Geol. Paläont. Mitt. Innsbruck, ISSN 0378–6870, Sonderband 4, S. 287–299, 1996

THE SYSTEMATIC POSITION OF *PSEUDOERTLISPONGUS* LAHM (RADIOLARIA) AND DESCRIPTION OF SOME NEW MIDDLE TRIASSIC AND LIASSIC RADIOLARIAN TAXA

Heinz W. Kozur

With 1 plate

Abstract:
Pseudoertlispongus LAHM is a transitional form between *Paroertlispongus* KOZUR & MOSTLER and *Oertlispongus* DUMITRICĂ, KOZUR & MOSTLER.
Paroertlispongus, *Pseudoertlispongus* and *Oertlispongus* appeared in successive order at the base of the Lower Anisian *Paroertlispongus diacanthus* Zone, at the base of the upper Subzone (*Yeharaia annulata* Subzone) of the uppermost Anisian *Spongosilicarmiger transitus* Zone and at the base of the Lower Ladinian *Spongosilicarmiger italicus* Zone (= base of *Reitziites reitzi* Zone s.str.)
One new genus, 7 new species and one new subspecies of Middle Triassic radiolarians and the Liassic genus *Liassobetracchium* n. gen. are described.

Zusammenfassung:
Pseudoertlispongus LAHM ist eine Übergangsform zwischen *Paroertlispongus* KOZUR & MOSTLER und *Oertlispongus* DUMITRICĂ, KOZUR & MOSTLER. *Paroertlispongus*, *Pseudoertlispongus* und *Oertlispongus* erscheinen in stratigraphischer Abfolge an der Basis der unteranisischen *Paroertlispongus diacanthus* Zone, in der oberen Subzone (*Yeharaia annulata* Subzone) der hoch-oberanisischen *Spongosilicarmiger transitus* Zone und an der Basis der unterladinischen *Spongosilicarmiger italicus* Zone (= Basis der *Reitziites reitzii* Zone).
Eine neue Gattung, 7 neue Arten und eine neue Unterart mitteltriassischen Radiolarien die liassische Gattung *Liassobetracchium* werden beschrieben.

1. Introduction

KOZUR & MOSTLER (1994) regarded *Pseudoertlispongus* LAHM, 1984 as a junior synonym of *Paroertlispongus*. At that time, only one species of *Pseudoertlispongus* was known that occurred in the middle Fassanian together with advanced *Paroertlispongus* KOZUR & MOSTLER, advanced *Oertlispongus* DUMITRICĂ, KOZUR & MOSTLER, *Baumgartneria* DUMITRICĂ and *Falcispongus* DUMITRICĂ. Shell sculpture and arrangement of the spines on the shell of *Pseudoertlispongus* correspond to *Paroertlispongus* and also the round cross section of the main polar spine throughout its length is typical for Paroertlispongus. The only difference is a slightly curved posterior end of the main polar spine. This last feature is transitional to *Oertlispongus* that has a recurved main polar spine with a short straight part and a long recurved part. However, the previously known distribution of *Pseudoertlispongus* with first appearance after the first appearance of *Oertlispongus* did not favour the possibility that *Pseudoertlispongus* is a transitional form between *Paroertlispongus* and *Oertlispongus*.

Now we have found rich *Pseudoertlispongus* faunas before the first appearance of *Oertlispongus* in Hungary as well as in Sicily. Therefore, the formerly known occurrence of *Pseudoertlispongus weddigei* was only the uppermost range of

Pseudoertlispongus together with advanced *Oertlispongus* that ranges, however, up to the Longobardian. The first appearance of *Paroertlispongus*, *Pseudoertlispongus* and *Oertlispongus* is therefore in clear stratigraphic order, independently from the fact that the primitive Oertlispongidae cooccur with advanced ones. The oldest known occurrence of *Paroertlispongus* is in the upper Lower Anisian *Paroertlispongus diacanthus* Zone. There, only forms with long, slender, in their middle part not widened main polar spine occur, and the opposite polar spine is not much different. Advanced *Paroertlispongus* with widening of the main polar spine in or after its mid-length appear in the Upper Anisian *Tetraspinocyrtis laevis* Zone from the *Paraceratites* trinodosus Zone of the ammonoid zonation. They ranges up to the upper Fassanian.

Pseudoertlispongus with terminally slightly curved main polar spine appeared in the uppermost Anisian upper Subzone (*Yeharaia annulata* Subzone) of the *Spongosilicarmiger transitus* Zone. With very slight changes, this genus ranges up to the upper Fassanian.

Oertlispongus with recurved main polar spine begins at the base of the Ladinian *Spongosilicarmiger italicus* Zone (base of the *Reitziites reitzi* zone s.str. in the ammonoid zonation). The oldest *Oertlispongus* species, *O. primus* n. sp., is a primitive form with a long straight part of the main polar spine that is only a little shorter than or as long as the curved part that is only very little recurved. The bent is already slightly flattened (oval cross section) as typical for several *Oertlispongus* species, but never present in *Paroertlispongus* and *Pseudoertlispongus*. This genus underwent a rapid evolution and advanced forms with very short straight part of the main spine occur from the middle Fassanian up to the Middle Longobardian. Contemporaneous with *O. primus*, a closely related form appeared, in which, however, the inward curved part is short, the bent of the main spine is strongly flattened and on its outer side slightly widened. These forms represent the oldest *Falcispongus*, *F. zapfei* n. sp., which is the ancestral form of the advanced oertlispongids with strongly differentiated main polar spine that characterize the Tethyan and partly also the Circum-Pacific Ladinian and Cordevolian.

In the present paper, the stratigraphically very important species from the transitional field of *Paroertlispongus*, *Oertlispongus* and *Falcispongus* are described. Furthermore some other new species and genera are described that are used in stratigraphical papers without systematic part, to avoid the use of nomina nuda.

2. Systematic part

Subclass Radiolaria MÜLLER, 1858
Order Polycystida EHRENBERG, 1838
Suborder Entactinaria KOZUR & MOSTLER, 1982
Superfamily Palaeoscenidiacea RIEDEL, 1967
emend. KOZUR & MOSTLER, 1982
Family Eptingiidae DUMITRICĂ, 1978

Genus *Cryptostephanidium* DUMITRICĂ, 1978

Type species: *Cryptostephanidium cornigerum* DUMITRICĂ, 1978

Cryptostephanidium sugiyamai n. sp.

Derivatio nominis: In honour of Prof. Dr. KAZUHIRO SUGIYAMA, Nagoya, for his excellent work on Lower and Middle Triassic radiolarians.
Holotypus: The specimen figured by SUGIYAMA (1992), Fig. 13-3; rep.-no. ESN 146172.
Locus typicus: Mt. Kinkazan section of Gifu, Gifu Prefecture, central Japan.
Stratum typicum: Bedded cherts, sample KIN 61 (see SUGIYAMA, 1992, Fig. 2), Lower Anisian *Hozmadia gifuensis* Zone.
Diagnosis: Pore frames with verrucose to irregular spiny surface. The three main spines are of unequal length. Their proximal third to half is three-bladed, their distal half is round.
Description: Shell small, subspherical. The surface of the pore frames is verrucose or covered with very small, irregular, partly oblique spines. Pores moderately large, mostly pentagonal. The three

main spines are situated in continuation of spines of the entactinarian spicular system. Their width decreases gradually from the base to the pointed needle-like distal end. The spine A is longer than the two spines L. the proximal third to half of the main spines is three-bladed. The furrows between the blades are wide, at the base of the spines deep, but they become shallow in distal direction. The distal half to 2/3 of the main spines has a circular cross section and no blades and furrows are present.

Measurements:
Diameter of shell: 85–100 µm
Length of main spines: 60–95 µm
Maximal width of the main spines: 20–25 µm

Occurrence: Common in the Lower Anisian of Karaburun peninsula (western Turkey) and in Japan.

Remarks: The Turkish material is rich in specimens, but not well preserved. Therefore, the specimen figured by SUGIYAMA (1992) was chosen as holotype.

Cryptostephanidium sugiyamai n. sp. is a transitional form between *Spongostephanidium* DUMITRICĂ, 1978 emend. KOZUR, KRAINER & MOSTLER, this volume, and *Cryptostephanidium* DUMITRICĂ, 1978. The proximal third to half of the main spines is already tricarinate as in *Cryptostephanidium*, the distal half to 2/3 of the main spines is needle-like with round cross section as in *Spongostephanidium*.

In the younger *Cryptostephanidium* species nearly the entire main spines are tricarinate. In the otherwise similar *C. verrucosum* DUMITRICĂ, 1978, the three main spines have equal length.

Suborder Spumellaria EHRENBERG, 1875
Superfamily Actinommacea HAECKEL, 1862
emend. KOZUR & MOSTLER, 1979
Family Pantanelliidae PESSAGNO, 1977

Genus *Liassobetraccium* n. gen.

Type species: *Betraccium bavaricum* KOZUR & MOSTLER, 1990

Derivatio nominis: According the similarity to *Betraccium* PESSAGNO and the occurrence in the Liassic.

Diagnosis: Cortical shell subspherical with high and coarse pore frames. The pores are very large, but irregular in size and shape. Most pores are triangular and tetragonal, but some pentagonal pores may be also present. Some pores may be divided by fragile secondary pore frames. Vertices of the pore frames with distinct nodes and spines. The three stout, three-bladed main spines are twisted or untwisted, equidistant and of the same size. Medullary shell present.

Occurrence: Hettangian of the Tethys.

Assigned species:
Betraccium bavaricum KOZUR & MOSTLER, 1990
Betraccium hettangicum KOZUR & MOSTLER, 1990
Betraccium inaequiporatum KOZUR & MOSTLER, 1990
Betraccium verticispinosum KOZUR & MOSTLER, 1990

Remarks: *Betraccium* PESSAGNO, 1979, is a very common Upper Norian and Rhaetian genus both in the Tethys and in the Circum-Pacific realm. It suddenly disappeared at the base of the Liassic (CARTER, 1993). However, there are some closely related species in the Hettangian that have been assigned to *Betraccium* by KOZUR & MOSTLER (1990). In contrast to typical Triassic *Betraccium* species, in all these species the pore frames encloses pores of different size and shape. In *Betraccium* all pores have the same size and pentagonal or hexagonal outline. In the Liassic forms the pore outline is in general triangular or tetragonal and only subordinately pentagonal outline of the pores is present. These Liassic species group is separated as *Liassobetraccium* n. gen.

Superfamily Sponguracea HAECKEL, 1862
emend. KOZUR & MOSTLER, 1981
Family Oertlispongidae KOZUR & MOSTLER, 1980 (in DUMITRICĂ et al., 1980)

Genus *Falcispongus* DUMITRICĂ, 1982

Type species: *Falcispongus falciformis* DUMITRICĂ, 1982

Falcispongus zapfei n. sp.
(Pl. 1, Fig. 10)

Derivatio nominis: in honour of Prof. emer. H. ZAPFE, Vienna, for his outstanding contributions to the Triassic stratigraphy.
Holotypus: The specimen on Pl. 1, Fig. 10; rep.-no. 14-4-94/V-5
Locus typicus: Outcrop ca. 350 m south of Pietra dei Saracini, Sosio Valley, western Sicily (Italy).
Stratum typicum: Basal 20 cm of red, strongly siliceous, marly limestones, sample Ko 5. Very base of the Ladinian, base of the *S. italicus* Zone.
Material: 2 specimens.
Diagnosis: The perpendicularly inward bent distal part of the main polar spine is considerably shorter than straight axial proximal part. Main polar spine at the bent flattened, with small widening at the outer side directly before the bent.
Description: Straight axial proximal part of the main polar spine in its upper part flat, with small widening at its outer side directly before the bent. The perpendicularly inward bent distal part is distinctly shorter than the straight part of the main polar spine. It is not recurved. Shell not preserved.
Measurements:
Length of the straight part of the main polar spine: 300–360 µm
Width of the straight part of the main polar spine at its proximal end (above the conical part that was originally within the shell): 30–33 µm
Width of the straight part of the main polar spine directly before the bent: 40–53 µm
Length of the inward curved part of the main polar spine: 160–200 µm
Occurrence: Lower part of *Oertlispongus primitivus* Subzone of the *S. italicus* Zone of western Sicily (lower Fassanian).
Remarks: *Falcispongus zapfei* n. sp. is the most primitive *Falcispongus* species. All other lower Ladinian species of this genus have a long inward curved and mostly also recurved distal part that is longer than the straight proximal part. The widening at the outer side of the distal end of the straight part of the main polar spine or (and) at the bent is more pronounced in the other *Falcispongus* species.

F. zapfei is similar both to *Pseudoertlispongus mostleri siciliensis* n. subsp. and to *Oertlispongus primus* n. sp. The main polar spine of *Pseudoertlispongus mostleri siciliensis* is not flattened near the bent and no widening at the outer side of the straight part of the main polar spine directly below the bent is present. In *Oertlispongus primus* n. sp., the inward curved part is about as long as the straight part. Apparently, at the base of the Ladinian both the first primitive *Oertlispongus* and the first primitive *Falcispongus* have evolved from *Pseudoertlispongus* of the *P. mostleri* group.

Genus *Oertlispongus* DUMITRICĂ, KOZUR & MOSTLER, 1980

Type species: *Oertlispongus inaequispinosus* DUMITRICĂ, KOZUR & MOSTLER, 1980

Oertlispongus primus n. sp.
(Pl. 1, Fig. 9)

Derivatio nominis: Oldest known true *Oertlispongus* species.
Holotype: The specimen on Pl. 1, Fig. 9; rep.-no. 14-4-94/V-24
Locus typicus: Outcrop ca. 350 m south of Pietra dei Saracini, Sosio Valley, western Sicily (Italy).
Stratum typicum: Basal 20 cm of red, strongly siliceous, marly liMestones, sample Ko 5. Very base of the Ladinian, base of the *S. italicus* Zone.
Material: 5 specimens.
Diagnosis: Straight proximal part of the main polar spine long, only a little shorter than or as long as the nearly perpendicularly inward curved part that is only insignificantly recurved.
Description: The straight axial proximal part of the main polar spine is long for the genus and only somewhat shorter than the inward curved part. In the proximal part the cross section of the main polar spine is round, but in its upper part and in the bent the main polar spine is flattened and has an oval cross section. The inward curved part lies nearly perpendicular to the straight axial part; it is only somewhat longer than or as long as the axial

straight proximal part. The inward curved part is nearly not recurved. Shell not preserved.

Measurements:

Length of the straight axial proximal part of the main polar spine: 280–295 µm

Width of the straight axial proximal part of the main polar spine at its proximal end (above the conical part that was originally within the shell): 27–29 µm

Width of the main polar spine directly before the bent: 39–43 µm

Length of the inward curved part of the main polar spine: 280–305 µm

Occurrence: Lower part of *Oertlispongus primitivus* Subzone of the *S. italicus* Zone. Basal part of Ladinian. Hungary and Sicily (Italy).

Remarks: *Oertlispongus primus* n. sp. is the oldest and most primitive *Oertlispongus* species. It has transitional character to *Pseudoertlispongus mostleri siciliensis*. It is distinguished from all *Pseudoertlispongus* species by its longer, strongly inward curved part that is nevertheless not or only a little longer than the straight axial proximal part of the main polar spine. Additionally, the main polar spine is flattened near the bent.

In all other *Oertlispongus* species the inward bent part is considerably longer than the straight proximal part and, except of few undescribed forms from the lowermost Ladinian, strongly recurved.

Falcispongus nicorae n. sp. displays a shorter inward bent part and a slight widening is present at the outer side of the bent.

Genus *Paroertlispongus* Kozur & Mostler, 1981

Type species: *Paroertlispongus multispinosus* Kozur & Mostler, 1981

Remarks: Three *Paroertlispongus* species occur in sample Ko 5 from the basal *S. italicus* Zone of Sosio Valley, Sicily (Italy), that are *P. multispinosus* Kozur & Mostler, 1981 (Pl. 1, Fig. 1), *P. rarispinosus* Kozur & Mostler, 1981 (Pl. 1, Fig. 2) and *P. chinensis* (Feng, 1992) (Pl. 1, Fig. 3). The first two species are only represented by isolated main polar spines, a very typical preservation for Oertlispongidae. The main polar spine of *P. multispinosus* is widest after its midlength. The main polar spine of *P. rarispinosus* is cylindrical in its proximal half and becomes needle-like towards its distal end. *P. chinensis* has several small, low ribs at the base of both polar spines.

Genus *Pseudoertlispongus* Lahm, 1984

Type species: *Pseudoertlispongus weddigei* Lahm, 1984

Occurrence: *Yeharaia annulata* Subzone of the *Spongosilicarmiger transitus* Zone (upper Illyrian) of the Tethys.

Remarks: *Pseudoertlispongus* has the same distribution of the second order spines on the spongy shell as *Paroertlispongus*, but the distal end of the main polar spine is curved. The straight part of the main polar spine is considerably longer than the curved part. In *Oertlispongus* the distribution of the second order spines is different from *Paroertlispongus* and *Pseudoertlispongus*, and the main spine is recurved. The straight part of the main polar spine is shorter than the curved part. By the presence of a distally somewhat curved spine, *Pseudoertlispongus* is a transitional form between *Paroertlispongus* and *Oertlispongus*. It appears considerably later than the first *Paroertlispongus*, but distinctly before the first *Oertlispongus*.

Pseudoertlispongus angulatus n. sp.

(Pl. 1, Figs. 4, 5)

Derivatio nominis: According to the abruptly inward curved distal end of the main polar spine.

Holotypus: The specimen on Pl. 1, Fig. 4; rep.-no. 16-2-95/II-104.

Locus typicus: Torrente San Calogero section (see Catalano, Di Stefano & Kozur, 1991).

Stratum typicum: Basal 10 cm of the gray radiolarite directly above the Changxingian red deep-water clay. Uppermost Anisian *Y. annulata* Subzone of the *S. transitus* Zone.

Material: 12 specimens.

Diagnosis: The main polar spine is widest immediately before the abrupt, angular bent in its distal third.

Description: The main polar spine is large. Its width increases gradually and slowly until the sharp angular bent in the distal third of the main polar spine. The straight, inward directed distal part of the main polar spine has different length and the angle with the straight axis of the main polar spine varies, but it is not larger than 45°. Only this inward directed part becomes narrower towards the pointed distal end. Shell not preserved.

Measurements:

Length of the main polar spine: 440–510 µm

Length of the straight axial part of the main polar spine: 350–370

Length of the inward bent part: 100–150 µm

Width of the proximal part of the main polar spine (above the conical part that was originally situated inside the shell): 30 µm

Width directly before the bent of the main polar spine: 35–46 µm

Occurrence: Uppermost Anisian (? and lowermost Ladinian) of western Sicily.

Remarks: In the other two known *Pseudoertlispongus* species, *P. weddigei* LAHM, 1984 and *P. mostleri* n. sp., the bent is gently curved. In *P. weddigei* additionally the main spine becomes narrower directly before the bent.

Pseudoertlispongus mostleri n. sp.

(Pl. 1, Figs. 6, 7)

1994 *Paroertlispongus weddigei* (LAHM, 1994) – KOZUR & MOSTLER, p. 69-70, Pl. 12, Figs. 12-14

Derivatio nominis: In honour of Univ.-Prof. Dr. H. MOSTLER for his outstanding contributions to the Triassic radiolarian research.

Holotypus: The specimen on Pl. 1, Fig. 6; 14-4-94/V-3.

Locus typicus: Outcrop ca. 350 m south of Pietra dei Saracini, Sosio Valley, western Sicily (Italy).

Stratum typicum: Basal 20 cm of red, strongly siliceous, marly limestones, sample Ko 5. Very base of the Ladinian, base of the *S. italicus* Zone.

Material: 35 specimens.

Diagnosis: Shell spongy with numerous by-spines that are not concentrated to any part of the shell. Main polar spine cylindrical, widest directly before or at the bent. The bent is gradual and rounded.

Description: The spherical spongy shell consists of several layers. Its surface is covered by numerous needle-like by-spines that start in well preserved forms from node-like elevations. The main polar spine is very long and mostly the only preserved part of a specimen. It is cylindrical and widest directly before the bent or at the bent. The bent is gradually rounded. The inward-curved distal part of the main polar spine is short, its angle with the long axial straight part of the main polar spine is around 45°, but in the subspecies *P. mostleri siciliensis* between 45° and nearly 90°. The second polar spine opposite or somewhat obliquely opposite to the main polar spine is long, needle-like, but rarely preserved.

Measurements: See under the subspecies.

Occurrence: Uppermost Anisian *Y. annulata* Subzone of the *S. transitus* Zone and lower Ladinian *S. italicus* Zone.

Remarks: *Pseudoertlispongus mostleri* is the transition form between *Pseudoertlispongus* and *Oertlispongus*. The spongy shell with nodes and by-spines on the entire surface corresponds to *Paroertlispongus multispinosus*. The main polar spine is also similar, but distally inward curved.

In *Oertlispongus primus* n. sp., the oldest *Oertlispongus* species, the early perpendicularly inward curved part is longer than or as long as the straight axial part of the main polar spine.

Pseudoertlispongus mostleri mostleri n. subsp.

(Pl. 1, Fig. 6)

Holotypus, locus typicus and stratum typicum: As for the species.

Material: 31 specimens.

Diagnosis: With the character of the species. The distal, inward bent part of the main polar spine is always short and its angle with the axial straight part of the main polar spine is not larger than 45°.

The main polar spine is broadest directly before the bent.

Measurements:
Diameter of shell: 180–267 µm
Length of the main polar spine: 350–430 µm
Width of the main polar spine at its proximal end (outside the shell or outside the conical part, if the shell is not preserved: 20–35 µm
Width of the main polar spine directly before the bent: 26–50 µm
Length of the inward curved distal part of the main polar spine: 50–95 µm
Length of the by-spines: 10–50 µm

Occurrence: Uppermost Anisian *Y. annulata* Subzone of the *S. transitus* Zone and Lower Fassanian *S. italicus* Zone of Hungary, Southern Alps and Sicily (Italy).

Remarks: In *Pseudoertlispongus mostleri siciliensis* n. subsp., the main polar spine is widest at the bent and the distal part is stronger inward curved.

Pseudoertlispongus mostleri siciliensis n. subsp.
(Pl. 1, Fig. 7)

Derivatio nominis: According to the occurrence in Sicily.

Holotype: The specimen on Pl. 1, Fig. 7; rep.-no.: 14-4-94/V-2.

Locus typicus and stratum typicum: As for the species.

Material: 4 specimens.

Diagnosis: With the character of the species. Main polar spine widest at the bent or of the same width throughout its straight axial part. Inward bent strong, partly nearly perpendicular to the straight axial part of the main spine.

Measurements:
Length of the main polar spine: 500–520 µm
Width of the main polar spine at its proximal end (after the conical part, that was originally inside the shell): 40–47 µm
Width of the main polar spine at the bent: 43–47 µm
Length of the inward curved distal part of the main polar spine: 133–147 µm

Occurrence: Upper part of the uppermost Anisian *Y. annulata* Subzone of the *S. transitus* zone and lower part of *Oertlispongus primitivus* Subzone of the *S. italicus* Zone.

Remarks: *Pseudoertlispongus mostleri mostleri* n. subsp. has a fewer inward bent distal part of the main polar spine that is widest directly before the bent.

In *Oertlispongus primus* n. sp. the inward part of the main polar spine is somewhat longer than or as long as the straight axial part of the main polar spine.

Superfamily Trematodiscacea HAECKEL, 1862 emend. KOZUR & MOSTLER, 1979
Family Relindellidae KOZUR & MOSTLER, 1980 (in DUMITRICĂ et al., 1980)

Genus *Pentaspongodiscus* KOZUR & MOSTLER, 1979

Type species: *Pentaspongodiscus tortilis* KOZUR & MOSTLER, 1979

Pentaspongodiscus lahmi n. sp.

1984 *Pentaspongodiscus anisicum* KOZUR & MOSTLER 1981 – LAHM, p. 57, Pl. 10, Fig. 1

Derivatio nominis: In honour of Dr. B. LAHM, München, who firstly found first this species.

Holotypus: The specimen figured by LAHM (1984) on Pl. 10, Fig. 1 under *Pentaspongodiscus anisicus* KOZUR & MOSTLER, 1981; rep.-no. Prot. 3623.

Locus typicus: Section Rec. A, 2.5 km SE of Recoaro, in the Val di Creme.

Stratum typicum: Limestone with siliceous nodules about 40 cm above the beginning of the pelagic limestones, sample Rec. A 9. Lower *S. italicus* Zone (Lower Ladinian).

Material: 23 specimens.

Diagnosis: The five untwisted tricarinate main spines are slender and shorter than the shell diameter.

Description: The discoidal shell is large compared with the length of the main spines. Its equatorial outline is round. It is spongy with *Alievum* pattern of the outer pore frames. Distinct small nodes

are present on the slightly elevated vertices. Five fragile short rays originate in all vertices. The five slender main spines are tricarinate, with a needle-like, round distal prolongation. They are untwisted and always shorter than the shell diameter.

Measurements:
Diameter of shells: 150–167 µm
Length of the main spines: 100–133 µm
Width of the main spines at their base: 23–25 µm

Occurrence: Lower Ladinian *S. italicus* Zone of Hungary and Italy.

Remarks: LAHM (1984) assigned this species to *Pentaspongodiscus anisicus* KOZUR & MOSTLER, 1981. However, this Upper Anisian species (ancestor of *P. lahmi)* has a pentagonal equatorial outline of the shell and the robust, long main spines are distinctly longer than the shell diameter.

Suborder Nassellaria EHRENBERG, 1875
Family Hinedorcidae KOZUR & MOSTLER, 1981

Genus *Picapora* KOZUR & MOSTLER, 1981

Type species: *Picapora robusta* KOZUR & MOSTLER, 1981

Picapora fassanica n. sp.

Derivatio nominis: According to the occurrence in the Fassanian.

Holotypus: The specimen figured by GORIČAN & BUSER (1990), Pl. 11, Fig. 1.

Locus typicus: 1.5 km north of Zaklanec near Horjul at the Zaklanec-Koreno road (southern part of the Slovenian Basin); see GORIČAN & BUSER, 1990, Fig. 1.

Stratum typicum: Cherty limestone below volcanics, sample Gr 10 (see GORIČAN & BUSER, 1990, Fig. 2).

Material: 23 specimens.

Diagnosis: A *Picapora* with small vertical horn.

Description: Cephalis subspherical (somewhat broader than high) with small pores that are mostly closed by a layer of microgranular silica; surface slightly verrucose. The apical horn is stout, tricarinate, with deep and broad furrows between the high and narrow blades. A distinct, but rather small and short, carinate vertical horn is present. Thorax larger than cephalis, with the same surface structure and mostly closed small pores. It has the shape of a cone frustum or it is subspherical. Its wide aperture is closed by a fragile thin layer with small pores that is often destroyed. The three feet are stout, moderately long, tricarinate. They run from the distal part of the cephalis on the surface of the thorax and are free only beyond the thorax. Cephalic spicular system with Mb, A, V, 2 L, D, 2 l. The spines A and V continue outside the shell as apical horn and horn V, whereas D and 2 L continue as feet.

Measurements:
Height of cephalis: 30–40 µm
Width of cephalis: 50–55 µm
Height of thorax: 50–60 µm
Width of thorax: 70–85 µm
Length of the apical horn: 40–45 m
Length of the free part of the feet: 50-55 µm

Occurrence: Fassanian of Slovenia, Hungary and Italy.

Remarks: The Julian *Picapora robusta* KOZUR & MOSTLER, 1981 has a very big vertical horn.

Family Triassocampidae
KOZUR & MOSTLER, 1981

Genus *Praeyeharaia* n. gen.

Type species: *Yeharaia transita* KOZUR & MOSTLER, 1994

Derivatio nominis: According to the ancestral position to *Yeharaia* NAKASEKO & NISHIMURA, 1979

Diagnosis: Test multicyrtid, conical. Cephalis conical, smooth with small apical horn. Thorax a little broader, but in general shorter than the cephalis, ring-like or hoop-like, with nodes or a ring of nodes; pores small, mainly closed. Abdomen cylindrical or hoop-like, nodose, with small, partly open pores. The postabdominal segments are in general inverted conical with a smooth, in the proximal segments slightly nodose proximal ring. The distal part of these segments is nodose. Below

the proximal ring a ring of rather large pores is present. In the distal part of the postabdominal segments a second, often incomplete pore ring is present. The proximal two postabdominal segments may be hoop-like, with indistinct proximal ring. Cephalic spicular system with A, V, 2 L, D, 2 l. Only spine A continues outside the shell wall as short apical spine. Sometimes also a tiny spine is present in prolongation of D.

Occurrence: Uppermost Anisian *S. transitus* Zone and Lower Ladinian *S. italicus* Zone.

Assigned species:

Yeharaia transita KOZUR & MOSTLER, 1994

Yeharaia japonica NAKASEKO & NISHIMURA, 1979

Yeharaia lata *KOZUR* & MOSTLER, 1994

Remarks: *Yeharaia* NAKASEKO & NISHIMURA, 1979, has a long apical spine and an inflated thorax and the postabdominal segments (except the first one) have only one ring of pores. *Triassocampe* DUMITRICĂ, KOZUR & MOSTLER, 1980 has no apical spine.

Praeyeharaia n. gen. is transitional between *Yeharaia* and *Triassocampe*. *Praeyeharaia* species have been in previous paper partly assigned to *Yeharaia*, partly to *Triassocampe*.

3. Stratigraphic evaluation

The Oertlispongidae are the most important Ladinian radiolarian guideforms of the Tethys. In previous studies, *Paroertlispongus* was found in the Illyrian and Fassanian, and rich *Oertlispongus* faunas with *O. inaequispinosus primitivus* KOZUR & MOSTLER were found in the lower Fassanian lower *Reitziites reitzi* ammonoid zone s. str. (*O. inaequispinosus primitivus* Subzone of the *S. italicus* radiolarian zone). Despite the fact that *Paroertlispongus* was regarded as the forerunner of *Oertlispongus* (KOZUR & MOSTLER, 1981), the transition forms between both genera, and the immediate forerunner of *Falcispongus* were not found.

In the upper subzone of the *S. italicus* Zone both advanced *Oertlispongus* with very short proximal straight part of the main polar spine (e.g. *O. inaequispinosus inaequispinosus*) and typical *Falcispongus* were found.

Investigations of rich further material of sample 100 D (*Kellnerites felsoeoersensis* ammonoid zone) from the Felsőőrs section in the Balaton Highland (Hungary) and investigations near the base of the *Reitziites reitzi* Zone in the Balaton Highland, Southern Alps and in Sicily have yielded the complete transitional series from *Paroertlispongus* to *Oertlispongus*. *Pseudoertlispongus mostleri*, n.sp. a transitional form between *Paroertlispongus* and *Oertlispongus* appeared near the base of the *Kellnerites felsoeoersensis* ammonoid zone. The radiolarian fauna of this level belongs to the upper subzone (*Yeharaia annulata* Subzone) of the *S. transitus* Zone. Beside of Ladinian elements, as *Eptingium manfredi manfredi* DUMITRICĂ, *Pseudoertlispongus mostleri* n. sp., *Triassocampe deweveri* (NAKASEKO & NISHIMURA), *T. scalaris* DUMITRICĂ, KOZUR & MOSTLER and *Yeharaia annulata* NAKASEKO & NISHIMURA, this fauna contains still dominating Anisian elements, listed in KOZUR, KRAINER & MOSTLER (this volume). Consequently, this fauna was assigned by KOZUR (1995) to the uppermost Anisian. It has, however, transitional character to Ladinian radiolarian faunas, but advanced Oertlispongidae, which dominate in the entire Ladinian, are still missing. They begin near the base of the *Reitziites reitzi* ammonoid zone at the base of the *S. italicus* radiolarian zone. There, not only *Pseudoertlispongus mostleri* n.sp. is present, but also the first *Oertlispongus* s. str. in which the lateral curved (and mainly distinctly recurved) distal part of the main polar spine is at least as long as the proximal straight part. In typical *Oertlispongus*, this distal part is strongly recurved and considerably longer than the straight proximal part. In *Oertlispongus primus* the inward curved part is about as long as the proximal straight part and it is therefore a perfect transition form between *Pseudoertlispongus mostleri siciliensis* and *Oertlispongus inaequispinosus*. In the same level also the first *Falcispongus*, *F. zapfei*, appeared. This form also derived from *Pseudoertlispongus mostleri siciliensis*, the inward curved part is still as short as in this

species and considerably shorter than the straight proximal part of the main polar spine, but it is already strongly flattened near the bent, and directly below the bent a small widening is present at the outer side of the straight part of the main polar spine. By this can be demonstrated that *Falcispongus* did not evolve from *Oertlispongus*, but directly from *Pseudoertlispongus*.

Throughout the Ladinian, the primitive Oertlispongidae continue beside the advanced forms. *Pseudoertlispongus mostleri* n.sp. and *P. angulatus* n.sp. are the only Oertlispongidae with differentiated main polar spine (inward curved distal part) in the uppermost Illyrian *Y. annulata* Subzone of the *S. transitus* Zone. Advanced Oertlispongidae with short straight proximal part of the main polar spine and long, recurved distal part are not yet present. These forms appeared at the base of the *S. italicus* Zone. In a very short interval these advanced forms are only represented by transitional forms to the primitive Oertlispongidae with very long straight proximal part of the main polar spine, but a little later already forms with very long recurved distal part and distinctly short straight proximal part of the main polar spine are present. However, the primitive Oertlispongidae still continue in this stratigraphic level, e.g. *Paroertlispongus*, *Pseudoertlispongus* and primitive *Oertlispongus*. In the Lower Longobardian highly advanced Oertlispongidae with strongly differentiated spines occur (genera *Pterospongus*, *Bogdanella* etc.), but *O. inaequispinosus* from the Fassanian continued into this level. Therefore, for the subdivision of the Middle Triassic radiolarian faunas, the first appearance of a certain taxon is very important and the exact age is indicated by the most advanced forms within a phylogenetic cline.

Acknowledgements

The author is very grateful for the financial support by the Deutsche Forschungsgemeinschaft and for the support by Univ. Prof. Dr. H. MOSTLER, Innsbruck.

References

CARTER, E.S. (1993): Biochronology and paleontology of uppermost Triassic (Rhaetian) radiolarians, Queen Charlote Islands, British Columbia, Canada. – Mémoires de Géologie (Lausanne), **11**, 175 pp., Lausanne 1993.

CATALANO, R., DI STEFANO, P. & KOZUR, H. (1991): Permian Circumpacific deep-water faunas from the Western Tethys (Sicily, Italy) – new evidences for the position of the Permian Tethys. – Palaeogeogr., Palaeoclimatol., Palaeoecol., **87**, 1–4, 75–108, Amsterdam.

DUMITRICĂ, P. (1978): Family Eptingiidae n. fam., extinct Nassellaria (Radiolaria) with sagittal ring. – Dari seama sed., 3. Paleont., **64**, 27–38, Bucureşti.

DUMITRICĂ, P. (1982): Triassic Oertlisponginae (Radiolaria) from eastern Carpathians and Southern Alps. – D. S. Inst. geol. geofiz., **67**, 3, 57–74, 2 figs., 12 pls., Bucureşti.

DUMITRICĂ, P., KOZUR, H. & MOSTLER, H. (1980): Contribution to the radiolarian fauna of the Middle Triassic of the Southern Alps. – Geol. Paläont. Mitt. Innsbruck, **10**, 1, 1–46, Innsbruck.

EHRENBERG, C.G. (1838): Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. – Abh. kgl. Akad. Wiss. Berlin, **1838**, 59–147, Berlin.

EHRENBERG, C.G. (1875): Fortsetzung der mikrogeologischen Studien als Gesammt-Uebersicht der mikroskopischen Paläontologie gleichartig analysirter Gebirgsarten der Erde, mit specieller Rücksicht auf den Polycystinen-Mergel von Barbados. – Abh. kgl. Akad. Wiss. Berlin, **1875**, 1–226, Berlin.

FENG, QINGLAI (1992): Permian and Triassic radiolarian biostratigraphy in south and southwest China. – J. China Univ. Geosci., **3**, 1, 51–62, Wuhan.

GORIČAN, S. & BUSER, S. (1990): Middle Triassic radiolarians from Slovenia (Yugoslavia). – Geologija, **31–32**, 133–197, Ljubljana.

GULLO, M. & KOZUR, H. (1993): First evidence of Scythian conodonts in Sicily. – N. Jb. Geol. Paläont. Mh., **1993**, 8, 477–488, Stuttgart.

HAECKEL, E. (1862): Die Radiolarien (Rhizopoda Radiolaria). Eine Monographie. – 572 pp., Berlin (Reimer).

KOZUR, H. (1995): The position of the Anisian-Ladinian boundary and the development of the radiolarian faunas in this level. – Proceedings First Croatian Geological Congress, **1**, 311–314, Zagreb.

KOZUR, H.W., KRAINER, K. & MOSTLER, H. (in press): Radiolarians and Facies of the Middle Triassic Loibl Forma-

tion, South Alpine Karawanken Mountains (Carinthia, Austria). – Geol. Paläont. Mitt. Innsbruck, Sonderbd. 4, 195–269, Innsbruck.

KOZUR, H. & MOSTLER, H. (1979): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil III: Die Oberfamilien Actinommacea HAECKEL 1862 emend., Artiscacea HAECKEL 1882, Multiarcusellacea nov. der Spumellaria und triassische Nassellaria. – Geol. Paläont. Mitt. Innsbruck, **9**, 1/2, 1–132, Innsbruck.

KOZUR, H. & MOSTLER, H. (1981): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil IV: Thalassosphaeracea HAECKEL, 1862, Hexastylacea HAECKEL, 1882 emend. PETRUSHEVSKAJA, 1979, Sponguracea HAECKEL, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria. – Geol. Paläont. Mitt. Innsbruck, Sonderband, 1–208, Innsbruck.

KOZUR, H. & MOSTLER, H. (1982): Entactinaria subordo nov., a new radiolarian suborder. – Geol. Paläont. Mitt. Innsbruck, **11**, 12, 399–414, Innsbruck.

KOZUR, H. & MOSTLER, H. (1990): Saturnaliacea DEFLANDRE and some other stratigraphically important Radiolaria from the Hettangian of Lenggries/Isar (Bavaria, Northern Calcareous Alps). – Geol. Paläont. Mitt. Innsbruck, **17**, 179–248, Innsbruck.

KOZUR, H. & MOSTLER, H. (1994): Anisian to Middle Carnian radiolarian zonation and description of some stratigraphically important radiolarians. – Geol. Paläont. Mitt. Innsbruck, Sonderband 3, 39–199, Innsbruck.

LAHM, B. (1984): Spumellarienfaunen (Radiolaria) aus den mitteltraissischen Buchensteiner-Schichten von Recoaro (Norditalien) und den obertriassischen Reiflingerkalken von Großreifling (Österreich) – Systematik, Stratigraphie. – Münchener Geowiss. Abh., A, **1**, 1–161, München.

NAKASEKO, K.& NISHIMURA, A. (1979): Upper Triassic Radiolaria from southwest Japan. – Sci. Rep., Col. Educ. Osaka Univ., **28**, 2, 61–109, Osaka.

PESSAGNO, E.A. (1977): Lower Cretaceous radiolarian biostratigraphy of the Great Valley sequence and Franciscan Complex, California Coastal Ranges. – Cushman Found. Foram. Re., Spec. Publ., **15**, 1–87, New York.

PESSAGNO, E.A., FINCH, W. & ABBOTT, P.L. (1979): Upper Triassic Radiolaria from the San Hipolto Formation, Baja California. – Micropaleontology, **25**, 2, 160–197, New York.

RIEDEL, W.R. (1967): Some new families of Radiolaria.- Proc. Geol. Soc. London, **1640**, 148–149, London.

SUGIYAMA, K. (1992): Lower and Middle Triassic radiolarians from Mt. Kinkazan, Gifu Prefecture, central Japan. – Trans. Proc. Palaeont. Soc. Japan, N.S. **167**, 1180–1223, Tokyo.

Author's address:
Dr. sc. H.einz W. Kozur, Rézsü u. 83, H-1029 Budapest, Hungary.

Plate 1

If not otherwise indicated, all figured specimens are from sample Ko 5 (basal 20 cm of red, strongly siliceous, marly limestones; very base of the Ladinian, base of the *S. italicus* Zone) in an Scythian to Ladinian section ca. 350 m south of Pietra dei Saracini, Sosio Valley, western Sicily, Italy (location see GULLO & KOZUR, 1993).

Fig. 1: *Paroeertlispongus multispinosus* KOZUR & MOSTLER, 1981, isolated main polar spine, x 130, rep.-no. 14-4-94/V-10.

Fig. 2: *Paroertlispongus rarispinosus* KOZUR & MOSTLER, 1981, isolated main polar spine, x 150, rep.-no. 14-4-94/V-7

Fig. 3: *Paroertlispongus chinensis* (FENG, 1992), x 100, rep.-no. 14-4-94/V-8

Figs. 4, 5: *Pseudoertlispongus angulatus* n.sp., x 200, sample SCK II/93, lowermost 10 cm of gray radiolarite directly above Changxingian red deep-water clay, *Yeharaia annulata* Subzone of *Spongosilicarmiger transitus* Zone, uppermost Anisian, Torrente San Calogero section (see CATALANO et al., 1991); Fig. 4: holotype, rep.-no. 16-2-95/II-104; Fig. 5: rep.-no. 16-2-95/II-106.

Fig. 6: *Pseudoertlispongus mostleri mostleri* n. sp., holotype, x 200, rep.-no. 14-4-94/V-3.

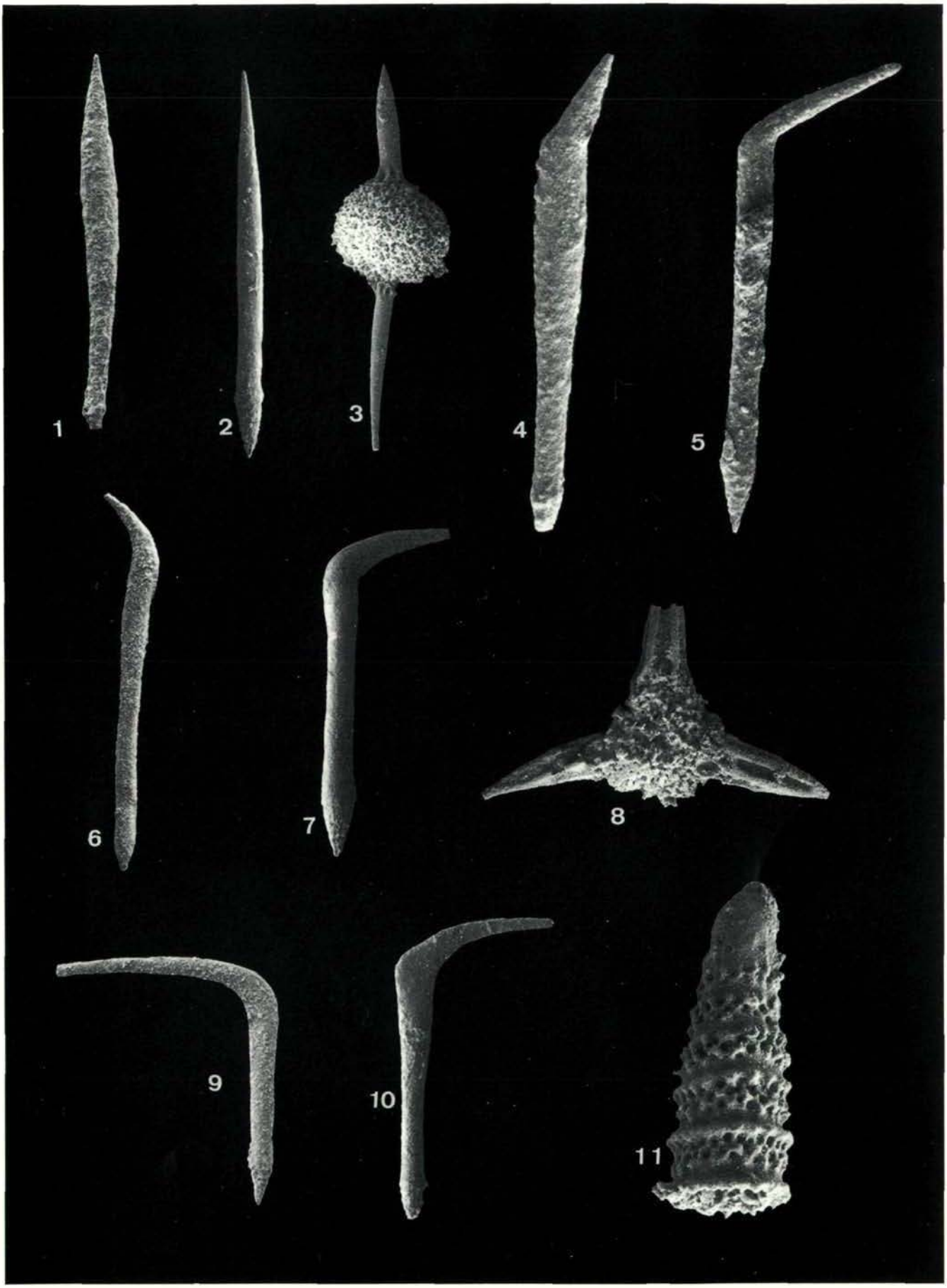
Fig. 7: *Pseudoertlispongus mostleri siciliensis* n. subsp., holotype, x 200, rep.-no. 14-4-94/V-2.

Fig. 8: *Eptingium manfredi manfredi* DUMITRICĂ, 1978, x 130, rep.-no. 14-4-94/V-9.

Fig. 9: *Oertlispongus primus* n. sp., holotype, x 145, rep.-no. 14-4-94/V-24.

Fig. 10 *Falcispongus zapfei* n. sp., holotype, x 150, rep.-no. 14-4-94/V-5.

Fig. 11: *Triassocampe scalaris baloghi* KOZUR & MOSTLER, 1994, x 300, rep.-no. 14-4-94/V-6.


1
2
3
4
5
6
7
8
9
10
11