



Pliocene bivalves (Pteriomorphia) of Algiers Sahel (Algeria): Systematics and palaeoecology

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Abstract: A hundred specimens of pteriomorph bivalves were collected from the marine deposits of the marly-sandy formations of Algiers Sahel, which correspond to transitional facies between the Piacenzian deep marly deposits and the Astian molassic deposits. They are herein analysed from a systematic, taphonomic, palaeoecological and paleoenvironmental point of view. The preliminary inventory list consists of 27 species belonging to eight families: Arcidae, Nuculidae, Glycymeridae, Spondyliidae, Pectinidae, Plicatulidae, Gryphaeidae, and Ostreidae. Two sedimentary units with different bivalve biodiversity are recognized: the first: a shallow infralittoral unit characterised by large *Flabelligerina alessii*, *Aequipecten angelonii*, *Ostrea lamellosa* and *O. edulis*; the second: A deeper unit of circalittoral environment mainly includes *Amusium cristatum*. These bivalve shells display sclerobiont traces. Bioerosion traces are mostly assignable to clionid sponges (*ENTOBIA* isp.), polychaete worms (*Maeandropolydora* isp. and *Caulostrepsis* isp.), bivalves (*Gastrochaenolites* isp.) and predatory gastropods (*Oichnus* isp.). Identified encrusting organisms are juvenile oyster shells, cirripedes, polychaete worms (serpulids), and indeterminate bryozoans. Analysis of boring and encrusting traces indicate a progressive environmental change from a relative high energy setting to a lower energy and deeper water setting, and correspond to a shallow sea with well-oxygenated waters.

Keywords:

- pteriomorph bivalves;
- systematics;
- taphonomy and paleoenvironment;
- marine Pliocene;
- Algeria

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Résumé : Bivalves ptériomorphes pliocènes du Sahel d'Alger (Algérie) : Systématique et paléo-écologie. - Une centaine de spécimens de bivalves ptériomorphes ont été récoltés dans les dépôts marins des formations marno-sableuses pliocènes du Sahel d'Alger qui correspondent à des faciès de transition entre les dépôts marneux profonds du Plaisancien et les dépôts molassiques de l'Astien. Ils sont ici analysés sur le plan taxonomique, taphonomique, paléoécologique et paléoenvironnemental. L'inventaire taxonomique préliminaire comprend 27 espèces appartenant à huit familles : Arcidae, Nuculidae, Glycymeridae, Spondylidae, Pectinidae, Plicatulidae, Gryphaeidae et Ostreidae. Deux unités sédimentaires avec une biodiversité différente des bivalves ont été reconnues : La première peu profonde de milieu infralittoral est caractérisée par *Flabellipecten alessii*, *Aequipecten angelonii*, *Ostrea lamellosa* et *O. edulis* ; la seconde, plus profonde, circalittorale comprend principalement *Amusium cristatum*. Les coquilles de ces bivalves comportent des traces de sclérobiontes. Les traces de bioérosion sont principalement attribuables à des éponges clionides (*Entobia* isp.), des polychètes (*Maeandropolydora* isp. et *Caulostrepsis* isp.), des bivalves (*Gastrochaenolites* isp.) et à des gastéropodes prédateurs (*Oichnus* isp.). Les organismes encroûtants identifiés sont des valves d'huîtres juvéniles, des balanes, des polychètes (serpulidés) et des bryozoaires indéterminés. L'analyse de ces traces majoritairement observées sur les bivalves de grande taille indiquerait plutôt un changement environnemental progressif, d'un milieu à haute énergie vers une à basse énergie et des eaux plus profondes, et devrait correspondre à une mer plutôt peu profonde avec des eaux bien oxygénées.

Mots-clefs :

- bivalves ptériomorphes ;
- systématique ;
- taphonomie et paléo-environnement ;
- Pliocène marin ;
- Algérie

1. Introduction

The Pliocene deposits of Algiers Sahel are composed of marls and sandy marls with intercalated sandstones and limestones, which are rich in benthonic fauna, especially bivalves. Quite a number of studies in this area reported the abundance of these bivalves but without any precise information on their systematics and palaeoecology (e.g., DELAGE, 1888; GLANGEAUD, 1932, 1936, 1968; DALLONI, 1934, 1954; AYMÉ, 1948, 1955, 1963; MURAUOUR, 1949, 1951; GLANGEAUD *et al.*, 1952; AYMÉ *et al.*, 1953; CABOT, 1968; YASSINI, 1973, 1975; SAADALLAH, 1981; SAOUDI, 1989; DJEDIAT, 2013).

During the construction of residential buildings in the southeastern suburb of Algiers in 2012-2013, extensive earthwork in the Pliocene marly-sandy deposits exposed two lithological sections that allowed us to collect a rich and diversified bivalve assemblage associated with some gastropods, brachiopods and bryozoans. The present study aims to describe the collected bivalve specimens, to define their systematics and to interpret their palaeoecological and palaeobiogeographical framework.

2. Geographic and geologic framework of the study area

The Algiers Sahel belongs to the inner zones of the Maghrebides range that represents the northern part of the Peri-Mediterranean Alpine orogen (DURAND DELGA, 1971). Of NE-SW direction, along the Mediterranean shore, the Algiers Sahel runs over an anticline structure and builds a high plateau, ranging between 200 m and 250 m in height, between the Chenoua and the Algiers massifs in the north and the Mitidja plain in the south. The main tectono-sedimentary units of the Algiers massif are as follows (Fig. 1):

1) The Palaeozoic metamorphic massif of Bouzareah, consisting of gneiss, schists, marble, and

micaschists. It displays traces of Hercynian and Alpine intense tectonics dividing the basement rocks into seven tectono-metamorphic units (SAADALLAH, 1981);

2) The Cenozoic strata represented by transgressive formations that overlie unconformably the metamorphic terrains. Their succession can be subdivided in three parts:

- the Miocene, more extensively outcropping in the south of the Mitidja basin. In the Oued Mazafran, AYMÉ *et al.* (1953) characterised a sedimentary series, including from base to top, Burdigalian sandy marls (350 m), a sandstone marker bed underlining the transition to the Upper Miocene, and a thick Upper Miocene marly succession, gypsiferous at its base (250 m), with thin sandstone intercalations at its top (300 m);
- the Pliocene deposits including from base to top: Piacenzian gypsiferous marls (1,000 m), a ca. 100 m thick Astian succession of glauconitic sandstones, sandy marls rich in benthonic fauna, and massive calcareous sandstones with large bivalves. They are followed by a reefal or subreefal complex, and marine and continental detrital beds (ca. 30 m), that initiated the Villafranchian infilling of the Mitidja basin (GLANGEAUD, 1932; GLANGEAUD *et al.*, 1952);
- the Quaternary displaying several regressive phases led to the deposition of diversified facies structured in the northern flank of the Algiers Sahel: the Pleistocene, which is composed of Calabrian, Sicilian and Tyrrhenian marine terraces (SAOUDI, 1989), and the Holocene which is characterised from base to top by a shelly facies, coastal silty mudstones rich in microfauna and red clayey sandy soils, resulting from the weathering of sandstone-carbonate facies, marls and gravels (DJEDIAT, 2013).

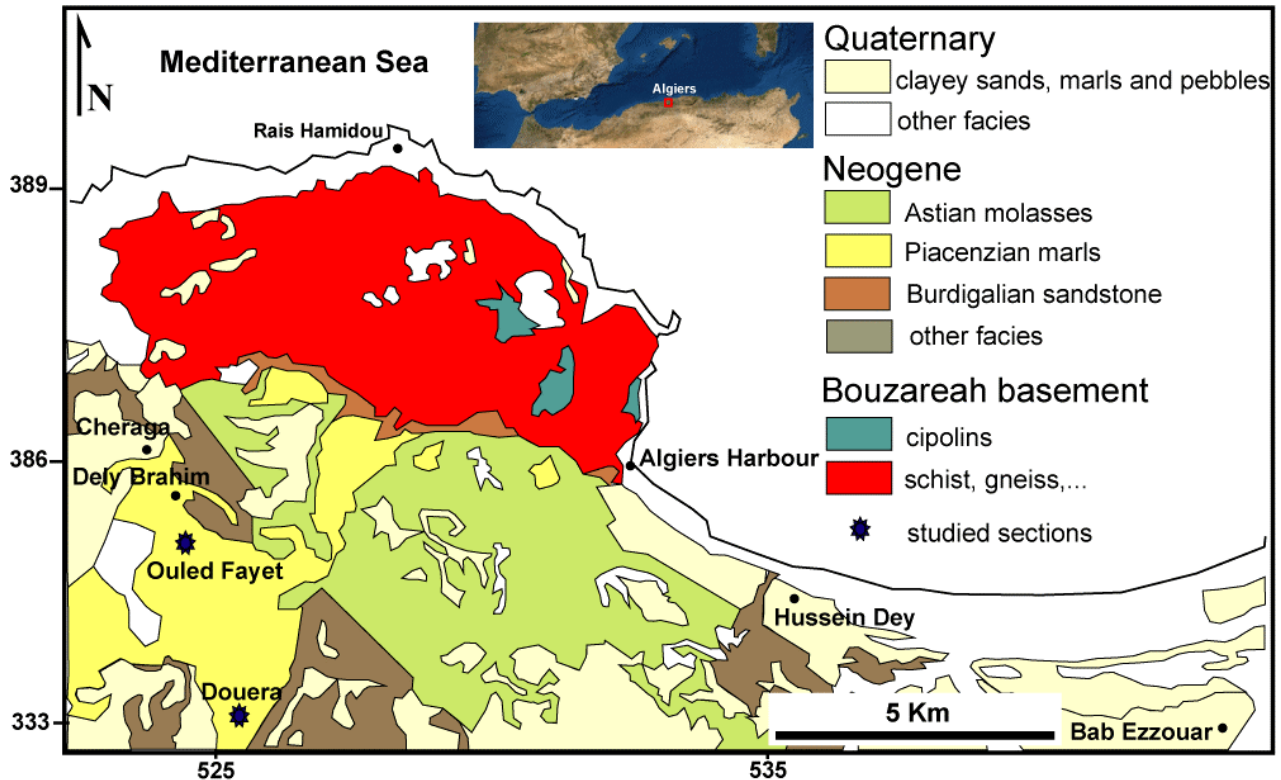


Figure 1: Geological map of Algiers and its surroundings (after AYMÉ, 1963), showing the location of the study area.
Figure 1 : Carte géologique d'Alger et de ses environs (d'après AYMÉ, 1963), montrant la localisation de la zone d'étude.

3. Material and methods

The studied material was collected in two selected sections of the Astian sandy marls of Algiers Sahel (Fig. 2), the first located at Ouled Fayet (UTMS coordinates: 36°42'37"N 2°56'08"E), and the second one at Douera (UTMS coordinates: 36°38'18"N 2°56'18"E). Both localities correspond to outcrops exposed thanks to intensive earthwork made for residential buildings purposes during the years 2012-2013. A hundred bivalve shells were collected and housed at the Laboratory of Animal Ecobiology (LEBA) from the *École Normale Supérieure* of Kouba (Algiers, Algeria). The collected shells were cleaned, numbered (ST: Sciences Terre), and photographed with a digital picture camera Nikon d3100.

Respective measurements of the shell valves are as follows: h= antero-posterior length; l= umbo-ventral length; c= hinge length when available.

4. Brief description of the study deposits

The study area belongs to the Astian of Algiers Sahel, which is mainly formed of sandy marls. The synthetic lithological succession at the Ouled Fayet section, displays from base to top three units (Fig. 2.B): 10 m of compact grey marls (unit a); ca. 30 m of brownish, fossiliferous, sandy marls with intercalated lumachellic levels rich in *Amusium cristatum* (unit b) and ca 25 m of yel-

lowish, fossiliferous sandy marls (unit c). At the Douera section, the retrieved bivalve specimens only came from the yellow, fossiliferous, sandy marls of unit c (ca. 10 m); this succession is inaccessible today since the building of a high school soon after our fossil collecting. Figure 2.B illustrates the stratigraphic distribution of the identified species collected in both localities.

5. Systematics

The 27 bivalve species listed in this work are recorded in Figure 2.B and illustrated in Figures 3 to 7. The shells are in good state of preservation. We used the classification of Pteriomorpha established by WALLER (1978).

Class Bivalvia LINNAEUS, 1758
Subclass Pteriomorpha BEURLIN, 1944
Order Arcoida STOLICZKA, 1871
Superfamily Arcacea LAMARCK, 1809
Family Arcidae LAMARCK, 1809
Subfamily Anadarinae REINHART, 1935
Genus *Anadara* GRAY, 1847

Type species: *Arca antiquata* LINNAEUS, 1758

***Anadara diluvii* (LAMARCK, 1805)**
 (Fig. 3a)

1805 *Arca diluvii* LAMARCK, VI, p. 219.

1898 *Anadara diluvii* (LAMARCK).- SACCO, XXVI, p. 20, Pl. IV, figs. 7-12.

1914 *Arca (Anadara) diluvii* LAMARCK.- COSSMANN & PEYROT, p. 149, Pl. VIII, figs. 3-6; Pl. X, figs. 53, 56.

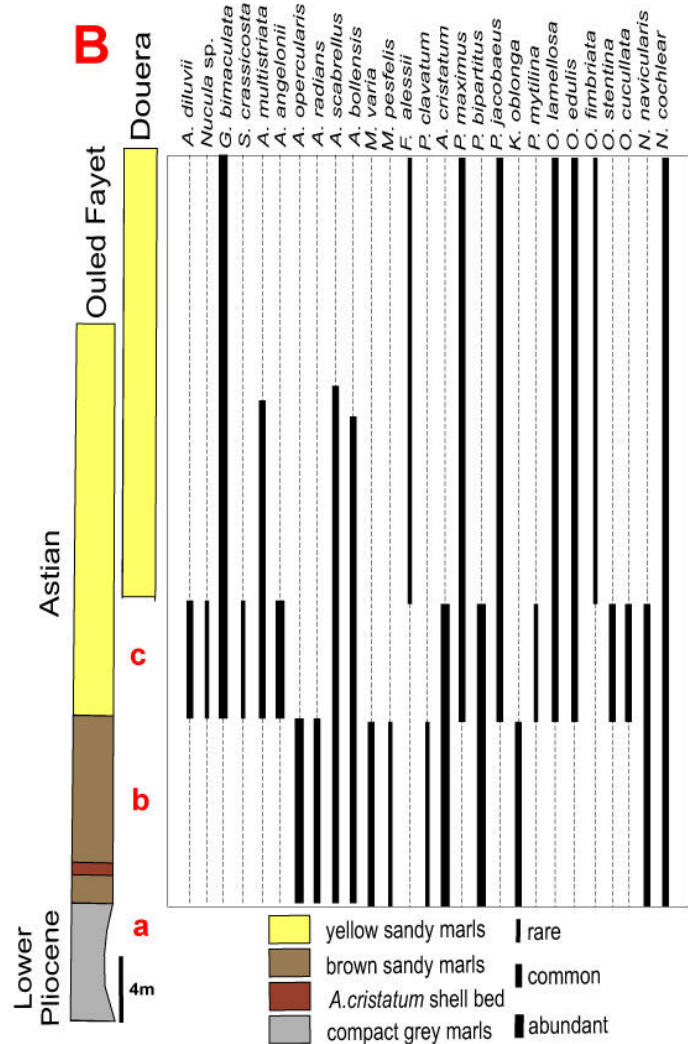


Figure 2: A (A1 and A2). Aerial and panoramic view of the Ouled Fayet section. **B.** Synthetic lithological log showing the stratigraphic distribution of the respective species collected in this study.

Figure 2 : A (A1 et A2). Vues aérienne et panoramique de la coupe d'Ouled Fayet. **B.** Coupe lithologique montrant la répartition stratigraphique des différentes espèces récoltées de cette étude.

- 1963 *Arca (Arca) diluvii* LAMARCK.- VENZO & PELOSIO, p. 139, Pl. XLII, figs. 6-8.
- 1975 *Anadara (Anadara) diluvii* (LAMARCK).- FEKI, p. 28, Pl. III, fig. 1.a-d.
- 1987 *Anadara (Anadara) diluvii* (LMK).- FRENEIX *et al.*, p. 12, Pl. I, fig. 9.
- 1994 *Anadara (Anadara) diluvii* (LAMARCK, 1805).- BEN MOUSSA, p. 63, Pl. 1, figs. 19-22.
- 2012 *Anadara (Anadara) diluvii* (LAMARCK, 1805).- SA-TOUR, p. 5, Fig. 4K.
- 2021 *Anadara diluvii* sensu SACCO, 1898, non LAMARCK, 1805.- BENYOUCEF *et al.*, Fig. 4A.

Material: Two right valves (ST136, l=34 mm, h=25 mm, c=25 mm; ST139, l=8 mm, h=10 mm, c=10 mm) and one left valve (ST138, l=33 mm, h=28 mm, c=23 mm), all coming from the yellow sandy marls of Ouled Fayet (unit c).

Description: The three collected valves are relatively small, oval, with rounded anterior side and clearly shorter than the posterior side. The rounded umbones are slightly prosogyrous. The ligament area is narrow and rather wide. The outer side of the valves is ornamented by some thirty unequal radial costulae wider than the interspaces.

Stratigraphic range: *A. diluvii* was first recorded in the Paratethys from the Oligocene of Hungary (MALATESTA, 1974). It is also known in the Aquitanian of the Atlantic-Mediterranean domain. It had a wide geographic distribution during the Miocene (Nordic, Atlantic, Mediterranean, and Paratethys domains). In the Pliocene, this taxon was restricted to the Atlantic-Mediterranean domain. Nowadays it is still scarce: Mediterranean Sea, Atlantic coast of Iberia, West coast of Africa to Angola, and Cape Verde Islands (FRENEIX *et al.*, 1987).

Ecology: This taxon is suspensivorous, slow burrowing, surficial as generally is the genus *Anadara* (STANLEY, 1970). According to PÉRÈS & PICARD (1964), *A. diluvii* characterises rather the circalittoral zone than the infralittoral one, mobile seabed and the biocoenosis of offshore detrital sea bottoms. It is abundant between -80 m and -100 m, less common in organogenic muds of the Algerian precontinent (CAULET, 1972). It is also reported between -20 m and -50 m in the continental shelf of the eastern Rif in Morocco (SAUBADE & TESSON, 1981).



Order Nuculoidea DALL, 1889
Family Nuculidae GRAY, 1824
Genus Nucula LAMARCK, 1799
Subgenus Nucula LAMARCK, 1799

Type species: *Arca nucleus* LINNAEUS, 1758

Nucula (Nucula) sp.
 (Fig. 3b)

Material: A single specimen (ST91) from the yellowish sandy marls of Ouled Fayet (unit c).

Description: The sampled specimen is an inner mould of small size (l=23 mm, h=25 mm, c=12 mm), of oval-triangular shape, slightly higher than wide and oblique, with opisthogyrous umbones displaced with respect to one another.

Stratigraphic range: *Nucula (Nucula) sp.* ranges from the Middle Miocene to the Recent.

Ecology: Species of the subgenus *Nucula (Nucula)* are ubiquitous, euryhaline and depositivorous, and live superficially burrowing in sandy bottoms, in depths not exceeding 100 m (PARENZAN, 1974). They tolerate low salinity and can live in lagoons (SAUBADE & TESSON, 1981), but mostly they are currently found offshore, on fine-sandy, coarse sand and silty bottoms around -180 m.

Superfamily Limopsacea DALL, 1895
Family Glycymerididae NEWTON, 1922
Subfamily Glycymeridinae NEWTON, 1922
Genus Glycymeris COSTA, 1778
Subgenus Glycymeris COSTA, 1778

Type species: *Glycymeris glycymeris* LINNAEUS, 1758

Glycymeris (Glycymeris)
***bimaculata deshayesi* (MAYER, 1868)**
 (Fig. 3c)

- 1795 *Arca bimaculata*.- POLI, p. 143, Pl. XXV, figs. 17-18;
 1868 *Pectunculus Deshayesi*.- MAYER, p. 53; 146
 1963 *Glycymeris bimaculata*.- TAVANI & TONGIORGI, p. 10, Pl. 1, fig. 1; Pl. 2, fig. 3; Pl. 4, figs. 1, 7-8.
 1987 *Glycymeris (Glycymeris) bimaculata (Poli, 1793) deshayesi* (MAYER, 1868).- FRENEIX *et al.*, p. 14, Pl. II, fig. 1.
 1994 *Glycymeris (Glycymeris) bimaculata deshayesi* (MAYER, 1868).- BEN MOUSSA, p. 66, Pl. 1, fig. 26.
 2012 *Glycymeris (Glycymeris) bimaculata deshayesi* (POLI, 1795).- SATOUR, p. 23, Pl. 1, fig. 4.
 2021 *Glycymeris cf. bimaculata* ((POLI, 1795).- BENYOUCEF *et al.*, p. 8-9, Fig. 4D.

Material: A complete shell (ST60, l=50 mm, h=50 mm, c=30 mm) and three inner moulds (ST76, l=40 mm, h=39 mm, c=30 mm; ST77, l=44 mm, h=40 mm, c=30 mm; ST106, l=55 mm, h=50 mm, c=40 mm) sampled from Ouled Fayet, as well as valve fragments from Douera (unit c).

Description: The complete specimen (ST60) displays a very thick and relatively large shell with two valves slightly offset on the dorsal side with respect to one another. The triangular ligament area shows a clearly visible taxodont hinge. These three inner moulds are of similar size. The shell outline is orbicular and displays a straight and slightly bulging umbo. The cardinal plate is wide and slightly arcuate. The outer surface is covered by fine concentric growth lines.

Stratigraphic range: *G. bimaculata bimaculata* appeared in the Mediterranean Pliocene, replacing *G. bimaculata deshayesi*, and ranges in the Atlantic, Mediterranean Sea and the Black Sea (FRENEIX *et al.*, 1987).

Ecology: This subspecies lives in infralittoral, soft sea bottoms and can be one of the characteristic components of the biocoenosis of fine and coarse sands under the influence of bottom water currents (PÉRÈS & PICARD, 1964).

Family Spondylidae GRAY, 1825
Genus Spondylus LINNAEUS, 1758

Type species: *Spondylus gaederopus* LINNAEUS, 1758

Spondylus (Spondylus) crassica
LAMARCK, 1819
 (Fig. 3d)

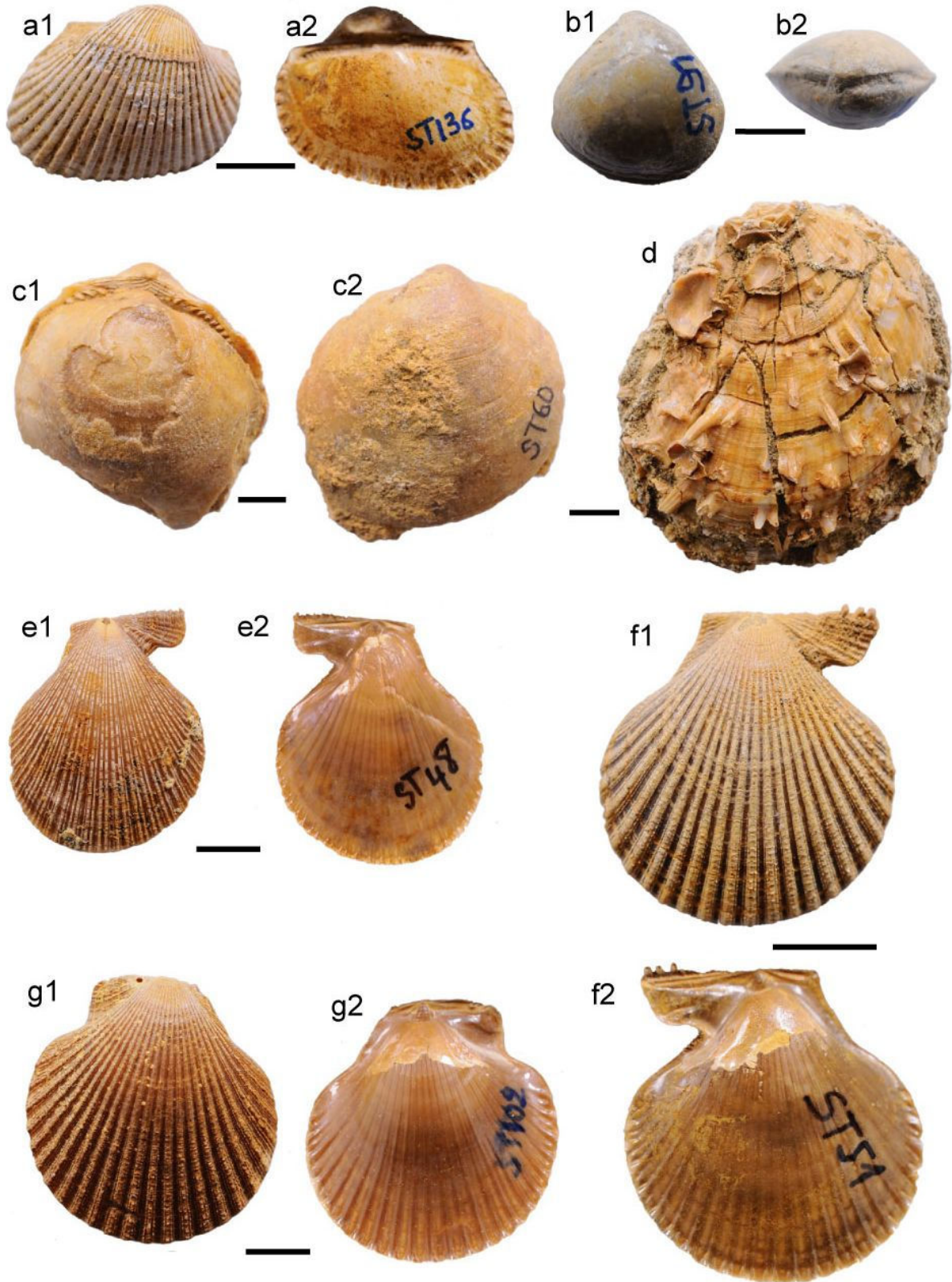
- 1819 *Spondylus crassica*.- LAMARCK, VI, p. 193.
 1898 *Spondylus crassica* LAMARCK.- SACCO, XXV, p. 5, Pl. I, fig. 17; Pl. II, figs. 1-2.
 1920 *Spondylus crassica* LAMARCK.- DOLLFUS & DAUTZENBERG, p. 452, Pl. XLVI, figs. 1-4.
 1963 *Spondylus crassica* LAMARCK.- VENZO & PELOSIO, p. 161, Pl. II, fig. 1.
 1974 *Spondylus (Spondylus) crassica* LAMARCK.- MALATESTA, p. 60, Pl. V, fig. 3.a-b.
 1987 *Spondylus (Spondylus) crassica* LAMARCK, 1819.- FRENEIX *et al.*, p. 35, Pl. VIII, figs. 2-3.
 1994 *Spondylus (Spondylus) crassica crassica* LAMARCK, 1819.- BEN MOUSSA, p. 105, Pl. 6, fig. 4.

Material: One single shell (ST37, l=80 mm, h=85 mm, C=50 mm) collected in the sandy marls unit of Ouled Fayet (unit c).

Description: This single specimen is thick, ovoid and of large size. It is clearly characterised by its strong ribs (4-7), evenly spaced and ornamented by wide scaly spines. The interspaces, much wider than the ribs, have two, underdeveloped but clearly visible, secondary ribs bearing quite numerous spines.

Stratigraphic range: *S. crassica* is a species of the Atlantic-Mediterranean Neogene, which appeared under its ancestral form, *S. crassica aquitanica* COSSMANN & PEYROT, in the Aquitanian from Aquitaine, France. From the Middle Miocene, this taxon acquired its derived form, *S. crassica crassica*, and became abundant and widespread in the Atlantic, Mediterranean Sea and the Paratethys. It reached its acme during the Pliocene, and at the upper boundary of its stratigraphic extension, this taxon became circum-Mediterranean and disappeared at the end of the Pliocene (ZAVAREI, 1973).

Ecology: As well as recent spondyles, this species was a suspensivorous and cemented its valves to hard substrates, living in shallow settings (down to -50 m) on coralligenous bottoms. *S. crassica* dwelled coralligenous bottoms between -25 and -30 m, likewise its live homologous sister taxon, *S. princeps* REEVE from the Gulf of California and Panama (FRENEIX *et al.*, 1987).



Order Pterioida NEWELL, 1965
Superfamily Pectinacea
RAFINESQUE, 1815 (emend.)
Family Pectinidae RAFINESQUE, 1815 (emend.)
Genus Talochlamys IREDALE, 1929
Type species: Chlamys islandica MÜLLER, 1776

Talochlamys multistriata (POLI, 1795)
 (Fig. 3e)
 1758 *Ostrea pusio* LINNAEUS, X, p. 698.
 1939 *Chlamys multistriata* POLI.- ROGER, p. 165, Pl. XXII, figs. 5-7, 11-15; Pl. XXIII, fig. 5; Pl. XXIV, figs. 8-9.
 1961 *Chlamys multistriata* POLI.- VEIGA FERREIRA, p. 452, Pl. XI, figs. 65-66.



◀ **Figure 3:** Bivalve taxa from the Pliocene of the Algiers Sahel. **a**, *Anadara diluvii* (LAMARCK, 1805), specimen ST136; **a1**, external view, right valve; **a2**, internal view, right valve; **b**, *Nucula (Nucula) sp.*, specimen ST91; **b1**, external view, right valve; **b2**, dorsal view; **c**, *Glycymeris bimaculata deshayesi* (MAYER, 1868), specimen ST60; **c1**, external view, left valve; **c2**, external view, right valve; **d**, *Spondylus crassicaosta* LAMARCK, 1819, specimen ST37; complete shell; **e**, *Talochlamys multistriata* (POLI, 1795), specimen ST48; **e1**, external view, right valve; **e2**, internal view, right valve; **f**, *Mimachlamys varia* (LINNAEUS, 1758), specimen ST51; **f1**, external view, left valve; **f2**, internal view, left valve; **g**, *Mimachlamys varia* (LINNAEUS, 1758), specimen ST102; **g1**, external view, right valve; **g2**, internal view, right valve. Scale bar= 10 mm for all.

Figure 3 : Bivalves du Pliocène du Sahel d'Alger. **a**, *Anadara diluvii* (LAMARCK, 1805), spécimen ST136 ; **a1**, vue externe, valve dextre ; **a2**, vue interne, valve dextre ; **b**, *Nucula (Nucula) sp.*, spécimen ST91 ; **b1**, vue externe, valve dextre ; **b2**, vue dorsale ; **c**, *Glycymeris bimaculata deshayesi* (MAYER, 1868), spécimen ST60 ; **c1**, vue externe, valve senestre ; **c2**, vue externe, valve dextre ; **d**, *Spondylus crassicaosta* LAMARCK, 1819, spécimen ST37 ; coquille complète ; **e**, *Talochlamys multistriata* (POLI, 1795), spécimen ST48 ; **e1**, vue externe, valve dextre ; **e2**, vue interne, valve dextre ; **f**, *Mimachlamys varia* (LINNÉ, 1758), spécimen ST51 ; **f1**, vue externe, valve senestre ; **f2**, vue interne, valve senestre ; **g**, *Mimachlamys varia* (LINNÉ, 1758), spécimen ST102 ; **g1**, vue externe, valve dextre ; **g2**, vue interne, valve dextre. Barre d'échelle = 10 mm pour tous.

- 1970 *Chlamys (Chlamys) multistriata* POLI.- RAFFI, p. 108, Pl. XXX, figs. 5-17.
 1987 *Chlamys (Mimachlamys) pusio* (LINNAEUS, 1758).- FRENEIX et al., p. 22, Pl. III, 2.
 1994 *Chlamys (Chlamys) multistriata* (POLI, 1795).- BEN MOUSSA, p. 76, Pl. 3, fig. 3.
 2003 *Crassodoma multistriata* (POLI, 1795).- COURVILLE & BONGRAIN, p. 138, Pl. 3, figs. 3-4.
 2012 *Crassodoma multistriata* (POLI, 1795).- SATOUR, p. 40, Pl. 1, fig. 13.
 2017 *Talochlamys multistriata* (POLI, 1895).- SPADINI, p. 10.

Material: Seven right valves (ST48, l=25 mm, h=30 mm, c=10 mm; ST54, l=20 mm, h=22 mm, c=10 mm; ST156, l=25 mm, h=25 mm, c=12 mm; ST183, l=19 mm, h=20 mm, c=12 mm; ST219, l=29 mm, h=26 mm, c=15 mm; ST220, l=22 mm, h=24 mm, c=10 mm; ST222, l=16 mm, h=21 mm, c=10 mm) collected in the sandy marls of Ouled Fayet and Douera (unit c).

Description: This taxon is easily identifiable thanks to its umbono-palleal oval, convex, slightly squashed shape, with some 40 fine, unequal radial ribs, of yellowish to brownish colour. The radial ridges are more or less rounded and the margin is slightly undulated. The dimensions of the different valves are small when compared to those of modern representatives, suggesting that these are juvenile specimens. Both auricles are unequal; the anterior one is three times larger than the posterior one. This latter is obliquely truncated and bears small spines, as well as fine ribs of the *Camptonectes* type.

Stratigraphic range: *Talochlamys multistriata* is a very common species, reported from the Aquitanian to the Recent, in the Boreal, Nordic, Lusitanian, Mauritanian, and eastern South-Atlantic bioprovinces, as well as in the Mediterranean, Indo-Mediterranean and St. Helena, southwards to South Africa (DIJKSTRA & GOUD, 2002).

Ecology: This taxon is suspensivorous, epibyssal or cemented, eurytopic, living from the infralittoral to the bathyal zones; however, it is more frequent in depths ranging from -10 m to -100 m. It bears numerous fine costulae developing by division on its right valve and by intercalation on its left valve. In the Mediterranean, this shell keeps its regular shape, but in the Atlantic at the adult stage, it cements to the substratum by its right valve that gets extremely irregular and strongly squamose, while its left valve flattens. By this moment, it exhibits the outline of the recent uncommon genus *Hinnites* (ROGER, 1939).

Genus *Mimachlamys* IREDALE, 1929

Type species: *Pecten asperrimus* LAMARCK, 1819

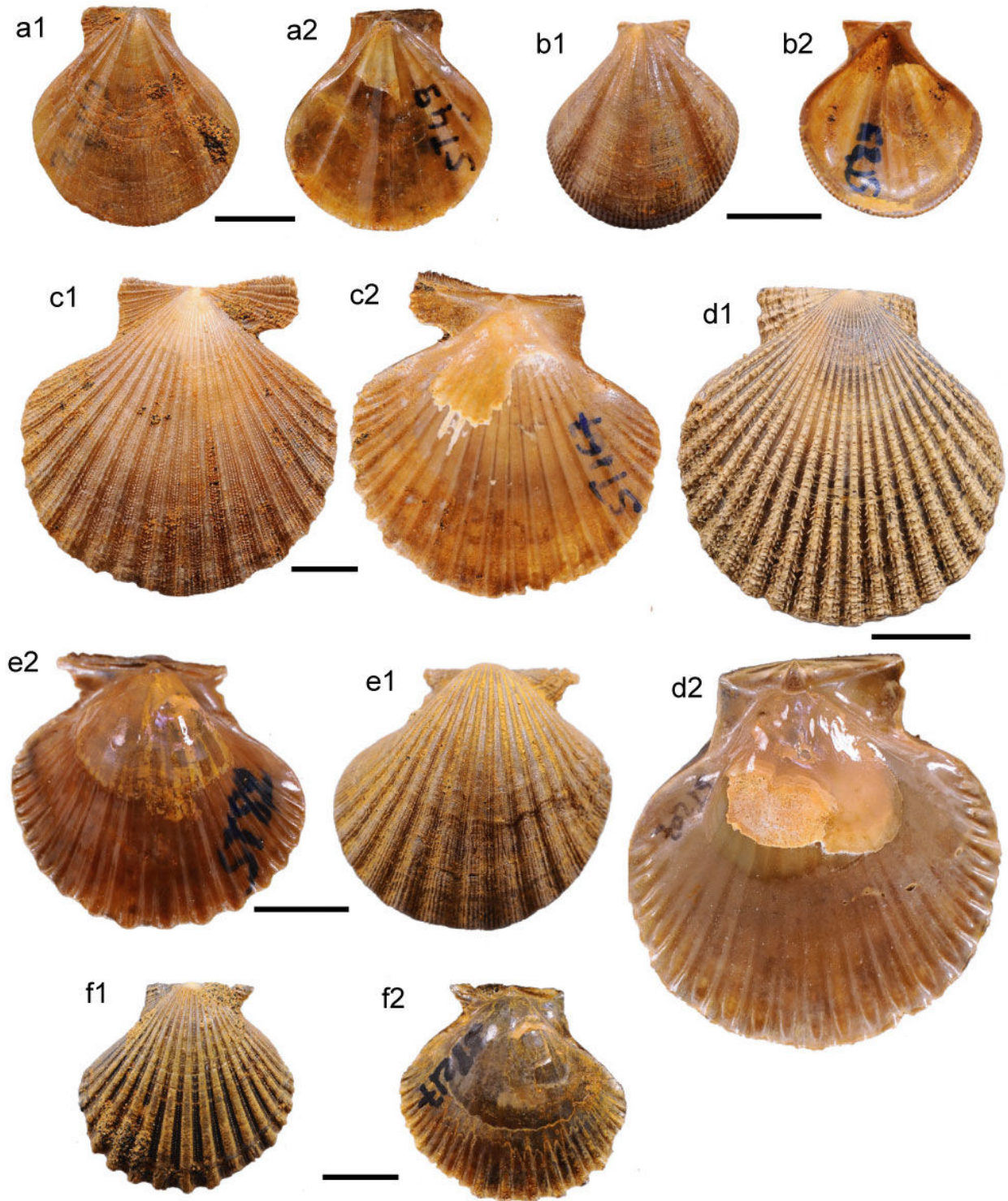
Mimachlamys varia (LINNAEUS, 1758)

(Fig. 3f-g)

- 1758 *Ostrea varia*.- LINNAEUS, X, p. 698.
 1939 *Chlamys varia* LINNAEUS.- ROGER, p. 197, Pl. XXII, figs. 21-23.
 1957 *Chlamys varia* LINNAEUS.- PERRODON, p. 207.
 1975 *Chlamys varia* LINNAEUS.- FEKI, p. 40, Pl. X, fig. 5.
 1989 *Chlamys (Chlamys) varia* (LINNAEUS).- LAURIAT-RAGE et al., p. 125.
 1994 *Chlamys (Aequipecten) radians* (NYST & WESTENDROP, 1839).- BEN MOUSSA, p. 73, Pl. 3, fig. 6.
 2012 *Mimachlamys varia* (LINNAEUS).- SATOUR, p. 33.
 2017 *Mimachlamys varia* (LINNAEUS).- SPADINI, p. 21-22.
 2021 *Mimachlamys varia* (LINNAEUS, 1758).- BENYOUCEF et al., p. 12, Fig. 5E.

Material: Two groups of specimens were collected from the brown sandy marls of Ouled Fayet (unit b). The first group is represented by two right valves (ST51, l=27 mm, h=29 mm, c=16 mm; ST156, l=21 mm, h=25 mm, c=12 mm). The second group includes a single complete shell (ST56, l=40 mm, h=41 mm, c=12 mm), a single left valve (ST102, l=44 mm, h=47 mm, c=20 mm) and a single right valve (ST143, l=31 mm, h=35 mm, c=15 mm).

Description: The shell resembles that of *Talochlamys multistriata* as it is inequivalve, higher than wider, of medium size, and carries 23 thin, rounded, radial ribs. The auricles are very unequal, finely crenulated with a distinct and rounded byssal sinus, with a ctenolium in the anterior auricle twice bigger than the posterior one, topped by three fine teeth on the posterior edge. The second group of specimens is characterised by a medium-size, equivalve, slightly higher than wide, and thicker shell. The valves are convex to rather flat and display rounded radial ribs and deep interspaces. The auricles are unequal and of triangular shape with fine ribs crossed by growth lines. The smaller posterior auricle is usually broken.



Stratigraphic range: *Mimachlamys varia*, as well as *T. multistriata*, are known from the western Mediterranean Sea since the Miocene (ROGER, 1939). *M. varia* is reported from the Aquitanian of Portugal to the Recent (VEIGA FERREIRA, 1961). Widespread during the whole Neogene, it reached the Nordic domain in the Pleistocene.

Ecology: This taxon, optionally epibyssal, dwells the different biotopes of the infralittoral and circalittoral zones. It ranges from southern Norway to the northern Gulf of Guinea. Nowadays this species dwells the Atlantic (frequent), Mediterranean Sea and the Adriatic.

According to CAULET (1972), it occurs frequently on the detrital sea bottoms of the Algerian shelf.



◀ **Figure 4:** Bivalve taxa from the Pliocene of the Algiers Sahel. **a**, *Manupecten pesfelis* (LINNAEUS, 1758), specimen ST49; **a1**, external view, left valve; **a2**, internal view, left valve; **b**, *Pseudamussium clavatum* (POLI, 1795), specimen ST85; **b1**, external view, right valve; **b2**, internal view, right valve; **c**, *Aequipecten opercularis* (LINNAEUS, 1758), specimen ST136; **c1**, external view, right valve; **c2**, internal view, right valve; **d**, *Aequipecten angelonii* STEFANI & PANTANELLI, 1878, specimen ST207; **d1**, external view, left valve; **d2**, internal view, left valve; **e**, *Aequipecten scabrella* (LAMARCK, 1819), specimen ST82; **e1**, external view, right valve; **e2**, internal view, right valve; **f**, *Aequipecten bollenensis* (MAYER, 1876), specimen ST217; **f1**, external view, right valve; **f2**, internal view, right valve. Scale bar = 10 mm for all.

Figure 4 : Bivalves du Pliocène du Sahel d'Alger. **a**, *Manupecten pesfelis* (LINNÉ, 1758), spécimen ST49 ; **a1**, vue externe, valve senestre ; **a2**, vue interne, valve senestre ; **b**, *Pseudamussium clavatum* (POLI, 1795), spécimen ST85 ; **b1**, vue externe, valve dextre ; **b2**, vue interne, valve dextre ; **c**, *Aequipecten opercularis* (LINNÉ, 1758), spécimen ST136 ; **c1**, vue externe, valve dextre ; **c2**, vue interne, valve dextre ; **d**, *Aequipecten angelonii* STEFANI & PANTANELLI, 1878, spécimen ST207 ; **d1**, vue externe, valve senestre ; **d2**, vue interne, valve senestre ; **e**, *Aequipecten scabrella* (LAMARCK, 1819), spécimen ST82 ; **e1**, vue externe, valve dextre ; **e2**, vue interne, valve dextre ; **f**, *Aequipecten bollenensis* (MAYER, 1876), spécimen ST217 ; **f1**, vue externe, valve dextre ; **f2**, vue interne, valve dextre. Barre d'échelle = 10 mm pour tous.

Genus *Manupecten* MONTEROSATO, 1872

Type species: *Manupecten pesfelis* (LINNAEUS, 1758)

Manupecten pesfelis (LINNAEUS, 1758) (Fig. 4a)

- 1758 *Ostrea pesfelis*.- LINNAEUS, p. 697.
1939 *Chlamys pesfelis* LINNAEUS.- ROGER, p. 178, Pl. XXVI, figs. 1-2.
1970 *Chlamys (Manupecten) pesfelis* (LINNAEUS).- RAFFI, p. 122, Pl. 27, fig. 8.
1994 *Chlamys (Manupecten) pesfelis* (L.).- BEN MOUSSA, p. 86, Pl. 3, fig. 14.
2014 *Manupecten pesfelis* (LINNAEUS, 1758).- SATOUR, p. 38.
2017 *Manupecten pesfelis* (LINNAEUS, 1758).- SPADINI, p. 10.

Material: Two left valves (ST49, l=26 mm, h=28 mm, c=10 mm; ST146, l=24 mm, h=24 mm, c=4 mm) collected from the brown sandy marls of Ouled Fayet (unit b).

Description: *Manupecten pesfelis* resembles *Pseudamussium clavatum*. The sampled valves are of small size and of yellowish to brownish colour. The ribs (5) are flatter and the auricles are slightly less developed than those of the former species, with the anterior auricle more developed.

Stratigraphic range: *M. pesfelis* is reported from the Pliocene of Cyprus (REED, 1935) and the Plio-Pleistocene of Syria (ROMAN, 1940).

Ecology: It dwells the coastal detrital sea bottoms of the circalittoral zone, mostly in the Mediterranean Sea, as well as the adjacent area of the eastern Atlantic from Portugal southwards to Cape Verde (PÉRÈS & PICARD, 1964).

Genus *Pseudamussium* MÖRCH, 1853

Type species: *Pecten septemradiatus* MÜLLER, 1776

Pseudamussium clavatum (POLI, 1795) (Fig. 4b)

- 1795 *Chlamys clavata* (POLI).- Peplum clavatum (POLI, 1795).
1795 *Ostrea clavata* POLI.- p. 160, Pl. 28, fig. 17.
1795 *Ostrea inflexa* POLI.- p. 160, Pl. 28, figs. 4-5.
1993 *Pseudamussium clavatum* (POLI, 1795).- POPPE & GOTO, p. 70, Pl. 10, fig. 6.a-b.
1999 *Pseudamussium clavatum* (POLI, 1795).- ARDOVINI & COSSIGNANI, p. 91, 2 Figs.
2002 *Pseudamussium clavatum* (POLI, 1795).- DIJKSTRA & GOULD, p. 56, Fig. 53.
2017 *Pseudamussium clavatum* (POLI, 1795).- SPADINI, p. 10.

Material: A single left valve (ST47, l=18 mm, h=19 mm, c=9 mm) and two right valves (ST74, l=18 mm, h=19 mm, c=9 mm; ST85, l=22 mm, h=23 mm, c=8 mm) collected from the brown sandy marls of Ouled Fayet (unit b), and also from the yellow sandy marls of both localities (unit c).

Description: *Pseudamussium clavatum* displays different macro- and microconic shells. The shell is slightly unequilateral, wider than high, with an anterior margin slightly wider than the posterior one, the right valve being more concave than the left one. The umbo is triangular and slightly protruding on the cardinal edge. While the valves are less curvaceous, their ventral margins are really curved, showing a spoon-like shape and five marked ribs wider than the interspace among which, the three in the middle being much wider. The ribs are rounded close to the umbo and flattened towards the outer margin. Both auricles are smaller but the anterior one being slightly larger than the posterior one. They display radial ribs, as well as growth lines oriented perpendicularly to the cardinal edge.

Stratigraphic range: *Pseudamussium clavatum* appeared in the Miocene.

Ecology: It occurs on the sandy and gravelly detrital sea bottoms of the circalittoral zone in the Mediterranean Sea and the eastern Atlantic.

Genus *Aequipecten* FISCHER, 1886

Type species: *Ostrea opercularis* LINNAEUS, 1758

Aequipecten opercularis (LINNAEUS, 1758) (Fig. 4c)

- 1758 *Ostrea opercularis*.- LINNAEUS, X, p. 698.
1939 *Chlamys opercularis* (L.).- ROGER, p. 131, Pl. 16, figs. 6-7; Pl. 17, figs. 3-5.
1972 *Chlamys (Aequipecten) opercularis* (L.).- CAPROTTI, p. 58, Pl. 1, fig. 5.



- 1978 *Chlamys (Aequipecten) opercularis* (L.).- STEININGER & SCHULTZ, p. 341.
 1987 *Aequipecten opercularis* (LINNAEUS, 1758).- FRENEIX *et al.*, p. 24, Pl. III, fig. 6.
 1994 *Chlamys (Aequipecten) opercularis* (L.).- BEN MOUSSA, p. 78.
 2017 *Aequipecten opercularis* (LINNAEUS, 1758).- SPADINI, p. 10.

Material: Five right valves (ST52, l=37 mm, h=38 mm, c=21 mm; ST55, l=46 mm, h=45 mm, c=27 mm; ST83, l=32 mm, h=32 mm, c=14 mm; ST134, l=25 mm, h=25 mm, c=11 mm; ST167, l=40 mm, h=39 mm, c=23 mm) and three left valves (ST50, l=38 mm, h=38 mm, c=20 mm; ST168, l=34 mm, h=35 mm, c=17 mm; ST182, l=30 mm, h=30 mm, c=12 mm) collected from the grey sandy marls of Ouled Fayet (unit b).

Description: The shell is rounded, almost equivalve and equilateral. The valve is easily recognizable thanks to the imprint of the adductor muscle and the byssal sinus of the anterior auricle, as well as to the set of small teeth building the ctenolium. The valve is weakly convex with a flat umbonal area. The umbo is straight and not contorted. Ornamentation consists of 21 radial ribs wider than the interspaces, terminated by spines and with less accentuated relief. The auricles are unequal and costate. Some forms bear triangular-outlined ribs.

Stratigraphic range: *Aequipecten opercularis* is a common and widespread taxon, ranging from the Miocene to the Recent, in the Nordic and Boreal bioprovinces, as well as in the Lusitanian-Mauritanian, Mediterranean, and central Paratethys ones. Nowadays it is found from Norway and the Faroe Islands to the Iberian Peninsula, the Açores, and the Canaries (TEBBLE, 1976).

Ecology: This species is suspensivorous and lives attached by a byssus or free-lying. It is an active swimmer, ranging from several metres deep down to -2,000 m (ROGER, 1939). In the Algerian continental margin, it is reported between -10 m and -150 m (CAULET, 1972).

Aequipecten angelonii
STEFANI & PANTANELLI, 1878
 (Fig. 4d)

- 1858 *Pecten angelonii* MENEGHINI (in litt.).
 1878 *Mimachlamys angelonii*.- STEFANI & PANTANELLI, p. 31.
 1939 *Chlamys angelonii* MENEGHINI.- ROGER, p. 138, Pl. XVIII, figs. 7-10; Pl. XX, figs. 5-9.
 1970 *Chlamys (Aequipecten) angelonii* (STEFANI & PANTANELLI).- RAFFI, p. 112, Pl. 27, fig. 9.
 1987 *Aequipecten angelonii* (STEFANI & PANTANELLI, 1878).- FRENEIX *et al.*, p. 25, Pl. IE, fig. X.
 1994 *Chlamys (Aequipecten) angelonii* (MENEGHINI, 1859).- BEN MOUSSA, p. 81.
 2017 *Aequipecten angelonii* (STEFANI & PANTANELLI, 1878).- SPADINI, p. 10.

Material: Five left valves (ST118, l=70 mm, h=70 mm, c=30 mm; ST202, l=74 mm, h=71 mm, c=15 mm; ST207, l=60 mm, h=60 mm, c=28 mm; ST210, l=52 mm, h=50 mm, c=28 mm; ST218, l=46 mm, h=48 mm, c=25 mm) collected from Ouled Fayet (unit b).

Description: The shell is of orange-yellow to brown, sometimes grayish in colour, of circular shape and variable size. It is inequivalve and displays 22 radial ribs slightly wider than the interspaces, with a spinose ornamentation consisting of two spine rows slanted towards the outer margin on both sides of the median row, especially developed close to the margin. The auricles are unequal and costate.

Stratigraphic range: It ranges from the Helvetian to the Pliocene, especially in the Auversian of Belgium, but its distribution is generally Mediterranean, with its acme in the Pliocene. This species also appears in the Burdigalian of SE France and spreads into the Atlantic and the Paratethys during the Middle Miocene. In the Pliocene, it was widespread in the Atlantic and the Mediterranean Sea, and disappears at the end of this period. In North Africa, it is reported from the "Sahelian" of Morocco (BEN MOUSSA, 1994).

Ecology: *A. angelonii* belongs to a species group adapted to shallow and agitated environments. According to DEMARCQ (1979), it occurs in the Burdigalian of the Rhône valley, often "in the platforms and well exposed shores, as well as in rocky shores". It dwells, like *C. radians*, both coarse and fine detrital facies.

***Aequipecten scabrella* (LAMARCK, 1819)**
 (Fig. 4e)

- 1819 *Pecten seniensis*.- LAMARCK, p. 182.
 1819 *Pecten scabrellus*.- LAMARCK, p. 183.
 1939 *Chlamys scabrella* (LAMARCK).- ROGER, p. 332, 342.
 1987 *Chlamys seniensis* (LAMARCK).- FRENEIX *et al.*, p. 24, Pl. III, figs. 7-10.
 1994 *Chlamys (Chlamys) varia* (LINNAEUS, 1758).- BEN MOUSSA, p. 77, Pl. 3, figs. 4-5, 10-11.
 2009 *Aequipecten scabrella* (LAMARCK).- JIMENEZ *et al.*, p. 7, figs. 3.f-i, 4.a-b.
 2012 *Pecten seniensis* (LAMARCK, 1819).- SATOUR, p. 35, Pl. 1, figs. 10-11.
 2017 *Aequipecten scabrellus* (LAMARCK, 1819).- SPADINI, p. 10.
 2021 *Aequipecten scabrella* (LAMARCK, 1819).- BENYOUCEF *et al.*, p. 11, Fig. 5B.

Material: Five right valves (ST79, l=32 mm, h=29 mm, c=15 mm); ST80, l=30 mm, h=26 mm, c=10 mm; ST181, l=45 mm, h=39 mm, c=12 mm; ST82, l=36 mm, h=34 mm, c=20 mm; ST185, l=38 mm, h=36 mm, c=15 mm) and a single left valve (ST135, l=30 mm, h=27 mm, c=17 mm) collected from the brown sandy marls of Ouled Fayet (unit b) and the yellow sandy marls of both localities (unit c).

Description: The valves are wider than high with a medium to rather high convexity, almost even for both valves. The number of ribs varies from 14 to 17; they are thinner than the interspaces and have rounded edges. Concentric lamellae are visible on the ribs and in the interspaces; their marked undulation gives birth to visible scales first in the interspaces and then in the rib flanks. *A. scabrella* displays wide morphological range. The size, number of ribs, convexity, and secondary ornamentation vary from an individual to another. The auricles are unequal, the



left auricle being wider and thinner with a small triangular, byssal sinus. The auricles bear radial ribs cut by growth lines.

Stratigraphic range: *Aequipecten scabrella* is very frequent in the Pliocene deposits of the Mediterranean Sea, ranging from the Miocene (Tortonian). It was replaced at the Pleistocene by *Aequipecten commutatus* (MONTEROSATO, 1875).

Ecology: It dwells the sandy/muddy sea bottoms of western Mediterranean Sea in depths ca -30 to -40 m (BENYOUCEF *et al.*, 2021).

***Aequipecten bollenensis* (MAYER, 1876)**

(Fig. 4f)

1876 *Pecten* (*Neitha*) *Bollenensis*.- MAYER-EYMAR, p. 169, Pl. VI, fig. 2.

1939 *Chlamys bollenensis* MAYER-EYMAR.- ROGER, p. 107, Pl. XIII, figs. 13-15; Pl. XV, figs. 9-11.

1961 *Chlamys bollenensis* MAYER-EYMAR.- VEIGA FERREIRA, p. 447, Pl. n, figs. 5-9.

1975 *Chlamys scabrella sarmenticia* GOLDFUS.- FEKI, p. 38, Pl. IX, fig. 4.

1994 *Chlamys* (*Argopecten*) *bollenensis* (MAYER-EYMAR, 1876).- BEN MOUSSA, p. 85, Pl. 3, fig. 9.

2017 *Aequipecten bollenensis* MAYER, 1876.- SPADINI, p. 10.

Material: Six right valves (ST137, l=31 mm, h=29 mm, c=11 mm; ST142, l=32 mm, h=30 mm, c=ind; ST157, l=25 mm, h=25 mm, c=10 mm; ST169, l=24 mm, h=23 mm, c=12 mm; ST217, l=27 mm, h=25 mm, c=13 mm; ST184, l=25 mm, h=25 mm, c=14 mm) and three left valves (ST47, l=18 mm, h=19 mm, c=9 mm; ST81, l=35 mm, h=34 mm, c=18 mm; ST84, l=34 mm, h=31 mm, c=14 mm) all collected in the grey sandy marls of Ouled Fayet (unit b) and the yellow sandy marls of both localities (unit c).

Description: The shell is unequilateral with a triangular shape, smaller than *A. scabrellus*. The right valve is more convex than the left one. Ribs (18) are slightly protruding, quadrate in section and wider than the interspaces.

Stratigraphic range: *A. bollenensis* has the same biogeographic range than *A. scabrella* but is shifted stratigraphically with respect to this latter. It appeared in the Burdigalian and got extinct in the Pleistocene. In the Miocene, it reached the Paratethys and even Minor Asia. In the Pliocene, this species became quite abundant, especially in the Mediterranean Sea (BEN MOUSSA, 1994).

Ecology: This taxon, more ubiquitous, usually occurs in the same facies and appears to dwell the same living environment than *A. scabrella*.

***Aequipecten radians* (NYST & WESTENDROP, 1839)**

(Fig. 5a)

1839 *Pecten radians*.- NYST & WESTENDROP, p. 15, Pls. H-I, fig. 19.

1939 *Chlamys radians* NYST.- ROGER, p. 134, Pl. XVI, figs. 8-12; Pl. XVII, fig. 9.

1945 *Pecten* (*Aequipecten*) *radians* NYST, 1839.- GLIBERT, p. 65, Pl. III, fig. 5.

1970 *Chlamys radians* (NYST).- BONGRAIN, p. 35, Pls. A-B.

1989 *Chlamys* (*Aequipecten*) *radians* (NYST).- LAURIAT-RAGE *et al.*, p. 125, Pl. II, fig. 8.

1994 *Chlamys* (*Aequipecten*) *radians* (NYST & WESTENDROP, 1839).- BEN MOUSSA, p. 73, Pl. 3, fig. 6.

2003 *Aequipecten radians* (NYST).- COURVILLE & BONGRAIN, p. 139, Pl. 3, figs. 6-8.

Material: Two complete shells (ST46, l=40 mm, h=42 mm, c=1.7 mm; ST78, l=43 mm, h=40 mm, c=22 mm) collected from the sandy marls of Ouled Fayet (unit b).

Description: Species of medium size. Both valves, slightly convex, build an equilateral shell in fan-shape, with 18 rounded-side ribs widening towards the outer margin. The shell surface is ornamented by fine and deep ribs. The unequal auricles display circular and oblique ribs and oblique ribs on the side areas. This species, wrongly called *seniensis* (ROGER, 1939), can be confused with *A. scabrella*.

Stratigraphic range: *A. radians*, mentioned in several Miocene basins of the Atlantic-Mediterranean domain, was first described in the Aquitanian of Bazadais (GLIBERT & POEL, 1965). During the Miocene, it was quite widespread in the Atlantic from Belgium (Anversian) to Morocco, and in the Mediterranean Sea. In the Pliocene, it occurred in the Mediterranean Sea and is more widespread in the Atlantic and disappeared before the Pleistocene.

Ecology: This taxon, quite common and widespread, frequently occurs in detrital facies, most likely in shallow settings (BEN MOUSSA, 1994).

Genus *Korobkovia* GLIBERT & POEL, 1965

Type species: *Korobkovia oblonga* PHILIPPI, 1844

***Korobkovia oblonga* (PHILIPPI, 1844)**

(Fig. 5b)

1844 *Pecten oblongum*.- PHILIPPI, p. 300, Pl. XVI, fig. 7.

1876 *Pecten comitatus*.- FONTANNES, p. 94

1897 *Pseudoamussium oblongum* PHILIPPI.- SACCO, XXV, p. 52, Pl. XIV, figs. 40-43.

1928 *Amusium oblongum* PHILIPPI.- DEPÉRET & ROMAN, p. 186, Pl. XXVIII, figs. 2-3, 3.a-b.

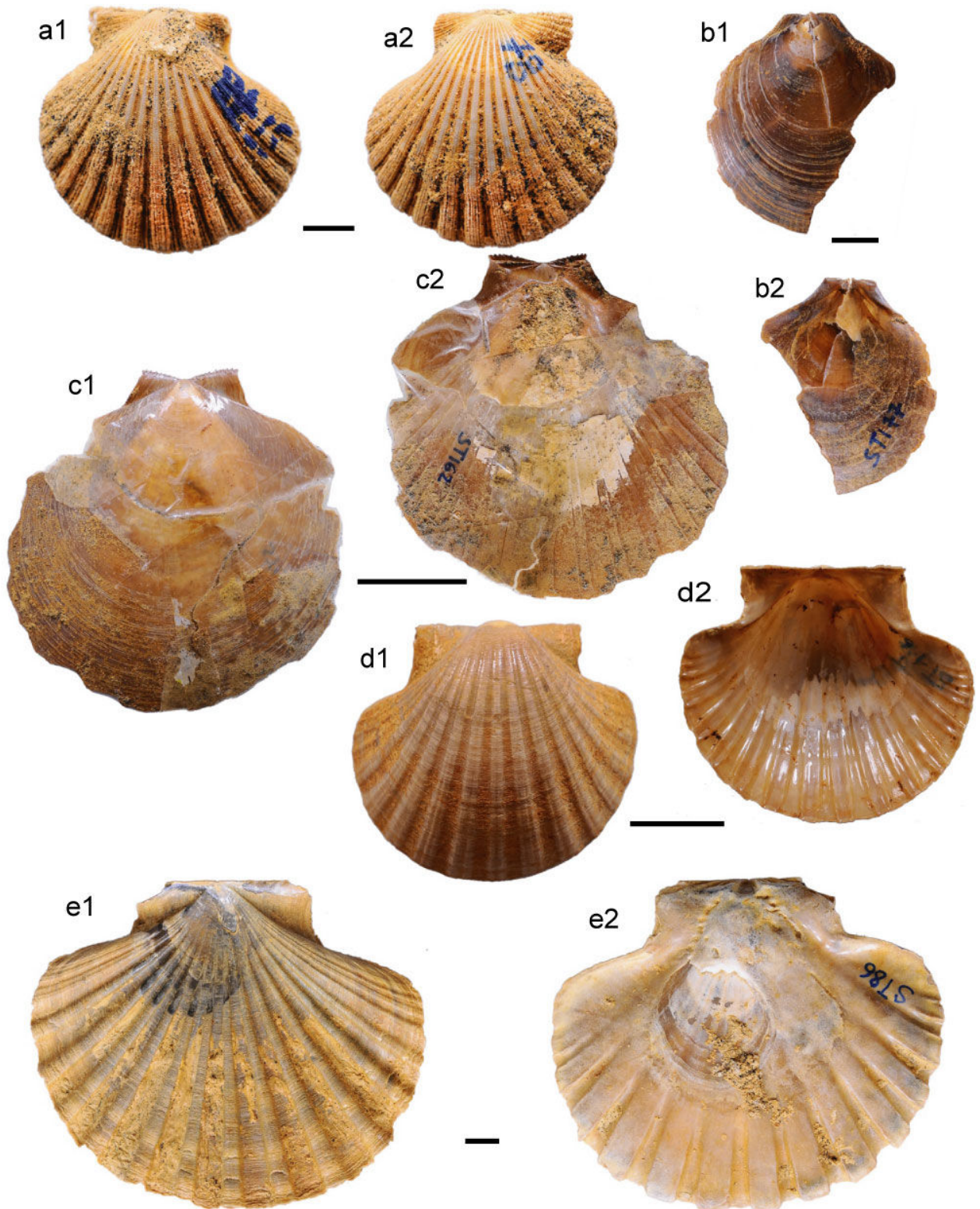
1977 *Korobkovia oblonga* (PHILIPPI).- GONZÁLEZ DONOSO & PORTA, p. 53, Pls. H-I, fig. 7.

1987 *Amusium oblongum* (PHILIPPI, 1841).- KHARRIM, p. 138, Pl. 12, fig. 2.

2017 *Korobkovia oblonga* (PHILIPPI, 1844).- SPADINI, p. 10.

Material: Three left valves (ST44, l=48 mm, h=54 mm, c=17 mm; ST164, l=76 mm, h=56 mm, c=31 mm; ST184, l=30 mm, h=36 mm, c=14 mm) and a single right valve (ST177, l=ind, h=50 mm, c=11 mm) all collected from the brownish sandy marls of Ouled Fayet (unit b).

Description: This is a thin, oval, small to medium size, higher than wide, rather flat, shell with a faintly protruding umbo and thin growth lines. It is characterised by the lack of costate ornamentation on the outer side of both valves and the inner side of the right valve. The left valve displays some 30 fine ribs on its inner side. Both tiny auricles are identical and draw a rectilinear cardinal margin unlike *Amusium cristatum*.



Stratigraphic range: *K. oblonga* is characteristic of the Pliocene of the western Mediterranean Sea: for example, in Spain, this species is restricted to the silts and fine-grained calcarenites of the base of the Pliocene (JIMÉNEZ *et al.*, 2009).

Ecology: It should have lived in the same biotopes than *A. cristatum* (see below).

Genus *Amusium* RÖDING, 1798

Type species: *Ostrea pleuronectes* LINNAEUS, 1758

***Amusium cristatum* (BRONN, 1827)**

(Fig. 5c)

- 1827 *Pecten cristatus*.- BRONN, p. 542, Pl. 6, fig. 3.
- 1928 *Amusium cristatum* BRONN.- DEPÉRET & ROMAN, p. 171, Pl. XXV, fig. 1.
- 1951 *Amusium cristatum* BRONN.- VEIGA FERREIRA, p. 160, Pl. V, figs. 15, 18-20.
- 1974 *Amusium cristatum* (BR.).- MALATESTA, p. 39, Pl. 4, fig. 2.
- 1987 *Amusium* (*Amusium*) *cristatum* (BRONN, 1827).- FRENEIX *et al.*, p. 21, Pls. H-I, fig. 1.



◀ **Figure 5** : Bivalve taxa from the Pliocene of the Algiers Sahel. **a**, *Aequipecten radians* (NYST & WESTENDROP, 1839), specimen ST78; **a1**, external view, left valve; **a2**, external view, right valve; **b**, *Korobkovia oblonga* (PHILIPPI, 1844), specimen ST177; **b1**, external view, right valve; **b2**, internal view, right valve; **c**, *Amusium cristatum* (BRONN, 1827), specimen ST162; **c1**, external view, left valve; **c2**, internal view, left valve; **d**, *Pecten bipartitus* (FORESTI, 1876), specimen ST116; **d1**, external view, left valve; **d2**, internal view, left valve; **e**, *Pecten maximus* (LINNAEUS, 1758), specimen ST86; **e1**, external view, left valve; **e2**, internal view, left valve. Scale bar= 10 mm for all.

Figure 5 : Bivalves du Pliocène du Sahel d'Alger. **a**, *Aequipecten radians* (NYST & WESTENDROP, 1839), spécimen ST78 ; **a1**, vue externe, valve senestre ; **a2**, vue externe, valve dextre ; **b**, *Korobkovia oblonga* (PHILIPPI, 1844), spécimen ST177 ; **b1**, vue externe, valve dextre ; **b2**, vue interne, valve dextre ; **c**, *Amusium cristatum* (BRONN, 1827), spécimen ST162 ; **c1**, vue externe, valve senestre ; **c2**, vue interne, valve senestre ; **d**, *Pecten bipartitus* (FORESTI, 1876), spécimen ST116 ; **d1**, vue externe, valve senestre ; **d2**, vue interne, valve senestre ; **e**, *Pecten maximus* (LINNÉ, 1758), spécimen ST86 ; **e1**, vue externe, valve senestre ; **e2**, vue interne, valve senestre. Barre d'échelle= 10 mm pour tous.

1994 *Amusium (Amusium) cristatum* (BRONN, 1827).- BEN MOUSSA, p. 103, Pl. 6, fig. 3.

2009 *Amusium cristatum* (BRONN, 1827).- JIMÉNEZ *et al.*, p. 15, Fig. 6.a-b.

2017 *Amusium cristatus* (BROCCHI, 1814).- SPADINI, p. 10.

Material: Four right valves (ST162, l=85 mm, h=90 mm, c=25 mm; ST163, l=95 mm, h/2=45 mm, c/2=30 mm; ST178, l= ind, h= ind, c=30 mm; ST175, l=35 mm, h=35 mm, c=ca 10 mm) and also several valve fragments all collected from the brown and yellow sandy marls of Ouled Fayet (units b and c).

Description: *Amusium cristatum* is represented by a fine and translucent, equivalve, equilateral, slightly wider than high, shell, often of large size. The outer smooth shell displays on its inner side 26 to 30 scaly ribs with pointed edges, irregularly spaced and sometimes geminated, fading towards the umbo and ending shortly before the outer margin. Both valves, identical and slightly convex, display fine growth lines and a smooth outline. The auricles are almost equal without any byssal sinus, but with spines along the cardinal line, that form an obtuse angle with the umbo. According to PHILIPPI (1844), the juvenile forms resemble *Korobkovia oblonga*.

Stratigraphic range: *A. cristatum* is essentially Mio-Pliocene, disappearing in the Pleistocene. It is mostly Mediterranean known from the Burdigalian. During the Miocene, it spread through the whole Mediterranean Sea, reached the Paratethys and extended into the Atlantic. In the Pliocene, it was widespread in all fine-grained facies of the Atlantic-Mediterranean domain.

Ecology: *A. cristatum* lived in calm waters, sandy-muddy soft sea bottoms, in depth ranging from -50 to -100 m. It is an excellent swimmer, with loose-sided valves and free adult stage, devoid of byssal attachment (FRENEIX *et al.*, 1987).

Genus Pecten MÜLLER, 1776
Subgenus Pecten MÜLLER, 1776

Type species: *Ostrea maxima* LINNAEUS, 1758

Pecten bipartitus FORESTI, 1876
(Fig. 5d)

1873 *Vola jacobaea* var.- COCCONI, p. 338.

1876 *Pecten (Pecten) bipartitus*.- FORESTI, p. 51, Tav. I, figs. 21-23.

1897 *Pecten reghiensis*.- SACCO, XXIV, p. 59, tav. XVIII, figs. 11-14.

1963 *Pecten bipartitus* (FOR.)- TAVANI & TONGIORGI, p. 30, Pl. 1; Pl. 2; Pl. 3; Pl. 4, figs. 1-2.

1987 *Pecten bipartitus* (FORESTI, 1876).- FRENEIX *et al.*, p. 27, Pl. IV, figs. 2-3.

2012 *Pecten bipartitus* (FORESTI, 1876).- SATOUR, p. 47.

2017 *Pecten bipartitus* FORESTI, 1876.- SPADINI, p. 10.

Material: One complete shell (ST88-212, l=43 mm, h=40 mm, c=20 mm), four right valves (ST75, l=58 mm, h=51 mm, c=3 mm; ST116, l=56 mm, h=50 mm, c=33 mm; ST203, l=53 mm, h=48 mm, c=27 mm; ST208, l=52 mm, h=48 mm, c=28 mm) and a single left valve (ST211, l=45 mm, h=43 mm, c=27 mm) all collected from the brown and yellow sandy marls of Ouled Fayet (units b and c).

Description: The shells are especially thin, inequivalve, slightly unequilateral and of medium to large size. The umbo-outer margin is shorter than the anterior-posterior one. The right valve is convex with a prominent umbo strongly protruding the cardinal line. The costulation consists of 13 ribs, sub-rectangular with rounded edge, and two thin ribbings on both sides of the valve. Interspaces are twice narrower than the ribs. Very fine, tightly spaced, growth lines run through the ribs and particularly the interspaces. They protrude on the ventral side. From a distance of the umbo, a longitudinal ridge divides the rib into two, sometimes three costulae, but such a costulation is not visible in juvenile forms. The left valve is flat to concave and hollow in the umbo area. It bears 13 ribs narrower than the interspaces, cut by thin, serrated and protruding, growth lines like in the right valve. The auricles are of medium size and subequal; the anterior auricle is costulated and shows a small byssal sinus and five to six radial ribs cut by thin, dense growth lines, all concentric and parallel on the ventral margin.

Stratigraphic range: *P. bipartitus* was first recorded in the Middle Miocene in southern Italy, being uncommon in the Tortonian (Sardinia, Morocco) and the Messinian (Algeria). It is mostly Pliocene in age in Italy, France, Spain, Algeria, Creta, and Syria (FRENEIX *et al.*, 1987).

Ecology: This species is found in calcarenite facies and medium- to coarse-grained sands.

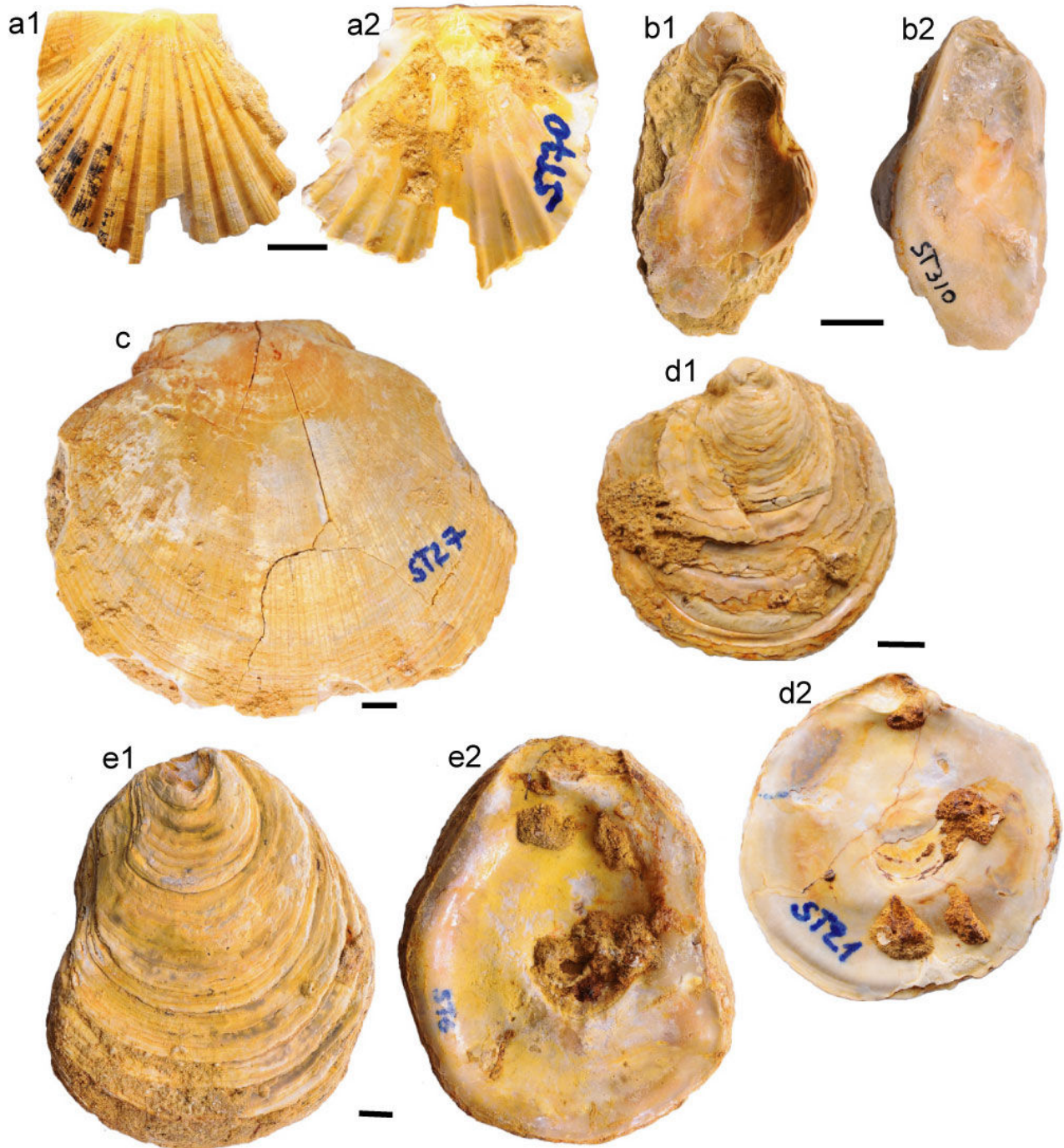


Figure 6: Bivalve taxa from the Pliocene of the Algiers Sahel. **a**, *Pecten jacobaeus* (LINNAEUS, 1758), specimen ST70; **a1**, external view; **a2**, internal view; **b**, *Plicatula mytilina* (PHILIPPI, 1836), specimen ST310; **b1**, external view, left valve; **b2**, internal view, left valve; **c**, *Flabellipecten alessii* (PHILIPPI, 1836), specimen ST27; **d**, *Ostrea lamellosa* (BROCCHI, 1814), specimen ST21; **d1**, external view, right valve; **d2**, internal view, right valve; **e**, *Ostrea edulis* (LINNAEUS, 1758), specimen ST6; **e1**, external view, right valve; **e2**, internal view, right valve. Scale bar= 10 mm for all.

Figure 6 : Bivalves du Pliocène du Sahel d'Alger. **a**, *Pecten jacobaeus* (LINNÉ, 1758), spécimen ST70; **a1**, vue externe ; **a2**, vue interne ; **b**, *Plicatula mytilina* (PHILIPPI, 1836), spécimen ST310 ; **b1**, vue externe, valve senestre ; **b2**, vue interne, valve senestre ; **c**, *Flabellipecten alessii* (PHILIPPI, 1836), spécimen ST27 ; **d**, *Ostrea lamellosa* (BROCCHI, 1814), spécimen ST21 ; **d1**, vue externe, valve dextre ; **d2**, vue interne, valve dextre ; **e**, *Ostrea edulis* (LINNÉ, 1758), spécimen ST6 ; **e1**, vue externe, valve dextre ; **e2**, vue interne, valve dextre. Barre d'échelle= 10 mm pour tous.

***Pecten maximus* (LINNAEUS, 1758)**

(Fig. 5e)

- 1758 *Ostrea maxima*.- LINNAEUS, X, p. 696.
 1778 *Pecten vulgaris*.- COSTA, p. 140, Pl. IX, fig. 3.
 1888 *Pecten medius* DANIEL.- ARNOULD LOCART, p. 150.
 1905 *Pecten maximus* (L).- CHOFFAT & DOLLFUS, p. 179-181.
 1952 *Pecten maximus* (L).- LECOINTRE, p. 5-173.
 1989 *Pecten maximus* (L).- LAURIAT-RAGE, p. 217.
 2009 *Pecten maximus* LINNAEUS, 1758.- JIMÉNEZ, p. 19, Figs. 8.c-d.

Material: Three left valves (ST12, l=85 mm, h=77 mm, c=40 mm; ST86, l=110 mm, h=92 mm, c=50 mm; ST88, l=80 mm, h=67 mm, c=34 mm) and a single right valve (ST120, l= ind, h=80 mm, c= ind), all collected from the yellow sandy marls of Ouled Fayet and Douera (unit c).

Description: This species bears rather thick, asymmetrical valves, with an upper (left) valve, flat or slightly concave in the umbo area, and a lower (right) curved valve slightly exceeding the left one on the edge. The dorsal-ventral length is always smaller than the antero-posterior one. Both valves bear wide radiating ribs (18 ribs on the left valve) characterised by their rounded section on the right valve and their quadrangle section on the left valve, and by the occurrence of ridges in rib interspaces, numerous concentric undulations and fine striae. Growth lines are marked on both valves at interspaces, especially on the left valve. The auricles are equal and slightly costate. There is a slight byssal sinus and the ctenolium is missing.

Stratigraphic range: The species is reported in the northern Atlantic, from Norway through the Channel, and the Iberian Peninsula to Sudan. It is rather common in the Pliocene deposits of Almeria (JIMÉNEZ *et al.*, 2009).

Ecology: *Pecten maximus* lives freely on the surface of sandy and fine-gravelly sea bottoms to a depth of approximately -150 to -200 m. This species is preferentially found in calcarenites, median- and coarse-grained sandstones and conglomerates.

***Pecten (Pecten) jacobaeus* (LINNAEUS, 1758)**

(Fig. 6a)

- 1758 *Ostrea Jacobea*.- LINNAEUS, X, p. 696. Lig., XXIV, pag. 58, Tav. XIII, figs. 1-10.
 1902 *Pecten jacobaeus* LINNAEUS.- DEPÉRET & ROMAN, p. 58, Pl. V, fig. 1, 1a.
 1907 *Pecten jacobaeus*.- CERRULI IRELLI, I, p. 98, Tav. VI, fig. 14.a-b.
 1957 *Pecten jacobaeus* (LINNAEUS).- PERRODON, p. 207.
 1975 *Pecten jacobaeus* (LINNAEUS).- FEKI, p. 32, Pl. V, fig. 5.
 1987 *Pecten jacobaeus* (LINNAEUS, 1758).- KHARRIM, p. 90, Pl. 5, fig. 1.
 2017 *Pecten jacobaeus* (LINNAEUS, 1758).- SPADINI, p. 10.

Material: Two, incomplete and thick, right valves (ST28, l=85 mm, h=80 mm, c= ind; ST70, l= ind, h= ind, c=50 mm) and a single inner mould (ST38, l=100 mm, h=98 mm, c=50 mm), all collected in the yellow sandy marls of Ouled Fayet and Douera (unit c).

Description: The collected specimens display an impressive size and are convex with a prominent umbo, but shorter than in *P. bipartitus*. The right valve bears 15 ribs with rectangular section, wider than the interspaces. Ribbings (4) run through the ribs and are lacking in the interspaces. Auricles are almost equal.

Stratigraphic range: This species appeared in the Pliocene, replacing *P. grayi* MICHELOTTI, 1847. From the early Pliocene, it is found abundantly in the Atlantic and the Mediterranean Sea where it still lives nowadays (BEN MOUSSA, 1994).

Ecology: *P. jacobaeus* lives freely set on the sea bottom with its right valve and can swim actively. This is an exclusive species of the coastal detrital biocoenosis (CAULET, 1972).

Genus *Flabellipecten* Sacco, 1897**Type species:** *Pecten alessii* PHILIPPI, 1836***Flabellipecten alessii* (PHILIPPI, 1836)**

(Fig. 6c)

- 1910-1912 *Flabellipecten alessii* (PHILIPPI, 1836).- DEPÉRET *et al.*, p. 141, Pl. XVIII, fig. 3, 3a.
 2009 *Flabellipecten alessii* (PHILIPPI, 1836).- JIMÉNEZ *et al.*, p. 17, 15.
 2017 *Flabellipecten alessii* (PHILIPPI, 1836).- SPADINI, p. 10.

Material: A single complete shell (ST27, l=125 mm, h=110 mm, c=99 mm) collected from the yellow sandy marls of Douera (unit c).

Description: The studied specimen is a complete, equivalve and equilateral shell, slightly wider than high. Both valves are weakly bulging, especially around the umbo, with a somewhat slightly flat left valve. The surface of this smooth shell displays fine ridges enhancing the position of ribs (about fifty) sometimes arranged in couplets. Their surface is ornamented by fine growth lines. Both auricles, devoid of jagged ridges, are almost identical and show a bundle of growth lines cut by radial ribs. The anterior auricle displays a shallow byssal sinus. DEPÉRET & ROMAN (1910) considered *F. alessii* as a variant of *F. flabelliformis* (BROCCHI, 1814) and described various intermediate morphologies between both species.

Stratigraphic range: *Flabellipecten alessii* was described by PHILIPPI (1836) in the Pliocene of Castrogiovanni, Sicily. It also occurs in Liguria, in the Piacenzian of Bordighera, in the surroundings of Nice, in the Piacenzian of Villeneuve-Loubet and in the Astian of Asti, Modena, Zenzano and Calabria. In summary, the species is exclusively limited to Sicily, Italy and Nice, and can be found in the Piacenzian and Astian (DEPÉRET & ROMAN, 1910-1912).

Family Plicatulidae GRAY, 1854**Genus *Plicatula* LAMARCK, 1801****Type species:** *Spondylus plicatus* LINNAEUS, 1758***Plicatula mytilina* PHILIPPI, 1836**

(Fig. 6b)

- 1836 *Plicatula mytilina*.- PHILIPPI, p. 86, Pl. 6, fig. 1.
 1914 *Plicatula mytilina* PHILIPPI.- COSSMANN & PEYROT, Pl.



20, figs. 39-42.

- 1965 *Plicatula mytilina* PHILIPPI.- GLIBERT & POEL, p. 45.
 1988 *Plicatula mytilina* PHILIPPI 1836.- STUDENCKA & STUDENCKI, p. 296.
 2003 *Plicatula mytilina* PHILIPPI.- LOZOUET *et al.*, p. 6, Pl. 14, figs. 1-6.

Material: Two right valves (ST301, l=30 mm, h=45 mm; ST310, l=31 mm, h=62 mm) collected from the yellow sandy marls of Ouled Fayet (unit c).

Description: Both valves are thick, flat, oval and dorso-ventrally elongated with a small, slightly opisthogyrous escutcheon. Irregular and rather spaced, growth lines are visible on the dorsal side. The inner surface displays a tiny, triangular, ligament area, base of which varies from 12 to 14 mm and shows an open, anterior-posteriorly elongated slit of some 5 mm. Vermiculate chomata are arranged outside the ligament area, along the anterior and posterior parts of the valve, much more visible in specimen ST301. The postero-anterior muscle scar in dorso-posterior position is subcircular, 7 mm in diameter and a bit more elongated dorso-ventrally in specimen ST310. Several other left valves, sometimes complete, are cemented on the outer surface of the right valve.

Stratigraphic range: *Plicatula mytilina* is reported from the Early Miocene to the Middle Pliocene (STUDENCKA & STUDENCKI, 1988).

Ecology: This is an epifaunal suspensivorous taxon preferring hard substrates.

Order Ostreoida FÉRUSAC, 1822 (emend.)
Suborder Ostreina FÉRUSAC, 1822 (emend.)
Superfamily Ostreacea RAFINESQUE, 1815
Family Ostreidae RAFINESQUE, 1815
Genus *Ostrea* LINNAEUS, 1758
Subgenus *Ostrea* LINNAEUS, 1758

Type species: *Ostrea edulis* LINNAEUS, 1758

Ostrea (Ostrea) lamellosa offreti
KILIAN, 1889
 (Fig. 6d)

- 1814 *Ostrea lamellosa*.- BROCCCHI, p. 564.
 1897 *Ostrea edulis* LINNAEUS var. *lamellosa* BROCCCHI.- SACCO, p. 7, Pl. H, figs. 3-4.
 1889 *Ostrea lamellosa* BROCCCHI.- KILIAN, p. 730, Pl. XVI, figs. 1-2.
 1920 *Ostrea edulis* LINNAEUS. var. *boblayei* DESHAYES.- DOLLFUS & DAUTZENBERG, p. 462, Pl. 98, figs. 1-13; Pl. 101, fig. 1.
 1965 *Ostrea (s.s.) edulis* LINNAEUS *lamellosa* (BROCCCHI).- GLIBERT & POEL, p. 58.
 1975 *Ostrea lamellosa* BROCCCHI.- FEKI, p. 43, Pl. XII, fig. 5.
 1988 *Ostrea (Ostrea) lamellosa* BROCCCHI, 1814.- FRENEIX *et al.*, p. 5, Pl. I, fig. 5.
 1994 *Ostrea (Ostrea) edulis lamellosa* BROCCCHI, 1814.- BEN MOUSSA, p. 116, Pl. 7, fig. 6.
 2012 *Ostrea lamellosa* (BROCCCHI, 1814).- SATOUR, p. 72, Pl. 3, figs. 4-5.

Material: A complete shell (ST6, l=90 mm, h=110 mm) and two right valves (ST42, l=80 mm, h=90 mm; ST69, l=80 mm, h=90 mm), all collected in the yellow sandy marls of Ouled Fayet and Douera (unit c).

Description: The large-sized complete shell (ST6) consists of a left valve with dense con-

centric and undulated lamellae of loose radial folds, while the right (opercular) valve displays more or less spaced, concentric imbricated lamellae. The two right valves are of relatively large size, thicker with a flat shape, more elongated from umbo to outer margin with a slight posterior elongation without any ornamentation, with a gyrostreiform escutcheon, a tiny triangular, ligament area, ca. 35 mm in diameter, and with fine striae. The muscle scar, sub-triangular and slightly stretched posteriorly, is subcentral and of ca. 25 mm in diameter. The edge of the right valve is thick and folded. The outer surface bears strongly marked and non-homogenous, lamellar growth lines.

Stratigraphic range: The subspecies disappeared by the end of the Pliocene and was replaced by *O. edulis edulis* LINNAEUS, 1758, still living today (BEN MOUSSA, 1994).

Ecology: This subspecies should have had the same environment as *O. edulis edulis*, which is found cemented to hard substrates, in oxygenated waters of the infralittoral zone, with quite variable salinity. It is suspensivorous, avoids very fine sediments and excessively turbid waters, and is adapted to various muddy, gravelly and rocky sea substrates, always immersed, ranging from -20 to -85 m in water depth. The water temperature must remain below 15°C in summer, the salinity being at least 25‰ (LAURAIN, 1984). However, it was less eurythermal than *O. edulis*, latitudinal distribution of which ranges from Norway to the Mediterranean Sea.

***Ostrea edulis* LINNAEUS, 1758**
 (Fig. 6e)

- 1758 *Ostrea edulis*.- LINNAEUS, p. 482, fig. 70.
 1814 *Ostrea edulis* L.- BROCCCHI, p. 562.
 1819 *Ostrea edulina*.- LAMARCK, p. 218, no. 22.
 1836 *Ostrea edulis* LINNAEUS.- DESHAYES, p. 244-245, no. 22 note 2.
 2000 *Ostrea edulis* LINNAEUS.- GOULVEN, p. 186.
 2021 *Ostrea edulis* LINNAEUS, 1758.- BENYOUCEF *et al.*, p. 9, Fig. 6.C.

Material: A single complete shell (ST67, l=75 mm, h=95 mm) and two right valves (ST5, l=80 mm, h=85 mm; ST21, l=65 mm, h=60 mm), all collected from the yellow sandy marls of Ouled Fayet and Douera (unit c).

Description: The complete, rather large-size, shell displays flat and subcircular valves bearing imbricated, irregularly spaced concentric lamellae towards the outer edge, and having a folded and chalky structure. The robust escutcheon, of ostreiform type, displays on its inner side a triangular ligament area covered by fine growth lines; this latter consists of a deep median pit in between two ridges. The muscle scar, kidney-shaped and slightly stretched backwards, is subcentral.

Stratigraphic range: *Ostrea edulis* is known from the Pliocene to the Recent (BENYOUCEF *et al.*, 2021). It is found from Norway to near Moroccan waters, along the Mediterranean shores and in the Black Sea. It is also reported in the Lower Chelif basin (NW Algeria).



Ecology: It dwells on sea bottoms not exceeding -40 m or ranges from the intertidal to the infralittoral zones. The adult forms can live attached to hard substrates (rocks, shell debris), but also on soft ones of sandy/muddy type (Global Biodiversity Information Facility, 2022).

Ostrea fimbriata

GRATELOUP in RAULIN & DELBOS, 1855

(Fig. 7a)

- 1855 *Ostrea fimbriata* GRATELOUP.- RAULIN & DELBOS, p. 1158, Pl. 16, figs. 1-7; Pl. 17, figs. 1-4.
 1914 *Ostrea fimbriata* GRATELOUP.- COSSMANN & PEYROT, Pl. 19, figs. 19-21; Pl. 20, figs. 14-15.
 1914 *Ostrea (Cubitostrea) producta* RAULIN & DELBOS.- COSSMANN & PEYROT, Pl. 19, figs. 1-4.
 1914 *Ostrea (Ostreola) duvergieri*.- COSSMANN & PEYROT, Pl. 20, figs. 23-28.
 2001 *Ostrea fimbriata* RAULIN & DELBOS.- SCHULTZ, p. 353, Pl. 52, figs. 4.a-b, 5.a-b.
 2002 *Ostrea producta*.- ROCHER, p. 41, Pl. 10, fig. 13.
 2003 *Ostrea fimbriata* (GRATELOUP, 1855).- LOZOUET et al., p. 7, Pl. 16, figs. 1-7; Pl. 17, figs. 1-4.
 2014 *Ostrea fimbriata* (RAULIN & DELBOS, 1855).- KRÍŽNAR & MIKUŽ, p. 55.

Material: A single complete shell (ST36, l=84 mm, h=95 mm) and two left valves (ST1, l=115 mm, h=110 mm; ST4, l=70 mm, h=70 mm), hollow and of brownish colour, all collected from the yellow sandy marls of Douera (unit c).

Description: These shells are of rather large size, quite thick, with a slightly concave and sub-circular shape. They display an opisthogyrous umbo of ostreiform type. The palleal edge of the costulated valve displays both crenulated ornamentation and edge, as well as lamellar growth lines. The ligament area is small and has a triangular shape. The umbonal cavity is missing. There is a large central, kidney-shaped muscle scar.

Stratigraphic range: *O. fimbriata* is only known at the Aquitanian.

Ecology: These individuals of *O. fimbriata* seem to be developed only on small-size hard substrates, separating them from soft substrates (fine sands, marls) or linked to the agitation of the environment (small pebbles, wood debris, etc.). The associated fauna is always littoral, with oligohaline affinity. On Mediterranean shores, we often use to collect individuals with aspect similar to that of *O. fimbriata* and assigned to the species *O. edulis*. Such a morphology is related to a series of environmental conditions: rather high temperature, normal salinity, water turbulence, and attachment on mobile substrate (LAURAIN, 1984).

***Ostrea stentina* PAYRAUDEAU, 1826**

(Fig. 7b)

- 1826 *Ostreola stentina*.- PAYRAUDEAU, Pl. I, figs. 6, 7.a-b.
 1962 *Ostrea stentina* (PAYR.).- PASTEUR-HUMBERT, p. 37, Pl. 15, fig. 54.
 1971 *Ostrea (Ostrea) stentina* (PAYR.).- STENZEL, p. 1139, Fig. J 112, 1.a-e, 2.a-e.
 1979 *Lopha (Ostreola) stentina* (PAYR.).- ROSSO, p. 472.
 1985 *Ostreola stentina* (PAYR.).- HARRY, p. 142, Fig. 20.

Material: Four left valves (ST214, l=30 mm, h=42 mm; ST222, l=35 mm, h=50 mm; ST302, l=30 mm, h=50 mm; ST307, l=30 mm, h=40 mm)

collected from the yellow sandy marls of Ouled Fayet (unit c).

Description: The collected valves are oval and rather small. They display undulated growth lines as more or less developed folds, lamellae of which are raised in places as spines. The folds build a characteristic serrated marginal edge. The inner side of the shell displays an umbonal cavity. The ligament area is rather narrow with a resilifer quite as wide as each bulge, except on specimen ST222. The escutcheon is slightly to strongly opisthogyrous. Vermiculate chomata are visible on both sides of the inner side of the shell and outside the ligament area. The rather large, adductor muscle insertion area is subcircular to kidney-shaped, and close to the dorsal margin.

Stratigraphic range: *Ostrea stentina* is known from the Neogene and mostly mentioned from the Quaternary in the Mediterranean basin. Nowadays it dwells the Mediterranean, the eastern Atlantic coast from Portugal down south to Angola, the western coast from North Carolina to Argentina, and the eastern Pacific coast from Alaska to Panama; but *O. stentina* is still unreported in the Indopacific domain, according to HARRY (1985).

Ecology: *O. stentina* is a mostly infralittoral (from several metres down to -35 m) oyster, but can reach the upper limit of the continental shelf and cannot stand any salinity decrease; it dwells in the wide-open bays in tropical, subtropical and temperate regions (FRENEIX, 1988).

***Saccostrea cucullata* BORN, 1778**

(Fig. 7c)

- 1778 *Ostrea cucullata*.- BORN, p. 114, Pl. 6, figs. 11-12.
 1835 *Ostrea echinata*.- QUOY & GAIMARD, p. 455, Pl. 76, figs. 13-14.
 1931 *Ostrea echinata*.- AWATI & RAI, p. 1-107.
 1971 *Saccostrea cucullata*.- STENZEL, N1134-N1135, Fig. J106.
 1985 *Saccostrea cucullata*.- MORRIS, p. 125-128, Pl. 3, figs. E-G.
 2009 *Saccostrea cucullata*.- LAM & MORTON, p. 110-112, Pls. 11-12.

Material: Three left valves (ST215, l=30 mm, h=30 mm; ST225, l=45 mm, h= ind; ST303, l=45 mm, h= ind) collected in the yellow sandy marls of Ouled Fayet (unit c).

Description: The collected left valves are of small size, slightly convex and of typical subtriangular shape. Only specimen ST215 is complete; specimens ST225 and ST303 are broken on their ventral side. The outer shape of the shells bears growth lines and undulations sometimes building spines at rib intersections. The shell edge is irregularly folded likewise the edge of the genus *Lopha*. The ligament area is small and of triangular shape, following the opisthogyrous escutcheon bend, and shows a crura at its lower base (specimen ST225). There is an umbonal cavity; the subcircular muscle scar, slightly dorsal-ventrally elongated (ca. 5 mm) is 15 mm in diameter. Vermiculate chomata are arranged outside the ligament area and are extending on the inner, anterior and posterior, parts of the valve.

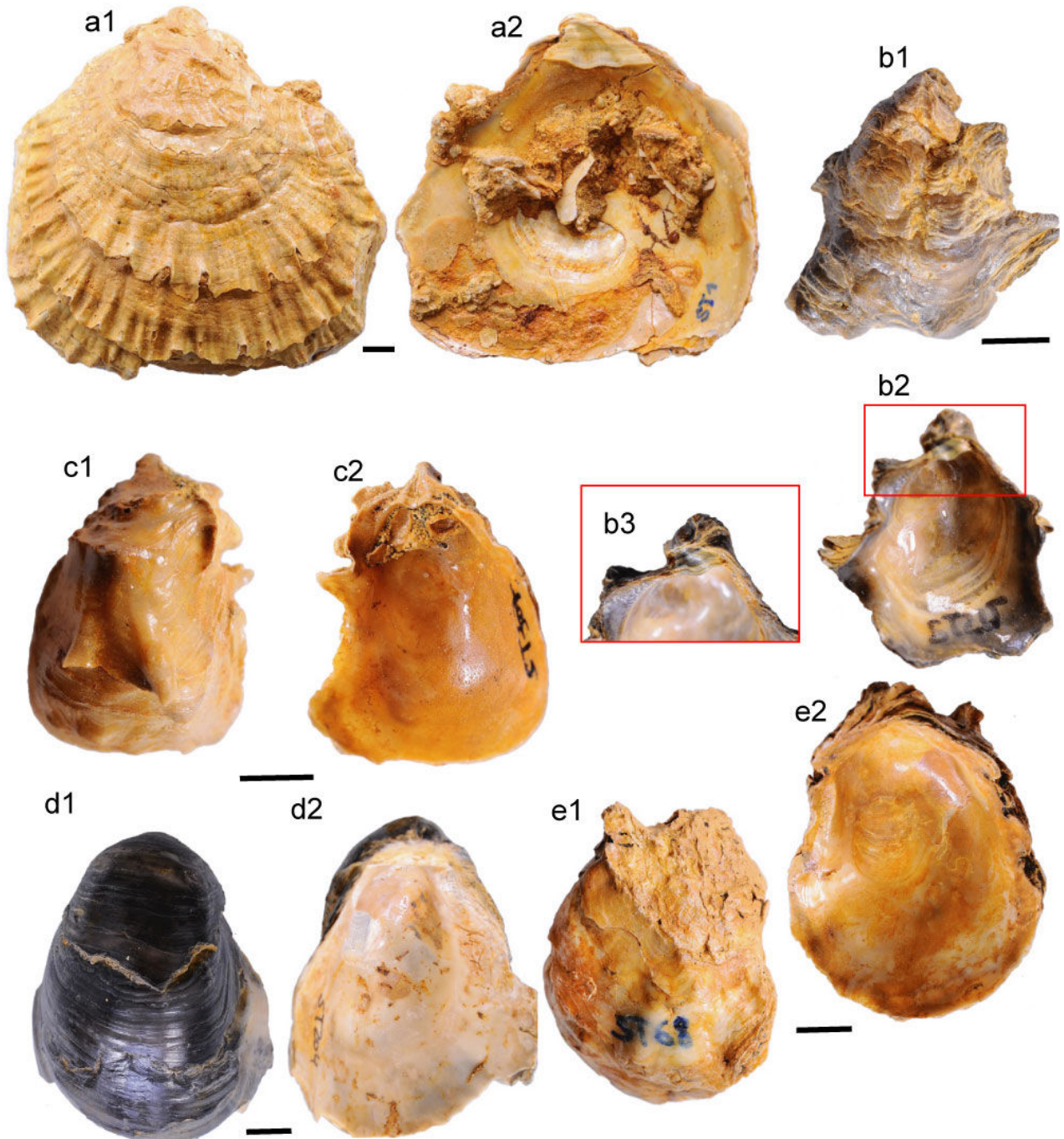


Figure 7: Bivalve taxa from the Pliocene of the Algiers Sahel. **a**, *Ostrea fimbriata* GRATELOUP in RAULIN & DELBOS, 1855, specimen ST1; **a1**, external view, left valve; **a2**, internal view, left valve; **b**, *Ostrea stentina* (PAYRAUDEAU, 1826), specimen ST225; **b1**, external view, left valve; **b2**, internal view, left valve; **b3**, detail of dorsal part; **c**, *Saccostrea cucullata* (BORN, 1778), specimen ST215; **c1**, external view, left valve; **c2**, internal view, left valve; **d**, *Neopycnodonte navicularis* (BROCCHI, 1814), specimen ST204; **d1**, external view, left valve; **d2**, internal view, left valve; **e**, *Neopycnodonte cochlear* (POLI, 1791), specimen ST68; **e1**, external view, left valve; **e2**, internal view, left valve. Scale bar= 10 mm for all.

Figure 7 : Bivalves du Pliocène du Sahel d'Alger. **a**, *Ostrea fimbriata* GRATELOUP in RAULIN & DELBOS, 1855, spécimen ST1 ; **a1**, vue externe, valve senestre ; **a2**, vue interne, valve senestre ; **b**, *Ostrea stentina* (PAYRAUDEAU, 1826), spécimen ST225 ; **b1**, vue externe, valve senestre ; **b2**, vue interne, valve senestre ; **b3**, détail de la partie dorsale ; **c**, *Saccostrea cucullata* (BORN, 1778), spécimen ST215 ; **c1**, vue externe, valve senestre ; **c2**, vue interne, valve senestre ; **d**, *Neopycnodonte navicularis* (BROCCHI, 1814), spécimen ST204 ; **d1**, vue externe, valve senestre ; **d2**, vue interne, valve senestre ; **e**, *Neopycnodonte cochlear* (POLI, 1791), spécimen ST68 ; **e1**, vue externe, valve senestre ; **e2**, vue interne, valve senestre. Barre d'échelle= 10 mm pour tous.



Stratigraphic range: *S. cucullata* is a typical species of the Neogene of the Mediterranean Sea and reported in the Miocene and Pliocene sediments (SACCO, 1898) and in the Pleistocene of East Africa, the southern Arabic Peninsula, Java, Middle East, Syria, Egypt, Cyprus and Turkey. This species is also reported in the subtropical and tropical Indo-Pacific domain, southern Japan and Australia (LAM & MORTON, 2009).

Ecology: *S. cucullata* dominates the eulittoral zone of the rocky shores like Hoi Ha Wan, Starfish Bay, Tso Woo Hang, Deep Bay, and Tai Tam Bay, and the mangroves like Ting Kok (MORTON, 1990; CHIU, 1998). It is scarce on exposed shores like Cheung Sha and Cape Aguilar. This taxon also occurs on immersed and protection concrete structures of the East Ping Chau pier, and individually scattered in the barnacle environment of Big Wave Bay, Hong Kong islands.

Family Gryphaeidae VYALOV, 1936
Subfamily Pycnodonteinae STENZEL, 1971
Genus Neopycnodonte STENZEL, 1971

Type species: *Neopycnodonte cochlear* POLI, 1795

***Neopycnodonte navicularis* BROCCHI, 1814**
 (Fig. 7d)

- 1814 *Ostrea navicularis*.- BROCCHI, Pl. 565.
 1897 *Pycnodonte cochlear*.- SACCO, p. 22, Pl. 8, figs. 1-14.
 1965 *Pycnodonte (Pycnodonte) cochlear navicularis* (BROCCHI).- GILBERT & POEL, p. 67.
 1988 *Neopycnodonte navicularis* (BROCCHI, 1814).- FRENEIX *et al.*, p. 2, Pl. I, figs. 1, 2.a-b.
 1994 *Neopycnodonte navicularis* (BROCCHI, 1814).- BEN MOUSSA, p. 115, Pl. 7, figs. 4-5.
 2012 *Neopycnodonte navicularis* (BROCCHI, 1814).- SATOUR, p. 64, Pl. 2, figs. 13-14.

Material: Two complete shells (ST68, l=57 mm, h=70 mm, ST204 right valve, l=60 mm, h=70 mm; ST213 left valve, l=42 mm, h=60 mm), two left valves (ST172, l=67 mm, h=90 mm; ST208, l=40mm, h=60 mm) and one right valve (ST124, l=55 mm, h=65 mm), all collected from the yellow sandy marls of Ouled Fayet (unit c).

Description: These are thin or thick, large-sized shells of ovoid shape. The left valve is very concave (hollow in boat-shape), whereas the right valve is flat or slightly concave. The outer surface is smooth, sometimes slightly folded (specimen ST68) and bears concentric, lamellar growth lines. The escutcheon is slightly opisthogyrous. The ligament area, sometimes twinned (specimen ST208), of triangular shape, displays two lateral bulges defining a median resilium. Vermiculate chomata, when present (lacking in specimens ST172 and ST208), are situated outside the ligament area, along the lateral, anterior and posterior, ridges. The oval muscular scar of the left valve is located towards the posterior end. The shape of the adductor muscle scar of the right

valve is much more circular. This latter bears an additional trace of adductor muscle as a gutter (specimen ST213) in the middle and below the ligament area.

Stratigraphic range: *N. navicularis* is known from the Early Miocene in the Mediterranean basin and the Paratethys to enter the Boreal domain (Belgium, Netherlands) during the Middle Miocene (FRENEIX *et al.*, 1988). In the Pliocene, it is widespread in the Mediterranean Sea; it disappeared in the late Pliocene and was replaced by *N. cochlear*, this latter still living today.

Ecology: The taxon dwelled attached or free-living on various sea bottoms in depths ranging from -50 and -300 m and in temperate waters of low turbidity (MALATESTA, 1974).

***Neopycnodonte cochlear* (POLI, 1795)**
 (Fig. 7e)

- 1795 *Ostrea cochlear*.- POLI, p. 179, 26, p. iii (index).
 1961 *Pycnodonte cochlear* (POLI).- LECOINTRE & RANSON, p. 29, Pl. 7, fig. 11.
 1981 *Pycnodonte cochlear* (POLI).- TORIGOE, p. 320, Pl. 9, figs. 1-7; Pl. 31, fig. 1.
 2003 *Neopycnodonte cochlear* (POLI, 1791).- VIDET, p. 22, Pl. 4, figs. 1-5.
 2012 *Neopycnodonte cochlear* (POLI, 1791).- SATOUR, p. 67, Pl. 2, fig. 15.

Material: A single complete shell (ST61 right valve, l=42 mm, h=70 mm; ST62 left valve, l=46 mm, h=80 mm) and four left valves (ST158, l=34 mm, h=50 mm; ST194, l=40 mm, h=56 mm; ST196, l=45 mm, h=72mm; ST197, l=35 mm, h=45 mm; ST209, l=34 mm, h=45 mm) all collected from the yellow sandy marls of Ouled Fayet and Douera (unit c).

Description: This taxon displays the same morphological characteristics than its ancestor, *Neopycnodonte navicularis*. The oval shell, thick or thin, or even sometimes chalky (specimen ST97), is inequivalve with concave left valve and plano-concave right one. Growth lines are lamellar, irregular and rather tight on the anterior side. The escutcheon is opisthogyrous. The triangular, ligament area displays two lateral ridges defining a shallow, median, resilifer. Vermiculate chomata are arranged outside the ligament area, along the lateral, anterior and posterior, ridges of the valve. The adductor muscle scar is subcircular in posterior position, closer to the ligament area than the ventral side.

Stratigraphic range: *N. cochlear* is ubiquitous species, widespread in the Mediterranean Sea, eastern and western Atlantic shores, Pacific Ocean, Indian Ocean, and the Red Sea. It lives in deep waters along the continental margins and slopes. It is especially abundant in the lower part of the circalittoral zone and, more particularly, between -25 and -150 m, well cemented to hard substrates (Global Biodiversity Information Facility, 2022).

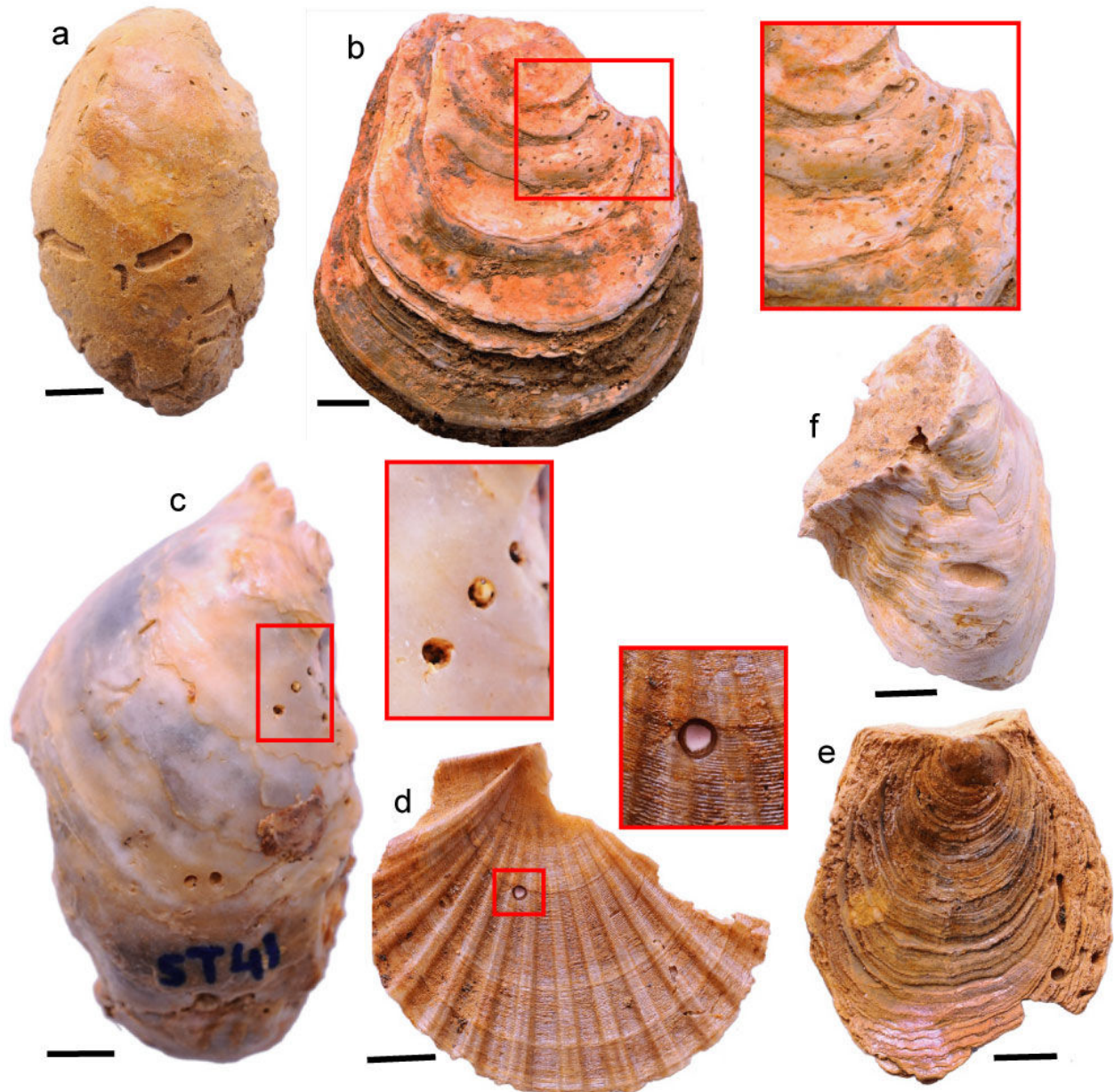


Figure 8: Bioerosion traces in Pliocene bivalves from the Algiers Sahel. **a**, outer surface of the left valve of *Neopycnodonte navicularis* (BROCCHI, 1814) showing *Caulostrepsis taeniola* (CLARKE, 1908), specimen ST195; **b**, *Entobia* isp. on the right valve of *Ostrea lamellosa* (BROCCHI, 1814), specimen ST42; **c-e**, *Oichnus simplex* (BROMLEY, 1981) on left valve of *Neopycnodonte navicularis* (BROCCHI, 1814), specimen ST41; left valve of *Pecten bipartitus* (FORESTI, 1876), specimen ST117, right valve of *Neopycnodonte cochlear* (POLI, 1795), specimen ST173; **f**, left valve of *Neopycnodonte cochlear* (POLI, 1795) showing *Gastrochaenolites torpedo* (KELLY & BROMLEY, 1984), specimen ST197. Scale bar= 10 mm for all.

Figure 8 : Traces de bioérosion observables dans les coquilles de bivalve du Pliocène du Sahel d'Alger. **a**, surface extérieure de valve senestre de *Neopycnodonte navicularis* (BROCCHI, 1814) comportant *Caulostrepsis taeniola* (CLARKE, 1908), spécimen ST195 ; **b**, *Entobia* isp. dans une valve dextre d'*Ostrea lamellosa* (BROCCHI, 1814), spécimen ST42 ; **c-e**, *Oichnus simplex* (BROMLEY, 1981) dans une valve senestre de *Neopycnodonte navicularis* (BROCCHI, 1814), spécimen ST41 ; valve senestre de *Pecten bipartitus* (FORESTI, 1876), spécimen ST117, valve dextre de *Neopycnodonte cochlear* (POLI, 1795), spécimen ST173 ; **f**, valve senestre de *Neopycnodonte cochlear* (POLI, 1795) comportant *Gastrochaenolites torpedo* (KELLY & BROMLEY, 1984), spécimen ST197. Barre d'échelle= 10 mm pour tous.

6. Endoskeletobionts (borings)

The Pliocene bivalve specimens of Algiers Sahel are weakly affected by boring and encrusting traces of organisms.

The bioerosive traces, observable on some bivalve specimens, are attributable to both endobionts and predators, and are mostly related to six ichnogenera:



6.1. Ichnogenus *Caulostrepsis* CLARKE, 1908
***Caulostrepsis taeniola* CLARKE, 1908**
 (Fig. 8a)

The figured specimens correspond to irregular, large-size, boring traces, with shape varying from simple, slightly curved galleries to U-shaped tubes with clavate (specimen ST403), rounded (specimen ST402) and sometimes single-pointed (specimen ST173) or double-pointed (specimen ST204) ends. This structure ranges from 2 to 17 mm in length by 1 to 4 mm in width. This ichnospecies, associated to *Entobia* isp., is preserved on both the outer and inner valve surfaces of *Neopycnodonte cochlear*, *N. navicularis* and *Aequipecten angelonii*. *Caulostrepsis taeniola* is a domichnion produced by several polychete families like siphonids (PARRAS & CASADIO, 2005).

6.2. Ichnogenus *Entobia* BRONN, 1838
***Entobia* isp.**
 (Fig. 8b)

This is the most abundant trace fossil. It is widely developed on the outer and some inner valve surfaces of *Ostrea lamellosa* (specimen ST42) and in articulated *Neopycnodonte navicularis* (specimen ST208). The genus *Entobia* is represented by a network of holes irregularly distributed, circular to elliptical and of variable size. The hole diameter ranges from 0.5 to 1 mm, devoid of any ornamentation. The drilling chambers do not penetrate the whole shell wall. In the present study we assign the trace material to *Entobia* isp., because it lacks diagnostic features. Borings assigned to the genus *Entobia* are produced by drilling sponges (Clionidae; BROMLEY & TENDAL, 1973; TAYLOR & WILSON, 2003).

6.3. Ichnogenus *Oichnus* BROMLEY, 1981
***Oichnus simplex* BROMLEY, 1981**
 (Fig. 8c-e)

These are circular, subcircular to slightly oval borings, varying from 0.7 to 1 mm in diameter, perpendicular to sub-perpendicular to the outer surface of the right valves of the oyster *O. edulis*. *Oichnus* specimens are usually interpreted as *Praedichnia* (*sensu* EKDALE, 1985) of the gastropod families Naticidae and Muricidae respectively (BROMLEY, 1981; PICKERILL & DONOVAN, 1998). *O. paraboloides* likely originates from naticid gastropods, whereas *O. simplex* is produced by muricid ones (PICKERILL & DONOVAN, 1998).

6.4. Ichnogenus *Gastrochaenolites* LEYMERIE, 1842
Gastrochaenolites torpedo
KELLY & BROMLEY, 1984
 (Fig. 8f)

This ichnotaxon is less represented. It shows an elongate, claviform structure on the outer part of the left valve of *Neopycnodonte cochlear* (specimen ST197). It is 10 mm-long and 4 mm-wide.

Specimens of *Gastrochaenolites* are interpreted by SEILACHER (1953) as Domichnia. Its ori-

gin refers usually to endolithic bivalves that bore mechanically or chemically shelly substrates such as Pholadidae, Gastrochaenidae and Mytilidae (WARME, 1975; KELLY & BROMLEY, 1984; FISCHER, 1990a, 1990b). Gastropods of the genus *Coralliophila* and some sipunculids can also produce structures belonging to the ichnogenus *Gastrochaenolites* (DONOVAN, 2013). The oldest record of this ichnogenus is of Early Ordovician age (EKDALE & BROMLEY, 2001).

6.5. Ichnogenus *Maeandropolydora* VOIGT, 1965

The genus *Maeandropolydora* differs from the genus *Caulostrepsis* (which appears as simple, U-shaped tube), by its complex and sinuous structure, as well as by the well-developed cylindrical shape of its galleries (e.g., BROMLEY & ALESSANDRO, 1983).

***Maeandropolydora sulcans* VOIGT, 1965**
 (Fig. 9a)

This ichnotaxon is particularly visible on the outer valve surfaces of *Neopycnodonte cochlear* and *N. navicularis*. It consists of one or several irregular, sinuous and sometimes coiled, cylindrical galleries, some 10 to 20 mm-long and 0.5 to 1 mm-wide. The ichnogenus *Maeandropolydora* is interpreted as resulting from the activity of annelid worms (BROMLEY & ALESSANDRO, 1983).

6.6. Ichnogenus *Pinaceocladichnus* MAYORAL, 1988 (Fig. 9b)

Visible on the left valve of *Neopycnodonte navicularis* (specimen ST402) as thin, regular, 1 mm-long, funnels with numerous bifurcations, giving a rhombic appearance. These traces are reported from the Oligocene to the Recent, and are assigned to ctenostome bryozoans (MAYORAL, 1988).

7. Episkeletobionts (encrustings)

Encrusting traces are seldom on Pliocene bivalve shells of Algiers Sahel. When available, they are usually concentrated on oyster specimens. Four types of encrusting organisms are identified among the study material:

7.1. Barnacles (Fig. 9c)

These are the most abundant encrusting traces on pteriomorph bivalve shells of Algiers Sahel. They belong to the genus *Balanus* and are well developed as aggregates on both the outer and inner valve surfaces of *O. edulis* (specimens ST4). Barnacles generally dwell any shallow marine settings (EL-SOROBY *et al.*, 2003).

7.2. Polychetes (Fig. 9d)

The first encrusting type is serpulid worms. Their preservation is lame and they scarcely occur on the outer surface of the left valves of *O. lamellosa* (specimen ST3) and *O. edulis* as thin limonitised tubes. Their dimensions range from 10 to 20 mm in length with 1 mm in diameter.

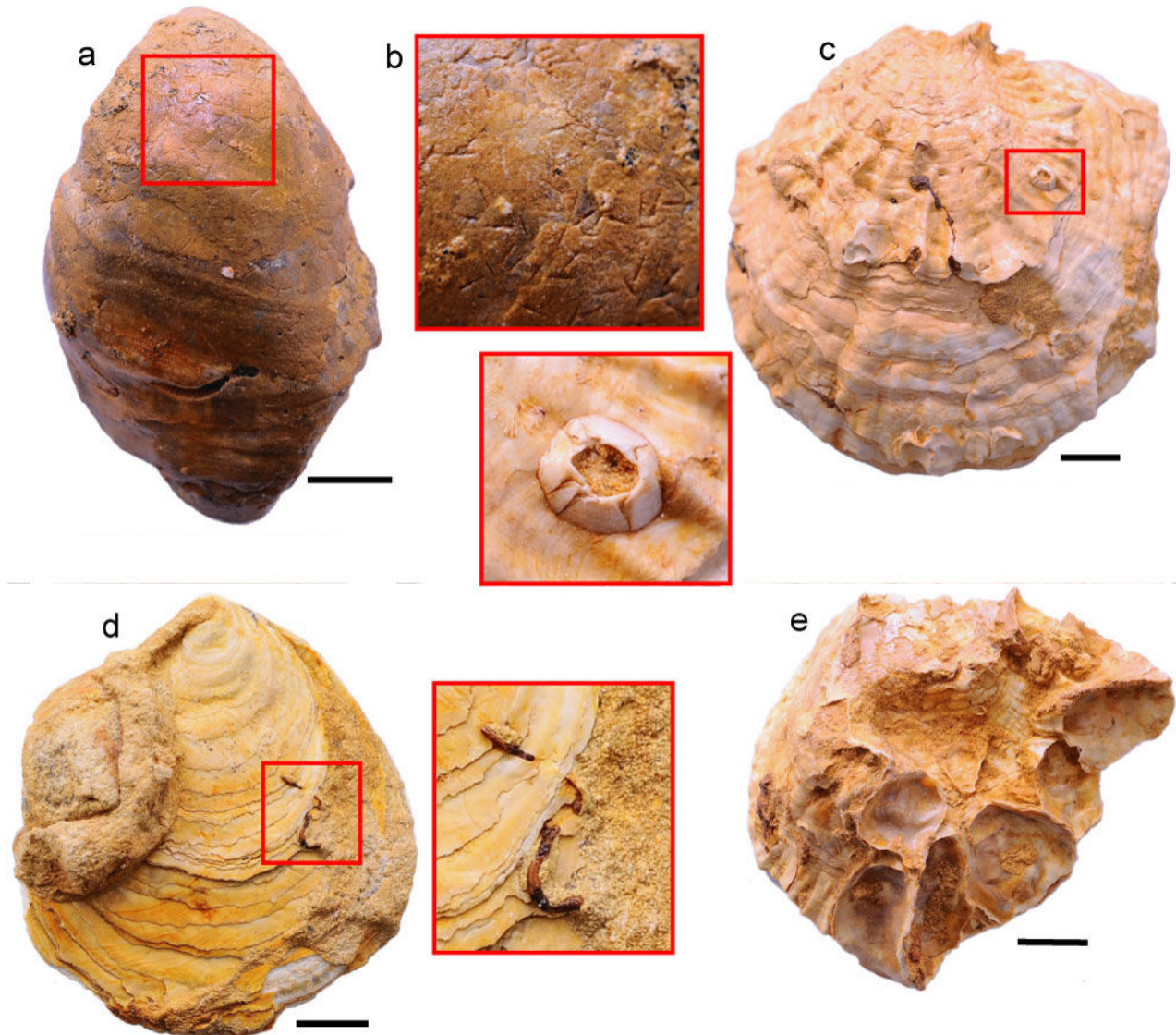


Figure 9: Epibionts on Pliocene bivalves from the Algiers Sahel. **a**, outer surface of right valve of *Neopycnodonte cochlear* (POLI, 1795) showing traces of *Maeandropolydora sulcans* (VOIGT, 1965), specimen ST402; **b**, traces of *Pinaceocladichnus* (MAYORAL, 1988) on the same specimen ST402; **c**, external surface of the left valve of *Ostrea fimbriata* (GRATELOUP in RAULIN & DELBOS, 1855) encrusted with barnacles, specimen ST4; **d**, external surface of the right valve of *Ostrea lamellosa* encrusted with ferruginised serpulids, specimen ST3; **e**, outer surface of right valve of *Ostrea edulis* (LINNAEUS, 1758) encrusted with juvenile oyster shells, specimen ST15. Scale bar= 10 mm for all.

Figure 9 : Épibiontes sur bivalves pliocènes du Sahel d'Alger. **a**, surface externe d'une valve droite de *Neopycnodonte cochlear* (POLI, 1795) montrant *Maeandropolydora sulcans* (VOIGT, 1965), spécimen ST402 ; **b**, *Pinaceocladichnus* (MAYORAL, 1988) sur le même spécimen ST402 ; **c**, surface externe d'une valve senestre d'*Ostrea fimbriata* (GRATELOUP in RAULIN & DELBOS, 1855) encroûtée de barnacles, spécimen ST4 ; **d**, surface externe d'une valve droite d'*Ostrea lamellosa* encroûtée avec des serpulides ferruginisés, spécimen ST3 ; **e**, surface externe d'une valve droite d'*Ostrea edulis* (LINNÉ, 1758) encroûtée par des coquilles d'huîtresjuvéniles, spécimen ST15. Barre d'échelle= 10 mm pour tous.

7.3. Juvenile oyster valves (Fig. 9e)

Numerous juvenile oyster valves are visible arranged in a circular pattern on the external side of the left valve. These juvenile valves represent several ontogenic stages, umbo-marginal dimensions range from 10 to 29 mm for specimen ST15, and from 5 to 10 mm for specimen ST4. The outer surface of *N. cochlear* (specimen ST15) and of *O. edulis* (specimen ST4) is encrusted by various ontogenetic stages of other disarticulated oyster specimens. As a rule, oysters are cement-

ing on the substrate by their left valve in a downward-convex position (BENYOUCEF *et al.*, 2021).

7.4. Bryozoans

Bryozoans represent the less abundant group among the studied encrusting organisms. They are mostly represented by whole colonies spreading from the outer part of the umbo of *Neopycnodonte navicularis* (specimen ST402). Bryozoans are sclerobionts attached to various hard substrates (TAYLOR, 1979, 2016; BRETON, 2017).



8. Taphonomic remarks and palaeoenvironmental interpretation

The study of the Pliocene deposits of the Algiers Sahel in the surroundings of Douera and those of Ouled Fayet shows a relative abundance of bivalves (Fig. 2B) unevenly distributed among the brown (unit b) and yellow sandy marls (unit c).

8.1. Unit b

At the base of this succession, the brown sandy marls yielded small to medium-size bivalve shells, except for some valves of *Amusium cristatum* that can reach up to 10 cm in height and 10 cm in width (specimens ST162 and ST163) and build monospecific shell beds in some places. The bivalve fauna consists mostly of a pectinid assemblage dominated by: *Amusium cristatum* (35%), *Pecten bipartitus* (30%) and *Aequipecten opercularis* (20%), but also contains in decreasing order: *Aequipecten bollenensis*, *A. radians*, *Mimachlamys varia*, *Aequipecten scabrella*, *Korobkovia oblonga*, *Pseudamussium clavatum*, and *Manupecten pesfelis*. The gryphaeids are represented by *Neopycnodonte navicularis*. The highest fragmentation rate of bivalve shells within the brown marly sands of Ouled Fayet is observed on those of *Amusium cristatum* and *Korobkovia oblonga* due to the brittleness of their valves, with fragmentation occurring by breakage firstly on its periphery and secondly on the valve surface. The shell bed, represent biological concentrations because the low fragmentation, absence of abrasion and many shells preserve the patterns of the original colouration, disarticulated shells occur concave-up and down, and they are unaffected by encrusting organisms or boring (KIDWELL, 1991). As for the rest of the bivalve assemblage, the specimens at hand display shells complete or slightly disarticulated with a weak to moderate fragmentation, supporting a preferential preservation within weak hydrodynamic settings. The wear of the pectinid bivalves is low with fragments showing non-blunt edges, non-altered colorations and slightly to non-deteriorated ornamentation, all that supporting a scarce post-mortem transport or even none. Furthermore, the occurrence of complete, non-worn and still connected, shells with populations showing various ontogenetic stages, and the presence of bio-erosive traces attributable to both endobionts and predators (barnacles, gastropods) on the outer surface of valves, all document a very short transport from the original life habitat to the fossilisation/burial site; subsequently, these assemblages are direct evidence of original environmental conditions. Likewise drilling and biogenic encrusting are abundant in depositional settings with low sedimentation rate and indurated sea bottom (LESCINSKY *et al.*, 2002).

The pectinids (*Pecten bipartitus*, *Aequipecten opercularis*, *A. bollenensis*, *A. radians*, *Mimachlamys varia*, and *Aequipecten scabrella*) occur indifferently in both calm and agitated environments,

on soft or hard substrates, and dwell all kind of marine settings from the infralittoral down to the circalittoral zones (FRENEIX *et al.*, 1987, 1988; SAINT MARTIN *et al.*, 2000; LACOUR *et al.*, 2002). In the environments of the Mediterranean Sea, *Pseudamussium clavatum* and *Manupecten pesfelis* mostly characterise the detrital, sandy and gravelly, sea bottoms of the circalittoral zone (PÉRÈS & PICARD, 1964).

Large-size, vagile and epibenthonic, specimens of *Amusium cristatum* and of *Korobkovia oblonga* suggest calm, muddy sea bottoms of the circalittoral zone; likewise, the oyster *Neopycnodonte navicularis* is a typical form of circalittoral sea bottoms, of depth ranging from -50 to -100 m (FRENEIX *et al.*, 1988; LACOUR, 1999; SAINT MARTIN *et al.*, 2000; LACOUR *et al.*, 2002; VIDET, 2003).

8.2. Unit c

The yellow marly sands of both localities of Douera and Ouled Fayet, yield a bivalve assemblage dominated by large-size specimens such as *Flabelligerella alessii*, *Ostrea fimbriata* and *Spondylus crassicauda*. Other associated pteriomorph bivalves are: *Pecten maximus*, *P. jacobaeus*, *Glycymeris bimaculata*, *Ostrea lamellosa*, *O. edulis*, and *Neopycnodonte cochlear*.

Small-size pectinids are represented by *Talochlamys multistriata*, *Mimachlamys varia*, *Aequipecten angelonii*, *A. scabrella*, *A. bollenensis*, and *Amusium cristatum*. They form assemblages with *Ostrea stentina*, *O. cucullata*, *Anadara diluvii*, *Nucula* sp., and *Plicatula mytilina*.

The state of preservation of shells within the yellow sandy marls of Douera and Ouled Fayet is relatively fair, with complete shells showing articulated, or slightly shifted, valves. The abrasion of pectinid valves is faint to nil with non-altered colours and ornamentation in excellent state of preservation (spines, ribs). All sampled fragments show non-blunt angles. Among the family Ostreidae, fragmentation is mainly observed in the marginal area and occurs as layered structures of the valves, regardless environmental hydrodynamics but rather related to intrinsic shell conditions. The assemblage of small-size pectinids such as *Talochlamys multistriata*, *A. angelonii*, *A. scabrella*, *A. bollenensis*, and *Mimachlamys varia*, indicate an infralittoral to bathyal zone. Whereas *T. multistriata* is frequent within depths ranging from -10 and -100 m, *A. angelonii* belongs to the group of species craving agitated waters (BEN MOUSSA, 1994). *G. bimaculata* dwells the fine to coarse sandy sea bottoms of the infralittoral zone under the influence of bottom currents. The occurrence of *Spondylus crassicauda* in this level indicates a median infralittoral type environment. *Plicatula mytilina* is an epifaunal, suspensivorous species dwelling hard substrates, likewise *Ostrea cucullata* dwelling the eulittoral zone of rocky shores. *Ostrea stentina* is essentially an infralittoral and intertidal oyster, ranging from several metres down to -35 m.



Large-size pectinids are represented by *Pecten maximus*, *P. jacobaeus* and *Flabellipecten alessii*. Like in present-day, these scallops live free-lying on the surface of sandy to fine-to-coarse gravel substrates. *Ostrea lamellosa* dwelled the intertidal to infralittoral zones down to -40 m water depth. This species records the last marine to brackish influences in the studied sections, considering that it could withstand temporary salinity decrease of at least 25‰ (FRENEIX *et al.*, 1988). *O. fimbriata* is associated to a littoral fauna with oligohaline affinity. *N. navicularis*, replaced by *N. cochlear*, usually dwells water depths ranging from -25 to -150 m, plainly attached to hard substrates.

The assemblage of large-size bivalves characterises the shallow inner shelf environments under the influence of high hydrodynamics and deposition of coarse detrital sediments; it corresponds to the thriving of large-size Pectinidae, Gryphaeidae and Ostreidae in environmental settings situated in the shallowest part of the infralittoral zone.

The bivalve assemblage within the yellow sandy marls suggests a shallow, agitated, marine setting, with some 'washover' influence evidenced by the occurrence of *Spondylus crassicauda* (LACOUR *et al.*, 2002). These observations are supported by the frequency of boring and encrusting traces mostly affecting large-size bivalves: the ichnogenus *Entobia* is strongly developed on the outer valve surfaces of *Ostrea lamellosa* and *Neopychnodonte navicularis*; *Oichnus simplex* is developed on the outer surfaces of *O. edulis* and *Pecten bipartitus*; *Caulostrepsis taeniola* and *Maeandropolydora sulcans* are mostly observed on the outer valve surface of *Neopychnodonte cochlear* and *N. navicularis*; *Gastrochaenolites torpedo* and *Pinaceocladichnus* occur on the outer valve surface of *Neopychnodonte navicularis*. As a whole, these observed fossil traces would indicate a shallow marine setting with well-oxygenated waters.

9. Conclusion

Bivalves form the main constituent of the fossil assemblages of the Pliocene formations of the Algiers Sahel. In this present study, 27 pteriomorph bivalve taxa, among which 13 are exclusively fossil species without modern representatives, six bioerosive ichnogenera and four encrusting ichnogenera, are identified. Some of these bivalve species (*Aequipecten angelonii*, *A. radians*, *A. bollenensis*, *Pecten bipartitus*, *Plicatula mytilina*, *Korobkovia oblonga*, *Ostrea fimbriata*, *O. stentina*, *O. cucullata*, and *O. navicularis*) are described for the first time, supplementing the early (preliminary) inventory list of Pliocene bivalves of Algeria. The biodiversity of bivalve fauna in platform environments is expressed through two units: the first shallow infralittoral unit, is characterised by large *Flabellipecten alessii*, *Aequipecten angelonii*, *Ostrea lamellosa* and *O. edulis*; whereas the second deeper unit, of cirralittoral environment, comprises *Amusium crista-*

tum, *Pseudamussium clavatum*, *Mimachlamys varia*, and *Manupecten pesfelis*. The *Amusium cristatum* shell beds represent biological concentrations.

Taphonomical data evidence short transport with faint valve wear and slight abrasion of ornamentation. Analysis of boring and encrusting traces, mostly observed on large-size bivalves, would indicate a progressive environmental change from a high energy setting to deeper water conditions with lower energy, and correspond to a rather shallow sea with well-oxygenated waters.

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