Bulogites multinodosus (Hauer, 1892) (Ammonoida, Ceratitida, Triassic: Middle Anisian)

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Bulogites multinodosus (Hauer, 1892) (Ammonoida, Triassic: Ceratitida) is revised in the context of a re-evaluation of the types of *B. mojsvari* (Arthaber, 1896), *B. reiflingensis* (Arthaber, 1896) and *B. sondershusanus* (Picard, 1892) together with a faunule mentioned by Spath (1934). We conclude herein that *B. mojsvari* and *B. reiflingensis* are synonyms of *B. multinodosus*. This relates also to *B. pseudovindelicus* (Arthaber, 1896) and *B. reiflingensis* var. *exigua* (Arthaber, 1896). *B. sondershusanus* is preliminarily kept as a separate species. • Key words: Ammonoida, Ceratitida, Pelsonian, *Bulogites multinodosus*, revision.

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The Anisian (Middle Triassic) ammonoid genus *Bulogites* Arthaber, 1912 (Ceratitida: Bulogitinae) is known from Europe, the United States and Asia (Fig. 1). In Europe, six species are related to the genus: *B. multinodosus* (Hauer, 1892), *B. sondershusanus* (Picard, 1892), *B. zoldianus* (Mojsisovics, 1882), *B. gosaviensis* (Mojsisovics, 1882) *B. mojsvari* (Arthaber, 1896) and *B. reiflingensis* (Arthaber, 1896). *B. multicostatus* Wang, 1965 *in* Zhao *et al*. (1965) is recorded from China and *B. mojsvari* from Nevada, USA (Monnet & Bucher 2005, Jenks *et al.* 2007). Although the genus seems to be widespread, the number of figured specimens is low (see synonymy list), making an assessment of the morphological variability within individual species difficult. This is unfortunate, because some of the species are morphologically hardly distinguishable. While *B. zoldianus* and *B. gosaviensis* can readily be distinguished based on their ornamentation and degree of involution, the group of *B. multinodosus*, *B. mojsvari*, *B. reiflingensis*, *B. pseudovindelicus* (Arthaber, 1896) and *B. reiflingensis* var. *exigua* (Arthaber, 1896) are virtually indistinguishable (comp. Assereto 1971). We therefore revised this group based on their types, publications and additional material mentioned by Spath (1934). This led us to conclude that *B. mojsvari*, *B. multinodosus*, *B. pseudovindelicus*, *B. reiflingensis* var. *exigua* and *B. reiflingensis* are conspecific and subjective synonyms of *B. multinodosus* (Hauer, 1892).

Abbreviations, depositories and methods

Institutional abbrevations are as follows: BGR = Bundesanstalt für Geowissenschaften und Rohstoffe, Spandau (X = Originalesammlung) (Berlin, Germany); BMNH = British Museum of Natural History, London; CNHM = Croatian Natural History Museum; GBA = Geologische Bundesanstalt (Vienna, Austria); HNHM = Geological and Palaeontological Department of the Hungarian Natural History Museum (Budapest); IPUV = Institute for Paleontology, University Vienna (Austria); Ist. Paleont. Univ. Milano = Istituto di Paleontologia dell'Università di Milano (Italy); NHW = Naturhistorisches Museum Wien (Vienna, Austria).

The data in Table 1 base on own measurements, on published figures and on data obtainable from the literature. Conch parameters are abbreviated as follows: d – diameter; wh – whorl height; ww – whorl width; uw – umbilical width. Following Korn (2010), the whorl width index (WWI – ww/wh) and the umbilical width index (UWI – uw/d) are applied, where possible, to describe compression and evolution of the conch. As a simple approximation to the degree of evolution, we used the ratio wh/d plotted against the diameter.

The suture terminology (EAUI) follows Korn *et al.* (2003): external lobe E; adventive lobe A; umbilical lobe U; internal lobe I.

Palaeontological Account

Order Ceratitida Hyatt, 1884
Superfamily Ceratitoidea Mojsisovics, 1879
Family Ceratitidae Mojsisovics, 1879
Subfamily Bulogitinae Mietto & Manfrin, 2005

Genus *Bulogites* Arthaber, 1912

Type species. – *Ceratites multinodosus* Hauer, 1892, pl. 3, fig. 1, by original designation of Arthaber (1912, p. 342).

Remarks. – The position of *Bulogites* within the classification of Triassic Ammonoida is an odyssey. Arkell *et al.* (1957) and Popov *et al.* (1958) listed it in the Ceratitidae Mojsisovics, 1879. Later, Tozer (1981) included *Bulogites* in the Balatonitidae Spath, 1951. Applying the classification of Tozer (1981), Monnet & Bucher (2005) shifted it into the Ceratitidae, subfamily Paraceratitinae Silberling, 1962 without further explanation. Bucher (1992) discussed the narrow relationship between *Bulogites* and *Reiflingites* based on the Arthaber material. In particular, their juvenile whorls show differences to that of *Balatonites*, why he objected to include *Bulogites* in the Balatonitida Spath 1951. Mietto & Manfrin, 2005 *in* Manfrin *et al*. (2005, p. 499) established the new subfamily Bulogitinae within the Ceratitidae: "*As regards the coiling and the degree of compression of the shell, the representatives of the subfamily show a precise and constant phylogenetic trend from involute, very compressed forms to quite evolute forms with a subquadrate or subhexagonal whorl section. Moreover all the genera attributed to Bulogitinae show an ornamentation that—although different among the various genera—is always characterized by marked ribs at every stage of development"*. Apart from *Bulogites*, *Salterites* Diener, 1905, *Reiflingites* Arthaber, 1896 and *Ticinites* Rieber, 1973 were included in this new subfamily. We follow this approach here.

We regard *B. multinodosus* (Hauer, 1892), *B. sondershusanus* (Picard, 1892), *B. zoldianus* (Mojsisovics, 1882), *B. gosaviensis* (Mojsisovics, 1882) and *B. multicostatus* Wang, 1965 *in* Zhao *et al*. (1965) as valid species of *Bulogites*. We treat *B. mojsvari* (Arthaber, 1896, pl. 4, fig. 6), *B. reiflingensis* (Arthaber, 1896, pl. 5, fig. 3), *B. pseudovindelicus* (Arthaber, 1896, pl. 5, fig. 4) and *B. reiflingensis* var. *exigua* (Arthaber, 1896, pl. 5, fig. 5) as a synonym of *B. multinodosus*. It is possibly this group, which was referred to as "*Multinodosus*-Gruppe" (*multinodosus* group) by Philippi (1901, p. 94), characterized by four rows of tubercles.

Bulogites anceps (Arthaber, 1896) could represent a separate species (see discussion below).

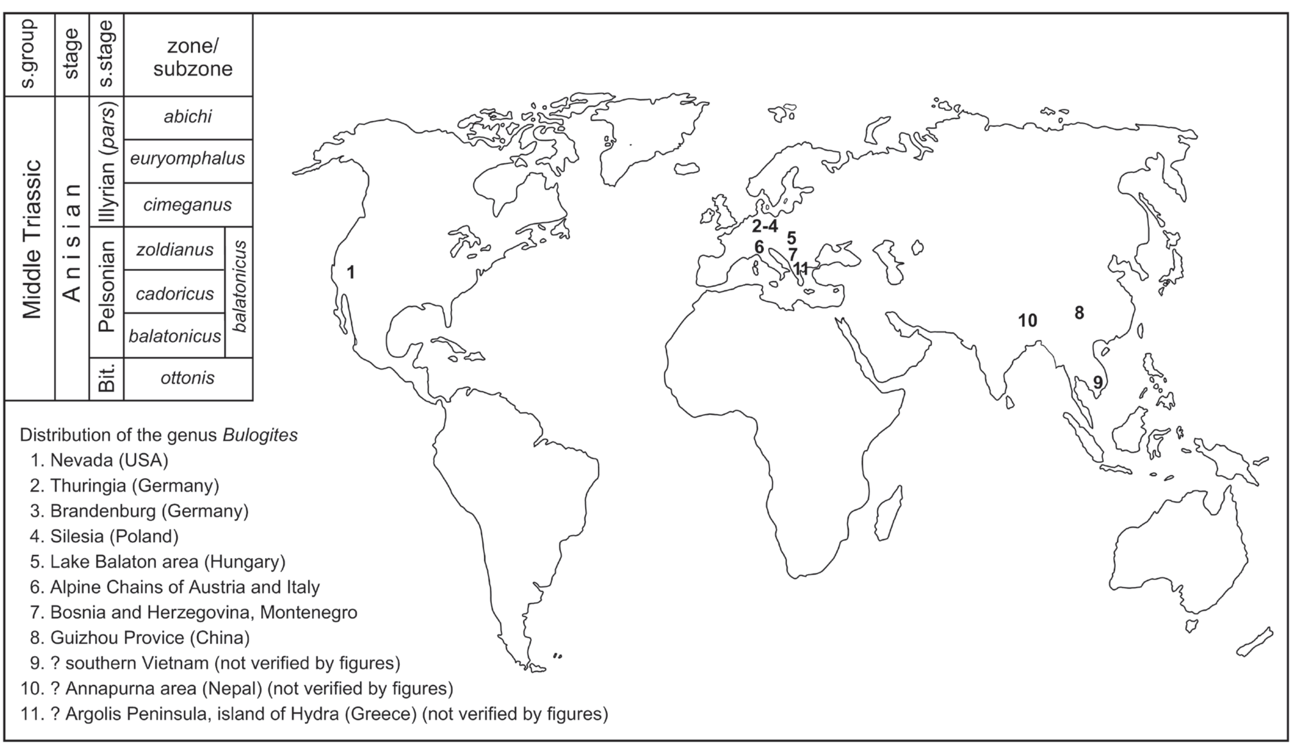

Figure 1. Ammonoid biostratigraphic subdivision of the Middle Triassic Anisian (*pars*) and the global distribution of *Bulogites* Arthaber, 1912. The biostratigraphic scheme follows Vörös (2003) and Monnet *et al*. (2008). For references see text. Abbreviations: Bit. – Bithynian; s. group – subgroup; s. stage – substage.

Table 1. Measurements and calculation of ratios (UWI – umbilical width index: uw/d; WWI – whorl width index: ww/wh; wh/d ratio) based on own measurements and literature data. Estimated values in italics (species id.: species as identified in the literature or by the authors). Abbreviations of conch parameters: d – diameter; wh – whorl height; ww – whorl width; uw – umbilical width.

author	species id	depository	d	wh	ww	uw	UWI	WWI	wh/d
Arthaber (1896, pl. 4, fig. 6)	*mojsvari*	1896/001/0027/1	91.0	44.0	23.0	22.0	0.24	0.52	0.48
Arthaber (1896, pl. 5, fig. 3)	*reiflingensis*	IPUV 4-24	70.0	25.0	23.0	22.0	0.31	0.92	0.36
Arthaber (1896, pl. 5, fig. 5)	*reif. var. exiguus*	IPUV 4-25	*36.0*	13.0	8.0	13.0	0.36	0.62	0.36
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	51.0	20.0	x	17.0	0.33	x	0.39
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	34.0	14.0	9.0	11.0	0.32	0.64	0.41
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	27.0	10.5	7.8	9.5	0.35	0.74	0.39
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	27.0	11.0	x	9.0	0.33	x	0.41
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	26.0	10.0	7.0	8.5	0.33	0.70	0.38
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	25.0	10.0	7.0	8.3	0.33	0.70	0.40
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	24.5	9.5	6.8	8.2	0.33	0.72	0.39
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	24.0	9.2	6.4	8.3	0.35	0.70	0.39
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	24.0	9.0	6.4	8.0	0.33	0.71	0.38
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	20.4	7.8	x	7.0	0.34	x	0.38
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	20.0	8.5	6.0	6.2	0.31	0.71	0.38
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	27.0	10.5	7.8	9.5	0.35	0.74	0.43
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	34.0	14.0	9.0	11.0	0.32	0.64	0.39
Assereto (1963, p. 55)	*r. reiflingensis*	Ist. Paleont. Univ. Milano	51.0	20.0	x	17.0	0.33	x	0.41
Assereto (1963, p. 58)	*r. optimus*	Ist. Paleont. Univ. Milano	33.5	12.2	9.6	12.7	0.38	0.79	0.36
Assereto (1963, p. 58)	*r. optimus*	Ist. Paleont. Univ. Milano	29.5	10.2	8.2	11.5	0.39	0.80	0.35
Assereto (1963, p. 58)	*r. optimus*	Ist. Paleont. Univ. Milano	28.0	10.5	8.4	10.0	0.36	0.80	0.38
Assereto (1963, p. 58)	*r. optimus*	Ist. Paleont. Univ. Milano	28.0	10.5	8.0	10.0	0.36	0.76	0.38
Assereto (1963, p. 58)	*r. optimus*	Ist. Paleont. Univ. Milano	20.0	7.2	6.0	7.5	0.38	0.83	0.36
Assmann (1937, pl. 21, fig. 3)	*mirabilis*	BGR X3430 1-3	105.0	41.0	32.0	38.0	0.36	0.78	0.39
Hauer (1892, pl. 3, fig. 1)	*multinodosus*	NHMW 1999z0026/0014	100.0	39.0	32.0	31.0	0.31	0.82	0.39
Monnet & Bucher (2005, pl. 4, fig. 3)	*mojsvari*	PIMUZ 25204	66.8	33.1	17.3	13.7	0.21	0.52	0.50
Monnet & Bucher (2005, pl. 4, fig. 1)	*mojsvari*	PIMUZ 25203	66.6	31.4	20.2	14.9	0.22	0.64	0.47
Monnet & Bucher (2005, pl. 4, fig. 2)	*mojsvari*	USNM 452800	83.3	35.7	*25.9*	22.4	0.27	*0.73*	0.43
Picard (1892, pl. 24, figs 1–4, 8)	*sondershusanus*	BGR X05636	99.0	37.0	30.0	34.0	0.34	0.81	0.37
Salopek (1918, pl. 1, fig. 2)	*multinodosus*	CNHM?	80.0	30.0	*27.0*	28.0	0.35	0.90	0.38
this work (Fig. 4A–C)	*multinodosus*	BMNH C20327	69.9	26.8	*20.0*	23.6	0.34	*0.75*	0.38
this work (Fig. 4D–F)	*multinodosus*	BMNH C30977	84.5	32.7	*26.0*	29.6	0.35	*0.80*	0.39
this work (Fig. 4G)	*multinodosus*	BMNH C30979	51.6	*19.1*	x	x	x	*x*	*0.37*
Turina (1912, p. 693)	*multinodosus*	?	60.0	24.0	18.0	20.0	0.33	0.75	0.40
Vörös (2003, p. 93)	*mojsvari*	HNHM	59.7	26.8	18.5	15.0	0.25	0.69	0.45
Vörös (2003, p. 93)	*mojsvari*	HNHM	52.0	24.0	16.5	13.8	0.27	0.69	0.46

Ceratites superbus Mojsisovics, 1882 was included into *Bulogites* by Spath (1934) without reasoning. Judging from figures in Mojsisovics (1882, pl. 33, figs 5, 6), its ornamentation deviates from that of *Bulogites*, in particular by the very bullate umbilical tubercles, the weak ornamentation in the lower third of the flank and the dense, slightly flexuous ribbing, outnumbering the umbilical tubercles significantly by a factor of 3.

Bulogites camunus Assereto, 1963 became type species of *Asseretoceras* Balini, 1992 (see discussion in Vörös 2018), which, however, is regarded as a synonym of *Reiflingites* by Mietto & Manfrin (2005).

Bulogites (?) cf. *vindelicus* (Mojsisovics, 1882) in Assereto (1963, pl. 6, fig. 2) shows the ventral groove typical of the species but atypical of *Bulogites*. Spath (1934) included it into *Paraceratites*, and we exclude it also from *Bulogites*.

The Ladinian *Bulogites langdaiensis* Wang, 1983 from southwestern Guizhou (China) is now included in *Yangites* Balini & Zou, 2015.

Occurrence. – *Bulogites* occurs in Thuringia (*B. sondershusanus*, Picard 1892) and Brandenburg (*B. zoldianus*, Siegel *et al.* 2022), both Germany, Poland (*B. sondershusanus*, Assmann 1937), Hungary (*B. gosaviensis*, *B. multinodosus*, *B. zoldianus*, *e.g.*, Vörös 2003), the Austrian and Italian Alpine chains (*B. gosaviensis*, *B. multinodosus*, *B. zoldianus*, *e.g.*, Arthaber 1892, Assereto 1963, Tatzreiter & Vörös 1991), Bosnia and Herzegovina (*B. multinodosus*, Hauer 1892), Montenegro (*B. multinodosus*, *e.g.*, Đaković 2018, Spath 1934), USA (*B. multinodosus*, *e.g.*, Bucher 1992) and China (*B. multicostatus*, *e.g.*, Zhao & Wang 1974). Questionable records because without figures and description exist from the Annapurna region of the Himalaya, Nepal (Waterhouse 1996), from Greece (*B. reiflingensis* from the Island of Hydra: Renz 1931a, b; Pomoni *et al*. 2013) and Vietnam (*B. multinodosus*: Khuc 2000) (Fig. 1).

Stratigraphically, *Bulogites* is limited to the terminal middle Anisian (terminal Pelsonian) *zoldianus* Subzone of the *B. balatonicus* Zone (Fig. 1, Monnet *et al*. 2008). As the genus is exclusively limited to the *zoldianus* Subzone, it is – even in fragments only identifiable to the genus – a good biostratigraphic marker for the terminal Pelsonian (Fig. 1).

Bulogites multinodosus **(Hauer, 1892)**
Figures 2–4

1892 *Ceratites multinodosus*; Hauer, pl. 3, fig. 1.
? 1895 *Ceratites* cfr. *C. Mojsvari* Arthaber. – Bukowski, p. 321.
1896 *Ceratites Mojsvari* Art. – Arthaber, pl. 4, fig. 6.
1896 *Ceratites* nov. sp. ex. aff. *multinodosi*. – Arthaber, pl. 4, fig. 8.
1896 *Ceratites multinodosus* Hauer. – Arthaber, pl. 4, fig. 7.
1896 *Ceratites Reiflingensis* Art. – Arthaber, pl. 5, fig. 3.
1896 *Ceratites pseudovindelicus* Art. – Arthaber, pl. 5, fig. 4.
1896 *Ceratites Reiflingensis* var. *exiguus* Art. – Arthaber, pl. 5, fig. 5.
1905 *Ceratites multinodosus* Hauer. – Airaghi, pl. 8, fig. 7.
1912 *Ceratites multinodosus* Hauer. – Turina, p. 692–693.
1915 *C. Mojsvari* v. Arthaber. – Diener, p. 85.
1915 *C. pseudovindelicus* v. Arthaber. – Diener, p. 87.
1915 *C. Reiflingensis* v. Arthaber. – Diener, p. 87.
1915 *C.* (*Bulogites*) *multinodosus* v. Hauer. – Diener, pp. 92, 93.
1915 *C.* (*Bulogites*) nov. sp. aff. *multinodosi* (Hau.) v. Arthaber. – Diener, p. 93.
non 1918 *Bulogites multinodosus* Hauer. – Salopek, pl. 1, fig. 2.
? 1926 *Ceratites* cf. *Reiflingensis* var. *exigua* Arth. – Alma, p. 112.
1933 *Ceratites reiflingensis* Arth. 1896. – Kutassy, p. 456.
1933 *Ceratites* (*Bulogites*) *multinodosus* Hauer. – Kutassy, p. 463.
1934 *Bulogites multinodosus* (Hauer). – Spath, p. 460, fig. 152.
? 1949 *Ceratites mojsvari* Arthaber. – Riedel, pl. 1, fig. 7.
1957 *Bulogites multinodosus* (Hauer). – Arkell *et al*., p. 153, fig. 5.
1963 *Bulogites reiflingensis reiflingensis* (Arthaber). – Assereto, pl. 5, figs 1–5.
1963 *Bulogites reiflingensis optimus* n. subsp. – Assereto, pl. 5, figs 6–11.
1987 *Bulogites mojsvari* (Arth.). – Vörös, pl. 3, fig. 2.
1991 *Bulogites mojsvari* (Arthaber, 1896). – Tatzreiter & Vörös, pl. 2, figs 8, 9.
1992 *Bulogites* cf. *B. mojsvari* (Arthaber). – Bucher, p. 438, figs 17, 18.
2003 *Bulogites mojsvari* (Arthaber, 1896). – Vörös, fig. a-19, pl. a-vi, figs 5–8.
2003 *Bulogites multinodosus* (Hauer, 1892). – Vörös, pl. a-vi, figs 3, 4.
2005 *Bulogites mojsvari* (Arthaber, 1896). – Monnet & Bucher, p. 32, fig. 30, pl. 4, figs 1–4.
2007 *Bulogites mojsvari.* – Jenks, Spielmann & Lucas, pl. 35g, h.
2015 *Bulogites mojsvari.* – Monnet, Brayard & Brosse, p. 43, fig. 2.9n.
2018 *Bulogites mojsvari* (Arthaber). – Đaković, p. 161, fig. 87.

Type. – Spath (1934) regarded the only figured specimen of Hauer (1892, pl. 3, fig. 1) as the holotype. Judging from the original description, Hauer had apparently a set of specimens available, why no monotypy exists. A lectotype needs, therefore, to be designated. Not being aware of an

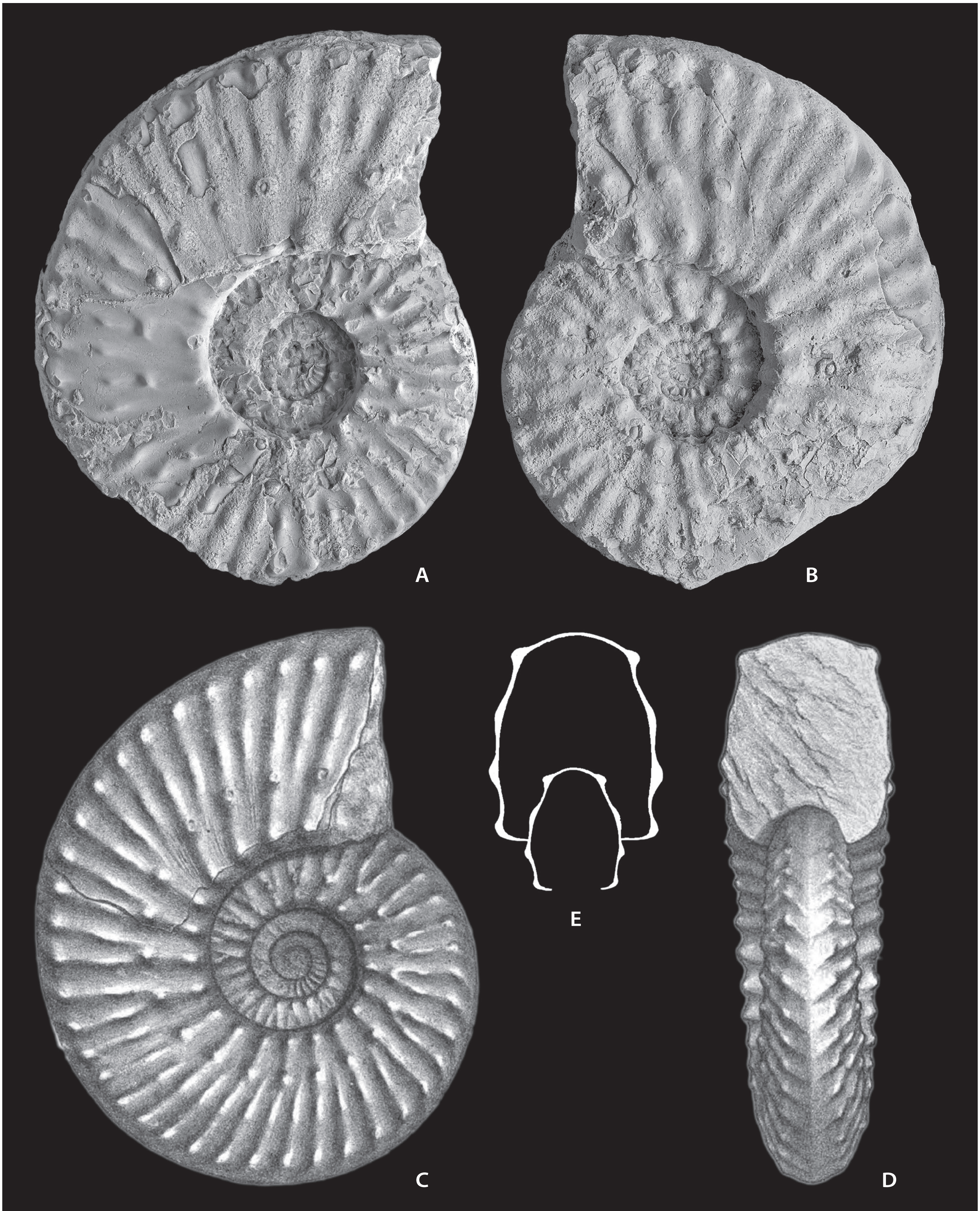

Figure 2. Lectotype of *Bulogites multinodosus* (Hauer, 1892) from Han Bulog near Sarajevo (Bosnia and Herzegovina), housed in the Naturhistorisches Museum Wien (collection number NHMW 1999z0026/0014). A – left side. B – right side. C, D – reproduction of the original figures of Hauer (1892, pl. 3, fig. 1); C – left side (Hauer 1892, pl. 3, fig. 1a); D – ventral view (Hauer 1892, pl. 3, fig. 1b). E – whorl section of the lectotype of *B. multinodosus* as figured by Arthaber (1896, pl. 4, fig. 7a). All natural size.

earlier designation, we designate *Ceratites multinodosus* Hauer, 1892, pl. 3, fig. 1 (on page 260 erroneously referred to as fig. iii) as the lectotype.

Material. – We considered the following material:

The original of Hauer (1892, pl. 3, fig. 1) from Han Bulog near Sarajevo (Bosnia and Herzegovina), deposited at the Naturhistorisches Museum Wien (collection number NHMW 1999z0026/0014) (Fig. 2).

The original of *B. mojsvari* (Arthaber, 1896, pl. 4. fig. 6) from the Reifling Limestone of Großreifling (Austria), deposited at the Geologische Bundesanstalt Wien (collection number 1896/001/0027/1) (Fig. 3A–C).

The type of *B. reiflingensis* (Arthaber, 1896, pl. 5, fig. 3) from the Reifling Limestone of Großreifling (Austria), located at the Institute of Palaeontology, University Vienna (reg. no. 4-24) (Fig. 3D–F) plus the original of *Ceratites Reiflingensis* var. *exiguus* Arthaber, pl. 5, fig. 5 (IPUV 4-25).

The specimens mentioned but not figured by Spath (1934, p. 461): BMNH C20327 from the Volujak Mountains (Bosnia and Herzegovina; locality and fauna details in Kraus 1916 and in Gugenberger 1925, 1927) (Fig. 4A–C), BMNH C30977-30980 from the Mali Durmitor Mountains (Montenegro), the latter were purchased from the local collector Vinzenz Hawelka in 1908, who also sold the material published by Kraus (1916) and Gugenberger (1925) to the Vienna University.

Specimen BMNH C 74501 from the Schreyer Alm near Bad Ischl in Austria (Fig. 4D –H).

Furthermore, we considered the holotypes (by monotypy) of *Balatonites sondershusanus* Picard, 1892 from the Lower Muschelkalk of Thuringia, Germany (X05636) (Fig. 5D, E) and *Ceratites mirabilis* Assmann, 1937 from the Lower Muschelkalk of Silesia, Poland (X3430 1-3) (Fig. 5A, B), the latter synonymized with *Bulogites sondershusanus*. Finally, we considered a yet undescribed, possible fragment of *B. sondershusanus* from Silesia, found in the Assmann collection (BGR Spandau X 13357) (Fig. 5C).

Description. – The original of Hauer (1892), refigured by Spath (1934, p. 460, fig. 152), Arkell *et al*. (1957) and here on Fig. 2, is large (d: *ca*. 110 mm) and is in wide parts an internal mould with parts of the recrystallized shell attached (Fig. 2A, B). A comparison of the type specimen with the original figures of Hauer (1892) (Fig. 2C, D) shows that these figures are somewhat idealized. The discoidal conch is weakly compressed (WWI: 0.82), and coiling is subevolute (UWI: 0.31, wh/d: 0.39 at 100 mm; comp. Fig. 6; Tab. 1) with largest thickness in costal section ca. in the lower third of the flank and approximately mid-flank in intercostal section. Although not recognizable in the historic documentation in Hauer (1892), the venter is shallow fastigate in shape, not broadly rounded (comp. Fig. 2E). While large parts of the left side exhibits internal ornament or a composite mould, respectively (Fig. 2A), the right side (Fig. 2B) shows the morphology of the external ornamentation. The umbilical wall is steep and slightly inclined inwards. At the umbilical shoulder, *ca.* 20 slightly bullate tubercles, slightly variable in strength, arise, sometimes a bit irregularly spaced (Fig. 2A). These give rise to first rectiradiate, later very weak, slightly prorsiradiate ribs, which link to a comparatively coarse inner lateral tubercle, which appears – where preservation is poorer – as a blunt tubercle. From there, straight prorsiradiate (Fig. 2A: left side) to slightly sigmoidal (Fig. 2B: right side) secondary ribs originate by bifurcation in earlier and intercalation in later growth stages. Ribs seem to strengthen towards the ventrolateral shoulder, where they terminate in a ventrolateral tubercle, *ca*. 35–40/whorl. The well-preserved areas on the left side of the lectotype, in particular, show the presence of bullate swellings in an outer lateral position. From ventrolateral tubercles, the ribs project forward, weaken rapidly to disappear, leaving the weakly subtriangular (fastigate) venter blank.

Specimen GBA 1896/001/0027/1, the original of *B. mojsvari* (refigured by Tatzreiter & Vörös, pl. 2, figs 8, 9 and here in Fig. 3A–C), is an incomplete composite mould of moderate size (d: 91 mm). The conch is weakly compressed (WWI: 0.52) and subinvolute (UWI: 0.24, wh/d: 0.48; Fig. 6, Tab. 1). It lacks parts of the whorl, and the reproduction in Arthaber (1896, pl. 4, fig. 6a) (Fig. 3B) is idealized. Ribbing pattern (Fig. 3A) is identical to that of the right side of the holotype of *B. multinodosus*. However, the thickening/tuberculation in the outer lateral position is poorly visible, although indicated in the whorl section given by Arthaber (1896, pl. 4, fig. 6c) (Fig. 3C).

The lectotype of *B. reiflingensis*, refigured by Assereto (1963, pl. 5, fig. 1) and here on Fig. 3D–F is of moderate size (d: 70 mm). The conch is subevolute (UWI: 0.31, wh/d: 0.36; Fig. 6, Tab. 1) and weakly compressed (WWI: 0.92; Tab. 1). It is also a fragment and reconstructed in Arthaber (1896, pl. 5, fig. 3a) (comp. Fig. 3D). Its mode of ribbing follows that of *B. multinodosus*, and the presence of a quadrituberculation, although weakly developed, was already recognised by Arthaber (1896, pl. 5, fig 3b) (Fig. 3F). The overall whorl section (Fig. 3F) is comparable to that of *B. multinodosus* (Fig. 2E), but both are more compressed than the lectotype of *B. reiflingensis* (Fig. 3F, Fig. 6, Tab. 1).

Specimen BMNH C20327 (Fig. 4A–C) from the Volujak Mountains (Bosnia and Herzegovina), fully septate, is subevolute (UWI: 0.34, wh/d: 0.38; Fig. 6, Tab. 1) and of moderate size (d: *ca*. 70 mm,). The specimen is a more robustly ornamented representative of the species, and it is a bit more inflated with a rounded venter; 19–20 strong and broad ribs/half whorl terminate each in a broad

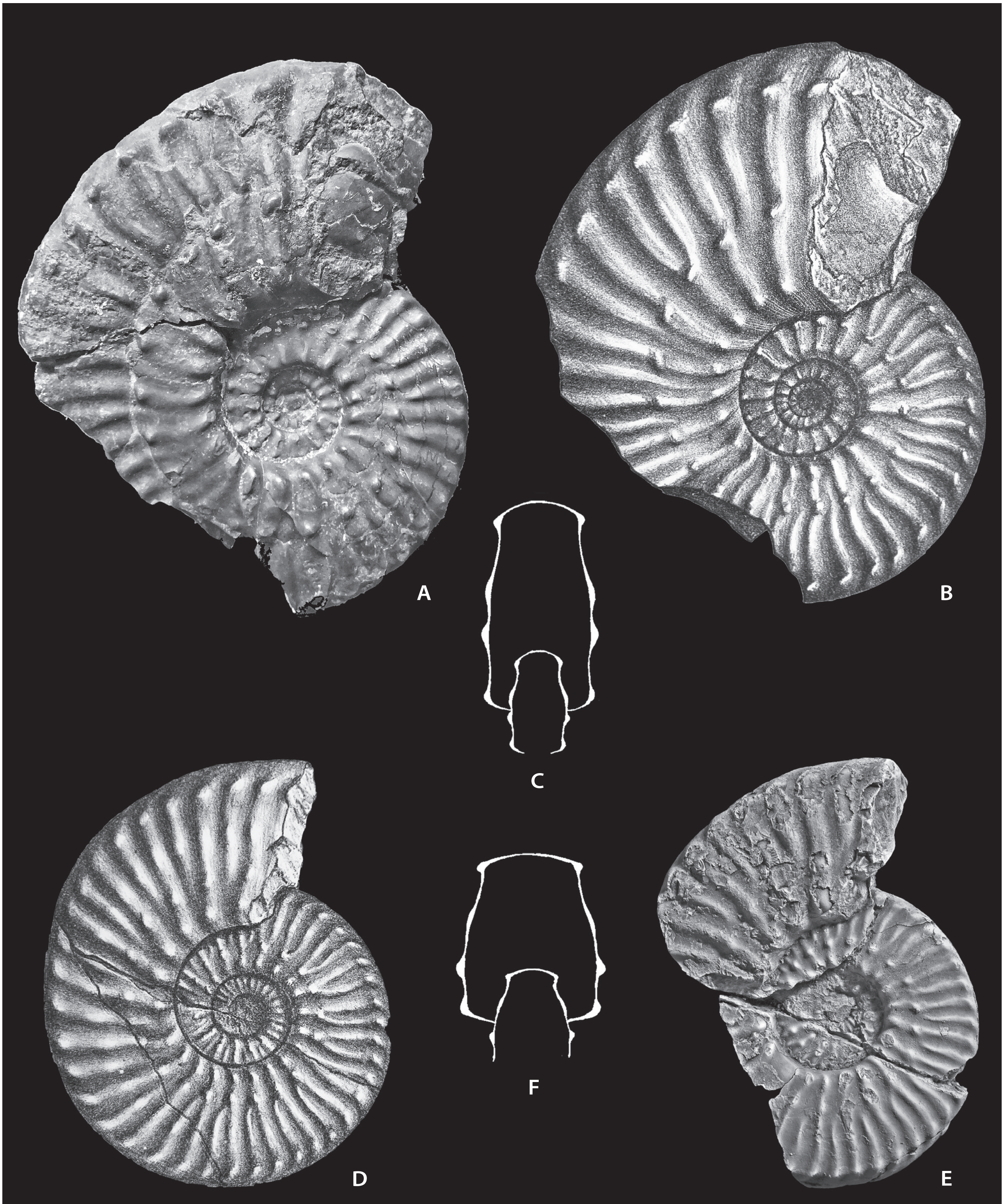

Figure 3. A – original of *B. mojsvari* (Arthaber, 1896) from the Reifling Limestone near Großreifling (Austrian Alps), deposited at the Geologische Bundesanstalt Wien (collection number 1896/001/0027/1). B – original illustration of *B. mojsvari* in Arthaber (1896, pl. 4, fig. 6a). C – whorl section of *B. mojsvari*, taken from Arthaber (1896, pl. 4, fig. 6c). D – original illustration of *B. reiflingensis* in Arthaber (1896, pl. 5, fig. 3a). E – original of *B. reiflingensis* (Arthaber, 1896) from the Reifling Limestone near Großreifling (Austrian Alps), deposited in the collections of the Palaeontological Institute, University Vienna (reg. no. 4-24). F – whorl section of *B. reiflingensis*, taken from Arthaber (1896, pl. 5, fig. 3b). All natural size.

ventrolateral tubercle. Equally strong are the ribs linking the umbilical with the inner lateral tubercle, which is the most prominent of the tubercles. A swelling of the ribs in an outer lateral position occurs sometimes, indicating the occurrence of an irregular quadrituberculation. A further, poorly preserved specimen representing this morphotype exists in the collection of the BMNH (C30980 from the Mali Durmitor Mountains, Montenegro).

In BMNH C30977 (Mali Durmitor Mountains, Montenegro; Fig. 4D–F), only the last part of the subevolute whorl is preserved (UWI: 0.35, wh/d: 0.39; Fig. 6, Tab.1). Preservation is, as in the type, different on the left (Fig. 4D) and the right side (Fig. 4E), and the first shows a more delicate ornament than the second. Weak to feeble (almost absent) ribs link from bullate umbilicolateral to inner lateral tubercles. There, ornament strengthens abruptly to form sigmoidal ribs, which terminate in oblique ventrolateral clavi (*ca*. 20/half whorl). At the position of the inner lateral tubercles, secondaries intercalate, bifurcation is not observed. Weak outer lateral bullae occur sporadically, confirming a latent occurrence of quadrituberculation at a certain ontogenetic stage. At the last part of the preserved whorls, the umbilical tubercles disappear. On the right side, ornament consists of thick rectiradiate ribs, broadening towards the ventrolateral tubercle. Umbilical and inner lateral tubercles are poorly visible, and outer lateral bullae are well-developed on some ribs. This ornament seems to represent details of the outer shell. Where the recrystallized shell broke away, such as in the terminal part of the conch, the same delicate ribbing like on the right side occurs (Fig. 4E), lacking also umbilical tubercles. BMNH C30977 is slightly compressed (WWI: 0.80) and comparably inflated like the type specimen (WWI: 0.81, Tab. 1). It lacks, however, the shallow fastigate shape of the venter, which is broadly rounded and smooth here (Fig. 4F).

Specimen BMNH C30979 is a subevolute (wh/d: 0.34) fragment of moderate size (d: 51 mm) and represents a strongly ribbed variant with sigmoidal ribs (Fig. 4G). Both umbilical and inner lateral tubercles are well-developed on some ribs, while faint outer lateral, bullate swellings are poorly developed or preserved, respectively. A similar morphotype is BMNH C74501 from the Schreyer Alp in Austria (Fig. 4H), in which, however, ribbing dominates apparently over tuberculation. This may also be a preservation effect: Where the recrystallized shell brakes off, umbilicolateral and inner lateral tubercles become visible.

Specimen BMNH C30978 (Mali Durmitor Mountains, Montenegro, not figured) is a fragment, representing half a whorl of a moderately involute conch, and only the right side is preserved. The original shell is substituted by calcite. Strong main ribs from umbilicolateral tubercles link to a row of inner lateral tubercles. At this level, almost equally strong secondaries arise by bifurcation or intercalation, terminating in *ca*. 20 ventrolateral tubercles/half whorl. A row of outer lateral tubercles is well-developed and particularly good visible on the internal (composite) mould, where parts of the recrystallized shell broke off.

The suture lines of *B. multinodosus* (Hauer 1892, pl. 3, fig. 1c), *B. mojsvari* (Arthaber 1896, pl. 4, fig. 6d) and *B. reiflingensis* (Arthaber 1896, pl. 5, fig. 3c) consist of a broad E with a small, acute internal saddle, a deep A without incisions at the neck and two to three small auxiliary lobes, significantly smaller than A. The suture line of a specimen from the original suite of Hauer (Arthaber 1896, pl. 4, fig. 7b) shows a U with an internal acute saddle, an incised deep A and two shallower incised auxiliary lobes on the flank. In total, 3 saddles are visible on the flank and a fourth is presumably located on the umbilical wall. In BMNH C20327 (Fig. 4C), U is not visible. The adventive lobe A – incised at the bottom – is deeper than the succeeding two auxiliary lobes. Three saddles occur on the flank, and it seems that a fourth might have been present at the umbilical wall.

In Figure 6, we plotted the ratio wh/d of the various species of *Bulogites*, considering also literature data (comp. Tab. 1). It shows variable values, and no clear trends can be extracted. In particular, the wh/d ratio of smaller specimens of *B. reiflingensis* (measurements of Assereto 1963) form a diffuse cloud (Fig. 6, Tab. 1). The dimensions of the specimen described by Turina (1912) fits to that of other specimens identified as *B. multinodosus* (comp. Tab. 1). It appears, however, that taxa described as *B. mojsvari* (green circles in Fig. 6) show larger wh/d ratios and lower UWI than *B. multinodosus* (red circles in Fig. 6), indicating that they are more involute. In particular, the specimens from the USA (Nevada) show extreme values (wh/d: 0.50, 0.47, 0.43; Fig. 6, Tab. 1). There is an overlap of *multinodosus* and *reiflingensis* (blue circle in Fig. 6). For comparison, we included also *B. sondershusanus* (black circles in Fig. 6; comp. "Discussion"), which shows low values that appear, in fact, to be located a bit outside the cloud of the other values. However, the overall low number of measurements demands a careful interpretation of the values, and more data are required.

Discussion. – When describing *B. multinodosus*, Hauer (1892) mentioned a cast of an ammonoid from Großreifling (Austria), sent to him by Arthaber, which, in his (Hauer)

Figure 4. *Bulogites multinodosus* (Hauer, 1892). A–C – BMNH C20327 from the Volujak Mountains (Bosnia and Herzegovina. D–F – BMNH C30977 from the Mali Durmitor Mountains (Montenegro). G – BMNH C30979 from the Mali Durmitor Mountains (Montenegro). H – BMNH C74501 from the Schreyer Alp (Austrian Alps). All natural size.


A
B
C
F
D
E
G
H

opinion, was his *Ceratites multinodosus*. Arthaber (1896, p. 51) had a different view and erected his species *C. mojsvari*: "*C. multinodosus ist bei geringerer Grösse evoluter, hat stärker abgeflachten Externtheil, breitere Windungen, höhere und kräftigere Rippen, welche zwischen Lateral- und Marginalknoten fast zu einer vierten Knotenreihe anschwellen, und hat die Verbindung zwischen Umbilical- und Lateralknoten stets deutlich entwickelt. Die Lobenlinie zeigt eher eine spitzbogige Entwicklung der Sättel, die Berührungslinie derselben ist radial und geradlinig verlaufend und zeigt nicht die grosse Höhendifferenz zwischen Extern- und ersten Lateralsattel, wie bei C. Mojsvari.*" [*C. multinodosus* is more evolute at smaller size, has a stronger flattened external part, broader whorls, higher and stronger ribs, which swell almost to a fourth row of tubercles between the lateral and marginal tubercle, and the link between the umbilical and lateral tubercle is always well-developed]. However, judging from the large similarity of the types of *B. multinodosus* (Fig. 2) and *B. mojsvari* (Fig. 3A, B), the morphological differences recognized by Arthaber (1896) reflect, in our view, merely morphological variations within one species. The measurement of conch parameters (Tab. 1) shows that Arthaber (1896) correctly recognized the differences in the degree of evolution between *multinodosus* and *mojsvari*, but, again, this is considered to be variation, which, in our view, does not justify the distinction of two species. There exists also a fourth row of (bullate) tubercles in an outer lateral position in *B. mojsvari* (also documented by Arthaber 1896; Fig. 3C), why we agree with Hauer (1892) in regarding *B. mojsvari* (Arthaber) as a synonym of *B. multinodosus* (Hauer). The tuberculation consisting of strong umbilical, inner lateral and ventrolateral tubercles and weak outer lateral bullate swellings is also visible in the fragment figured by Airaghi (1905, pl. 8, fig. 7). We also include *C. reiflingensis* Arthaber, 1896 (Fig. 3D–F), *Ceratites pseudovindelicus* Arthaber, 1896, pl. 5, fig. 4 and *Ceratites reiflingensis* var. *exiguus* Arthaber, 1896, pl. 5, fig. 5 (refigured by Assereto (1965, pl. 5, fig. 2) into *B. multinodosus*, which were already lumped – in our view correctly – together with *B. mojsvari* by Assereto (1971, p. 44): "*Die Stücke, die Arthaber (1896) bezeichnete als Ceratites mojsvari (Taf. 4, Fig. 6), C. reiflingensis (Taf. 5, Fig. 3), C. reiflingensis var. exigua (Taf. 5, Fig. 5), C. anceps (Taf. 5, Fig. 2) und C. pseudovindelicus (Taf. 5, Fig. 4) sind durch Übergänge verbunden und sollten deshalb meiner Meinung nach in einer Art vereinigt werden*." [The specimens, which Arthaber (1896) refers to as *Ceratites mojsvari* (pl. 4, fig. 6), *C. reiflingensis* (pl. 5, fig. 3), *C. reiflingensis* var. *exigua* (pl. 5, fig. 5), *C. anceps* (pl. 5, fig. 2) and *C. pseudovindelicus* (pl. 5, fig. 4) are linked by transitions and they should, in my opinion, united in one species."]. Specimen BMNH C30977 (Fig. 4D–F) can morphologically also be included into that group. A set of more coarsely ornamented specimens of *B. multinodosus* were figured by Vörös (2003 pl. a-vi, figs 5–8) as *B. mojsvari*, which link morphologically to the robust conchs of BMHH C20327 (Fig. 4A–C), BMHH C30979 (Fig. 4G) and BMHH C74519 (Fig. 4H). The ribbing of a specimen from Cividate (Italy), identified as *Ceratites mojsvari* and figured by Riedel (1949) could also fall into this group. However, as the venter is not figured, we remain careful with this interpretation. The variability is not only expressed by the mode of ornamentation but also by the shape of the venter, showing a gradual shift from shallow fastigate (*B.* "*mojsvari*") to rounded (*B.* "*reiflingensis*") to broadly rounded (BMNH C30977, Fig. 4F).

Alma (1926) lists *Ceratites* cf. *Reiflingensis* var. *exigua* Arth. from the Höttinger Alpe near Innsbruck, Bukowski (1895) mentioned *Ceratites cfr. C. Mojsvari Arthaber* from south Dalmatia (Croatia) and Renz (1931a, b) records *Ceratites reiflingensis* Arth. from Hydra (Greece), but, lacking descriptions and figures, these records must be regarded as uncertain.

The quality of the figure of *B. multinodosus* in Salopek (1918, pl. 1, fig. 2) is a bit poor. Although conch parameter fall in the variation of *B. multinodosus* (Tab. 1), the specimen seems to deviate from *B. multinodosus* and from *Bulogites* in general by the mode of ribbing (strong, straight main and secondary ribs in the last quarter of the preserved whorl) and tuberculation (four rows of almost equally strong tubercles). We therefore prefer to exclude the specimen from *Bulogites*.

Bulogites sondershusanus (Picard, 1892) remains problematical. The holotype (Fig. 6D) shows very strong ribbing, a quadrituberculated stage in the first interval of the last whorl, then a trituberculated final stage. The venter is broad and smoothly rounded (Fig. 6E). *Ceratites mirabilis* Assmann, 1937 (Fig. 6A, B) was included into *Bulogites sondershusanus* by Hagdorn (2020). We follow this view and regard "*C. mirabilis*" as a variation, in which ribbing dominates over tuberculation. The venter is extremely broad and almost sub-planulate. In the Assmann collection (BGR Berlin/Spandau), we found the mould of an ammonite, which shows a similar mode of ribbing like in "*C. mirabilis*" (X13357, Fig. 6C). We relate it tentatively to *B. sondershusanus*. Due to the overall very coarse mode of ribbing, the lack of any sigmoidal elements in ribbing and the lowest wh/d ratio, we tend to interpret *B. sondershusanus* as a separate species for the moment. So far, there exist three specimens only, but it may well be possible that some more material can be discovered in the Assmann collection, which is currently investigated by us. Riedel (1949, pl. 2, fig. 7) figures a fragment from Monte Rite, Italy, as *B. sondershusanus*. However, the mode of ribbing does not fit the type, and we would exclude it from *B. sondershusanus*. Whether or not the fragment can be

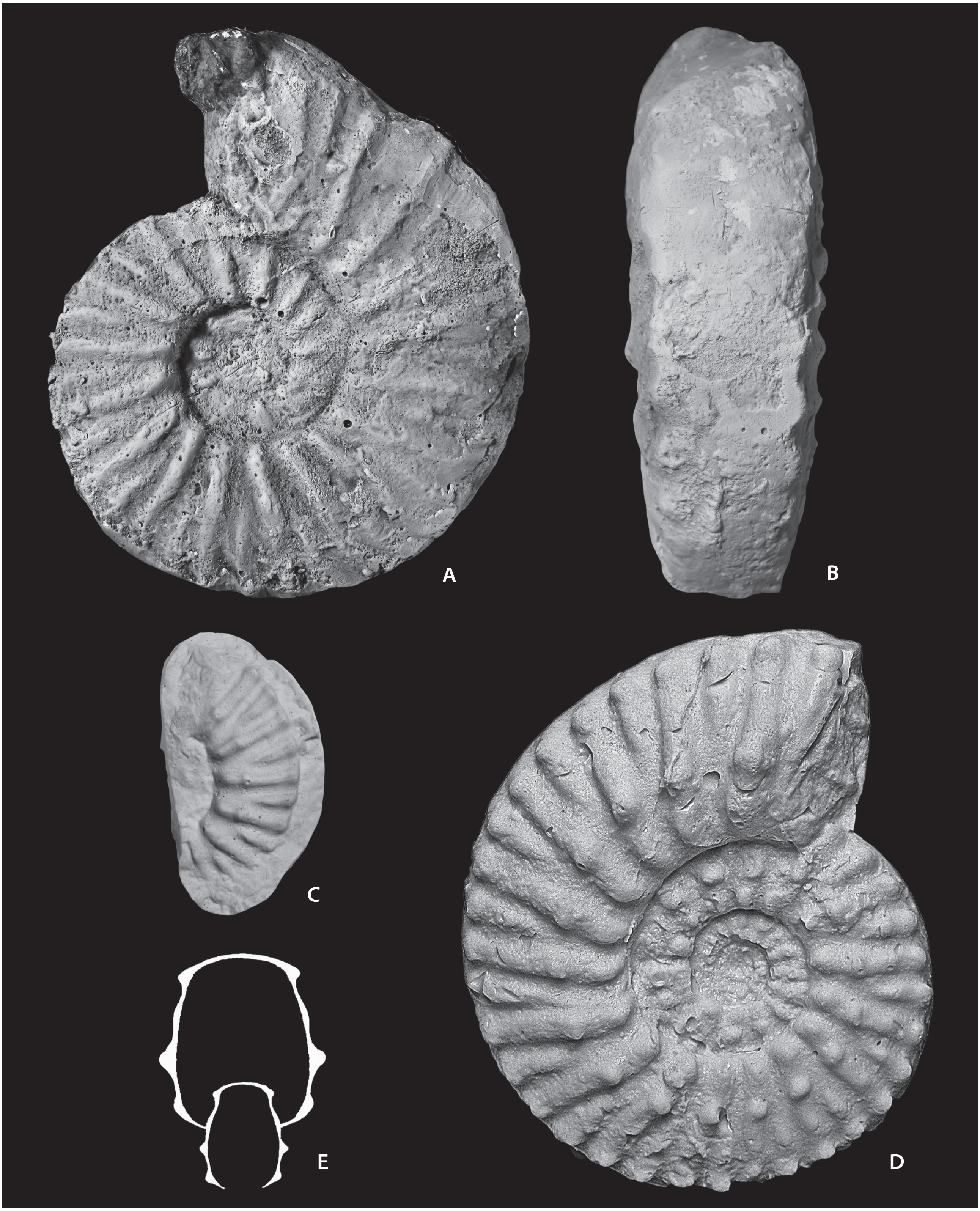

Figure 5. A, B – X3430 1-3, the holotype of *Ceratites mirabilis* Assmann, 1937, pl. 21, fig. 3 from the Lower Muschelkalk Subgroup of Silesia (Poland), included in *B*. *sondershusanus* (Picard, 1892) here (cast from the original mould). C – *B*. *sondershusanus* (Picard, 1892) from the Lower Muschelkalk of Silesia, Poland (Assmann collection, X 13357). D – X05636, the holotype of *Balatonites sondershusanus* Picard, 1892, pl. 24, fig. 1-4, 8 from the Lower Muschelkalk Subgroup of Thuringia (Germany) (cast from the original mould). E – whorl section of the holotype of *B*. *sondershusanus* as figured in Arthaber (1896, pl. 5, fig. 1b). All natural size.

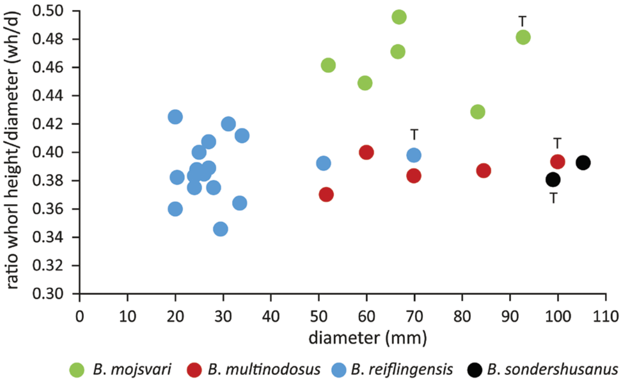

Figure 6. Ratio wh/d plotted against diameter in *Bulogites* (comp. Tab. 1). Abbreviation: T – type specimen.

related to *Bulogites* at all is hard to judge from the figure, which lacks details of the venter.

Bulogites zoldianus (Mojsisovics, 1882) differs from *B. multinodosus* by the dominance of ribbing over tuberculation, weak umbilicolateral tubercles and by its stronger prorsiradiate ribbing. Its inferred trituberculation (see discussion in Vörös 2003) is not always straight forward: Siegel *et al*. (2022, fig. 16) described and figured a specimen of *B. zoldianus* from Rüdersdorf (Germany) with weak outer lateral bullae.

Ceratites anceps Arthaber, 1896 was included in *Bulogites* by Assereto (1963). Its ornament is characterized by strong umbilical tubercles and sporadic inner lateral tubercles. Bifurcation of strong ribs can occur at least in the youngest whorls at the umbilical tubercle, and up to three intercalated ribs occur in the lower third of the flank. The venter is not figured. As the mode of ornament deviates from that of all other *Bulogites*, we currently regard it as a separate species – contrasting Assereto (1971). Assereto (1963, pl. 3, fig. 4) figured the presumed holotype, which is the original of Arthaber (1896, pl. 5 fig. 2) from Großreifling (Austria), housed in the Palaeontological Institute of the University of Vienna. Because Arthaber (1896) clearly mentioned more than one specimen of his new species in his original description, and a type was not established, a lectotype needs to be designated. We, therefore, designate *Ceratites anceps* Arthaber 1896, pl. 5, fig. 2 as the lectotype and keep *B. anceps* – with some doubt – as a separate species for the moment.

Specimens identified as *B. mojsvari* from Nevada (Monnet & Bucher 2005, Jenks *et al.* 2007) resemble the type of *B. multinodosus*, but they differ by a significantly higher wh/d ratio (0.43–0.50 *versus* 0.39; Fig. 6, Tab. 1). In addition, not all secondaries terminate in a ventrolateral clavus, and no outer lateral row of tubercles occur. The ornament seems to be much weaker, showing also secondaries, arising sometimes below the inner lateral tubercle. These differences could merely reflect the morphology of a local species.

Bulogites multicostatus Wang, 1965 *in* Zhao *et al.* (1965) differs from *B. multinodosus* by its trituberculation and the marked broadening of the ribs towards the ventrolateral clavi (see comments in Stiller & Bucher 2008).

Occurrence. – Well-documented *B. multinodosus* (described and figured) are recorded from the *zoldianus* Subzone (*balatonicus* Zone, Fig. 1) of Hungary, the Austrian and Italian Alps, Bosnia and Herzegovina and Montenegro. In the USA, it occurs in the terminal *Balatonites shoshonensis* Zone (Monnet & Bucher 2005).

Conclusions

Our main conclusions can be summarized as follows:

1) We interpret variations from more smoothly to coarsely ornamented morphotypes as variability within one species. This relates also to the variable shape of the venter and the degree of evolution. We, therefore, regard *B. mojsvari*, *B. reiflingensis*, *B. reiflingensis* var. *exigua* and *B. pseudovindelicus* as synonyms of *B. multinodosus*.

2) *Bulogites multinodosus* is characterized by a quadrituberculated stage in some phase of its ontogeny, although the outer lateral bullae are often reduced to weak swellings, which then can be rather felt than seen.

3) We regard *B. gosaviensis*, *B. multicostatus*, *B. zoldianus* and, with some doubt, *B. anceps* as further valid species.

4) We follow Hagdorn (2020) in regarding *B. mirabilis* as a synonym of *B. sondershusanus*.

5) For the moment, we tend to keep *B. sondershusanus* as a separate species.

6) The specimens from Nevada differ from European faunas by the higher wh/d ratios and differences in ornamentation, which are regarded to represent a morphological expression of a local fauna.

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