

Contributions to triviid systematics (Mollusca, Gastropoda), 6. Early Pliocene Triviidae from the western Mediterranean

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The rich Early Pliocene triviid faunas (thirteen species in four genera, viz., *Trivia*, *Niveria*, *Pusula* and *Cleotrivia*) from the Estepona area (southern Spain) are revised systematically and compared to Neogene assemblages recorded from elsewhere. One species, *C. esteponica*, is described as new.

KEY WORDS: Gastropoda, Triviidae, Zanclean, Miocene-Pliocene, western Mediterranean, Italy, systematics, new taxon.

Introduction

In our review of trivoid gastropods from the western Mediterranean, we started with the family Eratoidea (Fehse & Landau, 2002). Like the Eratoidea, the same comments on difficulty and controversy apply to triviids. Many of these problems are the result of poor original descriptions and figures, further confused by Schilder & Schilder (1971), who, in our opinion, reviewed much of the classification based on the figures without having seen the actual specimens. Even Cate (1979) in his review of the family limited many of the descriptions to copying the original data, without amplifying on the older, often incomplete or inadequate descriptions.

We have adopted several of Schilder's methods in our descriptions, but attempted to describe the conchological features of all the species fully. Several specific terms are used: dorsal rib count, characteristics of the dorsal sulcus and the form of the siphonal and anal canals (see Schilder, 1933a, p. 288, text-fig. 6).

The present work is based on material collected at three localities, between 5.5-9 km northeast of Estepona. The deposits consist of a variety of different facies, from coarse sands (Velerín Sands), representing nearshore or beach deposits, to fine clayey sands (Velerín Carretera), deposited at relatively greater depths and a coarse conglomerate (Velerín Conglomerates). All these deposits are of Early Pliocene (Zanclean) age (Vera-Peláez *et al.*, 1996, fig. 1).

Abbreviations —

BLP B. Landau Colln, Albufeira, Portugal;

BS Bellardi & Sacco collns, Torino;
CS F.A. Schilder Colln, currently at Humboldt
Universität, Museum für Naturkunde, Berlin;
DFB D. Fehse Colln, Berlin;
HNC Haus der Natur, Cismar;
IRScNB Institut royal des Sciences naturelles de Bel-
gique, Brussels;
MCSNM Museo civico di Storia naturale di Milano;
NHM The Natural History Museum, London.

Systematic palaeontology

Superfamily Trivioidea Troschel, 1863

Family Triviidae Troschel, 1863

Subfamily Triviinae Troschel, 1863

Genus *Trivia* Broderip, 1837

Type species — *Cypraea europaea* Montagu, 1808, by monotypy.

Trivia coccinelloides (J. de C. Sowerby, 1823)

Figure 1/1a-c

*1823 *Cypraea coccinelloides* J. de C. Sowerby, p. 107, pl. 378, fig. 1.

1843 *Cypraea coccinella* Def. — Nyst, p. 609, pl. 45, fig. 14.

- 1848 *Cypraea europaea* Mont. — Wood, p. 17, pl. 2, fig. 6.
 1872 *Cypraea europaea* Mont. — Wood, p. 5, pl. 5, fig. 24.
 1881 *Cypraea europaea* Mont. — Nyst, p. 59, pl. 5, fig. 2a, b.
 1894 *Trivia europaea* var. *coccinelloides* (Sow.). — Sacco, p. 46, pl. 3, fig. 27.
 1914 *Trivia sphaericulata* Lamarck — Harmer, p. 49, pl. 2, figs 15, 16.
 1914 *Trivia pisolina* (Lamarck) — Harmer, p. 50, pl. 2, fig. 17.
 1920 *Trivia europaea* (Montagu) — Harmer, p. 507, pl. 45, fig. 11.
 1932b *Trivia coccinelloides coccinelloides* (Sowerby, 1832) — Schilder, p. 107.
 1933b *Trivia coccinelloides coccinelloides* (Sow.) — Schilder, p. 9, text-figs 2-4.
 1941 *Trivia (Trivia) coccinelloides* Sowerby '23 — Schilder, p. 73.
 1958 *Trivia coccinelloides* Sowerby sp. 1823 subsp. *coccinelloides* — Glibert, p. 27, pl. 2, fig. 25a, b.
 1971 *Trivia (Trivia) coccinelloides coccinelloides* Sowerby, 1823 — Schilder & Schilder, p. 16.
 1998 *Trivia (T.) coccinelloides* (J. de C. Sowerby, 1823) — Marquet, p. 84, fig. 59.
 2001 *Trivia sphaericulata* (Lamarck, 1810) — da Silva, p. 242, pl. 10, figs 4-9.

Key to the genera of Triviidae from Estepona (Spain)

- | | |
|------------------------------------------------------------------------------------------------------------------------|-------------------|
| 1. Shell with dorsal sulcus | 2 |
| Shell without dorsal sulcus | <i>Trivia</i> |
| 2. Dorsal sulcus very narrow or crossed by ribs | 3 |
| Dorsal sulcus wide and smooth, the ribs forming tubercles at the edge | <i>Pusula</i> |
| 3. Shell very small, inflated; dorsal sulcus weakly developed and not extending across the whole dorsum | <i>Cleotrivia</i> |
| Dorsal sulcus clearly developed, extending the whole length of the dorsum, bisecting, narrowing or depressing the ribs | <i>Niveria</i> |

Distribution — Sutton (East Anglia), Coralline Crag (Wood, 1848); Walton-on-the-Naze (East Anglia), Red Crag; Antwerpen-Doel, Kallo (Belgium), 'Scaldisien' (Nyst, 1882); Kattendijk and Lillo formations, Belgium (Marquet, 1998); 'Astigiana, Piacentino, Liguria, Piacenziano ed Astiano', Italy (Sacco, 1894); Val do Freixo (Pombal, Portugal), Lower/Middle Pliocene (da Silva, 2001); Certaldo (Firenze, Italy), Piacenzian (DFB Colln); Latsia, near Nicosia (Cyprus), Pliocene (BLP Colln); Lucena (Huelva, Spain), Arenas de Huelva Formation, Zanclean (BLP Colln); Castellace (Italy), Siciliano Formation, Pleistocene (DFB Colln).

Material studied — From the Velerín Conglomerates, 19 specimens (BLP Colln), 8 specimens (DFB Colln); from Velerín Carretera, 3 specimens (BLP Colln); from the Velerín Sands, 6 specimens (BLP Colln); from Badagnano, 2 specimens and from T. Stirone, 15 specimens (Piacenzian, Italy; BLP Colln); from Certaldo (Firenze, Piacenzian, Italy), 1 specimen (DFB Colln); from Kallo (Oorderen Member, Lillo Formation), 12 specimens (BLP Colln) and 1 specimen (DFB Colln); from Walton-on-the-Naze (Red Crag, Pliocene), 1 specimen (DFB Colln); and from Castellace (Pleistocene), 1 specimen (DFB Colln).

Measurements — Maximum length and width up to 8.2 mm and 5.5 mm, respectively, but on average 6.5 mm and

5.4 mm, respectively; L/W ratio 1.21.

Description — Shell small, relatively fragile, and oval. Spire covered by callus, but visible beneath three vertical riblets extending upwards from the posterior terminal. Body whorl globose and rounded, equalling about 90% of total height, with the terminals well produced. The terminals are rounded adapically, straight abapically. Dorsum humped in the posterior third, completely covered by 20-26 strong ribs. Base slightly convex, with the terminals recurved. The aperture is narrow, strongly curved adapically and slightly widened in the area of the fossula. Outer lip broad, convex, widest in mid-portion, becoming narrower towards the terminals and tapering slightly inwards. The lip bears 19-23 strong, equal teeth. Siphonal and anal canals are slightly indented. Columella weakly convex, tapering steeply inwards, bordered internally by a strong carinal ridge, bearing 18-19 ribs, which continue onto the carinal ridge, where they become slightly stronger. Fossula broadly concave, not clearly delimited from the rest of the columella.

Range of variation — This species is characterised by the aperture being well to the right of the ventral mid-line, the fossula not delimited from the columella and the inner border of the columella and fossula not covered by the outer lip when seen in ventral view.

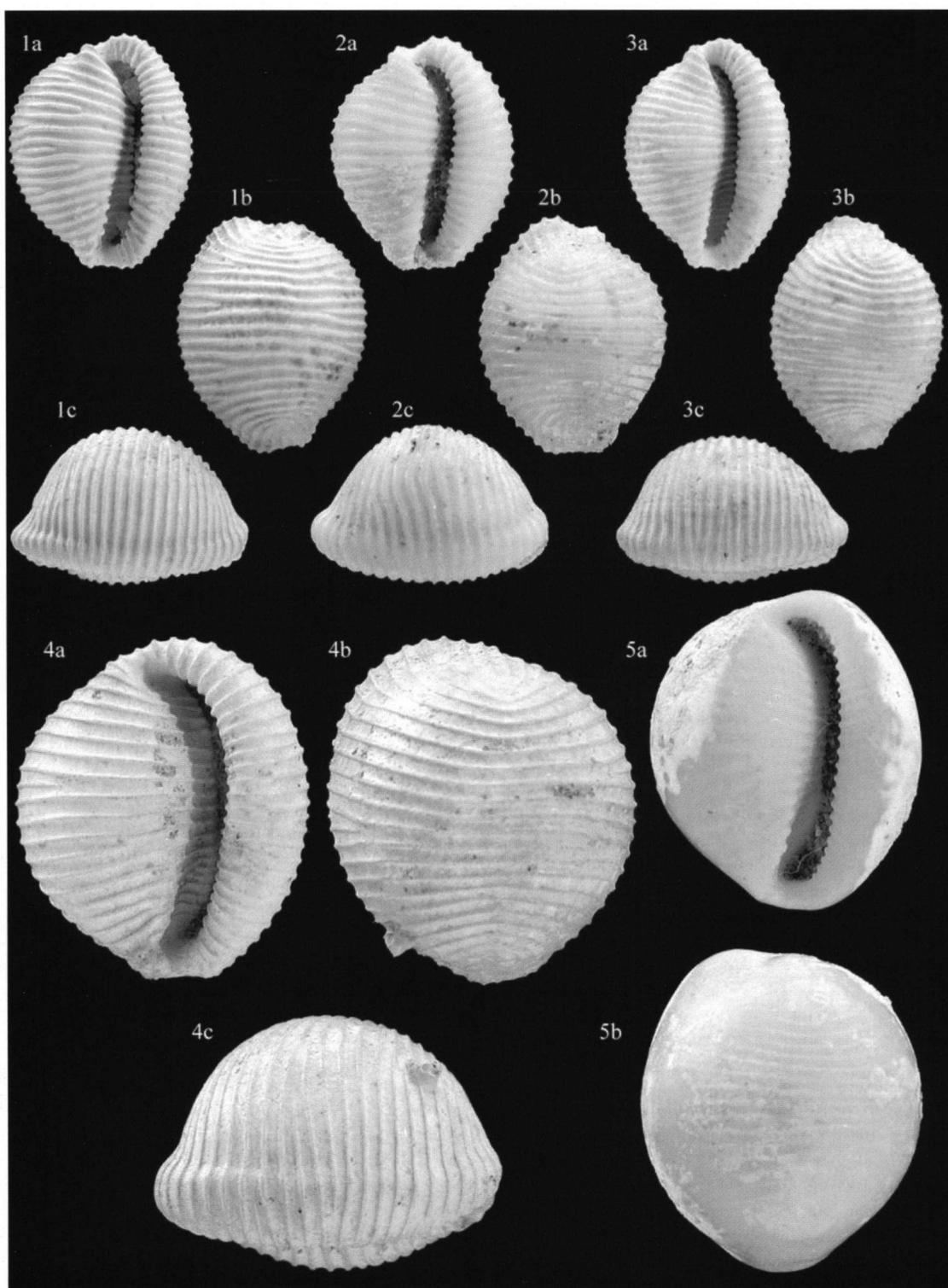


Figure 1. Triviid gastropods from the Zanclean of Estepona (Spain) (photos B. Landau):

- 1a-c *Trivia coccinelloides* (J. de C. Sowerby, 1823), Velerín Sands; original size = 7.1 mm (BLP Colln)
- 2a-c *Trivia candidula* (Gaskoin, 1836), Velerín Conglomerates; original size 7.8 mm (BLP Colln).
- 3a-c *Trivia acuminata* Schilder, 1932a, Velerín Conglomerates, original size = 8.0 mm (BLP Colln).
- 4a-c *Trivia sphaericulata* (Lamarck, 1810), Velerín Carretera, original size 17.1 mm (BLP Colln).
- 5a, b *Trivia perobsoleta* Sacco, 1894, Velerín Conglomerates, original size = 15.6 mm (BLP Colln).

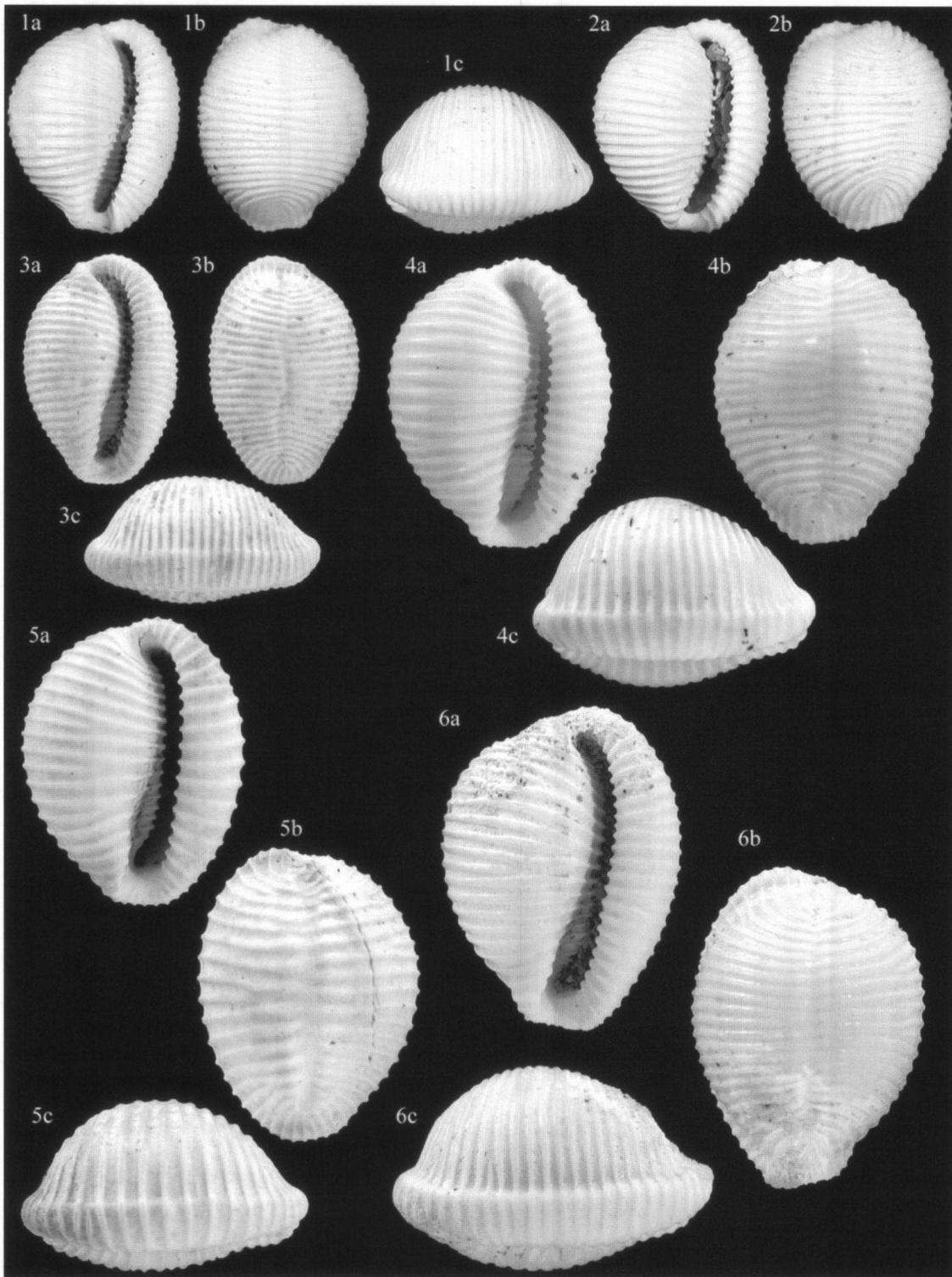


Figure 2. Triviid gastropods from the Zanclean of Estepona (Spain) (photos B. Landau):

- 1a-c, 2a, b *Trivia frigida* Schilder, 1932b, Velerín Conglomerates and Velerín Sands, respectively, original size = 6.2 mm and 6.1 mm, respectively (BLP Colln).
- 3a-c *Niveria dimidiata* (Bronn, 1831), Velerín Conglomerates, original size = 8.2 mm (BLP Colln).
- 4a-c *Niveria permixta* (de Cristofori & Jan, 1832), Velerín Conglomerates, original size = 13.8 mm (BLP Colln).
- 5a-c *Niveria avellanula* (Sacco, 1894), Velerín Conglomerates, original size = 14.1 mm (BLP Colln).
- 6a-c *Niveria dorsolaevigata* (Cocconi, 1873), Velerín Conglomerates, original size = 17.2 mm (BLP Colln).

The shells vary slightly in the development of the dorsal hump, and in the number of dorsal ribs and labial teeth.

Discussion — *Trivia coccinelloides*, best known from the Pliocene of the North Sea Basin, had an extended geographical range during the Early Pliocene, reaching the southern Atlantic Iberian coast.

We have also collected specimens from Zanclean deposits at Huelva, Spain, showing that it migrated through the Straits of Gibraltar into the Mediterranean. It is also found occasionally in Pliocene strata of Italy and Cyprus.

Schilder (1933b, pp. 8, 13) described a comparable form from the North Sea Basin under the name *Trivia coccinelloides parvula*. However, in the Kattendijk Formation of Belgium, *T. coccinelloides* and *T. c. parvula* co-occur, which means that these should be considered distinct at the species level. The North Sea Basin triviids will be discussed in detail in a forthcoming paper.

Trivia candidula (Gaskoin, 1836)

Figure 1/2a-c

1757 *Cypraea bitou* Adanson, p. 73, pl. 5, G. xi, fig. 3 (pre-Linnean).

*1836 *Cypraea candidula* Gaskoin, p. 201.

1932b *Trivia candidula* (Gask.), — Schilder, p. 108.

1941 *Trivia (Trivia) candidula* Gaskoin '36 — Schilder, p. 73.

1979 *Niveria (Cleotrivia) candidula* (Gaskoin, 1836) — Cate, p. 53, figs 61, 61a.

1999 *Trivia candidula* (Gaskoin, 1836) — Fehse, p. 7, pl. 1, fig. 2; pl. 2, fig. 6.

non 1996 *Pusula candidula* (Gaskoin, 1836) — Giannuzzi-Savelli *et al.*, p. 160, fig. 666a-c [= *Cleotrivia wernerii* Fehse, 1999].

Type — Lectotype, designated by Cate (1979, p. 53, pl. 15, figs 61, 61a), is NHM 1874.12.11.55.

Distribution — Extant in Florida (Fehse, 1999) and the Caribbean (Redfern, 2001); off the Canary Islands, western Africa to Málaga, western Mediterranean. This is the first fossil record of the species.

Material studied — From the Velerín Conglomerates, 20 specimens (BLP Colln), 8 specimens (DFB Colln); from Velerín Carretera, 5 specimens (BLP Colln); Recent specimens (DFB Colln) are from Lauderdale, Florida (1), Dry Tortuga Islands, USA (1), Málaga (trawled in 70-80 m depth (5); Palmeira, Sal Island, Cape Verde Islands (2) and Almadies, Senegal (4).

Measurements — Maximum length and width up to 8.1 mm and 6.2 mm, respectively, but on average 6.8 mm and 5.4 mm, respectively; L/W ratio 1.26.

Description — Shell small, relatively solid, and oval. Spire covered by callus. Body whorl globose and rounded, about 90% of total height, with the terminals depressed and straight. Dorsum humped in the posterior third, completely covered by 22-28 strong ribs. Base very slightly convex, with the terminals slightly recurved. The aperture is narrow and strongly curved adapically. Outer lip very broad, convex, widest in mid-portion, becoming narrower towards the terminals and tapering slightly inwards. Outer margin of the lip angularly callused. The lip bears 19-22 strong, equal teeth. Siphonal and anal canals indented. Columella weakly convex, tapering steeply inwards, bordered internally by a strong carinal ridge, bearing 16-18 ribs, which continue onto the carinal ridge, where they become slightly stronger. Fossula broadly concave, not clearly delimited from the rest of the columella. The carinal ridge is covered by the outer lip, when seen in ventral view.

Range of variation — This species is characterised by the broad outer lip, which has an angular outer edge, the centrally placed aperture and the carinal ridge which is not visible in ventral view. The height of the dorsal hump and the character of the ribs are very variable, being narrow in some specimens, while very broad with narrow interspaces in others.

Discussion — The absence of a dorsal sulcus, the central position of the aperture as well as other features discussed in Fehse (1999, p. 8), in our opinion favour assignment of this species to the genus *Trivia* rather than to *Cleotrivia* as suggested by Cate (1979, p. 53).

This species is easily distinguished from *T. coccinelloides* by the thickened outer lip, which has an angular outer margin and the centrally placed aperture. Despite its wide Recent distribution, we are not aware of any previous fossil record of *T. candidula*. We have extensive Caribbean and Mediterranean Neogene collections (BLP and DFB collns) at hand, in which this species is missing. This would suggest a western Mediterranean origin, as *T. candidula* does not occur in Italian faunas, having migrated to the western Atlantic in relatively recent times.

Trivia acuminata Schilder, 1932a

Figures 1/3a-c; 6/5a-c

1894 *Trivia europaea* var. *cocinelloides* (Sow.) — Sacco, p. 46, pl. 3, fig. 27.

1911 *Cypraea europaea* var. *pediculoides* Cerulli-Irelli (*partim*), p. 273, pl. 26, figs 15, 16.

*1932a *Trivia acuminata* Schilder, p. 257, text-fig. 2.

1932b *Trivia acuminata* Schil. — Schilder, p. 108.

1941 *Trivia (Trivia) acuminata* Schilder '32 — Schilder, p. 73.

1970 *Trivia (Trivia) acuminata* Schilder, 1932 — Pavia & Demagistris, p. 131, pl. 1, fig. 1.

1971 *Trivia (Trivia) acuminata acuminata* Schilder, 1932f

- Schilder & Schilder, p. 17.
1984 *Trivia europaea* var. *coccinelloides* (Sowerby, 1823)
— Ferrero Mortara *et al.*, p. 153, pl. 26, fig. 8a-c.

Type — Holotype is CS 3411.

Distribution — Upper Miocene of NE Atlantic (DFB Colln), Pliocene (Pavia & Demagistris, 1970; Ferrero Mortara *et al.*, 1984) and Lower Pleistocene of the western Mediterranean (Cerulli-Irelli, 1911).

Material studied — From the Velerín Conglomerates, 43 specimens (BLP Colln), 9 specimens (DFB Colln); from Velerín Carretera, 3 specimens (BLP Colln); from Certaldo (Firenze, Lower Piacenzian), 3 specimens (DFB Colln); from Castell'Arquato (Lower Piacenzian), 4 specimens (BLP Colln), 8 specimens (DFB Colln); from Brigné (Anjou, France, Lower Pliocene), 1 specimen (DFB Colln).

Measurements — Maximum length and width up to 7.8 mm and 5.7 mm, respectively, but on average 7.0 mm and 5.1 mm, respectively; L/W ratio 1.37.

Description — Shell small, solid, and elongated oval. Spire covered by callus. Body whorl somewhat elongated, globose and rounded, about 85% of total height, with the terminals produced and slightly rounded. Dorsum evenly rounded, completely covered by 24-30 strong ribs. Base almost straight, with the terminals weakly recurved. The aperture is relatively narrow, curved apically and widened in the fossular region. Outer lip broad, convex, regularly rounded, widest in mid-portion, becoming narrower towards the terminals. Outer margin of the lip slightly to strongly, angularly callused. The lip bears 21-22 strong, equal teeth. Siphonal and anal canals follow the shell profile. Columella convex, tapering steeply inwards, bordered internally by a weak carinal ridge, bearing 18-21 ribs, which continue onto the carinal ridge, where they do not become significantly stronger. Fossula broadly concave, not clearly delimited from the rest of the columella and slightly protruding.

Range of variation — The typical features of this species are the somewhat elongated shape, evenly rounded dorsum, high number of ribs and the slightly protruding fossula. The marginal callus on the outer lip varies from slightly developed to forming a marked angular step at the periphery. In a few specimens the shape is more globose.

Discussion — Schilder (1932a, p. 258), in discussing the Italian Pliocene Triviidae, considered the absence of a dorsal sulcus to be the main characteristic feature of this species. In a subsequent paper, he (Schilder, 1933b, p. 19) did not note the presence of *T. coccinelloides* in the Mediterranean. Therefore, the absence of the dorsal sulcus alone cannot be used to distinguish Pliocene triviids from the Mediterranean; it simply is a typical feature of the genus *Trivia*.

Both *T. coccinelloides* (see above) and *T. candidula* (see above) have more rounded shells, with a dorsal hump, fewer ribs, and have the fossula not protruding. In both, the siphonal and anal canals are indented, whereas in *T. acuminata* the canals follow the shell contour. *Trivia candidula* has a similarly callused outer margin of the lip, but may be distinguished by the more centrally placed aperture, with the carinal ridge covered by the apertural lip when seen in ventral view; *T. coccinelloides* has a non-callused lip margin.

Schilder (1941, pp. 73, 114) described *T. nana* from the Upper Miocene ('Tortonian') of Montegibbio, Italy; the holotype (CS 5084) is here illustrated in Figure 6/7a, b. This is a smaller species, with a more inflated, globular shell; ribs are fewer and coarser, the dorsum is considerably more elevated, the aperture very narrow and the extremities are only weakly developed. The differences in shell morphology are significant enough to consider them separate at the specific level.

Trivia acuminata is restricted to the Mediterranean and NE Atlantic. This is the first record from the Lower Pliocene; previously, the earliest record was Middle Pliocene of Valle Botto (Pavia & Demagistris, 1970, p. 131, pl. 1, fig. 1).

Trivia sphaericulata (Lamarck, 1810)

Figure 1/4a-c

- *1810 *Cypraea sphaericulata* Lamarck, p. 107.
- 1894 *Trivia sphaericulata* Lk. — Sacco, p. 47, pl. 3, fig. 29.
- 1894 *Trivia sphaericulata* var. *parvosphaera* Sacco, p. 48, pl. 3, fig. 30.
- 1894 *Trivia sphaericulata* var. *retusoides* Sacco, p. 48, pl. 3, fig. 31.
- 1894 *Trivia sphaericulata* var. *obsoleta* (Bon.) — Sacco, p. 48, pl. 3, fig. 32a, b.
- 1894 *Trivia sphaericulata* var. *pseudavellana* Sacco, p. 49, pl. 3, fig. 34.
- 1894 *Trivia sphaericulata* var. *propeavellana* Sacco, p. 49, pl. 3, fig. 35.
- 1932b *Trivia sphaericulata sphaericulata* (Lam.) — Schilder, p. 107.
- 1932b *Trivia testudinella pseudavellana* Sacco — Schilder, p. 104.
- 1941 *Trivia (Trivia) sphaericulata* Lamarck '10 — Schilder, p. 73.
- 1971 *Trivia (Trivia) sphaericulata sphaericulata* Lamarck, 1810 — Schilder & Schilder, p. 17.
- 1971 *Trivia (Sulcotrivia) testudinella pseudavellana* Sacco, 1894 — Schilder & Schilder, p. 17.
- 1984 *Trivia sphaericulata* (Lamarck, 1810) — Ferrero Mortara *et al.*, p. 153.

Distribution — Pliocene of the western Mediterranean.

Material studied — From the Velerín Conglomerates, 32

specimens (BLP Colln), 1 specimen (DFB Colln); from Velerin Carretera, 1 specimen (BLP Colln); from Rio Torsero (Italy), Lower Piacenzian, 7 specimens (DFB Colln); from Bacedasco (Italy), Lower Pliocene, 1 specimen (BLP Colln).

Measurements — Maximum length and width up to 15.4 mm and 12.9 mm, respectively, but on average 14.6 mm and 12.4 mm, respectively; L/W ratio 1.18.

Description — Shell large, solid, and spherical. Spire obscured by callus. Body whorl globose and rounded, about 95% of total height, with the terminals weakly produced and rounded. Dorsum evenly rounded, without a true dorsal sulcus, although a few specimens show a weak dorsal depression, which does not interrupt the ribs. Dorsum completely covered by 22-36 ribs, which vary in thickness and become more close set mid-dorsally. Base and terminals are evenly convex. Aperture wide and curved, especially in the adapically portion. Outer lip very broad, widest in mid-portion, becoming narrower towards the terminals. In some specimens the lip is elevated adapically. The lip is roundly keeled in cross section, with the narrower inner portion, sloping steeply inwards and the wider outer portion, less so, outwards. Outer margin of the lip slightly to strongly, angularly callused. The lip bears 19-25 strong, equal teeth. Siphonal and anal canals follow the shell profile. Columella convex, tapering steeply inwards, bordered internally by a weak carinal ridge, bearing 16-20 ribs, which continue onto the carinal ridge, where they do not become significantly stronger. The carinal ridge is strongly protruding in the fossular region. Fossula broadly concave and not clearly delimited from the rest of the columella.

Range of variation — The characteristic features of this taxon are the large size, globular shape, weakly developed terminals, the curved aperture and the strongly protruding carinal ridge at the fossular region. All the other characters are remarkably variable. The number and strength of the ribs and teeth, the outline in the typical form, which is rounded, is modified in some of the specimens with an elevated adapical part to the outer lip.

Discussion — This large and beautiful shell is easily distinguished from congeners by its large size and spherical shape. It is one of the larger members of the genus, with specimens from Estepona being even larger than those found in Italy. Sacco (1894, pp. 48, 49) indicated in his various 'varieties' the wide range of variation of this species. Schilder (1932b, p. 104) and Schilder & Schilder (1971, p. 17) referred Sacco's variety *pseudavellana* as a subspecies to *Niveria testudinella* (Wood, 1842), noting a depression on the sulcus. Both at Rio Torsero (Italy) and Estepona all of Sacco's varieties and intermediates between those described, are present. We note that the 'sulcus' seen by Schilder is not a real furrow, interrupting or depressing

the ribs, but a weak depression in the dorsum as described by Sacco. Our opinion is that Schilder based his decision on Sacco's figures, misinterpreting the strength of the so-called 'sulcus' mentioned and figured. There are no other features that distinguish the forms separated by Schilder from the nominal type. We agree with Sacco in considering all illustrated material of *Trivia sphaericulata*, with the exception of *T. sphaericulata* var. *parvavellana* and *T. s.* var. *perobsoleta*, as a single species, without specifying varieties.

Schilder & Schilder (1971, p. 17) mentioned yet another subspecies of *T. sphaericulata*, *T. s. crassa* Cocconi, 1873 from the Italian 'Tortonian'. Unfortunately, we could not obtain a copy of Cocconi's description and there is no material of this taxon in F.A. Schilder's Collection.

Trivia perobsoleta Sacco, 1894

Figures 1/5a, b; 5/3a-d

*1894 *Trivia sphaericulata* var. *perobsoleta* Sacco, p. 49, pl. 3, fig. 33.

1932b *Trivia perobsoleta* Sacco — Schilder, p. 107.

1971 *Trivia (Trivia) perobsoleta* Sacco 1894 — Schilder & Schilder, p. 17.

Type — Holotype is BS.043.12.007.

Distribution — Pliocene of the western Mediterranean.

Material studied — In addition to the holotype, ten specimens from the Velerin Conglomerates (BLP Colln).

Measurements — Maximum length and width up to 16.3 mm and 14.2 mm, respectively, but on average 14.0 mm and 12.1 mm, respectively; L/W ratio 1.16.

Description — Shell large, solid, and spherical. Spire covered by callus. Body whorl globosely inflated and rounded, about 95% of total height, with the terminals not produced and rounded. Dorsum strongly elevated and evenly rounded, without a dorsal sulcus. Dorsum bearing subobsolete ribs in 70% of specimens, 30% smooth and glossy with no ribs. Base and outer lip are evenly convex. Aperture wide and somewhat curved, especially in the adapically portion. Outer lip very broad in mid-portion, narrows abruptly towards the terminals. The lip is rounded in cross section, but anteriorly concave and sloping steeply inwards. Outer margin of the lip slightly angularly callused. The lip bears 18-24 fine denticles, which are only barely continued as ribs on the outer lip. Siphonal and anal canals follow the shell profile. The anal canal is indistinct. Columella nearly straight, tapering steeply inwards, without an inner carinal ridge, bearing 14-18 weak denticles, which are distinctly continued as fine ribs onto the columella but obscurely so onto the base. The inner fossular margin

slightly protrudes. Fossula shallow and clearly delimited from the rest of the columella.

Range of variation — The characteristic features of this species are the large size, very globular shape, very weakly developed terminals, the curved aperture and, most importantly, the character of the ribs, always obsolete on the sides of the shell and subobsolete to lacking on the dorsum. These ribs can be variable in strength, sometimes barely visible, whilst in other specimens they are reasonably strongly developed on the dorsum, but invariably absent on the sides even in well-preserved, non-eroded material.

Discussion — In discussing this species, it is important to distinguish it from juvenile specimens of *T. sphaericulata* (see above); the latter are also devoid of ribbing, but show the feature of an immature triviid, namely a lightweight shell, a spire not covered by callus, a non-callused outer lip and poorly developed dentition. Adult shells of *T. perobsoleta* are thick shelled, with the spire covered by callus, and have a thickened outer lip and well-developed dentition. The other features are similar to those of *T. sphaericulata*. Apart from the obsolete dorsal ribs, *T. perobsoleta* is somewhat more globular, the posterior end of the parietal lip is obsolete, the outer callused margin of the labial lip is less shouldered, the base is more convexly inflated and the columella and the fossula are less developed, without an inner adaxial carinal ridge. In view of these constant differences, we keep these two forms distinct.

Some of the specimens from Estepona have a completely smooth dorsum, but ribs present on the ventral side, similar to the Recent South African genus *Triviella* Jousseaume, 1884 and the Oligocene *Trivia francisca* Schilder, 1925 and *Trivia calva* Schilder, 1928 from Germany. A similar species occurs in the Atlantic Upper Miocene (Lower 'Redonian') of Sceaux (NW France), which will be discussed in a forthcoming paper.

Schilder (1932b, p. 107) and Schilder & Schilder (1971, p. 17) considered *T. perobsoleta* to be synonymous with *Niveria permixta*, but did not discuss their point of view. The latter, present also in Estepona, is quite different (see below).

Trivia frigida Schilder, 1932b

Figures 2/1a-c, 2a, b; 4/2a-c

1836 *Cypraea coccinella* Lam. — Philippi, p. 237 (*non* Lamarck)

1844 *Cypraea coccinella* Lam. — Philippi, p. 200.

1913 *Trivia frigida* (Monterosato, MS) — Gignoux, p. 532 (*nomen nudum*).

*1932b *Trivia mediterranea frigida* Schilder, p. 109.

1933b *Trivia frigida* Schil. — Schilder, p. 14.

1941 *Trivia (Trivia) frigida* Schilder '32 — Schilder, p. 73.

1971 *Trivia (Trivia) multilirata frigida* (Gignoux 1913)

Schilder 1932 — Schilder & Schilder, p. 17.

Types — Holotype is CS 221; paratype is CS 5168.

Distribution — Pliocene of the western Mediterranean, Altavilla Milicia (Sicily), 'Monte Pellegrino, Ficarazzi, Sciacca Gravina'; Lower Pleistocene (Schilder, 1932b).

Material studied — From the Velerin Conglomerates, 9 specimens (BLP Colln), 2 specimens (DFB Colln); from the Velerin Sands, 10 specimens (BLP Colln); from Cutrofiano (Lecce, Italy); Calabriano Formation (Lower Pleistocene), 13 specimens (DFB Colln).

Measurements — Maximum length and width up to 6.3 mm and 5.1 mm, respectively, but on average 5.6 mm and 4.6 mm, respectively; L/W ratio 1.22.

Description — Shell small, relatively fragile, inflated and oval. Spire covered by callus, faintly visible beneath 3-4 vertical riblets extending upwards from the posterior terminal. Body whorl globose and rounded, about 90% of total height, with the terminals slightly produced, the anterior straight, posterior rounded. Dorsum evenly rounded, completely covered by 26-30 fine ribs. Base rounded, with the posterior terminal strongly recurved. The aperture is fairly wide, curved apically, further widened in the fossular region. Outer lip relatively broad, convex, regularly rounded, widest in mid-portion, becoming narrower towards the terminals. Outer margin of the lip slightly angularly callused, becoming subobsolete in mid-portion. The lip bears 18-20 fine, equal teeth. Siphonal and anal canals slightly indented. Columella convex, tapering steeply inwards, bordered internally by a weak carinal ridge, bearing 16-17 ribs, which continue onto the carinal ridge, where they do not become significantly stronger. Fossula broadly concave, not clearly delimited from the rest of the columella and slightly protruding.

Range of variation — The characteristic features of this species are the small size, inflated shell, large number of fine ribs, in relation to the small size and the weakly produced terminals. The other shell features are relatively constant.

Discussion — Philippi (1836, p. 237) misidentified his material as *Cypraea coccinella* Lamarck, 1810. Schilder (1932b, p. 109) renamed Philippi's taxon, but failed to provide notes or illustrations. Therefore, it is questionable if Schilder actually saw Philippi's originals, since he designated two specimens in Philippi's Collection as types. The holotype is here illustrated for the first time (Figure 4/2a-c).

Ours is the first record of the species from the Lower Pliocene. *Trivia frigida* differs from *T. acuminata* (see above) in being less elongated, more inflated, with a larger number of ribs in relation to size, which are finer and more

close set. *Trivia coccinelloides* and *T. candidula* both have a dorsal hump, stronger and fewer ribs and a broader outer lip.

Yet another species of *Trivia* occurs in the Italian Pliocene, *T. subdilata* Schilder, 1941, the type (CS 5063) of which was not figured in the original paper. Here (Figure 6/6), we figure the type for the first time. *Trivia subdilata* has a very squat shell with a narrow, curved aperture, and the columella, fossula and labral lip are very wide. The base and labral lip are concave centrally where they slope

into the aperture. All marginal portions of the base and lip are elevated. The ribs are coarse, of equal strength and relatively widely spaced. None of the species discussed in the present paper are squat, and with such a depressed central base. *Trivia candidula* is similar, but lacks the above-mentioned features. *Trivia subdilata* is easily distinguished from *T. candidula* by the different shape of the aperture, the wider columella and fossula, the wider apertural lip and somewhat finer ribs, which are closer set on the dorsum.

Key to the identification of the genus Trivia from Estepona, Spain

- | | |
|-------------------------------------------------------------------|--------------------------|
| 1. Adult shell <10 mm | 2 |
| Adult shell >10 mm | 5 |
| 2. Adult shell with callused outer lip | 3 |
| Adult shell with non-callused or weakly callused lip margin | 4 |
| 3. Shell with centrally placed aperture and covered carinal ridge | <i>T. candidula</i> |
| Shell more elongated, thinner outer lip | <i>T. acuminata</i> |
| 4. Shell with dorsal hump, strong ribs and no lip margin | <i>T. coccinelloides</i> |
| Shell evenly rounded, numerous fine ribs, lip margin weak | <i>T. frigida</i> |
| 5. Ribs fully developed | <i>T. sphaericulata</i> |
| Ribs dorsally obsolete or absent | <i>T. peroboleta</i> |

Genus *Niveria* Jousseume, 1884b (= *Sulcotrivia* Schilder, 1933b)

Type species — *Cypraea nivea* Gray, 1824 (= *Trivia nix* Schilder, 1923), by original designation.

Discussion — Schilder (1933b, p. 18) erected the genus *Sulcotrivia*, with *Cypraea dimidiata* Bronn, 1831 as type, although *Sulcotrivia* shares important features in shell morphology with *Niveria* (see Schilder, 1939, pp. 173-174). In addition, both type species are closely similar. There are not enough differences to separate the members of both genera even on a subgeneric level, which is why Fehse (in press) favours synonymising *Sulcotrivia* with *Niveria*, a view subscribed to here.

Species of *Niveria* are not dorsally humped, but regularly rounded and have a clear dorsal furrow, not seen in *Trivia*. The dorsal sulcus is a distinct groove, which either depresses, interrupts or bisects the ribs and which is not just a weak depression or dimple in the centre of the dorsum, as seen in some specimens of *T. sphaericulata* (see above).

Niveria dimidiata (Bronn, 1831)

Figure 2/3a-c

*1831 *Cypraea dimidiata* Bronn, p. 16.

1894 *Trivia dimidiata* (Bronn) — Sacco, p. 53, pl. 3, fig.

46.

1894 *Trivia dimidiata* var. *laevisulcata* Sacco, p. 53, pl. 3, fig. 48.

1911 *Cypraea europaea* var. *pediculoides* Cerulli-Irelli (partim), p. 273, pl. 26, figs 19-21.

1925 *Trivia (Trivirostra) dimidiata* (Bronn, 1831) — Schilder, p. 63.

1932† *Trivia dimidiata* (Bronn, 1831) — Schilder, p. 105.

1970 *Trivia (Sulcotrivia) dimidiata* (Bronn, 1831) — Pavia & Demagistris, p. 132, pl. 1, fig. 9.

1971 *Trivia (Sulcotrivia) dimidiata dimidiata* (Bronn, 1831) — Schilder & Schilder, p. 18.

1984 *Trivia dimidiata* (Bronn, 1831) — Ferrero Mortara *et al.*, p. 155, pl. 27, fig. 6a-c.

1992 *Trivia dimidiata* (Bronn, 1831) — Cavallo & Repetto, p. 66, fig. 118.

1998 *Trivia subaffinis* Bugnone, 1880 — Smriglio *et al.*, p. 161, text-figs 35-38.

Distribution — Pliocene of the western Mediterranean (Sacco, 1894).

Material studied — From the Velerin Conglomerates, 25 specimens (BLP Colln), 6 specimens (DFB Colln); from the Arenas de Huelva Formation of Lucena (Lower Pliocene), 1 specimen (BLP Colln); from San Gimignano (Italy), Lower Piacenzian, 9 specimens (BLP Colln); from Valle Botto and Baldichieri (Italy), Upper Piacenzian, 1 and 5 specimens, respectively (DFB Colln).

Measurements — Maximum length and width up to 8.6

mm and 5.9 mm, respectively, but on average 7.4 mm and 5.1 mm, respectively; L/W ratio 1.44.

Description — Shell medium sized, relatively solid and elongated oval. Spire covered by callus. Body whorl elongated-globose and rounded, almost 100% of total height. The terminals are weakly produced, especially the posterior terminal and rounded. Dorsum rounded, completely covered by 26-36 strong ribs. A dorsal sulcus, of variable strength, extends longitudinally across the centre of the dorsum, in the majority of specimens bisecting most of the ribs, the latter becoming thickened adjacent to the furrow. Base slightly convex, with the terminals recurved. The aperture is relatively narrow in the posterior portion and curved adapically, wider in the anterior part. Outer lip somewhat broadened, convex, widest in mid-portion, becoming narrower towards the terminals and regularly rounded. Outer margin weakly angularly callused. The lip bears 19-24 strong, equal teeth. Siphonal and anal canals are slightly protruding. Columella convex, tapering steeply inwards, bordered internally by a weak carinal ridge. Columella bearing 18-21 ribs, which continue onto the carinal ridge. Fossula broadly concave and delimited from the rest of the columella.

Range of variation — The characteristic features of this species are the elongated shape, the low profile and the dorsal sulcus, which bisects most of the ribs. The number of ribs and width are somewhat variable. The strength of the sulcus is also variable, but always present extending the whole length of the dorsum. The outer lip is not very broad in comparison with other congeners and usually only weakly callused. A number of specimens are smaller, slightly more globose and the dorsal sulcus depresses rather than bisects most of the ribs. The other shell characteristics are similar to those of the typical form.

Discussion — The present taxon, type of the genus *Sulcotrivia*, clearly shows what we understand to be a true dorsal sulcus. In this species almost all the ribs are interrupted and the bisected ends thickened. Schilder & Schilder (1971, p. 18) mentioned *Niveria selmae* (O. Boettger, 1901) as a Miocene subspecies of *N. dimidiata*. However, *N. selmae* (Figure 6/8a-c) is distinguished from *N. dimidiata* by the more inflated shell with finer, fewer ribs, by the better developed columella and fossula, and the ribs are not bisected by the dorsal sulcus and are considerably thickened along the furrow, which is why we consider these taxa to be distinct.

Niveria dimidiatoaffinis (Sacco, 1894), common in the Atlantic Middle Miocene ('Pontilevian' of the Loire Basin, France), is similar to *N. dimidiata*; this species will be discussed in a forthcoming paper.

Niveria permixta (de Cristofori & Jan, 1832)
Figure 2/4a-c

- *1832 *Cypraea permixta* de Cristofori & Jan, p. 15.
- 1932b *Trivia permixta* Crist. & Jan, 1832 — Schilder, p. 105.
- 1941 *Trivia (Sulcotrivia) permixta* Cristofori-Jan — Schilder, p. 74.
- 1970 *Trivia (Sulcotrivia) dorsolaevigata* Sacco, 1894 — Pavia & Demagistris, p. 133, pl. 1, fig. 4.
- 1971 *Trivia (Sulcotrivia) permixta permixta* Cristofori-Jan, 1832 — Schilder & Schilder, p. 18.
- 1978 *Cypraea permixta* De Cristofori & Jan, 1832 — Pinna & Spezia, p. 139, pl. 21, fig. 1, 1a.
- 1992 *Trivia dorsolaevigata* Cocconi, 1873 — Cavallo & Repetto, p. 66, fig. 119.

Type — Lectotype, designated by Pinna & Spezia (1978, p. 139, pl. 21, fig. 1, 1a), is MCSNM i.4314.

Distribution — Pliocene of the western Mediterranean.

Material studied — From the Velerin Conglomerates, >50 specimens (BLP Colln), 10 specimens (DFB Colln); from the Velerin Sands, 3 specimens (BLP Colln); from Certaldo (Italy), Piacenzian, 1 specimen (DFB Colln).

Measurements — Maximum length and width up to 14.7 mm and 11.2 mm, respectively, but on average 12.6 mm and 9.9 mm, respectively; L/W ratio 1.26.

Description — Shell large, solid, somewhat elongated to very inflated, oval. Spire covered by callus, but faintly visible beneath 3-5 vertical riblets extending upwards from the posterior terminal. Body whorl varies from somewhat elongated and globose to greatly inflated, about 90% of total height. The terminals are rounded, the anterior strongly produced, the posterior weakly so. Dorsum rounded to strongly humped in the posterior third, covered by 30-34 ribs. On mid-portion of the shell, the ribs become much wider towards the summit, where in most specimens they are obsolete, to a variable degree. The summit has a polished appearance due to callus deposited over the ribs, rather than abrasion. A dorsal sulcus, of variable strength and width, extends longitudinally across the centre of the dorsum, bisecting some of the ribs, depressing others. Base convex, with the terminals recurved. The aperture is relatively narrow in the posterior portion and curved adapically, wider in the anterior part. Outer lip broadened, convex, widest in mid-portion, becoming narrower towards the terminals and regularly rounded, bearing 20-25 strong, equal teeth. Outer lip, with a strong angular margin. Siphonal and anal canals are slightly protruding. Columella convex, tapering steeply inwards, bordered internally by a strong carinal ridge. Columella bearing 18-23 ribs, which run onto the carinal ridge, where they become thickened. The carinal ridge is strongly protruding in the fossular region. Fossula deeply concave and clearly delimited from the rest of the columella. In most specimens a colour pattern is preserved; dorsal part brown, base and outer lip white.

Range of variation — This species is characterised by the callus on the summit of the dorsum and the only slightly produced posterior terminal. Other features are very variable, as the name would suggest.

Discussion — Despite the dorsal hump, seen in many of the specimens, the presence of a strong dorsal sulcus depressing or bisecting all the ribs favours assignment of this species to the genus *Niveria* rather than to *Trivia*. The curious deposition of thick callus onto the summit of the dorsum seen in *N. permixta* is not unique; *N. floridana* (Olsson & Harbison, 1952), from the Pinecrest Beds (Pliocene, Florida), and *N. dorsolaevigata* (see below) show the same feature.

Niveria dorsolaevigata (Cocconi, 1873)

Figures 2/6a-c; 5/1a-c

- *1873 *Trivia affinis* Duj. var. *dorsolaevigata* Cocconi, p. 162.
- 1894 *Trivia dorsolaevigata* (Cocc.) — Sacco, p. 52, pl. 3, fig. 44.
- 1894 *Trivia dorsolaevigata* var. *sulconitens* Sacco, p. 52, pl. 3, fig. 45.
- 1932b *Trivia dorsolaevigata* Cocconi, 1873 — Schilder, p. 105.
- 1941 *Trivia (Sulcotrivia) dorsolaevigata* Sacco '94 — Schilder, p. 74.
- 1970 *Trivia (Sulcotrivia) dorsolaevigata* Sacco, 1894 — Pavia & Demagistris, p. 133, pl. 1, fig. 4.
- 1984 *Trivia dorsolaevigata* Cocconi, 1873 — Ferrero Mortara *et al.*, p. 155.

Distribution — Pliocene of the western Mediterranean.

Material studied — From the Velerín Conglomerates, 16 specimens (BLP Colln); Colli Astesi (Italy), Upper Piacenzian, 1 specimen (BS.043.12.017).

Measurements — Maximum length and width up to 17.4 mm and 13.1 mm, respectively, but on average 14.6 mm and 11.1 mm, respectively; L/W ratio 1.31.

Description — Shell large, relatively solid, inflated and oval. Spire covered by callus, faintly visible beneath 4-6 vertical riblets extending upwards from the posterior terminal. Body whorl globose and inflated, about 90-95% of total height. The terminals are rounded, the anterior strongly produced, the posterior weakly so. Dorsum rounded, bearing 30-36 fine ribs. A narrow dorsal sulcus extends longitudinally across the centre of the dorsum, depressing most of the ribs, bisecting a few in the anterior portion. Base convex, with the terminals strongly recurved. The aperture is relatively narrow below the posterior terminal, becoming progressively wider abapically. Outer lip broadened, convex, widest in mid-portion, becoming narrower towards the terminals and regularly rounded,

bearing 21-23 strong, equal teeth. Outer lip, with a strong angular margin. Siphonal and anal canals follow the shell profile. Columella convex, tapering steeply inwards, bordered internally by a carinal ridge. Columella bears 17-21 ribs, which run onto the carinal ridge, which is strongly protruding in the fossular region. Fossula deeply concave and delimited from the rest of the columella. A colour pattern is preserved on one of the specimens, consisting of two irregularly formed brown spots, one at either extremity of the dorsal sulcus.

Range of variation — This species is characterised by the large size, the fine ribs and the narrow dorsal sulcus. There is no significant variation in the specimens found.

Discussion — This species most closely resembles *N. permixta* (see above), but differs in being larger, with finer ribs (although number of ribs is similar), which do not become thicker towards the summit. The dorsal sulcus is narrower, and only occasionally are there (see Figure 5/1a-c) a light callus on the summit and the fossula more developed. Lastly, the coloration is different, uniformly brown with a white base and lip in *N. permixta*, white with two spots on the dorsum in *N. dorsolaevigata*. From *N. avellanula* (see below), the present species differs in being larger, more globose with much finer and more numerous ribs, with the dorsal sulcus much narrower, the columella tapering much more steeply inwards and the fossula being more concave and more protruding.

Niveria avellanula (Sacco, 1894)

Figures 2/5a-c; 6/1a-d

- *1894 *Trivia avellanula* Sacco, p. 51, pl. 3, fig. 43.
- 1932b *Trivia avellanula* Sacco, 1894 — Schilder, p. 104.
- 1941 *Trivia (Sulcotrivia) avellanula* Sacco '94 — Schilder, p. 74.
- 1971 *Trivia (Sulcotrivia) excoccinella avellanula* Sacco, 1894 — Schilder & Schilder, p. 17.
- 1984 *Trivia avellana* var. *avellanula* Sacco, 1894 — Ferrero Mortara *et al.*, p. 155, pl. 27, fig. 1a-c.

Type — Lectotype, designated by Ferrero Mortara *et al.* (1984), is BS.043.12.015.

Distribution — Middle Miocene of Italy and Pliocene of the western Mediterranean.

Material studied — From the Velerín Conglomerates, 3 specimens (BLP Colln); from the Arenas de Huelva Formation (Lucena), Lower Pliocene, 1 specimen (BLP Colln); from Montegibbio, Upper Miocene ('Tortonian'), 1 specimen (BLP Colln); from San Gimignano (Italy), Lower Piacenzian, 1 specimen (DFB Colln).

Measurements — Maximum length and width up to 14.2

mm and 11.2 mm, respectively, but on average 13.2 mm and 10.2 mm, respectively; L/W ratio 1.30.

Description — Shell large, solid, somewhat elongated and inflated, oval. Spire covered by callus, barely visible beneath 2-3 vertical riblets, extending upwards from the posterior terminal. Body whorl elongated globose, about 90% of total height. The terminals are rounded, the anterior produced, the posterior weakly so. Dorsum rounded, slightly elevated in mid-portion, covered by 20-22 strong ribs. A fairly wide dorsal sulcus, of variable strength, extends longitudinally across the centre of the dorsum. The ribs become thickened at the edge of the sulcus, narrowing as they cross the depression. Base very weakly and regularly convex. The aperture is relatively wide. Outer lip broadened, convex, widest in mid-portion, becoming narrower towards the terminals and regularly rounded, bearing 16-20 strong, equal teeth. Outer lip, with a strong angular margin. Siphonal and anal canals are slightly protruding. Columella concave, tapering inwards, bordered internally by a weak carinal ridge. Columella bears 16-17 ribs, which run onto the carinal ridge, where they become thickened. The carinal ridge is slightly protruding in the fossular region. Fossula concave and not clearly delimited from the rest of the columella.

Range of variation — The characteristic features of this species are the strong ribs and the character of the sulcus. Of the two adult specimens available, one is slightly more inflated. The more depressed specimen is almost identical to the shell illustrated by Ferrero Mortara *et al.* (1984, pl. 27, fig. 1a-c).

Discussion — Schilder & Schilder (1971, p. 17) referred this as a subspecies to *Trivia (Sulcotrivia) excocinella* from the Atlantic Middle Miocene ('Pontilevian' of the Loire Basin, France), but this is more inflated, the dorsal profile being more rounded, or elevated in the posterior portion, whereas *N. avellanula* is more depressed, or elevated in mid-portion. The former has more numerous, finer ribs. The subspecific status given by Schilder & Schilder (1971) would suggest a phylogenetic lineage, which we feel is unclear.

The present species is distinguished from *N. permixta* (see above) by the better developed dorsal sulcus, wider aperture, the less developed fossula, the less steeply inwardly slanting columella and, above all, the absence of callus on the dorsum. *Niveria dimidiata* (see above) is much smaller, more elongated, with a much narrower dorsal sulcus that bisects most of the ribs.

Niveria parvavellana (Sacco, 1894)

Figures 3/1a-c, 2a, b; 6/4a-d

*1894 *Trivia sphaericulata* var. *parvavellana* Sacco, p. 49, pl. 3, fig. 36.

1894 *Trivia dimidiata* var. *eratopsoides* Sacco, p. 53, pl. 3, fig. 47.

1932b *Trivia parvavellana* Sacco 1894 — Schilder, p. 104.

1941 *Trivia (Sulcotrivia) parvavellana* Sacco '94 — Schilder, p. 74.

1971 *Trivia (Sulcotrivia) dimidiata parvavellana* Sacco, 1894 — Schilder & Schilder, p. 18.

1984 *Trivia sphaericulata* var. *parvavellana* Sacco, 1894 — Ferrero Mortara *et al.*, p. 154.

Type — Lectotype, designated by Ferrero Mortara *et al.* (1984), is BS.68.043.12.010.

Distribution — Upper Miocene (Lower 'Redonian') of the NE Atlantic (DFB Colln) and Pliocene of the western Mediterranean.

Material studied — From the Velerin Conglomerates, 87 specimens (BLP Colln), 9 specimens (DFB Colln); from the Velerin Sands, 10 specimens (BLP Colln); from Brigné (Anjou), Upper Miocene ('Redonian'), 3 specimens (DFB Colln).

Measurements — Maximum length and width up to 8.4 mm and 6.3 mm, respectively, but on average 7.2 mm and 5.5 mm, respectively; L/W ratio 1.31.

Description — Shell small, solid, inflated and oval. Spire covered by callus, barely visible beneath 2 vertical riblets, extending upwards from the posterior terminal. Body whorl globose, about 95% of total height. The terminals are produced, the anterior flattened, the posterior rounded. Dorsum evenly rounded, covered by 16-20 strong, somewhat irregular ribs. A narrow dorsal sulcus, of variable strength, extends longitudinally across the centre of the dorsum. The ribs become thickened at the edge of the sulcus and either bisected or narrowed as they cross the depression. Base almost straight, with the anterior terminal hardly recurved and the posterior strongly so. The aperture is narrow, strongly curved apically and widened in the area of the fossula. Outer lip broadened, convex, widest in mid-portion, becoming narrower towards the terminals and regularly rounded, bearing 19-22 strong, equal teeth. Outer lip, with an angular margin. Siphonal and anal canals are slightly indented. Columella concave, tapering inwards, bordered internally by a weak carinal ridge. Columella bears 17-19 ribs, which run onto the carinal ridge, which is slightly protruding in the fossular region. Fossula concave and not clearly delimited from the rest of the columella. In most of the specimens a clear colour pattern is visible; it consists of a small brown spot on the anterior end of the dorsal sulcus, a patch surrounding the posterior end and mid-dorsally a larger patch on either side of the sulcus, which, in some specimens, are fused.

Range of variation — This species is characterised by its small size, inflated form, the irregular character of the ribs, the slightly indented canals and the colour pattern. The

strength of the sulcus and the character of the ribs as they cross are very variable; in some specimens clearly bisected, in others continuous and depressed, although in the latter case they are narrowed across the depression.

Discussion — Schilder & Schilder (1971, p. 18) considered this taxon to be a subspecies of *Trivia (S.) dimidiata*, assuming *T. (S.) d. parvavellana* to occur in the Middle Pliocene and *T. (S.) d. dimidiata* to be restricted to the Upper Pliocene, both in Italy. The two forms share similar

shell features and, when considering them to be stratigraphically isolated, we can understand Schilder & Schilder's conclusion. However, these types co-occur in Zanclean strata at Estepona, which makes their subspecific status impossible. *Niveria dimidiata* differs in being more elongated, less globose, and in having a lower dorsal profile. The ribs are more numerous (26-36 vs 16-20) and regular in character, whereas those of *N. parvavellana* are wavier and frequently interrupted on both dorsal sides.

Key to the identification of the genus Niveria from Estepona, Spain

1. Adult shell >10 mm	2
Adult shell <10 mm	4
2. Number of ribs more than 26	3
Ribs strong and fewer than 26, sulcus broad, ribs not bisected, but thickened on the edge of the sulcus, narrowed in the depression	<i>N. avellanula</i>
3. Shell globose, ribs fine and numerous, sulcus narrow	<i>N. dorsolaevigata</i>
Shell with humped dorsum and callus on the summit	<i>N. permixta</i>
4. Shell elongated, with more than 22 ribs, which are regular	<i>N. dimidiata</i>
Shell globose, with fewer than 22 ribs, which are irregular	<i>N. parvavellana</i>

Genus *Pusula* Jousseaume, 1884b

Ferrero Mortara *et al.*, p. 155.

Type species — *Cypraea radians* Lamarck, 1810, by original designation.

Discussion — Although some members of the genus display all typical features (see Cate, 1979), the position of the aperture and the depression of the base are variable. In our view, the only constant characters that clearly separate this group from other triviids are the dorsal sulcus, which in most cases is wide and smooth, with the ribs sharply bisected and forming tubercles, spinous in some species, as well as the fewer, coarser ribs.

***Pusula subpediculus* (d'Orbigny, 1852)**

Figures 3/6a-c, 7a, b; 5/2a-d

- 1847 *Cypraea pediculus* L. ? Sismonda, p. 47.
- *1852 *Cypraea subpediculus* d'Orbigny, p. 170.
- 1894 *Pusula pediculus* var. *subpediculus* (Orb.) — Sacco, p. 54, pl. 3, fig. 49.
- 1932b *Trivia subpediculus* Orbigny, 1852 — Schilder, p. 105.
- 1941 *Trivia (Sulcotrivia) subpediculus* Orbigny '52 — Schilder, p. 74.
- 1971 *Trivia (Sulcotrivia) permixta subpediculus* Orbigny, 1852 — Schilder & Schilder, p. 18.
- 1984 *Pusula pediculus* var. *subpediculus* Sacco, 1894 —

Distribution — Pliocene of the western Mediterranean.

Material studied — From the Velerín Conglomerates, 30 specimens (BLP Colln), 4 specimens (DFB Colln); from Colli Astesi (Italy), Upper Piacenzian, 1 specimen (BS.043.13.001).

Measurements — Maximum length and width up to 13.6 mm and 9.9 mm, respectively, but on average 12.0 mm and 8.6 mm, respectively; L/W ratio 1.39.

Description — Shell large, solid and elongated oval. Spire covered by callus. Body whorl elongated-globose and rounded, almost 95% of total height. Terminals rounded, anterior produced, posterior weakly so. Dorsum rounded, completely covered by 20-22 strong, irregular ribs, which are somewhat wavy and frequently interrupted on both dorsal sides. A strong, wide, smooth dorsal sulcus extends longitudinally across the centre of the dorsum, bisecting all of the ribs, the latter forming prominent tubercles adjacent to the furrow. Base almost straight, with the posterior terminal recurved. The aperture is wide, becoming even wider in the anterior portion. Outer lip somewhat broadened, convex, widest in mid-portion, becoming narrower towards the terminals and regularly rounded. Outer margin angularly callused. The lip bears 13-16 strong, equal teeth. Siphonal and anal canals follow the shell profile.

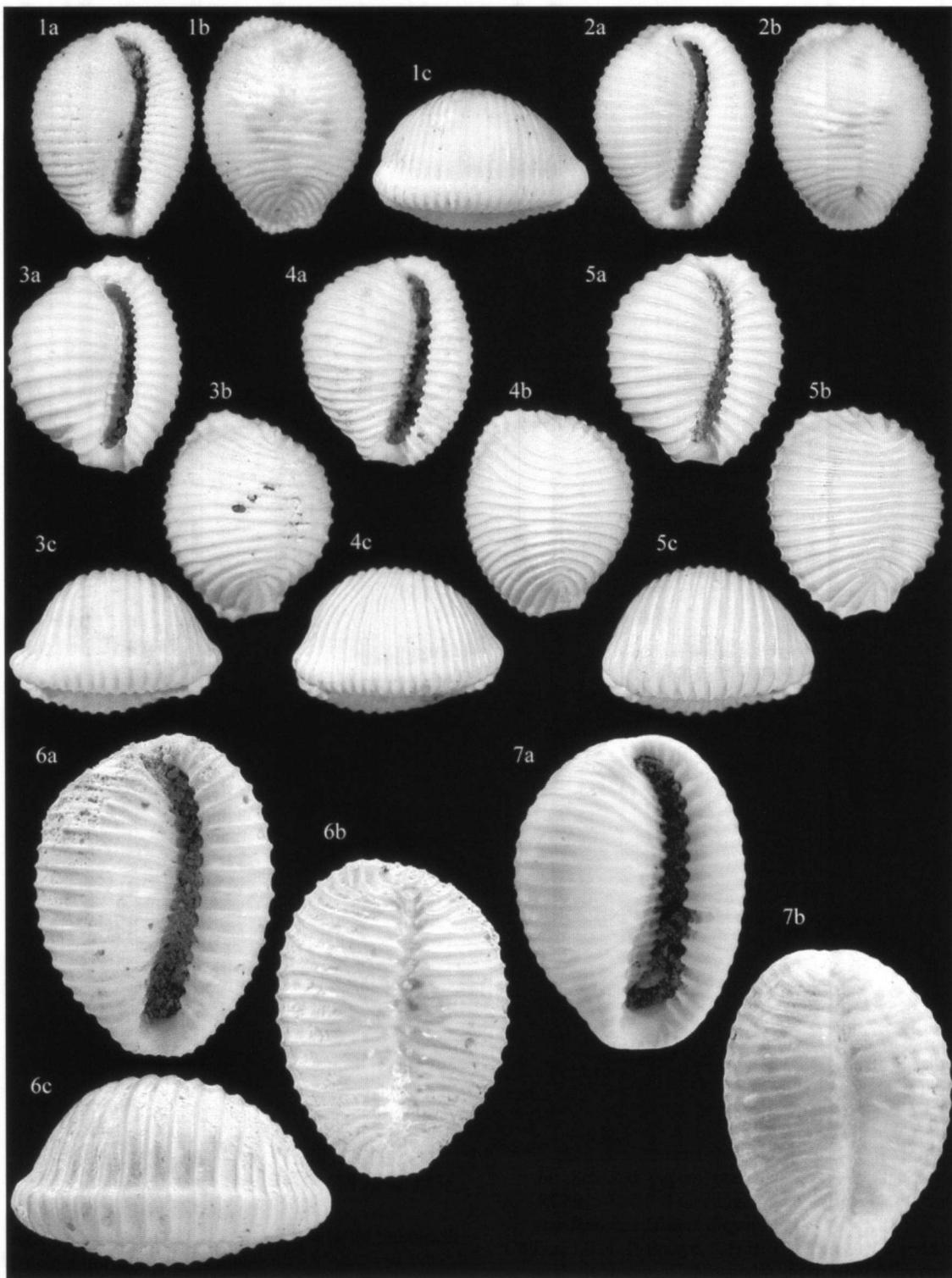


Figure 3. Triviid gastropods from the Zanclean of Estepona (Spain) (photos B. Landau):

1a-c, 2a, b *Niveria parvavellana* (Sacco, 1894), Velerín Conglomerates, original size = 6.9 mm and 7.2 mm, respectively (BLP Colln).
3a-c, 4a-c, 5a-c *Cleotrivia esteponica* n. sp., Velerín Conglomerates (3), Velerín Sands (4) and Velerín Carretera (5), original size = 5.4 mm, 5.5 mm and 5.2 mm, respectively (BLP Colln).
6a-c, 7a, b *Pusula subpediculus* (d'Orbigny, 1852), Velerín Conglomerates, original size = 14.2 mm and 12.5 mm, respectively (BLP Colln).

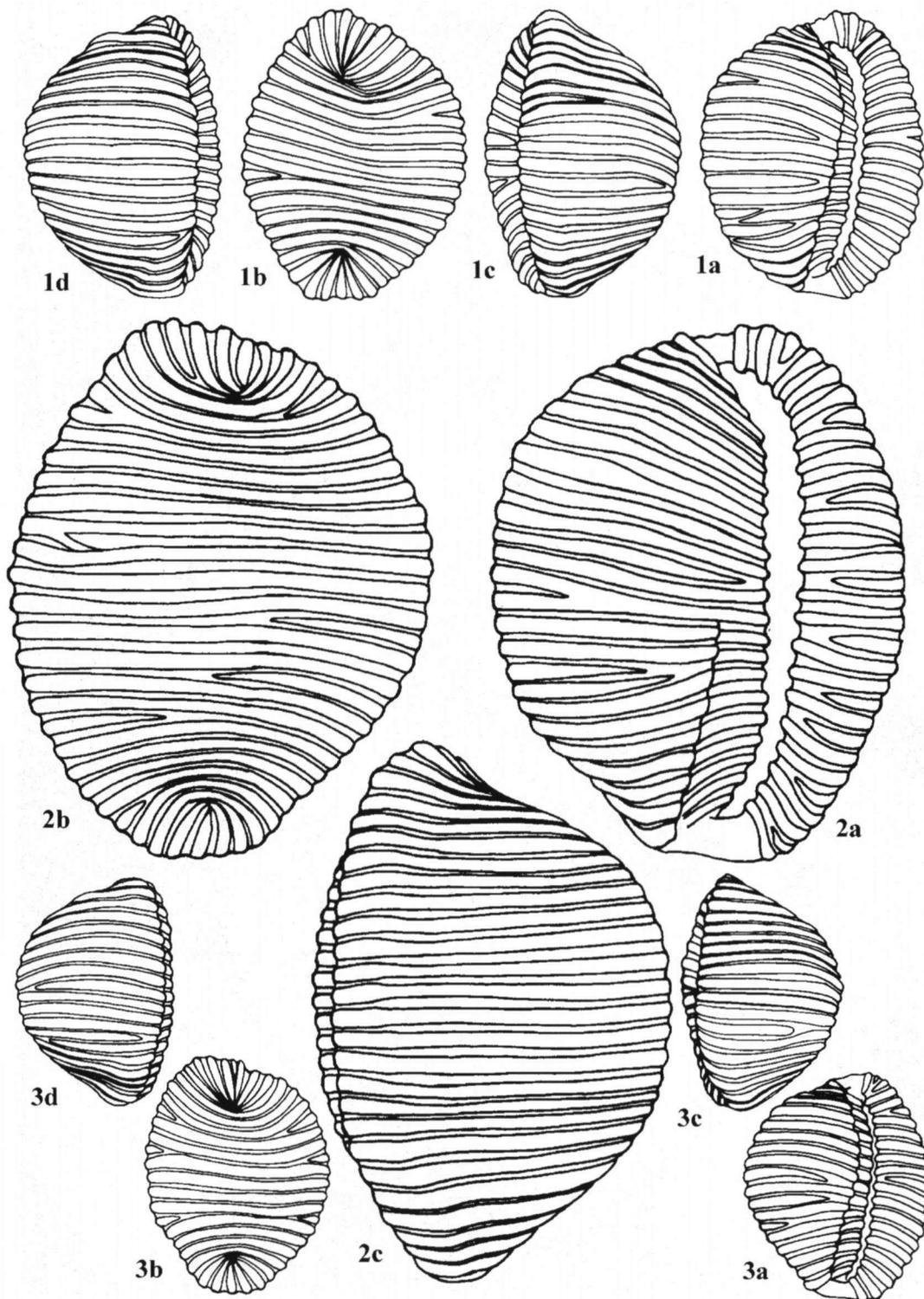


Figure 4. Triviid gastropods from the Zanclean of Estepona (Spain) (drawings D. Fehse):

1a-d, 3a-d *Cleotrivia esteponica* n. sp.; HNC 57306 (1, **holotype**) and HNC 57307 (3, **paratype**), respectively, Velerin Conglomerates, original size = 7.0 mm and 5.7 mm, respectively.

2a-c *Trivia frigida* Schilder, 1932b, CS 221 (**holotype**), Altavilla (Italy), Upper Piacenzian, original size = 12.0 mm.

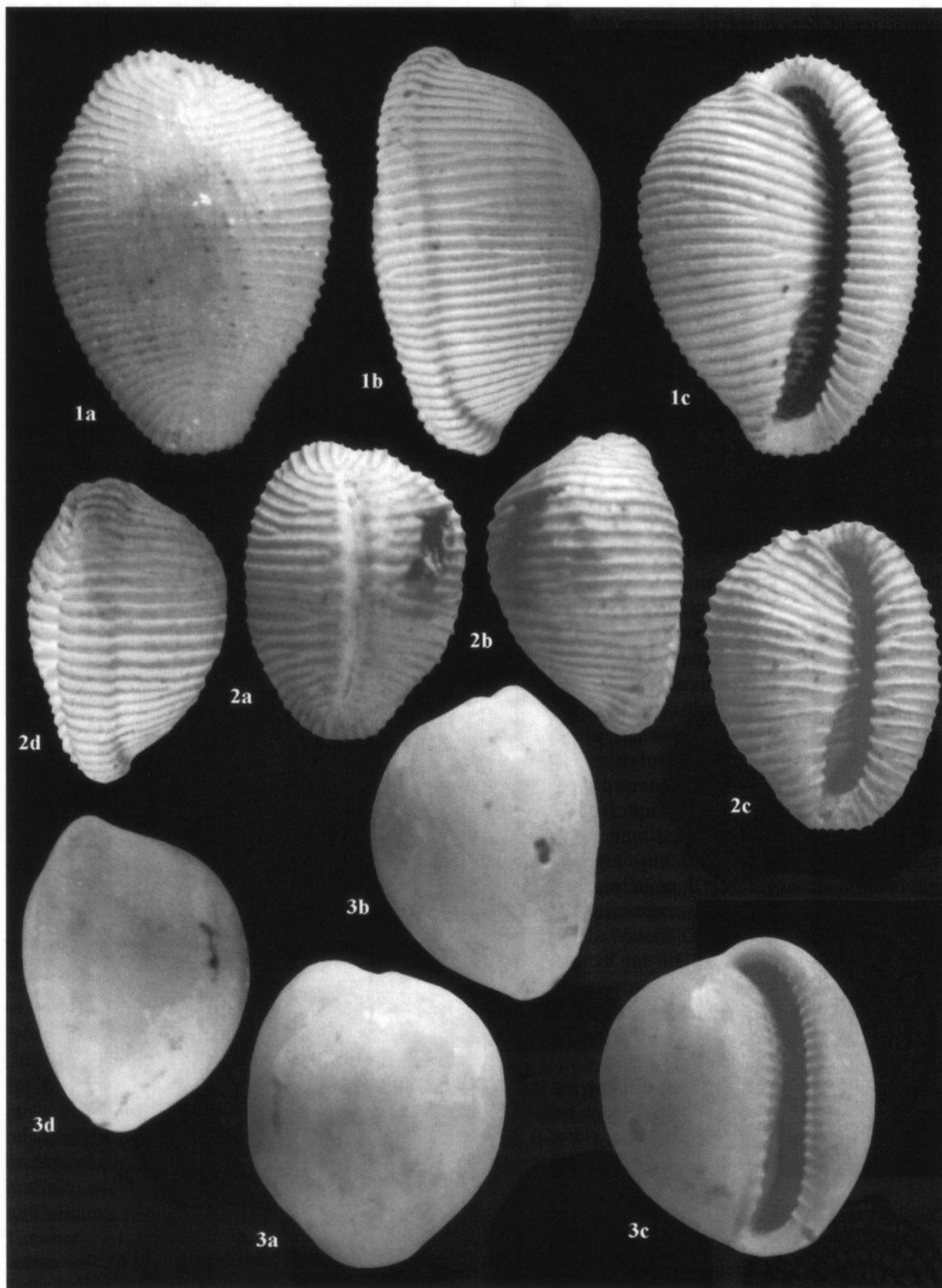


Figure 5. Triviid gastropods from the Piacenzian of Italy (photos D. Ormezzano):

- 1a-c *Niveria dorsolaevigata* (Cocconi, 1873), BS.043.12.017, Colli Astesi (Italy), Upper Piacenzian, original size = 18.8 mm.
2a-d *Pusula subpediculus* (d'Orbigny, 1852), BS.043.13.001, Colli Astesi (Italy), Upper Piacenzian, original size = 14.2 mm.
3a-d *Trivia perobsoleta* Sacco, 1984, BS.043.12.007 (**holotype**), Ventimiglia (Italy), Lower Piacenzian, original size = 14.7 mm.

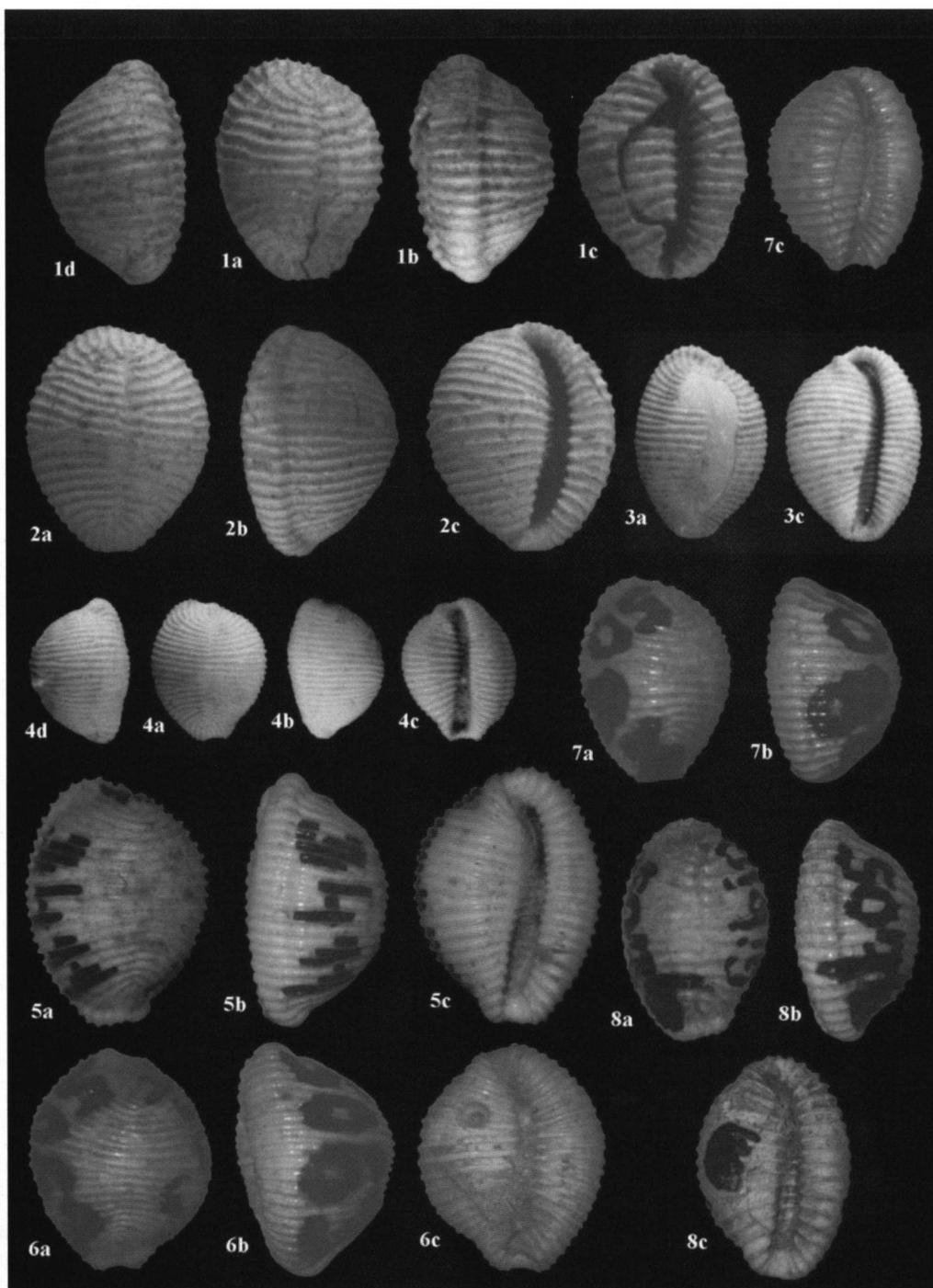


Figure 6. Triviid gastropods from the Miocene and Pliocene of Italy (photos D. Ormezzano [1-4] and D. Fehse [5-8]):

- 1a-d *Niveria avellanula* (Sacco, 1894), BS.043.12.015 (**lectotype**), Zinola (Italy), Lower Piacenzian, original size = 10.4 mm.
 2a-c *Niveria* cf. *avellana* (J. de C. Sowerby, 1823), BS.043.12.015/01, Zinola (Italy), Lower Piacenzian, original size = 10.4 mm.
 3a, c *Niveria* cf. *dimidiata* (Bronn, 1831), BS.043.12.017/01 (**paratype** of *N. dorsolaevigata*), Colli Astesi (Italy), Upper Piacenzian, original size = 9.0 mm (compare Smriglio *et al.*, 1998, text-figs 35-38).
 4a-d *Niveria parvavellana* (Sacco, 1894), BS.043.12.010 (**lectotype**), Rio Torsero (Italy), Lower Piacenzian, original size = 6.6 mm.
 5a-c *Trivia acuminata* Schilder, 1932a, CS 3411 (**holotype**), Empoli? (Toscane, Italy), Lower Piacenzian, original size = 7.5 mm.
 6a-c *Trivia subdilatata* Schilder, 1941, CS 5063 (**holotype**), Castell'Arquato (Italy), Lower Piacenzian, original size = 6.4 mm.
 7a-c *Trivia nana* Schilder, 1941, CS 5084 (**holotype**), Montegibbio (Modena, Italy), 'Tortonian' (Middle Miocene), original size = 6.0 mm.
 8a-c *Niveria selmae* (Boettger, 1901), CS 5076, Montegibbio (Modena, Italy), 'Tortonian' (Middle Miocene), original size = 4.9 mm.

Columella convex, tapering inwards, with the carinal ridge limited to the fossular region. Columella bearing 14-16 ribs. Fossula weakly concave and poorly delimited from the rest of the columella. A colour pattern is preserved on all specimens; it consists of a beige background on the dorsum and a white base and lip. Darker brown patches are superimposed on the beige background of the dorsum, at either side of the sulcus. The patches are arranged in three groups, at either extremity of the dorsal sulcus and mid-dorsally.

Range of variation — This species is characterised by the elongated shape, flattened base, wide aperture and the wide dorsal sulcus. There is little variation amongst the population from Estepona, with some of the shells slightly more inflated, less elongated than the norm.

Discussion — This species is quite different to *N. permixta* (see above), which again suggests that Schilder & Schilder (1971) did not see any of the Pliocene triviids in Sacco's Collection. It differs from that species in having a much stronger, smooth dorsal sulcus which completely bisects all the ribs. There is no dorsal callus in *P. subpediculus*, the aperture is much wider and the fossula less developed.

The present taxon more closely resembles the Pliocene-Recent *P. pediculus* (Linné, 1758), which has finer, more numerous and irregular ribs, wavier with a larger number of interruptions. The apertural lip is broader, aperture subcentral and the anal canal indented. Although Sacco (1894, p. 54) proposed *subpediculus* as an ancestor of *pediculus*, this is impossible, as both occur in the Lower Pliocene, *subpediculus* in the Mediterranean and *pediculus* in the Caribbean (BLP Colln). A possible ancestral species to both may be *P. parvicosta* (Bronn, 1862) from the Middle Miocene of the Canary Islands (Schilder, 1928, p. 275, text-figs 7, 8).

Genus *Cleotrivia* Iredale, 1930

Type species — *Cypraea pilula* Kiener, 1843, by original designation.

Discussion — The characteristic features of this genus are the small, globular or subglobular, bulbously inflated shell, the presence of a dorsal sulcus of variable strength, which hardly influences the dorsal ribbing and short blunt terminals. There are two distinct groups within the genus. The Recent Indo-Pacific taxa, in which the sulcus is deeply grooved, extending the whole length of the dorsum, and the Atlantic-Caribbean forms, in which the sulcus is most strongly developed mid-dorsally, but shorter, not extending all the way between the terminals. In the latter group the sulcus only slightly depresses the dorsal ribbing. Furthermore, the extant Atlantic-Caribbean species are less globose than their Indo-Pacific counterparts. In the European Neogene, the species have a combination of features, a globular shell like the Recent Indo-Pacific taxa, but only a weak dorsal sulcus as seen in the Caribbean species. It is

assumed that the two groups were separated for a long time and members of the genus emigrated to the Paratethys during the Late Oligocene or Early Miocene (Fehse, 1999, p. 8).

Cleotrivia esteponica n. sp.

Figures 3/3a-c, 4a-c, 5a-c; 4/1a-d, 3a-d

Types — Holotype is HNC 57306; paratype is HNC 57307.

Type locality and horizon — Velerín Conglomerates, Lower Pliocene (Zanclean), Estepona, Spain.

Derivation of name — Named after the city of Estepona.

Distribution — Known only from Velerín (Estepona, Spain).

Material studied — from the Velerín Conglomerates, 9 specimens (BLP Colln), 4 specimens (DFB Colln); from the Velerín Sands, 7 specimens (BLP Colln); from the Velerín Carretera, 6 specimens (BLP Colln).

Measurements — Maximum length and width up to 5.4 mm and 4.4 mm, respectively, but on average 5.2 mm and 4.3 mm, respectively; L/W ratio 1.20.

Description — Shell very small, relatively fragile, and spherical. Spire covered by callus, faintly visible beneath 3 vertical riblets extending upwards from the posterior terminal. Body whorl globose and rounded, about 90% of total height, with the terminals strongly produced and flattened. Dorsum evenly rounded, without a true dorsal sulcus, but a weak dorsal depression, which modifies the ribs. Dorsum completely covered by 20-22 strong, irregular ribs, with interruptions. Where the ribs cross the dorsal depression, they are usually modified; interrupted, narrowed and occasionally unaltered. Base and terminals are evenly convex. Aperture curved, slightly wider in the anterior portion. Outer lip broad, widest in mid-portion, becoming narrower towards the terminals. The lip is evenly rounded and the outer margin weakly callused. The lip bears 15-18 fine, equal teeth. Siphonal and anal canals wide and indented. Columella convex, tapering steeply inwards, bordered internally by a very weak to subobsolete carinal ridge, bearing 13-15 ribs, which continue onto the carinal ridge, where they do not become significantly stronger. The carinal ridge protrudes in the fossular region. Fossula concave, not clearly delimited from the rest of the columella.

Range of variation — This species is characterised by the small size, greatly inflated shell, poorly developed dorsal sulcus and short, blunt terminals. The shape is fairly constant, the shells varying mainly in details of the ribs, number of interrupted ribs and character as they cross the sulcus, as well as in the strength of the dorsal depression.

Discussion — This is the first member of the genus *Cleotrivia* to be described from the European fossil record. It is similar to *C. weneri* Fehse, 1999 from the coast of West Africa, but also occurring in the Alboran Sea [Giannuzzi-Savelli *et al.*, 1996, p. 160, fig. 666a-c, as *Pusula candidula* (Gaskoin, 1836)]. *Cleotrivia esteponica* n. sp. differs from the extant species in being more inflated, with a more elevated dorsum and a weaker dorsal sulcus. In view of the similarity between the two, the new species might be ancestral to *C. weneri*.

The thermophilic genus *Cleotrivia*, unknown until recently from fossil strata in the eastern Atlantic and Mediterranean, is represented by these two species only. We have found several undescribed representatives of the genus in Middle-Late Miocene French Atlantic faunas ('Serravallian' and 'Lower Redonian') (Fehse & Landau, work in progress). In Pliocene and Recent faunas, species numbers decline, becoming confined to the West African coast and adjacent Mediterranean, but not extending further into it. There are no species known from the Miocene or Pliocene of the eastern Mediterranean. Another predominantly West African genus occurring in Estepona is *Cymbium*, represented by *C. ibericum* Landau & Marquet, 2000.

Conclusions

The triviid fauna from Estepona is very rich, with thirteen species representing four genera. This is the largest number of genera present in any European Neogene deposit. The study of these strata is of particular interest on account of its unique geographical position, straddling the Atlantic and Mediterranean. The fauna is of the typical Mediterranean type, but with strong West African influence, as shown by the presence of the genera *Cleotrivia* and *Cymbium*, as well as a large number of as yet undescribed marginellids.

Apart from the great variety, the number of individuals and their size are both greater than those found in the neighbouring Italian deposits. Their habitat is usually littoral or sublittoral, occurring on rocky substrates, which is needed for the growth of the ascidians they feed on (Fretter & Graham, 1981, p. 329). Their requirements are similar to those of eratooids, which are equally well represented in number and reach greater size (Fehse & Landau, 2002) than conspecific specimens from Italy.

The present are the first reliable records of all of these triviid species from the Lower Pliocene (Zanclean). Apart from *Cleotrivia esteponica* n. sp. and *Trivia candidula*, all species are known also from the Middle and Upper Pliocene of Italy.

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