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# Seasonal analysis of polychaetes from the Gediz River Delta (Izmir Bay, Aegean Sea)

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*Spatial and temporal distributions of polychaetes inhabiting the Gediz River Delta were studied seasonally at 11 stations during summer 1998 - spring 1999. A total of 83 species belonging to 31 families were encountered, of which* Micronephthys maryae *SAN MARTÍN, 1982,* Prionospio multibranchiata *BERKELEY, 1927 and* Aricidea claudiae *LAUBIER, 1967 were new records for the Turkish fauna. Among the families, Spionidae ranked first in terms of number of species (14 species, 17% of the total number of species) and individuals (3922 individuals, 48% of the total number of individuals). The Gediz River Delta was mainly dominated by* Capitella capitata *(FABRICIUS, 1780),* Polydora ciliata *(JOHNSTON, 1838),* Streblospio shrubsolii *(BUCHANAN, 1890),* Spio decoratus *BOBRETZKY, 1870,* Heteromastus filiformis *(CLAPARÈDE, 1864) and* Hediste diversicolor *(O. F. MÜLLER, 1776). Species assemblages in the area and variations in community indices at stations with respect to seasons were determined and discussed.*

**Key words:** Polychaeta, seasonal analysis, species associations, pollution, Aegean Sea

## INTRODUCTION

The Gediz River Delta, which covers almost a total area of 20400 ha, is one of the biggest deltas in Turkey. In the past, the river waters poured into the inner part of Izmir Bay through the two main branches (Fig. 1), but because of the river's high alluvium capacity, it had been foreseen that the shallow inner bay would pose a danger of filling by sediments, so the river bed was changed to the present situation in 1886 by establishing a canal. Involving many marshy grounds, saltpans, drainage channels and streams, the Delta is of great ecological and economical importance. Since the Gediz Plain is intensively subjected to farming and industrialization, the river has been dramatically polluted. The Gediz River, which enters the outer part of the Izmir Bay, contributes considerably to the prevailing pollution in Izmir Bay. It is well known that such disturbed areas receive dense populations of some opportunistic animals, particularly polychaetes (REISH, 1955; PEARSON and ROSENBERG, 1978). In order to establish a feasible and effective pollution-monitoring program, it is prerequisite that the actual status and seasonal dynamics of the most characteristic

biota, particularly benthic polychaetes, should be examined.

Concerning bottom fauna of river Deltas in the Mediterranean Sea, there has been a restricted number of studies, with available information given by AMBROGI and BEDULLI (1981), AMBROGI *et al.* (1983), GOUVIS and KOUKOURAS (1993), GOUVIS *et al.* (1997) and ERGEN *et al.* (1998).

The present study elucidates spatial and temporal variations of polychaete communities inhabiting the Gediz River Delta, and constitutes an initial fauna database for monitoring the area, which is subject to both domestic and industrial pollution.

## MATERIAL AND METHODS

The investigated area is located in the northern part of Izmir Bay (eastern Aegean Sea). A total of 11 stations, located in the opening of the Gediz River (station 1), the lagoons (stations 2, 4, 7 and 10), the old branch of the Gediz River (station 9) and the marine sites (stations 3, 5, 6, 8 and 11) close to the lagoons (depths ranging from 0.3 to 2.5 m), were sampled seasonally during July 1998 - April 1999 by a grab sampling ca. 225 $cm^{-2}$ area (Fig. 1, Table 1). Samples were sieved through 0.5 mm mesh, and the retained fauna was placed in separate jars containing 4% seawater formaldehyde solution. In the laboratory, samples were rinsed in freshwater and sorted according to taxonomic groups and preserved in 70% ethanol. Afterwards polychaetes were identified and counted under stereo- and compound microscopes.

Polychaetes were identified mainly according to FAUVEL (1923, 1927), DAY (1967), FAUCHALD (1977) and BIANCHI (1981).

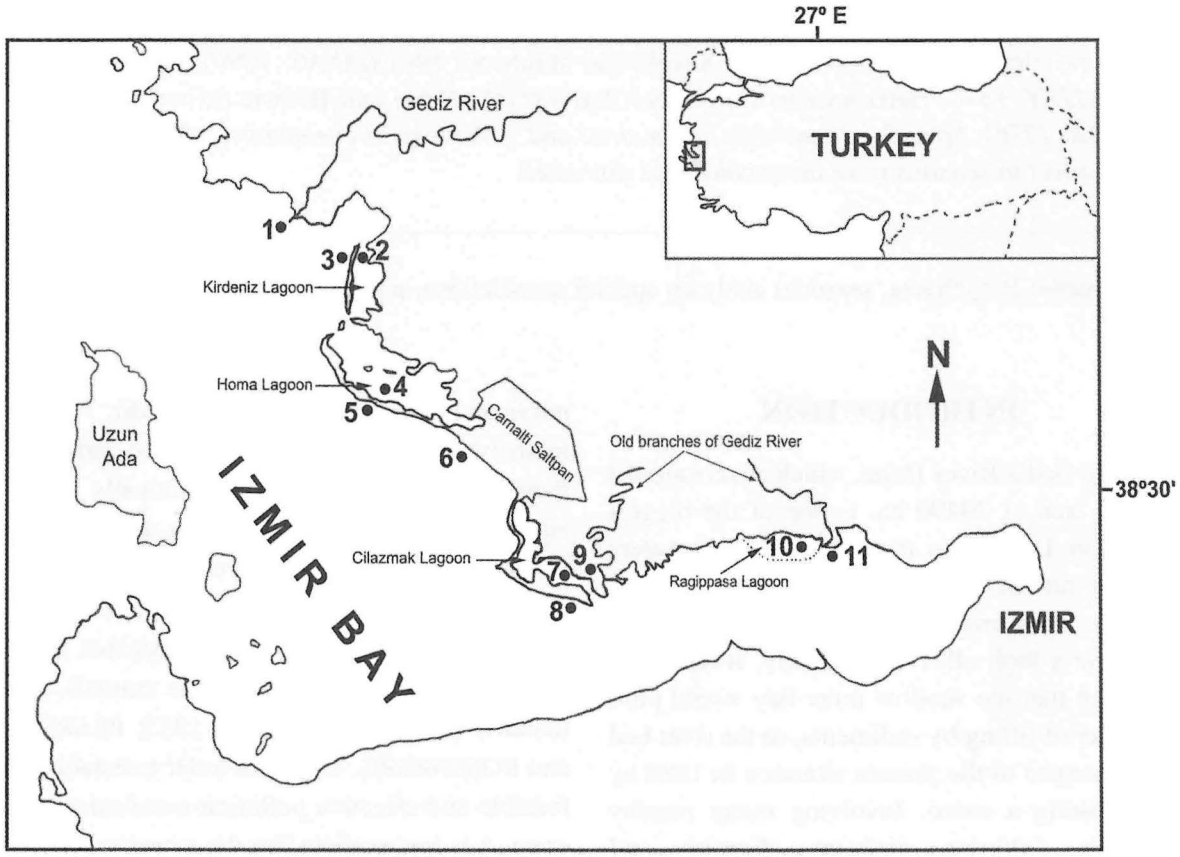


*Fig. 1. Map of the investigated area with location of sampling sites*

*Table 1. Depths, biotope structures, localities and coordinates of stations*

| Station | Co-ordinates | Depth (m) | Biotope | Locality |
|---|---|---|---|---|
| 1 | 38°35'10"N 26°48'53"E | 1 | Mud | Opening of the Gediz River |
| 2 | 38°33'28"N 26°49'59"E | 0.4 | Mud | Kirdeniz Lagoon |
| 3 | 38°33'21"N 26°49'39"E | 0.4 | Muddy sand | Off Kirdeniz Lagoon |
| 4 | 38°31'25"N 26°50'33"E | 0.4 | Mud | Homa Lagoon |
| 5 | 38°31'39"N 26°50'42"E | 2.5 | Muddy sand | Off Homa Lagoon |
| 6 | 38°29'04"N 26°54'42"E | 2.5 | Muddy sand | Off Camalti Saltpan |
| 7 | 38°28'00"N 26°55'22"E | 0.5 | Mud | Cilazmak Lagoon |
| 8 | 38°25'58"N 26°56'54"E | 2.5 | Muddy sand | Off Cilazmak Lagoon |
| 9 | 38°27'06"N 26°57'05"E | 0.3 | Mud | Old branch of the Gediz River |
| 10 | 38°27'37"N 27°02'22"E | 0.3 | Mud | Ragippasa Lagoon |
| 11 | 38°27'40"N 27°02'32"E | 1 | Muddy sand | Off Ragippasa Lagoon |

Temperature and salinity parameters of the surface water of stations were measured in the field.

In order to interpret the qualitative and quantitative data, SOYER's (1970) Frequency Index, SHANNON-WEAVER's (1949) Diversity Index (*H'*) and PIELOU's (1975) Evenness Index (*J'*) were applied to the presence, absence and abundance of the species. After the raw numerical data of seasonal samples were transformed by the logarithmic transformation, yji= log (xji+1), the BRAY- CURTIS (1957) Similarity Index was calculated.

## RESULTS

Temperature values greatly varied among seasons and ranged from 9.5 °C (station 3, winter) to 30.6 °C (station 11, summer) (Table 2). Salinity values also varied among stations and seasons. A big fluctuation in the salinity value was estimated at station 1 (0.44 psu in winter, 35.9 psu in summer), which is greatly affected by the water regime of the Gediz River. Similar fluctuations were also observed in the shallow lagoons, where the water circulation was weak. In the Homa Lagoon (station 4), the salinity value attained its highest score (44 psu).

*Table 2. Seasonal trends of the temperature and salinity values of surface waters of stations*

| Stations | Temperature (°C) | | | | Salinity (psu) | | | |
|---|---|---|---|---|---|---|---|---|
| | Summer 1998 | Autumn 1998 | Winter 1999 | Spring 1999 | Summer 1998 | Autumn 1998 | Winter 1999 | Spring 1999 |
| 1 | 27.6 | 21.0 | 10.0 | 18.8 | 35.9 | 19.49 | 0.44 | 10.8 |
| 2 | 28.6 | 18.5 | 10.5 | 21.8 | 38.4 | 33.53 | 32.1 | 27.2 |
| 3 | 28.6 | 18.0 | 9.5 | 22.0 | 38.4 | 32.73 | 31.6 | 25.2 |
| 4 | 27.8 | 19.0 | 10.3 | 20.3 | 41.4 | 44.0 | 32.5 | 29.8 |
| 5 | 25.6 | 19.6 | 11.0 | 20.1 | 38.6 | 36.0 | 32.7 | 34.1 |
| 6 | 28.0 | 19.3 | 11.3 | 21.0 | 38.6 | 34.6 | 33.9 | 34.6 |
| 7 | 30.0 | 22.3 | 11.6 | 23.0 | 38.5 | 34.4 | 31.4 | 35.0 |
| 8 | 27.6 | 20.5 | 11.5 | 20.5 | 38.4 | 32.5 | 33.03 | 33.2 |
| 9 | 28.8 | 20.5 | 11.0 | 22.3 | 37.9 | 35.2 | 16.4 | 21.2 |
| 10 | 31.0 | 20.5 | 14.6 | 26.0 | 33.6 | 33.1 | 21.36 | 34.6 |
| 11 | 30.6 | 20.0 | 11.6 | 22.3 | 26.4 | 31.4 | 22.45 | 30.7 |

A total of 83 polychaete species and 8029 specimens belonging to 31 families were identified in the Gediz River Delta (Table 3). *Micronephthys maryae*, *Prionospio multibranchiata* and *Aricidea claudiae* are new records for the Turkish polychaete fauna.

*Table 3. List of polychaete species found and their presence and total number of individuals at each station*

| Species | STATIONS 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PHYLLODOCIDAE | | | | | | | | | | | |
| *Eumida* cf. *sanguinea* ØRSTED, 1843 | - | - | - | - | - | 1 | - | - | - | - | - |
| *Eulalia* sp. | - | - | 1 | - | - | 1 | - | - | - | - | - |
| *Phyllodoce* cf. *maculata* (LINNE, 1767) | - | - | - | - | - | 1 | - | - | - | - | - |
| *Mysta picta* (QUATREFAGES, 1865) | - | - | - | 4 | - | 1 | - | - | - | - | - |
| HESIONIDAE | | | | | | | | | | | |
| *Ophiodromus pallidus* (CLAPARÈDE, 1864) | - | - | 1 | - | - | 1 | - | 3 | - | - | 3 |
| PILARGIDAE | | | | | | | | | | | |
| *Sigambra tentaculata* (TREADWELL, 1941) | - | - | - | 3 | 97 | 6 | - | 20 | - | - | - |
| SYLLIDAE | | | | | | | | | | | |
| *Proceraea picta* EHLERS, 1864 | - | - | - | - | - | 1 | - | - | - | - | - |
| *Pionosyllis* sp. | 1 | - | - | 1 | - | 6 | - | - | - | - | - |
| *Exogone* (*Exogone*) *naidina* (ØRSTED, 1845) | - | - | 1 | 1 | 1 | 4 | - | - | - | - | - |
| *Exogone* (*Exogone*) *dispar* (WEBSTER, 1879) | - | - | - | - | - | 5 | - | - | - | - | - |
| *Exogone* sp. | - | - | - | - | - | 2 | - | - | - | - | - |
| *Grubeosyllis clavata* (CLAPARÈDE, 1863) | - | - | 1 | - | - | - | - | - | - | - | - |
| *Sphaerosyllis hystrix* CLAPARÈDE, 1863 | - | - | - | - | - | 4 | - | - | - | - | - |
| *Sphaerosyllis pirifera* CLAPARÈDE, 1868 | - | - | - | - | 3 | 9 | - | - | 1 | - | - |
| *Syllis armillaris* (O. F. MÜLLER, 1776) | - | - | - | - | - | 2 | - | - | - | - | - |

*Table 3. cont'd*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NEREIDIDAE | | | | | | | | | | | |
| *Hediste diversicolor* (O. F. MÜLLER, 1776) | 4 | 8 | 3 | 25 | - | - | 144 | - | 113 | 51 | - |
| *Neanthes caudata* (Delle CHIAJE, 1828) | - | 2 | - | 2 | - | 3 | 1 | - | - | 1 | - |
| *Neanthes succinea* (FREY & LEUCKART, 1847) | - | - | - | - | - | - | - | - | 1 | - | - |
| *Nereis zonata* MALMGREN, 1867 | - | - | 1 | - | - | - | - | - | - | - | - |
| *Platynereis dumerilii* (AUD. & EDW., 1833) | - | - | - | - | 1 | 8 | - | - | - | - | - |
| *Nereis* sp.1 | - | - | 1 | - | - | - | - | - | - | - | - |
| *Nereis* sp.2 | - | - | - | 1 | - | - | - | - | - | - | - |
| NEPHTYIDAE | | | | | | | | | | | |
| *Micronephthys maryae* SAN MARTÍN, 1982 | - | - | - | - | 5 | 1 | - | - | - | - | - |
| *Nephtys hombergi* SAVIGNY, 1818 | - | - | - | - | 7 | 2 | - | 2 | - | - | - |
| *Nephtys* sp. | - | - | - | - | - | - | - | 1 | - | - | - |
| GLYCERIDAE | | | | | | | | | | | |
| *Glycera tridactyla* (SCHMARDA, 1861) | - | - | 4 | 11 | 5 | 5 | - | 5 | - | - | 3 |
| *Glycera rouxii* (AUDOUIN & EDW., 1833) | - | - | - | - | - | 2 | - | 1 | - | - | - |
| *Glycera* sp. | - | - | - | - | - | 2 | - | - | - | - | - |
| ONUPHIDAE | | | | | | | | | | | |
| *Diopatra neapolitana* Delle CHIAJE, 1841 | - | - | - | - | - | - | - | - | - | 1 | - |
| EUNICIDAE | | | | | | | | | | | |
| *Eunice vittata* (Delle CHIAJE, 1829) | - | - | - | - | - | 2 | - | - | - | - | - |
| *Nematonereis unicornis* GRUBE, 1840 | - | - | - | - | - | 1 | - | - | - | - | - |
| LUMBRINERIDAE | | | | | | | | | | | |
| *Lumbrineris latreilli* AUD. & EDW., 1834 | - | - | - | - | 1 | 1 | - | - | - | - | - |
| *Lumbrineris gracilis* (EHLERS, 1868) | - | - | - | - | 3 | - | - | - | - | - | - |
| OENONIDAE | | | | | | | | | | | |
| *Drilonereis filum* (CLAPARÈDE, 1868) | - | - | - | - | - | 1 | - | - | - | - | - |
| DORVILLEIDAE | | | | | | | | | | | |
| *Schistomeringos rudolphi* (D. CHIAJE, 1828) | - | - | - | - | - | 4 | - | - | - | - | - |
| ORBINIIDAE | | | | | | | | | | | |
| *Scoloplos armiger* (O. F. MÜLLER, 1776) | - | - | - | - | 3 | - | - | - | - | - | - |
| PARAONIDAE | | | | | | | | | | | |
| *Aricidea assimilis* TEBBLE, 1959 | - | - | - | - | 16 | 1 | - | 1 | - | - | - |
| *Aricidea claudiae* LAUBIER, 1967 | - | - | - | - | 25 | 1 | - | - | - | - | - |
| *Aricidea* sp. | - | - | - | - | 6 | 2 | - | - | - | - | - |
| *Paradoneis lyra* (SOUTHERN, 1914) | - | 1 | - | - | 43 | 4 | 1 | - | - | - | - |
| SPIONIDAE | | | | | | | | | | | |
| *Aonides oxycephala* (SARS, 1862) | - | - | - | - | - | 1 | - | - | - | - | - |
| *Laonice cirrata* (SARS, 1851) | - | - | - | - | - | 1 | - | - | - | - | - |
| *Malacoceros fuliginosus* (CLAPARÈDE, 1868) | - | 8 | 235 | 27 | - | 39 | - | 1 | - | 59 | 30 |
| *Scolelepis cantabra* (RIOJA, 1918) | - | - | - | - | 2 | - | - | - | - | - | - |
| *Scolelepis* cf. *bonnieri* (MESNIL, 1896) | - | - | - | - | 1 | - | - | - | - | - | - |
| *Nerine* sp. | - | - | - | 1 | - | - | - | - | - | - | - |
| *Polydora ciliata* (JOHNSTON, 1838) | 24 | - | 12 | 68 | 11 | 20 | 2 | 12 | 9 | 1424 | 67 |
| *Paraprionospio pinnata* (EHLERS, 1901) | - | - | - | - | 1 | - | - | - | - | - | - |
| *Prionospio fallax* SÖDERSTRÖM, 1920 | - | - | 1 | - | 47 | 14 | - | 46 | - | - | - |
| *Prionospio multibranchiata* BERKELEY, 1927 | 1 | - | 2 | 35 | 44 | 10 | - | 116 | - | - | 1 |
| *Prionospio* sp. | - | - | - | 4 | 1 | - | - | - | - | - | 2 |
| *Spio decoratus* BOBRETZKY, 1870 | 113 | - | 27 | 138 | 17 | 5 | 4 | 319 | 8 | 10 | 31 |
| *Spio filicornis* (O. F. MÜLLER, 1776) | - | - | 1 | - | - | 1 | - | - | - | - | - |
| *Streblospio shrubsolii* (BUCHANAN, 1890) | 60 | - | 18 | 61 | 2 | - | 62 | - | 658 | - | 8 |
| CHAETOPTERIDAE | | | | | | | | | | | |
| *Spiochaetopterus costarum* (CLAPARÈDE, 1870) | - | - | - | - | 4 | - | - | - | - | - | - |

*Table 3. cont'd*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CIRRATULIDAE | | | | | | | | | | | |
| *Chaetozone* cf. *setosa* MALMGREN, 1867 | - | - | - | - | 6 | 10 | - | 2 | - | - | - |
| *Cirriformia tentaculata* (MONTAGU, 1808) | - | - | - | - | - | 4 | - | - | - | - | - |
| *Cirratulus* sp. | - | - | 1 | - | 9 | 5 | - | - | - | - | - |
| *Monticellina heterochaeta* LAUBIER, 1961 | - | 1 | 1 | - | 83 | 4 | - | 1 | - | - | - |
| CTENODRILIDAE | | | | | | | | | | | |
| *Ctenodrilus serratus* (SCHMIDT, 1857) | - | - | - | - | - | - | - | - | - | 4 | - |
| OPHELIIDAE | | | | | | | | | | | |
| *Ammotrypane* sp. | - | - | - | - | - | 1 | - | - | - | - | - |
| COSSURIDAE | | | | | | | | | | | |
| *Cossura* cf. *coasta* KITAMORI, 1960 | - | - | 1 | - | 92 | - | - | 13 | 1 | - | - |
| STERNASPIDAE | | | | | | | | | | | |
| *Sternaspis scutata* (RENIER, 1807) | - | - | - | - | 36 | - | - | - | - | - | - |
| CAPITELLIDAE | | | | | | | | | | | |
| *Capitella capitata* (FABRICIUS, 1780) | - | 6 | 44 | 44 | 16 | 157 | 1271 | 51 | 37 | 882 | 48 |
| *Pseudoleiocapitella fauveli* HARMELIN, 1964 | - | - | - | 1 | 12 | - | 1 | - | - | - | - |
| *Heteromastus filiformis* (CLAPARÈDE, 1864) | 2 | - | - | 29 | 243 | 37 | - | 92 | 2 | - | 1 |
| *Notomastus latericeus* SARS, 1851 | - | - | - | - | 2 | - | - | - | - | - | - |
| MALDANIDAE | | | | | | | | | | | |
| *Euclymene lumbricoides* QUATREFAGES, 1865 | - | - | - | - | - | 1 | - | - | - | - | - |
| *Euclymene* sp. | - | - | - | - | - | 2 | - | - | - | - | 2 |
| OWENIDAE | | | | | | | | | | | |
| *Owenia fusiformis* Delle CHIAJE, 1842 | - | - | - | - | 1 | 1 | - | - | - | - | - |
| SABELLARIIDAE | | | | | | | | | | | |
| *Sabellaria alveolata* (LINNE, 1767) | - | - | - | - | - | 4 | - | - | - | - | - |
| *Sabellaria spinulosa* LEUCKART, 1849 | - | - | - | - | 2 | 2 | - | - | - | - | - |
| PECTINARIIDAE | | | | | | | | | | | |
| *Pectinaria koreni* (MALMGREN, 1866) | - | - | - | 1 | - | - | 1 | - | - | - | - |
| AMPHARETIDAE | | | | | | | | | | | |
| *Melinna palmata* GRUBE, 1870 | - | - | 1 | - | 1 | 1 | - | - | - | - | - |
| TEREBELLIDAE | | | | | | | | | | | |
| *Terebella lapidaria* LINNE, 1767 | - | - | 1 | - | - | 2 | - | - | - | - | 1 |
| SABELLIDAE | | | | | | | | | | | |
| *Amphiglena mediterranea* (LEYDIG, 1851) | - | - | 1 | - | - | 1 | - | - | - | - | - |
| *Chone collaris* LANGERHANS, 1880 | - | - | - | - | - | 2 | - | - | - | - | - |
| SERPULIDAE | | | | | | | | | | | |
| *Hydroides elegans* (HASWELL, 1883) | - | - | - | - | - | 5 | 2 | - | - | - | 1 |
| *Hydroides dianthus* (VERRILL, 1873) | - | - | - | - | 1 | 1 | - | - | - | - | - |
| *Serpula concharum* LANGERHANS, 1880 | - | - | 1 | - | - | 3 | - | 1 | - | - | 4 |
| *Serpula vermicularis* LINNE, 1767 | - | - | - | - | - | 1 | - | - | - | - | - |
| *Vermiliopsis striaticeps* (GRUBE, 1862) | - | - | - | - | - | 3 | - | - | - | - | - |
| SPIRORBIDAE | | | | | | | | | | | |
| *Neodexiospira pseudocorrugata* (BUSH, 1904) | - | - | 1 | - | - | 2 | - | - | - | - | - |

Among families, Spionidae ranked first in terms of number of species (14 species, 17% of the total number of species) and individuals (3922 individuals, 48% of the total number of individuals) (Fig. 2a, b). Other families represented by a high number of individuals in the area were Capitellidae (2978 individuals, 37%), Nereididae (370 individuals, 5%) and Cirratulidae (127 individuals, 2%). The families Syllidae (9 species, 11% of total number of species) and Nereididae (7 species, 8%) also had a high number of species.

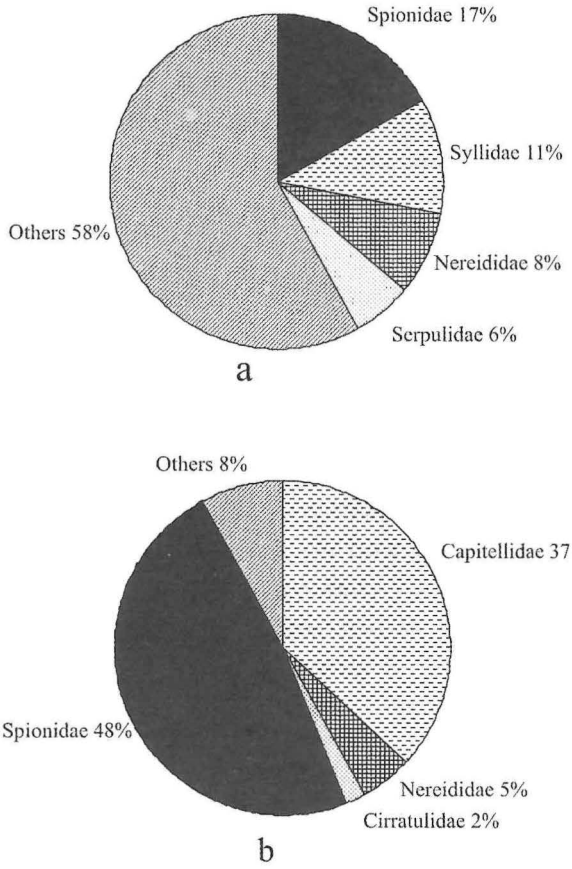


*Fig. 2. Relative dominance of the polychaete families by number of species (a) and individuals (b)*

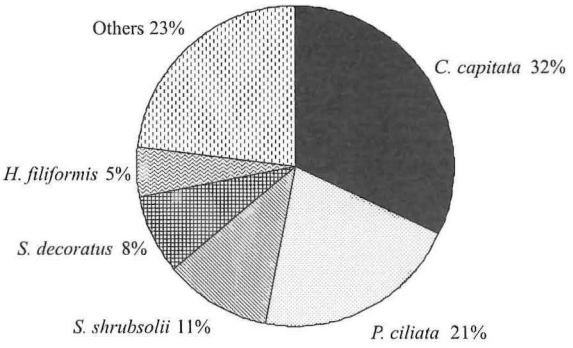


*Fig. 3. Relative dominance of the species in the Gediz River Delta*

The Gediz River Delta supported dense populations of *Capitella capitata* (32% of total number of specimens), *Polydora ciliata* (21%), *Streblospio shrubsolii* (11%), *Spio decoratus* (8%) and *Heteromastus filiformis* (5%) (Fig. 3). These dominant species accounted for up to 77% of the total number of individuals collected in the area in all seasons.

As for the Frequency-Index values, the following three species were recognised as Constant in the area: *S. decoratus* (75%), *C. capitata* (70%) and *P. ciliata* (61%). Eight species classified as Common were *Hediste diversicolor* (43%), *S. shrubsolii* (43%), *H. filiformis* (38%), *Prionospio multibranchiata* (39%), *Malacoceros fuliginosus* (36%), *Glycera tridactyla* (32%), *Prionospio fallax* (30%) and *Sigambra tentaculata* (27%). A total of 72 species were found to be rare in the area.

Population densities of several species considerably varied among seasons. Specimens keying out to *Capitella capitata* appeared to comprise only one species, which was encountered at all stations except for station 1. There were established dense populations at stations 3, 4, 6, 7, 8 and 10, and reached its maximum quantities at stations 7 (54780 ind. $m^{-2}$, winter), 10 (26180 ind. $m^{-2}$, spring; 10780 ind. $m^{-2}$, winter) and 6 (5852 ind. $m^{-2}$, autumn). In contrast to its high abundance level in the other seasons, this species suddenly disappeared in the samples collected in summer. The other abundant species in the area was *Polydora ciliata*, which particularly dominated station 10 (50820 ind. $m^{-2}$, winter; 10428 ind.$m^{-2}$, spring). Unlike *C. capitata*, it was able to build up a relatively dense population in summer (1584 ind. $m^{-2}$, station 11). However, *P. ciliata* occupied stations 4, 10 and 11, particularly in winter and spring. *Streblospio shrubsolii* was the other preferential species in the area and constituted dense populations at stations 7 and 9. Its maximum density was found at station 9 (14256 ind. $m^{-2}$, winter; 5280 ind. $m^{-2}$, spring; 5280 ind. $m^{-2}$, summer). Similar to *S. shrubsolii*, *Hediste diversicolor* also had high population densities at stations 7 (4400 ind. $m^{-2}$, autumn) and 9 (2992 ind. $m^{-2}$, winter). The species *Spio decoratus* and *Heteromastus filiformis* reached their maximum abundance levels at stations 8 (12580 ind. $m^{-2}$, winter) and 5 (6556 ind. $m^{-2}$, summer), respectively.

The highest number of specimens were found at station 10 in winter, with 66060 ind. $m^{-2}$ belonging to only 6 species, of which *Polydora ciliata* accounted for up to 79% of the total populations (Fig. 4). The following stations had dense polychaete populations: 7 (60570 ind. $m^{-2}$, autumn; *Capitella capitata* 92% of total number of individuals), 10 (39240 ind. $m^{-2}$, spring; *Capitella capitata* 68%) and 9 (18045 ind. $m^{-2}$, winter; *Streblospio shrubsoli* 81%). Stations 10, 2 and 3 had a small number of specimens in spring and summer.

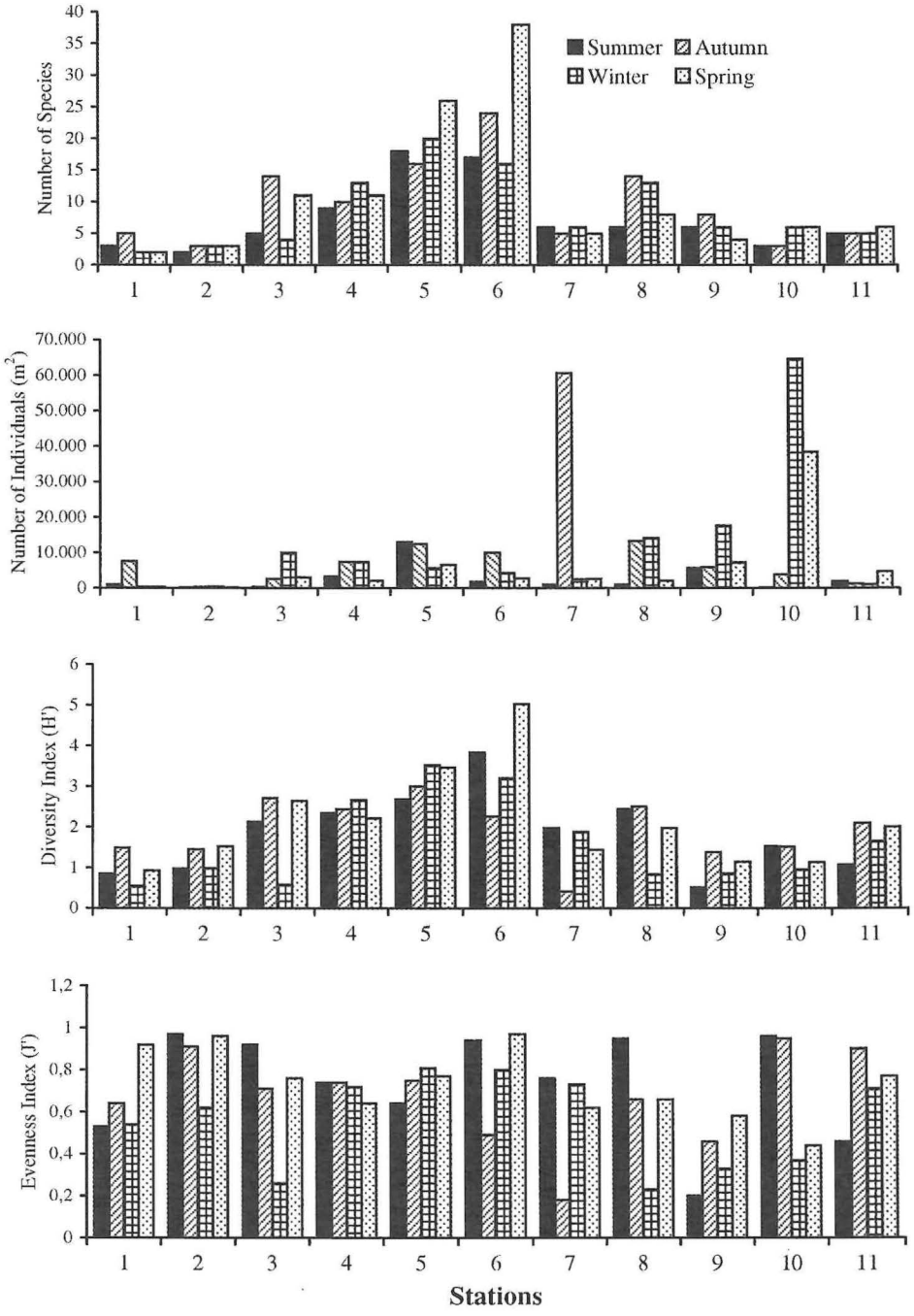


*Fig. 4. Seasonal fluctuations of number of species, number of individuals, Diversity Index (H') and Evenness Index (J') at stations*

The highest number of species were found at stations 6 (38 species, spring) and 5 (26 species, spring) (Fig. 4). Stations located at the opening of the Gediz River (station 1 in winter and spring) and the Kirdeniz Lagoon (station 2, in summer) had the lowest number of species. With respect to the abundance levels of the key species of the samples, the values of the Diversity and Evenness Indices varied among stations and seasons (Fig. 4). The Diversity Index values ranged from 0.41 (station 7, autumn) to 5.02 (station 6, spring) and Evenness values from 0.18 (station 7, autumn) to 0.97 (station 6, spring). The values of Diversity- and Evenness Indices remained fairly constant at station 4 in all seasons and markedly fluctuated at stations 3, 6, 7 and 10.

The BRAY-CURTIS cluster analysis grouped seasonal samples as indicated in Fig. 5. As seen from the dendrogram, stations 7 and 9 joined each other at the high similarity level of 57%, where *Hediste diversicolor* dominated the stations. Some samples of stations 3 and 4, involving a similar species composition and the same dominant species also joined each other in the high similarity level. The other association composed of the samples A1, W4, A4, A11, S8, W8 and Sp8 had a similarity level of 35% and was principally occupied by *Spio decoratus*. Samples S2, A2, Sp2, S3 and W11, which had low species richness, constituted a group (42% similarity) where only *Malacoceros fuliginosus* and *Capitella capitata* were dominant. The samples taken at station 10 constituted a group, mainly due to high population densities of *Polydora ciliata*. Stations 3 and 11 linked to station 10 at a relatively low similarity level (35%). The last species association was found at stations 5, 6 and 8, which included a variety of polychaete species typical of the muddy-sand bottom of Izmir Bay.

Numerical data coming from seasonal samples were pooled according to stations in order to determine possible species associations existing at the different stations (Fig. 6). A high similarity level was calculated among stations 7, 9 and 10, which were dominated by *Hediste diversicolor*, *Streblospio shrubsolii* and *Capitella capitata*, all highly tolerant to the environmental fluctuations. The other species association occurred at stations 1, 4, 3 and 11, which had a relatively low number of species and were densely inhabited by *Malacoceros fuliginosus*, *Polydora ciliata* and *Spio decora-*

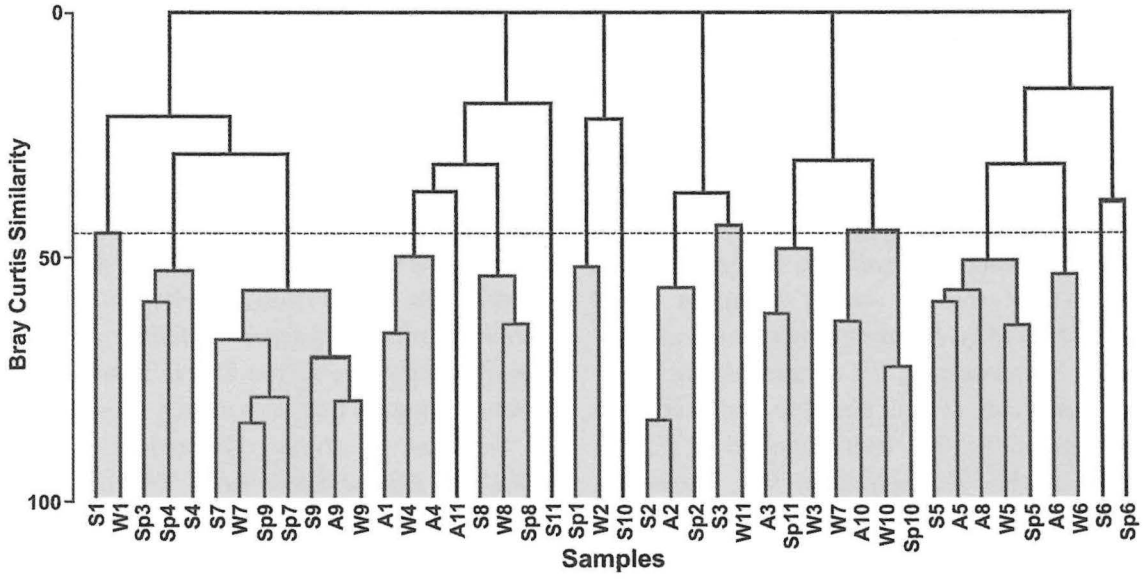


*Fig. 5. BRAY-CURTIS Similarity between seasonal samples (S: Summer, A: Autumn, W: Winter, Sp: Spring)*

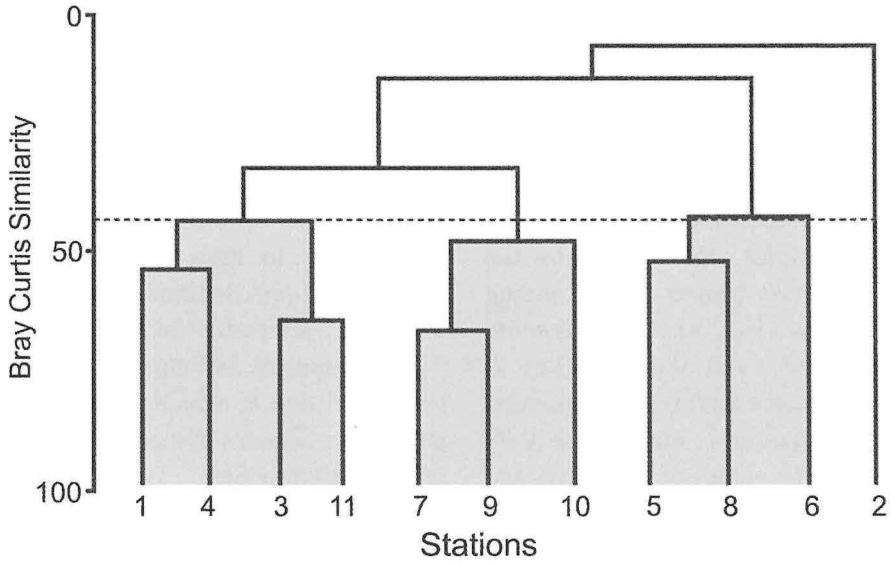


*Fig. 6. BRAY-CURTIS Similarity between stations*

*tus*. Stations 5, 8 and 6 (similarity 50%) were isolated from the other stations, mainly because of a high number of species and dense populations of *Sigambra tentaculata* and *Heteromastus filiformis*. Finally, no similarity between station 2 and others was noted as the station possessed low species richness in all seasons.

## DISCUSSION

The faunistic analysis of samples taken from the Gediz River Delta yielded a total of 83 polychaete species belonging to 31 families, of which *Micronephthys maryae*, *Prionospio multibranchiata* and *Aricidea claudiae* are new records for the Turkish fauna. *M. maryae* was originally described from the Balearic Islands (Spain) on shallow sandy bottoms (SAN MARTÍN, 1982). *P. multibranchiata* is characterized by possessing 7-11 pairs of long apinnate branchiae. It was possibly confused with what previously has been reported as *P. cirrifera* in the Mediterranean Sea. However, recent studies (MACIOLEK, 1985; MACKIE, 1984) showed that *P. multibranchiata* inhabits particularly the southern Atlantic coasts including the Mediterranean Sea, whereas *P. cirrifera* occurs solely in the northern waters of the Atlantic Ocean. Therefore, the previous records of *P. cirrifera* from the Mediterranean Sea should be re-examined. The paraonid *A. claudiae* was originally described from Banyuls-sur-Mer (France) on the muddy substratum at depths ranging from 35 to 200 m (LAUBIER, 1967). This species was also frequently found on the muddy sand bottom of Izmir Bay (unpublished data).

Stations located in different parts of the Gediz River Delta were inhabited by different dominant polychaete species, possibly related to dynamics of environmental conditions prevailing in the area. As a rule, stations subjected to relatively fluctuating water conditions were densely colonized by opportunistic species such as *Capitella capitata*, *Spio decoratus*, *Streblospio shrubsolii*, *Polydora ciliata*, *Heteromastus latericeus* and *Hediste diversicolor*. Similarly, the Evros Delta, located in the northern Aegean Sea, was mainly dominated by *C. capitata*, *H. diversicolor* and *H. filiformis* (GOUVIS and KOUKOURAS, 1993). *Spio filicornis* was also one of the dominant species of the Evros Delta. This species is morphologically similar to *S. decoratus* but clearly differs from it in bearing bidentate hooks (tridentate on

*S. decoratus*) (see DAUVIN, 1989). *Spio filicornis* reached a maximum density of 12580 ind. $m^{-2}$ in the Evros Delta, whereas *S. decoratus* received the same density score as *S. filiformis* at station 8 (12584 ind. $m^{-2}$, winter) in the present study.

The opportunistic species *C. capitata*, widely used as a bioassay organism and universal pollution indicator (POCKLINGTON and WELLS, 1992), establishes dense populations in organically polluted bottoms (PEARSON and ROSENBERG, 1978; BELLAN, 1982) and estuarine areas (WARREN, 1976), where low specific competition for food and space, and high input of organic matter prevail. *C. capitata* breeds throughout the year (WARREN, 1976). It reached a density of 1450 ind. $m^{-2}$ in the Evros Delta (GOUVIS and KOUKOURAS, 1993), and a density of 172450 ind. $m^{-2}$ in the Ebro Delta - Mediterranean coast of Spain (MARTÍN and GRÉMARE, 1997). MARTÍN and GRÉMARE (1997) observed two dominance peaks of *C. capitata* in winter and spring. However, we found its dominance peaks took place in autumn (54700 ind. $m^{-2}$) and spring (26180 ind. $m^{-2}$).

The spionid *Streblospio shrubsolii* was reported as a tube-dwelling organism inhabiting upper muddy sediment in enclosed estuarine zones and brackish waters (SARDÁ and MARTÍN, 1993). The reported population densities of *S. shrubsolii* were 65668 ind. $m^{-2}$ (August) in the Ebro Delta (SARDÁ and MARTÍN, 1993) and 69000 ind. $m^{-2}$ (July) in the Gironde Estuary on the Atlantic coast of France (BACHELET, 1987). In the Gediz River Delta, this species attained its maximum (14256 ind. $m^{-2}$, winter) and minimum (4136 ind. $m^{-2}$, autumn) densities at station 9. It occurred at all stations except 2, 6, 8 and 10. It is apparent that this species prefers bottoms (especially stations 7 and 9) with low salinity values but high organic matter.

The high tolerance of *Hediste diversicolor* to environmental factors allows this species, despite its low competitiveness, to be one of the main macrobenthic components of unique biotopes where the fitness of stronger competitors is reduced (KRISTENSEN, 1988). The sediment type (ARIAS and DRAKE, 1995) does not affect the spatial distribution of this species. *Hediste diversicolor* species was previously reported from a drainage channel of the Gediz River, with a density of 3225 ind. $m^{-2}$ (ERGEN *et al.*, 2000; ÇINAR and ERGEN, 2001). The same population density level of this species was also observed in Danish coastal waters (1000-3000 ind. $m^{-2}$) by KRISTENSEN (1988); in the Evros Delta, north Aegean Sea (3840 ind.$m^{-2}$) by GOUVIS and KOUKOURAS (1993); and in the Loire Estuary, France (3248 ind. $m^{-2}$ in December; 2000 ind. $m^{-2}$ in March) by GILLET (1990). In the Bay of Cádiz (SW Spain), its population densities varied from 653 ind. $m^{-2}$ to 2626 ind. $m^{-2}$, with a peak in late autumn-early winter and late spring-early summer (ARIAS and DRAKE, 1995). We also observed its maximum dominance levels in autumn (4400 ind. $m^{-2}$, station 7) and winter (2992 ind. $m^{-2}$, station 9).

The highest species diversity and richness were found at marine stations 5 and 6, which contained a diverse species composition typical for the muddy sand bottom of Izmir Bay (ERGEN, 1976; ÇINAR *et al.*, 1998; 2002). These stations were also occupied by some opportunistic or semi-polluted water species such as *Sigambra tentaculata*, *Paradoneis lyra*, *Malacoceros fuliginosus*, *Polydora ciliata*, *Prionospio fallax*, *P. multibranchiata*, *Monticellina heterochaeta*, *Capitella capitata*, *Heteromastus filiformis*, *Hydroides elegans* and *H. dianthus*. Syllid species (Table 3), known to very sensitive to pollution, were mainly found at station 6. Different species assemblages present in the area were mainly controlled by local environmental conditions and some dominant and frequent species such as *Capitella capitata*, *Polydora ciliata*, *Streblospio shrubsolii*, *Spio decoratus*, *Heteromastus filiformis*, *Hediste diversicolor*, *Prionospio multibranchiata*, *Malacoceros fuliginosus*, *Glycera tridactyla*, *Prionospio fallax* and *Sigambra tentaculata*.

## CONCLUSIONS

The present study enhances our knowledge about the spatial and temporal distribution of the polychaete fauna inhabiting different localities of the Gediz River Delta, which provides a good nursery area for fishes and birds of great commercial and ecological importance. Although the Turkish Ministry of the Environment in 1999 has accepted this Delta as the 1st priority Nature Site, its biological and ecological components are increasingly being destroyed by a variety of pollutants. If effective and continuous precautions to prevent discharge of untreated wastes into the river and Delta can not be undertaken, this world treasure will unfortunately disappear in the near future!

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# Sezonska analiza poliheta iz delte rijeke Gediz (Izmirski zaljev, Egejsko more)

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## SAŽETAK

U radu se iznose prostorna i vremenska raspodjela poliheta nastanjenih u delti rijeke Gediz, proučavane sezonski na 11 postaja od ljeta 1998. do proljeća 1999. Ustanovljene su ukupno 83 vrste koje pripadaju 31 obitelji. Vrste *Micronephthys maryae* SAN MARTÍN, 1982, *Prionospio multibranchiata* BERKELEY, 1927 i *Aricidea claudiae* LAUBIER, 1967 su nove za tursku faunu. Među porodicama, Spionidae su najbrojnije vrstama (14 vrsta, 17% od ukupnog broja vrsta) i jedinkama (3922 jedinki, 48% od ukupnog broja jedinki). U delti rijeke Gediz prevladavaju *Capitella capitata* (FABRICIUS, 1780), *Polydora ciliata* (JOHNSTON, 1838), *Streblospio shrubsolii* (BUCHANAN, 1890), *Spio decoratus* (BOBRETZKY, 1870), *Heteromastus filiformis* (CLAPARÈDE, 1864) i *Hediste diversicolor* (O. F. MÜLLER, 1776). Određene su asocijacije vrsta u području, te varijacije biocenoloških indeksa po sezonama.

**Ključne riječi:** poliheti, sezonska analiza, asocijacije vrsta, zagađenje, Egejsko more