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Short communication

An enigmatic Maastrichtian small benthic Foraminifera of the Tarbur Formation (Iran, Zagros zone)

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The Maastrichtian carbonates of the Tarbur Formation from the Zagros zone (SW Iran) are very rich in larger Foraminifera. Additionally, smaller benthic Foraminifera occur as well, one of them presented here as Zagrosaria pinnata gen. et sp. nov. It occurs abundantly at the Mandegan section within two levels corresponding to the lower photic zone. Based on the existence of a central pile along with an umbilical plate, and the lacks of true interiomarginal apertures, likely represented by a perforate surface, the suprageneric placing of Zagrosaria gen. nov. remains controversial. The ultimate aperture is represented by a central elongate double-bifid slot that arguably lies on a finely perforated and heavy feathered apertural face. Based on the reduced dimensions and lack of dimorphism the new taxon could be considered an epifaunal or shallow-infaunal r-strategist.

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1. Introduction

The Tarbur Formation (James and Wynd, 1965) is a lithostratigraphic unit recording the widespread occurrence of a shallow carbonate shelf that settled, during the Maastrichtian, on the top of the Zagros peripheral bulge or along the border of the facing foreland basin (Piryaei et al., 2010; Saura et al., 2011; Barrier et al., 2018). Its emplacement is interpreted to be driven by a regional Maastrichtian transgression event (Saura et al., 2011). Based on the common occurrence of larger Foraminifera, rudists, corals and Dasycladacean green algae (Pirbaluti et al., 2013; Afghah, 2016; Rashidi and Schlagintweit, 2017), these carbonates were presumably deposited under oligotrophic or mesotrophic conditions, in the illuminated waters of the photic zone (Consorti et al., 2019). Diversity of Foraminifera reach a very high value and includes both small and large species (Schlagintweit and Rashidi, 2016; Consorti and Rashidi, 2018, 2019). Such as diversity was likely driven by the existence of several environments, generated by food availability, bottom type and light penetration along the shelf gradient (Hottinger, 1997; Hohenegger, 2000). Going throughout the water depth that received a few light penetration, number of small foraminifers is somewhat very notable. The shape and dimension along with the facies of the embedding limestone may lead, at a hasty eye, to point a keeled planktonic form such as Globotruncanina Cushman. A closer look in thin section reveals, instead, an umbilical shell infilling (e.g. umbilical plug), among the other features, that can be frankly associated to a benthic undescribed rotaliid Foraminifera.

Aim of the present contribution is to formally define this small Maastrichtian taxon through a detailed analysis of its shell architecture in thin sections. Some features appear innovative into a single taxon so far within the rotaliids. This would open a new view on the complex character of the group, which includes both larger and smaller species (Hottinger, 2014).

2. Stratigraphic guidelines

The studied section is located at the northern side of Mount Dena in the High Zagros Belt, about 65 km far away from the town of Semirom. The total thickness of the Tarbur Formation here measured is about 272 m. The succession conformably overlies the Gurpi Formation and in turn is unconformably overlaid by the conglomerates of the Pliocene Bakhtiari Formation (Fig. 1). The section encompasses three lithostratigraphic units; the first composed by thick-bedded limestones, the second represented by medium-bedded limestones with marly limestone intercalations,
and the third consisting of marly limestones. The lithostratigraphic subdivision and a comprehensive list of larger foraminifera found in the Mandegan section is shown in fig. 4 of Schlagintweit and Rashidi (2016). The new Foraminifera occurs in the lowermost and upper part of the section (Fig. 1). The Greenwich coordinates of the log base are N31°04'99.97" – E 51°40'93.24".
3. Material and method

After an initial sampling throughout the section, we have selected the rock samples where accumulation is extraordinarily abundant. Because isolated specimens were not available, samples have been cut to obtain giant thin sections (12 cm × 15 cm). We have recovered more than four hundred specimens, around fifty of them under axial, sub-axial and transversal diagnostic views for micropaleontological analysis. The two thin sections containing the holotype, paratypes and further specimens from the type level selected and figured in this work are deposited in the palaeontological collection of the Natural History Museum of Trieste with the acronym T19771 and T19772. Method and terminology are from Hottinger (2006a, 2014).

4. Systematic micropaleontology

Phylum Foraminifera (Orbigny, 1826) Pawlowski et al., 2013
Class Globothalamea Pawlowski et al., 2013
Order Rotaliida Delage and Hérouard, 1896
Superfamily ?Rotalioidea Ehrenberg, 1839, revised Hottinger (2014)

Remarks. The new species barely resembles some Late Cretaceous representatives of the Discorbinelloidea Sigal such as the genus Epistominella Husezima and Maruhasi as well as Chilostomelloidea Brady with the genus Globorotalides Broten. Affinities with Praestorrsella (Visser; family Glabratellidae; Late Campanian and Maastrichtian) seems unlikely. The umbilical geometry of the early spire and the canal system suggest closeness with Rotalioidea but the existence of a complex adult aperture and the lack of a clear umbilical plate in the youngest chambers may contrast with the definition of the superfamily as stated by Consorti et al. (2017).

Genus Zagrosaria nov.
Type species: Zagrosaria pinnata sp. nov.

Derivatio nominis. The generic name is given from Zagros mountains (the type locality); and the Latin suffix -aria. Gender feminine. Diagnosis. Small-sized trochospiral shell. The dorsal side is evolute, flat to slightly convex and keeled. The ventral side is strongly convex, involute, bulged and ornamented by feathered sutures. The first ontogenetic stage comprises roughly two whorls where the ventral side gets occupied by a central umbilical pile, producing a plug surrounded by vertical funnels. Chambers are prismatic to trapezoidal. They are roughly triangular in ventral view, wider than higher with a keeled acute periphery in the first ontogenetic step, then higher and inflated at the end of ontogenesis. The umbilical plate occurs in the early whorls. Ventral sutures are radial and feathered, especially towards the umbilical termination. Aperture composed by an interiomarginal row of pores in the early ontogenetic stage. The main apertural face consists of a finely-perforated plate that bears a wide central and double-bifid elongated slot. The slot is produced by a sort of hooked terminations of the ultimate chambers, possibly related to an umbilical flap. The canal system is composed of intraseptal interlocular spaces throughout, and funnels, placed between the pile and the umbilical plate, which extend along to the pile height. Sutural canals connecting with the intraseptal interlocular spaces are present. Dimorphism has not been observed.

Fig. 2. Camera lucida drawings of Zagrosaria pinnata gen. et sp. nov. A (¼ Fig. 3I). Holotype, axial section. B (¼ Fig. 3D). sub-axial section. C (¼ Fig. 4B). Section passing through the ultimate aperture. Note the double-bifid slot. D (¼ Fig. 4A). Transversal section. E (¼ Fig. 4N). Transversal section passing through the proloculus. F (¼ Fig. 5O). sub-axial section. G (¼ Fig. 5I). Oblique basal section. Scale bar 0.2 mm for all illustrations. Abbreviations: a: aperture, f: feather, fu: funnel, is: intraseptal canal, k: keel, p: pile, per: perforated apertural surface, sc: sutural canal, up: umbilical plate.
Fig. 3. Thin sections of Zagrosaria pinnata gen. et sp. nov. from the type level. I: Holotype (T19771). A, C, E, G (right), I, K, O, P, Q-T. Axial sections. B, D, J, L, N. Sub-axial sections. G (left). Tangential section. H, M. Oblique sections passing through the ventral side. Scale bar 0.2 mm for all pictures. Abbreviations: a: aperture, f: feather, fu: funnel, is: intraseptal canal, k: keel, p: pile, up: umbilical plate.
Fig. 4. Thin sections of Zagrosaria pinnata gen. et sp. nov. from the type level. A, D, E-H. Transversal section showing the ventral termination of the umbilical pile and the apertures of the early whorls. B. Transversal section passing through the main double-bifid apertural slot. C, K, N. Transversal section passing through the prolocular area. I, J, L, M, O-T. Transversal section cutting the base of the chambers. Scale bar 0.2 mm for all the pictures. Abbreviations: a: aperture, f: feather, is: intraseptal canal, p: pile, sc: sutural canals.
Differential diagnosis. Zagrosaria gen. nov. differs from Pararotalia Le Calvez by the lack of a toothplate. The occurrence of the folia in Rotorbinella Bandy spot a significant difference with Zagrosaria gen. nov., that lacks such element. The small Rotalidium Vicedo and Robles-Salcedo differs from Zagrosaria gen. nov. by the presence of folia and by the occurrence of so-called supplementary dorsal chamberlets that typically appear only in alveolinoids (Hottinger, 2006a; Vicedo et al., 2019). Elazigina Sirel possesses an un-keeled dorsal side, a massive umbilical plug surrounded by piles and a thick wall, unlike Zagrosaria. The adult double-bifid aperture differentiates the new genus from all rotaliid-like morphotypes so far reported.

Remarks. The aperture is the most enigmatic trait when analyzing Zagrosaria in thin sections. It is unclear whether the double-bifid slot appears also in the earlier whorls where, according to our observations, the apertures seem to be represented just by a barely feathered plate pierced by thin pores likely acting as intercameral foramina. Camera lucida reconstructions of these areas (Fig. 2D) show how pores get bordered by a cerebroid crest, or probably by peristomes that merge each other’s, resembling those of the
Paleocene Scarificatina Moorkens (see Hottinger, 2014, pl. 9.3). The same type of perforation is obviously present over the main apertural face, where the double-bifid slot occurs (Fig. 2C). Nature and geometry of these perforated surfaces, however, cannot be determined in detail with the material at our disposition lacking isolated specimens. Moreover, the adult apertural slot bears some sort of elongated feathers in its shallow interior. In other cases, instead it seems entirely occupied by some kind of structure, or covered by a plate of unknown origin. The adult bifid slot follows the convex geometry of the ventral side. Searching for isolated specimens would help to add details on the aperture thus maybe revealing a clearer understanding on its suprageneric placing.

**Zagrosaria pinnata** sp. nov.

Figs. 3–5

*Holotype*. Specimen T19771 in figure 3I

*Type locality*. Mandegan section, Mont Dena, Zagros Zone, SW Iran. See reference in the column (Fig. 1).

*Type horizon*. Lower part of the Tarbur Formation, upper Maastrichtian.

*Derivatio nominis*. From the Latin *pinnatus* = with wings, referring to the shape of the sutural ventral ornamentation.

**Total number of studied specimens.** More than 400.

*Diagnosis*. Small lamellar trochospiral shell. Low convex dorsal side ornamented by costae that follow a spiral pattern. The periphery of the shell is angular and keeled. The ventral side is strongly convex, traversed by sunken radial sutures that are heavily ornamented by feathered ridges. Feathering attains a roughly fan shape. Ornamentation also consists in regularly spaced ventral crests that may fuse with the umbilical ends of the feathered ridges. The aperture is interiomarginal in the first two whorls, then represented by a central double-bifid slot, about 155 μm in length, that connects the shell interior with the ambient environment. The trochosphere consists of 3 whorls. The first two whorls are composed by small prismatic chambers, which are wider than high. The last whorl is built by higher trapezoidal chambers. There are at least 6–7 chambers in the first whorl; 9–10 in the second and 10 in the last one. Maximum height of chambers in the first whorl is about 30 μm. The maximum height of the last chambers attains 0.2 mm. The tiny proloculus is 12 μm in diameter. The maximum diameter of the umbilical pile is 41 μm at its ventral end, whereas its height is approximately of 50 μm. The shell diameter varies from 0.22 mm to 0.34 mm; the shell height ranges between 0.20 mm and 0.29 mm. The diameter to height ratio varies between 1.10 and 1.17. The
intraskeletal interlocular space is present along the septa; the diameter of the dorsal sutureal canals ranges between 13 μm and 15 μm. Wall thickness is among 12 μm and 22 μm. Holotype measurements. Diameter: 0.31 mm; height: 0.29 mm. Associated foraminifera of the type level. Canalispinia iapptyia Robles-Salcedo et al., Cibicoides succedens (Brotzen), Sirtina orbitoriiformis Brönnimann, Goupillauldina cf. iranica Rahaghi. Geographic and stratigraphic distribution. Maastrichtian of the Zagros Mountains. Its dispersal is possibly wider, likely throughout the Middle East platforms.

5. Paleoecology

The small size, relatively simple umbilical architecture, and the lack of adult dimorphism suggest an r-strategy of life. This would indicate the absence of algal endo-symbionts (Hottinger, 2001, 2006b). The Zagrosaria-bearing deposit comprises packstone-wackestone made of bioclasts that derive from the mechanical abrasion of larger foraminifers, echinoids and bivalves (Fig. 6). Zagrosaria occurs often well preserved with a density of 3–5 specimens per mm square. The lack of porcellaneous and agglutinating taxa, that generally abound (Schlagintweit and Rashidi, 2016; Schlagintweit et al., 2016), and the presence of flat-shelled (Sirtina orbitoriiformis and Goupillauldina) and rare planktonic Foraminifera placed Zagrosaria in the lower part of the photic zone (Hottinger, 1983; Hohenegger, 2000; Robles-Salcedo et al., 2013; Consorti and Köröglu, 2019). This would match with the paleoenvironment of Praeostorrsella rostae in the Late Cretaceous (Hottinger and Caus, 1993). However, the amount of bivalve remains and Canalispinia fragments suggests a relatively narrow bathymetry influenced by bioclastic discharges from a constantly agitated setting. An ecological comparison may be attempted among the morphogroups established in recent small benthic Foraminifera referring to the shell mineralogy and the overall geometry, including ornamentation and distribution of pores. Assessments are not straightforward as some species have a fixed habit, whereas others may change tendency, depending to certain environmental parameters (Corliss, 1991; Jorissen, 1999; Hottinger, 2000 among others). Based on the occurrence of fine pores on the aperture, heavy ventral ornamentations and a plano-convex geometry, Zagrosaria pinnata n. sp. could be considered epifaunal or shallow-infaunal (see Jorissen, 1999).

6. Conclusions

A new small benthic Foraminifera has been described as Zagrosaria pinnata gen. et sp. nov. from the shallow-water carbonates of the Tarbur Formation of the Zagros zone in SW Iran. It is characterized by a plano-convex geometry with three trochospheric whorls, heavy feathered ventral ornamentation, dorsal keel and a double-bifid main apertural slot. The umbilical pile and the umbilical plate are only seat in the first two whors indicating anyway a close relationship with representatives of the superfamily Rotalioidea. The unclear nature of the early apertures and the architecture of the last whorl are however an enigmatic trait that should be further deepened using isolated specimens. These shell features seem innovative and are here reported together for the first time so far within one rotaliid species. Comparison with recent smaller benthic Foraminifera point to an epifaunal or shallow-infaunal life style.

CRediT authorship contribution statement

Lorenzo Consorti: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing - original draft, Writing - review & editing. Koorosh Rashidi: Data curation, Funding acquisition, Supervision, Validation, Writing - review & editing.

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