Polyplacophora from the Pliocene of Vale de Freixo: Central-West Portugal

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KEY WORDS: Mollusca, Polyplacophora, Neogene, Pliocene, Portugal, new species.

ABSTRACT This paper reports the presence of five species of Molluscs belonging to the Class Polyplacophora which have been identified in the Pliocene (uppermost Zanclean to lower Piacenzian) of the Carnide Sandstone Formation outcropping in Vale de Freixo, Pombal region, central-west Portugal. This is the first documentation (description and illustration) of fossil chitons from the Neogene of Portugal. The only earlier reference is the record of *Chaetopleura fulva* (Wood, 1815), now known as *C. angulata* (Spengler, 1797), in a list of malacofauna from the Pliocene of Marinha Grande, central-west Portugal. Five species of chitons have been identified. Four of the species are known: *Lepidopleurus (Leptochiton) cancellatus* (Sowerby, 1840), *Callochiton septemvalvis* (Montagu, 1803), *Lepidochitona (L.) cinerea* (Linnaeus, 1767) and *Chiton (Rhyssoplax) corallinus* (Risso, 1826). One species (*Ischnochiton zbyi* sp. nov.) is described as new. All these species (excluding *Ischnochiton zbyi* sp. nov.) range continuously from the Miocene to the present in the Mediterranean. All the extant species occur in the Mediterranean Sea, being *Chiton corallinus* endemic to the Mediterranean. Only three of the species still live off the Atlantic coast of Europe (*Lepidopleurus cancellatus*, *Callochiton septemvalvis* and *Lepidochitona cinerea*).

RIASSUNTO Cinque specie di molluschi poliplacofori sono stati raccolti nel Pliocene (Zancleano superiore/Piacenziano inferiore) della "Vale de Freixo", regione di Pombal, Portogallo centro-occidentale. Il giacimento fossilifero fa parte della Formazione Carnide Sandstone, del bacino terziario di Mondego. Il presente ritrovamento rappresenta la prima documentazione di poliplacofori fossili nel Neogene del Portogallo. In precedenza era stata segnalata *Chaetopleura fulva* (Wood, 1815), ora conosciuta come *C. angulata* (Spengler, 1797), in un elenco di molluschi del Pliocene di Marinha Grande, ma non è stato possibile reperire tale materiale presso il Museo di Mineralogia e Geologia dell'Università di Coimbra, presso il quale doveva essere depositato. Sono state rinvenute 5 specie, tra cui una nuova: *Lepidopleurus (Leptochiton) cancellatus* (Sowerby, 1840), *Callochiton septemvalvis* (Montagu, 1803), *Lepidochitona (L.) cinerea* (Linnaeus, 1767), *Chiton (Rhyssoplax) corallinus* (Risso, 1826) e *Ischnochiton zbyi* sp.nov. La nuova specie è confrontata con altre due specie che presentano alcune caratteristiche simili, *I. exaratus* (G.O.Sars, 1878) e *I. dolii* Van Belle & Dell'Angelo, 1998. Delle 4 specie già conosciute, tutte attualmente viventi in Mediterraneo, 3 sono viventi anche lungo le coste atlantiche europee (*Lepidopleurus cancellatus*, *Callochiton septemvalvis* e *Lepidochitona cinerea*), mentre *Chiton corallinus* è una specie endemica del bacino mediterraneo. Tutte le specie ritrovate, ad eccezione di *Ischnochiton zbyi*, presentano una distribuzione temporale continua, nell'area Mediterranea, dal Miocene all'attuale, con la sola necessità di confermare le segnalazioni pleistoceniche di *Lepidopleurus cancellatus*.

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INTRODUCTION

The occurrence of fossils of Pliocene marine molluscs from central-west Portugal (Caldas da Rainha, Marinha Grande and Pombal regions) has been documented for more than one hundred years (*vide* CHOFFAT, 1889). Nonetheless, none of the classic localities has produced a malacofauna as diverse or well preserved as that at Vale de Freixo, Pombal region (Fig. 1).

The existence of marine fossiliferous sediments in the Pombal region was first recognised by TAIXEIRA & ZBYSZEWSKI (1951).

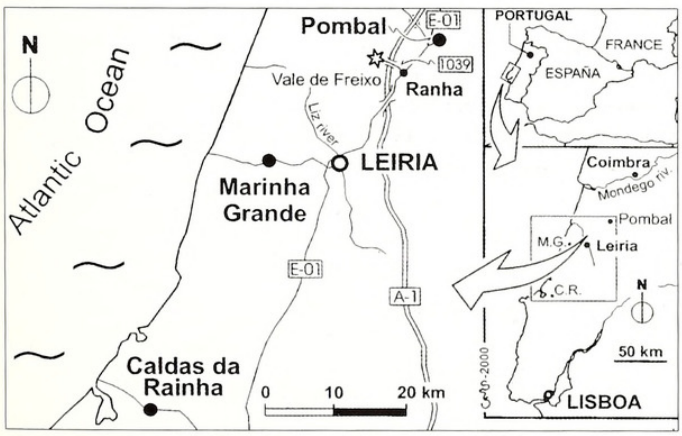


Fig. 1 - Study area. Location of Vale de Freixo outcrop. Central-west Portugal.

The Pliocene mollusc fossils from these outcrops, as well as those from the remaining Pliocene outcrops of central-west Portugal, were examined by ZBYSZEWSKI (1959). After Zbyszewski's papers, until the late 1980's, the study of Portuguese Pliocene malacofaunas ceased, with only two brief contributions in the 1970's from BRÉBION (1971, 1974).
In the last decade, after the discovery of the Vale de Freixo site in the early 1980's, the study of Pliocene malacofaunas from Portugal has received new vigour (SILVA, 1990, 1992, 1996, 2001; GILI *et al.*, 1995; SILVA, LANDAU & MARTINELL, 2000). This renewed interest is herein continued with a description of the Polyplacophora from these deposits.

GEOLOGICAL AND STRATIGRAPHICAL SETTING

The Meso-Cenozoic sedimentary record of the Portuguese central-west Atlantic margin constitutes the Lusitanian Basin. In Lutetian times (Middle Eocene) distensive faulting, related to the Pyrenean orogen, defines two Tertiary sub-basins: the northern Mondego Basin and the southern Lower Tagus Basin (CUNHA, 1992; CUNHA *et al.*, 1993). The Pliocene (Piacenzian) sedimentary record of the Pombal region (as well as that of Caldas da Rainha and Marinha Grande) is part of the Mondego Basin.
In the Mondego Basin, the Pliocene is composed of shallow marine sediments (micaceous fine yellowish siliciclastic sand-

stones), nearshore sediments (mudstones and lignites with diatomites) and continental sediments (conglomerates and coarse sandstones) (CUNHA, 1992; CUNHA *et al.*, 1993). The Pliocene sequence shows a regressive evolution that, according to CACHÃO (1989) and CUNHA *et al.* (1993), may be correlated to the 3rd order global sea level cycle N°3.7 of HAQ *et al.* (1987).

The outcrop of Vale de Freixo corresponds to the lowermost section of the Pliocene sequence of the Mondego Basin. The Pliocene stratigraphic sequence in the Pombal region is composed of two members (CACHÃO, 1989): the Carnide Sandstone Formation (Formação Arenito de Carnide) below, and, above, the Paredes/Roussa Sandstone Formation (Formação Arenitos de Paredes/Roussa). The Paredes/Roussa Sandstone Fm has not yielded, so far, any marine macro or micro somatofossils (i.e. body fossils). The Carnide Sandstone Fm consists generally of fine yellowish silty micaceous sand without evident macro or micro somatofossils. Locally, the lowermost section of the Carnide Sandstone Fm contains a short fossiliferous sequence consisting of a basal conglomerate and a fine grey sand relatively rich in marine molluscan fossil shells.

At Vale de Freixo the basal fossiliferous beds of the Carnide Sandstone Fm have a maximum thickness of approximately 1 m (Fig. 2). Albeit their short vertical and horizontal expression, these beds are remarkable for their relatively abundant and well-preserved macrofossils, consisting largely of the remains of bivalves and gastropods (for more details see GILI et al., 1995), but yielding also fossils of fish otholits (NOLF & SILVA, 1997), rare shark teeth and corals, small irregular echinoids, vegetal detritus (e.g. *Pinus* macro-remains, small cones and pine-needles) and, of course, chiton plates. The material studied here was collected from bed 3.

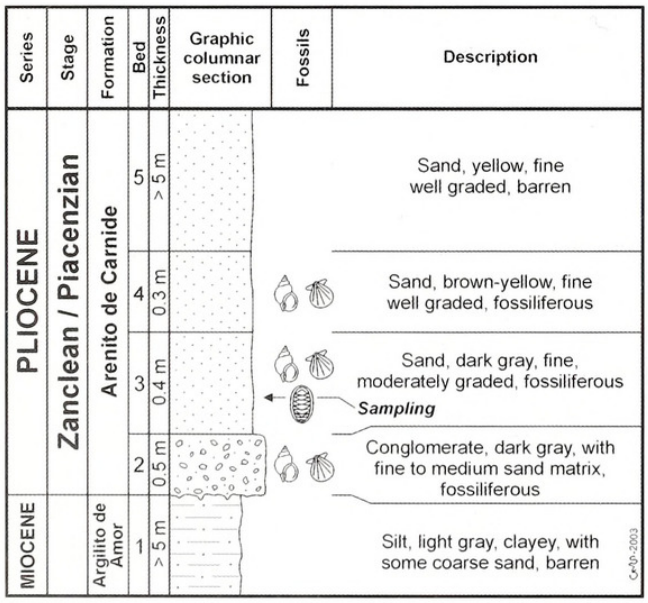


Fig. 2: Stratigraphy of the Vale de Freixo section

According to CACHÃO(1990), updated after BERGGREN *et al.*, (1995), the calcareous nannofossil assemblage in bed 3 of Vale de Freixo indicates placement in the *Discoaster tamalis*, CN12a, biozone of OKADA & BUKRY's (1980), after the LAD (Last Appearance Datum) of *Sphenolithus* spp. – Pliocene, uppermost Zanclean to Piacenzian.

Recent dating of pectinid shells from that same bed, based on $^{87}Sr/^{86}Sr$ isotope analysis, point to a Zanclean to early Piacenzian age (SILVA, 2001). The overlapping distribution of calcareous nannofossil biozone CN12a and the $^{87}Sr/^{86}Sr$ isotope analysis data suggest an uppermost Zanclean to lower Piacenzian stratigraphic positioning for the fossiliferous beds of Vale de Freixo (SILVA, 2001). Therefore, the assemblage of molluscs from that site, with several elements of tropical affinity, corresponds to the MPMU1 (Mediterranean Pliocene Molluscan Unit 1) of RAFFI & MONEGATTI (1993), i.e. precedes the c. 3,3-3,1 Ma ecobiostratigraphic extinction event (immigration and local extinction) of benthic mollusc taxa of tropical affinity (as defined by RAFFI *et al.*, 1989 and MONEGATTI & RAFFI, 2001).

PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY OF THE VALE DE FREIXO MALACOFAUNA

The fossil assemblage indicates that in Vale de Freixo, during late Zanclean to early Piacenzian times, there was a shallow marine infralittoral environment with a fine sandy substrate and normal marine salinity (calcareous nannofossils: CACHÃO, 1989; molluscs: SILVA, 1993, 2001, GILI *et al.*, 1995; fish otholites: NOLF & SILVA, 1997). The presence at Vale de Freixo of thermophilic benthic gastropods (e.g. genera *Ficus, Amalda, Persicula, Xenophora* and *Strioterebrum*), suggests that warm water temperatures (warmer than today) prevailed in the Iberian Atlantic frontage at this latitude during late Zanclean to early Piacenzian times (SILVA, LANDAU & MARTINELL, 2000; SILVA, 2001; LA PERNA, LANDAU & SILVA, 2003).

The malacofauna from Vale de Freixo shows an interesting combination of Mediterranean and Northern European Pliocene species (GILI *et al.*, 1995) as well as a number of representatives of thermophilic species and genera currently occurring only farther to the south, off the coast of West Africa. Species such as *Solariella cincta* (Philippi, 1836), *Tribia uniangulata* (Deshayes, 1830) and *Solatia piscatoria* (Gmelin, 1791), found at Vale de Freixo and presently absent in the European Atlantic and Mediterranean coasts, today occur off the West African coast. Similarly genera such as *Ficus, Amalda* and *Strioterebrum*, also represented in the malacofauna of Vale de Freixo, disappeared from European waters during Middle Pliocene (SILVA, LANDAU & MARTINELL, 2000).

This southward migration (or range shift) and local extinction (implying a range restriction) of Pliocene thermophile benthic gastropods from the Pliocene European Atlantic frontage and the Mediterranean reflects successive climatic cooling events occurring during Plio-Pleistocene times (*vide* RAFFI & MONEGATTI, 1993; BARNES *et al.*, 1995; STANLEY & RUDDIMAN, 1995).

POLYPLACOPHORA IN THE PORTUGUESE PLIOCENE

The first and, until this work, the only record of fossil Polyplacophora from the Portuguese Pliocene goes back to MORAIS (1941). He reported *Chaetopleura fulva* (Wood, 1815), now known as *Chaetopleura (C.) angulata* (Spengler, 1797), in a list of malacofauna from the Pliocene of Marinha Grande (Guarda Nova and Matos). The fossils were identified by Reginald Cox, Palaeontologist at the British Museum (Natural History), but unfortunately, no description or illustration of the specimen(s) were given. According to MORAIS (1941), the specimen(s) of *Chaetopleura fulva*, together with the remaining malacofauna from Guarda Nova and Matos, were presented to the Mineralogical and Geological Museum of the University of Coimbra, but it was impossible to locate such material.

Chaetopleura angulata has a very interesting modern disjunct distribution, occurring along the SW Iberian Atlantic coast and off the coast of South America from Cabo Frio (Brazil) to Cape Horn. KAAS (1954) and KAAS & VAN BELLE (1987) suggested this species was introduced in the European Continent, transported to the Iberian Peninsula by Spanish and Portuguese trade vessels.

The fossil occurrence of *Chaetopleura tehuelcha* (D'Orbigny, 1841) [=*C. angulata* (Spengler, 1797)] was also reported in South American Pleistocene and Holocene of Uruguay (FIGUEIRAS, 1961, 1962). Unfortunately, both references lack any description or illustration.

Should Kaas and Van Belle be right, it would be impossible to find *Chaetopleura fulva* in the Portuguese Pliocene. On the other hand, should the specimen identified by Reginald Cox really be a *Chaetopleura fulva* (Wood, 1815), it would provide valuable insights about the origin and the geological history and the distribution of this species. It his, therefore, rather unfortunate that this specimen(s) could not be located.

We have not been able to confirm or refute the occurrence of this species in the Portuguese Pliocene, as none of the material found at Vale de Freixo is attributable to *Chaetopleura fulva*, and it was impossible to examine the specimen identified by Cox.

Five species of Pliocene Polyplacophora (one new to Science) have been identified from Vale de Freixo:

Lepidopleurus (Leptochiton) cancellatus (Sowerby, 1840)
Ischnochiton zbyi sp. nov.
Callochiton septemvalvis (Montagu, 1803)
Lepidochitona (Lepidochitona) cinerea (Linnaeus, 1767)
Chiton (Rhyssoplax) corallinus (Risso, 1826)

SYSTEMATIC PALAEONTOLOGY

Class POLYPLACOPHORA Gray, 1821
Order NEOLORICATA Bergenhayn, 1955
Suborder LEPIDOPLEURINA Thiele, 1910
Superfamily LEPIDOPLEUROIDEA Pilsbry, 1892
Family LEPIDOPLEURIDAE Pilsbry, 1892
Genus *Lepidopleurus* Risso, 1826
Subgenus *Leptochiton* Gray, 1847

Lepidopleurus (Leptochiton) cancellatus (Sowerby, 1840)
(figs 3 - 4)

Chiton cancellatus Sowerby II, 1840: figs. 104, 104a-b, 105.
Chiton tuberculatus Leach, 1852: 230 (*non* Linnaeus, 1758).
Lepidopleurus sulci Baluk, 1971: 455, pl.2, figs 1-4.

Lepidopleurus cancellatus – MALUQUER, 1915: 231, tav.14, fig.3. – LAGHI, 1977: 98, tav.1, figg.1-3. – GAGLINI, 1985: II, tav.2, fig.4.
Lepidopleurus (L.) cancellatus – MALATESTA, 1962: 147, figg.3-4.
Lepidopleurus (Leptochiton) cancellatus – DELL'ANGELO & PALAZZI, 1989: 58, tav.6-7. – DELL'ANGELO & SMRIGLIO, 1999: 48, tav.10-11, figg.18-19. – DELL'ANGELO *et al.*, 2001: 146, fig.5.
Leptochiton (L.) cancellatus – KAAS & VAN BELLE , 1985a: 43, fig. 16. – DELL'ANGELO & PALAZZI, 1986: 10, figg. 6-8,41,51,65, 67,69.
Lepidopleurus sulci – BALUK, 1984: 285-286, pl. 2, figs 1-3; pl. 3, figs 1-2; pl. 4, fig. 4.

Material

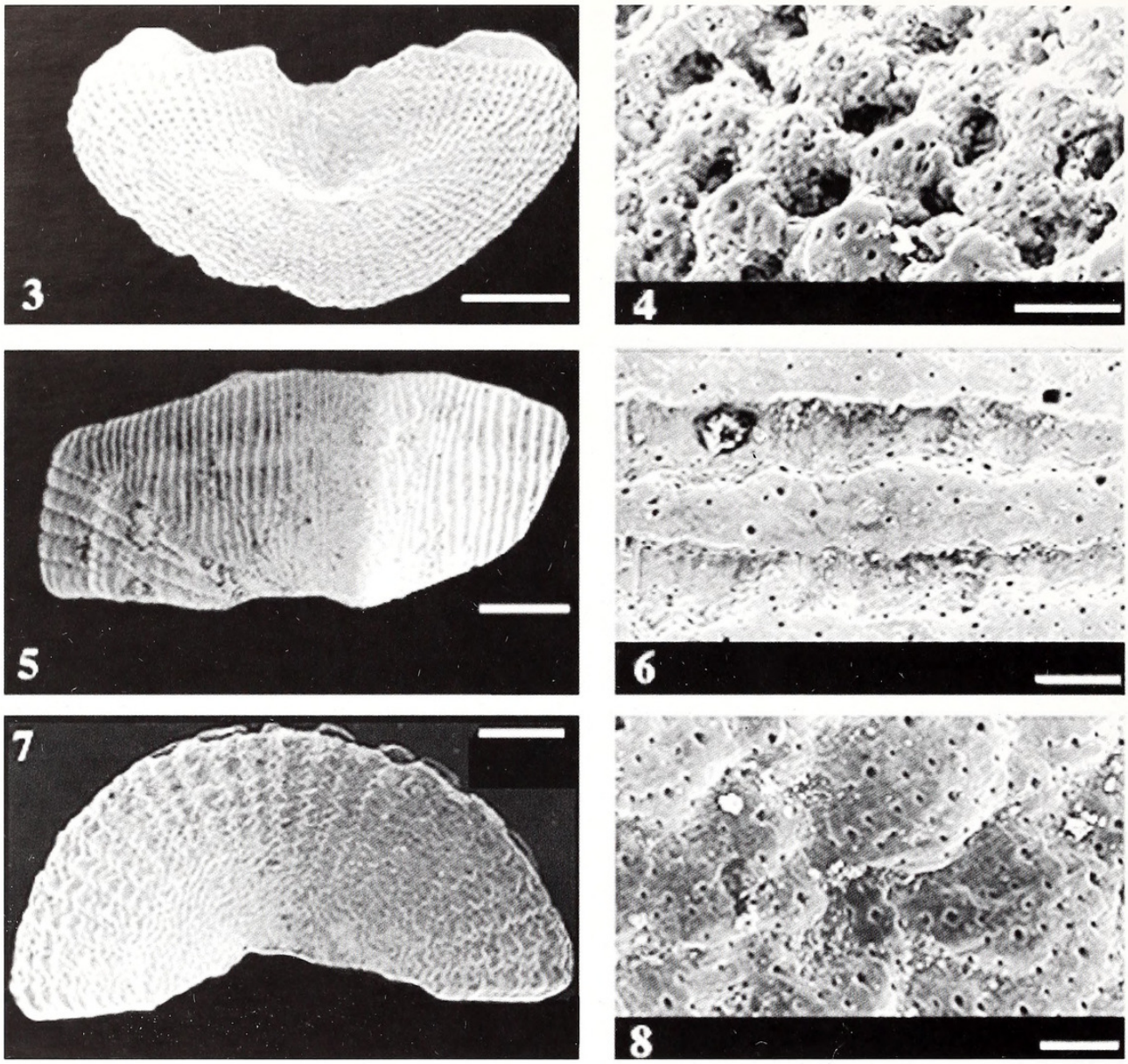
2 valves, 1 intermediate (width 2,5 mm) and 1 posterior (width 2,2 mm).

Remarks

Lepidopleurus cancellatus is closely related to other recent Atlantic and Pacific species: *L. sarsi* (Kaas, 1981) and *L. rugatus* (Carpenter in Pilsbry, 1892). The species is characterised by an evenly sculptured tegmentum with very small roundish granules arranged in radiating rows on the head valve, the lateral areas of intermediate valves and the postmucronal area of tail valve, in longitudinal series with very narrow interstices on the central and antemucronal areas. LAGHI (1977) and DELL'ANGELO & PALAZZI (1989) consider *Lepidopleurus sulci* Baluk, 1971, a species from the Miocene (Badenian) of the Korytnica Clays (Central Poland), a junior synonym of *L. cancellatus*. The species has a very variable ornamentation and consequently many fossil reports of the species from European localities are to be confirmed, as discussed in DELL'ANGELO & PALAZZI (1989).

Distribution

Today, *Lepidopleurus (L.) cancellatus* occurs in the Atlantic Ocean, along the coasts of British Islands, France, Spain and Portugal, and in the Mediterranean Sea. It was reported from the Miocene (Badenian) of Poland (under the name of *Lepidopleurus sulci*) and from various Italian Pliocene localities, e.g. Campore (Parma prov.), Pietrafitta, Poggibonsi and Serre di Rapolano (Siena prov.) and Orciano Pisano (Pisa prov.). ANTEVS (1917) and BROGGER (1900/01) report the species from the Pleistocene of Sweden and Norway, but their reports need confirmation (no chiton valves are present in the Brogger collection at the Palaeontological Museum of the Oslo University).



Figs 3-4: *Lepidopleurus cancellatus*, tail valve: 3: scale bar = 500 µm; 4: microsculpture, scale bar = 50 µm.
Figs 5-6: *Ischnochiton zbyi*, holotype, intermediate valve: 5: scale bar = 1 mm; 6: longitudinal striae, scale bar = 100 µm.
Figs 7-8: *Ischnochiton zbyi*, paratype, head valve: 7: scale bar = 500 µm; 8: microsculpture, scale bar = 50 µm.

Suborder ISCHNOCHITONINA Bergenhayn, 1930
Family ISCHNOCHITONIDAE Dall, 1889
Subfamily ISCHNOCHITONINAE Dall, 1889
Genus *Ischnochiton* Gray, 1847

Ischnochiton zbyi sp. nov.
(figs 5 - 11)

Description

Head valve semicircular; front slope straight to slightly concave, posterior margin widely V-shaped, notched in the middle; tegmentum with microgranulose sculpture with subgranulose radiating ribs, becoming obsolete towards the apex in some valves, 19-24 ribs near the apex, splitting up to 30-53 near the periphery of the valve, very narrow with interstices. Ribs concentrically crossed by numerous growth lines.

Intermediate valves broadly rectangular; dorsal elevation 0,26-0,36, carinated, with side slopes straight, not beaked; front and hind margins straight, side margins slightly convex, lateral areas moderately elevated, sculptured like head valve, with six radiating ribs, in some valves becoming obsolete towards the mucro; central area with 22-26 longitudinal sulci on both sides of the smooth jugum, interstices slightly narrower than sulci.

Tail valve depressed, wider than longer; front margin straight to slightly angular, hind margin almost semicircular, mucro subcentral, slightly raised; hind slope slightly concave directly behind the mucro; antemucronal area sculptured like central area of intermediate valves, with a smaller number of longitudinal sulci; postmucronal area with 24-26 radiating ribs, crossed by rather deep concentric grooves; in some valves this sculpture becomes indis-

tinct near the mucro.
Articulamentum whitish, apophyses wide (not complete in the examined material); jugal sinus narrow, straight in intermediate valves, convex in the posterior valve; slit formula 10-11/1/7-11, slits inequidistant.

Type material
30 valves, 11 anterior (maximum width 5,8 mm), 14 intermediate (maximum width 5,6 mm) and 5 posterior (maximum width 4,3 mm).
Holotype: National Natural History Museum of the Lisbon University (1 intermediate valve, n. MNHN/UL.II.406). Paratypes: National Natural History Museum of the Lisbon University (2 valves, n. MNHN/UL.II.407 and 408), Zoological Museum of the Bologna University (3 valves, n. 12692), B. Dell'Angelo collection (3 valves, n. FW49), C.M. da Silva collection (21 valves, n. VFX.03.312 to 332).

Etymology
The species is named after Georges Zbyszewski, Portuguese "classical" geologist, palaeontologist and archaeologist of Russian origin, born in Gatchina, near St. Petersburg (22/10/1909), and deceased in Lisbon (01/03/1999), affectionately known among is disciples simply as Prof. Zby, hence the name *I. zbyi*. It was G. Zbyszewski who in the late 1940's discovered the Pliocene fossiliferous outcrops in the Pombal region, where Vale de Freixo is located.

Type locality
Vale de Freixo (Pombal region, Leiria district, central-west Portugal), Carnide Sandstone Formation. So far, the species is only known from the type locality.

Type stage
Pliocene, uppermost Zanclean to lower Piacenzian. *Discoaster tamalis* CN12a biozone of Okada & Bukry (1980) and Mediterranean Pliocene Molluscan Unit 1 of Raffi & Monegatti (1993).

Remarks
The subgeneric assignment of taxa belonging to *Ischnochiton* is partly based on characteristics of the perinotum, a feature no longer observable in the fossil material from Vale de Freixo. Consequently, a subgeneric assignment for *Ischnochiton zbyi* is impossible.
The studied specimens cannot be assigned to any of the hitherto recognised fossil or recent European *Ischnochiton* species, and thus the authors regard them as representing a new taxa at the species level.
The main characters differentiating *Ischnochiton zbyi* sp. nov. from the two more similar ones, *Ischnochiton exaratus* (G.O.Sars, 1878) and *I. dolii* Van Belle & Dell'Angelo, 1998 are reported in Table 1.
The studied material is not well preserved, many plates are incomplete and some important characters are missing. For example, no intermediate or tail valves have complete apophyses. An important characteristic of the species is the microgranulose tegmentum, with many small tubercles that are clearly visible between the radial ribs in terminal areas and on parts of the tegmentum in the well preserved valves.
Ischnochiton zbyi sp. nov. specimens are the most common among all known chiton material from the Pliocene of Portugal.

Characteristics	*Ischnochiton zbyi* sp. nov.	*Ischnochiton exaratus*	*Ischnochiton dolii*
Tegmentum	Microgranulose	?	?
Head valve	Notched in the middle	Notched in the middle	Notched in the middle
Head valve, sculpture	Subgranulose radiating ribs, 19-24 near the apex, splitting up near the periphery of the valve	Fine radiating and concentrical grooves, giving it a granulose appearance	Flattish, subgranulose radiating ribs, 17-26 near the apex, splitting up near the periphery of the valve
Intermediate valve	Not beaked Dorsal elevation 0,26-0,36 Carinated	Not beaked Dorsal elev. 0,28-0,62 More or less carinated	Not beaked Dorsal elev. 0,34-0,50 Carinated
Intermediate valve Central area	22-26 longitudinal sulci per side	14 irregular, longitudinal grooves per side, the grooves towards the jugum not reaching the posterior margin of the valve	13-19 longitudinal sulci per side, the 3-4 innermost sulci forwardly converging towards the jugum
Intermediate valve Lateral areas	6 radiating ribs	3-6 radiating grooves crossed by narrower concentric grooves, cutting the ribs into squarish to more or less transversely elongate granules	4-5 radiating ribs, in some valves becoming obsolete towards the side margin
Posterior valve, mucro	Subcentral, little raised	Subcentral, not swollen, somewhat acute	Slightly antemedian, little raised
Posterior valve Postmucronal area	24-26 radiating ribs, crossed by rather deep concentric grooves	Like head valve	18-20 radiating, flattish ribs, crossed by rather deep concentric grooves
Articulamentum	Apophyses wide	Apophyses evenly arched, not much projecting	Apophyses wide, short, evenly rounded
Slit formula	10-11/1/7-11	10-13/1-2/10-12	9-10/1/7-8

Table 1. Main characters differentiating *Ischnochiton zbyi* sp. nov. from *I. exaratus* (G.O.Sars, 1878) and *I. dolii* Van Belle & Dell'Angelo, 1998.

Subfamily CALLOCHITONINAE Plate, 1901
Genus *Callochiton* Gray, 1847

***Callochiton septemvalvis* (Montagu, 1803)**

Chiton septemvalvis Montagu, 1803: 3.
Chiton discors Maton & Rackett, 1807: 20.
Chiton achatinus Brown, 1823: 402.
Chiton euplaeae O.G.Costa, 1829: i,iv, tav. 1, fig. 3.
Lepidopleurus punctulatus Leach, 1852: 228, pl.10, fig.7.
Chiton cranchianus Leach, 1852: 230.
Chiton doriae Capellini, 1859: 325, tav. 12, fig. 2.

Chiton rariplicatus Reuss, 1860: 258, pl. 8, figg. 9-11.
Chiton laevis var. *minor* Monterosato, 1872: 29.
Onithochiton rhygophilum de Rochebrune, 1884: 32 (*fide* Thiele, 1909).
Callochiton laevis var. *unicolor, bicolor* Dautzenberg & Durouchoux, 1906: 14.
Callochiton achatinus euboecus Kattoulas, Koukouras & Economidis, 1973: 22, figg. 6-7.

Callochiton laevis – Laghi, 1977: 108, tav. 2, figg. 14-18. – Baluk, 1984: 290.
Callochiton doriae – Maluquer, 1915: 241, pl. 14, fig. 14; pl. 15, fig. 22.
Callochiton achatinus – Bellomo & Sabelli, 1995: 201.
Callochiton (C.) achatinus – Malatesta, 1962: 158, fig. 15.
Callochiton septemvalvis – Kaas & Van Belle, 1985b: 11, fig. 2. – Dell'Angelo & Forli, 1995: 226, figg. 10,17. – Dell'Angelo & Smriglio, 1999: 125, figg. 55-63, pls. 40-41. – Dell'Angelo *et al.* 2001: 147, fig. 10.
Callochiton septemvalvis septemvalvis – Kaas, 1978: 73.
Callochiton septemvalvis euplaeae – Kaas 1978: 73.
Callochiton euplaeae – Gaglini, 1985: XI, tav. 4, fig. 4; tav. 8, figg. 5-6; tav. 9, figg. 1-2.
Callochiton rariplicatus – Baluk, 1971: 461, pl.5, figg. 1-5.

Material
2 intermediate valves, 1 complete (width 2 mm) and another partly broken (width 2,3 mm).

Remarks
In the examined material, the complete intermediate valve has no trace of scars, the other has five scars on the unique pleural area preserved.
This species of *Callochiton* has been long known under the names of *C. laevis* (Montagu, 1803, *non* Pennant, 1777), *C. achatinus* (Brown, 1823), or even *C. doriae* (Capellini, 1859). Kaas (1978) proposed the name *Callochiton septemvalvis* (Montagu, 1803) for this taxon, and the separation of the typical Atlantic form, *C. septemvalvis septemvalvis*, from the Mediterranean one, *C. septemvalvis euplaeae* (O.G.Costa, 1829), at subspecific level. The latter characterised by a smaller size and by the presence of 3-5 longitudinal scars on the pleural areas. Dell'Angelo & Palazzi (1994) suggested the adoption of the name *Callochiton septemvalvis* to designate this species in its complex, also considering that *Chiton euplaeae* was clearly described by O.G. Costa (1829) as having a smooth surface, without any trace of scars. The discussion of the relationship between the two taxa is given in Dell'Angelo & Palazzi (1994) and Dell'Angelo & Smriglio (1999).
Laghi (1977) considered the Miocene (Badenian) specimens from Korytnica (Poland), identified by Baluk (1971) as *Callochiton rariplicatus* (Reuss, 1860), as well as those from the Miocene of the Vienna Basin illustrated by Reuss (1860) and Sulc (1934), conspecific with *Callochiton septemvalvis*, a synonymy accepted by Baluk (1984). The authors agree with Laghi (1977).

Distribution
Presently, *Callochiton septemvalvis* is widely distributed in the north-eastern Atlantic Ocean, ranging from Norway in the north down into the Canary islands and the Mediterranean Sea. *Callochiton septemvalvis* was reported from the Miocene of central-eastern Europe (under the name of *Chiton rariplicatus* Reuss, 1860) and in the Italian locality of Montegibbio (Modena prov.). *Callochiton septemvalvis* is more common in the Italian Plio-Pleistocene.

Subfamily LEPIDOCHITONINAE Iredale, 1914
Genus *Lepidochitona* Gray, 1821
Subgenus *Lepidochitona s.str.*

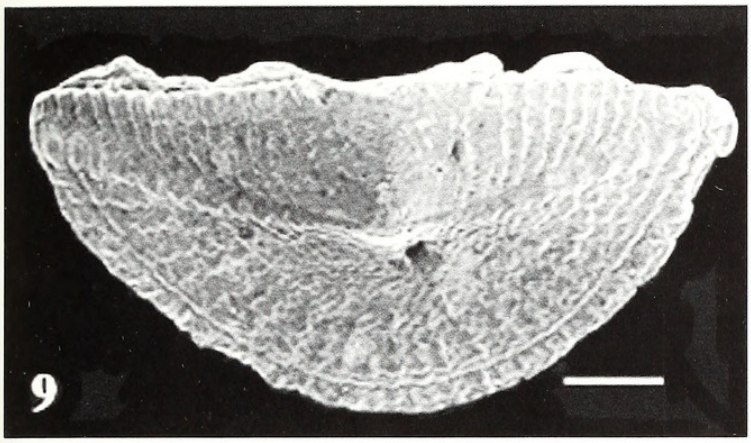
***Lepidochitona (L.) cinerea* (Linnaeus, 1767)**
(figs. 13-14)

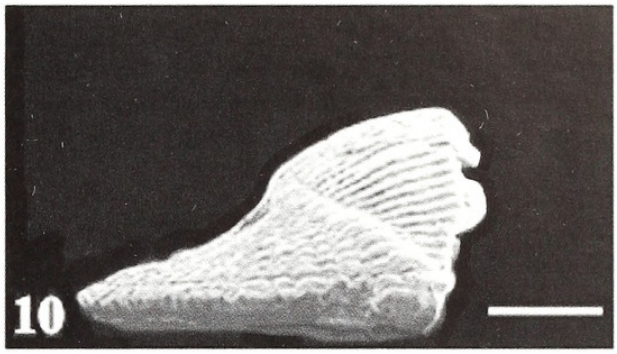
Chiton cinereus Linneo, 1767: 1107.
Chiton marginatus Pennant, 1777: 71, tav. 36, fig. 2.
?Chiton cimex Gmelin, 1791: 3206.
Chiton cimicinus Spengler, 1797: 79, tav. 6, fig. 11 (*partim*).
Chiton quinquivalvis Brown, 1823: 402 (emend. *quinquevalvis*).
?Chiton fuscatus Brown, 1827: tav.35, fig. 17.
Chiton variegatus Philippi, 1836: 107 (*non* Bolten in Röding, 1798, *nec* de Blainville, 1825).
Lepidopleurus carinatus Leach, 1852: 228.
Chiton variegatus Leach, 1852: 232 (*non* Bolten in Röding, 1798, *nec* de Blainville, 1825, *nec* Philippi, 1836).
Ischnochiton marginatus (Pennant, 1777) var. *adumbrata, albocarinata, miniata, nigrescens, rubrocarinata, straminea* Dautzenberg & Durouchoux, 1906: 14.

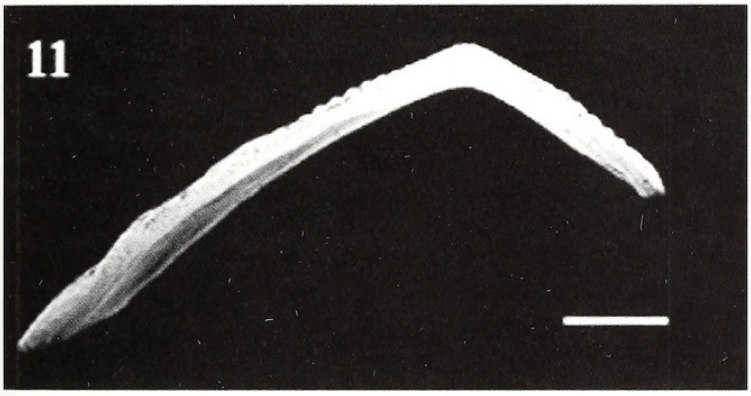
Chiton cinereus – Dodge, 1952: 23.
Non Chiton cinereus – Fabricius, 1780: 423 (= *Tonicella rubra*). – Poli, 1791: 4, tav. 3, figg. 1-20 (= *Lepidochitona caprearum*). – Montagu, 1803: 3 (= *Lepidopleurus asellus*).
Lepidochitona cinerea – Laghi, 1977: 105, tav. 3, figg. 1-4. – Gaglini, 1985: vii, tav. 3, fig. 1; tav. 7, figg. 1-2. – Forli, Dell'Angelo & Taviani, 1999: 111, tav. 1, fig. 7. – Dell'Angelo *et al.*, 2001: 148, figg. 12, 15.
Lepidochitona (L.) cinereus – Malatesta, 1962: 155, figg. 11-12.
Lepidochitona (L.) cinerea – Kaas & Van Belle, 1981: 9, figg. 2-17,128/1. – Kaas & Van Belle, 1985b: 84, fig. 39. – Dell'Angelo & Forli, 1995: 227, fig. 14. – Dell'Angelo, Palazzi & Pavia, 1999: 264, tav. 2, figg. 1-3. – Dell'Angelo & Smriglio, 1999: 138, tav. 44-45, figg. 67-72.
Ischnochiton marginatus – Maluquer, 1915: 244, tav. 15, figg. 18-21.

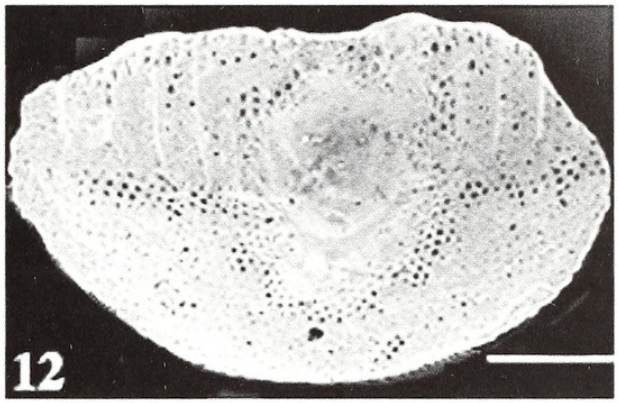
Material
1 anterior valve, complete, width 2 mm.

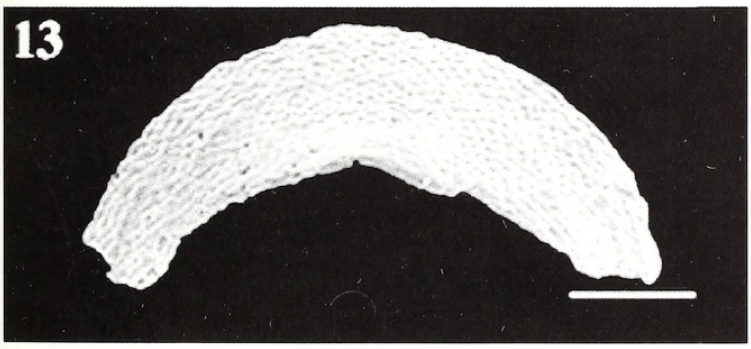
Remarks
The only anterior valve present in our material is rather well preserved, clearly showing the sculptured tegmentum, with fine granules arranged in a quincunx pattern, characteristic to this species.











Figs 9-10: *Ischnochiton zbyi*, paratype, tail valve: 9: scale bar = 500 µm; 10: lateral view, scale bar = 500 µm.
Fig. 11: *Ischnochiton zbyi*, holotype, intermediate valve, scale bar = 1 mm.
Fig. 12: *Chiton corallinus*, tail valve, scale bar = 500 mm.
Figs 13-14: *Lepidochitona cinerea*, head valve: 13: scale bar = 500 µm; 14: microsculpture, scale bar = 10 µm.

This species had a complicated taxonomical history. Early authors mistook *Lepidopleurus (Leptochiton) asellus* (Gmelin, 1791) for *Chiton cinereus* Linnaeus, 1767, adopting the younger name *Ch. marginatus* Pennant, 1777. HANLEY (1855) settled the true status of *Chiton cinereus* Linnaeus, 1767, concluding that it was the same taxon named *Ch. marginatus* by Pennant and subsequent authors.

A similar species, *L. subgranosa* Baluk, 1971 was recorded from the Miocene (Badenian) of Poland, and considered by LAGHI (1977) a junior synonym of *L. cinerea*. This synonymy was not accepted by BALUK (1984), that considers the ornamentation of *L.subgranosa* more similar to that of *L. canariensis* (Thiele, 1909) than to the one in *L.cinerea.*

Distribution

Today, *Lepidochitona (L.) cinerea* is widely distributed in the European Atlantic coasts, ranging from Norway in the north down until the Iberian Peninsula, and into the Mediterranean and the Black Sea; it also occurs in the north-western Atlantic coast of Morocco. This species has been reported from Italian localities ranging from Miocene to Pleistocene and possibly from the Miocene of Eastern Europe (Poland), as well from the Pleistocene of Norway (always uncommon).

Family CHITONIDAE Rafinesque, 1815
Subfamily CHITONINAE Rafinesque, 1815
Genus *Chiton* Linnaeus, 1758
Subgenus *Rhyssoplax* Thiele, 1893

***Chiton (Rhyssoplax) corallinus* (Risso, 1826)**
(fig. 12)

Lepidopleurus corallinus Risso, 1826: 268.
Chiton rubicundus O.G.Costa, 1829: i,iii, tav.1, fig. 2.
Chiton freelandi Forbes, 1844: 188.
Chiton pulchellus Philippi, 1844: 83, tav. 19, fig. 14 (*non* Gray, 1828).
Chiton denudatus Reuss, 1860: 259, tav. 8, figg. 14-15.
Chiton philippii Issel, 1870: 5 (*nom.nov.pro Chiton pulchellus* Philippi, 1844).
Chiton corallinus var. *flava, albida* Monterosato, 1878: 77.
Chiton rubellus Carpenter MS, Pilsbry, 1893 (*non* Nardo, 1847): 182 (*nomen nudum*).

Chiton corallinus – Maluquer, 1915: 259, tav. 16, figg. 30-31. – Laghi, 1977: 109, tav. 2, figg. 9-12. – Baluk, 1984: 290. – Gaglini, 1985: XIV, tav. 5, fig. 2; tav. 6, figg. 1-2. – Dell'Angelo & Giusti, 1997: 55, figg. 14,16. – Dell'Angelo *et al.*, 2001: 152, fig. 25.
Chiton (Chiton) corallinus – Malatesta, 1962: 163, figg. 20-21.
Chiton (Rhyssoplax) corallinus – Dell'Angelo & Smriglio, 1999: 174, tav. 58-59, figg. 97-107.
Chiton denudatus – Baluk, 1971: 462, pl. 5, figg. 9-11.

Material
2 posterior valves, maximum width 2,3 mm.

Remarks
The two posterior valves available are rather well preserved, allowing the identification of the species, characterised by having the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve smooth, not sulcated by radial ribs as in *Chiton olivaceus* Spengler, 1797.
Laghi (1977) considered *Chiton denudatus* Reuss, 1860, a species from the Miocene of Steinabrunn (Vienna Basin), Rudoltice (Bohemia) and Korytnica (Central Poland), a junior synonym of *Chiton corallinus*, a synonymy accepted by Baluk (1984) and subsequent authors.
The occurrence of *Chiton corallinus* in the Portuguese Pliocene is very interesting since this taxon seems currently endemic to the Mediterranean Sea. Its absence from the Recent Atlantic may be hypothetically interpreted as a range restriction, due to the onset of cooler water conditions in the region after mid-Pliocene times. This Plio-Pleistocene range restriction of *Chiton corallinus* follows the general pattern of local extinction, southward immigration (shift), and range restriction recorded for Portuguese Pliocene termophilic gastropods (Gili, Silva & Martinell, 1995; Silva, Landau & Martinell, 2000; Silva, 2001).

Distribution
Today, *Chiton corallinus* occurs only in the Mediterranean Sea. This species was reported from the Miocene of central-eastern Europe (under the name of *Chiton denudatus* Reuss, 1860) and from the Tortonian of Montegibbio (Modena prov.). This species is more common in the Italian Plio-Pleistocene.

CONCLUSIONS

This paper represents the first described and illustrated account of fossil chitons from the Neogene of Portugal.
Five species of Molluscs belonging to the Class Polyplacophora have been identified in the Pliocene (uppermost Zanclean to lower Piacenzian) of the Carnide Sandstone Formation outcropping in the Pombal region, Vale de Freixo site, central-west Portugal. One species, *Ischnochiton zbyi* sp. nov., is described as new. The remaining four taxa, *Lepidopleurus cancellatus, Callochiton septemvalvis, Lepidochitona cinerea* and *Chiton corallinus*, are common Recent eastern Atlantic and Mediterranean species.
Chiton corallinus, one of the species identified in the Portuguese Pliocene, seems presently endemic to the Mediterranean basin. This absence from the European Atlantic coasts may be hypothetically interpreted as a case of range contraction due to the onset of cooler water conditions in the region after middle Piacenzian times.
All these species (excluding *Ischnochiton zbyi* sp. nov.) range, in the Mediterranean, continuously from the Miocene to the present. Only the Pleistocene reports of *Lepidopleurus cancellatus* need to be confirmed. At least three of the studied species (*Lepidopleurus cancellatus, Callochiton septemvalvis* and *Chiton corallinus*) are also present in the Middle Miocene (Badenian) of central-eastern Europe. Unfortunately, the data on the Miocene and the Pliocene chiton faunas from Spain and France (both from the Mediterranean and the Atlantic) is insufficient to allow further discussion on their distribution in the Neogene of western Mediterranean and the Atlantic frontage.

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