THE BIVALVIA (MOLLUSCA) FROM THE UPPER MIOCENE OF THE SAIS BASIN (SOUTHERN RIFIAN CORRIDOR, MOROCCO). PALAEOBIOGEOGRAPHY AND PALAEOECOLOGY

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Abstract: The grey marls of the Sais basin, Tortonian-Messinian in age, yielded rich and rather diverse faunas of bivalves. They come from seven localities which are approximately on a line between the Fes region, eastwards, to the Meknes region, westwards. This basin shows the closest affinities with the Tortonian of the Mediterranean (mainly Italy, Greece, Bulgaria) as shown by *Pecten seguenzai* and *Linga agassizi.* These relations were largely favoured by the Southern Rifian Corridor which enabled a direct connection between the Mediterranean and the Sais Basin, up to the closing of the Strait of Taza during the Messinian. Comparisons between the bivalve faunas of the Upper Miocene of the Mediterranean and Atlantic approaches, and because of the southern latitude of the Sais Basin, it may be inferred that the climate was subtropical. From a palaeoecological point of view, the bivalve faunas of the Sais Basin are of interest because all fossils, *i.e.* both aragonitic and calcitic ones, are well preserved. The fossils were transported on short distances by selective currents ; they represent components of thanatocenoses which originated in slightly different biotopes. The fauna as a whole indicates a normal salinity (brackish and lagunal forms are lacking) ; it lived in shallow environments (infralittoral and upper circalittoral).

Key words: Bivalves, Late Miocene, Southern Rifian Corridor, Morocco, Palaeobiogeography, Palaeoecology.

Resumen: Las margas grises de la cuenca del Sais, datadas del Mioceno superior (Tortoniense-Messiniense), contienen una fauna de bivalvos muy diversificada. La fauna procede de siete localidades alineadas entre Fes al este y Meknes al oeste. Esta cuenca tiene mucha similitud con el Tortoniense mediterráneo (principalmente Italia, Grecia y Bulgaria) que contienen también *Pecten seguenzai* y *Linga agassizi.* El Corredor Sur Rifeño facilitó la comunicación entre el Mediterráneo y la cuenca del Sais, hasta que en el Messiniense se cerró el Estrecho de Taza. La comparación de la fauna de bivalvos entre el Mediterráneo y el Atlántico y la posición muy meridional de la Cuenca del Sais permiten concluir que existió un clima subtropical. La conservación de todos los fósiles bivalvos de concha calcítica y aragonítica de la Cuenca del Sais tiene interés paleoecológico. Los fósiles sufrieron un corto transporte por la acción de corrientes selectivas ; representan los componentes de tanatocenosis procedentes de biotopos algo diferentes. Toda la fauna es de salinidad normal (no se ha reconocido ninguna especie salobre o lagunar) y se desarrolló en un medio somero (Infralitoral y parte superior del Circalitoral).

Palabras clave: Bivalvos, Mioceno superior, Corredor Sur Rifeño, Marruecos, Paleobiogeografía, Paleoecología.

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The present preliminary study of the bivalve faunas from the Upper Miocene of the Sais Basin (areas of Fes and Meknes) adds to the numerous malacological works (or in which malacological sections are included) undertaken for years in the Neogene of the northern Morocco basins (Chavan, 1944 ; Lecointre, 1952 ; Ben Moussa, 1994; González Delgado *et al.*, 1995 ; Civis *et al.*, 1997a,b). The palaeogeographical history of the Southern Rifian Corridor from its opening during the Early Miocene to its closure (Strait of Taza) during the Messinian enabled the development of rich marine faunas found in various facies. The faunas of the Tortonian and Messinian marls and clays of Fes and Meknes include numerous bivalves. In this paper, bivalves are studied from biostratigraphical, palaeobiogeographical and palaeoecological points of

view and their place in the background of the broad Atlanto-Mediterranean realm is assigned.

Geological setting and palaeogeographical evolution

The Sais Basin is located south to the Rif. It stretches from a region west to Meknes to an area east to Fes, *i.e.* to the Strait of Taza. It is a part of the Southern Rifian Corridor which opened during the Early Neogene (post-sheet sedimentation). It directly connected the Atlantic Ocean to the Mediterranean ; Feinberg, 1986 ; Cirac, 1987 ; Saint Martin, 1990 ; Rakic-El Bied, 1990 ; Benson *et al.*, 1991) (Fig. 1).

The sediments which correspond to the Late Miocene transgression are generally labelled «Tortonian marls», «blue marls» or «grey marls». The thickness of these marls can be over 1000 m (bore holes) in the middle of the corridor. Despite the term «Tortonian marls», these sediments (which are sometimes clays) extend up to the Messinian (Wernli, 1988) where they progressively shift to marine sands the matrix of which is carbonated. The latter sands represent the so-called «Sahelian» of old authors. The upper part of the sands is Miocene-Pliocene in age as are the sediments from the Zemmours-Mamora region, west to the Sais Basin (Cirac, 1987). The present study deals only with the Upper Miocene.

In the Fes area, the observable thickness of the Upper Miocene marls can reach 50 m ; they crop out on the margins of the basin and in quarries. They are characterized by their wealth in bioclasts, and the presence of gypsum and pyrite. The faunas of bivalves are rich and diverse; the endobiontic species are predominant which results from the fine grained nature of the sediments. In this part of the basin, the Uppermost Miocene sands which overlie the marls and clays are not thick. They comprise quartzose components and bioclasts which are abundant locally. The bivalves are not frequent and more poorly preserved than in the marls, indicating rather high hydrodynamic energy.

In the western part of the basin, the thickness of the marly deposits in the sector of Ain Lorma and Meknes can also reach 50 m. The thickness of the sands is similar to that of marls. The fossiliferous sites of Meknes and chiefly Ain Lorma produced a fauna of bivalves which is even richer than in the Fes region. On the other hand, in the Uppermost Miocene sands at Ain Lorma and Meknes the bivalves are not frequent.

The studied bivalves come from localities which belong to the upper, and even uppermost, part of the «blue marls» facies and to the base of the «yellow sands» which general overlie the marls. South to Fes, in the quarries in which the marls are worked, two fossiliferous sites were found 10 to 20 m below the sands (Ain Zitoune and Fes). Sampling was made near the Oued Madhouma, between Fes and Meknes, where the section is not complete because it is truncated by a quaternary terrace. An abondant collecting was made in typical blue marls of a quarry, north of Meknes. The others fossiliferous localities are located west of Meknes, very close to the Oued Kell (Saint Martin, 1990): Ain Lorma 1 and Ain Lorma 2, in the uppermost part of the marls and in the base of the yellow sands

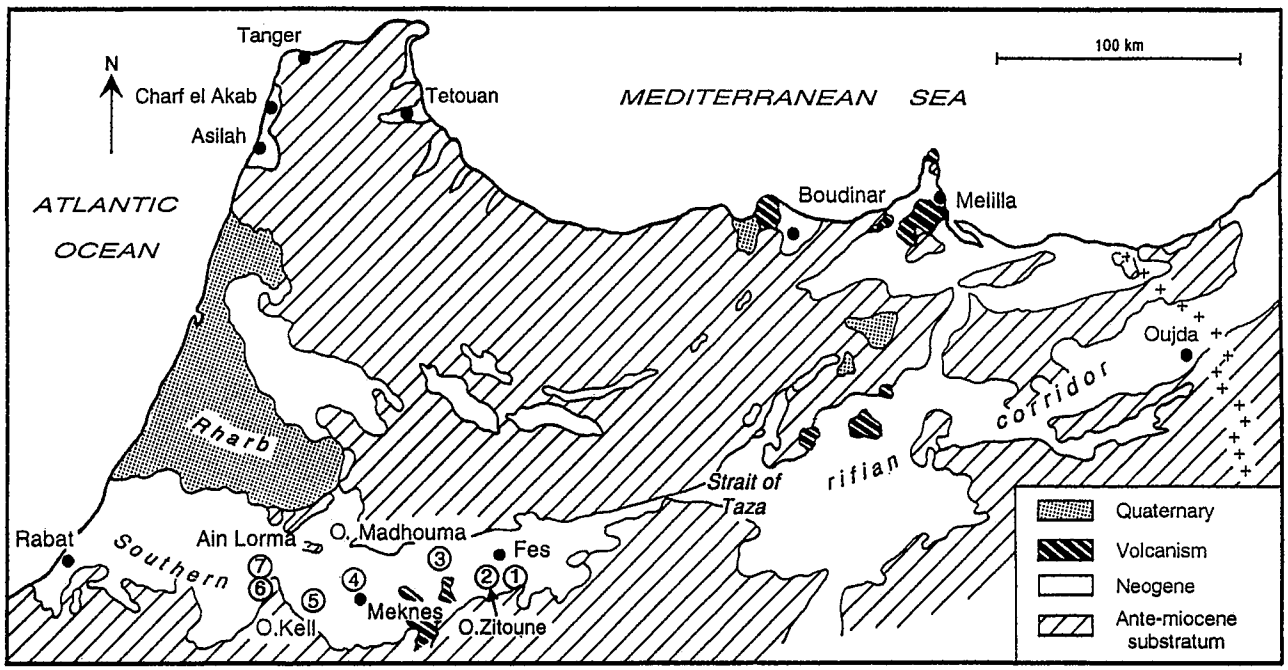

Figure 1 .- Geographical location of the Upper Miocene sites in the Sais Basin: 1) Fes ; 2) Oued Zitoune ; 3) Oued Madhouma ; 4) Meknes ; 5) Oued Kell ; 6) Ain Lorma 1 ; 7) Ain Lorma 2 (after Saint Martin, 1990 and Ben Moussa, 1994 ; modified).

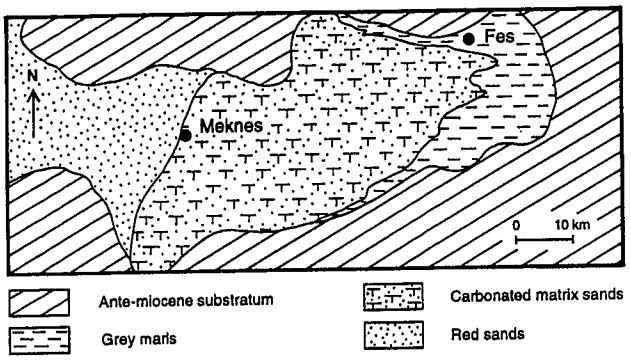

Figure 2 .- Distribution of main facies of the Uppermost Miocene and Lowermost Pliocene in the Sais Basin (after Cirac, 1987 ; modified).

respectively, and, upstream, Oued Kell in the upper part of the marls. The enclosing sediment generally yielded a rich microfauna comprised of planctonic foraminifera, identified by M.Boutakiout, H.Feinberg, and also according to Wernli (1988). This microfauna leads to regard the bivalve localities as, at least, late Tortonian, and even to securely consider some of them as Messinian in age, a stage characterized by *Globorotalia conomizea* (Oued Madhouma, Ain Lorma: Wernli, 1988) or by nannoplancton (area of Fes - Sidi-Harazem: Rouchy, 1982).

From a palaeogeographical point of view, the history of the Sais Basin during the Late Miocene may be summarized as follows: 1) the Tortonian transgression completely flooded the Southern Rifian Corridor, very fossiliferous marls (and clays) deposited in the whole basin; 2) by the end of the Messinian, the Strait of Taza more or less closed, which stopped interchanges with the Mediterranean. The closing of the Strait of Taza resulted in the western withdrawal of the sea in the Fes region ; then, this region was the eastern limit of the carbonated matrix sands (Ben Moussa *et al.*, 1997) (Fig. 2).

Methodology

Because of the richness and the very good preservation of the shells, our initial aim was to do an inventory of the fauna (J.P.P. and J.P.SM.) in order to render a palaeoecolological picture of Sais Basin. As far as the macrofauna is concerned, surface collectings were made. Washing sediments yielded small forms and microfauna. No statistical study was made because of the numerous very small specimens which are not identified at the species level. They were made without bias toward any taxon and they are quantitatively representative of the proportions of species (most frequent species are over a hundred specimens). There is no level in the blue marls in which shells accumulated, except in their uppermost part. Since the marls form a very homogeneous facies, no section was made, excepting along Oued Kell and at Ain Lorma where the shift from blue marls (Ain Lorma 1) to sands (Ain Lorma 2) may be noticed on the same section (Saint Martin, 1990, p.196 et 197).

Composition of the bivalve faunas

The bivalves collected in the Upper Miocene of the Sais Basin come from seven samplings which are inequally rich. This is a consequence of differences in facies (marly or sandy facies). 48 species are identified, they represent 21 families (Table I). The Pectinidae slightly outnumber the Veneridae, which is usual in a Miocene fauna. On the other hand, rather numerous specimens are only identified at genus or family level ; these specimens are generally incomplete or small, or even very small. The richest populations comprise small species (*Nuculana bonellii, N. fragilis, Pecten seguenzai, Gouldia minima, Corbula gibba*) or juvenile individuals of medium-sized species (*Anadara diluvii, Glans intermedia, Venus multilamella, Pitar rudis*). Adults of medium-sized species are not frequent. Only a few specimens of large species are found (Pinnidae, *Amusium cristatum* s.l., *Flabellipecten fraterculus,* Ostreidae, *Acanthocardia paucicostata, Glossus humanus*). Fragmentary specimens of large species, including *Panopea* sp., are also found among fragments of various sizes. Two remarks may be inferred from this preliminary analysis: 1) most species lived in fine grained sediments, which accounts for the good preservation of fossils and the majority of endobiontic forms ; 2) the localities correspond to thanatocenoses gathering various biotopes.

Geological age of the bivalve faunas

As in every Neogene fauna in the Atlanto-Mediterranean realm, extant species make up a substantial component (26 species / 48 species) of the fauna from the Upper Miocene of the Sais Basin. The remaining part of the fauna comprises 7 species known in the Neogene and the Quaternary, 11 Neogene species, and 4 which do not extend beyond the Miocene (of which 2 do not extend beyond the Tortonian). The species which are unknown after the Miocene include 2 Pectinidae (*Chlamys linguafelis* and *Pecten seguenzai*) and 2 Lucinidae (*Linga agassizi* and *Divaricella ornata*) (Table I).

-*Chlamys linguafelis* (= *fasciculata* Millet) is restricted to the Miocene ; it is known from the Paratethys (Eggenburgian to Badenian), from the whole Mediterranean realm up to northeastern Morocco (Ben Moussa, 1994), locally in the Atlantic realm (Langhian to Messinian in the Loire basin), and from the Miocene of the Azores. *C. linguafelis* (9 or 10 radial folds) is superseded in the Pliocene by *C. pesfelis* (Linnaeus) (6 or 7 radial costae). During field work, these two species enable to distinguish the Miocene from the Pliocene.

BIVALVES \ LOCALITIES	Ain Lorma 1	Ain Lorma 2	Oued Kell	Meknes	Oued Madhouma	Oued Zitoune	Fes	Miocene	Pliocene	Quaternary	Present
NUCULIDAE											
Nucula (N.) nucleus (Linné)	+										
Nucula (N.) placentina (Lamarck)	++	+		++	+	+	+				
Nucula (Lamellinucula) sulcata Bronn					+						
NUCULANIDAE											
Nuculana (N.) hoernesi (Bellardi)						+	+				
Nuculana (Ledella) bonellii (Bellardi)	++++					+	+				
Nuculana (Saccella) fragilis (Chemnitz)					+	+	+				
Yoldia (Cnesterium) longa Bellardi	++++	+		++		+	+				
ARCIDAE											
Anadara (A.) diluvii (Lamarck)	++++	+		++		++++	+				
NOETIIDAE											
Striarca lactea (Linné)	+										
LIMOPSIDAE											
Limopsis (Pectunculina) anomala s.l. (Eichwald)			+			+	++				
Limopsis (Pectunculina) recisa (Defrance)							+				
GLYCYMERIDIDAE											
Glycymeris (G.) glycymeris inflata (Brocchi)	+										
Glycymeris (G.) sp.	+										
MYTILIDAE											
Modiolus (M.) sp.	+	+									
Lithophaga (L.) lithophaga (Linné)	+										
PINNIDAE											
Pinna tetragona Brocchi						+					
Atrina pectinata s.l. (Linné)				+							
Pinna sp. 1				+							
Pinnidae indet.				++	+		+				
PECTINIDAE											
groupe *Amusium*											
Amusium (A.) cristatum (Bronn)	+++	+	+	++		++					
Propeamussium felsineum (Foresti)						+					
groupe *Eburneopecten*											
Palliolum similis (Laskey)	+++						++				
groupe *Chlamys*											
Chlamys (Mimachlamys) varia (Linné)					+						
Chlamys (Mimachlamys) pusio (Linné)			++		++						
Chlamys (Manupecten) linguafelis (Almera & Bofill)			+								
groupe *Pecten*											
Pecten (P.) seguenzai Depéret & Roman	++++	+++		+	+	++++	++++				
Flabellipecten fraterculus (Sowerby)	+	+	++			+					
Pectinidae indet.		+			+	+	++				
ANOMIIDAE											
Anomia (A.) ephippium s.l. (Linné)	++	+	+			+					
Anomiidae indet.			+								
LIMIDAE											
Limaria (Limatulella) loscombii (Sowerby)						++					
Limea (L.) strigilata (Brocchi)	+++						++				
OSTREIDAE											
Hyotissa hyotis (Linné)			+	+							
Ostrea (O.) lamellosa s.l. Brocchi			+	+							
Ostreola stentina (Payraudeau)			++	++	++						
Ostreidae indet.			++	++	++		+				
LUCINIDAE											
Linga (Bellucina) agassizi (Michelotti)						++					
Myrtea (Myrtea) spinifera (Montagu)						++++					
Lucinoma borealis (Linné)		+		+++	+	++	+				
Divaricella ornata (Agassiz)						+	+				
Lucinidae indet.						++	+				
CARDITIDAE											
Glans (Centrocardita) intermedia (Brocchi)	++++	+					+				
CARDIIDAE											
Cardium (Bucardium) hians (Brocchi)	+										
Acanthocardia (A.) paucicostata (Sowerby)	+										
Plagiocardium (Papillicardium) papillosum (Poli)	+++					++					
Laevicardium sp.	++										
MACTRIDAE											
Spisula (S.) subtruncata triangula (Renieri)					+						
TELLINIDAE											
Tellina (Serratina) serrata (Brocchi)	++					+					
Solecurtus antiquatus Pulteney											
Tellinidae indet.	+++			++		++					
GLOSSIDAE											
Glossus (G.) humanus (Linné)	++										
VENERIDAE											
Venus (Ventricoloidea) multilamella Lamarck	++++	+		++++		++	+				
Venus (Dosina) alternans (Bonelli)	+										
Gouldia (G.) minima (Montagu)	+++	+		+		++					
Pitar (P.) rudis (Poli)	++++					++	++				
Clausinella scalaris (Bronn)	+										
Timoclea (T.) ovata (Pennant)	+++										
Veneridae indet.					+						
CORBULIDAE											
Corbula (Varicorbula) gibba (Olivi)	++++	+	+++	+++	++	++++	++				
Corbulidae indet.											
HIATELLIDAE											
Panopea (P.) sp.			+	+							
BIVALVIA indet.	++	+	+	+		+	+				

Table I .- Bivalves from the Upper Miocene of the Sais Basin.

-*Pecten seguenzai* is not widespread. It is known only from the Mediterranean Tortonian, in Italy and also in Crete (Merle *et al.*,1990).

-*Linga agassizi* is not frequent. It first appears in the Chattian of Aquitaine and extends up to the Tortonian in Mediterranean (Italy), in Bulgaria (Kojumbdieva, 1960), and in the hellenic area (Dermitzakis & Georgiades-Dikeoulia, 1984).

-*Divaricella ornata* is known from the whole Lower and Middle Miocene of the Atlanto-Mediterranean realm and from the Paratethys, as also from the Tortonian of Bulgaria. It was also reported from the Tortonian of Atlantic Morocco (Lecointre, 1952). *D. divaricata* (Linnaeus) replaces *D. ornata* in the Pliocene. The former species is smaller and its striae are less marked ; it occurs in the Pliocene of northeastern Morocco (Ben Moussa, 1994) and southeastern Spain (Andrés, 1987).

On the other hand, *Flabellipecten fraterculus* is a common species in the Atlanto-Mediterranean Miocene, but it is rare in the Paratethys area (Ottnangian only). The climax of this species took place during the Tortonian (Demarcq, 1990). The species is frequent in the Tortonian and Messinian of northeastern Morocco ; it became extinct before the Pliocene, except in the western Mediterranean where it occurs in the Pliocene of Tetouan (Ben Moussa, 1994).

The malacofauna, as a whole, appears to belong to the Tortonian as demonstrated by *Pecten seguenzai* which is present nearly everywhere in the studied area and which is restricted to this stage. Studies of the microfaunas of every locality might provide more precise ages (Tortonian, Messinian, Pliocene).

As far as the inversion of the Pectinidae / Veneridae ratio at the Miocene-Pliocene transition is concerned (Ben Moussa, 1994, p.179), it should be noted that in the Upper Miocene localities of the Sais Basin the faunas are consistent with this ratio: The Pectinidae outnumber the Veneridae. However, these results are somewhat biased because endobiontic species are more numerous than epibiontic species, in connection with the presence of fine grained sediments.

Palaeobiogeography

Relations with northeastern Morocco

Precise palaeobiogeographical comparisons between the faunas of the Upper Miocene marls of the Sais Basin (48 species) and the marly facies of the Tortonian (9 species) and Messinian (18 species) of northeastern Morocco cannot be easily analysed (Ben Moussa *et al.*, 1987; Ben Moussa *et al.*, 1988; Ben Moussa, 1994). This mainly results from the fact that the fine grained part of the sediment, in the Sais Basin, favoured the presence (and also the preservation) of small species which sometimes make up rich populations (Nuculanidae, Limopsidae, small Veneridae, *Corbula gibba*) or of juvenile individuals of medium-sized species (*Anadara diluvii, Glans intermedia, Venus multilamella*). In northeastern Morocco, small individuals are not preserved in coarsed grained sediments ; as a consequence, mainly medium-sized and large specimens (numerous Pectinidae) are recovered there. Only 6 species are present in both areas: *Anadara diluvii, Amusium cristatum* s.l., *Flabellipecten fraterculus, Anomia ephippium* s.l., *Ostrea lamellosa* s.l., *Pitar rudis.*

Relations with the Atlantic approaches

The faunas of the Sais Basin appear to be more closely related, from a palaeobiogeographical point of view (Alvinerie *et al.*, 1992) to those of the Tortonian of southern Portugal at Cacela (Chavan, 1940) than to those of the Tortonian of Atlantic Morocco (Lecointre, 1952), which is geographically closer ; this depends on facies causes. In fact, Spain, Portugal and Morocco make up a homogeneous palaeobiogeographical area (Gonzàlez Delgado *et al.*, 1995).

Relations with the Mediterranean

However the closest palaeobiogeographical relations appear between the Sais Basin and the Mediterranean Tortonian, chiefly the Tortonian of northern Italy (36 species out of 48 from the Sais Basin are known in Italy) (Sacco,1897-1901). Among the 36 species common to both region, the most significant (because they are the less frequent) are the following: *Nuculana bonellii, Limea strigilata, Linga agassizi, Venus alternans, Propeamussium felsineum.*

The most important fact is that the Sais Basin fauna is also related to the eastern Mediterranean fauna in the hellenic area (Dermitzakis & Georgiades-Dikeoulia, 1984 ; Merle *et al.*, 1990), where two rare species (*Pecten seguenzai* and *Linga agassizi*) also present in the Sais basin, are reported. To the North, in Bulgaria, Kojumbdgieva (1960) studied a Tortonian fauna which also includes significant species present in the Sais Basin: *Nuculana hornesi, Amusium cristatum* s.l., *Divaricella ornata.*

From a palaeoclimatical point of view, one may consider that, during the Late Miocene, in the Mediterranean realm and in the Lusitano-Moroccan regions (Georgiades-Dikeoulia *et al.*, 1997) the climate was warm, of subtropical type, despite a certain drop in temperature which took place during the Serravallian (Demarcq, 1989) and which more perceptibly affected the Atlantic regions north to Gibraltar (Lauriat-Rage *et al.*, 1993). This warm climate even enabled the building of reefs in the Mediterranean area (Saint Martin, 1990).

These data argue for the palaeobiogeographical homogeneity of the Mediterranean and its direct dependances during the Late Miocene. During the Tortonian and early Messinian, the Strait of Taza did enable faunal interchanges between the whole Mediterranean and the Sais Basin, as demonstrated by the presence of rare, or comparatively rare, species.

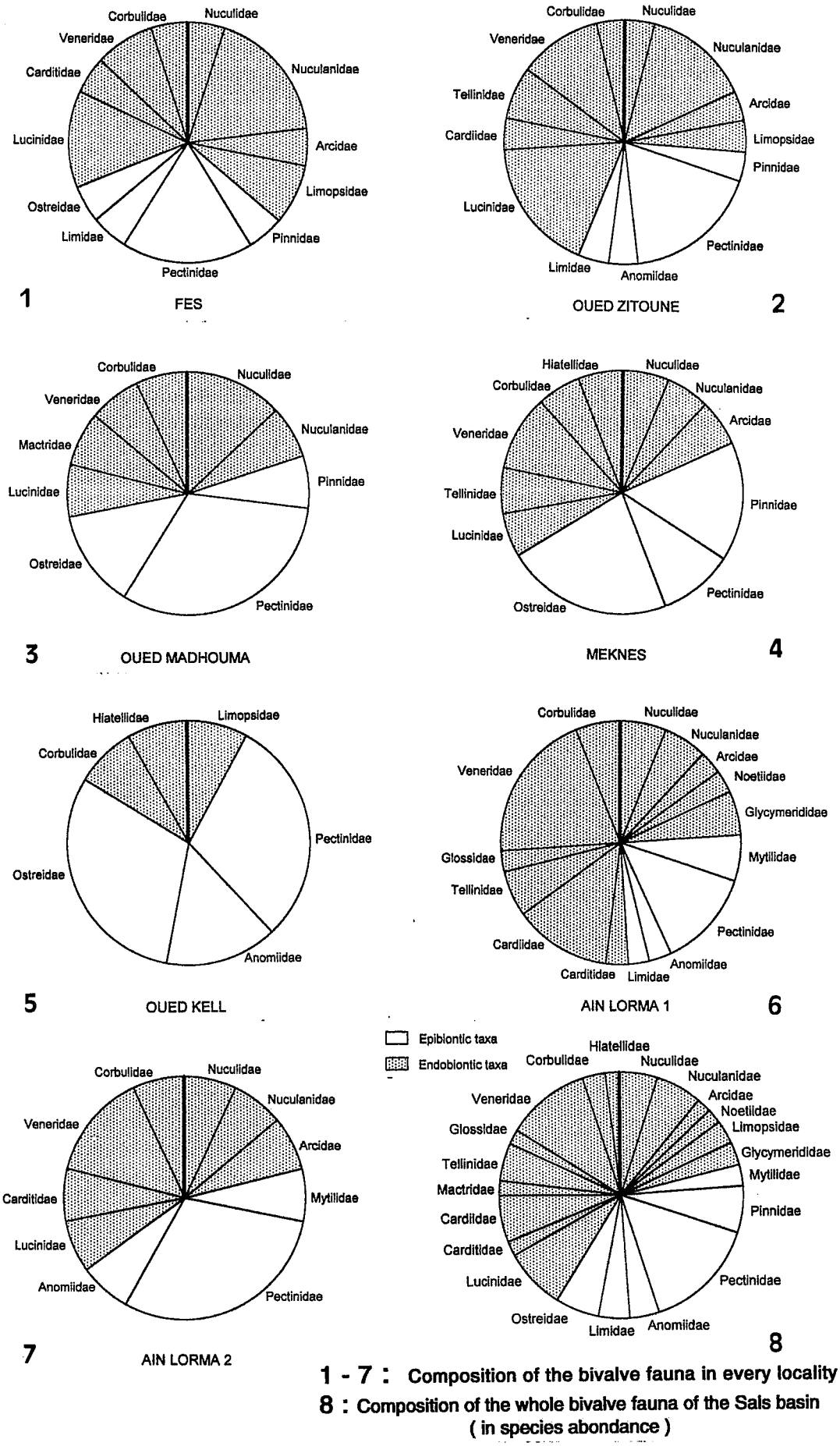

Figure 3 .- Family ratio (in species abundance) of the bivalve faunas in the Sais Basin.

Taphonomy

The taphonomic analysis of the fauna also shows that the bivalves underwent a transportation: there are few individuals belonging to the larger species (up to about 80 mm), *i.e.., Glycymeris glycymeris inflata, Amusium cristatum* s.l., *Flabellipecten fraterculus, Acanthocardia paucicostata, Glossus humanus*. Morever, they are often broken (large fragments of *Panopea* sp.). Conversely, large populations of species of small size (*Nuculana bonellii, Yoldia longa, Pecten seguenzai, Myrtea spinifera, Gouldia minima, Corbula gibba),* as also of juvenile individuals of medium-sized species (*Anadara diluvii, Glans intermedia, Venus multilamella, Pitar rudis*) were easily transported by currents owing to their lightness. But this selective transportation (sizing of the valves) probably acted on short distances as demonstrated by: 1) the good state of preservation of the specimens ; 2) the presence of complete individuals (valves in connection) belonging to *Nucula placentina, Nuculana bonellii, Anadara diluvii, Glycymeris glycymeris inflata, Pinna pectinata, P. tetragona, Myrtea spinifera, Glans intermedia, Glossus humanus, Corbula gibba* ; 3) the approximately balanced number of right and left valves in the richest populations (Nuculanidae, *Anadara diluvii, Glans intermedia,* Veneridae, *Corbula gibba*). It should be noted that the absence of various growth stages of medium-sized species (*Anadara diluvii, Glans intermedia, Venus multilamella, Pitar rudis*) probably results from a selective sorting during transportation, but the possibility of death rates which affected certain populations at various growth stages should be also considered. Besides, *Lithophaga lithophaga* and *Hyotissa hyotis* which live on hard bottoms (rocky or even reefal) were transported on longer distances.

Palaeoecology

As a result of the nature of the sediments (more or less argillaceous or sandy marls) which favours endobiontic species, the fauna is only comparately diverse (Piquet & Saint Martin, 1986). However, the Sais Basin lacks some endobiontic species which are frequent in the Upper Miocene (for exemple, the Tapetinae *Paphia vetula*). Among the epibiontic taxa, some families are either absent (Spondylidae, Chamidae) from the basin, which is consistent with the facies, or comparately little represented (Pectinidae, Ostreidae), even if the Pectinidae are the prevailing family (15% of the species). So, this fauna is unbalanced ; it comprises mainly endobionts (12 families, 62%) while epibionts represent only 38% (6 families) of the fauna. The proportions are even more unbalanced according to the studied localities, which results from the fact that some of them yielded only a few species (Aïn Lorma 2, Oued Kell, Oued Madhouma) (Fig.3). All endobionts are superficial burrowers except *Venus multilamella* and *Panopea* sp. which are deep burrowers. The epibionts are rather diverse, with or without byssus. It should be stated that the argillaceous facies of the locality of Meknes includes two ecological types: the Pinnidae (semi-infaunal) on one hand, and various Nuculidae and Tellinidae (endobiontic) on the other hand.

All bivalves indicate a fully marine environment, without lagunal or brackish forms, of various depths. The vast majority of species are distributed from the infralittoral to circalittoral stages. Among the more littoral are: *Acanthocardia paucicostata* and *Spisula subtruncata triangula. Nuculana sulcata, Nuculana fragilis, Anadara diluvii, Amusium cristatum* s.l. *Venus multilamella* range among the more circalittoral. According to the geological context, the environment was probably transitional between the infralittoral and the upper part of the circalittoral.

Conclusions

The study of marine faunas (the bivalves in the present paper) of the Upper Miocene of the Sais Basin shows the important role of malacological faunas in: 1) the interpretation of the age of the localities, owing to the presence of significant taxa of the Tortonian, and 2) the palaeobiogeographical field as they demonstrate the homogeneity of the Mediterranean realm during the Late Miocene, from the Atlantic approaches to continental Greece, Crete, and Bulgaria which results from the presence of a direct connection between the Sais Basin and Mediterranean.

On the other hand, the seven fossiliferous localities of the Sais Basin (which outcrop in an area about 110 km long), enables a preliminary palaeoecological analysis of the bivalves. These fossils which come from marly facies (silty argillaceous) comprise a majority of endobionts. They complete the malacological faunas already found and studied in the various areas of northern Morocco.

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