر نوعا من هذه الحيوانات أثناء هذه الدراسة تنتمي إلى ٦ أجناس محـــتواه في ٦ عـــائلات ومن بين هذه الأنواع وجد أن ثلاثة منها فقط تكون ٨٦% من جميع الأعداد التي تم تسجيلها وهي : ـــ

سنتروباجس كرويري ، بارا كلانس بارفز ، وكلاوزو كلانس اريكونز . حيث تنتمي هذه الأنواع إلى عائلات سنتروباجيدي ، بارا كالانيدي وسيدوكالانيدي علي الترتيب . ولقد وجد أن اقل كثافة عددية لهذه الكائنات سجلت في فصل الشتاء بينما اكبر كثافة عدديه لها كانت في فصل الصيف .

دلت الدراسة علي أن العوامل المؤثرة علي تواجد هذه الكائنات وكذلك علي كثافتها العددية هي درجة حرارة الماء وملوحته والأوكسجين الذائب فيه وكذلك شفافية الماء بينما كان تـــأثير تركيز أيون الهيدروجين ثانويا.أوضحت الدراسة أن المعاملات البيئية تتغير خلال فصول السنة مما يدل علي أن النظام البيئي في المنطقة محل الدراسة متغير .