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The xenophorid gastropods of the Mediterranean Pliocene: the record of the Siena Basin

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ABSTRACT – The systematics of fossil Euro-Mediterranean xenophorids is still relatively unknown, due to the many problems involved in studying them (very conservative shell structure, few available shell characters, the fact that the attached objects modify whorl shape and vary in amount, the rarity of certain species and the difficulty of finding well preserved specimens). Most of the relevant literature dates back to the classic monographs on Tertiary molluscs by M. Hörnes, F. Sacco and M. Cossmann.

Seven species have been reported from the Euro-Mediterranean Pliocene: *Xenophora crispa* (König, 1825), *X. deshayesi* (Michelotti, 1847), *X. infundibulum* (Brocchi, 1814), *X. plioitalica* Sacco, 1896, *X. scaldensis* Glibert, 1958, *Stellaria plioextensa* (Sacco, 1896), and *S. testigera* (Bronn, 1831). However, all but three (*X. crispa*, *X. infundibulum*, and *S. testigera*) are practically unknown.

This paper is devoted to six species found in the Siena Pliocene Basin, a classic Italian Pliocene area. Five of them (*X. crispa*, *X. infundibulum*, *X. plioitalica*, *S. plioextensa*, and *S. testigera*) are redescribed and current knowledge about them summarized; the sixth species, known from a dozen specimens, is described as new: *X. davolii* n. sp. In the remarks to the new species, the status and the relationships of some classical Euro-Mediterranean Tertiary xenophorid species, i.e. *X. deshayesi* (Michelotti, 1847), *X. burdigalensis* (Gratoloup, 1847) and *X. grateloupi* (D'Orbigny, 1852), are discussed.

A neotype is designated for two species (*X. crispa* and *S. testigera*) and a proposal of neotype designation is made for some Miocene species: *X. deshayesi*, *X. burdigalensis*, and *X. grateloupi*.

RIASSUNTO – [Gasteropodi xenoforidi del Pliocene del Mediterraneo: l'esempio del Bacino di Siena] – Gli xenoforidi fossili dell'area Euro-Mediterranea sono ancora poco noti a causa delle molte difficoltà che da sempre si incontrano nello studio di questi peculiari gasteropodi (conchiglia molto conservativa; pochi caratteri disponibili; il fatto che gli oggetti attaccati alle conchiglie possono variare considerevolmente in numero e forma e modificare la forma dei giri; la rarità di alcune specie e la difficoltà di trovare esemplari ben conservati). Non è un caso, quindi, che la letteratura più rilevante disponibile consista ancora delle classiche monografie sui molluschi terziari come quelle di M. Hörnes, F. Sacco e M. Cossmann.

Nel Pliocene Euro-Mediterraneo, si trovano sette specie: *Xenophora crispa* (König, 1825), *X. deshayesi* (Michelotti, 1847), *X. infundibulum* (Brocchi, 1814), *X. plioitalica* Sacco, 1896, *X. scaldensis* Glibert, 1958, *Stellaria plioextensa* (Sacco, 1896) e *S. testigera* (Bronn, 1831), ma a parte tre (*X. crispa*, *X. infundibulum* e *S. testigera*), le altre sono praticamente sconosciute.

Questo lavoro è dedicato alle sei specie trovate nel Bacino Neogenico di Siena, un'area classica del Pliocene italiano. Cinque di queste (*X. crispa*, *X. infundibulum*, *X. plioitalica*, *S. plioextensa* e *S. testigera*) sono ridescritte e dettagliatamente analizzate sulla base di quanto noto su ciascuna di esse; la sesta, uno xenoforide di grandi dimensioni, noto da una dozzina di esemplari, viene descritta come nuova: *X. davolii* n. sp. Nell'analisi della nuova specie sono state esaminate la validità e le relazioni di alcuni classici xenoforidi terziari dell'area Euro-Mediterranea: *X. deshayesi* (Michelotti, 1847), *X. burdigalensis* (Gratoloup, 1847) e *X. grateloupi* (D'Orbigny, 1852).

Un neotipo è stato designato per due specie (*X. crispa* e *S. testigera*) e una proposta per la designazione di un neotipo è fatta per altre tre specie (*X. deshayesi*, *X. burdigalensis* e *X. grateloupi*).

INTRODUCTION

Xenophorids are a small group of small to large, slightly mobile, sediment feeding, marine caenogastropods, having conical to depressed, trochiform shells, with a narrow to wide, simple to digitate peripheral flange separating base from spire and an aperture overhung by a sort of roof consisting of the final dorsal portion of the last whorl. They are characterized by some interesting behaviours, the most peculiar of which is the ability to attach foreign bodies (shells, pebbles, coral skeletons, plates and spines of sea urchins, plates of balanid cirripeds, shark teeth, man-made objects, etc.) to the dorsal surface of the

peripheral flange or digitations of their shell (Vignon, 1923; Morton, 1958; Faber, 1978; Zhu Min-Da, 1984; Feinstein & Cairns, 1998; Ponder & De Keyser, 1998; Kreipl & Alf, 1999). The adaptive value of this behaviour is not clear. It may be an antipredatory strategy (a visual camouflage in shallow waters; an olfactory or tactile camouflage in deep waters) or have a functional value (lifting the shell above the ground to enable the mollusc to graze without moving; increasing stability or weight to prevent overturning of the shell by currents and turbulence) (Shank, 1969; Linsley & Yochelson, 1973; Berg, 1974, 1975; Feinstein & Cairns, 1998). However, other peculiar behaviours, including

stromboidean locomotion, feeding in the area protected by the shell, below the peripheral flange and the roof created by the final portion of the last whorl and burying their faeces, suggests that attachment of foreign bodies is part of a strategy for escaping predator detection (Morton, 1958; Linsley & Yochelson, 1973; Zhu Min-Da, 1984; Ponder & De Keyser, 1998; Kreipl & Alf, 1999).

Xenophorid shells are very attractive and therefore popular with shell collectors (Faber, 1978; Lambiotte, 1979; Goud & Kronenberg, 1988-89; Kreipl & Alf, 1999). The starting point of modern taxonomy of the family is Ponder's (1983) extensive review of extant taxa. Although Ponder's review also included a report on anatomical morphology, his revision was mainly based on shell characters, because in his words the "anatomy appears to be fairly uniform" and only a small amount of material was available for anatomical study. The shell characters utilized for taxonomy are: the amount and relative size of foreign material attached to the shell surface (1), the width of the peripheral flange (2), the spire angle (3), the dorsal sculpture and shape of the whorls (4), the sculpture and shape of the base (5), the shape and size of the umbilicus (6), the shape of the basal margin of the aperture (7) and colour, particularly of the base (8) (Ponder, 1983, p. 3).

Ponder (1983) recognized 22 extant species, all belonging to a single genus, *Xenophora* Fischer von Waldheim, 1807, in turn, split into three subgenera: *Xenophora* (s.s.), *Stellaria* Möller, 1832, and *Onustus* Swainson, 1840.

Xenophora (s.s.) is characterized by "shell with peripheral flange narrow, simple, non-porcellaneous ventrally; umbilicus moderate to closed; foreign objects attached to all whorls and occupying more than 1/3 of the dorsal surface; mantle edge tentaculate, foot typically with remnant of sole on metapodium, ctenidial filaments of moderate length; operculum smooth externally, subtriangular to suboval, rarely stromboid" (Ponder, 1983, p. 18). *Xenophora* (s.s.) includes 13 species: the American *X. conchyliophora* (Born, 1780), the Mediterranean and eastern Atlantic *X. crispa* (König, 1825), and the Indo-Pacific *X. cerea* (Reeve, 1845), *X. corrugata* (Reeve, 1842), *X. flindersi* (Cotton & Godfrey, 1938), *X. granulosa* Ponder, 1983, *X. japonica* Kuroda & Habe, 1971, *X. mekronensis* (Newton, 1905), *X. neozelanica* Suter, 1908, *X. pallidula* (Reeve, 1842), *X. peroniana* (Iredale, 1929), *X. solarioides* (Reeve, 1845) and *X. tenuis* Fulton, 1938. According to Ponder (1983, p. 4), these species can be grouped into two informal subgroups. The former includes "typical species of medium size showing heavy to moderate attachment of foreign objects, a narrow peripheral flange and a very narrow to closed umbilicus", such as *X. conchyliophora*, *X. cerea*, *X. corrugata*, *X. japonica*, *X. neozelanica*, *X. pallidula*, etc., and the latter, "small to medium-sized species showing moderate to heavy

attachment of foreign bodies, a narrow peripheral flange and a moderate umbilicus", such as *X. crispa* and *X. solarioides*.

Stellaria is characterized by "shell large, widely umbilicate, with wide peripheral flange which is simple in some species or is digitate or divided into numerous long, hollow, narrow, parallel-sided spines; attached foreign objects small, covering little of dorsal surface; mantle edge mostly smooth, ctenidial filaments very long; foot lacks metapodial sole; operculum smooth externally, subtriangular to suboval" (Ponder, 1983, p. 50) and includes five extant species, mainly Indo-Pacific: *X. solaris* (Linnaeus, 1758), *X. testigera* (Bronn, 1831), *X. chinensis* (Philippi, 1841), *X. gigantea* Schepman, 1909, and *X. lamberti* (Souverbie, 1871). The five species assigned to *Stellaria* may be grouped in three informal subgroups (Ponder, 1983, p. 4). The first includes a "large species with little foreign material attached, a wide umbilicus, strong radial sculpture on the base and a wide peripheral flange divided into tubular spines" (*X. solaris*), the second a "species of medium size, with very little foreign material attached, digitate peripheral flange, a very narrow umbilicus" (*X. testigera*), and the third three "large species with little foreign material attached, a moderate to wide umbilicus, a smooth to strongly sculptured base and a wide, simple peripheral flange" (*X. chinensis*, *X. gigantea*, and *X. lamberti*).

Onustus is characterized by "shell thin with wide peripheral flange or weakly digitate, porcellaneous below; umbilicus narrow to wide, sometimes plugged with callus; foreign objects attached to periphery on few to all whorls, small and inconspicuous, leaving most of shell surface exposed; foot lacks sole on metapodium, mantle edge smooth, ctenidial filaments very long; operculum radially ridged externally or almost smooth, bearing only very fine radial striae" (Ponder, 1983, pp. 58-59) and includes four species: the Indo-Pacific *X. indica* (Gmelin, 1791) and *X. exuta* (Reeve, 1842) and the western Atlantic *X. caribaea* Petit de la Saussaye, 1857 and *X. longleyi* Bartsch, 1931.

The supraspecific systematics proposed by Ponder (1983) has largely been adopted without objections. Only recently did Kreipl *et al.* (1999), Kreipl & Alf (1999) and Nielsen & De Vries (2002) adopt *Xenophora*, *Stellaria* and *Onustus* as distinct genera, because "differences between these taxa are large enough to advocate genus state" (Kreipl *et al.*, 1999, p. 179). However, while *Xenophora* and *Onustus* seem to have a consistent taxonomic sense, *Stellaria* seems composite, making it problematic to separate from *Onustus*. This genus/subgenus includes very different entities: one species, *Trochus solaris*, with tubular (hollow) peripheral digitations which has sometimes recently been assigned to a distinct monotypic genus (*Stellaria* or *Haliphoebus* Fischer, 1879; Mallory, 1978; Lambiotte, 1979; Abbott & Dance, 1981); one

species, *Phorus testigerus*, with solid blunt peripheral digitations and unique anatomical characters (penis structure), always regarded as a peculiar member of *Xenophora* and never associated with *Stellaria* (or *Haliphoebus*) or *Onustus* (or *Tugurium*); three species, *Trochus chinensis*, *Xenophora gigantea*, and *X. lamberti*, having a large peripheral flange with non porcellaneous lower surface and without peripheral digitations, which Lambiotte (1979) assigned to *Tugurium* together with the four species later assigned to *Onustus* by Ponder (1983). Species of *Onustus* are really very similar to these three species differing only in porcellaneous lower surface of peripheral flange; moreover all these species except *X. gigantea* and *X. longleyi* (assigned to *Trochotugurium* Sacco, 1896, by Mallory, 1978) also share a wavy inner basal margin of peristome.

Species of *Stellaria* and *Onustus* share some anatomical characters (foot without metapodial sole; mantle edge mostly smooth or smooth; very long ctenidial filaments) which distinguish them from species of *Xenophora* (foot with remnant of metapodial sole; mantle edge tentaculate; ctenidial filaments of moderate length). We therefore prefer to recognize two genera, rather than three: *Xenophora* and *Stellaria*. The latter genus may be split into subgenera: *Stellaria* (s.s.) for *T. solaris*, *Stellaria* (n. subgen. ?) for *P. testigerus* and *Stellaria* (*Onustus*) for *T. chinensis*, *X. gigantea*, *X. lamberti*, *T. indicus*, *P. exutus*, *X. caribaea* and *X. longleyi*. According to Kreipl *et al.* (1999) and Kreipl & Alf (1999), *Xenophora* is also divided into subgenera: *Xenophora* (s.s.) and the monotypic *Austrophora* Kreipl, Alf & Kronenberg, 1999 (type species: *Onustus flindersi* Cotton & Godfrey, 1938).

Shell characters support easy identification of some extant species, but the identification of others is somewhat controversial. Shell morphology is very conservative and species-specific characters are modest, especially within the nominotypical subgenus. Some characters (dorsal sculpture, whorl and suture shape) are often difficult to evaluate because most of the spire is covered with attached objects or their scars and others (amount and size of foreign material attached to surface) may depend on the available material. Notwithstanding this, Ponder's (1983) systematic account of xenophorid species has largely been accepted (Goud & Kronenberg, 1988-89; Wilson *et al.*, 1993; Kreipl & Alf, 1999) and few points of taxonomic conflict have been raised, for example the status of *X. robusta* (Verrill, 1870) and *X. senegalensis* Fischer, 1873 (see Hutsell, 1994; Kreipl & Alf, 1999) (for the list of extant species, see Tab. 1).

The systematics of fossil Euro-Mediterranean xenophorids is still relatively unknown, which is not surprising considering the problems involved in studying them. Besides those listed for extant species, they include the rarity of certain fossil xenophorids and the difficulty of finding well preserved specimens. Most of the relevant literature dates back to the

classic monographs on Tertiary molluscs by M. Hörnes, F. Sacco and M. Cossmann. The only recent exhaustive survey is a little known paper by Zhu Min-Da (1984); other recent contributions include Glibert (1949, 1952, 1958), Erüal-Erentöz (1958), Kojumdgieva & Strachimirov (1960), Hölzl (1962), Pelosio (1967), Baldi (1973), Janssen (1984), Bařuk (1995), Marquet (1997), Wienrich (2001) and Landau *et al.* (2004). A narrative fossil history of xenophorids is proposed by Ponder (1983, pp. 10-15, Fig. 5). The paper of Zhu Min-Da (1984) is based on the study of 400 specimens assigned to 27 different species, but does not make any significant taxonomic contribution. The other papers discuss one or more xenophorids in the context of faunal reports.

Seven species are reported from the Euro-Mediterranean Pliocene (Sacco, 1896; Marquet, 1997), and all but three (*X. crispa*, *X. infundibulum*, and *S. testigera*) are practically unknown. The present paper is devoted to the six species found in the Siena Neogene Basin, one of which is described as new. The Siena Neogene Basin, a classic Italian Pliocene area (for general information see Bossio *et al.*, 1992, 1993), occupies an almost central portion of the long graben that extends SE from Valle del Serchio to Val di Paglia. It is limited to the west by the Montagnola Senese and the Murlo-Montalcino ridge, to the north by the Monteriggioni high, that separates it from the Val d'Elsa Basin, and to the east by the Rapolano ridge, that divides it from the Valdichiana Basin, an area directly connected to the Siena Basin, at least in the Middle Pliocene, and continues to the south with the Radicofani Basin, from which it is separated by the Pienza-San Quirico d'Orcia high. It contains limited lacustrine sediments of the Upper Miocene and abundant marine sediments of the Lower-Middle Pliocene. The marine sedimentary cycle began in the early Lower Pliocene (*Sphaeroidinellopsis seminulina* s.l. zone) and ended in the late Middle Pliocene (*Globorotalia aemiliana* zone). Detailed surveys with stratigraphic, sedimentological and palaeoenvironmental analysis are in progress by A. Costantini, A. Lazzarotto, and F. Sandrelli of the Dipartimento di Scienze della Terra, Università di Siena.

Species found in the Siense Pliocene are redescribed and current knowledge about them summarized. Morphological nomenclature is usually that used by Ponder (1983), including the term "spire" for the upper parts of the whorls, adapical to the peripheral flange; the aperture terms are illustrated in the Text-fig. 1. Dimensions are measured excluding attached objects (unless otherwise specified) and spire angle is taken as a rough measure of the mean spire angle (Cox, 1960), i.e. the angle between the straight lines joining the apex to the periphery of the last whorl on opposite sides of the shell in apertural view. The nomenclature and taxonomy of molluscan species found attached to the shells are according to Cavallo & Repetto (1992). The material examined is

Tab. 1 - Extant xenophorids. Marine zoogeographic regions according to Briggs (1974).

Species	Geographic distribution	Main references	Remarks
The species of <i>Xenophora</i>:			
<i>X. cerea</i> (Reeve, 1845)	Indo-West Pacific (Western Indian Ocean, Red Sea, Indo-Polynesian and Northwestern Australia Provinces) and Japan Regions	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	Conchologically and anatomically very similar to the American <i>X. conchyliophora</i> and to the sympatric <i>X. peroniana</i> .
<i>X. conchyliophora</i> (Born, 1780)	Carolina, Western Atlantic (Caribbean, West Indian and Brazilian Provinces), California (Cortez and San Diego Provinces) and Eastern Pacific (Mexican and Panamanian Provinces) Regions	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	Conchologically and anatomically very similar to the tropical Indo-West Pacific <i>X. cerea</i> and <i>X. peroniana</i> .
<i>X. corrugata</i> (Reeve, 1842)	Indo-West Pacific Region (Western Indian Ocean, Indo-Polynesian and Northwestern Australia Provinces)	Ponder (1983), Stewart & Kosuge (1983), Goud & Kronenberg (1988-89), Bosch <i>et al.</i> (1995), Kreipl & Alf (1999)	
<i>X. crispa</i> (König, 1825)	Mediterranean-Atlantic (Lusitania Province) and Eastern Atlantic (West African Province) Regions	Ponder (1983), Goud & Kronenberg (1988-89), Giannuzzi-Savelli <i>et al.</i> (1997), Kreipl & Alf (1999)	There is much controversy about its relationship with the western Atlantic <i>X. senegalensis</i> Fischer, 1879.
<i>X. flindersi</i> (Cotton & Godfrey, 1938)	Southern Australia Region (Southeastern Australia Province)	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	<i>X. flindersi</i> is assigned to the subgenus <i>Austrophora</i> Kreipl, Alf & Kronenberg, 1999, distinguished by stromboid operculum and paucispiral protoconch. Extant specimens assigned to the nominotypical subspecies. Another subspecies, <i>X. flindersi ludbrookae</i> Ponder, 1983, occurs in the Lower Pleistocene and possible Upper Pliocene of Western Australia.
<i>X. granulosa</i> Ponder, 1983	Indo-West Pacific Region (Indo-Polynesian Province)	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	Very similar to, maybe conspecific with, <i>X. tenuis</i> Fulton, 1838.
<i>X. japonica</i> Kuroda & Habe, 1971	Indo-West Pacific (Indo-Polynesian Province) and Japan Regions	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	
<i>X. mekronensis</i> (Newton, 1905)	Indo-West Pacific Region (Indo-Polynesian and Northwestern Australia Provinces)	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	Extant specimens assigned to the subspecies <i>X. mekronensis konoii</i> Habe, 1953. Nominotypical subspecies only occurs in the Pliocene of Mekran Coast, Iran.
<i>X. neozelanica</i> Suter, 1908	Northern New Zealand Region (Auckland and Kermadec Provinces)	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	Two extant subspecies are recognized. The nominotypical one occurs in New Zealand seas, the other, <i>X. neozelanica kermadecensis</i> Ponder, 1983, is restricted to Kermadec Islands.
<i>X. pallidula</i> (Reeve, 1842)	Indo-West Pacific (Western Indian Ocean, Indo-Polynesian and Northwestern Australia Provinces), Japan and Southern Australia (Southwestern Australia Province) Regions	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Bosch <i>et al.</i> (1995), Kreipl & Alf (1999)	
<i>X. peroniana</i> (Iredale, 1929)	Indo-West Pacific (Northeastern Australia and Hawaiian Provinces), Southern Australia (Southeastern Australia Province) and Tasmanian Regions	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	Two extant subspecies are recognized. The nominotypical one occurs in eastern Australia, the other, <i>X. peroniana kondoi</i> Ponder, 1983, is restricted to Hawaii Islands.

Continued.

Tab. 1 - Continued.

<i>X. senegalensis</i> Fischer, 1873	Eastern Atlantic Region (West African Province)	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	Ponder (1983) regarded <i>X. senegalensis</i> as not more than an ecological form of <i>X. crispa</i> (König, 1825), but according to Kreipl & Alf (1999) there are no intermediate forms between the two. Therefore they consider <i>X. senegalensis</i> as a distinct species.
<i>X. solarioides</i> (Reeve, 1845)	Indo-West Pacific Region (Western Indian Ocean, Indo-Polynesian and Northwestern Australia Provinces)	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	Extant specimens assigned to the nominotypical subspecies. The Upper Miocene or Pliocene <i>X. solarioides jezleri</i> Cox, 1948, is very similar to <i>X. senegalensis</i> Fischer, 1879
<i>X. tenuis</i> Fulton, 1938	Japan Region	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	
The species of <i>Stellaria</i>:			
<i>S. caribaea</i> Petit de la Saussaye, 1857	Carolina and Western Atlantic (Caribbean, West Indian and Brazilian Provinces) Regions	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	
<i>S. chinensis</i> (Philippi, 1841)	Indo-West Pacific (Western Indian Ocean, Red Sea, Indo-Polynesian and Northwestern Australia Provinces) and Japan Regions	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Bosch <i>et al.</i> (1995), Kreipl & Alf (1999)	Extant specimens are assigned to the nominotypical subspecies. Another subspecies, <i>S. chinensis dunkeri</i> (Martin, 1879), occurs in the Miocene of Java. <i>S. chinensis</i> is very similar to <i>S. lamberti</i> (Souverbie, 1871).
<i>S. exuta</i> (Reeve, 1842)	Indo-West Pacific (Western Indian Ocean, Indo-Polynesian and Northwestern Australia Provinces) and Japan Regions	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	
<i>S. gigantea</i> (Schepman, 1909)	Indo-West Pacific (Western Indian Ocean, Indo-Polynesian and Northwestern Australia Provinces) and Japan Regions	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	
<i>S. indica</i> (Gmelin, 1791)	Indo-West Pacific (Western Indian Ocean, Indo-Polynesian and Northwestern Australia Provinces) Region	Ponder (1983), Goud & Kronenberg (1988-89), Wilson <i>et al.</i> (1993), Kreipl & Alf (1999)	
<i>S. lamberti</i> (Souverbie, 1871)	Indo-West Pacific Region (Indo-Polynesian Province)	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	
<i>S. longleyi</i> Bartsch, 1931	Carolina and Western Atlantic (Caribbean, West Indian and Brazilian Provinces) Regions	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	The extant xenophorid species with the most reduced distribution. <i>S. lamberti</i> is very similar to <i>X. chinensis</i> (Philippi, 1844).
<i>S. solaris</i> (Linnaeus, 1758)	Indo-West Pacific Region (Western Indian Ocean and Indo-Polynesian Provinces)	Ponder (1983), Goud & Kronenberg (1988-89), Bosch <i>et al.</i> (1995), Kreipl & Alf (1999)	
<i>S. testigera</i> (Bronn, 1831)	Eastern Atlantic (West African Province), Southern Africa (Southwest African Province) and Indo-West Pacific (Western Indian Ocean Province) Regions	Ponder (1983), Goud & Kronenberg (1988-89), Kreipl & Alf (1999)	Extant specimens assigned to distinct subspecies: <i>S. testigera digitata</i> (Martens, 1878) occurs along the west African coast and <i>S. testigera profunda</i> (Ponder, 1983) occurs in northernmost East Africa and Gulf of Aden.

kept in public institutions and private collections for which the following acronyms are used: AFMSN, Museo di Storia Naturale dell'Accademia dei Fisiocritici di Siena; IPUM, Dipartimento del Museo di Paleobiologia e dell'Orto Botanico, Università di Modena e Reggio Emilia; DSTUT, Dipartimento di

Scienze della Terra, Università di Torino; FPC, F. Pizzolato collection, Arezzo; GMC, G. Manganelli collection, Siena; IGF, Museo di Storia Naturale, Sezione di Geologia e Paleontologia, Università di Firenze; MMAS, Museo del Mare Antico, Salsomaggiore; MRSN, Museo Regionale di Scienze

Naturali, Torino; VSC, V. Spadini collection, Lucignano. Details on the collection localities are given in Tab. 2.

THE XENOPHORIDS OF THE PLIOCENE BASIN
OF SIENA

Class GASTROPODA Cuvier, 1795
Subclass ORTHOGASTROPODA
Ponder & Lindberg, 1995
Superorder CAENOGASTROPODA Cox, 1960
Order SORBEOCONCHA Ponder & Lindberg, 1997
Suborder HYPGASTROPODA
Ponder & Lindberg, 1997
Infraorder LITTORINIMORPHA
Golikov & Starobogatov, 1975
Superfamily XENOPHOROIDEA Troschel, 1852
Family XENOPHORIDAE Troschel, 1852

Genus XENOPHORA Fischer von Waldheim, 1807
Type species – *Xenophora laevigata* Fischer von Waldheim, 1807, by subsequent designation (Harris, 1897).

X. laevigata is a junior synonym of *Trochus conchyliophorus* Born, 1780.

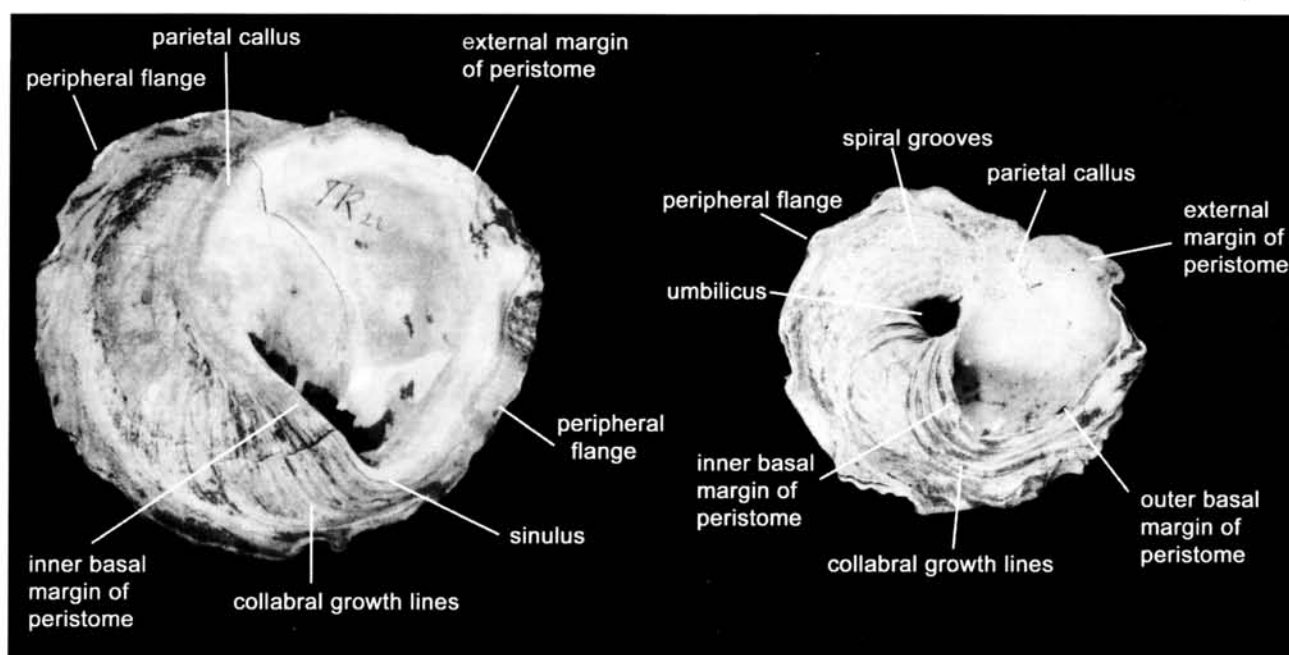
XENOPHORA CRISPA (König, 1825)
Pl. 1, figs 1-10, Text-figs 2-3

1825 *Trochus crispus* KÖNIG, p. 3, Pl. 5, fig. 58.

Type material – “Not known” according to Ponder (1983, p. 45). To definitively clarify the identity of *Trochus crispus* we designate the specimen figured by Sacco (1896, Pl. 2, fig. 22; BS.066.01.006) as the neotype (Text-fig. 3).

Locality	age	lithology	references
Siena Basin			
Barca (Castelnuovo Berardenga, SI) UTM: 32TPN9802	Lower Pliocene (<i>Globorotalia puncticulata</i> zone)	sand and sandstone	A. Costantini (pers. comm.)
Finerri (Asciano, SI) UTM: 32TQN124879	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shale”	A. Costantini (pers. comm.)
Fornace di Rapolano quarry (Rapolano, SI) UTM: 32TQN1092	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shale”	Brogi <i>et al.</i> (1999)
Guistrigona (Castelnuovo Berardenga, SI) UTM: 32TQN0199	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	sand, sandstone and silty sand	A. Costantini (pers. comm.)
I Sodi quarry (Asciano – Castelnuovo Berardenga, SI) UTM: 32TQN0198, 0298	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shale”	A. Costantini (pers. comm.)
La Querce (Castelnuovo Berardenga, SI) UTM: 32TQN0399	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	sand, sandstone and silty sand	A. Costantini (pers. comm.)
Monsindoli quarry (Siena, SI) UTM: 32TPN8894	Lower Pliocene (<i>Globorotalia puncticulata</i> zone)	“shale”	Costantini (2004) and pers. comm.
Podere Capanna (Rapolano, SI) UTM: 32TQN096999	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shale”	A. Costantini (pers. comm.)
Podere Terrarossa (Castelnuovo Berardenga, SI) UTM: 32TQN0801	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	sand, sandstone and silty sand	A. Costantini (pers. comm.)
Poggiodarno (Asciano, SI) UTM: 32TQN065935	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shale”	A. Costantini (pers. comm.)
Poggio Vangelo (Asciano, SI) UTM: 32TPN996966	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shale”	A. Costantini (pers. comm.)
San Vittorio (Asciano, SI) UTM: 32TQN976937	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shales”	A. Costantini (pers. comm.)
Vescona (Asciano, SI) UTM 32TQN026942	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	“shale”	A. Costantini (pers. comm.)
Val di Chiana Basin			
Poggi Gialli (Sinalunga, SI) UTM: 32TQN2589	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	sand, sandstone and silty sand	A. Costantini (pers. comm.)
Podere Casuccia (Torrita di Siena, SI) UTM: 32TQN2581	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	sand, sandstone and silty sand	A. Costantini (pers. comm.)
Radicofani Basin			
Lucciolabella (Pienza, SI) UTM: 32TQN2568	Lower Pliocene (<i>Globorotalia puncticulata</i> zone)	silty shale and silt	Costantini & Dringoli (2003)
Monte Calcinai (Radicofani, SI) UTM: 32TQN3055	Lower Pliocene (<i>Globorotalia puncticulata</i> zone)	“shale”	Liotta & Salvatorini (1994)
Poggio Rotondo (Sarteano, SI) UTM: 32TQN3064	Middle Pliocene (<i>Globorotalia aemiliana</i> zone)	silt	Costantini & Dringoli (2003)

Tab. 2 - Collection localities in the Pliocene Basins of Siena, Val di Chiana and Radicofani.



Text-fig. 1 - Nomenclature of base and aperture. On the left a shell of *Xenophora infundibulum* (Brocchi, 1814), on the right a shell of *Xenophora crispa* (König, 1825), both from the Pliocene of Terre Rosse (V. Spadini collection).

Type locality – König (1825) reported *T. crispus* “cum praecedente [*Trochus agglutinans* Lam.]”, i.e. “in calcario cerithico et in argilla prope Grignon Galliae, & c.” Fischer (1879) and Sacco (1896) regarded this locality as mistaken. Sacco (1896) claimed that it probably comes from an Italian Pliocene locality and Ponder (1983, p. 45) restricted the type locality to “Asti, Italy (Astian, Upper Pliocene)”. However, without designation of a lectotype or neotype, these actions are of no nomenclatural significance. After the present designation of the neotype, the type locality becomes definitively “Astigiana”.

Diagnosis – A species of *Xenophora* characterized by small size (1), robust, variably shaped from almost discoidal to trochiform shell (2), with narrow, irregular, roughly round (where attached objects absent) peripheral flange (3); about 7-8 whorls having variable profile (4); spire surface free of attached objects or their scars, representing about 30-60% of entire surface (5), and with fine wavy meandering subspiral, sometimes opisthocline, riblets (6); attached objects (mainly bivalve and gastropod shells and fragments of shells and pebbles) from small to proportionally very large (7); scars of attached objects usually deep (8); base from slightly convex to almost flat (9); basal sculpture consisting of collabral growth lines and spiral grooves more distinct near umbilicus and having more or less granular appearance (10); basal margin of peristome very curved and thickened and with jutting outer portion (11); umbilicus small and deep but often slit-like or hidden by parietal callus (12).

Description – Shell (Pl. 1, figs 1-10) dextral, small in size, robust, variably shaped from almost discoidal to trochiform, with pointed apex and narrow, irregular, roughly round (where attached objects absent) peripheral flange; spire more or less conical (angle ranges from 70° to 105°) with probably 7-8 regularly growing whorls (first whorls always eroded); last whorl large, sometimes slightly dilated; sutures from shallow to deep; profile of whorls variable: where attached objects are absent or small, whorls flat to very slightly convex, where attached objects are large and numerous, whorl profile irregular with lower part inflated and surmounting suture or periphery; spire surface free of attached objects or their scars, representing about 30-60% of entire surface, with very fine wavy meandering subspiral, sometimes opisthocline, riblets intersected by prosocline growth lines; attached objects from small to proportionally very large, mainly (about 90%) shells and fragments of shell of bivalves and gastropods or pebbles, and secondarily (about 10%) balanid cirriped plates, bryozoans and foraminifers (largest object is a pebble 19 mm in length and 13 mm in width) (for other details on attached objects see Tab. 3); scars of attached objects usually deep; base from slightly convex to almost flat with very variable ornamentation consisting of collabral growth lines more marked near aperture and spiral grooves more distinct near umbilicus and having a more or less granular appearance, apparently due to intersection with growth lines (in some well preserved specimens, very thin subspiral or opisthocline riblets are present in areas of lower sur-

Localities	Diameter (mm)	Height (mm)	Angle (degrees)	number of attached objects in last whorl	number of attached objects in penultimate whorl	Attached objects
Terre Rosse n: 62	38.6 ± 3.8 (31 – 45) n: 33	26.9 ± 4.0 (18 – 31) n: 29	84.2 ± 7.3 (70 – 100) n: 34	7.2 ± 1.0 (5 – 8) n: 32	6.9 ± 1.4 (5 – 10) n: 32	Shells and fragments of shells of bivalves (<i>Acanthocardia</i> , <i>Amusium cristatum</i> , <i>Anadara diluvii</i> , <i>Chlamys</i> , <i>Chamelea gallina</i> , <i>Corbula gibba</i> , <i>Glans intermedia</i> , <i>Glycymeris</i> , <i>Megaxinus</i> , <i>Nucula placentina</i> , <i>Pecten</i> , <i>Pelecypora</i> , <i>Tellina</i> sp., <i>Timoclea ovata</i> , <i>Venus verrucosa</i> and others unidentified), shells and fragments of shells of gastropods (<i>Aporrhais pespelecani</i> , ? <i>Bittium</i> , <i>Calcarata calcarata</i> , <i>Cancellaria cancellata</i> , <i>Cancilla</i> , <i>Cerithium</i> , <i>Clavatula romana</i> , <i>Clavatula rustica</i> , <i>Conus</i> , <i>Cymathium</i> , <i>Diloma patulum</i> , <i>Gemmula contigua</i> , <i>Nassarius</i> , <i>Natica tigrina</i> , <i>Strioterebrum</i> , <i>Sveltia varicosa</i> , <i>Turricula dimidiata</i> , <i>Turritella</i> and others unidentified), fragments of shells of scaphopods (<i>Dentalium</i>), plates of cirripeds, tubes of serpulid annelids (<i>Ditrupa</i>) and pebbles.
Podere Capanna n: 9			90 – 105 n: 3			Tests of foraminifera, shells and fragments of shells of bivalves (<i>Acanthocardia</i> , ? <i>Anadara diluvii</i> , <i>Chlamys</i> , <i>Nucula</i> , <i>Nuculana</i> , <i>Pelecypora</i> and others unidentified) and shells and fragments of shells of gastropods (<i>Nassarius</i> and others unidentified).

Tab. 3 - Shell parameters of *Xenophora crispa* (König, 1825).

face of peripheral flange); aperture large and oblique because innermost basal margin is behind by almost one third of whorl; peristome interrupted with upper and lower vertices united by a parietal callus; columellar margin thickened and slightly reflected; basal margin of peristome J-shaped with inner portion curved, thickened and initially slightly reflected and outer portion usually jutting and sharp; external margin irregular, thin and sharp; umbilicus small and deep, sometimes bordered by marked spiral line which forms a sort of keel, but often slit-like or covered by parietal callus.

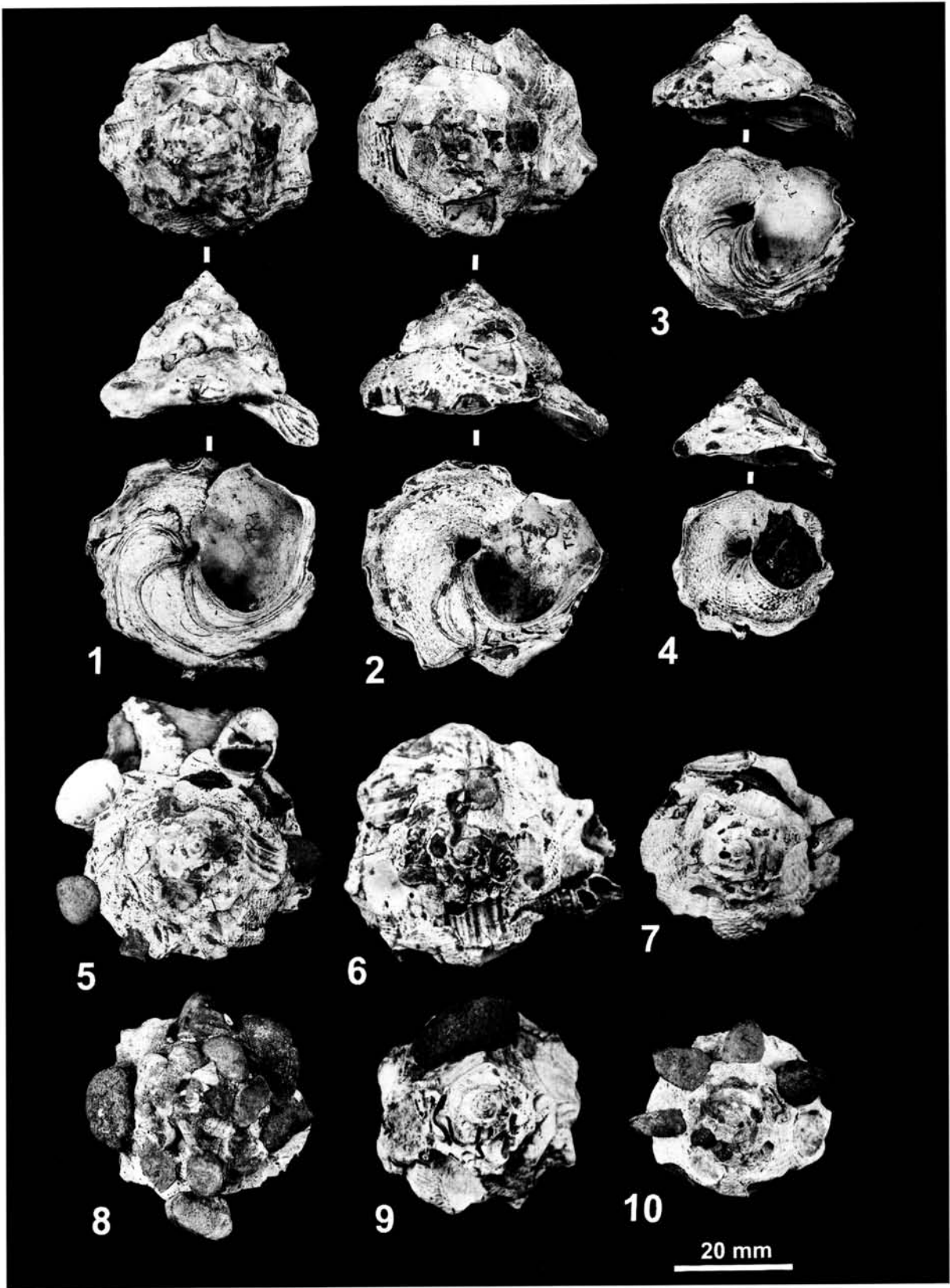
Dimensions – Diameter: 31–45 mm; height: 18–30 mm (for more details, see Tab. 3). Dimensions of other Italian Pliocene specimens: D: up to 37–38 mm (De Franchis, 1895); D: up to 50 mm, H: up to 35 mm (Sacco, 1896). Dimensions of Lower Pleistocene specimens: D: up to 58–59 mm (De Franchis, 1895). Dimensions of extant specimens: D: up to 42 mm, H: up to 33.4 mm (Ponder, 1983); D: up to 43 mm, H: up to 34 mm (Goud & Kronenberg, 1988–89; Kreipl & Alf, 1999).

Material – Siena Basin: 94 shells from Barca (1, GMC), Guistrigona (7, GMC; 6, VSC), Podere Capanna (9, VSC) and Terre Rosse (13, FPC; 49, VSC). Val di Chiana Basin: 4 shells from Poggi Gialli (3, FPC) and Podere Casuccia (1, FPC). Radicofani Basin: 5 shells from Poggio Rotondo (5, VSC).

Geographic and stratigraphic distribution – *Xenophora crispa* occurs in the central and western Mediterranean and the western Atlantic from France (Gulf of Biscay) to Angola, in the Azores and the Capo Verde Islands (Ponder, 1983). It has been extensively recorded from the Pliocene and the Pleistocene of the Mediterranean area, especially from Italian outcrops. Judging from published reports, the species was very widespread in the Lower-Middle Pliocene (Ruggieri, 1950, 1962; Lecointre, 1952; Caretto, 1963; Glibert, 1963; Moroni & Paonita, 1964; Caprotti, 1967, 1970; D'Alessandro, 1971; Malatesta, 1974; Marasti & Raffi, 1976; Pavia, 1976; Montefameglio *et al.*, 1980; Anfossi *et al.*, 1982; Aimone & Ferrero Mortara, 1983; Zhu Min-Da, 1984; Gonzales Delgado, 1988; Cavallo & Repetto,

EXPLANATION OF PLATE 1

Figs 1-10 - *Xenophora crispa* (König, 1825) from the Middle Pliocene of Terre Rosse (Castelnuovo Berardenga) (V. Spadini collection).



1992; Tabanelli & Segurini, 1994; Andreoli & Marsigli, 1996; Vera-Peláez *et al.*, 1996; Bogi & Cauli, 1998; Repetto, 1998; Landau *et al.*, 2004) the Upper Pliocene and the Lower-Middle Pleistocene (Cerulli Irelli, 1914; De Fiore, 1937; Ruggieri, 1949, 1950; Giannini, 1951; Malatesta & Nicosia, 1955; Malatesta, 1960; Glibert, 1963; Moshkovitz, 1963; Papani & Pelosio, 1963; Pelosio, 1964; Ruggieri & Greco, 1967; Zaccaria, 1968; Compagnoni *et al.*, 1969; Keraudren, 1970-71; Di Geronimo, 1975; Menesini & Ughi, 1983; Zhu Min-Da, 1984; Leone *et al.*, 1998; Taviani *et al.*, 1998). Its apparent absence in the Tyrrhenian malacofaunas (cf. Fontana-Zanco, 1933; Segre, 1952a, b, 1954; De Stefani, 1953; Malatesta, 1954; Comaschi Caria, 1955; Cuerda Barcelò, 1957; Ruggieri & Buccheri, 1968; Keraudren, 1970-71; Durante, 1975; Durante & Settepassi, 1977; Ruggieri & Unti, 1988) might be due to the fact that the Tyrrhenian outcrops are of littoral facies, an environment where *X. crista* does not live.

There are three records from the Miocene, two from the "Hervétien" of Aquitaine (Salles, Largileyre, and Saint-Étienne-d'Orthe; Cossmann & Peyrot, 1919) and another, from the "Tortonian" of Stazzano (Sacco, 1896). The report from Salles (Cossmann & Peyrot, 1919, Pl. 13, figs 5-6) is listed with a question mark in the synonymy of *Xenophora deshayesi* (Michelotti, 1847) by Bařuk (1995), but the shell illustrated (Cossmann & Peyrot, 1919, Pl. 13, figs 5-6) actually seems very similar to that of *X. crista*; on the contrary, the identity of the shell from Saint-Étienne-d'Orthe (Cossmann & Peyrot, 1919, Pl. 18, fig. 91) is very uncertain and likewise that of the shell from Stazzano (Sacco, 1896), kept in the Bellardi-Sacco collection at the Museo Regionale di Scienze Naturali of Turin (BS.066.01.011/01).

The ecology and biology of live *X. crista* are relatively unknown. Adam & Knudsen (1955, as *X. mediterranea*) reported that living specimens were dredged from bottoms of variable nature between depths of 97 and 263 m in West Africa. Le Loeuff *et al.* (1971, as *X. mediterranea*) stated that it lives in deep water (below 150 m) along the coasts of West Africa. Poppe & Goto (1991) reported that living specimens occur on "gravel bottoms between 40 and 300 m" on the continental slope.

X. crista is common and widespread in the Lower and Middle Pliocene of Siena Basin whence it was already reported by De Franchis (1895).

Remarks – The taxonomy and nomenclature of this small xenophorid has long been discussed from the point of view of relationships between extant Mediterranean and Atlantic forms, and between fossil and extant Mediterranean forms. Much early controversy arose from the fact that König did not give the exact locality of collection, but wrote "cum praecedente [*Trochus agglutinans*] rarus" in the legend (*T. agglutinans* Lamarck, 1804, was described from

the Eocene of the Basin of Paris) (Text-fig. 2). Shortly after, specimens from the Italian Pliocene (Bronn, 1831), the Italian Pleistocene (Philippi, 1836), the Mediterranean (Weinkauff, 1873) and the Atlantic (Martens, 1876) were assigned to this species. Fischer (1879, p. 211) wrote: "[...] qu'il est impossible de conserver le nom de *Xenophora crista*; l'espèce n'est pas décrite, son gisement est faux, et l'on ne peut savoir si la figure représente une coquille éocène, miocène ou pliocène" and consequently proposed to replace it with the names *Xenophora commutata* Fischer, 1879, for the Italian Pliocene forms, *Xenophora trinacria* Fischer, 1879, for the Sicilian Pleistocene ones, *Xenophora mediterranea* Tiberi, 1863, for the extant Mediterranean ones, and *Xenophora senegalensis* Fischer, 1873, for the extant Atlantic ones. However, Sacco (1896) observed that the shell figured by König (1825) is probably from the Italian Pliocene, where *X. crista* is very common. Consequently, he did not think it necessary to substitute König's name as proposed by Fischer (1879). In line with Sacco (1896), Ponder (1983) recently designated Asti (Italy) as the type locality of the species, but this has no nomenclatural significance, without designation of a neotype. To definitively clarify the identity of *Trochus crispus* and define its type locality, we designate the specimen figured by Sacco (1896, Pl. 2, fig. 22; BS.066.01.006) from "Astigiana" as the neotype (Text-fig. 3).



*TROCHUS, Linn. Lam. (Mollusca. Gastropoda: pectinibranchia:)

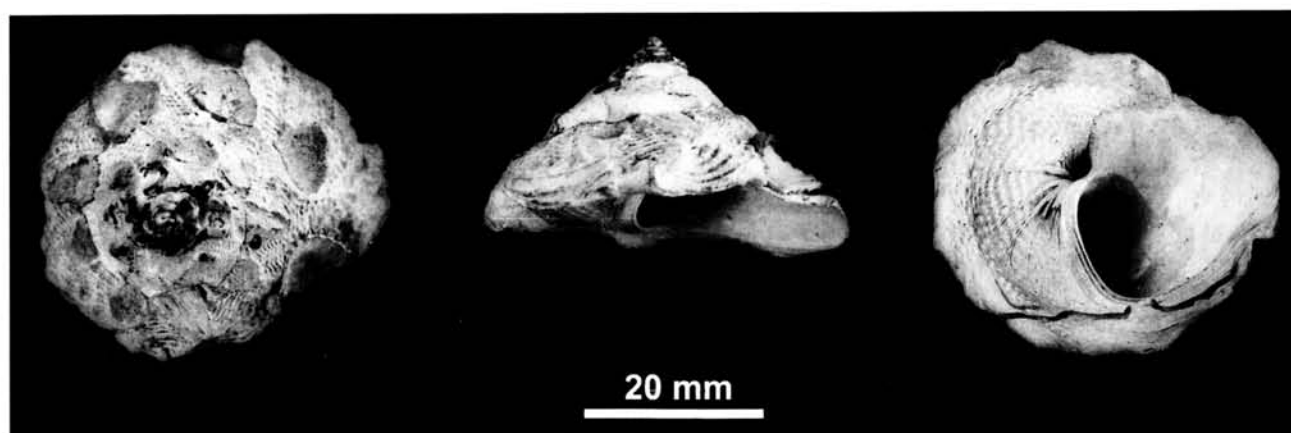
Fig. 57. *TROCHUS agglutinans* Lam.

Hab. in calcario cerithico et in argilla prope Grignon Galliae, &c.

Fig. 58. *TROCHUS crispus*. n.

Cum praecedente, rarus. Distinguitur a ceteris basi reticulato-crispa.

Text-fig. 2 - Original description and illustration of *Xenophora crista* (König, 1825).



Text-fig. 3 - Neotype of *Xenophora crispa* (König, 1825) from Pliocene of "Astigiana" (Bellardi-Sacco collection, Museo Regionale di Scienze Naturali, Turin, Italy, BS.066.01.006).

The prevalent opinion is currently that the Plio-Pleistocene and extant Mediterranean and Atlantic forms belong to the same monotypic species. Scholars including Sacco (1896) and more recently Ponder (1983) who examined much extant and fossil material strongly supported this conclusion. Only a few recent authors have assigned the extant specimens to a different species (*X. mediterranea*) or a subspecies (*X. crispa mediterranea*), but they were sceptical about the possibility of distinguishing it from *X. crispa* (Adam & Knudsen, 1955) or did not go into the question (Garavelli, 1969; Parenzan, 1970; Le Loeuff *et al.*, 1971; Settepassi, 1971; D'Angelo & Gargiulo, 1978; Lambiotte, 1979; Nordsieck & Garcia-Talavera, 1979; Marin & Ros, 1990).

Another controversial subject is the status of *X. senegalensis*. Although Lambiotte (1979) and Ponder (1983) listed it as a junior synonym of *X. mediterranea* and *X. crispa*, respectively, Le Loeuff *et al.* (1971), Goud & Kronenberg (1988-89) and Kreipl & Alf (1999) consider it a distinct species. Le Loeuff *et al.* (1971) regarded the Mediterranean *X. mediterranea* as specifically distinct from the West Atlantic *X. senegalensis* on the basis of statistical and ecological data. Kreipl & Alf (1999) considered the West Atlantic *X. senegalensis* a different species, partially sympatric with western Atlantic and Mediterranean *X. crispa*, because they were "not able to find any intermediate forms between *crispa* and *senegalensis*" (Kreipl & Alf, 1999, p. 53).

Xenophora aringus De Gregorio, 1885 (p. 70; type locality: "Altavilla (pliocene)") was established for a form with shell similar to that figured by Hörnes (1856, Pl. 44, fig. 3) as *Xenophora cumulans* (Brongniart, 1823), but with higher spire, subgranular base, posteriorly slightly angled whorls and small umbilicus. As far as we know, the status of De Gregorio's species has never been discussed. Ruggieri *et al.* (1958, p. 8) wrote that the taxa established by

De Gregorio are not available, but this is not true. We looked for type material of this species, but without success. The small umbilicus and subgranular base described by De Gregorio support *X. aringus* as a junior synonym of *X. crispa*, the only *Xenophora* species known from the Sicilian Pliocene.

Ponder (1983) grouped *X. crispa* and the tropical Indian and Pacific *X. solarioides* (Reeve, 1845) into an informal group of "small to medium species showing moderate to heavy attachment of foreign bodies, a narrow peripheral flange and a moderate umbilicus" but remarked that though the two species are similar, they are not closely related.

Sacco (1896) considered *X. crispa* to be derived from the Eocene-Oligocene *X. cumulans*, through *X. cumulans* var. *transiens* Sacco, 1896, of the Vienna Basin, but this hypothesis is unlikely in the light of current knowledge of Mediterranean palaeogeography. Ponder (1983) suggested that it may have evolved from Miocene *X. burdigalensis* (Gratoloup, 1847), a Lower Miocene species according to Cossmann & Peyrot (1919). The most likely hypothesis is that *X. crispa* evolved in the Atlantic during the Upper Miocene and entered the Mediterranean at the start of the Pliocene. Support for this hypothesis might come from the re-examination of the material from the Miocene of the Aquitaine Basin assigned to this species by Cossmann & Peyrot (1919) and from the Miocene of Florida, assigned to *Xenophora delecta floridana* Mansfield, 1930, an entity apparently very similar to *X. crispa* (Text-fig. 4).

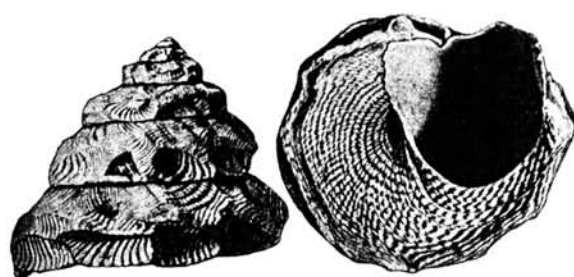
XENOPHORA DAVOLII n. sp.
Pl. 2, figs 1-4, Pl. 3, figs 1-3

Diagnosis – A species of *Xenophora* characterized by very large size (1), robust gradate shell (2), with narrow, irregular shaped, sharply keeled peripheral flange (3); about 7-9 whorls having irregular profile

(4); spire surface mostly free of attached objects or their scars (5), smooth with very irregular and prominent rugae, opisthocline in last whorls (6); attached objects (bivalve and gastropod shell fragments and pebbles) proportionally very large (7); scars of attached objects usually deep (8); base slightly concave (9); basal sculpture consisting of distinct collabral growth lines (10); basal margin of peristome slightly curved, thickened and slightly reflected (11); umbilicus absent (12).

Description – Shell (Pl. 2, figs 1-4; Pl. 3, figs 1-3) dextral, very large in size, robust and gradate, with pointed apex and very narrow, irregular shaped, sharply keeled peripheral flange; spire conical (spire angle about 70°), with probably 7-9 regularly growing whorls (first whorls always eroded); last whorl large, not dilated; profile of whorls variable: where attached objects are absent, whorls slightly convex, but where they are present, whorls irregular with lower part inflated and surmounting suture or periphery; sutures usually shallow; spire surface mostly free of attached objects and their scars, smooth with very irregular, prominent, drop-like rugae, which in last whorls, especially toward periphery, take opisthocline direction, intersected by faint prosocline growth lines (at points of intersection, growth lines sometimes have squamulate appearance); opisthocline riblets absent; attached objects proportionally very large, consisting of shell fragments and pebbles (largest object still attached is a 34×27 mm pebble, but scars of larger objects are visible); scars of attached objects usually deep; base slightly concave with distinct collabral growth lines (spiral lines not evident in the only adult shell having base free of sediment, but visible in a juvenile shell which lacks collabral growth lines); aperture large and oblique because innermost basal margin is almost one quarter of a whorl behind; peristome interrupted with upper and lower vertices united by large parietal callus covering columellar and inner portion of basal margin; basal margin of peristome with inner portion slightly curved, thickened and initially slightly reflected and outer portion initially jutting and then coinciding with internal surface of peripheral flange; external margin unknown; umbilicus absent.

Dimensions – The largest specimen (Pl. 2, fig. 1) is about 17 cm in diameter and 12 cm in height including attached objects.



Text-fig. 4 - Holotype of *Xenophora delecta floridana* Mansfield, 1930, from the Miocene of Florida. This entity is apparently very similar to *Xenophora crispa* (the shell is 38 mm in diameter and 30 mm in height; from Mansfield, 1930, Pl. 18, figs 5-6).

Type material – Eleven specimens from the following localities of the Siena Basin: Terre Rosse (6, VSC; 1, AFMSN), Guistrigona (1, VSC) and La Querce (1, FPC; 1, GMC). Another specimen was found at Podere Casuccia (1, VSC) in the Val di Chiana Basin. The holotype (Pl. 2, fig. 1) is kept in the Museo di Storia Naturale dell'Accademia dei Fisiocritici di Siena.

Type locality – Terre Rosse (Castelnuovo Berardenga).

Etymology – After Franco Davoli (Modena, Italy), for his many important contributions on the Neogene marine molluscs of the Euro-Mediterranean area.

Geographic and stratigraphic distribution – *Xenophora davolii* n. sp. is known from a few specimens collected in some Middle Pliocene outcrops of the Siena Basin, all of them deposited in shallow marine environments.

Remarks – Before describing a new species, we carefully checked that it did not correspond to some nominal taxon of the many created by past authors for Neogene xenophorids (Tab. 4). Once this was done, we proceeded to describe it as new.

The narrow peripheral flange makes it possible to assign *Xenophora davolii* n. sp. to *Xenophora*. Its gigantic size immediately distinguishes it from all extant *Xenophora* species. In fact, large *Xenophora*, such as *X. pallidula* (Reeve, 1842), *X. neozelanica* Suter, 1908, and *X. corrugata* (Reeve, 1842) do not exceed 90 mm in shell diameter. Only two extant

EXPLANATION OF PLATE 2

Figs 1-4 - *Xenophora davolii* n. sp.

- 1) Holotype, Museo di Storia Naturale dell'Accademia dei Fisiocritici di Siena. Middle Pliocene of Terre Rosse (Castelnuovo Berardenga);
- 2) G. Manganelli collection. Middle Pliocene of La Querce (Castelnuovo Berardenga);
- 3) V. Spadini collection. Middle Pliocene of Terre Rosse (Castelnuovo Berardenga);
- 4) F. Pizzolato collection. Middle Pliocene of La Querce (Castelnuovo Berardenga).



species, *Stellaria gigantea* Schepmann, 1909, and *Stellaria longleyi* Bartsch, 1931, have larger shells, but are very different from that of *X. davolii* n. sp. (for *S. gigantea*, see Goud & Kronenberg, 1988-89, Figs 35, 40; Kreipl & Alf, 1999, Pl. 20; for *S. longleyi*, see Goud & Kronenberg, 1988-89, Figs 35, 43; Kreipl & Alf, 1999, Pl. 28). The coarse opisthocline rugae are vaguely reminiscent of those of *X. granulosa* Ponder, 1983, *X. mekronensis* (Newton, 1905) and *X. tenuis* Fulton, 1838 (for *X. granulosa* see Goud & Kronenberg, 1988-89, Figs 1, 27; Kreipl & Alf, 1999, Pl. 7; for *X. mekronensis*, see Kreipl & Alf, 1999, Pl. 10; for *X. tenuis* see Goud & Kronenberg, 1988-89, Figs 1, 26; Kreipl & Alf, 1999, Pl. 17).

X. davolii n. sp. is easily distinguished from the other congeneric Mediterranean Pliocene species such as *X. crispa* (König, 1825), *X. infundibulum* (Brocchi, 1824) and *X. plioitalica* (Sacco, 1896). It is distinct from *X. crispa* by its larger size, absence of umbilicus, different whorl profile and sculpture (*X. crispa* is small with dorsal sculpture consisting of fine wavy meandering subspiral, sometimes opisthocline, riblets and umbilicus small or slit-like; Pl. 1, figs 1-10). It is also distinct from *X. infundibulum* and *X. plioitalica* by its gradate shell, convex whorls, dorsal surface smooth with very irregular and prominent rugae, which in the last whorls, especially toward the periphery, take an opisthocline direction, its capacity to agglutinate very large bodies and the curved basal margin of its peristome (*X. infundibulum* has flat whorls, minor agglutination capacity, dorsal sculpture consisting of evident opisthocline riblets, aperture very large and inner basal margin of peristome straight; Pl. 5, figs 1-4; Pl. 6, figs 1-3; *X. plioitalica* has flat or slightly convex whorls, dorsal sculpture consisting of wavy vermiculate opisthocline, aperture small and auriculate; Pl. 7, figs 1-3). Moreover, *X. davolii* is distinct from *X. scaldensis* from the Belgian Pliocene by large size, absence of umbilicus, whorl profile and sculpture (*X. scaldensis* is of medium size, with dorsal sculpture consisting of "irregular plicae" and umbilicus small; Marquet, 1997, pp. 72-73, Pl. 1, fig. 7).

X. davolii may already have been reported from the Italian Pliocene by Sacco (1896) as *Xenophora deshayesi* (Michelotti, 1847) on the basis of one incomplete shell from the "Astigiana", Piedmont Basin. This shell (Pl. 4, fig. 6) is large, has a gradate shape and agglutinates very large bodies, like *X. davolii*, but it has proportionally more attached objects and its dorsal surface free of attached objects or their scars does not seem smooth. Unfortunately, it lacks the last whorl (where the rugae become more evident and prominent) and the aperture, so that a definitive determination is impossible. There is another report of Pliocene *X. deshayesi* (Della Campana, 1890), but it has been impossible to check.

X. deshayesi is a species frequently recorded from the European Tertiary (Hörnnes, 1856; Michelotti, 1861; Locard, 1877; Seguenza, 1881; Koenen, 1882;

Parona, 1887; Della Campana, 1890; Sacco, 1896; Gignoux, 1913; Cossmann & Peyrot, 1919; Friedberg, 1923; Kautsky, 1925; Venzo, 1935; Sorgenfrei, 1940, 1958; Beets, 1946; Sieber, 1947, 1958; Glibert, 1949, 1952, 1963; Erünał-Erentöz, 1958; Kojumdieva & Strachimirov, 1960; Hözl, 1962; Anderson, 1965; Janssen, 1972, 1984; Nordsieck, 1972; Baldi, 1973; Bałuk & Radwański, 1977; Ponder, 1983; Zhu Min-Da, 1984; Bałuk, 1995; Lozouet *et al.*, 2001; Wienrich, 2001; Harzhauser *et al.*, 2003). Its status is nevertheless uncertain and its relationships to other Miocene nominal species, such as *X. burdigalensis* (Grateloup, 1847) and *X. grateloupi* (D'Orbigny, 1852), are not at all clear. Sacco (1896, p. 21) claimed "è una specie che passa gradualissimamente sia alle forme eoceniche, *confusa*, *cumulans*, *Benettiae*, sia alle viventi *trochiformis*, *pallidula*, ecc. tanto che dopo aver esaminato, non solo le figure, ma numerosi esemplari di ogni piano e di molte località, un vero carattere netto distintivo di questa specie non saprei indicarlo".

Although some authors (Sacco, 1896; Cossmann & Peyrot, 1919; Zhu Min-Da, 1984) have studied topotypical material, the lectotype or the neotype has never been designated. The only exhaustive redescrptions of *X. deshayesi* are those of Hörnnes (1856), Cossmann & Peyrot (1919) and Zhu Min-Da (1984). The only redescrptions of *X. burdigalensis* are those of Cossmann & Peyrot (1919), Janssen (1984) and Zhu Min-Da (1984), but that of Janssen (1984) may be based on misidentified material. The only redescrption of *X. grateloupi* is that of Cossmann & Peyrot (1919). Although revision of these taxa is beyond the aim of this paper, we thought it useful to define them to discuss their relationships with the Pliocene species.

Status of Phorus deshayesi Michelotti, 1847, and allied Miocene species – Michelotti (1847, pp. 173-174) described *Phorus deshayesi* as "P[horus]. testâ conicâ, corpora varia agglutinante; anfractibus planis, superne rugis laxè cancellatâ; basi sulcis radiantibus obliquis instructâ; umbilico tecto; margine simplici" from "La colline de Turin, les environs de Bordeaux, la Touraine et la Pologne". According to Michelotti (1847) some materials misidentified as *Trochus benettiae* by Brongniart (1823, p. 56, Pl. 6, figs 3a-3b; "Loignan près Bordeaux" and "la montagne de Supergue près Turin"), Pusch (1837, p. 110; "Londonon, an der Superga bei Turin und bei Bordeaux") and Dujardin (1837, p. 284; "faluns de Manthelan") matched to his species.

Grateloup (1840, but actually 1847, caption of Troques Pl. 1, fig. 1) introduced *Trochus conchyliophorus* var. *burdigalensis* for a shell from Saubrigues, listing as synonyms: "*Troc. Benettiae*. Sow. Miner. Conch. t. 98. f. 1. 2. de Bast. Foss. n.° 1. Al. Brogn. Vic. pl. 6. f. 3. Grat. Tabl. 189. Grat. Cat. zool. n.° 181". These five entries include the original descrip-

Tab. 4 - Nominal taxa of the species group introduced for Neogene xenophorids. The list is mainly derived from Ponder & Cooper (1983) and includes all currently known valid and invalid nominal taxa established for Neogene xenophorids. Many taxa, introduced by Sacco (1896) as varieties, have controversial nomenclatural status. In fact, they often refer to infrasubspecific taxa and as such are not available (ICZN, 1999: Art. 45.6.4). Their infrasubspecific status is supported by the fact that these nominal taxa often coexist temporally and geographically with other forms including the nominotypical one, e.g. *X. crispa* var. *elator*: "Piacenziano ed Astiano: (col tipo, ma alquanto rara)", *X. crispa* var. *depressor*: "Piacenziano ed Astiano: (col tipo, ma poco frequente)"; *X. testigera* var. *elatuscula*: "... Piacenziano: Colla forma tipica (poco frequente)"; etc. They may only be available under Art. 45.6.4.1, i.e. if a subsequent author adopted them as the valid name of a species or subspecies before 1983. Original combination, complete reference, type locality (as originally given) and some remarks are given for each nominal taxon.

Nominal taxon and references	Type locality	Remarks
[<i>Phorus</i>] <i>Aquensis</i> D'Orbigny, 1852: 41, by indication (Grateloup, 1847, Troques Pl. 1, figs 3-4, excl. figs 1-2 and synonymy).	Miocene; "France, St-Paul (Landes)" (D'Orbigny, 1852); "Dax ... à St-Paul, fal. jaun., 2. ° ét., sup." (Grateloup, 1847).	A junior objective synonym of <i>Trochus conchyliophorus</i> var. <i>parisiensis</i> Grateloup, 1847. According to Cossmann & Peyrot (1919), a junior synonym of <i>Xenophora burdigalensis</i> (Grateloup, 1847).
<i>Xenophora aringus</i> De Gregorio, 1885: 70.	Pliocene; Sicily, "Altavilla".	A junior synonym of <i>Xenophora crispa</i> (König, 1825) (this paper).
<i>Trochus Bellardii</i> Michelotti, 1840: 14.	Pliocene; Italy, "presso Verduno in Piemonte".	According to Sacco (1896), a junior synonym of <i>Stellaria testigera</i> (Bronn, 1831).
<i>Xenophora birmanica</i> Noetling, 1901: 280-281, Pl. 18, figs 21-21a.	Miocene, "Zone of <i>Aricia humerosa</i> "; Burma, Thayetmyo.	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).
<i>Phorus Borsoni</i> Sismonda, 1847: 50, by indication (Michelotti, 1847, 175, Pl. 7, fig. 1).	Miocene; Italy, "Terr. mioc. Taur. (Sismonda, 1847); "La colline de Turin et Tortone" (Michelotti, 1847).	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Onustus</i>).
[<i>Trochus conchyliophorus</i>] var. <i>Burdigalensis</i> Grateloup, 1847, Troques Pl. 1, fig. 1.	Miocene; France, "Dax ... à Saubrigues, Fal. bl., 2. ° ét., inf."; material from other localities is cited by bibliographical references.	<i>Xenophora burdigalensis</i> (Grateloup, 1847).
<i>Trochus colligens</i> Michelotti, 1840: 14.	Miocene; Italy, "Tortonese".	According to Sacco (1896), a junior synonym of <i>Stellaria testigera</i> (Bronn, 1831).
<i>Xenophora commutata</i> Fischer, 1879: 211.	Pliocene, "Astésan ... typique à Altavilla (Sicilie)".	A junior synonym of <i>Xenophora crispa</i> (König, 1825).
<i>Trochus crispus</i> König, 1825: 3, Pl. 5, fig. 58.	König reported it "cum praecedente [<i>Trochus agguittinans</i> Lam.]", i.e. "in calcario cerithico et in argilla prope Grignon Galliae, & c." Type locality, restricted to "Asti, Italy (Astian, Upper Pliocene)" by Ponder (1983: 45), is definitively fixed by the present neotype designation.	<i>Xenophora crispa</i> (König, 1825).
<i>Phorus delectus</i> Guppy, 1876: 529, Pl. 28, fig. 10.	Miocene; Dominican Republic, Haiti.	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).
<i>Xenophora depressa</i> Pantanelli, 1887: 125-126, Pl. 5, figs 6-7.	Miocene ("Argilla del miocene inferiore"); Italy, "Torre della Maina".	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Stellaria</i>) species.
[<i>Xenophora</i>] (<i>X[enophora]</i> .) <i>crispa</i> var. <i>depressor</i> Sacco, 1896: 22, Pl. 2, fig. 24.	Pliocene, "Piacenziano ed Astiano [del Piemonte e della Liguria]: (col tipo, ma poco frequente)", Italy. The shell illustrated is from Ceriale.	A junior synonym of <i>Xenophora crispa</i> (König, 1825).
<i>Phorus deshayesi</i> Michelotti, 1847: 173-174.	Miocene, "La colline de Turin, les environs de Bordeaux, la Touraine et la Pologne". If and when the designation of the proposed neotype is ruled by the ICZN, the type locality will begin "Colli Torinesi".	<i>Xenophora deshayesi</i> (Michelotti, 1847).
<i>Xenophora Dunkeri</i> Martin, 1879: 71-72, Pl. 12, fig. 7.	Miocene; Java (Ponder & Cooper, 1983).	<i>Stellaria chinensis dunkeri</i> (Martin, 1879) (see Ponder, 1983).
[<i>Xenophora</i>] (<i>X[enophora]</i> .) <i>deshayesi</i> var. <i>elatespirata</i> Sacco, 1896: 21, Pl. 2, fig. 21.	Miocene, "Elveziano: Colli torinesi (non rara)", Italy.	According to Ponder & Cooper (1983), a junior synonym of <i>Xenophora deshayesi</i> (Michelotti, 1847).
[<i>Xenophora</i>] (<i>X[enophora]</i> .) <i>crispa</i> var. <i>elator</i> Sacco, 1896: 22, Pl. 2, fig. 23.	Pliocene, "Piacenziano ed Astiano [del Piemonte e della Liguria]: (col tipo, ma alquanto rara)", Italy. The shell illustrated is from the Lower Pliocene of Bordighera.	A junior synonym of <i>Xenophora crispa</i> (König, 1825).

Continued.

Tab. 4 - Continued.

[<i>Xenophora</i>] (<i>Xenophora</i> .) <i>testigera</i> var. <i>elatuscula</i> Sacco, 1896: 25, Pl. 3, fig. 2.	Miocene, "Elveziano: Colli torinesi, Baldissero, S. Raffaele (non rara)", Italy. Pliocene, "Piacenziano [del Piemonte e della Liguria]: colla forma tipica (poco frequente)", Italy.	A junior synonym of <i>Stellaria testigera</i> (Bronn, 1831).
[<i>Xenophora</i> (<i>Xenophora</i>) <i>infundibulum</i>] var. <i>expansior</i> Sacco, 1896: 24.	Pliocene, [del Piemonte e della Liguria], Italy.	A junior synonym of <i>Xenophora infundibulum</i> (Brocchi, 1814).
<i>trochus Farinesi</i> De Serres, 1831: 73-75.	"Terrains marins tertiaires du Midi de la France ... dans les marnes sableuses marines, qui forment de petites collines sur les rives de la Têt à Millar et à Neffiach, ou sur les rives du Tech au Boulon et à Banyuls-dels-Aspre".	According to Sacco (1896), a junior synonym of <i>Xenophora infundibulum</i> (Brocchi, 1814).
<i>Xenophora flemingi</i> Beu, 1977: 233-235, figs 2, 5, 7, 8, 10, 13-17.	Lower Miocene, "Concretionary Member of Otahu Formation, between Clifden Limestone and Calamity Point, south bank Waiau River, Clifden, Southland", New Zealand.	<i>Xenophora flemingi</i> Beu, 1977.
<i>Xenophora delecta</i> var. <i>floridana</i> Mansfield, 1930: 121-122, Pl. 18, figs 5-6.	Miocene, "Harveys Creek, half a mile above abandoned mill, Leon County, Fla.", US.	A <i>Xenophora</i> species very similar to <i>Xenophora crispa</i> (König, 1825).
<i>Phorus grateloupi</i> [sic] D'Orbigny, 1852: 7, by indication (Grateloup, 1847: Troques Pl. 1, fig. 2, excl. figs 1, 3, 4).	Miocene, "France, Dax, Saubrigues (D'Orbigny, 1852); "Dax ... à Saubrigues, Fal. bl., 2. ° ét., inf." (Grateloup, 1847).	<i>Xenophora grateloupi</i> (D'Orbigny, 1852).
[<i>Xenophora</i>] (<i>Tugurium</i> .) <i>plioitalicum</i> [sic] var. <i>gracilior</i> Sacco, 1896: 25-26, Pl. 3, Fig. 7.	Pliocene, "Piacenziano: Rio del Molino di Galatea presso Chieri (rara)", Italy.	A junior synonym of <i>Xenophora plioitalicum</i> (Sacco, 1896).
<i>Xenophora hawley</i> Loel & Corey, 1932: 269-270, Pl. 63, fig. 12.	"Vaqueros horizon, Lower Miocene only? Abundant in western Santa Ynez Mountains in the above noted zone, Santa Barbara County and present in San Luis Obispo region (Corral de Piedra Creek)", California, US.	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).
<i>Xenophora helvetica</i> Dollfus & Dautzenberg, 1886: 142, by indication ("Trochus Bennetti Duj. non Brong."). <i>Xenophora helvetica</i> "Mayer" Kaufmann, 1872: 504, is a <i>nomen nudum</i> .	Miocene; France, faluns de la Touraine (Dollfus & Dautzenberg, 1886); "faluns de Manthelan" (Dujardin, 1837).	Ponder & Cooper (1983) considered <i>Xenophora helvetica</i> available from Rutsch (1929); actually it is available since Dollfus & Dautzenberg (1886) because accompanied by an indication. According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).
<i>Xenophora hoi</i> Wang, 1984: 350-351, Pl. 4, figs. 4-6.	Miocene; Chiufenerh-shan, Kuohsing-hsiang, Nantou-hsien, central Taiwan; uppermost part of Shihmem Member of the Shuilikeng Formation (late early Miocene).	A nominal species based on very badly preserved specimens.
<i>O[nustus]. imperforatus</i> Gabb, 1873: 241.	Miocene, Santo Domingo, Dominican Republic.	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Onustus</i>).
<i>Trochus infundibulum</i> Brocchi, 1814: 352-353, Pl. 5, fig. 17.	Pliocene, "... nel Piacentino, a San Geminiano e a Libiano in Valdera", Italy.	<i>Xenophora infundibulum</i> (Brocchi, 1814).
[<i>Trochus conchyliophorus</i>] var. <i>italica</i> [sic] Grateloup, 1847: Troques Pl. 1, fig. 2.	Miocene; France, "Dax ... à Saubrigues, Fal. bl., 2. ° ét., inf."; material from other localities is cited by bibliographical references.	A not available senior objective synonym of <i>Phorus grateloupi</i> D'Orbigny, 1852.
<i>Xenophora jezleri</i> Cox, 1948: 20-21, Pl. 1, figs 11a-11c.	Neogene (Upper Miocene or Pliocene, Ponder, 1983); Sabah, Dent Peninsula.	<i>Xenophora solarioides jezleri</i> Cox, 1948 (see Ponder, 1983).
<i>Xenophora kantzulina</i> Wang, 1984: 347-349, Pl. 3, figs. 1-4, Pl. 4, fig. 8.	Miocene; Hanging bridge of Kantzulin, Kuohsing-hsiang, Nantou-hsien, central Taiwan; Changhukeng Member of the Shuilikeng Formation (late early Miocene).	A nominal taxon in need of revision.
<i>Xenophora</i> (<i>Xenophora</i>) <i>flindersi ludbrookae</i> Ponder, 1983: 27-28, Figs 13d, 17i, j.	"Roe Plain, Eucla Basin, Western Australia at Hampton Microwave Repeater Tower ... Lower Pleistocene and possible Upper Pliocene", south Western Australia.	<i>Xenophora flindersi ludbrookae</i> Ponder, 1983.
<i>Tugurium makiyamai</i> Itoigawa & Nishikawa, 1976: 147-148, Pl. 35, figs 7-8.	Miocene, "Todani, Osa-cho, Atetsu-gun, Okayama Pref. ... lowermost part of the upper member of Bihoku group", Japan.	According to Ponder & Cooper (1983), probably a <i>Xenophora</i> (<i>Stellaria</i>).
<i>Tugurium mekranense</i> Newton, 1905: 301, Pl. 17, figs 8-10.	Pliocene, "Mekran Beach, off the Ormara Headland, Baluchistan", Iran.	<i>Xenophora mekranense</i> (Newton, 1905) (see Ponder, 1983).

Continued.

Tab. 4 - Continued.

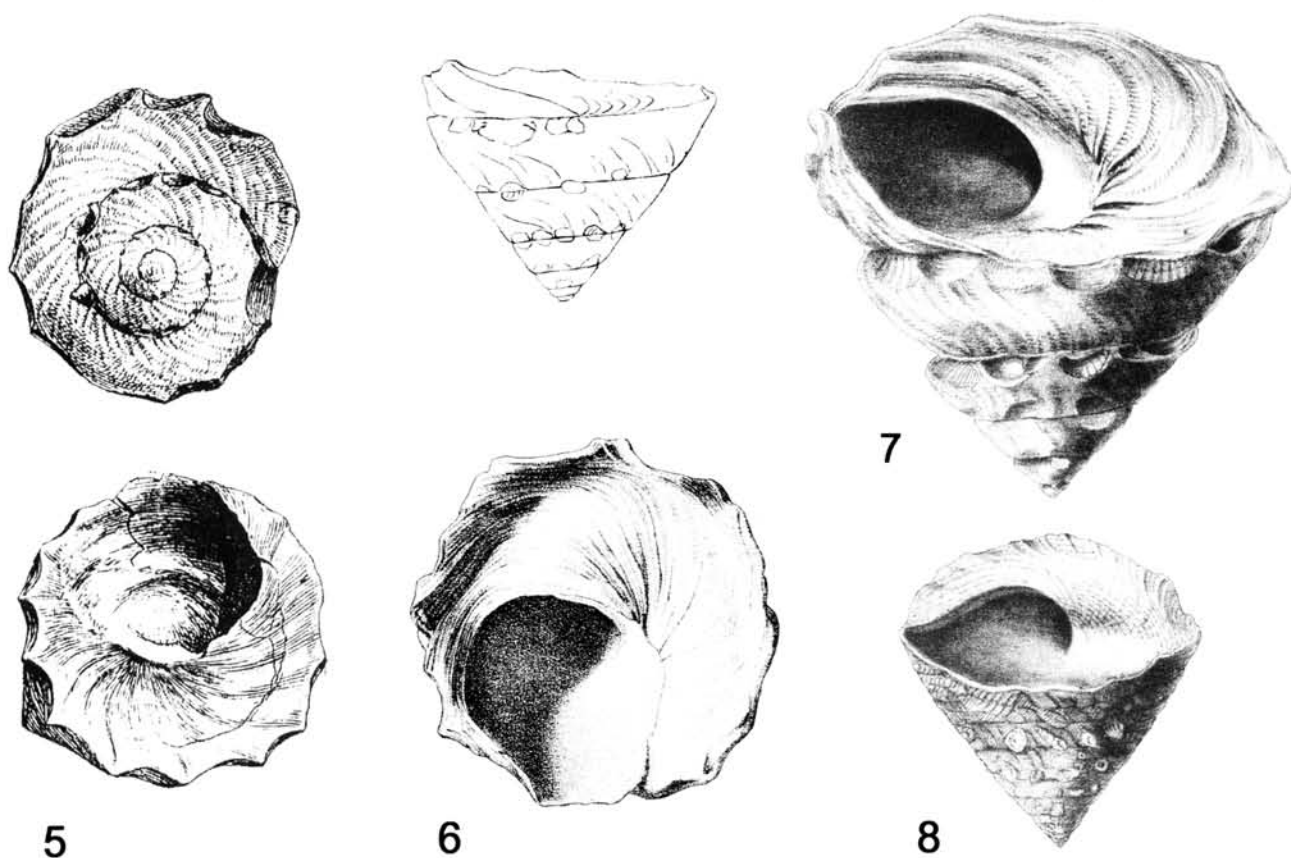
[<i>Xenophora</i>] (<i>Tugurium</i> .) <i>borsoni</i> var. <i>pagodaeformis</i> Sacco, 1896: 28, Pl. 4, fig. 5.	Miocene, "Elveziano: Colli torinesi, Baldissero (non rara)", Italy. The shell illustrated is from Colli Torinesi.	According to Ponder & Cooper (1983), a junior synonym of <i>Xenophora</i> (<i>Onustus</i>) <i>borsoni</i> (Sismonda, 1847).
[<i>Trochus conchyliophorus</i>] var. <i>Parisiensis</i> Grateloup, 1847, Troques Pl. 1, figs 3-4.	Miocene; France, "Dax ... à St-Paul, fal. jaun., 2. ° ét., sup."	According to Cossmann & Peyrot (1919), a junior synonym of <i>Xenophora burdigalensis</i> (Grateloup, 1847).
<i>Xenophora paulinae</i> Nielsen & De Vries, 2002: 75, Figs 12-16.	Miocene; Intertidal platform at Punta Perro, central Chile; Navidad Formation, Tortonian.	<i>Xenophora paulinae</i> Nielsen & De Vries, 2002
<i>Xenophora peroni</i> Locard, 1877: 109-110, Pl. 1, figs 12-13.	Miocene; Corse, Bonifacio.	A nominal species based on very badly preserved specimens.
[<i>Xenophora</i>] (<i>Tugurium</i>) <i>plioextensum</i> [sic] Sacco, 1896: 27, Pl. 4, fig. 3.	Pliocene, "Piacenziano: Monte Castello presso Alessandria (poco frequente)", Italy.	<i>Stellaria plioextensa</i> (Sacco, 1896).
[<i>Xenophora</i>] (<i>Tugurium</i>) <i>plioitalicum</i> [sic] Sacco, 1896: 25, Pl. 3, fig. 6.	Pliocene, "Piacenziano: Albenga (rara)", Italy.	<i>Xenophora plioitalica</i> Sacco, 1896.
[<i>Xenophora</i>] (<i>Tugurium</i>) <i>postextensum</i> [sic] Sacco, 1896: 26, Pl. 3, figs 8, 9, pl. 4, fig. 1.	Miocene, "Aquitano: Colli torinesi, Langhe, Ceva (frequente). Langhiano: Colli torinesi (poco frequente). Elveziano: Colli torinesi, Robella, Barbaresco presso Alba, Cavesana, Langhe, Monregalese (frequente). Tortoniano inferiore ? Stazzano (non raro)", Italy.	According to Ponder & Cooper (1983), a probable junior synonym of <i>Xenophora</i> (<i>Stellaria</i>) <i>depressa</i> (Pantanelli, 1887).
<i>Xenophora sanyiensis</i> Wang, 1984: 349-350, Pl. 4, figs. 1-3.	Pliocene; Sanyi, Miaoli-hsien, northern Taiwan; Shihiliufen Shale (early Pliocene).	A nominal species based on very badly preserved specimens.
<i>Xenophora deshayesi scaldensis</i> Glibert, 1958: 24.	Miocene, "Helvétien (Bassin de la Loire)", France and "Anversien (Sables d'Anvers)", Belgium.	<i>Xenophora scaldensis</i> Glibert, 1958 (see Marquet, 1997).
<i>Xenophora solariformis</i> Tesch, 1920: 73-74, Pl. 133, fig. 214a-c.	Pliocene; Timor (Ponder & Cooper, 1983).	According to Ponder (1983), a junior synonym of <i>Stellaria solaris</i> (Linnaeus, 1758).
<i>Xenophora subconica</i> Boettger 1882: 70, Pl. 5, figs 14a-14b.	Miocene; Sumatra (Ponder & Cooper, 1983).	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).
<i>Xenophora</i> (<i>Xenophora</i>) <i>suezi</i> Abbas, 1977: 127, Pl. 5, fig. 6.	Miocene, "Burdigalian, Agrud Member, Agrud", Egypt.	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).
<i>Xenophora</i> (<i>Tugurium</i>) <i>tatei</i> Harris, 1897: 254-255, Pl. 7, figs 7a-b.	"Eocene: Victoria and South Australia ... from Muddy Creek" (Harris, 1897); "Muddy Creek, Victoria (Balcombian, Miocene)" (Ponder, 1983).	<i>Xenophora tatei</i> Harris, 1897 (see Ponder, 1983).
[<i>Xenophora</i>] (<i>X[enophora]</i> .) <i>testigera</i> var. <i>tauroturrita</i> Sacco, 1896: 25, Pl. 3 fig. 3.	Miocene, "Elveziano: Colli torinesi (poco frequente)", Italy.	According to Ponder & Cooper (1983), a junior synonym of <i>Stellaria testigera</i> (Bronn, 1831).
<i>Xenophora terpstrai</i> Dey, 1961: 58-59, Pl. 5, figs 9, 10.	Miocene of Quilon, Kerala (India).	According to Ponder & Cooper (1983), a junior synonym of <i>Xenophora solarioides jezleri</i> Cox, 1848.
<i>Phorus testigerus</i> Bronn, 1831: 61.	"Cq. Ba. C. 15". "Cq." is for Castell'arquato, "Ba.", a slip for "Bc", is for Bacedasco, "C" is for "Jüngerer Grobkalk, blau, thonig, in den Apenninen". Following the present neotype designation, the type locality becomes: Bacedasco.	<i>Stellaria testigera</i> (Bronn, 1831).
[<i>Xenophora</i>] <i>testudinarium</i> Benoist, 1878: LXXXVIII.	Miocene, "Tortonien ... Largileyre, situé dans le bourg de Salles", France.	A <i>nomen nudum</i> .
<i>X[enophora]</i> . <i>textilina</i> Dall, 1892: 361.	"Older Miocene of the Chipola beds", Florida, US.	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).
<i>Xenophora Trinacria</i> Fischer, 1879: 211.	Pleistocene; Sicily, Ficarazzi.	A junior synonym of <i>Xenophora crispa</i> (König, 1825).
<i>Xenophora Turicensis</i> Heer, 1862: 34 (fide Ponder & Cooper, 1983, who tentatively attributed authorship to J.R.A. Moussun), Kaufmann, 1872: 504.	Miocene, Switzerland.	A <i>nomen nudum</i> .
[<i>Xenophora</i> (<i>Xenophora</i>) <i>cumulans</i>] var. <i>transiens</i> Sacco, 1896: 23, by indication (Hörnes, 1856, Pl. 44, fig. 13).	Miocene, Loibersdorf (Hörnes, 1856), Austria.	According to Ponder & Cooper (1983), a <i>Xenophora</i> (<i>Xenophora</i>).

tion (Sowerby, 1815) and four subsequent reports (Brongniart, 1823; Basterot, 1825; Grateloup, 1832, 1838) of *Trochus benettiae*, a British Eocene species regarded as a junior synonym of *Stellaria? schroeteri* (Gmelin, 1891) by Ponder & Cooper (1983).

D'Orbigny (1852, p. 7) introduced *Phorus grateloupi* for the shell from Saubrigues, figured as *Trochus conchyliophorus* var. *italica* in Grateloup's Atlas (Grateloup, 1847, Troques Pl. 1, fig. 2).

The correspondence between *P. deshayesi* and *T. conchyliophorus* var. *burdigalensis* was apparently supported by Sismonda (1847), D'Orbigny (1852), Hörnes (1856), Locard (1877), and Du Boucher (1884-85) who listed fig. 1 of Troques plate 1 of Grateloup's Atlas as "*T. benettiae*" or "*T. conchyliophorus*" in the synonymy of *X. deshayesi*. Sacco (1896) was convinced of their synonymy and first realized the apparent priority of Grateloup's name, but he did not think it necessary to make any nomenclatural change because "dopo mezzo secolo che si usa da tutti l'appellativo *Deshayesi* sembra più opportuno di conservarlo che non di sostituirlo con un nome proposto come varietà e mai da alcuno accennato".

Cossmann & Peyrot (1919) revised *T. conchyliophorus* var. *burdigalensis* and discussed its relationship to *X. deshayesi*. They first clarified the exact date of publication of Grateloup's Atlas as 1847 not 1840, because one of them [A.P.] had the proofs of the atlas with "Bon à tirer, 17 avril 1847" hand-written by Grateloup. Consequently, under these conditions they would not have hesitated to give priority to Michelotti's name if the two species had been synonyms. In fact, they regarded *T. conchyliophorus* var. *burdigalensis* and *P. deshayesi* as distinct taxa, identified by the characters of the base: "les stries concentriques de *X. Deshayesi* sont assez régulièrement écartées, quoique moins distantes vers le centre, tandis que les fines stries subobliques de *X. burdigalensis* sont partout plus serrées, ponctuées et beaucoup moins profondes; les plis d'accroissement de l'échancrure du plafond décrivent – chez *X. Deshayesi* – une courbe bien plus ample et plus creuse, commençant plus tôt vers le centre, devenant moins rapidement parallèle au bord périphérique, tandis que les plis de *X. burdigalensis* restent plus longtemps perpendiculaires dans leur rayonnement et font à la périphérie



Text-figs 5-6 - *Trochus benettiae*. 5) from Sowerby (1815, Pl. 98); 6) from Brongniart (1823, Pl. 6, figs 3a-3b);

Text-figs 7-8 - *Trochus conchyliophorus*. 7) *T. c.* var. *burdigalensis* from Grateloup (1847, Troques Pl. 1, fig. 1); 8) *T. c.* var. *italica* from Grateloup (1847, Troques Pl. 1, fig. 2).

The shells illustrated in Text-figs 5-7 are syntypes of *T. conchyliophorus* var. *burdigalensis*, that in Text-fig. 6 of *Phorus deshayesi* and that in Text-fig. 8 of *T. conchyliophorus* var. *italica* and its junior objective synonym *Phorus grateloupi*. Magnification and orientation of some figures modified with respect to the original.

un arc plus subit pour devenir parallèles au bord festonné". They figured a shell from Léognan (Cossmann & Peyrot, 1919, Pl. 17, figs 105-106) (Text-fig. 9) to which they referred as the "néotype de cette espèce" (p. 258), or as the "plésiotype" (p. 261). According to Cossmann & Peyrot (1919), the shell reported as *T. benettiae* by Brongniart (1823, 56, Pl. 6, figs 3a-3b) (Text-fig. 6) belonged to this species. On the contrary, the shell reported by Hörnes (1856, 442, Pl. 44, fig. 12) is actually considered to belong to *X. deshayesi*. Cossmann & Peyrot (1919) assigned very small (25 mm in diameter and 12 mm in height), low-spined shells to *X. deshayesi* based on the fact that "Hoernes, dans son Atlas (pl. 44, fig. 12a), a fait représenter un spécimen presque aussi surbaissé que ceux de Mancient, et il lui attribue la même dénomination *Deshayesi*". It is evident that they misinterpreted Hörnes's legend of plate 44. In fact, fig. 12.a does not represent a low-spined *X. deshayesi*, but an apertural view of a shell of *X. deshayesi*, then illustrated in basal view as 12.b. What they considered a low-spined *X. deshayesi* is fig. 13, i.e. a shell assigned by Hörnes to *Xenophora cumulans* (Brongniart, 1823).

Cossmann & Peyrot (1919, 265-267) also revised *P. grateloupi*, which they confirmed as a distinct species, similar to *X. trinacria* Fischer, 1879, from the Pliocene of Sicily. They realized that this nominal taxon was first named by Grateloup (1847) as *Trochus conchyliophorus* var. *italica*, but thought it inappropriate to reintroduce this specific epithet. Finally, they figured a shell of *X. grateloupi* from Saubrigues (Pl. 13, figs 3-4) (Text-fig. 10) to which they referred as "néotype" (p. 261).

Subsequent authors accepted the distinction between *X. deshayesi* and *X. burdigalensis* (? Mongin, 1952; Erünał-Erentöz, 1958; Glibert, 1963; Janssen, 1984; Zhu Min-Da, 1984; Rocher, 2002), with the exception of Baldi (1973) and Bałuk (1995) who questioned the validity of *X. burdigalensis*, because the differences in base sculpture used by Cossmann & Peyrot (1919) to distinguish this species from *X. deshayesi* were "hardly relevant" (Baldi, 1973, p. 266) and "of very low importance, and it may result from individual variability" (Bałuk, 1995, p. 179). Apart from Ponder (1983), no one seems to have reported *X. grateloupi* again.

Michelotti (1847) indicated that the material of *P. deshayesi* was in "Mus. Soc. Holl." and his "Cabinet", the former denoting the Société Hollandaise des Sciences à Haarlem [now Hollandsche Maatschappij der Wetenschappen te Haarlem] and the latter his own collection. Today, the Hollandsche Maatschappij der Wetenschappen te Haarlem no longer has a paleontological collection (B. Dortland-Bier, personal communication). Michelotti's private collection was at the Istituto di Geologia of the Università di Roma [now Dipartimento di Scienze della Terra], in part of the building which was damaged by the bombing of 19th July 1944 (Fabiani & Maxia, 1953). In what

remains of the collection, no material of *P. deshayesi* is present (R. Manni, personal communication). Michelotti's concept of *P. deshayesi* is based on materials from "La colline de Turin, les environs de Bordeaux, la Touraine et la Pologne". He certainly studied specimens from "La colline de Turin", whereas the other materials (Brongniart, 1823; Dujardin, 1837; Pusch, 1837) may only have been cited from literature. Cossmann & Peyrot (1919) considered the shell from Loignan figured by Brongniart (1823) to belong to *X. burdigalensis* and used "un calque de la base du type de Colli Torinesi (*in* Sacco, Moll. terz. Piem. 1896, parte XX, p. 20, pl. II, fig. 20)" for their re-definition of the species, revealing that they (and others, e.g. Glibert, 1963, p. 24) regarded Colli Torinesi as the true type locality of Michelotti's species. The shell illustrated by Sacco (1896) (BS.066.01.001) (Pl. 4, fig. 1) has no type status because there is no sure evidence that it belonged to the material studied by Michelotti (1847), but it is the first from Colli Torinesi to be figured and it has been used as reference for interpreting Michelotti's species. It belongs to a subadult specimen and is one of best preserved of the many specimens from Colli



Text-fig. 9 - *Xenophora burdigalensis* sensu Cossmann & Peyrot (1919) from Léognan (from Cossmann & Peyrot, 1919, Pl. 17, figs 105-106). Magnification and orientation modified with respect to the original.

Torinesi. We therefore propose it be designated as the neotype of *P. deshayesi*. However before doing this, it is necessary to definitively ascertain whether the shell figured by Brongniart (1823, Pl. 6, figs 3a-3b) still exists and if so, to apply to the ICZN to set aside its type status.

Type material of *X. burdigalensis* consists of shells collected at Saubrigues and figured by Grateloup (1847, Troques Pl. 1, fig. 1) (Text-fig. 7) and the shells illustrated by Sowerby (1815, Pl. 98, larger figures, from Great Britain) and Brongniart (1823, Pl. 6, fig. 3a-3b, from Loignan près Bordeaux) (Text-figs 5-7). The figures of these shells are very fine, but that of Grateloup does not show aperture shape. The shell figured by Brongniart (1823) corresponds very well, especially in aperture shape, to that from Léognan illustrated by Cossmann & Peyrot (1919, Pl. 17, figs 105-106) (Text-fig. 6), to which they referred as the "neotype de cette espèce" (p. 258).

Type material of *X. grateloupi* consists of material collected at Saubrigues and figured by Grateloup (1847, Troques Pl. 1, fig. 2) (Text-fig. 8). Unfortunately, this shell is illustrated in a way that obscures aperture shape. A fine shell from Saubrigues is figured by Cossmann & Peyrot (1919, Pl. 13, figs 3-4) (Text-fig. 10), but it seems to have a lower spire than that illustrated by Grateloup. Again, Cossmann & Peyrot (1919) referred to this specimen as the "neotype de cette espèce" (p. 258).

We do not know whether the syntypes of *X. burdigalensis* and *X. grateloupi* still exist. Once their loss is definitively ascertained, we propose designating the shell illustrated by Cossmann & Peyrot (1919) in figs 105-106 of plate 17 as the neotype of *X. burdigalensis* and that illustrated in figs 3-4 of plate 13 as the neotype of *X. grateloupi*. In fact, Cossmann & Peyrot's "Conchologie néogénique de l'Aquitaine" is a milestone of European Neogene molluscan paleontology. It has always been widely consulted and their revision of the Miocene xenophorids has been a basis for subsequent understanding of these nominal taxa. Consequently, when a neotype becomes necessary, one should consider choosing it from their collections or at least in line with their species concept. Cossmann & Peyrot (1919) referred to some of these specimens as "neotypes", though not in the sense required by the Code of Nomenclature.

Only designation of the types can open the way to a modern revision of the European Miocene xenophorids enabling clarifications of the status of the nominal taxa described till now, the status of the many different forms usually assigned to *X. deshayesi* and the geographic and stratigraphic distribution of



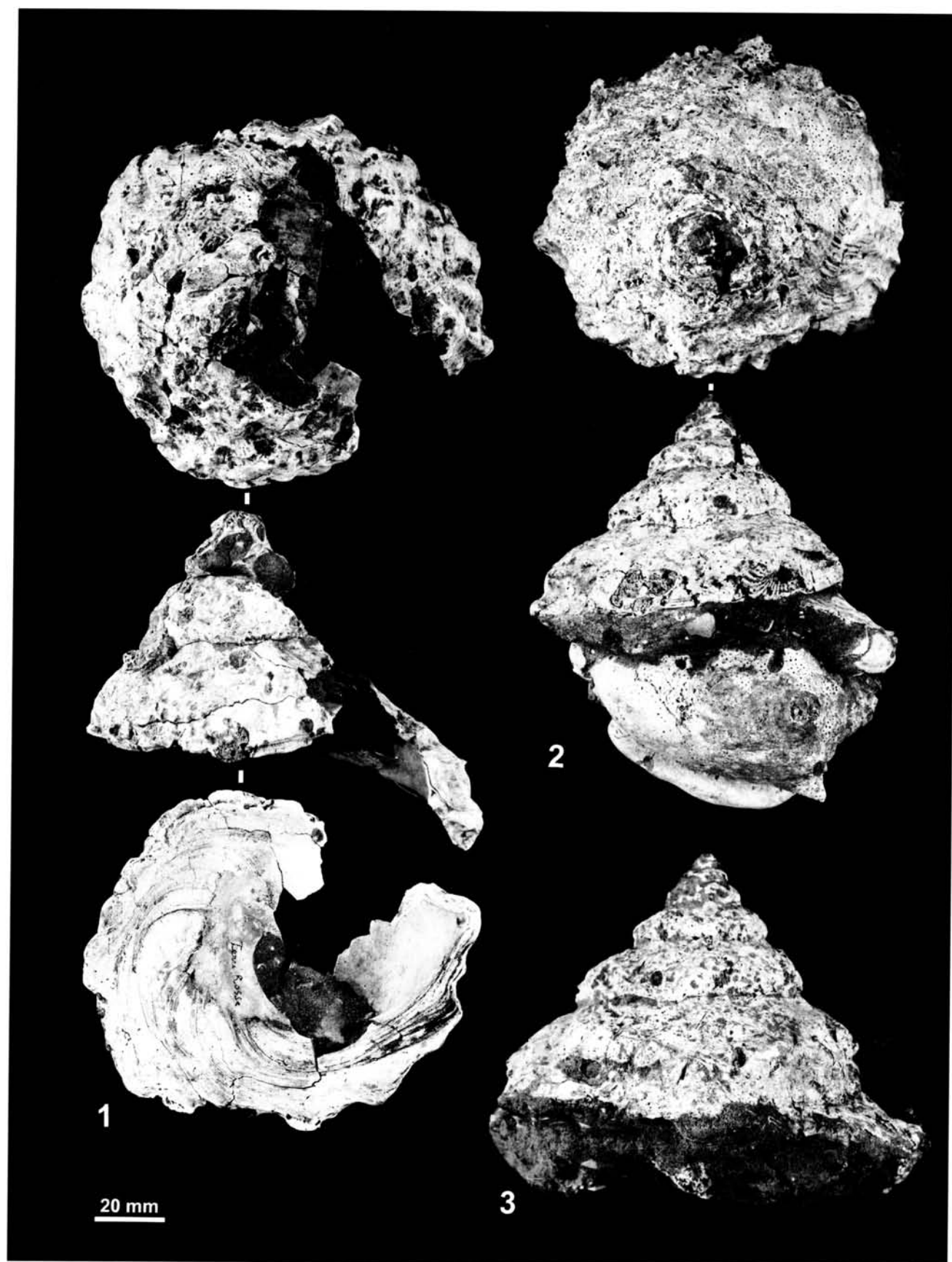
Text-fig. 10 - *Xenophora grateloupi* sensu Cossmann & Peyrot (1919) from Léognan (from Cossmann & Peyrot, 1919, Pl. 13, figs 3-4). Magnification and orientation of some figures modified with respect to the original.

the valid species. Many of the forms assigned to *X. deshayesi* differ remarkably in shell shape and size, sculpture and aperture shape and size. For example, specimens of *X. deshayesi* from Colli Torinesi (Pl. 4, figs 1-3) and those from Vienna Basin (Pl. 4, fig. 6; see also Hörnes, 1856, Pl. 44, fig. 12.b) have a different structure of the peristomal basal margin. In the Pliocene specimens, such differences are constant and distinguish different species.

Conclusive remarks on Xenophora davolii n. sp. – For the present, accepting these three nominal species: *X. burdigalensis*, *X. deshayesi*, and *X. grateloupi*, in the above sense, *X. davolii* n. sp. is again distinct from them by larger size, smooth dorsal sur-

EXPLANATION OF PLATE 3

Figs 1-3 - *Xenophora davolii* n. sp. from the Middle Pliocene of Terre Rosse (Castelnuovo Berardenga) (Fig. 1, G. Manganelli collection; Figs 2-3, V. Spadini collection).



face with very irregular and prominent rugae and its proportionally larger aperture (at least with respect to *X. deshayesi* and *X. burdigalensis*), however its relationship to the others remains obscure. It may be one of the last offshoots, together with *X. infundibulum* and *X. plioitalica*, of the *X. deshayesi* group of forms sensu Ponder (1983), a group characterized by "rather large, evenly conical shells, with narrow, simple peripheral flanges and, in most but not all species, reduced areas of agglutination" and including several species from the Eocene to the Pliocene (*X. wemmelensis* Glibert, 1938, *X. petrophora* Koenen, 1892, *X. deshayesi*, *X. burdigalensis*, *X. grateloupi*, *X. infundibulum*, and *X. plioitalica*).

XENOPHORA INFUNDIBULUM (Brocchi, 1814)
Pl. 5, figs 1-4, Pl. 6, figs 1-3

1814 *Trochus infundibulum* BROCCHI, pp. 352-353, Pl. 5, fig. 17;
Reprint of 1843, pp. 132-133, Pl. 5, fig. 17.

Type material – A syntype from San Geminiano [sic] is in the Brocchi collection at the Museo Civico di Storia Naturale di Milano, no. 4929 (see Rossi Ronchetti, 1955: 159-161, Fig. 81; Pinna & Spezia, 1978: 160, Pl. 40, fig. 1). Rossi Ronchetti (1955) and Pinna & Spezia (1978) attributed to this specimen the status of a holotype, but this is mistaken. In fact, Brocchi (1814) based his description more than one specimen (at least from three different localities) and did not designate any "type".

Type locality – Brocchi (1814) cited three localities: Piacentino, San Geminiano [sic] and Libiano.

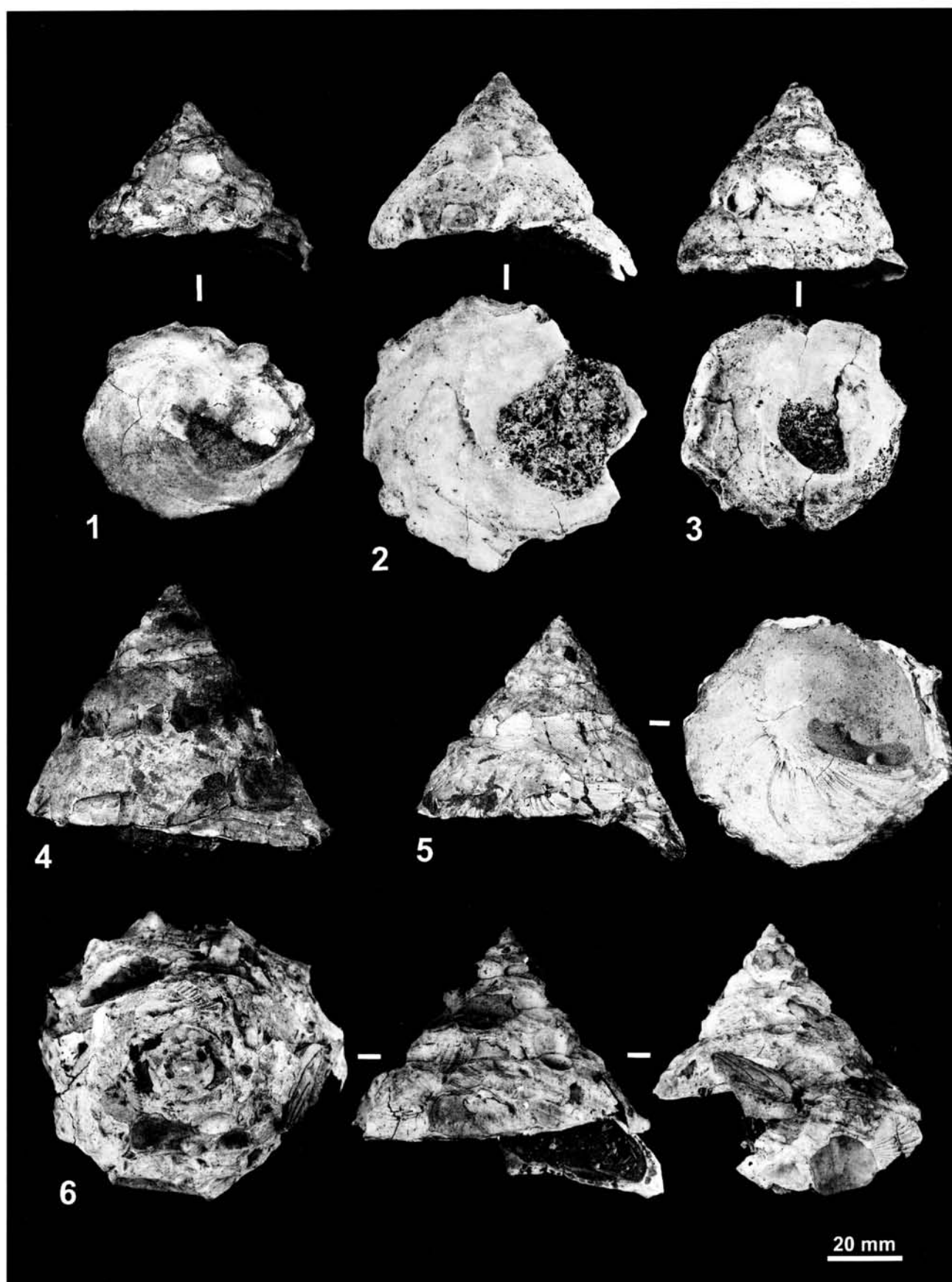
Diagnosis – A species of *Xenophora* (s.s.) characterized by large size (1), robust trochiform shell (2), with narrow, slightly wavy, sharply keeled peripheral flange (3); spire with 7-9 flat or very slightly convex whorls (4); 90% of spire surface free of attached objects or their scars (5); with fine close vermiculate opisthocline riblets intersected by prosocline growth lines (6); attached objects (mainly bivalve shells and fragments thereof) always very small or small except in last quarter of last whorl (7); scars of attached objects usually deep (8); base funnel-shaped (9); basal sculp-

ture consisting of collabral growth lines, weak or very weak spiral lines and sometimes very thin opisthocline riblets (10); basal margin of peristome straight and thickened up to periphery, then absent and replaced by peripheral flange; where basal margin of peristome attaches to peripheral flange, there is often a sort of sinulus (11); umbilicus absent (12).

Description – Shell (Pl. 5, figs 1-4, Pl. 6, figs 1-3) dextral, very large in size, robust and trochiform with pointed apex and narrow, slightly wavy, sharply keeled peripheral flange; spire conical (spire angle about 80°; range: 70°–85°) with about 7-9 regularly growing whorls; last whorl large, dilated only in final quarter (shell outline oval or drop-like in dorsal view: Pl. 5, fig. 1, Pl. 6, figs 1-3); first whorls always eroded; last whorls flat or very slightly convex, sometimes last two whorls very slightly concave before lower suture or periphery; sutures shallow; about 90% of spire surface free of attached objects or their scars, with fine close vermiculate opisthocline riblets intersected by prosocline growth lines; attached objects always very small, except in last quarter of last whorl, consisting mainly (about 90%) of small bivalve shells and small fragments of bivalve shells, and secondarily (about 10%) of balanid cirriped plates, small fragments of gastropod shells, tubes of serpulid annelids and small pebbles; foreign objects always attached by convex surface; number and size of attached objects rather constant on all whorls, so that in first whorls they are closer and there is proportionally less surface free; largest objects consisting of fragments of shells and whole shells of bivalves and gastropods attached in last quarter of last whorl (largest object found is a *Natica* shell 18 mm in diameter) (for other details on attached objects see Tab. 5); scars of attached objects usually deep; base funnel-shaped with collabral growth lines more marked near aperture, sometimes weak spiral lines and very weak opisthocline riblets near periphery (in some specimens, crossing of spiral lines and opisthocline riblets gives base edge a microgranular appearance); aperture very large and oblique because innermost basal margin is behind by about half a whorl; peristome interrupted with upper and lower vertices united by thick porcellaneous parietal callus; columellar margin of peristome covered by

EXPLANATION OF PLATE 4

- Figs 1-3 – *Xenophora deshayesi* (Michelotti, 1847) from Colli Torinesi (Bellardi-Sacco collection, Museo Regionale di Scienze Naturali, Turin, Italy:
1) BS.066.01.001, figured by Sacco (1896: Pl. 2, fig. 20) and herein proposed as the neotype of *X. deshayesi*. Note that the strong spiral grooves in Sacco's figure are a photographic artefact;
2) BS.066.001.004;
3) BS.066.01.009.
- Figs 4-5 – Two xenophorid shells from Gainfahnen (Austria). Naturhistorisches Museum Wien, Vienna, Austria, 1855 XLV 315 and 1856 L 126. Shells from this and other Paratethydean sites are usually assigned to *X. deshayesi* (Michelotti, 1847).
- Fig. 6 – The shell from the Pliocene of "Astigiana" (Bellardi-Sacco collection, Museo Regionale di Scienze Naturali, Turin, Italy, BS.066.01.001) assigned by Sacco (1896) to *X. deshayesi* (Michelotti, 1847).



parietal callus; inner basal margin straight, radial and thickened up to periphery; outer basal margin usually absent and replaced by wavy, knobbed (due to large objects attached on dorsal surface) lower surface of peripheral flange (only exceptionally there is a thin outer basal margin); external margin thin and sharp; where inner basal margin peristome attaches to peripheral flange there is often a sort of sinulus; umbilicus absent (also in juvenile shells).

Dimensions – Diameter: 66–116 mm; height: 51–84 mm; spire angle: 70°–85° (for more details, see Tab. 5). Dimensions of other Pliocene specimens: D: 54.0–115.0 mm, H: 30.0–65.0 mm (Sacco, 1896); D: 50.0–120.0 mm, H: 30.0–70.0 mm (Caprotti, 1967); D: 50.4–120.0 mm, H: 30.0–70.0 mm (Malatesta, 1974); D: 65.0–136.0 mm, H: 46.0–83.0 mm (Zhu Min-Da, 1984).

Material – Siena Basin: 48 shells from Barca (1, GMC; 3, VSC), Guistrigona (1, GMC; 15, VSC) and Terre Rosse (28, VSC).

In addition to Sienese material we studied material from the Pliocene of Colli Astesi, Piedmont (5, MRSN BS.066.01.012 and BS.066.01.013) and Lucena del Puerto, Huelva (1, MMAS).

Geographic and stratigraphic distribution – *X. infundibulum* had a wide distribution around the Mediterranean in the Miocene and Pliocene, although the Miocene records, often based on fragmentary specimens, require revision as for identification and stratigraphic setting. The species has been reported from the “Helvétien” or “Pontilévien” of France (Salles; Cossmann & Peyrot, 1919; Glibert, 1963), the “Tortonian” of Portugal (Cacella; Dollfus *et al.*, 1903; Cossmann & Peyrot, 1919) and Italy (Benestare, Casa Nova di Calisese, Modenese, Stazzema; Seguenza, 1881; Sacco, 1896; Caprotti, 1970; Ruggieri & Davoli, 1984), the “Sahélien” of Tunisia (Stchepinsky, 1938) and Morocco (Dar-bel-Hamri; Gentil, 1919; Chavan, 1940; Lecoindre, 1952; Glibert, 1963), the “Miocene” of Sardinia (Cagliari; Comaschi Caria, 1959) and the Pliocene of Spain (Estepona, Huelva, Malaga, Millas; Andrés, 1980; Zhu Min-Da, 1984; Castaño *et al.*, 1988; Gonzales Delgado, 1988; Santos *et al.*, 2003; Landau *et al.*, 2004), Algeria (Bir Touta, Oued Nador, Sidi-Moussa; De Lamothe & Dautzenberg, 1907; Cossmann, 1916), France (la Trinité; Risso, 1826), Italy (Piedmont, Liguria, Emilia Romagna, Tuscany, Umbria; Brocchi, 1814; Seguenza, 1877; Sacco, 1896, 1904; Ruggieri, 1962; Glibert, 1963; Palla,

1967; Caprotti, 1967, 1970, 1974; Malatesta, 1974; Pavia, 1976; Montefameglio *et al.*, 1980; Giannelli *et al.*, 1981; Chirli, 1988; Cavallo & Repetto, 1992; Andreoli & Marsigli, 1996; Vera-Peláez *et al.*, 1996; Forli *et al.*, 2003), Syria and Lebanon (Haffé, Mandjila, Amerko, Nahr Snobar, Cheikh Khalil, Quemine, Kherbet el Katrié, Tannechmaniye; Roman, 1940; Zhu Min-Da, 1984). Malatesta (1974) reported it from the Pliocene of Sicily, probably by error (as far as we know, the species has never been found from the Sicilian Pliocene).

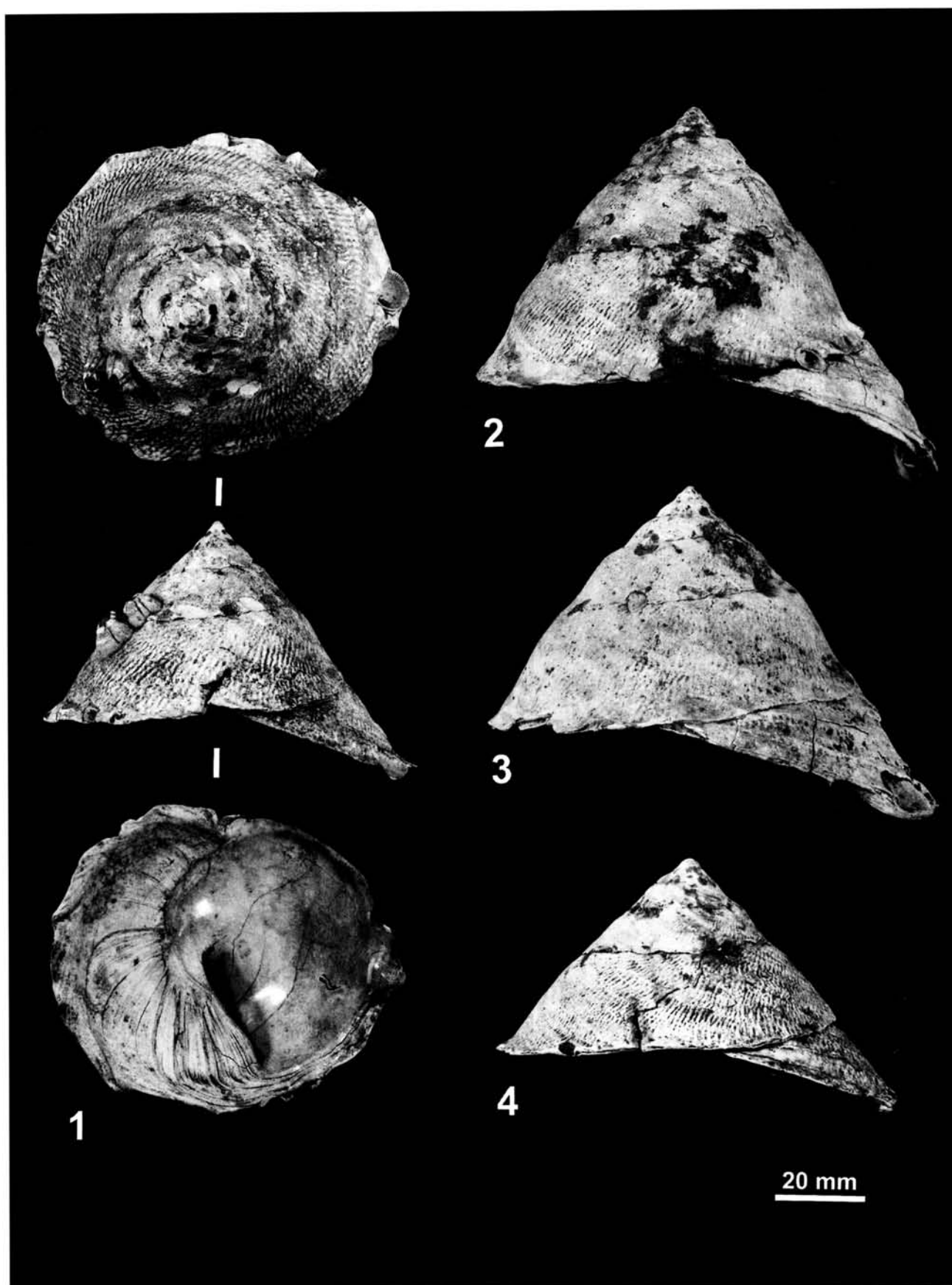
X. infundibulum is the most common and widespread xenophorid species in the Lower and Middle Pliocene of the Siena Basin where it was first reported by De Stefani and Pantanelli (1878) and recently by Forli *et al.* (2003). It has also been found in the Pliocene of the Val di Chiana (Città della Pieve; Verri, 1886) and Radicofani Basins (Poggio Rotondo; Malatesta, 1974).

Remarks – Despite its abundance and diffusion in the Italian Pliocene, descriptions and illustrations of *X. infundibulum* are limited (cf. Sacco, 1896, p. 23, Pl. 1, fig. 26; Sacco, 1904, Pl. 26, fig. 9; Rossi Ronchetti, 1955, pp. 159–161, Fig. 81; Palla, 1967, pp. 956–957, Pl. 71, figs 9a–9b; Caprotti, 1967, pp. 189–190; Caprotti, 1970, Pl. 7, fig. 5; Malatesta, 1974, p. 215, Pl. 16, figs 8a–8b; Zhu Min-Da, 1984, pp. 22–23, Pl. 3, fig. 1; Cavallo & Repetto, 1992, Fig. 109; Andreoli & Marsigli, 1996, Pl. 1, figs 4–6). This is perhaps due to the fact that the species, one of the largest gastropods of the Mediterranean Pliocene, is easy to identify and complete specimens are rare.

The Siena Basin material consists of very fine specimens (Pl. 5, figs 1–4, Pl. 6, figs 1–3) that enabled detailed study which revealed that some of the more peculiar characters of this species are new: last whorl dilated in final quarter; oval or drop-like shell outline in dorsal view; large objects attached to terminal portion of last whorl; inner basal margin of peristome straight and radial as far as periphery; outer basal margin of peristome absent and replaced by lower surface of peripheral flange; frequent presence of a sort of sinulus where basal margin of peristome attaches to peripheral flange. The oval or drop-like shell outline in dorsal view is evident in the shell figured by Cavallo & Repetto (1992, Fig. 109), large objects (or their scars) attached to the terminal portion of the last whorl are evident in the shells figured by Palla (1967, Pl. 71, fig. 9b), Caprotti (1970, Pl. 7, fig. 5), Chirli (1988, Pl. 2, fig. 3) and Cavallo & Repetto (1992, Fig. 109) and the sinulus is also evident in a specimen from Colli Astesi

EXPLANATION OF PLATE 5

Figs 1–4 – *Xenophora infundibulum* (Brocchi, 1814) from the Middle Pliocene of Terre Rosse (Castelnuovo Berardenga). V. Spadini collection.



Localities	Diameter (mm)	Height (mm)	Angle (degrees)	number of attached objects in last whorl	number of attached objects in penultimate whorl	number of attached objects in antipenultimate whorl	Attached objects
Barca n: 4	88 – 112 n: 3	60 – 82 n: 3	78 – 80 n: 2	7 – 15 n: 2	6 – 8 n: 2	12 – 15 n: 2	Shells and fragments of shells of bivalves (<i>Acanthocardia</i> , ? <i>Diplodonta</i> , ? <i>Arca</i> , <i>Chamelea gallina</i> , ? <i>Ensis</i> , <i>Phaxas</i> , <i>Gari</i> , <i>Glans intermedia</i> , ? <i>Pandora</i> , <i>Timoclea ovata</i> and others unidentified), plates of cirripeds and small pebbles.
Guistrigona n: 16	89 ± 13 (67 – 112) n: 13	64 ± 8 (51 – 76) n: 13	77.8 ± 2.4 (75 – 80) n: 13	10.9 ± 2.2 (7 – 13) n: 9	12.7 ± 3.7 (8 – 19) n: 9	14.2 ± 2.9 (11 – 19) n: 9	Shells and fragments of shells of bivalves (<i>Acanthocardia</i> , <i>Chamelea gallina</i> , <i>Chlamys</i> , <i>Clausinella</i> , <i>Corbula gibba</i> , <i>Dosinia</i> , <i>Gari</i> , <i>Glans intermedia</i> , <i>Glycymeris</i> , <i>Nucula placentina</i> , <i>Nuculana pella</i> , <i>Ostrea</i> , <i>Timoclea ovata</i> and others unidentified), fragments of shells of gastropods (<i>Strioterebrum</i> and others unidentified), plates of cirripeds and small pebbles.
Terre Rosse n: 28	93 ± 14 (66 – 116) n: 23	98 ± 10 (51 – 84) n: 23	77.5 ± 3.4 (70 – 85) n: 21	8.5 ± 3.1 (1 – 16) n: 22	8.4 ± 3.9 (1 – 17) n: 22	13.2 ± 3.2 (7 – 18) n: 18	Shells and fragments of shells of bivalves (<i>Acanthocardia</i> , ? <i>Amusium cristatum</i> , <i>Anadara diluvii</i> , ? <i>Diplodonta</i> , <i>Chamelea gallina</i> , <i>Chlamys</i> , <i>Corbula gibba</i> , <i>Dosinia</i> , <i>Glans intermedia</i> , <i>Glycymeris</i> , <i>Nucula placentina</i> , <i>Nuculana commutata</i> , <i>Ostrea</i> , <i>Paphia</i> , <i>Pecten</i> , <i>Tellina</i> , <i>Timoclea ovata</i> and others unidentified), shells and fragments of shells of gastropods (<i>Nassarius</i> , <i>Natica</i>), fragments of shells of scaphopods (<i>Dentalium</i>), plates of cirripeds, tubes of serpulid annelids (<i>Ditrupa</i>) and small pebbles.

Tab. 5 - Shell parameters of *Xenophora infundibulum* (Brocchi, 1814).

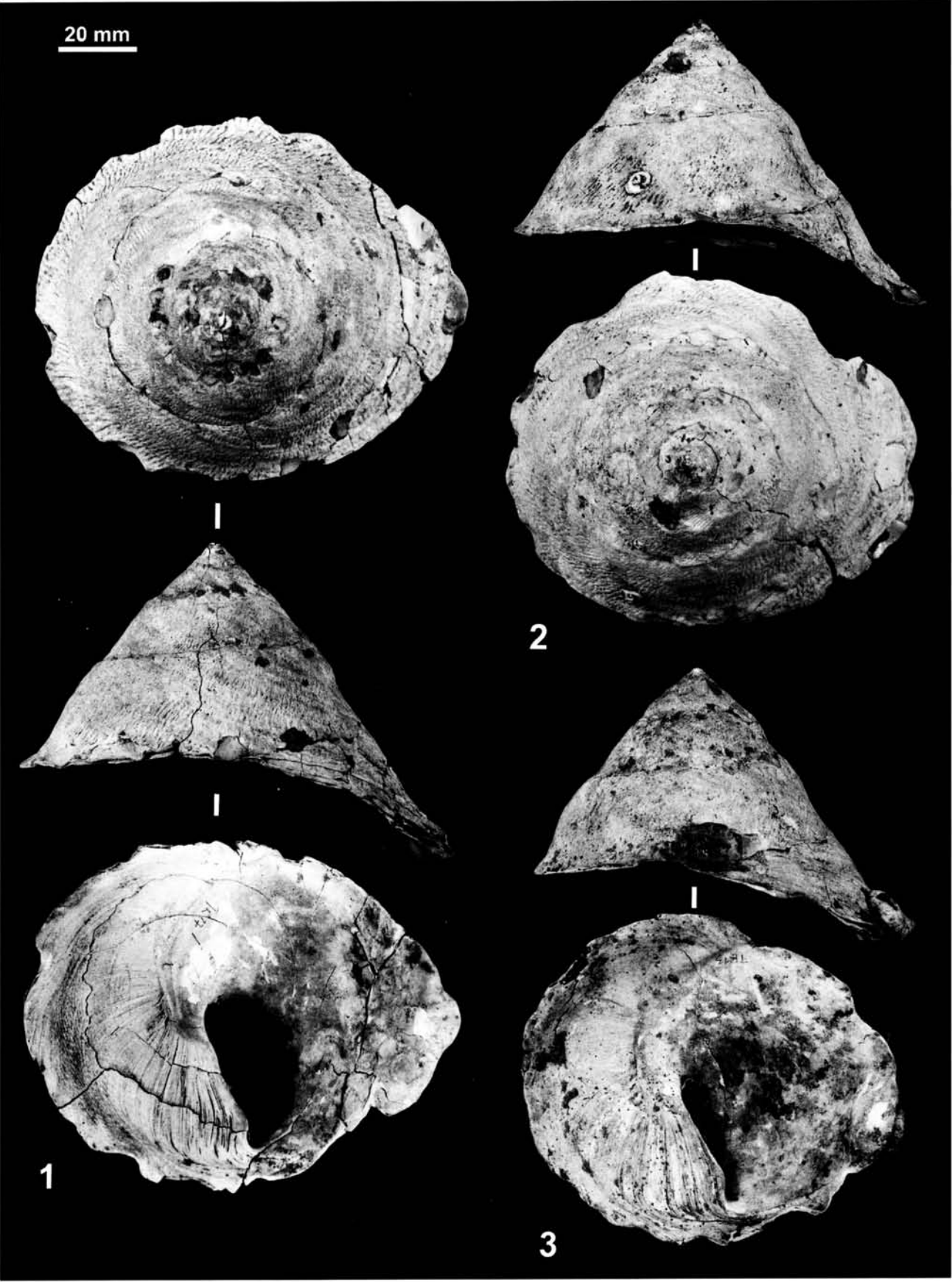
(BS.066.01.012/02). Specimens from the Upper Miocene of Salles (France) (Cossmann & Peyrot, 1919, Pl. 13, fig. 1) and Cacella (Portugal) (Dollfus *et al.*, 1903, Pl. 32, fig. 1) and the Pliocene of Huelva (Gonzales Delgado, 1988, Pl. 3, fig. 3; Santos *et al.*, 2003, Pl. 2, figs 1-2, 5) and Estepona (Landau *et al.*, 2004, Pl. 19, fig. 2b) differ from those from the Italian Pliocene by the absence of the sinulus; moreover those from Upper Miocene of Salles and Cacella

also differ by having an evident thin outer basal margin. Specimens from the "Néogène de Karaman, d'un niveau plutôt Helvétien", assigned to *X. deshayesi* by Erüal-Erentöz (1958, Pl. 3, figs 24-24a) are indistinguishable from the Upper Miocene forms of *X. infundibulum* such as those from Salles (Cossmann & Peyrot, 1919, Pl. 13, fig. 1).

Sacco (1896, p. 24) claimed that specimens from the "Astigiana" have a wider shell with a less stream-

EXPLANATION OF PLATE 6

Figs 1-3 - *Xenophora infundibulum* (Brocchi, 1814) from the Middle Pliocene of Terre Rosse (Castelnuovo Berardenga). V. Spadini collection.



lined spire than that figured by Brocchi (1814, Pl. 5, fig. 17) and those from Tuscany examined by him. He therefore suggested it be assigned to a distinct variety: *X. infundibulum* var. *expansior*. This form was subsequently reported from the "Helvétien" or "Pontilévien" of Salles (Cossmann & Peyrot, 1919; Glibert, 1963). The spire angle in the Tuscan specimens examined ranges from 70° to 85° and shells from Colli Astesi kept in the Bellardi-Sacco collection (BS.066.01.012/01, 02, 03, BS.066.01.013/01, 02) have similar angles.

X. infundibulum is one of the most characterized xenophorids. The flat whorls, very large aperture, straight and radial inner basal peristome and the absence of outer basal peristome distinguish it from all other xenophorid species. *X. deshayesi* sensu Hörnes (1856, Pl. 44, fig. 12.b) has aperture and peristome reminiscent of *X. infundibulum*, but the aperture is smaller and a thin outer basal peristome is present (see also Pl. 4, fig. 5). Other materials assigned to *X. deshayesi* (Pl. 4, fig. 4; Kautsky, 1925, Pl. 6, fig. 9; Glibert, 1949, Pl. 12, fig. 20) or to *X. burdigalensis* (Janssen, 1984, Pl. 53, fig. 5) have rather flat whorls and traces of opisthocline riblets but differ by rather large bodies attached to the sutures. *X. grateloupi* sensu Cossmann & Peyrot (1919, Pl. 13, figs 3-4) (Text-fig. 10) has flat whorl shape, a modest amount of attached objects, opisthocline riblets and a large aperture like *X. infundibulum*, but the inner basal margin seems slightly concave and the outer basal margin is evident, though thin.

Ponder (1983) listed *X. infundibulum* and *X. flemingi* Beu, 1977, from the New Zealand Lower-Middle Miocene, in an informal, morphologic group including "species [of] medium to large size, with medium to tall spire, straight whorl outline, rather narrow peripheral flange with only small objects attached, non-umbilicate". These species are not at all related: *X. flemingi* is similar to *X. infundibulum* in whorl shape and sculpture but it is completely different in aperture and peristome (for *X. flemingi*, see Beu, 1977, pp. 233-235, Figs 2, 5, 7, 8, 10, 13-17). In fact, Ponder (1983) regarded *X. infundibulum* as a species of the *X. deshayesi*-group of forms.

Cossmann & Peyrot (1919) regarded *X. infundibulum* as intermediate between *X. burdigalensis* and *X. deshayesi* due to "sa base plus infundibuliforme" and "les stries d'accroissement du plafond qui sont bien longtemps rectilignes, plus subitement arquées vers la périphérie", but different from these two species and

all Eocene and Oligocene forms due to "sa base creusée". *X. grateloupi* sensu Cossmann & Peyrot (1919) is the most similar species to *X. infundibulum*, indeed so similar that differences warrant further study. *X. grateloupi* sensu Cossmann & Peyrot (1919) and *X. infundibulum* may have descended from forms with rather flat whorls and traces of opisthocline riblets, usually assigned to *X. deshayesi*.

XENOPHORA PLIOITALICA Sacco, 1896

Pl. 7, figs 1-3

1896 [*Xenophora*] (*Tugurium*) *plioitalicum* SACCO, p. 25, Pl. 3, fig. 6.

Type material – Only the holotype (BS.066.02.002) which is in the Bellardi-Sacco collection at the Museo Regionale di Scienze Naturali of Turin (Pl. 6, fig. 1). The holotype has also been figured by Ferrero Mortara *et al.* (1984, Pl. 43, figs 2a-2b).

Type locality – "Piacenziano: Albenga" Liguria, Italy. According to Ferrero Mortara *et al.* (1984): Lower Pliocene.

1896 [*Xenophora*] (*Tugurium*.) *plioitalicum* var. *gracilior* SACCO, pp. 25-26, Pl. 3, Fig. 7.

Material – The original specimen (BS.066.02.003) is in the Bellardi-Sacco collection at the Museo Regionale di Scienze Naturali of Turin.

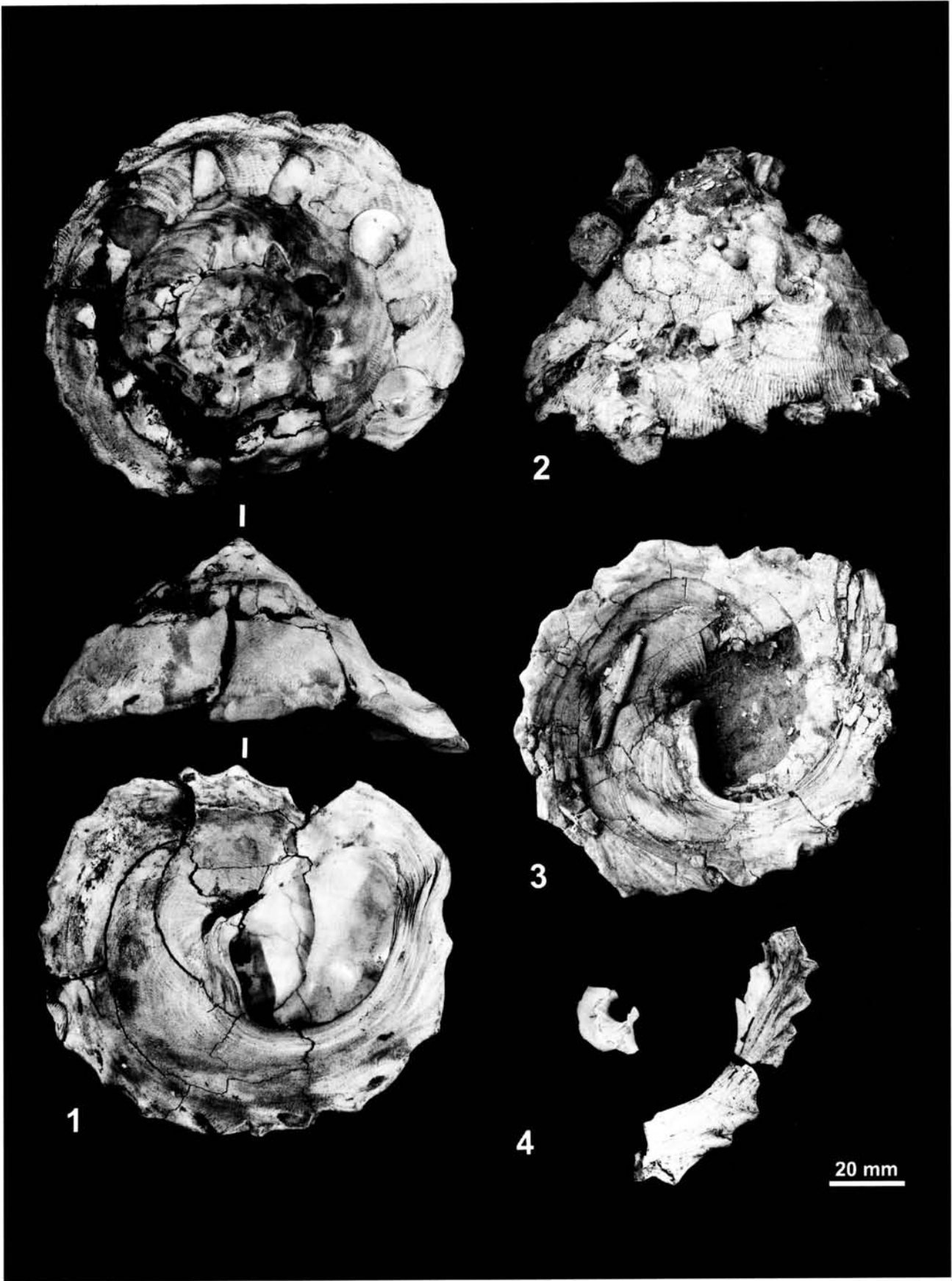
Locality – "Piacenziano: Rio del Molino di Galatea presso Chieri (rara)", Italy. According to Ferrero Mortara *et al.* (1984): Lower Pliocene.

Diagnosis – A species of *Xenophora* characterized by large size (1), robust trochiform shell (2), with narrow, irregular, roughly round (where attached objects absent) peripheral flange (3); spire with 6-7 (?) flat or slightly convex whorls (4); most of spire surface free of attached objects or their scars (5); with wavy vermiculate opisthocline riblets (6); attached objects (mainly bivalve and gastropod shells) small to medium in size (7); scars of attached objects usually deep (8); base slightly concave (9); basal sculpture consisting of very faint collabral growth lines, many very small spiral lines and very thin wavy opisthocline riblets (10); aperture auriculate with basal margin of peristome J-shaped (11); umbilicus small and partially covered by columellar margin (12).

EXPLANATION OF PLATE 7

Figs 1-4 - *Xenophora plioitalica* Sacco, 1896.

- 1) Holotype; Bellardi-Sacco collection, Museo Regionale di Scienze Naturali, Turin, Italy, BS.066.02.002, from Pliocene of Albenga;
- 2-3) Quarantelli collection, Museo del Mare Antico, Salsomaggiore, Italy. Upper Miocene of Torrente Stirone;
- 4) G. Manganelli collection. Two fragments (umbilicus and outer basal margin of peristome in basal view) of a shell from the Lower Pliocene of Monsindoli (Siena).



Description – Shell (Pl. 7, figs 1-3) dextral, large in size, robust, trochiform, with pointed apex and narrow, irregular, roughly scalloped and round (where attached objects absent) peripheral flange; spire conical (spire angle about 85° to 100°) with about 6-7 (?) regularly growing whorls; last whorl large, but not dilated; last whorls flat or very slightly convex with warty and wrinkled appearance; sutures shallow; most of spire surface free of attached objects or their scars, with numerous wavy vermiculate opisthocline riblets intersected by faint or more evident prosocline growth lines; opisthocline riblets very small in first whorls; attached objects small to medium in size, consisting of shells and fragments of bivalve (*Nucula* and others unidentified) and gastropod shells, naticid gastropod opercula (*Natica*), foraminifers and small pebbles; attached objects small, numerous and very close to each other in the first whorls; larger and well spaced in the last whorls (12 in the penultimate whorl and 11 in the last whorl of the holotype of *T. plioitalicum*); scars of attached objects usually moderately deep to deep; base slightly concave with very fine faint collabral growth lines (more evident near aperture), many very small spiral lines (more evident near centre of base), and very thin wavy opisthocline riblets (more evident near periphery); aperture auriculate, large and oblique because innermost basal margin is behind by almost a quarter of a whorl; peristome apparently almost continuous, with upper and lower vertices united by thick porcellaneous parietal callus; columellar margin reflected and thickened; basal margin J-shaped, thickened and initially reflected; outer basal margin proportionally large; external margin slightly thickened (sometimes non porcellaneous but with collabral growth lines); umbilicus small and partially covered by peristomal margin.

Dimensions – The best specimen (holotype of *X. plioitalica*) is 114 mm in diameter and 63 mm in height.

Material – Siena Basin: three very fragmentary specimens from Monsindoli (GMC).

In addition to Sienese material, we studied four specimens, two from the Pliocene of Albenga (MRSN BS.066.02.002, holotype of *X. plioitalicum*) and Rio del Molino di Galatea (MRSN BS.066.02.003, original specimen of *X. plioitalicum* var. *gracilior*) and two from the Upper Miocene of the Torrente Stirone (Quarantelli collection, MMAS).

Geographic and stratigraphic distribution – *X. plioitalica* was originally recorded from two localities (Albenga and Rio del Molino di Galatea presso Chieri) of the Lower Pliocene of Piedmont and Liguria (Sacco, 1896). It was subsequently reported from the "Middle Miocene" of Montebello (Emilia Romagna) by Moroni (1958) and the "Upper Miocene" of Dar-bel-Hamri (Morocco) by Gentil

(1919), but both reports must be considered with prudence. The specimens examined by us are from the Upper Miocene of the Torrente Stirone and the Pliocene of Siena.

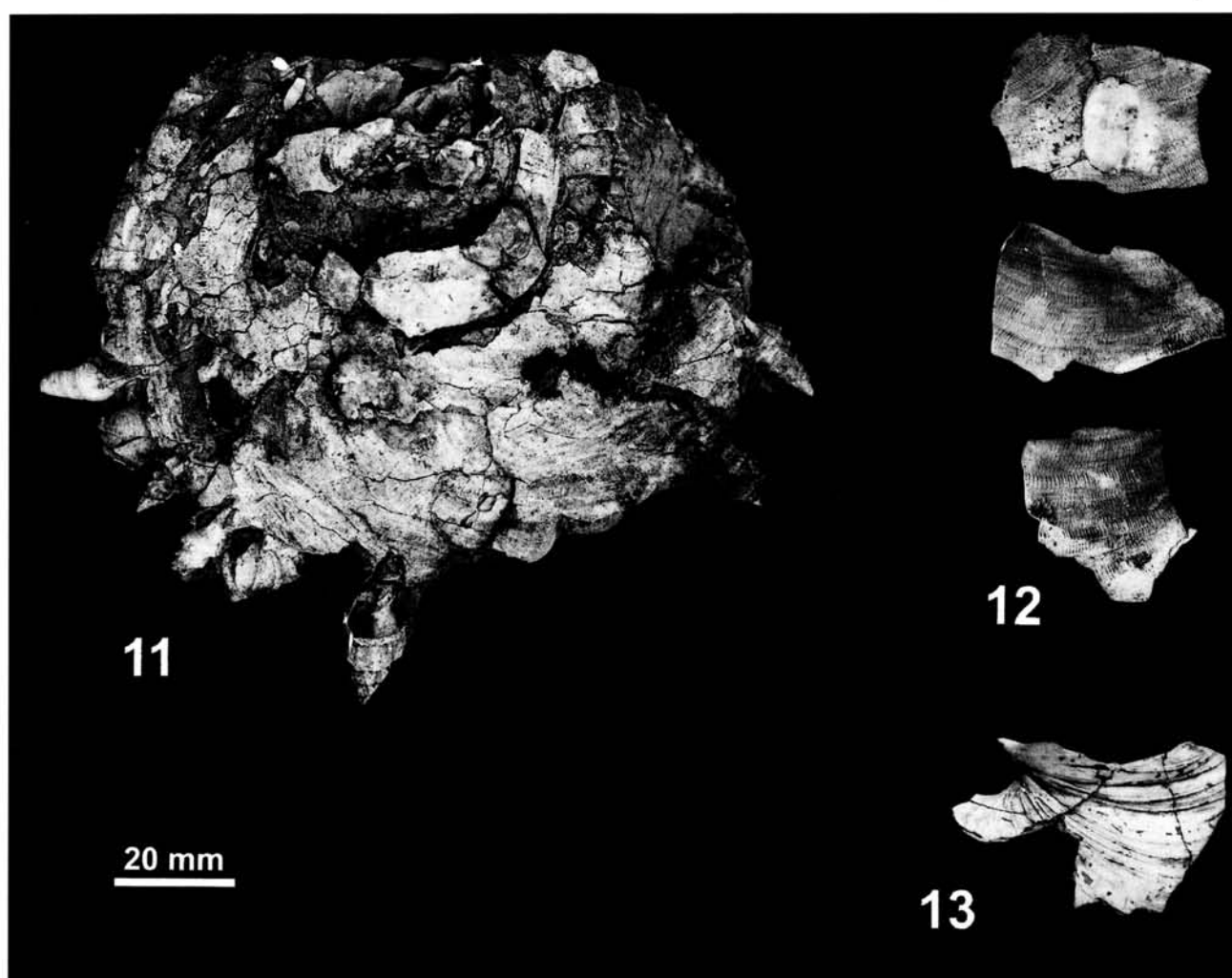
The species is new for the Siena Basin where it is only known from the Lower Pliocene of Monsindoli quarry.

Remarks – We assigned some very fragmentary and crushed specimens found in the Monsindoli quarry, near Siena, to this species. The most complete specimen is a large shell with an estimated diameter of about 10 cm (Pl. 7, fig. 4). Its size and dorsal opisthocline riblets recall *X. infundibulum* (Brocchi, 1814), but it has an umbilicus (umbilicus absent in *X. infundibulum*), the free peripheral flange is roughly scalloped and round (sharply keeled in *X. infundibulum*), the outer basal peristome is well developed (outer basal peristome absent in *X. infundibulum*), around umbilicus there are distinct, narrow spiral lines (spiral lines at the centre of base very faint in *X. infundibulum*) and below the peripheral flange there are very thin opisthocline riblets (thin opisthocline riblets below peripheral flange absent or barely evident in *X. infundibulum*).

Cossmann (1916), Ponder & Cooper (1983) and Ferrero Mortara *et al.* (1984) regarded the names "*plioitalicum*" and "*plioitalicum* var. *gracilior*" as originally introduced in combination with *Tugurium*, but Sacco (1896) regarded *Tugurium* to be a subgenus of *Xenophora*. Consequently, the original combination of these two nominal taxa is "*Xenophora* (*Tugurium*) *plioitalicum*" and "*Xenophora* (*Tugurium*) *plioitalicum* var. *gracilior*" despite the fact that Sacco listed them equivocally in the text as "*Tugurium plioitalicum*" and "*T. plioitalicum* var. *gracilior*" and used these names in the legend of the plate (this equivocal treatment is not exclusive to this genus, but the rule throughout Sacco's text whenever there are subgenera).

The original material of *X. plioitalica* probably consists of only one specimen (which consequently has the status of a holotype), like that of *X. plioitalica* var. *gracilior*. Although Sacco does not comment on this, in the case of the former he only gave the dimensions of one specimen and in the case of the latter it is evident that the description is based on a single specimen when he writes "forse è un esemplare non completamente adulto...". Examination of these specimens, originally in the Audenino collection but now in the Bellardi-Sacco collection, enabled us to ascertain that these two taxa are synonyms and that the original specimen of *X. plioitalica* var. *gracilior* is indeed a juvenile specimen.

X. plioitalica is one of the best distinguished European Neogene xenophorids (no fossil or extant *Xenophora* species has a similar clearly auriculate aperture and no large-sized fossil or extant *Xenophora* species has an umbilicus), but it is also a rare species, so far known from few specimens. It recalls *X.*



Text-figs 11-13 - *Stellaria* cf. *plioextensa* (Sacco, 1896).

11) Complete shell, Quarantelli collection, Museo del Mare Antico, Salsomaggiore, Italy. Pliocene of Campore di Salsomaggiore;

12) Fragments of dorsal portion of a shell, G. Manganelli collection. Middle Pliocene of I Sodi (Asciano);

13) Fragment of basal portion of a shell, V. Spadini collection. Middle Pliocene of Fornace di Rapolano (Rapolano).

infundibulum in some features (spire shape, few attached objects and vermiculate opisthocline riblets), but it is distinct from it in many other characters (aperture; umbilicus; basal margin of peristome; basal sculpture; peripheral flange).

Ponder (1983, p. 14) surmised that *X. plioitalica* was an offshoot of the *X. deshayesi* group, "perhaps from a form close to *X. grateloupi* (D'Orbigny, 1852)". *X. grateloupi* (in the sense of Cossmann & Peyrot, 1919) shares vermiculate opisthocline riblets with *X. plioitalica*, but differs in shape and size of the aperture and absence of umbilicus. As stated above, because it is very similar to the Miocene *X. infundibulum* it is unlikely to be related to *X. plioitalica*.

Outside the Mediterranean area the only material somewhat reminiscent of *X. plioitalica* is an incomplete shell from the Miocene of Winterswijk-Miste

(The Netherlands), published as *X. deshayesi* by Janssen (1984, Pl. 54, fig. 1) on the basis of what seemed to be a small umbilicus.

Genus *STELLARIA* Möller, 1832

Type species *Trochus solaris* Linnaeus, 1767, by monotypy.

STELLARIA cf. *PLIOEXTENSA* (Sacco, 1896)

Text-figs 11-13

1896 [*Xenophora*] (*Tugurium*) *plioextensum* SACCO, p. 27, Pl. 4, figs 3-3a.

Type material – No type material exists in the Bellardi-Sacco collection at the Museo Regionale di Scienze Naturali of Turin (Ferrero Mortara *et al.*, 1984).

Type locality – “Piacenziano: Monte Castello presso Alessandria (poco frequente)”, Italy.

Diagnosis – A species of *Stellaria* (*Onustus*), characterized by large size (1), fragile and almost discoidal shell (2), with large thin peripheral flange, porcellaneous below (3); spire with about 7 flat or slightly convex whorls (4); most of spire surface free of attached objects or their scars (5); with very small delicate wavy vermiculate opisthocline riblets (6); attached objects (shells and fragments of bivalve and gastropod shells) small to medium in size (7); scars of attached objects very shallow along suture, but deeper along peripheral flange (8); base convex (9); basal sculpture consisting of robust collabral growth lines and very thin spiral lines (10); basal margin of peristome curved and initially thickened and reflexed (11); umbilicus round and deep (12).

Description – Shell (Text-figs 12-13) dextral, large in size, very fragile and almost discoidal with pointed apex and large thin peripheral flange, porcellaneous below; spire conical depressed (spire angle obtuse) with about seven regularly growing whorls; last whorl large, sometimes slightly dilated; whorls flat or slightly convex; sutures very shallow; most of spire surface free of attached objects or their scars, with very small, delicate wavy vermiculate opisthocline riblets intersected by weak prosocline growth lines and some prosocline rugae; attached objects only along sutures of last whorls, widely spaced, small to medium in size and consisting of fragments of bivalve shells (a specimen from Pliocene of Campore di Salsomaggiore has gastropod shells; *Sveltia lyrata*, *Gemmula rotata*, *G. contigua*, *Stenodrilla bellardii*, *Turricula dimidiata*, etc.; Text-fig. 11) attached along peripheral flange; scars of attached objects usually shallow (deeper in the specimen from Pliocene of Campore di Salsomaggiore); base robust, convex with robust collabral growth and very thin wavy spiral lines; growth lines originate from umbilicus where they are disposed diagonally, then collabrally cross base, terminating abruptly, slightly raised, at junction with peripheral flange; aperture unknown; basal margin of peristome curved (judging from many fragments with marked collabral growth lines; Text-fig. 13) and initially thickened and well reflected; umbilicus wide, round and deep.

Dimensions – Estimated diameter of largest specimens around 10-15 cm.

Material – Siena Basin: all the material consists of crushed and fragmentary shells from the following localities: Poggio Vangelo, I Sodi, Vescona, San Vittorio, Poggiodarno, Fornace di Rapolano, and Finerri.

In addition to Siennese material, we studied a shell from the Pliocene of Campore di Salsomaggiore

(Quarantelli collection, MMAS) and a badly preserved whole specimen, still partly embedded in shale, without collection data in the Museo di Storia Naturale dell'Accademia dei Fisiocritici.

Geographic and stratigraphic distribution – *S. plioextensa* was described from the Pliocene of Monte Castello near Alessandria (Piedmont, Italy). Our records for the Pliocene of Salsomaggiore and Siena are the first reports of the species since its description.

The species is new for the Siena Basin, where it may be locally common in the “shale” outcrops deposited in intermediate-depth marine environments of the Middle Pliocene.

Remarks – We tentatively assign this *Stellaria* (*Onustus*) species to *Xenophora plioextensa* Sacco, 1896. The description of this nominal species was based on such bad materials that Sacco was not sure whether they actually belonged to a xenophorid: “non parebbero neppure *Tugurium*, ricordando invece alcune *Pleurotomaria*, se non avessero una grande somiglianza coi giovani di *T. extensum* del Sowerby”. Although Sacco's diagnosis is defective (“*Testa crassula, conica. Anfractus primi et medii laeves, laeviter convexuli, sublucidi, corpora aliena non colligentes. Umbilicus latus, profundus sublaevis*”), it is consistent with a species of *Onustus*, especially in view of the large umbilicus. Unfortunately the type material in the Bellardi-Sacco collection at the Museo Regionale di Scienze Naturali of Turin no longer exists (Ferrero Mortara *et al.*, 1984) and Sacco's figures are of no help because they illustrate two internal moulds. Only the study of new material from Monte Castello can clarify the identity of this nominal taxon.

Cossmann (1916, p. 195) confirmed it as a valid species: *X. (Trochotugurium) plioextensa*, occurring “dans le Plaisancien d'Italie et dans le Scaldisien d'Anvers” and figured a fine shell (Cossmann, 1916, Pl. 11, figs 20-21), without giving the locality of collection. This shell does not belong to a *Stellaria* (*Onustus*) species and seems to have a base, aperture and umbilicus similar to the shell figured by Marquet (1997, Pl. 1, fig. 7) as *Xenophora scaldensis* Glibert, 1958, from the Pliocene of Kallo (Belgium).

Ponder (1983, p. 15) briefly discusses the relationships of *S. plioextensa*, stating that together with the Italian Miocene *Phorus borsoni* Sismonda, 1847, and *Xenophora depressa* Pantanelli, 1887, it probably belongs to the lineage that began with *Trochus extensus* Sowerby, 1821. Many other nominal taxa, described from the Tertiary of northern Italy, belong or might belong to *Stellaria* (*Onustus*): *Xenophora (Tugurium) oligostriatum* Sacco, 1896, *X. (T.) subextensum* var. *ornatoparva* Sacco, 1896, *X. (T.) borsoni* var. *pagodaeformis* Sacco, 1896, and *X. (T.) postextensum* Sacco, 1896. Apart from *P. borsoni*, they are based on badly preserved material and their status and relationships are therefore difficult to evaluate.

Also *X. depressa*, which the fine figure by Pantanelli (1887) suggests it was described on a well preserved shell, was actually based on a shell in very poor condition (personal unpublished data).

Of the four extant species, *S. longleyi* (Bartsch, 1931) is the most similar to *S. cf. plioextensa* because both have the porcellanous lower surface of the peripheral flange and a concave profile of the inner basal peristome; the other species of *Stellaria* with porcellanous lower surface of peripheral flange have a wavy inner basal margin of peristome (see Kreipl & Alf, 1999: Pls 26-28).

STELLARIA TESTIGERA (Bronn, 1831)
Pl. 8, figs 1-4

1831 [*Phorus*] *testigerus* BRONN, p. 61.

Type material – It is very improbable that type material still exists (see remarks, below). To definitively clarify the identity of this nominal taxon, we designate the specimen from Bacedasco (IPUM 9882) illustrated in Pl. 9, fig. 2 as the neotype.

Type locality – “Cq. Ba. C. 15”. “Cq.” is Castellarquato, “Ba.” is a slip for “Bc” i.e. Bacedasco, “C” are the “Jüngerer Grobkalk, blau. thonig, in den Apenninen”.

Diagnosis – A species of *Stellaria* characterized by medium size (1), robust and trochiform shell (2), with slightly obtuse peripheral flange, divided into long large blunt digitations, each bearing a foreign object distally (3); spire with 7-9 flat whorls (4); 80-90% of spire surface free of attached objects or their scars (5); with small wavy subspiral threads more evident in the lower half of whorls; in last whorl, some threads divert from their subspiral course, becoming more evident and irregular and ending in digitations, giving their dorsal surface a slightly warty and wrinkled appearance (6); attached objects (shells and fragments of shells) small to medium in size, present in last whorl only on distal end of digitations (7); scars of attached objects from shallow to deep (8); base slightly convex (9); basal sculpture consisting of collabral growth lines and sometimes weak spiral lines (10); basal margin of peristome J-shaped (11); umbilicus small, sometimes slit-like (12).

Description – Shell (Pl. 8, figs 1, 4) dextral, medium in size, robust and trochiform with pointed apex and slightly obtuse peripheral flange, divided into 7-9 long large blunt digitations (8-13 in extant specimens; Ponder, 1983); spire conical (angle about 90°; 75°-85° in extant specimens; Ponder, 1983) with about 7-9 regularly growing whorls (first whorls always eroded); last whorl usually not dilated; whorls always flat; sutures very shallow; at least about 80-90% of spire surface free of attached objects or their

scars, with small wavy subspiral threads more evident in the lower half of whorls, intersected by faint or more evident but irregular prosocline growth lines; in last whorl, some threads divert from their subspiral course, becoming more evident and irregular and ending in digitations, giving dorsal surface slightly warty appearance; attached objects small to large in size, consisting of fragments of bivalve shells (in one case a claw of a decapod crustacean), present in last whorl only on distal end of digitations (those attached along sutures of first whorls are not generally retained in adult shells); scars of attached objects usually shallow; base slightly convex, with collabral growth lines and weak spiral lines, more evident and regular near umbilicus, close and wavy on peripheral flange (in some specimens spiral lines near umbilicus very evident and crossing growth lines giving granular appearance to base similar to that of *X. crispa*; see Pl. 8, fig. 3 and Sacco, 1896, Pl. 3, fig. 1c); aperture large and oblique because innermost basal margin is behind by almost a quarter of a whorl; peristome interrupted with upper and lower vertices united by weak parietal callus; columellar margin sometimes thickened and slightly reflected; basal margin of peristome J-shaped, thin and sharp; external margin irregular, thin and sharp; umbilicus small and deep, sometimes slit-like.

Dimensions – Diameter: up to 72 mm; height: up to 47 mm. Dimensions of other Italian Pliocene specimens: D: up to 63 mm, H: up to 40 mm (Sacco, 1896); D: 55.8–64.2 mm, H: 40.0–47.5 mm (Pelosio, 1967); D: up to 56.2 mm, H: up to 32 mm (Caprotti, 1967). Dimensions of extant specimens: D: up to 65.0 mm, H: up to 80.7 mm (Ponder, 1983); D: up to 83 mm, H: up to 67 mm (Goud & Kronenberg, 1988-89; Kreipl & Alf, 1999).

Material – Siena Basin: most of the material consists of crushed and fragmentary shells from the following localities: Monsindoli, I Sodi, Podere Capanna and Terre Rosse; the best specimens are from Monsindoli (2, FPC; 2, IGF 5985E and IGF 8199E) and from Terre Rosse (1, VSC). In the Radicofani Basin, south of the Siena Basin, *S. testigera* is common at Lucciolabella and Monte Calcinaiolo.

In addition to Sienese material we studied material from other Pliocene localities: Bacedasco (1, IPUM 9882), Priocca (1, DSTUT), Rio Torsero (2, MRSN BS066.01.014 and BS066.01.016) and Savona (1, MRSN BS066.01.015).

Geographic and stratigraphic distribution – Live *S. testigera* occur in two distinct areas with two subspecies: *S. testigera digitata* Martens, 1878, is widespread along the West African coasts from Senegal to Namibia and *X. testigera profunda* Ponder, 1983, in the Gulf of Aden and northeast Africa (Ponder, 1983).

The ecology and biology of extant *S. testigera* are relatively unknown. Adam & Knudsen (1955) reported that living specimens of *S. testigera digitata* were dredged from bottoms of variable nature between depths of 170 and 263 m and Le Loeuff *et al.* (1971) stated that this entity lives on the continental slope and belongs to the bathyal fauna. Ponder (1983) reported that *S. testigera profunda* was dredged between depths of 450 and 730 m.

According to Ponder (1983), *S. testigera* is recorded from the Oligocene to the Pliocene of several European localities; however we do not know any Oligocene record and W. Ponder (personal communication) thinks that the Oligocene indication may be based on an error. The species has been reported from the Miocene of Paratethys (Germany, Austria and Bulgaria), the Miocene and Pliocene of the Mediterranean (Miocene: Corsica, southern and northern Italy; Pliocene: southern Spain, Sardinia, central-northern Italy and Maritime Alps) (Hörnes, 1856; Locard, 1877; Seguenza, 1877, 1881; Koenen, 1882; Sacco, 1896; Cossmann, 1916; Ruggieri, 1957; Moroni, 1958; Kojumdzieva & Strachimirov, 1960; Dieni & Massari, 1966; Caprotti, 1967, 1970, 1974; Pelosio, 1967; Csepregy-Meznerics, 1969; Marasti & Raffi, 1976, 1977; Montefameglio *et al.*, 1980; Anfossi *et al.*, 1982; Zhu Min-Da, 1984; Cavallo & Repetto, 1992; Tabanelli & Segurini, 1994; Andreoli & Marsigli, 1996; Harzhauser *et al.*, 2003; Landau *et al.*, 2004). Sacco (1896) stated that the species is also recorded from the "Astiano" of "Astigiana", but this is questioned by Pelosio (1967).

S. testigera was reported from the Siena Basin by Hörnes (1856) and De Stefani & Pantanelli (1878), where it may be locally common in "shale" outcrops deposited in intermediate-depth marine environments of the Lower and Middle Pliocene.

Remarks – Fine fossil shells of *S. testigera* are very rare. Two very fine specimens are from Priocca (Montefameglio *et al.*, 1980, Fig. 10) and from Rio Torsero (Sacco, 1896, Pl. 3, fig. 1c); the latter (Pl. 9, fig. 3) is interesting because it has very evident spiral lines near the umbilicus which cross growth lines, giving a granular appearance to the base similar to that of *X. crista*. Most of the material is crushed or incomplete, lacking the last part of the aperture (Pelosio, 1967, Pl. 36, figs 20a-20d, Pl. 37, figs 1a-1d; Caprotti, 1970, Pl. 7, fig. 3; Cavallo & Repetto,

1992, Fig. 110; Andreoli & Marsigli, 1996, Pl. 1, figs 7-9) and our specimens are no exception. Although this makes careful comparisons between fossil and extant specimens difficult, it is evident that at least Pliocene specimens have remarkable variability in spire angle, length of peripheral digitations and dorsal and basal sculpture.

The earliest Miocene specimens from northern Italy are smaller and more conical than Pliocene or extant ones. Sacco distinguished them partly as *X. testigera* var. *elatuscula* and partly as *X. testigera* var. *tauroturrita*, both of which are usually regarded as junior synonyms of *X. testigera* (Ponder & Cooper, 1983). Hopefully, the status of these nominal taxa will be investigated again, especially that of *X. testigera* var. *tauroturrita* which includes specimens rather different from the Pliocene and extant ones.

Phorus testigerus was described by Bronn (1831) from the "Jüngerer Grobkalk, blau. thonig, in den Apenninen" of Castellarquato and Bacedasco. Bronn's collection was acquired by L. Agassiz for the Museum of Comparative Zoology (Harvard, Massachusetts, US) (R. Janssen, personal communication) and his fossil molluscs are housed in the Invertebrate Paleontology Dept. No syntype of *P. testigerus* has been found in what remains of the collection (F. Collier, personal communication).

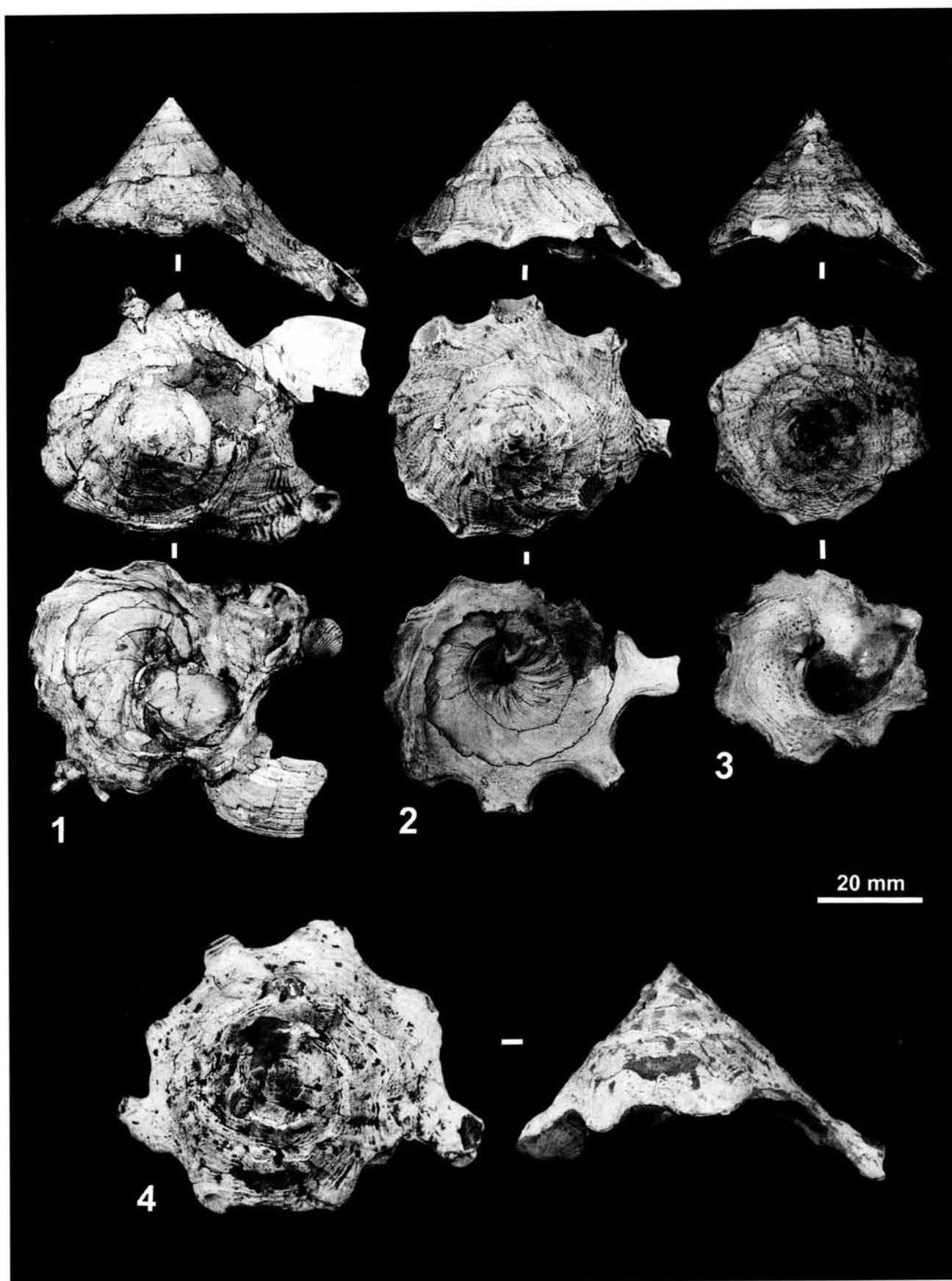
The original description is poor and does not offer elements supporting sure identification of the nominal taxon described by Bronn. Only *S. testigera* seems present at Bacedasco (Hörnes, 1856; Cocconi, 1873; Pelosio, 1967), but three species (*X. crista*, *X. infundibulum* and *S. testigera*) occur at Castellarquato (Hörnes, 1856; Cocconi, 1873; Glibert, 1963; Caprotti, 1967; Zhu Min-Da, 1984).

The first authors to cite Bronn's species were Hauer (1837, p. 420) in a list of species from the Vienna Basin and Michelotti (1847, pp. 174-175, Pl. 7, fig. 6) on the basis of specimens from Tortona and Bacedasco. However, Michelotti (1840) illustrated a shell whose identity is not clear: some characters recall *S. testigera* and *X. crista* (dorsal subspiral threads) and others match *X. crista* (absence of evident peripheral digitations and last whorl dilated) (Text-fig. 14). *S. testigera* was subsequently reported by Sismonda (1847, p. 50), Bronn (1848, p. 968), D'Orbigny (1852, p. 41) and Hörnes (1856, p. 444, Pl. 44, fig. 14). The latter is the first author to give a sufficiently clear figure (albeit of an incomplete shell

EXPLANATION OF PLATE 8

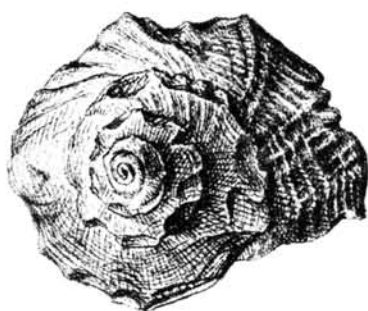
Figs 1-4 – *Stellaria testigera* (Bronn, 1831).

- 1) F. Pizzolato collection, from the Lower Pliocene of Monsindoli (Siena);
- 2) Neotype, Museo di Paleobiologia e dell'Orto Botanico, Modena, Italy, IPUM 9882. Pliocene of Bacedasco;
- 3) Rio Torsero, Bellardi-Sacco collection, Museo Regionale di Scienze Naturali, Turin, Italy, BS.066.01.016;
- 4) V. Spadini collection. Middle Pliocene of Terre Rosse (Castelnuovo Berardenga).



Tab. 6 – Synopsis of characters distinguishing the Italian Pliocene *Xenophora* species.

	<i>X. crispa</i>	<i>X. davorii</i>	<i>X. infundibulum</i>	<i>X. plioitalica</i>	<i>S. plioextensa</i>	<i>S. testigera</i>
Size	small	very large	large	large	large	medium
Shell	robust, from almost discoidal to trochiform	robust and gradate	robust and trochiform	robust and trochiform	fragile and discoidal	robust and trochiform
Peripheral flange	narrow, irregular, roughly round (where attached objects absent)	narrow, irregular shaped, sharply keeled (where attached objects absent)	narrow, slightly wavy, sharply keeled	narrow, irregular, roughly round (where attached objects absent)	large, thin and porcellaneous below	slightly obtuse, divided into some large and long blunt digitations
Whorl profile	variable	irregular	flat or very slightly convex	flat or slightly convex	flat	flat
Percentage of spire surface free from attached objects or their scars	about 30-60%	most of surface	about 90%	most of surface	most of surface	probably 80-90%
Spire sculpture	with fine wavy meandering subspiral, sometimes opisthocline, riblets	with very irregular and prominent, opisthocline drop-like rugae, intersected by faint prosocline growth lines	with close fine vermiculate opisthocline riblets	with very small wavy vermiculate opisthocline riblets	with very small delicate wavy vermiculate opisthocline riblets	with small wavy subspiral threads more evident in the lower half of whorls; in last whorl some threads become more evident and irregular and end in digitations
Attached objects	mainly bivalve and gastropod shells, fragments of shells and pebbles from small to proportionally very large	very large fragments of shells of bivalves and gastropods, and pebbles	mainly bivalve shells and fragments of same, always very small to small except in last quarter of last whorl	fragments of bivalve shells, small to medium in size	bivalve shells and fragments of same, small to medium in size	bivalve shells and fragments of same, small to medium in size, present in last whorl only on distal end of digitations
Scars of attached objects	usually deep	usually deep	usually deep	usually deep	shallow along sutures, deeper along peripheral flange	usually shallow
Base	slightly convex to almost flat	slightly concave	funnel-shaped	slightly convex	convex	slightly convex
Basal margin of peristome	J – shaped, thickened and with jutting outer portion	curved, thickened and slightly reflected	straight and thickened as far as periphery then absent; at attachment to peripheral flange, there is usually a sort of sinulus	J – shaped, thickened and initially reflected	curved and initially thickened and reflected	J – shaped
Basal sculpture	collabral growth lines and spiral grooves more distinct near umbilicus and having a more or less granular sculpture	distinct collabral growth lines	collabral growth lines, weak or very weak spiral lines and sometimes very thin opisthocline riblets	very weak collabral growth lines more evident near aperture, many very small spiral lines and very small wavy vermiculate opisthocline riblets	robust collabral growth lines and very thin spiral lines	collabral growth lines and sometimes weak spiral lines
Umbilicus	small and deep but often slit-like or covered by parietal callus	absent	absent	round and deep or slit-like and covered by peristomal margin	round and deep	small, sometimes slit-like



Text-fig. 14 - *Xenophora testigera* (Bronn, 1831) illustrated by Michelotti (1840). This figure is the first illustration of Bronn's species, but it is uncertain whether the shell illustrated really belongs to *X. testigera*.



Text-fig. 15 - *Xenophora testigera* from "Loibersdorf" illustrated by Hörnes (1856) (slightly enlarged with respect to the original).

from Baden) for recognition of the species as it is currently understood (Text-fig. 15). Thanks to this good figure, subsequent identifications have probably been consistent. However, because designation of a neotype is advisable to clarify the identity of a nominal taxon, we designate the specimen from Bacedasco (IPUM 9882) illustrated in Pl. 9, fig. 2 as the neotype.

Ponder (1983) states that fossil and extant specimens must be assigned to distinct chronosubspecies: *S. testigera testigera* includes specimens from the Miocene to the Pliocene of Europe, *S. testigera digitata* Martens, 1878, specimens from West Africa and *S. testigera profunda* Ponder, 1983, extant specimens from the Gulf of Aden and northeast Africa. However, some of the characters listed by Ponder to differentiate extant subspecies from fossil *S. testigera testigera* have only relative value due to wide variability in the fossils. For example, it is doubtful to distinguish the fossil nominotypical subspecies from extant ones on the basis of the length of peripheral digitations (shorter in fossil specimens, longer in extant ones).

St. Jean (1982) and Ponder (1983) hypothesize that *S. testigera* originated in the western Atlantic from *S. conica* (Dall, 1892) of the Eocene of Mississippi. The latter is very similar to *S. testigera*, being mainly distinguished by smaller size (for *S. conica*, see St. Jean, 1982, first two figures at p. 19). However, the long gap in stratigraphic distribution between the Eocene *S. conica* and the Miocene *S. testigera* is surprising.

Another recently described species, *Stellaria kriegelbartholdi* Nielsen & De Vries, 2002, is very similar to *S. testigera* except for its closed umbilicus (Nielsen & De Vries, 2002, pp. 75-77, Figs 17-20). This species is very interesting because it is the first report of an entity of the *S. testigera* group from the southern hemisphere (Millongue Formation, Peninsula Arauco, south-central Chile), but unfortunately its uncertain stratigraphic age (Eocene or Miocene) prevents more detailed comment.

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