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NOVALESIA PRODUCTA (MAGNIEZ, 1972), A LITTLE-KNOWN BENTHIC FORAMINIFER FROM THE APTIAN TAFT FORMATION OF CENTRAL IRAN

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Abstract. The larger benthic foraminifera *Novalesia producta* (Magniez) is a common constituent in the faunal assemblages of inner platform wackestone-packstone microfacies of the Aptian Taft Formation, Central Iran. The abundant specimens observed in thin-sections allow a detailed morphological and biometrical analysis of the taxon that extends the known data.

Keywords: Benthic foraminifera, taxonomy, biostratigraphy, palaeobiogeography.

INTRODUCTION

Lower to mid-Cretaceous peri-Tethyan shallow-water carbonates are rich in larger benthic foraminifera. Among the most common and widely known are the conical agglutinated Orbitolinidae that may be (depending on the taxon) of biostratigraphic relevance (e.g., Moullade et al., 1985; Schroeder et al., 2010). These '*Orbitolina* limestones' are usually accompanied by more or less well diversified assemblages of other larger and smaller benthic foraminifera (e.g., Arnaud-Vanneau, 1980). In Central Iran, such carbonates are known as the Taft or Shah Kuh Formation (Wilmsen et al., 2013, 2020) displaying abundant (larger) benthic foraminifera (e.g., Hanifzadah et al., 2015; Schlagintweit et al., 2013a, b, 2020; Yazdi-Moghadam et al., 2021). In the present contribution, we report on the occurrence of *Novalesia producta* (Magniez), originally described from the Aptian-Albian of Spain, in the Aptian Taft Formation of Central Iran. The relatively rich material comprising juvenile and adult specimens allows a detailed morphological and biometrical study from Central Iran, including comparison with the western Neotethys occurrences (e.g., Spain, S-France).

GEOLOGICAL SETTING

The mountainous region around Anarak is part of the so-called Yazd Block of Central Iran (Berberian & King, 1981; Aghanabati, 2004; Wilmsen et al., 2020, for overviews). Transgressive Lower Cretaceous shallow-water limestones ('*Orbitolina* limestones') overlie conglomerates and sandstones which in turn are underlain by the Late Paleozoic to Triassic Anarak metamorphic complex (e.g. Torabi, 2011; Buchs et al., 2013; Wilmsen et al., 2020). The Lower Cretaceous carbonates of the Yazd Block that are generally assigned to the Barremian-Aptian interval were recently investigated with respect to microfacies, sedimentology and micropaleontology by Bucur et al. (2012), Wilmsen et al. (2013), and Schlagintweit & Wilmsen (2014). *Novalesia producta* (Magniez) is here reported from two localities, the Anarak and Herisht sections (Fig.1).

Anarak section

The base of the studied section is located ~3.1 km north of Anarak village. For previous studies see Bucur et al. (2016) and Schlagintweit & Rashidi (2022). *Novalesia producta* occurs in wackestones-packstones with orbitolinids such as *Dictyoconus*? *pachymarginalis* Schroeder or *Palaeodictyoconus actinostoma* Arnaud-Vanneau & Schroeder, *Mayncina bulgarica* Laug et al., *Charentia cuvillieri* Neumann, *Nezzazata* sp., *Everticyclammina* sp., *Sabaudia minuta* (Hofker) (Fig. 2), and miliolids. For further discussion of benthic foraminifera in the area see Schlagintweit et al. (2013a, fig. 3; 2013b, fig. 3).

Herisht section

The Herisht section is located in the central district of Ardakan County in the province of Yazd. This section is located about 12 km northeast of Ardakan city. For previous studies see Schlagintweit et al. (2013a, b) and Bucur et al. (2016).

SYSTEMATIC PALAEONTOLOGY

The classification follows Kaminski (2014).

Order Lituolida Lankester, 1885

Remarks: The order is defined as 'Test free or attached, multilocular or becoming so, uniserial, biserial, multiserial, or coiled in early stage, later may uncoil;

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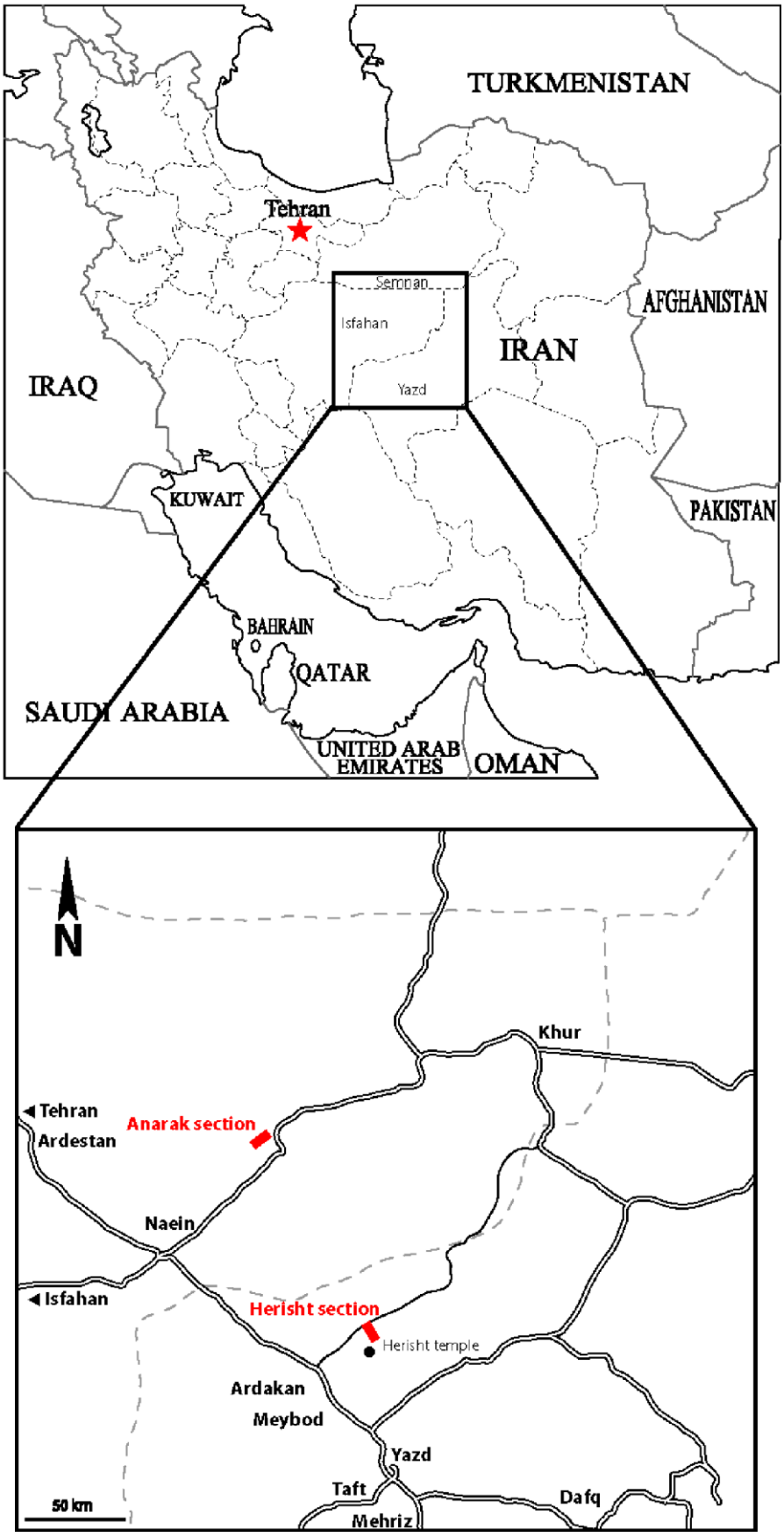

Fig. 1. Location of the studied sections at Anarak and Herisht in Central Iran. Anarak section: 33º20´22.66´´N, 53º41´53.68´´E. Herisht section: 32º25´37.61´´N (from Schlagintweit et al., 2013a, fig. 1).

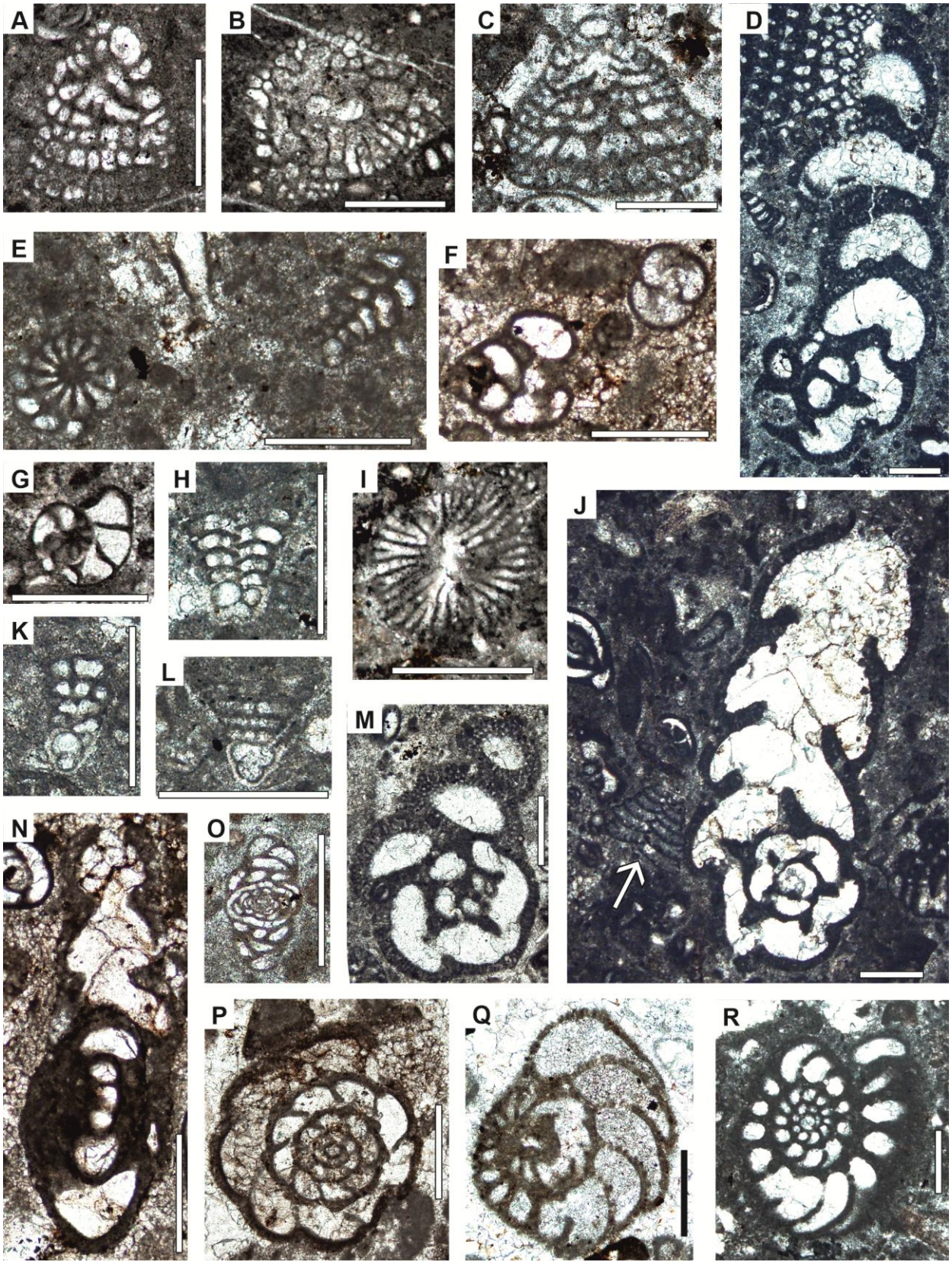

Fig. 2. Benthic foraminifera from the Aptian Taft Formation of the Herisht (**A-C, G, I)** and Anarak (**D-F, H, J-R**) sections. **A-C.** Orbitolinidae gen. et sp. indet. **D, J, M.** *Everticyclammina* sp.; Note the presence of *Sabaudia minuta* (Hofker) in **J** (white arrow); **E.** *Nezzazata* sp. (left) and *Novalesia producta* (Magniez) (right). **F.** *Siphovalvulina* sp., oblique and transverse sections. **G.** *Nezzazata* sp.; **H-I, K-L**. *Sabaudia minuta* (Hofker). **N, P.** *Charentia cuvillieri* Neumann. **O.** *Glomospira* cf. *urgoniana* Arnaud-Vanneau. **Q-R.** *Mayncina bulgarica* Laug et al. Thin-sections: T94 (A-B), T72 (C), AQ20 (D, J, M), AQ14 (E), AQ23 (F), T73 (G), AQ18 (H, K-L), T73 (I), AQ23 (N), AQ36 (P), AQ17 (Q), AQn18 (R); Scale bars = 0.30 mm.

chamber interior simple, or may be partially divided by septula in advanced forms; wall agglutinated with organic, microgranular, or calcitic cement; simple and nonperforate' (Kaminski, 2014, p. 97). It should be stressed that, in any future classification, the term **septula** should (in our opinion) be replaced by the more neutral term **partitions** because the former are related to the foramina and exclude per definition exoskeletal beams (see Hottinger, 2006), that is dealt with in the genus *Novalesia* Magniez, 1974 herein. Another possibility would be an inclusion of *Novalesia* in another order, e.g. Loftusiida Kaminski & Mikhalevich, 2004 where the term **internal partitions** is used (Kaminski, 2014, p. 101). This order includes morphologically and structurally (e.g., biserial compressed test, vertical and horizontal partitions) comparable taxa such *Cuneolina* d'Orbigny or *Vercorsella* Arnaud-Vanneau, 1980 (Loeblich & Tappan, 1987; Kaminski, 2014). Without indicating any taxonomic grouping, Arnaud-Vanneau (1980, p. 516) included the three mentioned genera (and others like *Sabaudia* Charollais & Brönnimann) and their description into a group of foraminifera exhibiting a test with subdivided chambers ('tests à structure cloissonaire') and furthermore into the subgroup with biserial chamber arrangements that might exhibit an initial planispiral stage.

Suborder Spiroplectamminina Mikhalevich 1992
Superfamily Spiroplectamminoidea Cushman, 1927
Family Spiroplectamminidae Cushman, 1927
Subfamily Novalesiinae Loeblich & Tappan, 1964

Remarks: Loeblich & Tappan (1987, p. 114) stress the presence of 'radially arranged vertical partitions' and the optional occurrence of 'secondary horizontal partitions' (see the above comment for the Lituolida).

Genus ***Novalesia*** Magniez, 1974
Type-species: *Spiroplectamminoides productus* Magniez, 1972

Remarks: The genus is defined as follows: 'Test free, elongate, early stage planispiral, later biserial as in *Spiroplectammina*, nearly circular in section; wall finely agglutinated, interior of each chamber subdivided by about four thin radial vertical septula projecting in from the outer wall but not quite reaching the median septum separating the two series of chambers, less frequently a supplementary horizontal septulum may be present in later chambers; aperture a low interiomarginal slit. L. Cretaceous (U. Aptian to L. Albian) (Loeblich & Tappan, 1987, p. 114). Following the generally accepted terminology as provided by Hottinger (2006), radial partitions should be named "beams" and the horizontal septulum as a "rafter".

Novalesia producta (Magniez, 1972)
Figs. 2E, 3

*1972 *Spiroplectamminoides productus* sp. nov. – Magniez, pl. 1, figs. 1-13, pl. 4, figs. 1-12, fig. 3.
1974 *Novalesia producta* (Magniez) gen. et comb. nov. – Magniez, p. 155.
1980 *Novalesia producta* (Magniez) – Arnaud-Vanneau, p. 538, pl. 44, figs. 3-5, pl. 69, figs. 11-15, text-figs. 197-198.
1995 *Novalesia producta* (Magniez) – Arnaud-Vanneau & Sliter, p. 551, pl. 1, fig. 8.
1995 *Novalesia producta* (Magniez) – Kirmaci et al., pl. 5, figs. 7-10.
1995 *Novalesia producta* (Magniez) – Koch et al., pl. 1, fig. 10.
2011 *Pseudotextulariella* cf. *scarselai* (De Castro) – Roozbahani, pl. 2, fig. 10.
Non 2015 *Novalesia producta* (Magniez) – Madhavaraju et al., 1-4 (= bi- or triserial agglutinated taxon with simple chambers), 5 (possible).
?2016 *Novalesia producta* (Magniez) – Yavari et al., fig. 4F.
Non 2016 *Novalesia* cf. *producta* (Magniez) – Hemmati et al., pl. 3, fig. 15 (= bi- or triserial agglutinated taxon with simple chambers).
2022 *Praechrysalidina infracretacea* – Hassani, fig. 9.5.

Description: Test elongate, conical, and slightly compressed (~cylindroconical) (Figs. 3C-D). Cross sections are oval to nearly circular. The subspherical proloculus is followed by an early planispirally coiled stage, about half a whorl, that comprises three to six chambers (e.g., Figs. 3A, G). The winding plane of this spire is arranged perpendicular to the plane of biseriality. The chambers are interconnected by basal (interio-marginal) slit-like foramina. The early planispiral stage is followed by a biserial stage that consists of up to 25 chambers also displaying interio-marginal foramina (Fig. 3B). The biserial chambers gradually increase in width while the height remains more or less constant. The relationship between the relevant parameters, number of chambers in the biserial stage and the total test height exhibits a linear curve regression (Fig. 4). The chambers are subdivided by four to five vertical partitions (or beams) protruding into the lumen without reaching the center (= plane of biseriality). Horizontal partitions (one or two?) may be present in the last ontogenetic adult part of the test. Cross-sections through the adult test part display vertical partitions (usually four per chamber) (Figs. 3M-O, Q-S). The wall is homogeneous (non-canaliculate), microgranular to finely agglutinated.
Dimensions: See table 1.
Remarks: On the one hand, the available biometric data of the Iranian specimens lie within the known range of

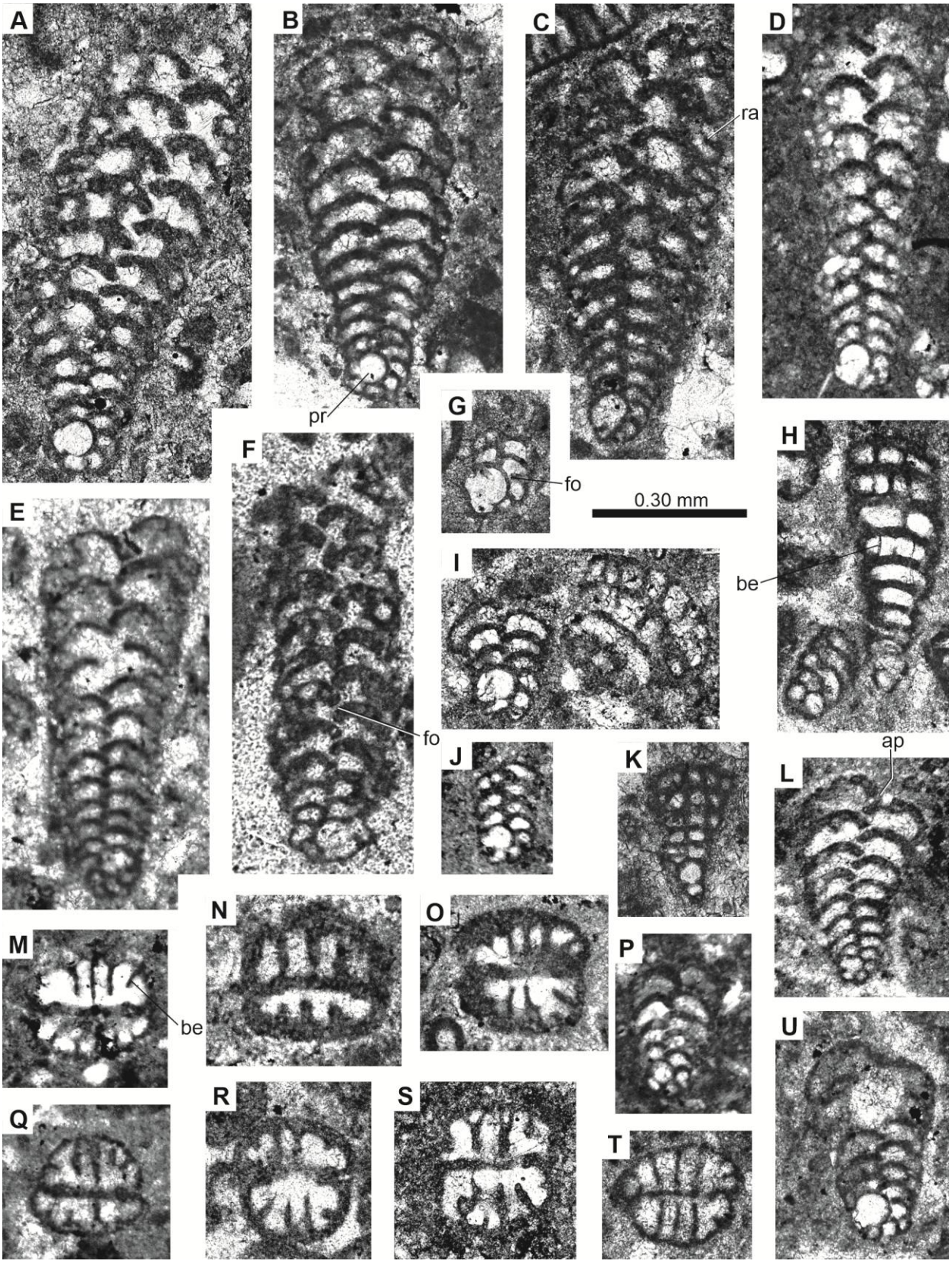

Fig. 3. *Novalesia producta* (Magniez) from the Aptian Taft Formation of the Anarak (**A-G, I, K, T**) and the Herisht (**H, J, L-S**) sections. Longitudinal section perpendicular to the plane of biseriality in adult (**A-F**), medium-sized (**L, U)** and juvenile specimens (**G, I** left, **J, P**). Oblique sections (**H** left below, **I** right). Longitudinal sections in the plane of biseriality (**K**). Transverse sections (**M-O, Q-S**). Thin-sections: AQ20 (A-C, G), AQ2 (D), AQ24 (E), AQ15 (F), AQ18 (I, K), T72 (H, O, R, T), T52 (J), T21 (L), T40 (M), T72 (O), T20 (P), T23 (S). Abbreviations: ap = aperture, be = beam, fo = foramen, pr = proloculus, ra = rafter.

the original material as recorded by Magniez (1972) but extends this at both the lower and upper end (e.g., test length: Fig. 4). Axial sections, especially of juvenile specimens appear to be simple and undivided, and can therefore be confused with a variety of biserial agglutinated taxa that exhibit an initial planispiral stage such as, for example, representatives of the Spiroplectammininae Cushman, 1927 (e.g., Loeblich & Tappan, 1987).

Stratigraphy: In the Taft Formation of SW Iran, *N. producta* occurs in inner platform wackestones-packstones associated with other (larger) benthic foraminifera (Fig. 2). Among the orbitolinids, the species may be associated with praeorbitolinids, mesorbitolinids, *Iraqia simplex* Henson, *Palaeodictyconus actinostoma* Arnaud-Vanneau & Schroeder and *Dictyoconus*? *pachymarginalis* Schroeder indicating an overall Aptian age. The type-material of Spain is latest Aptian-earliest Albian in age (Magniez, 1972). Arnaud-Vanneau (1980) recorded *N. producta* from an interval spanning the early Barremian to the early Aptian of southern France and Kirmaci et al. (1996) from the late Aptian of Turkey. A late Aptian age was indicated also by Koch et al. (1998) for occurrences in Slovenia.

CONCLUSIONS

The microfauna associated with orbitolinids in the Lower Cretaceous Taft Formation of Iran is still not well studied compared to other equivalent Urgonian-type shallow-water carbonates of the western Neotethys realm (e.g., Spain, France, Italy). One example is represented by *Novalesia producta* (Magniez) representing a common taxon associated with orbitolinids in the Taft Formation. The biometric data of the Iranian specimens extends the known biometric data range as reported in the original description.

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Table 1. Biometric data (in mm except number of chambers) of some specimens of *Novalesia producta* (Magniez) from the Aptian of Central Iran. Prol. diam. = diameter of proloculus; N planisp. st. = number of chambers in the planispiral stage; N biserial st. = number of chambers in the biserial stage.

Sample	AQ20	AQ20	AQ20	AQ2	AQn24	AQ15	AQ20	T52	T21	T30	AQ20
Figure	3A	3B	3C	3D	3E	3F	3G	3J	3L	3P	3U
Height	0.87	0.76	0.87	0.80	0.75	0.79	0.19	0.20	0.42	0.30	0.43
Width	-	0.34	0.34	0.31	0.32	0.29	0.14	0.13	0.25	0.27	0.27
Thickness	-	-	-	-	-	-	-	-	-	-	-
Prol. diam.	0.064	0.059	0.057	0.068	0.044	0.068	0.073	0.048	0.023	0.038	0.064
N planisp. st.	5	6	5	3	5	5	4	4	5	4	5
N biserial st.	24	22	23	21	22	18	4	7	15	8	12

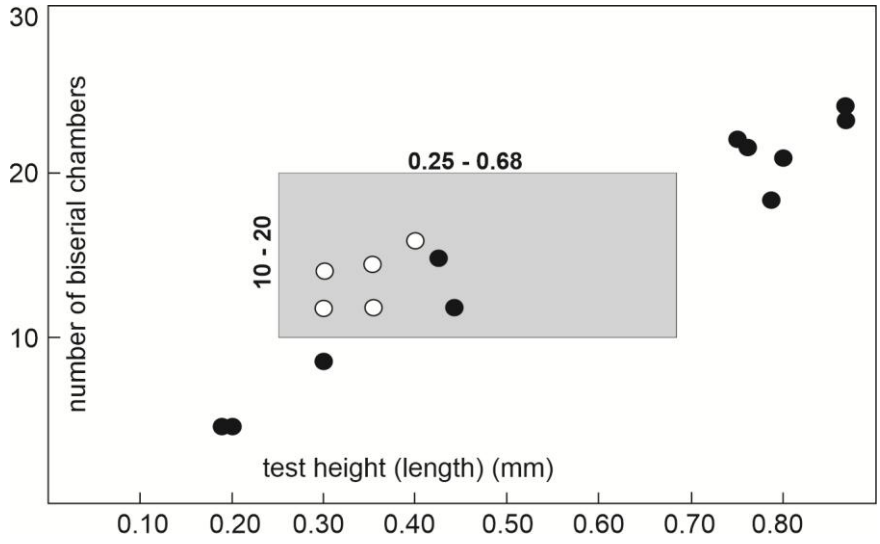

Fig. 4. *Novalesia producta* (Magniez): test height (or length) against number of biserial chambers. Black dots = data from the Aptian Taft Formation of Central Iran, white dots = data measured from axial sections in Magniez (1972, pl. 4), late Aptian-early Albian of Spain. The grey field delimits the respective data ranges of the two parameters as indicated in the original description.

helpful remarks. The English has been refreshed by Mike Bidgood (Oldmeldrum).

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