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Interannual changes in the composition of the macrobenthic fauna of Drana lagoon (Evros Delta, N. Aegean Sea): preliminary note

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ABSTRACT. The qualitative and quantitative composition of macrobenthic fauna of Drana lagoon, Evros Delta, was investigated during summer of 1981, 1997 and 1998. Since 1987 Drana lagoon has been isolated from the sea due to the obstruction of its narrow opening. In September 1998, samples were collected in an emerged and in a submerged site, since the major part of the lagoon was temporarily drained due to evaporation. An alteration in the faunal composition characterized by the vanishing of marine species and an increase of the dominance of the most resistant estuarine species (*Hydrobia* sp., *Hediste diversicolor*, *Gammarus aequicauda*), was recorded during July 1997 in relation to September 1981. This alteration may be the result of the lagoon's isolation from the sea. Furthermore, this isolation resulted in the temporary drainage of the major part of the lagoon during September 1998, when *Hydrobia* sp. showed a 98% dominance at the submerged site and was the unique species found at the emerged one. Number of species and total density together with biomass had comparatively higher values in September 1981 and in July 1997 samples, respectively. Species diversity and evenness showed significantly lower values in September 1998 samples while evenness had significantly higher values in July 1997 samples.

KEY WORDS: Interannual changes, macrozoobenthos, lagoon, Aegean Sea.

INTRODUCTION

Lagoons and estuaries of the Mediterranean have been the subject of extensive studies. However, our knowledge on the temporal changes of the qualitative and quantitative composition of their macrobenthic fauna is very restricted. Some relatively recent publications refer mainly to seasonal variation (e.g. GUELORGET & MICHEL, 1979a; 1979b; REIZOPOULOU et al., 1996; GOUVIS et al., 1997; KEVREKIDIS, 1997; ARVANITIDIS et al., 1999). Changes in the composition of the macrobenthic fauna occurring several years after the first records are of special interest, particularly if an alteration in the hydrological regime of a lagoon has been taken place during this period. It is known that hydrological factors must be responsible for the biological organization of Mediterranean lagoons rather than hydrochemical or sedimentological ones (FRISONI et al., 1984).

We studied the qualitative and quantitative composition of the macrobenthic fauna in Drana lagoon (Evros delta, N. Aegean Sea) during summer of 1981, 1997 and 1998. Since 1987 Drana lagoon has been isolated from the sea due to the obstruction of its narrow opening.

MATERIAL AND METHODS

The Evros Delta is located at the NE end of the Aegean Sea (Fig. 1). The Drana lagoon, one of the four lagoons of the delta (Fig. 1), is biologically significant since, among others, a large number of avifauna species inhabits the area. Fresh water occasionally enters the lagoon area mainly from the stream Mikri Maritsa and from drainage channels (Fig. 1). In the past the lagoon communicated with the sea through a narrow opening 4m wide. In order for the Drana lagoon to be drained, its opening was

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obstructed in 1987 and since then there has been no direct communication with the sea. However permanent drainage of the lagoon has not occurred until today. In September 1998, due to evaporation, the largest part of the lagoon was drained for a period of 3 weeks except for a small area (about 1/5 of the lagoon) in the site DA_1 (Fig.1), which remained submerged.

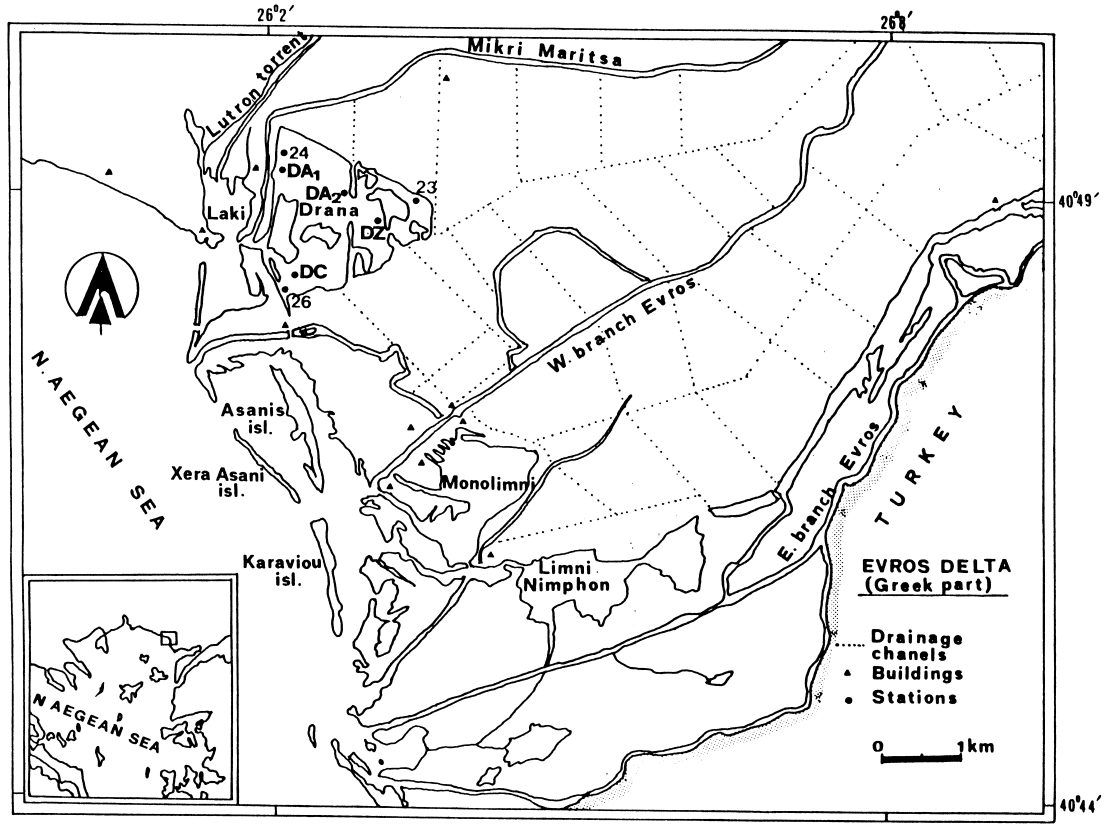

Fig. 1. – Map of Evros Delta showing the sampling stations.

Samples of the macrobenthic fauna were taken from Drana Lagoon at the sites 23, 24 and 26 in September 1981, DA_1, DA_2, DC and DZ in July 1997 and DA_1 and DC in September 1998 (Fig.1). Each sample was made up of 4 random replicates at each site in September 1981 and at DA_1 site in September 1998 and of 2 random replicates at each site in July 1997 taken by a modified Van Veen grab; the grab covered a surface of 400 cm^2 (20 cm x 20 cm) and penetrated to a depth of 20 cm. In September 1998, 2 random replicates were taken at the emerged DC site with the use of a corer having a 20 cm diameter and penetrating to a depth of 20 cm. The samples were sieved in the field through a 0.5 mm screen. In each sampling site, depth, salinity and the temperature of the water near the bottom, as well as the temperature of the sediment at a depth of 1 cm were also measured. These water physicochemical parameters were also measured at DA_1 and DC sites in September 1997. All animals were identified, counted and the wet weight was measured after drying on laboratory tissue. Bivalve and gastropod shells were not included in weight determinations.

In order to determine the similarity among species, cluster analysis was performed on faunal abundance data (R-analysis). The Bray-Curtis similarity coefficient was used on log transformed data [x = log(x+1)]. Hierarchical clustering of species was achieved using the group-average sorting strategy (LANCE & WILLIAMS, 1967).

Species diversity (H') was estimated using Shannon's formula: $HH' = \sum_{i=1}^{S} pi \log_2 pi$.

Evenness (J) was measured by the formula $H'/\log_2 S$, where S = total number of species. Statistical analyses [one-way analysis of variance, least-significant difference method (L.S.D.)] were performed on log transformed data (x = ln x).

RESULTS

The values of the physicochemical parameters in the sampling sites are given in Table 1. The water salinity exceeded 40‰ in September 1981, varied between 14.8‰ and 17.0‰ in July 1997 and between 50.3‰ and 53.7‰ in September 1997 and had a value of 11.2‰ at the submerged site in September 1998.

TABLE 1

Water and sediment data of sampling sites

Date	Stations	Water			Sediment
		Depth (cm)	Salinity (‰)	Temp. (°C)	Temp. (°C)
Sept. 1981	23	50	>40.0	22.0	21.7
Sept. 1981	24	15	>40.0	17.0	18.6
Sept. 1981	26	40	>40.0	21.2	20.6
July 1997	DA1	30	15.6	32.7	32.6
July 1997	DA2	55	14.8	30.7	30.0
July 1997	DC	25	15.9	27.2	27.3
July 1997	DZ	40	17.0	29.3	28.0
Sept. 1997	DA1	20	50.3	20.2	-
Sept. 1997	DC	20	53.7	20.0	-
Sept. 1998	DA1	25	11.2	23.3	22.3
Sept. 1998	DC	-	-	-	-

A total of 12 macrobenthic species were collected during the three different sampling periods. The abundance, dominance and wet weight biomass of the species for each sample are given in Table 2.

Hierarchical classification of the species, on the basis of similarity in their distribution in the samples, is shown in a dendrogram (Fig. 2). At the 16.5% similarity level, 3 species groups were distinguished: group A, which includes the polychaetes *Capitella giardi* and *Scolelepis tridentata*, the bivalves *Abra ovata* and *Cerastoderma glaucum* and the mysid *Mesopodopsis slabberi*; group B which includes the gastropod *Hydrobia* sp., the polychaete *Hediste diversicolor* and the amphipod *Gammarus aequicauda* and group C, which includes the polychaete *Streblospio shrubsolii* and the amphipod *Corophium orientale*. The polychaete *Spio decoratus* and the decapod *Crangon crangon* were not included in any species group.

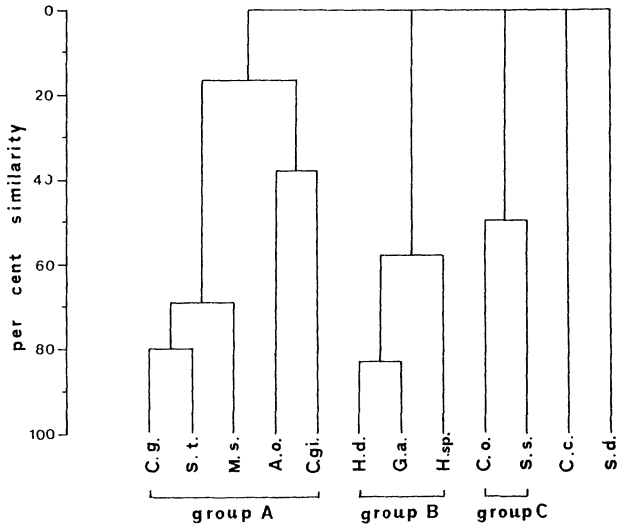

Fig. 2. – Dendrogram of hierarchical classification of species data.

The number of individuals, dominance and biomass of the species groups in each sampling period (Sept. 1981, July 1997, Sept. 1998) are given in Table 3.

A total of 10 species were collected during September 1981 (Table 2). B species group showed a high mean dominance, A species group had a remarkable mean dominance, while the cumulative mean dominance of *S. decoratus* and *C. crangon* was 0.6% (Table 3). *Hydrobia* sp. having a mean abundance of 270 ind./0.1m^2, a mean biomass of 128.3 mg/0.1m^2 and a mean dominance of 71%, was the only species of B group found in all samples (Table 2). From the species of A group, *A. ovata* was found in all samples having a mean abundance of 186.3 ind./0.1m^2, a mean biomass of 62.0 mg/0.1m^2 and a mean dominance of 21.8% (Table 2). Moreover, *C. giardi* had a remarkable mean abundance of 9 ind./0.1m^2 and mean dominance of 4.5% (Table 2).

Only the three species of B group and one species of C group (*S. shrubsolii*) were found during July 1997 (Table 2). The gastropod *Hydrobia* sp., the sizable polychaete *H. diversicolor* and the amphipod *G. aequicauda* were recorded in all stations, having a mean abundance of 741 ind./0.1m^2, 126 ind./0.1m^2 and 127 ind./0.1m^2, a mean biomass of 280.0 mg/0.1m^2, 2356.0 mg/0.1m^2, and 327.0 mg/0.1m^2 and a mean dominance of 73.2%, 16.8% and 9.9%, respectively (Table 2). Consequently, B species group had a very high mean dominance (Table 3). *S. shrubsolii* (C species group) was only collected in DC site and had an extremely low mean abundance, mean biomass and mean dominance (Tables 2 and 3).

The above four species, together with *A. ovata* and *C. glaucum* (A species group) and *C. orientale* (C species group), were also found at the site DA_1 in September 1998 having, except *Hydrobia* sp., very low values of abundance and dominance (Table 2). *Hydrobia* sp. had a high abundance, biomass and dominance at this site, while it was the only species found at the emerged site DC (Table 2). B species group had a dominance of 99.2% in site DA_1, while the corresponding value of both A and C species groups was 0.4% (Table 2).

The major biological parameters (total density, total biomass, number of species, species diversity and evenness) of each sampling period are summarized in Table 3. Total number of species and mean number of species had comparatively higher values during September 1981 (Table 3). Total density and biomass had comparatively higher mean values during July 1997 (Table 3). Species diversity and evenness showed significantly lower values in September 1998 samples while evenness had significantly higher values in July 1997 samples (Fisher LSD coefficient, $P<0.05$) (Tables 3 and 4). The statistics of the differences in the number of species, total density, total biomass, species diversity and evenness, concerning the 3 sampling periods, are given in Table 4.

TABLE 2

Species abundance (A, ind./0.1m^2), dominance (D, %) and wet weight biomass (B, mg/0.1m^2) in the samples

	September 1981									July 1997													September 1998					
	23			24			26			DA_1			DA_2			DC			DZ			DA_1			DC		
Species	**A**	**D**	**B**	**A**	**D**	**B**	**A**	**D**	**B**	**A**	**D**	**B**	**A**	**D**	**B**	**A**	**D**	**B**	**A**	**D**	**B**	**A**	**D**	**B**	**A**	**D**	**B**
Gastropoda																												
Hydrobia sp.	151	83.9	65.6	347	38.0	182.5	312	90.9	136.5	234	65.4	122.4	851	83.3	550.4	660	71.7	148	1219	72.6	298.6	683	98.0	1201.9	33	100	40.5
Bivalvia	4	2.2	12.1	542	59.5	171.5	13	3.8	2.3													1	0.2	68.1			
Abra ovata (Philippi, 1836)																											
Cerastoderma glaucum (Poiret, 1789)				3	0.3	215.3																1	0.2	300.8			
Polychaeta																											
Capitella giardi (Mensil, 1897)	24	13.3	27.1	3	0.3	1.1																					
Hediste diversicolor (Muller, 1776)				3	0.3	10.9	3	0.9	202.3	108	30.2	4458.8	155	15.2	1258	150	16.3	278.5	91	5.4	3427.4	6	0.8	309.6			
Scolelepis tridentata Southern, 1914)				3	0.3	3																					
Spio decoratus Bebretzsky, 1870							5	1.5	0.6							3	0.3	0.3									
Streblopsio shrubsolii (Buchanan, 1890)																						1	0.2	0.1			
Mysidacea																											
Mesopodopsis slabberi (Van Beneden, 1861)				8	0.8	4.4																					
Amphipoda																											
Corophium orientale (Schellenberg, 1928)																						1	0.2	0.2			
Gammarus aequicauda (Martynov, 1931)				5	0.5	20.6	10	2.9	11.3	16	4.4	182.8	15	1.5	59.1	108	11.7	303.3	369	22.0	763	3	0.4	60.2			
Decapoda																											
Crangon crangon (Linnaeus, 1758)	1	0.6	39																								

TABLE 3

Number of individuals (A, ind./0.1 m^2), dominance (D, %) and wet weight biomass (B, mg/0.1 m^2) of species groups, as well as the major biological parameters of the benthic ecosystem in each sampling period (mean values ± SE).

Date / Sites		**Sept. 1981** 23, 24, 26	**July 1997** DA_1, DA_2, DC, DZ	**Sept. 1998** DA_1, DC
Spio decoratus	**A**	1.7±1.7		
	D	0.4±0.4		
	B	0.2±0.2		
Crangon crangon	**A**	0.3±0.3		
	D	0.2±0.2		
	B	13.0±13.0		
Group A	**A**	200.0±179.5		1.0±1.0
	D	26.8±17.5		0.2±0.2
	B	145.9±125.0		184.0±184.0
Group B	**A**	277.0±267.0	994.0±270.8	362.5±329.5
	D	72.6±17.1	99.9±0.1	99.6±0.3
	B	210.0±82.0	2963.0±990.0	806.0±766.0
Group C	**A**		0.8±0.8	1.0±1.0
	D		0.1±0.1	0.2±0.2
	B		0.1±0.1	0.2±0.2
Total Nr. Species		10	4	7
Nr. species/0.1 m^2		5.7±1.2	3.3±0.3	4.0±3.0
Nr. individuals/0.1 m^2		479.0±222.5	995.0±270.8	364.5±331.5
Wet weight biomass (...) mg/0.1m^2 (...)		369±135	2935±1011	1414±1373
HH'		0.848±0.171	1.013±0.100	0.086±0.086
J		0.345±0.043	0.601±0.056	0.030±0.030
Description		The lagoon communicated with the sea	The lagoon was isolated from the sea	The lagoon was isolated from the sea and its major part was drained (DC site)

TABLE 4

Comparison between two and three sampling periods (Fisher LSD coefficient and factor-F correspondingly) concerning number of species, total number of individuals, total biomass, species diversity (H') and evenness (J).

Sample group	**Nr. species**	**Nr. individuals**	**Biomass**	**H'**	**J**
Sept. 81 - July 97	1.133	2.053	2.682	0.538	0.415*
Sept. 81 - Sept. 98	1.355	2.453	3.205	0.813*	0.628*
July 97 - Sept. 98	1.285	2.327	3.041	0.788*	0.608*
Sept. 81 - July 97 - Sept. 98	1.008	1.727	2.105	16.714**	46.515***
		where :	*P<0.05	**P<0.01	***P<0.001

DISCUSSION

Species group B showed increased numbers of individuals and dominance in July 1997 and September 1998 samples, in relation to September 1981 ones. The 3 species of this group are resistant estuarine species. *Hydrobia* sp. was the only species that appeared in all samples collected from Drana lagoon during September 1981, July 1997 and September 1998. Moreover, it was the most dominant species in all sampling periods. *Hydrobia* species, being characteristic inhabitants of brackish waters, tolerate extreme salinity values and usually prefer areas isolated from the sea (e.g. MARAZANOF, 1969; KEVREKIDIS et al., 1996). *H. diversicolor* and *G. aequicauda* showed a remarkable abundance and dominance only in July 1997 samples. These species are considered characteristic inhabitants of brackish waters, showing a very euryhaline and resistant character and having usually higher abundance in areas isolated from the sea (e.g. KEVREKIDIS & KOUKOURAS, 1988; GOUVIS et al., 1998).

Species group A, including 2 estuarine species (*A. ovata* and *C. glaucum*) and 3 marine species (*C. giardi, S. tridentata* and *M. slabberi*), showed a remarkable dominance only in September 1981 samples. *A. ovata* and *C. glaucum* have been considered characteristic inhabitants of brackish waters preferring areas with a greater degree of contact with the sea, than *Hydrobia* species (e.g. FRISONI et al., 1984; KEVREKIDIS et al., 1996). *C . giardi, S. tridentata* and *M. slabberi*, together with *S. decoratus* and *C. crangon*, were not found in July 1997 and September 1998 samples. All these species are marine ones occurring more or less often in estuaries and lagoons (e.g. BELLAN, 1971; MAKINGS, 1977; HATZAKIS, 1982; HOLTHUIS, 1987; GRAVINA et al., 1988; ARVANITIDIS, 1994; GOUVIS et al., 1998).

Species group C including 2 estuarine species (*S. shrubsolii* and *C. orientale*) was found only in July 1997 and September 1998 samples, having a very low dominance. *S. shrubsolii* has been reported in enclosed, brackish European zones (e.g. SARDA & MARTIN, 1993). *C. orientale* is an exclusive inhabitant of lagoons being very euryhaline, but showing a less resistant character than *G. aequicauda* (e.g. KEVREKIDIS & KOUKOURAS, 1988).

The alteration in the faunal composition in July 1997 and September 1998 in relation to September 1981 characterized by the vanishing of marine species and the increase both in dominance and number of individuals of the most resistant estuarine species (*Hydrobia* sp., *H. diversicolor*, *G. aequicauda*) may mainly be the result of Drana lagoon's isolation from the sea. FRISONI et al. (1984) reported that hydrological factors must be responsible for the biological organization of the Mediterranean lagoons rather than hydrochemical or sedimentological factors, mainly because they control the rate of exchange with the open sea and consequently the renewal rhythm of certain marine elements necessary for the organisms (vitamins, trace elements, etc.). The small_difference in sampling times during the summer period of 1981 and of 1997 (September and July respectively) should not play a noticeable role in the alteration in the faunal composition since the species composition of an estuarine assemblage remains generally homogeneous throughout the year (BOESCH et al., 1976; GOUVIS et al., 1997; KEVREKIDIS, 1997).

Furthermore, the lagoon's isolation from the sea resulted in the temporary drainage of the major part of the lagoon during September 1998, when *Hydrobia* sp. showed a 98% dominance and an increased abundance at the submerged site and was the only species found at the emerged one. All *Hydrobia sp.p*. possess the ability to survive periods of emergence by burrowing into substrate and closing the operculum (BRITTON, 1985). Moreover, BRITTON (1985) reported that *H. acuta* is able to survive up to four months in a state of inactivity within damp clay or sand.

Species diversity and evenness showed significantly lower mean values in September 1998 samples while evenness had a significantly higher mean value in July 1997. Moreover, evenness mean values of September 1981 and 1998 samples being lower than 0.6 indicate, according to ODUM (1980) scale, that the assemblage was under pressure mainly during these periods.

Finally the development of the macrobenthic fauna of Drana lagoon after its reflooding is of a special interest and is the subject of research that is in progress.

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