Lower Triassic (Spathian) radiolarians from the Kuzu area (Tochigi Prefecture, central Japan)

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ABSTRACT
A well-preserved Lower Triassic radiolarian fauna was found in a siliceous claystone and chert sequence in the Kuzu area of the Ashio Terrane, central Japan. This fauna includes "Paleozoic type" radiolarians represented by spicular type Palaeoscenidiidae and Entactiniidae with some common species of the Late Early Triassic *Parentactinia nakatsugawaensis* (Pn) Assemblage. Spathian conodonts *Neospathodus triangularis* (Bender) and *Neohindeodella benderi* (Kozur & Mostler) co-occur with these radiolarians. Based on the faunal analysis and chronological dating by conodonts, this radiolarian fauna probably represents an older part of the Pn Assemblage, where "Paleozoic type" Entactiniidae are still a dominant component in Early Triassic time.

KEY WORDS
Ashio Terrane, conodonts, Entactiniidae, Palaeoscenidiidae, Radiolaria, Spathian, Lower Triassic.

RÉSUMÉ
Radiolaires triassiques inférieurs (Spathien) de la région de Kuzu (Préfecture de Tochigi, Japon central).
Une faune bien conservée de radiolaires du Trias inférieur a été trouvée dans une série de pélites siliceuses et de jaspes dans la région de Kuzu, Ashio Terrane, Japon central. Cette faune inclut des radiolaires de « type paléozoïque » représentés par des spicules de type Palaeoscenidiidae et Entactiniidae avec quelques espèces communes de l'Assemblage à *Parentactinia nakatsugawaensis* (Pn) de la fin du Trias inférieur. Des conodontes spathiens *Neospathodus triangularis* (Bender) et *Neohindeodella benderi* (Kozur & Mostler) co-existent avec ces radiolaires. Sur la base des faunes analysées et de la datation par les conodontes, cette faune de radiolaires représente probablement une partie ancienne de l'assemblage à *P. nakatsugawaensis*, dans lequel les Entactiniidae de « type Paléozoique » sont encore dominants au Trias inférieur.

MOTS CLÉS
Terrane d'Ashio, conodontes, Entactiniidae, Palaeoscenidiidae, Radiolaria, Spathien, Trias inférieur.

INTRODUCTION

Since radiolarian extraction by the HF method was established, the biostratigraphy and taxonomy of Triassic radiolarians has developed rapidly mainly in the European Tethys (e.g., Kozur & Mostler 1972; Dumitrica 1978a, b; De Wever *et al.* 1979), western North America (e.g., Pessagno *et al.* 1979; Blome 1984), and western Pacific regions (e.g., Nakaseko & Nishimura 1979; Yao 1982). Due to the scarcity of radiolarian-bearing Lower Triassic sequences around the world, Lower Triassic radiolarian biostratigraphy lags well behind that of the Middle Triassic to Jurassic (e.g., Matsuoka & Yao 1986; Hori 1988, 1990; Matsuoka 1995a, b; Sugiyama 1997).
Lithological and geochemical investigations have recently been undertaken in Upper Permian and Lower Triassic sequences involving the Permian-Triassic (P-T) boundary in various areas in Japan (Yamakita 1987; Ishida *et al.* 1992; Kuwahara *et al.* 1991; Sugiyama 1992; Kamata & Kajiwara 1996). Only limited information is available on the biostratigraphy of Lower Triassic radiolarians (Sashida 1983, 1991; Sashida & Igo 1992; Sugiyama 1992, 1997; Blome & Reed 1992; Nagai & Mizutani 1993; Kozur *et al.* 1996). Biostratigraphic and taxonomic investigations are important to establish the transition between the Paleozoic and Mesozoic radiolarian faunas. Accordingly, this paper presents results of a detailed investigation of Lower Triassic radiolarians in the Kuzu area of the Ashio Terrane, Tochigi Prefecture. In a preliminary report, Kamata (1995) described Lower Triassic radiolarian biostratigraphy from a section belonging to the Kuzu Complex. In this paper, the systematics of Lower Triassic radiolarians from two samples in the same section are presented.

GEOLOGIC SETTING

Lower Triassic radiolarians were obtained from a

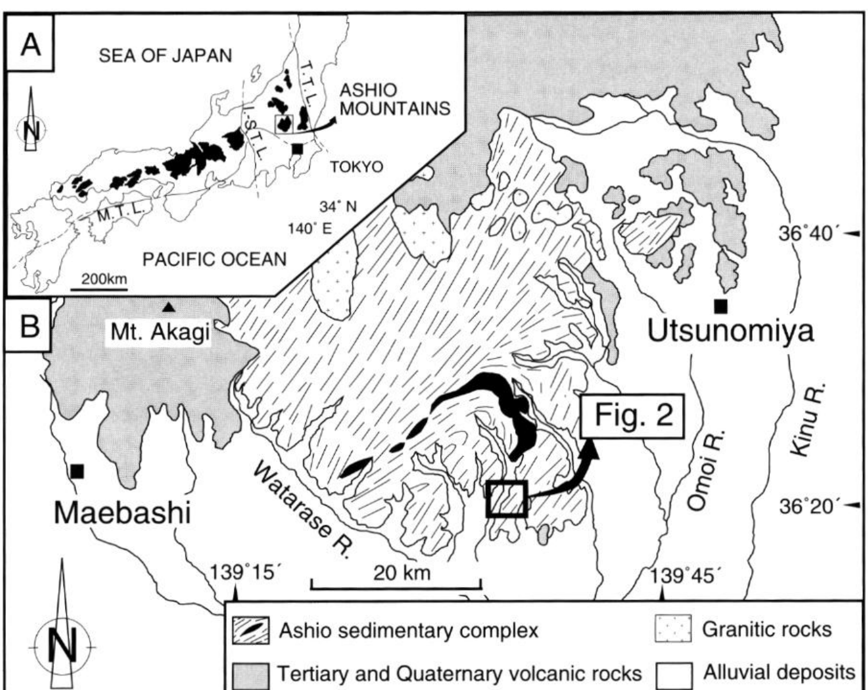

FIG. 1. — Index map showing **A**, the distribution of Inner Zone of southwest Japan; **B**, the outline of geology of the Ashio Mountains; **M.T.L.**, Median Tectonic Line; **I.-S.T.L.**, Itoigawa-Shizuoka Tectonic Line; **T.T.L.**, Tanakura Tectonic Line.

siliceous claystone and bedded chert sequence of the Kuzu Complex (Kamata 1996) in the Ashio Terrane (Fig. 1). The Kuzu Complex consists mainly of stacked slices of a chert-clastic sequence with huge thrust sheets of greenstone and limestone. The chert-clastic sequence is formed of Lower Triassic black carbonaceous or siliceous claystone, Middle Triassic to Lower Middle Jurassic chert, and Middle to Lower Upper Jurassic clastic rocks (Kamata 1996, 1997). The investigated section, belonging to the lower part of this complex, is located at the southeastern part of Tanuma Town, Aso-Gun, Tochigi Prefecture (Fig. 2). It is exposed along a road-cut of the Natural Laboratory of Tokyo University of Agriculture and Technology. The section is composed of alternating black siliceous claystone and dark gray chert with pale green siliceous claystone interbeds. The occurrence of representative species of the *Parentactina nakatsugawaensis* (Pn) Assemblage of Sugiyama (1992) were reported from this section previously (Kamata 1995). The tentative stratigraphy of this section is established in ascending order as follows (Figs 3, 4):

Unit A. Strongly sheared sandstone, approximately 2 m thick.
Unit B. Gray, medium-grained sandstone including blocks of bedded chert yielding Upper Triassic radiolarians, about 8 m thick.

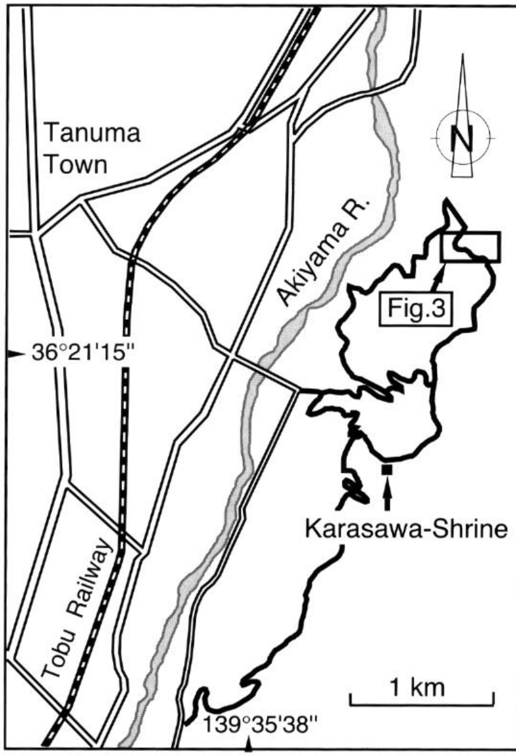

FIG. 2. — Locality map showing the location of the study section.

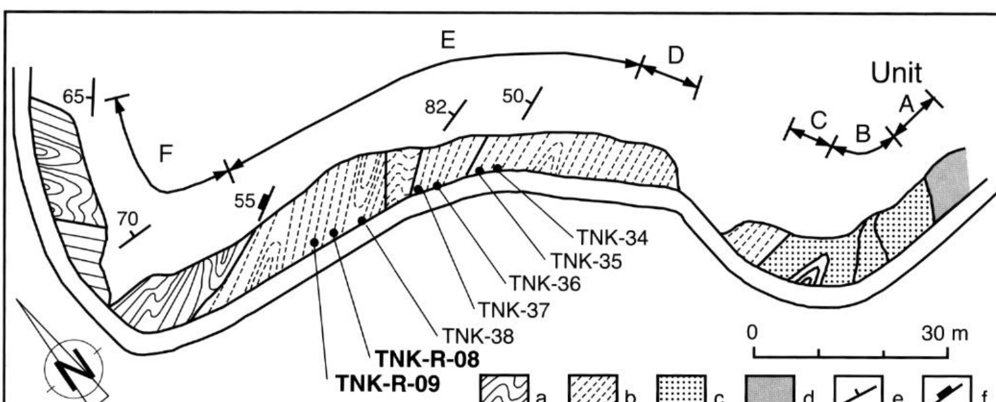

FIG. 3. — Route map along the road-cut of the Natural Laboratory of Tokyo Institute of Agriculture and Technology showing the occurrence of siliceous rocks and radiolarian localities. **a**, gray bedded chert; **b**, greenish gray siliceous claystone intercalated with black siliceous claystone and black chert; **c**, sandstone; **d**, sheared zone; **e**, strike and dip of bedding plane; **f**, strike and dip of fault plane.

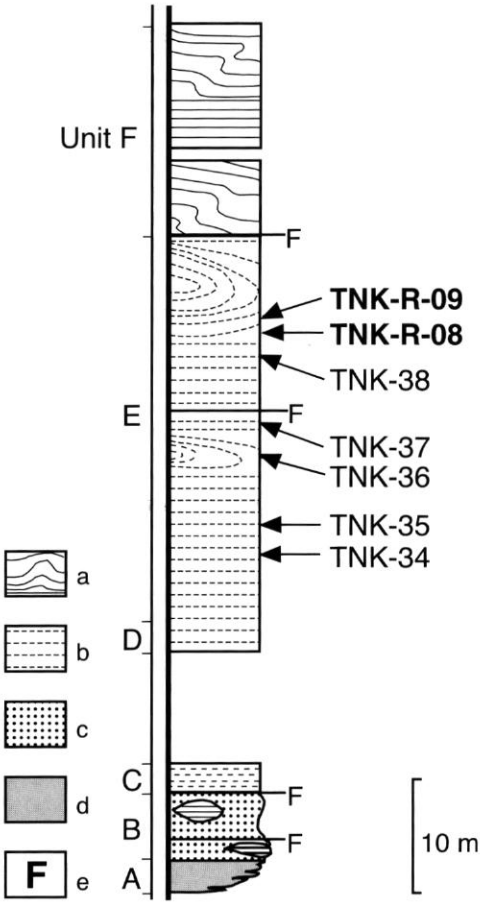

FIG. 4. — Columnar section of the study section. **a**, bedded chert; **b**, siliceous claystone with layer of chert; **c**, sandstone; **d**, sheared zone; **e**, fault.

Units C, D. Both units composed of pale green, fissile, siliceous claystone; well-developed scaly cleavages developed subparallel to bedding plane.
Unit E. Unit composed mainly of pale green claystone with intercalations of black siliceous and/or gray to black chert layers a few centimeters thick. The black siliceous claystone is rather muddy compared with the chert, and more siliceous than the pale green siliceous claystone. The black siliceous claystone is similar to the muddy chert of Sugiyama (1992). Thickness and amount of the black siliceous claystone and chert layers increases upwards in the unit; siliceous claystone and chert layers alternate in the upper part. Minor folding is present. Alternating black siliceous claystone (TNK-R-08) and black chert (TNK-R-09) from the upper part of Unit E contain Spathian radiolarians and conodonts. Radiolarian fauna from samples TNK-34 to 38 described by Kamata (1995) is also of Spathian age.
Unit F. Well-bedded gray to black chert containing Middle Triassic radiolarians of the *Triassocampe deweveri* Assemblage of Yao (1982).

GEOLOGIC AGE AND RADIOLARIAN FAUNA

Sample TNK-R-09 contains a radiolarian fauna comparable to the *Parentactinia nakatsugawaensis* Assemblage of Sugiyama (1992) and also a rich conodont fauna composed of *Neospathodus triangularis* (Bender 1970), *N. clinatus* Orchard & Sweet, 1995, *Cornudina igoi* Koike, 1996, *Neohindeodella benderi* (Kozur & Mostler, 1970), and many unidentified ramiform elements (Fig. 5). No age-diagnostic conodonts are present in sample TNK-R-08 which contains very well-preserved radiolarians.
Neospathodus triangularis (Bender, 1970) and *Neohindeodella benderi* (Kozur & Mostler, 1970) are well-known Late Early Triassic conodont species (Fig. 6). The occurrence of *Neospathodus triangularis* (Bender, 1970) has been reported from the Spathian of the Tethyan region in Kashmir, the Salt Range, Spiti, and Japan (e.g., Sweet *et al.* 1971; Goel 1977; Koike 1981; Matsuda 1985). Matsuda (1985) and Sweet (1988) summarized the conodont zonations and indicated ranges of Lower Triassic conodonts based on these biostratigraphic investigations. In these regions, *N. triangularis* is one of the main components of the Spathian conodont fauna. The base of the *N. triangularis-N. hormeri* zone (Matsuda 1985) and *N. triangularis* zone (Sweet 1988), both indicative of the lower Spathian, are defined by the first occurrence of this species. In Japan, *N. triangularis* is a characteristic species of the *N. triangularis-N. ? collinsoni* zone of the lower Spathian (Koike 1981). Furthermore, Koike (1996) described *Cornudina igoi* from the Taho Formation distributed in Ehime Prefecture south-

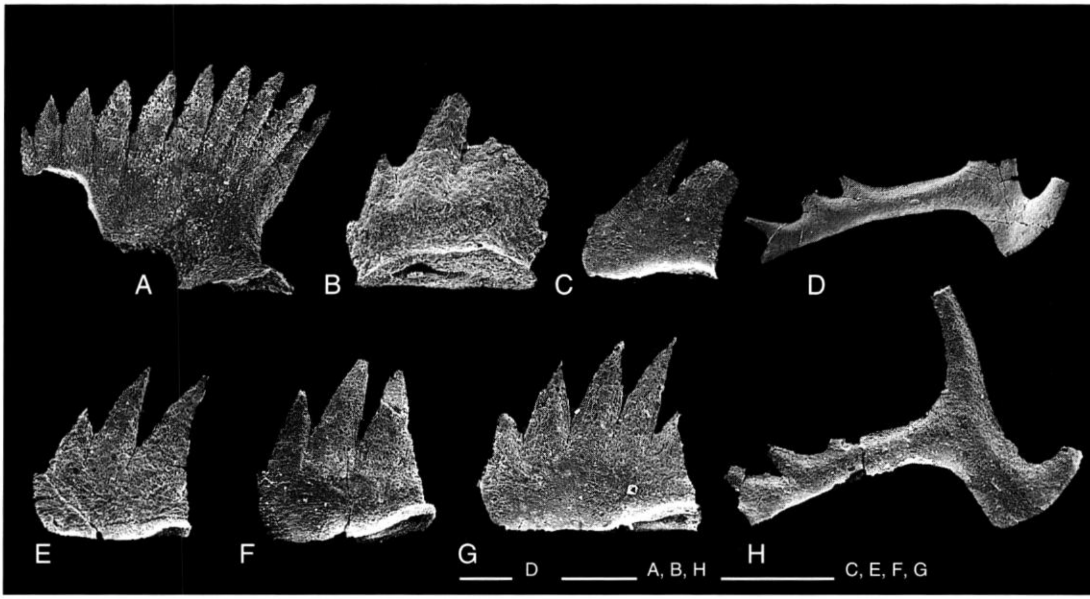

FIG. 5. — Spathian conodonts from the TNK-R-09. **A**, *Neospathodus triangularis* (Bender); **B**, **C**, *Cornudina igoi* Koike; **D**, **H**, *Neohindeodella benderi* (Kozur & Mostler); **E**, **F**, *Neospathodus* sp.; **G**, ? *Neospathodus clinatus* Orchard & Sweet. Scale bars: 100 µm.

west Japan, and indicated that this species occurs in the basal part of the *N. triangularis-N. hormeri* zone of the lower Spathian (Fig. 6).

The radiolarian fauna in this paper consists mainly of Palaeoscenidiidae and Entactiniidae with some common species of the Pn Assemblage of Sugiyama (1992) and TR1 zone of Sugiyama (1997). The fauna is represented by species of *Archaeosemantis*, *Parentactinia*, *Entactinia* (?), *Entactinosphaera* (?), *Cryptostephanidium*, and *Pantanellium* (?) (Fig. 7). Tripod or mono-segmented Nassellarians, such as *Hozmadia* and multi-segment Nassellaria such as *Triassocampe* rarely occur.

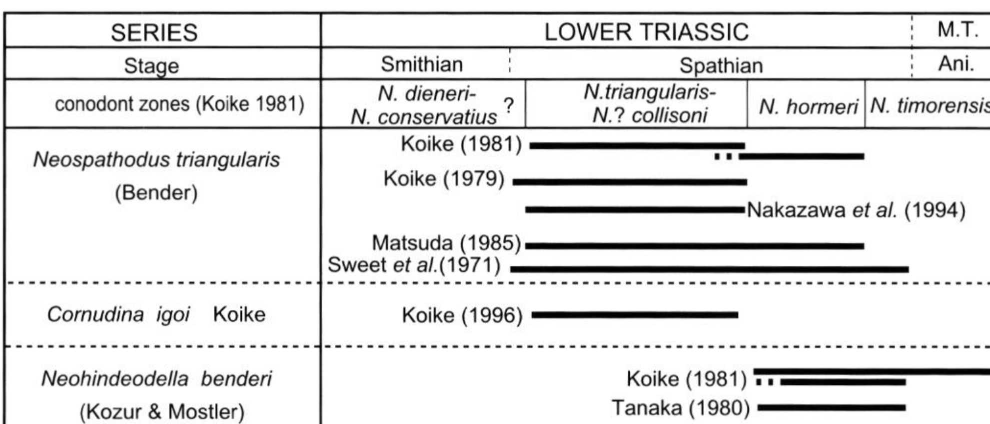

FIG. 6. — Known ranges of detected conodont species plotted on the conodont zones proposed by Koike (1981).

species \ sample number	Lithology	TNK-34	TNK-35	TNK-36	TNK-37	TNK-38	TNK-R-08	TNK-R-09
		s.c.	ch.	s.c.	ch.	ch.	s.c.	ch.
Archaeosemantis brevispinosa Kamata		–	–	–	–	–	+	–
Archaeosemantis cristianensis Dumitrica		+	+	–	–	–	+	+
Archaeosemantis sp.		+	+	+	–	–	+	+
Archaeothamnulus sp.		+	+	+	–	–	+	–
Parentactinia karasawayamaensis Kamata		–	–	–	–	–	+	–
Parentactinia nakatsugawaensis Sashida		+	–	+	+	+	+	+
Parentactinia sp. A		–	–	–	–	–	+	–
Parentactinia okuchichibuensis (Sashida)		–	–	–	–	–	+	–
Parentactinia sp.		+	+	+	–	–	+	+
Protopsium sp.		+	+	+	–	+	–	+
Plafkerium sp.		–	–	–	+	–	–	–
Pantanellium (?) *virgeum* Sashida		+	–	–	–	–	+	–
Pantanellium (?) sp. A		–	–	–	–	–	+	–
Pantanellium (?) sp.		+	+	+	+	+	+	+
Tiborella agria Sugiyama		–	–	–	+	–	–	–
Hozmadia cf. *ozawai* Sugiyama		–	+	–	–	–	+	–
Hozmadia sp.		–	+	+	+	–	+	+
Cryptostephanidium longispinosum (Sashida)		–	+	+	+	–	+	–
Cryptostephanidium sp.		–	–	+	+	–	+	–
Oertlispongus sp.		–	+	–	–	–	+	–
Triassobipedis (?) sp.		–	+	+	+	–	–	–
Zevius (?) sp.		–	+	–	–	–	+	–
Entactinia (?) tanumaensis Kamata		–	–	–	–	–	+	–
Entactinia nikorni Sashida and Igo		–	–	+	–	–	–	–
Polyentactinia (?) *crux* Sugiyama		–	–	–	–	–	+	–
Polyentactinia furutanii Sugiyama		–	–	–	–	–	+	–
Polyentactinia sp.		–	–	–	–	–	+	–
Entactinosphaera (?) *sashidai* Kamata		–	–	–	–	–	+	–
Entactinosphaera chiakensis Sashida and Igo		–	–	–	–	–	+	–
Entactinosphaera sp.		–	+	–	–	–	+	+
Thaisphaera (?) *igoi* Kamata		–	–	–	–	–	+	–
Entactiniidae gen. et sp. indet.		+	+	+	+	–	+	–

FIG. 7. — List of Early Triassic radiolarians from the study section. **s.c.**, siliceous claystone; **ch.**, chert.

Sugiyama (1992) considered the age of Pn Assemblage as late Spathian based on co-occurring conodonts belonging to the *Neospathodus hormeri* Assemblage but stated that the lower limit of this assemblage is unknown. Recently, Sugiyama (1997) compared TR0 and TR1 with the lower part and the upper part of the Pn Assemblage of Sugiyama (1992), respectively. In this study, *N. triangularis* (Bender, 1970) and *Cornudina igoi* Koike, 1996 are associated with some common radiolarian species of the Pn Assemblage. Kusunoki & Imoto (1996) also reported a radiolarian fauna attributed to the Pn Assemblage associated with the lower Spathian conodonts *N. triangularis* and *Gondolella jubata* (Sweet, 1970). They emphasized that the Pn Assemblage ranges down to the lower Spathian. This present evidence suggests that the range of some species of the Pn Assemblage may extend down to the lower Spathian.

As briefly stated above, the radiolarian fauna discussed here has both Paleozoic and Lower Triassic affinities. The family Entactiniidae is particularly abundant exceeding more than 50% of the total number of the identified radiolarian species within this fauna. Considering the range of the conodonts, the radiolarian fauna represents an older part of the Pn Assemblage (Sugiyama 1992) and

TR0 (Sugiyama 1997), and "Paleozoic type" Entactiniidae are still a dominant component in Early Triassic assemblages. Futher analysis of Spathian radiolarian faunas is necessary because *Follicuculus*, a representative species of TR0, has not been found in the studied section.

METHODS AND TECHNIQUES

Radiolarian specimens were separated from siliceous rock samples in the following manner: (1) rock samples were crushed into small fragments of several centimeters; (2) crushed samples were placed in five percent hydrofluoric acid for 24 hours; (3) samples were washed and sieved using a mesh of 50 µm opening, the residue was dried in an oven. Well-preserved radiolarian specimens were mounted on an SEM plug and gold coated in a vacuum evaporator. The surface features and inner structures were observed with the Scanning Electron Microscope.

SYSTEMATIC PALEONTOLOGY

All figured specimens are deposited in collections of the Department of Earth Sciences, University of Yamaguchi (DEUY).

Subclass RADIOLARIA Müller, 1858
Order POLYCYSTINA Ehrenberg, 1838
emend. Riedel, 1967
Suborder SPUMELLARIA Ehrenberg, 1875
Family PALAEOSCENIDIIDAE Riedel, 1967
emend. Holdsworth, 1977
Genus *Archaeosemantis* Dumitrica, 1978b

Archaeosemantis brevispinosa n. sp.
(Fig. 8A-C)

TYPES. — Holotype, Figure 8A, TNK-R-08, DEUY-YK3617; paratypes, Figure 8B, TNK-R-08, DEUY-YK3627, Figure 8C, DEUY-YK3618.

ETYMOLOGY. — *Brevispinosa* means having short spines.

OCCURRENCE. — Sample TNK-R-08, Kuzu area, central Japan.

DIMENSIONS (µm). — Based on eight specimens: length of apical spines 5.0 to 21.8 (average 15.9); length of basal spines 72.8 to 126.0 (average 85.3).

DESCRIPTION

Species composed usually of eight spines consisting of four apical spines and four basal spines, arising from a short median bar (MB). The four basal spines are conical, short, rod-like, and rugged. Two, commonly straight basal spines diverge from one end of MB. Three or four apical spines; spines conical, very short, and obliquely divergent upward from end of MB at a smaller angle.

REMARKS

Compared with other *Archaeosemantis*, the basal and apical spines of this species are shorter. *Archaeosemantis cristianensis* is similar to this species, but differs by possessing long and downwardly curved basal spines.

Archaeosemantis cristianensis
Dumitrica, 1982
(Fig 8D, H)

Archaeosemantis pterostephanus Dumitrica (part) 1978b: 52, pl. 5, figs 7, 8 (non pl. 5. figs 9-12).
Archaeosemantis cristianensis Dumitrica, 1982: 423, pl. 1, fig. 11, pl. 3, fig. 11, pl. 4, figs 5, 7, 11, pl. 6, fig. 2, pl. 7, figs 3, 12, 13. – Ando *et al.* 1991, pl. 9, fig. 12. – Nagai & Mizutani 1993: 7, pl. 1, fig. 9.
Archaeosemantis venusta Sashida, 1983: 171, pl. 36, figs 1-9; 1991: 686, fig. 5-4, 5, 6, 7, 8. – Nagai & Mizutani 1993: 7, pls 1, 11.
Archaeosemantis sp. aff. *A. venusta* Sashida, 1991: 686, figs 5-9. – Kamata 1995: fig. 6-1, 2.
Archaeosemantis sp. – Sashida 1991: 686, fig. 5-1, 2, 3.
Archaeosemantis cristianensis Dumitrica, 1982 morphotype A Sugiyama, 1992: 1209, fig. 14-3.
Archaeosemantis cristianensis Dumitrica, 1982 morphotype B Sugiyama, 1992: 1209, fig. 14-6.

OCCURRENCE. — Common in TNK-R-08, 09, Kuzu area, Tochigi Prefecture. Mt. Kinkazan and Minokamo City, Gifu Prefecture. Kanto Mountains, Saitama Prefecture, central Japan. Vicentinian Alps, Italy.

REMARKS

Dumitrica (1982) described specimens of *A. cristianensis* having broad variation in the disposition and length of spines. Sugiyama (1992) proposed two morphotypes A and B for this species, and stated that phenotypic variation is caused by the rotation of half of morphotype A around the axis of the median bar (MB).

Genus *Parentactinia* Dumitrica, 1978b
Parentactinia karasawayamaensis n. sp.
(Fig. 9G-M)

TYPES. — Holotype, Figure 9H, TNK-R-08, DEUY-YK3495; Paratypes, Figure 9G, TNK-R-08, DEUY-YK3654; Figure 9I, TNK-R-08, DEUY-YK3653; Figure 9J, TNK-R-08, DEUY-YK3650; Figure 9 K, TNK-R-08, DEUY-YK3635; Figure 9L, TNK-R-08, DEUY-YK3657; Figure 9M, TNK-R-08, DEUY-YK3533.

ETYMOLOGY. — Species name *karasawayamaensis* comes from Karasawayama Shrine close to the studied section.

OCCURRENCE. — Abundant in TNK-R-08, Kuzu area, central Japan.

DIMENSIONS (µm). — Based on ten specimens: shell diameter, 160 to 190 (average 178); length of apical or basal spines 100 to 220 (average 175); all spines broken, see Fig. 9L; wall thickness less than 10.

DESCRIPTION

Species with spherical latticed shell and a spicule consisting of seven or eight rod-like spines arising from a short eccentric MB. Rod-like spines straight and penetrating the wall of shell. Cortical shell, thin, and relatively smooth surfaced, enclosing an eccentric spicule with seven or eight radial spines and a very short MB. Cortical shell nearly spherical and supported by all radial spines. Pore pattern of shell composed of intersections of bars forming numerous quadrangular or triangular pore frames. Main radial spines long, rod-like, and occasionally curved upward outside of shell. Internal spines arise from MB and penetrate the shell wall. Main spines slightly thicker outside shell wall than in the internal portion. Four apical spines situated in the upper hemisphere diverge upwardly at about 45° above the horizontal plane. Commonly three or four basal spines. MB is eccentrical.

REMARKS

This new species is similar to *Polyentactinia* (?) *phatthalungensis*, reported by Sashida & Igo (1992), but the latter has an uneven shell wall formed of intersecting bars.

Parentactinia nakatsugawaensis
Sashida, 1983
(Figs 8E-G, I-N, 9A)

Unnamed Spumellaria – Matsuda & Isozaki 1982: pl. 3, figs 33-35.
Parentactinia nakatsugawaensis Sashida, 1983: 172-173, pl. 37, figs 1-9; 1991: 687. fig. 5-15, 16, figs 6-1, 3-6. – Sugiyama 1992: 1212, fig. 14-7-10. – Blome & Reed 1992: 376, fig. 14-3, 4. – Nagai & Mizutani 1993: pl. 1, figs 1-6. – Kamata 1995: fig. 6-4, not 8. – Kusunoki & Imoto 1996: 91, fig. 1. – Sugiyama 1997: 184, fig. 27-2, 3.
Parentactinia virgata Sashida, 1991: 689, fig. 7.

OCCURRENCE. — Abundant in TNK-R-08, 09, Kuzu area, Tochigi Prefecture. Mt. Kinkazan and Minokamo City, Gifu Prefecture. Southern Kameoka City, Kyoto Prefecture. Kanto Mountains, Saitama Prefecture, central Japan. Oregon, USA.

DIMENSIONS (µm). — Based on forty-three specimens: length of apical spines 21 to 65 (average 42); length of basal spines 65 to 234 (average 106); diameter of incomplete shells 120 to 230 (average 136).

REMARKS

This species consists of four apical and four basal spines with a loose latticed shell. The basal spines of some specimens have stout, slightly curved, long branches. Four or five branches diverge medially to distally along the basal spines. Two shorter branches are conical and diverge upward. Two additional long stout, rod-like branches diverge inward. Diameter of branches slightly smaller less that of basal spines. Each long branch bears two to four directional spinules distally. The spinules anastomose with each other forming a loosely reticulate shell. Some specimens possess an almost complete single shell. Surface of the shell rugged due to minute spinules; pores irregular in shape. Shell is supported by the basal spines and is incomplete apically. MB eccentrically situated or tangent to the shell.
Parentactinia nakatsugawaensis was first described by Sashida (1983) from black chert of the Kanto

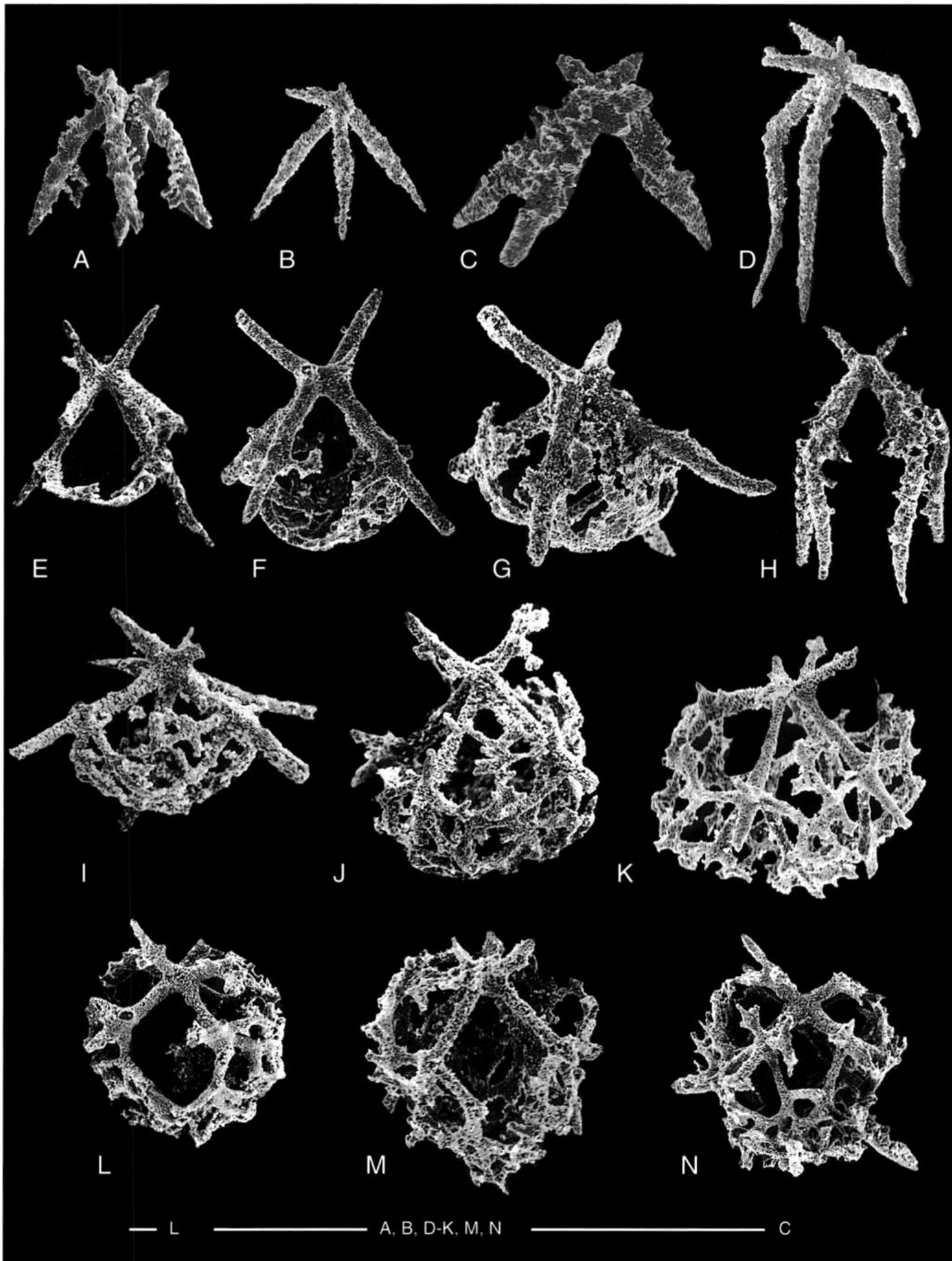

FIG. 8. — **A-C**, *Archaeosemantis brevispinosa* Kamata n. sp., **A**, holotype, DEUY-YK3617; **B**, paratype, DEUY-YK3627; **C**, paratype, DEUY-YK3618; **D**, **H**, *A. cristianensis* Dumitrica; **D**, DEUY-YK3629, **H**, DEUY-YK3481; **E-G**, **I-N**, *Parentactinia nakatsugawaensis* Sashida; **E**, DEUY-YK3538; **F**, DEUY-YK3479; **G**, DEUY-YK3545; **I**, DEUY-YK3509; **J**, DEUY-YK3603; **K**, DEUY-YK3486; **L**, DEUY-YK3506; **M**, DEUY-YK3588; **N**, DEUY-YK3422. Scale bars: 100 µm.

Mountains; later Sugiyama (1992) described this species in greater detail and considered it diagnostic of the Pn Assemblage of the upper Lower Triassic. The shell of this species is well preserved and shows variations in development in my material.

***Parentactinia* sp. A**
(Fig. 9B)

FIGURED SPECIMEN. — Figure 9B, TNK-R-08, DEUY-YK3609.

OCCURRENCE. — Rare in TNK-R-08, Kuzu area, central Japan.

DIMENSIONS (µm). — Based on two specimens: length of long apical spines 100 to 160 (average 129): length of short apical spines less than 20; diameter of incomplete shells 140 to 175 (average 157); width of basal hemisphere approximately 350.

REMARKS
This species is composed of four apical and four basal spines with an incomplete latticed shell. Basal spines very long, thick, rod-like, slightly curved upward, and gently tapered distally. Loose hemispheric shell is supported by the four basal spines.
Parentactinia sp. A is easily distinguished from *P. nakatsugawaensis* by possessing very thick basal and apical spines.

Parentactinia okuchichibuensis
(Sashida, 1991)
(Fig. 9C)

Archaeothamnulus okuchichibuensis Sashida, 1991: 687, fig. 5-10-14.
Parentactinia okuchichibuensis (Sashida) – Sugiyama 1992: 1213, fig. 16-2a, 2b. – Nagai & Mizutani 1993: pl. 1, figs 7, 8. – Kusunoki & Imoto 1996: 91, fig. 2.

OCCURRENCE. — Common in TNK-R-08, 09, Kuzu area, Tochigi Prefecture. Mt. Kinkazan and Minokamo City, Gifu Prefecture. Southern Kameoka City, Kyoto Prefecture. Kanto Mountains, Saitama Prefecture, central Japan.

REMARKS
Sugiyama (1992) transferred this species from *Archaeothamnulus* to *Parentactinia* because it possesses two apical spines. In my material, this species also has two apical spines.

Family ENTACTINIIDAE Riedel, 1967
Genus *Entactinia* Foreman, 1963
***Entactinia* (?) *tanumaensis* n. sp.**
(Fig. 9D-F)

TYPES. — Holotype, Figure 9D, TNK-R-08, DEUY-YK3500; paratypes, Figure 9E, TNK-R-08, DEUY-YK3522; Figure 9F, TNK-R-08, DEUY-YK3643.

ETYMOLOGY. — *Tanumaensis* is derived from Tanuma Town. Studied section is located at the southeastern part of Tanuma Town.

OCCURRENCE. — Common in TNK-R-08, Kuzu area, central Japan.

DIMENSIONS (µm). — Based on five specimens: length of main spines 50 to 110 (average 78.7): diameter of shell 80 to 100 (average 90).

DESCRIPTION
Species with a well-developed latticed shell with five to six rod-like main spines and numerous bi-spines. Latticed shell spherical with five to six needle-like primary spines. Primary spines possess shallow grooves proximally and strongly taper distally. Spine length nearly equal to diameter of shell. Shell wall rather thick, penetrated by variably-sized rounded pores. Numerous radial and very short bi-spines arise from the shell wall. Internal construction unknown.

REMARKS
This species is similar to *Entactinia nikorni* Sashida & Igo (1992), but differs from the later by possessing strongly tapered needle-like primary spines. This species is questionably assigned to *Entactinia* because of the absence of three-bladed spines.

Genus *Entactinosphaera* Foreman, 1963

***Entactinosphaera* (?) *sashidai* n. sp.**
(Fig. 10A-D)

TYPES. — Holotype, Figure 10A, TNK-R-08, DEUY-YK3483; paratypes, Figure 10B, TNK-R-08, DEUY-YK3490; Figure 10C, TNK-R-08, DEUY-YK3508, Figure 10E, TNK-R-08, DEUY-YK3434.

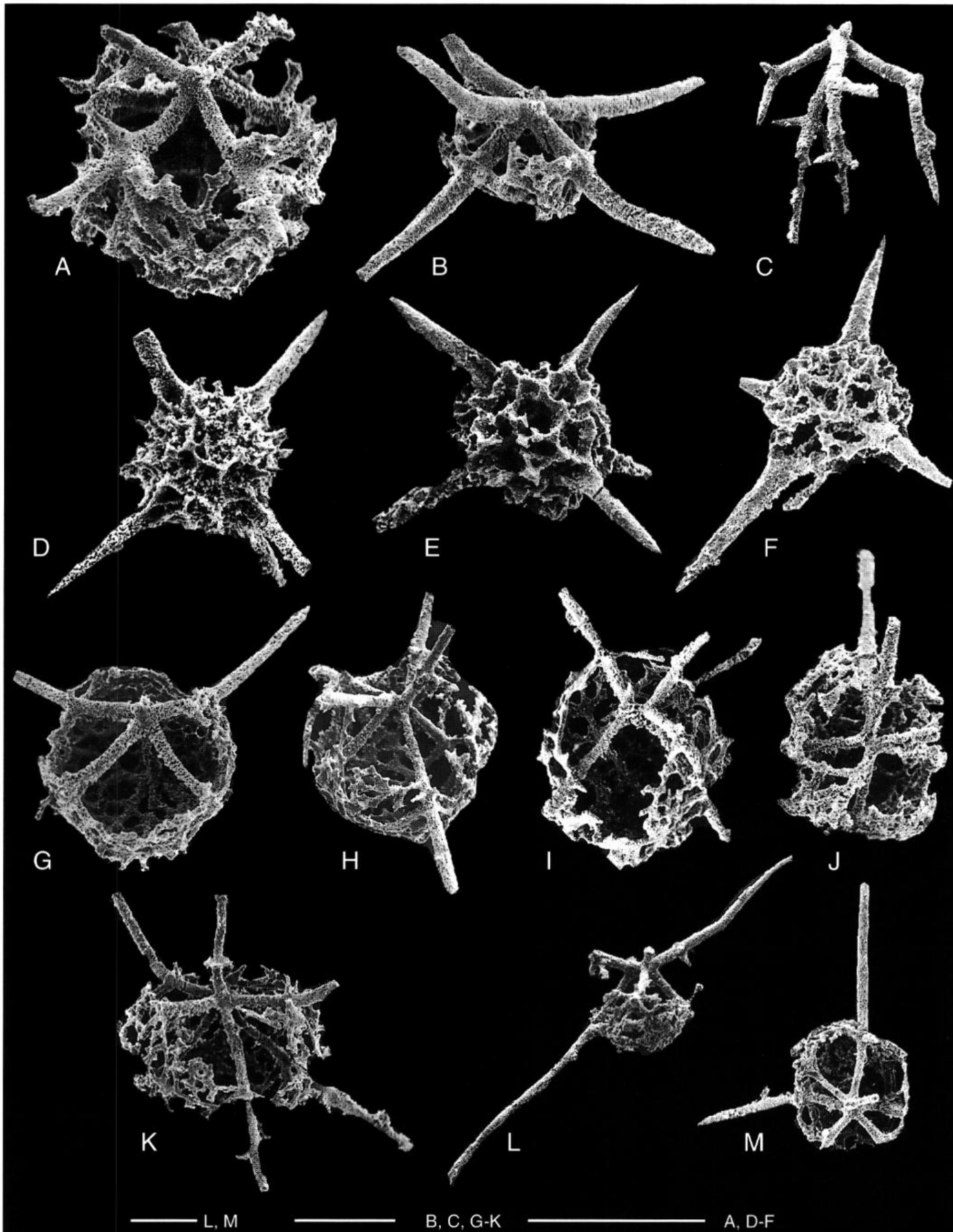

FIG. 9. — **A**, *Parentactinia nakatsugawaensis* Sashida, DEUY-YK3593; **B**, *Parentactinia* sp. A, DEUY-YK3609; **C**, *Parentactinia okuchichibuensis* (Sashida), DEUY-YK3616; **D-F**, *Entactinia* (?) *tanumaensis* Kamata n. sp.; **D**, holotype, DEUY-YK3500; **E**, paratype, DEUY-YK3522; **F**, paratype, DEUY-YK3643; **G-M**, *Parentactinia karasawayamaensis* Kamata n. sp., **G**, paratype, DEUY-YK3654; **H**, holotype, DEUY-YK3495; **I**, paratype, DEUY-YK3653; **J**, over view, paratype, DEUY-YK3650; **K**, paratype, DEUY-YK3653; **L**, long apical and basal spines are preserved, paratype, DEUY-YK3657; **M**, over view, paratype, DEUY-YK3533. Scale bars: 100 µm.

ETYMOLOGY. — Species name, sashidai is named for Associate Professor Katsuo Sashida of Tsukuba University in honor of his contribution to the study of Lower Triassic radiolarians.

OCCURRENCE. — Common in TNK-R-08, Kuzu area, central Japan.

DIMENSIONS (µm). — Based on five specimens : shell diameter, 100 to 150 (average 128); length of main spines, 120 to 210 (average 145).

DESCRIPTION

Test small, spherical, spongy with four to six needle-like main spines. Shell wall of some specimens develops minute circular pores and humps. Main spines taper to a point. Spines one to two times diameter of shell. Internal structure unknown.

REMARKS

Entactinosphaera (?) *sashidai* n. sp. is similar to *E. chiakensis* but differs by possessing a spongy shell.

Entactinosphaera chiakensis
Sashida & Igo, 1992
(Fig. 10I, J, L-N)

Entactinosphaera chiakensis Sashida & Igo, 1992: 1302, fig. 14-1-7, 9, 10, 15.

OCCURRENCE. — Common in TNK-R-08, Kuzu area, central Japan. Phatthalung, southern Peninsular Thailand.

REMARKS

This species consists of outer and inner shells with four to six needle-like spines. Two shells are connected by secondary spines.

Family ACTINOMMIDAE Haeckel, 1862
emend. Riedel, 1967
Genus *Thaisphaera* Sashida & Igo, 1992
Thaisphaera (?) ***igoi*** n. sp.
(Fig. 10E-H, K)

TYPES. — Holotype, Figure 10F, TNK-R-08, DEUY-YK3647; paratypes, Figure 10E, TNK-R-08, DEUY-YK3637; Figure 10G, TNK-R-08, DEUY-YK3655; Figure 10H, TNK-R-08, DEUY-YK3622; Figure 10K, TNK-R-08, DEUY-YK3591.

ETYMOLOGY. — The species is named in honor of Prof. Emeritus Hisayoshi Igo who introduced me to the study of the Ashio Terrane.

OCCURRENCE. — Common in TNK-R-08, Kuzu area, central Japan.

DIMENSIONS (µm). — Based on nine specimens: cortical shell diameter, 140 to 180 (average 160); medullary shell diameter, 50 to 60, length of main spines 100 to 180 (average 110); wall thickness 13-20 (average 15); pore diameter less than 20.

DESCRIPTION

Test consisting of a cortical shell with five to six primary spines and an inner medullary shell; both shells are spherical. Cortical shell thin-walled, composed of circular to subcircular pores with small nodes at vertices. Inner shell much smaller than outer shell; diameter approximately one third of the outer shell. Cortical and medullary shells connected by six thin, rod-like beams. Four to five primary spines are thick, three bladed, and taper distally; primary spines aligned with internal beams. Length of primary spines commonly equal to diameter of cortical shell.

REMARKS

Thaisphaera (?) *igoi* n. sp. resembles *Entactinosphaera chiakensis* Sashida & Igo, but differs from it by possessing three-bladed and shorter main spines. *Thaisphaera* (?) *igoi* is also very similar to *T. minuta* Sashida & Igo, but differs by having longer and thicker primary spines.

Family PANTANELLIIDAE Pessagno, 1977
Pantanellium (?) ***virgeum*** Sashida, 1991
(Fig. 11D, G-J, L)

Pantanellium (?) *virgeum* Sashida, 1991: 691, fig. 7-9-14. – Nagai & Mizutani 1993: pl. 3, fig. 4-6. – Kamata 1995: fig. 6-6, 7.

OCCURRENCE. — Rare in TNK-R-08, 09, Kuzu area, Tochigi Prefecture. Mt. Kinkazan and Minokamo City, Gifu Prefecture. Kanto Mountains, Saitama Prefecture, central Japan.

REMARKS

Test composed of an ellipsoidal to subspherical cortical shell, a spherical medullary shell and two rod-like bipolar spines. Well-preserved material

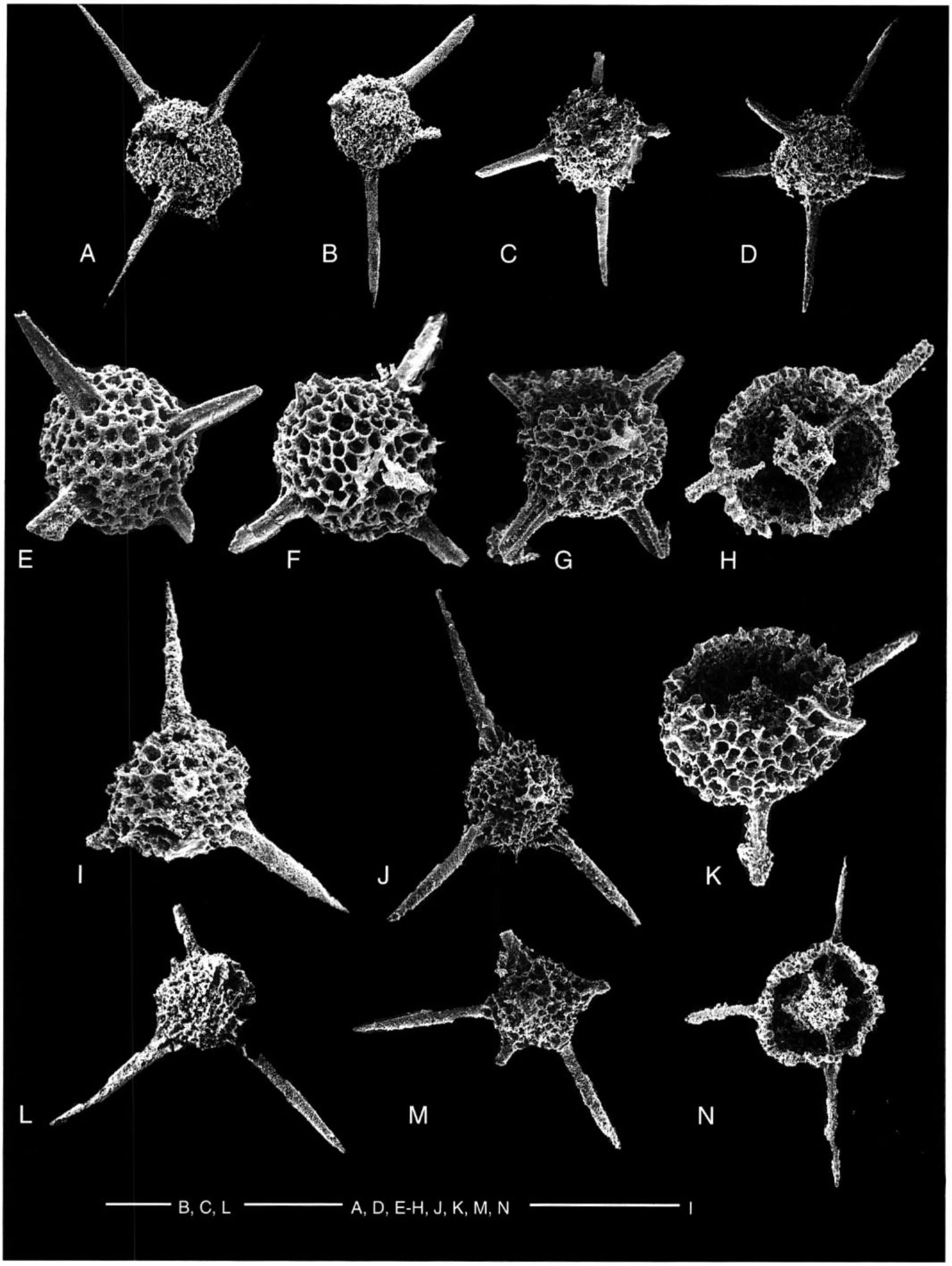

FIG. 10. — **A-D**, *Entactinosphaera* (?) *sashidai* Kamata n. sp., **A**, holotype, DEUY-YK3483, **B**, paratype, DEUY-YK3490; **C**, paratype, DEUY-YK3508; **D**, paratype, DEUY-YK3434; **E-H**, **K**, *Thaisphaera* (?) *igoi* Kamata n. sp.; **E**, paratype, DEUY-YK3637; **F**, holotype, DEUY-YK3647; **G**, paratype, DEUY-YK3655; **H**, showing internal structure, paratype, DEUY-YK3622; **K**, paratype, DEUY-YK3591; **I**, **J**, **L-N**, *Entactinosphaera chiakensis* Sashida & Igo; **I**, DEUY-YK3492; **J**, DEUY-YK3520; **L**, DEUY-YK3421; **M**, DEUY-YK3433; **N**, showing inner shell, DEUY-YK3485. Scale bars: 100 µm.

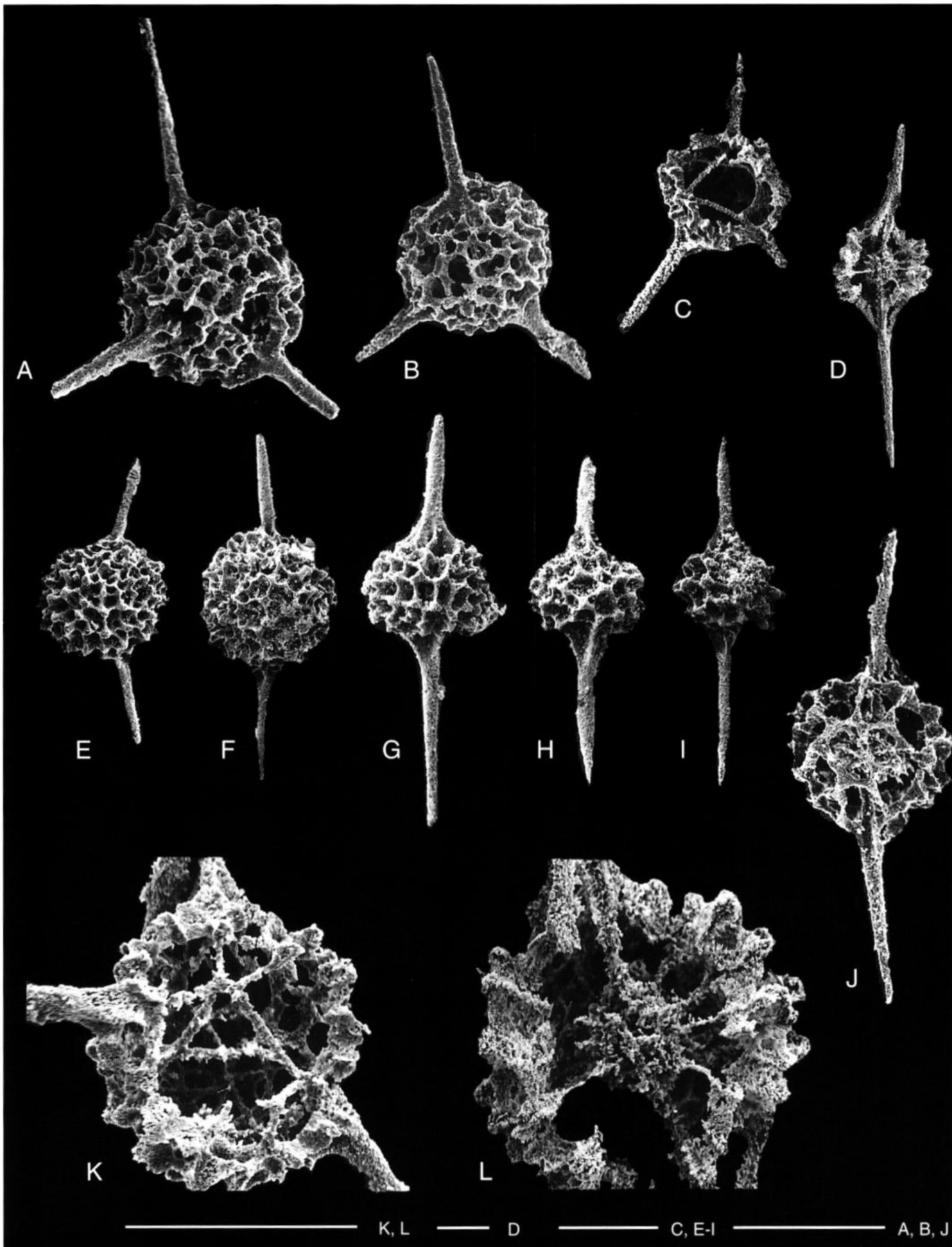

FIG. 11. — **A**-**C**, **K**, *Cryptostephanidium longispinosum* (Sashida); **A**, DEUY-YK3625; **B**, DEUY-YK3634; **C**, showing arch-like skeleton of aj, DEUY-YK3641; **K**, showing internal structure of A, L, D, and V spinules, DEUY-YK3633; **D**, **G**-**J**, **L**, *Pantanellium* (?) *virgeum* Sashida; **D**, DEUY-YK3474; **G**, DEUY-YK3614; **H**, DEUY-YK3649; **I**, DEUY-YK3438; **J**, DEUY-YK3498; **L**, enlargement of D showing cortical shell and beams, DEUY-YK3475; **E**, **F**, *Pantanellium* (?) sp. A; **E**, DEUY-YK3466; **F**, DEUY-YK3430. Scale bars: 100 µm.

shows the medullary shell connected to the cortical shell by numerous radial beams (Fig. 11D, L).

Pantanellium (?) sp. A
(Fig. 11E, F)

FIGURED SPECIMENS. — Figure 11E, TNK-R-08, DEUY-YK3466; Figure 11F, TNK-R-08, DEUY-YK3430.

OCCURRENCE. — Rare in TNK-R-08, 09, Kuzu area, central Japan.

REMARKS

Test consists of a subspherical to spherical shell with bipolar spines. Shell wall has very small, irregular elliptical to circular pores with well-developed nodes. Bipolar spines very thin and possessing slight grooves proximally.

Pantanellium (?) sp. A is distinguished from *P.* (?) *virgeum* Sashida by having thin spines and a spherical to subspherical shell with many pores.

Suborder NASSELLARIA Ehrenberg, 1875
Family EPTINGIIDAE Dumitrica, 1978a
Genus *Cryptostephanidium* Dumitrica, 1978a

Cryptostephanidium longispinosum
(Sashida, 1991)
(Fig. 11A-C, K)

Spongostephanidium longispinosum Sashida, 1991: 694, fig. 7-1-8.
? *Tripocyclia japonica* Nakaseko & Nishimura, 1979 – Blome *et al.* 1986, pl. 8.3, fig. 18.
Cryptostephanidium longispinosum (Sashida) – Sugiyama 1992: 1205, fig. 13-1, 2. – Nagai & Mizutani 1993: pl. 2, fig. 1-3. – Kamata 1995: 28, figs 6-16.

OCCURRENCE. — Abundant in TNK-R-08, 09, Kuzu area, Tochigi Prefecture. Mt. Kinkazan and Minokamo City, Gifu Prefecture. Kanto Mountains, Saitama Prefecture, central Japan. Oregon USA.

REMARKS

Studied specimens are quite similar to those above listed for *Cryptostephanidium longispinosum*. Internal shell structure is well observed in broken specimens (e.g., Fig. 11-C, K) which clearly show a MB, long apical and primary lateral spines, and the vertical and dorsal spines as well as the sagittal ring.

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