ISSN 0031-0204

日本古生物学會
報告・紀事

Transactions and Proceedings
of the
Palaeontological Society of Japan

New Series No. 151

日 本 古 生 物 学 会

Palaeontological Society of Japan

October 31, 1988

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The fossil on the cover is *Vicarya yokoyamai* Takeyama, an Early Middle Miocene gastropod from the Kurosedani Formation at Kakehata, Yatsuo-cho, Nei-gun, Toyama Prefecture, central Japan (Collected by T. Kotaka and K. Ogasawara, IGPS No. 99075, photo by S. Ohtomo and Y. Kikuchi, x0.9).

All communication relating to this journal should be addressed to the
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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 151, pp. 501–522, 21 Figs., October 31, 1988

861. EARLY JURASSIC PLANTS IN JAPAN.
PART 8. SUPPLEMENTARY DESCRIPTION AND CONCLUDING REMARKS*

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Abstract. This is the last (8th) of our serial papers. It deals with the supplementary description of newly obtained fossil plants and gives concluding remarks on the Early Jurassic plants in Japan. Based on the floristic composition, we recognized the Kuruma-type and Nishinakayama-type floras in late Early Jurassic time in Japan. The Nishinakayama-type flora is unique and exotic and there is no comparable flora in Eurasia. The Kuruma-type flora in Japan is similar in the floristic composition to coeval or nearly coeval floras in South China. In addition, we briefly reviewed Early Jurassic floras in Eurasia from a paleophytogeographical point of view. The taxa described in this paper are *Gleichenites* ? sp. A, *Phlebopteris* sp. A, *Dictyophyllum kotakiense* Kimura et Tsujii, *Sphenopteris* sp. H, *Ptilophyllum shinadaniense* Kimura et Tsujii, *P.* sp. cf. *P. hsiangshanense* Wu, *P.* sp. A, *Pterophyllum* ? sp., *Pseudoctenis nipponica* Kimura et Tsujii and *Nilssonia* sp. B from the Kuruma Group, and *Sphenopteris* sp. G, *Otozamites* sp. C and *Pseudoctenis* ? sp. from the Nishinakayama Formation.

Foreword

This is the last (8th) of our serial papers devoted to the Early Jurassic plants in Japan. It deals with the supplementary description of fossil plants newly obtained from the Shinadani and Negoya Formations, Kuruma Group and the Nishinakayama Formation, Toyora Group. Our concluding remarks regarding the late Early Jurassic floras in Japan and comparison of them with those of other regions of Eurasia are included.

Table 1 shows the stratigraphical sequence of Jurassic and Lower Cretaceous strata in Japan and their correlation between different sedimentary basins. The Mizukamidani Formation, the uppermost unit of the Kuruma Group overlies conformably the marine Otakidani Formation (Kobayashi *et al.*, 1957; Goto, 1983) and has been thought to be barren of fossils. Recently, Goto (1983, 1986) found the sterile leaves of *Onychiopsis elongata* (Geyler) Yokoyama (identification made by Kimura), with uncertain affinity, from the Mizukamidani Formation. The first occurrence of *Onychiopsis* which is an important element of younger Mesozoic floras in Japan, has been recognized in the lower part of the Middle Jurassic Utano Formation bearing younger Mesozoic-type plants, and these *Onychiopsis*-bearing formations overlie conformably both the Nishinakayama Formation (Kimura *et al.*, 1986; Kimura and Ohana, 1987a, b) and Otakidani Formation, respectively. Therefore, the stratigraphical boundary between the older and younger Mesozoic floras in Japan is considered to lie between the Shinadani and Mizukamidani Formations in the Hida Massif

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*Received May 8, 1987; revised manuscript accepted August 1, 1988

Table 1. Jurassic and Early Cretaceous plant-bearing formations in Japan. Formations or groups of marine origin are marked in italics; all others of non-marine origin. Asterisks denote plant-bearing formation or group. See text for p–q. Thick solid line (r–s) indicates the boundary between the Inner and Outer Zone floras ranging in age from Late Jurassic to Early Cretaceous.

Geological age			Toyora District		Inner Zone of Japan							r Outer Zone of Japan						
					Okayama Pref.	Hida Massif					Joetsu District	Southern Kitakami Massif				Soma District		SW-Japan
Early Cretaceous	K_1^3	Albian	Kanmon G.	Shimonoseki F.		Tetori SG.	Itoshiro G.	Kitadani F.*					*Choshi G.* (K_1^1-K_1^3), Sebayashi F. (K_1^3), *Todai F.* (K_1^2), Yuasa, *Arida* and Nishihiro F. (K_1^1-K_1^3), Tatsukawa, *Hanoura* and Hoji F. (K_1^1-K_1^3), Ryoseki and *Yunoki F.* (K_1^1-K_1^3), Kawaguchi (K_1^1), and *Yatsushiro F.* (K_1^3)					
		Aptian									?							
	K_1^2	Barremian		Wakino F.				Akaiwa F.*			Tokurazawa F.*							
		Hauterivian																
		Valanginian						Oguchi F.*			?				*Ayukawa F.**			
	K_1^1	Berriasian		*Yoshimo F.* Kiyosue F.*								Shishiori G.	*Isokusa F.*			Somanakamura G.	*Koyamada F.*	
Jurassic		Tithonian		?									*Kogoshio F.**				Tomizawa F.*	*Torinosu G.*
		Kimmeridgian												Ojika G.	*Oginohama F.**		*Nakanosawa F.*	
		Oxfordian		?			*Kuzuryu G.**						*Moné F.**				Tochikubo F.* ?	
		Callovian	Toyora G.										Ishiwaritoge F.				*Yamagami F.*	s
		Bathonian		*Utano F.**											*Tsukinoura F.*		*Awazu F.*	
		Bajocian					?										*Hatsuno F.*	
		Aalenian			?				Kuruma G.	Mizukamidani F.	?	*Shizugawa G.**						
		Toarcian		p *Nishinakayama F.**	*Yamaoku F.**					*Otakidani F.* *Shinadani F.**	*Iwamuro F.**		q					
		Pliensbachian		?	?					*Teradani F.* *Negoya F.**	?							
		Sinemurian		*Higashinagano F.**						*Kitamatadani F.*								
		Hettangian								Jogodani F.								

(roughly late Toarcian-early Aalenian time as indicated by a broken line p-q in Table 1). The occurrence of other plant-taxa is likely to be made from the Mizukamidani Formation in future studies.

Thus, the Kuruma and Toyora Groups represent a very important part of the geologic sequence to know the chronological change of fossil plants during Early Jurassic–early Middle Jurassic times.

Few fossil plants known from the Shizugawa Group and the Higashinagano Formation of the Toyora Group are not worthy of our further discussion.

Supplementary description

Fossil plants from the Kuruma Group

Filicales

Gleicheniaceae

Genus *Gleichenites* Seward, 1926

Gleichenites ? sp. A

Figures 3a–b, 18a–b

Material: SHI-129 and 17 other specimens. *Horizon*: Shinadani Formation.

Locality and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); rather rare.

Description: Many fertile penultimate pinnae detached possibly from two large tripinnate leaves are obtained. No whole leaf is known. Main axis, although not in organic connection, is thick, and is 2 cm wide. Penultimate pinnae preserved are more than 12 cm long and 8 cm wide, possibly lanceolate in form, with thick axis, up to 3 mm wide. Ultimate pinnae are closely or sometimes rather remotely set, elongate-triangular in outline, typically 3 cm long and up to 6 mm wide near the base, attached alternately to the penultimate pinna axis at a right angle, but at a wider angle distally. They are sometimes falcate, typically sending off 27 katadromic pairs of pinnules at a wide angle. Pinnules are regularly segmented, set closely, rectangular or triangular in form with rounded or obtusely pointed apex, attached to the pinna axis by the whole base, typically 2.5 cm long and up to 1.5 mm wide. Midnerve is distinct, persisting to the tip; laterals are invisible. Sori (?) are superficial, circular in form, about 0.3 mm in diameter; 7 pairs of them are arranged on both sides of the midnerve. Details of sori (?) are unknown because of their poor preservation.

Remarks: These leaves are characterized by having small-sized pinnules with circular sori (?) which are arranged regularly on both sides of midnerve. Owing to the poor preservation of sori (?), we could not establish precisely the generic affinity of our leaf. However, our leaves remind us of the gleicheniaceous plant because of their thick main and penultimate pinna axes and perpendicularly disposed ultimate pinnae. Therefore, we identified provisionally them as *Gleichenites* ? sp. A.

Gleichenites ? sp. described by Kimura and Ohana (1987a) from the Nishinakayama Formation (Loc. no. 068) differs from the present *Gleichenites* ? sp. A in having semi-circular pinnules. It is unfortunate that the botanical affinity of such finely preserved leaves can not be established more precisely.

Matoniaceae

Genus *Phlebopteris* Brongniart, 1836

Phlebopteris sp. A

Figures 1a–g, 10a–e

Phlebopteris sp. A: Kimura and Tsujii, 1981, p. 187, pl. 30, fig. 1; text-figs. 1a–b.

Additional material: SHI-072 and 41 other specimens. *Horizon*: Shinadani Formation. *Locality* and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); locally common, but fragmental.

Description: Kimura and Tsujii (1981) described *Phlebopteris* sp. A on the basis of four pinna fragments from the Negoya Formation. Subsequently, Tsujii collected many additional specimens from the Shinadani Formation. The main rachises are mostly 1 cm wide, sending off terminally two short arms. In the specimen shown in Fig. 10b (or Fig. 1a), a basal arm sends off sterile pinnae of which four are preserved; they are more than 8 cm long; pinna axis is 2 mm thick with a broad median ridge, and sends off alternately disposed pinnules laterally, mostly at a right angle to the axis. Sterile pinnules are closely set, but not in contact laterally; adjacent pinnules are connected by a distinctive web, 1–2 mm wide. Sterile pinnules are 0.5–0.75 cm wide near the base and more than 2.5 cm long at the middle of pinna. They become shorter, triangular or semi-circular near the base of pinna. Midnerve is distinct both in sterile and fertile pinnules; in sterile pinnules, it gives off laterals forking at once forward and backward branches which join those of adjacent branches to form primary arches (or meshes). The primary arches are usually wider than height, never including any branch veins. The primary arches send off one or two branch veins to form secondary arches on the acroscopic side, and successively to form third arches in a similar way on the basiscopic side. Arches (or meshes) become smaller in size and irregular in form toward the margin of pinnules. Each final arch sends off one or two outer veins running nearly transversely to the margins. These outer veins are simple or occasionally forking once. Secondary and third arches (or meshes) are often invisible. Basal web connecting adjacent pinnules contains a few forward and backward running veins close to the pinna axis.

Fertile pinnae send off long and narrow pinnules alternately and remotely, more than 2.2 cm long and 2.5 mm wide as shown in Figs. 1f–g. Lateral veins of fertile pinnules are indistinct and details of fructification are invisible.

Remarks: Although many additional fertile specimens were obtained, we could not clearly determine their reproductive character. However, it is certain that our *Phlebopteris* sp. A is distinguishable in its venation of sterile pinnules from *P. polypodioides* Brongniart, *P. woodwardi* Leckenby and *P. dunkeri* (Schenk) Schenk redescribed in detail by Harris (1961) on the basis of the Yorkshire material.

Harris (1961, 1980) discussed the systematic position of *Phlebopteris* (*Laccopteris*), *Matonidium* and *Matonia* mainly on the basis of their reproductive organs. So far as the venation of our sterile pinnule is concerned, there is little possibility that our leaves belong to *Matonia*.

Dipteridaceae

Genus *Dictyophyllum* Lindley et Hutton, 1834
Dictyophyllum kotakiense Kimura et Tsujii

Figure 11

Dictyophyllum kotakiense Kimura et Tsujii: Kimura and Tsujii, 1981, p. 192, pl. 30, figs. 9–11; text-figs. 4a–g.

Additional material: SHI-056 and 12 other specimens. *Horizon*: Shinadani Formation. *Locality* and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); locally common.

Remarks: Many additional sterile leaf-fragments were obtained from the Shinadani Formation. Of these specimens, a small-sized leaf referable to this species is illustrated here.

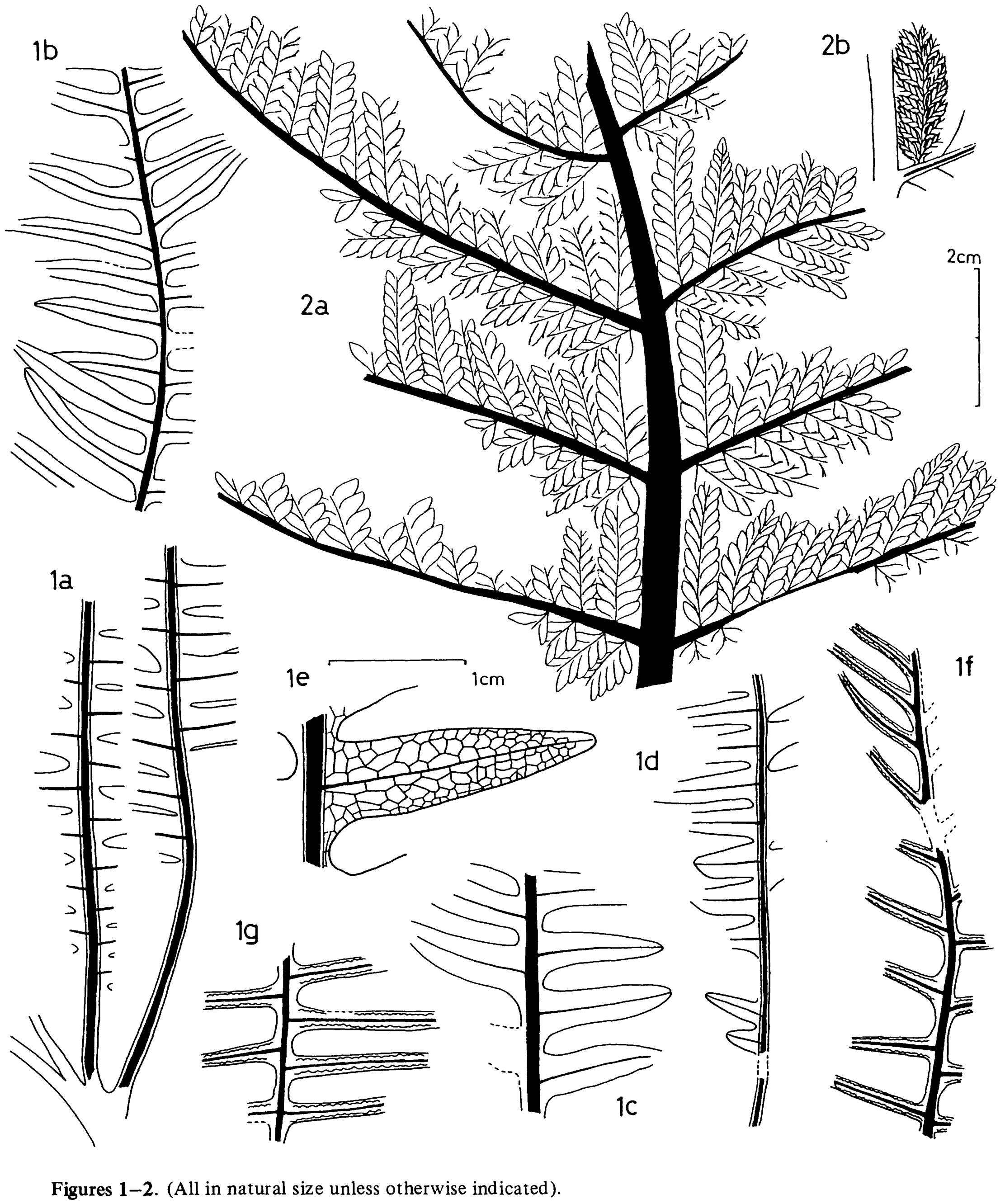
Unclassified fern

Form-genus *Sphenopteris* Sternberg, 1825
Sphenopteris sp. H

Figures 2a–b

Material: SHI-178, 180, 201, 205. *Horizon*: Shinadani Formation. *Locality* and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); rare.

Description: A large leaf-fragment and several small leaf-fragments were obtained. Leaf is possibly tripinnate. Main rachis is 5 mm wide at the preserved base, sending off penultimate pinnae suboppositely at intervals of 2.3 cm and at an angle of 70 degrees; they are all incomplete, more than 8 cm long, laterally overlapping with each other. Ultimate pinnae are set closely, more than 15 katadromic pairs on a thick penultimate pinna axis at an angle of 50 degrees. Acroscopic basal pinna is longer than others and is arranged at a wide angle to the penultimate pinna axis. Typical pinnae are elongate-triangular in form, 2 cm long and up to 0.5 cm wide, and send off 9 pairs of pinnules at an angle of about 30 degrees.

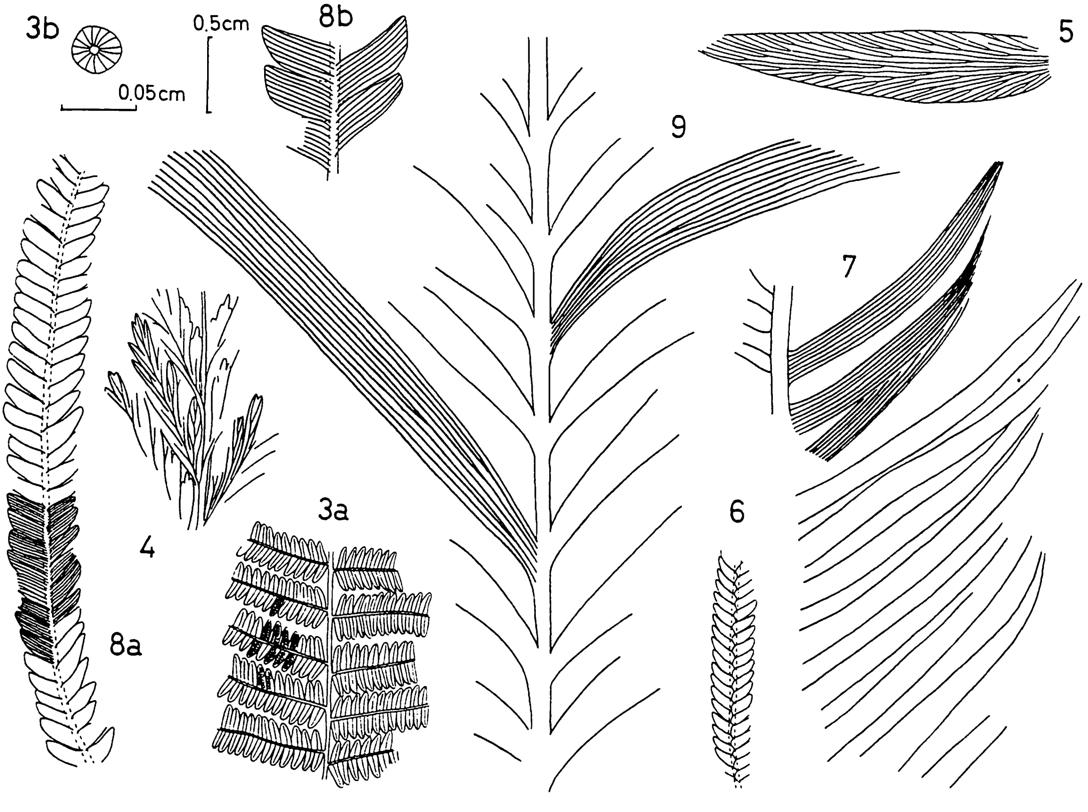


Figures 1–2. (All in natural size unless otherwise indicated).
1a-g. *Phlebopteris* sp. A. **1a-d**; sterile pinnae. **1e**; enlarged from **1c** to show the venation. **1f-g**; fertile pinnae (all drawn from SHI-072).
2a-b. *Sphenopteris* sp. H. **2a**; a large-sized sterile leaf (drawn roughly from SHI-178). **2b**; drawn partly from **2a** to show a detailed form of pinnules and venation.

Pinnules are closely set to the very slender pinna axis, rhomboidal in form, typically 4 mm long and 2 mm wide; laminae are often contiguous with each other. Margins are shallowly serrated in the proximal pinnules, but entire in the apical ones; serration is directed forward, typically 4 pairs and with obtusely pointed apex. Venation is rather of the *Sphenopteris*-type; midnerve persists to the tip, sending off katadromically simple laterals at a narrow angle; each serration receives a simple lateral vein. No pinnule is found on the main rachis between adjacent penultimate pinnae or on the penultimate pinna axis between adjacent ultimate pinnae.

Remarks: The present leaf is characterized by its large size with thick main and penultimate pinna axes and with very thin pinna axis, by the acroscopic basal pinnae at a wide angle to the penultimate pinna axis, and by the rhomboidal pinnules with a small number of simple lateral veins.

It is highly probable that the present leaf is specifically distinct, but, because of its poor preservation, we refrain from giving it a new specific name other than classifying it as *Sphenopteris* sp. H.



Figures 3–9. (All in natural size unless otherwise indicated).

3a–b. *Gleichenites* ? sp. A. **3a**; a fertile leaf-fragment (drawn from SHI-172). **3b**; a sorus (?) enlarged (drawn from SHI-172).

4. *Sphenopteris* sp. G; a broken fern-like penultimate pinna (drawn from NI-G1).

5. *Pseudoctenis* ? sp.; a single detached pinna (drawn from NI-1006).

6. *Otozamites* sp. C; a leaf-fragment (drawn from NI-1001).

7. *Pterophyllum* ? sp.; drawn from NNW-869.

8a–b. *Ptilophyllum* sp. cf. *P. hsiangshanense* Wu. **8a**; a leaf-fragment (drawn from NNW-878). **8b**; partly enlarged from 8a to show the venation.

9. *Pseudoctenis nipponica* Kimura et Tsujii; drawn from SHI-133.

Unfortunately, we could not photographically illustrate the present leaves, because they were preserved as faint impression on the bedding plane of black shale.

Bennettitales

Genus *Ptilophyllum* Morris, 1840

Ptilophyllum shinadaniense Kimura et Tsujii

Figures 19a–c

Ptilophyllum shinadaniense Kimura et Tsujii: Kimura and Tsujii, 1982, p. 270, pl. 41, figs. 5–6; text-figs. 7a–c.

Additional material: SHI-080 and 12 other specimens. *Horizon*: Shinadani Formation. *Locality* and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); locally common.

Additional description: Leaf is fairly long, more than 16.5 cm long, elongate-lanceolate (or narrowly lanceolate) in outline, up to 4 cm wide, bearing more than 56 alternate pairs of pinnae (Fig. 19c).

Remarks: Kimura and Tsujii (1982) established this species on the basis of three leaf-fragments from the Shinadani Formation. Recently, Tsujii collected many additional specimens referable to this species. The occurrence of this species is therefore no longer as rare as formerly stated and can be common locally. Based upon those newly obtained leaves, the leaf-size (width) ranges from 1 cm to 4 cm at their widest portion and the pinna-size ranges from 1.2 cm x 2 mm to 2.5 cm x 3–4 mm.

Ptilophyllum sp. cf. *P. hsiangshanense* Wu

Figures 8a–b, 13

Comparable specimens: *Ptilophyllum hsiangshanense* Wu: Wu *et al.*, 1980, p. 103, pl. 15, figs. 3–5; pl. 16, fig. 1; pl. 19, figs. 9–10a; pl. 20, fig. 7; pl. 21, figs. 5–6.

Material: NNW-878, 879. *Horizon*: Negoya Formation. *Locality* and *occurrence*: Nishineiridani (see Kimura and Tsujii, 1980a); rare.

Description: Leaf so far as preserved, it is 7.8 cm long, nearly parallel-sided for the most part, with comparatively thick rachis, 1 mm wide, sending off 32 alternate pairs of pinnae at an angle of about 50–60 degrees. Pinnae are attached to the upper edges of rachis, rectangular or triangular in form, with truncate, obliquely truncate or obtusely pointed apex; typically 0.65 cm long and up to 3 mm wide near the base; basal margins are straight and not decurrent, but acroscopic basal margin is sometimes slightly contracted. Veins originate from the pinna base, five to seven in number, arranged in parallel and end at the distal margin; they are mostly simple, but an occasional one is once forked. Cuticle is not preserved.

Remarks: Kimura and Tsujii (1982) described *Ptilophyllum* sp. cf. *P. cutchense* Morris, *P. nipponicum* Kimura et Tsujii, *P.* sp. B from the Negoya and Iwamuro Formations and *P. shinadaniense* Kimura et Tsujii and *P.* sp. A from the Shinadani Formation. The present leaf does not agree with any of them in its pinna form and size. Among these forms, *Ptilophyllum* sp. B is most close to the present leaf, but is distinguished by its pinnae with an obtusely pointed or broadly rounded apex and with from five to nine veins.

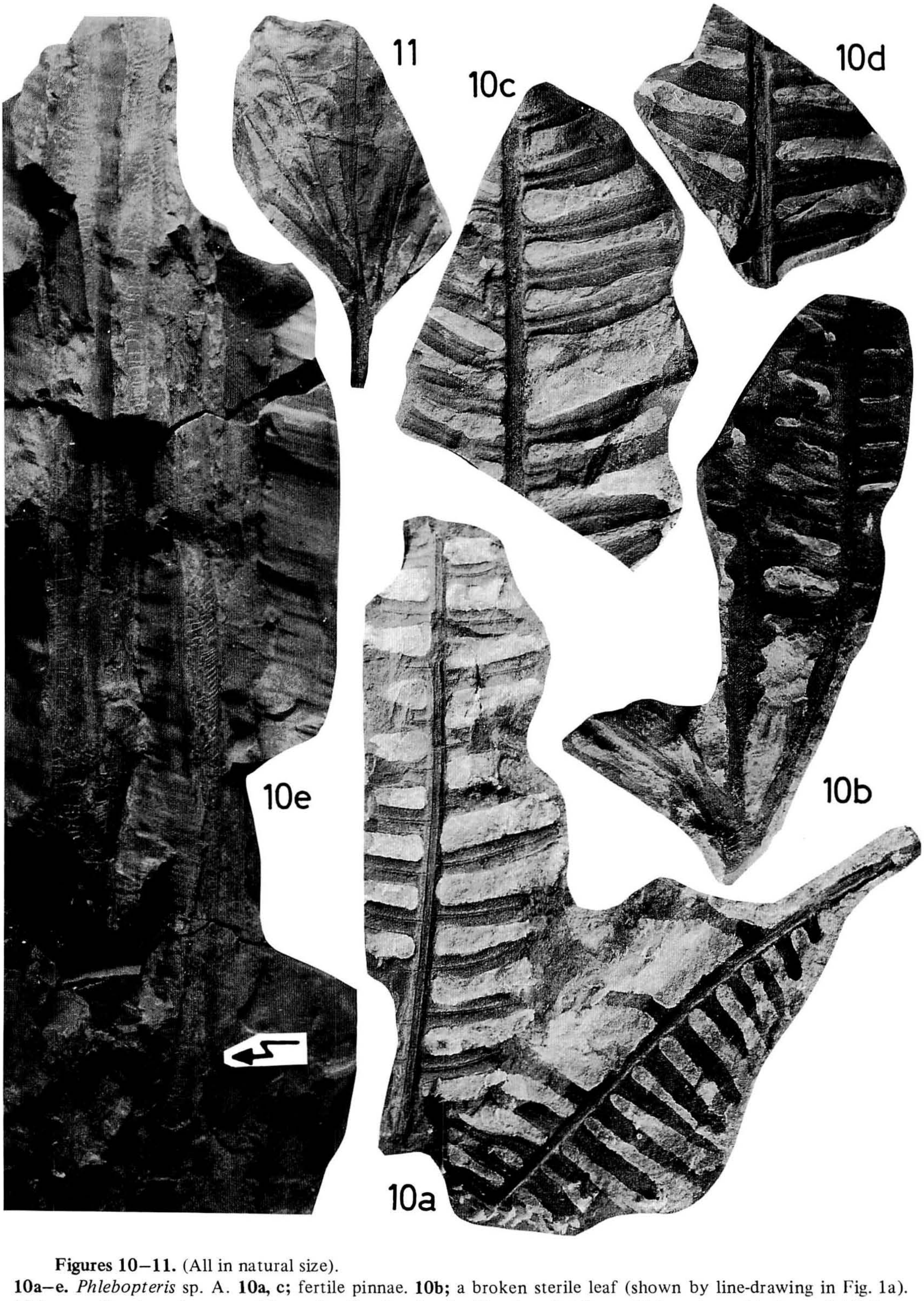
Our leaf resembles those small-sized leaves of *Ptilophyllum hsiangshanense* originally described by Wu (in Wu *et al.*, 1980) from the Lower-Middle Jurassic Xiangxi Formation, Western Hubei, China, in its pinna form, size and venation. Because we have only a single leaf fragment, we refrain from making a full identity of our leaf to the Chinese species and name it simply *Ptilophyllum* sp. cf. *P. hsiangshanense.*

Ptilophyllum sp. A

Ptilophyllum sp. A: Kimura and Tsujii, 1982, p. 271, pl. 43, fig. 11; text-figs. 8, 8'.

Additional material: SHI-055 and 3 other specimens. *Horizon*: Shinadani Formation. *Locality* and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); rare.

Remarks: Kimura and Tsujii (1982) described



Figures 10–11. (All in natural size).
10a–e. *Phlebopteris* sp. A. **10a, c;** fertile pinnae. **10b;** a broken sterile leaf (shown by line-drawing in Fig. 1a). **10d;** a sterile pinna fragment (shown by line-drawing in Figs. 1c, e). **10e;** a thick main rachis (arrow) (all from SHI-072).
11. *Dictyophyllum kotakiense* Kimura et Tsujii; a small-sized leaf (SHI-056).

Ptilophyllum sp. A on the basis of a single specimen obtained from the Shinadani Formation. Recently, Tsujii collected four additional leaf-fragments referable to *Ptilophyllum* sp. A, but at present no addition is needed to the original description.

Genus *Pterophyllum* Brongniart, 1828

Pterophyllum ? sp.

Figures 7, 15a–b

Material: NNW-868 (869; counter part). *Horizon*: Negoya Formation. *Locality* and *occurrence*: Nishineiridani (see Kimura and Tsujii, 1980a); rare.

Description: A single leaf-fragment was obtained. Its rachis is comparatively thick, 3.5 mm wide. Pinnae are long and narrow, linear, 5 cm long and 4 mm wide, gradually narrowing toward the acuminate apex, often falcate, rather remotely set with a gap about 2–3 mm wide, and attached oppositely or suboppositely to the lateral sides of rachis by the whole base at an angle of about 55 degrees. Pinna base is slightly expanded but not contracted near the base. Six veins are originated at the base of pinna, simple, parallel and end at the distal margin, but not converging at apex. Cuticle is not preserved.

Remarks: The present leaf differs from those of *Pseudoctenis nipponica* Kimura et Tsujii known from the Negoya and Iwamuro Formations in that the pinnae of *P. nipponica* become generally narrower toward the base, often contracted near the base and sometimes markedly expanded at the base.

Some leaves of *Tyrmia latior* described by Ye (in Wu *et al.*, 1980) from the Xiangxi Formation, Western Hubei, China, resemble in form our leaf, but is distinct by their shorter pinnae.

The leaves of *Pterophyllum firmifolium* described by Ye (in Wu *et al.*, 1980) and *P. decurrens* by Sze (1949) also from the Xiangxi Formation are most close to our leaf in general aspect, but we refrain from making the generic and specific identity of our inadequately preserved leaf with either of them. Thus, we describe our leaf simply as *Pterophyllum* ? sp.

Cycadales

Genus *Pseudoctenis* Seward, 1911

Pseudoctenis nipponica Kimura et Tsujii

Figures 9, 16a–b

Pseudoctenis nipponica Kimura et Tsujii: Kimura and Tsujii, 1983, p. 36, pl. 12, figs. 2–3; pl. 13, figs. 2–4; pl. 14, fig. 1; text-figs. 2a–d.

Additional material: SHI-133 and 3 other specimens. *Horizon*: Shinadani Formation. *Locality* and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); rather rare.

Remarks: Several leaf-fragments were obtained first from the Shinadani Formation. They are referable to those originally described by Kimura and Tsujii (1983) as *Pseudoctenis nipponica* from the Nagoya and Iwamuro Formations. Fig. 9 (drawn from Fig. 16b) shows a leaf-fragment bearing seven remotely set pairs of pinnae; each with a small number of veins (5-6 in number at base), forking near the base in the manner as shown in text-fig. 2b (Kimura and Tsujii, 1983).

Genus *Nilssonia* Brongniart, 1825

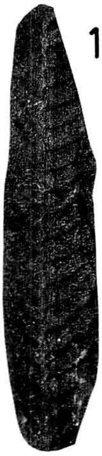
Nilssonia sp. B

Figures 17a–c, 20

Nilssonia sp. B: Kimura and Tsujii, 1983, text-figs. 7a–b.

Additional material: SHI-054 and 11 other specimens. *Horizon*: Shinadani Formation. *Locality* and *occurrence*: Shinadani (see Kimura and Tsujii, 1980a); locally common.

Remarks: Kimura and Tsujii (1983) described *Nilssonia* sp. B on the basis of two leaf-fragments. Recently, Tsujii collected many additional leaf-fragments referable to *Nilssonia* sp. B. According to these newly obtained specimens, the leaf-width ranges from 1 to 2.5 cm. *Nilssonia* sp. B is not as rare as formerly mentioned, but can be common locally.


14


16a

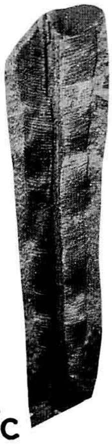

15b


13


12


15a


16b


17c


17b


17a

Fossil plants from the Nishinakayama Formation

Form-genus *Sphenopteris* Sternberg, 1825

Sphenopteris sp. G

Figure 4

Material: NI-G1 (collected by H. Ishida). *Locality* and *occurrence*: Ishimachi (Loc. no. 062; see Kimura *et al.*, 1986); very rare.

Description: A single, fern-like, penultimate pinna was obtained. In this specimen, only 6 broken ultimate pinnae are preserved. The specimen was discovered together with an ammonite fossil. Ultimate pinnae are closely set, overlapping with each other laterally, lanceolate in form, 1.25 cm long and up to 0.25 mm wide, attached to the axis at an angle of 30 degrees, and send off 4 or 5 pairs of pinnules anadromically. Pinnules are lanceolate or oblanceolate in form, directed forward, typically 5 mm long and up to 1 mm wide; margins are entire or shallowly lobed once near the apex or rarely twice; apices of pinnules and lobes are obtusely pointed. A single vein originates from the base of pinnule, forking sympodially twice or in some instances up to four times; each lobe receives a single vein.

Remarks: The present fern-like leaf-fragment is characterized by its small-sized and anadromically dissected pinnules with the *Sphenopteris*-type venation. Kimura and Ohana (1987a) described in detail six types of fern-like leaves with the *Sphenopteris*-type venation from the Middle Jurassic Utano Formation on the south side of the Tabe Fault. Among these six types, *Sphenopteris* sp. B is common to both Nishinakayama and Utano Formations. However, none of them agree in general morphology with the present leaf-fragment. Thus, we provisionally identify the present leaf-fragment as *Sphenopteris* sp. G.

The present leaf-fragment has been thought to have no paleobotanical value, but we endeavour to describe even such a poorly preserved specimen, because fossil plants, especially ferns or fern-like plants, rarely occur in the Nishinakayama Formation.

Bennettitales

Genus *Otozamites* Braun, 1842

Otozamites sp. C

Figures 6, 14

Material: NI-1001 (collected by T. Fukutomi). *Locality* and *occurrence*: Ishimachi (Loc no. 062; see Kimura *et al.*, 1986); very rare.

Description: A single bennettitalean leaf-fragment was obtained. It is more than 3 cm long and up to 5.5 mm wide and nearly parallel-sided for the most part; rachis is comparatively thick and sends off closely and alternately disposed small-sized pinnae from its upper surface. Pinnae are subulate or rectangular in form, typically 3.5 mm long and up to 1 mm wide, abruptly narrowed toward the obtusely pointed apex; pinna base is asymmetrical, not decurrent; acroscopic basal angle is moderately developed; basiscopic basal angle is usually concealed by the acroscopic basal angle of opposite pinna. Veins are invisible. Cuticle is not preserved.

Remarks: Judging from the general habit of the present leaf, it is highly probable that our leaf belongs to *Otozamites* or *Ptilophyllum*. At present, we prefer to assign it to *Otozamites*, because of its moderately developed acroscopic basal angle of pinnae.

Kimura *et al.* (1986) described three types of *Otozamites* leaves from the Nishinakayama

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← **Figures 12–17.** (All in natural size unless otherwise indicated).

12. *Pseudoctenis* ? sp.; detail is shown in Fig. 5 (NI-1006).

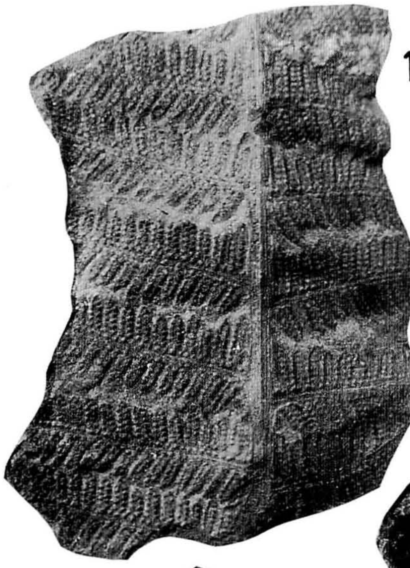
13. *Ptilophyllum* sp. cf. *P. hsiangshanense* Wu; enlarged twice (NNW-879).

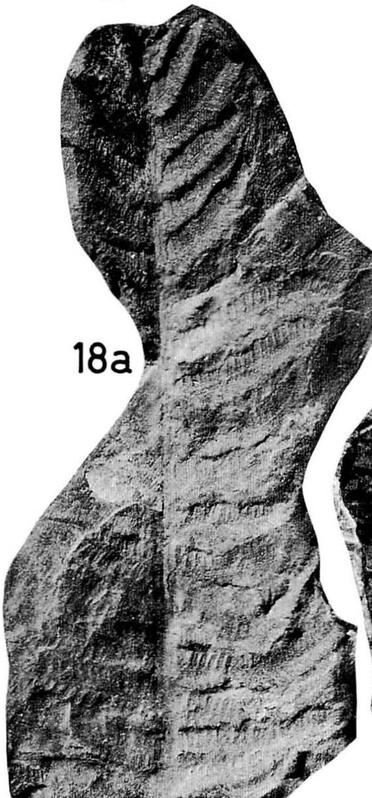
14. *Otozamites* sp. C; detail is shown in Fig. 6, but veins are indistinct (NI-1001).

15a–b. *Pterophyllum* ? sp. **15a**; (NNW-868). **15b**; detail is shown in Fig. 7 (NNW-869).

16a–b. *Pseudoctenis nipponica* Kimura et Tsujii. **16b**; detail is shown in Fig. 9 (all from SHI-133).

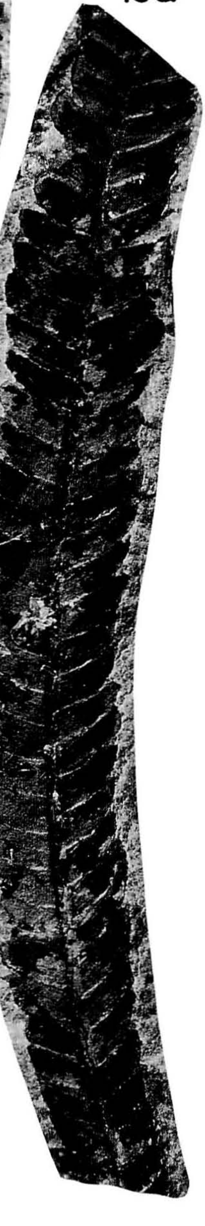
17a–c. *Nilssonia* sp. B; leaves of varied size (SHI-054).


18b


18a


19c


20


19a


19b

Formation. Among these, the present leaf resembles those of *Otozamites micropinnatus* in its small-sized leaf, but is distinguished by its shorter pinnae.

The detailed comparison of such small-sized *Otozamites* leaves was made by Kimura *et al.* (1986). However, we refrain from making a specific identity of our present leaf specimen and call it simply *Otozamites* sp. C, because our leaf is not complete to establish its taxonomic identification.

Cycadales

Genus *Pseudoctenis* Seward, 1911

Pseudoctenis ? sp.

Figures 5, 12

Material: NI-1006. *Locality* and *occurrence*: Ishimachi (Loc. no. 064A; see Kimura *et al.*, 1986); very rare.

Description: A single detached pinna was obtained. It has the following features: Lanceolate in form, more than 4.7 cm long and up to 9 mm wide, apex missing and base contracted; 9 or 10 veins originating at the base, then repeatedly forked dichotomously, radiating and ending at all the margin except for a few median ones which run straight for the most part, then radiating near the apex. Cuticle is not preserved.

Remarks: It is quite difficult to determine specific and even generic attribution of our detached pinna. However, our pinna resembles externally those of *Pseudoctenis oleosa* described originally by Harris (1949) from the Middle Jurassic of Yorkshire, but its venation is fairly different from those of the latter.

So far as we know, no pinnae comparable with ours have been recorded. Therefore, we provisionally identify our pinna as *Pseudoctenis*? sp.

Concluding remarks

Table 2 shows the list and occurrence of fossil plant-taxa described from the Kuruma Group including the Shinadani and Negoya Formations, Alternating beds of sandstone and shale (Kr_2), Plant-bearing beds in the Kotaki Coal-Field, Iwamuro Formation (Kimura and Tsujii, 1980a, b, 1981, 1982, 1983, 1984 and the present paper) and the Nishinakayama Formation (Kimura *et al.*, 1986; Kimura and Ohana, 1987a, b and the present paper).

A glance of Table 2 easily suggests that there were two distinct floras in the late Liassic time in Japan, the Kuruma-type and Nishinakayama-type floras. No species common to both floras has so far been described.

1. Characteristic of the Kuruma-type flora.

This type of flora has been known from the Kuruma Group and the Iwamuro and Yamaoku Formations and its characteristic includes the following:

Equisetales: *Equisetites* is varied and abundant, but *Neocalamites* is only represented by a single form.

Ferns: 1) Such osmundaceous ferns as *Todites* are varied and abundant, 2) *Phlebopteris* (Matoniaceae) leaves are abundant, especially in the Shinadani Formation, 3) two types of dicksoniaceous ferns and four types of dipteridaceous ferns, such as *Clathropteris, Dictyophyllum, Thaumatopteris* and *Hausmannia* are present, but they are rather rare except for *Dictyophyllum,* 4) *Cladophlebis* leaves with uncertain affinity are varied and abundant, and they are accompanied by a rare presence of two types of fern leaves with the *Sphenopteris*-type venation.

Pteridospermales: Only a single species of *Ctenozamites* is represented.

Bennettitales: Two types of both *Otozamites*

←— **Figures 18–20.** (All in natural size unless otherwise indicated).

18a–b. *Gleichenites* ? sp. A. **18b;** detail is shown in Fig. 3a (all from SHI-129).

19a–c. *Ptilophyllum shinadaniense* Kimura et Tsujii. **19a;** enlarged twice from Fig. 19b (SHI-080). **19c;** a large-sized leaf (SHI-080).

20. *Nilssonia* sp. B; a larger leaf (SHI-054).

Table 2. List of fossil plants of the Kuruma-type and Nishinakayama-type floras (late Liassic) in Japan. Their abundances are indicated: VA; very abundant, LA; locally abundant, A; abundant, C; common, LC; locally common, RR; rather rare, R; rare, VR; very rare.

Formations / Taxa described	Kuruma Group (s. l.)					Toyora G.
	Shinadani F.	Negoya F.	Kr$_2$	(Kotaki)	Iwamuro F.	Nishi-nakayama F.
Equisetites iwamuroensis Kimura			LA		LA	
E. mori-gunpeii Kimura et Tsujii	LA					
E. nipponicus Kimura et Tsujii		LA		RR		
E. sp. A		RR				
E. sp. B	R					
E. sp. C	R					
Neocalamites sp. A			LA	LA	LA	
Marattia asiatica (Kawasaki) Harris		LA	R	R	R	
Todites sp. cf. *T. denticulatus* (Brongniart) Krasser	R	A	A	R	A	
T. fastuosus (Kimura) Kimura et Tstujii	RR	VA			VA	
T. neiridaniensis Kimura et Tsujii		LA			R	
Osmundopsis nipponica Kimura et Tsujii		RR				
Gleichenites ? sp. A	RR					
G. ? sp.						R
Phlebopteris sp. A	LC	RR				
Ph. sp.						R
Coniopteris neiridaniensis Kimura et Tsujii		RR				
C. sp. A	R					
Clathropteris meniscoides Brongniart	RR	RR	R		R	
Dictyophyllum kotakiense Kimura et Tsujii	LC	C		R		
Thaumatopteris elongata Oishi		R	R		RR	
Hausmannia (Protorhipis) sp. A					VR	
Cladophlebis sp. cf. · *Asterotheca okafujii* Kimura et Ohana	R	C	R		R	
C. sp. cf. *Todites fukutomii* Kimura et Ohana	VR	R				
C. sp. cf. *T. yamanoiensis* (Yokoyama) Kimura et Ohana		RR		R	R	
C. kurumensis Kimura et Tsujii	R	R	R		VR	
C. pseudodelicatula Oishi		RR			RR	
C. raciborskii Zeiller	R	RR	RR	R	RR	
C. sp. A					VR	
C. sp. B					VR	
C. sp. C	VR					
Sphenopteris sp. A		RR				
S. sp. B						VR
S. sp. G						VR
S. sp. H	R					
Ctenozamites sarrani (Zeiller) Harris		VR				
C. ? sp.						VR
Anomozamites sp. A					VR	

and *Pterophyllum* and six types of *Ptilophyllum* are present and some of them are abundant; *Zamites* leaves have not been found.

Cycadales: Both *Ctenis* and *Pseudoctenis* are represented by a single species. *Nilssonia* is varied and abundant.

Unclassified cycadophyte: Represented by *Cycadites* only, but it is very rare.

Ginkgoales: Five types of leaves are represented, some are common.

Czekanowskiales: Both *Czekanowskia* and *Phoenicopsis* are represented by a single species.

Coniferales: *Elatocladus, Storgaardia* and four types of *Podozamites* are represented; all are rare except for *Podozamites* ex gr. *distans.* A single cone-scale of *Swedenborgia* is known. No conifer with scale-like leaves has been known except for indeterminable shoots with minor scale-like leaves arranged spirally on the axis as those of extant *Widdringtonia.*

Unclassified plants: Six types of *Taeniopteris* are represented. In addition to the above, some

Formations / Taxa described	Kuruma Group (s. l.)					Toyora G.
	Shinadani F.	Negoya F.	Kr_2	(Kotaki)	Iwamuro F.	Nishi-nakayama F.
Otozamites fujimotoi Kimura					R	
O. micropinnatus Kimura, Naito et Ohana						R
O. neiridaniensis Kimura et Tsujii	RR	A				
O. sp. A						R
O. sp. B						R
O. sp. C						VR
Pterophyllum ex gr. *propinquum* Goeppert	RR	LA	R	R	RR	
P. sp. A					R	
P. ? sp.		R				
Ptilophyllum nipponicum Kimura et Tsujii		C				
P. shinadaniense Kimura et Tsujii	LC					
P. sp. cf. *P. cutchense* Morris		R				
P. sp. cf. *P. hsiangshanense* Wu		R				
P. sp. A	R					
P. sp. B		VR			R	
Zamites toyoraensis Oishi						R
Z. sp.						R
Ctenis kaneharai Yokoyama	LC	R				
Pseudoctenis nipponica Kimura et Tsujii	RR	LC			LC	
P. sp.						R
Nilssonia japonica Kimura et Tsujii	RR	LA			LA	
N. sp. cf. *N. inouei* Yokoyama		R			R	
N. sp. A		R				
N. sp. B	LC					
N. sp. C		R				
N. sp. D	VR					
N. sp. E		R	VR			
Cycadites sp. cf. *C. saladini* Zeiller		VR				
Ginkgo ex gr. *sibirica* Heer		VR	LC		LC	
Sphenobaiera nipponica Kimura et Tsujii		LC				
S. sp. cf. *S. eurybasis* Sze	VR	R			VR	
S. sp. cf. *S. ophioglossum* Harris et Millington		LC				
Ginkgoidium ? sp. A					VR	
Czekanowskia ex gr. *rigida* Heer	RR		RR		LC	
Phoenicopsis ex gr. *angustifolia* Heer	LC	RR	RR	RR		
Elatocladus sp. A	R					
E. sp. B		VR				
Storgaardia spectabilis Harris		RR				
Podozamites ex gr. *distans* (Presl) Braun	RR	C	RR	RR	C	
P. sp. A					R	
P. sp. B					R	
P. sp. C		R			R	
Swedenborgia sp. A					VR	
Brachyphyllum ex gr. *expansum* (Sternberg) Seward						C
Cupressinocladus sp. A						R
C. sp. B						R

undetermined organs were found. One of these is possibly a vertically crushed bennettitalean gynoecium (*Bennetticarpon* ? sp.).

Obviously, the Kuruma-type flora is a member of the *Dictyophyllum-Clathropteris* floras in East Asia which range in age from the Late Triassic to early Middle Jurassic. It is distinguished, however, from the Late Triassic *Dictyophyllum-Clathropteris* floras known extensively from Japan, Southern Primorye, Northeast China, South China and Southeast Asia by the absence of such Triassic elements as *Lobatannularia, Chiropteris, Anthrophyopsis, Drepanozamites, Podozamites* with very narrow leaves, and *Cycadocarpidium,* and by a small number of taxa of dipteridaceous ferns and *Pterophyllum.*

The Kuruma-type flora is also distinguished from the Middle Jurassic Utano flora, a single

Formations / Taxa described	Kuruma Group (s. l.)					Toyora G.
	Shinadani F.	Negoya F.	Kr_2	(Kotaki)	Iwamuro F.	Nishinakayama F.
Geinitzia sp.						R
Elatides sp.						C
Araucarites sp. cf. *A. cutchense* Feistmantel						LC
Taeniopteris gracilis Kimura					R	
T. sp. cf. *T. jourdyi* Zeiller		LA	R		LA	
T. sp. A		R			R	
T. sp. B					VR	
T. sp. C					R	
T. sp. D		R			VR	

representative of this age in Japan (Kimura and Ohana, 1987a, b) in the floristic composition. The latter is characterized by the presence of such younger Mesozoic elements as *Onychiopsis elongata, Acrostichopteris, Adiantopteris, Zamites* and *Araucarites.*

The Kuruma-type flora also differs from the Middle Jurassic floras in China. The latter is characterized by the presence of varied and abundant dicksoniaceous ferns, varied ginkgoaleans and czekanowskialeans, and by the rarity of dipteridaceous and matoniaceous ferns.

2. Characteristic of the Nishinakayam-type flora.

This type of flora has been known only from the Nishinakayama Formation, Toyora Group. Despite a great deal of effort expanded toward collecting fossil plants from this formation by Gentaro Naito and many others for more than 30 years, taxa known from this formation are not so numerous (Table 2).

The Nishinakayama-type flora is characterized by the following:

1) Plants belonging to Equisetales, Marattiales and Osmundales are not known. 2) Ferns are only represented by *Gleichenites* ? sp., *Phlebopteris* sp., and two forms of *Sphenopteris* with uncertain affinity. Dicksoniaceous and dipteridaceous ferns have not been found at all. 3) Only *Ctenozamites* ? sp. is known in Pteridospermales. 4) Four types of *Otozamites* leaves and two types of *Zamites* leaves are known in Bennettitales. Other bennettitaleans have not so far been found. 5) Only *Pseudoctenis* sp. is known in Cycadales. 6) Ginkgoaleans and czekanowskialeans are not known. 7) Four types of shoots with scale-like leaves, araucarian cone-scales and leafy shoots (*Elatides* sp.) are known in Coniferales. *Podozamites*-shoot has not been found.

So far as we know, there is no flora comparable with the Nishinakayama-type flora in Eurasia. Although the number of the taxa of the Nishinakayama-type flora is not so numerous, we now think that this type of flora might have flourished in the subtropical-tropical region in those of the Jurassic world. This is supported by the presence of Tethys-type ammonites in the Nishinakayama Formation.

3. Comparison of the Kuruma-type flora with the Early Jurassic floras in other regions of Eurasia.

Fig. 21 shows main localities of early and late Liassic and undifferentiated Early Jurassic plants in East Asia drawn by Kimura mainly with reference to Ye and Li (1980, 1982), Zhang (1985) and Vakhrameev (1964). However, it is difficult to date them precisely, because most of these plant-beds are of non-marine origin except for those in Japan and some in South China (Guanyintan and Jinji Formations and Lantang Group).

In Eurasia, we roughly recognized the following five types of Early Jurassic floras: I) Siberian-type, II) Kuruma-type, III) Middle Asian-type, IV) South European-type and V) Nishinakayama-type.

I) The Siberian-type floras are characterized by: 1) the rarity of dipteridaceous ferns, bennettitaleans and cycadaleans, 2) the presence of varied ginkgoaleans and czekanowskialeans, and 3) the absence of *Ptilophyllum, Zamites* and conifers with scale-like leaves.

The following plant-beds (or formations) belong to the Siberian-type (each number in parenthesis corresponds to that shown in Fig. 21): Daxigou (24), Xiaomeigou (25), Yangxia (27), Badaowan and Sangonghe (28), Wudanggou (29), Fuxian (31), Yongdingzhuang and Lower Yaopo (32), Beipiao (33), Yingzi (34), Hongqi (35), Chayihe (36), Changliangzi (37), Yihe (38), Iukhtin (40), Ukugut (41), Nerejaslov (42), Makarov (43), Karaldin, Sartakov and Tersjukov (44), Taisugan (45), Alakul (46), Ashchikul (47) and Maikuduk, Dubov and Sokur (48). Fossil plants from Wensu locality (26) is little known.

In addition to the above, the Early Jurassic Siberian-type floras are known from Turgai, Cheljabinsk and eastern part of the Ural Mountains. These Siberian-type floras are distributed to the north of the X-Y line in Fig. 21. Dipteridaceous ferns are sparsely known in most of these floras. In a Late Triassic time, dipteridaceous ferns are restricted in their distribution to the *Dictyophyllum-Clathropteris* Paleofloristic Province as shown by Kimura (1984a, b, 1985) and Kimura and Kim (1984a, b). Accordingly, it is quite certain that by an Early Jurassic time, some dipteridaceous ferns expanded their distribution northward.

Notwithstanding that the Nansuletu Group (30 in Fig. 21) located far to the north of the X-Y line in Fig. 21, its flora is of the Kuruma-type according to the floristic composition shown by Zhang (1985). This is only a single exceptional case in those floras distributed to the north of the X-Y line in Fig. 21.

II) Characteristics of the Kuruma-type floras in Japan have already been discussed. The flora of the Yamaoku Formation (Konishi, 1954), although it is as yet to be described and illustrated, obviously belongs to the Kuruma-type.

In South China, late Liassic floras of the following plant-beds (or formations) are of the Kuruma-type: Baitianba (21), Xiangxi (20), Wuchang (19), Xiangshan (7) and Majian (9).

The early Liassic Guanyintan flora (Zhou, 1984) is fundamentally of the Kuruma-type, it is characterized by the presence of varied *Otozamites* leaves and *Brachyphyllum* leafy-shoots and by the absence of *Ptilophyllum*.

However, the Guanyintan, Tanglong, Baitianba and Xiangxi floras somewhat resemble coeval floras of South Europe in the presence of conifers with scale-like leaves, such as *Brachyphyllum*. No such conifers with scale-like leaves have been known in the Kuruma-type floras in Japan with only exception of the sparse occurrence of '*Widdringtonia*'-like delicate leafy-shoots (undescribed).

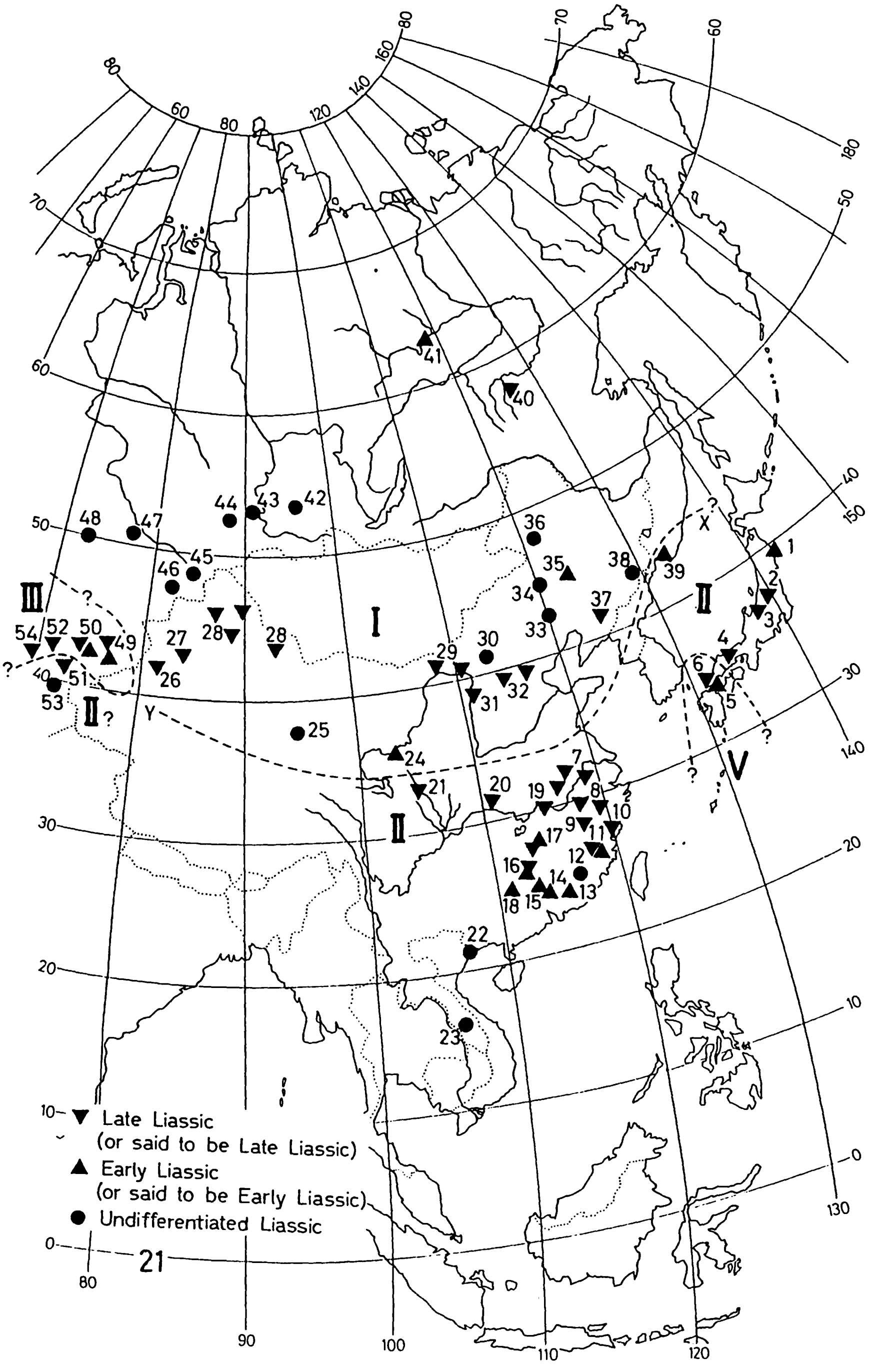
We are of the opinion that the Liassic floras from East Greenland (Harris, 1937) and South Sweden (Lundblad, 1950, 1959) are rather of the Kuruma-type.

III) Middle Asian-type floras are distributed mostly in the mountainous region in Gissar (Hissar) and Fergana (Ferghana) Ranges, southern part of the Ural Mountains and eastern part of the Caspian Sea (including Karatau Range).

Barnard (1973) did not take the presence of this type of floras seriously. However, the Middle Asian-type floras of Early Jurassic age are characterized by: 1) the rarity of dipteridaceous ferns, bennettitaleans, cycadaleans and conifers with scale-like leaves, and 2) the presence of dicksoniaceous ferns, varied ginkgoaleans, and *Ferganiella*.

Although the Early Jurassic Middle Asian-type floras resemble those coeval Siberian-type floras in the rarity of dipteridaceous ferns, bennettitaleans and cycadaleans, they are quite distinct from the latter in the common presence of marattiaceous and matoniaceous ferns which are very rare in the latter. Of these Middle Asian-type floras, however, such floras as from Tuarkyr (West Turkmen; not indicated in Fig. 21) and eastern part of the Fergana Range (51) are rather of the Kuruma-type, because they include varied bennettitaleans and cycadaleans. Therefore, the Middle Asian-type floras will possibly be divided further into two floristic types in future studies.

IV) Those floras from the Lower Jurassic plant-beds intercalated mostly with strata of marine origin in France, Luxemburg, South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Germany, Italy, Hungary and Rumania are characterized by the presence of such pteridosperms as *Thinnfeldia* and conifers with scale-like leaves (cheirolepidiaceous conifers) plus the presence of matoniaceous and dipteridaceous ferns, bennettitaleans, cycadaeleans and ginkgoaleans, and the rarity of dicksoniaceous ferns, czekanowskialeans and *Podozamites*. We therefore designated them as the South European-type.

V) The Nishinakayama-type flora is at present known only from the upper Liassic Nishinakayama Formation, Toyora Group, Japan. For the Early Jurassic interval, Vakhrameev (1964, 1966) proposed the Siberian and Indo-European Paleofloristic Areas in Eurasia. His Indo-European Area was further paleophytogeographically subdivided by himself into European, Middle Asian and East Asian Provinces.

Our Siberian-type, Kuruma-type, Middle Asian-type and South European-type floras nearly correspond to those of Vakhrameev's Siberian Area, East Asian, Middle Asian and southern part of European Provinces respectively.

Known fossil plants from Nroth Viet Nam (22) and Laos (23) are too few to draw any

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← **Figure 21.** Main localities of the Early Jurassic plants in East Asia, with their sources and floristic types. (F; formation, G; group, Asterisk; marine origin or partly marine origin)

Japan: **1.** Niranohama F.* (Hettangian) (Asama, 1968) and Hosoura F.* (Hettangian-Aalenian) (Shimakura, 1936), Miyagi Prefecture. **2.** Iwamuro F.*, Gumma Prefecture (Kimura, 1959; Kimura and Tsujii, 1980a–b, '81, '82, '83, '84). **3.** Kuruma G.*, Niigata, Nagano and Toyama Prefectures (Oishi, 1931; Kimura and Tsujii, 1980a–b, '81, '82, '83, '84). **4.** Yamaoku F.*, Okayama Prefecture [Konishi, 1954 (list)]. **5.** Higashinagano F.*, Toyora G. [Oishi, 1940; Takahasi, 1973a–b; Takahasi and Mikami, 1975 (list)]. **6.** Nishinakayama F.*, Toyora G. [Oishi, 1940 (pars); Huzioka, 1938; Takahasi, 1973a–b; Takahasi and Mikami, 1975 (list); Kimura, Naito and Ohana, 1986].

South China [sources depend mainly on Zhang, Z. C., 1985 (list), unless otherwise mentioned]: **7.** Xiangshan F., Jiangsu and Anhui. **8.** Yuetan F., South Anhui. **9.** Majian F., West Zhejiang. **10.** Longpu and Maonong F., West Zhejiang. **11.** Fengping F., West Zhejiang. **12.** Lishan F., North Fujian. **13.** Lower part of Songling G., East Guangdong. **14.** Lantang G.*, East Guangdong. **15.** Jinji F.*, North Guangdong. **16.** Tanglong and Maoxianling F., Southeast Jiangxi. **17.** Zaoshang and Menkoushan F., Jiangxi and Hunan (Zhang, C. F., 1985). **18.** Guanyintan F., Southwest Hunan and Guangxi (Zhou, Z. Y., 1984). **19.** Wuchang F., Southeast Hubei. **20.** Xiangxi F., West Hubei (Sze, 1949; Wu, S. Q. *et al.*, 1980). **21.** Baitianba F., North Hubei.

North Viet Nam: **22.** Moncay (Patte, 1927, in Vozenin-Serra and Boureau, 1978).

Laos: **23.** Muong-Phine (Vozenin-Serra and Boureau, 1978).

North and Northwest China [sources depend mainly on Zhang, Z. C., 1985 (list) unless otherwise mentioned]: **24.** Daxigou F., Lanzhou, Gansu. **25.** Xiaomeigou F., northern margin of the Chaidamu Basin. **26.** Wensu, West Xinjiang. **27.** Yangxia F., Kelasu G., northern margin of Talimu Basin, Xinjiang (Gu, D. Y., 1984). **28.** Badaowan and Sangonghe F., Shuixigou G., Zhungeer and Tulufan Basins, Xinjiang (Gu, D. Y., 1984; Wu, S. Q. and Zhou, H. Z., 1986). **29.** Wudanggou F., Shiguaigou G., Yinshan, Neimeng. **30.** Nansuletu G., Neimeng. **31.** Fuxian F., North Shaanxi (Huang, Z. G. and Zhou, H. Q., 1980). **32.** Yongdingzhuang F., Dadong, Shanxi and Lower Yaopo F., Mentougou G., Xishan, Beijing (Chen, F. *et al.*, 1984; Li, B. X. and Hu, B., 1984).

Northeast China [sources depend mainly on Zhang, W. *et al.*, 1980 and Zhang, Z. C., 1985 (list)]: **33.** Beipiao F., West Liaoning. **34.** Yingzi F., Zhaowudameng, Neimeng. **35.** Hongqi F., Daxinganling, West Jilin. **36.** Chayihe F., Yanjiagou G., Butehaqi, Hulunbeierqi, Neimeng. **37.** Changliangzi F., Benxi, East Liaoning. **38.** Yihe F., Linjiang, South Jilin.

Soviet Union [sources depend mainly on Vakhrameev (1964; list) and Sixtel and Khudaiberdyev (1968), unless otherwise mentioned]. **39:** Petrovka River area*, Southern Primorye (Krassilov and Schorochova, 1973). **40.** Iukhtin F., upper course of the Aldan. **41.** Ukugut F., Vilui River area. **42.** Nerejaslov F., Kansk Basin. **43.** Makarov F., Chulymo-Enisei Basin, northeastern part of Krasnojarsk. **44.** Karaldin, Sartakov and Tersjukov F., Kuznetsk Basin. **45.** Taisujan F., Kenderlyk Basin, eastern part of Zaisan. **46.** Alakul F., near Alakul Lake. **47.** Ashchikul F., Maikjuben Basin, western part of Pavlodar. **48.** Maikuduk, Dubov and Sokur F., Karagandin River area. **49.** Dzhil F., southern part of Issyk Kul Lake. **50.** Kyzylsuek and Agulak F., Son Kul Lake region. **51.** Tujuk F., eastern part of Fergana Range. **52.** Kok-Jangak Coal-Field, eastern part of Dzhalabad. **53.** Lower part of Suljuktin F., southern part of Fergana Range (Khudaiberdyev *et al.*, 1971). **54.** Angren F., southern part of Tashkent (Gomolitzky *et al.*, 1981).

detectable conclusion.

Notes: All specimens described in this paper are kept in the Department of Astronomy and Earth Sciences, Tokyo Gakugei University.

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日本のジュラ紀前期植物化石ーその 8（記載の追加および結論）：来馬層群から得られたつぎの分類群について記載を行った：*Gleichenites* ? sp. A, *Phlebopteris* sp. A, *Dictyophyllum kotakiense* Kimura et Tsujii, *Sphenopteris* sp. H, *Ptilophyllum shinadaniense* Kimura et Tsujii, *P.* sp. cf. *P. hsiangshanense* Wu, *P.* sp. A, *Pterophyllum* ? sp., *Pseudoctenis nipponica* Kimura et Tsujii および *Nilssonia* sp. B，また西中山層から，*Sphenopteris* sp. G, *Otozamites* sp. C および *Pseudoctenis* ? sp. を追加記載した。

日本のジュラ紀前期植物群は，来馬型と西中山型に区別され，それらの間には共通する属種は発見されていない。私どもはユーラシア大陸で従来知られているジュラ紀前期植物群について詳細な検討を行い，それらは，来馬型および西中山型のほか，シベリア型，中央アジア型および，南ヨーロッパ型の 5 類型に区別されることを明らかにした。　木村達明・大花民子・辻井正則

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 151, pp. 523–542, 10 Figs., October 31, 1988

862. ADDITIONAL NOTE ON UPPER PERMIAN RADIOLARIAN FAUNA FROM ITSUKAICHI, WESTERN PART OF TOKYO PREFECTURE, CENTRAL JAPAN*

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Abstract. Well-preserved upper Permian radiolarians were recovered abundantly from a chert block embedded in the Unazawa Formation distributed in Kashiwara, Itsukaichi Town, Tokyo Prefecture, central Japan. A part of this radiolarian fauna including the Families Entactiniidae, Palaeoactinomiidae, Palaeoscenidiidae and Phacodiscidae and the Superfamily Latentifistulidea has already been described by the present authors. This study is an addition to the continuing investigation of this fauna and several newly discriminated genera and species of Entactiniidae, Tormentidae, Albaillellidae and Spumellaria Incertae sedis are described. Among them, two genera *Uberinterna* and *Triplanospongos* and ten species are proposed as new to science.

This paper also attempts to compare the present radiolarian fauna with that of the Ultra-Tamba Belt of Southwest Japan and of the Delaware Basin of West Texas.

Introduction and acknowledgments

The study of the upper Paleozoic Radiolaria began with the classical works on the European Tethyan regions by Rüst (1892). Taxonomic works of the upper Paleozoic Radiolaria were resumed during the latter half of 1940's with investigation by Deflandre (*e.g.* 1946), and were followed by Foreman (1959, 1963) and Holdsworth (*e.g.* 1966, 1969) based on specimens separated from hard rocks by the hydrofloric or hydrochloric acid extraction method. Since the latter half of 1970's, the character of upper Paleozoic radiolarian fauna has been clarified in various areas of the world based on detailed observations with the use of a scanning electron microscope (Ormiston and Lane, 1976; Ormiston and Babcock, 1979; Won, 1983; Ishiga and Imoto, 1980; Ishiga *et al.*, 1982b; Cheng, 1986; Gourmelon, 1987 and others). The upper Permian bilaterally symmetrical Radiolaria has been described by Takemura and Nakaseko (1981), Ishiga *et al.* (1982b), Ishiga and Miyamoto (1986), and Caridroit and De Wever (1986) from Southwest Japan. Recently, an abundant and well-preserved upper Permian polycystine fauna has been reported by De Wever and Caridroit (1984), Sashida and Tonishi (1985, 1986) and Caridroit and De Wever (1986). However, radiolarian faunas comparable to this Japanese Upper Permian fauna have not been recognized outside of Japan, except for the

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* Received March 25, 1988; revised manuscript accepted August 4, 1988

Guadalupian Albaillellaria (Ormiston and Babcock, 1979) and Spumellaria (Nazarov and Ormiston, 1985) from the Delaware Basin of West Texas. In this article, a three-fold subdivision of the Permian System is applied because of the popularity of such a usage among Japanese biostratigraphers.

This paper is the third report on the description of Upper Permian radiolarians from Itsukaichi and several new genera and species of Entactiniidae and Spumellaria Incertae sedis as well as new species of Tormentidae and Albaillellidae are proposed from newly discriminated assemblages. The present authors also attempt to compare the present fauna with that of the Ultra-Tamba Belt of Japan and of the Delaware Basin of West Texas, U.S.A.

The present authors express their deep appreciation to Professor Hisayoshi Igo of the Institute of Geoscience, University of Tsukuba for his advice and continuous encouragement throughout the course of the present study and for his critical reading of the manuscript.

Geologic setting

The present authors once assumed that a chert block yielding a rich Upper Permian radiolarian fauna is intercalated as a lenticular body within a shale facies of the Unit B of the Chichibu System (Sashida and Tonishi, 1985). The senior author recently restudied the geology of the Itsukaichi area. The following is a brief summary of geology in this area from the north to south (Fig. 1).

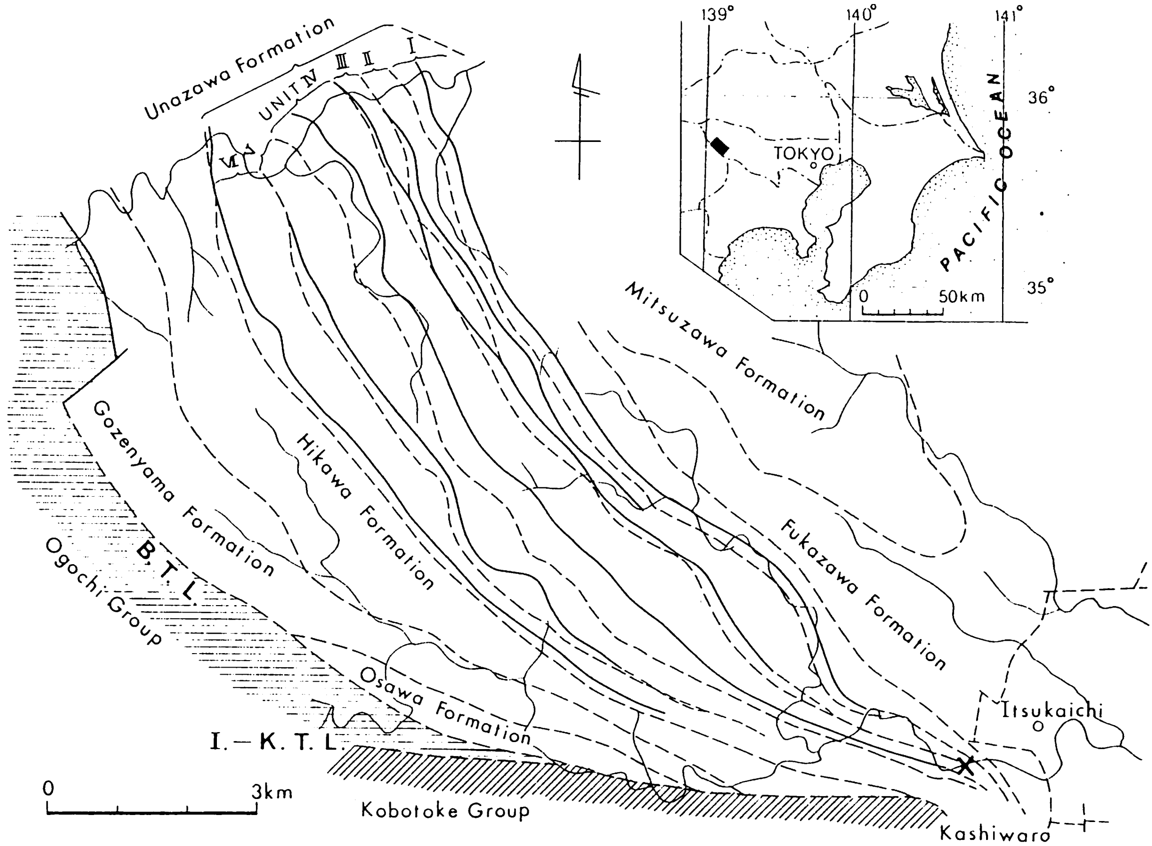


Figure 1. Index map of the fossil locality.
X: fossil locality, B.T.L.: Butsuzo Tectonic Line, I.-K.T.L.: Itsukaichi–Kawakami Tectonic Line.

1) Mitsuzawa Formation (Takashima and Koike, 1984)

The Mitsuzawa Formation is mainly composed of a Lower to Middle Jurassic phyllitic shale including exotic blocks of chert and limestone. The total thickness of this formation is more than 700 m.

2) Fukazawa Formation (Takashima and Koike, 1984)

This formation consists mainly of a Middle Jurassic black shale and sandstone containing exotic blocks of chert and limestone. Its total thickness amounts to 800 m.

3) Unazawa Formation (Fujimoto, 1939; Takashima and Koike, 1984)

The Unazawa Formation consists mainly of chert, siliceous shale and sandstone, and a repetitive sequence of these lithologies by tectonic deformations is characteristic of this formation. A sequence consisting of chert, siliceous shale and sandstone, in ascending order, repeats six times in this formation. The senior author tentatively named these six sequences, Unit I to Unit VI, beginning with the northernmost one. A sandstone bed in the upper part of Unit IV intercalates a volcaniclastic layer containing limestone and chert blocks. The total thickness of the formation exceeds 2000m.

4) Hikawa Formation (Fujimoto, 1939; Takashima and Koike, 1984)

This Upper Jurassic formation is characterized by the lower massive sandstone and the upper pebbly shale containing exotic blocks of chert and limestone. The total thickness of the formation is about 600m.

5) Gozenyama Formation (Fujimoto and Suzuki, 1957; Takashima and Koike, 1984)

The Gozenyama Formation is Early Cretaceous in age and is composed of a phyllitic shale containing blocks of chert, limestone and volcaniclastic rocks of various sizes. This formation attains the total thickness of 1300m.

6) Ozawa Formation (Takashima and Koike, 1984)

This Lower Cretaceous formation is composed of a phyllitic shale including small-sized sandstone blocks. The total thickness of this formation exceeds 400 m.

The six formations trend in a NW-SE direction and dip steeply northward. They are in contact with each other by northward-dipping, high-angled reverse faults.

The chert block containing the Upper Permian radiolarians described in this paper is intercalated within a volcaniclastic layer of Unit IV of the Unazawa Formation (Fig. 1). This volcaniclastic layer was formerly named the "Shiromaru Paleozoic Formation", because it contains limestone blocks yielding Carboniferous to Permian fusulinids.

Sample and age

The chert block which bears Upper Permian radiolarians has a maximum diameter of about 10 m, and exhibits a synfold with a northwest-plunging axis at an angle of 45 degrees (Sashida and Tonishi, 1985, Fig. 2). This chert block comprises 130 individual layers of chert, each of which is separated by a thin film of mudstone, and these layers are altogether about 5 m thick. The present authors sampled every layers in this chert block. Of these rock samples A-4, -7, -8 and -12 contain abundant and well-preserved radiolarian specimens. In particular, those specimens from samples A-4 and A-7 are treated in this paper.

Samples A-4 and A-7 yield albaillellids such as *Follicucullus scholasticus* Ormiston and Babcock morphotype II Ishiga and Miyamoto, *F. ventricosus* Ormiston and Babcock, *Albaillella levis* Ishiga, Kito and Imoto, *Neoalbaillella ornithoformis* Takemura and Nakaseko, and *N. grypus* Ishiga, Kito and Imoto. The specific compositions of this albaillellid fauna is characteristic of the *Neoalbaillella ornithoformis* Assemblage-Zone which is the uppermost radiolarian zone in the Permian System of Southwest Japan (Ishiga, 1986b). Ishiga (1986b) estimated the geologic age of this assemblage zone to be late Late Permian.

Comparison of the Upper Permian radiolarian fauna of Itsukaichi with both the faunas of the Ultra-Tamba Belt of Southwest Japan and the Delware Basin of North America

In the Upper Permian radiolarian assemblages of Japan, two distinct groups are recognized based upon the specific composition and the lithofacies in which radiolarians are preserved. One assemblage is characterized by an association of albaillellids including *Follicucullus scholasticus*, *F. ventricosus* and some representative species of *Neoalbeillella* (*e.g.*, *N. optima*, *N. gracilis*, and *N. ornithoformis*). This assemblage is characterized by the entire absence of *F. bipartitus* Caridroit and De Wever, *F. hamatus* Caridroit and De Wever, *F. falx* Caridroit and De Wever and *F. orthogonus* Caridroit and De Wever. In the Ultra-Tamba Belt, this assemblage occurs in a clastic rock facies (Musashino *et al.*, 1987), whereas it is usually recovered from a bedded chert facies of both the Mino-Tamba Belt and the Chichibu Belt of Southwest Japan. The other assemblage is dominated by the presence of *Follicucullus hamatus*, *F. bipartitus*, *F. charveti*, *F. falx*, *F. orthogonus* and by the absence of species of the genus *Neoalbaillella*. This assemblage is confirmed in clastic rocks or finely alternating beds of siliceous shale and black shale from the Kamigori and Tatsuno Formations of the Ultra-Tamba Belt (Caridroit and De Wever, 1984, 1986) and in similar lithologies in the Kurosegawa Belt of the outer zone of Southwest Japan (Ishiga and Miyamoto, 1986; Yamakita, 1986). Ishiga and Miyamoto (1986) named the latter *Follicucullus bipartitus*– *F. charveti* assemblage, and they considered that this assemblage is coeval with the radiolarian assemblage of the upper part of the *Follicucullus scholasticus* Assemblage Zone in the chert facies of Southwest Japan. However, the variety of species of the upper Permian radiolarian faunas from the chert facies is quite small except for the albaillellid. On the other hand, a rich radiolarian fauna composed of Entactiniidae, Latentifistulidea and Albaillellidae is reported from upper Permian clastic rocks of the Ultra-Tamba Belt (De Wever and Caridroit, 1984; Caridroit and De Wever, 1986). These authors described many species of *Follicucullus*, such as *F. bipartitus*, *F. charveti*, *F. falx*, *F. orthogonus*, *F. hamatus*, *F. hamatus uncinatus*, and *F. scholasticus*. Among them, *F. scholasticus* is the only species in common between the faunas of Itsukaichi and Ultra-Tamba Belt. Also, they erected a few new families Deflandrellidae and Ormistonellidae in the Superfamily Latentifistulidea, and several new genera and species were introduced in Latentifistulidae. In these stauraxon polycystines, *Ishigaum trifustis* De Wever and Caridroit, *Nazarovella gracilis* De Wever and Caridroit and *Pseudotormentus kamigoriensis* De Wever and Caridroit occur in both of the faunas. At the generic level, *Deflandrella* and *Latentifistula* are also in common between the two faunas. As already described by the present authors, the fauna of Itsukaichi contains rich and varied genera and species in the Family Entactiniidae. On the other hand, only four entactiniid species, such as *Haplentactinia* ? *ichikawai* Caridroit and De Wever, *Entactinia* ? sp., *Entactinosphaera aubouini* Caridroit and De Wever and *E. echinata* ? (Hinde) were described from the Ultra-Tamba Belt. However, there are no species of entactiniid in common between the two faunas. Caridroit and De Wever (1986) considered that the difference in the specific composition between those Upper Permian radiolarian faunas characterized by *Neoalbaillella* and those comprising varied species of *Follicucullus* resulted from the difference in lithofacies, diagenetic process, paleoenvironment and paleogeography. Ishiga (1986a) also stated that the radiolarian species of the *Follicucullus bipartitus*– *F. charveti* assemblage might have inhabited the ocean near the land because they are usually found in clastic rocks. Further investigations are necessary to confirm this problem by accumulating detailed field and faunal data.

Ormiston and Babcock (1979) were the first to describe two species of *Follicucullus* from the Permian Lamar Limestone of West Texas, North America. Later, Nazarov and Ormiston (1985) introduced rich Spumellarians from the Lamar and Heglar Limestones of the Bell Canyon Formation of the Delaware Mountain Group. Nazarov and Ormiston (1985) discriminated five radiolarian units in the Permian of the Delaware Basin. Among them, the Guadalupian faunal unit is represented by the lower *Hegleria mammifera* and the upper *Follicucullus ventricosus* Units. The *Follicucullus ventricosus* unit is characterized by an association of such species as *Entactinosphaera cimelia* Nazarov and Ormiston, *Entactinia tyrrelli* Nazarov and Ormiston, *Entactinia parapycnoclada* Nazarov and Ormiston, *Hegleria mammifera* Nazarov and Ormiston, *Ruzhencevispongus girtyi* Nazarov and Ormiston, *Copicyntroides asteriformis* Nazarov and Ormiston, *Latentifistula densa* Nazarov and Ormiston, *Raphidociclicus gemellus americanus* Nazarov and Ormiston, *Octatormentum babcockae* Nazarov and Ormiston, *Tetragregnon scalpratus* Nazarov and Ormiston, *Copiellintra* sp., *Follicucullus ventricosus* Ormiston and Babcock, *F. scholasticus* Ormiston and Babcock and *Copicyntra* sp. Among them, *F. ventricosus* and *F. scholasticus* are the species in common between the two faunas.

As stated earlier, our knowledge of the Upper Permian radiolarian taxonomy and Permian radiolarian biostratigraphy outside of Japan is quite insufficient, and we are now in the process of accumulating more data from North America, Europe, Russia, China and other areas. These data are hoped to solve the problems of paleobiogeography of radiolarians, inter-regional correlation of various radiolarian zones and depositional environments of radiolaria-bearing rocks.

Systematic description

In the following description, the morphological terminology for those species belonging to the Family Entactiniidae and the Superfamily Latentifistulidea, basically follows that of Nazarov and Ormiston (1985) and that of *Neoalbaillella* is adopted from Takemura and Nakaseko (1981) and Ishiga *et al.* (1982b). All the specimens described herein deposited in the collection of Institute of Geoscience, University of Tsukuba (IGUT).

Order Polycystina Ehrenberg, 1838, emend. Riedel, 1967

Suborder Albaillellaria Deflandre, 1953, emend. Holdsworth, 1969

Family Albaillellidae Deflandre, 1952

Genus *Neoalbaillella* Takemura and Nakaseko, 1981

Type species: *Neoalbaillella ornithoformis* Takemura and Nakaseko, 1981, Upper Permian: Tamba Belt, Southwest Japan.

Neoalbaillella pseudogrypus Sashida and Tonishi, n. sp.

Figures 9-1–6.

Neoalbaillella grypus Takemura and Nakaseko; Sashida and Tonishi, 1985, pl. 7, fig. 2.

Diagnosis: *Neoalbaillella* of bilaterally symmetrical shell with strongly curved apical cone and cylindrical pseudoabdomen having 3 to 4 horizontal rows of large square to rectangular windows.

Description: Apical cone imperforate, curves strongly to ventral side. Its apex sometimes curves downward. Pseudothorax and pseudoabdomen cylindrical, with 4 to 5 horizontal rows of windows. Pseudothorax with dorsal and ventral triangular blade-like wings. Pseudoabdomen with two rods, ventral and dorsal rods extending vertically downward and having 2 or 3 short spines projecting outwardly. Pore frames of shell wall arranged in 5 or more horizontal rows. Traveculae circular and lying on inner surface of shell wall. Each row of pore frames has 10 to 12 windows. Windows of upper 2 rows small, elliptical and those of center rows square to oblong. Pore frames of the upper first to fourth horizontally extended and touched with ventral wing. Usually, the second frame connected with Y-rod. Other frames adjoin lamellar-blade of ventral wing and rather large pores located between them. Shape of these pores trapezoidal at upper and middle parts. Lower edge of ventral wing connected with the fifth frame, making reverse trapezoidal pore. The fifth frame often protrudes toward the same direction of Y-rod. Length of dorsal wing about two-thirds of ventral wing. X-rod of dorsal wing extends nearly perpendicularly to dorsal rod. Lamellar-blade of dorsal wing contacts dorsal rod and possesses 1 or 2 windows of circular to subcircular or triangular shape.

Remarks: This new species is similar to *Neoalbaillella grypus* Ishiga, Kito and Imoto in having a strongly bended apical cone. However, this new species is distinguishable from the latter by having longer pseudoabdomen and many windows of rectangular to oval shape. Moreover, this species has characteristic pores in the skirt of its ventral wing. *Neoalbaillella pseudogrypus*, n. sp. differs from other species of *Neoalbaillella* in its strongly curved apical cone.

Measurements (in μm): Length of shell body including apical cone, 250–271; maximum diameter of shell, 95–100; length of Y-rod at ventral wing, 142–214; maximum width of window, 25–36; maximum length of window, 25–29, based on 20 specimens.

Etymology: Combination of latin *pseudo* and species name *grypus*.

Type: Holotype, Fig. 9-1, sample, A-4, IGUT-KS0234: Paratypes, Fig. 9-2, sample, A-4, IGUT-KS0235; Fig. 9-3, sample, A-4, IGUT-KS0240; Fig. 9-4, sample, A-7, IGUT-KS0236; Fig. 9-5, sample, A-7, IGUT-KS0208; Fig. 9-6, sample, A-4, IGUT-KS0212.

Suborder Spumellaria Ehrenberg, 1875

Family Entactiniinae Riedel, 1967

Subfamily Entactiniidae Riedel, 1967, emend. Nazarov, 1975

Tribus Entactiniini Nazarov, 1975

Genus *Entactinosphaera* Foreman, 1963

Type species: *Entactinosphaera esostrogyla* Foreman, 1963, Upper Devonian, Huron Member of the Ohio Shale, U.S.A.

Entactinosphaera pseudocimelia Sashida and Tonishi, n. sp.

Figures 7-1–3, 6–8.

? Entactiniidae gen. et sp. indet. Yamakita, 1986, pl. 1, fig. 17.

Diagnosis: *Entactinosphaera* with 2 three-bladed major spines. Inner shell bearing rather short spines.

Description: Outer shell spherical with two major spines. Inner shell much smaller than outer one. Diameter of inner shell usually less than one-third to one-fourth that of outer shell. Inner shell with circular pores. Internal framework within inner shell not distinct in available material. Inner and outer shell united by a pair of massive, three-bladed cross-beams which thicken gradually away from inner shell and join with two major external spines. Numerous, thin, rod-like spines arising from inner shell. Some specimens (*e.g.* Fig. 7-8) have very long spines arising from inner shell, rarely contact with outer shell like a pair of cross-beam (Fig. 7-7). Wall of outer shell thin. Outer shell surface bears numerous acute ridges or partitions intersecting in disorganized manner to form polygonal cells. These cells separate groups of pores in numbers ranging from 1 to 4, most frequently with 2 pores per cell. Inner surface of outer shell smooth. Major spines usually three-bladed, rarely four-bladed, just like a bundle of 3 thin rods which gently tapers. Sometimes one of major spines displays torsion of about 60 degrees.

Remarks: This new species resembles *Entactinosphaera cimelia* Nazarov and Ormiston described from the Guadalupian Lamar Limestone of West Texas in the feature of ridges or partitions of the outer surface of the outer shell. However, this new species can be distinguished from the latter by having three-bladed major spines shaped like a bundle of 3 thin and gently tapering rods.

Measurements (in μm): Diameter of outer shell, 140–175; diameter of inner shell, 38–44; length of major spines, 71–143, based on 15 specimens.

Etymology: Combination of latin *pseudo* and species name *cimelia*.

Types: Holotype, Fig. 7-1, sample, A-4, IGUT-KS0320: Paratypes, Fig. 7-2, sample, A-4, IGUT-KS0235; Fig. 7-3, sample, A-7, IGUT-KS0789; Fig. 7-6, sample, A-4, IGUT-KS3328; Fig. 7-7, sample, A-4, IGUT-KS0150; Fig. 7–8, sample, A-7, IGUT-KS0096.

Entactinosphaera brevispinosa Sashida and Tonishi, n. sp.

Figures 7-9–13.

Diagnosis: *Entactinosphaera* having a rather large outer shell with 0 to 6 short major spines and polygonal cells on outer surface of outer shell.

Description: Outer shell spherical with fewer than six major three-bladed spines. Inner shell small, thin-walled, penetrated by predominantly rounded pores. Diameter of inner shell less than one-fourth the outer shell. Internal framework within inner shell not distinct, but several very thin spicules present in available specimens. Numerous, thin and rod-like spines arising from inner shell. Inner and outer shells united by a pair of massive, three-bladed crossbeams with thicken rapidly away from inner shell and unit with two major external spines. In some specimens, one of rod-like spines from inner shell touches inner surface of outer shell. Wall of outer shell thin. Shell surface bears numerous acute ridges or partitions intersecting in disorganized manner to form polygonal cells. These cells surround groups of pores numbering from 1 to 5. Short major spines three-bladed, and not twisted. The number of spines variable. Length of major spines less than half the diameter of outer shell.

Remarks: This new species is characterized by having a rather large spherical outer shell and variable numbers of the short major spines. The number of major spines is an important criterion for the polycystine taxonomy. However, many kinds of radiolarian taxa which have inconsistent numbers of major spines in the same species were reported from the Paleozoic rocks. For example, *Entactinosphaera crassiclatratus* Nazarov and Ormiston from the Guadalupian Lamar Limestone has 2 to 6 major spines. In the present collection, there are some specimens which either have rudimentary major spines or lack the spine entirely. In the latter case, these specimens have a tendency to develop an outer shell which bear cells surrounding only one pore. The present authors tentatively included these specimens in *Entactinosphaera brevispinosa,* n. sp. Those specimens of this new species having 6 major spines resemble *Entactinosphaera* ? *crassispinosa* Sashida and Tonishi described from the same chert. However, the latter species has a smaller outer shell and thicker major spines than those of the former.

Measurements (in μm): Diameter of outer shell, 280–330; diameter of inner shell, 45–60; length of major spine, 60–105, based on 12 specimens.

Etymology: Latin *brevis* meaning short and *spinousus* thorny or spinouse.

Types: Holotype, Fig. 7-9, sample, A-4, IGUT-KS0455: Paratypes, Fig. 7-10, sample, A-4, IGUT-KS3347; Fig. 7-11, sample, A-4, IGUT-KS3346; Fig. 7-12, sample, A-4, IGUT-KS3316; Fig. 7-13, sample, A-4, IGUT-KS0432.

Entactinosphaera sp.

Figures 7-4,5.

Remarks: Several poorly preserved specimens were obtained. This unnamed species is quite similar to *Entactinosphaera cimelia* Nazarov and Ormiston in general shell shape. However, it differs from the latter in having wider major spines. Although this unidentified species somewhat resembles *Entactinosphaera pseudocimelia,* n. sp., it is distinguishable from the latter in its major spines having a triangular cross section. Specific designation is rendered until more well-preserved specimens are accumulated.

Measurements (in μm): Diameter of outer shell, 110–140; diameter of inner shell, 30–38; length of major spines, 170–220, based on five specimens.

Types: Illustrated specimens, Fig. 7-4, sample, A-7, IGUT-KS0421; Fig. 7-5, sample, A-4, IGUT-KS0753.

Tribus Triaenosphaeriniini Gourmelon, 1987

Type genus *Triaenosphaera* Deflandre, 1973

Genus *Triaenoshpaera* Deflandre, 1973 emend. Gourmelon, 1987

Type species: *Triaenosphaera sicarius* Deflandre, 1973, Lower Carboniferous, Montagne Noire, France.

Remarks: The genus *Triaenosphaera* was originally introduced by Deflandre (1973) from the Lower Carboniferous of France. Subsequently, Holdsworth *et al.* (1978) examined specimens of *Triaenosphaera sicarius* Deflandre from an Upper Devonian chert of the Ford Lake Shale of Alaska. They distinguished two morphotypes; *Triaenosphaera sicarius* Deflandre (s.s.) which has four major spines and *T. sicarius* (s.l.) having fewer than three major spines. Very recently, Gourmelon (1987) documented many Tournaisian Radiolaria from Montagne Noire in France. He erected up a new Tribe Triaenosphaeriniini in the Family Entactiniidae. The genus *Triaenosphaera* is characterized by a single spherical shell with four tetrahedrally arranged spines. The four internal spicules have also a tetrahedral disposition.

Triaenosphaera minutus Sashida and Tonishi, n. sp.

Figures 8-1–6.

Diagnosis: *Triaenosphaera* with small spherical shell and four radially arranged three-bladed major spines.

Description: Small spherical shell with four major spines. Cortical shell comprises small pore frames with poorly developed nodes at their vertices. Hexagonal pore frames usually dominating. Thirty to 35 pores present on outer surface of hemisphere. Four major spines having a tetrahedral disposition and comprise 3 narrow longitudinal ridges alternating with 3 narrow longitudinal grooves. Grooves and ridges almost equal in width. Length of 4 major spines usually equal and four-fifths of diameter of shell and their distal end acute. Three-bladed thin internal tetrahedral spicules continuous with major spines at the inner surface of shell.

Remarks: *Triaenosphaera minutus*, n. sp. is somewhat similar in general shell feature to *T. sicarius* Deflandre described by Gourmelon (1987). However, the former species has larger pores, fewer numbers of pores and shorter major spines than those of the latter.

Measurements (in μm): Diameter of shell, 80–96; length of major spines, 60–75; diameter of pores, 7–11; number of pores on hemisphere; 28–31, based on 15 specimens.

Etymology: Latin *minutus* meaning small.

Types: Holotype, Fig. 8-1, sample, A-4, IGUT-KS3489: Paratypes, Fig. 8-2, sample, A-4, IGUT-KS3488; Fig. 8-3, sample, A-7, IGUT-KS3478; Fig. 8-4, sample, A-4, IGUT-KS3490; Fig. 8-5, sample, A-4, IGUT-KS0437; Fig. 8-6, sample, A-4, IGUT-KS3497.

Subfamily Astroentactiniinae Nazarov and Ormiston, 1985

Tribus Somphoentactiniini Kozur and Mostler, 1981

Genus *Copicyntra* Nazarov and Ormiston, 1985

Type species: Copicyntra acilaxa Nazarov and Ormiston, 1985, Upper Carboniferous, southern Ural, U.S.S.R.

Copicyntra akikawaensis Sashida and Tonishi, n. sp.

Figures 7-14–17.

Diagnosis: *Copicyntra* with 5 to 6 concentric spheres and long conical spines.

Description: Spherical outer shell with numerous long conical spines. Number of concentric sphere between outer shell and inner most porous sphere being usually 4 to 5. Inner sphere small with many rounded pores. Radial cross-beams arising from inner sphere and having a three-bladed form. External spines connect with radial cross-beam at base of outer shell. External spines long and rod-like, acuminate in distal part. Length of external spine exceeds a half the diameter of outer shell. Three-bladed or thin rod-like pillars also combine superimposed concentric spheres. External spines numbering from 17 to 20 on hemisphere. Outer spongy shell represented by disorganized intervention of thin skeletal fibers forming small cells.

Remarks: *Copicyntra akikawaensis,* n. sp., differs from the previously reported species of *Copicyntra* in having fewer number of concentric spheres and. rod-like external spines. This new species somewhat resembles *Copicyntra cuspidata* Nazarov and Ormiston reported from the Permian Artinskian Stage, southern Ural in general shell feature. However, the latter is distinguished from the former by having three-bladed external spines.

Measurements (in μm): Shell diameter, 150–200; diameter of inner sphere, 36–45; average diameter of intercalated shells proceeding inward by from outer spongy layer, 160, 133, 113, 110 and 80; spine length, 40–93, based on 15 specimens.

Etymology: Species name *akikawaensis* is derived from Akikawa-river.

Types: Holotype, Fig. 7-14, sample, A-4, IGUT-KS3345: Paratypes; Fig. 7-15, sample, A-4, IGUT-KS0467; Fig. 7-16, sample, A-4, IGUT-KS3332; Fig. 7-17, sample, A-7, IGUT-KS3458.

Genus *Uberinterna* Sashida and Tonishi, n. genus.

Type species: *Uberinterna virgispinosum* Sashida and Tonishi, n. sp.

Diagnosis: Astroentactiniinae with thick spongy outer shell and porous inner shell. Inner shell comprises 4 to 5, rarely more, thin concentric spheres. Internal spheres connected with each other by numerous thin rod-like beams. Internal spheres also being crossed by radial cross-beams joining with base of major spines.

Remarks: This new genus is distinguished from other genera of Astroentactiniinae, such as *Somphoentactinia* Nazarov and *Spongentactinella* Nazarov by having concentric internal spheres. On the other hand, the genera *Copicyntra* Nazarov and Ormiston and *Copicyntroides* Nazarov and Ormiston have superimposed thin concentric spheres. The new genus *Uberinterna* is additionally characterized by three-bladed cross-beams. These features of cross-beams are not recognized in the previously reported genera of Astroentactiniinae.

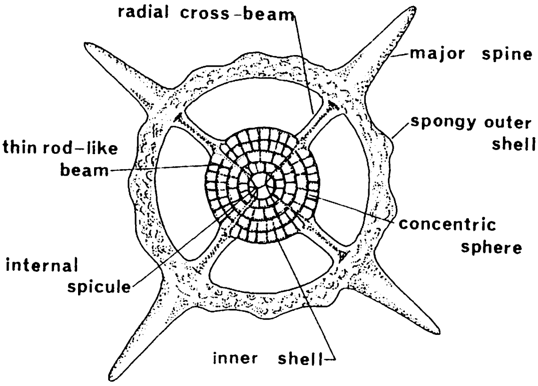


Figure 2. Schematic profile of *Uberinterna virgispinosum* Sashida and Tonishi, n. g., n. sp., presenting its nomenclature.

Etymology: Latin *uber* meaning abundant and *interna,* inner part; gender, neuter.

Uberinterna virgispinosum Sashida and Tonishi, n. sp.

Figures 2; 8-7–12.

Diagnosis: *Uberinterna* with thick spongy outer shell and 4 to 5 thin concentric spherical shells. Several major spines rod-like and rather short.

Description: Spherical outer shell, thick and spongy with several rod-like spines. Outer surface of outer shell uneven lacking any small spines, whereas inner surface usually smooth (Figs. 8–9, 12). However, some specimens have spongy fabric and intervening fibers, which are in contact with outer surface of inner shell. Thickness of outer shell wall exceeds one-fifth the one of a half diameter of outer shell. Major spines rather short and conical or rod-like. They gradually taper off to a distal end. Sometimes, wide and rather deep grooves develop from base to one-third the length of major spines. Six major spines counted in well-preserved specimens. Inner shell comprises 4 to 5 thin concentric spheres.

Innermost sphere has a thin wall penetrated by rounded oval pores. Several thin internal spicules observed in innermost sphere, but their disposition not clear in presently available specimens. Three to 4 concentric spheres small with rounded pores. Each concentric sphere being connected by thin rod-like beams. Rarely very small secondary spines or nodes developing on outer surface of outermost sphere of inner shell. Diameter of inner shell less than a half diameter of outer shell. Six radial cross-beams arising from inner shell have a three-bladed form. They become gradually wide toward inner surface of outer shell and contact with external spines.

Remarks: This new species somewhat resembles *Thecentactinia riedeli* (Foreman) in general shell shape. However, the former is easily distinguished from the latter by the above described shell characters.

Measurements (in μm): Diameter of outer shell, 250–300; thickness of spongy layer of outer shell, 25–30; length of external spines, 65–100; diameter of outermost sphere of inner shell, 85–93; diameter of innermost sphere, 25–33; average diameter of intercalated spheres proceeding inwardly from the outermost sphere of inner shell, 80, 47 and 33, based on 11 specimens.

Etymology: Latin *virga*, twig or branch and *spinosus*, thorny.

Types: Holotype, Fig. 8-7, sample, A-4, IGUT-KS3496: Paratypes, Fig. 8-8, sample, A-4, IGUT-KS3453; Fig. 8-9, 12, sample, A-4, IGUT-KS3492; Fig. 8-10, sample, A-7, IGUT-KS0301; Fig. 8-11, sample, A-4, IGUT-KS3487.

Superfamily Latentifistulidea Nazarov and Ormiston, 1983

Family Tormentidae Nazarov and Ormiston, 1983

Genus *Tetratormentum* Nazarov and Ormiston, 1985

Type species: *Tetratormentum narthecium* Nazarov and Ormiston, Upper Carboniferous, Gzhelian Stage, southern Ural, U.S.S.R.

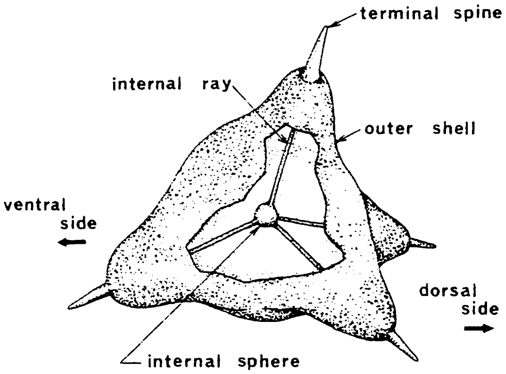


Figure 3. Schematic view of *Tetratormentum acutum* Sashida and Tonishi, n. sp. presenting its nomenclature.

Tetratormentum acutum Sashida and Tonishi, n. sp.

Figures 3; 10-7, 10

Diagnosis: *Tetratormentum* with distorted pyramidal shell. One small spherical internal sphere with very thin four-rayed internal framework enclosed in rather thick spongy shell (Fig. 3).

Description: Outer spongy pyramidal shell thick, rather large and distorted toward dorsal side. Spongy fabric of outer shell very fine. Distal end of spongy shell abruptly tapers toward terminal spine. Internal framework represented by a nonporous sphere somewhat shifted toward base. Three very thin rays arising from sphere at an angle of about 120 degrees from one another and fourth one bended toward dorsal side at an angle of about 30 degrees from a vertex (Fig. 10-10). Diameter of internal sphere less than one-fourth the length of internal ray. Internal ray gradually thicken toward distal part and connected with external spine at base of spongy shell. Terminal spines fairly thick and conical. Some forms possessing 2 or 3 short and shallow openings near base. Length of well-preserved terminal spine about one-third of internal ray.

Remarks: *Tetratormentum acutum*, n. sp. is characterized by its distorted spongy shell with fairly massive and conical terminal spines. This new species somewhat resembles *Tetrator-*

mentum narthecium Nazarov and Ormiston, the type species of the genus *Tetratormentum*, However, the latter species has a more rounded pyramidal shell and thinner terminal spines than the former.

Measurements (in μm): Height of pyramid except terminal spine, 235–255; basal width, 280–330; diameter of internal sphere, 35–45; diameter of internal rays, 4–8; length of terminal spines, 7–10, based on 9 specimens.

Etymology: Latin *acutus* meaning acute or sharpened.

Types: Holotype: Fig. 10-10, sample, A-4, IGUT-KS0948: Paratype, Fig. 10-7, sample, A-4, IGUT-KS0945.

Tetratormentum globiforme Sashida and Tonishi, n. sp.

Figures 4; 10–11,12.

Diagnosis: *Tetratormentum* with globular coarse spongy shell and porous internal sphere. External terminal spines thick and long conical arising from internal rays (Fig. 4).

Description: Globular shell thick with a porous internal sphere and conical massive external spines which arise from internal rays. Spongy shell comprising fairly coarse spongy fabric, sometimes creating an impression of it being divided into several layers. Inner surface of shell usually smooth, but sometimes coarse spongy fabric of shell combined with internal sphere. Porous internal sphere spherical to depressed spherical with circular to oval pores. Diameter of internal sphere less than one-third of the outer shell diameter. Internal rays arising from internal sphere at an angle of 120 degrees from one another and the fourth ones arranged perpendicularly to other three. Usually, internal rays rod-like, but sometimes three-bladed. Thick terminal spines also rod-like and gradually taper off distally.

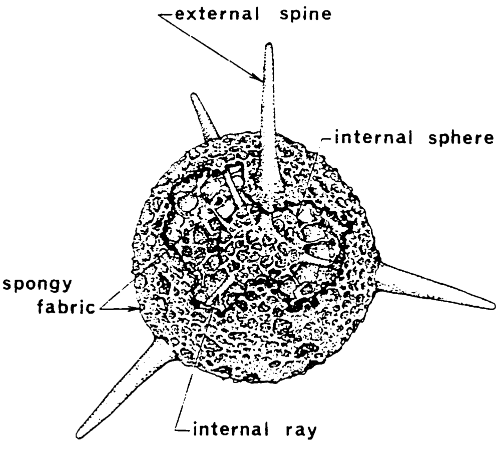


Figure 4. Schematic view of *Tetratormentum globiforme* Sashida and Tonishi, n. sp. presenting its nomenclature.

Remarks: In some specimens, there observed are one or two incomplete spheres made of a coarse spongy fabric in which the internal sphere is closed. The present authors tentatively included these forms to this species.

Measurements (in μm): Diameter of shell, 300–350; diameter of internal sphere, 70–90; maximum diameter of terminal spines, 35–50; length of the terminal spines 120–180, based on 8 specimens.

Etymology: Latin *globus* meaning ball and *formis*, shaped.

Types: Holotype, Fig. 10-11, sample, A-4, IGUT-KS0923: Paratype, Fig. 10-12, sample, A-4, IGUT-KS0946.

Genus *Octatormentum* Nazarov and Ormiston, 1985

Type species: *Octatormentum cornelli* Nazarov and Ormiston, 1985: Lower Permian, Leonardian Stage, Bone Spring Limestone, West Texas, U.S.A.

Octatormentum ? floriferum Sashida and Tonishi, n. sp.

Figures 5; 10-1–4.

Diagnosis: Tormentidae with spongy shell and internal sphere. Spongy shell of double pyramidal form with six major spines, four emerging at apices of each pyramid. External spines continuous with 6 internal rays (Fig. 5).

Description: Rather large shell of double

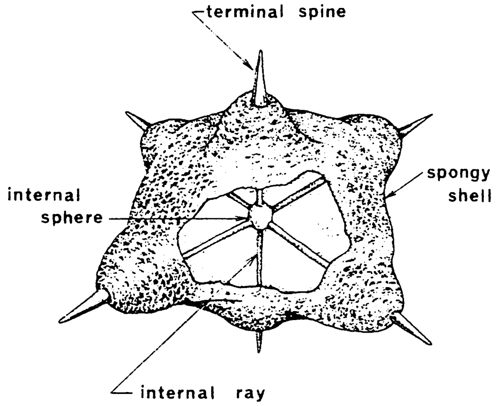


Figure 5. Schematic view of *Octatormentum* ? *floriferum* Sashida and Tonishi, n. sp. presenting its nomenclature.

pyramidal form whose distal half of apices protruded in a dome-like fashion. Terminal spines emerging at 4 equatorial corners and 2 apices. Diameter of dome-like protrusion less than height of shell. Shell thick and spongy. Inner surface of shell smooth, but rarely fine-spongy fabrics sticking out. Internal sphere small, nonporous and covered with 6 emerging rays. Junction of these rays not observable within the sphere. Diameter of internal sphere less than one-fifth that of outer shell. Internal sphere situated at the center of shell. Internal rays thin, rod-like and continuous to base of major external spines. External spines rod-like, finely three-bladed at the basal part, and gradually tapering off distally. Six external spines usually equal length. Maximum length of external spines nearly equal with diameter of dome-like protrusion.

Remarks: According to Nazarov and Ormiston (1985), the genus *Octatormentum* is characterized diagnostically by having 3 shells and 6 major spines. Although the present authors' specimens have only 2 shells, other shell features are quite identical with the criteria given by Nazarov and Ormiston (1985). Therefore, the present authors tentatively assign this new species to the genus *Octatormentum*. *Octatormentum* ? *floriferum*, n. sp. is easily distinguished from other previously described species of *Octatormentum* by the above-mentioned shell characters.

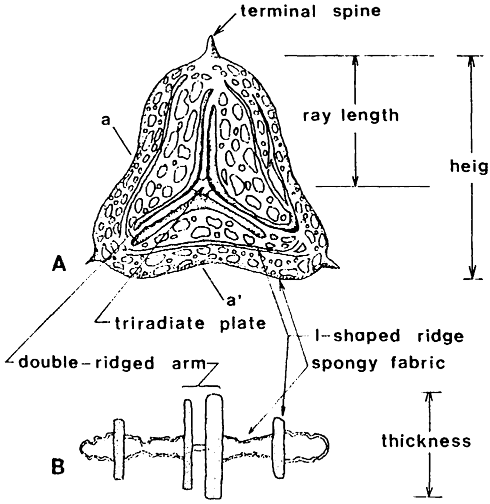


Figure 6. Schematic view of *Triplanospongos musashiensis* Sashida and Tonishi, n. g., n. sp. presenting its nomenclature.

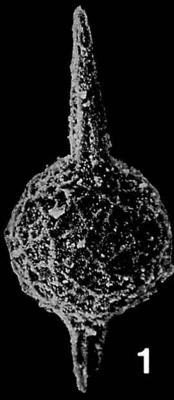
A: External view, B: Two times enlarged cross section along the profile a-a'.

Measurements (in μm): Maximum height of shell excluding terminal spine, 290–320; maximum diameter of shell, 300–350; diameter of internal sphere, 30–45; length of external terminal spines, 45–55, based on 8 specimens.

Etymology: Latin *florifer* meaning flower bearing.

Types: Holotype: Fig. 10-2, sample, A-4,

→ **Figure 7.** **1–3, 6–8**: *Entactinosphaera pseudocimelia* Sashida and Tonishi, n. sp. **1**, holotype, x 150, sample A-4, IGUT-KS0320; **2**, paratype, x 200, sample A-4, IGUT-KS0235; **3**, paratype, x 150, sample A-7, IGUT-KS0789; **6**, paratype, x 150, sample A-4, IGUT-KS3328; **7**, paratype, x 200, sample A-4, IGUT-KS0150; **8**, paratype, x 200, sample A-7, IGUT-KS0096. **4,5**: *Entactinosphaera* sp. **4**, x 200, sample, A-7 IGUT-KS0421; **5**, x 100, sample, A-4 IGUT-KS0753. **9–13**: *Entactinosphaera brevispinosa* Sashida and Tonishi, n. sp. **9**, holotype, x 100, sample A-4, IGUT-KS0455; **10**, paratype, x 100, sample A-4, IGUT-KS3347; **11**, paratype, x 100, sample A-4, IGUT-KS3346; **12**, paratype, x 100, sample A-4, IGUT-KS3316; **13**, paratype, x 100, sample A-4, IGUT-KS0432. **14–17**: *Copicyntra akikawaensis* Sashida and Tonishi, n. sp. **14**, holotype, x 225, sample A-4, IGUT-KS3345; **15**, paratype, x 150, sample A-4, IGUT-KS0467; **16**, paratype, x 150, sample A-4, IGUT-KS3332; **17**, paratype, x 150, sample A-7, IGUT-KS3458.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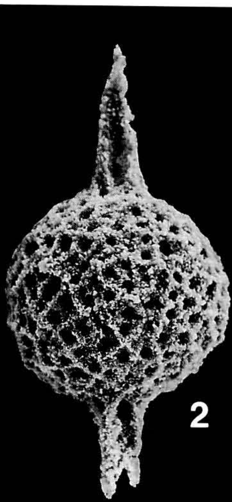
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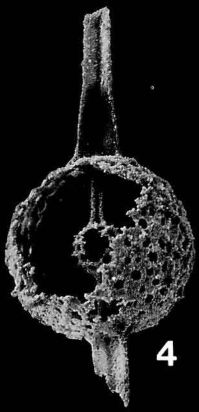
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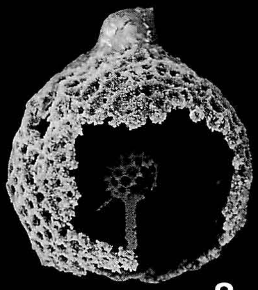
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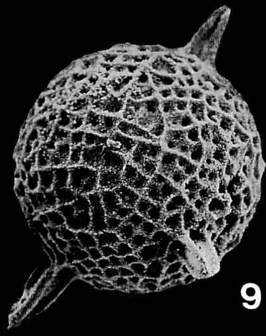
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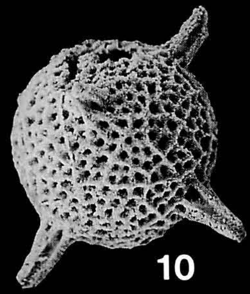
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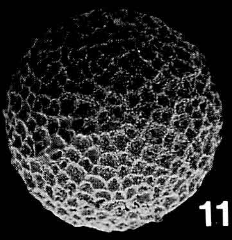
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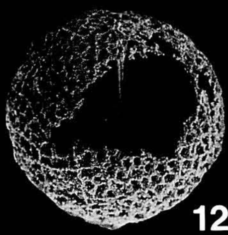
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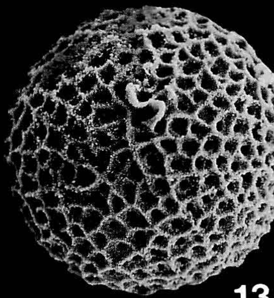
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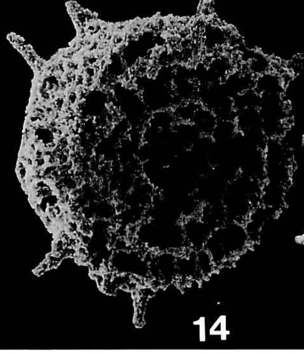
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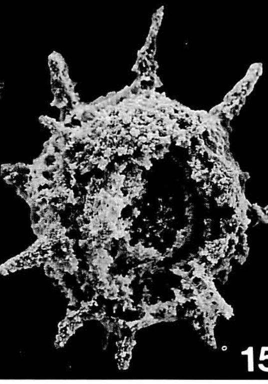
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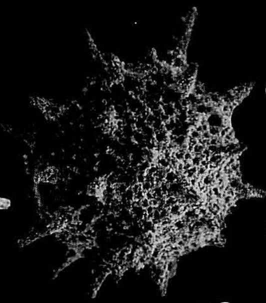
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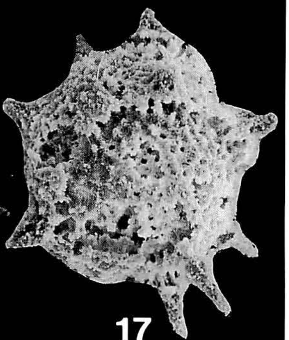
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IGUT-KS3454: Paratypes, Fig. 10-1, sample, A-4, IGUT-KS3452; Fig. 10-3, sample, A-4, IGUT-KS3471; Fig. 10-4, sample, A-4, IGUT-KS3472.

Octatormentum ? sp.

Figures 10-5,6,8,9.

Description: Three-sided, rather large and thin spongy bipyramidal shell enclosing six-rayed internal framework. Dome-like protrusions present at each corner. Small modes also developing at the top of dome-like protrusion and being continuous with 6 internal rays. Internal rays rather thick and rod-like. Internal sphere not observed amongst presently available material.

Remarks: Several poorly preserved specimens were obtained. This unidentified species characteristically has three-sided bipyramidal shell. The poor state of preservation prevents observation of the internal sphere. Some characters of this unidentified species differ from the criteria of the genus *Octatormentum*. Because, this species has a bipyramidal shell with six internal rays, the present authors questionably assigned this unidentified species to the genus *Octatormentum*. Both the generic and specific designations of this taxon are waived until well-preserved specimens become available.

Measurements (in μm): Maximum height of outer shell, 270–285; maximum diameter of outer shell, 260–280, based on 5 specimens.

Types: Illustrated specimens: Fig. 10-5,6, sample, A-4, IGUT-KS0820; Fig. 10-8,9, sample, A-4, IGUT-KS0923.

Spumellaria incertae sedis

Genus *Triplanospongos* Sashida and Tonishi, n. genus.

Type species: *Triplanospongos musashiensis* Sashida and Tonishi, n. sp.

Diagnosis: Shell comprising three double-ridged arms with triangular spongy fabrics and conical terminal spines. Arms radiating from the center of shell at an angle of 120 degrees. Small triradiate plate present at the center of shell. One or two narrow ridges, I-shaped in cross section, being arranged parallel to arm at nearly mid-part of spongy shell. This ridge coming in contact with arm at distal end of shell or amalugamated with surrounding spongy fabrics.

Remarks: *Triplanospongos*, n. g. is quite similar to the genus *Foremanhelena* De Wever and Caridroit of the Family Tormentidae in outer shell shape. However, the shell structure of the former genus is completely different from the latter. Namely, this new genus does not have the tube-like triradiate arms and spherical central shell. This character is not recognized in other genera of the Superfamily Latentifistulidea. Therefore, the present authors place this new genus in the Spumellaria incertae sedis. The genus *Tetraditryma* Baumgartner of the Mesozoic Family Hagiastridae possess basically H-shaped external beams. Nevertheless, the ray of the genus *Tetraditryma* is composed of a medullary shell, cortical bar, cortical walls and pores (Baumgartner, 1980, fig. 4).

Etymology: Latin *tri* meaning three, *plano* to make flat, and *pongos* sponge; gender masculine.

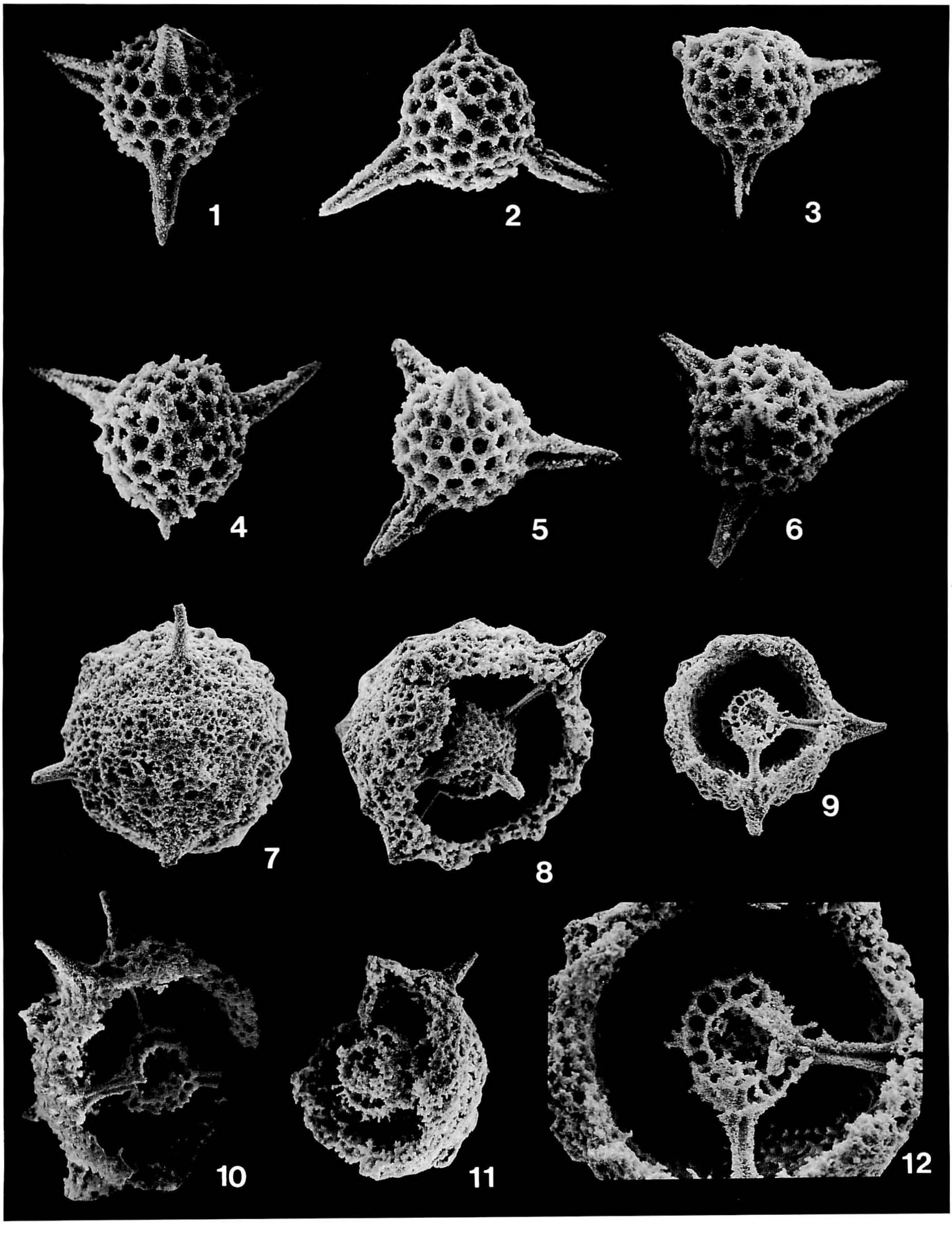
Triplanospongos musashiensis Sashida and Tonishi, n. sp.

Figures 6; 9-7–12.

? *Paronaella* sp. A, Wakita, 1983, pl. 7, fig. 7.
Angulobracchia ? sp., Yoshida and Murata, 1985, pl. 2, fig. 18.

→ **Figure 8.** **1–6:** *Triaenosphaera minutus* Sashida and Tonishi, n. sp. **1**, holotype, x 350, sample A-4, IGUT-KS3489; **2**, paratype, x 350, sample A-4, IGUT-KS3488; **3**, paratype, x 350, sample A-7, IGUT-KS3478; **4**, paratype, x 350, sample A-4, IGUT-KS3490; **5**, paratype, x 350, sample A-4, IGUT-KS0437; **6**, paratype, x 350, sample A-4, IGUT-KS3497.

7–12: *Uberinterna virgispinosum* Sashida and Tonishi, n. sp. **7**, holotype, x 100, sample A-4, IGUT-KS3496; **8**, paratype, x 150, sample A-4, IGUT-KS0301; **9**, paratype, x 100, sample A-4, IGUT-KS3492; **10**, paratype, x 150, sample A-7, IGUT-KS0301; **11**, paratype, x 150, sample A-4, IGUT-KS3487; **12**, x 350, enlargement of the internal shell of Fig. **8-9**.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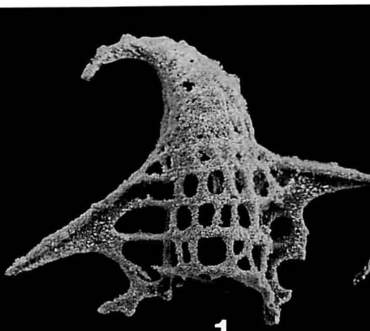
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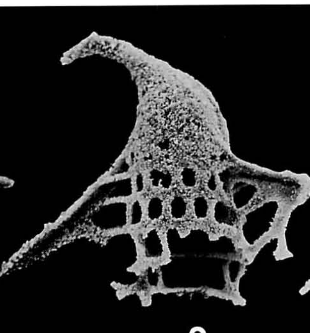
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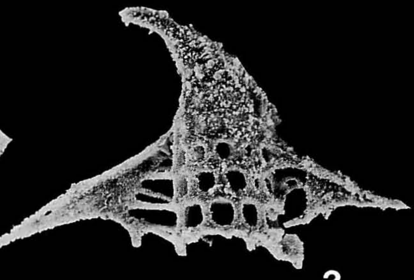
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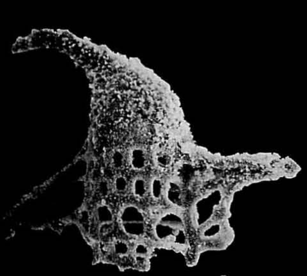
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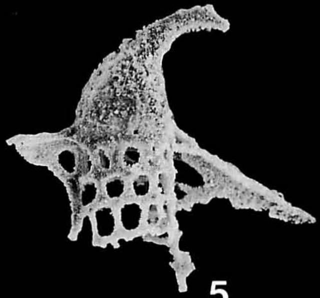
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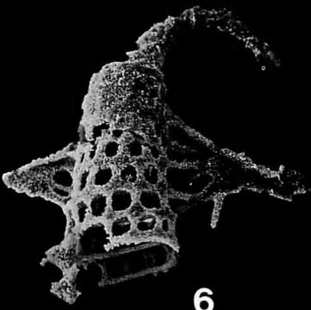
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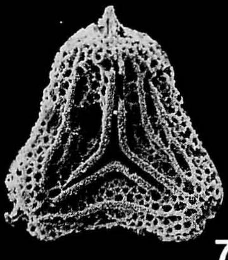
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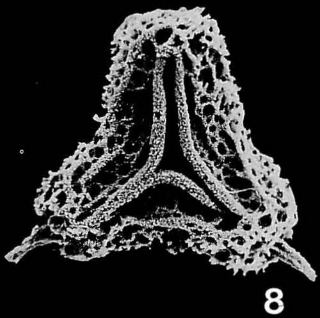
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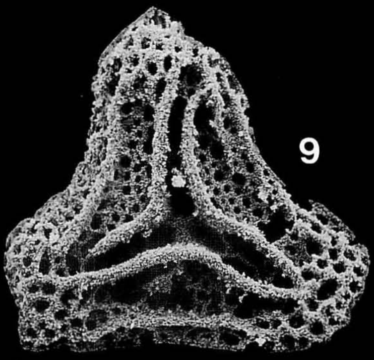
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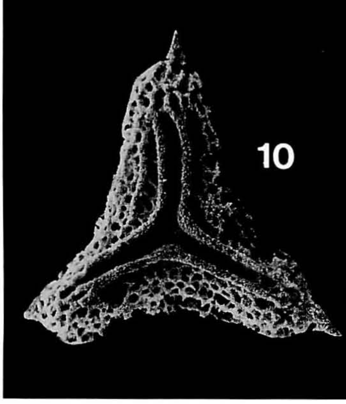
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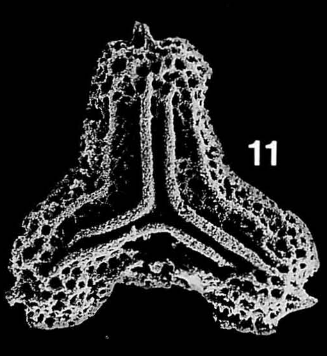
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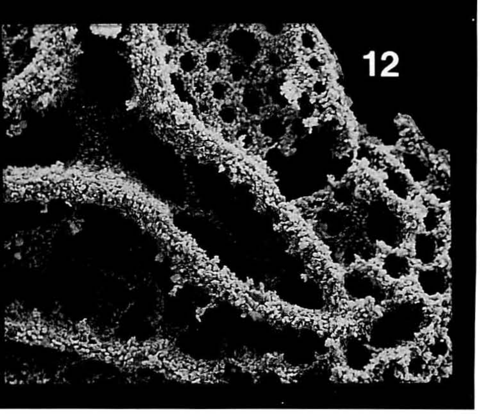
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Diagnosis: Triangular platy shell comprising three arms and covered by spongy fabrics. Each arm of triangular spongy shell tipped by a rather long, conical, terminal spine.

Description: Triangular platy shell comprising three double-ridged arms and covered by spongy fabrics. Arms diverging at an angle of 120 degrees from center. Triradiate and rather massive small plate located at center of shell. One of two ridges fabricating double-ridged arm usually disappearing at the distal end. In rare instances, both ridges becoming amalgamated with each other to form single-ridged arm. At distal part of shell, arm merging with spongy fabric. One or two massive I-shaped ridge running parallel to arm in the middle part of spongy shell and the ridge often coming to merge with one of ridges on the arm. Spongy fabrics serving to connect arm and I-shaped ridge in such manner as shown in Fig. 6. Pores of spongy fabric rather large and circular to oval. Spongy fabrics usually covering I-shaped ridges at the distal part of shell. A rather long conical spine terminating from one of ridges on the arm at distal end. Three narrow and shallow grooves present near the base of spines. Length of spines about one-third the distance from center to distal end of arm. Three side of triangular spongy shell slightly indented near mid-point as marked a or a' in Fig. 6. Thickness of double-ridged arm being nearly one-third of length of arm.

Remarks: As discussed earlier, *Triplanospongos musashiensis*, n. sp. resembles *Foremanhelena triangula* De Wever and Caridroit. Furthermore, this new species is similar to *Tormentum circumfusum* Nazarov and Ormiston described from the Lower Permian of southern Ural in its outer shell shape. However, this new species is easily distinguished from these two species by lacking the important character of stauraxon polycystines.

Measurements (in μm): Length of rays from center to distal end of shell, 170–230; height of triangle, 340–400; thickness of shell, 65–72; length of terminal spines 45–90, based on 25 specimens.

Etymology: Species name *musashiensis* comes from the ancient geographical name, Musashi, for the western part of Tokyo Prefecture.

Types: Holotype, Fig. 9-7, sample, A-4, IGUT-KS0371: Paratype, Fig. 9-8, sample, A-4, IGUT-KS0372; Figs. 9-9,12, sample, A-7, IGUT-KS0766; Fig. 9-10, sample, A-4, IGUT-KS0370; Fig. 9-11, sample, A-4, IGUT-KS0826.

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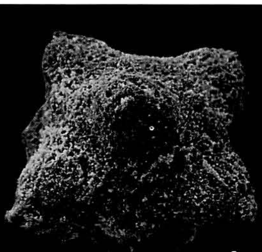
← **Figure 9.** **1–6:** *Neoalbaillella pseudogrypus* Sashida and Tonishi, n. sp. **1**, holotype, x 150, sample A-4, IGUT-KS0234; **2**, paratype, x 150, sample A-4, IGUT-KS0235; **3**, paratype, x 150, sample A-4, IGUT-KS0240; **4**, paratype, x 150, sample A-7, IGUT-KS0236; **5**, paratype, x 150, sample A-7, IGUT-KS0208; **6**, paratype, x 150, sample A-4, IGUT-KS0212.

7–12: *Triplanospongos musashiensis* Sashida and Tonishi, n. sp. **7**, holotype, x 100, sample A-4, IGUT-KS0371; **8**, paratype, x 150, sample A-4, IGUT-KS0372; **9**, paratype, x 175, sample A-7, IGUT-KS0766; **10**, paratype, x 150, sample A-4, IGUT-KS0370; **11**, paratype, x 150, sample A-4; IGUT-KS0826; **12**, x 350, enlargement of the central part of shell and triradiate plate.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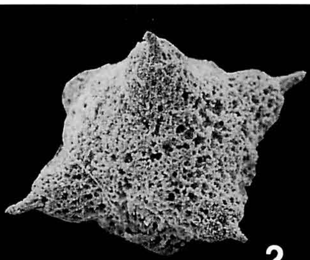
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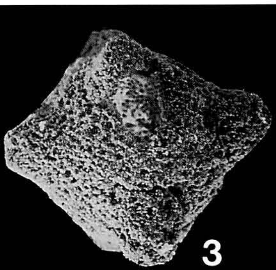
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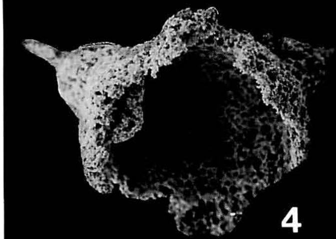
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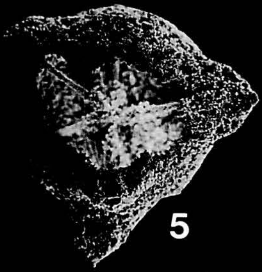
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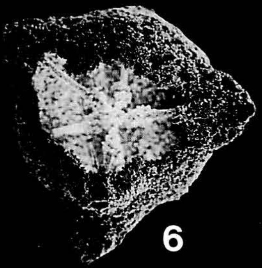
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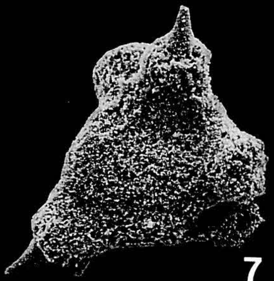
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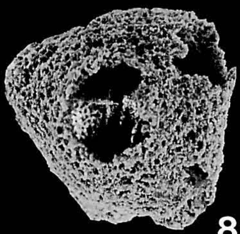
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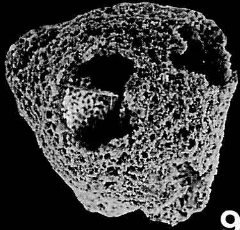
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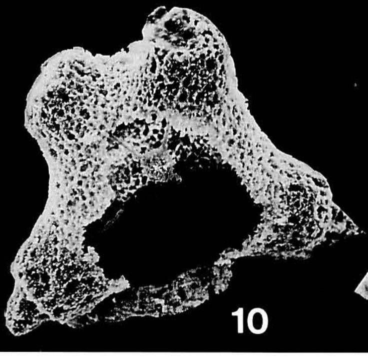
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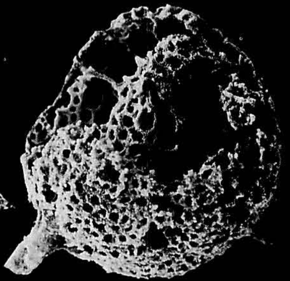
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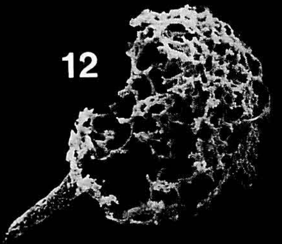
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Defl., parfait intermediaire entre les periaxoplastidies et les Pylentonemides. *Ibid*., vol. 276, D, pp. 1147–1151, pls. 1–2.

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← **Figure 10. 1–4:** *Octatormentum* ? *floriferum* Sashida and Tonishi, n. sp. **1,** paratype, x 75, sample A-4, IGUT- KS3452; **2,** holotype, x 75, sample A-4, IGUT-KS3453; **3,** paratype, x 75, sample A-4, IGUT-KS3471; **4,** paratype, x 75, sample A-4, IGUT-KS3472.

5, 6, 8, 9: *Octatormentum* ? sp. **5, 6,** x 150, a stereo pair showing internal rays, sample A-4, IGUT-KS0820; **8, 9,** x 150, a stereo pair showing internal feature, sample A-4, IGUT-KS0923.

7, 10: *Tetratormentum acutum* Sashida and Tonishi, n. sp. **7,** paratype, x 100, sample A-4, IGUT-KS0945; **10,** holotype, x 150, sample A-4, IGUT-KS0948.

11, 12: *Tetratormentum globiforme* Sashida and Tonishi, n. sp. **11,** holotype, x 100, sample A-4, IGUT-KS0923; **12,** paratype, x 100, sample A-4, IGUT-KS0946.

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(JE): in Japanese with English abstract, (J): in Japanese.

Kashiwara 柏原, Itsukaichi Town 五日市町, Akikawa 秋川, Musashi 武蔵.

東京都西部，五日市から産する上部ペルム系放散虫の追加報告：東京都五日市町柏原付近に分布する海沢層に含まれるチャート岩塊からは保存良好な上部ペルム系放散虫が多量に産する。この放散虫動物群のうち，Entactiniidae, Palaeoactinomidae, Palaeoscenidiidae, Phacodiscidae科及びLatentifistulidea超科の一部についてはすでに筆者らにより記載・報告されている。本研究ではEntactiniidae, Tormentidae, Albaillellidae科及び所属不明のSpumellariaについて新たに検討を行い，*Uberinterna, Triplanospongos*の2新属を含め，10種の新種を識別し，記載した。本研究ではさらに五日市産上部ペルム系放散虫動物群と西南日本超丹波帯の上部ペルム系放散虫動物群及び北米West TexasのDelaware Basinの放散虫動物群との比較も行った。 指田勝男・遠西敬二

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 151, pp. 543–563, 9 Figs., October 31, 1988

863. SOME CHARACTERISTIC RADIOLARIANS FROM LOWER JURASSIC BEDDED CHERTS OF THE INUYAMA AREA, SOUTHWEST JAPAN*

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Abstract. Four radiolarian species, including two new species, of the family Syringocapsidae Foreman are described from the lowest Jurassic bedded cherts of the Inuyama area, central Japan. These species belonging to the genera *Katroma, Syringocapsa* and *Gigi* are representatives of the *Parahsuum simplum* Assemblage, one of the important early Jurassic radiolarian assemblages established in Southwest Japan. On the basis of morphology and biostratigraphic distribution, both genera *Gigi* and *Katroma* are regarded as descendants of the genus *Syringocapsa.*

The species of *Katroma* in the Lower Jurassic are biostratigraphic marker taxa because of their short range and world-wide occurrences. Therefore, the upper part of the *Parahsuum simplum* Assemblage-zone with species of *Katroma* is probably assignable to upper Sinemurian to upper Pliensbachian.

Introduction

Since 1980, attention of radiolarian workers of the world has been focused on early Jurassic radiolarians because of the lack of sufficient data on their stratigraphic distribution, morphology and phylogeny. Pessagno and his colleagues and De Wever systematically described Early Jurassic radiolarian species from North America, Turkey and Greece (Pessagno and Blome, 1980; Pessagno and Poisson, 1981; De Wever, 1982a, b; Pessagno and Whalen, 1982, *etc.*). In Japan, Yao, Matsuda and Isozaki (1980) were the first to document the occurrence of an early Jurassic radiolarian assemblage from the bedded cherts of the Inuyama area. Yao (1982) described these early Jurassic radiolarians and named this assemblage the *Parahsuum simplum* Assemblage. Later, numerous biostratigraphic studies of early Jurassic radiolarians have followed to establish detailed radiolarian zones. However, a number of early Jurassic radiolarian species still remain undescribed, because paleontological studies have not been carried out to the fullset extent except for those by Isozaki and Matsuda (1985), Kishida and Hisada (1985), Yoshida (1986), Hori and Yao (1988) and Sashida (1988). The purpose of this paper is to describe the earliest Jurassic radiolarians of the genera *Katroma, Gigi* and *Syringocapsa,* from the bedded cherts in the Inuyama area (Mino Terrane), the Inner Zone of Southwest Japan. These species are significant in establishing an Early Jurassic correlation of radiolarian zones between Japan and other areas in the world, because 1) they are short ranged and co-occur with well-known index species reported from east-central Oregon, Queen Charlotte Islands, British Columbia and Turkey, and 2) they occur commonly from the Lower Jurassic rocks throughout Southwest Japan, with

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*Received June 9, 1988; revised manuscript accepted September 1, 1988.

the diagnostic species of the *Parahsuum simplum* Assemblage (Yao, 1982), first recognized and described as an early Jurassic radiolarian assemblage in Japan as mentioned above.

Acknowledgments

The present author wishes to express her thanks to Dr. Akira Yao of Osaka City University for his helpful advice and critical reading of her manuscript. Sincere thanks are due to Dr. Yukio Isozaki of Yamaguchi University for his encouragement and critical reading of the manuscript.

Geologic setting

This paper deals with radiolarians mainly from the Inuyama area (Mino Terrane), Southwest Japan. In addition to the Inuyama area, the present author carried out a supplementary and comparative examination of radiolarians from three other areas, the Norikuradake area, the Kuzu area and the Kuma area, Southwest Japan.

1. The Inuyama Area (lat. 35°25± 2'N., long. 136°58± 2'E.)

The Mino Terrane in the Inner Zone of Southwest Japan is composed of a Paleozoic and Mesozoic sedimentary complex consisting of greenstone, limestone, radiolarian chert and detrital clastic rocks, that is interpreted as the Jurassic (partly earliest Cretaceous?) subduction complex (Wakita, 1987; Otsuka, 1988). The Inuyama area is located in the southwestern part of the Mino Terrane, approximately 40km north of Nagoya City (Fig. 1).

The sedimentary complex of the Inuyama area comprises bedded chert and clastic rocks, and it forms a large westward-plunging synform

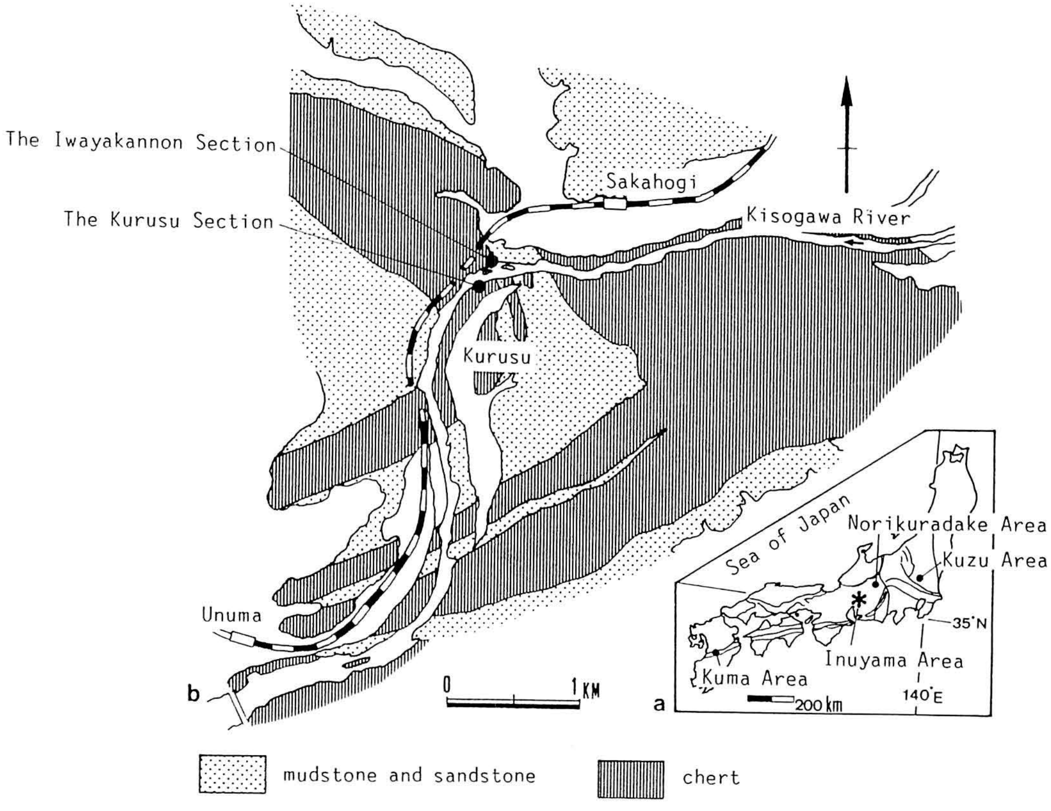


Figure 1. Index map of study areas (a) and geological sketch map of the Inuyama area (modified from Kondo and Adachi, 1975; Yao, Matsuda and Isozaki, 1980) and study sections are shown in it (b).

called the "Sakahogi Syncline" of Mizutani (1964). The bedded chert, more than 100m thick, ranges from Middle Triassic (partly late Early Triassic?) to Early Jurassic in age. The clastics, less than 300m thick, consist of siliceous mudstone, mudstone, sandstone, tuffaceous mudstone and pebbly mudstone, all of which are Middle Jurassic in age. The Triassic to Lower Jurassic chert and the overlying Middle Jurassic clastics, a pair of which is tentatively called the chert-clastics sequence (defined by Otsuka, 1985) in this paper, are tectonically repeated at least four times in this area (Yao, Matsuda and Isozaki, 1980) as shown in Fig. 1.

The chert-clastics sequence, beautifully exposed along the Kisogawa River in the Inuyama area, has been investigated by many workers to establish a Triassic and Jurassic radiolarian biostratigraphy. Yao (1972, 1979), and Ichikawa and Yao (1976) systematically described Middle Jurassic radiolarians (the *Unuma echinatus* Assemblage) from manganese nodules occurring in a red siliceous mudstone of this area. Nakaseko and Nishimura (1979) described Upper Triassic radiolarians from the bedded cherts of this area. Yao, Matsuda and Isozaki (1980) revealed continuous faunal change of Middle Triassic to Lower Jurassic radiolarians in a bedded chert sequence of this area. They carefully examined an individual bedded chert sequence in a continuous outcrop and clarified the vertical distribution of conodonts and radiolarians. Consequently, they documented for the first time successive occurrences of latest Triassic (Rhaetian) and early Jurassic radiolarians.

The present author studied two other continuous bedded chert sections in this area, namely the Iwayakannon Section and the Kurusu Section (Fig. 1). The former section ranges from the uppermost Triassic to Lower Jurassic and the latter section represents only the Lower Jurassic.

1-a. Iwayakannon Section (lat. 35°25'06"N., long. 136°58'07"E.)

This section is located on the right bank of the Kisogawa River, approximately 1.2 km (distance in a straight line) west-southwest of the Sakahogi railway station, in Sakahogi Town, Gifu Prefecture (Fig. 1). The bedded chert of this section, approximately 25m thick, consists of a rhythmically interbedded sequence of chert and mudstone. The thickness of individual chert layer varies from 2 to 9 cm (mostly 3.5–4 cm), and that of mudstone layer is mostly a few millimeters, with the exception of one layer of several centimeters in thickness lying between IYII14 and IYII15 (Fig. 2). The strike of the bedded chert generally trends in a north-northwest to northwest direction and dips steeply westward or almost vertically. The color of the chert varies considerably, exhibiting green, gray, red, white and black hues. The base of the section is sharply bounded by a fault, resting directly on the exposure of Upper Triassic bedded chert. At the top of the section, on the other hand, the chert is coherent with a pale green Middle Jurassic tuffaceous mudstone, from which characteristic species of the *Unuma echinatus* Assemblage (Yao, Matsuda and Isozaki, 1980) are obtained. From the top of the section, characteristic species of the *Parahsuum* (?) *grande* (= *Parahsuum* sp. D) Assemblage (Yao, Matsuoka and Nakatani, 1982) are extracted. A stratigraphic break, equivalent to one radiolarian assemblage-zone (the *Hsuum hisuikyoense* Assemblage-zone), is present between the top of the chert and the mudstone.

A sketch map of the outcrop is shown in Fig. 2 and sampling points are marked on it. The lithologic column of the section and stratigraphic distribution of representative species in this section are illustrated in Fig. 3.

Three early Jurassic radiolarian assemblages, namely the *Parahsuum simplum* Assemblage (Yao, 1982), the *Acanthocircus hexagonus* Assemblage (Hori, 1987) and the *Parahsuum* (?) *grande* (= *P.* sp. D) Assemblage (Yao, Matsuoka and Nakatani, 1982) in ascending order, are recognized in this section. Radiolarian specimens analyzed were obtained from Samples IYII27, IYIII1 and IYII24. These samples are biostratigraphically assignable to the lower part of the *Parahsuum simplum* Assemblage-zone.

1-b. Kurusu Section (lat. 35°25'01"N., long. 136°58'02"E.)

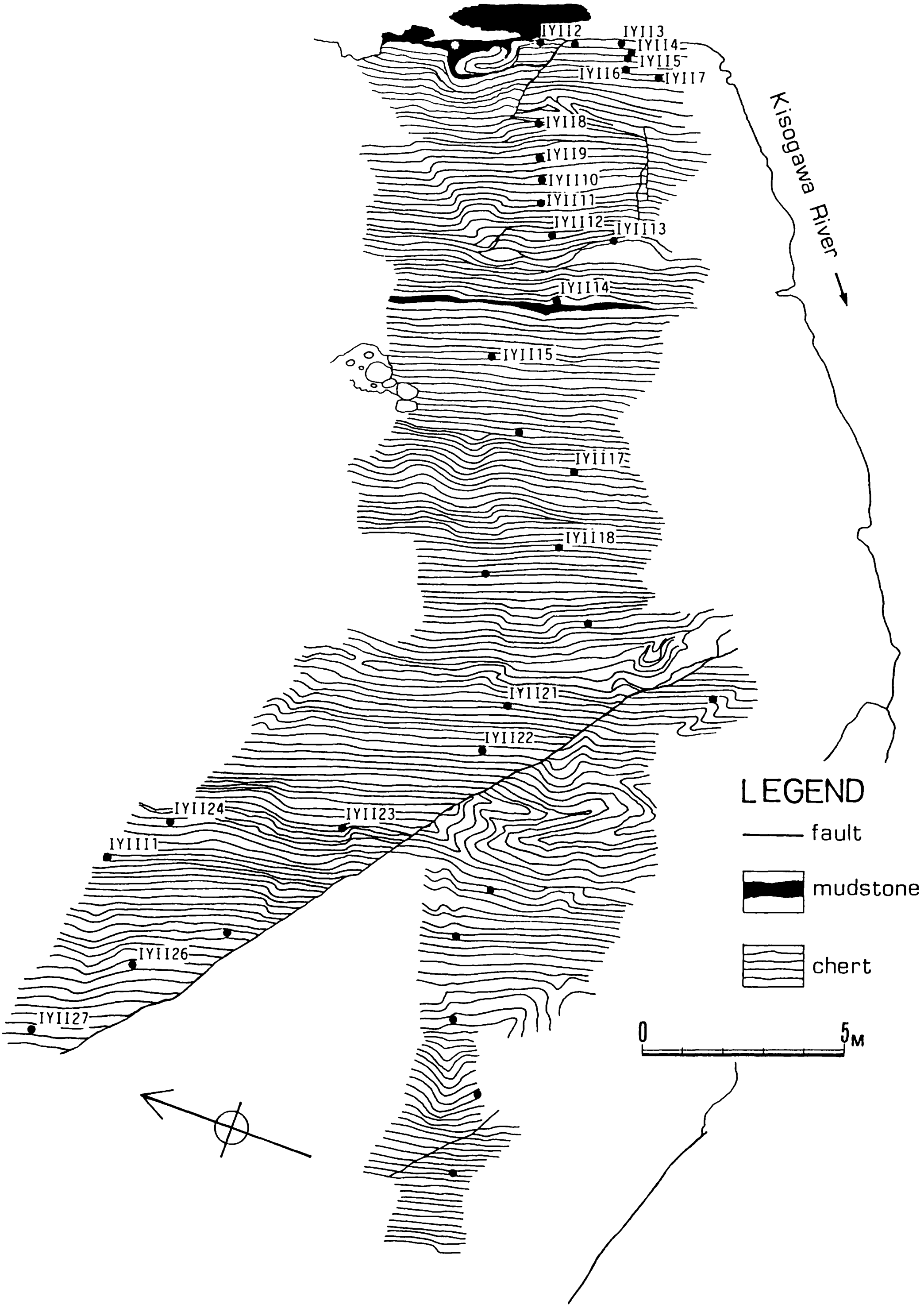


Figure 2. Sketch map of the outcrop of the Iwayakannon Section and sampling points marked on it.

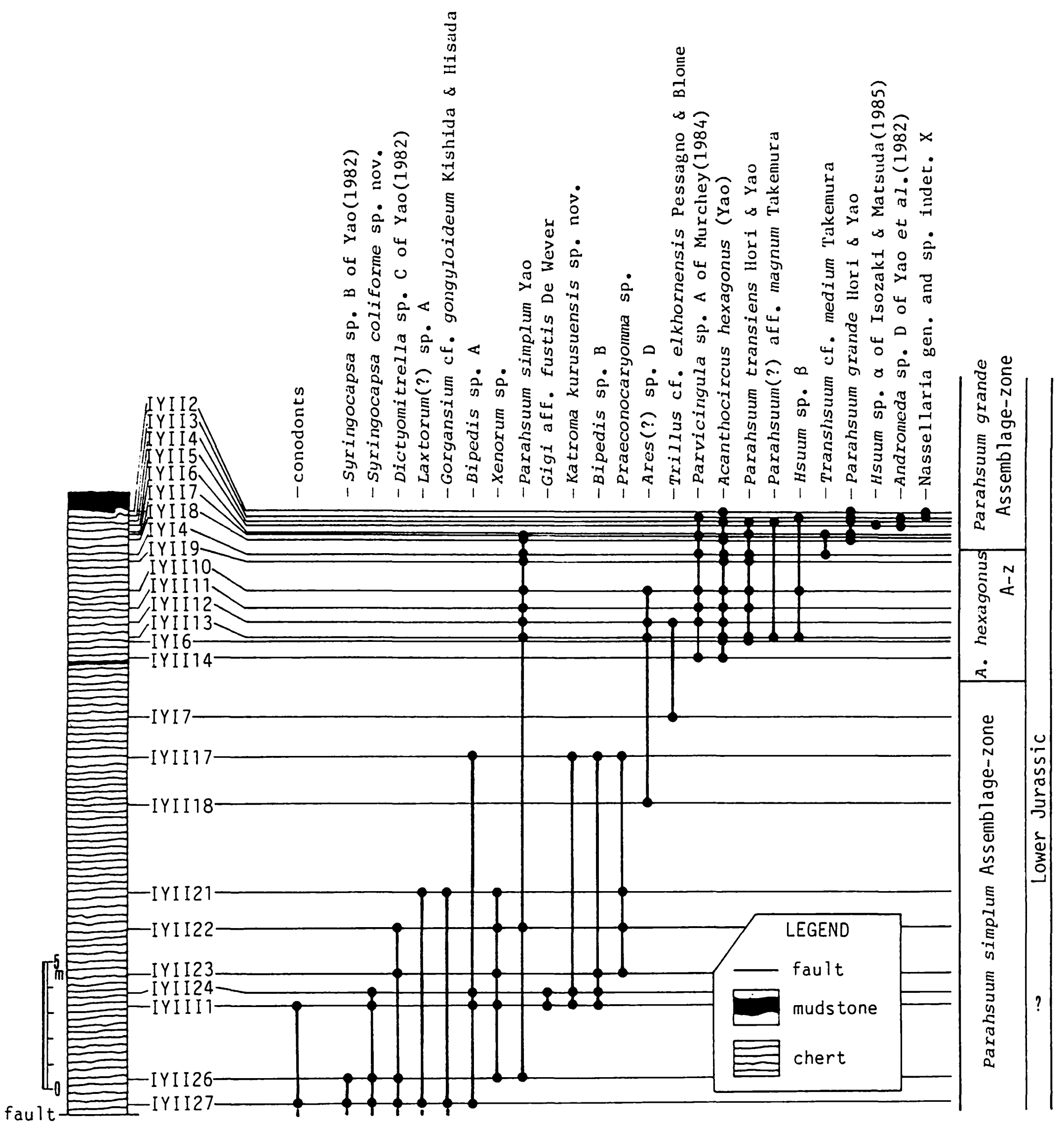


Figure 3. Lithologic column of the Iwayakannon Section and stratigraphic distribution of representative species.

This section is located on the left bank of the Kisogawa River, about 0.4 km north of the Kurusu village, Inuyama City, Aichi Prefecture (Fig. 1). This section is composed of a rhythmically interbedded sequence of chert and mudstone. The thickness of individual chert layer varies from 1 to 7 cm (mostly 4–4.5 cm), and the mudstone layer is very thin (mostly 1–3mm) except for one layer (ca. 10cm thick) occurring below KU(a)5. The Lower Jurassic portion of the bedded chert in this section, attaining 35m in thickness, is conformably underlain by an Upper Triassic bedded chert. The top of the section is covered with river gravels and sands. The chert exhibits a wide range of color, varying from mostly gray and green to partly red. The bedded chert generally strikes N 35–40°W and dips 50–60°S. In these chert layers, some sedimentary structures such as convolute lamination are observed. Carbonate veins ((Ca,Mn)CO_3) of

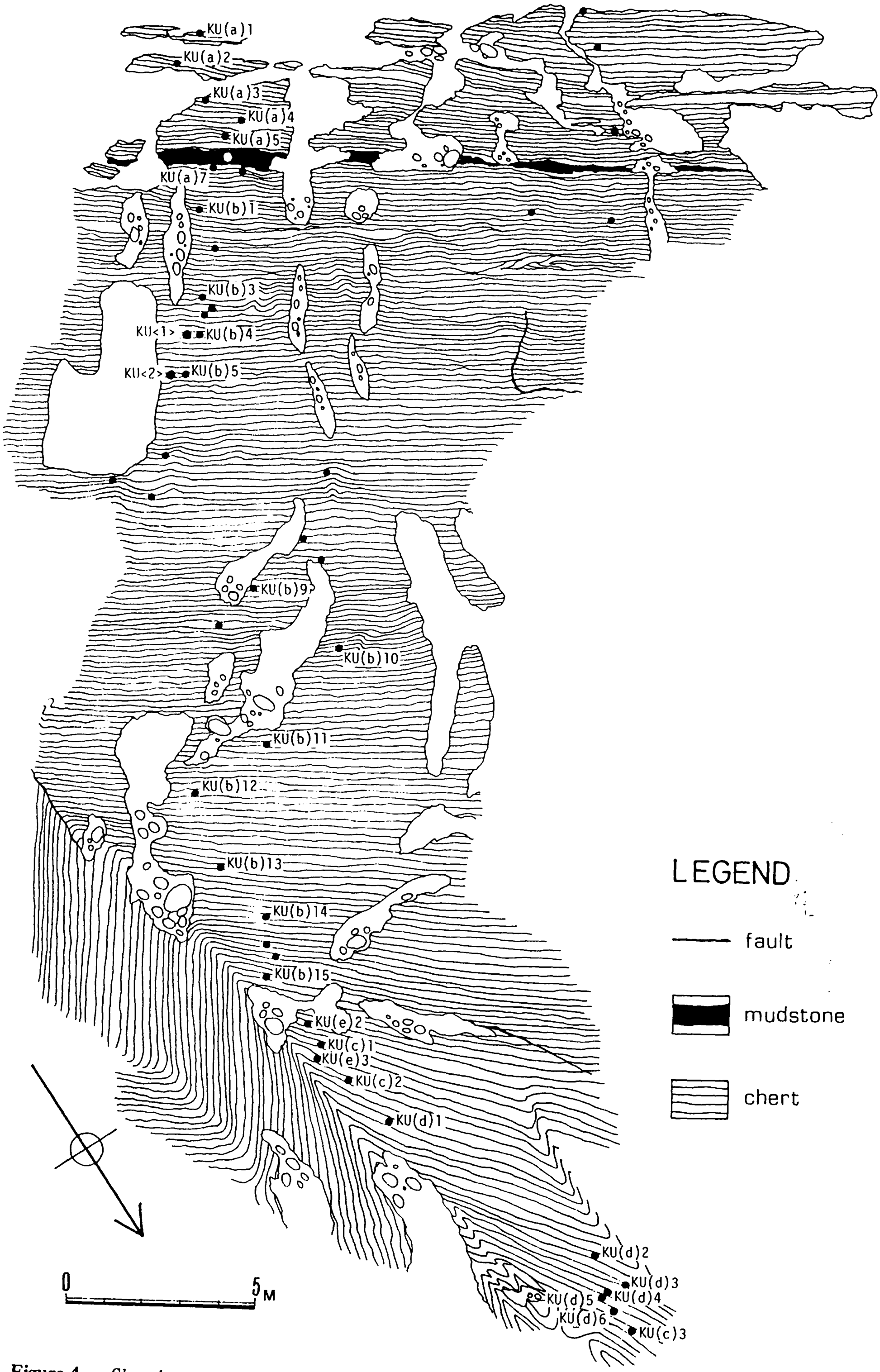


Figure 4. Sketch map of the outcrop of the Kurusu Section and sampling points marked on it.

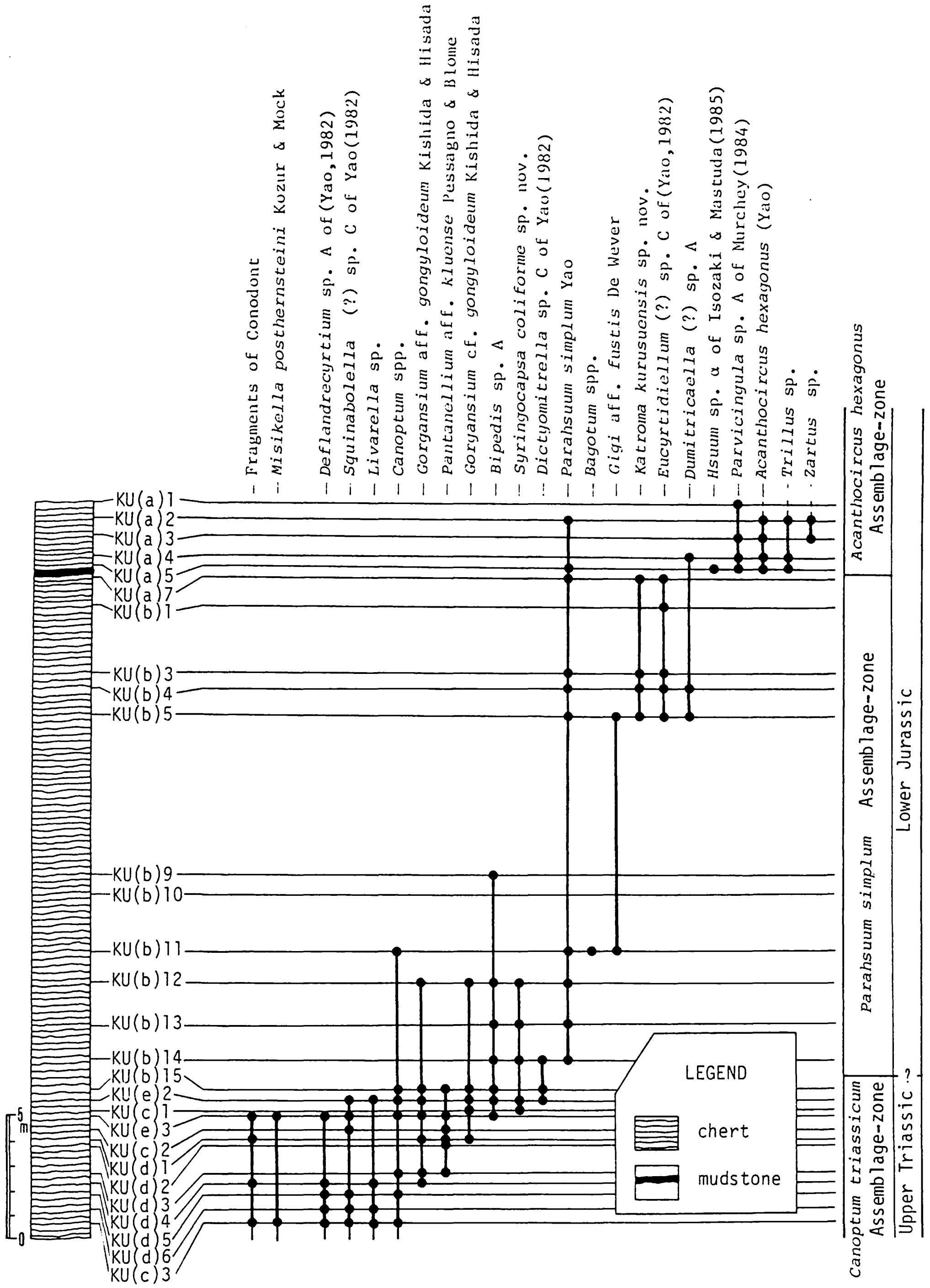


Figure 5. Lithologic column of the Kurusu Section and stratigraphic distribution of representative species.

several millimeters thick intruded the bedded chert at some horizons in this section.

A sketch map of the outcrop is shown in Fig. 4 and sampling points are marked on it. The lithologic column of the section and stratigraphic distribution of representative species in this section are shown in Fig. 5.

Three radiolarian assemblages of a late Triassic to early Jurassic age, namely the *Canoptum triassicum* Assemblage (Yao, 1982), the *Parahsuum simplum* Assemblage (Yao, 1982) and the *Acanthocircus hexagonus* Assemblage (Hori, 1987) in ascending order, are recognized in this section. The latest Triassic (Rhaetian) conodont *Misikella posthernsteini* Kozur and Mock occurred together with the characteristic species of the *Canoptum triassicum* Assemblage in the lower part of the section (Samples, KU(c)3 and KU(e)3). Five biohorizons useful for age assignment in this section are the final occurrence of *M. posthernsteini* (KU(e)3), the first and final occurrences of *Pantanellium* aff. *kluense* (KU(d)3, KU(b)15), the presence of *Bagotum* spp. (KU(b)11) and the first occurrence of the genus *Trillus* (KU(a)5).

Radiolarian specimens analyzed were obtained from Samples KU(b)5, KU<2>, KU(b)4 and KU<1>. These samples belong biostratigraphically to the upper part of the *Parahsuum simplum* Assemblage-zone.

2. The Norikuradake Area (lat. 36°8± 1'N., long. 137°37± 1'E.)

This area is about 35km west of Matsumoto City, Nagano Prefecture, in the eastern part of the Mino Terrane, the Inner Zone of Southwest Japan (Fig. 1). According to Otsuka (1988), the Mesozoic sedimentary complex of this area, namely the Yukawa Complex, is composed of Jurassic chert, siliceous mudstone, mudstone and sandstone. The present samples were obtained from a bedded chert in the chert-clastics sequence of this complex.

3. The Kuzu Area (lat. 36°26± 4'N., long. 139° 35± 4'E.)

This area is about 85km north of Tokyo, in the Ashio Terrane that is regarded as the eastern extension of the Mino Terrane (Fig. 1). Igo and Nishimura (1984) reported early Jurassic radiolarians from continuous chert sequences of the "Adoyama Formation". The present samples were obtained from bedded cherts of this "formation"

4. The Kuma Area (lat. 32°21± 4'N., long. 130° 37± 4'E.)

This area is situated along the midstream of the Kumagawa River, Kumamoto Prefecture, Kyushu, in the Chichibu Terrane, the Outer Zone of Southwest Japan (Fig. 1). The biostratigraphy of Late Paleozoic and Mesozoic radiolarians has been studied in this area and approximately 20 radiolarian zones from the Permian to Cretaceous interval were proposed by Nishizono *et al.* (1982), Nishizono and Murata (1981), Sato and Nishizono (1983) and Sato, Murata and Yoshida (1986). The present samples were obtained from bedded cherts and mudstones in this area.

Methods and materials

A chert sample weighing about 0.6 kg was collected from each single layer of bedded chert. Samples were treated with a 5% solution of hydrofluoric acid for 18–20 hours and then rinsed with tap water. Residues retained on a 74-μm opening screen were boiled in a solution containing the equal volume of 36% hydrochloric acid, 61% nitric acid and water for a few minutes to dissolve any remaining organic matter and then washed thoroughly if further cleaning is needed. More than one glass slide made for residues of every sample was investigated by a transmitted light microscope. Residues containing well-preserved radiolarians as well as those representing any important biohorizon, were dried, and then 100–200 specimens were hand-picked with the aid of binocular microscope and observed by a scanning electron microscope. However, specimens from the bedded cherts treated in this study are not preserved well enough to describe their internal structures because of strong recrystallization and replenishment with silica. The type and figured specimens have been deposited and registered in the Department of Geosciences, Osaka City University. In the section of Systematic paleontology and figure captions, the OCU MR number refers to the registration number of the specimen at the reposition. The number following F or FL represents photograph number, and other unaccompanied number refers to individual specimen.

Systematic paleontology

Subclass RADIOLARIA Müller, 1858

Superorder POLYCYSTINA Ehrenberg, 1838, emend. Riedel, 1967

Order NASSELLARIA Ehrenberg, 1875

Family SYRINGOCAPSIDAE Foreman, 1973

Type genus: *Syringocapsa* Neviani, 1900, p. 662.

Diagnosis: Original definition by Foreman (1973, p. 265) "Cyrtoidea with the multiple segments of the proximal part very small and the single segment of the distalmost part very large and expanded. A terminal tube may or may not be present. None of the proximal segments are hidden and the cryptocephalic and cryptothoracic nassellaria of Dumitrica (1970) are therefore excluded."

Remarks: Foreman (1973) originally defined this group belonging to the subfamily Syringocapsinae. Afterward, Pessagno (1977, p. 90) suggested that this subfamily should be treated as a family.

Constituent genera: *Dibolachras* Foreman, 1973; *Podobursa* Wisniowski, 1889; *Podocapsa* Rüst, 1885; *Sethocapsa* Haeckel, 1881; *Syringocapsa* Neviani, 1900; *Trisyringium* Vinassa, 1901; *Urocyrtis* Pantanelli, 1880; *Gigi* De Wever, 1982a; *Katroma* Pessagno and Poisson, 1981, emend. De Wever, 1982a.

Genus *Katroma* Pessagno and Poisson, 1981, emend. De Wever, 1982

1981 *Katroma* Pessagno and Poisson, p. 62.

1982a *Katroma* Pessagno and Poisson, emend. De Wever, p. 193.

1982b *Katroma* Pessagno and Poisson, emend. De Wever – De Wever, p. 303.

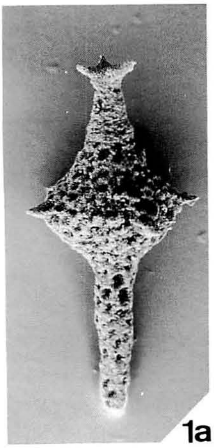
1987 *Katroma* Pessagno and Poisson – Yeh, p. 79

Type species: *Katroma neagui* Pessagno and Poisson, 1981, p. 62 (pl. XII, figs. 1–5, pl. XV, fig. 3.)

Diagnosis: Test composed of 3 or 4 chambers, cephalis, thorax, abdomen and/or postabdomen, and tube. Outline of test forming spindle-shape with radial spines on the most expanded part of test. Cephalis hemispherical with some horns or a branched apical horn. Thorax forming truncated cone. Cephalo-thorax conical without developed strictures. The last chamber, abdomen or a post-abdominal chamber, hemispherical larger than previous chambers and with solid spines radially arranged on the medial part. Tube porous and elongated conical to cylindrical.

Remarks: Pessagno and Poisson (1981, p. 62) defined this group as a new genus which differs from *Podobursa* Wisniowski by having an open tube on its final post-abdominal chamber. De Wever (1982a, b) emended its definition, pointing out that most of the species belonging to this genus possess closed tubes. Therefore, the terminal form of the tube is not an important character to distinguish *Katroma* from *Podobursa*. De Wever indicated that this genus differs from *Podobursa* by having three chambers and spines (apical and others) on cephalis. The number of chambers, however, is not significant to distinguish *Katroma* from *Podobursa*, because some species of *Podobursa* (*e.g.*, *Podobursa tricola* Foreman, 1973) possess three chambers as those of *Katroma* do. Accordingly, *Katroma* is distinguished from *Podobursa* by having plural spines and/or a branched spine, or both on cephalis and by lacking developed strictures on the proximal portion of the test.

Katroma is also morphologically similar to *Dibolachras* Foreman, 1973, *Podocapsa* Rüst, 1885 and *Gigi* De Wever, 1982a. *Dibolachras* is distinct from *Katroma* in the same characters as *Podobursa* by lacking plural spines, or a branched one, on cephalis and by having strong strictures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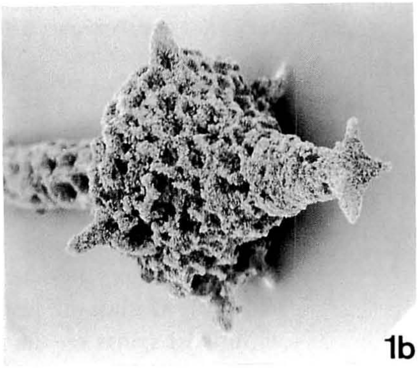
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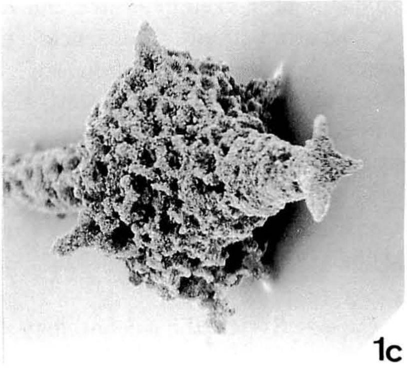
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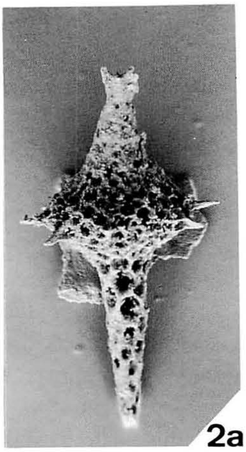
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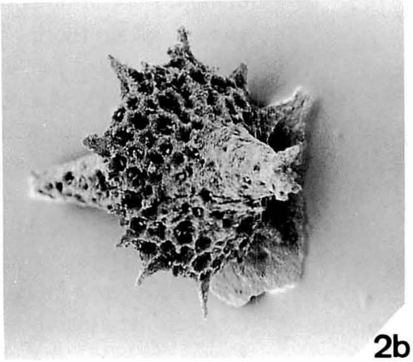
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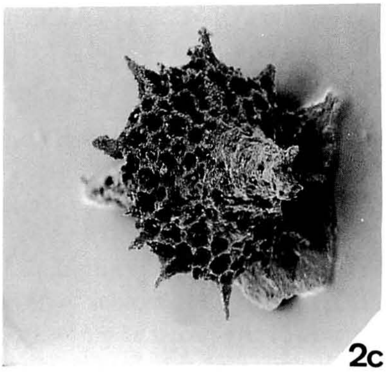
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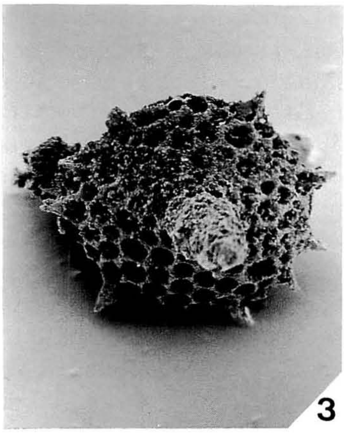
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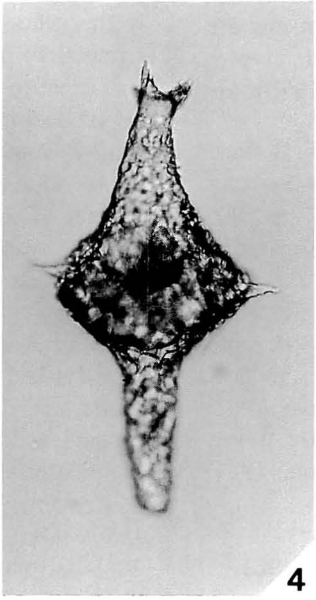
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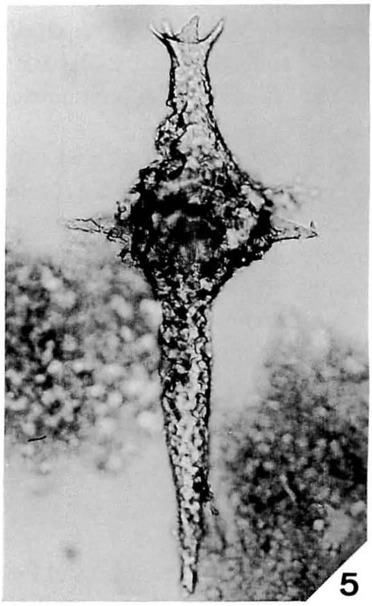
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Table 1. Measurements of *Katroma kurusuensis*, sp. nov.

Specimen	Fig.	Width	Total Height	Length of Tube	Length of Spine	Number of Branch
KU<2>I/II No.1(36.4x91.8)		117.1	321.4+	135.3+	23.0	4
KU<2>I/II No.1(36.0x93.0)	1-4	137.4	316.6+	110.7+	26.7	3
* KU(b)5 No.1(46.8x89.4)	1-5	118.2	406.4	209.6	38.3	4
KU<2>-24		116.4	286.2+	118.4+	----	3?
KU<2>-23		112.5	349.3	178.3	26.3	3
** KU<2>-21	1-1a-1c	120.4	307.2+	125.0+	24.3	4
KU<1>-11		100.7	271.1	122.4	21.7	3?
KU<1>-12		119.1	315.8	145.4	----	--
KU(b)4-11	1-2a-2c	132.2	312.5	137.5	24.8	3
KU(b)4-21		128.3	283.6	136.8	27.6	3?
KU(b)5II-15		132.9	306.6+	132.9+	----	4
KU(b)5II-16		128.9	334.2	148.0	----	4?
KU(b)5II-22		75.0	203.3	89.5	22.4	3?
KU(b)5II-31		78.3	277.6	125.7	----	3
KU(b)5II-35		117.1	284.9	125.7	27.0	3
Average		115.6	305.1	136.1	26.2	
Maximum		137.4	406.4	209.6	38.3	
Minimum		75.0	203.3	89.5	21.7	

** : Holotype, * : Paratype

on the proximal portion of the test. *Katroma* differs from *Podocapsa* by lacking porous wings and by having a branched apical horn. *Gigi* can be discriminated from *Katroma* by lacking circumferential spines.

Constituent species: *Katroma neagui* Pessagno and Poisson, 1981, emend. De Wever, 1982a; *Katroma bicornus* De Wever, 1982a; *Katroma* sp. A of De Wever (1982a); ? *Katroma* sp. 2 of De Wever (1982a); *Katroma milloti* Schaaf, 1984; *Katroma clara* Yeh, 1987; *Katroma* sp. B of Yeh (1987).

Katroma kurusuensis Hori, sp. nov.

Figures 6-1a–5

1986 *Katroma* sp. M – Hori, fig. 7.

Description: Test composed of 3 or 4 chambers. Cephalis with an apical horn having 3 or 4 branches; branches, triangular in cross-section. Cephalo-thorax conical without developing stricture. Abdomen or a post-abdominal chamber polygonal in axial section at most expanded portion. Six to 12 circumferential spines projected radially from the most expanded portion of test; spines solid, and triangular in cross-section. Terminal tube cylindrical to conical; distal end of tube closed. Meshwork consisting of circular to polygonal pore frame; pores becoming elliptical distally.

Measurements: (in micrometer; based on 15 specimens shown in Table 1).

Remarks: *Katroma kurusuensis* sp. nov. morphologically resembles *Katroma clara* Yeh, but the former species differs from the latter species

←— **Figure 6.** *Katroma kurusuensis*, sp. nov.

1a–c. Holotype, OCU MR 4000, KU<2>-21

(b) and **(c)** stereoscopic pair, oblique apical view **(a)** x 150, **(b)**, **(c)** x 300

2a–c. OCU MR 4002, KU(b)4–11 **(b)** and **(c)** stereoscopic pair, oblique apical view **(a)** x 150, **(b)**, **(c)** x 225

3. OCU MR 4003, KU(b)4–12, oblique basal view, x 225

4. OCU MR 4004, KU<2> I/II No. 1 (36.0x93.0), x 187

5. Paratype, OCU MR 4001, KU(b)5 No. 1 (46.8x89.4), x 187

All figures are scanning electron micrographs except for **4**, **5** transmitted light photomicrographs.

by having longer and bladed circumferential spines, and by possessing a horn with 3 to 4 branches; branches are triangular in cross-section. *K. kurusuensis* differs from both *K. neagui* Pessagno and Poisson and *K. bicornus* De Wever by possessing an apical horn with 3 or 4 branches; branches are triangular in cross-section. *K.* sp. M (Hori 1986, p. 52, fig. 7) is a provisional name given to this species.

Etymology: This name is derived from the type locality of this species, Kurusu village, Inuyama City, Aichi Prefecture.

Type species: Holotype, OCU MR 4000 (F02670) (KU<2>-21) from the Kurusu Section. Paratype, OCU MR 4001 (FL002-19) (KU(b)5 No.1 (46.8x89.4)) from the Kurusu Section.

Type locality: The Kurusu Section, Inuyama area, Inuyama City, Aichi Prefecture, central Japan.

Occurrence: Southwest Japan; Inuyama area (Mino Terrane), Kuma area (Chichibu Terrane), Kuzu area (Ashio Terrane).

Range: Middle Early Jurassic (Sinemurian to Pliensbachian).

In the Kurusu Section, the horizon of the first occurrence of this species (Sample KU(b)5) is 9.58m above the horizon of occurrence of *Bagotum* spp. This implies that *K. kurusuensis* firstly appeared later than species of *Bagotum.* According to Pessagno and Whalen (1982), the oldest species of *Bagotum* (*Bagotum erraticum* Pessagno and Whalen) appeared in the Sinemurian part of the Kunga Formation (QC 549), Queen Charlotte Islands, British Columbia, Canada. Therefore, the first appearance of *K. kurusuensis* was during a post-Sinemurian or Sinemurian time. In the UC Section of the Inuyama area (Hori, 1986), the first occurrence horizon of this species is below the final occurrence horizon of *Pantanellium* cf. *danaense* Pessagno and Blome, 1980. *P. danaense* was reported from the Rhaetian(?)-Hettangian interval and the upper Upper Sinemurian part (*Echioceras raricostatum* Zone) of the Kunga Formation (Pessagno and Blome, 1980). Taking the above-mentioned facts into account, *K. kurusuensis* presumably first appeared during the Sinemurian.

In both the Kurusu and the Iwayakannon Sections, the final occurrence horizon of *K. kurusuensis* is below the first occurrence horizon of the genus *Trillus.* However, in the UC Section (Sample UC6), *K. kurusuensis* (= *K.* sp. M) occurred together with *Trillus* cf. *elkhornensis* Pessagno and Blome. The co-occurrence of *Trillus elkhornensis* and *Katroma* was reported from the Upper Pliensbachian part of the Nicely Formation (*Amaltheus margaritatus* Zone – *Pleuroceras spinatum* Zone), eastern Oregon (Pessagno and Blome, 1980). Thus, the range of *K. kurusuensis* probably extends upwards at least to the upper Pliensbachian.

Katroma sp. N

Figures 7-1–3

1986 *Katroma bicornus* De Wever – Sashida *et al.*, p. 42–43, fig. 5-1
1987 *Katroma* sp. B – Yeh, pl. 5, fig. 20, pl. 6, fig. 3.

Remarks: This species is distinguished from *K. kurusuensis*, sp. nov. and *K. bicornus* De Wever in having only an apical horn of varying forms. *K.* sp. N has an apical horn which bears very small spines at its medial portion (Fig. 7-3).

Katroma sp. N differs from *K. neagui* Pessagno and Poisson in having solid and bladed circumferential spines.

Measurements: (in micrometer; based on 8 specimens shown in Table 2).

Occurrence: Southwest Japan; Inuyama area (Mino Terrane), Kuma area (Chichibu Terrane).

Genus *Syringocapsa* Neviani, 1900

1900 *Syringocapsa* Neviani, p. 662.
1901 *Trisyringium* Vinassa, p. 507.
1954 *Trisyringium* Vinassa – Campbell, p. D142.
1973 *Syringocapsa* Neviani – Foreman, p. 268.
1975 *Syringocapsa* Neviani – Foreman, p. 617.
1979 *Syringocapsa* Neviani – De Wever *et al.*, p. 91.
1981 *Syringocapsa* Neviani – Petrushevskaya, p. 188.
1982b *Syringocapsa* Neviani – De Wever, p. 290–291.
April 1984 *Syringocapsa* Neviani – Blome, p. 52–53.
December 1984 *Syringocapsa* Neviani – Baumgartner,

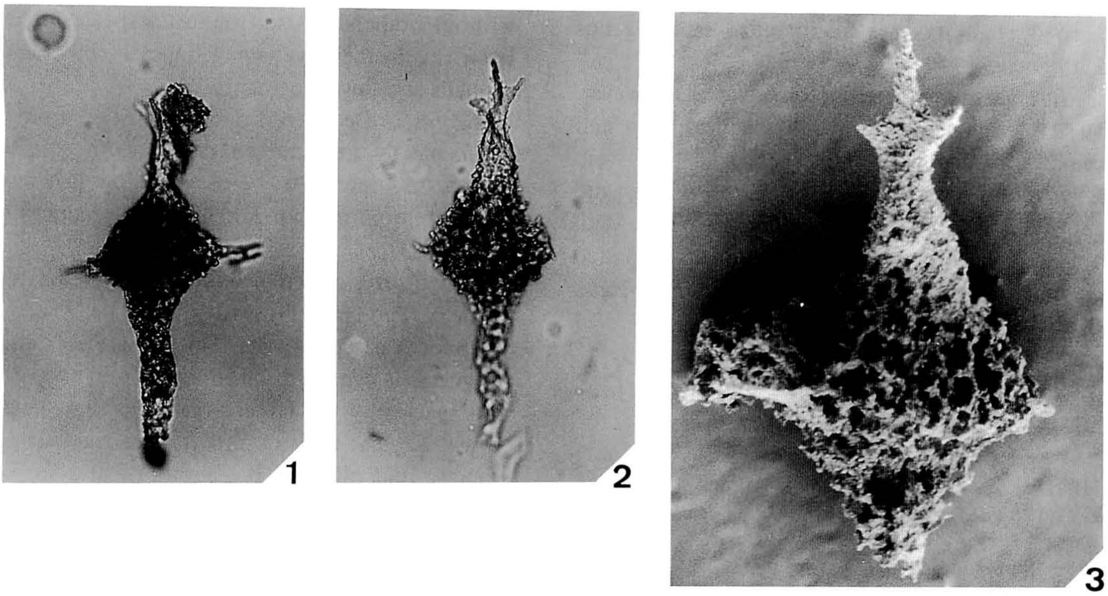

Figure 7. *Katroma* sp. N.
1. OCU MR 4005, KU<2>I/II No. 1 (38.4x95.0), x 155
2. OCU MR 4006, KU<2>I/II No. 1 (38.2x92.0), x 155 **3.** OCU MR 4007, KU(b)5–16, x 300
1, 2 are transmitted light photomicrographs except for **3**, scanning electron micrograph.

Table 2. Measurements of *Katroma* sp. N

Specimen	Fig.	Width	Length of Cephalic Part	Total Height	Length of Tube	Length of Spine
KU<2>I/II No.1(38.4x95.0)	7-1	109.6	176.5	317.6+	131.6+	33.7
KU<2>I/II No.1(38.2x92.0)	7-2	106.4	195.7	322.5+	128.9+	18.7+
KU(b)5-04	7-3	109.9	189.5	-----	-----	50.0
KU(b)5-07		79.6+	209.2	-----	-----	30.3
KU(b)5-09		152.0	230.3	-----	-----	27.0
KU(b)5II-18		81.6	184.9	307.9	123.0	46.1
KU(b)5II-28		110.5	184.9	-----	-----	----
KU(b)5II-38		97.4+	190.8	307.2	116.4	----
Average		105.9	195.2	313.8	125.0	34.3
Maximum		152.0	230.3	322.5+	131.6+	50.0
Minimum		79.6+	176.5	307.2	116.4	18.7+

p. 786.

Type species: *Theosyringium robustum* Vinassa, 1900, p. 343 (pl. 3, fig. 30), by monotype.

Diagnosis: Test comprising 2 to 4 chambers, cephalis, thorax or abdomen, or both, possibly more chambers, and closed tube. Outline of test forming spindle-shape without radial spines, with some strictures weakly or strongly developing at joints of chambers. Cephalis with or without an unbranched apical horn. The last chamber most expanded.

Remarks: Since Foreman (1973) treated the genus *Syringocapsa* as the type genus of the subfamily Syringocapsinae, several species of *Syringocapsa*, including some new species, have been described. According to the original description by Neviani (1900), *Syringocapsa* is defined to possess 3 chambers, however, most of the species belonging to *Syringocapsa* possess more than 3 chambers. Therefore, syringocapsids with

2 to 4 chambers are all included in the genus *Syringocapsa.*

Syringocapsa differs from *Gigi* De Wever, 1982a by lacking a crown-like apical horn and spines on cephalis. This genus differs from *Dibolachras* Foreman, 1973, *Katroma* Pessagno and Poisson, 1981, and *Podobursa* Wisniowski, 1889 by lacking spines on the most expanded chamber. *Syringocapsa* differs from *Podocapsa* Rüst, 1885 by lacking porous wings.

Syringocapsa coliforme Hori, sp. nov.

Figures 8-1–10

March 1982 *Syringocapsa* sp. C – Yao, pl. 4, fig. 16.
June 1982 *Syringocapsa* sp. C – Yao *et al.*, pl. 2, fig. 14
1983 *Syringocapsa* sp. C – Yao, fig. 2–18.
March 1983 *Syringocapsa* sp. C of Yao – Ishida, pl. 1, fig. 10.
? 1985*Katroma triangularis* Kishida and Hisada, pl. 3, fig. 6,7.
1986 *Katroma* sp. – Matsuoka and Yao, pl. I, 1.
1986 *Syringocapsa* sp. C (Yao, 1982) – Hori, fig. 6-5
December 1986 *Syringocapsa* sp. A – Yoshida, p. 17, pl. 6, fig. 11.

Description: Test consisting of 2 or 3 chambers, long, slender, spindle-shaped with closed tube. Cephalis small, having a solid, long apical horn, which terminating in a point. Apical horn smooth, mostly circular in cross-section. Some specimens possessing a slender, weak-bladed apical horn. Cephalo-thorax conical forming tear-shaped with weak strictures. The distalmost chamber expanded, decreasing rapidly in width at joint of the tube. Tube, long, slender, conical, closed, and terminating in a pointed spine. Meshwork of test consisting of polygonal to circular pore frames. Average ratio of height to maximum width, approximately 3.9:1.

Measurements: (in micrometer; based on 29 specimens shown in Table 3).

Remarks: *Syringocapsa coliforme* sp. nov. is very similar to *Gigi* sp. aff. *G. fustis* De Wever (described below) in its size and shape, but the former is distinguished from the latter by possessing a short, conical tube, and a larger proximal portion of test and a simple long horn without branches. Also, the latter species differs from the former by having delicate spine(s) on cephalis and fewer segments.

G. fustis De Wever is distinguished from *S. coliforme* by the same characters as those of *G.* aff. *fustis* described below and by having a globular proximal portion of test and smoother surface.

S. coliforme also morphologically resembles *S.* sp. A of Yao (pl. 3, fig. 12 in Yao, 1982) and *S.* sp. B of Yao (pl. 4, figs. 14, 15 in Yao, 1982). However, it can be discriminated from the latter two species by the larger average ratio of height to width. That ratio of *S. coliforme* is about 3.9, whereas that of *S.* sp. B is about 1.7 and *S.* sp. A is about 2.6.

Etymology: The species name is derived from the Latin compound word, *colus+formis,* meaning spindle-shaped.

Type specimen: Holotype, OCU MR 4008 (FL001-21) (IYII27II No. 1 (37.3x89.9)) from the Iwayakannon Section. Paratype, OCU MR 4016 (F01724) (IYII27II-19) from the Iwayakannon Section.

Type locality: The Iwayakannon Section, Inuyama area, Sakahogi-cho, Kamo-gun, Gifu Prefecture, central Japan.

Occurrence: Southwest Japan; Inuyama area (Mino Terrane), Norikuradake area (Mino Terrane), Kuzu area (Ashio Terrane).

Range: Latest Triassic (Rhaetian) to early Early Jurassic (Sinemurian ?).

In the Kurusu Section, the horizon of the first occurrence of *S. coliforme* (Sample KU(c)1) is situated at 22cm above the horizon of the final occurrence of the latest Triassic conodont *Misikella posthernsteini* (Sample KU(e)3) (Fig. 5). At the horizon of Sample KU(e)2, *S. coliforme* occurred with such late Triassic radiolarians, as *Squinabolella* (?) sp. C of Yao (1982) and *Livarella* sp. These facts indicate the horizon of the first occurrence of *S. coliforme* to be in the upper Triassic. Additionally, *S. coliforme* also occurred immediately below the horizon of the last occurrence of *Pantanellium* aff. *kluense* of Pessagno and Blome (1980). According to Pessagno and Blome (1980), *P.* aff. *kluense*

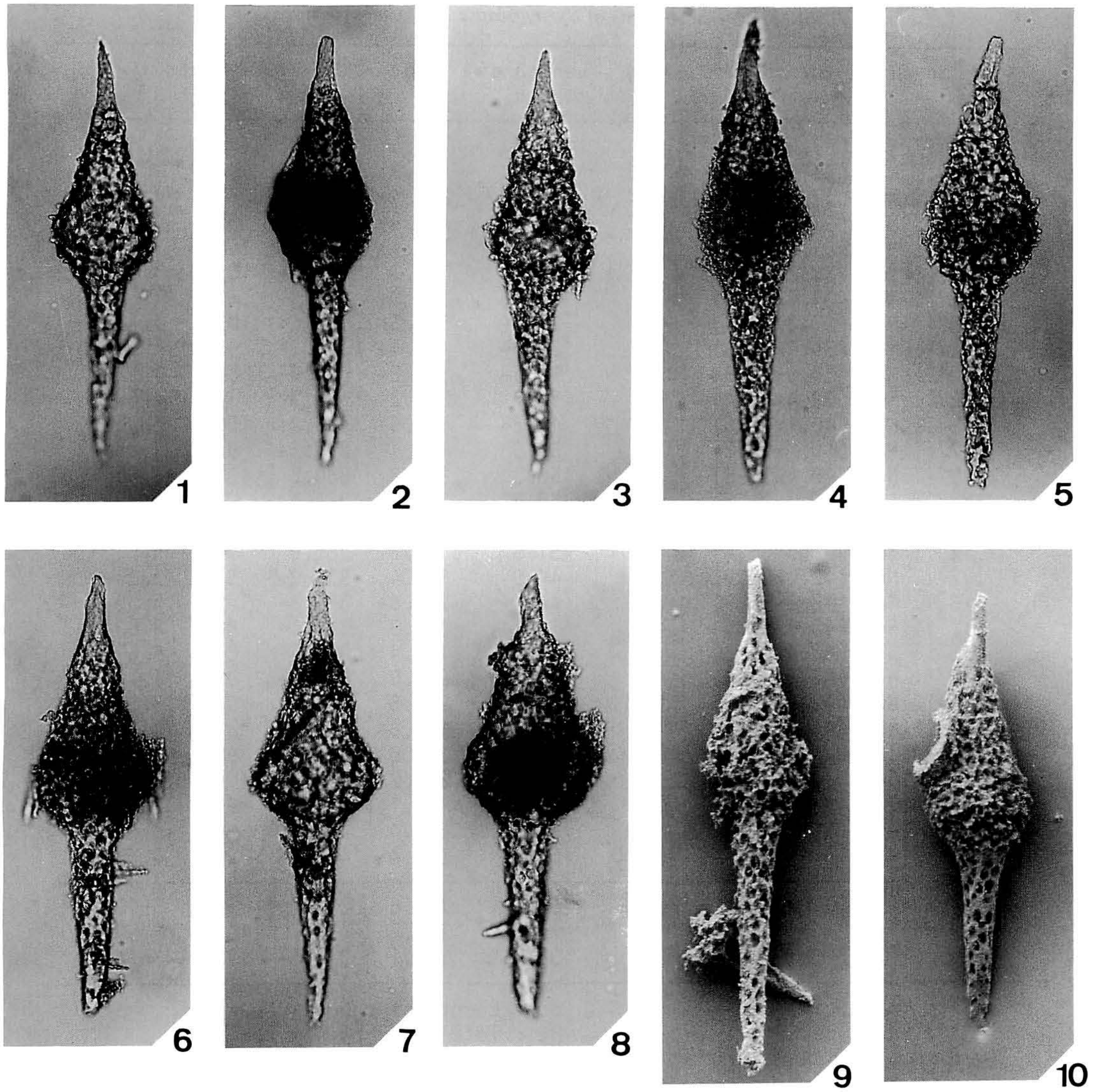

Figure 8. *Syringocapsa coliforme*, sp. nov.
1. Holotype, OCU MR 4008, IYII27II No. 1 (37.3x89.9) **2.** OCU MR 4009, IYII27II No. 1 (41.1x98.4) **3.** OCU MR 4010, IYII27II No. 1 (37.0x89.7) **4.** OCU MR 4011, IYII27II No. 1 (37.3x90.7) **5.** OCU MR 4012, IYII27II No. 1 (37.7x91.1) **6.** OCU MR 4013, IYII27II No. 1 (42.0x97.7) **7.** OCU MR 4014, IYII27II No. 1 (40.6x91.3) **8.** OCU MR 4015, IYII27II No. 1 (42.1x90.9) **9.** Paratype, OCU MR 4016, IYII27I-19 **10.** OCU MR 4017, IYII27I-29.
All figures, x155, are transmitted light photomicrographs except for **9, 10,** scanning electron micrographs.

occurs from the Rhaetian (?) to Hettangian part of the Kunga Formation of Queen Charlotte Islands. Therefore, *S. coliforme* probably ranges at least from the Rhaetian to the Hettangian.

The horizon of the final occurrence of *S. coliforme* is 230cm above the horizon of KU(b)11 with *Bagotum* spp. According to Pessagno and Whalen (1982), the oldest species of *Bagotum* was reported from the Sinemurian. In the Iwayakannon Section, the horizon of the final occurrence of *S. coliforme* is roughly assigned to the horizon of co-occurrence of the

Table 3. Measurements of *Syringocapsa coliforme*, sp. nov.

Specimen	Fig.	Length of Horn	Lc	Ht	Width	H/w
** IY27II No.1(37.3x89.9)	8-1	57.2	193.6	349.7	89.8	3.89
IY27II No.1(37.0x89.7)	8-3	52.9	197.9	378.6	93.0	4.07
IY27II No.1(37.3x90.7)	8-4	56.1	206.4	389.8	89.3	4.37
IY27II No.1(37.7x91.1)	8-5	48.1	198.9+	376.5+	85.6	4.40+
IY27II No.1(37.1x94.5)		48.1+	197.9+	379.1+	107.0	3.55+
IY27II No.1(37.8x94.8)		51.9	197.3	325.1+	103.2	3.15+
IY27II No.1(37.9x95.9)		37.4+	193.0+	381.3+	89.8	4.24+
IY27II No.1(37.2x97.7)		36.4+	197.3+	385.6+	103.7	3.72+
IY27II No.1(36.9x96.5)		39.0+	183.4+	315.5+	96.3	3.28+
IY27II No.1(39.5x88.8)		32.6+	195.2+	388.2+	86.1	4.51+
IY27II No.1(39.4x89.4)		56.7	210.2	373.3+	82.9	4.50+
IY27II No.1(40.1x90.6)		41.2+	198.9+	395.2+	100.0	3.95+
IY27II No.1(40.7x90.8)		53.5	194.7	315.5+	96.3	3.28+
IY27II No.1(40.6x91.3)	8-7	58.3	211.2	380.2	107.0	3.56
IY27II No.1(40.9x91.8)		58.3	170.6	324.6	95.7	3.39
IY27II No.1(41.5x92.0)		57.8	220.3	400.5+	93.6	4.28+
IY27II No.1(42.3x88.6)		57.8	188.2	385.0	70.1+	5.50-
IY27II No.1(42.0x89.9)		44.9	190.4	335.3+	87.2	3.85+
IY27II No.1(42.1x90.9)	8-8	44.4+	209.6+	366.8+	109.6	3.35+
IY27II No.1(43.7x92.5)		56.1	181.3	325.1+	90.4	3.60+
IY27II No.1(42.4x94.3)		63.6	198.4	394.7	85.6	4.61
IY27II No.1(43.2x91.4)		55.1	215.0	402.1+	96.3	4.18+
IY27II No.1(42.0x97.7)	8-6	50.8	207.5	363.1	102.7	3.54
IY27II No.1(41.1x98.4)	8-2	35.3+	189.8+	356.7+	87.7	4.07+
IYII24II-20		77.0	223.0	404.0	98.7	4.09
IYII24II-19		63.8	213.2	367.8+	105.9	3.47+
IYII24II-11		48.0	167.1	324.3+	90.8	3.57+
* IYII27I-19	8-9	64.5	219.4	438.7	96.8	4.53
IYII27I-29	8-10	64.5+	219.4+	432.3+	90.3	4.79+
Average		52.1	199.6	370.8	94.2	3.98
Maximum		77.0	223.0	438.7	109.6	5.50-
Minimum		32.6+	167.1	315.5+	70.1+	3.15+

** : Holotype
* : Paratype
Lc : Length of cephalic part
Ht : Total height

genera *Gigi* and *Katroma*. In Turkey, the co-occurrence of *Gigi* and *Katroma* was reported from Sample 1662-D (of Pessagno and Poisson, 1981 and De Wever, 1982a) which was obtained from beds a few ten of meters below a bed bearing Late Pliensbachian ammonites (De Wever, 1982a). Pessagno and Poisson (1981) assigned the Turkish radiolarian assemblage of Sample 1662-D to the Early Pliensbachian age on the basis of their radiolarian data. Therefore, it is positive that the range of *S. coliforme* extends to the Sinemurian.

Considering the above-mentioned facts, *S. coliforme* is regarded to range at least from the latest Triassic (Rhaetian) to Sinemurian, but its occurrence from the Pliensbachian is still uncertain.

Genus *Gigi* De Wever, 1982

1982a *Gigi* De Wever, p. 194.
1982b *Gigi* De Wever – De Wever, p. 340.

Type species: *Gigi fustis* De Wever, 1982

Diagnosis: Test comprising 2 to 3 chambers, cephalis, thorax or abdomen, or both and closed tube, without radial spines. The proximal portion subspherical, having smooth surface and circular pores with a crown-like apical horn and thorn(s).

Tube porous and elongated cylindrically, sometimes weakly expanded near the distal end.

Remarks: The genus *Gigi* was originally described under the family Eucyrtidiidae Ehrenberg, 1847 by De Wever (1982a). Later, he treated this group as incertae sedis (De Wever, 1982b). The present author classifies the genus *Gigi* to the family Syringocapsidae Foreman. According to De Wever's definition, the genus *Gigi* has two segments with closed tube, cephalis with a crown-like or needle-like apical horn, and thorn(s). However, it is difficult to distinguish species of *Gigi* from those of *Syringocapsa* solely by the possession of a needle-like apical horn.

Constituent species: *Gigi fustis* De Wever, 1982a; *Gigi elliptica* (Kishida and Hisada, 1985); *Gigi triangularis* (Kishida and Hisada, 1985); *Gigi* sp. aff. *G. fustis* (in this paper)

Gigi sp. aff. *G. fustis* De Wever, 1982

Figures 9-1,2

Remarks: *Gigi* aff. *fustis* differs from *G. fustis* by having a longer apical horn and much longer cephalo-thorax with polygonal pore frames, whose surface is not smooth. This form also morphologically resembles *Syringocapsa coliforme*, sp. nov. The former is distinguished from the latter by having a cylindrical tube, globular proximal portion of the test and branched apical horn.

Occurrence: Southwest Japan; Inuyama area (Mino Terrane), Norikuradake area (Mino Terrane), Kuzu area (Ashio Terrane).

Extended remarks

In this section, the phylogenic relationship among four species of the family Syringocapsidae described in this paper, *i.e. Katroma kurusuensis* sp. nov., *K.* sp. N, *Gigi* sp. aff. *G. fustis* and *Syringocapsa coliforme*, sp. nov., is discussed on the basis of their morphology and biostratigraphic distribution. Also mentioned is the biostratigraphic utility of the species of *Katroma* for establishing a world-wide correlation.

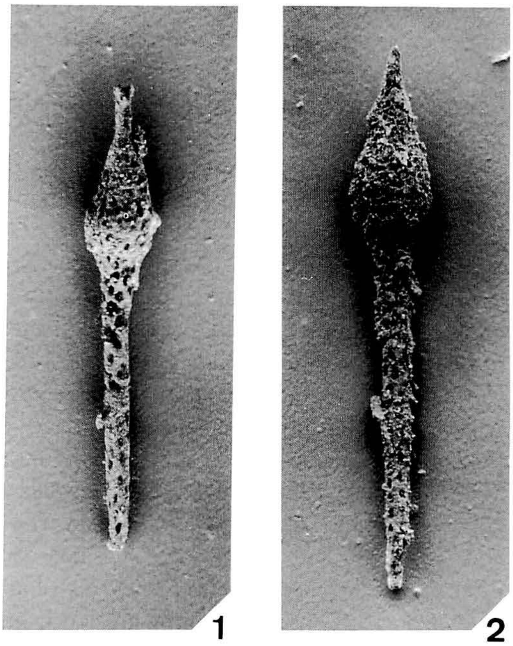

Figure 9. *Gigi* sp. aff. *G. fustis* De Wever
1. OCU MR 4018, IYIV1–28. **2.** OCU MR 4019, IYIV1–29. Figures, x155, are scanning electron micrographs.

Since some or various species of the genera *Syringocapsa, Katroma* and *Gigi* from the Lower Jurassic of Southwest Japan morphologically resemble one another, it is assumed that there are phylogenic relationships among these species. In particular, *Syringocapsa coliforme* is very similar to *Gigi* sp. aff. *G. fustis* in its size and structure of the shell. In all the sections dealt with in this paper, *S. coliforme* always appeared earlier than *G.* aff. *fustis* (Figs. 3, 5). From these facts, it is possible that *S. coliforme* gave rise to *G.* aff. *fustis* and furthermore that *Syringocapsa coliforme* is the ancestor of *Gigi.* Dumitrica (personal communication? to De Wever; See De Wever, 1982a, b) insisted that *Gigi* gave rise to *Katroma.* The present author, however, disagrees with his opinion, because *Katroma* made its first appearance approximately at the same time as *Gigi* in those continuous sections of the Inuyama area. In addition, species belonging to *Katroma* are morphologically more similar to some species of *Syringocapsa* (*e.g., S. coliforme*) than to those of *Gigi*, particularly in the number of chambers and shape of shell. By comparing the first appearance horizon of these species, the present author tentatively regards that both *Gigi* and *Katroma* branched off from *Syringocapsa* during an early Early Jurassic time.

Because of the reasons mentioned below, taxa of *Katroma* are important to establish a correlation of the Lower Jurassic radiolarian zones of Southwest Japan with those of the North American and other regions; 1) Taxa of *Katroma* are cosmopolitans in the Lower Jurassic, reported from various localities, such as Turkey, Greece, eastern U.S.S.R. (Amur area), North America and Southwest Japan (Pessagno and Poisson, 1981; De Wever, 1982a, b; Tikhomirova, 1985; Murchey, 1984; Isozaki, 1984; Kishida and Hisada, 1985, 1986; Hori, 1986; Sashida, Tonishi and Igo, 1986; Sato, Murata and Yoshida, 1986, *etc.*); 2) Occurrence and frequency distribution of *Katroma* are independent of host rock lithology. Species of *Katroma* occur from chert, siliceous mudstone, mudstone and limestone; 3) They are short ranged and co-occur with diagnostic species of the Lower Jurassic radiolarian zones. For example, the range of *K. kurusuensis* is probably limited in the Sinemurian and Pliensbachian and co-occurs with diagnostic species of the *Parahsuum simplum* Assemblage-zone (Yao, 1982), as mentioned above, one of the important early Jurassic radiolarian assemblage-zones in Southwest Japan.

These reasons form the basis to consider that species of *Katroma* are the good marker taxa for international correlation of Early Jurassic radiolarians. In Southwest Japan, the occurrence of these species is limited in the upper part of the *Parahsuum simplum* Assemblage-zone. Thus, the upper part of the *Parahsuum simplum* Assemblage-zone roughly corresponds to the following Lower Jurassic radiolarian zones of previous authors, MH-1 of Murchey (1984) in Calfornia, *Katroma* (?) cf. *bicornus* – *Lithocampe sichotica* Complex of Tikhomirova (1985) in the Amur area (U.S.S.R.) and Zones 04 – 01? of Pessagno *et al.* (1987) in North America. Among them, Zones 04 – 01 established by Pessagno *et al.* (1987) are defined on the basis of co-occurrence of radiolarians and ammonites in the Queen Charlotte Islands, British Columbia and east-central Oregon; *e.g.* the radiolarians of the Zone 04 occur with the lower Sinemurian ammonites, while the top of the Zone 01 lies within the Toarcian. According to these data at present, therefore, the age of the upper part of the *Parahsuum simplum* Assemblage-zone is probably assigned to late Sinemurian to late Pliensbachian, and furthermore may extend down to early Sinemurian and/or up to early? Toarcian.

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西南日本犬山地域下部ジュラ系チャート層から産出した放散虫化石について：Syringocapsidae 科 3 属に属する 4 種を犬山地域の下部ジュラ系チャート層より記載した。これら 4 種の属する *Katroma* 属, *Syringocapsa* 属, *Gigi* 属は, 形態上の共通点が多い。本論では, それぞれの相違を明確にした上で 3 属の系統関係を考察した。記載した種は, *Katroma kurusuensis*, *Syringocapsa coliforme* の 2 新種と *Katroma* sp. N, *Gigi* sp. aff. *G. fustis* である。*K. kurusuensis* と *S. coliforme* の産出範囲は, 共産するコノドントや放散虫化石からそれぞれ Sinemurian から Pliensbachian, Rhaetian から Sinemurian ? と推定される。下部ジュラ系に産する *Katroma* 属は, 北米, ギリシア, トルコ, ソ連東部などから報告されており, 西南日本では *Parahsuum simplum* 群集帯（Lower Jurassic）の上部に産する。よって, この属に属する種は, 化石帯の国際対比をする上で重要である。*Parahsuum simplum* 群集帯上部は, これらの産出層準から判断すれば, 北米の Pessagno ら（1987）の Zones 04-01, Murchey（1984）の MH-1, ソ連東部の Tikhomirova（1985）による *Katroma*(?) cf. *bicornus-Lithocampe sichotica* Complex にそれぞれ対応し, その年代は少なくとも Sinemurian 後期から Pliensbachian 後期にわたると推定される。

堀　利栄

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 151, pp. 564–569, 1 Fig., October 31, 1988

864. A TETHYAN BIVALVE, *POSIDONOTIS DAINELLII*, FROM THE LOWER JURASSIC OF WEST JAPAN*

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Abstract. A *Monotis*-like thin-shelled bivalve occurs from the *Fontanelliceras fontanellense* Zone (upper Pliensbachian) of the Nishinakayama Formation in west Japan. This bivalve, though formally undescribed, has been noticed by some foreign investigators from the standpoint of biogeography, because such a bivalve often shows episodic occurrence and wide geographic distribution. Recently, I observed some well-preserved materials of this species stored in the Hiroshima Unviersity and the Mine City Museum of History and Folk Custom, reaching a conclusion that it belongs to *Posidonotis dainellii* from the nearly contemporaneous dark shales of Italy and Greece. The obliquely truncated auricles and radial costae of three orders, which may be diagnostic of this species, are well recognized in the Japanese specimens. The wide geographic distribution is probably related to the pseudoplanktonic mode of life. This bivalve, as well as some ammonoids in the same fossil zone, is regarded as a noticeable element indicating a marine faunal connection with the Mediterranean region at that time.

It has long been known since Matsumoto and Ono (1947) that a *Monotis*-like thin-shelled bivalve occurs from the lower part of the Nishinakayama Formation of the Toyora Group (upper Pliensbachian) in west Honshu, Japan. Some specimens of this bivalve, though formally remain undescribed, were illustrated by Hayami (1961, pl.14, fig.7) as *Amonotis* sp., and assigned to *Posidonotis* by Hayami (1969) and Tanabe *et al.* (1982) and to *Pectinula* by Hallam (1977). Tanabe *et al.* (1982) studied the litho- and biofacies of this formation and pointed out that the sedimentary environment is comparable with that of the "Posidonienschiefer" of west Germany. The dark shale bearing this bivalve is more or less tuffaceous and especially well laminated with scarce bioturbation and fossils of definite benthic organisms.

In Jurassic such *Monotis*-like bivalves episodically appeared several times; *e.g. Diotis* in the lower Lower Jurassic, *Pectinula* and *Posidonotis* in the upper Pliensbachian-lower Toarcian, and *Aulacomyella* in the Kimmeridgian. Their opportunistic and exclusive occurrences as well as extensive geographic distribution have attracted the attention of many stratigraphers and paleontologists from biostratigraphic, autoecologic and biogeographic viewpoints (Losacco, 1942; Hayami, 1969; Hallam, 1977; Hillebrandt, 1981; Damborenea, 1987; *etc.*).

Recently I could observe several additional well-preserved specimens of this bivalve in the collections of the Hiroshima University and the Mine City Museum of History and Folk Custom. Its taxonomic affinity and biogeographic significance also became much clearer through Damborenea's (1987) comprehensive study of related bivalves in South America and Europe. On this occasion I systematically describe this characteristic bivalve and discuss several related problems.

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*Received June 9, 1988; accepted September 1, 1988.

Description of species

? Family Posidoniidae Frech, 1909

Genus *Posidonotis* Losacco, 1942

Posidonotis dainellii Losacco

Figures 1A–1E

1942 *Posidonotis Dainellii* Losacco, p.3, text-fig. 2-1, pl.1, figs.3–9.
1961 *Amonotis* sp.: Hayami, p.252, pl.14, fig.7.
1969 *Posidonotis* sp.: Hayami, p.379.
1977 *Pectinula* sp.: Hallam, p.64.
1982 *Posidonotis* sp.: Tanabe *et al.*, p.56.
1987 *Posidonotis dainellii* Losacco ?: Damborenea, p.194, text-figs.30a-d.

Type:–Losacco (1942) failed to designate the type specimen of this species, and therefore all the illustrated specimens including two slabs with moulds of numerous valves (p1.1, figs.4–9) are regarded as syntypes.

Material:–The following description is mainly based on a solitary well-preserved right valve (Fig.1A, 14.7mm long, 11.8mm high, preserved in the Geological and Mineralogical Institute, Hiroshima University) collected by A. Ono from the *Fontanelliceras fontanellense* Zone of the Nishinakayama Formation at Loc. Ty 98 (in Matsumoto and Ono, 1947) near the mouth of Sakuraguchi Valley, south of Ishimachi, Toyoda Town, Yamaguchi Prefecture. It is also supplemented by several slabs with numerous internal and external moulds preserved in the Hiroshima University, University of Tokyo and the Mine City Museum of History and Folk Custom collected at the same locality and from the same horizon at Loc.2 (in Tanabe *et al.*, 1982), a quarry, south of Nishinakayama, Kikukawa Town, the same prefecture.

Diagnosis:– Type species of *Posidonotis* characterized by thin, subequivalve and prosoclinally oval shells with height much smaller than length, straight postero-dorsal margin much longer than antero-dorsal, umbonal angle as large as 130 degrees, clearly demarcated, flattened, obliquely truncated auricles and notably cancellate sculpture which consists of regular commarginal lamellae and more than 35 radial costae of three orders of prominence in adult stage.

Descriptive remarks.–The shell is preserved only in a specimen (Fig.1A), in which radial costae of three orders are clearly distinguishable. The primary costae are about ten in number and persistently strong especially in the middle part. One secondary costa is regularly intercalated on each interspace of primary costae, and one tertiary costa appears between the primary and secondary costae only in the late growth stage. So far as the present specimen is concerned, the anterior auricle is weakly rimmed dorsally and more than three times larger than the posterior. Its growth lines do not indicate any trace of byssal notch even in the young stage.

All the other specimens are external and internal moulds. Though the auricles are commonly incomplete and tertiary costae are often difficult to observe even in large individuals, every essential character of disk seems to be identical between the two valves. There are several interesting slabs on which internal and external moulds of numerous individuals are impressed (*e.g.* Figs.1D, 1E). Some of them are articulated but in many cases two valves are more or less dislocated. The radial costae are generally strong in the middle part of disk and somewhat weakened towards the antero- and postero-dorsal peripheries. Because of the extremely thin shell, the hinge, ligament and muscle structures are difficult to observe in any available specimen.

Affinity:– Recently, Damborenea (1987) pointed out that the Japanese specimens (Hayami, 1961, pl.14, fig.7) are close to *Posidonotis dainellii* from the upper Lower Jurassic of Sabina (Italy). Because all the original specimens of *P. dainellii* appear to be incomplete and rather poorly preserved, the species identity of the Japanese specimens is not very decisive. However, the general outline and size of disk as well as the mode and number of radial costae are so similar that specific distinction seems to be unnecessary. Furthermore, the gregarious specimens on several slabs from the lower Toarcian of Chionistra massif of Greece, which were pre-

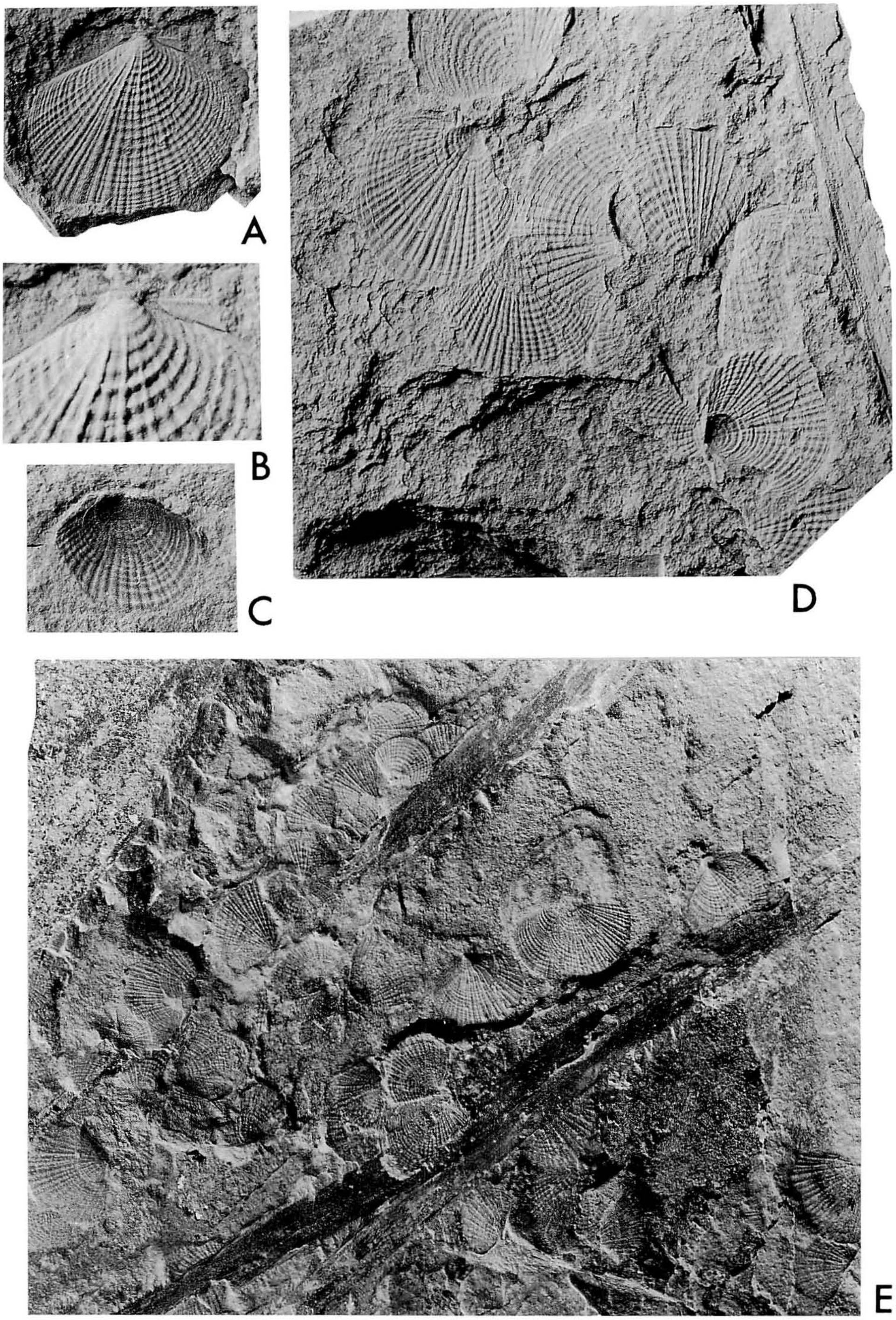

Figure 1. *Posidonotis dainellii* Losacco, 1942
A: Right valve, x 2. Loc. Ty 98 (Matsumoto and Ono, 1947), southwest of Ishimachi, Toyoda Town, Yamaguchi Pref.; Hiroshima Univ. coll. **B:** The umbonal part of the same specimen, x 5. **C:** Right external mould, x 2. Loc. the same; Hiroshima Univ. coll. **D:** A slab with many external and internal moulds, x 2. Loc. near the mouth of Sakuraguchi Valley, southwest of Ishimachi, Toyoda Town, Yamaguchi Pref. UMUT MM4839. **E:** A slab with many external and internal moulds with plant stems, x 1. Loc. 2 (Tanabe *et al.*, 1982), a quarry, south of Nishinakayama, Kikukawa Town, Yamaguchi Prefecture; Mine City Museum of History and Folk Custom coll.

viously collected by Renz (1927) and illustrated by Damborenea (1987, p.197, text-fig.30a-d) as *Posidonotis dainellii* ?, are firmly identical with the present specimens in every character of disk. The Japanese specimens may be a little older than the Greek ones, since the age of the former has generally been regarded as late Pliensbachian by the coexistence of *Fontanelliceras fontanellense.* Yet, the age discrepancy, if present, must be very slight, because such Toarcian-type ammonites as *Harpoceras okadai* and *Dactylioceras helianthoides* already appeared in the same fossil zone (Hirano, 1973; Tanabe *et al.* 1982).

Hallam (1977) pointed out that the Japanese specimens of this bivalve illustrated by Hayami (1961) may belong to the genus *Pectinula,* which was proposed by Leanza (1943) on the basis of *P. cancellata* Leanza, 1943, from the Middle Lias of Neuquen (Argentina). According to Damborenea's unpublished data distributed in the Circum-Pacific Jurassic Field Conference at Tsukuba, 1985, in Argentina this bivalve ranges from the uppermost Pliensbachian to the lowest Toarcian and therefore is almost contemporaneous with the Japanese specimens. As was described by Damborenea (1987), this South American species is clearly different from *Posidonotis dainellii* (including the present specimens) in the much taller and prosoclinal shell, smaller umbonal angle, larger auricles and fewer radial costae, though the mode of cancellate sculpturing is considerably similar.

Damborenea (1987) treated *Pectinula* as a junior synonym of *Posidonotis.* Furthermore, she regarded *Posidonotis* as belonging to the Entoliidae mainly on the basis of the auricular structure of *Pectinula cancellata.* According to her restoration, *Pectinula cancellata* show elevated dorsal margins above the hinge axis in both valves and the presence of byssal notch in the young stage. The restoration seems to be somewhat strange because such elevated dorsal margins are restricted to either valve (commonly right valve) in the Entoliidae and other pectinacean families. Anyhow, the present specimens of *Posidonotis dainellii* do not reveal any *Entolium*-like appearance. The auricles, though incomplete in most specimens, are much smaller than those of *P. cancellata* and show neither elevated dorsal margins above the hinge line nor the presence of byssal notch in the young stage. The shape of the anterior auricles of both valves appears to be rather similar to that of *Halobia* and Paleozoic species of *Posidonia.* The disk also does not remind me of that of an entoliid, because the outline is too inequilateral for a pectinacean and because the internal moulds indicate the absence of auricular crura of *Entolium*-type. I am, therefore, of the opinion that the synonymous relation between *Posidonotis* and *Pectinula* as well as their familial assignment is still debatable.

Autoecology:–*Posidonotis dainellii* often occurs exclusively and gregariously in dark shales, and very similar mode of fossil occurrence is known in Italy, Greece and Japan. In the Nishinakayama Formation many valves (partly articulated) appear to form crowded colonies around some plant stems like *Zamites* (Fig.1D, 1E), though their actual attachment by byssus has not yet been ascertained. No fossils of definite benthic organisms are found in association, and a considerably anaerobic bottom condition is indicated. It is indirectly suggested that this bivalve was pseudoplanktonic, as considered by Hillebrandt (1981).

Biogeographic significance:–From the above comparative study *Posidonotis dainellii* is concluded to be a widely distributed Tethyan bivalve which shows a relatively short stratigraphic range from the latest Pliensbachian to the early Toarcian. This view is consistent with the predominance of Tethyan (especially Italian) elements in the ammonite fauna of the lower Nishinakayama Formation (Arkell, 1956; Sato, 1962; Hirano, 1973). The Early Jurassic bivalve faunas of west Japan are generally composed of endemic species to eastern Asia (Hayami in press). The unusually wide geographic distribution of this bivalve was probably related to its pseudoplanktonic mode of life. Incidentally, *Pseudomytiloides matsumotoi* from the superjacent Toarcian beds of the Nishinakayama

Formation, which is surely pseudoplanktonic according to Tanabe (1983), may be also an extensively distributed species because it is hardly distinguishable from *Pseudomytiloides dubius* from the coeval argillaceous formations of western Europe and various Tethyan regions (*e.g.* Caucasus, Iran and Vietnam).

As was suggested by Damborenea (1987), *Pectinula cancellata* may be also a widely distributed species, since three nominal species described by Hyatt (1894) and Crickmay (1933) from the Lower Jurassic of California are possibly conspecific with the South American species. Though the taxonomic kinship between *Posidonotis dainellii* and *Pectinula cancellata* is still debatable, the two species seem to characterize distinct major marine faunal provinces in low and middle latitudinal regions at that time, because their stratigraphic ranges and modes of occurrence are quite similar.

Acknowledgements

I thank Emeritus Professor Akira Hase and Dr. Yuji Okimura of the Hiroshima University and Mr. Fumio Takahashi of Mine City Museum of History and Folk Custom for the loan of several interesting specimens, Dr. Kazushige Tanabe for his cooperation in the field work, and also Professor Koichiro Ichikawa of Osaka University of Technology and Dr. Alberto C. Riccardi of Museo de Ciencias Naturales (La Plata) for their kind information about related bivalve.

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西日本の下部ジュラ系産のテチス系二枚貝 *Posidonotis dainellii*：本州西端部の豊浦層群西中山層の *Fontanelliceras fontanellense* 帯（プリンスバキアン後期）に *Monotis* 様二枚貝（正式には未記載）が産出することは，これまでに海外の研究者からも注目されていた。今回，広島大学および美禰市歴史民族資料館に保管されている保存良好の標本を検討した結果，この種はイタリー・ギリシヤのほぼ同期の黒色頁岩から知られる *Posidonotis* の模式種 *P. dainellii* にほぼ確実に同定され，従来不明確であった本種の耳状部や表面彫刻の詳細があきらかとなった。本種の広汎な分布は擬浮遊性の生活様式（産状から強く示唆される）と関係があると考えられ，同じ化石帯から産するアンモナイト群と共に，地中海方面との生物地理上の関連を示す要素として注目される。

速水　格

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 151, pp. 570–581, 15 Figs., October 31, 1988

865. SOME INOCERAMIDS (BIVALVIA) FROM THE CENOMANIAN (CRETACEOUS) OF JAPAN – IV

AN INTERESTING NEW SPECIES FROM HOKKAIDO*

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Abstract. A specimen obtained by K. T. from his Member Tc (=IIc of T. M.), *i.e.* the middle part of the Mikasa Formation in the Ikushumbets Valley, was labelled as *Inoceramus* cf. *etheridgei* Woods and is hold in the Geological Museum of the Geological Survey of Japan. This is restudied by us together with other relevant specimens from the Upper Cenomanian strata in the Ikushumbets and Oyubari areas, central Hokkaido. They represent a new species which is allied to *I. scalprum* Böhn (=*I. etheridgei* Woods, currently included in *I. virgatus* Schlüter as a variety or a subsp. by some authors), but characterized by regular concentric ribs in addition to fine concentric lirae. This species resembles *I. atlanticus* (Heinz) but is distinguished by a dissimilar outline of the shell caused by its anteriorly concave growth axis instead of the nearly straight to weakly convex one of that species. We interpret that this species may have evolved from the *scalprum*-like form of the variable species *I. virgatus*, with development of distinct ribs. There seems to be a reduction in size at higher levels than the type locality. Some of the specimens previously reported under *I. tenuistriatus* Nagao et Matsumoto from the Cenomanian strata in various regions of the world may be preferably transferred to this species.

Introduction

One of us (Tanaka, 1985) listed some fossil specimens from the Cretaceous System of Japan, hold in the Geological Museum of the Geological Survey of Japan (GSJ), Tsukuba, which he obtained, sometimes with coworkers, during the field works to prepare geological maps on scale 1:50,000 in various areas of Japan. The other of us (T. M.) has recently visited the Museum to look at several specimens selected from the list. One of them, GSJ. F8275 from Ikushumbets, central Hokkaido, listed as *Inoceramus* cf. *etheridgei* Woods, was particularly interesting to him, because it did give him a hint to solve an entangled problem (to be discussed below) in which palaeontologists specializing in the inoceramids have been involved.

We have investigated this particular specimen together with other relevant ones, mostly those collected by T. M., sometimes with his colleagues, through field works in the Oyubari area (adjacent to the south of the Ikushumbets area), now kept in the Geological Collections, Kyushu University (GK) and partly those from the Ikushumbets area, deposited in the Institute of Geology and Palaeontology, Tohoku University. Sendai (IGPS). As a result a new species is established in this paper, giving remarks

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*Received March 30, 1988; accepted July 10, 1988.

on its implications in the taxonomy of the Inoceramidae.

This paper is added as Part IV of the serial papers under the above indicated major title, which was intended at the beginning to consist of three parts (Matsumoto and Noda, 1986, p. 410).

Systematic description

Genus *Inoceramus* Sowerby, 1814

Type species:–*Inoceramus cuvierii* Sowerby, 1814.

Remarks:–In this paper the genus *Inoceramus* is used in a broad sense as in Matsumoto *et al.* (1987, p. 148). As to the technical terms and their abbreviations we follow those in Matsumoto and Noda (1986, P. 410).

Inoceramus nodai sp. nov.

Figures 1–3, 5–13

1966 *Inoceramus tenuistriatus* (?) Nagao et Matsumoto; Pergament, p. 47, pl. 13, figs. 2–4; pl. 14, figs. 2–4.

? 1977 *Inoceramus tenuistriatus* ? Nagao and Matsumoto; Kauffman and Powell, p. 67, pl. 2, fig. 5; pl. 3, figs. 7, 9, 10.

1982 *Inoceramus tenuistriatus* Nagao & Matsumoto; Keller, p. 62, pl. 1, figs. 3a, b.

1985 *Inoceramus* cf. *etheridgei* Woods; Tanaka, p. 57.

Material:–Holotype, GSJ, F8275A (Fig. 1), BV, in a calcareous nodule collected by K. Tanaka at loc. Iw32 (=T. M.'s loc. Ik1043) from the siltstone in the main part of K. T.'s Member Tc (=T. M.'s Member IIc), Middle Member of the Mikasa Formation exposed across the main stream of the River Ikushumbets, central Hokkaido.

Paratypes, 36 specimens enumerated as follows: (1) GSJ. F8275B, RV, partly cropping out from the same nodule as the holotype; (2–4) small, probably juveniles, IGPS. 86187B (Fig. 2), C (Fig. 3) (both RV) and D (LV) in a calcareous nodule of sandy siltstone, Member IIc of the Mikasa Formation on the River Ikushumbets, without record of collector; (5, 6) GK. H8259A, B (Fig. 5) (RV and LV) in a nodule collected by T. Matsumoto with Y. Kawashita from the mudstone at loc. Y5111e5; (7–12) GK. H8260A (Fig. 6) B, C, D (these four LV) and E, F (RV) collected by T. M. at loc. Y5111e4 from the same bed as (5, 6), *i.e.* in the uppermost part of the probable extension of Member IIm (Matsumoto, 1942, p. 230), Taki-no-sawa route, Oyubari area, central Hokkaido; (13) GK. H8269A (RV) (Fig. 7) and (14, 15) GK. H8270A (RV) and B (RV) from loc. Y5111; (16, 17) GK. H8272A (LV) (Fig. 8) and B (RV) from loc. Y5112; (18–24) GK. H8273A (Fig. 13), B (Fig. 10), D, F (Fig. 12), G (Fig. 9) (all these five LV) and C (RV) (Fig. 11) and H (RV) from loc. Y5113; (25–29) GK. H8274A, B (LV) and C, D, E (RV) from loc. Y5113; (30–36) GK. H8275A, B (RV) and C, D, E, F, G (LV) from loc. Y5111; 13–36 developed or separated by T. M. from the calcareous nodules obtained through the field work (in 1969) by T. M. and H. Okada from sandy siltstone beds in the unit of alternating sandstone and siltstone, probable extension of Member IIm.

The above enumerated specimens are mostly internal moulds or composite internal moulds, with partly attached inner shell layer. External moulds are available for GK. H8259, GK. H8269 and GK. H8272B.

Etymology:–This species is dedicated to Dr. Masayuki Noda who has contributed much to the taxonomy and biostratigraphy of the Inoceramidae.

Diagnosis:–Shell medium to small sized, subequivalve and inequilateral. Valves gently convex in general, but for moderately convex umbonal part. Beak at the anterior end, small, pointed and not much exceeding the hinge line even in the left valve. Anterior hinge angle (=apical angle, α) 95° to 110°. Axis of growth nearly straight in young shell and gradually curved forward with growth, forming anteriorly concave curvature. Anterior margin nearly straight or gently concave and abruptly bent at the antero-ventral edge to the asymmetrically subcircular ventral margin, which passes to the longly arcuate posterior margin. Hinge line of moderate length (s/1=2/3 in the holotype), forming obtuse angle (125°–

140°) with the posterior margin. Postero-dorsal wing-like part narrow, to which the main part of the disk gradually inclines. The maximum inflation of valve immediately in front of the growth-axis; anterior side nearly vertical or overhanging.

Surface of shell ornamented with fine and dense concentric lirae and fairly regular concentric ribs of low to moderate intensity. Concentric rings may be discernible on some part of the internal mould, corresponding to the sharper lirae on the shell surface.

Dimensions:—See Table 1.

Observation:—The holotype consists of both

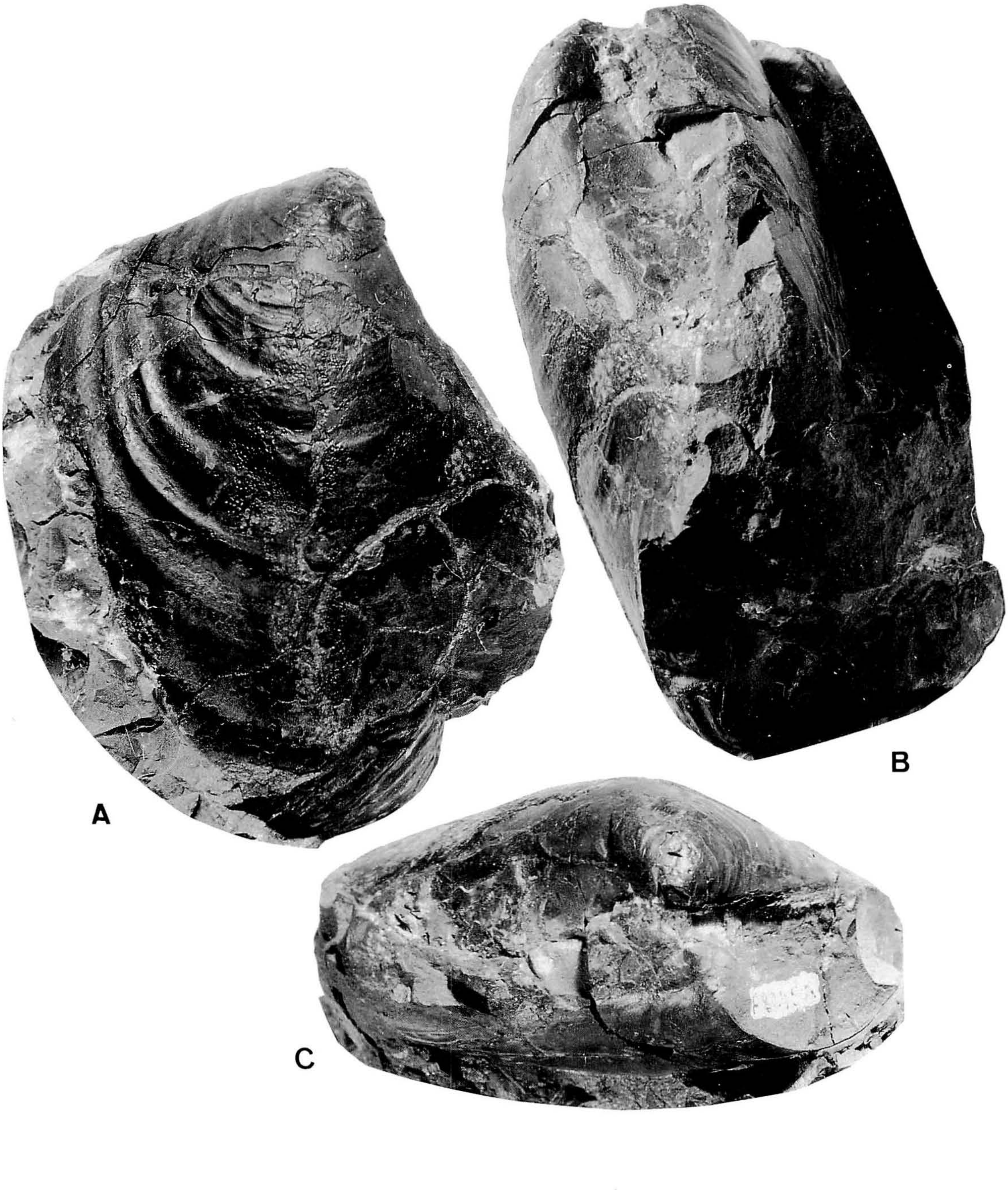


Table 1. Measurements of *I. nodai* on selected specimens

Specimen	V	h	l	l/h	H	L	L/H	b	b/h	s	s/l	α	β	γ	δ
GSJ. F8275	R	81.2	66.2	.82	86.0	69.8	.81	22.0	.27	43.0	.65	100°	–	137°	63°
GSJ. F8275	R	61.0	51.2	.84	63.0	52.2	.83	–	–	–	–	–	–	–	–
GSJ. F8275	R	34.3	30.7	.85	39.0	33.2	.85	–	–	–	–	–	–	–	–
GSJ. F8275	R	18.3	17.1	.93	21.2	19.0	.90	–	–	–	–	–	–	–	–
IGPS. 86187B	R	16.9	13.2	.80	17.2	13.6	.79	4.1	.25	9.3	.70	105°	–	125°	65°
IGPS. 86187C	R	9.0	8.0	.89	10.7	8.8	.82	2.2	.24	5.6	.70	105°	–	130°	50°
GK. H8259A	R	17.3	14.3	.83	17.8	15.2	.85	4.8	.28	10.5	.73	110°	–	100°	55°
GK. H8269A	R	27.8	21.8	.78	29.6	23.2	.78	6.4	.23	14.0	.64	103°	–	130°	60°
GK. H8272A	L	22.0	19.6	.89	24.0	20.8	.87	6.2	.28	13.0	.66	97°	80°	125°	50°
GK. H8273A	L	20.0	17.6	.88	21.5	19.5	.90	6.2	.31	–	–	115°	75°	–	55°
GK. H8273B	L	21.0	18.0	.86	22.4	18.8	.84	6.8	.32	13.2	.73	113°	75°	–	60°
GK. H8273C	R	15.7	14.0	.89	17.5	14.7	.84	5.0	.32	9.6	.68	100°	–	–	62°
GK. H8273G	L	20.0	17.4	.87	22.0	18.7	.85	6.6	.33	12.4	.71	95°	80°	125°	58°

Figure 1. *Inoceramus nodai* sp. nov.
Holotype, GSJ. F8275A (BV), from loc. Iw32 (= Ik1043) of the River Ikushumbets, lower part of Member Tc (=IIc), Mikasa Formation (K. Tanaka Coll.). **A:** lateral view of RV, with a ventral portion of a paratype, GSJ. F8275B at the bottom; **B:** anterior view of RV and half exposed LV, with a posterior view of GSJ. F8275B at the bottom; **C:** dorsal view of BV (umbo of LV deficient); **D:** RV in particular view, showing its umbonal part better than **A**; all in natural size (× 1).
Photos (Figs. 1–15) by courtesy of Dr. Masayuki Noda.

valves, of which the left valve is deficient in lacking the umbonal part and only half exposed. We had to stop triming the concealed posterior half; otherwise the better preserved right valve would be destroyed, because the specimen is too fragile. The right valve is a composite internal mould for the major part and the inner shell layer is attached to the posterodorsal part and some other portions, where fine concentric lirae are discernible in addition to the regular ribs. The ribs are low but rather sharp at their summit. So far as the visible part is concerned, the difference in the convexity or breadth (b) of the valve is slight between the left and right valves of the holotype.

Another right valve (paratype 1), which crops out from the same nodule as the holotype, has somewhat coarser and rather rounded ribs as compared with those of the holotype, although the difference is by no means great.

Other paratypes (2 to 36), which came from comparatively higher parts of the Upper Cenomanian, are smaller than the holotype. Some of them may be juveniles. The largest of them is 35 mm in H and may be adult. Others may be at least middle-aged (see remarks below). Those from locs. Y5111, Y5112 and Y5113 are often embedded in school, but left and right valves are mostly separated. As far as the well preserved specimens are concerned, the beak of the left valve is slightly projected beyond the hinge line.

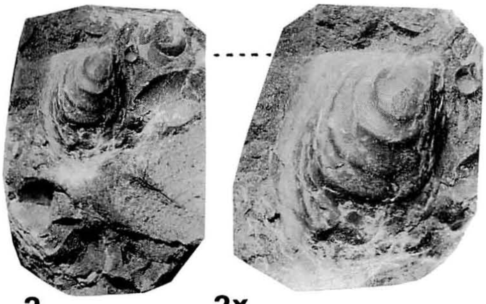
Of the paratypes 2 to 36, the figured 12 specimens are better preserved in showing both the shell-form and ornamentation. Even in the unillustrated specimens with deficient outline, the ornament may be well shown. In the normal cases of this small form, the ribs are distinct and rather sharply headed (*e.g.* GK. H8259A; GK. H8273A, B, C; GK. H8274A, B). In the less convex valves, which may be originally so in some cases but due to secondary compression in other cases, the major ribs are low, but fine and dense, concentric lirae may be well shown (*e.g.* GK. H8269A, B; GK. H8272A, B; GK. H8275A, B, C, D).

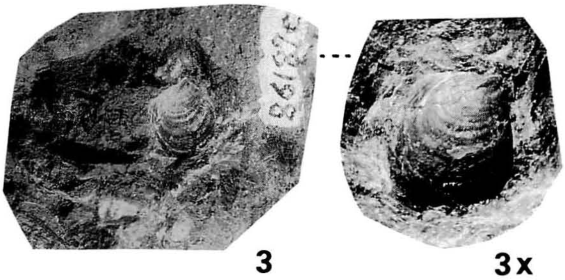
The major ribs are normally regular in the gradual increase in strength and interval, but the irregularity by bifurcation or intercalation may sometimes occur. The ribs begin to develop distinctly at the stage with H=15 mm in the holotype. In the smaller paratypes from locs. Y5111–Y5113, the ribs begin to be discernible at H=8 to 11 mm and in the case of very small IGPS. 86187C and B, probably from the higher bed than the holotype in the Ikushumbets route, there are 4 and 6 ribs at their H=10 mm and 15 mm respectively. Generally the intervals of the ribs are narrower and the ribs look to be more crowded in many, if not all, of the small paratypes as compared with those of the holotype. The above facts suggest that there is variation in size and that many of the small specimens from the higher part of the Upper Cenomanian may be already middle-aged and the largest one (H=35 mm) may be adult.

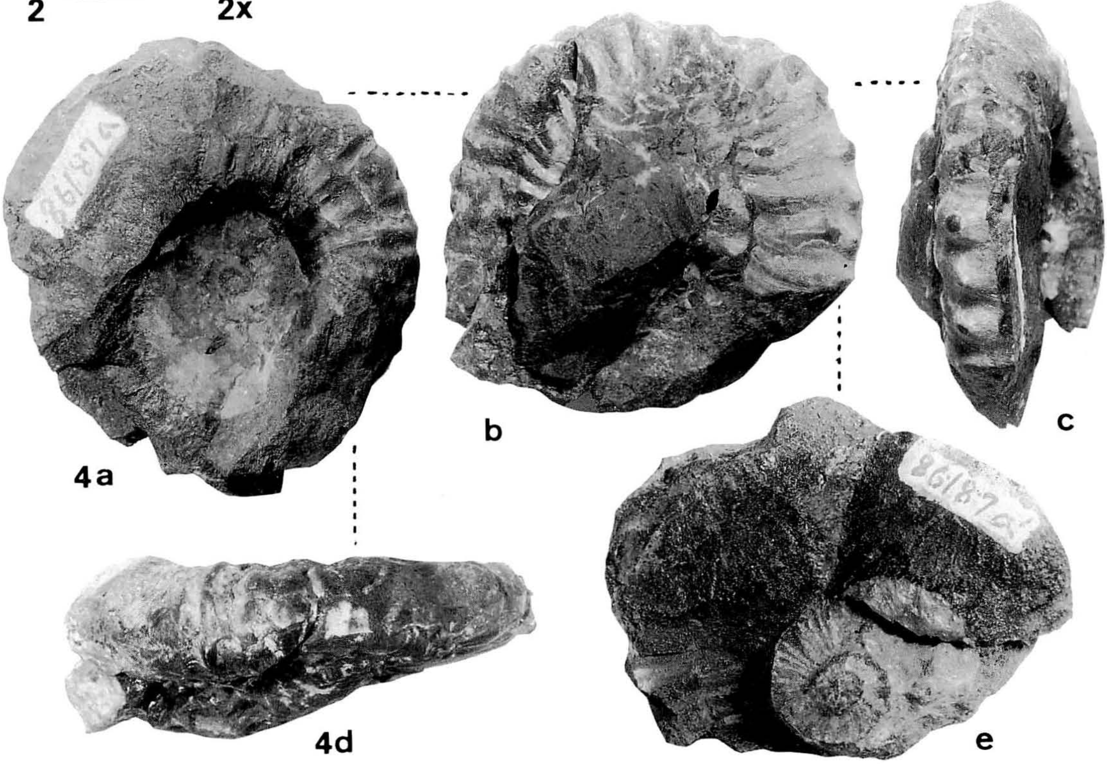
There is also some extent of variation in shell-form. For example, GK. H8269A and IGPS. 86187B represent a comparatively higher form with a smaller ratio of L/H or l/h than that of the normal form. They are contained in the same nodule as some examples of the normal form and the difference in the value of L/H or l/h is not great (see Table 1). The convexity of the valves varies to some extent. The ratio b/h, which may reflect the convexity, ranges from 0.24 to 0.33 in the measured specimens.

Comparison and discussion:—With respect to the regular concentric ribs combined with fine and dense concentric lirae, this species is similar to *Inoceramus atlanticus* (Heinz). The latter species was proposed by Heinz (1936, p. 96), under the genus *Camptoceramus* Heinz, 1932 (*nom. nud.*) for the two illustrated specimens of *I. crippsi* var. *reachensis* in Woods (1911, p. 278, pl. 48, fig. 5 and pl. 49, fig. 1), from the Zone of *Holaster subglobosus* (Lower Chalk, Cenomanian) of England. Later Woods' pl. 48, fig. 5 was designated as the lectotype by Pergament (1966, p. 58) prior to Keller's (1982, p. 58) too late designation of the other specimen.

Incidentally, Kauffman (1978, p. iv• 4) called Woods' pl. 48, fig. 5 *I.* (*Mytiloides* ?) *reachensis reachensis* Etheridge and Woods' pl. 49, fig. 1 *I.* (*Mytiloides* ?) *reachensis* n. subsp. A, without giving comments on *I. atlanticus* (Heinz), and mentioned further that the former occurs in the *Neostringoceras carcitanense* Zone and the latter in the *Mantelliceras saxbii* Zone. On examining the above specimens in the British Museum (Natural History) and also their plaster casts in Kyushu University (GK. H9581 and GK. H9582), one of us (T. M.) considered that they could possibly be referred to the genus *Mytiloides*, because of the evenly very fine and dense concentric lirae on the very thin shell in addition to regular major ribs. In fact Matsumoto (1959, p. 85) and Matsumoto and Noda (1975) mentioned as a working hypothesis that *I.*







Figures 2, 3. *Inoceramus nodai* sp. nov.
Paratypes, IGPS. 86187B **(2)** and C **(3)** (RV, probably juveniles), from the Ikushumbets. **2, 3:** x 1; **2 x, 3 x:** enlarged, x 2.

Figure 4. *Tarrantoceras* aff. *stantoni* Stephenson.
IGPS. 86187A, contained with B and C in one and the same nodule, Member IIc (presumably its uppermost part), Mikasa Formation. Right **(a)** and left **(b)** lateral, earlier **(c)** and later **(d)** ventral views of the outer whorl; external mould of inner whorls **(e)**, x 1.

reachensis (of Woods) could belong to the ancestral root stock from which *Mytiloides labiatus* (Schlotheim) may have offshooted. Anyhow, the above view is a suggestion for the question to what genus belongs the species proposed in this paper. We should, however, reserve the final answer until reliable evidence is obtained.

Aside from the question of generic assignment, we should mention here as to the validity of *I. atlanticus.* One of us (T. M.) once (in 1954) studied the syntypes of *Inoceramus latus* var. *reachensis* Etheridge, 1881 in the Sedgwick Museum, Cambridge. They are SM. B7173, B7174 and B7175 from the Totternhoe Stone of Burwell, Cambridgeshire, and more or less secondarily deformed or compressed. One of them, SM. B7173, figured by Etheridge (1881, p. 142, pl. 1, fig. 3) was designated by Woods (1911, p. 278) as the type, *i.e.* lectotype. It is much more elongated along the more oblique growth-axis than the above mentioned specimens of Woods (see Table 2). Therefore, the separation of *I. atlanticus* from *I. reachensis* (s. str.) can be justified. The two nominal species are, however, so similar in showing evenly dense and very fine concentric lirae on the very thin shell in addition to regular major ribs that subspecific distinction may be preferable. Without inspecting more specimens from successive levels, it is difficult to draw a final conclusion. In this paper, we tentatively use the specific name *I. atlanticus* on the ground of the above difference in shell form.

I. atlanticus has been reported also from the Cenomanian of France (Sornay, 1978, pl. 1, fig. 4), Germany (Keller, 1982, p. 57, pl. 1, fig. 6) and probably Kamchatka (Pergament, 1966, p. 58, pl. 5, fig. 3 with cf.). In every figured example of *I. atlanticus,* the axis of growth is at first nearly straight and then slowly curved toward the posterior, forming a gently convex curvature to the anterior.

In this new species, the axis of growth is at first nearly straight but soon curved toward the anterior, forming distinctly an anteriorly concave line. This character is constantly kept in every specimen examined. On account of this difference, the outline of the shell is also dissimilar between the two species.

The fine and dense concentric lirae and the general shell-form as well as the stratigraphic occurrences suggest that the two species may have diverged from a variable species *I. virgatus* Schlüter (recently redefined by Matsumoto *et al.*, 1987), acquiring the better developed major concentric ribs.

Should the subspecific definition by Keller (1982) be maintained, then the origin of *I. nodai* sp. nov. would be ascribed to *I. virgatus scalprum* Böhm and that of *I. atlanticus* could be so to *I. virgatus virgatus* Schlüter. Matsumoto *et al.* (1987) have denied the subspecific separation because of the presence of forms with mixed characters and the coexistence of various forms in the same province of the same geological age. However, in some late age of the Cenomanian, the divergence into two (or more) species my have taken place. Anyhow, the above interpretation would be disharmonious with the aforementioned suggestion to refer *I. atlanticus* (=*I. reachensis* of Woods) to *Mytiloides,* unless *I. virgatus* is referable to *Mytiloides.*

Table 2. Measurements of the discussed species on selected specimens.

Specimen	V	h	l	l/h	H	L	L/H	S	s/l	s/L	α	β	δ
(1) Dibley Coll.	R	~42	40	.95	45	~42	.93	~22	.55	.52	–	135°	65° – 70°
(2) BM. L10378	R	70	63	.90	68	61	.89	32	.51	.52	120°	120°	60° – 65°
(3) SM. B7173	R	74	69	.93	90	60	.67	32	.46	.53	93°	140°	48°
(4) USNM. 169393	R	10.5	7.9	.75	11.1	8.3	.89	4.5	.57	.54	95°	124°	63° – 78°

(1) *I. atlanticus,* lectotype; (2) *I. atlanticus,* paralectotype;
(3) *I. reachensis,* lectotype; (4) *I.* aff. *ginterensis*

I. nodai sp. nov. is somewhat similar to *I. tenuistriatus* Nagao et Matsumoto, 1939. We should recall here that Matsumoto (1959, p. 84) once mentioned that *I. tenuistriatus* is somewhat allied to *I. etheridgei* Woods, 1911 (=*I. virgatus scalprum* Böhm, 1915) but is evidently later (Turonian) in age. Kauffman (1977, p. 178; 1978, p. iv•4–5) also regarded *I. tenuistriatus* as a member of "the *I. etheridgei* lineage."

I. tenuistriatus was established on several syntypes from the celebrated exposures (locs. Ik2012–2014) of the Upper Turonian strata on the River Pombets (see Matsumoto, 1984, fig. 3). It was defined fairly clearly and is now being restudied by Noda (1988) in parallel with this work. That species is constantly small and somewhat inequivalve, with more convex umbonal part which is steeply inclined to the postero-dorsal wing-like part. Its axis of growth is straight throughout, without showing such a curvature as that of *I. nodai.* It has fine and dense concentric lirae as those of this species but is devoid of such regular concentric ribs as those of *I. nodai* and *I. atlanticus.* Only weak concentric subcostae or undulations may occur irregularly in some specimens of *I. tenuistriatus.*

Those forms which have been described or reported under *I. tenuistriatus,* with or without a query, from the Cenomanian of various regions outside Japan by Pergament (1966), Kauffman and Powell (1977), Kauffman (1978, without fig.) and Keller (1982) (see above list of synonyms) are not referred to the named species. We are inclined to transfer them to *I. nodai* on the basis of their described and illustrated characters, although the final conclusion should be deferred until we examine the actual specimens or at least their replicas.

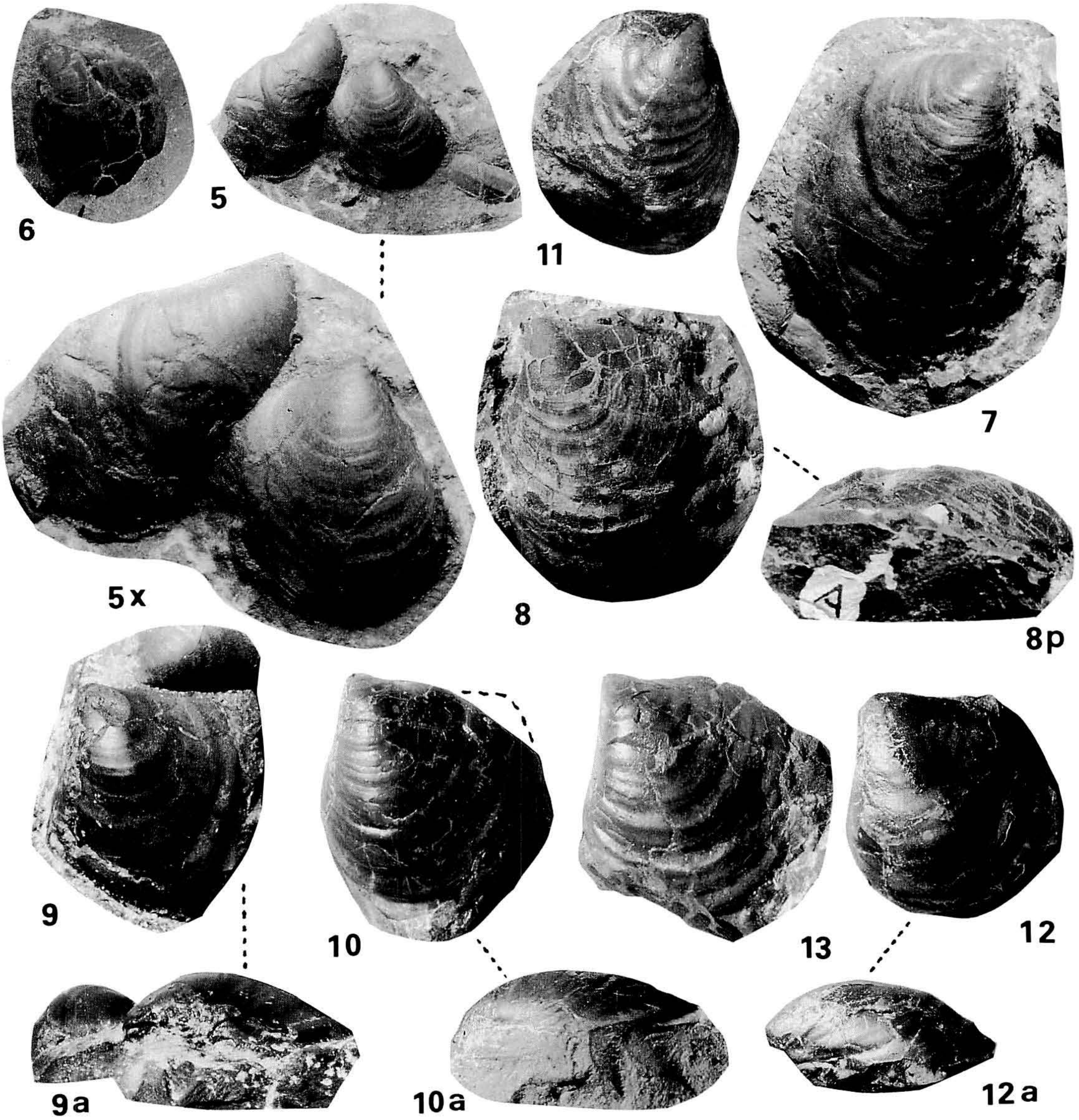
Although *I. tenuistriatus* and *I. nodai* sp. nov. are distinguished, the two species might be genetically related. If the characters in the early growth-stage of *I. nodai* were retained and extended to a small-sized adult of the descendant, *I. tenuistriatus* could be formed. To verify this hypothetical presumption of paedomorphosis, it is eagerly required to study the material from the lower part of the Turonian.

In this connexion it is interesting to see that the investigated specimens of *I. nodai* from the upper part of the Upper Cenomanian are small as compared with the typical form (holotype and others) from the lower part of the same substage in the sequence of Hokkaido.

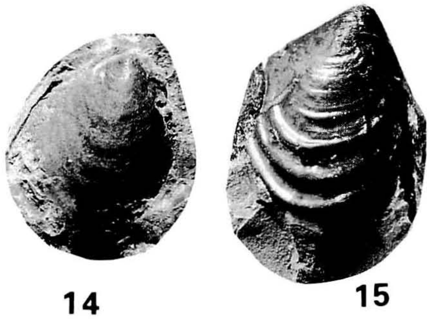
A comparatively higher form among the population of *I. nodai* from higher levels, as represented by IGPS. 86187B (Fig. 2) and GK. H8269A (Fig. 7), is noteworthy in its similarity to a peculiar form said by Kauffman and Powell (1977, pl. 1, fig. 1) as "a young *I. ginterensis* Pergament showing abnormally close, regular juvenile rugae", from the Hartland Member of Oklahoma. That North American form is indeed similar to *I. ginterensis* in the outline of shell, but such regular ribs do not appear on the young shell of typical *I. ginterensis.* It should be called *I.* aff. *ginterensis* (Table 2–4) or could be called *I.* aff. *nodai.*

We should mention here that there is another peculiar form represented by GK. H8269B (Fig. 14) and GK. H8271A (Fig. 15), which were intermingled with some specimens of *I. nodai.* It differs from the latter species in its obliquely elongated outline with straight growth-axis, smaller apical angle and narrowly raised, regular ribs of stronger curvature. Although the two specimens are immature or middle-aged, they resemble the holotype and other examples of *Inoceramus schoendorfi* (Heinz) from the Upper Cenomanian of Germany (near Hanover) and Denmark and Upper and Middle Cenomanian of France (see Sornay, 1980, p. 2, pl. 1, figs. 1–5). *I. schoendorfi* may be allied to but is clearly distinct from *I. nodai* by the above characteristics. We call the above mentioned form from Hokkaido tentatively *I.* cf. *schoendorfi.*

Occurrence:—The nodule, which contains the holotype and the paratype 1, was obtained by K. T. from his loc. Iw32, i.e. T. M.'s loc. Ik1043. It is on the main course of the River Ikushumbets, about 530 m downstream from the Katsurazawa dam and slightly upstream from the entrance of a small branch stream called the Suido-no-sawa. The nodule was in dark grey siltstone which belongs to the lower part of the Middle Member of the Mikasa Formation, marked Tc by K. T. (in Matsuno *et al.*, 1964, p. 28) or IIc by T. M. For the location on the route map and stratigraphic section see figs. 2 and 4 in Matsumoto (1965) and for the general stratigraphy of the Ikushumbets Valley see Matsumoto *et al.* (1978, p.



Figures 5–13. *Inoceramus nodai* sp. nov. Paratypes.
5: GK. H8259A (RV) and B (LV. oblique view of anterolateral part) from loc. Y5111e5 (T. Matsumoto Coll.), x 1. **5 x:** *Ditto,* enlarged, x 2. **6:** GK. H8260A (LV) from loc. Y5111e4 (T. M. Coll.), x 1.5. **7:** GK. H8269A (RV) from loc. Y5111 (T. M. & H. Okada Coll.), x 1.5. **8:** GK. H8272A (LV) from loc. Y5112 (T. M. & H. O. Coll.), x 1.5. **8p:** *Ditto,* posterior view, x 1.5. **9, 9a:** GK. H8273G (LV); **10, 10a:** GK. H8273B (LV); **11:** GK. H8273C (RV); **12, 12a:** GK. H8273F (LV); **13:** GK. H8273A (LV), these five in the same nodule from loc. Y8213 (T. M. & H. O. Coll.); **9a, 10a** and **12a** are anterior views of **9, 10** and **12**; all x 1.5. **5–13** on the Taki-no-sawa route, extension of Member IIm (of the Shiyubari, Matsumoto, 1942), Oyubari area.



Figures 14, 15. *Inoceramus* cf. *schoendorfi* (Heinz). **14:** GK. H8269B (RV), probably juvenile, contained with GK. H8269A (Fig. 7) in the same nodule. **15:** GK. H8271A (RV), probably middle aged, contained with GK. H8270A, B (*I. nodai*, no fig.) in one and the same nodule. Both from loc. Y5111, Taki-no-sawa route, extension of Member IIm, Oyubari area (T. M. & H. O. Coll.). × 1.5.

xxxiii•3–5, figs. 6–8). From the main part of Member IIc occur *Eucalycoceras pentagonum* (Jukes-Browne) and *Calycoceras* cf. *naviculare* (Mantell) (see Matsumoto, 1975), indicating the lower part of the Upper Cenomanian.

IGPS. 86187B–D, *i.e.* paratypes 3–5, are in a dark grey calcareous nodule from Member IIc of the Ikushumbets Valley. The nodule contains *Tarrantoceras* aff. *stantoni* Stephenson (IGPS. 86187A) (Fig. 4) and numerous, drifted vegetable fragments, suggesting its derivation from the uppermost part of Member IIc, *i.e.* the Zone of *Euomphaloceras* (*Kanabiceras*) *septemseriatum*, next higher zone than the *Pentagonum* Zone.

Numerous specimens from locs. Y5111, 5112 and 5113 are in calcareous nodules contained in mudstone layers of a member of alternating sandstone and shale in the section along the stream Taki-no-sawa, Oyubari area. This member corresponds to Member IIm (Matsumoto, 1942) of the Shiyubari area, adjacent to the northeast of the Oyubari area. It is referred to the Upper Cenomanian because it contains *Damesites* cf. *laticarinatus* Saito et Matsumoto and *Marshallites compressus* Matsumoto and because it is immediately below the bed with *Pachydesmoceras kossmati* Matsumoto and *Pseudaspidoceras flexuosum* Powell, the latter of which is an index of the Basal Turonian (Kennedy *et al.*, 1987). This bed is followed above by a unit of mudstone characterized by *Mytiloides mytiloides* (Mantell) in the main part with intercalated key beds of tuff and tuffite. This unit certainly corresponds to Member IIn of the Shiyubari area (Matsumoto, 1942) and referred to the Lower Turonian.

This new species has been established on the material from the Upper Cenomanian of the Ikushumbets and Oyubari sections, but its true range has yet to be worked out by further investigations of other sections.

Probable examples of this species outside Japan illustrated under *I. tenuistriatus* (with or without a query) are from the Zone of *Dunveganoceras albertense* and that of *Sciponoceras gracile-E.* (*Kanabiceras*) *septemseriatum* in the Upper Cenomanian of Oklahoma (Kauffman *et al.*, 1977), also the Middle Cenomanian of the Sack-Mulde, Germany (Keller, 1982) and the Upper Cenomanian of the Koryak-Kamchatka region (Pergament, 1966).

Acknowledgements

We wish to thank Dr. Nobukazu Kanbe and Dr. Toru Sakamoto, the former and the present Keepers of the Museum, Geological Survey of Japan, and Professor Tamio Kotaka of Tohoku University for their generosities to let us study the GSJ and IGPS specimens on loan. Thanks are extended to Dr. Masayuki Noda for his friendly help in taking photographs and for the fruitful discussions and also to Dr. Yoshio Sato of GSJ for his assistance in various ways. One of us (T. M.) greatly appreciate the kindness of Drs. Gregorio Lopez and S.R.A. Kelly for supply of a Spanish paper and Etheridge's respectively, the help of Drs. Hakuyu Okada, again Dr. M. Noda, Mr. Yoshitaro Kawashita and Ms. Kikuye Kato in his frequent field works in the Oyubari area, and the assistance of Miss Yoshimi Tanigawa in preparing the typescript.

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Fukuoka 福岡, Hachioji 八王子, Hokkaido 北海道, Ikushumbets (Ikushunbetsu) 幾春別, Iwamizawa 岩見沢, Katsurazawa 桂沢, Kyushu 九州, Mikasa 三笠, Nakayama 中山, Oyubari 大夕張, Pombets (Ponbetsu) 奔別, Sendai 仙台, Shiyubari (Shuyubari) 主夕張, Suido-no-sawa 水道の沢, Taki-no-sawa 滝の沢, Tohoku 東北, Tokyo 東京, Tsukuba 筑波.

本邦白亜系セノマニアン階産イノセラムス—Ⅳ。興味のある北海道産1新種：地質調査所地質標本室に保管の標本で，かって田中が幾春別の三笠層中部（セノマニアン上部）から得たGSJ. F8275を松本が見て，かねてからの疑問を解く鍵となると直観し，同じく幾春別産の東北大標本，大夕張滝の沢のⅡm相当部層（セノマニアン最上部）産の多数の九大標本と併せて共同研究した。その結果これらは田中が予見したように，“*Inoceramus etheridgei* Woods”（後に*I. scalprum* Böhmと改名，最近は*I. virgatus* Schlöterの亜種または1変異型とされる）と類似するが，同心細輪（lirae）に加えて，中程度の強さの規則正しい主肋が発達する。従って*I. atlanticus* (Heinz)に類似するが，殻の成長軸が常に前方に凹の曲線を描き，それに伴って殻の輪郭も*I. atlanticus*と異なる。よって上記GSJ標本をホロタイプ，その他をパラタイプスとして，新種*I. nodai*を設立し，図示・記載した。

なお*I. reachensis* Etheridge, 1881のレクトタイプはWoods (1911, pl. 48, fig. 5; pl. 49, fig. 1)が図示した“*I. reachensis*”とは区別できる（英国で原標本を松本が検討）から，後者に基づきHeinz（1936）が提唱した*I. atlanticus*は採用してよい。

*I. virgatus*はセノマニアン下半部（最下部除外）に産する。今回扱った*I. nodai*の標本は同階上部に産するが，最上部では小柄である。その小柄のものでも，チューロニアン上部産の*I. tenuistriatus* Nagao et Matsumotoとの差異は明確である。（本研究と平行して後者を野田が研究し1988年本号に記載。）ところが海外で複数の著者がセノマニアン産の“*I. tenuistriatus*”を報告している。実物を見ていないから断言は控えるが，図示・記述のもの（同階上部，時に中部産）に関しては，その同定は誤で，*I. nodai*とした方がよいと思われる。この判断が正しいとすると，*I. nodai*はセノマニアン上半部の示準化石種として重要となるであろう。

松本達郎・田中啓策

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 151, pp. 582–600, 9 Figs., October 31, 1988

866. A NOTE ON *INOCERAMUS TENUISTRIATUS* NAGAO ET MATSUMOTO (BIVALVIA) FROM THE UPPER TURONIAN (CRETACEOUS) OF JAPAN

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Abstract. In the original description *Inoceramus tenuistriatus* Nagao et Matsumoto, 1939 was well defined, but the species has not been always understood correctly by some foreign researchers. In this paper *I. tenuistriatus* is biometrically restudied on a population sample from the type locality. The statistics are taken for eight characters on 30 left and 27 right valves. A revised description of *I. tenuistriatus* is given, including the result of the biometric examination. I discuss the relationship of the redefined *I. tenuistriatus* with the so-called "*I.* (*I.*) *tenuistriatus*" (with or without query) from the Cenomanian of Euramerica and the Pacific Coast of the USSR. It has been confirmed that the so-called "*I.* (*I.*) *tenuistriatus*" should be morphologically discriminated from the sample specimens of the type locality. In connection with this, I agree with Matsumoto and Tanaka (1988) in their suggestion that the so-called "*I.* (*I.*) *tenuistriatus*" may be identical with *I. nodai* Matsumoto et Tanaka, 1988 from the Upper Cenomanian of Hokkaido.

The stratigraphic unit of the type locality of *I. tenuistriatus* is clearly assigned to the Upper Turonian on the evidence of associated species. Besides, "*I. tenuistriatus*" has been reported to occur at several horizons other than the Upper Turonian in various areas of Japan, the true range of this species is yet to be worked out further.

Introduction

Inoceramus tenuistriatus Nagao et Matsumoto, 1939 was established on the basis of six specimens from the Upper Turonian of the Pombets area, central Hokkaido. In the original description by Nagao and Matsumoto (1939, p. 272–274), this species is well defined by its own characteristics with some extent of variation in outline and surface ornamentation.

Meanwhile, the occurrence of *I. tenuistriatus* in the Cenomanian rocks of Euramerica and East Asia was recorded by several authors (Vereschagin *et al.*, 1965; Pergament, 1966; Kauffman, 1975, 1977b, 1978; Kauffman and Powell, 1977 and Keller, 1982). But their specimens differ from the type specimens in size, outline and surface ornamentation, so far as their illustrations are concerned. The authors may have misunderstood the concept of this species. Anyhow the species so-called "*I.* (*I.*) *tenuistriatus*" has begun to walk freely regardless of the type specimens and type locality. This may have given undesirable influence even on the students in Japan.

Besides, Kauffman (1977a, p. 178) mentioned that Japanese Turonian and Euramerican Cenomanian specimens appear to be identical externally, and also detailed study on their morphology still need to be done to demonstrate that they are conspecific rather than a case of homeomorphy.

Received June 16, 1988; revised manuscript accepted September 1, 1988

The present paper, therefore, aims to give a clear redefinition of *I. tenuistriatus* by means of biometry on a population sample from the type locality. This would offer a foundation for the precise comparison between this species and the so-called "*I.* (*I.*) *tenuistriatus*".

Before going further, I thank Emeritus Professor Tatsuro Matsumoto of Kyushu University for his suggestion of this problem and kind help throughout the present study including comment on manuscript and loan of a large number of specimens of his own collection now kept at Kyushu University. I am indebted to Professor Itaru Hayami of the University of Tokyo, Emeritus Professor Tamio Kotaka of Tohoku University and Professor Makoto Kato of Hokkaido University for their kindness in giving facilities for the access to the syntypes. My gratitude is also extend to Messrs. Kikuo Muramoto of Mikasa Museum, Takemi Takahashi, Yoshitaro Kawashita of Mikasa and Masao Futakami of Kawamura Gakuen Women's University, Chiba Prefecture for their help in the field work and loan of useful specimens.

Method

In this paper, at first statistic method is applied for mensural characters on a population sample from the type locality. The specimens examined do not necessarily represent one living population in a strict sense, but are regarded as a population sample in a broad sense because they were obtained from one and the same biostratigraphic unit (Zone of *Mytiloides incertus*) exposed on a continuous outcrop of a limited extent.

Left and right valves are measured and taken into statistics separately, on account of the inequivalveness. The mean values (m), standard deviations (s) and Pearson's coefficient of variation (v=100s/m) of selected characters are calculated. Then the chi-square test is used for the evaluation of normal distribution in selected characters. If the chi-square value (X^2) is not significant, Student's t-test is applied to evaluate the significance of morphological difference between left and right valves. Before the t-test is adopted, F-test is made. If the F-value is significant, the t-value is calculated by Welch's method.

Average relative growth of shell length vs. shell height and that of shell breadth vs. shell height are examined separately for left and right valves. These are demonstrated by reduced major axes on logarithmic graph paper and expressed by the power functions [$\mathrm{l}=\beta \mathrm{h}^{\alpha}$, $\mathrm{b}=\beta \mathrm{h}^{\alpha}$] and

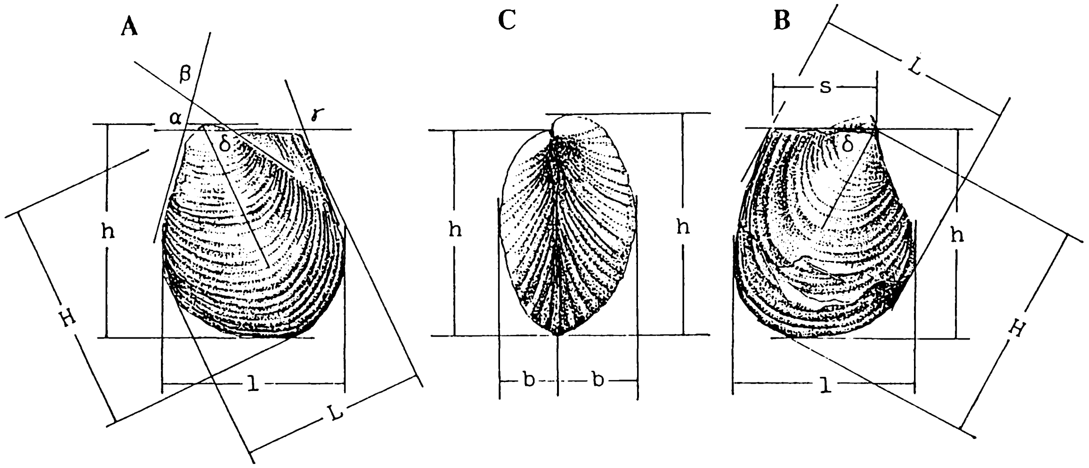

Figure 1. Basic morphology for measurements. **A:** lateral view of left valve, **B:** lateral view of right valve, **C:** anterior view. h: shell height, **l:** shell length, b: shell breadth, **s:** length of hingeline, H: maximum linear dimension from umbo to ventral extremity, L: maximum linear dimension perpendicular to H, α: anterior hinge angle, β: beak angle, angle of umbonal inflation, γ: posterior hinge angle, δ: obliquity, angle between hingeline and H.

the correlation coefficient is calculated for each of them. Isometric or allometric relationship for each sample is evaluated by means of *K*-test on the basis of sample size (N), growth index (α) and correlation coefficient (r).

The basic linear measurements and angles are shown in Fig. 1. For the method of measurements, the readers may refer to Noda (1983), and for the procedure of statistics and their analyses, see Hayami (1969), Hayami and Matsukuma (1971) and Tanabe (1973).

Palaeontological description

Family Inoceramidae Zittel, 1881

Genus *Inoceramus* Sowerby, 1814

Type species:–*Inoceramus cuvierii* Sowerby, 1814.

Remarks:–Although the genus *Inoceramus* has been divided into several subgenera, the specific characters of *Inoceramus tenuistriatus* Nagao et Matsumoto described below are well harmonious with the definition of the nominate subgenus by Cox (1969), except for its small size. Hayami (1975) and Kauffman (1977a, 1978) already assigned the present species to the nominate subgenus, although without mentioning a reason. According to Matsumoto (personal communication, 1988), as the taxonomic criteria at generic or subgeneric level the shell structure and hinge structure should be regarded as more important than external characters. Because the internal structure of *I. tenuistriatus* is not clarified at present, therefore I have to use *Inoceramus* in a broad sense in this paper.

Inoceramus tenuistriatus Nagao et Matsumoto, 1939

Figures 5-1–7; 6-1–11; 7-1–11; 8-1–6; 9

1939 *Inoceramus tenuistriatus* Nagao et Matsumoto, p. 272–274, pl. 24, fig. 8; pl. 26, figs. 1–4.

1959 *Inoceramus tenuistriatus*: Matsumoto, p. 84.

non 1965 *Inoceramus tenuistriatus*: Vereschagin, Kinasov, Parakechov and Terehova, p. 37, pl. 24, figs. 1, 2.

non 1966 *Inoceramus tenuistriatus* (?): Pergament, p. 47, 48, pl. 13, figs. 2–4; pl. 14, figs. 2–4.

1975 *Inoceramus* (*Inoceramus*) *tenuistriatus*: Hayami, p. 53.

1976 *Inoceramus tenuistriatus*: Noda and Matsumoto, no. 45–265, fig. 6.

1977a *Inoceramus* (*Inoceramus*) *tenuistriatus*: Kauffman, p. 178.

non 1977b *Inoceramus tenuistriatus* ?: Kauffman, p. 230, pl. 4, fig. 9.

non 1977 *Inoceramus* (*Inoceramus*) *tenuistriatus* ?: Kauffman and Powell, p. 66–68, pl. 2, fig. 5; pl. 3, figs. 7, 9, 10.

? 1978a *Inoceramus* (*Inoceramus*) *tenuistriatus* ?: Kauffman, p. IV 4, 5.

? 1978a *Inoceramus* (*Inoceramus*) *tenuistriatus*: Kauffman, p. IV 4, 5.

non 1978b *Inoceramus* (*Inoceramus*) *tenuistriatus* ?: Kauffman, pl. 8, fig. 9.

1980 *Inoceramus tenuistriatus*: Futakami, Tanabe and Obata, pl. 1, fig. 4.

non 1982 *Inoceramus tenuistriatus*: Keller, p. 62–64, pl. 1, fig. 3a, b.

Lectotype:–HK7192 (Nagao and Matsumoto, 1939, p. 262, pl. 26, fig. 1) designated by Pergament (1966, p. 47) without examining the actual specimen.

Material:–Ninety one specimens, that is, JG.H2980a, b, 2981b, c from Loc. Ik2012; JG.H2970, 2971a–f from Ik2013b; JG.H2863 a–1, 2977a, b from Ik2013d; GK.H10088a–c from Ik2013e; JG.H2783, 2862a, b, 2865a–f from Ik2013h; JG.H2968a, b, 2972a–h, 2973 a–g, 2975, 2976a, b, 2978a–c, GK. H 8278a, b, 8280a, b, 8281, 8282, 8283a–c, 8284 from Ik2013 (without record of further subdivision); GK.H8279a, b from Ik2014a; JG.H2969, 2974 from the Juichino-sawa (a little stream) of Ik2014; JG.H2784a, b, 2977a, b from Ik2014; UMUT.MM6484 (=TK.I-701), 6485a–c (=I-702a–c), 6485d (=I-700), HK7185, 7187, 7192, IGPS22751a, b, 22751', 22769 from Ponbetu (Pombets), Ishikari Province (somewhere in the outcrop from Ik2012 to Ik2014, although not precisely described in the original labels) and JG.H2982b from Ik2727 of the Pombets-Gono-sawa, of which fifty seven specimens are used for measurements and statistics.

The repositories of the examined specimens are as follows: GK: Geological Collections, Kyushu University, Fukuoka, HK: Geological Collections, Hokkaido University, Sapporo, IGPS: Geological and Paleontological Collections, Tohoku University, Sendai, JG: Collections of Jonan Geological Association kept tentatively in Noda's personal laboratory, Oita and UMUT: Collections of University Museum, the University of Tokyo, Hongo, Tokyo.

Biometry:—Measurements on left and right valves are separately shown in Tables 1 and 2. The frequency distribution of the characters examined, *i.e.*, α, β, γ, δ, l/h, b/h, L/H and s/l, are demonstrated in Fig. 2. As is clear from Fig. 2, the characters show roughly normal distribution in both valves. As to the beak angle (β) somewhat different ranges are shown between left and right valves. The simple ratio L/H is platykurtic in the left valve and left skewed in the right one. The biometric characters of the left and right valves are separately shown in

Table 1. Measurements of *Inoceramus tenuistriatus* Nagao et Matsumoto (left valve). linear dimension in mm.

specimen	h	l	b	s	H	L	α	β	γ	δ	l/h	b/h	L/H	s/l
IGPS22751	29.9	26.0	11.0	16.0	33.0	27.0	109°	80°	113°	71°	0.87	0.37	0.82	0.62
JG.H2783	24.6	18.7	9.7	12.9	25.6	19.3	107°	70°	104°	79°	0.76	0.39	0.75	0.69
JG.H2862a	31.2	26.5	12.2	15.7	36.0	28.0	107°	76°	115°	76°	0.85	0.39	0.78	0.59
JG.H2862f	17.9	13.7	7.0	7.8	20.7	14.0	101°	74°	120°	71°	0.77	0.39	0.68	0.60
JG.H2863b	39.5	32.3	14.0	18.2	42.1	33.2	100°	70°	118°	67°	0.82	0.35	0.79	0.56
JG.H2863d	23.7	19.8	8.2	11.7	26.1	20.9	93°	66°	115°	60°	0.81	0.35	0.80	0.61
JG.H2865a	29.5	25.7	11.7	16.6	36.3	26.6	94°	69°	–	61°	0.87	0.40	0.73	0.65
JG.H2865e	11.6	9.0	5.0	4.3	13.3	9.0	96°	70°	–	64°	0.78	0.43	0.68	0.48
JG.H2968a	26.0	21.2	10.4	13.8	27.6	23.8	108°	78°	104°	78°	0.82	0.40	0.86	0.65
JG.H2968b	28.7	23.3	9.8	13.0	30.9	24.0	107°	81°	112°	72°	0.81	0.34	0.78	0.56
JG.H2970	26.0	21.3	8.1	13.1	27.7	21.6	100°	80°	123°	70°	0.82	0.31	0.80	0.62
JG.H2971a	17.4	12.7	5.5	6.6	18.3	13.6	113°	83°	106°	77°	0.73	0.32	0.74	0.52
JG.H2971b	16.6	12.7	4.3	6.0	17.8	13.0	–	–	–	–	0.77	0.26	0.73	0.47
JG.H2972a	16.4	14.7	5.3	7.4	17.0	15.3	105°	80°	119°	60°	0.90	0.32	0.90	0.50
JG.H2972c	18.8	14.4	6.1	8.6	19.4	15.8	103°	80°	121°	70°	0.77	0.32	0.81	0.60
JG.H2973a	25.6	22.8	8.8	11.1	27.7	23.6	110°	76°	120°	72°	0.89	0.34	0.85	0.49
JG.H2973c	16.7	12.7	4.9	6.9	17.8	13.2	102°	80°	113°	71°	0.76	0.29	0.74	0.54
JG.H2973f	26.3	23.1	10.4	12.2	28.2	23.9	109°	84°	114°	69°	0.88	0.40	0.85	0.52
JG.H2974	28.0	21.6	7.9	12.0	30.1	22.0	102°	76°	112°	70°	0.77	0.28	0.73	0.56
JG.H2977a	19.0	15.8	4.5	7.2	20.0	17.9	108°	–	110°	71°	0.83	0.24	0.90	0.46
JG.H2977b	23.7	19.5	8.1	11.8	24.5	20.2	102°	81°	106°	70°	0.82	0.34	0.82	0.61
JG.H2979a	37.7	31.0	14.2	17.8	38.6	32.0	100°	81°	114°	74°	0.82	0.38	0.83	0.57
JG.H2980	36.2	23.5	11.2	11.6	38.0	26.5	101°	85°	121°	66°	0.70	0.31	0.70	0.46
GK.H10088a	35.4	24.7	12.7	14.3	37.0	28.0	95°	84°	109°	73°	0.70	0.36	0.76	0.58
GK.H10088b	22.0	16.7	8.6	9.2	23.0	17.1	107°	71°	101°	65°	0.76	0.39	0.74	0.55
GK.H8280b	17.2	14.3	6.0	9.6	20.3	14.0	98°	88°	116°	58°	0.83	0.35	0.69	0.67
GK.H8283a	27.1	21.0	10.0	–	29.5	23.6	102°	83°	125°	62°	0.77	0.37	0.80	–
GK.H8284	27.0	21.6	10.5	12.4	28.8	20.6	105°	84°	117°	67°	0.80	0.39	0.72	0.57
MM6485d	24.4	22.6	9.4	10.8	27.4	23.2	112°	89°	127°	68°	0.93	0.39	0.85	0.48
HK7192	24.0	21.0	11.8	14.0	27.0	23.0	110°	82°	120°	65°	0.88	0.49	0.85	0.67

reference: l/h: simple ratio of shell length vs. shell height, b/h: simple ratio of shell breadth vs. shell height, H/L: simple ratio of L vs. H, s/l: simple ratio of the length of hinge-line vs. shell height.
For others readers may refer to Fig. 2.

Tables 3 and 4. As is clear from the coefficients of variation, every character shows in general small variation in each valve except for b/h and s/l. The results of chi-square test are also shown in Tables 3 and 4. The chi-square values (X^2) are generally smaller than the significant limit at the 5 percent level except the beak angle (β) of the left valve and the posterior hinge angle (γ) of the right valve. The null hypothesis, therefore, would not be rejected in general but some suspicion remains.

The results of F-test and t-test between the right and left valves are shown in Table 5. Because the F-value for the beak angle and simple ratio s/l are significant, t-values were calculated by Welch's method. The t-values are significant at 5 percent limit in beak angle and simple ratio b/h, but the differences of other characters are not significant. These suggest that the beak angle and the simple ratio b/h are important to examine the inequivalveness.

The average relative growth of shell length vs. shell height and that of shell breadth vs. shell height are demonstrated in Fig. 3 and the data of the reduced major axes are shown in Table 6. Based on the growth index (α), correlation coefficient (r) and sample size (N), the K-test is adopted to evaluate the average relative growth. The K-values obtained are 0.25, 0.92, −1.15 and −0.24, all of which do not reject the hypothesis

Table 2. Measurements of *Inoceramus tenuistriatus* Nagao et Matsumoto (right valve). linear dimension in mm.

specimen	h	l	b	s	H	L	α	β	γ	δ	l/h	b/h	L/H	s/l
IGPS22751	27.0	24.0	9.0	17.2	30.0	25.0	90°	90°	115°	66°	0.89	0.33	0.83	0.72
JG.H2784	18.7	14.1	6.2	9.6	19.7	15.0	100°	90°	113°	64°	0.75	0.33	0.76	0.68
JG.H2862b	29.0	23.6	–	13.7	30.7	26.0	102°	90°	118°	69°	0.81	–	0.85	0.58
JG.H2862d	25.8	19.7	8.5	12.5	27.1	20.0	103°	88°	–	71°	0.76	0.33	0.74	0.63
JG.H2863c	24.2	17.5	8.2	8.6	26.0	19.0	106°	85°	106°	70°	0.72	0.34	0.73	0.49
JG.H2863e	21.2	18.2	8.0	9.9	23.1	18.5	102°	86°	105°	70°	0.86	0.38	0.80	0.54
JG.H2865b	11.2	8.9	3.1	4.3	12.3	9.0	102°	86°	–	69°	0.79	0.28	0.73	0.48
JG.H2971c	11.4	10.6	4.0	4.4	13.5	11.8	94°	87°	119°	69°	0.93	0.35	0.87	0.42
JG.H2972b	21.0	17.0	6.4	7.1	23.3	18.8	101°	86°	121°	63°	0.81	0.30	0.81	0.42
JG.H2972e	21.0	17.2	6.7	7.4	23.0	17.4	103°	86°	121°	62°	0.82	0.32	0.76	0.43
JG.H2973b	19.3	17.4	6.5	7.1	21.8	18.2	96°	87°	112°	60°	0.90	0.34	0.83	0.41
JG.H2973d	12.7	9.5	–	5.1	13.6	9.8	–	–	–	–	0.75	–	0.72	0.54
JG.H2973e	12.2	10.3	3.4	5.3	13.0	10.5	105°	82°	113°	77°	0.85	0.28	0.81	0.51
JG.H2975a	23.7	18.6	8.1	10.0	26.2	20.7	110°	98°	117°	72°	0.78	0.44	0.78	0.54
JG.H2978	21.9	18.5	6.1	11.1	22.6	18.4	110°	91°	112°	72°	0.84	0.28	0.83	0.60
JG.H2979b	21.9	18.7	7.2	10.6	22.3	18.6	105°	91°	118°	64°	0.85	0.33	0.83	0.57
JG.H2980b	32.6	25.1	9.0	12.0	37.0	24.8	94°	90°	–	68°	0.77	0.28	0.67	0.48
JG.H2981b	22.6	18.3	7.6	9.9	23.5	18.2	109°	86°	116°	64°	0.81	0.34	0.77	0.54
GK.H8278a	24.3	18.8	6.4	15.0	26.4	23.8	92°	90°	111°	54°	0.77	0.26	0.90	0.80
GK.H8278b	18.5	13.4	6.4	8.6	19.0	16.2	98°	84°	120°	53°	0.72	0.35	0.85	0.64
GK.H8279b	15.8	12.9	3.9	8.5	16.7	13.3	99°	85°	115°	60°	0.82	0.25	0.80	0.66
GK.H8282	16.1	12.7	5.5	7.3	17.0	14.4	105°	88°	111°	64°	0.79	0.34	0.85	0.57
MM6484	29.7	26.6	8.3	11.7	30.5	25.4	106°	94°	125°	66°	0.91	0.28	0.83	0.64
MM6485a	24.8	20.9	7.6	12.0	26.8	22.2	104°	97°	122°	68°	0.84	0.31	0.83	0.57
MM6485b	25.6	21.6	7.7	11.1	27.7	24.6	106°	94°	116°	67°	0.84	0.30	0.89	0.51
HK7185	37.0	32.0	12.0	–	40.0	34.2	105°	84°	114°	72°	0.86	0.32	0.86	–
HK7187	22.0	19.0	8.0	12.8	24.0	21.0	99°	89°	112°	68°	0.86	0.36	0.88	0.67

of isometry ($-1.96 \leqq K \leqq 1.96$).

Specific characters:—Shell small, very thin, inequivalve and inequilateral. Left valve higher than long, with simple ratio l/h=0.81 on average, considerably inflated and gibbous both antero-posteriorly and along the growth axis (Fig. 4), which is straight throughout growth; antero-dorsal part perpendicular to the plane of valve and more or less concave; posterior and postero-dorsal part also steep, forming a step to a distinct but small wing-like area; umbo situated at the anterior end, small and short, slightly projecting beyond the hinge line and curved considerably inwards and a little forwards; beak angle about 78° on average with small variation. Right valve lower and less inflated in comparison with the left; umbo terminal and inconspicuous with a nearly rectangular beak; anterior part steep and posterior one gradually flattened, passing into a wing-like area without any sharp boundary. Antero-dorsal margin concave in the left valve and slightly so in the right, antero-ventral margin rounded, ventral margin asymmetrically curved, passing gradually into the long posterior one, posterior margin straight and forming an obtuse angle (104° to 127°) with the hinge line, which is slightly longer than a half of shell length on average.

Surface of shell almost smooth except for very fine concentric lirae, low and narrow concentric rings frequently discernible on internal mould, each of which corresponds to a concentric lira. Low and broad concentric undulations may develop rarely.

Description:—The specimens JG.H2968a (Figs. 5-6A–C), 2970 (Fig. 6-3), 2973f (Fig. 8-2) and IGPS22751a (Figs. 5-1A–C) of left valve, and JG.H2862 (Figs. 8-1C–D), 2975a (Fig. 6-6), 2978 (Fig. 6-7) and IGPS22751b (Figs. 5-2A–C) of right valve are typical form. JG.H2865a, b

Table 3. Biometric characters of *Inoceramus tenuistriatus* Nagao et Matsumoto (left valve).

	α	β	γ	δ	l/h	b/h	L/H	s/l
N	29	28	27	29	30	30	30	29
m	103.7	78.6	114.6	68.9	0.810	0.355	0.783	0.567
s	5.41	6.01	6.71	5.49	0.0575	0.0522	0.0672	0.0670
σ	5.31	5.90	6.58	5.39	0.0565	0.0513	0.0617	0.0659
ν	5.23	7.65	5.86	7.97	7.10	14.70	8.01	11.82
$X^2_{0.05}$	4.14 $\nu=3$	$\underline{17.33}$ $\nu=1$	3.72 $\nu=1$	3.17 $\nu=1$	3.17 $\nu=1$	5.51 $\nu=2$	2.33 $\nu=1$	2.95 $\nu=1$

reference: N: sample size, m: mean value, s: standard deviation, σ: population standard deviation, ν: Pearson's coefficient of variation, $X^2_{0.05}$: chi-square value at 0.05 significant limit, ν: degree of freedom, under line: significant

Table 4. Biometric characters of *Inoceramus tenuistriatus* Nagao et Matsumoto (right valve).

	α	β	γ	δ	l/h	b/h	L/H	s/l
N	26	26	23	26	27	25	27	26
m	101.8	88.6	115.3	66.2	0.819	0.321	0.808	0.563
s	5.34	3.95	4.92	5.48	0.0559	0.0412	0.0572	0.0958
σ	5.24	3.87	4.81	5.37	0.0549	0.0404	0.0562	0.0965
ν	5.25	4.46	4.27	8.28	6.83	12.83	7.08	17.50
$X^2_{0.05}$	3.58 $\nu=2$	2.77 $\nu=1$	$\underline{4.06}$ $\nu=1$	0.90 $\nu=1$	1.38 $\nu=1$	2.03 $\nu=1$	2.12 $\nu=2$	1.68 $\nu=2$

Table 5. *F*-test and Student's *t*-test between left and right valves for selected characters of *Inoceramus tenuistriatus* Nagao et Matsumoto.

		α	β	γ	δ	l/h	b/h	L/H	s/l
LV	*N*	29	28	27	29	30	30	30	29
	m	103.7	78.6	114.6	68.9	0.810	0.355	0.783	0.567
	s	5.41	6.01	6.71	5.49	0.0575	0.0522	0.0627	0.0670
F value		1.0264	2.3150	1.8600	1.0037	1.0583	1.6053	1.2015	2.1623
significance		○	●	○	○	○	○	○	●
t value		1.308	7.256	0.414	1.823	0.598	2.641	1.556	0.174
significance		○	●	○	○	○	●	○	○
RV	*N*	26	26	23	26	27	25	27	26
	m	101.8	88.6	115.3	66.2	0.819	0.321	0.808	0.563
	s	5.34	3.95	4.92	5.48	0.0559	0.0412	0.0572	0.0985

reference: LV: left valve, RV: right valve, ● : significant, ○ : not significant
For others readers may refer to Table 3 and Fig. 2.

Table 6. Data of the average relative growth of *Inoceramus tenuistriatus.*

		α	β	log β	$\overline{h'}$	$\overline{l'}$	$\overline{b'}$	*r*	*N*	*K*
LV	l vs. h	1.011	0.779	0.1084	1.3801	1.2869		0.9712	30	.0.25
	b vs. h	1.090	0.264	0.5784	1.3801		0.9259	0.8709	30	0.92
RV	l vs. h	0.936	0.994	0.0026	1.3214	1.2341		0.9508	27	− 1.15
	b vs. h	0.984	0.331	0.4801	1.3245		0.8223	0.9385	25	− 0.24

reference: α : growth index (slope of the reduced major axis), β : Y intercept, $\overline{h'}$: mean of h′ (h =logh), $\overline{l'}$: mean of l′ (l′=logl), $\overline{b'}$: mean of b′ (b′=logb), *r* : correlation coefficient, *N*: sample size, *K*: *K*-value

(Fig. 6-11), 2971a, b (Fig. 6-12), 2974 (Fig. 7-7), GK.H10088a (Figs. 7-9A–C), 8280b (Fig. 5-3), JG.H2784 (Fig. 8-6), 2863c (Fig. 5-7) and 2865 (Fig. 6-11) are considerably elongated along the growth axis, whereas the specimens JG.H2971c (Fig. 6-12), 2972c (Fig. 7-11) and GK.H8278a (Fig. 7-10) are somewhat broadened. A specimen JG.H2982 (Fig. 9) from Loc. Ik2727m of the Pombets-Gono-sawa is considerably inflated with unusually globose umbo for the right valve. On the surface of the specimens JG.H2968a (Figs. 5-6A–C), b (Figs. 6-1A, B), 2972a, b, c (Fig. 7-11), 2973e, 2979, 2980 and GK.H8278a (Fig. 7-10) which preserved shelly material, fine concentric lirae are precisely shown, but the fine ornament is defaced from its brittle surface. JG.H2784 (Fig. 8-6), 2863b (Fig. 5-7), 2865 (Fig. 6-11), 2977 (Fig. 5-5), GK.H8280 (Fig. 6-8), 8282 (Fig. 7-8), 8278b (Fig. 7-2), 10088b (Fig. 7-1) and 10088a (Fig. 7-9) preserved the inner layer only, on which minor concentric rings and striae are clearly developed. JG.H2971 (Fig. 6-12), 2982 (Fig. 9) and IGPS22756b (Figs. 5-2A–C) are internal moulds which are ornamented by weak, low and round-topped concentric rings. Shell layer partly remains on the specimens IGPS22751a (Figs. 5-1A–C), JG.H2970 (Fig. 6-3), 2973f (Fig. 8-2), 2975a (Fig. 6-6), 2978 (Fig. 6-7) and 2869 (Figs. 7-1A–E). The concentric lirae on the surface

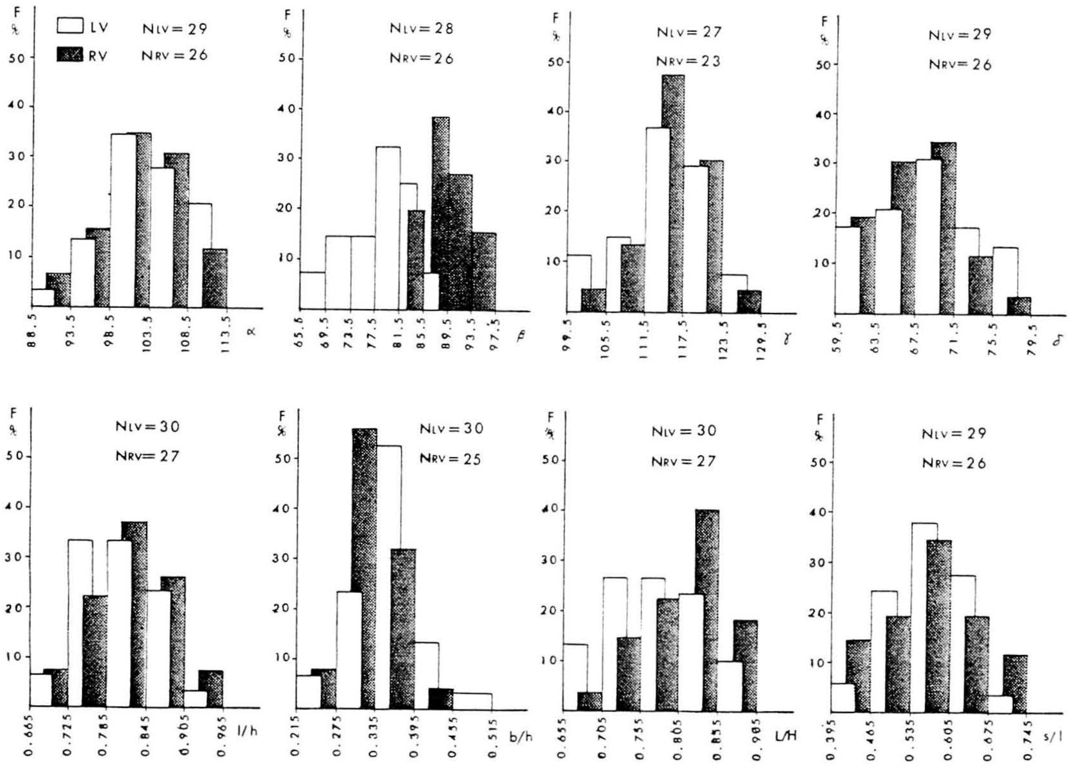

Figure 2. Histogram showing the frequency of selected characters.

may correspond to the concentric rings on the internal mould as Matsumoto and Noda (1986, p. 410) already mentioned. On the surface of JG.H2968a (Figs. 5-6A–C), 2968b, (Fig. 6-3), 2977c, GK.H8278a (Fig. 7-10), the concentric lirae are superimposed on minor concentric undulations which are indistinct, low and irregular in distance. As an exceptional case, concentric riblets of second order by Matsumoto and Noda (1986, p. 411) are discernible on JG.H2784 (Fig. 8-4).

Remarks:—Although some of the specific characters described above are based on biometric analyses, no significant alteration is needed to the original definition of the species by Nagao and Matsumoto (1939, p. 272). Additionally the following points are clarified through the present study. (1) The extent of variation in the shell form is small except the shell convexity and simple ratio s/l as shown in Tables 3 and 4. (2) The shell is not greatly inequivalve, but there is a distinct difference between left and right valves in the beak angle (β) and shell convexity (b/h). (see Table 5) (3) Through the *K*-test, the average relative growth has been confirmed that there is no significant change in the measured characters with growth. For instance, the values of l/h and b/h are almost constant throughout growth.

Comparison and discussion:—The specimens described and illustrated under "*I.* (*I.*) *tenuistriatus*" by authors, with or without a query, from the Cenomanian of various regions of the world are quite questionable in specific identification.

The specimens described by Pergament, 3580-138, 139, 140 (Pergament, 1966, pl. 13, figs. 2–4), 3580-141, 142 and 143 (pl. 14, figs. 2–4) from the Cenomanian (and Turonian ?) of Sakhalin and the Pacific Coast of the USSR,

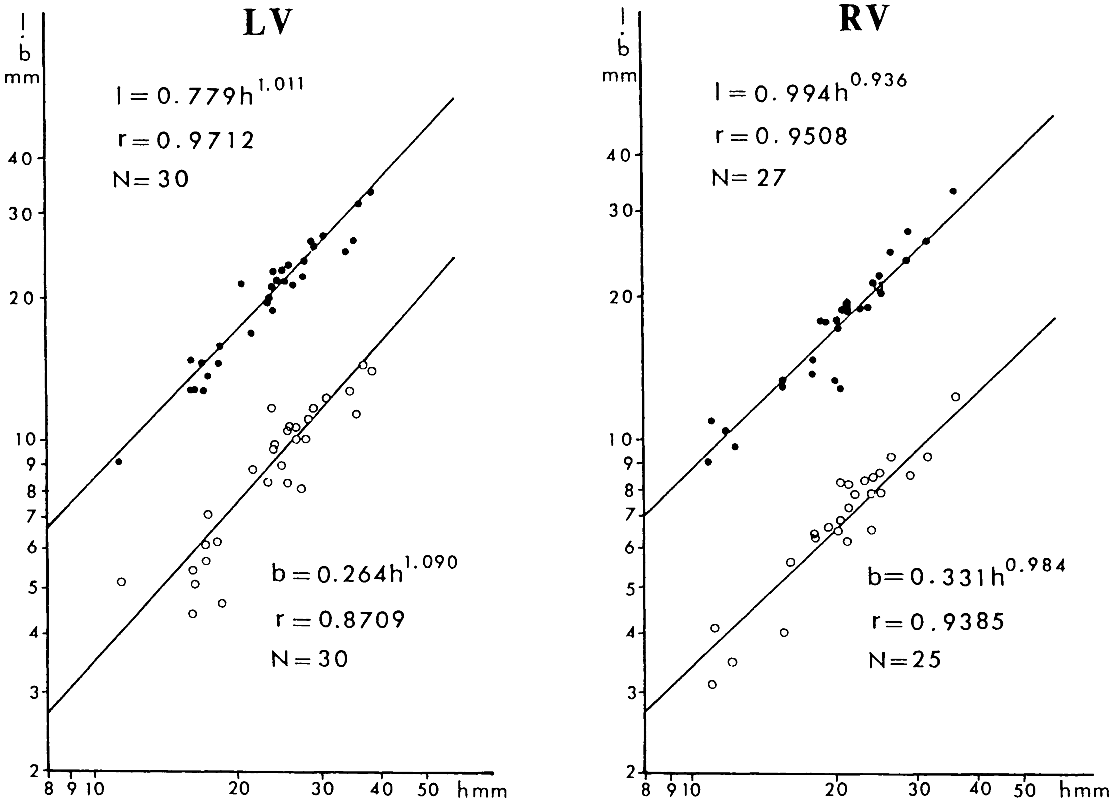

Figure 3. Diagram showing the average relative growth of *Inoceramus tenuistriatus*. LV: left valve, RV: right valve.

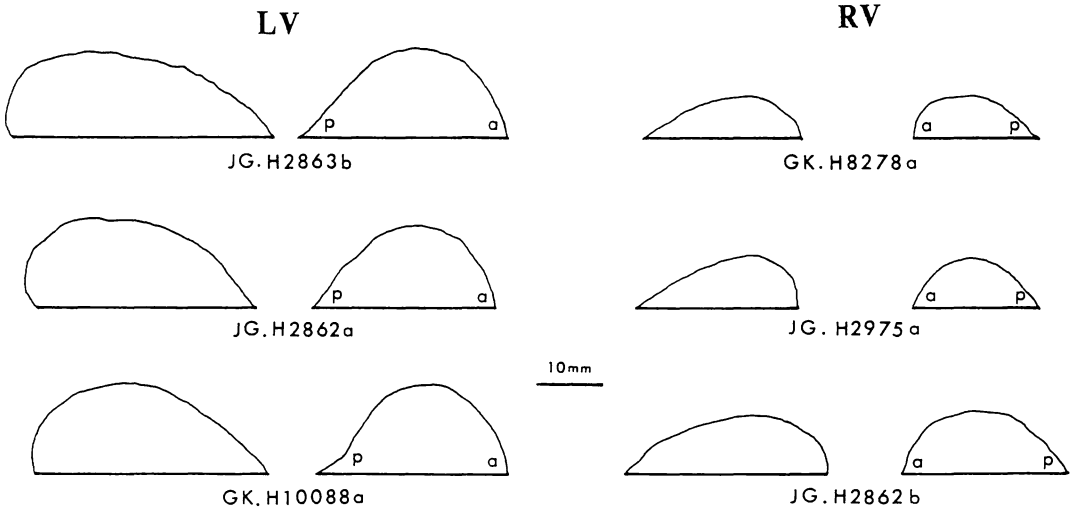

Figure 4. Shell convexity of *Inoceramus tenuistriatus*, LV: left valve, RV: right valve. left side: cross section along the growth axis, right side: cross section along the line perpendicular to the growth axis at the highest point of shell convexity, a: anterior, p: posterior

resemble the present species in general aspect. But from the *t*-test between the specimens and the population sample from the type locality, significant difference has been confirmed. The beak angle of the Pergament's specimens 3580-140 and 142 are 95° and 98°, left and right valves respectively and the *t*-values between a pair of samples are 2.681 and 2.335 which are larger than 2.052 and 2.060 at 5 percent significant limit, at degree of freedom 27 and 25 for the left and right valves respectively, and also the *t*-value of the simple ratio l/h between the population sample of the type locality and 3580-143 is 3.250, which is also larger than 2.042 at the 5 percent significant limit. Moreover, the simple ratio l/h of 3580-143 (l/h=1.00) is outside of the possible range ($m \pm 3s$ = 0.697~0.983) of the population sample. In addition the major concentric ribs are predominant in the Russian specimens. From above examination, the Russian specimens, therefore, can be at least morphologically discriminated from the present species.

The specimens USNM169399, 169401, 169402 and 169403 of Kauffman and Powell (1977) from the Upper Cenomanian of Oklahoma are clearly distinct from the Japanese specimens from the Upper Turonian of the type locality by their much larger size, weaker convexity and well-developed major concentric ribs.

The specimens described by Keller (1982) from the Middle Cenomanian of the Sack-Mulde area near Alfeld, West Germany are also discriminated from the studied specimens of *I. tenuistriatus* from Hokkaido by their larger ratio of L/H (Keller, 1982, p. 63, fig. 30), weaker convexity (observed by photographs), indistinct posterior wing and major concentric ribs developed in the early growth-stage onward. If *t*-test were applied for a pair of left and right valves of the German specimens and also between the German and Japanese specimens, the result would show clear difference. But I refrain, here from the evaluation because of insufficient information on the German specimens.

In connection with the above comparison, according to Matsumoto's personal communication, Matsumoto and Tanaka have recently established *Inoceramus nodai* on sufficiently numerous specimens from the Upper Cenomanian strat of Hokkaido. They suggested that what was described under "*I.* (*I.*) *tenuistriatus*" (with or without a query) by several authors from the Cenomanian of oversea regions may be preferably transferred to *I. nodai.* I am fully agreeable with their view. I have hesitated for a long time to give comments on the specific assignment of "*I.* (*I.*) *tenuistriatus*". The young shell of *I. nodai* Matsumoto et Tanaka, 1988 closely resembles the right valve of the present species in marginal outline, shell convexity, nearly straight growth axis and fine concentric lirae, but differs gradually with growth from the present species by comparatively larger size, anteriorly curved growth axis, development of the major concentric ribs and slightly inequivalve or subequivalve with less gibbous and gently convex shell.

Previously Nagao and Matsumoto (1939) pointed out the resemblance between the present species and *I. etheridgei* Woods, 1911 (p. 278, pl. 49, figs. 2–4) from the Lower Chalk of England and Matsumoto (1959, p. 84) once suggested that *I. tenuistriatus* might be preferably separated as a subspecies of *I. etheridgei,* but he noticed some difference and evidently delayed occurrence in age. Kauffman (1977a, p. 178; 1978, p. iv 4–5) also regarded the present species as a member of the "*I. etheridgei* lineage"

Incidentally *I. etheridgei* in the sense of Woods (1911) was a homonym of *I. etheridgei* Etheridge, Jr., 1901 and renamed as *I. scalprum* Böhm, 1915, which is currently regarded as a subspecies or variety of *I. virgatus* Schlüter (see Matsumoto *et al.* 1987, p. 157–162; Sornay, 1978, p. 510).

Following Matsumoto and Tanaka (1988), the origin of *I. nodai* may be ascribed to a form of *I. virgatus* (=*I. virgatus scalprum* of the Keller's sense). According to Matsumoto *et al.* (1987) *I. virgatus* is considerably variable in shell form, ontogenetic change of obliquity and ornamentation.

In connection with the lineage of *I. tenuis-*

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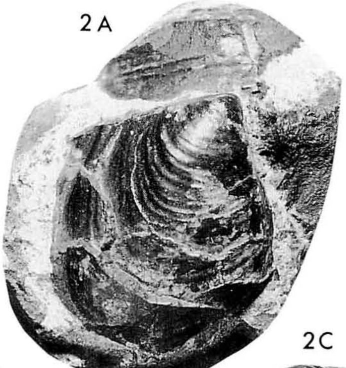

2B


1C


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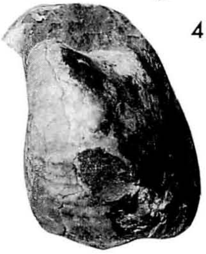
2C


6A


4A


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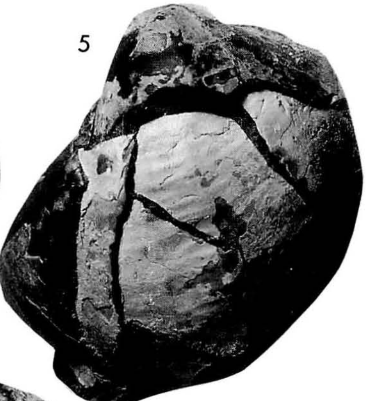

6B


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6C


triatus, it is noteworthy to see that the specimens of *I. nodai* from a higher stratigraphic position, *i.e.*, the upper part of the Upper Cenomanian in the Oyubari area, Hokkaido are generally smaller in size than its holotype from the lower part of the Upper Cenomanian in the Ikushumbets area. The immediate ancestor of *I. tenuistriatus* which could link phylogenetically with *I. nodai* is so far unknown and should be search for from the lower part of the Turonian. Besides the species of *I. inaequivalvis* Schlüter from the Middle Turonian of Euramerica and *I. submametensis* Zonova, 1982 from the Turonian of the Pacific Coast of the USSR may be related to the lineage of *I. tenuistriatus.* I withhold, at present, to discuss the detailed phylogenetic consideration, since it is a side issue from the aim of this study.

Occurrence:—For some reasons, some authors thought that the original location and stratigraphic position of *I. tenuistriatus* were obscure. Nagao and Matsumoto (1939, p. 273) reported clearly that the six syntypes are all from the lowest part of the Upper Ammonite beds along the Pombetu [=Pombets in this and other recent papers]. One of the authors (T. M.) told me that this means the continuous outcrop of a unit (Member IIIa′) of fine-sandy siltstone, which is subdivided into Ik2012, Ik2013 and Ik2014 for convenience. This outcrop is now celebrated for the occurrence of several important species, as has been already reported by Matsumoto (1965, 1984), Matsumoto *et al.* (1981) and Matsumoto and Noda (1983). Its location is shown in Fig. 10 of this paper, Long. 141° 58'46"–50"E, Lat. 43° 16'20"–23"N. This unit belongs to the Zone of *Mytiloides incertus* (Matsumoto and Noda, 1983; Noda 1984).

Numerous specimens are included in calcareous nodules in fine-sandy siltstone of Unit IIIa′ of the Upper Yezo Group; commonly closed or articulate and rarely separated valves. Associated megafossils listed by Matsumoto *et al.* (1981) are as follows: *Mytiloides incertus* (Jimbo), *M.* sp., *Inoceramus pedalionoides* Nagao et Matsumoto, *I.* (*I.*) sp., *Damesites ainuanus* Matsumoto, *Subprionocyclus neptuni* (Geinitz), *S. normalis* (Anderson), *Prionocyclus abberrans* Matsumoto, *P. cobbani* Matsumoto, *Reesidites minimus* (Hayasaka et Fukada), *Lymaniceras planulatum* Matsumoto, *Nipponites bacchus* Matsumoto et Muramoto, *Scalarites densicostatus* Matsumoto, *Scaphites* aff. *subdelicatulus* Cobban et Gryc, *S. yonekurai* Yabe, *Otoscaphites* aff. *prerini* (Anderson) and *Sciponoceras intermedium* Matsumoto et Obata, of which *M. incertus, S. neptuni* and *S. normalis* are world-wide zonal indices of the Upper Turonian. A lot of carbonized vegetable drifts and amber or retinite are frequently contained in nodules.

A single specimen JG.H2982 is from Loc. Ik2727m, the upper reaches of the Pombets-Gono-sawa (Takino-sawa or Takiyoshi-zawa), a tributary of the R. Pombets, together with *Lymaniceras planulatum.* For details readers may refer to Matsumoto and Noda (1985, p. 265).

The occurrence of *I. tenuistriatus* has been already recorded by a number of researchers (Yoshida and Kambe, 1955; Igi *et al.*, 1958; Tsushima *et al.*, 1958; Tanabe, 1972; Matsumoto and Okada, 1973; Obata and Futakami, 1975; Tanabe *et al.*, 1977; Hirano *et al.*, 1980, 1981; Futakami, 1982; Futakami and Miyata, 1983; Sekine *et al.*, 1985), in various areas, *e.g.*, Soashibets, Hatonosu, Manji, Oyubari and Osawa (=Kamihobets) areas of central Hokkaido; Obira area, northwestern Hokkaido and Uwajima area, western Shikoku. Some specimens from the previously listed localities may, however, need reexamination with reference to the present

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← **Figure 5.** *Inoceramus tenuistriatus* Nagao et Matsumoto. **1.** IGPS coll. cat. no. 22751a, left valve, x 1.17. from Pombets, precisely undescribed on the original label, probably Ik2012-2014. One of the syntypes. **A:** lateral view, **B:** anterior view, **C:** dorsal view. **2.** IGPS coll. cat. no. 22751b, right valve, x 1.25, same locality. **A:** lateral view, **B:** anterior view, **C:** dorsal view. **3.** GK.H8284, left valve, x 1.17. Loc. Ik2013. **4.** IGPS coll. cat. no. 22751-2, left valve, x 1.17. from Pombets. **A:** lateral view, **B:** anterior view. **5.** JG.H2979, left valve, x 1.1. Loc. Ik2014. **6.** JG.H2968a, left valve, natural size. Loc. Ik2013. **A:** lateral view, **B:** anterior view, **C:** dorsal view. **7.** JG.H2863, natural size. Loc. Ik2013d.

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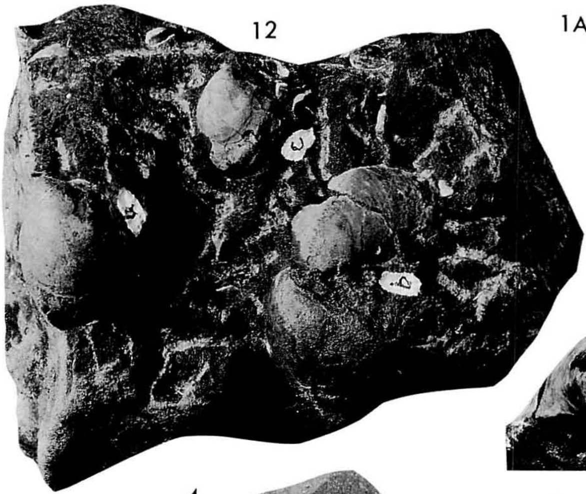

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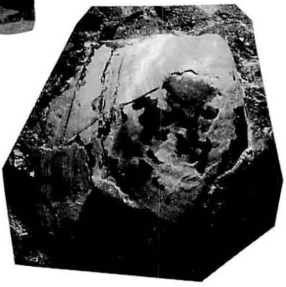

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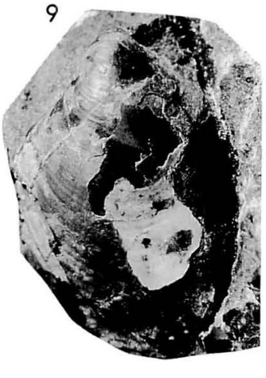

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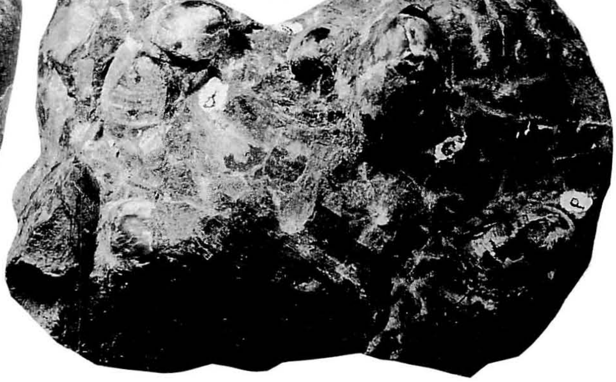

redefinition.

The material of *I. tenuistriatus* dealt with in this paper is limited to the Upper Turonian of Hokkaido, but the true stratigraphic range and geographic distribution of this species are to be worked out further.

Conclusion

To solve the taxonomic and biostratigraphic confusion of *Inoceramus tenuistriatus,* I attempted to restudy this species by means of biometric examination on a population sample from the type locality. The results obtained are as follows.

1. In addition to the original definition by Nagao and Matsumoto (1939), an extent of variation, a degree of inequivalveness and ontogenetic change of shell form are quantitatively displayed by means of statistics, *t*-test and analysis of the average relative growth respectively. For example, (1) the characters examined show in general a small variation (smaller than 9.00 in Pearson's coefficient of variation) except for b/h and s/l in both valves, (2) the inequivalveness is mainly expressed by the difference in beak angle (=78.6° in LV and 88.6° in RV on average) and simple ratio b/h (0.355 in LV and 0.321 in RV on average) and (3) the average relative growth is nearly isometric, which implies that the shell form is almost invariable at every stage of growth.

2. The so-called "*I.* (*I.*) *tenuistriatus*" (with or without a query) from various horizons of the Cenomanian of Euramerica and the Pacific Coast of the USSR is morphologically distinct from the population sample from the type locality, as shown by the result of *t*-test and other examination.

3. I agree with Matsumoto and Tanaka (1988) in their remarks that the specimens so-called "*I.* (*I.*) *tenuistriatus*" from oversea regions would be preferably transferred to *I. nodai* Matsumoto et Tanaka, which was established on the specimens from the Upper Cenomanian of the Ikushumbets and Oyubari areas, central Hokkaido.

4. Some of the previously recorded specimens from various areas of Japan may need reexamination with reference to the result of this study. The numerous specimens of *I. tenuistriatus* dealt with in this paper are all from the Upper Turonian of Hokkaido. The true stratigraphic range and geographic distribution of this species are yet to be worked out further.

5. The problem as to the origin and immediate ancestor of *I. tenuistriatus* is likewise remains unsolved.

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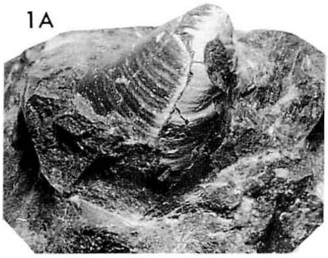
← **Figure 6.** *Inoceramus tenuistriatus* Nagao et Matsumoto. **1.** JG.H2968b, left valve, natural size. Loc. Ik2013. **A:** lateral view, **B:** dorsal view. **2:** JG.H2973b, right valve, x 1.35. Loc. Ik2013. **3.** JG.H2970, left valve, x 1.25. Loc. Ik2013b. **4.** UMUT.MM6484=TK.I-701, right valve, natural size. from Pombets, precisely unknown. One of the syntypes. **5.** UMUT.MM6485=TK.I-700, right valve, x 1.15. from Pombets. One of the syntypes. **6.** JG.H2975a, right valve, x 1.25, Loc. Ik2013. **7.** JG.H2978, right valve, x 1.25. Loc. Ik2013. **8.** GK.H8280, left valve, x 1.25. Loc. Ik2013. **9.** JG.H2973a, left valve, x 1.25. Loc. Ik2013. **10.** UMUT.MM6485a=TK.I-702a, right valve, natural size. from Pombets. precisely unknown. One of the syntypes. **11.** JG.H2865, natural size, Loc. Ik2013h.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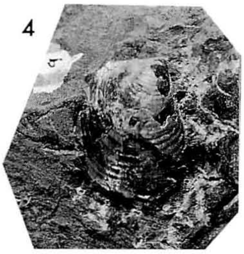
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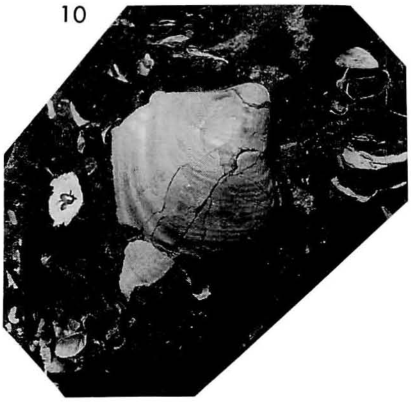
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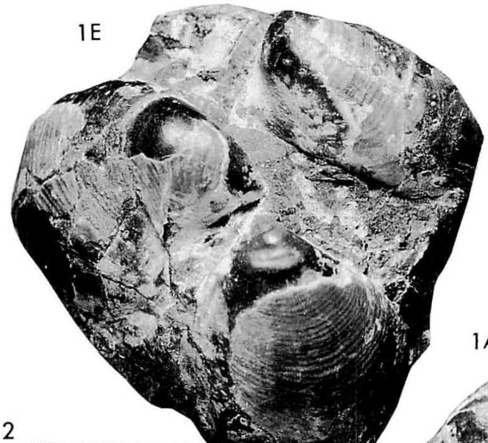
← **Figure 7.** *Inoceramus tenuistriatus* Nagao et Matsumoto. **1.** GK.H10088b, left valve, x 1.17. Loc. Ik2013e, **A:** lateral view, **B:** anterior view. **2.** GK.H8278b, right valve, x 1.25. Loc. Ik2013. **3.** GK.H8283a, left valve, x 1.13. Loc. Ik2013. **4.** GK.H8279, right valve, x 1.19. Loc. Ik2014a. **5.** GK.H8281, right valve, x 1.19. Loc. Ik2013. **6.** UMUT.MM6485c=TK.I-702c, right valve, x 1.18. from Pombets. One of the syntypes. **7.** JG.H2974, left valve, x 1.25. Loc. Ik2014. **8.** GK.H8282, right valve, x 1.18. Loc. Ik2013. **9.** GK.H10088a, left valve, x 1.25. Loc. Ik2013. **10.** GK.H8278a, right valve, natural size. Loc. Ik2013. **11.** JG.H2972, natural size. Loc. Ik2013.

1E



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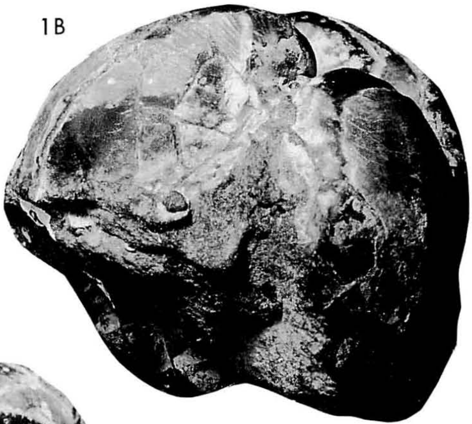

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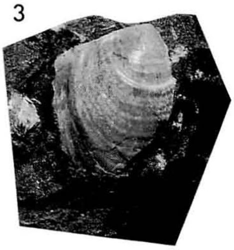

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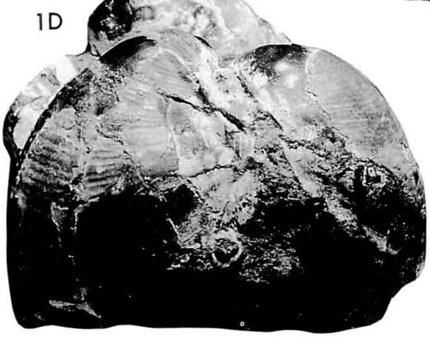

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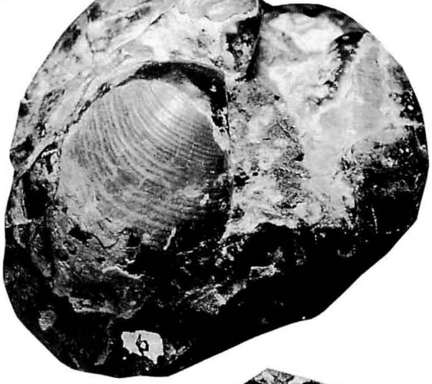

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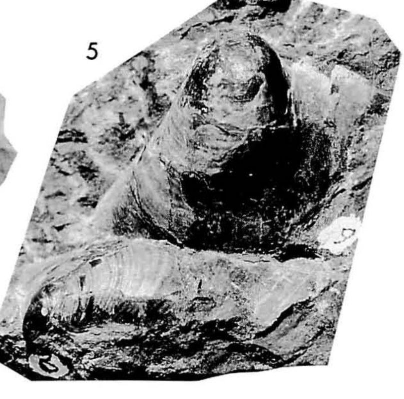

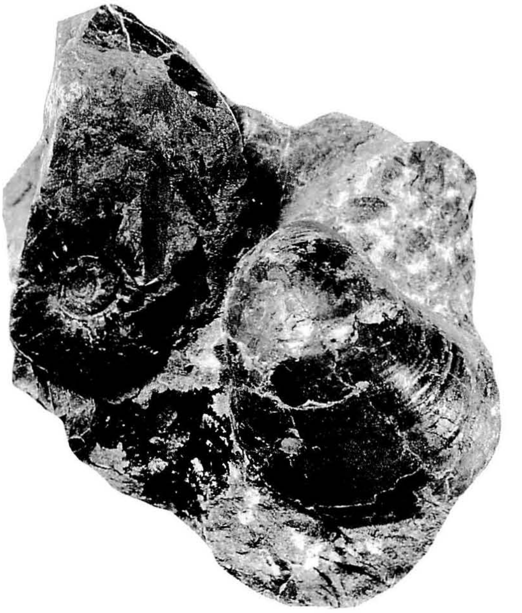

Figure 9. *Inoceramus tenuistriatus* Nagao et Matsumoto. JG.H2982, right valve, natural size. Loc. Ik2727m. associated with *Lymaniceras planulatum* Matsumoto.

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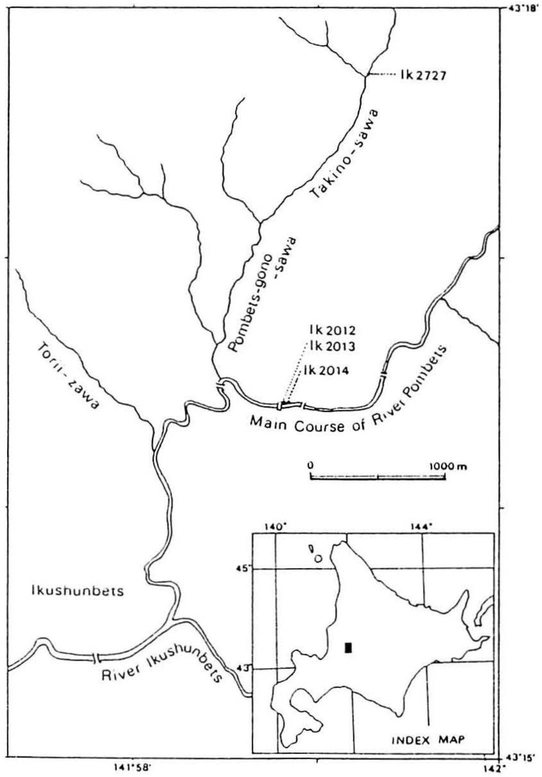

Figure 10. Map showing the type locality of *Inoceramus tenuistriatus* Nagao et Matsumoto, in the Pombets area, central Hokkaido.

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← **Figure 8.** *Inoceramus tenuistriatus* Nagao et Matsumoto. **1.** JG.H2862, ca × 1.25. Loc. Ik2013h. **A:** lateral view of 2862a (left valve), **B:** posterior view of 2862a, **C:** lateral view of 2862b (right valve), **D:** posterior view of 2862b, **E:** dorsal view of articulated both valves. **2.** JG.H2973f, left valve, × 1.25. Loc. Ik2013. **3.** GK.H8283b, right valve, × 1.25. Loc. Ik2013. **4.** JG.H2784, right valve, × 1.27. Loc. Ik2014. **5.** JG.H2977b, left valve, × 1.25. Loc. Ik2013d. **6.** GK.H8277, natural size. Loc. Ik2014a, associated with *Lymaniceras planulatum* Matsumoto.

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Asahikawa 旭川, Gono-sawa 五の沢, Hatonosu 鳩ノ巣, Horokanai 幌加内, Ikushumbets 幾春別, Ikushumbets-Dake 幾春別岳, Kamihobets 上穂別, Manji 万字, Mikasa 三笠, Obira 小平, Osawa 長和, Oyubari 大夕張, Pombets 奔別, Pombetu (Ponbetu) 奔別, Saku 佐久, Sapporo 札幌, Soashibets 惣芦別, Takino-sawa 滝ノ沢, Takiyoshi-zawa 滝吉沢, Tappu 達布, Torii-zawa 鳥居沢, Uwajima 宇和島, Yezo 蝦夷（エゾ).

日本のチューロニアン上部から産する*Inoceramus tenuistriatus* Nagao et Matsumotoについて：*Inoceramus tenuistriatus* Nagao et Matsumoto, 1939の原著での記載・図示はかなり明確であるにもかかわらず，海外の研究者には本種が必らずしも正しく理解されていないきらいがある。そこで本論では本種の模式産地から得られた多くの標本について計測を行い，個体群の概念から再検討を試みた。これらの結果をふまえて本種を再定義した。その上で欧米やソビエト太平洋岸のセノマニアン産のいわゆる“*Inoceramus* (*I.*) *tenuistriatus*”について比較検討した。その結果，それらは本種とは形態的に区別されることが明らかとなった，それはむしろ，北海道セノマニアン上部の材料に基づいて設立された，*I. nodai* Matsumoto et Tanaka, 1988に同定されるのではないかという松本・田中の示唆に賛意を表したい。本種の模式産地の地層は随伴する化石からチューロニアン上部であることは明らかである。今回は模式産地の個体群についてのみ扱ったので本種の真の層序的産出範囲が上下にどこまでのびるのかは今後の課題として残しておく。

野田雅之

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会第137回例会

日本古生物学会第137回例会が1988年6月25・26日に福島県立博物館で開催された（参加者121名）。

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個人講演

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美祢層群産 *Taeniopteris* 属について……内藤源太朗

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古海洋学ワークショップ…………世話人　大場忠道

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Errata

No. 150, 858. Tatsuro MATSUMOTO and Yoshiro MOROZUMI:
A sphenodiscid ammonite acquired rarely from the Cretaceous of Japan.

page	line	read	for
466R	18	broad	long
468L	38	*Menambolites*	*Nenambolites*

行事予定

	開催地	開催日	講演申込締切日
1989年年会・総会	京都大学	1989年2月3日～5日	1988年11月20日
1989年第138回例会	長崎大学	1989年6月24日～25日	1989年4月10日

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日本古生物学会行事係（葉書で申し込んで下さい）

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世話人・鎮西清高・亀井節夫が予定されています。

○文部省科学研究費補助金（研究成果公開促進費）による。

1988年10月25日 印刷
1988年10月31日 発行

ISSN 0031-0204
日本古生物学会報告・紀事

新篇 151号

2,500円

発行者 日本古生物学会
文京区弥生2-4-16
日本学会事務センター内
（振替口座 東京 84780番）
（電話 03－817－5801）
編集者 猪郷久義・斎藤常正
編集幹事 野田浩司
印刷者 東京都練馬区豊玉北2の13
学術図書印刷株式会社 富田 潔
（電話 03－991－3754）

Transactions and Proceedings of the Palaeontological
Society of Japan

New Series No. 151 October 31, 1988

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