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# MONTHLY CHANGES IN THE COMPOSITION AND ABUNDANCE OF MEROPLANKTON AND PELAGIC POLYCHAETES OF THE CILICIAN BASIN SHELF WATERS (EASTERN MEDITERRANEAN)

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## ABSTRACT

Taxonomic composition of the meroplankton and the pelagic polychaetes of the Cilician basin shelf waters was investigated for the first time. Analysis of monthly net samples shows that the meroplankton and the pelagic polychaetes of the region are represented under 5 phyla, 10 classes, and 34 families. Pelagic nectochaete larvae of the family Spionidae (Polychaeta) and zoeas of family Grapsidae (Decapoda) were the dominating groups throughout the year. Typical stenohaline taxa formed by classes of Enteropneusta, Ophiuroidea, Asteroidea, Echinoidea, and Holothuroidea were also observed. The predominance of the decapod larvae was a distinguishing feature of the winter period. Diversity was highest during the spring (Margalef's Index **d** = 4.3, 5.4, and 5.6 for March, April, and May, respectively) and lowest during August (**d** = 1.9) and November (**d** = 2.3). Results of multivariate analysis (Multi-Dimensional Scaling) revealed a distinct summer population that varied greatly from the rest of the periods. Temperature rather than salinity was found to be more effective in controlling the abundance and diversity in the region.

## INTRODUCTION

Planktonic larvae are composed of two groups: the larvae of various holoplankton, and the larvae of large pelagic and benthic animals. Due to their great abundance and diversity, these two groups occupy an important niche in the marine coastal plankton communities. During breeding seasons, the importance of meroplankton becomes even more evident. Since they appear periodically at definite seasons (spring, summer, or autumn), they are called seasonal plankton. Except for Protozoa, almost all the marine invertebrates undergo a planktonic larval stage during development. The presence of larvae in the plankton is controlled by a number of factors: spawning time, water temperature, duration of pelagic stage, food availability and abundance (phytoplankton,

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zooplankton), as well as the hydrodynamic regime of the water body (prevailing currents, upwelling and downwelling) (Zhong, 1988).

The marine ecosystems of the Cilician basin shelf waters have experienced significant natural and anthropogenic changes due to rapid industrial growth and population explosion in the Cukurova region within the last three decades. Currently, a sharp contrast exists between the highly eutrophic coastal area supplied by land-based nutrient sources and the nutrient-limited, oligotrophic open sea. Beyond that, the coastal ecosystems of the eastern Mediterranean have been greatly altered with major changes in the drainage systems, such as the construction of the Aswan Dam in the upper Nile (Halim et al., 1967). Following this event, land-based nutrient input to the eastern Mediterranean was greatly blocked and resulted in a relatively non-fertile, oligotrophic water system along its drainage area. Shortage of nutrients first diminished phytoplankton productivity, and subsequently the zooplankton as the second step in the marine food chain (el Sayed and van Dijken, 1995).

A number of studies have dealt with changes at different trophic levels in the Cilician basin shelf waters (Gucu et al., 1992, 1994; Uysal and Mutlu, 1993; Gucu and Bingel, 1995; Kideys and Gucu, 1995; Uysal et al., 2002). The introduction of alien species through Lessepsian migration from the Red Sea also represents a notable example of anthropogenic effects in this region. To date, almost nothing is known about meroplankton and pelagic polychaetes from the Cilician basin. Especially, almost no pertinent literature on the pelagic polychaetes from the Cilician basin was found except for the early study conducted by Kimor and Wood (1975). The aim of this study was to provide preliminary information and data on these two planktonic communities. The meroplankton composition of the Mediterranean was studied earlier by the British scientists Knight-Jones (1954) and Southern (1908); the French scientists Guerin (1970), Cazaux (1972), and Bhaud and Cazaux (1982); the Spanish scientist Vives (1966, 1967); and, finally, by the Russian scientists Mileikovsky (1973, 1974) and Murina (1995, 1997a,b, 1999).

## MATERIALS AND METHODS

Plankton samples for this study were collected from a single station offshore the Institute of Marine Sciences of Middle East Technical University, Turkey, located on the northeastern coast of the Mediterranean Sea (Fig. 1), at monthly intervals during the year 1998 (station coordinates 34°22′E, 36°30′N). Plankton samples were hauled vertically from a standard depth of 100 m (just above the bottom) to the surface using a Nansen net with a mouth opening of 0.385 $m^2$ and 112-micron mesh size. A single net tow was performed each month. On board R/V *Erdemli* net contents were preserved in a 4% borax-buffered formaldehyde solution in seawater. Enumeration and identification of the net samples were done under a binocular microscope using the Bogorov chamber. For each sampling, the entire net content was sorted ignoring the subsampling. For the taxonomic identification of meroplankton of the Cilician basin we referred to the important work of Rose (1957), and to the monograph of Bhaud and Cazaux (1982). Also, we referred to the Brasil Catalogue on marine larvae of Vannucci (1959–1961). The polychaetes were identified according to Stop-Bowitz (1948, 1977, 1984).



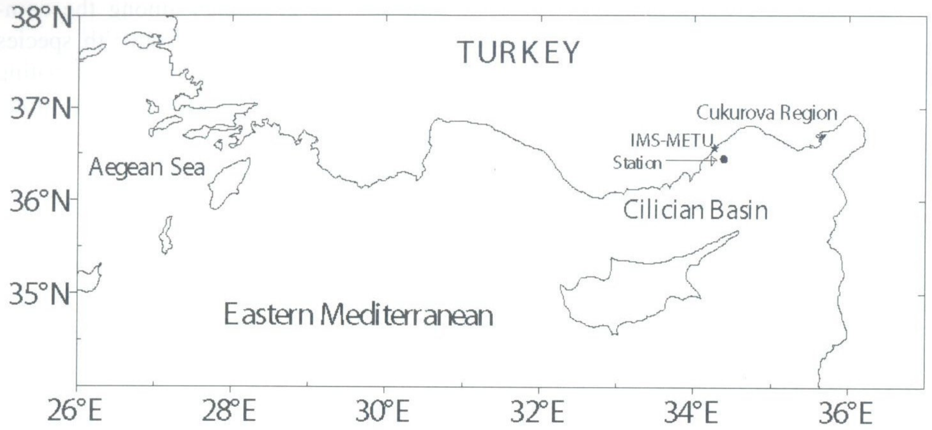


Fig. 1. Location of the sampling station in the Cilician basin (northeastern Mediterranean).

Sea surface temperature and salinity were measured simultaneously using a CTD probe (Sea Bird model). CTD casts covered the whole water column from surface to near bottom. This system contained sensors, batteries, and tape recording units. The data recorded during the casts were later processed by the computers in the Institute laboratories. Five liters of water taken by Nansen bottles was filtered through the GF/F filters (previously dried at 105 ± 5 °C for three h and pre-weighed) for their TSS (Total Suspended Sediment) contents. The filtrates were then kept at 105 ± 5 °C overnight and weighed again, and the difference was used in the calculations. One liter of seawater was filtered through GF/F filters and extracted into 90% acetone solution for chlorophyll measurements. The fluorescence intensity of clear extracts was then measured by the standard fluorometric method (Holm-Hansen and Riemann, 1978) using a Hitachi F-3000 model fluorometer. A 20-cm-diameter Secchi disk was used for Secchi depth measurements.

For statistical analysis both the abundance of meroplanktonic forms and pelagic polychaetes were used. Root–root transformation was applied to adjust the weight of abundant species or groups. To calculate monthly population similarities, the Bray–Curtis coefficient was used (Uysal and Sur, 1995). Then the similarity matrix was formed between every pair of samples in a lower triangular array for further clustering and ordination. For a graphic representation of such timely relations among populations, a dendogram showing clustered groups at an arbitrary cut-off level was constructed. Among the various hierarchical sorting strategies the group-average sorting was preferred to produce a dendogram from the similarity matrix. This joins two groups of samples together at the average level of similarity between all members of one group and all members of the other. In order to visualize monthly sample relationships, ordination was done by delineating dendogram classes on the corresponding ordination via Multi-Dimensional Scaling (MDS) (FAO/IOC/UNEP, 1991).

To determine discriminating species responsible for groupings among the community, contribution to average dissimilarity ($\bar{\delta}$) or similarity ($\bar{S}$) from i'th species was calculated. Higher $\bar{\delta}_i$ and a high ratio of $\bar{\delta}_i/SD(\delta_i)$ pointed out the discriminating species. Contribution of the i'th species ($\bar{S}_i$) to the average similarity within a group ($\bar{S}$) was computed (FAO/IOC/UNEP, 1991). This indicates that the species concerned is consistently prominent in that group. Community diversity indices applied to the present data included Margalef's Index (**d**), Shannon–Wiener Index (**H′**) for species richness, and Pielou's Evenness Index (**J′**) for proportional representation (for details see Uysal and Sur, 1995). For the analysis of multispecies data and the associated environmental variables both STATGRAPHICS (Univariate Statistics Package) and PRIMER (Multivariate Analyses Package - Plymouth Routines in Multivariate Ecological Research), a number of PC programs written at the Plymouth Marine Laboratory, UK were used (FAO/IOC/UNEP, 1991).

## RESULTS AND DISCUSSION

Taxonomic composition of the meroplankton and pelagic polychaetes of the Cilician basin shelf waters were investigated for the first time. Analysis of monthly samples taken from a single shelf station showed that the meroplankton and the pelagic polychaetes of the region are represented under 5 phyla, 10 classes, and 34 families. Names of taxa and species encountered in the region, as well as their numerical abundance per m², are given in Table 1. A total of 12 pelagic polychaete larvae, 3 gastropod larvae, 5 decapod species, and 6 adult pelagic polychaete species were identified during the study period. Pelagic nectochaete larvae of the family Spionidae (Polychaeta) and zoeas of family Grapsidae (Decapoda) were the dominant groups throughout the year. Dominant individuals that were frequently observed in most of the samples are illustrated in Figs. 2 and 3. Typical stenohaline taxa formed by classes of Enteropneusta, Ophiuroidea, Asteroidea, Echinoidea, and Holothuroidea were also observed.

Considerable seasonal differences were observed in the taxonomic composition and quantitative distribution of both groups. The meroplankton during December, January, and February 1998 was composed of 4 phyla, 4 classes, and 16 families. Forming 66% of the total meroplankton abundance, the predominance of the decapod larvae was a distinguishing feature of the winter period. In this group, individuals of family Grapsidae comprised 38% of total meroplankton with an abundance of 174 individuals/m² during February. Meroplanktonic polychaetes were most abundant during December (161 individuals/m²), less so in January (39 individuals/m²), and almost disappeared during February (only 5.2 individuals/m²). Among these, *Prionospio caspersi* with a maximum abundance of 114 individuals/m² in December and *P. malmgreni* with a highest abundance of 31 individuals/m² in the same month have made the highest contribution to the winter population. Pelagic polychaete species identified in winter are *Tomopteris elegans*, *Vanadis studeri*, *Travisiopsis lobifera*, *Pelagobia serrata*, and *Maupasia caeca*. Density of Ostracoda was as high as 317 indviduals/m² during January. Overall, abundance was highest during the winter, when the water column was thor-



Table 1
List of taxa and species encountered in the region. Numbers represent numerical abundance per m²

| Taxa and Species / Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Meroplankton (invertebrates)** | | | | | | | | | | | | |
| **Phylum Annelida** | | | | | | | | | | | | |
| Class Polychaeta | | | | | | | | | | | | |
| Family Polynoidae | | | | | | | | | | | | |
| *Harmothoe imbricata* (Linne, 1767) | | | | | | | 7.8 | | | | | |
| Family Spionidae | | | | | | | | | | | | |
| *Prionospio caspersi* Laubier, 1962 | 26 | | | 5.2 | 10.4 | | | | 46.8 | | 10.4 | 114 |
| *Prionospio cirrifera* Wirén, 1883 | | | | 10.4 | | | | | | 2.6 | | |
| *Prionospio malmgreni* Claparede, 1868 | | 5.2 | 2.6 | | 36.4 | 5.2 | | 15.6 | 15.6 | 7.8 | | 31.2 |
| *Prionospio* sp. | | | 15.6 | 36.4 | 62.4 | 26 | | 36.4 | 31.2 | 15.6 | 18.2 | |
| *Polydora antennata* Claparede, 1868 | | | | | 10.4 | | | | | | | |
| *Scolelepis fuliginosa* Claparede, 1868 | 2.6 | | | 5.2 | 10.4 | | | | | 5.2 | | |
| *Microspio mecznikowianus* (Claparede, 1869) | | | | 10.4 | 5.2 | | | | | | | |
| *Pygospio elegans* Claparede, 1863 | | | | 5.2 | 5.2 | | | | | | | |
| *Nerine cirratulus* (Della Chiaje, 1827) | | | | | 10.4 | | | | | | | |
| *Spio filicornis* (O.F. Muller, 1776) | | | | 5.2 | 5.2 | | | | | | | |
| Family Cirratulidae | | | | | | | | | | | | |
| *Audouinia filigera* (Delle Chiaje, 1828) | | | 2.6 | | | | | | | | | |
| Family Sabellariidae | | | | 36.4 | 5.2 | | | | 2.6 | | | |
| Family Nereididae | | | | 5.2 | 5.2 | | 2.6 | | | | | |
| Family Chrysopetalidae | | | 2.6 | 5.2 | | 2.6 | | | | | | |
| Family Maldanidae | 2.6 | | | | | 7.8 | | | | | | |
| Family Ariciidae | 5.2 | | 2.6 | | 5.2 | 2.6 | 2.6 | | | | | 15.6 |
| Family Amphinomidae (rostraria larva) | 2.6 | | | | | | | | | | | |
| Class Phoronidea (actinotrocha larva) | | | | | 5.2 | | | 2.6 | | | | |

*table continues next page*

Table 1—*continued*

| Taxa and Species / Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Phylum Mollusca** | | | | | | | | | | | | |
| Class Bivalvia | | | | 114 | 130 | 5.2 | | | | | | |
| Class Gastropoda | | 26 | 2.6 | 26 | 36.4 | | 46.8 | | 5.2 | 18.2 | | 5.2 |
| Family Caecidae | | | | | | | | 2.6 | | | | |
| Family Haeminoeidae | | | | | | | | | | | | |
| *Haminoea navicula* (Costa, 1778) | | | | 15.6 | | | | | | | | |
| Family Retusidae | | | | | | | | | | | | |
| *Retusa truncatella* (Locard, 1892) | | | | 5.2 | 10.4 | | | | | | | |
| Family Limapontiidae | | | | | | | | | | | | |
| *Limapontia capitata* (Muller, 1773) | 10.4 | | 2.6 | | | | | | | | | |
| **Phylum Arthropoda** | | | | | | | | | | | | |
| Class Crustacea | | | | | | | | | | | | |
| Order Decapoda | 7.8 | 44.2 | 13 | 2.6 | 10.4 | 26 | 10.4 | | | 5.2 | 15.6 | 10.4 |
| Family Palinuridae | | | | | | | | | | | | |
| *Palinurus* sp. | | | | | | | 2.6 | | | 5.2 | | |
| Family Porcellanidae | | 2.6 | | | | | | | | | | |
| Family Alpheidae | | | | | | | | | | | | |
| *Athanas nitescens* Leach, 1814 | | 5.2 | | | | | 2.6 | | | | | |
| *Athanas* sp. | 2.6 | 36.4 | | 2.6 | 2.6 | | 2.6 | | | | | |
| Family Paguridae | | | | | | | | | | | | |
| *Pagurus* sp. | 5.2 | 13 | 2.6 | 7.8 | | | 7.8 | | | | | |
| Family Hyppolytidae | | | 2.6 | | | | | | | | | |
| *Hyppolyte* sp. | 7.8 | 39 | | 2.6 | | 7.8 | 2.6 | | 5.2 | | | |
| *Lysmata* sp. | | | | | 5.2 | | | | 7.8 | | | |
| Family Canceridae | | | | | | | | | | | | |
| *Cancer pagurus* Linne, 1766 | | | | | 2.6 | | | | | 5.2 | | |



| Taxa and Species / Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family Hymenosomatidae | | | | | | | | | | | | |
| *Elamena* sp. | | | | | 2.6 | | | | | | | |
| Family Penaeidae | | | 20.8 | | | | | | | | | |
| *Gennades* sp. | 2.6 | 18.2 | | | | | 2.6 | | | | | |
| Family Grapsidae | 10.4 | 174 | 5.2 | 2.6 | | 15.6 | 62.4 | | 80.6 | | | 5.2 |
| Family Xanthidae | 7.8 | 52 | | 2.6 | | 5.2 | 5.2 | | | | | |
| Family Homaridae | | | | | | | | | 2.6 | | | |
| *Homarus* sp. | 5.2 | 10.4 | | | | | | | | | | |
| Family Latreillidae | | | 7.8 | | | | | | | | | |
| *Latreutes* sp. | 7.8 | 26 | | 7.8 | 7.8 | | 15.6 | | 2.6 | 5.2 | | 5.2 |
| Family Portunidae | | | | | | | | | | | | |
| *Carcinus mediterraneus* Czerniavsky, 1884 | 5.2 | | | | | | | | | | | |
| Family Palaemonidae | | | | | | | | | | | | |
| *Palaemon* sp. | | 2.6 | | 2.6 | | | 10.4 | | | | | |
| Family Majidae | | | | | | | | | | | | |
| *Schizophrys aspera* H. Milne-Edwards, 1834 | | | | | | | | | 5.2 | | | |
| Order Cirripedia (nauplius, cypris larvae) | | | | | | 18.2 | | | | | | |
| Family Balanidae (cypris, nauplius larvae) | | | 36.4 | | 15.6 | | | | | | | |
| Order Stomatopoda | | | | | | | | | | | | |
| *Squilla* sp. | | 2.6 | | | | | 2.6 | | | | | |
| **Phylum Echinodermata** | | | | | | | | | | | | |
| Class Asteroidea (bipinnaria, brachiolaria larvae) | | | 2.6 | 5.2 | | | | 2.6 | | 2.6 | | |
| Class Echinoidea (echinopluteus larva) | | | | | 15.6 | | | | 5.2 | | | |
| Class Holothuroidea (auricularia, doliolaria larvae) | | | 2.6 | | 5.2 | | | 5.2 | | | | |
| **Phylum Hemichordata** | | | | | | | | | | | | |
| Class Enteropneusta (tornaria larva) | 2.6 | | | 5.2 | 5.2 | | | | | 33.8 | | 10.4 |

*table continues next page*

Table 1—*continued*

| Taxa and Species / Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Holoplankton (Invertebrates)** | | | | | | | | | | | | |
| Class Polychaeta | | | | | | | | | | | | |
| Family Tomopteridae | | | | | | | | | | | | |
| *Tomopteris* sp. | | | 36.4 | 10.4 | 15.6 | | | | 2.6 | 5.2 | | |
| *Tomopteris elegans* Berkeley, 1924 | 20.8 | 10.4 | | | | 46.8 | 5.2 | | | 2.6 | 10.4 | 31.2 |
| Family Iospilidae | | 2.6 | | | | | | | | 2.6 | | |
| Family Alciopidae | | | | 5.2 | | | | | | 5.2 | | |
| *Vanadis studeri* Apstein, 1893 | | | | | | | | | | | | 5.2 |
| *Vanadis* sp. | 15.6 | 2.6 | 10.4 | | 5.2 | 2.6 | 2.6 | | 2.6 | 2.6 | 15.6 | 10.4 |
| Family Typhloscolecidae | | | 2.6 | | 15.6 | | | | | 5.2 | 2.6 | 10.4 |
| *Typhloscolex grandis* Stop-Bowitz, 1948 | | | | | | | | 5.2 | | | | |
| *Travisiopsis lobifera* Levinsen, 1885 | | 2.6 | 2.6 | | | 26 | | | | | 2.6 | |
| Family Lopadorhynchidae | | | | | | | | | 15.6 | 5.2 | 2.6 | |
| *Pelagobia serrata* Southern, 1909 | 44.2 | 5.2 | 62.4 | 31.2 | 46.8 | 5.2 | | | | 26 | 15.6 | 52 |
| *Maupasia caeca* Viguier, 1886 | 2.6 | | | 5.2 | | | | | | | 2.6 | |
| Class Turbellaria | | | | | | 2.6 | | | | | | |
| Class Crustacea | | | | | | | | | | | | |
| Order Ostracoda | 317 | 138 | 265 | 93.5 | 57.2 | 67.6 | 135 | 26 | 80.6 | 98.7 | 125 | 114 |
| Class Gastropoda | | | | | | | | | | | | |
| Order Pteropoda | 18.2 | 5.2 | 26 | | 15.6 | 36.4 | 5.2 | | | 5.2 | | 52 |



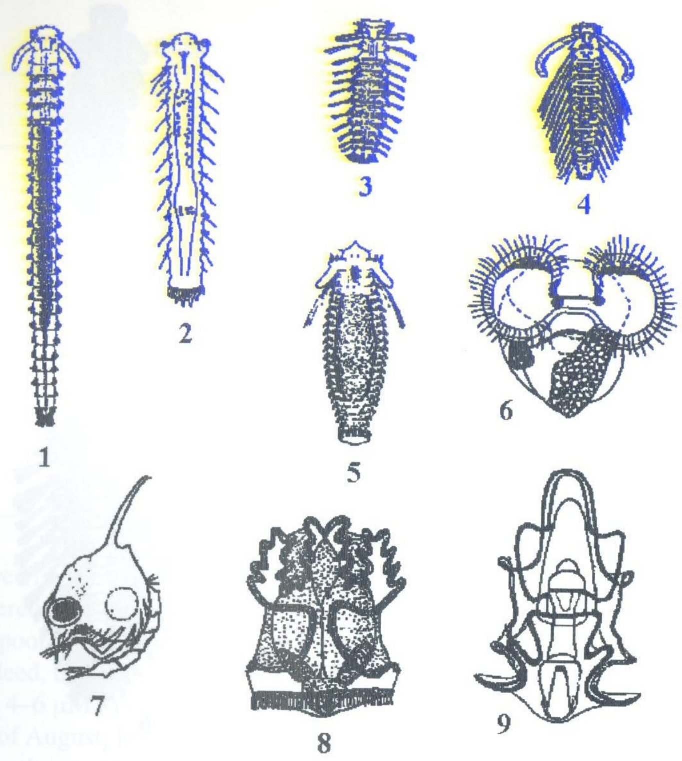

Fig. 2. Pelagic larvae of the benthic invertebrates. The nectochaetes of class Polychaeta: 1—*Prionospio malmgreni*, 2—*P. caspersi*. 3—*Scolelepis fuliginosa*, 4—*Microspio mecznikowianus*, 5—*Nerine cirratulus*, 6—veliger of *Limopontia capitata* (class Gastropoda), 7—zoea of family Grapsidae (Decapoda), 8—tornaria of class Enteropneusta, 9—bipinnaria of class Asteroidea ( 1, 3–5 from Bhaud and Cazaux (1982); 2—from Guerin (1970); 1, 8, 9 from Rose (1957); 7—original).

oughly mixed down to the bottom. Total number of individuals reached a maximum of 623 indviduals/m$^2$ during February and, on the average, abundance was highest during winter compared to the other seasons. In addition, maximal meroplankton abundance totalling 457 individuals/m$^2$ within the 0–100-m layer was recorded during this month. Community diversity was low during December (species richness **d** = 2.5, see Table 2) but high during January (**d** = 4.3). Highest diversity was observed in January with 15 families. Despite this high figure, both the Shannon and Evenness indices remained low in this month as almost more than half of the population belonged to order Ostracoda.

Highly diverse meroplankton composition including 5 phyla, 9 classes, and 20 families was observed during spring (March, April, and May). Total meroplankton abundance was low during March (135 individuals/m$^2$), much higher during April (327 individuals/m$^2$), and was highest during May (384 individuals/m$^2$). Predominance of the polychaete larvae in April (comprised 38% of total meroplankton) and May (45%)

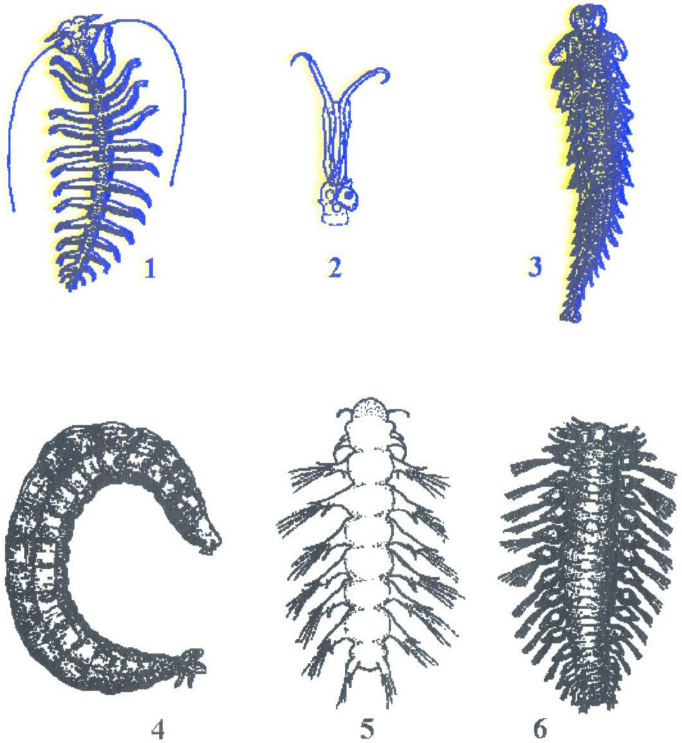


Fig. 3. Pelagic polychaetes: 1—*Tomopteris elegans*, 2—*Vanadis studeri*, 3—*Travisiopsis lobifera*, 4—*Typhloscolex grandis*, 5—*Pelagobia serrata*, 6—*Maupasia caeca* (1, 3, 4, 6 from Stop-Bowitz (1977); 2 and 5 original).

was a distinguishing feature. Nectochaetes of family Spionidae (especially of genus *Prionospio*) outnumbered (156 individuals/m$^2$) the meroplankton during May. During spring, pelagic polychaetes composed of 4 families, 5 genera, and 3 species. Pelagic polychaetes identified to species level were *Travisiopsis lobifera*, *Pelagobia serrata*, and *Maupasia caeca*. Having 265 individuals/m$^2$ Ostracoda made a significant contribution to the fauna in March. Overall, community diversity was highest during the spring (Margalef's Index **d** = 4.3, 5.4, and 5.6 for March, April, and May, respectively).

Summer meroplankton were composed of 4 phyla, 7 classes, and 15 families. Pelagic polychaetes were represented by 4 families and 6 species. The total population abundance remained lowest during this warm period compared to the rest of the year. Especially, the population abundance was found to be lowest (96 individuals/m$^2$) during August. Total number of only 8 taxa were identified during this month. This eventually led to a sudden decrease in species diversity from June and July to August (Margalef's Index **d** = 3.5, 3.7, and 1.9 for June, July, and August, respectively). Starting from early July, 38.9 salinity waters occupied the entire shelf area indicating an intense advection of nutrient-rich Atlantic deep waters to the region. Extremely high nitrate levels (up to 2



Table 2
Monthly changes in community diversity indices in the region

| Month | Total individual abundance/m$^2$ | Total # taxa and species | Richness **d** | Shannon **H′** | Evenness **J′** |
|---|---|---|---|---|---|
| January | 548 | 24 | 4.3 | 1.8 | 0.6 |
| February | 623 | 22 | 3.8 | 2.3 | 0.7 |
| March | 535 | 24 | 4.3 | 2.0 | 0.6 |
| April | 473 | 29 | 5.4 | 2.6 | 0.8 |
| May | 566 | 31 | 5.6 | 2.8 | 0.8 |
| June | 309 | 18 | 3.5 | 2.4 | 0.8 |
| July | 327 | 19 | 3.7 | 2.0 | 0.7 |
| August | 96 | 8 | 1.9 | 1.6 | 0.8 |
| September | 319 | 17 | 3.3 | 2.1 | 0.8 |
| October | 265 | 21 | 4.3 | 2.3 | 0.8 |
| November | 221 | 11 | 2.3 | 1.6 | 0.7 |
| December | 462 | 14 | 2.5 | 2.1 | 0.8 |

μM) observed in the whole water column between 15 July and 25 August in shelf waters was considered a unique event for the region. In general, the basin waters are regarded as nutrient poor and the average nitrate concentration for the surface waters is around 0.2 μM. Indeed, this low-salinity water in the Levantine basin may hold elevated nitrate levels up to 4–6 μM (Yilmaz and Tuğrul, 1998). This water mass remained in the basin till the end of August, leading to a "high nutrient, low chlorophyll" case. This was also evident from the very low total chlorophyll *a* concentrations (< 0.2 μg/l), the low total suspended sediment contents (average 3.9 mg/l), and the very high secchi depth readings (average 31 m) observed during this period (Fig. 4). As these water masses were advected from deep below the euphotic zone far offshore, they eventually contain relatively poor and distinct fauna than compared to the shelf waters. Decapod larvae contributed much to the total abundance during July, and zoeas composed only 45% of the total number of meroplankton in June and 70% in July, and finally disappeared totally in August. Among the polychaete species, *Tomopteris elegans* (47 individuals/m$^2$) and *Travisiopsis lobifera* (26 individuals/m$^2$ ) were dominant in June. Abundance of Ostracoda and Pteropoda remained lower compared to the levels attained in winter and spring.

Taxonomic composition of the autumn meroplankton contained 5 phyla, 6 classes, and 10 families. The dominating groups were nectochaetes of genus *Prionospio* and zoea of family Grapsidae. Genus *Prionospio* itself formed 40% of total meroplankton abundance during autumn. In September, almost half of the pelagic larvae were composed of polychaetes and decapods. A gradual decrease in total abundance was observed from September to November in this season. Polychaete *Pelagobia serrata* was most abundant in October (26 individuals/m$^2$) and November (16 individuals/m$^2$). The abundance of Ostracoda was insignificant. The community was found to be more diverse in October than in November (Margalef's Index **d** values are 3.3, 4.3, and 2.3 for September, October, and November, respectively).

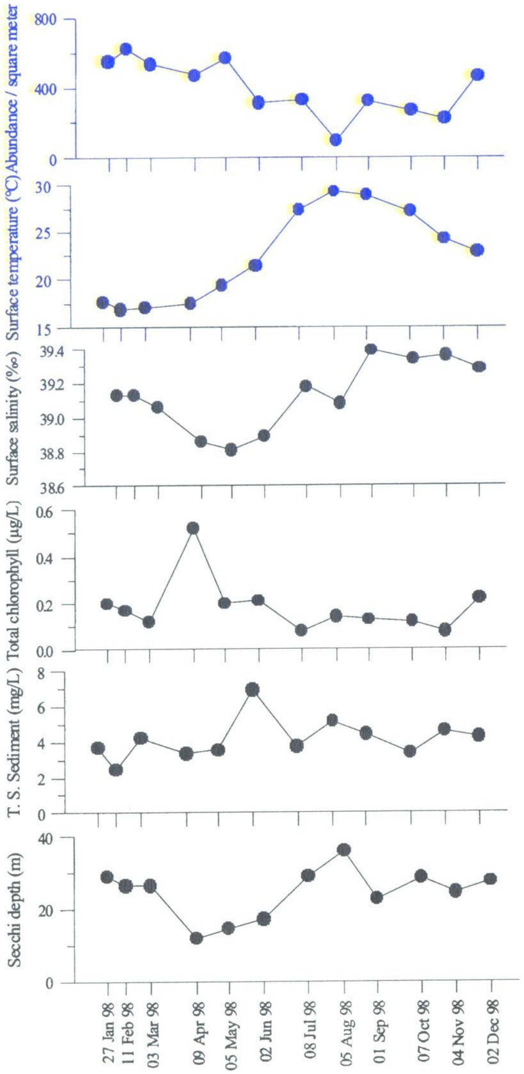


Fig. 4. Monthly changes in the population total abundance, surface temperature, salinity, chlorophyll, total suspended sediment, and Secchi depth at the sampling station.

Taxonomic composition of the meroplankton and pelagic polychaetes of the Cilician basin shelf waters displayed considerable monthly changes throughout the year. Figure 5 is a dendogram showing monthly affinities based on the abundance of all taxa and species identified, using the Bray–Curtis measure of similarity. In the figure, the dashed line drawn at the arbitrary similarity level of 43% delineated 5 main groups. The largest,



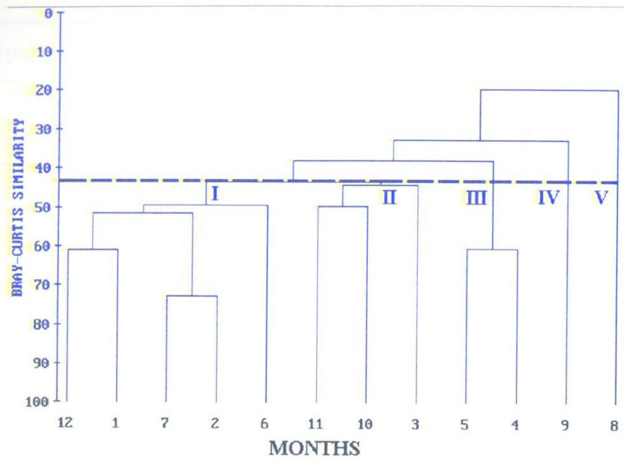


Fig. 5. Dendogram showing classification of the monthly populations with five major clusters distinguished at an arbitrary similarity level of 43 %. (1 denotes January, 12 denotes December).

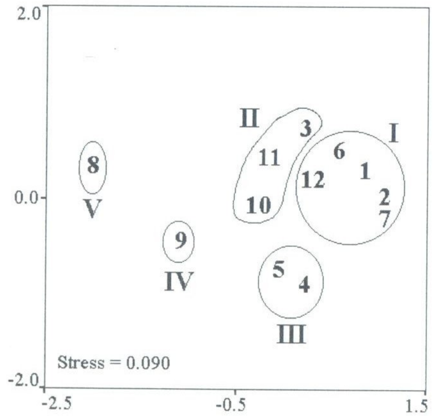


Fig. 6. Two-dimensional non-metric MDS ordination of monthly meroplankton assembleges.

group I, comprised the whole winter period (December, January, and February) and part of the summer months (June and July). Group II includes both the late autumn and early spring populations. Group III is composed solely of the spring months April and May. Being the smallest of all, groups IV and V represented the much warmer late summer, early autumn periods. All of these five groups and associated physical parameters were ordinated by means of MDS to conform to groups defined from the dendogram (Figs. 6, 7a,b). Similar to the dendogram, results of multivariate analysis (Multi-Dimensional Scaling) have shown that the late summer community composition varied much from the rest of the periods (Fig. 6). As described above, this was mainly due to the intrusion

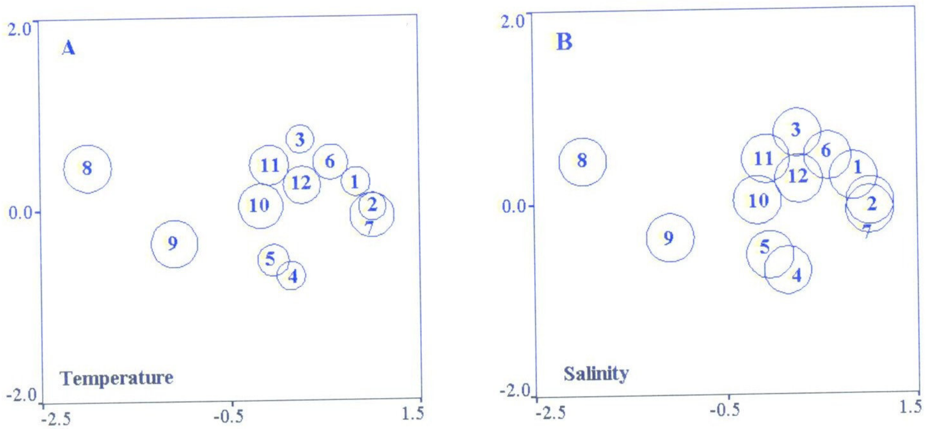


Fig. 7. MDS of 12 months with values of (a) surface temperature ranging between minimum16.88 °C in February and maximum 29.29 °C in August); (b) surface salinity ranging between minimum 38.81 in May and maximum 39.39 in September) superimposed for each month.

of deep Atlantic waters to the shelf area during this period. MDS plots of superimposed values of surface temperature (Fig. 7a) and surface salinity (Fig. 7b) indicated that temperature rather than salinity was more effective in controlling the abundance and diversity in the region. The highest affinity observed between February and July is noteworthy despite the apparent temperature contrast (Fig. 7b). Surface temperature ranged between 16.88 and 29.29 °C, being lowest in March and highest in August 1998. Throughout the study period, the surface salinity varied between 38.81 and 39.39 ppt, being lowest in May and highest in September 1998.

Species clustering or ordination is generally less informative than methods that highlight species that contribute to patterns of sample clustering or ordination. For this, discriminating species between and within the groups responsible for such distribution are tabulated in Tables 3 and 4. The first five dominant species that contribute much to similarity within groups are listed in Table 3. Higher species contribution ($\bar{S}_i$) and ratio {$\bar{S}_i$/SD($S_i$)} highlight species consistently prominent in a given group. Table 3 indicates that order Ostracoda, family Grapsidae, *Tomopteris elegans*, species of Decapoda, and order Pteropoda, with higher ratios, contributed much to the similarity in the first group. In the second group, order Ostracoda, *Pelagobia serrata*, *Prionospio* sp., Decapoda, and *Vanadis* sp. were consistently prominent.

Species displaying a major role in discriminating groups are given in Table 4. Group II is separated from group I, lacking family Grapsidae, family Xanthidae, and *Hippolyte* sp. *Prionospio* sp. was consistently prominent in the second group. Similarly, group I is separated from group III, missing Bivalvia, *Prionospio* sp, family Sabellariidae, and *Tomopteris* sp. *Tomopteris elegans* was totally absent in group III and consistently present in the first group.



Table 3
Species contributions ($\bar{S}_i$) to average similarities ($\bar{S}$) within groups

| Group | $\bar{S}$* | Species | $\bar{S}_i$ | SD($S_i$) | $\bar{S}_i$/SD($S_i$) | $\Sigma\bar{S}_i$% |
|---|---|---|---|---|---|---|
| I | 53.9 | Ostracoda | 8.8 | 0.9 | 9.9 | 16.3 |
| | | Family Grapsidae | 5.1 | 1.0 | 4.9 | 25.6 |
| | | *Tomopteris elegans* | 5.0 | 1.1 | 4.8 | 34.9 |
| | | Decapoda | 5.0 | 0.7 | 7.4 | 44.2 |
| | | Pteropoda | 4.8 | 1.3 | 3.9 | 53.1 |
| II | 46.2 | Ostracoda | 10.2 | 1.7 | 5.9 | 21.9 |
| | | *Pelagobia serrata* | 6.5 | 0.7 | 9.7 | 36.1 |
| | | *Prionospio* sp. | 6.3 | 1.0 | 6.1 | 49.7 |
| | | Decapoda | 5.2 | 1.1 | 4.6 | 60.9 |
| | | *Vanadis* sp. | 4.6 | 1.3 | 3.6 | 70.8 |

* $\bar{S}$ = Average similarity within the group. Groups III, IV, and V are missing because they do not have enough sub-members for comparison.

Table 4
Species contribution ($\bar{\delta}_i$) to total average dissimilarity ($\bar{\delta} = \Sigma\bar{\delta}_i$) between all groups

| Group | $\bar{\delta}$* | Species | $\bar{\delta}_i$ | SD($\delta_i$) | $\bar{\delta}_i$/SD($\delta_i$) | $\Sigma\bar{\delta}_i$ % |
|---|---|---|---|---|---|---|
| I & II | 56.3 | Family Grapsidae | 2.8 | 1.7 | 1.6 | 5.0 |
| | | *Prionospio* sp. | 2.5 | 1.2 | 2.1 | 9.4 |
| | | Family Xanthidae | 2.1 | 1.3 | 1.7 | 13.2 |
| | | *Hippolyte* sp. | 2.1 | 1.2 | 1.7 | 16.8 |
| | | *Prionospio caspersi* | 1.9 | 1.9 | 1.0 | 20.2 |
| I & III | 62.7 | Bivalvia | 3.4 | 0.7 | 4.7 | 5.4 |
| | | *Prionospio* sp. | 2.4 | 1.1 | 2.3 | 9.2 |
| | | *Tomopteris elegans* | 2.3 | 0.5 | 4.3 | 12.9 |
| | | Family Sabellariidae | 2.2 | 0.7 | 3.4 | 16.5 |
| | | *Tomopteris* sp. | 2.1 | 0.1 | 15.5 | 19.8 |
| II & III | 60.6 | Bivalvia | 3.9 | 0.5 | 8.1 | 6.4 |
| | | Family Sabellariidae | 2.4 | 0.8 | 3.1 | 10.3 |
| | | *Microspio mecznikowianus* | 2.0 | 0.4 | 5.4 | 13.5 |
| | | *Retusa truncatella* | 1.9 | 0.3 | 7.6 | 16.7 |
| | | *Spio filicornis* | 1.8 | 0.2 | 7.8 | 19.6 |
| I & IV | 70.6 | Family Grapsidae (zoea) | 4.5 | 0.4 | 11.2 | 6.4 |
| | | Family Grapsidae | 3.5 | 1.2 | 3.0 | 11.3 |
| | | *Tomopteris elegans* | 3.2 | 0.8 | 3.9 | 15.8 |
| | | Pteropoda | 3.1 | 1.0 | 3.1 | 20.2 |
| | | Decapoda | 3.0 | 0.5 | 5.9 | 24.5 |

*table continues next page*

Table 4—*continued*

| Group | $\bar{\delta}$ * | Species | $\bar{\delta}_i$ | SD($\delta_i$) | $\bar{\delta}_i$/SD($\delta_i$) | $\Sigma\bar{\delta}_i$ % |
|---|---|---|---|---|---|---|
| II & IV | 64.8 | Family Grapsidae (zoea) | 4.9 | 0.9 | 5.3 | 7.5 |
| | | *Pelagobia serrata* | 3.8 | 0.3 | 14.0 | 13.3 |
| | | *Prionospio caspersi* | 3.1 | 1.3 | 2.4 | 18.1 |
| | | Decapoda | 3.0 | 0.9 | 3.4 | 22.6 |
| | | *Harmothoe imbricata* | 2.7 | 0.5 | 5.3 | 26.8 |
| III & IV | 62.5 | Bivalvia | 3.9 | 0.1 | 32.3 | 6.3 |
| | | Family Grapsidae (zoea) | 3.5 | 0.2 | 18.7 | 11.9 |
| | | Family Lopadorhynchidae | 2.4 | 0.1 | 18.7 | 20.4 |
| | | *Harmothoe imbricata* | 2.0 | 0.1 | 18.7 | 23.6 |
| | | *Microspio mecznikowianus* | 2.0 | 0.3 | 5.7 | 26.7 |
| I & V | 84.7 | Family Grapsidae | 4.7 | 1.5 | 3.1 | 5.6 |
| | | *Tomopteris elegans* | 4.3 | 1.2 | 3.7 | 10.6 |
| | | Pteropoda | 4.2 | 1.4 | 2.9 | 15.6 |
| | | Decapoda | 4.1 | 0.7 | 5.8 | 20.4 |
| | | *Prionospio* sp. | 4.0 | 2.1 | 1.9 | 25.2 |
| II & V | 74.9 | *Pelagobia serrata* | 5.2 | 0.6 | 8.1 | 7.0 |
| | | Decapoda | 4.2 | 1.5 | 2.7 | 12.5 |
| | | *Vanadis* sp. | 3.9 | 1.8 | 2.2 | 17.8 |
| | | *Typhloscolex grandis* | 3.5 | 0.9 | 3.7 | 22.4 |
| | | Holothuroidea | 3.5 | 0.9 | 3.7 | 27.0 |
| III & V | 81.4 | Bivalvia | 4.9 | 0.2 | 22.4 | 6.1 |
| | | *Pelagobia serrata* | 3.7 | 0.02 | 223.2 | 10.6 |
| | | Gastropoda | 3.5 | 0.03 | 129.6 | 14.9 |
| | | Family Sabellariidae | 3.0 | 1.2 | 2.5 | 18.5 |
| | | *Tomopteris* sp. | 2.8 | 0.01 | 223.2 | 21.9 |

* $\bar{\delta}$ = Average dissimilarity within the groups.

## CONCLUSION

Taxonomic composition of the meroplankton and the pelagic polychaetes of the Cilician basin shelf waters was investigated for the first time. Meroplankton and the pelagic polychaetes of the Cilician basin were represented under 5 phyla, 10 classes, and 34 families during 1998. Pelagic nectochaete larvae of the family Spionidae (Polychaeta) and zoeas of family Grapsidae (Decapoda) were the dominant groups throughout the year. The presence of trochophora, metatrochophora, nectochaeta, rostraria larvae of Polychaeta; ophiopluteus, echinopluteus, auricularia, doliolaria, pentactula, bipinnaria, brachiolaria larvae of Echinodermata; zoea, mysis, megalopa larvae of Decapoda; nauplius, cypris larvae of Cirripedia; tornaria of Enteropneusta; and actinotrocha larvae of Phoronidea makes the basin waters remarkably species diverse. Diversity was highest during the



spring (Margalef's Index **d** = 4.3, 5.4, and 5.6 for March, April, and May, respectively) and lowest during August (**d** = 1.9) and November (**d** = 2.3). A distinct summer population was observed due to replenishment of the shelf waters with less saline, nutrient-rich Atlantic deep waters. Among the ambient factors, temperature rather than salinity was found to be more effective in controlling the meroplankton abundance and diversity in the region.

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