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Stratigraphy of the Devonian Kamianama Formation in the Kuzuryu Lake–Ise River area, Fukui Prefecture and Its Favositid Coral Fauna

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Abstract The Kamianama Formation in the Kuzuryu Lake–Ise River area of Fukui Prefecture, Central Japan is lithologically subdivided into the Oisedani and Hakubado Members in ascending order. Following our previous paper Niko and Senzai (2006) on the auloporid tabulate corals, 17 species of favositids are described herein from the formation. They are *Klaamannipora oborensis* sp. nov., *Mesofavosites igoi* (Kamei, 1955), *Sapporipora kamitakaraensis* Tsukada, 2005, *Pachyfavosites katoi* Niko, 2007, *Plicatomurus flexuosus* (Kamei, 1955), *Squameopora takarensis* (Kamei, 1955), *Squameofavosites fukujensis* (Kamei, 1955), *S. ichinotanensis* (Kamei, 1955), *S. sugiyamai* (Kamei, 1955), *Isurugiopora obesa* Niko, 2005, *I. ishiokai* sp. nov., *Striatopora takayamaensis* Niko, 2005, *Thamnopora hayasakai* Niko, 2005, *Thamnoptychia mana* sp. nov., *Parastriatopora innae* Dubatolov, 1963, *Alveolites* sp. cf. *A. maillieuxi* Lecompte, 1933, and *Coenites kameii* sp. nov. In the Kamianama tabulate coral fauna, the *Squameofavosites sugiyamai*, *Thamnoptychia mana, Klaamannipora oborensis,* and *Isurugiopora obesa* assemblages are recognized. The *Squameofavosites sugiyamai* and probably also *T. mana* assemblages belong to the Oisedani Member that is correlated with the Lochkovian (early Early Devonian) to Emsian (late Early Devonian) Takaharagawa Member of the Fukuji Formation in the Fukuji area, Gifu Prefecture. The Hakubado Member contains the *K. oborensis* and *I. obesa* assemblages, and is correlative with the Emsian to probably Eifelian (early Middle Devonian) Ozako Member of the Fukuji Formation.

Key words: Early to Middle Devonian, tabulate corals, Favositida, Kamianama Formation, Oisedani Member, Hakubado Member, Fukui

Introduction

In the Hida-Gaien Belt of Central Japan, the Lower to Middle Devonian sediments have the exposures in the Omi area, Niigata Prefecture (Ibaraki *et al*., 2010), the Fukuji area, Gifu Prefecture (Kamei, 1952) and the Kuzuryu Lake–Ise River area, Fukui Prefecture (Ishioka and Kamei, 1950). The shallow marine facies in these areas respectively represented by the exotic limestone blocks in the Permian accretionary complex, the Fukuji Formation and the Kamianama Formation, among them the last of which is the most unclear strata.

The Kamianama Formation crops out as more than 10 east-west trending small blocks in the Nojiri, Otani and Hakogase districts in the Kuzuryu Lake area and in the Kamiise and Nakaise districts in the Ise River area (Fig. 1; see also fig. 1 in Niko and Senzai, 2006). The elucidation of the detailed stratigraphic succession and accurate estimation of thickness concerning the formation is hampered by its poor exposure with scattered distribution by thick vegetation

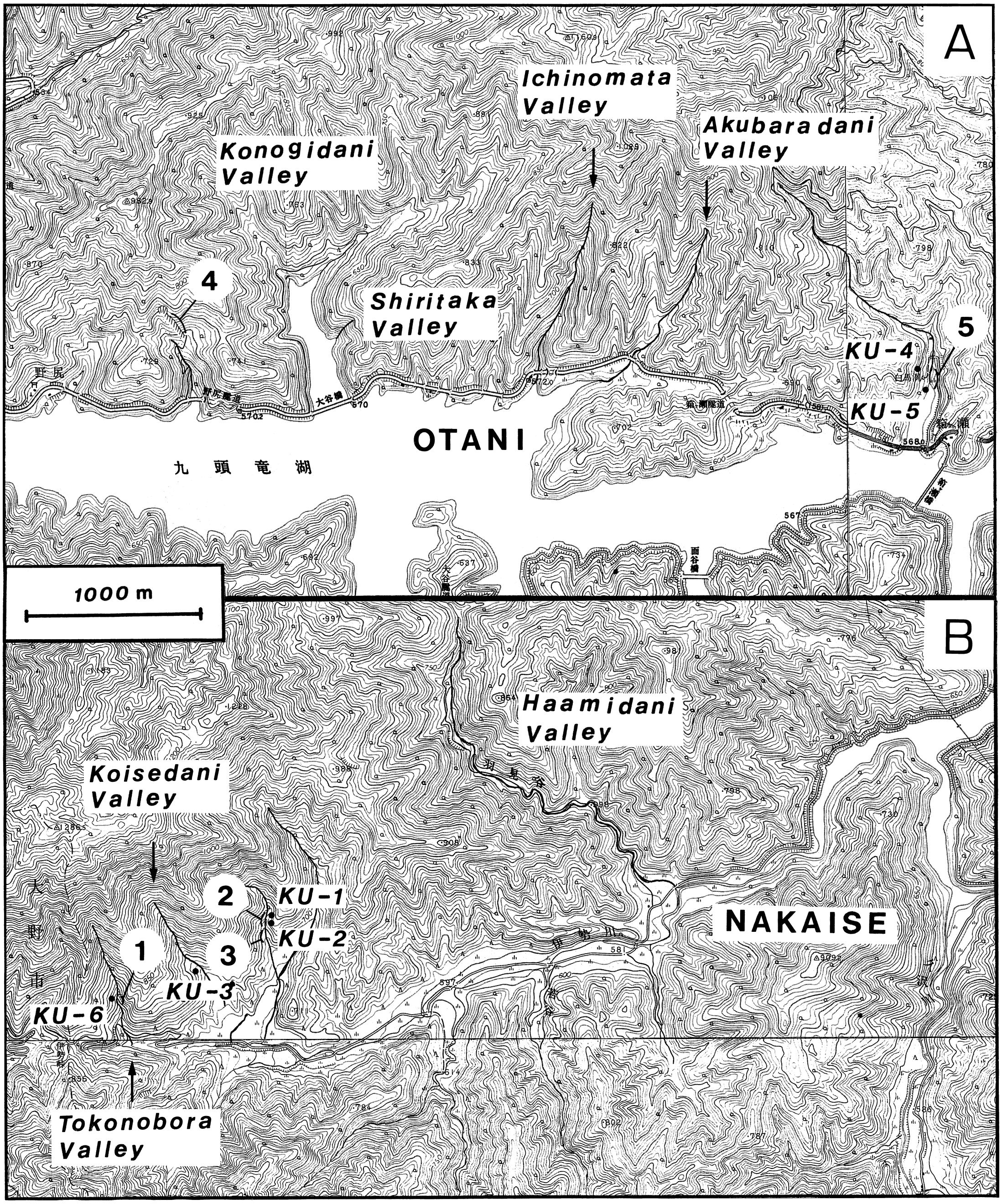


Fig. 1. Index maps of the Kuzuryu Lake area (A) and the Ise River area (B) showing positions of stratigraphic columnar sections (1–5), coral localities (KU-1–6) and distribution area of the Kamianama Formation in the Otani, Kamiise and Nakaise districts. Geographic locations of the Nojiri, Hakogase and Kamiise districts, the Iyamadani, Oboradani, Tanobora, Shibasudani, Kamaharadan and Oisedani Valleys are given in fig. 1 of Niko and Senzai (2006). Note corrections on valley names (Koisedani and Tokonobora) indicated in Senzai and Niko (2007). Used base maps are “Echizenasahi”, “Shiratori” and “Heikedake” of 1 : 25,000 quadrangles published by Geographical Survey Institution.

and intense faulting. In addition, the adjacent occurrence of the shallow marine sediments and the pelagic ones complicates these problems. Thus, previous workers (e.g., Ozaki, 1955; Kawai *et al*., 1957; Yamada, 1967; Kurihara, 2003) merely described some discontinuous outcrops and have not yet revealed the whole aspect of the Kamianama Formation. The first purpose of this study is to reconstruct its original sequence. The arrangements of stratigraphic columns in a chronological framework are generalized interpretations based on recent lithostratigraphic knowledge from the Fukuji Formation, Gifu Prefecture (Niko, 2007). As the second purpose, the present paper describes 17 species of favositids in a serial our work on the tabulate coral fauna of the Kamianama Formation. Research history and auloporids of the formation are referable in preceding Niko and Senzai (2006).

The examined coral specimens are kept in Hikaru Memorial Museum (prefixed HMM) and National Science Museum (prefixed NSM).

Stratigraphy

Our geologic knowledge of the Middle Paleozoic strata in the Kuzuryu Lake–Ise River area makes rapid progress by the recent T. Kurihara's (with his collaborator) works including Kurihara and Sashida (1998) and Kurihara (2000, 2003). Especially, 1) separation the pelagic sediments from the Kamianama Formation, 2) age determination of the excluded Kagero and Shibasudani Formations using radiolarians, and 3) contradiction on Sohma *et al*. (1983)'s opinion, who regarded the all older rocks as olistolith in the Jurassic olistostromal complex at the base of the Tetori Group, are important. We follow this up-to-date geologic setting besides some minor emendations of the Kamianama Formation. They are as follows; the age of the limestones vicinity of a stalactite grotto, Hakubado, corrects the Devonian (probably the early Middle Devonian; see the discussion in the following chapter) from a previous view of the Late Silurian, consequently the limestones are not thought to be the exotic blocks in the early Early Devonian Shibasudani Formation, and an outcrop in the Tokonobora Valley is overturned.

The Kamianama Formation trends east-west with ranges of N45°W to N70°E, and steeply dips north in the Kuzuryu Lake area and steeply dips south in the Kamiise district of the upper Ise River area. Judging from the geopetal structure (Fig. 2-3), north-ward the formation becomes younger in each fault block. The formation is divided here into the Oisedani and Hakubado Members in ascending order (Fig. 3). It has an estimated total thickness of more than 220 m.

Oisedani Member (new name)

Type locality and geographic distribution: The type locality for the Oisedani Member is an eastern flank of a tributary (Kamaharadani Valley) of the Oisedani Valley (columnar section 2 in Fig. 3) of the Kamiise district. The upper part of this member, cut away by the fault, is found in the Tokonobora Valley (columnar section 1) of the Kamiise district. In addition, this member is also exposed in the Oboradani Valley of the Nojiri district and the Koisedani Valley of the Kamiise district. Although we can not detect any outcrop, float brocks derived from the Oisedani Member are found in the main stream of the Oisedani Valley of the Kamiise district, the Haamidani Valley of the Nakaise district, the Iyamadani (Sanmaidani) Valley of the Nojiri district, the Ichinomata and Akubaradani Valleys of the Otani district, and the Tanobora Valley of the Hakogase district.

Lithology: The Oisedani Member consists of limestones and argillaceous limestones with a minor amount of black calcareous shales, and felsic pyroclastic rocks including greenish gray mudstone to greenish sandstone (Fig. 2-4) and greenish tuff (Fig. 2-5). The limestones are characteristically black- to dark gray-colored, fossiliferous, more or less argillaceous and well-bedded, of which lithofacies dominates in bioclastic wackestones (Fig. 2-1), peloidal wackestones, peloidal packstones (Fig. 2-2) and lime-mudstones, in addition coral bafflestones, stromatoporoidal bindstones, and bioclastic packstones

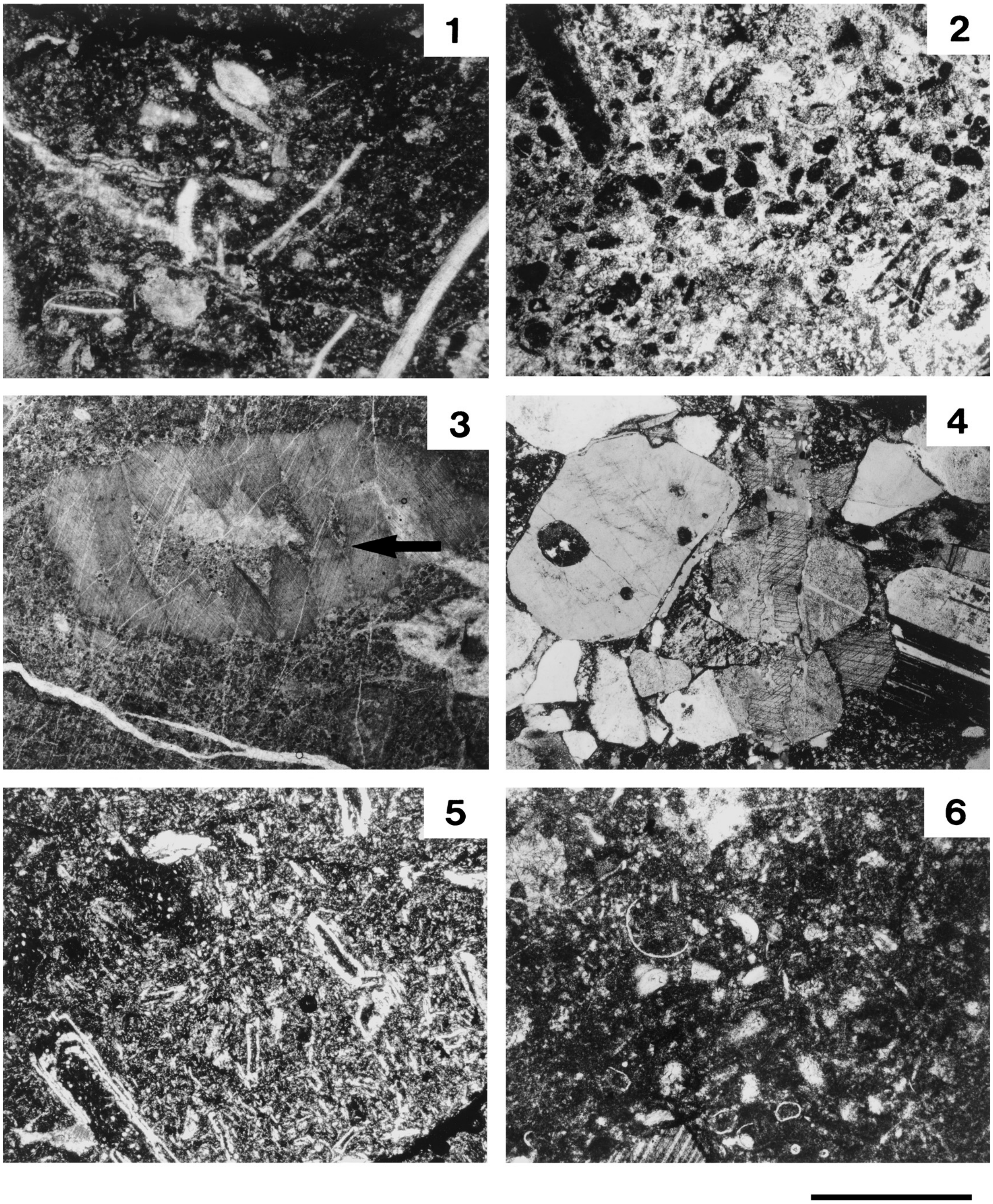


Fig. 2. Lithology of the Kamianama Formation. **1**–**5**, the Oisedani Member. **6**, the Hakubado Member. All figures are photomicrographs of thin sections. **1**, bioclastic wackestone, scale bar equals 1.0 mm for this figure. **2**, peloidal packstone, scale bar equals 1.0 mm for this figure. **3**, geopetal structure (arrow), scale bar equals 0.4 mm for this figure. **4**, tuffaceous sandstone, note corroded quartz grain, cross-polar image, scale bar equals 1.0 mm for this figure. **5**, felsic tuff, cross-polar image, scale bar equals 1.0 mm for this figure. **6**, bioclastic wackestone, scale bar equals 1.0 mm for this figure.

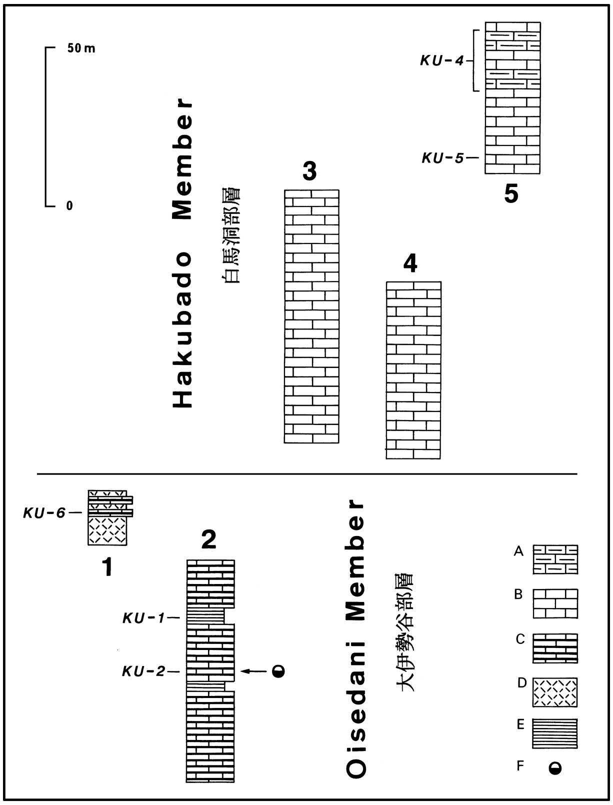


Fig. 3. Stratigraphic columnar sections of the Kamianama Formation. Horizones containing favositid corals (KU-1, 2, 4–6) and geopetal structure are indicated. Lower and upper ends of all columns are cut by faults. **A**, massive limestone with light buff to reddish brown in color. **B**, massive limestone with light gray in color. **C**, bedded limestone to argillaceous limestone. **D**, tuffaceous mudstone to sandstone and tuff. **E**, calcareous shale. **F**, geopetal structure.

are also recognized as rare cases.

Thickness: The member probably exceeds a thickness of *ca*. 90 m.

Hakubado Member (new name)

Type locality and geographic distribution: The type locality is a western flank of the Shibasudani Valley (columnar section 5) of the Hakogase district, in which a stalactite grotto, Hakubado, is formed by dissolution of limestones. Outside the type locality this member crops out on a ridge between the Tokonobora and Koisedani Valleys in the Kamiise district, in a tributary (Kamaharadani Valley) of the Oisedani Valley (columnar section 3), in the Oboradani Valley (columnar section 4), and at the northern shore of the Kuzuryu Lake near the Hakogase Bridge of the Hakogase district. Although we can not detect any outcrop, float blocks derived from the Hakubado Member are found in a tributary (Shiritaka Valley) of the Konogidani Valley of the Otani district.

Lithology: The Hakubado Member is entirely made up of massive light-colored limestones indicating mostly light gray, and lacks terrigenous sediments. Except for the uppermost part that is characterized by the partial stain in buff to reddish brown and the predominance of bioclastic wackestones (Fig. 2-6), usually barren peloidal wackestones with uncommonly intercalations of stromatoporoidal bafflestones are predominant throughout the member. The occurrence of diversified coral fossils is confined to the uppermost part.

Thickness: The member probably exceeds ca. 130 m thick.

Favositid and Auloporid Coral Faunas and Correlation

Total 261 favositid tabulate coral specimens, representing 17 species, are herein identified from the Kamianama Formation. Within these, the *Squameofavosites sugiyamai* assemblage, the *Thamnoptychia mana* assemblage, the *Klaamannipora oborensis* assemblage, and the *Isurugiopora obesa* assemblage can be recognized. The lithostratigraphic reconstruction seems to be warranted by the faunal analysis.

The *Squameofavosites sugiyamai* assemblage contains *Mesofavosites igoi* (Kamei, 1955; abundant), *Sapporipora kamitakaraensis* Tsukada (2005; abundant), *Plicatomurus flexuosus* (Kamei, 1955; common), *Squameopora takarensis* (Kamei, 1955; common), *Squameofavosites fukujensis* (Kamei, 1955; rare), *S. ichinotanensis* (Kamei, 1955; common), *S. sugiyamai* (Kamei, 1955; very abundant), *Thamnopora hayasakai* Niko (2005; abundant), *Parastriatopora innae* Dubatolov (1963; common), and *Coenites kameii* sp. nov. (very abundant). Previously documented all auloporid tabulate corals in Niko and Senzai (2006), including *Aulopora sorayamaensis* Niko (2001; rare), *Romingeria cristata* Niko (2001; common), *Multithecopora kamianamaensis* Niko and Senzai (2006; common) and *Syringoporella fujiwarai* Niko and Senzai (2006; common), are also typical components. The assemblage characteristically occurs in the Oisedani Member and shows close relationships to corals from the Lochkovian (early Early Devonian) to Emsian (late Early Devonian) Takaharagawa Member of the Fukuji Formation, with 10 taxa in common.

The *Thamnoptychia mana* assemblage is based on knowledge derived from a float block of greenish gray tuffaceous shale. The block was probably derived from the upper part of the Oisedani Member, and represents by each single specimen of *Thamnoptychia mana* sp. nov. and *Alveolites* sp. cf. *A. maillieuxi* Lecompte, 1933. Counterpart of the assemblage is not still documented in the Fukuji Formation.

The *Klaamannipora oborensis* assemblage consists of *Klaamannipora oborensis* sp. nov. (rare) and *Isurugiopora ishiokai* sp. nov. (rare). The assemblage is restricted to the main part of the Hakubado Member, whose counterpart in the Fukuji Formation is not still documented.

The *Isurugiopora obesa* assemblage consists of characteristic corals, namely *Mesofavosites igoi* (Kamei, 1955; rare), *Pachyfavosites katoi* Niko (2007; common), *Isurugiopora obesa* Niko (2005; abundant), and *Striatopora takayamaensis* Niko (2005; rare). Of these, except for *M. igoi* that occurs widely in the Takaharagawa Member to the lower part of the Ozako Member in the Fukuji Formation, all species are common to the uppermost part (probably Eifelian; early Middle Devonian) of the Ozako Member. The assemblage is recovered from the uppermost part of the Hakubado Member at locality KU-4 in the Shibasudani Valley. This discovery is resulted in deny the Ohno *et al*. (1977)'s suggestion that a limestone block containing a Silurian trilobite *Encrinurus* sp. cf. *E. similes* Kobayashi and Hamada (1985; 1987) represents the eastern margin of the present limestones containing the *Isurugiopora obesa* assemblage near a Hakubado Grotto and they are synchronous. Kurihara and Sashida (1998) and Kurihara (2003) regarded the limestones as exotic inclusions surrounded by the Early Devonian clastic sequences. Their hypothesis, however, is not reasonable owing to the younger age of the limestones than the host rocks.

From the above facts it is concluded that the Oisedani and Hakubado Members in the Kamianama Formation are respectively correlative with the Takaharagawa and Ozako Members in the Fukuji Formation.

Systematic Paleontology

Order Favositida Wedekind, 1937

Suborder Favositina Wedekind, 1937

Superfamily Favositoidea Dana, 1846

Family Favositidae Dana, 1846

Subfamily Favositinae Dana, 1846

Genus ***Klaamannipora*** Mironova, 1974

Type species: *Favosites coreaniformis* Sokolov, 1952a.

Klaamannipora oborensis sp. nov.

(Figs. 4-1–8)

Holotype: NSM PA16409, from which 10 thin sections were made.

Other specimens: Thirteen thin sections were studied from the seven paratypes, NSM PA16402, 16403, 16405, 16407, 16408, 16410, 16716. In addition, three poorly preserved specimens, NSM PA16404, 16406, 16712, were questionably assigned to this new species.

Diagnosis: Species of *Klaamannipora* with slender branches, whose most common diameters are 6–8 mm; corallites gently divergent; numbers of corallites in transverse section of usual branches are 23–57; diameters of adult corallites approximately 1.4 mm; opening angle of calices are 43°–60°; intercorallite walls have 0.04–0.20 mm in thickness; tabulae well developed, 4–10 in 2.5 mm; in addition to complete tabulae, incomplete tabulae are frequently developed.

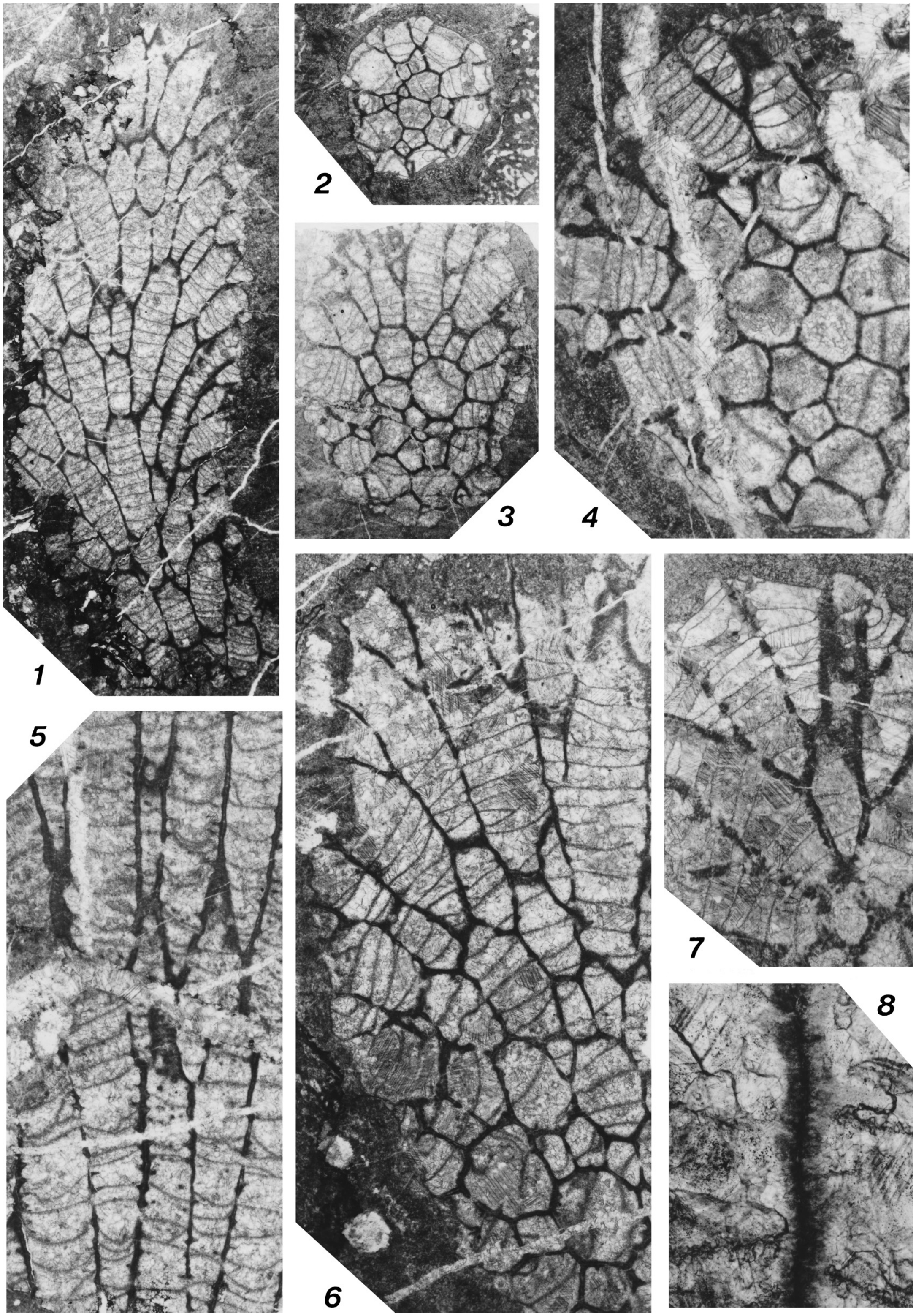
Description: Coralla ramose with cylindrical to subcylindrical branches, cerioid; branching probably rare; total corallum diameter and growth form unknown owing to fragile nature; diameters of branches small for the genus, range from 4 to 12 mm, 6–8 mm most common. Corallites prismatic; there are 23 to 57 corallites in transverse section of usual branch; transverse sections of proximal corallites have 3–5 sides, then ontogenetically shift 7–10 sided profiles in distal ones; corallite diameters relatively large, range from 0.3 to 1.9 mm, with 1.4 mm mean in adult corallites; each corallite gradually expanded and gently divergent to form oblique and shallow calice in its distal end; opening angle of calices is 43°–60° to branch surface; transverse sections of tabularia and calical pits are polygonal; increase of new corallite is lateral, uncommonly occurs in axial zone of branch. Intercorallite walls mostly thin in axial zone with 0.04–0.09 mm, but their thickness in peripheral zone and in gerontic (?) branches increases attaining 0.20 mm; structure of intercorallite walls differentiated into median dark line and stereoplasm, the latter of which consists of rect-radiate fibers; mural pores common, usually occur on corallite faces as mid-wall pores, but angle pores are also developed; profiles of mural pores are longitudinally elongated elliptical with 0.16×0.23 mm in diameter of typical one; some mural pores are closed by pore plate; septal spines rod-like with wide base to short conical having 0.10–0.14 mm in length of protrude portion; distribution of septal spines is variable, sporadic to abundant; tabulae well developed, usually complete, but incomplete tabulae are frequently recognized especially in peripheral zone; complete tabulae have weakly sagging to nearly flat, or rarely uparched; through axial and peripheral zones, there are 4–10 tabulae in 2.5 mm of corallite length; thickened tabula is not developed.

Etymology: The specific name is derived from the Oboradani Valley, where the tabulate coral was recovered.

Occurrence: Except for a specimen (NSM PA16712), collected from gray limestone (peloidal wackestone) in the Kamaharadani Valley, all examined specimens of *Klaamannipora oborensis* sp. nov. were collected from the float blocks of light gray limestone (peloidal wackestone) in the Oboradani Valley.

These specimens are derived from the main part of the Hakubado Member.

Discussion: There are seven previously described species referable to *Klaamannipora* from the Early Silurian to Early Devonian in Estonia, the Arctic Urals, Iran, and Siberia (Mironova, 1974; Niko *et al*., 2000). Among them, *K. oborensis* sp. nov., that represents the first record of the genus in Japan, shows some affinities with a Ludlow (Late Silurian) species, *K. coreaniformis* (Sokolov, 1952a, p. 53, 54, pl. 20, figs. 3–6), from Sarema Island of Estonia in its slender branch diameters for the genus and approxi-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mate measurements of its intercorallite wall thickness. Distinctive respects of these species are as follows, the calices of *K. oborensis* are oblique with 43°–60° in opening angle, whereas *K. coreaniformis* has the perpendicularly oriented calices, numbers of the tabulae in the axial zone of the branch, *i.e.*, 4–10 in 2.5 mm of corallite length of *K. oborensis versus* 2–4 in ditto of *K. coreaniformis*, and the frequently developed incomplete tabulae in *K. oborensis* are not recognized in *K. coreaniformis*. The oblique calices are also documented in an Early Devonian species, *K. rzonsnickajae* (Dubatolov, 1959, p. 116–118, pl. 40, figs. 1, 2a, b, v, 3a, b) from the Kuznetsk Basin, southwestern Siberia, however its branch diameters are larger, approximately 10–20 mm, than those of the new species indicating commonly 6–8 mm.

Genus ***Mesofavosites*** Sokolov, 1951

Type species: *Mesofavosites dualis* Sokolov, 1951.

Mesofavosites igoi (Kamei, 1955)

(Figs. 5-1, 2)

Mesofavosites igoi (Kamei); Niko, 2006, p. 14, 16, figs. 1-1–3; 2-1–5 [with earlier synonymy]; Niko, 2007, p. 62, 64, figs. 4-1–5.

Mesofavosites cf. *igoi* (Kamei); Ibaraki *et al.*, 2009, p. 423, 424, figs. 2-A–D.

Material examined: Twenty-nine coralla, NSM PA16411–16438, 16684.

Occurrence: Calcareous shale (NSM PA16411, 16416, 16417) at locality KU-1. Black limestone (bioclastic wackestone; NSM PA16437) at locality KU-3. Black limestone (bioclastic wackestone; NSM PA16684) at locality KU-6. Float block of light gray limestone (bioclastic wackestone; NSM PA16438) near locality KU-4. Float blocks of calcareous shale (NSM PA16420, 16421) and argillaceous limestone (NSM PA16412–16415, 16418, 16419) in the Kamaharadani Valley. Float blocks of argillaceous limestone (NSM PA16424, 16425, 16427, 16428, 16430), black limestone (wackestone to bioclastic wackestone; NSM PA16429) and dark gray limestone (bioclastic wackestone; NSM PA16426) in the Oboradani Valley. Float block of tuffaceous limestone in the Tokonobora Valley (NSM PA16423). Float blocks of argillaceous limestone (NSM PA16431–16434) and black limestone (wackestone to bioclastic wackestone; NSM PA16435, 16436) in the Tanobora Valley. Tuffaceous limestone (NSM PA16422) of unknown locality.

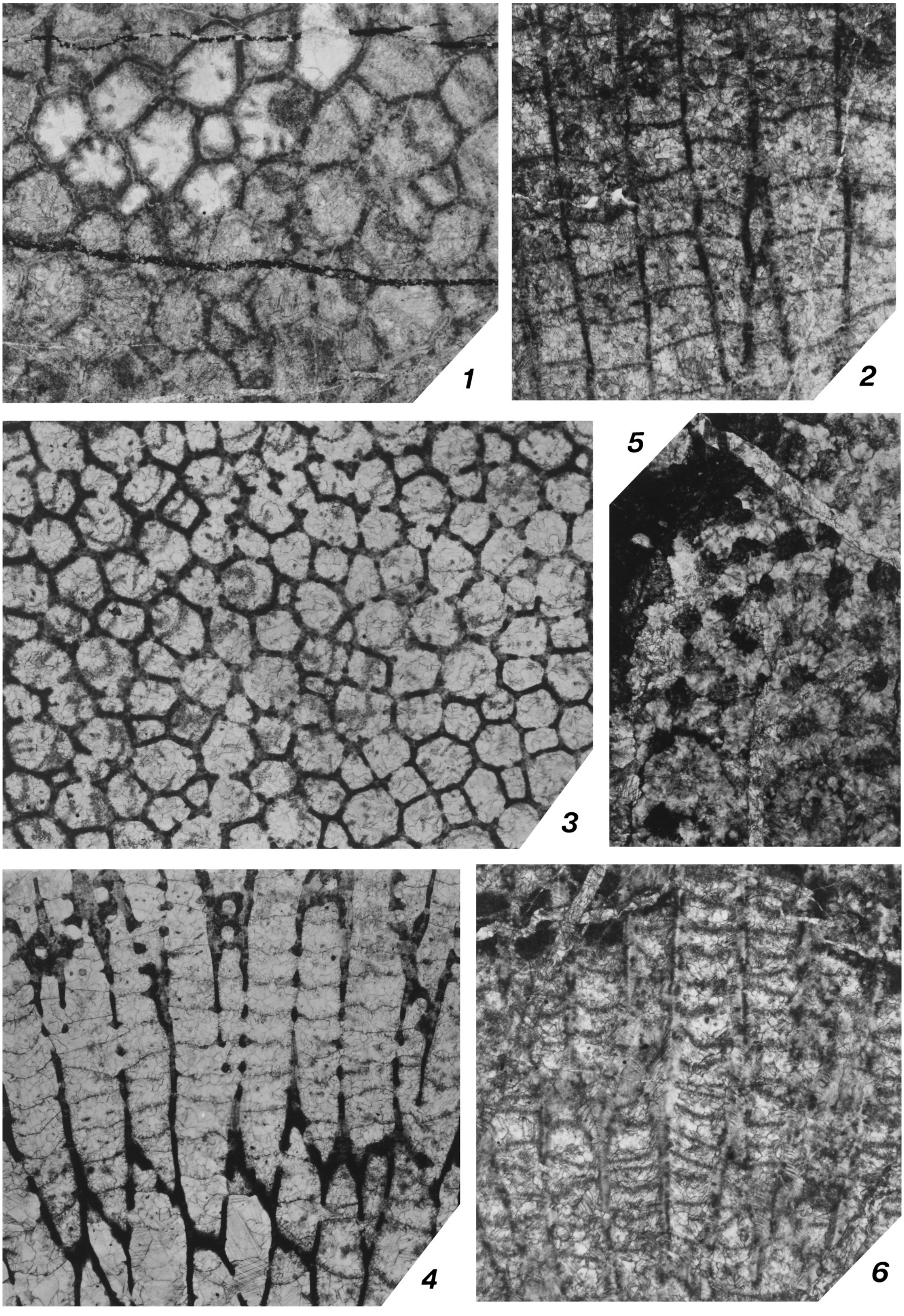
Except for a specimen, NSM PA16438, derived from the Hakubado Member, the specimens of *Mesofavosites igoi* are derived from the Oisedani Member.

Remarks: Stratigraphic study of the Fukuji Formation in Gifu Prefecture (Niko, 2007) reveals that *Mesofavosites igoi* ranges from the Lochkovian to Emsian Takaharagawa Member and the lower part (probably Emsian) of the Ozako Member. A poorly preserved and immature specimen identified as *M*. cf. *igoi* was reported also from a float block of black limestone in the Omi area (Ibaraki *et al.*, 2009), whose area represents the eastern margin of the Hida-Gaien Belt. This species is the second most abundant favositines in the Kamianama Formation, and is a useful index fossil in the belt.

Genus ***Sapporipora*** Ozaki *in* Shimizu, Ozaki and Obata, 1934

Type species: *Sapporipora favositoides* Ozaki *in* Shimizu, Ozaki and Obata, 1934.

Fig. 4. *Klaamannipora oborensis* sp. nov., thin sections. **1**, **2**, **4**, **6**–**8**, holotype, NSM PA16409. **1**, longitudinal section of branch, note oblique calices, ×5. **2**, transverse section of branch, ×5. **4**, transverse to oblique sections of corallites, ×10. **6**, transverse to longitudinal sections of corallites, ×10. **7**, transverse to longitudinal sections of corallites, note thickened intercorallite walls and incomplete tabulae, ×10. **8**, partial enlargement to show intercorallite wall structure, longitudinal section, ×75. **3**, paratype, NAM PA16405, oblique section of branch, ×5. **5**, paratype, NSM PA16402, longitudinal sections of corallites, ×10.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Sapporipora kamitakaraensis Tsukada, 2005
(Figs. 5-3, 4)

Sapporipora kamitakaraensis Tsukada; Niko, 2006, p. 16, 18, figs. 2-6–8 [with earlier synonymy]; Niko, 2007, p. 64, figs. 5-1–6 [with additional synonymy]; Hirata, 2008, p. 34, pl. 1, fig. a.

Material examined: Twenty-four coralla, HMM03136; NSM PA16439–16460, 16680.

Occurrence: Calcareous shale (HMM03136; NSM PA16442, 16444–16448) at locality KU-1. Black limestone (bioclastic wackestone; NSM PA16460) at locality KU-2. Float blocks of argillaceous limestone (NSM PA16439, 16440, 16449, 16680) and black limestone (bioclastic wackestone; NSM PA16441, 16443) in the Kamaharadani Valley. Float blocks of calcareous shale (NSM PA16452) and black limestone (bioclastic wackestone; NSM PA16450, 16451) in the Oboradani Valley. Float block of black limestone (wackestone) in the Oisedani Valley (NSM PA16459). Float blocks of argillaceous limestone (NSM PA16454–16458) and black limestone (bioclastic wackestone; NSM PA16453) in the Tanobora Valley.

These specimens are derived from the Oisedani Member.

Remarks: *Sapporipora kamitakaraensis* is easily recognized by its small corallite diameters, uniformly thickened intercorallite walls and numerous mural pores. In the type locality (Fukuji), this species has been known from the Takaharagawa Member.

Subfamily Pachyfavositinae Mironova, 1965

Genus ***Pachyfavosites*** Sokolov, 1952b

Type species: *Calamopora polymorpha* var. *tuberosa* Goldfuss, 1826.

Pachyfavosites katoi Niko, 2007
(Figs. 5-5, 6)

Pachyfavosites katoi Niko, 2007, p. 66, 68, figs. 6-1–5.

Material examined: Eleven coralla, NSM PA16461–16470, 16711.

Occurrence: Light gray to light brownish gray limestone (bioclastic wackestone; NSM PA16461–16467) at locality KU-4. Float blocks of light gray limestone (bioclastic wackestone; NSM PA16468–16470) near locality KU-4 and light gray limestone (bioclastic wackestone; NSM PA16711) in the Tokonobora Valley.

These specimens are derived from the uppermost part of the Hakubado Member.

Remarks: The specific description by Niko (2007) is adequate and is not repeated here. *Pachyfavosites katoi* is easily distinguished from *P. hidensiformis* (Mironova, 1961, p. 149, 150, pl. 5, figs. 1a, b, v, g) in the Lower Devonian (Lochkovian) of Salair, southwestern Siberia by the smaller corallite diameters (approximately 1.2 mm *versus* 1.6 mm in *P. hidensiformis*), the thinner intercorallite walls (up to 0.36 mm *versus* 0.42 mm in *P. hidensiformis*) and the fewer septal spines in the peripheral zone of corallum. The type specimens of *P. katoi* were recovered from the uppermost (possibly Eifelian) part of the Ozako Member in the Fukuji area.

Genus ***Plicatomurus*** Chang, 1959

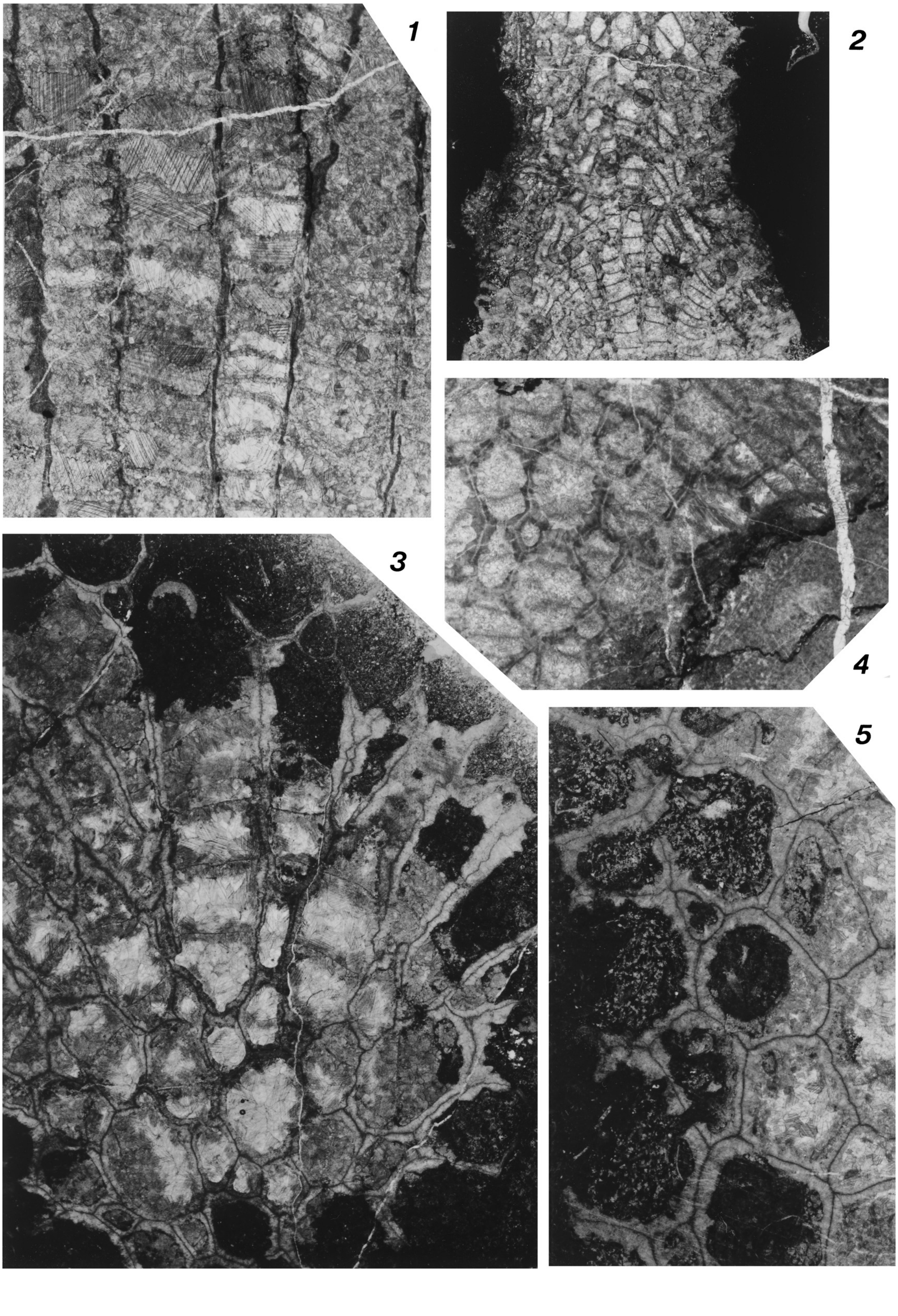
Type species: *Plicatomurus solidus* Chang, 1959.

Plicatomurus flexuosus (Kamei, 1955)
(Figs. 6-3, 5)

Plicatomurus flexuosus (Kamei); Niko, 2006, p. 18, 20, figs. 3-1–5 [with earlier synonymy]; Niko, 2007, p. 68, figs. 7-1–3.

Material examined: Eleven coralla, NSM

Fig. 5. **1**, **2**, *Mesofavosites igoi* (Kamei, 1955), thin sections. **1**, NSM PA16425, transverse sections of corallites, ×10. **2**, NSM PA16419, longitudinal sections of corallites, ×10. **3**, **4**, *Sapporipora kamitakaraensis* Tsukada, 2005, thin sections, HMM03136. **3**, transverse sections of corallites, ×10. **4**, longitudinal to oblique sections of corallites, ×10. **5**, **6**, *Pachyfavosites katoi* Niko, 2007, thin sections. **5**, NSM PA16470, transverse sections of corallites, ×10. **6**, NSM PA16465, longitudinal sections of corallites, ×10.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PA16478–16488.

Occurrence: Calcareous shale (NSM PA16478–16482, 16484–16487) at locality KU-1. Float blocks of black limestone (bioclastic wackestone; NSM PA16483) in the Kamaharadani Valley. Float block of black limestone (wackestone; NSM PA16488) in the Tanobora Valley.

These specimens are derived from the Oisedani Member.

Remarks: The stratigraphic distribution of *Plicatomurus flexuosus* in the type locality (Fukuji) ranges from the lower to middle parts of the Takaharagawa Member.

Genus ***Squameopora*** Preobrazhenskiy, 1967

Type species: *Favosites forbesi takarensis* Kamei, 1955.

Squameopora takarensis (Kamei, 1955)

(Figs. 6-2, 4)

Squameopora takarensis (Kamei); Niko, 2006, p. 21, 22, figs. 4-7–9; 5-3 [with earlier synonymy]; Niko, 2007, p. 68, 70, 72, figs. 7-4, 5; 8-1–6 [with additional synonymy].

Material examined: Six coralla, NSM PA16495–16499, 16681.

Occurrence: Float blocks of argillaceous limestone (NSM PA16681) and black limestone (bioclastic wackestone; NSM PA16495, 16496) in the Kamaharadani Valley. Float blocks of argillaceous limestone (NSM PA16499) and dark gray to black limestone (bioclastic wackestone; NSM PA16497, 16498) in the Oboradani Valley.

These specimens are derived from the Oisedani Member.

Remarks: Although poor, the Kamianama specimens agree well with the types from the Takaharagawa Member of the Fukuji area, in their ramose coralla, thickened intercorallite walls, low conical septal spines and closely spaced peripheral tabulae.

Subfamily Emmonsiinae Lecompte, 1952

Genus ***Squameofavosites*** Chernyshev, 1941

Type species: *Favosites hemisphericus* var. *bohemica* Počta, 1902; renamed *Squameofavosites cechicus* Galle, 1978.

Squameofavosites fukujensis (Kamei, 1955)

(Figs. 7-2, 5)

Squameofavosites fukujensis (Kamei); Niko, 2006, p. 22, 24, figs. 5-5–7 [with earlier synonymy]; Niko, 2007, p. 72, figs. 9-1–5 [with additional synonymy].

[non] *Squameofavosites fukujiensis* [sic] (Kamei); Hirata, 2008, p. 34, pl. 1, figs. c-1, 2.

[?] “*Squameofavosites*” sp., Hirata, 2008, p. 35, pl. 2, figs. e-1, 2.

Material examined: A single corallum, NSM PA16570.

Occurrence: Dark gray limestone pebble (wackestone) in float block of conglomerate, assignable to the Mesozoic Otani Conglomerate, in the Ichinomata Valley.

Remarks: The stratigraphic distribution of *Squameofavosites fukujensis* in the type locality (Fukuji) probably restricts to the lower part of the Takaharagawa Member. Although limestone pebbles in the Otani Conglomerate span the time from Early Devonian to Middle Permian (e.g., Ozaki *et al*., 1954; Yamaguchi and Ohta, 1965), bio- and lithofacies of the coral bearing limestone suggest that it was derived from the Oisedani Member.

Squameofavosites ichinotanensis (Kamei, 1955)

(Figs. 6-1; 7-1)

Favosites ichinotanensis Kamei; Niko, 2006, p. 14, figs. 1-1–7 [with earlier synonymy].

Fig. 6. **1**, *Squameofavosites ichinotanensis* (Kamei, 1955), NSM PA16503, longitudinal thin sections of corallites, ×10. **2**, **4**, *Squameopora takarensis* (Kamei, 1955), thin sections. **2**, NSM PA18881, longitudinal section of branch, ×5. **4**, NSM PA16497, transverse to oblique sections of corallites, ×10. **3**, **5**, *Plicatomurus flexuosus* (Kamei, 1955), thin sections. **3**, NSM PA16486, oblique section of branch, ×10. **5**, NSM PA16482, transverse sections of distal corallites, ×10.

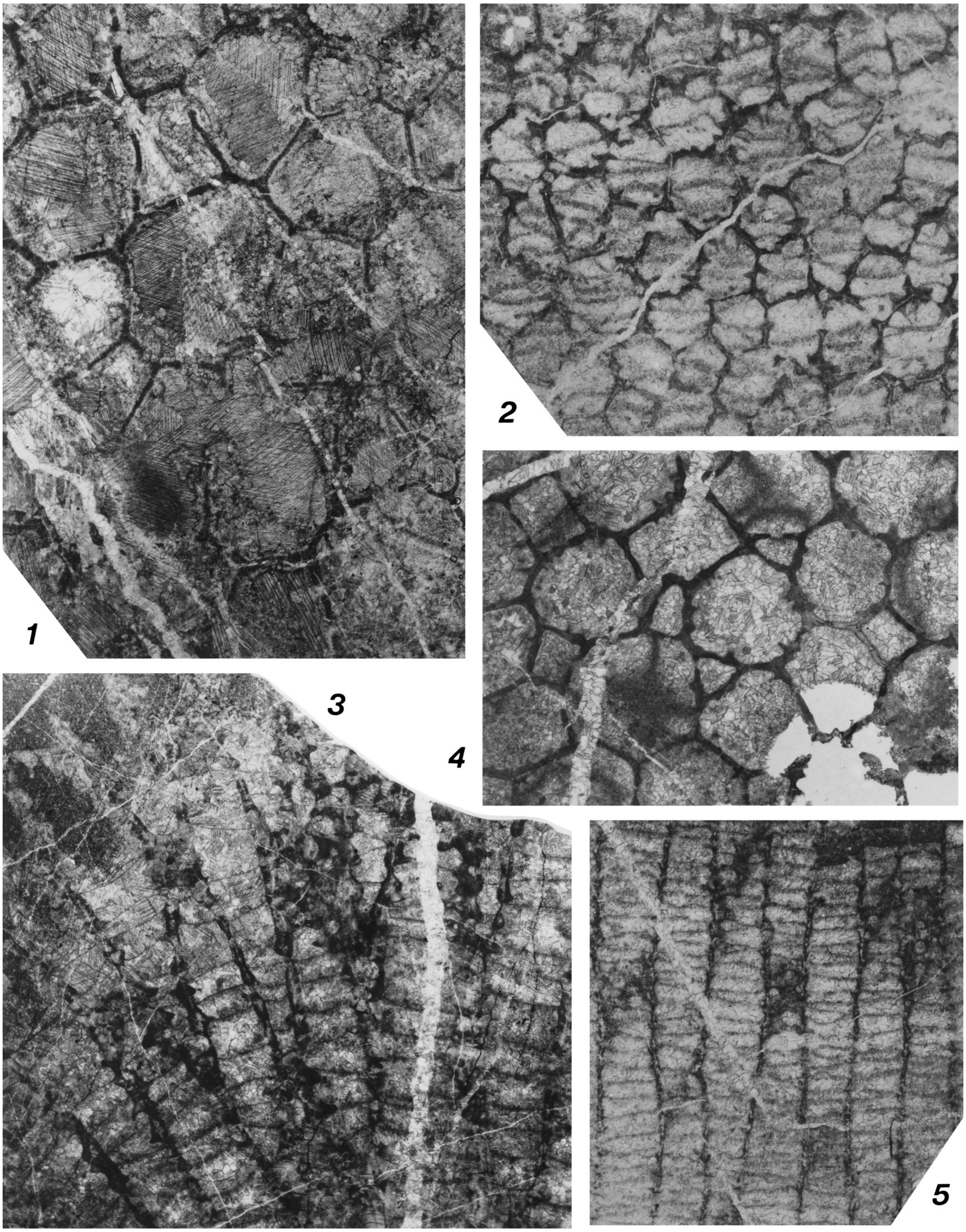


Fig. 7. **1**, *Squameofavosites ichinotanensis* (Kamei, 1955), NSM PA16503, transverse thin sections of corallites, ×10. **2**, **5**, *Squameofavosites fukujensis* (Kamei, 1955), NSM PA16570, thin sections. **2**, transverse sections of corallites, ×10. **5**, longitudinal sections of corallites, ×10. **3**, **4**, *Squameofavosites sugiyamai* (Kamei, 1955), thin sections. **3**, NSM PA16516, longitudinal sections of corallites, ×10. **4**, NSM PA16551, transverse sections of corallites, ×10.

Squameofavosites ichinotanensis (Kamei); Niko, 2007, p. 72, 74, figs. 10-1–5.

Material examined: Five coralla, NSM PA16500–16503, 16683.

Occurrence: Float blocks of calcareous shale (NSM PA16502) and argillaceous limestone (NSM PA16500, 16501, 16683) in the Kamaharadani Valley. Float block of black limestone (wackestone; NSM PA16503) in the Oboradani Valley.

These specimens are derived from the Oisedani Member.

Remarks: The stratigraphic distribution of *Squameofavosites ichinotanensis* in the type locality (Fukuji) ranges from the lower to middle parts of the Takaharagawa Member.

Squameofavosites sugiyamai (Kamei, 1955)

(Figs. 7-3, 4)

Squameofavosites sugiyamai (Kamei, 1955); Niko, 2006, p. 24, 26, figs. 5-4; 6-1–4 [with earlier synonymy]; Niko, 2007, p. 74, 76, figs. 11-1–4 [with additional synonymy]; Hirata 2008, p. 34, pl. 1, figs. b-1–3.

[?] *Squameofavosites fukujiensis* [sic] (Kamei); Hirata, 2008, p. 34, pl. 1, figs. c-1, 2.

[?] *Squameofavosites* sp., Hirata, 2008, p. 34, pl. 1, fig. d.

Material examined: Sixty-seven coralla, NSM PA16504–16569, 16682.

Occurrence: Calcareous shale (NSM PA16509–16512) at locality KU-1. Argillaceous limestone (NSM PA16569) at locality KU-2. Float block of black limestone (wackestone; NSM PA16404) in the Iyamadani Valley. Float blocks of argillaceous limestone (NSM PA16507, 16508, 16513–16515, 16682) and black limestone (bioclastic wackestone; NSM PA16505, 16506) in the Kamaharadani Valley. Float blocks of argillaceous limestone (NSM PA16517, 16519–16525, 16528), black limestone (bioclastic wackestone; NSM PA16516, 16526, 16527) and dark gray limestone (bioclastic wackestone; NSM PA16518) in the Oboradani Valley. Float block of black limestone (bioclastic wackestone; NSM PA16569) in the Oisedani Valley. Float blocks of argillaceous limestone (NSM PA16529, 16530, 16532–16539, 16545, 16548, 16550–16553, 16555, 16556, 16558–16560, 16562, 16564, 16565, 16567) and black limestone (bioclastic wackestone to wackestone; NSM PA16531, 16540–16544, 16546, 16547, 16549, 16554, 16557, 16561, 16563, 16566) in the Tanobora Valley.

These specimens are derived from the Oisedani Member.

Remarks: The stratigraphic distribution of *Squameofavosites sugiyamai* in the type locality (Fukuji) ranges from the lower to upper parts of the Takaharagawa Member. This species is the most abundant favositines in the Kamianama Formation.

Superfamily Pachyporoidea Gerth, 1921

Family Pachyporidae Gerth, 1921

Genus ***Isurugiopora*** Niko, 2005

Type species: *Isurugiopora obesa* Niko, 2005.

Emended diagnosis: Tabulae rare to well-developed. See Niko (2005, p. 16) for other diagnostic features of the genus.

Remarks: Based on morphologic information of *Isurugiopora ishiokai* sp. nov. (this report), a minor emendation of the generic diagnosis on the tabula nature is added.

Isurugiopora obesa Niko, 2005

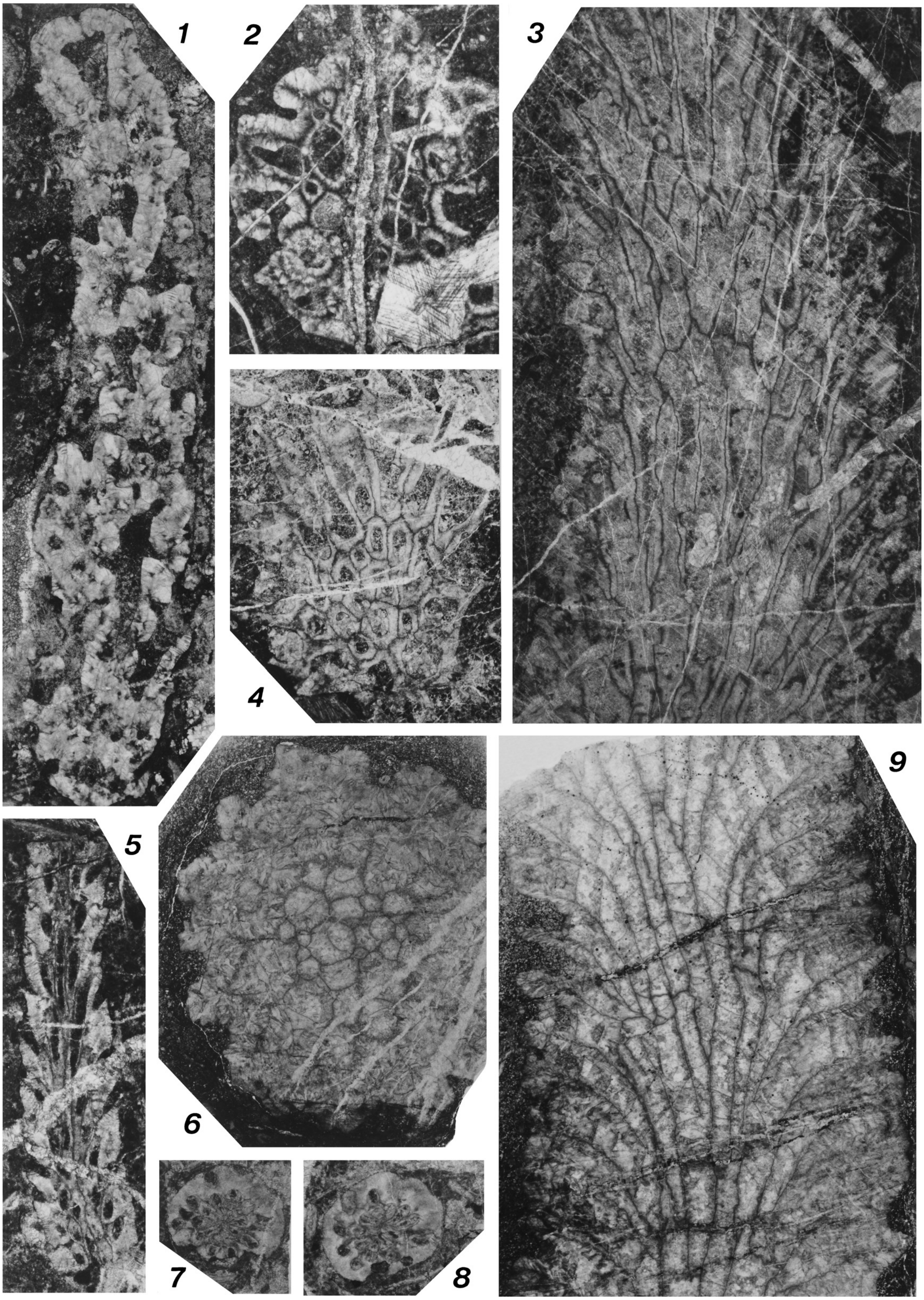
(Figs. 8-1, 2)

Isurugiopora obesa Niko, 2005, p. 18, 20, figs. 3-1–7; 4-1–8.

Material examined: Fourteen coralla, NSM PA16612–16625.

Occurrence: Light gray to light brownish gray limestone (bioclastic wackestone; NSM PA16612–16614) at locality KU-4. Float blocks of black limestone (bioclastic wackestone; NSM PA16615) and light gray, gray to light brownish gray limestone (bioclastic wackestone; NSM PA16616–16625) near locality KU-4.

Except for a specimen, NSM PA16615, whose stratigraphic position is unclear, the specimens of *Isurugiopora obesa* are derived from the uppermost part of the Hakubado Member.



Remarks: The diagnostic features of *Isurugiopora obesa* have been adequately documented by Niko (2005), thus they are not repeated here. The type specimens of *I. obesa* were recovered from the uppermost part of the Ozako Member in the Fukuji area. This species is compared to *I. ishiokai* sp. nov under that species.

Isurugiopora ishiokai sp. nov.

(Figs. 9-1–7)

Holotype: NSM PA16653, from which two thin sections were made.

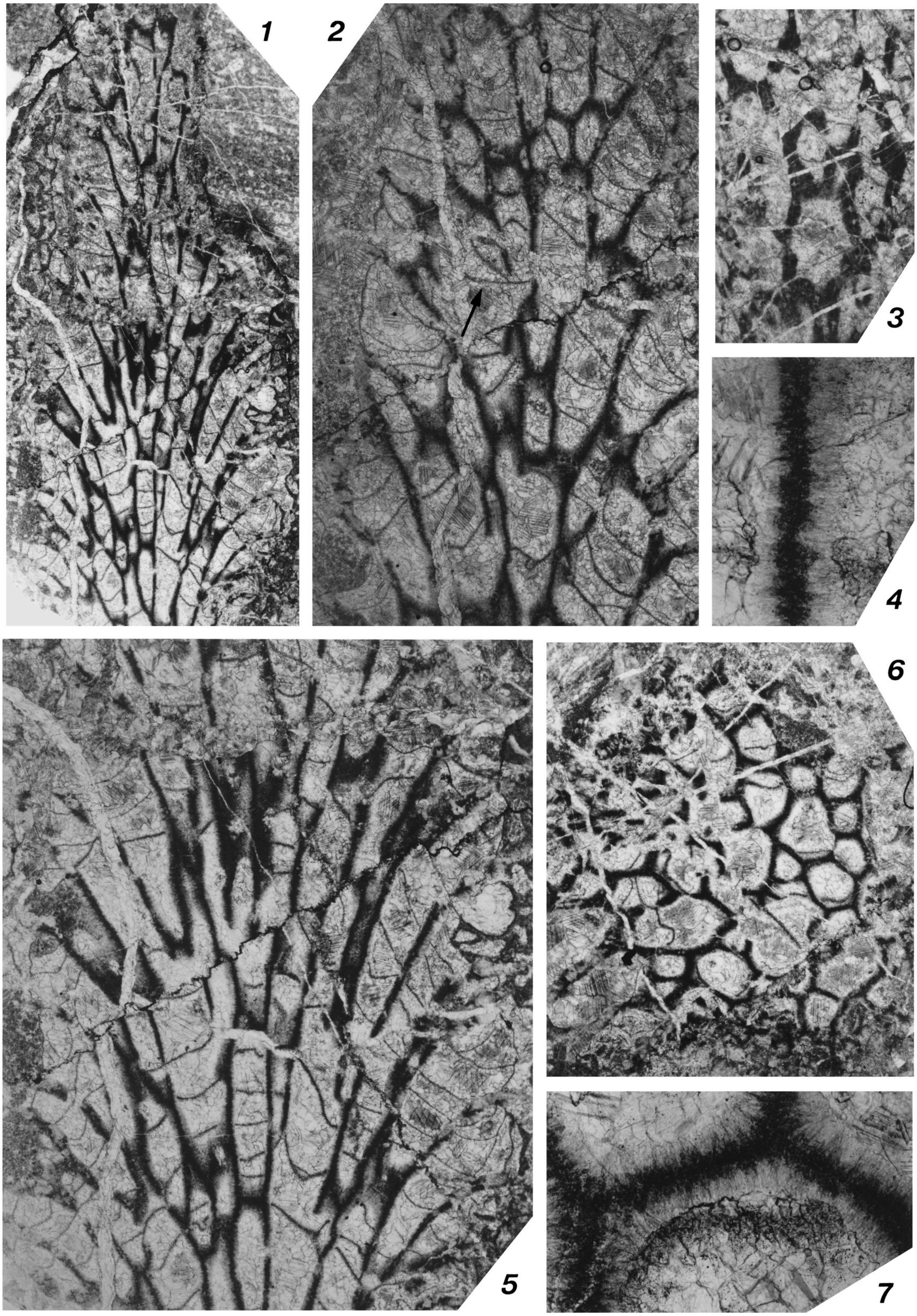
Other specimens: Twenty-one thin sections were studied from the three paratypes, NSM PA16645, 16648, 16652. In addition, five coralla, NSM PA16646, 16647, 16649–16651, were also examined.

Diagnosis: Species of *Isurugiopora* with branch diameter of usually 4.3–9.2 mm, 43–56 in number of corallites in transverse section of branch, approximately 1.3 mm in corallite diameter near calical rim; usual calical opening 34°–72° in angle to branch surface; intercorallite walls attain 0.42 mm in thickness; mural pores large, 0.22×0.33 mm in typical ones; tabulae common to well developed; there are 2–7 tabulae in 2.5 mm; continuous tabula between adjoining corallites is rarely recognized.

Description: Coralla ramose with cylindrical branches having 4.3–9.2 mm in usual diameter, cerioid; branching rare, bifurcate; total corallum diameter and growth form unknown owing to fragile nature. Corallites prismatic to subprismatic, 4–6 sided in immature corallites, then ontogenetically shift to 6–10 sided or somewhat rounded subpolygonal in adult ones; depressed corallite face commonly occurs; there are 43–56 corallites in transverse section of branch; diameters of corallites range from 0.5 to 1.5 mm, with 1.3 mm mean near calical rim; each corallite differentiated into gradually divergent proximal portion forming axial zone of branch and outwardly curved distal portion forming peripheral zone of branch, but this differentiation is not always clear; corallite inflation is moderate; ratios of axial zone width per branch diameter are approximately 0.6 in holotype; calices obliquely upwards with usually 34°–72° in opening angle to branch surface; tabularia wide for the genus indicating subcircular or sub-stellate profiles, then they shift to very shallow calices; increase of new corallite is lateral, commonly occurs in axial zone. Intercorallite walls thick even in axial zone, where their thickness is 0.17–0.25 mm, furthermore gradually thickened attaining 0.42 mm in peripheral zone to form indistinct peripheral stereozone; constituents of intercorallite walls are exceptionally inflated median dark line and stereoplasm, whose microstructure is rect-radiate fibers; thickness of median dark line attains 0.07 mm; mural pores large, well-developed, forming a single row on each corallite face as mid-wall pores; profile of typical mural pore is longitudinally elongated elliptical with 0.22×0.33 mm in diameter; in peripheral stereozone, mural pore replaced by narrow and curved mural tunnel; diameters of mural tunnels range from 0.07 to 0.14 mm; septal spines very rare, robust, approximately 0.2 mm in length of protrude portion; tabulae common to well-developed, mostly complete and rarely incomplete; complete tabulae have nearly flat, oblique, weakly sagging, sinuate or uparched profiles; continuous tabula between adjoining two corallites through mural pore or tunnel is rarely recognized; there are 2–7 tabulae in 2.5 mm of corallite length.

Etymology: The specific name honors Dr. Ko-

Fig. 8. **1**, **2**, *Isurugiopora obesa* Niko, 2005, thin sections. **1**, NSM PA16624, longitudinal section of branch, slightly off its axis, ×10. **2**, NSM PA16613, transverse section of branch, ×10. **3**, **4**, *Thamnopora hayasakai* Niko, 2005, thin sections. **3**, NSM PA16629, longitudinal section of branch, ×10. **4**, NSM PA16630, oblique section of branch, ×10. **5**, **7**, **8**, *Striatopora takayamaensis* Niko, 2005, NSM PA16626, thin sections. **5**, longitudinal section of branch, × 10. **7**, **8**, transverse sections of branches, ×10. **6**, **9**, *Parastriatopora innae* Dubatolov, 1963, thin sections. **6**, HMM03589, transverse section of branch, × 5. **9**, NSM PA16655, longitudinal section of branch, ×5.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kichi Ishioka, who first documented the Devonian (as Gotlandian at that time) rocks of the present Kuzuryu Lake–Ise River area in Ishioka and Kamei (1950).

Occurrence: Dark gray to gray limestone (peloidal wackestone; NSM PA16645–16652) from locality KU-3. Gray limestone (peloidal wackestone; NSM PA16653) from locality KU-5. Float block of gray limestone (stromatoporoidal biolithite; NSM PA16645) in the Oboradani Valley.

These specimens are probably derived from the main part of the Hakubado Member.

Discussion: *Isurugiopora ishiokai* sp. nov. differs from *I. obesa* in possessing the more larger branch diameters (4.3–9.2 mm *versus* 3.6–5.7 mm in *I. obesa*), the larger peripheral corallite diameters (1.3 mm *versus* 1.1 mm in *I. obesa*) and the less thickened intercorallite walls in the peripheral stereozone (0.42 mm in maximum thickness versus 0.73 mm in ditto of *I. obesa*) and the well-developed tabulae in the partial corallites. In addition, the continuous tabula between the adjoining corallites in the new species is not documented from *I. obesa.*

Genus ***Striatopora*** Hall, 1851

Type species: *Striatopora flexuosa* Hall, 1851.

Striatopora takayamaensis Niko, 2005

(Figs. 8-5, 7, 8)

Striatopora takayamaensis Niko, 2005, p. 20, 22, figs. 5-1–10.

[non] *Striatopora takayamaensis* Niko; Hirata, 2006, p. 20, pl. 4, figs. 12-1, 2.

Material examined: A single corallum, NSM PA16626.

Occurrence: Light gray limestone (bioclastic wackestone) at locality KU-4.

The specimen is derived from the uppermost part of the Hakubado Member.

Remarks: Niko (2005) presented a full description of *Striatopora takayamaensis*, that has been reported from the uppermost part of the Ozako Member. The Kamianama specimen is somewhat poor in preservation, and presents no additional morphologic knowledge for the original description of the Fukuji specimens.

Genus ***Thamnopora*** Steininger, 1831

Type species: *Thamnopora madreporacea* Steininger, 1831.

Thamnopora hayasakai Niko, 2005

(Figs. 8-3, 4)

Thamnopora hayasakai Niko, 2005, p. 22, 2426, figs. 6-1–9; Hirata, 2006, 18, pl. 3, figs. 9-1–3.

Striatopora sp., Tsukada, 2005, p. 84, 85, pl. 16, figs. 1–11; pl. 17, figs. 1–8.

Material examined: Eighteen coralla, HMM03136, 03542, NSM PA16627–16642.

Occurrence: Calcareous shale (NSM PA16637) at locality KU-1. Black limestone (bioclastic wackestone; NSM PA16640, 16641) at locality KU-2. Float blocks of calcareous shale (HMM03136, 03542) and black limestone (bioclastic wackestone to wackestone; NSM PA16627–16636, 16642) in the Kamaharadani Valley. Float block of calcareous shale (NSM PA16658) in the Oboradani Valley. Float block of black limestone (bioclastic wackestone; NSM PA16639) in the Tanobora Valley.

These specimens are derived from the Oisedani Member.

Remarks: A full description of *Thamnopora hayasakai* was presented by Niko (2005) and that

Fig. 9. *Isurugiopora ishiokai* sp. nov., thin sections. **1**, **2**, **4–7**, holotype, NSM PA16653. **1**, longitudinal section of branch, ×5. **2**, longitudinal to oblique sections of corallites, arrow indicates continuous tabula between adjoining corallites, ×10. **4**, partial enlargement to show intercorallite wall structure, longitudinal section, ×75. **5**, partial enlargement of Fig. 9-1, showing longitudinal sections of corallites, ×10. **6**, transverse section of branch, ×10. **7**, partial enlargement to show intercorallite wall structure, transverse section, ×75. **3**, paratype, NSM PA16652, transverse to oblique sections of distal corallites, × 10.

information is not repeated here. The stratigraphic distribution of this species in the type locality (Fukuji) ranges from the lower to middle parts of the Takaharagawa Member.

Genus ***Thamnoptychia*** Hall, 1876

Type species: *Striatopora* (*Thamnoptychia*) *limbata* Eaton, 1832.

Thamnoptychia mana sp. nov.

(Figs. 10-1–8)

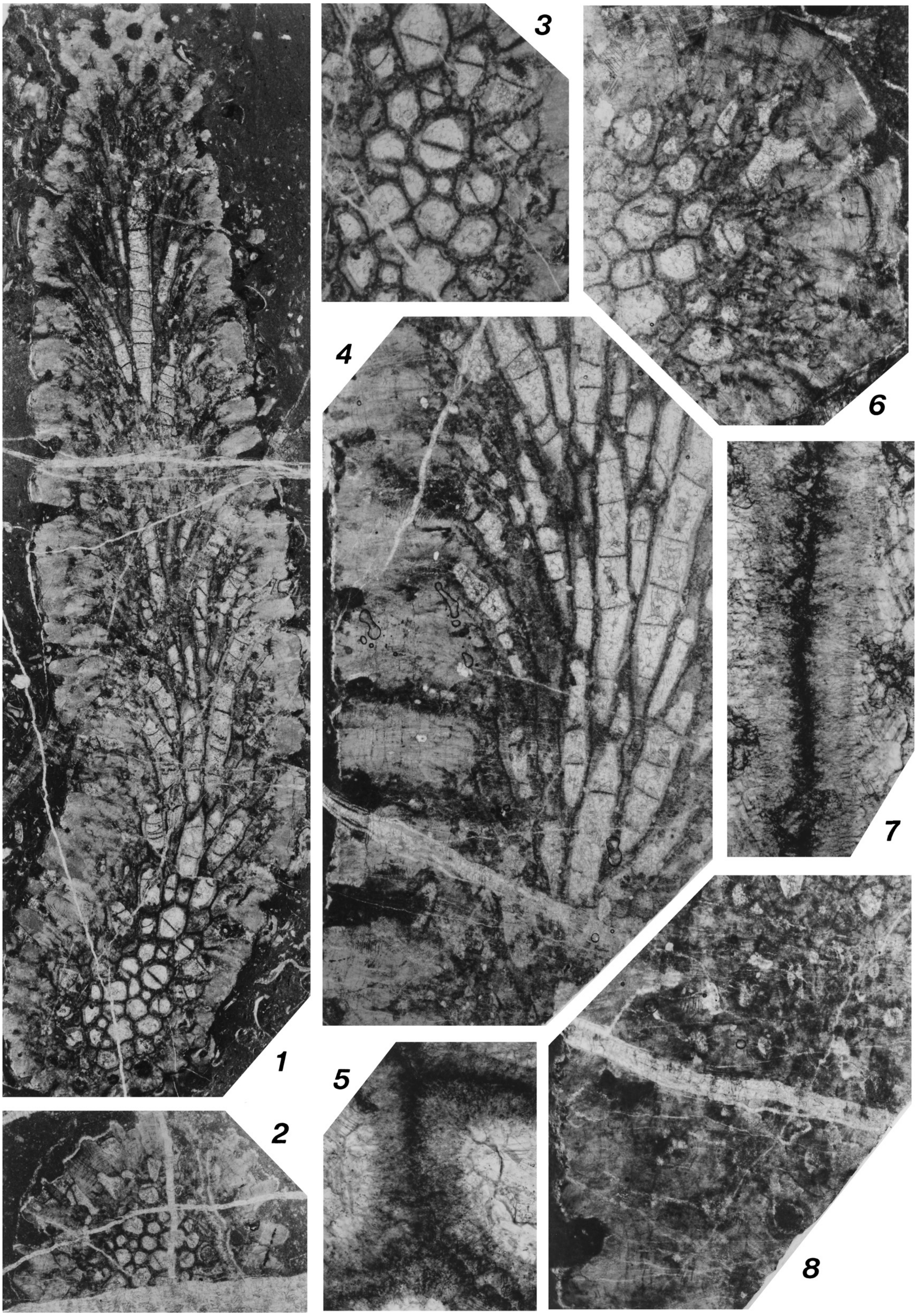
Holotype: NSM PA16644, from which 21 thin sections were made.

Diagnosis: Species of *Thamnoptychia* with approximately 7–8 mm in usual branch diameter and rare branching; center to center distances of neighboring calical pits (nearly equal to diameters of peripheral corallites) are 1.1–1.3 mm; peripheral zone (=peripheral stereozone) narrow; ratios of peripheral zone width per branch diameter are approximately 0.5; thickness of intercorallite walls attains 0.71 mm in peripheral stereozone; mural tunnels are common to well-developed.

Description: Corallum of an only available specimen is ramose with cylindrical and relatively slender branches for the genus having 3.7–8.9 mm, approximately 7–8 mm in usual diameter, cerioid; branching rare, bifurcate; total corallum diameter and growth form unknown for fragile nature. Corallites prismatic, 4–5 sided in immature corallites, then ontogenetically shift to 5–9 sided in more distal ones, where depressed corallite face commonly occurs; because of thickened intercorallite walls and disappearance of median dark lines, profiles of peripheral corallites become obscure; there are 56–63 corallites in transverse section of branch; calices deep, or shallow in rare cases, with cylindrical calical pits, whose diameters range from 0.3 to 0.6 mm; diameters of corallites are 0.3–1.0 mm in axial zone of branch; center to center distances of neighboring calical pits (nearly equal to diameters of peripheral corallites) are 1.1–1.3 mm; each corallite consists of gradually divergent proximal portion forming axial zone of branch and distal nearly straight portion forming peripheral zone of branch; calices perpendicularly oriented to branch surface; corallite inflation is gradual; increase of new corallite is lateral, uncommonly occurs in axial zone; transverse sections of tabularia of axial zone are subcircular to rounded subpolygonal. Intercorallite walls moderately thick, 0.15–0.25 mm, in axial zone, furthermore walls abruptly increase in thickness attaining 0.71 mm in peripheral zone, where thickened walls form peripheral stereozone; peripheral zone (=peripheral stereozone) is narrow for the genus; ratios of peripheral zone width per branch diameter are approximately 0.5; except for intercorallite walls in peripheral zone, they are differentiated into median dark line and stereoplasm, the latter of which microstructure is rectradiate fibers; thickened intercorallite walls exhibit apparent growth lamella; mural pores uncommon in axial zone, they are replaced by weakly curved mural tunnels in peripheral zone; profile of typical mural pore is elliptical with longitudinal elongation, 0.20×0.25 mm in diameter; mural tunnels are common to well-developed, having usually circular profiles, and 0.15 mm in diameter of typical one; apparent septal spine is not observable; tabulae well-developed, mostly complete; profiles of tabulae are flat, oblique or sagging; there are 3–6 tabulae in 2.5 mm of corallite length; diaphragms are rarely recognized in mural tunnels.

Etymology: The specific name is derived from

Fig. 10. *Thamnoptychia mana* sp. nov., holotype, NSM PA16644, thin sections. **1**, longitudinal to oblique section of branch, ×5. **2**, transverse section of branch, ×5. **3**, partial enlargement of Fig. 10-1, showing transverse sections of proximal corallites, ×10. **4**, longitudinal sections of corallites, ×10. **5**, partial enlargement to show intercorallite wall structure, transverse section, ×75. **6**, transverse to oblique sections of corallites, note well-developed mural tunnels, ×10. **7**, partial enlargement to show intercorallite wall structure, longitudinal section, ×75. **8**, transverse sections of distal corallites, ×10.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a legendary daughter, named Mana-hime. She enters a folk-tale of Fukui Prefecture.

Occurrence: Float block of greenish gray tuffaceous shale co-occurring with *Alveolites* sp. cf. *A. maillieuxi* Lecompte, 1933 in the Oboradani Valley.

Discussion: *Thamnoptychia mana* sp. nov., can be easily distinguished from the type species of the genus, *T. limbata* (Eaton, 1832, p.39, pl. 5, fig. 52; Hall, 1876, pl. 32, figs. 9–13; Ross, 1953, p. 85, 86, pl. 27. figs. 3–7 as *Trachypora romingeri* Ross, 1953; Hill, 1981, figs. 395-2a–c) from the Givetian strata of the Middle Devonian Hamilton Group, New York, primarily by its narrower peripheral zone (=peripheral stereozone) of the branches. Width of peripheral zone per branch diameter of *T. mana* sp. nov. is approximately 0.5, whereas the ratios range from 0.73 to 0.75 in *T. limbata*. *Thamnoptychia vermiculosa* (Lesueur, 1821, p. 293, pl. 17, figs. 20a–c; Stumm, 1964, p. 70, pl. 75, figs. 14–16, 18–20) from the Middle Devonian of New York, Ontario, Indiana and Kentucky, *T. dichoforma* (Wang, 1981, p. 50, pl. 27, figs. 3a, b) from the Upper Silurian of Xinjiang Uygur, Northwest China and *T. yanagidai* Niko (2009, p. 13, 14, pl. 2, figs. 1–6) from the Early Carboniferous of the Akiyoshi Limestone Group in Yamaguchi Prefecture, Southwest Japan also have the much wider peripheral zones than that of *T. mana*.

Family Parastriatoporidae Chudinova, 1959

Genus ***Parastriatopora*** Sokolov, 1949

Type species: *Parastriatopora rhizoides* Sokolov, 1949.

Parastriatopora innae Dubatolov, 1963

(Figs. 8-6, 9)

Parastriatopora innae Dubatolov; Niko, 2005, p. 26, 28, figs. 7-1–6; 8-1–6; Hirata, 2006, p. 20, pl. 4, figs. 14-1, 2.

Material examined: Ten coralla, HMM30589, NSM PA16654–16660, 16709,16710.

Occurrence: Float blocks of calcareous shale (HMM03589; NSM P16655,16656), argillaceous limestone (NSM PA16659, 16660) and black limestone (bioclastic wackestone; NSM PA16654) in the Kamaharadani Valley. Float blocks of black limestone (bioclastic wackestone; NSM PA16809, 16710) in the Oboradani Valley. Float blocks of black limestone (bioclastic wackestone; NSM PA16657, 16658) in the Oisedani Valley.

These specimens are derived from the Oisedani Member.

Remarks: Previous records of *Parastriatopora innae* are the Upper Silurian to Lower Devonian of the Kuznetsk Basin of southwestern Siberia (Dubatolov, 1963; Chudinova, 1964) and the lower part of the Takaharagawa Member.

Suborder Alveolitina Sokolov, 1950

Family Alveolitidae Duncan, 1872

Subfamily Alveolitinae Duncan, 1872

Genus ***Alveolites*** Lamarck, 1801

Type species: *Alveolites suborbicularis* Lamarck, 1801.

Alveolites sp. cf. ***A. maillieuxi*** Lecompte, 1933

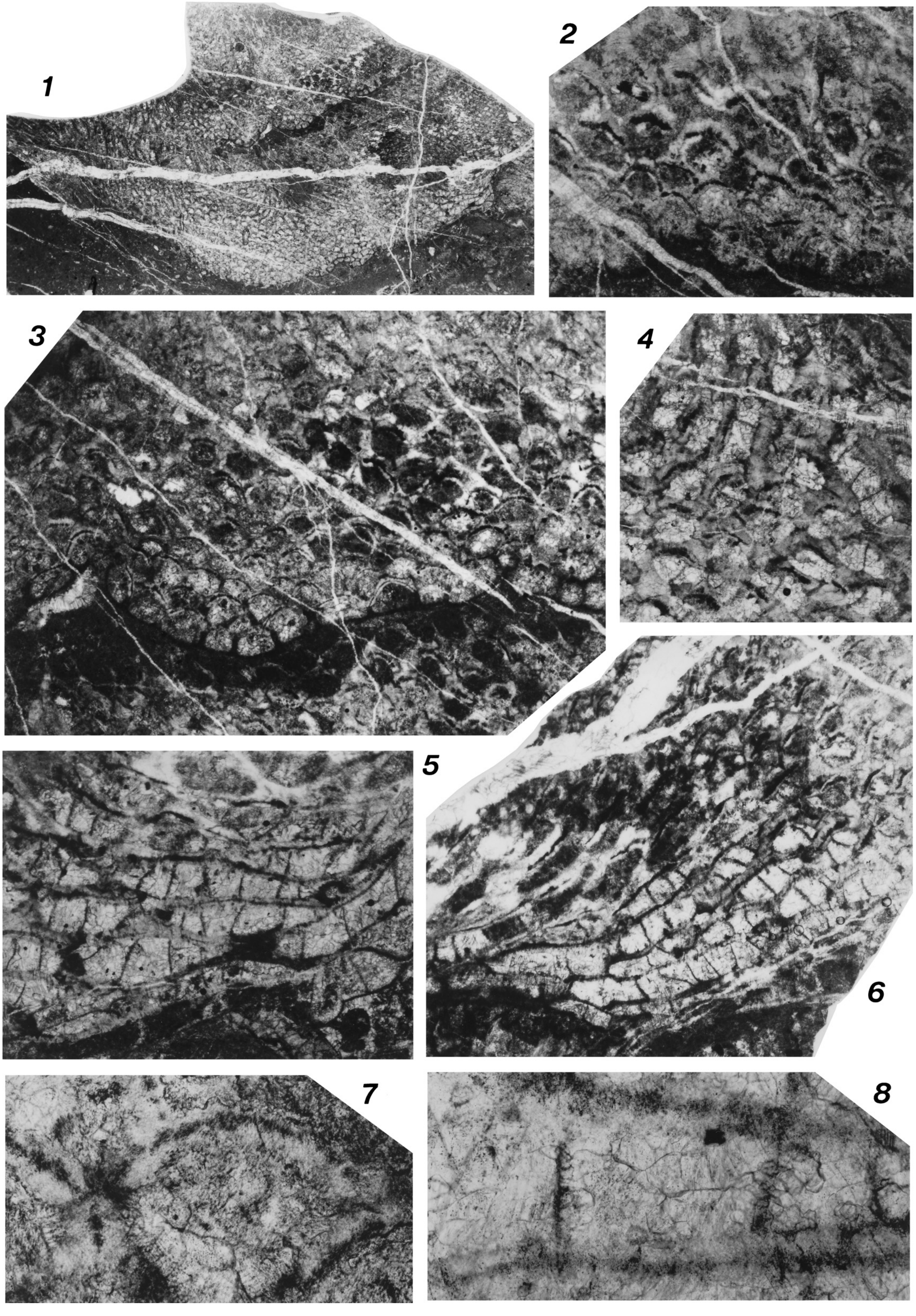
(Figs. 11-1–8)

Compare:

Alveolites maillieuxi Lecompte, 1933, p. 36–38, pl. 3, figs. 2, 3, 3a; Chernyshev, 1951, p. 56, 57, pl. 14, figs. 1–7; Zhang, 1981, p. 131, 132, pl. 44, figs. 2a, b.

Material examined: A single corallum, NSM PA16695.

Fig. 11. *Alveolites* sp. cf. *A. maillieuxi* Lecompte, 1933, NSM PA16695, thin sections. **1**, longitudinal section of corallum, ×2. **2**, transverse sections of proximal corallites, ×14. **3**, transverse sections of corallites, ×10. **4**, longitudinal to oblique sections of distal corallites, note thickened intercorallite walls, ×14. **5**, longitudinal to oblique sections of proximal corallites, ×14. **6**, longitudinal to oblique sections of corallites, ×10. **7**, partial enlargement to show intercorallite wall structure, transverse section, ×75. **8**, partial enlargement to show intercorallite wall structure, longitudinal section, ×75.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Description: Corallum encrusting, thick tabular in growth form with at least 200 mm in diameter and 135 mm in height, alveolitoid. Corallites reclined; except for most proximal corallites in basal portion of corallum, where they nearly horizontal, growth direction of corallites is obliquely upward with 26°–73° in angle to substratum; transverse sections of corallites are sub-trapezoidal to fan-shaped, rarely semicircular to semi-elliptical; corallite sizes range from 0.4 to 0.8 mm in width and 0.4 to 0.5 mm in height; form ratios (width/height) of corallites are 0.5–0.9; calices shallow; increase of new corallite is lateral, frequently occurs in basal portion of corallum. Intercorallite walls relatively thin in proximal corallites with 0.04–0.09 mm, then thickened attaining 0.21 mm in distal ones, differentiated into median dark line and stereoplasm of rect-radiate fibers; mural pore rare to uncommon, situate on narrow sides of corallite faces, probably circular in profile with approximately 0.15 mm in diameter; septal spines high conical, usually rare, but partly crowded, short; protruded portions of septal spines are 0.04–0.06 mm in length; tabulae well-developed, mostly complete, roughly rectangular, or oblique in rare cases, to corallite; there are 3–8 tabulae in 2.5 mm of corallite length.

Occurrence: From an identical block with *Thamnoptychia mana* sp. nov. (this report).

Discussion: The Kamianama specimen matches closely the original description of *Alveolites maillieuxi* from the Givetian (upper Middle Devonian) of Ardenne, Belgium. Because of the only obtained corallum is not well preserved, it being left under open nomenclature. *Alveolites maillieuxi* is also known to occur from the Middle Devonian of the Kuznetsk Basin of southwestern Siberia and Kazakhstan (Chernyshev, 1951) and Gansu Province of North China (Zhang, 1981).

Family Coenitidae Sardeson, 1896

Genus ***Coenites*** Eichwald, 1829

Type species: *Coenites juniperinus* Eichwald, 1829.

Coenites kameii sp. nov.

(Figs. 12-1–12)

Gertholites? sp., Tsukada, 2005, p. 86, pl. 17, figs. 9, 10.

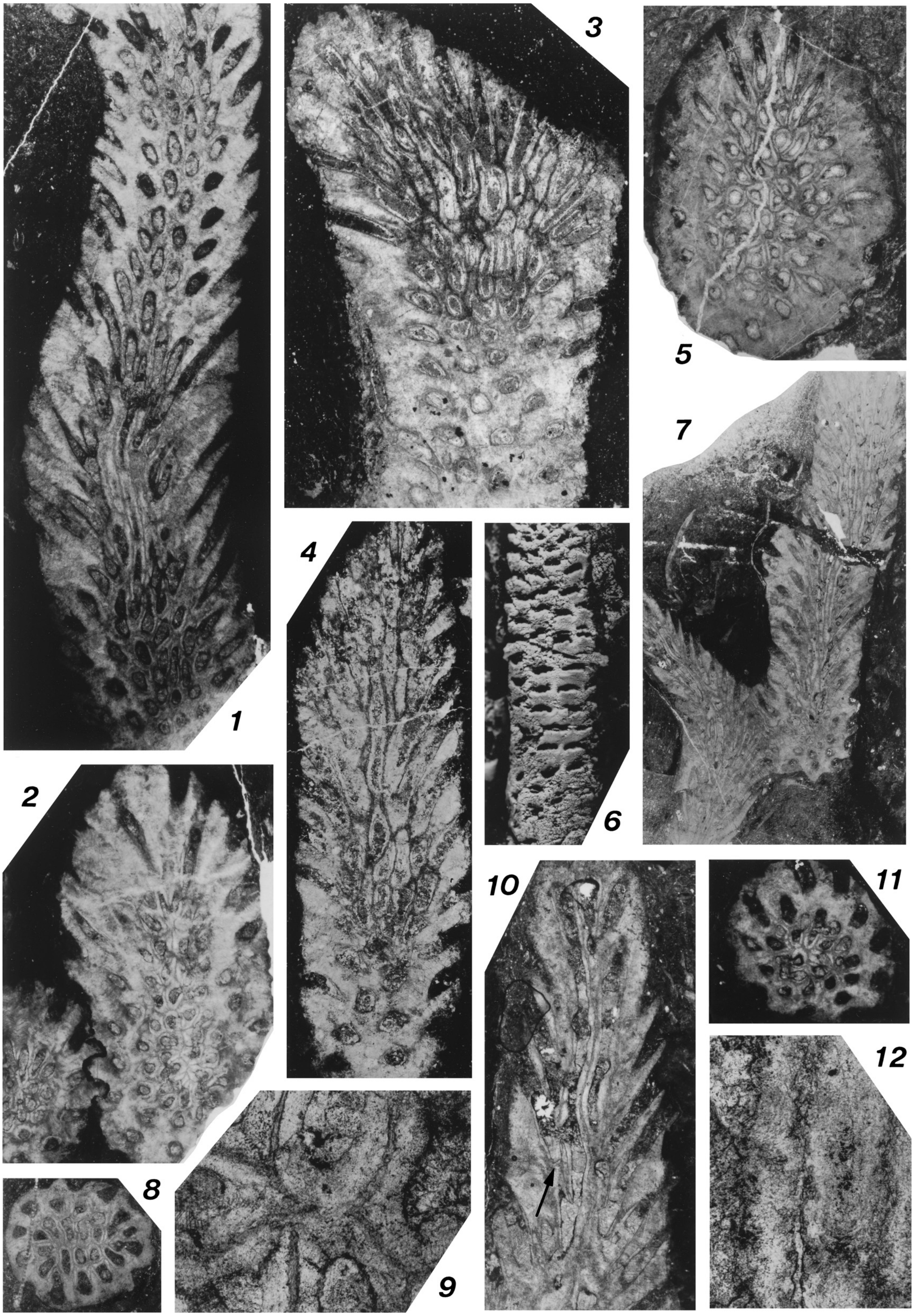
Striatopora takayamaensis Niko; Hirata, 2006, p. 20, pl. 4, figs. 12-1, 2.

Holotype: NSM PA16572, from which two thin sections were made.

Other specimens: Twenty thin sections and a weathered piece were studied from the nine paratypes, NSM PA16401, 16571, 16573–16575, 16584, 16588, 16590, 16606. In addition, thirty-three specimens, NSM PA16576–16583, 16585–16587, 16589, 16591–16605, 16607–16611, 16685, were also examined.

Diagnosis: Species of *Coenites* with relatively slender branches, usually 2.6–3.7 mm in diameter; anastomoses of branches are rare; calices oblique with 21°–60° in opening angle; apertures of calical pits are crescentic or waved slit-like, horizontally oriented, having 0.6–0.8 mm in width and 0.2–0.3 mm in height; Intercorallite wall thickness attains 0.41 mm in peripheral stereozone; peripheral zone of branch (=peripheral stereozone) per branch diameter ratios approximately 0.5–0.8; mural pores common, but

Fig. 12. *Coenites kameii* sp. nov. **1**, **2**, **9**, **12**, holotype, NSM PA16572, thin sections. **1**, longitudinal to slightly oblique section of branch, ×10. **2**, oblique sections of branches, ×10. **9**, partial enlargement to show intercorallite wall structure, transverse section, ×75. **12**, partial enlargement to show intercorallite wall structure, longitudinal section, ×75. **3**, paratype, NSM PA16588, oblique thin section of branch, ×10. **4**, paratype, NSM PA16575, longitudinal thin section of branch, ×10. **5**, paratype, NSM PA16606, transverse thin section of branch, ×10. **6**, paratype, NSM PA16401, external view of branch on a weathered piece, ×5. **7**, **10**, paratype, NSM PA16590, thin sections. **7**, longitudinal section of corallum, note anastomosed branches, ×5. **10**, longitudinal section of branch, arrow indicates tabula, ×10. **8**, **11**, paratype, NSM PA16571, transverse sections of branches, ×10.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restricted in axial zone of branch; tabulae rare, nearly flat.

Description: Coralla ramose composed of cylindrical to subcylindrical branches, cerioid-like in axial zone and alveolitoid in peripheral zone of branch; adjoining branches rarely anastomosed; diameters of branches relatively slender for the genus, range from 2.1 to 5.6 mm, usually 2.6–3.7 mm; branching frequent, bifurcate; total corallum diameter and growth form unknown owing to fragile nature. Corallites slender for the order but moderate for the genus; each corallite consists of longitudinally directed proximal portion forming axial zone of branch and outwardly directed distal portion forming peripheral zone of branch; transverse sections of corallites are indistinct polygonal in axial zone, then they may shift to elliptical profiles having longitudinal depression near branch surface; diameters of polygonal corallites are 0.17–0.29 mm; there are 31–96 corallites in transverse section of branch; increase of new corallite is lateral, uncommonly occurs in axial zone; calices deep, to open oblique upward with 21°–60° in angle to branch surface; apertures of calical pits are crescentic with arched upper margin or waved slit-like with folded (usually two) upper margin, they are horizontally oriented; lower margins of apertures are nearly straight to weakly folded; sizes of apertures are 0.6–0.8 mm in width and 0.2–0.3 mm in height; form ratios (height/width) of apertures range from 0.3 to 0.4. Intercorallite walls differentiated into median dark line and stereoplasm in proximal corallites, but this differentiation becomes obsolescent by disappearing median dark line in distal corallites, where thickness of intercorallite walls abruptly increased as peripheral stereozone, thus profiles of corallites become obscure; thickness of intercorallite walls is 0.06–0.15 mm in proximal corallites and attains 0.41 mm in peripheral stereozone; ratios of peripheral zone (=peripheral stereozone) per branch diameter are approximately 0.5–0.8; mural pores common, but restricted in axial zone; they occur on corallite face as mid-wall pores, large, elliptical with longitudinal elongation, 0.11×0.17 mm in diameter of typical one; no apparent septal spine recognized; tabulae rare, complete, nearly flat.

Etymology: The specific name honors Dr. Tadao Kamei, who first documented the Devonian (as Gotlandian) rocks of the present Kuzuryu Lake–Ise River area in Ishioka and Kamei (1950).

Occurrence: Calcareous shale (NSM PA16401, 16571–16573, 16577, 16580, 16589–16595) and argillaceous limestone (NSM PA16576, 16578, 16579) at locality KU-1. Black limestone (bioclastic wackestone; NSM PA16685) at locality KU-6. Float blocks of argillaceous limestone (NSM PA16574, 16575, 16581, 16588, 16588) and black limestone (bioclastic wackestone; NSM PA16582–16587) in the Kamaharadani Valley. Float blocks of calcareous shale (NSM PA16604), argillaceous limestone (NSM PA16596, 16599, 16602, 16603), black limestone (bioclastic wackestone; NSM PA16597, 16600, 16601) and dark gray limestone (bioclastic wackestone; NSM PA16598) in the Oboradani Valley. Float blocks of black limestone (bioclastic wackestone; NSM PA16609–16611) in the Oisedani Valley. Float blocks of argillaceous limestone (NSM PA16605–16608) in the Tanobora Valley.

These specimens are derived from the Oisedani Member.

Discussion: Although the overall shapes of the corallites of *Coenites kameii* sp. nov. and *C. tenella* Gürich (1896, p. 146, pl. 5, figs. 9a–c) are similar, the latter can be separated from the new species by its slightly smaller diameter of the branches (1.5–3.0 mm *versus* usually 2.6–3.7 mm in *C. kameii*) and more numerous mural pores. *Coenites tenella* is based on specimens from the Givetian of Poland and also recoded from the Eifelian (lower Middle Devonian) to Givetian in the Kuznetsk Basin, southwestern Siberia (Chernyshev, 1951; Dubatolov, 1963) and the Lower to Middle Devonian in Da Xinggan Ling (Da Hinggan Ling), Northeast China (Dubatolov *et al*., 1959). An Early Devonian species, *C. anastomosus* Mironova (1974, p. 97, 98, pl. 51, fig. 1) from Altai, southwestern Siberia differs from *C. kameii* by having frequent anastomoses of the branches. *Coenites fukujiensis* Niko (2003, p. 19, 21, figs. 1-1–4; 2-1–4), occurs from the Late Silurian (probably late Ludlow) Hitoegane Formation in the Hitoegane area, Gifu Prefecture (Niko, 2004), can be readily distinguished from *C. kameii* by its larger branch diameters (usually 3.6–5.2 mm) and strong sinuations of the intercorallite walls. The originally designated type stratum of *C. fukujiensis* by Niko (2003) as "probably derived from the Early Devonian Fukuji Formation" is questionable.

Based on the specimens from the Takaharagawa Member of the Fukuji Formation, this species was erroneously described as *Gertholites*? sp. indet. by Tsukada (2005) or *Striatopora takayamaensis* by Hirata (2006).

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