

Wuchiapingian (Late Permian) Tabulate Corals from the Maizuru Group in the Yakuno Area, Kyoto Prefecture

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Abstract A Wuchiapingian (early Late Permian) tabulate coral fauna occurs in impure limestone, what is called the “Takauchi Limestone”, belonging to the Nukata Formation of the Maizuru Group in the Yakuno area, Kyoto Prefecture, Central Japan. Within the abundant, but relatively low in diversity, corals, three species are identified; namely *Praemichelinia lii* sp. nov. (Micheliniidae, Favositida), *Yakunopora matsushitai* gen. et sp. nov. (Pachyporidae, Favositida), and auloporid, gen. et sp. indet. (Auloporida). Among the previously known pachyporid genera closely resembling *Yakunopora* is *Acaciapora*. The most diagnostic feature of *Yakunopora* is the alternately arranged squamulae, whereas *Acaciapora* lacks such regularity in a squamula arrangement. The Takauchi fauna represents the youngest tabulate corals ever documented from Japan.

Key words: Wuchiapingian (Late Permian), tabulate corals, Favositida, *Praemichelinia*, *Yakunopora* gen. nov., Auloporida, Maizuru Group, Kyoto.

Introduction

Since discoveries of crinoids and bryozoans by Kochibe (1895; Mastushita, 1961) and a lytoniind brachiopod *Leptodus richthofeni* Kayser by Mashiko (1934; Shimizu, 1961), diverse Permian invertebrates have been found in a small (less than 30 m across) carbonate dominated lens exposed at the Yakuno area, Kyoto Prefecture, Central Japan. This fossiliferous lens consists of dark greenish gray to gray impure limestone with minor amounts of calcareous shale, and it is informally called the “Takauchi Limestone”. Nakazawa *et al.* (1957) pointed out that the limestone belongs to the Nukata [Nukada] Formation (Oishi, 1933; redefined by Nakazawa, 1951) of the Maizuru Group (Nakazawa and Okada, 1949). Foraminifer evidence relates the Takauchi fauna with the *Palaeofusulina simplex-Colaniella minima* zone indicating the Wuchiapingian (early Late Permian) in age (Ishii *et al.*, 1975).

The Takauchi fauna contains abundant, but relatively low in diversity, tabulate corals, including *Praemichelinia lii* sp. nov., *Yakunopora mat-*

sushitai gen. et sp. nov., and auloporid, gen. et sp. indet. They represent the youngest tabulate corals ever documented from Japan. Because the paleobiogeographic implications of the occurrence of *Praemichelinia* have been discussed earlier by Li and Niko (2002), the purpose of this paper is to present results of taxonomic studies on these corals. All specimens described herein are kept in the National Science Museum (abbreviation NSM).

Systematic Paleontology

Order Favositida Wedekind, 1937

Suborder Favositina Wedekind, 1937

Superfamily Favositoidea Dana, 1846

Family Micheliniidae Waagen and Wentzel, 1886

Subfamily Micheliniinae Waagen
and Wentzel, 1886

Genus *Praemichelinia* Lafuste
and Plusquellec, 1980

Type species: *Beaumontia? guerangeri* Milne-Edwards and Haime, 1851.

Praemichelinia lii sp. nov.

(Figs. 1-1-7)

Praemichelinia sp. indet., Li and Niko, 2002, p. 73, 74, figs. 2-A-D.

Holotype: NSM PA15558, from which six thin sections were made.

Other specimens: Eleven thin sections were studied from the two paratypes, NSM PA 15559, 15560.

Diagnosis: Species of *Praemichelinia* with 4.1–5.2 mm in usual corallite diameter; intercorallite walls uniformly thickened with usually 0.50–0.69 mm in thickness; microlamella in stereoplasm indicates sharp bend; septal spines not numerous for genus; mural pores relatively small; tabulae thickened by layer of fine rect-radiate fibers.

Description: Coralla massive (bulbous?) with bluntly pointed base, approximately 53 mm in maximum observed diameter of holotype, cerioid; holotheca attains 0.90 mm in thickness, with radiciform processes in basal corallum. Corallites large, usually prismatic with 4–7 sides in transverse sections, or fan-shaped to more or less deformed subtrapezoid transverse sections verging on holotheca, 1.7–7.7 mm usually 4.1–5.2 mm in diameter; arrangement of corallites may be radial; calices relatively shallow, lack calical modification; usual transverse sections of tabularia and calical pits are polygonal; increase of new corallite is not observable in sectioned parts. Intercorallite walls uniformly thickened, range from 0.19 to 0.86 mm, usually 0.50–0.69 mm, in thickness, differentiated into median dark line with weak situations and stereoplasm, latter of which consists of microlamellae and innermost thin layer of fine rect-radiate fibers; each

microlamella runs oblique to median dark line, and indicates sharp bend with proximal direction in its midway; mural pores circular in profiles, occur on corallite faces and near edges, numerous, forming more than 7 rows, but relatively small; diameters of mural pores range from 0.04 to 0.19 mm; in proximal corallite, mural pores sealed by stereoplasm; septal spines common and not numerous in comparing to typical forms of the genus, low to high conical, range from 0.10 to 0.21 mm in length of protruded portions into tabularia; tabulae incomplete, crowded, up-arched; tabulae thickened by thin layer consisting of fine rect-radiate fibers that are developed on proximal side of tabulae and continuous with innermost thin layer of stereoplasm; thickness of tabulae attains 0.23 mm; septal spine-like projections sporadically developed on tabulae.

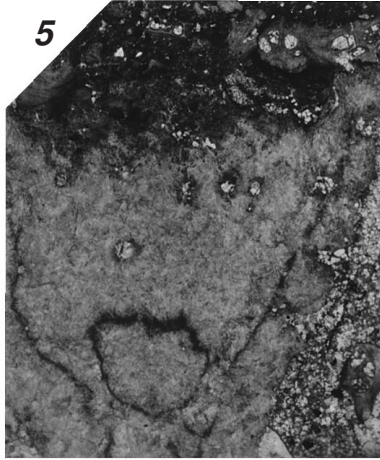
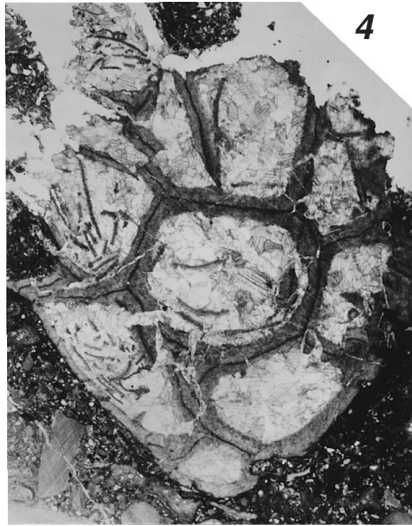
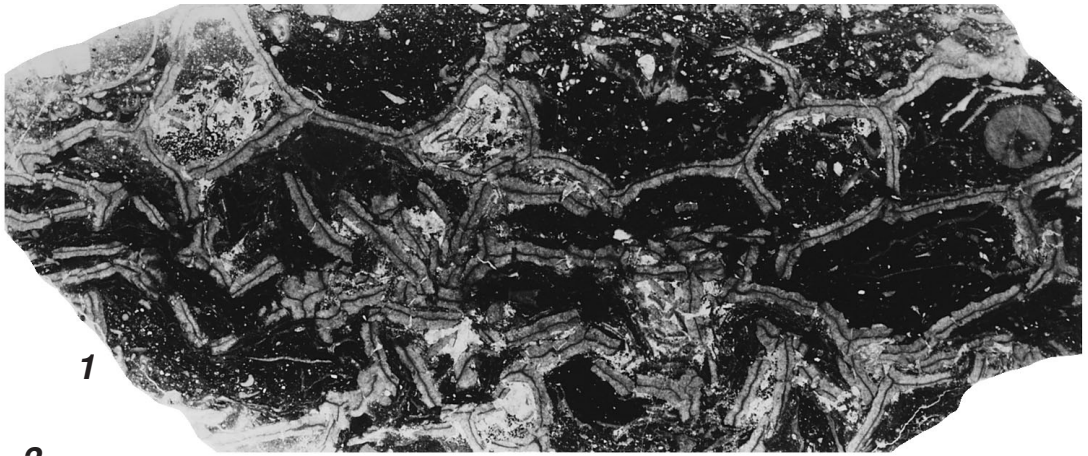
Etymology: The specific name honors Mr. Eiichi Li, who discovered the holotype of this coral.

Occurrence: Float blocks of impure limestone obtained from the south-facing slope near Takauchi [Takauti] village (see fig. 1 in Li and Niko, 2002; =loc. MN. 9 in Nakazawa *et al.*, 1957).

Discussion: Based on two specimens that are herein designated as the holotype and paratype (NSM PA15559), Li and Niko (2002) preliminarily reported as *Praemichelinia* sp. indet. Additional thin sections made from the holotype and a newly collected specimen (paratype NSM PA15560) lead some dimensional and morphological emendations, of which new findings are added in the description above.

As noted by Li and Niko (2002) the characteristic intercorallite wall structure of the Takauchi specimens suggests the close relationship be-

Fig. 1. *Praemichelinia lii* sp. nov., thin sections. 1–3, holotype, NSM PA15558. 1, transverse section of corallum, $\times 5$. 2, partial enlargement of transverse sections of intercorallite walls, to show septal spine (arrow), $\times 14$. 3, partial enlargement of longitudinal section of intercorallite wall, to show its microstructure, $\times 50$. 4, paratype, NSM PA15559, transverse section of basal corallum, $\times 5$. 5–7, paratype, NSM PA15560. 5, partial enlargement of longitudinal sections of corallites near calical rim, to show mural pores, $\times 14$. 6, longitudinal (slightly oblique) section of corallum, $\times 5$. 7, partial enlargement of Fig. 1-6, to show thickened tabulae, $\times 14$.



tween this species and *Praemichelinia indica* (Waagen and Wentzel, 1886, p. 853, 854, pl. 99, figs. 1a–c; Lafuste and Plusquellec, 1985, text-figs. 23-A, B; 24-A, B, pl. 4, figs. 1, 2) from the Upper Permian in the Salt Range (West Pakistan) of the Peri-Gondwana region. However, *Praemichelinia lii* sp. nov. has the somewhat smaller corallite diameters (usually 4.1–5.2 mm versus 6–8 mm in *P. indica*) and much fewer septal spines than those of *P. indica*. In addition, the thickened tabulae are seldom in *P. indica*.

Superfamily Pachyporoidea Gerth, 1921

Family Pachyporidae Gerth, 1921

Genus *Yakunopora* nov.

Type species: Yakunopora matsushitai sp. nov., by monotypy.

Diagnosis: Coralla ramose with slender, roughly cylindrical branches in mature specimens; branches composed of gradually divergent, prismatic corallites; corallite diameters small for family; calical opening obliquely upward; intercorallite walls thick even proximal corallites in branch axis, then gently thickened further in distal ones, lack distinct peripheral stereozone; mural pores form a single row on each corallite face; septal spines sporadic; squamulae alternately arranged, numerous, very long; thin diaphragms present.

Etymology: The generic name is derived from the type locality named the Yakuno area.

Yakunopora matsushitai sp. nov.

(Figs. 2-1–7; 3-1–5)

Holotype: NSM PA15580, from which five thin sections were made.

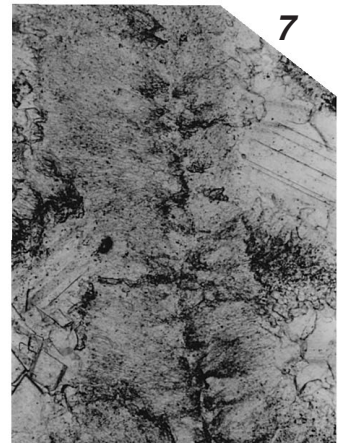
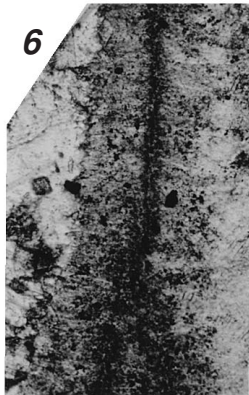
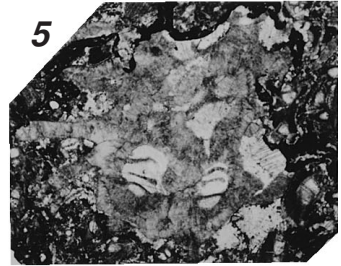
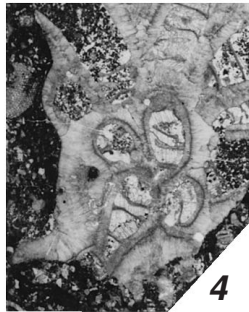
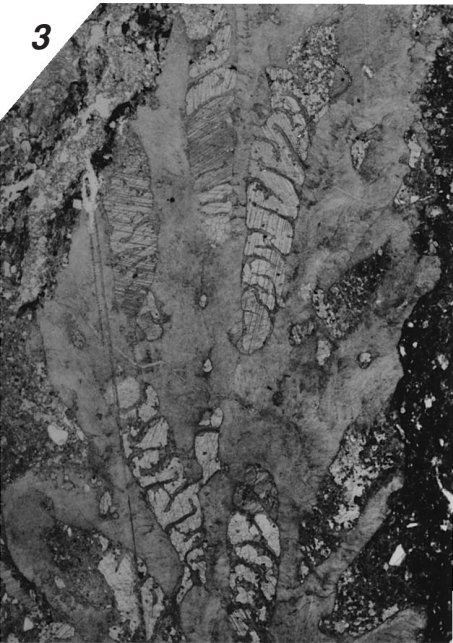
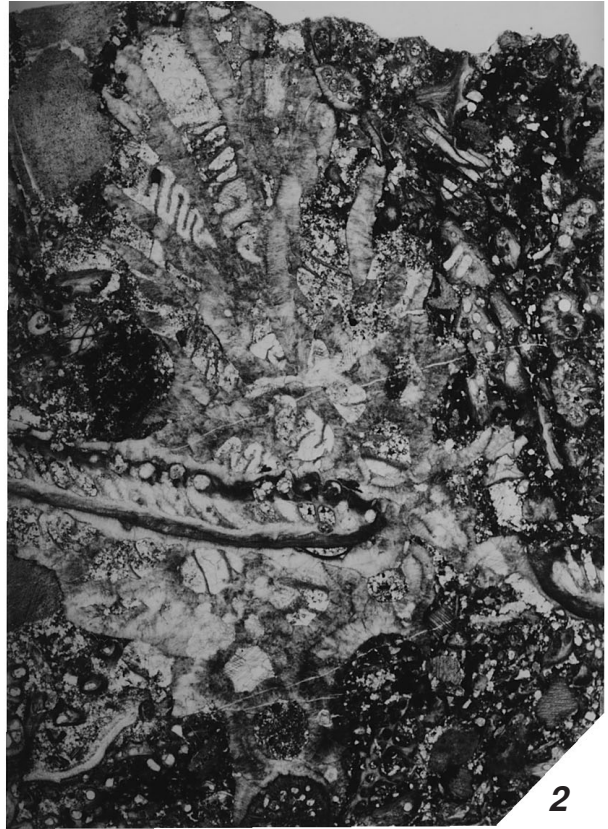
Other specimens: Twenty-five thin sections

were studied from the 11 paratypes, NSM PA15561, 15563, 15566, 15568, 15571, 15576, 15577, 15579, 15585, 15589, 15592. In addition, 20 specimens, NSM PA15562, 15564, 15565, 15567, 15569, 15570, 15572–15575, 15578, 15581–15584, 15586–15588, 15590, 15591, were also examined.

Diagnosis: As for the genus.

Description: Coralla small, encrusting to semicircular in early growth stages, then become ramose with roughly cylindrical branches in mature specimens, cerioid; branching rare, probably bifurcate; maximum observed corallum diameter is approximately 13 mm (paratype, NSM PA15568); diameters of branches are slender, 3.2–4.5 mm (exceptionally attaining 8.2 mm near branching point). Corallites prostrate in most proximal portions with subtrapezoidal transverse sections; branches in mature specimens composed of gradually divergent, prismatic corallites with indistinct 6–8 sided transverse sections; branch differentiation to axial and peripheral zones is indistinct; diameters of corallites are small for the family Pachyporidae, 0.5–1.3 mm with 0.9 mm mean; there are 10–24 corallites in transverse section of branch; calices relatively shallow; calical opening obliquely upward with approximately 35°–60° in angle to branch surface; transverse sections of tabularia and calical pits are subcircular to subpolygonal, having 0.48–0.81 mm in diameter near calical rim; increase of new corallites is lateral, commonly occurs in axial zone of branch. Intercorallite walls thick, 0.13–0.38 mm, even proximal corallites in axial zone of branches, then gently thickened further in distal corallites attaining 0.60 mm; thus, distinct peripheral stereozone not developed; microstructure of intercorallite walls differentiated into median dark line and stereoplasm, latter of

Fig. 2. *Yakunopora matsushitai* gen. et sp. nov., thin sections. 1, 6, 7, holotype, NSM PA15580. 1, longitudinal section of branch, $\times 14$. 6, 7, partial enlargements of longitudinal sections of intercorallite walls of proximal (Fig. 2-6) and distal (Fig. 2-7) corallites, $\times 100$. 2, paratype, NSM PA15563, longitudinal section of corallum, encrusting on bryozoan, $\times 10$. 3, paratype, NSM PA15571, longitudinal section of branch, $\times 14$. 4, paratype, NSM PA15566, transverse section of branch, $\times 10$. 5, paratype, NSM PA15579, transverse section of branch, $\times 10$.



which consists of rect-radiate fibers; median dark line becomes obscure in distal corallites; mural pores well-developed, but small in diameter, forming a single row on each corallite face, sub-circular to longitudinally elliptic in profile; diameters of typical mural pores are approximately 0.10 mm, 0.10×0.13 mm; septal spines sporadic, conical with 0.17 mm in length of protruded portion into lumen; squamulae alternately arranged, numerous, 3–8 in 1 mm of corallite length; each squamula thin, very long; ratios of its length per lumen diameter are approximately 0.77; profiles of squamulae somewhat variable, ranging from weakly concave to weakly convex; some squamulae have strongly curved (proximally or distally) tips; tabula-like thin diaphragms rarely developed between adjoining two squamulae.

Etymology: The specific name honors the late Dr. Susumu Matsushita, in recognition of his contribution to the studies of regional geology in Kyoto Prefecture.

Occurrence: Float blocks of impure limestone. Locality is identical with that of *Praemichelinia lii* sp. nov. Identified substrata of each specimen are as follows: bryozoans (NSM PA15563, 15564) and brachiopod (NSM PA15585).

Discussion: Several respects, including dimensions of the branches and the corallites, structure of the intercorallite walls, and the well-developed squamulae, most closely ally the new genus with a Middle Carboniferous genus *Acaciapora* Moore and Jeffords (1945; type species, *Michelinia subcylindrica* Mather, 1915, p. 97, pl. 1, fig. 18; Moore and Jeffords, 1945, p. 182, 183, text-figs. 190–192, 202, pl. 14, figs. 7–9; Lafuste and Tourneur, 1991, p. 100, 101, text-figs. 1–3, 4a, b, 5a, b, 6a–d, 7a–h, 8, pl. 1, figs. 1–5, pl. 2, figs. 1–4) from Laurentia. The squamulae of *Yakunopora matsushitai* gen. et sp. nov. are alter-

nately arranged, in contrast to the lacking such regularity in those of previously known species of *Acaciapora*. Moreover, the squamulae of *Acaciapora* are less numerous and somewhat shorter than those of *Yakunopora*.

Yakunopora matsushitai shares the squamula structure with some Permian species belonging to *Sutherlandia* Cocke and Bowsher (1968; type species, *S. irregularis* Cocke and Bowsher, 1968, p. 3, 5, text-figs. 2-1–4), *Pseudoacaciapora* Lin (1983; type species, *Pseudoacaciapora* [sic] *sinensis* Lin, 1983, p. 81, pl. 3, figs. 1a–d, pl. 5, figs. 5a, b), and *Squameodendropora* Lin (1983; type species, *S. xizangensis* Lin, 1983, p. 85, pl. 6, figs. 2a, b, 3a–c). However, the usual coralla of *Sutherlandia* and *Pseudoacaciapora* are spherical, unlike *Yakunopora*, its coralla are ramose. *Squameodendropora* differs from *Yakunopora* in having the thick cylindrical branches, the distinct peripheral stereozone where the intercorallite walls attain 1.5 mm in thickness, and the narrowed lumina with the crescentic to slit-like profiles in some corallites.

Order Auloporida Sokolov, 1947

Superfamily Auloporoidea Milne-Edwards and Haime, 1851

Family Auloporidae Milne-Edwards and Haime, 1851

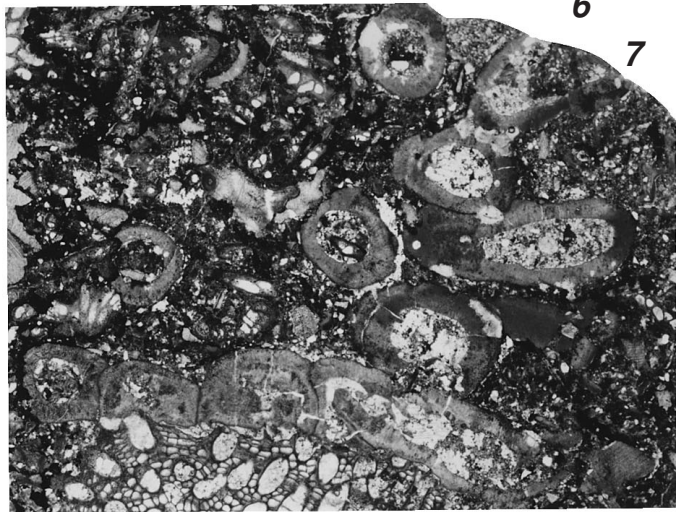
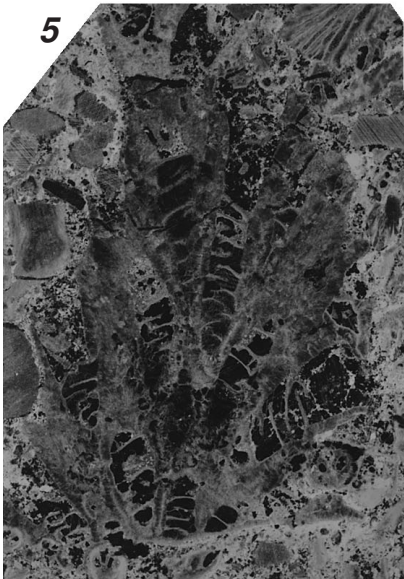
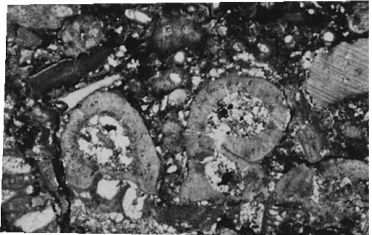
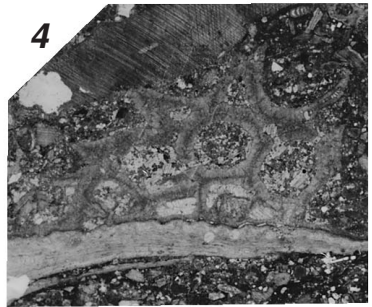
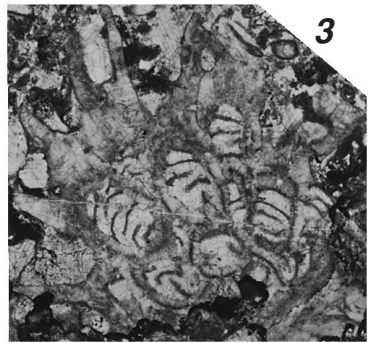
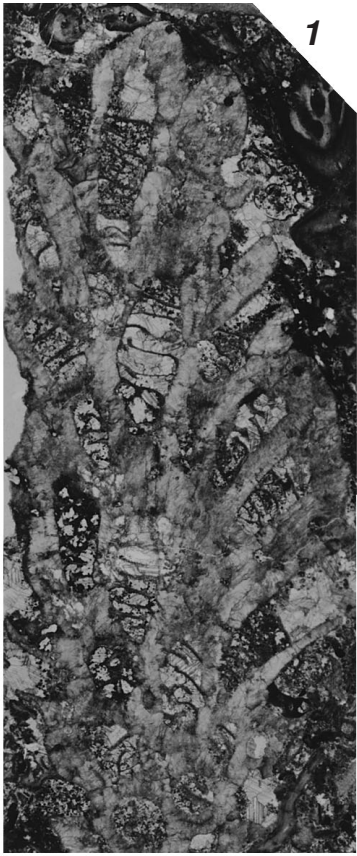
Auloporida, gen. et sp. indet.

(Figs. 3-6, 7)

Material examined: A single corallum, NSM PA15593.

Description: Corallum has encrusting proximal portion that arises upwardly directed distal corallites; proximal portion of corallum consists of alveoloid-like corallites with semicircular to subtrapezoidal transverse sections; distal coral-

Fig. 3. 1–5, *Yakunopora matsushitai* gen. et sp. nov., thin sections. 1, paratype, NSM PA15561, longitudinal section of branch, ×10. 2, paratype, NSM PA15571, longitudinal section of branch, ×10. 3, paratype NSM PA15592, near transverse section of branch, ×10. 4, paratype, NSM PA15585, oblique section of corallum, encrusting on brachiopod, ×10. 5, paratype, NSM PA15589, oblique section of branch, negative print, ×10. 6, 7, auloporida, gen. et sp. indet., NSM PA15593, transverse to oblique thin sections of corallites, ×10.



lites phacelo-ceriod, indicating subcircular to subpolygonal transverse sections; diameters of typical corallites are 1.1–1.6 mm; connecting tubule absent. Corallite walls thick, typically 0.31–0.44 mm in phaceloid corallites; their microstructure differentiated into epitheca and stereoplasm (of rect-radiate fibers?); septal spines rare, whose protruded portions attain to 0.15 mm length; tabula is not recognized in sectioned parts of corallites.

Occurrence: Float block of impure limestone. Locality is identical with that of *Praemichelinia lii* sp. nov. Substratum of this specimen is bryozoan.

Discussion: This indeterminate species is represented by a single poorly preserved specimen, whose external gross corallum shape is not observable. Assignment to the family Auloporidae lies upon the encrusting proximal portion of the corallum, the phacelo-ceriod distal corallites, and absence of the connecting tubule, however it has to be considered as no more than tentative.

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Mr. Eiichi Li graciously introduced me to fossil localities in the Yakuno area, and donated the holotype of *Praemichelinia lii* sp. nov. Fieldwork could not have been possible without his help. I am also indebted to Messrs. Yoshihito Senzai and Kouzou Fujiwara, who assisted collect specimens for this study.

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