

The occurrence of *Hemihaploceras schwageri* (Neumayr, 1873) in the Upper Jurassic (Kimmeridgian, Beckeri Zone) of SW Germany and its stratigraphical significance

Armin SCHERZINGER¹, István FÖZY², Günter SCHWEIGERT³

Key words: Kimmeridgian, Submediterranean Province, ammonites, biostratigraphy, correlation.

Abstract. The presence of the Tethyan ammonite species *Hemihaploceras schwageri* (Neumayr, 1873) is reported from the upper Kimmeridgian Obere-Felsenkalke Formation in the Upper Jurassic of SW Germany. The oppeliid genus *Hemihaploceras* Spath, 1925 occurs in two ammonite assemblages of the Beckeri Zone. The first one lies in the *kiderleni* Biohorizon within the Subeumela Subzone. The other one represents the herein newly introduced *schwageri* Biohorizon of the basal Setatum Subzone. Both ammonite assemblages comprises a mixture of Mediterranean and Submediterranean taxa accompanied by very rare taxa of Subboreal origin. The phyletic relationships between *H. schwageri* and other species included in *Hemihaploceras* are discussed.

INTRODUCTION

After more than a hundred years of intensive collecting and study of the ammonite fauna and stratigraphy of the Upper Jurassic Beckeri Zone in SW Germany, a significant collection of ammonites has accumulated. Besides the classical locality of Grabenstettener Steige in the middle part of the Swabian Alb, one of the most relevant outcrops for sampling upper Kimmeridgian ammonites in Swabia is the Kolbinger Steige section. This section is exposed along the road connecting the town of Mühlheim a. d. Donau with the village of Kolbingen, about two kilometres north of the Danube Valley. The sections studied herein are not far away from the Kolbinger Steige (Fig. 1). The lithostratigraphy and parts of the ammonite faunas of the Kolbinger Steige

section were studied previously by Berckhemer (1922), Berckhemer, Rebholz (1926), Roll (1931), Bubeck (1933), Aldinger (1945), Ziegler (1955, 1958, 1959, 1962), Berckhemer, Hölder (1959), Seeger (1961), Höroldt (1964), Schweigert (1994), Schweigert *et al.* (1996), and Schweigert, Zeiss (1999). These studies focussed on the rather common and often well-preserved ammonites of the Upper Jurassic Untere-Felsenkalke, Obere-Felsenkalke and Liegende-Bankkalke formations.

Berckhemer, Hölder (1959: 77, pl. 16, fig. 74; see below) reported a single strikingly evolute taramelliceratid, SMNS 19490, as *Hemihaploceras nobile* (Neumayr, 1873). It was said to originate from beds tentatively assigned to the Subeumela Subzone of Herrlingen–Lautern near Ulm. This specimen was re-studied and is now determined as *Hemihaploceras*

¹ Maurenstraße 26, 78194 Immendingen-Hattingen, Germany; armin.scherzinger@t-online.de.

² MTA-MTM-ELTE Research Group for Paleontology, 1431 Budapest, Pf. 137, Hungary; semiformiceras@gmail.com.

³ Staatliches Museum für Naturkunde, Rosenstein 1, 70191 Stuttgart, Germany; guenter.schweigert@smns-bw.de.

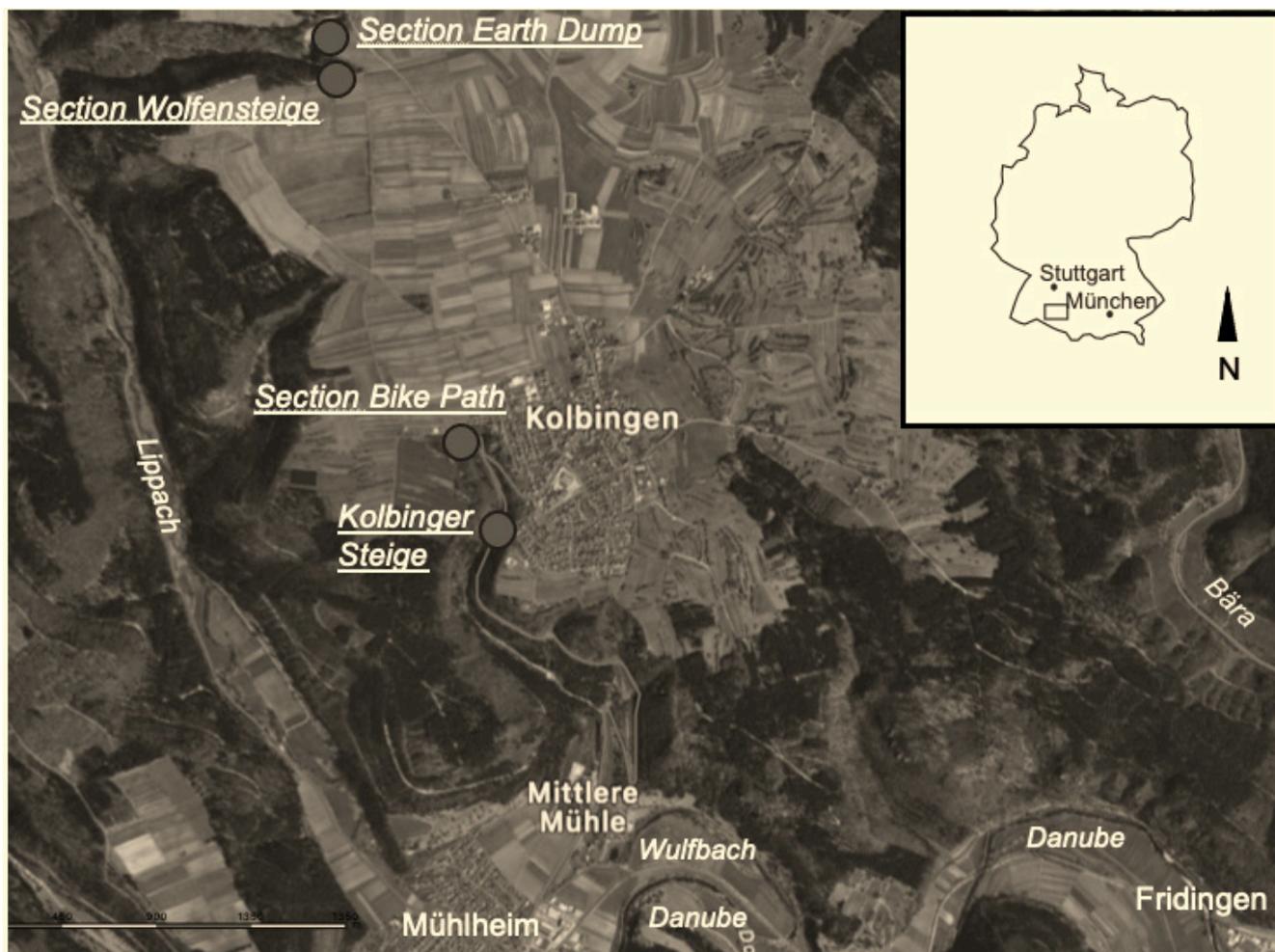


Fig. 1. Studied Upper Kimmeridgian localities in the vicinity of Kolbingen, SW Germany

schwageri (Neumayr, 1873). According to the lithology and light yellowish colour of the rock matrix, its stratigraphical position is located in the lowermost Setatum Subzone.

One of us (A.S.) collected one additional specimen, herein described as *?Hemihaploceras* sp. [m] from the *kiderleni* Biohorizon of the Subeumela Subzone of the Kolbinger Steige (Fig. 1).

In a higher bed of the Obere-Felsenkalke Formation, just below the bed with the *supinum* Biohorizon of the Setatum Subzone (see below), we recognised in three sections near the village of Kolbingen (see Fig. 1) a previously unknown ammonite fauna, which we publish herein as an assemblage characteristic of the *schwageri* Biohorizon. Surprisingly, beside numerous *Virgatixioceras* n. sp. and some oppeliids and aspidoceratids we found several specimens of the Mediterranean ammonite species *Hemihaploceras schwageri* (Neumayr, 1873) (see below). From another locality near the village of Storzingen, SW Swabian Alb, we found two

additional specimens of this rare species in the same stratigraphic level (see below).

The aim of this study is to describe this new material and to discuss its phyletic relationships and palaeobiogeographic implication. In this context, it became necessary to reconsider the type material of *Oppelia schwageri* and closely related taxa introduced by Neumayr (1873), including *Oppelia nobilis*, the type species of *Hemihaploceras* Spath, 1925, from the upper Kimmeridgian of present-day Romania.

MATERIAL AND METHODS

The ammonites from southern Germany described herein were collected by the first author (A.S.) during numerous visits to the sections near Kolbingen and Storzingen over the last decades (Fig. 1). The specimens were prepared mechanically with fine pneumatic chisels and needles. This newly

studied material is housed in the collection of the Staatliches Museum für Naturkunde Stuttgart, Germany (acronym: SMNS). Studied material for comparison is housed in the GeoSphere Austria, Vienna (acronym: GS), Geological Museum of the former Hungarian Geological Institute (today part of the SZTFH, Budapest, Hungary (acronym: GM) and Piobbico and Apecchio museums, Italy.

Abbreviations. [M] = Macroconch (female); [m] = microconch (male); d = diameter; wh = whorl height; ww = whorl width; uw = umbilical width.

AMMONITE FAUNA OF THE *KIDERLENI* BIOHORIZON

The *kiderleni* Biohorizon (Fig. 2) of the upper Kimmeridgian Beckeri Zone, Subeumela Subzone, was briefly introduced by Schweigert *et al.* (1996). It is founded on a rather diverse ammonite assemblage sampled from sections at Grabenstettener Steige, Gerhausen, Blaustein–Herrlingen, Lenningen–Schopfloch, Kolbinger Steige and Möhringer Tunnel near Immendingen, all located in the area of the Swabian Alb (Berckhemer, Hölder, 1959; Schweigert, 1992). This ammonite assemblage comprises a mixture of Mediterranean and Submediterranean taxa accompanied by a few very rare taxa of Subboreal origin. This seems to result from a sea-level highstand during the early Beckeri Zone, Subeumela Subzone, allowing an easy faunal exchange between palaeobiogeographically far distant areas. Moreover, during this interval, terrigenous influx was extremely low thus lead-

ing to the purest limestones occurring during the Beckeri Zone of Swabia and Franconia as a climatic response to coeval high sea-level (Leinfelder, 1993). The *kiderleni* Biohorizon is the type horizon of *Taramelliceras kiderleni* Berckhemer, Hölder, 1959.

Ammonites of the *kiderleni* Biohorizon: *Physodoceras hermanni* (Berckhemer, 1922) [M], *Sutneria subeumela* (Schneid, 1915) [m], *Taramelliceras acallopistum* (Fontannes, 1879) [M], *Taramelliceras kiderleni* Berckhemer, Hölder, 1959 [M], *Taramelliceras pugile* (Neumayr, 1873) [M], *?Hemihaploceras* (“*Lingulaticeras*”) sp. [m], *Lingulaticeras* sp. [m], *Oxyoppelia* sp. [M], *Hybonotoceras pressulum* (Neumayr, 1873) [M], *Hybonotoceras* cf. *beckeri* (Neumayr, 1873) [M], *Hybonotella attenuatum* Berckhemer, Hölder, 1959 [m], *Virgataxioceras* n. sp. A [M+m], *Aulacostephanus contejeani* (Thurmann in Thurmann, Etallon, 1861) [M], *Aulacostephanus undorae* (Pavlov, 1886) [m].

Records of the *kiderleni* Biohorizon: Middle Swabian Alb (Grabenstetten, Gerhausen, Blaustein–Herrlingen, Lenningen–Schopfloch), Western Swabian Alb (Kolbingen, Möhringer Tunnel near Immendingen). In all studied sections, the position of the *kiderleni* Biohorizon is sandwiched between the *pedinopleura* and *subsidents* biohorizons of the Subeumela Subzone (see Fig. 2). The typical rock type is a bright white limestone.

AMMONITE FAUNA OF THE *SCHWAGERI* BIOHORIZON

The *schwageri* Biohorizon of the upper Kimmeridgian Beckeri Zone, Setatum Subzone, is introduced herein (Figs. 2–4). It is based on an ammonite assemblage recorded in three sections near Kolbingen and Storzigen in W Swabia (Fig. 1). Ammonites from the vicinity of Kolbingen were reported by Berckhemer, Hölder (1959) and several other authors (see information above). As is the case with the *kiderleni* Biohorizon, the *schwageri* Biohorizon comprises ammonite taxa of Mediterranean and Submediterranean origin, but those of Subboreal origin are missing. This seems again the result of relatively high sea-level during the middle part of the Beckeri Zone.

Ammonites of the *schwageri* Biohorizon: *Virgataxioceras* n. sp. B [M+m], *Hemihaploceras schwageri* (Neumayr, 1873) [M], *Hemihaploceras* (“*Lingulaticeras*”) cf. *tenuifalcatum* (Neumayr, 1873) [m], *Taramelliceras pugile* (Neumayr, 1873) [M], *Oxyoppelia* sp. [M], *Physodoceras* sp. [M].

Records of the *schwageri* Biohorizon: SW Swabian Alb (Kolbingen, Storzigen). In the studied sections at Kolbingen, the ammonite assemblage of the *schwageri* Biohori-

Stage	Substage	Zone	Subzone	Horizon
Kimmeridgian	Upper Kimmeridgian	Beckeri	Ulmense	<i>rebouletianum</i>
				<i>hoelderi</i>
				<i>zio-wepferi</i> β
				<i>zio-wepferi</i> α
			Setatum	<i>siliceus</i>
				<i>uracensis</i>
				<i>ornatum</i>
				<i>supinum</i>
				<i>schwageri</i>
				<i>minutum</i>
			Subeumela	<i>fischeri</i>
				<i>subsidents</i>
				<i>kiderleni</i>
				<i>pedinopleura</i>

Fig. 2. Chronostratigraphy and ammonite biohorizons of the interval Subeumela to basal Ulmense subzones in Southern Germany, with indication of the position of *Hemihaploceras schwageri*

Succession of biohorizons modified after Schweigert (2007, 2015)

zon originates from a 215 to 220 cm-thick white-yellowish limestone bed. Above this limestone bed and another 10–15 cm-thick bed of limestone there follows a 52 cm-thick, brown-yellowish limestone bed that contains the ammonite assemblage of the *supinum* Biohorizon. The latter is dominated by *Virgataxioceras supinum* (Schneid, 1915) and *Oxyoppelia pseudopolitula* (Berckhemer, 1922). Below the limestone bed with the *schwageri* Biohorizon and two unfossiliferous limestone beds of 2.5–8.0 cm and 19.0–23.0 cm thickness, respectively, we have recorded *Oxyoppelia fischeri* (Berckhemer, 1922) from a bed which is over 180 cm in thickness.

In the Grabenstettener Steige section (Berckhemer, Hölder, 1959: fig. 1, p. 12) there exists an equivalent limestone bed, there 280 cm in thickness and lacking ammonites according to these authors. Above this bed these authors reported *Virgataxioceras supinum* (Schneid) and *Oxyoppelia* sp. Below this thick bed is the occurrence of the *minutum* Biohorizon (*Virgataxioceras minutum* (Berckhemer, 1922)) and the next bed below represents the biohorizon of *Oxyoppelia fischeri* (Berckhemer, 1922).

In the section 1 km E of Storzingen the interval from the *fischeri* Biohorizon up to the *zio-wepferi* Biohorizon α (Sub-eumela, Setatum and basal Ulmense subzones) is represented by thick-bedded to massive limestones where it is hard to follow individual beds laterally. In the lowest part of this section, just above the occurrence of *Oxyoppelia fischeri* (Berckhemer, 1922), we found the remains of two ammo-

nites – *Hemihaploceras schwageri* (Neumayr, 1873) and *Hemihaploceras* (“*Lingulaticeras*”) cf. *tenuifalcatum* (Neumayr, 1873).

The combination of a large-sized new species of *Virgataxioceras*, *Oxyoppelia* sp., *Hemihaploceras schwageri* (Neumayr) and *Hemihaploceras* (“*Lingulaticeras*”) cf. *tenuifalcatum* (Neumayr) is unique for Late Jurassic ammonite faunas in Swabia, for the *schwageri* Biohorizon.

The study of phyletic lineages within age-diagnostic ammonite genera in Swabia, especially those of *Hybonotoceras*, *Virgataxioceras* and *Physodoceras/Sutneria* has helped to test and refine the stratigraphic concept, which finally has led to the recognition of a detailed succession of biohorizons (Fig. 2.).

SYSTEMATIC PALAEOLOGY

Order Ammonitida Haeckel, 1866

Suborder Ammonitina Hyatt, 1889

Family Oppeliidae H. Douvillé, 1890

Genus *Hemihaploceras* Spath, 1925

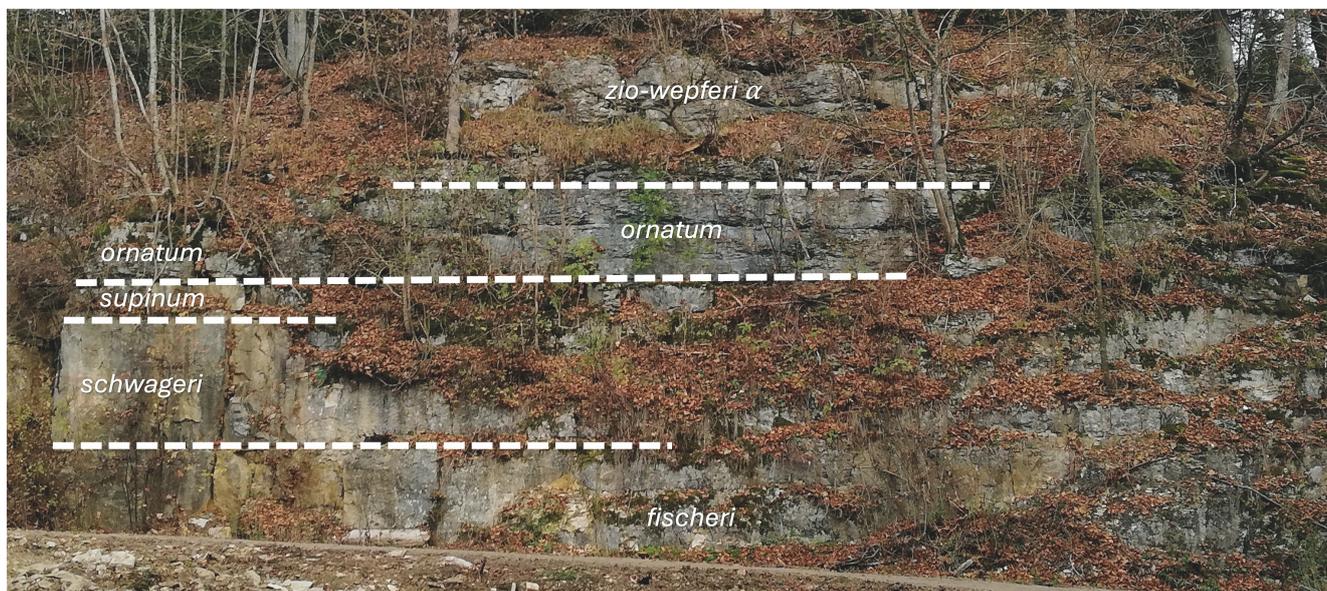


Fig. 3. An outcrop, 1.6 kilometres NW of Kolbingen (exposed in the N direction)

The wall exposes the lowest part of the Liegende-Bankkalke Formation and the upper part of the Obere-Felsenkalke Formation containing the *schwageri* Biohorizon. Photo by A.S. 2024

***Hemihaploceras schwageri* (Neumayr, 1873)**

Figs. 5A–G, 6C

1873. *Oppelia schwageri* nov. sp. – Neumayr: 168, pl. 33, fig. 5
 1878. *Haploceras Fialar* Opper – Herbich: 147, pl. 4, fig. 3a–c
 1879. *Oppelia nobilis*, Neumayr – Fontannes: 46, pl. 7, figs. 3, 4
 1916. *Oppelia Łóczyi* n. sp. – Jekelius, p. 271, pl. 4, fig. 9, 10
 1959. *Taramelliceras (Hemihaploceras) nobile* (Neumayr) – Berckhemer, Hölder: 77, pl. 16, fig. 74
 1977. *Hemihaploceras nobile* (Neumayr, 1873) – Sapunov: 69, fig. 1, pl. 6, fig. 4
 1978. *Taramelliceras (Taramelliceras?) schwageri* (Neum.) – Olóriz: 98, pl. 7, fig. 1
 1979. *Hemihaploceras nobile* (Neumayr, 1873) – Sapunov: 59, pl. 13, figs. 1–4
 1993. *Hemihaploceras (Zittelliceras) schwageri* (Neumayr, 1873) – Sarti: 68, pl. 4, fig. 5
 1994. *Taramelliceras (Hemihaploceras) nobile* (Neumayr 1873) – Schlegelmilch: 156, pl. 11, fig. 7
 2011. *Hemihaploceras schwageri* (Neumayr, 1873) – Fözy *et al.*: pl. 1, figs. 2.5, 2.6
 2022. *Hemihaploceras nobile* (Neumayr) – Fözy *et al.*: pl. 11, figs. 1a, b

Diagnosis. See Neumayr (1873: 168).

Microconchs corresponding to *Hemihaploceras schwageri* (Neumayr, 1873) are present in the *schwageri* Biohorizon as “*Lingulaticeras*” cf. *tenuifalcatum* (Neumayr, 1873).

Description. The most complete specimen of our newly collected material (SMNS 70744/1, Fig. 5A, B) is a three-dimensionally preserved mould of a macroconch without peristome preserved up to a diameter of 51.5 mm. The innermost whorls up to the beginning of the last whorl are smooth. At the beginning of the outer whorl, fine, retroradiate ribs are discernible. On the outer whorl, a tuberculate venter is visible, and approximately at the beginning of the body-chamber, the first coarse tubercles appear near the ventral shoulders. The latest stage corresponds well with a macroconchiate body-chamber fragment from the same bed and locality (SMNS 70744/2, Fig. 5H). Its venter is ornamented with elongate tubercles. In a macroconchiate specimen, two-thirds of the ammonite shell are preserved (SMNS 70744/4, Fig. 6C), but parts of the outer whorl became lost before burial. It shows the smooth inner whorls of the phragmocone and the following stage consisting of retrocostate ribs. A small-sized, more involute specimen, adult microconch (SMNS 70744/3, Fig. 6A) shows smooth innermost whorls and fine, retroradiate ribs on the outer whorl. The body-chamber comprises the last half whorl; however, the aperture is not preserved.

From the locality Storzigen we report a juvenile, completely smooth, evolute macroconch with the body-chamber

comprising little less than half a whorl (SMNS 70446/1, Fig. 6H). A second unfigured specimen (SMNS 70746/2) from the same locality represents a fragmentary body-chamber with a falcooid ribbing and a densely tuberculated venter.

From the *kiderleni* Biohorizon of the Kolbinger Steige section, a very evolute, almost smooth-shelled specimen is preserved with one third of the outer whorl belonging to the body-chamber (SMNS 70745, Fig. 6B). In the latest preserved stage, the onset of weak falcooid ribbing is discernible. We consider this specimen most likely being a microconchiate *Hemihaploceras*.

Comparisons. Unfortunately, the monotypic holotype of *Oppelia schwageri* Neumayr, 1873, pl. 33, fig. 5 could not be traced in the collection of the former Geologische Bundesanstalt in Vienna, now GeoSphere Austria, and must be considered lost (personal com. Davide Di Franco to G.S., 2024). Neumayr (1873, p. 168) reported the presence of smooth inner whorls followed by a fine-ribbed intermediate stage.

In our material any sculpture is missing on the innermost whorls and the shell looks smooth. On the last two whorls fine, retroradiate ribs are visible. This ribbing style strongly resembles that of *Lingulaticeras tenuifalcatum* (Neumayr, 1873) and *L. semicostatum* (Berckhemer in Hölder, Ziegler, 1959). The latter may represent the microconch partner of

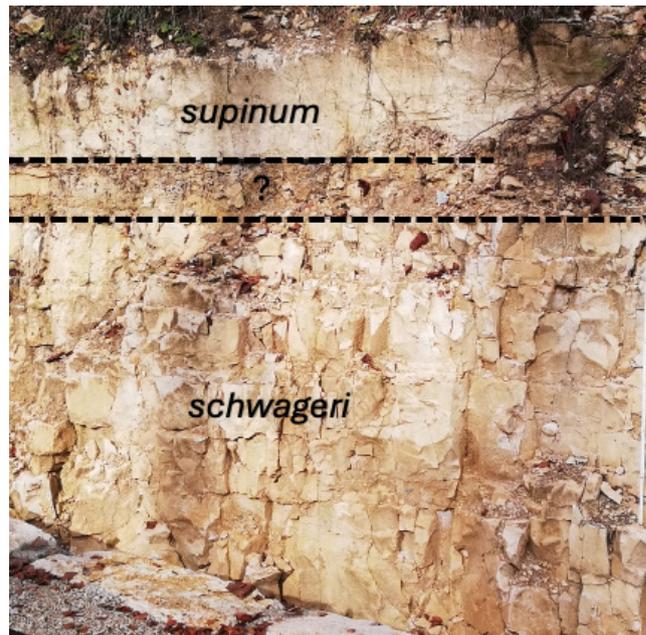


Fig. 4. Outcrop wall, 0.1 kilometres W of Kolbinger (exposed in the N direction)

The wall exposes the pure micritic limestones of the Obere-Felsenkalk Formation. The thick limestone bed contains the *schwageri* Biohorizon; the thicker limestone bed above at the top contains the *supinum* Biohorizon. Photo by A.S. 2024

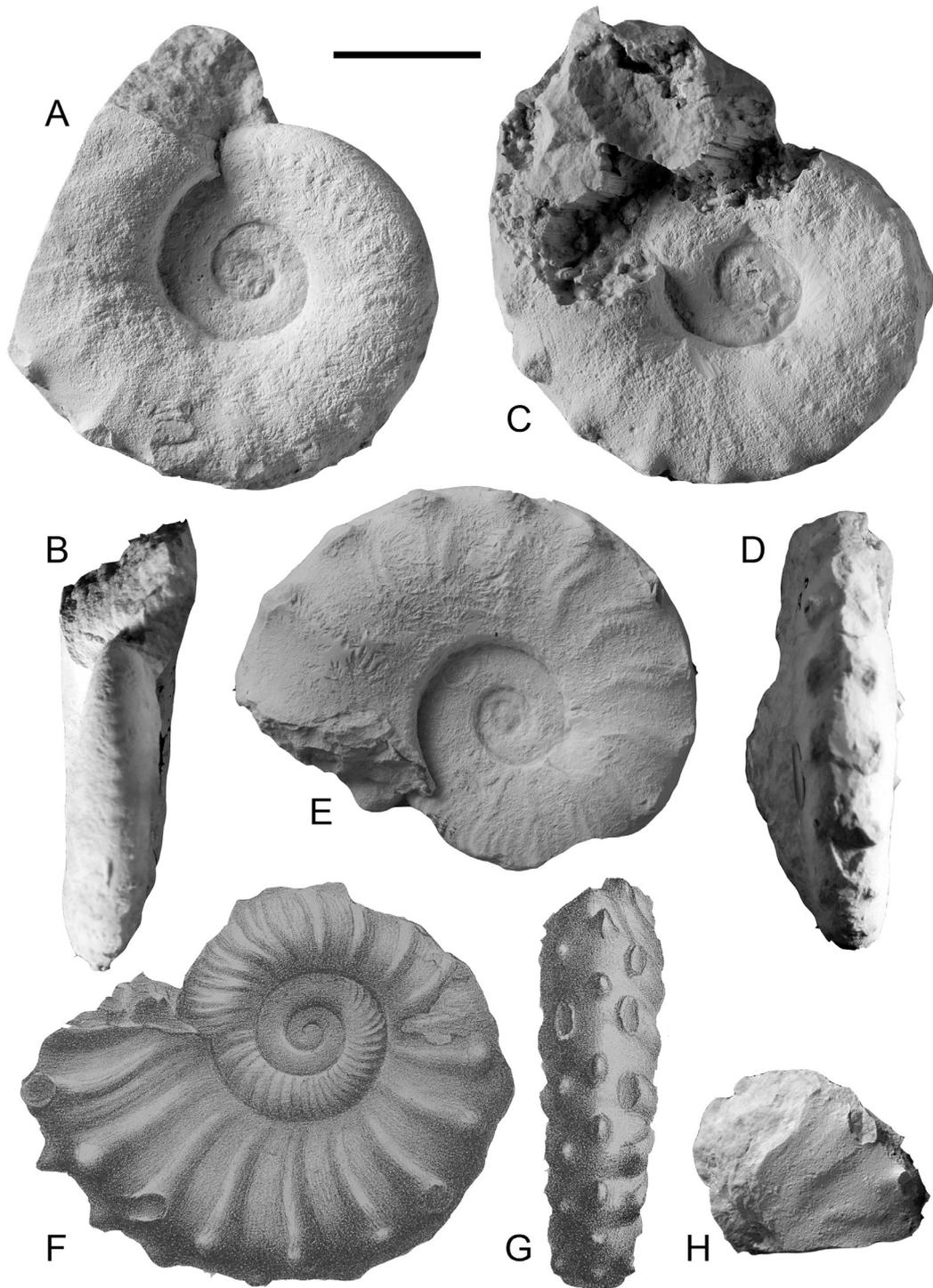


Fig. 5A, B, H. *Hemihaploceras schwageri* (Neumayr), SMNS 70744/1, 70744/2, Kolbingen, *schwageri* Hz., Beckeri Z., Setatum Subz. An adult macroconch with body-chamber in lateral (A) and ventral (B) views, and a fragment (H). **C, D.** *Hemihaploceras schwageri* (Neumayr), SMNS 19493, leg. Bracher; original by Berckhemer, Hölder (1959, p. 77, pl. 16, fig. 74), Herrlingen-Lautern, Beckeri Z., Setatum Subz. An adult macroconch in lateral (C) and ventral (D) views. **E.** *Hemihaploceras schwageri* (Neumayr), SZTFH: J988, original by Jekelius, 1916, *Oppelia Lóczyi*, p. 271, pl. 4, fig. 9, Bucegi Mountains, Poltiza, Romania, macroconch in lateral view. **F, G.** *Hemihaploceras schwageri* (Neumayr), original by Neumayr, 1873, *Oppelia Schwageri*, p. 167, pl. 33, fig. 5a, b, Gyilkos-kő, Romania, specimen lost, macroconch in lateral (F) and ventral (G) views. Scale bar: 20 mm

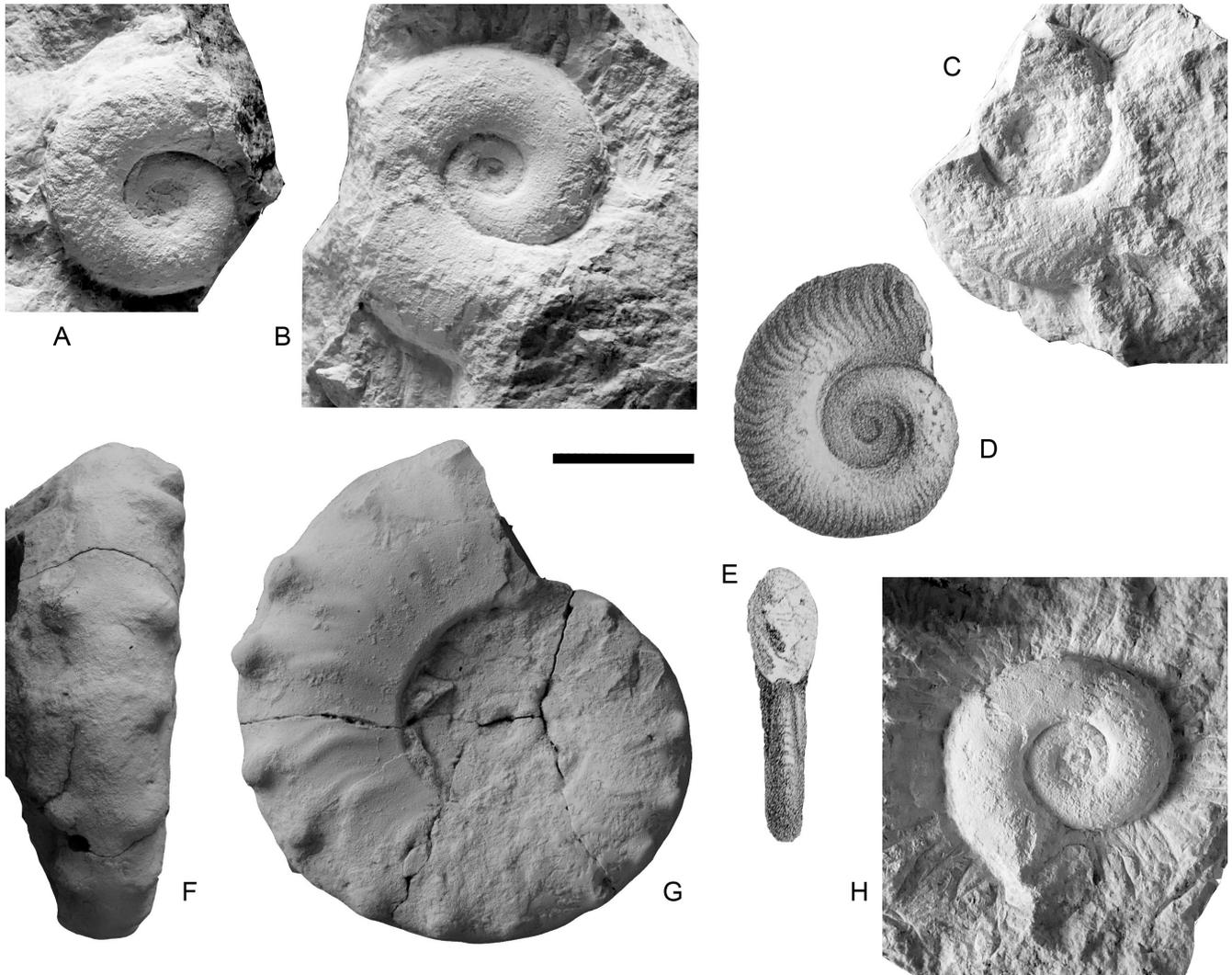


Fig. 6A. *Hemihaploceras* (“*Lingulaticeras*”) cf. *tenuifalcatum* (Neumayr), SMNS 70744/3, Kolbingen, *schwageri* Hz., Beckeri Z., Setatum Subz. An incomplete microconch in lateral view. **B.** ?*Hemihaploceras* (“*Lingulaticeras*”) sp. [m], SMNS 70745, Kolbingen, *kiderleni* Hz., Beckeri Z., Subeumela Subz. Incomplete microconch in lateral view. **C.** *Hemihaploceras schwageri* (Neumayr), SMNS 70744/4, Kolbingen, *schwageri* Hz., Beckeri Z., Setatum Subz. An incomplete macroconch in lateral view. **D, E.** *Hemihaploceras* (“*Lingulaticeras*”) *tenuifalcatum* (Neumayr), [m], original by Neumayr, 1873, *Oppelia tenuifalcatum*, p. 162, pl. 31, fig. 6a, b, Gyilkos-kő, Romania, microconch in lateral (D) and ventral (E) views. **F, G.** *Hemihaploceras nobile* (Neumayr), SZTFH: J997 original by Neumayr, 1873, *Oppelia nobilis*, p. 167, pl. 32, fig. 3a, b, Gyilkos-kő, Romania, macroconch in lateral (F) and ventral (G) views. **H.** *Hemihaploceras schwageri* (Neumayr), SMNS 70746/1, Storzingen, *schwageri* Hz., Beckeri Z., Setatum Subz. A juvenile macroconch in lateral view. Scale bar: 20 mm

late representatives of *Taramelliceras* ex gr. *platyconcha* (Gemmellaro, 1872) from the *semicostatum* α , β and γ biohorizons in the upper Pseudomutabilis Zone of S Germany (Scherzinger *et al.*, 2016). On the outer whorl, a regular finely tuberculate venter is visible. At the beginning of the body-chamber, the first tubercles near the ventral shoulders appear. The tubercles both on the venter and on the ventral shoulders become very coarse towards the peristome. The smooth shell on the innermost whorls and the coarse tubercles on the body-chamber fit well with the illustration provided by Neumayr (1873).

In our opinion *Oppelia loczyi* Jekelius, 1916 is a junior subjective synonym of *Oppelia schwageri* Neumayr, 1873. Both taxa exhibit exactly the same ontogenetic development of ornamentation (inner whorls smooth, fine ribs on the intermediate stage, typical coarse-ribbed ornamentation on the outer whorl and body-chamber plus tubercles on the venter).

Hemihaploceras nobile (Neumayr, 1873) seems smooth on the innermost whorls according to the specimen SZTFH: J.997, Budapest (Fig. 6G and Neumayr, 1873, pl. 32, fig. 2. Neumayr (1873, p. 168) reported seven specimens of *Oppelia nobilis*. Among these syntypes, Neumayr reported the

fragment of a big-sized specimen with tubercles occurring on the adult venter. This observation would confirm the late appearance of tubercles also on the venter and not only on the ventrolateral shoulders. Herbich (1878) reported additional specimens of *Oppelia nobilis* from the type locality, unfortunately, this material was never figured.

Occurrences. Upper Kimmeridgian of SW Germany, Beckeri Zone, Setatum Subzone, *schwageri* Hz. (data published herein), Beckeri Zone of Ardèche Mts, SE France (Fontannes, 1879), Carpathian Mts of Romania (Neumayr, 1873; Jekelius, 1916), Betic Cordillera of S Spain (Olóriz, 1978), Bulgaria (Sapunov, 1979), Venetian Alps of Italy (Sarti, 1993); middle part of the Beckeri Zone, Hungary (Főzy *et al.*, 2011, 2022).

DISCUSSION

In our studies we have distinguished in Swabia two different populations of *Hemihaploceras* and its dimorphic partner “*Lingulaticeras*” cf. *tenuifalcatum* (Neumayr) in two biohorizons of the Beckeri Zone, Setatum and Subeumela subzones. However, on the basis of the available specimens we cannot distinguish the two *Hemihaploceras* populations on a species level. The presence of a Mediterranean ?*Hemihaploceras* sp. in the *kiderleni* Biohorizon and the co-occurrence of the Subboreal taxa *Aulacostephanus contejeani* (Thurmann in Thurmann, Etallon, 1861) and *Aulacostephanus undorae* Pavlow, 1886 (= *A. plataulax* Buckman, 1925) allows a precise correlation between the lower part of the Beckeri Zone in the Mediterranean and Submediterranean provinces and the upper Eudoxus Zone in the Subboreal Province of S England and W France (Baier, Schweigert, 2001; Schweigert, Vallon, 2005).

Material collected bed-by-bed from other Kimmeridgian deposits in Europe and N Africa is scarce. *Hemihaploceras nobile* is reported from the Cavouri Zone of Spain, the Lessinian Alps of Italy, Hungary, and Carpathians of Romania (e.g., Olóriz, 1978; Benetti, Pezzoni, 1983; Főzy, 1989, 1990; Főzy *et al.*, 2011; Grigore, 2021). In S Germany, there is no record of *Hemihaploceras* in the Pseudomutabilis Zone, which corresponds approximately to the Cavouri Zone of the Mediterranean Province (Scherzinger *et al.*, 2016). The ammonite fauna of the *pedinopleura* Biohorizon in SW Germany is still very incomplete in records of significant ammonite species because of the scarcity of fossiliferous outcrops and the lack of new samples in Swabia (e.g., Seeger, 1961).

Favre (1877) figured a few years after Neumayr’s monograph a *Hemihaploceras nobile* from the Swiss Alps. More information about the stratigraphic level of this specimen was not given.

All figured records of *Hemihaploceras* from Bulgaria (Sapunov, 1977, 1979; Metodiev, 2018) are from the Beckeri Zone (Subeumela – Setatum subzones, Sapunov, 1977: 69, fig. 1). In our opinion all specimens figured in Sapunov (1977, pl. 6, fig. 4; 1979, pl. 13, figs. 1–4) represent *Hemihaploceras schwageri*. The incomplete ammonite figured by Metodiev (2018, fig. 1c, d) could be *Hemihaploceras nobile* because of its more evolute innermost whorls and the higher, more involute body-chamber in comparison with *Hemihaploceras schwageri*.

Olóriz (1978: 98–99, 117–119) reported *Hemihaploceras schwageri* (as *Taramelliceras* (?*Taramelliceras*) *schwageri*) from the Beckeri Zone and *Hemihaploceras nobile* from the Cavouri and Beckeri zones of Spain, Subbetic Cordillera.

Sarti (1988: 468) noted *Hemihaploceras nobile* from the Beckeri/Pressulum Zone of the Venetian Alps, Northern Italy.

Cecca *et al.* (1990: fig. 55) listed *Hemihaploceras piccininii* from the Beckeri Zone from Monte Nerone, Central Italy. One of the authors (I.F.) had the opportunity during a visit to study the *Hemihaploceras* specimens stored in the Piobbico and Apecchio museums, Italy. Among the ammonites we identified also *Hemihaploceras schwageri*.

Di Bucci *et al.* (1994: 84) listed *Hemihaploceras nobile* from the Beckeri Zone of Monte Scoccioni – Castelletta, Appenins, Italy.

Főzy (1995: 136, pl. 21, fig. 1) illustrated *Hemihaploceras nobile* from the Late Kimmeridgian of Seno di Guidaloca, Sicily.

Benzaggagh, Atrops (1997: 137, fig. 6, pl. 3, fig. 1) figured from the Beckeri Zone of the Rif, Morocco *Hemihaploceras nobile*.

Dumitrica *et al.* (1997: 172) cited *Hemihaploceras* from Peles Valley, near the town Sinaia, Bucegi Massif, at the southern end of the Eastern Carpathians, Romania.

Zeiss *et al.* (2003) reported a fragmentary specimen of *Hemihaploceras nobile* (Neumayr, 1873) from Jurassic beds of Japan. The age of this specimen was determined with the help of a co-occurring ammonite then identified as a macroconchiate “*Virgataxioceras* sp.”. The latter is very close to undescribed early representatives of *Subplanites* Spath, 1925 collected from Jurassic limestones of Ethiopia. These large-sized microconchiate forms co-occur with *Hybonoticeras knopi* (Neumayr, 1873), which is an age-diagnostic species of the lowermost Beckeri Zone. In conclusion, *Hemihaploceras nobile* (Neumayr, 1873) ranges from the Cavouri Zone to the lowermost Beckeri Zone.

Khudoley (2004: 51) erroneously reported *Hemihaploceras* from the Tithonian of Morocco.

Mandl *et al.* (2010) listed *Hemihaploceras nobile*, associated with *Sowerbyceras loryi* (Munier-Chalmas in Hébert, 1875), “*Haploceras*” *jungens* (Neumayr, 1873) and *Sutneria*

cf. *eumela* (d'Orbigny, 1847) from the same bed of a micritic limestone (bed number 7) in a section of the Salzkammergut area, Austria.

Fözy *et al.* (2011: 415, table 1; fig. 2.5, 2.6) reported *Hemihaploceras schwageri* from bed 68, Beckeri Zone, Lokut section, Bakony Mountains, Transdanubian Range, Hungary, associated with *Hemihaploceras nobile* in the same bed.

Reháková *et al.* (2011, p. 73, pl. 7, fig. 6) recorded the evidence of an incomplete *Hemihaploceras* from the Pieniny Klippen Belt, Carpathians, Western Ukraine. This find indicates an Upper Kimmeridgian age, either corresponding to the highest part of the Cavouri Zone or the Beckeri Zone. The innermost whorls are not visible, thus hampering a more precise determination.

Bujtor *et al.* (2021, pl. 6, figs. E1, E2) figured a fragmentary *Hemihaploceras* from Hungary, Mecsek Mountains. This ammonite collected from the scree could be a body-chamber fragment of *Hemihaploceras nobile*.

Grigore (2011, fig. 9; 2021: fig. 2) listed *Hemihaploceras nobile* from the Cavouri and lowest Beckeri zones, *Hemihaploceras schwageri* from the top of the Cavouri and the lower part of the Beckeri zones, as well as *Hemihaploceras loczyi* from the middle part of the Beckeri Zone of the Haghimas Mountains, Eastern Carpathians, Romania. On his pl. 2, figs. 3 and 4 the author figured two ammonites as *Hemihaploceras nobile* from the Acanthicum and Eudoxus zones of Ghilcos (North Ghilcos), Haghimas Mountains, Eastern Carpathians, Romania. We have some doubts about whether these ammonites belong to *Hemihaploceras*. The specimen illustrated on his pl. 2, fig. 3 could be an evolute *Lingulaticeras* and the specimen on pl. 2, fig. 4 represents a fragmentary *Taramelliceras*. Both genera are abundant in the Acanthicum, Pseudomutabilis and Cavouri zones of the Submediterranean and Mediterranean Province. This author also figured a crushed specimen (pl. 2, fig. 5a, b) of *Hemihaploceras schwageri* as *Hemihaploceras loczyi* from the Beckeri Zone of the same locality. According to his fig. 2, this ammonite was collected from the middle part of the Beckeri Zone, more or less in a similar position to the *schwageri* Biohorizon in Swabia. It seems the originals of *Hemihaploceras nobile*, published by Neumayr (1873) could originate from the lower part of the Beckeri Zone in Ghilcos at the type locality. Unfortunately, Grigore did not illustrate any material from the base of the Beckeri Zone.

Grigore (2019, pl. 1, fig. 14) assigned a fragmentary ammonite from the Beckeri Zone of Ghilcos to *Lingulaticeras semicostatum* Berckhemer in Hölder, Ziegler, 1959. It is more involute than true *Lingulaticeras semicostatum*. This ammonite either is an inner whorl of *Hemihaploceras schwageri* (Neumayr, 1873) or its supposed microconch *Hemihaploceras* (“*Lingulaticeras*”) *tenuifalcatum* (Neu-

mayr, 1873). Such a specimen was figured by Fontannes (1879, pl. 7, fig. 4) from Crussol, SE France; also the sculpture at the beginning of the outer whorl of another specimen on the same plate in the same paper (Fontannes, 1879, pl. 7, fig. 3) is very similar. In SE France and SW Germany, *Lingulaticeras semicostatum* is abundant in the higher part of the Pseudomutabilis Zone (Hölder, Ziegler, 1959; Scherzinger *et al.*, 2016) but absent in the Beckeri Zone.

The ammonite figured in Schneid (1915, pl. 6, fig. 10) does not belong to *Hemihaploceras nobile*, but is a fragmentary *Taramelliceras pugile* (Neumayr, 1873).

CONCLUSIONS

According to the original description by Neumayr (1873: 168), *Oppelia nobilis*, the type species of *Hemihaploceras* Spath, 1925, shows a line of elongate mid-ventral tubercles plus tubercles at the ventrolateral ends of the protruding ribs. This feature was said to be typical of *Zittelicer* Santantonio, 1983 and used to distinguish between *Hemihaploceras s. str.* and *Zittelicer*. Because of the presence of ventral tubercles in both taxa, the types of which are placed within a single phyletic lineage, we treat them synonymous. Confusing are in this respect are the remarks by Cecca *et al.* (1985: 31): “The Beckeri-zone shows great development of Taramelliceratinae with evolute shells, such as *Taramelliceras (T.) pugiloides* (Canavari) and *Hemihaploceras (Zittelicer) piccininii* (Zittel), both of which lack the ventral row of tubercles (Santantonio, 1983)”.

In our opinion there exists a phylogenetic line: first *Hemihaploceras nobile* (Neumayr, 1873), top of the Cavouri Zone, Mediterranean Province; additional *Hemihaploceras nobile* (Neumayr, 1873) in the lower part of the Beckeri Zone; and finally *Hemihaploceras schwageri* (Neumayr, 1873), middle part of the Beckeri Zone. Part of this lineage seems also to contain *Hemihaploceras piccininii* (Zittel, 1869). We disagree with Santantonio (1983) that the ancestor of *Hemihaploceras schwageri* (Neumayr, 1873) is *Taramelliceras pugile* (Neumayr, 1873). Both ammonites, *Hemihaploceras s. str.* and *Taramelliceras pugile* coexist in the Beckeri Zone of Swabia and Bulgaria.

Acknowledgements. We thank Dr. Davide Di Franco, Vienna, for valuable information about type specimens housed in the GeoSphere Austria collection. The paper benefited from the helpful suggestions of the reviewers, Lubomir Metodiev, Sofia, Bulgaria and Carlo Sarti, Bologna, Italy, and from linguistic improvements by John Wright (London). This is a Paleo contribution no. 440 of HUNREN–MTM–ELTE Research Group for Paleontology.

REFERENCES

- ALDINGER H., 1945 – Zur Stratigraphie des Weißen Jura δ in Württemberg. *Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereins, Neue Folge*, **31**: 111–152.
- BAIER J., SCHWEIGERT G., 2001 – Zum Vorkommen von *Aulacostephanus yo* (d’Orbigny) im Schwäbischen Jura (Ober-Kimmeridgium, SW-Deutschland). *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, **3**: 184–192.
- BENETTI A., PEZZONI N., 1983 – Paleontologia. Ammoniti del Malm della Lessinia Centrale (Oxfordiano medio-superiore, Kimmeridgiano e Titoniano inferiore (Proposta di una zonazione ed elenco di alcune specie). *Bollettino del Museo Civico di Storia Naturale di Verona*, **10**: 3.
- BENZAGGAGH M., ATROPS F., 1997 – Stratigraphie et association de faune d’ammonites des zones du Kimméridgien, Tithonien et Berriasien basal dans le Prérif interne (Rif, Maroc). *Newsletter Stratigraphy*, **35**, 3: 127–163.
- BERCKHEMER F., 1922 – Beschreibung wenig bekannter und neuer Ammonitenformen aus dem oberen Weißen Jura Württembergs. *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*, **78**: 68–79.
- BERCKHEMER F., HÖLDER H., 1959 – Ammoniten aus dem Oberen Weißen Jura Süddeutschlands. *Beihefte zum Geologischen Jahrbuch*, **35**: 135.
- BERCKHEMER F., REBHOLZ E., 1926 – Kolbinger Steige. Exkursionsbericht vom 19.08.1926. *Zeitschrift der Deutschen Geologischen Gesellschaft*, **78**: 247–249.
- BUBECK W., 1933 – Stratigraphie und Tektonik bei Fridingen und Mühlheim im Donautal. *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*, **89**: 1–64.
- BUCKMAN S.S., 1925 – Type Ammonites, VI. Wheldon & Wesley, London.
- BUJTOR L., ALBRECHT R., FARKAS C.S., MAKÓ B., MARÓTI D., MIKLÓSY Á., 2021 – Kimmeridgian and early Tithonian cephalopods from the Kisújbánya Limestone Formation, Zengővárkony (Mecsek Mountains, southern Hungary), their faunal composition, palaeobiogeographic affinities, and taphonomic character. *Carnets de Géologie*, **21**: 265–314.
- CECCA F., CRESTA S., PALLINI G., SANTANTONIO M., 1985 – Remarks on the Kimmeridgian – Lower Tithonian ammonite biostratigraphy of two sections in the Central Apennines (Italy). *Newsletter on Stratigraphy*, **15**: 28–36.
- CECCA F., CRESTA S., PALLINI G., SANTANTONIO M., 1990 – Il Giurassico di Monte Nerone (Appennino marchigiano, Italia Centrale): Biostratigrafia, litostratigrafia ed evoluzione paleogeografica. In: Atti II Convegno Internazionale ‘Fossili – Evoluzione – Ambiente’, Pergola, Ottobre, 1987 (Eds. G. Pallini et al.): 63–139.
- DI BUCCI D., FRIELLO P., PALLINI G., SANTANTONIO M., 1994 – Il sistema giurassico di piattaforma carbonatica pelagica/bacino nell’area di M. Scoccioni – Castelletta (Appennino marchigiano). *Palaeopelagos, Special Publication*, **1**: 79–91.
- DOUVILLÉ H., 1890 – Sur la classification des Cératites de la Craie. *Bulletin de la Société Géologique de France, Série 3*, **18**: 275–292.
- DUMITRICA P., BAUMGARTNER P.O., GORCIAN S., 1997 – *Pterotraps* n. gen., a new genus of Jurassic hagiastriidae (radiolaria). *Revue de Micropaléontologie*, **40**: 167–179.
- FAVRE E., 1877 – La Zone à Ammonites acanthicus dans les Alpes de la Suisse et de la Savoie. *Mémoires de la Société Paléontologique Suisse*, **4**, 3: 113.
- FONTANNES F., 1879 – Description des Ammonites des calcaires du Château de Crussol (Ardèche) (Zone à *Oppelia tenuilobata* et *Waagenia beckeri*). Lyon, Paris. F. Savy.
- FÖZY I., 1989 – Felsőjura ammonitesz biosztratigráfia a Bakony hegységben. *Földtani Közlöny, Bulletin of the Hungarian Geological Society*, **119**: 133–156.
- FÖZY I., 1990 – Ammonite succession from the three Upper Jurassic sections in the Bakony Mts. (Hungary). In: Atti II Convegno Internazionale ‘Fossili – Evoluzione – Ambiente’, Pergola, Ottobre, 1987 (Eds. G. Pallini et al.): 323–339.
- FÖZY I., 1995 – Upper Jurassic ammonites from Seno di Guidaloca (Western Sicily). *Hantkeniana*, **1**: 131–143.
- FÖZY I., JANSSEN N.M.M., PRICE G.D., 2011 – High-resolution ammonite, belemnite and stable isotope record from the most complete Upper Jurassic section of the Bakony Mts (Transdanubian Range, Hungary). *Geologica Carpathica*, **62**, 5: 413–433.
- FÖZY I., SCHERZINGER A., SZIVES O., 2022 – Late Jurassic–Early Cretaceous (Kimmeridgian–Barremian) ammonites of the Bakony Mountains (Transdanubian Range, Hungary). In: Fauna, biostratigraphy, facies and paleotectonic evolution of the Late Jurassic–Early Cretaceous formations in the Bakony Mountains (Transdanubian Range, Hungary) (Ed. I. Fözy): 243–360. Institute of Geosciences University of Szeged, Geolitera Publishing House.
- GEMMELLARO G.G., 1872 – Sopra i cefalopodi della Zona con *Aspidoceras acanthicum*, Opp. sp. di Burgilamuni, presso Favara, prov. di Girgenti. *Giornale di Scienze naturali ed economiche*, **8**: 137–159.
- GRIGORE D., 2011 – Kimmeridgian – Lower Tithonian ammonite assemblages from Ghilcos – Haghimas Massif (Eastern Carpathians – Romania). *Acta Palaeontologica Romaniaae*, **7**: 177–189.
- GRIGORE D., 2019 – *Glochiceras* Hyatt (Oppelidae, Ammonoidea) from the Upper Jurassic deposits of the Haghimas Mts. (The Eastern Carpathians – Romania). *Oltenia. Studii si comunicari. Stiintele Naturii*, **35**: 2: 29–36.
- GRIGORE D., 2021 – Species of Taramelliceratinae Spath (*Taramelliceras* and *Hemihaploceras*) from the Upper Jurassic deposits of Haghimas Mts. (The Eastern Carpathians – Romania). *Muzeul Olteniei Craiova. Oltenia. Studii si comunicari. Stiintele Naturii*, **37**: 22–30.
- HAECKEL E., 1866 – Allgemeine Entwicklungsgeschichte der Organismen. Berlin. Reimer.
- HÉBERT E., 1875 – Observations sur le travail de M. Pillet relatif à la colline de Lémenc. *Bulletin de la Société géologique de France*, **3**, 3: 387–388.
- HERBICH F., 1878 – Das Szekerland mit Berücksichtigung der angrenzenden Landesteile, geologisch, und paläontologisch beschrieben. *Mittheilungen aus dem Jahrbuche der königlichen ungarischen Geologischen Anstalt*, **5**, 2: 181.

- HÖLDER H., ZIEGLER B., 1959 – Stratigraphische und faunistische Beziehungen im Weißen Jura (Kimmeridgien) zwischen Süddeutschland und Ardèche. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **108**, 2: 150–214.
- HÖROLDT U., 1964 – Morphologie und Systematik der weißjurassischen Ammoniten-Gattungen *Streblites* und *Ochetoceras* unter besonderer Berücksichtigung des Hohlkiels [Inaugural-Dissertation zur Erlangung des Grades eines Doktors der Naturwissenschaften der Mathematisch-naturwissenschaftlichen Fakultät der Eberhards-Karls-Universität zu Tübingen] [Unpublished PhD thesis].
- HYATT A., 1889 – Genesis of the Arietitidae. *Smithsonian Contributions to Knowledge*, **673**: 1–238.
- JEKELIUS E., 1916 – A Brassói Hegyek Mezozoós Faunája. III–VII. A Brassói Dogger- és Malmfauna. *A Magyar Királyi. Földtani Intézet Évkönyve, Kötet. E. Füzet*, **24**: 98. Budapest.
- KHUDOLEY K.M., 2004 – The Biogeography of the Earth at the end of the Jurassic (Tithonian Age and its equivalents) from the perspectives of fixism and mobilism. *Regional Geology and Metallogeny*, **22**: 39–58 [in Russian].
- LEINFELDER R.R., 1993 – Upper Jurassic reef types and controlling factors. A preliminary report. *Profil*, **5**: 1–45.
- MANDL G.W., DULAI A., SCHLÖGL J., SIBLÍK M., SZABÓ J., SZENTE I., VÖRÖS A., 2010 – First results on stratigraphy and faunal content of the Jurassic between Bad Mitterndorf and Toplitzsee (Salzkammergut, Austria). *Abhandlungen der Geologischen Bundesanstalt*, **65**: 77–134.
- METODIEV L., 2018 – New indication of the *Hyboniticeras beckeri* ammonite Zone (Kimmeridgian) of the Teteven area (Central Fore-Balkan) and its significance. *Review of the Bulgarian Geological Society*, **79**, 3: 97–98.
- NEUMAYR M., 1873 – Die Fauna der Schichten mit *Aspidoceras acanthicum*. *Abhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt*, **5**: 141–257.
- OLÓRIZ F., 1978 – Kimmeridgiano-Tithonico inferior en el sector central de las Cordilleras Béticas (Zona Subbética). *Paleontologia, Bioestratigrafía. Tesis doctorales Universidad Granada*, **184**: 758 pp.
- d'ORBIGNY A., 1847 – Paléontologie française. Description zoologique et géologique de tous les animaux mollusques et rayonnés fossiles de France: comprenant leur application à la reconnaissance des couches. *Terrains Jurassiques. Vol. 1. Paris*
- PAVLOW A.P., 1886 – Les ammonites de la zone à *Aspidoceras acanthicum* de l'est de la Russie. *Mémoires du Comité Géologique*, **2**, 3: 91.
- REHÁKOVÁ D., MATYJÁ A., WIERZBOWSKI A., SCHLÖGL J., KROBICKI M., BARSKI M., 2011 – Stratigraphy and microfacies of the Jurassic and lowermost Cretaceous of the Veliky Kamenets section (Pieniny Klippen Belt, Carpathians, Western Ukraine). *Volumina Jurassica*, **9**: 61–104.
- ROLL A., 1931 – Die Stratigraphie des oberen Malm im Lauchertgebiet (Schwäbische Alb) als Grundlage für tektonische Untersuchungen. *Abhandlungen der Preussischen geologischen Landes-Anstalt, Neue Folge*, **135**: 164.
- SANTANTONIO M., 1983 – Ammoniti rare della famiglia Haploceratidae nel Malm dell'Appennino umbro-marchigiano-sabino. *Geologica Romana*, **22**: 147–155.
- SAPUNOV I., 1977 – Ammonite Stratigraphy of the Upper Jurassic in Bulgaria. III. Kimmeridgian: Substages, Zones and Subzones. *Geologica Balcanica*, **7**, 1: 63–80.
- SAPUNOV I., 1979 – Ammonoidea. Les Fossiles de Bulgarie. III. 3. Jurassique supérieur. Sofia (Acad. Bulg. Sci.).
- SARTI C., 1988 – Biostratigraphic subdivision for the Upper Jurassic of the Venetian Alps (Northern Italy) on the base of ammonites. In: 2nd International Symposium on Jurassic Stratigraphy, Lisboa (Eds. R.B. Rocha, A.F. Soares): 459–476.
- SARTI C., 1993 – Il Kimmeridgiano delle Prealpi Veneto-Trentine: Fauna e biostratigrafia. *Memorie del Museo Civico di Storia naturale di Verona (II Serie), Sezione Scienze della Terra*, **5**: 145.
- SCHERZINGER A., SCHWEIGERT G., FÖZY I., 2016 – First record of the Mediterranean zonal index *Mesosimoceras cavouri* (Gemmellaro, 1872) in the Upper Jurassic (Pseudomutabilis Zone, *semicostatum* γ horizon) of SW Germany and its stratigraphical significance. *Volumina Jurassica*, **14**: 145–154.
- SCHLEGELMILCH R., 1994 – Die Ammoniten des südwestlichen Malm. Stuttgart, Jena, New York. G. Fischer Verlag.
- SCHNEID T., 1915 – Die Geologie der fränkischen Alb zwischen Eichstätt und Neuburg a.D. *Geognostische Jahreshefte*, **27**: 59–172.
- SCHWEIGERT G., 1992 – Ein *Aulacostephanus undorae* (Pavlow) im Oberkimmeridgium Süddeutschlands, mit Bemerkungen zum palökologischen Umfeld. *Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereins, Neue Folge*, **74**: 139–148.
- SCHWEIGERT G., 1994 – Über einige bemerkenswerte Ammoniten im Oberkimmeridgium der Schwäbischen Alb (Südwestdeutschland). *Stuttgarter Beiträge zur Naturkunde, Serie B*, **203**: 15.
- SCHWEIGERT G., 2007 – Ammonite biostratigraphy as a tool for dating Upper Jurassic lithographic limestones from South Germany – first results and open questions. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **245**, 1: 117–125.
- SCHWEIGERT G., 2015 – Biostratigraphie der Plattenkalke der Südlichen Frankenalb. In: Solnhofen – Ein Fenster in die Jurazeit (Eds. G. Arratia et al.): 57–60. München (Pfeil).
- SCHWEIGERT G., VALLON L., 2005 – First record and correlation value of *Aulacostephanus cf. subundorae* (Pavlow) (Ammonoidea, Upper Jurassic) from SW Germany. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, **2**: 65–82.
- SCHWEIGERT G., ZEISS A., 1999 – *Lithoceras ulmense* (Opepel) (Ammonitina) – eine wichtige Leitart des Ober-Kimmeridgiums. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **211**: 49–73.
- SCHWEIGERT G., KRISHNA J., PANDEY B., PATHAK D.B., 1996 – A new approach to the correlation of the Upper Kimmeridgian Beckeri Zone across the Tethyan Sea. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **202**: 345–373.
- SEEGER D., 1961 – Die Delta-Epsilon-Grenzsichten im Schwäbischen Weißen Jura. *Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereins, Neue Folge*, **43**: 49–72.

- SPATH L.F., 1925 – The collection of fossils and rocks from Somaliland made by B.K.W. Wyllie and W.R. Smellie. Part VII. Ammonites and Aptychi. *Monographs of the Geological Department of the Hunterian Museum*, **1**: 111–164.
- THURMANN J., ETALLON A., 1861 – Lethaea bruntrutana, ou études paléontologiques et stratigraphiques sur le Jura bernois, et en particulier sur les environs de Porrentruy. *Neue Denkschriften der allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften*, **18**: 1–145.
- ZEISS A., SCHWEIGERT G., SATO T., YAO A., 2003 – Late Kimmeridgian Ammonites from the Yura Formation of Kii, SW Japan. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, **1**: 1–10.
- ZIEGLER B., 1955 – Die Sedimentation im Malm Delta der Schwäbischen Alb. *Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereins, Neue Folge*, **37**: 29–55.
- ZIEGLER B., 1958 – Die Ammonitenfauna des tieferen Malm Delta in Württemberg. *Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereins, Neue Folge*, **40**: 171–201.
- ZIEGLER B., 1959 – Profile aus dem Weißen Jura delta der Schwäbischen Alb. *Arbeiten aus dem geologisch-paläontologischen Institut der Technischen Hochschule Stuttgart, Neue Folge*, **21**: 1–70.
- ZIEGLER B., 1962 – Die Ammonitengattung *Aulacostephanus* im Oberjura (Taxonomie, Stratigraphie, Biologie). *Palaeontographica, Abteilung A*, **119**: 1–172.
- ZITTEL K.A., 1869 – Geologische Beobachtungen aus den Central-Appenninen. *Benecke's Geognostisch-Paläontologische Beiträge*, **2**: 91–176.