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MICROFAUNAL DISTRIBUTION IN THE SURFACE SEDIMENTS OF AMVRAKIKOS GULF (WESTERN GREECE)

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ABSTRACT

Sedimentological and microfaunal research carried out in the Amvrakikos Gulf (Western Greece), revealed distinct sedimentary patterns and species diversities of foraminifera and ostracoda, influenced by the deltaic activity of Louros and Arachthos rivers. Particularly, the distribution of the microfauna seems to be influenced also by environmental conditions such as depth, salinity, dissolved oxygen, turbidity, organic content in the sediment, as well as the nature of the surface sediment. With the exception of some widespread species, the rest show a preference on low energy, with higher degrees of salinity and oxygen, environments. Moreover, microfaunal diversities increase with increasing depth and organic content in the sediment.

ΣΥΝΟΨΗ

Ιζηματολογικές και μικροπαλαιοντολογικές έρευνες που έλαβαν χώρα στον Αμβρακικό Κόλπο, έδειξαν σαφείς ιζηματολογικές ενότητες και κατανομές ειδών τρηματοφόρων και οστρακωδών, οι οποίες επηρεάζονται από τη δελταϊκή δραστηριότητα των ποταμών Λούρου και □αχθου. Ειδικότερα, η κατανομή της μικροπανίδας φαίνεται να επηρεάζεται επίσης από περιβαλλοντικούς παράγοντες όπως το βάθος, την αλατότητα, το οξυγόνο σε διάλυση, τη θολερότητα, την περιεκτικότητα σε οργανικά στο ίζημα, όπως επίσης και τη φύση του επιφανειακού ιζήματος. Με εξαίρεση μερικών ευρέως διαδεδομένων ειδών, τα υπόλοιπα δείχνουν προτίμηση σε χαμηλής ενέργειας, με υψηλούς δείκτες σε αλατότητα και οξυγόνο, περιβάλλοντα. Επί πλέον, οι εμφανίσεις της μικροπανίδας αυξάνουν με την αύξηση του βάθους και της περιεκτικότητας σε οργανικά στο ίζημα.

1. INTRODUCTION - REGIONAL SETTING

The aim of this paper is to present various species of microfossils (Foraminifera and Ostracoda) found in the surface sediments of Amvrakikos Gulf, as well as to combine micropaleontological and sedimentological data, in an initial attempt to understand sedimentary patterns and microfaunal distribution in the gulf.

Amvrakikos Gulf is a restricted, enclosed embayment, located between the regions of Epirus and Aetoloakarnania (Western Greece, Fig. 1). It has an irregular shape and its maximum dimensions are 18.5 nautical miles length, 10 nautical miles width and 60m depth. Its only connection to the adjacent Ionian Sea is located on its western side and measures some 600 m width and 7-10 m depth.

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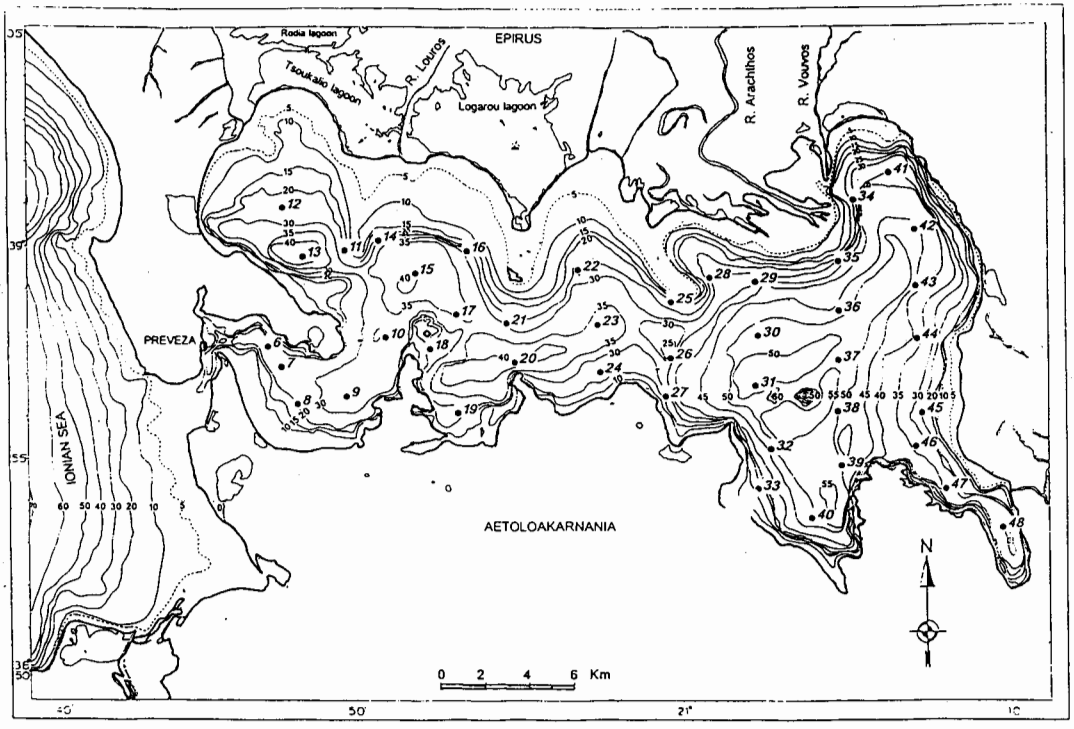


Fig. 1: Bathymetry and sampling stations in the Amvrakikos Gulf.

The coastal system of the gulf is quite complicated and includes a substantial number of lagoons (6 major ones with depths varying from 0.5 to 1 m but in some locations down to 4 m) and two major deltas (from Louros and Arachthos rivers). These deltas and most of the lagoons are located at the northern part of the gulf whereas, at the eastern and southern part, there are only some weddies comprising the local hydrographic network.

The region is built up of three geotectonic units, overthrusted one upon the other; The Ionian Unit (shallow and deep water carbonates, flysch), the Gavrovo Unit (shallow water carbonates, flysch) and the Pindos Unit (typical deep water alternations of carbonates and siliceous materials, flysch). As for the post-alpine formations, they include Recent and Pleistocene delta sequences, terra rossa and alluvial fans.

The general structural trends and lineaments of the region are of NNW-SSE orientation (I.F.P. & I.G.R.S., 1966). On smaller, more local scales, there are other orientations as well. A probable cause for the genesis of the Amvrakikos Gulf is attributed to the fault zone that crosses the Ziros lake (Tziavos et al, 1989).

2. SEDIMENTOLOGY

The sedimentological and micropaleontological study of the surficial sediments was based on a set of 43 surface samples (Stations 6-48), taken during a cruise in 1986 aboard the R/V "Aegaio" of the National Centre for Marine Research, using a Macintyre sampler (Tziavos et al, 1989). This was followed by laboratory analyses for the determination of granulometry and carbonate content.

The surface sediments of the gulf are mostly greenish-grey (Oyama & Takehara, 1967). Notable exceptions are the samples from the strait connecting the gulf to the adjacent Ionian Sea, which are brownish and are characterised by

substantial amounts of biogenic material.

The sedimentation in the Amvrakikos Gulf is controlled mainly by the source rocks in the land (carbonates, flysch), the landscape, the climatic conditions, and the sediment transport due to hydrodynamics.

The two main sources of sediment supply in the gulf are the Louros and Arachthos rivers, whose networks develop mainly into the carbonates and flysch of Epirus. This leads to specific patterns of sedimentation in the gulf, as it is also evident from the Folk surface sediment distribution map (Tziavos et al, 1989, Fig. 2).

Generally, fine-grained sands are mainly deposited at the western part of the gulf (Louros), whereas silt prevails in the eastern region, due to different mainland rocks (carbonates at the western part, flysch at the eastern). The sand fraction is present throughout the coastlines due to hydrodynamic, wave and basin configuration factors (mainly at the shallower northern coasts of the gulf). The more tranquil and clear environment of the western part of the gulf leads to higher diversities in the microfaunas, as we will see below.

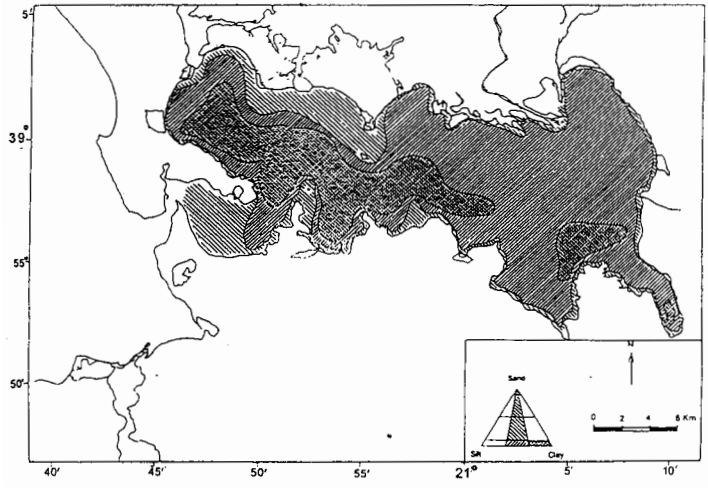


Fig. 2: Surface sediment distribution in the Amvrakikos Gulf (according to Folk,1974)

3. MICROFAUNAL DISTRIBUTION

For microfaunal analyses, samples of the 43 stations were selected, washed through a 63ì sieve, and subsequently dried. The samples were split and all the foraminifera and ostracoda contained (everything larger than 125ì) were picked, mounted in Chapman slides, identified and counted. The results are displayed in Table 1.

Table 2 is dealing with the most abundant benthic foraminiferal genera in the gulf.

Table 3 combines bathymetrical and sedimentological data, i.e. sand, silt and clay percentages in each station.

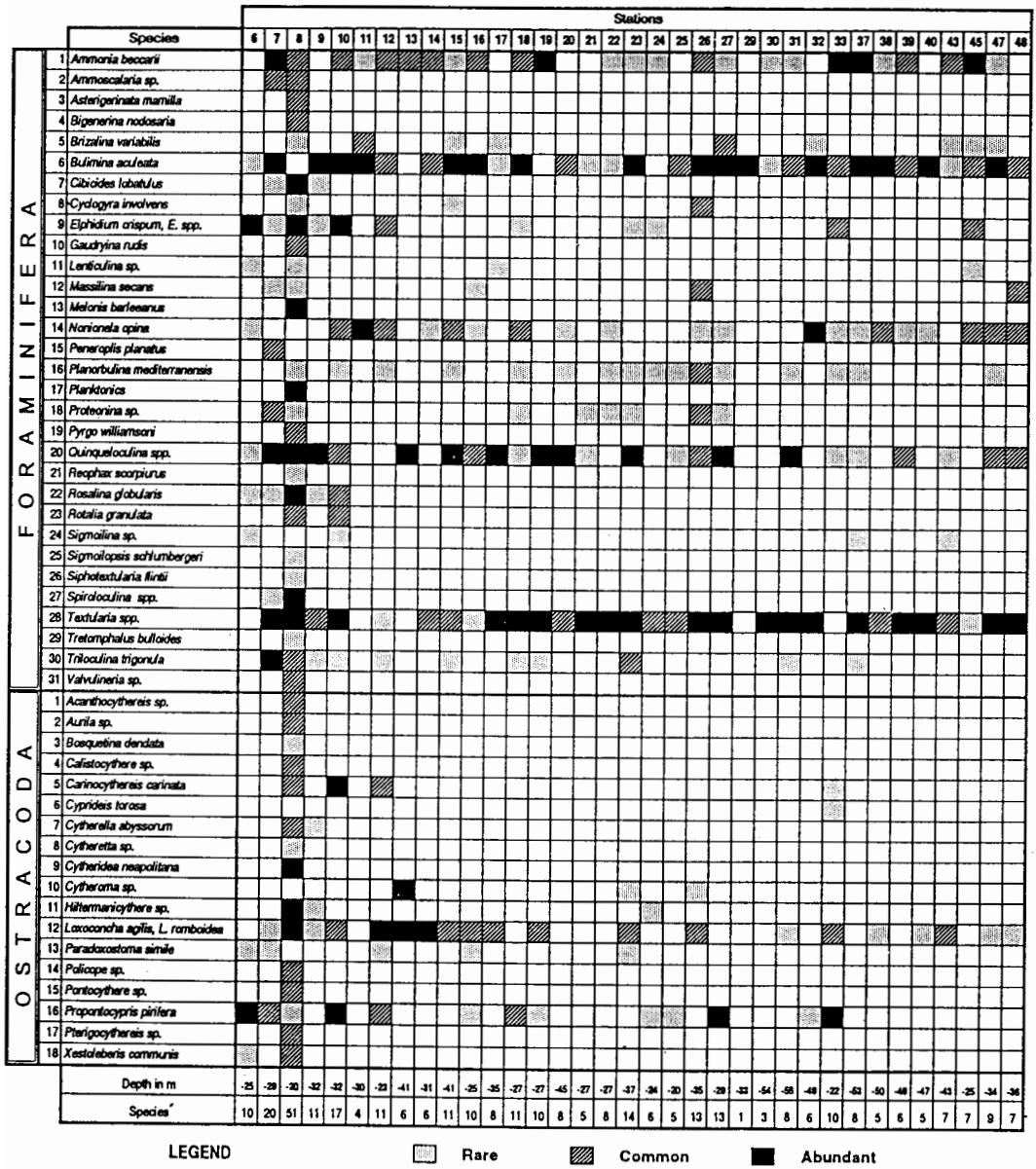
Table 4 displays the distribution of the most abundant genera of benthic foraminifera in the gulf.

Determination of the samples was based on Loeblich & Tappan (1964), Colom (1974), Murray (1971), Jorissen (1988), Tziavos (1977), Bonaduce et al (1975), Hanai et al (1988), de Deckker et al., (1988) and A Stereo-Atlas of Ostracod Shells (since 1973). It should be stressed that more attention was paid to lump taxa with specific paleoenvironmental properties, and not to get involved into taxonomic problems. The approach used is semi-quantitative, since the relative frequencies of the taxa are indicated as, rare, common and abundant, where the appearance was 1-3, 4-7, and more than 8 individuals respectively.

4. DISCUSSION AND CONCLUSIONS

The benthic microfauna of the Amvrakikos Gulf (foraminifera and ostracods) is characteristic of a low salinity, rich in nutrients, coastal to shallow

Table 1: Microfaunal distribution in the Amvrakikos Gulf



marine environment. That is why, with the exception of station 8 (near the gulf entrance), the diversity of marine foraminiferal species - as well as their abundance - is rather low (Bandy & Arnal 1960). Moreover, planktonic foraminifera were found only in station 8 (mainly *Globigerinoides ruber)*. The absence of planktonic foraminifera in the adjacent stations 6, 7, and 9 indicates a sort of circular current pattern that inhibits deposition of planktonic foraminiferal tests in these stations.

Among the benthic foraminiferal species, the most abundant ones are *Bulimina aculeata*, *Textularia* spp., *Ammonia beccarii*, *Nonionella opina* and the

Table 2: The most abundant benthic foraminifera in the Amvrakikos Gulf

Genera	Stations																																		
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30	31	32	33	37	38	39	40	43	45	47	48
Ammonia		9	5		5	2	4	6	3	2	4		4	8			2	1	2		3	2		1	1		12	9	2	4		3	8	2	
Bulimina	1	10		9	9	8	3		6	8	7	2	13		6	1	1	10		3	18	15	10	1	5	17	4	7	21	6	8	2	5	24	4
Elphidium	13	1	27	2	7		3						1					1	1								5						3		
Nonionella	1				5	8	4		2	3	2		6		2		2	2			2	2				10	1	2	3	1	1		3	3	3
Planorbulina			2		1		2			1			2		2		1	1	1	2	4	1			1		1	2					2		
Quinqueloculina	2	20	24	14	3			8		7	3	6	1	11	5	2		6		1	2	11			17		2	1		6		1		5	4
Textularia		14	16	4	12		2		5	4	1	12	7	8	3	7	6	18	4	5	20	6		17	16	20		19	5	13	4	3	1	19	9
Triloculina		16	6	1	1		2			1			1	1				3							1			1							

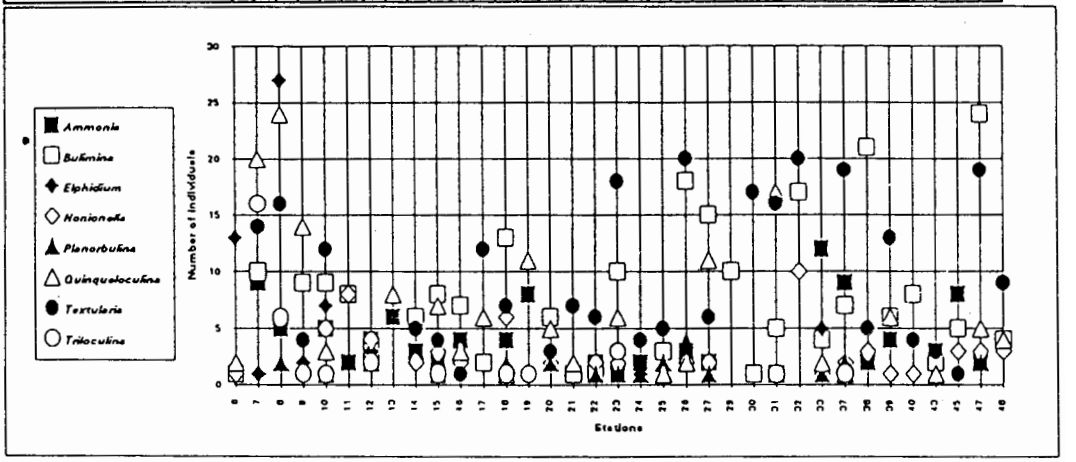
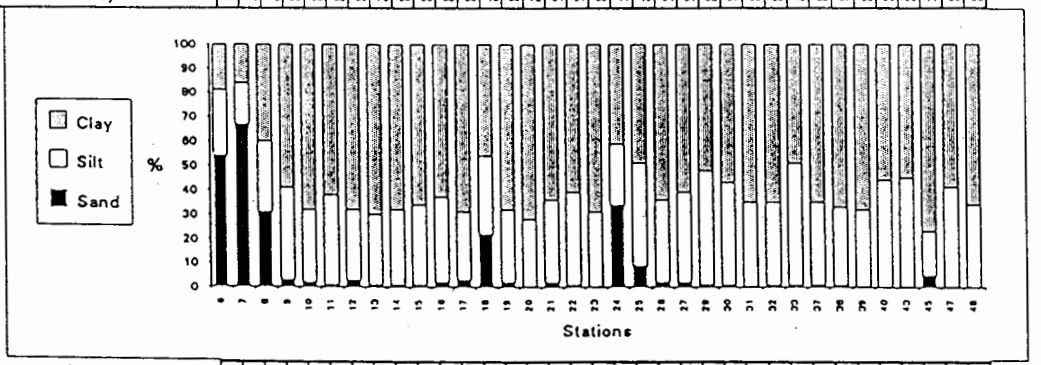


Table 3: Sedimentological and bathymetrical data of the Amvrakikos Gulf

	Percent																																		
Sand	54	67	31	3	2	1	3	1	1	1	2	3	22	2	0	2	1	0	34	9	2	2	1	1	0	1	1	1	1	0	0	5	0	0
Silt	27	17	29	38	30	37	29	29	31	33	35	28	32	30	28	34	38	31	25	42	34	37	47	42	35	34	50	34	32	32	44	45	18	41	34
Clay	19	16	40	59	68	62	68	70	68	66	63	69	46	68	72	64	61	69	41	49	64	61	52	57	65	65	49	65	67	68	56	55	77	59	66



Depth in m	25	29	20	32	32	30	23	41	31	41	25	35	27	27	45	27	27	37	24	20	35	29	33	54	58	49	22	53	50	49	47	43	25	34	36

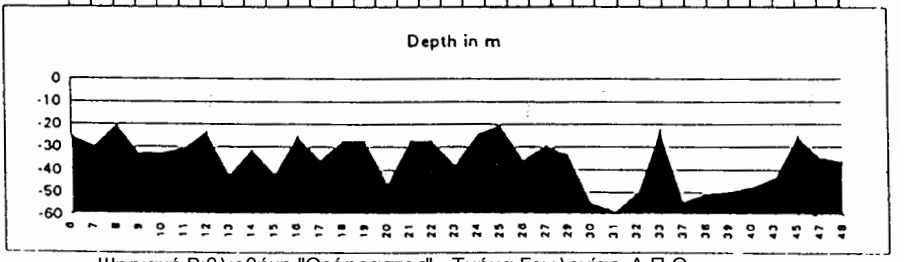
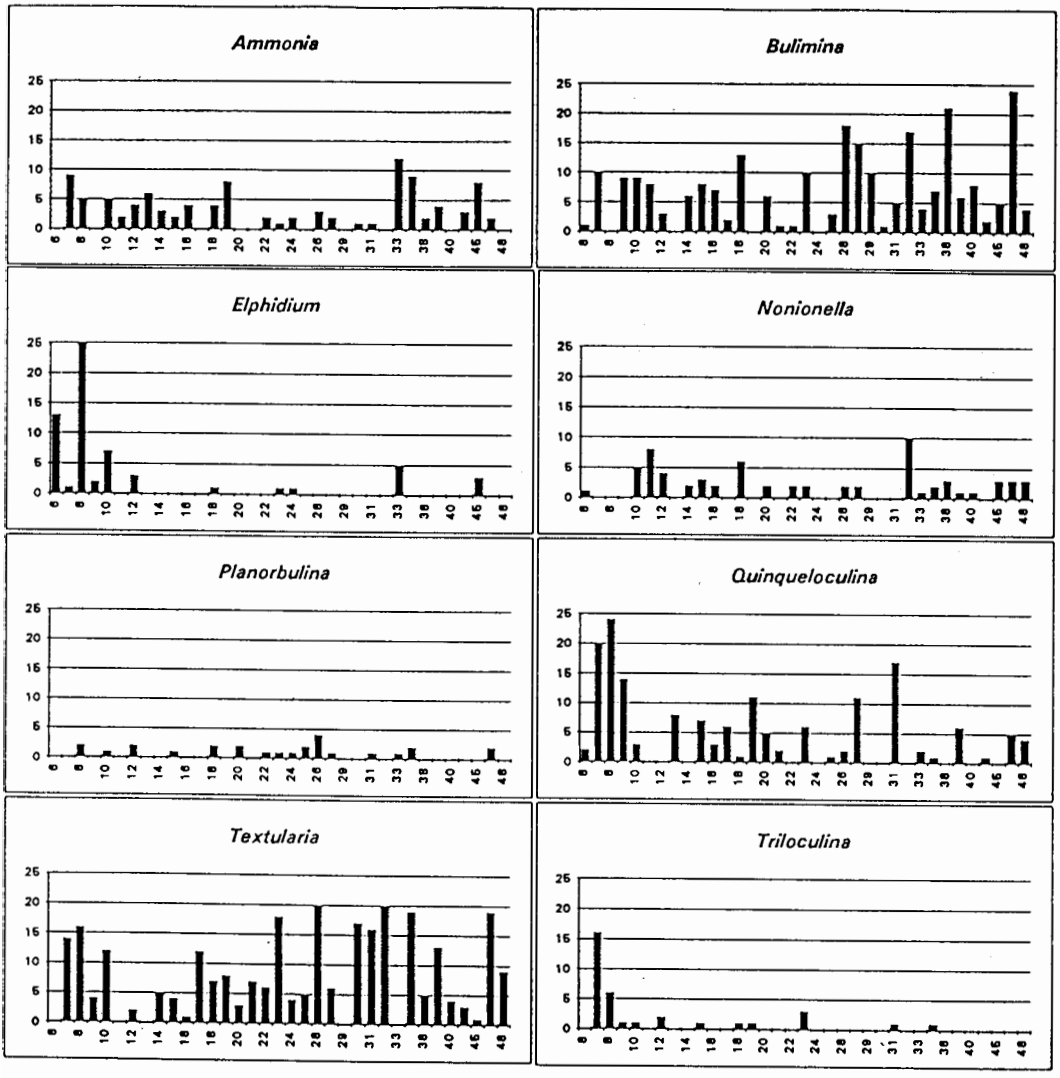


Table 4: Diversity of the most abundant genera of benthic foraminifera



Quinqueloculina group. As for the ostracods, most common taxa all over the stations are *Loxoconcha agilis*, *Loxoconcha romboidea* and *Propontocypris pirifera*. There seems to be no particular preference of any of the above mentioned taxa to thrive at certain depth spans.

As a general rule, the higher diversity of taxa is observed from stations whose water depth is down to 30 meters; samples 7 and 8 are indicative of this (Fig.1). It is apparent that the diversity decreases towards east, a fact that should be ascribed to lower salinity but also to the higher nutrient content, which promotes eutrophism and therefore, oxygen deficiency conditions right above the bottom. The higher diversity of taxa in samples 6, 7 and 8 should be attributed to the higher oxygen content in the waters near the entrance of the gulf, due to their replenishment by fresh Ionian Sea water. At the eastern part of the gulf, water circulation and subsequent oxygenation of the waters is low. This, along with the vertical water stratification due to Arachthos river discharge lead to oxygen depletion conditions; *Bulimina aculeata* and *Textularia*

spp. seem to be the most tolerant taxa in these conditions.

Another reason for the lower diversity of taxa in the eastern part of the gulf is the Arachthos river delta. Stations 28, 34, 35, 36, 41, 42, 44, i.e. at the Arachthos delta contain no microfossils at all, whereas stations influenced by the delta, such as 29, 30, 43 display lower values of diversity. It is likely that the lower diversity is related to the increased turbidity, as well as decreasd salinity near the delta. Arachthos' hydrological basin is mainly developing in flysch and, therefore, the sediment supply of Arachthos river is substantially higher than the one of Louros river . This leads to a pronounced turbidity in the delta front of Arachthos river, further confirmed by the agglutinated *Textularia* species, which, in many cases (stations 30, 43) tolerate the turbidity. It is documented that *Textularia* spp. prefer a muddy substatum and slightly hyposaline waters (Dermitzakis & Kourouni, 1982). Its cosmopolitan appearance should, therefore, be attributed to such conditions, which are apparent in the Gulf (Fig. 2, Table 3).

Elphidium spp. is abundant in waters down to 32m depth (samples 6, 8, 10), whereas *Ammonia* follows closely, but not as strictly (e.g. sample 37, 53m water depth). Nevertheless, its frequency increases towards east. It seems that *Elphidium* prefers a more or less sandy substratum (stations 6, 8) and well oxygenated waters (entrance of the gulf), whereas *Ammonia* is more tolerant to oxygen deficiency conditions, as well as salinity deviations.

Bulimina aculeata and *Textularia* spp. show a more or less reverse pattern in abundance (Table 1). Comparison of the relative frequencies of each taxa with the surface sediment distribution in the gulf (Fig. 2), reveals a definite preference of *Bulimina aculeata* for finer sediments (silt, clay).

Nonionella opina is present at stations deeper than 20 meters and as deep as 50 meters or more (stations 30, 31). It thrives in the gulf, therefore, between 20 and 60 meters and tolerates less oxygenated waters.

Quinqueloculina group and *Triloculina trigonula* are more abundant at the western and central part of the gulf, with a few exceptions (stations 31, 37). The common denominator of all these stations seems to be tranquillity of the waters and no tolerance for turbidity (they are absent near the Arachthos delta). The same applies (as expected) for *Planorbulina mediterranensis,* which is an epiphytic species.

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