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New Spumellaria (Radiolaria) from the Early Tuvalian *Spongotortilispinus moixi* Zone of Southeastern Turkey, with some Remarks on the Age of this Fauna

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3 Text-Figures, 6 Plates

Türkei
Trias
Karn
Tuval
Radiolaria
Spumellaria
Taxonomie

Contents

Neue Spumellarien (Radiolaria) aus der *Spongotortilispinus-moixi*-Zone (Unteres Tuvalium) der südöstlichen Türkei und einige Bemerkungen zum Alter dieser Fauna

Zusammenfassung

Das untersuchte Radiolarien führende Profil ist die Typuslokalität der *Spongotortilispinus moixi*-Zone und liegt in der Huğlu-Einheit der Mersin-Mélange in der SE-Türkei. Die Geologie dieses Profils wird kurz diskutiert und seine geographische Lage und die stratigraphische Position der Radiolarien führenden Probe G11 mit den am besten erhaltenen Radiolarien wird in den Abbildungen 1–3 gezeigt. Das Alter der *S. moixi*-Zone an ihrer Typuslokalität und auch das Alter der nächst älteren, neu aufgestellten *Elbistanium gracilis*-Zone von Elbistan (östliche Türkei) werden im Detail diskutiert, wobei besonderes Augenmerk auf die Änderungen in den Radiolarienfaunen vom Jul zum Untertuval gelegt wird. Die untertuvalische *S.-moixi*-Zone ist die zweitälteste Radiolarien-Zone des Tuval. Die Bedeutung des mittelkarnischen feuchten Intermezzos („Pluvial-Episode") für die Faunenänderungen vom Oberjul zum Untertuval wird diskutiert.

Zwei neue Gattungen, 27 neue Arten und 10 neue Unterarten werden aus der Typuslokalität der *S.-moixi*-Zone beschrieben. Zusätzlich werden die neue Gattung *Goricanella* KOZUR, MOSTLER & OZSVÁRT n. gen. und die neuen Arten *Goricanella hexaspinosa* KOZUR, MOSTLER & OZSVÁRT n. gen. n. sp. sowie *Capnuchosphaera goestlingensis* n. sp. aus dem julischen oberen Göstling-Kalkstein von Göstling beschrieben. Die letztere Art kommt auch in der *S. moixi*-Zone vor. Die Familien Spongopallidae KOZUR, KRAINER & MOSTLER, Spongotortilispinidae KOZUR & MOSTLER und Archaeoacanthocircidae KOZUR, MOIX & OZSVÁRT werden emendiert.

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Abstract

The geological setting of the radiolarian-bearing section that has been investigated in the Huğlu Unit of the Mersin Mélange in SE Turkey is shortly discussed, and the geographic location and stratigraphic position of the radiolarian-bearing sample G11 from the type locality of the *Spongotortilispinus moixi* Zone are shown in Text-Figs. 1–3. The age of the *Spongotortilispinus moixi* Zone at its type locality, and also the age of the next older, newly established *Elbistanium gracile* Zone of Elbistan (Eastern Turkey), are discussed in detail with particular emphasis on changes from the Julian to lower Tuvalian (Carnian, Late Triassic) radiolarian faunas. *T. gracile* Zone is the oldest radiolarian zone within the Tuvalian, but its beginning could slightly predate the substage boundary within the latest Julian. The *S. moixi* Zone is the second radiolarian zone of the lower Tuvalian. The importance of the middle Carnian wet intermezzo ("pluvial event") for the faunal changes from the upper Julian to lower Tuvalian is discussed.

Two new genera, 27 new species and 10 new subspecies are described here from the *S. moixi* Zone at its type locality. Additionally, the new genus *Goricanella* KOZUR, MOSTLER & OZSVÁRT n. gen. and its type species *Goricanella hexaspinosa* KOZUR, MOSTLER & OZSVÁRT n. gen. n. sp., as well as the new species *Capnuchosphaera goestlingensis* KOZUR, MOSTLER & OZSVÁRT n. sp. from the Julian upper Göstling Limestone of Göstling, Austria, are described. The latter species occurs also in the *S. moixi* Zone. The families Spongopalliidae KOZUR, KRAINER & MOSTLER, Spongotortilispinidae KOZUR & MOSTLER, and Archaeoacanthocircidae KOZUR, MOIX & OZSVÁRT are also emended here.

1. Introduction

MOIX et al. (2007) established the lower Tuvalian *Spongotortilispinus moixi* radiolarian zone from the Huğlu Unit of the Mersin Mélange in SE Turkey and described a few of the radiolarian species from this zone. Numerous further radiolarian taxa subsequently were described from the type locality of the *S. moixi* Zone by KOZUR et al. (2007a, b, c), and more are described in the present paper. Altogether, about 100 new taxa have been described from this zone, which recently has been also recognized in Rhodos (Greece) with an identical fauna (MOIX et al., 2008). From the type locality, an additional approximately 200 new taxa will be described in forthcoming papers. These radiolarians, when compared with radiolarian faunas described by TEKIN & BEDI (2007a,b) from Elbistan (eastern Turkey), allow a very firm assignment of the *S. moixi* Zone as the second radiolarian zone within the lower Tuvalian. Moreover, a correlation can be recognised between the faunal changes among radiolarians across the Julian-Tuvalian boundary and the end of the middle Carnian wet intermezzo. Before the description of new taxa and an emendation of some previously described taxa, the geological setting at the type locality of the *S. moixi* Zone and the age of this zone and of the next older, newly established *Elbistanium gracile* Zone are discussed in detail.

2. Investigated Section

The investigated area is situated in the Mersin Ophiolitic Complex (MOC) north of Erdemli (Mersin, southern Turkey) and is bounded by the villages of Gâvuruçtuğu to the north and Sorgun to the south (Text-Figs. 1, 2). The investigated section lies within the Tavusçayırı Block previously described in several publications (MASSET & MOIX, 2004; MOIX et al., 2007; KOZUR et al., 2007a, 2007b, 2007c). This specific succession is found only in the Upper Cretaceous Sorgun Ophiolitic Mélange (SOM), which is part of the MOC (see Text-Fig. 2 for location and Text-Fig. 3 for the log) that occurs as blocks or as broken formation. The Tavusçayırı Block in the sense of MASSET & MOIX (2004) will be described in detail in another paper. The dating differs considerably from that of the Tavusçayırı section made by PARLAK & ROBERTSON (2004).

The sequence starts at its base with breccias, followed by polygenic conglomerates that lie unconformably above the breccias. The conglomerates are followed by black calciturbidites passing upward into a thin platform sequence of probable early Carnian age. The top of the platform represents a paleo-topography that is filled by red pelagic limestones rich in ammonoids of middle Carnian age, including *Joannites cymbiformis* (WULFEN 1793), *Joannites* sp., *Megaphyllites jarbas* (MÜNSTER 1841), *Coroceras* sp., *Neoprotrachyceras* sp., *Sirenites* cf. *senticosus* (DITTMAR 1866). These collectively indicate the *Trachyceras austriacum* Zone of upper Julian (det. L. KRYSTYN, Vienna). These red pelagic limestones are, in turn, overlain by a volcanic (Pietra Verde-like tuffs) interval where pelagic and re-deposited limestones are interstratified. It passes then upward into a thick sequence composed of pelagic limestones that are intercalated with several debris-flows and calciturbidites. This sequence typically ends with a large breccia, but in a few places it is overlain by a well-developed Ammonitico Rosso of middle Toarcian age that contains *Hildoceras* sp., *Porpoceras* sp., and *Calliphylloceras* sp. (det. J. GUEX, Lausanne).

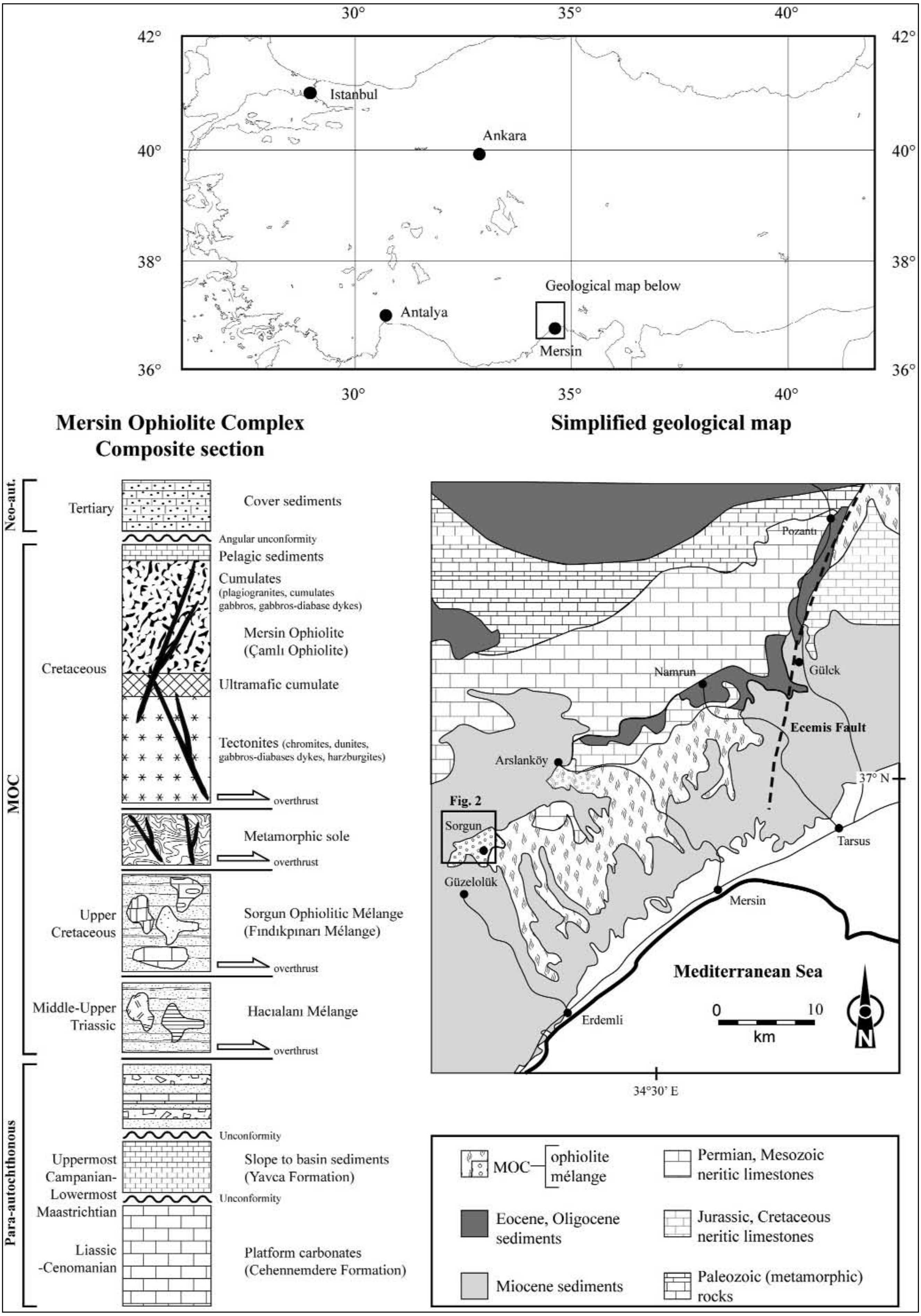
Above the Ammonitico Rosso, the uppermost part of the section is made of a breccia followed by upper Dogger radiolarites with *Archaeospongoprunum imlayi* PESSAGNO 1977, *Homoeoparonaella* cf. *argolidensis* BAUMGARTNER 1980, *Paronaella broennimanni* PESSAGNO 1977, *Stichocapsa robusta* MATSUOKA 1984, *Teichertus splendidus* HULL 1997, *Transhsuum maxwelli* (PESSAGNO 1977), *Tricolocapsa conexa* MATSUOKA 1982, *Tritrabs casmaliaensis* (PESSAGNO 1977) (det. P. DUMITRICĂ, Gümligen).

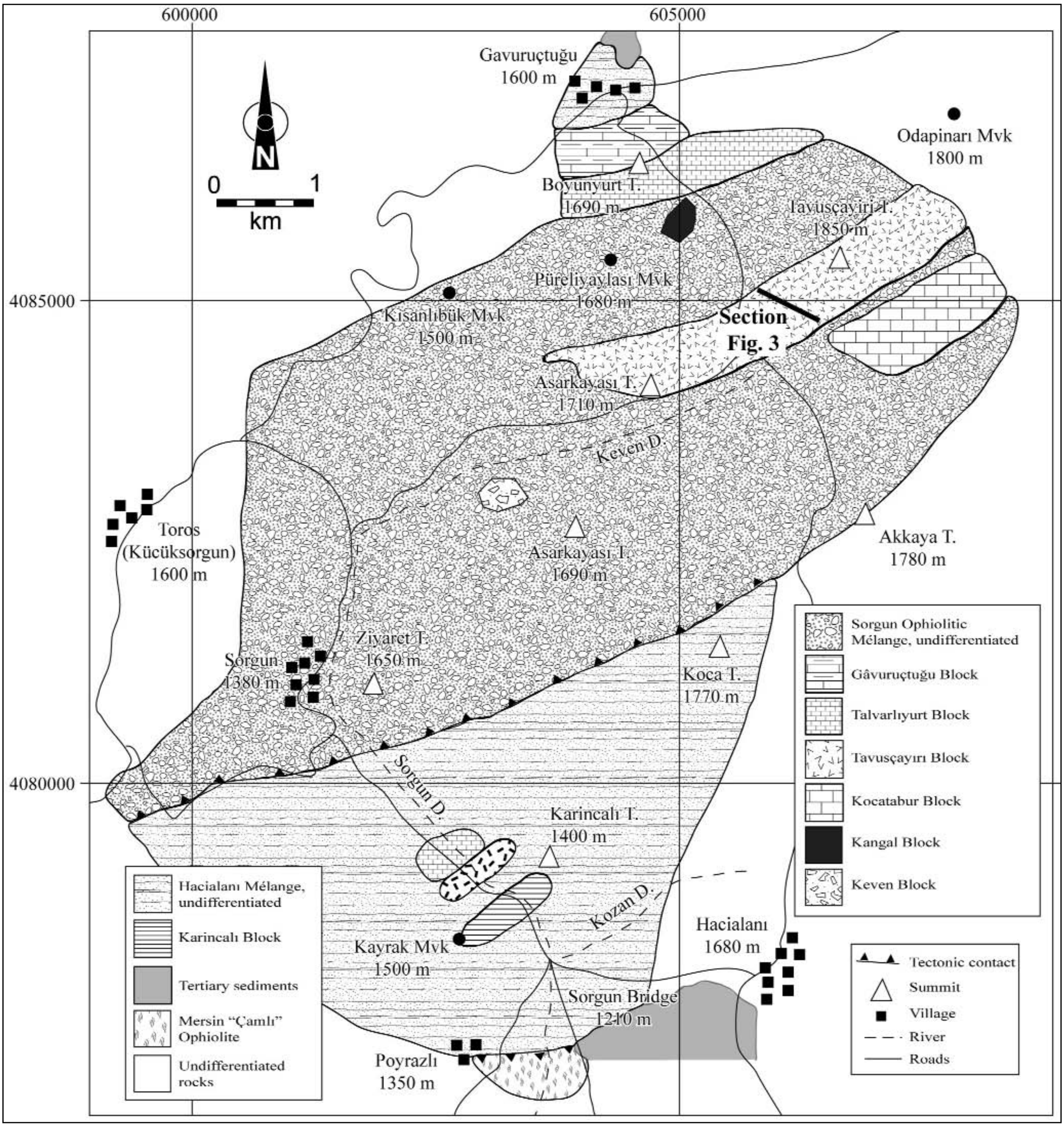
This succession corresponds to the Huğlu-type sequence developed farther to the west, first described by ÖZGÜL (1976) in the Bozkır Units and by MONOD (1977) in the Beyşehir-Hoyran Nappes. The development of the Huğlu Unit was stratigraphically revised by KOZUR (1997). All the newly described taxa described in this paper come from a radiolarian-rich sample (G11, for position in section see Text-Fig. 3). This sample came from a limestone intercalation, within thick green tuffs, that belongs to the lower Tuvalian *Spongotortilispinus moixi* Zone (MOIX et al., 2007).

3. Age of the Investigated Radiolarian Fauna and Remarks on Late Julian – Early Tuvalian Faunal Changes in Connection with the Middle Carnian Wet Intermezzo

The first radiolarians from sample G11 were described by MOIX et al. (2007) in the paper in which they established the *Spongotortilispinus moixi* Zone. Additional species from this zone have been described by KOZUR et al. (2007a, b, c), in the present paper, and many more will be described in future papers. From the beginning, MOIX et al. (2007) assigned the *S. moixi* Zone to the lower Tuvalian. This was

Text-Fig. 1. ➽
General map of Turkey, with a composite section and simplified geological map of the Mersin Ophiolitic Complex (MOC).
Compiled after PARLAK (1996) and ÖZER et al. (2004), modified from MOIX et al. (2007).
Includes the location of Text-Fig. 2.


30°
35°
40°
42°
40°
38°
36°
Istanbul
Ankara
Antalya
Geological map below
Mersin
Mersin Ophiolite Complex
Composite section
Simplified geological map
Neo-aut.
Tertiary
Cover sediments
Angular unconformity
Pelagic sediments
Cumulates
(plagiogranites, cumulates gabbros, gabbros-diabase dykes)
Mersin Ophiolite
(Çamlı Ophiolite)
Cretaceous
Ultramafic cumulate
Tectonites (chromites, dunites, gabbros-diabases dykes, harzburgites)
overthrust
MOC
Metamorphic sole
overthrust
Upper
Cretaceous
Sorgun Ophiolitic Mélange
(Fındıkpınarı Mélange)
overthrust
Middle-Upper
Triassic
Hacıalanı Mélange
overthrust
Unconformity
Para-autochthonous
Uppermost
Campanian-
Lowermost
Maastrichtian
Slope to basin sediments
(Yavca Formation)
Unconformity
Liassic
-Cenomanian
Platform carbonates
(Cehennemdere Formation)
Pozantı
Namrun
Gülek
Ecemis Fault
Arslanköy
37° N
Fig. 2
Sorgun
Tarsus
Güzelolük
Mersin
Mediterranean Sea
Erdemli
0
10
km
N
34°30' E
MOC
ophiolite
mélange
Permian, Mesozoic
neritic limestones
Eocene, Oligocene
sediments
Jurassic, Cretaceous
neritic limestones
Miocene sediments
Paleozoic (metamorphic)
rocks



Text-Fig. 2.
Geological map of the studied area showing the occurrence and location of the mélanges and the main blocks.
Includes the location of the section shown in Text-Fig. 3.

based on the occurrence of *Paragondolella noah* (HAYASHI 1968) in the absence of *Gladigondolella* spp. (which ranges up to the top of the Julian), and in the absence of *Paragondolella carpathica* (MOCK 1979) and of the middle–late Tuvalian species of *Carnepigondolella* KOZUR 2003, none of which appear until the middle Tuvalian. Now that many more radiolarian species from the G11 level are published or described and prepared for publication, its radiolarian fauna can be meaningfully re-evaluated for more precise dating.

At the time that MOIX et al. (2007) described the index species and a few other species from the *S. moixi* Zone, the next older rich radiolarian fauna that had been described was one found in the lower to middle Julian strata of Göstling and Großreifling (Northern Calcareous Alps, Austria), described and stratigraphically evaluated by KOZUR & MOSTLER (e. g. 1972, 1978, 1979, 1981, 1994) and LAHM (1984), and from the Julian of Turkey (TEKIN, 1999). This fauna is found in the beds immediately below and within the "middle Carnian wet intermezzo" of upper Julian *Austrotrachyceras austriacum* Zone. The phrase "middle Carnian wet intermezzo" (MCWI) was introduced by KOZUR & BACHMANN (2008) to replace other previously used terms for the same interval, such as "Northern Alpine Raibl Event" (ANGERMEIER et al., 1963), "middle Carnian wet interval" (KOZUR, 1972a, 1975), "Reingraben turning point" or "Reingraben Event" (SCHLAGER & SCHÖLLNBERGER, 1974), "Carnian Pluvial Episode" (SIMMS & RUFFELL, 1989), and "Carnian crisis" (HORNUNG, 2007). The term "pluvial" is not used here because, although this stratigraphic interval had a wetter climate in the normally dry girdle around the Tropic of Cancer than the underlying and overlying beds (KOZUR, 1972a, 1975), this was not a true pluvial climate in the Germanic Basin and in the adjacent northwestern Tethys. A true pluvial climate, however, surely prevailed to the north in the sediment source area (eastern shoulder uplift of a rift west of Scandinavia) for the huge amounts of sands that were transported southward at that time into the Germanic Basin and through this area into the northern shelf of the Meliata-Hallstatt Ocean. The MCWI can be recognised throughout the Tethys region (e. g. HORNUNG, 2007) and also in continental areas like the Germanic Basin (e. g. KOZUR, 1972a, 1975; BACHMANN & KOZUR, 2004; HORNUNG, 2007) and the Newark Basins (KOZUR & WEEMS, 2007), where it is indicated by thick fluviatile deposits.

Age-equivalent radiolarian faunas are known in Hungary from the Nosztor Limestone within the Veszprém Marl Formation, a typical deposit of the MCWI. They belong to the radiolarian *Tetraporobrachia haeckeli* Zone and are very similar to the slightly older beds of the Göstling Limestone. All radiolarian species found in the Göstling Limestone are also present in the Nosztor Limestone, and only a very few new taxa appear such as *Spinocapnuchosphaera* n. gen., which is common in the lower Tuvalian but very rare in the *Austrotrachyceras austriacum* ammonoid zone of late Julian age where only one very rare species is present. Also appearing for the first time is a member of the family Hsuidae PESSAGNO & WHALEN, represented by one rare new genus. By the lower Tuvalian, however, several taxa of Hsuidae are present, though they are still rather rare and become abundant only during the Jurassic. Obviously, the MCWI had no significant influence on the radiolarian fauna, and the ammonoid fauna immediately below the MCWI and within this interval until its top also is very uniform and belongs to one ammonoid Zone (the *Austrotrachyceras austriacum* Zone of late Julian age). The conodont fauna immediately below the MCWI and from this interval up to its top also is uniform, consisting mainly of *Gladigondolella tethydis* (HUCKRIEDE 1958) and *P. noah*. In the Pindos-Huğlu Ocean, *Carnepigondolella nodosa* (HAYASHI 1968) s.s. (= *"Epigondolella" carnica* KRYSTYN 1975, a junior synonym) is rather common in the lower *A. austriacum* Zone (and in the upper part of the underlying *T. aonoides* Zone), but in the Northern Alps it occurs only rarely at this level and in other areas this species either has not yet been found or is very rare. The evaluation of these quite different faunal groups shows that the MCWI had no significant influence on marine faunas. The shallow marine ostracod faunas often contain a significant fraction of euryhaline marine species (which typically are not found in fully marine sediments without salinity fluctuations but rather in brackish deposits or in marine facies with slightly lower or higher than normal salt content), such as *Simeonella alpina* BUNZA & KOZUR 1971 which occurs not only in the Raibl and Lunz Beds and equivalent deposits in Hungary, but also in the basal Schilfsandstein of the northern and central Germanic Basin. This does indicate a greatly increased influx of fresh water into shallow marginal marine environments of Tethys, which reduced the salt content of the water, but no similar variability of the salt content can be seen in the outer shelf and slope environments (e. g. Hallstatt Limestone). The very diverse ostracod faunas of the Hallstatt Limestone consist of stenohaline marine species that did not tolerate even slight variation, either higher or lower, in the salt content of sea water. In this area, the strong fresh water input in the shelf of the Meliata-Hallstatt Ocean cannot be recognised.

In contrast, distinct changes in some stratigraphically important fossil groups can be observed either in the uppermost Julian or at the base of the Tuvalian and within the lower Tuvalian. The ammonoid fauna of the *Austrotrachyceras austriacum* Zone is replaced by the *Tropites* fauna at the base of the Tuvalian. The conodonts show a slight change with the extinction of the genus *Gladigondolella*, which by then was represented only by a single upper Julian species, *G. tethydis*. New forms (perhaps with exception of *Paragondolella postinclinata* KOZUR 2003) did not appear until later, with the blooming of *Carnepigondolella* in the middle Tuvalian. It is important to note that *G. tethydis* was restricted to the Tethys and parts of Panthalassa, and did not occur in high latitudes or along the continental slope of western North America. This extinction of *Gladigondolella* often tends to be overemphasized, because in its distribution area it is common in pelagic sediments up to the top of the Julian and its disappearance is not preceded by reduction of frequency or regional distribution. In other areas, however, where *Gladigondolella* is absent, the upper Julian and lower Tuvalian conodont faunas are identical and therefore can be only assigned to a single conodont zone.

As for ostracod faunas, all genera and many species range across the Julian-Tuvalian boundary. No new genera appear in the lower Tuvalian, but a few new species, like *Mostlerella nodosa* KOZUR 1971 and *Simeonella nostorica* (MONOSTORI 1994), do appear. These are all benthic shallow water species (found from intratidal to 30–50 m water depth).

Among radiolarian faunas, a distinct change at or near the Julian-Tuvalian boundary can be observed as in the ammonoid faunas. However, nearly all late Julian genera persist throughout the early Tuvalian, and generic extinctions occur only among a few short-ranging transitional forms such as the Julian *Angulocircus* LAHM 1984, which is not present in our fauna. Several species straddle the Julian/Tuvalian boundary, such as *Tetraporobrachia haeckeli* KOZUR & MOSTLER 1979, but in our fauna this Julian index species is already very rare (about one specimen per 10000 other radiolarians). A few other Julian species remain common in the lower Tuvalian, such as *Annulopolpus parviaperturus* (KOZUR & MOSTLER 1979), *Capnuchosphaera goestlingensis* KOZUR, MOSTLER & OZSVÁRT n. sp., *Picapora robusta* KOZUR & MOSTLER 1981 and *Weverella tetrabrachiata* KOZUR & MOSTLER 1979, and this is generally also the case for long-ranging species, such as *Bulbocyrtium reticulatum* KOZUR & MOSTLER 1981, *Karnospongella bispinosa* KOZUR & MOSTLER 1981, *Palaeosaturnalis triassicus* (KOZUR & MOSTLER 1972), *Pseudosaturniforma carnica* KOZUR & MOSTLER 1979 and *Spongotortilispinus tortilis* (KOZUR & MOSTLER 1979).

Beside these persistently abundant species, however, numerous new taxa begin to appear in the lower Tuvalian. Especially striking is the first appearance of families and genera that later are common in the Jurassic, or from the Norian and Rhaetian to the Jurassic. These taxa include the Unumidae KOZUR 1984, which are already rather diverse, the genus *Podobursa* WISNOWSKI 1888 with several species, and the genus *Syringocapsa* NEVIANI 1900. The Hsuidae PESSAGNO & WHALEN 1982, which were extremely rare in the middle Carnian, became more diverse in the lower Tuvalian but remained rare still and only became common in the Jurassic. Also, a few genera not known to range higher than the Norian, such as *Alatipicapora* TEKIN 1999, are already rather diverse in the lower Tuvalian. About 300 new radiolarian taxa, unknown from the upper Julian, appear in the lower Tuvalian. Most of them are new species of genera that already were present in the Julian. About 100 of these new taxa have been described in MOIX et al. (2007), KOZUR et al. (2007a, b, c) and in the present paper, and about 200 more new taxa will be described in forthcoming papers. Even though the change from the Julian to the lower Tuvalian radiolarian faunas is very distinct, it is no stronger than the change between the Longobardian and Cordevolian radiolarian faunas or the Cordevolian and Julian radiolarian faunas. Nevertheless, it still is one of the major radiolarian turnovers within the Triassic.

The changes in the radiolarian faunas start either at the base of the Tuvalian or within the uppermost Julian, and they do not occur at a single level but rather within the basal lower Tuvalian over a short stratigraphic interval. This can be readily demonstrated by the radiolarian fauna of the Köseyahya Nappe (Elbistan, eastern Turkey), described by TEKIN & BEDI (2007a, b). This radiolarian fauna, as far as known, is transitional between the radiolarian fauna of the Göstling Limestone (middle to upper Julian *Tetraporobrachia haeckeli* Zone [KOZUR & MOSTLER, 1994]) that begins just before the MCWI, and the lower Tuvalian radiolarian fauna of the *Spongotortilispinus moixi* Zone. Most of the radiolarian species of the *T. haeckeli* Zone are still present and common, including the index species *T. haeckeli*, and for this reason this fauna was assigned to the Julian *T. haeckeli* Zone by TEKIN & BEDI (2007a, b). On the other hand, *Castrum* BLOME 1984, which is common in the Tuvalian, *Podobursa*-like forms tentatively assigned to *Katroma* PESSAGNO & POISSON 1981 by TEKIN & BEDI (2007a, b), several *Syringocapsa* species, *Trialatus* YEH 1990, and the first representative of the Unumidae are present. These are all typical of our lower Tuvalian fauna from the *S. moixi* Zone. Besides the presence of species characteristic of the Julian *T. haeckeli* Zone, several other species within the same genera are present which were not yet present in the *T. haeckeli* Zone as originally defined but are typical of the *S. moixi* Zone.

A few forms are restricted to the Elbistan fauna. Especially characteristic is *Elbistanium* TEKIN 2007a, and the *Elbistanium gracile* Zone is established for this fauna (defined below). Unlike most faunal turnovers, the upper Julian – lower Tuvalian turnover starts with the appearance of new taxa in the absence of extinctions. Step by step extinctions follow only later, within the lower and middle Tuvalian. When new taxa begin to appear (in the *E. gracile* Zone), this does not greatly change the faunal composition in comparison with the preceding *T. haeckeli* Zone. As the immigrants become more common, however, the species representative of the *T. haeckeli* Zone become very rare and they are progressively replaced by new species of the same genera. At this point the differences from the *T. haeckeli* Zone become considerable, and we are in the *S. moixi* Zone.

This leads to the question of the causes of the upper Julian – lower Tuvalian faunal turnover. A sudden catastrophic event can be excluded. Regarding different faunal elements, the nekton (ammonoids) and plankton (radiolarians) were strongly affected. Benthic organisms were only slightly affected, specifically the shallow water (0–50 m) ostracod faunas. The primarily nektobenthic Triassic conodonts were only slightly affected, as documented by the disappearance of *G. tethydis* in the absence of any new taxa to replace it. Only a few Triassic conodont species were surface dwellers, as evidenced by their occurrence in anoxic sediments in monospecific conodont faunas [for example, the Cordevolian *Pseudofurnishius murcianus* VAN DEN BOOGAARD 1966, the middle-upper Julian *Nicoraella budaensis* KOZUR & MOCK, the middle Norian *Epigondolella praeslovakensis* KOZUR, MASSET & MOIX 2007 (in MOIX et al., 2007), and the uppermost middle Norian to upper Norian or possibly earliest Rhaetian *Mockina slovakensis* (KOZUR 1972b)]. It is not clear how the surface dwellers among the conodonts were affected, but it may be that the disappearance of *Nicoraella budaensis* KOZUR & MOCK is directly related to the latest Julian–early Tuvalian faunal turnover.

The beginning of the MCWI did not significantly influence the radiolarian fauna, because the *T. haeckeli* Zone immediately below the MCWI ranges without any distinct changes upward at least into the middle of the *Austrotrachyceras austriacum* Zone, well inside the MCWI. The obvious faunal changes occurred close to the Julian-Tuvalian boundary, which was near the end of the MCWI. During and especially at the end of the MCWI, at the base of the Tuvalian, a distinct increase in sea water temperatures has been observed. The calculated water temperature from the measured $\delta^{18}O$ of conodonts by HORNUNG et al. (2007a, b) for the Hallstatt Limestones of the Alps increases from around 15°C to 23–25°C. These obviously represent bottom water temperatures, the more as the investigated conodonts are nektobenthic types (KOZUR & BACHMANN, in press). The calculated temperatures (HORNUNG et al., 2007a,b), if regarded as bottom water temperatures, fit well with the palaeolatitude of the depositional area of the Hallstatt Limestones, at the margin of the Meliata-Hallstatt Ocean (for palaeolatitude, see, e. g., STAMPFLI & KOZUR [2006]), and with a water depth of about 100–200 m for most of the Hallstatt Limestones.

Rich ostracod faunas from the Hallstatt Limestones of Slovakia, evaluated by KOZUR (in prep.), show a mixture of cold bottom water faunas and warm surface water faunas. Together, they indicate water depths of 100–200 m, which are in agreement both with the water depth estimates by HORNUNG et al. (2007a), and also their water temperature estimates of 10–20°C, when their data are interpreted as bottom water temperatures. The abrupt increase of the bottom water temperatures to 23–25°C at the base of the Tuvalian (HORNUNG et al., 2007b) indicates seemingly both unusually high surface water temperatures well above 30°C and probably also distinct changes in the oceanic water circulation pattern, partly connected with the closure of the Paleotethys. These unusually high water temperatures may be the principal reason for the faunal turnover, including the distinct faunal changes among the radiolarians. In favour of this hypothesis is the fact that the benthos living below 100 m water depth was practically unaffected.

4. Definition of the *Elbistanium gracile* Zone

A new radiolarian zone is described below, the Elbistanium gracile Zone:

Definition: Co-occurrence of *Elbistanium* spp. with species characteristic of the *Tetraporobrachia haeckeli* Zone, along with several other taxa not present below this zone including *Castrum* spp., *Syringocapsa firma* TEKIN 2007a, *S. nuda* TEKIN 2007a, *Podobursa* ? spp., *Spinocapnuchosphaera* spp., and the first Unumidae.

Lower boundary: FAD of *Elbistanium gracile* TEKIN [nom. corr. for *Elbistanium gracilum* TEKIN 2007b, because of Latin gracilis (-is, -e) and *Goestlingella tueysuezi* TEKIN 2007a].

Upper boundary: Most importantly, FAD of *Spongotortilispinus moixi* KOZUR & MOSTLER 2007 (in MOIX et al., 2007), *Karnospongella multispinosa* KOZUR, MOIX & MOSTLER 2007 (in MOIX et al., 2007), *Zhamojdasphaera rigoi* KOZUR, MOIX & MOSTLER 2007 (in MOIX et al., 2007), but also FAD of more than 100 species described in KOZUR et al. (2007a, b, c), MOIX et al. (2007), and in the present paper, and also the first radiation of the Unumidae and Husidae. Extinction of *Elbistanium*, extinction or strong decline of most species that range from the *T. haeckeli* Zone up to the *E. gracile* Zone.

Occurrence: So far only known from Elbistan (eastern Turkey).

Age: The age of this zone is not yet tightly constrained. TEKIN & BEDI (2007a, b) did not report any conodonts from the *E. gracile* Zone, and the halobians were not determined. They assigned this fauna to the Julian *T. haeckeli* Zone, because all species of this zone are still present in a similar frequency. However, they recognised that the fauna is somewhat younger than the *T. haeckeli* Zone from the type locality (there equivalent to the lower *A. austri-*

acum Zone). The only biostratigraphic datum except radiolarians is the occurrence of *Tropites subbullatus* (det. L. KRYSTYN, Vienna) about 1.6 m above the highest occurrence of the radiolarian fauna of the *E. gracile* Zone. This species defines the middle Tuvalian. Unit 1 below the radiolarian-bearing unit consists of a sandstone-marl alternation. It surely belongs to the MCWI of late Julian age. Unit 2 consists of a clayey limestone, marl and mudstone alternation that could be either the uppermost part of the MCWI (in this case topmost Julian) or the first unit above the MCWI (in that case lowermost Tuvalian). This unit has yielded the most samples of the *E. gracile* Zone. Unit 3 consists of cherty limestone with thin marl and mudstone intercalations. It belongs to the beds above the MCWI and therefore can be assigned to the basal Tuvalian. As it has the same radiolarian fauna as in the underlying unit 2, probably the entire *E. gracile* Zone belongs to the lowermost Tuvalian. Its maximum possible range, however, could be uppermost Julian to lowermost Tuvalian.

The recognition of an earliest Tuvalian age for at least the upper part of the *E. gracile* Zone allows a more precise placement of the lower Tuvalian *S. moixi* Zone as the second radiolarian zone of the lower Tuvalian.

5. Systematics

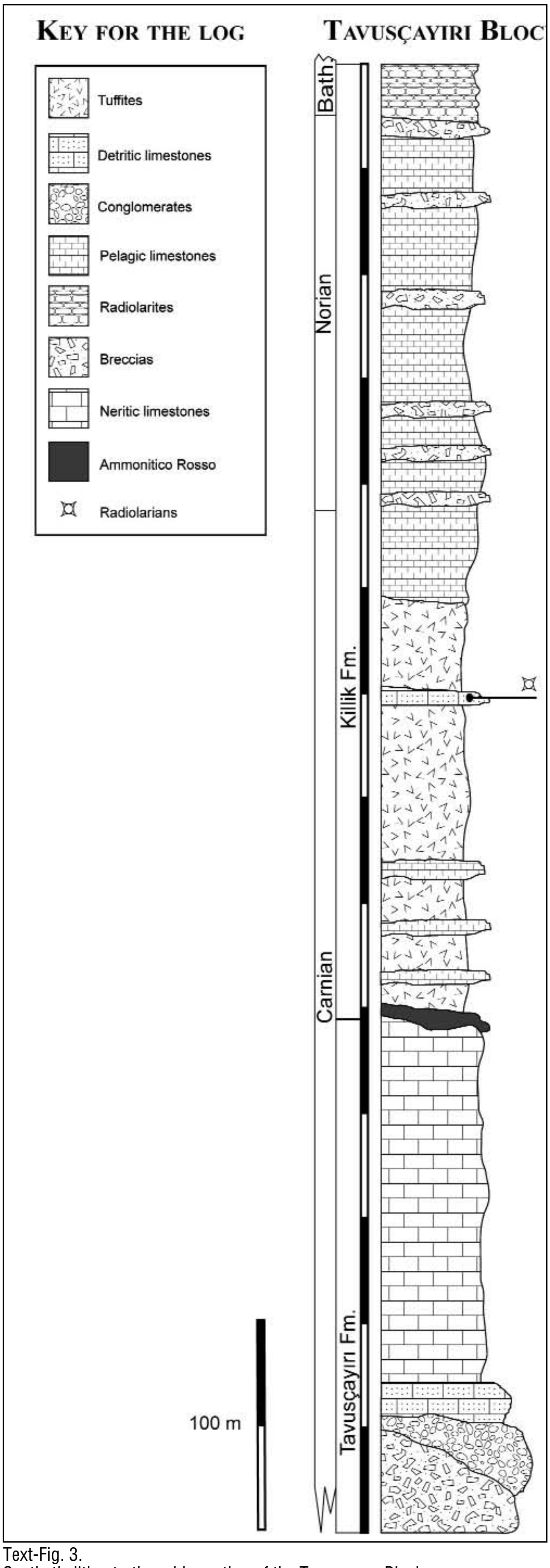
Unless otherwise indicated, the type locality of the new species described below is in the Huğlu Unit of the Mersin Ophiolitic Mélange north of Erdemli (Mersin, southern Turkey) (Text-Figs. 1, 2). The investigated section corresponds to the Tavusçayırı Block, previously described in several publications (MASSET & MOIX, 2004; MOIX et al., 2007; KOZUR et al., 2007a, b, c). The type stratum is a limestone within a thick tuff interval, from which a sample was taken (G11, see Text-Fig. 3) that has yielded numerous well preserved radiolarians representative of the lower Tuvalian *Spongotortilispinus moixi* Zone. All illustrated material has been deposited in the Hungarian Natural History Museum in Budapest.

Order: Spumellaria EHRENBERG 1875
Family: Capnuchosphaeridae DE WEVER 1979
Subfamily: Capnuchosphaerinae DE WEVER 1982
Genus: *Capnuchosphaera* DE WEVER 1979 emend.

Type species: *Capnuchosphaera triassica* DE WEVER 1979.

Occurrence: Carnian to middle Norian, worldwide.

Remarks: In the original diagnosis, DE WEVER et al. (1979) mentioned that the shell may or may not have spines. Numerous very small, needle-like spines may occur in a number of different typical *Capnuchosphaera* species, but there is a particular subset of these species that have very long, needle-like but strong spines which may be as long as the tumidaspinae. These forms are separated as an independent genus, *Spinocapnuchosphaera* n. gen. (see below). Doing this, however, requires an emendation of *Capnuchosphaera* to exclude forms with such long needle-like spines. BLOME (1983) and PESSAGNO et al. (1979) published an emended diagnosis of *Capnuchosphaera*, in which they did not mention any such big spines except for the tumidaspinae. They did report a medullary shell in some forms that they assigned to *Capnuchosphaera*, which also have tricarinate main spines. We



Text-Fig. 3.
Synthetic lithostratigraphic section of the Tavusçayırı Block.
Location is shown on Text-Fig. 2.

have not found any typical *Capnuchosphaera* which posses these features so we conclude that they probably do not belong to this genus. Perhaps a very fragile, as yet undetected medullary shell may be present in a few forms. DE WEVER et al. (2001) assigned *Capnuchosphaera* to the Entactinaria, but we have opened hundreds of well preserved shells and never found any sign of an inner spicular system and DE WEVER et al. (2001) also reported that they never found any trace of an entactinarian spicular system. Therefore, in the absence of any evidence for an inner spicular system, we henceforth regard the Capnuchosphaeridae as Spumellaria.

Spinocapnuchosphaera n. gen. is distinguished by its possession of some needle-like but strong and long spines which may be as long as the tumidaspinae.

Capnuchosphaera barnabasi n. sp.

(Pl. 2, Fig. 1)

Derivatio nominis: For Barnabás OZSVÁRT, Szentendre (Hungary) who is Péter OZSVÁRT's oldest son.

Holotypus: The specimen on Pl. 2, Fig. 1, Rep.-no. M 2009.1.1., Holder no. 23-9-04/V-97.

Material: More than 100 specimens.

Diagnosis: Cortical shell spherical, single layered but with an incomplete second layer. Tetragonal to mostly polygonal pore frames with high walls that bear pointed nodes or short needle-like spines at the vertices. Some of the pores are subdivided by fragile bars which represent a second layer that typically is not preserved. The three tumidaspinae are arranged in one plane with an angle of 120 degrees separating them. The spinal tunnel and spinal tumor either are not separated or only slightly separated from each other, and together they form a short, spindle-like structure. The distal part of the spinal tumor is very elongated, tricarinate and changes gradually into the extremely long (twice as long as the remaining tumidaspina), needle-like spinal shaft that is in its basal part also tricarinate. The length of the spinal shaft can differ within a single specimen, and one is generally longer than the other two, which even so are very long. The large oval tumidapores are well-developed.

Remarks: *Capnuchosphaera crassa* YEH 1990 has a somewhat longer spinal tunnel and a significantly shorter spinal shaft. *Capnuchosphaera* n. sp. aff. *C. barnabasi* n. sp. (Pl. 2, Fig. 2) is very similar, but the tumidaspinae have a nearly bipolar arrangement because two of them are very close and attached to each other in their proximal part, while the third tumidaspina is situated on the opposite side of the shell.

Capnuchosphaera borbalae n. sp.

(Pl. 1, Fig. 2)

Capnuchosphaera deweveri KOZUR & MOSTLER 1979 emend. BLOME 1983, pars – YEH 1990, p. 8, only Pl. 2, Fig. 5

Derivatio nominis: In honour of Borbála ERDŐS who is the wife of one of the authors (Péter Ozsvárt).

Holotypus: The specimen on Pl. 1, Fig. 2, Rep.-no. M 2009.3.1., Holder no. 23-9-04/VI-29.

Material: More than 50 specimens.

Diagnosis: Big spherical double-layered cortical shell. Inner layer with numerous small to very small circular to oval and polygonal pores. Outer layer with large tetragonal to polygonal (rarely triangular) pore frames with small spines at vertices. The three tumidaspinae, of equal to sometimes slightly different length and one and a half to slightly more than two times longer than the diameter of the cortical shell, are arranged in a single plane with an angle of 120 degrees separating them. Spinal tunnel relatively short, smooth and bearing slightly depressed grooves longitudinally on proximal portion. Spinal tumor wide, strongly twisted, with three narrow or moderately wide ridges not subdivided by a median furrow. Furrows between the ridges deep, either wider distally than proximally or of the same width throughout their length. The tumidaspinae terminate in an exceptionally long, slightly curved, needle-like spinal shaft that is slightly broader proximally than distally. Spinal shaft is two-thirds to three-fourths of the total length of a given tumidaspina.

Occurrence: Lower Tuvalian of Mersin Mélange and probably from the lower Tuvalian in an upper Anisian to lower Norian mixed fauna from Busuanga Island, Philippines.

Remarks: *C. deweveri* has no spines at the vertices of the outer layer of the cortical shell, a narrower spinal tumor and a considerably shorter terminal shaft on the tumidaspinae. YEH (1990) assigned several different species to the taxon *C. deweveri*, and one of his illustrated specimens (YEH, 1990, Pl. 2, Fig. 5) belongs to *C. borbalae* n. sp. The species *C. tortuospinosa* n. sp. and *C. mersinensis* n. sp. are distinguished from *C. borbalae* n. sp. by a median furrow that is present proximally on the very wide ridges of the spinal tumor.

Capnuchosphaera bragini n. sp.

(Pl. 1, Fig. 7)

Capnuchosphaera sp. – BRAGIN 1986, Pl. 1, Fig. 10.

Derivatio nominis: In honour of Prof. Dr. Nikita Yu. BRAGIN, Moscow, for his outstanding work on Triassic radiolarians and stratigraphy.

Holotypus: The specimen on Pl. 1, Fig. 7, Rep.-no. M 2009.4.1., Holder no. 8–12–03/I-8.

Material: 12 specimens.

Diagnosis: Medium-sized spherical double-layered cortical shell. Inner layer fragile (often only partly preserved), with numerous very small pores with roundish, oval and irregular outlines. Outer layer with triangular to mostly polygonal pore frames separated by strongly elevated ridges between the pores. Numerous very thin, fragile and often not preserved, small, needle-like spines are present at the vertices. The three robust tumidaspinae of approximately equal length are about one and a half to two times longer than the diameter of the cortical shell, and arranged in one plane with an angle of 120 degrees separating them. Spinal tunnel long, smooth, circular to subcircular in cross section, and gradually widening slightly toward the distal end. Shallow furrows sometimes present on the distal part of the spinal tunnel. Spinal tumor flares slightly to moderately strongly, rather abruptly, and bears three large terminal pores. The spinal shaft is moderately long, needle-like, somewhat wider proximally, narrows slightly in its mid-length and then becomes very narrow toward its distal end.

Occurrence: Lower Tuvalian of Mersin Mélange, upper Carnian (Tuvalian) of Sakhalin.

Remarks: *Capnuchosphaera* sp. BRAGIN 1986 is identical with our new species. A late Carnian to middle Norian age is indicated for the illustrated specimen. TEKIN (1999) assigned a lower Norian species to *Capnuchosphaera concava* DE WEVER 1979, but it does not belong to this species because it has a much shorter spinal tunnel. This form is very similar to *Capnuchosphaera bragini*, but it has no needle-like small spines on the cortical shell. This may be due to bad preservation in TEKIN's material. In one illustrated specimen (TEKIN, 1999, Pl. 3, Fig. 6) the tumidaspinae show a slight widening in their middle part. Seemingly, as in *Capnuchosphaera lea* DE WEVER 1979, the cortical shell has only one layer.

Capnuchosphaera ciliciensis n. sp.

(Pl. 2, Fig. 4)

Derivatio nominis: In allusion to its occurrence in Cilicia, the ancient name of the southeastern coast of Asia Minor.

Holotypus: The specimen on Pl. 2, Fig. 4, Rep.-no. M 2009.6.1., Holder no. 23-9-04/V-93.

Material: More than 100 specimens.

Description: Double-layered spherical cortical shell. Inner layer with numerous oval and circular pores; outer layer with tetragonal to mostly polygonal pore frames separated by strongly elevated ridges bearing very small pointed cones to conical spines at the vertices. The ridges between the pores are arranged in irregular lines. Smooth tumidaspinae of equal length are arranged in a single plane with an angle of 120 degrees separating them. Tumidaspinae approximately one and a half times longer than the diameter of the cortical shell. Spinal tunnel of tumidaspinae is relatively long and smooth. Spindle-shaped spinal tumor develops gradually from the spinal tunnel and may have a shallow indistinct longitudinal depression. Its distal part is relatively short, with three high ridges that rapidly lower towards the spinal shaft and border three drop-shaped tumidapores. Spinal shaft long (if fully preserved almost half of the total length of a given tumidaspina), straight, and needle-like.

Occurrence: Lower Tuvalian of the Mersin Mélange, SE Turkey.

Remarks: *Capnuchosphaera crassa* YEH 1990 has a single-layered cortical shell and a strongly widened spinal tumor with a longer three-ridged distal part. *Capnuchosphaera* cf. *ciliciensis* n. sp. is transitional to *C. crassa*. It has a relatively short spinal tunnel and a strongly widened spinal tumor with a longer distal part, which are features present (shape of spinal tumor) or possibly present (length of spinal tunnel) in *C. crassa*. In contrast, the spinal shaft, when fully preserved, is long and the outer pores may be subdivided by bars representing an incomplete inner layer. *Capnuchosphaera barnabasi* n. sp. is distinguished from this species by the presence of only a single layered cortical shell, a shorter spinal tunnel, a longer distal part of the spinal tumor, and a much longer spinal shaft.

Capnuchosphaera crassa YEH 1990

(Pl. 2, Figs. 5, 7)

Capnuchosphaera crassa YEH 1990, p. 8, Pl. 1, Figs. 8, 11–13, 18, 19.

Occurrence: Probably lower Tuvalian part of an upper Illyrian to lower Tuvalian mixed fauna from radiolarites from Busuanga Island, Philippines; lower Tuvalian from the Mersin Mélange, SE Turkey and from Pizzo Mondello in western Sicily.

Remarks: The upper Tuvalian or lower Norian *Capnuchosphaera crassa* sensu GORIČAN et al. (1999) has a strongly separated subspherical spinal tumor. It is similar to the lower Norian *C. crassa* sensu TEKIN (1999, Pl. 3, Fig. 11), which has, however, a shorter spinal tunnel. The other specimen assigned by TEKIN (1999, Pl. 3, Fig. 10) to C. crassa has a bigger shell compared with its tumidaspinae.

Capnuchosphaera crassa crassa YEH 1990

(Pl. 2, Fig. 5)

Capnuchosphaera crassa YEH 1990, p. 8, Pl. 1, Figs. 8, 11–13, 18, 19.

Occurrence: As for the species.

Remarks: This form was well described and documented by YEH (1990), but later other younger, early Norian species also were assigned to *C. crassa* which are distinguishable either by a much bigger cortical shell or by a strongly widened spinal tumor with a longer spinal shaft (TEKIN [1999], and following him BRAGIN [2007]).

Capnuchosphaera crassa yforma n. subsp.

(Pl. 2, Fig. 7)

Derivatio nominis: In allusion to its tumidaspinae, which are arranged in a "Y"-shape.

Holotypus: The specimen on Pl. 2, Fig. 7, Rep.-no. M 2009.9.1., Holder no. 23-9-04/III-107.

Material: One specimen.

Diagnosis: Single-layered spherical cortical shell, with tetragonal to hexagonal pore frames. Walls between the pores elevated, with very small conical pointed nodes at the vertices. The three long tumidaspinae are arranged in a "Y"-shape, but in a single plane. Spinal tunnel long, smooth, mostly slightly widened in their distal direction or the same width along their whole length. Spindle-shaped, moderately widened spinal tumor develops gradually from the spinal tunnel. Its tricarinate distal part is relatively short. Tumidapores moderately large, drop-shaped; spinal shaft short.

Occurrence: Basal Tuvalian from the Mersin Mélange, SE Turkey.

Remarks: *Capnuchosphaera crassa yforma* n. subsp. is distinguished from *C. crassa crassa* YEH 1990 by its Y-shaped arrangement of the tumidaspinae. The differences in the arrangement of the tumidaspinae may be a pathologic feature, especially in view of the fact that only one specimen has been found. For this reason, we recognize this form only as a subspecies.

Capnuchosphaera cylindrica n. sp.

(Pl. 1, Figs. 10, 11)

Capnuchosphaera sp. cf. *C. lea* DE WEVER – NICORA et al. 2007, Pl. 6, Fig. 7.

Derivatio nominis: In allusion to its slender cylindrical tumidaspinae.

Holotypus: The specimen on Pl. 1, Fig. 10, Rep.-no. M 2009.10.1., Holder no. 23-9-04/III-152.

Material: More than 100 specimens.

Diagnosis: The cortical shell is spherical to subspherical and consists of a single layer. A few pores are subdivided by very fragile bars which may represent a very indistinct and fragile second layer. Other roundish to pentagonal, occasionally hexagonal large pores are separated from each other by slightly to moderately elevated ridges that bear very small, needle-like spines at the vertices. The three long, cylindrical tumidaspinae are of equal length, arranged in a single plane with an angle of 120 degrees separating them and are approximately one and a half times longer than the diameter of the cortical shell. Spinal tunnel exceptionally long, smooth, and cylindrical. Spinal tumor either elongated, only slightly or not at all widened or short, slightly to moderately widened, with three shallow depressions in the widened part. Tumidapores large. The tumidaspinae terminate in a moderately long, straight, needle-like spinal shaft that is equal to approximately one-third of the total length of a given tumidaspina.

Occurrence: Lower Tuvalian of Mersin Mélange, SE Turkey, and Lagonegro Basin, southern Italy; lower Norian of Pizzo Mondello, western Sicily.

Remarks: *Capnuchosphaera lea* DE WEVER 1979 is smaller than this species and has shorter tumidaspinae with a shorter spinal tumor and a shorter spinal shaft. *C. lea* sensu YEH (1990) which does not belong to that species is similar to this new species, but the spinal tunnel of the slender tumidaspinae is distinctly widened in its middle part as compared to our new form.

Capnuchosphaera cylindrica cylindrica n. subsp.

(Pl. 1, Fig. 10)

Capnuchosphaera sp. cf. *C. lea* DE WEVER – NICORA et al. 2007, Pl. 6, Fig. 7.

Holotypus: As for the species.

Material: More than 50 specimens.

Diagnosis: With the characteristics of the species. In addition, spinal tumor elongated, not widened or only indistinctly widened.

Remarks: In *Capnuchosphaera cylindrica retusaspinosa* n. subsp., described below, the spinal tumor is distinctly widened, shorter and has shallow longitudinal depressions between the widened parts.

Capnuchosphaera cylindrica retusaspinosa n. subsp.

(Pl. 1, Fig. 11)

Derivatio nominis: In allusion to the blunt to broadly rounded end of its spinal tumor.

Holotypus: The specimen on Pl. 1, Fig. 11., Rep.-no. M 2009.11.1., Holder no. 23-9-04/V-104.

Material: More than 50 specimens.

Diagnosis: With the characteristics of the species. In addition, the slightly, but distinctly widened spinal tumor is short, blunt or broadly rounded, and has three shallow longitudinal depressions between its widened parts.

Remarks: See under the remarks of species and under the remarks of *Capnuchosphaera cylindrica cylindrica* n. subsp.

Capnuchosphaera goestlingensis KOZUR, MOSTLER & OZSVÁRT n. sp.

(Pl. 2, Fig. 11)

Capnuchosphaera n. sp. aff. *C. triassica* DEWEVER – KOZUR & MOSTLER 1979, p. 75, Pl. 10. Fig. 3.

Derivatio nominis: In allusion to its occurrence at the locality of Göstling, Austria.

Holotypus: The specimen illustrated by KOZUR & MOSTLER (1979) on Pl. 10, Fig. 3.

Material: 8 specimens.

Locus typicus: Göstling, Austria.

Stratum typicum: Upper Göstling Limestone, bed Y-6 (KOZUR & MOSTLER, 1994), lower *Austrotrachyceras austriacum* Zone, lower part of upper Julian.

Diagnosis: Subspherical, single-layered cortical shell, in upper view subtriangular to subcircular in outline (perpendicular to the plane of tumidaspinae). Pores small, roundish to oval. The three short tumidaspinae of equal length are arranged in a single plane with an angle of 120 degrees separating them. Spinal tunnel short, broad, smooth. Spinal tumor longer than spinal tunnel, distinctly widened, with three narrow, twisted, high ridges of equal width present throughout their length. Spinal shaft very short, needle-like, very narrow.

Occurrence: Lower part of upper Julian Göstling Limestone of Austria; lower Tuvalian of Mersin Mélange, SE Turkey.

Remarks: *Capnuchosphaera triassica* DE WEVER 1979 has, in contrast to this form, a clearly double-layered, spherical shell. The three twisted ridges of the spinal tumor are wide proximally but distally very narrow.

Capnuchosphaera gracilispinosa n. sp.

(Pl. 1, Figs. 4, 5)

Derivatio nominis: In allusion to its very slender, fragile spinal shaft.

Holotypus: The specimen on Pl. 1, Fig. 4, Rep.-no. M 2009.13.1., Holder no. 23-9-04/V-102.

Material: More than 100 specimens.

Diagnosis: Relatively small, spherical, double-layered cortical shell. Inner layer with numerous small to very small circular to oval and polygonal pores. Outer layer with large tetragonal to polygonal, rarely triangular pore frame with very small spines at vertices. The three tumidaspinae are robust, of equal length, approximately one and a half times longer than the diameter of the cortical shell, and arranged in a single plane with an angle of 120 degrees between them. Spinal tunnel long, broad, smooth, distinctly widened distally. Spinal tumor wide, strongly twisted, with three proximally widened ridges not subdivided by a median furrow. The initial portion of the ridges runs either obliquely to the axis of the tumidaspina or nearly horizontal to it and then forms a blade-like crest. Furrows between the ridges deep and broad. Spinal shaft very slender and fragile, needle-like, mostly broken away. If not broken, the length of spinal shaft is approximately half of the total length of a given tumidaspina. However, in *Capnuchosphaera gracilispinosa turkensis* n. subsp. so far only forms with short spinal shafts have been found.

Occurrence: Lower Tuvalian of Mersin Mélange.

Remarks: *Capnuchosphaera triassica* DE WEVER 1979 has a larger cortical shell with less distinct spines at the vertices of the outer pore frames, and the terminal spinal shaft is much smaller (if preserved). *C. borbalae* n. sp. has more distinct spines at the vertices of the outer pore frames and a longer and not so fragile spinal shaft. Two subspecies, *C. gracilispinosa gracilispinosa* and *C. gracilispinosa turkensis* are distinguished below.

Capnuchosphaera gracilispinosa gracilispinosa n. subsp.

(Pl. 1, Fig. 4)

Holotypus: As for the species.

Material: More than 100 specimens.

Diagnosis: With the characteristics of the species. Additionally, initial portion of the ridges of the spinal tumor runs obliquely to the axis of the tumidaspinae. Spinal shaft, if preserved, very long.

Remarks: In *Capnuchosphaera gracilispinosa turkensis* n. subsp. the initial portion of the blades of the spinal tumor protrudes nearly horizontally, forming a blade-like crest.

Capnuchosphaera gracilispinosa turkensis n. subsp.

(Pl. 1, Fig. 5)

Derivatio nominis: In reference to its occurrence in Turkey.

Holotypus: The specimen on Pl. 1, Fig. 5, Rep.-no. M 2009.14.1., Holder no. 23-9-04/IV-36.

Material: 5 specimens.

Diagnosis: With the characteristics of the species. Additionally, the initial portion of the blades of the spinal tumor protrudes nearly horizontally, forming a blade-like crest. The distal portion of the blades is oblique. The preserved spinal shaft is very short and very fragile.

Remarks: In *Capnuchosphaera gracilispinosa gracilispinosa* n. subsp. no blade-like crest is present along the proximal part of the spinal tumor, which is formed by the horizontally protruding initial portion of the blades in this subspecies.

Pathological ? *Capnuchosphaera gracilispinosa* n. sp.

(Pl. 1, Fig. 6)

Remarks: Only one specimen is present in which the tumidaspinae are arranged at quite different angles. In other respects, it is similar to *C. gracilispinosa* though there are also some differences in the shell structure. As there is only one specimen, and it may represent a pathology, it should not be described for now as an independent species.

Capnuchosphaera mersinensis n. sp.

(Pl. 1, Fig. 3)

Derivatio nominis: In reference to its occurrence in the Mersin Mélange, Turkey.

Holotypus: The specimen on Pl. 1, Fig. 3, Rep.-no. M 2009.16.1., Holder no. 23-9-04/III-63.

Material: More the 50 specimens.

Diagnosis: Small spherical double-layered cortical shell. Inner layer with numerous very small to small roundish and oval pores; outer layer with large tetragonal to polygonal pore frames with minute spines at vertices. The three tumidaspinae are of equal length, more than three times longer than the diameter of the cortical shell, and arranged in a single plane with an angle of 120 degrees between them. Spinal tunnel smooth, relatively short, circular in cross-section. Spinal tumor wide, strongly twisted, with three high ridges, proximally very broad and distally narrow, that have in their proximal region a very broad but very shallow median furrow, the margins of which are slightly elevated to narrow ridges only at the beginning and end of the median furrow. Furrows between the primary ridges are deep, and wider distally than proximally. Terminal spinal shaft very long, straight or slightly curved distally, needle-like, usually somewhat wider proximally than distally.

Occurrence: Lower Tuvalian of the Mersin Mélange and the Lagonegro Basin.

Remarks: *Capnuchosphaera triassica* DeWever 1979 (typical forms which probably are of early Tuvalian age) is mainly distinguished from this species by the very short terminal spinal shaft; otherwise it is quite similar. The middle Carnian *C. deweveri* has no distinct spines at the vertices of the outer pore frames, the ridges of the spinal tumor are less twisted and the terminal spinal shaft is shorter. The upper Tuvalian *C. deweveri* does not belong to *C. deweveri*, but is more similar to *Capnuchosphaera mersinensis* n. sp. It is distinguished from this new species by the narrow ridges on the spinal tumor, which have no median furrow. The very similar *Capnuchosphaera tortuospinosa* n. sp. is distinguished by very small but distinct spines on the vertices of the outer pore frame, and always has a straight needle-like terminal spinal shaft that has the same width throughout its entire length. The ridges of the spinal tumor are proximally not as wide as in *C. mersinensis*, their median furrow is narrower but deeper and the secondary ridges are more distinct.

Capnuchosphaera mostleri n. sp.

(Pl. 1, Fig. 9)

Derivatio nominis: In honour of Univ.-Prof. Dr. Helfried Mostler, Innsbruck, for his outstanding contributions to radiolarian research.

Holotypus: The specimen on Pl. 1, Fig. 9, Rep.-no. M 2009.17.1., Holder no. 23-9-04/I-113.

Material: 5 specimens.

Diagnosis: The cortical shell is subspherical and apparently consists of a single layer; though some pores are subdivided by very fragile, thin bars that may represent a second layer. Pore frames pentagonal to hexagonal, partly elongated. The three long tumidaspinae are of about equal length and arranged in a single plane with an angle of 120 degrees between them. They are approximately one and a half times longer than the diameter of the cortical shell. Spinal tunnel long, smooth and circular in cross section widening slightly toward its distal end. Spinal tumor elongated and not widened. Its distal part is pyramidal with three well developed ridges that have a wide base and a narrow distal part. It bears three relatively large, oval, well-developed tumidapores. The tumidaspinae terminate in a short, straight, needle-like spinal shaft.

Occurrence: Lower Tuvalian of the Mersin Mélange.

Remarks: *Capnuchosphaera cylindrica* n. sp. has longer and narrower cylindrical tumidaspinae and numerous very small spines on the cortical shell. *Capnuchosphaera lea* De Wever 1979 is smaller and has shorter tumidaspinae that have a very short spinal tumor.

Capnuchosphaera multispinosa n. sp.

(Pl. 3, Fig. 2)

Derivatio nominis: In allusion to its long secondary spines on the tumidaspinae.

Holotypus: The specimen on Pl. 3, Fig. 2, Rep.-no. M 2009.18.1., Holder no. 27-11-04/II-125.

Material: 7 specimens.

Diagnosis: Double-layered cortical shell subspherical to spherical, with subtriangular, subcircular or circular outline in upper view (perpendicular to the plane of tumidaspinae). Inner layer with very small roundish and oval pores, often only partly preserved. Outer pore frames trigonal to pentagonal with small to moderately large pores, only slightly separated from the inner layer. The large tumidaspinae are arranged in a single plane with 120 degrees separation between each other. Spinal tunnel moderately long to long, smooth, in the proximal part sometimes with some small pores. Spinal tumor large, in the proximal part with three very long, needle-like, basally somewhat broader lateral spines that may be basally bifurcated, so that at most five lateral spines can be observed on any one spinal tumor. The distal part of the spinal tumor is large, pyramidal with three high and narrow ridges and a wide, moderately deep furrow between them. Spinal shaft needle-like, short.

Occurrence: Lower Tuvalian of the Mersin Mélange, SE Turkey.

Remarks: *Capnuchosphaera tumorspinosa* n. sp. has well developed lobes at the distal margin of the spinal tumor which terminates in a long spine. These lobes in *C. multispinosa* n. sp. are reduced to a point that they appear to be only a broadened base of the spines.

Capnuchosphaera oesii n. sp.

(Pl. 1, Fig. 12)

Derivatio nominis: In honour of Dr. Attila ŐSI, Budapest, for his outstanding work on Cretaceous Ankylosauria (Dinosauria) from Hungary.

Holotypus: The specimen on Pl. 1, Fig. 12, Rep.-no. M 2009.20.1., Holder no. 23-9-04/V-106.

Material: 3 specimens.

Diagnosis: The cortical shell is circular in outline and consists of a single layer with pentagonal to polygonal pore frames. The walls between the pores are elevated and have very short spines to pointed nodes at the vertices. Tumidaspinae are of equal length, relatively long (about 1.5 x longer than the diameter of cortical shell) and arranged in a single plane with an angle of 120 degrees between them. Spinal tunnel long, circular in cross section, smooth, widens slightly in distal direction to about the middle part and then tapers again slightly. Spinal tumor not widened, with relatively large tumidapores. The tumidaspinae terminate in a rather massive, long, slightly curved needle-like spinal shaft that tapers gradually in its distal direction. Length of spinal shaft is approximately equal to maximum length of its respective spinal tunnel.

Remarks: In *Capnuchosphaera bragini* n. sp. the spinal tumor is distinctly widened and the spinal shaft is somewhat shorter than in this form. The spines on the cortical shell are needle-like and somewhat longer. *Capnuchosphaera mostleri* n. sp. has a longer spinal tumor and a shorter spinal shaft.

Capnuchosphaera ottomanensis n. sp.

(Pl. 2, Figs. 8, 10)

Derivatio nominis: In allusion to its occurrence in an area that once was a part of the former Ottoman Empire.

Holotypus: The specimen on Pl. 2, Fig. 8, Rep.-no. M 2009.21.1., Holder no. 23-9-04/V-101.

Material: More than 50 specimens.

Diagnosis: Cortical shell subspherical to spherical and double-layered. Inner layer bears numerous small oval to circular pores; outer layer with large pentagonal to hexagonal pore frames with elevated walls that bear small conical to somewhat longer needle-like spines at the vertices. Tumidaspinae of equal length, broad and arranged in a single plane with either an angle of 120 degrees between all of them or else with two tumidaspinae much closer to each other but symmetrically arranged relative to the third one. Tumidaspinae approximately one and a half times longer than the diameter of the cortical shell. Spinal tunnel short to very short, proximally with roundish to oval pores that have indistinct longitudinal ridges between them, distal part smooth and mostly without pores. Spinal tumor large, merged with or only indistinctly separated from the spinal tunnel, the length of its distal part variable but with blunt, rounded, or rarely pointed ends. The tumidapores are very large. Spinal shaft very long, needle-shaped, with a uniformly narrow diameter throughout its length.

Occurrence: Basal Tuvalian from the Mersin Mélange, SE Turkey.

Remarks: Differs from *Capnuchosphaera lea* DEWEVER 1979 in that *C. lea* has a single-layered shell, its spinal tunnel is much longer, and the spinal shaft is short with broad tumidapores and long spinal shaft.

Capnuchosphaera ottomanensis ottomanensis n. subsp.

(Pl. 2, Fig. 8)

Derivatio nominis and holotype: As for the species.

Material: More than 50 specimens.

Diagnosis: With the characteristics of the species. Additionally, tumidaspinae arranged so that there is an angle of 120 degree between any two adjacent spines or the angle between two spines is a little less than the angles to the third spine. Distal end of the spinal tumor blunt or broadly rounded.

Occurrence: Tuvalian from the Mersin Mélange, SE Turkey.

Remarks: *Capnuchosphaera ottomanensis carterae* n. subsp. is distinguished by the arrangement of the tumidaspinae, in that two of them are much more closely spaced to each other than to the third one. Moreover, the distal end of the tumidaspinae is pointed or narrowly rounded, and part of the spinal tumor is distinctly separated from the spinal tunnel and its distal part is longer.

Capnuchosphaera ottomanensis carterae n. subsp.

(Pl. 2, Fig. 10)

Derivatio nominis: In honour of Prof. Dr. Elisabeth S. CARTER, Portland State University.

Holotypus: The specimen on Pl. 2, Fig. 10, Rep.-no. M 2009.23.1., Holder no. 23-9-04/V-100.

Material: 4 specimens.

Diagnosis: With the characteristics of the species. Additionally, two tumidaspinae are much closer to each other than to the third one. The spinal tumor is slightly to distinctly separated from the spinal tunnel, its distal end is narrowly rounded to pointed and (in the latter case) the distal part of the spinal tumor is rather long.

Occurrence: Lower Tuvalian from the Mersin Mélange, SE Turkey.

Remarks: *Capnuchosphaera ottomanensis ottomanensis* n. subsp. is distinguished by the arrangement of the tumidaspinae, with an angle less than 120 degrees between two of them. Additionally, the distal ends of the tumidaspinae are always blunt to broadly rounded.

Capnuchosphaera tortuospinosa n. sp.

(Pl. 1, Fig. 1)

? *Capnuchosphaera deweveri* KOZUR & MOSTLER 1979 emend. BLOME 1983, pars – YEH 1979, p. 8, only Pl. 10, Fig. 8.

Derivatio nominis: In allusion to its strongly twisted tumidaspinae.

Holotypus: The specimen on Pl. 1, Fig. 1, Rep.-no. M 2009.24.1., Holder no. 23-9-04/I-19.

Material: 10 specimens.

Diagnosis: Double-layered spherical cortical shell. Inner layer with numerous small to very small roundish to oval pores, outer layer with large polygonal pore frames with strongly elevated ridges and indistinct very short spines at vertices. The three tumidaspinae are of equal length, more than twice as long as the diameter of the cortical shell, and arranged in a single plane with an angle of 120 degrees separating them. Spinal tunnel smooth, relatively short, and circular in cross-section. Spinal tumor wide, strongly twisted, with three proximally broad but distally narrow high ridges that are proximally divided into two ridges separated by a shallow, narrow furrow. Furrows between the primary ridges deep, proximally narrow, distally wide. Terminal spinal shaft very long, straight, needle-like, and of uniform diameter throughout its entire length.

Occurrence: Lower Tuvalian of Mersin Mélange. Most probably also present in the lower Tuvalian part of an upper Anisian to lower Norian mixed fauna from Busuanga Island, Philippines (YEH, 1990).

Remarks: In *C. deweveri* the tumidaspinae are more slender, their spinal tunnel is longer, the spinal tumor is less twisted and has proximally narrow ridges without a median furrow on the spinal tumor. The spinal shaft is shorter and somewhat broader.

YEH (1990, Pl. 10, Fig. 8) illustrated a form with corroded tumidaspinae that most probably belongs to *Capnuchosphaera tortuospinosa* n. sp. The character of the cortical shell and the very typical terminal spinal shaft are as in the new species. Due to the corrosion of the spinal tumor, it cannot be determined if the ridges are proximally subdivided by a median furrow or not. However, it can be seen that the spinal tumor is as broad as in *C. tortuospinosa* and not slender as in *C. deweveri*. Thus, the assignment of this form to *C. tortuospinosa* is probable, even though it cannot be excluded that this form belongs to an upper Tuvalian undescribed species assigned by BLOME (1983) to *C. deweveri*. TEKIN (1999) assigned two lower Norian specimens of two different species to *C. deweveri*. One of them (TEKIN, 1999, Pl. 3, Fig. 12) is similar to *Capnuchosphaera tortuospinosa* n. sp., but it is distinguishable from that taxon by its longitudinal ribs and pores on the proximal half of the spinal tunnel and by a much shorter terminal spinal shaft. The other specimen (TEKIN, 1999, Pl. 3, Fig. 13) is more similar to *C. deweveri*, but also distinguishable from that form by its radial ribs and pores in the proximal half of the spinal tunnel, and by its more twisted and less slender spinal tumor; it does, however, have proximal narrow ridges without a median furrow as in *C. deweveri*.

Capnuchosphaera tumorspinosa n. sp.

(Pl. 3, Fig. 1)

Derivatio nominis: In allusion to the long spines on the lobes of the spinal tumor.

Holotypus: The specimen on Pl. 3, Fig. 1, Rep.-no. M 2009.25.1., Holder no. 23-9-04/IV-92.

Material: More than 100 specimens.

Diagnosis: Subspherical, double-layered cortical shell, in upper view (perpendicular to the plane of tumidaspinae) subcircular to subtriangular. Inner layer with very small roundish to oval pores; outer layer with trigonal to polygonal (but mostly pentagonal) pore frames with elevated walls that may form indistinct ridges on the shell surface. Very small conical pointed nodes may be present at the vertices. The broad and moderately large tumidaspinae are of equal length and arranged in a single plane with an angle of 120 degrees between adjacent tumidaspinae. Length of tumidaspinae approximately equal to the diameter of the cortical shell. Spinal tunnel broad and moderately long. Spinal tumor with three triangular lobes, each bearing a long and obliquely outward-directed spine that distally becomes more slender. The outer margin of the lobes is marked by a ridge that connects adjacent lobes at the base of the spinal tumor. It is concave between lobes and runs along the triangular, distally directed margin of the lobes. This results in the basal ridge of the spinal tumor being strongly wavy. Tumidapores large. Distal part of spinal tumor large, robust, consisting of a tricarinate pyramid with shallow to moderately deep furrows between the ridges. Spinal shaft very short and needle-like.

Occurrence: Lower Tuvalian of the Mersin Mélange, SE Turkey, and of the Lagonegro Basin, Italy.

Remarks: *Capnuchosphaera tricornis* DE WEVER 1979 is distinguished from this species by the nearly straight basal ridge of its spinal tumor, which is nearly perpendicular to the spinal tunnel and not or only slightly wavy.

Capnuchosphaera tuvalica n. sp.

(Pl. 2, Fig. 12)

Derivatio nominis: In reference to its occurrence in the Tuvalian.

Holotypus: The specimen on Pl. 2, Fig. 12, Rep.-no. M 2009.26.1., Holder no. 23-9-04/I-138.

Material: More than 100 specimens.

Diagnosis: Relatively small, spherical to subspherical, double-layered cortical shell. Inner layer with very small circular and oval pores; outer layer with tetragonal to polygonal pore frames with only slightly elevated walls that bear very small conical pointed nodes at the vertices. The three large tumidaspinae are arranged in a single plane with an angle of 120 degree between adjacent tumidaspinae. Spinal tunnel long, smooth and of equal width throughout its length. Spinal tumor sharply separated from the spinal tunnel, proximally strongly widened by three obliquely outward-directed lobes connected by a ridge which is also present at the outer margin of the lobes, readily visible both on the lower and upper sides. The long distal part of the spinal tumor is tricarinate and pyramidal, with rather shallow and proximally wide furrows between the three broad ridges. Tumidapores relatively wide. Spinal shaft very long (much longer than the remaining part of the tumidaspinae), needle-like and very narrow along its entire length.

Remarks: *C. concava* has a larger shell than this species in comparison to the length of its tumidaspinae, the spinal shaft is much shorter, and there is no large, tricarinate and pyramidal distal part of the spinal tumor that strongly overreaches the lobes. In *C. tricornis* the proximal ridge of the spinal tumor is situated nearly perpendicular to the spinal tunnel, the three lobes of the spinal tumor end in a spine and the spinal shaft is much shorter. *Capnuchosphaera theloides* DE WEVER 1979 has a straight basal ridge on the spinal tumor that runs perpendicular to the spinal tunnel along the entire base of the spinal tumor. Additionally, the spinal shaft (if not broken or broken away) is much longer in *C. tuvalica* n. sp. than in *C. theloides*.

Capnuchosphaera cf. *C. palawanensis* YEH 1990

(Pl. 2, Fig. 3)

Capnuchosphaera palawanensis YEH 1990, p. 9, Pl. 2, Fig. 1; Pl. 10, Figs. 5, 6.

Occurrence: Tuvalian of the Mersin Mélange in SE Turkey, upper Illyrian to basal Tuvalian mixed fauna in cherts from Busuanga Island, Philippines.

Remarks: Our material corresponds well to *C. palawanensis* YEH, but the spinal shaft on all three tumidaspinae is broken, so we cannot determine the original length of the spinal shaft.

Genus: *Spinocapnuchosphaera* n. gen.

Type species: *Spinocapnuchosphaera tekini* n. sp.

Derivatio nominis: In allusion to its similarity to the genus *Capnuchosphaera* DE WEVER 1979 and the presence of long spines beside the tumidaspinae.

Diagnosis: Test consists of a spherical to subspherical, single or double-layered cortical shell, with three large tumidaspinae in a single plane, which are generally at angles of about 120 degrees from each other. Additionally, there are long, needle-like but rather robust spines that generally are not located in the same plane as the tumidaspinae. Inner features not yet known.

Remarks: The genus *Capnuchosphaera* DE WEVER 1979 is similar but lacks the large, needle-like spines present in *Spinocapnuchosphaera* on the test beside the tumidaspinae.

Occurrence: Very rare in the upper Julian of Hungary; common in the lower Tuvalian of Turkey, Rhodos island (Greece) and Lagonegro Basin (Italy).

Assigned species:
- *Spinocapnuchosphaera tekini* n. sp.
- *Spinocapnuchosphaera hantkeni* n. sp.
- *Spinocapnuchosphaera odoghertyi* n. sp.
- *Spinocapnuchosphaera szentei* n. sp.
- *Spinocapnuchosphaera szivesae* n. sp.
- *Spinocapnuchosphaera tricuspidata* n. sp.
- *Spinocapnuchosphaera venusta* n. sp.

Spinocapnuchosphaera tekini n. gen. n. sp.
(Pl. 3, Figs. 5–8)

Derivatio nominis: In honour of Dr. Uğur Kağan TEKIN, Ankara for his outstanding work on Triassic radiolarians from Turkey.

Holotypus: The specimen on Pl. 3, Fig. 5, Rep.-no. M 2009.28.1., Holder no. 23-9-04/V-111.

Material: More than 100 specimens.

Diagnosis: Test is composed of a large shell, three moderately large tumidaspinae and two to four relatively short needle-like spines. Spherical cortical shell single-layered, but a network of very fragile beams may be present on the inner side of the pore frames representing an indistinct inner layer. Pore frames polygonal with high walls that have very small needle-like spines on the vertices. The three long tumidaspinae are arranged in a single plane with an angle of 120 degrees between each of them. Tumidaspinae of approximately equal length, maximally more than twice as long as the diameter of the cortical shell when the spinal shaft is fully preserved. Spinal tunnel short, smooth, distinctly widening towards distal end. A shallow longitudinal furrow may be present. Spindle-shaped spinal tumor develops gradually from the spinal tunnel. It bears three oval, well-developed tumidapores. The tumidaspinae terminate in a long, normally straight but rarely curved, needle-like spinal shaft. Occasionally the terminal lobes of one of the tumidaspinae bear four to five relatively short spines. Additionally, the cortical shell bears usually two but rarely up to four long, needle-like but robust, rod-shaped spines. If two rod-shaped spines are present, they are oriented at right angles to the plane of the tumidaspinae. If there are more than two rod-shaped spines, they are irregularly distributed and not situated in the plane of the tumidaspinae.

Occurrence: Lower Tuvalian of the Mersin Mélange, SE Turkey; Rhodos island, Greece; and from the Lagonegro Basin, southern Italy.

Remarks: *Spinocapnuchosphaera hantkeni* n. sp. and *S. szentei* n. sp. differ from this species in that they have a blunt or wavy distal end of the spinal tumor.

Spinocapnuchosphaera tekini tekini n. subsp.
(Pl. 3, Figs. 5–6)

Derivatio nominis and holotype as for the species.

Material: More than 100 specimens.

Diagnosis: With the characteristics of the species. Additionally, always two large needle-like spines are present, situated at nearly a right angle to the plane of the tumidaspinae. Marginal spines on the distal end of the tumidaspinae never present.

Occurrence: As for the species.

Remarks: *Spinocapnuchosphaera tekini hugluensis* n. subsp., described next, has four irregularly distributed large, needle-like spines.

Spinocapnuchosphaera tekini hugluensis n. subsp.
(Pl. 3, Fig. 7)

Derivatio nominis: In reference to its occurrence in the Huğlu Unit of the Mersin Mélange.

Holotypus: The specimen on Pl. 3, Fig. 7, Rep.-no. M 2009.29.1., Holder no. 23-9-04/V-110.

Material: More than 10 specimens.

Diagnosis: With the characteristics of the species. Additionally, four slightly curved long, needle-like spines are present beside the tumidaspinae which are irregularly distributed but never located in the plane of the tumidaspinae.

Occurrence: Lower Tuvalian of the Mersin Mélange.

Remarks: *Spinocapnuchosphaera tekini tekini* n. subsp. has only two long, needle-like spines beside the tumidaspinae, and these are situated approximately perpendicular to the plane of the tumidaspinae.

Spinocapnuchosphaera tekini marginospinosa n. subsp.
(Pl. 3, Fig. 8)

Derivatio nominis: In allusion to the spines on the terminal lobes of one of the tumidaspinae.

Holotypus: The specimen on Pl. 3, Fig. 8, Rep.-no. M 2009.30.1., Holder no. 23-9-04/I-53.

Material: One specimen.

Diagnosis: With the characteristics of the species. Additionally, two long, needle-like spines are present beside the tumidaspinae which are situated approximately perpendicular to the plane of the tumidaspinae. In one of the tumidaspinae, the distal lobes of the spinal tumor bear relatively short spines on their distal ends that are directed obliquely outward.

Occurrence: In the lower Tuvalian of the Mersin Mélange.

Remarks: The otherwise similar *Spinocapnuchosphaera tekini tekini* n. subsp. has no spines on the distal lobes of the spinal tumor.

Spinocapnuchosphaera hantkeni n. gen. n. sp.
(Pl. 4, Fig. 1)

Derivatio nominis: In honour of Maximilian VON HANTKEN (1821–1893), an Austro-Hungarian-born mining engineer who was one of the pioneers of micropaleontology.

Holotypus: The specimen on Pl. 4, Fig. 1, Rep.-no. M 2009.31.1., Holder no. 23-9-04/V-232.

Material: 3 specimens.

Diagnosis: Double-layered spherical cortical shell. Inner layer robust, with numerous small triangular to oval or more rarely roundish pores. Pore frames of the outer layer are triangular to polygonal or very rarely roundish with large to moderately large, moderately elevated walls and vertices with nodes or very short spines. The three long tumidaspinae of equal length are arranged in a single plane with a slight variance in their angles (~ 110–130 degrees) relative to each other. Spinal tunnel relatively short, slightly widening toward its distal end. Spinal tumor distinctly wider than spinal tunnel, but not distinctly separated from it because it develops gradually from the spinal tunnel. The distal end of the spinal tumor is wavy. Three tumidapores are present. The spinal shaft is needle-like and long (more than half of the total length of the tumidaspinae). In addition, the cortical shell bears up to a few (but usually two) long, needle-like spines.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: *Spinocapnuchosphaera szentei* n. sp. (described below) is similar, but has many more needle-like large accessory spines. In addition, the walls between the pores of the outer layer are higher, and the inner layer is more fragile and therefore often not preserved in parts of the cortical shell.

Spinocapnuchosphaera odoghertyi n. gen., n. sp.

(Pl. 3, Fig. 10)

Derivatio nominis: In honour of Dr. Luis O'DOGHERTY, Cadiz, for his outstanding work on Cretaceous and Jurassic radiolarians from the Tethyan realm.

Holotypus: The specimen on Pl. 3, Fig. 10, Rep.-no. M 2009.32.1., Holder no. 27-11-04/II-99.

Material: 35 specimens.

Diagnosis: The double-layered cortical shell is spherical. Inner layer fragile, often not preserved, with numerous small roundish and oval pores. Outer layer with moderately large to small, tetragonal to polygonal pore frames with elevated walls that bear small conical spines on the vertices. The three long tumidaspinae are of equal length and arranged in a single plane with an angle of 120 degrees between them. They are approximately twice as long as the diameter of the cortical shell. Spinal tunnel short to moderately long, slender, with a uniform width or slightly widening either distally or in its central region. It is either smooth or has very small pores that are mostly closed by a layer of microgranular silica. Spinal tumor develops gradually from the spinal tunnel. Its distal part is tricarinate and develops gradually into a very robust, long, broad-based needle-like, straight to slightly curved spinal shaft. Tumidapores relatively small and triangular. In addition, the cortical shell bears two long, needle-like, straight or slightly curved spines.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: *Spinocapnuchosphaera venusta* n. sp. is distinguished from this species by its longer spinal tunnel and broader spinal tumor. Additionally, the spinal shaft is not as robust.

Spinocapnuchosphaera szentei n. gen. n. sp.

(Pl. 3, Fig. 12)

Derivatio nominis: In honour of Dr. István SZENTE of Budapest (Eötvös University) for his outstanding work on Mesozoic bivalves.

Holotypus: The specimen on Pl. 3, Fig. 12, Rep.-no. M 2009.33.1., Holder no. 23-9-04/VI-168.

Material: 13 specimens.

Diagnosis: Cortical shell double-layered and spherical. Inner layer bears numerous roundish and oval pores. Outer layer with moderately large to large, mainly pentagonal to hexagonal pore frames with high to very high walls bearing indistinct minute spines on the vertices. The three long tumidaspinae are of approximately equal length and arranged in a single plane with the angles between them varying from 110 to 130 degrees. Spinal tunnel short, tumid, slightly widening distally. Spinal tumor distinctly wider than spinal tunnel, but not distinctly separated from it because it develops gradually from the spinal tunnel. The distal end of the spinal tumor is blunt to wavy. The three tumidapores are large. The spinal shaft is long, needle-like (about half of the total length of the tumidaspinae). In addition, the cortical shell bears eight or more long, needle-like spines.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: Most similar is *Spinocapnuchosphaera hantkeni* n. sp., which has the same development of the tumidaspinae but differs in that it has far fewer (usually two) accessory spines. The walls between the pores of the outer layer are lower and the inner layer is more robust. *Spinocapnuchosphaera szivesae* n. sp. is distinguished by having a conical distal end on the spinal tumor that has three high and somewhat twisted blades. The accessory spines are proximally broader and tricarinate at least proximally.

Spinocapnuchosphaera szivesae n. gen. n. sp.

(Pl. 4, Fig. 2)

Derivatio nominis: In honour of Dr. Ottilia SZIVES, Hungarian Natural History Museum, Budapest for her outstanding work on Cretaceous ammonites.

Holotypus: The specimen on Pl. 4, Fig. 2, Rep.-no. M 2009.34.1., Holder no. 23-9-04/V-115.

Material: 2 specimens.

Diagnosis: Double-layered subspherical cortical shell. Inner fragile layer, partly broken away, with small to very small oval or roundish pores. Pentagonal, hexagonal, or very rarely roundish pore frames of the outer layer large to moderately large, walls elevated, vertices with very short spines. The three long tumidaspinae are of equal length and arranged in a single plane with variable angles (~ 90–140 degrees) between each other. Spinal tunnel moderately long and widening slightly distally. In its basal part, close to the cortical shell, short longitudinal lines of small indistinct pores are present that are situated in shallow furrows between indistinct low, short, longitudinal ridges. Spinal tumor distinctly wider than spinal tunnel, but not distinctly separated from it because it develops gradually from the spinal tunnel. The distal end of the spinal tumor is relatively long and conical, with three high, slightly twisted blades. Three large tumidapores are present. The spinal shaft is needle-like and long (but in both present specimens not fully preserved). In addition, the cortical shell bears several long spines (three are visible on one hemiglobe) that are basally or proximally tricarinate but distally needle-like.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: *Spinocapnuchosphaera hantkeni* n. sp. and *S. szentei* both have a blunt to wavy distal end of the spinal tumor. In *S. hantkeni* there are fewer and in *S. szentei* there are more accessory spines which are always needle-like.

Spinocapnuchosphaera tricuspidata n. gen. n. sp.

(Pl. 3, Fig. 9)

Derivatio nominis: In allusion to the triangular and three-bladed ends on its tumidaspinae.

Holotypus: The specimen on Pl. 3, Fig. 9, Rep.-no. M 2009.35.1., Holder no. 23-9-04/I-97.

Material: More than 50 specimens.

Diagnosis: The double-layered spherical cortical shell is relatively small. Inner layer with small roundish and oval pores. Large to moderately large pore frames of the outer layer trigonal to polygonal, with slightly elevated polygonal ridges that bear very short, indistinct, conical nodes on the vertices. Three large tumidaspinae are comprised of relatively long, smooth spinal tunnels of equal width. Spinal tumor consists of three triangular pointed, obliquely outward-directed lobes that are sharply separated from the spinal tunnel by a distinct narrow ridge connected with the marginal ridge of the adjacent lobes. Three wide tumidapores are present. Tumidaspinae terminate in large, three-bladed, pointed pyramids that bear a short, straight, needle-like spinal shaft. The ridges of this pyramid are connected with the outer ridge of the lobes of the spinal tumor. In addition, the cortical shell bears a long, needle-like, straight to subtly curved spine.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: So far, no species of *Spinocapnuchosphaera* similar to this form are known.

Spinocapnuchosphaera venusta n. gen. n. sp.

(Pl. 3, Fig. 11)

Derivatio nominis: In allusion to the aesthetically pleasing shape of its test.

Holotypus: The specimen on Pl. 3, Fig. 11, Rep.-no. M 2009.36.1., Holder no. 23-9-04/III-66.

Material: 8 specimens.

Diagnosis: The spherical cortical shell is indistinctly double-layered. The fragile inner layer has very small circular and oval pores; the outer layer has small polygonal pore frames with slightly elevated walls that bear very small, conical to needle-like spines on the vertices. The three long tumidaspinae are of equal length and arranged in a single plane. They are about twice as long as the diameter of the shell. Spinal tunnel long, smooth, and widens slightly distally. Spinal tumor distinct, moderately wide, with three moderately twisted rather high ridges that transform proximally to a high, narrow ridge that lies oblique to or nearly perpendicular to the spinal tunnel and clearly separates the spinal tunnel from the spinal tumor. Adjacent ridges on any given specimen are partly connected on the distal end of the spinal tunnel and partly interrupted. Tumidapores well-developed and relatively large. The distal part of the spinal tumor is pointed and terminates in a long, straight, needle-like spinal shaft. In addition to the tumidaspinae, the cortical shell also bears two long, needle-like, straight to faintly curved spines situated nearly perpendicular to the plane of the tumidaspinae.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: The spinal tumor of *Spinocapnuchosphaera odoghertyi* is more slender than in this species, is not so clearly separated from the spinal tunnel by rather high twisted ridges, and the spinal shaft is more robust and distinctly broader at its base.

Pathological *Spinocapnuchosphaera* sp.

(Pl. 4, Fig. 3)

Remarks: There is one specimen from a *Spinocapnuchosphaera* in which two spinal shafts are present in the distal part of one tumidaspina, while in the other two only one spinal shaft can be seen (the other one broken away?). All of these spinal shafts have their origin in the margin of the spinal tumor. Until we find at least a second example of this morphology, we regard this form as a pathological *Spinocapnuchosphaera*.

Genus: *Tetracapnuchosphaera* KOZUR & MOSTLER 2006

Type species: *Tetracapnuchosphaera globosa* KOZUR & MOSTLER 2006.

Occurrence: Longobardian to lower Tuvalian of the Tethys.

Remarks: *Tetracapnuchosphaera* is distinguished from all other genera of family Capnuchosphaeridae DE WEVER 1979 in having four tetragonally arranged tumidaspinae. It is very interesting that this genus is already common in the Longobardian, where no species of *Capnuchosphaera* co-occurs with *Tetracapnuchosphaera*. A range of Longobardian to Julian was reported by KOZUR & MOSTLER (2006), but our material has demonstrated that this genus may be still rarely present in the lower Tuvalian, though assignment of these Tuvalian forms to *Tetracapnuchosphaera* is not quite certain. Their different ranges, Cordevolian to middle Norian for *Capnuchosphaera* and Longobardian to Tuvalian for *Tetracapnuchosphaera*, clearly indicate that both are independent genera. On the other hand, the inner character of *Tetracapnuchosphaera* is not yet known. Therefore it is not yet certain that it belongs to the same family as *Capnuchosphaera*, and we cannot entirely exclude the possibility yet that *Tetracapnuchosphaera* is an entactinarian genus.

Tetracapnuchosphaera? *voeroesi* n. sp.

(Pl. 4, Fig. 4)

Derivatio nominis: In honour of Dr. Attila VÖRÖS, Budapest, founding professor of The Research Group for Paleontology (Hungarian Academy of Sciences – Hungarian Natural History Museum), for his outstanding work on Mesozoic ammonites and brachiopods.

Holotypus: The specimen on Pl. 4, Fig. 4, Rep.-no. M 2009.38.1., Holder no. 23-9-04/V-96.

Material: 2 specimens.

Diagnosis: Test is composed of a large single-layered spherical cortical shell with four large tumidaspinae. Pore frames of the cortical shell are tetragonal to pentagonal with high walls that bear very small spines on their vertices. Three of the four long tumidaspinae are of equal length and arranged in one plane, the fourth is located at a low angle oblique to this plane. The spinal tunnel of the tumidaspinae is rather long, smooth but with an indistinct shallow radial furrow in its slightly widened distal part that extends to the proximal part of the spindle-shaped spinal tumor that gradually develops from the end of the spinal tunnel. The spinal tumor is widest close to its middle part and distally pointed, where it has three ridges developed between three oval tumidapores. Spinal shaft long, straight and needle-like. Length of spinal shaft is at least half of the total length of its respective tumidaspina.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: The other known *Tetracapnuchosphaera* species have a tetrahedral arrangement of the tumidaspinae, in which the spinal tumor is quite different with a blunt distal end and without a spinal shaft.

Capnuchosphaeridae gen. et spec. indet.

(Pl. 3, Fig. 4)

Remarks: There is a single specimen of a *Capnuchosphaera*-like species with its third tumidaspina broken away. At the end of densely distributed needle-like short spines on the outer shell surface, a fragile loose outer shell is present which lies above the double-layered cortical shell with its fragile inner layer that is mostly reduced to a few bars. It is possible that such another extra layer is present in several *Capnuchosphaera* species with dense short needle-like spines on the vertices of the cortical shell, such as *Capnuchosphaera borbalae* n. sp. and *C. ottomanensis* n. sp. However, our form does not belong to either of these species because the distal end of the spinal tumor is different. This specimen represents a new species for which, unfortunately, only one imperfect specimen is known. The loose and fragile outer layer was preserved only because it was partly protected by an adjacent sponge spicule.

Family: Spongopalliidae KOZUR, KRAINER & MOSTLER 1996 emend.

Emended diagnosis: Shell spherical, subspherical, or ellipsoidal, in upper view circular, subcircular, oval, subrectangular or rectangular. Stratigraphically older forms have two medullary shells, which are clearly separated from the thick spongy mantle. In Upper Triassic forms, the spongy mantle becomes thicker and thicker until it finally fills the entire shell with a spongy meshwork. In early forms it reaches to the outer surface of the (outer) medullary shell, then later the medullary shell (s) are incorporated into the spongy meshwork and finally they are replaced altogether by the spongy meshwork, which is more compact where it replaces the former medullary shells. The outer medullary shell mostly has rather small to medium-sized pores, and the inner one mainly has a few big pores though it sometimes can be solid (a secondary feature?). The stratigraphically oldest forms have two opposite tricarinate polar spines, but in more advanced forms one to four tumidaspinae are present. In forms with two tumidaspinae, the polar spines are of equal or only slightly different size. If there are four tumidaspinae, they are arranged in a cross-like pattern within a single plane. At their distal end, the tumidaspinae transform into a widened, tricarinate twisted region, or else a spinal tumor is present that in Upper Triassic forms has a short to long spinal shaft. This terminal spine continues within the wall of the tumidaspinae, but rarely (only in *Goricanella*) it is in a central position in the centre of a flower-like distal structure.

Occurrence: Upper Illyrian to lower Tuvalian of Tethys.

Assigned genera: *Spongopallium* DUMITRICĂ, KOZUR & MOSTLER 1980, *Weverella* KOZUR & MOSTLER 1979, *Ligulatubus* TEKIN & MOSTLER 2005, *Tubospongopallium* TEKIN & MOSTLER 2005.

Remarks: The family Spongopalliidae was established by KOZUR et al. (1996) for forms with two polar, tricarinate spines (*Spongopallium* DUMITRICĂ, KOZUR & MOSTLER 1980) or tumidaspinae (later named as *Tubospongopallium* TEKIN & MOSTLER 2005) that originate from a rather fragile inner latticed medullary shell that is surrounded by an outer, likewise rather fragile latticed shell. This inner structure is surrounded by a thick spongy mantle. A similar inner structure with at least one latticed medullary shell, and sometimes two latticed medullary shells occurs in *Weverella* KOZUR & MOSTLER 1979 which has four tumidaspinae in a cross-like arrangement. Interestingly, in all of these forms the proximal prolongation of the spinal shaft runs within the wall of the tumidaspinae, as it does in several Late Palaeozoic Ruzhencevispongacea. This is also the case in our lower Tuvalian *Tubospongopallium*. TEKIN & MOSTLER (2005) have documented forms with only one tumidaspina. We have emended the definition of the Spongopalliidae to include these forms with one, two or four tumidaspinae, while noting that most of the primitive forms have only two tricarinate polar spines.

The inner structure of all of these forms is very similar. However, both in lower Tuvalian *Tubospongopallium* and *Weverella*, the spongy mantle tends to get thicker, reaching the latticed medullary shells that will then become more and more incorporated into the spongy meshwork until the latticed medullary shells finally disappear. It is not quite certain whether the Spongopalliidae belong to the Entactinaria or to the Spumellaria. We found one example within the Spongopallidae, where the needles in the inner continuation of the tumidaspinae reach to the center, but possibly because of recrystallisation (?) the small medullary shell (microsphere) is solid in this form as in most Permian Ruzhencevispongacea. Thus, we could not definitely determine if there is an Entactinarian spicular system inside the microsphere. Also it is not possible so far to recognise whether the inner medullary shell is a modified pentactine. Generally, forms in which the inner spines (often in continuation of the outer main spines) extend all the way or close to the centre of the shell, are Entactinaria. Unless we find solid additional evidence for Entactinarian characters pointing to the Spongopallidae, we choose to leave them within the Spumellaria.

Type species: *Weverella tetrabrachiata* KOZUR & MOSTLER 1979.

Genus: *Weverella* KOZUR & MOSTLER 1979

Weverella gracilispinosa n. sp.

(Pl. 4, Figs. 5–6)

Derivatio nominis: In allusion to its smooth graceful spines.

Holotypus: The specimen on Pl. 4, Fig. 6, Rep.-no. M 2009.40.1., Holder no. 23-9-04/II-135.

Material: 15 specimens.

Diagnosis: Test with a rather dense spongy shell and four tumidaspinae arranged in a cross-like pattern within a single plane. In upper view, the spongy shell is subdeltoid in outline and slightly compressed perpendicular to the plane of the tumidaspinae. Outer pore frames have tiny nodes or spines on the vertices. Tumidaspinae approximately equal in length, with a length that corresponds about to the diameter of the cortical shell. They are circular in cross section and bear on their upper side an oval, deep hole in their proximal region. Spinal tunnel of tumidaspinae long and smooth except for the hole. The short spinal tumor develops gradually from the spinal tunnel. It is slightly widened distally in all four tumidaspinae and bears a single, large tumidapore. The tumidaspinae terminate in a short, needle-like spinal shaft. This spinal shaft extends along the whole wall of the tumidaspinae.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: *Weverella longispinosa* n. sp. differs in having at least one very long spinal shaft. Additionally, only one spinal tumor is distinctly widened distally. Exceptionally, a second spinal tumor also is very slightly widened but usually only beyond a distal narrowing of the spinal tunnel.

In *Weverella longispinosa*, described next, the continuation of the spinal shaft continues within the wall along the entire length of the tumidaspinae. In that feature, both of these two species are very similar to some Permian Ruzhencevispongacea Kozur 1980.

Weverella longispinosa n. sp.

(Pl. 4, Figs. 7–9)

Derivatio nominis: In allusion to the long spinal shafts on its tumidaspinae.

Holotypus: The specimen on Pl. 4, Fig. 7, Rep.-no. M 2009.41.1., Holder no. 23-9-04/I-31.

Material: More than 100 specimens.

Diagnosis: The subglobular spongy shell is circular, subcircular, rectangular or subrectangular in upper view and often slightly compressed perpendicular to the plane of the four tumidaspinae. Outer pore frames with elevated walls pentagonal to hexagonal, with tiny nodes on the vertices. Tubular smooth tumidaspinae arranged in a nearly cross-like pattern with an angle between 80 and 100 degrees between adjacent tumidaspinae. They are as long as the diameter of the shell or somewhat longer and either are of uniform diameter throughout their entire length or taper slightly toward their distal end. In one tumidaspina the distal third may be distinctly curved. The spinal tunnel of tumidaspinae is long and smooth and bears a deep oval hole in its proximal region. The spinal tunnel continues inside the outer part of the shell, and the part inside the shell has a few pores between narrow, low ridges. This can be seen only if the outer shell is dissolved or otherwise removed (see Pl. 4, Fig. 8). Spinal tumor barely visible, usually recognisable only in one (but very rarely two) of the tumidaspinae. It bears a single, relatively large tumidapore. Three of the tumidaspinae terminate in a short, needle-like spinal shaft, the fourth bears a long, massive, straight spinal shaft. All spinal shafts continue inside the wall of the tumidaspinae along their entire length.

Occurrence: Lower Tuvalian of Tethys.

Remarks: See under *Weverella gracilispinosa* n. sp. Three subspecies can be distinguished.

Weverella longispinosa longispinosa n. subsp.

(Pl. 4, Fig. 7)

Derivatio nominis and holotypus: As for the species.

Material: More than 100 specimens.

Diagnosis: With the characteristics of the species. Globular to subglobular shell, in upper view subcircular or circular. The spinal tumor can be pointed at its distal end, slightly narrowed toward its distal end, or occasionally the distal end of one spinal tumor may be faintly widened.

Occurrence: Lower Tuvalian of Tethys.

Remarks: In *Weverella longispinosa subrectangularis* the shell in upper view is rectangular or subrectangular and the spinal tumor often is widened on two of the tumidaspinae.

Weverella longispinosa curvata n. subsp.

(Pl. 4, Fig. 8)

Derivatio nominis: In allusion to the curved distal third in one of its tumidaspinae.

Holotypus: The specimen on Pl. 4, Fig. 8, Rep.-no. M 2009.42.1., Holder no. 23-9-04/II-153.

Material: 2 specimens.

Diagnosis: With the characteristics of the species. The distal end of one tumidaspina is distinctly curved laterally and in a second tumidaspina it is slightly curved. Spinal tumor not separated from spinal tunnel and not terminally widened in any of the tumidaspinae.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: *Weverella longispinosa curvata* is distinguished from the other two subspecies of *W. longispinosa* by the laterally distinctly curved distal third of one of the tumidaspinae.

Weverella longispinosa subrectangularis n. subsp.

(Pl. 4, Fig. 9)

Derivatio nominis: In allusion to the subrectangular outline of the shell in upper view.

Holotypus: The specimen on Pl. 4, Fig. 9, Rep.-no. M 2009.43.1., Holder no. 23-9-04/II-144.

Material: 5 specimens.

Diagnosis: With the characteristics of the species. Additionally, outline of the shell in upper view subrectangular or rectangular and distal end of the spinal tumor usually widened in two tumidaspinae.

Occurrence: Lower Tuvalian part of the Huğlu Unit of the Mersin Mélange.

Remarks: See under *Weverella longispinosa longispinosa* n. subsp.

Weverella tetrabrachiata Kozur & Mostler 1979

(Pl. 4, Fig. 10–11; Pl. 5, Figs. 1–4)

Weverella tetrabrachiata Kozur & Mostler 1979, p. 76–77, Pl. 14, Fig. 8.

Weverella tetrabrachiata aspinosa Kozur & Mostler 1981, p. 77, Pl. 63, Fig. 3.

Occurrence: Upper Julian to lower Tuvalian of Tethys.

Remarks: Kozur & Mostler (1979, 1981) considered *W. tetrabrachiata tetrabrachiata* Kozur & Mostler 1979 to be characterized by short terminal spines on the distal margin of the spinal tumor and *W. tetrabrachiata aspinosa* Kozur & Mostler 1981 to be characterized by having only lobes on the distal margin of the spinal tumor. In our lower Tuvalian material, however, we have found all transitional stages between these two morphotypes, and the two morphologies occur throughout the entire range of the species. Therefore, we now regard the above mentioned differences as being due to intraspecific variability and no longer separate two subspecies of W. tetrabrachiata based on these features.

Genus: *Paraweverella* n. gen.

Type species: *Paraweverella tenuispinosa* n. gen. n. sp.

Derivatio nominis: In allusion to its similarity to the genus *Weverella* KOZUR & MOSTLER 1979.

Diagnosis: The spongy shell is subspherical. Four slender tubular tumidaspinae are present, three of them situated in a single plane and the fourth oriented perpendicular to this plane.

Remarks: In *Weverella* KOZUR & MOSTLER 1979 all spines are situated in a single plane.

Assigned species: *Paraweverella tenuispinosa* n. sp.

Paraweverella tenuispinosa n. gen. n. sp.
(Pl. 4, Fig. 12)

Derivatio nominis: In allusion to its tenuous primary spines.

Holotypus: The specimen on Pl. 4, Fig. 12, Rep.-no. M 2009.45.1., Holder no. 23-9-04/I-160.

Material: 1 specimen.

Diagnosis: With the characteristics of the genus. The spongy meshwork of the test has pores ranging in size from medium to very small. The long, slender, smooth tubular tumidaspinae are all about the same length. The spinal tunnel is long, and widest proximally; its diameter decreases distally until its mid-length and then remains constant to the point where the spinal tumor gradually develops from the spinal tunnel. One roundish tumidapore present. The tumidaspinae terminate in a short, needle-like spinal shaft that has a wide, triangular, two-carinate base. The spinal shaft is situated on the distal margin of the spinal tumor and is continuous within the margin of the tumidaspinae.

Genus: *Goricanella* KOZUR, MOSTLER & OZSVÁRT n. gen.

Type species: *Goricanella hexaspinosa* KOZUR, MOSTLER & OZSVÁRT n. gen. n. sp.

Derivatio nominis: In honour of Dr. Špela GORIČAN, Ljubljana, Slovenia, for her outstanding work on Mesozoic radiolarians.

Diagnosis: Spherical to ellipsoidal shell with two long, straight, polar spines. The shell is composed of a latticed medullary shell and a barely discernible outer medullary shell which is covered by a thick spongy mantle. Polar spines tubular, rounded three-bladed, and slightly twisted distally, connected to the shell by numerous longitudinal, slender columns that have distinct grooves visible between them. Polar spines may terminate in numerous secondary spines. Inner part of polar spines divided into three internal canals by thin, vertical lamellae. At the triple-junction of lamellae, a straight needle-like spine may be present.

Remarks: *Dumitricasphaera* KOZUR & MOSTLER 1979 has solid tricarinate polar spines that are slightly twisted against each other and a different structure of the spongy shell consisting of 5–6 densely spaced shells connected by short, needle-like beams. *Xiphosphaera* HAECKEL 1881 does not have a thick spongy mantle of the test and no secondary spines arranged in a flower-like structure at the distal end of the polar spines. *Tubospongopallium* TEKIN & MOSTLER 2005 differs in having tubular polar spines that lack terminal flower-like arrangements formed by the secondary spines.

Assigned species: *Goricanella hexaspinosa* KOZUR, MOSTLER & OZSVÁRT n. gen. n. sp.

Goricanella hexaspinosa KOZUR, MOSTLER & OZSVÁRT n. gen. n. sp.
(Pl. 4, Figs. 14–16)

Derivatio nominis: In allusion to the six small secondary spines at the distal end of its polar spines.

Holotypus: The specimen on Pl. 4, Fig. 14, Rep.-no. M 2009.47.1., Holder no. 27-11-04/I-60.

Material: 15 specimens.

Locus typicus: Göstling, Austria.

Stratum typicum: Upper Göstling Limestone, bed AS 8 (KOZUR & MOSTLER, 1994), lower *Austrotrachyceras austriacum* Zone, lower part of upper Julian.

Diagnosis: Ellipsoidal test composed of latticed inner medullary shell and barely discernible outer medullary shell covered by a thick spongy mantle. The two polar spines are rounded three-bladed, tubular, and approximately equal in length with a few minute pores. The polar spines are slightly twisted distally and connected to the shell by numerous longitudinal, slender columns. They terminate in six short, triangular secondary spines that are arranged in a flower-like structure. The inner part of polar spines is subdivided into three internal canals by thin, longitudinal lamellae. The terminal triple-junction of the lamellae bears a short, straight needle-like spine.

Genus: *Tubospongopallium* TEKIN & MOSTLER 2005

Tubospongopallium inaequispinosum n. sp.
(Pl. 4, Fig. 13)

Derivatio nominis: In allusion to its polar spines of variable length.

Holotypus: The specimen on Pl. 4, Fig. 13, Rep.-no. M 2009.46.1., Holder no. 23-9-04/II-43.

Material: More than 30 specimens.

Diagnosis: The shell is spherical to subspherical and slightly compressed in its vertical direction. The latticed medullary shell has slightly elevated circular to polygonal pore frames. A second inner latticed medullary shell cannot be recognised and may not be present. The medullary shell is surrounded by a thick spongy mantle. The two long polar tumidaspinae are of unequal length, smooth and have large, elongated-oval terminal tumidapores.

Remarks: *Tubospongopallium inaequispinosum* n. sp. is distinguished from all other species of *Tubospongopallium* by having polar spines of variable length.

Family: Parasaturnalidae KOZUR & MOSTLER 1972

Remarks: The Triassic parasaturnalids are characterised by a single undifferentiated flat saturnalid ring, which may be still open in primitive forms. The Archaeoacanthocircidae KOZUR, MOIX & OZSVÁRT 2007b are distinguished by a differentiated saturnalid ring, in which a distinct ridge is present on the outer margin of the ring that is situated in adjacent quarters alternating on the upper and lower side of the ring. Interestingly, species belonging to these two families almost never co-occur. In the

Cordevolian and Julian, Parasaturnalidae are common, but Archaeoacanthocircidae are absent. In the *S. moixi* Zone of the lower Tuvalian, Archaeoacanthocircidae are very common, but Parasaturnalidae have not been found. In the upper Tuvalian and lower Norian, Parasaturnalidae are common, Archaeoacanthocircidae are absent or rare, and the occurrence of one of these families generally excludes the occurrence of the other. In the middle Norian to Rhaetian Parasaturnalidae are common, but Archaeoacanthocircidae are unknown. This mutually exclusive distribution pattern is probably caused by temperature differences in the water column at the different depositional sites, because upper Tuvalian and lower Norian Archaeoacanthocircidae are so far only known from the equatorial Neotethys.

Occurrence: Cordevolian to Upper Cretaceous.

Family: Archaeoacanthocircidae KOZUR, MOIX & OZSVÁRT 2007b

Remarks: The Archaeoacanthocircidae are distinguished from the Parasaturnalidae by a ridge at the outer margin of a complete or incomplete (open) saturnalid ring (except in most primitive forms where there are two opposite wings on the polar spines). This ridge is located alternately on the upper and lower side in the four quarters of the ring or in opposite parts of the wing (Pl. 6, Figs. 7–9). This emendation of the Archaeoacanthocircidae reflects the exclusion of *Dumitricasphaera planustyla* LAHM 1984, from *Huglusphaera* KOZUR, MOIX & OZSVÁRT 2007b and its assignment to *Angulocircus* LAHM 1984 (see under *Angulocircus* below), which does not belong to the Archaeoacanthocircidae. The diagnosis of the Archaeoacanthocircidae by KOZUR et al. (2007b, p. 176) remains unchanged, except that also in primitive forms with an open (or on one side open) saturnalid ring the marginal ridge is always present.

In the Acanthocircidae PESSAGNO 1977, the ridge occurs only on the upper side of the ring.

Occurrence: Tuvalian to lower Norian, in the upper Tuvalian and lower Norian only known from the Neotethys. The originally reported rare occurrence in the Julian is no longer valid because the Julian species *Dumitricasphaera planustylus* LAHM 1984 does not belong to the archaeoacanthocircid genus *Huglusphaera* KOZUR, MOIX & OZSVÁRT 2007, as assumed by KOZUR et al. (2007b), but rather to *Angulocircus* LAHM 1984 (see below).

Family: Spongotortilispinidae KOZUR & MOSTLER 2007 emend.

Remarks: Originally only *Spongotortilispinus* KOZUR & MOSTLER 2007 (in MOIX et al., 2007), and *Zhamojdasphaera* KOZUR & MOSTLER 1979 were assigned to the Spongotortilispinidae. However, in the late Ladinian to early Norian portion of the range of this family, additional genera with the general characteristics of the Spongotortilispinidae also occur: *Dumitricasphaera* KOZUR & MOSTLER 1979, *Angulocircus* LAHM 1984, and perhaps also *Vinassaspongus* KOZUR & MOSTLER 1979 for which the inner structure of the shell is not well known. In these genera the spongy shell consists of several shells interconnected by numerous beams within the narrow intervening spaces. The two polar spines (or three spines in triangular arrangement) are twisted. The generic-level differences include polar spines with two or three terminal wings (*Angulocircus* and *Dumitricasphaera* KOZUR & MOSTLER 1979), propeller-like elevated ridges on the spines (*Zhamojdasphaera*), no modifications of the ridges on the spines (*Spongotortilispinus* and *Vinassaspongus*) or presence of two polar spines or of three spines in triangular arrangement. This emendation of the Spongotortilispinidae concerns only the number of genera that should be assigned to this family; the family description and individual generic descriptions remain unchanged.

Occurrence: Late Ladinian to early Norian of Tethys.

Assigned genera:
Spongotortilispinus KOZUR & MOSTLER 2007 (in MOIX et al., 2007).
Dumitricasphaera KOZUR & MOSTLER 1979.
? *Vinassaspongus* KOZUR & MOSTLER 1979.
Zhamojdasphaera KOZUR & MOSTLER 1979.
Angulocircus LAHM 1984.

Genus: *Angulocircus* LAHM 1984

Type species: *Spongosaturnalis bipartitus* KOZUR & MOSTLER 1972.

Remarks: *Angulocircus* has two opposite polar spines with very large, flat, broad terminal wings. The distal ends of the wings may almost touch the distal ends of the opposite wings, but these opposite distal ends of the wings are not fused into a saturnalid ring. These wings are commonly moderately to nearly perpendicularly twisted against each other and these twisted spines are similar to those of the bipolar Spongotortilispinidae KOZUR & MOSTLER 2007 (in MOIX et al., 2007). Rarely they are situated in one plane or only slightly twisted, so far only in *Angulocircus bipartitus* (KOZUR & MOSTLER 1972) where they look either like a saturnalid ring with two narrow breaks consisting of two half-rings. *A. bipartitus* (Pl. 6, Fig. 5) or a similar form, in which the polar spines either are not twisted or only slightly twisted against each other, is probably the ancestor of the Parasaturnalidae.

The generally large spongy shell consists of several (usually 5–6) closely spaced shells. It is connected with the wings by two short broad polar spines that proximally are often broken up into a cluster of narrow spines. In some forms, the entire polar spines are broken up into two or a cluster of narrowly spaced polar spines that are similar to the auxiliary spines. When the shell reaches as far as the wings or slightly onto the wings, additional auxiliary spines are present which connect the shell with the wings.

Species, assigned by KOZUR & MOSTLER (1983) tentatively and with reserve to *Pseudoheliodiscus* KOZUR & MOSTLER 1972, were subsequently assigned to the new genus *Angulocircus* and placed in the Parasaturnalidae by LAHM (1984). He also recognised that the two wings are mostly twisted against each other, and it was in allusion to this feature that the generic name *Angulocircus* was chosen. KOZUR & MOSTLER (1990) accepted his placement of these forms in a new genus but assigned *Angulocircus* to the Oertlispongidae KOZUR & MOSTLER 1980 (in DUMITRICĂ et al., 1980) on the assumption that these species were the forerunners of the Parasaturnalidae. However, it now seems more likely that forms with two equal polar spines and large, flat, broad wings, closely related to *A. bipartitus*, were the forerunners of the Parasaturnalidae and not the Oertlispongidae with their strongly heteropolar polar spines.

DUMITRICĂ & HUNGERBÜHLER (2007) have proposed putting forms with both open and complete rings into the same genus, regarding the width of the ring as a more useful generic character. However, in all saturnalid lineages, the width of the ring within one lineage is only a species character and often is variable to a certain degree within even a single species.

D. planustyla (Pl. 6, Fig. 4) belongs within *Angulocircus*. In the only illustrated specimen, the shell is strongly corroded. However, it can readily be seen that the broad polar spines are proximally broken up into bunches of short spines connecting the shell with the wings and that the two wings are distinctly twisted against each other. KOZUR et al. (2007b) erroneously assigned *D. planustyla* to *Huglusphaera*, but it clearly does not belong in that genus because it lacks a marginal ridge on the wings that lies alternately on the upper and lower sides in adjacent halves of the wing. Additionally, in *Huglusphaera* the wings are not distinctly twisted against each other as they are in *D. planustyla*. Therefore, *D. planustyla* is not even a representative of the Archaeoacanthocircidae. TEKIN & DUMITRICĂ in DUMITRICĂ & HUNGERBÜHLER (2007) established a new genus (*Behrlahmium*) for *D. planustyla*, but this name is a junior synonym of *Angulocircus* LAHM 1984.

In Julian limestones of Száka-hegy (Balaton Highland, Hungary), several representatives of the *Angulocircus planustylus* group are found that display different qualities of preservation and show different degrees of twisting of the polar spine. Three of them are illustrated on Pl. 6, Figs. 1–3 and will be described in another paper. For now, the most interesting and important fact about these forms is that in all species of this group there is found a morphological series ranging from slightly to strongly twisted forms. Therefore, the degree of twisting of the polar spines is an intraspecific feature.

Occurrence: Ladinian and Carnian, common only in the Julian.

Assigned species:

Spongosaturnalis bipartitus KOZUR & MOSTLER 1972.
Pseudoheliodiscus ? interruptus KOZUR & MOSTLER 1983.
Synonym: *Angulocircus longispinosus* LAHM 1984.
Angulocircus multispinosus LAHM 1984.
Synonym: *Angulocircus laterospinosus* LAHM 1984.
Dumitricasphaera planustyla LAHM 1984.
Angulocircus n. sp. ex gr. *Angulocircus planustylus* (LAHM).

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Plate 1

Fig. 1: *Capnuchosphaera tortuospinosa* n. sp.
Holotype.
Rep.-no. M 2009.24.1., Holder no. 23-9-04/I-19.

Fig. 2: *Capnuchosphaera borbalae* n. sp.
Holotype.
Rep.-no. M 2009.3.1., Holder no. 23-9-04/VI-29.

Fig. 3: *Capnuchosphaera mersinensis* n. sp.
Holotype.
Rep.-no. M 2009.16.1., Holder no. 23-9-04/III-63.

Fig. 4: *Capnuchosphaera gracilispinosa gracilispinosa* n. subsp.
Holotype.
Rep.-no. M 2009.13.1., Holder no. 23-9-04/V-102.

Fig. 5: *Capnuchosphaera gracilispinosa turkensis* n. subsp.
Holotype.
Rep.-no. M 2009.14.1., Holder no. 23-9-04/IV-36.

Fig. 6: Pathological? *Capnuchosphaera gracilispinosa* n. sp.
Rep.-no. M 2009.15.1., Holder no. 23-9-04/IV-12.

Fig. 7: *Capnuchosphaera bragini* n. sp
Holotype.
Rep.-no. M 2009.4.1., Holder no. 8-12-03/I-8.

Fig. 8: *Capnuchosphaera* sp. cf. *C. bragini* n. sp.
Rep.-no. M 2009.5.1., Holder no. 23-9-04/V-103.

Fig. 9: *Capnuchosphaera mostleri* n. sp.
Holotype.
Rep.-no. M 2009.17.1., Holder no. 23-9-04/I-113.

Fig. 10: *Capnuchosphaera cylindrica cylindrica* n. subsp.
Holotype.
Rep.-no. M 2009.10.1., Holder no. 23-9-04/III-152.

Fig. 11: *Capnuchosphaera cylindrica retusaspinosa* n. subsp.
Holotype.
Rep.-no. M 2009.11.1., Holder no. 23-9-04/V-104.

Fig. 12: *Capnuchosphaera oesii* n. sp.
Holotype.
Rep.-no. M 2009.20.1., Holder no. 23-9-04/V-106.

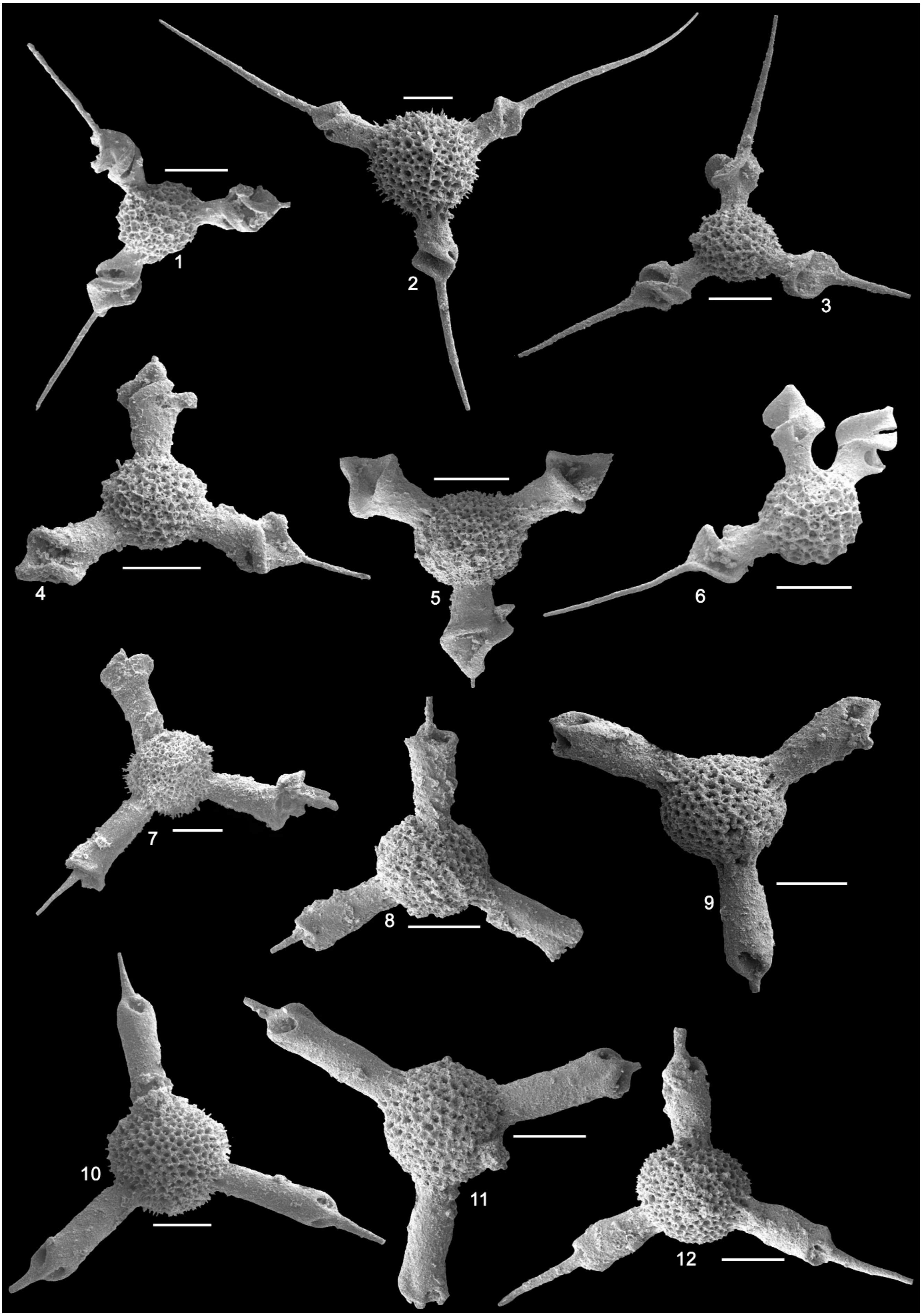

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Plate 2

Fig. 1: *Capnuchosphaera barnabasi* n. sp.
Holotype.
Rep.-no. M 2009.1.1., Holder no. 23-9-04/V-97.

Fig. 2: *Capnuchosphaera* sp. aff. *C. barnabasi* n. sp.
Rep.-no. M 2009.2.1., Holder no. 23-9-04/II-45.

Fig. 3: *Capnuchosphaera* cf. *C. palawanensis* YEH, 1990.
Rep.-no. M 2009.27.1., Holder no. 23-9-04/VII-1.

Fig. 4: *Capnuchosphaera ciliciensis* n. sp.
Holotype.
Rep.-no. M 2009.6.1., Holder no. 23-9-04/V-93.

Fig. 5: *Capnuchosphaera crassa crassa* YEH, 1990.
Rep.-no. M 2009.7.1., Holder no. 23-9-04/III-18.

Fig. 6: *Capnuchosphaera* sp. cf. *C. crassa* YEH, 1990.
Rep.-no. M 2009.8.1., Holder no. 23-9-04/III-35.

Fig. 7: *Capnuchosphaera crassa yforma* n. subsp.
Holotype.
Rep.-no. M 2009.9.1., Holder no. 23-9-04/III-107.

Fig. 8: *Capnuchosphaera ottomanensis ottomanensis* n. subsp.
Holotype.
Rep.-no. M 2009.21.1., Holder no. 23-9-04/V-101.

Fig. 9: *Capnuchosphaera* sp. cf. *C. ottomanensis* n. sp.
Rep.-no. M 2009.22.1., Holder no. 27-11-04/II-63.

Fig. 10: *Capnuchosphaera ottomanensis carterae* n. subsp.
Holotype.
Rep.-no. M 2009.23.1., Holder no. 23-9-04/V-100.

Fig. 11: *Capnuchosphaera goestlingensis* KOZUR, MOSTLER & OZSVÁRT n. sp.
Rep.-no. M 2009.12.1., Holder no. 23-9-04/V-131.

Fig. 12: *Capnuchosphaera tuvalica* n. sp.
Holotype.
Rep.-no. M 2009.26.1., Holder no. 23-9-04/I-138.

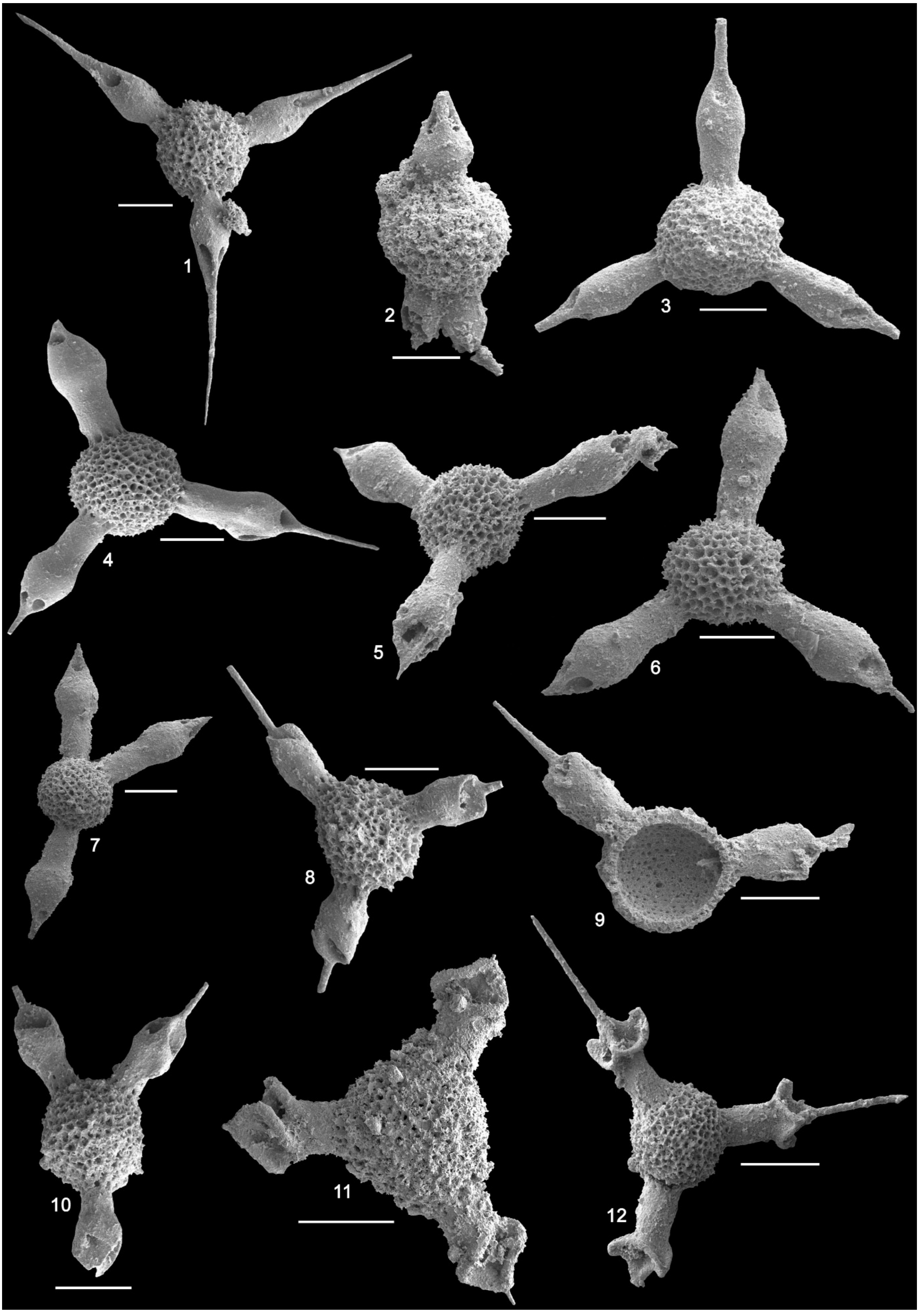
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Plate 3

Fig. 1: *Capnuchosphaera tumorspinosa* n. sp.
Holotype.
Rep.-no. M 2009.25.1., Holder no. 23-9-04/IV-92.

Fig. 2: *Capnuchosphaera multispinosa* n. sp.
Holotype.
Rep.-no. M 2009.18.1., Holder no. 27-11-04/II-125.

Fig. 3: *Capnuchosphaera* sp. cf. *C. multispinosa* n. sp.
Rep.-no. M 2009.19.1., Holder no. 23-9-04/IV-111.

Fig. 4: Capnuchosphaeridae gen. et spec. indet.
Rep.-no. M 2009.39.1., Holder no. 27-11-04/II-133.

Fig. 5: *Spinocapnuchosphaera tekini tekini* n. subsp.
Holotype.
Rep.-no. M 2009.28.1., Holder no. 23-9-04/V-111.

Fig. 6: *Spinocapnuchosphaera tekini tekini* n. subsp.
Paratype.
Rep.-no. M 2009.28.2., Holder no. 23-9-04/VI-188.

Fig. 7: S*pinocapnuchosphaera tekini hugluensis* n. subsp.
Holotype.
Rep.-no. M 2009.29.1., Holder no. 23-9-04/V-110.

Fig. 8: *Spinocapnuchosphaera tekini marginospinosa* n. subsp.
Holotype.
Rep.-no. M 2009.30.1., Holder no. 23-9-04/I-53.

Fig. 9: *Spinocapnuchosphaera tricuspidata* n. gen. n. sp.
Holotype.
Rep.-no. M 2009.35.1., Holder no. 23-9-04/I-97.

Fig. 10: *Spinocapnuchosphaera odoghertyi* n. gen. n. sp.
Holotype.
Rep.-no. M 2009.32.1., Holder no. 27-11-04/II-99.

Fig. 11: *Spinocapnuchosphaera venusta* n. gen. n. sp.
Holotype.
Rep.-no. M 2009.36.1., Holder no. 23-9-04/III-66.

Fig. 12: *Spinocapnuchosphaera szentei* n. gen. n. sp.
Holotype.
Rep.-no. M 2009.33.1., Holder no. 23-9-04/VI-168.

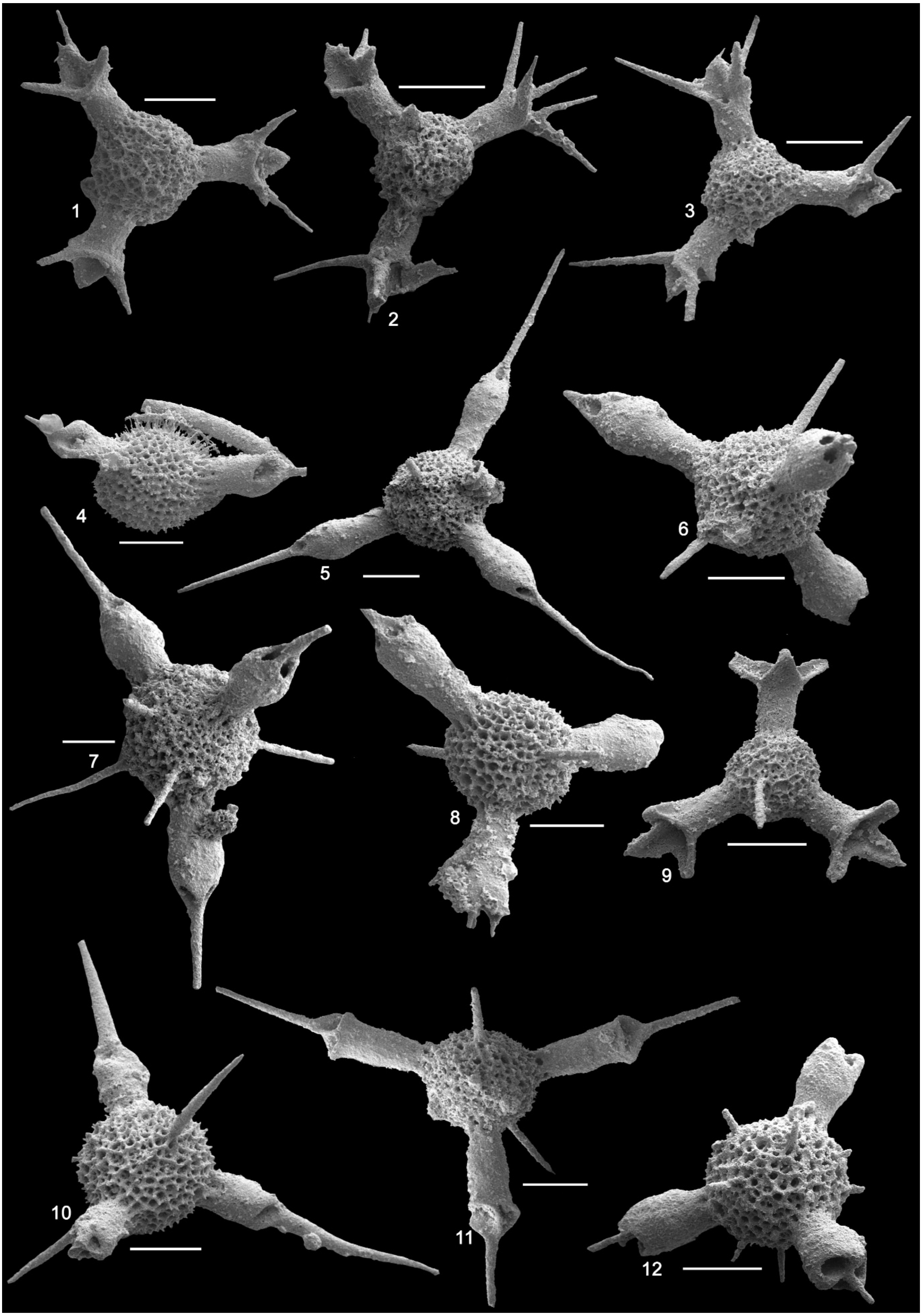
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Plate 4

Fig. 1: *Spinocapnuchosphaera hantkeni* n. gen. n. sp.
Holotype.
Rep.-no. M 2009.31.1., Holder no. 23-9-04/V-232.

Fig. 2: *Spinocapnuchosphaera szivesae* n. gen. n. sp.
Holotype.
Rep.-no. M 2009.34.1., Holder no. 23-9-04/V-115.

Fig. 3: Pathological *Spinocapnuchosphaera* sp.
Rep.-no. M 2009.37.1., Holder no. 27-11-04/II-83.

Fig. 4: *Tetracapnuchosphaera* ? *voeroesi* n. sp.
Holotype.
Rep.-no. M 2009.38.1., Holder no. 23-9-04/V-96.

Fig. 5: Inner structure of spongy shell of the *Weverella gracilispinosa* n. sp.
Rep.-no. M 2009.40.2., Holder no. 23-9-04/VIII-1.

Fig. 6: *Weverella gracilispinosa* n. sp.
Holotype.
Rep.-no. M 2009.40.1., Holder no. 23-9-04/II-135.

Fig. 7: *Weverella longispinosa longispinosa* n. subsp.
Holotype.
Rep.-no. M 2009.41.1., Holder no. 23-9-04/I-31.

Fig. 8: *Weverella longispinosa curvata* n. subsp.
Holotype.
Rep.-no. M 2009.42.1., Holder no. 23-9-04/II-153.

Fig. 9: *Weverella longispinosa subrectangularis* n. subsp.
Holotype.
Rep.-no. M 2009.43.11., Holder no. 23-9-04/II-144.

Fig. 10: *Weverella tetrabrachiata* KOZUR & MOSTLER, 1979.
Rep.-no. M 2009.44.1., Holder no. 23-9-04/III-87.

Fig. 11: Inner structure of the *Weverella tetrabrachiata* KOZUR & MOSTLER, 1979.
Rep.-no. M 2009.44.2., Holder no. 23-9-04/VIII-2.

Fig. 12: *Paraweverella tenuispinosa* n. gen. n. sp.
Holotype.
Rep.-no. M 2009.45.1., Holder no. 23-9-04/I-160.

Fig. 13: *Tubospongopallium inaequispinosum* n. sp.
Holotype.
Rep.-no. M 2009.46.1., Holder no. 23-9-04/II-43.

Fig. 14: *Goricanella hexaspinosa* KOZUR, MOSTLER & OSZVÁRT n. gen. n. sp.
Holotype.
Göstling, Austria, upper Göstling Limestone.
Sample AS 8 (see KOZUR & MOSTLER, 1994).
Lower *Austrotrachyceras austricum* ammonoid zone, *Tetraporobrachia haeckeli* radiolarian zone, lower part of upper Julian.
Rep.-no. M 2009.47.1., Holder no. 27-11-04/I-60.

Fig. 15: *Goricanella hexaspinosa* KOZUR, MOSTLER & OSZVÁRT n. gen. n. sp.
Paratype.
Locality, sample and age as for Fig. 14.
Rep.-no. M 2009.47.2., Holder no. 27-11-04/I-55.

Fig. 16: *Goricanella hexaspinosa* KOZUR, MOSTLER & OSZVÁRT n. gen. n. sp.
Paratype.
Locality, sample and age as for Fig. 14.
Rep.-no. M 2009.47.3., Holder no. 27-11-04/I-58.

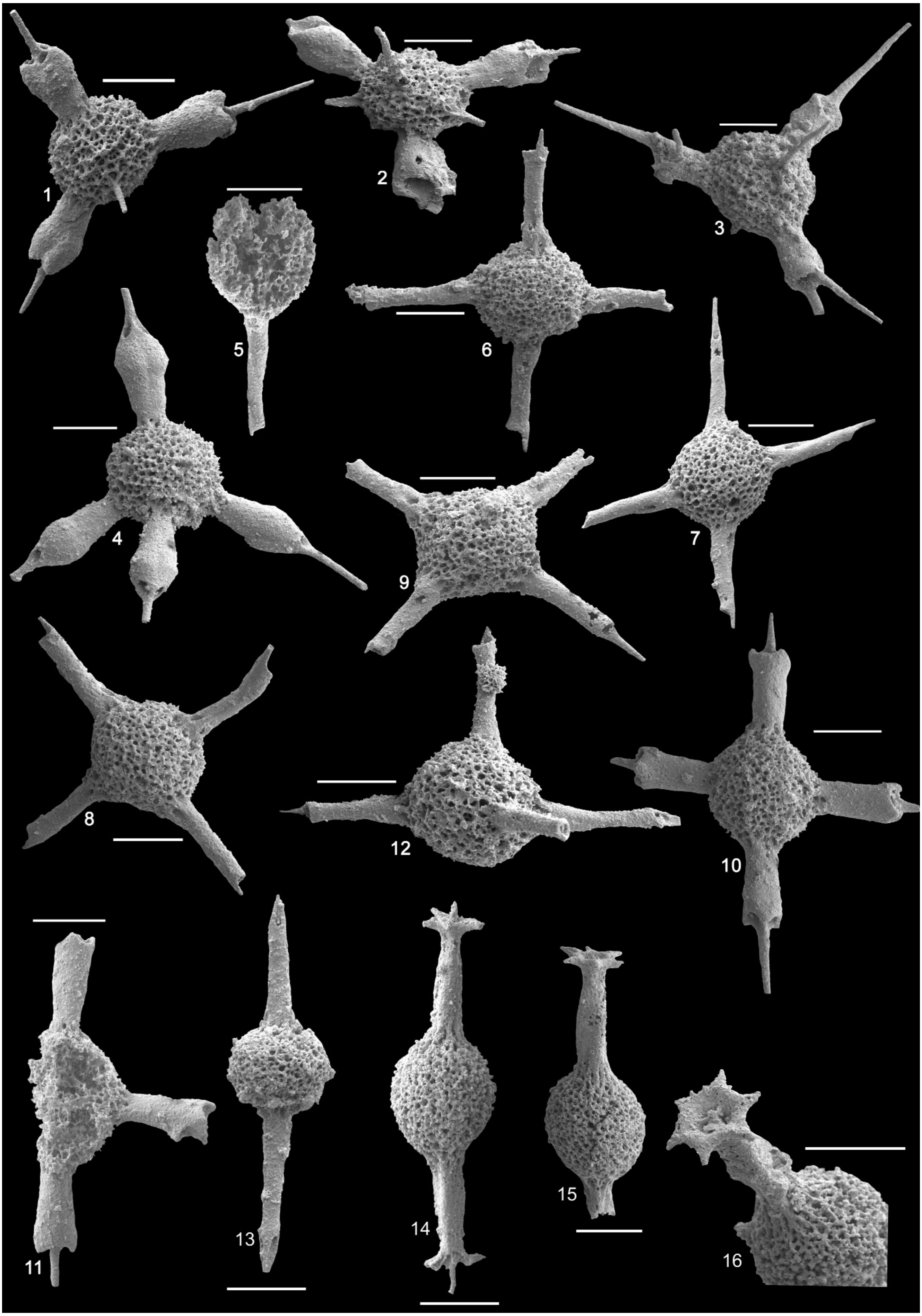
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Plate 5

Inner structure of *Weverella tetrabrachiata* KOZUR & MOSTLER, 1979

Fig. 1: Thick spongy mantle and indistinctly separated medullary shells.
Rep.-no. M 2009.44.3.

Fig. 2: Other specimen, thick spongy mantle and a part of the medullary shell are visible.
Rep.-no. M 2009.44.4.

Fig. 3: Detail of Fig. 1, central part of the shell.

Fig. 4: Other specimen. Thick spongy mantle and a small part of a medullary shell.
Rep.-no. M 2009.44.5., Holder no. 23-9-04/VIII-3.

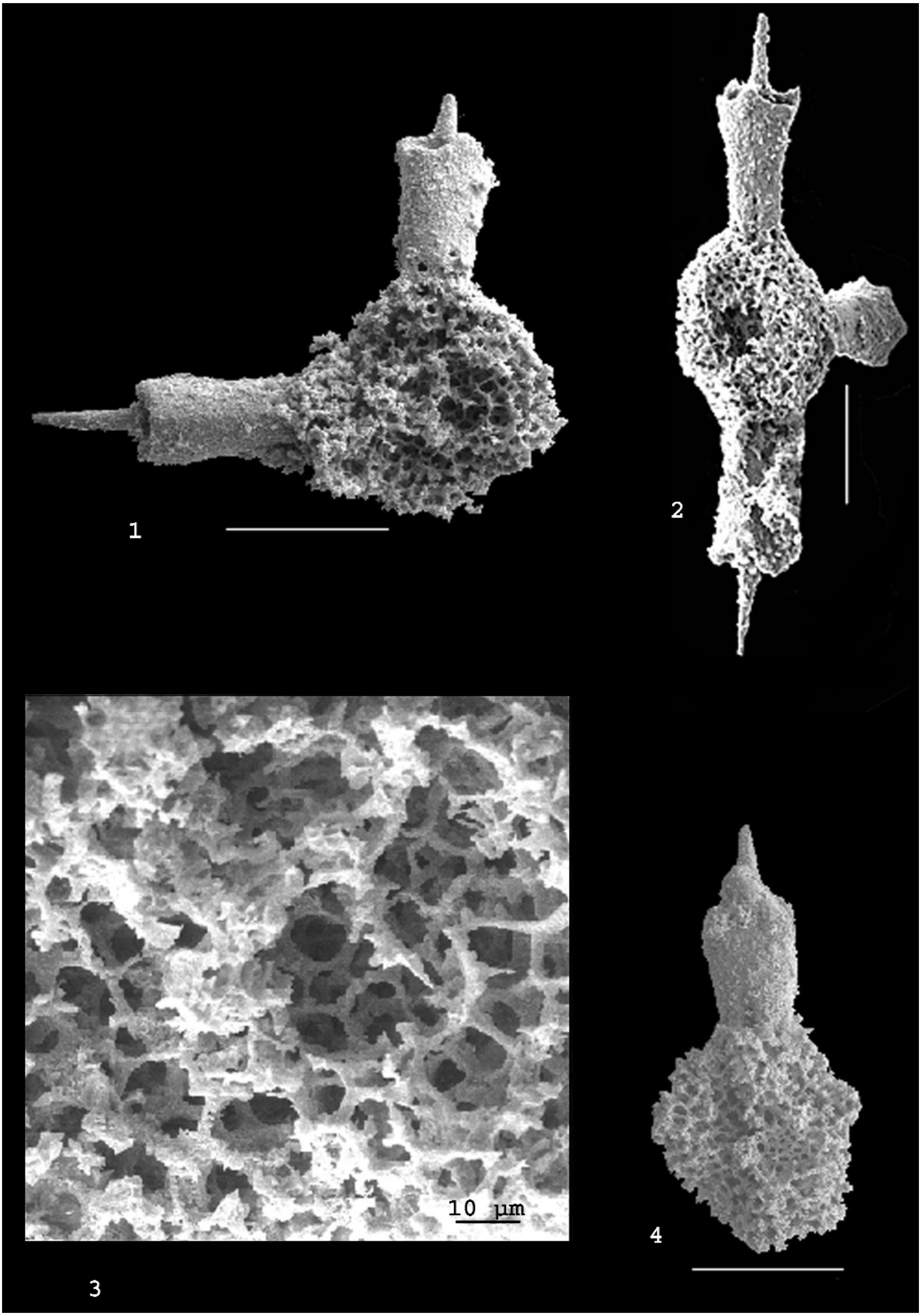
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Plate 6

Figs. 1–3: *Angulocircus* n. sp. aff. *A. planustylus* LAHM, 1984.
Only separated from this species by longer denticles on the wings.
Száka-hegy, Balaton Highland, Julian.
Fig. 1: Only one polar spine with wings preserved.
Fig. 2: Wings moderately twisted against each other.
Fig. 3: Wings strongly twisted against each other.

Fig. 4: *Angulocircus planustylus* (LAHM, 1984).
Holotype.
Wings moderately twisted against each other.
Großreifling (Austria), sample Gß1, Julian Göstling Limestone.
After LAHM (1984, Pl. 12, Fig. 9).

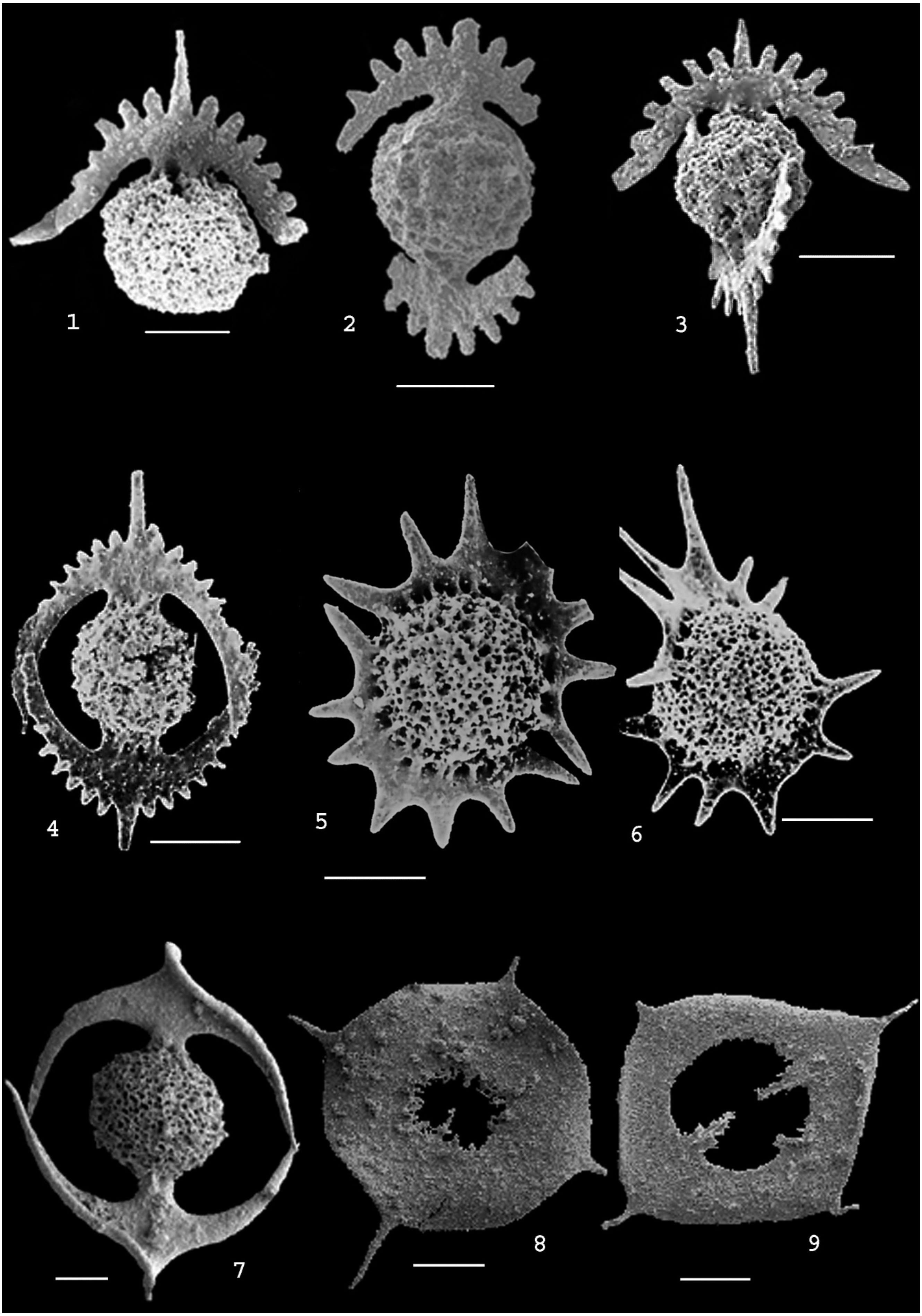
Fig. 5: *Angulocircus bipartitus* (KOZUR & MOSTLER, 1972).
Wings not twisted against each other.
Großreifling (Austria), sample Gß1, Julian Göstling Limestone.
After LAHM (1984, Pl. 18, Fig. 4).

Fig. 6: *Angulocircus interruptus* (KOZUR & MOSTLER, 1983)
Holotype of the junior synonym *Angulocircus longispinosus* LAHM, 1984.
Wings strongly twisted against each other.
Großreifling (Austria), sample Gß1, Julian Göstling Limestone.
After LAHM (1984, Pl. 18, Fig. 6).

Fig. 7: *Huglusphaera weemsi* KOZUR, MOIX & OZSVÁRT, 2007.
Wings not fused.
M 2008.72.1., Holder no. 23-9-04/V-148.
After KOZUR et al. (2007b, Fig. 1C).

Fig. 8: *Archaeoacanthocircus deweveri* (DUMITRICĂ & HUNGERBÜHLER, 2007).
Rep.-no. M 2009.48.1., Holder no. 23-9-04/VI-55.

Fig. 9: *Archaeoacanthocircus rectangularis* KOZUR, MOIX & OZSVÁRT.
Shell not preserved. In this case the auxiliary spines at the inner margin of the ring may totally disappear as in the illustrated specimen.
Rep.-no. M 2009.49.1., Holder no. 23-9-04/VI-53.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