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

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KEYWORDS
Ashio Terrane, conodonts, Entactiniidae, Palaeoscenidiidae, Radiolaria, Spathian, Lower Triassic.

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.

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; Dmitrieva 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
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.

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**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.
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 *Neospadiodus 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.

*Neospadiodus triangularis* (Bender, 1970) and *Neohindeodella benderi* (Kozur & Mostler, 1970) are well-known Late Early Triassic species (Fig. 6). The occurrence of *Neospadiodus 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-
Spathian radiolarians

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 *Triassicampe* rarely occur.

![Fig. 6](image)

Fig. 6. — Known ranges of detected conodont species plotted on the conodont zones proposed by Koike (1981).
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 *Gondoella 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. Further 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 PALAEOSCENIDIDAE Riedel, 1967
emend. Holdsworth, 1977
Genus Archaeosemantis Dumitrca, 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**
Dumitrca, 1982
(Fig 8D, H)

*Archaeosemantis pterostephanus* Dumitrca (part) 1978b: 52, pl. 5, figs 7, 8 (non pl. 5, figs 9-12).

*Archaeosemantis cristianensis* Dumitrca, 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.* — Sashida 1991: 686, figs 5-1, 2, 3.


**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**
Dumitrca (1982) described specimens of *A. cristianensis* having broad variation in the disposi-
tion 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* Dumitrlica, 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 9K, 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** (pm). — 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 eccentric.

**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)


*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** (pm). — 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; B, DEUY-YK3629, H, DEUY-YK3481; E-G, H-K, 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.


**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 PANTANELLIDAE Pessagno, 1977

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


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 A; 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.


**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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