Early Carboniferous tabulate corals from the *Endothyra* Zone of the Omi Limestone, Niigata Prefecture, central Japan

Shuji NIKO, Yousuke IBARAKI and Jun-ichi TAZAWA

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Abstract

Four species of tabulate corals were found from impure limestone, which characteristically contains lithoclasts of basaltic rocks, occurring within the late Visean (middle Early Carboniferous) *Endothyra* Zone of the Omi Limestone near Fukugakuchi Cave in the Omi area, Niigata Prefecture, central Japan. They include *Acaciapora* sp. indet., *Sinkiangopora*? sp. indet., *Mandulapora*? sp. indet., and *Multithecopora fukugakuchiensis* sp. nov. A possible phylogenetic relationship between the new species and *Multithecopora hiratai* Niko, 2006, from the Akiyoshi Limestone Group is recognized. Previously, the genera, *Acaciapora* and *Multithecopora*, were not recorded from the Omi Limestone.

Kew words: *Acaciapora, Mandulapora, Multithecopora fukugakuchiensis* sp. nov., *Sinkiangopora*, Tabulata, Visean.

Introduction

Following our previous paper, Niko et al. (2010), this concerns additional four species of tabulate corals from the late Visean (middle Early Carboniferous) *Endothyra* Zone (Tazawa et al., 2002) of the Omi Limestone. Specimens examined in this study were collected from locality E4 near Fukugakuchi Cave in the Omi area, Itoigawa, Niigata Prefecture, central Japan (Fig. 1). Lithofacies of this locality is reddish to brownish impure limestone that characteristically contains lithoclasts of basaltic rocks and is generally brecciated. Repository of the present material is the Fossa Magna Museum, under the catalog numbers FMM2041－2065.

* Department of Environmental Studies, Faculty of Integrated Arts and Sciences, Hiroshima University, Hiroshima 739-8521, Japan
** Fossa Magna Museum, Ichinomiya 1313, Itoigawa 941-0056, Japan
*** Hamaura-cho 1-260-1, Chuo-ku, Niigata 951-8151, Japan
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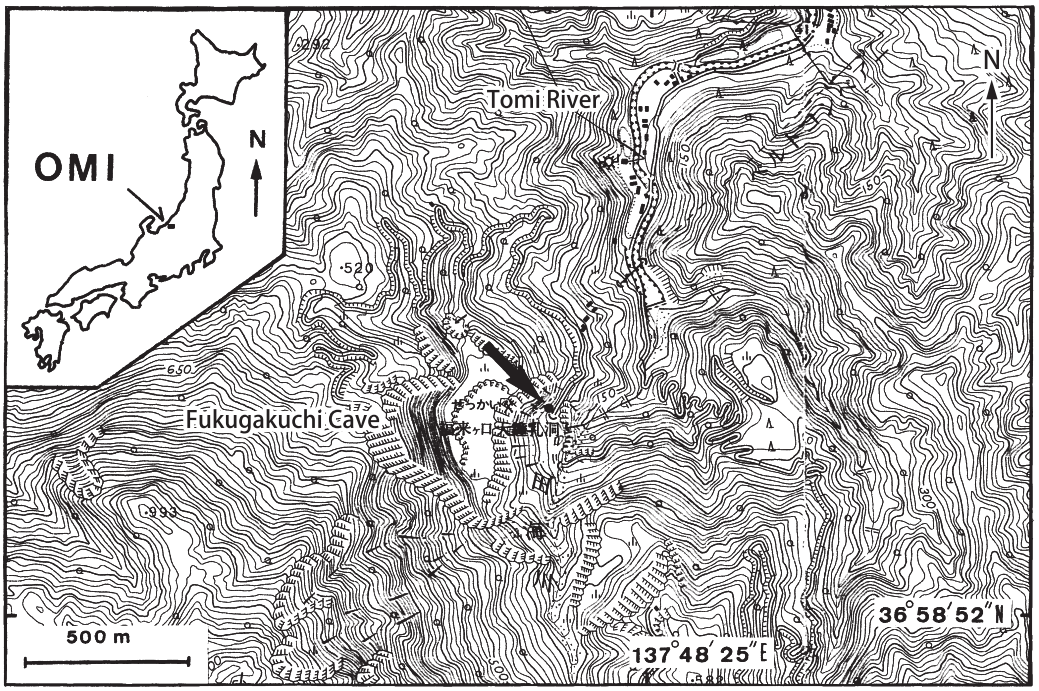

Fig. 1. Index map showing the fossil locality (arrow; loc. E4) in the Omi area, Niigata Prefecture on the topographical map of "Kotaki" scale 1:25,000 published by the Geospatial Information Authority of Japan.

Systematic Paleontology

Subclass Tabulata Milne-Edwards and Haime, 1850

Order Favositida Wedekind, 1937

Suborder Favositina Wedekind, 1937

Superfamily Pachyporoidea Gerth, 1921

Family Pachyporidae Gerth, 1921

Genus *Acaciapora* Moore and Jeffords, 1945

Type species.—*Michelinia subcylindrica* Mather, 1915.

Acaciapora sp. indet.

Figs. 2-1, 2

Material.—FMM2041 – 2043.

Description.—Three fragmentary branches indicating cylindrical outlines are available for study; their diameters exceptionally small, 2.4 – 2.9 mm; there are 8 – 10 corallites in transverse sections. Corallites subprismatic to nearly cylindrical in parts, gradually

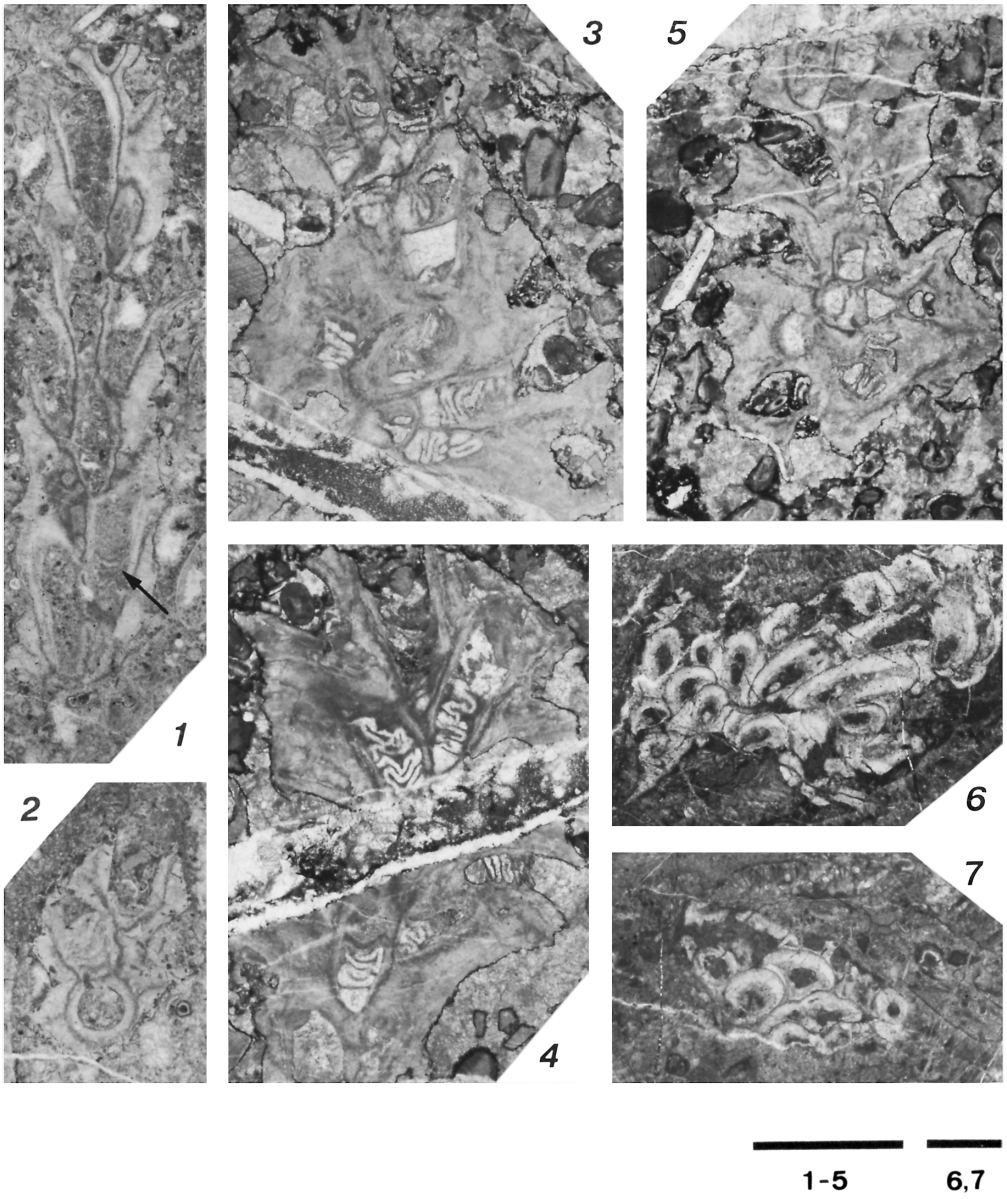

Fig. 2. 1, 2: *Acaciapora* sp. indet., thin sections. **1**, FMM2041, longitudinal section of branch, arrow indicates squamula, **2**, FMM2042, oblique (near transverse) section of branch. **3–5**: *Sinkiangopora*? sp. indet., thin sections, FMM2044, oblique sections of branch. **6, 7**: *Mandulapora*? sp. indet., thin sections, FMM2045, longitudinal sections of corallum. Scale bars = 2 mm.

divergent, and cerioid in arrangement; approximate diameters of corallites are 0.6–1.2 mm; calices strongly oblique. Intercorallite walls thickened, attaining 0.44 mm in peripheral zone of branch; mural pores occur on corallite faces; squamulae uncommon, relatively wide;

profiles of squamulae indicate weak proximal concavities; no apparent septal spine and tabula are recognized.

Discussion.—This species is attributed to *Acaciapora* based on its slender branches consisting of a small number of corallite counts in transverse sections and the presence of the squamulae. *Acaciapora* sp. indet. represents the first record of the genus from the Omi Limestone.

Acaciapora kanmerai Niko (2011, p. 10, 11, pl. 1, figs. 1 – 7) from the transitional facies (Early Carboniferous; probably late Tournaisian) of the lowest pyroclastic and the main limestone units in the Akiyoshi Limestone Group, Yamaguchi Prefecture is sufficiently similar to the present Omi species except for differences of corallum and corallite diameters. Although there is a possibility that the both species represent different growth stages of an identical taxon, the material is not enough to solve the problem.

Genus *Sinkiangopora* Chi, 1961

Type species.—*Sinkiangopora sinkiangensis* Chi, 1961.

Sinkiangopora? sp. indet.

Figs. 2-3 – 5

Material.—FMM2044.

Remarks.—A single specimen is present, which probably represents a fragment of the cylindrical(?) branch. Accurate corallite shape is not clear due to its insufficient preservation and poor orientation of examined thin sections. The questionable assignment to *Sinkiangopora* is based upon the possession of the strongly thickened intercorallite walls, the well-developed squamulae, and the complete tabulae.

Order Auloporida Sokolov, 1947

Superfamily Syringoporoidea Fromentel, 1861

Family Periphaceloporidae Hill, 1981

Genus *Mandulapora* Ding *in* Ding et al., 1984

Type species.—*Mandulapora permica* Ding *in* Ding et al., 1984.

Mandulapora? sp. indet.

Figs. 2-6, 7

Material.—FMM2045.

Remarks.—This species is represented by a single fragmentary specimen. Its adherent nature of the corallum and alveolitoid-like corallites suggest a relationship with *Mandulapora*, but available material is too limited to the generic identification.

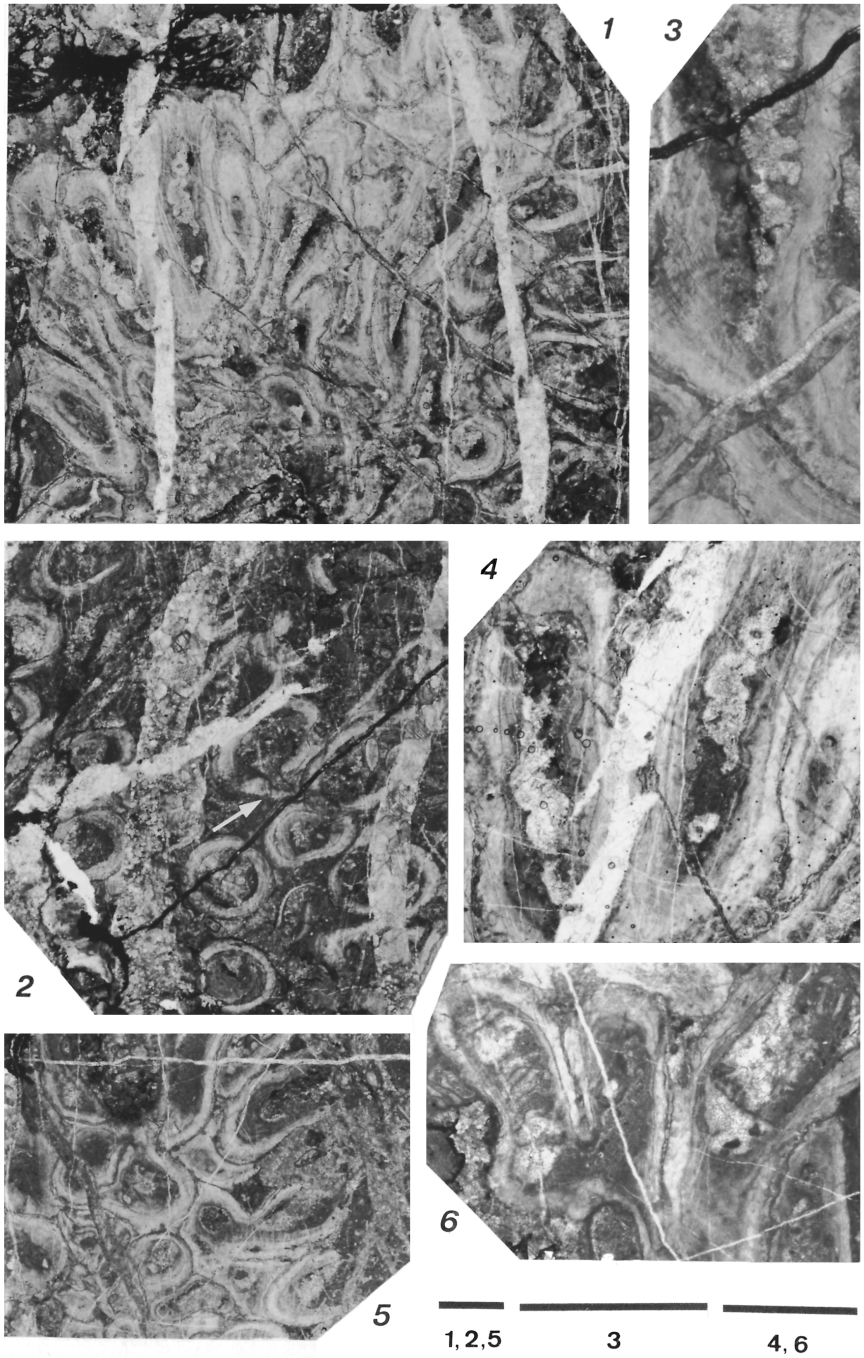

Fig. 3. *Multithecopora fukugakuchiensis* sp. nov., thin sections. **1 – 4**: holotype, FMM2061. **1,** longitudinal section of corallum, **2**, transverse section of corallum, arrow indicates connecting process, **3**, partial enlargement to show intercorallite wall structure and details of septal spines, longitudinal section, **4**, partial enlargement of Fig. 3-1, showing thickened intercorallite walls and well-developed septal spines. **5, 6**: paratype, FMM2063. **5**, transverse section of corallum, **6**, partial enlargement to show details of connecting process and tabulae. Scale bars = 2 mm.

Family Multithecoporidae Sokolov, 1950

Genus *Multithecopora* Yoh, 1927

Type species.—*Multithecopora penchiensis* Yoh, 1927.

Multithecopora fukugakuchiensis sp. nov.

Figs. 3-1 – 6

[?] *Pseudoromingeria kotoi* (Yabe and Hayasaka); Yoshida et al., 1987, p. 229 (listed without illustration and description).

Etymology.—The specific name is derived from a famous limestone cave, named Fukugakuchi, near the type locality.

Material.—Holotype, FMM2061, from which two thin sections were prepared. Thirteen thin sections were studied from the three paratypes, FMM2052, 2063, 2065. In addition, 16 fragmentary and poorly preserved specimens, FMM2046 – 2051, 2053 – 2060, 2062, 2064, were also examined.

Diagnosis.—Species of *Multithecopora* with phacelo-cerioid coralla and approximately 2.0 mm in diameter of adult corallites; usual corallite walls have 0.27 – 0.79 mm in thickness in phaceloid portion; septal spines common to well-developed; tabulae occurrence variable, almost absent to crowded; complete tabulae most common.

Description.—Coralla have somewhat variable growth forms indicating nodular, domical to turf-like, whose approximate measurements are 51 mm in diameter and 15 mm in height in the holotype and 25 mm in diameter and 7 mm in height in the largest paratype (FMM2065); contiguous corallites frequently occur to form phacelo-cerioid colonies. Corallites prostrate in basal portion of corallum, then they turn upward in growth direction; transverse sections of corallites are circular in phaceloid or subtrapezoidal, fan-shaped to indistinct polygonal in cerioid portions; corallite diameters 1.03 – 2.51 mm, with 2.0 mm mean in adult ones; calices faintly inflated in their rims with very deep calical pits; increase of new corallite is probably bifurcate; connecting processes very rare, relatively thick in diameter with approximately 0.6 – 0.9 mm; length of processes are variable, ranging approximately 0.1 – 0.5 mm; diameters of connecting canals are 0.13 – 0.36 mm. Corallite walls composed of thin epitheca and inner layer of stereoplasm in phaceloid and median dark line (fused epitheca) and stereoplasm on its each side in cerioid portions; in addition, stereoplasm differentiated inner darker and outer more transparent layers; microstructure of stereoplasmic layers is lamellar; tabularia (lumina) narrowed by thickening of stereoplasm; wall thicknesses usually range 0.27 – 0.79 mm in phaceloid and attain 1.00 mm as intercorallite wall in cerioid portions; septal spines common to well-developed having thick rod- to needle-like shapes of protrude portions into tabularium, 0.15 – 0.25 mm in length; tabulae variable in mode of occurrence, almost absent to crowded, commonly complete with nearly flat to weakly sagging (concave proximally) profiles.

Discussion.—The new species records the first occurrence of *Multithecopora* from the Omi Limestone. The other named species of the genus from Japan, *M. hiratai* Niko (2006, p. 2, 3, pl. 1, figs. 1 − 5) from the Akiyoshi Limestone Group, Yamaguchi Prefecture and *M. yabei* Niko (1998, p. 124, 126, figs. 3 A, 7G, 8 A − D) from the Ichinotani Formation, Gifu Prefecture, have less developed cerioid portions than does *M. fukugakuchiensis* sp. nov. Among the previously known two species, the Early Carboniferous (late Tournaisian) species, *M. hiratai*, indicates a possible phylogenetic relationship with *M. fukugakuchiensis* because of its corallite diameters (approximately 1.9 mm) and wall thickness (0.10 − 0.73 mm) are nearly identical with measurements of *M. fukugakuchiensis*. The mode of occurrence and shape of the septal spines of *M. hiratai* are also similar to those of the new species.

Locality of *Pseudoromingeria kotoi* in the Yoshida et al. (1987)'s list situates stratigarphically a few meters above of the present locality E4 and also belongs to the *Endothyra* Zone (Yoshida and Okimura, 1992). They were unaware of the living period of this aulocystid species whose types were described from the Capitanian (late Middle Permian) strata of the Akasaka Limestone, Gifu Prefecture (Yabe and Hayasaka, 1915; Niko, 2009). Because gross corallite and corallum morphologies in *Pseudoromingeria* and *Multithecopora* show some similarities, there is a possibility that *P. kotoi* in the Omi Limestone was a misidentification for *M. fukugakuchiensis*.

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