Proceedings of the First International Conference (Egyptian British Biological Society, EBB Soc)
Egyptian Journal of Biology, 2001, Vol. 3, pp 116-123 **© Printed in Egypt. Modern Press, Cairo.**

On the ecological role of Copepoda in the Suez Canal marine ecosystem

Hamed El-Serehy[1*], Sawsan Aboul-Ezz[2], Amein Samaan[2] and Nasser Saber[2]

1. Suez Canal University, Faculty of Science, Department of Marine Science, Ismailia, Egypt
2. National Institute of Oceanography and Fisheries, Alexandria, Egypt

ABSTRACT

Species-specific abundance of copepods was determined at monthly intervals at 10 stations in the Suez Canal water between June 1994 and May 1995. Sampling stations were chosen to represent different environmental conditions and human activities along the navigational path-way of the canal. A total of 24 copepod species belonging to 17 genera within the orders: Calanoida, Cyclopoida and Harpacticoida were recorded in the present investigation. The densities of total copepods in the surface layer (0-5 m) were higher than those in the sub-surface (5-10 m) and near bottom layer (10-15 m). Copepod nauplii and copepodites formed 22 % and 58 % of the total copepod counts, while the rest comprised the adult copepods. In the Suez Canal, only 3 species formed the main bulk of copepods, namely: *Oithona nanan* (Giesbrecht), *Paracalanus crassirostris* (Dahi) and *Euterpina acutifrons* (Dana) and with an average of 5590, 438 and 496 ind. m^{-3}, respectively. There was a seasonal cycle with low winter and high summer abundance in the canal water. The copepod community of the Suez Canal is characterized by low species diversity. The inverse relationship observed between equitability and the magnitude of standing crop of copepods was discussed. Moreover, the importance of copepods in the marine food web and secondary productivity in the canal water, as well as their response to environmental variations in the Suez Canal ecosystem were discussed.

KEYWORDS: Zooplankton, Copepoda, food web, marine ecosystem, Suez Canal

INTRODUCTION

Copepods frequently form the largest component of zooplankton biomass and are major herbivores in marine communities. They and their developing progeny form the main food supply for many plankton predators such as pelagic fish and medusae (Cushing 1995; Hay 1995). The production of copepods in any natural water mass is often considered equivalent to the secondary producers as most of them, particularly their larval and copepodite stages feed directly on phytoplankton. They usually outnumber other planktonic groups both numerically and in number of species. The distribution of Copepoda in the Suez Canal was first estimated by the end of the 19th century (Giesbrecht 1897). Later on, Thompson & Scott (1903) enumerated the different copepod species in samples collected from Suez Canal. Gurney (1927) reported copepods and cladocerans in Suez Canal and Suez Bay, while MacDonald (1933) studied the distribution of phytoplankton and zooplankton in the Suez Canal. More recently, Kimor (1972) estimated the copepod group among the fauna of the Suez Canal. Abou-Zeid (1990) studied the distribution of zooplankton in Lake Timsah on the Suez Canal with especial reference to Copepoda. El-Serehy & Shalaby (1994) studied the distribution and numerical abundance of zooplankton along the Suez Canal. Finally, El-Serehy *et al*. (2000) discussed the distribution of zooplankton communities and their relationship to environmental variables in the Suez Canal marine ecosystem. Other related investigations were also conducted about the distribution of copepod and zooplankton communities in the Red Sea (Ponomareva 1966; Gordeyeva 1970), in the Suez Gulf and Suez Bay (Aboul-Ezz *et al*. 1995) In the Gulf of Aqaba (Almeida Prado Por 1985), in the Arabian Gulf (Michel 1986; Hussein 1992; El-Serehy 2000) as well as in south Eastern Mediterranean (Dowidar & El-Maghraby 1971; Hussein 1977; Nour El-Din 1987).

* Address for Correspondence

The present study deals with the spatial distribution and seasonal variation of copepods in Suez Canal, as well as the effect of the prevailing environmental conditions on their abundance.

MATERIALS AND METHODS

10 stations were selected to represent different habitats in the Suez Canal as shown in Figure 1. The stations of 111, VI and VII are affected by different inland discharges since they receive domestic effluents from the main sewer of Port Said City (St. III) and Ismailia City (St. VI & VII), and also freshwater from Lake Manzalah (St. III) and Abassa freshwater Canal (St. VI &SVII). Quantitative sampling of zooplankton was performed monthly in the Suez Canal during the period June 1994 to May 1995, using standard plankton net (55-µm-mesh size and with a mouth diameter of 17 cm and a total length of 100 cm) provided with a closing mechanism. At each station, the net was hauled vertically from a depth of 5 metres to the surface, then from 10 to 5 metres and finally from 15 to 10 metres, depending on the proper depth of the sampling station. The collected samples were then preserved in 4% formalin solution and their volumes were adjusted to 100 ml. Sub-samples of 2 ml were transferred into a counting cell and each plankter was counted separately under an inverted microscope. For each samples three replicates were estimated. Accurate identification of copepods was carried out by inspection of separate organisms on glass slides while they were embedded in a mixture of glycerol, alcohol and water ina ratio of 1: 1: 2 respectively. A solution of ligin pink in polyvinyl lactophenol proved to be a satisfactory medium and stain in the same time. Species were identified using Newell (1963); Mori (1964); Gonzalez & Bowman (1965); Bradford-Grieve (1972 & 1994); Bradford-Grieve & Jillett (1980); Bradford-Grieve *et al.* (1983) and Heron & Bradford-Grieve (1995).

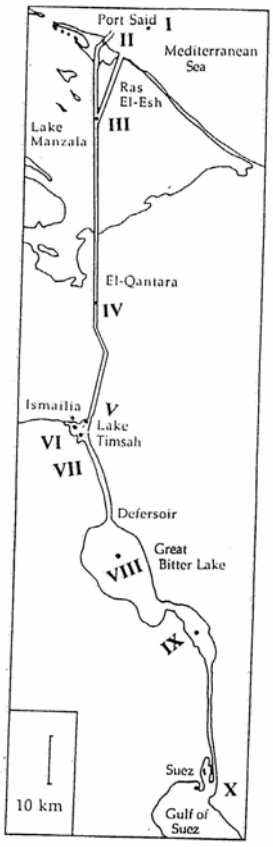

Figure 1: A map of the Suez Canal.

The choice of an index to measure species diversity is complicated by the fact that it comprises two components – species richness and species evenness or equitability – and although some indices combine both components, this can obscure potentially useful information (Death & Winterbourn 1995). Thus, several indices have been used; each of which measures a slightly different aspect of diversity. These are: (i) species number; (ii) Margelef's index (Margelef 1968; Clifford & Stephenson 1975), which is a simple measure of species richness; and (iii) Heip's index (Heip 1974) which measures evenness or equitability. During sampling, the surface water temperature was measured (to 0.1 ^{O}C.) in the different stations by a standard thermometer. The subsurface and near- bottom temperatures were measured with a reversing thermometer fitted to a frame on a Nansin bottle. The water salinity was measured by using an induction salinometer YSI Model 303 S.C.T. meter. The salinometer was constantly calibrated by using standard seawater.

RESULTS

The sub-class Copepoda appeared as the predominant component of zooplankton in the Suez Canal. It contributed numerically 52.3 % of the total zooplankton population with an annual average of 33250; 17930 and 10243 org./m^3 for the surface layer, sub-surface and the near

bottom layer respectively. The adult copepods formed only 20 % of their total counts while copepod nauplii and copepodites represented the rest. The Copepod community comprised 24 species belonging to 17 genera within the orders Calanoida (15 species), Cyclopoida (6 species), and Harpacticoida (3 species) (Table 1). Only 3 species formed the main bulk of copepods, namely *Oithona nana* (Gisbrecht), *Paracalanus crassirostris* (Dahi) and *Euterpina acutifrons* (Dana).

The copepodite stages contributed collectively 22 % of the total copepod counts. Their vertical distribution showed the highest values in the surface and near-bottom layers of station V (average 14009 and 3368 copepodites/m^3 for the two layers respectively), and the sub-surface layer of station II (average 7523 copepodites/m^3), while the lowest records were observed at station X (Fig 2). Regarding their monthly variations, their higher densities were observed in summer with peak in June, while the lowest were recorded in winter especially in January. The nauplii larvae of Copepoda dominated both the adult forms and copepodite stages, They formed numerically about 58% of the total copepod counts appearing, more dense at stations II and V, but less dense at station IX. Their monthly counts showed peaks of abundance in July, beside other lower ones in November. The lowest counts of copepod nauplii were encountered in winter (Fig. 3).

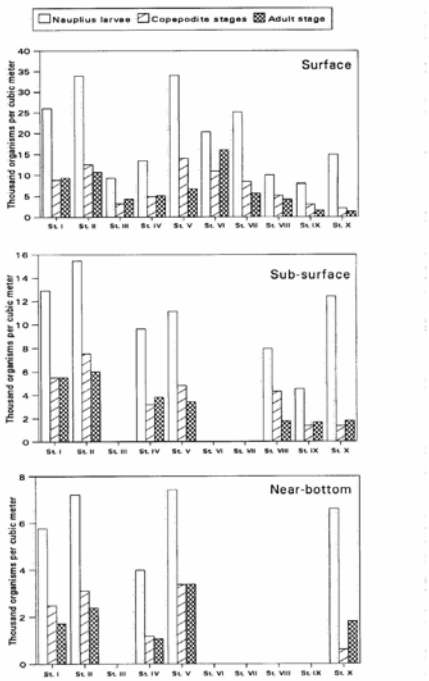

Fig.(2): average annual values of the different stages of Copepoda recorded at the different stations in the Suez Canal during the period June, 1994-May,1995

The copepod community in the Suez Canal is characterized by low species diversity (Table 2). During the present study, copepod species diversity changed from one station to the other, with very low species diversity recorded at stations III and VII and higher diversity at stations I in the north and IX in the south An inverse relationship was observed between equitability and the magnitude of standing crop of copepods, as indicated at station (VI), which harbored the relative high density, but exhibited low evenness.

Members of the Order Cyclopoida formed collectively 84.7 % of the adult copepods in the Suez Canal (average 5711 organisms/m^3) and were represented by 6 species belonging to 4 genera. *Oithona nana* (Giesbrecht) was the dominant species (Table 3) and it contributed numerically 97.8 % of the total cyclopoids (average 5590 org./m^3). It appeared to be more dominant at stationVI. The species was reported all the year round, showing maximum existence during summer with a peak in July (Table 4). The other cyclopoid species (*Oithona plumifera* Baird; *Oncaea media* Giesbrecht; *Lubbockia squillimana* Claus; *Corycaeus erythraeus* Dana and *Corycaeus medius* Gurney) were very rare and constituted collectively 2.2 % of the total cyclopods.

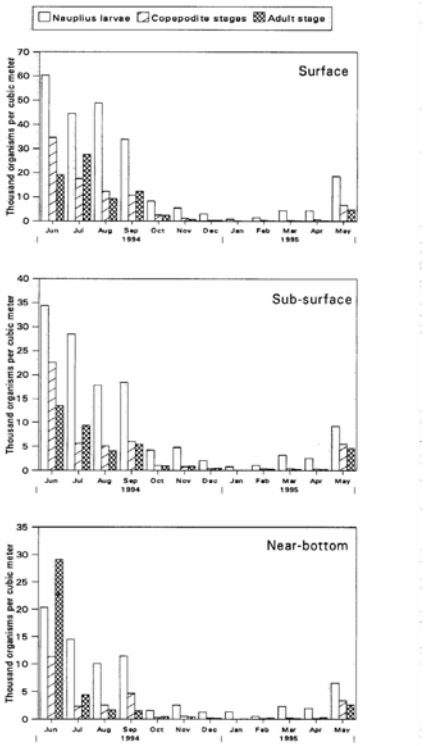

Fig.(3): Monthly variation of the different stages of Copepoda recorded in the Suez Canal during the period June, 1994-May, 1995.

Calanoida contributed collectively 7.7 % of the adult copepods (average 523 org./m^3), represented in the Suez Canal by 15 species. *Paracalanus crassirostris* (Dahi) prevailed other calanoids, forming 83.7 % of their total counts (average 438 org./m^3). The highest density of *Paracalanus crassirostris* was recorded at station IV. The species appeared in the plankton samples during the whole investigation period with a maximum abundance in summer and a peak in June. Other calanoids (14 species) were rare and formed collectively 16.3 % of the total counts. Like calanoids, harpacticoids were less common and contributed only 7.6 % of the adult copepods (average 512 org./m^3). They were represented by 3 species belonging to 3 genera. *Euterpina acutifrons* (Dana) dominated the other harpacticoids and formed 96.8 % of their total counts (average 496 org./m^3). The species appeared more frequent at stations IV & V. It was found throughout the whole investigation period showing a peak in June, while it continued in low counts during winter months. The other two-harpacticoid species, namely: *Microstella norvegica* (Boeck), *Clytemnestra scutellata* (Dana) appeared as scattered specimens during a few months.

Table 1: List of copepod species recorded in the Suez Canal ten stations during June 1994 - May 1995.

	Stations									
Species	I	II	III	IV	V	VI	VII	VIII	IX	X
Calanoida										
Paracalanus crassirostris Dahl	86	149	162	690	981	175	104	560	119	515
Paracalanus parvus Claus	19	10	1	9	2	1	0	10	2	8
Acrocalanus gibber Giesbrecht	8	6	0	83	74	1	0	60	32	26
Centropages ponticus Karawiew	11	11	0	92	26	14	21	19	1	0
Centropages furcatus Dana	5	1	0	26	18	4	0	17	0	1
Acartia negligens Dana	5	3	0	9	1	2	1	1	1	0
Acartia centrura Giesbrecht	1	1	1	1	25	4	1	1	2	5
Acartia latisetosa Dana	4	1	0	1	21	0	0	1	2	0
Acartia fossae Gurney	1	1	1	1	3	0	0	3	4	16
Temora stylifera Dana	1	0	0	1	1	0	0	0	1	2
Tortanus gracilis Brady	0	0	0	0	0	0	0	0	0	3
Clausocalanus arcuicornis Dana	11	10	1	23	14	1	0	0	1	0
Ctenocalanus vanus Giesbrecht	0	0	0	0	0	0	0	0	0	26
Pontellopsis regalis Giesbrecht	2	0	0	0	0	0	0	0	0	0
Labidocera minuta Giesbrecht	0	0	0	3	0	0	0	0	0	0
Cyclopoida										
Oithona nana Giesbrecht	4806	5853	3780	1760	2576	15663	5373	1641	1239	482
Oithona plumifera Baird	0	0	0	0	0	0	1	15	1	18
Oncaea media Giesbrecht	1	1	0	1	1	0	0	30	38	6
Lubbockia squilimana Claus	2	1	1	1	0	0	0	0	0	0
Corycaeus erythraeus Dana	0	0	0	0	0	0	0	1	1	6
Corycaeus medius Gurney	0	0	0	0	0	0	0	0	3	0
Harpacticoida										
Euterpina acutifrons Dana	418	302	311	605	741	139	83	458	130	237
Microsetella norvegica Boeck	6	8	13	8	19	2	2	30	5	1
Clytemnestra scutellata Dana	1	4	1	1	1	4	1	1	1	1

Table 2: Number of adult copepods, copepod species, richness and equitability recorded at the Suez Canal of ten stations during the period June 1994 - May 1995.

	I	II	III	IV	V	VI	VII	VIII	IX	X
No. of ind./m^3	53388	6362	4272	3312	4504	16010	5587	2848	1583	1353
No. of species	18	16	10	18	16	12	10	16	18	15
Richness	1.67	1.44	0.93	1.76	1.46	0.93	0.95	1.54	1.85	1.47
Equitability	0.13	0.11	0.08	0.14	0.11	0.07	0.1	0.13	0.15	0.12

Table 3: Average annual values of adult copepods (ind./m^3) recorded at the different stations of the Suez Canal during the period June 1994-May 1995.

	Cyclopoida		Calanoida		Harpacticoida	
St. No.	*Oithona nana*	Other species	*Paracalanus crassirostris*	Other species	*Euterpina acutifrons*	Other species
I	8669	2	132	65	433	15
II	9994	2	262	47	408	7
III	3782	1	162	4	311	14
IV	2692	2	1437	265	684	8
V	5450	1	960	99	1964	32
VI	15663	0	175	27	132	6
VII	5373	1	104	23	74	3
VIII	2643	90	673	131	589	58
IX	1050	59	190	71	143	10
X	596	54	284	120	224	11
Average	5590	21	438	85	496	16

Table 4: Monthly variations of adult copepods (ind./m^3) recorded at the different stations of the Suez Canal during the period June 1994-May, 1995.

	Cyclopoida		Calanoida		Harpacticoida	
St. No.	*Oithona nana*	Other species	*Paracalanus crassirostris*	Other species	*Euterpina acutifrons*	Other species
Jun. 94	13490	171	3104	594	3826	111
Jul.	26357	2	449	119	765	1
Aug.	8592	2	307	36	316	1
Sep.	11811	1	357	56	100	1
Oct.	1795	9	398	15	182	47
Nov.	325	16	218	225	133	4
Dec.	223	29	74	266	112	3
Jan.95	58	3	10	10	25	2
Feb.	103	3	10	43	67	5
Mar.	125	7	15	47	37	4
Apr.	185	6	18	31	51	5
May	4021	3	299	27	340	1

DISCUSSION

In the Suez Canal, Copepoda represents the most important component of zooplankton. This agrees with estimations carried out in other regions where copepods constituted 70.7 % of the total zooplankton in the eastern Mediterranean offshore of Egypt (Hussein 1977), 83.0% in Kuwaiti waters (Michel *et al*. 1986) and 65.5% along coastal water of United Arab Emirates on the Arabian Gulf (El-Serehy 1999). A total of 87 zooplankton species were encountered in the canal of which 24 copepod species were recorded, most of them belonging to both the Mediterranean and Red Sea. This is much lower than the number of copepods recorded in Mediterranean and Red Sea. Thus Hussein (1977) estimated 112 copepod species in the Egyptian Mediterranean waters. On the other hand, Halim (1969) gave a list of 155 species recorded in the Red Sea. The lower number of the copepod species recorded in the Suez Canal may be because most of these copepods (23 species) are immigrant species to the canal either from Red Sea or from Mediterranean Sea. The Suez Canal ecosystem has many barriers against the process of transmigration of planktonic species (El-Serehy 1992; El-Serehy *et al*.

2000). Thus the immigrant copepod species are inforced to cope against different obstacles which off course are fatal to those delicate organisms.

From a total of 24 copepod species recorded in the Suez Canal water during the present investigation, only 3 species formed the main bulk of copepods, while the other 21 species persisted as infrequent or rare forms. Thus these three dominant copepod species of Suez Canal, viz.: *Oithona nana* (Giesbrecht); *Paracalanus crassirostris* (Dahl) and *Euterpina acutifrons* (Dana) are more likely to be the highly tolerant immigrant copepod species. The most important environmental conditions controlling the spatial and seasonal distribution of zooplankton in general and copepod in particular comprise water temperature, salinity, available food supply and predation. Each copepod species has absolute ranges of both temperature and salinity outside of which development does not proceed. So, the significance of temperature as an important factor controlling the abundance of copepod has been pointed out by several authors (Sewel 1948; Deevey 1960; Goldman & horne 1983). They mentioned that, water temperature and salinity are the chief factors in regulating the distribution of copepods in seawater. Patalas (1972) mentioned that, when excess food is available for zooplankton, its abundance would depend mainly on temperature. Arnemo (1965) illustrated that the fluctuations in the abundance of planktonic forms might not only be related to water temperature but also to its indirect influences on their food item. Generally, most of the dominant and frequent species of Copepoda in the Suez Canal are eurythermic forms and can be tolerate a wide range of temperature variation.

During this study, high numbers of copepods were recorded during summer (July) and early autumn (September), while they were frequent during spring and very rare during winter (Figs. 3, 4). It appears that, temperature is the main factor determining the distribution of copepods in the Suez Canal as a whole, either directly or via their nutritional requirements. The monthly records of Suez Canal temperature (Fig. 3) shows an annual cycle with minimum values in January and maximum values in July and August. The warm summer temperature may encourage the copepod population on one hand, and enhance high nutritional values in the canal water on the other hand, which in turn provides a food supply of microscopic algae and tintinnids as a preferable food items for copepods.

On the other hand, the factor of salinity has a unique situation in Suez Canal, where it fluctuates in an annual cycle at stations, I, II, IV, V, VIII, IX and X with maximal value of about 38 ‰ in summer and minimal values of about 33 ‰ in winter. However, periodic intrusions of fresh water at stations III, IV and VII produce erratic fluctuations of salinity at these stations. The movement of these less saline water within the canal creates some irregularity in the salinity at other stations. This situation for salinity in the Suez Canal in particular (Fig. 5) support the supposition of the temperature as a key environmental factor in direct relation to the species of copepod organisms that thrive in the canal, and also in relation to the influence of temperature on such features as oxygen solubility and, through evaporation, on salinity.

Cyclopoids outranked the other copepod groups (Table 3) in the Suez Canal, where they were represented by very high individual numbers. According Raymont (1983) cyclopoids are usually more plentiful in warm areas.

During the present study, stations III and VII were characterized by low species diversity (Tables 1 and 2) compared to that other stations. Both stations are affected by different inland discharges as they receive domestic effluents from the main sewer of Port Said and Ismailia City, respectively. The inverse relationship which has been observed between equitability and the magnitude of the standing crop of adult copepods at station VI (Table 2) can be attributed to the huge increase of one species, *Oithona nana*, which comprised a population density of 15663 Ind./m^3 at this station (Table 3)

Nauplius larvae and copepodite stages of Copepoda in the Suez Canal dominated the adult organisms and they persisted all the year round. This may be either because they belong to several species which have different breeding season or because under favorable conditions the previously mentioned dominant species have more than one breeding season per year, producing more than one generation each year (Goldman & Horne 1983). However, the summer appeared to be the main breeding season for copepods in the Suez Canal particularly in June, when the larval stages contributed about 80.8% of the total copepods. Such high density in the larval stages corresponds to a high temperature of 27.5^{o}C and high salinity of 41.7 4 ‰.

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الملخص العربى

الدور البيئي لمجدافيات الأرجل في النظام البيئي البحري لقناة السويس

حامد السريحى1 – سوسن أبو العز2 – أمين سمعان2 – ناصر صابر2
1- جامعة قناة السويس – كلية العلوم – قسم علوم البحار- الإسماعيلية- مصر
2- المعهد القومي لعلوم البحار والمصائد – إسكندرية – مصر

تم دراسة الوفرة العددية والنوعية لمجدافيات الأرجل من خلال عينات شهرية تم جمعها من 10 محطات مختارة على طول مجرى قناة السويس لتعكس الظروف البيئية المختلفة. وقد أثمر البحث عن حصر لعدد 22 نوعاً من المجدافيات تنتمي إلى 17 جنسا ضمن ثلاثة مجموعات رئيسية. وقد سجلت الطبقات السطحية أعلى كثافة عددية مقارنةً بتلك تحت السطحية والقريبة من القاع. وكانت النسبة المئوية ليرقانات النوبليوس 85 % ، الأطوار المجدافية 22 % و الأطوار اليافعة 20 %. وتعتبر أنواع أويثونا نانا ، باراكالاناس كراسيروستريس ، يوتيريباينا أوكيوتيفرونس هى الأنواع الثلاثة السائدة فى مجتمع المجدافيات من حيث الوفرة العددية والتوزيع الموسمي الذي سجل أعلى معدل له خلال فصل الصيف بينما انخفض مسجلاً اقل قيمه بحلول فصل الشتاء. ويناقش البحث عدالة التوزيع لمجدافيات الأرجل في مياه القناة ، ودورها في السلسلة الغذائية والإنتاجية الثانوية في النظام البيئي للقناة ومدى استجابة المجدافيات لما يطرأ على هذا النظام من تغيير.