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Notes on the systematics, morphology and biostratigraphy of fossil holoplanktonic Mollusca, 6. Biostratigraphical interpretation of an assemblage from Poggio Musenna (Sicily, Italy) in comparison to northern Italian and Maltese localities[1]

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Miocene holoplanktonic Mollusca from the Tellaro Formation at Poggio Musenna (SE Sicily, Italy) are compared with assemblages from the Blue Clay Formation in the Maltese Archipelago and from Tetti Borelli (N. Italy, province of Asti). Similarities in benthic assemblages of the Tellaro and Blue Clay formations are merely the result of identical depositional environments and do not indicate the same age. The Tellaro Formation was analysed for nannoplankton and found to belong to zone NN10 (Middle Tortonian). The S. Agata Fossili Formation (Montaldo Member) of Tetti Borelli may be dated as Early to Middle Tortonian, as indicated by the nannoplankton and holoplanktonic molluscan assemblages. In contrast, the Maltese Blue Clay Formation is of Serravallian age. In Malta pteropods of Tortonian age are found reworked in the Messinian Green Sand Formation.

Key words: Mollusca, Gastropoda, Heteropoda, Euthecosomata, Miocene, Serravallian, Tortonian, Messinian, biostratigraphy.

INTRODUCTION

In their 1981 paper Di Geronimo, Grasso & Pedley described a limonitised fauna from a clayey deposit of Miocene age from SE. Sicily. They provided a palaeoecological analysis of that assemblage and compared it with a clayey deposit in Malta, concluding on a Tortonian age for both. Their material includes some pteropod species, reason enough for me to try and collect some material from that locality for the RGM collections. Thanks to the co-operation of Professor Italo Di Geronimo (University of Catania) the basic material of the paper referred to was available. He was also kind enough to accompany me to the locality of Poggio Musenna, the main occurrence of the limonitised clay fauna.

The new material contains abundant holoplanktonic molluscs, which allow a revised correlation with deposits in the Maltese archipelago, and a comparison with a well-known locality in northern Italy. Heteropoda and Pteropoda from Musenna are housed in the collections of the National Museum of Natural History (Palaeontology Department) at Leiden (The Netherlands) with registration numbers RGM 397.489-512.

[1] For no. 5 in this series see Basteria 63: 109-110, 1999.

THE POGGIO MUSENNA LOCALITY

The locality Musenna Hill (= Poggio Musenna) is situated in the Ippari River valley, c. 4 km S. of the city of Vittoria, Sicily. Miocene clays of the Tellaro Formation crop out in a restricted area bordered by fault scarps in NE.-SW. and NW.-SE. direction (Lentini, 1984). Additional outcrops of fossiliferous Tellaro Formation clays are found at the Ippari River mouth, near Scoglitti. These localities however, have not been sampled for the present study.

At Musenna, some 60 m of greyish-brown clays are, in part well-exposed, accessible in a rather restricted area, comprising only several hundreds of metres. Overlying deposits in this area include the Early Pliocene Trubi Formation and Quaternary deposits.

Fossils in the Tellaro clays are scattered, which means that bulk-processing of the sediment is not very rewarding. Washed out specimens however, are quite common in places on the exposed surface. Calcitic shells such as pectinids and ostreids occur in shell preservation, originally aragonitic fossils are found as limonitic internal moulds or as cavity infilled pseudomorphs, frequently compressed or distended. In the latter case the specimens show many cracks, and appear (sometimes much) larger than their original dimensions.

The threefold subdivision described by Di Geronimo et al. (1981: 176) was easily recognised in the field on the dominant benthic molluscan species and ahermatypic corals. A good collection of benthic and holoplanktonic species was collected together with Professor Di Geronimo in June 1994 and during a second visit in June 1995. In the material collected by myself holoplanktonic molluscs were only encountered in approximately the lower third part of the section exposed. The benthic material was not identified beyond genus level and is not considered in the present paper. Hence, the following observations and conclusions are based exclusively on the holoplanktonic molluscs.

HETEROPODS AND PTEROPODS FROM POGGIO MUSENNA

From Musenna Hill, Di Geronimo et al. (1981: 186) listed four pteropod species. The numbers of specimens present in their material, as housed in the collection at the Istituto di Geologia dell'Università, in Catania, are given in table 1. A specimen identified *Vaginella* sp. is included in this collection, but not listed in their paper. Revised identifications are also given in table 1.

Di Geronimo et al. (1981)	level:	base	middle	top	this paper
Diacria sangiorgii Scarsella		-	-	1	*Diacria sangiorgii* Scarsella, 1934
Creseis aff. *spina* Reuss		1	-	-	Dentaliidae sp. indet.
Cuvierina aff. *paronai* Checchia Rispoli		1	-	-	*Cuvierina paronai* Ch.-R., 1921
Cuvierina cf. *intermedia* Bellardi		31	-	-	*Cuvierina inflata* (Bellardi, 1873)
(*Vaginella* sp.)		1	-	-	presumed echinoid spine

Table 1. Specification and revision of holoplanktonic Mollusca from Musenna Hill underlying the paper of Di Geronimo et al. (1981).

The single fragmentary specimen identified as *Creseis* aff. *spina* is an internal mould with a length of c. 7 mm and a smaller diameter of slightly more than 2 mm, far too large to represent *Creseis spina* (compare Janssen & Zorn, 1993). Furthermore, vague longitudinal striae are present, strongly suggesting Dentaliidae s. lat. The specimen identified as *Vaginella* sp. indeed resembles the (broken) basal part of a species of that genus, but is one of those curious objects, that presumably represent echinoid spines. They show a rapidly increasing shaft diameter and an elliptical distal plane, obliquely situated with respect to the axis of the spine. The surface shows a fine 'irregular' radial micro-ornament. Another such spine was present among the specimens identified as *Cuvierina* cf. *intermedia*. Identical objects are present in the material collected by myself.

Two days of collecting at Musenna yielded quite a number of holoplanktonics, among which are several additional species, as specified in table 2.

COMPARISON OF THE MUSENNA HILL HOLOPLANKTONIC MOLLUSC ASSEMBLAGE WITH THE MALTESE BLUE CLAY FORMATION FAUNA

The Blue Clay Formation in the Maltese archipelago overlies a usually quite thick deposit of Aquitanian to Langhian lime wackestones and packstones, the so-called *Globigerina* Limestone, subdivided by two main layers of phosphatic concretions, accompanied by hardgrounds. The transition from the *Globigerina* Limestone to the Blue Clay is usually gradual, with frequently a recurrence of a limestone bed in the basal part of the clay. The glauconitic Green Sand Formation is found overlying the Blue Clay, which in turn is capped by the Upper Coralline Limestone Formation (Rehfeld & Janssen, 1995).

The Blue Clay Formation outcrops mainly in the NW part of Malta and on Gozo, here are good outcrops in the form of c. 45° slopes, below usually vertical cliffs of Upper Coralline Limestone, with a rather thin Green Sand Formation inbetween. The thickness of the clay may reach 70 m.

The age of the Blue Clay Formation has been discussed in various papers. Based on planktonic Foraminifera, Felix (1973) included the entire Blue Clay in the *Orbulina universa* Zone, which means a Langhian-Serravallian age, an opinion shared by Giannelli & Salvatorini (1975). The latter authors dated the base of the Blue Clay Formation as Langhian and the top as Tortonian. Calcareous nannoplankton was studied by Martini (1971), who assigned the Blue Clay Formation to standard zones NN5 and NN6 (= Langhian-Serravallian), but Hojjatzadeh (1978) found the Blue Clay to belong to NN6 and NN7 (Serravallian). Mazzei (1985) considered the base of the Blue Clay to be of Langhian age and dated its higher part as Serravallian-Tortonian.

In a recent paper however, Kienel et al. (1995), also on the basis of calcareous nannoplankton, favoured another age assignment. They concluded that the entire Blue Clay Formation is of Serravallian age (NN5-8). To NN5 they also referred the Upper *Globigerina* Limestone, thus considering the transition between the limestone and the clay to coincide with the Langhian/Serravallian boundary. Furthermore, they postulated an important sedimentary hiatus between the clay and the overlying Green Sand Formation, comprising the entire Tortonian and the earliest Messinian. They assigned the Green Sand Formation to the Messinian.

The state of preservation of fossils in the Blue Clay Formation closely resembles that in the Tellaro Formation at Musenna Hill: calcitic species in shell preservation, and aragonitic fossils as limonitic internal moulds or pseudomorphs. There are also distinct

similarities in the compositional character of benthic communities, including bivalves, scaphopods, gastropods and other invertebrates, such as e.g. ahermatypic corals, as well as in nectonic organisms, such as the cephalopods *Sepia* and *Aturia*. Taken together with sedimentary characteristics this attests to a comparable depositional environment.

Macrofossil concentration in the Blue Clay, as in Musenna Hill, is low and amassing a representative collection of specimens can only be achieved by picking isolated specimens washed out of the sediment from the surface. Not all outcrops yield the same concentration of fossils and some are practically barren. The fossil concentration and diversity differ in the various levels as well.

Di Geronimo et al. (1981) specified the fossil assemblage of the Maltese Blue Clay Formation, using data from Fuchs (1876) and Pedley (1975). Apparently no new material was collected by them. They mentioned only two taxa of pteropods, viz. *Vaginella depressa* Daudin (after Fuchs) and *Vaginella* sp. (after Pedley). These names most probably refer to *Vaginella austriaca* Kittl, 1886, a species restricted to the basal third of the Blue Clay. Higher in the section, starting roughly in the middle part of the clay, and continuing to the very top, other pteropod species are found, viz. *Cuvierina 'columnella urceolaris'* (Mørch, 1850) sensu d'Alessandro & Robba, 1981, *C. grandis* d'Alessandro & Robba, 1981, *C. paronai* Checchia-Rispoli, 1921, *Edithinella varanica* (Sirna, 1968) and *Vaginella lapugyensis* Kittl, 1886. As yet unidentified limacinids belonging to at least two species have so far been encountered only in a washing residue from the uppermost levels of the clay, directly below the boundary with the overlying Green Sand.

When comparing the Blue Clay holoplanktonic association with that of Poggio Musenna in Sicily it is striking that none of the eleven species present at Musenna occur in the Maltese Blue Clay and that of the six species from the Blue Clay Formation known to date, all but one (*C. paronai*) are missing at Musenna. This, of course, implies a considerable age difference between these two deposits, which apparently are similar in facies only.

An age assignment of the Blue Clay appears to be possible, if the distribution of some of the species encountered is considered. The pteropods *Cuvierina 'columnella urceolaris'* and *C. grandis* were described from various localities in the Salentina area (S. Italy), dated Late Serravallian to Tortonian (d'Alessandro & Robba, 1981). *C. grandis* is also known to occur in some Serravallian localities in N. Italy [Robba, 1977: 608, as *Cuvierina* cf. *columnella* (Rang, 1827); d'Alessandro & Robba, 1981: 649, 651]. Its occurrence at Arguello, one of Robba's 1977 localities, could be confirmed by myself. As demonstrated by Kienel et al. (1995), a Tortonian age for the Blue Clay, as postulated by Di Geronimo et al. (1981), is impossible. Therefore, these two pteropod species indicate a Serravallian age.

The occurrence of *Vaginella austriaca* in the basal portion of the Blue Clay does not contradict this age assignment, as this species is known to occur in the Langhian-Serravallian interval. Apparently it does not extend into the later Serravallian.

THE AGE OF THE TELLARO FORMATION OF POGGIO MUSENNA

The holoplanktonic molluscan association encountered at Musenna Hill may be compared with an assemblage known from Tetti Borelli, a locality in the Turin Hills, N. Italy, first described by Pavia & Robba (1979), and revised by Janssen (1995). The irrespective data are given in table 2.

species	Poggio Musenna	Tetti Borelli
Heteropoda		
Protatlanta rotundata (Gabb, 1873)	2 (0.4)	1 (0.4)
Thecosomata		
Limacinidae		
Limacina atlanta Mørch, 1874)	7 (1.4)	-
Limacina inflata (d'Orbigny, 1836)	-	15 (6.0)
Limacina wilhelminae A.W. Janssen, 1989		3 (1.2)
Limacina sp.	4 (0.8)	-
Limacina sp. indet. (presumably *L. wilhelminae/L. atlanta*)	28 (5.7)	-
Cavoliniidae		
Creseinae		
Styliola subula (Quoy & Gaimard, 1827)	16 (3.8)	-
Cuvierininae		
Cuvierina inflata (Bellardi, 1873)	286 (57.5)	3 (1.2)
Cuvierina ludbrooki (Caprotti, 1962)	24 (4.9)	112 (44.5)
Cuvierina paronai Checchia-Rispoli, 1921	32 (6.5)	-
Clioinae		
Clio giulioi A.W. Janssen, 1995	-	5 (2.0)
Cavoliniinae		
Cavolinia gypsorum (Bellardi, 1873)	1 (0.2)	-
Diacria sangiorgii Scarsella, 1934	47 (9.4)	26 (10.4)
Diacrolinia elioi A.W. Janssen, 1995	-	2 (0.8)
Edithinella caribbeana (Collins, 1934)	46 (9.2)	84 (33.5)
Vaginella aff. *victoriae* A.W. Janssen, 1995	1 (0.2)	-
totals	494 (100)	251 (100)

Table 2. Holoplanktonic molluscan assemblages from the Tellaro Formation at Poggio Musenna (Sicily, Ragusa, Italy), and from the S. Agata Fossili Formation, Montaldo Member, of Tetti Borelli (Asti, Italy). Numbers for Poggio Musenna are based on the RGM collections, those for Tetti Borelli include all material from various collections seen by the author. Percentages are given between brackets.

Pavia & Robba (1979) recorded 153 species of Mollusca, inclusive of five holoplanktonic gastropod species, while Pavia (1991) studied the Scaphopoda of Tetti Borelli, and Davoli (1995) the Cancellariidae. The locality has subsequently been frequently sampled and the number of species has increased considerably. Species over 20 mm in size are virtually absent. A good array of this material is housed in the private collection of Mr B. G. Roest (Vianen, The Netherlands).

The age of the Borelli locality was determined by planktonic Foraminifera. Pavia & Robba (1979) assigned it to the 'Messiniano superiore', having found the Borelli assemblage to belong to the *Globorotalia conomiozea* Zone, and in particular to the *Turborotalia multiloba* Subzone. They also concluded on a hemipelagic type of sedimentation in a bathyal environment, with turbiditic redeposition of sublittoral material.

Professor Giulio Pavia (in litt., 1995) informed me of a re-analysis of the planktonic Foraminifera, carried out by Dr. D. Violanti (Torino University). The presence of *Turborotalia multiloba* indicates the *Gt. conomiozea* Zone, *T. multiloba* Subzone. The assem-

blage also contains ancestral forms of the *Gt. margaritae* lineage (i.e. *Gt. praemargaritae*, and particularly intermediate forms between *Gt. p. praemargaritae and G. p. primitiva*). This now favours an assignment to the mid Early Messinian. The setting is described by Dr. Violanti as 'significant of the passage between outer shelf and slope'.

These two foraminiferal samples however, were not taken from the Tetti Borelli outcrop that yielded the rich molluscan associations. Professor Pavia wrote to me (March 3, 1999): 'Actually I collected the two samples described by Premoli Silva in 1979 and more recently by Violanti in an outcrop not so far from the locality we know. The sample was referred to as coming from a clayey layer underlying the fossiliferous sands as actually it is covered by resedimented sandy and fossiliferous beds with the same facies. The sampled outcrop is 300-400 metres far form the outcrop you know and can be correlated by structural reasons (southern slope of the Superga anticline).'

Professor E. Martini (Frankfurt am Main, Germany) was kind enough to analyse samples from both Poggio Musenna and Tetti Borelli for nannoplankton. The Tetti Borelli sample was taken from the clay layer running obliquely through the fossiliferous sands, on 14 September 1995 by Dr. P.A.M. Gaemers (Leiden, The Netherlands), the Poggio Musenna sample was collected by myself from the lower third of the section, in 1995. The results were quite surprising, as the Sicilian sample was found to belong with certainty in nannoplankton zone NN10 (Middle Tortonian). The Tetti Borelli sample also is very probably of Tortonian age, the nannoplankton is poorly preserved, but there are no species characteristic for Messinian (no Ceratoliths, no *D. quinqueramus*).

As the Tetti Borelli sediments for a great deal are redeposited as turbidites from higher portions of the sea bottom, inclusive of the shelf, it may not be excluded that the nannoplankton in the clay sample is reworked as well. Still, a Tortonian age is favoured by the holoplanktonic Mollusca, as discussed below.

A comparison of the holoplanktonic molluscan data from Musenna Hill and Tetti Borelli (table 2) reveals similarities, as well as differences. The differences noted in the recovered assemblages may have natural causes (e.g. diversity of living populations), but are undoubtedly in part the result of different states of preservation of the fossils. At Musenna, the material is preserved as limonitic casts, whereas at Tetti Borelli the specimens occur in usually rather poor shell preservation, in relatively coarse-grained serpentinite sands. This makes recovery of particularly the smaller species (such as limacinids) at Borelli quite difficult. On the other hand, the generally crushed condition of the limonitic specimens of Musenna have a stronger effect on the smaller species, more than on larger ones, which explains the large number of unidentifiable limacinids in that assemblage. The relative numbers of e.g. *Cuvierina inflata* certainly reflect differences in the original composition of the living assemblages.

Four species occur in both faunas and three of these, viz. *Cuvierina ludbrooki, Diacria sangiorgii* and *Edithinella caribbeana,* are common in both. The fourth, *C. inflata*, makes up 57.5% at Musenna, and only 1.2% at Tetti Borelli. Among the species which occur at only one of these localities, it is especially striking to see *C. paronai* (6.5% at Musenna, but absent in Borelli), and *Limacina inflata* (6.1% at Borelli, but not recognised at Musenna).

Still, the difference in age is minor only, and I date both assemblages as Tortonian. The occurrence of *C. paronai* at Musenna Hill shows the Borelli assemblage to be slightly younger. Apparently, this species ranges into the Tortonian, although it was not yet known to occur in strata younger than Serravallian. The apparently rapid evolution of the Cuviericinae will be the subject of a forthcoming paper (Janssen, in prep.).

THE MALTESE GREEN SAND FORMATION

Up to now only two pteropod specimens have been recovered from the Maltese Green Sand (RGM collection). They are both preserved as blackish phosphoritic internal moulds, and belong to *Cuvierina inflata* and *Edithinella caribbeana*, species common both at Musenna Hill and Tetti Borelli. They indicate that formerly Tortonian sediments were present, the fossils of which are now found reworked in the Green Sand Formation, dated as Messinian by Kienel et al. (1995).

CONCLUSIONS

1. The striking similarity in lithology and benthic faunas between the Maltese Blue Clay Formation and the Tellaro Formation at Musenna Hill is not an indication of their being coeval, but merely points to similar depositional environments.
2. The Serravallian age of the Blue Clay Formation in Malta is confirmed by the holoplanktonic molluscan fauna, i.e. by the co-occurrence of *Cuvierina grandis*, *C. 'columnella urceolaris'* sensu d'Alessandro & Robba, 1981, and *Edithinella varanica.*
3. A Tortonian age (nannoplankton zone NN10) is found for the Tellaro Formation of Musenna Hill, and less certainly also for the assemblage of the S. Agata Fossili Formation, Montaldo Member, of Tetti Borelli (N. Italy, Asti). The Tellaro Formation assemblage is assumed to be only slightly older than the one at Tetti Borelli, as indicated by the holoplanktonic molluscs.
4. The occurrence of *Cuvierina inflata* and *Edithinella caribbeana* in the Messinian Green Sand Formation of Malta indicates that fossils from former Tortonian sediments occur as reworked elements.

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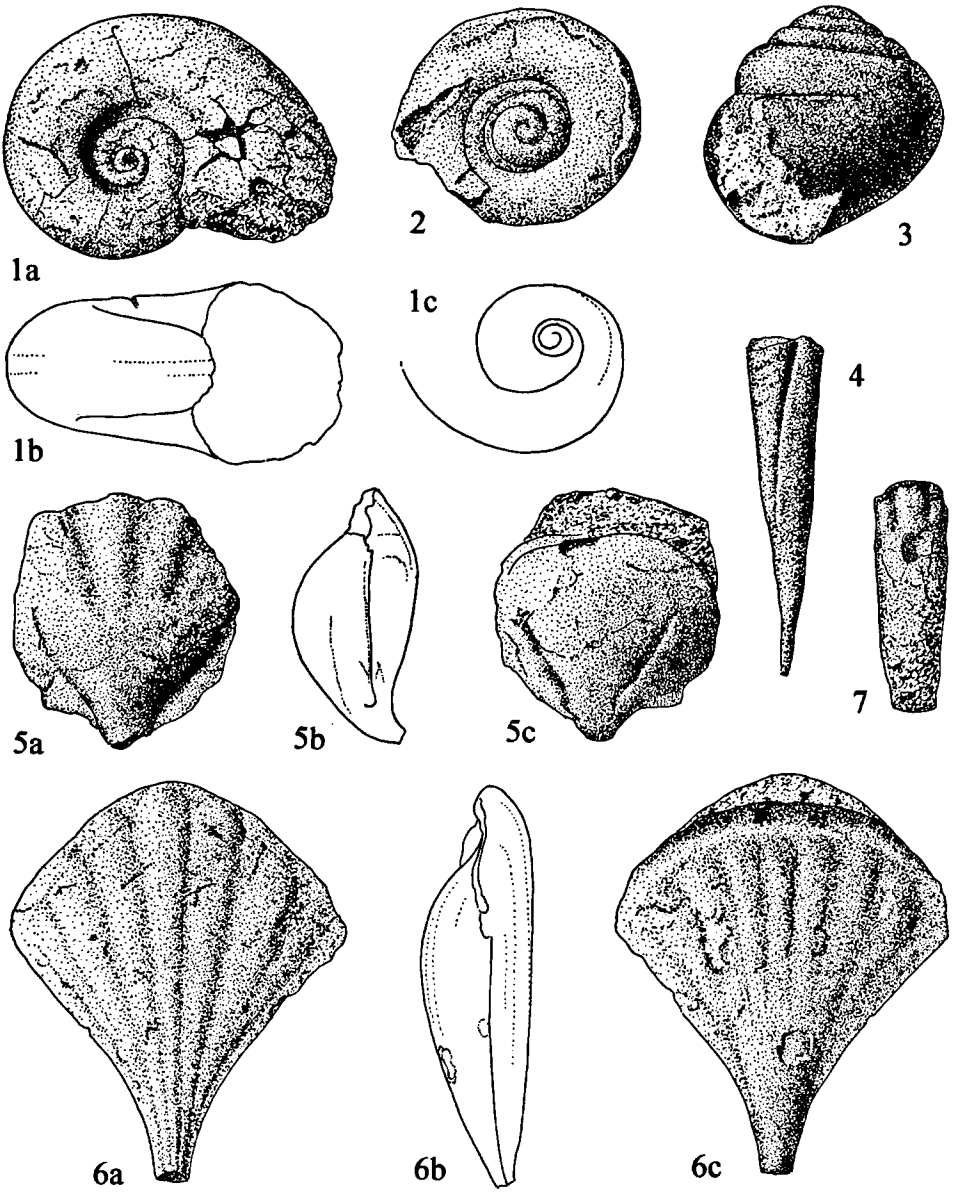
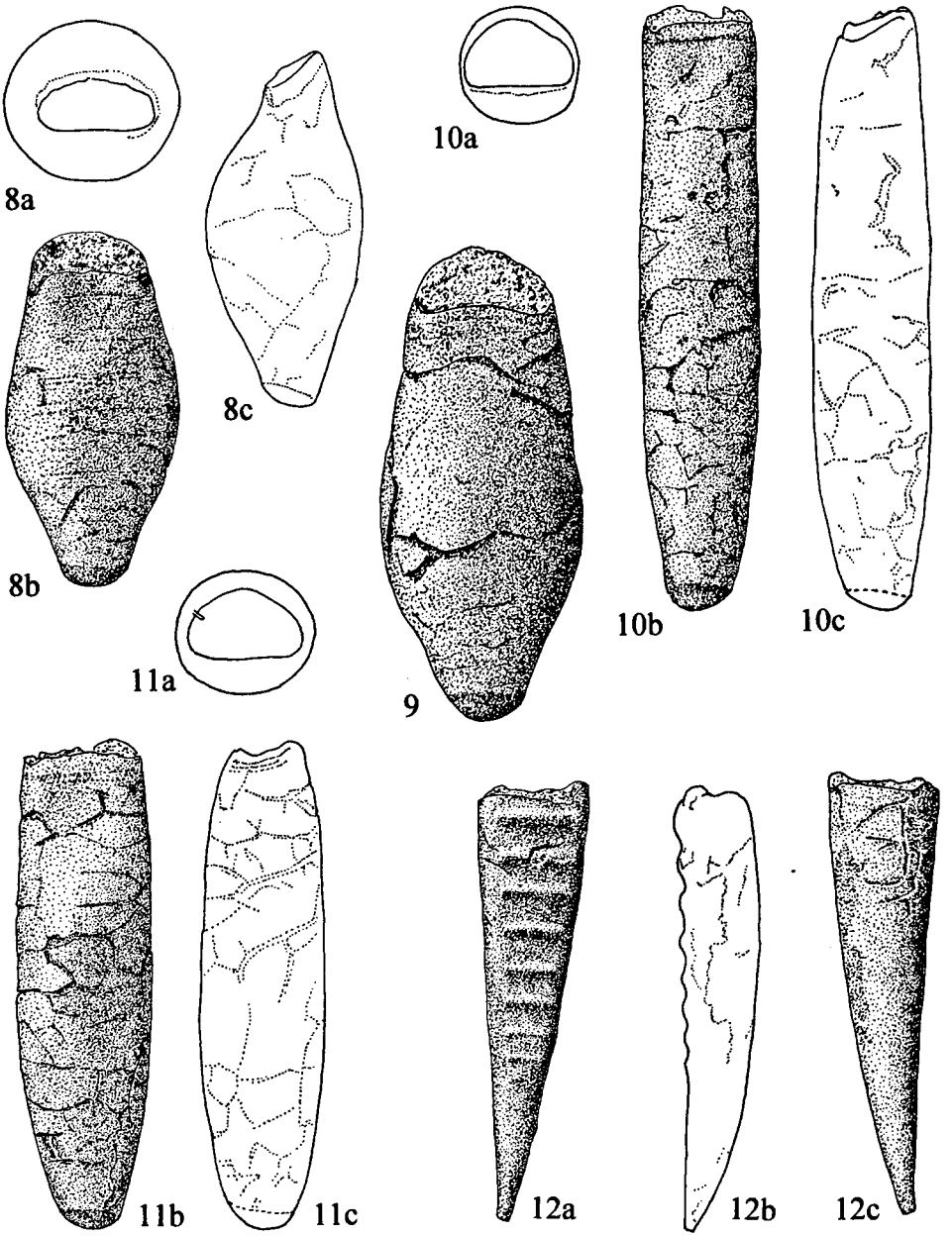


Figs. 1-12. Holoplanktonic mollusc assemblage from the Tortonian Tellaro Formation of Poggio Musenna (Sicily, Ragusa). 1a-c, *Protatlanta rotundata* (Gabb, 1873); 2, *Limacina atlanta* Mørch, 1874); 3, *Limacina* sp.; 4, *Styliola subula* (Quoy & Gaimard, 1827); 5a-c, *Cavolinia gypsorum* (Bellardi, 1873); 6a-c, *Diacria sangiorgii* Scarsella, 1934; 7, *Vaginella* aff. *victoriae* A.W. Janssen, 1995; 8a-c, 9, *Cuvierina inflata* (Bellardi, 1873); 10a-c, *Cuvierina ludbrooki* (Caprotti, 1962); 11a-c, *Cuvierina paronai* Checchia-Rispoli, 1921; 12a-c, *Edithinella caribbeana* (Collins, 1934). Figs 1c, 2, 3: X 33, other figs. X 8.


8a
8c
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