

Lamellaptychi from the Lower Cretaceous of south-east Spain (Murcia and Jaén provinces)

Zdeněk Vašíček, Miguel Company, and Lucie Měchová

With 5 figures

Abstract: This paper presents the results of a study of the aptychi collected from nine Lower Cretaceous sections belonging to the Subbetic Zone in SE Spain. The aptychi were collected together with stratigraphically significant Late Berriasian/Early Valanginian, Late Valanginian and Late Hauterivian ammonites. In this collection of aptychi, 18 species of three genera are identified; three species are new: *Mortilletilamellaptychus undulatiformis* n. sp., *Thorolamellaptychus subangulatus* n. sp., and *Didayilamellaptychus praeangulatus* n. sp.

Key words: Lower Cretaceous, aptychi, ammonite zonation, Betic Cordillera.

1. Introduction

The aim of this paper is the systematic study of aptychi collected from several Lower Cretaceous sections in SE Spain and their stratigraphic position with respect to the current standard ammonite zonation for the Mediterranean area. This contribution is a result of the cooperation between the Institute of Geonics of the Czech Academy of Sciences in Ostrava (Czech Republic) and the Department of Stratigraphy and Palaeontology of the University of Granada (Spain) in the field of biostratigraphic research on the Lower Cretaceous pelagic sediments.

The studied material was collected bed-by-bed in nine Lower Cretaceous sections located in the regions of Caravaca, Cehegín, and Fortuna (Murcia province), and La Guardia (Jaén province) (Fig. 1). All the sections are accurately dated thanks to the occurrence of abundant stratigraphically significant ammonites (e.g., COMPANY 1987; AGUADO et al. 2000; COMPANY et al. 2003; COMPANY & TAVERA 2013).

Among the ca. 50 aptychi collected, only about 3/4 of the valves were determinable due to their state of preservation. All of them are calcitic, ribbed valves that belong, from a systematic point of view, to the family Lamellaptychidae. They correspond to three genera (*Mortilletilamellaptychus*, *Thorolamellaptychus* and *Didayilamellaptychus*) and 18 species, three of which are new (*Mortilletilamellaptychus undulatiformis*, *Thorolamellaptychus subangulatus* and *Didayilamellaptychus praeangulatus*) and four have been only identified with reservation.

The stratigraphic position of the studied aptychi is referred to the ammonite zonation recently proposed by the IUGS Lower Cretaceous Ammonite Working Group, the “Kilian Group” (REBOULET et al. 2014). This study extends the data on Early Cretaceous aptychi from SE Spain previously published by CALZADA & SANTAFÉ (1986) and VAŠÍČEK & HOEDEMEAEKER (1997).

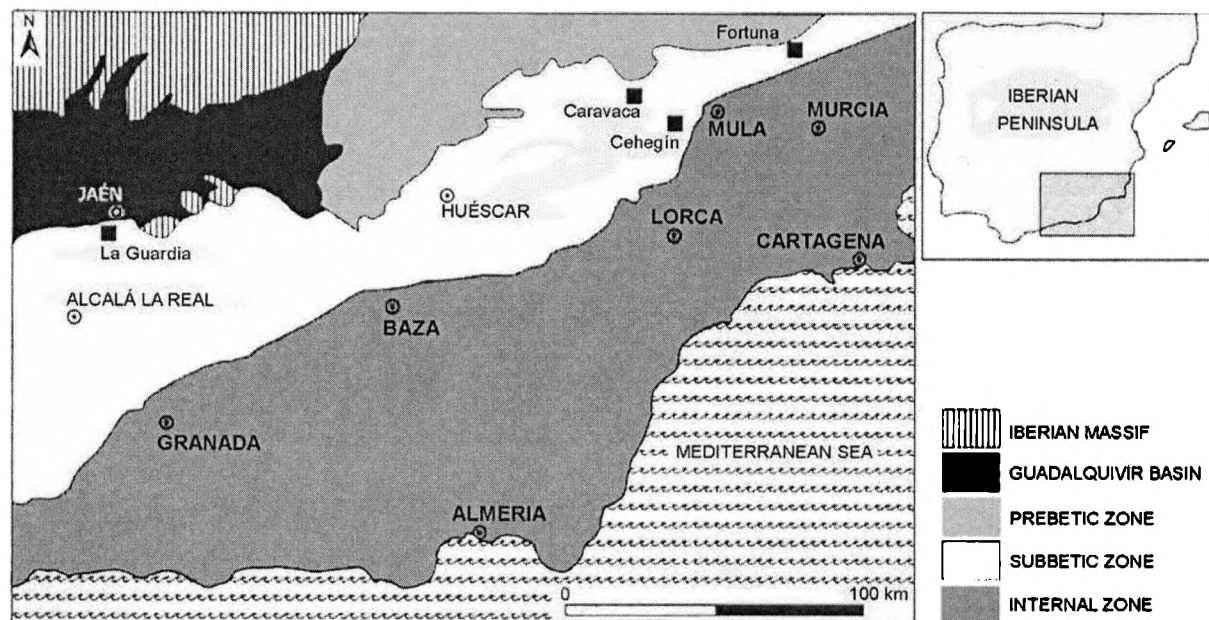


Fig. 1. Generalized geology of the area under study.

2. Geological setting

During the Mesozoic and Paleogene, the external zones of the Betic Cordillera constituted the passive palaeomargin of the Iberian Plate. The proximal part of this margin corresponded to the Prebetic Zone, an epeiric domain extending from a shallow marine platform in the north to more distal, hemipelagic environments to the south, connecting with the Subbetic Zone. The latter was a wide palaeogeographic domain characterized by basinal facies. The morphology of the Subbetic Zone was quite complex, with well-defined troughs and swells caused by an Early Jurassic rifting phase. Thick successions of pelagic sediments were accumulated in the troughs, whereas more reduced and discontinuous sequences were deposited on the structural highs; nevertheless, these differences progressively decreased during the Cretaceous.

All aptychi under study come from Lower Cretaceous sections belonging to the Subbetic Zone. The lithologic successions are always similar in these sections and are composed of marly micritic limestone beds alternating rhythmically with grey marlstone interbeds. Macrofossil remains in these sediments are abundant (mainly ammonites and rare belemnites, bivalves, gastropods, pygopid brachiopods, and irregular echinoids).

3. Aptychi – basic characteristics

Aptychi are calcitic, valvular forms, subtrigonal in shape that constitute pair systems (Fig. 2A, B). Both valves were connected together along the symphysal edge with an organic tissue (ENGESER & KEUPP 2002). In sediments aptychi are usually found as isolated valves.

The issue of the function and taxonomic assignment of aptychi has already been discussed for several centuries. The first publications on this topic date from the beginning of the 18th century (an overview of the oldest sources was provided by TRAUTH 1927). Even at the beginning of the 19th century, it was assumed that the valvular forms of aptychi belonged to bivalves. In light of these ideas, the mentioned structures were given different names. *Trigonellites* PARKINSON, 1811 was the most widely used one. Later, however, the generic name *Aptychus*, introduced by MEYER in 1831, became accepted usage.

The 20th century brought new findings in the taxonomy and stratigraphy of aptychi and also new advances concerning their functional significance. During the first half of the century, it was the work of TRAUTH (1927-1938) that provided the most significant results. Above all, he was concerned with the basic taxonomy and nomenclature of the aptychi (among other issues, he

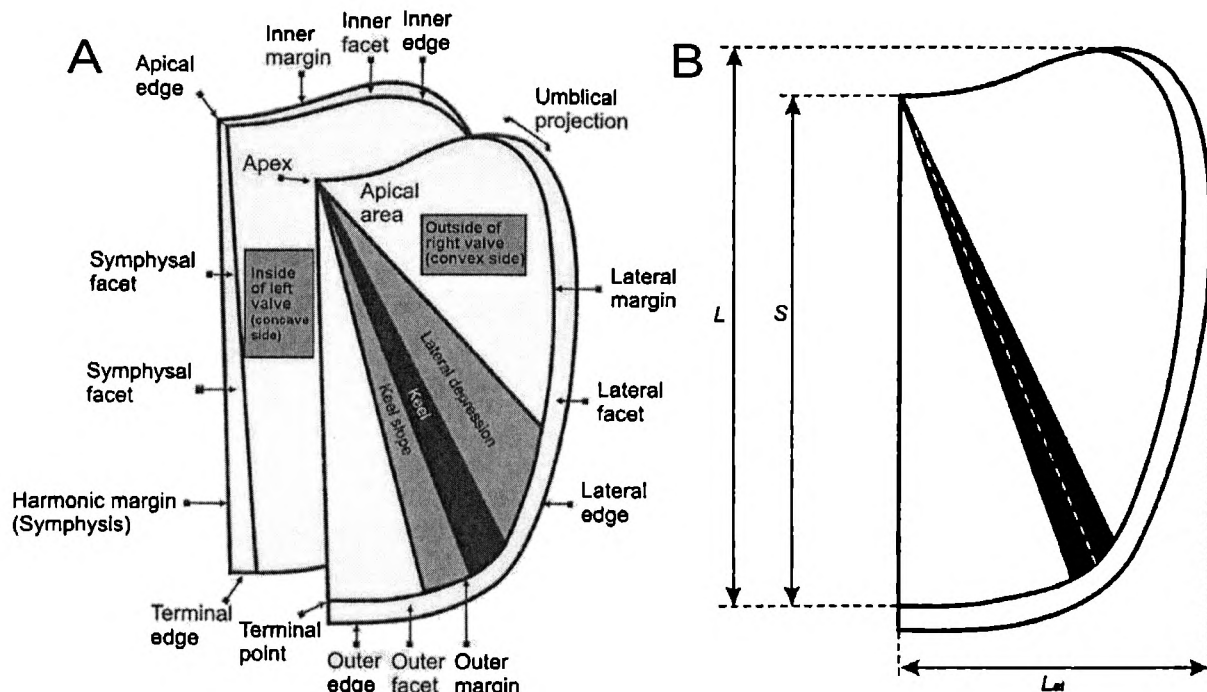


Fig. 2. Terminology of aptychi valves (MĚCHOVÁ et al. 2010). A – Descriptive terms, B – basic length parameters.

defined 14 Jurassic and Cretaceous genera). The second half of the 20th century brought further progress in the knowledge of aptychi (for important contributions see e.g., STEFANOV 1961, GASIOROWSKI 1962a, 1962b, HOŮŠA 1974, several studies by RENZ, starting from 1972, RENZ & HABICHT 1985, VAŠÍČEK et al. 1994, VAŠÍČEK 1996, TURCOLET 1994, 2000, etc.).

At the beginning of the 21st century continued the initial trend in the clarification of the systematic position and function of aptychi (ENGESER & KEUPP 2002; REBOULET & RARD 2008; VAŠÍČEK 2010; PARENT et al. 2014), clarification of the stratigraphic and palaeogeographic distributions and occurrences of known species, and also in the description of further taxa. Most usually, aptychi are regarded as mandibles of jaw apparatuses of ammonites (e.g., LEHMANN 1972; LEHMANN & KULICKI 1990; VAŠÍČEK et al. 2012, among others). A proposal for and a justification of a new concept for the parataxonomy of Early Cretaceous aptychi was presented by MĚCHOVÁ et al. (2010).

4. Material preservation and morphology

All valves of the studied collection come from marly limestone beds. For the majority of the specimens, the covering sediment was removed using an electric vibrating needle. Most of the specimens are fragmentary, and only a small part of them are complete separate valves. Only one has preserved both valves joined together. The valves, in which ribbing on the outer surface is not favourably preserved or in which only the apical area is preserved (i.e. terminal region is missing), are usually not determinable.

Most of the studied valves fall into the category of medium-sized valves, i.e. length $L = 12\text{--}28$ mm. In the descriptions of the taxonomic part, smaller valves are designated as juvenile and larger valves as large. Medium- and large-sized valves, with non-corroded ribbing in the juvenile area are mainly used for reliable determination.

The morphological terms used in the description of valves of aptychi are illustrated in Fig. 2A. In the measurement of dimensional parameters of valves, the following basic length indices (Fig. 2B) are employed: L – length or size of valve, i.e. distance between the inner margin of the valve and the terminal point; S – distance between the terminal point and the apex; Lat – maximal width of valve. The values taken

from fragmentary specimens are denoted by an apostrophe (L', S') to indicate an uncertainty in the measurement. As the value of S is close to that of L, the measurement of it is of substantial importance only if the value of L cannot be measured. The ratio Lat/L informs about whether the valve is "slender" or "stout".

5. Systematic palaeontology

The taxonomic arrangement follows that proposed by MĚCHOVÁ et al. (2010).

Family Lamellaptychidae MĚCHOVÁ, HOUŠA & VAŠÍČEK, 2008

Type genus: *Lamellaptychus* TRAUTH, 1927, p. 228.

This family includes calcite valves with a three-layered structure. Prominent lamellar ribs are developed on the convex side of the valve.

Genus *Mortilletilamellaptychus* MĚCHOVÁ, VAŠÍČEK & HOUŠA, 2010

Type species: *Aptychus Mortilleti* PICTET & LORIO, 1858, p. 50.

Thin-walled valves with a keel and a lateral depression. In close vicinity of the symphyseal edge, most of the ribs bend towards the terminal point and end at the symphysis. Adult ribs end at the outer margin. In the stratigraphically youngest representatives, the last few ribs may bend in a complicated way.

Mortilletilamellaptychus mortilleti (PICTET & LORIO, 1858)

Fig. 3A, B

1858 *Aptychus Mortilleti* PICTET & LORIO. – PICTET & LORIO, p. 50, pl. 11, figs. 9b (lectotype), 9d; ?9a, 11, ?12, non fig. 10 (= ?*Thorolamellaptychus aplanatus* GILLIÉRON, 1873).

2010 *Mortilletilamellaptychus mortilleti* (PICTET & LORIO). – MĚCHOVÁ et al., p. 244, fig. 9F (cum syn.).

Material: Four valves. The first specimen (CPUG.M.Qp₁.(-4).4) is a medium-sized, almost complete valve in which the ribs are not preserved in the juvenile area. The second and third valves (CPUG.M.SL₁.5.28, CPUG.M.SL₁.9.5) are imperfectly or incompletely preserved. The last specimen (CPUG.M.Qp₁.6.11) is a juvenile with a somewhat corroded surface.

Description: Vaulted valves with a poorly developed keel and an only slightly indicated lateral depression. Ribs are thin and closely spaced, only gently inflected on the flanks. The ribs are slightly bent between the keel and the symphysis, running in an arch-like manner towards the outer margin. They form an angle of about 40° with the symphysis. Near the symphyseal margin, the ribs bend continuously towards the terminal point. The near-symphyseal region is vaulted, and the ribs converge with it at an angle of about 15°, although the last ribs run almost parallel to the outer margin. The last two of them end at the outer margin.

Measurements: CPUG.M.Qp₁.(-4).4: L' (almost L) = 13.0 mm, S = 12.5 mm, Lat = 7.0 mm, Lat/L about 0.54. Juvenile specimen CPUG.M.Qp₁.6.11 has a length L = 10.6 mm.

Remarks: *M. mortilleti* differs from the close species *M. mendrisiensis* (RENZ & HABICHT) and *M. morbiensis* (RENZ & HABICHT) by a smaller length of the ribs converging on the symphyseal margin and by the fact that only 1 or 2 last ribs end at the outer margin. In addition, *M. morbiensis* is characterised by a high keel and a well-marked depression below it.

Distribution: *M. mortilleti* is a comparatively abundant species that occurs in the Mediterranean area from the Late Berriasian to the lower part of the Late Valanginian.

Fig. 3. A, B – *Mortilletilamellaptychus mortilleti* (PICTET & LORIO). A: CPUG.M.Qp₁.(-4).4, section M.Qp₁ (Cehegin), Peregrinus Zone, the same Subzone; B: CPUG.M.Qp₁.6.11, x4, section M.Qp₁ (Cehegin), Upper Valanginian, Peregrinus Zone, Nicklesi Subzone. C – *Mortilletilamellaptychus* cf. *mortilleti* (PICTET & LORIO), CPUG.M.BG1.1a, section M.BG1 (Cehegin), Upper Valanginian, Peregrinus Zone. D, E – *Mortilletilamellaptychus beyrichodidayi* (TRAUTH). D: CPUG.M.Qp₂.14.19, section M.Qp₂ (Cehegin), Lower Valanginian, lower part of Pertransiens Zone; E: CPUG.M.Qp₁.(-1).8, x2, section M.Qp₁ (Cehegin), Upper Valanginian, Peregrinus Zone. F – *Mortilletilamellaptychus* cf. *beyrichodidayi* (TRAUTH), CPUG.M.Qp₂.19.10, section M.Qp₂/Y.Qp₂ (Cehegin), Lower Valanginian, upper part of Pertransiens Zone. G, H – *Mortilletilamellaptychus bicurvatus* (RENZ & HABICHT); G: CPUG.M.Qp₁.(-7).8, section M.Qp₁ (Cehegin), Upper Valanginian, Peregrinus Zone and Subzone. H: CPUG.M.SL₁.9.5, x3, section (Fortuna), Peregrinus Zone. I – *Mortilletilamellaptychus* cf. *morbiensis* (RENZ & HABICHT), CPUG.M.Qp₂.12.66, section M.Qp₂/Yp₂ (Cehegin), Lower Valanginian, lower part of Pertransiens Zone. J – *Mortilletilamellaptychus undulatiformis* n. sp., holotype, CPUG.M.Qp₁.(-19).3, section M.Qp₁ (Cehegin), Upper Valanginian, Verrucosum Zone. K – *Mortilletilamellaptychus* cf. *carinatus* (RENZ & HABICHT), CPUG.M.Qp₂.2.11, section M.Qp₂/Yp₂ (Cehegin), Upper Berriasian, upper part of the Boissieri Zone. L – *Thorolamellaptychus bermudensis* (RENZ), CPUG.M.Qp₁.10.8, section M.Qp₂/Y.Qp₂ (Cehegin), Lower Valanginian, lower part of Pertransiens Zone. M – *Thorolamellaptychus aplanatus* (GILLIÉRON), CPUG.M.Qp₁.6.7, section M.Qp₁ (Cehegin), Upper Valanginian, Peregrinus Zone, Nicklesi Subzone. Scale bars equal 1 cm.

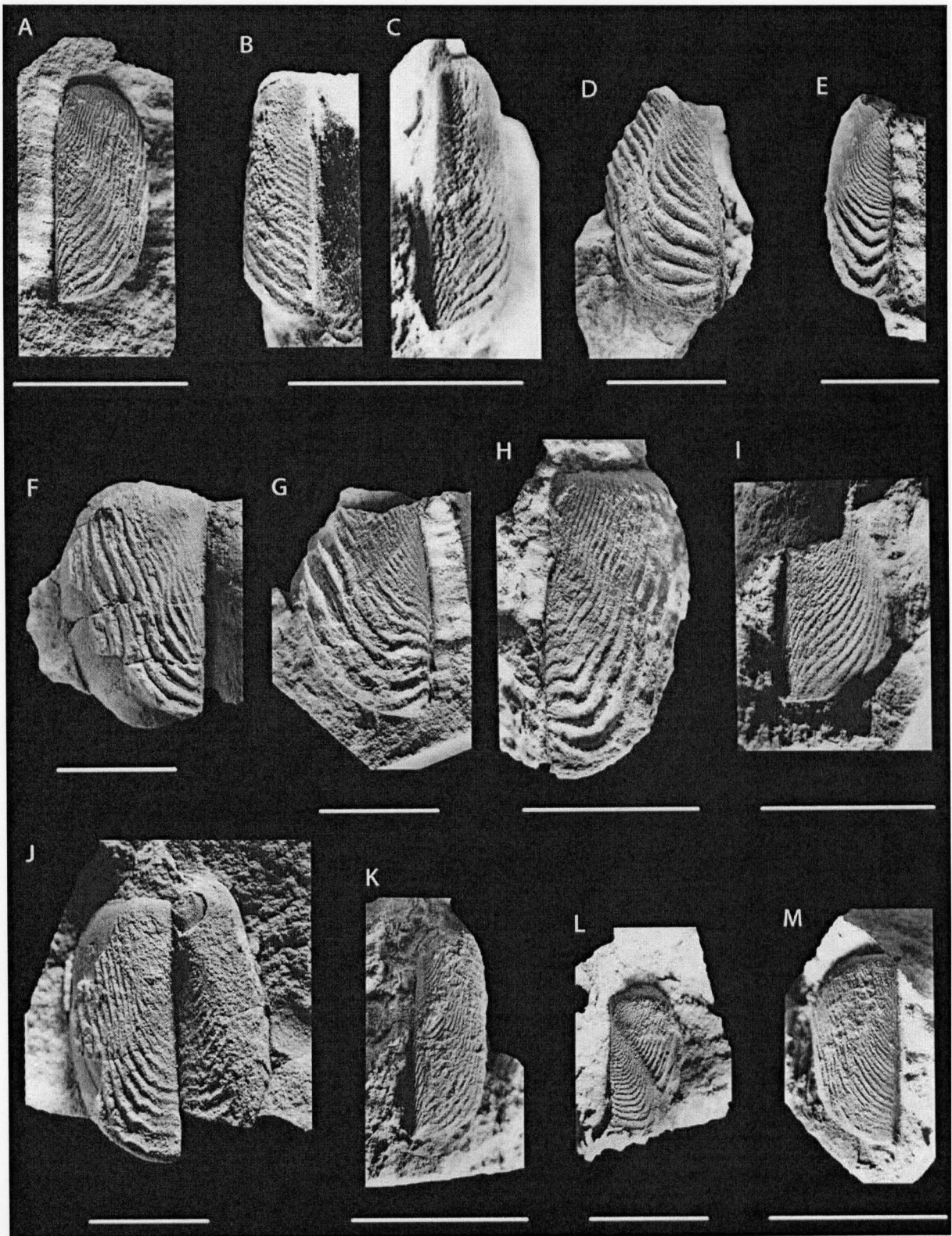


Fig. 3.

Occurrences: Section M.Qp₁ (Cehegín) and section M.SL₁ (Fortuna), Peregrinus Zone, Upper Valanginian.

Mortilletilamellaptychus cf. mortilleti (Pictet & Loriol, 1858)
Fig. 3C

Material: A small-sized, almost complete valve (CPUG.M.BG1.1a). Ribs are somewhat corroded, especially in the juvenile area.

Description: Vaulted valve with an indistinct keel and without lateral depression. Thin and closely spaced ribs. Ribs on the flank of the valve are almost straight. They bend on the keel and run towards the symphysal margin at an angle of about 40°. Juvenile ribs bend towards the terminal point in a short section close to the symphysal margin. In the more mature part of the valve, the ribs are probably somewhat less bent in an arch-like manner towards the symphysis. They converge with the symphysal margin at an angle of 20° as a bundle of thin ribs close to each other. In the terminal region, they form a bundle of four ribs intersecting the outer margin. The last adult ribs follow the outer margin, which is connected with discordance of ribs.

Measurements: L = 13 mm, S = 12 mm, Lat = 6.8 mm, Lat/L = 0.52.

Remarks: The small valve resembles *M. mortilleti*. The discordance between the bundle of the juvenile ribs and the adult ribs impedes an unambiguous determination.

Occurrence: Section M.BG1 (Cehegín), Peregrinus Zone, Upper Valanginian.

Mortilletilamellaptychus beyrichodidayi (Trauth, 1938)
Fig. 3D, E

1938 *Lamellaptychus beyricho-didayi* n. f. – Trauth, p. 200, pl. 14, fig. 5.

1985 *Lamellaptychus ambiguus* Renz. – Renz & Habicht, p. 406, pl. 3, figs. 21–22.

1985 *Lamellaptychus* aff. *ambiguus* Renz. – Renz & Habicht, p. 406, pl. 5, figs. 19–20.

2010 *Mortilletilamellaptychus beyrichodidayi* (Trauth). – Měchová et al., p. 251, fig. 10D (cum syn.).

Material: Five subadult to adult valves. Valve CPUG.M.SL₁.7.14 has the complete outline preserved, but most of the original calcite valve has disappeared; a fairly well preserved, almost complete (CPUG.M.Qp₁(-6).7); a valve (M.Qp₁(-1).8) with the apex broken off, and three subadult fragments in which more than a third of the juvenile area is missing (CPUG.M.Qp₂.14.19, CPUG.M.Qp₂.12.67, and CPUG.M.Qp₁.0.4).

Description: Valves with a distinct rounded keel and a

shallow lateral depression. Ribs below the keel area usually sigmoidally bent at first, farther only inflected. Closely-spaced and thin juvenile ribs, forming an angle of about 30° with the symphysal margin. Subadult ribs bend at a blunt angle to the terminal point and converge along the margin in a short section. At the beginning, these ribs form a very acute angle (of about 10°), that become gradually greater. Adult ribs are stronger and more widely spaced than the juvenile ones. At the beginning, the ends of the ribs run towards the terminal point. Gradually, oblique ribbing above the keel towards the terminal point disappears, and the ribs meet the symphysal margin simply at an angle of less than 80°. The last ribs are slightly inclined back to the apex. On the stratigraphically younger valves of larger size, the last ribs can be subangularly bent.

Measurements: Valve CPUG.M.SL₁.7.14 has the following dimensions: L = 27.0 mm, S = 25 mm, Lat = 17.2 mm, Lat/L = 0.64. Dimensions of specimen CPUG.M.Qp₁(-6).7 are as follows: L = 20.3 mm, S = 18.6 mm, Lat = 12.4 mm, Lat/L = 0.61. Spec. M.Qp₁(-1).8 at L = 19.4 mm has S' = 17.5 mm, Lat = 12.2 mm, Lat/L = 0.63. Fragment of valve CPUG.M.Qp₂.14.19 has a length L' = 20 mm. Actual length of the valve was probably 25–28 mm.

Remarks: The valves are characterised by a greater width Lat so that Lat/L exceeds the value of 0.61. The incomplete, imperfectly preserved valves designated by Renz (1979) and Renz & Habicht (1985) as *Lamellaptychus ambiguus* or as *L. cf. ambiguus* most likely correspond to merely fragments of valves of *M. beyrichodidayi*.

Distribution: Stratigraphically well-dated finds of *M. beyrichodidayi* in the Slovak Outer and Central Western Carpathians come from the lower part of the Late Valanginian.

Occurrences: Section M.Qp₂ (Cehegín), lower part of Pertransiens Zone, Lower Valanginian; section M.Qp₁ (Cehegín) and section M.SL₁ (Fortuna), Peregrinus Zone, Upper Valanginian.

Mortilletilamellaptychus cf. beyrichodidayi (Trauth, 1938)
Fig. 3F

Material: A rather large specimen with an original valve split off along the whole lateral area (CPUG.M.Qp₂.19.10). Juvenile ribs are strongly corroded.

Description: In the juvenile area there is a conspicuous sharp keel that almost disappears in the adult part. Below the keel there is a shallow lateral depression on which the ribs are slightly bent. On the valve flanks, the ribs run obliquely subparallel to the outline of the valve.

Juvenile ribs converge along a long part of the symphysal margin at an angle of about 15°. There they form a bundle of thin and closely spaced ribs. Adult ribs are markedly stronger, quite widely spaced. The contact between them and the juvenile ribs is sub-discordant. At the beginning they

run towards the symphyseal margin at an angle of about 40°. This angle increases rapidly and the still almost straight ribs bend in an arch-like manner in the terminal region. The last ribs in the non-preserved terminal region probably followed the external outline.

Measurements: L' (almost L) = 23 mm, S = 21.6, Lat = 14.4, Lat/L = 0.63.

Remarks: In its ribbing style this specimen resembles an immature valve of *M. beyrichodidayi*. However, the ambiguously preserved discordance between the bundle of the juvenile ribs and the adult ribs does not correspond to this species.

Occurrence: Section M.Qp₂/Y.Qp₂ (Cehegín), upper part of Pertransiens Zone, Lower Valanginian.

Mortilletilamellaptychus bicurvatus (RENZ & HABICHT, 1985)
Fig. 3G, H

1938 *Lamellaptychus sub-mortilleti* n. n. var. n. *retroflexa*. – TRAUTH, p. 201, pl. 14, fig. 6.

1961 *Lamellaptychus mortilleti* (PICTET et LORIOL). – STEFANOV, p. 217, pl. 3, fig. 1, non fig. 4 (undeterminable).

1985 *Lamellaptychus bicurvatus* new name. – RENZ & HABICHT, p. 409, pl. 3, figs. 25–26, 28, non fig. 27 (= *Mortilletilamellaptychus stefanovi* VAŠÍČEK et al., 2012).

2010 *Mortilletilamellaptychus bicurvatus* (RENZ and HABICHT). – MĚCHOVÁ et al., p. 250, fig. 10C (cum syn.).

2012 *Mortilletilamellaptychus bicurvatus* (RENZ & HABICHT). – VAŠÍČEK et al., p. 258, fig. 5.3.

Material: A fairly well-preserved valve of rather large dimensions (CPUG.M.SL₁.9.5) and other two incomplete valves missing about one quarter to one third of their juvenile area (CPUG.M.Qp₁(-7).8, CPUG.M.Qp₁(-4).11.).

Description: Valves with a relatively weak, wide and rounded keel that fades out towards the terminal region. Juvenile ribs are thin and closely spaced. They run at an angle of about 25° between the keel and the symphyseal margin. In close proximity to the symphyseal margin the ribs flatten in a quite long section, making with the symphyseal region an angle of about 10°. The following ribs strengthen and intercostal spaces between them widen. At the very beginning of the more mature part, at a greater distance from the symphyseal margin, a sigmoidal bend of ribs appears and after it, the final part of the ribs run obliquely, in an arch-like manner, towards the symphyseal margin. The following ribs are S-shaped; the ends of the ribs in a short section run towards the terminal point. The ribs end at the symphyseal margin at an angle of 70–80°. The last two ribs form a simple, heavily vaulted arch in the terminal region. Their ends are inclined towards the apex.

Measurements: On the complete valve CPUG.M.SL₁.9.5, L = 26.6 mm, S = 25.0 mm, Lat = 16.5 mm, Lat/L = 0.62. Incomplete valve CPUG.M.Qp₁(-7)8 has L' = 19.5 mm.

Distribution: Late Valanginian of the Western Carpathians, Northern Calcareous Alps, Switzerland, and Bulgaria.

Occurrence: Section M.SL₁ (Fortuna), Upper Valanginian, Peregrinus Zone, M.Qp₁ (Cehegín), Peregrinus Zone.

Mortilletilamellaptychus stanislavi MĚCHOVÁ,
VAŠÍČEK & HOUŠA, 2010

2010 *Mortilletilamellaptychus stanislavi* sp. nov. – MĚCHOVÁ et al., p. 248, fig. 9L.

Material: Two incomplete, poorly preserved valves lying on the same bedding plane (CPUG. Y.Qp₂.29B.27).

Description: The final part of the juvenile ribs very likely converges along the symphyseal margin. More adult ribs bend angularly in the close vicinity of this area.

Remark: The above-mentioned features correspond to the morphology of valves of *M. stanislavi* MĚCHOVÁ et al., 2010.

Distribution: The species is known from the Late Valanginian (Calpionellites Zone and Campylotoxus ammonite Zone) of the Outer and Central Western Carpathians and from the Valanginian of southern Switzerland.

Occurrence: Section Y.Qp₂ (Cehegín), upper part of Pertransiens Zone, Lower Valanginian.

Mortilletilamellaptychus undulatiformis n. sp.
Fig. 3J

Etymology: Undulatiformis – from Latin, according to the undulated adult ribs.

Holotype: Specimen CPUG.M.Qp₁(-19).3, illustrated in Fig. 3J. It is deposited in the collection of the University of Granada.

Type locality and horizon: Section M.Qp₁, Cehegín (Murcia province); Upper Valanginian, Verrucosum ammonite Zone (Verrucosum Subzone).

Diagnosis: The juvenile ribs converge along the symphyseal margin. In the following ribs, the angle at which the ribs run to the symphysis gradually increases up to 80°. The last adult ribs are undulated.

Material: A pair of relatively small, almost complete valves, the left of which is more favourably preserved in the terminal region (CPUG.M.Qp₁(-19).3). The juvenile ribs are preserved better on the right valve.

Description: Vaulted valves with an indistinct, rounded keel and without lateral depression. At the beginning, ribs are thin and closely spaced; at the end, ribs are stronger and more widely spaced. The juvenile ribs converge along

the symphyseal margin. Ribs on the flanks of the valves run obliquely, subparallel to the lateral margin. Between the keel and the symphysis, the juvenile ribs run at an angle of about 35° towards the symphyseal margin. In the vicinity of it, the ribs flatten and run towards the terminal point and converge, in a rather short section, along the symphysis at an angle of about 10°. In the following ribs, the angle at which the ribs run towards the symphysis gradually increases up to almost 80°. The last ribs, close to the outline of the outer margin, also bend in their final, within a very short section, to the terminal point. They end at the symphysis. The last ribs are undulated between the keel and the symphysis. The undulation is evoked through closely spaced radial lines running from the apex to terminal margin.

Measurements (left valve): L = 16 mm, S = 15.4 mm, Lat = 8.0 mm, Lat/L = 0.50.

Occurrence: Section M.Qp₁ (Cehegín), Verrucosum Zone, Upper Valanginian.

Mortilletilamellaptychus cf. morbiensis (RENZ & HABICHT, 1985)
Fig. 31

1985 *Lamellaptychus morbiensis* new form. – RENZ & HABICHT, p. 410, pl. 4, figs. 4, 10.

Material: An incomplete fragment of a medium-sized valve from which a substantial part of the apical area is missing (CPUG.M.Qp₂.12.66).

Description: Vaulted valve with a distinct rounded keel and a shallow lateral depression. The area between the keel and the symphyseal margin is slightly concave likewise the area below the keel. Thin and closely spaced ribs that are preserved only in the more adult part of the valve. In the lower part of the keel, the ribs are slightly bent towards the outer margin. They run towards the symphyseal margin at an angle of about 45°. In the vicinity of the zone of greatest vaulting of the keel, they are S-shaped and slightly bent to the opposite side and run in a long section towards the terminal apex. On the symphyseal margin, with which they make an angle of about 30°, they do not form any separate bundle of ribs. The last five adult ribs run obliquely, ending at the outer margin.

Measurements: L' = 13.5 mm (by estimation, the complete valve could be 18–20 mm in size).

Remarks: The holotype (RENZ & HABICHT 1985, pl. 4, fig. 4) has a conspicuous sigmoidal bend of ribs in the lateral depression. In our specimen, this sigmoidal bend is not evident, like it is observed in the paratype (RENZ & HABICHT 1985, pl. 4, fig. 10), which is smaller in size.

Distribution: According to RENZ & HABICHT (1985) typical representatives of *M. morbiensis* come from the Valanginian-Hauterivian boundary of southern Switzerland.

Occurrences: Section M.Qp₂/Yp₂ (Cehegín), lower part of Pertransiens Zone, Lower Valanginian. So far, this species was only known from Late Valanginian deposits, above the base of the Maiolica Formation of southern Switzerland.

Mortilletilamellaptychus cf. carinatus (RENZ & HABICHT, 1985)
Fig. 3K

1985 *Lamellaptychus carinatus* new form. – RENZ & HABICHT, p. 408, pl. 3, fig. 20 a, b.

Material: A small, almost complete valve heavily corroded on the surface (spec. CPUG.M.Qp₂.2.11).

Description: Strongly vaulted valve with a strikingly protruding, obliquely running keel (designatable as a carina) that divides the valve into two roughly equal parts, namely a flat area between the keel and the symphyseal margin and a shallow depression below the keel. Ribs are thin and closely spaced. On the flanks of the valve, the ribs are almost straight, subparallel to the lateral margin. In the area of the conspicuous keel, the ribs become oblique. In the vicinity of the symphyseal margin, but not in the close proximity to it, the inclination of ribs diminishes; they bend and approach the mentioned margin at an angle of about 20°. Along the symphyseal margin, a bundle of closely spaced, thin ribs is formed. The mentioned bundle ends in the terminal region at the outer margin. The last adult ribs miss the mentioned near-symphyseal bend because about 5 of them follow the outer margin of the valve and end at the outer margin. Between the bundle of the symphyseal ribs and the adult ribs, a slight discordance can be seen.

Measurements: L' (almost L) = 13.0 mm, S = 12 mm, Lat = 6.5 mm, Lat/L = about 0.50.

Remarks: The morphology of the valve from Spain corresponds well to the description of the type specimen by RENZ & HABICHT (1985). In our photograph, highlighting the symphyseal area, we failed to catch the strikingly protruding keel.

Distribution: According to RENZ & HABICHT (1985) the type comes from the Valanginian of southern Switzerland.

Occurrence: Section M.Qp₂/Yp₂ (Cehegín), Boissieri ammonite Zone, Alpillensis/Otopeta Subzone, Upper Berriasian.

Genus *Thorolamellaptychus* TURCULET, 1994

Type species: *Aptychus Thoro* OPPEL, 1863, p. 250.

Thin and closely spaced ribs that follow the shape of the valves both in the juvenile and in the adult stage. All or almost all the ribs end at the symphyseal margin. More complicated ribbing at final developmental stages.

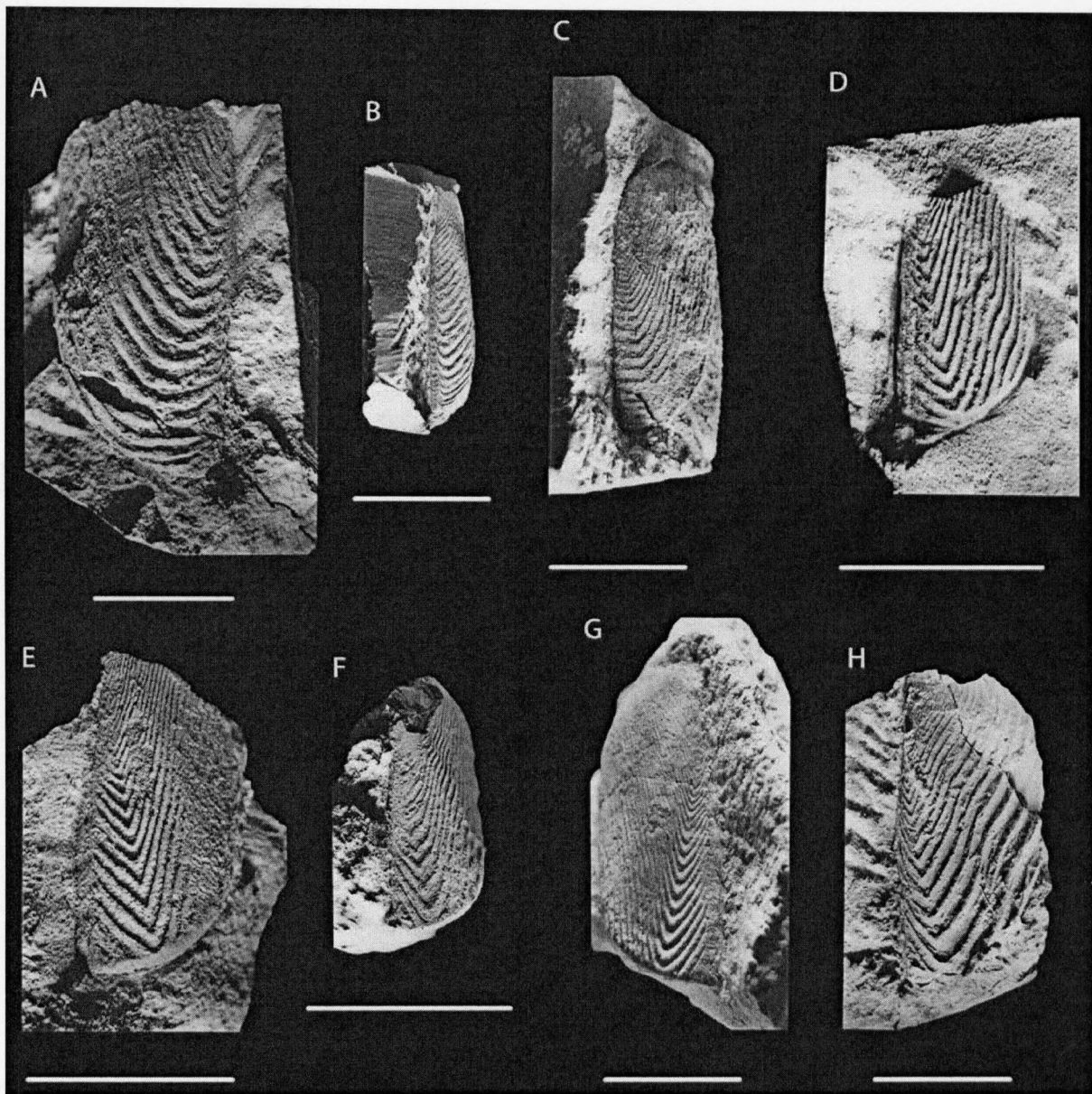


Fig. 4. A, B – *Thorolamellaptychus symphysocostatus* (TRAUTH), A: CPUG.Y.T.24.43; B: CPUG.Y.T.30.81, showing the crenulated symphysal facet. Both from section Y.T (Caravaca), Lower Valanginian, upper part of Neocomiensiformis Zone. C – *Thorolamellaptychus subangulatus* n. sp., holotype, CPUG.Y.T.14.29, section Y.T (Caravaca), Lower Valanginian, lower part of Neocomiensiformis Zone. D – *Didayilamellaptychus angulocostatus* (PETERS), CPUG.X.G.8.9, section X.G (La Guardia), Upper Hauterivian, Balearis Zone. E – *Didayilamellaptychus angulicostatus* (PICTET & LORIOL), CPUG.X.V₁(-2).73, section X.V₁, Upper Hauterivian, Balearis Zone. F – *Didayilamellaptychus cristobalensis* (O'CONNELL), CPUG.X.V₁(-1).51, section X.V₁ (Cehegín), Upper Hauterivian, Balearis Zone. G – *Didayilamellaptychus renzi* MĚCHOVÁ, VAŠÍČEK & HOŮŠA, CPUG.X.V₁(-2).75, section X.V₁ (Cehegín), Upper Hauterivian, Balearis Zone. H – *Didayilamellaptychus praeangulatus* n. sp., holotype, CPUG.Y.Qp₂29B.26, section M.Qp₂/Y.Qp₂, Lower Valanginian, base of Neocomiensiformis Zone. Scale bars equal 1 cm.

The specimens were whitened with ammonium chloride. Photographs by K. MEZIHORÁKOVÁ (Ostrava). The collection of aptychi will be deposited in the collections of University in Granada cited under inventory number with the prefix CPUG (Colecciones Paleontológicas de la Universidad de Granada).

Thorolamellaptychus aplanatus (GILLIÉRON, 1873)

Fig. 3M

- ?1854 *Aptychus aplanatus* PETERS. – PETERS, p. 443.
 ?1868 *Aptychus noricus* WINKLER. – WINKLER, p. 27, pl. 4, fig. 14.
 1873 *Aptychus aplanatus*, PETERS. – GILLIÉRON, p. 238, pl. 10, fig. 3 a–c (lectotype).
 1938 *Lamellaptychus aplanatus* (GILL.) f. typ. – TRAUTH, p. 171, pl. 12, figs. 8–10.
 1985 *Lamellaptychus aplanatus* (GILLIÉRON). – RENZ & HABICHT, p. 403, pl. 3, figs. 4–5 ?6, 7–11.
 1994 *Lamellaptychus aplanatus aplanatus* (GILLIÉRON). – VAŠÍČEK et al., p. 76, pl. 23, fig. 6 (cum syn.).

Material: A single favourably preserved valve (CPUG.M.Qp₁.6.7) and two other imperfectly preserved valves (CPUG.Y.Qp₂.22.46, CPUG.YT.8.37).

Description: Small-sized, thin-walled valves with a keel and a shallow lateral depression. Ribs are thin and closely spaced. Juvenile ribs run obliquely at an angle of about 30° towards the symphysal margin. Adult ribs follow the outline of the valve. The last two ribs end at the outside margin.

Measurements: Spec. CPUG.M.Qp₁.6.7 has L = 12.0 mm, S = 10.8 mm, Lat = 6.8 mm, Lat/L = 0.57.

Remarks: There is some confusion about whether this species is a junior synonym of *Thorolamellaptychus noricus* (WINKLER, 1868). The problem arises from the fact that the small-sized holotype of WINKLER's species is imperfectly preserved and that it was originally figured only as a schematic drawing. The species name *aplanatus* was used firstly by PETERS (1854), who provided only a general description of the species without illustration. The original material of PETERS was probably not available neither for GILLIÉRON (1873) nor for TRAUTH (1938). GILLIÉRON (1873) not only described but also illustrated *Lamellaptychus aplanatus* under the authorship of PETERS. Later, TRAUTH (1938) as well as RENZ & HABICHT (1985) took over his interpretation, but under the authorship of GILLIÉRON. However, the latter two authors included in the synonymy of the species only one of the valves figured by GILLIÉRON (1873, pl. 10, fig. 4). In accordance with RENZ & HABICHT (1985) we regard the mentioned specimen as the lectotype of the species. Interestingly, however, none of the former mentioned authors, nor JAKSCH (1968), compared *Th. aplanatus* with *Th. noricus*.

Distribution: *Th. aplanatus* has been reported in the literature from a wide stratigraphic interval, embracing the Late Tithonian to Hauterivian. In the Central Western Carpathians it is known from the Lower Valanginian and the lower part of the Upper Valanginian.

Occurrences: The complete valve comes from the section M.Qp₁ (Cehegín), Peregrinus ammonite Zone (Nicklesi Subzone), Upper Valanginian. The other two come from the Lower Valanginian; one from the upper part of Pertransiens Zone (section Y.Qp₂, Cehegín), and the other from the lower part of the Neocomiensiformis Zone (section YT, Caravaca).

Thorolamellaptychus bermudensis (RENZ, 1979)

Fig. 3L

- 1977 *Lamellaptychus* indet. 1. – RENZ, p. 504, pl. 1, figs. 23a, b, ?24a–c.
 1979 *Lamellaptychus bermudensis* n. sp. – RENZ, p. 592, pl. 1, fig. 2.
 1985 *Lamellaptychus bermudensis* RENZ. – RENZ & HABICHT, p. 400, figs. 21–24 (cum syn.).
 non 2000 *Lamellaptychus* cf. *bermudensis* RENZ. – VAŠÍČEK & FAUPL, p. 614, pl. 1, fig. 5 (= *Thorolamellaptychus aplanatus retroflexus* TRAUTH, 1938).
 2010 *Thorolamellaptychus bermudensis* (RENZ). – MĚCHOVÁ et al., p. 254, fig. 10J (cum syn.).

Material: A single, medium-sized valve, rather incomplete in its terminal region (CPUG.M.Qp.10.8).

Description: The valve is characterised by a sharp, strongly protruding keel, designated as a carina, which divides the valve into a narrower symphysal-terminal slightly concave part and a larger marginal and apical area. This part is also concave, especially below the keel. Juvenile ribs are thin and closely spaced, bending back towards the apex in an arch-like manner between the keel and the symphysal area. The ribs end simply at the symphysal margin at an angle of about 80°. On the flank below the keel, the ribs are only negligibly bent.

Measurement: L' (almost L) = 13.7 mm.

Remarks: RENZ (1979) designated the specimen illustrated in his pl. 1, fig. 2 as the holotype of *L. bermudensis*. The subsequent designation by RENZ & HABICHT (1985) of the pair of juvenile valves from the Cape Verde Basin figured by RENZ 1977 (pl. 1, fig. 23a, b) as holotype is therefore not valid. In addition, RENZ (1978: 904, pl. 1, fig. 8 a, b) meanwhile created *L. postbermudensis* as a new species that was considered by RENZ & HABICHT (1985) as a junior synonym of *L. bermudensis*. In spite of certain nomenclatorial discrepancies, the RENZ's conclusion in favour of *L. bermudensis* can be accepted.

Distribution: RENZ's holotype (RENZ 1979) comes from the Berriasian of the Western Bermuda Rise. His other material comes from the bottom of the Atlantic Ocean (Berriasian and Valanginian), and from southern Switzerland (RENZ 1983; RENZ & HABICHT 1985). This species occurs in the Lower Valanginian in the Czech part of the Outer Western Carpathians. RENZ & HABICHT (1985: 400) also mentioned its occurrence in the Betic Cordillera (southern Spain, Málaga province). It is evident that the geographical distribution of the mentioned species is considerable.

Occurrence: Section M.Qp₂/Y.Qp₂ (Cehegín), lower part of Pertransiens Zone, Lower Valanginian.

Thorolamellaptychus symphysocostatus (TRAUTH, 1938)

Fig. 4A, B

- 1938 *Lamellaptychus angulocostatus* (PET.) var. n. *symphysocostata*. – TRAUTH, p. 208, pl. 14, figs. 15–16.
 2010 *Thorolamellaptychus symphysocostatus* (TRAUTH). – MĚCHOVÁ et al., p. 254, fig. 101 (cum syn.).

Material: Two large, favourably preserved valves (CPUG.Y.T.24.43, CPUG.Y.T.30.81) and two incomplete valves (CPUG.Y.T.21.67, CPUG.Y.T.25.57).

Description: Vaulted valves. Ribs follow the external outline. In the vicinity of the symphysis, the ribs bend subangularly back towards the apex. On the adult ribs, the subangular bend disappears. Nevertheless, the symphysal facet remains crenulated in the full length.

Measurements: Specimen CPUG.Y.T.30.81: L = 33.6 mm, S = 30.0 mm, Lat = 16.6 mm, Lat/L = 0.49.

Remarks: The ribbing of this species resembles that of *Th. lorioli* (RENZ, 1979), in which the symphysal facet is, however, smooth. In comparison with other findings of *Th. symphysocostatus*, the valves from Spain are odd in size.

Distribution: In the Central Western Carpathians (Slovakia) and in the Eastern Alps, *Th. symphysocostatus* occurs in the Valanginian, in the Campylotoxus (now Neocomiensiformis) to Peregrinus ammonite zones.

Occurrence: Section Y.T (Caravaca), upper part of the Neocomiensiformis ammonite Zone, middle part of the Lower Valanginian.

Thorolamellaptychus subangulatus n. sp.

Fig. 4C

Etymology: Subangulatus – according to the almost angular bending of ribs.

Holotype: Specimen CPUG.Y.T.14.29, illustrated here in Fig. 4C. It is deposited in the collections of the University in Granada.

Type locality and horizon: Section Y.T, Caravaca; Lower Valanginian, lower part of the Neocomiensiformis ammonite Zone.

Diagnosis: Ribs bend subangularly on the keel, forming an angle of about 125°.

Material: Two valves. Holotype (CPUG.Y.T.14.29) is rather an incomplete, medium-sized valve, the other valve (CPUG.M.BG(-2).a) is incomplete.

Description: Medium-sized valve with a flat lateral area and a rounded keel. The keel is located comparatively close to the symphysal margin. The thin and closely spaced ribs in the lateral area are only slightly inflected. Between the keel and the symphysal margin, more specifically in the vicinity of the keel, the ribs bend subangularly. After bending the

ribs run almost perpendicular to the symphysal margin at first, and then they are slightly inclined towards the terminal margin. The two branches created by the rib bending make an obtuse angle of about 125°. The line drawn through the points of bends makes an angle of about 10° with the symphysal margin.

Measurement: L' = 21.5 mm.

Occurrences: Lower part of the Neocomiensiformis Zone (Lower Valanginian) in sections Y.T (Caravaca) and M.BG (Cehegin).

Genus *Didayilamellaptychus* TURCULET, 1994

Type species: *Aptychus Didayi* COQUAND, 1841, p. 389.

Usually thick-walled, medium- to large-sized valves with thin to strong ribs. Adult ribs bend back to the apex in a curved to angular manner. The last few ribs can be incomplete.

Didayilamellaptychus angulocostatus (PETERS, 1854) Fig. 4D

- 1854 *Aptychus angulocostatus* PETERS. – PETERS, p. 441.
 2010 *Didayilamellaptychus angulocostatus* (PETERS). – MĚCHOVÁ et al., p. 260, fig. 11F (cum syn.).
 2012 *Didayilamellaptychus angulocostatus* (PETERS). – VAŠÍČEK et al., p. 263, fig. 8.6 (cum syn.).

Material: Two poorly preserved fragments rather small in size (CPUG.X.G.8.9, CPUG.X.Ag1.124.15).

Description: Valves with a keel, but lacking lateral depression. Between the keel and the symphysis there is a distinct angular, at the end subangular, bend of the ribs back to the apex. The branch of ribs adjacent to the symphysis is not straight, but slightly curved. The last rib in the terminal region is incomplete.

Measurement: The first fragment has a length L' of 12 mm, hence the complete valve could be about 15 mm in size.

Remarks: A closely related species is *D. angulicostatus* (PICTET & LORIOU 1858) described below. It differs from *D. angulocostatus* (PETERS, 1854) by the fact that it has at least a weakly developed lateral depression and that both branches forming the angular ribs are straight. The described valve, which differs from the type material by inflection bending of the ribs below the keel, resembles in this respect a valve figured as *Lamellaptychus angulocostatus* aff. *angulocostatus* (PETERS) by VAŠÍČEK & HOEDEMAEKER (1997, pl. 1, fig. 9).

Distribution: *D. angulocostatus* occurs in the whole Mediterranean region. However, data on its wide stratigraphic range (Berriasian to Early Barremian – see e.g. STEFANOV 1961 or RENZ & HABICHT 1985) are dubious. This species is

known with certainty only from the Hauterivian, probably only from the Late Hauterivian.

Occurrences: One valve (CPUG.X.G.8.9) comes from the Balearis ammonite Zone (Krenkeli Subzone), section X.G of La Guardia (Jaén province), the other one from the Balearis Zone and Subzone, section X.Ag₁ of Caravaca, in both cases Upper Hauterivian.

Didayilamellaptychus angulicostatus

(Pictet & Loriol, 1858)

Fig. 4E

- 1858 *Aptychus angulicostatus*. – Pictet & Loriol, p. 46, pl. 10, figs. 3 (lectotype), 76-12, non figs. 4-5 (= *Didayilamellaptychus* cf. *renzi* Měchová et al., 2010).
2010 *Didayilamellaptychus angulicostatus* (Pictet & Loriol). – Měchová et al., p. 262, fig. 11 G, H (cum syn.).

Material: Four valves, most of them incomplete (CPUG.X.V₁(-11).76, CPUG.X.V₁(-5).32, CPUG.X.V₁(-5).33, CPUG.X.V₁(-2).73).

Description: Medium-sized valves with a distinct keel and a shallow lateral depression. Ribs on the outer area follow more or less the outline of the valve. In the lateral depression, they are usually inflected. In the area between the keel and the symphysis, the ribs bend angularly and run back to the apex. The last ribs are incomplete.

Measurements: CPUG.X.V₁(-11).76: L = 22.6 mm, S = 21.2, Lat = 11.6 mm, Lat/L = 0.51.

Distribution: Similar to the distribution of *D. angulocostatus*, i.e. Late Hauterivian, including the Ohmi ammonite Zone.

Occurrences: Section X.V₁ (Cehegín), Balearis ammonite Zone (Upper Hauterivian). Specimen CPUG.X.V₁(-11).76 comes from the Krenkeli Subzone; the other specimens from the Angulicostatus Subzone.

Didayilamellaptychus cristobalensis (O'Connell,

1921)

Fig. 4F

- 1921 *Aptychus cristobalensis*, new species. – O'Connell, p. 7, figs. 7 (lectotype), 8.
2010 *Didayilamellaptychus cristobalensis* (O'Connell). – Měchová et al., p. 263, fig. 11 J (cum syn.).
2012 *Didayilamellaptychus cristobalensis* (O'Connell). – Vašíček et al., p. 264, fig. 8.9 (cum syn.).

Material: A single small-sized, not perfectly preserved valve (CPUG.X.V₁(-1).51).

Description: Valve with a distinct keel and an indistinct lateral depression. Between the keel and the symphysal margin,

the ribs bend conspicuously back towards the apex. In the juvenile area, the bend of the ribs is simply subangular to angular, whereas the more adult ribs show a double-folded denticulation coinciding with the angular bending. The final ribs are bent angularly backwards as simply as the juvenile ribs.

Measurements: The valve has L = 13.6 mm, S' = 12.0 mm, Lat = 7.8 mm, Lat/L = 0.57.

Distribution: The precise stratigraphic position of the type material from the Caribbean area is unknown. *D. cristobalensis* occurs in Bulgaria in the Early Hauterivian, in the Western Carpathians in the Late Hauterivian (Vašíček et al. 2012).

Occurrence: Section X.V₁ (Cehegín), Balearis ammonite Zone (Angulicostatus Subzone), Upper Hauterivian.

Didayilamellaptychus renzi Měchová, Vašíček &

Houša, 2010

Fig. 4G

- 2010 *Didayilamellaptychus renzi* n. sp. – Měchová et al., p. 266, fig. 11M, N (cum syn.).
2012 *Didayilamellaptychus renzi* Měchová, Vašíček & Houša. – Vašíček et al., p. 265, fig. 8.10.

Material: A single, relatively well-preserved valve (CPUG.X.V₁(-2).75) and a fragment (CPUG.X.V₁(-5).31).

Description: Valve rather large, with a prominent rounded keel and without lateral depression. Thin and closely spaced ribs, which are only slightly inflected in the area below the keel. On the flank of the valve, they run subparallel to the outline. In the area between the keel and the symphysal margin, the ribs bend sharply back towards the apex. In juvenile ribs the bend is angular, later it becomes subangular. The two branches connected with the angular bend form an angle of 40–45°. The arms of ribs adjacent to the symphysis are slightly bent. The line drawn through the points of subangular bending describes an angle of 10° with the symphysal margin. The ribs end at the symphysal margin at an angle of about 30°. The last three ribs are incomplete.

Measurements: CPUG.X.V₁(-2).75: L = 24.0 mm, S = 23.0 mm, Lat = 11.6 mm, Lat/L = 0.48.

Remark: The recently defined species *D. renzi* is close to *D. filicostatus* (Stefanov, 1961). In the latter species the ribs in the area of bending have a somewhat different shape (see Stefanov's holotype refigured by Vašíček et al. 2012, fig. 10).

Distribution: *D. renzi* is known from the Early Hauterivian of Bulgaria, and from the Late Hauterivian of Slovakia, Switzerland, the Caribbean region and the bottom of the Atlantic Ocean.

Occurrence: Section X.V₁ (Cehegín), Balearis ammonite Zone (Angulicostatus Subzone), Upper Hauterivian.

Didayilamellaptychus praeangulatus n. sp.

Fig. 4H

Etymology: Praeangulatus – prefix *prae* expresses the unexpectedly early occurrence of ribs of angular type.

Holotype: Specimen CPUG.Y.Qp₂.29B.26, illustrated here in Fig. 4H. It is deposited in the palaeontological collections of the University of Granada.

Type locality and horizon: Section M.Qp₂/Y.Qp₂, Cehegín; Lower Valanginian, base of the Neocomiensiformis ammonite Zone.

Diagnosis: Valve with a sharply angular bending of ribs near the symphysal margin.

Material: A single valve, relatively large in size, with an incompletely preserved terminal region and unpreserved inner margin (CPUG.Y.Qp₂. 29B.26). Juvenile ribbing near the apex is neither well-preserved.

Description: Slightly vaulted thin-walled valve with a weak keel that fades out towards the outer margin. The ribs are quite thin and only slightly bent on the flanks of the valve. In the area between the keel and the symphysal margin, all the ribs, from the first preserved ones up to those at the terminal end, are sharply angularly bent. The zone of bending of the ribs is quite close to the symphysal margin along about one half of the area between the keel and the mentioned margin. A line drawn through the point of bending of ribs makes an angle of about 10° with the symphysal margin. Both arms formed by bent ribs make together an angle of about 60°. The rib arms adjoined to the symphysal facet are slightly arch-shaped and run towards the facet at an angle of about 35°. The last two adult ribs are incomplete in the terminal region. The bending of the last and preceding ribs is not sharply angular, but somewhat rounded.

Measurements: Only the parameter $S = 24$ mm is objectively measurable.

Remarks: The clear angular bending of the preserved ribs allows to assign this valve to the genus *Didayilamellaptychus*. *D. praeangulatus* n. sp. resembles in its ribbing *D. renzi* MÉCHOVÁ et al., 2010. However, the last species has a considerably younger stratigraphic age. In addition, its ribs are more closely spaced, and the bending angle of the ribs is smaller (about 40°). Other similar Late Hauterivian species with angular ribs are usually thick-walled.

Occurrence: Section M.Qp₂/Y.Qp₂ (Cehegín), base of the Neocomiensiformis Zone, Lower Valanginian. *D. praeangulatus* would be the stratigraphically oldest representative of the genus *Didayilamellaptychus*.

6. Stratigraphic evaluation

The aptychi from section M.Qp₂/Y.Qp₂ (Cehegín) belong to the Boissieri and Pertransiens ammonite

zones (uppermost Berriasian to basal Valanginian). This is evidenced by the occurrence of ammonites like *Fauriella boissieri* (Pictet), *Tirnovella alpillensis* (MAZENOT), *Thurmanniceras pertransiens* (SAYN) and others. In the lower part of the section, the following species of aptychi were determined: *Mortilletilamellaptychus* cf. *carinatus*, *M.* cf. *morbiensis*, *M. beyrichodidayi* and *Thorolamellaptychus bermudensis*. In the upper part of the section, *M.* cf. *beyrichodidayi*, imperfectly preserved *M. stanislavi*, *Th. aplanatus*, and *Didayilamellaptychus praeangulatus* n. sp. occur.

The aptychi from section YT (Caravaca) belong to the Neocomiensiformis ammonite Zone (middle part of Lower Valanginian). They are accompanied by ammonite species like *Neocomites neocomiensiformis* (UHLIG), *Luppovella superba* (SAYN), *Olcostephanus stephanophorus* (MATHERON), *Valanginites dolioliformis* (ROCH), and others. Three species of aptychi occur here: *Th. symphysocostatus* (more specimens), *Th. aplanatus* and *Th. subangulatus* n. sp.

The sections M.Qp₁ (Cehegín) and M.SL₁ (Fortuna) include deposits of Late Valanginian age. The Verrucosum Zone, recognized by the occurrence of *Neohoploceras submartini* (MALLADA), *Karakaschiceras inostranzewi* (KARAKASCH), *Paquiericeras paradoxum* SAYN, and other ammonites, is only represented in the M.Qp₁ section, and has yielded a single specimen of *M. undulatiformis* n. sp. In the Peregrinus Zone, present in both sections, an association of aptychi rather rich in diversity and number occurs, namely *M. bicurvatus*, *M. mortilleti*, *M. beyrichodidayi*, and *Th. aplanatus*. They are accompanied by stratigraphically significant ammonites like *Neocomites peregrinus* (RAWSON & KEMPER), *Olcostephanus nicklesi* WIEDMANN & DIENI, *Rodighieroites cardulus* COMPANY, *Olcostephanus balestrai* (RODIGHIERO), etc.

The section X.V₁ (Cehegín) represents the Upper Hauterivian, namely the higher part of the Balearis ammonite Zone. The subzonal ammonite index *Crioceratites krenkeli* SARKAR and *Cr. angulicostatus* (D'ORBIGNY) are present. The aptychi association is represented merely by aptychi with angularly arranged ribs: *Didayilamellaptychus angulicostatus*, *D. cristobalensis* and *D. renzi*.

One valve of *D. angulocostatus* comes from section X.Ag₁ (Caravaca) (Balearis ammonite Zone, Balearis Subzone), and another valve of the same species comes from section X.G (La Guardia) (Balearis ammonite Zone, Krenkeli Subzone), Upper Hauterivian.

stages		sections		M.Qp ₂ /Y.Qp ₂	YT
		ammonite zones	subzones		
BARR.	Lower				
HAUTERIVIAN	Upper	"Pseudothurmannia ohmi"			
		Balearites balearis	Cr. angulicostatus		
			Crioceratites krenkeli		
			Binelliceras binelli		
			Bal. balearis		
	Lower	Plesiospidiscus ligatus			
		Subsaynella sayni			
		Lyticoceras nodosoplicatum			
		Crioceratites loryi			
		Acanthodiscus radiatus			
VALANGINIAN	Upper	Criosarasinella furcillata			
		Neocomites peregrinus	Okostephanus nicklesi		
			N. peregrinus		
		Saynoceras verrucosum			
	Lower	Karakaschiceras inostranzewi			
		Neocomites neocomiensiformis			
		"Thurmanniceras" petransiens			
BERRIASIAN	Upper	Subthurmannia boissieri	Thurmanniceras otopeta		
			Tirnovella alpillensis		
			Berriasella picteti		
			Malbos. paramimounum		

7. Discussion

The most diverse assemblages of aptychi in the studied collection occur in Berriasian/Valanginian boundary deposits near Cehegín and in the middle part of the Upper Valanginian both in Cehegín and Fortuna. A rather wide spectrum of aptychi was also found in the upper part of Upper Hauterivian in Cehegín (Fig. 5).

The genus *Mortilletilamellptychus* is the most abundant one within the spectrum of aptychi species coming from the Berriasian/Valanginian boundary deposits (section M.Qp₂/Y.Qp₂ - Cehegín). Among the species of this genus, *M. cf. carinatus* and *M. cf. morbiensis* were only known from southern Switzerland (RENZ & HABICHT 1985). The first one was found by these authors in the Lower/Upper Valanginian boundary beds, and the other one in the uppermost Valanginian.

Analogously, the find of *M. beyrichodidayi* in the basal Valanginian of the same section is quite surprising, since this species usually occurs in the Late

Valanginian. Poorly preserved valves of *M. stanislavi* and *Thorolamellptychus bermudensis* were also found near the Berriasian/Valanginian boundary. The find of *D. praeangulatus* n. sp. at the base of the Neocomiensiformis Zone probably represents the oldest record of the genus *Didayilamellptychus*.

In the section Y.T (Caravaca, Neocomiensiformis Zone), relatively abundantly occur large-sized valves of *Th. symphysocostatus*. Subangular bending of ribs in the vicinity of the symphysis disappears in the case of last ribs, but not the crenulation on the symphysis facet. Moreover, a single finding of a valve (holotype) of *Thorolamellptychus subangulatus* n. sp. is also of interest.

In the middle part of the Upper Valanginian (sections near Cehegín and Fortuna) the representative of the genus *Mortilletilamellptychus* predominates again. Here, small valves of *M. cf. mortilleti*, *M. bicurvatus* and *M. beyrichodidayi* occur. The latter mentioned species is remarkable for the tendency of adult ribs to bend subangularly, which is not evident

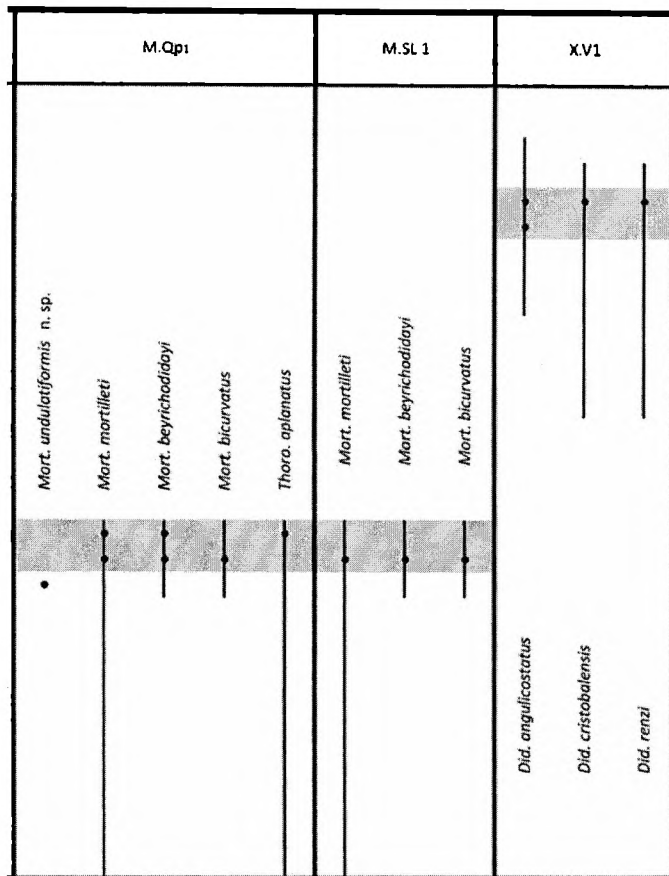


Fig. 5. Distribution of determined aptychi in the sections under study. Age according to REBOULET et al. (2014).

on the valves from the Lower Valanginian. There, the occurrence of a single valve of *Th. aplanatus* was recorded as well.

In the studied material, aptychi known from the latest Valanginian, Early Hauterivian and early Late Hauterivian are missing.

In the upper part of the Upper Hauterivian in the section X.V₁ (Cehegín), three species of thick-walled valves with angularly bent ribs from the range of *D. angulicostatus* occur. On the same stratigraphic level, *D. angulicostatus* can occur as well. At the end of the Hauterivian, the last representatives of the family Lamellaptychidae, represented by the genus *Didayilamellaptychus*, disappear.

8. Conclusions

The studied collection of aptychi from Lower Cretaceous pelagic carbonate deposits of south-eastern Spain corresponds to a time span from the Late Berriasian to

the Late Hauterivian. All findings come from sections which are well-dated by zonal index ammonites (Fig. 5).

The oldest section M.Qp₂/Y.Qp₂ (Cehegín) contains an association of aptychi with thin-walled valves of the uppermost Berriasian and basal Valanginian, in which representatives of *Mortilletilamellaptychus* predominate. This association is composed of 4 species of *Mortilletilamellaptychus*, one of *Thorolamellaptychus* and the new species *Didayilamellaptychus praeangulatus*, which is probably the oldest representative of the genus.

In section Y.T (Caravaca), corresponding to the middle part of the Lower Valanginian, only valves of the genus *Thorolamellaptychus* were found. *Th. symphysocostatus* is the most common form, and a new species, *Th. subangulatus* has been recorded.

A large amount of the aptychi come from the middle part of the Upper Valanginian (sections M.Qp₁ - Cehegín and M.SL₁ - Fortuna). All valves except one belong to representatives of the genus *Mortilletilamellaptychus*. *M. undulatifformis* found at the base of the section

Cehégín (Verrucosum Zone) is a new species. From a stratigraphical point of view, it is *M. bicurvatus* that proves to be the most significant taxon.

The youngest representatives of the family Lamellaptychidae occur in the Balearis Zone (Upper Hauterivian) in the sections X.V₁ (Cehégín), X.Ag₁ (Caravaca) and X.G (La Guardia). They are represented by 4 related species of the genus *Didayilamellaptychus*.

Acknowledgements

The present paper was supported by the project for long-term development of Institute of Geonics, Czech Academy of Sciences, No. RVO 68145535. We acknowledge the photographer K. MEZIHORÁKOVÁ (Ostrava) for taking all photographs and O. MALEK for the arrangement of the illustrations. The authors like to thank the reviewers Ph. HOEDEMAEKER (Naturalis Biodiversity Center Leiden) and G. SCHWEIGERT (Staatliches Museum für Naturkunde Stuttgart) for constructive remarks, suggestions and also for linguistic help.

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Manuscript received: January 7th, 2015.

Revised version accepted by the Stuttgart editor: February 20th, 2015.

Addresses of the authors:

ZDENĚK VÁŠÍČEK, Institute of Geonics of Academy of Sciences of the Czech Republic, Studentská 1768, CZ-708 00 Ostrava-Poruba, Czech Republic;
e-mail: zdenek.vasicek@ugn.cas.cz;

MIGUEL COMPANY, Departamento de Estratigrafía y Paleontología, Facultad de Ciencias, Universidad de Granada, Campus de Fuentenueva s/n, 18002 Granada, Spain;

LUCIE MĚCHOVÁ, U Jízdárny 572, CZ-76764, Velká Polom, Czech Republic.