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Early Cenomanian (Late Cretaceous) ammonoids from the Miyanohara Formation in the Sakawa area, Shikoku, southwestern Japan

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Abstract. Mid-Cretaceous ammonoids, Euhystrichoceras nicaisei, Mantelliceras japonicum, and Hypostlingoceras japonicum were collected from float rocks probably derived from the middle part of the Miyanohara Formation in the Sakawa area, Shikoku, southwestern Japan. Although it has been suggested that the stratigraphic correlation of this formation based mainly on bivalves such as trigoniids needs to be reexamined, the occurrence of these ammonoids confirms that the
middle part of the Miyanohara Formation is correlated to the lower Cenomanian. The results of this study support the suggestion that the shallow marine deposits of the mid-Cretaceous that contain similar molluscan fauna are widely distributed throughout the northwestern Pacific region.

Key words: ammonoid, Cenomanian, Cretaceous, Miyanohara Formation, Sakawa, Sotoizumi Group

Introduction

Paleozoic and Mesozoic strata are intricately distributed in the Sakawa area, Kochi, located in the Chichibu Belt in the Outer Zone of southwestern Japan, where several geological and paleontological studies have been conducted since the 19th century (e.g. Naumann and Neumayr, 1890; Yabe, 1901, 1927; Yehara, 1923; Kobayashi, 1931, 1941; Matsumoto, 1954; Tashiro, 1985; Tashiro and Matsuda, 1986; Kozai and Ishida, 2006). The uppermost part of the Cretaceous deposits in this area is composed of the Miyanohara Formation (Yehara, 1927; Kobayashi, 1932; Fukuji, 1941; Katto et al., 1961) belonging to the Sotoizumi Group and exposed in a narrow region that extends from Miyanohara district within Sakawa Town to
Ochiko district within Ochi Town (Katto and Tashiro, 1982; Wakita et al., 2007) (Figure 1).

Diverse bivalve fossils, such as trigoniids, are known from the Miyanohara Formation, and the formation has been correlated to the upper Albian–Cenomanian based on these bivalves (Amano, 1956; Tashiro and Matsuda, 1983a, b; Matsuda, 1985; Tashiro and Katto, 1995; Wakita et al., 2007).

On the other hand, Yoshihara and Komatsu (2006) have suggested that stratigraphic correlations of the Miyanohara Formation and other mid-Cretaceous strata in southwestern Japan based on trigoniids need to be reexamined. In addition, although ammonoids Desmoceras sp., Mantelliceras sp., Calycoceras? sp., and Sharpeiceras sp. were also reported from the Miyanohara Formation and were shown to be consistent with the correlation based on bivalves (Matsumoto, 1954, 1977; Matsumoto et al., 1982; Katto and Tashiro, 1982; Matsuda, 1985; Wakita et al., 2007), details on these ammonoids, such as figures and localities, have not been provided.

In the course of the geological survey of the Cretaceous strata in southwestern Japan, we discovered six specimens of three ammonoid species, *Euhystrichoceras nicaisei* (Coquand, 1862), *Mantelliceras japonicum* Matsumoto, Muramoto and Takahashi, 1969, and *Hypostlingoceras japonicum* Matsumoto and Takahashi, 2000, from the Miyanohara Formation.

We describe these ammonoids and discuss their significance here.
Geologic notes and fossil occurrences

Wakita et al. (2007) have divided the Miyanohara Formation into the following four parts: lowest (My1), lower (My2), middle (My3), and upper parts (My4) (Figure 1). They have indicated that each part consists of slumping deposits dominated by mudstone >150 m thick, mudstone ~55 m thick, very fine- to fine-grained sandstone ~30 m thick, and mudstone-dominated strata >170 m thick, respectively.

In this study, sandstones and mudstones of the Miyanohara Formation were observed in some localities along the Yanasegawa River, a tributary of the Niyodogawa River, and along roads in Miyanohara, Otakawa, and Shoda districts within Sakawa Town (Figure 1, 2). Conglomerate beds up to several decimeters thick and composed of rounded pebbles up to 5 cm in diameter were also intercalated in the bluish gray, fine-grained sandstone at Loc. 2. Sandstones at Locs. 2–4 contain abundant bivalve and gastropod fossils and are thought to be within the My3 of Wakita et al. (2007).

The six ammonoid specimens (Figure 3) described in this paper were collected from float rocks at Loc. 1 along the Yanasegawa River. The four specimens of KMNH IvP 905002–905005 were found in the same large rock of about 3 m in diameter, and the two specimens of KMNH
IvP 905001 and 905006 were from other smaller rocks of several decimeters in diameter. These float rocks are bluish gray, fine-grained calcareous sandstone and contain several bivalve fossils. Judging from the localities and lithologic characters, these float rocks are considered to be derived from the My3. The collected ammonoids are generally well preserved, including their body chambers; however, cheilostome bryozoan colonies are attached to the internal surfaces of the body chamber of one Mantelliceras japonicum specimen (KMNH IvP 905001; Figure 3C), which indicates that there was a specific period of time between death and complete burial of the animal.

**Systematic paleontology**

Morphological terminology and measurements follow Matsumoto (1954, p.246), Arkell (1957), Haggart (1989, table 8.1), and Matsumoto and Takahashi (2000). Higher-level classifications are adopted from Wright *et al.* (1996). Cooper and Owen (2011) have considerably revised the classification of Schloenbachiidae and included *Euhystrichoceras* in this family; however, it has been suggested that further examination of its classification is needed (Kennedy, 2013; Wilmsen *et al.*, 2013). Thus, the suprageneric classification of *Euhystrichoceras* also follows Wright *et al.* (1996).
Institution abbreviations.—GK, Department of Earth and Planetary Sciences, Kyushu University, Fukuoka, Japan; KMNH, Kitakyushu Museum of Natural History and Human History, Kitakyushu, Japan; MCM, Mikasa City Museum, Mikasa, Japan.

Other abbreviations.—$D$, shell diameter (diameter of the preserved last whorl in the case of *Hypostlingoceras*); $U$, umbilical diameter; $H$, whorl height; $W$, whorl width; $NW$, number of the preserved whorls; $Hp$, total height of the preserved whorls; $Ht$, total shell height from the preserved last whorl to the estimated apex; $ap$, estimated apical angle; $h$, height of an exposed outer flank of a late whorl; $d$, diameter of the same whorl; $R$, number of ribs on the same whorl; $T$, number of upper tubercles; $t$, number of lower tubercles ($D$ and $NW$ to $t$ for *Hypostlingoceras* were originally used by Matsumoto and Takahashi, 2000).

Suborder Ammonitina Hyatt, 1889

Superfamily Acanthocerataceae Grossouvre, 1894

Family Brancoceratidae Spath, 1934

Subfamily Mortoniceratinae H. Douvillé, 1912

Genus *Euhystrichoceras* Spath, 1923

Type species.—*Ammonites nicaisi* Coquand, 1862.
Euhystrichoceras nicaisei (Coquand, 1862)

Figures 3D–I, 4A

Ammonites nicaisei Coquand, 1862, p. 323, pl. 35, figs. 3–4.

Mortoniceras (?) nicaisei (Coquand). Pervinquiére, 1907, p. 235, pl. 11, figs. 13a–b, 14a–c, 15a–c, text-figs. 95, 96; Pervinquiére, 1910, p. 65, pl. 6, figs. 6–19, text-figs. 95, 96.

Mortoniceras nicaisei (Coquand). Collignon, 1928–1929, p. 31, pl. 16, fig. 16.

Schloenbachia (Inflaticeras) nicaisei (Coquand). Collignon, 1931, p. 74, pl. 3, figs. 16, 17.

Euhystrichoceras nicaisei (Coquand). Juignet and Kennedy, 1976, p. 79, pl. 5, figs. 5a–b, 6a–c; Kennedy and Wright, 1981, p. 420, pl. 59, figs. 1–16, 21–23, text-figs. 1a, 2d; Kennedy and Juignet, 1984, p. 131, fig. 26a–c; Matsunaga, 2005, pl. 8, figs. 4, 5; Cooper and Owen, 2011, p. 301, fig. 5E–F.

Lectotype.—One of Coquand’s specimens from west of Boghar, Algeria, refigured by Pervinquiére (1910, pl. 6, fig. 7) and Kennedy and Wright (1981, pl. 59, figs. 8–10), designated by Juignet and Kennedy (1976, p. 80).

Material.—Two specimens, KMNH IvP 905002 (Figures 3D–G, 4A) and KMNH IvP 905003 (Figure 3H–I), were collected from the same float rock at Loc. 1 along the Yanasegawa
River, a tributary of the Niyodogawa River, in the Sakawa area, Shikoku (Figure 1).

Description.—Very small, fairly evolute shell with moderately wide umbilicus. Slightly compressed to slightly depressed whorl section with a broadly rounded to slightly fastigate and keeled venter, rounded ventral shoulders, rounded (early growth stage) to slightly convex (later growth stage) flanks with maximum whorl width near rounded umbilical shoulders, and low, steeply inclined umbilical walls. Ornamentation consists of inner lateral and ventrolateral tubercles, concave to slightly sinuous, prorsiradiate ribs, and lirae (visible on body chamber of KMNH IvP 905003). Secondary ribs frequently branched from primary ribs at inner lateral tubercles. In the last part of the body chamber, ribs become denser and tubercles weaken. Suture line simple, with broad external lobe and asymmetrically bifid first and second lateral saddles. Lateral lobe relatively narrow and simple.

Measurements.—At $D = 17.7$ mm of KMNH IvP 905002, $U = 6.3$ mm, $H = 6.4$ mm, $W = 5.3$ mm, $U/D = 0.36$, $W/H = 0.83$.

Occurrence.—*Euhystrichoceras nicaisei* is known from the lower Cenomanian strata in France, Tunisia, Algeria, and Madagascar (Kennedy and Juignet, 1984). This species also occurs in the lower Cenomanian of the Yezo Group in the Soeushinai (e.g. Matsumoto *et al.*, 2004) and Kami-ashibetsu (Matsunaga, 2005) areas, Hokkaido, northeastern Japan. The present specimens were found in float rocks probably derived from the middle part of the Miyanohara Formation.
(My3), Sotoizumi Group in the Sakawa area.

Family Acanthoceratidae Grossouvre, 1894

Subfamily Mantelliceratinae Hyatt, 1903

Genus Mantelliceras Hyatt, 1903

*Type species.*—*Ammonites mantelli* J. Sowerby, 1814.

*Mantelliceras japonicum* Matsumoto, Muramoto and Takahashi, 1969

Figures 3A–C, 4B

*Mantelliceras japonicum* Matsumoto, Muramoto and Takahashi, 1969, p. 253, pl. 25, figs. 1, 2, pl. 26, figs. 1–3, pl. 27, figs. 1, 2, text-figs. 1, 2; Matsunaga, 2005, pl. 9, fig. 1; Misaki et al., 2008, fig. 4.1, 2.

*Holotype.*—GK.H5428, from Loc. Ik. 1100 (Matsumoto et al., 1969, text-fig. 9) along the Ikushunbetsu River in the Mikasa area, Hokkaido, northeastern Japan (Matsumoto et al., 1969, p. 253, pl. 25, fig. 1, pl. 26, fig. 1, text-figs. 1, 2)

*Material.*—One specimen, KMNH IvP 905001 (Figures 3A–C, 4B), was collected from a
float rock at Loc. 1 along the Yanasegawa River, a tributary of the Niyodogawa River, in the Sakawa area, Shikoku (Figure 1).

Description.—Medium sized, moderately involute (early growth stage) to fairly evolute (later growth stage) shell with moderately wide umbilicus. Suboval to subcircular whorl section with a broadly rounded venter, rounded ventral shoulders, slightly convex flanks with maximum whorl width near rounded umbilical shoulders, and nearly vertical umbilical walls. Ornamentation consists of straight to slightly convex, rectiradiate to slightly rursiradiate ribs, lirae, and inner and outer umbilical and inner and outer ventrolateral tubercles. Ribs generally alternate between long and short. Long ribs arise from umbilical seam and short ribs begin near mid-flank. On main part of body chamber, long ribs on one side extend to short ones on other side, and alternate from side to side. Tubercles become weaker on body chamber. Suture line only partly exposed, and broad first lateral saddle and narrower lateral lobe visible.

Measurements.—At \( D = 119.3 \) mm of KMNH IvP 905001, \( U = 43.5 \) mm, \( H = 45.6 \) mm, \( W = 42.6 \) mm, \( U/D = 0.36 \), \( W/H = 0.93 \).

Occurrence.—This species is known from the lower Cenomanian of the Mikasa Formation, Yezo Group in the Mikasa (Matsumoto et al., 1969) and Kami-ashibetsu (Matsunaga, 2005) areas, Hokkaido, northeastern Japan and the lower Cenomanian of the Sotoizumi Group in the Aridagawa area, Wakayama, southwestern Japan (Misaki et al., 2008). The specimen described
here was found in a float rock probably derived from the middle part of the Miyanohara Formation (My3), Sotoizumi Group in the Sakawa area.

Suborder Ancyloceratina Wiedmann, 1966

Superfamily Turrilitaceae Gill, 1871

Family Turrilitidae Gill, 1871

Genus *Hypostlingoceras* Matsumoto and Takahashi, 2000


*Hypostlingoceras japonicum* Matsumoto and Takahashi, 2000

Figures 3J–P, 4C, 5A–G

*Hypostlingoceras japonicum* Matsumoto and Takahashi, 2000, p. 269, figs. 7–10.

*Hypostlingoceras mikasaense* Matsumoto and Takahashi, 2000, p. 271, figs. 11–12.

*Holotype.* — GK.H8542, from the Ganseki-zawa River (a tributary of the Kami-ichino-sawa River), Mikasa area, Hokkaido, northeastern Japan (Matsumoto and Takahashi, 2000, p. 269, figs. 7, 8)
**Material.**—Three specimens, KMNH IvP 905004 (Figures 3J–K, 5C), KMNH IvP 905005 (Figures 3L–M, 4C, 5B) and KMNH IvP 905006 (Figures 3N–P, 5G), were collected from float rocks at Loc. 1 along the Yanasegawa River, a tributary of the Niyodogawa River, in the Sakawa area, Shikoku (Figure 1). Four specimens, GK.H8540–8542 and MCM-A0875, from the Mikasa area, Hokkaido were also examined for comparison. GK.H8540 is the holotype of *Hypostlingoceras mikasaense* from the Ganseki-zawa River (Matsumoto and Takahashi, 2000, fig. 11). GK.H8541 is the paratype from the Suido-no-sawa River (Matsumoto and Takahashi, 2000, fig. 9). GK.H8542 is the holotype (see details above). To avoid damaging these type specimens, resin casts taken from GK.H8540–8542 were whitened with magnesium oxide and illustrated (Figure 5A, D, E). MCM-A0875 (Figure 5F) is a plaster cast of an unregistered specimen from a float rock in the Kami-ichino-sawa River.

**Emended diagnosis.**—Rather small shell, with low to moderate apical angle. In the early growth stage, whorl section relatively angular with mid-flank shoulder bearing coarse and strong tubercles. In the next transitional stage, low transverse ribs arise and mid-flank tubercles gradually weaken. In the later growth stage, exposed side relatively rounded and ornamented with dense transverse ribs with obscure mid-flank tubercles. Tubercles aligned on the two ridges at lower end of exposed side throughout growth.

**Description.**—Sinistral, tightly coiled helical shell, with apical angle of about 20–30°.
Ornamentation generally consists of tubercles on the mid-flank and the two ridges at lower end of exposed side and transverse ribs, and their characteristics change with growth. In the early growth stage (less than 6–8 mm in diameter for KMNH IvP 905004–905006), coarse and strong tubercles on the mid-flank shoulder. In the next transitional stage, low transverse ribs gradually develop and mid-flank tubercles on these ribs become weaker. In the later growth stage (over 8–10 mm in diameter for KMNH IvP 905004–905006), transverse ribs become denser and mid-flank tubercles become obscure. Throughout these growth stages, tubercles aligned on the two narrow parallel ridges separated by a narrow groove at lower end of exposed side. Tubercles on the lower rows often more numerous than that on the median row in the younger stage (at 8.2 mm in diameter of KMNH IvP 905005, $T = 18$, $t = 21$), but the former become less numerous than the latter in the later stage (see Measurements for $T$ and $t$ of a late whorl in KMNH IvP 905005 and 905006). An additional row of tubercles rarely arises below the lower two rows (visible only on the basal surface of the last whorl in KMNH IvP 905005). Whorl section relatively angular with mid-flank shoulder and lower two ridges during the younger stage. Then, as mid-flank tubercles become weaker, exposed side becomes relatively rounded. Suture line partially observed on the exposed side of KMNH IvP 905005, and relatively broad first lateral saddle and relatively shallow lateral lobe visible.

*Measurements.*—KMNH IvP 905004: $NW = 2.5$, $Hp = 10.9$, $Ht = 22.2$, $D = 7.4$, $ap = 24^\circ$, $h$
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= 3.9, d = 6.6, h/d = 0.59, T = 15, t = 15; KMNH IvP 905005: NW = 4, Hp = 18.3, Ht = 35.5, D = 9.4, ap = 19°, h = 6.2, d = 9.3, h/d = 0.64, T = 29, t = 24; KMNH IvP 905006: NW = 6.5, Hp = 39.4, Ht = 46.2, D = 21.7, ap = 29° (estimated from undeformed parts), h = 10.9, d = 21.4, h/d = 0.51, T = 39, t = 34. Measurements basically follow Matsumoto and Takahashi (2000); however, although Matsumoto and Takahashi (2000) measured T and t on the whorl two volutions before where h and d were measured, these values were measured on a late whorl where h and d were measured in this study because three successive volutions in specimens from the Miyanohara Formation are rarely preserved in good condition. R is not shown because R corresponds to T on the same late whorl.

Discussion.—Matsumoto and Takahashi (2000) have distinguished Hypostlingoceras mikasaense from H. japonicum by its larger apical angle, smaller h/d value, stronger mid-flank tubercles in the younger stage, and coarser and less numerous ribs on the later whorls; however, each specimen of Hypostlingoceras shows a considerable range in the apical angle, h/d, and tubercle strength (Figure 5; measurements of this study and Matsumoto and Takahashi, 2000), and although both KMNH IvP 905004 and 905005 show a relatively small apical angle and rather large h/d value, they have relatively strong mid-flank tubercles in the younger stage. In addition, KMNH IvP 905006 has a relatively large apical angle, relatively small h/d value, and relatively weak mid-flank tubercles in the younger stage. The timing of the end of the
tubercle-dominated stage (= early growth stage) and beginning of the rib-dominated stage (= later growth stage) and rib density also vary depending on the specimen and its growth stage (Figure 5); GK.H8540 (holotype of *H. mikasaense*) does not have especially coarse ribs. These observations suggest that both taxa are conspecific.

A plaster cast of an unregistered specimen of *Hypostlingoceras* from a float rock from the Kami-ichino-sawa River, Mikasa area, Hokkaido is housed in the Mikasa City Museum, Hokkaido (MCM-A0875; Figure 5F). Because of its characteristics, this specimen also considered to belong to this species.

On the other hand, mid-flank tubercles of GK.H8541 become obscure much earlier than those in other specimens. In addition, the tubercles along the lower two rows in GK.H8541 are very weak throughout growth, although those of other specimens are relatively strong in the later stage. These facts may indicate the necessity for further examination of the taxonomic affiliation of GK.H8541. However, following Matsumoto and Takahashi (2000), GK.H8541 is tentatively referred to this species at this time, because specimens similar to GK.H8541 and significant information about it were not obtained from the Miyano-hara Formation in this study.

*Occurrence.*—This species is known from the lower Cenomanian of the Mikasa Formation, Yezo Group in the Mikasa area, Hokkaido, northeastern Japan (Matsumoto and Takahashi, 2000). The present specimens were found in float rocks probably derived from the middle part
of the Miyanohara Formation (My3), Sotoizumi Group in the Sakawa area.

Discussion

The ammonoids obtained in this study are useful for stratigraphic correlation. *Mantelliceras japonicum* and *Hyposlingoceras japonicum* are known from the lower Cenomanian of the Yezo Group in Hokkaido, northeastern Japan (e.g. Matsumoto et al., 1969; Matsumoto and Takahashi, 2000), and *Euhystrichoceras nicaisei* occurs in the lower Cenomanian of Algeria, Tunisia, Madagascar, and France, and the Soeushinai and Kami-ashibetsu areas in Hokkaido (e.g. Kennedy and Wright, 1981; Matsumoto et al., 2004; Matsunaga, 2005). Bivalves have typically been used as important index fossils for correlation of the Miyanohara Formation, and the middle part of this formation (My3) has been correlated to the lower Cenomanian mainly based on trigoniids such as *Pterotrigonia pustulosa* (Nagao), *P. mifunensis* (Tamura and Tashiro), and *P. amakusensis* Tashiro and Matsuda (e.g. Tashiro and Matsuda, 1983a, b; Matsuda, 1985; Tashiro and Katto, 1995; Wakita et al., 2007). However, Yoshihara and Komatsu (2006) have suggested that it is necessary to reexamine the correlation of this formation because the distribution of trigoniids is controlled by the depositional environment. The results of this study reconfirm that the My3 is correlated to the lower Cenomanian.
The wide distribution of the mid-Cretaceous shallow marine deposits containing a similar bivalve fauna in Japan has been remarked by many researchers, and it is also indicated that the species composition of bivalves of the Miyanohara Formation is similar to that of the upper Albian–lower Cenomanian strata in the Mikasa area in Hokkaido, Misakubo area in Shizuoka, Aridagawa area in Wakayama, Monobe area in Kochi, and Goshoura Island in Kumamoto (e.g. Matsuda, 1985; Komatsu and Maeda, 2005; Yoshihara and Komatsu, 2006; Misaki et al., 2008). On the other hand, the ammonoid species, *Mantelliceras japonicum* and *Hypostlingoceras japonicum*, are also found from the Mikasa area (Matsumoto et al., 1969; Matsumoto and Takahashi, 2000), and *M. japonicum* and *M. cf. japonicum* are known from the Aridagawa and Monobe areas, respectively (Matsumoto, 1982; Misaki et al., 2008); therefore, the results of this study suggest that ammonoid faunas in these areas are also similar to each other, as suggested by Misaki et al. (2008). It seems that similar shallow marine environments were widely distributed in the northwestern Pacific region in mid-Cretaceous time.

In this study, the cosmopolitan ammonoid species *Euhystrichoceras nicaisei* was also collected from the Miyanohara Formation. *Euhystrichoceras nicaisei* and/or *E. cf. nicaisei* have hitherto been reported from the Soeushinai and Kami-ashibetsu areas in Hokkaido (Hashimoto et al., 1965, p. 19, 22; Matsumoto et al., 1969, p. 287, 2004, p. 72; Matsumoto, 1975, p. 156; Inoma, 1980, p. 178; Matsumoto and Inoma, 1999, p. 36; Matsunaga, 2005, pl. 8, figs. 4, 5).
Matsumoto (1975) considered that the *E. nicaisei*-bearing bed in the Soeushinai area is older than the *Mantelliceras japonicum*-bearing bed in the Mikasa area; however, Matsumoto *et al.* (2004) have remarked that *E. nicaisei* is contained in the atypical part of the *Stoliczkaia (Lamnayella) japonica* Assemblage Zone in the Soeushinai area and that this zone is correlated to the *M. japonicum* Assemblage Zone in the Mikasa area. They thought that the difference in ammonoid faunas of the Mikasa and Soeushinai areas was caused by the depositional environment of the former being shallower than that of the latter. Matsumoto *et al.* (2004) have also suggested that the atypical part in the Soeushinai area may represent more of an offshore open sea environment than the typical part, considering that the ammonoid fauna of the atypical part is composed of cosmopolitan species. On the other hand, in the Kami-ashibetsu area, Matsunaga (2005) recovered *E. nicaisei* from just below the horizon where *M. japonicum* was obtained. In addition, along the Ganseki-zawa River in the Mikasa area, *H. japonicum* was reported from the *M. japonicum* Zone (Matsumoto and Takahashi, 2000), and *Mantelliceras* sp. and *Euhystrichoceras* sp. were collected as float at the same locality (Futakami, 1986, table 1).

In this study, *E. nicaisei*, *M. japonicum*, and *H. japonicum* were collected from float rocks at Loc. 1 probably derived from the middle part of the Miyanooha Formation (My3). This indicates that the stratigraphic ranges of these species are either very close or overlap, although their detailed relationship is not clear. More studies are needed to elucidate the detailed
stratigraphic relationship of these ammonoids and the relationships between their distributions and depositional environments.

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Figure captions

**Figure 1.** Index map (A) and route map (B) of the study area in the Sakawa area, Shikoku, southwestern Japan. The stratigraphic division of the Miyanohara Formation by Wakita *et al.* (2007) is also shown in B.

**Figure 2.** Columnar sections of the Miyanohara Formation in the study area.

**Figure 3.** Ammonoids from float rocks at Loc. 1 probably derived from the middle part of the Miyanohara Formation (My3). A–C, *Mantelliceras japonicum* Matsumoto, Muramoto and Takahashi, KMNH IvP 905001; A, ventral view; B, left lateral view; C, close-up of the internal mold of the body chamber encrusted by a cheilostome bryozoan colony; D–I, *Euhystrichoceras nicaisei* (Coquand); D–G, KMNH IvP 905002; D, right lateral view; E, ventral view; F, left lateral view; G, apertural view; H, I, KMNH IvP 905003; H, right lateral view; I, ventral view; J–P, *Hypostlingoceras japonicum* Matsumoto and Takahashi; J, K, KMNH IvP 905004; J, lateral view; K, basal view; L, M, KMNH IvP 905005; L, lateral view; M, basal view; N–P, KMNH IvP 905006. N, O, lateral view; P, basal view. Scale bars are 10 mm. White arrows indicate the positions of the last septa. The positions of the last septa of two specimens (KMNH
IvP 905003 and 905006) cannot be determined because of the mode of preservation.

**Figure 4.** External sutures of ammonoids from float rocks at Loc. 1 probably derived from the middle part of the Miyayohara Formation (My3). A, *Euhystrichoceras nicaisei* (Coquand), KMNH IvP 905002, at $H = 3.8$ mm; B, *Mantelliceras japonicum* Matsumoto, Muramoto and Takahashi, KMNH IvP 905001, at $H = 30.7$ mm; C, *Hypostlingoceras japonicum* Matsumoto and Takahashi, KMNH IvP 905005, at 3.2 mm in height of an exposed outer flank. E, external (ventral) lobe; L, lateral lobe (= adventive lobe, A, of Korn et al., 2003).

**Figure 5.** Comparison of apical angles and ornamentations of *Hypostlingoceras japonicum* Matsumoto and Takahashi specimens. A, resin cast of the paratype of *H. japonicum* (GK.H8541) originally illustrated by Matsumoto and Takahashi (2000, fig. 9), from the lower Cenomanian *Mantelliceras japonicum* Zone of the Mikasa Formation along the Suido-no-sawa River in the Mikasa area, Hokkaido; B, KMNH IvP 905005, from Loc. 1 in the Sakawa area, Shikoku; C, KMNH IvP 905004, from Loc. 1 in the Sakawa area, Shikoku; D, resin cast of the holotype of *H. japonicum* (GK.H8542) originally illustrated by Matsumoto and Takahashi (2000, figs. 7, 8), from the lower Cenomanian *M. japonicum* Zone of the Mikasa Formation along the Ganseki-zawa River (a tributary of the Kami-ichino-sawa River) in the Mikasa area, Hokkaido;
E, resin cast of the holotype of *H. mikasaense* (GK.H8540) originally illustrated by Matsumoto and Takahashi (2000, fig. 11), from the lower Cenomanian *M. japonicum* Zone of the Mikasa Formation along the Ganseki-zawa River (a tributary of the Kami-ichino-sawa River) in the Mikasa area, Hokkaido; F, MCM-A0875, plaster cast of an unregistered specimen from a float rock from the Kami-ichino-sawa River in the Mikasa area, Hokkaido; G, KMNH IvP 905006, from Loc. 1 in the Sakawa area, Shikoku.