Bela pseudoappeliusi n. sp. (Neogastropoda: Mangeliidae) from the Plio-Pleistocene of Italy

Francesco NALDI, Giano DELLA BELLA & Daniele SCARPONI

ABSTRACT - A new species of mangeliid, Bela pseudoappeliusi (Neogastropoda, Conoidea), is described from the Plio-Pleistocene of Italy. The systematic description is based on a series of eleven specimens selected from the numerous findings in northern and central Italy (Piedmont, Emilia-Romagna, Tuscany and Lazio). The new species shows affinities to Bela (s.l.) appeliusi (Bellardi, 1877) with regard to particular features such as shell dimension, teleoconch sculpture and aperture morphology. The study includes a detailed survey of the type locality as well as a brief account of occurrences at other localities.

INTRODUCTION

The family Mangeliidae was established by Fischer as the Mangeliinae in the second half of the 19th century (Fischer, 1883). However, its taxonomic placement has been highly debated and a general consensus regarding the latter has only been agreed on recently (Taylor et al., 1993; Rosenberg, 1998 and others). Fischer (1883) included the Mangeliinae within the Conidae; it was subsequently assigned to the family Turridae (e.g., Hedley, 1922; Powell, 1966) and the Conidae (e.g., Taylor et al., 1993). Disagreement regarding the higher level taxonomic classification persisted at least until the beginning of the 21st century and may have been due to the differential emphasis that taxonomists placed on the variety of distinguishing characters used for systematic description (teleoconch-protoconch features, radula morphology, etc.). In addition, factors related to convergence and homoplasy have rendered shell characters a much less reliable tool in conoidean taxonomy than was formerly assumed (e.g., Bouchet & Sysoev, 2001). This has led to contradictory classifications and unsatisfactory consensus among the scientific community (Bouchet & Rocroi, 2005; Garilli & Galletti, 2007; Figueira & Absalão, 2010 among others).

A new and hopefully more stable classification of the Conoidea has been outlined (Bouchet et al., 2011) based on recent molecular phylogenetic analyses (Puillandre et al., 2008, 2011) and their relatively high congruence with a comprehensive anatomical classification of hard (e.g., protoconch), and soft tissues (see Taylor et al., 1993).

In this working classification the family Mangeliidae is characterized by small to medium shells (length < 30 mm), with prominent axial and/or spiral teleoconch sculpture; the latter often being represented by spirally aligned granules that are especially evident on the subsutural ramp. Furthermore, the anal sinus is subsutural, the shoulder is often angulated and the protoconch is usually multispiral with the nucleus being smooth or spirally lirate; the remaining whorls often bear axial ribs sometimes overlapped by spiral elements. The radula consists of only marginal teeth, being variously shaped (from semi-enrolled to true hypodermic; see Bouchet et al., 2011).

Among the more than fifty extant genera of this family the genus Bela Gray, 1847 is one of the most emblematic of the ‘troublesome’ Mangeliidae. Bela was established by Gray (1847) based on Murex nebula Montagu, 1803. The precise identification of the latter is unclear and a more detailed analysis of this taxon is deemed necessary in order to avoid erroneous assignments to the genus (Mariottini et al., 2009). Indeed, since its establishment, Bela has often been used as a ‘wastebasket taxon’ for a vast array of unrelated eastern Atlantic-Mediterranean Cenozoic turrids s.l. (see Powell, 1966). Hence, the numerous fossil and Recent species assigned to Bela require thorough revision. Among the hundreds of species documented as belonging to Bela (see Tucker, 2004), the World Register of Marine Species (http://www.marinespecies.org), estimated that approximately 28 can be stated as being Recent representatives, and Tucker (2004) reported only 44 as being valid Cenozoic fossil species.
In the present study research has been focused on a number of shells that preserve an original combination of features that, as far as the authors are aware, have not been recognized to date in other mangeliids. *Bela pseudoappeliusi* is described herein as a new species for the Plio-Pleistocene of Italy and is compared with the closely related mangeliid, *Bela* (s.l.) *appeliusi* (Bellardi).

This paper forms part of a series of contributions on the taxonomy and biodiversity of fossil coneidaeans from the Plio-Pleistocene of the Mediterranean Basin (Scarponi & Della Bella, 2004, 2010; Ceregato et al., 2006; Della Bella & Scarponi, 2007; Garilli & Galletti, 2007; Mariottini et al., 2009; Spada & Della Bella, 2010; Scarponi et al., 2011a, b among others).

MATERIALS AND METHODS

The material examined in the present study consists of twenty specimens that have been ascertained herein as belonging to *Bela* (s.l.) *appeliusi* and forty-three specimens that have been attributed to *Bela pseudoappeliusi* n. sp. In order to better evaluate the variability of the latter and to compare quantitatively the morphologic variations between the two taxa, a batch of eleven specimens for each species was retained sufficient. Hence, a range of shell characters were carefully measured both on the holotype as well as on ten randomly selected shells for each species (see Appendices I-II and Tab. 1). However, it should be noted that both juvenile shells (teleoconch < 2.5 whorls) and excessively damaged shells were excluded (i.e., seven and 20 respectively) from the original batch of specimens prior to the selection process (see above). Consequently, the description of the new species is based on five shells collected from the Terre Rosse outcrop (Siena Basin, Italy) and six shells from localities in Latium and Tuscany (Appendix I). All the studied material is housed in the Museo Geologico Giovanni Capellini (MGGC) in Bologna, except for the holotype of *B. (s.l.) appeliusi*, housed in the Bellardi-Sacco (BS) collection in the Museo di Scienze Naturali (Torino, Italy).

SYSTEMATICS

Class GASTROPODA Cuvier, 1795
Order NEOGASTROPODA Thiele, 1929
Superfamily CONOIDEA Fleming, 1822
Family MANGELIIDAE Fischer, 1883

Genus *Mangelia* Gray, 1847

Type species - *Murex nebula* Montagu, 1803.

Remarks - According to Mariottini et al. (2009), as identification of the type species of this genus is still uncertain, a neotype should be proposed in order to stabilize the genus name usage. Furthermore, the opinion expressed by Mariottini et al. (2009) regarding the doubtful generic attribution to *Bela* or *Pleurotoma brachystomum* Philippi, 1844 and its related species is supported by the authors herein. Meanwhile, pending molecular analysis in order to arrive at a better generic definition of *Bela*, the authors follow Mariottini et al. (2009) and include only species morphologically similar to *Bela zonata* (Locard, 1891) within the genus. As for other representatives currently placed within this genus (such as *Bela appeliusi*), attribution to *Bela* (s.l.) pending future revision has been adopted herein.

*Bela pseudoappeliusi* n. sp.
(Fig. 1a-c; Fig. 2a-c; Appendix I)

1997 *Mangelia appeliusi* Bellardi - Chirilli, p. 62, Pl. 17, fig. 17; Pl. 18, figs 1-2.

Etymology - After the Greek pseudo (false) and the word *appeliusi* (dedicated to Appelius), referring to the comparative species *Bela* (s.l.) *appeliusi* (Bellardi, 1877).

Type material - In total 11 specimens: Holotype (MGGC-23470), and four paratypes (MGGC-23471 to -23474), from the Terre Rosse locality (Siena Basin; Pliocene sands of the S. Vivaldo Formation); three paratypes (MGGC-23475 to -23577), from Montelibretti (Roma); two paratypes (MGGC-23478 to -23579), from Morrorna (Terricciola, Pisa); one paratype (MGGC-23480), from Montopoli in Val d’Arno (Pisa).

Additional material - Thirty-two specimens housed within the collections of the MGGC (inventory number MGGC-23482), even though attributed to the new species, are not considered as belonging to the type series (see provision 72.4.6 of International Code of Zoological Nomenclature, 1999). The material includes: three shells from Villalvernia (Alessandria); one shell from Vignola (Modena); 15 shells from Terre Rosse (Siena); eight shells from Montelibretti (Roma), two shells from Morrorna and three shells from San Pietro quarry (Siena).

Type locality - Terre Rosse (lat. 43°19′51″N; long. 11°35′11″E, geographic coordinate on the World Geodetic System of 1984 [WGS84]), Castelnuovo Berardengha (Siena, Italy). Type material described herein is from the uppermost two meters of a 5.5 m thick, richly fossiliferous, coarse to medium sand body (see below).

Diagnosis - Shell small-sized, protoconch of 3.1 whorls (on average), nucleus spirally lirate and immersed, last protoconch whorl with low granulose axial riblets on the final 0.5 portion, axial sculpture strong, consisting of suture-to-suture rounded ribs, spiral sculpture of thin, heterogeneous, granulose threads, rounded shoulder, anal sinus rounded, subsutural.

Description - Shell small (average L = 4.5 mm, σ = 0.8 mm; D = 2.1 mm, σ = 0.4 mm) (L = length; D = diameter; σ = standard deviation; Tab. 1), biconical, turriculate, solid, with conical spire and rounded body whorl. Protoconch (Fig. 1a-c), dome-shaped of - on average - 3.1 convex whorls (average: L = 0.63 mm, σ = 0.06 mm; D = 0.65 mm, σ = 0.05 mm; Tab. 1). Apical whorl small, rather immersed, spirally lirate, otherwise smooth except for the final half, where low and evenly curved axial riblets are overrun by 3-4 rows of globose tubercles. Protoconch-
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σ = 0.8 mm; Tab. 1), running from suture to suture and thinner at the adapical suture. Spiral sculpture overrides the axial ribs, consisting on the subsutural ramp of several thin and uniform threads separated by incised lines; on the remaining whorl threads are thicker and irregularly alternated by thinner elements; interspaces of variable size. Each thread is densely indented by growing stage lirae and, especially on the subsutural ramp, it resembles a string of densely packed granules. Aperture rather narrow, elongated, sub-rectangular; siphonal canal very short, rather broad, left-deviated (aperture-canal average length = 2.0 mm, σ = 0.2 mm; Tab. 1). Outer lip without varix, thin, smooth within, rounded in profile; anal sinus subsutural, relatively broad and rounded. Inner lip straight with a thin parietal callos.

Remarks - The new species (Figs 1-2; Tab. 1 and Appendix I), shows a combination of features (i.e., rounded shoulder, margined sutures, protoconch sculptural pattern, morphology of the aperture and sinus), suggesting assignment to the genus Bela Gray, 1847 and, more specifically, to the B. zonata group. Bela pseudoappeliusi n. sp. shows close affinities to the Mediterranean Pliocene mangeliid Bela (s.l.) appeliusi (Bellardi, 1877) in particular with regard to shell dimension and teleoconch sculpture (i.e., evident axial ribs overrun by densely indented spirals) (Fig. 2). In addition, certain features of B. (s.l.) appeliusi such as the sub-rectangular aperture, the short siphonal canal as well as the rounded, subsutural anal sinus show great similarity to those of B. pseudoappeliusi. Indeed, no significant (at this sample size) difference in the average value of a variety of teleoconch features (e.g., teleoconch length, diameter; see t-test in Tab. 1) was highlighted by basic morphometric analyses of selected specimens (Appendix I).

However, when compared to B. pseudoappeliusi, it may be noted that Bela (s.l.) appeliusi shows flatter and shorter spire whorls with a strongly angulated shoulder as well as thinner and more numerous axial ribs that are overrun by less dense spiral threads (Fig. 2 and Tab. 1). Furthermore, the protoconch of B. (s.l.) appeliusi is notably larger in dimension, with a significantly higher protoconch embryonic whorl length/number ratio (Tab. 1). Lastly, the protoconch sculpture of B. (s.l.) appeliusi is clearly reticulate, being composed of marked axial and spiral elements (Fig. 1d-f).

In summary the new species differs from B. (s.l.) appeliusi in having a strongly convex whorl outline, a rounded shoulder, thicker and less numerous axial ribs, a shorter and more convex subsutural ramp, a denser spiral sculpture and a lower teleoconch whorl length/number ratio (see Fig. 2 and Tab. 1). At protoconch level, the main differences reside in the smaller dimension of B. pseudoappeliusi (Tab. 1) and in the sculpture of the ultimate protoconch whorl (Fig. 1). Indeed, ornamentation in B. pseudoappeliusi is restricted to the ultimate half whorl of the protoconch and is characterized by granulose axial riblets. In contrast, ornamentation in B. (s.l.) appeliusi is reticulated, present all along the ultimate whorl and shows more numerous and stronger spiral elements.

Fig. 1 - Scanning electron microscope photos of protoconch features. Bela pseudoappeliusi n. sp.: a) MGCG-23477-paratype, Montelibretti (Roma), Calabrian(?); b) MGCG-23482-spec. 1, Villalvernia (Alessandria), Zanclean-Piacenzian; c) MGCG-23482-spec. 2, Montopoli in Val d’Arno (Pisa), Piacenzian. Bela (s.l.) appeliusi (Bellardi): d-e) MGCG-23493 and -23494, Marano sul Panaro (Modena), Piacenzian; f) MGCG-23495, Monte Alto (Piacenza), Piacenzian. Scale bars 0.1 mm; MGCG-23477 = shell number given in Appendix I; spec. = specimen.
STRATIGRAPHICAL INFORMATION RELATED TO THE TYPE SERIES

The greater part of the type series material (i.e., holotype and four paratypes) was collected from a small outcrop named Terre Rosse, located near Castelnuovo Berardenga (Siena Basin, Italy).

The upper Miocene (Tortonian) to upper Pliocene (Piacenzian) deposits of the Siena basin are among the best-preserved of the richly fossiliferous successions occurring in Tuscany (Manganelli et al., 2010 and references therein). However, Miocene continental (alluvial to lacustrine) deposits have a scattered geographical distribution and depositional sequences are complex as a result of the intra-Messinian regional unconformity (Costantini et al., 2009). Conversely, Zanclean to Piacenzian successions outcrop extensively and are a few hundred meters in thickness. They overlay both the upper Miocene deposits and the Ligurian units. Marine sedimentation persisted until the Piacenzian, when a generalized uplift led to emersion of the area (see Bossio et al., 1993 and references therein). Unfortunately, there are relatively few detailed sedimentological studies of the area. According to Aldinucci et al. (2007) and Bosca...
and have been referred to the uppermost depositional unit of the latter by Boscaini (2011).

The section is ~ 9 m thick and consists of a variety of lithofacies that can be grouped into two main units of contrasting lithologies (Fig. 3). The lower to middle-upper marine deposits of the section are richly fossiliferous and are attributed to the San Vivaldo Formation (Fig. 3). The succession includes 5.5 m of massive, fining-upward sandstone capped by 0.5 m of homogeneous silty-clays. The latter are in turn overlain by poorly laminated siltstone to massive sandstone (about 1 m thick). The uppermost part of the section is characterized by barren alternations of centimeter to decimeter tabular pebbles and plane-paralleled bedded sands and clays that unconformably

The Terre Rosse section (Fig. 3) occurs along the bank of a gully amid thick vegetation and the sedimentary deposits crop out for some kilometers. According to the Geological Map of Italy (Costantini et al., 2009), the Terre Rosse deposits form part of the San Vivaldo Formation and have been referred to the uppermost depositional unit of the latter by Boscaini (2011).

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The holotype and four paratypes were collected from a level approximately 1 meter below the top of the thick fossiliferous sandstone (bulk sample 4 in Fig. 3). The use of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit geochronologically proved unsuccessful due to the nature of traditional biomarkers to constrain the stratigraphic unit

The localities and horizons of the remaining type series specimens are as follows (Appendix I):

1. Montelibretti (Roma), silty clay deposits (lat. 42°08′0″N; long. 12°44′0″E, WGS84), attributed with doubt to the Calabrian.

2. Morrone, Terricciola (Pisa), silty sand deposits attributed to the Piacenzian (lat. 43°31′48″N; long. 10°39′49″E, WGS84).

3. San Pietro quarry, Montopoli in Val d’Arno (Pisa), clay deposits attributed to the Piacenzian (lat. 43°37′24″N; long. 10°52′54″E, WGS84).

In the outcrops above, specimens of the newly described species were found in association with infralittoral to circalittoral molluscan assemblages. Unfortunately, a more detailed reference for the stratigraphic position of the occurrences and data related to paleoecology is not available.

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REFERENCES


Boscaini N. (2011). I depositi plio-peistocenici di valle incisa del torrente Ambra (Toscana, Italia): interazioni tra tettonica e...
APPENDIX I

Quantitative evaluation of eleven shell features of the twenty-two studied shells belonging to *Bela pseudoappeliusi* n. sp. and *B. (s.l.) appeliusi* (Bellardi, 1877). Ten randomly sampled shells as well as the holotype were examined for each species. Abbreviations: D = diameter; Hol. = holotype; L = length; Par. = paratype; # = number; ? = feature not quantifiable.

<table>
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<th>Specimen</th>
<th>Locality</th>
<th>Bela pseudoappeliusi</th>
<th>Bela (s.l.) appeliusi</th>
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APPENDIX II

Visual depiction of the morphological characters measured on the studied shells. Abbreviations: AL = aperture length; BWL = body whorl length; D = diameter; PD = protoconch diameter; SL = shell length; 2°wh = second whorl.