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NOTES ON FOSSIL CHITONS. 5. POLYPLACOPHORA FROM THE PLIOCENE OF WESTERN LIGURIA, NORTHWEST ITALY

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Abstract. This study describes the chiton fauna (Mollusca, Polyplacophora) from deposits of the Pliocene marine sequence of Western Liguria in northwestern Italy between Genova (Genoa) and Ventimiglia. The studied fossils consist of 9,657 valves from nine sites (Bussana, Rio Sant'Antonino, Garlenda, Salea, Caranchi, Rio Torsero, Zinola, Sestri Ponente, and Borzoli; see Fig. 1) taken from the lower clayey formation named Argille di Ortovero (Ortovero Clay). From these we identified 31 species, 22 of which were already known, 5 are identified only at generic level, and four are described as new: *Leptochiton josei* sp. n., *Ischnochiton ligusticus* sp. n., *Connexochiton roccai* sp. n., and *Lepidochitona pliocinerea* sp. n. Only three species (*Lepidopleurus cajetanus, Chiton corallinus* and *Acanthochitona fascicularis*) occur in all the studied sites but, even so, it is difficult to evaluate their relative prevalence. *Ch. corallinus* and *Lepidop. cajetanus* are most common, representing 46% and 31% respectively of the total valves found. Some species found are particularly noteworthy; *Lept. alveolus* previously not known as a fossil, except a dubiously identified record from the Eocene/Oligocene of Washington; *Lept. bedullii* and *I. martinelli* are known only from few Pliocene localities. Four species are described as new, and this increases the number of Mediterranean Pliocene determined species known to 37. *Connexochiton roccai* sp. n. represent the first report of *Connexochiton* as a fossil. Seventeen (55%) of the species found are still living in the Mediterranean Sea and 13 of these also occur in the eastern Atlantic. Only one species, *Lept. alveolus*, occurs as a living species in the Atlantic but is absent from the Mediterranean Sea. Five determined species are known only from Mediterranean Pliocene, and 12 are recorded for the first time from the Ligurian Pliocene. The analysis of the Ligurian samples suggests a shallow water depositional environment, possibly from lower infralittoral to circalittoral depth, and suggests a mixture of faunal elements from different depths and environments.

Riassunto. Sono discussi i chitoni (Mollusca, Polyplacophora) raccolti nei depositi pliocenici della Liguria occidentale tra Genova e Ventimiglia. Esaminando i detriti provenienti da nove località (Bussana, Rio Sant'Antonino, Garlenda, Salea, Caranchi, Rio Torsero, Zinola, Sestri Ponente e Borzoli; Fig. 1) e dagli strati argillosi della formazione delle "Argille di Ortovero", sono state isolate 9.657 piastre che sono risultate appartenere a 31 specie, di cui 22 già note, 5 determinate solo a livello di genere e 4 descritte e proposte come nuove: *Leptochiton josei* sp. n., *Ischnochiton ligusticus* sp. n., *Connexochiton roccai* sp. n. e *Lepidochitona pliocinerea* sp. n. Solamente 3 specie (*Lepidopleurus cajetanus, Chiton corallinus* e *Acanthochitona fascicularis*) sono risultate presenti in tutte le località; due di queste (*Ch. corallinus* e *Lepidop. cajetanus*) sono le specie più frequenti assommando, rispettivamente, il 46% e il 31% del totale delle piastre rinvenute. Particolarmente interessante, tra le specie reperite, la presenza di *Lept. alveolus*, specie mai rinvenuta allo stato fossile, se si eccettua una segnalazione non confermata dall'Eocene/Oligocene di Washington, e di *Lept. bedullii* e *I. martinelli,* segnalati solo sporadicamente da poche località plioceniche. Con le 4 nuove specie descritte, il numero di specie determinate relative al Pliocene del Mediterraneo sale a 37. *Connexochiton roccai* sp. n. rappresenta la prima segnalazione del genere *Connexochiton* allo stato fossile. Diciassette delle specie rinvenute (55%) sono ancora viventi nel Mediterraneo e 13 di queste sono presenti anche lungo le coste atlantiche europee. Solo una specie, *Lept. alveolus*, vive nell'Atlantico ma è assente in Mediterraneo. Cinque specie sono conosciute solo per il Pliocene del Mediterraneo (oltre alle altre 5 specie determinate solo a livello di genere), mentre 12 specie sono segnalate per la prima volta per il Pliocene della Liguria. L'analisi dei campioni sembra indicare paleoambienti di bassa profondità, probabilmente dall'infralitorale inferiore al circalitorale, con un quadro faunistico commisto, come sembrerebbe suggerire la presenza di elementi faunistici provenienti da profondità ed habitat diversi.

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Introduction

The Pliocene marine sequence of Western Liguria, between Genova and Ventimiglia, has been well known since the 19th century (Sasso 1827; Pareto 1846; Issel 1877, 1892; Squinabol 1887; Della Campana 1890; Arduini 1895), and several contributions emphasised fossil assemblages of molluscs (Bellardi & Sacco 1873-1904; Hornung 1920, 1923, 1927; Robba & Ostinelli 1975, 1976; Robba 1978, 1981, 1990; Bernasconi 1981, 1989; Bernasconi & Robba 1984, 1994; Andri et al. 2005; Sosso & Dell'Angelo 2010). Despite this molluscan emphasis, Polyplacophora (chitons) have received much less attention (Laghi 1977; Zanaroli 1985; Dell'Angelo & Palazzi 1989; Dell'Angelo & Forli 1995a; Sosso & Dell'Angelo 2010). Even Sacco (1897), in his monumental "I molluschi dei terreni terziarii del Piemonte e della Liguria", gives only scant attention to chitons, with only two species recorded from the Pliocene of Zinola (Savona). The present study is based on the accumulated collection of a very large number of valves from nine Ligurian localities, and this has allowed us to better compare chitons to other studied molluscan groups.

Material and methods

The Pliocene marine sequence of Western Liguria consists of a lower clayey formation Ortovero Clay, which is overlain by the Monte Villa Conglomerate (Bernasconi & Robba 1984; Robba 1990). The Pliocene rocks are restricted to the coastal area, extending landward for only a few kilometres. All the localities considered here refer to the Ortovero Clay, and these are listed below from west to east (Fig. 1).

1) Bussana (Imperia)

A small gully southwest of Bussana Vecchia (43°49'60"N, 7°49'52"E), gray, clayey silt belonging to the Ortovero Clay, referred to late Zanclean to early Piacenzian (Boni & Peloso 1973; Crovato 1988). The section corresponding to the samples studied herein has a classic gully morphology, typical of the clayey outcrops of western Liguria, with more than 10 m of vertical development. The locality is already well-known for its rich molluscan fauna (Crovato 1988; Crovato & Micali 1993; Forli et al. 2009; Sosso et al. 2009).

2) Rio Sant'Antonino (Savona)

The outcrop of Rio Sant'Antonino (44°04'14"N, 08°07'44"E) is located on the right bank along the homonymous stream at 1 km from Cava Zunino (Robba & Ostinelli 1975), a former quarry near the chapel of Sant'Antonino. This outcrop was easily accessible during the years 1980-1990, but is now covered by shrubs (July 2010, MS).

In the upper part of the outcrop a wide section was uncovered, made of different size pebbles, sometimes rounded, piled up to 60-80 cm. In the interstices and chinks among rocks there were clay deposits, yellowish sand, small pebbles, and the chitons examinated in this research, along with a great number of other mostly small molluscs, foraminifera, and otoliths. This studied section slopes upon the Ortovero Clay, which is 10 m thick, and rests upon the Albenga Formation; the contact with the overlying Monte Villa Conglomerate is not well exposed.

3) Garlenda (Savona)

This locality (44°02'23"N, 08°07'05"E) is mentioned as the near quarries of Villanova 1 and Villanova 2 (Robba & Ostinelli 1975); it is located on the right along the road from Villanova to Garlenda, in quarries no longer active. It is the lowest outcrop of the Albenga basin (40 m above sea level) composed of gray silty clay (Ortovero Clay) of Zanclean age (Robba 1990; Pedriali & Robba 2005).

4) Salea (Savona)

A small former quarry (44°05'06"N, 08°10'47"E) close to the village of Salea (Savona); the age is late Zanclean to early Piacenzian (Bernasconi & Robba 1984).

5) Caranchi (Savona)

The outcrop (44°05'21"N, 08°12'11"E), presently hidden by a landslide and by urbanization (July 2010, MS), was located on the right side of the stream Rio Torsero, along a narrow gully, about 0.4 km from Casa Bruno and Rio Torsero. The gray silty clay belongs to the Ortovero Clay; the age is MPL 4 (foraminiferal biozone, see Rio & Sprovieri 1986), i.e. early Piacenzian (Violanti 1987; Bernasconi & Robba 1994; Pedriali & Robba 2005).

6) Rio Torsero (Savona)

This locality (44°05'31"N, 08°12'41"E) is long well known for its very rich mollusc fauna (Bellardi 1877; Arduini 1895; Hornung 1920, 1923, 1927; Bernasconi 1981; Sosso & Dell'Angelo 2010). The outcrop occupies both banks of the Torsero stream, just under the A10 highway bridge, southwest of the village of Ceriale near Albenga. The section exposes 8.50 m of light gray, very sandy, clayey silt forming the uppermost part of the Ortovero Clay. The clayey silt preserves planktonic foraminiferal assemblages indicating a MPL3 to MPL4,

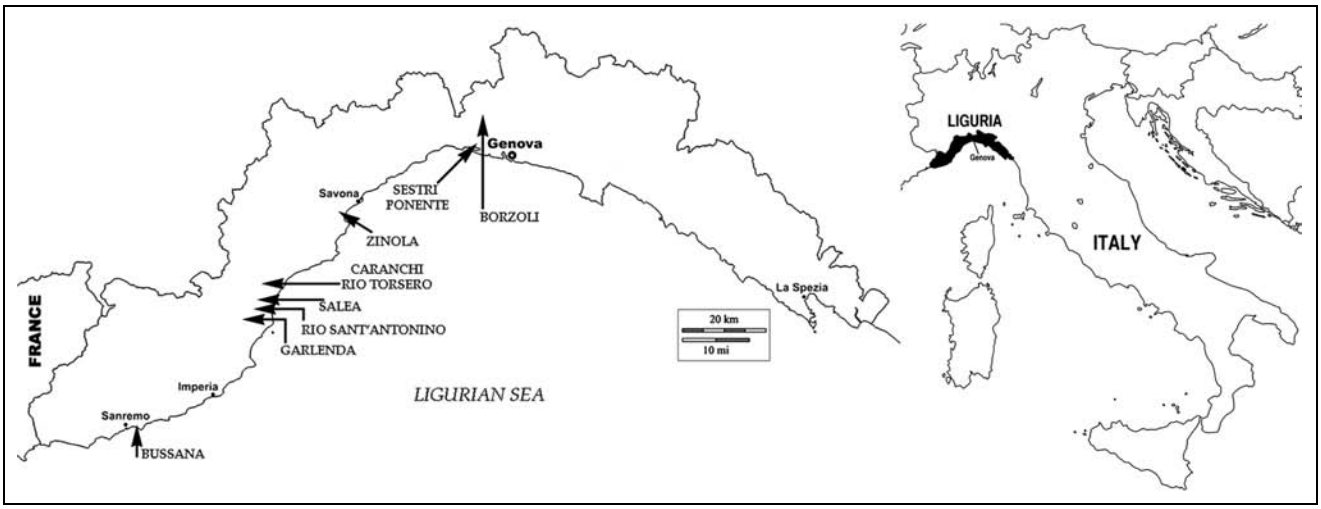


Fig. 1 - Location map.

i.e. a late Zanclean to early Piacenzian age (Violanti 1987; Bernasconi & Robba 1994; Pedriali & Robba 2009).

7) Zinola (Savona)

Another classic locality (44°17'38"N, 08°26'22"E), located between Savona and Vado Ligure. It is presently reduced to a small site along the border of the Savona – Cadibona motorway about 1 km south of Madonna del Monte (Savona), with filling material from the classic locality (Sosso 1999). The age is late Zanclean to early Piacenzian (Bernasconi & Robba 1984; Bernasconi 1989).

8) Sestri Ponente (Genova)

The site (44°25'33"N, 08°50'53"E) lies at Sestri Ponente. Samples of clayey silt were taken during the construction of parking areas for Piazza Oriani and the "Stabilimento Ospedaliero P. A. Micone" and for a building on Canepa Boulevard. These three sampling areas are about 200 m apart from each other. The age of this site is comparable with Borzoli (below; Razzore 1892).

9) Borzoli (Genova)

Another well known locality (44°25'53"N, 08°51'34"E) lies north of Sestri Ponente (Della Campana 1890; Razzore 1892). According to Giammarino & Tedeschi (1980), the mainly pelitic sequence contains the transition between foraminiferal biozones MPL3 and MPL4, Zanclean – lower Pliocene. A lower circalittoral environment, about 200 m depth, is indicated for the deposition of this layer (Marini 1977; Bernasconi & Robba 1984).

Large amounts of bulk sediment were collected by the authors (MS, MP) and Giuseppe Priora between 1980 and 2000, especially in outcrops no longer accessible, and this material is the basis of the present work. The material was successively washed in sieves (diameter 0.5, 1.0, 2.0 mm), and the material retained in the 1.0 mm and 2.0 mm fractions were then examined for chiton valves using a stereomicroscope. A JEOL model JSM-5200 scanning electron microscope (SEM) at the Zoological Museum, Bologna University, was used for examination of valve sculpture.

The maximum width of the valves (head, intermediate, and tail) of each species is given. Many valves are incomplete, or are only small fragments, but the maximum width (maximum right-left dimension perpendicular to the longitudinal body axis) is given always for complete valves. There are only two exceptions relating to species known from a unique incomplete valve (*Leptochiton alveolus* and *Lept. scabridus*).

All the figured material is deposited at MZB, where the BD collection will be deposited, too.

Fossil valves from chitons from Ligurian sites are not present in the collections of the Museo Civico di Storia Naturale, Genova, Italy.

The following abbreviations are used:

AL A. Lugli private Collection, Carpi, Modena, Italy.
BD B. Dell'Angelo Collection, Genova, Italy (will be deposited in MZB).
BS Bellardi & Sacco Collection, Museo di Geologia e Paleontologia, Università di Torino (now stored at the Museo Regionale di Scienze Naturali di Torino), Italy.
FG F. Giovine private Collection, Villa San Giovanni, Reggio Calabria, Italy.
IRSN Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium.
K P. Kaas Collection, now in RMNH, Leiden, The Netherlands.
LSL The Linnean Society of London, London, United Kingdom.
MCZR Museo Civico di Zoologia, Roma, Italy.
MGR Museo di Geologia, Roma, Italy.
MME Museo Municipal de Estepona, Spain.
MNHN Muséum National d'Histoire Naturelle, Paris, France.
MP M. Prudenza - G. Priora private Collection, Milano, Italy.
MS M. Sosso private Collection, Genova, Italy.
MSNG Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy.
MSNP Museo di Storia Naturale, Parma, Italy.
MU Malta University, Malta.
MZB Zoological Museum of Bologna University, Bologna, Italy.
NHMUK The Natural History Museum [formerly British Museum (Natural History)], London, United Kingdom.
NRS Naturhistoriska Riksmuseet, Stockholm, Sweden.
PG P. Giuntelli private Collection, Genova, Italy.
PU Museo di Geologia e Paleontologia, Università di Torino, Italy.
RA R. Ardovini private Collection, Roma, Italy.
RM R. Marquet Collection, Antwerp (Belgium), to be transferred to IRSN, Brussels.
RMNH Nationaal Natuurhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie), Leiden, The Netherlands.
RSMNH Royal Scottish Museum of Natural History, Edinburgh, United Kingdom.
SR S. Raimondi private Collection, Genova, Italy.
USNM U.S. National Museum of Natural History, Washington (D. C.), USA.
VB R. A. Van Belle Collection, now in IRSN, Brussels, Belgium.
WEM Wood End Museum of Natural History, Scarborough, England.
ZMHU Zoologisches Museum an der Humboldt Universität, Berlin.

Previous records of chitons from the Ligurian Pliocene

Few chiton species were previously recorded from Western Liguria. Sacco (1897) recorded only two species from the Ligurian Pliocene, both from Zinola (Savona): *Lepidopleurus cajetanus* (Poli, 1791), and *Chiton olivaceus* var. *plioparva* Sacco, 1897, the latter has been attributed to either *Ch. corallinus* (Risso, 1826) or *Stenosemus dolii* (Van Belle & Dell'Angelo, 1998) by Laghi (1977). Sacco (1897) attributed all the Pliocene valves of *Chiton* to *Ch. olivaceus* var. *plioparva,* and the Miocene ones to *Ch. miocenicus* Michelotti, 1847; he did not consider any to be *Ch. corallinus*.

Sosso & Dell'Angelo (2010) reported and illustrated 11 species from Rio Torsero: *Lepidopleurus cajetanus, Leptochiton cancellatus* (Sowerby, 1840), *Ischnochiton rissoi* (Payraudeau, 1826), *I. ulivii* Dell'Angelo & Forli, 1996, *Rhyssoplax corallinus, R. olivaceus* (Spengler, 1797), *Lepidochitona cinerea* (Linnaeus, 1767), *Lepidoc. monterosatoi* Kaas & Van Belle 1981, *Acanthochitona fascicularis* (Linnaeus, 1767), *A. crinita* (Pennant, 1777) and *Craspedochiton altavillensis* (Seguenza, 1876). Their specimens attributed to *I. ulivii* are recognised here as a new species, *I. ligusticus* sp. n.

The only other records, to our knowlege, of species from the Ligurian Pliocene are:

– *Lepidopleurus cajetanus* from Borzoli (Dell'Angelo & Palazzi 1989: 47) and from Zinola (Laghi 1977: 93; Zanaroli 1985);

– *Chiton corallinus* from Zinola (Laghi 1977: 93; Zanaroli 1985; Sosso 1999: 134);

– *Chiton miocenicus* from Borzoli (Dell'Angelo & Forli 1995b: 78: as *C. saeniensis* Laghi, 1984);

– *Lepidochitona caprearum* (Scacchi, 1836) from Rio Sant'Antonino (Dell'Angelo & Forli 1995b: 229; Dell'Angelo & Smriglio 1999; Dell'Angelo et al. 2001b: 148).

– *Stenosemus dolii* from Zinola [Laghi 1977: 93; Zanaroli 1985: as *Lepidozona dorsuosa* (Haddon, 1886)].

Systematics

We follow the systematic classification proposed by Sirenko (2006). Since many of the Mediterranean basin chiton species discussed have been described in detail in other recent publications (e.g. Laghi 1977; Dell'Angelo et al. 1999, 2001b, 2004; Dell'Angelo & Smriglio 1999; Garilli et al. 2005), only short synonymy (related to fossil taxa), some comments and stratigraphic ranges are given below. The geographic range and habitat of present-day species were described in a monograph series by Kaas & Van Belle (1985a, 1985b, 1987, 1990, 1994) and Kaas et al. (2006), as well as by Dell'Angelo & Smriglio (1999). The bibliographic references reported for each described species include only papers with reports of fossils, except where the species is originally described from Recent material, in which cases we include the original description, and updated complete descriptions of the species characteristics (but exclude additional occurrences or reports in the literature of Recent spcecimens).

Class **Polyplacophora** Gray, 1821

Subclass **Loricata** Shumacher, 1817

Order **Lepidopleurida** Thiele, 1909

Suborder **Lepidopleurina** Thiele, 1909

Family Leptochitonidae Dall, 1889

Genus *Lepidopleurus* Risso, 1826

Type species: *Chiton cajetanus* Poli, 1791, by subsequent designation (Herrmannsen 1846). Non: *Lepidopleurus* (Carpenter MS) Dall, 1879 (= *Lepidozona* Pilsbry, 1892).

Remarks. The genus is known from Eocene to Recent.

Lepidopleurus cajetanus (Poli, 1791)

Pl. 1, figs A-M

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 38).

1791 *Chiton cajetanus* Poli, p. 10, pl. 4, figs 1-2.

1818 *Chiton foliatus* Allan, p. 459.

1860 *Chiton decoratus* Reuss, p. 257, pl. 8, fig. 7.

1897 *Lepidopleurus cajetanus* - Sacco, p. 90, pl. 7, figs 26-31.

1934 *Lepidopleurus* (*Lepidopleurus*) *decoratus* Šulc, p. 3.

1965 *Lepidopleurus decoratus* - Bałuk, p. 366, pl. 1, figs 1-4.

1971 *Lepidopleurus decoratus* - Bałuk, p. 453, pl. 1, figs 1-4.

1977 *Lepidopleurus cajetanus* - Laghi, p. 95, pl. 1, figs 13-20.

1984 *Lepidopleurus cajetanus* - Bałuk, p. 284, pl. 4, figs 1-2.

1984 *Lepidopleurus cajetanus* - Ferrero Mortara et al., p. 299.

1985 *Lepidopleurus cajetanus* - Zanaroli, p. 5.

1988 *Lepidopleurus cajetanus* - Macioszczyk, p. 50, pl. 1, figs 1-5.

1988 *Lepidopleurus cajetanus* - Studencka & Studencki, p. 39, pl. 1, figs 1-3.

1989 *Lepidopleurus* (*Lepidopleurus*) *cajetanus* - Dell'Angelo & Palazzi, p. 45, pls 1-2.

1999 *Lepidopleurus* (*Lepidopleurus*) *cajetanus* - Dell'Angelo & Smriglio, p. 38, figs 10-15, pls 6-7.

2003 *Lepidopleurus cajetanus* - Kroh, p. 131, pl. 1, fig. 1, pl. 2, figs 2-3.

2004 *Lepidopleurus cajetanus* - Chirli, p. 4, pl. 1, figs 9-15.

2004 *Lepidopleurus* (*Lepidopleurus*) *cajetanus* - Dell'Angelo et al., p. 26, pl. 7, figs 4, 8.

2005 *Lepidopleurus* (*Lepidopleurus*) *cajetanus* - Dulai, p. 30, pl. 1, figs 1-10, pl. 2, figs 1-6.

2005 *Lepidopleurus* (*Lepidopleurus*) *cajetanus* - Garilli et al., p. 129, pl. 1, figs 1-2.

2009 *Lepidopleurus cajetanus* - Koskeridou et al., p. 305, figs 7.1-7.3.

2010 *Lepidopleurus cajetanus* - Sosso & Dell'Angelo, p. 14, fig. p. 16.

2010 *Lepidopleurus cajetanus* - Studencka & Dulai, p. 261, text-figs 3A-G.

Type material: Probably lost. Iconolectotype designated by Dell'Angelo & Palazzi (1989), specimen figured by Poli (1791: pl. 4, fig. 1).

Type locality: Gaeta (Latina prov.), Tyrrhenian Sea (41°12'53"N, 13°34'35"E).

Material examined: Bussana: 221 valves (41 head, 135 intermediate, and 45 tail) (BD, PG, SR); Rio Sant'Antonino: 2,282 valves (361 head, 1,329 intermediate, and 592 tail) (BD, MP, PG); Garlenda: 67

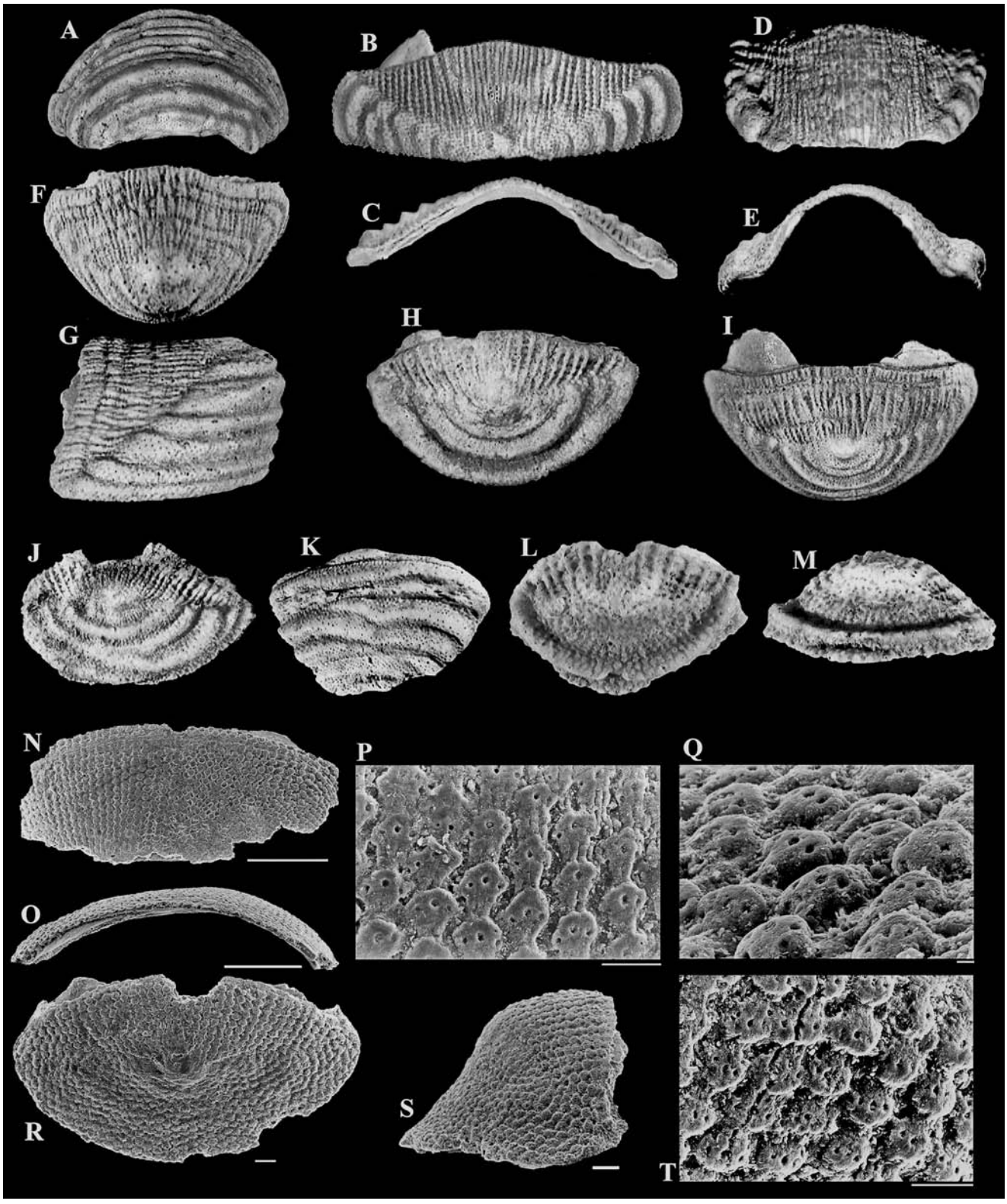
PLATE 1

Figs A-M - *Lepidopleurus cajetanus* (Poli, 1791).
A, Bussana, head valve, MZB 45690, width 4.5 mm, dorsal view. B-C, Bussana, intermediate valve, MZB 45691, width 5.3 mm, dorsal and frontal views, respectively. D-E, Borzoli, intermediate valve, MZB 45692, width 5.2 mm, dorsal and frontal views, respectively, valve with the starting point of concentric ribs in lateral areas neighbouring the lateral margin, and not near the apex, as in valve of Figure 2B. F-I, tail valves. F-G, Rio Sant'Antonino, MZB 45693, width 6.2 mm, dorsal and lateral views, respectively, final ontogenetic postlarval stage. H, Rio Sant'Antonino, MZB 45694, width 3 mm, dorsal view, first ontogenetic postlarval stage. I, Bussana, MZB 45695, width 5.4 mm, dorsal view, second ontogenetic postlarval stage. J-M, anomalous valves. J-K, valves with the concentric, terraced ribs partially overlapping one upon another in an irregular way. J, Rio Sant'Antonino, tail valve, MZB 45696, width 4 mm. K, Bussana, head valve, MZB 45697, width 3.6 mm. L-M, Bussana, tail valve, MZB 45698, width 1.7 mm, dorsal and posterior views, respectively, with a prominent concentric rib on the postmucronal area, adjacent to the posterior margin.
Figs N-T - *Leptochiton cancellatus* (Sowerby, 1840), Rio Sant'Antonino.
N-Q, intermediate valve, MZB 45699. N-O, dorsal and frontal views, respectively. P, detail of the sculpture of the central area, granules in the longitudinal chains. Q, the same, by a lateral view. R-T, tail valve, MZB 45700. R-S, dorsal and lateral views, respectively. T, detail of the sculpture of the central area.
Scale bars 500 μm: N, O; 100 μm: R, S; 50 μm: P, T; 10 μm: Q.

valves (10 head, 37 intermediate, and 20 tail) (MP); Salea: 1 intermediate valve (BD); Caranchi: 5 intermediate valves (MP); Rio Torsero: 2 intermediate valves (BD, MP); Zinola: 13 valves (1 head, 7 intermediate, and 5 tail) (BD); Sestri Ponente: 13 valves (9 intermediate, and 4 tail) (BD); Borzoli: 381 valves (47 head, 243 intermediate, and 91 tail) (BD).

Remarks. The species is characterized by a tegmentum sculptured with strong, concentric, terraced ribs on the head valve, lateral areas of intermediate valves and postmucronal area of the tail valve. Additionally there are branching or anastomosing longitudinal chains of granules in the central area of intermediate valves and antemucronal area of the tail valve. Detailed descriptions of this species are given by Dell'Angelo & Smriglio (1999) and Dulai (2005).

The species has remarkable variations in morphology when young. Laghi (1977: fig. 3a-b) illustrated



how in tail valves the mucro is almost central in juvenile specimens but moves backward (even to the end of the valve) as individuals grew older, due to the bending of the posterior area on the ventral side. The first postlarval stage of juvenile *Lepidopleurus cajetanus* is characterized by a leptochitonid-like sculpture, i.e. with small cords of tubercles but without the presence of "steps" on the valves and with the mucro anterior or pre-central (Pl. 1, fig. H). Later, the typical sculpture of "steps" appears on the valves, but the mucro is still subcentral and the small cords of tubercles are not canceled (Pl. 1, fig. I). Then, in the final stage, the small cords are almost indistinguishable in the "step" zone, while the mucro is situated more posteriorly and the outline is more triangular (Pl. 1, figs F-G). These features are also well figured by Dulai (2005: pl. 2, figs 1, 3-4) in valves of *Lepidopleurus cajetanus* from Middle Miocene (Badenian) of Hungary.

Some intermediate valves from Rio Sant'Antonino show variability in the sculpture of the lateral areas, with the starting point of the concentric ribs neighbouring the lateral margin (Pl. 1, fig. D) and not near the apex, as in normal valves (Pl. 1, fig. B). Consequently, the frontal view of the intermediate valves is also different (compare Pl. 1, fig. C, normal valve, and fig. E). The longitudinal ribs in the central and antemucronal areas run more or less parallel to each other, but sometimes two ribs fuse together or intercalating ribs appear between them, and the pattern seem very irregular (Pl. 1, fig. I; Dulai 2005: pl. 1, fig. 5).

Many valves of this species were found in our material, 2,985 valves in total, of which 76% (n= 2,282) are from the Rio Sant'Antonino outcrop. Elsewhere this species is rather uncommon as a fossil despite the robustness of its valves and the fact that it is locally abundant and common as a living species (Dell'Angelo et al. 2004: p. 26).

Some anomalous valves have been found:

– one tail valve from Bussana with a very prominent concentric rib on the postmucronal area, adjacent to the posterior margin, giving a peculiar look to the valve (Pl. 1, figs L-M);

– one tail valve from Rio Sant'Antonino with the concentric, terraced ribs of the postmucronal area partially overlapping one upon another in an irregular way (Pl. 1, fig. J); the same anomaly is present in one head valve from Bussana (Pl. 1, fig. K);

– one tail valve from Borzoli, with an injury on the postmucronal area, resulting in a lack of terraced ribs but with continuous sculpturing.

Distribution. Middle Miocene: Badenian of Central Paratethys, Austria, Czech Republic, Poland, Romania, Hungary, Ukraina (Dulai 2005; Dell'Angelo et al. 2007; Studencka & Dulai 2010). Late Miocene: Italy (Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Spain (Dell'Angelo et al. 2004), and Italy (Laghi 1977; Dell'Angelo et al. 2001b; Chirli 2004; Sosso & Dell'Angelo 2010; this paper). Pleistocene: Italy (Sabelli & Taviani 1979), Greece and Cyprus (Garilli et al. 2005; Koskeridou et al. 2009). Recent: Atlantic Ocean, from Spain and Portugal south to Morocco and Canary Islands; Mediterranean (Dell'Angelo & Smriglio 1999).

Genus *Leptochiton* Gray, 1847

Type species: *Chiton cinereus* Montagu, 1803 (misapplication of name), by subsequent designation (Gray 1847a), non Linnaeus, 1767 (= *Chiton asellus* Gmelin, 1791).

Remarks. The genus is known from the Paleocene to the Recent.

Leptochiton cancellatus (Sowerby, 1840)

Pl. 1, figs N-T

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 48).

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

1934 *Lepidopleurus* cf. *cancellatus* - Šulc, p. 6 (fide Bałuk 1971).

1962 *Lepidopleurus* (*L.*) *cancellatus* - Malatesta, p. 147, figs 3-4.

1977 *Lepidopleurus cancellatus* (*non* Sowerby, 1840) - Laghi, p. 98, pl. 1, figs 1-3 [= *Leptochiton scabridus* (Jeffreys, 1880): Dell'Angelo & Palazzi 1989: p. 61].

1988 *Leptochiton* (*L.*) *sulci* (*non* Bałuk, 1971) - Studencka & Studencki, p. 45 (fide Studencka & Dulai 2010: p. 261).

1999 *Lepidopleurus* (*Leptochiton*) *cancellatus* - Dell'Angelo & Smriglio, p. 48, pls 10-11, figs 18-19.

2001b *Lepidopleurus* (*Leptochiton*) *cancellatus* - Dell'Angelo et al., p. 146, fig. 5.

2002 *Lepidopleurus* (*Leptochiton*) *cancellatus* - Marquet, p. 12, pl. 2, fig. 1.

2003 *Lepidopleurus* (*Leptochiton*) *cancellatus* - Dell'Angelo & Silva, p. 9, figs 3-4.

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

2010 *Leptochiton cancellatus* - Sosso & Dell'Angelo, p. 14, fig. p. 16.

2010 *Leptochiton cancellatus* - Studencka & Dulai, p. 260, figs 2 A-D.

Type material: Lost (fide Kaas & Van Belle 1985a: p. 43).

Type locality: ? coast of Great Britain, probably Oban, Scotland (56°24'46"N, 5°28'24"W) (fide Kaas & Van Belle 1985a: p. 43).

Material examined: Bussana: 1 intermediate valve (BD); Rio Sant'Antonino: 16 valves (13 intermediate, and 3 tail) (MP); Caranchi: 2 intermediate valves (MP); Rio Torsero: 1 intermediate valve (BD); Sestri Ponente: 1 tail valve (BD); Borzoli: 5 intermediate valves (BD).

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 in the central area of the intermediate valves and the antemucronal area of the tail valve, with

reduced intercostal spaces. Detailed descriptions of this species are given by Kaas & Van Belle (1985a) and Dell'Angelo & Smriglio.

Leptochiton sulci (Bałuk, 1971) is a very similar species described from the Middle Miocene (Early Badenian) of the Paratethys (Poland: Korytnica). It was considered conspecific with *Lept. cancellatus* by Laghi (1977), Dell'Angelo & Palazzi (1989), Dell'Angelo & Smriglio (1999) and Dell'Angelo & Silva (2003). However the two taxa showing differences discernable: in *Lept. sulci* the granules are less dense, longitudinally arranged and joined by a narrow ridge, whereas in *Lept. cancellatus* they lay partially one upon the other; they differ also in the number and arrangement of the aesthetes: in *Lept. cancellatus* each granule has a central macroaesthate with six lateral microaesthetes whereas there are only two to three lateral microaesthetes in *Lept. sulci*. So, we consider the two species as different, following Bałuk (1971, 1984) and Studencka & Dulai (2010).

The valves of most members of the genus *Leptochiton* are small, fragile and very difficult to find, so additional material will be required to better understand the relationships among the European Miocene *Leptochiton*, considering also that the Ukrainian findings of *Lept. cancellatus* reported by Studencka & Dulai (2010) considerably extend the distribution of this species.

Distribution. Middle Miocene: Badenian of Central Paratethys, Austria (Šulc 1934) and Ukraine (Studencka & Dulai 2010). Pliocene: scarce records from Portugal (Dell'Angelo & Silva 2003), Italy (Dell'Angelo & Palazzi 1989; Dell'Angelo et al. 2001b; Sosso & Dell'Angelo 2010; this paper), Belgium (Marquet 2002). Pleistocene: Sweden and Norway (Dell'Angelo & Palazzi 1989; Dell'Angelo & Smriglio 1999), not recorded from Mediterranean area. Recent: Atlantic Ocean, Britain and Ireland and the coast of France, Spain and Portugal; Mediterranean (Dell'Angelo & Smriglio 1999).

Leptochiton alveolus (M. Sars in Lovén, 1846)

Pl. 2, figs A-D

1846 *Chiton alveolus* M. Sars *in* Lovén, p. 159.

1981 *Leptochiton alveolus* - Kaas, p. 223, figs 8, 10A-B.

1984 *Leptochiton alveolus* - Wu & Okutani, p. 6, pl. 1, figs 3-4, pl. 3, figs 9-14, pl. 4, fig. 1, pl. 5, figs 1-4.

1987 *Leptochiton alveolus* - Kaas & Van Belle, p. 25.

2005 *Leptochiton alveolus* - Dell'Angelo & Bonfitto, p. 5, figs 13-16.

2010 *Leptochiton alveolus* - Schwabe & Sellanes, p. 51.

Type material: NRS, type collection n. 104, one specimen in alcohol, the valves missing (lectotype, designed by Kaas 1981: p. 223).

Type locality: Bohuslän (Sweden), 58°17'41"N, 11°12'58"E.

Material examined: Zinola: 1 intermediate valve, incomplete, width 2.9 mm (BD).

Remarks. The species is characterized by the tegmentum covered with pronounced, neatly separated, rounded to oval granules, more or less distinctly quincuncially arranged on all the valves surface, the lateral areas indiscernible from the central areas, and arched intermediate valves. Detailed descriptions of this species were given by Kaas (1981) and Wu & Okutani (1984).

The characters of the single valve available are sufficient to identify the species with certainty (compare with the photos of a single intermediate valve from Sula Ridge, Norway, dredged at 215 m, Pl. 2, fig. D, and with more details in Dell'Angelo & Bonfitto 2005, figs 13-16).

Other species with the same kind of tegmentum sculpture, fully covered with randomly or quincuncially arranged granules, are *Leptochiton tavianii* Dell'Angelo, Landau & Marquet, 2004 from the Pliocene of Estepona (Spain), where, however, the granules are characterized by a fungiform section and are arranged in a beehive structure, and *Lept. salicensis* Dell'Angelo & Bonfitto, 2005 from the Pleistocene of Salice (South Italy), with more solid and dissimilar intermediate valves, and granules that are more polygonal.

The systematic history of this species is rather complex, and the number of synonyms is very high (Kaas 1981). The species was initially considered cosmopolitan, living in the Atlantic, Pacific and Indian Oceans. The geographic distribution of the synonymous species indicated that *Lept. alveolus* seems to be restricted to the Atlantic Ocean, while *Lept. belknapi* Dall, 1878 is confined to the Pacific and Indian Oceans (Wu & Okutani 1984). Other material reported for this species from the Olympic Peninsula, Washington, USA (Goedert & Campbell 1995; Squires & Goedert 1995), is not conspecific with the present specimen but may be *L. belknapi* (Schwabe & Sellanes 2010).

Distribution. Pliocene: Italy, Liguria (this paper). Recent: North Atlantic (Wu & Okutani 1984).

Leptochiton scabridus (Jeffreys, 1880)

Pl. 2, figs E-G

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 63).

1880 *Chiton scabridus* Jeffreys, p. 33.

1977 *Lepidopleurus cancellatus* (*non* Sowerby 1840) - Laghi, pl. 1, figs 1-3 (fide Dell'Angelo & Palazzi 1989).

1989 *Lepidopleurus* (*Leptochiton*) *scabridus* - Dell'Angelo & Palazzi, p. 65, pls 16-17.

1999 *Lepidopleurus* (*Leptochiton*) *scabridus* - Dell'Angelo & Smriglio, p. 63, figs 25-26, pls 16-17.

2005 *Lepidopleurus* (*Leptochiton*) *scabridus* - Garilli et al., p. 130, pl. 2, figs 1-4.

Type material: Syntypes: 1 specimen, Goodrington, Torbay (USNM 177391); 15 specimens, Jersey (USNM 177392) (fide Warén 1980).

Type locality: Goodrington, Torbay, England (50°24'59"N, 3°33'14"W); and Jersey (Channel Islands).

Material examined: Sestri Ponente: 1 intermediate valve, incomplete, width 1.7 mm (BD).

Remarks. The species is characterized by the rather irregular granules sculpturing the tegmentum, of subquadrangular/subrhomboidal shape and well separated from each other, arranged in radial series on the head valve, the lateral areas of intermediate valves and the postmucronal area of the tail valve; these granules are in longitudinal series in the central area of the intermediate valves and the antemucronal area of the tail valve, where they make a square mesh. The tegmentum presents a rough surface, on which the granules are extended into a body usually formed by two or three longitudinal varices that become unified or merge together along the external margin of the valve (Pl. 2, fig. F). Detailed descriptions of this species are given by Kaas & Van Belle (1985a) and Dell'Angelo & Smriglio (1999).

The single intermediate valve is incomplete and not in very good condition. The characteristics are sufficient to identify the species with certainty. The fossil reports are very scarce; however, this species is very similar to the more common *Leptochiton cancellatus* and some records may represent misidentifications.

Distribution. Late Miocene: Italy (Tortonian of Rio di Bocca d'Asino, Alessandria, and Montegibbio, Modena; Dell'Angelo & Palazzi 1989). Pliocene: Italy: Liguria (this paper) and Emilia, "La Tagliata", Modena (Laghi 1977, as *Lept. cancellatus*). Pleistocene: Greece (Kyllini, NW Peloponneso: Garilli et al. 2005). Recent: Atlantic Ocean, S.W. England, Jersey, and northern France (the English Channel), northern Spain, Canary Islands and Angola; Mediterranean Sea, Italy (Adriatic Sea, Apulia, Tuscany, Sicily), Greece, and Malta (Dell'Angelo & Smriglio 1999).

Leptochiton bedullii Dell'Angelo & Palazzi, 1986

Pl. 2, figs H-L

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 71).

1986 *Leptochiton* (*L.*) *bedullii* Dell'Angelo & Palazzi, p. 7, figs 17-18, 23-24, 27-31, 49-50, 58-62.

1989 *Lepidopleurus* (*Leptochiton*) *boettgeri* (*non* Šulc, 1934) - Dell'Angelo & Palazzi, p. 72, pl. 20, figs 2-5, pl. 22, fig. 5.

1989 *Lepidopleurus* (*Leptochiton*) *boettgeri* (*non* Šulc, 1934) – Dell'Angelo & Palazzi, pl. 20, fig. 1 (= *Leptochiton* sp.: Dell'Angelo et al. 2012).

1999 *Lepidopleurus* (*Leptochiton*) *bedullii* - Dell'Angelo & Smriglio, p. 71, pls 19-20, figs 28, 29, 29/1, 29/2.

2001b *Lepidopleurus* (*Leptochiton*) *bedullii* - Dell'Angelo et al., p. 146, fig. 3.

2004 *Lepidopleurus boettgeri* (*non* Šulc, 1934) – Chirli, p. 4, pl. 1, figs 3-8.

Type material: Holotype: MSNP. Paratypes: MZB (1 intermediate valve from Porto Cesareo, Lecce, Italy); AL (a specimen from Capraia Island).

Type locality: Laghi Alimini (Lecce, Italy) (40°12'16"N, 18°27'46"E), a specimen collected on *Posidonia* at a depth of 10 m.

Material examined: Bussana: 2 intermediate valves (BD); Rio Sant'Antonino: 5 valves (3 intermediate, and 2 tail) (MP); Rio Torsero: 1 intermediate valve (BD); Sestri Ponente: 1 intermediate valve (BD); Borzoli: 2 valves (1 intermediate, and 1 tail) (BD).

Remarks. The species is characterized by the tegmentum sculptured with roundish thick granules arranged in radial series on the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve, in longitudinal series in the central area of the intermediate valves and the antemucronal area of the tail valve, with large smooth spaces between the series of tubercles, and a characteristic curved arrangement of longitudinal series of granules neighbouring the lateral areas. Detailed descriptions of this species are given by Dell'Angelo & Palazzi (1986) and Dell'Angelo & Smriglio (1999).

This elusive species has been described based on three living individuals and a few loose Recent plates collected at Laghi Alimini (Lecce), Capraia Island (Tuscan Archipelago), and Punta Prosciutto (Taranto). It is similar to *Leptochiton boettgeri* from the Miocene of Kostej (Romania), known only for two valves (one head and one tail) (Dell'Angelo & Palazzi 1989; Kaas & Van Belle 1994).

Distribution. Pliocene: very scarce records from Italy: Liguria (this paper), Tuscany (Dell'Angelo & Smriglio 1999; Chirli 2004). Recent: rarely found in some Mediterranean localities: Italy, Malta, Tunisia, Turkey, Greece and Cyprus (Dell'Angelo & Smriglio 1999).

PLATE 2

Figs A-D - *Leptochiton alveolus* (Poli, 1791).
A-C, Zinola, incomplete intermediate valve, MZB 45701. A, dorsal view. B, detail of the sculpture of the central area. C, detail of the sculpture of the lateral area, by a lateral view. D, Norway, Sula Ridge, intermediate valve, dredged at 215 m, dorsal view.
Figs E-G - *Leptochiton scabridus* (Jeffreys, 1880). Sestri Ponente, incomplete intermediate valve, MZB 45702.
E, dorsal view. F, detail of the sculpture of the central area. G, granules, by a lateral view.
Figs H-L - *Leptochiton bedullii* Dell'Angelo & Palazzi, 1986, Sestri Ponente, incomplete intermediate valve, MZB 45703.
H, dorsal view. I-J, detail of the sculpture of the central area. K-L, detail of the sculpture of the lateral area.
Figs M-R - *Leptochiton josei* sp. n.
M-O, Sestri Ponente, holotype MZB 49985, intermediate valve. M, dorsal view. N, detail of the sculpture of the central area. O, frontal view. P-R, Bussana, paratype MZB 49984, tail valve. P, dorsal view. Q, detail of the sculpture of the contact between antemucronal and postmucronal areas. R, lateral view.
Scale bars 1 mm: D; 500 μm: A, E, H, M, O, P, R; 100 μm: B, C, I, K, Q; 50 μm: F, N; 10 μm: G, J, L.

Leptochiton josei sp. n.

Pl. 2, figs M-R

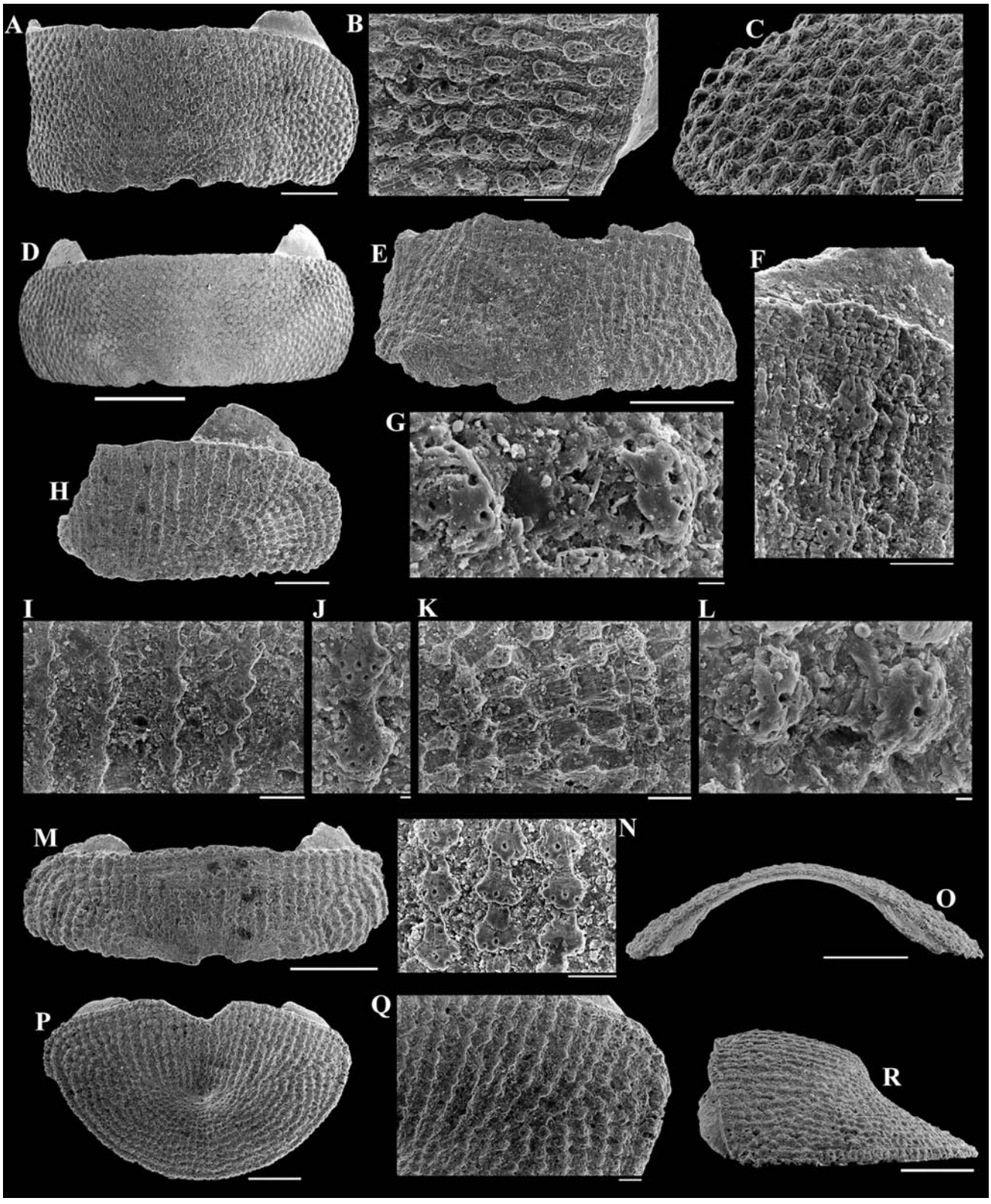
Material examined: Bussana: 6 valves (2 intermediate, and 4 tail valves) (BD); Rio Sant'Antonino: 4 valves (2 intermediate, and 2 tail) (MP); Caranchi: 1 intermediate valve (MP); Sestri Ponente: 1 intermediate valve (BD).

Type material: Holotype: MZB 49985, one complete intermediate valve (Pl. 2, figs M-O). Five paratypes: MZB 49984, one complete tail valve from Bussana (Pl. 2, figs P-R); MSNG 56535, one intermediate valve from Caranchi; BD, one tail valve from Bussana; MP, one intermediate valve from Rio Sant'Antonino; MS, one tail valve from Rio Sant'Antonino.

Type locality: Genova, Sestri Ponente, Italy (44°25'33"N, 08°50'53"E).

Type stage: Lower Pliocene (Zanclean).

Etymology: In honour of Giuseppe Priora, "Jose" to his friends, who discovered (with his wife Micaela Prudenza) the Rio



Sant'Antonino site in the 1970s, and eagerly contributed to the knowledge of fossil molluscs from Western Liguria.

Description. Intermediate valve (holotype, width 2.08 mm, Pl. 2, fig. M) rectangular with slightly rounded corners, anterior and posterior margins almost straight, apex indistinct, not much elevated (height/width 0.24), rounded, lateral areas scarcely differentiated, with some concentric growth lines. Tail valve (paratype MZB, width 3 mm, Pl. 2, fig. P) semi-elliptical, anterior margin slightly convex, central prominent mucro, postmucronal slope concave just underneath mucro.

Sculpture of tegmentum formed by rather irregular granules, of roundish- subquadrangular shape, well separate from each other. Granules arranged in irregular longitudinal series on central area of intermediate valves (ca. 30-33, one or two tending to bifurcate) and antemucronal area of tail valve (ca. 38-40, gradually converging posteriorly, some bifurcate); irregular stem structure between granules (Pl. 2, fig. N). Each granule bearing central megalaesthete, several micraesthetes irregularly disposed along margin. Granules arranged in irregular radial series, crossed by growth lines, on lateral areas of intermediate valves (5-6), postmucronal area of tail valve (50-52); granules narrower, more compressed from one side.

Articulamentum without insertion laminae. On ventral side of intermediate valves, posterior area comprised of expanded central zone with straight anterior margin. Apophyses wide, triangular in intermediate valves, trapezoidal in tail ones.

Remarks. The material available consists of 9 valves, 4 intermediate (only one complete, the holotype) and 5 tail (one complete, 2 almost complete). In spite of the scarcity of the material, the characters are well defined, and suitable for the description of the species as new. We did not find any head valves of this species.

Comparisons. The fossil *Leptochiton* species from the Mediterranean area can be separated in three groups, characterized by:

First group: tegmentum uniformly covered by granules quincuncially or randomly disposed, not arranged in longitudinal or radial series (as in *Lept. josei*). This group comprises only three species: *Lept. alveolus*, reported also in this paper, and two others (*Lept. taviani* and *Lept. salicensis*).

Second group: head valve, lateral areas of intermediate valves, and postmucronal area of tail valve covered with granules arranged either irregularly or quincuncially (and not in radial series as in *Lept. josei*), while the granules on central area of intermediate valves and antemucronal area of tail valve are disposed in longitudinal series. This group comprises four species: *Lept. cimicoides* (Monterosato, 1879) (from the Plio-Pleistocene of Italy), *Lept. sarsi* Kaas, 1981 (from some bathyal Pleistocene outcrops in southern Italy), *Lept. geronensis* Kaas & Van Belle, 1985a (from the Pleistocene of Riparbella, Pisa), and *Lept. abacinus* Dell'Angelo & Palazzi, 1989 (from the Pleistocene of Pezzo, Reggio Calabria). Also the Recent Atlantic/Mediterranean *Lept. xanthus* Kaas & Van Belle, 1990, belongs to this group of species.

Third group: head valve, lateral areas of intermediate valves, and postmucronal area of tail valve covered with granules arranged in radial series; central area of intermediate valves and antemucronal area of tail valve with granules disposed in longitudinal series. This group includes many species. Four of them [*Leptochiton asellus* (Gmelin, 1791), a living Atlantic/Mediterranean species also dubiously reported as fossil, *Lept. cancellatus* from European Neogene, *Lept. algesirensis* (Capellini, 1859) from Plio-Pleistocene of Italy, and *Lept. bedullii* Dell'Angelo & Palazzi, 1986, reported also here] have united granules, also partially overlapping each other in some species, and this main character does not agree with *Lept. josei* which has granules well separate from each other. The only known fossil species with granules well separated from each other is *Lept. scabridus*, reported also here. It differs from *Lept. josei* in having a completely different and characteristic sculpture, the tegmentum presents a rough surface, on which the granules are extended into a body usually formed by two or three longitudinal varices that become unified or merge together along the external margin of the valve. Also three species from the Middle Miocene (Badenian) of Paratethys belong to this group:

PLATE 3

Figs A-C - *Leptochiton* sp., Garlenda, incomplete head valve, MZB 45704.
A, dorsal view. B, detail of the sculpture, by a lateral view. C, granules.
Figs D-F - *Hanleya hanleyi* (Bean in Thorpe, 1844).
D-E, Zinola, tail valve, MZB 45705. D, dorsal view. E, detail of the sculpture, by a lateral view. F, Rio S. Antonino, half intermediate valve, MZB 45706, dorsal view.
Figs G-K - *Ischnochiton rissoi* (Payraudeau, 1826).
G-H, Bussana, head valve, MZB 45707. G, dorsal view. H, detail of the sculpture. I-J, Rio Torsero, intermediate valve, MZB 45708, width 6 mm, dorsal and ventral views, respectively. K, Bussana, tail valve, MZB 45709, width 7 mm, dorsal view.
Figs L-T - *Ischnochiton korytnicensis* Bałuk, 1971.
L, Sestri Ponente, incomplete head valve, MZB 45710, 3.3 mm, dorsal view. M, Rio Torsero, half intermediate valve, MZB 45711, width 2.5 mm, ventral view showing two slits. N-P, Borzoli, intermediate valve MZB 45712. N-O, dorsal and frontal views, respectively. P, detail of the sculpture. Q, Rio Torsero, tail valve, MZB 45713, dorsal view. R-S, Bussana, tail valve MZB 45714. R, detail of the sculpture, mucro is on the right. S, lateral view. T, Bussana, tail valve, MZB 45715, width 5 mm, ventral view.
Scale bars 1 mm: G, N, O, S; 500 μm: A, D, F, P, Q; 100 μm: B, E, R; 50 μm: C, H.

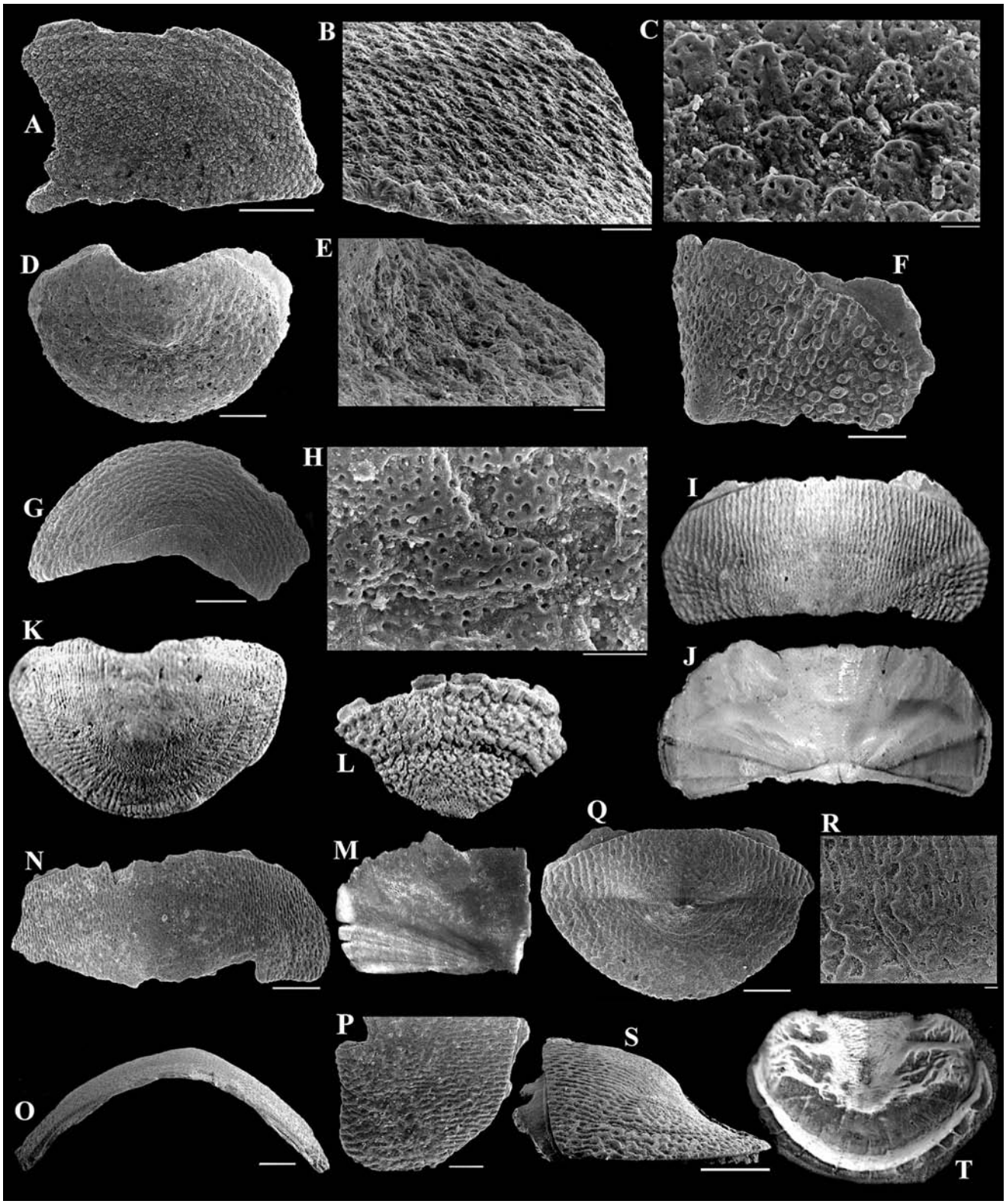
Lept. boettgeri (see under *Lept. bedullii*), *Lept. srameki* (Šulc, 1934), a species similar to *Lept. algesirensis,* and *Lept. sulci* (see under *Lept. cancellatus*).

Leptochiton sp.

Pl. 3, figs A-C

Material examined: Garlenda: 1 head valve, incomplete (MP).

Description. The unique valve available, a small fragile fragment of a head valve, is characterized by the fine and small irregular granules, that randomly cover all the valve's surface. The granules are of a quadrangular irregular shape, enough elevated, with 6-8 aesthetes on the top, one on the centre and the others on the periphery, of the same dimensions, without a distinction between its macro- and micraesthetes.



Remarks. As reviewed above, only three fossil Mediterranean species are known with the tegmentum uniformly covered by quincuncially or randomly disposed granules: *Lept. alveolus*, reported also here (with different rounded to oval granules), *Lept. tavianii* Dell'Angelo, Landau & Marquet, 2004 (with the granules characterized by a fungiform section and arranged in a beehive structure) and *Lept. salicensis* (Dell'Angelo & Bonfitto, 2005) (with very solid valves and polygonal granules more densely arranged).

The scarcity of material does not permit us to identify with certainty the valve found, so it is preferable to leave it as *Leptochiton* sp., waiting for more material to give a specific determination.

Distribution. Pliocene: Liguria (this paper).

Family Hanleyidae Bergenhayn, 1955

Genus *Hanleya* Gray, 1857

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

Remarks. The genus is known from the Oligocene to the Recent.

Hanleya hanleyi (Bean in Thorpe, 1844)

Pl. 3, figs D-F

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 85).

1844 *Chiton hanleyi* Bean in Thorpe, p. 263, fig. 57.
1860 *Chiton multigranosus* Reuss, p. 259, pl. 8, figs 8a-b.
1971 *Hanleya multigranosa* - Bałuk, p. 456, pl. 1, figs 5-7.
1977 *Hanleya hanleyi* - Laghi, p. 99, pl. 3, figs 5-9.
1979 *Hanleya multigranosa* - Sabelli & Taviani, p. 158, pl. 1, fig. 4.
1984 *Hanleya multigranosa* - Bałuk, p. 287, pl. 5, figs 1a-b.
1984 *Hanleya* cf. *hanleyi* - Janssen, p. 40, pl. 1, fig. 1.
1984 *Hanleya hanleyi* - Marquet, p. 336, pl. 1, fig. 3.
1995 *Hanleya hanleyi* - Bellomo & Sabelli, p. 201, fig. 1.
1997 *Hanleya hanleyi* - Dell'Angelo & Giusti, p. 51, fig. 2.
1999 *Hanleya hanleyi* - Dell'Angelo & Smriglio, p. 85, figs 34-36, pls 25-26.
1999 *Hanleya hanleyi* - Dell'Angelo et al., p. 262, pl. 1, figs 1, 3.
2001 *Hanleya hanleyi* - Dell'Angelo et al., p. 147, fig. 8.
2002 *Hanleya hanleyi* - Marquet, p. 13, pl. 2, fig. 2.
2004 *Hanleya hanleyi* - Dell'Angelo et al., p. 30, pl. 2, fig. 8.

Type material: WEM (*fide* Kaas & Van Belle, 1985: p. 193).

Type locality: Scarborough, Yorkshire, Great Britain (54°16'45"N, 0°22'49"W).

Material examined: Rio Sant'Antonino: 8 valves (2 head, 4 intermediate, and 2 tail) (MP); Caranchi: 1 intermediate valve (MP); Zinola: 1 tail valve (BD); Borzoli: 1 intermediate valve (BD).

Remarks. The species is characterized by its uniformly sculptured tegmentum with roundish granules, arranged without special order on the head valve, lateral areas of the intermediate valves and postmucronal area of the tail valve, in longitudinal rows, fine and close set on jugum, increasing in size and converging posteriorly towards side the margins in the pleural areas and the antemucronal area of the tail valve.

Detailed descriptions of this species are given by Kaas & Van Belle (1985a) and Dell'Angelo & Smriglio (1999). A small number of incomplete and not well preserved valves have been found, but the characters are sufficient to identify the species with certainty.

We follow Laghi (1977) and Sirenko (1997) in considering the insertion plates in the genus *Hanleya* to be well developed in the head valve, scarcely or hardly developed in the other valves, and always without teeth. These characteristics have been variously interpreted by different authors, and are thoroughly discussed by Laghi (1977) and Sirenko (1997).

Hanleya multigranosa (Reuss, 1860) from the Middle Miocene (Badenian) of Central Paratethys is considered conspecific with the present species.

Distribution. Middle Miocene: Badenian of the central European basins (as *H. multigranosa*), and North Sea basin (Janssen 1984). Late Miocene: Tortonian of Montegibbio, Modena and Messinian of Borelli, Turin (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: scarce records from Great Britain, Belgium (Marquet 2002) and Italy (Dell'Angelo & Smriglio 1999; this paper). Pleistocene: Norway and Italy (Dell'Angelo & Smriglio 1999). Recent: Atlantic Ocean from the Barents Sea to the Canary Islands, off the east coast of N. America, and the Mediterranean Sea (Dell'Angelo & Smriglio 1999).

Order **Chitonida** Thiele, 1909

Suborder **Chitonina** Thiele, 1909

Family Ischnochitonidae Dall, 1889

Genus *Ischnochiton* Gray, 1847

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

For synonymy, see Kaas & Van Belle 1990.

Remarks. The genus is known from the Eocene to the Recent. The current systematic treatment of the subgenera of *Ischnochiton* is mainly based on girdle characters, so it is preferable to not use the subgenus level for fossil species.

Ischnochiton rissoi (Payraudeau, 1826)

Pl. 3, figs G-K

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 100).

1826 *Chiton rissoi* Payraudeau, p. 87, pl. 3, figs 4-5.
1934 *Ischnochiton rudolticensis* Šulc, p. 23, pl. 2, figs 41-43.

1962 *Ischnochiton* (*Ischnochiton*) *rissoi* - Malatesta, p. 160, figs 16-17.

1965 *Ischnochiton rudolticensis* (*non* Šulc 1934) - Bałuk, p. 369, pl. 1, fig. 7 (= *I. korytnicensis*: Bałuk 1984).

1971 *Ischnochiton rudolticensis* - Bałuk, p. 458, pl. 3, figs 5-8.

1977 *Ischnochiton* (*Simplischnochiton*) *rissoi* - Laghi, p. 104, pl. 1, figs 4-9.

1984 *Ischnochiton rissoi* - Bałuk, p. 287, pl. 6, figs 2a-b.

1988 *Ischnochiton* cf. *korytnicensis* (*non* Bałuk, 1971) - Studencka & Studencki, p. 45 (= *I. rissoi*: Studencka & Dulai 2010: p. 265).

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

1999 *Ischnochiton* (*Ischnochiton*) *rissoi* - Dell'Angelo & Smriglio, p. 100, pls 29-31, figs 40-48.

2001b *Ischnochiton rissoi* - Dell'Angelo et al., p. 150, figs 20, 23.

2003 *Ischnochiton rissoi* - Kroh, p. 132, pl. 1, fig. 5.

2004 *Ischnochiton rissoi* - Chirli, p. 6, pl. 2, figs 3-9.

2004 *Ischnochiton* (*Ischnochiton*) *rissoi* - Dell'Angelo et al., p. 34, pl. 4, figs 3-4.

2005 *Ischnochiton rissoi* - Dulai, p. 33, pl. 3, figs 1-5.

2005 *Ischnochiton* (*Ischnochiton*) *rissoi* - Garilli et al., p. 132, pl. 2, figs 5-6.

2009 *Ischnochiton* (*Ischnochiton*) *rissoi* - Koskeridou et al., p. 314, figs 8.1-8.2.

2010 *Ischnochiton rissoi* - Sosso & Dell'Angelo, p. 14, fig. p. 16.

2010 *Ischnochiton rissoi* - Studencka & Dulai, p. 264, text-figs 4A-C.

Type material: Syntype, MNHN 6109.

Type locality: Bonifacio, Corse, France (41°23'10"N, 9°09'31"E).

Material examined: Bussana: 4 valves (1 head, 2 intermediate, and 1 tail) (BD, PG); Rio Sant'Antonino: 26 valves (2 head, 22 intermediate, and 2 tail) (BD, MP); Garlenda: 1 intermediate valve (MP); Rio Torsero: 6 valves (1 head, 4 intermediate, and 1 tail) (BD, PG, SR); Borzoli: 7 valves (3 head, and 4 intermediate) (BD).

Remarks. The species is characterized by a tegmental sculpture consisting of concentric vermicular ribs, often intersected by fine radial furrows, on the head valve, lateral areas of intermediate valves and postmucronal area of the tail valve. The ribs continue longitudinally on the central area of intermediate valves and on the antemucronal area of the tail valve, more spaced near the lateral margins, thinner and closer together in the jugal area. The species is highly variable, with a complicated synonymy, and detailed descriptions are given by Kaas & Van Belle (1990) and Dell'Angelo & Smriglio (1999).

Ischnochiton korytnicensis Bałuk, 1971 differs from *I. rissoi* in the type of ornamentation, with closely spaced nodular elevations that are irregular in outline and irregularly distributed (see below).

The material found is scarce, and the valves are mainly incomplete and eroded, so in many cases the characteristics that allow one to identify *I. rissoi* or *I. korytnicensis* are not easily detectable (i.e. missing lateral areas in incomplete intermediate valves). The valves from Ligurian localities show some differences in their ornamentation: radial ribbing is stronger than concentric ribbing on head valve, the lateral areas of intermediate valves and the postmucronal area of tail valve. They are similar to the valves from the Pliocene of Serre di Rapolano in Tuscany, as illustrated by Dell'Angelo et al. (2001b: figs 20, 23).

Distribution. Middle Miocene: Badenian of Central Paratethys (Czech Republic, Poland, Ukraine, Romania, Austria, Hungary, also under the name of *Ischnochiton rudolticensis*) (Dulai 2005; Studencka & Dulai 2010). Late Miocene: Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Italy (Sosso & Dell'Angelo 2010; this paper) and Spain (Dell'Angelo et al. 2001b, 2004). Pleistocene: Italy, and Greece (Garilli et al. 2005). Recent: Mediterranean Sea (Dell'Angelo & Smriglio 1999).

Ischnochiton korytnicensis Bałuk, 1971

Pl. 3, figs L-T

1965 *Ischnochiton rudolticensis* (*non* Šulc 1934) - Bałuk, p. 369, pl. 1, fig. 7 (fide Bałuk 1984).

1971 *Ischnochiton korytnicensis* Bałuk, p. 458, pl. 3, figs 1-4.

1977 *Ischnochiton rissoi* (*non* Payraudeau 1826) - Laghi, p. 104, pl. 1, fig. 9 (partim, *non* figs 4-8 = *I. rissoi*).

1979 *Ischnochiton korytnicensis* - Bałuk & Radwanski, p. 231.

1984 *Ischnochiton korytnicensis* - Bałuk, p. 288, pl. 6, figs 1a-1b.

1985 *Ischnochiton* (*Simplischnochiton*) *korytnicensis* - Zanaroli, p. 107, pl. 2, figs 7-8.

1988 *Ischnochiton korytnicensis* - Macioszczyk, p. 52, pl. 2, fig. 9.

1988 *Ischnochiton korytnicensis* - Studencka & Studencki, p. 43.

1988 *Ischnochiton* cf. *korytnicensis* (*non* Bałuk 1971) - Studencka & Studencki, p. 45 (= *I. rissoi*: Studencka & Dulai 2010: p. 265).

1999 *Ischnochiton* (*Simplischnochiton*) *korytnicensis* – Dell'Angelo et al., p. 267, pl. 3, figs 1-2.

2010 *Ischnochiton korytnicensis* – Studencka & Dulai, p. 265.

Type material: Holotype in Bałuk's collection, reg. No. BkK-A15, an intermediate valve illustrated in Bałuk (1971: pl. 3, fig. 2).

Type locality: Korytnica, 24 km SSW of Kielce (50°39'49"N, 20°31'41"E), southern slopes of the Holy Cross Mts. (Poland), Middle Miocene (Badenian).

Material examined: Bussana: 15 valves (12 intermediate, and 3 tail) (BD, PG); Rio Sant'Antonino: 3 valves (2 head, and 1 intermediate) (MP); Rio Torsero: 2 valves (1 head, and 1 tail) (BD); Sestri Ponente: 1 head valve (BD); Borzoli: 2 intermediate valves (BD).

Remarks. The species is characterized by a tegmental sculpture consisting of closely spaced, elevated nodules, irregular in outline and irregularly distributed, on the head valve, the lateral areas of the intermediate valves and the postmucronal area of the the tail valve, and longitudinal, clearly undulate ribs, on the central area of the intermediate valves and the antemucronal area of the tail valve. A detailed description of *I. korytnicensis* was given by Bałuk (1971).

This species is similar to *I. rissoi*, from which it differs mainly in the ornamentation of head valve, the lateral areas of the intermediate valves and the postmu-

cronal area of the tail valve composed of irregular, closely spaced, and elevated nodules, whereas *I. rissoi* shows concentric vermicular ribs. These differences seem sufficient to separate the two species even though *I. rissoi* is a variable species with many junior synonyms (Dell'Angelo & Smriglio 1999).

Distribution. Middle Miocene: Badenian of Poland (Bałuk 1984; Macioszczyk 1988).

Late Miocene: Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Italy, Liguria (this paper).

Ischnochiton martinelli Dell'Angelo, Landau & Marquet, 2004

Pl. 4, fig. A

2004 *Ischnochiton martinelli* Dell'Angelo, Landau & Marquet, p. 33, pl. 4, fig. 8, pl. 5, figs 1-4, 6-8, pl. 6, figs 1-8, pl. 7, fig. 1.

2005 *Ischnochiton martinelli* - Schwabe, p. 98.

2012 *Ischnochiton martinelli* - Dell'Angelo et al., p. 58, figs 3M-O.

Type material: Holotype: MZB 25051 (intermediate valve, 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); IRSN IST 6450 (3 valves); BD 4567 (3 valves); RM (3 valves).

Type locality: Velerín Carretera, near Estepona, Málaga, Spain (36°26'03"N, 5°06'30"W), Early Piacenzian (Pliocene).

Material examined: Rio Sant'Antonino: 1 intermediate valve (MP); Caranchi: 2 intermediate valves (BD, MP).

Remarks. This species is characterized by the distinctly carinated intermediate valves, and a tegmental sculpturing consisting of radial nodulose riblets on the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve. The central area of the intermediate valves and the antemucronal area of the tail valve have a reticulate sculpture in the jugal area, consisting of obliquely intersecting vermicular ribs, tending to form a series of longitudinal striae in each pleural area, often somewhat eroded, and an almost smooth area in the outermost parts of the pleural area. This species is similar to *Ischnochiton anserinus* Laghi, 1977, a rare species from the Lower Pliocene of Italy (Emilia, Tuscany and Sicily), and only known from intermediate valves. The main difference is that the lateral areas of the intermediate valves of *I. anserinus* are sculptured with a fine granularity, giving them a smooth appearance. A detailed description of *I. martinelli* was given by Dell'Angelo et al. (2004).

Only three intermediate valves are present in the material examined, and only one of them is complete (from Caranchi, Pl. 4, fig. A) and attributable with certainty to *I. martinelli*. The second valve from Caranchi is incomplete and the lateral areas are not visible. The valve from Rio Sant'Antonino is eroded, and the sculpture of the unique lateral area is not preserved. We attribute them to this species because the sculpturing of the central area of these two valves agrees with *I. martinelli.*

Distribution. Pliocene: Spain (Dell'Angelo et al. 2004) and Italy, Sicily (Altavilla; Dell'Angelo et al. 2012) and Liguria (this paper).

Ischnochiton ligusticus sp. n.

Pl. 4, figs B-M

2010 *Ischnochiton ulivii* (*non* Dell'Angelo & Forli 1996) - Sosso & Dell'Angelo, p. 14, fig. p. 16.

Material examined: Bussana: 20 valves (4 head, 13 intermediate, and 3 tail) (BD); Rio Sant'Antonino: 40 valves (5 head, 33 intermediate, and 2 tail) (MP); Garlenda: 20 valves (1 head, 15 intermediate, and 4 tail) (MP); Caranchi: 5 valves (3 intermediate, and 2 tail) (BD, MP); Rio Torsero: 2 intermediate valves (BD); Zinola: 4 valves (1 head, 1 intermediate, and 2 tail) (BD); Sestri Ponente: 4 intermediate valves (BD); Borzoli: 9 valves (1 head, 7 intermediate, and 1 tail) (BD).

Type material: Holotype: MZB 49983, a complete intermediate valve from Bussana (Pl. 4, figs B-D). Ten paratypes: MZB 49982, a complete head valve from Zinola (Pl. 4, fig. E); MSNG 56536, an intermediate valve from Rio Torsero (Pl. 4, fig. F); MZB 49981, a complete tail valve from Caranchi (Pl. 4, figs G-I); BD, an head valve from Bussana (Pl. 4, figs J-K); BD, an intermediate valve from Bussana (Pl. 4, figs L-M); MS, a complete tail valve from Bussana; BD, a complete tail valve from Zinola; MP, a complete tail valve from S. Antonino; PU 109800, a complete intermediate valve from Rio Torsero; PU 109801, a complete tail valve from Caranchi.

Type locality: Bussana (Imperia), Italy (43°49'60"N, 7°49'52"E).

Type stage: Lower Pliocene (Zanclean).

Etymology: with reference to the findings from Ligurian sites.

Description. Head valve semicircular (paratype MZB 49982, width 3.2 mm, Pl. 4, fig. E), posterior margin widely V-shaped, front slope straight. Intermediate valve (holotype, width 3.6 mm, Pl. 4, fig. B) rectangular with slightly rounded corners, anterior and posterior margins practically straight, apex not very visible, moderately elevated (height/width 0.33), rounded to subcarinate, lateral areas scarcely differentiated. Tail valve (paratype MZB 49981, width 3.6 mm, Pl. 4, fig. G) semi-circular, anterior margin almost straight, mucro central, not prominent, antemucronal slope practically straight, postmucronal slope slightly concave just behind mucro.

Tegmentum uniformly sculptured with very irregular granules, arranged in segments of various size and shape, slightly overlapping each other, forming rugosities. On head valve, lateral areas of intermediate valves and postmucronal area of tail valve, some rugosities acquiring vaguely concentrical zig-zag pattern, producing undulating macrosculpture (Pl. 4, fig. J); in central area of intermediate valves and antemucronal area of tail valve, rugosities sometimes giving impression of very irregular longitudinal chains of granules (Pl. 4, fig. D),

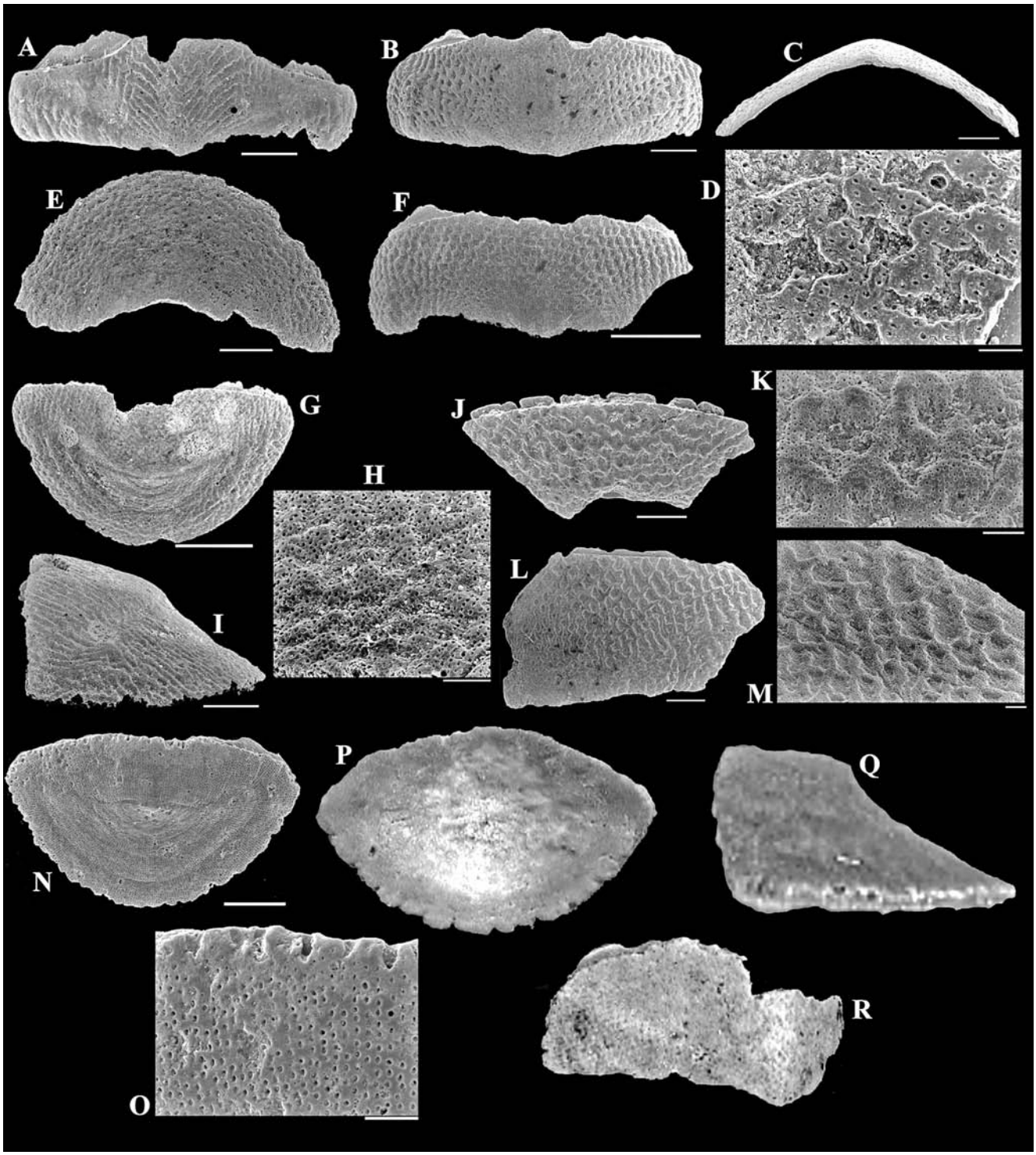


PLATE 4

Figs A - *Ischnochiton martinelli* Dell'Angelo, Landau & Marquet, 2004, Caranchi, MZB 45716, dorsal view.
Figs B-M - *Ischnochiton ligusticus* sp. n.
B-D, Bussana, holotype MZB 49983, intermediate valve. B-C, dorsal and frontal views, respectively. D, detail of the sculpture of the central area. E, Zinola, paratype MZB 49982, head valve, dorsal view. F, Rio Torsero, paratype MSNG, intermediate valve, dorsal view. G-I, Caranchi, paratype MZB 49981, tail valve. G, dorsal view. H, detail of the sculpture of the postmucronal area, by a posterior view. I, lateral view. J-K, Bussana, paratype BD, incomplete head valve. J, dorsal view. K, detail of the sculpture. L-M, Bussana, paratype BD, incomplete intermediate valve. L, dorsal view. M, detail of the sculpture.
Figs N-R - *Ischnochiton* ? sp.
N, Caranchi, tail valve, MZB 45717, dorsal view. O, detail of the sculpture of antemucronal area. P-Q, Caranchi, tail valve, MZB 45718, width 1.6 mm, ventral and lateral views, respectively. R, Sestri Ponente, half intermediate valve, MZB 45719, width 2.1 mm, dorsal view.
Scale bars 1 mm: G; 500 µm: A-C, E; F, I, J, L; 100 µm: H, K, M, N; 50 µm: D, O.

or sinuose and intersecting each other, giving impression of network of irregular, elongate pits (Pl. 4, fig. M). Many aesthetes irregularly distributed on granules' surface (Pl. 4, fig. D).

Articulamentum always with incomplete large apophyses, slit formula 12 / 1 / 10-12. Teeth of irregular width, deeply incised.

Remarks. The material available comprises many valves, but most are incomplete, especially the intermediate ones, where often only the central part is preserved. The apophyses and the slits in the articulamentum are mostly broken or hardly visible. Notwithstanding, the characters are well defined, and suitable for the description of the species as new.

Comparisons. The tegmentum sculpture is very characteristic, and different from the four East Atlantic Recent species from the Cape Verde Archipelago characterized by an evenly granulose tegmentum: *Ischnochiton cessaci* (de Rochebrune, 1881) also from Mauritania, Sénégal, Angola, and Canary Islands, *I. goreensis* Thiele, 1909 also from Sénégal, *I. paessleri* Thiele, 1909, and *I. nicklesi* Kaas & Van Belle, 1990 also from Dakar.

Stenosemus chiversi (Ferreira, 1981) shows a similar sculpture. It is a rare bathyal species only known from the type material (two specimens from the NE Pacific, 4390 m) and another specimen from the Western Pacific, 4572 m (Kaas & Van Belle 1990). Apart from the different geographic distribution and habitat, this species differs from *I. ligusticus* in many other characters, i.e. the slit formula (28 / 3-4 / 25) and the dorsal elevation (0.48).

The present species is superficially very similar to *I. ulivii* Dell'Angelo & Forli, 1996, a species described from the Tuscan Pliocene, from which it differs mainly by its greater size and the very irregular sculpture. *Ischnochiton ulivii* is by contrast a small species characterized by small granules quincuncially arranged on the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve and by a decidedly pitted sculpture in the central area of intermediate valves and the antemucronal area of the tail valve.

Ischnochiton ligusticus differs from *I. korytnicensis* mainly by the irregular granulose sculpture on all the valve's surface, and not only on the head valve, the lateral areas of the intermediate valves, and the postmucronal area of the tail valve, as in *I. korytnicensis*.

Ischnochiton? sp.

Pl. 4, figs N-R

Material examined: Rio S. Antonino: 1 head valve (MP); Caranchi: 1 tail valve (MP); Sestri Ponente: 4 valves (3 intermediate, and 1 tail) (BD).

Description. Head valve semicircular, front slope almost straight, widely V-shaped. Intermediate valve rectangular (Pl. 4, fig. R), posterior margin about straight, side margins slightly rounded, apex well evident, lateral areas raised. Tail valve semi-elliptical (Pl. 4, fig. N), front margin about straight, mucro situated anteriorly, not prominent, posterior slope slightly concave directly behind the mucro (Pl. 4, fig. Q).

Tegmentum of all valves smooth, glossy.

Articulamentum weakly developed, glossy white, slit formula ? / 1 / 12, slits fairly equidistant in tail valve (Pl. 4, fig. P), slit rays clearly indicated in intermediate valves.

Remarks. This species is characterized by small valves that are completely smooth and glossy, with relatively uniform pores. The incompleteness and bad preservation of the valves do not permit us to give more than a provisional generic assignment. The teeth in the insertion plates (slit formula ? / 1 / 12) are worn, so it is not possible to see if they are pectinated or not. The species appeared at first similar to *Chiton capecchii* Chirli, 2004, known from the Tuscan Pliocene, but it differs in having a smooth tegmentum; very fine radial and longitudinal striae are always present in *Ch. capecchii*.

Distribution. Pliocene: Liguria (this paper).

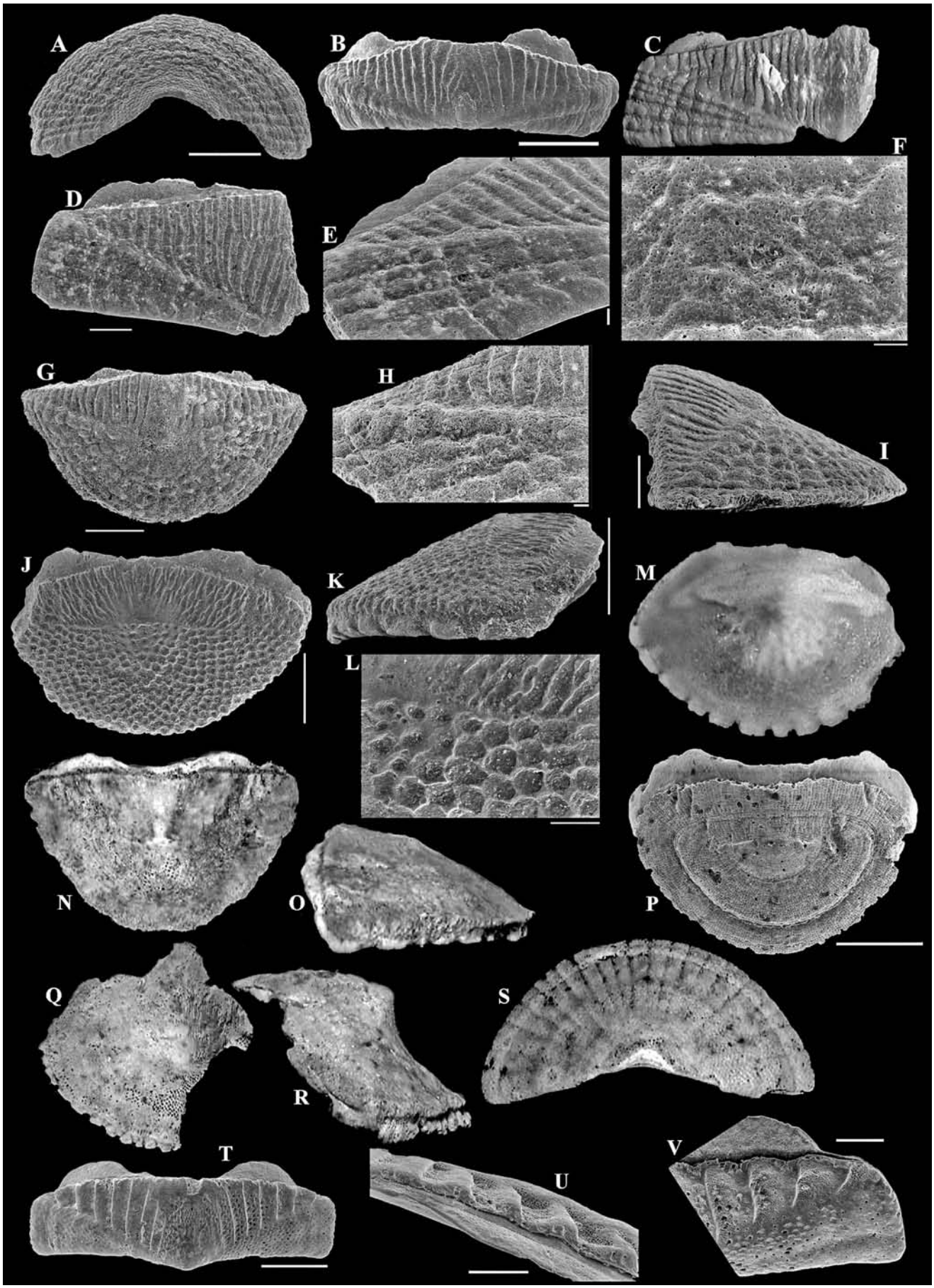
Genus *Stenosemus* von Middendorff, 1847

Type species: *Chiton albus* Linnaeus, 1767, by subsequent designation (Winckworth 1926).

Remarks: The genus is known from the Pliocene to the Recent.

PLATE 5

Figs A-I - *Stenosemus dolii* Van Belle & Dell'Angelo, 1998.
A, Borzoli, head valve, MZB 45720, dorsal view. B, Rio Sant'Antonino, intermediate valve, MZB 45721, dorsal view. C, Rio S. Antonino, half intermediate valve, MZB 45722, width 4 mm, dorsal view. D-F, Borzoli, half intermediate valve, MZB 45723. D, dorsal view. E-F, detail of the sculpture. G-I, Borzoli, tail valve, MZB 45724. G, dorsal view. H, detail of the sculpture. I, lateral view.
Figs J-M - *Connexochiton roccai* sp. n., Borzoli, holotype, MZB 49980, tail valve.
J-K, dorsal and lateral views, respectively. L, detail of the sculpture. M, ventral view, width 1.5 mm.
Figs N-P - *Callochiton septemvalvis* (Montagu, 1803).
N-O, Rio Sant'Antonino, tail valve, MZB 45725, width 3.3 mm, dorsal and lateral views, respectively. P, Caranchi, abnormal tail valve, MZB 45726, showing the developing of a new insertion plate, dorsal view.
Figs Q-R - *Callochiton* sp., Rio Sant'Antonino, incomplete tail valve, MZB 45727, width 3.2 mm, dorsal and lateral views, respectively.
Figs S-V - *Chiton olivaceus* Spengler, 1797.
S, Bussana, head valve, MZB 45728, width 4.4 mm, dorsal view. T-V, Bussana, intermediate valve, MZB 45729. T, dorsal view. U, detail of longitudinal ribs, by a frontal view. V, detail of the sculpture.
Scale bars 1 mm: A, B, G; 800 µm: T; 500 µm: D, I, P; 400 µm: J, K; 300 µm: U, V; 100 µm: E, F, H; 80 µm: L.


A
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Stenosemus dolii Van Belle & Dell'Angelo, 1998

Pl. 5, figs A-I

Chresonymy and synonymy (Fossil and Recent taxa) in Dell'Angelo et al. (2012).

1897 *Chiton olivaceus* var. *plioparva* (*non* Sacco, 1897) - Sacco, p. 89, (partim, not specimens figured in pl. 7, figs 1-5 = *Ch. corallinus*, fide Laghi 1977).

1977 *Lepidozona dorsuosa* (*non* Haddon, 1886) - Laghi, p. 105, pl. 2, figs 1-4.

1985 *Lepidozona dorsuosa* (*non* Haddon, 1886) - Zanaroli, p. 111, pl. 2, figs 1-6.

1989 *Ischnochiton vanbellei* (*non* Kaas 1985) - Smriglio et al., p. 126, figs 3, 4a-b.

1997 *Ischnochiton exaratus* (*non* Sars 1878) - Dell'Angelo & Giusti, p. 51, figs 4, 6, 9.

1998 *Ischnochiton dolii* Van Belle & Dell'Angelo, p. 77, figs 1-5.

1999 *Ischnochiton* (*Stenosemus*) *dolii* - Dell'Angelo & Smriglio, p. 115, fig. 53, pls 36-38.

1999 *Ischnochiton vanbellei* (*non* Kaas 1985) - Ardovini & Cossignani, p. 27, fig. p. 27.

1999 *Ischnochiton* (*Simplischnochiton*) *exaratus* (*non* Sars 1878) - Dell'Angelo et al., p. 268, pl. 2, figs 2, 4-7, pl. 3, fig. 6.

2000 *Ischnochiton* (*Stenosemus*) *dolii* - Dell'Angelo & Giusti, p. 55.

2001b *Ischnochiton dolii* - Dell'Angelo et al., p. 150.

2004 *Ischnochiton dolii* - Dell'Angelo et al., p. 34.

2004 *Ischnochiton* (*Stenosemus*) aff. *vanbellei* (*non* Kaas 1985) - Dell'Angelo et al., p. 34, pl. 7, figs 2, 5-6.

2005 *Ischnochiton dolii* - Schwabe, p. 94.

2012 *Stenosemus dolii* - Dell'Angelo et al., p. 58, figs 4A-K.

Type material: Holotype: an intermediate valve, 3 x 7.5 mm (MZB 11302). Paratypes: five valves (MZB 11303), four valves (IRSN IG 28523), three valves (MNHN), 138 valves (RA), 80 valves (FG), 90 valves (BD P151F), 12 valves (VB F1003a).

Type locality: Tyrrhenian Sea, off Civitavecchia, Italy, in a Roman amphora (= dolium) at a depth of 550 m (333 valves in the muddy contents) (42°04'04"N, 11°45'31"E).

Material examined: Rio Sant'Antonino: 39 valves (5 head, 31 intermediate, and 3 tail) (MP); Garlenda: 2 intermediate valves (MP); Zinola: 7 valves (1 head, and 6 intermediate) (BD); Borzoli: 43 valves (4 head, 35 intermediate, and 4 tail) (BD).

Remarks. The species was described on the basis of many separate subfossil valves found in a Roman amphora ("dolium") off Civitavecchia, at a depth of 550 meters (Van Belle & Dell'Angelo 1998), and afterwards other valves from a thanatocoenosis from the South Ligurian Sea, between Corsica and Capraia Island, at a depth of 350-500 m were collected (Dell'Angelo & Giusti 1997, 2000). Later live specimens from Thyrrenian Sea were found, at a depth between 150 and 480 m (Dell'Angelo & Smriglio 1999; Dell'Angelo et al. 2001a).

The valves available in the new fossil material are almost always incomplete and worn, only 3 of 49 total intermediate valves are complete.The lateral areas of the intermediate valves have 2-4 subgranulose, rather flat, radial ribs (Pl. 5, figs B, D); the ribs tend to split, so 7-8 radial ribs can be present near the lateral margin. One figured valve (Pl. 5, fig. C) clearly shows this feature, where 4 radial ribs start from the apex, splitting in the last quarter towards the lateral margin, with three of the splits well defined while the fourth is only present as a marked thickening. The tail valves are not elevated, slope almost straight, with only a little concavity just under the mucro.

The finding of many valves of *S. dolii* from the Pliocene of Altavilla (Sicily), where it represents the most abundant species, permitted Dell'Angelo et al. (2012) to better define the characteristics of the species. Additionally, the valves from the Pliocene of Estepona (Spain) previously identified by Dell'Angelo et al. (2004) as *I.* (*Stenosemus*) aff. *vanbellei*, the valves from the Pliocene of Northern Apennines (Zinola, Valle Andona and Castell'Arquato) previously identified by Laghi (1977) as *Lepidozona dorsuosa* (Haddon, 1886), and the valves from the Lower Messinian of Borelli (Turin hills) previously identified by Dell'Angelo et al. (1999) as *I. (Simplischnochiton) exaratus* (Sars, 1878) were identified as *S. dolii*.

Stenosemus dolii is similar to *I. zbyi* Dell'Angelo & Silva, 2003, and *S. vanbellei* (Kaas, 1985b). The differences are discussed by Dell'Angelo & Silva (2003: table 1 p. 11) and Dell'Angelo & Smriglio (1999: table p. 116).

Distribution. Late Miocene: Italy (Messinian of Borelli, Turin) (Dell'Angelo et al. 1999). Pliocene: Spain (Dell'Angelo et al. 2004), and Italy (Dell'Angelo et al. 2012; this paper). Pleistocene: Italy (valves dredged between Capraia and Capo Corso, at a depth of 350-500 m) (Van Belle & Dell'Angelo 1998; Dell'Angelo & Giusti 1997, 2000). Recent: Mediterranean Sea, off the Latium coast and in the Tuscan Archipelago, between 150 and 560 m, and in association with white coral biocoenosis (Dell'Angelo & Smriglio 1999).

Genus *Connexochiton* Kaas, 1979

Type species: *Connexochiton platynomenus* Kaas, 1979, by original designation.

Diagnosis: Of very small size, elongate oval, tegmental sculpture granulose, slit formula many / 1 / many, teeth short, propped, apophyses connected by a lamina, without notches in between, girdle covered with imbricating, striated scales.

Remarks. The genus was not previously known in the fossil record.

Connexochiton roccai sp. n.

Pl. 5, figs J-M

Type material: Holotype: MZB 49980, a tail valve from Borzoli (Pl. 5, figs J-M).

Type locality: Borzoli (Genova), Italy (44°25'53"N, 8°51'34"E).

Type stage: Lower Pliocene (Zanclean).

Etymology: in honour of Massimo Rocca, who eagerly contributed to the knowledge of fossil molluscs from Pliocene of North Italy.

Description. Tail valve small, semicircular, rather flat, mucro situated anteriorly, not prominent, antemucronal and postmucronal slopes almost straight.

Tegmentum rather coarsely granulose, arranged in segments of various size and shape on antemucronal area, slightly overlapping each other to form very irregular longitudinal rugosities, obliquely oriented with respect to the anterior-posterior axis. On postmucronal area, granules fused forming fine network.

Apophyses rounded, wide, connected across jugal portion. Insertion plate thick, eaves solid, teeth rough, irregular, 10 slits visible, total number estimated at 12.

Remarks. The characteristic features of the unique tail valve warrant the assignment of this species to *Connexochiton*. Other genera show the apophyses connected across the jugal portion, but all these have characteristics not agreeing with this Ligurian Pliocene valve e.g., *Callochiton* Gray, 1847 (with a finely granulose sculpture, eaves spongy, extra-pigmentary eyes present), *Lepidozona* Pilsbry, 1892 (with a jugal plate notched at the sides, and a different tegmental sculpture), *Chaetopleura* Shuttleworth, 1853 (with a tegmental sculpture usually consisting of pustules).

The valve's characters are very distinctive and well defined, and for these reasons, and also considering that this is the first record of this genus as a fossil, we have described this single tail valve as a new species.

Comparisons. Five species of living *Connexochiton* are known, including three from the Atlantic [*Co. moreirai* (Righi, 1973), *Co. platynomenus* Kaas, 1979, and *Co. bromleyi* (Ferreira, 1985)], and two from the Pacific (*Co. discernibilis* Kaas, 1991, and *Co. kaasi* Saito, 1997). The three Atlantic species have a strong granulose sculpture on the whole tegmentum, and *Co. discernibilis* has a sculpture of radial grooves and a series of wavy depressions. Only *Co. kaasi* has a granulose sculpture with some resemblance with this valve from Borzoli, but the pattern is opposite to that found in *Co. roccai*, with the network in central and antemucronal areas, and irregular concentric wrinkles in lateral and postmucronal areas.

Family Callochitonidae Plate, 1901

Genus *Callochiton* Gray, 1847

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

Remarks. The genus is known from the Oligocene to the Recent.

Callochiton septemvalvis (Montagu, 1803)

Pl. 5, figs N-P

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 125).

1803 *Chiton septemvalvis* Montagu, p. 3.

1860 *Chiton rariplicatus* Reuss, p. 258, pl. 8, figs 9-11.

1971 *Callochiton rariplicatus* - Bałuk, p. 461, pl. 5, figs 1-5.

1977 *Callochiton laevis* (*non* Pennant 1777) - Laghi, p. 108, pl. 2, figs 14-18.

1984 *Callochiton laevis* (*non* Pennant 1777) - Bałuk, p. 290.

1999 *Callochiton septemvalvis* - Dell'Angelo & Smriglio, p. 125, pls 40-41, figs 55-63.

2003 *Callochiton septemvalvis* - Dell'Angelo & Silva, p. 11.

2004 *Callochiton septemvalvis* - Chirli, p. 8, pl. 3, figs 1-4.

2004 *Callochiton septemvalvis* - Dell'Angelo et al., p. 34, pl. 3, figs 2, 5.

2005 *Callochiton septemvalvis* - Garilli et al., p. 134, pl. 2, figs 7-10.

2006 *Callochiton septemvalvis* - Dell'Angelo & Vardala-Theodorou, p. 326, 2 figs.

2009 *Callochiton septemvalvis* - Koskeridou et al., p. 314, figs 8.3-8.4.

Type material: Holotype NHMUK (fide Kaas & Van Belle 1985b).

Type locality: Great Britain, Salcomb Bay (50°13'06"N, 3°46'47"W).

Material examined: Bussana: 36 valves (2 head, 23 intermediate, and 11 tail) (BD); Rio Sant'Antonino: 52 valves (4 head, 37 intermediate, and 11 tail) (MP); Garlenda: 1 intermediate valve (MP); Caranchi: 8 valves (4 intermediate, and 4 tail) (BD, MP); Rio Torsero: 5 intermediate valves (BD, MP); Zinola: 1 head valve (BD); Sestri Ponente: 11 valves (2 head, 5 intermediate, and 4 tail) (BD); Borzoli: 12 valves (9 intermediate, and 3 tail) (BD).

Remarks. Detailed descriptions of *Callochiton septemvalvis* are given by Kaas & Van Belle (1985b) and Dell'Angelo & Smriglio (1999). This species has a very complicated taxonomic history, reported by Dell'Angelo & Smriglio 1999. The valves reported herein are mainly incomplete and poorly preserved, but have the same tegmental sculpture as living specimens, i.e., a dense and uniform set of cords, barely visible with the naked eyes, with 3-6 longitudinal scars in the pleural area.

A tail valve from Caranchi (Pl. 5, fig. P) shows the development of a new insertion plate under the already existing one, an abnormality already known but rarely reported, and especially rare in fossil valves (Dell'Angelo & Schwabe 2010).

Distribution. Middle Miocene: Badenian of Central Paratethys (also as *Ca. rariplicatus* Reuss, 1860) (Bałuk 1984). Late Miocene: Italy, Montegibbio, Modena (Dell'Angelo & Smriglio 1999). Pliocene: Italy (Dell'Angelo et al. 2001b; this paper), Portugal (Dell'Angelo & Silva 2003) and Spain (Dell'Angelo et al. 2004). Pleistocene: Italy (Dell'Angelo et al. 2001b; Chirli 2004), Greece (Koskeridou et al. 2009). Recent: Northeastern Atlantic Ocean, from Norway to the Canary Islands; Mediterranean Sea (Dell'Angelo & Smriglio 1999).

Callochiton sp.

Pl. 5, figs Q-R

Material examined: Rio S. Antonino: one tail valve (MP).

Description. Tail valve more than semicircular and quite elevated, with a small subcentral mucro, antemucronal slope slightly convex, postmucronal slope strongly concave just behind the mucro. Tegmentum eroded, some scars are visible on the antemucronal area.

Articulamentum with irregular insertion teeth quite pronounced, ca. 10 in the half posterior margin preserved.

Remarks. The unique tail valve present in our material is not complete and poorly preserved, but with characters that do not agree with the other European fossil *Callochiton* species.

Only three fossil *Callochiton* species are known from Europe: *Ca. septemvalvis* (Montagu, 1803), *Ca. zigzag* Šulc, 1934 (from the Miocene of Czech Republic and Poland) and *Ca. calcatus* Dell'Angelo & Palazzi, 1994 (from the Italian Pleistocene). *Callochiton* sp. differs from *Ca. septemvalvis* and *Ca. calcatus* mainly in the profile of the tail valve (compare with Dell'Angelo & Smriglio 1999: 133, fig. 7), with the postmucronal slope strongly concave just behind the mucro. It differs from *Ca. zigzag* in the different profile of the tail valve (compare with Bałuk 1971: pl. 5, fig. 8) and in having fewer insertion teeth (30 in tail valve of *Ca. zigzag*).

Distribution. Pliocene: Liguria (this paper).

Family Chitonidae Rafinesque, 1815

Genus *Chiton* Linnaeus, 1758

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

Remarks. The genus is known from the Cretaceous to the Recent, and has been subdivided in many subgenera (Kaas et al. 2006), some of which (e.g., *Rhysoplax* Thiele, 1893) were elevated by Sirenko (2006) to full genera, mainly based on the soft parts of living specimens. Here all the species listed below are considered belonging to the genus *Chiton* s.l. The main characters of the species considered here are given in Tab. 1 (including *Ch. saeniensis*, for completeness).

Sculpture of lateral areas of intermediate valves	radial ribs		smooth		smooth or very light radial flattish ribs	some light ribs near the side margin
Species characters	*C. olivaceus*	*C. miocenicus*	*C. corallinus*	*Chiton* sp. A	*C. saeniensis*	*Chiton* sp. B
Maximum width (mm) of head-intermediate-tail valves	4.6 - 6.3 - 3.5	11 - 15 - 10.5	5.8 - 7 - 5.2	/ - 6 - /	15 - 20 - 14	/ - 3,2 - 3.9
Height/width	0.30-0.45	0.21-0.36	0.3-0.4	0.5-0.65		
Profile of intermediate valves	carinate	carinate	carinate	carinate	carinate	
Sculpture of:						
* head valve	30-40 radial ribs, often bifurcating, light growth lines	many radial ribs, often bifurcating, more irregular, growth lines	smooth		smooth or very light radial flattish ribs, growth lines pronounced	
* lateral areas of intermediate valves	3-6 radial ribs, light growth lines	5-10 radial ribs, more irregular, growth lines	smooth	smooth	smooth or very light radial flattish ribs, growth lines pronounced	smooth, except for some light radial ribs near the side margin
* central area of intermediate valves	6-15 longitudinal ribs on each side	15-25 longitudinal ribs on each side	7-10 longitudinal ribs on each side	5-8 longitudinal ribs on each side	smooth or very light longitudinal flattish ribs, growth lines pronounced	smooth, except for 3-4 small scars obliquely directed near the side margin
* antemucronal area of tail valve	as central area of intermediate valves	as central area of intermediate valves	as central area of intermediate valves		as central area of intermediate valves	as central area of intermediate valves
* postmucronal area of tail valve	25-35 radial ribs, light growth lines	many radial ribs, often bifurcating, more irregular, growth lines	smooth		smooth or very light radial flattish ribs, growth lines pronounced	smooth, except for some light radial ribs near the side margin
Slit formula	9-10 / 1 / 13-14	9-10 / 1 / 13-14	8-10 / 1 / 9-12	? / 1 / ?	11-11 / 2 / 12	? / 1 / ?

Tab. 1 - Main characters of *Chiton* species.

Chiton olivaceus Spengler, 1797

Pl. 5, figs S-V

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 169).

1797 *Chiton olivaceus* Spengler, p. 73, pl. 6, fig. 8.
1883 *Gymnoplax bohemicus* de Rochebrune, p. 63.
1934 *Chiton bohemicus* - Šulc, p. 25, pl. 2, figs 48, 50-54.
1935 *Chiton bohemicus* - Ashby & Cotton, p. 393.
1965 *Gymnoplax bohemicus* - Bałuk, p. 368, pl. 1, figs 5-6.
1977 *Chiton olivaceus* - Laghi, p. 109, pl. 2, figs 5-8.
1984 *Chiton olivaceus* - Laghi, p. 559, text-figs 1a-d.
1988 *Chiton olivaceus* - Macioszczyk, p. 54, pl. 3, figs 4-6.
1999 *Chiton* (*Rhyssoplax*) *olivaceus* - Dell'Angelo & Smriglio, p. 169, pls 56-57, figs 86-96.
2001b *Chiton olivaceus* - Dell'Angelo et al., p. 152.
2005 *Chiton* (*Rhyssoplax*) *olivaceus* - Garilli et al., p. 138, pl. 4, figs 1-5.
2005 *Chiton* (*Rhyssoplax*) *olivaceus* - Dulai, p. 38, pl. 3, figs 6-8.
2007 *Chiton* (*Rhyssoplax*) *olivaceus* - Dell'Angelo et al., p. 42, figs 4d, 4f.
2009 *Rhyssoplax olivacea* - Koskeridou et al., p. 315, figs 9.3-9.4.
2010 *Chiton olivaceus* - Studencka & Dulai, p. 266, text-fig. 5.

Type material: Lost. The type series of *Chiton olivaceus* is no longer present in the collection of the Zoological Museum of the University of Copenhagen (fide Kaas & Knudsen 1992: p. 60).

Type locality: Off the coast of North Africa.

Material examined: Bussana: 8 valves (2 head, and 6 intermediate) (BD); Caranchi: 3 intermediate valves (MP); Rio Torsero: 2 valves (1 head, and 1 intermediate) (BD); Sestri Ponente: 3 valves (1 intermediate, and 2 tail) (BD); Borzoli: 10 valves (9 intermediate, and 1 tail) (BD).

Remarks. A detailed description of *Chiton olivaceus* is given by Dell'Angelo & Smriglio (1999). *Chiton olivaceus* is the most common and best known Mediterranean species, easily recognizable by its characteristic sculpture of rather coarse but highly variable radial ribs on the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve, and of longitudinal ribs on the pleural areas of the intermediate valves and the antemucronal area of the tail valve.

The variability of the fossil forms is so vast, both in the morphology of the valves and in the characteristics of the sculpture, that the early authors established various specific taxa, e.g. *Ch. rudelsdorfensis* Van Belle, 1980 (nom. n. pro *Gymnoplax bohemicus* de Rochebrune, 1883) from the basin of Vienna, Austria, *Ch. zibinicus* Doderlein, 1862, from Modena's basin, Italy, and *Ch. miocenicus* Michelotti, 1847, from the hills around Turin, Italy. Some authors have considered these fossils forms as ancestors of *Ch. olivaceus* (i.e. Malatesta 1962), others as synonyms of *Ch. olivaceus* living in the Mediterranean (i.e. Laghi 1977). The synonymy with *Ch. bohemicus* was accepted by subsequent authors (e.g. Macioszczyk 1988; Dell'Angelo et al. 1999; Dulai 2005; Studencka & Dulai 2010).

Chiton zibinicus was described by Doderlein from Tortonian of Montegibbio with the diagnosis: "*Ch. miocenici Micht. prox. sed distinctus*", without illustrations. Sacco (1897) considered this species as a variety of *Ch. olivaceus*, and figured a tail valve (pl. 7, figs 6-7).

New material of valves examined in this study are all worn and mostly incomplete. The only complete and well-preserved intermediate valve is figured (Pl. 5, fig. T). This confirms the scarcity of finding this species in Pliocene outcrops, e.g. Chirli (2004) did not report *Ch. olivaceus* from Tuscan Pliocene.

Distribution. Middle Miocene: Badenian of Central Paratethys (under the name of *Ch. bohemicus*) (Dulai 2005; Dell'Angelo et al. 2007; Studencka & Dulai 2010). Late Miocene: Italy (Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Spain (Dell'Angelo et al. 2004), and Italy (Laghi 1977; Dell'Angelo et al. 2001b; Sosso & Dell'Angelo 2010; this paper), always rather uncommon. Pleistocene: Italy (Sabelli & Taviani 1979), Greece and Cyprus (Garilli et al. 2005; Koskeridou et al. 2009). Recent: Atlantic Ocean, both on the southern coast of Portugal and at Tangiers; Mediterranean and Marmara Sea (Dell'Angelo & Smriglio 1999; Kaas et al. 2006).

Chiton corallinus (Risso, 1826)

Pl. 6, figs A-S

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 174), and Kaas et al. (2006: p. 154).

1826 *Lepidopleurus corallinus* Risso, p. 268.
1860 *Chiton denudatus* Reuss, p. 259, pl. 8, figs 14-15.
1897 *Chiton olivaceus* var. *plioparva* Sacco, p. 89, pl. 7, figs 1-5 (partim, fide Laghi 1977).
1934 *Chiton corallinus denudatus* - Šulc, p. 24, pl. 2, figs 44-45.
1971 *Chiton denudatus* - Bałuk, p. 462, pl. 5, figs 9-11.
1977 *Lepidopleurus corallinus* - Arnaud, p. 112.
1977 *Chiton corallinus* - Laghi, p. 109, pl. 2, figs 9-12.
1984 *Chiton corallinus* - Bałuk, p. 290.
1999 *Chiton* (*Rhyssoplax*) *corallinus* - Dell'Angelo & Smriglio, p. 174, pls 58-59, figs 97-107.
2004 *Chiton corallinus* - Chirli, p. 13, pl. 4, figs 17-18, pl. 5, figs 1-2.
2004 *Chiton* (*Rhyssoplax*) *corallinus* - Dell'Angelo et al., p. 39, pl. 3, figs 4, 7.
2005 *Chiton corallinus* - Dulai, p. 36, pl. 4, figs 1-4.
2005 *Chiton* (*Rhyssoplax*) *corallinus* - Garilli et al., p. 139, pl. 4, figs 6-10.
2006 *Chiton* (*Rhyssoplax*) *corallinus* - Kaas et al., p. 154, fig. 56.
2009 *Rhyssoplax corallina* - Koskeridou et al., p. 315, figs 8.5-8.8, 9.1-9.2.
2010 *Chiton corallinus* - Studencka & Dulai, p. 265.

Type material: Presumed lost, not present in the Risso collection, MNHN (fide Arnaud 1977).

Type locality: France, Nice (43°41'09"N, 7°15'52"E).

Material examined: Bussana: 565 valves (67 head, 417 intermediate, and 81 tail) (BD, PG); Rio Sant'Antonino: 2620 valves (320 head, 1,990 intermediate, and 310 tail) (BD, MP, PG); Garlenda: 364 valves (29 head, 296 intermediate, and 39 tail) (MP); Salea: 2 intermedi-

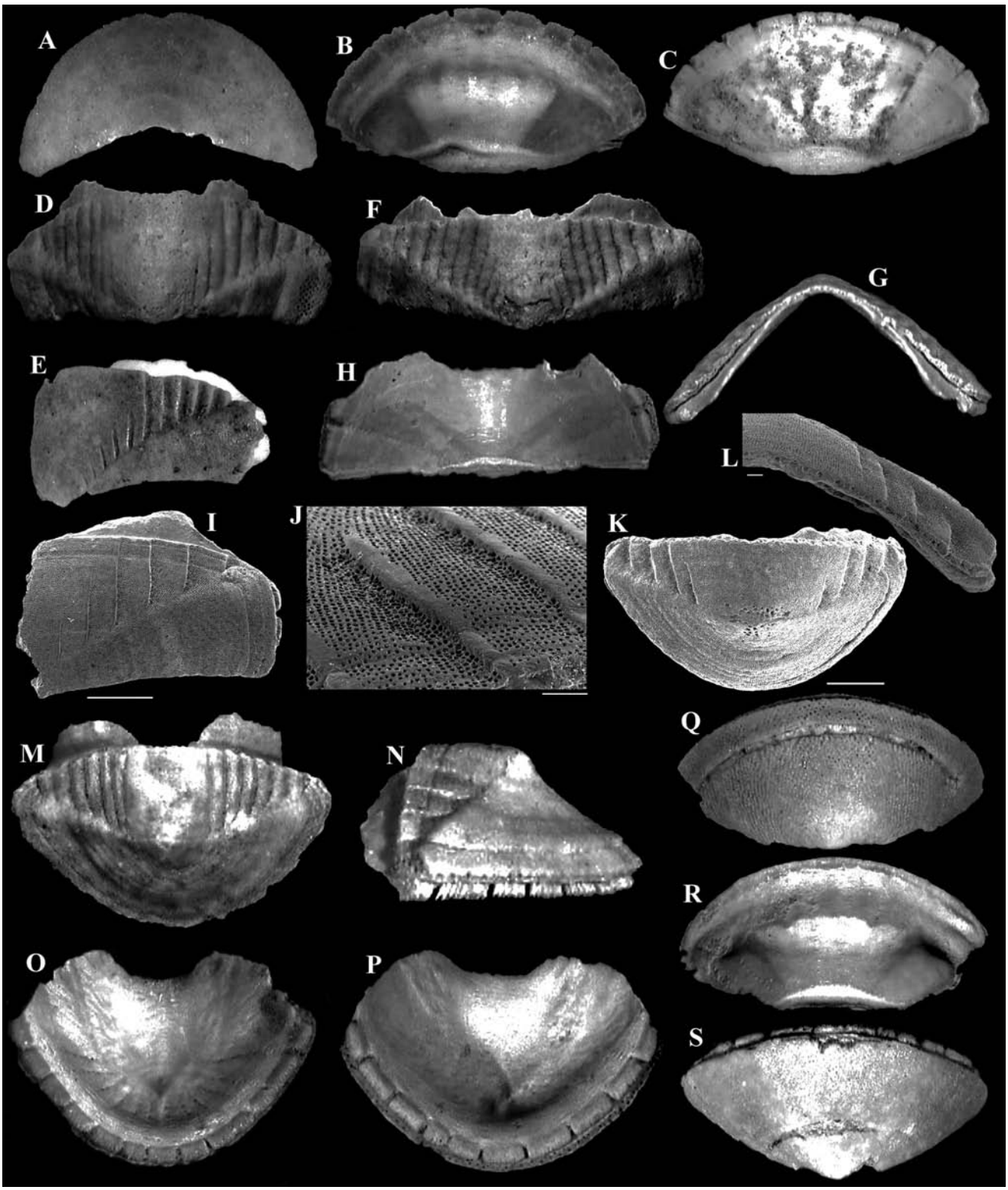


PLATE 6

Figs A-S - *Chiton corallinus* (Risso, 1826).
A-C, Rio Sant'Antonino, head valves. A-B, MZB 45730, width 2.1 mm, dorsal and ventral views respectively, 8 slits. C, MZB 45731, width 3 mm, ventral view, 10 slits. D, Rio Sant'Antonino, intermediate valve, MZB 45732, width 3.5 mm, dorsal view. E, Bussana, half intermediate valve, MZB 45733, width 4 mm, dorsal view. F-H, Rio Sant'Antonino, intermediate valve, MZB 45734, width 5 mm, dorsal, frontal and ventral views, respectively. I-J, Bussana, half intermediate valve, MZB 45735. I, dorsal view. J, detail of the sculpture of central area, by a lateral view. K-L, Bussana, tail valve, MZB 45736. K, dorsal view. L, detail of the sculpture of antemucronal area, by a frontal view. M-P, Rio Sant'Antonino, tail valves. M, MZB 45737, width 2.6 mm, dorsal view. N, MZB 45738, width 2.2 mm, lateral view. O, MZB 45739, width 3 mm, ventral view, 12 slits. P, MZB 45740, width 2.5 mm, ventral view, 9 slits. Q-S, Rio Sant'Antonino, anomalous head valves, which present an injury and develop a new insertion plate under the already existing one. Q, MZB 45741, width 3.5 mm, dorsal view. R-S, MZB 45742, width 3.4 mm, ventral and dorsal views, respectively.
Scale bars 500 μm: I, K; 100 μm: J, L.

ate valves (BD); Caranchi: 34 valves (2 head, 27 intermediate, and 5 tail) (BD, MP); Rio Torsero: 29 valves (6 head, 18 intermediate, and 5 tail) (BD, MP, PG); Zinola: 87 valves (20 head, 57 intermediate, and 10 tail) (BD); Sestri Ponente: 69 valves (10 head, 50 intermediate, and 9 tail) (BD); Borzoli: 635 valves (60 head, 476 intermediate, and 99 tail) (BD).

Remarks. A detailed description of *Chiton corallinus* is given by Dell'Angelo & Smriglio (1999) and Kaas et al. (2006). The species is characterized by having a smooth surface of the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve, while the pleural areas are sculptured on each side by 7-10 small outward-leaning folds of tegmentum (Pl. 6, figs J, L).

This is the most abundant species found in the Ligurian Pliocene, the number of available valves is very high (46% of the total), and even if the valves are almost always incomplete and worn, some observations on the variability can be made. The longitudinal folds on the pleural areas are usually parallel to each other, almost all reaching the anterior margin, except one or two near the apex (Pl. 6, fig. D), or can be obliquely arranged/oriented towards the jugal region (Pl. 6, fig. F). The valves from Bussana usually have a different layout, with 11 folds per side, of which the first six reach the anterior margin, while the other five are always shorter and closer to the apex (Pl. 6, fig. E). The valves are carinate or subcarinate, more or less elevated (Pl. 6, fig. G), with the dorsal elevation varying between 0.3 and 0.4. The slit formula is 8-10 / 1 / 9-12.

Šulc (1934) already mentioned the similarity between *Chiton denudatus* Reuss, 1860 from the Miocene of Vienna and *Ch. corallinus* (the only difference reported was the tendency of the tail valve to vary its posterior profile from roundish to triangular).

Two head valves in the new material preserve shell scars due to injury, which caused the development of a new insertion plate under the older one (Pl. 6, figs Q, R-S).

Distribution. Middle Miocene (Badenian) of central-eastern Europe (Studencka & Studencki 1988; Studencka & Dulai 2010). Late Miocene: Italy (Tortonian of Montegibbio, Modena) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Portugal (Dell'Angelo & Silva 2003), Spain (Dell'Angelo et al. 2004), and Italy (Laghi 1977; Dell'Angelo et al. 2001b; Chirli 2004; Sosso & Dell'Angelo 2010; this paper). Pleistocene: Italy (Dell'Angelo et al. 2001b, 2007), Greece (Garilli et al. 2005; Koskeridou et al. 2009). Recent: Mediterranean Sea and the northern part of the Atlantic coast of Marocco (Dell'Angelo & Smriglio 1999; Kaas et al. 2006).

Chiton miocenicus Michelotti, 1847

Pl. 7, figs A-H

1847 *Chiton miocenicus* Michelotti, p. 132, pl. 16, fig. 7.
1847 *Chiton polii* Deshayes 1833 - Sismonda, p. 25.
1890 *Chiton miocenicus* - Sacco, N° 1742.
1890 *Chiton polii* Deshayes 1833 - Sacco, N° 1743 (*fide* Sacco 1897: 90).
1897 *Chiton miocenicus* - Sacco, p. 89, pl. 7, figs 8-20.
1919 *Chiton miocaenicus* (*non* Michelotti 1847) - Cossmann & Peyrot, p. 32, pl. 2, figs 21-22 [fide Dell'Angelo & Palazzi 1989: p. 55].
1977 *Chiton olivaceus* (*non* Spengler 1797) - Laghi, p. 109, pl. 2, fig. 13 (partim).
1978 *Chiton olivaceus* (*non* Spengler 1797) - Laghi & Russo, p. 272, pls 1-7 (partim).
1984 *Chiton miocenicus* - Ferrero Mortara et al., p. 299.
1989 *Chiton miocenicus* - Dell'Angelo & Palazzi, p. 55.
1992 *Chiton* (*Rhyssoplax*) *olivaceus* (*non* Spengler 1797) - Cavallo & Repetto, p. 30, fig. 3b.
1995b *Chiton saeniensis* (*non* Laghi 1984) - Dell'Angelo & Forli, p. 78 (partim).
1999 *Chiton miocenicus* - Forli et al., p. 113, pl. 1, figs 4-6.
1999 *Chiton* (*Rhyssoplax*) *olivaceus* f. *miocenicus* – Dell'Angelo et al., p. 271, pl. 4, figs 1, 3, 5-8.
2001b *Chiton miocenicus* - Dell'Angelo et al., p. 152, fig. 27.
2004 *Chiton miocenicus* - Chirli, p. 14, pl. 5, figs 11-15.
2004 *Chiton miocenicus* - Dell'Angelo et al., p. 39, pl. 5, fig. 5, pl. 7, figs 3, 7.

Type material: MGR (fide Sacco 1897: pl. 7, fig. 11 "es. tip. fig.").

Type locality: The Turin hills, Italy (45°03'01"N, 7°48'01"E).

Material examined: Bussana: 4 valves (1 head, 2 intermediate, and 1 tail) (BD); Rio Sant'Antonino: 332 valves (48 head, 262 intermediate, and 22 tail) (MP, PG); Garlenda: 5 intermediate valves (MP); Rio Torsero: 1 intermediate valve (BD); Borzoli: 89 valves (16 head, 71 intermediate, and 2 tail) (BD).

Remarks. *Chiton miocenicus* is a species that closely resembles *Ch. olivaceus*, and was considered in the past either a synonym of the latter or a distinct species. It was described based on valves from the Turin hills, one intermediate valve was well figured (Michelotti 1847: pl. 16, fig. 7).

Many subsequent authors considered the species a synonym of *Ch. olivaceus*, e.g. Laghi 1977, and Laghi & Russo 1978 (these authors studied with SEM 19 valves of living *Ch. olivaceus* and 5 valves of *Ch. miocenicus* from Montegibbio, concluding that the Recent and fossil valves examined show the same structures and architecture). Other authors considered *Ch. miocenicus* a distinct species, e.g. Monterosato (1879), and Sacco (1897).

Chiton miocenicus differs from *Ch. olivaceus* for many characters. The valves are wider and have a greater number of longitudinal ribs on the central areas of the intermediate valves (15-25 on each side, vs. 8-15 in *Ch. olivaceus*) and the lateral areas of the intermediate valves (5-10 vs. 3-6 in *Ch. olivaceus*), and the sculpture is more irregular and less distinguishable.

Distribution. Early Miocene: Italy, Turin hills (Sacco 1897). Late Miocene: Italy (Tortonian of Montegibbio, Modena, and Messinian of Borelli) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Spain (Dell'Angelo et al. 2004), and Italy (Dell'Angelo et al. 2001b; Chirli 2004; this paper).

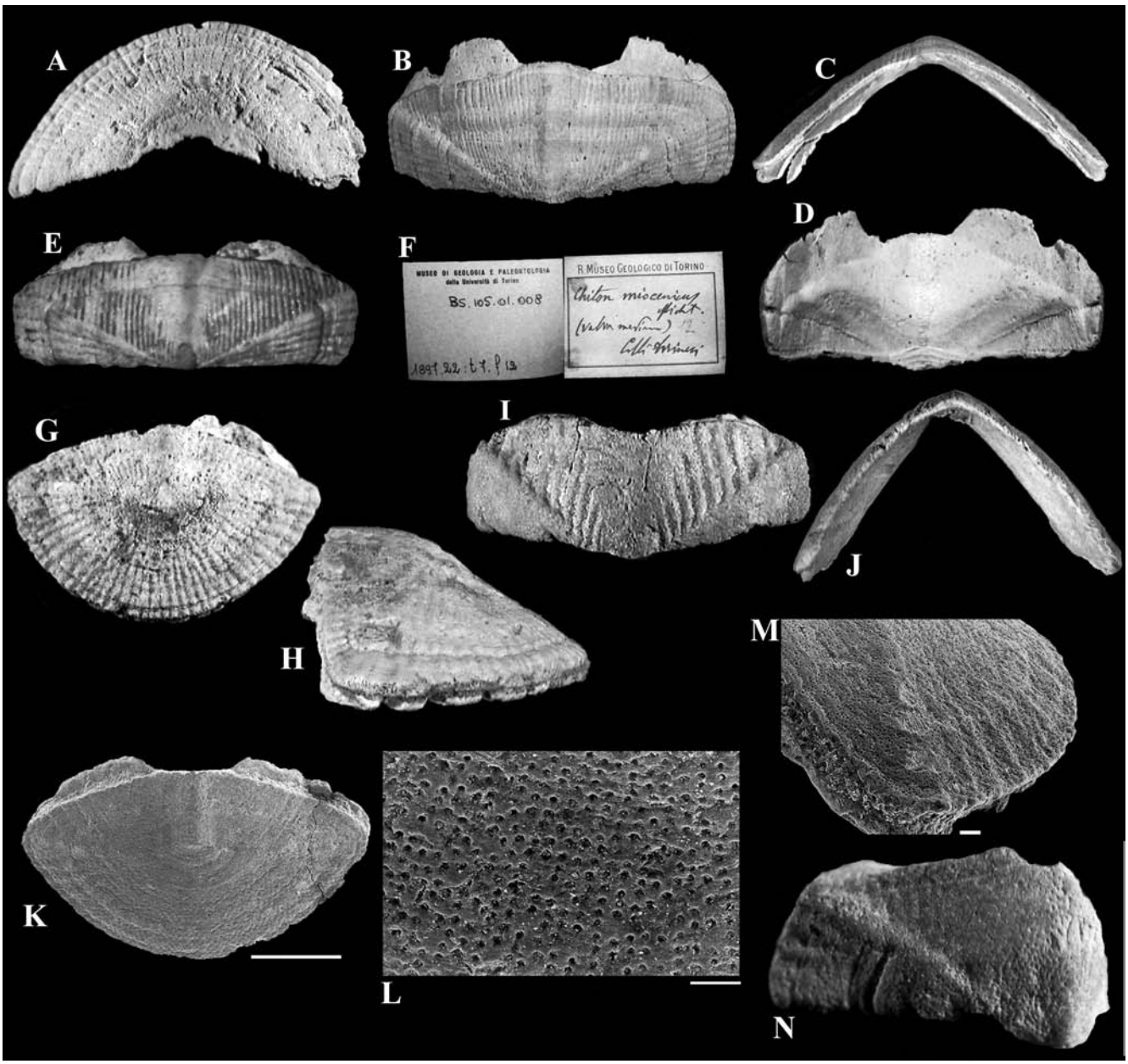


PLATE 7

Figs A-H - *Chiton miocenicus* Michelotti, 1847.
A, Rio Sant'Antonino, head valve, MZB 45743, width 11 mm, dorsal view. B-D, Rio Sant'Antonino, intermediate valve, MZB 45744, width 13 mm, dorsal, frontal and ventral views, respectively. E-F, BS, BS.105.01.008, figured specimen (Sacco, 1897: pl. 7, fig. 12). E, width 13 mm, dorsal view. F, original label. G-H, Rio Sant'Antonino, tail valves. G, MZB 45745, width 8 mm, dorsal view. H, MZB 45746, width 10.5 mm, lateral view.
Figs I-J - *Chiton* sp. A., Borzoli, intermediate valve, MZB 45747, width 4 mm, dorsal and frontal views, respectively.
Figs K-N - *Chiton* sp. B.
K-M, Borzoli, tail valve, MZB 45748. K, dorsal view. L, detail of central area. M, detail of the light flattish ribs near the side margin, by a lateral view. N, Sestri Ponente, half intermediate valve, MZB 45749, width 3.2 mm, dorsal view.
Scale bars 1 mm: K; 100 μm: M; 50 μm: L.

Chiton sp. A

Pl. 7, figs I-J

Material examined: Bussana: 13 intermediate valves (BD); Rio S. Antonino: 4 intermediate valves (BD, MP); Caranchi: 5 intermediate valves (BD, MP); Borzoli: 13 intermediate valves (BD).

Description. Intermediate valves broadly rectangular, elevated, carinate, dorsal elevation 0.5-0.65, front margin slightly concave in the central part, side margins truncated, hind margin straight but for the small apex, lateral areas somewhat raised, clearly defined.

Lateral areas smooth, central area with 5-9 irregular, longitudinal ribs at both sides of the rather broadly triangular, smooth jugum, the 2-4 innermost ribs not reaching the valve's front margin.

Articulamentum with apophyses wide, rounded, one deep slit at both sides, slit ray clearly indicated.

Remarks. Only intermediate valves are present, differing from *Chiton corallinus* (Risso, 1826) mainly by the more elevated intermediate valves, dorsal elevation 0.5-0.65 vs 0.3-0.4 in *Ch. corallinus*.

The species is also similar to *Ch. etruscus* Dell'Angelo & Forli, 1995 from the Pleistocene of Riparbella (Pisa), from which it differs in having greater size, more carinated and less rounded valves, more irregular sculpture of central area, less fine/delicate ribbing.

Distribution. Pliocene: Italy, Liguria (this paper).

Chiton sp. B

Pl. 7, figs K-N

Material examined: Bussana: 1 tail valve (BD); Sestri Ponente: 2 intermediate valves (BD); Borzoli: 4 valves (2 intermediate, and 2 tail) (BD).

Description. Intermediate valve rectangular (only fragments are present), posterior margin a little concave at the left side of the well pronounced apex, lateral areas raised. Tegmentum smooth, except for 3-4 small scars obliquely directed, in pleural area near the side margin, and for some light ribs in lateral areas, but only near the side margin.

Tail valve semielliptical little elevated, with a small anterior mucro, antemucronal slope straight, postmucronal slope little concave just behind the mucro. Sculpture of the antemucronal area like the pleural area of intermediate valves, postmucronal area with some light ribs restricted to the posterior margin.

Articulamentum scarcely visible, slit formula: ? / 1 /?.

Remarks. These small valves can not be attributed with certainty to any of the *Chiton* species known. At first they appear to be *Chiton saeniensis* Laghi, 1984, a species known from the Tuscan Pliocene, but that species has smooth valves, or at most very light flat ribs (longitudinal on central areas, radial on terminal valves and lateral areas), but in this species are always present throughout the valve areas, not only in a small part near the margins, as in *Ch.* sp. B. The same distinguishing characters apply to *Ch. capecchii* Chirli, 2004, another species from the Tuscan Pliocene, characterized by valves of small dimensions (maximum width 3.2 mm). To give a better comparison of the main considered characters, also *Chiton saeniensis* is included in Table 1.

Distribution. Pliocene: Italy, Liguria (this paper).

Suborder **Acanthochitonina** Bergenhayn, 1930

Family Tonicellidae Simroth, 1894

Genus *Lepidochitona* Gray, 1821

Type species: *Chiton marginatus* Pennant, 1777 (= *Chiton cinereus* Linnaeus, 1767), by monotypy.

Remarks. The genus is known from the Paleocene to the Recent. The subgeneric assigments within *Lepidochitona* are mainly based on girdle characters (Kaas & Van Belle, 1985b: 81) not available for fossils; we do not use subgenera.

Fossil valves of *Lepidochitona* are very difficult to identify, given their scarcity, often poor preservation, and the subtle differences of some diagnostic characters. Three middle Miocene (Badenian) species from the Paratethys [*Lepidoc. lepida* (Reuss, 1860), *Lepidoc. subgranosa* Bałuk, 1971, and *Lepidoc. baluki* Macioszczyk, 1988] have been compared by Bałuk (1971, 1974) and Laghi (1977) with some of the Recent ones (*Lepidoc. cinerea*, *Lepidoc. caprearum*, *Lepidoc. monterosatoi* and *Lepidoc. canariensis* (Thiele, 1909).

Lepidochitona cinerea (Linnaeus, 1767)

Pl. 8, figs A-E

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 138).

1767 *Chiton cinereus* Linnaeus, p. 1107.

1962 *Lepidochitona* (*L.*) *cinereus* - Malatesta, p. 155, figs 11-12.

1977 *Lepidochitona cinerea* - Laghi, p. 105, pl. 3, figs 1-4.

1984 *Lepidochitona cinerea* - Laghi, p. 556.

1985b *Lepidochitona* (*L.*) *cinerea* - Kaas & Van Belle, p. 84, fig. 39.

1992 *Lepidochitona cinerea* - Cavallo & Repetto, p. 30, fig. 2.

1995a *Lepidochitona* (*L.*) *cinerea* - Dell'Angelo & Forli, p. 227, fig. 14.

1999 *Lepidochitona cinerea* - Forli et al., p. 111, pl. 1, fig. 7.

1999 *Lepidochitona* (*L.*) *cinerea* - Dell'Angelo & Smriglio, p. 138, pls 44-45, figs 67-72.

1999 *Lepidochitona* (*L.*) *cinerea* - Dell'Angelo et al., p. 264, pl. 2, figs 1, 3.

2001b *Lepidochitona cinerea* - Dell'Angelo et al., p. 148, figs 12, 15.

2001b *Lepidochitona cinerea* (*non* Linnaeus 1767) - Dell'Angelo et al., p. 148, figs 12, 15 (partim, the valves from Serre di Rapolano).

2003 *Lepidochitona* (*L.*) *cinerea* - Dell'Angelo & Silva, p. 12, figs 13-14.

2004 *Lepidochitona cinerea* - Chirli, p. 10, pl. 3, figs 7-9.

2004 *Lepidochitona* (*L.*) *cinerea* - Dell'Angelo et al., p. 36, pl. 3, fig. 6.

2004 *Lepidochitona cinerea* (*non* Linnaeus 1767) - Dell'Angelo et al., p. 36, pl. 3, fig. 6 (partim).

2004 *Lepidochitona cinerea* (*non* Linnaeus 1767) - Chirli, pl. 3, fig. 9 (partim) (= *Lepidoc. pliocinerea*).

2005 *Lepidochitona* (*L.*) *cinerea* - Garilli *et al.*, p. 136, pl. 3, figs 1-3.

2009 *Lepidochitona* (*L.*) *cinerea* - Koskeridou *et al.*, p. 318, figs 10.3-10.5.

Type material: LSL (fide Dodge 1952: 23).

Type locality: "In O. Norvegico".

Material examined: Bussana: 2 intermediate valves (BD); Caranchi: 2 valves (1 head, and 1 intermediate) (BD, MP); Borzoli: 1 head valve (BD).

Remarks. The species is characterized by the fine subquadrangular granules uniformly covering its tegmentum. The granules are arranged in irregular quincunx, sometimes giving the impression of forming more or less longitudinal striae towards the margins. Detailed descriptions of *Lepidoc. cinerea* were given by Kaas & Van Belle (1985b) and Dell'Angelo & Smriglio (1999), while information on valve structure was given by Baxter & Jones (1981) and Baxter (1982).

Lepidochitona subgranosa Bałuk, 1971, recorded from the Badenian (middle Miocene) of Poland, was considered by Laghi (1977) to be a junior synonym of *Lepidoc. cinerea*. Bałuk (1984) regarded the ornamentation of *Lepidoc. subgranosa* more similar to that of *Lepidoc. canariensis* (Thiele, 1909) than to that of *Lepidoc. cinerea*.

The differences to *Lepidochitona pliocinerea*, are reported with this latter species.

Distribution. Late Miocene: Italy (Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Italy (Laghi 1977; Dell'Angelo et al. 2001b; Chirli 2004; Sosso & Dell'Angelo 2010; this paper); Portugal (Dell'Angelo & Silva 2003); Spain (Dell'Angelo et al. 2004). Pleistocene: Italy (Emilia, Tuscany, Apulia, Sicily) (Dell'Angelo et al. 2001b, 2007), Greece (Garilli 2005; Koskeridou et al. 2009). Recent: Mediterranean and Black Sea and Atlantic, along all the European coast, and from southern Greenland to Senegal and Massachusetts (Dell'Angelo & Smriglio 1999).

Lepidochitona caprearum (Scacchi, 1836)

Pl. 8, figs F-K

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 143).

1836 *Chiton caprearum* Scacchi, p. 9.

1848 *Chiton corrugatus* Reeve, pl. 28, sp. & fig. 185.

1977 *Middendorffia caprearum* - Laghi, p. 108.

1988 *Lepidochitona corrugata* - Macioszczyk, p. 52, pl. 2, figs 1, 2, 3a-b.

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

2001b *Lepidochitona caprearum* - Dell'Angelo et al., p. 147, fig. 11.

2005 *Lepidochitona caprearum* - Cretella et al., p. 116, fig. 1a.

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

Type material: Lectotype MCZR E20/12698 (Monterosato coll.), designated by Gaglini (1985), figured by Gaglini (1985: pl. 1, figs 1-2) and Cretella et al. (2005: fig. 1a).

Type locality: Capri Island (Neaples), Italy (40°32'42"N, 14°14'36"E).

Material examined: Rio Sant'Antonino: 48 valves (2 head, 44 intermediate, and 2 tail) (BD, MP); Zinola: 1 intermediate valve (BD); Sestri Ponente: 3 intermediate valves (BD); Borzoli: 6 intermediate valves (BD).

Remarks. This species has a long and rather complex nomenclatural history, summarized by Dell'Angelo & Smriglio (1999). It is characterized by the tegmentum uniformly covered with rough granules arranged in irregular quincunx. The granules are rounded and elevated, with one central megalaesthete surrounded by 15-20 micraesthetes (Pl. 8, fig. G). This layout is typical of *Lepidoc. caprearum*; the illustrations in Dell'Angelo & Smriglio (1999: pl. 47, figs K, L), do not show the micraesthetes on the dirty valves, and the granules seem less densely distributed compared to the ones of Pl. 8, fig. G.

This species has been rarely reported from the Plio-Pleistocene, and its occurrence in the Miocene of the Paratethys should be verified given the numerous *Lepidochitona* species described from that area.

Two anomalous valves were found. One tail valve from Rio Sant'Antonino, which has a new insertion plate developing under the already existing one (Pl. 8, fig. I), and an intermediate valve from Borzoli (Pl. 8, figs J-K) that represents a case of coalescence, well known in living chitons (Taki 1932; Dell'Angelo & Schwabe 2010) but rare in fossil valves (the only known to date is reported by Dell'Angelo & Forli 1995b: two intermediate valves of *Chiton saeniensis* from the Pliocene of Serre di Rapolano, Pisa).

Distribution. Middle Miocene: Badenian of Poland (Macioszczyk 1988, as *L. corrugata*). Late Miocene: Italy (Tortonian of Montegibbio, Modena) (Laghi 1977;

PLATE 8

Figs A-E - *Lepidochitona cinerea* (Linnaeus, 1767).
A, Borzoli, head valve, MZB 45750, width 1.8 mm, dorsal view. B-E, Caranchi, intermediate valve, MZB 45751. B-C, dorsal and frontal views, respectively. D, detail of the sculpture. E, ventral view, width 3 mm.
Figs F-K - *Lepidochitona caprearum* (Scacchi, 1836).
F-G, Rio Sant'Antonino, head valve, MZB 45752. F, dorsal view. G, detail of the sculpture. H, Rio S. Antonino, intermediate valve, MZB 45753, dorsal view. I, Rio Sant'Antonino, anomalous tail valve, MZB 45754, dorsal view, which develop a new insertion plate under the already existing one. J-K, Borzoli, anomalous intermediate valve, MZB 45755, width 2.6 mm, dorsal view, that represent a case of coalescence.
Figs L-Q - *Lepidochitona canariensis* (Thiele, 1909).
L-N, Rio Sant'Antonino, intermediate valve, MZB 45756. L-M, dorsal and frontal views, respectively. N, detail of the sculpture. O-Q, Sestri Ponente, tail valve, MZB 45757. O-P, dorsal and lateral views, respectively. Q, detail of the sculpture.
Scale bars 800 µm: F, I; 600 µm: H; 500 µm: B, C, L, M; 100 µm: N-P; 60 µm: G; 50 µm: D, Q.

Dell'Angelo et al. 1999). Pliocene: Italy (Laghi 1977; Dell'Angelo & Forli 1995b; Dell'Angelo et al. 2001b; Chirli 2004; this paper). Pleistocene: Italy (Dell'Angelo et al. 2001b, 2007), Greece (Koskeridou et al. 2009). Recent: Mediterranean Sea and Atlantic, along the southern coast of Spain and Portugal and in the Selvagens Islands (Dell'Angelo & Smriglio 1999).

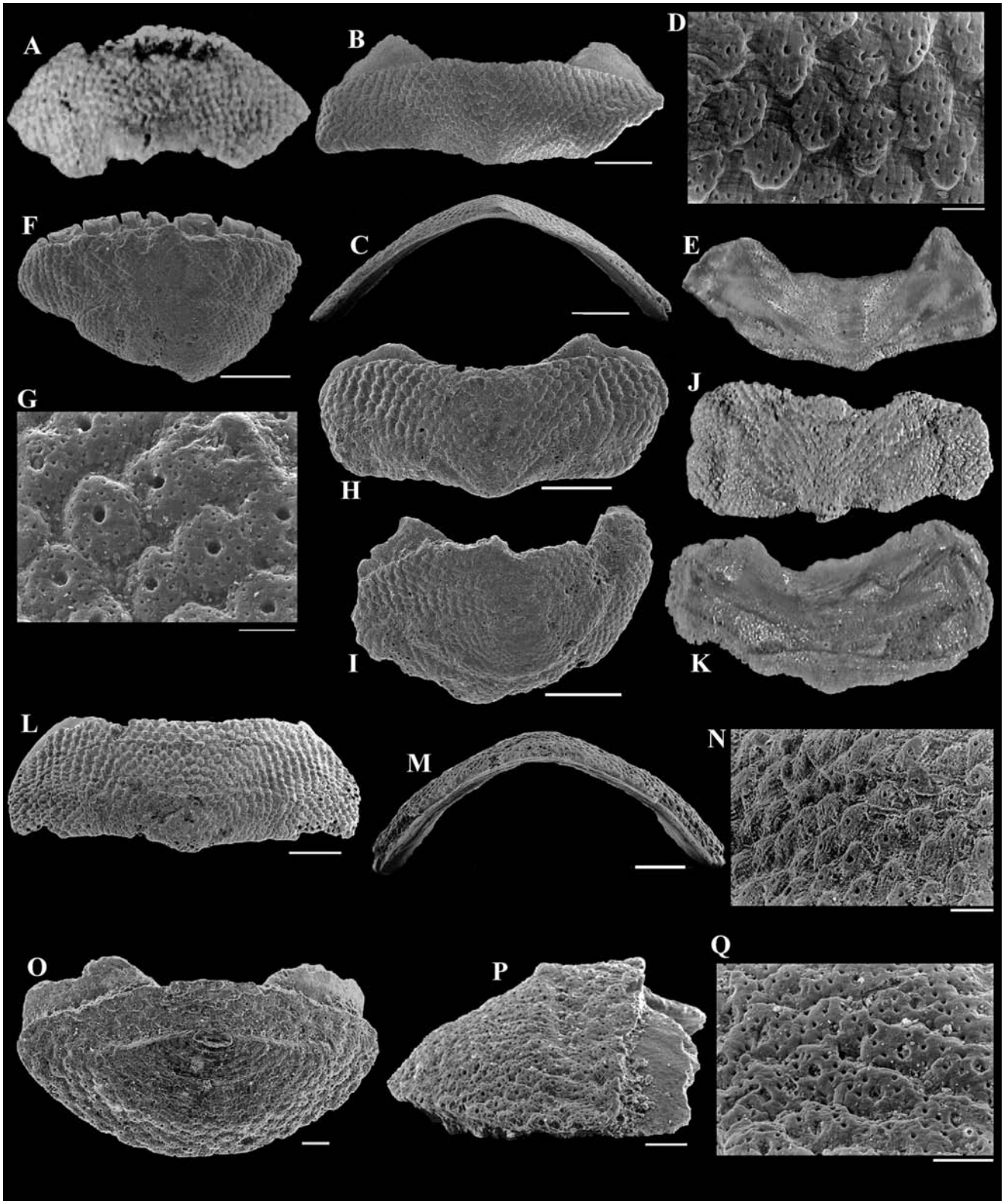
Lepidochitona canariensis (Thiele, 1909)

Pl. 8, figs L-Q

Chresonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 154).

1909 *Trachydermon canariensis* Thiele, p. 15, pl. 2, figs 14-25.

1999 *Lepidochitona* (*L.*) *canariensis* - Dell'Angelo & Smriglio, p. 154, pl. 51, fig. 78.



2004 *Lepidochitona* (*L.*) *canariensis* - Dell'Angelo et al., p. 36, pl. 3, fig. 3.

2009 *Lepidochitona* (*L.*) cf. *canariensis* - Koskeridou et al., p. 316, figs 9.5-9.7.

Type material: Holotype ZMHU 101918.

Type locality: Canary Islands, Tenerifa, Puerto (28°27'40"N, 16°14'47"W).

Material examined: Bussana: 1 intermediate valve (BD); Rio Sant'Antonino: 2 intermediate valves (MP); Rio Torsero: 1 intermediate valve (BD); Sestri Ponente: 2 tail valves (BD); Borzoli: 3 intermediate valves (BD).

Remarks. The species is characterized by the tegmentum with uniform granules, rough roundish granules coarser than those of *Lepidoc. cinerea*, with a tendency to form longitudinal striae converging in the pleural area of the intermediate valves. Detailed descriptions of *Lepidoc. canariensis* are given by Kaas & Van Belle (1985b) and Dell'Angelo & Smriglio (1999).

Distribution. Pliocene: Italy (Liguria, this paper), Spain (Dell'Angelo et al. 2004).

Pleistocene: Greece (Koskeridou et al. 2009). Recent: Mediterranean Sea (Morocco) and Atlantic Ocean, Madeira and the Canary Islands (Dell'Angelo & Smriglio 1999).

Lepidochitona monterosatoi Kaas & Van Belle, 1981

Pl. 9, figs A-F

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 158).

1981 *Lepidochitona* (*L.*) *monterosatoi* Kaas & Van Belle, p. 23, figs 7-9.

1985b *Lepidochitona* (*L.*) *monterosatoi* - Kaas & Van Belle, p. 99, fig. 46.

1988 *Lepidochitona monterosatoi* - Macioszczyk, p. 52, pl. 2, figs 6-8.

1995a *Lepidochitona* (*L.*) *monterosatoi* - Dell'Angelo & Forli, p. 229, fig. 7.

1999 *Lepidochitona monterosatoi* - Forli et al., p. 111, pl. 1, fig. 7.

1999 *Lepidochitona* (*L.*) *monterosatoi* - Dell'Angelo & Smriglio, p. 158, pls 52-53, text-figs 79-83.

2001b *Lepidochitona monterosatoi* - Dell'Angelo et al., p. 148, fig. 14.

2004 *Lepidochitona monterosatoi* - Chirli, p. 11, pl. 3, figs 10-11.

2009 *Lepidochitona* (*L.*) *monterosatoi* - Koskeridou et al., p. 320, figs 10.8-10.10.

2010 *Lepidochitona monterosatoi* - Sosso & Dell'Angelo, p. 15, fig. p. 17.

Type material: Holotype: RMNH 55386/1. Paratypes: VB 2587a/1: Toulon, Le Carnier (France), 17 m; VB 2587b/1, K 4849/1, MNHN/1: Torba (Turkey), 3 m; IRSN 26095/1: Tuscan Archipelago (Italy), 1-40 m.

Type locality: Cap d'Antibes, Port de l'Olivette (France), 43°33'06"N, 7°07'13"E, on a stone on sandy bottom, 0.5 m.

Material examined: Bussana: 9 valves (4 intermediate, and 5 tail) (BD); Rio Sant'Antonino: 15 valves (3 head, 11 intermediate, and 1 tail) (MP); Caranchi: 1 intermediate valve (BD); Borzoli: 4 valves (1 head, and 3 intermediate) (BD).

Remarks. The species is characterized by its uniformly granulated tegmentum with roundish/oval granules, arranged in quincunx on the head valve, the lateral and the jugal areas of the intermediate valves, and the antemucronal area of the tail valve, arranged in curved and diverging longitudinal series on the pleural areas of the intermediate valves. Detailed descriptions of *Lepidoc. monterosatoi* are given by Kaas & Van Belle (1985b) and Dell'Angelo & Smriglio (1999).

The species is rather rare both in living and fossil state, and complete valves can be easily distinguished from the other *Lepidochitona* species by their subcarinate valves, the larger dorsal elevation, the elevated lateral areas of the intermediate valves, and the sculpture of the tegmentum granules. Some valves from Rio Sant'Antonino are robust and thick (Pl. 9, figs C-D).

Distribution. Middle Miocene: Badenian of Poland (Macioszczyk 1988).

Pliocene: Italy (Forli et al. 1999; Dell'Angelo et al. 2001b; Chirli 2004; Sosso & Dell'Angelo 2010; this paper). Pleistocene: Italy (Dell'Angelo & Forli 1995a); Greece (Koskeridou et al. 2009). Recent: Mediterranean Sea (Spain, France, Italy, Croatia, Greece, Cyprus, Turkey, Tunisia) and the Red Sea (Dahlak Islands) (Dell'Angelo & Smriglio 1999; Koukouras & Karachle 2005).

Lepidochitona pliocinerea sp. n.

Pl. 9, figs G-Z

2001b *Lepidochitona cinerea* (*non* Linnaeus 1767) - Dell'Angelo et al., p. 148, figs 12, 15 (partim, the valves from Serre di Rapolano).

PLATE 9

Figs A-F - *Lepidochitona monterosatoi* Kaas & Van Belle, 1981.
A-B, Caranchi, intermediate valve, MZB 45758, width 2 mm, dorsal and ventral views, respectively. C-D, Rio Sant'Antonino, intermediate valve, MZB 45759, dorsal and frontal views, respectively. E-F, Rio Sant'Antonino, tail valve, MZB 45760, dorsal and lateral views, respectively.
Figs G-Z - *Lepidochitona pliocinerea* sp. n.
G-I, Bussana, Holotype MZB 49979, intermediate valve. G, dorsal view. H, detail of the sculpture of the central area. I, the same, by a lateral view. J-M, Rio Sant'Antonino, Paratype MZB 49978, head valve. J-K, dorsal and ventral views, respectively. L, detail of the sculpture. M, the same, by a lateral view. N-P, Bussana, Paratype MZB 49977, tail valve. N-O, dorsal and lateral views, respectively. P, detail of the sculpture of the antemucronal area. Q, Rio Sant'Antonino, Paratype MP, head valve, ventral view, a more thick valve, with slit rays very evident. R-T, Serre di Rapolano, Paratype BD, intermediate valve, width 7.8 mm, dorsal, ventral and frontal views, respectively. U-W, Serre di Rapolano, Paratype BD, tail valve, width 8.3 mm, dorsal, lateral and ventral views, respectively. X-Z, Rio Sant'Antonino, a fragment of a thick intermediate valve, width 2 mm. X, dorsal view. Y, in section, to see the thickness of the valve. Z, ventral view.
Scale bars 1 mm: G, J, N, O, R, U, V; 500 μm: C-F; 200 μm: H, P; 80 μm: I; 50 μm: L, M.

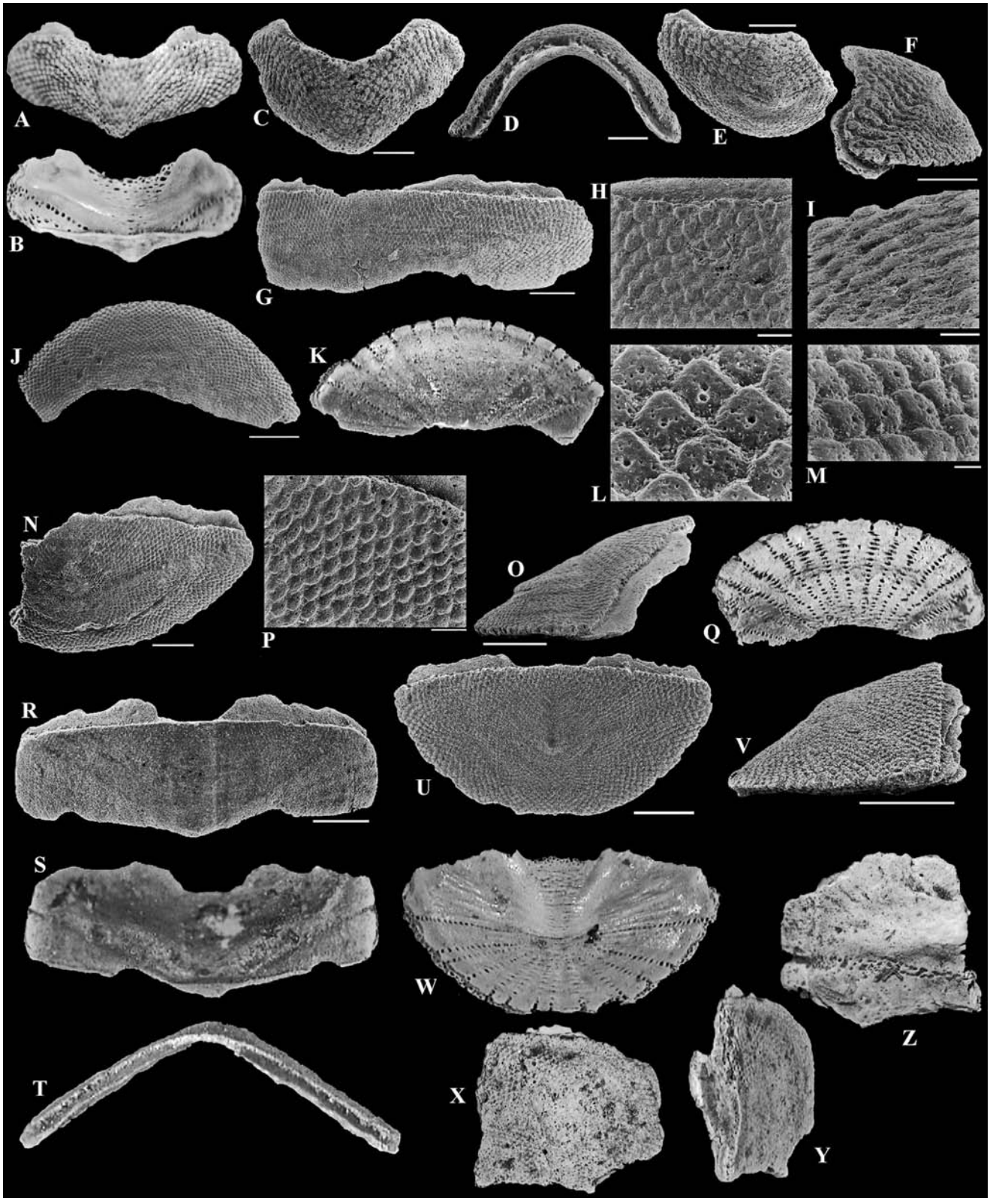
2004 *Lepidochitona cinerea* (*non* Linnaeus 1767) - Chirli, pl. 3, fig. 9.

2004 *Lepidochitona cinerea* (*non* Linnaeus 1767) - Dell'Angelo et al., p. 36, pl. 3, fig. 6.

Material examined: Bussana: 10 valves (1 head, 7 intermediate, and 2 tail) (BD); Rio Sant'Antonino: 75 valves (16 head, 58 intermediate, and 1 tail) (MP); Garlenda: 2 intermediate valves (MP); Caranchi: 4 valves (1 head, and 3 intermediate) (BD, MP); Sestri Ponente: 2 intermediate valves (BD); Borzoli: 14 valves (1 head, 12 intermediate, and 1 tail) (BD).

Other material examined: Serre di Rapolano (Siena, Italy: Pliocene, 43°20.30'N, 11°35.89'E): 21 valves (4 head, 13 intermediate, and 4 tail) (BD); Estepona (Malaga, Spain: Pliocene, 36°26'36"N, 5°06'21"W): 6 valves (3 intermediate, and 3 tail) (BD).

Type material: Holotype: MZB 49979, an intermediate valve (Pl. 9, figs G-I). Seven Paratypes: MZB 49978, an head valve from Rio



Sant'Antonino (Pl. 9, figs J-M); MZB 49977, a tail valve from Bussana (Pl. 9, figs N-P); MSNG 56537, a tail valve from Bussana; MP, an head valve from Rio Sant'Antonino (Pl. 9, fig. Q); BD, a complete intermediate valve from Serre di Rapolano (Pl. 9, figs R-T); BD, a complete tail valve from Serre di Rapolano (Pl. 9, figs U-W); MS, an intermediate valve from Sestri Ponente.

Type locality: Bussana (Imperia), Italy (43°49'60"N, 7°49'52"E).

Type stage: Lower Pliocene (Zanclean).

Etymology: similar to *Lepidochitona cinerea* and more frequently found from the Ligurian Pliocene.

Description. Valves solid, often remarkably thick (Pl. 9, figs X-Z). Head valve about one third of a circle. Intermediate valves broadly rectangular, subcarinated (height/width = 0.31 for intermediate valves from Serre di Rapolano, Pl. 9, fig. T), posterior margin almost straight, drawn out to small apex, not beaked, lateral areas not distinctly separated from central area. Tail valve oval, mucro subcentral, not prominent, antemucronal and postmucronal slopes practically straight. Tegmentum evenly sculptured all over with irregularly roundish granules, arranged in irregular quincunx. Each granule bearing more or less central megalaesthete, several micraesthetes (15-20) irregularly arranged along margin, also in depressions between granules (Pl. 9, fig. L). Articulamentum with apophyses short, very wide, jugal sinus straight to slightly convex, narrow about one seventh of total width. Slit formula 15-16 / 1 / 11-13, slit rays well marked, insertion teeth of very irregular width. Maximum valve width: 7.5, 15 and 6.2 mm, respectively, for head, intermediate, and tail valves (estimated for intermediate ones).

Remarks. Many of the examined valves are small fragments, with a width of less than 2 mm, only 9 valves (3 head, 4 intermediate, and 2 tail) from Bussana and Rio Sant'Antonino are almost complete. Also some valves (before determined as *Lepidoc. cinerea*) from the Pliocene of Serre di Rapolano (Siena, Italy) and Estepona (Spain) belong to *Lepidoc. pliocinerea*.

A greater thickness of the valves is visible in some valves from Rio Sant'Antonino (Pl. 9, figs Q, X-Z).

Comparisons. The new species differs from *L. cinerea* mainly in:

(i) Larger apophyses, starting from the jugal area. These are narrower and more triangular in *Lepidoc. cinerea*. The jugal sinus is narrow in *Lepidoc. pliocinerea*, much wider in *Lepidoc. cinerea*, compare Pl. 8, fig. B vs. Pl. 9, fig. R, and Pl. 8, fig. E vs. Pl. 9, fig. S for the ventral view. The different slope in tail valves. Antemucronal and postmucronal slopes almost straight in *Lepidoc. pliocinerea* (Pl. 9, figs O, V), while the postmucronal slope is concave under the mucro in *Lepidoc. cinerea* (compare Kaas & Van Belle 1985b: fig. 39.4; Dell'Angelo & Smriglio 1999: pl. 45, fig. I).

(ii) More irregularly roundish granules (Pl. 9, figs H, M), while in *Lepidoc. cinerea* they are oval-subquadrangular and more regular (Pl. 8, fig. D).

(iii) The greater number of slits, mainly in the head valve. *Lepidochitona cinerea* is described as typically having a slit formula 8-10 / 1 / 8-12 (Kaas & Van Belle 1985b; Dell'Angelo & Smriglio 1999). The number of slits is a very variable character, Baxter (1982) gives 7-11 / 1 / 6-16, with the modes of the slit frequencies of head and tail valves similar to the "typical numbers" (mode 8 for head valve, 9, 10 or 11 for tail valve). The slit formula of the studied material of *Lepidoc. pliocinerea* is 15-16 / 1 / 11-13 for Ligurian, 15-16 / 1 / 14-15 for Serre di Rapolano, and ? / 1 / 12-13 for Estepona.

(iv) The greater width of its valves. The data available from the literature on living specimens is usually reported as the length of the whole animal. Baxter (1982) gave a maximum width less than 8 mm for intermediate valves of living specimens from Scotland. The maximum width of hundreds of *Lepidoc. cinerea*'s valves in BD collection are respectively (for head, intermediate, and tail valves) 4.5, 6.3 and 4.3 mm for Atlantic (Getares, Spain) and 6.5, 8.5 and 6 mm for Mediterranean (Arenzano, Genova). Data from literature for fossil valves are respectively 1.7, 5.3 and no tail valves from Tuscan Pliocene (Chirli 2004), 2, 2.2 mm and no tail valves from Pleistocene of Riparbella (Dell'Angelo & Forli 1995a). The maximum widths of the studied material are respectively 7.5, 8.5 and 6.2 for Ligurian (intermediate valves not complete, maximum estimated width 15 mm), 9, 9 and 8 mm for Serre di Rapolano (estimated maximum width for intermediate valves 15 mm), and 10, 15.6 and 7.5 mm for Estepona.

PLATE 10

Figs A-G - *Acanthochitona fascicularis* (Linnaeus, 1767), Rio Sant'Antonino. A, head valve, MZB 45761, width 3 mm, dorsal view. B, intermediate valve, MZB 45762, width 3 mm, dorsal view. C, tail valve, MZB 45763, width 3,5 mm, dorsal view. D-E, intermediate valve, MZB 45764. D, dorsal view. E, detail of the sculpture. F-G, tail valve with some additional slits on the insertion plate, MZB 45765, width 2.1 mm, dorsal and ventral views, respectively.

Figs H-M - *Acanthochitona crinita* (Pennant, 1777).

H, Garlenda, head valve, MZB 45766, width 1.5 mm, dorsal view. I-J, Bussana, intermediate valve, MZB 45767. I, dorsal view. J, detail of the sculpture. K-M, Rio Torsero, tail valve, MZB 45768. K-L, dorsal and lateral views, respectively. M, detail of the sculpture.

Figs N-Q - *Acanthochitona oblonga* (Leloup, 1981), Bussana, intermediate valves. N, MZB 45769, dorsal view. O, detail of the sculpture. P, MZB 45770, dorsal view. Q, detail of the sculpture.

Figs R-W - *Craspedochiton altavillensis* (Seguenza, 1876).

R-S, Zinola, head valve, MZB 45771, width 4 mm, dorsal and ventral views, respectively. T-U, Rio Sant'Antonino, intermediate valve, MZB 45772, width 4.2 mm, dorsal and ventral views, respectively. V-W, Borzoli, tail valve, MZB 45773, width 3 mm, dorsal and ventral views, respectively.

Scale bars 800 μm: D; 400 μm: I, K, N, P; 300 μm: L; 80 μm: J, M, O, Q; 40 μm: E.

Family Acanthochitonidae Pilsbry, 1893

Genus *Acanthochitona* Gray, 1821

Type species: *Chiton fascicularis* Linnaeus, 1767, by monotypy.

Remarks. The genus is known from the Miocene to the Recent.

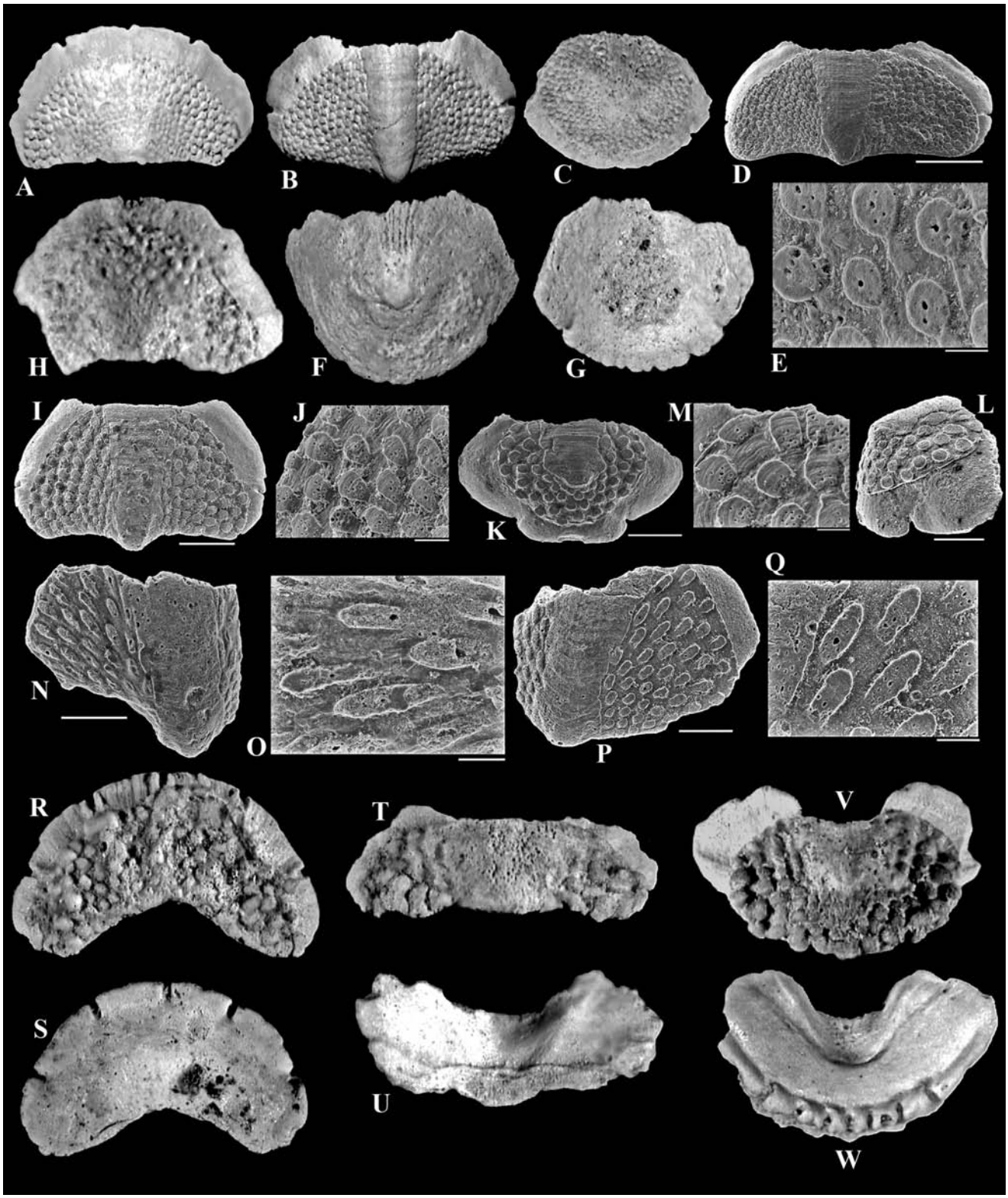
Acanthochitona fascicularis (Linnaeus, 1767)

Pl. 10, figs A-G

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 192).

1767 *Chiton fascicularis* Linnaeus, p. 1106.

1826 *Acanthochites communis* Risso, p. 268.



1977 *Acanthochitona communis* - Laghi, p. 110, pl. 3, figs 13-19.
1977 *Acanthochitona fascicularis* (*non* Linnaeus 1767) - Laghi, p. 111, pl. 3, figs 20-21.
1984 *Acanthochitona fascicularis* (*non* Linnaeus 1767) - Bałuk, p. 291, pl. 9, fig. 2 (= *A. crinita*).
1995a *Acanthochitona fascicularis* - Dell'Angelo & Forli, p. 235, figs 8, 11.
1999 *Acanthochitona fascicularis* - Dell'Angelo & Smriglio, p. 192, pls 64-65, figs 113-123.
1999 *Acanthochitona fascicularis* - Dell'Angelo et al., p. 273, pl. 5, figs 1, 3-5, pl. 5, figs 3, 4, 6.
2001 *Acanthochitona fascicularis* - Dell'Angelo et al., p. 153, figs 30, 33.
2004 *Acanthochitona fascicularis* - Chirli, p. 16, pl. 6, figs 9-17.
2004 *Acanthochitona fascicularis* - Dell'Angelo et al., p. 40, pl. 3, fig. 8, pl. 4, fig. 1.
2005 *Acanthochitona fascicularis* - Garilli et al., p. 139, pl. 5, figs 1-3.
2006 *Acanthochitona fascicularis* - Dell'Angelo & Vardala-Theodorou, p. 331, fig. 6.
2007 *Acanthochitona fascicularis* - Dell'Angelo et al., p. 44, fig. 4e.
2007a *Acanthochitona fascicularis* - Dell'Angelo et al., p. 141.
2009 *Acanthochitona fascicularis* - Koskeridou et al., p. 322, figs 11.3-11.8.
2010 *Acanthochitona fascicularis* - Sosso & Dell'Angelo, p. 15, fig, p. 17.

Type material: The species is in The Linnean Society of London (fide Dodge, 1952: 21). Neotype designated and figured by Kaas (1985a: p. 588, fig.1), MNHN, a specimen 20 x 11 mm.

Type locality: "In Barbaria". Neotype: Oran, Algerie (35°42'51"N, 0°37'42"W).

Material examined: Bussana: 39 valves (9 head, 20 intermediate, and 10 tail) (BD); Rio Sant'Antonino: 427 valves (39 head, 345 intermediate, and 43 tail) (BD, MP); Garlenda: 10 valves (1 head, and 9 intermediate) (MP); Salea: 1 intermediate valve (BD); Caranchi: 42 valves (3 head, 36 intermediate, and 3 tail) (BD); Rio Torsero: 36 valves (4 head, 28 intermediate, and 4 tail) (BD, MP, PG, SR); Zinola: 2 valves (1 intermediate, and 1 tail) (BD); Sestri Ponente: 5 valves (2 head, 2 intermediate, and 1 tail) (BD); Borzoli: 73 valves (7 head, 56 intermediate, and 10 tail) (BD).

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

Kaas (1985a) designated a neotype, but did not describe the microstructure of granules for this species. However, these were well studied by Fischer & Renner (1979: figs 2, 4-6, 11, 15), and that description agrees with our material from the Ligurian Pliocene (Pl. 10, fig. E).

Two *Acanthochitona* species reported from Miocene of the Paratethys, *A. sandeciana* Bałuk, 1965, and *A. faluniensis* (de Rochebrune, 1883), differ mainly by the shape and size of the granules covering the tegmentum as well as the ornamentation of the jugal area. These species, well discussed by Studencka & Dulai (2010), were considered valid species (Bałuk, 1965, 1971, 1984; Studencka & Dulai 2010) or synonyms (Laghi, 1977; Dell'Angelo et al. 1999) of *A. fascicularis.*

One new tail valve from Rio Sant'Antonino (Pl. 10, figs F-G) shows some additional slits on the insertion plate, a character for which Laghi (1977) established *Craspedochiton (Pseudoacanthochitona) ambiguus* Laghi, 1977, on valves from "La Tagliata" and Solignano (Modena, lower Pliocene). The latter species was classified in *Acanthochitona* by Dell'Angelo et al. (1999) and Bałuk (1984: 292), who noted that "additional slits on the insertion plates of tail valves appear also in some of the Korytnica specimens, and... result from a rippling of a part of the insertion plate, in between the main slits".

Distribution. Middle Miocene: Badenian of Romania (Dell'Angelo et al. 2007).

Late Miocene: Italy (Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Spain (Dell'Angelo et al. 2004) and Italy (Dell'Angelo et al. 2001b; Chirli 2004; Sosso & Dell'Angelo 2010; this paper). Pleistocene: Italy (Dell'Angelo et al. 1995a, 2001, 2007a), Greece, and Cyprus (Garilli et al. 2005; Koskeridou et al. 2009). Recent: the whole Mediterranean Sea and the Atlantic Ocean, from the English Channel and Brittany to the Azores and the Canary Islands (Dell'Angelo & Smriglio 1999).

Acanthochitona crinita (Pennant, 1777)

Pl. 10, figs H-M

Chresonymy and synonymy (Recent taxa) in Dell'Angelo & Smriglio (1999: p. 198).
1777 *Chiton crinitus* Pennant, p. 71, pl. 36, figs 1, A1.
1971 *Acanthochitona lacrimulifera* Bałuk, p. 484, pl. 2, figs 6-9.
1977 *Acanthochitona fascicularis* (*non* Linnaeus 1767) - Laghi, p. 111, pl. 3, figs 20-21.
1984 *Acanthochitona fascicularis* (*non* Linnaeus 1767) - Bałuk, p. 291, pl. 9, fig. 2.
1995a *Acanthochitona crinita* - Dell'Angelo & Forli, p. 236, fig. 13.
1999 *Acanthochitona crinita* - Dell'Angelo & Smriglio, p. 198, pls 66-68, figs 124-130.
1999 *Acanthochitona crinita* - Dell'Angelo et al., p. 275, pl. 5, figs 2, 6.
2001 *Acanthochitona crinita* - Dell'Angelo et al., p. 153, fig. 32.
2004 *Acanthochitona crinita* - Dell'Angelo et al., p. 40, pl. 4, figs 2, 5.
2004 *Acanthochitona crinita* - Chirli, p. 16, pl. 6, figs 7-8.
2009 *Acanthochitona crinita* - Koskeridou et al., p. 322, figs 11.1-11.2.
2010 *Acanthochitona crinita* - Sosso & Dell'Angelo, p. 15, fig, p. 17.
2010 *Acanthochitona lacrimulifera* - Studencka & Dulai, p. 268.

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

Type locality: Neotype: Hebrides Islands, Monach Island, North Uist, Great Britain (57°31.5'N, 07°38.5'W).

Material examined: Bussana: 209 valves (7 head, 189 intermediate, and 13 tail) (BD, SR); Rio Sant'Antonino: 105 valves (4 head, 98 intermediate, and 3 tail) (BD); Garlenda: 6 valves (1 head, and 5 intermediate) (MP); Caranchi: 8 intermediate valves (BD, MP); Rio Torsero: 5 valves (4 intermediate, and 1 tail) (BD); Zinola: 1 intermediate valve (BD); Sestri Ponente: 22 valves (3 head, 18 intermediate, and 1 tail) (BD); Borzoli: 18 valves (1 head, 16 intermediate, and 1 tail) (BD).

Remarks. *Acanthochitona crinita* is an extremely variable species with a very complicated synonymy. It is characterized by the tegmentum uniformly covered with oval to more or less elongated, flat-topped, drop shaped granules. A detailed description is given by Dell'Angelo & Smriglio (1999). Even though Kaas (1985a) designated a neotype, nothing has been said on the microstructure of granules, that agree with that reported for living specimens, e.g., compare with Bonfitto et al. (2011: fig. 2).

Acanthochitona lacrimulifera was interpreted as a direct ancestral form of the Recent *A. crinita* (by Bałuk 1971: as *A. fascicularis*). *A. lacrimulifera* was considered a synonym of *A. crinita* (Laghi, 1977: as *A. fascicularis*) (Bałuk 1984; Dell'Angelo et al. 1999; Studencka & Dulai 2010).

Distribution. Middle Miocene: Badenian of Poland (Bałuk 1971, 1984, as *A. lacrimulifera*, *A. fascicularis*). Late Miocene: Italy (Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Spain (Dell'Angelo et al. 2004) and Italy (Dell'Angelo et al. 2001b; Chirli 2004; Sosso & Dell'Angelo 2010; this paper). Pleistocene: Italy (Dell'Angelo et al. 1995a, 2001), and Greece (Koskeridou et al. 2009). Recent: Mediterranean Sea and the Atlantic coast of Europe (as far north as Norway), plus Madeira, the Azores, the Canary Islands, and the Cape Verde Archipelago (Dell'Angelo & Smriglio 1999).

Acanthochitona oblonga (Leloup, 1981)

Pl. 10, figs N-Q

1981 *Acanthochiton oblongus* Leloup, p. 1, figs 1a-d, pl. 1.

1985 *Acanthochitona oblonga* - Gaglini, p. xviii, pl. 1, fig. 6; 1989: 9.

1985a *Acanthochiton oblongus* - Kaas, p. 596, figs 39-43.

1995a *Acanthochitona crinita* f. *oblonga;* Dell'Angelo & Forli, p. 237, fig. 6.

1999 *Acanthochitona oblonga* – Dell'Angelo & Smriglio, p. 200, figs 124-130, pl. 67, figs K-L, pl. 68, figs Q-V.

2011 *Acanthochitona oblonga* - Bonfitto et al., p. 174, figs 2A-B, 4C, 6C.

Type material: Holotype at the MU.

Type locality: Malta, Salina Bay (35°56'20"N, 14°27'50"E), "under rocks at 3 meters depth, July 1974".

Material examined: Bussana: 7 intermediate valves (BD); Rio Sant'Antonino: 1 intermediate valve (MP).

Remarks. This species is characterized by the very extended sharp granules of the tegmentum. Several specimens were reported from the Mediterranean Sea (Dell'Angelo & Smriglio 1999) showing that this species is locally very common along the South Apulian Adriatic coast where specimens exibit granules variable from typical drop shaped to a shape extended even more than what originally described by Leloup.

This species is so similar to *A. crinita* that Kaas (1985a) and Dell'Angelo & Smriglio (1999) consider them as conspecific. Bonfitto et al. (2011), demonstrated that *A. oblonga* is a valid species based on morphological and molecular characters.

The valves found agree with the microstructure of the granules reported for living specimens by Bonfitto et al. (2011: fig. 3).

Distribution. Pliocene: Italy: Liguria (this paper). Pleistocene: Italy: Riparbella (Pisa) (Dell'Angelo & Forli 1995a). Recent: Southern Mediterranean Sea in scattered Italian localities, Malta, Cyprus, Tunisia (Dell'Angelo & Smriglio 1999; Bonfitto et al. 2011).

Genus *Craspedochiton* Shuttleworth, 1853

Type species: *Chiton laqueatus* Sowerby, 1842, by monotypy.

Remarks. The genus is known from the Eocene to the Recent.

Craspedochiton altavillensis (Seguenza, 1876)

Pl. 10, figs R-W

Chresonymy and synonymy (Fossil taxa) in Dell'Angelo *et al.* (2012).

1876 *Chiton altavillensis* Seguenza, p. 264.

1883 *Gymnoplax deslongchampsi* de Rochebrune, p. 69, pl. 3, fig. 6.

1897 *Acanthochiton costatus*? var. *astensis* Sacco, p. 91, pl. 7, figs 39-47.

1977 *Craspedochiton deslongchampsi* - Laghi, p. 112, pl. 4, figs 4-8.

1988 *Craspedochiton altavillensis* - Dell'Angelo & Palazzi, p. 174, fig. 1.

1999 *Craspedochiton altavillensis* - Dell'Angelo et al., p. 276, pl. 6, figs 1, 2, 5.

2001 *Craspedochiton altavillensis* - Dell'Angelo et al., p. 153, fig. 31.

2004 *Craspedochiton altavillensis* - Chirli, p. 17, pl. 6, fig. 18.

2004 *Craspedochiton altavillensis* - Dell'Angelo et al., p. 40, pl. 2, figs 4, 7.

2005 *Craspedochiton altavillensis* - Garilli et al., p. 140, pl. 5, figs 4-10.

2010 *Craspedochiton altavillensis* - Sosso & Dell'Angelo: 15, fig. p. 17.

2012 *Craspedochiton altavillensis* - Dell'Angelo et al., p. 64, figs 6D-H.

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

Type locality: Altavilla Milicia (Palermo, Sicily), Italy (38°02'35"N, 13°32'53"E).

Material examined: Rio Sant'Antonino: 47 valves (8 head, 31 intermediate, and 8 tail) (BD, MP, PG); Garlenda: 3 valves (1 head, 1 intermediate, and 1 tail) (MP); Caranchi: 1 intermediate valve (MP); Rio Torsero: 2 intermediate valves (BD, PG); Zinola: 1 head valve (BD); Borzoli: 25 valves (2 head, 21 intermediate, and 2 tail) (BD).

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; the elevation and the density of granules on the tegmentum is variable.

The synonymy of *Cr. deslongchampsi* with *Cr. altavillensis* has been discussed by Dell'Angelo & Palazzi (1988), who also designated neotypes after verifying the lack of type material of Seguenza and de Rochebrune (Bertolaso & Palazzi 2000). Dell'Angelo et al. (1999) briefly discussed the other *Craspedochiton* species from the Turin hills [*Cr. costatus* (Sacco, 1897)] and the Paratethys [*Cr. profascicularis* (Boettger, 1905), *Cr. schafferi* (Šulc, 1934)].

Distribution. Early Miocene: Italy, Turin hills (Dell'Angelo et al. 1999). Middle Miocene: Badenian of Romania and Poland (Dell'Angelo et al. 1999). Late Miocene: Italy (Tortonian of Montegibbio, Modena, and Messinian of Borelli, Turin) (Laghi 1977; Dell'Angelo et al. 1999). Pliocene: Spain (Dell'Angelo et al. 2004), and Italy (Dell'Angelo et al. 2001b; Chirli 2004; Sosso & Dell'Angelo 2010; this paper). Pleistocene: Italy (Torrente Stirone, Parma, and Dattilo, Trapani), and Greece (Garilli et al. 2005).

Discussion

This paper is the first comprehensive and illustrated account of fossil chitons from the Pliocene of Western Liguria, and represents an important extension of the data reported by Sacco (1897) where the Ligurian Pliocene chitons were poorly represented.

Chitons sourced from the nine Ligurian Pliocene localities include 31 species, 22 of which are already known, four are described as new, and 5 assigned only at generic level, represented by 9,657 valves (Tab. 2). The maximum valve width (mm) for each species is also reported in Table 2. Three values are reported for head, intermediate, and tail valves. A forward slash "/" indicates that the value is not available for the corresponding valves.

Only three species (*Lepidopleurus cajetanus, Chiton corallinus* and *Acanthochitona fascicularis*) occur at all the studied sites. Due to the different sampling strategies used by various collectors at the different sites, it is not possible to quantitatively evaluate the abundance of the species, the more common ones just reflecting a higher sampling effort. However, *Ch. corallinus* and *Lepidop. cajetanus* seem to be really common, representing 46% and 31% respectively of the total number of valves. At the opposite extreme, five species (*Leptochiton alveolus, Lept. scabridus*, *Lept.* sp., *Connexochiton roccai* sp. n. and *Callochiton* sp.) are represented by single valves.

The majority of valves (64% of the total) and the greatest number of species (24 of 31) were found at Rio Sant'Antonino, an outcrop constantly sampled for 20 years. We found only four valves of three species at Salea due to the difficulty of sample at that locality, a former quarry now used as a dumping site. By contrast, with only occasional sampling of sediment clayey silt during excavations, we found valves of 17 different species at Sestri Ponente. It suggests a high chiton species richness in the area due to a particularly favourable but poorly understood setting.

The Ligurian Pliocene chitons include European species that generally have a Neogene to Quaternary distribution (Tab. 3). Seventeen species (55%) are also known from the Miocene. Seventeen of the species found (55%) are still living in the Mediterranean Sea (13 of which also occur in the eastern Atlantic), and one species (*Lept. alveolus*) is still living in the Atlantic only. Ten species are known only from Mediterranean Pliocene (*Leptochiton josei* sp. n., *Ischnochiton martinelli, I. ligusticus* sp. n., *Connexochiton roccai* sp. n., *Lepidochitona pliocinerea* sp. n. and the five species assigned only at generic level), and only *Craspedochiton altavillensis* has a Miocene to Pleistocene range.

The fauna of the Ligurian Pliocene outcrops here studied is the most diverse polyplacophoran fauna ever reported from a single European Pliocene area (31 species from the nine localities investigated, and a maximum of 24 species from the single locality of Rio Sant'Antonino). There are 37 determined species known from the Mediterranean Pliocene, permitting a comparison of the recenty published chiton faunas from Altavilla (Dell'Angelo et al. 2012: 12 species from 5 sites, and a maximum of 10 species from a single site), Estepona (Málaga, Spain, Dell'Angelo et al. 2004: 17 species from 5 localities, and a maximum of 11 species from the single site of Velerin Antena), and Tuscany (Dell'Angelo et al. 2001b; Chirli 2004: 24 species, and a maximum of 16 species from the early Pliocene of Pietrafitta, Siena).

This summary (Tab. 4) reveals that six species are common to all sites: *Hanleya hanleyi, Ischnochiton rissoi, Callochiton septemvalvis, Acanthochitona crinita, A. fascicularis,* and *Craspedochiton altavillensis.* At the opposite extreme, 16 species have been found at only a single site, and the high proportion of such cases highlights the difficulty of evaluating the abundance of such species.

Localities	1	2	3	4	5	6	7	8	9		Maximum valves' width (mm)
Species											
Lepidopleurus cajetanus	221	2,282	67	1	5	2	13	13	381	2,985	7 - 8.7 - 8
Leptochiton cancellatus	1	16			2	1		1	5	26	/ - 3.5 - 2.3
Leptochiton alveolus							1			1	/ - 2.9 - /
Leptochiton scabridus								1		1	/ - 1.7 - /
Leptochiton bedullii	2	5				1		1	2	11	/ - 2.5 - 2.2
Leptochiton josei sp. n.	6	4			1			1		12	/ - 2.1 - 3
Leptochiton sp.			1							1	/ - 2.1 - /
Hanleya hanleyi		8			1		1		1	11	2.5 - 4.2 - 2.9
Ischnochiton rissoi	6	26	1			6			7	46	5.7 - 6 - 7
Ischnochiton korytnicensis	15	3				2		1	2	23	4 - 6 - 5
Ischnochiton martinelli		1			2					3	/ - 3.2 - /
Ischnochiton? sp.		1			1			4		6	1.4 - 2.1 - 1.6
Ischnochiton ligusticus sp. n.	20	40	20		5	2	4	4	9	104	4 - 7 - 5
Stenosemus dolii		39	2				7		43	91	5 - 5.8 - 4.5
Connexochiton roccai sp. n.									1	1	/ - / - 1.5
Callochiton septemvalvis	36	52	1		8	5	1	11	12	126	3 - 4.5 - 3.3
Callochiton sp.		1								1	/ - / - 3.2
Chiton olivaceus	8				3	2		3	10	26	4.6 - 6.3 - 3.5
Chiton corallinus	565	2,620	364	2	34	29	87	69	635	4,405	6 - 7.5 - 5.2
Chiton miocenicus	4	332	5			1			89	431	11 - 15 - 10.5
Chiton sp. A	13	4			5				13	35	/ - 6 - /
Chiton sp. B	1							2	4	7	/ - 3.2 - 3.9
Lepidochitona cinerea	2				2				1	5	1.8 - 3 - /
Lepidochitona caprearum		48					1	3	6	58	3.1 - 3.5 - 3.2
Lepidochitona canariensis	1	2				1		2	3	9	/ - 3 - 1.2
Lepidochitona monterosatoi	9	15			1				4	29	2.5 - 2.6 - 2.7
Lepidochitona pliocinerea sp. n.	10	75	2		4			2	14	107	7.5 - 8.5 - 6.2
Acanthochitona fascicularis	39	427	10	1	42	36	2	5	73	635	3 - 5.5 - 3.7
Acanthochitona crinita	209	105	6		8	5	1	22	18	374	2.5 - 3 - 1.8
Acanthochitona oblonga	7	1								8	/ - 2 - /
Craspedochiton altavillensis		47	3		1	2	1		25	79	6.2 - 9 - 5.6
total	1,175	6,154	482	4	125	95	119	145	1,358	9,657	

Tab. 2 - Number of valves found by locality/species and maximum valve width. Localities: 1: Bussana; 2: Rio Sant'Antonino; 3: Garlenda; 4: Salea; 5: Caranchi; 6: Rio Torsero; 7: Zinola; 8: Sestri Ponente; 9: Borzoli.

Tab. 3 - Stratigraphic range of the species.

Taxa	Miocene	Pliocene	Pleistocene	Recent	
				Medit.	Atlantic
Lepidopleurus cajetanus	x	x	x	x	x
Leptochiton cancellatus	x	x	x	x	x
Leptochiton alveolus		x			x
Leptochiton scabridus	x	x	x	x	x
Leptochiton bedullii		x		x	
Leptochiton josei sp. n.		x			
Leptochiton sp.		x			
Hanleya hanleyi	x	x	x	x	x
Ischnochiton rissoi	x	x	x	x	
Ischnochiton korytnicensis	x	x			
Ischnochiton martinelli		x			
Ischnochiton ligusticus sp. n.		x			
Ischnochiton? sp.		x			
Stenosemus dolii	x	x	x	x	
Connexochiton roccai sp. n.		x			
Callochiton septemvalvis	x	x	x	x	x
Callochiton sp.		x			
Chiton olivaceus	x	x	x	x	x
Chiton corallinus	x	x	x	x	x
Chiton miocenicus	x	x			
Chiton sp. A		x			
Chiton sp. B		x			
Lepidochitona cinerea	x	x	x	x	x
Lepidochitona caprearum	x	x	x	x	x
Lepidochitona canariensis		x	x	x	x
Lepidochitona monterosatoi	x	x	x	x	
Lepidochitona pliocinerea sp. n.		x			
Acanthochitona fascicularis	x	x	x	x	x
Acanthochitona crinita	x	x	x	x	x
Acanthochitona oblonga		x	x	x	
Craspedochiton altavillensis	x	x	x		
total	17	31	17	17	13

Valves of fossil chitons are often fragmentary and rare in sedimentary deposits, are often overlooked by collectors and researchers (Puchalski et al. 2008), and, therefore, the high number of valves presented here is exceptional. A few works on Neogene chitons based on a large number of valves are known from the literature, e.g. Itoigawa et al. 1978 (4,500 valves, 32 species from the Pleistocene of Boso Peninsula, Japan) and Vendrasco et al. 2012 (more than 15,000 valves, of 22 species from southern California, U.S.A.).

Twelve species (not considering the five species identified only at generic level) are recorded for the first time from the Ligurian Pliocene: *Leptochiton alveolus, Lept. scabridus, Lept. bedullii, Lept. josei* sp. n., *Hanleya hanleyi, Ischnochiton korytnicensis, I. martinelli, Connexochiton roccai* sp. n., *Callochiton septemvalvis, Lepidochitona canariensis, Lepidoc. pliocinerea* sp. n., *Acanthochitona oblonga*.

Among the 17 living Mediterranean species, nine (*Lepidopleurus cajetanus*, *Leptochiton scabridus, Lept.*

Tab. 4 - Mediterranean Pliocene species.

	Taxa	Liguria	Altavilla	Estepona	Tuscany
1	*Lepidopleurus cajetanus*	x		x	x
2	*Leptochiton algesirensis*		x	x	x
3	*Leptochiton alveolus*	x			
4	*Leptochiton bedullii*	x			x
5	*Leptochiton cancellatus*	x	x		x
6	*Leptochiton cimicoides*				x
7	*Leptochiton josei* sp. n.	x			
8	*Leptochiton scabridus*	x			
9	*Leptochiton tavianii*			x	
10	*Parachiton africanus*			x	
11	*Hanleya hanleyi*	x	x	x	x
12	*Ischnochiton anserinus*		x		x
13	*Ischnochiton korytnicensis*	x			
14	*Ischnochiton ligusticus* sp. n.	x			
15	*Ischnochiton martinelli*	x	x	x	
16	*Ischnochiton rissoi*	x	x	x	x
17	*Ischnochiton ulivii*			x	x
18	*Stenosemus dolii*	x	x	x	
19	*Connexochiton roccai* sp. n.	x			
20	*Callochiton calcatus*				x
21	*Callochiton septemvalvis*	x	x	x	x
22	*Chiton capecchii*				x
23	*Chiton corallinus*	x		x	x
24	*Chiton etruscus*				x
25	*Chiton miocenicus*	x		x	x
26	*Chiton olivaceus*	x			x
27	*Chiton saeniensis*				x
28	*Lepidochitona canariensis*	x		x	
29	*Lepidochitona caprearum*	x	x		x
30	*Lepidochitona cinerea*	x		x	x
31	*Lepidochitona monterosatoi*	x			x
32	*Lepidochitona pliocinerea* sp.n.	x			
33	*Lepidochitona verrucosa*				x
34	*Acanthochitona crinita*	x	x	x	x
35	*Acanthochitona fascicularis*	x	x	x	x
36	*Acanthochitona oblonga*	x			
37	*Craspedochiton altavillensis*	x	x	x	x
	total	26	12	17	24

bedullii, Chiton olivaceus, *Lepidochitona cinerea, Lepidoc. caprearum, Lepidoc. canariensis, Lepidoc. monterosatoi,* and *Acanthochitona oblonga*) are typically infralittoral species, six (*Leptochiton cancellatus, Ischnochiton rissoi, Callochiton septemvalvis, Chiton corallinus, Acanthochitona fascicularis* and *A. crinita*) have a wider bathymetric range, from the intertidal to deeper than 100 m. Only one (*Stenosemus dolii*) can be considered deep water taxa (Dell'Angelo & Smriglio 1999); although *Hanleya hanleyi* occurs over a wide range including deep water records, from 15-500 m. *Leptochiton alveolus*, presently living in the Atlantic Ocean, must be added to the deep-sea group, having a bathymetric range from 100 m to almost 5000 m (Kaas 1981).

Taken together, these bathymetric comparisons suggest mostly shallow water depositional environments, possibly from lower infralittoral to circalittoral depth. The finding of some deep water species, together with shallower ones, suggests the presence of a potential mixture of faunal elements from different depths and

Maximum valves' width (mm)	Liguria	Altavilla	Estepona	Tuscany
Species				
Lepidopleurus cajetanus	7 - 8.7 - 8		6.6 - 9.3 - 6.3	5.5 - 8 - 6.7
Leptochiton cancellatus	/ - 3.5 - 2.3	/ - 2.3 - 2.4		/ - 3.3 - 2.6
Hanleya hanleyi	2.5 - 4.2 - 2.9	/ - 2.6 - /	2.1 - 4 - /	/ - 2 - /
Ischnochiton rissoi	5.7 - 6 - 7	/ - 7 - 4.5	3.5 - 7.3 - 6.8	/ - 4.3 - 8.3
Ischnochiton martinelli	/ - 3.2 - /	2.3 - 5.2 - 3.5	4.8 - 6.5 - 4.1	
Stenosemus dolii	5 - 5.8 - 4.5	5.2 - 8 - 6	/ - 6.4 - /	
Callochiton septemvalvis	3 - 4.5 - 3.3	/ - 2 - 3.2	/ - 3.7 - 2.6	/ - 4 - 1.5
Chiton corallinus	6 - 7.5 - 5.2		6.7 - 9.5 - 6.5	/ - 3.7 - 2.1
Chiton miocenicus	11 - 15 - 10.5		14.5 - 19.5 - 12.2	7.9 - 13.5 - 9.2
Lepidochitona cinerea	1.8 - 3 - /			
Lepidochitona caprearum	3.1 - 3.5 - 3.2	/ - 4 - /		2.5 - / - /
Lepidochjitona canariensis	/ - 3 - 1.2		2.3 - / - /	
Lepidochitona monterosatoi	2.5 - 2.6 - 2.7			/ - 3.8 - /
Lepidochitona pliocinerea sp. n	7.5 - 8.5 - 6.2		10 - 15.6 - 7.5	9 - 15 - 8
Acanthochitona fascicularis	3 - 5.5 - 3.7	4.3 - 5 - 2	3.2 - 6.8 - 2.7	4.5 - 3.5 - 2.5
Acanthochitona crinita	2.5 - 3 - 1.8	/ - 3.3 - /	2.2 - 3.5 - /	2.5 - 2.2 - /
Craspedochiton altavillensis	6.2 - 9 - 5.6	13.5 - 23 - 8.6	8.7 - 15.6 - ?	/ - / - 8

Tab. 5 - Maximum valve width (mm).

environments. This also confirms the results of Robba (1990) on the taxonomic structure of the molluscan communities (Gastropoda, Bivalvia, and Scaphopoda) from several Pliocene localities around Albenga Country, considered largely dominated by species belonging to three "bathymetric categories", infralittoral-circalittoral, circalittoral, and widely eurybathic.

The width of valves is not always used as a diagnostic feature of modern chitons. We report here (Tab. 5) the maximum valve width found for the Ligurian Pliocene, supplemented by corresponding data from the literature for Altavilla (Dell'Angelo et al. 2012), Estepona (Dell'Angelo et al. 2004), and Tuscany (Dell'Angelo et al. 2001b; Chirli 2004, and this paper) whenever a comparison is possible.

Three values are reported: head, intermediate, and tail valves. A forward slash "/" indicates that the value is not available for the corresponding valves.

Nine anomalous or scarred valves were found, relating to *Lepidopleurus cajetanus, Callochiton septemvalvis, Chiton corallinus,* and *Lepidochitona caprearum* (see above). The reports of anomalous chitons are rare, and the available data refer mainly to living chitons where there is an estimated frequency of about 2-5‰ (summarized by Dell'Angelo & Schwabe 2010). Dell'Angelo & Forli (1995b) found two coalesced valves among the over 1,000 they examined, this estimate is consistent with the number of anomalous valves found from the Ligurian Pliocene (9 valves, 1‰ of the total).

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