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Original Article

Ontogeny of *Canadoceras kossmati* Matsumoto, a Campanian pachydiscid ammonoid from Hokkaido, Japan

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Abstract. Ontogenetic shell development of *Canadoceras kossmati* Matsumoto is studied from a diameter 20 to 120 mm by gradually removing preceding outer whorl section from a well-preserved specimen extracted from a float calcareous concretion found in the middle course of the Nukibetsu River, in the Asahi area in Biraori Town, southern central Hokkaido. At a diameter of about 20 mm, the specimen exhibits a moderately wide umbilicus and fairly depressed whorl section. Ornamentation consists of numerous, prorsiradiate ribs as well as prominent major ribs with umbilical tubercles and shallow constrictions followed immediately by major ribs. Intercalated ribs arise at an inner to mid-flank position. As diameter increases, the whorl section gradually becomes more compressed, and relative umbilical width becomes slightly greater. Ribs become much coarser and more distant, major ribs increase in strength, and the distinctive umbilical tubercles characteristic of major ribs at smaller diameter gradually lose strength and become bluntly rounded. This ontogenetic shell development suggests that *C. kossmati* is clearly distinguishable from the holotypes of the other three *Canadoceras* species from the middle Campanian *Sphenoceramus schmidti*-bearing beds of the Yezo Group: *C. yokoyamai*, *C. mysticum* and *C. minimum*.

Key wards: ammonoid, Campanian, *Canadoceras kossmati*, Cretaceous, Hokkaido, ontogeny
(Recieved 11 October 2017)

Introduction

Specimens referable to *Canadoceras* Spath, 1922 (Ammonoidea, Pachydiscidae) occur in the middle Campanian of the Yezo Group in Hokkaido and Sakhalin, and are relatively common in the *Sphenoceramus schmidti*-bearing beds (Matsumoto, 1954; Pyarkova, 1987; Zonova *et al*., 1993; Shigeta *et al*., 1999; Kodama *et al*., 2002; Maeda *et al*., 2005, 2010), from which the following four species have been described: *C. yokoyamai* (Jimbo, 1894), *C. kossmati* Matsumoto, 1954, *C. mysticum* Matsumoto, 1954, and *C. minimum* Matsumoto and Miyauchi, 1984. The relatively small-sized type specimens of these species (30 to 100 mm in shell diameter) are probably immature shells and consequently, it is difficult to identify medium to large-sized specimen at the species level because ontogenetic shell development has not yet been clarified for each taxon.

Non-deformed ammonoid specimens with preserved inner whorls are often found in calcareous concretions in the Yezo Group, and ontogenetic shell development can be observed by gradually removing the preceding whorl section in ~1/4 whorl increments. Many authors have studied the ontogenetic shell growth of ammonoids from the Yezo Group in this manner (Matsumoto, 1953; Matsumoto and Obata, 1955; Hirano, 1975; Tanabe, 1977; Obata *et al*., 1979; Tanabe and Shigeta, 1987; Shigeta, 1989; Maeda, 1993; Nishimura *et al*., 2006, etc.).

A fairly large-sized, well-preserved specimen assignable to *Canadoceras*, which was collected by Toshio Shimanuki (Sapporo, Hokkaido), is housed in the National Museum Nature and Science (Tsukuba). In this paper, I describe its ontogenetic shell development and discuss its relationship with previously described species of *Canadoceras*.

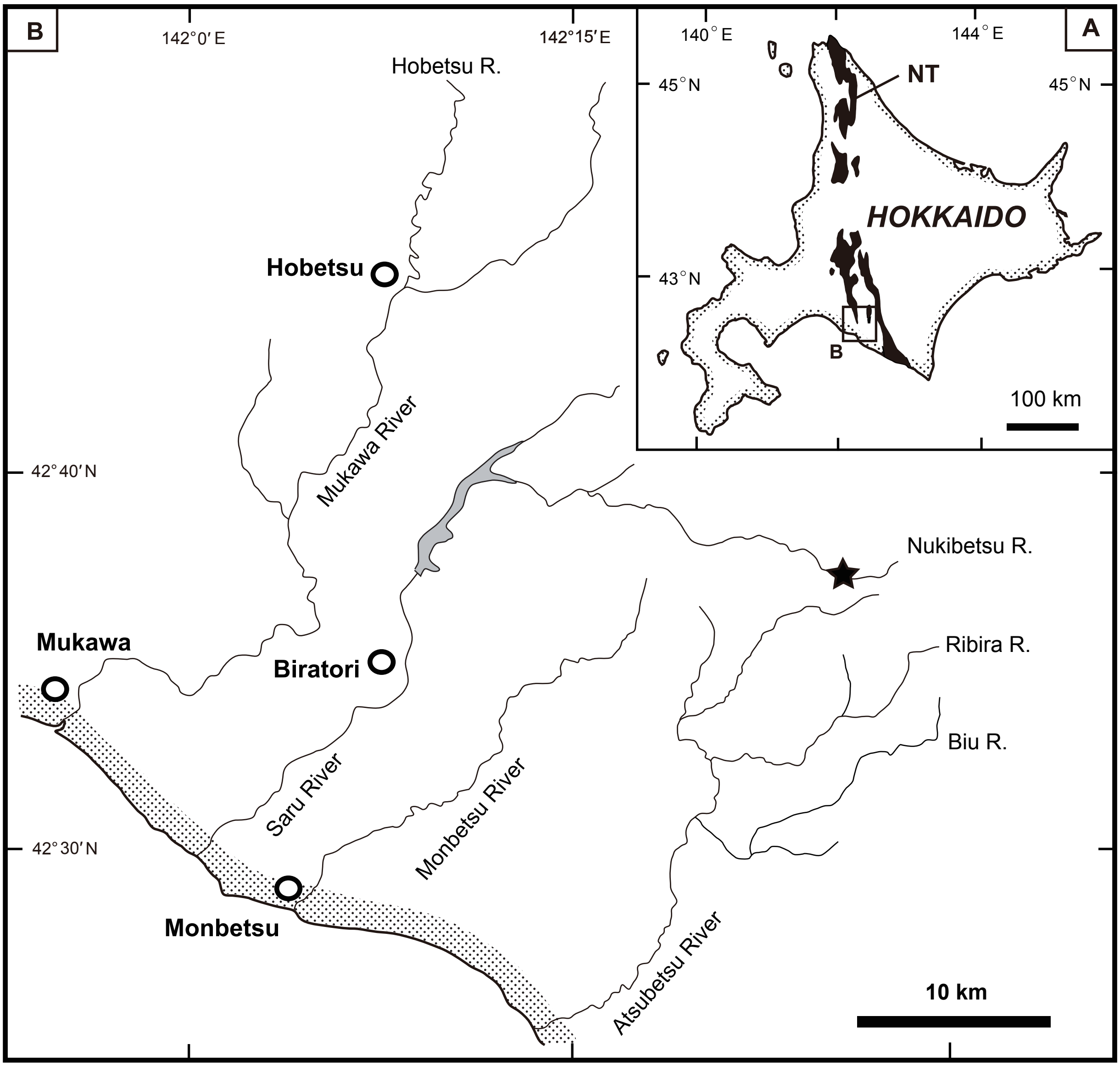

Figure 1. Index map showing distribution of the Yezo Group (black areas) in Hokkaido (**A**) and collection locality of the *Canadoceras kossmati* specimen in the Asahi area in Biraori Town (indicated by star, **B**). NT, Nakatonbetsu.

Material and methods

Material

A single specimen (NMNS PM35190), measuring about 150 mm in diameter, was examined in this study. It was extracted from a float calcareous concretion found in the middle course of the Nukibetsu River, a tributary of the Saru River, in the Asahi area in Biratori Town, southern central Hokkaido, where fossiliferous middle Campanian strata of the Yezo Group are distributed in a narrow band (Figure 1; Yoshida *et al*., 1959; Kanie and Kawashita, 1981; Masuda *et al*., 2013). Although the exact horizon from which the concretion originated is uncertain, judging from where it was found and its lithology, it almost certainly came from the sandy mudstone of the *Sphenoceramus schmidti*-bearing beds.

Methods

In order to perform a biometric analysis of the specimen's shell morphology, its outer whorl was removed in four segments of about one quarter whorl each, and then shell diameter (D), umbilical diameter (U), whorl height (H) and whorl width (W), were measured for each remaining shell with the aid of a slide caliper (accuracy, ±0.05 mm). Two geometric parameters, relative umbilical size (U/D) and relative whorl thickness (W/H), were calculated for each shell.

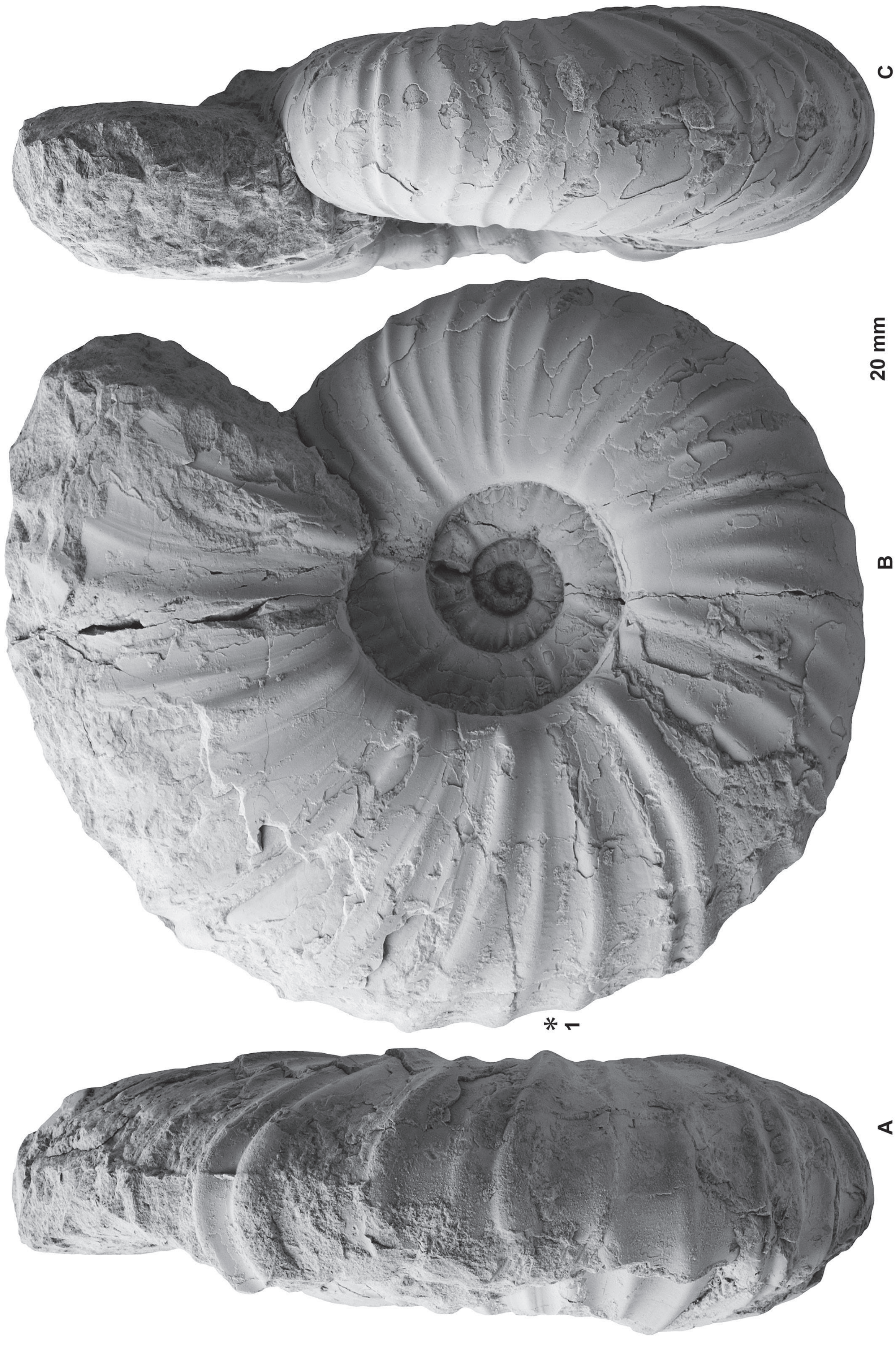

Figure 2. Original specimen of *Canadoceras kossmati* Matsumoto, 1954, NMNS PM35190, from the Asahi area in Biraori Town, southern central Hokkaido. Figures 3–5 illustrate the same specimen following the removal of successive ~1/4 whorl segments. **A**, ventral view; **B**, left lateral view; **C**, apertural view. Numbered asterisk (1) indicates position where whorl segment was removed, resulting in Figure 3A–C.

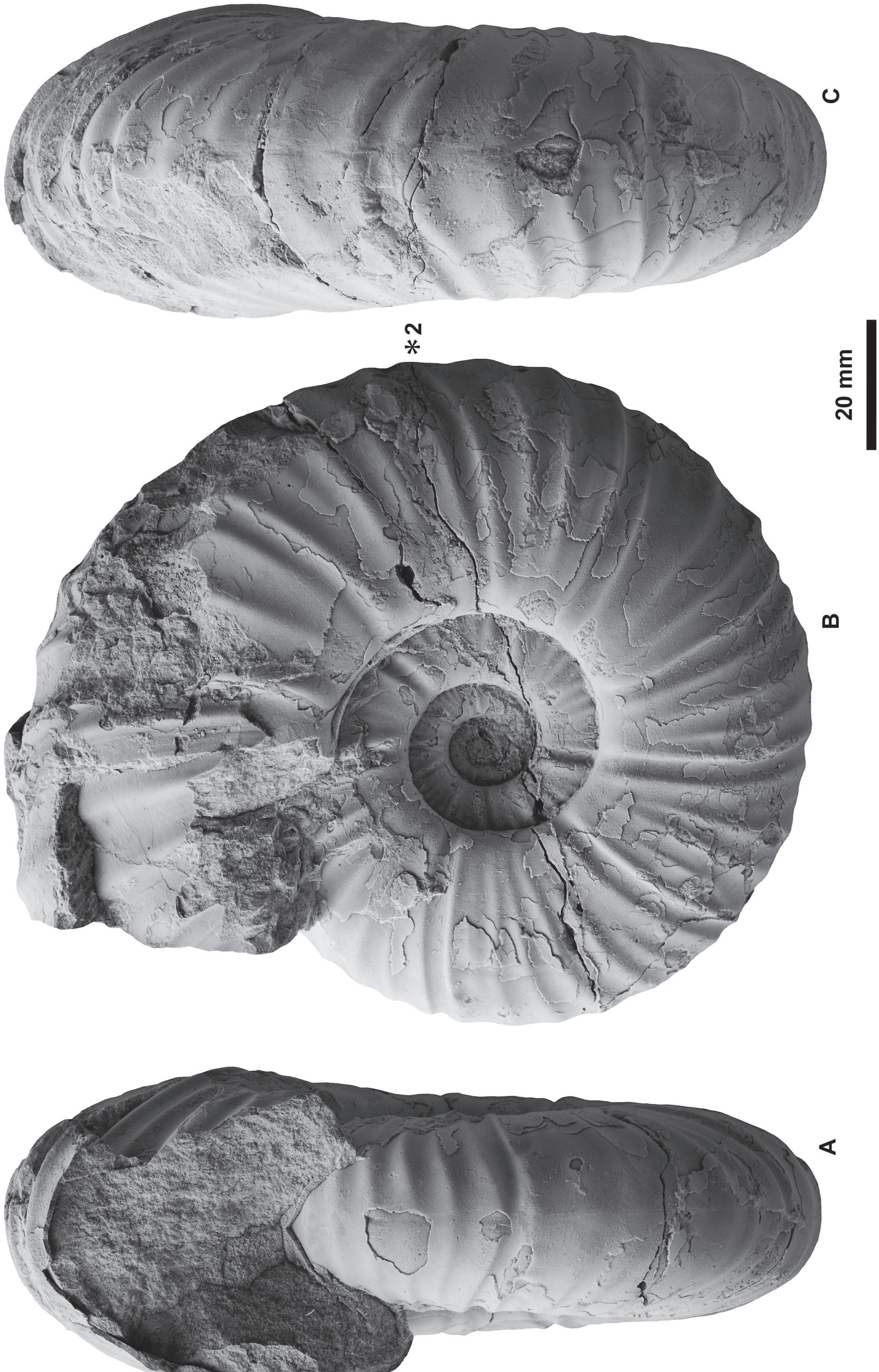

Figure 3. **A**, apertural view; **B**, right lateral view; **C**, ventral view. Numbered asterisk (2) indicates position where whorl segment was removed, resulting in Figure 4A–C.

Figure 4. **A**, **D**, right lateral views; **B**, **E**, apertural views; **C**, **F**, ventral views; **G**, left lateral view. Numbered asterisks (3) and (4) indicate positions where whorl segments were removed, resulting in Figure 4D–G and Figure 5A–D, respectively.

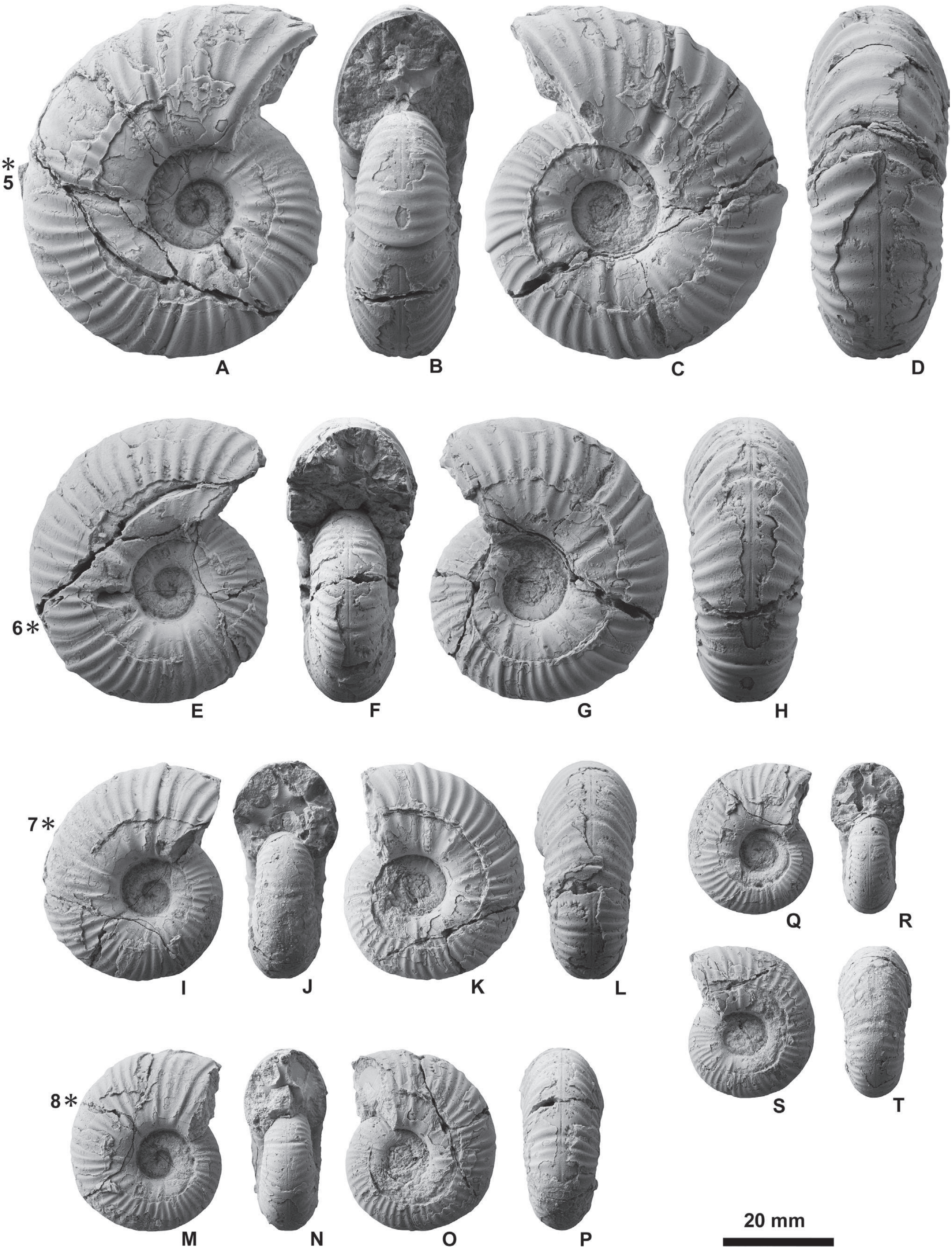

Figure 5. **A**, **E**, **I**, **M**, **Q**, left lateral views; **B**, **F**, **J**, **N**, **R**, apertural views; **C**, **G**, **K**, **O**, **S**, right lateral views; **D**, **H**, **L**, **P**, **T**, ventral views. Numbered asterisks (5) to (8) indicate positions where whorl segments were removed, resulting in Figure 5E–H, I–L, M–P and Q–T, respectively.

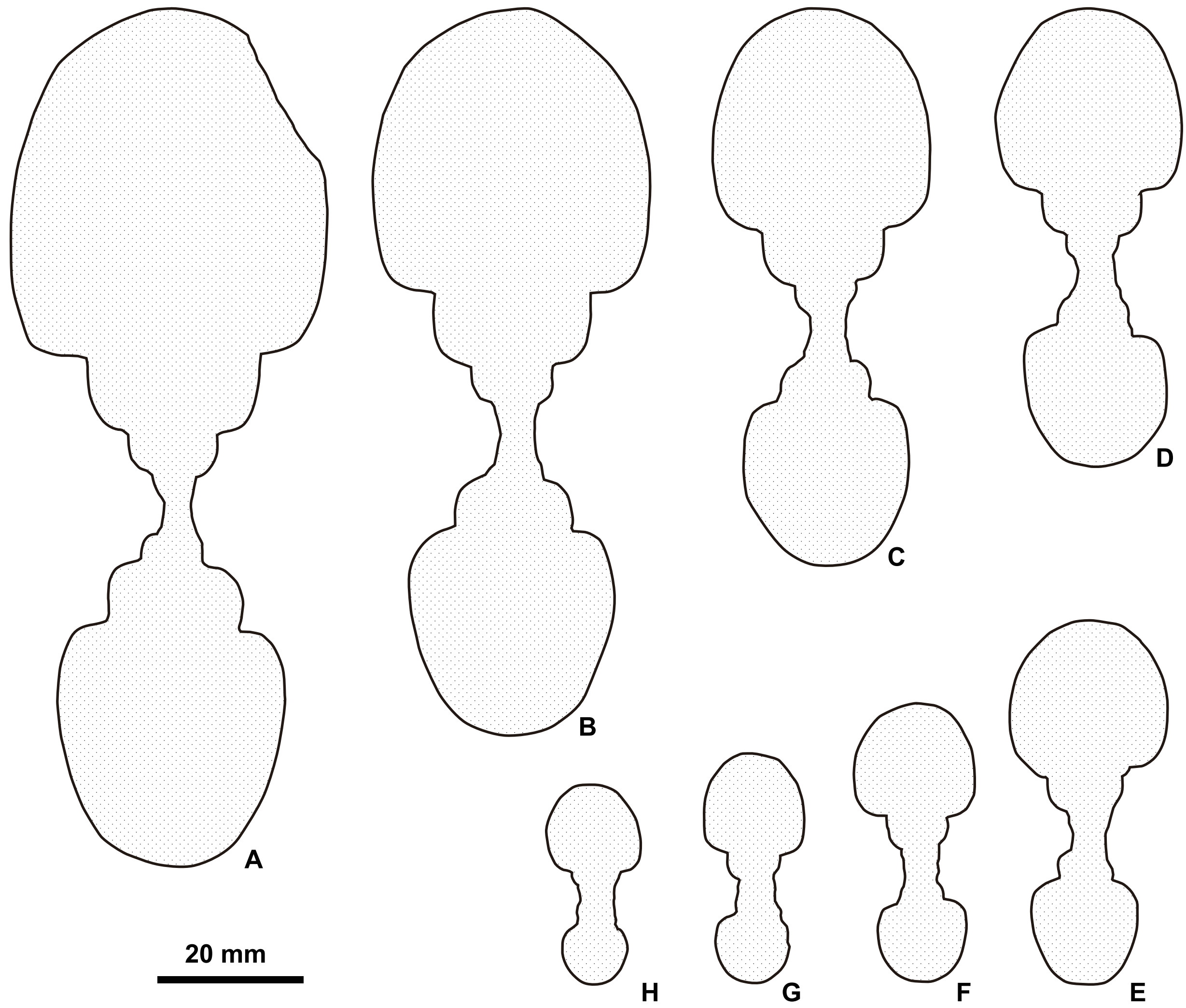

Figure 6. Whorl cross sections of *Canadoceras kossmati* Matsumoto, 1954, NMNS PM35190, from the Asahi area in Biraori Town, southern central Hokkaido (**A–H**).

Ornamentation was also observed at each stage.

Each conch was photographed from three or four directions (left and/or right lateral, apertural, and ventral views, Figures 2–5), and two plaster casts were made of each. Whorl cross sections were examined by cutting the respective plaster casts (Figure 6). All fragments of the original specimen and one set of plaster casts are kept in the National Museum Nature and Science (Tsukuba) and the other set of plaster casts (HMG-1989a–i) is kept in the Hobetsu Museum (Mukawa, Hokkaido).

Results

Ontogenetic changes in whorl morphology expressed by umbilical width (*U/D*) and whorl thickness (*W/H*) versus shell diameter (*D*), show a slight increase in umbilical width and a more noticeable decrease in whorl thickness with growth (Figure 7, Table 1). At a diameter of about 20 mm, the specimen exhibits a moderately wide umbilicus (*U/D* = 0.28) and fairly depressed whorl section (*W/H* = 1.13). As diameter increases, the whorl section gradually becomes more compressed and umbilical size becomes slightly wider. At a diameter of 120 mm, the shell has a slightly wider umbilicus (*U/D* = 0.31) and fairly compressed whorl section (*W/H* = 0.91).

Ornamentation at a diameter of about 20 mm consists of numerous, prorsiradiate ribs as well as prominent major ribs with umbilical tubercles and shallow constrictions followed immediately by major ribs. Intercalated ribs arise at the inner to mid-flank position. After crossing the flank, the ribs project gently forward on the ventrolateral shoulders, before crossing

Table 1. Measurements (in mm) of herein described specimen of *Canadoceras kossmati* Matsumoto, 1954, NMNS PM35190, from the Asahi area in Biraori Town, southern central Hokkaido. *D*, shell diameter; *U*, umbilical diameter; *H*, whorl height; *W*, whorl width.

D	*U*	*H*	*W*	*U/D*	*W/H*
21.0	6.0	8.9	10.1	0.28	1.13
27.3	7.8	13.1	12.1	0.29	1.08
31.4	9.0	14.4	13.6	0.29	1.06
38.2	11.0	16.5	16.0	0.29	1.03
50.0	14.5	21.4	21.7	0.29	0.99
62.7	19.0	25.0	26.0	0.30	0.96
77.0	23.1	29.0	30.7	0.30	0.94
85.0	26.7	33.8	31.4	0.31	0.93
99.8	31.2	37.0	40.3	0.31	0.92
117.6	36.3	43.2	47.5	0.31	0.91
143.0	44.5	—	—	0.31	—

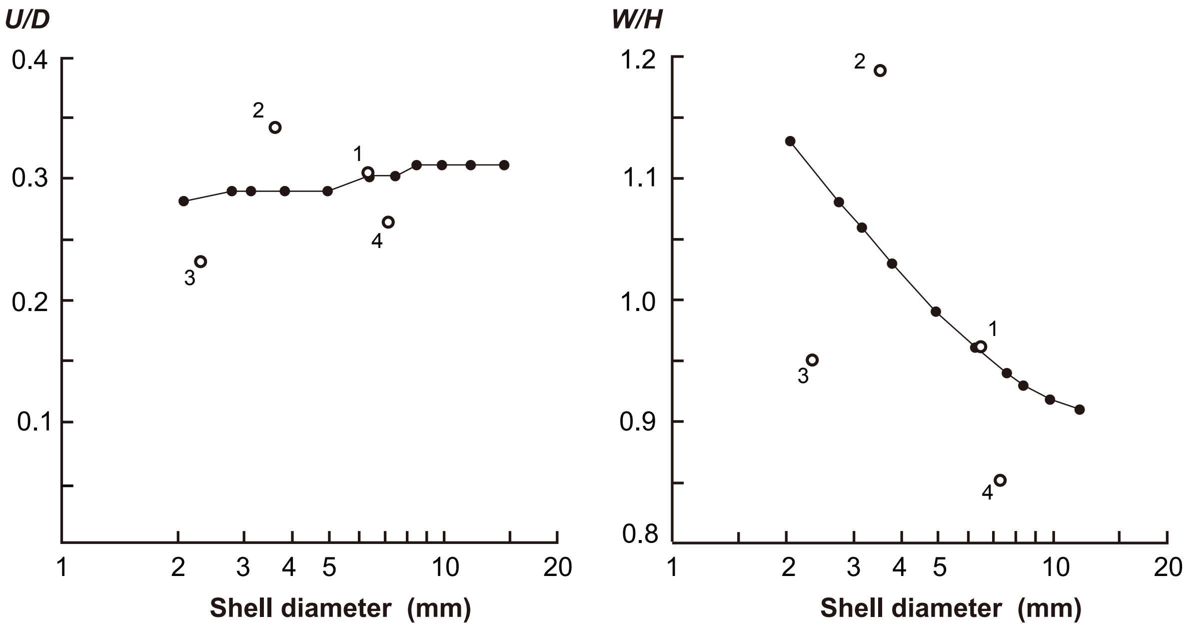

Figure 7. Scatter diagrams of *U/D* (umbilical diameter/shell diameter) versus *D* (shell diameter) and *W/H* (whorl width/ whorl height) versus *D* (shell diameter) for *Canadoceras kossmati* Matsumoto, 1954 (solid circles, NMNS PM35190, the shells illustrated in Figures 2–5 above) and holotypes of the four *Canadoceras* species described from the middle Campanian *Sphenoceramus schmidti*-bearing beds in the Yezo Group (open circles). Open circle numbers correspond as follows. 1, *C. kossmati*, UMUT MM7650; 2, *C. yokoyamai* (Jimbo, 1894), UMUT MM7511; 3, *C. mysticum* Matsumoto, 1956, GK. H5184; 4, *C. minimum* Matsumoto and Miyauchi, 1984, GK. H5976. Note that the ratios *U/D* vs *D* and *W/H* vs *D* for the holotype of *C. kossmati* agree perfectly with ontogenetic curve for NMNS PM35190, while the ratios for the other three holotypes clearly represent different morphologies.

the venter in a convex arch (Figure 5Q–T). As the shell grows, its ribs become much coarser and more distant, major ribs increase in strength and the distinctive umbilical tubercles on these ribs become less prominent and more bluntly rounded (Figures 3–5). At a diameter of 120 mm, the shell has prominent major ribs with umbilical bullae, two or three intercalated ribs that begin on the umbilical shoulder or inner flank, and shallow constrictions followed immediately by major ribs (Figure 2).

Discussion

Canadoceras kossmati described by Matsumoto (1954, p. 295, p. 13, fig. 1), was based on an immature

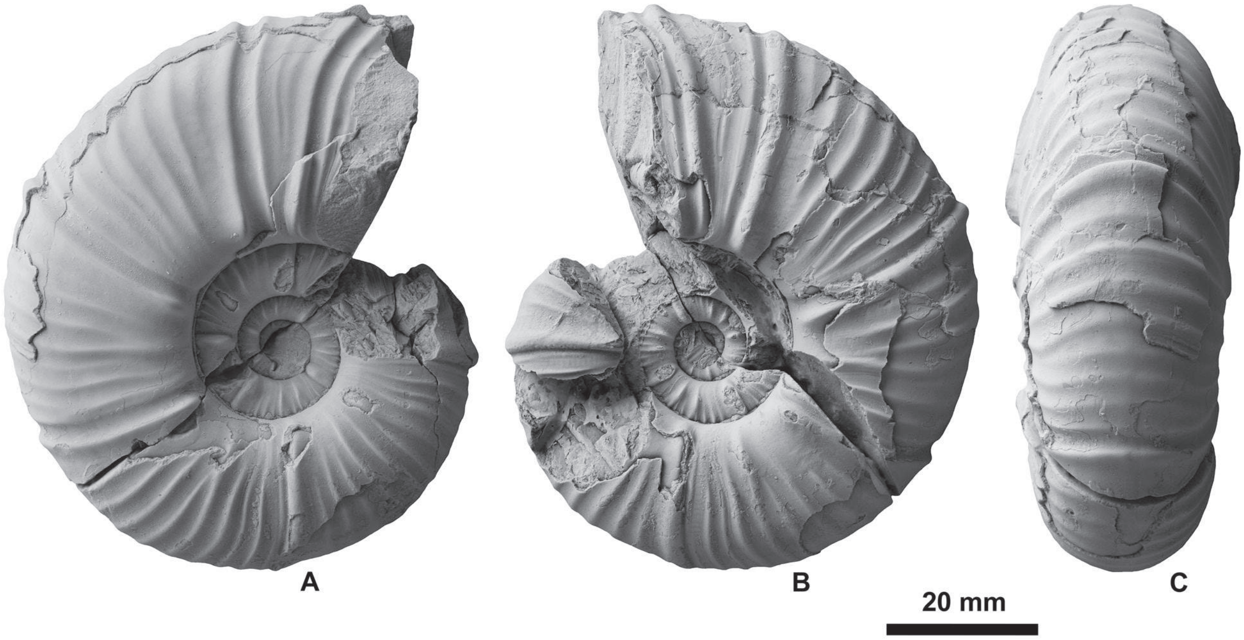

Figure 8. *Canadoceras kossmati* Matsumoto, 1954, UMUT MM7650 (holotype), from the Nakatonbetsu area, northern Hokkaido. Its exact collection locality and horizon are unknown. **A**, left lateral view; **B**, right lateral view; **C**, ventral view.

holotype (UMUT MM7650, about 77 mm in diameter) from the Nakatonbetsu area, northern Hokkaido (Figure 8). The values of the two geometric parameters (*U/D*, *W/H*) for the holotype exactly match those of NMNS PM35190 at an equivalent diameter (~*D* = 65 mm, *U/D* = 0.30, *W/H* = 0.96; Figure 7). This observation suggests that NMNS PM35190 is assignable to *Canadoceras kossmati* and its growth pattern represents the ontogenetic shell development of *Canadoceras kossmati*.

Three additional species of *Canadoceras* have been described from the middle Campanian *Sphenoceramus schmidti*-bearing beds of the Yezo Group. *Canadoceras yokoyamai*, described by Jimbo (1894, p. 31, pl. 2, fig. 3), was based on an immature specimen (UMUT MM7511, ~45 mm in shell diameter) from the Nakatonbetsu area, northern Hokkaido. A comparison of shell growth patterns reveals that the holotype of *C. yokoyamai* is much more depressed and its umbilicus is wider than *C. kossmati*. Both species can be clearly distinguished at equivalent sizes (Figure 7). The holotypes of *Canadoceras mysticum*, GK. H5158 (Matsumoto, 1954, p. 307, pl. 19, fig. 1) from the Nakagawa area, and *C. minimum*, GK. H5976 (Matsumoto and Miyauchi, 1984, p. 50, pl. 20, fig. 1) from the Soya area are much more compressed and their umbilicus are narrower than *C. kossmati*. Their shell morphology also clearly differs from *C. kossmati* at equivalent sizes (Figure 7).

Matsumoto (1954, p. 295) also described various sized specimens from Hokkaido and Sakhalin as *Canadoceras kossmati* in addition to an immature holotype. Many of them show similar features in shell shape and ornamentation as observed in NMNS PM35190, suggesting that his assignment was reasonable. However, GK. H3440 differs from NMNS PM35190 in its growth pattern. The whorl section of GK. H3440 is fairly compressed (*W/H* = 0.89) at a diameter of 29 mm, becomes more depressed as diameter increases, and exhibits *W/H* = 0.97 at a diameter of 79 mm (measurements after Matsumoto). Because the trend of the change in whorl section is different from NMNS PM35190, which becomes more slender during ontogeny (Figure 7), GK. H3440 may not be assignable to *C. kossmati*. A study of the ontogenetic shell development of other species of *Canadoceras* may provide important keys for correct species assignment.

Concluding remarks

This study documents the ontogenetic shell development of *Canadoceras kossmati* up to a diameter of 120 mm based on a single specimen. However, since adult shells of *C. kossmati* probably exceed 500 mm in diameter, it thus becomes necessary to study the ontogenetic shell development of specimens larger than 120 mm. Furthermore, the taxonomic validity of external shell characters, i.e., whorl shape and ornamentation, should be confirmed by studies of large samples.

Acknowledgments

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References

Hirano, H., 1975: Ontogenetic study of Late Cretaceous *Gaudryceras tenuiliratum*. *Memoirs of the Faculty of Science*, *Kyushu University*, *Series D*, *Geology*, vol. 22, p. 165–192.

Jimbo, K., 1894: Beiträge zur Kenntniss der Fauna der Kreideformation von Hokkaido. *Palaeontologische Abhandlungen Neue Folge*, Band 2, p. 1–48.

Kanie, Y. and Kawashita, Y., 1981: Occurrence of a giant capulid gastropod from the Upper Cretaceous of the Kaminukibetsu area, southern-central Hokkaido. *Science Report of the Yokosuka City Museum*, no. 28, p. 85–90.

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*, vol. 108, p. 366–384. (*in Japanese with English abstract*)

Masuda, A., Sato, T. and Nishimura, T., 2013: A plesiosaurian fossil from the Upper Cretaceous in Nukibetsu River, Biratori, Hokkaido. *Bulletin of the Hobetsu Museum*, no. 28, p. 7–12.

Matsumoto, T., 1953: The ontogeny of *Metaplacenticeras subtilistriatum* (Jimbo). *Japanese Journal of Geology and Geography*, vol. 23, p. 139–150.

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

Matsumoto, T. and Miyauchi, T., 1984: Some Campanian ammonites from the Soya area. *Palaeontological Society of Japan*, *Special Paper*, no. 27, p. 33–76.

Matsumoto, T. and Obata, I., 1955: Some Upper Cretaceous desmoceratids from Hokkaido and Saghalien. *Memoirs of the Faculty of Science*, *Kyushu University*, *Series D*, *Geology*, vol. 5, p. 119–151.

Maeda, H., 1993: Dimorphism of Late Cretaceous false-Puzosiine ammonites, *Yokoyamaoceras* Wright and Matsumoto, 1954 and *Neopuzosia* Matsumoto, 1954. *Transactions and Proceedings of the Palaeontological Society of Japan*, *New Series*, no. 169, p. 97–128.

Maeda, H., Kumagae, T., Matsuoka, H. and Yamazaki, Y., 2010: Taphonomy of large *Canadoceras* (ammonoid) shells in the Upper Cretaceous Series in South Sakhalin, Russia. *Paleontological Research*, vol. 14, p. 56–68.

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.

Nishimura, T., Maeda, H. and Shigeta, Y., 2006: Ontogenetic shell development of a Cretaceous desmoceratine ammonoid "*Tragodesmoceroides subcostatus*" Matsumoto, 1942 from Hokkaido, Japan. *Paleontological Research*, vol. 10, p. 11–28.

Obata, I., Tanabe, K. and Futakami, M., 1979: Ontogeny and variation in *Subprionocyclus neptuni*, an Upper Cretaceous collignoniceratid ammonite. *Bulletin of the National Science Museum*, *Series C*, vol. 5, p. 51–86.

Pyarkova, Z. N. (*ed.*), 1987: *Reference Section of Cretaceous Deposits in Sakhalin (Naiba Section)*, 197 p. Nauka, Leningrad. (*in Russian*)

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., Maeda, H., Uemura, K. and Solov'yov, A. V., 1999: Stratigraphy of the Upper Cretaceous System in the Kurl'on Peninsula, South Sakhalin, Russia. *Bulletin of the National Science Museum*, *Series C*, vol. 25, p. 1–27.

Spath, L. F., 1922: On the Senonian ammonite fauna of Pondoland. *Transactions of the Royal Society of South Africa*, vol. 10, p. 113–148.

Tanabe, K., 1977: Functional evolution of *Otoscaphites puerculus* (Jimbo) and *Scaphites planus* (Yabe), Upper Cretaceous ammonites. *Memoirs of the Faculty of Science*, *Kyushu University*, *Series D*, *Geology*, vol. 23, p. 367–407.

Tanabe, K. and Shigeta, Y., 1987: Ontogenetic shell variation and streamlining of some Cretaceous ammonites. *Transactions and Proceedings of the Palaeontological Society of Japan*, *New Series*, no. 147, p. 165–179.

Yoshida, T., Matsuno, K., Satoh, H. and Yamaguchi, S., 1959: *Explanatory Text of the Geological Map of Japan, Scale 1:50000, Biu (Sapporo-56)*, 47 p. Geological Survey of Hokkaido, Sapporo. (*in Japanese with English abstract*)

Zonova, T. D., Kazintsova, L. I. and Yazykova, E. A., 1993: *Atlas of Index Fossils in the Cretaceous Fauna of Sakhalin*, 327 p. Nedra, St. Petersburg. (*in Russian; original title translated*)

Yasunari Shigeta, 2019. Ontogeny of *Canadoceras kossmati* Matsumoto, a Campanian pachydiscid ammonoid from Hokkaido, Japan. *The Bulletin of the Hobetsu Museum*, **34**, 1–11.
重田康成，2019. 北海道産のカンパニアン期パキディスカス科アンモナイト *Canadoceras kossmati* Matsumoto の個体発生．むかわ町穂別博物館研究報告，**34**，1–11.

（要　旨）

平取町旭の貫気別川中流で採集された保存良好な *Canadoceras kossmati* Matsumoto の成長に伴う殻形態の変化が，殻を徐々に壊すことによって，殻直径 20 mm から 120 mm まで詳細に研究された．殻直径 20 mm の殻は，中程度に広いへそとやや横に膨らんだ螺管断面，前方に傾く多くの肋，へそ周辺に突起を持つ主肋とその直後にあらわれる浅いくびれ，側面内側から中央部で挿入される肋で特徴づけられる．殻のサイズが増加するにつれて，螺管断面は徐々に縦長になり，へそは殻直径に対して相対的にやや広くなる．肋はより粗く，より明瞭になり，主肋はその強さを増す．主肋のへその周りの突起は不明瞭で，わずかな高まりになる．このような個体発生に伴う殻形態の変異は，*Canadoceras kossmati* が蝦夷層群の同時代の地層（カンパニアン階中部、*Sphenoceramus schmidti* 帯）から記載された 3 種の *Canadoceras*（*C. yokoyamai*，*C. mysticum*，*C. minimum*）のホロタイプと明瞭に区別されることを示す．