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Auloporid Tabulate Corals from the Carboniferous Ichinotani Formation, Gifu Prefecture

Shuji Niko

Department of Environmental Studies, Faculty of Integrated Arts and Sciences,
Hiroshima University, 1–7–1 Kagamiyama, Higashihiroshima,
Hiroshima, 739–8521 Japan

Abstract Previously poorly known tabulate coral fauna of the Ichinotani Formation in the Fukuji area, Gifu Prefecture, Central Japan has been investigated. Eight species of Carboniferous tabulate corals ascribed to the order Auloporida are described as new and accompanied by stratigraphic data: *Cladochonus cylindratus* n. sp., Serpukhovian; *C. hamadai* Igo and Adachi, 1980, Bashkirian to Gzhelian; *Remesia*? sp. indet., Serpukhovian; *Syringopora ichinotaniensis* n. sp., Visean or Serpukhovian; *S.* sp. indet., Visean or Serpukhovian; *Multithecopora yabei* n. sp., Visean or Serpukhovian; *M.*? sp., indet. 1, probable Visean or Serpukhovian, *M.*? sp. indet. 2, Moscovian. *Cladochonus hamadai* is common in the Oboradani Formation, Fukui Prefecture, and closely related species with this fauna are reported from the Oboradani Formation and the Onimaru Formation, Iwate Prefecture in Japan and in North and South China, East Avalonia and Baltica.

Key words: Auloporida, Carboniferous, Ichinotani Formation, new species, stratigraphic distributions, tabulate corals, taxonomic descriptions.

Introduction

The Ichinotani Formation (Kamei, 1952; redefined by Igo, 1956) is made up largely of limestone cropping out in the Fukuji area, Gifu Prefecture, Central Japan, of which strata were lithologically subdivided into 61 units grouped into the Lower, Middle and Upper Members by Adachi (1985). It ranges in chronostratigraphically from middle Early Carboniferous (Visean) to late Late Carboniferous (Gzhelian). Tabulate corals from the formation have been known since the close of the 1950's when Minato and Kato (1957), Fujimoto and Igo (1958) and Kato (1959) reported the occurrence of *Syringopora*. Subsequently, Igo and Adachi (1980, 1981), Niikawa (1980) and Adachi (1985) added *Cladochonus* (and *Sinopora*?) to this fauna. Among them, only a single species of *Cladochonus hamadai* Igo and Adachi, 1980 has been described and illustrated. The purpose of this paper is to reveal the specific composition, with the data of their stratigraphic distributions using Adachi's lithostratigraphic nomenclature, of the Ichinotani tabulate coral fauna based on recent collections made by myself. Fossil localities are shown in Fig. 1. Three species, viz. *Cladochonus*

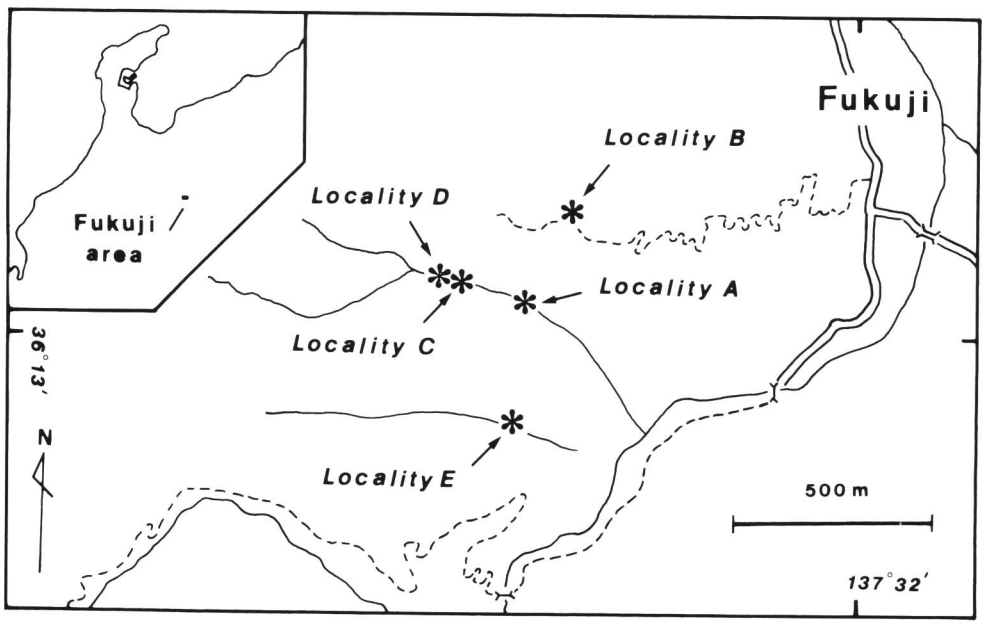


Fig. 1. Index map of the Fukuji area, Gifu Prefecture showing coral localities. Locality A and B are identical with fusulinid localities examined in Niko (1987).

cylindratus, *Syringopora ichinotaniensis* and *Multithecopora yabei*, are new.

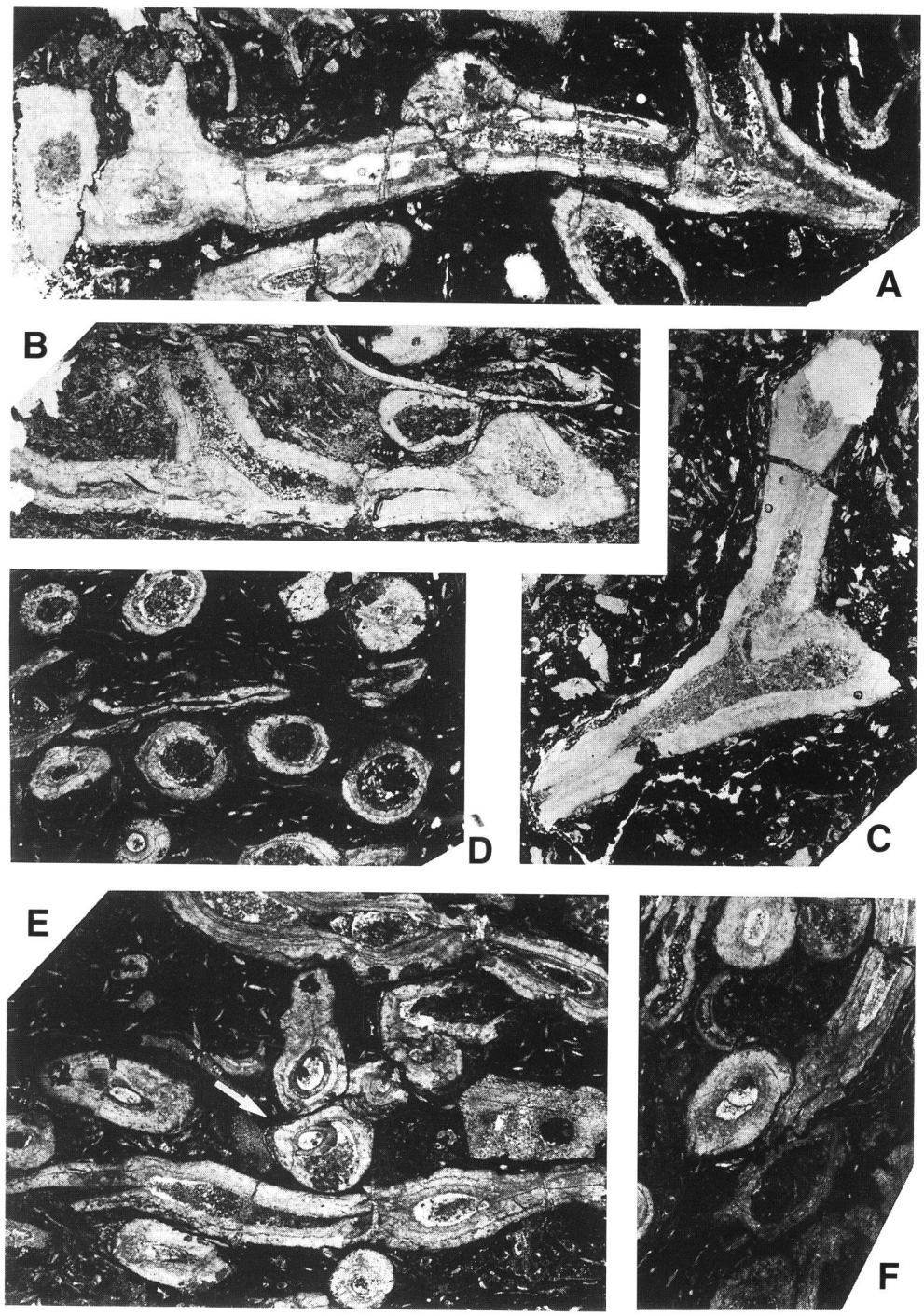
The specimens studied herein are deposited in the National Science Museum, Tokyo (NSM).

Systematic Paleontology

Order Auloporida Sokolov, 1947
Superfamily Auloporicae Milne-Edwards and Haime, 1851
Family Pyrgiidae Fromentel, 1861
Genus *Cladochonus* M'Coy, 1847

Type species: *Cladochonus tenuicollis* M'Coy, 1847.

Fig. 2. *Cladochonus cylindratus* n. sp., holotype, NSM PA14370, thin sections. A, perpendicular to substrate, longitudinal section, ×10. B, perpendicular to substrate, longitudinal section, ×10. C, parallel to substrate, longitudinal section, ×10. D, parallel to substrate, transverse section, ×10. E, parallel to substrate, longitudinal and transverse sections, arrow indicates intracalicular offset, ×10. F. parallel to substrate, longitudinal and transverse sections, note complete tabula, ×10.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Cladochonus cylindratus n. sp.

(Figs. 2 A–F)

Holotype: NSM PA14370, from which fourteen thin sections were made.

Diagnosis: Species of *Cladochonus* with relatively small corallite diameter, approximately 1.1 mm, and nearly cylindrical external surface of calices; tabulae vary rare, complete; septal spines short, sporadic.

Description: Corallum encrusting, mat-like in growth form with maximum observed diameter approximately 65 mm; each corallite consists of proximal prostrate portion, 3.8–4.2 mm in length, and nearly cylindrical free portion forming oblique calice, 1.4–1.6 mm in length; corallites subcircular cross sections, their diameter relatively small for genus, ranging from 0.6 to 1.5 mm, usually 1.0–1.3 mm with 1.1 mm mean; calices very deep; increase of corallites unilateral, daughter corallite of offset arises at basal portion of preceding calice as intracalicular and peripheral type, then branches off. Corallite walls mostly very thick, attain 0.53 mm, composed of thin dark layer of epitheca and inner more translucent layer of microlamellar stereoplasm with banded structure; thickness of stereoplasm somewhat variable, ratio of tabularium diameter per corresponding corallite diameter declines to 0.16; tabulae very rare, in case of existence they concave distally to nearly flat, complete; septal spines short, usually 0.13 mm in length, sporadic.

Discussion: *Cladochonus cylindratus* n. sp. is distinguished from the most similar species *C. hamadai* Igo and Adachi, 1980 on the basis of its smaller corallite diameter (approximately 1.1 mm versus 1.5–2.0 mm in *C. hamadai*), fewer tabulae and shorter septal spines.

Etymology: The specific name is derived from the Latin *cylindrus* (=cylinder) in reference of its external calice shape.

Occurrence and age: Obtained from black argillaceous limestone in the upper part of the Unit 1, Lower Member, Ichinotani Formation at locality A. Serpukhovian (late Early Carboniferous).

Cladochonus hamadai Igo and Adachi, 1980

(Figs. 3 D, 4 E)

Cladochonus hamadai Igo and Adachi; Niko *et al.*, 1997, p. 47, 48, figs. 6-1–5 (with preceding synonym list).

Material: Seven thin sections and one etched piece were studied from two specimens (NSM PA14372, 14373).

Remarks: Although the internal structure of the present specimens is poorly preserved by silicification, their general corallite shape and size, and mode of increase agree well with the diagnosis of *Cladochonus hamadai* described by Igo and Adachi (1980) from the same formation and Niko *et al.* (1997) from the Oboradani

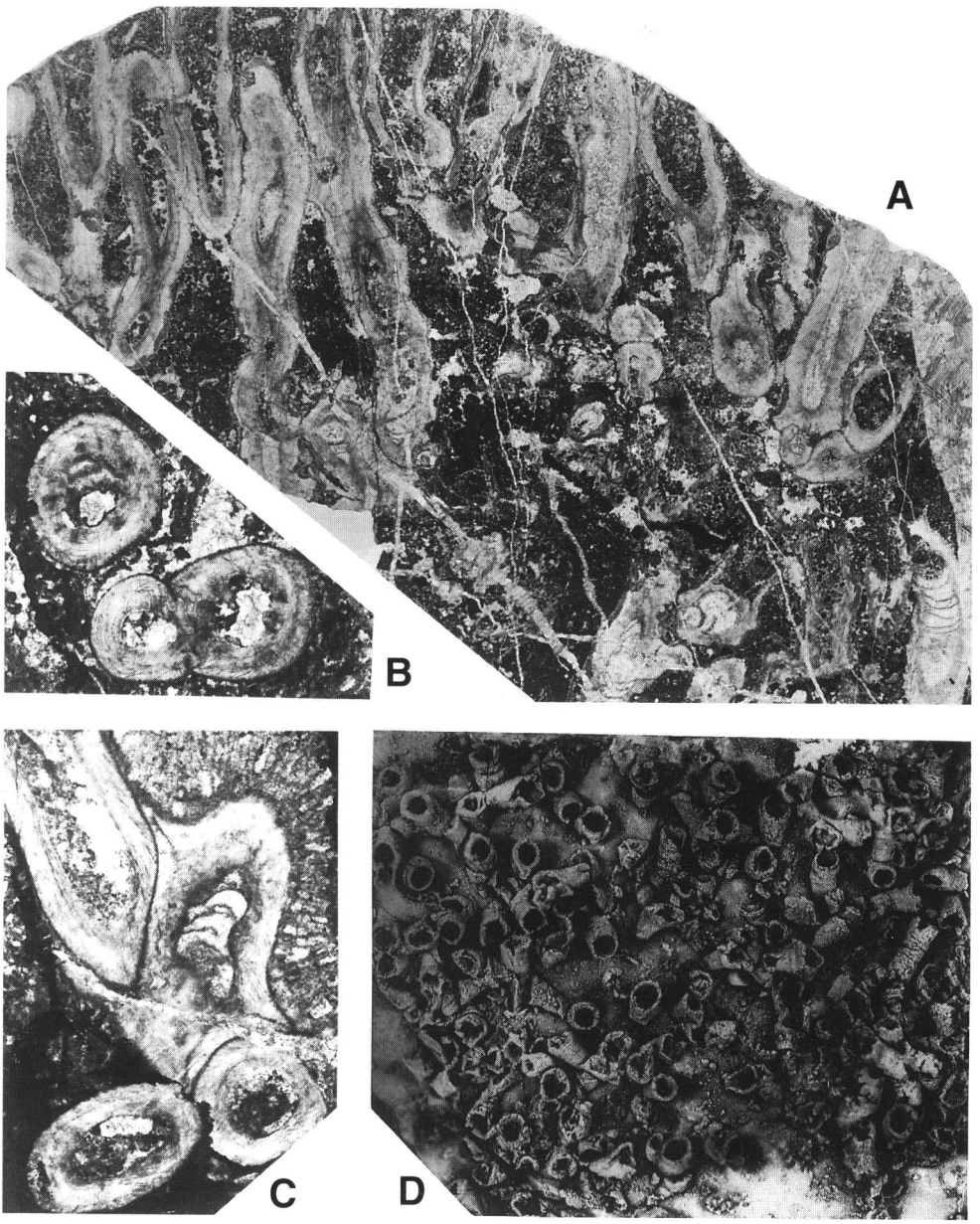


Fig. 3. A, *Multithecopora yabei* n. sp., paratype, NSM PA14378, thin longitudinal section, ×5. B, C, *Multithecopora*? sp. indet. 2, thin sections, NSM PA14380, B, transverse section, ×10, C, transverse and longitudinal sections, ×10. D, *Cladochonus hamadai* Igo and Adachi, NSM PA14372, etched specimen, ×2.

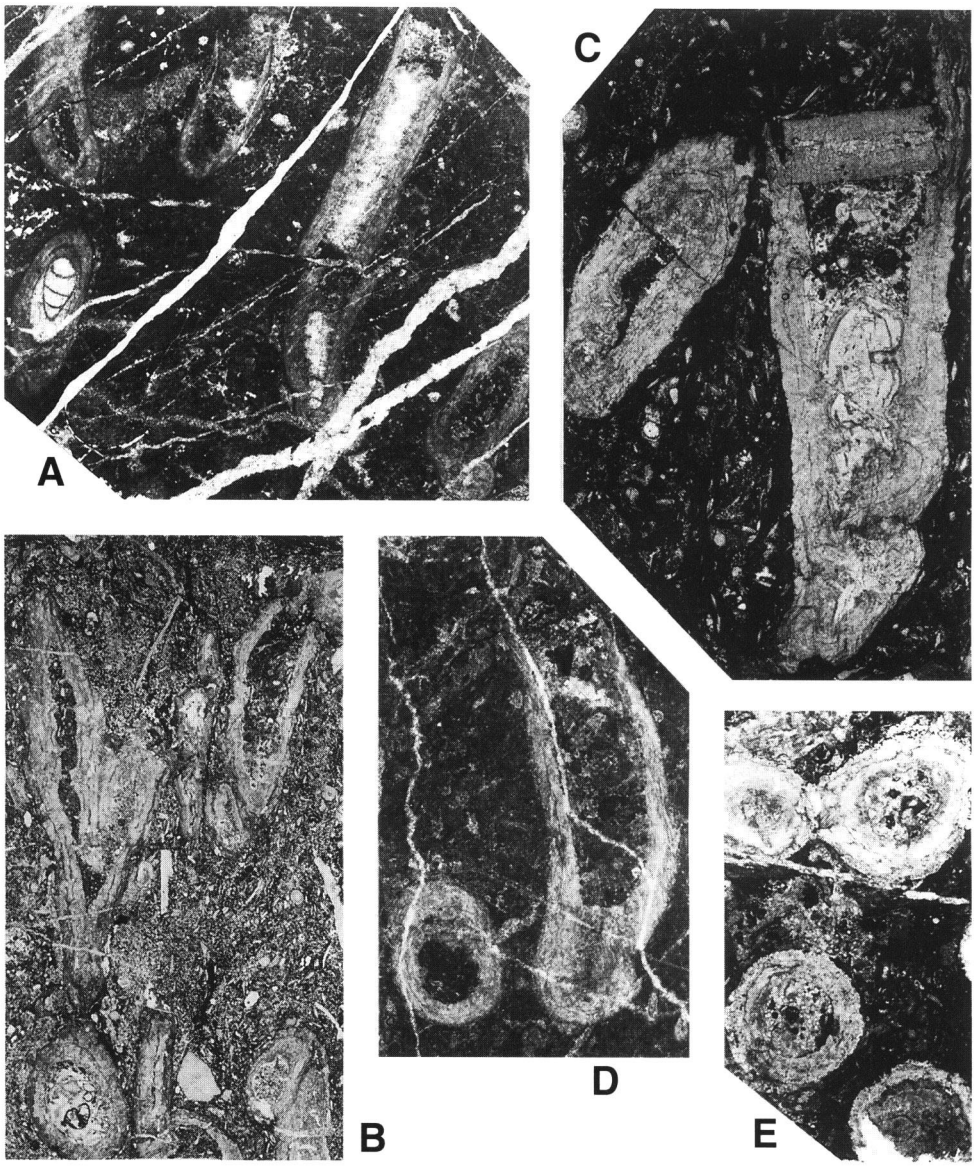


Fig. 4. A, D, *Multithecopora*? sp. indet. 1, NSM PA14379, thin sections, A, longitudinal section, ×5, D, longitudinal and transverse sections, ×10. B, C, *Remesia*? sp. indet., NSM PA14371, thin sections, B, longitudinal and transverse sections, ×5, C, longitudinal section, ×10. E, *Cladochonus hamadai* Igo and Adachi, NSM PA14373, thin transverse section, parallel to substrate, ×10.

Formation, Fukui Prefecture. Documented range of this species is the Bashkirian (early Late Carboniferous) to Gzhelian (late Late Carboniferous).

Occurrence and age: Obtained from a black limestone block in talus at locality C (NSM PA14372) and dark gray limestone of a float block at locality E (NSM PA14373). The both blocks derived from the Middle Member, Ichinotani Formation. Bashkirian or Moscovian (middle Late Carboniferous).

Family Romingeriidae Sokolov, 1950
Genus *Remesia* Kettner, 1934

Type species: *Remesia tubulosa* Kettner, 1934.

***Remesia*? sp. indet.**
(Figs. 4 B, C)

Material: Eleven thin sections were studied from a single specimen (NSM PA14371).

Description: Corallum fasciculate, may be dendroid; each corallite usually subcircular cross section, attains 2.6 mm in diameter; corallite walls very thick, indicating banded structure with lamellar microstructure; septal spines long, numerous; tabulae incomplete.

Discussion: A single available specimen from the Ichinotani Formation does not allow detailed comparisons and generic identification for ill preservation. However, its general corallite shape and wall structure most approach to *Remesia tubulosa* Kettner (1934, figs. 8–13), from the Givetian (Middle Devonian) of Czechoslovakia, among the known auloporids.

Occurrence and age: Identical with *Cladochonus cylindratus* (this report).

Superfamily Syringoporicae Fromentel, 1861
Family Syringoporidae Fromentel, 1861
Genus *Syringopora* Goldfuss, 1826

Type species: *Syringopora ramulosa* Goldfuss, 1826.

***Syringopora ichinotaniensis* n. sp.**
(Figs. 5 A–E, 6 A–C)

Holotype: NSM PA14374, from which twelve thin sections were made.

Other specimen: Two thin sections were studied from a single paratype, NSM PA14375.

Diagnosis: Species of *Syringopora* characterized by partial anastomosis of coralla with strongly flexuous corallites, relatively sparse connecting tubuli and very

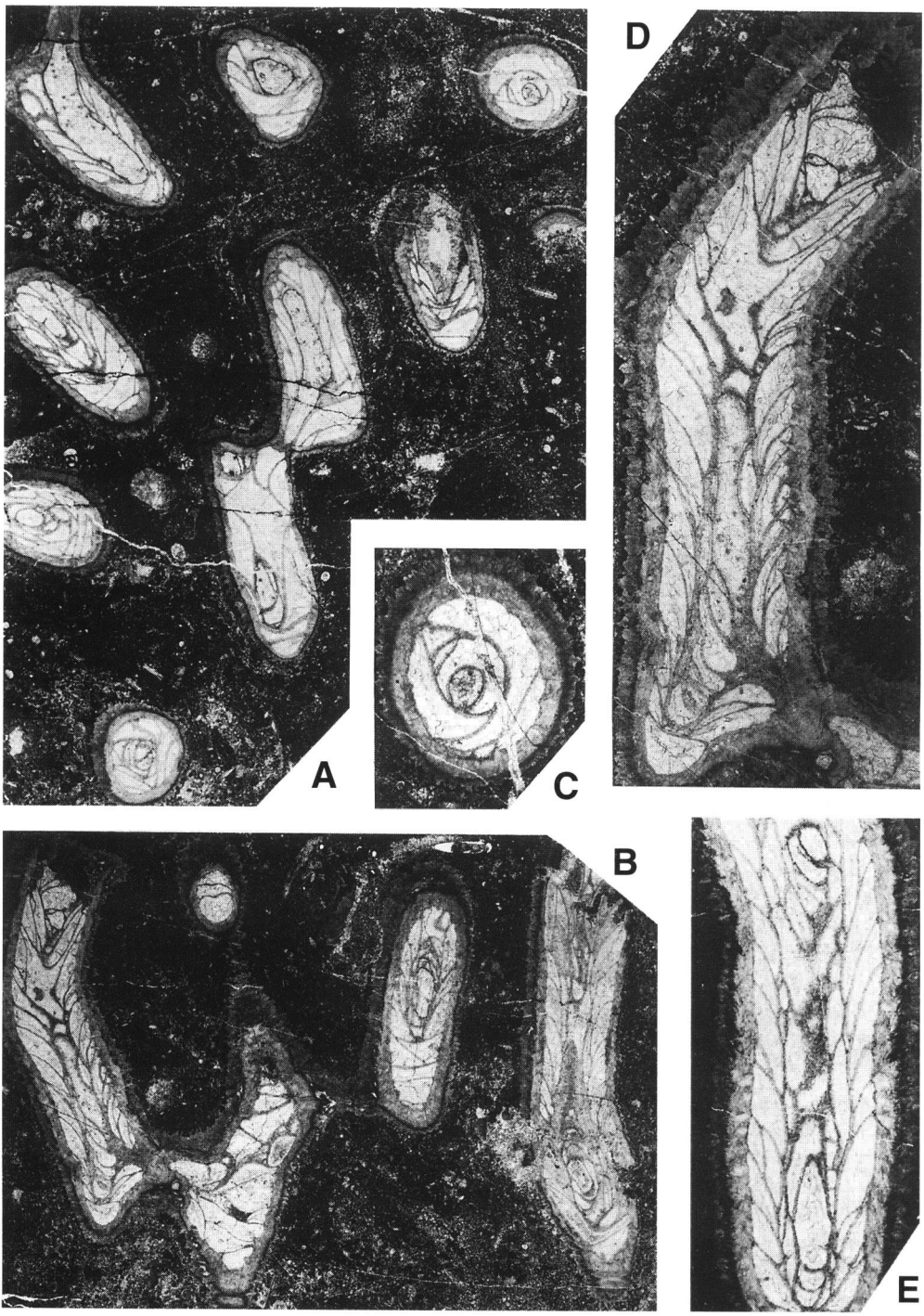


Fig. 5. *Syringopora ichinotaniensis* n. sp., holotype, NSM PA14374, thin sections. A, transverse and oblique sections, ×5. B, longitudinal section, ×5. C, transverse section, ×10. D, E, longitudinal sections, ×10.

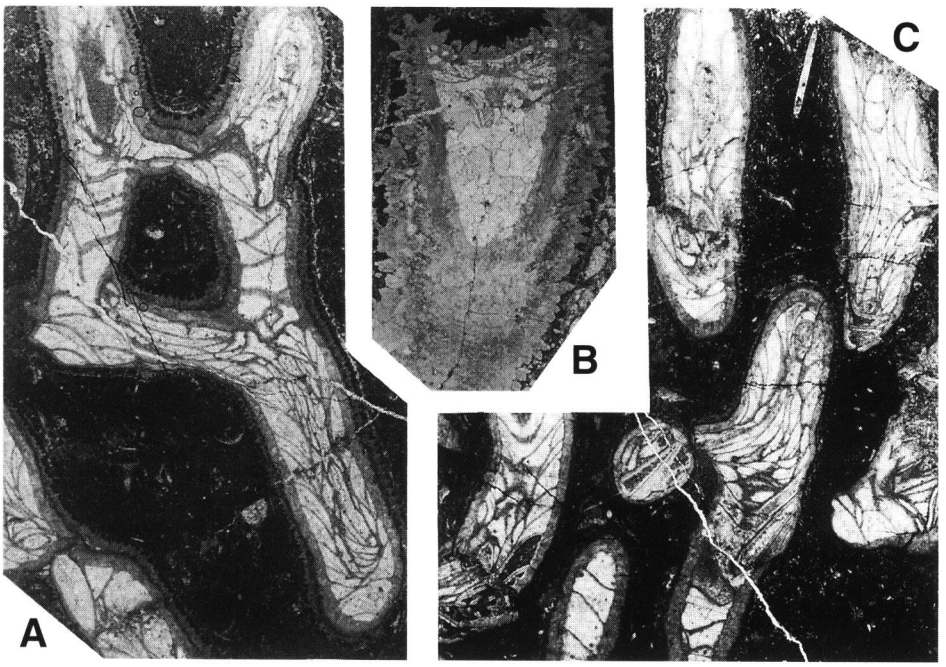


Fig. 6. *Syringopora ichinotaniensis* n. sp., thin sections. A, B, holotype, NSM PA14374, A, longitudinal section, note anastomosis of corallum (center), ×5, B, longitudinal section of calice, ×10. C, paratype, NSM PA14375, longitudinal and transverse sections, ×5.

thick walls; corallite diameter approximately 2.3 mm, their spacing sparse, usually 3–6 per cm^2; number of tabulae usually 6–12 in 5 mm of corallite length; septal spines short.

Description: Coralla large, more than 150 mm in diameter, phaceloid with partial anastomosis by anastomosing branches; each corallite cylindrical, strongly flexuous, subcircular cross section, diameter ranging from 1.8 to 2.5 mm with 2.3 mm mean; spacing of corallites sparse, usually 3–6 per cm^2; calices deep, external surface of calices nearly cylindrical; neighboring corallites joined by relatively sparse connecting tubuli, that diameter 0.9–1.2 mm. Corallite walls very thick, attain 0.41 mm, composed of thin outer layer of epitheca and inner thicker layer of stereoplasm with undulating microlamellar structure; septal spines short, attain 0.14 mm in length, but numerous, slightly upturned; tabulae infundibuliform or vesicular, abundant, usually 6–12 in 5 mm of corallite length, forming axial syrinx, that situates nearly central of each corallite in position, 0.5–0.6 mm in diameter, and crossed by frequent axial tabellae; axial tabellae usually complete and concave distally or nearly horizontal, and indicate strong obliquity and dissepiment-like form as rare variations; spine-like projections, attain 0.33 mm in length, bear on tabulae, particularly well-developed

into axial syrinx.

Discussion: With the exception of the partial anastomosis in coralla of *Syringopora ichinotaniensis* n. sp., it is closely similar to *S. ramulosa* Goldfuss (1826, pl. 25, figs. 7a, b; Milne-Edwards and Haime, 1852, pl. 46, figs. 3, 3a, b, c, 4?; Chi, 1933, pl. 1, figs. 3 a–c; Sokolov, 1955, figs. 49 a, b), that elected on the basis of specimen from the German Carboniferous. Although the internal structure of *Syringopora ramulosa* has been unclear in the German types, Sokolov (1955) figured longitudinal and transverse sections based on the homotypic material from the Moscow Basin. In comparison with the Russian material, this new species differs in its shorter septal spines. *Syringopora ramulosa* also known from South China and East Avalonia.

The surface "epithecal scale"-like structure in holotype is not epitheca, and is probably assignable to encrusting chaetetids. It is clarified by the same epiorganiams also cover on the calice as indicating in Fig. 6 B. Termier and Termier (1945) erected *Syringoalcyon* (reillustrated by Hill, 1981, fig. 446) for a syringoporid having "epithecal scales", of which structure seems to be identical with those of *Syringopora ichinotaniensis*. The present observations support the Young and Noble's (1987) statement that *Syringoalcyon* is a junior subjective synonym of *Syringopora*.

Etymology: The specific name is derived from the Ichinotani Formation.

Occurrence and age: Obtained from the black limestone blocks in talus at locality A. The blocks derived from the Unit 1, Lower Member, Ichinotani Formation. Visean (middle Early Carboniferous) or Serpukhovian.

Syringopora sp. indet.

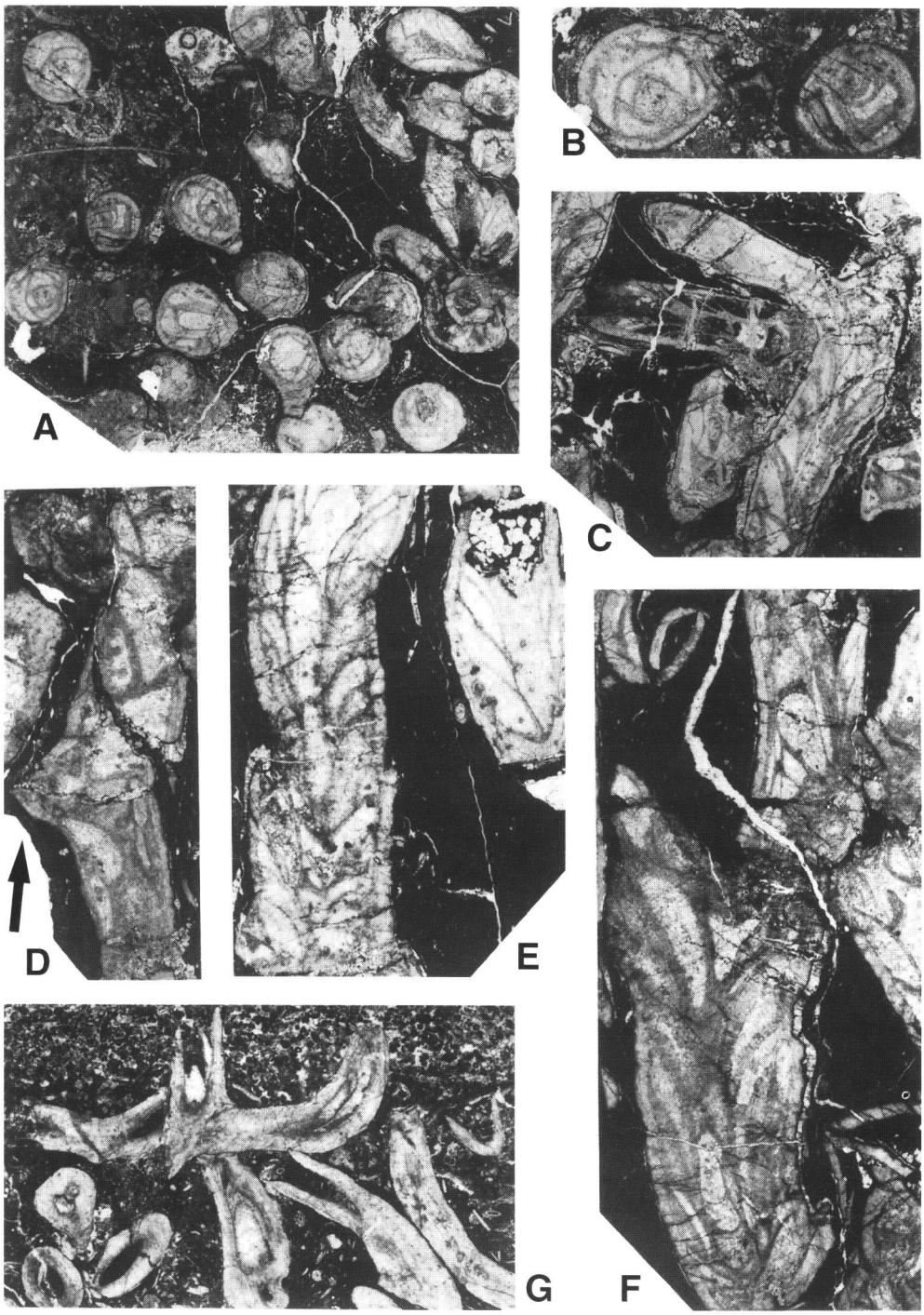
(Figs. 7 A–F)

Material: Eighteen thin sections were studied from a single specimen (NSM PA14376).

Description: Corallum phaceloid, consisting of cylindrical corallites with subcircular to circular cross sections, ranging from 1.2 to 2.5 mm with 2.0 mm mean in corallite diameter; increase of corallites lateral; corallites form frequent bifurcate branching; connecting tubuli present, but vary rare. Corallite walls thick, but relatively thin for genus; tabulae infundibuliform forming axial syrinx; septal spines short, in addition spine-like projections also recognized on tabulae; axial tabellae complete, sparse, both concave and convex distally.

Discussion: The bifurcate branching in corallites and the poorly developed connecting tubuli of the species are diagnostic feature of "*Kueichowpora*" (Chi, 1933), of

Fig. 7. A–F, *Syringopora* sp. indet., NSM PA14376, thin sections, A, transverse section, ×5, B, transverse section, ×10, C, longitudinal section, note lateral increase of corallite, ×5, D, longitudinal section, arrow indicates probable connecting tubule, ×10, E, longitudinal section, x10, F, longitudinal section, note bifurcate branching, ×10. G, *Multithecopora yabei* n. sp., holotype, NSM PA 14377, thin longitudinal section, note lateral increase of corallite, ×5.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which genus, however, was synonymized with *Syringopora* by Laub (1979). This study follows Laub's statement.

The present specimen is deformed but appears similar in morphology, except for the possession of septal spines and axial tabellae, to "*Kueichowpora*" *setamaiensis* Minato (1955, pl. 31, figs. 3, 5, 6, text-fig. 25).

Occurrence and age: Obtained from a black argillaceous limestone block in talus at locality A. This block derived from the Unit 1, Lower Member, Ichinotani Formation. Visean or Serpukhovian.

Family Multithecoporidae Sokolov, 1950

Genus *Multithecopora* Yoh, 1927

Type species: *Multithecopora penchiensis* Yoh, 1927.

Multithecopora yabei n. sp.

(Figs. 3 A, 7 G, 8 A–D)

Holotype: NSM PA14377, from which eight thin sections were made.

Other specimen: Seven thin sections were studied from a single paratype, NSM PA14378.

Diagnosis: Species of *Multithecopora* with partial adhesion of corallites; diameter of corallite relatively small, approximately 1.6 mm; tabulae variable in spacing, partly crowded, complete or incomplete; septal spine may lacking.

Description: Coralla thick turf-like in growth form with maximum observed size 85 mm in diameter and 27 mm in height, usually phaceloid, but partial adhesion with up to 5 corallites frequently recognized; corallites almost cylindrical and circular to subcircular cross sections, or hemispherical cross sections in rare cases at adhered portions, relatively small for genus, 1.0–1.9 mm, with 1.6 mm mean in diameter; spacing of corallites usually 15–17 per cm^2; calices deep, external surface of calices slightly inflated; branching rare, increase of corallite lateral, with nearly right-angled from parent, then new corallite curve abruptly upward; neighboring corallites joined by sporadically and irregularly distributed connecting tubuli. Corallite walls mostly very thick, attain 0.67 mm in cylindrical corallites, but somewhat variable in thickness, composed of thin epitheca and inner thick stereoplasm indicating weakly banded structure with lamellar microstructure, in addition radially fibrous innermost layer partly developed in stereoplasm; mural pores, indicating circular in cross sections, rarely developed in adhered portions, approximately 0.25 mm in diameter; tabulae variable in spacing usually indicate scattering distribution with complete forms, but crowded in part of thin walled corallites where complete or incomplete; complete tabulae strongly concave; septal spine not observed, may be lacking.

Discussion: *Multithecopora yabei* n. sp. is most similar to *M. penchiensis* Yoh

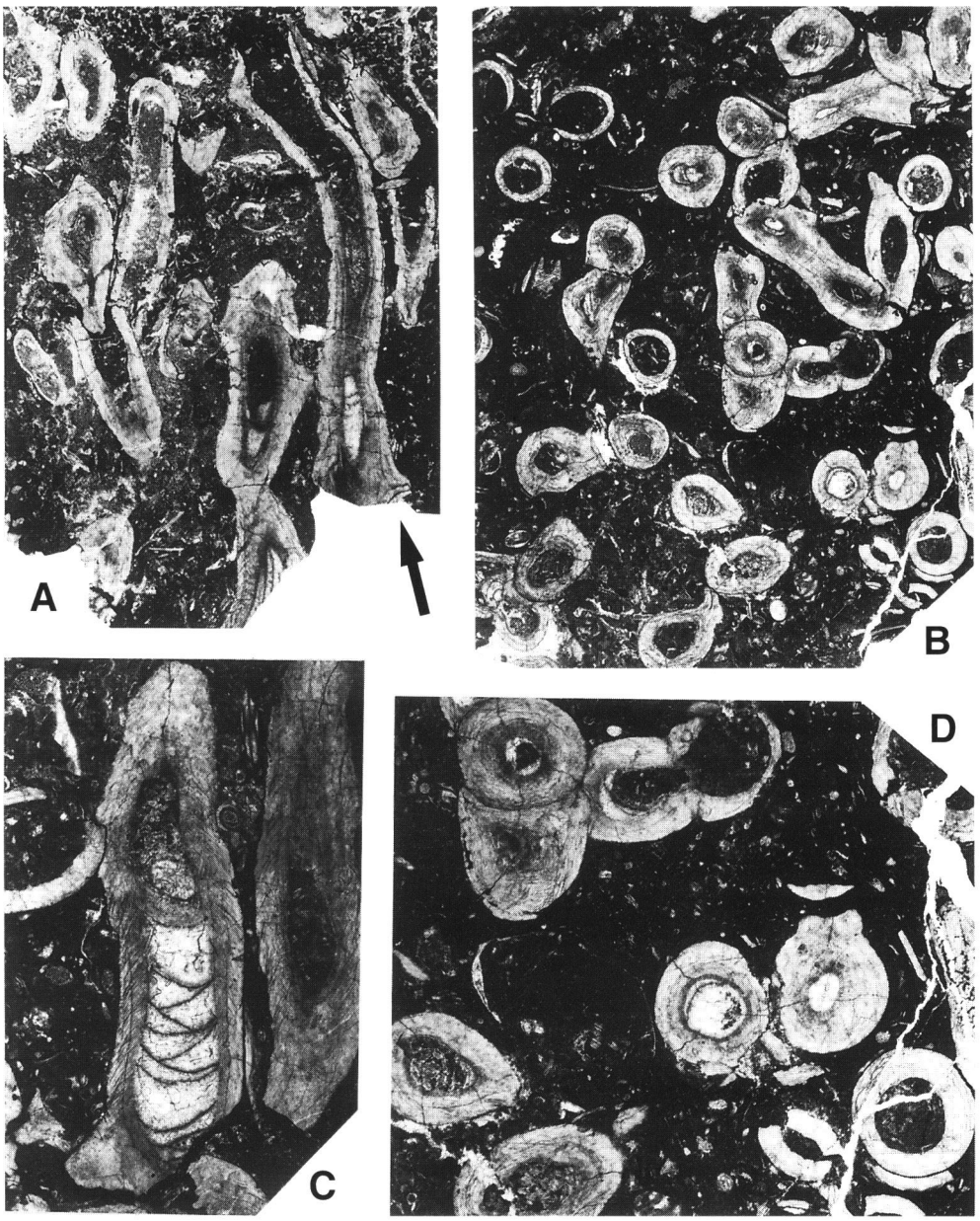

Fig. 8. *Multithecopora yabei* n. sp., holotype, NSM PA14377, thin sections. A, longitudinal section, arrow indicates connecting tubule, ×5. B, transverse section, ×5. C. longitudinal section, ×10. D, transverse section, ×10.

(1927, figs. 1–3), known from the Moscovian of North China. This new species can be distinguished from the Chinese species by its smaller diameter of corallites (approximately 1.6 mm versus 2.1–2.5 mm in *Multithecopora penchiensis*) and the variation of its tabulae spacing with the incomplete forms.

Development of connecting tubuli is poor and sporadic in *Multithecopora*, thus the generic identification using only limited thin sections is apt to mislead as other phaceloid genera of Auloporidae, Pyrgiidae and Sinoporidae. Thus, the taxonomic position of "*Sinopora*" *choiana* Minato and Kato (1974, pl. 6, figs. 2, 3, pl. 7, figs. 1, 2) reported by Niikawa (1980) from the Ichinotani Formation needs re-scrutinizing.

Etymology: The specific name honors the late Dr. Hisakatsu Yabe, in recognition of his contributions to the study of Japanese Paleozoic corals as a pioneer.

Occurrence and age: Obtained from brown limestone of a float block at locality B (NSM PA14377) and dark gray limestone of a float block at locality E (NSM PA14378). The both blocks derived from the Unit 1, Lower Member, Ichinotani Formation. Visean or Serpukhovian.

***Multithecopora*? sp. indet. 1**

(Figs. 4 A, D)

Material: Two thin sections were studied from a single specimen (NSM PA14379).

Description: Corallum phaceloid consisting of cylindrical corallites that indicate approximately 1.8 mm in diameter and relatively low spacing density; external calices cylindrical; connecting tubule not observed in examined thin sections. Corallite walls thick with short, sporadic septal spines; tabulae rear, both concave and convex distally, complete or incomplete.

Discussion: The possession of the connecting tubule is not yet confirmed in this species, thus the generic assignment is pending. However, the observed characters most resemble those in *Multithecopora*. This species is diagnosed by its low spacing density of the corallites and short septal spines.

Occurrence and age: Obtained from a dark gray limestone block in talus at locality A. This block probably derived from the Unit 1, Lower Member, Ichinotani Formation. Probable Visean or Serpukhovian.

***Multithecopora*? sp. indet. 2**

(Figs. 3 B, C)

Material: Three thin sections were studied from a single specimen (NSM PA14380)

Description: Corallum phaceloid with partial adhesion of adjacent 2–4 corallites; each corallite cylindrical, subcircular cross section, approximately 1.7 mm in di-

ameter; connecting tubule not observed in examined thin sections. Corallite walls very thick, with long, distinct septal spines; tabulae partly crowded, convex distally, usually complete.

Discussion: Until the confirmation of the possession or lacking of connecting tubule in this species, the generic assignment is pending. However, the observed characters are much those known from *Multithecopora*. This species is diagnosed by its well-developed septal spines.

Occurrence and age: Obtained from gray limestone with red shale fragments as extraclasts in the Unit 46, Upper Member, Ichinotani formation at locality D. Moscovian.

Acknowledgments

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