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The marine fossils malacofauna in a Plio-Pleistocene section from Vallin Buio (Livorno, Italy)

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ABSTRACT In the present paper the occurrence of marine fossil malacofauna in a Plio-Pleistocenic section from Vallin Buio (surroundings of Livorno) is described. Three different mollusc associations are present. The oldest one is typical of the Italian Lower Pliocene, the other two, are characteristic of the Upper Pleistocene fauna. Specimens, sometime poorly preserved, are not numerous for each section, but all the identified species are compatible with the respective fossil associations. The fossil malacofauna in the calcarenitic level referred to the Upper Pleistocene shows a remarkable affinity with the biotic component of the *posidonietum* biocenosis.

KEY WORDS Pliocene; Upper Pleistocene; molluscs; posidonietum;Vallin Buio; Livorno.

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INTRODUCTION

In the present paper the occurrence of a marine fossil malacofauna, detected in 1999 by two of the authors (AC and MF), in a Plio-Pleistocenic section in Vallin Buio (Cisternino), in the surroundings of Livorno, is described.

The most interesting level in limestone, infringing on the underlying Pliocenic one, includes a poorly preserved malacofauna that, however, shows a strong affinity with the mollusk community of the current biocenosis of the marine ecosystem called “Posidonieto”, *Posidonietum oceanicae* (Funk, 1927) Molinier, 1958.

The study in detail of the malacofauna from Cisternino (Livorno) was previously performed by Bogi & Cauli (1997) and Cauli & Bogi (1997-98), limited to an outcrop of Pliocene sediments, the same as those occurring in the lower part of the section, outcropping about a kilometer south-east from Vallin Buio. Additional data were taken from reports of the IX meeting of the Italian Palaeontological Society including several contributions on the eastward malacofauna occurring, on the so-called "Sezione degli Archi", with layers from the Upper Miocene to the Middle Pleistocene (Bossio et al., 1981).

MATERIAL AND METHODS

The largest molluscs were collected manually in the various levels of the section, while, by sieving approximately 5 dm^3 of the reddish sand interspersed with and included within the limestone, some species smaller in size have been identified; the poor state of conservation of this finer fraction allowed us to find only a few specimens.

ABBREVIATIONS. AC = A. Ciampalini; d = maximum diameter; exx = exemplares; h = height; l = width; m asl = meters above sea level; MF = M. Forli. For cartography and acronyms used in the text we referred to the Geological Map of Tuscany, Scale 1:10,000 (CARG project).

Geological setting

The peculiarity of the geological section under study, outcropping over a cliff near Vallin Buio (Livorno), is to have the Upper Pleistocene sediments resting in contact with those of the Pliocene without any other intermediate Pleistocenic layer. The section is located along the provincial road of "Sorgenti" on the right of "Rio Valle Lunga"; this section was highlighted as a result of an excavation for the construction of the road, in the direction of the Ugione stream, 43°34'05" N - 10°21'06"E, 8 m asl (Fig. 1).

The section develops with a maximum thickness of about 3 meters and a length of 20/30 meters degrading in both directions. Currently it is in a poor state of preservation. Its appearance has been modified by some small landslides which prevented the observation in minute detail of the reciprocal arrangement between Pliocene limestone and clay, even if it is still possible to roughly reconstruct the original arrangement of the overlying strata.

The levels of interest, not mapped in the Geological Map of Tuscany 1:10,000 (CARG project) because of their small thickness, present to the bed a layer of about 1 meter attributed to the formation of the Blue Clay (FAA = p of the geological map 1:25,000 of Livorno Province) of the marine environment, from neritic to upper bathyal and chronologically attributed to the Pliocene (Barsotti et al., 1974), and to the roof a layer of about 100-130 cm thick represented by the Red Sands of Donoratico (QSD = former q_9 of the 1:25,000 map, cf. Sands of Ardenza), that may be referred to a continental environment (aeolian, colluvial and of alluvial plain) attributable to the Upper Pleistocene.

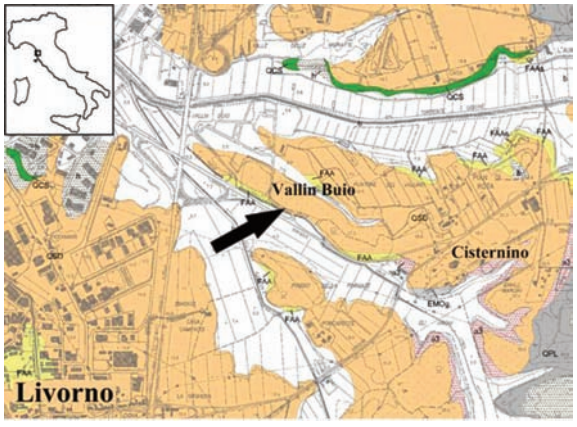


Figure 1. Study area from Geological Map of Tuscany, Scale 1:10,000 (CARG Project).

In the sands of Donoratico, on the terrace of Livorno and also nearby Vallin Buio, Ajaccia, Lupinaio, and Campacci (Sammartino, 1989; Ciampalini & Sammartino, 2007) were found some Middle-Paleolithic artifacts that confirm the attribution of the summit sands of the section to the Sands of Ardenza (Malatesta, 1940). The middle layer, about 80-100 cm thick, which lies in transgression on blue clay (FAA) and consists of a calcarenite with many bioclasts, remnants of marine gastropods and bivalves and few pebbles, is attributable lithologically to the "Panchina" layer (see Castiglioncello Calcarenites Formation cartography 1:25,000) (QCP = q_8).

Malatesta (1942) described small outcrops of the "Panchina" formation to the east of Livorno, near the Cigna little bridge, at the "Fornaci Anelli", at Porcarecce, in "Santo Stefano ai Lupi" and also in the area of Cisternino. The outcrop was previously studied by the stratigraphic standpoint by one of the authors (Ciampalini, 2002) and, at present, we refer to this work because now the exposure is no longer visible with the initial definition. The succession showed above the substrate consisting of blue clay slightly altered and abundant carbonate nodules, a level of marine calcarenites (maximum thickness of 100 cm) followed by a layer of polygenic gravel in a reddish matrix here and there with clastic rocks (maximum diameter 2-3 cm) of 30/40 cm, and finally, in likely continuity, a layer with a max thickness of 100-130 cm formed by reddish sands, presumably from an ancient dune (Fig. 2).

RESULTS

In the upper part of the layer with a calcarenitic base only two species of gastropods and two of bivalves were found (Table 1), with well-preserved

specimens (showing original colors). However, all of them agree with a single depositional facies, relating to a brackish environment with sedimentation of fine sand. These specimens were taken just below the polygenic gravels (see section of Vallin Buio in figure 2). These molluscs are to be considered a little more recent than those present within the calcarenite (Figs. 3–10).

Most fossils come from the calcarenite and compressed sands either included within or filling the cavities (Table 2). The quality of preservation is very poor because the shells are often eroded and fragmented. This is partly due to the softening of the shell because of water percolating from the upper layer and partly to the mode of fossilization itself.

However, even if battered, the species can be identified. There are three Polyplacophora, thirty-five gastropods, thirty bivalves and two Scaphopoda; among gastropods the most abundant are *Cerithium vulgatum* Bruguière, 1792, *Tricolia speciosa* (Mühlfeld, 1824), *Bolma rugosa* (Linnaeus, 1758) with other species referable to the same type of environment, i.e. *Posidonia* prairies (Peres & Picard, 1964; Barsotti et al., 1974).

Among Bivalvia, remains of *Glycymeris glycymeris* (Linnaeus, 1758) are the most abundant with forty valves and a complete specimen, though small in size, about 3 cm, followed by *Chamelea gallina* (Linnaeus, 1758) with eighteen shells, small compared to the average size of the species, which suggests a selective post-mortem transport, since all the bivalves examined are more or less of the same size.

The only remains that seem to be in situ are those of *Spondylus gaederopus* (Linnaeus, 1758) included within the limestone but not in the sands inside the cavities. The biggest one, although incomplete, is over 7 cm tall, from the apex to the opposite edge of the shell. In the absence of a complete paleo-ecological study, due to the lack of samples and subsequent counts of specimens carried out properly, it can reasonably be assumed that molluscs occurring in this level lived in a marine environment of sandy bottom alternating to or near to *Posidonia* prairies, the so-called "posidonieti" (Figs. 11–42) typical of the infralittoral, which is also confirmed by the presence of Poliplacophora that for the upper Pleistocene sediments of the surroundings of Livorno, are known exclusively from this location (Dell'Angelo et al., 2001).

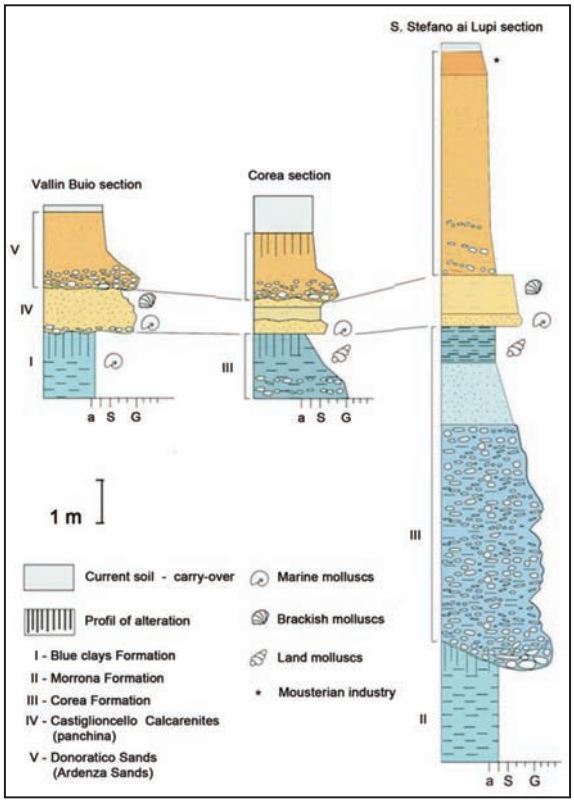
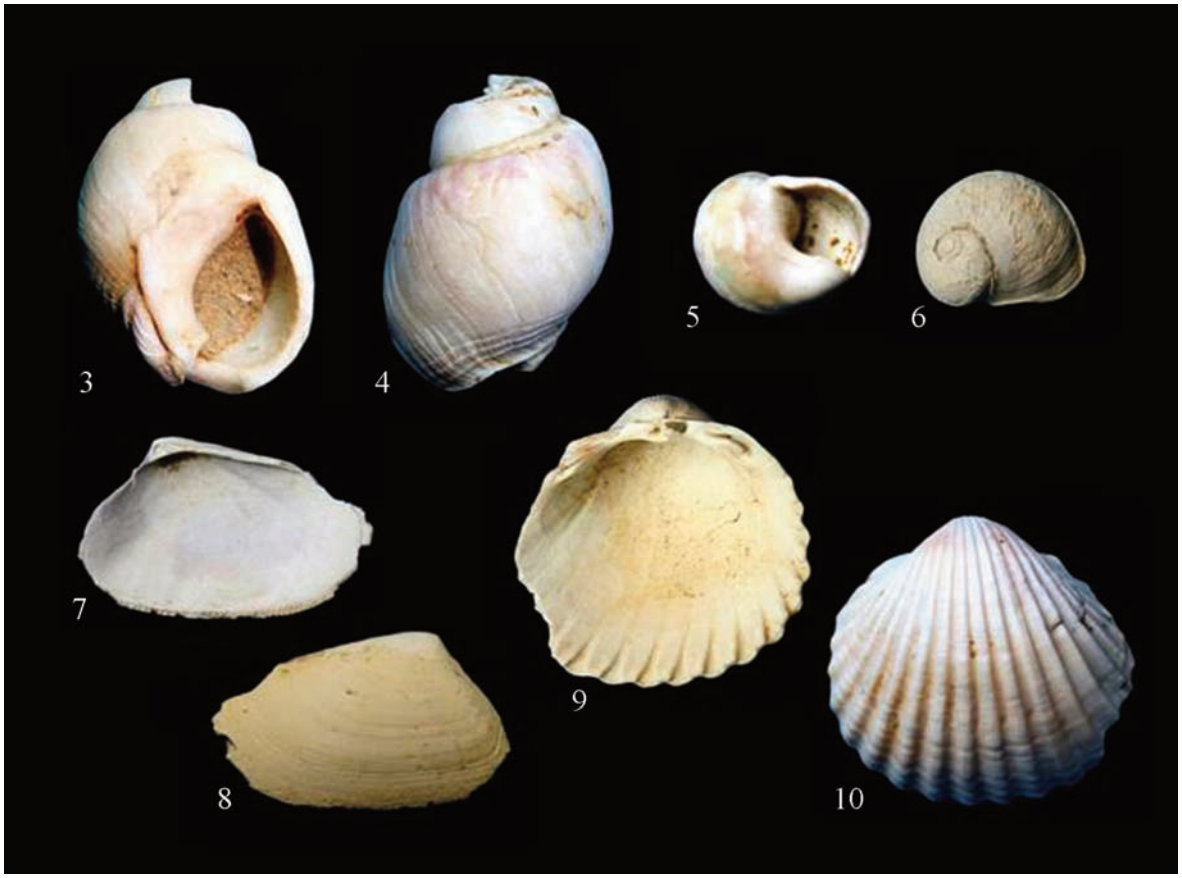


Figure 2. Stratigraphic columns of the sections of "Vallin Buio", "Corea" (from Ciampalini et al., 2006), modified; and of "Santo Stefano ai Lupi" (from Malatesta, 1940, 1942), modified and updated.

Species	N. exx.	Level
GASTROPODA		
Nassarius mutabilis (Linnaeus, 1758)	1	IV
Cyclope neritea (Linnaeus, 1758)	1	IV
BIVALVIA		
Cerastoderma glaucum (Bruguière, 1789)	3	IV
Donax trunculus Linnaeus, 1758	1	IV

Table 1. List and amount of molluscs found in the upper part of the layer IV of the Vallin Buio section shown in figure 2.

In the lower part of the section, attributable to the Lower Pliocene, eight species of Gastropoda, three of Bivalvia and three of Scaphopoda were recovered (Table 3). For a detailed discussion of the Pliocene fauna see Bogi & Cauli (1997) and Cauli



Figures 3, 4. *Nassarius mutabilis* (Linnaeus, 1758) d=14 mm., h=20.5 mm. Figures 5, 6. *Cyclope neritea* (Linnaeus, 1758) d=12 mm., h=6.3 mm.; Figures 7, 8. *Donax trunculus* (Linnaeus, 1758) l=21 mm., h=13 mm. Figures 9, 10. *Cerastoderma glaucum* (Bruguiére, 1798) l=22.4 mm., h=21 mm.

& Bogi (1997-98), who extensively described and discussed the same malacofauna, coming from a place at south-east of the small valley where the outcrop described herein is located. Among the species found in Vallin Buio two not previously reported by these authors are listed below (Figs. 43–59).

GASTROPODA Cuvier, 1795
PATELLOGASTROPODA Lindberg, 1986
LOTTIOIDEA Gray, 1840
LOTTIDAE Gray, 1840
Tectura Gray, 1847

Tectura virginea (O.F. Müller, 1776) (Fig. 52)

One specimen, of average size (3 mm. in length), a little eroded with damaged margins. The species is reported from the Miocene and currently lives on muddy bottoms of the intertidal plan (Chirli, 2004).

CAENOGASTROPODA Cox, 1960
STROMBOIDEA Rafinesque, 1815
APORRHAIDAE Gray, 1850
Aporrhais da Costa, 1778

Aporrhais peralata (Sacco, 1893) (Figs. 45–47)

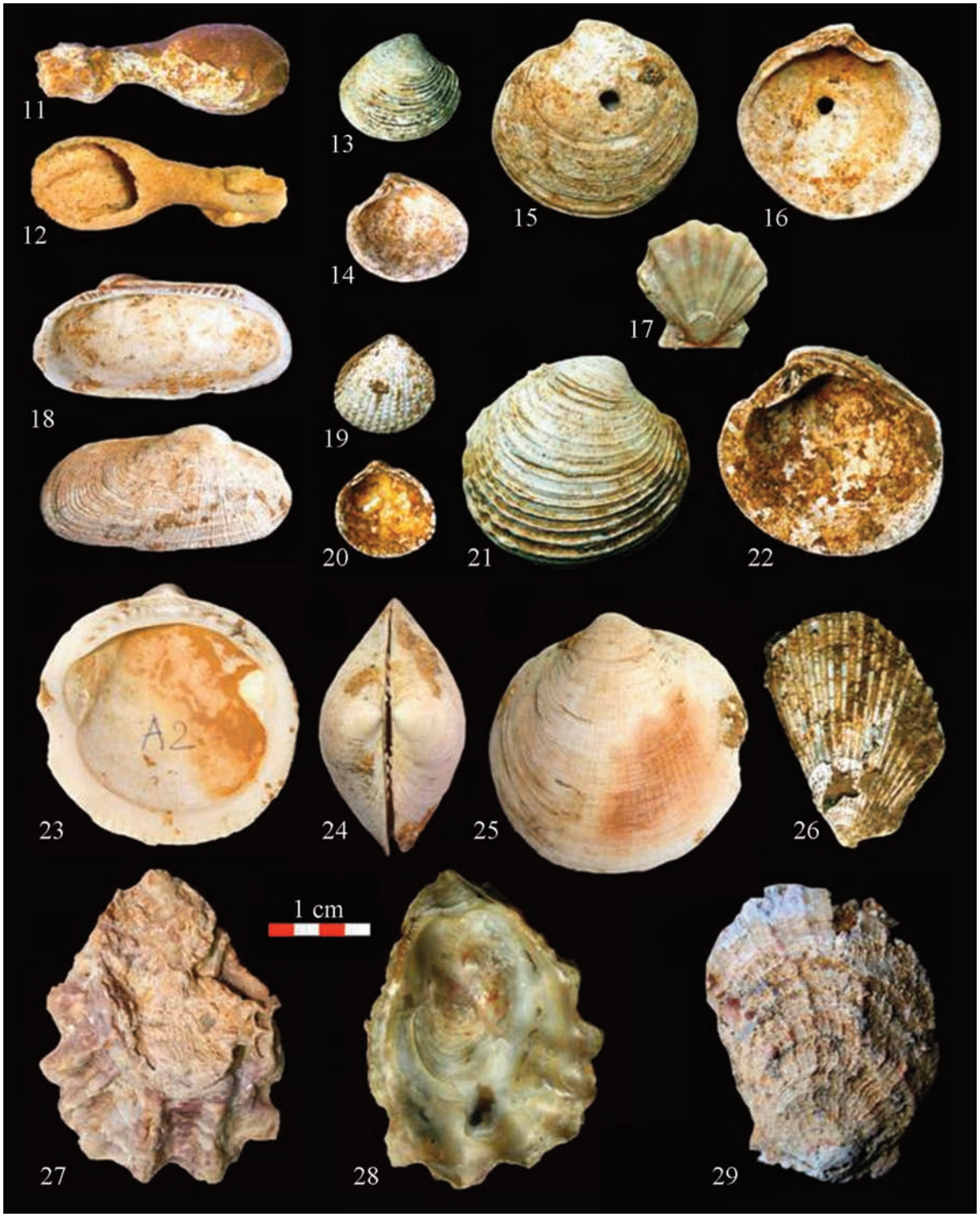
One specimen of average size (d = 8.5 mm.; h = 17.3 mm.) with broken digit ends, but, overall, the shell is definitely recognizable. The species is reported for various locations of Central and Northen Italy in deep Pliocenic clay sediments (Brunetti & Forli, 2013).

DISCUSSION AND CONCLUSIONS

The fossil molluscs of the Pliocenic sediments are compatible with those listed and described by

	Species	N. exx.	Level
	POLYPLACOPHORA		
1	*Lepidopleurus cajetanus* (Poli, 1791)	10	IV
2	*Chiton olivaceus* Spengler, 1797	1	IV
3	*Acanthochitona fascicularis* (Linnaeus, 1767)	1	IV
	GASTROPODA		
1	*Tectura virginea* (O.F. Müller, 1776)	3	IV
2	*Diodora graeca* (Linnaeus, 1758)	2	IV
3	*Gibbula ardens* (Von Salis, 1793)	1	IV
4	*Jujubinus esasperatus* Pennant, 1777	7	IV
5	*Clanculus cruciatus* (Linnaeus, 1758)	2	IV
6	*Clanculus jussieui* (Payraudeau, 1826)	2	IV
7	*Calliostoma* sp.	2	IV
8	*Bolma rugosa* (Linnaeus, 1758)	5	IV
9	*Homalopoma sanguineum* (Linnaeus, 1758)	1	IV
10	*Tricolia pullus* (Linnaeus, 1758)	42	IV
11	*Tricolia tenuis* (Michaud, 1829)	14	IV
12	*Tricolia speciosa* (Mühlfeld, 1824)	7	IV
13	*Smaragdia viridis* (Linnaeus, 1758)	1	IV
14	*Bittium reticulatum* (da Costa, 1778)	28	IV
15	*Cerithium vulgatum* Bruguière, 1792	16	IV
16	*Monophorus* sp.	6	IV
17	*Rissoa* sp.	1	IV
18	*Alvania cimex* (Linnaeus, 1758)	1	IV
19	*Alvania discors* (Allan, 1818)	9	IV
20	*Alvania geryonia* (Nardo, 1847)	1	IV
21	*Alvania mamillata* Risso, 1826	4	IV
22	*Crisilla semistriata* (Montagu, 1808)	1	IV
23	*Caecum trachea* (Montagu, 1803)	2	IV
24	*Vermetus triquetrus* Bivona Ant., 1832	1	IV
25	*Calyptraea chinensis* (Payraudeau, 1826)	1	IV
26	*Euspira guilleminii* (Linnaeus, 1758)	1	IV
27	*Hexaplex trunculus* (Linnaeus, 1758)	1	IV
28	*Columbella rustica* (Linnaeus, 1758)	1	IV
29	*Euthria cornea* (Linnaeus, 1758)	1	IV
30	*Chauvetia brunnea* (Donovan, 1804)	1	IV
31	*Cyclope pellucida* Risso, 1826	1	IV
32	*Conus ventricosus* Gmelin, 1791	5	IV
33	*Mangelia* sp.	1	IV
34	*Turbonilla rufa* (Philippi, 1836)	1	IV
35	*Turbonilla pusilla* (Philippi, 1844)	1	IV
	BIVALVIA		
1	*Nucula nucleus* (Linnaeus, 1758)	2	IV
2	*Saccella commutata* (Philippi, 1844)	1	IV
3	*Arca noae* (Linnaeus, 1758)	1	IV
4	*Barbatia barbata* (Linnaeus, 1758)	6	IV
5	*Barbatia clathrata* (Defrance, 1816)	2	IV
6	*Striarca lactea* (Linnaeus, 1758)	1	IV
7	*Glycymeris glycymeris* (Linnaeus, 1758)	47	IV
8	*Glycymeris insubrica* (Brocchi, 1814)	11	IV
9	*Limopsis* cf. *aurita* (Brocchi, 1814)	1	IV
10	*Cardita calyculata* (Linnaeus, 1758)	4	IV
11	*Goodallia triangularis* (Montagu, 1803)	11	IV
12	*Flexopecten flexuosus* (Poli, 1795)	2	IV
13	*Spondylus gaederopus* (Linnaeus, 1758)	3	IV
14	*Lima lima* (Linnaeus, 1758)	6	IV
15	*Anomia ephippium* (Linnaeus, 1758)	1	IV
16	*Ostrea stentina* Payraudeau, 1826	1	IV
17	*Ctena decussata* (Costa O.G., 1829)	1	IV
18	*Myrtea spinifera* (Montagu, 1803)	1	IV
19	*Lucinella divaricata* (Linnaeus, 1758)	15	IV
20	*Chama gryphoides* (Linnaeus, 1758)	11	IV
21	*Angulus tenuis* (da Costa, 1778)	1	IV
22	*Moerella donacina* (Linnaeus, 1758)	1	IV
23	*Donax* sp.	4	IV
24	*Laevicardium crassum* (Gmelin, 1791)	1	IV
25	*Papillicardium papillosum* (Poli, 1791)	13	IV
26	*Dosinia exoleta* (Linnaeus, 1758)	4	IV
27	*Chamelea gallina* (Linnaeus, 1758)	32	IV
28	*Venus verrucosa* (Linnaeus, 1758)	12	IV
29	*Pitar rudis* (Poli, 1795)	1	IV
30	*Corbula gibba* (Olivi, 1792)	30	IV
31	*Rocellaria dubia* (Pennant, 1777)	1	IV
	SCAPHOPODA		
1	*Antalis vulgaris* (da Costa, 1778)	2	IV
2	*Cadulus gibbus* Jeffreyes, 1883	1	IV

Table 2. List and amount of molluscs found in the lower part of the layer IV of the Vallin Buio section shown in figure 2.



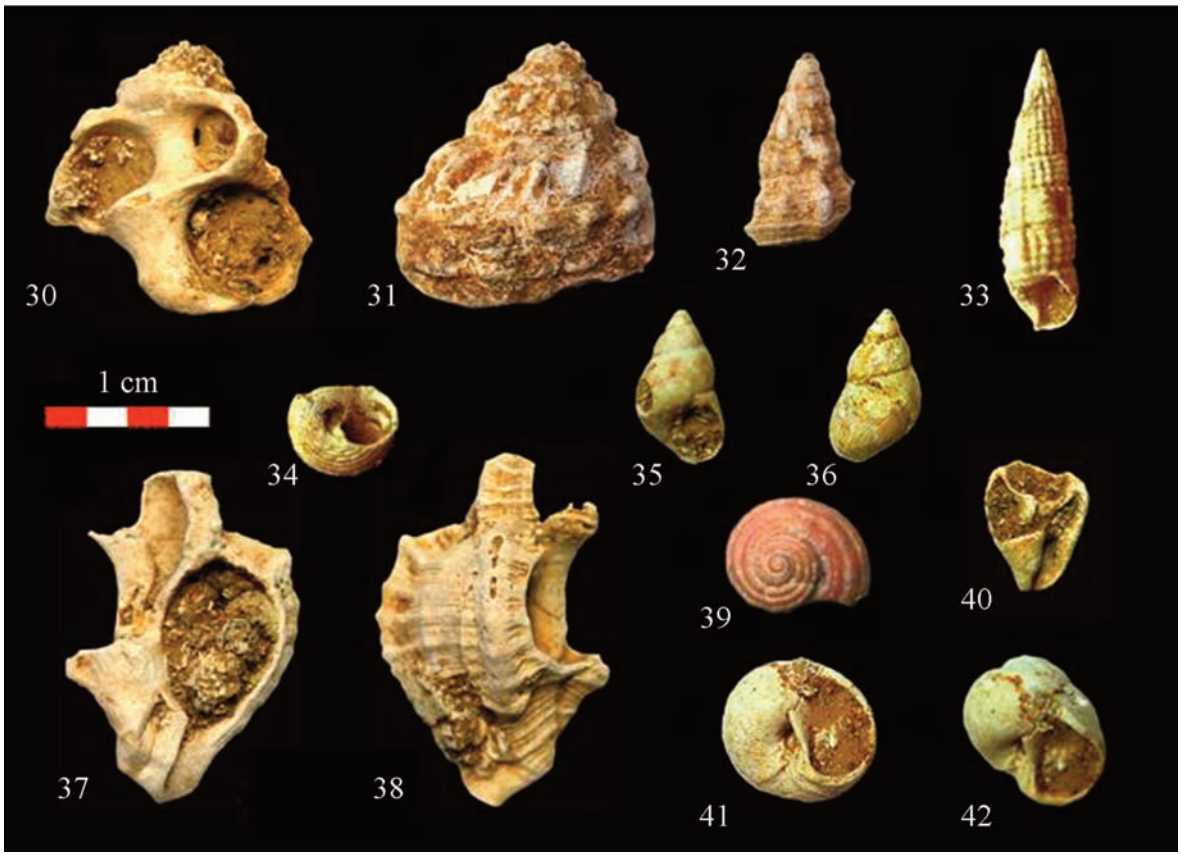
Figures 11, 12. *Rocellaria dubia* (Pennant, 1777) internal/external model l=32 mm., h=12.5 mm. Figures 13, 14. *Chamelea gallina* (Linnaeus, 1758) l=12.4 mm., h=11mm. Figures 15, 16. *Dosinia exoleta* (Linnaeus, 1758) l=22.4 mm., h=21.7 mm. Figure 17. *Flexopecten flexuosus* (Poli, 1795) l=14 mm., h=14 mm. Figure 18. *Barbatia barbata* (Linnaeus, 1758) l=26.4 mm., h=13.5 mm. Figures 19, 20. *Papillicardium papillosum* (Poli, 1791) l=11.6 mm., h=12 mm. Figures 21, 22. *Venus verrucosa* (Linnaeus, 1758) l=24.4 mm., h=22.5 mm. Figures 23-25. *Glycymeris glycymeris* (Linnaeus, 1758) l=33.3 mm., h=33.2 mm.; Figure 26. *Lima lima* (Linnaeus, 1758) l=27 mm., h=20 mm. Figures 27, 28. *Ostreola stentina* Payraudeau, 1826 l=32.4 mm., h=24.3 mm. Figure 29. *Spondylus gaederopus* (Linnaeus, 1758) l=33 mm., h=28.5 mm.

	Species	N. exx.	Level
	GASTROPODA		
1	*Tectura virginea* (O.F.Müller, 1776)	1	I
2	*Turritella spirata* (Brocchi, 1814)	4	I
3	*Aporrhais peralata* (Sacco, 1893)	1	I
4	*Euspira helicina* (Brocchi, 1814)	5	I
5	*Nassarius cabrierensis* (Fontannes, 1878)	3	I
6	*Nassarius italicus* (Mayer, 1876)	3	I
7	*Turricula dimidiata* (Brocchi, 1814)	2	I
8	*Stenodrillia allionii* (Bellardi in Seguenza, 1875)	1	I
	BIVALVIA		
1	*Nucula piacentina* Lamarck, 1819	1	I
2	*Bathyarca cf philippiana* (Nyst, 1848)	2	I
3	*Limopsis aurita* (Brocchi, 1814)	1	I
	SCAPHOPODA		
1	*Dentalium sp.*	2	I
2	*Dentalium sexangulum* Gmelin, 1791	3	I
3	*Gadilina triquetra* (Brocchi, 1814)	1	I

Cauli & Bogi (1997–98) who consider the malacological paleo-communities as characteristic of muddy bottoms, corresponding to a transition zone separating the circalittoral and bathyal planes, dated between the end of Zanclean and the beginning of Piacenziano. Marine Mollusca in the formation of the "Sandy Calcarenites of Castiglioncello" (commonly called "Panchina") now reported as QCP (1:10,000 map, CARG project) is known in detail from a study carried out in the dry dock of the "Torre del Fanale" (Livorno) (Barsotti et al., 1974).

Table 3. List and amount of molluscs found in the Pliocenic clays, level I of the Vallin Buio section shown in figure 2.

Figures 30, 31. *Bolma rugosa* (Linnaeus, 1758). Figure 32. *Cerithium vulgatum* Bruguière, 1792. Figure 33. *Bittium reticulatum* (da Costa, 1778) d=3 mm., h=11 mm. Figure 34. *Clanculus cruciatus* (Linnaeus, 1758). Figures 35, 36. *Tricolia speciosa* (Mühlfeld, 1824) d=4 mm., h=7.3 mm. Figures 37, 38. *Hexaplex trunculus* (Linnaeus, 1758); Figure 39. *Homalopoma sanguineum* (Linnaeus, 1758) x4; Figure 40. *Columbella rustica* (Linnaeus, 1758). Figure 41, 42. *Euspira guilleminii* (Payraudeau, 1826) d=9 mm., h=6 mm.



Figures 43, 44. *Strenodrilla allionii* (Bellardi in Seguenza, 1875), d=7 mm., h=22 mm. Figures 45-47. *Aporrhais peralata* (Sacco, 1893) d=8,5 mm., h=17,3 mm. Figures 48, 49. *Nassarius italicus* (Mayer, 1876) d=9,2 mm., h=18 mm. Figures 50, 51. *Limopsis aurita* (Brocchi, 1814) l=12 mm., h=13 mm. Figure 52. *Tectura virginea* (O.F. Müller, 1776); Figures 53, 54. *Bathyarca* cf. *philippiana* (Nyst, 1848) l=10.3 mm., h=7 mm. Figures 55, 56. *Turricula dimidiata* (Brocchi, 1814) d=10 mm., h=30.5 mm.; Figures 57, 58. *Euspira helicina* (Brocchi, 1814) d=12.4 mm., h=12 mm. Figure 59, 60. *Dentalium sexangulum* Gmelin, 1791 d=7 mm., h=38.5mm.

The level is devoid of "warm guests", particularly of those forms currently found along the Senegalese coasts, so it is possible that the layer belongs to more advanced stages of the Tyrrhenian transgression s.s. dating from 125 ka (MIS 5e).

Actually, even in the dry dock of Livorno (Barsotti et al., 1974) with the exception of the first 30-40 cm in which there were, among other forms, species typical of tropical seas warmer than the Mediterranean, in the rest of the section these species disappeared, being replaced by a "normal" fauna just as that found in the present study.

Malatesta (1942) reported that in the area of Santo Stefano ai Lupi at the base of the escarpment (Gronda dei Lupi) that divided the plain of Pisa from the "Terrace" of Livorno, emerged a bench in thin slabs of limestone with some rests of marine fauna. Towards the top there was an increase in sand fraction, and at the same time the fauna became more and more scarce until it consisted of a few brackish forms, with above all layers reddish dune-sand. Bacci et al. (1939) taking into account data from surveys and field observations, suggested the following reconstruction of the series (see also Barsotti et al., 1974; Dall'Antonia & Mazzanti, 2001; Ciampalini, 2002), from the roof to the bed: slightly clayey sand ending with a soil, very fine reddish aeolian sand with evidence of stratification; coarser reddish dune-sand; small cross-bedding gravel, reddish sand with brackish fauna; bench irregularly cemented or sand with calcareous granules and beach fauna ever more clayey towards the base; continental clay; grey sand; and pebbles.

Malatesta (in Bacci et al., 1939) considered the layers at the base of the section as part of the Tyrrhenian transgression with a continental level intercalated, as confirmed by Barsotti et al. (1974) on the basis of the excavation of the dry dock of the "Torre del Fanale", with sections showing the two benches separated by a continental layer. However, according to most recent studies, the layers below the "Panchina" (Panchina I Auct.) might belong to an intercalated cycle of the middle terminal Pleistocene, dating up to about 180 Ka (MIS 6), with fluvial gravel base separated by a surface of erosion from the silty clays of the Lower Pleistocene (Zanchetta et al., 2006; Ciampalini et al., in press).

In the Vallin Buio section the calcarenites with molluscs rely on the underlying Pliocenic clay sediments, showing sedimens at first of the "Panchina" type and then sandy, first with coarse-grained sedimentation and then thiner. Molluscs shown in figures 3–10 are from the upper part of this layer, immediately below the gravel and are most likely to be referred to a cooling phase, with more temperate climatic characteristics, dating to approximately 100–80 ka (MIS 5d–5b).

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