

Discovery of the middle Campanian ammonoid *Menuites soyaensis* (Matsumoto and Miyauchi) in the Aridagawa area, Wakayama, Southwest Japan

Yasunari Shigeta^{1*} and Ryuji Yamamoto²

¹ Department of Geology and Paleontology, National Museum of Nature and Science,
4–1–1 Amakubo, Tsukuba, Ibaraki 305–0005, Japan

² Association of Ayukawa Town Planning, 43–1 Ayukawahamaminami, Ishinomaki, Miyagi 986–2523, Japan

*Author for correspondence: shigeta@kahaku.go.jp

Abstract *Menuites soyaensis* is one of several ammonoid taxa that represent the upper middle Campanian *Metaplacenticerias subtilistriatum-Hoplitoplacenticerias monju* Zone in Japan. Although upper middle Campanian zonal-index ammonoids have not been found in the Toyajo Formation of the Sotoizumi Group in the Aridagawa area, Wakayama, Southwest Japan, the discovery of a single specimen referable to this species confirms that the uppermost part of the Nakaibara Siltstone Member correlates with the upper middle Campanian. In Hokkaido and Sakhalin, the ammonoid fauna that includes *M. soyaensis* is referred to as the “Soya Fauna”. Because associated ammonoids differ from those in the Toyajo Formation, the Soya Fauna may be restricted to the Yezo Group of Hokkaido and Sakhalin.

Key words: ammonoid, Campanian, Cretaceous, *Menuites soyaensis*, Toyajo Formation, Wakayama

Introduction

Various horizons in the Toyajo Formation of the Sotoizumi Group in the Aridagawa area, Wakayama, Southwest Japan are well known for their rich Campanian ammonoid faunas (Misaki and Maeda, 2009). The following three ammonoid zones established by Toshimitsu *et al.* (1995) as part of the Japanese Upper Cretaceous biostratigraphic zonation scheme are recognized in the formation, in ascending order: *Canadoceras kossmati*, *Didymoceras awajiense* and *Pachydiscus awajiensis*. They correlate with the three-subdivision scheme for the Campanian (Shigeta *et al.*, 2016) as follow: the *Canadoceras kossmati* Zone with the lower middle Campanian, the *Didymoceras awajiense* Zone with the lower upper Campanian, and the *Pachydiscus awajiensis* Zone with the upper upper Campanian. Until now, typical upper middle Campanian index ammonoids have not been reported from the Toyajo Formation, but a specimen referable to *Menuites soyaensis* (Matsumoto and Miyauchi, 1984) was discovered recently by co-author R. Yamamoto in the Aridagawa area (Fig. 1).

Menuites soyaensis, one of the representative

ammonoid taxa of the upper middle Campanian *Metaplacenticerias subtilistriatum-Hoplitoplacenticerias monju* Zone of Toshimitsu *et al.* (1995), occurs frequently in the Yezo Group in Hokkaido, Japan and Sakhalin, Russian Far East (Matsumoto and Miyauchi, 1984; Maeda *et al.*, 2005; Shigeta and Izukura, 2018). In this paper, we document the occurrence of the species for the first time outside of Hokkaido and Sakhalin, and discuss its biostratigraphic implications.

Notes on stratigraphy

The Toyajo Formation is exposed in a narrow band along the E–W trending ridge of Mt. Toyajo in the Aridagawa area, Wakayama, Southwest Japan. Generally composed of siltstone, sandstone, and alternating beds of sandstone and mudstone, the formation is divided into the Nakaibara Siltstone, Hasegawa Muddy Sandstone and Buyo Sandstone members in ascending order (Misaki and Maeda, 2009).

The inoceramid *Sphenoceras schmidtii* (Michael, 1899) occurs in the lower and lower upper parts of the 700 m thick Nakaibara Siltstone Member, while the ammonoid *Canadoceras kossmati* Matsumoto, 1954 is found in the upper part

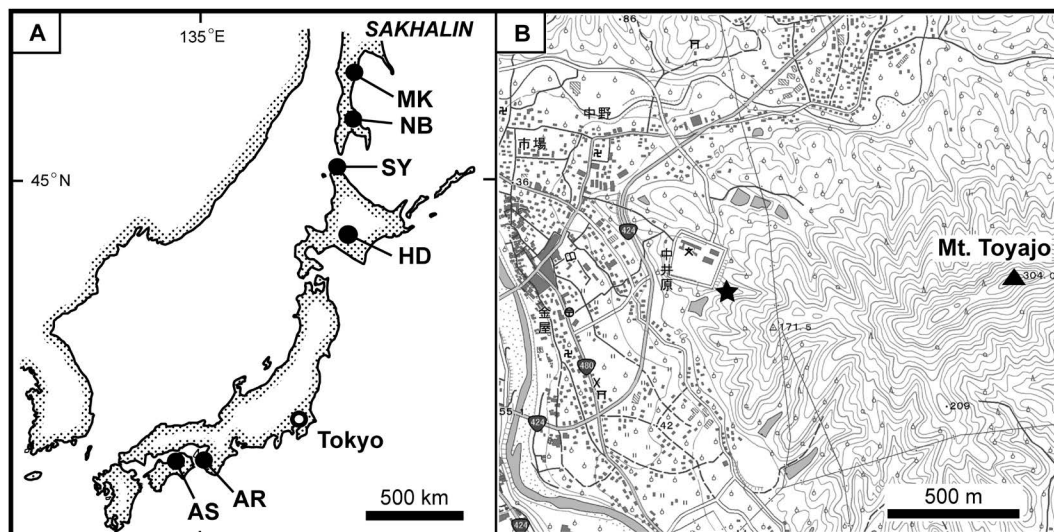


Fig. 1. Index map (A) showing fossil localities mentioned in the text and locality (B) of the described *Menuites soyaensis* (Matsumoto and Miyauchi, 1984) specimen (indicated by star, based on the digital topographic map of the Geospatial Information Authority of Japan). AR, Aridagawa; AS, Asan Mountains, HD, Hidaka; MK, Makarov; NB, Naiba; SY, Soya Cape.

(Misaki and Maeda, 2009). The 590 m thick Hasegawa Muddy sandstone Member includes the ammonoid *Didymoceras awajiense* (Yabe, 1901) in the lower to middle parts and the ammonoid *Pachydiscus awajiensis* Morozumi, 1985 in the upper part. The +490 m Buyo Sandstone Member is generally unfossiliferous, but Misaki and Maeda (2009) reported a fragment of an ammonoid shell from the lower part of the member.

The specimen referable to *Menuites soyaensis* described herein was obtained from a float calcareous concretion that most likely came from the uppermost part of the Nakaibara Siltstone Member in the Aridagawa area. The concretion also contained *Tetragonites popetensis* Yabe, 1903, *Canadoceras* sp., *Parasolenoceras* sp., *Ryugasella* sp. and *Baculites* sp.

Paleontological description

Morphological terms are those used in Arkell (1957). Quantifiers used to describe the shape of shell replicate those proposed by Matsumoto (1954, p. 246) and modified by Haggart (1989, table 8.1).

Abbreviations for shell dimensions: *D*, shell diameter; *U*, umbilical diameter; *H*, whorl height; *W*, whorl width.

Institution abbreviations: GK, Department of Earth and Planetary Sciences, Kyushu University, Fukuoka; WMNH, Wakayama Prefectural Museum

of Natural History, Kainan.

Suborder Ammonitina Hyatt, 1889

Superfamily Desmoceratoidea Zittel, 1895

Family Pachydiscidae Spath, 1922

Genus *Menuites* Spath, 1922

Type species: *Ammonites menu* Forbes, 1846.

Menuites soyaensis

(Matsumoto and Miyauchi, 1984)

Fig. 2

Pachydiscus soyaensis Matsumoto and Miyauchi, 1984, p. 41, pls. 11–13, pl. 16, fig. 1, pl. 17, fig. 2, pl. 21, fig. 3.

Menuites soyaensis (Matsumoto and Miyauchi). Kodama *et al.*, 2002, fig. 8A, B; Maeda *et al.*, 2005, figs. 13.1, 13.2; Shigeta and Izukura, 2018, p. 18, figs. 5, 6A–D.

Holotype: GK. H5972, figured by Matsumoto and Miyauchi (1984, p. 41, pl. 11), from the *Schlueteria kawadai* Subzone of the *Metaplacenticerat subtilistriatum* Zone (middle Campanian) at Soya harbor (Loc. W7B in Matsumoto and Miyauchi, 1984), in the Soya area, northern Hokkaido.

Material examined: One specimen, WMNH-Ge-1140210790, extracted from a float calcareous concretion found in a small valley about 150 m east-southeast of Kanaya Junior High School (Fig. 1), which is equivalent to localities 0303–0305 along Valley S-1 of Misaki and Maeda (2009).

Description: Moderately involute with circular

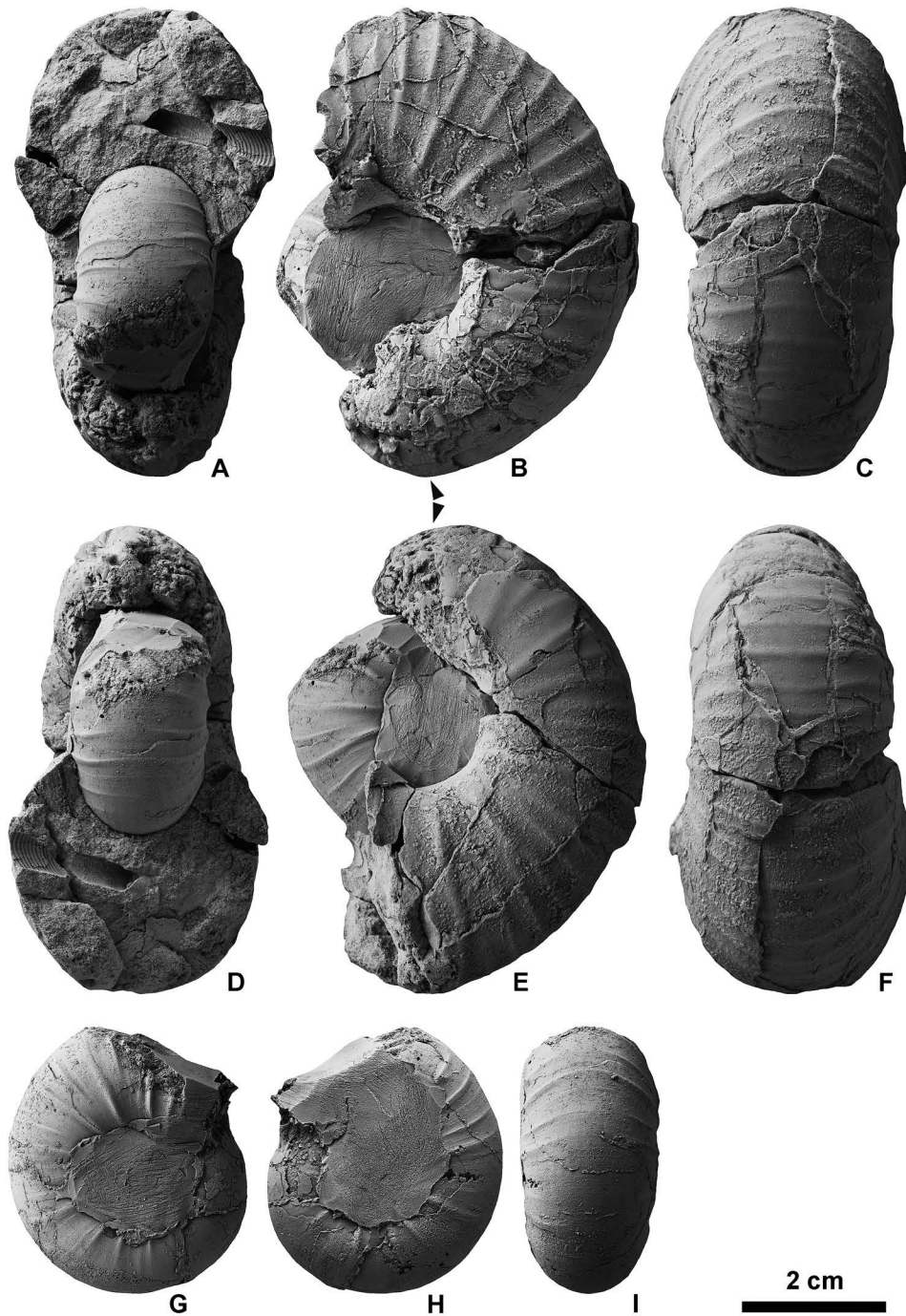


Fig. 2. *Menuites soyaensis* (Matsumoto and Miyauchi, 1984), WMNH-Ge-1140210790, from the calcareous concretion of this study found in the Aridagawa area. A–F, body chamber and silicon rubber cast of phragmocone made from the outer mold; A, D, apertural view; B, right lateral view; C, F, ventral view; E, left lateral view; G–I, silicon rubber cast of phragmocone; G, left lateral view; H, right lateral view; I, ventral view. Arrow indicates position of last septum.

whorl section, rounded venter, indistinct ventral shoulders, and gently convex flanks with maximum whorl width at mid-flank. Umbilicus fairly narrow, with high, convex wall and rounded shoulders. Major ribs arise from tubercles with elongated base near umbilical shoulder, become straight and prosiradiate or rursiradiate on flanks, projecting forwards and feebly concave on ventrolateral shoulder,

before crossing venter in a broad convex arch. One to three intercalated ribs between primary ribs arise on inner to mid-flank. Ribs weaken or disappear on venter in juvenile forms, but become stronger as shell grows larger. Major ribs 7 and ventral ribs 24 per half whorl. Suture partly visible.

Measurements: Taken at $D = 65.0$ mm, $U = 16.0$ mm, $H = 28.0$ mm, $W = 32.6$ mm, $U/D = 0.24$,

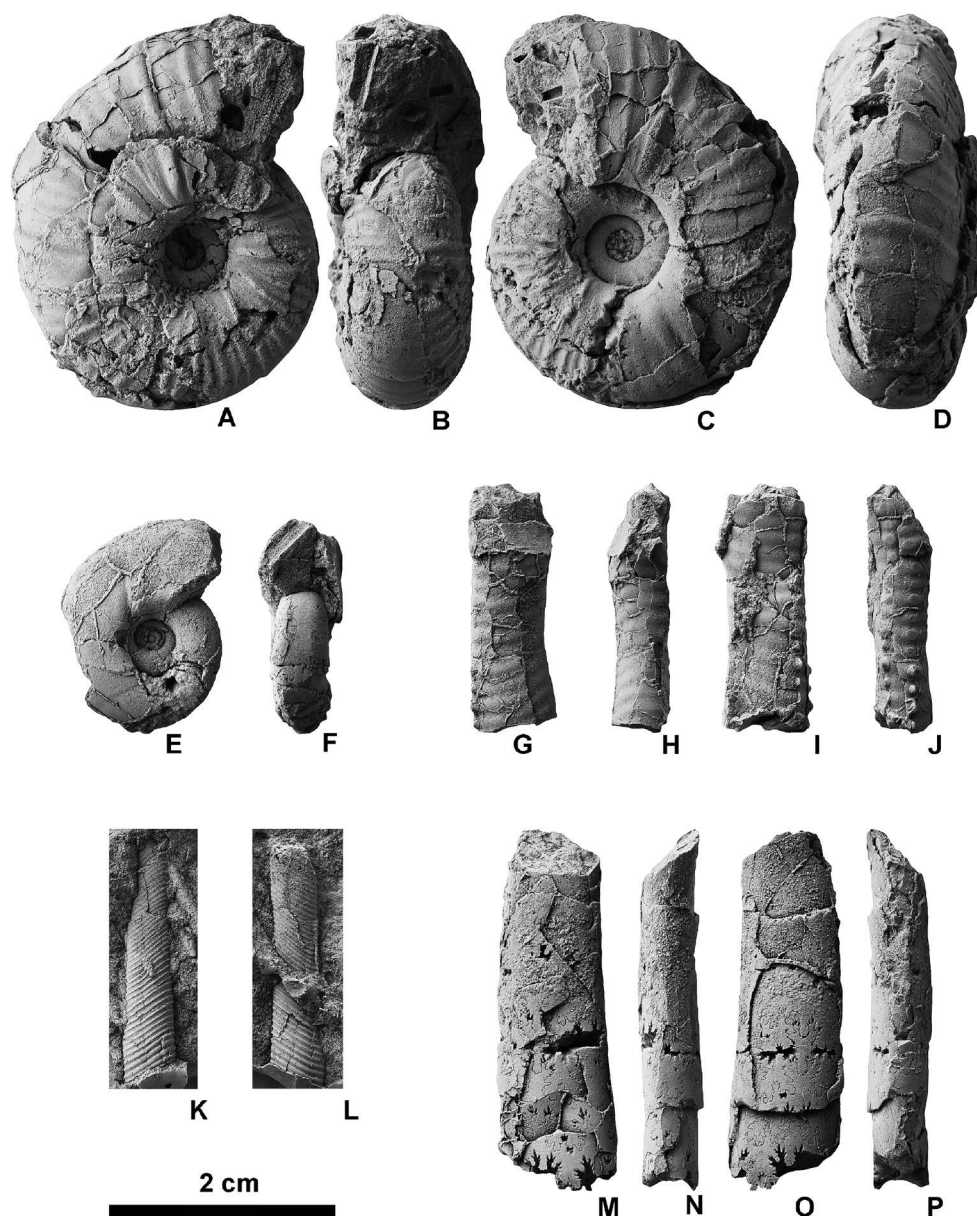


Fig. 3. Co-occurring ammonoids in the calcareous concretion of this study from the Aridagawa area. A–D, *Canadoceras* sp., WMNH-Ge-1140210791; A, left lateral view; B, apertural view; C, right lateral view; D, ventral view; E, F, *Tetragonites popetensis* Yabe, 1903, WMNH-Ge-1140210792; E, left lateral view; F, apertural view; G–J, *Parasolenoceras* sp., WMNH-Ge-1140210793; G, lateral view; H, dorsal view; I, lateral view rotated 180 degrees from G; J, ventral view; K, L, *Ryugasella* sp., WMNH-Ge-1140210794 (silicon rubber cast); K, lateral view; L, lateral view rotated 180 degrees from K; M–P, *Baculites* sp., 1140210795; M, lateral view; N, dorsal view; O, lateral view rotated 180 degrees from M; P, ventral view.

$W/H = 1.16$.

Remarks: This species was originally described as *Pachydiscus* Zittel, 1884 by Matsumoto and Miyachi (1984). See Shigeta and Izukura (2018) for a discussion of the generic assignment to *Menuites*.

Occurrence: Described specimen was collected from a float concretion. Although the exact horizon from which the concretion came is uncertain, judging from where it was found and its lithology, it almost certainly came from the uppermost part of

the Nakaibara Siltstone Member of the Toyajo Formation. *Menuites soyaensis* is known from the upper middle Campanian in the Soya Cape and Hidaka areas in Hokkaido and the Naiba and Makarov areas in Sakhalin.

Discussion

The uppermost part of the Nakaibara Siltstone Member of the Toyajo Formation, which contains

Diplomoceras sp., is thought to be correlated with the upper middle Campanian or possibly even a slightly higher horizon (Misaki and Maeda, 2009), because this taxon is known to range from the upper middle Campanian *Metaplacesticerias subtilistriatum-Hoplitoplacesticerias monju* Zone to the Maastrichtian in Japan (Matsumoto, 1984; Maeda *et al.*, 2005; Shigeta *et al.*, 2015; Kurihara *et al.*, 2016). The discovery of the *Menuites soyaensis* specimen of this study confirms that the uppermost part of the member corresponds to the upper middle Campanian.

A comparable ammonoid fauna from the Yezo Group of Hokkaido and Sakhalin, referred to as the “Soya Fauna” (Matsumoto and Miyauchi, 1984; Kodama *et al.*, 2002; Maeda *et al.*, 2005; Shigeta and Izukura, 2018), also contains *Menuites soyaensis*. This fauna is also associated with the following representative ammonoids: *Schluterella kawadai* Matsumoto and Miyauchi, 1984, *Canadoceras multicostatum* Matsumoto, 1954 and *Gaudryceras crassicostratum* (Jimbo, 1894).

The calcareous concretion of this study from the Aridagawa area yielded five ammonoid specimens (WMNH-Ge-1140210791–1140210795) in addition to the *Menuites soyaensis* specimen (Fig. 3). Specimen WMNH-Ge-1140210792 is a juvenile form of *Tetragonites popetensis*, which is abundant in the Soya Fauna. Specimen WMNH-Ge-1140210791 is assignable to *Canadoceras*. Its fairly depressed whorl section ($W/H = 1.1$) is somewhat similar to *Canadoceras kossmati* Matsumoto, 1954, but its umbilicus ($U/D = 0.26$) is narrower than *C. kossmati* ($U/D = 0.29$ at a shell diameter of 30–40 cm, see Shigeta, 2019). The specimen’s juvenile shell (35 mm in shell diameter) precludes a definitive assignment. Even though specimens WMNH-Ge-1140210793–1140210795 are fragmental, their distinctive features enable us to assign them with reasonable confidence to the genera *Parasolenoceras*, *Ryugasella* and *Baculites* respectively. *Parasolenoceras* and *Baculites* both occur in the Soya Fauna (Matsumoto and Miyauchi, 1984). *Ryugasella* has not yet been recorded in the Soya Fauna, but it frequently occurs in the lower middle Campanian in Hokkaido and Sakhalin (Wright and Matsumoto, 1954).

Schluterella kawadai, *Canadoceras multicostatum* and *Gaudryceras crassicostratum*, all of which

characterize the Soya Fauna, have not yet been reported from either the Aridagawa area or the Asan Mountains of Southwest Japan (Fig. 1; Bando and Hashimoto, 1984). This non-occurrence suggests that the Soya Fauna may be restricted to the Yezo Group of Hokkaido and Sakhalin, but further geological and paleontological work is required, because fossils are rather rare in the uppermost part of the Nakaibara Siltstone Member.

Acknowledgments

We thank Akihiro Misaki for valuable comments on the first draft. Thanks are extended to Jim Jenks (West Jordan, Utah) for his helpful suggestions and improvement of the English text.

References

- Arkell, W. J. (1957) Introduction to Mesozoic Ammonoidea. In: Arkell, W. J., Furnish, W. M., Kummel, B., Miller, A. K., Moore, R. C., Schindewolf, O. H., Sylvester-Bradley, P. C. and Wright, C. W. (Eds.), *Treatise on Invertebrate Paleontology, Part L, Mollusca 4, Cephalopoda, Ammonoidea*. Geological Society of America, New York and University of Kansas Press, Lawrence, pp. L81–129.
- Bando, Y. and Hashimoto, H. (1984) Biostratigraphy and ammonite fauna of the Izumi Group (Late Cretaceous) in the Asan Mountains. *Memoires of the Faculty of Education, Kagawa University, Part 2*, **34**: 11–39. (In Japanese with English summary)
- Forbes, E. (1846) Report on the fossil Invertebrata from southern India, collected by Mr. Kaye and Mr. Cunliffe. *Transactions of the Geological Society of London, Series 2*, **7**: 97–174.
- Haggart, J. W. (1989) New and revised ammonites from the Upper Cretaceous Nanaimo Group of British Columbia and Washington State. *Geological Survey of Canada Bulletin*, **396**: 181–221.
- Hyatt, A. (1889) Genesis of the Arietidae. *Smithsonian Contributions to Knowledge*, **673**: 1–238.
- Jimbo, K. (1894) Beiträge zur Kenntniss der Fauna der Kreideformation von Hokkaido. *Paläontologische Abhandlungen, Neue Folge*, **2**: 1–48.
- Kodama, K., Maeda, H., Shigeta, Y., Kase, T. and Takeuchi, T. (2002) Integrated biostratigraphy and magnetostratigraphy of the upper Cretaceous System along the River Naiba in southern Sakhalin, Russia. *Journal of the Geological Society of Japan*, **108**: 366–384. (In Japanese with English abstract)
- Kurihara, K., Kano, M., Sawamura, H. and Sato, Y. (2016) The last surviving ammonoid at the end of the Cretaceous in the north Pacific region. *Paleontological Research*, **20**: 116–120.
- Maeda, H., Shigeta, Y., Fernando, A. G. S. and Okada, H.

- (2005) Stratigraphy and fossil assemblages of the Upper Cretaceous System in the Makarov area, southern Sakhalin, Russian Far East. *National Science Museum Monographs*, **31**: 25–120.
- Matsumoto, T. (1954) The Cretaceous System in the Japanese Islands. 324 pp. Japan Society for the Promotion of Science, Tokyo.
- Matsumoto, T. (1984) Ammonites from the Upper Campanian of the Teshio Mountains. *Palaeontological Society of Japan, Special Paper*, **27**: 5–32.
- Matsumoto, T. and Miyauchi, T. (1984) Some Campanian ammonites from the Soya area. *Palaeontological Society of Japan, Special Paper*, **27**: 33–76.
- Michael, R. (1899) Über Kreidefossilien von der Insel Sachalin. *Jahrbuch der Königlich Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin*, **18**: 153–164.
- Misaki, A. and Maeda, H. (2009) Lithostratigraphy and biostratigraphy of the Campanian–Maastrichtian Toyajo Formation in Wakayama, southwestern Japan. *Cretaceous Research*, **30**: 1398–1414.
- Morozumi, Y. (1985) Late Cretaceous (Campanian and Maastrichtian) ammonites from Awaji Island, Southwest Japan. *Bulletin of the Osaka Museum of Natural History*, **39**: 1–58.
- Shigeta, Y. (2019) Ontogeny of *Canadoceras kossmati* Matsumoto, a Campanian pachydiscid ammonoid from Hokkaido, Japan. *Bulletin of the Hobetsu Museum*, **34**: 1–11.
- Shigeta, Y. and Izukura, M. (2018) Discovery of the middle Campanian (Late Cretaceous) “Soya Fauna” ammonoids in the Hidaka area, Hokkaido, Japan. *Bulletin of the Hobetsu Museum*, **33**: 11–25.
- Shigeta, Y., Izukura, M., Nishimura, T. and Tsutsumi, Y. (2016) Middle and late Campanian (Late Cretaceous) ammonoids from the Urakawa area, Hokkaido, northern Japan. *Paleontological Research*, **20**: 322–366.
- Shigeta, Y., Nishimura, T. and Nifuku, K. (2015) Middle and late Maastrichtian (latest Cretaceous) ammonoids from the Akkeshi Bay area, eastern Hokkaido, northern Japan and their biostratigraphic implications. *Paleontological Research*, **19**: 107–127.
- Spath, L. F. (1922) On the Senonian ammonite fauna of Pondoland. *Transactions of the Royal Society of South Africa*, **10**: 113–148.
- Toshimitsu, S., Matsumoto, T., Noda, M., Nishida, T. and Maiya, S. (1995) Towards an integrated mega-, micro- and magneto-stratigraphy of the Upper Cretaceous in Japan. *Journal of the Geological Society of Japan*, **101**: 19–29. (In Japanese with English abstract)
- Wright, C. W. and Matsumoto, T. (1954) Some doubtful Cretaceous ammonites genera from Japan and Saghalien. *Memoirs of the Faculty of Science, Kyushu University, Series D, Geology*, **4**: 107–134.
- Yabe, H. (1901) Note on three Upper Cretaceous ammonites from Japan, outside of Hokkaido. *Journal of the Geological Society of Tokyo*, **8**: 1–4.
- Yabe, H. (1903) Cretaceous Cephalopoda from the Hokkaido. Part 1: *Lytoceras*, *Gaudryceras*, and *Tetragonites*. *Journal of the College of Science, Imperial University of Tokyo*, **18**: 1–55.
- Zittel, K. A. (1884) Cephalopoda. In: Zittel, K. A. (Ed.), *Handbuch der Palaeontologie*, Band 1, Abt. 2, Lief 3. Oldenbourg, Munich and Leipzig, pp. 329–522.
- Zittel, K. A. (1895) *Grundzüge der Palaeontologie*. 971 pp. Oldenbourg, Munich and Leipzig.