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A new species of the heteromorph ammonoid *Phylloptychoceras* from the lowest Maastrichtian of Hokkaido, Japan

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Abstract. A new Cretaceous heteromorph ammonoid, *Phylloptychoceras horitai* sp. nov., is described from the lowest Maastrichtian of Hokkaido, Japan. Its shell is ornamented with very weak, broadly rounded ribs and its suture line is characterized by a deeply incised, trifid dorsal lobe and three bifid lateral saddles with minor indentations. This occurrence suggests that *Phylloptychoceras* evolved in the North Pacific during late Campanian or early Maastrichtian time and then achieved worldwide distribution during late Maastrichtian time.

Key words: ammonoid, Cretaceous, Hokkaido, Maastrichtian, *Phylloptychoceras*, *Polyptychoceras*

Introduction

Phylloptychoceras Spath, 1953, a genus belonging to the family Diplomoceratidae Spath, 1926, is one of the trombone-shaped heteromorph ammonoids of the Late Cretaceous. Complete specimens are unknown, but its shell most likely consists of several straight, parallel shafts with U-shaped whorls connecting the successive shafts, very similar to the allied genus *Polyptychoceras* Yabe, 1927. The genus is monospecific and its type species *Ph. sipho* was described by Forbes (1846) from the Upper Maastrichtian of Pondicherry, southern India. Specimens assigned to this genus are also known from the upper Campanian or lower Maastrichtian of California (Anderson, 1958) and the upper Maastrichtian of Europe and Chile (Stinnesbeck, 1986; Birkelund, 1993; Ward and Kennedy, 1993; Jagt *et al*., 2006).

Early Maastrichtian ammonoids are fairly abundant in outcrops of the Hakobuchi Formation in the Hobetsu area of south-central Hokkaido, and over the past 65 years, nearly ten species of ammonoids have been described (Matsumoto, 1947, 1954, 1977, 1979, 1984a; Matsumoto and Saito, 1954; Shigeta, 1989; Matsumoto and Toshimitsu, 1992, 1995, 1996; Shigeta *et al*., 2010; Shigeta and Nishimura, 2013). Recently, Yoshiyuki Horita (Mukawa, Hokkaido) collected several fragments referable to *Phylloptychoceras* from the Hakobuchi Formation (lowest Maastrichtian) in the Hobetsu area. We herein describe these specimens as a new species of *Phylloptychoceras* and discuss the origin and evolution of this taxon.

Notes on stratigraphy

Outcrops of the Hakobuchi Formation, which are widely distributed in the Hobetsu area, make this region one of the best reference sections of the uppermost Cretaceous in the North Pacific realm (Matsumoto, 1942, 1954; Tanaka, 1960). Representing the uppermost member of the Yezo Group, the formation consists mainly of sandstone and has been divided into four lithologic units, IVa–IVd (Matsumoto, 1942) or Ha–Hd (Tanaka, 1960). With regard to lithology, the units of each scheme are essentially identical, differing only by letter designation.

Unit IVa, composed mainly of sandstone associated with conglomerate, sandy mudstone and coal beds, contains the Campanian index inoceramid bivalve *Shenoceramus schmidti* (Michael, 1899) in its middle part (Tanaka, 1960). Unit IVb, dominated by sandy mudstone, contains *Nostoceras hetonaiense* Matsumoto, 1977 and *Pachydiscus japonicus* Matsumoto, 1947, both of which are indicative of the lowest Maastrichtian

(Matsumoto, 1947, 1954, 1977; Tanaka, 1960). Unit IVc, consisting of sandstone with intercalations of conglomerate and sandy mudstone beds, contains a late early Maastrichtian fossil assemblage in its upper part, which includes *Pachydiscus kobayashii* (Shimizu, 1935), *P. gracilis* Matsumoto, 1979, *Gaudryceras izumiense* Matsumoto and Morozumi, 1980, and *Sphenoceramus hetonaianus* (Matsumoto, 1952) (Matsumoto, 1979; Matsumoto and Toshimitsu, 1992; Matsumoto *et al*., 1993; Shigeta *et al*., 2010). Unit IVd is composed mainly of unfossiliferous sandy mudstone.

The specimens upon which we based our new species of *Phylloptychoceras* were obtained from a float calcareous concretion that most likely came from exposures of the Unit IVb sandy mudstone along the banks of the Tonai-sawa River in the Hobetsu area.

Paleontological description

Systematic descriptions follow the classification established by Wright *et al*. (1996). Morphological terms in the systematic description are those used in the *Treatise on Invertebrate Paleontology* (Moore, 1957).

Institution abbreviations.—HMG = Hobetsu Museum, Mukawa, Hokkaido.

Superfamily Turrilitoidea Gill, 1871
Family Diplomoceratidae Spath, 1926
Genus ***Phylloptychoceras*** Spath, 1953

Type species.—*Ptychoceras sipho* Forbes, 1846.

Remarks.—Howarth (1965, p. 368) and Wright *et al.* (1996) treated *Phylloptychoceras* as a subgenus of *Polyptychoceras*, but Jagt *et al*. (2006) pointed out that both genera can be clearly distinguished by differences in ornamentation and the suture line. Thus, *Phylloptychoceras* is characterized by its deeply incised, trifid dorsal lobe and the same style of low, broad uniform ribbing. We agree with this interpretation and treat it as an independent genus.

Spath (1953, p. 16) included in his new genus *Phylloptychoceras* the type species *Ptychoceras sipho* from southern India and *Ph. zelandicum* Marshall, 1926 from New Zealand, but his generic diagnosis was based entirely on the type species. Henderson (1970) restudied the taxonomy of *Ph. zelandicum* and recognized that the characters of the shell and suture line did not match the generic diagnosis of *Phylloptychoceras*; he then proposed a new genus *Astreptoceras* based on *Ph. zelandicum*, which exhibits a bifid dorsal lobe.

Phylloptychoceras horitai sp. nov.

Figures 1, 2

Types.—Holotype, HMG-1587a; paratypes, three specimens, HMG-1587b, c, d. Type specimens were extracted from a float calcareous concretion found in the Tonai-zawa River (42°43′41.8″N, 142°14′12.4″E), a branch of the Saru River, in the Hobetsu area.

Diagnosis.—*Phylloptychoceras* with very weak, broadly interspaced ribs and simple suture line with deeply incised, trifid dorsal lobe and three bifid lateral saddles with minor indentations.

Etymology.—Named after Yoshiyuki Horita, who collected the specimens.

Description.—Holotype, HMG-1587a (Figure 1M–P), a fragment of phragmocone consisting of a straight shaft (46.0 mm long) and a portion of a U-shaped whorl adjoined at its adapical end that exhibits a very slowly increasing diameter and a nearly circular cross section. Ornamentation consists of very weak, broadly interspaced, radial or slightly prorsiradiate ribs and a constriction on the adapical end. Suture line simple with deeply incised, trifid dorsal lobe, bifid ventral lobe, and three narrow-stemmed, bifid lateral saddles with many small indentations (Figure 1Q).

HMG-1587b (Figure 1E–H), a fragment of phragmocone consisting of a straight shaft (46.5 mm long) and part of a U-shaped whorl at its adoral end. Adapical portion of shaft varies slightly from its straight course. Ornamentation consists of very weak, low, broadly rounded ribs. Suture line pattern same as holotype.

HMG-1587c (Figure 1A–D), a very short (18 mm long) straight fragment consisting mostly of body chamber with the last septum and very weak ornamentation.

HMG-1587d (Figure 1I–L), a fragment of body chamber consisting of straight shaft (85.0 mm long) adjoined with a U-shaped whorl at its adoral end, followed by a short, straight shaft (25 mm long), thus forming a hook. Whorl section nearly circular. Ornamentation consists of low, broadly interspaced ribs, which are very weak and transverse on dorsum, strong, straight and feebly prorsiradiate on flanks, and weak and transverse on venter. Ribs become much weaker and more crowded on U-shaped whorl and then disappear on short shaft.

Comparison.—*Phylloptychoceras horitai* sp. nov. is very close to *Ph. sipho* (Forbes, 1846), but differs by its much weaker and denser ribs and much simpler suture line. It resembles *Cyrtoptychoceras undulatus* (Forbes, 1846) in having low, broadly interspaced ribs. However, the latter has a single curved shaft, while the former possesses straight shafts and U-shaped whorls. This new species is similar to *Polyptychoceras pseudogaultinum* (Yokoyama, 1890) in having the trombone-like shell and

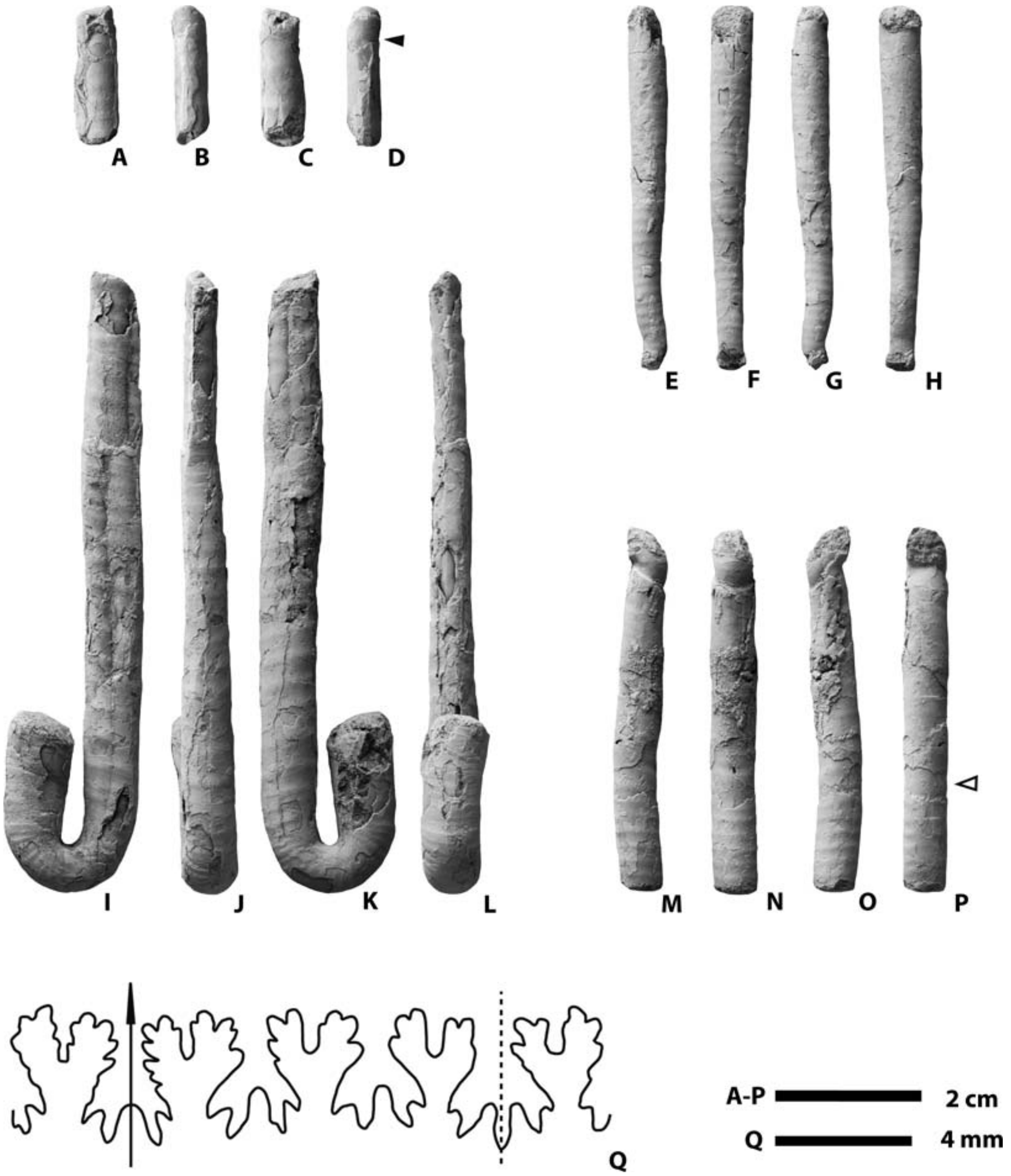

Figure 1. *Phylloptychoceras horitai* Shigeta and Nishimura sp. nov., from the Hobetsu area, Hokkaido. **A–D**, HMG-1587c, paratype; A, lateral view; B, ventral view; C, lateral view rotated 90 degrees from B; D, dorsal view, showing the position of the last septum (black arrow); **E–H**, HMG-1587b, paratype; E, lateral view; F, ventral view; G, lateral view rotated 90 degrees from F; H, dorsal view; **I–L**, HMG-1587d, paratype; I, lateral view; J, ventral view; K, lateral view rotated 90 degrees from J; L, frontal view; **M–P,** HMG-1587a, holotype; M, lateral view; N, ventral view; O, lateral view rotated 90 degrees from N; P, dorsal view; **Q**, suture line of holotype, taken at white arrow in view (P). Solid line represents the siphuncle, and broken line indicates the middle dorsal position.

broadly interspaced ribs (Okamoto and Shibata, 1997), but is easily distinguished by its deeply incised, trifid dorsal lobe (Figure 1Q). *Poly. pseudogaultinum* has a slightly incised, trifid dorsal lobe (Yokoyama, 1890, pl. 20, fig. 2a).

Discussion.—The four specimens described here were collected from a single calcareous concretion, and even though they were not connected to each other, the compact nature of their occurrence in the concretion suggests that they probably belong to the same individual (Figure 2).

Parts of U-shaped whorls are observable on the adapical end of HMG-1587a and the adoral end of HMG-1587b, and since these shafts were preserved adjacently

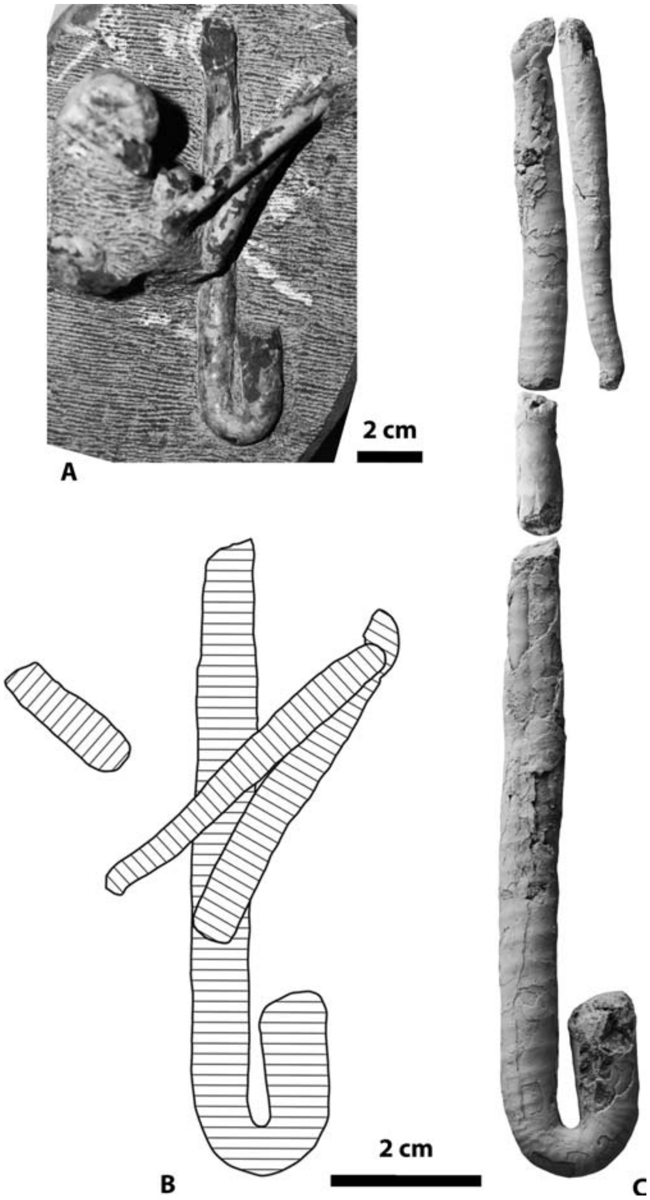

Figure 2. *Phylloptychoceras horitai* Shigeta and Nishimura sp. nov., HMG-1587a–d, from the Hobetsu area, Hokkaido. **A**, mode of occurrence in a calcareous concretion; **B**, diagrammatic sketch; **C**, reconstruction of the shell.

in the concretion, they most likely were connected to each other before fragmentation. Specimen 1587c probably connected the adoral end of HMG-1587a with the adapical end of body chamber HMG-1587d, because the last septum is observable in HMG-1587c. If they did connect with each other in this manner, then the straight shaft is at least 155 mm long (Figure 2).

Occurrence.—HMG-1587a–d were found in a float calcareous concretion together with *Tetragonites terminus* Shigeta, 1989 (HMG-1588) and *Damesites hetonaiensis* Matsumoto, 1954 (HMG-1589). Although the exact horizon from which the concretion originated is uncertain, judging from the locality where it was found, its lithology and co-occurring fossils, it almost certainly came from the sandy mudstone of Unit IVb of the Hakobuchi Formation, which can be correlated with the *Nostoceras hetonaiense* Zone of earliest Maastrichtian age (Toshimitsu *et al*. 1995).

Discussion

Early species of *Phylloptychoceras* are restricted to the North Pacific realm. Anderson (1958) described a small specimen as *Neocyrtochilus bryani* from the upper Campanian or lower Maastrichtian of California. Although the suture line, one of the most significant diagnostic characters, has never been illustrated, it was apparently assigned to *Phylloptychoceras* only on the basis of its similar shell morphology and ornamentation (Kennedy and Henderson, 1992). This evidence plus the fact that *Ph. horitai* sp. nov. occurs in the lowest Maastrichtian of Hokkaido suggests that *Phylloptychoceras* probably originated in the North Pacific realm during late Campanian or early Maastrichtian time.

Among the family Diplomoceratidae, *Phylloptychoceras* and *Polyptychoceras* share a trombone-shaped shell, oblique ribs, a lack of tuberculation, and a simple suture line with a trifid dorsal lobe (Wright *et al*., 1996), all of which suggest a close phylogenetic relationship (Spath, 1953). Several species of *Polyptychoceras* occur in the Coniacian to upper Campanian of Hokkaido (Yokoyama, 1890; Jimbo, 1894; Yabe, 1927; Wright and Matsumoto, 1954; Matsumoto, 1977, 1984b; Matsumoto and Nihongi, 1979; Okamoto and Shibata, 1997) and the upper Santonian and lower Campanian on Vancouver Island (Whiteaves, 1879). Notwithstanding the occurrence of *Polyptychoceras* in the upper Campanian or basal Maastrichtian of Angola (Howarth, 1965) and the reported occurrence of questionable fragments from the upper Santonian to Campanian of northern Germany (Schlüter, 1872; Wiedmann, 1962) and the upper Campanian of Graham Land of the Antarctic Peninsula (Spath, 1953), the flourishing of *Polyptychoceras* and appearance of early species of *Phylloptychoceras* in the North Pacific realm suggests that *Phylloptychoceras* originated from *Polyptychoceras* in this province. The suggestion seems to be supported by the morphological similarity between *Ph. horitai* sp. nov. and *Poly. pseudogaultinum*.

Reports of *Phylloptychoceras* from the upper Maastrichtian of Europe (Birkelund, 1993; Ward and Kennedy, 1993; Jagt *et al*., 2006), southern India (Forbes, 1846; Kennedy and Henderson, 1992) and Chile

(Stinnesbeck, 1986) suggest that this genus most likely extended its geographical distribution during late Maastrichtian time. Although the occurrence of this late Maastrichtian taxon in the North Pacific realm has not yet been accurately documented, the late Maastrichtian ammonoid fauna of the Northwest Pacific does include certain pandemic species, i.e., *Zelandites varuna* (Forbes, 1846) and *Pseudophyllites indra* (Forbes, 1846), which contrasts with the early Maastrichtian ammonoid fauna, which is characterized by many endemic or North Pacific species (Maeda *et al*., 2005). The previous scarce record of *Phylloptychoceras* in the upper Maastrichtian in the Pacific realm seems superficial because the circum-Pacific upper Maastrichtian sections remain largely to be investigated in detail.

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References

Anderson, F. M., 1958: Upper Cretaceous of the Pacific Coast. *Geological Society of America Memoir*, vol. 71, p. 1–378.

Birkelund, T., 1993: Ammonites from the Maastrichtian White Chalk of Denmark. *Bulletin of the Geological Society of Denmark*, vol. 40, p. 33–81.

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*, vol. 7, p. 97–174.

Gill, T., 1871: Arrangement of the families of mollusks. *Smithsonian Miscellaneous Collections*, vol. 227, p. 1–49.

Henderson, R. A., 1970: Ammonoidea from the Mata Series (Santonian–Maastrichtian) of New Zealand. *Special Papers in Palaeontology*, vol. 6, p. 1–82.

Howarth, M. K., 1965: Cretaceous ammonites and nautiloids from Angola. *Bulletin of the British Museum (Natural History), Geology*, vol. 10, p. 335–412.

Jagt, J. W. M., Goolaerts, S., Jagt-Yazykova, E. A., Cremers, G. and Verhesen, W., 2006: First record of *Phylloptychoceras* (Ammonoidea) from the Maastrichtian type area, The Netherlands. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, vol. 76, p. 97–103.

Jimbo, K., 1894: Beiträge zur Kenntniss der Fauna der Kreideformation von Hokkaido. *Paläontologische Abhandlungen, Neue Folge*, vol. 2, p. 149–194.

Kennedy, W. J. and Henderson, R. A., 1992: Heteromorph ammonites from the Upper Maastrichtian of Pondicherry, South India. *Palaeontology*, vol. 35, p. 693–731.

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*, vol. 31, p. 25–120.

Marshall, P., 1926: The upper Cretaceous ammonites of New Zealand. *Transactions and Proceedings of the New Zealand Institute*, vol. 56, p. 129–210.

Matsumoto [= Matumoto], T., 1942: Fundamentals in the Cretaceous stratigraphy of Japan, Part 1. *Memoirs of the Faculty of Science, Kyushu Imperial University, Series D, Geology*, vol. 1, p. 129–280.

Matsumoto, T., 1947: A note on the Japanese Pachydiscidae. *Science Reports of the Faculty of Science, Kyushu University, Geology*, vol. 2, p. 34–46. (*in Japanese*)

Matsumoto, T., 1952: Appendix. Notes on a new species of *Inoceramus*. *In*, Tanaka, K., Matsumoto, T. and Maeda, Y. *eds.*, The Izumi Group in the southernmost part of the Island of Awaji. *Journal of Geography* (*Chigaku Zasshi*), vol. 61, p. 67–72. (*in Japanese with English abstract*)

Matsumoto, T., 1954: *The Cretaceous System in the Japanese Islands*, 324 p. Japan Society for the Promotion of Science, Tokyo.

Matsumoto, T., 1977: Some heteromorph ammonites from the Cretaceous of Hokkaido. *Memoirs of Faculty of Science, Kyushu University, Series D, Geology*, vol. 23, p. 303–366.

Matsumoto, T., 1979: Palaeontological descriptions Part 1. Some new species of *Pachydiscus* from the Tombetsu and the Hobetsu Valleys. *In*, Matsumoto, T., Kanie, Y. and Yoshida S. *eds.*, Notes on *Pachydiscus* from Hokkaido. *Memoirs of Faculty of Science, Kyushu University, Series D, Geology*, vol. 24, p. 47–73.

Matsumoto, T., 1984a: Some gaudryceratid ammonites from the Campanian and Maastrichtian of Hokkaido. Part 1. *Science Report of the Yokosuka City Museum*, no. 32, p. 1–10.

Matsumoto, T., 1984b: Some ammonites from the Campanian (Upper Cretaceous) of northern Hokkaido. Part 1. Ammonites from the Upper Campanian of the Teshio Mountains. *Palaeontological Society of Japan, Special Paper*, no. 35, p. 5–32.

Matsumoto, T. and Morozumi, Y., 1980: Late Cretaceous ammonites from the Izumi Mountains, Southwest Japan. *Bulletin of the Osaka Museum of Natural History*, no. 33, p. 1–31.

Matsumoto, T. and Nihongi, M., 1979: An interesting mode of occurrence of *Polyptychoceras* (Cretaceous heteromorph ammonite). *Proceedings of the Japan Academy, Series B*, vol. 55, p. 115–119.

Matsumoto, T. and Saito, R., 1954: A nearly smooth pachydiscid from Hokkaido, Japan. *Japanese Journal of Geology and Geography*, vol. 24, p. 87–92.

Matsumoto, T. and Toshimitsu, S., 1992: On a leading ammonite species *Pachydiscus kobayashii* from the Hobetsu district, Hokkaido. *Bulletin of the Hobetsu Museum*, no. 8, p. 1–16.

Matsumoto, T. and Toshimitsu, S., 1995: Restudy of *Gaudryceras venustum* Matsumoto from the Hobetsu district, Hokkaido. *Bulle-*

tin of the Hobetsu Museum, no. 11, p. 1–16.

Matsumoto, T. and Toshimitsu, S., 1996: A phylloceratid ammonite species from the Maastrichtian of the Hobetsu district, Hokkaido. *Bulletin of the Hobetsu Museum*, no. 12, p. 1–8.

Matsumoto, T., Toshimitsu, S. and Noda, M., 1993: On a Maastrichtian (Cretaceous) inoceramid species *Sphenoceramus hetonaianus* (Matsumoto) from the Hobetsu district, Hokkaido. *Bulletin of the Hobetsu Museum*, no. 9, p. 1–20.

Michael, R., 1899: Über Kreidefossilien von der Insel Sachalin. *Jahrbuch der Königlich Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin*, Bd. 18, p. 153–164.

Moore, R. C., 1957: *Treatise on Invertebrate Paleontology, Part* L, *Mollusca 4, Cephalopoda, Ammonoidea*, 490 p. Geological Society of America, New York, and University of Kansas Press, Lawrence.

Okamoto, T. and Shibata, M., 1997: A cyclic mode of shell growth and its implications in a Late Cretaceous heteromorph ammonite *Polyptychoceras pseudogaultinum* (Yokoyama). *Paleontological Research*, vol. 1, p. 29–46.

Schlüter, C., 1872: Cephalopoden der oberen deutschen Kreide. *Palaeontographica*, vol. 22, p. 25–120.

Shigeta, Y., 1989: Systematics of the ammonite genus *Tetragonites* from the Upper Cretaceous of Hokkaido. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series*, no. 156, p. 319–342.

Shigeta, Y. and Nishimura, T., 2013: A new species of *Gaudryceras* (Ammonoidea, Gaudryceratidae) from the lowest Maastrichtian of Hokkaido, Japan and its biostratigraphic implications. *Paleontological Research*, vol. 17, p. 47–57.

Shigeta, Y., Tanabe, K. and Izukura, M., 2010: *Gaudryceras izumiense* Matsumoto and Morozumi, a Maastrichtian ammonoid from Hokkaido and Alaska and its biostratigraphic implications. *Paleontological Research*, vol. 14, p. 202–211.

Shimizu, S., 1935: The Upper Cretaceous cephalopods of Japan, Part 1. *Journal of the Shanghai Science Institute, Section II*, vol. 1, p. 159–226.

Spath, L. F., 1926: On new ammonites from the English Chalk. *Geological Magazine*, vol. 63, p. 77–83.

Spath, L. F., 1953: The Upper Cretaceous cephalopod fauna of Graham Land. *Falkland Islands Dependencies Survey, Science Report*, vol. 3, p. 1–60.

Stinnesbeck, W., 1986: Zu den faunistischen und palökologischen Verhältnissen in der Quiriquina Formation (Maastrichtium), Zentrales-Chiles. *Palaeontographica, Abteilung A*, vol. 194, p. 99–237.

Tanaka, K., 1960: Cretaceous deposits in the Tomiuchi district, southern Central Hokkaido. *Bulletin of the Geological Survey of Japan*, vol. 11, p. 543–554. (*in Japanese with English abstract*)

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*, vol. 101, p. 19–29. (*in Japanese with English abstract*)

Ward, P. D. and Kennedy, W. J., 1993: Maastrichtian ammonites from the Biscay region (France, Spain). *The Paleontological Society Memoir*, vol. 34, p. 1–58.

Whiteaves, J. F., 1879: On the fossils of the Cretaceous rocks of Vancouver and adjacent islands in the Strait of Georgia. *Geological Survey of Canada, Mesozoic Fossils*, vol. 1, part 2, p. 93–190.

Wiedmann, J., 1962: Ammoniten aus der Vascogotischen Kreide (Nordspanien) 1. Phylloceratina, Lytoceratina. *Palaeontographica Abteilung A*, Bd. 118, p. 119–237.

Wright, C. W., Callomon, J. H. and Howarth, M. K., 1996: *Treatise on Invertebrate Paleontology, Part L, Mollusca 4, Revised, Vol. 4, Cretaceous Ammonoidea*, 362 p. Geological Society of America, Boulder, and University of Kansas Press, Lawrence.

Wright, C. W. and Matsumoto, T., 1954: Some doubtful Cretaceous ammonite genera from Japan and Saghalien. *Memoirs of Faculty of Science, Kyushu University, Series D, Geology*, vol. 4, p. 107–134.

Yabe, H., 1927: Cretaceous stratigraphy of the Japanese Islands. *Science Reports of the Tohoku Imperial University, Second Series (Geology)*, vol. 11, p. 27–100.

Yokoyama, M., 1890: Versteinerung aus der japanischen Kreide. *Palaeontographica*, vol. 36, p. 159–202.