

Selected Acanthoceratids from Hokkaido : Studies of the Cretaceous Ammonites from Hokkaido and Saghalien-XIX

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Selected Acanthoceratids from Hokkaido

(Studies of the Cretaceous Ammonites
from Hokkaido and Saghalien—XIX)

By

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Abstract

On the basis of our recent collections nine species of the Acanthoceratidae are described in this paper. They are two species of *Mantelliceras*, of which one is new, a magnificent new species of *Sharpeiceras*, two horned species of *Acanthoceras*, two species of *Euomphaloceras*, including a new, peculiar one, a species of *Kanabicerias* and a new species of a new genus related to *Watinoceras*.

The stratigraphic succession of these and also other, previously described species of acanthoceratids are summarized into a zonal scheme, with a conclusion of international correlation. In addition, brief remarks are given on the evolutionary history of the Acanthoceratidae.

Introduction

Since one of us (T.M.), together with coworkers (MATSUMOTO *et al.*, 1957), monographed the acanthoceratid ammonites from the Upper Cretaceous of Hokkaido, more specimens of the family have been assembled through our cooperative field work. Some of them are palaeontologically interesting and deserve description. They are also important for the international correlation of the Cretaceous strata. In the present paper we describe selected nine species which are assigned to *Mantelliceras*, *Sharpeiceras*, *Acanthoceras*, *Euomphaloceras*, *Kanabicerias* and a new genus. In connexion with the description of species, remarks are given on some genera, especially at length on *Sharpeiceras*, *Euomphaloceras* and a new genus related to *Watinoceras*.

It would be desirable to define a species on the basis of a sufficient number of specimens. For some reasons, however, ammonites of the Acanthocerataceae, except for a few special cases, do not occur so abundantly in Hokkaido. Only the first species, a new *Mantelliceras*, is represented by a fairly large number of specimens. We dare describe other eight species, including three new ones,

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on the material of a limited number of specimens, and hope that the collections would be increased in the future by kind cooperation of the persons who have interests in the group. Anyhow, we wish that the results of our study may contribute for further improvement of knowledge.

In the following systematic descriptions one of us (T. MATSUMOTO) is primarily responsible for the identification of species and exclusively so for the description of certain genera. The other two of us are partly responsible for the observation, as well as for collecting and cleaning the specimens. The authorship of new taxa are indicated in the respective places, depending on the responsibility.

The described specimens from Hokkaido are mostly preserved at the Type-Specimen Room, Department of Geology, Kyushu University, Fukuoka, which is indicated by a symbol GK. in the text. Symbols or abbreviations for other repositories of the specimens which may be cited in the text are as follows:

AMNH.: American Museum of Natural History, New York

BEG.: Bureau of Economic Geology, University of Texas, Austin

BM.: British Museum (Natural History), London

GSI.: Geological Survey of India, Calcutta

GSM.: Geological Survey and Museum, London

GT.: Geological Institute, University of Tokyo

MNHN.: Museum National d'Histoire Naturelle, Paris

MUR.: MURAMOTO's private collection, Mikasa, Hokkaido

SM.: Sedgwick Museum, Cambridge, England

USNM.: United States National Museum, Washington, D. C.

For the localities of the described fossils, normally indicated by numbers, a reader is requested to refer to the already published papers, especially MATSUMOTO, 1965, figs. 1-5, and MATSUMOTO, 1942, pls. 10 and 12. Some new localities are explained in the concluding remarks of this paper.

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Systematic Descriptions

Family Acanthoceratidae DE GROSSOUVRE, 1894

Subfamily Mantelliceratinae HYATT, 1903

Genus *Mantelliceras* HYATT, 1903*Type-species*.—*Ammonites mantelli* J. SOWERBY, 1814

Remarks.—The description of the generic diagnosis, with a discussion on the affinity, has already been given (MATSUMOTO *et al.*, 1957, p. 5). It has been, furthermore, noted (MATSUMOTO *et al.*, 1966) that *Submantelliceras* SPATH, 1923, as well as *Utaturiceras* WRIGHT, 1956, should be separated from *Mantelliceras* as distinct genera.

In addition to a rare species, *Mantelliceras* (?) *nagaoi* MATSUMOTO, SAITO and FUKUDA, 1957, from the Abeshinai area of Teshio Province, there are at least three species from the Ikushumbets area, Ishikari Province, of which two are described in this paper.

Mantelliceras japonicum MATSUMOTO,

MURAMOTO and TAKAHASHI, sp. nov.

Pl. 25, Figs. 1–2; Pl. 26, Figs. 1–3; Pl. 27, Figs. 1–2; Text-figs. 1–2

Material.—The holotype is GK. H5428 [Mu. 12716], from loc. Ik. 1100, representing a mature stage; paratypes GK. H5594, from loc. Ik. 1065g, H5609, H5427, H5426, H5560, and H5559, from loc. Ik. 1100, representing various growth-stages (Coll. MURAMOTO and MATSUMOTO). There are other examples from loc. Ik. 1054 and Ik. 1100, of which three of MURAMOTO's collection are mentioned below.

Specific diagnosis.—The shell is of moderate size, attaining to about 140 mm. at the full-growth stage. The adult body-whorl occupies at least a half volution.

Whorls are moderately involute in the young shell, embracing about two thirds (in height) of the inner whorl, but the adult body-whorl becomes evolute. The umbilicus is of moderate size, about 30 to 36 percent of the shell diameter, becoming larger in the adult shell. It is surrounded by a steep wall.

The whorl is nearly as broad as high or somewhat higher than broad, becoming more compressed at the adult stage. The intercostal whorl section is subelliptical, having a moderately arched venter, rather flat or very gently convex flanks and more or less rounded umbilical shoulders. The costal section of the tuberculate immature whorl is roughly trapezoid-polygonal, being broadest between the upper umbilical tubercles. The costal section of the adult whorl is subelliptical, being similar to the intercostal section.

The shell is nearly smooth at the early immature stage, up to the diameter of about 5 mm. The rest, main part of the phragmocone is ornamented with moderately strong and distant ribs and fairly strong tubercles. The ribs are at first prorsiradiate especially near the umbilical margin and become nearly rectiradiate in the main part of the septate whorl. The ribs are separated by



Fig. 1. *Mantelliceras japonicum* MATSUMOTO, MURAMOTO and TAKAHASHI, n. sp. Whorl-section of the holotype, GK. H5428. (T. MAT. delin.)

somewhat wider interspaces. They are alternately long and short. A long rib on one side may be extended to a short one on the other side and *vice versa*. The short ribs are free from the umbilical tubercles, while the long ribs are provided with two umbilical tubercles, of which the upper one is prominent and the lower one is less so or sometimes very faint. The two tubercles are separated at variable distance depending on individuals, but the distance is in any case clearly shorter than that between the upper umbilical and the lower ventrolateral tubercles and is nearly as long as or shorter than that between the upper and the lower ventrolateral ones. The upper ventrolateral tubercle is somewhat clavate and normally stronger than the lower one. The distance between the outer ventrolateral tubercles on both sides of the siphonal area is nearly as short as or somewhat wider than that between the upper and the lower ventrolateral ones. The ribs straightly connect the two upper ventrolateral tubercles across the siphonal area, although with slight lowering and broadening.

The tubercles begin to be weakened at a diameter of about 80 mm., i.e. at the last stage of the phragmocone or at the beginning of the adult body-whorl, and finally disappear in the last part of the body-whorl, although the upper umbilical and the lower ventrolateral ones may persist as low bulges on the ribs for some period. In the earlier part of this weakly or non-tuberculate whorl ribs are still alternately long and short. A long one on one side may be extended to a short one on the other. In the last part all the ribs are almost equally long. In the adult whorl some of the ribs are more or less projected near the umbilical margin, but on the main part of the flank and on the venter they are nearly rectiradiate or occasionally even slightly rursiradiate. They are moderately broad and elevated, crossing the venter without weakening. They are separated by slightly wider interspaces.

Sutures are of typical *Mantelliceras* type, having two broad, rather massive, bipartite lateral saddles and narrower lobes, with less deep and less numerous minor incisions. E is the longest; L is nearly as deep as E and asymmetrically trifid or apparently bifid at the bottom; much smaller, two or two and a half auxiliary lobes are seen on the external part. The first lateral saddle is nearly twice as broad as the second, being situated on the zone of lower and upper ventrolateral tubercles.

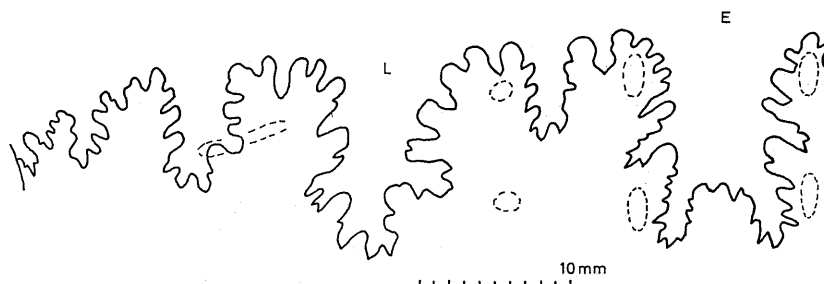


Fig. 2. *Mantelliceras japonicum* MATSUMOTO, MURAMOTO and TAKAHASHI, n. sp. External suture of the holotype, GK. H5428, at whorl-height=31 mm. Dotted lines indicate the base of tubercles. (T. MAT. *delin.*)

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
GK. H5428 (c)	118.6(1)	43.2(.36)	44.0(.37)	39.0(.33)	0.88
(ic)			41.5	37.0	0.89
(-1/2 vol.) (c)	76.0(1)	26.0(.34)	29.5(.39)	29.5(.39)	1.00
GK. H5426 (c)	75.3(1)	23.5(.31)	31.5(.42)	32.9(.44)	1.04
(ic)	73.2(1)	23.0(.31)	30.5(.41)	31.8(.43)	1.04
(-1/2 vol.) (ic)			21.5	22.0	1.02
GK. H5427 (c)	34.6(1)	10.8(.31)	13.8(.40)	13.5(.39)	0.98
MUR. Ik5001	129.5	45.8	47.5	41.0	0.86
MUR. 12443 (malform)	109.0(1)	41.0(.37)	39.0(.36)	—	
(-1/4 vol.) (c)	94.4(1)	33.8(.35)	38.3(.40)	34.1(.36)	0.9
GK. K5609 (c)	80.0(1)	25.6(.32)	33.6(.42)	30.0(.37)	0.89

(c)=costal, (ic)=intercostal

Variation.—On the basis of the observation on numerous specimens from loc. Ik 1100, a bed in the recently excavated quarry, it is noticed that there is a considerable extent of variation in the shell form, from a comparatively thick-whorled one to a comparatively compressed one, and in the ornamentation, with variable persistency of the strongly tuberculate stages. The holotype and a paratype, GK. H5609, may represent the average form.

Comparison.—The present species is allied to *Mantelliceras tuberculatum* (MANTELL, 1822), represented by an example illustrated by SHARPE (1857, pl. 18, fig. 6 under *Ammonites mantelli*) (see SPATH, 1926, p. 82, and WRIGHT and WRIGHT, 1951, p. 37), from the Lower Cenomanian *Varsians* zone of England, and other examples illustrated by COLLIGNON (1964, p. 68, pl. 338, figs. 1511–1512; p. 69, pl. 339, figs. 1513–1517; p. 73, pl. 341, fig. 1526) from the Cenomanian zone of *Mantelliceras mantelli* of Madagascar, in the strongly tuberculate immature shell and the general aspects of the shell-form. It is distinguished from the latter by its more distant and less numerous ribs and on the average somewhat more compressed whorls, with less inflated flanks. The evolute shell-form at the adult stage may be another distinction.

In the general aspects of shell-form the present species resembles *Mantelliceras mantelli* (J. SOWERBY) (SHARPE, 1857, p. 40, pl. 18, fig. 7; WRIGHT, and WRIGHT, 1951, p. 24), from the Lower Cenomanian *Varsians* zone of England and the *M. mantelli* zone of Madagascar (COLLIGNON, 1964, p. 66, pl. 337,

figs. 1506–1508; p. 68, pl. 338, figs. 1509–1510), but is distinguished by more distant and less numerous ribs and stronger tubercles. The latter seems to have a more involute shell and narrower umbilicus. In an example of *M. mantelli* in the collection from the Isle of Wight, England, and in some other examples a long rib on one side of the whorl is extended to a short one on the other side. This feature is the same as that seen in many examples of the present species, but it does not seem to be a well stabilized character, because there are exceptions. In the adult shell of *M. mantelli* the upper ventrolateral tubercles persist for a longer period than the lower and the alternating long and short ribs are seen even in a large shell (with diameter of about 140 mm.), as illustrated by COLLIGNON (1954, pl. 337, fig. 1508). In the adult shell of our species, *M. japonicum*, the upper and lower ventrolateral tubercles are weakened nearly simultaneously, but the lower ones may rather persist for a slightly longer period, although they remain as indistinct low bulges. The equally long ribs, without intercalation of shorter ones, on the last part of the adult shell may be characteristic of *M. japonicum*.

An imperfectly preserved specimen, from Ikushumbets, which was previously described as *Mantelliceras* (?) sp. (MATSUMOTO *et al.*, 1957, p. 5, text-fig. 1) is probably a fragmentary example of the present species.

Occurrence.—Fairly commonly found in nodules at locs. Ik 1100 and Ik 1054 of the main valley of the Ikushumbets, zone of *Mantelliceras japonicum* (provisionally called the zone of *Mantelliceras* n. sp. by MATSUMOTO, 1965, fig. 5), sandstone of the lower part of unit IIb, Mikasa Formation [= *Trigonia* Sandstone of YABE, 1926], Lower Cenomanian. Specimens are found also on the right wall of the Shimo-ichi-no-sawa (locally called Torii-zawa) on the extension of the same zone.

Mantelliceras cantianum SPATH

Pl. 27, Fig. 3; Pl. 28, Fig. 1 (?)

1857. *Ammonites navicularis*, SHARPE, p. 39, pl. 18, fig. 1, 2 (non MANTELL, 1822).

1926. *Mantelliceras cantianum* SPATH, p. 82.

? 1931. *Mantelliceras budaense* ADKINS, p. 41, pl. 2, fig. 3; pl. 4, fig. 10.

1951. *Mantelliceras cantianum*, WRIGHT and WRIGHT, p. 24.

1964. *Mantelliceras cantianum*, COLLIGNON, p. 80, pl. 344, fig. 1532–1534.

Types.—Holotype, BM. 36834 [=SHARPE, 1857, pl. 18, fig. 1] by original designation (SPATH, 1926a); paratype, BM.C. 5027 [=SHARPE, 1857, pl. 18, fig. 2], both of which were examined by one of us (T. MATSUMOTO).

Material.—GK. H5608, from loc. Ik 1100 (coll. T. TAKAHASHI), is a typical example from Hokkaido. GK. H5610, from the same locality (coll. T. TAKAHASHI) could be referable to this species, but is provisionally called *Mantelliceras* sp. aff. *M. cantianum* (see below). There are several other examples in T. TAKAHASHI's private collection from the same locality.

Specific characters.—The shell is moderately large, nearly 120 mm. in

diameter in the holotype, moderately involute, about a half of the inner whorl being embraced by the outer one, and has a comparatively narrow umbilicus, which is nearly or less than 30 percent of the shell diameter.

The whorl is somewhat broader than high and roundish in section, having inflated flanks, subrounded umbilical shoulder and a broadly rounded venter.

The ribs are coarse, strong, and rather rigid. In the later stages of typical specimens they are separated by somewhat wider interspaces, being about 33 per whorl. Usually the ribs are alternately long and short, but occasionally two shorter ones may be intercalated between the longer ones. On the flank the longer ribs are somewhat stronger than the shorter ones, but on the venter they are almost equally strong.

The long ribs have two rows of tubercles around the umbilicus, one at the umbilical shoulder and the other on the lower part of the flank at a short distance from the umbilical shoulder. In most growth-stages every rib has two ventrolateral tubercles, lower one just at the ventrolateral shoulder and the upper one on the venter at some distance from the siphonal line. The tubercles are rounded at the base, although the upper ventrolateral tubercles may be somewhat clavate in certain growth-stages. There are no perceptible siphonal tubercles and the ribs cross the venter transversely, without notable projection nor weakening. On the last part of the adult whorl the tubercles are weakened and tend to be absorbed by the coarsened ribs.

The suture is of *Mantelliceras* type. The saddles are bifid and subrectangular in rough outline; the lobes are narrower than the saddles and moderately deep. Minor incisions are shallow, but the branches at the bottom of L are moderately deep.

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.	Ribs
BM. 36834	116 (1)	34 (.29)	51 (.44)	55 (+ ?) (.47)	1.08	33
BM. C. 5027	59 (1)	16 (.27)	26.5 (.40)	34 (.57)	1.3	34 (?)
GK. H5608 (−20°)	63.0 (1)	17.0 (.27)	27.2 (.43)	33.5 (.53)	1.23	33
GK. H5610	97.5 (1)	29.5 (.30)	38.2 (.39)	37.2 (.38)	0.97	40
(− 90°)	88.3 (1)	26.5 (.30)	36.5 (.41)	41.0 (.46)	1.12	39
(−180°)	68.0 (1)	19.0 (.28)	30.5 (.45)	35.0 (.51)	1.14	37
SM. B35663	96.5 (1)	27.0 (.28)	41.5 (.43)	46 (+ ?)	1.1	31
for comparison						
BEG. 17017	82.0 (1)	25.0 (.30)	35.3 (.43)	39.3 (.48)	1.11	23

Variations.—On examining several British specimens, including the holotype, it is noticed that there is some extent of variation in the proportion between breadth and height, coarseness and density of the ribs and strength or persistency of tubercles. This is also recognized in a number of specimens from Hokkaido. One of them, GK. H5608, is very close to the paratype, BM. C. 5027 [=SHARPE, 1857, pl. 18, fig. 2], although its ribs are somewhat coarser in the preserved last part.

GK. H5610, among other specimens, deviates considerably from the holotype in its more crowded ribs and less persistency of ventrolateral tubercles, but is

essentially of *cantianum* type in its inflated and subrounded shell form and coarse ribbing. Provisionally it may be called *Mantelliceras* sp. aff. *M. cantianum*, but it could be an extreme variant of *M. cantianum*. It is interesting that the last portion of the body-whorl of this specimen becomes somewhat evolute and is reduced in size, showing an unusually compressed form immediately behind the aperture.

On the other hand, the holotype of *Mantelliceras budaense* ADKINS (1931, p. 41, pl. 2, fig. 3; pl. 4, fig. 10), BEG. 17017, from the top bed of Buda Limestone, Texas, which one of us (T. MAT.) once studied, has widely separated, less numerous ribs (23 per whorl) but is otherwise essentially similar to the typical specimens of *M. cantianum*. Whether the above difference occurs constantly in the Texas specimens or not should be studied by further collection. It is, however, possible, that *budaense* could be a subspecies, or even a variety, of *M. cantianum*. A specimen from the Chalk Marl, Isle of Wight, preserved at Sandown Museum (Catalog. no. 1984), England, shows an intermediate feature in that it has 27 fairly distant ribs. It is, however, larger than BEG. 17017, about 125 mm. in diameter, and on its last part of the outer whorl the tubercles are lost. Although it was labelled as *Mantelliceras naviculare*, it is probably an adult shell of *M. cantianum*.

COLLIGNON (1964, p. 80) has demonstrated certain variability in the character of umbilical tubercles for the Madagascar specimens of *M. cantianum*.

Comparison and affinity.—*M. cantianum* resembles *M. mantelli* (SOWERBY) (see SHARPE, 1857, pl. 18, fig. 7) and *M. tuberculatum* (MANTELL) (see SHARPE, 1857, pl. 18, fig. 6) but is distinguished by more rounded whorls and more robust, more rigid, coarser ornamentation.

The affinity of *M. cantianum* with certain species of *Calycoceras* has been noted by WRIGHT (personal talk) on the basis of such specimens as SM. B 35634, from Sandy Chloritic Marl, Eggerton Hill, Dorset (England), which is very similar to typical *M. cantianum* but has an incipient row of siphonal tubercles. An examples which show a similar feature are found in the collections from the Takambets (GK. H5619) and from Ik 1103, Mikasa Sandstone on the western wing, near Ikushumbets.

Occurrence.—Loc. Ik 1100, Katsurazawa quarry, Ikushumbets valley, Lower part of unit IIB, Mikasa Formation.

British specimens occur in the *Varians* Zone, Lower Cenomanian of southern England.

Genus *Sharpeiceras* HYATT, 1903

Type-species.—*Ammonites laticlavus* SHARPE, 1855 (original designation).

Synonym.—*Tlahualiloceras* KELLUM and MINTZ, 1962.

Generic characters.—A fairly large shell consists of rather evolute whorls, which are more or less higher than broad and typically subrectangular in

section but may be modified to subelliptical (in intercostal section) at the adult stage of some species.

Ribs are nearly rectiradiate, single, and almost equally long in the type- and allied species, with tubercles at the umbilical shoulders, at or near the middle of the flanks, at the ventrolateral shoulders and on the venter at some distance from the siphonal line on every rib. In an exceptional case the upper lateral tubercle appears in addition to the fours. At certain stages of some species secondary ribs are branched or intercalated at or near the umbilical tubercles. On the adult body-whorl of some species the ventrolateral and sometimes also the ventral tubercles are strengthened to form horns.

Sutures are more deeply incised than that of *Mantelliceras*. Especially the lateral lobe is deep, being characterized by narrow and deep branches in its lower part. Saddles are less massive than in *Mantelliceras*. There are several, descending auxiliaries.

Remarks.—The following species are referred to the genus *Sharpeiceras*:

S. laticlavium (SHARPE, 1855) (England, Madagascar, Tunisia?, Algeria?)

S. schlueteri HYATT, 1903 (Germany, Madagascar)

S. indicum (KOSSMAT, 1895) (India, Madagascar)

S. mexicanum (BÖSE, 1927) (Mexico)

S. occidentale BENAVIDES-CÁCERES, 1956 (Peru)

S. florencae SPATH, 1925 (S. Africa, Iran, Texas)

S. tlhualiloense (KELLUM and MINTZ, 1962) (Mexico)

S. vohipalense COLLIGNON, 1964 (Madagascar)

S. mosambiquense (CHOFFAT, 1903) (SE. Africa)

S. kongo n. sp. (described below) (Japan)

S. mexicanum was described by BÖSE (1927, p. 253, pl. 10, fig. 6; pl. 11, fig. 1) as a variety of *S. laticlavium* from the Buda Limestone, Coahuila, Mexico. It indeed resembles *S. laticlavium*, but is distinct in that the ribs are almost always bifurcated at the umbilical tubercle. In the holotype of *S. laticlavium* bifurcated or intercalated ribs are only discernible on the whorl with height of 25 to 35 mm, but on the main part of its outer whorl the ribs are simple. *S. mexicanum* is also similar to *S. indicum*, but in the latter species the secondary ribs occur only in the late growth-stage and the ribs are rectiradiate as compared with the somewhat prorsiradiate ones in the Mexican species. The whorl of *S. mexicanum* is more compressed (B/H = about 0.7) than that of *S. laticlavium* (B/H = 0.84) but less so than that of *S. indicum* (B/H = 0.6), so far as the type-specimens are concerned.

The tubercles of *Sharpeiceras* are normally in four rows, but in *S. mosambiquense* (CHOFFAT) (1903, p. 25, pl. 4, fig. 4; pl. 7, fig. 1) another row of tubercles is added to them in the upper lateral part.

As SPATH (1925, p. 199) pointed out, "*Acanthoceras*" *laticlavium* var. *byzacenica* PERVINQUIÈRE (1907, p. 301 pl. 14, fig. 4) does not probably belong to *Sharpeiceras*. It may be a fragmentary immature shell of a species of *Utaturiceras* WRIGHT, 1956, which is more finely ribbed than *U. vicinale* (STOLICZKA, 1864) (redefined by MATSUMOTO and SARKAR, 1966, p. 297, pl. 32,

fig. 1; pl. 33, figs. 1-3; text-figs. 1-4).

PERVINQUIÈRE's (1907, p. 302) example of "*A. laticlavium*" from Rebeiba, Tunisia, with "extremely developed twinned outer tubercles," might be a new species of *Sharpeiceras*, but, without seeing illustration or the specimen itself, it is difficult to give a definite conclusion.

HYATT's (1903, p. 111) assignment of *Ammonites inconstans* SCHLÜTER (1871, p. 7, pl. 3, figs. 1-5) to *Sharpeiceras* is not warrantable. SCHLÜTER's specimens are identical with *Acompsoceras sarthense* (GUÉRANGÈRE, 1867), as PERVINQUIÈRE (1907, p. 303) pointed out.

Specimens which should be referred to *Mantelliceras* were sometimes incorrectly referred to *Sharpeiceras*, but the generic distinction is clear, as is remarked below. Thus *Ammonites cabardinensis* SIMONOWITCH, BACEWITCH and SOROKIN, 1874, which was reillustrated by ORLOV (1958, pl. 57, fig. 3) under the generic name *Sharpeiceras*, should be transferred to *Mantelliceras*, as *Mantelliceras indianense* HYATT, 1903, should be kept in *Mantelliceras*.

Tlahualiloceras tlahualiloense KELLUM and MINTZ, 1962, on which *Tlahualiloceras* was set up by the two authors, is very close to *Sharpeiceras florencae* SPATH, 1925, and can be only distinguished by its somewhat more compressed whorls. There is, accordingly, no generic distinction between *Sharpeiceras* and *Tlahualiloceras*, and thus *Tlahualiloceras* KELLUM and MINTZ, 1962, falls in a synonym of *Sharpeiceras* HYATT, 1903.

Comparison and affinities.—*Sharpeiceras* is allied to but distinguished from *Mantelliceras* HYATT, 1903. In *Mantelliceras* whorls are less evolute, ribs are as a rule alternately long and short, the ribs on the outer whorl are predominant over tubercles, which, accordingly, do not form horns, and furthermore, sutural saddles are more massive and lobes are broader and less deeply incised than in *Sharpeiceras*. In the typical species of *Mantelliceras* the umbilical tubercles are double, instead of forming an independent lateral tubercle. In some species, however, lateral tubercles are distinctly developed, as in *M. indianense* HYATT, 1903 (see STOLICZKA, 1864, pl. 44, fig. 1; COLLIGNON, 1964, pl. 345, fig. 1536), and *M. lateretuberculatum* COLLIGNON, 1964 (p. 94, pl. 348, fig. 1548; pl. 349, fig. 1552), and, thus, a *Sharpeiceras* like alignment of tubercles is shown.

Morphologically *Mantelliceras* could be ancestral to *Sharpeiceras*, but undoubted species of *Mantelliceras* are contemporary with those of *Sharpeiceras*. I am rather inclined to regard *Submantelliceras* SPATH, 1923 [type-species *S. aimalense* (COQUAND, 1862), from the basal part of the Cenomanian] as possibly a common ancestor of *Mantelliceras* and *Sharpeiceras*. As is discussed at length in another paper (MATSUMOTO et al., 1966), *Submantelliceras* is similar to but well distinguishable from the compressed subgroup of *Mantelliceras* (i.e. subgroup of *M. hyatti*), as well as from the typical group of *Mantelliceras*, by a particular pattern of sutures and other characters, although the type and other representative species of *Submantelliceras* are based on small, probably immature specimens. In the pattern of suture *Sharpeiceras* is closer to *Submantelliceras* than to typical *Mantelliceras*. In the shell form, characterized by evolute and subrectangular whorls, and general aspects of the ornament, species of

Sharpeiceras could be derived through such species as *Submantelliceras villei* (COQUAND, 1862).

It is interesting to note that the holotype of *S. laticlavium* (SHARPE), GSM. 7755, according to my observation, shows at a certain immature stage gently flexuous and somewhat prorsiradiate ribs* with inserted or branched secondaries and that of *S. mexicanum* (BÖSE) has more frequently bifurcated, prorsiradiate ribs. These characters may show an intimate relation to *Submantelliceras*, although the ribs of the two specimens are distinctly provided with lateral tubercles.

In connexion with this problem, it is requested to study early immature stages of *Sharpeiceras*. The hitherto described species of *Sharpeiceras*, including the new one in this paper, are always represented by more or less large specimens and no specimens of small, immature stages of the same species have been described in detail. Anyhow, typical species of *Submatelliceras* have involute whorls, more or less flexuous ribs with numerous secondaries, and no lateral tubercles.

In the hypernodosity of the body-whorl, somewhat compressed, sub-rectangular whorls, and sutural pattern, certain species of *Sharpeiceras* resemble the type-species [*G. lozoi* YOUNG, 1958] and allied species of *Graysonites* YOUNG, 1958, from the lower part of Lower Cenomanian (see MATSUMOTO, 1959c, p. 65–71). In *Graysonites*, however, the outer and inner ventrolateral tubercles are united into a ventrolateral horn on the body-whorl, the mediolateral tubercles are absent or very indistinct, the whorls are less evolute and the *Submantelliceras* like characters are persistent up to a considerable diameter of the septate whorl.

Occurrence.—Species of *Sharpeiceras* occur characteristically in the Lower Cenomanian. The genus shows world-wide distribution, although the hitherto described species (and specimens) are not so numerous as in the case of *Mantelliceras*.

Sharpeiceras kongo MATSUMOTO, MURAMOTO and TAKAHASHI, sp. nov.

Pl. 29, Fig. 1; Pl. 30, Fig. 1; Text-figs. 3–4

Material.—Holotype: T. TAKAHASHI Coll. No. 425261, from loc. Ik 1100, Ikushumbets. Paratypes: GK. H5604 [Muramoto Coll.], a large but wholly septate specimen, from loc. Ik 1100, and T. TAKAHASHI Coll. No. 405161, an incomplete and deformed specimen, from loc. Ik 1101 ("Mamushi-zawa"), close to the type-locality.

Etymology.—*Kongo*, a deity who is believed to guard *Buddha* against demons. The rigid and strongly ornamented aspect of this large ammonite reminds us of the figure of Kongo, exemplified by the well known sculpture in the temple of Todaiji, Nara.

Diagnosis.—The shell is large, nearly 300 mm in diameter at the adult

* The drawing in SHARPE (1855, pl. 14, fig. 1) does not quite correctly illustrate this feature.

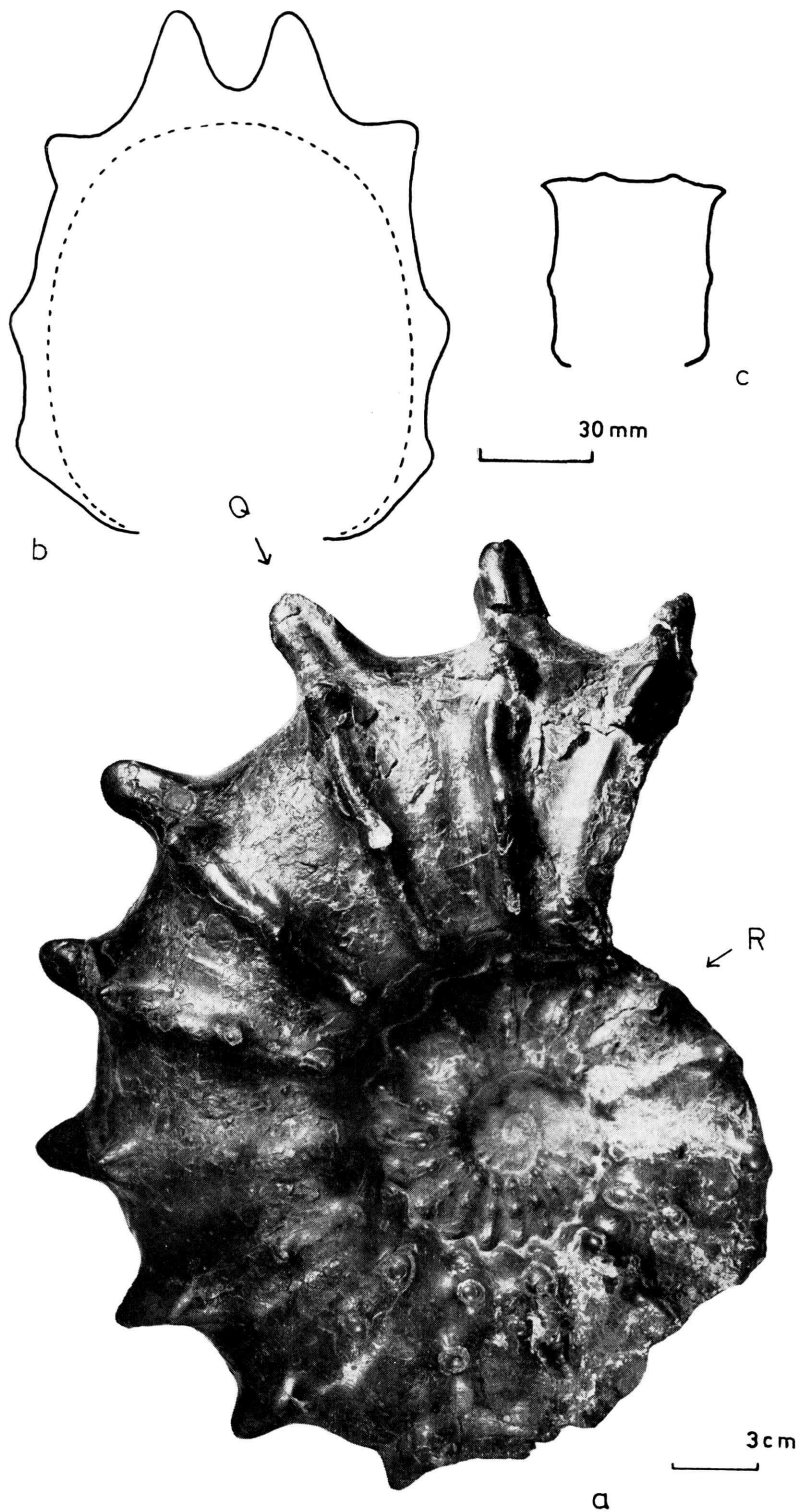


Fig. 3. *Sharpeiceras kongo* MATSUMOTO, MURAMOTO and TAKAHASHI, n. sp. Lateral view (a) and whorl-sections (b, c) at Q and R.

stage. Whorls are rather evolute, the outer one slightly embracing the ventral part of the inner one. The umbilicus is moderately deep and of moderate size, about one third of the entire shell diameter, as it is encircled by fairly rapidly increasing whorls. The body-whorl occupies about a half volution and its apertural end is somewhat reduced in breadth and height.

The septate whorl is nearly rectangular in section, having plane and parallel flanks and a rather flat venter. It is somewhat higher than broad. The adult body-whorl keeps the same proportion of height and breadth, about 10: 8.5 on the average. It has, however, somewhat more rounded section, with gently inflated flanks and a moderately arched venter.

The ribs are nearly rectiradiate, occasionally slightly concave, and almost equally long at least in the outer two whorls. They are widely separated. Their distance regularly increases with growth. In the last entire whorl of the holotype there are only 15 ribs, of which 8 are on the body-whorl. The tubercles are in four rows on each side, of which the lateral one is a little closer to the umbilical one than to the ventrolateral one.

On the septate whorls ribs are moderately broad and rather low, while tubercles are predominant over ribs. The low ribs scarcely cross the venter. Of the tubercles in four rows, the ventrolateral one is the most prominent, stretching somewhat sideward so as to lean against the steep wall of the outer whorl. The lateral and umbilical tubercles are of moderate intensity and rounded at their base. The ventral tubercles are low to moderately elevated, and somewhat clavate, with the highest point at the anterior part of the clavus. The paired ventral clavi on either side of the siphonal line are moderately separated. The shell may be slightly elevated on the siphuncle, as in some other acanthoceratids, but a distinct keel is never formed.

On the body-whorl the ribs are rigid and very strong, increasing their elevation with growth. They cross the venter. The tubercles are also enlarged and very prominent on the body-whorl. The ventrolateral tubercles are stronger than the lateral and the umbilical ones, forming smaller horns. The ventral tubercles are the most prominent, forming larger horns on the main part of the body-whorl. The paired ventral horns are characteristically approximated, with a V-shaped valley between them at the middle of the venter. They are upright in frontal (or back) view, and asymmetrically elevated in lateral view, with an almost vertical posterior wall and a moderately inclined anterior wall. Their base is elliptical, somewhat, but not much elongated spirally. On the anterolateral side of the horn a shallow depression may be discernible, which is extended from a very shallow furrow along the anterior foot of the steeply elevated rib. The horns on the rib near the apertural end are somewhat lower than those on the preceding rib.

The suture is deeply incised and of typical *Sharpeiceras* pattern (e.g. that illustrated by SCHLÜTER, 1872, pl. 7, figs. 7, 8 and by KOSSMAT 1895, pl. 24, fig. 6b) in which the large L (first lateral lobe) has a narrow stem and deep branches at the bottom and on the sides.

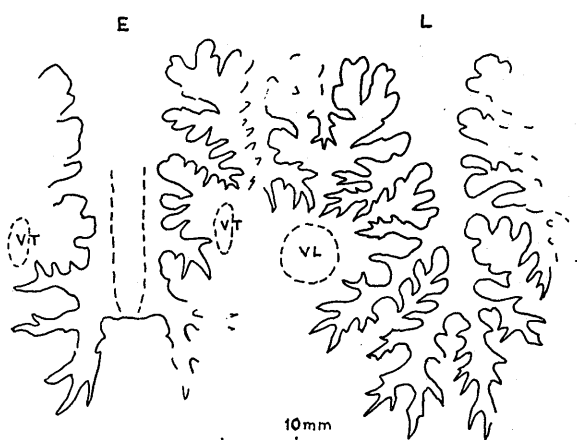


Fig. 4. *Sharpeiceras kongo* MATSUMOTO, MURAMOTO and TAKAHASHI, n. sp. Part of the external suture of the holotype at world-height=55 mm.

(T. MAT. delin.)

Measurements (in mm).—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
Holotype of <i>S. kongo</i>					
(1) (ic)	286 (1)	103 (.36)	108 (.38)	87 (.30)	0.80
(2) (c)	310 (1)	101 (.33)	143 (.46)	122 (.39)	0.85
(3) (ic)	271 (1)	95 (.35)	108 (.40)	94 (.35)	0.87
(4) (ic)	201 (1)	66 (.32)	84 (.42)	71 (.35)	0.84
(5) (ic)	135 (1)	45 (.33)	55 (.40)	45 (.33)	0.82
Paratype					
GK. H5604 (ic)	Ca 250 (1)	85 (.34)	95 (.38)	76 (.30)	0.80
For comparison, Holotype of					
<i>S. laticlavium</i> (meas. by MAT.)	129 (1)	35 (.27)	59 (.45)	50 (.38)	0.84 (c)
<i>S. florencae</i> (after SPATH)*	200 (1)	66 (.33)	84 (.42)	76 (.38)	0.90
	160 (1) (c)	51 (.32)	72 (.45)	66 (.41)	0.91
	100 (1)	30 (.30)	43 (.43)	36 (.36)	0.84
<i>S. vohipalense</i> (after COLLIGNON)	162 (1)	58 (.36)	66 (.41)	50 (.31)	0.76 (ic)
				67 (.41)	1.0 (c)

(1): At the apertural end; (2) along the last third rib, about 45° back from (1); (3) behind (2), between the ribs; (4) about 180° back from (1); (5) about 270° back from (1); (c): costal, (ic): intercostal.

* SPATH's (1925, p. 198) indication of 0.38 for the height in proportion to the diameter of 200 mm. is probably a misprint. Here the approximate measurements from the figure are indicated.

Comparison.—At least ten species of *Sharpeiceras* are known from various regions of the world, but for some reasons they are everywhere represented by a small number of specimens. Accordingly the extent of variation is not precisely described for each species. Under these circumstances comparisons are made with respect to the criteria which have been normally regarded as distinct enough for the specific separation, although some of the distinctions might be only subspecific.

In the adult shell *Sharpeiceras kongo* resembles *S. florencae* SPATH (1925, p. 198, pl. 37), from the Cenomanian of "Maputoland", southeastern Africa, in somewhat inflated flanks, distant and strong ribs, and especially well developed ventrolateral and ventral horns of the body-whorl. The two species are also similar to each other in the shell-form of the septate stage, which is evolute, flattened on flanks, and subquedrate in section, having almost the same proportion of breadth to height as that of *S. laticlavium* (SHARPE). *S. kongo* has, however, much more distant and less numerous ribs (15 or 16 per whorl as compared with 25 or more in *S. florencae*) on the septate whorls, and more highly elevated ribs on the body-whorl than *S. florencae*. The approximated, strong ventral horns are, furthermore, characteristic of *S. kongo*.

The present species is somewhat similar to *S. tlahuliloense* (KELLUM and MINTZ) (1962, p. 276, pl. 6, fig. 1; pl. 7, figs. 1-2; pl. 8, fig. 1), from the Lower Cenomanian of Coahuila, Mexico, in the large, evolute shell, distant ribs on the body-whorl, and prominent outer tubercles. In the septate stages the Mexican species, like *S. florencae*, has more numerous and less distant ribs than *S. kongo*. In this respect and in the more rigid ribs and also the stronger horns on the body-whorl *S. kongo* is distinct from the Mexican species.

S. kongo is allied to *S. vohipalense* COLLIGNON (1964, p. 104, pl. 354, fig. 1565), from the Lower Cenomanian of Madagascar, in the distant ribs and the strong tubercles. The ventral tubercles are particularly strengthened on the body-whorl of the former, while they are lowered and clavate on that of the latter. The adult whorl of *S. kongo* is much larger and more inflated than that of *S. vohipalense*. Thus the adult shell of the Madagascar species considerably resembles the septate shell of the Japanese one.

Sharpeiceras occidentale BENAVIDES-CÁCERES (1956, p. 465, pl. 54, figs. 5-6), from the Lower Cenomanian *Mariella lewesiensis* zone of Peru, is characterized by fairly approximated allocation of the paired ventral tubercles. In *S. kongo*, however, the ventral tubercles are approximated only on the adult body-whorl and normally separated on the septate whorls. *S. kongo* is, furthermore, distinguished from *S. occidentale* in its more inflated body-whorl, much more distant ribs, stronger tubercles, and especially the intensified ribbing and hypernodosity in the adult.

A highly crushed specimen, from the Miyanohara Sandstone of the Cretaceous sequence of the Ochi-Sakawa area, Shikoku, in the collection of the University of Tokyo, which one of us (MAT.) saw once but seems to be missing now, is smaller than the specimens from Hokkaido but has clavate ventral tubercles in addition to the less clavate ventrolateral and the bullate lateral and umbilical ones on each ribs. The ribs are of nearly equal length, about 13 within the preserved two thirds of the entire whorl, and separated by wider interspaces. A horn is preserved on one of the ventral tubercles of this small specimen. Thus the specimen is closely allied to, if not identical with, *S. kongo*, from Hokkaido. It has a smaller umbilicus, although the size is not exactly measurable, owing to the secondary deformation.

This ammonite from the Miyanohara Sandstone, which can be temporarily called *Sharpeiceras* sp. aff. *S. kongo*, is associated with other ammonites and trigonians, of which an immature specimen of *Mantelliceras* is probably identical with *Mantelliceras japonicum*.

Occurrence.—The described three specimens were obtained from loc. Ik 1100, Katsurazawa quarry, and adjacent loc. Ik 1101 on the northern wall of the V-shaped valley of the Ikushumbets, from the sandstone bed belonging to the 20 m. unit in the lower part of IIB of the Mikasa Formation. It contains, among others, a number of specimens of *Mantelliceras japonicum*.

To the flank of the body-whorl of the holotype a few small flat valves of *Anomia* [?] sp. are attached, facing their beak to the dorsad orientation.

Subfamily Acanthoceratinae DE GROSSOUVRE, 1894

Genus *Acanthoceras* NEUMAYR, 1875

Type-species.—*Ammonites rhotomagensis* DEFRANCE in BRONGNIART, 1822, as designated by DE GROSSOUVRE, 1894 (p. 27).

Remarks.—The generic diagnosis has been given recently (MATSUMOTO and OBATA, 1966), with a discussion on the extent and variability of the genus. As stated on that occasion, the species with strong horns on the outer whorl are intimately related to the less strongly horned or normally tuberculated ones and it is not natural to separate merely on that account the two subgroups as distinct genera.

Few works have been devoted to make clear the extent of variation of *Acanthoceras* species. Even for *Acanthoceras rhotomagensis*, the type-species itself, this is unfortunately true. Our present material is not either sufficient for this purpose, but we would not take the species concept of too little variability.

As has been mentioned by WRIGHT (1963, p. 605), there are certain species which are difficult to place in either *Acanthoceras* or *Calycoceras*. For the time being they are included in *Acanthoceras*. Examples are *A. tapara* WRIGHT, 1963, *A. mirialampiense* WRIGHT, 1963, and also *A. hunteri* KOSSMAT, 1895. No example of this kind of form is found in the present collection from Hokkaido.

Acanthoceras amphibolum MORROW

Pl. 31, Fig. 1

1935 *Acanthoceras* ? *amphibolum* MORROW, p. 40, pl. 49, figs. 1–4, 6; pl. 51, figs. 3, 4; text-fig. 4.

1953. *Acanthoceras hazzardi* STEPHENSON, p. 201, pl. 48, figs. 1–2; pl. 49, fig. 4.

1966. *Acanthoceras amphibolum*, MATSUMOTO and OBATA, p. 45, text-figs. 4–6.

1966. *Acanthoceras hazzardi*, MATSUMOTO and OBATA, p. 45, text-fig. 7.

Types.—MORROW established this species on a large number of specimens, from two nearby localities in the upper Graneros Shale of Kansas, and illustrated five syntypes of different growth-stages, which one of us (T. MAT.) studied at the University of Kansas.

As the shell shows a great change of characters with growth, it is difficult to select a lectotype.

Material.—GK. H5593, from loc. Ik 1051 (Coll. SHIBUYA, a school-boy of the Mikasa High School), and another specimen, T. TAKAHASHI's Coll. No. 424304 [Ik. TA4], from loc. Ik. 1102, are examples from Hokkaido.

Specific characters.—The shell is of moderate size, attaining to approximately 150 mm. at the full-grown stage. It is not much involute, less than a third of the inner whorl being embraced by the outer one. It increases fairly rapidly and especially remarkably so in the young shell. Accordingly the umbilicus is at first fairly narrow and later becomes moderate, ranging from 23 to 30 percent of the entire shell diameter.

The whorl is nearly as high as broad, or slightly higher than broad, or *vice versa*, depending on individuals or on growth-stages. It is generally subquadrate in section, although the hypernodosity in the adult shell may modify the general aspect. The umbilical wall is high and very steep.

The ribs are weak or of moderate intensity. They are separated by wider interspaces, becoming more distant as the shell grows. They are at first slightly prorsiradiate and later nearly rectiradiate. The shorter ribs occur rather infrequently in the immature shell.

The tubercles are generally predominant over the ribs, especially so on the adult whorl where hypernodosity is remarkable. In the young shell the umbilical tubercles are bullate and highest at a point at some distance above the umbilical margin; the lower and upper ventrolateral and siphonal tubercles are nearly equidistant on the venter, and more or less clavate, of which the lower ventrolateral ones are somewhat more prominent than others. On the whorl of middle growth-stages, with diameters of about 40 to 65 mm. (may be 50 to 75 mm., in some individuals), the lower ventrolateral tubercles are gradually enlarged, while the upper ventrolateral and mid-ventral ones gradually weakened. Occasionally the weak and low ventral ribs are doubled, forming a loop at the lower ventrolateral tubercle. In such a case the upper ventrolateral and mid-ventral, smaller tubercles are twice as numerous as the larger lower ventrolateral ones, but this character is by no means firmly settled, and one by one correspondence of the ventral tubercles can be also seen in some other parts. In addition the clavate mid-ventral tubercles may sometimes, but not always, form a low keel like elevation above the siphonal line, but this should not be called a distinct keel nor a firmly established character.

In the mature shell, i.e. on the last part of the septate whorl and on the adult body-whorl, the weakened upper ventrolateral tubercle is united into a much enlarged lower ventrolateral tubercle, which becomes finally a ventrolateral horn. The horn stretches obliquely sideward and upward. The umbilical tubercle is also enlarged at this stage, with its highest point shifting upward to the lower lateral point. The ribs are much distant at this stage.

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
Syntype (1) (c)	27.0(1)	6.3(.23)	14.8(.54)	15.4(.57)	1.04

Syntype (2) (c)	57.7	15.5(.27)	25.7(.44)	24.6	0.94
Syntype (3) (c)	Ca 95	—	39.0(.41)	39.5(.41)	1.01
(ic)			37.5	35.5	0.94
Syntype (4) (c)	—	—	46.0	45.5	0.99
(c)	—	—	39.5	40.0	1.01
“ <i>A. hazzardi</i> ”					
holotype (c)	76.0(1)	21.0(.27)	33.3(.44)	35.4(.46)	1.06
(ic)			32.8	31.2	0.95
GK. H5593 (c)	126.0	37.2(.29)	56.0(.44)	61.0(.46)	1.09
(ic)	117.0	34.3(.29)	51.0(.43)	52.0(.44)	1.02
TA. 4 (deformed) Ca 100	Ca 30	(.3)	46.5(.46)	44.0(.44)	0.94

Remarks.—Based on the observation of numerous specimens from the Interior Province of North America, including MORROW's syntypes, of *Acanthoceras amphibolum* and the holotype of *A. hazzardi*, from Texas, we are inclined to regard *A. hazzardi* as a mere variety of *A. amphibolum*. A slight difference that the upper ventrolateral tubercles disappear slightly earlier in the holotype of *A. hazzardi* than in the illustrated syntypes of *A. amphibolum* can be regarded as variation. In this respect the specimens from Hokkaido are rather closer to the latter. An incompletely preserved specimen, BM. 2399 (GRIMSDALE Collection), labelled as *Acanthoceras cunningtoni*, from the Cenomanian of Cherdstock, England, is probably another example of *A. amphibolum*.

Comparison.—*Acanthoceras amphibolum* MORROW resembles *Acanthoceras latum* CRICK, 1907 (p. 195, pl. 12, fig. 2, 2a), from the Cenomanian of Zululand, South Africa. The distinction is in that the African species has much thicker whorl (with B./H. 1.17 in the holotype) and clearly more persistent ventral tubercles. Although CRICK ascribed *A. latum* to the group of *A. cunningtoni*, it is not referred to *Euomphaloceras* because it does not show multiplication of ventral tubercles nor constriction like depressions on the venter.

Occurrence.—The described specimens from Hokkaido came from loc. Ik 1051 and Ik 1102, sandstone bed in the main part of member IIb of the Mikasa Formation, Ikushumbets area.

A. amphibolum occurs abundantly as a zonal index at a level in the middle part of the Cenomanian sequence in the Western Interior Province of North America (see COBBAN and REESIDE, 1952). The representative in Texas, called *A. hazzardi*, occurs in the Lewisville member of the Woodbine Formation (STEPHENSON, 1953).

In view of the presence of a probable example in the British Cenomanian, in addition to the above three regions, a widespread distribution of the species can be expected.

Acanthoceras cornigerum CRICK

Pl. 32, Fig. 1; Text-fig. 5

1907. *Acanthoceras cornigerum* CRICK, p. 207, pl. 13, fig. 1.

1957. *Acanthoceras cornigerum*, MATSUMOTO, SAITO and FUKADA, p. 18, text-fig. 5.

Holotype.—BM. C. 18230, described and illustrated by CRICK, 1907 (p. 207, pl. 13, fig. 1).

Material.—GK. H5607 [=Ik. TA3], from loc. Ik 1102, Ikushumbets valley, central Hokkaido (collected by T. TAKAHASHI).

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
BM.C. 18230 (c)	69 (1)	21 (.30)	30 (.43)	33 (.48)	1.10
(ic)	63 (1)	21 (.46)	24 (.38)	26 (.41)	1.08
(-1/2 vol.) (c)	44.0(1)	13.0(.29)	19.0(.47)	22.5(.51)	1.18
GK.H 5607 (ic) <i>Ca</i>	120 (1)	42.8(.35)	46.2(.38)	55.2(.46)	1.19
(c) (last septum) <i>Ca</i>	118 (1)	37 (.31)	54 (.45)	61 (.51)	1.12

(The dimensions of the holotype measured by MATSUMOTO may be slightly different from those by CRICK, 1907)

Descriptive remarks.—The specimen from Hokkaido is larger than the holotype. The former is probably an adult shell, with the last suture at the intercostal diameter of about 110 mm., while the latter is wholly septate and somewhat eroded.

The whorl is somewhat broader than high and broadest in the lower part, or between the umbilical tubercles, being roughly trapezoid in section.

The outer whorl of Hokkaido specimen has widely separated, strong, recirradiate ribs, which are provided with prominent tubercles at some distance above the umbilical margin and at the ventrolateral shoulder. On the last half whorl the ventrolateral tubercles become horns which are projected obliquely sideward and upward.

On the inner whorl the ribs are alternately long and short. They are not so strong nor so distant as those on the outer whorl, but those with umbilical tubercles are moderately strong. They are somewhat prorsiradiate and sometimes flexuous. The siphonal and upper and lower umbilical tubercles are concealed by the embracing outer whorl and impressed on the internal surface of the latter. The umbilical tubercles are closer to the umbilical margin.

In all the above characters the Hokkaido specimen is very similar to and probably conspecific with the holotype from South Africa, although the distant ribs and prominent tubercles of the adult type appear at a smaller diameter in the holotype.

Acanthoceras cornigerum CRICK resembles *Acanthoceras amphibolum*

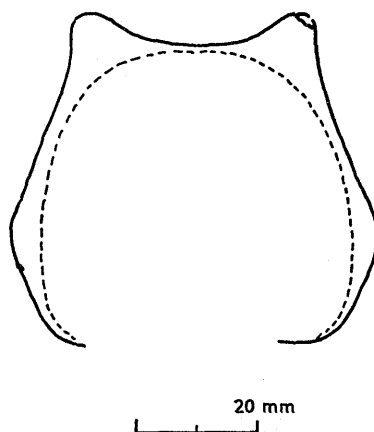


Fig. 5. *Acanthoceras cornigerum* CRICK. Costal whorl section of a specimen from Hokkaido, GK. H5607. (T. MAT. delin.)

MORROW, 1935 (emended above), in the horned and distantly costate outer whorl, but it is distinguished in its roughly trapezoid instead of quadrate whorl-section and frequent intercalation of shorter ribs on the inner whorl.

Occurrence.—Loc. Ik 1102, on the northwestern wall of the valley of the Ikushumbets, in sandstone of member IIb (the same level as loc. Ik 1051) of the Mikasa Formation, central Hokkaido.

Genus *Euomphaloceras* SPATH, 1923

Type-species.—*Ammonites euomphalus* SHARPE, 1855 (original designation).

Synonyms.—*Cunningtoniceras* COLLIGNON, 1937 (with type-species *Ammonites cunningtoni* SHARPE, 1855); *Lotzeites* WIEDMANN, 1959 (with type-species *Acanthoceras aberrans* KOSSMAT, 1895).

Generic characters.—The shell may attain to a fairly large size in the full-grown stage. The whorl is rather evolute, encircling a deep umbilicus, and more or less depressed, with a broad venter and subquadrate to coronate cross section.

Prominent tubercles at or above the umbilical shoulder and at the ventrolateral shoulder are diagnostic. The ventrolateral tubercles are more or less spinose on the inner whorl and horn-like on the outer whorl. On the flank ribs are straight, over which the tubercles predominate; there may be intercalated shorter ribs, but they are normally infrequent and disappear on the outer whorl. On the broad venter of the young to middle growth-stages the ribs are multiplied, by branching at the ventrolateral tubercles and also by intercalation. On these minor ribs there are small siphonal tubercles, which are sooner or later weakened and finally disappear. In addition to them there are tubercles between the siphonal row and the ventrolateral ones. They are as numerous as the siphonal tubercles in some cases or less numerous in other cases on account of the state that a single clavate tubercle occurs in the place of two small ones of the intermediate (i.e. upper ventrolateral) row on the venter. Anyhow, the multiplication of ventral tuberculation is characteristic. In these young to middle growth-stages the multiplied ribs cross the venter transversely but sometimes with a slight projection; they may be periodically accompanied with constrictions; their prominence in relation to tubercles is variable, in other words the ventral ribs are predominant over ventral tubercles or *vice versa*, depending on species or even on individuals. Sooner or later on the outer whorl the upper ventrolateral tubercles are amalgamated with the main, lower one, which, in turn, are enlarged into horns. In this stage the ventral ribs are lowered or even become obsolete.

The suture is fundamentally of *Acanthoceras* type, but its details may be considerably modified depending on species and on growth-stages. The saddle between E and L is massive and subsquarish in some species, subtrapezoid in some others, and even narrow and converging in others. L may vary in breadth and shape.

Remarks.—In addition to *E. euomphalum* (SHARPE), with which *Acantho-*

ceras giltairi PERVINQUIÈRE, 1907, is a synonym, *E. cunningtoni* (SHARPE, 1855), *E. meridionale* (STOLICZKA, 1864) and *E. lonsdalei* (Adkins, 1928) are undoubtedly assigned to *Euomphaloceras*.

On the basis of the observation of a considerable number of specimens, we would generally agree with WRIGHT's (1963, p. 608) recent view in taking in this genus "little account of minor variations in the size and direction of the ventrolateral horns on the outer whorl or in the prominence of tubercles in relation to ribs on the venter in the middle growth-stages", although we would prefer to distinguish *E. meridionale* from *E. cunningtoni*.

Acanthoceras aberrans KOSSMAT, 1895, is referable to *Euomphaloceras* on account of prominence of the umbilical and ventrolateral tubercles and multiplication of ribbing (with reduced tubercles) on the venter of immature shells. It is more closely allied to *E. euomphalum* than to any species of *Calycoceras*. Therefore, Lotzeites WIEDMANN, 1959, established on *A. aberrans* as type-species, is better included in *Euomphaloceras*.

Although we have not observed the original specimen, the holotype of "*Calycoceras* (*Lotzeites*) *lotzei* WIEDMANN, 1959 (p. 732, text-fig. 1, pl. 2, figs. 1, 2) is probably an immature shell of a *Euomphaloceras*, whose adult shell is not known. On the other hand, *Acanthoceras bathyomphalum* KOSSMAT, 1895 (p. 197 [101], pl. 25 [11], fig. 4a-d) is certainly assigned to *Calycoceras*. Its holotype is a small, probably immature shell. In our collection there is a larger example (MURAMOTO Coll. 16883, from Nishikatsura-zawa, Mikasa Sandstone on the western wing of the Ikushumbets anticline) of over 100 mm. in diameter, which is essentially similar to the holotype. Its whorl is much depressed, with the proportion of about 1.5 between breadth to height, and an arched venter. It is ornamented with ribs of moderate intensity, fairly strong, umbilical and ventrolateral tubercles, and three rows of weaker ventral tubercles. The ventrolateral tubercles do not show horn-like exaggeration. Shorter ribs are branched at or intercalated near the umbilical tubercles as in other *Calycoceras*, but no branching occurs at the ventrolateral tubercles nor are there extra intercalates on the venter. Thus *Calycoceras bathyomphalum* is not related to *Euomphaloceras aberrans*.

It could be expected that *Calycoceras* might have lead to a form with hypernodosity and multiplied ventral ribbing, just as *Acanthoceras* gave rise to *Euomphaloceras*. But actually such a hypothetical phylogenetic series has not been confirmed. '*Acanthoceras*' *aberrans* does not lie on such a line of descent. On the outer whorl of *Calycoceras* ventrolateral tubercles as well as the ventral ones are weakened and absorbed by the predominant ribs, and can have nothing to do with ventrolateral hypernodosity.

HANCOCK (1959, p. 250) preliminarily reported the existence of a species, from the middle part of the Cenomanian of France, which could be placed under a new subgenus representing an intermediate position between *Acanthoceras* and *Euomphaloceras*. His information is so brief that we cannot give comments on that species. Anyhow, it is probably certain that *Euomphaloceras* was derived from *Acanthoceras* through such species as *Acanthoceras latum*

CRICK, 1907, and *Acanthoceras evolutum* SPATH, 1926.

Acanthoceras athabascense WARREN and STELECK, 1955 (p. 71, pl. 5, figs. 5, 6; pl. 7, figs. 1, 3, 4; pl. 8, figs. 1-3; pl. 9, fig. 2), from the Cenomanian of Alberta, was regarded by Canadian palaeontologists (e.g. JELETZKY, 1968, p. 24) as being closely allied to *Euomphaloceras cunningtoni* or *E. euomphalum*, but it does not show the *Euomphaloceras* type multiplication of ventral ornaments. It resembles more closely, and possibly conspecific with, *Acanthoceras amphibolum* MORROW (redescribed above), although more or less different condition of preservation between the specimens of Canada and the United States gives us difficulty in concluding the identity.

In the previous paper (MATSUMOTO et al., 1957) several imperfectly preserved specimens from Hokkaido were described under *Euomphaloceras* cf. *euomphalum* and *Euomphaloceras* [*Acanthoceras*?] sp. indet. The former may be called in our present knowledge *Euomphaloceras* cf. *cunningtoni*. There is another specimen, GK. H5611 [=MURAMOTO Coll. 16200], which is referable to *Euomphaloceras lonsdalei*. Its large outer whorl is much deficient and its next inner whorl (about 80 mm. in diameter across the intercostal part), has sideward produced ventrolateral horns and the ventral ornament of *lonsdalei* type (see remarks in page 275), but the siphonal tubercles are somewhat irregular in intensity and shape. The specimen came from the sandstone bed in the main part of unit IIb of the Mikasa Formation, exposed on a small stream (Suido-no-sawa) hanging on the right wall of the main valley of the Ikushumbets.

Besides these imperfect specimens, there are better preserved ones in our present collection which are identified with *E. meridionale* and another interesting one which represents a new species. The last one is atypical and peculiar in having numerous secondary ribs, but is better ascribed to *Euomphaloceras* than to any other genera.

Euomphaloceras meridionale (STOLICZKA)

Pl. 33, Figs. 1-2; Pl. 34, Fig. 1; Text-fig. 6

- 1864. *Ammonites meridionalis* STOLICZKA, p. 76, pl. 41, fig. 1a-c.
- 1897. *Acanthoceras meridionale*, KOSSMAT, p. 20 [127].
- 1907. *Acanthoceras meridionale* var. *africana* PERVINQUIÈRE, p. 278, pl. 15, figs. 2a, b, 3, 4a, b; text-fig. 106.
- 1907. *Acanthoceras meridionale* var. *tuberculata* PERVINQUIÈRE, p. 28, pl. 15, figs. 5a, b, 6a, b.
- 1963. *Euomphaloceras cunningtoni meridionale*, WRIGHT, p. 608, pl. 89, fig. 1.

Lectotype.—GSI. 175, figured specimen of STOLICZKA (1864, pl. 41, fig. 1, 1a-c), from Odium, Middle Utatur Group, southern India, here designated. This is wholly septate. The largest syntype, measured by STOLICZKA as 230 mm. in diameter, seems to be missing.

Material.—GK. H5592 (Coll. M. WADA, 1958, the then school-boy of the Mikasa High School), GK. H5606 (Coll. T. TAKAHASHI, TA. 2), GK. H5612

[=MURAMOTO 12456, collected by K. MURAMOTO], and GK. H5613 [Coll. T. TAKAHASHI] are the specimens from Hokkaido.

Specific characters.—The shell is large, about or somewhat over 200 mm. in diameter at the full-grown stage.

The whorl is rather evolute and shows a moderate rate of growth, encircling an umbilicus of moderate size (about 30 percent of diameter). It is much depressed, with proportion of 10: 14.5(± 2) between breadth to height and is subrectangular in intercostal section, having a very broad venter, subparallel flanks, a nearly vertical, high umbilical wall, and abruptly rounded ventrolateral and umbilical shoulders.

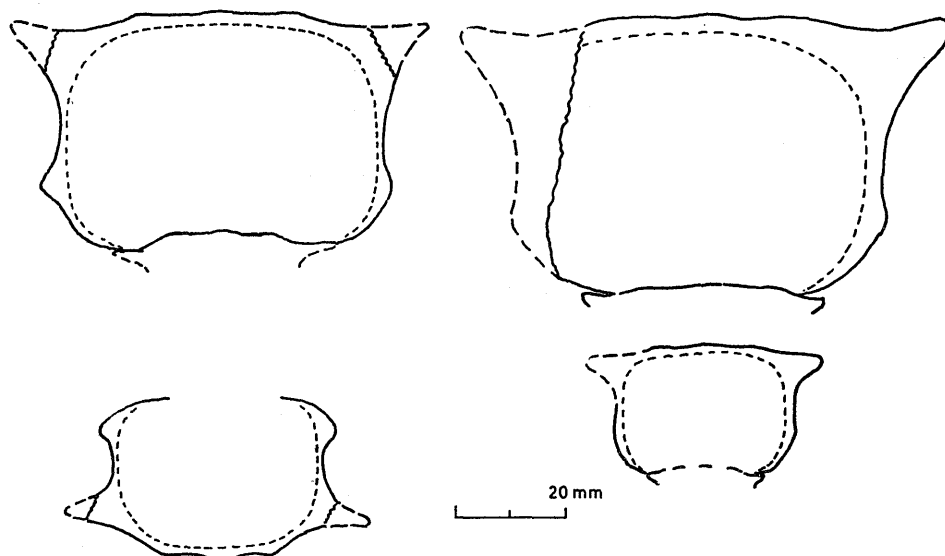


Fig. 6. *Euomphaloceras meridionale* (STOLICZKA). Costal whorl-sections. Left: Lectotype, GSI. 175, from southern India, right: a specimen from Hokkaido, GK. H5612. (T. MAT. *delin.*)

The inner whorls are ornamented with distant major ribs, which are provided with bullate umbilical and spinose ventrolateral tubercles, and multiplied ventral ribs which have smaller tubercles in three rows. Constrictions are discernible along some of the ventral ribs. The multiplication of ribbing on the venter is resulted from the bifurcation of a major ribs at the ventrolateral tubercle and also from the intercalation of a rib between the major ones. The anterior one of the bifurcated ribs may show a gentle forward curve; other ribs straightly cross the venter. The umbilical tubercles are most elevated at a point somewhat above the umbilical margin, increasing their elevation as the shell grows. The ventrolateral spines are stretched sideward, leaning against the umbilical wall of the outer whorl. The ventral tubercles are rounded or elongated transversely. They are twice or three time as numerous as the ventrolateral ones.

On the outer whorl the major ribs are very widely separated and the tubercles above the umbilical shoulder and at the ventrolateral periphery are very prominent. Especially the ventrolateral tubercles form horns which are thick and rounded at the base and remarkably stretched sideward (i.e. perpendicular to the flank) and may be curved slightly upward at the apex. The ventral ribs and tubercles are sooner or later weakened and finally disappear.

The suture is of *Acanthoceras* type, with a massive and large first lateral saddle. The lateral lobe (L) is asymmetrically bipartite, with narrow branches, but its stem is not so narrowed.

Variation.—As the available specimens are not sufficiently numerous, the extent of variation can be only roughly given. In addition to a certain variability in the proportion between whorl breadth and height (i.e. 1.5 ± 0.1), the relative predominance between ribs and tubercles on the venter is variable, as exemplified by PERVINQUIÈRE'S (1907) varieties *africana* and *tuberculata*. There is also variation in the density, intensity and persistency of the ventral ornaments.

In the lectotype from India, which is a shell of middle growth-stage, the ventral ribs and tubercles are of moderate density, intensity and persistency.

Some of the Tunisian specimens (PERVINQUIÈRE, 1907, pl. 15, figs. 3, 4) seem to have more persistent and stronger ventral ribs than the Indian lectotype, although the intercalated ribs disappear earlier than the major ones. On the other hand, in the available specimens from Hokkaido the ventral ribs, as well as the ventral minor tubercles, are weaker and disappear earlier than in the Indian lectotype, and, accordingly, the venter looks almost smoothish on the entire outer whorl, from the late part of the septate stage up to the apertural end. Furthermore, in both GK. H5612 and H5613 the ventral minor tubercles of the early and middle growth-stages are bullate (i.e. elongated transversely along the ribs) instead of clavate or rounded. Should these features constantly occur in the Japanese specimens, they would deserve subspecific distinction. As the available material is insufficient, we refrain from establishing a new subspecies at this moment. For the same reason, whether the varieties *africana* and *tuberculata* deserve subspecific ranking or not is not decided here.

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
GSI. 175 (ic)	97.0(1)	31.0(.32)	39.2(.40)	56.0(.58)	1.42
(-20°) (c) (excl. spine)	98.5(1)	29.0(.29)	42.0(.41)	60.0(.61)	1.43
GK. H5592 (c)	223.0(1)	66.0(.29)	99.0(.44)	142.0(.63)	1.43
(-20°) (ic)	195.0(1)	57.0(.29)	82.5(.42)	101.0(.52)	1.36
GK. H5612 (c) (excl. spine)	—	—	51.0	76.0	1.49
(-320°) (c) (excl. spine)	56.7(1)	16.8(.29)	24.5(.43)	36.0(.51)	1.47
GK. H5613 (c) (excl. spine)	20.5(1)	5.8(.28)	8.0(.39)	13.2(.64)	1.65
For comparison					
BM. 88704 (last septum) (ic)	118 (1)	38 (.31)	50 (.42)	59 (.50)	1.18
USNM. 105970 (c)	125 (1)	40 (.32)	50 (.40)	63 (.50)	1.26
BEG. 2410 (inner whorl) (c)	80 (1)	22 (.27)	34 (.42)	43 (.54)	1.26
" <i>A. c. cornuta</i> "	154 (1)	56 (.36)	59 (.38)	84 (.55)	1.42
" <i>E. c. pervinquieri</i> "	87 (1)	29 (.33)	36 (.41)	51 (.59)	1.41

" <i>A. m. africana</i> "	40	(1)	12	(.30)	18	(.45)	26	(.64)	1.44
" <i>A. m. tuberculata</i> "	37	(1)	11	(.30)	17	(.46)	22	(.60)	1.30
" <i>A. c.</i> " PERVINQUIÈRE	67	(1)	22	(.32)	26	(.39)	38	(.57)	1.46

BM. 88704: holotype of *Ammonites cunningtoni* SHARPE, 1855.

USNM. 105970: holotype of *Acanthoceras ? eulessanum* STEPHENSON, 1953

BEG. 2410: holotype of *Acanthoceras lonsdalei* ADKINS, 1928.

"*A. cunningtoni*" PERRVINQUIÈRE, 1907, pl. 15, fig. 1a-c.

Comparison.—We generally agree with WRIGHT (1963) in allowing considerable variability and in refraining from erecting too many species in *Euomphaloceras*, but as regards the way of specific distinction we are not necessarily of the same opinion with him. We think it better to distinguish *E. meridionale* (STOLICZKA) from *E. cunningtoni* (SHARPE, 1855) specifically rather than subspecifically. In India, northern Australia and other areas they occur in the same province. In other words they do not show a clear geographic separation. They show, however, a considerable difference in morphological features as explained below, which must be related to some ecological difference and seems to deserve specific separation. In the early to middle growth stages of *E. meridionale* each major rib is divided at the ventrolateral tubercle and a minor or shorter rib is normally alternated with the major ones, although there is occasionally no intercalation. Thus multiplication of ribbing is distinct on the venter. On each of the ventral ribs there are three, nearly equally small tubercles, of which one is on the siphonal line. In *E. cunningtoni* the siphonal tubercles are two to three times as numerous as the ventrolateral tubercles, but corresponding to two of these siphonal tubercles there is on either side a clavate tubercle which is somewhat stronger than the siphonal one but weaker than the ventrolateral one. In this connexion the branching of the major rib at the ventrolateral tubercle is not so distinct as in *E. meridionale*.

In all the examined specimens of *E. meridionale* the ventrolateral tubercles are stretched mainly sideward, being nearly perpendicular to the flank, while in the holotype and other typical specimens of *E. cunningtoni* they are extended obliquely upward and sideward, forming a ventral valley in the costal section (see MATSUMOTO et al., 1957, text-fig. 13).

On the average *E. meridionale* has much broader whorl than *E. cunningtoni*. As is indicated in the measurements, the proportion of whorl-breadth to height in the lectotype and other examples of *E. meridionale* is much larger (1.4–1.6) than that in the holotype of *E. cunningtoni* (~1.2) and the holotype of *Acanthoceras ? eulessanum* STEPHENSON (1953, pl. 47, fig. 5, pl. 48, figs. 3, 4), a synonym of *E. cunningtoni*. The proportion is, however, variable and the variations of the two species in this respect is overlapping to some extent.

Euomphaloceras lonsdalei (ADKINS) (1928, p. 244, pl. 26, fig. 5, pl. 27, fig. 3) seems to have been misunderstood. Its holotype, BEG. 2410, is nearly as broadly whorled as, or even somewhat broader than, the typical form of *E. cunningtoni*, but is not so thick as typical *E. meridionale*. In the ventral

ornamentation of the early to middle growth-stages *E. lonsdalei* shows somewhat intermediate feature between *E. cunningtoni* and *E. meridionale*. In the early stage of BEG. 2410, up to a diameter of about 60 mm., one of the two ventral ribs which are divided from each major rib at the ventrolateral tubercle is somewhat broader than the other and also than the intercalated rib and the upper ventrolateral tubercle on the former is stronger and more elongated (i.e. clavate) than other ventral tubercles. The siphonal tubercles are three times as numerous as the ventrolateral ones and of subequal intensity. In the middle growth-stages of 60 to 80 mm. diameters the branching of the rib becomes indistinct and a single, clavate upper ventrolateral tubercle corresponds to each large, lower one and to each two of the siphonal tubercles, showing the *cunningtoni* type ornamentation. In the last stage ventral ornaments are weakened, and the upper ventrolateral clavus is united into a ventrolateral horn. It is furthermore noticed that in the holotype of *E. lonsdalei* the major ribs are somewhat more numerous than in *E. meridionale* and *E. cunningtoni*, being 13 or 14 as compared with 10 or 11 in the latter, and the ventral ribbing is more crowded. The apex of the ventrolateral tubercle is broken in the holotype, but seems to show a sideward rather than upward direction. Although there could be variation in these features, we should not neglect the facts observed in the holotype.

On the basis of the above observation of the holotype of *E. lonsdalei*, it can be considered that some specimens previously referred to *E. cunningtoni* may be better transferred to *E. lonsdalei*. For example, one of PERVINQUIÈRE's specimen (1907, pl. 15, fig. 1) and *E. euomphalum pervinquieri* COLLIGNON (1964, p. 145, pl. 373, fig. 1) seem to be referable to *E. lonsdalei*, but without seeing the specimens it is difficult to give the final decision.

Anyhow, the distinction between *E. meridionale* and *E. cunningtoni* is clearer than that between *E. lonsdalei* and *E. cunningtoni*.

Occurrence.—The Hokkaido specimens of *E. meridionale* were obtained at loc. Ik 1052 and nearby localities from a sandstone bed in the lower part of member IIb of the Mikasa Formation, above the bed with *Mantelliceras japonicum* and below the bed with *Calycoceras orientale*, in the sequence of the Ikushumbets valley. Also loc. Ik 1103 of the same valley, on the western wing of the Ikushumbets anticline.

The lectotype is recorded to have come from the Middle Utatur Group, Odium, southern India, without information of more precise horizon. PERVINQUIÈRE's specimens are from the Cenomanian of Mrhila, Bireno, and Sidi bou Goubriane, Tunisia. According to PERVINQUIÈRE the same species is said to have been found in France, although we cannot confirm the identification without seeing the specimens. WRIGHT (1963) reported the occurrence of an example in beach pebbles at Moonkinu, on the south-east coast of Bathurst Island, northern Australia.

Euomphaloceras asura MATSUMOTO and MURAMOTO, sp. nov.

Pl. 35, Fig. 1; Pl. 36, Fig. 1; Text-fig. 7

Etymology.—*Asura* (Sanskrit) a deity in Buddhism, who likes to fight. The highly ornamented form of this ammonite reminds us of a sculpture of *Asura* [*Ashura* in Japanese].

Material.—GK. H5602, from loc. T1165p, Saku area, Teshio Province (collected by MATSUMOTO and MURAMOTO). No other specimen is available at present.

Specific characters.—The shell is large and widely umbilicate, consisting of moderately growing evolute whorls. The whorl is much depressed, with proportion of about 1.4 between breadth and height in intercostal parts, coronate in section, having a steeply inclined umbilical wall without angular shoulder, somewhat diverging flanks, subangular ventrolateral shoulders and a flat and broad venter.

Distant major ribs, nine per whorl, are provided with strong ventrolateral horns and bullate umbilical tubercles which are pointed at a considerable distance from the umbilical margin. On the inner whorl, preceding to the last one, the ventrolateral horns are stretched obliquely sideward and upward, leaning against the steeply inclined umbilical wall of the outer whorl. On the outer whorl itself the umbilical tubercles are shifted still higher up and tend to be united with the ventrolateral horns, which, in turn, are much enlarged as the shell grows and finally in the last part the two ventrolateral horns are modified to two high flares, which are vertically elevated to form steep transverse walls, with a narrow gap between them at the middle of the venter.

In addition to the major ribs and tubercles there are minor, narrower ribs on the interspaces and also on the major ones, some of which form loops at the ventrolateral tubercles. They occur on the last two whorls and are three times (earlier) to five times (later) as numerous as the major ones. Some of the interspaces between the minor ribs are deeper than others, showing a constriction like aspect. The minor ribs are distinct and persistent on the flank, but weak and become almost obsolete on the venter. On the flank the ribs are nearly rectiradiate, but some are slightly rursiradiate. On the venter they run transversely, without showing notable projection. As the minor ribs are weak on the venter, the ventral, multiplied, minor tubercles are scarcely discernible on the outer whorl. Probably they have disappeared in the middle growth-stage, although there are faint traces of them on the early part of the outer

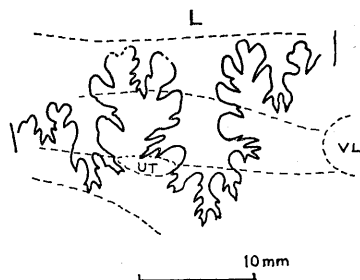


Fig. 7. *Euomphaloceras asura* MATSUMOTO and MURAMOTO, sp. nov. Part of the external suture of the holotype, GK. H5602. Ventral part is not shown. Dotted lines indicate position of the summit of ribs and the base of tubercles (UT: umbilical tubercles, VL: ventrolateral tubercle).

(T. MAT. delin.)

whorl.

The suture is generally of *Acanthoceras* pattern. The first lateral saddle is large, massive, and paralld sided. The lateral lobe is comparatively narrow. The last suture is at an intercostal diameter of about 120 mm. The body-chamber occupies about a half whorl, which is slightly reduced in breadth and height in the last part.

Measurements of holotype.—

Position	Diameter	Umbilicus	Height	Breadth	B./H.
Last part (ic)	182(1)	79(.43)	61(.34)	73(.40)	1.2
— 90° (c) (excl. horn)	160(1)	64(.40)	64(.40)	92(.57)	1.4
—180° (ic)	Ca. 116(1)	52(.44)	42(.36)	60(.52)	1.4
—330° (c)			32	46	1.4

Comparison.—The present species is somewhat similar to *Euomphaloceras aberrans* (KOSSMAT) (1897, p. 202 [106], pl. 24[10], fig. 4a-c), from the Middle Utatur Group of southern India, in the coronate whorl-section, spinose ventrolateral tubercles, presence of minor ribs between the tuberculated ribs on the flank as well as on the venter, and earlier disappearance of ventral tubercles. It is, however, distinguished from that species in its more distant, less numerous, major ribs, more numerous minor ribs, which are distinct on the flank and weaker on the venter, less arched, i.e., flatter venter and different pattern of suture, with more squarish first lateral saddle and much narrower lateral lobe. Holotype of *E. aberrans* is small and probably immature. How the ornamentation would change on the outer whorl of that Indian species is not known.

Anyhow, in the persistency of the minor ribs on the flank, earlier disappearance of ventral tubercles, and flared ventrolateral tubercles at the last stage, *E. asura* is considerably different from the better known species of *Eomphaloceras*, such as *E. euomphalum*, *E. cunningtoni* and *E. meridionale*, being atypical species of the genus.

The flaring of the ventrolateral tubercles reminds us of a similar feature in *Dunveganoceras* WARREN and STELCK, 1940, but in other respects, such as the highly depressed whorl, much predominant ventrolateral tubercles, and multiplication of minor ribbing, the species cannot be assigned to that genus.

Occurrence.—Loc. T1165p, Saku-gakko-no-sawa, Saku-Abeshinai area, Teshio Province, northwestern Hokkaido. This is a rolled (or fallen) block probably derived from unit IIB-c (see map of MATSUMOTO, 1942, pl. 10) and contains *Anagaudryceras* cf. *sacya* (FORBES), *Zelandites* sp. and *Inoceramus* cf. *penatulus* PERGAMENT, in addition to *Euomphaloceras asura*. Unit IIB-c at this locality is regarded to belong to the highest part of the Cenomanian in the sequence of the Saku-Abeshinai area. The conformably overlying unit IIC contains, among others, *Fagesia thevestensis* (PERON), a Lower Turonian index.

Genus *Kanabiceras* REESIDE and WEYMOUTH, 1931

Type-species.—*Acanthoceras* (?) *kanabense* STANTON, 1894=*Scaphites* (?) *septemseriatus* CRAGIN, 1893.

Generic characters.—Rather small and evolute shells, consisting of depressed whorls. Distant major ribs are more or less prorsiradiate, provided with tubercles at the umbilical shoulder and spinose ones at the ventrolateral shoulder. Minor ribs are multiplied on the venter by branching and intercalation. The ventral tubercles are also multiplied. As least in young to middle growth-stages the venter has periodic constrictions usually along the extension of the major ribs and three rows of tubercles, of which the siphonal ones are aligned on a low keel like elevation and the paired ones are oblique. Sutures are of *Acanthoceras* type.

Comparison and affinity.—In shell-form and ornamentation *Kanabicerias* is very close to *Euomphaloceras*, but is distinguished in its smaller size and in that in certain growth-stages the siphonal tubercles form a nodose keel and the paired ventral tubercles are obliquely arranged along the projected curvature of the ribs. This distinction may be obscured on the whorl of the late growth-stage, in which ribs are prorsiradiate on the flanks in *Kanabicerias*.

For the reason of morphological resemblance and the stratigraphic occurrence *Kanabicerias* is regarded as a descendant of *Euomphaloceras*.

Kanabicerias septemseriatum (CRAGIN)

Pl. 37, Figs. 1–3

1893. *Scaphites* (?) *septem-seriatus* CRAGIN, p. 240.
 1894. *Acanthoceras* (?) *kanabense* STANTON, p. 181, pl. 36, figs. 6–8.
 1927. *Acanthoceras kanabense*, MOREMAN, p. 95, pl. 13, fig. 5.
 1931. *Kanabicerias kanabense*, REESIDE and WEYMOUTH, p. 11.
 1942. *Neocardioceras septemseriatum*, MOREMAN, p. 213, pl. 33, figs. 11, 12; text-fig. 2f.
 1952. *Lyelliceras stanislausense* ANDERSON, p. 247, pl. 8, fig. 5, 5a.
 1959. *Kanabicerias septemseriatum*, MATSUMOTO, p. 99, pl. 24, fig. 1a–c; text-figs. 52, 53.

Holotype.—CRAGIN's original specimen in the collection of BEG., University of Texas, which came from the Eagle Ford Formation of Dallas County, Keenan's Crossing of Trinity River, Texas. Its plaster cast (GK. H9137) is kept in Kyushu University.

Material.—The specimens from Hokkaido are GK. H5601, from loc. Ik 987f (T. MATSUMOTO Coll.), GK. H5614, from loc. Ik 1038 (T. MURAMOTO Coll.), and GK. H5562, from a nearby locality (T. TAKAHASHI Coll.). A fragmentary specimen, GT. I-3355, from loc. T852r (T. MATSUMOTO Coll.) may be referred to this species. There are some more examples in our private collections.

The specimens from America which one of us (T. MATSUMOTO, 1959) studied are brought into comparison.

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
GK. H5601	28.3(1)	10.4(.36)	11.0(.39)	16.4(.58)	1.48
GK. H5614	73.0(1)	26.8(.36)	26.0(.35)	18×2(.49)	1.39
(–190°) (c)	—	—	15.0	21.5	1.43
GK. H5562	—	—	Ca. 16	25	1.5

Descriptive remarks.—The specific diagnosis, variation, and comparison with other species were given at length on the previous occasion (MATSUMOTO, 1959, pp. 99–102). There is essentially no need of revision for that description*.

Of the three specimens from Hokkaido, GK. H5601, which is small and probably immature, shows most typically the diagnostic characters of *K. septemseriatum*. Namely, evolute and depressed whorls, with inflated flanks and a broadly arched venter, major lateral ribs with umbilical tubercles and ventrolateral spinose tubercles, and minor, multiple, somewhat projected ventral ribs, which are provided with obliquely bullate tubercles on either side of the siphonal row of tubercles which, in turn, are aligned on a low, keel-like elevation. Some of the minor ribs may extend down to the flank, forming occasional intercalates between the major ribs on the flank.

Two other, larger specimens, GK. H5562 and GK. H5614, do not show such a notable projection of ventral ribs as in the above described small one, and accordingly the paired ventral tubercles are not necessarily obliquely elongated, but the ribs between the umbilical and ventrolateral tubercles are remarkably projected and the long ventrolateral spines are stretched forward in lateral view and obliquely upward and sideward in back or frontal view. On the fragmentary whorl of GK. H5562 and on the main part of the outer whorl of GK. H5614 the siphonal keel like elevation persists, but on the last part of the latter specimen it is lost and the siphonal tubercles are interrupted as on the inner whorl of normal *Acanthoceras* or that of *Euomphaloceras*.

The holotype and some other specimens, including GK. H5601 and H5614, have a few minor ribs even on the flank, of which some are purely intercalatory and others may form a loop at the ventrolateral tubercle. In this feature and other characters *K. septemseriatum* is fairly close to the inner whorl of *Euomphaloceras asura* (described above), although the prorsiradiate ribbing enables us to distinguish the former from the latter even in lateral view.

Occurrence.—Loc. Ik 987f, rock floor of the main stream of the Ikushumbets; loc. Ik 1038, cliff on the right bank of the same place, and another locality in a small tributary, Suido-no-sawa. All belong to a layer of siltstone at the top of unit IIc, middle member of the Mikasa Formation, central Hokkaido. A fragmentary whorl, GT. I-3355, which can be called *Kanabicerias* cf. *septemseriatum*, came from loc. T 852r, member IIc-d (β) of Chirashinai, a tributary of the Teshio, northwest Hokkaido.

The holotype is recorded to have come from the Britton member, Eagle Ford Formation, Lower Turonian, Texas.

Subfamily Mammitinae HYATT, 1900
Genus *Sumitomoceras* MATSUMOTO, nov.

Etymology.—Dedicated to the Sumitomo Coal Mining Company, who have

* There are, however, misprints. Read *K. septemseriatum* for *K. kanabense* in lines 23 and 29 of page 101 and lines 7 and 6 of p. 102.

provided fascilities for the study.

Type-species.—*Sumitomoceras faustum* MATSUMOTO and MURAMOTO sp. nov. (described below).

Generic characters.—The shell of this genus is rather small, discoidal, and fairly widely umbilicate, with a little involution. Its whorl is more or less compressed, with nearly parallel flanks and an arched venter.

Ribs are of unequal length, some of which are branched at the umbilical tubercles and others intercalated. The immature shell is provided with umbilical tubercles at the end of the long ribs and also lower and upper ventrolateral tubercles on each rib. In addition to them small siphonal tubercles are discernible in the early immature stage, but they soon disappear. In the middle and late growth stages the ventrolateral tubercles are weakened and then disappear, while the ribs are numerous, show a gentle projection at the ventrolateral shoulder, and distinctly run across the venter without interruption. The interspaces behind some of the long ribs may be somewhat deeper than others and can be called shallow constrictions.

Sutures are fundamentally of *Acanthoceras* type, the saddle between E and L is bifid, squarish and parallel sided; L is fairly deep, narrow, and asymmetrically bifid at the bottom.

Remarks.—In addition to the type-species, *Ammonites ushas* STOLICZKA, 1864, is assignable to *Sumitomoceras*. *Acanthoceras amudariense* ARCHANGUELSKY, 1916 (excluding "var. *horridum*"), may also be referred to *Sumitomoceras* rather than to *Watinoceras*.

Comparison and affinity.—The immature shell of *Sumitomoceras* is very similar to that of *Watinoceras* WARREN, 1930, in many respects. In the middle to late growth-stages of *Sumitomoceras*, the ventrolateral tubercles are weakened and then completely lost, while the ribs are distinct and cross the venter transversely. In the corresponding stages of *Watinoceras* the ventrolateral tubercles persist and there is a ventral depression between the rows of upper ventrolateral tubercles. As far as the type-species are concerned, the suture of *Watinoceras* is simpler, having broader saddles, shallower lobes and shallower incisions than that of *Sumitomoceras*.

In connexion with the relation between the two genera, remarks should be given on *Watinoceras* itself. *Watinoceras* was introduced to accomodate a single species, *W. reesidei* WARREN, 1930, from the Lower Turonian of the Western Interior province of Canada. WARREN's (1930, p. 66) description of the generic diagnosis is as follows:

"Discoidal forms, slightly involute and laterally compressed. Costae generally alternating in length, not crossing the venter, developing two rows of nodes on each side of the venter and occasional nodes on the umbilical border in gerontic stages".

If this diagnosis is maintained, the distinction between *Watinoceras* and *Sumitomoceras* is very clear. Although WARREN included no species other than *W. reesidei*, *Acanthoceras coloradoense* HENDERSON, 1908 (p. 259, pl. 13, fig. 10), from the Lower Turonian of Colorado, *Acanthoceras horridum* ARCHANGUELSKY

1916 (p. 49, pl. 8, figs. 8–10, 14–15), (which was originally proposed as a variety of *A. amudariense* but is distinct enough for specific separation), from the Lower Turonian of Turkestan, and probably also a species incorrectly referred to "*Schloenbachia gracillima* KOSSMAT" by PETRASCHECK (1902, p. 153 [23], pl. 9 [3], fig. 3a, b), from the *Labiatus*-Pläner (Lower Turonian) of Germany, are assigned to *Watinoceras*.

The illustrated specimens, including the holotype, of *Watinoceras reesidei* WARREN (1930, p. 67, pl. 3, fig. 2; pl. 4, figs. 9–12) are small. Accordingly there might remain a doubt whether they were actually mature or not. WARREN mentioned the existence of larger specimens which have a body-chamber. Therefore I would rely on his description, unless some objections would occur in subsequent collections.

In the meanwhile WRIGHT (1957) gave a generic diagnosis of *Watinoceras* somewhat more comprehensively, to accomodate *Acanthoceras amudariense* ARCHANGUELSKY, 1916, from Turkestan. To cite from him (Wright, 1957, p. L 416) "Early whorls compressed, finely ribbed, with inner and outer ventrolateral and siphonal tubercles as in *Neocardioceras*, but siphonal row soon lost; later, venter may be concave between rows of ventrolateral clavi or rounded, with ribs passing over in chevrons; ornament usually coarsens with age."

As is described below, the immature shells, up to a diameter of about 30 mm., of the type-species of *Sumitomoceras* resembles the illustrated specimens of *A. amudariense*, but the ribs of the former does not show such ventral chevrons as those of the latter. Whether *A. amudariense* is referred to *Sumitomoceras* or *Watinoceras* may depend on authors' opinion. I am rather inclined to ascribe *A. amudariense* to *Sumitomoceras*, because in its later growth-stages the ventrolateral tubercles are weakened and the ribs pass over the venter.

I agree with WRIGHT (1957) in considering the derivation of *Watinoceras* from *Neocardioceras*. Similarly but along another line of descent *Sumitomoceras* probably came from *Neocardioceras*, although in the Japanese sequence examples of the latter has not been found and only those of *Protacanthoceras*, the immediate ancestor of *Neocardioceras*, have been confirmed. Thus, *Sumitomoceras* and *Watinoceras* are in a sisterhood relationship, deviating considerably from each other.

The young shells of *Sumitomoceras* and *Watinoceras* are somewhat similar to *Mantelliceras*. *Watinoceras* was once placed under *Mantelliceratinae* on that account. But the resemblance is not genetical, because the siphonal row of tubercles discernible in early young stage, among other features, tells the close affinity with *Neocardioceras* of the *Acanthoceratinae*. For this reason and for its close relation with *Mammites*, *Watinoceras* has been correctly transferred to the *Mammitinae* by WRIGHT (1957). Although *Sumitomoceras* shows characters considerably different from *Mammites*, it can be assigned to the same subfamily, because of its close relationship with *Watinoceras*.

It is interesting to note that the immature shell of *Sumitomoceras* is somewhat similar to *Holcodiscoides* and the adult shell is remarkably so to

certain species of *Kossmaticeras* (e.g. *K. theobaldianum*) of the Kossmaticeratidae and to *Mesopuzosia* or *Kitchinites* of the Puzosiidae. This is an example of homoeomorphy which suggests a similarity in mode of life.

Occurrence.—The type-species of *Sumitomoceras* occurs in the Lower Turonian of Japan, as does *S. amudariense* in the Lower Turonian of Turkestan. The age of *S. ushas* in India is not precisely known.

Sumitomoceras faustum MATSUMOTO and MURAMOTO, sp. nov.

Pl. 38, Figs. 1–4; Text-fig. 8

Etymology.—*Faustum*: bringing good luck.

Material.—Holotype: GK. H5595, from loc. Ik 1038 Ikushumbets valley. Paratypes: GK. H5561, H5600, H5615, H5616, and H5617, from the type-locality. The holotype is an adult shell. Paratypes are of various growth-stages. All the specimens were collected by T. MURAMOTO, except for GK. H5561 by T. TAKAHASHI, in the field work conducted by T. MATSUMOTO.

Specific characters.—The early immature shell, less than 15 mm. or so in diameter, as represented by GK. H5617 and H5616, is moderately involute, about a half (in height) of the inner whorl being embraced by the outer, consisting of moderately growing discoidal whorl, which is somewhat higher than broad, flattened on sides and fairly narrowly arched on the venter. There are distant, small, rounded tubercles at the umbilical shoulder, seven or so per whorl, from which spring long, prorsiradiate ribs, alternating with shorter ones. Ribs are projected on the ventrolateral shoulder where they have two tubercles, lower and upper. Between the upper ventrolateral tubercles on the venter the ribs are weakened and there is a siphonal row of weak, clavate tubercles, which sooner or later disappear.

In the late immature shell, of diameters between 15 mm. to 25 or 30 mm., as exemplified by GK. H5600 and H5615, and also the inner whorls of GK. H5561 and H5595, the whorl is discoidal, less involute and somewhat compressed, with flat and parallel flanks, perpendicular but low umbilical walls, sloping ventrolateral shoulders and a gently arched or nearly flat venter. There are numerous ribs of unequal length, some of which spring in pairs from the umbilical tubercles, and some others intercalated. They are moderately or slightly sigmoidal, regularly projected on the ventrolateral shoulder, and cross the venter transversely, although with slight weakening. There are no siphonal tubercles. Every rib has small but distinct, two ventrolateral tubercles, lower and upper. The tubercles at the umbilical shoulder, near the end of the long ribs, are small but prominent in this stage, being stronger than the ventrolateral ones, slightly stretched sideward, and more numerous than in the earlier stage, 12 or so per whorl. The ribs are somewhat weakened above the umbilical tubercles on the lower part of the flank.

In the probably adult shell, i.e. in the late part of the septate whorl and in the body-whorl, of diameters from about 30 mm. to about 60 mm. or more, the umbilicus is of moderate size and the involution is small, concealing the

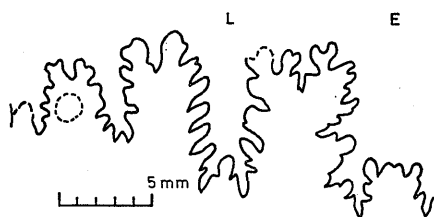


Fig. 8. *Sumitomoceras faustum* MATSUMOTO and MURAMOTO, sp. nov. External suture of a paratype, GK. H5561, at whorl-height=17 mm.

(T. MAT. *delin.*)

venter of the inner whorl down to the row of lower ventrolateral tubercles. The whorl is somewhat higher than broad, with a proportion of about 0.8 between breadth and height, but the flank is very gently inflated, passing gradually to the rounded venter; the umbilical shoulder is subrounded and the umbilical wall is low and steep. The ribs on the outer whorl are numerous, of moderate intensity, and of unequal length, with shorter ones intercalated near or branched at the umbilical tubercles. They are curved gently forward on the ventrolateral shoulder and cross the venter nearly transversely or with a slight projection. On the flank some of them are moderately sigmoidal and others less so. The ribs are separated by interspaces slightly broader than or nearly as narrow as the ribs. Periodically the interspace behind the less sigmoidal rib is somewhat deeper than others, showing an aspect of a gently prorsiradiate constriction. In the early part of the outer whorl the lower ventrolateral tubercles may remain as faint elevations on the ribs, but they disappear sooner or later. In the main part the lower as well as the upper ventrolateral tubercles are completely lost, but the umbilical tubercles persist, occurring normally at every second or third ribs.

The suture is fundamentally of *Acanthoceras* type, with a massive, squarish, bifid, first lateral saddle (between E and L). The lateral lobe (L) is deep and narrow, much narrower and slightly shorter than E; U_2 is small, less than half of L in depth and breadth. Minor incisions are moderately deep and narrow in late growth-stages.

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
GK. H5595	65.0(1)	24.5(.38)	25.2(.39)	20.5(.31)	0.81
(-150°)	47.0(1)	15.5(.33)	19.0(.40)	16.0(.34)	0.84
GK. H5561 (-150°)	44.0(1)	14.7(.31)	17.6(.40)	15.4(.35)	0.87
GK. H5600	Ca. 37. (deformed)				
(-120°)	28.5(1)	9.7(.34)	11.2(.39)	9.0(.31)	0.80
(-210°)	23.4(1)	6.8(.29)	9.6(.41)	8.0(.34)	0.83
GK. H5616	13.4(1)	4.6(.34)	5.4(.40)	4.8(.35)	0.88
GK. H5617	10.4(1)	2.9(.28)	4.5(.43)	4.1(.39)	0.91
For comparison					
GSI. 211 (<i>A. ushas</i>)	28.0(1)	10.2(.36)	11.8(.42)	10.5(.37)	0.89

Variation.—GK. H5595, holotype, is 65 mm. in diameter and certainly a mature shell, which has the body-chamber of a little over a half whorl. GK. H5561, a paratype, of about 60 mm. in diameter, is wholly septate, and accordingly must have been about 80 mm. in diameter at the full-growth stage. The ventrolateral tubercles disappear earlier in the former than in the latter.

The flanks change from a flattened state to a gently inflated one in the former somewhat earlier than in the latter. Other smaller specimens also show minor differences in the proportion of breadth to height, relative size of umbilicus, and persistency of ventrolateral tubercles. More specimens are needed to make clear the extent of variation with more accuracy.

Comparison.—The present species resembles *Acanthoceras amudariense* ARCHANGUELSKY (1916, p. 48, pl. 7, figs. 7–13), from the Lower Turonian of Turkestan, in the trituberculate immature stages, but the flank of the former is flatter and has weaker ribs than that of the latter. In the late growth-stages, the ribs of the former do not show such chevrons as those of the latter, but cross the venter transversely.

The holotype of *Ammonites ushas* STOLICZKA (1864, p. 100, pl. 51, fig. 2, 2a, 2b), from the yellowish calcareous shale of the Utatur Group, at Odium, southern India, is very similar to the late immature shell of *Sumitomoceras faustum*, although it is somewhat more widely umbilicate and has broader whorls than our specimen of the corresponding size. As these differences are minor, the two nominal species could be identical. However, in STOLICZKA's specimen (GSI. 211), which one of us (T. MATSUMOTO) studied at Calcutta, sutures are not exposed and the outer whorl as large as the holotype of *S. faustum* is missing. Therefore, it is difficult to conclude the identity. Until better preserved topotypes are obtained, it is better to use the proposed new name for the species from Hokkaido, which in itself is distinct.

It is interesting to note that the adult shell of the present species is apparently similar to that of *Kossmaticeras theobaldianum* (KOSSMAT, 1897) and to the shell of the middle growth-stage of *Mesopuzosia indopacifica* MATSUMOTO, 1954. It would be rather surprising to know that such a discoidal, *Kossmaticeras* like ammonite as this species is of identical family (Acanthoceratidae) with such highly ornate, depressed ammonites like *Euomphaloceras asura* MATSUMOTO and MURAMOTO.

Occurrence.—Loc. Ik 1038, a cliff on the right side of the Ikushumbets, about 450 m. downstream from the Katsurazawa dam. The specimens came from calcareous nodules contained in siltstone of the uppermost part of unit IIc, middle part of the Mikasa Formation. The associated species are *Kanabicerias septemseriatum* (CRAGIN), *Sciponoceras kossmati* (NOWAK) (emend. MATSUMOTO and OBATA, 1962), *Inoceramus cf. labiatus* (SCHLOTHEIM), etc., indicating a Lower Turonian age.

Concluding Remarks

Remarks are concisely given below primarily on the basis of the descriptions in this paper as well as those in the previous publications.

Taxonomic results.—Selected nine species described in this paper are as follows, indicating the authorship in parentheses with abbreviations, MAT.; T. MATSUMOTO, MUR.; T. MURAMOTO, and TAK.: T. TAKAHASHI.

(1) *Mantelliceras japonicum*, n. sp. (MAT., MUR., & TAK.), p. 253, Pl. 25, Figs.

- 1-2; Pl. 26, Figs. 1-2; Pl. 27, Figs. 1-2
- (2) *Mantelliceras cantianum* SPATH (MAT., MUR. & TAK.), p. 256, Pl. 27, Fig. 3; Pl. 28, Fig. 1
 - (3) *Sharpeiceras kongo*, n. sp. (MAT., MUR. & TAK.), p. 261, Pl. 29, fig. 1; Pl. 30, fig. 1
 - (4) *Acanthoceras amphibolum* MORROW (MAT. & MUR.), p. 266, Pl. 31, fig. 1
 - (5) *Acanthoceras cornigerum* CRICK (MAT., MUR. & TAK.), p. 268, Pl. 32, fig. 1
 - (6) *Euomphaloceras meridionale* (STOLICZKA) (MAT. & MUR.), p. 272, Pl. 33, Figs. 1-2; Pl. 34, Fig. 1
 - (7) *Euomphaloceras asura*, n. sp. (MAT. & MUR.), p. 277, Pl. 35, Fig. 1; Pl. 36, Fig. 1
 - (8) *Kanabicerias septemseriatum* (CRAGIN) (MAT., MUR. & TAK.), p. 279, Pl. 37, Figs. 1-3
 - (9) *Sumitomoceras faustum*, n. sp. (MAT. & MUR.), p. 283, Pl. 38, Figs. 1-4

In connexion with the description of nine species, including four new ones, a new genus, *Sumitomoceras*, has been introduced and some other genera are revised to a considerable extent.

These are good addition to the twenty-one species described more than ten years ago (MATSUMOTO and HASHIMOTO, 1953; MATSUMOTO *et al.*, 1957). There are still more species, at least ten, which have not yet been monographed. Thus, species of the Acanthoceratidae from the Cretaceous of Hokkaido can now be said considerably numerous, in spite of the condition that we have refrained from unnatural splitting of species.

Stratigraphic sequence of acanthoceratid species in the Cretaceous of Hokkaido.—One of us (MATSUMOTO, 1959) has given general remarks on the zonal succession of species of ammonoid and inocerami in the Cretaceous of Hokkaido and has recently shown (MATSUMOTO, 1965, figs. 2-5; 1967 [in Japanese], fig. 12.4) the stratigraphic positions of selected species in the Cretaceous sequence of the Ikushumbets valley.

We have been engaged for years in a field work to make clear the biostratigraphic sequence in the last mentioned area. A sandstone quarry has been recently excavated, cutting the lower part of the Mikasa Formation on the eastern wing of an anticline. Still more artificial exposures are being extended eastward (i.e. stratigraphically upward) to construct a new road. The new outcrops have yielded more fossils of acanthoceratids, among others, some of which are described in the present paper. As these localities were not indicated in the previously published map (MATSUMOTO, 1965, figs. 2 facing p. 6), a sketch map (Fig. 9) is added here.

In addition to the Ikushumbets and adjacent areas in Ishikari Province, central Hokkaido, the Abeshinai-Saku and adjacent areas in Teshio Province, northwestern Hokkaido, are places where acanthoceratid ammonites are obtainable, since there are comparatively shallow sea sediments. More scattered occurrence of acanthoceratids is known in other areas, where sediments of comparatively off-shore environments predominate.

In this paper we do not intend to explain in detail the stratigraphic

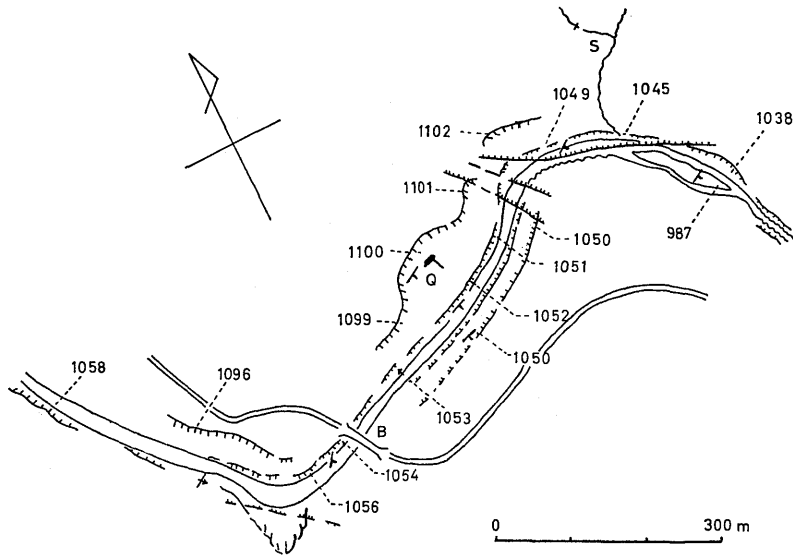


Fig. 9. Map showing location of exposures at and near the Katsurazawa quarry (Q) in the Ikushumbets valley. B: bridge called Ohashi, S: small stream called the Suido-no-sawa (indicating an unnumbered locality of *Euomphaloceras* sp. cf. *E. lonsdalei* with ×). See MATSUMOTO, 1965, fig. 2 for the map of adjacent areas.

sequence of the above areas, but show a summarized result about the succession of acanthoceratid species in the Cretaceous of Hokkaido in ascending order.

(1) In the zone of *Desmoceras kossmati*, which is somewhat above the beds with *Mortoniceras* sp., in the Soeushinai-Shumarinai area, Teshio Province, occurs *Graysonites* sp. aff. *G. adkinsi*, together with *Stoliczkaia* sp. aff. *S. dorstensis* NEUMAYR, *S.* sp. aff. *S. africana* PERVINQUIÈRE, *Euhystrioceras nicaisei* (COQUAND), *Prionocycloides poratum* (COQUAND), etc. In the same zone of the Ikushumbets valley, which is above the beds with *Mortoniceras* (*Durnovarites*) sp. and *Mortoniceras* (*Cantabrigites*) *imaii* (YABE and SHIMIZU), only fragmentary specimens of *Graysonites* have occurred. North in the Cape Soya area a large, undescribed, new species of *Acompsoceras* was found as a fall from the mudstone containing *Desmoceras kossmati*. Outside Hokkaido, one of us (MATSUMOTO, 1960) has already reported *Graysonites* sp. cf. *G. fountaini* YOUNG from the bed with *Desmoceras kossmati* in Kyushu.

(2) In the succeeding part, typified by the lower 20 m. of member IIb of the Mikasa Formation (eastern wing) in the Ikushumbets valley, *Mantelliceras japonicum* MATSUMOTO, MURAMOTO and TAKAHASHI is characteristically found, which is associated with *Mantelliceras cantianum* SPATH, another compressed species of *Mantelliceras*, and also *Sharpeiceras kongo* MATSUMOTO, MURAMOTO and TAKAHASHI. In the same unit *Desmoceras poronaicum* YABE, *Desmoceras* (*Pseudouhligella*) *japonicum* YABE, *Zelandites inflatus* MATSUMOTO, *Parajaubertella imlayi* MATSUMOTO, *Turritiles costatus* LAMARCK, *Hypoturritiles komotai* (YABE), and *Sciponoceras baculoides* (MANTELL) occur commonly. The as-

semblage defines the subzone of *Mantelliceras japonicum* in the basal part of the broad zone of *Desmoceras japonicum*.

(3) This is followed by the main or middle part of the zone of *Desmoceras japonicum*, typified by the sandstone of the main part (about 100 m.) of unit IIb of the Mikasa Formation, Ikushumbets valley, and the sandy siltstone of unit IIb of the Abeshinai-Saku area, in which *Inoceramus concentricus nipponicus* NAGAO and MATSUMOTO is also common. This part characteristically contains *Calycoceras orientale* MATSUMOTO, *Calycoceras asiaticum* (JIMBO) and *Calycoceras spinosum* (KOSSMAT), all belonging to the subgroup of *Calycoceras newboldi* (KOSSMAT). It can be called the subzone of *Calycoceras orientale*.

For some reasons the actual sequence of acanthoceratid ammonites in this part on the eastern wing of the Ikushumbets anticline apparently shows finer succession. Namely the *Mantelliceras* bearing silty sandstone is followed by thick sandstone beds containing abundant specimens of *Pterotrigonia hokkaidoana* (YEHARA), with intercalated silty fine sandstone. These *Trigonia* beds, 10 m. or so in thickness, are not rich in ammonites, and, in turn, followed by another sequence, about 25 m., of sandstone beds in which smaller gastropods are embedded among others, as exposed on loc. Ik 1051, Ik 1052, Ik 1050, and Ik 1102. From this part horned acanthoceratids have been collected. They are *Acanthoceras amphibolum* MORROW, *Acanthoceras cornigerum* CRICK, another, undescribed, horned *Acanthoceras* related to *A. latum* CRICK, *Euomphaloceras meridionale* (STOLICZKA) and *E. cf. lonsdalei* (ADKINS). Then comes another sequence of more or less silty, fine-grained sandstone beds, with intercalated thinner layers of less muddy sandstone and also glauconitic, tuffaceous sandstone, outcropping at localities Ik 1045–Ik 1050. In this part, which may be altogether 65 m. or so thick, *Desmoceras* (*Pseudouhligella*) *japonicum* occurs commonly and *Calycoceras orientale* is found here and there. Large puzosiid species, probably referable to *Puzosia* and *Austiniceras* may be also found there.

The above described detailed succession of acanthoceratids may be apparent and does not necessarily mean that *Acanthoceras amphibolum*, *A. cornigerum* and *Euomphaloceras meridionale* are older than *Calycoceras orientale* and *C. asiaticum*. In other words, they may be contemporary and the apparent differentiation in occurrence may imply the difference in ecological and sedimentological conditions. The former group of horned acanthoceratids may be liable to be embedded more frequently in sediments of shallower environments and the latter group of hornless *Calycoceras* may be so in those of slightly off-shore environments. In the silty sandstone on the western wing of the Ikushumbets anticline, in which *Calycoceras asiaticum* is common, an immature specimen of *Euomphaloceras meridionale* was obtained along with *Calycoceras bathyomphalum* (KOSSMAT).

In the Abeshinai area two examples of *Euomphaloceras cf. cunningtoni* were obtained from the lower and upper parts of unit IIb and specimens of *Calycoceras orientale* and *C. spinosum* from the upper and middle parts of IIb. In the Shiyubari area, where more fine-grained sediments of probably off-shore facies predominate, *Calycoceras orientale* and *Calycoceras cf. stoliczkai* COLLIG-

NON have been found in the middle part of the zone of *Desmoceras japonicum*. (4) The succeeding zone is the upper part of the broad zone of *Desmoceras japonicum* and typified by the main part, about 50 m. siltstone of member IIc (uppermost 10 m. excluded) of the Mikasa Formation (on the eastern wing) in the Ikushumbets valley. Large shells of *Inoceramus* of *concentricus* group, i.e. *Inoceramus pennatulus* PERGAMENT and related forms, commonly occur in this part, while acanthoceratids are few. The identified species are *Calycoceras naviculare* (MANTELL), *Eucalycoceras pentagonum* (JUKES-BROWNE) and *Protacanthoceras* sp. Large puzosiid ammonites, probably of *Pachydesmoceras* and *Austiniceras* may be found here and there.

Unit IIB-c of the Abeshinai-Saku area, from which *Euomphaloceras asura* MATSUMOTO and MURAMOTO was obtained, is probably correlated with this part for the reason of the stratigraphic position and also of the association of *Inoceramus pennatulus*.

(5) The assemblage of species in the uppermost 10 m. of member IIc of the Ikushumbets area is different from that in the main part of the same member described above, inspite of the similarity in lithology. It is characterized by *Kanabicerias septemseriatum* (CRAGIN) and *Sumitomoceras faustum* MATSUMOTO and MURAMOTO, and accompanied *Sciponoceras kossmati* (NOWAK) and *Inoceramus labiatus* (SCHLOTHEIM). In the Yamabe-Kanayama area, about 35 km. east from Ikushumbets across the Yubari range, *Pseudaspidoceras sorachiense* MATSUMOTO and HASHIMOTO was found in the bed with *Inoceramus labiatus*.

Unit IIc in the Abeshinai-Saku area is probably correlated with the above mentioned parts in the Ishikari Province, but from that unit only a fragmentary whorl of *Kanabicerias* cf. *septemseriatum* has been obtained. It contains *Fagesia thevestensis* (PERON), a vascoceratid, among others.

(6) In the succeeding part, sandstones of unit IID in the Ikushumbets area, no acanthoceratid has been found. It is divided to the zone of *Inoceramus hobetsensis* below and that of *Inoceramus teshioensis* above. In the Hatonosu dome of the Yubari area an undescribed species of *Romaniceras* occurs in the zone of *I. hobetsensis*. In the Shiyubari-Hobets area, east of Yubari, *Romaniceras* aff. *uchauxiense* COLLIGNON, *Romaniceras* (?) *otatumei* MATSUMOTO, SAITO and FUKADA, *Yubariceras yubarensis* MATSUMOTO, SAITO and FUKADA and probably also *Yubariceras* sp. aff. *Y. (?) adkinsi* (JONES) show scattered distribution in the zone of *Inoceramus hobetsensis*. Although *Romaniceras* and *Yubariceras* have longer ranges, the successive sequence of species have not yet been precisely known. Examples in Japan seem to occur rather commonly in the zone of *Inoceramus hobetsensis*, with which *Subprionocyclus neptuni* (GEINITZ) is often associated. The exact stratigraphic position of *Romaniceras pseudo-deverianum* (JIMBO) is not known.

(7) To sum up, on the basis of the assemblage of characteristic species, the above explained zonal succession in the Cretaceous sequence of Hokkaido can be correlated with the following stages or substages in terms of international scale:

1. Zone of *Desmoceras kossmati* containing *Graysonites* aff. *adkinsi*, etc.: Basal Cenomanian [lower Lower Cenomanian]

2. Lower part of the zone of *Desmoceras japonicum*=subzone of *Mantelliceras japonicum*: Lower Cenomanian [upper Lower Cenomanian]
3. Middle part of the zone of *Desmoceras japonicum*=subzone of *Calycoceras orientale-Euomphaloceras meridionale*: Middle Cenomanian (as defined by HANCOCK, 1959) [lower Upper Cenomanian by some authors]
4. Upper part of the zone of *Desmoceras japonicum*=subzone containing *Calycoceras naviculare*: Upper Cenomanian [upper Upper Cenomanian]
5. Zone of *Inoceramus labiatus-Kanabicerias septemseriatum*: Lower Turonian
6. Zone of *Inoceramus hobetsensis*, containing several species of *Romanticeras* and *Yubariceras*: Middle Turonian [=lower Upper Turonian by some authors]
7. Zone of *Inoceramus teshioensis*, with subzone of *Subprionocylus normalis* below and that of *Reesidites minimus* above (No acanthoceratid has been found): Upper Turonian [=upper Upper Turonian by some authors]

The above conclusion may be still tentative, for it involves some unsettled points. Although the succession of the species, or better to say the succession of the assemblage of characteristic species, in the Cretaceous of Hokkaido is generally in harmony with that in other well studied regions, such as western Europe, Western Interior-Gulf Coast of North America, California, Madagascar and other areas, the details are not quite identical. For brevity we would not explain here at length those provincial dissimilarities. How they are explained and what is the most reliable conclusion of interregional correlation are the problem to be still worked out. Anyhow, the zonal succession established in the Cretaceous of Hokkaido would be one of the good reference scales for the international correlation and the acanthoceratids afford good evidence for the problem.

Notes on the evolutionary history of the Acanthoceratidae (by Tatsuro MATSUMOTO)

- (1) The Acanthoceratidae include various forms but seem to be monophyletic, having their ultimate origin in *Stoliczkaia* (Lyelliceratidae) of late Albian-early Cenomanian ages. Their extent of variability or divergency is considerably great, as is exemplified below.
- (2) *Stoliczkaia* itself is a rather small, compressed, less strongly ornamented ammonite. Its immediate derivatives *Submantelliceras* and *Utaturiceras* are still compressed and small to moderate in size. *Mantelliceras*, a probable successor of *Submantelliceras*, includes compressed to moderately inflated species, with moderately strengthened ribbing and tuberculation. Its size at the adult stage is in most cases moderate, nearly or less than 130 mm. in diameter, but may become exceptionally large as in *M. nagaoi* MATSUMOTO, SAITO and FUKADA (1957, pl. 12).
- (3) *Sharpeiceras* is probably another descendant from *Submantelliceras* rather than that from *Mantelliceras*, acquiring evolute, subrectangular shell-form, regularly arranged, predominant tubercles and fairly complex sutures. Its adult whorl may become very large and show hypernodosity in some species, as

beautifully illustrated by *Sharpeiceras kongo*.

(4) The hypernodosity appears also on the adult whorl of *Graysonites*, while in *Acompsoceras* the adult whorl becomes smoothish. The two genera were probably derived from a common ancestor, *Stoliczkaia* directly or by way of *Submantelliceras*. They have complex sutures consisting of numerous elements (see MATSUMOTO *et al.*, 1960, 1966) and include species of large size.

(5) On the other hand *Cottreautes* and *Neopulchellia* are small and finely ornamented, although the hitherto described species may be based on immature shells. They have also numerous sutural elements. (There are no examples from Hokkaido.)

(6) Thus, in the early phase of the evolutionary history of the Acanthoceratidae, in early Cenomanian, at least eight taxa of generic rank have already been diverged, of which *Submantelliceras* and *Mantelliceras* form a main stock, leading to later genera, but others are short branches or offshoots and dead-ended, without giving rise to descendants.

(7) *Calycoceras*, of middle to late Cenomanian ages, was directly derived from *Mantelliceras*, acquiring the siphonal row of tubercles in the early to middle growth-stages. It includes not only the species of rounded whorl but also those of depressed whorl, some of which may reach a considerably large size. *Eucalycoceras* is probably a descendant of *Calycoceras*, acquiring more involution and compression of whorls and denser ribbing. It includes species of moderate size.

Less well known *Paracalycoceras* (of Lower Cenomanian), with weaker ventral tubercles on the inner whorls and rursiradiate ribs on the outer whorl, and *Tunesites* [= ? *Hourcquiceras*], with marked constrictions, are probably offshoots from the main stock of *Mantelliceras-Calycoceras*.

(8) As these genera are intimately connected with *Mantelliceras*, they have been assigned to the subfamily *Mantelliceratinae*. They differ, however, considerably from various, early Cenomanian offshoots of *Stoliczkaia-Submantelliceras*. Therefore it would be desirable to group the latter into another subfamily, which commonly have more or less involute and compressed whorls, bituberculate venter and numerous, typically fairly deeply incised sutural elements. The proposed subfamily is named here **Utaturiceratinae** MATSUMOTO, nov., which include *Submantelliceras*, *Utaturiceras*, *Graysonites*, *Acompsoceras*, *Cottreautes* and *Neopulchellia*.

(9) In the genera mentioned in (7) the ribs are as a rule dominant over tubercles. On the last whorl the ventral tubercles are weakened and may be finally absorbed by the ribs. This has been similarly noticed in *Mantelliceras*.

In the typical genera of the Acanthoceratinae the tubercles predominate over tubercles. *Acanthoceras* itself is certainly derived from *Calycoceras*, acquiring squarish whorl section. On the outer whorl of certain species of *Acanthoceras* ventrolateral horns are developed as in some species of *Sharpeiceras*. *Acanthoceras* gave rise to *Euomphaloceras*, with multiplication of ventral ornaments. The latter, in turn, led to *Kanabicerias*, with projection of ventral ribs and formation of a nodose siphonal keel at least in certain growth-stages.

Euomphaloceras and *Kanabicerias* have ventrolateral horns or spines. The former is large but the latter is reduced in size.

(10) While *Euomphaloceras* and *Kanabicerias* have depressed shell form, *Protacanthoceras* is compressed and rather small, having approximated ventral clavi. Whether it is a derivative of *Eucalycoceras* or *Acanthoceras* may be questionable, but a certain, undescribed species *Protacanthoceras* in C. W. WRIGHT's collection seems to indicate closer affinity with *Acanthoceras*. *Neocardioceras*, of the Lower Turonian, a probable descendant from *Protacanthoceras*, with fastigate venter, has a row of close siphonal tubercles, which tend to form a nodose keel. It is considered as a possible ancestor of the Collignoniceratidae, although no example of *Neocardioceras* has been found from the Cretaceous of Hokkaido.

(11) *Neosaynoceras*, known from the Lower Cenomanian of Africa, is unusually smaller than other acanthoceratids. It is a homoeomorph of *Saynoceras*, but how it is connected with *Acanthoceras* is not precisely known. No example has been found in Japan.

(12) *Dunveganoceras*, from the uppermost part of Cenomanian, is another aberrant acanthoceratid genus, showing on its large outer whorl dominant rounded ribs, ventrolateral horns, or bulges, or flares, which may form wall like ribs. Similar, if not identical, ventrolateral flares are developed on the last part of the outer whorl of *Euomphaloceras asura* described in this paper. We are not yet successful in obtaining examples of *Dunveganoceras* from Japan.

(13) *Watinoceras* of the Lower Turonian, is a rather small, compressed acanthoceratid genus, which has double ventrolateral tubercles. It is apparently similar to *Mantelliceras*, but has in its early immature shell siphonal row of tubercles. It is probably a derivative of *Neocardioceras* and is assigned to Mammitinae because of its affinity with *Mammites*. In a new genus, *Sumitomoceras*, the ventral tubercles are lost in middle to late growth-stages. It is a homoeomorph of *Kossmaticeras*, but is in sisterhood relation with contemporary *Watinoceras*, because they closely resemble each other in the immature stages. *Bunueites* is another relative of *Watinoceras*, which has its own particular characters. It is reported from Nigeria (REYMENT, 1954) and has not been found from Japan.

(14) Other, more typical genera of Mammitinae, such as *Mammites*, *Pseudaspidoceras* and *Metasigaloceras*, have more prominent tubercles, which may form horns in some species, and may reach a larger size. They all have no siphonal tubercles and their sutures are a little simpler than those of most Acanthoceratinae.

(15) *Metoicoceras* is a compressed and involute derivative of *Acanthoceras*, with weakening of tubercles and modification of sutures to pseudoceratitic type. It includes several species of uppermost Cenomanian to lower Turonian ages, and represents the Metoicoceratinae. For some reasons no example of this widespread genus has been found in Japan, as in the case of other pseudoceratites.

(16) *Romaniceras*, a multituberculate derivative of *Calycoceras* appears in late Cenomanian and ranges up to late Turonian. In its outer whorl the tubercles

may be absorbed by predominant ribs as in that of *Calycoceras*. In parallel with this there is *Yubariceras**, a multituberculate derivative of *Acanthoceras*. Likewise there could be multituberculate derivatives of *Eucalycoceras* and *Tunesites*, but the evidence is yet insufficient.

(17) In many of the genera of the Acanthoceratidae, such as *Mantelliceras*, *Sharpeiceras*, *Calycoceras*, *Eucalycoceras*, *Acanthoceras*, *Euomphaloceras*, *Kanabicerias*, *Protacanthoceras*, *Romaniceras*, *Metoicoceras* and *Mammites*, the generic diagnosis is most remarkably manifested in comparatively middle growth-stages of ontogeny. In more or less early immature stages the character of a genus is as a rule common with or similar to that of the young to middle growth-stages of its ancestral genus. However, in several genera a new character appears in early growth-stage, such as the double ventrolateral tubercles in *Stoliczkaia*, the increase in the number of sutural elements in *Submantelliceras*, the siphonal row of tubercles in *Calycoceras*, and the nodose keel in *Neocardioceras*, each of which has potentiality of leading to more descendants of a family or sub-familiy group.

In some cases the distinction between related genera becomes less clear in the late growth-stage, as between *Mantelliceras* and *Calycoceras*, or *Calycoceras* and *Romaniceras*, or *Acanthoceras* and *Euomphaloceras*, or *Euomphaloceras* and *Kanabicerias*, the outer whorls of two of the combination being similar to each other. There are, however, some genera in which the distinction becomes clearer in rather later growth-stages, such as *Utaturiceras*, *Graysonites*, *Dunveganoceras*, *Sumitomoceras* and *Pseudaspidoceras*. They are all offshooted dead-ends, showing deviation from the allied genera.

(18) The multiple divergency of the Acanthoceratidae probably implies the adaptive radiation as well as the orthogenetic evolution. Various types of shell-form, ornamentation and sutures may be respectively related to certain modes of life and ecological conditions of animals. How a particular character, e.g. a complex or simple suture, rounded or squarish whorl, strong and rigid or weak and flexuous ribbing, horn-like, or flared, or multiple tuberculation, was related to what kind of habitat and acted in what sort of living ought to be made clear. The similarity in mode of life may give a similar character. Thus, a horned body-whorl occur in a number of species which are not necessarily directly related to one another, such as certain species of *Graysonites*, *Sharpeiceras*, *Acanthoceras*, *Euomphaloceras*, *Dunveganoceras* and *Mammites*. A moderately ribbed outer whorl with feeble or no ventral tubercles is seen in many species of *Mantelliceras*, *Calycoceras*, *Romaniceras* and some of *Eucalycoceras*, *Sumitomoceras* and *Metoicoceras*. A smoothish body-whorl is found in some species of *Stoliczkaia*, *Acompsoceras*, *Eucalycoceras* and *Metoicoceras*. The change of shell characters in most acanthoceratids may be related to the change of living conditions with growth. These involve further problems to be studied.

* *Schindewolfites* WIEDMANN, 1959, can be included in, or possibly immature form of, *Yubariceras* MATSUMOTO, SAITO and FUKADA, 1957.

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