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LATE LADINIAN (MIDDLE TRIASSIC) SPUMELLARIA (RADIOLARIA) FROM THE DINARIDES OF BOSNIA AND HERZEGOVINA

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Abstract. A limestone sample from southern Bosnia and Herzegovina near Fojnica town yielded extremely abundant and well-preserved radiolarians. The radiolarians are late Ladinian in age and clearly indicate the *Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone based on the index forms and associated fauna. A highly diverse spumellarian fauna is described from this sample. Within the defined spumellarian fauna, five genera (*Ligulatubus, Tubospongopallium, Hexacatoma, Octostella* and *Discofulmen)*, seventeen species (*Dumitricasphaera galeata, D. trialata, Spongostylus bosniensis, Spongopallium crassum, Ligulatubus yaoi, Tubospongopallium gracile, T. kozuri, T. tornatum, Archaeospongoprunum globosum, Veghicyclia cruciforma, V. krystyni, Hexacatoma elegantissima, H. nobleae, Octostella pulchra, Pentaspongodiscus similediscus*, *Discofulmen dumitricai, D. ishidai*) are new.

Riassunto. Un campione di calcare raccolto presso la città di Fojnica in Bosnia meridionale-Erzegovina ha fornito una fauna a radiolari estremamente abbondante e ben conservata. I radiolari sono di età tardo ladinica e sono riferibili alla sottozona a *Spongoserrula fluegeli* della zona a *Muelleritortis cochleata,* sulla base delle specie indice e dalla fauna associata. Una fauna a Spumellaria molto diversificata viene descritta in questo campione. Entro questa fauna a Spumellaria sono individuati come nuovi cinque generi (*Ligulatubus, Tubospongopallium, Hexacatoma, Octostella* and *Discofulmen)*, e diciassette specie (*Dumitricasphaera galeata, D. trialata, Spongostylus bosniensis, Spongopallium crassum, Ligulatubus yaoi, Tubospongopallium gracile, T. kozuri, T. tornatum, Archaeospongoprunum globosum, Veghicyclia cruciforma, V. krystyni, Hexacatoma elegantissima, H. nobleae, Octostella pulchra, Pentaspongodiscus similediscus*, *Discofulmen dumitricai, D. ishidai*).

Introduction

Late Ladinian radiolarians have been previously documented by Nakaseko & Nishimura (1979), Dumitrica (1982), De Wever (1984), Kozur & Krahl (1984), Bragin (1986, 1991), Dosztaly (1989, 1991, 1993), Kozur (1988a, b), Kolar-Jurkovsek (1989, 1990), Gorican & Buser (1990), Kozur & Mostler (1981, 1994, 1996a, b), Halamic & Gorican (1995), Sugiyama (1997), Tekin (1999). Of these publications, two papers (Kozur &

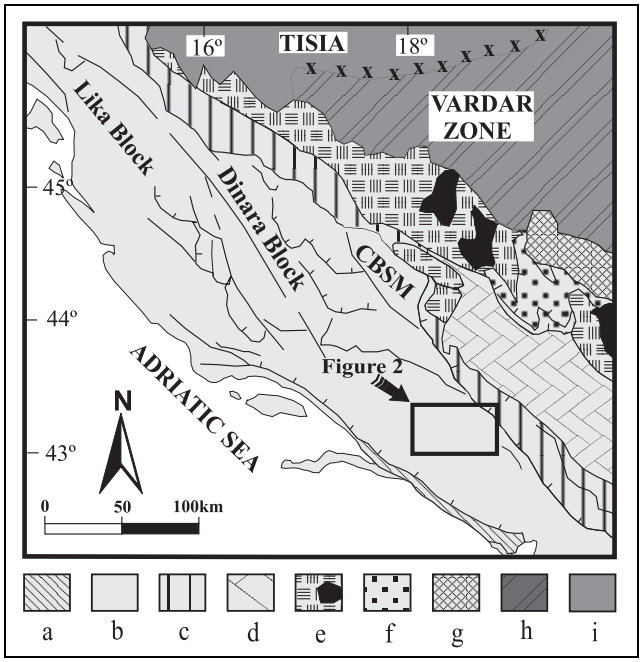

Fig. 1 - Geological outline of the Dinarides and the Vardar Zone with surrounding area (after Dimitrijevic 2001). Legend: a. Budva Zone, b. Dalmatian-Herzegovinan Zone, c. Sarajevo Sigmoid, d. East Bosnian Durmitor Nappe, e. Dinaric Ophiolitic Belt (mélange and ultramafics), f. Devetak Nappe Pile, g. Drina and Ivanjica blocks, h. Vardar Zone, i. Pannonian Basin. CBSM: Central Bosnian Schist Mountains; line of "x" gives approximate boundary between Tisia and the Vardar Zone.

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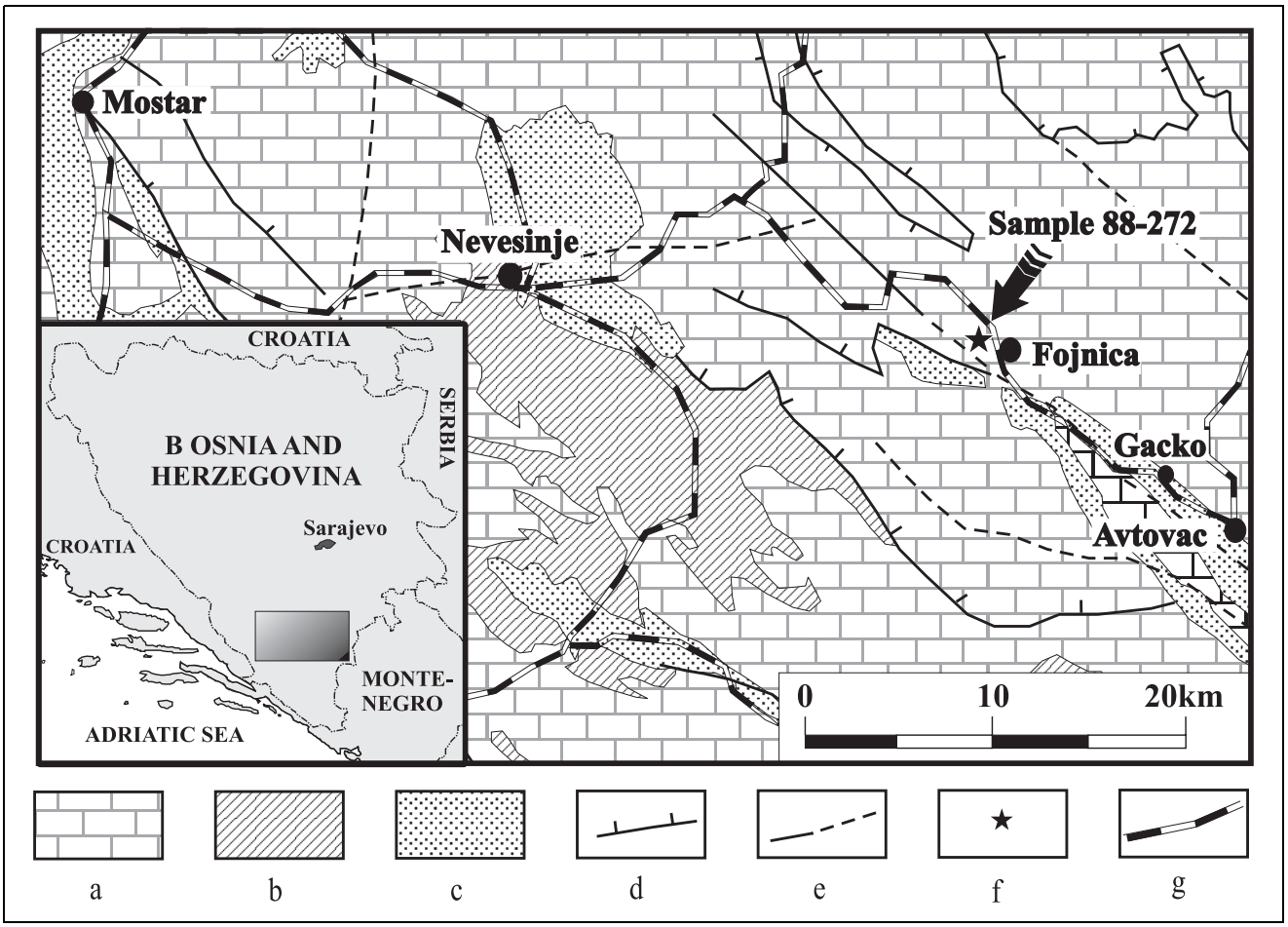


Fig. 2 - Geological map of the sampling region and its surroundings (simplified after Cicic 1985). Inset map shows the locality of the main map. Legend: a. Undifferentiated Mesozoic limestones, dolostones, clastic rocks, and diabase-chert, b. Tertiary sediments, c. Quaternary deposits, d. Major thrusts, e. Major faults, f. Sampling point, g. Main roads.

Mostler 1996a, b) deal with late late Longobardian radiolarians obtained from Bosnia and Herzegovina near Fojnica town. These studies focused mainly on the Muelleritortiidae and Oertlispongidae; many new taxa were described and their stratigraphical occurrence was evaluated.

The radiolarians studied by Kozur and Mostler (1996a, b) from Bosnia and Herzegovina are late late Longobardian in age and indicative of the *Spongoserrula fluegeli* subzone of the *Muelleritortis cochleata* Zone. This age assignment was also confirmed by the presence of the conodont element, *Budurovignathus mungoensis* (Diebel) (Kozur & Mostler 1996a, b). The aim of the present study is to document the remaining Spumellarian radiolarians from this sample. Taxonomic studies of Entactinaria and Nassellaria from this sample are a subject of a separate paper (Tekin & Mostler 2005.)

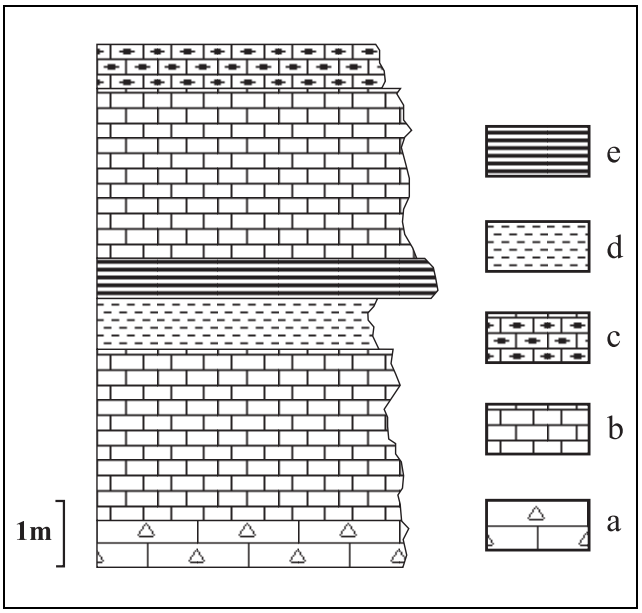


Fig. 3 - Succession with radiolarian-bearing limestone below and above a thin radiolarite-tuffite intercalation (from Mudrenovic and Gakovic 1964). Legend: a. Calcarenite, b. Radiolarian-bearing limestone, c. Cherty limestone, d. Tuffaceous claystone, e. Red radiolarite.

Geology and Material

Some of the important units in the Dinarides in the southwest Vardar Zone, from northeast to southwest are the Drina-Ivanjica Block,

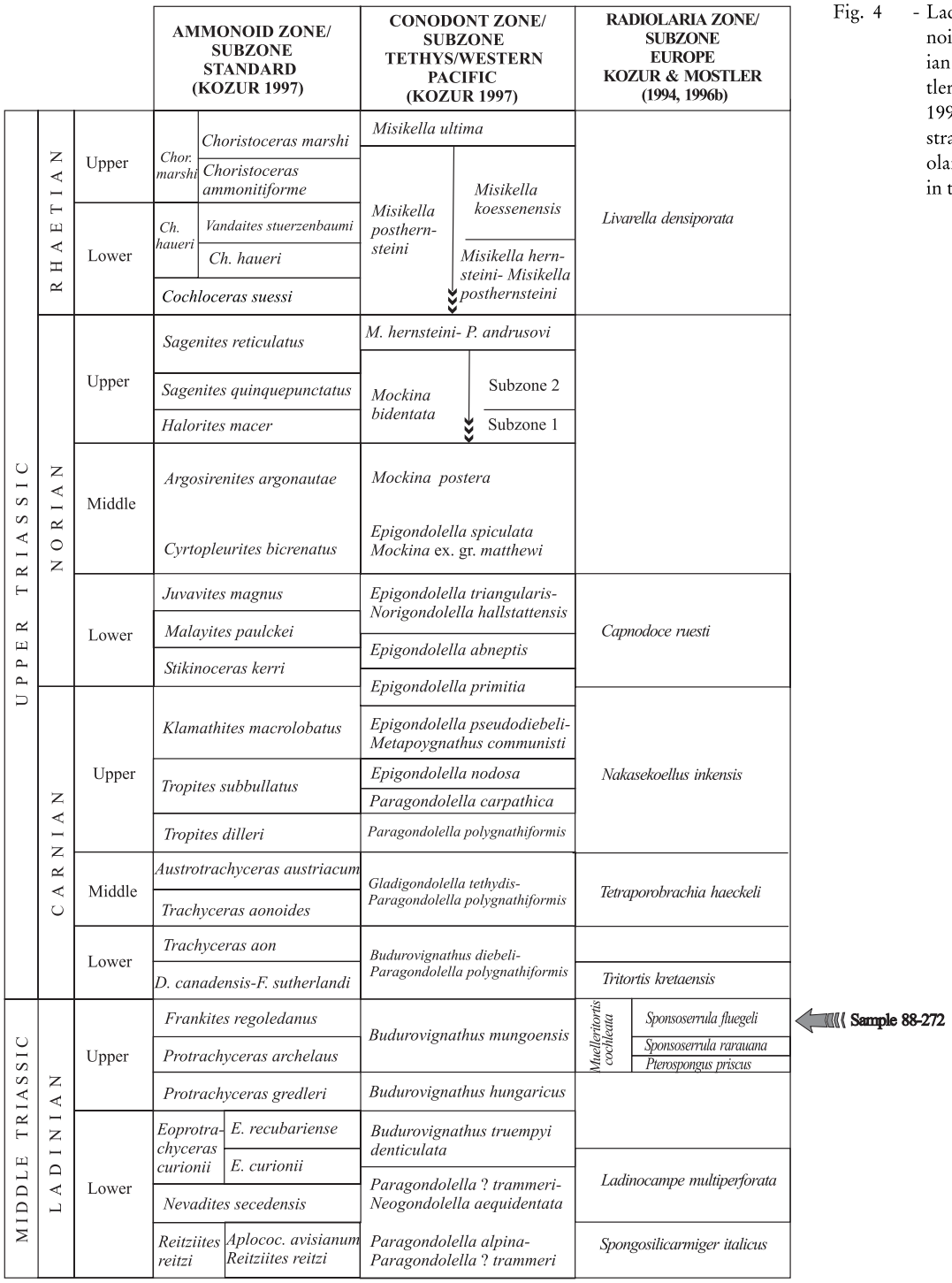


Fig. 4 - Ladinian to Rhaetian ammonoid, conodont and radiolarian zonations (Kozur & Mostler 1994, 1996a, b; Kozur 1997). Arrow indicates the stratigraphic position of Radiolaria bearing sample (88-272) in this study.

Dinaric Ophiolite Belt, East Bosnian Durmitor Zone, Sarajevo Sigmoid, Dalmatian-Herzegovinan Zone and Budva Zone (Dimitrijevic 2001) (Fig. 1). Within these zones, the Dalmatian-Herzegovinan Zone, known also as the "High Karst Nappe", comprises Mesozoic carbonates and associated rock units (Dimitrijevic 2001).

Radiolarians examined in this study are from a micritic limestone sample (Number: 88-272) collected by Prof. Dr. L. Krystyn (Vienna) from Varosci Creek, two km west of Fojnica near the road of Gacko - Mostar (Latitude: 43°13' 40" N; Longitude: 18°25' 50" E; Fig. 2). Mesozoic dolostones and limestones together with clastic rocks and cherts are widely exposed near Fojnica (Cicic 1985) (Fig. 2). Based on Mudrenovic & Gakovic (1964), the succession in this region is composed of calcarenite, pelagic limestone, cherty limestone, tuffitic claystone and radiolarite (Fig. 3). As this limestone sample was taken from a floated block, it is not apparent whether it was derived from below or above the tuffaceous claystone-chert intercalation.

Systematic Palaeontology

As previously explained, age of the sample 88-272 in this study is assigned as late late Ladinian based on the conodont and radiolarian fauna. They are indicative of *Budurovignathus mungoensis* conodont zone and *Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Radiolaria Zone (Kozur & Mostler 1996a, b; Kozur 1997) (Fig. 4).

The following abbreviations are utilised; HT: Holotype, Min.: Minimum, Max.: Maximum, Av.: Average. All materials are from sample 88-272. All holotypes and paratypes with collection numbers, GPU 2003/TEMO 1-091 - GPU 2003/TEMO1-161, are stored at the Institute of Geology and Palaeontology of Innsbruck University.

Subclass **Radiolaria** Müller, 1858

Order **Polycystina** Ehrenberg, 1838

Suborder **Spumellariina** Ehrenberg, 1838

Family Actinommidae Haeckel, 1862 emend. De Wever et al., 2001

Subfamily Actinomminae Haeckel, 1862

Genus *Acanthosphaera* Ehrenberg, 1858

Type Species: *Acanthosphaera haliphormis* Ehrenberg, 1861.

Acanthosphaera nicorae Kozur, Krainer & Mostler, 1996

Pl. 1, fig. 1

1996 *Acanthosphaera nicorae* Kozur, Krainer & Mostler, p. 221, pl. 8, fig. 9.

Range. Middle Triassic; late Anisian - late late Ladinian.

Occurrences. Austria; Hungary; Fojnica, Bosnia and Herzegovina.

Genus *Carinaheliosoma* Kozur & Mostler, 1981 emend. Lahm, 1984

Type Species: *Carinaheliosoma densiporata* Kozur & Mock in Kozur & Mostler, 1981.

Carinaheliosoma carinata (Kozur & Mostler, 1979)

Pl. 1, fig. 2

1979 *Heliosoma carinata* Kozur & Mostler, pp. 50-51, pl. 9, figs. 1-3.

1981 *Carinaheliosoma carinata* (Kozur & Mostler) - Kozur & Mostler, p. 68.

1984 *Carinaheliosoma carinata* - Lahm, pp. 65-66, pl. 11, fig. 9.

1999 *Carinaheliosoma carinata* - Bragin & Krylov, p. 545, fig. 2A, D.

1999 *Carinaheliosoma carinata* - Tekin, pp. 63-64, pl. 1, figs. 1-2.

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone) - Late Triassic; early Norian (*Epigondolella abneptis* Conodont Zone)

Occurrences. Goestling, Grossreifling, Austria; Mamonia Complex, Cyprus; Antalya, Turkey; Fojnica, Bosnia and Herzegovina.

Genus *Heliosoma* Haeckel, 1882 emend. Kozur & Mostler, 1979

Type Species: *Heliosoma radians* Haeckel, 1887.

Heliosoma? mocki (Kozur & Mostler, 1979)

Pl. 1, fig. 3

1979 *Acanthosphaera? mocki* Kozur & Mostler, pp. 49-50, pl. 7, fig. 1.

1981 *Heliosoma? mocki* (Kozur & Mostler) - Kozur & Mostler, p. 65, pl. 57, fig. 2.

1984 *Acanthosphaera mocki* - Gorican & Kolar-Jurkovsek, pl. 6, fig.1.

1984 *Heliosoma? mocki* - Lahm, pp. 64-65, pl. 11, fig. 6.

1990 *Heliosoma? mocki* - Kolar-Jurkovsek, p. 80, pl. 4, fig. 3.

Range. Middle Triassic; early Ladinian - Late Triassic; middle Carnian.

Occurrences. Goestling, Austria; Recoaro, north Italy; Slovenia; Fojnica, Bosnia and Herzegovina.

Family Stylosphaeridae Haeckel, 1862 emend. Kozur & Mostler, 1979

Genus *Dumitricasphaera* Kozur & Mostler, 1979 emend. Lahm, 1984

Type Species: *Dumitricasphaera goestlingensis* Kozur & Mostler, 1979.

Dumitricasphaera galeata n. sp.

Pl. 3, figs 3-4

Etymology. Galeata (Lat.), helmeted.

Types. Holotype, GPU 2003/TEMO 1-091 (Pl. 3, Fig. 3); paratype, GPU 2003/TEMO 1-092 (Pl. 3, Fig. 4).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Shell spherical to subspherical, spongy with two short polar spines. Polar spines tricarinate, straight and unequal with thin ridges and deep grooves. Three secondary spines branch off from each ridge in the middle part of the spine. Secondary spines

PLATE 1

Scanning electron photomicrographs of late Ladinian Spumellaria from Fojnica, Bosnia and Herzegovina. All materials are from sample 88-272. Scale = number of microns for each figure.

Fig. 1 - *Acanthosphaera nicorae* Kozur, Krainer & Mostler, scale bar = 100µm.

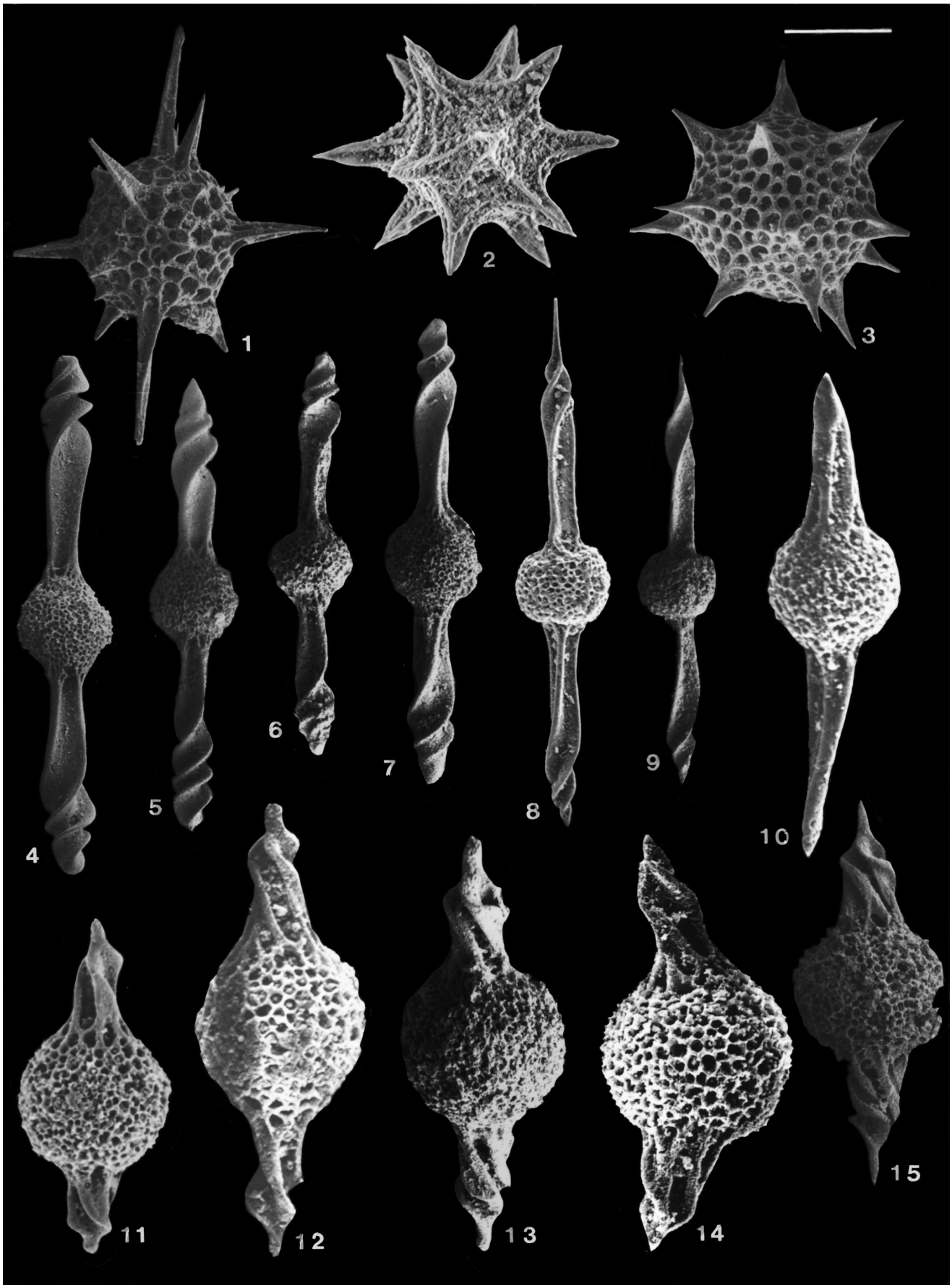
Fig. 2 - *Carinaheliosoma carinata* (Kozur & Mostler), scale bar = 80µm.

Fig. 3 - *Heliosoma? mocki* (Kozur & Mostler), scale bar = 100µm.

Figs. 4-9 - *Spongostylus bosniensis* n. sp, 4. Holotype, scale bar = 133µm, 5-9. Paratypes, scale bar = 155, 155, 165, 100 and 133µm respectively.

Fig. 10 - *Spongostylus koppi* (Lahm), scale bar = 100µm.

Figs. 11-15 - *Spongopallium crassum* n. sp., 11. Holotype, scale bar = 133µm, 12-15. Paratypes, scale bar = 100, 100, 100 and 118µm respectively.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short to moderately long, expanded medially then gradually decreasing in width distally. Secondary spines without denticles, pointed and slightly curved towards the central part.

Remarks. *Dumitricasphaera galeata* n. sp. differs from *D. simplex* Tekin (1999, p. 66, pl. 2, figs 1-2) in having shorter polar spines with centrally expanded secondary spines instead of gradually tapering secondary spines. It is differentiated from *D. goestingensis* Kozur & Mostler (1979, p. 60, pl. 3, fig. 1) by having shorter and wider secondary spines without denticles on the polar spines. It is compared to *Dumitricasphaera trialata* n. sp. under the latter species.

Measurements (μm). (Based on three specimens)

	HT	Min.	Max.	Av.
Max. diameter of shell	125	125	140	132
Length of polar spines	100	100	130	110

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Dumitricasphaera sp. aff. **D.? pennata** Gorican in Gorican & Buser, 1990

Pl. 3, fig. 5

aff. 1990 *Dumitricasphaera*? *pennata* Gorican in Gorican & Buser, p. 143, pl. 4, figs. 9a-b, 10.

Remarks. It differs from holotype of *D. pennata* Gorican (1990, pl. 4, fig. 9) by having a wings without ornamentations as thorns.

Range. Middle Triassic; late Ladinian.

Occurrences. Fojnica, Bosnia and Herzegovina.

Dumitricasphaera trialata n. sp.

Pl. 3, figs 6-8

1990 *Dumitricasphaera*? cf. *trispinosa* (Kozur & Mostler) - Gorican & Buser, p. 143, pl. 4, fig. 14

1999 *Dumitricasphaera* sp. A Tekin, pp. 66-67, pl. 2, figs 3-4

Etymology. Tri (Lat.), three; alata (Lat.), winged.

Types. Holotype, GPU 2003/TEMO 1-093 (Pl. 3, Fig. 6); paratypes, GPU 2003/TEMO 1-094 (Pl. 3, Fig. 7), GPU 2003/TEMO 1-095 (Pl. 3, Fig. 8).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Shell subpherical, spongy with two polar spines. Polar spines short usually unequal, straight or slightly inclined and tricarinate with thin ridges and wide, deep grooves. Near distal end, three moderately long secondary spines branch off from each ridge. Secondary spines slightly curved towards the shell, tapering distally without denticles and pointed.

Remarks. *Dumitricasphaera trialata* n. sp. is differentiated from *D. trispinosa* (Kozur & Mostler, 1979, p. 57, pl. 5, fig. 3) by possessing inwardly rather than outwardly curved secondary spines. It differs from *Dumitricasphaera galeata* n. sp. in having longer, thinner and tapering secondary spines instead of medially inflated secondary spines.

Measurements (μm). (Based on six specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	150	140	160	150
Length of polar spines	80	80	120	100
Width of polar spines, at widest point	50	40	50	43

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrences. Vrsic, Slovenia; Antalya, Turkey; Fojnica, Bosnia and Herzegovina.

Genus *Spongostylus* Haeckel, 1882

Type Species: *Spongostylus hastatus* Haeckel, 1887.

Spongostylus bosniensis n. sp.

Pl. 1, figs 4-9

1989 *Spongostylus* sp. A Yeh, p. 67, pl. 13, figs 7, 22

Etymology. This species is named after its type locality, Bosnia and Herzegovina.

Types. Holotype, GPU 2003/TEMO 1-096 (Pl. 1, Fig. 4); paratypes, GPU 2003/TEMO 1-097 (Pl. 1, Fig. 5), GPU 2003/TEMO 1-098 (Pl. 1, Fig. 6), GPU 2003/TEMO 1-099 (Pl. 1, Fig. 7), GPU 2003/TEMO 1-100 (Pl. 1, Fig. 8), GPU 2003/TEMO 1-101 (Pl. 1, Fig. 9).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Shell spherical to subspherical, relatively small, spongy consisting of numerous densely

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PLATE 2

Scanning electron photomicrographs of late Ladinian Spumellaria from Fojnica, Bosnia and Herzegovina. All materials are from sample 88-272. Scale = number of microns for each figure.

Figs. 1-6 - *Ligulatubus yaoi* n. gen., n. sp., 1. Holotype, scale bar = 90μm, 2-6. Paratypes, scale bar for all figures = 90μm.

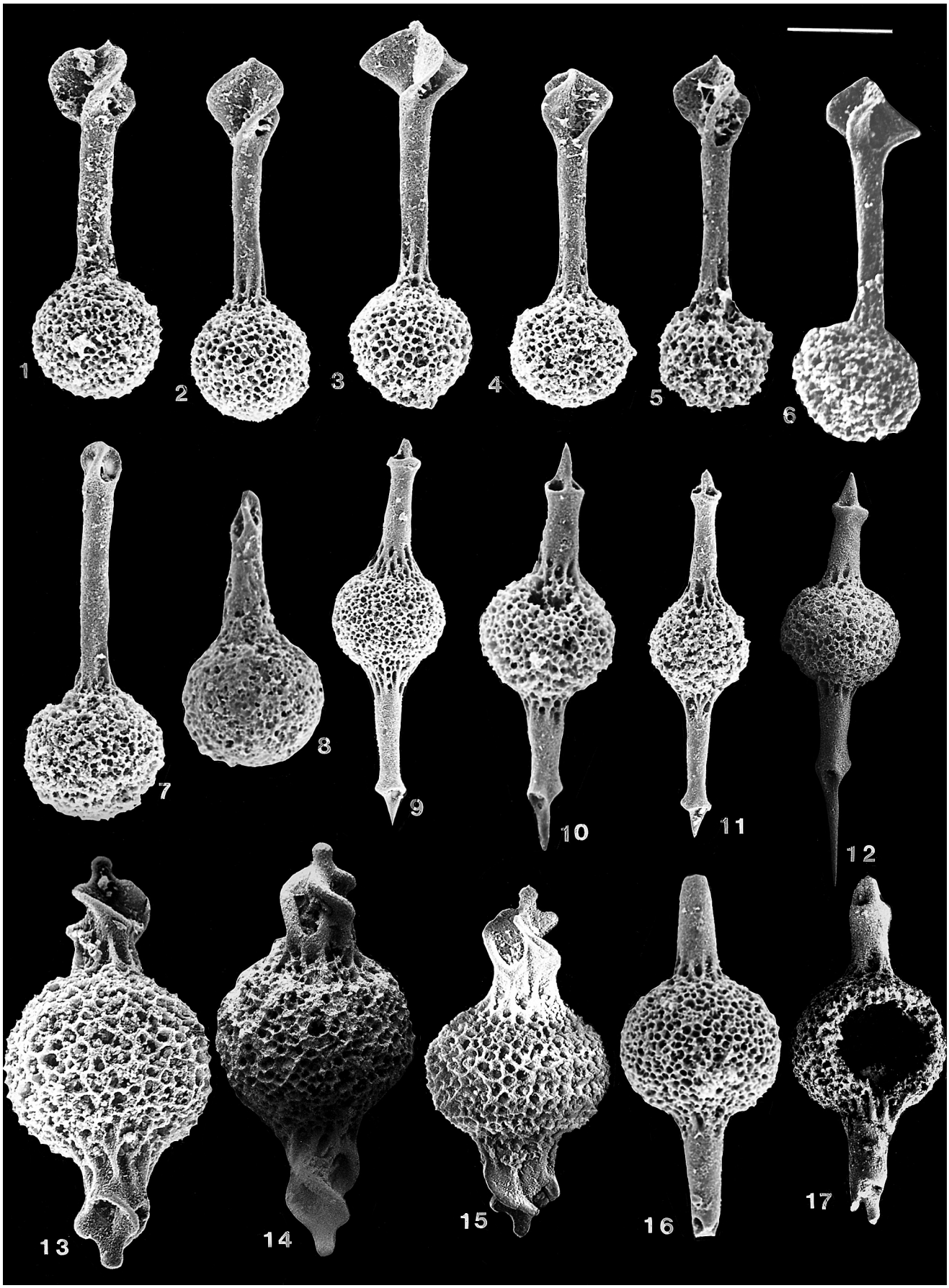
Fig. 7 - *Ligulatubus* sp. A, scale bar = 90μm.

Fig. 8 - *Ligulatubus* sp. B, scale bar = 90μm.

Figs. 9-12 - *Tubospongopallium gracile* n. gen., n. sp., 9. Holotype, scale bar = 120μm, 10-12. Paratypes, scale bar = 95, 120 and 130 μm respectively.

Figs. 13-15 - *Tubospongopallium kozuri* n. gen., n. sp., 13. Holotype, scale bar = 80μm, 14-15. Paratypes, scale bar = 80 and 100μm respectively.

Figs. 16-17 - *Tubospongopallium* sp. A, scale bar = 90μm and 100μm respectively.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spaced spongy shell around the microsphere. Two polar spines situated at opposite directions. Polar spines long, unequal, tricarinate with thin ridges and wide, deep grooves. Polar spines straight proximally then dextrally twisted distally and generally terminated with blunt end.

Remarks. *Spongostylus bosniensis* n. sp. is differentiated from *S. tortilis* Kozur & Mostler (1979, pp. 56-57, pl. 4, fig. 2, pl. 11, fig. 6, pl.18, fig. 2) by having polar spines with a long, straight proximal part and a short twisted distal part instead of polar spines with a short, straight proximal part and a long, twisted distal part. It also differs from *S. slovenica* (Kolar-Jurkovsek, 1989, p. 158, fig. 2, no. 1-3) by having a longer polar spines with longer proximally straight and strongly twisted distal part.

Measurements (μm). (Based on eight specimens)

	HT	Min.	Max.	Av.
Max. diameter of shell	120	71	133	106
Max. length of polar spines (including tips)	273	190	300	247
Width of polar spines at the base	40	20	53	39

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrences. East central Oregon, USA; Fojnica, Bosnia and Herzegovina.

Spongostylus koppi (Lahm, 1984)

Pl. 1, fig. 10

1984 *Cromyostylus*? *koppi* Lahm, p. 68, pl. 12, figs. 1, 2.

1986 *Spongopallium* sp. Kozur & Reti, p. 34, fig. 6H.

1990 *Spongopallium*? *koppi* (Lahm) - Gorican & Buser, p. 157, pl. 4, fig. 1.

non 1990 *Spongopallium* cf. *koppi* - Gorican & Buser, pl. 4, figs. 2-4 (= *Spongostylus tricostatus* Kozur, Krainer & Mostler).

1995 *Spongopallium*? *koppi* - Kellici & De Wever, p. 160, pl. 4, fig. 14.

1999 *Spongostylus koppi* (Lahm) - Sashida et al., 1999, p. 771, fig. 8. 12.

Range. Middle Triassic; late Anisian - late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrences. Recoaro, North Italy; Hungary; Slovenia; Timor Islands, Indonesia; Fojnica, Bosnia and Herzegovina.

Family Spongopallidae Kozur, Krainer & Mostler, 1996

Genus *Spongopallium* Dumitrica, Kozur & Mostler, 1980

Type Species: *Spongopallium contortum* Dumitrica, Kozur & Mostler, 1980.

Spongopallium crassum n. sp.

Pl. 1, figs 11-15

1990 *Spongopallium contortum* Dumitrica, Kozur & Mostler – Gorican & Buser, pl. 4, fig. 8 *non* fig. 7.

Etymology. Crassum (Lat.), thick, dense, solid.

Types. Holotype, GPU 2003/TEMO 1-102 (Pl. 1, Fig. 11); paratypes, GPU 2003/TEMO 1-103 (Pl. 1, Fig. 12), GPU 2003/TEMO 1-104 (Pl. 1, Fig. 13), GPU 2003/TEMO 1-105 (Pl. 1, Fig. 14), GPU 2003/TEMO 1-106 (Pl. 1, Fig. 15).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Outer shell subspherical, latticed with spongy meshwork. Polar spines rather short, unequal, perpendicular or slightly inclined to the shell, sinistrially twisted, tricarinate with wide ridges and deep grooves. Tips of polar spines short and needle-like.

Remarks. *Spongopallium crassum* n. sp. is differentiated from *S. contortum* Dumitrica, Kozur & Mostler (1980, p. 16, pl. 2, fig. 5, pl. 11, fig. 1) by possessing more highly, sinistrally twisted polar spines instead of slightly dextrally twisted polar spines.

Measurements (μm). (Based on five specimens)

	HT	Min.	Max.	Av.
Max. diameter of shell	175	150	180	167
Max. length of polar spines (including tips)	150	125	150	135
Max. width of polar spines	63	50	70	58

Range. Middle Triassic; late late Ladinian

Occurrences. Vrsic, Slovenia; Fojnica, Bosnia and Herzegovina.

PLATE 3

Scanning electron photomicrographs of late Ladinian Spumellaria from Fojnica, Bosnia and Herzegovina. All materials are from sample 88-272. Scale = number of microns for each figure.

Figs. 1-2 - *Tubospongopallium tornatum* n. gen., n. sp., 1. Holotype, scale bar = 90μm, 2. Paratype, scale bar = 100μm.

Figs. 3-4 - *Dumitricasphaera galeata* n. sp., 3. Holotype, scale bar = 90μm, 4. Paratype, scale bar = 90μm.

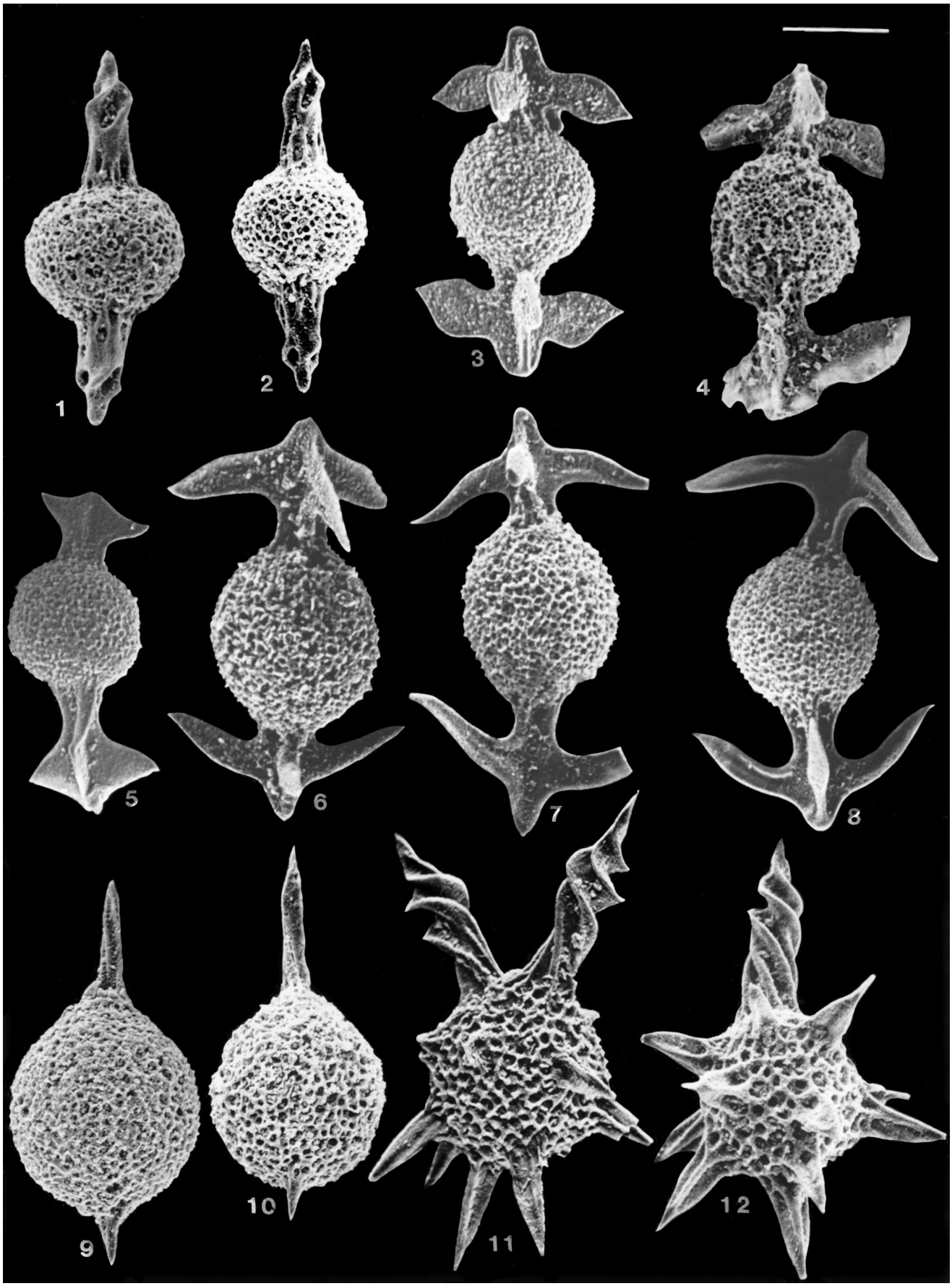
Fig. 5 - *Dumitricasphaera* sp. aff. *D.*? *pennata* Gorican, scale bar = 130μm.

Figs. 6-8 - *Dumitricasphaera trialata* n. sp., 6. Holotype, scale bar = 100μm, 7-8. Paratypes, scale bar for both figures = 100μm.

Figs. 9-10 - *Archaeospongoprunum globosum* n. sp., 9. Holotype, scale bar = 100μm, 10. Paratype, scale bar = 100μm.

Fig. 11 - *Gomberellus* sp. aff. *G. hircicornus* Dumitrica, Kozur & Mostler, scale bar = 100μm.

Fig. 12 - *Gomberellus longobardicus* Kozur & Mostler, scale bar = 110μm.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Genus *Ligulatubus* n. gen.

Type Species: *Ligulatubus yaoi* n. gen., n. sp.

Etymology. Ligula,ae (Lat.), spoon; tubus (Lat.), pipe, tube.

Description. Outer shell latticed with spongy meshwork. A single spine situated at one side of shell. Spine hollow, tube-shaped generally with ridges and grooves proximally. Distal part spine tricarinate with ridges separated by pores connected to tube.

Remarks. *Ligulatubus* n. gen. differs from *Spongopallium* Dumitrica, Kozur & Mostler, 1980 by having one hollow, tube-shaped spine with tricarinate distal end instead of two completely solid, tricarinate primary spines. It is differentiated from *Tubospongopallium* n. gen. in having a one tube-shaped spine instead of two polar spines. Although the inner structure of the *Ligulatubus* n. gen. is not clear, it is placed in Family Spongopallidae due to the presence of spongy shell.

Included Species. *Ligulatubus yaoi* n. gen., n. sp.

Ligulatubus yaoi n. sp.

Pl. 2, figs 1-6

Etymology. This species is named for Prof. Dr. Akira Yao (Osaka City University, Osaka, Japan) in honour of his great contributions to the knowledge of Palaeozoic and Mesozoic Radiolaria.

Types. Holotype, GPU 2003/TEMO 1-107 (Pl. 2, Fig. 1); paratypes, GPU 2003/TEMO 1-108 (Pl. 2, Fig. 2), GPU 2003/TEMO 1-109 (Pl. 2, Fig. 3), GPU 2003/TEMO 1-110 (Pl. 2, Fig. 4), GPU 2003/TEMO 1-111 (Pl. 2, Fig. 5), GPU 2003/TEMO 1-112 (Pl. 2, Fig. 6).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test as with genus. Outer shell spherical to subspherical, spongy cover. Single spine long, hollow, tube-shaped, circular in axial section with several ridges and wide grooves basally. Spine slightly tapering medially then inflated distally. The most distal part of tube highly widened, represented by dextrally, strongly twisted tricarinate part with very thin ridges and deep, wide ellipsoidal pores connected to the hollow tube.

Remarks. *Ligulatubus yaoi* n. sp. is differentiated from *L.* sp. A by having a slightly smaller shell, shorter tube with highly widened, highly twisted distal end.

Measurements (μm). (Based on eight specimens)

	HT	Min.	Max.	Av.
Max. diameter of shell	120	100	120	115
Length of tube (including tip)	220	170	240	215
Width of tube at base	25	25	40	37

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Ligulatubus sp. **A**

Pl. 2, fig. 7

Short definition. Test as with genus. Outer shell subsphaerical with spongy shell. Single spine long, tube-shaped, hollow and approximately uniform in width throughout length except the most distal part. Basal part of spine with wide ridges and deep grooves. Distal part of the spine slightly widened, dextrally twisted tricarinate part with thin ridges separated by deep, wide ellipsoidal pores.

Remarks. *Ligulatubus* sp. A differs from *Ligulatubus* sp. B in having a longer, slender, more uniform spine with slightly, dextrally twisted distal tricarinate part. It is compared to *L. yaoi* n. sp. under the latter species.

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Ligulatubus sp. **B**

Pl. 2, fig. 8

Short definition. Outer shell small with spongy meshwork. Primary spine tube-shaped tapering distally with slightly sinistrially twisted tricarinate part.

Remarks. *Ligulatubus* sp. B is compared to *L.* sp. A under the latter taxa.

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone)

Occurrence. Fojnica, Bosnia and Herzegovina.

Genus *Tubospongopallium* n. gen.

Type Species: *Spongopallium*? *tubulispina* Kozur & Krainer & Mostler, 1996

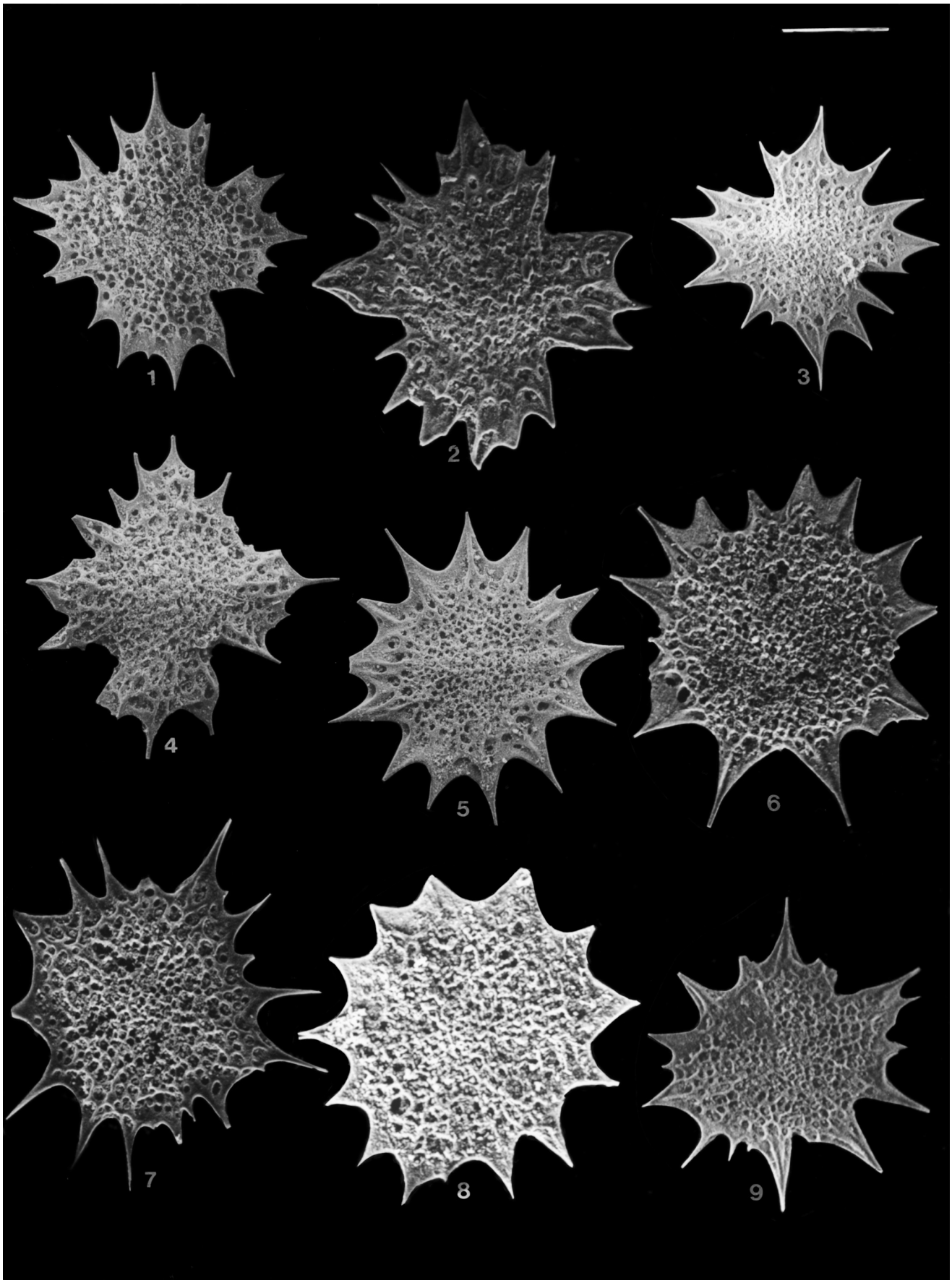
Etymology. Tubus (Lat.), a pipe, tube; *Spongopallium*, a genus name.

PLATE 4

Scanning electron photomicrographs of late Ladinian Spumellaria from Fojnica, Bosnia and Herzegovina. All materials are from sample 88-272. Scale = number of microns for each figure.

Figs. 1-4 - *Veghicyclia cruciforma* n. sp., 1. Holotype, scale bar= 130μm, 2-4. Paratypes, scale bar = 100, 130 and 130μm respectively.

Figs. 5-9 *Veghicyclia krystyni* n. sp., 5. Holotype, scale bar= 165μm, 6-9. Paratypes, scale bar = 130, 130, 130 and 165μm respectively.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Description. Outer shell spherical to subspherical, latticed with thick spongy mantle (pl. 2, fig. 17) and two polar spines. Inner shell structure not clear. Spines hollow, tube-shaped, circular to subcircular in axial section with ridges and grooves at the base. Distally spines represented by tricarinate parts with ridges separated by pores. Needle-like spines present or not at tips of polar spines.

Remarks. *Tubospongopallium* n. gen. differs from *Spongopallium* Dumitrica, Kozur & Mostler, 1980 by having two hollow, tube-shaped polar spines with tricarinate distal end instead of two completely, solid tricarinate polar spines. It has been compared to *Ligulatubus* n. gen. under the latter genus.

Included Species. *Tubospongopallium tubulispina* (Kozur, Krainer & Mostler, 1996); *Tubospongopallium gracile* n. sp.; *Tubospongopallium kozuri* n. sp.; *Tubospongopallium tornatum* n. sp.

Tubospongopallium gracile n. sp.

Pl. 2, figs 9-12

Etymology. Gracile (Lat.), slender, thin, slim.

Types. Holotype, GPU 2003/TEMO 1-113 (Pl. 2, Fig. 9); paratypes, GPU 2003/TEMO 1-114 (Pl. 2, Fig. 10), GPU 2003/TEMO 1-115 (Pl. 2, Fig. 11), GPU 2003/TEMO 1-116 (Pl. 2, Fig. 12).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Outer shell subspherical, latticed with spongy mantle. Two spines situated at opposite directions. Spines tube-shaped, hollow, unequal, straight, long and subcircular in axial section. Basal parts of polar spines with small, circular to ellipsoidal pores, slightly tapering distally except at tips where tubes are expanded. Distal parts of spines tricarinate with thin ridges and wide, circular pores. In some cases, long, tapering, needle-like spine tip also present distally.

Remarks. *Tubospongopallium gracile* n. sp. is differentiated from *T. kozuri* n. sp. in having longer, straight and slender tube-shaped polar spines instead of strongly twisted, tube-shaped polar spines. It differs from *Tubospongopallium tubulispina* (Kozur & Krainer & Mostler, 1996, p. 229) by having longer, thinner tube-shaped polar spines. It is compared to *Tubospongopallium* sp. A and *T. tornatum* n. sp. under latter species.

Measurements (μm). (Based on eight specimens)

	HT	Min.	Max.	Av.
Max. diameter of shell	140	120	146	134
Length of tubes (including tips)	196	140	200	170
Width of tubes at base	46	36	50	41

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Tubospongopallium kozuri n. sp.

Pl. 2, figs 13-15

Etymology. This species is dedicated to Dr. Heinz W. Kozur (Budapest, Hungary) in honour of his great contributions to the knowledge of Triassic Radiolaria.

Types. Holotype, GPU 2003/TEMO 1-117 (Pl. 2, Fig. 13); paratypes, GPU 2003/TEMO 1-118 (Pl. 2, Fig. 14), GPU 2003/TEMO 1-119 (Pl. 2, Fig. 15).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test as with genus. Outer shell spherical to subsphaerical and spongy. Polar spines equal or subequal, thick, short, tube-shaped, subcircular in axial section with many thin ridges and deep, wide grooves at basal parts. Distal parts of polar spines represented by strongly, sinistrially twisted, wide tricarinate ends with thin ridges and large, ellipsoidal pores. Short, knob-like spines with blunt termination present at tips of polar spines.

Remarks. *Tubospongopallium kozuri* n. sp. is differentiated from *T. tornatum* n. sp. in having shorter and thicker tube-shaped polar spines with sinistrially twisted tricarinate distal part instead of tube-shaped polar spines with dextrally twisted tricarinate distal part. *T. kozuri* n. sp. is compared to *T. gracile* n. sp. under the latter species.

Measurements (μm). (Based on seven specimens)

	HT	Min.	Max.	Av.
Max. diameter of shell	152	120	155	133
Length of tubes (including tips)	84	84	100	94
Width of tubes at base	60	45	60	52

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

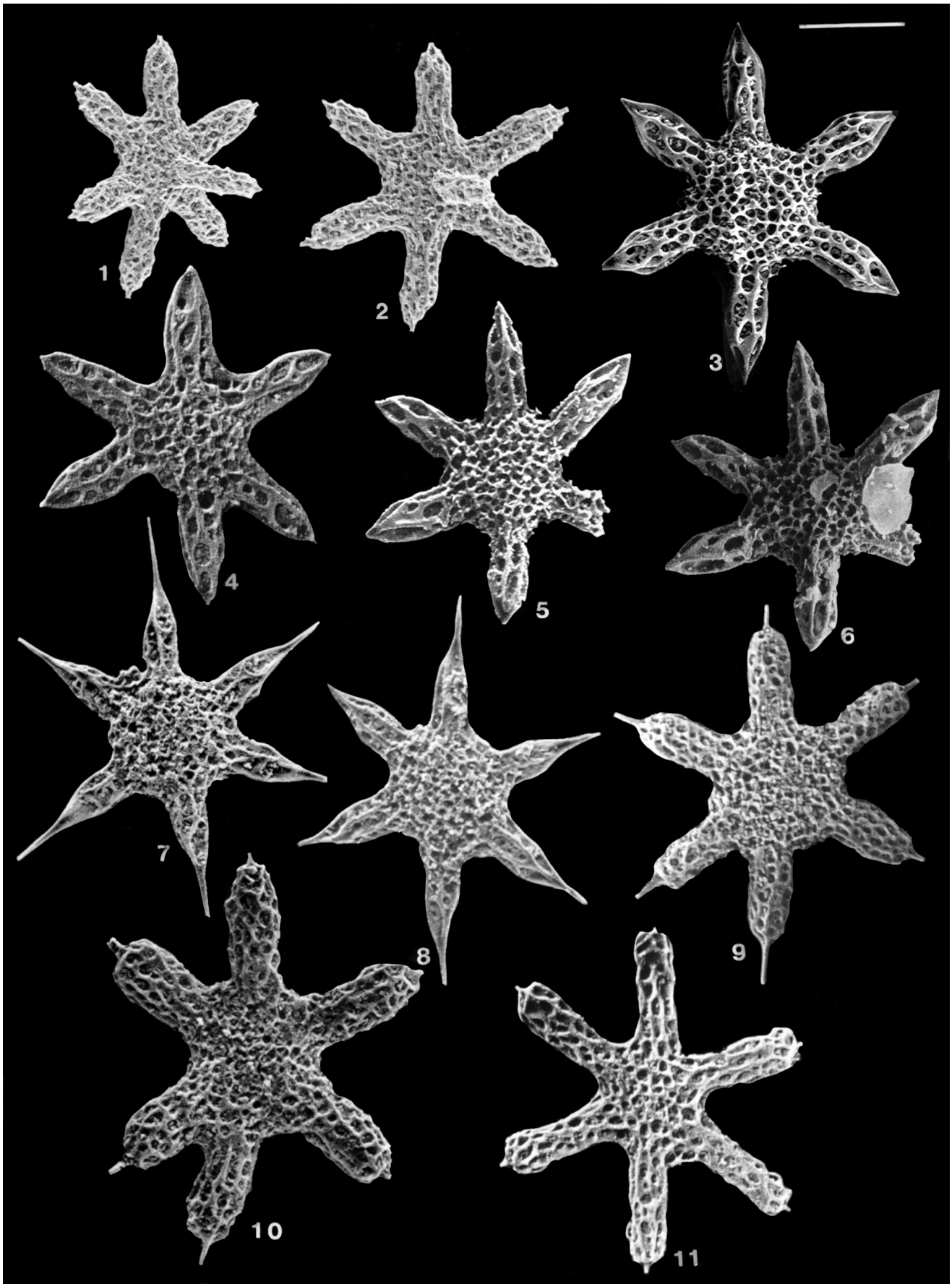
PLATE 5

Scanning electron photomicrographs of late Ladinian Spumellaria from Fojnica, Bosnia and Herzegovina. All materials are from sample 88-272. Scale = number of microns for each figure.

Figs. 1-2 - Pathologic specimens of *Hexacatoma nobleae* n. sp., scale bar for both figures = 100μm.

Figs. 3-6 - *Hexacatoma elegantissima* n. gen., n. sp., 3. Holotype, scale bar = 80μm, 4-8. Paratypes, scale bar= 80, 85, 85, 80 and 80μm respectively.

Figs. 9-11 - *Hexacatoma nobleae* n. sp., 9. Holotype, scale bar = 80μm, 10-11. Paratypes, scale bar = 75 and 80μm respectively.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Tubospongopallium tornatum n. sp.

Pl. 3, figs 1-2

Etymology. Tornatum (Lat.), twisted.

Types. Holotype, GPU 2003/TEMO 1-120 (Pl. 3, Fig. 1); paratype, GPU 2003/TEMO 1-121 (Pl. 3, Fig. 2).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test as with genus. Polar spines tube-shaped, circular to subcircular in axial section, slightly tapering distally with several thin to moderately wide ridges and wide, deep grooves at the base. Distal part of the polar spines characterised by strongly dextrally twisted, tricarinate part with thin ridges and large, ellipsoidal pores. Circular, short, wide, distally tapering needle-like spines with blunt termination present at tips of polar spines.

Remarks. *Tubospongopallium tornatum* n. sp. differs from *T. gracile* n. sp. in having shorter, wider polar spines with strongly, dextrally twisted tricarinate distal parts instead of polar spines with straight distal parts. It is compared to *Tubospongopallium kozuri* n. sp. under the latter species.

Measurements (μm). (Based on three specimens)

	HT	Min.	Max.	Av.
Max. diameter of shell	150	125	152	139
Length of tubes (including tips)	125	120	126	123
Width of tubes at base	50	45	52	49

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Tubospongopallium sp. **A**

Pl. 2, figs 16-17

Short definition. Test as with genus. Polar spines unequal, tube-shaped, circular in axial section with several thin ridges and deep grooves at basal parts. Polar spines slightly tapering distally, terminated with short tricarinate part marked by thin to moderately thick ridges and deep, ellipsoidal pores.

Remarks. *Tubospongopallium* sp. A is differentiated from *Tubospongopallium tubulispina* (Kozur, Krainer & Mostler, 1996, p. 229) by having distally tapering tube-shaped polar spines instead of distally inflating tube-shaped polar spines. It differs from *T. gracile* n. sp. in having shorter and slightly wider spines.

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone)

Occurrence. Fojnica, Bosnia and Herzegovina.

Family Archaeospongoprunidae Pessagno, 1973 emend. Kozur & Mostler, 1981

Subfamily Archaeospongoprunae Pessagno, 1973 emend. Kozur & Mostler, 1981

Genus *Archaeospongoprunum* Pessagno, 1973

Type Species: *Archaeospongoprunum venadoensis* Pessagno, 1973.

Archaeospongoprunum globosum n. sp.

Pl. 3, figs 9-10

Etymology. Globosum (Lat.), spherical, round.

Types. Holotype, GPU 2003/TEMO 1-122 (Pl. 3, Fig. 9); paratype, GPU 2003/TEMO 1-123 (Pl. 3, Fig. 10).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test as with genus. Shell subspherical to subellipsoidal with spongy meshwork consisting of trigonal, tetragonal and pentagonal pore frames. Polar spines unequal, tricarinate with thin ridges and wide grooves, slightly sinistrially twisted.

Remarks. *Archaeospongoprunum globosum* n. sp. differs from *A. mesotriassicum* Kozur & Mostler (1981, pp. 40-41, pl. 42, figs. 3-4) by possessing a more globular, inflated shell with unequal and slightly, sinistrially twisted tricarinate polar spines instead of shell with approximately equal, straight, tricarinate polar spines. It is differentiated from *Paroertlispongus hermi* (Lahm, 1984, p. 42, pl. 7, fig. 1) in having a completely tricarinate polar spines instead of only basally tricarinate polar spines.

Measurements (μm). (Based on four specimens)

	HT	Min.	Max.	Av.
Length of shell (in direction of polar spines)	200	180	210	197
Width of shell	170	140	170	158
Length of longer spine	110	110	160	133
Length of shorter spine	45	35	45	43

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone)

Occurrence. Fojnica, Bosnia and Herzegovina.

Family Gomberellidae Kozur & Mostler, 1981

Genus *Gomberellus* Dumitrica, Kozur & Mostler, 1980

Type Species: *Gomberellus hircicornus* Dumitrica, Kozur & Mostler, 1980.

Gomberellus sp. aff. **G. hircicornus** Dumitrica, Kozur & Mostler, 1980

Pl. 3, fig. 11

aff. 1980 *Gomberellus hircicornus* Dumitrica, Kozur & Mostler, p. 6, pl. 10, fig. 6; pl. 14, fig. 3.

aff. 1984 *Gomberellus hircicornus* - Lahm, p. 52, pl. 8, fig. 11.

aff. 1990 *Gomberellus hircicornus* - Gorican & Buser, p. 146, pl. 1, fig. 9.

aff. 1994 *Gomberellus hircicornus* - Kozur & Mostler, p. 55, pl. 7, figs. 12-14.

aff. 1995 *Gomberellus hircicornus* - Kellici & De Wever, p. 146, pl. 2, figs. 3, 4.

Remarks. It differs from the holotype of *Gomberellus hircicornus* Dumitrica, Kozur & Mostler (1980, pl. 10, fig. 6) in having larger pores, more torsioned spines and wider secondary spines.

Range. Middle Triassic; late Ladinian.

Occurrence. Fojnica, Bosnia and Herzegovina.

Gomberellus longobardicus Kozur & Mostler, 1994

Pl. 3, fig. 12

1994 *Gomberellus longobardicus* Kozur & Mostler, pp. 55-56, pl. 7, fig. 10; pl. 8, figs. 1, 3, 6.

Range. Middle Triassic; late Ladinian.

Occurrences. Köveskál, Balaton Highland, Hungary; Fojnica, Bosnia and Herzegovina.

Family Veghicycliidae Kozur & Mostler, 1972

Genus *Veghicyclia* Kozur & Mostler, 1972

Type Species: *Veghicyclia pulchra* Kozur & Mostler, 1972.

Veghicyclia cruciforma n. sp.

Pl. 4, figs 1-4

Etymology. Crucis (Lat.), cross; forma (Lat.), shaped.

Types. Holotype, GPU 2003/TEMO 1-124 (Pl. 4, Fig. 1); paratypes, GPU 2003/TEMO 1-125 (Pl. 4, Fig. 2), GPU 2003/TEMO 1-126 (Pl. 4, Fig. 3), GPU 2003/TEMO 1-127 (Pl. 4, Fig. 4).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Cortical shell large, spongy and flat, discoidal in outline. Equatorial disc roughly cruciform, pores varying in shape: irregular, circular to subelliptical. Pores at outer part of equatorial disc slightly larger than pores of the inner part. The most distal part of disc smooth and poreless. Fourteen to seventeen irregularly arranged peripheral spines of different size and shape present. Some spines long and needle-like, others wide triangular to elongated triangular; all tricarinate with thin ridges and wide grooves.

Remarks. *Veghicyclia cruciforma* n. sp. is differentiated from *V. pulchra* Kozur & Mostler (1972, pp. 11-12, pl. 4, figs 14, 17) by having a flat discoidal cortical shell with curiciform equatorial disc. It differs from *Veghicyclia krystyni* n. sp. by having a curiciform equatorial disc with irregularly arranged peripheral spines.

Measurements (μm): (Based on four specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	133	125	146	135
Width of equatorial disc	67	60	80	68
Max. length of peripheral spines	73	60	85	75

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone)

Occurrence. Fojnica, Bosnia and Herzegovina.

Veghicyclia krystyni n. sp.

Pl. 4, figs 5-9

Etymology. This species is dedicated to Prof. Dr. Leopold Krystyn (Vienna, Austria) in honour of his contributions to the knowledge of Triassic stratigraphy.

Types. Holotype, GPU 2003/TEMO 1-128 (Pl. 4, Fig. 5); paratypes, GPU 2003/TEMO 1-129 (Pl. 4, Fig. 6), GPU 2003/TEMO 1-130 (Pl. 4, Fig. 7), GPU 2003/TEMO 1-131 (Pl. 4, Fig. 8), GPU 2003/TEMO 1-132 (Pl. 4, Fig. 9).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Cortical shell large, flat discoidal, spongy. Equatorial disc narrow with scattered circular to elliptical pores of varying size. Distalmost part of the equatorial disc poreless, smooth. Twelve to fifteen peripheral spines approximately regularly arranged but of different shape and size. Peripheral spines mainly triangular to elongated triangular, tricarinate with thin ridges and wide grooves; sometimes long, thin, needle-like, circular in axial section.

Remarks. *Veghicyclia krystyni* n. sp. differs from *V. haeckeli* Kozur & Mostler (1972, pp. 11-12, pl. 4, figs 14, 17) by possessing flat discoidal cortical shell with scattered pores on the equatorial disc instead of discoidal cortical shell with regular pores on the equatorial disc and lesser, longer peripheral spines. It is compared to *Veghicyclia cruciforma* n. sp. under the latter species.

Measurements (μm). (Based on five specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	166	160	173	167
Width of equatorial disc	91	70	91	77
Max. length of peripheral spines	108	70	108	99

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Family Capnuchosphaeridae De Wever, 1979 emend. Pessagno, 1979 and emend. Blome, 1983

Genus *Hexacatoma* n. gen.

Type Species: *Hexacatoma elegantissima* n. gen., n. sp.

Etymology. Hexa (Lat.); six, *Catoma*, a genus name.

Description. Cortical shell hexagonal in outline with six radially arranged primary spines in same plane. Cortical shell consisting of double-layered pore frames. Outer layer of meshwork consisting of large, elevated, polygonal pore frames with nodes at pore frame vertices. Inner layer of meshwork with smaller, polygonal pore frames. Primary spines generally symmetrically arranged, equal to subequal in length sometimes two spines slightly longer than the others. Proximal part of the primary spines hollow composed of linearly and/or irregularly arranged elevated pore frames. Distal part of the primary spines sometimes tricarinate with very short to long needle-like spines at tips.

Remarks. *Hexacatoma* n. gen. differs from *Catoma* Blome, 1983 by possessing six primary spines instead of four. It is differentiated from *Hexaporobrachia* Kozur & Mostler, 1979 in having six primary spines in same plane instead of six primary spines in two different planes. *Hexacatoma* n. gen. also differs from *Natraglia* Pessagno in Pessagno et al., 1979 by having cortical shell with double layered pore frames and six hollow primary spines instead of spongy test with solid six brachia.

Included Species. *Hexacatoma elegantissima* n. sp.; *Hexacatoma nobleae* n. sp.

Hexacatoma elegantissima n. sp.

Pl. 5, figs 3-8

Etymology. Elegantissima (Lat.), fine, neat.

Types. Holotype, GPU 2003/TEMO 1-133 (Pl. 5, Fig. 3); paratypes, GPU 2003/TEMO 1-134 (Pl. 5, Fig. 4), GPU 2003/TEMO 1-135 (Pl. 5, Fig. 5), GPU 2003/TEMO 1-136 (Pl. 5, Fig. 6), GPU 2003/TEMO 1-137 (Pl. 5, Fig. 7), GPU 2003/TEMO 1-138 (Pl. 5, Fig. 8).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test as with genus. Surface of the shell slightly convex. Cortical shell consisting of double-layered pore frames. Outer layer of meshwork consisting of large, elevated, polygonal (tetragonal to hexagonal, mainly pentagonal) pore frames with massive nodes at pore frame vertices. Inner layer of meshwork with smaller, polygonal (trigonal to pentagonal, mainly tetragonal) pore frames with subcircular to ellipsoidal pores of varying size. Basal part of primary spines hollow, composed of linearly arranged elevated pore frames with subcircular to ellipsoidal, large pores. Distal part of the primary spines tricarinate with thin ridges separated by large, ellipsoidal pores. The most distal parts of the primary spines with very short to long, needle-like, pointed spines.

Remarks. *Hexacatoma elegantissima* n. sp. differs from *Hexacatoma nobleae* n. sp. in having a primary spines with larger, linearly arranged pore frames instead of primary spines with mainly irregularly, rarely regularly arranged, smaller pore frames.

Measurements (μm). (Based on ten specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	100	92	108	97
Length of primary spines (including tips)	90	72	112	92

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone)

Occurrence. Fojnica, Bosnia and Herzegovina.

Hexacatoma nobleae n. sp.

Pl. 5, figs 1, 2, 9-11

1982 *Natraglia luminosa* Pessagno - De Wever, p. 266, pl. 33, fig. 5

1990 *Natraglia luminosa* Pessagno - Gorican & Buser, p. 148, pl. 1, fig. 1

Etymology. This species is dedicated to Assoc. Prof. Dr. Paula J. Noble (California State University Sacramento, California, USA) in honour of her contributions to the knowledge of Palaeozoic Radiolaria.

Types. Holotype, GPU 2003/TEMO 1-139 (Pl. 5, Fig. 9); paratypes, GPU 2003/TEMO 1-140 (Pl. 5, Fig. 10), GPU 2003/TEMO 1-141 (Pl. 5, Fig. 11).

Holotype. The specimen is illustrated on plate 5, figure 9. Sample 88-272.

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test as with genus. Surface of the shell slightly convex. Cortical shell consisting of double-layered pore frames. Outer layer of meshwork consisting of large, elevated, polygonal (pentagonal to hexagonal, mainly pentagonal) pore frames with nodes at pore frame vertices. Inner layer of meshwork consisting

PLATE 6

Scanning electron photomicrographs of late Ladinian Spumellaria from Fojnica, Bosnia and Herzegovina. All materials are from sample 88-272. Scale = number of microns for each figure.

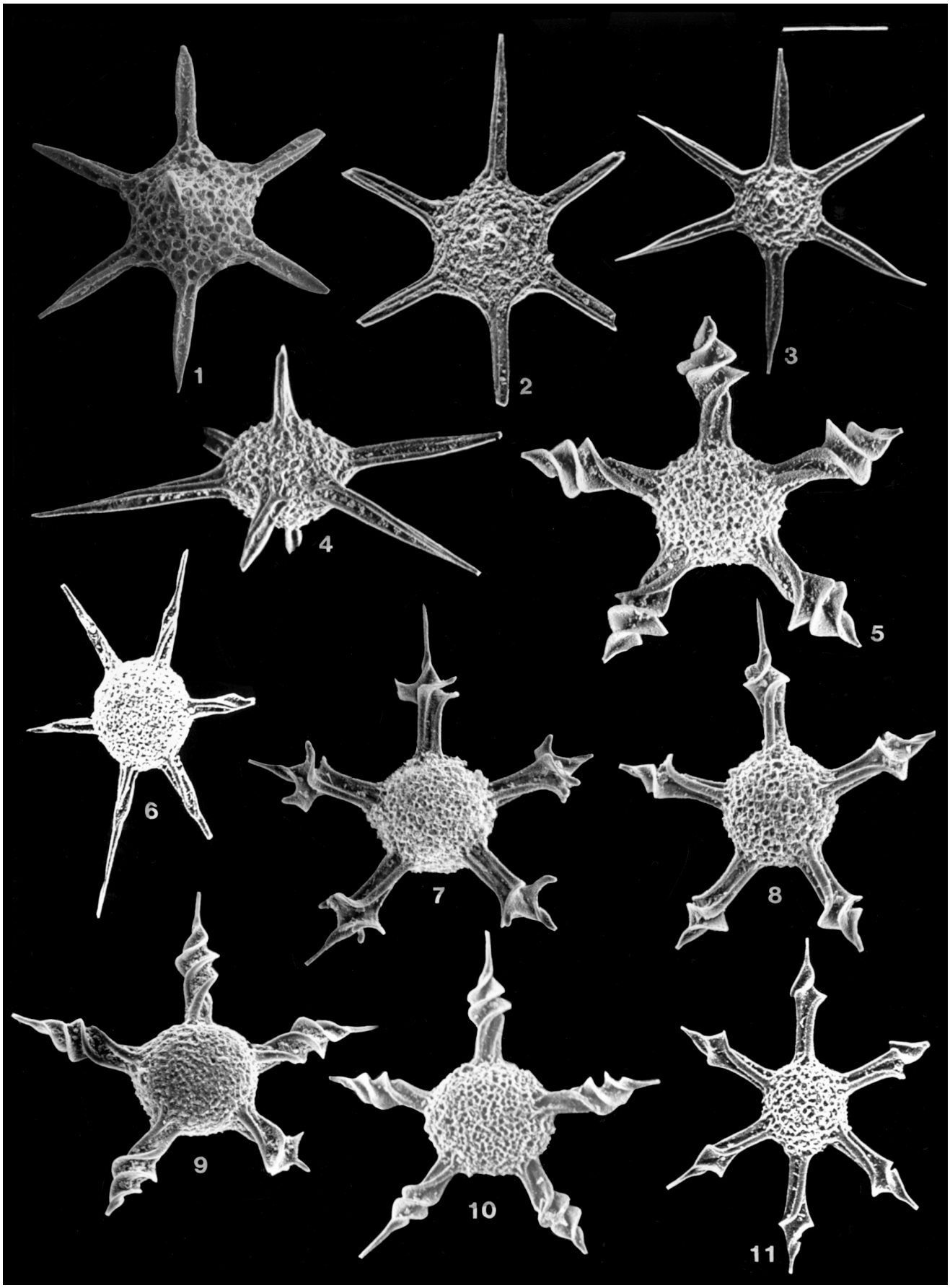
Figs. 1-4 - *Octostella pulchra* n. gen., n. sp., 1. Holotype, scale bar = 130μm, 2-4. Paratypes, scale bar for all figures= 130μm.

Fig. 5 - *Pentaspongodiscus discoides* Tekin, scale bar = 80μm.

Fig. 6 - *Pentaspongodiscus mesotriassicus* Dumitrica, Kozur & Mostler, scale bar = 100μm.

Figs. 7-10 - *Pentaspongodiscus similediscus* n. sp., 9. Holotype, scale bar = 100μm, 7, 8, 10. Paratypes, scale bar for all figures = 100μm.

Fig. 11 - *Pentaspongodiscus steigeri* Lahm, scale bar = 130μm.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of smaller, polygonal (trigonal to pentagonal, mainly trigonal) pore frames with subcircular to ellipsoidal pores in different size. Basal parts of the primary spines hollow, composed of mainly irregularly, rarely linearly arranged elevated pore frames with subcircular to ellipsoidal pores in different size. Distal parts of the primary spines tricarinate with thin ridges separated by small, ellipsoidal pores. Primary spines slightly inflating distally until tricarinate part then tapering. Distalmost part of the primary spines represented by very short, proximally tricarinate then needle-like, pointed spines.

Remarks. *Hexacatoma nobleae* n. sp. has been compared to *H. elegantissima* n. sp. under the latter species. Pathologic specimens of *Hexacatoma nobleae* n. sp. (Pl. 5, figs 1, 2) have one more primary spine perpendicular to other spines.

Measurements (μm). (Based on nine specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	100	92	110	103
Length of primary spines (including tips)	102	86	104	94

Range. Middle Triassic; late Ladinian - Late Triassic; middle Carnian.

Occurrences. Greece; Mokronog, Slovenia; Fojnica, Bosnia and Herzegovina.

Family Relindellidae Kozur & Mostler in Dumitrica Kozur & Mostler, 1980

Genus *Octostella* n. gen.

Type Species: *Pentaspongodiscus*? *dihexacanthus* Carter, 1993.

Etymology. Octo (Lat.), eight; stella (Lat.), star.

Description. Cortical shell large, hexagonal to subhexagonal in outline with six radial and two polar spines. Cortical shell with double-layered pore frames. Outer layer of meshwork consisting of irregular, polygonal pores with nodes at pore frame vertices. Inner layer of meshwork consisting of much smaller polygonal pores. Radial spines long, straight to twisted and tricarinate. Polar spines shorter than radial spines, tricarinate.

Remarks. *Octostella* n. gen. differs from *Pentaspongodiscus* Kozur & Mostler, 1979 in having latticed cortical shell with two polar spines instead of spongy cortical shell without polar spines. It is tentatively assigned to Relindellidae Kozur & Mostler, 1980 because of its latticed cortical shell.

Included Species. *Octostella dihexacanthus* (Carter, 1993); *Octostella pulchra* n. sp.

Octostella pulchra n. sp.

Pl. 6, figs 1-4

Etymology. Pulchra (Lat.), beautiful, handsome, fine.

Types. Holotype, GPU 2003/TEMO 1-142 (Pl. 6, Fig. 1); paratypes, GPU 2003/TEMO 1-143 (Pl. 6, Fig. 2), GPU 2003/TEMO 1-144 (Pl. 6, Fig. 3), GPU 2003/TEMO 1-145 (Pl. 6, Fig. 4).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test as with genus. Surface of the shell convex. Outer layer of meshwork consisting of irregular, polygonal pores with nodes at pore frame vertices. Inner layer of meshwork consisting of polygonal (trigonal to hexagonal, mainly pentagonal) pore frames with circular to ellipsoidal pores of varying size. Radial spines long, straight to slightly dextrally twisted, tricarinate with thin, rounded ridges and deep, wide grooves. Radial spines gradually tapering distally, pointed. Polar spines tricarinate with thin ridges and wide grooves; polar spines shorter than radial spines.

Remarks. *Octostella pulchra* n. sp. differs from *Octostella dihexacanthus* (Carter, 1993, pp. 87-88, pl. 13, figs. 1-3) by possessing relatively smaller, hexagonal cortical shell with straight to slightly dextrally twisted polar spines instead of subglobular cortical shell with moderately, dextrally twisted polar spines.

Measurements (μm). (Based on four specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	153	113	160	137
Length of radial spines	150	150	230	182
Length of polar spines	80	80	100	90

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Genus *Pentaspongodiscus* Kozur & Mostler, 1979

Type Species: *Pentaspongodiscus tortilis* Kozur & Mostler, 1979.

Pentaspongodiscus discoides Tekin, 1999

Pl. 6, fig. 5

1990 *Pentaspongodiscus* cf. *ladinicus* Dumitrica, Kozur & Mostler - Gorican & Buser, p. 151, pl. 2, fig. 4

1995 *Pentaspongodiscus* aff. *ladinicus crosi* Kellici & De Wever, p. 156, pl. 4, fig. 5

1999 *Pentaspongodiscus discoides* Tekin, pp. 121-122, pl. 22, figs. 5-7

Range. Middle Triassic; early Ladinian - late Ladinian (*M. cochleata* Rad. Z. /*S. fluegeli* Rad. Subz.).

Occurrences. Vrsic and Mokronog, Slovenia; Marmolada Massif, Northern Italy; Antalya, Turkey; Fojnica, Bosnia and Herzegovina.

Pentaspongodiscus mesotriassicus Dumitrica, Kozur & Mostler, 1980

Pl. 6, fig. 6

1980 *Pentaspongodiscus mesotriassicus* Dumitrica, Kozur & Mostler, p. 10, pl. 8, fig. 7

1984 *Pentaspongodiscus mesotriassicus* - Lahm, p. 56, pl. 9, fig. 11

1990 *Pentaspongodiscus mesotriassicus* - Gorican & Buser, p. 151, pl. 2, figs. 1, 2.

1994 *Pentaspongodiscus mesotriassicus* - Kozur & Mostler, pl. 9, fig. 7

1995 *Pentaspongodiscus mesotriassicus* – Kellici & De Wever, p. 153, pl. 4, fig. 2

1996 *Pentaspongodiscus mesotriassicus* - Kozur, Krainer & Mostler, p. 231, pl. 4, fig. 14

Range. Middle Triassic; late Anisian - late Ladinian.

Occurrences. Slovenia; Vicentian Alps, Marmolada Massif, North Italy; Carinthia, Austria; Fojnica, Bosnia and Herzegovina.

Pentaspongodiscus similediscus n. sp.

Pl. 6, figs 7-10

? 1990 *Pentaspongodiscus* cf. *ladinicus* Dumitrica, Kozur & Mostler - Gorican & Buser, p. 151, pl. 2, fig. 4.

Etymology. Similis (Lat.), similar; discus (Lat.), disc.

Types. Holotype, GPU 2003/TEMO 1-146 (Pl. 6, Fig. 9); paratypes, GPU 2003/TEMO 1-147 (Pl. 6, Fig. 7), GPU 2003/TEMO 1-148 (Pl. 6, Fig. 8), GPU 2003/TEMO 1-149 (Pl. 6, Fig. 10).

Holotype. The specimen is illustrated on plate 6, figure 9. Sample 88-272.

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Test small to medium in size, subdiscoidal to subspherical in shape, spongy. Five long spines arranged in one plane. Length of radial spines longer than diameter of cortical shell. Radial spines straight to slightly dextrally twisted proximally then strongly dextrally twisted distally, tricarinate with thin, rounded ridges and wide, deep grooves. Tips of radial spines represented by long, needle-like spines.

Remarks. *Pentaspongodiscus similediscus* n. sp. is differentiated from *P. crosi* Kellici & De Wever (1995, p. 154, pl. 4, fig. 4) by possessing wider, subdiscoidal to subspherical disc. It differs from *P. discoides* Tekin (1999, pp. 121-122, pl. 22, figs. 5-7) by having more spherical disc with longer radial spines.

Measurements (μm)**.** (Based on four specimens)

	HT	Min.	Max.	Av.
Diameter of test	110	105	110	107.5
Length of radial spines	140	140	150	145

Range. Middle Triassic; late late Ladinian.

Occurrences.? Vrsic and Mokronog, Slovenia; Fojnica, Bosnia and Herzegovina.

Pentaspongodiscus steigeri Lahm, 1984

Pl. 6, fig. 11

1984 *Pentaspongodiscus steigeri* Lahm, pp. 56-57, pl. 9, fig. 12

1996 *Pentaspongodiscus steigeri* - Kozur, Krainer & Mostler, p. 231, pl. 4, fig. 15.

1999 *Pentaspongodiscus steigeri* - Tekin, p. 122, pl. 22, figs. 8-9

Range. Middle Triassic; late Anisian - Late Triassic; early Carnian.

Occurrences. Recoaro, North Italy; Carinthia, Austria; Antalya, Turkey; Fojnica, Bosnia and Herzegovina.

SPUMELLARIA INCERTAE SEDIS

Genus *Discofulmen* n. gen.

Type Species: *Discofulmen dumitricai* n. gen., n. sp.

Etymology. Discus (Lat.), disc; fulmen (Lat.), pillar.

Description. Cortical shell large, flat discoidal with many peripheral spines. Cortical shell double-layered. Outer layer of meshwork consisting of latticed pore frames with nodes at vertices of bars. Peripheral spines numerous and of varying shape. One or two peripheral spines substantial longer, tricarinate, slightly dextrally twisted basally then strongly twisted with needle-like spines at tips. Remaining spines straight to slightly sinistrially twisted, tricarinate with needle-like spines at their tips.

Remarks. *Discofulmen* n. gen. is differentiated from *Gomberellus* Dumitrica, Kozur & Mostler, 1980 by having a flat discoidal cortical shell with double-layered pore frames instead of spherical to subspherical, spongy cortical shell. It differs from also *Orbiculiforma* Pessagno, 1973 by having a flat discoidal shell with double-layered pore frames instead of centrally depressed shell with irregular polygonal pore frames.

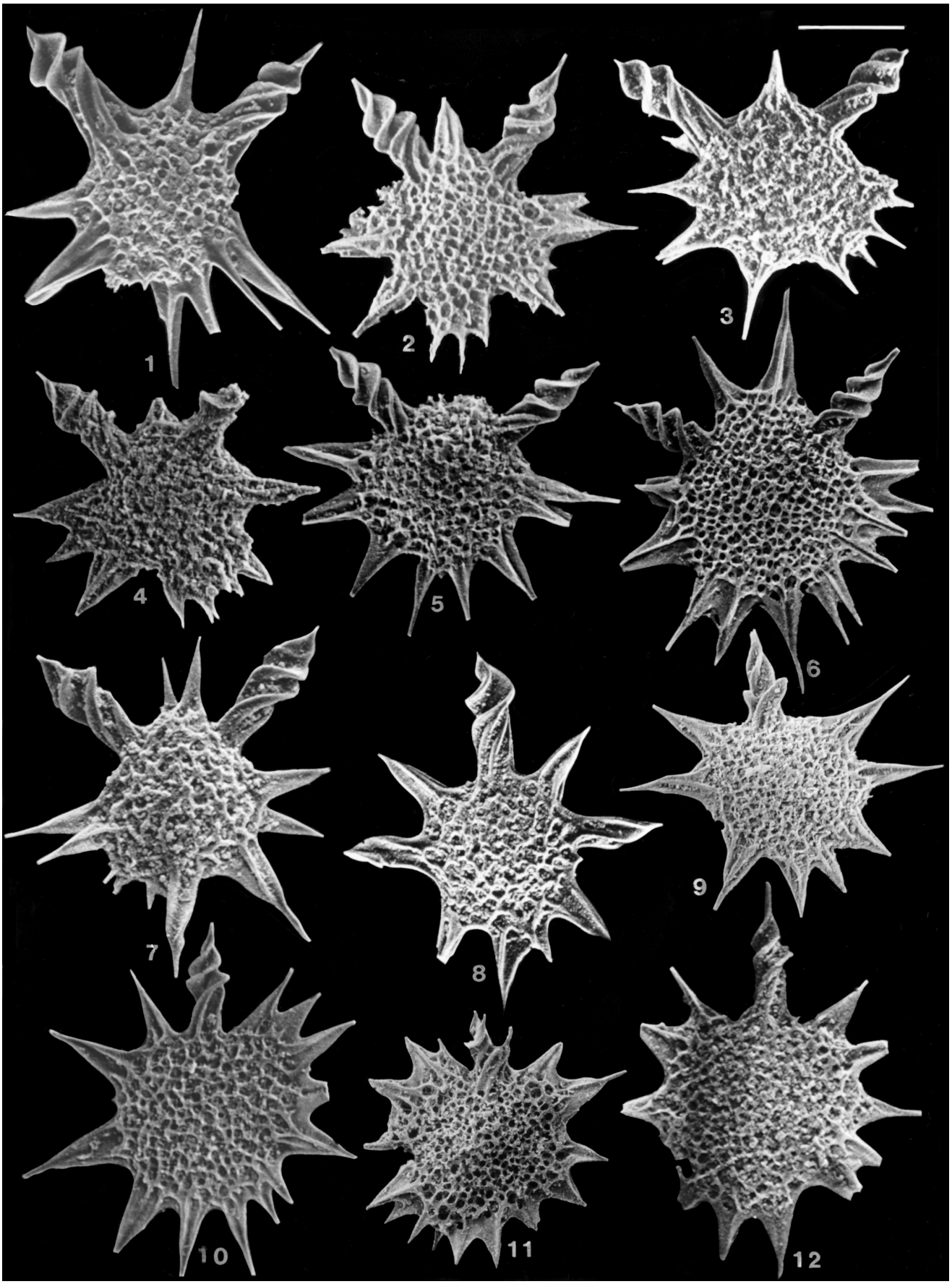
Included Species. *Discofulmen dumitricai* n. sp.; *Discofulmen ishidai* n. sp.

PLATE 7

Scanning electron photomicrographs of late Ladinian Spumellaria from Fojnica, Bosnia and Herzegovina. All materials are from sample 88-272. Scale = number of microns for each figure.

Figs. 1-7 - *Discofulmen dumitricai* n. sp., 1. Holotype, scale bar = 105μm, 2-7. Paratypes, scale bar for all figures = 110μm.

Figs. 8-12 - *Discofulmen ishidai* n. sp., 8. Holotype, scale bar = 110μm, 9-12. Paratypes, scale bar for figures 9, 10, 12 = 110μm, scale bar for figure 11 = 130μm.


1
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Discofulmen dumitricai n. sp.

Pl. 7, figs 1-7

Etymology. This species is named for Dr. Paulian Dumitrica (Bern, Switzerland) in honour of his great contributions to the study of Mesozoic Radiolaria.

Types. Holotype, GPU 2003/TEMO 1-150 (Pl. 7, Fig. 1); paratypes, GPU 2003/TEMO 1-151 (Pl. 7, Fig. 2), GPU 2003/TEMO 1-152 (Pl. 7, Fig. 3), GPU 2003/TEMO 1-153 (Pl. 7, Fig. 4), GPU 2003/TEMO 1-154 (Pl. 7, Fig. 5), GPU 2003/TEMO 1-155 (Pl. 7, Fig. 6), GPU 2003/TEMO 1-156 (Pl. 7, Fig. 7).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Cortical shell large, flat discoidal, circular to subcircular in outline with ten to fifteen peripheral spines. Cortical shell consisting of double-layered pore frames. Outer layer of pore frames mainly tetragonal to pentagonal with high, prominent and rounded nodes at vertices of bars. Peripheral spines shorter than the diameter of cortical shell. Two peripheral spines, usually longer than the others, tricarinate, slightly dextrally twisted at basal parts then strongly twisted with short, needle-like tips. Ridges of peripheral spines thin, bifurcated basally while grooves deep and wide. The other peripheral spines straight or slightly sinistrially twisted, tapering distally and tricarinate with thin ridges and wide grooves; spines usually terminated with needle-like points.

Remarks. *Discofulmen dumitricai* n. sp. is differentiated from *D. ishidai* n. sp. by possessing numerous peripheral spines of which two are strongly dextrally twisted instead of numerous peripheral spines of which only one is strongly, dextrally twisted.

Measurements (μm)**.** (Based on seven specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	158	155	183	169
Max. length of twisted spines	135	116	154	133
Max. length of straight spines	130	67	130	97

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

Discofulmen ishidai n. sp.

Pl. 7, figs 8-12

Etymology. This species is named for Prof. Dr. Keisuke Ishida (University of Tokushima, Tokushima, Japan) in honour of his contributions to the study of Mesozoic Radiolaria.

Types. Holotype, GPU 2003/TEMO 1-157 (Pl. 7, Fig. 8); paratypes, GPU 2003/TEMO 1-158 (Pl. 7, Fig. 9), GPU 2003/TEMO 1-159 (Pl. 7, Fig. 10), GPU 2003/TEMO 1-160 (Pl. 7, Fig. 11), GPU 2003/TEMO 1-161 (Pl. 7, Fig. 12).

Type Locality. Varoski creek, 2 km west of Fojnica, Bosnia and Herzegovina (see locality description).

Description. Same as with genus. Cortical shell large, flat discoidal, circular in outline with nine to sixteen peripheral spines. Two different types of peripheral spines present: one spine slightly dextrally twisted at basal parts then strongly twisted at distal parts, tricarinate with thin ridges and wide, deep grooves. Basal parts of ridges bifurcated. Needle-like, pointed spines present at tip of this spine. The other spines straight to slightly sinistrially twisted, tricarinate with very thin ridges and wide grooves. Needle-like, pointed spines present at tips of these spines.

Remarks. *Discofulmen ishidai* n. sp. has been compared to *Discofulmen dumitricai* n. sp. under the latter species.

Measurements (μm)**.** (Based on five specimens)

	HT	Min.	Max.	Av.
Diameter of cortical shell	167	155	194	174
Max. length of twisted spines	128	90	144	124
Max. length of straight spines	89	84	106	96

Range. Middle Triassic; late late Ladinian (*Spongoserrula fluegeli* Subzone of *Muelleritortis cochleata* Zone).

Occurrence. Fojnica, Bosnia and Herzegovina.

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