Bull. Natl. Mus. Nat. Sci., Ser. C, 45, pp. 13–18, December 27, 2019

Middle Devonian tabulate corals from the Kamiarisu Formation, Iwate Prefecture, Japan

Shuji Niko

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

Abstract A coral fauna was discovered from the lowest part of the Kamiarisu Formation in Iwate prefecture, Northeast Japan. Among the faunal constituents, two species of pachyporid tabulate corals, *Gracilopora*? sp. indet. and *Thamnopora sumitaensis* sp. nov., are described herein. The new species is diagnosed by its relatively slender corallites, abundant mural pores, well-developed septal spines in peripheral stereozone, and commonly developed tabulae. On the basis of similarities between the species and such previously known taxa as *Thamnopora itoae* Niko, Ibaraki and Tazawa, 2014, *T. nicholsoni* (Frech, 1885), and *T. siavis* Dubatolov in Dubatolov *et al.*, 1959, the fauna is considered to be of Middle Devonian (probably Givetian) age. Co-occurrence of *Gracilopora*? sp. indet. will not contradict this conclusion. Although the Kamiarisu Formation has been assigned to the Silurian, its age should be changed upwardly by this new finding.

Key words: pachyporid tabulate corals, *Gracilopora*, *Thamnopora*, Givetian, Southern Kitakami Belt, Northeast Japan

Introduction

During the field work in May, 2017, an abundant coral fauna was discovered from the Kamiarisu Formation (Tazawa *et al.*, 1984) belonging within the Southern Kitakami Belt, Northeast Japan. This discovery represents the first record of fossil corals from the formation. Among the constituents of this fauna, the present paper focuses on relatively well-preserved tabulate corals and discusses their stratigraphic significance. Two localities from which the material was taken are in the Kamiarisu area of Sumita-cho, Kesen-gun, Iwate Prefecture (Figure 1). Locality 1 occurs at latitude 39°15′9″N and longitude 141°41′43″E, where a forest road cuts fossiliferous shale. Except for tabulates, fossils in this outcrop are rugose corals, brachiopods, and bryozoans. Locality 2 occurs at latitude 39°15′17″N and longitude 141°41′44″E, where shale and intercalates of thin sandstone layers are exposed on stream bank near the junction of the Tuchikura-zawa and Kannozawa Valleys. The both rocks of Locality 2 yielded rich fossils including brachiopods, bryozoans and crinoids, but tabulates ware obtained only from sandstone. Rugose corals were not detected in this locality. Judging from north-south to N 5°E strikes with nearly vertical dips of the shales and the absence of disturbed stratification by fault between locality 1 and 2, these two localities probably situate the same stratigraphic horizon that represents the lowest part of the Kamiarisu Formation (Figure 2).

All specimens examined in this study are prefixed NSMS and housed in National Museum of Nature and Science, Tokyo.

Systematic Paleontology

Subclass Tabulata Milne-Edwards and Haime, 1850

Order Favositida Wedekind, 1937

Suborder Favositina Wedekind, 1937

Superfamily Pachyporidae Gerth, 1921

Family Pachyporidae Gerth, 1921

Genus ***Gracilopora*** Chudinova, 1964

Type species: *Gracilopora acuta* Chudinova, 1964.

Gracilopora? sp. indet.

(Figs. 3-A, B)

Material examined: NMNS PA18684.

Description: A single internal mold was available for study; it is ramose corallum formed by cylindri-

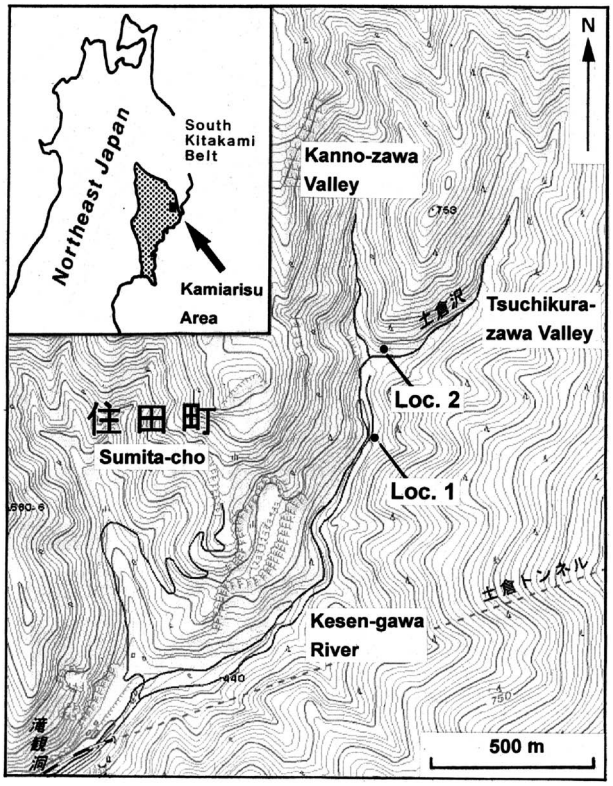


Fig. 1. Index map showing fossil localities in the Kamiarisu area, Sumita-cho, Iwate prefecture, Northeast Japan, on the "Digital Japan Basic Map" published by Geospatial Information Authority of Japan.

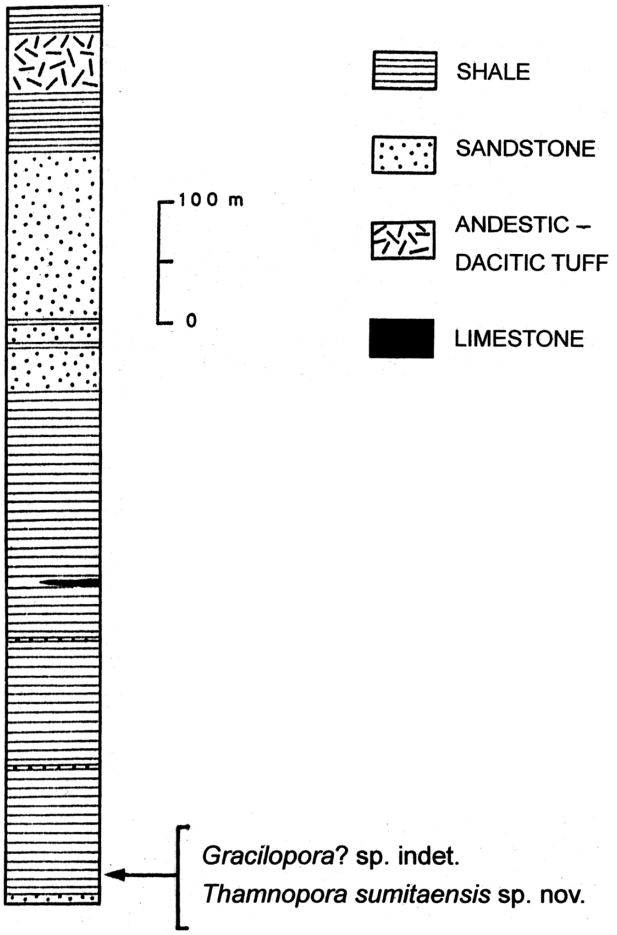


Fig. 2. Stratigraphic column of the Kamiarisu Formation (alter Tazawa *et al.*, 1984) showing position of the present tabulate corals.

cal branches; branching frequent and probably bifurcate; branches slender, approximately 2–3 mm in diameter, and composed by numerous and gradually inflated corallites; diameters of corallites are very small, up to 0.5 mm; each corallite differentiated into proximal narrowly divergent portion and distal outwardly curved one; calical opening is perpendicular to branch surface.

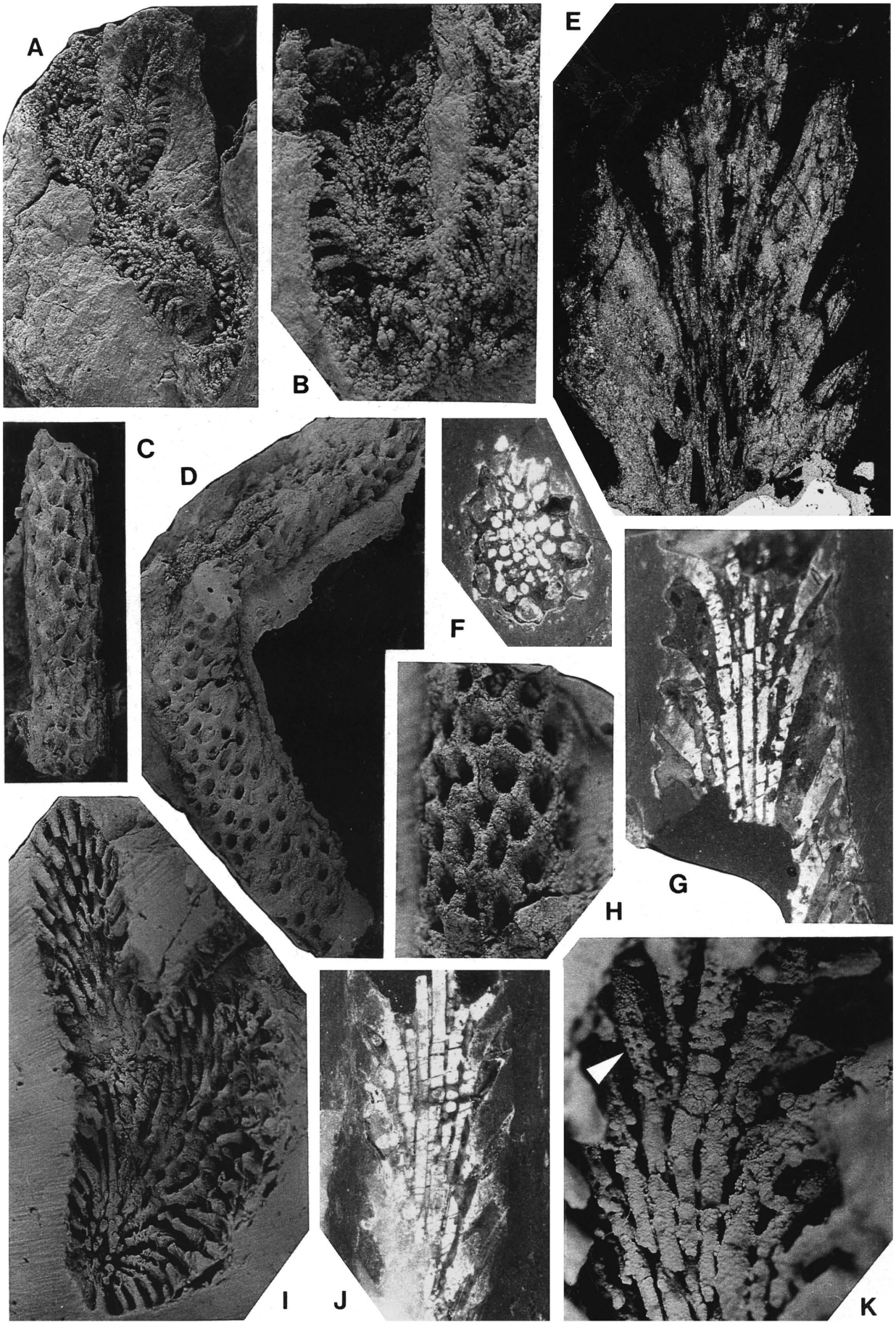
Occurrence: Locality 1.

Discussion: The present corallum is tentatively placed in *Gracilopora* on the basis of the possessions of slender branches composed by numerous corallites having very small diameters. Its corallite morphology also is suggestive of *Egosiella* Dubatolov in Sokolov, 1955, but the Kamiarisu specimen does not show anastomoses of adjoining branches that are the most diagnostic features of the latter genus.

Genus ***Thamnopora*** Steininger, 1831

Type species: *Thamnopora madreporacea* Steininger, 1831.

Fig. 3. **A**, **B**, *Gracilopora*? sp. indet., NMNS PA18684. **A**, weathered surface, showing longitudinal section of branches, ×5. **B**, partial enlargements of Fig. 3-A, ×10. **C–K**, *Thamnopora sumitaensis* sp. nov. **C**, paratype, NMNS PA18649, external view of branch, silicon rubber replica, ×2. **D**, paratype, NMNS PA18653, external views of branches, silicon rubber replica, ×2. **E**, paratype, NMNS PA18655, longitudinal thin section, ×10. **F**, **G**, holotype, NMNS PA18654. **F**, transverse polished section, ×5. **G**, longitudinal polished section, ×5. **H**, **I**, paratype, NMNS PA18650. **H**, external view of branch, silicon rubber replica, ×5. **I**, weathered surface, showing longitudinal and oblique sections of branches, ×2.5. **J**, paratype, NMNS PA18660, longitudinal polished section, ×5. **K**, paratype, NMNS PA18652, weathered surface, showing longitudinal sections of corallites, arrow indicates vestiges of septal spines, ×10.


A
B
E
C
D
F
G
H
I
J
K

Thamnopora sumitaensis sp. nov.

(Figs. 3-C–K)

Material examined: Holotype, NMNS PA18654. Paratypes, NMNS PA18649–18653, 18655–18663. In addition, 20 specimens, NMNS PA18664–18683, were also assigned to this species.

Diagnosis: Species of *Thamnopora* with 5–12 mm in usual diameters of branches and relatively slender corallites having diameters of 0.2–2.1 mm; intercorallite walls attain approximately 0.8 mm in thickness; mural pores abundant; short conical septal spines well-developed in peripheral stereozone; tabulae common.

Description: Coralla ramose with cylindrical to rarely foliose branches, cerioid; branching common, bifurcate or trifurcate; diameters of branches are relatively slender for the genus, 5–12 mm in cylindrical one; corallum diameter and growth form are unknown owing to fragile nature. Corallites prismatic, mostly 4–6 sided; there are approximately 50–70 corallites in transverse section of branch; each corallites differentiated into proximal portion that runs nearly parallel with branch axis and outwardly curved distal one; inflation of corallite is gradual in proximal and relatively rapid in distal portions; diameters of corallites 0.2–2.1 mm, with 1.7 mm mean at calical rim; calices open obliquely upward with approximately 40°–75° in angle for branch surface; calical pits very deep; lateral increases of new corallites frequently occur in axial zone of branch. Intercorallite walls weakly thickened, 0.13–0.21 mm in axial zone, then they increase in thickness up to approximately 0.8 mm and form indistinct peripheral stereozone; walls consist of median dark line and stereoplasm; microstructure of stereoplasm is not preserved; tabularia (lumina) subcylindrical; mural pores abundant on corallite faces, subcircular in profile, approximately 0.1–0.2 mm in diameter; septal spines common in axial zone and well-developed in peripheral stereozone, short conical; tabulae common, complete.

Occurrence: Localities 1 (NMNS PA18649–18682) and 2 (NMNS PA18683).

Etymology: The specific name is derived from Sumita-cho. The type locality of the new species belongs to this town.

Discussion. The above description is based on the type series consisting of fifteen specimens. Except for a paratype (NMNS PA18655, Fig. 3-E), skeletons of these specimens are dissolved and their internal structures are preserved as "steinkern". Accordingly, darker parts in branches of the holotype (Figs. 3-F, G) and a paratype (NMNS PA18660, Fig. 3-J) are acrylic resins injected into traces of intercorallite walls and tabulae.

The most closely related species to *Thamnopora sumitaensis* sp. nov. is *T. itoae* Niko, Ibaraki and Tazawa (2014, pp. 61, 63, figs. 2-1–3, 4-1–6). They show the similarities in the measurements of branch diameters, intercorallite wall thickness, the mode of occurrence of mural pores, and the possession of well-developed septal spines at their peripheral zones. The principal differences between the two species are slightly smaller corallite diameters (approximately 1.4 mm in distal parts) and somewhat fewer development of tabulae in *T. itoae*. The new species rather closely resembles *T. nicholsoni* (Frech, 1885, pp. 104, 105) and *T. siavis* Dubatolov in Dubatolov *et al.* (1959, pp. 22, 23, pl. 7, figs. 2a–e), but it differs from the latter two species principally in having well-developed septal spines.

Significance

Although *Thamnopora* ranges from Silurian to Devonian, most species of the genus have been recorded from Devonian strata (Hill, 1981; May, 1997). Exceptional late Silurian species, such as *T. senzaii* Niko, 2003, and *T. suberidaniensis* Niko, 2003, possess slender branches, small diameters of corallites and thin intercorallite walls, whose primitive characters are not recognized in *T. sumitaensis* sp. nov. from the Kamiarisu Formation. The new species is closely related with *T. itoae*, *T. nicholsoni*, and *T. siavis*. The stratigraphic position of *T. itoae* is unclear per se, because the species occurs from limestone pebbles belonging to Mesozoic conglomerate. However, some index species, such as *Thamnoptychia mana* Niko and Senzai, 2010, and *Heliolites porosus* (Goldfuss, 1826), associated with *T. itoae* warrant its Givetian (late Middle Devonian) age (Niko *et al.*, 2014, 2015, 2016, 2019). *Thamnopora nicholsoni* has been reported widely from Givetian strata of Germany, Novaya Zemlya, Ukraine, Morocco, the Kuznetsk Basin, southwest

Siberia, South China, and the Kuzuryu Lake-Ise River area of central Japan (Niko and Senzai, 2011). *Thamnopora siavis* is a rare species and restricted to the Eifelian (early Middle Devonian) of the Wunuerh Formation in Da Xinggan Ling (Da Hinggan-ling), Inner Mongolia (Lin *et al.*, 1988). These facts are clearly indicative of a Middle Devonian age for the fauna. Furthermore, it is a probable Givetian as a more refined age determination. Because *Gracilopora* is known from Lower to Middle Devonian rocks (Hill, 1981), co-occurrence of *G.*? sp. indet. will not contradict this conclusion.

The Kamiarisu Formation was proposed by Tazawa *et al.* (1984) for the thick (more than 700 m) stratum consisting mainly of shale, sandstone and andesitic to dacitic tuff with minor amount of limestone (Figure 2). It is exposed in a north-south trending narrow area (15 km × 0.2–2.0 km) of Sumita-cho, in which a drainage basin of the Tuchikura-zawa to Kanno-zawa Valleys is the type locality. In advance of a new stratigraphic name, Tazawa *et al.* (1984) thought this formation is the Silurian on the basis of the occurrence of a brachiopod *Pentamerus* sp., from the lowest shale bed at locality 2 in this paper, but Kaneko and Kawamura (1989) reported Devonian-type trilobites from the Matsugara-zawa Valley (a small tributary of the Tuchikura-zawa Valley) and doubted the original age determination. Taking into consideration 1) age and stratigraphic horizon of the present tabulate corals, 2) presence of Devonian species in *Pentamerus* (e.g., Vai, 1967; Mottequin, 2019), 3) age of the above-mentioned trilobites, 4) abundant occurrence of terrestrial plant fossils (Kaneko and Kawamura, 1989) and 5) thickness, it can be concluded that the lowest Kamiarisu Formation is Middle Devonian (probably Givetian) in age and the more upper parts possibly extend to Late Devonian. It is thought that the Kamiarisu Formation corresponds to the Sunagohata Member of the Senjyogataki Formation (Osawa, 1983; Okami *et al.*, 1987) in the adjoining Kamaishi area. Synchronous deposits with the formation may also develop in the upper Nakazato Formation (Yabe and Sugiyama, 1937; Chen and Tazawa, 2003; the Hikoroichi area), the lower Tobigamori Formation (Noda, 1934; Onuki, 1956; Ehiro and Takaizumi, 1992; the Nagasaka area) and the lower Choanji Formation (Yabe and Sugiyama, 1937; Tazawa and Niikawa, 2018; Tazawa, 2018; the Hikoroichi area) in the Southern Kitakami Belt.

Acknowledgements

I am grateful to Dr. Masayuki Ehiro and Mr. Atsushi Kaneko for sharing their knowledge of fossil localities in the Kamiarisu area. Thanks are also extended to Dr. Tetsuo Sugiyama, who provided kind comments and suggestions on the manuscript as a reviewer.

References

Chen, X. and Tazawa, J. (2003) Middle Devonian (Eifelian) brachiopods from the Southern Kitakami Mountains, Northeast Japan. *Journal of Paleontology*. **77**:1040–1052.

Chudinova, I. I. (1964) Tabulata of the Lower and Middle Devonian of the Kuznetsk Basin. *Akademiia Nauk SSSR*, *Trudy Paleontologicheskogo Instituta*, **101**: 1–82, pls. 1–35. (In Russian)

Dubatolov, V. N., Lin, B. and Tchi, Y. (1959) Tabulatomorphic corals and heliolitid corals from the Devonian of the Unor area (middle parts of Da Xinggan Ling). *Stratigraphy and Paleontology*, *Series B*, **1**: 1–53, pls. 1–16. (In Chinese with Russian abstract)

Ehiro, M. and Takaizumi, Y. (1992) Late Devonian and Early Carboniferous ammonoids from the Tobigamori Formation in the Southern Kitakami Massif, Northeast Japan and their stratigraphic significance. *The Journal of the Geological Society of Japan*, **98**: 197–204, pl. 1.

Frech, F. (1885) Die Korallenfauna des Oberdevons in Deutschland. *Zeitchrift der Deutschen Geologischen Gesellschaft*, **37**, 20–130, pls. 1–11.

Gerth, H. (1921) Die Anthozoën der Dyas von Timor. *Paläontologie von Timor*, **9**: 65–147, pls.145–150.

Goldfuss, A. (1826) Petrefacta Germaniae, tam ea, quae in Museo Universitatis Regiae Borussicae Fridericiae Wilhelmiae Rhenanae servantur, quam alia quaetunque in Museis Hoeninghusiano, Muenstriano aliisque extant, iconibus et descriptionibús illustrata. Abbildungen und Beschreibungen der Petrefacten Deutschlands und der angranzenden Länder, unter Mitwirkung des Herm Grafen Georg zu Münster. pp. 77–164, pls. 26–50, Arnz & Co., Düsseldorf.

Hill, D. (1981) Part F, Coelenterata. Supplement 1, Rugosa and Tabulata. In: Moore R. C. *et al.* (Ed.), Treatise on Invertebrate Paleontology. The Geological Society of America and the University of Kansas, Boulder, Colorado and Lawrence, Kansas, pp. F1–F762.

Kaneko, A. and Kawamura, T. (1989) Devonian trilobite fossil assemblage from the Kamiarisu Formation, Kitakami Mountains. *Abstracts of the 1989 Annual Meeting of the Palaeontological Society of Japan*, p. 100. (In Japanese)

Lin, B., Tchi, Y., Jin, C., Li, Y. and Yan, Y. (1988) Mono-

graph of Palaeozoic Corals. Tabulatomorphic Corals. Volume 2, 493 pp. Geological Publishing House, Beijing. (In Chinese)

May, A. (1997) Statistics on *Thamnopora* (Tabulata, Devonian). *Boletín de la Real Sociedad Española de Historia Natural*, *Seccíon Geológica*, **91**: 217–230.

Milne-Edwards, H. and Haime, J. (1850) A monograph of the British Fossil Corals. First part. Introduction; Corals from the Tertiary and Cretaceous Formations. 71 pp., 11 pls., Monographs of the Palaeontographical Society, London.

Mottequin, B. (2019) An annotated catalogue of types of Silurian–Devonian brachiopod species from southern Belgium and northern France in the Royal Belgian Institute of Natural Sciences (1870–1945), with notes on those curated in other Belgian and foreign institutions. Geologica Belgica, **22**: 47–89.

Niko, S. (2003) Ludlow (late Silurian) pachyporid tabulate corals from the Suberidani Group, Tokushima Prefecture. *Bulletin of the National Science Museum*, *Series C*, **29**: 9–18.

Niko, S., Ibaraki, Y. and Tazawa, J. (2014) Devonian tabulate corals from pebbles in Mesozoic conglomerate, Kotali, Niigata Prefecture, central Japan. Part 1: Favositina. *Scientific Reports of Niigata University (Geology)*, **29**: 53–66.

Niko, S., Ibaraki, Y. and Tazawa, J. (2015) Devonian tabulate corals from pebbles in Mesozoic conglomerate, Kotali, Niigata Prefecture, central Japan. Part 2: Alveolitina. *Scientific Reports of Niigata University (Geology)*, **30**: 15–25.

Niko, S., Ibaraki, Y. and Tazawa, J. (2016) Devonian tabulate corals from pebbles in Mesozoic conglomerate, Kotali, Niigata Prefecture, central Japan. Part 3: Heliolitida. *Scientific Reports of Niigata University (Geology)*, **31**: 1–6.

Niko, S., Ibaraki, Y. and Tazawa, J. (2019) Devonian tabulate corals from pebbles in Mesozoic conglomerate, Kotali, Niigata Prefecture, central Japan. Part 4: Auloporida. *Scientific Reports of Niigata University (Geology)*, **34**: 1–8.

Niko S. and Senzai, Y. (2006) Devonian auloporid tabulate corals from the Kamianama Formation, Fukui Prefecture. *Bulletin of the National Science Museum*, *Series C*, **32**, 31–40.

Niko S. and Senzai, Y. (2010) Stratigraphy of the Devonian Kamianama Formation in the Kuzuryu Lake–Ise River area, Fukui Prefecture and its favositid coral fauna. *Bulletin of the National Museum of Nature and Science*, *Series C*, **36**, 31–59.

Niko S. and Senzai, Y. (2011) Additional material of favositid tabulate corals from the Devonian Kamianama Formation, Fukui Prefecture, Japan. *Bulletin of the National Museum of Nature and Science*, *Series C*, **37**, 29–41.

Noda, M. (1934) Geological research in the region around Nagasaka, in the western part of the Kitakami Mountains. *The Journal of the Geological Society of Japan*, **41**: 431–456, pl. 9. (In Japanese)

Okami, K., Ehiro, M., Kuriyagawa, H. and Asanuma, A. (1987) *Leptophloeum* bearing formation in the "Hayachine Tectonic Belt", Kitakami Massif, Northeast Japan. *The Journal of the Geological Society of Japan*, **93**: 321–327. (In Japanese with English abstract)

Onuki, Y. (1956) Geology of the Kitakami Massif. In: Iwate Prefecture (Ed.), Explanatory Text of the Geology of Iwate Prefecture. Sasaki Shuppan, Sendai, pp. 1–189. (In Japanese)

Osawa, M. (1983) Geological study on the "Hayachine Tectonic Belt". *Contributions from the Institute of Geology and Paleontology*, *Tohoku University*, **85**: 1–30. (In Japanese with English abstract)

Steininger, J. (1831) Bemerkungen über die Versteinerungen, whlche in dem Uebergangs-Kalkgebirge der Eifel gefunden werden. 44 pp. Trier.

Tazawa, J. (2018) Late Devonian brachiopods from Choanji, South Kitakami Belt, Japan, and their stratigraphic significance. *Paleontological Research*, **22**: 129–144.

Tazawa, J., Muramoto, K. and Mori. K. (1984) *Pentamerus* (Silurian Brachiopoda) from Kamiarisu in the Southern Kitakami Mountains, Northeast Japan. *The Journal of the Geological Society of Japan*, **90**: 353–355. (In Japanese)

Tazawa, J. and Niikawa, I. (2018) *Desquamatia* (*Seratrypa*) from the Upper Devonian Choanji Formation in the South Kitakami Belt, Japan, and its Stratigraphical significance. *The Journal of the Geological Society of Japan*, **124**: 111–116. (In Japanese with English abstract)

Vai, G. B. (1967) Devonian inferieur biohermal des Alpes Carniques centrales. *Mémoires du Bureau de Recherches Géologiques et Miniéres*, **33**: 285–300.

Wedekind, R. (1937) Einführung in die Grundlagen der Historischen Geologie. II. Band. Mikrobiostratigraphie, Die Korallen- und Foraminiferenzeit. 136 pp., 16 pls. Ferdinand Enke, Stuttgart.

Yabe, H. and Sugiyama, T. (1937) Preliminary report on the fossiliferous Gotlandian and Devonian deposits newly discovered in the Kitakami Mountainland. *Proceedings of the Imperial Academy*, **13**: 417–420.