

Notes on fossil chitons. 4. Polyplacophora from the Pliocene of Altavilla (NW Sicily)

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Abstract

This paper discusses the chiton fauna (Mollusca, Polyplacophora) from some deposits at Altavilla Milicia (NW Sicily) presumably older than the late Upper Pliocene. The study material consists of 550 valves from 5 samples (ORTO1-2 and KYLA1-3a) of the "Sabbie di Altavilla" Formation. This is the first comprehensive account of fossil chitons from the Pliocene of Sicily. We identified 14 species: *Leptochiton cancellatus*, *L. algesirensis*, *Leptochiton* sp., *Hanleya hanleyi*, *Ischnochiton rissoi*, *I. anserinus*, *I. martinelli*, *Stenosemus dolii*, *Callochiton septemvalvis*, *Chiton* sp., *Lepidochitona caprearum*, *Acanthochitona fascicularis*, *A. crinita* and *Craspedochiton altavillensis*. Two species (*S. dolii* and *C. altavillensis*) represent 77.3 % of the total amount of the valves. The finding of *I. anserinus* and *I. martinelli* is particularly important since these rare, scarcely known species, were reported only from few Pliocene localities in Italy and Spain. Nine species are still living in the Mediterranean, of which seven also occur off the Atlantic coasts of Europe. Two species are known only from the Mediterranean Pliocene (*Ischnochiton anserinus* and *I. martinelli*), and only *Craspedochiton altavillensis* has a Miocene to Pleistocene distribution. The still living *Leptochiton algesirensis* dates back to late Paleogene (Oligocene), but is so far not recorded from the Miocene. Eight species are new for Altavilla: *Leptochiton cancellatus*, *Hanleya hanleyi*, *Ischnochiton rissoi*, *I. martinelli*, *Callochiton septemvalvis*, *Lepidochitona caprearum*, *Acanthochitona fascicularis* and *A. crinita*. The analysis of the Altavilla samples suggests shallow water depositional palaeoenvironments, possibly from lower infralittoral to circalittoral depth, with the exception of the oldest investigated layer (sample ORTO1) for which a lower circalittoral-epibathyal environment is supposed. The occurrence of the extant bathyal species *Stenosemus dolii* in ORTO2 and KYLA1-3a suggests that this species had wider eco-bathymetric requirements during the Pliocene, as no evidence of reworking has been observed in these samples and in their respective layers.

Key words

Polyplacophora, Pliocene, Mediterraneo, Sicilia, Altavilla, paleoecologia, sistematica.

Riassunto

[Note sui chitoni fossili. 4. Polyplacophora del Pliocene di Altavilla (Sicilia nord-occidentale)]. Vengono discussi i chitoni (Mollusca, Polyplacophora) rinvenuti in alcuni depositi pliocenici di Altavilla Milicia (Sicilia nord-occidentale) la cui età è presumibilmente non più recente del tardo Piacenziano. Sono state raccolte 550 piastre isolate da 5 campioni (ORTO1-2 e KYLA1-3a) della formazione delle "Sabbie di Altavilla". Il presente lavoro rappresenta il primo studio dettagliato sui chitoni fossili del Pliocene della Sicilia. Sono state identificate 14 specie, 12 delle quali già conosciute e 2 determinate solo a livello di genere: *Leptochiton cancellatus*, *L. algesirensis*, *Leptochiton* sp., *Hanleya hanleyi*, *Ischnochiton rissoi*, *I. anserinus*, *I. martinelli*, *Stenosemus dolii*, *Callochiton septemvalvis*, *Chiton* sp., *Lepidochitona caprearum*, *Acanthochitona fascicularis*, *A. crinita* e *Craspedochiton altavillensis*. Due specie (*S. dolii* e *C. altavillensis*) rappresentano il 77,3 % del totale delle piastre. Il ritrovamento di *I. anserinus* e *I. martinelli* è particolarmente importante perché queste due rare specie sono state segnalate solo da poche località del Pliocene italiano e spagnolo. Nove specie sono ancora viventi in Mediterraneo, 7 delle quali anche lungo le coste atlantiche europee; due specie sono invece conosciute solo per il Pliocene del Mediterraneo (*I. anserinus* e *I. martinelli*), e solo *C. altavillensis* ha un range di distribuzione dal Miocene al Pleistocene. La specie ancora vivente *Leptochiton algesirensis* è nota fin dal Paleogene (Oligocene), ma mancano segnalazioni per il Miocene. Otto specie sono segnalate per la prima volta per Altavilla: *Leptochiton cancellatus*, *Hanleya hanleyi*, *Ischnochiton rissoi*, *I. martinelli*, *Callochiton septemvalvis*, *Lepidochitona caprearum*, *Acanthochitona fascicularis* e *A. crinita*. La fauna a chitoni e le associazioni a molluschi di Altavilla suggeriscono dei paleoambienti di poca profondità, probabilmente dall'infralitorale inferiore al circalitorale, ad eccezione del campione ORTO1, per il quale si suppone un ambiente circalitorale-epibatiale. La specie *Stenosemus dolii*, attualmente vivente in ambienti epibatiali, tra 150 e 560 m, in associazione con coralli bianchi, è stata ritrovata in livelli pertinenti all'infracircalitorale (campioni ORTO2 e KYLA1-3a), dove non sono state osservate evidenze di rimaneggiamento. Si ipotizza che tale specie avesse una distribuzione eco-batimetrica diversa da quella attuale. Sono state rinvenute 3 piastre intermedie (relative a *I. rissoi*, *S. dolii* e *Chiton* sp.) incrostate da briozoi.

Parole chiave

Polyplacophora, Pliocene, Mediterranean, Sicily, Altavilla, palaeoecology, systematics.

Introduction

The late Neogene-Quaternary Altavilla Milicia succession, cropping out at a few kilometres from Palermo (NW Sicily), is known since the nineteenth century (Calcara, 1841; Libassi, 1859). In fact, several papers were dedicated to its molluscan assemblages, with special regards to Bivalvia and Gastropoda (Seguenza, 1873/77; Gignoux, 1913; Cipolla, 1914; Ruggieri et al., 1959, 1967; Moroni & Paonita, 1964; Giannuzzi Savelli & Reina, 1984, 1988). A good summary of recent works can be found in Greco & Lima (1974) and Greco (1986). Very few information on Polyplacophora (Tiberi, 1877; Dell'Angelo & Palazzi, 1989) from this site has been provided, so that the finding of a large number of valves permits us to reduce this gap in comparison with the knowledge of the Pliocene molluscs from this locality.

Material and methods

Material comes from that part of the Altavilla succession known as Altavilla s.s. (Moroni & Paonita, 1964). It mainly consists of silty fine sand with few intercalated muddy layers cropping out on the right side of the Milicia river, just below the village of Altavilla Milicia, at about 20 km south-east from Palermo (NW Sicily, Fig. 1). The succession belongs to the "Sabbie di Altavilla" Formation (Ruggieri et al., 1967). The lowermost part of this Formation is formed by the Pliocene (presumably Zanclean) conglomerates and sands with *Strombus coronatus* DeFrance, 1827, cropping out at Canamasca, at about 1 km south from the village of Altavilla Milicia (Moroni & Paonita, 1964; Ruggieri et al., 1967; Sprovieri, 1971).

In particular, most of the studied material is from the ATPA1 (samples ORTO1 and ORTO2) and ATPA2 (samples KYLA1, KYLA3 and KYLA3a) sections, about 15 and 5 m thick, respectively (Fig. 2). Both sections, which are still under study, crop out in the lower, southernmost part of the whole Altavilla s.s. succession. As a whole, they mainly consist of yellowish fine silty sand, with prevalent infaunal assemblages, also in life position (mainly bivalves such as, *Venus multilamella* (Lamarck, 1818), *Pelecycora islandicoides* (Lamarck, 1818) and tellinaceans), intercalated with sandstone layers bearing prevalent epifauna [mainly the brachiopod *Terebratula ampulla* (Brocchi, 1814) and pectinids, most especially *Flabellipecten flabelliformis* (Brocchi, 1814)]. The annelid *Ditrupa* sp. mostly occurs in the lower half portion of the ATPA2 section. The gastropod *Strombus coronatus* has been found in the middle part of the same section. In their respective upper parts, both sections show a whitish-yellowish sandstone with abundant *Lucinoma borealis* (Linnaeus, 1767), allowing correlation (Fig. 1b). The basal layer of the ATPA1 section is formed by bluish sandy mud containing two alignments of rose-shaped gypsum concretions. In the lowermost portion, abundant plant remains (mainly leaves) occur. It is worth noting the occurrence, only in the sample ORTO1, of *Entalina tetragona* (Brocchi, 1814), a lower circalittoral-bathyal scaphopod.

It is difficult to attribute a precise age to the investigated ATPA sections, since a detailed stratigraphic setting of the Altavilla s.s. succession, according to the modern Pliocene biostratigraphy, as well as a layer-by-layer description, are lacking. A study is in progress by two of the authors of the present article (V.G. and A.R.) in order to fill this gap. However, it is reasonable that the deposits are not younger than the late Upper Pliocene, according to the modern two-folded subdivision (Zanclean, Piacenzian) of Pliocene, as ratified by Gibbard et al. (2010). This is based on the following assumptions: the fact that a not better defined layer, cropping out in the middle-upper part of the Altavilla s.s. succession, and overlaying the here discussed sections, was attributed by Ruggieri & D'Arpa (1992) to the late Piacenzian-very early Gelasian *Discoaster pentaradiatus* biozone, ranging from about 2.8 to 2.5 Ma (Sprovieri, 1993);

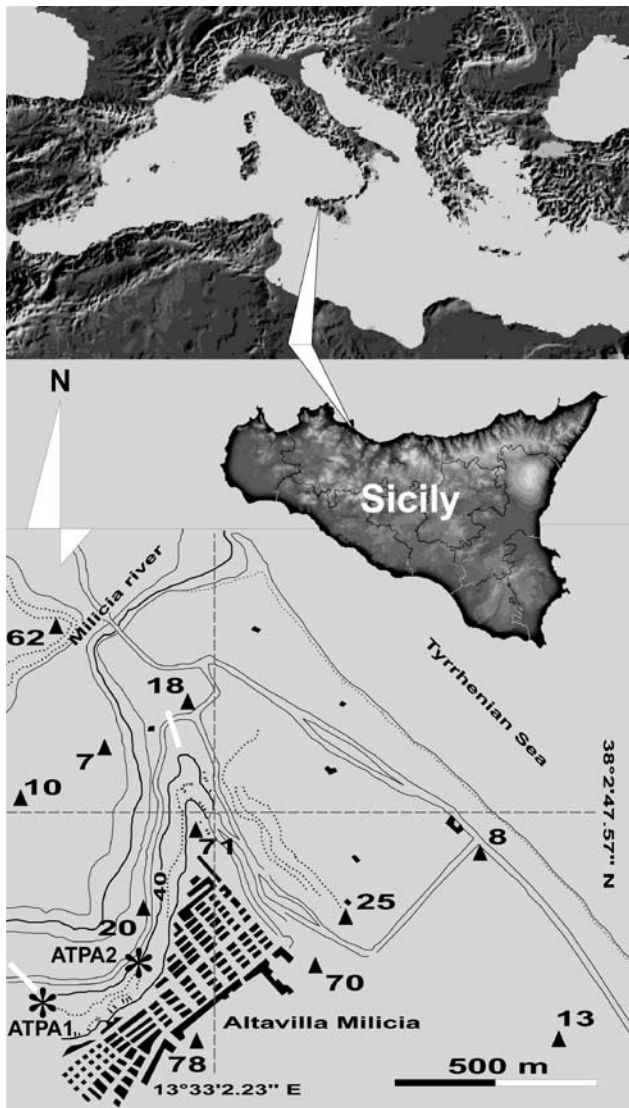


Fig. 1. Location of the Polyplacophora bearing deposits (asterisks) from the Pliocene Altavilla s.s. succession, NW Sicily. The two white segments delimitate the Altavilla s.s. outcrop. The topographic sketch and elevations a.s.l. (meters) are from IGM sheet n. 33, scale 1: 25,000.

Fig. 1. Localizzazione dei siti (asterischi) di Altavilla s.s., Sicilia nord-occidentale, in cui sono stati rinvenuti poliplacofori. I due segmenti bianchi delimitano il giacimento di Altavilla s.s. Lo schizzo topografico con le quote indicate (in metri) è ripreso dal foglio IGM n. 33, scala 1: 25.000.

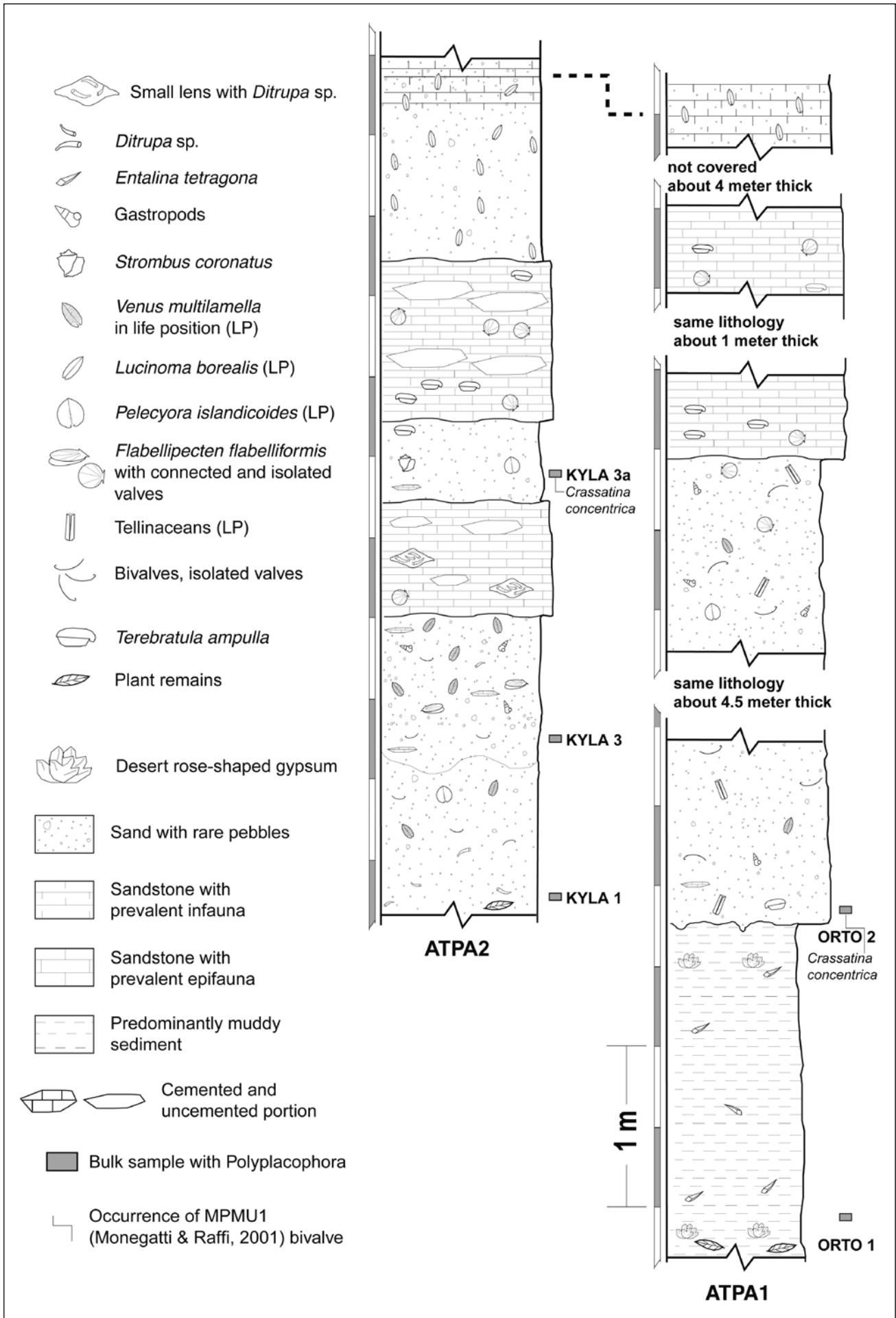


Fig. 2. Stratigraphic logs of the ATPA1-2 sections at Altavilla Milicia, Palermo, NW Sicily.

Fig. 2. Log stratigrafici delle sezioni ATPA1-2 ad Altavilla Milicia, Palermo, Sicilia nord-occidentale.

the occurrence of the Zanclean-middle Piacenzian MP-MU1 (Monegatti & Raffi, 2001) bivalve *Crassatina concentrica* (Dujardin, 1837) in the lower part of ATPA1 section (sample ORTO2) and in the middle portion of the ATPA2 section (sample KYLA3a).

A lot of valves in the Dell'Angelo collection were recovered some years ago from Altavilla s.s., but without precise indication of the collecting point. This material will be cited in the text as from Altavilla s.s. (*tout court*), with no reference to stratigraphy.

The following abbreviations are used:

AG	A. Germanà collection, Catania, Italy;
AR	A. Reitano collection, Catania, Italy;
BD	B. Dell'Angelo collection, Genova, Italy;
IRSNB	Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium;
MME	Museo Municipal de Estepona, Estepona, Spain;
MNHN	Muséum National d'Histoire Naturelle, Paris, France;
MPUM	Museo Paleontologico dell'Università di Modena, Modena, Italy;
MZB	Museo Zoologico dell'Università di Bologna, Bologna, Italy;
NHM	The Natural History Museum [formerly British Museum (Natural History)], London, United Kingdom;
RM	R. Marquet Collection, Antwerp, Belgium;
RSMNH	Royal Scottish Museum of Natural History, Edinburgh, United Kingdom.

Previous records of chitons from Altavilla

In literature, a single species described from the Altavilla Milicia outcrop is known: *Chiton altavillensis* Seguenza, 1876 (now *Craspedochiton altavillensis*). The same species was also described by older authors, always from Altavilla, with taxa now considered synonyms of the former: *Chiton squamosus* Libassi, 1859 (non Linnaeus, 1764), and *Chiton (Acanthochites?) pliocaenicus* Brugnone MS, Tiberi, 1877.

To our knowledge the only other records of Polyplacophora from Altavilla are: *Chiton miocenicus* Michelotti, 1847 var. (Seguenza, 1876: p. 264); *Ischnochiton anserinus* Laghi, 1977: 2 valves (1 intermediate and 1 tail) (Zanaroli, 1985: locality 16 in Tab. 2); *Stenosemus dolii* (Van Belle & Dell'Angelo, 1998): 7 valves (2 head, 4 intermediate and 1 tail) (Zanaroli, 1985: locality 16 in Tab. 2, determined as *Lepidozona dorsuosa*); *Leptochiton algesirensis* (Capellini, 1859): 1 intermediate valve (Dell'Angelo & Palazzi, 1989: p. 61); *Leptochiton* sp.: 1 intermediate valve (Dell'Angelo & Palazzi, 1989: p. 72, pl. 20, fig. 1, determined as *Leptochiton bedullii* Dell'Angelo & Palazzi, 1986).

Systematics

We follow the systematics proposed by Sirenko (2006). Since many of the chiton species herein reported have been fully described in other works (e.g. Dell'Angelo &

Smriglio, 1999; Dell'Angelo et al., 2004), only some comments, additional data and stratigraphic ranges are given below. The bibliographic references reported for each species are related only to papers with fossil reports or complete descriptions.

Class Polyplacophora Gray, 1821
Subclass Loricata Schumacher, 1817
Order Lepidopleurida Thiele, 1909
Family Leptochitonidae Dall, 1889
Genus *Leptochiton* Gray, 1847

Leptochiton Gray, 1847a: p. 127. Type species: *Chiton cinereus* Montagu, 1803, non Linnaeus, 1767 (= *Chiton asellus* Gmelin, 1791), by subsequent designation (Gray, 1847b).

Leptochiton cancellatus (Sowerby, 1840) (Fig. 3A-C)

Chiton cancellatus Sowerby II, 1840: figs 104, 104a-b, 105.

Lepidopleurus (Leptochiton) cancellatus - Dell'Angelo & Smriglio, 1999: p. 48, pls 10-11, figs 18-19 (bibliography and synonymy); Dell'Angelo et al., 2001b: p. 146, fig. 5; Marquet, 2002: p. 12, pl. 2, fig. 1; Dell'Angelo & Silva, 2003: p. 9, figs 3-4.

Lepidopleurus cancellatus - Chirli, 2004: p. 5, pl. 1, figs 16-18, pl. 2, figs 1-2.

Leptochiton cancellatus - Sosso & Dell'Angelo, 2010: p. 14, fig. p. 16; Studencka & Dulai, 2010: p. 260, figs 2A-D.

Type

Unknown, probably lost (*vide* Kaas & Van Belle, 1985a: p. 43).

Type locality

Coast of Great Britain, probably Oban, Scotland.

Material examined

Altavilla s.s.: 1 tail valve, width 2.4 mm (BD); Altavilla s.s.: ORTO2: 2 intermediate valves, maximum width 1.8 mm; KYLA3: 2 valves (1 intermediate, width 2 mm, and 1 tail, width 2 mm); KYLA3a: 2 valves (1 intermediate, width 2.3 mm, and 1 tail, width 1.8 mm) (AG, AR).

Remarks

The species is characterized by the rounded intermediate valves, and the tegmentum sculptured with very dense granules arranged in radial series on the head valve, the lateral areas of intermediate valves, and the postmucronal area of the tail valve, in longitudinal series on the central areas, with reduced intercostals spaces.

The seven valves recovered are well preserved, though generally not complete. They fully agree with descriptions and figures provided by Kaas & Van Belle (1985a) and Dell'Angelo & Smriglio (1999).

This is the first report from the Pliocene of Sicily.

Distribution

Leptochiton cancellatus lives in the British Islands, the Atlantic coast of France, Spain and Portugal, and in the Mediterranean (Dell'Angelo & Smriglio, 1999). It was

reported from the Middle Miocene (Badenian) of central Paratethys (Poland and Ukraine: Studencka & Dulai, 2010). Very scarce records from Italian Plio-Pleistocene localities (Dell'Angelo et al., 2001b), the Pliocene of Kallo (Belgium: Marquet, 2002) and Vale de Freixo (Portu-

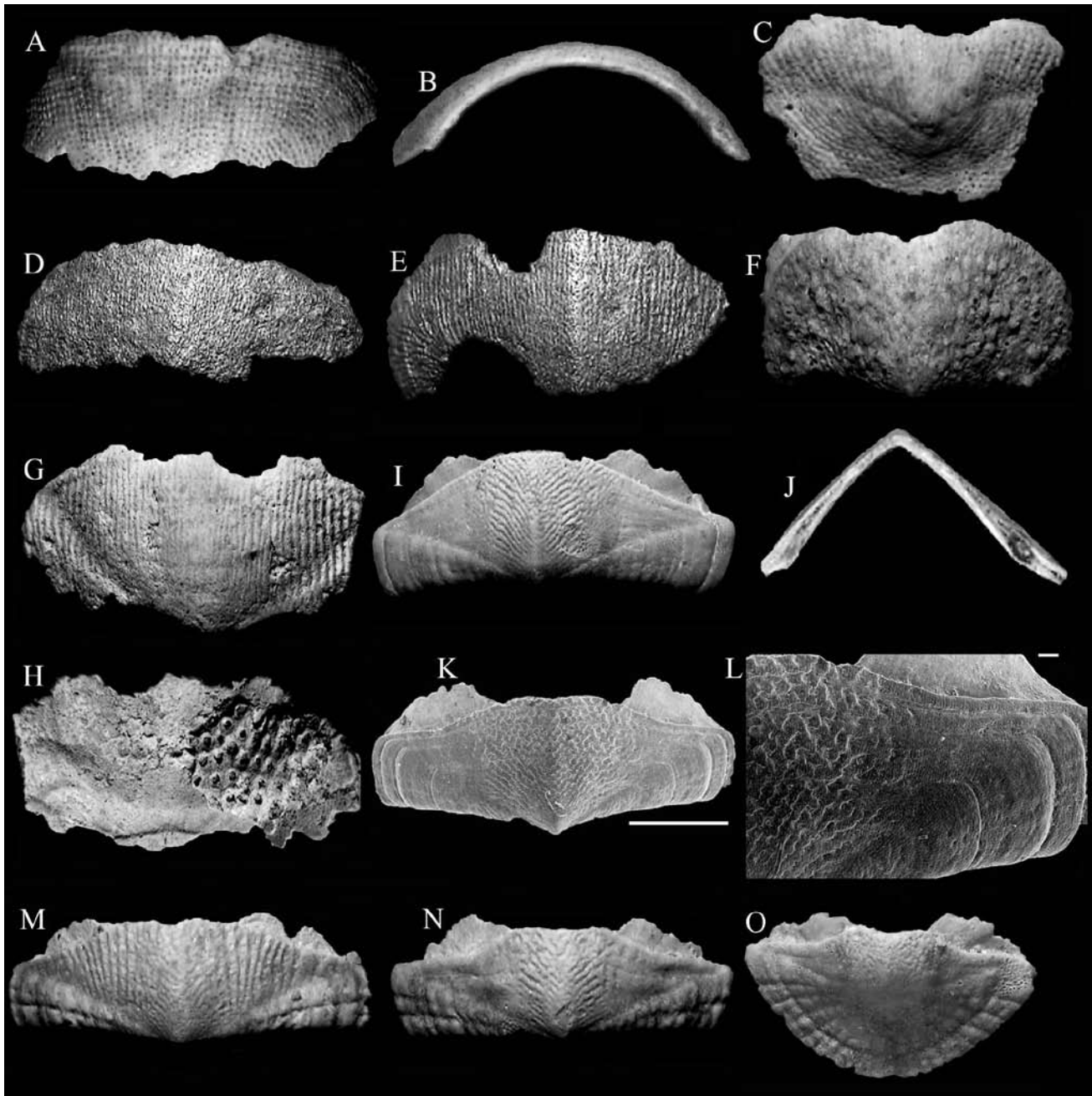


Fig. 3. A-C. *Leptochiton cancellatus* (Sowerby, 1840), Altavilla, KYLA3a. **A, B.** Intermediate valve, dorsal and frontal views, respectively, width 2.3 mm. **C.** Tail valve, dorsal view, width 1.8 mm. **D.** *Leptochiton algesirensis* (Capellini, 1859), Altavilla s.s., intermediate valve, dorsal view, width 5.2 mm. **E.** *Leptochiton* sp., Altavilla s.s., intermediate valve, dorsal view, width 4.5 mm. **F.** *Hanleya hanleyi* (Bean in Thorpe, 1844), Altavilla s.s., intermediate valve, dorsal view, width 2.6 mm. **G, H.** *Ischnochiton rissoi* (Payraudeau, 1826), Altavilla, ORTO2, intermediate valve, width 7 mm. **G.** Dorsal view. **H.** Ventral view, showing an undetermined bryozoan formation on the half right side. **I-L.** *Ischnochiton anserinus* Laghi, 1977, Altavilla, intermediate valves. **I.** KYLA3a, dorsal view, width 4.3 mm. **J.** Altavilla s.s., with no information on the stratigraphic layer, frontal view, width 3.4 mm. **K, L.** KYLA3a, width 3.8 mm. **K.** Dorsal view. **L.** Detail of the sculpture of the pleural area. **M-O.** *Ischnochiton martinelli* Dell'Angelo, Landau & Marquet, 2004, Altavilla, KYLA3a. **M.** Intermediate valve, dorsal view, width 4 mm. **N.** Intermediate valve, dorsal view, width 3.7 mm. **O.** Tail valve, dorsal view, width 3.4 mm. Scale bars: **K.** 1 mm; **L.** 100 μ m.

Fig. 3. A-C. *Leptochiton cancellatus* (Sowerby, 1840), Altavilla, KYLA3a. **A, B.** Piastra intermedia, viste dorsale e frontale, larghezza 2,3 mm. **C.** Piastra posteriore, vista dorsale, larghezza 1,8 mm. **D.** *Leptochiton algesirensis* (Capellini, 1859), Altavilla s.s., piastra intermedia, vista dorsale, larghezza 5,2 mm. **E.** *Leptochiton* sp., Altavilla s.s., piastra intermedia, vista dorsale, larghezza 4,5 mm. **F.** *Hanleya hanleyi* (Bean in Thorpe, 1844), Altavilla s.s., piastra intermedia, vista dorsale, larghezza 2,6 mm. **G, H.** *Ischnochiton rissoi* (Payraudeau, 1826), Altavilla, ORTO2, piastra intermedia, larghezza 7 mm. **G.** Vista dorsale. **H.** Vista ventrale, con una formazione di briozoi indeterminati sulla metà destra della piastra. **I-L.** *Ischnochiton anserinus* Laghi, 1977, Altavilla, piastre intermedie. **I.** KYLA3a, vista dorsale, larghezza 4,3 mm. **J.** Altavilla s.s., senza informazioni stratigrafiche, vista frontale, larghezza 3,4 mm. **K, L.** KYLA3a, larghezza 3,8 mm. **K.** Vista dorsale. **L.** Dettaglio della scultura dell'area pleurale. **M-O.** *Ischnochiton martinelli* Dell'Angelo, Landau & Marquet, 2004, Altavilla, KYLA3a. **M.** Piastra intermedia, vista dorsale, larghezza 4 mm. **N.** Piastra intermedia, vista dorsale, larghezza 3,7 mm. **O.** Piastra posteriore, vista dorsale, larghezza 3,4 mm. Barra di scala: **K.** 1 mm; **L.** 100 μ m.

gal: Dell'Angelo & Silva, 2003), and probably from the Pleistocene of Sweden and Norway (Dell'Angelo & Palazzi, 1989; Dell'Angelo & Smriglio, 1999).

***Leptochiton algesirensis* (Capellini, 1859)
(Fig. 3D)**

Chiton algesirensis Capellini, 1859: p. 327, pl. 12, figs 3a-c.
Lepidopleurus (Leptochiton) algesirensis – Dell'Angelo & Palazzi, 1989: p. 61, pls 8-13; Dell'Angelo & Smriglio, 1999: p. 53, pls 12-13, figs 20-23 (bibliography and synonymy); Dell'Angelo et al., 2001b: p. 145, fig. 2; 2004: p. 26, pl. 2, fig. 3.

Type

Unknown, possibly in École des Mines, Paris (*vide* Kaas & Van Belle, 1985a: p. 44).

Type locality

Algeciras, Spain.

Material examined

Altavilla s.s.: 1 intermediate valve, width 5.2 mm (BD).

Remarks

A detailed description of this species is in Kaas & Van Belle (1985a) and Dell'Angelo & Smriglio (1999). Fossil findings are rare, and old records are doubtful and in need of critical revision. The unique intermediate valve found is in bad condition of preservation, but shows sufficient characters for its identification at species level. Many series of longitudinal and radial granules are visible in the central and lateral areas, and the valve is subcarinate, not regularly rounded as in *L. cancellatus*. The present valve was found many years ago (Dell'Angelo & Palazzi, 1989), and no additional material was found during our research.

Distribution

Leptochiton algesirensis lives in the western Mediterranean (Spain, Sardinia, Tyrrhenian coasts of peninsular Italy, Sicily, Morocco and Tunisia) and in the eastern Atlantic Ocean (Bretagne, Portugal, Canary Islands, Madeira and Senegal) (Dell'Angelo & Smriglio, 1999). It was reported from the Oligocene of western Germany (Dell'Angelo & Palazzi, 1989). There are very few records from Italian Plio-Pleistocene localities (Dell'Angelo & Palazzi, 1989).

***Leptochiton* sp.
(Fig. 3E)**

Lepidopleurus (Leptochiton) boettgeri - Dell'Angelo & Palazzi, 1989: p. 72, pl. 20, fig. 1.

Material examined

Altavilla s.s.: 1 intermediate valve, width 4.5 mm (BD).

Remarks

The unique intermediate valve found was already illustrated in Dell'Angelo & Palazzi (1989: pl. 20, fig. 1) as *Lepidopleurus (Leptochiton) boettgeri* Šulc, 1934 (now *Leptochiton bedullii* Dell'Angelo & Palazzi, 1986). The examination of additional Recent and fossil material of *L. bedullii* permits us to amend such an identification, but the identity of the valve from Altavilla remains unclear. Some characters (e.g. the large spaces among the longitudinal series of granules near the lateral margin, and the typical curved series connecting lateral and central areas) do not correspond to those shown by other Pliocene comparable species (e.g. *L. cancellatus* or *L. algesirensis*), so we prefer to leave this material indeterminate at species level. As a consequence, *L. bedullii* must be deleted from the list of chitons known from Altavilla.

Distribution

Known only from the Pliocene of Altavilla.

Family Hanleyidae Bergenhayn, 1955
Genus *Hanleya* Gray, 1857

Hanleya Gray, 1857: p. 186. Type species: *Hanleya debilis* Gray, 1857 (= *Chiton hanleyi* Bean in Thorpe, 1844), by monotypy.

***Hanleya hanleyi* (Bean in Thorpe, 1844)
(Fig. 3F)**

Chiton hanleyi Bean in Thorpe, 1844: p. 263, fig. 57.
Hanleya hanleyi - Dell'Angelo & Smriglio, 1999: p. 85, pls 25-26, figs 34-36 (bibliography and synonymy); Dell'Angelo et al., 1999: p. 262, pl. 1, figs 1, 3; 2001: p. 147, fig. 8; 2004: p. 30, pl. 2, fig. 8; Marquet, 2002: p. 13, pl. 2, fig. 2.

Type

Wood End Natural History Museum, Scarborough, United Kingdom (*vide* Kaas & Van Belle, 1985a: p. 193).

Type locality

England, Yorkshire, Scarborough.

Material examined

Altavilla s.s.: 1 intermediate valve, width 2.6 mm (BD).

Remarks

The species is characterized by a tegmentum uniformly sculptured with roundish granules, irregularly arranged on head valve, lateral areas of intermediate valves and postmucronal area of tail valve, in longitudinal rows, fine and close set on jugum, increasing in size and converging posteriorly towards side margins in pleural areas and antemucronal area of tail valve. The single intermediate valve fully agrees with descriptions and figures provided by Kaas & Van Belle (1985a) and Dell'Angelo & Smriglio (1999).

This is the first report of this species from the Pliocene of Sicily.

Distribution

Hanleya hanleyi lives in the Atlantic Ocean, from the Barents Sea to the Canary Islands, off the East coast on N America, and in the Mediterranean Sea (Dell'Angelo & Smriglio, 1999). It was reported from the Badenian of the central European basins, the Hemmoor Stufe of Miste (North Sea basin), the Italian Tortonian (Montegibbio Modena) and Messinian (Borelli, Turin) (Dell'Angelo et al., 1999). There are a few records from the Pliocene of Great Britain (Coralline Crag), Belgium (Kallo: Marquet, 2002) and Italy (Modena, Messina and Sicily), and from the Pleistocene of Norway and Italy [Sicily, Calabria, Torrente Stirone (Parma) and Riparbella (Pisa)] (Dell'Angelo et al., 1999).

Order Chitonida Thiele, 1909
Suborder Chitonina Thiele, 1909
Family Ischnochitonidae Dall, 1889
Genus *Ischnochiton* Gray, 1847

Ischnochiton Gray, 1847a: p. 126. Type species: *Chiton textilis* Gray, 1828, by subsequent designation (Gray, 1847b: p. 168).

The systematics of the *Ischnochiton* at the subgenus level is mainly based on girdle's characters, and should be therefore applied to living material only.

Ischnochiton rissoi (Payraudeau, 1826) (Fig. 3G, H)

Chiton rissoi Payraudeau, 1826: p. 87, pl. 3, figs 4-5.

Ischnochiton (Simplischnochiton) rissoi - Dell'Angelo et al., 1999: p. 265, pl. 3, figs 3, 5.

Ischnochiton rissoi - Sabelli & Taviani, 1979: p. 160, pl. 1, figs 17-19; Batuk, 1984: p. 287, pl. 6, figs 2a-b; Dell'Angelo et al., 2001b: p. 150, figs 20, 23; Kroh, 2003: p. 132, pl. 1, fig. 5; Chirli, 2004: p. 6, pl. 2, figs 3-9; Dulai, 2005: p. 33, pl. 3, figs 1-5; Sosso & Dell'Angelo, 2010: p. 14, fig. p. 16; Studencka & Dulai, 2010: p. 264, figs 4 A-C.

Ischnochiton (Ischnochiton) rissoi - Dell'Angelo & Smriglio, 1999: p. 100, pls. 29-31, figs 40-48 (bibliography and synonymy); Dell'Angelo et al., 2004: p. 34, pl. 4, figs 3-4; Garilli et al., 2005: p. 132, pl. 2, figs 5-6; Koskeridou et al., 2009: p. 314, figs 8.1-8.2.

Type

Syntype: MNHN 6109.

Type locality

France, Bonifacio (Corse).

Material examined

Altavilla s.s.: ORTO2: 1 intermediate valve, width 7 mm; KYLA3a: 2 valves (1 intermediate, width 3.3 mm, and 1 tail, width 4.5 mm) (AG, AR).

Remarks

The species is characterized by a tegmental sculpture consisting of concentric vermicular ribs, often intersected by fine radial furrows, on the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve. The ribs continue longitudinally on the central areas of the intermediate valves and on the antemucronal area of the tail valve. The species is highly variable, as reflected by its long synonymy list. The material examined is scarce, only three valves, but well enough preserved, and fully agree with descriptions and figures provided by Kaas & Van Belle (1990) and Dell'Angelo & Smriglio (1999).

This is the first report of this species from Altavilla.

Distribution

Presently *I. rissoi* lives only in the Mediterranean Sea. Not recorded for the Atlantic, except in the surroundings of Gibraltar (some old records from the Canary, Selvagens and Azores Islands should be confirmed, Dell'Angelo & Smriglio, 1999). It has been reported from the Badenian of central Paratethys (Czech Republic, Poland, Ukraine, Romania, Austria, Hungary) (Dulai, 2005; Studencka & Dulai, 2010), the Tortonian and the Messinian of northern Italy (Laghi, 1977; Dell'Angelo et al., 1999) as well as from many Italian and Spanish Pliocene localities (Dell'Angelo et al., 2004). It is more frequent in Pleistocene of south Italy and Greece, and scarcely recorded from other Italian localities (Garilli et al., 2005).

Ischnochiton anserinus Laghi, 1977 (Fig. 3I, L)

Ischnochiton (Simplischnochiton) anserinus Laghi, 1977: p. 104, pl. 1, figs 10-12; Kaas & Van Belle, 1981: p. 20.

Ischnochiton (S.) anserinus - Zanaroli, 1985: p. 109, pl. 3, fig. 1.
Ischnochiton anserinus - Dell'Angelo et al., 2001b: p. 150, figs 19-22; 2004: p. 33.

Type

Holotype: MPUM 18956 (1 intermediate valve, figured by Laghi, 1977: pl. 1, fig. 10). Paratypes: MPUM 18957 (1 head and 1 intermediate valves, figured by Laghi, 1977: pl. 1, figs 11-12); MPUM 18958 (7 intermediate valves).

Type locality

Tagliata, Modena, north Italy, Lower Pliocene.

Material examined

Altavilla s.s.: 2 intermediate valves, maximum width 3.5 mm (BD); Altavilla s.s.: ORTO2: 2 intermediate valves, maximum width 4.7 mm; KYLA3a: 5 intermediate valves, maximum width 4.3 mm (AG, AR).

Remarks

This species is characterized by the distinctly carinated intermediate valves (Fig. 3J), and the tegmentum sculp-

tured with a fine granularity formed by a trellis-work of diagonal furrows, well evidenced in the jugal area of intermediate valves, giving a smooth appearance on the pleural and lateral areas (Figs 3K-L). Laghi established his new species on the basis of nine not well-preserved and incomplete intermediate valves, and only a small fragment of a head valve. All subsequent records of *I. anserinus* refer to intermediate valves, and also in the material from Altavilla head and tail valves are not available. The intermediate valves are distinctly carinated in frontal view (compare Fig. 3I with fig. 19 in Dell'Angelo et al., 2001b). This rare species is somewhat related to *I. martinelli* Dell'Angelo, Landau & Marquet, 2004; the differences are discussed under the latter species.

Distribution

Known only from the Pliocene of Northern Apennines (Tagliata and "Cà del Reggiano", Modena) (Laghi, 1977), Tuscany (Luciana and Pietrafitta "Podere Sant'Ulviere") (Dell'Angelo et al., 2001b) and Sicily (Altavilla) (Zanaroli, 1985, and this paper).

Ischnochiton martinelli Dell'Angelo, Landau & Marquet, 2004 (Fig. 3M-O)

Ischnochiton martinelli Dell'Angelo, Landau & Marquet, 2004: p. 33, pl. 4, fig. 8, pl. 5, figs 1-4, 6-8, pl. 6, figs 1-8, pl. 7, fig. 1; Schwabe, 2005: p. 98.

Type

Holotype: MZB 25051 (1 intermediate valve, figured by Dell'Angelo et al., 2004: pl. 4, fig. 8, pl. 5, figs 1-4, 6-8, pl. 6, fig. 1). Paratypes: MZB 25052 (3 valves); MME (3 valves); IRSNB 6450 (3 valves); BD 4567 (3 valves); RM (3 valves).

Type locality

Velerín Carretera, near Estepona (Málaga, Spain), Early Piacenzian (Pliocene).

Material examined

Altavilla s.s.: ORTO2: 7 valves (6 intermediate, maximum width 5 mm, and 1 tail, width 3.5 mm); KYLA3a: 17 valves (1 head, width 2.3 mm, 13 intermediate, maximum width 5.2 mm, and 3 tail, maximum width 3.3 mm) (AG, AR).

Remarks

This species is characterized by having distinctly carinated intermediate valves, and a tegmental sculpture consisting of radial nodulose riblets on the head valve, the lateral areas of intermediate valves and the post-mucronal area of tail valve. Intermediate valves and antemucronal area of tail valve present a reticulate sculp-

ture in jugal area, consisting of obliquely intersecting vermicular ribs, tending to form a series of longitudinal striae in pleural areas, often somewhat eroded, and an almost smooth area in extreme part of pleural areas. It is somewhat related to *Ischnochiton anserinus* Laghi, 1977. The main difference is in the lateral areas of intermediate valves, which in *I. anserinus* is more finely sculptured by a trellis-work of diagonal furrows, giving a smooth appearance.

Distribution

Previously known only from the Pliocene of Estepona (Málaga, Spain).

Genus *Stenosemus* von Middendorff, 1847

Stenosemus von Middendorff, 1847: p. 34. Type species: *Chiton albus* Linnaeus, 1767, by subsequent designation (Winckworth, 1926).

Stenosemus dolii (Van Belle & Dell'Angelo, 1998) (Figs 4A-K)

Ischnochiton dolii Van Belle & Dell'Angelo, 1998: p. 77, figs 1-5; Dell'Angelo et al., 2001b: p. 150; 2004: p. 34; Schwabe, 2005: p. 94.

Ischnochiton (Stenosemus) dolii - Dell'Angelo & Smriglio, 1999: p. 116, fig. 53, pls 36-38; Dell'Angelo & Giusti, 2000: p. 55.

Ischnochiton vanbellei - Smriglio et al., 1989: p. 126, figs 3, 4a-b; Ardovini & Cossignani, 1999: p. 27, fig. p. 27.

Ischnochiton (Stenosemus) aff. vanbellei - Dell'Angelo et al., 2004: p. 34, pl. 7, figs 2, 5-6.

Ischnochiton exaratus - Dell'Angelo & Giusti, 1997: p. 51, figs 4, 6, 9.

Ischnochiton (Simplischnochiton) exaratus - Dell'Angelo et al., 1999: p. 268, pl. 2, figs 2, 4-7, pl. 3, fig. 6.

Lepidozona dorsuosa - Laghi, 1977: p. 105, pl. 2, figs 1-4; Zanaroli, 1985: p. 111, pl. 2, figs 1-6.

Type

Holotype: an intermediate valve, 3 x 7.5 mm (MZB 11302). Paratypes: five valves (MZB 11303), four valves (IRSNB 28523), three valves (MNHN), other valves in private collections.

Type locality

Tyrrhenian Sea, off Civitavecchia, Italy

Material examined

Altavilla s.s.: 8 valves (2 head, maximum width 4 mm, 5 intermediate, maximum width 4.8 mm, and 1 tail, width 5 mm,) (BD); Altavilla s.s.: ORTO1: 4 intermediate valves, width 4.8 mm; ORTO2: 56 valves (12 head, maximum width 4.5 mm, 36 intermediate, maximum width 8 mm, and 8 tail, maximum width 6 mm); KYLA3: 2 intermediate valves, maximum width 4 mm; KYLA3a: 245 valves (45 head, maximum width 5.2 mm, 167 intermediate, maximum width 6.7 mm, and 33 tail, maximum width 5.2 mm) (AG, AR).

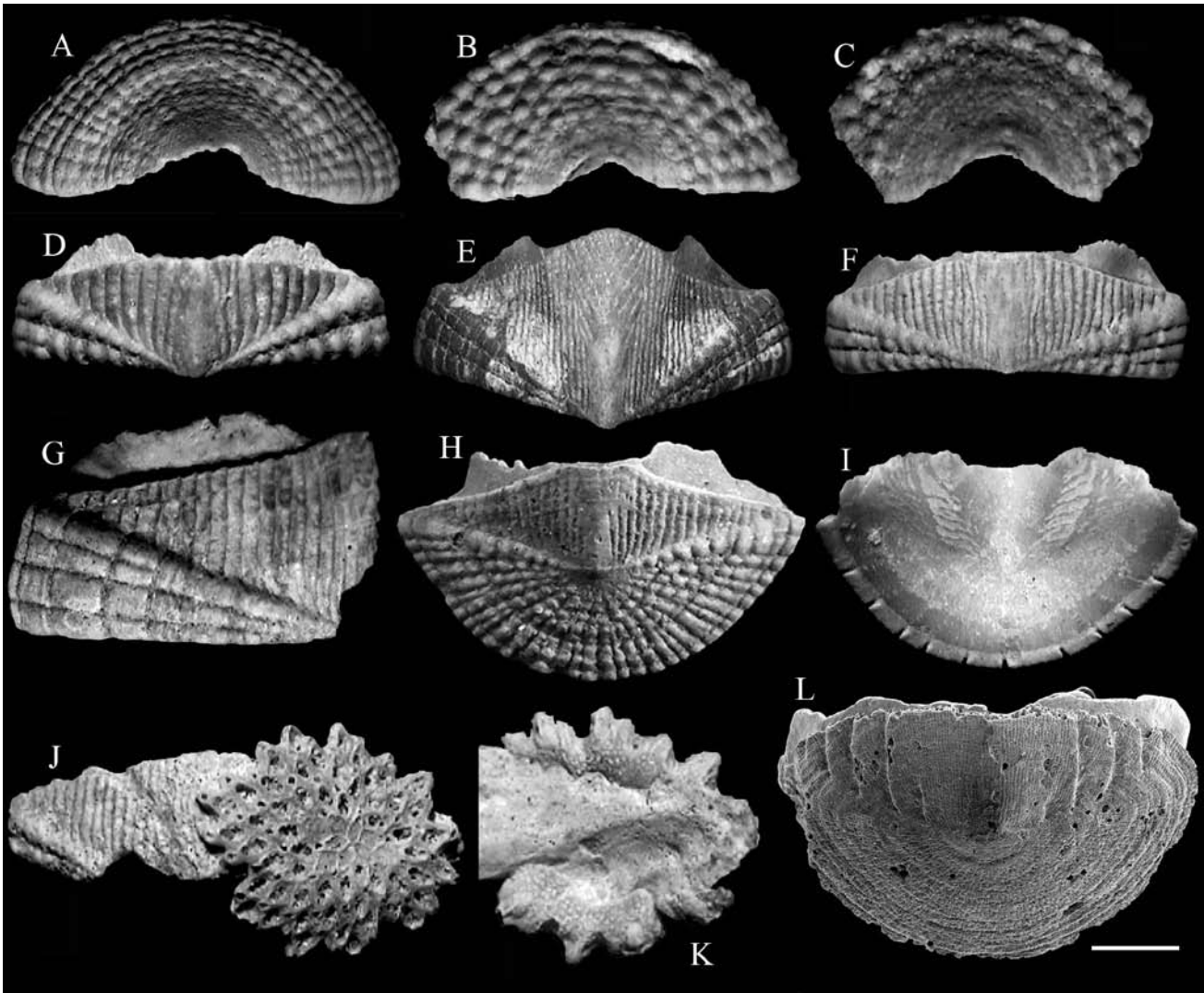


Fig. 4. A-K. *Stenosemus dolii* (Van Belle & Dell'Angelo, 1998), Altavilla. **A-C.** Head valves, KYLA3a, dorsal views. **A.** Width 4.2 mm, subgranulose radial ribs. **B.** Width 2.5 mm, granulose radial ribs. **C.** Width 1.7 mm, more granulose radial ribs, present only in the area near the anterior margin. **D-G.** Intermediate valves, KYLA3a, dorsal view. **D.** Width 3.7 mm, lateral areas with 2 subgranulose radial ribs. **E.** Width 6 mm, valve ii with a sculpture of grooves converging towards the apex visible on the upper part of jugal area. **F.** Width 4.7 mm, lateral areas with 3-4 more granulose and splitted radial ribs. **G.** Width 4.1 mm, lateral areas with rather flat radial ribs. **H.** Tail valve, KYLA3a, dorsal view, width 3.5 mm. **I.** Tail valve, KYLA3a, ventral view, width 3.4 mm. **J, K.** Intermediate valve, KYLA3a, width 5.6 mm, showing a bryozoan formation [*Discoporella intermedia* (Michelotti, 1838)] on the half right side. **J.** Dorsal view. **K.** Ventral view, close-up of the bryozoan formation, length 3 mm. **L.** *Callochiton septemvalvis* (Montagu, 1803), Altavilla, ORTO2, tail valve, dorsal view, width 2.4 mm. Scale bar: **L.** 500 μ m.

Fig. 4. A-K. *Stenosemus dolii* (Van Belle & Dell'Angelo, 1998), Altavilla. **A-C.** Piastre anteriori, KYLA3a, viste dorsali. **A.** Larghezza 4,2 mm, costole radiali subgranulose. **B.** Larghezza 2,5 mm, costole radiali granulose. **C.** Larghezza 1,7 mm, costole radiali piú granulose, presenti solo nella zona vicino al margine anteriore. **D-G.** Piastre intermedie, KYLA3a, vista dorsale. **D.** Larghezza 3,7 mm, aree laterali con 2 costole radiali subgranulose. **E.** Larghezza 6 mm, piastra ii con una scultura di solchi convergenti verso l'apice visibili sulla parte superiore dell'area jugale. **F.** Larghezza 4,7 mm, aree laterali con 3-4 costole radiali piú granulose e biforcate. **G.** Larghezza 4,1 mm, aree laterali con costole radiali appiattite. **H.** Piastra posteriore, KYLA3a, vista dorsale, larghezza 3,5 mm. **I.** Piastra posteriore, KYLA3a, vista ventrale, larghezza 3,4 mm. **J, K.** Piastra intermedia, KYLA3a, larghezza 5,6 mm, con una formazione di briozoi [*Discoporella intermedia* (Michelotti, 1838)] sulla metà destra della piastra. **J.** Vista dorsale. **K.** Vista ventrale, dettaglio della formazione di briozoi, larghezza 3 mm. **L.** *Callochiton septemvalvis* (Montagu, 1803), Altavilla, ORTO2, piastra posteriore, vista dorsale, larghezza 2,4 mm. Barra di scala: **L.** 500 μ m.

Remarks

The species was described upon many loose subfossil valves found in a Roman amphora (in Latin *dolium*) off Civitavecchia, at a depth of 550 m (Van Belle & Dell'Angelo, 1998). Later, additional valves were found between Corsica and Capraia Island, at 350-500 m (Dell'Angelo & Giusti, 1997, 2000). Finally, one living specimen was recovered, in a fragment of amphora collected at 480 m off the Latium coast (as *Ischnochiton vanbellei* Kaas, 1985; Dell'Angelo & Smriglio, 1999), and two more in the Tuscan Archipelago at 150-250 m (Dell'Angelo

et al., 2001a). The species was attributed to the genus *Stenosemus* Middendorff, 1847 on the basis of the dorsal girdle's conic scales (Kaas & Van Belle, 1990).

The great number of available valves permits some considerations on the variability of the sculpture of the valves.

Head valve. Subgranulose radial ribs (20-26 at the apex), tending to bifurcate near the anterior margin, crossed by well evident growth lines (Fig. 4A), more granulose in some cases (Fig. 4B) or still more granulose, but present only in the area near the anterior margin, smooth near the apex (Fig. 4C).

Intermediate valves. Lateral areas with subgranulose radial ribs, from 2 (**Fig. 4D**) to 5, always tending to split near the lateral margin, rather flat (**Fig. 4G**) or tending to more granulose (**Fig. 4D, F**). Central area with 13-23 longitudinal grooves on each side, normally all reaching the anterior edge, only in some valves the 2-4 more internal ones may not reaching the margin and converging towards the jugum, or become very irregular. The jugum is normally smooth, but when the more internal longitudinal grooves are converging towards it (normally in valve ii) a sculpture of grooves converging towards the apex is visible on the upper part (**Fig. 4E**). Tail valve. Both sides of the jugal angle of the anterior margin are always slightly concave (**Fig. 4H**), not straight as reported in the original description. Longitudinal grooves in the antemucronal area (14-15) and subgranulose radial ribs in the postmucronal area (14-16, counted at the mucro and tending to split) show the same variability already evidenced by head and intermediate valves.

Slit formula: 9-10/1/6-10, teeth very irregular in width (**Fig. 4I**).

The abundant material examined well agrees with descriptions and figures provided by Van Belle & Dell'Angelo (1998) and Dell'Angelo & Smriglio (1999). The valves width shown by the specimens from Altavilla (5.2, 8 and 6 mm for head, intermediate and tail valves, respectively) is somewhat different from sizes given in the original description (7, 7.5 and 6.5 mm). Another minor difference is in the number of radial ribs in lateral areas of intermediate valves (2-5 *vs.* 4-5 in original description). All these discrepancies are indicative of a wide intraspecific variability, allowing a better definition of the characteristics of the species. This also permits to attribute to *S. dolii* the valves from the Pliocene of Estepona (Spain) determined by Dell'Angelo et al. (2004) as *Ischnochiton (Stenosemus) aff. vanbellei* Kaas, 1985, on the basis of the 2-3 subnodulose ribs on the lateral areas of intermediate valves, considered at that time not agreeing with *S. dolii*. We attribute to *S. dolii* also the valves from the Pliocene of Northern Apennines (Zinola, Valle Andona and Castell'Arquato) determined by Laghi (1977) as *Lepidozona dorsuosa* (Haddon, 1886), and the valves from the Lower Messinian of Borelli (Turin hills) determined by Dell'Angelo et al. (1999) as *Ischnochiton (Simplischnochiton) exaratus* (Sars, 1878).

Stenosemus dolii may be compared to *Ischnochiton zbyi* Dell'Angelo & Silva, 2003, and *S. vanbellei* (Kaas, 1985). The differences are discussed and reported by Dell'Angelo & Silva (2003: Tab. 1, p. 11) and Dell'Angelo & Smriglio (1999: Table p. 116).

Distribution

Presently *Stenosemus dolii* is known only from the Mediterranean Sea, off the Latium coast and the Tuscan Archipelago, between 150 and 560 m, and in association with "white corals" (Dell'Angelo & Smriglio, 1999). It has been reported from the Lower Messinian of Borelli

[Turin hills, as *Ischnochiton exaratus* (Sars, 1878)] (Dell'Angelo et al., 1999), the Pliocene of a few Italian localities (Zinola, Valle Andona, Castell'Arquato and Altavilla) and Estepona (Spain) (this paper), and the Pleistocene of Tuscany (many valves dredged between Capraia and Capo Corso, at a depth of 350-500 m, Van Belle & Dell'Angelo, 1998; Dell'Angelo & Giusti, 1997, 2000).

Family Callochitonidae Plate, 1901

Genus *Callochiton* Gray, 1847

Callochiton Gray, 1847a: 126. Type species: *Chiton laevis* Montagu, 1803 (*non* Pennant, 1777) = *Callochiton septemvalvis* (Montagu, 1803), by subsequent designation (Gray, 1847b).

Callochiton septemvalvis (Montagu, 1803) (**Fig. 4L**)

Chiton septemvalvis Montagu, 1803: p. 3.

Callochiton septemvalvis - Dell'Angelo & Smriglio, 1999: p. 125, pls 40-41, figs 55-63 (bibliography and synonymy); Dell'Angelo & Silva, 2003: p. 11; Dell'Angelo et al., 2004: p. 34, pl. 3, figs. 2, 5; Garilli et al., 2005: p. 134, pl. 2, figs 7-10; Dell'Angelo & Vardala-Theodorou, 2006: p. 326, 2 figs; Koskeridou et al., 2009: p. 314, figs 8.3-8.4.

Type

Holotype: NHM (*vide* Kaas & Van Belle, 1985b).

Type locality

England, Salcomb Bay

Material examined

Altavilla s.s.: ORTO2: 1 tail valve, width 2.4 mm; KY-LA3a: 4 valves (1 intermediate, width 2 mm, and 3 tail, maximum width 3.2 mm) (AG, AR).

Remarks

The material examined is scarce, only five valves, but well enough preserved, to see the same tegmental sculpture as occurring in living specimens, i.e. a dense and uniform set of cords, barely visible with the naked eyes, with 4-5 longitudinal scars in the pleural area, almost all (mainly the first four) reaching the valve's anterior margin. They fully agree with descriptions and figures provided by Kaas & Van Belle (1985b) and Dell'Angelo & Smriglio (1999).

Distribution

Presently *Callochiton septemvalvis* is widely distributed in the north-eastern Atlantic Ocean, from Norway to the Canary Islands and in the Mediterranean Sea (Dell'Angelo & Smriglio, 1999). It has been reported from the Badenian of central Paratethys and the Miocene of Montegibbio (Modena) (Dell'Angelo & Smriglio, 1999).

The species is common in the Italian Plio-Pleistocene, and is also recorded from the Portuguese (Dell'Angelo & Silva, 2003) and Spanish (Dell'Angelo et al., 2004) Pliocene. It is mentioned also from the Pleistocene of Greece (Koskeridou et al., 2009).

Family Chitonidae Rafinesque, 1815
Subfamily Chitoninae Rafinesque, 1815
Genus *Chiton* Linnaeus, 1758

Chiton Linnaeus, 1758: 667. Type species: *Chiton tuberculatus* Linnaeus, 1758, by subsequent designation (Dall, 1879).

Chiton sp.
(Fig. 5A-K)

Material examined

Altavilla s.s.: ORTO1: 2 valves (1 head, width 4.5 mm, and 1 intermediate, width 5.5 mm); ORTO2: 7 intermediate valves, maximum width 4.8 mm; KYLA1: 1 head valve, width 7.3 mm; KYLA3: 1 intermediate valve, width 1.8 mm; KYLA3a: 33 valves (3 head, maximum width 4.8 mm, 22 intermediate, maximum width 9 mm, and 8 tail, maximum width 4.5 mm) (AG, AR).

Description

Head valve semi-oval, front slope straight, posterior margin widely V-shaped. Intermediate valves broadly rectangular, carinate, with anterior and posterior margins more or less straight, side margins truncated, apex not very accentuated, lateral areas somewhat raised, clearly defined. Tail valve more or less triangular, the length about half the width, mucro median, hind slope concave.

Head valve, lateral areas of intermediate valves, and postmucronal area of the tail valve smooth. The central areas with up to 10 longitudinal, smooth, flattish ribs at both sides of the smooth jugum.

Apophyses wide, rounded, separated by a narrow jugal sinus. The insertion laminae are subdivided into not equidistant denticles, finely pectinated. Slit formula: 9/1/10-11.

Remarks

Some valves found at Altavilla belonging to the genus *Chiton* (i.e. with pectinated teeth of insertion plates) are characterized by the smoothness of the head valve, the lateral areas of intermediate valves, and the postmucronal area of the tail valve. This features are shared by *Chiton corallinus* Risso, 1826, one of the most common species of the Italian Pliocene, *C. phaseolinus* Monterosato, 1879, and *C. etruscus* Dell'Angelo & Forli, 1995. However, the valves from Altavilla differ from *C. corallinus* in their shape, generally wider and less elevated, and are more converging to the species known as *Chiton miocenicus* Michelotti, 1847, which differs, however, by having the head valve, the lateral areas of intermediate

valves, and the postmucronal area of the tail valve with a sculpture of radial ribs. One intermediate valve from KYLA3a (Figs 5G-I) is very similar to *R. corallinus*, but has a more expanded lateral area (Fig. 5G) and presents 2 slits on the right side (Fig. 5H). Also *C. phaseolinus* and *C. etruscus* have a different, regularly rounded shape, and a delicate sculpture of the central area.

Seguenza (1876: p. 264) reported from Altavilla *Chiton miocenicus* Michelotti, 1847 var. with a short diagnosis: "Questa forma pliocenica differisce dal tipo della *Superga* per le linee d'accrescimento impresse e meglio distinte". He underlined the presence of marked growth lines as a distinctive character from *C. miocenicus*, and his short description was most probably based on material conspecific with the present one. Unfortunately, our material consists of incomplete and not well preserved valves (except some tail valves in good conditions, one of which is illustrated, Fig. 5B). Additional, better preserved material is needed for understanding their status at species level, and its relationship with *C. miocenicus*.

Distribution

Known only from the Pliocene of Altavilla.

Suborder Acanthochitonina Bergenhayn, 1930
Superfamily Mopalioidae Dall, 1889
Family Tonicellidae Simroth, 1894
Genus *Lepidochitona* Gray, 1821

Lepidochitona Gray, 1821: p. 234. Type species: *Chiton marginatus* Pennant, 1777 (= *Chiton cinereus* Linnaeus, 1767), by monotypy.

Lepidochitona caprearum (Scacchi, 1836)
(Fig. 5L-N)

Chiton caprearum Scacchi, 1836: p. 9, note 9.

Lepidochitona caprearum - Dell'Angelo et al., 2001b: p. 147, fig. 11; Cretella et al., 2005: p. 116, fig. 1a.

Lepidochitona (L.) *caprearum* - Dell'Angelo & Smriglio, 1999: p. 143, pls 46-48, figs 73-76 (bibliography and synonymy).

Lepidochitona (*Lepidochitona*) *caprearum* - Koskeridou et al., 2009: p. 318, figs 9.8-9.9, 10.1-10.2.

Middendorfia caprearum - Laghi, 1977: p. 108.

Type

Lectotype: MCZR E20/12698 (Monterosato coll.), designed by Gaglini (1985, pl. 1, figs 1-2: "Coll. Petit, da Scacchi come Ch. Caprearum (Capri! Na[poli]!)", 9.5 x 6.4 mm) (Cretella et al., 2005: p. 116, fig. 1a).

Type locality

Capri, "*Caprearum scopulos incolit*" ("It lives on the cliffs of Capri", Cretella et al., 2005: p. 116).

Material examined

Altavilla s.s.: KYLA3a: 2 intermediate valves, maximum width 4 mm (AG, AR).

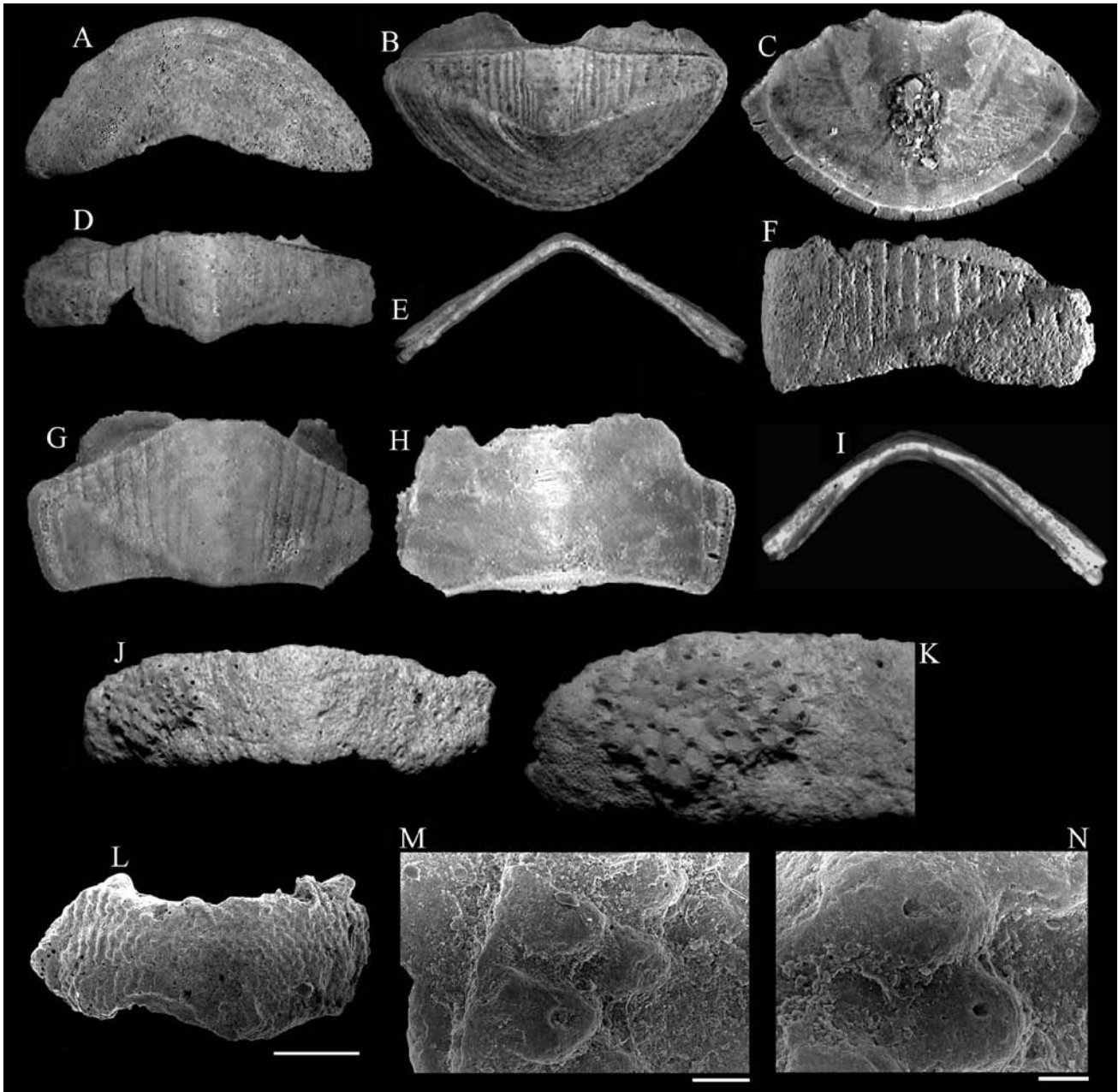


Fig. 5. A-K. *Chiton* sp., Altavilla. **A.** Head valve, KYLA1a, dorsal view, width 7.3 mm. **B, C.** Tail valve, KYLA3a, width 5.6 mm, dorsal and ventral views, respectively. **D-F.** Intermediate valves, KYLA3a. **D, E.** width 4 mm, dorsal and frontal views, respectively. **F.** Half right valve, width 6 mm. **G-I.** Intermediate valve, KYLA3a, width 3.5 mm, dorsal, ventral, and frontal views, respectively. **J, K.** Intermediate valve, KYLA3a, width 9 mm, showing a bryozoan formation (*Schizomavella* sp.) on the left dorsal side. **J.** Dorsal view. **K.** Close-up of the bryozoan formation. **L-N.** *Lepidochitona caprearum* (Scacchi, 1836), KYLA3a, intermediate valve, width 4 mm. **L.** Dorsal view. **M.** Detail of sculpture. **N.** Close-up of granules. Scale bars: **L.** 1 mm; **M.** 100 μ m; **N.** 50 μ m.

Fig. 5. A-K. *Chiton* sp., Altavilla. **A.** Piastra anteriore, KYLA1a, vista dorsale, larghezza 7,3 mm. **B, C.** Piastra posteriore, KYLA3a, larghezza 5,6 mm, viste dorsale e ventrale. **D-F.** Piastre intermedie, KYLA3a. **D, E.** larghezza 4 mm, viste dorsale e frontale. **F.** Mezza piastra destra, larghezza 6 mm. **G-I.** Piastra intermedia, KYLA3a, larghezza 3,5 mm, viste dorsale, ventrale e frontale. **J, K.** Piastra intermedia, KYLA3a, larghezza 9 mm, con una formazione di briozoi (*Schizomavella* sp.) sul lato dorsale sinistro. **J.** Vista dorsale. **K.** Dettaglio della formazione di briozoi. **L-N.** *Lepidochitona caprearum* (Scacchi, 1836), KYLA3a, piastra intermedia, larghezza 4 mm. **L.** Vista dorsale. **M.** Dettaglio della scultura. **N.** Dettaglio dei granuli. Barra di scala: **L.** 1 mm; **M.** 100 μ m; **N.** 50 μ m.

Remarks

This species has a long and rather confusing nomenclatural history, summarized by Dell'Angelo & Palazzi (1999). It is characterized by the tegmentum uniformly covered with rough granules arranged in irregular quincunx pattern. The material examined is scarce, only two, incomplete intermediate valves, and fully agree with descriptions and figures provided by Kaas & Van Belle (1985b as *L. corrugata*) and Dell'Angelo & Smriglio (1999).

This is the first report from Altavilla.

Distribution

Presently *Lepidochitona caprearum* lives in the Mediterranean Sea, and in Atlantic, along the southern coast of Spain and Portugal and in the Selvagens Islands (Dell'Angelo & Smriglio, 1999). It has been scarcely reported from the Plio-Pleistocene of Italy (Sabelli & Taviani, 1979; Dell'Angelo & Smriglio, 1999) and it is also mentioned from the Pleistocene of Greece (Koskeridou et al., 2009). The occurrence of this species in the Miocene of Northern Apennines (Laghi, 1977) should be verified

by a direct comparisons between *Lepidochitona* material from that area and the numerous *Lepidochitona* species described from the Miocene of central-eastern Europe [*L. lepida* (Reuss, 1860), *L. subgranosa* Bařuk, 1971, *L. baluki* Macioszczyk, 1988).

Superfamily Cryptoplacoidea H. & A. Adams, 1858
Family Acanthochitonidae Pilsbry, 1893
Genus *Acanthochitona* Gray, 1821

Acanthochitona Gray, 1821: p. 234. Type species: *Chiton fascicularis* Linnaeus, 1767, by monotypy.

***Acanthochitona fascicularis* (Linnaeus, 1767)
(Fig. 6A, B)**

Chiton fascicularis Linnaeus, 1767: n. 1106.

Acanthochitona fascicularis - Kaas, 1985: p. 585, figs 1-6; Dell'Angelo & Smriglio, 1999: p. 192, pls 64-65, figs 113-123 (bibliography and synonymy); Dell'Angelo et al., 1999: p. 273, pl. 5, figs 1, 3-5, pl. 5, figs 3, 4, 6; 2001: p. 153, figs 30, 33; 2004: p. 40, pl. 3, fig. 8, pl. 4, fig. 1; 2007: p. 44, fig. 4e; Chirli, 2004: p. 16, pl. 6, figs 9-17; Garilli et al., 2005: p. 139, pl. 5, figs 1-3; Dell'Angelo & Vardala-Theodorou, 2006: p. 331, fig. 6; Koskeridou et al., 2009: p. 322, figs 11.3-11.8; Sosso & Dell'Angelo, 2010: p. 15, fig. p. 17.

Acanthochitona communis - Sabelli & Taviani, 1979: p. 160, pl. 1, figs 13-14.

Type

Neotype designated and figured by Kaas (1985: p. 588, fig. 1), MNHN, size 20 x 11 mm.

Type locality

Oran, Algerie.

Material examined

Altavilla s.s.: ORTO1: 2 intermediate valves, maximum width 2.5 mm; ORTO2: 10 valves (9 intermediate, maximum width 3 mm, and 1 tail, width 1.2 mm); KYLA3a: 15 valves (3 head, maximum width 4.3 mm, 11 intermediate, maximum width 5 mm, and 1 tail, width 2 mm) (AG, AR).

Remarks

Acanthochitona fascicularis is an extremely variable species (Dell'Angelo & Smriglio, 1999) with a very complicated synonymy (Kaas, 1985). It is characterized by the tegmentum uniformly covered with small roundish granules arranged along orderly arched lines on the valves, except for the jugal area, and by its flat or slightly concave surface.

The material examined is well enough preserved, and fully agree with descriptions and figures provided by Kaas (1985) and Dell'Angelo & Smriglio (1999).

This is the first report from Altavilla.

Distribution

Presently *A. fascicularis* occurs in the whole Mediterranean and in the Atlantic, from the British Channel and Brittany to the Azores and the Canary Islands (Dell'Angelo & Smriglio, 1999). It was reported from the Badenian of central-eastern Europe (Dell'Angelo et al., 2007), the Italian Tortonian (Montegibbio) and Messinian (Borelli) (Laghi, 1977; Dell'Angelo et al., 1999). It is widely recorded from the Mediterranean Plio-Pleistocene (Sabelli & Taviani, 1979; Dell'Angelo et al., 2001b, 2004; Garilli et al., 2005; Koskeridou et al., 2009).

***Acanthochitona crinita* (Pennant, 1777)
(Fig. 6C)**

Chiton crinitus Pennant, 1777: p. 71, pl. 36, figs 1, A1.

Acanthochitona crinita - Kaas, 1985: p. 588, figs 7-50; Dell'Angelo & Smriglio, 1999: p. 198, pls 66-68, figs 124-130 (bibliography and synonymy); Dell'Angelo et al., 1999: p. 275, pl. 5, figs 2, 6; 2001: p. 153, fig. 32; 2004: p. 40, pl. 4, figs 2, 5; Chirli, 2004: p. 16, pl. 6, figs 7-8; Koskeridou et al., 2009: p. 322, figs 11.1-11.2; Sosso & Dell'Angelo, 2010: p. 15, fig. p. 17.

Acanthochitona fascicularis - Laghi, 1977: p. 111, pl. 3, figs 20-21; Sabelli & Taviani, 1979: p. 160, pl. 1, fig. 15; Bařuk, 1984: p. 291, pl. 9, fig. 2.

Type

Neotype designated and figured by Kaas (1985: p. 591, fig. 27), RSMNH 1978.052.02601.

Type locality

Hebrides Islands, Monach Is., North Uist, 57°31.5' N, 07°38.5' W.

Material examined

Altavilla s.s.: KYLA3a: 1 intermediate valve, width 3.3 mm (AG, AR).

Remarks

Acanthochitona crinita shows a high degree of intraspecific variability (Kaas, 1985) and has a very complicated synonymy (Dell'Angelo & Smriglio, 1999). It is characterized by the tegmentum uniformly covered with oval to more or less elongated drop shaped granules. The material examined is very scarce, a single intermediate valve, but fairly well preserved, and fully agree with descriptions and figures provided by Dell'Angelo & Smriglio (1999). Compared with the neotype, our material shows less closely spaced granules and this difference is regarded as due to intraspecific variability. This is the first report from Altavilla.

Distribution

At present, *A. crinita* occurs in nearly the whole Mediterranean Sea, with scarce records from the African

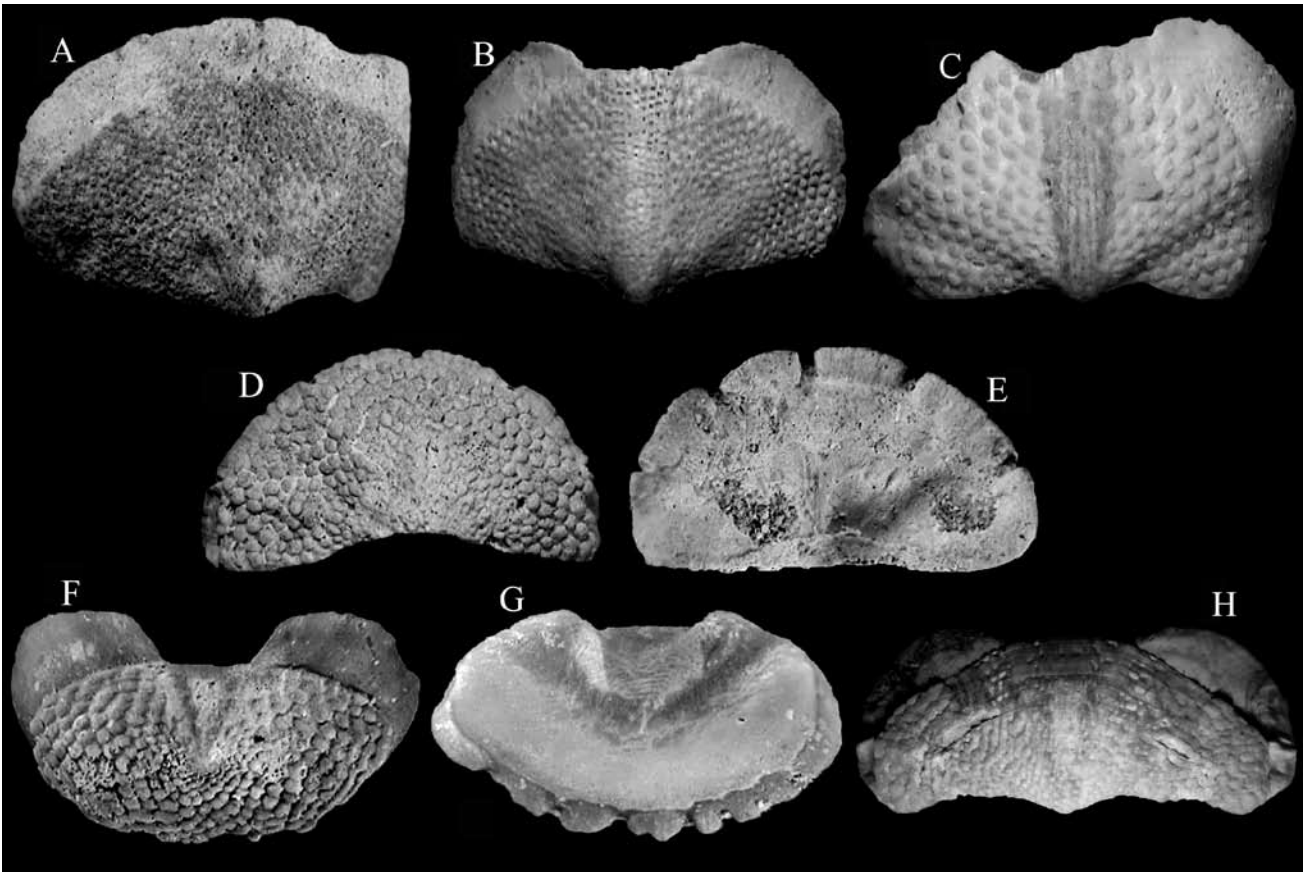


Fig. 6. A, B. *Acanthochitona fascicularis* (Linnaeus, 1767), Altavilla. **A.** Head valve, KYLA3a, dorsal view, width 4.3 mm. **B.** Intermediate valve, ORTO2, dorsal view, width 3 mm. **C.** *Acanthochitona crinita* (Pennant, 1777), Altavilla, intermediate valve, KYLA3a, dorsal view, width 3.3 mm. **D-H.** *Craspedochiton altavillensis* (Seguenza, 1876), Altavilla. **D, E.** Head valve, ORTO2, width 9 mm, dorsal and ventral views, respectively. **F, G.** Tail valve, ORTO2, width 8.6 mm, dorsal and ventral views, respectively. **H.** Intermediate valve, Altavilla s.s., with no information on the stratigraphic level, width 23 mm, dorsal view.

Fig. 6. A, B. *Acanthochitona fascicularis* (Linnaeus, 1767), Altavilla. **A.** Piastra anteriore, KYLA3a, vista dorsale, larghezza 4,3 mm. **B.** Piastra intermedia, ORTO2, vista dorsale, larghezza 3 mm. **C.** *Acanthochitona crinita* (Pennant, 1777), Altavilla, piastra intermedia, KYLA3a, vista dorsale, larghezza 3,3 mm. **D-H.** *Craspedochiton altavillensis* (Seguenza, 1876), Altavilla. **D, E.** Piastra anteriore, ORTO2, larghezza 9 mm, viste dorsale e ventrale. **F, G.** Piastra posteriore, ORTO2, larghezza 8,6 mm, viste dorsale e ventrale. **H.** Piastra intermedia, Altavilla s.s., senza informazioni stratigrafiche, larghezza 23 mm, vista dorsale.

coast, and along the Atlantic coasts of Europe (up to Norway) and North America. It is also known from Madeira, the Azores, the Canary Islands, and the Cape Verde Archipelago (Dell'Angelo & Palazzi, 1999). It has been reported from the Badenian of central-eastern Europe (Laghi, 1977; Bałuk, 1984), the Tortonian of Montegibbio and the Messinian of Borelli (Laghi, 1977; Dell'Angelo et al., 1999). It has also been found in many Pliocene and Pleistocene Italian sites (Sabelli & Taviani, 1979; Dell'Angelo et al., 2001b, 2004; Chirli, 2004), although less frequently than *A. fascicularis*, and from the Pleistocene of Greece (Koskeridou et al., 2009).

Genus *Craspedochiton* Shuttleworth, 1853

Craspedochiton Shuttleworth, 1853: p. 191. Type species: *Chiton laqueatus* Sowerby, 1841, by monotypy.

***Craspedochiton altavillensis* (Seguenza, 1876)
(Fig. 6D-H)**

Chiton altavillensis Seguenza, 1876: p. 264.

Craspedochiton altavillensis - Dell'Angelo & Palazzi, 1988: p. 174, fig. 1; Dell'Angelo et al., 1999: p. 276, pl. 6, figs 1, 2, 5

(bibliography and synonymy); 2001: p. 153, fig. 31; 2004: p. 40, pl. 2, figs 4, 7; Chirli, 2004: p. 17, pl. 6, fig. 18; Garilli et al., 2005: p. 140, pl. 5, figs 4-10; Sosso & Dell'Angelo, 2010: p. 15, fig. p. 17.

Chiton squamosus Libassi, 1859 (non Linnaeus, 1764): p. 14.

? *Chiton* sp. Seguenza, 1862: p. 11.

? *Chiton* (*Acanthochites*?) *pliocenicus* Brugnone MS, Tiberi, 1877: p. 159.

Gymnoplax deslongchampsii de Rochebrune, 1883: p. 69, pl. 3, fig. 6.

Type

Neotype (MZB 7062, a head valve) designated by Dell'Angelo & Palazzi (1988: fig. 1).

Type locality

Altavilla Milicia (Palermo, Sicily).

Material examined

Altavilla s.s.: 14 valves (3 head, maximum width 13.5 mm, 9 intermediate, maximum width 23 mm, and 2 tail,

maximum width 7 mm) (BD); Altavilla s.s.: ORTO1: 11 valves (2 head, maximum width 8.6 mm, 8 intermediate, maximum width 8 mm, and 1 tail, width 6 mm); ORTO2: 45 valves (7 head, maximum width 9 mm, 34 intermediate, maximum width 11.5 mm, and 4 tail, maximum width 8.6 mm); KYLA1: 3 intermediate valves, maximum width 7.5 mm; KYLA3: 2 intermediate valves, maximum width 7.2 mm; KYLA3a: 35 valves (7 head, maximum width 9.8 mm, 23 intermediate, maximum width 21 mm, and 5 tail, maximum width 6.5 mm) (AG, AR).

Remarks

The species is characterized by a tegmentum covered with large and elevated granules of irregular shape, except on the jugal area. The shape of the granules is highly variable, from single granules, regularly ellipsoidal, to coalescing granules fused to form true irregular cords, as the elevation and the density of granules on the tegmentum is also variable. The synonymy between *altavillensis* and *deslongchampsii* was discussed by Dell'Angelo & Palazzi (1988), who also designated a neotype after verifying the lack of type material of Seguenza and de Rochebrune. The material examined fully agrees with descriptions and figures provided by Dell'Angelo et al. (1999).

Chiton (*Acanthochites*?) *plioacaenicus* Brugnone MS, Tiberi, 1877 was described from Altavilla. The original description is somewhat difficult to be interpreted and contains a mention to *Chiton squamosus* Libassi, 1859 (non Linnaeus, 1764), which is a synonym of *Chiton altavillensis* (Dell'Angelo & Palazzi, 1988). The location of the type material is unknown, and Tiberi's species is tentatively kept as a synonym of *Craspedochiton altavillensis*.

Distribution

The species was reported from the Burdigalian of Turin hills, Badenian of central-eastern Europe, Tortonian of Montegibbio and Messinian of Borelli (Dell'Angelo et al., 1999). There are a few records from some Italian and Spanish Pliocene localities (Dell'Angelo et al., 2001b, 2004; Sosso & Dell'Angelo, 2010) and two reports from the Lower Pleistocene (Santerian of Torrente Stirone, Parma: Sabelli & Taviani, 1979, and Emilian of Dattilo, Trapani: Garilli et al., 2005). It is also recorded from Pleistocene deposits in Greece (Garilli et al., 2005).

Discussion

This is the first comprehensive and illustrated account of fossil chitons from the Pliocene of Altavilla (NW Sicily), and also the first work fully dedicated to chitons for the late Neogene of Sicily.

Chitons sourced from the Altavilla s.s. succession include 14 species, represented by 550 valves (Tab. 1). Most of the valves belong to *Stenosemus dolii* and *Craspedochiton altavillensis*, which represent 77.3 % of the total amount. Six species (*Leptochiton algesirensis*, *Leptochiton* sp., *Hanleya*

hanleyi, *Ischnochiton rissoi*, *Lepidochitona caprearum* and *Acanthochitona crinita*) are known from only three valves or less per species. *Craspedochiton altavillensis* is the only species found in all the studied samples.

Eight species are here reported for the first time in the Pliocene of Altavilla: *Leptochiton cancellatus*, *Hanleya hanleyi*, *Ischnochiton rissoi*, *I. martinelli*, *Callochiton septemvalvis*, *Lepidochitona caprearum*, *Acanthochitona fascicularis* and *A. crinita*.

With 14 species, the studied assemblage from Altavilla provides further evidence of the relatively high diversity of the polyplacophora assemblages in the Mediterranean Pliocene, after those recorded from the Early Pliocene of Estepona (Málaga, Spain, 18 species) (Dell'Angelo et al., 2004) and Pietrafitta (Siena, Italy, 16 species) (Dell'Angelo et al., 2001b).

The Altavilla chitons include European species that generally have a Neogene to Quaternary distribution (Tab. 2). Only the extant *Leptochiton algesirensis* dates back to late Paleogene (Oligocene), but with no Miocene record. Nine of the species found are still living in the Mediterranean Sea (of which 7 also occur in the eastern Atlantic), four are known only from the Mediterranean Pliocene (*Leptochiton* sp., *Ischnochiton anserinus*, *I. martinelli* and *Chiton* sp.), and only *Craspedochiton altavillensis* has a Miocene to Pleistocene distribution.

Among the nine living Mediterranean species found at Altavilla, *Leptochiton algesirensis* and *Lepidochitona caprearum* are typical infralittoral taxa; *Leptochiton cancellatus*, *Ischnochiton rissoi*, *Callochiton septemvalvis*, *Acanthochitona fascicularis* and *A. crinita* have a wider, meso-circalittoral bathymetric range (rarely deeper); *Hanleya hanleyi* usually lives in circalittoral to epibathyal bottoms (rarely shallower). This substantially agrees with the palaeoenvironmental reconstruction inferred from most of the Altavilla samples, suggesting lower infralittoral to circalittoral paleodepths, as indicated by the occurrence of species such as the bivalves *Flabellipecten flabelliformis*, *Lucinoma borealis*, *Pelecycora islandicoides*, and *Venus multilamella*, often with articulated valves and/or in life position. The only discordant occurrence seems that of *Stenosemus dolii*, a species living at bathyal depths in association with white corals. In spite of its modern distribution, this species is a common component in most of the studied chiton-assemblages (Tab. 1). The only occurrence which could match its present-day distribution could be that recorded in the lower part of the ATPA1 section (sample ORTO1), referred to lower circalittoral-epibathyal depths, as suggested by the occurrence of the scaphopod *Entalina tetragona*. In the lack of evidence of reworking from bathyal bottoms, a possible interpretation is that in the Pliocene *S. dolii* had a wider eco-bathymetric distribution than the present days.

Three intermediate valves encrusted, evidently post-mortem, by bryozoans were found. They are *Ischnochiton rissoi* from ORTO2 (with undetermined bryozoan on the articulamentum, Fig. 3H), *Stenosemus dolii* from KYLA3a (with a *Discoporella intermedia* colony on the tegmentum, Fig. 4J, K), and *Chiton* sp. from KYLA3a (with a *Schizomavella* sp. colony on the tegmentum, Fig. 5J, K).

Taxa	Altavilla s.s.	ORTO1	ORTO2	KYLA1	KYLA3	KYLA3a	Total
<i>Leptochiton cancellatus</i>	1		2		2	2	7
<i>Leptochiton algesirensis</i>	1						1
<i>Leptochiton</i> sp.	1						1
<i>Hanleya hanleyi</i>	1						1
<i>Ischnochiton rissoi</i>			1			2	3
<i>Ischnochiton anserinus</i>	2		2			5	9
<i>Ischnochiton martinelli</i>			7			17	24
<i>Stenosemus dolii</i>	8	4	56		2	245	315
<i>Callochiton septemvalvis</i>			1			4	5
<i>Chiton</i> sp.		2	7	1	1	33	44
<i>Lepidochitona caprearum</i>						2	2
<i>Acanthochitona fascicularis</i>		2	10			15	27
<i>Acanthochitona crinita</i>						1	1
<i>Craspedochiton altavillensis</i>	14	11	45	3	2	35	110
Total	28	19	131	4	7	361	550

Tab. 1. Number of valves found at Altavilla sections by samples/species.

Tab. 1. Numero di piastre rinvenute ad Altavilla per siti campionati/specie.

Taxa	Oligocene	Miocene	Pliocene	Pleistocene	Recent	
					Mediterranean	Atlantic
<i>Leptochiton cancellatus</i>		x	x	x	x	x
<i>Leptochiton algesirensis</i>	x		x	x	x	x
<i>Leptochiton</i> sp.			x			
<i>Hanleya hanleyi</i>		x	x	x	x	x
<i>Ischnochiton rissoi</i>		x	x	x	x	?
<i>Ischnochiton anserinus</i>			x			
<i>Ischnochiton martinelli</i>			x			
<i>Stenosemus dolii</i>		x	x	x	x	
<i>Callochiton septemvalvis</i>		x	x	x	x	x
<i>Chiton</i> sp.			x			
<i>Lepidochitona caprearum</i>		?	x	x	x	x
<i>Acanthochitona fascicularis</i>		x	x	x	x	x
<i>Acanthochitona crinita</i>		x	x	x	x	x
<i>Craspedochiton altavillensis</i>		x	x	x		

Tab. 2. Stratigraphic distribution of the species from the Altavilla s.s. succession.

Tab. 2. Distribuzione stratigrafica delle specie rinvenute ad Altavilla.

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