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Systematic position and origin of the Cretaceous ammonoid genus *Takahashia*

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Abstract. A second specimen of *Takahashia eureka* Matsumoto, 1984, from the lowest Cenomanian in the Hobetsu area of Hokkaido (Northern Japan), is described, and the diagnosis of the taxon is revised following a careful reexamination of the holotype. The presence of partially developed, minutely crinkled ribs on the shell implies that *Takahashia* had a close phylogenetic relationship with the long-ranging taxon *Lytoceras* (upper Sinemurian-Cenomanian), and we therefore assign it to the subfamily Lytoceratinae of the family Lytoceratidae. Evolution of *Takahashia* from *Lytoceras* supports the existence of a unique fauna in the North Pacific at the Albian-Cenomanian transition.

Key words: Ammonoid, Cenomanian, Cretaceous, Hokkaido, *Takahashia eureka*

Introduction

Takahashia Matsumoto, 1984, a monospecific Cretaceous ammonoid genus described from the upper Lower Cenomanian in the Ikushumbetsu area of Hokkaido, consists only of the holotype of the type species, *T. eureka*. The type specimen is wholly septate, and had its body chamber been preserved, the shell diameter would be fairly large, up to 250 mm in diameter (Klein *et al.*, 2009). The shell is characterized by fairly involute coiling, a very high whorl expansion rate and a subcircular whorl section. However, the features of the shell at the early to middle growth stages are unknown since its inner whorls are not preserved.

Although the shell features of *Takahashia* resemble the Santonian-Maastrichtian genus *Pseudophyllites* Kossmat, 1895, Matsumoto (1984) regarded *Takahashia* as an independent heterochronous offshoot of *Tetragonites* Kossmat, 1895 because of the difference in age. However, *Takahashia* has moderately strong radial ribs in addition to fine ribs, and Klein *et al.* (2009) treated *Takahashia* as a gaudryceratid ammonoid.

Gaudryceratid ammonoids in the lower Cenomanian of Hokkaido are more diverse and abundant than in underlying older sediments and more than ten species have been described (Matsumoto, 1943, 1984, 1995; Matsumoto *et al.*, 1972, 1997; Shigeta, 1996), most of which are endemic species restricted to Hokkaido and Sakhalin. The determination of the systematic position of *Takahashia* may provide an important key to the understanding of the phylogenetic divergence and endemism of ammonoids occurring at or about the time of the Albian-Cenomanian transition (Shigeta, 1996).

Coauthor M. Izukura recently discovered a well preserved, midsized specimen referable to *Takahashia eureka* in lower Cenomanian sediments in the Hobetsu area (Hokkaido, Northern Japan). Close observation of the new specimen and the holotype revealed that the genus *Takahashia* was allied to neither tetragonitids nor gaudryceratids, but to lytoceratids. In this paper we describe this newly found specimen, reexamine the holotype, revise the diagnosis for the genus, and discuss the systematic position and origin of *Takahashia*.

Paleontological description

Morphological terms are those used in the *Treatise on Invertebrate Paleontology* (Moore, 1957). Quantifiers used to describe the shape of the ammonoid 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.—HMG=Hobetsu Museum, Mukawa, Hokkaido; GK=Department of Earth and Planetary Sciences, Kyushu University, Fukuoka.

Superfamily Lytoceratoidea Neumayr, 1875
Family Lytoceratidae Neumayr, 1875
Subfamily Lytoceratinae Neumayr, 1875
Genus ***Takahashia*** Matsumoto, 1984

Type species.—*Takahashia eureka* Matsumoto, 1984.

Revised diagnosis.—Fairly large lytoceratid with very involute to fairly involute coiling, a very high whorl expansion rate and a subcircular whorl section. Shell surface ornamented with fine rursiradiate, minutely crinkled ribs, which curve backward on flank and form a shallow sinus on venter of subadult and adult shells. Suture with an asymmetric, slender stemmed bifid lateral lobe (L) with the external part deeper than the internal branch in adult shell.

Occurrence.—Early Cenomanian of Hokkaido, Japan.

Remarks.—The minutely crinkled ribs clearly imply that *Takahashia* is assigned to Lytoceratinae as discussed later.

Takahashia eureka Matsumoto, 1984

Figures 1A, 2

Takahashia eureka Matsumoto, 1984, p. 33, fig. 1A, 1B; Wright *et al.*, 1996, p. 8, fig. 3-2a, 2b; Toshimitsu and Hirano, 2000, p. 566; Klein *et al.*, 2009, p. 208.

Holotype.—GK. H5567, figured by Matsumoto (1984, p. 33, fig. 1A, 1B), from the upper Lower Cenomanian *Mantelliceras japonicum* Zone in the Mikasa Formation of the Yezo Group at Loc. IK1101 on the right-bank cliff of the Ikushumbetsu River, Mikasa area, Hokkaido, Japan.

Material examined.—HMG-1524, consisting of part of the body chamber and phragmocone, was extracted from a float calcareous concretion found 1.5 km upriver from the mouth of the Sasao-no-sawa Valley (42°51′19″N, 142°11′16″E), a branch of the Hobetsu River, in the Hobetsu area, south-central Hokkaido, Japan.

Description.—Very involute, fairly depressed shell with semicircular whorl section and convex flanks gradually converging to an arched venter from rounded umbilical shoulders. Umbilicus fairly narrow and deep with high, gently convex, sub-vertical wall. Ornamentation consists of delicate spiral lines and fine, rursiradiate, minutely crinkled ribs as well as growth lines, which curve backwards on flank and form a shallow sinus on venter. Suture line finely and deeply incised, partly visible. Umbilical shoulder at outer margin of second umbilical lobe (U_2).

Measurements.—Taken at the last septum of HMG-1524, D=42.9 mm, U=8.4 mm, H=21.9 mm, W=29.9 mm, U/D=0.19, W/H=1.36.

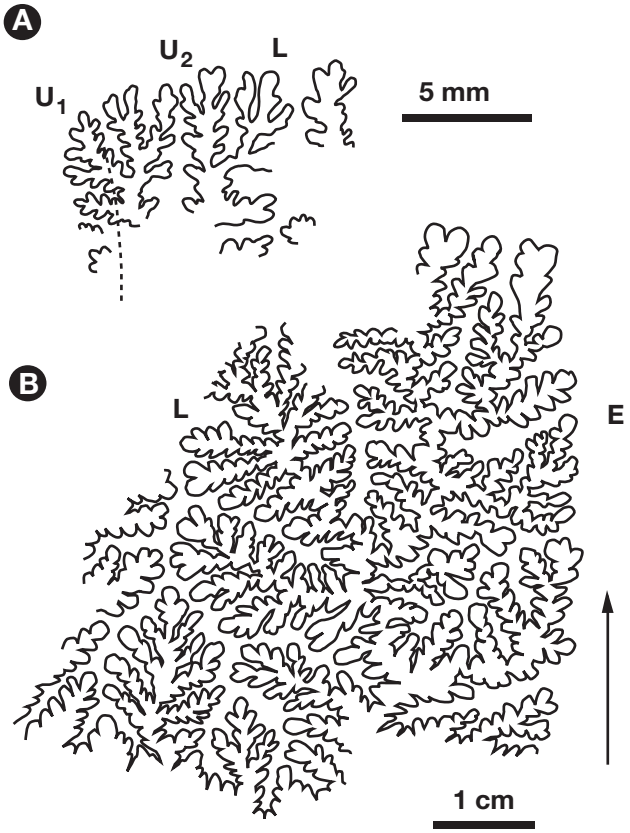

Figure 1. Suture lines of *Takahashia eureka* Matsumoto, 1984. **A**. HMG-1524, from the Hobetsu area, Hokkaido, at H=18.8mm. **B**. GK. H5567 (holotype), from the Mikasa area, Hokkaido, at H=74.0 mm. Solid line represents the siphuncle, and broken line indicates the position of the umbilical shoulder. E: external (ventral) lobe, L: lateral lobe, U_1: first umbilical lobe, U_2: second umbilical lobe.

Occurrence.—HMG-1524 was collected from a float calcareous concretion in the Sasao-no-sawa Valley. Although the exact horizon from which the concretion came is uncertain, judging from its locality and lithology, it almost without doubt came from the mudstone of the Inasato Formation of the Yezo Group (Takahashi *et al.*, 2002). In this vicinity, the formation contains *Parajaubertella kawakitana* Matsumoto, 1943 and *Gabbioceras yezoense* Shigeta, 1996, both of which are characteristic of the *Stoliczkaia japonica* Zone and the *Graysonites wooldridgei* Zone of the lower Lower Cenomanian in Hokkaido (Matsumoto *et al.*, 2004). Therefore, we are fairly certain HMG-1524 came from the lower Lower Cenomanian.

Discussion.—The present specimen is morphologically very close to the preadult stage of *Parajaubertella kawakitana* and *Parajaubertella zizoh* Matsumoto, Yokoi and Kawashita, 1997, but its ribs are rursiradiate, in contrast to the prorsiradiate ribs of *Parajaubertella*. *Gabbioceras*

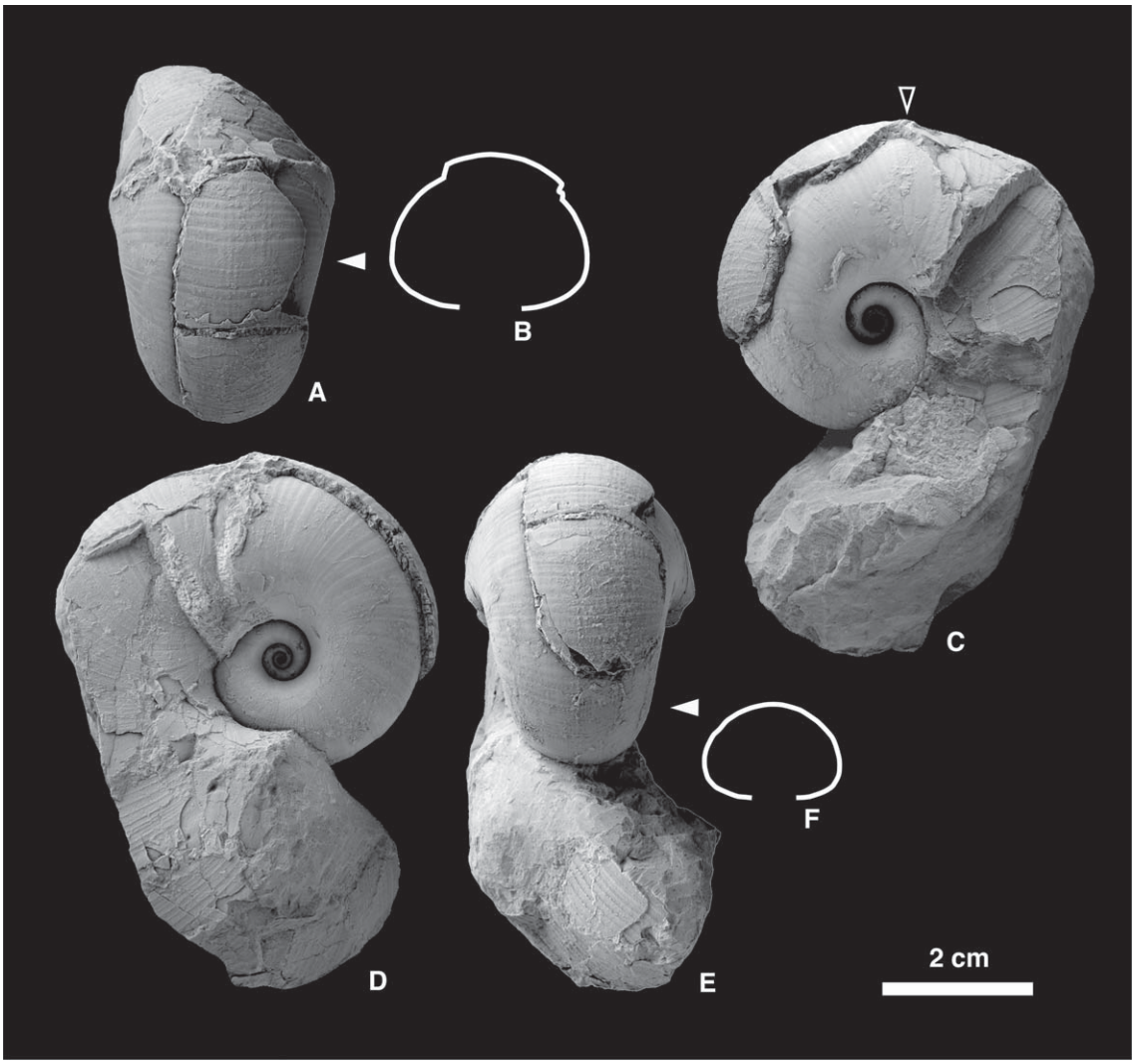

Figure 2. *Takahashia eureka* Matsumoto, 1984, HMG-1524, from the Hobetsu area, Hokkaido. **A**. Ventral view. **B**. Whorl cross section at white arrow. **C**. Left lateral view. Black arrow indicates position of last septum. **D**. Right lateral view. **E**. Apertural view. **F**. Whorl cross section at white arrow.

mikasaense Shigeta, 1996 is also very close, but its umbilicus is funnel-shaped and its shell surface is smooth.

The holotype of *Takahashia eureka* is fairly large, but since its inner whorls are not preserved (Figure 3), a direct comparison with the present specimen at the same shell size is impossible. However, the combination of its fine rursiradiate ribs and shallow ventral sinus along with its very involute coiling and fairly depressed shell enable us to identify it as *T. eureka*.

Discussion

Higher taxonomic position of *Takahashia*

Matsumoto (1984) and later Wright *et al.* (1996) stated that *Takahashia* could be affiliated with *Pseudophyllites* because of their similarity in adult shell size and outer shell morphology, and both assigned it to the family Tetragonitidae Hyatt, 1900. However, *Takahashia* differs from *Pseudophyllites* in that it possesses moderately strong rursiradiate ribs, which have never been documented on tetragonitid ammonoids, but which do occur on some gaudryceratids. For these reasons, Klein *et al.* (2009) treated *Takahashia* as a gaudryceratid ammonoid and assigned it to the subfamily Gaudryceratinae Spath, 1927 within the family Gaudryceratidae Spath, 1927.

However, our careful reexamination of the holotype of *Takahashia eureka* leads us to the conclusion that it represents a member of the lytoceratid ammonoids. Its shell surface is ornamented with weakly crenulated ribs (Figures 3, 4), which until now have never been documented. The partly exposed suture line at a whorl height of H=74.0 mm shows

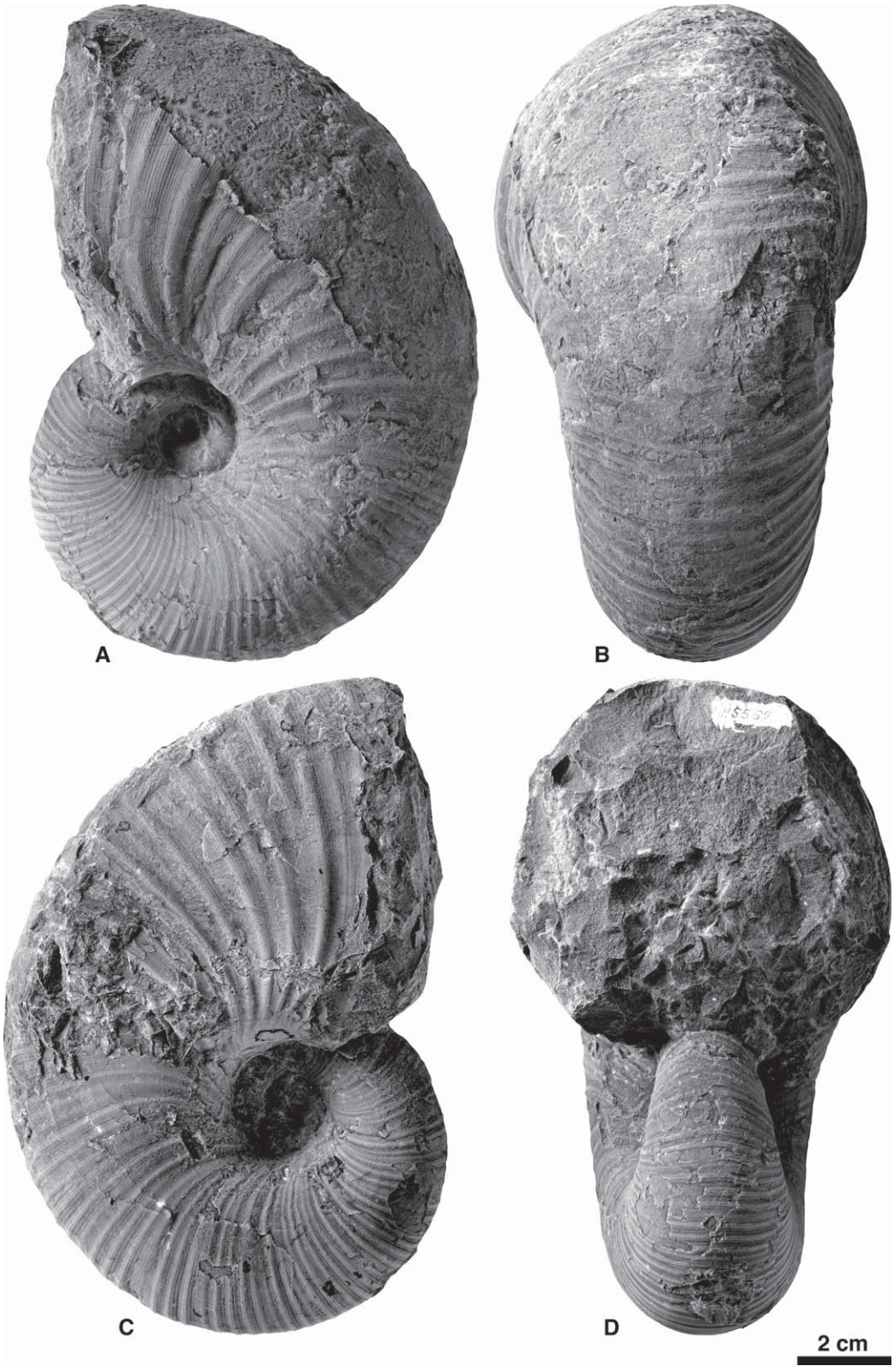

Figure 3. *Takahashia eureka* Matsumoto, 1984, GK. H5567 (holotype), from the Mikasa area, Hokkaido. **A**. Right lateral view. **B**. Ventral view. **C**. Left lateral view. **D**. Apertural view.

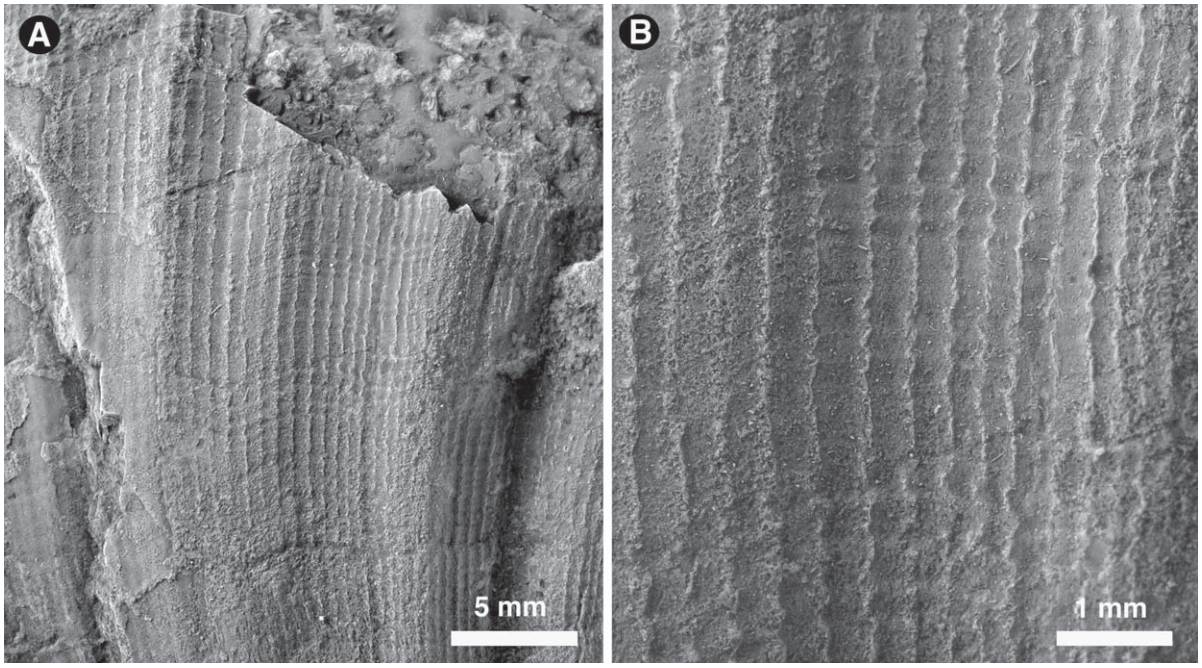

Figure 4. Minutely crinkled ribs developing on the shell of the holotype (GK. H5567) of *Takahashia eureka* Matsumoto, 1984. **A**. Ribbing pattern on right side of shell, on last part of the preserved phragmocone. **B**. Close-up of the ribs in A.

an asymmetric, slender stemmed bifid lateral lobe (L) with its external part deeper than the internal branch (Figure 1). Although no further information of a systematic and phylogenetic nature can be gathered from the suture line, the crinkled ribs clearly implies that *Takahashia* is a lytoceratid ammonoid, because this feature is typical of *Lytoceras* Suess, 1865 and is characteristic of the subfamily Lytoceratinae (Moore, 1957; Hoffmann, in press). Therefore, we prefer to reassign *Takahashia* to the Lytoceratinae by revised diagnosis.

Origin and evolution of *Takahashia*

Two lytoceratid species with crinkled ribs, *Lytoceras ezoense* Yabe, 1903 and *L. mahadeva* (Stoliczka, 1865) are known from the Albian of Hokkaido (Futakami, 1996; Toshimitsu and Hirano, 2000). Both species were formerly assigned to "*Ammonoceratites*" Bowdich, 1822 by many authors, but due to the lack of apomorphic characters for "*Ammonoceratites*" and the presence of crenulated ribs with irregularly spaced flares (Kennedy and Klinger, 1978), this genus is now regarded as a junior subjective synonym of *Lytoceras* (Klein *et al.*, 2009).

Lytoceras ezoense is characterised by an increased whorl expansion rate compared to that of *L. mahadeva* and is therefore easy to distinguish. During ontogeny the species can become fairly large, reaching approximately 200 mm in diameter, which fits very well with the observed shell size of *Takahashia*. Judging from shell morphology, *L. ezoense* with crinkled ribs, spiral lirae and a slightly increased whorl expansion rate is best interpreted as a connecting form between the more evolute *L. mahadeva* and the more involute *Takahashia eureka*.

Gaudryceratid ammonoids in the lower Cenomanian of Hokkaido are more diverse and abundant than from underlying sediments (Matsumoto, 1943, 1984, 1995; Matsumoto *et al.*, 1972, 1997; Shigeta, 1996), and most of them are endemic species restricted to Hokkaido and Sakhalin. Because of this evidence, Shigeta (1996) pointed out that phylogenetic divergence and endemism of gaudryceratid ammonoids occurred during the early Cenomanian. A similar phenomenon is known in kossmaticeratid ammonoids (Matsumoto, 1955, 1991; Bando *et al.*, 1987) and it is reported for lytoceratid ammonoids for the first time in this paper.

Iba and Sano (2007, 2008) have recently documented a stepwise demise of Tethyan biota during the latest Aptian to latest Albian in the Northwest Pacific, and they discussed the existence of a "vicariance event", which separated the North Pacific from the Tethyan biotic realm, resulting in the establishment of the North Pacific biotic province. The evolution of *Takahashia* from *Lytoceras* and the occurrence of many other endemic ammonoids support the existence of a unique fauna in the North Pacific at the Albian-Cenomanian transition following the "Albian vicariance event".

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