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Robustoconus tisljari n. gen., n. sp., a new larger benthic foraminifer from the Middle Jurassic (Early Bajocian) of the Adriatic Carbonate Platform of Croatia

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ABSTRACT

The new larger benthic foraminifer *Robustoconus tisljari* n. gen., n. sp. is described from Middle Jurassic (Early Bajocian) high-energy shallow-water limestones of the Dubrovnik area in the south-eastern part of the Adriatic Carbonate Platform. *Robustoconus* represents a large dimorphic agglutinated foraminiferan with a coarse exoskeleton typical of representatives of the Family Hauraniidae. Differences to the allied genera *Spiraloconulus* ALLEMANN & SCHROEDER and *Bostia* BASSOULLET are discussed. The occurrence of a further new genus of larger foraminifera provides additional evidence for a high origination rate in the Middle Jurassic. The restriction of *Robustoconus tisljari* to the *Timodonella sarda* taxon-range zone highlights its biostratigraphic interest.

Keywords: Benthic foraminifera, systematics, Middle Jurassic, Adriatic carbonate platform, Croatia

1. INTRODUCTION

Larger benthic foraminifera are widely distributed in Jurassic shallow-water carbonates of the Adriatic Carbonate Platform, i.e. the Karst Dinarides (e.g. RADOIČIĆ, 1966; NIKLER & SOKAČ, 1968; GUŠIĆ, 1969a, b, 1977; VELIĆ, 1977, 2007; GUŠIĆ & VELIĆ, 1978; VELIĆ & SOKAČ, 1978; SCHLAGINTWEIT & VELIĆ, 2011). During recent investigations of Aalenian–Bajocian limestones of Biokovo Mt. and Dubrovnik area, new and poorly known taxa were described by SCHLAGINTWEIT & VELIĆ (2011). Previously, the Middle Jurassic shallow-water carbonates of the Karst Dinarides were considered to be poor in benthic foraminifera. The aforementioned investigations however, have shown that these are distinctly richer in taxa than the Lower Jurassic strata, with many of these representing index forms (VELIĆ, 2007). In the framework of on-going studies, another new Middle Jurassic larger benthic foraminiferan is recognized, described as *Robustoconus tisljari* n. gen., n. sp.

2. GEOLOGICAL SETTING

The Middle Jurassic platform carbonates containing *Robustoconus tisljari* n. gen., n. sp. crop out near Osojnik in the vicinity of Dubrovnik, southern Croatia (Fig.1). Tectonically, they belong to the southwestern marginal area of the Adriatic Carbonate Platform (VLAHOVIĆ et al., 2005). These carbonates were deposited in shallow water environments strongly influenced by currents and waves, with the

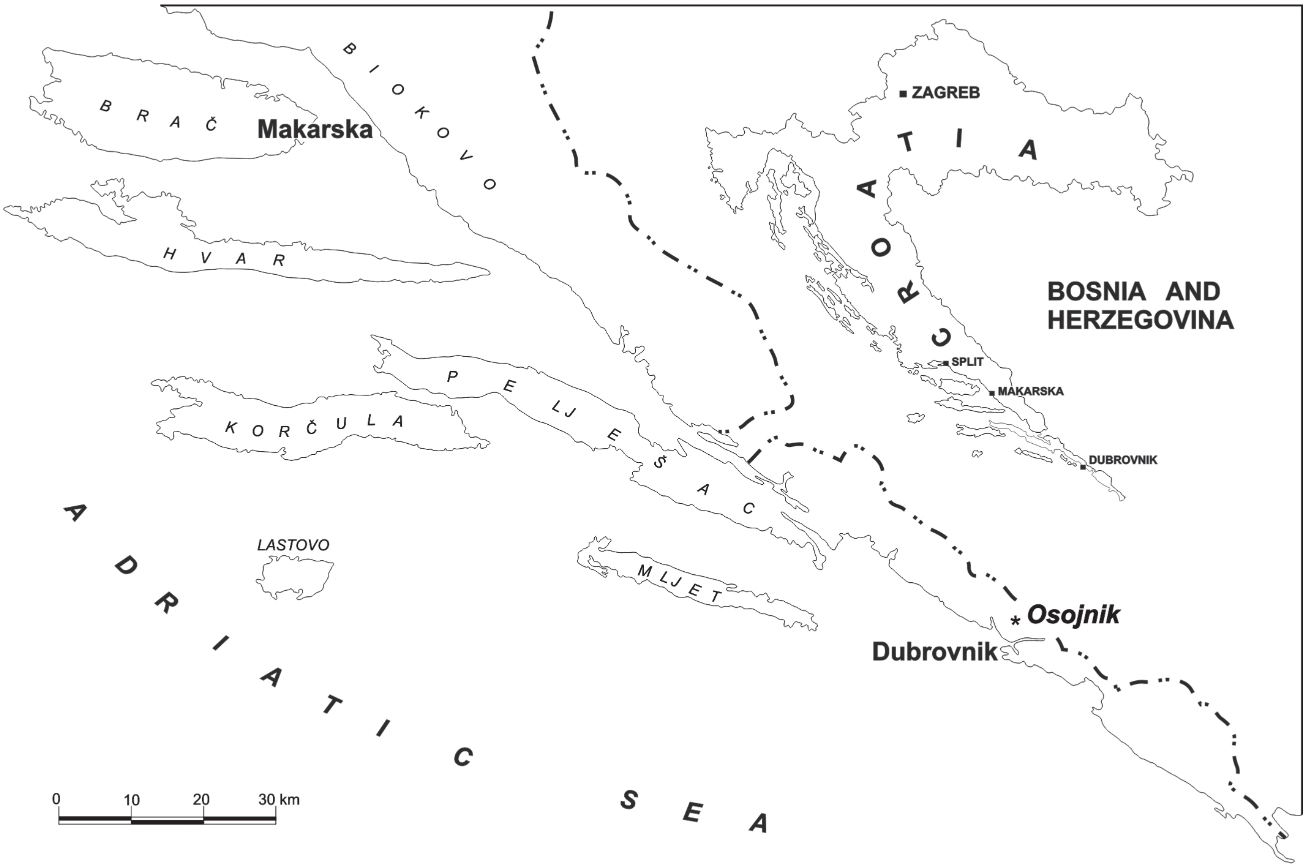

Figure 1: Geographic position of the investigated Osojnik profile ca 5 km north of Dubrovnik, in southern Croatia (asterisk).

occasional development and destruction of patch reefs (see SCHLAGINTWEIT & VELIĆ, 2011, for more details). In general, they are represented by various types of skeletal-intraclastic/bioclastic grainstones and oncoidal facies, with abundant tests of larger benthic foraminifera.

This Early Middle Jurassic profile lies ca. 1 km south-southeast of Osojnik, on the road connecting the village with Dubrovnik (Figs. 1–2). Abundant specimens of *R. tisljari* n. gen., n. sp. occur in thick bedded skeletal-intraclastic/bioclastic grainstones (sample O-26; Fig. 3), ca. 20 metres above the last occurrence of *Timidonella sarda* BASSOULLET, CHABRIER & FOURCADE (see Osojnik section – SCHLAGINTWEIT & VELIĆ, 2011).

3. SYSTEMATIC PALAEONTOLOGY

The suprageneric classification of agglutinated-conical benthic foraminifera (= *pro parte* the so-called „larger agglutinated foraminifera") provided by LOEBLICH & TAPPAN (1987) was criticised recently by VECCHIO & HOTTINGER (2007) as not taking into account the architecture of the exo- and endoskeletal elements and their pattern. Such a scheme was introduced some decades ago by SEPTFONTAINE (1988) and was incorporated in the „*year 2000 classification*" of KAMINSKI (2004) that is followed here.

Class Foraminiferida

Order Loftusiida KAMINSKI & MIKHALEVICH, 2004
Suborder Orbitolinina KAMINSKI, 2004
Superfamily Pfenderinacea SMOUT & SUDGEN, 1962
Family Hauraniidae SEPTFONTAINE, 1988
Subfamily Amijiellinae SEPTFONTAINE, 1988
Genus *Robustoconus* nov. gen.

Origin of the name: robustus (lat.) = robust and conus (lat.) = cone. Named after the high-conical test (A- and most B-forms), combined with the thick, coarse hypodermal network.

Diagnosis: Test conical to cylindrical, with an early planispiral and involute coiled stage, later rectilinear. Cone base slightly arched in the juvenile stage, becoming distinctly convex in adult chambers. Macrospheric specimen with a small simple subspherical proloculus. Microspheric tests, large and may be slightly flabelliform. Wall microgranular calcareous, agglutinated, and may include large grains especially in the central part. Chambers subdivided into a marginal and central zone. Coarse exoskeleton of radial (beams and intercalary beams) and horizontal partitions (rafters) forming a network of chamberlets in the marginal zone. The complex central zone consists of anastomizing septal excrescences (with constrictions and swellings) that reach into the cham-

Figure 2: Geographic map (Dubrovnik sheet, no. 625-3-1), scale 1:25.000 showing the location of sample O-26 containing the holotype of *Robustoconus tisljari* n. gen., n. sp. near Osojnik.

ber interior, but do not span between two succesive septa, leaving instead a continuous open space at the proximal parts of the chambers. This peculiar type of endoskeleton that strongly reduces the volume of the chamber interior may be obscured in specimens where large amounts of agglutinated particles are incorporated in the test. Intracameral foramina single, interiomarginal in the coiled part, becoming multiple, irregularly distributed in the central zone of the rectilinear part.

Type species: *Robustoconus tisljari* nov. sp.

Comparisons: *Robustoconus* belongs to a group of large benthic foraminifera exhibiting a „structure exosqueletique complexe grossiere" (HOTTINGER, 1967) or hauraniiform subepidermal network (réseaux hypodermique) (SEPTFONTAINE, 1980). These forms are included in the family Hauraniidae SEPTFONTAINE (see KAMINSKI, 2004). *Robustoconus* can be compared with *Spiraloconulus* ALLEMANN & SCHROEDER, 1972, and the allied genus *Bostia* BASSOULLET, 1998, as well as with *Timidonella* BASSOULLET, CHABRIER & FOURCADE, 1974.

With respect to *Timidonella*, only cylindriform macrospheric specimens (e.g. VELIĆ, 2007: pl. 6, fig. 3) can be taken for comparison given that the microspheric generation is characterized by discoidal tests (BASSOULLET et al., 1974). *Timidonella* possesses an endoskeleton of pillars connecting consecutive septa.

The differences of *Robustoconus* to both *Spiraloconulus* and *Bostia* are more delicate needing comprehensive discussion. *Spiraloconulus* differs from *Robustoconus* by the construction of its exoskeleton consisting of a rather narrow marginal zone of thin-walled chamberlets and a large central zone with septa typically agglutinating large grains (ALLE-

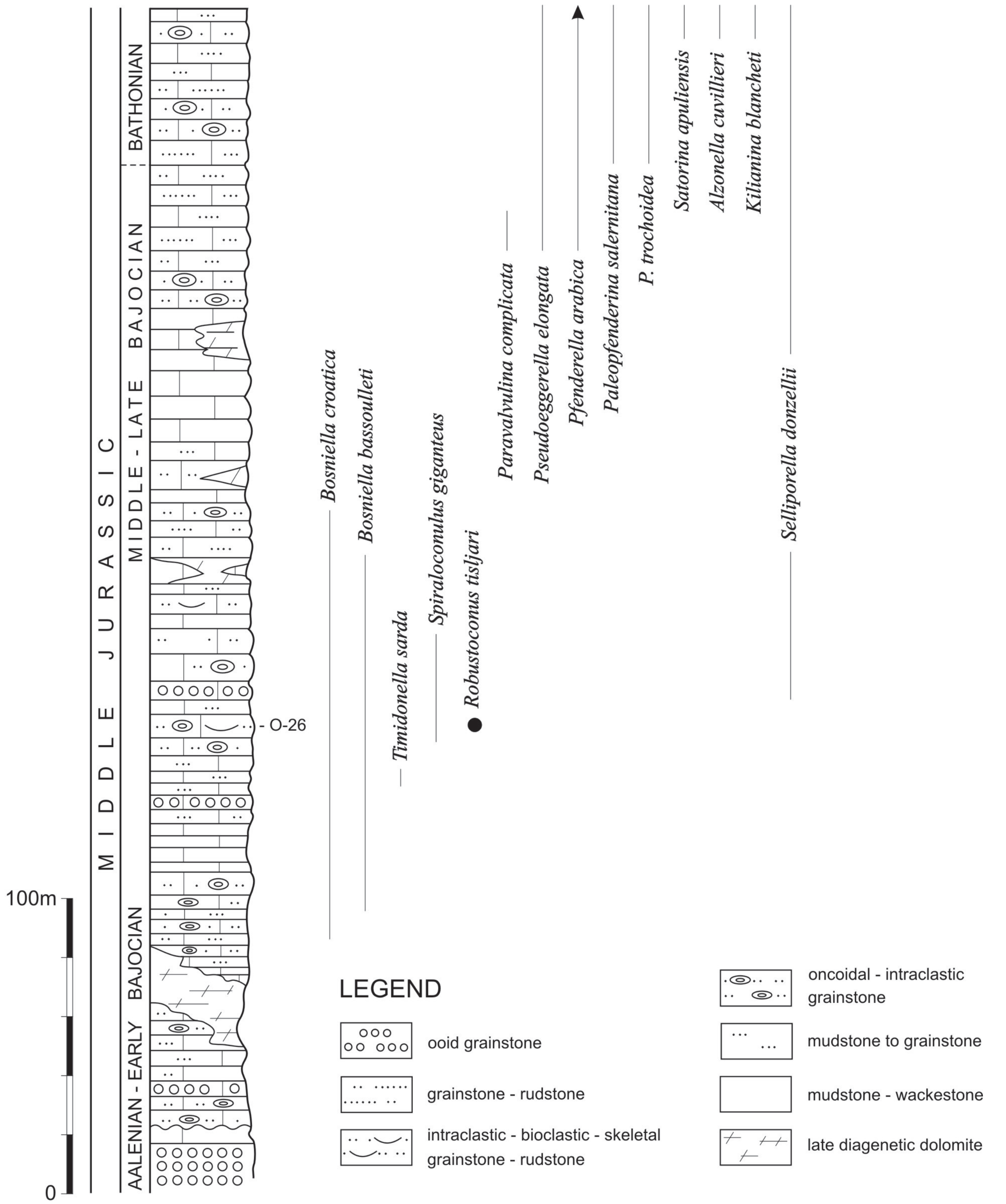

Figure 3: Lithostratigraphy of the Osojnik section and the distribution of important larger benthic foraminifers, with the position of *Robustoconus tisljari* n. gen. n. sp. (sample O-26).

MANN & SCHROEDER, 1972; CHERCHI & SCHROEDER, 1981) (Fig. 4). In fact, the central zone is „relatively simple“ in *Spiraloconulus* where the „partly coarse agglutination of the chamber floors (remark: roofs!) can easily be mistaken for a complex structure“ (ALLEMANN & SCHROEDER, 1972: p. 207). This statement was given for the type-species *S. perconigi* where the agglutination of foreign material is concentrated within the septa and the chamber interior is more or less free. In *S. giganteus*, the chamber interior of micropsheric specimens may be largely filled with

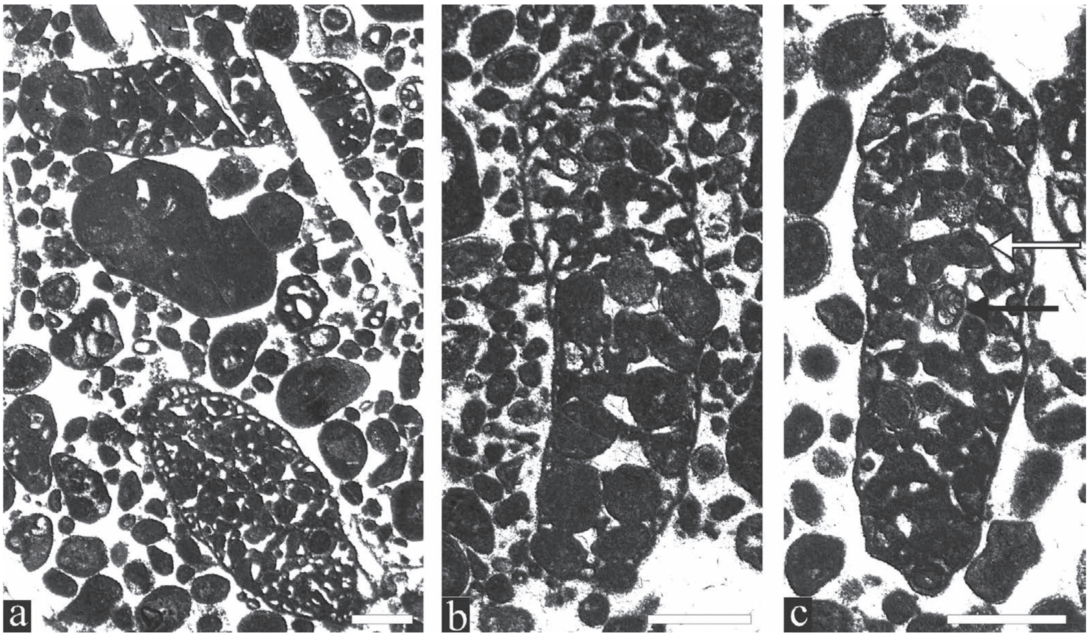

Figure 4: *Spiraloconulus giganteus* CHERCHI & SCHROEDER from the Bajocian of Mount Biokovo, Croatia. a) Oolitic grainstone with two specimens. b) Longitudinal section. Note the simple central zone composed of large individual ooids that in the lower test portion stretch between two successive septula. c) Longitudinal section. Note ooids (white arrow) and small benthic foraminifer (black arrow) attached to the chamber rooves. Scale bars 0.5 mm.

ooids connected to the septa and to adjacent ooids by means of very thin walls as a biomineralized part of the test. Notwithstanding, BOUDAGHER-FADEL (2008: p. 179) defines the genus *Spiraloconulus* as possesing an „endoskeleton(s) of pillars from septum to septum" obviously adopting the classification of LOEBLICH & TAPPAN (1987), placing the genus within the pillaroid family Spirocyclinidae. In fact, *Spiraloconulus* (and also *Bostia*) is placed in the subfamily Amijiellinae (SEPTFONTAINE, 1988; KAMINSKI, 2004) where representatives usually do not develop pillars. The central zone of *Robustoconus* is made up of a complex structure of anastomizing micritic septal excrescences (with constrictions and swellings) that reach deep into the chamber lumen (= trabécules micritiques of BASSOULLET, 1998). However, they do not span between two succesive septa, instead leaving a continuous open space at the proximal parts of the chambers. Therefore these cannot be termed interseptal pillars (see HOTTINGER, 2006). This type of endoskeleton is often obscured in specimens where large amounts of agglutinated particles are incorporated in the tests of *Robustoconus*. In *Bostia*, BASSOULLET (1996) speaks of an agglutinated endoskeleton. For the genus *Limognella* (see below), SEPTFONTAINE (1988: p. 244) assumes that such an endoskeletal structure is only pretend due to the highly

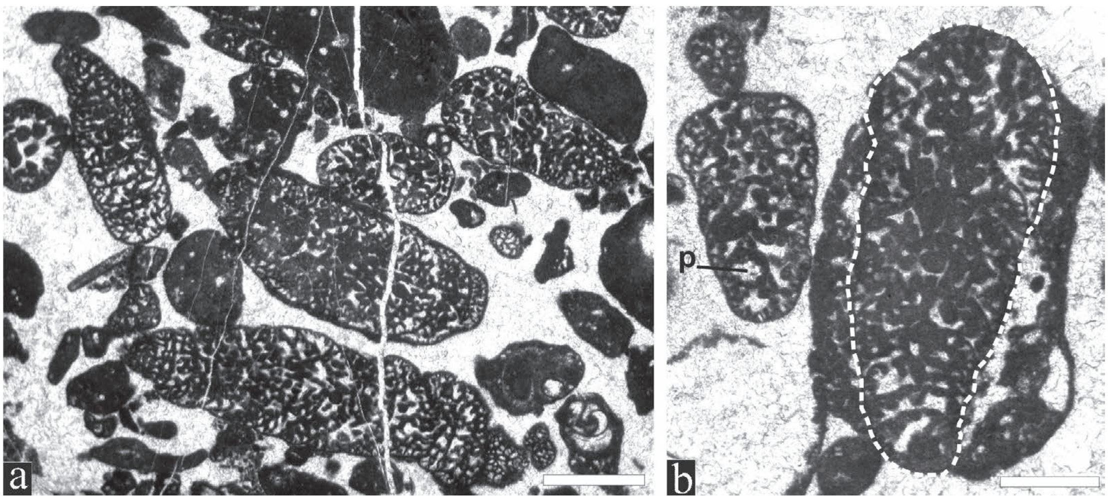

Figure 5: a) Grainstone with abundant *Robustoconus tisljari* showing moderate parallel orientation of their cylindroconical tests. Thin-section 0-26/5. Scale bar 1 mm. b) Two specimens of *Robustoconus tisljari* in longitudinal section, the left one showing an initial spire with protoconch (p). Note the different dimensions and the difference in chamber convexity resulting in a more flattened (left) or convex apertual face (right) in large specimen. The specimen on the right (outlined by the dashed white-line) occurs in a packstone intraclast. Thin-section 0-26/6. Scale bars 0.5 mm.

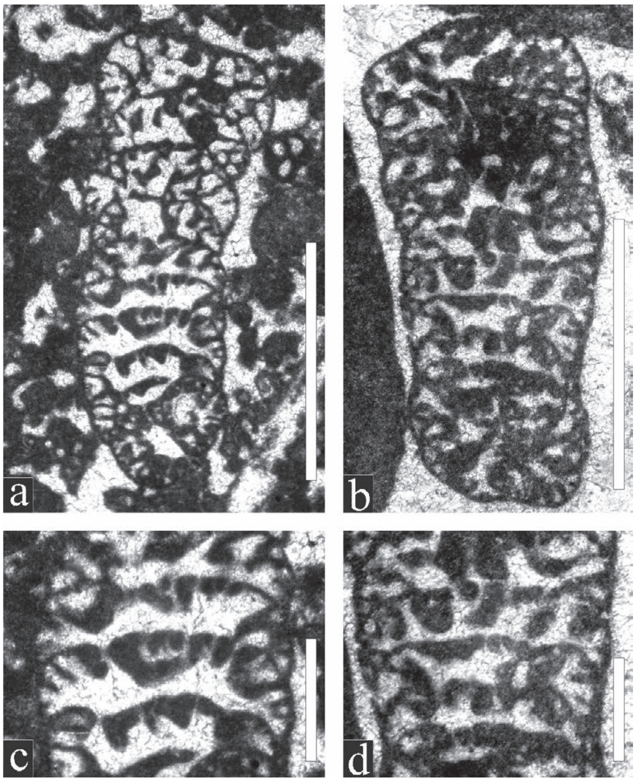

Figure 6: *Robustoconus tisljari* nov. gen., n. sp. from the Early Bajocian of Croatia. a) Longitudinal specimen of a macrospheric specimen with short initial spire, holotype. The upper part passes obliquely through the reticular network. Thin-section 0-26/3. Scale bar 1 mm. b) Longitudinal section. Thin-section 0-26. Scale bar 1 mm. c) Detail from *a* showing four chambers without endoskeletal pillars connecting subsequent septa. Note the numerous horizontal marginal plates. Scale bar 0.3 mm. d) Detail from *c* showing the free spaces at the proximal parts of the chambers. Scale bars 0.3 mm.

agglutinated character. In this respect, returning to the genus *Spiraloconulus*, the type-species *S. perconigi* can be considered as a species with no endoskeleton, whereas the short micritic walls connecting adjacent agglutinated grains in *S. giganteus* can be considered as endoskeletal structures.

Concerning the development of the macrospheric embryo, it is uncertain whether in *Robustoconus* it is unilocular or bilocular, e.g. as in *Spiraloconulus perconigi* (see ALLEMANN & SCHROEDER, 1972). In any case it is not complex as in *Timidonella*, *Orbitopsella*, *Cymbriaella* or *Bostia*, composed of a rather large single spherical proloculus that is enclosed by a thin wall and a large spheroconch (e.g. BASSOULLET et al., 1974; BASSOULLET, 1998; FUGAGNOLI, 1999). In most cases, a single subspherical proloculus is observable in *Robustoconus* with a diameter of 0.1 to 0.2 mm, distinctly smaller than the giant spheroconch of *Bostia* with a size of 0.6 to 1.0 mm (BASSOULLET, 1996: p. 192). In rare cases, a second crescent-shaped chamber, slightly separated from the proloculus is discernible in *Robustoconus* that is interpreted as the first post-embryonic chamber rather than a deuterconch. Let us remember that structural differences in the embryonic apparatus are widely accepted criteria in larger benthic foraminifera. Besides the giant complex embryonic apparatus in *Bostia*, this species also differs from *Robustoconus* by the distinctly reduced to absent initial spire. It should be mentioned that KAMINSKI (2000: p. 269) considers *Bostia* „to represent a more advanced stage in the evolution of the *Spiraloconulus* lineage“.

Last but not least, we also have to mention the genus *Limognella* PELISSIÉ & PEYBERNÈS, 1982. Whereas CHERCHI & SCHROEDER (1983) consider *Limognella* a synonym of *Spiraloconulus*, BASSOULLET (1999: p. 193) stresses morphological differences. A third view was expressed by SEPTFONTAINE (1988: p. 244) regarding *Limognella* a synonym of *Alzonella* BERNIER & NEUMANN, 1970. However, PELISSIÉ & PEYBERNÈS (1982: Pl. 2, Fig. 7) illustrated a single transverse section of a microspheric forms of *Limognella* exhibiting a flattened test with subparallel opposite sides. Transverse sections of *Spiraloconulus* are almost exlusively round (cylindrical enrolled part), and slightly elliptical shapes can only be observed in exceptional cases. There are also examples where test compression is used for genus differentiation, e.g. *Planisepta* (SEPTFONTAINE in KAMINSKI, 2000) versus *Lituosepta* CATI, 1959. The occurrence of both orbitoliniform (*S. perconigi*) and ammobaculitoid forms (*S. giganteus*) within the same genus, however, makes the test morphology highly problematic as a generic criterion.

Robustoconus tisljari nov. sp.

(Figs. 5–10; Pls. 1–4)

Origin of the name: In memory and dedication to Josip Tišljar for his numerous contributions to geology, especially to the carbonate sedimentology of the Adriatic carbonate platform (i.e. Karst Dinarides in Croatia, Slovenia, Bosnia and Herzegovina, and Montenegro).

Holotype: Longitudinal section illustrated in Fig. 6a, c thin-section 0–26/3.

Paratypes: All other specimens illustrated in the present paper.

Material: From sample 0–26, 11 thin-sections (2.5 x 7.5 cm) were made, numbered 0–26, 0–26/1 to 0–26/10 each containing about 40 to ~70 variously sectioned specimens.

Depository: Croatian Natural History Museum, Demetrova 1, 10000 Zagreb, Croatia.

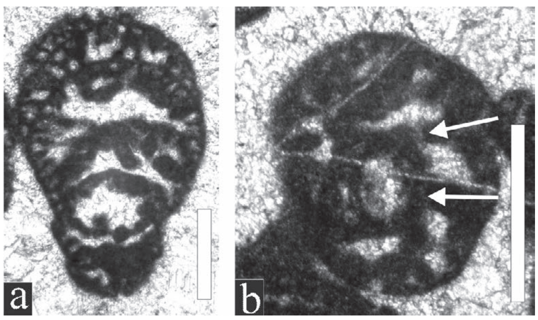

Figure 7: *Robustoconus tisljari* nov. gen., n. sp. from the Early Bajocian of Croatia. a) Slightly oblique axial section through the planispiral involute initial spire of a megalospheric specimen. Thin-section 0-26/1. Scale bar 0.3 mm. b) Equatorial section through a juvenile specimen only consisting of the initial planispiral part. Note the interio-marginal intercameral foramina (arrows). Thin-section 0-26/5. Scale bars 0.3 mm.

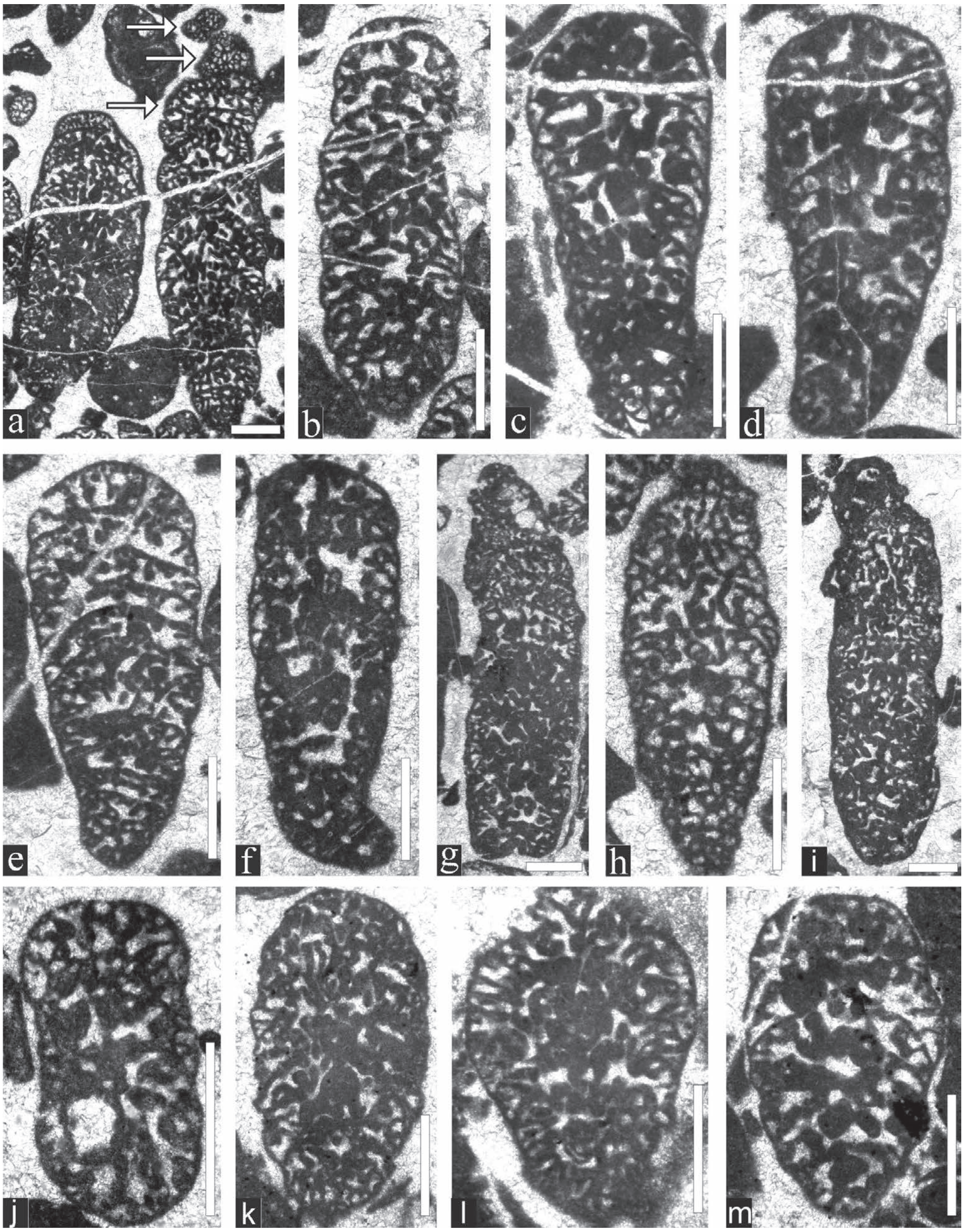

PLATE 1

Robustoconus tisljari, different longitudinal, tangential (a-j) and oblique sections (k-m), mostly of supposedly microspheric specimens; Figure j shows a megalospheric specimen.
Early Bajocian of Croatia.

a Two specimens in oblique longitudinal section. Note the irregular growth of the uppermost part of the test (arrows) of the specimen on the right. Thin-section 0-26/5.
b Oblique longitudinal section. Thin-section 0-26/10.
c Oblique longitudinal section. Thin-section 0-26/2.
d Longitudinal section. Thin-section 0-26/2.
e Longitudinal section. Thin-section 0-26/4.
f Longitudinal section; note the initial test bending. Thin-section 0-26/5.
g Oblique longitudinal to tangential section. Thin-section 0-26/4.
h Oblique longitudinal section. Thin-section 0-26/4.
i Longitudinal-tangential section. Thin-section 0-26/10.
j Longitudianl section of a juvenile specimen showing initial spire with proloculus. Thin-section 0-26/8.
k Oblique section. Note the micritic endoskeletal structure of the central zone devoid of agglutinated material (see also Fig. l). Thin-section 0-26/1.
l Oblique section of a test with an elliptical enrolled part. Thin-section 0-26/2.
m Oblique section, thin-section 0-26/1.
Scale bars 0.5 mm.

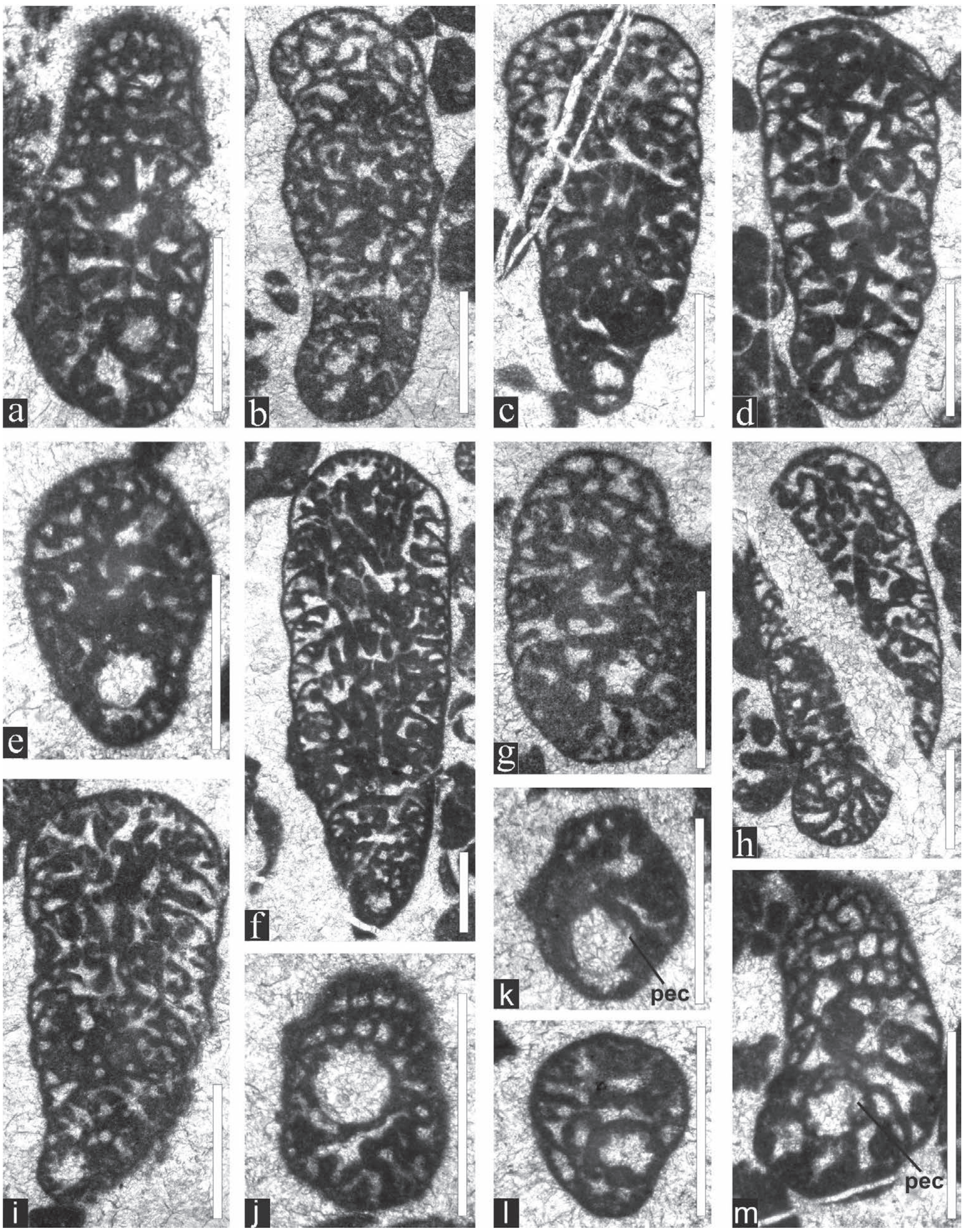

PLATE 2

Robustoconus tisljari, different sections of macrospheric specimens.
Early Bajocian of Croatia.

- **a** Oblique longitudinal section of specimen showing initial spire with proloculus. Thin-section 0-26/5.
- **b** Longitudinal section of specimen showing initial spire and proloculus. Thin-section 0-26/10.
- **c** Oblique longitudinal section passing through the proloculus. Thin-section 0-26.
- **d** Oblique longitudinal section of specimen showing initial spire with proloculus. Thin- section 0-26/2.
- **e** Oblique section passing through the proloculus. Thin-section 0-26/5.
- **f** Longitudinal-tangential section cutting the proloculus marginally. Note the subparallel longitudinal orientation of the micritic endoskeletal elements devoid of agglutinated particles (see also Fig. d). Thin-section 0-26/8.
- **g** Oblique section passing through the initial spire and proloculus, thin-section 0-26.
- **h-i** Longitudinal section cutting the initial spire (with about 9 chambers in h) and proloculus. Thin-sections 0-26/5 and O-26/8.
- **j-l** Oblique section through the initial part with proloculus. Thin-sections 0-26/4, and O-26/2 (k-l).
- **m** Note the sickle-shaped first post-embryonic chamber (pec). Thin-section 0-26/2.

Scale bars 0.5 mm.

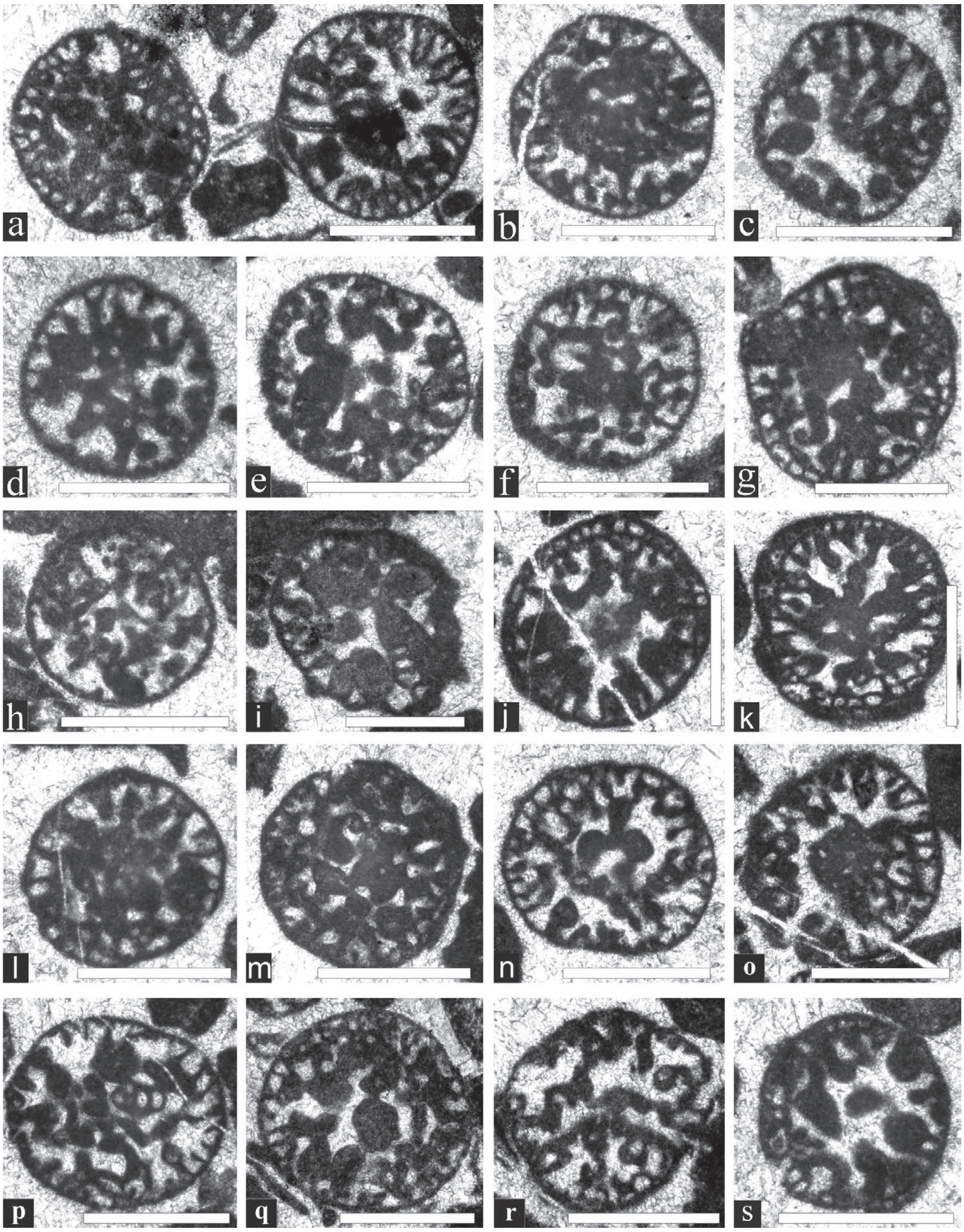

PLATE 3

Robustoconus tisljari, transverse to slightly oblique transverse sections of small specimens.
Early Bajocian of Croatia.

a Thin-section 0-26/7.
b Thin-section 0-26/2.
c Thin-section 0-26.
d Thin-section 0-26/2.
e Thin-section 0-26/3.
f Thin-section 0-26.
g Thin-section 0-26/9.
h Thin-section 0-26/4.
i Note the large agglutinated grains (amongst a small textulariid foraminifer) in the central zone. Thin-section 0-26/5.
j Thin-section 0-26/5.
k Thin-section 0-26/5.
l Thin-section 0-26/6.
m Thin-section 0-26/6.
n Thin-section 0-26/7.
o Thin-section 0-26/8.
p Thin-section 0-26/9.
q Thin-section 0-26/8.
r Thin-section 0-26/10.
s Thin-section 0-26/8.

Scale bars 0.5 mm.

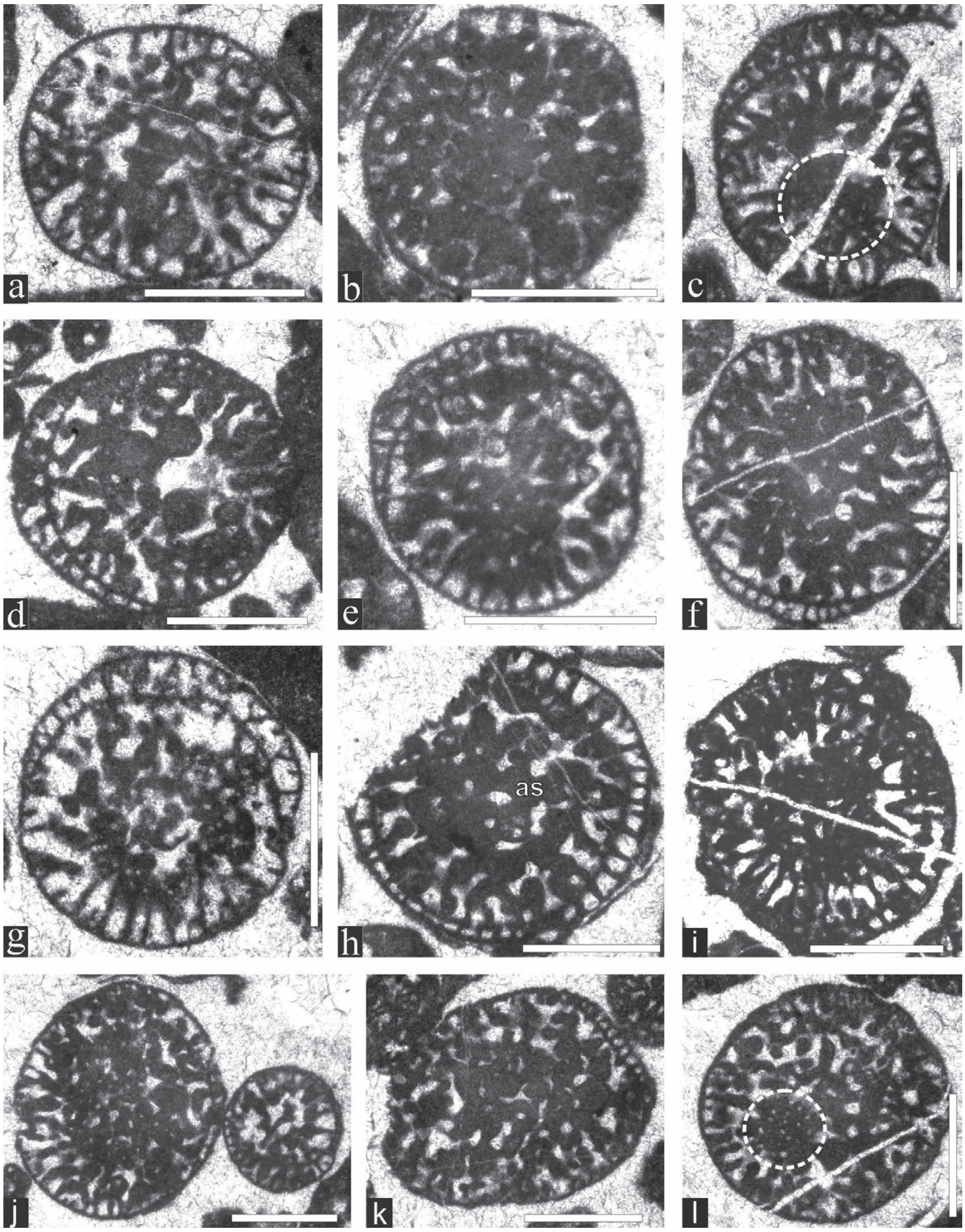

PLATE 4

Robustoconus tisljari, transverse to slightly oblique transverse sections of large specimens.
Early Bajocian of Croatia.

a Thin-section 0-26/4.
b Note the strongly reduced chamber volume resulting from the dense and thick anastomizing endoskeletal network. Thin-section 0-26/2.
c Note the transect of part of the septum with irregular distributed tiny foramina (white dashed circle). Thin-section 0-26/2.
d Thin-section 0-26/3.
e Thin-section 0-26/3.
f Thin-section 0-26/6.
G Thin-section 0-26/7.
h Note the anastomosing septulae (as) of the central zone. Thin-section 0-26/5.
i Thin-section 0-26/7.
j Thin-section 0-26/7.
k Thin-section 0-26/9.
l Note the transect of part of the septum with irregular distributed tiny foramina (white dashed circle). Thin-section 0-26/8.
Scale bars 0.5 mm.

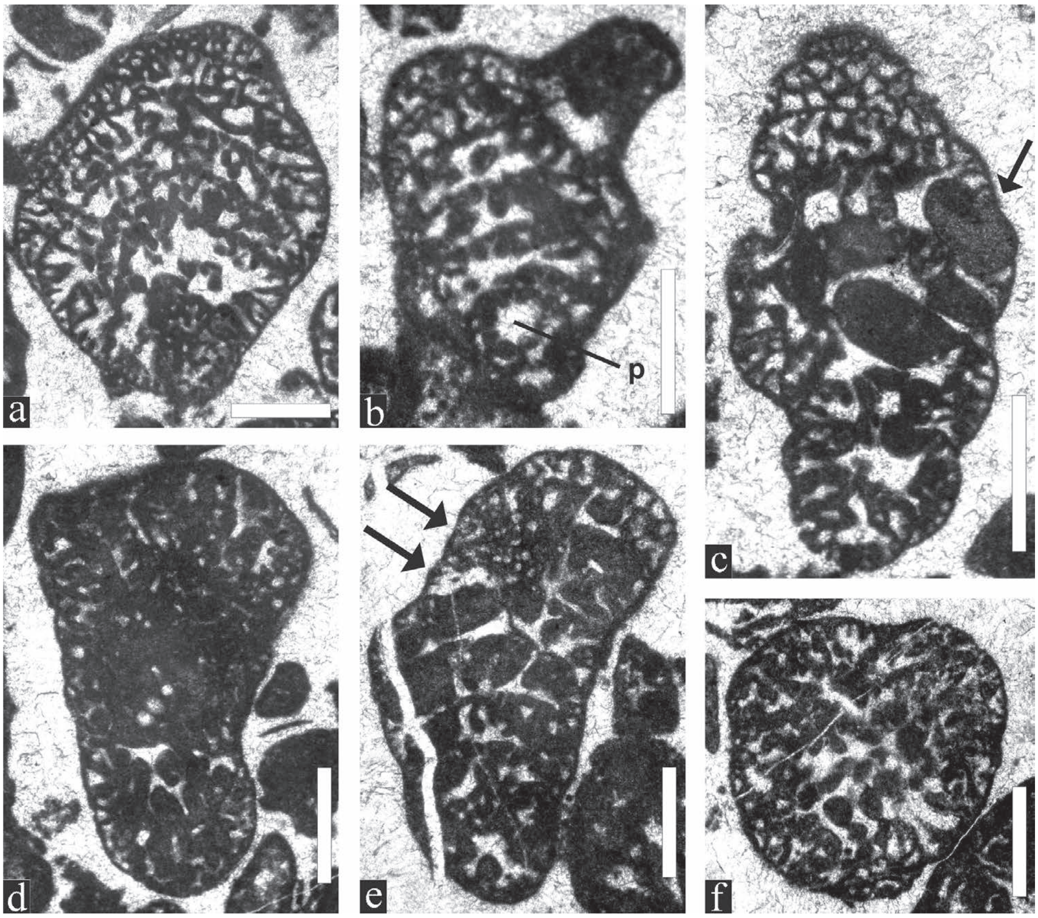

Figure 8: *Robustoconus tisljari* nov. gen., n. sp. from the Early Bajocian of Croatia. a) Oblique section of a large microspheric flabelliform test. Thin-section 0-26/2. b) Oblique axial section of a megalospheric specimen passing through the initial spire and the proloculus. Note the aberrant test excrescence (branching). Thin-section 0-26/3. c) Oblique longitudinal section of a microspheric specimen with large agglutinated micritized lithoclasts. The arrow points to a lithoclast incorporated into the marginal zone that lacks a network in this part. Note the irregular test growth. Thin-section 0-26. d) Oblique section of a slightly flabelliform test. Thin-section O 26-6. e) Specimen with irregular morphology, most likely resulting from partial test damage (arrows) that was not fatal enabling ongoing chamber formation. Thin-section O 26-7. f) Oblique transverse section of a specimen exhibiting a marginal test irregularity (upper side). Thin-section O 26-8. Scale bars 0.5 mm.

Type-locality: the road cut on the eastern slope of Sv. Ilija hill, ca. 1 km SSE from Osojnik, on the road from Osojnik to Dubrovnik (GPS, x=6506425, y=4728797; Fig. 2).

Type-level: thick bedded, light-brownish coloured to white skeletal-intraclastic/bioclastic grainstone/rudstone limestone of Lower Bajocian age.

Diagnosis: Being monospecific so far, the species diagnosis corresponds to the genus diagnosis.

Description: Test high conical to cylindrical, with an early planispiral and involute coiled stage, later rectilinear in specimens attributed to megalospheric forms (e.g., Fig. 6a, Pl. 2b, d). Occasionally, tests with irregular protuberances („pseudo-branching") at the ventral side (Fig. 8b) or slightly flabelliform outline (Figs. 8d-e) are observed in addition.

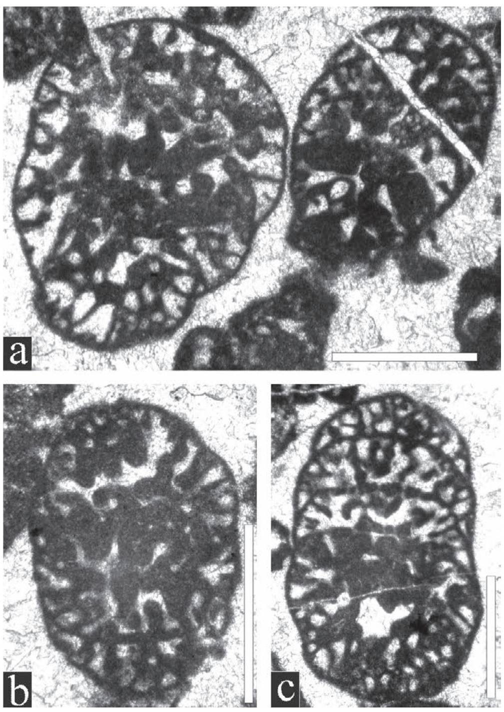

Figure 9: *Robustoconus tisljari* nov. gen., n. sp. from the Early Bajocian of Croatia. a-c) Oblique sections, most probably all microspheric specimens. Note the thick dense and vermiform network of partitions in b. In c, four chambers are obliquely transacted and the network becomes continuously coarser from the marginal parts towards the chamber interior. Thin-sections 0-26/8, 0-26/4 and 0-26/7. Scale bars 0.5 mm.

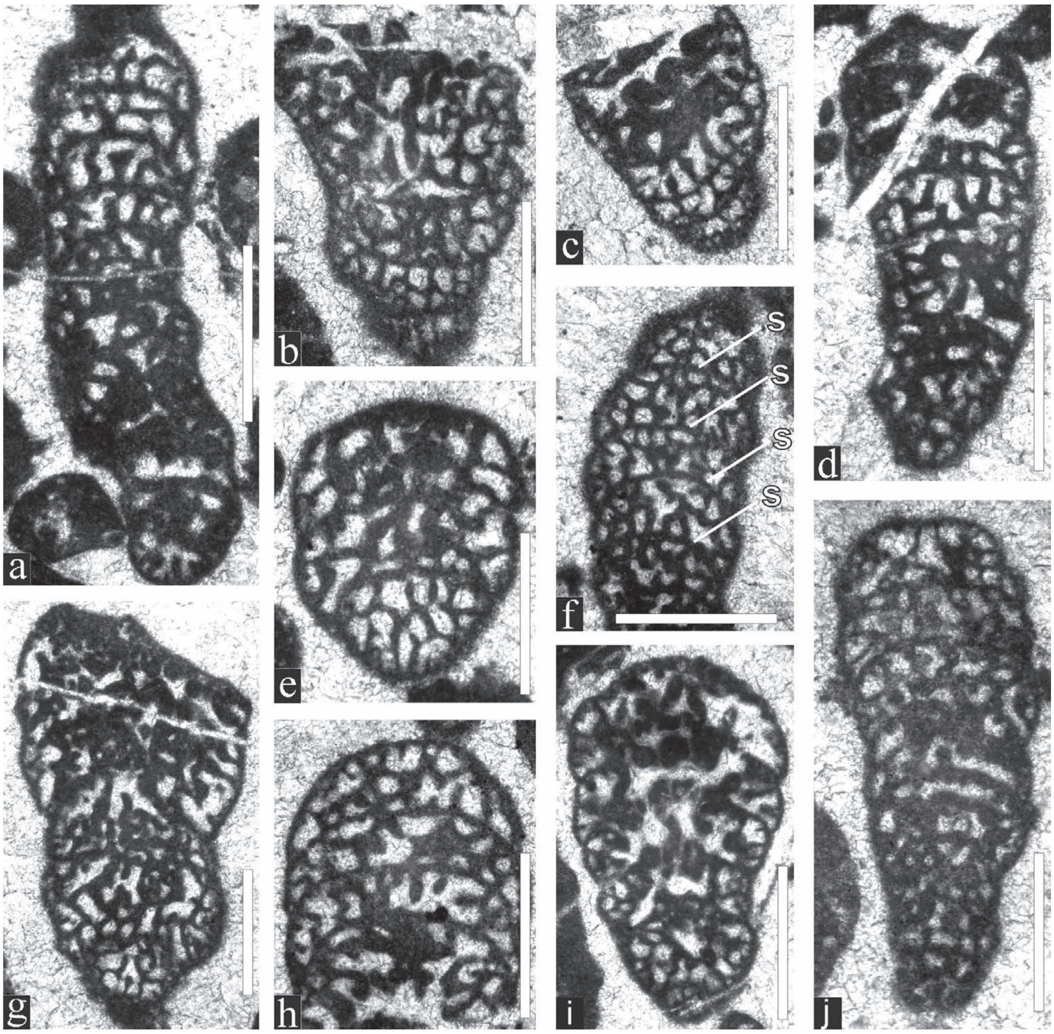

Figure 10: *Robustoconus tisljari* nov. gen., n. sp. from the Early Bajocian of Croatia. a-j) Oblique and tangential sections passing through the epidermal network of beams and rafters. From the marginal part towards the chamber interior, the network becomes successively coarser. Note also the thickening at the junction points. s = septum (f). Thin-sections 0-26/5 (a, e), 0-26/4 (b), 0-26/7 (c), 0-26/9 (d, l), 0-26/1 (f), 0-26/8 (g), 0-26/10 (h, j). Scale bars 0.5 mm.

The test height of adult specimens is most frequently within the range of 1.7 mm to 2.5 mm. The greatest observed specimen measures 5.9 mm in height and 1.54 mm in diameter (Pl. 1a).

The short initial planispirally involute coiled part (height ~0.3 to 0.5 mm) consists of about one (? one and a half) whorl(s) of low crescent-shaped chambers (5 to 10 in number). This part may be apical or eccentric in position. Transverse sections through the enrolled part are approximately circular to slightly elliptical. In the coiled part, the intracameral foramina are single and interio-marginal in position (Fig. 7b). The macrospheric proloculus is simple with a diameter of ~0.1 mm to ~0.2 mm (most values between 0.13 and 0.16 mm). In sections parallel to the plane of coiling the shape of the proloculus is subspherical, whereas in sections perpendicular to the plane of coiling it appears ovally compressed (Fig. 6a). The proloculus is followed by a second crescent-shaped chamber closely attaching the proloculus (Pl. 2, Fig. m). It is interpreted as the second post-embryonic chamber rather than as a deuteroconch. The uncoiled rectilinear stage corresponds to the main part of the test with up to about 15 uniserial chambers. During ontogeny, the almost flat chamber base successively becomes distinctly convex as appears also the ventral surface of the cone. In transverse sections, the rectilinear part is round, occasionally slightly elliptical (Pls. 3–4) and in rare cases also with some marginal embayments visible in transverse section (Fig. 8f). Other test irregularities may result from very large agglutinated particles (Fig. 8c).

Each chamber is subdivided into a marginal zone and a central zone (Pls. 3–4). The marginal zone consists of radial partitions (beams and 1 to 2 intercalary beams) and short horizontal partitions forming a network of chamberlets (Fig. 9). The diameter of these chamberlets exhibiting polygonal outlines varies between 0.06 and 0.08 mm in shallow tangential sections. Towards the chamber interior, the chamberlets increase in size along with a thickening of the exoskeletal elements. There may be 2 to 3 (rarely 4) rows of chamberlets per chamber displaying an irregular alternating position (Fig. 8c, upper part).

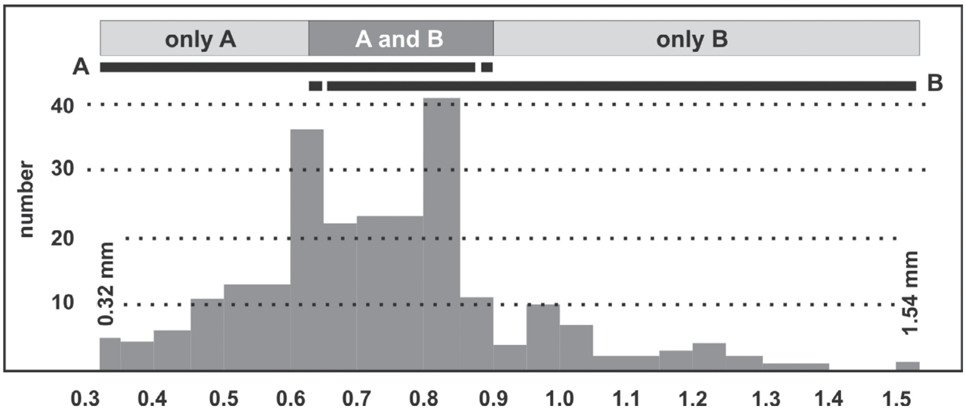

Figure 11: Test diameter (mm) of *Robustoconus tisljari* in transverse sections showing two separated maxima and their interpretation in terms of different generations (A- or macrospheric and B- or microspheric). Number of measured specimens = 242. Further explanations in the text.

The central zone is made up of rather thick micritic septal excrescences (with constrictions and swellings) showing a general subparallel orientation toward the test axis (e.g. Pl. 2f). As visible in transverse sections, they form an anastomosing network (Pls. 3–4). This structure forms a peculiar type of endoskeleton that may occupy large parts of the chamber lumen (e.g., Pl. 4b). The amount and also the size of agglutinated grains is rather variable. In many cases these grains are clearly recognizable as small lithoclasts with micritic rims or small benthic foraminifera (Fig. 8c, Pl. 3i, p). Homogeneous micritic grains (peloids) may also be agglutinated and are often indistinguishable from thickenings of the endoskeletal elements. In longitudinal sections, a continuous open space in the proximal part of the chamber base is discernible (Fig. 6, Pl. 1c-e). No interseptal structures (pillars) are present. Laterally, the endoskeletal elements fuse with those of the exoskeleton.

In the uniserial stage, there are numerous tiny intercameral foramina (width about 0.01 to 0.03 mm) piercing the septa and exhibiting an irregular distribution throughout the middle part of the central zone (Pl. 4c, l).

Remarks: Irregular aberrant tests as observed in *Robustoconus* are reported for instance from the Middle Jurassic *Bostia irregularis* (BASSOULLET, 1998), the Upper Jurassic *Anchispirocyclina* (RAMALHO, 1971) or the Lower Cretaceous *Torremiroella* (BRUN & CANÉROT, 1979). The reasons for these abnormalities are unknown. Tests of *Spiraloconulus giganteus* displaying both irregular internal structures and external morphologies were reported by CHERCHI & SCHROEDER (1981) resulting from large agglutinated ooids. In another case, partial test damage of *Robustoconus tisljari* (Fig. 8e) was the most likely cause of unusual growth. Test abnormalities are also reported from modern benthic foraminifera. They may be related to environmental stress conditions, e.g., warm water sources in deep sea areas (MERIÇ et al., 2003) or other factors (see for example, MUKHOPADHYAY, 2012).

A test dimorphism is assumed for *Robustoconus*. This can be suggested from specimens with a clear pronounced proloculus in a given size range (Pl. 2), whereas in other specimens it is not detectable in longitudinal sections. Megalospheric forms are usually high-cylindroconical, whereas slightly flabelliform tests can be referred to B-forms (Fig. 8d-e). Another indication was obtained from the size dimensions. In thin-sections, 242 transverse sections were measured resulting in a range from 0.32 to 1.54 mm for the test width (Fig. 11). The data show two maxima, from which the smaller one (between 0.6 and 0.65 mm) is attributed to macrospheric specimens. However, it must be noted that this is only an interpretation, as from the inner structure the two generations cannot be distinguished. Therefore the data are assumed as representing a mixture of both generations and adult/juvenile specimens within a given assemblage.

Stratigraphy: According to the foraminiferal assemblage at the type locality (Fig. 3), the stratigraphic range of *Robustoconus tisljari* n. gen. n. sp. can be considered as Early Bajocian.

Microfacies: Sample 0–26 represents an intraclastic grainstone clearly dominated by the overall presence of tests of *Robustoconus tisljari* (Fig. 5). Other foraminifera include common textulariids and some rare specimens of *Bosniella bassoulleti* SCHLAGINTWEIT & VELIĆ. Calcareous algae are very rare and are only represented by scattered porostromate algae and rare debris of an unknown tiny *Clypeina* species. Remains of gastropods (including nerineids) are common.

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REFERENCES

ALLEMANN, F. & SCHROEDER, R. (1972): *Spiroconulus perconigi* n. gen. n. sp. a new Middle Jurassic foraminifer of Oman and Spain. – Rev. Espan. Micropal. Num. extraord., 199–203.

BANNER, F.T., WHITTAKER, J.E., BOUDAGHER-FADEL, M.K. & SAMUEL, A. (1997): *Socotraina*, a new hauraniid genus from the Upper Lias of the Middle East (Foraminifera, Textulariina).– Revue de Micropaléontologie, 40/2, 115–123. DOI.org/10.1016/S0035-1598(97)90514–6

BASSOULLET, J.-P. (1998): Un nouveau grand foraminifère *Bostia irregularis* n. gen., n. sp. (Lituolacea, Hauraniidae) du Jurassique moyen de Dordogne (France).– Revue de Micropaléontologie, 41/3, 181–195. DOI: 10.1016/S0035-1598(98)90164-7

BASSOULLET, J.-P., CHABRIER, G. & FOURCADE, E. (1974): *Timidonella sarda* n. gen., n. sp., nouveau Lituolidé (Foraminifère) du Dogger.– C. R. Acad. Sc. Paris, 279, 2015–2018.

BERNIER, P. & NEUMANN, M. (1970): *Alzonella cuvillieri* n. gen., n. sp., nouveau genre de Foraminifère du Bathonien de la bordure méridionale des Cévennes.– Revue de Micropaléontologie, 13/1, 3–12.

BRUN, L. & CANÉROT, J. (1979): *Torremiroella hispanica* n. gen., n. sp. un nouveau Lituolidé (Foraminifère) du Barrémien Supérieur du Maestrazgo (Espagne).– Bull. Cent. Rech. Explor.-Prod. Elf-Aquitaine, 3/2, 311–335.

CATI, F. (1959): Nuovo Lituolide nei calcari grigi Liassici del Vincento.– Giornale di Geologia, ser. 2, 7, 1–10.

CHERCHI, A. & SCHROEDER, R. (1981): *Spiraloconulus giganteus* n. sp., a new lituolid foraminifer from the Dogger of NW Sardinia (Italy).– Bolletino della Società Paleontologica Italiana, 20/2, 163–168.

CHERCHI, A. & SCHROEDER, R. (1983): Remarks on *Spiraloconulus giganteus* CHERCHI & SCHROEDER, 1982 and *Limognella dufaurei* PELISSIÉ & PEYBERNÈS, 1982.– Géobios, 16/2, 249–250. DOI: 10.1016/S0016-6995(83)80024-2

FUGAGNOLI, A. (1999): *Cymbriaella*, a new foraminiferal genus (Textulariina) from the Early Jurassic of the Venetian Prealps (Northeastern Italy).– Revue de Micropaléontologie, 42, 99–110. DOI.org./10.1016/S0035-1598(99)90102-2

GUŠIĆ, I. (1969a): Some new and inadequately known Jurassic foraminifera from Central Croatia.– Geol. vjesnik, 22, 55–88.

GUŠIĆ, I. (1969b): Biostratigraphic and micropaleontologic characteristics of some Jurassic cross-sections in central Croatia.– Geol. vjesnik, 22, 89–97.

GUŠIĆ, I. (1977): A new foraminiferal family, Biokovinidae, from the Jurassic of the Dinarides and its phylogenetic relationships.– Palaeont. Jugoslavica, 18, 7–31.

GUŠIĆ, I. & VELIĆ, I. (1978): *Lituolipora polymorpha* n. gen., n. sp. (Foraminiferida, Lituolacea?) from the Middle Liassic of the Outer Dinarids in Croatia and the establishment of a new family, Lituoliporidae.– Geol. vjesnik, 30, 73–93.

HOTTINGER, L. (1967): Foraminifères imperforés du Mesozoïque marocain.– Notes et Mémoires du Service Géologique, 209, 1–128.

KAMINSKI, M.A. (2000): The new and reinstated genera of agglutinated foraminifera published between 1986 and 1996.– In: HART, M.B., KAMINSKI, M.A. & SMART, C.W. (eds.): Proc. 5th Int. Workshop agglutinated foraminifera, Grzybowski Foundation Special Publication, 7, 185–219.

KAMINSKI, M.A. (2004): The year 2000 classification of the agglutinated foraminifera.– In: BUBÍK, M. & KAMINSKI, M.A. (eds.): Proc. 6th Int. Workshop agglutinated foraminifera, Grzybowski Foundation Special Publication, 8, 237–255.

LOEBLICH, A.R., Jr. & TAPPAN, H. (1987): Foraminiferal genera and their classification.– 2 volumes, 1–970, (Van Nostrand Reinhold) New York.

MERIÇ, E., AVŞAR, N., BERGIN, F. & BARUT, I.F. (2003): A note on three abnormal samples of benthic foraminifers from the Dikili Bay (Turkey) in the northeastern Aegean Sea: *Peneroplis planatus* (Fichtel and Moll), *Rosalina* sp., and *Elphidium crispum* (Linne).–Mineral Res. Explor. Bull., 127, 1–14.

MUKHOPADHYAY, S.K. (2012): *Guembelitria* (foraminifera) in the upper cretaceous-lower paleocene succession of the Langpar Formation, India and its paleoenvironmental implication.– Journal of the Geological Society of India, 79/6, 627–651. doi: 10.1007/s12594-012-0101-4.

NIKLER, L. & SOKAČ, B. (1968): Biostratigraphy of the Jurassic of Velebit (Croatia).– Geol vjesnik, 21, 161–176.

PELISSIÉ, T. & PEYBERNÈS, B. (1982): Étude micropaléontologique du Jurassique Moyen/Supérieur du Causse de Limogne (Quercy).– Revue de Micropaléontologie, 25/2, 111–132.

RADOIČIĆ, R. (1966): Microfaciès du Jurassique des Dinarides externes de la Yougoslavie.– Geologia, 9, 5–378.

RAMALHO, M.M. (1971): Contribution à l´étude micropaléontologique et stratigraphique du Jurassique supérieur et du Crétacé inférieur des environs de Lisbonne (Portugal).– Serv. Geol. Portugal Mem., 19, 1–212.

SCHLAGINTWEIT, F. & VELIĆ, I. (2011): New and poorly known Middle Jurassic larger benthic foraminifera from the Karst Dinarides of Croatia.– Geol. Croat., 64/2, 81–99. doi: 10.4154/gc.2011.08

SEPTFONTAINE, M. (1988) Vers une classification évolutive des Lituolidés (foraminifères) jurassiques en milieu de plate-forme carbonatée.– Revue de Paléobiologie vol. spec. 2 (Benthos ´86), 229–256.

SMOUT, A.H. & SUGDEN, W. (1962): New Information on the foraminiferal genus *Pfenderina*.– Palaeontology, 4, 581–591.

VECCHIO, E. & HOTTINGER, L. (2007): Agglutinated conical foraminifera from the Lower-Middle Eocene of the Trentinara Formation (southern Italy).– Facies, 53/4, 509–533. doi: 10.1007/s10347-007-0112-6

VELIĆ, I. (1977): Jurassic and Lower Cretaceus Assemblage-zones in Mt. Velika Kapela, central Croatia.– Acta geol., 9, 15–37.

VELIĆ, I. (2005): Benthic foraminifera assemblages and stratigraphic subdivision of the Middle Jurassic in Karst Dinarides, Adriatic carbonate platform.– In: VELIĆ, I., VLAHOVIĆ, I. & BIONDIĆ, R. (eds.): 3rd Croatian Geological Congress, Opatija, 2005, Abstracts book, Croatian geological Survey Zagreb, 159–160.

VELIĆ, I. (2007): Stratigraphy and palaeobiogeography of Mesozoic benthic foraminifera of the Karst Dinarides (SE Europe).– Geol. Croat., 60, 1–113.

VELIĆ, I. & SOKAČ, B. (1978): Biostratigraphic analysis of the Jurassic and Lower Cretaceous in wider region of Ogulin (central Croatia).– Geol. vjesnik, 30, 309–337.

VLAHOVIĆ, I., TIŠLJAR, J., VELIĆ, I. & MATIČEC, D. (2005): Evolution of the Adriatic Carbonate Platform: Palaeogeography, main events and depositional dynamics.– Palaeogeography, Palaeoclimatology, Palaeoecology, 220/3–4, 333–360. DOI.org/10.1016/j.palaeo.2005.01.011

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