MAASTRICHTIAN LARGER BENTHIC FORAMINIFERA FROM THE ARABIAN PLATE SENSU LATO: NEW DATA FROM SOMALIA, TURKEY, AND IRAN

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Abstract Larger benthic foraminifera from the upper Maastrichtian Auradu Formation of Somalia exhibit striking matches with the assemblages from the time-equivalent Tarbur Formation of Iran and other, but less well studied, litostratigraphic units in SE Turkey (e.g., Garzan Fm.). Some taxa, among also new ones, described from Somalia need taxonomic updates (revision, synonymy, re-instatement). Dukhania? cherchii Luger is considered a junior synonym of Acordiella? tarburensis Schlagintweit & Rashidi, and Pseudorbitolina schroederi Luger is re-instanted and considered a valid taxon, different from the Campanian P. marthaе Douvillé of the western Tethyan domain. The genus Cyclospinella Galloway is reported for the first time from the upper Maastrichtian of Iran.

Keywords: Upper Cretaceous, Somaliland, Anatolia, Middle East, larger benthic foraminifera

INTRODUCTION

In 2014 Peter Luger, having finished (but not published) his habilitation thesis at the University of Berlin passed away. Four years later his work was finally published entitled “Micropalaeontology (Foraminiferida, Ostracoda), biostratigraphy and facies development of the Cretaceous of Northern Somalia including a contribution concerning the geodynamic development of eastern Gondwana during the Cretaceous to basal Paleocene”. It was published in German in the series Documenta Naturae Abhandlungen dated 6th of December 2018 with two volumes, text (part 1, 370 pages), and plates (part 2, 49 plates). Both volumes are available online (https://www.amh-geo.com/startseite/fachzeitschriften/doc-nat-abhandlungen). The studied strata include Lower Cretaceous (Aptian) to Early Paleogene formations of northern Somalia. It is worth mentioning that in the last years the rift basin at the northern part of Somalia (“Somaliland”), located at the horn of Africa, got into the focus for oil exploration activities (Ali, 2006, 2015; Davidson et al., 2018). The Auradu Limestone Formation (or Auradu Formation), a thick shallow-water carbonate succession, was previously believed to be exclusively of Paleogene age (e.g., Carbone et al., 1993). A late Maastrichtian age for the lower part of the Auradu Formation was evidenced by Cherchi et al. (1993), noting the occurrence of the large benthic foraminifera (LBF) Loftusia and Omphalocyclus. The plates of LBF by Luger (2018) from the upper Maastrichtian part of the Auradu Formation show similarities to time-equivalent assemblages reported from the Tarbur Formation of SW Iran (Zagros Zone), investigated by the present author in recent years (e.g., Schlagintweit et al., 2016a, b). As the work of Luger (2018) also includes new species, the present paper provides a taxonomic review of some of the taxa (preferentially agglutinating forms). The present compilation is supplemented by some data from SE Turkey (e.g., Meriç, 1974a, b; Köyülüoğlu, 1986; Çoruh et al., 1997, e.g. Garzan Formation), that geotectonically belongs to the northernmost part of the Arabian Plate (e.g., Özer et al., 2009, Fig. 1). In this region, the Garzan Formation is a regional important oil reservoir, with the Garzan field east of Batman City as its type-locality (e.g., Temple and Perry, 1962; Ala and Moss, 1979; Yıldızel, 2008). Other occurrences of Maastrichtian shallow-water carbonates with rich assemblages of LBF are known from Iraq (Tanjero Formation, Aqra Limestone), Qatar, Oman (Simisima Formation), and Saudi Arabia (Aruma Formation) (e.g., Barriend and Vrielynck, 2008) (Fig. 1).

SOME REMARKS ON MAASTRICHTIAN SUBSTAGES AND BIOSTRATIGRAPHY

Biostratigraphy of Maastrichtian shallow-water carbonates is mainly based on the vertical distribution of the larger benthic foraminifera (e.g., Wynd, 1965; Tarbur Formation of Iran). that sometimes has been tentatively calibrated using the occurrence of some associated planktonic foraminifera (see e.g., Robles-Salcedo et al., 2019 and Consorti and Köroğlu, 2019 among the most recent literature). Whereas the total duration of the Maastrichtian stage is well known (6.15 ± 0.05 Ma acc. to Thiebault et al., 2012), there are still contrasting views on its subdivisions (two-fold or three-fold), and their respective time frames (Fig. 2 above). The common subdivision differentiates the Maastrichtian into two substages, lower and upper although there is no agreement on the boundary criterion (see Ogg and Hinnov, 2012). The different usage makes it problematic to subsequent workers placing in context, for instance, a taxon said to be restricted to the middle Maastrichtian, e.g. some Loftusia species (see Meriç and Görümsü, 2001, Fig. 2a). It is noteworthy here that the monographic work of Meriç and Görümsü (2001, fig. 7) includes 15 species, each indicated with a distinct stratigraphic distribution (lower, middle, upper Maastrichtian). In this context, especially the occurrence of the nearly cosmopolitan sildelolitids, namely Siderolites calcitrupoides Lamark and Canalispsina iapygia Robles-Salcedo et al., in or closely related to Loftusia-bearing strata is noteworthy. Both species are restricted to the upper Maastrichtian (Robles-
C. iapygia and S. calcitrapoides have been reported from several sections of the Tarbur Formation, preferentially in the lower part (Schlagintweit and Rashidi, 2016; Consorti et al., 2019; Septfontaine et al., 2019), commonly associated with Omphalocyclus/Pseudomphalocyclus, more rarely with Orbitoides, and Pseudedomia hamaouii Rahaghi. Already Cox (1937) reported that in Iran, species of Loftusia are frequently associated with Omphalocyclus macroporus Lamarck and Siderolites Lamarck. For the Tarbur Formation, Wynd (1965) established a Omphalocyclus-Loftusia assemblage zone of Maastrichtian age (including also the basal Sachun Formation) with, among others, Siderolites as typical accompanying taxon (Wynd, 1965, pl. 25b Siderolites = Canalispina iapygia). Within the Omphalocyclus-Loftusia assemblage zone, Wynd (1965) differentiated an upper, Elphidella multiscissurata subzone. This taxon has been taxonomically revised by Consorti et al. (2019) becoming Palaeoelphidium multiscissuratum (Smout) (Fig. 2 below). In this Palaeoelphidium multiscissuratum subzone (new name!), also the occurrence of siderolithids has been mentioned by Wynd (1965) documenting its upper Maastrichtian age (see discussion in Schlagintweit et al., 2016a). For the two siderolithids S. calcitrapoides and S. denticulatus, Robles-Salcedo et al. (2018, fig. 20) postulated the range of both up to the K/Pg boundary encompassing the Pseudoguembelina hariaensis and Plummerita hantkeninoides planktonic foraminifera zones. At least for the former zone, the occurrence of Siderolites is verified (e.g., Schlagintweit et al., 2016c).

**MATERIAL AND METHODS**

The present paper represents a compilation of some larger benthic foraminifera using own material from the Tarbur Formation of Iran, and literature illustrations from the Auradu Formation of Somalia, and the Garzan Formation of Turkey (Table 1). In the provided synonymy list other occurrences are also included. The material from the Tarbur Formation comes from the following three sections Fasa section (Folded Zagros Belt): see Rashidi and Schlagintweit (2019). For overall geological setting see also Piryaie et al. (2010)

**MICROPALAEONTOLOGY**

As only remarks are provided (no systematic descriptions), the considered taxa are treated in alphabetical order (leaving apart the suprageneric status). The synonymy includes information of the lithostratigraphic occurrences.

Accordiella? turbarensis Schlagintweit & Rashidi 2016

Fig. 3a–b

*2016 Accordiella? turbarensis n. sp. – Schlagintweit and Rashidi, p. 54, fig. 5a pars, 6–7, 8 pars (late Maastrichtian Tarbur Formation of Iran).
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Fig. 2 Above: Subdivision of the Maastrichtian stage: comparison of different used substages and biostratigraphic use of selected larger benthic foraminifera. Examples: *Loftusia minor* (acc. to Meriç and Görmüş, 2001), *Siderolitidae* (acc. to Robles-Salcedo et al., 2018, 2019), and relationship to biozonation of Wynd (1965) (modified herein). Below: Example of the *Palaeoelphidium multisissuratum* subzone (new name) of the *Omhaleocyclus-Loftusia* assemblage zone sensu Wynd (1965), upper Maastrichtian Tarbur Formation, SW Iran. *Loftusia* sp. in the middle with agglutinated test of *Palaeoelphidium multisissuratum* (Smout) (detail from Luger, 2018, pl. 26, fig. 10, illustrated as *Laffiteina aff. jaskii* Rahaghi), and *Omhaleocyclus* (O).
Table 1 Distribution of the Maastrichtian (mostly larger) benthic foraminifera treated in the present compilation (for references see synonymy for each taxon).

| Taxa                          | Formation, area | Auradu Fm. Somalia | Simisima Fm. Qatar | Tarbur Fm. SW Iran | Garzan equivalent Fm. SE Turkey |
|-------------------------------|-----------------|--------------------|--------------------|--------------------|-------------------------------|
| Accordiella? tarburensis      |                 | X                  | X                  | X                  | X                             |
| Antalyna korayi               |                 | X                  | X                  | X                  | X                             |
| Broeckinella arabica          |                 | X                  | X                  | X                  |                               |
| Broeckinella grandis          |                 | X                  | X                  |                    |                               |
| Canalispinia lapygia          |                 |                    | X                  | X                  |                               |
| Cyclopsinella steinmanni      |                 | X                  |                    | X                  |                               |
| Dictyoconella? minima         |                 | ?                  | X                  |                    |                               |
| Dictyoconella complanata      |                 |                    | X                  |                    |                               |
| Dictyoconus bahktiari         |                 | X                  |                    | X                  | X                             |
| Gen. et sp. indet.            |                 |                    | X                  |                    |                               |
| Gyroconulina columellifera    |                 | X                  | X                  |                    | X                             |
| Palaeoelphidium multisisc-    |                 |                    |                    |                    |                               |
| surata                       |                 | X                  |                    |                    |                               |
| Pseudedomia hamaouii          |                 | X                  |                    | X                  | X                             |
| Pseudorbitolina schroderi     |                 |                    |                    |                    |                               |

2018 Dukhania? cherchii n. sp. – Luger, p. 88, pl. 13, 6–7, non 9 (= Gyroconulina columellifera), 10-11 (late Maastrichtian Auradu Formation of Somalia).

Remarks: From the lower Auradu Formation, Luger (2018) established a new species as Dukhania? cherchii (Fig. 3b), that is considered a junior synonym of Accordiella? tarburensis (Fig. 3a). The maximum test height is up to 1.8 mm for the Somali, and up to 1.4 mm for the Iranian specimens. In both cases, the generic identity of the described species was indicated with some doubts (Accordiella Farinacci, family Pfenderinidae: triserial, with endoskeletal plates and pillars; Dukhania Henson, family Chrysalidinidae: triserial becoming biserial, with endoskeletal pillars, see Loeblich and Tappan 1988). Because of its marginally strongly overlapping chambers, and the extensive endoskeleton consisting of numerous pillars, Dukhania indeed seems to be closer to the Maastrichtian forms than Accordiella. For the moment being the name of the validly described taxon Accordiella? tarburensis is maintained. Last but not least, some axial sections of Gyroconulina columellifera Schroder & Darmoian (see also below) show similarities (Fig. 3d). The marginal part of the chambers in the latter however displays subdivisions (exoskeleton).

Antalyna korayi Farinacci & Köylüoğlu, 1985
Fig. 3o-t

*1985 Antalyna korayi n. gen., n. sp. – Farinacci and Köylüoğlu, p. 106, pl. 1–2 (upper Maastrichtian of SW Turkey).
2018 Antalyna korayi Farinacci & Köylüoğlu – Luger, p. 57, pl. 2F, fig. 10, non 8–9 (= Gen. et sp. indet.) (Maastrichtian Auradu Fm. of Somalia).

Remarks: This species has been described by Farinacci and Köylüoğlu (1985) from the upper Maastrichtian of SW Turkey. The type-locality belongs to the Bey Dağlari Autochthon, part of the Western Taurides (see Sari et al., 2009). Farinacci and Köylüoğlu (1985) assigned Antalyna to the family Nezzazatidae Hamaoui & Saint-Marc (agglutinating wall) and notwithstandingly to the superfamily Miliolacea Ehrenberg (porcellaneous wall). A. korayi is not rather frequent in the Iranian Tarbur Formation (Fig. 3p-t). It has a low trochospirally coiled test with angular periphery, and a shallow delicate subepidermal meshwork (with “partitions” of equal length).

Broeckinella arabica Henson, 1948
not figured

*1948 Broeckinella arabica n. gen., n. sp. – Henson, p. 93, pl. 7, fig. 6, text-fig. 13a–c (Maastrichtian Simisima Fm. of Qatar).
1978 Broeckinella arabica Henson – Cherchi and Schroeder, p. 514, fig. 1 A-C (Maastrichtian Simisima Fm. of Qatar).
1986 Dictyoconella complanata Henson – Köylüoğlu, pl. 96, fig. 1 (Maastrichtian Garzan Fm. of Turkey).
1997 Dictyoconella complanata Henson – Çoruh et al., pl. 76, fig. 6 (Maastrichtian Garzan Fm. of Turkey).
2004 Dicyclina schlumbergeri – Khosrow Tehrani and Aghah, pl. 2, fig. 4 (upper Maastrichtian Tarbur Fm. of Iran).
2008 Dicyclina schlumbergeri – Khosrow Tehrani et al., pl. 1, fig. 6 (upper Maastrichtian Tarbur Fm. of Iran).
2016 Broeckinella arabica Henson – Schlagintweit and Rashidi, p. 57, fig. 9a–e (upper Maastrichtian Tarbur Fm. of Iran).
2018 Broeckinella arabica Henson – Rashidi and Schlagintweit, fig. 3j (upper Maastrichtian Tarbur Fm. of Iran).
2020 Broeckinella arabica Henson – Schlagintweit and Rashidi, p. 60, figs. 4, 5b-d, 6 (upper Maastrichtian Tarbur Fm. of Iran).
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Fig. 3 Larger benthic foraminifera from the Maastrichtian of Iran (Tarbur Fm.: a, d, f-h, j-k, m-n, p-t), Somalia (Au-radu Formation: b-c, e, l, o), and Turkey (Garzan Fm.: i). a-b Accordiella? *tarburensis* Schlagintweit & Rashidi (a from Schlagintweit and Rashidi, 2016, fig. 6a, holotype, Mandegan section; b from Luger, 2018, pl. 13, fig. 6 as Dukhania? *cherchii*, holotype). c, g *Dictyoconus bakhtiari* Schlagintweit, Rashidi & Babadipour (c from Schlagintweit et al., 2016b, fig. 10b: Naghan section; g from Luger (2018, pl. 6, fig. 4 as *Dictyoconus* sp. 1)). d, e-f, h *Gyroconulina colu-mellifera* Schroeder & Darmoian (e from Luger, 2018, pl. 7, fig. 3; f, h from Schlagintweit et al., 2016a, fig. 4k, Mandegan section; f, h Naghan section). i-n Gen. et sp. indet. (i from Çoruh et al., 1997, pl. 76, fig. 5 as *Dictyoconella complanata*; j from Luger, 2018, pl. F-2, fig. 9 as *Antalyna korayi*; j-k, m-n Naghan section). o-t *Antalyna korayi* Farinacci & Köylüoğlu (o from Luger, 2018, pl. F-2, fig. 10; p-t Naghan section).
**Remarks:** Besides the known occurrences in the Maastrichtian Simsima Formation of Qatar (Henson, 1948), and Tarbur Formation of Iran (Schlagintweit and Rashidi, 2020), *B. arabica* is also known from the Garzan Formation SE Turkey figured as *Dictyoconella complanata* (see synonymy).

**Canalispina iapygia** Robles-Salcedo, Vicedo, Parente & Caus, 2019

Fig. 4a–c

1988 *Siderolites calcitrapoides* Lamarck – Sartorio and Venturini, pag. 129 (Maastrichtian of Sicily and Yemen).

1988 *Siderolites denticulatus* (Douvillé) – Merić, pl. 1, figs. 1–8.

1994 *Siderolites calcitrapoides* Lamarck – Parente, pl. 1, fig. 6 (upper Maastrichtian of southern Italy).

1997 *Siderolites calcitrapoides* Lamarck – Parente, pl. 26, fig. 4 (upper Maastrichtian of southern Italy).

1997 *Siderolites calcitrapoides* Lamarck – Çoruh et al., pl. 74, fig. 1 (Maastrichtian Besni Fm. of SE Turkey), pl. 76, fig. 3 (Maastrichtian Garzan Fm. of SE Turkey).

2002 *Siderolites calcitrapoides* Lamarck – Abramovich et al., pl. 3, figs. 4–6 (upper Maastrichtian of Madagascar).

2003 *Siderolites calcitrapoides* Lamarck – Abdelghany, figs. 10.13–10.14 (Maastrichtian Simsima Fm. of Oman).

2004 *Siderolites calcitrapoides* Lamarck – Zambetakis-Lekkas and Kemeridou, fig. 3c (Maastrichtian of E-Greece).

2008 *Siderolites calcitrapoides* Lamarck – Al-Kubaysi, lower figure page 18 (Maastrichtian Aqra Fm. Iraq).

2017 *Siderolites denticulatus* – Solak et al., fig. 12v (Maastrichtian of S-Turkey, western Central Taurides).

Fig. 4 Larger benthic foraminifera from the Maastrichtian of Iran (Tarbur Fm.: a-b, d, f), Turkey (Garzan Fm.: e), Qatar (Simsima Formation: c). a-e *Canalispina iapygia* Robles-Salcedo et al. (a-b, Fasa section; c from Çoruh et al., 1997, pl. 76, fig. 3 as *Siderolites calcitrapoides*). d-f *Dictyoconella complanata* Henson (d, f Naghan section, e from Henson, 1948, pl. 10, fig. 14). T = *Tarburina zagrosiana* Schlagintweit & Rashidi in f. m.t. = marginal trough in e and d.
2019 *Siderolites calcitrapoides* Lamarck – Abdallah and Al-Dulaimi, pl. 1, fig. 1 (Maastrichtian Aqra Fm. of Iraq).

*2019 Canalispsina iapygia* Robles-Salcedo et al. – Robles-Salcedo et al., figs. 4, 6–7 (upper Maastrichtian of southern Italy).

2019 *Canalispsina iapygia* Robles-Salcedo et al. – Septfontaine et al., fig. 5 (upper Maastrichtian Tarbur Fm. of Iran).

2019 *Canalispsina iapygia* Robles-Salcedo et al. – Consorti et al., fig. 5 (upper Maastrichtian Tarbur Fm. of Iran).

**Remarks:** According to Robles-Salcedo et al. (2019), *C. iapygia* represents an upper Maastrichtian marker taxon. It has been reported from the Garzan Fm. of SE Turkey as *Siderolites calcitrapoides* Lamarck (Çoruh et al., 1997). Main differences between *Siderolites* Lamarck and *Canalispsina* refer to the microstructure of the spines (Robles-Salcedo et al., 2019; Consorti et al., 2019). In the Tarbur Formation, both taxa are present.

**Cyclopsinella steinmanni** (Munier-Chalmas, 1887)

Fig. 5

1963 *Cyclopsinella steinmanni* (Munier-Chalmas) – Gendrot, p. 531, pl. 1, figs. 6-10, text-figs. 1-2.

1971 *Cyclopsinella steinmanni* (Munier-Chalmas) – Ramirez del Pozo, pl. 116, pars (upper Santonian of northern Spain).

1974b *Cyclopsinella steinmanni* (Munier-Chalmas) – Meriç, pl. 1, figs. 1-3 (Maastrichtian of SE Turkey).

?2019 *Cyclopsinella roselli* n. sp. – Villalonga et al., p. 10, fig. 10a-e (middle Campanian Terradets Limestone of NE Spain).

2018 *Saudia* sp. – Luger, p. 61, pl. 4, fig. 10 (Maastrichtian Auradu Fm. of Somalia).

**Remarks:** This taxon, which sometimes attains an irregular-discoidal morphology in axial sections, seems to be extremely rare in the Auradu Formation of Somalia (Fig. 5a). Luger (2018, p. 61) did neither provide any description nor dimensional data. Measured from the illustration, the shown axial section is ~4 mm in diameter, ~0.35 mm in thickness, and consists of more than 45 annular chambers. The chamber height is continuously increasing throughout ontogeny resulting in biconcave disk-like outline in axial sections. The low magnification and poor quality of the image, however, do not allow further insights into other details such as the initial chambers. In the adult chambers, aligned central pillars (cyclopsellidinid endoskeleton sensu Hottinger, 2006, p. 12) are well recognizable. This feature, and the lack of an endoskeleton in the early part of the test, is also displayed in the specimen from the Tarbur Formation shown in Figure 5b. In another specimen from the Tarbur Formation, a sporadic single, very short (= rudimentary) rafter in the marginal chamber part can be observed (Fig. 5e). This feature has never been observed in older (Cenomanian-Campanian) species. It is here considered as an intraspecific variation like reported from some orbitolinds (e.g., *Simplorbillina manasi* Ciry & Rat; see Schroeder, 1985). The specimens from Somalia and Iran are well comparable to the upper Santonian forms of southern France (Gendrot, 1964) (Fig. 5d). From SE Turkey, *C. steinmanni* has been reported by Meriç (1974) from the Maastrichtian of oil drilling wells Şemlo-1 and Malalabdi-1, Siirt Province. No lithostratigraphic unit has been indicated by Meriç, but it should correspond to the so-called Koçalı Complex, a lithostratigraphic equivalent of the Garzan Formation (Hosgör and Košt’ák, 2012, fig. 2).

Another species of the genus *Cyclopsinella* has recently been described by Villalonga et al. (2019) as *C. roselli* from the middle Campanian of NE Spain. However, some important taxonomic works on *Cyclopsinella* by Gendrot (1963), Neumann (1964), Meriç (1974a, b), and Cherchi (1980, 1985) have not been taken into consideration by Villalonga et al. (2019). Otherwise, a pure comparison and analysis of the therein provided data with respect to test diameter and number of chambers should have made very doubtful its creation (Table 2). In this context, the overlapping stratigraphy, upper Santonian-Maastrichtian for *C. steinmanni* (see synonymy), and middle Campanian for *C. roselli*, is also worth mentioning. By the way, the specimens of *C. roselli* show an almost complete fusion of the pillars in the interior of the last chambers. The typical tendency of this particular pattern (Hottinger, 2006, p.12) has not been mentioned in the description of *C. roselli*.

**Zekritia** (type-species *Z. langhami*) described by Henson (1948) from the Cenomanian of Qatar might be a junior synonym of *Cyclopsinella* (see Gendrot, 1964; Fourcade et al., 1994). *Z. langhami* would then be a junior synonym of the Cenomanian *C. neumannae* Cherchi (see Cherchi, 1980, 1985). In fact, the single section shown by Henson (1948, pl. 11, fig. 7) displays the typical cyclopsellid structure of the pillars (Hottinger, 2006, p. 12). Loeblich and Tappan (1987, p. 715) treat *Zekritia* as a genus of uncertain status.

**Dictyoconella complanata** Henson, 1948

Fig. 5d–f

*1948 Dictyoconella complanata* n. gen., n. sp. – Henson, p. 25, pl. 6, figs. 2-3, 16, pl. 10, fig. 14 (Maastrichtian Simsim Fm. of Qatar).

2004 *Dicyclina schlumbergeri*, Dictyoconella sp. – Khosrow Tehran and Afghāl, pl. 2, fig. 4, 10 (Maastrichtian Tarbur Fm. of Iran).

? 2014 *Antalyina korayı* Farinacci & Köylüoğlu – Afghāl and Yaghmour, pl. 2, fig. 5 (Maastrichtian Tarbur Fm. of Iran).

**Remarks:** In his important monograph on Mesozoic-Cenozoic Larger Benthic Foraminifera from the area of the Middle East-South-Western Asia, Henson (1948) erected the genus *Dictyoconella* for more or less “compressed-conical” dictyoconids including the two species *D. complanata* and *D. minima*. Both are however structurally completely different and cannot be assigned to the same genus (see Schlagintweit et al., 2016b). A revision is currently under preparation. The type-species *D. complanata* was described from Maastrichtian carbonates of the Simsim Fm. of the Dukhan No. 1 well of Qatar. Henson (1948, p. 24–25) noted the presence of a “zone with undivided chamber space” (or marginal ridge) between the marginal (with exoskeleton) and central zones


Table 2 Comparison of biometric and stratigraphic data of *Cyclopsinella steinmanni* (Munier Chalmas) and its assumed junior synonym *Cyclopsinella roselli* Villalonga et al.

| species reference | *Cyclopsinella steinmanni* (Munier Chalmas, 1887) acc. to Gendrot, 1964 * Cheri, 1980 ** | *Cyclopsinella roselli* Villalonga et al., 2019 |
|-------------------|------------------------------------------|------------------------------------------------|
| Test diameter     | up to 10 mm * 6-7 mm **                  | average 4.4 mm (maximum 5.1 mm) average about 8.0 mm (maximum 9.1 mm) |
| Number of chambers| up to 50 *                                | Average 42 may be over 50 (average 48) |
| Number of initial chambers without endoskeleton | 9-12                                    | 14-17 |
| Stratigraphy      | Upper Santonian-Maastrichtian            | Middle Campanian |
| Occurrences       | S-France, N-Spain, Somalia, SE Turkey, SW Iran | NE-Spain |

**Remarks:** In the paper about late Maastrichtian orbitolinids of Schlagintweit et al. (2016b), a table with the dimensions of *Dictyoconus bakhtiari* has been forgotten. It is included here supplementing the original description (Table 3). For *Dictyoconus* sp. 1 (= *Dictyoconus bakhtiari*) Schlagintweit, Rashidi & Babadipour, Luger (2018) observed only megalospheric specimens, with proloculi diameters up to 0.21 mm (Schlagintweit et al. 2016b: up to 0.2 mm), and test height up to 2.34 mm (up to 2.5 mm). According to Luger (2018), *Dictyoconus* sp.
Table 3 Biometric data of *Dictyoconus bakhtiari* from the upper Maastrichtian Tarbur Formation of SW Iran (see Schlagintweit et al., 2016b).

| test diameter (d) | test height (h) | d/h | diameter protoconch | diameter deutoconch | Number of chambers last mm | Thin-section |
|------------------|----------------|-----|---------------------|---------------------|---------------------------|-------------|
| 2.0              | 2.0            | 1.0 | -                   | -                   | 10                        | 2NG 53      |
| -                | -              | -   | 0.17                | -                   | -                         | NG 53-1     |
| 1.9              | 2.4            | 0.8 | -                   | -                   | 8                         | NG 52-2     |
| 1.7              | 2.5            | 0.7 | -                   | -                   | 9                         | NG 53-2     |
| 2.0              | 2.2            | 0.9 | -                   | -                   | 10                        | NG 64       |
| 4.8 (B-form)     | -              | -   | -                   | -                   | -                         | 2NG 81      |
| 4.5 (B-form)     | -              | -   | -                   | -                   | -                         | NG 87-2     |
| 3.6 (B-form)     | -              | -   | -                   | -                   | -                         | 2NG 87-2    |
| 4.15 (B-form)    | 3.2            | 1.3 | -                   | -                   | -                         | 2NG 83      |
| 1.7              | 2.1            | 0.81| 0.2                 | 0.16                | 9                         | 2NG 87-2    |
| 1.2              | 0.83           | 1.45| 0.17                | 0.12                | -                         | 2NG 87-3    |
| 1.85             | 2.4            | 0.8 | -                   | 0.2                 | 10                        | Ni 62-1     |
| 2.0              | 2.2            | 0.9 | -                   | -                   | 9                         | NG 54       |
| 1.85             | 2.1            | 0.9 | 0.15                | 0.2                 | 10                        | 2NG 32      |
| 1.55             | 1.8            | 0.86| -                   | -                   | 10                        | 2NG 16      |
| 1.62             | 1.92           | 0.84| -                   | -                   | 10                        | 2NG 16      |
| 1.45             | 2.2            | 0.65| 0.17                | -                   | 10                        | 2NG 27      |
| 2.0              | 2.4            | 0.85| -                   | -                   | 9                         | 2NG 53      |
| 2.4              | 2.3            | 1.05| -                   | -                   | 9                         | NG 83-3     |
| 1.6              | 1.45           | 1.1 | 0.19                | 0.165               | -                         | 2NG 112     |
| 1.15             | 1.0            | 1.15| 0.2                 | 0.23                | -                         | 2NG 69      |

Ranges A forms: 1.2 – 2.4

Ranges B forms: 3.6 – 4.8

1 (Fig. 3c) is rather frequent in the lower (= upper Maastrichtian) part of the Auradu Formation.

**Gen et. sp. indet**

Fig. 3i–n

1997 *Dictyoconella complanata* Henson – Çoruh et al., pl. 76, fig. 5 (late? Maastrichtian Garzan Formation).

2004 *Antalyna korayi* Farinacci & Köylüoğlu – Khosrow Tehrani and Afghah, pl. 1, fig. 11 (late? Maastrichtian Tarbur Formation of Iran).

2008 *Antalyna korayi* Farinacci & Köylüoğlu – Khosrow Tehrani et al, pl. 1, fig. 1 (late? Maastrichtian Tarbur Formation of Iran).

2009 *Antalyna korayi* Farinacci & Köylüoğlu – Afghah, pl. 1, fig. 1 (late? Maastrichtian Tarbur Formation of Iran).

2009 *Dictyoconella* sp. – Afghah, pl. 1, fig. 3 (late? Maastrichtian Tarbur Formation of Iran).

2018 *Antalyna korayi* Farinacci & Köylüoğlu – Luger, pl. 2, figs. 8–9 (late? Maastrichtian Auradu Formation of Somalia).

2018 *Dicyclina* sp. – Payandeh et al., pl. 6, fig. 3, Maastrichtian Tarbur Fm. of Iran).

**Remarks:** This species has been reported several times from the Maastrichtian Tarbur Formation of Iran assigned either to *Dictyoconella* Henson, *Dicyclina* Schlumberger, or *Antalyna* Farinacci & Köylüoğlu (see synonymy). It is currently under detailed study, believed to be different to these genera. Apart from the Iranian Tarbur Formation, it is also reported from the Turkish Garzan Formation (Çoruh et al., 1997). From the upper Maastrichtian Auradu Formation of Somalia it was reported as *A. korayi* (Luger, 2018, pl. 2, figs. 8–9).

**Gyroconulina columellifera** Schroeder & Darmoian, 1977

Fig. 3d-f, h

1977 *Gyroconulina columellifera* n. gen., n. sp. Schroeder & Darmoian, p. 120, pl. 1, figs. 1–4, pl. 2, figs. 1–7, text-fig. 2 (Maastrichtian Aqra Formation of Iraq).

1985 *Gyroconulina columellifera* Schroeder & Darmoian – Al-Rawi and Al-Hamadani, pl. 4, fig. 3 (?), 4.

1986 *Gyroconulina columellifera* Schroeder & Darmoian – Farinacci and Yeniyiay, p. 260, not figured.

1986 *Gyroconulina aquaesensis* n. sp. – Lawa et al., p. 77, pl. 1, figs. 3–6, pl. 2, figs. 7–8, pl. 4, figs. 16–17.

1986 *Gyroconulina columellifera* Schroeder & Darmoian – Lawa et al., pl. 1, figs. 1–2, pl. 2, figs. 9–10, pl. 3, figs. 11–13, pl. 4, figs. 14–15.
1995 *Gyroconulina columellifera* Schroeder & Darmoian – Whittaker et al., pl. 11, figs. 1–2, pl. 58, figs. 1–5 (Maastrichtian of Iraq, and Saudi Arabia).

1997 *Coskinolina* sp. – Coruh et al., pl. 75, fig. 3 (Maastrichtian Garzan Formation of Turkey).

2014 *Coskinolina* sp. Afgha and Yaghmour, pl. 2, fig. 2 (Maastrichtian Tarbur Formation, Iran).

2016a *Gyroconulina columellifera* Schroeder & Darmoian – Schlagintweit et al., p. 172, figs. 3–5, 6B pars (late Maastrichtian Tarbur Formation, Iran).

2018 *Gyroconulina columellifera* Schroeder & Darmoian – Luter, p. 68, pl. 7, figs. 1–3 (late Maastrichtian Auradu Formation of Somalia).

2018 *Dukhania?* cherchii n. sp. – Luter, p. 68, pl. 13, fig. 9 (late Maastrichtian Auradu Formation of Somalia).

**Remarks:** For detailed descriptions see Schroeder & Darmoian (1977) and Schlagintweit et al. (2016a).

*Palaeoephidium multicissuratum* (Smout, 1955)

Fig. 2 below, pars

1955 *Elphidiella multicissurata* n. sp. – Smout, p. 208, figs. 6-9 (upper Maastrichtian, Qatar, and Saudi Arabia).

2018 *Laffiteina aff. jaskii* Rahaghi – Luter, pl. 26, fig. 10 (upper Maastrichtian Auradu Formation of Somalia).

2018 *Palaeoephidium multicissuratum* (Smout) n. gen., n. comb. – Consorti et al., p. 166, figs. 3-5 (upper Maastrichtian Tarbur Formation of Iran) (cum syn.).

**Remarks:** The species has been described by Smout (1955) as *Elphidiella multicissurata* from Maastrichtian marls of Qatar, associated with *Siderolites, Lofusia,* and *Omphaloclycus.* In addition, Smout noted the occurrence in the Aqra Limestone of Iraq within an equivalent assemblage of LBF. For the Tarbur Formation of Iran, Wynd (1965) established an upper *Elphidiella multicissurata* subzone within his *Omphaloclycus Lofusia* assemblage zone. In some recent papers, it has been illustrated as *Rotalia skourensis* (Pirbalutí et al., 2013, fig. 8.13; Payandeh et al., 2016, pl. 1, fig. 6). This taxon is considered by Consorti et al. (2018) as the oldest *Elphidium*-like foraminifer known so far.

*Pseudedomia hamaoui* Rahaghi, 1976

Fig. 6

1976 *Pseudedomia hamaoui* n. sp. – Rahaghi, p. 6, pl. 1, fig. 1-11 (Campanian Gurpi Formation of Iran).

1997 *Fallotia* sp. – Çoruh et al., pl. 74, figs. 4–5 (late? Maastrichtian Besni Formation of Turkey).

2010 *Fallotia?* sp. (probably new genus) – Sirel, pl. 2, figs. 5–13 (late Maastrichtian Beyobasi Formation of Turkey).

2016a *Fallotia jacquoti* Douvillé – Schlagintweit et al., fig. 7L (late Maastrichtian Tarbur Formation of Iran).

2017 *Pseudedomia hekimhanensis* Görmüş – Solak et al., fig. 12 T1-T3 (Maastrichtian of S-Turkey).

2018 *Pseudedomia* sp. – Luter, p. 95, pl. 16, fig. 10 (late Maastrichtian Auradu Formation of Somalia).

**Remarks:** Test diameter is mostly between 1.6 mm and 2.0 mm (maximum 2.2 mm), thickness is 0.3 mm to 0.5 mm. The tiny proloculus observed in some forms has a diameter from 0.06 mm to 0.07 mm (Fig. 6d). Adult specimens consist of up to 15 planispirally-involute coiled whorls. The original material of Rahaghi was deriving from two localities in the Zagros Zone belonging to the so-called Lopha Limestone Member of the Gurpi Formation and assigned to the upper Campanian (Wynd, 1965; Hashmie et al., 2020). *P. hamaoui* is intermediate in size between the smaller *P. hekimhanensis* from the late Campanian-Maastrichtian of Turkey (Görmüş, 1999) and the larger type-species *P. striata* from the Maastrichtian of Qatar (Henson, 1948). The specimens from Iran have been observed in the lower part of the Tarbur Formation in bioclastic packstones together with siderolitids, and *Omphalocyclus* (Fig. 6a). In southern Turkey it is recorded as *P. hekimhanensis* by Solak et al. (2019, fig. 9) from strata assigned to the lower Maastrichtian, namely an “*Orbitoides, Omphaloclycus, Siderolites* assemblage zone”.

*Pseudorbitolina schroederi* Luger, 2018

Fig. 7

1948 *Pseudorbitolina marthae* Douvillé – Henson, p. 102, pl. 6, fig. 17, pl. 11, fig. 6?, text-fig. 16 (Maastrichtian Simsima Formation of Qatar, see Sugden and Standing, 1975).

1974b *Pseudorbitolina marthae* Douvillé – Meriç, pl. 1, figs. 1-4, pl. 2, figs. 1-3 (upper Maastrichtian of SE Turkey).

1979 *Pseudorbitolina marthae* Douvillé – Radoičić, pl. 8, figs. 1-3 (Maastrichtian of Iraq).

2016b *Pseudorbitolina* cf. *marthae* Douvillé – Schlagintweit et al., p. 41, Figs. 3e–f, 11 (Maastrichtian of Iran).

2016 Antalya korayı Farinacci & Köylüoğlu – Deghani et al., pl. 2, fig. 13 (Maastrichtian Tarbur Fm. of Iran).

2016 *Pseudorbitolina marthae* Douvillé – Al-Kubaysi and Abid, figs. 6–1 to 6–3 (*Suraqalatia brasieri* Görmüş, Lawa & Al Nuaimy).

2018 *Pseudorbitolina schroederi* n. sp. – Luger, p. 72, pl. 7, figs. 6–9 (upper Maastrichtian Auradu Formation of Somalia).

**Remarks:** With its convexo-concave test of annular-concentric chambers more or less throughout the complete ontogeny, *Pseudorbitolina* represents a rather unusual representative among the orbitolinids. In the drawing of Douvillé (1912, fig. 3), the monospecific genus *Pseudorbitolina* shows a subspherical proloculus in apical position displaying a septulated supraembryonic zone at its top (like in *Palariborbitina*, see Schroeder, 1963, fig. 1). The thin-section specimens illustrated by Neumann (1978, pl. 1, fig. 7, pl. 2, fig. 6) in transverse sections instead show an embryo in apical position consisting of a spherical proloculus and a hemispherical septulated deuteroconch arranged laterally to the former. In conclusion, there are still informations lacking on the exact structure of the embryo in *Pseudorbitolina* (incl. interpretation of elements). In the revision of the species provided by Neumann (1978), the author concludes that it represents a good marker for the Campanian. Schlagintweit et al. (2016b, p. 41) already remarked that obviously there is a
Maastrichtian Larger Benthic Foraminifera from the Arabian Plate sensu lato: new data from Somalia, Turkey, and Iran

Fig. 6 *Pseudedomia hamaouii* Rahaghi from the Campanian (Lopha Limestone Member: b), and upper Maastrichtian of Iran (Tarbur Formation: a, d), and Somalia (Auradu Formation: c). a Bioclastic packstone with *P. hamaouii* Rahaghi, *Siderolites calcitrapoides* Lamarck (S), and *Omphalocyclus macroporus* Lamarck (O); Fasa section. b from Rahaghi (1976, pl. 1, fig. 11). c from Luger (2018, pl. 16, fig. 10 as *Pseudedomia sp.*). d Fasa section.

Fig. 7 *Pseudorbitolina Schroederi* Luger from the Maastrichtian of Somalia (Auradu Formation, a-b), and Iran (Tarbur Formation, c-d). a, b from Luger (2018, pl.7, figs. 7-8; holotype in 7), c-d from Naghan section (d from Schlagintweit et al. (2016b, fig. 11c as *Pseudorbitolina marthae*).
stratigraphic discrepancy between the occurrences in Western Europe and the Middle East area (incl. also the record from Somalia; see synonymy). Both, Merić (1974) and Schlagerweit et al. (2016b) also remarked the greater test dimensions of the Middle East specimens.

Luger (2018, p. 72) described Pseudorbitolina Schroederi as possessing the same internal structure like the type-species P. martiaue. The test size (diameter) of the Campanian P. martiaue is 2-3 mm (Douville, 1910; Neumann, 1978). For the Maastrichtian P. Schroederi Luger (2018) indicated a maximum diameter of 6.08 mm. The separation of two Pseudorbitolina species based on size, different stratigraphy, and apparently different palaeobiogeographic distribution is accepted here. Note that in the Maastrichtian deposits of SE Turkey, P. martiaue is restricted to the southeastern part belonging to the Arabian platform (Meric, 1974a; Oz et al., 2009).

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