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POLYPLACOPHORA FROM THE MIOCENE OF NORTH ITALY. PART 2: CALLOCHITONIDAE, CHITONIDAE, LEPIDOCHITONIDAE, ACANTHOCHITONIDAE AND CRYPTOPLACIDAE

BRUNO DELL' ANGELO*[1], PIERO GIUNTELLI[2], MAURIZIO SOSSO[3] & MARTA ZUNINO[2]

[1]*Corresponding author. Museo di Zoologia, Via Selmi 3, 40126 Bologna, Italy. E-mail: bruno.dellangelo@chitons.it
[2]Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso 35, 10125 Torino, Italy.
[3]Via Bengasi 4, 16153 Genova, Italy.

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Abstract. This study completes the description of the chiton fauna (Mollusca, Polyplacophora) from deposits of the Miocene marine sequence of North Italy, located in Piedmont and Emilia Romagna regions. This second and final part describes chitons belonging to five families: Callochitonidae, Chitonidae, Lepidochitonidae, Acanthochitonidae and Cryptoplacidae. Nineteen species were identified, of which two are described as new (*Chiton sulcomarginatus* sp. n. and *Craspedochiton brunettii* sp. n.), and 17 were already known. *Craspedochiton mutinocrassus* is the new name attributed to the species previously known as *Acanthochiton costatus* or *A. costatus* var. *mutinocrassa*; *Chiton sulcomarginatus* sp. n., *Lepidochitona monterosatoi*, *L. pliocinerea*, and *Acanthochitona oblonga*, previously known only up to Pliocene, are reported for the first time from the Miocene of Italy. The stratigraphic distribution of numerous species thought to first appear in the Late Miocene (*Callochiton doriae*, *Chiton olivaceus*, *C. corallinus*, *Acanthochitona fascicularis*, *A. crinita*, and *Craspedochiton altavillensis*) is here extended to the Early Miocene. The distribution of *Cryptoplax weinlandi* is extended to the Middle Miocene (Serravallian). In total 35 chiton species (with 3.003 valves) were identified in the Italian Miocene (including both parts of this series). Ten species became extinct at the end of the Miocene, six in the Pliocene, two in the Pleistocene, and 17 are extant. Of the extant species nine occur both in the Atlantic and Mediterranean, two exclusively in the Atlantic and six only in the Mediterranean. The number of species reported from the Torino Hill assemblages (Burdigalian?) is increased from three listed by Sacco (1897) to nine. Thirty-four of the 35 species (excluding only *Lepidopleurus benoisti*) occur in the Tortonian-Messinian Po Basin. Thirteen (37%) of the species are also found in the Miocene Paratethys (Austria, Poland, Czech Republic, Hungary, Romania and Ukraine), which can be explained by connections between the Proto-Mediterranean and Paratethys during the Miocene.

Introduction

The present work is the second and final part of a study on the chiton fauna (Mollusca, Polyplacophora) from deposits of the Miocene marine sequence of North Italy, located in the Piedmont and Emilia Romagna regions, and follows the published part 1 describing the families: Leptochitonidae, Hanleyidae, Ischnochitonidae and Callistoplacidae (Dell'Angelo et al. 2015). In this part we treat the species belonging to the families Callochitonidae, Chitonidae, Lepidochitonidae, Acanthochitonidae and Cryptoplacidae.

Material and Methods

Large amounts of bulk sediment were collected by the authors between 1990 and 2014, especially in outcrops no longer accessible, and this material is the basis of the present work. Additional specimens were provided by other collectors (Luca Bertolaso, Reggio Emilia; Mauro Brunetti, Bologna; Massimo Rocca, Torino). The material housed at the Museo Regionale di Scienze Naturali di Torino (Bellardi & Sacco Collection) and at the Museo di Geologia e Paleontologia, Università di Torino (mainly collected by G. Pavia from Borelli) was examined. The bulk samples were 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. Taxonomic features of the recovered valves were studied and detected by using a Cambridge S-360 scanning electron microscope (SEM) at the Dipartimento di Scienze della Terra dell'Università di Torino.

All the chiton valves were collected in 13 localities (Fig. 1), described in part 1 by geographical position (coordinates) and stratigraphy, supported by important literature references. For ease of reference the 13 localities are reported in Tab. 1.

The maximum width (maximum right-left dimension perpendicular to the longitudinal body axis) of the valves (head, intermediate, and tail) of each species was measured, and is also given if the valves were incomplete, or are only small fragments.

All the figured material is at MZB, where the Bruno Dell'Angelo collection will be housed too.

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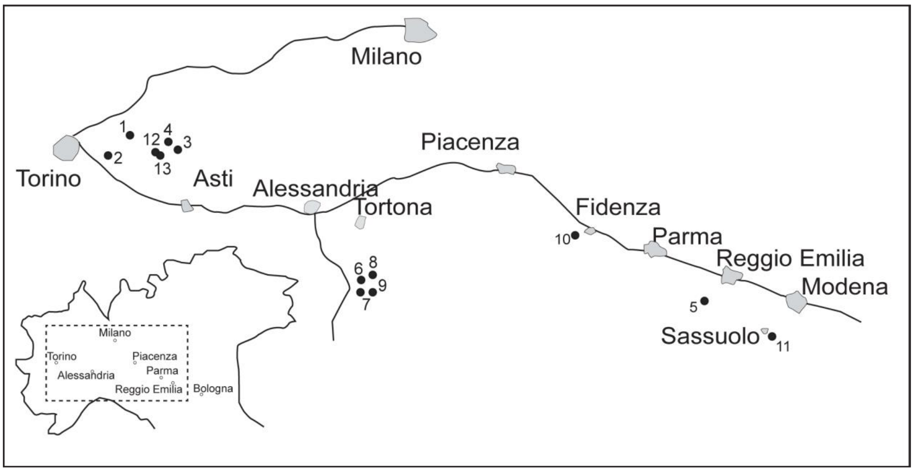


Fig. 1 - Study area and sites location. 1: Sciolze; 2: Valle Ceppi; 3: Rocco di Passerano; 4: Albugnano; 5: Monchio di Sarzano Casina; 6: Villa Monti; 7: Rio di Bocca d'Asino; 8: Sant'Agata Fossili; 9: Vargo; 10: Vigoleno; 11: Montegibbio: 12: Borelli; 13: Moncucco Torinese.

The following abbreviations are used:

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;

LSL - The Linnean Society of London, London, U.K.;

MCZR - Museo Civico di Zoologia, Rome, Italy;

MGPT - Museo di Geologia e Paleontologia, Università di Torino, Italy;

MGR - Museo di Geologia, Rome, Italy;

MHNBx - Muséum d'Histoire naturelle de Bordeaux, France;

MNHN - Muséum National d'Histoire Naturelle, Paris, France;

MPUM - Museo di Paleontologia dell'Università di Modena, Italy;

MRSN - Museo Regionale di Scienze Naturali di Torino, Italy;

MSNG - Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy;

MU - Malta University, Malta;

MZB - Museo di Zoologia dell'Università di Bologna

NHMUK - The Natural History Museum [formerly British Museum (Natural History)], London, U.K.;

NHMW - Natural History Museum Wien, Austria;

PG - P. Giuntelli Collection, Torino, Italy (will be deposited in MGPT);

RMNH - Nationaal Natuurhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie), Leiden, The Netherlands;

RSMNH - Royal Scottish Museum of Natural History, Edinburgh, U.K.

All information on reported occurrences of chitons in the northern Italian Miocene are reviewed in the first part of this work (Dell'Angelo et al. 2015).

Systematics

We follow the classification proposed by Sirenko (2006), except for the genus *Lepidochitona*. For this we follow Kelly & Eernisse (2008). Since many of the chiton species were already exhaustively described from other Mediterranean Neogene sites (e.g. Laghi 1977; Dell'Angelo et al. 1999, 2004, 2012, 2013; Garilli et al. 2005), only short synonymy related to fossil taxa, some comments and stratigraphic ranges are given below. For species already discussed by the senior author and collaborators in the work covering the Pliocene of W. Liguria (Dell'Angelo et al. 2013), the synonymy is updated with new references when necessary. The geographic range and habitat of still living species were described by Dell'Angelo & Smriglio (1999).

MIOCENE		LOCALITIES		
Stage	estimated age (Ma)	Localities	Formation	Coordinates
Aquitanian	23.03 – 20.44			
Burdigalian	20.44 – 15.97	Sciolze	Termofourà Fm	45°05'46.5" N, 7°52'06.9" E
		Valle Ceppi	Termofourà Fm	45°03'47.1" N, 7°47'43.9" E
Langhian	15.97 – 13.82	Rocco di Passerano	Areniti di Tonengo Fm	45°04'34.0" N, 8°01'44.2" E
		Albugnano	Baldissero Fm	45°04'09.7" N, 7°59'02.6" E
Serravallian	13.82 – 11.62	Monchio di Sarzano Casina	Cigarello Fm	44°31'42.37"N, 10°29'39.49"E
Tortonian	11.62 – 7.246	Villa Monti	S. Agata Fossili Fm	44°44' 01.7" N, 8°52'31.5" E
		Rio di Bocca d'Asino	S. Agata Fossili Fm	44°53'21" N, 8°53'14" E
		Sant'Agata Fossili	S. Agata Fossili Fm	44°47'02.7" N, 8°55'26.4" E
		Vargo	S. Agata Fossili Fm	44°44'36.9" N, 8°54'07.2" E
		Vigoleno	Termina Fm	44°49'08.91" N, 9°54'13.75" E
		Montegibbio	Termina Fm	44°29'52.79"N 10°46'58.35"E
Messinian	7.246 – 5.333	Borelli	Marne di S. Agata Fm	45°03' 52.8" N, 7°56'27.4" E
		Moncucco Torinese	Marne di S. Agata Fm	45°03'57.2" N, 7°55'48.6" E

Tab. 1 - Localities and link to the Miocene stages.

Class **Polyplacophora** Gray, 1821
Subclass **Loricata** Shumacher, 1817
Order **Chitonida** Thiele, 1909
Suborder **Chitonina** Thiele, 1909
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 1847)

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

Callochiton septemvalvis (Montagu, 1803)

Pl. 1, figs 1-4

1803 *Chiton laevis* Montagu, p. 2 (*non* Pennant, 1777).

1803 *Chiton septemvalvis* Montagu, p. 3.

1971 *Callochiton rariplicatus* (Reuss) – Bałuk, p. 461, pl. 5, figs 1-5 (*partim*).

1977 *Callochiton laevis* (Montagu) – Laghi, p. 108, pl. 2, figs 14-18 (*partim*).

1978 *Callochiton septemvalvis septemvalvis* (Montagu) – Kaas, p. 73.

1984 *Callochiton laevis* (Montagu) – Bałuk, p. 290 (*partim*).

2003 *Callochiton septemvalvis* (Montagu) – Dell'Angelo & Silva, p. 11 (*partim*).

2004 *Callochiton septemvalvis* (Montagu) – Dell'Angelo et al., p. 34 (*partim*).

2009 *Callochiton septemvalvis* (Montagu) – Koskeridou et al., p. 314 (*partim*).

Non 1995 *Callochiton septemvalvis* (Montagu) – Dell'Angelo & Forli, p. 226, figs 10, 17 (= *Callochiton doriae*).

Non 1997 *Callochiton septemvalvis* (Montagu) – Dell'Angelo & Giusti, p. 51, fig. 5 (= *Callochiton doriae*).

Non 2001 *Callochiton septemvalvis* (Montagu) – Dell'Angelo et al., p. 147, fig. 10 (= *Callochiton doriae*).

Non 2004 *Callochiton septemvalvis* (Montagu) – Chirli, p. 8, pl. 3, figs 1-4 (= *Callochiton doriae*).

Non 2005 *Callochiton septemvalvis* (Montagu) – Garilli et al., p. 134, pl. 2, figs 7-10 (= *Callochiton doriae*).

Non 2012 *Callochiton septemvalvis* (Montagu) – Dell'Angelo et al., p. 60, fig. 4L (= *Callochiton doriae*).

Non 2013 *Callochiton septemvalvis* (Montagu) – Dell'Angelo et al., p. 83, pl. 5, figs N-P (= *Callochiton doriae*).

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

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

Material examined: Rio di Bocca d'Asino: 33 valves (4 head, 22 intermediate, and 7 tail) (BD, MZB 32062-32063, PG); Montegibbio: 10 valves (1 head, and 9 intermediate) (BD, MZB 32064). Maximum width of the valves: 2 / 5.5 / 3.8 mm.

Remarks. Detailed descriptions of this species were presented in Kaas & Van Belle (1985) and Dell'Angelo & Smriglio (1999). This species has a very complicated taxonomic history, reported by Dell'Angelo & Smriglio (1999). Kaas (1978) proposed to separate at subspecific level the typical Atlantic form (*Callochiton septemvalvis septemvalvis*) from the Mediterranean one (*C. septemvalvis euplaeae* O.G. Costa, 1829), characterized by the smaller size and the presence of longitudinal grooves on the pleural areas. Dell'Angelo & Palazzi (1994) adopted the sole taxon *C. septemvalvis* for this species, considering that the only difference is the presence of longitudinal grooves in Mediterranean specimens, absent in the Atlantic ones.

The material examined herein showed a great variability in the sculpture of tegmentum, with longitudinal grooves present in the valves from Sciolze, Albugnano, Villa Monti, and not present in the valves from Montegibbio, while the valves from Rio di Bocca d'Asino have both types of sculpture, with or without longitudinal grooves.

Sigwart et al. (2013) in a study on chiton phylogeny included specimens of *Callochiton septemvalvis* from France (Atlantic Ocean) and *Callochiton euplaeae* from Croatia (Adriatic Sea) and showed they are genetically different. So we attribute the valves of *Callochiton* here examined with the presence of longitudinal grooves on the pleural areas to *Callochiton septemvalvis*, and the valves without longitudinal grooves to *Callochiton doriae* (Capellini, 1859) (the taxon *Callochiton euplaeae* is a *nomen dubium*, see below).

The head valves have not characters that permit the attribution to one of the two species, and we consider the 4 head valves from Rio di Bocca d'Asino tentatively attribuitable to *Callochiton septemvalvis* for the fact that the number of valves of *C. septemvalvis* from this locality is greater than that of *C. doriae*.

The reports of *Callochiton septemvalvis* in literature must be reconsidered, to confirm the attribution to *C. septemvalvis* or *C. doriae*.

A head valve from Rio di Bocca d'Asino shows the development of a new insertion plate underlying an already existing one, an abnormality that is already known but rarely reported, and is especially rare in fossil valves (Dell'Angelo & Schwabe 2010).

Distribution. Middle Miocene: Paratethys (Langhian-Serravallian): central-eastern Europe (also as *C. rariplicatus* Reuss, 1860) (Bałuk 1984). **Late Miocene:** Proto-Mediterranean Sea (Tortonian):

Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio (Laghi 1977; Dell'Angelo & Smriglio 1999; this paper). **Pliocene:** northeastern Atlantic, Mondego Basin, Portugal (Dell'Angelo & Silva 2003); western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004). **Pleistocene:** Greece (Koskeridou et al. 2009). **Recent:** Northeastern Atlantic Ocean, from Norway to the Canary Islands) (Dell'Angelo & Smriglio 1999).

Callochiton doriae (Capellini, 1859)

Pl. 1, figs 5-9

1859 *Chiton doriae* Capellini, p. 325, pl. 12, .

1879 *Chiton laevis* var. *doriae* Capellini – Monterosato, p. 26.

1971 *Callochiton rariplicatus* (Reuss) – Bałuk, p. 461, pl. 5, figs 1-5 (*partim*).

1977 *Callochiton laevis* (*non* Montagu) – Laghi, p. 108, pl. 2, figs 14-18 (*partim*).

1978 *Callochiton septemvalvis euplaeae* (*non* O.G. Costa) – Kaas, p. 73.

1984 *Callochiton laevis* (*non* Montagu) – Bałuk, p. 290 (*partim*).

1995 *Callochiton septemvalvis* (*non* Montagu) – Dell'Angelo & Forli, p. 226, figs 10, 17.

1997 *Callochiton septemvalvis* (*non* Montagu) – Dell'Angelo & Giusti, p. 51, fig. 5.

2001 *Callochiton septemvalvis* (*non* Montagu) – Dell'Angelo et al., p. 147, fig. 10.

2003 *Callochiton septemvalvis* (*non* Montagu) – Dell'Angelo & Silva, p. 11 (*partim*).

2004 *Callochiton septemvalvis* (*non* Montagu) – Chirli, p. 8, pl. 3, figs 1-4.

2004 *Callochiton septemvalvis* (*non* Montagu) – Dell'Angelo et al., p. 34, pl. 3, figs 2, 5 (*partim*).

2005 *Callochiton septemvalvis* (*non* Montagu) – Garilli et al., p. 134, pl. 2, figs 7-10.

2009 *Callochiton septemvalvis* (*non* Montagu) – Koskeridou et al., p. 314, figs 8.3-8.4 (*partim*).

2012 *Callochiton septemvalvis* (*non* Montagu) – Dell'Angelo et al., p. 60, fig. 4L.

2013 *Callochiton septemvalvis* (*non* Montagu) – Dell'Angelo et al., p. 83, pl. 5, figs N-P.

Non 1829 *Chiton euplaeae* O.G. Costa, p. i, iv, pl. 1 (*nomen dubium*).

Type material: Unknown. Not present at MSNG (M. Tavano, pers. comm.)

Type locality: Gulf of La Spezia.

Material examined: Sciolze: 3 valves (2 intermediate, and 1 tail) (MZB 32059, PG); Albugnano: 2 intermediate valves (MZB 32060, PG); Villa Monti: 1 tail valve (MZB 32061); Rio di Bocca d'Asino: 20 valves (10 intermediate, and 10 tail) (BD, MZB 32062-32063, PG). Maximum width of the valves: 4.6 / 5.8 / 3.8 mm.

Remarks. This species is very similar to *Callochiton septemvalvis* (see above), from which it differs by the presence of some longitudinal grooves on pleural areas of intermediate valves and antemucronal area of tail valve. The number of longitudinal grooves is variable, between 4 and 8, with short grooves along the diagonal ridge (Pl. 1, fig. 7) or with many of the grooves reaching the anterior margin (Pl. 1, fig. 9).

This species was called *Chiton euplaeae* by O.G. Costa (1829) and *Chiton doriae* by Capellini (1859), but the correct attribution of *C. euplaeae* is doubtful, as already reported by Dell'Angelo & Palazzi (1994). *Chiton euplaeae* was described by O.G. Costa as a species with a smooth surface, without any trace of scars. The original diagnosis is: "*Ch. octoclypeolatum fusco-testaceum subovalis, anterius angustatum; clypeolis omnibus laevibus; ligamento eleganter imbricato squamulis oblongis aurantiis, nob.*", and few lines after: "*Tutta la superficie è levigata*" (the whole surface is smooth). Moreover it is important to consider that two authors (Issel and Monterosato) had the opportunity to check the type of *Chiton euplaeae*, and they conclude to attribute this species to *Chiton polii* Philippi, 1836 [= *Lepidochitona caprearum* (Scacchi, 1836)] (Issel 1870: 6; Monterosato 1879: 23), what makes risky to insert *Chiton euplaeae* in the synonymy of *Callochiton* in general and *C. septemvalvis* in particular.

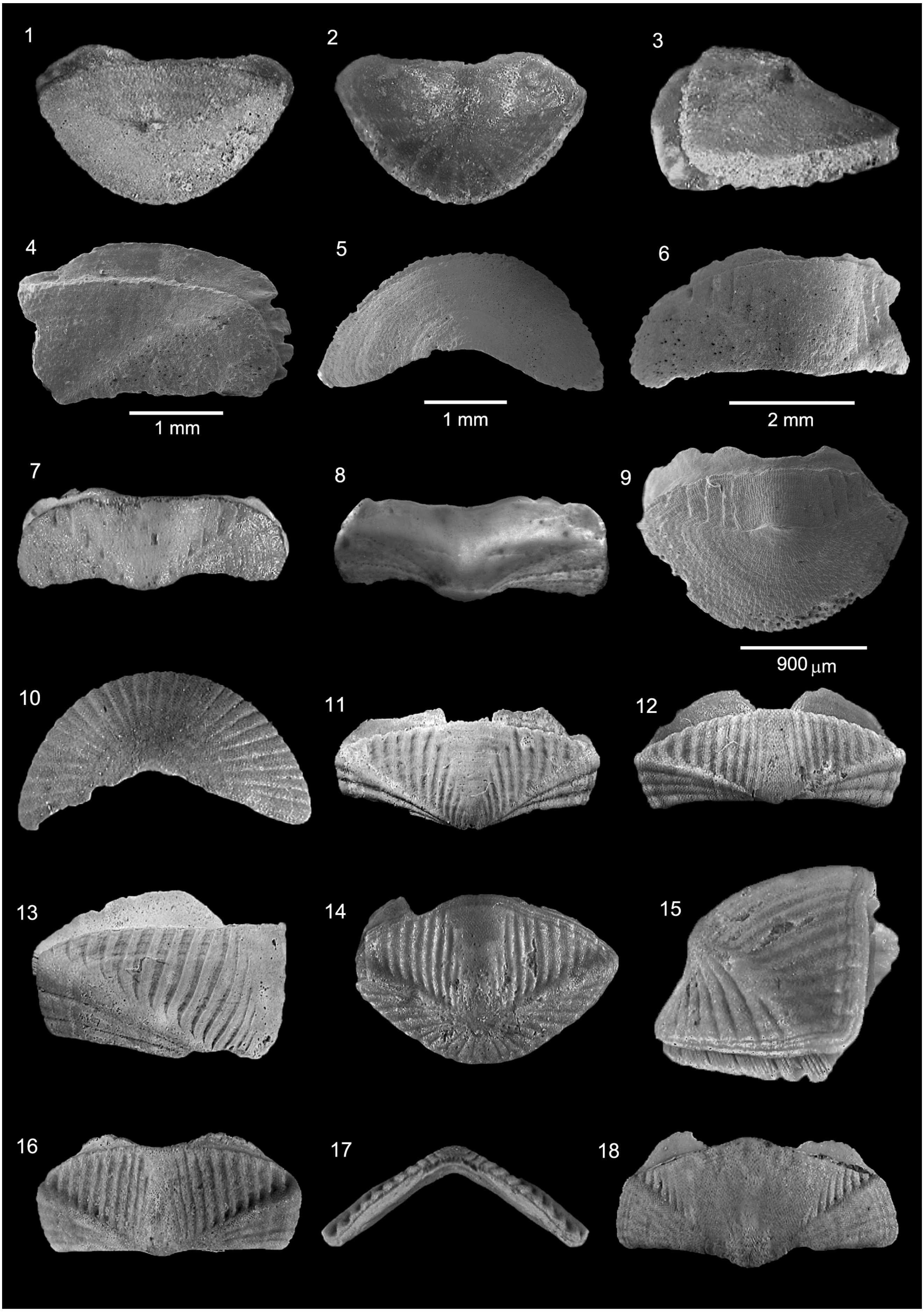
Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): North Italy: Sciolze (this paper). **Middle Miocene:** Proto-Mediterranean Sea (Langhian): Po Basin: Albugnano (this paper); Paratethys (Langhian-Serravallian): central-eastern Europe (also as *C. rariplicatus* Reuss, 1860) (Bałuk 1984). **Late Miocene:** Proto-Mediterranean Sea (Tortonian): Po Basin, N Italy: Villa Monti,

PLATE 1

Figs 1-4 - *Callochiton septemvalvis* (Montagu, 1803). 1-3) Rio di Bocca d'Asino, tail valve, MZB 32063, width 3 mm, dorsal, ventral and lateral views. 4) Montegibbio, intermediate valve, MZB 32064, dorsal view.

Figs 5-9 - *Callochiton doriae* (Capellini, 1859). 5) Rio di Bocca d'Asino, head valve, MZB 32062, dorsal view. 6) Sciolze, intermediate valve, MZB 32059, dorsal view. 7-8) Albugnano, intermediate valve, MZB 32060, width 4 mm, dorsal and ventral views. 9) Villa Monti, tail valve, MZB 32061, dorsal view.

Figs 10-18 - *Chiton olivaceus* Spengler, 1797. 10-15 - Rio di Bocca d'Asino. 10) Head valve, MZB 32065, width 5.5 mm, dorsal view. 11) Intermediate valve, MZB 32066, width 7.2 mm, dorsal view. 12) Intermediate valve, MZB 32067, width 6.8 mm, dorsal view. 13) Intermediate valve, MZB 32068, width 6.3 mm, dorsal view. 14-15) Tail valve, MZB 32069, width 8 mm, dorsal and lateral views. 16-17) Montegibbio, intermediate valve, MZB 32070, width 7.4 mm, dorsal and frontal views. 18) Borelli, intermediate valve, MGPT PU 135049, width 6.6 mm, dorsal view.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Rio di Bocca d'Asino (Laghi 1977; Dell'Angelo & Smriglio 1999; this paper). **Pliocene:** northeastern Atlantic, Mondego Basin, Portugal (Dell'Angelo & Silva 2003); western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Dell'Angelo et al. 2001, 2013; Chirli 2004). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo & Forli 1995; Dell'Angelo & Giusti 1997), Greece (Koskeridou et al. 2009). **Recent:** Mediterranean Sea (Dell'Angelo & Smriglio 1999).

Family Chitonidae Rafinesque, 1815
Subfamily Chitoninae 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. The genus *Chiton* has been subdivided in many subgenera (Kaas et al. 2006), some of which (e.g. *Rhyssoplax* Thiele, 1893) were considered by Sirenko (2006) to be valid at full generic level. In this paper, all species within the subfamily Chitoninae are referred to the genus *Chiton*.

Chiton olivaceus Spengler, 1797
Pl. 1, figs 10-18

1797 *Chiton olivaceus* Spengler, p. 73, pl. 6, fig. 8.
Additions to the bibliography in Dell'Angelo et al. (2013: 85):
1862 *Chiton zibinicus* Doderlein, p. 15.
1897 *Chiton olivaceus* var. *zibinicus* Dod. – Sacco, p. 89, pl. 7, figs 6-7.
2013 *Chiton olivaceus* Spengler – Dell'Angelo et al., p. 85, pl. 5, figs S-V.

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: Albugnano: 2 intermediate valves (PG); Villa Monti: 16 valves (1 head, 12 intermediate, and 3 tail) (BD); Rio di Bocca d'Asino: 196 valves (14 head, 108 intermediate, and 74 tail) (BD, PG, MZB 32065-32069); S. Agata Fossili: 3 valves (1 head, 1 intermediate, and 1 tail) (BD); Vigoleno: 7 valves (5 intermediate, and 2 tail) (BD); Montegibbio: 27 valves (1 head, 22 intermediate, and 4 tail) (BD. MZB 32070); Borelli: 4 valves (3 intermediate, and 1 tail) (MGPT PU 135049, PG). Maximum width of the valves: 5 / 10 / 10.7 mm.

Remarks. Detailed descriptions of this species were published in Dell'Angelo & Smriglio (1999) and Kaas et al. (2006). The species is characterized by having a highly variable radial ribs sculpture on the 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 6-15 small outward-leaning folds of tegmentum.

The material examined showed great variability in the sculpture of tegmentum, as already reported by Dell'Angelo et al. (2013) for this species from the Pliocene of Liguria. The longitudinal folds on the pleural areas may be parallel to each other (Pl. 1, figs 12, 14), or obliquely arranged towards the jugal region (Pl. 1, figs 11, 13), which can be smooth for a large part (Pl. 1, fig. 17) or almost completely covered by folds (Pl. 1, figs 12, 16). The longitudinal folds on pleural area normally all reaching the anterior margin, but in some cases the grooves near the jugum stop just short of it (Pl. 1, figs 11, 17).

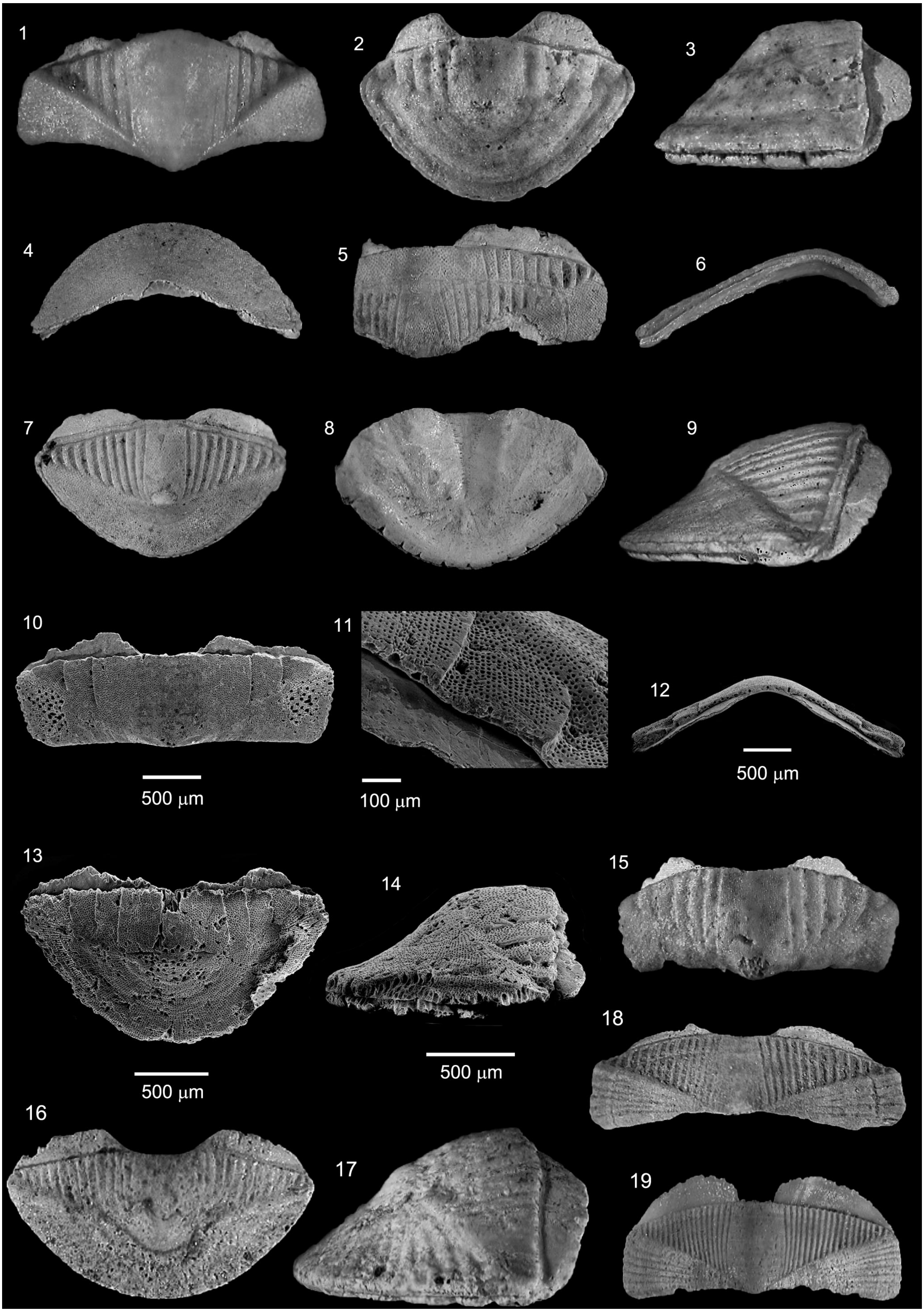
We agree with Sacco (1897) and Laghi (1977) in considering *Chiton zibinicus* Doderlein, 1862 (described from the Tortonian of Montegibbio with the diagnosis: "*Ch. miocenici Micht. prox. sed distinctus*", without illustrations, and figured by Sacco 1897: pl. 7, figs 6-7) as a junior synonym of *C. olivaceus*.

Distribution. Middle Miocene: Proto-Mediterranean Sea (Langhian): Po Basin: Albugnano (this paper); Paratethys (Langhian-Serravallian): central-eastern Europe (also as *C. bohemicus*) (Dulai 2005; Dell'Angelo et al. 2007; Studencka & Dulai 2010). **Late Miocene:** Proto-Mediterranean Sea (Tortonian and Messinian): Po Basin, N Italy: Villa Monti, Rio di Bocca d'Asino, S. Agata Fossili, Vigoleno, Montegibbio, Borelli (Laghi 1977; Dell'Angelo

PLATE 2

Figs 1-15 - *Chiton corallinus* (Risso, 1826). 1) Albugnano, intermediate valve, MZB 32074, width 3 mm, dorsal view. 2-3) Rio di Bocca d'Asino, tail valve, MZB 32075, width 2.8 mm, dorsal and lateral views. 4-9) Valle Ceppi. 4) Head valve, MZB 32071, width 6.3 mm, dorsal view. 5-6) Intermediate valve, MZB 32072, width 6 mm, dorsal and frontal views. 7-9) Tail valve, MZB 32073, width 6.8 mm, dorsal, ventral and lateral views. 10-14) Montegibbio. 10-12) Intermediate valve, MZB 32076. 10) dorsal view. 11) Detail of the sculpture. 12) frontal view. 13-14) Tail valve, MZB 32077, dorsal and frontal views. 15) Monte Castellaccio (Ravenna), Pliocene (Zanclean), intermediate valve, MZB 32078, width 2.4 mm, dorsal view.

Figs 16-19 - *Chiton miocenicus* Michelotti, 1847. 16-17) Albugnano, tail valve, MZB 32079, width 7 mm, dorsal and lateral views. 18) Montegibbio, intermediate valve, MZB 32080, width 12.7 mm, dorsal view. 19) Borelli, intermediate valve, MZB 32081, width 12.3 mm, dorsal view.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500 µm
16
17
19

et al. 1999; this paper). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Dell'Angelo et al. 2001, 2013; Sosso & Dell'Angelo 2010). **Pleistocene:** central Mediterranean, Italy (Sabelli & Taviani 1979; Dell'Angelo et al. 2001), 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 Seas (Dell'Angelo & Smriglio 1999; Kaas et al. 2006).

Chiton corallinus (Risso, 1826)

Pl. 2, figs 1-15

1826 *Lepidopleurus corallinus* Risso, p. 268.

Additions to the bibliography in Dell'Angelo et al. (2013: 85):

2013 *Chiton corallinus* Risso - Dell'Angelo et al., p. 85, pl. 6, figs A-S.

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: Valle Ceppi: 17 valves (3 head, 10 intermediate, and 4 tail) (BD, MZB 32071-32073, PG); Sciolze: 10 valves (1 head, 8 intermediate, and 1 tail) (PG); Albugnano: 2 intermediate valves (MZB 32074, PG); Villa Monti: 40 valves (2 head, 30 intermediate, and 8 tail) (BD, PG); Rio di Bocca d'Asino: 112 valves (11 head, 74 intermediate, and 27 tail) (BD, MZB 32075, PG); Vargo: 2 valves (1 intermediate, and 1 tail) (PG); Vigoleno: 11 valves (6 intermediate, and 5 tail) (BD); Montegibbio: 8 valves (1 head, 3 intermediate, and 4 tail) (BD, MZB 32076-32077); Borelli: 1 intermediate valve (BD). Maximum width of the valves: 6.5 / 6.5 / 6.8 mm.

Remarks. Detailed descriptions of this species were presented in 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 5-10 small outward-leaning folds of tegmentum.

This is a variable species, the preserved valves are almost always incomplete and worn. The number of longitudinal folds on the pleural and antemucronal areas is variable, from 2 (see below), up to 13 (Pl. 2, fig. 5).

All the valves from Valle Ceppi show some differences from more typical (extant) *C. corallinus*. We illustrate 3 valves (head, intermediate and tail, Pl. 2, figs 4-9). They are generally wider, less elevated, the number of longitudinal ribs in pleural and antemucronal areas is higher, the shape of the tail valve is different (mucro subcentral tending to posterior; antemucronal slope convex, almost straight in typical *C. corallinus*; postmucronal slope concave, not almost straight as in typical *C. corallinus*, compare Pl. 2, figs 2-3 vs. figs 7-9). These valves are similar to those described by Dell'Angelo et al. (2012: p. 61, figs 5A-F, 5J-K) as *Chiton* sp. from the Pliocene of Altavilla.

Some small intermediate and tail valves from Montegibbio (width less than 3 mm) have a shape and sculpture a little different from typical *C. corallinus*. We illustrate an intermediate (Pl. 2, figs 10-12, width 2.8 mm) and a tail (Pl. 2, figs 13-14, width 2.1 mm) valves. The intermediate valve shows a broadly rectangular shape, height/width ratio 0.26 (0.3-0.4 in typical extant *C. corallinus*), lateral areas not much elevated but clearly defined (more elevated in typical *C. corallinus*), and central area with two small longitudinal folds on either side (7-10 on each side more pronounced in typical *C. corallinus*). The tail valve tends towards a triangular shape, mucro in anterior position (subcentral in *C. corallinus*), and antemucronal area with three small longitudinal folds on either side, similar to those of the intermediate valve. Even though we have referred to typical *Chiton corallinus* above, extant *Chiton corallinus* specimens actually show a much broader intraspecific variability than has been previously illustrated in the literature and likewise illustrations of juvenile specimens are still lacking. The main feature of the valves from Montegibbio is represented by the small number (less pronounced) of longitudinal folds on central and antemucronal areas, but it is not clear if the number of longitudinal

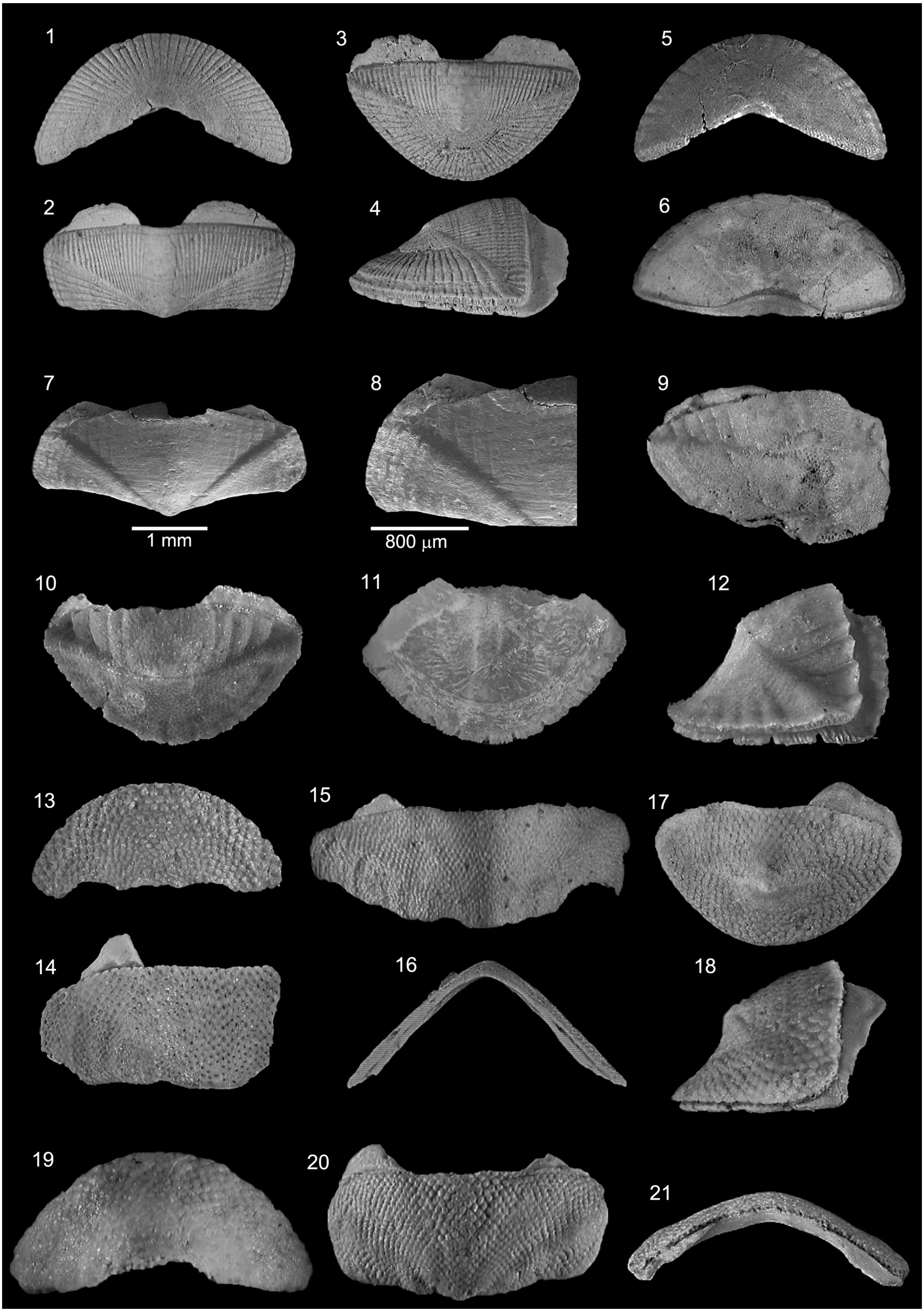
PLATE 3

Figs 1-4 - *Chiton miocenicus* Michelotti, 1847, Borelli. 1) Head valve, MGPT PU 135296, width 9.8 mm, dorsal view. 2) Intermediate valve, MGPT PU 135297, width 13 mm, dorsal view. 3-4) Tail valve, MGPT PU 135298, width 10 mm, dorsal and lateral views.

Figs 5-12 - *Chiton sulcomarginatus* sp. n. 5-6) Montegibbio, head valve, Paratype MZB 32085, width 4.6 mm, dorsal and ventral views. 7-9) Albugnano. 7-8) Intermediate valve, Paratype MZB 32082, width 3.6 mm, dorsal and ventral views. 9) Tail valve, Paratype MZB 32083, width 2.7 mm, dorsal view. 10-12) Rio di Bocca d'Asino, tail valve, Holotype MZB 32084, width 2.5 mm, dorsal, ventral and lateral views.

Figs 13-18 - *Lepidochitona cinerea* (Linnaeus, 1767). 13-14) Montegibbio. 13) Head valve, MZB 32087, width 2 mm, dorsal view. 14) Half intermediate valve, MZB 32088, width 2.1 mm, dorsal view. 15-16) Borelli, intermediate valve, MZB 32089, width 4 mm, dorsal and frontal views. 17-18) Rio di Bocca d'Asino, tail valve, MZB 32086, width 2.6 mm, dorsal and ventral views.

Figs 19-21 - *Lepidochitona caprearum* (Scacchi, 1836). 19) Rio di Bocca d'Asino, head valve, MZB 32090, width 2.2 mm, dorsal view. 20-21) Borelli, intermediate valve, MZB 32092, width 3.4 mm, dorsal and frontal views.


1
3
5
2
4
6
7
8
9
1 mm
800 µm
10
11
12
13
15
17
14
16
18
19
20
21

folds increases with the valve's growth (and so with the valve's width) or if these valves represent adult (fully grown) specimens of a species different from *C. corallinus*. An intermediate valve from the Pliocene (Zanclean) of Monte Castellaccio (Ravenna) is illustrated for comparison (Pl. 2, fig. 15); the width is 2.4 mm, smaller than the intermediate valve from Montegibbio (2.8 mm), but the shape and sculpture is similar to that of adult specimens of *C. corallinus*, with 6 large longitudinal folds on either side, different from the valve from Montegibbio. We provisionally consider the valves from Montegibbio as juvenile specimens of *C. corallinus*, and await further material to clarify the problem of intraspecific variability in *C. corallinus*. Macioszczyk (1988: 54, pl. 3, fig. 7) illustrated a tail valve (width 1.7 mm) determined as *Chiton* sp. from the middle Miocene (Badenian) of Węglinek (Poland) similar to the material here discussed, showing two small longitudinal folds on either side.

Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): N Italy: Valle Ceppi, Sciolze (this paper). **Middle Miocene:** Proto-Mediterranean Sea (Langhian): Po Basin: Albugnano (this paper); Paratethys (Langhian-Serravallian): central-eastern Europe (Studencka & Studencki 1988; Studencka & Dulai 2010). **Late Miocene:** Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Villa Monti, Rio di Bocca d'Asino, Vargo, Vigoleno, Montegibbio, Borelli (Laghi 1977; Dell'Angelo et al. 1999; this paper). **Pliocene:** northeastern Atlantic, Mondego Basin, Portugal (Dell'Angelo & Silva 2003); western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Dell'Angelo et al. 2001, 2013; Chirli 2004; Sosso & Dell'Angelo 2010). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo et al. 2001, 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. 2, figs 16-19; Pl. 3, figs 1-4

1847 *Chiton miocenicus* Michelotti, p. 132, pl. 16, fig. 7.

Additions to the bibliography in Dell'Angelo et al. (2013: 87):

1919 *Chiton miocenicus* Michelotti – Cossmann & Peyrot, p. 32, pl. 2, figs 21-22.

2013 *Chiton miocenicus* Michelotti – Dell'Angelo et al., p. 87, pl. 7, figs A-H.

2015 *Gymnoplax orbignyi* de Rochebrune, 1883 – Dell'Angelo et al., p. 224, pl. 2, figs 14-17.

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

Type locality: The Torino Hill, Italy (45°03'01''N, 7°48'01''E).

Material examined: Sciolze: 2 tail valves (PG); Valle Ceppi: 23 valves (21 intermediate, and 2 tail) (PG); Albugnano: 43 valves (6 head, 30 intermediate, and 7 tail) (MZB 32079, PG); Villa Monti: 11 valves (2 head, 8 intermediate, and 1 tail) (BD, PG); Rio di Bocca d'Asino: 149 valves (32 head, 101 intermediate, and 16 tail) (BD, PG); Vargo: 1 head valve (PG); Montegibbio: 78 valves (1 head, 66 intermediate, and 11 tail) (BD, MZB 32080, LB); Borelli: 406 valves (56 head, 318 intermediate, and 32 tail) (BD, MGPT PU 135296-135298, MZB 32081, PG); Moncucco Torinese: 1 head valve (PG). Maximum width of the valves: 12 / 16 / 11 mm.

Remarks. Dell'Angelo et al. (2013; see their Tab. 1) already concluded that while *Chiton miocenicus* closely resembles *C. olivaceus*, it still differs from *C. olivaceus* in many characters. Michelotti described *C. miocenicus* based on valves from Torino Hill, with a single intermediate valve well figured (Michelotti 1847: pl. 16, fig. 7).

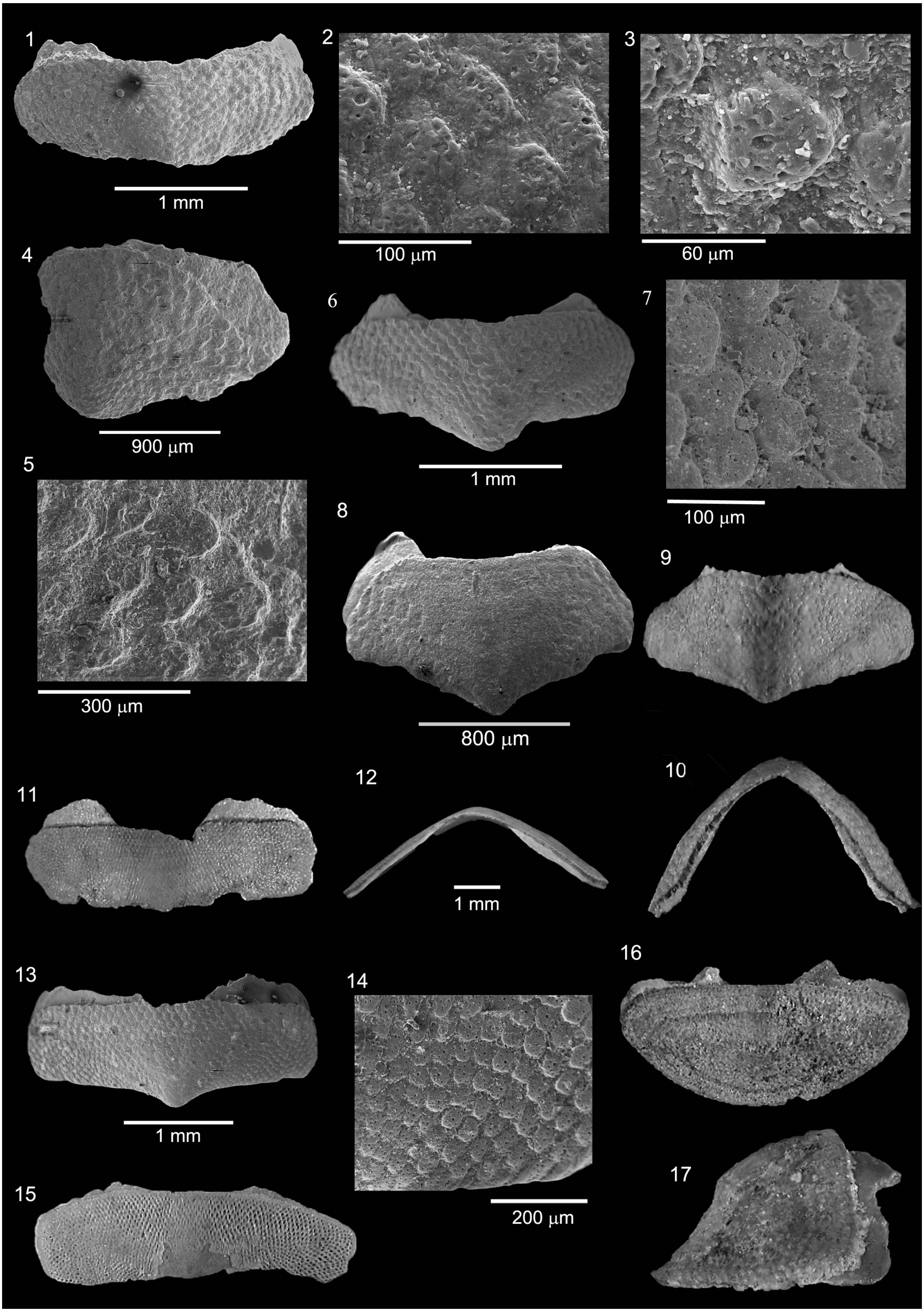
This species is common in the Tortonian and Messinian sites studied, and the more abundant material at hand has made it possible to better characterise this species, adding to the characters reported in Dell'Angelo et al. (2013: Tab. 1). One specimen lot of 19 complete head valves examined (with a range of width between 5.3 and 10.5 mm), showed a number of radial ribs between 30 and 45, increasing with the width of the valves. The number of slits in the articulamentum is almost always 8, rarely 9 (in 2 valves) or 10 (in 2 valves). The shape of tail valves is different from *C. olivaceus*, less elevated (compare Pl. 2, fig. 17 vs. Pl. 1, fig. 15), with the anterior slope slightly convex (more convex in *C. olivaceus*) and

PLATE 4

Figs 1-3 - *Lepidochitona caprearum* (Scacchi, 1836), Rio di Bocca d'Asino, intermediate valve, MZB 32091. 1) Dorsal view. 2-3) Details of the sculpture.

Figs 4-10 - *Lepidochitona monterosatoi* Kaas & Van Belle, 1981. 4-5) Monchio di Sarzano Casina, intermediate valve, MZB 32093. 4) Dorsal view. 5, detail of the sculpture. 6-7) Rio di Bocca d'Asino, intermediate valve, MZB 32094. 6) Dorsal view. 7) Detail of the sculpture. 8) Montegibbio, intermediate valve, MZB 32096, dorsal view. 9-10) Rio di Bocca d'Asino, intermediate valve, MZB 32095, width 2.3 mm, dorsal and frontal views.

Figs 11-17 - *Lepidochitona pliocinerea* Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013. 11-12) Albugnano, intermediate valve, MZB 32097, width 5.7 mm, dorsal and frontal views. 13-14) Montegibbio, intermediate valve, MZB 32099. 13) Dorsal view. 14) Detail of the sculpture. 15) Borelli, intermediate valve, MGPT PU 135299, width 7 mm, dorsal view. 16-17) Rio di Bocca d'Asino, tail valve, MZB 32098, width 3.8 mm, dorsal and lateral views.


1
1 mm
2
100 μm
3
60 μm
4
900 μm
5
300 μm
6
1 mm
7
100 μm
8
800 μm
9
10
11
12
1 mm
13
1 mm
14
200 μm
15
16
17

the posterior slope almost straight (concave close to the mucro in *C. olivaceus*).

In the first part of this work (Dell'Angelo et al. 2015), we considered *Gymnoplax orbigny* de Rochebrune, 1883 (proposed as "*nomen substitutivum*" for *Chiton subcajetanus* d'Orbigny, 1852) as a junior synonym of *Chiton miocenicus*, based on a syntype of *Gymnoplax orbignyi* preserved at MNHN A13586, an intermediate valve (Dell'Angelo et al. 2015: pl. 2, figs 14-17).

Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): N Italy: Sciolze, Valle Ceppi (Michelotti 1847; this paper). **Middle Miocene:** northeastern Atlantic (upper Langhian/early Serravallian): Aquitaine Basin, France (Cossmann & Peyrot 1919); Proto-Mediterranean Sea (Langhian): Po Basin: Albugnano (this paper). **Late Miocene:** Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Villa Monti, Rio di Bocca d'Asino, Vargo, Montegibbio, Borelli, Moncucco Torinese (Laghi 1977; Dell'Angelo et al. 1999; this paper). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Dell'Angelo et al. 2001, 2013; Chirli 2004).

Chiton sulcomarginatus sp. n.

Pl. 3, figs 5-12

2013 *Chiton* sp. B – Dell'Angelo et al., p. 89, pl. 7, figs K-N.

Type locality: Rio di Bocca d'Asino (Alessandria), Piedmont, Italy.

Type stage: Miocene (Tortonian).

Type material: Holotype: MZB 32084 (tail valve, width 2.5 mm, Pl. 3, figs 10-12). Paratypes: MZB 32082 (intermediate valve from Albugnano, width 3.6 mm, Pl. 3, figs 7-8); MZB 32083 (tail valve from Albugnano, width 2.7 mm, Pl. 3, fig. 9); MZB 32085 (head valve from Montegibbio, width 4.6 mm, Pl. 3, figs 5-6).

Other material: Albugnano: 1 head valve (PG); Rio di Bocca d'Asino: 2 valves (1 head and 1 tail) (BD); Montegibbio: 1 head valve (BD);Bussana (Liguria, Pliocene): 2 valves (1 intermediate and 1 tail) (BD); Sestri Ponente (Liguria, Pliocene): 2 intermediate valves (BD); Borzoli (Liguria, Pliocene): 4 valves (3 head and 1 tail) (BD). Maximum width of the valves: 4.6 / 3.6 / 3.9 mm.

Etimology: From the Latin *sulco* = furrow and *marginatus* = edged, with reference to the striped sculpture near the margins.

Diagnosis: Tegmentum sculptured with some light ribs restricted to the area near the margins in head valve, lateral areas of intermediate valves and postmucronal area of tail valve, and with 3-4 small scars obliquely directed in pleural area of intermediate valves and antemucronal area of tail valve. Slit formula: 8-9 / 1 / 10.

Description. Head valve semicircular, smooth except some light ribs restricted to the area near the anterior margin. Intermediate valve rectangular, posterior margin a little concave at both sides 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: 8-9 / 1 / 10.

Remarks. These small valves can not be attributed with certainty to any of the *Chiton* species known, and we consider these valves conspecific to the valves from the Pliocene of Liguria, already described as *Chiton* sp. B by Dell'Angelo et al. (2013).

Comparisons. The main differential character is the presence of 3-4 small scars obliquely directed, in pleural and antemucronal areas near the side margin, and of some light ribs only in a small part near the margins of head valve, and lateral and postmucronal areas. The differences with *Chiton saeniensis* Laghi, 1984 and *C capecchii* Chirli, 2004 were already reported by Dell'Angelo et al. (2013: Tab. 1, as *Chiton* sp. B).

Distribution. Middle Miocene: Proto-Mediterranean Sea (Langhian): Po Basin: Albugnano (this paper). **Late Miocene:** Proto-Mediterranean Sea (Tortonian): Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio (this paper). **Pliocene:** central Mediterranean, N Italy (Dell'Angelo et al. 2013).

Suborder **Acanthochitonina** Bergenhayn, 1930
Superfamily Mopalioidea Dall, 1889
Family Lepidochitonidae Iredale, 1914
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.

Lepidochitona cinerea (Linnaeus, 1767)
Pl. 3, figs 13-18

1767 *Chiton cinereus* Linnaeus, p. 1107.
Additions to the bibliography in Dell'Angelo et al. (2013: 89):
1897 *Lepidopleurus marginatus* (Penn.) – Sacco, p. 90, pl. 7, 2).
2013 *Lepidochitona cinerea* (Linnaerus) – Dell'Angelo et al., p. 89, pl. 8, figs A-E.

Type material: LSL (*fide* Dodge 1952: 23).
Type locality: "In O. Norvegico".
Material examined: Villa Monti: 2 intermediate valves (BD); Rio di Bocca d'Asino: 42 valves (14 head, 25 intermediate, and 3 tail) (BD, MZB 32086, PG); Montegibbio: 18 valves (5 head, 12 intermediate, and 1 tail) (BD, MZB 32087-32088); Borelli: 2 valves (1 head, and 1 intermediate (MZB 32089, MGPT). Maximum width of the valves: 4.5 / 5 / 2.6 mm.

Remarks. Detailed descriptions of this species were included in Kaas & Van Belle (1985) and Dell'Angelo & Smriglio (1999). 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.

Sacco (1897) described and figured (pl. 7, 2) as *Lepidopleurus marginatus* (Pennant, 1777) a head valve from the Tortonian of "Stazzano", identified by Laghi (1977) as *Lepidochitona cinerea*.

For comparison with *Lepidochitona pliocinerea*, see under the latter.

Distribution. Late Miocene: Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Villa Monti, Rio di Bocca d'Asino, Montegibbio, Borelli (Sacco 1897; Laghi 1977; Dell'Angelo et al. 1999; this paper). **Pliocene:** northeastern Atlantic, Mondego Basin, Portugal (Dell'Angelo & Silva 2003); western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Laghi 1977; Dell'Angelo et al. 2001, 2013; Chirli 2004; Sosso & Dell'Angelo 2010). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo et al. 2001, 2007), Greece (Garilli et al. 2005; Koskeridou et al. 2009). **Recent**: Mediterranean, Black Sea and Atlantic, along all the European coast, and from southern Greenland to Senegal (Dell'Angelo & Smriglio 1999).

Lepidochitona caprearum (Scacchi, 1836)
Pl. 3, figs 19-21; Pl. 4, figs 1-3

1836 *Chiton caprearum* Scacchi, p. 9.
Additions to the bibliography in Dell'Angelo et al. (2013: 90):
2013 *Lepidochitona caprearum* (Scacchi) – Dell'Angelo et al., p. 90, pl. 8, figs F-K.

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 di Bocca d'Asino: 13 valves (2 head, and 13 intermediate) (BD, MZB 32090-32091, PG); Montegibbio: 2 intermediate valves (BD, LB); Borelli: 2 intermediate valves (BD, MZB 32092). Maximum width of the valves: 2.2 / 3.4 / - mm.

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, and the rounded profile of intermediate valves.

The species is rather rare as a fossil, and its occurrence in the Miocene of the Paratethys (Macioszczyk 1988, as *L. corrugata*) should be confirmed, given the numerous *Lepidochitona* species described from that area.

Distribution. Late Miocene: Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio, Borelli (Laghi 1977; Dell'Angelo et al. 1999; this paper). **Pliocene:** central Mediterranean, Italy (Laghi 1977; Dell'Angelo et al. 2001, 2013; Chirli 2004). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo et al. 2001, 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 monterosatoi Kaas & Van Belle, 1981
Pl. 4, figs 4-10

1981 *Lepidochitona* (*L.*) *monterosatoi* Kaas & Van Belle, p. 23, figs 7-9.
Additions to the bibliography in Dell'Angelo et al. (2013: 92):
2013 *Lepidochitona monterosatoi* Kaas & Van Belle – Dell'Angelo et al., p. 92, pl. 9, figs A-F.

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: Monchio di Sarzano Casina: 2 valves (1head, and 1 intermediate) (BD, MZB 32093); Rio di Bocca d'Asino: 16 intermediate valves (BD, MZB 32094-32095, PG); Montegibbio:

7 valves (1 head, 4 intermediate, and 2 tail) (BD, MZB 32096). Maximum width of the valves: 2 / 2.5 / 2 mm.

Remarks. Detailed descriptions of this species were reported in Kaas & Van Belle (1985) and Dell'Angelo & Smriglio (1999). Besides its distinctive subcarinate valve profile, 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.

The species is rather rare both in living and fossil states, but complete valves can be easily distinguished from the other *Lepidochitona* species by their subcarinate profile and larger dorsal elevation (Pl. 4, fig. 10), the elevated lateral areas of the intermediate valves (Pl. 4, fig. 9), and the sculpture of the tegmentum granules (Pl. 4, figs 4-9). It is more difficult to determine incomplete, small or poorly preserved valves, like most of those contained in our material, e.g. the two valves from the Serravallian of Monchio di Sarzano Casina (Pl. 4, figs 4-5), for which the attribution to *Lepidochitona monterosatoi* can be only tentative.

An intermediate valve from Rio di Bocca d'Asino (Pl. 4, figs 9-10) is particularly elevated, heigth/width ratio = 0.54, vs. 0.40 – 0.41 reported by Kaas & Van Belle (1985) and Dell'Angelo & Smriglio (1999), and also in this case the attribution to *Lepidochitona monterosatoi* remains uncertain.

The species is rather rare in fossil state, and its occurrence in the Miocene of the Paratethys (Macioszczyk 1988: p. 52, pl. 2, figs 6-8) should be verified given the numerous *Lepidochitona* species described from that area.

Distribution. Middle Miocene: Proto-Mediterranean Sea (Serravallian): Monchio di Sarzano Casina (this paper). **Late Miocene:** Proto-Mediterranean Sea (Tortonian): Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio (this paper). **Pliocene:** central Mediterranean, Italy (Forli et al. 1999; Dell'Angelo et al. 2001, 2013; Chirli 2004; Sosso & Dell'Angelo 2010). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo & Forli 1995), Greece (Koskeridou et al. 2009). **Recent:** Mediterranean Sea and the Red Sea (Dahlak Islands) (Dell'Angelo & Smriglio 1999; Koukouras & Karachle 2005).

Lepidochitona pliocinerea
Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013
Pl. 4, figs 11-17

2013 *Lepidochitona pliocinerea* Dell'Angelo, Sosso, Prudenza & Bonfitto, p. 92, pl. 9, figs G-Z.

Type material: Holotype: MZB 49979, an intermediate valve. Seven Paratypes: MZB 49978 (Rio Sant'Antonino); MZB 49977 (Bussana); MSNG 56537 (Bussana), and private collections.

Type locality: Bussana (Imperia), Italy (43°49'60''N, 7°49'52''E); Lower Pliocene (Zanclean).

Material examined: Sciolze: 1 intermediate valve (PG); Albugnano: 1 intermediate valve (MZB 32097); Rio di Bocca d'Asino: 21 valves (16 intermediate, and 5 tail) (BD, MZB 32098, PG); Montegibbio: 10 valves (1 head, and 9 intermediate) (BD, MZB 32099); Borelli: 2 intermediate valves (BD, MGPT PU 135299). Maximum width of the valves: 3 / 7 / 3.5 mm.

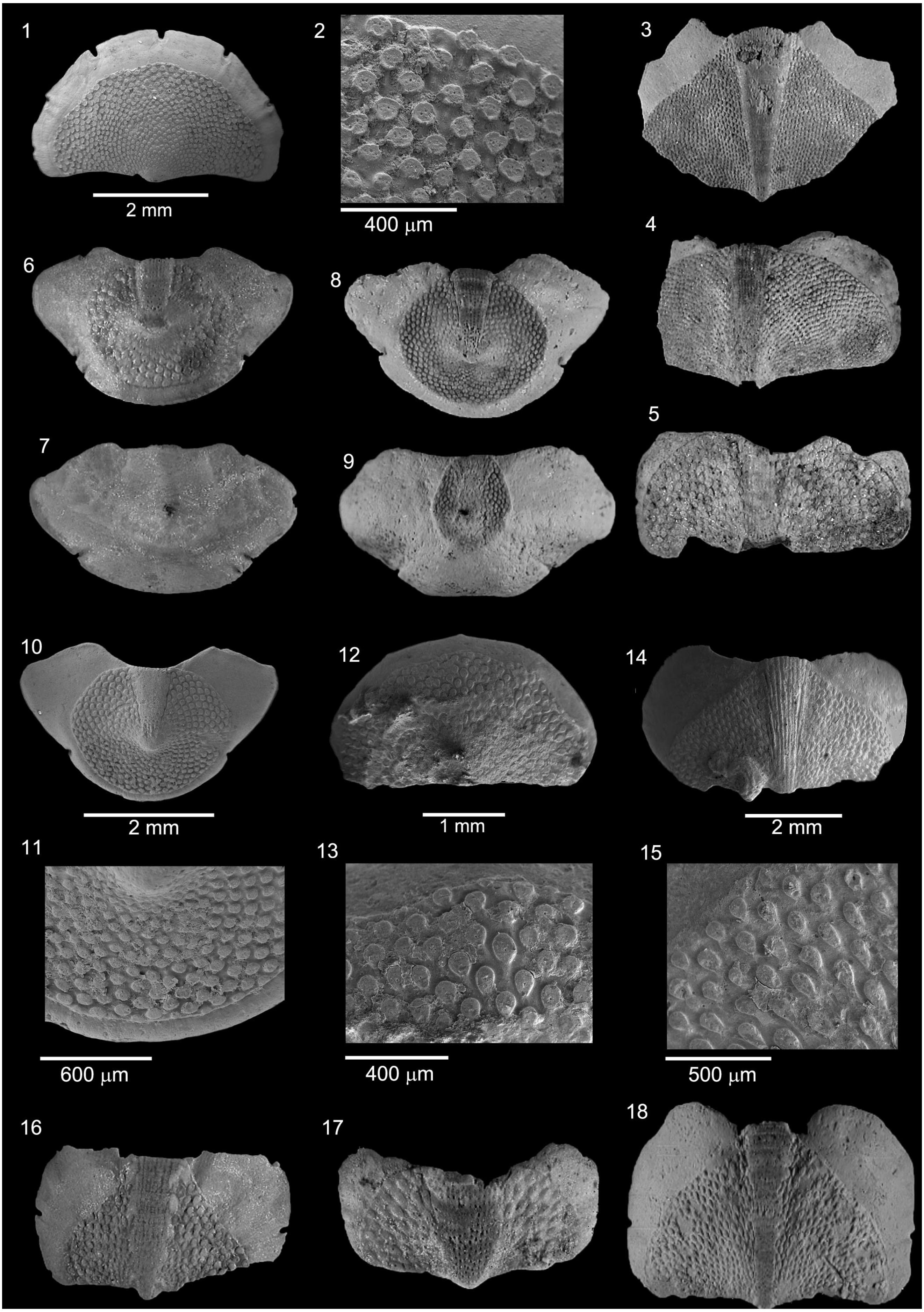
Remarks. This species was described by Dell'Angelo et al. (2013) from the Pliocene of Liguria, Tuscany (Serre di Rapolano) and from Estepona Basin, Spain. It is very similar to *L. cinerea*, from which it differs by the greater width and the different shape (laterally more elongate) of its valves, the larger apophyses starting from the jugal area, the different slope in tail valve, the greater number of slits (slit formula 15-16 / 1 / 11-15 vs. 8-10 / 1 / 8-12 in *L. cinerea*), and the more irregularly roundish granules (Dell'Angelo et al. 2013).

These new records for the species extend the stratigraphic distribution of *L. pliocinerea* to the Early Miocene. The valves are not as well preserved as those from the Ligurian Pliocene, but the characters are evident enough to confirm the attribution to *L. pliocinerea*.

PLATE 5

Figs 1-11 - *Acanthochitona fascicularis* (Linnaeus, 1767). 1-7) Rio di Bocca d'Asino. 1-2) Head valve, MZB 32100. 1) Dorsal view. 2) Detail of the sculpture. 3-5) Intermediate valves. 3) MZB 32101, width 7.8 mm, dorsal view. 4) MZB 32102, width 5 mm, dorsal view. 5) MZB 32103, width 5 mm, dorsal view. 6-7) Tail valve, MZB 32104, width 3.5 mm, dorsal and ventral views, with an additional slit on the insertion plate. 8-9) Borelli, tail valves. 8) MZB 32106, width 5 mm, dorsal view. 9) MZB 32107, width 7.5 mm, dorsal view, with a reduced tegmentum. 10-11) Rio di Bocca d'Asino, tail valve, MZB 32105. 10) Dorsal view. 11) Detail of the sculpture.

Figs 12-18 - *Acanthochitona crinita* (Pennant, 1777). 12-15) Albugnano. 12-13) Head valve, MZB 32108. 12) Dorsal view. 13) Detail of the sculpture. 14-15) Intermediate valve, MZB 32109. 14) dorsal view. 15) Detail of the sculpture. 16) Rio di Bocca d'Asino, intermediate valve, MZB 32110, width 3.5 mm, dorsal view. 17) Montegibbio, intermediate valve, MZB 32112, width 2.3 mm, dorsal view. 18) Borelli, intermediate valve, MZB 32113, width 6 mm, dorsal view.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Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): N Italy: Sciolze (this paper). **Middle Miocene**: Proto-Mediterranean Sea (Langhian): Po Basin: Albugnano (this paper). **Late Miocene:** Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio, Borelli (this paper). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Dell'Angelo et al. 2013).

Superfamily Cryptoplacoidea H. & A. Adams, 1858
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. 5, figs 1-11

1767 *Chiton fascicularis* Linnaeus, p. 1106.
Additions to the bibliography in Dell'Angelo et al. (2013: 95):
2013 *Acanthochitona fascicularis* (Linnaeus) – Dell'Angelo et al., p. 95, pl. 10, figs A-G.

Type material: No chiton specimen even remotely resembling this species as described by Linnaeus is present in the Linnaeus' collection at LSL (*fide* Dodge 1952: p. 21). Neotype designated and figured by Kaas (1985: p. 588, fig.1), MNHN.

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

Material examined: Valle Ceppi: 2 valves (1 intermediate and 1 tail) (BD); Villa Monti: 32 valves (6 head, 21 intermediate and 5 tail) (BD, PG); Rio di Bocca d'Asino: 396 valves (36 head, 328 intermediate and 32 tail) (BD, MZB 32100-32105, PG); S. Agata Fossili: 10 valves (7 intermediate and 3 tail) (PG); Vigoleno: 2 valves (1 intermediate and 1 tail) (BD); Montegibbio: 94 valves (5 head, 78 intermediate and 11 tail) (BD); Borelli: 17 valves (14 intermediate and 3 tail) (BD, MGPT, MZB 32106-32107, PG). Maximum width of the valves: 5.3 / 8 / 7.5 mm.

Remarks. Detailed description of this species were presented in Dell'Angelo & Smriglio (1999). *Acanthochitona fascicularis* is an extremely variable species with a 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.

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. The validity of these species, well discussed by Studencka & Dulai (2010), is contentious; considered valid by Bałuk (1965, 1971, 1984) and Studencka & Dulai (2010) and synonyms of *A. fascicularis* by Laghi (1977) and Dell'Angelo et al. (1999).

We observed much variation in the studied material, including the shape of the valves (Pl. 5, figs 3-5 for intermediate valves) and the structure of the mainly small roundish granules (Pl. 5, figs 2, 11), but less frequently larger and more spaced granules (Pl. 5, fig. 5). The tail valve shows the tegmentum with an outline almost circular to more ellipsoidal, but we illustrate a tail valve from Borelli (Pl. 5, fig. 9) with a reduced tegmentum more straight in the jugal area (this could also be due to a loss of part of the tegmentum due to the poor preservation of the valve, but it is difficult to verify).

One tail valve from Rio di Bocca d'Asino shows an additional slit on the insertion plate (Pl. 5, figs 6-7), a character not so rare in *Acanthochitona* specimens [see Bałuk (1984: 292), Dell'Angelo et al. (1999: 196), Dell'Angelo et al. (2013: 96, pl. 10, fig. F-G)].

PLATE 6

Figs 1-2 - *Acanthochitona crinita* (Pennant, 1777), Rio di Bocca d'Asino, intermediate valve, MZB 32111, width 2.5 mm, dorsal and frontal views.

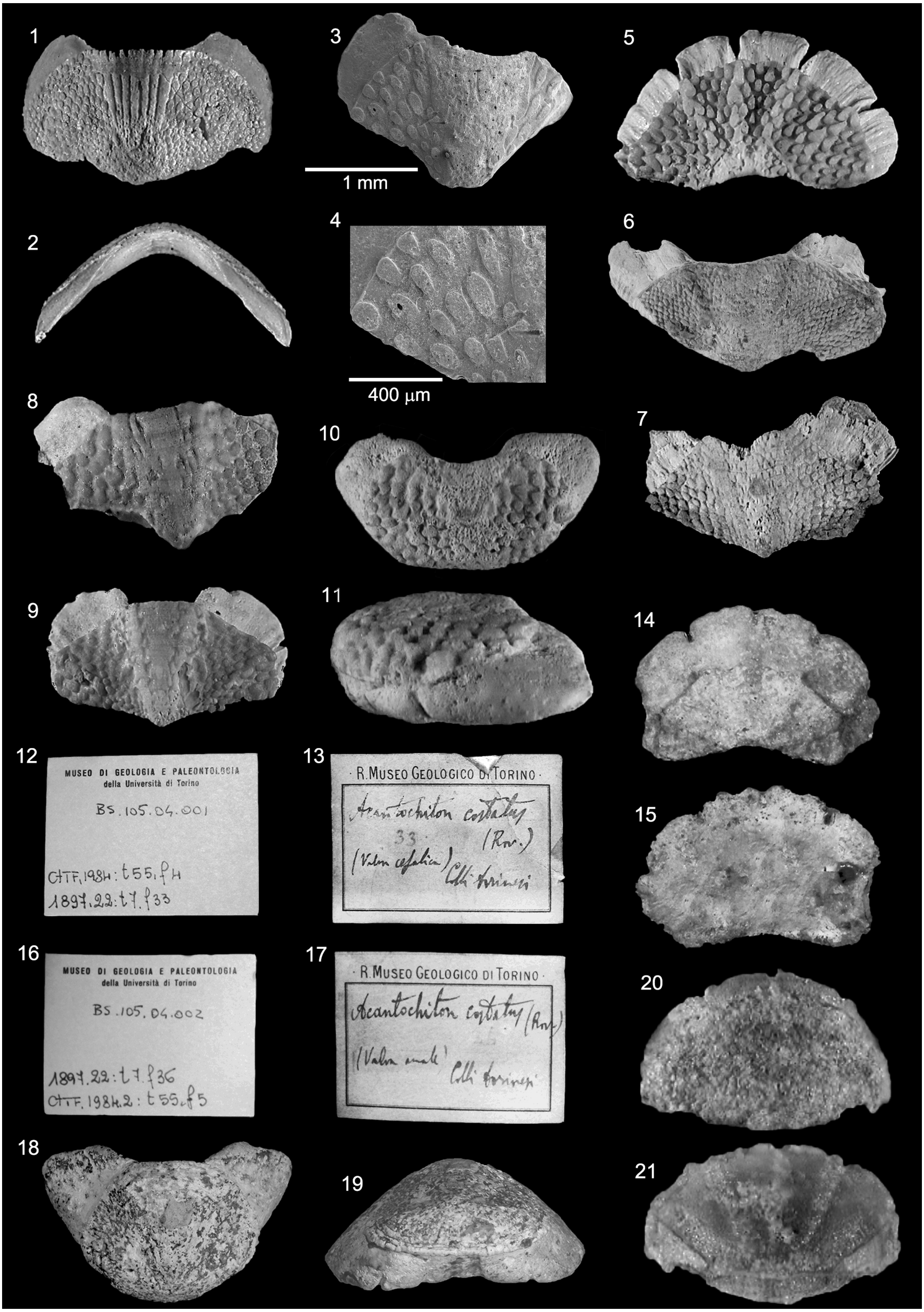
Figs 3-4 - *Acanthochitona oblonga* (Leloup, 1981), Montegibbio, intermediate valve, MZB 32114, dorsal view.

Figs 5-11 - *Craspedochiton altavillensis* (Seguenza, 1876). 5) Borelli, head valve, MZB 32119, width 7.8 mm, dorsal view. 6-7) Valle Ceppi, intermediate valves. 6) MZB 32115, width 14.3 mm, dorsal view. 7) MZB 32116, width 8.6 mm, dorsal view. 8) Rio di Bocca d'Asino, intermediate valve, MZB 32117, width 5.2 mm, dorsal view. 9) Borelli, intermediate valve, MZB 32120, width 7 mm, dorsal view. 10-11) Rio di Bocca d'Asino, tail valve, MZB 32118, width 4.7 mm, dorsal and lateral views.

Figs 12-15 - *Craspedochiton mutinocrassus* (Sacco, 1897), Sciolze, head valve figured as *Acantochiton* (sic!) *costatus* by Sacco (1897: pl. 7, fig. 33), MRSN, BS.105.04.001, width 10 mm. 12-13) Original labels. 14-15) Dorsal and ventral views.

Figs 16-19 - *Craspedochiton*? sp., Sciolze, tail valve figured as *Acantochiton* (sic!) *costatus* by Sacco (1897: pl. 7, figs 35-37), MRSN, BS.105.04.002, width 18.5 mm. 16-17) original labels. 18-19) dorsal views.

Figs 20-21 - *Craspedochiton minutulus* Bałuk, 1971, Montegibbio, head valve, MZB 32121, width 1.2 mm, dorsal and ventral views.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Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): N Italy: Valle Ceppi (this paper). **Middle Miocene:** Paratethys (Langhian-Serravallian): Romania (Dell'Angelo et al. 2007). **Late Miocene:** Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Villa Monti, Rio di Bocca d'Asino, S. Agata Fossili, Vigoleno, Montegibbio, Borelli (Laghi 1977; Dell'Angelo et al. 1999; this paper). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Dell'Angelo et al. 2001, 2013; Chirli 2004; Sosso & Dell'Angelo 2010). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo & Forli 1995; Dell'Angelo et al. 2001), 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. 5, figs 12-18; Pl. 6, figs 1-2

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

Additions to the bibliography in Dell'Angelo et al. (2013: 96):

2013 *Acanthochitona crinita* (Pennant) – Dell'Angelo et al., p. 96, pl. 10, figs H-M.

Type material: Neotype designated and figured by Kaas (1985: p. 591, 7), 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: Sciolze: 5 valves (4 intermediate, and 1 tail) (PG); Valle Ceppi: 1 intermediate valve (BD); Albugnano: 10 valves (1 head, 7 intermediate, and 2 tail) (MZB 32108-32109, PG); Rio di Bocca d'Asino: 23 valves (2 head, and 16 intermediate) (BD, MZB 32110-32111, PG); Montegibbio: 11 valves (10 intermediate, and 1 tail) (BD, MZB 32112); Borelli: 2 intermediate valves (MGPT, MZB 32113). Maximum width of the valves: 3.5 / 5.8 / 4.2 mm.

Remarks. *Acanthochitona crinita* is an extremely variable species with a complicated synonymy. It is characterized by the tegmentum uniformly covered with oval to more or less elongated, flat-topped, drop shaped granules. Detailed description of this species were presented in Dell'Angelo & Smriglio (1999).

Acanthochitona oblonga (Leloup, 1981) differs by the very elongate granules (3-5 times as long as wide, vs. 1-2 times in *A. crinita*) and a different number of microaesthetes, 6-9 vs. 12-16 in *A. crinita* (Schmidt-Petersen et al. 2015: Tab. 1). *Acanthochitona pilosa* Schmidt-Petersen, Schwabe & Haszprunar, 2015 is a recent described Mediterranean species from Banyuls sur Mer, France, which differs from *A. crinita* by the shape of the valves (intermediate valves with triangle shaped posterior end and no pronounced apex in *A. pilosa*, posterior margin concave at both sides of the pronounced apex in *A. crinita*, compare Pl. 5, figs 16-18 with fig. 5b in Schmidt-Petersen et al. 2015), more oval and densely packed granules, and the presence of dense dorsal straight spicules on perinotum (absent or sparse, and curved if present in *A. crinita*).

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

We observed much variation in the studied material, some small intermediate valves from Rio di Bocca d'Asino, of width 2.5-2.8 mm (Pl. 6, figs 1-2), show a rounded profile of the valves, with no trace of separation between jugal and lateropleural areas, larger jugal area, and more elliptical granules.

These new records for the species extend the stratigraphic distribution of *A. crinita* to the Early Miocene.

Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): N Italy: Sciolze, Valle Ceppi (this paper). **Middle Miocene:** Proto-Mediterranean Sea (Langhian): Po Basin: Albugnano (this paper); Paratethys (Langhian-Serravallian): Poland (Bałuk 1971, 1984, as *A. lacrimulifera*, *A. fascicularis*). **Late Miocene:** Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio, Borelli (Laghi 1977; Dell'Angelo et al. 1999; this paper). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy (Dell'Angelo et al. 2001, 2013; Chirli 2004; Sosso & Dell'Angelo 2010). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo & Forli 1995; Dell'Angelo et al. 2001), 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. 6, figs 3-4

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

Additions to the bibliography in Dell'Angelo et al. (2013: 96):

2013 *Acanthochitona oblonga* (Leloup) – Dell'Angelo et al., p. 97, pl. 10, figs N-Q.

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: Rio di Bocca d'Asino: 1 intermediate valve, width 4 mm (BD); Montegibbio: 3 intermediate valves, maximum width 2.8 mm (BD, MZB 32114).

Remarks. This species is characterized by the very extended sharp granules of the tegmentum, and is so similar to *A. crinita* that Kaas (1985) and Dell'Angelo & Smriglio (1999) considered them as conspecific. Bonfitto et al. (2011) demonstrated that *A. oblonga* is a valid species based on morphological and molecular characters.

Fossil valves are scarce and until now found only in the Pliocene of Liguria (Dell'Angelo et al. 2013) and Pleistocene of Riparbella (Dell'Angelo & Forli 1995).

These new records for the species extend the stratigraphic distribution of *A. oblonga* to the Late Miocene (Tortonian).

Distribution. Late Miocene: Proto-Mediterranean Sea (Tortonian): Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio (this paper). **Pliocene:** central Mediterranean, Italy: Liguria (Dell'Angelo et al. 2013). **Pleistocene:** central Mediterranean, Italy: Riparbella (Dell'Angelo & Forli 1995). **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, 1841, by monotypy.

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

Craspedochiton altavillensis (Seguenza, 1876)

Pl. 6, figs 5-11

1876 *Chiton altavillensis* Seguenza, p. 264.

Additions to the bibliography in Dell'Angelo et al. (2012: 64; 2013: 97):

1905 *Acanthochites profascicularis* Boettger, p. 208, n° 702.

1934 *Cryptoconchus* (*Craspedoplax*) *profascicularis* (Boettger) – Šulc, p. 13.

1934 *Cryptoconchus* (*Craspedoplax*) *profascicularis* (Boettger) – Zilch, p. 199, pl. 1, fig. 17.

2013 *Craspedochiton altavillensis* Seguenza – Dell'Angelo et al., p. 97, pl. 10, figs R-W.

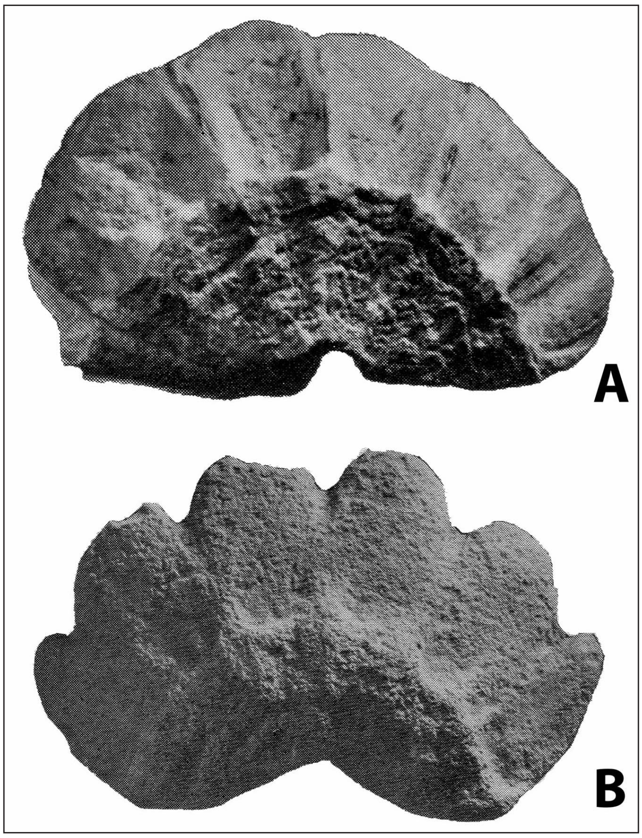


Fig. 2 -The two valves from Montegibbio (coll. Doderlein) figured by Laghi (1977) as *Craspedochiton costatus.* A) MPUM 6090. B) MPUM 6090a. (from Laghi, 1977, pl. 4, figs 2a, 3).

Type material: Neotype (MZB 7062, head valve) designated by Dell'Angelo & Palazzi (1989: fig. 1).

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

Material examined: Valle Ceppi: 3 valves (2 intermediate and 1 tail) (MZB 32115-32116, PG); Rio di Bocca d'Asino: 8 valves (1 head, 4 intermediate and 3 tail) (BD, MZB 32117-32118, PG); Montegibbio: 2 intermediate valves (LB); Borelli: 8 valves (1 head and 7 tail) (BD, MZB 32119-32120, MGPT, PG,). Maximum width of the valves: 7.8 / 14.3 / 5.5 mm.

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 and the granulation patterns are highly variable, from single granules, regularly ellipsoidal, to coalescing granules fused to form irregular cords; the elevation and the density of granules on the tegmentum is variable.

The synonymy of *Craspedochiton deslongchampsi* with the senior accepted name *C. altavillensis* is discussed by Dell'Angelo & Palazzi (1989), who also designated a neotype after verifying the lack of type material of Seguenza (Bertolaso & Palazzi 2000).

Specimens of this species are less common in the Miocene than in the Pliocene (see Dell'Angelo et al., 2012, 2013 for Altavilla and Liguria), the valves are generally smaller and often incomplete. Particularly interesting are the two intermediate valves from Valle Ceppi (Pl. 6, figs 6-7), which despite showing a great variability in the ellipsoidal granules, smaller and more packed, extend the stratigraphic distribution of this species to the Burdigalian.

Acanthochites profascicularis Boettger, 1905 was described on the basis of a single head valve of small dimensions (width 6 mm) found at Coştei (Early Badenian, Romania), and later figured by Zilch (1934, b). Both Šulc (1934) and Zilch (1934) claimed that Early Miocene specimens from the Torino Hill (Piedmont, Italy) identified by Sacco (1897) as *Acantochiton costatus* belong to this species, attributed to the genus *Cryptoconchus* (*Craspedoplax*), but the Sacco's taxon can not be utilized, as *costatus* Sacco, 1897 was preoccupied by *A. costatus* Adams & Angas, 1864. Subsequent authors considered Boettger's species, *profascicularis*, either as a distinct species or as a synonym of Sacco's species, *costatus*. Dell'Angelo et al. (1999) attributed Boettger's (1905) species to the genus *Craspedochiton*, and considered *C. profascicularis* a junior subjective synonym within the variability of *C. altavillensis*, on the basis of the comparison with the neotype of the latter species (Dell'Angelo et al. 1999, figs 2A, 2C).

Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): N Italy: Valle Ceppi (this paper). **Middle Miocene:** Paratethys (Langhian-Serravallian): Poland, Romania (Dell'Angelo et al. 1999). **Late Miocene:** Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy: Rio di Bocca d'Asino, Montegibbio, Borelli (Laghi 1977; Dell'Angelo et al. 1999; this paper). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al. 2004); central Mediterranean, Italy: Liguria (Dell'Angelo et al. 2001, 2012, 2013; Chirli 2004; Sosso & Dell'Angelo 2010). **Pleistocene:** central Mediterranean, Italy: Torrente Stirone, Parma, Dattilo (Trapani), and Greece (Garilli et al. 2005).

Craspedochiton mutinocrassus (Sacco, 1897)

Pl. 6, figs 12-15

1897 *Acantochiton* (sic) *costatus* var. *mutinocrassa* Sacco, p. 91, pl. 7, fig. 38.

1897 *Acantochiton* (sic) *costatus* (Rov.) Sacco, p. 91, pl. 7, figs 33-35 (*partim*, non figs 36-37 = *Craspedochiton* ? sp.).

1977 *Craspedochiton costatus* (Sacco) – Laghi, p. 112, pl. 4, figs 1-3.

1984 *Acanthochiton costatus* Sacco – Ferrero Mortara et al., p. 300, pl. 55, fig. 4 (*partim*, non fig. 5).

1985 *Acanthochiton costatus* Sacco – Zanaroli, table 2.

1999 *Acanthochiton costatus* Sacco – Dell'Angelo et al., p. 283.

1999 *Acanthochiton costatus* var. *mutinocrassa* Sacco – Dell'Angelo et al., p. 283.

2010 *Craspedochiton costatus* (Sacco) – Studencka & Dulai, p. 270.

Non 1897 *Acantochiton* (sic) *costatus* ? var. *astensis* Sacc., p. 91, pl. 7, figs 39-47 [= *Craspedochiton altavillensis* (Seguenza, 1876)].

Type material: Syntype MPUM 6090, head valve, coll. Doderlein, figured by Sacco (1897: pl. 7, 8), Laghi (1977: pl. 4,) and here (text-fig. 1A).

Type locality: Montegibbio (Miocene, Tortonian).

Material examined: Sciolze: 1 head valve, BS.105.04.001, width 10 mm, figured by Sacco (1897: pl. 7, figs 33) and Laghi (1977: pl. 4, fig. 1).

Remarks. Sacco (1897) described the new species *Acantochiton* (sic) *costatus* based on some head valves from the Torino Hill (Sacco, pl. 7, figs 33-35) and some tail valves (Sacco, pl. 7, figs 36- 37), all from the same locality, although conspecificity among those head plates was already considered doubtful by the same author. The head valves are characterized by the presence of large radial ribs, large granules of irregular oval shape, and especially by the insertion lamina particularly expanded. Only one of the three valves figured by Sacco is still present in the Bellardi-Sacco collection (the one figured in Sacco: pl. 7, 3, width 10 mm), whereas the other two valves from the Collection Rovasenda are missing.

Sacco also described another head valve from Montegibbio as *Acantochiton* (sic) *costatus* var. *mutinocrassa* (Sacco: pl. 7, 8); this specimen is identical to the head valves from the Torino Hill, but larger (width 22 mm).

Craspedochiton costatus was considered a valid species by some authors (Laghi 1977; Baluk 1984) or a synonym of other related species by others, e.g. *C. profascicularis* (Boettger, 1905) (Šulc 1934; Zilch 1934; Studencka & Dulai 2010) or *C. altavillensis* (Dell'Angelo et al. 1999).

In our opinion, the remarkable expansion of the insertion lamina is an important character to differentiate these valves from *C. altavillensis*, where the insertion lamina is reduced to a rather narrow band that does not appear to vary with the valve's size. Dell'Angelo et al. (2012) examined 110 valves of *C. altavillensis* from the Pliocene of Altavilla (topotypics), including 19 head valves (maximum width 13.5 mm), one of which is figured by Dell'Angelo et al. (2012, fig. 6D) of width 9 mm (and therefore comparable with the valve figured by Sacco (pl. 7, fig. 33) and also reported here (Pl. 6, figs 12-15) of width 10 mm, and which presents the expansion of the insertion lamina almost equal to the length of the tegmentum. Even more obvious is the expansion of the insertion lamina in each of the two head valves from Montegibbio figured by Laghi (1977), the valve described by Sacco as *A. costatus* var. *mutinocrassa* (Laghi, pl. 4, fig. 2) and a still larger one (Laghi, pl. 4, fig. 3, width 29 mm) where the expansion of the insertion lamina is greater than the length of the tegmentum (Fig. 2).

The relationship of *Craspedochiton costatus* with *C. profascicularis* (Šulc 1934; Zilch 1934; Studencka & Dulai, 2010) is not consistent, as *C. profascicularis* is a synonym of *C. altavillensis* (see discussion above).

The taxon *Acanthochiton costatus* Adams & Angas, 1864 has priority over the fossil *Acanthochiton costatus* Sacco, 1897, for which we propose the name *Craspedochiton mutinocrassus* (Sacco, 1897).

Therefore, only three head valves can be reliably attributed to *Craspedochiton mutinocrassus*: the valve from Sciolze (Sacco 1897, pl. 7, fig. 33; Laghi 1977, pl. 4, fig. 1; Ferrero Mortara et al. 1984, pl. 55, fig. 4; this paper, Pl. 6, figs 12-15) and the two valves from Montegibbio (Sacco 1897, pl. 7, fig. 38; Laghi 1977, pl. 4, figs 2-3; this paper, fig. 2).

It is not possible to identify with certainty the tail valves figured by Sacco (1897, pl. 7, figs 36-37) as *A. costatus*, whose conspecificity with head valves was already considered doubtful by the same author. The shape of the tegmentum of the valves is different from that of *C. altavillensis* (more oval, see Dell'Angelo et al. 2012, fig. 6F), as also the form of the apophysis. Even the attribution to the genus *Craspedochiton* is uncertain, since the articulamentum does not present the 9 large teeth typical of *C. altavillensis* (Dell'Angelo et al. 1999). The study of the valve from the Bellardi-Sacco collection here figured (Pl. 6, fig. 16-19) allows us to see only a couple of incisions, which may also correspond to those typical of the genus *Acanthochitona*, but the others may be missing due to erosion or incompleteness of the posterior margin of the valve. We therefore prefer to leave the previously described valve in open nomenclature as *Craspedochiton*? sp.

Acantochiton costatus? var. *astensis* Sacco, 1897 from the Pliocene of "Astigiana" belong to *Craspedochiton altavillensis*, as already reported by other authors (Laghi 1977; Dell'Angelo et al. 1999; Studencka & Dulai 2010).

Distribution. Early Miocene: Proto-Mediterranean Sea (Burdigalian): N Italy: Sciolze (Sacco 1897; Laghi 1977; this paper). **Late Miocene:** Proto-Mediterranean Sea (Tortonian): Po Basin, N Italy: Montegibbio (Sacco 1897; Laghi 1977; this paper).

Craspedochiton minutulus Bałuk, 1971

Pl. 6, figs 20-21; Pl. 7, figs 1-8

1971 *Craspedochiton minutulus* Bałuk, p. 465, pl. 6, figs 9-13.

1977 *Craspedochiton minutulus* Bałuk – Laghi, p. 113, pl. 4, figs 13-16.

1984 *Craspedochiton minutulus* Bałuk – Bałuk, p. 293, pl. 10, figs 1-5, pl. 11, figs 1-7.

1985 *Craspedochiton minutulus* Bałuk – Zanaroli, p. 117, pl. 1, figs 8-9.

1988 *Craspedochiton minutulus* Bałuk – Studencka & Studencki, p. 43, 44.

1988 *Craspedochiton minutulus* Bałuk – Macioszczyk, p. 55, pl. 4, figs 1-3.

1999 *Craspedochiton minutulus* Bałuk – Dell'Angelo et al., p. 285.

2010 *Craspedochiton minutulus* Bałuk – Studencka & Dulai, p. 271.

2011 *Craspedochiton minutulus* Bałuk – Dell'Angelo et al., p. 949.

Type material: Holotype in Bałuk's collection, reg. No. BkK-A57, an intermediate valve illustrated in Bałuk (1971: pl. 6, fig. 9).

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: Rio di Bocca d'Asino: 3 valves (2 intermediate and 1 tail) (BD);

Montegibbio: 28 valves (4 head, 15 intermediate, and 9 tail) (BD, MZB 32121-32124); Maximum width of the valves: 1.5 / 1.8 / 1.5 mm.

Remarks. This species was described by Bałuk (1971, 1984) on the basis of many valves from the Middle Miocene (Badenian) of Korytnica

(Poland). The valves were all of small size, maximum width 1.4/1.9/1.6 mm. The species was also reported by Laghi (1977) from the Tortonian of Montegibbio. The new material found from Rio di Bocca d'Asino and Montegibbio permit us to confirm the presence of this species in the Tortonian of N. Italy.

Distribution. Middle Miocene: Paratethys (Langhian-Serravallian): Poland (Bałuk 1971, 1984; Macioszczyk 1988). **Late Miocene:** Proto-Mediterranean Sea (Tortonian): Po Basin, Italy: Rio di Bocca d'Asino, Montegibbio (Laghi 1977; Dell'Angelo et al. 1999; this paper).

Craspedochiton brunettii sp. n.

Pl. 7, figs 9-12

Type locality: Montegibbio, Modena (Emilia, Italy).

Type stage: Miocene (Tortonian).

Type material: Holotype: MGPT PU 135300 (a tail valve, width 9.5 mm).

Etymology: The specific name honours our friend M. Mauro Brunetti (Bologna), who collected this valve from Montegibbio, and has greatly contributed to the knowledge of the Neogene malacofauna of Italy.

Diagnosis: Tail valve flat, bell shaped at the top, semicircular in the lower part, length/width ratio of the tail tegmentum area = 0.87; not elevated and little evident, subcentral mucro. Tegmentum covered with large, densely arranged and elevated granules of irregular shape, almost ellipsoidal to quadrangular, sometimes joining to form irregular radiating cords, becoming larger and coalescing towards the margins. Articulamentum thick, with nine deep and dorsally slightly elevated slits; apophyses expanded with rounded edges.

Description. Tail valve flat (Pl. 7, fig. 9), bell shaped at the top, semicircular in the lower part, length/width ratio of the tegmentum area = 0.87; anterior margin slightly sinuous bordering a large and triangular jugal area, side margins sinuous, rounded posterior margin; subcentral mucro, not elevated and little evident, anterior and posterior slopes slightly convex (Pl. 7, fig. 11).

Tegmentum covered with large, densely arranged and elevated granules of irregular shape, except on the jugal area, becoming larger and coalescing towards the margins (Pl. 7, fig. 12). The shape of the granules is highly variable, from single granules, almost ellipsoidal to quadrangular, to coalescing granules fused to form irregular cords, especially in the vicinity of the jugal area where they are also less evident. Some granules close to the posterior margin are rectangular in shape, 2-3 times larger than the neighboring granules.

Articulamentum thick (Pl. 7, fig. 10). There are nine slits, which are deep and dorsally slightly elevated, forming a channel (Pl. 7, fig. 11). The teeth are broad and roughed dorsally, very irregular. Apophyses expanded with rounded edges, widely separated by an unconnected sinus.

Remarks. This tail valve is very clearly different from the more common species *C. altavillensis*, and the presence of the insertion lamina with numerous slits and granules with the top convex confirm the attribution to the genus *Craspedochiton*. The valve's characters are very distinctive and well defined, and also considering that the fossil records of European *Craspedochiton* are uncommon and not yet well defined, we have described the single tail valve from Montegibbio as a new species.

Comparisons. The main difference with the tail valves of *Craspedochiton altavillensis* regards the form of the tegmentum, oval in *C. altavillensis* with the width about twice the length (length / width ratio = ca. 0.5), much more lengthened and with a characteristic bell shape at the top in *C. brunettii* sp. n. (length / width ratio = 0.87). Furthermore the jugal area is narrower in *C. altavillensis*, the valves are higher and with the mucro in most anterior position, and the granules are more regular.

This valve has the shape of the tegmentum more similar to that described by Sacco (1897, pl. 7, fig. 36) as *Acantochiton costatus* and left undetermined at specific level in the discussion of the

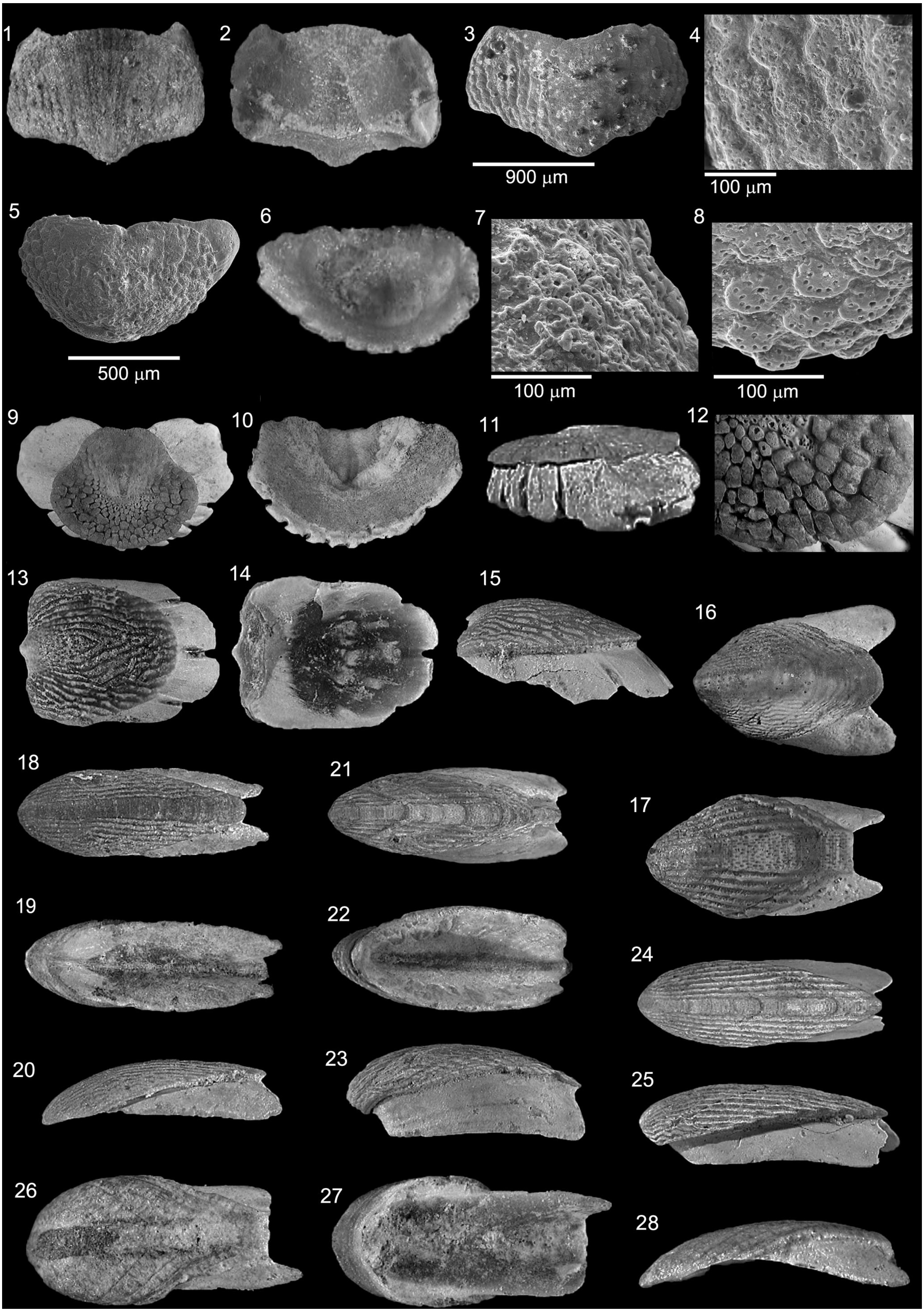
PLATE 7

Figs 1-8 - *Craspedochiton minutulus* Baluk, 1971, Montegibbio. 1-4) Intermediate valves. 1-2) MZB 32122, width 1.5 mm, dorsal and ventral views. 3-4) MZB 32123. 3) Dorsal view. 4) Detail of the sculpture. 5-8) Tail valve, MZB 32124. 5-6) Dorsal and ventral views. 7-8) Detail of the sculpture.

Figs 9-12 - *Craspedochiton brunettii* sp. n., Montegibbio, tail valve, Holotype MGPT PU 135300, width 9.5 mm. 9-11) Dorsal, ventral and lateral views. 12) Detail of the sculpture.

Figs 13-25 - *Cryptoplax weinlandi* Šulc, 1934. 13-16) Villa Monti. 13-15) Head valve, MZB 32125, width 2.9 mm, dorsal, ventral and lateral views. 16) Intermediate valve, MZB 32126, width 6.3 mm, dorsal view. 17) Borelli, intermediate valve, MZB 32130, width 3.7 mm, dorsal view. 18-25) Villa Monti. 18-20) Intermediate valve, MZB 32127, width 7.3 mm, dorsal, ventral and lateral views. 21-25) Tail valves. 21-23) MZB 32128, width 7 mm, dorsal, ventral and lateral views. 24-25) MZB 32129, width 6.5 mm, dorsal and lateral views.

Figs 26-28 - *Cryptoplax lanceolatus* Laghi, 1977, Montegibbio, intermediate valve, MZB 321331, width 3 mm, dorsal, ventral and lateral views.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latter species (see above). The length/width ratio is 0.76, closer to the value found for *C. brunettii* sp. n. (0.87) and very different from the value ca. 0.50 of *C. altavillensis*; moreover the shape of the tegmentum and apophyses are completely different.

Craspedochiton schafferi (Šulc, 1934), known from a single tail valve from the middle Miocene (Badenian) of Paratethys, whose holotype was figured in Kroh (2003, pl. 2, fig. 4), show some similarity with C. *brunettii* sp. n., but differs from the shape of the tegmentum (more rounded and without the characteristic bell shape at the top) and the more regular shape of the granules, ellipsoidal, size fairly constant and less dense.

Distribution. Late Miocene: Proto-Mediterranean Sea (Tortonian): Po Basin, Italy: Montegibbio (this paper).

Family Cryptoplacidae H. & A. Adams, 1858
Genus *Cryptoplax* de Blainville, 1818

Type species: *Chiton larvaeformis* de Blainville in Burrow, 1815, by subsequent designation (Gray 1821: 234).

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

Cryptoplax weinlandi Šulc, 1934

Pl. 7, figs 13-25

1901 *Cryptoplax weinlandi* (Rolle) – Boettger: 180 (*nomen nudum*).
1934 *Cryptoplax weinlandi* Šulc, p. 21, pl. 2, figs 36-40.
1934 *Cryptoplax weinlandi* Šulc – Zilch, p. 199, pl. 1, figs 18-22.
1971 *Cryptoplax weinlandi* Šulc – Baluk, p. 466, pl. 6, figs 1-8.
1977 *Criptoplax* (sic!) *weinlandi* Šulc – Laghi, p. 114.
1982 *Cryptoplax weinlandi* Šulc – Ruggieri, p. 81, fig. 1.
1985 *Criptoplax* (sic!) *weilandi* (sic!) Šulc – Zanaroli, p. 119, pl. 3, figs 2-4.
1988 *Cryptoplax weinlandi* Šulc – Studencka & Studencki, p. 43.
2001 *Cryptoplax weinlandi* Šulc – Dulai, p. 45, pl. 2, figs 4-6, pl. 3, figs 1-6.
2003 *Cryptoplax weinlandi* Šulc – Kroh, p. 135, pl. 1, figs 8-12.
2005 *Cryptoplax weinlandi* Šulc – Dulai, p. 40, pl. 5, figs 5-12, pls 6-7, pl. 8, figs 1-12.
2007 *Cryptoplax weinlandi* Šulc – Dell'Angelo et al., p. 45, fig. 5.
2010 *Cryptoplax weinlandi* Šulc – Studencka & Dulai, p. 271.

Type material: unknown, not present in NHMW.

Type locality: Rudoltice, Czech Republic (the first locality reported by Šulc).

Material examined: Monchio di Sarzano Casina: 2 intermediate valves (BD); Villa Monti: 426 valves (37 head, 323 intermediate, and 66 tail) (BD, MZB 32125-32129, PG);

Rio di Bocca d'Asino: 83 valves (13 head, 56 intermediate, and 14 tail) (BD, PG); Vargo: 1 intermediate valve (PG); Vigoleno: 29 valves (1 head, 25 intermediate, and 3 tail) (BD);

Montegibbio: 14 valves (2 head, 10 intermediate, and 2 tail) (BD); Borelli: 2 intermediate valves (MZB 32130, PG). Maximum width of the valves: 6 / 9.8 / 8.5 mm.

Remarks. The species is characterized by the elongate intermediate valves, the smooth jugal area and the pleurolateral areas ornamented by a few (up to six per side) longitudinal, slightly undulated ribs, also in the tail valve. The head valve is elongated semicircular in outline, ornamented by closely spaced, slightly wavy longitudinal ribs. Detailed descriptions of *Cryptoplax weinlandi* were presented in Bałuk (1971) and Dulai (2005).

Cryptoplax weinlandi was first mentioned by Boettger (1901) to be described by Rolle, but, as reported by Šulc (1934) and Zilch (1934), the description of this species was never published by Rolle (the name was known only from his unpublished manuscript).

As pointed out by Šulc (1934), the shape and appearance of the intermediate valves of *C. weinlandi* is variable. Some valves are characterized by an almost equal length and width and by more longitudinal, slightly undulated ribs in the pleurolateral areas, up to 10 per side (Pl. 7, figs 16-17) and are interpreted as the intermediate valve ii, others are large sized, elongate triangular in outline, and are interpreted as the intermediate valve iii-vii (Pl. 7, figs 18-20). Complete discussions of the length-width relationships of intermediate valves of *C. weinlandi* from Hungary and Romania were given by Dulai (2005) and Dell'Angelo et al. (2007), and we fully agree with their observations.

The great number of intermediate valves (323) from the single locality of Villa Monti permits to show a certain variability in the tegmentum sculpture: more regular longitudinal ribs (Pl. 7, figs 18, 24) or irregular and wavy (Pl. 7, figs 16, 21), and also a variable size of articulamentum in tail valves (Pl. 7, figs 23, 25).

Distribution. Middle Miocene: Proto-Mediterranean Sea (Serravallian): Monchio di Sarzano Casina (this paper); Paratethys (Langhian-Serravallian): Austria, Czech Republic, Poland, Hungary, Romania (Šulc 1934; Baluk 1984; Dulai 2001, 2005; Dell'Angelo et al. 2007). **Late Miocene:** Proto-Mediterranean Sea (Tortonian and Messinian): Po Basin, Italy: Villa Monti, Rio di Bocca d'Asino, Vargo, Vigoleno, Montegibbio, Borelli (Laghi 1977; Dell'Angelo et al. 1999; this paper); "Upper Miocene" of Petralia Sottana, Palermo (Ruggieri 1982).

Cryptoplax lanceolatus Laghi, 1977

Pl. 7, figs 26-28

1977 *Criptoplax* (sic!) *lanceolatus* Laghi, p. 114, pl. 4, figs 17-18.
1985 *Criptoplax* (sic!) *lanceolatus* Laghi – Zanaroli, table 2.
2005 *Cryptoplax lanceolatus* Laghi – Dulai, p. 42.
2007 *Cryptoplax lanceolatus* Laghi – Dell'Angelo et al., p. 47.

Type material: Holotype MPUM n° 18972 (a tail valve, figured by Laghi, 1977: pl. 4, fig. 18).

Type locality: Montegibbio, Miocene (Tortonian).

Material examined: Montegibbio: 1 intermediate valve, width 3 mm (MZB 32131).

Original description (translated from Laghi, 1977). Plate I trapezoidal, longer than wide, almost completely dehusked. The ornamentation residual of the tegmentum is given by three arcuate ribs, trapezoidal, centered in the apex, of increasing size and by weak gritty ribs, aligned forward, only visible on the left side of the valve. Shortly before the outer rib the edge of the tegmentum is seen, and a narrow insertion plate that does not appear incised, perhaps because the teeth are completely worn out.

On the ventral side is visible, posteriorly, the apical area in the shape of a circular segment; the two lateral ditches that housed the transverse muscle and a deep median ditch like a spoon.

The plate VIII has diamond shape. Jugal area smooth, on which are seen, aligned in parallel rows, the exit holes of the aesthetes channels. Lateral-pleural areas ornamented with gritty ribs aligned forward. Before the plate is incomplete, however are visible fragments of the apophyses.

Remarks. *Cryptoplax lanceolatus* was described on the basis of a single head and tail valve from Montegibbio, and has not been reported subsequently.

We attribute a single intermediate valve, also from Montegibbio, to this species. It has a pentagonal outline and longitudinal rows of irregular granules (the "gritty ribs" of Laghi), quite different in form from the longitudinal, slightly undulated ribs typical of *C. weinlandi*. The surface of the valve is quite eroded, but the "gritty ribs" are still recognizable. The length of the valve (3 mm) is also consistent with the length of the tail valve reported by Laghi (2.5 mm). The shape of the tegmentum is quite different from intermediate valves of *C. weinlandi* of similar length (compare with Pl. 7, fig. 17).

Therefore, we confirm the existence of two species of *Cryptoplax* in the Italian Miocene: *C. weinlandi* is widespread in the Upper Miocene (Tortonian/Messinian) and Middle Miocene (Langhian/Serravallian) of Italy and Paratethys. *Cryptoplax lanceolatus* is very uncommon and found only in the Upper Miocene Tortonian of Montegibbio.

Only one other species of *Cryptoplax* is known from the Miocene of the Paratethys, *C. margitae* Dulai, 2001 from the Early Badenian of Hungary (only two intermediate valves reported from two different localities). This species is characterized by the pentagonal outline and the lateral areas ornamented by 5 longitudinal rows of rounded granules each side, that seem similar to the sculpture of *C. lanceolatus*. The outline seemed a little different (compare with Dulai, 2005, pl. 8, fig. 13) to that of *C. lanceolatus*, and the dimensions smaller (length 1.4 mm vs. 3 mm of *C. lanceolatus*). Considering the scant material representing these two specied, we prefer to consider them as distinct, waiting for more material to better characterize them.

Chitonellus gigas O.G. Costa (1854), described from an intermediate valve from the Pleistocenic outcrop of Cannitello (Reggio Calabria) cannot be referred to the genus *Cryptoplax* (= *Chitonellus* Lamarck, 1819), so the generic attribution of Costa's species remains uncertain (Dell'Angelo et al. 2007, p. 47).

Distribution. Late Miocene: Proto-Mediterranean Sea (Tortonian): Po Basin, Italy: Montegibbio (Laghi 1977; this paper).

Discussion

The following considerations take into account the whole of the chiton fauna hitherto recorded for the Miocene of North Italy, also the families Leptochitonidae, Hanleyidae, Ischnochitonidae and Callistoplacidae reported in our previous contribution (Dell'Angelo et al. 2015).

Chiton material consists of 3,003 valves belonging to 35 species, of which 4 have been described as part of this project (herein; Dell'Angelo et al. 2015), and 2 classified at genus level only (Tab. 2).

	Burdigalian		Langhian		Serr.	Tortonian						Messinian		total
localities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Lepidopleurus cajetanus						79	61			1	22	40		**203**
Lepidopleurus benoisti	3	2												**5**
Leptochiton cancellatus						1	8				2			**11**
Leptochiton scabridus							3				1			**4**
Leptochiton salicensis			1									1		**2**
Parachiton statianus sp. n.							7							**7**
Hanleya nagelfar							2					1		**3**
Hanleya mediterranea											2	1		**3**
Ischnochiton rissoi						2	12				4	1		**19**
Ischnochiton korytnicensis						3	39				21	9		**72**
Ischnochiton ligusticus							3				2			**5**
Stenoplax paviai				1		1	41					1		**44**
Stenosemus dolii							1	1			2	6		**10**
Stenosemus sp. A												1		**1**
Stenosemus sp. B											1			**1**
Callistochiton borellianus sp. n.												1		**1**
Callochiton septemvalvis							33				10			**43**
Callochiton doriae	3			2		1	19							**25**
Chiton olivaceus				2		16	196	3		7	27	4		**255**
Chiton corallinus	10	19		2		40	112		2	11	8	1		**205**
Chiton miocenicus	2	23		43		11	149		1		78	406	1	**714**
Chiton sulcomarginatus sp. n.				3			3				2			**8**
Lepidochitona cinerea						2	42				18	2		**64**
Lepidochitona caprearum							13				2	2		**17**
Lepidochitona monterosatoi					2		16				7			**25**
Lepidochitona pliocinerea	1			1			21				10	2		**35**
Acanthochitona fascicularis		2				32	396	10		2	94	17		**553**
Acanthochitona crinita	5	1		10			23				11	2		**52**
Acanthochitona oblonga							1				3			**4**
Craspedochiton altavillensis		3					8				2	8		**21**
Craspedochiton mutinocrassus											1			**1**
Craspedochiton minutulus							3				28			**31**
Craspedochiton brunettii sp. n.											1			**1**
Cryptoplax weinlandi					2	426	83		1	29	14	2		**557**
Cryptoplax lanceolatus											1			**1**
total/locality	**24**	**50**	**1**	**64**	**4**	**614**	**1295**	**14**	**4**	**50**	**374**	**508**	**1**	**3003**
total/age	**74**		**65**		**4**	**2351**						**509**		**3003**

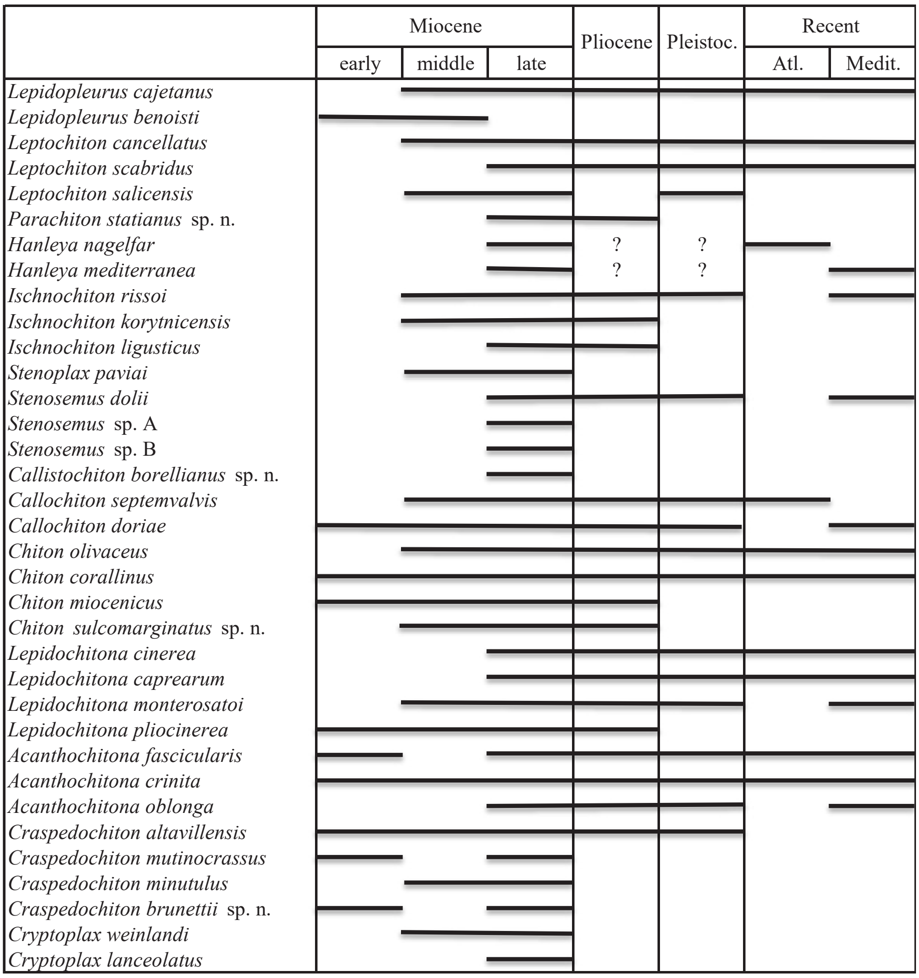
Tab. 2 - Number of valves found by locality/species. Localities: 1: Sciolze; 2: Valle Ceppi; 3: Rocco di Passerano; 4: Albugnano; 5: Monchio di Sarzano Casina; 6: Villa Monti; 7: Rio di Bocca d'Asino; 8: Sant'Agata Fossili; 9: Vargo; 10: Vigoleno; 11: Montegibbio: 12: Borelli; 13: Moncucco Torinese.

The number of valves found in each locality varies widely, partly due to the different sampling strategies adopted by collectors. Although the collection was made without an established quantitative strategy, from the relative abundances, *Chiton miocenicus*, *Acanthochitona fascicularis* and *Cryptoplax weinlandi* appear nevertheless to be the most abundant taxa by representing 23.7% , 18.4% and 18.5% respectively of the total number of valves. At the opposite extreme, six species (*Stenosemus* sp. A, *Stenosemus* sp. B, *Callistochiton borellianus* sp. n., *Craspedochiton mutinocrassus*, *C. brunettii* sp. n. and *Cryptoplax lanceolatus*) are represented by single valves. The majority of valves (43% of the total) have been found at Rio di Bocca d'Asino, an outcrop constantly sampled for 25 years, while the most diverse association of species (27 of 35) was found at Montegibbio.

The 13 sites cited in this article encompass the whole Miocene Epoch, with the exception of Aquitanian for which no polyplacophorans are known from Italy. Taxa discussed here pertain to species only known in Neogene to Quaternary deposits of Europe (Tab. 3), none of which reported for the Oligocene. Regarding the stratigraphic distribution of the 35 taxa identified by us, 10 (29%) became extinct in the Miocene, 6 in the Pliocene, and 2 in the Pleistocene (*Leptochiton salicensis* and *Craspedochiton altavillensis*); the remaining 17 (49% of the total) are still extant, of which 9 are distributed in the Atlantic and Mediterranean, 2 in the Atlantic (*Hanleya nagelfar* and *Callochiton septemvalvis*), and 6 only reported from the Mediterranean.

Noticeably, if one takes our data at face value, the highest diversity in the Miocene chiton fauna of Italy is reached in the upper Miocene with as many as 34 taxa out of a total of 35 species known so far.

Tab. 3 - Geochronological distribution of the species from Northern Italy discussed in this paper, and their post-Miocene presence.



Eleven species (not including those whose nomenclature is still open) are first records for the Italian Miocene: *Leptochiton salicensis*, *Parachiton statianus* sp. n., *Hanleya nagelfar, H. mediterranea*, *Ischnochiton ligusticus, Callistochiton borellianus* sp. n., *Callochiton doriae*, *Chiton sulcomarginatus* sp. n., *Lepidochitona pliocinerea*, *Acanthochitona oblonga*, *Craspedochiton brunettii* sp. n.

Four taxa (*Chiton corallinus*, *C. miocenicus*, *Acanthochitona crinita* and *Lepidochitona pliocinerea*) boast a remarkable stratigraphic longevity, being present from the Burdigalian up to the Messinian, although not collected yet in the Serravallian.

Our study moderately increases the number of chitons from the classic localities collectively known as of Torino Hill, by adding as many as 6 species (*Callochiton doriae, Chiton corallinus, Lepidochitona pliocinerea, Acanthochitona fascicularis, A. crinita, Craspedochiton altavillensis*) to the 3 previously reported by Sacco from this site (1897: *Middendorffia subcajetana, Chiton miocenicus* and *Acantochiton costatus*).

We provide in Tab. 4 a taxonomic update of Sacco's taxa, inclusive of those chitons from other northern Italian Miocene localities (Tortonian of Stazzano and Montegibbio), as well as their interpretation by Laghi, 1977.

The data on the worldwide Miocene chiton fauna are scarce. Some informations are known from Australia and New Zealand (Ashby 1925, 1929; Ashby & Cotton 1936, 1939; Cotton & Godfrey 1940; Beu & Maxwell 1990); Japan (Itoigawa & Nishimoto 1975; Itoigawa et al. 1977, 1981-1982); W. Pacific Islands (Beets 1941; Ladd 1966); E. Africa (Davis 1954).

More informations are known for the Miocene chiton fauna from Europe, mainly regarding the Aquitanian Basin, and the Paratethys. Four species are known from the Aquitanian Basin (de Rochebrune 1883; Cossmann & Peyrot 1919): *Acanthochitona dulignoni* (de Rochebrune, 1883), *Lepidochitona leognanensis* (Cossmann & Peyrot, 1919), *Lepidopleurus benoisti* and *Chiton miocenicus*, the last two species also present in the chiton fauna here studied. A comparison of the Italian Miocene chiton fauna with its Paratethys counterpart reveals some interesting traits. While the two Miocene faunas show, in fact,

Sacco, 1891	Locality	Laghi, 1977	this paper
Middendorffia subcajetana (D'Orbigny)	Torino Hill, Sciolze	*Lepidopleurus subcajetanus*	*Lepidopleurus benoisti*
Chiton miocenicus Michelotti	Torino Hill, Sciolze	*Chiton olivaceus*	*Chiton miocenicus*
Chiton olivaceus var. *zibinicus* Doderlein	Montegibbio	*Chiton olivaceus*	*Chiton olivaceus*
Lepidopleurus marginatus (Pennant)	Stazzano	*Lepidochitona cinerea*	*Lepidochitona cinerea*
Acantochiton costatus (Rov.) Sacco n. sp.	Torino Hill, Sciolze	*Craspedochiton costatus*	*Craspedochiton mutinocrassus* *Craspedochiton* ? sp.
Acantochiton costatus var. *mutinocrassa* Sacco n. var.	Montegibbio	*Craspedochiton costatus*	*Craspedochiton mutinocrassus*

Tab. 4 - Emended nomenclature of Miocene chitons from northern Italy recorded by Sacco (1897) and Laghi (1977).

some taxonomic differences with a substantial number of taxa that are at present only known either in the Proto-Mediterranean or in the Paratethys, yet the two areas shared as many as 13 species (Tab. 5). This is not surprising given the postulated interconnections between the Proto-Mediterranean Sea and the Paratethys at the time (Rögl 1998; Harzhauser et al. 2003; Harzhauser & Piller 2007; Bartol et al. 2014). Admittedly, such an exercise is still somehow hampered by the insufficient knowledge of the Paratethyan chiton fauna, whose knowledge is at present based upon published (Šulc 1934; Bałuk 1971, 1984; Macioszczyk 1988; Studencka & Studencki 1988; Dulai 2001, 2005; Kroh 2003; Dell'Angelo et al. 2007; Studencka & Dulai 2010), and unpublished data, with 28 taxa ascertained so far, even if with some pending taxonomic issues (Tab. 5).

Finally, the 15 extant Mediterranean species assist in a broad actualistic understanding of main characteristics of host marine habitats in the geological past. Seven species (*Lepidopleurus cajetanus*, *Leptochiton scabridus, Chiton olivaceus*, *Lepidochitona*

Miocene North Italy	both N. Italy and Paratethys	Miocene Paratethys
	Lepidopleurus cajetanus **(1)**	
	Lepidopleurus benoisti **(1)**	
	Leptochiton cancellatus	
		Leptochiton srameki (Šulc, 1934)
		Leptochiton boettgeri (Šulc, 1934)
		Leptochiton sulci (Bałuk, 1971)
Leptochiton scabridus		
Leptochiton salicensis		
		Parachiton africanus (Nierstrasz, 1906) **(2)**
Parachiton statianus sp. n.		
Hanleya nagelfar		
		Hanleya multigranosa (Reuss, 1860)
Hanleya mediterranea		
	Ischnochiton rissoi **(3)**	
	Ischnochiton korytnicensis	
Ischnochiton ligusticus		
Stenoplax paviai		
Stenosemus dolii		
Callistochiton borellianus sp. n.		
	Callochiton septemvalvis	
	Callochiton doriae	
		Callochiton zig-zag (Šulc, 1934)
	Chiton olivaceus **(4)**	
	Chiton corallinus **(5)**	
Chiton miocenicus		
Chiton sulcomarginatus sp. n.		
		Chiton jüttneri Šulc, 1934
Lepidochitona cinerea		
Lepidochitona caprearum		
Lepidochitona monterosatoi		
Lepidochitona pliocinerea		
		Lepidochitona lepida (Reuss, 1860)
		Lepidochitona boravicensis (Šulc, 1934)
		Lepidochitona subgranosa Bałuk, 1971
		Lepidochitona baluki Macioszczyk, 1988
Acanthochitona fascicularis		
	Acanthochitona crinita	
Acanthochitona oblonga		
		Acanthochitona faluniensis (de Rochebrune, 1883)
		Acanthochitona plana (Šulc, 1934)
		Acanthochitona sandeciana Bałuk, 1965
	Craspedochiton altavillensis **(6)**	
Craspedochiton mutinocrassus		
		Craspedochiton schafferi (Šulc, 1934)
	Craspedochiton minutulus	
Craspedochiton brunettii sp. n.		
	Cryptoplax weinlandi	
Cryptoplax lanceolatus		
		Cryptoplax margitae Dulai, 2001
20 (+ 13) = 33	**13**	**16 (+ 13) = 29**

Tab. 5 - Comparison between Miocene northern Italian and Paratethys taxonomically emeded chiton fauna at species level: previously reported in the literature as (1) *Lepidopleurus decoratus* Reuss, 1860, (2) *Parachiton thielei* (Šulc, 1934), (3) *Ischnochiton rudolticensis* (Šulc, 1934), (4) *Chiton bohemicus* (de Rochebrune, 1883), (5) *Chiton denudatus* Reuss, 1860, (6) *Craspedochiton profascicularis* (Boettger, 1905).

species	Tortonian (Piedmont)						Zanclean (Liguria)					
	total	head	int.	tail	int./head	int./tail	total	head	int.	tail	int./head	int./tail
Lepidopleurus cajetanus	163	42	59	62	1,40	0,95	2985	460	1768	757	3,84	2,34
Ischnochiton korytnicensis	63	5	35	23	7,00	1,52						
Chiton olivaceus	249	17	148	84	8,71	1,76						
Chiton corallinus	173	14	114	45	8,14	2,53	4405	514	3333	558	6,48	5,97
Chiton miocenicus	239	36	175	28	4,86	6,25	431	65	341	25	5,25	13,64
Lepidochitona cinerea	62	19	39	4	2,05	9,75						
Acanthochitona fascicularis	534	47	435	52	9,26	8,37	635	65	498	72	7,66	6,92
Cryptoplax weinlandi	553	53	415	85	7,83	4,88						

Tab. 6 - Ratios of numbers of intermediate-to-head valves and intermediate-to-tail valves in the fossil chiton assemblages from the Tortonian localities (Villa Monti, Rio di Bocca d'Asino, Sant'Agata Fossili, Vargo, Vigoleno and Montegibbio) and from the Pliocene (Zanclean) of the localities from Liguria. Only species with 60 or more total valves known from these deposits were included in this analysis.

cinerea, L. caprearum, L. monterosatoi, and *Acanthochitona oblonga*) are at present typical of the infralittoral stage; seven (*Leptochiton cancellatus, Ischnochiton rissoi, Callochiton septemvalvis, C. doriae*, *Chiton corallinus, Acanthochitona fascicularis* and *A. crinita*) have a wider bathymetric range, from the intertidal to deeper than 100 m; *Hanleya mediterranea* is circalittoral species (Sirenko, 2014), and *Stenosemus dolii* is presently confined at bathyal depths, often associated deep-water corals (Dell'Angelo & Smriglio 1999), although we cannot exclude that in the past this species (as well as others) had different ecological requirements (Dell'Angelo et al. 2012). Summarizing for diversity patterns at the level of genus or species, in the past as today the chiton fauna was most diverse

The number of valves collected for each species typically show a deviation from the 1:6:1 expected ratio of valve types in the chiton fossil record (Vendrasco 1999; Puchalsky 2005; Vendrasco et al. 2012). The analysis of chiton valve sorting for each species with 60 or more chiton valves found in the Tortonian deposits is presented in Tab. 6. We have also included for comparison the same data for 4 species also present in the deposits from the Pliocene (Zanclean) of Liguria with a large number of valves found (Dell'Angelo et al. 2013).

All species in this assemblage had a different ratio from the expected, and in some cases (e.g. *Lepidopleurus cajetanus*) the ratio is dramatically skewed from the expected, the number of head, intermediate and tail valves is similar, and even the number of tail valves collected exceeds that of intermediate ones. The only species for which the ratio is near the expected is *Acanthochitona fascicularis*, with the values slightly higher but quite similar to each other, contrary to what occurs for most of the species here considered. The data are represented in Fig. 3.

Many factors may bias chiton valve ratios in fossil assemblages. The valve types in chiton individuals have physical differences (mass, volume, surface area, thickness, and growth style), the species tend to live in the rocky intertidal or shallow subtidal zones where currents can be strong and destructive, and their valves are typically delicate, especially for subtidal species (Vendrasco 1999; Puchalsky 2005; Vendrasco et al. 2012). Also the relative pre-

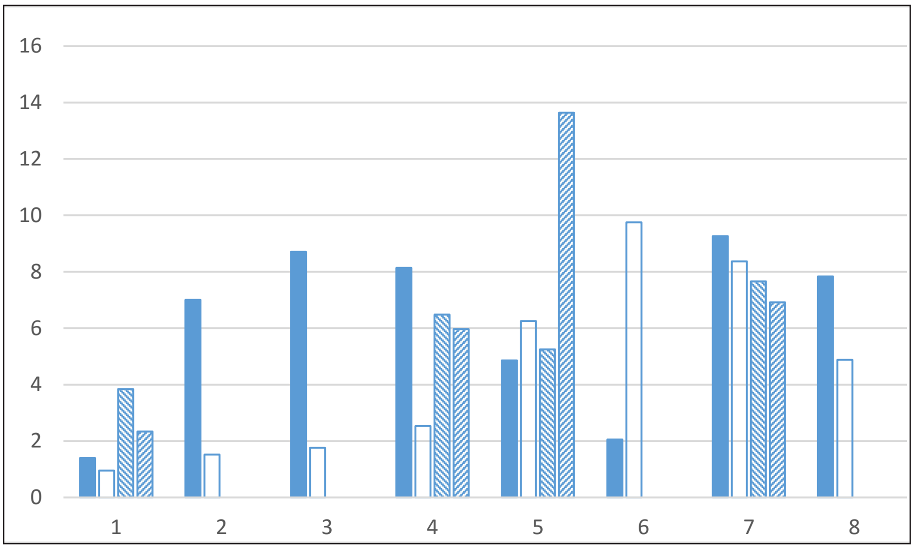


Fig. 3 - Ratios of numbers of intermediate-to-head valves and intermediate-to-tail valves in the fossil chiton assemblages from the Tortonian of Piedmont (blue bars and white bars, respectively) and from the Zanclean of Liguria (hatched bars). Abbreviations. 1 = *Lepidopleurus cajetanus*; 2 = *Ischnochiton korytnicensis*; 3 = *Chiton olivaceus*; 4 = *Chiton corallinus;* 5 = *Chiton miocenicus;* 6 = *Lepidochitona cinerea*; 7 = *Acanthochitona fascicularis*; 8 = *Cryptoplax weinlandi.*

servation potential of different valve types (e.g. differences in robustness and the unequal dispersal and destruction of chiton valves) can contribute to the different ratio from the expected (Sigwart et al. 2014). The number of intermediate plates can also be distorted by they are generally more brittle and easier to break, and often in the debris can be collected half-plates and then counted twice (Dell'Angelo & Palazzi 1989).

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