Egyptian Journal of Biology, 2004, Vol. 6, pp 126-135
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# Distribution patterns of planktonic Copepod crustaceans in the coral reef and sandy areas along the Gulf of Aqaba, Red Sea, Egypt

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**ABSTRACT**

74 planktonic copepod species were collected from sandy coastal areas of the Gulf of Aqaba (Ras Burka & Nuweiba); 48 of them were also found in the waters of coral reef areas (Hibika & Abu Galum). Seasonal changes in the vertical and horizontal distribution of planktonic copepods are described for a 100-m water column. Four different distribution patterns are highlighted: (1) horizontal patchiness with an inverse distribution pattern in sandy and coral reef areas; (2) a vertical distribution pattern where about 50% are in the upper 25 m of the water column; (3) a seasonal distribution pattern where adults and larvae exhibit considerable fluctuations, with a peak in winter (December) and a minimum during summer (August); (4) a latitudinal gradient with peak population density at northern stations, declining southwards.

**Keywords**: Copepoda, Distribution, Gulf of Aqaba, Red Sea

## INTRODUCTION

Copepods constitute the bulk of the zooplankton, and are an important intermediate link in the marine food chain. They are therefore of special interest in studying marine ecosystems. Different species of copepods occupy different positions in the food chain according to their feeding habits, and herbivorous, carnivorous and omnivorous copepod species play quite different roles in the transfer of energy between trophic levels (Neunes 1965).

Coral reefs are diverse ecosystems, with high productivity and abundance of organisms in relatively nutrient-poor waters (Goreau *et al* 1971). Although the role of Copepoda in coral-reef communities is not yet clear, their contribution in energy transfer along the food chain of the coral reef ecosystem is very important (Alldregde & King 1977; Roman *et al.* 1990). They represent a significant part of the diet of various coral reef inhabitants (Robichaux *et al.* 1981).

The Gulf of Aqaba is a narrow deep basin, extending 180 km from its northern tip to a shallow sill of 252 m at the straits of Tiran, where it opens to the Red Sea (Hall 1975). The Gulf is on average 14 km wide, and reaches a depth of 1800 m at its deepest point. It is totally surrounded by desert: Sinai to the west, and the Jordanian-Saudi desert to the east. Water temperatures range from 26 $^{o}$C at the surface to about 21 $^{o}$C at the bottom, maintained throughout the year. Salinity is relatively high (40.2 to > 41‰) (Khalil & Abd El-Rahman 1997).

The distribution of Copepoda in the Gulf of Aqaba was first described by Schmidet (1973) who provided preliminary data on the displacement volume and numerical abundance of the total copepod assemblage from one station in the northern part. Por (1979) reported eighteen species from the Gulf coasts, and Kahan & Bar-El (1982) identified new species of Harpacticoida. The first counts of calanoid Copepoda were reported by Almeida Prado-Por & Por (1981), and Vaissiere & Seguin (1984) provided preliminary studies of zooplanktonic groups from the coral reef and open sea areas. Almeida Prado-Por (1983, 1985, 1990) studied the diversity, dynamics and daily vertical cycle of the Calanoida. Echelman & Fishelson (1990) listed surface zooplankton in the

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northern part of the Gulf. Other studies done on zooplankton of the Gulf of Aqaba include Genin *et al* (1995), Khalil & Abdel-Rahman (1997), Abdel-Rahman (1999), El-Serehy & Abdel-Rahman (1999), Al-Najjar (2000), Bottger-Schnack *et al* (2001), Sommer *et al.* (2002) and Abdel-Rahman & El-Serehy (2004).

The present study highlights the vertical, horizontal and seasonal distribution patterns of the planktonic copepods of sandy and coral reef areas of the Gulf.

## MATERIALS AND METHODS

Three cruises were carried out during 1999 in order to study the distribution strategies of Copepoda in two different habitats of sandy and coral reef areas of the Gulf of Aqaba during spring (April), summer (August) and winter (December). Four sites were selected, two of which (Ras Burka & Nuweiba) represent sandy coasts, while the other two (Hipika & Abu Galoum) lie in coral reef coasts (Fig. 1). Collections were made during daytime at high tide. British Admiralty tide table predictions for Sharm El-Sheikh area were checked before each visit. Four fixed transects, one at each site, were laid out in the sandy and coral reef sites, each running for 2 km perpendicular to the sea shore. Each transect was divided into four stations at equal distance. A plastic line knotted at 500 m intervals and a 100 meter measuring tape were used to define transects in these surveys. At each station along the transect, four vertical tows were performed, using a closing standard plankton net of 55 µm-mesh size and with a mouth diameter of 17 cm, at four different depths: from 25m to the surface; 50m to 25m; 75m to 50m and from 100 m to 75m.

The samples were placed in suitable plastic bottles and immediately fixed with 4% neutral formalin. In the laboratory, the collected samples were examined in large Petri dishes. Then sub-samples of 5 ml each were transferred into a counting chamber and each copepod species was counted separately using an inverted microscope. For each sample, three sub-samples were estimated. The accurate identification of copepods was done by dissecting each copepod, using fine needles on a glass slide in a 1:1:2 mixture of glycerin, alcohol, and water. Species were identified using Giesbrecht (1892), Tregouboff & Rose (1957), Newell (1963), Mori (1964), Gonzalez and Bowman (1965), Williamson (1967), Bradford-Grieve (1972 & 1994), Bradford-Grieve & Jillett (1980), Bradford-Grieve *et al.* (1983), Heron & Bradford-Grieve (1995) and Boltovskoy (1999).

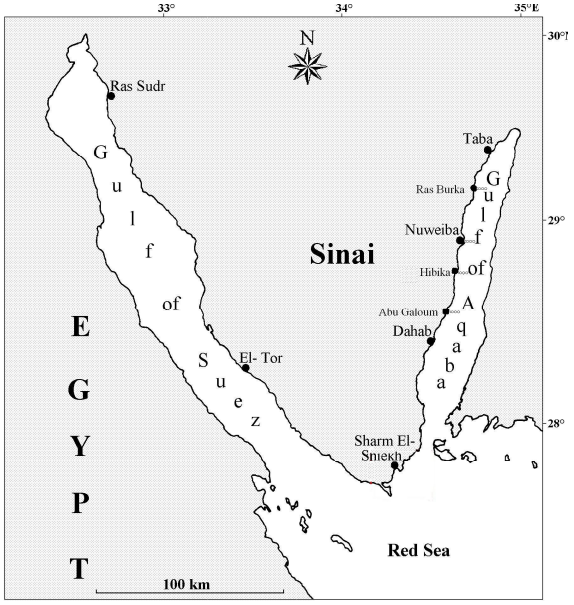


**Fig. 1.** Map of the Gulf of Aqaba showing the sampling localities.

## RESULTS

A total of 74 species of Copepoda were recorded, belonging to 36 genera, 42 families and 4 orders (Calanoida, Poecilostomatoida, Cyclopoida, and Harpacticoida). A taxonomic account of the recorded species and their habitats (C: Coral Reef, S: Sandy areas) are given below.

**Order: Calanoida**

**Family: Acartiidae**

1. *Acartia centrura* Giesbrecht, 1889 **(S)**
2. *Acartia negligens* Dana, 1846 **(S, C)**

**Family: Paracalanidae**

3. *Acrocalanus gibber* Giesbrecht, 1888 **(S)**
4. *Acrocalanus gracilis* Giesbrecht, 1888 **(S, C)**
5. *Acrocalanus longicornis* Giesbrecht, 1888 **(S)**
6. *Paracalanus aculeatus* Giesbrecht, 1888 **(S)**
7. *Paracalanus indicus* Wolfenden, 1905 **(S, C)**
8. *Paracalanus parvus Claus*, 1863 **(S, C)**

**Family: Aetideidae**

9. *Euchirella messinensis* Claus, 1863 **(S, C)**

**Family: Scolecithricidae**

10. *Macandrewella chelipes* Giesbrecht, 1896 **(S , C)**
11. *Scolecithricella auropecten* Giesbrecht, 1892 **(S, C)**
12. *Scolecithrix ctenopus* Giesbrecht, 1888 **(S, C)**

**Family: Pontellidae**

13. *Calanopia elliptica* Dana, 1849 **(S, C)**
14. *Calanopia minor* A.Scott, 1902 **(S)**
15. *Pontellina plumata* Dana, 1849 **(S, C)**
16. *Pontellopsis villosa* Brady, 1883 **(S, C)**

**Family: Calanidae**

17. *Calanus (Nannocalanus) minor* Claus, 1863 **(S, C)**
18. *Calanus plumchrus* Marukawa, 1921 **(S, C)**
19. *Calanus robustior* Giesbrecht, 1888 **(S, C)**
20. *Calanus tenuicornis* Dana, 1849 **(S, C)**
21. *Calanus (Undinula) vulgaris* Dana, 1852 **(S, C)**

**Family: Calocalanidae**

22. *Calocalanus pavo Dana*, 1852 **(S, C)**
23. *Calocalanus pavoninus* Farran, 1936 **(S)**
24. *Calocalanus styliremis* Giesbrecht, 1888 **(S)**

**Family: Candaciidae**

25. *Candacia curta* Dana, 1849 **(S, C)**
26. *Candacia longimana Claus*, 1863 **(S, C)**
27. *Candacia pectinata* Brady, 1878 **(S, C)**
28. *Candacia simplex* Giesbrecht, 1889 **(S, C)**
29. *Candacia tenuimana* Giesbrecht, 1889 **(S, C)**
30. *Candacia truncata* Dana, 1849 **(S, C)**
31. *Candacia varicans* Giesbrecht, 1892 **(S, C)**

**Family: Centropagidae**

32. *Centropages elongatus* Giesbrecht, 1896 **(S, C)**
33. *Centropages furcatus* Dana, 1849 **(S)**

**Family: Clausocalanidae**

34. *Clausocalanus arcuicornis* Dana, 1849 **(S)**
35. *Clausocalanus farrani Sewell*, 1929 **(S, C)**
36. *Clausocalanus furcatus* Brady, 1883 **(S, C)**
37. *Ctenocalanus vanus* Giesbrecht, 1888 **(S, C)**

**Family: Eucalanidae**

38. *Rhincalanus nasutus Giesbrecht, 1888* **(S, C)**

**Family: Euchaetidae**

39. *Euchaeta concinna* Dana, 1849 **(S, C)**

**Family: Lucicutiidae**

40. *Lucicutia flavicornis* Claus, 1863 **(S, C)**

**Family: Augaptilidae**

41. *Haloptilus longicornis Claus*, 1863 **(S, C)**
42. *Haloptilus ornatus* Giesbrecht, 1892 **(S, C)**

**Family: Mecynoceridae**

43. *Mecynocera clausi* Thompson, 1888 **(S, C)**

**Family: Metridinidae**

44. *Pleuromamma indica* Wolfenden, 1905 **(S, C)**

**Family: Phaennidae**

45. *Phaenna spinifera* Claus, 1863 **(S)**

**Family: Temoridae**

46. *Temora stylifera Dana*, 1849 **(S)**
47. *Temoropia mayumbaensis* T. Scott, 1894 **(S)**

**Order: Poecilostomatoida**

**Family: Oncaeidae**

48. *Lubbockia squillimana* Claus, 1863 **(S)**
49. *Oncaea conifera* Giesbrecht, 1891 **(S, C)**
50. *Oncaea dentipes* Giesbrecht, 1891 **(S)**
51. *Oncaea media* Giesbrecht, 1891 **(S)**
52. *Oncaea venusta* Philippi, 1843 **(S, C)**

**Family: sapphirinidae**

53. *Copilia mirabilis* Dana, 1852 **(S, C)**
54. *Sapphirina opalina* Dana, 1849 **(S)**

**Family: Corycaeidae**

55. *Corycaeus flaccus* Giesbrecht, 1891 **(S, C)**
56. *Corycaeus limbatus* Brady, 1883 **(S, C)**
57. *Corycaeus giesbrechti* F. Dahl, 1894 **(S, C)**
58. *Corycaeus latus* Dana, 1849 **(S, C)**
59. *Corycaeus clausi* F. Dahl, 1894 **(S)**
60. *Corycaeus erythraeus* Cleve, 1903 **(S)**
61. *Corycaeus ovalis* Claus, 1863 **(S)**
62. *Corycaeus speciosus* Dana, 1848 **(S)**
63. *Corycaeus subulatus* Herrick, 1887 **(S)**
64. *Farranula carinata* Giesbrecht, 1891 **(S, C)**
65. *Farranula gibbula* Giesbrecht, 1891 **(S)**
66. *Farranula rostrata* Claus, 1863 **(S, C)**

**Order: Cyclopoida**

**Family: Oithonidae**

67. *Oithona nana* Giesbrecht, 1892 **(S, C)**
68. *Oithona plumifera* Baird, 1843 **(S, C)**
69. *Oithona similis* Claus, 1866 **(S)**

**Order: Harpacticoida**

**Family: Clytemnestridae**

70. *Clytemnestra scutellata* Dana, 1848 **(S)**

**Family: Euterpinidae**

71. *Euterpina acutifrons Dana, 1848* **(S, C)**

**Family: Miraciidae**

72. *Macrosetella gracilis Dana, 1847* **(S)**

**Family: Ectinosomatidae**

73. *Microsetella norvegica Boeck, 1865* **(S)**
74. *Microsetella rosea* Dana, 1848 **(S, C)**

All 74 copepod species were recorded in the water of the sandy stations of Ras Burka & Nuweiba, while only 48 species were recorded in the coral reef stations of Hibika & Abu Galum. Thus 26 copepod species (12 Calanoida, 10 Poecilostomatoida, 1 Cyclopoida and 3 Harpacticoida) were absent from the water of coral reef stations.

The population density of planktonic Copepoda increased offshore at the coral reef stations of Hibika and Abu Galum, while it increased inshore at the sandy sites of Ras Burka and Nuweiba (Fig 2). Approximately 50% of the planktonic copepod populations occurred in the upper 25 m of the water column of the Gulf, while less than 10% occurred at depths between 75 and 100 m (Fig 3).

Seasonally, adult and larval stages exhibited considerable fluctuations in their occurrence and abundance (Fig 4), with a peak in winter and minimum abundance values during summer.

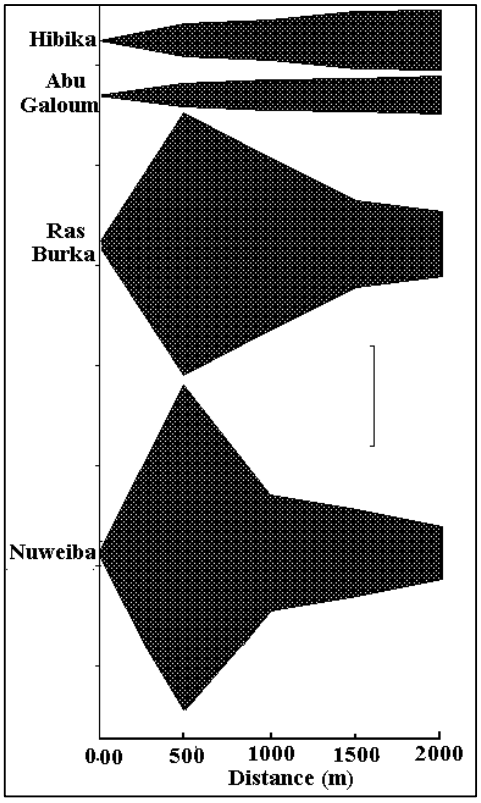


**Fig. 2.** Horizontal patchiness of planktonic copepods in the four stations along the Gulf of Aqaba during the present study (scale bar=2000 ind./$m^3$).

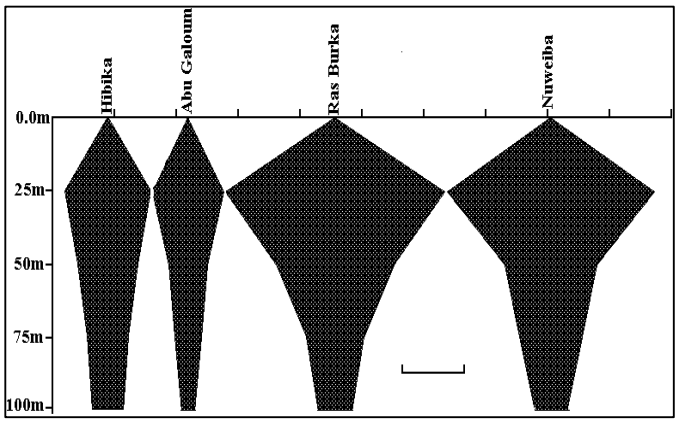


**Fig. 3.** Vertical distribution of planktonic copepods in the four stations along the Gulf of Aqaba during the present study (scale bar=2000 ind./$m^3$).

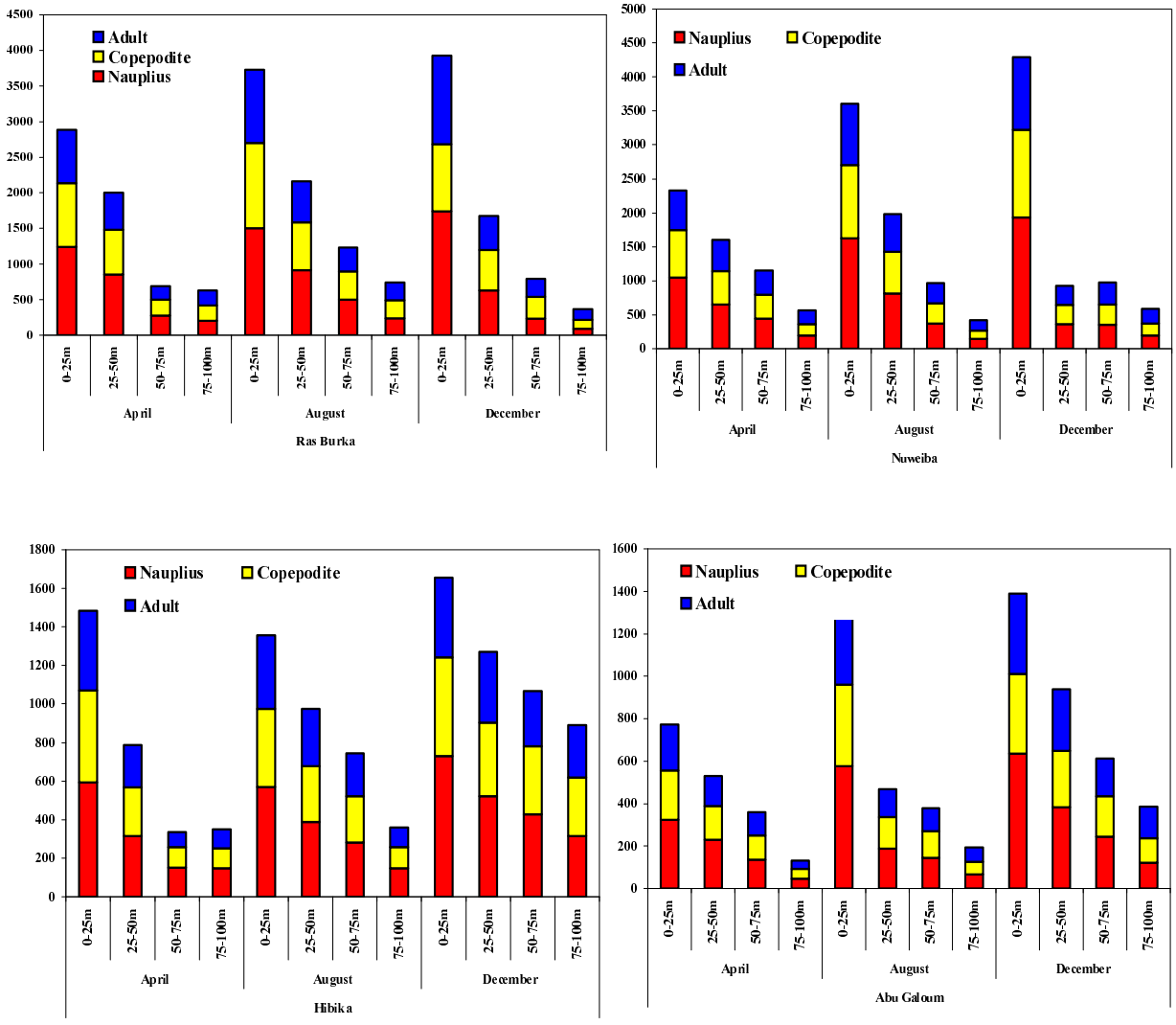


**Fig. 4. Seasonal variations of population structure of planktonic copepods at different depths in the Gulf of Aqaba during the present study.**

## DISCUSSION

In the Gulf of Aqaba, Copepoda are the dominant zooplankton group, comprising nearly 70% of the total number of metazooplankton (Schmidt 1973; Echelman & Fishelson 1990; Khalil & Abdel-Rahman 1997; El-Serehy & Abdel-Rahman 1998 and Al-Najjar 2000). The distribution pattern of planktonic copepods in the coral reef areas is usually controlled by a variety of different factors. The great abundance of natural enemies and predators is more likely to be the most important factor (Barnes & Hughes 1999). Moreover, observations of feeding items of different coral reef fish and examination of their gut contents clearly indicate feeding on at least one endemic reef copepod species (Williams *et al*. 1988). Moreover, there is intense predation on copepod species by reef inhabitants, as well as by zooplanktivores in waters flowing over coral reefs (Glynn 1973; Johannes & Gerber 1974 and Hamner *et al*. 1988). These can explain the decrease in copepod species composition (48 species) in the water of coral reef stations of Hibika and Abu Galum in comparison to those of the sandy stations (74 species) of Ras Burka and Nuweiba.

Data suggest that Calanoida (12 species: *Acartia centrura, Acrocalanus gibber*, *A. longicornis*, *Paracalanus aculeatus, Calanopia minor*, *Calocalanus pavoninus, C. styliremis*, *Centropages furcatus, Clausocalanus arcuicornis*, *Phaenna spinifera, Temora stylifera*, *Temoropia mayumbaensis*) and Poecilostomatoida (10 species: *Lubbockia squillimana, Oncaea dentipes, O. media, Sapphirina opalina, Corycaeus clause*, *C. erythraeus*, *C. ovalis, C. speciosus, C. subulatus, Farranula gibbula; Oithona similes*) be considered the most preferrable food items for coral reef zooplanktivores in the Gulf of Aqaba followed by Harpacticoida (3 species: *Clytemnestra scutellata*, *Macrosetella gracilis* and *Microsetella norvegica* ) and finally Cyclopoida (1 species: *Oithona similes*).

From the data in Figure 2, an inverse relationship was observed between horizontal patchiness of planktonic copepods in coral reef and sandy areas, i.e. higher copepod density inshore at sandy areas and offshore at coral reef areas. Such an inverse relationship is attributed to the existence of nutrient and detritus substances which encourage the flourishing of phytoplankton as food for planktonic copepods.

The mean abundance of planktonic copepods in the coral reef areas of the Gulf of Aqaba is comparable with estimates from other coral reef sites such as the Great Barrier reef (Alldredge & King 1977; Roman *et al*. 1990) and the Marshal Islands (Gerber & Marshal, 1982), but of lower magnitude than in the Caribbean (Glynn, 1973). However, there are likely to be considerable differences between populations of copepods according to local environmental conditions.

Bechmann (1984) attributed the winter peak of zooplankton in the Indian Ocean and the Persian Gulf, which pours into the Red Sea through Bab El Mandab during winter, to the water exchange pattern prevailing toward the Red Sea. As summer approaches, the plankton density in the Red Sea decreases as the surface habitat becomes more hostile due to increasing temperature, and the recruitment from the Gulf diminishes with decreasing rate of water exchange. This hypothesis can explain the winter peak of planktonic copepods in the Gulf of Aqaba.

The fluctuation in copepod abundance of the Gulf of Aqaba seems to be closely related to particular hydrographic conditions prevailing in this environment (Kimor & Golandsky 1977). According to the hypothesis suggested by Mergner & Schuhmacher (1974) and Hulings (1979), the surface water flows southward on both sides of the Gulf, while the deeper water flows northward along the east coast and southward along the western bank. With the prevailing north wind, this circulation induces an upwelling in the northern part of the Gulf. These can explain the higher population density of planktonic

copepods at the northern stations of Ras Burka and Nuweiba compared with the southern ones.

In conclusion, four different distribution patterns are exemplified by planktonic copepods in the Gulf of Aqaba: (1) horizontal patchiness with an inverse distribution pattern in the sandy and coral reef areas; (2) vertical distribution pattern with an approximately 50% of the populations occurred in the upper 25 m of the 100-m water column of the Gulf, while less than 10% occurred between 75 and 100 m; (3) seasonal distribution pattern for copepod population structure, where the adult and larval copepods exhibit considerable fluctuation in their occurrence and abundance, with a peak in winter (December) and minimum abundance values during summer (August); (4) a site distribution pattern with a peak in population density at the northern stations and declines southward.

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## الملخص العربى

# أنماط التوزيع لمجدافيات الأرجل القشرية الهائمة فى مناطق الشعاب المرجانية والرملية على طول خليج العقبة بشمال ا لبحر الأحمر – مصر

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١- جامعة قناة السويس –كلية العلوم – قسم علوم البحار – الاسماعيلية – مصر
٢- المعهد القومى لعلوم البحار والمصايد –السويس– مصر

تم فى هذه الدراسة تجميع وتعريف عدد أربعة وسبعين نوعا من المجدافيات الهائمة، منها ثمان واربعين نوعا تم حصرها فى كل من منطقتى الدرسة المختلفتين على السواء : منطقة الشعاب المرجانية (حبيكة و أبو جالوم) والمنطقةالرملية (راس بركة و نويبع) بخليج العقبة بينما اقتصر وجود الست وعشيرين نوعا الأخرى على المنطقة الرملية فقط. ويعرض البحث استراتيجيات التوزيع لهذه الأنواع مجتمعة فى أربعة أنماط رئيسية هى: ١- التوزيع الأفقى والذى أظهرازديادا مضطردا فى أعداد المجدافيات كلما اتجهناالى المياه المفتوحة بعيدا عن الشاطئ فى مناطق الشعاب المرجانية وهو وضع معاكس تماما لنمط التوزيع فى مناطق البيئات الرملية. ٢- التوزيع الرأسى على طول عمود الماء وحتى عمق ١٠٠ متر، حيث حظيت الطبقة السطحية وحدها بنسبة خمسين بالمائة من أعداد المجدافيات بينما قلت هذه النسبة بصورة حادة لتسجل مانسبته عشرة فى المائة فقط فى المنطقة القاعية. ٣- التوزيع الموسمى والذى أظهر تأرجحا فى توزيع مختلف الأطوار اليافعة واليرقية باختلاف الفصول على مدار العام حيث سجل فصل الشتاء أعلى وفرةعددية بينما جاءت أقل كثافة عددية مع حلول فصل الصيف الحار. ٤- نسبة التوزيع فى المنطقة كانت بكثافة ووفرة عددية هائلة فى شمال الخليج بالمقارنة مع أعداد قليلة كلما اتجهنا جنوبا على طول خليج العقبة.