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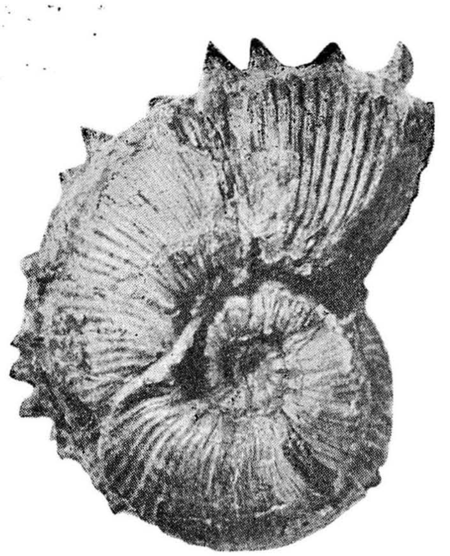

日本古生物学会

Palaeontological Society of Japan
April 15, 1982

The fossil on the cover is an adult example (T. TAKAHASHI coll.) of *Mikasaites orbicularis* MATSUMOTO (subfamily Marshallitinae, family Kossmaticeratidae) from the Lower Cenomanian (Cretaceous) of the Mikasa area, central Hokkaido. (photo by M. NODA, natural size)

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740. CRETACEOUS TETRAGONITID AMMONITE JAWS: A COMPARISON WITH MODERN *NAUTILUS* JAWS*

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Abstract. The morphology and mineral composition of jaw apparatuses in *Tetragonites glabrus*, *Gaudryceras denseplcatum*, *G. tenuiliratum* and *G.* sp. are described. The studied material is well-preserved specimens in some calcareous nodules from the Turonian-Maastrichtian of Hokkaido and Sakhalin. The upper and lower jaws of these species consist of black outer lamella, reduced short inner lamella and covering rostra. The two lamellae are composed of carbonate apatite, and the rostra are calcareous covering. The lamellae and rostra may have been diagenetically replaced from chitin and aragonite respectively, judging from the comparison with modern cephalopod jaws. The calcareous rostra of the upper and lower jaws are analogous to rhyncholite (upper jaw) and conchorhynch (lower jaw) of modern *Nautilus* instead of coleoids in the internal microstructure, and mineral and chemical composition. These evidences suggest an analogy in feeding habits between tetragonitid ammonites and *Nautilus*, although the ammonites have larger and stronger jaws.

Introduction

Anaptychi and aptychi are often preserved in ammonoid body chambers. They have been interpreted as ammonoid opercula (e.g. Retowski, 1891; Schmidt, 1928; Trauth, 1927-1936; Nagao, 1931a-c, 1932; Fischer & Fay, 1953; Arkell, 1957; Schindewolf, 1958) or jaw apparatuses (e.g. Meek & Hayden, 1864; Kennedy & Cobban, 1976). Recently, Closs (1967a, b) discovered several examples of anaptychus (upper jaw)—radula associations within the living chambers of an Upper Carboniferous ammonoid, *Eoasianites* (*Glaphyrites*) *rionegrensis* Closs, and Lehmann (1967, 1971b, 1979) reported *in situ* aptychi or anaptychi and radulae in some Jurassic ammonites. Thus, aptychi and anaptychi have been confirmed as the lower jaws of ammonites in Jurassic examples (Lehmann, 1967, 1970, 1971a, 1972, 1976, 1978, 1979; Lehmann & Weitschat, 1973; Kaiser & Lehmann, 1971). Recently Zakharov (1979) described the jaw apparatuses of Cretaceous *Tetragonites*. Lehmann *et al.* (1980) described the jaw apparatuses of Lytoceratacea. On the other hand, rhyncholite and conchorhynch were interpreted as calcified elements of nautiloid jaws (d'Orbigny, 1825; Foord, 1891; Rutte, 1962; Teichert *et al.*, 1964; Gasiorowski, 1973; Shimansky, 1962; Müller, 1974; etc.) or coleoid jaws (Biguet, 1819; Gaillardot, 1824; de Blainville, 1827; etc.), but some were considered to belong to ammonoids (Schmidt-Effing, 1972; Mundlos, 1973; Tanabe *et al.*, 1980; etc.).

Almost all cephalopods have jaw apparatuses and radulae. The taxonomic and ecological implications of jaw apparatuses in modern coleoids were studied

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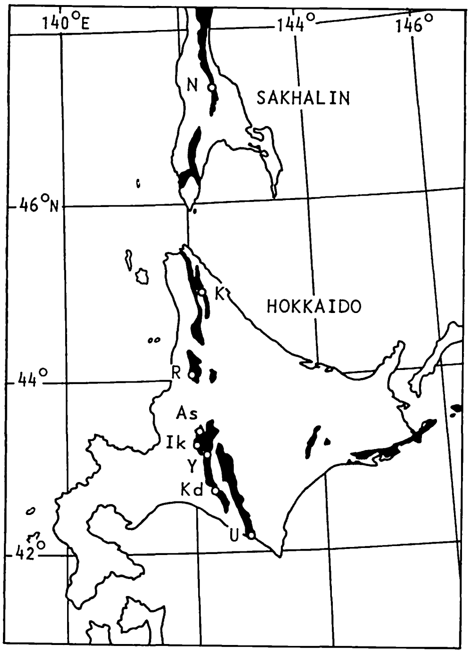
by Clarke (1962), Nixon (1969) and others, and those in *Nautilus* by Okutani & Mikami (1977) and Saunders *et al.* (1978).

Most previous works on ammonoid jaws have been done mainly on the basis of the Jurassic materials from Europe. However, Nagao (1931a-c, 1932) reported Cretaceous aptychi and anaptychi from Hokkaido and south Sakhalin, and Trauth (1935) redescribed Nagao's *Neoanaptychus*.

Kanie *et al.* (1978) preliminarily reported the jaw apparatuses of some Late Cretaceous ammonites from Hokkaido and Sakhalin. They recognized in some specimens that a pair of lower and upper jaws are preserved in the body chamber; calcareous coverings similar to rhyncholite and conchorhynch exist in the rostra of lower and upper jaws; the ammonite jaws are biomineralogically comparable with those of extant *Nautilus*. Furthermore, the tetragonitid jaws were interpreted to be analogous to those of *Nautilus* owing to similar feeding habit (Kanie & Tanabe, 1979; Tanabe *et al.*, 1980).

This paper presents a description of the general morphology of the teragonitid ammonite jaws from the Upper Cretaceous of Hokkaido and Sakhalin (Text-fig. 1), and compares them with the jaw apparatuses of modern *Nautilus* by some mineralogical analysis. On the basis of the results obtained, the tetragonitid jaws are restored.



Text-fig. 1. Locations of the specimens studied and exposures of Cretaceous deposits (solid area). N: Naibuchi, K: Tombetsu, R: Obira, As: Ashibetsu, Ik: Ikushumbetsu, Y: Oyubari, Kd: Furenai, and U: Urakawa areas.

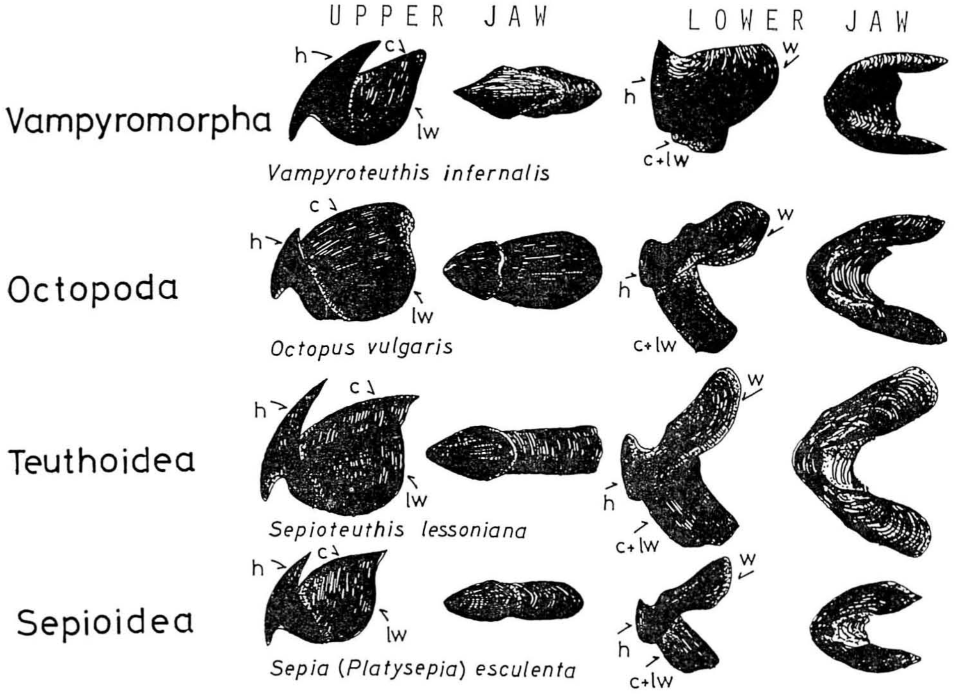
The depositories of the specimens examined are as follows (abbreviations are shown in parentheses):

Yokosuka City Museum, Yokosuka 238 (YCM)
Department of Geology, Kyushu University, Fukuoka 812 (GK)
Department of Geology and Mineralogy, Hokkaido University, Sapporo 060 (UH)
Japanese Expert Consultation on Living Nautilus. c/o Yokosuka City Museum (JECOLN)
Y. Kawashita's private collection, 2 A1-5, Tomatsu-Chiyoda-cho, Mikasa 068-22
M. Nihongi's private collection, 8S, 22W, Chuo, Sapporo 064 (MN)
T. Takahashi's private collection, 28-109, Hanazono-cho, Mikasa 068-22

General morphology

Comparison with modern cephalopods

Identification of lower and upper jaws.— The lower jaw is distinguished from the upper one by several characters (Text-figs. 2, 3), namely, the larger size of lamellae (compared with the height and width of living chambers), the broader lamella angle (angle between left and right sides of the outer lamellae) and less



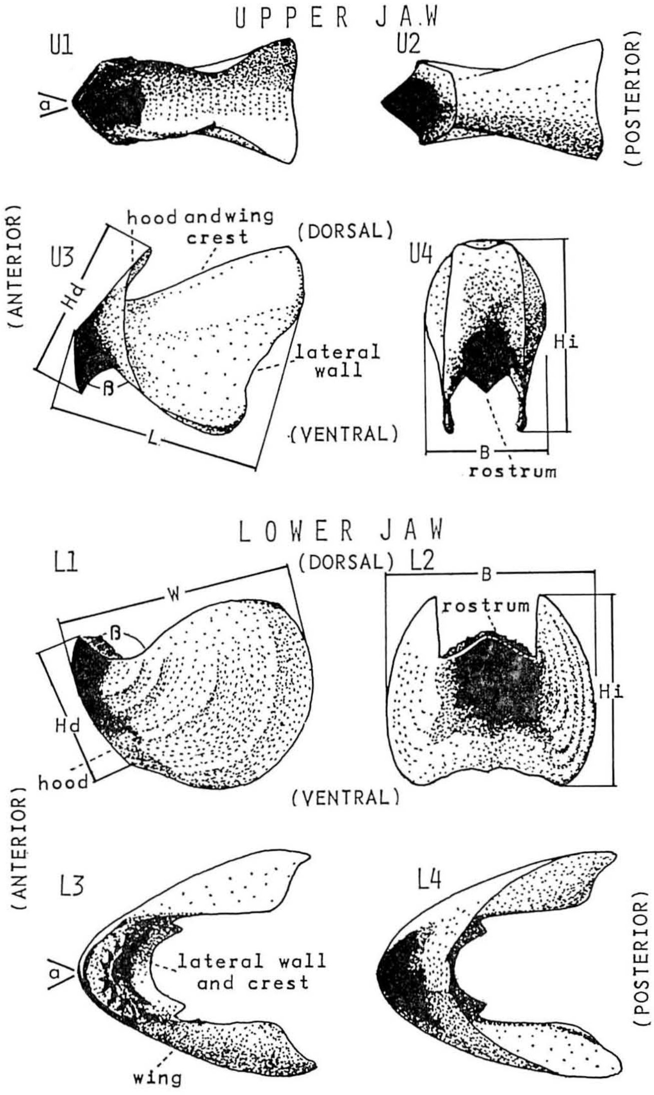
Text-fig. 2. Various kinds of basic morphologies in modern coleoid jaws. Upper jaw of the Vampyromorpha cited from Iverson & Pinkas (1971) and lower jaw from Clarke (1980). Octopoda, Teuthoidea and Sepioidea cited from Tanabe *et al.* (1980). Terminologies are based on Clarke (1962). w: wing, c: crest, lw: lateral wall, h: hood.

extended hood area (Clarke, 1962 for coleoids; Okutani & Mikami, 1977 and Saunders *et al.*, 1978 for *Nautilus*).

Morphological comparison with modern cephalopods.—The morphological features of the tetragonitid jaws (Text-figs. 4, 7) can be correlated with those of living *Nautilus* rather than with those of modern coleoides. These ammonite jaws are characterized by the presence of rhyncholites and conchorhynchs at the anterior part of the jaws (Tanabe *et al.*, 1980), The *Nautilus* jaw is also covered with rhyncholite and conchorhynch (Text-fig. 3; Okutani & Mikami, 1977; Saunders *et al.*, 1978). Those of coleoids, however, lack calcareous coverings visible with the naked eye (Text-fig. 2). The lower jaw of the Tetragonitidae is morphologically similar to those of *Nautilus* and *Vampyroteuthis infernalis* in the scarcely extended crest and lateral wall. In the Tetragonitidae the upper jaw more or less resembles the lower jaw except for the more extended wings covering the reduced short lateral walls and crest, whereas in these living cephalopods the upper and lower jaws are morphologically quite different from each other.

Description of jaw apparatuses

The jaw specimens examined are attributed to *Gaudryceras* and *Tetragonites* (Tetragonitidae: Lytoceratina). They were previously named *Neoanaptychus* by Nagao



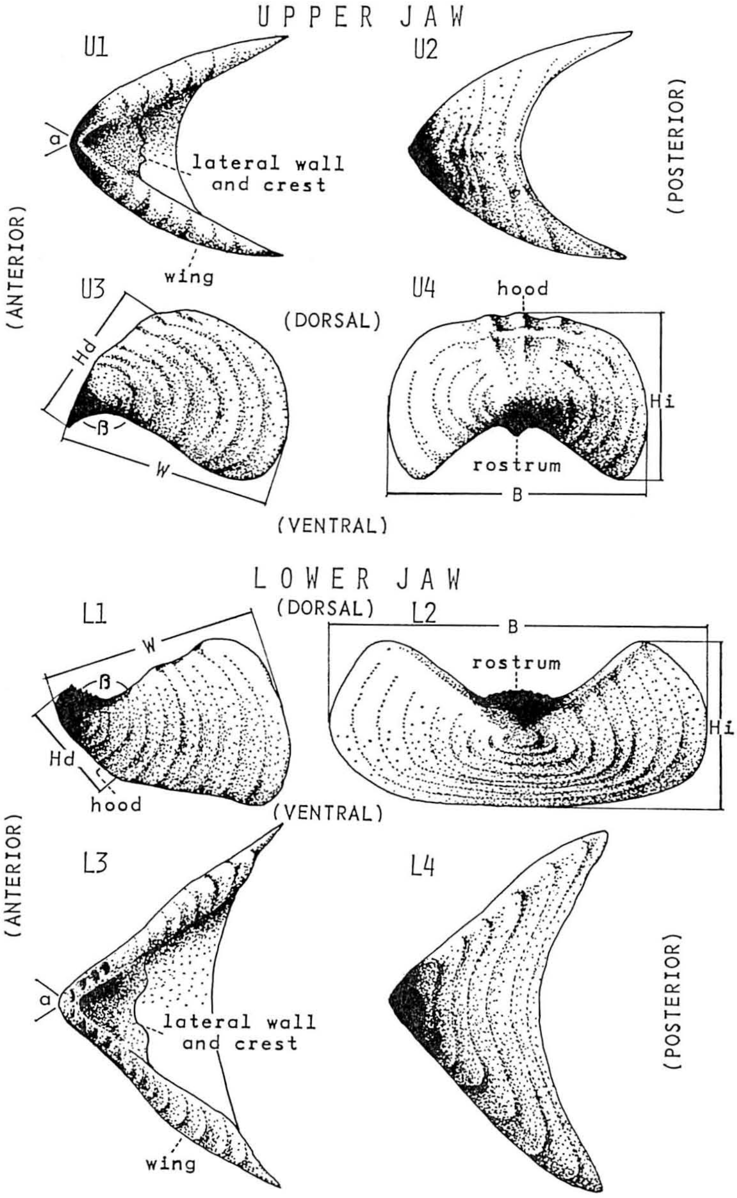
Text-fig. 3. Basic morphology of modern *Nautilus* jaw. L: length of lateral wall, W: length of wing, Hd: length of hood, Hi: height, B: breadth, α: wing (lateral wall) angle, β: jaw angle. Terminologies are mostly based on Okutani & Mikami (1977) and Saunders *et al.* (1978). Solid area is covered with a calcareous covering.

(1931a) and *Anaptychus* by Trauth (1935).

Family Tetragonitidae Hyatt, 1900
Subfamily Gaudryceratinae Spath, 1927
Genus *Gaudryceras* Grossouvre, 1894

Jaws of *Gaudryceras* spp.

General characters: The lower and upper jaws are of *Anaptychus* type. They are broader than high. Lower jaw is larger and broader than upper one. Both



Text-fig. 4. Restoration of *Gaudryceras* jaw and the measurements. W: length of wing, Hi: height, B: breadth, Hd: length of hood, α: wing angle, β: jaw angle. Solid area is covered by a calcareous covering. U1 and L3 (Lehmann *et al.*, 1980).

lower and upper jaws are constructed by wing, hood and rostrum with calcareous covering and crest plus minor lateral wall beneath them. Wing angle (α, angle between left and right sides of the wings; Text-fig. 7) is wide in the lower jaw.

Jaw angle (β) is obtuse; the curve between rostrum and wing margin is gentle without notch. The black lamellae are made up of apatitic mineral and covered with a thin calcite layer.

Remarks: The specific distinction of these jaws in accordance with the classification of *Gaudryceras* is difficult at present.

Upper jaw (Pl. 39, Figs. 1-3,5; Text-fig. 4-U)

Previously described material: The following specimens are attributable to the upper jaws of *Gaudryceras* spp.

1931c. *Neoanaptychus* sp. form 7, Nagao, p. 216, pl. 15, fig. 6.

1935. *Anaptychus tenuiliratus* (Nagao), Trauth, pp. 452-454.

Material: Attributed to *Gaudryceras denseplicatum* (Jimbo) *in situ*. GK.H8087. Loc. R4041p2, the upper part of the Obirashibe River, Obira area, northwestern Hokkaido. Lower Santonian (H. Hirano & K. Tanabe coll.) ; to *G. tenuiliratum* Yabe *in situ*. UH3191. Loc. the Ikushumbetsu River about 200 m east from the junction with the Kikumezawa, Ikushumbetsu area, central Hokkaido. Santonian (R. Saito coll.) ; to ? *G. tenuiliratum* Yabe. GK.H2262. Loc. N146, the lower part of the Santan, Naibuchi area, south Sakhalin. Santonian (T. Matsumoto coll.) ; to ? *G. tenuiliratum* Yabe. Loc. Kawakami, the Obirashibe River, Obira area. Sahtonian ? (T. Takahashi coll.) ; to ? *G*. sp. Loc. Y5251a, the lower part of the Hakkinzawa, Oyubari area, central Hokkaido. Turonian (T. Matsumoto, H. Hirano & K. Tanabe coll.) ; to ? *G*. sp. Loc. R4040b, the upper part of the Obirashibe River, Obira area, northwestern Hokkaido. Upper Coniacian (H. Hirano & K. Tanabe coll.) ; to ? *G*. sp. MN6, 83c. Loc. the upper part of the Yubarigoenosawa, Ikushumbetsu area. Coniacian ? (T. Nihongi coll.) ; to ? *G*. sp. (=*Neoanaptychus* form 7) UH3193. Loc. Kikumezawa, Ikushumbetsu area. Santonian ? (R. Saito coll.) ; to ? *G*. sp. GK.H3220. Loc. Ur512Y4, the Ikandai Valley, Urakawa area, southern-central Hokkaido. Lower Campanian (T. Matsumoto coll.) ; to ? *G*. sp. GK.H8088. Loc. K57, Heitarozawa, Tombetsu area, northern Hokkaido. Upper Maastrichtian (T. Matsumoto, H. Okada, I. Orita & T. Muramoto coll.).

Description: The wings are triangular and make up the greater part of the upper jaw. Wing surface is marked by concentric costae and numerous growth lines of variable prominence. The wings are slightly compressed towards the flank of the living chamber, and combine a hood at the antero-dorsal part, being narrowly flat at the dorsal part; growth lines gently concave toward anterior direction. In some specimens (e.g., Pl. 39, Fig. 1b), folds or a groove are found; wings posteriorly projected in later growth stage. Crest and lateral wall are small. Wing

Table 1. Measurements (in mm) of upper jaws of *Gaudryceras* spp.

Specimen	W	Hd	Hi	B	α	β	Lh	(Hi/LH)
UH3193	56.9	38.4	37.0	58.0	60°	165°	—	—
MN6	58.8+	41.5	29.2	40.0	49°	155°	—	—
GK.H8086	34.7	31.2	25.7	30.9*	51°	170°	—	—
R4040b	33.4+	30.7	27.4+	27.0*	65°	165°	—	—
GK.H3220	28.7	24.3	25.0+	32.9	48°	165°	—	—
GK.H8087	23.7	18.7	23.1+	—	—	135°	29.2	(0.64)
GK.H2262	16.5	14.9	18.8	14.0	47°	160°	—	—
UH3191	12.7	10.9	11.6	14.4+	87°*	170°	18.9	(0.61)

W: wing, Hd: hood, Hi: height, B: breadth, α: wing angle, β: jaw angle, Lh: height of living chamber, *: deformed specimen.

angle is 47-65°.

The rostrum projects toward the ventral side and is covered with a calcite layer. In specimen MN6 (Pl. 39, Fig. 1), the poorly preserved rostral tip fills inside of the rostrum. The rostrum, originally sharp-topped, decreases in thickness toward the wings; the outer surface of the wings is covered with a light-colored, thin (approximately 500 μm thick) calcite layer. The jaw angle is generally obtuse (135-170°), without a notch (Table. 1).

Remarks: In comparison with *Gaudryceras*, the upper jaw of *Nautilus* has less extended wings, larger lateral wall and narrower jaw angle (118-119°). The upper jaw of *Tetragonites* is clearly distinguished from that of *Gaudryceras* in the higher, narrower and more rounded outline.

Lower jaw (Pl. 39, Figs. 4-6; Text-figs. 4-1, 5, 6-1)

Previously described material: The following specimens are attributable to the lower jaws of *Gaudryceras* spp.

1931a. *Neoanaptychus tenuiliratum* Nagao, pp. 106-109, fig. 1.

1931c. *Neoanaptychus tenuiliratus* Nagao, p. 216, pl. 15, fig. 1.

1935. *Anaptychus tenuiliratus* (Nagao), Trauth, pp. 452-454.

Material: Attributed to *Gaudryceras denseplicatum* (Jimbo). GK. H8054. Loc. R2101p, the upper part of the Obirashibe River, Obira area, northwestern Hokkaido. Lower Turonian (T. Matsumoto & H. Hirano coll.) ; to *G. tenuiliratum* Yabe. GK. H8049. Loc. R2251b, the middle part of the Kamikinenbetsu River, Obira area. Upper Turonian (T. Matsumoto & H. Hirano coll.) ; to *G.* sp. GK. H8059. Loc. Y1664a, the upper part of the Shiyubari River, Oyubari area, central Hokkaido. Santonian (Y. Haraguchi coll.) ; to *G.* sp. GK. H8048. Loc. Kd905, Furenai area, central Hokkaido. Campanian (T. Matsumoto coll.) ; to ? *G. denseplicatum* (Jimbo). YCM. Ur307002. Loc. U307p, the Ikandai Valley, Urakawa area, southern-central Hokkaido. Lower Campanian (Y. Kanie coll.) ; to ? *G.* sp. GK. H8045. Loc. As1140, the lower part of the Souashibetsu River, Ashibetsu area, central Hokkaido. Coniacian (T. Matsumoto coll.).

Description: Wings are triangular and make up the greater part of the lower jaw. Wing surface is marked by concentric costae and numerous growth lines. Wings are slightly compressed toward the side of living chamber; the hood combines wings at the antero-ventral part, being flat, occasionally folded at the ventral part (Text-fig. 4-L2); growth lines gently concave toward the aperture. Wing angle is 80-87°. Wings are made up of carbonate apatite in the specimen YCM. Ur307002.

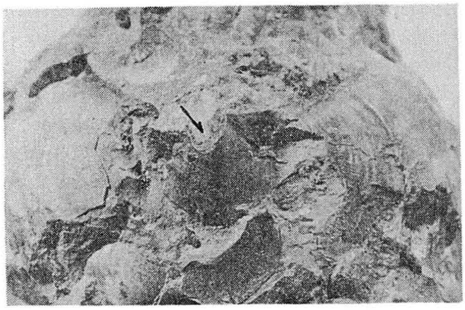
Lateral wall is small. Thick calcareous substance (rhyncholite) covers entire lateral wall (Text-fig. 5). Lateral wall continues to rostrum at the tip of beak. The rostrum is covered with a calcareous layer forming a beak which consists of an alveolus structure of 2 mm wide at the dorsal part, though decreasing in thickness to 0.5 mm toward posterior part of the wing and hood areas (Text-fig. 6-1).

Remarks: The general morphology of the lower jaw in *Gaudryceras* is similar to that of *Nautilus* except for the longer wing, partly flattened hood, and larger

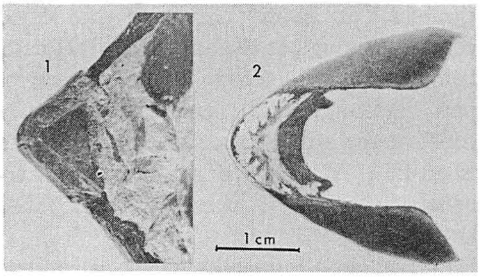
Table 2. Measurements (in mm) of lower jaw of *Gaudrycers denseplicatum* (?).

Specimen	W	Hd	Hi	B	α	β	Lh	(Hi/Lh)
YCM. Ur 307002	37.8	25.0+	34.0*	51.0+	80°	140°	—	—

Symbols as in Table 1. * deformed specimen.



Text-fig. 5. Crest and lateral wall structure (arrow) of the lower jaw probably attributable to *Gaudryceras* sp., GK. H8045, from loc. As1140, the lower part of the Souashibetsu River, Ashibetsu area. Coniacian. ×2.3. Photo by K. Tanabe.



Text-fig. 6. Alveolus structure of *Gaudryceras denseplicatum* (1), YCM. Ur307002, from loc. U307p, the Ikandai Valley, Urakawa area. Lower Campanian (Tanabe *et al.*, 1980) and *Nautilus macromphalus* (2), JECOLN.M5, from Nouméa, New Caledonia. Both are the lower jaws (dorsal views). Photos by Kanie.

jaw angle. The lower jaw of *Tetragonites* is clearly distinguished from that of *Gaudryceras* in the greater height, narrower wing angle, and larger jaw angle.

Subfamily Tetragonitinae Hyatt, 1900
Genus *Tetragonites* Kossmat, 1895

Jaws of *Tetragonites glabrus* (Jimbo, 1894)

General characters: Lower jaw is broader than high. It is slightly larger than upper jaw. The breadth of upper jaw is approximately equal to or smaller than height. The jaw plate consists of outer lamellae (wing and hood) and inner lamellae (minor crest plus lateral wall). Wing angle (α) is wide in lower jaw. Jaw angle (β) is obtuse to rectangular; the curve between rostrum and wing margin is gentle without notch. The wing is mainly composed of apatitic mineral with a thin covering of calcite layer.

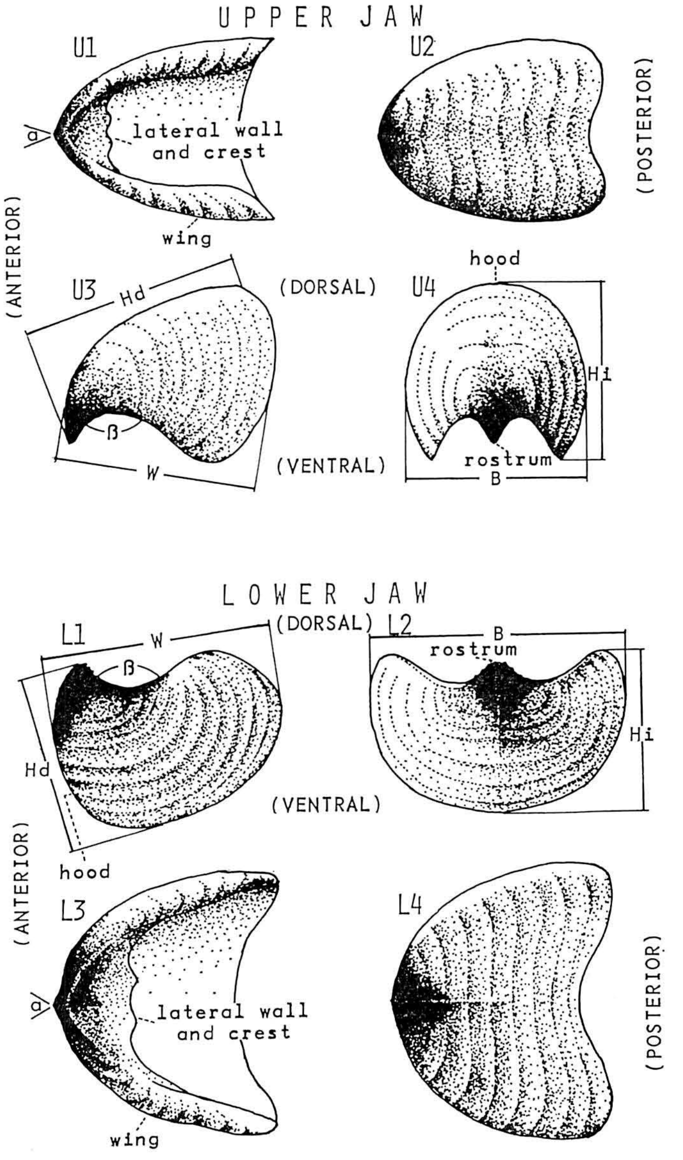
Upper jaw (Pl. 40, Figs. 1-3; Text-fig. 7-U)

Material: Attributed to *Tetragonites glabrus* (Jimbo) *in situ*. GK. H2073. Loc. N143a, the lower part of the Santan, Naibuchi area, south Sakhalin. Lower Santonian (T. Matsumoto coll.) ; to *T. glabrus* (Jimbo) *in situ*. GK423. Loc. Sakhalin. Upper Cretaceous (collector unknown) ; to ? *T.* sp. Loc. the lower part of the Kaneobetsu, Oyubari area, central Hokkaido. Turonian (Y. Kawashita coll.).

Description: The wings are triangular and make up the greater part of the upper jaw. Wing surface is marked by concentric costae and numerous growth lines. Wings are slightly compressed toward the side of living chamber; the hood is flat or waved in dorsal part; growth lines concave toward the anterior part. Crest and lateral wall unclear. Wing angle is approximately 55°.

The rostrum is sharply projected toward the ventral side and covered with a thick calcareous layer (rhyncholite), decreasing the thickness toward the wing; outer surface of wings is covered with a thin (ca. 500 μm thick) calcite layer (Pl. 40, Fig. 2). The jaw angle is approximately 55° in Kawashita's specimen, without a notch (Table 3).

Remarks: The lateral wall and crest of *Tetragonites* are reduced to a short



Text-fig. 7. Restoration of *Tetragonites* jaw and the measurements. Legends are shown in text-figure 4. U1 and L3 (Lehmann *et al.*, 1980).

inner lamella as compared with those of the upper jaw of *Nautilus*.

Lower jaw (Pl. 40, Figs. 3-5; Text-fig. 7-L)

Previously described material: The following specimens are attributable to the lower jaws of *Tetragonites glabrus*.

1931a. *Neoanaptychus tenuiliratum* Nagao, pp. 106-109, fig. 2.

1931c. *Neoanaptychus* sp. form 5, Nagao, p. 216, pl. 15, fig. 4.

Table 3. Measurements (in mm) of upper jaw of *Tetragonites glabrus*.

Specimen	W	Hd	B	Hi	α	β	Lh	(Hi/Lh)
Kawashita's coll.	32.3	27.9	20.0*	28.0	55°	100°	—	—
GK423	17.3+	13.8+	—	—	—	—	38**	(0.48)

Symbols as in Table 1. * deformed specimen; ** restored.

Table 4. Measurements (in mm) of lower jaws of *Tetragonites glabrus*.

Specimen	W	Hd	B	Hi	α	β	Lh	(Hi/Lh)
GK. H8043	28.9	23.2	18.9*	23.0*	—	135°	—	—
GK. H8049	26.2	—	20.0+	30.9*	85°	115°	—	—
UH3194	24.6	19.3	13.4	30.5+	95°	100°	—	—
MN83a	16.6	10.4	11.0*	27.0+	95°	150°	—	—
GK. H2073	10.0	10.3	7.2*	25.0*	70°	—	37**	(0.36*)
UMUT. MM 6999	14.6	13.4	7.8	21.0	90°	110°	—	—

Symbols as in Table 1. * deformed specimen; ** restored.

1931c. *Neoanaptychus* sp. form 1, Nagao, p. 216, pl. 15, fig. 2.
1931c. *Neoanaptychus* sp. form 4, Nagao, p. 216, pl. 15, fig. 3.
1935. *Anaptychus tenuiliratus* (Nagao), Trauth, pp. 452-454, pl. 14, fig. 6.
1935. *Anaptychus tenuiliratus* var. *lata* Trauth, pp. 455-456, pl. 14, figs. 8, 9.
1979. *Anaptychus sakhalinensis* Yu. Zakharov, p. 87, pl. 20, fig. 2.

Material: Attributed to *Tetragonites glabrus* (Jimbo). GK. H8049. Loc. R2251b, the middle part of the Kamikinenbetsu River, Obira area, northwestern Hokkaido. Upper Turonian (H. Hirano & K. Tanabe coll.) ; to *T. glabrus* (Jimbo) *in situ*. GK. H2073. Loc. N143a, the lower part of the Santan, Naibuchi area, south Sakhalin. Santonian (T. Matsumoto coll.) ; *T. glabrus* (Jimbo) *in situ*. GK. H8043. Loc. N382, the Juhachirinpan-Ichinosawa, Naibuchi area. Santonian (T. Matsumoto coll.) ; to ? *T*. sp. MN83a. Loc. Takishita-Nakakinenbetsuzawa, the middle part of the Obirashibe River, Obira area. Upper Turonian (M. Nihongi coll.) ; to ? *T*. sp. (=*Neoanaptychus* form 5) UH3194. Loc. Kikumezawa, just above the junction with the Ikushumbetsu River, Ikushumbetsu area, central Hokkaido. Santonian (R. Saito coll.) ; to ? *T*. sp. UMUT. MM6999. Loc. Na & H-Cr738, the second eastern tributary of the Naibuchi River, Naibuchi area. Santonian (M. Kawada coll.).

Description: The wings are quadrate to triangular and make up the greater part of the lower jaw. Wing surface is marked by concentric costae and numerous growth lines. Wings are gently compressed toward the side of living chamber; the hood is flat and sometimes folded at the ventral part (Nagao, 1931c, pl. 15, fig. 4); growth lines gently concave toward the anterior part. Wing angle is 90-95° (Table 4). Crest and lateral wall are small, existing as inner lamella. Thin calcite layer covers the greater part of outer surface of the wings. Wings are continuous to the rostrum at the tip of the beak (Pl. 40, Fig. 5c). The rostrum is sharp-topped, but denticles as cutting edge are not preserved; rostrum is covered with a calcite layer, the thickness of which decreases toward the posterior part of wings.

Table 5. Measurements (in mm) of jaw appoffaratuses of adult *Nautilus macromphalus*. The specimens are from of Nouméa, New Caledonia.

Specimen		W(L)	Hd	B	Hi	α	β	Lh	(Hi/Lh)
JECOLN. M4	up.	(31.3)	19.0	17.0	25.3	33°	119°	94	(0.27)
	low.	28.9	19.5	33.0	24.5	52°	102°		(0.26)
JECOLN. M5	up.	(34.0)	21.5	27.2	25.4	31°	118°	93	(0.27)
	low.	29.0	18.3	30.6	23.7	51°	102°		(0.26)

W: length of wing (lower jaw), L: length of lateral wall (upper jaw), Hd: length of hood, B: breadth, Hi: height, α: wing (lower jaw) or lateral wall (upper jaw) angle, β: jaw angle, Lh: height of living chamber, as illustrated in Text-figure 3.

Table 6. Comparison of jaw size of tetragonitid ammonites and modern *Nautilus*.

Genus		Upper	Lower
Gaudryceras	Hi/Lh	0.64-.61(2.4-2.3)	—
	W/Lh	0.81-.67(2.3-2.0)	—
Tetragonites	Hi/Lh	0.48(1.8)	0.47 (1.5-1.3)
	W/Lh	0.27(0.8)	0.19*(—)
Nautilus	Hi/Lh	0.27(1.0)	0.26 (1.0)
	WL/Lh	0.36-.33(1.0)	0.36-.31 (1.0)

Hi: height, W: length of wing, L: length of lateral wall, Lh: length of living chamber. The number in parentheses is the ratio with that of *Nautilus*. *: deformed specimen.

Remarks: The general outline of the lower jaw of *Tetragonites* is closely similar to that of *Nautilus* except for the narrower wing angle (51-52°) and smaller size (Table 5).

Discussion: The upper jaw plates of tetragonitid ammonites are morphologically more similar to those of octopods than decapods, and they resemble those of *Nautilus* more closely than octopods (Text-figs. 2, 3). Namely, the crest and lateral wall of the lower jaw of *Nautilus* are shortly reduced as in tetragonitid ammonites. Meanwhile, the upper jaw of modern *Nautilus* consists of wide inner lamellae (lateral wall and crest) and shortly reduced outer lamellae (hood and wing).

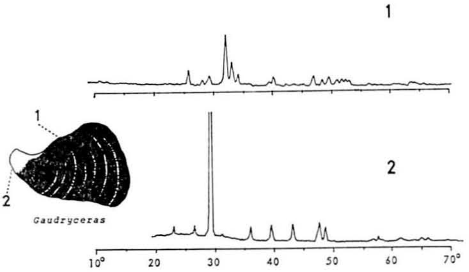
The outer and inner lamellae are morphologically similar between the upper and lower jaws in tetragonitid ammonites. The ratio of jaw height to living chamber height is less than 100 percent; for example, the upper jaw of *Gaudryceras* is 61-64%; the upper jaw of *Tetragonites* is 48% and lower jow 47%; the upper jaw of *Nautilus macromphalus* is 27% and lower jaw 26% (see Tables 5, 6).

Table 6 gives the size of the jaw apparatuses of tetragonitid ammonites in relation to the living chambers. The size of the jaw apparatuses in *Gaudryceras* is 1.7-2.4 times and in *Tetragonites* is 1.3-1.8 times as large as that of adult *Nautilus macromphalus*.

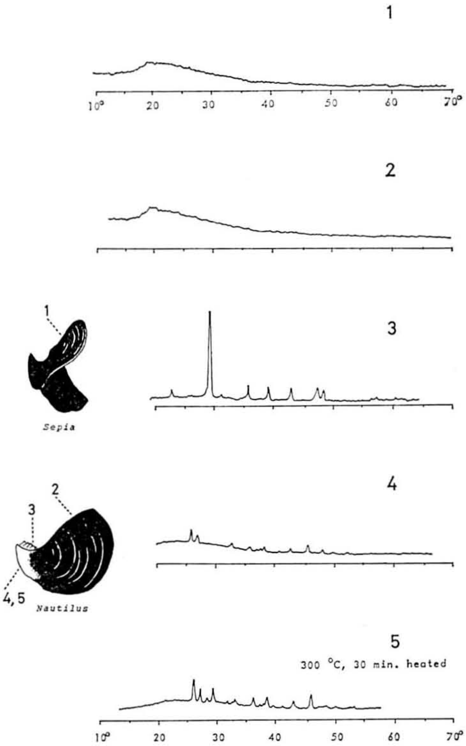
Sharp denticles are present on the alveolus structure in living *Nautilus*, but unknown in the Tetragonitidae. However, it may be due to the matter of fossilization (Text-fig. 6-2).

Mineral composition

The mineral composition of the jaw plates of tetragonitid ammonites was



Text-fig. 8. X-ray powder diffraction patterns of the lower jaw attributed to *Gaudryceras denseplicatum*. 1. Carbonate apatite, 2. calcite. The specimen examined is preserved in a calcareous nodule, from loc. U307p, Ikandai Valley, Urakawa area, southern-central Hokkaido. All pattens are obtained by Cu/Ni radiation. Chart speed 20 mm/min. Scanning speed 2°/min. Analyzed by A. Kato and S. Matsubara.



Text-fig. 9. X-ray powder diffraction patterns of the lower jaws attributed to two kinds of modern cephalopods. 1, 2. Nearly amorphous materials with broad bands about d=4.4 Å only, 3. calcite, 4. aragonite, 5. aragonite and calcite (heated by Y. Fukuda). *Sepia* sp. from Mexico Bay. *Nautilus macromphalus* from Nouméa, New Caledonia. Patterns were taken under the same recording conditions as those in Text-figure 8.

analyzed by an X-ray powder diffraction method. The patterns are compared with those of modern coleoids by the same method. The specimens examined are the lower jaws of *Gaudryceras* sp., *Tetragonites glabrus, Nautilus macromphalus* and *Sepia* sp. It was found that the calcareous covering of the rostrum in *Gaudryceras* is made up of calcite (Text-fig. 8-2), whereas the black outer lamella (wing) is composed mainly of well-crystallized carbonate apatite (Text-fig. 8-1). The whole surface of the outer lamellae in *Gaudryceras* (Pl. 39, Fig. 1b) and *Tetragonites* (Pl. 40, Fig. 2) is covered with a calcite layer about 500 μm thick. The layers grades into the calcareous covering of the rostrum. The lower jaw plate of *Nautilus* consists of outer and inner lamellae, calcareous rostrum, and denticles. The former two are made up of chitin (Saunders *et al.*, 1978), but the X-ray powder diffraction studies show that almost all materials display broad bands near d=4.4 Å only as represented by Text-figure 9-2, also that of *Sepia* (Text-fig. 9-1). The calcareous covering of the rostrum is composed of aragonite (Text-fig. 9-4), but the denticles are of calcite (Text-fig. 9-3). Another test showed that a pair of the aragonitic rostra changed into calcite by heating at 300°C in half an hour (Text-fig. 9-5). The wing surface of the jaw of *Nautilus macromphalus* shows similarities with that of *Tetragonites*, a prismatic layer covers the outer surface of the wings of *Nautilus macrom-*

phalus (Fukuda, 1978).

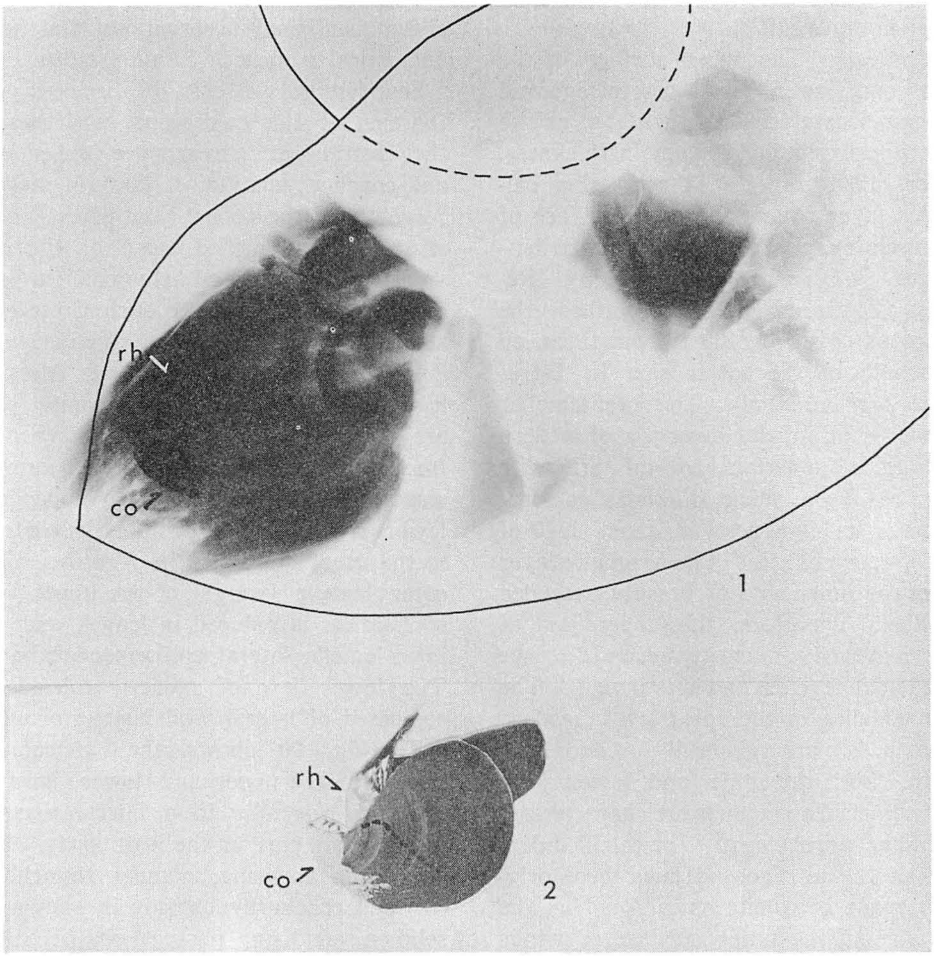
Discussion: The wing surface of the upper and lower jaws of tetragonitid ammonites are covered with a calcite layer, approximately 500 μm in thickness. Hölder (1958) reported that a thin calcareous layer covers the outer surface of a Jurassic anaptychus, probably attributable to *Psiloceras torus* d'Orbigny. Recently, Zakharov (1979) described the calcareous covering, 100-200 μm thick, on the lamella of the lower jaw in *Tetragonites popetensis* Yabe. The outer lamellar surface (wing) of the lower jaw of modern *Nautilus* is underlain by an aragonite layer, 50-75 μm thick (Fukuda, personal comm.). Its thickness is about 1/10 of that of tetragonitids. The aragonite layer covers the inner side of broadly extended lamellae. Therefore, the upper jaw of modern *Nautilus* is mostly occupied by the inner lamellae (crest and lateral wall). The outer lamellae of the upper jaw in modern cephalopods are generally reduced in length. Both the upper and lower jaws of tetragonitid ammonites are characterized by similar morphology. The calcified denticles of the tetragonitid jaws were originally made of calcite as in *Nautilus*, the rostrum and the outer surface of wings consisted of aragonite, and the wings were made up of chitin. During the course of fossilization, the rostrum and outer surface may have changed into calcite and the wings into carbonate apatite. This suggests that aragonite has changed into calcite during diagenesis. Such a conversion of aragonite into calcite is also indicated in the septa of *Subptychoceras* sp. (specimen YCM. Ur307001) preserved in the same nodule.

Restoration of jaws

The restoration of tetragonitid ammonite jaws is undertaken on the basis of the above mentioned observations and some anatomical studies of living *Nautilus*.

Saunders *et al.* (1978) discussed the function of the calcareous coverings of the rostral part, rhyncholite (upper jaw) and conchorhynch (lower jaw). in modern *Nautilus* and the extinct Nautilida. Tanabe *et al.* (1980) clarified some of the previously known fossil rhyncholites and conchorhynchs belong to such Cretaceous ammonites as *Gaudryceras, Tetragonites, Zelandites* and *Neophylloceras*. Morphologically the tetragonitid ammonite jaws are most similar to those of living *Nautilus*. However, the analogous internal structure is observed between upper and lower jaws of the ammonites in contrast to the great difference in *Nautilus*. The outer lamella (wings) of the upper jaws of *Nautilus* is reduced in length and the inner lamella (lateral wall) extends broadly. The lower jaw of modern coleoids is composed of lateral wall instead of wing.

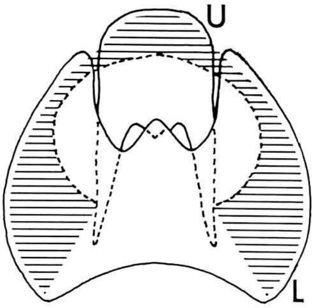
Text-fig. 10 shows the articulation system of the upper and lower jaws of *Nautilus pompilius* in a buccal mass in the anterior part of the soft body. The calcareous covering, namely rhyncholite (rh) and conchorhynch (co), is shown as solid on soft X-ray photographs (Text-fig. 10), whereas the lamellae mostly made of chitin are faintly shadowed. Text-fig. 10-2 shows the articulated upper and lower jaws of *Nautilus macromphalus*. The muscle system between the upper and lower jaws of the present two species of *Nautilus* is designed in Text-figure 11 on the basis of data above mentioned and some anatomical studies. Namely, the wing and lateral wall are distinguished from the attachment muscle system on the lamellae and the existence of the calcareous covering; the outer surface of the wing is covered with a calcareous layer and the muscle attaches inside; the inner surface of the lateral wall is overlain



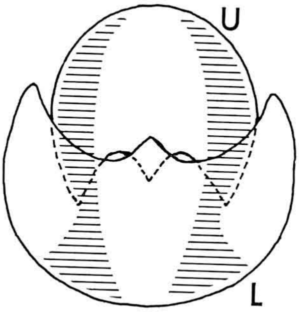
Text-fig. 10. The articulation of the upper and lower jaws of modern *Nautilus*. rh: rhyncholite, co: conchorhynch. Photos by Kanie. 1. Soft X-ray photograph of the jaw apparatus of *Nautilus pompilius* Linnaeus (natural size). Specimen JECOLN. P2 ♀. Loc. —150 m, off Bindoy, Negros Oriental, Philippines. Condition: 30 seconds for an integral time, 40 kV-6 mA for an energy level per channel with Softex-EMB. 2. Lateral view of an articulated jaw of *Nautilus macromphalus* Sowerby (natural size). Specimen JECOLN. M5 ♀. Loc. off Nouméa, New Caledonia.

by a calcareous layer and underlies the muscle attachment.

It is suggested that the articulation and muscle system of both upper and lower jaws of tetragonitids are quite different from those of living cephalopods. The attachment areas of the muscles of tetragonitids are inferred from the morphological features of the muscle-scar, though there is no information on the jaw muscle-scar. The muscle attachments of the lower jaw in tetragonitids might be inside of the wing (Text-fig. 12), because of the existence of a calcareous layer on the wing surface. The muscle of the upper jaw also attaches inside of the wings



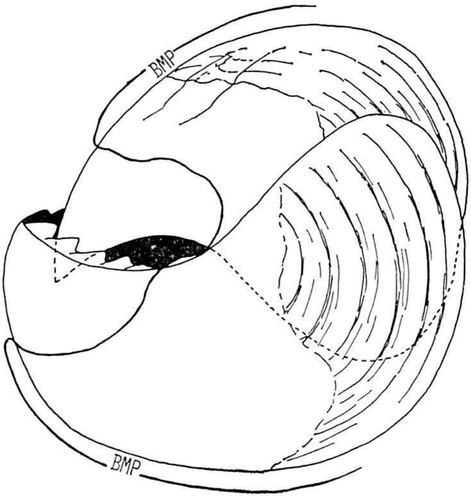
Text-fig. 11. Anterior view of articulated upper and lower jaws of modern *Nautilus* species with jaw muscles (horizontal lines). U: upper jaw, L: lower jaw.



Text-fig. 12. Anterior view of articulated upper and lower jaws of a tetragonitid ammonite. Horizontal lines show the presumed jaw muscular system. U: upper jaw, L: lower jaw. Discussed with Y. Fukuda and K. Tanabe.

based on the similar lamellar structure. Therefore, the buccal mass system and morphological feature of the upper and lower jaws suggest an articulation system of the tetragonitid ammonite jaws as shown in Text-figure 13.

The feeding habits of tetragonitid ammonites which have a conchorhynch at the rostral part of the lower jaw are partly inferred from those of *Nautilus* with similar conchorhynch. Dean (1901), Bidder (1962), Haven (1972), Mikami & Okutani (1977), Kanie & Tanabe (1979),



Text-fig. 13. Restored jaw apparatus of tetragonitid ammonite within a buccal mass. The apparatus is covered with buccal membrance and papillae (BMP). Discussed with Y. Fukuda and K. Tanabe.

and others observed the feeding habits of living *Nautilus*. In their views, *Nautilus* mostly scavenges animals on the sea floor and rarely feed on slow moving benthos. The function of the rhyncholites and conchorhynchs to bite and cut up a prey has already demonstrated by Tanabe *et al.* (1980) through the observations of crop content remains. *Nautilus* is a slow moving animal, its maximum swimming speed being 25 cm/sec (Ward *et al.*, 1977), and usually 2.8 cm/sec (Mikami *et al.*, 1980). The tetragonitid animals with similar shells to *Nautilus* are probably also slow swimmers.

Conclusions

The general morphology of the jaw apparatuses of Late Cretaceous *Tetragonites* and *Gaudryceras* is described. They are of anaptychus-type, and are often preserved *in situ* within the body chambers. The upper and lower jaws are distinguished from each other by differences of morphology, size, internal structure and others. The tetragonitid ammonite jaws are more similar to those of modern *Nautilus* than to those of coleoids especially in the existence of calcareous coverings at the rostral part.

The jaw lamellae of tetragonitid ammonites are composed of carbonate apatite, and the rostra grade into wing surface layer consisting of calcite, whereas the lamellae of modern cephalopods consist of chitin. The rostra and denticles of *Nautilus* jaws are made up of aragonite and calcite, respectively. The outer lamellae of modern *Nautilus* are overlain by very thin aragonite layers. Therefore, the ammonite jaws originally seem to have been analogous to modern cephalopod jaws in regard to mineral composition and internal structure.

Based on the similarities of jaws and shell morphology, tetragonitid ammonites are interpreted to be analogous to *Nautilus* in living habits. The jaw apparatuses of tetragonitid ammonites are relatively large and probably stronger in comparison with those of *Nautilus.*

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References

Arkell, W.J. (1957a): Aptychi. *In* Moore, R.C. ed. *Treatise on Invertebrate Paleontology*, p. L99-L100, L437-441, Geol. Soc. Amer. & Univ. Kansas Press.

Bidder, A.M. (1962): Use of the tentacles, swimming and buoyancy control in the pearly *Nautilus*. *Nature*, vol. 196, no. 4853, p. 451-454.

Biguet, F. (1819): *Caractère du rhyncolyte. Considérations sur les Bélemnites, suivites d'un essai de Bélemnitologie Synoptique.*, 63 p., 1 pl. Kindelem.

De Blainville, M.H. (1827): *Mémoire sur les Bélemnites. Supplément.*, 136 p., 5 pls. Levrault.

Clarke, M.R. (1962): The identification of cephalopod "beaks" and the relationship between beak size and total body weight. *Bull. British Mus.* (*Nat. Hist.*), ser. Zool., vol. 8, no. 10, p. 419-480, pls. 13-22.

—— (1980): Cephalopoda in the diet of sperm whales of the southern hemisphere and their bearing on sperm whale biology. *Discovery Rept.*, vol. 37, p. 1-324.

Closs, D. (1967a): Goniatiten mit Radula und Kiefer-Apparat in der Itararé-Formation von Uruguay. *Paläont. Z.*, Bd. 41, Nr. 1-2, S. 19-37, Taf. 1-3.

—— (1967b): Upper Carboniferous anaptychi from Uruguay. *Ameghiniana*, t. 5, no. 4, p. 145-148.

Dean, B. (1901): Notes on living *Nautilus*. *Amer. Naturalist*, vol. 35, no. 418, p. 819-837.

Fischer, A.G. and Fay, R.O. (1953): A spiny aptychus from the Cretaceous of Kansas. *State Geol. Surv. Kansas Bull.*, vol. 102, pt. 2, p. 77-92, pls. 1-2.

Foord, A.H. (1891): *Mandible of Nautiloids.*

Catalogue of the Fossil Cephalopoda in the British Museum (Natural History), vol. 2, 399 p., 86 figs. Longmans & Co.

Fukuda, Y. (1978) : SEM observation on *Nautilus macromphalus* (in Japanese). *Hitachi Scientific Instrument News*, vol. 21, no. 1, p. 2-8.

Gaillardot, C. A. (1824) : Sur des becs de Sèche fossiles. *Ann. Sci. Nat.*, t. 2, p. 485-489, pl. 2.

Gasiorowski, S. M. (1973) : Les rhyncholites. *Geobios*, no. 6, f. 2-3, p. 127-197, pls. A-G.

Haven, N. (1972) : The ecology and behavior of *Nautilus pompilius* in the Philippines. *Veliger*, vol. 15, no. 2, p. 75-81.

Hölder, H. (1958) : Ein neuer Anaptychus, vermutlich von *Psiloceras* (*Caloceras*) *torus* (D'Orb.). *N. Jb. Paläont., Mh.*, 1954, Nr. 6, S. 280-282.

Iverson, I. L.K. and Pinkas, L. (1971) : A pictorial guide to beaks of certain eastern Pacific cephalopods. *Fish Bull.*, 152, p. 83-105.

Kaiser, P. and Lehmann, U. (1971) : Vergleichende Studien zur Evolution des Kiefrapparates rezenter und fossiler Cephalopoden. *Paläont. Z.*, Bd. 45, Nr. 1-2, S. 18-32.

Kanie, Y., Obata, I. and Mikami, S. (1977) : Some observations on *Nautilus macromphalus* Sowerby in breeding aquarium from paleontological points of views (in Japanese). *Jour. Geol. Soc. Japan*, vol. 83, no. 4, p. 247-249.

—— and Tanabe, K. (1979) : Preliminary report on the ecology of *Nautilus pompilius* in the Philippine sea (in Japanese). *Ann. Rept. Yokosuka City Mus.*, no. 25, p. 26-29.

——, ——, Fukuda, Y., Hirano, H. and Obata, I. (1978) : Preliminary study of jaw apparatus in some late Cretaceous ammonites from Japan and Sakhalin (in Japanese). *Jour. Geol. Soc. Japan*, vol. 84, no. 10, p. 629-631, pl. 1.

Kennedy, W. J. and Cobban W. A. (1976) : Aspects of ammonite biology, biogeography, and biostratigraphy. *Spec. Paps. Palaeont.*, no. 17, p. 1-94, pls. 1-11.

Lehmann, U. (1967) : Ammoniten mit Kieferapparat und Radula aus Lias-Geschieben. *Paläont. Z.*, Bd. 41, Nr. 1-2, S. 38-45, Taf. 4.

—— (1970) : Lias-Anaptychen als Kieferelemente (Ammonoidea). *Ibid.*, Bd. 44, Nr. 1-2, S. 25-31, Taf. 2.

—— (1971a) : Jaws, radula, and crop of *Arnioceras* (Ammonoidea). *Palaeontology*, vol. 14, pt. 2, p. 338-341, pl. 61.

—— (1971b) : New aspects in ammonite biology. *Proc. North American Paleont. Conv.*, p. 1251-1269.

—— (1972) : Aptychen als Kieferelemente der Ammoniten. *Paläont. Z.*, Bd. 46, Nr. 1-2, S. 34-48, Taf. 9-10.

—— (1976) : *Ammoniten, ihr Leben und ihre Umwelt.* 171S. Enke.

—— (1978) : Über den Kieferapparat von Ammoniten der Gattung *Parkinsonia. Mitt. Geol. Paläont. Inst., Univ. Hamburg*, H. 48, S. 79-84, Taf. 2.

—— (1979) : The jaws and radula of the Jurassic ammonite *Dactylioceras. Palaeontology*, vol. 22, pt. 1, p. 265-271.

——, Tanabe, K., Kanie, Y. und Fukuda, Y. (1980) : Über den Kieferapparat der Lytoceratacea (Ammonoidea). *Paläont. Z.*, Bd. 54, Nr. 3-4, S. 319-329.

—— and Weitschat, W. (1973) : Zur Anatomie und Ökologie von Ammoniten : Funde von Kropf und Kiemen. *Ibid.*, Bd. 47, Nr. 1-2, S. 69-76.

Meek, F. B. and Hayden, F. V. (1864) : Palaeontology of the Upper Missouri Invertebrates. *Smithon. Contr. Knowledge*, vol. 14, no. 5, p. 118-121.

Mikami, S. and Okutani, T. (1977) : Preliminary observations on maneuvering, feeding, copulating and spawning behaviors of *Nautilus macromphalus* in captivity. *Japan. Jour. Malacol.*, vol. 36, no. 4, p. 29-41.

——, ——, Hirano, H., Kanie, Y. and Hamada, T. (1980) : Behaviors in captivity. *In* Hamada, T., Obata, I. and Okutani, T. eds., *Nautilus macromphalus in Captivity.* p. 11-22. Tokai Univ. Press.

Müller, A. H. (1974) : Über den Kieferapparat fossiler und rezenter Nautilida (Cephalopoda) mit Bemerkungen zur Ökologie, Funktionsweise und Phylogenie. *Freiberger Forschungshefte*, Abt. C, Bd. 298, S. 7-17.

Mundlos, R. (1973) : Ist Conchorhynch ein Ceratiten-Kiefer ? *Paläont. Z.*, Bd. 47, Nr. 3-4, S. 156-162.

Nagao, T. (1931a) : The occurrence of anaptychus-bodies in the Upper Cretaceous of Japan. *Proc. Imp. Acad. Tokyo*, vol. 7, no. 3, p. 106-109.

—— (1931b) : New discoveries of aptychus in two species of ammonites from the Upper Cretaceous of Japan. *Ibid.*, vol. 7, no. 4, p. 165-168.

—— (1931c) : Anaptychus and aptychus lately aquired from the Upper Cretaceous of Hokkaido, Japan. *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 1, no. 2, p. 215-222, pl. 15.

—— (1932) : Discovery of a *Desmoceras* operculum. *Proc. Imp. Acad. Japan*, vol. 8, p. 175-178.

Nixon, M. (1969) : Growth of the beak and radula of *Octopus vulgaris*. *Jour. Zool., London*, vol. 159, p. 363-379, pls. 1-2.

Okutani, T. and Mikami, S. (1977) : Description on beaks of *Nautilus macromphalus* Sowerby. *Japan. Jour. Malacol.*, vol. 36, no. 3, p. 115-121.

D'Orbigny, A. (1825) : Notice sur les becs de cephalopodes fossiles. *Ann. Sci. Nat.*, t. 5, p. 211-221, pl. 6.

Retowski, O. (1891) : Die Aptychen sind echte Ammonitendeckel. *N. Jb. Mineral. Geol. Palaeont.*, Bd. 2, S. 220-221.

Rutte, I. (1962) : Der Kieferapparat triassischer Nautiliden. *Paläont. Z.*, Bd. 36, Nr. 1-2, S. 79-92, Taf. 8.

Saunders, W. B., Spinosa, C., Teichert, C. and Bancs, R. C. (1978) : The jaw apparatus of recent *Nautilus* and its palaeontological implications. *Palaeontology*, vol. 21, pt. 1, p. 129-141.

Schindewolf, O. H. (1958) : Über Aptychen (Ammonoidea). *Palaeontographica*, Abt. A, Bd. 11, S. 1-46, Taf. 1-9.

Schmidt, M. (1928) : Anaptychen von *Lytoceras cornu copiae* Young a. Bird. *N. Jb. Mineral. Geol. Palaeont.*, Abt. B, Bd. 61, S. 399-432, Taf. 15.

Schmidt-Effing, R. (1972) : Ein Ceratit mit Kiefer-Apparat aus dem Muschelkalk des Saarlandes. *Paläont. Z.*, Bd. 46, Nr. 1-2,

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Explanation of Plate 39

Figs. 1-6. Jaw apparatuses of *Gaudryceras* species.

1a, b. Upper jaw probably attributed to *Gaudryceras* sp. a: ventral, b: lateral views. ×1. MN6. Loc. the upper part of the Yubarigoenosawa, the Ikushumbetsu River, Ikushumbetsu area, central Hokkaido. Upper Yezo Group (Coniacian ?). M. Nihongi coll. (Kanie *et al.*, 1978) 2. Lateral view of the upper jaw attributed to *Gaudryceras* sp. ×1. UH3193. Loc. the Kikumezawa, the Ikushmbetsu River, Ikushumbetsu area. Upper Yezo Group (Santonian ?). R. Saito coll. 3. Mode of occurrence of the upper jaw in *Gaudryceras denseplicatum* (Jimbo). ×1. GK. H8087. Loc. R4041p2, the upper part of Obirashibe River, Obira area, nortwestern Hokkaido. Upper Yezo Group (Lower Santonian). H. Hirano and K. Tanabe coll. 4. Upper view of the deformed lower jaw attributed to *Gaudryceras* sp. ×2. GK. H8059. Loc. the upper part of the Kamikinenbetsu River, Obira area. Middle Yezo Group (Upper Turonian). T. Matsumoto coll. 5a-c. Upper jaw of *Gaudryceras tenuiliratum* Yabe. a: mode of occurrence, b: lateral, c: anterior views. a(×1), b, c(×2). UH3191. Loc. the Ikushumbetsu River, 200 m east from the junction with the Kikumezawa, Ikushumbetsu area. Upper Yezo Group (Santonian). R. Saito coll. (Nagao, 1931a, c; Tanabe *et al.*, 1980). 6a, b. Lower jaw probably attributed to *Gaudryceras denseplicatum* (Jimbo). a: dorsal, b: lateral views, co: conchorhynch. ×1 YCM. Ur307002. Loc. U307p, Ikandai Valley, Urakawa area, southern-central Hokkaido. Upper Yezo Group (Lower Campanian). Y. Kanie coll. (Kanie *et al.*, 1978; Lehmann *et al.*, 1980)

Photos, without whitening, by Kanie (1-3, 5, 6) and K. Tanabe (4).

1 a

1 b

2

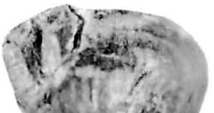
3

4

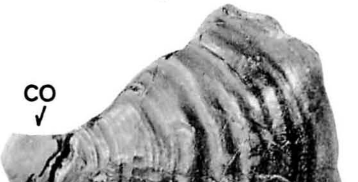
6 a

5 a

5 b



5 c



6 b

S. 49-55, Taf. 11.

Shimanskii, V.N. (1962): Subclass Ectocochlia (in Russian; English ed., 1974). *In* Orlov, Yu. A. Chief ed. *Fundamentals of Palaeontology*, vol. 5, p. 18-32. Izdatel 'Academii Nauk.

Tanabe, K., Fukuda, Y., Kanie, Y. and Lehmann, U. (1980): Rhyncholites and conchorhynchs as calcified jaw elements in some Cretaceous ammonites. *Lethaia*, vol. 13, no. 2, p. 155-166.

——, Hirano, H. and Kanie, Y. (1980): The jaw apparatus of *Scalarites mihoensis*, a late Cretaceous ammonite. *Prof. S. Kanno Mem. Vol.*, p. 141-147, pl. 20.

Teichert, C., Moore, R.C. and Zeller, D.E.N. (1964): Rhyncholites. *In* Moore, R.C. ed. *Treatise on Invertebrate Paleontology*, p. K567-584. Geol. Soc. Amer. & Univ. Kansas Press.

Trauth, F. (1927-1936): Aptychenstudien. I. *Ann. Naturhist. Mus. Wien*, Bd. 41, S. 171-259 (1927); II. Bd. 42, S. 121-193, Taf. 3-5 (1928); III-V. Bd. 44, S. 329-411, Taf. 3-5 (1930); VI-VII. Bd. 45, S. 17-136, Taf. 1 (1932); VIII. Bd. 47, S. 127-145, Taf. 3 (1936).

—— (1935): Anaptychi und anaptychusähnliche Aptychi der Kreide. *N. Jb. Mineral. Geol. Palaeont.*, Abt. B, Bd. 74, S. 448-468, Taf. 14.

Ward, P., Stone, R., Westermann, G. and Martin, A. (1977): Notes on animal weight, cameral fluids, swimming speed, color polymorphism of the cephalopod *Nautilus pompilius* in the Fiji Islands. *Paleobiology*, vol. 3, no. 4, p. 377-388.

Zakharov, Yu. D. (1979): New finds of rhyncholites, anaptychi, aptychi, and remains of cephalopod radula at USSR territory (in Russian). In Gramm, M.N. ed. *Fossil Invertebrates of Far East*, p. 80-91, 99-100, pls. 19-20. Vladiostok.

Ashibetsu 芦別, Furenai 振内, Hakkinzawa 白金沢, Ikandai 井寒台, Ikushumbetsu 幾春別, Juhachirinpan-Ichinosawa 18林班一の沢, Kamikinenbetsu 上紀念別, Kaneobetsu 金尾別, Kikumezawa 菊面沢, Naibuchi 内淵, Nakakinenbetsu 中紀念別, Obira 小平, Obirashibe 小平蘂, Oyubari 大夕張, Santan 三丹, Shiyubari 主夕張, Souashibetsu 双芦別, Takishita 滝下, Tombetsu 頓別, Urakawa 浦河, Yubarigoenosawa 夕張越の沢

現生頭足類顎器との比較研究によるテトラゴニテス科アンモナイトの顎器：北海道・樺太の白亜紀チューロニアン〜マーストリヒシアン階産の石灰質ノジュール中に保存された *Tetragonites glabrus*, *Gaudryceras denseplicatum*, *G. tenuiliratum*, *G.* sp. の顎器の形態と鉱物組成を記載した。これらの顎器は，外ラメラ・わい小化した内ラメラと石灰質の嘴状部より構成されている。前者はカーボネイトアパタイト，後者はカルサイトよりなり，現生頭足類の顎器と比較検討することによって，それぞれキチンとアラゴナイトより置換されたと考えられる。石灰質嘴状部は，内部構造・鉱物，化学組成から，現生オウムガイ類のリンコライト（上顎）・コンコリンク（下顎）に酷似する。これらの資料に基づいて，テトラゴニテス科アンモナイトの顎器と口球の一部を復元した。これらのアンモナイトの顎器は，オウムガイ類よりがん丈で，住房部の大きさに対する顎器の大きさの比はより大きい。この事実は，テトラゴニテス科アンモナイトがオウムガイ類と類似の食生活をしていたことを示唆する。

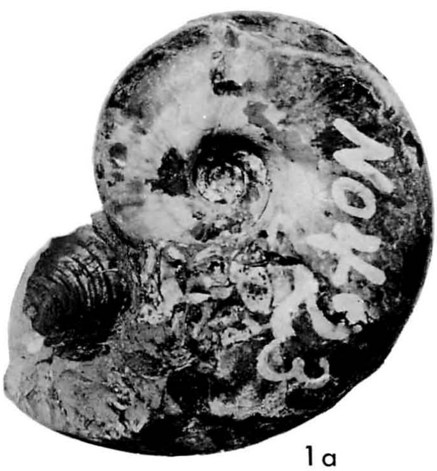
蟹江康光

Explanation of Plate 40

Figs. 1-5. Jaw apparatuses of *Tetragonites glabrus* (Jimbo).

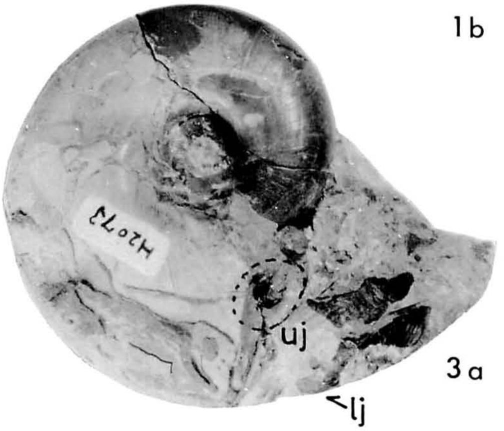
1a, b. Mode of occurrence (a) and lateral views (b) of upper jaw. a(×1), b(×2). GK423. Loc. Sakhalin. Horizon unknown (Upper Cretaceous). collector unknown. 2. Lateral view of upper jaw; white calcareous covering is observable. ×1.5. Loc. the lower part of the Kaneobetsu, Oyubari area, central Hokkaido. Middle Yezo Group (Turonian). Y. Kawashita coll. (Tanabe *et al.*, 1980). 3a, b. Mode of occurrence of lower and upper jaws (a), dorsal view of lower jaw (b). lj: lower jaw, uj: rostral part of upper jaw. a(×3/4), b(×2). GK.H2073. Loc. N143a, the lower part of the Santan, Naibuchi area, south Sakhalin. Upper part of the Miho Group (Lower Santonian). T. Matsumoto coll. (Kanie *et al.*, 1978; Tanabe *et al.*, 1980; Lehmann *et al.*, 1980). 4a, b. Lateral (a) and deformed dorsal (b) views of the lower jaw. ×2. GK.H8049. Loc. R2251b, the middle part of the Nakakinenbetsu River, Obira area, northwestern Hokkaido. Saku Formation (Upper Turonian). H. Hirano and K. Tanabe coll. 5a-c. Mode of occurrence (a), lateral (b) and dorsal (c) views of the lower jaw. a(×1), b, c(×2). GK. H8043. Loc. N382, the Juhachirinpan-Ichinosawa, the Naibuchi River, Naibuchi area. Upper part of the Miho Group (Santonian). T. Matsumoto coll. (Tanabe *et al.*, 1980).

Photos, without whitening, by K. Tanabe (1b, 3-5), I. Obata (1a) and Kanie (2).



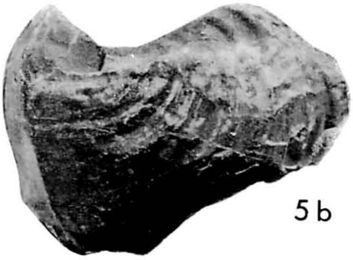
1a

1b



3a

2



5b

3b

4a

5a

4b

5c

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 125, pp. 259-276, pls. 41-43, April 15, 1982

741. EARLY JURASSIC PLANTS IN JAPAN. PART 4*

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Tokyo Gakugei University, Koganei, Tokyo 184

Abstract. This is the fourth of our serial papers on the early Jurassic plants in Japan. In this paper we describe *Ctenozamites sarrani* belonging to Pteridospermales, and *Anomozamites* sp. A, *Otozamites fujimotoi*, *O. neiridaniensis* sp. nov., *Pterophyllum* ex gr. *propinquum*, *P.* sp. A, *Ptilophyllum* cfr. *cutchense*, *P. nipponicum* sp. nov., *P. shinadaniense* sp. nov., *P.* sp. A. and *P.* sp. B, all belonging to Bennettitales.

The occurrence of *Ctenozamites* and *Ptilophyllum* is the first record not only in the early Jurassic flora but also in the older Mesozoic floras in Japan.

Introduction and acknowledgements

In continuation of our previous papers (Kimura and Tsujii, 1980a, b, '81), we here describe the fossil plants belonging to the Pteridospermales and Bennettitales from the Lower Jurassic Kuruma Group and Iwamuro Formation. The details of stratigraphy of plant-beaing formations and localities were given in our first paper (Kimura and Tsujii, 1980a).

We express our sincere gratitude to Professor Emeritus Thomas M. Harris, F. R. S. of the University of Reading for his helpful suggestions and [critical reading over the present manuscript. We also give our thanks to Mr. Gumpei Mori, Mr. Noriyuki Sasaki and Mr. Akihiro Kobayashi for their kind help in collecting the fossils here described.

Systematic description

Pteridospermales

Genus *Ctenozamites* Nathorst 1886: 122

Ctenozamites sarrani (Zeiller) Harris

Pl. 41, Fig. 1; Text-fig. 1

Ctenopteris sarrani Zeiller: Zeiller, 1903, p. 53, pls. 6-7, fig. 1, la; pl. 8, figs. 1-2 (Hongay Coal-Field, North Viet-Nam); p. 292, pl. 44, figs. 3-4 (Tai-pin-tchang, North Yunnan; corresponding possibly to the Yipinglang Group): Sze, 1956, pp. 39, 146, pl. 35, figs. 3, 3a, 4 (Upper Triassic Yanchang Group, N-China).

Ctenozamites sarrani (Zeiller) Harris: Harris, 1961, p. 170 (name): Sze et al., 1963, p. 198, pl. 58, fig. 1 (reinserted from Sze, 1956, pl. 35, fig. 3a); pl. 59, figs. 2, 3 (from Sze, 1956, pl. 35, figs. 3, 4): Li P.C., 1976, p. 126, pl. 40, figs. 5, 6 (Upper Triassic Yipinglang Group).

Material: NNW-146, 846 (counterpart) (Nishi-Neiridani).

Description: Pl. 41, Fig. 1 shows two pinna fragments. Leaf-outline and forking of main rachis are unknown. The pinnae are more than 14 cm long and 5.2 cm wide, nearly parallel-sided and with a thick

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* Received June 13, 1981; Read Jan. 23, 1981 at Sendai.

pinna rachis, 4 mm wide with longitudinal ribs on its surface. Segments (or pinnules) are typically rhomboidal, 2.9 cm long and 1.7 cm wide, and arising on the upper side of pinna rachis at a wide angle. The apex of segments is obtuse or rounded, its margins are entire and are flat but apical margins are sometimes reflexed. The bases of segments are not contracted. Veins are 10-11 in number at base, then forking once or twice, but the marginal ones are mostly simple. They are nearly parallel and end in the outer margin. Text-fig. 1 shows the form of typical pinnules and venation. The cuticle is not preserved.

Distribution and occurrence: In the Kuruma Group, a single specimen was obtained from the Negoya Formation. This species has been known from the Upper Triassic of North Viet-Nam and of North and Middle China.

Remarks: Our leaf corresponds in size and outline of segments (pinnules) to *Ctenozamites sarrani*. But it is somewhat different from Zeiller's original specimens of *Ctenopteris sarrani*. Differnces are: In the original specimens, the veins are more crowded and generally forking once, and the segments arise at reduced angle and are usually directed forwards, instead of arising at wide angle in ours.

Our leaf resembles a well-known European species, *Ctenozamites cycadea* (Berger) Schenk (references, see Harris, 1961, p. 169; 1964, p. 95). But our leaf differs from *Ctenozamites cycadea* in its large-sized segments with denser veins forking twice, instead of medium-sized segments (2 cm long and 1 cm wide, according to Harris, 1961, '64) with coarser veins (usually 6) forking once-twice in *C. cycadea*.

Ctenozamites cycadea finely illustrated by Delle (1967) from the Middle Jurassic of Tkvarchelian Coal-Basin (Transcaucasia) and *Ctenopteris cycadea* (Brongniart) by Yang (1978) from the Upper Triassic Daqiaode Formation, Sichuan, are also similar in form of segments to ours, but they are distinguished from ours by their medium-sized segments with coarser veins forking once or twice. *Ctenopteris megaphylla* described by Yang (1978) from the Upper Triassic Daqiaode Formation resembles *Ctenozamites sarrani* in form but smaller.

Ctenozamites usnadzei originally described by Doludenko and Svanidze (1969) from the Callovian of Georgia and later by Barnard and Miller (1976) from the Middle Jurassic of Iran, is distinguished from ours by its rhomboidal segments typically with a free acroscopic margin and decurrent basiscopic margin, and further by its small-sized segments with 1-3 small teeth at apex.

Recently 6 new *Ctenozamites* species were described from the Upper Triassic of China by Hsü et al. (1975) and Chen and Duan (1979a, b). Among them *Ctenozamites otoeis* described by Chen and Duan (1979a) from the Upper Triassic of Yanbian, has segments of similar size to our specimen of *C. sarrani*, but they are longer and have a decurrent base. The veins are more crowded.

This is the first record of the genus *Ctenozamites* in Japan.

Bennettitales

Genus *Anomozamites* Schimper, 1870: 140

Anomozamites sp. A

Anomozamites sp.: Kimura, 1959a, p. 22, pl. 8, fig. 3 (Iwamuro).

Material: A-0558 (a single specimen).

Remarks: Our leaf-fragment resembles *Anomozamites major* (Brongniart) Nathorst, and also *Pterophyllum pinnatifidum* Harris. Further material is needed for specific determination.

Genus *Otozamites* Braun, 1842

Otozamites fujimotoi Kimura

Text-figs. 2a-b

Otozamites fujimotoi Kimura: Kimura, 1959a, p. 23, pl. 12, figs. 2-4, 6; text-figs. 12-13 (Iwamuro).

Material: Lectotype; A-4090 (Iwamuro). Paralectotypes; A-2037, 2054, 2081. Other specimens; A-0432, 0489, 0491, 2053, 2064-2066, 2068, 2088, 2091, 4091, 4094. *Stratum typicum*: Iwamuro Formation. *Locus typicus*: Iwamuro, Shirasawa-mura, Tone-gun, Gumma Prefecture. *Derivatio nominis*: After Professor Emeritus H. Fujimoto of the Tokyo University of Education.

Emended diagnosis: (Length and apex of leaf unknown.) In middle region rachis 2 mm wide, lamina 6 cm wide but narrower in basal part of leaf. Pinnae varied in form according to their position on a leaf, attached perpendicularly to the upper side of rachis by the lower half of base, thus the upper half free, forming a distinct angle entirely covering the rachis and the lower part of opposite pinna base. Pinnae mostly elongated but the proximal ones broadly deltoid or circular in form. Elongated pinnae 3 cm long or more, nearly parallel-sided, typically 1 cm wide. Deltoid or circular pinnae 8-20 mm long or more and 10-14 mm wide, with pointed apex. Circular pinnae with rounded apex restricted to basal part of a leaf. Veins on the lower half of pinna mostly simple or once forked and parallel, but those on free angle radiating, simple or once forked. Concentration of veins about 20 per cm. (Cuticle not preserved.)

Distribution and occurrence: *Otozamites fujimotoi* is occasional in the Iwamuro Formation, and seems to be local.

Comparison and remarks: Since Kimura (1959a) described this species, only a few additional specimens were obtained. *Otozamites fujimotoi* is characterized by its varied pinnae in form, with distinct acroscopic basal angle.

Otozamites gissaricus illustrated by Iminov (1976) from the Middle Jurassic of Central Asia, is similar in form to ours, but *O. gissaricus* is a smaller leaf with narrower pinnae, especially on the proximal part of a leaf.

Specimens determined by Iminov (1976) from the Upper Triassic of Central Asia as *Otozamites pamiricus* Prynada are distinguished from *O. fujimotoi* by its pinnae with rounded or truncated apex. *Otozamites ptilophylloides* originally described by Barnard and Miller (1976) from the Middle Jurassic of Iran is similar in pinna form to *O. fujimotoi*, but it is macroscopically distinguished from ours by its pinnae mostly with rounded apex and smaller number of veins in each pinna.

Although we still do not know the form of the whole leaf of *Otozamites fujimotoi*, we feel sure it is distinct for its varied and characteristic pinna forms with distinct acroscopic angle.

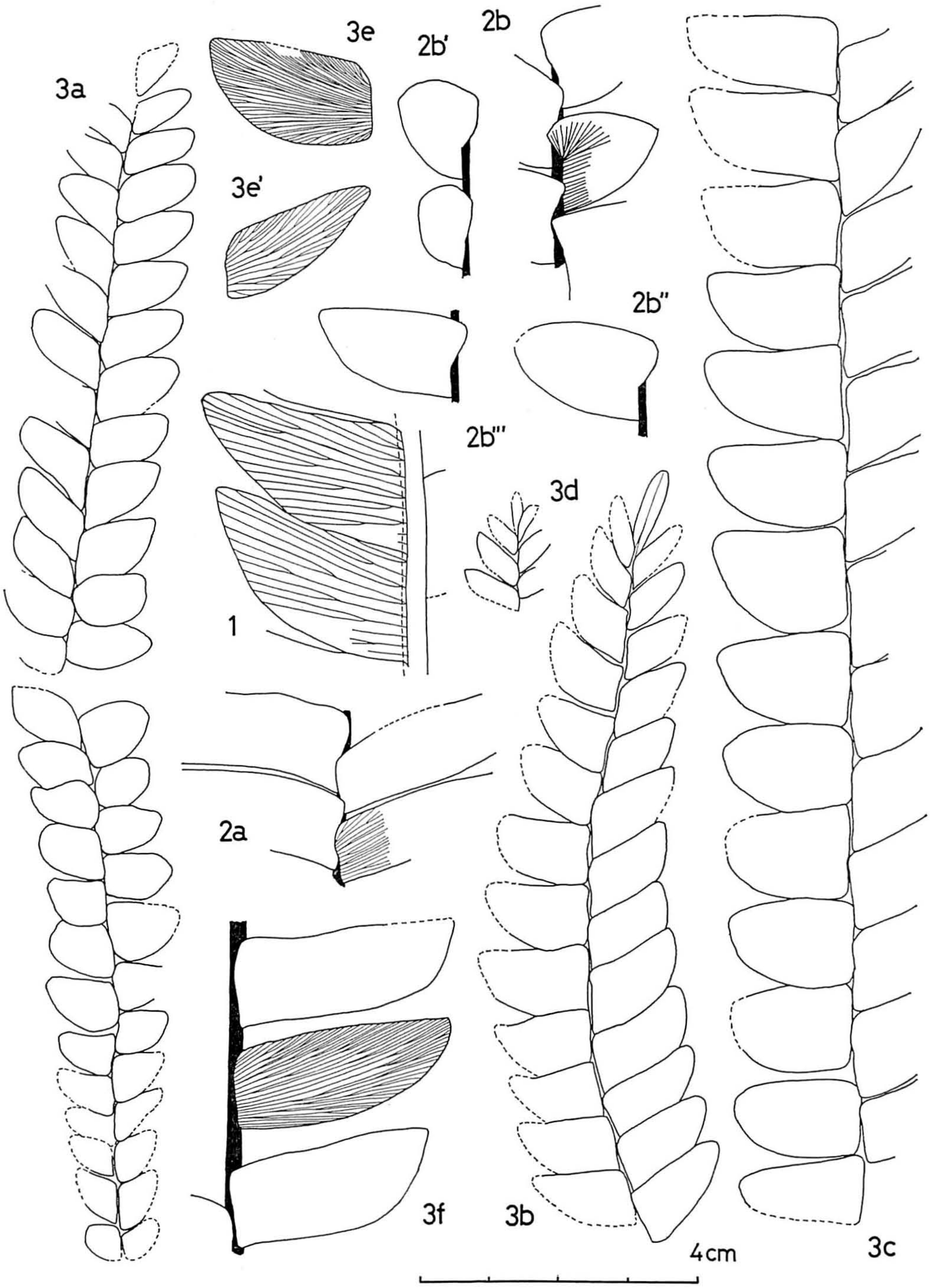
Otozamites neiridaniensis Kimura and Tsujii sp. nov.

Pl. 42, Figs. 1-5; Pl. 43, Figs. 1-2;
Text-figs. 3a-f

Otozamites molinianus Zigno: Oishi, 1940, p. 333, pl. 31, figs. 3, 3a, 4 (Neiridani).

Otozamites sp.: Oishi, 1940, p. 336, pl. 30, fig. 5 (Neiridani).

Material: Holotype; NEE-095 (Higashi-Neiridani). Paratypes; NEE-065, 174, TOB-013A, B, 050B, 050B', 050C (Tobiiwadani), NNW-084 (Nishi-Neiridani), NEG-251 (Negoya). Other specimens; NE-026 and other 9 specimens (Neiridani), NEE-007 and other 64, NNW-002 and other 57, NEG-006 and other 49, DAI-004 and other 38 (Dairagawa), TOB-


3a
3e
2b'
2b
3e'
2b''
2b'''
3d
1
2a
3f
3b
4cm
3c

004 and other 21.

Stratum typicum: Negoya Formation, Kuruma Group. *Locus typicus*: Higashi-Neiridani, Asahi-machi, Shimo-Niikawa-gun, Toyama Prefecture (see Kimura and Tsujii, 1980a, p. 342, fig. 2). *Derivatio nominis*: After the Neiridani where the holotype and many other specimens were collected.

Diagnosis: Leaf rather large, long and narrow, linear; length estimated at 30 cm or more, width over the middle leaf typically about 2-2.5 cm, occasionally 3.7 cm. Leaf tapering gradually to both ends. Rachis rather thin, 1 mm wide, usually concealed. Pinnae oval or short-rectangular in form, typically 1.2 cm long and 0.8 cm wide, with rounded or obtusely pointed apex, attached on the upper side of rachis by the lower two-thirds or three-fourths of their width (accordingly upper one-third or one-fourth of acroscopic basal part free), at an angle of 60-90 degrees. Acroscopic basal corner slightly auriculated but seldom covering the pinna on the opposite side of the rachis. Basiscopic basal angle slightly contracted or occasionally straight but not decurrent. Near the leaf base, pinnae becoming shorter and more deltoid but still broad, and near the leaf apex, pinnae becoming narrower. Veins arising from proximal two-thirds or three-fourths of pinna base and radiating into the acroscopic corner and the rest of pinna, branching at all levels, at a concentration of 15 per cm at base. (Petiole not known and cuticle not preserved.)

Distribution and occurrence: *Otozamites neiridaniensis* is abundant in the Negoya Formation and rather rare in the Shinadani Formation. A doubtful leaf-fragment is known from Neiridani.

Comparison and discussion: *Otozamites neiridaniensis* is characterized by its oval or short-rectangular pinnae with a rounded or obtusely pointed apex. Its auricle is developed slightly if at all and its veins are crowded.

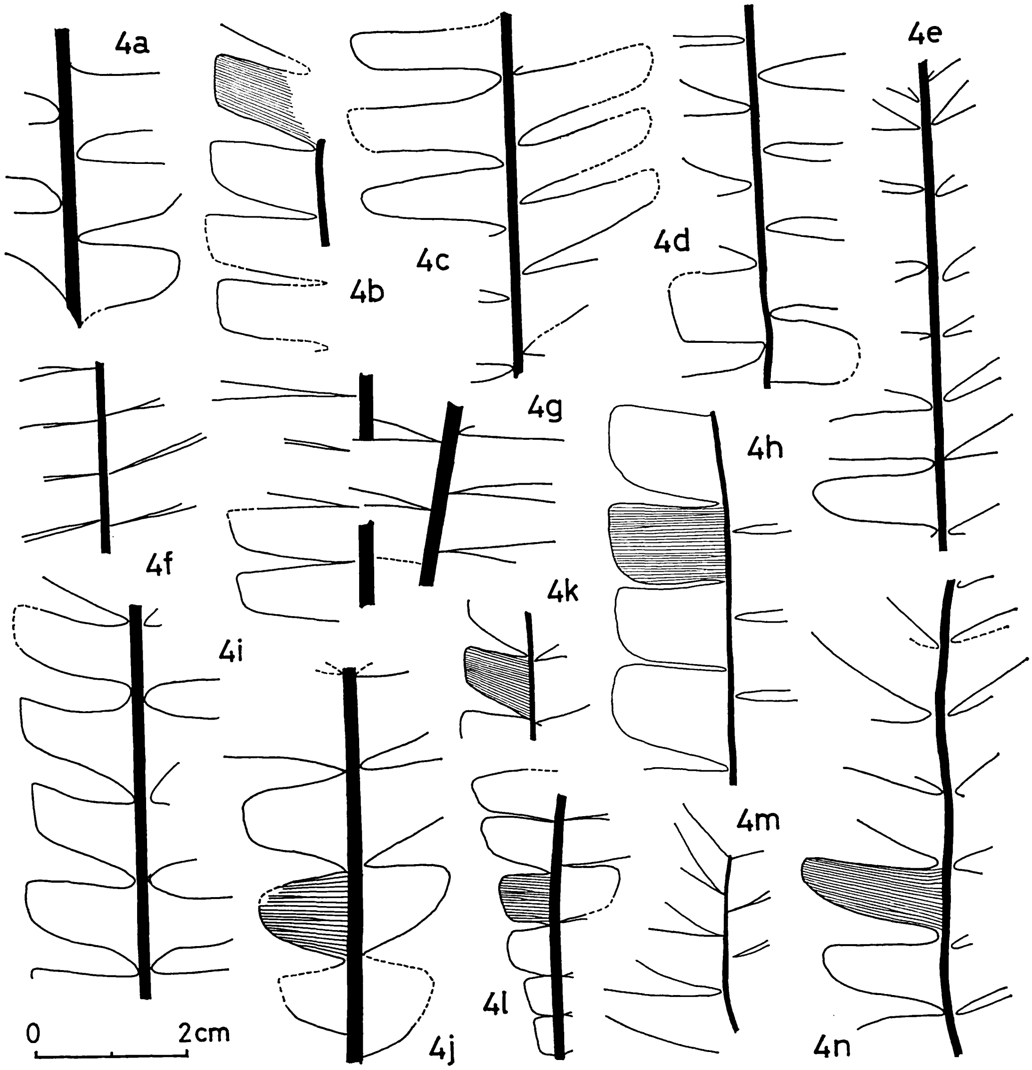
Oishi (1940) described several leaf-fragments from Neiridani (exact locality not clear) as *Otozamites molinianus*. But our observation of his figures shows that they do not belong to Zigno's species but to *Otozamites neiridaniensis*, because in his pinnae auricles are scarcely developed. In *Otozamites molinianus*, auricles are distinctly developed (Zigno, 1883; Möller, 1903). Oishi (1940) also described a single leaf-fragment as *Otozamites* sp. from Neiridani. This specimen agrees possibly with the basal pinnae of *Otozamites neiridaniensis*.

Among 160 *Otozamites* species hitherto known from the Mesozoic plant-beds, the following species resemble ours in rectangular or triangular pinnae with rounded or obtusely pointed apex, and with not or only slightly expanded auricle:

Text-figs. 1-3. (All natural size)

1. *Ctenozamites sarrani* (Zeiller) Harris; Outline of pinnules and venation (NNW-146; counterpart of NNW-846 shown in Pl. 41, Fig. 1).
2. *Otozamites fujimotoi* Kimura. 2a: A leaf-fragment with elongated and auriculated pinnae (A-4091; counterpart of A-4090 shown in Kimura, 1959a, text-fig. 12e). 2b-b‴: Deltoid and auriculate pinnae at the basal part of a leaf (A-2054; redrawn from Kimura, 1959a, text-fig. 12b, a, d, c respectively).
3. *Otozamites neiridaniensis* Kimura and Tsujii sp. nov. 3a: A medium sized leaf (NEE-095, holotype; Pl. 42, Fig. 1). 3b: Ditto, with apex (TOB-050B, paratype). 3c: A large-sized leaf (TOB-050B′, paratype; Pl. 42, Fig. 2). 3d: Apical part of a broken leaf (TOB-013B, paratype). 3e-e′: Pinnae, showing the venation (NEE-255). 3f: A large-sized pinnae, showing the venation (NNW-084, paratype; Pl. 43, Fig. 1).

Otozamites falsus Harris: Harris, 1949, '69; Middle Jurassic of Yorkshire. *O. indosinensis* Zeiller: Zeiller, 1903; Upper Triassic of North Viet-Nam. *O. kondoi* Oishi: Oishi, 1940; Upper part of Middle Jurassic Moné Formation, NE-Japan. *O. parallelus* Phillips: Harris, 1969; Middle Jurassic of Yorkshire. *O. reglei* (Brongniart) Saporta: Brongniart, 1828; Bartholin, 1894; Möller, 1903 (cfr. *reglei*); Lower Jurassic of Bornholm. *O. simpsoni* Harris: Harris, 1949 (regarded as *O. feistmanteli* Zigno), '69; Middle Jurassic of Yorkshire.



Text-fig. 4. *Pterophyllum* ex gr. *propinquum* Goeppert; varied leaf-forms and venation. 4a: (NNW-459). 4b: (NNW-666). 4c: (NNW-670). 4d: (NNW-850). 4e: (NNW-531). 4f: (NNW-743). 4g: (NNW-810). 4h: (NNW-539). 4i: (NNW-743). 4j: (NNW-356; Pl. 43, fig. 5). 4k: (NNW-657). 4l: (NNW-326). 4m: (NNW-314). 4n: (NNW-009). (All natural size)

These differ as follows: *Otozamites falsus* has mostly rhomboid pinnae with an acute apex. *O. indosinensis, O. parallelus* and *O. simpsoni* have more elongate pinnae. *Ptilophyllum khargaense* (Kilpper, 1966) from the Middle Jurassic (?) of Egypt has pinnae of rather similar shape but the lower ones differ in being imbricate. The closest to our species is *Otozamites kondoi* but its pinnae have a nearly symmetrical base and its veins which are coarser, only fork near their origin.

Genus *Pterophyllum* Brongniart, 1828: 25

Pterophyllum jaegeri Brongniart described by Oishi (1931) from Tsuchizawa is not *Pterophyllum* but referable to *Nilssonia* sp. A to be described later.

Pterophyllum ex gr. *propinquum* Goeppert

Pl. 41, fig. 2; Pl. 42, figs. 6-7; Pl. 43, figs. 3-6; Text-figs. 4a-n

Specimens from East Asia:

Pterophyllum propinquum Goeppert: Oishi, 1931, p. 245, pl. 18, figs. 1-2 (Tsuchizawa, Kuruma Group): Yabe and Oishi, 1933, p. 227, pl. 34, fig. 2 (Lower-Middle Jurassic of Liaoning, NE-China): Oishi, 1940, p. 344 (remarks): Kimura, 1959b, p. 70, pl. 2, fig. 2 (Kotaki Coal-Field, Kuruma Group): Sze et al., 1963, p. 157, pl. 61, fig. 8 (reinserted from Yabe and Oishi, 1933, pl. 34, fig. 2).

Pterophyllum aff. *propinquum* Goeppert: Yabe and Oishi, 1929, p. 91, pl. 18, fig. 6 (Daedong Group, N-Korea).

For Europeaw references, see Antevs, 1919, p. 28.

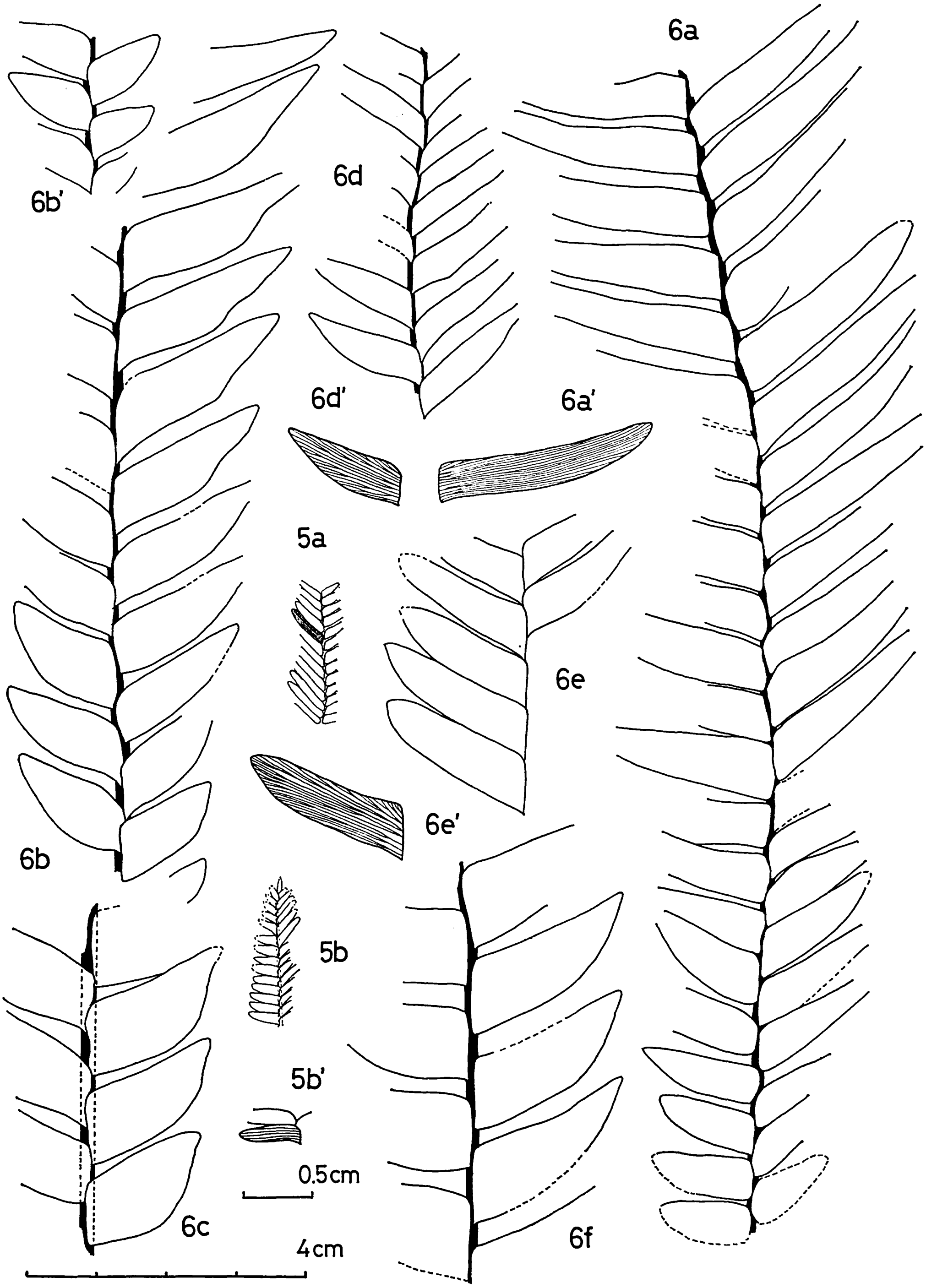
Material: NNW-009 and other 32 specimens (Nishi-Neiridani), DAI-027 (Dairagawa), SHI-035, 040 (Shinadani), Kr-087, 090 (Tsuchizawa), 4962113 (Kotaki Coal-Field), A-7535, 751124 (Iwamuro).

Description: Leaves are varied in size and form, but are mostly medium-sized and oblanceolate in outline. Leaves taper gradually towards the proximal end, are more than 6.5 cm long and 4 cm wide at the widest portion, and possibly contract suddenly at the apex. The rachis is rather thin, 2 mm wide. The petiole is not known. The pinnae arise at a wide angle from the lateral margins of rachis. They are rectangular, up to 2 cm long and are shorter towards the base of the leaf. The width of pinnae is variable but often about 1.2 cm; pinnae near the leaf apex are narrow. Margins of adjacent pinnae are mostly apart but are always connected to one another near the rachis by a web of lamina. The apex of pinnae is truncate in lower part of leaf, but rounded in the middle of leaf. Veins are parallel and simple or often fork once. Their concentration is typically 25 per cm at the middle of pinna. The cuticle is not preserved. Text-figs. 4a-n show varied pinna forms and venation.

Distribution and occurrence: This species is locally very abundant in the Negoya Formation, but rather rare in the Shinadani and Iwamuro Formations. In East Asia, this species occurs in the Lower-Middle Jurassic of NE-China and the Upper Triassic (?) of N-Korea.

Remarks: *Pterophyllum* ex gr. *propinquum* is characterized by its rectangular pinnae with an expanded base and truncated or rounded apex. Our leaves are indistinguishable from *Pterophyllum propinquum* illustrated in detail by Antevs (1919) from the Liassic Hör Sandstone, Sweden, although in our large collection, leaves with elongated pinnae such as Antevs' pl. 3, figs. 10-12 have not been found.

The leaves regarded by Oishi (1931) as *Pterophyllum propinquum* from Tsuchizawa and by Yabe and Oishi (1929) as *P.* aff. *propinquum* from N-Korea are


6b'
6d
6a
6d'
6a'
5a
6e
6b
6e'
5b
5b'
0.5cm
6c
4cm
6f

indistinguishable from ours, although the Korean leaf is about twice as large as ours. A leaf-fragment regarded by Yabe and Oishi (1933) as *Pterophyllum propinguum* possibly from the Beipiao Group (Lower-Middle Jurassic), NE-China is similar in pinna form to ours.

Pterophyllum leaves with similar pinna form to ours have been described as follows:

Pterophyllum pinnatifidum Harris: Harris, 1932; Rhaetic of East Greenland. *P. kochi* Harris: Harris, 1926, '32; Ditto: Lundblad, 1950; Rhaeto-Liassic of Sweden. *P. abnorme* Etheridge: Walkom, 1917: Jones and Jersey, 1947; Upper Triassic of Queensland. *P. sensinovianum* Heer: Heer, 1876; Jurasso-Cretaceous of the upper Amur: Vakhrameev and Doludenko, 1961; Upper Jurassic of Bureja Basin.

They are distinguished from ours as mentioned below. In *Pterophyllum pinnatifidum*, pinna apices are often acuminate. In *Pterophyllum kochi*, pinna bases are not contiguous except in the apical part of leaf and are square in the middle of leaf, and slightly contracted in the proximal part of leaf. In ours, pinna bases are usually contiguous from one pinna to the next.

A little known *Pterophyllum abnorme* is distinguished from ours by its usually twice forked veins instead of simple or once forked ones in ours. In *Pterophyllum sensinovianum*, its pinnae are more elongated than those of ours.

Pterophyllum propinquum illustrated by Iminov (1976) from the Upper Triassic of Pamir is, in our opinion, rather close to *P. tsetzei* Schenk or to *P. subaequale* Hartz because of its large-sized leaves with more elongated pinnae.

Pterophyllum sp. A illustrated by Weber (1968) from the Rhaeto-Liassic of Bayreuth resembles *P. propinquum*. *Pterophyllum exhibens* originally described by Li, P. C. (1964) from the Upper Triassic Xujiahe Formation, Sichuan and later by Zhou, T. S. (1978) from the Upper Triassic Wenbinshan Formation, Fujian, China, is similar in its expanded pinna base, but it is distinguished by its more elongated pinnae with smaller number of veins (5-12) in each pinna.

Pterophyllum sp. A

Pterophyllum sp. A and sp. B: Kimura, 1959a, p. 24, pl. 9, figs. 2-3 (Iwamuro).

Remarks: Kimura (1959a) illustrated two *Pterophyllum* leaf-fragments as *P.* sp. A and sp. B. Our study convinced us that they are conspecific but the specimens are too poorly preserved to determine. Their cuticle is not preserved.

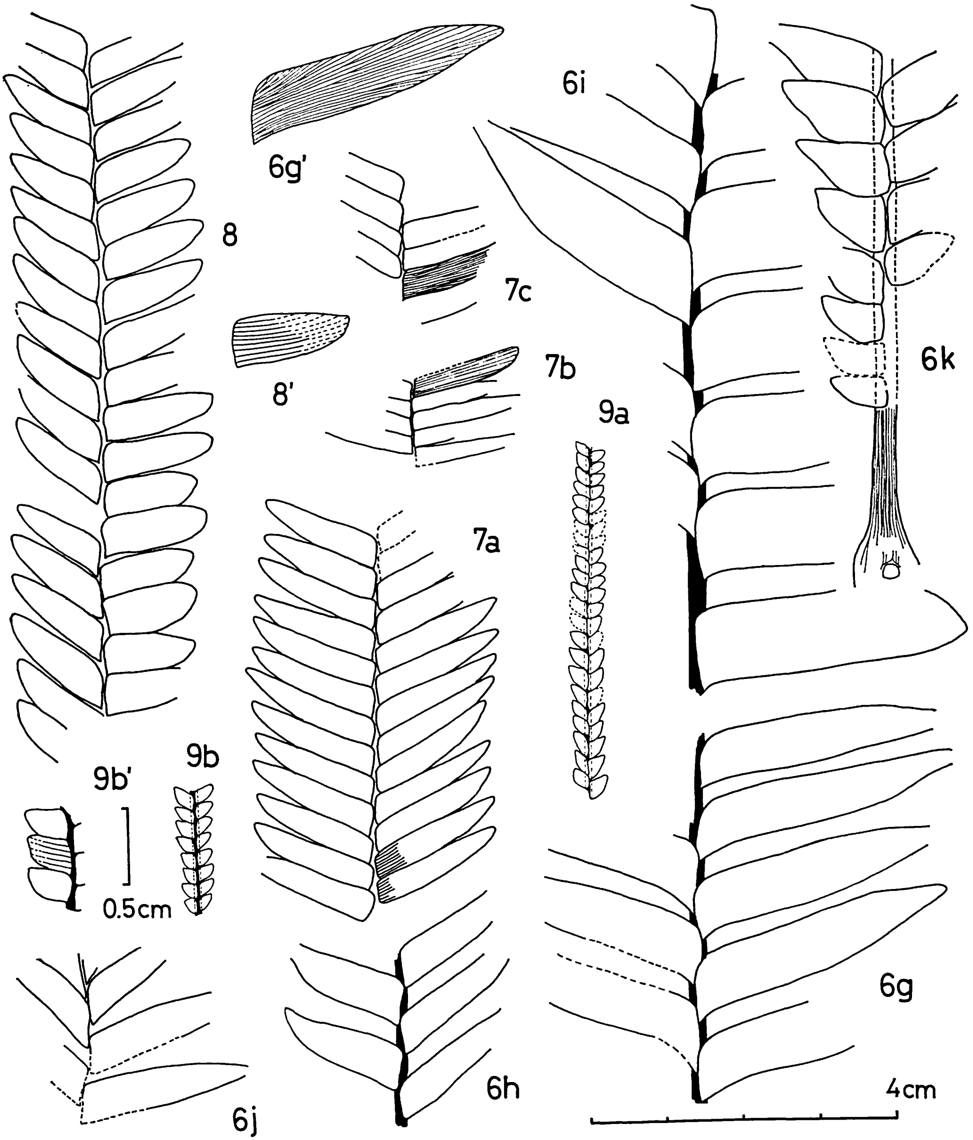
Text-figs. 5-6 (a-f). (All natural size, unless otherwise indicated)

5. *Ptilophyllum* cfr. *cutchense* Morris. 5a: A leaf-fragment, showing the venation (TE-001; Pl. 43, Fig. 7). 5b: Ditto, with apex (TE-003; Pl. 43, Fig. 8). 5b′: Venation drawn from 5b.
6. *Ptilophyllum nipponicum* Kimura and Tsujii sp. nov. 6a: A typical leaf (NEG-720, holotype; Pl. 43, Fig. 9). 6a′: Venation drawn from 6a. 6b: Lower part of a leaf (NNW-806, Pl. 41, Fig. 3). 6b′: Possibly representing the basal part of 6b. 6c: Basal part of a leaf, bearing broader pinnae with truncated distal margin (NE-067, paratype). 6d: Apical part of a medium-sized leaf bearing rather remotely set pinnae (NNW-353, paratype; Pl. 41, Fig. 4). 6d′: Venation drawn from 6d. 6e: A leaf-fragment bearing rectangular pinnae (NEE-074; Pl. 42, Fig. 8). 6e′: Venation drawn from 6e. 6f: A leaf-fragment bearing broader and remotely set pinnae (NNW-745).

Genus *Ptilophyllum* Morris, 1840: 327

About 60 Mesozoic species have been described. Many of them have similar pinnae. Thus except the leaves with distinct morphological features, it is getting difficult to identify them depending only on their macroscopical forms. Our knowledge of the epidermis of this genus owes much to the studies of Jacob and Jacob (1954), Kilpper (1965, '66), Harris (1941, '42, '46, '49, '53, '69), Doludenko (1963), Bose and Kasat (1972) and Barnard and Miller (1976).

We recognized five forms in the Lower Jurassic of Japan. This is the first record



of this genus in the older Mesozoic floras in Japan. The phytogeographical implication on the occurrence of this genus in the Japanese Lower Jurassic will be mentioned in our later paper treating the concluding chapter of this series.

Key to the Japanese Lower Jurassic species of *Ptilophyllum*

1.	Leaf large-sized, widest part over 5.4 cm	*P. nipponicum* sp. nov.
1′.	Leaf medium-sized about 3 cm wide	2
1″.	Leaf small-sized width less than 1 cm	3
2.	Pinnae elongate-rectangular	*P. shinadaniense* sp. nov.
2′.	Pinnae elongate-oval or rectangular	*P.* sp. A
3.	Pinnae elongate-triangular	*P.* cfr. *cutchense*
3′.	Pinnae rhombic	*P.* sp. B

Ptilophyllum cfr. *cutchense* Morris

Pl. 43, Figs. 7-8; Text-figs. 5a-b

Comparable specimens:

Ptilophyllum cutchense Morris: Bose and Kasat, 1972, p. 118, pl. 1, figs. 7-10; pl. 2, figs. 14-17 (Upper Jurassic of Rajmahal Hills and Lower Cretaceous Jabalpur Series, India).

Material: TE-001, 003 (Teradani, Negoya Formation).

Description: Two small-sized leaf-fragments were obtained. The leaves are 0.8-1 cm wide with an acuminate apex as shown in Pl. 43, Fig. 7. The rachis which is partially exposed, is about 0.5 mm wide. Pinnae are attached on upper surface of rachis, closely set or imbricate, mostly attached by entire base, arising at an angle of about 60-90 degrees. Pinnae are as a whole linear, elongate-triangular, sometimes rhomboidal, sublate or ovate in form; margins are straight. Apices are usually obtuse or rounded and the basiscopic basal margin straight, slightly contracted, rounded or decurrent. Veins arise from the whole base. They are parallel, mostly simple, 5 in number on each pinna. Cuticle is not preserved.

Distribution and occurrence: This form is rare and known only from Teradani, Negoya Formation.

Remarks: Our leaves reaves resemble closely some smaller leaves illustrated by Bose and Kasat (1972) as *Ptilophyllum cutchense*. *Ptilophyllum horridum* Roy and *P. institacallum* Bose are allied forms to *P. cutchense*. But both are distinguished from our leaves by their radiating

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Text-figs. 6 (g-k)-9. (All natural size, unless otherwise indicated)

6. *Ptilophyllum nipponicum* Kimura and Tsujii sp. nov. 6g: A leaf-fragment bearing elongated pinnae with decurrent base and contracted acroscopic base (NNW-241, paratype). 6g′: Vanation drawn from 6g. 6h: Small-sized leaf-fragment (NNW-353, paratype). 6i: Large-sized leaf-fragment bearing broader pinnae with slightly decurrent base (NNW-241, paratype). 6j: Apical part of a leaf (NE-169). 6k: Basal part of a leaf with thick petiole of which base is expanded. Pinnae are small-sized, and with straight or slightly contracted base (NNW-111, paratype; Pl. 43, Fig. 10).
7. *Ptilophyllum shinadaniense* Kimura and Tsujii sp. nov. 7a: A part of leaf (SHI-007, holotype; Pl. 41, Fig. 5). 7b: A leaf-fragement, showing the venation (SHI-024, paratype). 7c: Ditto (SHI-019, paratype; Pl. 41, Fig. 6).
8. *Ptilophyllum* sp. A; a part of leaf (SHI-030; Pl. 43, Fig. 11). 8′: Venation drawn from 8.
9. *Ptilophyllum* sp. B. 9a: A part of leaf (NEG-51; Pl. 43, Fig. 12). 9b: Ditto (A-0379). 9b′: Venation drawn from 9b.

and forked veins instead of mostly simple and parallel ones.

Ptilophyllum cantherifera originally described by Douglas (1969) from the Lower Cretaceous of Victoria (Australia) is similar in form, but is distinguished by its pinnae attached by central basal area instead of by the entire base in ours.

Thus our leaves are most like the small-sized *Ptilophyllum cutchense*, but we here refrain from fully identifying them with this Indian species, because our leaves without cuticle are only two and incomplete.

Ptilophyllum nipponicum Kimura and Tsujii sp. nov.

Pl. 41, Figs. 3-4; Pl. 42, Fig. 8; Pl. 43; Figs. 9-10; Text-figs. 6a-k

Material: Holotype; NEG-270 (Negoya). Paratypes; NNW-111, 241, 353, 697, 806 (Nishi-Neiridani), NE-067 (Neiridani). Other specimens; NEG-071 and other 3 specimens, NNW-004 and other 6, NEE-074 (Higashi-Neiridani), NE-169, DAI-086 (Dairagawa), IN-001, 002 (Inumatadani).

Stratum typicum: Negoya Formation, Kuruma Group. *Locus typicus*: The Negoya, Asahi-machi, Shimo-Niikawa-gun, Toyama Prefecture. *Derivatio nominis*: After Nippon meaning Japan in Japanese.

Diagnosis: Leaf large, oblong or oblanceolate in form; the widest part 5.4 cm. (Whole length and leaf apex unknown.) Rachis slender 2 mm wide at the middle of leaf but 3 mm wide at the basal part. Petiole about 5 cm long with striated surface, base distinctly expanded. Pinnae varied in form according to their position on a leaf, attached on the upper side of rachis at an angle of 50-90 degrees by entire base, set closely but sometimes remotely. Middle pinnae elongate-rectangular, typically 3.5-4 cm long and 0.5-1 cm wide. Apical pinnae similar in form to those of middle ones but smaller in size. Basal pinnae typically deltoid in form, 1.5 cm long and 0.5-0.8 cm wide at base, but smaller towards the base of leaf. Acroscopic basal margin mostly rounded and basiscopic basal margin straight, slightly contracted or slightly decurrent. Apex acutely or obtusely pointed. Veins numerous, divergent, forking at all levels, 28-30 per cm in density at the middle of pinna. (Cuticle not preserved.)

Distribution and occurrence: *Ptilophyllum nipponicum* is common only in the Negoya Formation.

Comparison and discussion: It is clear that our leaves belong to *Ptilophyllum* redefined by Harris (1969), because our acroscopic pinna base is not auriculated and the basiscopic pinna base is typically decurrent.

Ptilophyllum nipponicum is characterized by its large-sized leaf with elongated pinnae above and deltoid pinnae below with divergent and forked veins, and its thick petiole and expanded base.

Several *Ptilophyllum* species with large leaves have been described. *Ptilophyllum nipponicum* closely resembles *P. hirsutum* Thomas and Bancroft described in detail by Harris (1949, '69) from the Middle Jurassic of Yorkshire. But the pinnae of *Ptilophyllum hirsutum* do not have a decurrent basal margin.

Ptilophyllum harrisianum described by Kilpper (1968) from the Liassic of N-Iran has pinnae of similar size but with an auriculate acroscopic base. Kilpper's *Ptilophyllum zirabense* (1968) has more elongated pinnae.

Ptilophyllum shinadaniense Kimura and Tsujii sp. nov.

Pl. 41, Figs. 5-6; Text-figs. 7a-c

Material: Holotype; SHI-007 (Shinadani).

Paratypes; SHI-019, 024.

Stratum typicum: Shinadani Formation, Kuruma Group (see Kimura and Tsujii, 1980a, p. 342, fig. 2). *Locus typicus*: The Shinadani (near Agero Village), a branch of the Dairagawa, Omi-machi, Nishi-Kubiki-gun, Niigata Prefecture. *Derivatio nominis*: After the locality, the Shinadani where the holotype and paratypes were collected.

Diagnosis: Leaf medium-sized, 3 cm wide. (Whole length unknown.) Pinnae arising at an angle of 65-80 degrees to the rachis, elongate-rectangular in form, typically 1.8 cm long and 3.5-4 mm wide. Width of pinnae about one-fifth its length. Pinnae straight or very slightly falcate, apex obtusely pointed, basiscopic basal angle normally decurrent but often concealed by the pinna below. Veins arising from whole base of pinna, nearly parallel, often forking once at the middle of pinna, 8-10 in number in each pinna. (Cuticle not preserved.)

Distribution and occurrence: *Ptilophyllum shinadaniense* is rare and known only from the Shinadani Formation.

Discussion and comparison: *Ptilophyllum shinadaniense* is characterized by its medium-sized elongate-rectangular pinnae with parallel veins often forking once.

Ptilophyllum contiguum originally described by Sze (1949) and later by Wu et al. (1980) from the Lower Jurassic Xiangxi (formerly Hsiangchi) Formation in W-Hubei, China has pinnae of similar form. But it is distinguished by its small-sized leaf (13.5 cm long and 1.6 cm wide) and fewer veins (4-6 in each pinna).

Ptilophyllum basekgabense originally described by Barnard and Miller (1976) from the Middle Jurassic of N-Iran has smaller pinnae (8-15 mm long and up to 3 mm wide) with fewer veins (4-5 in each pinna).

Some leaves of *Ptilophyllum caucasicum* Doludenko and Svanidze from the Upper Jurassic of Georgia resemble *P. shinadaniense*, but others have very long and narrow pinnae (Doludenko and Svanidze, 1969).

Ptilophyllum boreale (Heer) (Seward, 1917; *Zamites borealis* by Heer, 1874) from the Lower Cretaceous of Greenland is distinguished by its stout rachis and fewer veins (3-5 in number in each pinna).

Ptilophyllum sokalense described by Doludenko (1963) from the Jurassic of W-Ukraine has pinnae of similar form, but their basiscopic margin is mostly straight or slightly contracted.

Ptilophyllum sp. A

Pl. 43, Fig. 11; Text-fig. 8, 8′

Material: SHI-030 (Shinadani).

Description: Leaf medium-sized, elongated, 2.5 cm wide over the most part; neither end known. Pinnae elongate-oval or rectangular, attached by entire base on the upper side of rachis (2 mm wide) at an angle of 60-90 degrees, 1.4 cm long and 0.5 cm wide. Acroscopic basal angles mostly rounded or slightly decurrent, apices rounded or obtusely pointed. Veins indistinct, possibly simple and parallel, not radiating, 9 in each pinna. (Cuticle not preserved.)

Distribution and occurrence: A single specimen was obtained from the Shinadani Formation.

Remarks: Our specimen is characterized by its elongate-oval or rectangular pinnae. Our specimen is distinguished from *Ptilophyllum shinadaniense* from the same locality by its shorter pinnae.

Some leaves regarded as *Ptilophllum caucasicum* Doludenko and Svanidze (Doludenko and Svanidze, 1969; Doludenko and Orlovskaja, 1976) from the Upper Jurassic of Georgia and Kazakhstan are similar in pinna form and venation to ours, but others have very long and narrow pinnae.

Ptilophyllum sp. B

Pl. 41, Fig. 7; Pl. 43, Fig. 12; Text-figs. 9a-b′

Material: A-0379, 0456, 7564 (Iwamuro), NEG-051 (Negoya).

Description: Leaves small-sized, long and narrow and nearly parallel-sided, 4 mm wide. Rachis 1 mm wide but mostly concealed. Pinnae rhombic, attached by entire base at a wide angle on the upper side of rachis, closely set or imbricate, apices usually obtuse, acroscopic basal margin straight or rounded, basiscopic basal margin mostly straight but sometimes slightly contracted. Veins indistinct, arising from the whole base, parallel, probably simple, about 5 in each pinna. (Cuticle not preserved.)

Distribution and occurrence: This form occurs sparsely in the Iwamuro and Negoya Formations.

Remarks: Judging from the mode of pinna attachment and venation, our leaves may belong to *Ptilophyllum*. So far as we know, such small-sized leaves as ours have been described as *Ptilophyllum* or *Otozamites* as follows: *Ptilophyllum bengalense* (Oldham) Schimper: Kilpper, 1968; Liassic of N-Iran. *P. elongatum* Douglas: Douglas, 1969; Lower Cretaceous of Victoria (Australia), *P. kazachstanicum* Genkina: Genkina, 1963; Middle Jurassic of Eastern Ural. *P. marginatum* Prosvirjakova: Prosvirjakova, 1966; Middle Jurassic of Mangwishlak. *P. minor* Kilpper: Kilpper, 1968, Liassic of N-Iran. *Otozamites abreviatus* Feistmantel: Feistmantel, 1879 (pars): Jurassic of Madras Coast. *O. bengalensis* (Oldham and Morris) Schimper: Oldham and Morris, 1862 (regarded by them as *Palaeozamia bengalensis*); Jurassic of India. *O. bunburyanus* Zigno: Zigno, 1881; Middle Jurassic of Italy. *O. contiguus* Feistmantel: Feistmantel, 1876; Jurassic of India. *O. kilpperiana* Barnard and Miller: Barnard and Miller, 1976; Middle Jurassic of N-Iran. *O. tenuatus* (Leckenby) Harris: 1969; Middle Jurassic of Yorkshire. *O. vemavaramensis* Bose and Jain: Bose and Jain, 1967; Upper Jurassic (?) of India.

Among these, our leaves are most like *Ptilophyllum bengalensis* in pinna form. But we refrain from determining it specifically because our leaves are all incomplete.

References

Antevs, E. (1919): Die liassische Flora des Hörsandsteins. *K. Svensk. Vet.-Akad. Handl.*, Bd. 59, no. 8, p. 1-71, pls. 1-6.

Barnard, P.D.E. and Miller, J.C. (1976):

Explanation of Plate 41

Fig. 1. *Ctenozamites sarrani* (Zeiller) Harris: A part of leaf, with two pinna fragments. Judging from their wedge-shaped arrangement, they may represent the pinnae forking dichotomously below (NNW-846; counterpart of NNW-146 partly shown in Text-fig. 1), ×1.

Fig. 2. *Pterophyllum* ex gr. *propinquum* Goeppert; (NNW-695), ×1.

Figs. 3-4. *Ptilophyllum nipponicum* Kimura and Tsujii sp. nov.; both, ×1. 3. Lower half of a leaf (NNW-806, paratype; Text-fig. 6b). 4. Apical part of a leaf, with rather remotely set pinnae (NNW-353; Text-fig. 6d, d′).

Figs. 5-6. *Ptilophyllum shinadaniense* Kimura and Tsujii sp. nov.; both, ×1. 5. (SHI-007, holotype; Text-fig. 7a). 6. (SHI-019, paratype; Text-fig. 7c).

Fig. 7. *Ptilophyllum* sp. B; a leaf-fragment (A-7564), ×2.


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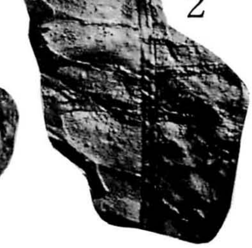
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Flora of the Shemshak Formation (Elburz, Iran). Part 3: Middle Jurassic (Dogger) plants from Katumbargah, Vesek Gah and Imam Manak. *Palaeontographica, Abt. B*, Bd. 155, p. 31-117, pls. 1-15.

Bartholin, C.T. (1892): Nogle i den bornholmske Juraformation fore kommende Planteforsteninger. *Bot. Tidskr.*, Kjøbenhavn, Bd. 19, p. 87-115, pls. 1-6.

Bose, M.N. and Jain, K.P. (1967): *Otozamites vemavaramensis* sp. nov. from the Upper Gondwana of the east coast of India. *Palaeobotanist*, vol. 15, no. 3, p. 314-315, pl. 1.

Bose, M.N. and Kasat, M.L. (1972): The genus *Ptilophyllum* in India. *Ibid.*, vol. 19, no. 2, p. 115-145, pls. 1-14.

Brongniart, A. (1828-1838): *Histoire des végétaux fossiles ou recherches botaniques et géologiques sur les végétaux renfermés dans les diverses couches du globe.* 1 (1828-1837). xii+488 p., 171 pls., 2 (1837-1838). 72 p., 28 pls. Paris.

Chen, Y., Duan, S.Y. and Zhang, Y.C. (1979a): New species of the late Triassic plants from Yanbian, Sichuan, I. *Acta Bot. Sinica*, vol. 21, no. 1, p. 57-63, pls. 1-3 (in Chinese).

——, —— and —— (1979b): Ditto, III. *Ibid.*, vol. 21, no. 3, p. 269-273, pls. 1-3 (in Chinese).

Delle, G.V. (1967): The Middle Jurassic flora of the Tkvarchelian Coal-Basin (Trans-Caucasia). *In* 'Palaeobotanika VI'. *Komarov Bot. Inst., Acad. Sci. USSR, Acta, ser. 8*, p. 51-132, pls. 1-25 (in Russian).

Doludenko, M.P. (1963): New species of *Ptilophyllum* from the Jurassic of the western Ukraine. *Journ. Bot.*, Acad. Sci. USSR, T. 48, no. 6, p. 796-805, pls. 1-4 (in Russian).

Doludenko, M.P. and Orlovskaja, E.R. (1976): Jurassic flora of the Karatau. *Acad. Sci. USSR, Trans.*, vol. 284, p. 1-262, incl. pls. 1-89 (in Russian).

Doludenko, M.P. and Svanidze, Ts. I. (1969): The late Jurassic flora of Georgia. *Geol. Inst., Acad. Sci. USSR, Trans.*, vol. 178, p. 1-118, pls. 1-81 (in Russian).

Douglas, J.G. (1969): The Mesozoic floras of Victoria. Pts. 1-2. *Geol. Surv. Victoria*, Mem. 28, p. 1-310, incl. pls. 1-51.

Feistmantel, O. (1876): Jurassic (Oolitic) flora of Kach. *In* 'Fossil flora of the Gondwana System, Vol. 2'. *Mem. Geol. Surv. India, Palaeont. Indica, ser. 11*, pts. 1-2, p. 1-80, pls. 1-12.

—— (1879): Fossil flora of the Upper Gondwanas on the Madras Coast. *In* 'The fossil flora of the Upper Gondwanas'. *Ibid.*, vol. 1, no. 4, p. 191-233, pls. 1-16.

Genkina, R.Z. (1963): Fossil flora of the Mesozoic coal-bearing deposits of the East Ural-field of Oesk Coal-Basin *Inst. Geol. Exploit. Foss. Fuel, Acad. Sci. USSR*, p. 1-115, pls. 1-51 (in Russian).

Harris, T.M. (1926): The Rhaetic flora of Scoresby Sound East Greenland. *Medd. om Grønland*, Bd. 68, nr. 2, p. 44-148, pls. 1-13.

—— (1932): Ditto. Pt. 3: Caytoniales and Bennettitales. *Ibid.*, Bd. 85, nr. 5, p. 1-133, pls. 1-18.

—— (1941): On *Ptilophyllum gracile* sp. n. *Ann. Mag. Nat. Hist.*, London, ser. 11, vol. 8, p. 132-140.

—— (1942): Notes on the Jurassic flora of Yorkshire. 1-3. 1. *Ptilophyllum caytonense* sp. n.; 2. *Deltolepis crepidota* gen. et sp. n.; 3. On *Nilssonia compta* and its reference to *Beania gracilis*. *Ibid.*, ser. 11, vol. 9, p. 586-587.

—— (1946): Ditto. 31-33. 31. *Ptilophyllum pectinoides* (Phillips) Morris; 32. *Coniopteris arguta* (L. & H.) Seward; 33. *Stenopteris nana* sp. n. *Ibid.*, ser. 11, vol. 13, p. 392-411.

—— (1949): Ditto. 40-42. 40. *Otozamites anglica* (Seward) n. comb.; 41. The narrow-leaved *Otozamites* species; 42. *Ptilophyllum hirsutum* Thomas & Bancroft and its differentiation from *P. pecten* (Phillips). *Ibid.*, ser. 12, vol. 2, p. 275-299.

—— (1953): Ditto. 58-60. 58. Bennettitalean scale-leaves; 59. *Williamsonia himas* sp. n.; 60. *Williamsonia setosa* Nathorst. *Ibid.*, ser. 12, vol. 6, p. 33-52.

—— (1961): The form and structure of *Ctenozamites cycadea*. *Bull. Brit. Mus. (Nat. Hist.), Geol.*, vol. 6, no. 6, p. 159-

173, pls. 31-32.

—— (1964) : *The Yorkshire Jurassic flora. II. Caytoniales, Cycadales and Pteridosperms.* viii+191 p., 7 pls. Brit. Mus. (Nat. Hist.).

—— (1969) : *Ditto. III. Bennettitales.* v+186 p., 7 pls. *Ibid.*

Heer, O. (1874) : Die Kreide-Flora der arctischen Zone. *K. Svensk. Vet.-Akad. Handl.*, Bd. 12, no. 6, p. 1-138, pls. 1-38.

—— (1876) : Beiträge zur Jura-Flora Ostsibiriens und des Amurlandes. *Acad. Imp. Sci., St.-Pétersb., Mém.*, T. 22, p. 1-122, pls. 1-31.

Hsü, J., Chu, C.N., Chen, Y., Hu, Y.F. and Tuan, S.Y. (1975) : New genera and species of the late Triassic from Yungjen, Yunnan, II. *Acta Bot. Sinica*, vol. 17, no. 1, p. 70-76, pls. 1-6 (in Chinese).

Iminov, Y.C. (1968) : New Jurassic plants from Middle Asia and North Afghanistan. *In* 'The Palaeobotany of Uzbekistan I'. p. 95-104, pls. 35-37. FAN, Tashkent.

—— (1976) : *Cycadophytes of the late Triassic and Jurassic of Middle Asia and their stratigraphic significance.* 72 p., 48 pls. *Ibid.*

Jacob, K. and Jacob, C. (1954) : Cuticular study of Indian *Ptilophyllum* fronds from Cutch and Jubbulpore. *Mem. Geol. Surv. India, Palaeont. Indica, N.S.*, vol. 33, no. 1, p. 1-34, pls. 1-10.

Jones, O.A. and Jersey, N.J. de (1947) : The flora of the Ipswich Coal Measures—Morphology and floral succession. *Univ. Queensl. Pap., Dept. Geol., N.S.*, vol. 3, nos. 3-4, p. 1-88, pls. 1-10.

Kilpper, K. (1965) : Nomenklatur und Geschichte mesozoischer Pflanzen. 1. Die Gattung *Ptilophyllum* Morris (in Grant). *N. Jb. Geol. Paläont. Mh.*, Bd. 4, p. 193-205.

—— (1966) : *Ptilophyllum kharganense* n. sp. aus der Kharga-Oase, westliche Wüste, Ägypten (Mittel Jura ?). *Palaeontographica, Abt. B*, Bd. 117, p. 75-82, pl. 30.

—— (1968) : Einige Bennettiteen-Blatter aus dem Lias von Karmozd-Zirab (N-Iran). *J. Linn. Soc. (Bot.)*, vol. 61, no. 384, p. 129-135, pls. 1-3.

Kimura, T. (1959a) : Mesozoic plants from the Iwamuro Formation (Liassic), Tonegun, Gumma Prefecture, Japan. *Bull. Sen. High Sch., Tokyo Univ. Educ.*, no. 3, p. 1-59, incl. pls. 1-12.

—— (1959b) : Mesozoic plants from the Kotaki Coal-Field, the Kuruma Group, Central Honshu, Japan. *Ibid.*, p. 61-83, incl. pls. 1-2.

Kimura, T. and Tsujii, M. (1980a) : Early Jurassic plants in Japan, Part 1. *Trans. Proc. Palaeont. Soc. Japan, N.S.* no., 119, p. 339-358, pls. 38-40.

—— and —— (1980b) : Ditto. Part 2. *Ibid.*, 120, p. 449-465, pls. 54-56.

—— and —— (1981) : Ditto. Part 3. *Ibid.*, no. no. 124, p. 187-207, pls. 30-32.

Li, P.C. (1964) : Fossil plants from the Hsuchiaho Series of Kwangyüan, Northern Szechuan. *Mem. Inst. Geol. Palaeont., Acad. Sinica*, no. 3, p. 101-178, pls. 1-20 (in Chinese with English description).

Li, P.C., Tsao, C.Y. and Wu, S.C. (1976) : Mesozoic plants from Yunnan. *In* 'Mesozoic fossils of Yunnan, Vol. 1'. p. 87-

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Explanation of Plate 42

Figs. 1-5. *Otozamites neiridaniensis* Kimura and Tsujii sp. nov.; all figures, ×1. 1, 3. Leaves of typical size. 1; (NNE-095, holotype; Text-fig. 3a), 3; (NE-046). 2. A large-sized leaf (TOB-050B′, paratype; Text-fig. 3c). 4. Basal part of a leaf (NEE-250). 5. Ditto (NEE-073).

Figs. 6-7. *Pterophyllum* ex gr. *propinquum* Goeppert; both, ×1. Leaf-fragments. 6; (NNW-073), 7; (NNW-600).

Fig. 8. *Ptilophyllum nipponicum* Kimura and Tsujii sp. nov.; apical part of a leaf (NEE-074; Text-fig. 6e), ×1.


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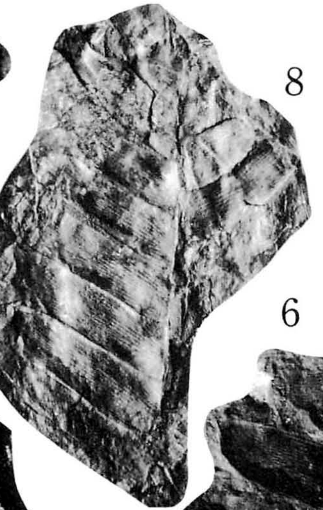
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160, pls. 1-47. Ke-Xue-Chu-Ban-She, Peking (in Chinese).

Lundblad, A.B. (1950) : Studies in the Rhaeto-Liassic floras of Sweden. I. Pteridophyta, Pteridospermae, and Cycadophyta from the Mining District of NW Scania. *K. Svensk. Vet.-Akad. Handl., N.S.*, Bd. 1, no. 8, p, 1-82, pls. 1-13.

Möller, H. (1903) : Bidrag till Bornholms Fossila Flora (Rhät och Lias). Gymnospermer. *Ibid.*, Bd. 36, no. 6, p. 3-48, pls. 1-7.

Oishi, S. (1931) : Mesozoic plants from Kita-Otari, Prov. Shinano, Japan. *Journ. Fac. Sci., Hokkaido Imp. Univ., ser. 4*, vol. 1, no. 2, p. 223-255, pls. 16-18.

—— (1940) : The Mesozoic floras of Japan. *Ibid.*, vol. 5, nos. 2-4, p. 123-480, pls. 1-48.

Prosvirjakova, Z.P. (1966) : *Jurassic flora of Mangwishlak and its significance for stratigraphy.* 174 p., 35 pls. VSEGEI, Acad. Sci. USSR (in Russian).

Oldham, T. and Morris, J. (1862) : Fossil flora of the Rajmahal Series in the Rajmahal Hills. *In* 'Fossil flora of the Gondwana System, Vol. 1, pt. 1'. *Mem. Geol. Surv. India, Palaeont. Indica, ser. 2 (1-4)*, p. 1-52, pls. 1-35.

Seward, A.C. (1917) : *Fossil plants. Vol. 3.* xviii+656 p. Cambridge.

Sze, H.C. (1949) : Die mesozoischen Flora aus der Hsiangchi kohlen Series in West Hupeh, China. *Palaeont. Sinica, N.S., ser. A*, no. 2, p. 1-71, pls. 1-15.

—— (1956) : Older Mesozoic plants from the Yenchang Formation, Northern Shensi. *Ibid.*, no. 5 (139), p. 1-110 (Chinese part), 111-217 (English part), pls. 1-56.

Sze, H.C., Li, X.X., Li, P.C., Wu, S.C., Zhoh, T.Y., Ye, M.N. and Shen, G.L.. (1963) : *Fossil plants of China, Vol. 2. Mesozoic plants of China.* iv+429 p., 118 pls. Ke-Xue-Chu-Ban-She, Peking (in Chinese).

Vakhrameev, V.A. and Doludenko, M.P. (1961) : Late Jurassic and early Cretaceous floras from the Bureja Basin and its significance for stratigraphy. *Geol. Inst., Acad. Sci. USSR, Trans.*, vol. 54, p. 1-136, pls. 1-60 (in Russian).

Walkom, A.B. (1917) : Mesozoic floras of Queensland. Part 1.-concluded. The flora of the Ipswich and Walloon Series. (d)-(f). *Queensl. Geol. Surv. Publ.*, no. 259, p. 1-48, incl. pls. 1-9.

Weber, R. (1968) : Die fossile Flora der Rhät-Lias-Übergangschichten von Bayreuth (Oberfranken) under besonderer Berücksichtigung der Coenologie. *Erlanger geol. Abh.*, Heft 72, p. 1-73, pls. 1-17.

Wu, S.Q., Ye, M.N. and Li, B.X. (1980) : Upper Triassic and Lower and Middle Jurassic plants from the Hsiangchi Group, Western Hubei. *Mem. Nanjing Inst. Geol. Palaeont., Acad. Sinica*, no. 14, p. 63-131, pls. 1-39 (in Chinese with English abstract).

Yabe, H. and Oishi, S. (1929) : Notes on some fossil plants from Korea and China belonging to the genera *Nilssonia* and *Pterophyllum*. *Jap. Journ. Geol. Geogr.*, vol. 6, nos. 3-4, p. 85-101, pls. 18-20.

—— and —— (1933) : Mesozoic plants from Manchuria. *Sci. Rep., Tohoku Imp. Univ., sec. ser.*, vol. 12, no. 2B, p. 195-238, pls. 30-35, 1 tab.

Yang, X.H. (1978) : *Palaeontological atlas of Southwest China. Division* of Sichuan. Part 2. p. 469-684, pls. 155-190. Di-Zhi-Chu-Ban-She, Peking (in Chinese).

Zeiller, R. (1903) : *Flore fossile des gîtes de Charbon du Tonkin* (Études des gîtes minéraux de la France). 328 p., 56 pls. Paris.

Zhou, T.S. (1978) : On the Mesozoic coal-bearing strata and fossil plants from Fujian Province. *Prof. Pap. Stratigr. Palaeont.*, no. 4, p. 88-134, pls. 15-30 (in Chinese).

Zigno, A. de (1856-1885) : *Flora Fossilis Formationis Oolithicae. Le Piante Fossili dell'Oolite.* 2 vols. Padova. Vol. 1, Livr. 1, p. 1-32, pls. 1-6 (1856) ; Livr. 2, p. 33-64, pls. 7-12 (1858) ; Livr. 3-5, p. 65-223, pls. 13-25 (1867) ; Vol. 2, Livr. 1, p. 1-48, pls. 26-29 (1873) ; Livr. 2-3, p. 49-120, pls. 30-37 (1881) ; Livr. 4-5, p. 121-203, pls. 38-42 (1885).

Geographical names in Japan: Agero 上路, Dairagawa 大平川, Higashi-Neiridani 東寝入谷, Inumatadani 犬俣谷, Iwamuro 岩室, Kita-Otari 北小谷, Kotaki 小滝, Kuruma 来馬, Moné 舞根, Nariwa 成羽, Negoya 似虎谷, Neiridani 寝入谷, Nishi-Neiridani 西寝入谷, Shinadani 榀谷, Teradani 寺谷, Tobiiwadani 飛岩谷, Tsuchizawa (Tunzawa) 土沢, Geographical names in China (with former expression in parentheses): Beipiao (Peipiao) 北票, Daqiaode 大蕎地, Fujian 福建, Hubei (Hupeh) 湖北, Liaoning 遼寧, Sichuan (Szechuan) 四川, Taipingchang (Tai-ping-tchang) 太平場, Wengbinshan 文賓山, Xujiahe (Hsuchiaho) 須家河, Xiangxi (Hsiangchi) 香渓, Yanbian 塩辺, Yanchang (Yenchang) 延長, Yipinglang 一平浪, Yongren (Yungjen) 永仁, Yunnan 雲南, Geographical name in Korea (with former expression): Daedong (Taedong) 大同

日本の初期ジュラ紀植物化石。その 4：前編につづき，来馬層群および岩室累層からつぎのシダ種子およびベネチテス目に属する植物化石を記載した。

シダ種子目：*Ctenozamites sarrani* (Zeiller) Harris

ベネチテス目：*Anomozamites* sp. A, *Otozamites fujimotoi* Kimura, *O. neiridaniensis* Kimura and Tsujii sp. nov., *Pterophyllum* ex gr. *propinquum* Goeppert, *P.* sp. A, *Ptilophyllum* cfr. *cutchense* Morris, *P. nipponicum* Kimura and Tsujii sp. nov., *P. shinadaniense* Kimura and Tsujii sp. nov., *P.* sp. A, *P.* sp. B.

以上のうち，*Ctenozamites* 属は，日本で最初の産出であり，*Ptilophyllum* 属は，日本の古期中生界からの最初の産出である。とくに後者の産出は，日本の初期ジュラ紀植物群の古植物地理的位置を判断する上で重要な資料となる。 木村達明・辻井正則

Explanation of Plate 43

Figs. 1-2. *Otozamites neiridaniensis* Kimura and Tsujii sp. nov.; both, ×1. 1. A large-sized leaf-fragment with elongated pinnae (NNW-084, paratype; partly shown in Text-fig. 3f). 2. Basal part of a leaf (TOB-032).

Figs. 3-6. *Pterophyllum* ex gr. *propinquum* Goeppert; all figures, ×1. Leaf-fragments. 3; (NNW-240), 4; (NNW-356B), 5; (NNW-356; Text-fig. 4j), 6; (NNW-014).

Figs. 7-8. *Ptilophyllum* cfr. *cutchense* Morris; both, ×1. Unsatisfactorily preserved leaf-fragments. 7; (TE-001; Text-fig. 5a), 8; (TE-003; Text-fig. 5b).

Figs. 9-10. *Ptilophyllum nipponicum* Kimura and Tsujii sp. nov; both, ×1. 9. A leaf lacking both apical and basal portions (NEG-270, holotype; Text-fig. 6a, a′). 10. Basal part of a leaf with petiole of which base is expanded; upper arrow indicates a thick rachis and lower one an expanded petiole-base (NNW-111, paratype; Text-fig. 6k).

Fig. 11. *Ptilophyllum* sp. A; a leaf-fragment (SHI-030; Text-fig. 8), ×1.

Fig. 12. *Ptilophyllum* sp. B; a leaf-fragment (NEG-051; Text-fig. 9a), ×2.

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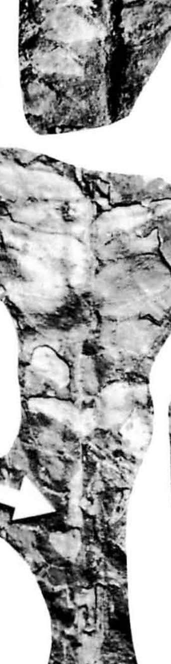

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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 125, pp. 277-295, pls. 44-48, April 15, 1982

742. JAPANESE MIOCENE CIRRIPED *BALANUS SENDAICUS*: A COMPARISON WITH TETHYAN *BALANUS CONCAVUS* GROUP*

TOSHIYUKI YAMAGUCHI

Geological Institute, Faculty of Science, University of Tokyo, Tokyo 113

Abstract. *Balanus sendaicus* was described as a new species by Hatai, Masuda and Noda (1976) based on a single scutum from the Miocene Moniwa Formation, northern Honshu, Japan. However, the scutum deposited in the Saito Ho-on Kai Museum, Sendai, Japan (Hatai *et al.*, 1976) could not be found. Tergum and shell wall, which with scutum comprise the skeletal elements, had not been described. According to my investigation of topotype materials and of materials illustrated by Hatai *et al.* (1976), the shell walls described and illustrated under the name of *B. rostratus* by Hatai *et al.* (1976) belong to *B. sendaicus*. *B. sendaicus*, including tergum undescribed by Hatai *et al.* (1976), is therefore defined in this paper. *B. sendaicus* is distinct from the already known taxa, as mentioned by Hatai *et al.* (1976). However, *B. sendaicus* is closely related to the extinct *B. concavus* sensu de Alessandri (1906), which flourished in the Mediterranean region (Tethys) from the Oligocene to Pleistocene. *B. sendaicus* belongs to the *B. concavus* species group represented by the nominal species based on having transverse septa in longitudinal (parietal) tubes of shell wall and the characteristic ornamentation of scutum. Disappearance of the *B. concavus* group from the Atlantic and the Mediterranean regions in Pleistocene is mysterious as mentioned by Pilsbry (1916), though "four" species belonging to the *B. concavus* group are living in the eastern Pacific (Newman, 1979). *B. sendaicus* is restricted to the Miocene, is the first fossil record of the *B. concavus* group from the east Asia, and indicates the presence of a connection between the Tethys and the east Asia.

Introduction

Balanus sendaicus was proposed as a new species by Hatai, Masuda and Noda (1976), based on a single scutum from the Miocene Moniwa Formation of the Sendai area of northeast Honshu, Japan. Seven new species including *B. sendaicus*, an already known species of *B. rostratus*, and an indetermined species of *Balanus* were described from the same locality. Four new species including *B. sendaicus* were based on scuta and three new species, *B. rostratus* and *B.* sp. based on the shell walls. No tergum was described.

Fossil specimens are usually found as fragmental skeletal elements of shell wall and opercular valves, and therefore it is difficult to reconstruct the exoskeleton of a species from the mixture of fragments of several extinct species. Under these circumstances, each fragmental skeletal element, such as shell wall, scutum or tergum, has been frequently chosen as

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* Received June 30, 1981; read Jan. 24, 1981 at Sendai.

representative of a new species. Thus in some cases, an individual consisting of three kinds of skeletal elements, may possesses three different species names. Therefore, biological study of fossil specimens of extinct species is faced with difficulties unless basic work, revealing the precise combination of skeletal elements, is done first. When a complete shell wall is discovered, it is necessary to determine whether or not opercular valves are preserved in the shell cavity.

In this paper the following points are considered: 1) Description of shell wall and tergum of *B. sendaicus*, whose original description was based on a single scutum, 2) The status of *B. sendaicus* as a previously unknown taxon, as discussed by Hatai *et al.* (1976), 3) The affinity of *B. sendaicus* with known species and species groups, and 4) The stratigraphic and geologic distributions in Japan and the paleoecological significance of *B. sendaicus*.

Balanus sendaicus, type-locality and formation

The type-locality of this species is an outcrop (Loc. 4) of the Miocene Moniwa Formation situated about 200 m south of the Oide Bridge across the Natori River, near Moniwa, Sendai City, Miyagi Prefecture, northeast Honshu, Japan. The Miocene Moniwa Formation overlies the Miocene Takadate Andesite with a clino-unconformity. *B. sendaicus* was collected from the basal part of the Moniwa Formation which consists of gravelly calcareous medium-grained sandstone containing very abundant well preserved marine fossils. Reports on brachiopods, shark teeth, fossil problematica, and on pelecypods have already been published (Hatai *et al.*, 1973, 1974a, 1974b, 1974c, respectively). A report on cirripeds was the fifth of this series from the same locality. Besides *B. sendaicus*, shell walls but no terga of *B. rostratus*, *B. miyagiensis*, *B. tohokuensis*, *B. rikuzenensis*, and *B.* sp. and scuta of *B. oidensis*, *B. moniwaensis*, and *B. natorianus* were described. Except for *B. rostratus* and *B.* sp., all were proposed as new species.

Combination of skeletal elements of *B. sendaicus*

The writer has collected many well preserved fossil cirripeds from the above locality. Four species by shell walls, five species by scuta, and two species by terga were distinguished. However, the combination of these exoskeleton elements was not clear. Judging from shell size and the frequency of occurrence of each element, it was presumed that shell wall of *B. rostratus* and scutum of *B. sendaicus*, as described by Hatai *et al.* (1976) and a previously undescribed tergum probably constituted skeletal elements of one species. This is also supported by the fact that the following morphological characteristics of shell walls of *B. rostratus* identified by Hatai *et al.* (1976) are clearly different from the true *B. rostratus* proposed by Pilsbry (1916); narrow radii and oblique summits of radii. In order to confirm the above conjecture additional material was sought.

Recently some shell walls collected from the same locality, identical with *B. rostratus* of Hatai *et al.* (1976), were found to contain paired scuta and terga within their shell cavity. The specimen of *B. rostratus* illustrated by Hatai *et al.* (1976, pl. 2, fig. 2, left, and Pl. 44, Figs. 2a-c, left, in this paper) was also found to contain four opercular valves in its shell cavity (Pl. 44, Figs. 2d-g, in this paper). It is important to note that morphologically these scuta are identical with the holotype scutum of *B. sendaicus* (Hatai *et al.* 1976, pl. 2, figs. 9 and 10). It can, therefore, be concluded that *B. sendaicus* is conspecific with *B. rostratus* of Hatai *et al.* (1976). However, *B. rostratus* of Hatai *et al.* (1976) is not the true *B. rostratus* in the sense of Pilsbry (1916) and the name *B. sendaicus* should be used. As a result of the confirmation of the correct combination of skeletal elements, the taxonomic status and the affinity of *B. sendaicus* can be discussed.

In the description of *B. sendaicus*, Hatai *et al.* (1976) pointed out that "In the external sculpture, the present scutum resembles that of *Balanus concavus* Bronn (Pilsbry, 1916, p. 100, pl. 21, fig. 1), a Pliocene species of the British Red Crag especially in cancellated sculpture, bifurcation of the longitudinal striae, general shape of scutum,...". Thus, owing to distinct growth ridges and longitudinal ridges or striations frequently bifurcated on external surface, scutum of *B. sendaicus* possesses common morphological characteristics found in scuta of all members of the *B. concavus* species group. The tergum of *B. sendaicus* described here also has a long spur and partially closed spur furrow, characteristics found in some members of the *B. concavus* group. These morphological characteristics found in *B. sendaicus* are also present in members of the *B. perforatus* species group. However, in members of the *B. concavus* group, the external surface of scutum is heavily ornamented, the aperture is small, and the carina strongly curved. Therefore, *B. sendaicus* is regarded as a member of the *B. concavus* group.

Morphological comparisons of *B. sendaicus* with the living taxa of the *B. concavus* group

According to Newman and Ross (1976), the *B. concavus* group contains the following "five" living taxa, *B. aquila* (=*B. gregarius* (Conrad), 1856; a senior synonym of *B. aquila* Pilsbry, 1907, see Zullo, 1964:360, 1969:6, 1979:4), *B. concavus concavus*, *B. c. mexicanus*, *B. eyerdami* (=*B. panamensis* Rogers, 1948; a senior synonym of *B. eyerdami* Henry, 1960, D. P. Henry, pers. comm., in Newman and Ross, 1976:102), and *B. regalis*. *B. concavus concavus* of Newman and Ross (1976) includes the two already known "*B. c. indicus*" and *B. c. sinensis* as synonyms of *B. c. concavus* (Newman and Ross, 1976). *B. c. mexicanus* lacking the transverse septa in the parietal tubes of shell wall does not belong to the *B. concavus* group in the strict sense, but is close to *B. pacificus* of the *B. perforatus* group (Newman, pers. comm.). These four extant members exclusive of *B. c. mexicanus* are living in Indo-Pacific, *B. c. concavus* in Dar-es-Salaam of Tanzania, the Persian Gulf and Hong Kong, and the other three species on the eastern Pacific. In the following paragraph, *B. sendaicus* is compared with these four "living" taxa of the *B. concavus* group on the basis of morphology.

B. gregarius (Conrad), 1856 was originally described as *Tamiosoma gregaria*, a new genus and species of a rudistid pelecypod by having the peculiar, elongate, vesiculose basis. This species is the most widespread and commonly encountered barnacle in the Miocene and Pliocene formations of central and southern California and Baja California regions (Zullo, 1964, 1969, 1979). "It was not until the opercular valves were described by Woodring", *in* Woodring *et al.* (1940), "that any

Table 1. List of members of the *B, concavus* group and geographic and stratigraphic ranges quoted from Newman and Ross (1976) except for *B. concavus concavus* and "*B. concavus indicus*". [Oligo.: Oligocene, Mio.: Miocene, Plio.: Pliocene, Pleisto.: Pleistocene]

Balanus	*bloxhamensis* Weisbord, 1966:48, fossil, (Florida; Mio.)
B.	*concavus concavus* Bronn sensu de Alessanri, 1906:295, fossil (Europe; Oligo.-Pleisto.)
B.	*c. alloplax* Pilsbry and Olsson, 1951:200, fossil, (Ecuador; Oligo.)
B.	*c. chesapeakensis* Pilsbry, 1916:103, fossil, (Maryland; Mio.)
B.	*c. coosensis* Dall, 1909:138, fossil, (Oregon; Mio.)
B.	*c. dallonii* Davadie-Suaudeau, 1952:20, fossil, (Algeria; Plio.)
B.	*c. eseptatus* Pilsbry, 1924:1, fossil, (Haiti; Mio.)
B.	*c. finchii* Lea, 1833:211, fossil, (Maryland; Mio.)
B.	*c. glyptopoma* Pilsbry, 1916:102, fossil, (east USA; Mio., Panama & east Mexico; Plio.)
B.	"*c. indicus*" Nilsson-Cantell, 1932:2, living, [Dar-es-Salaam, Tanzania]
B.	*c. oligoseptatus* Kolosváry, 1961:149, fossil, (USSR; Oligo.)
B.	*c. proteus* Conrad, 1834:134, fossil, (east USA; Mio.-Plio.)
B.	*c. raphanoides* Moroni-Ruggieri, 1952:71, fossil, (Italy; Plio.)
B.	*c. rariseptatus* Pilsbry, 1918:186, fossil, (Panama; Mio.)
B.	*c. rubescense* Seguenza, 1876:450, fossil, (Italy; Tertiary)
B.	*c. scutorum* Seguenza, 1876:74, fossil, (Italy; Plio.)
B.	*gregarius* (Conrad), 1856:315, living, [California, 0-18 m], fossil, (central, southern & Baja California; Mio.-Plio.)
B.	*indicus* Withers, 1923:291. fossil, (Pakistan; Mio.)
B.	*panamensis* Rogers, 1948:95, living, [Gulf of California to Pacific coast of Panama]
B.	*polyporus* Pilsbry, 1924:2, fossil, (Haiti; Mio.)
B.	*regalis* Pilsbry, 1916:108, living, [southern & Baja California]
B.	*sendaicus* Hatai, Masuda and Noda, 1976:13, fossil, (Japan; Mio.)
B.	*talquinensis* Weisbord, 1966:37, fossil, (Florida; Mio.)
B.	*vadászi* Kolosváry, 1949:2, fossil, (Europe; Mio.)

attempt could be made to determine the affinities of this unique species." "Woodring concluded that *B. gregarius* was related to the *B. concavus* Bronn group." "Comparison of well preserved opercular valves with those of the extant Pacific coast species *B. aquila* reveals no apparent differences. The only major distinction in the two species would appear to be a tendency for the formation of elongate cellular basis in the fossils. However, this unique basis has now been discovered in extant specimens of *B. aquila* taken by the Allan Hancock Foundation off Santa Rosa Island, California. It is probable that the prevalence of elongate basis in fossils is related to past environmental conditions (warm, shallow embayments with high sedimentation rates) which are not widespread along the Pacific coast today." (Zullo, 1964:360). The morphological characteristics of this species, such as deeply sunken radii, growth ridge of scutum divided into beads by striations, and the rather narrow spur of tergum considerably close to the basiscutal angle,

Table 2. Morphological comparisons of *B. sendaicus* with the extinct *B. concavus concavus* sensu de Alessandri (1906) and the living taxa of the *B. concavus* group. ○: agreed; × : disagreed. Informations on parietal tubes of shell wall in fossil European *B. c. concavus* and living *B. gregarius* are by courtesy of Newman (in press, pers. comm.).

	B. sendaicus	"*B. concavus indicus*"	*B. gregarius*	*B. concavus concavus*	*B. panamensis*	*B. regalis*
Shell wall	surface smooth	○	×	○	○	×
	radii wide	○	×	×	×	×
	summits of radii oblique	○	×	○	○	×
	parietal tubes with septa	×	○	○	○	○
Scutum	surface strongly sculptured	○	×	×	×	×
	adductor ridge weak	○	×	×	○	×
	spur furrow closed	×	○	○	×	○
Tergum	spur short	○	×	×	×	×
	basal margin straight	×	×	○	○	○

are different from those of *B. sendaicus.*

B. panamensis Rogers, 1948 [Holotype, Calif. Acad. Sci. Dept. Paleo. Type Coll. 9434; paratypes, 9435-9437] was collected from C. A. S. Loc. 32532 of Chame Point, Canal Zone, Panama. Nature of shell form, toothed orifice, internal and basal margins of scutum, external surface of tergum, and basal margin of tergum found in this species are similar to those of *B. sendaicus.* Relatively narrow radii in comparison with *B. sendaicus,* weakly sculptured external surface of scutum, and shallow and opened spur furrow of tergum found in this species are apparently distinct from those of *B. sendaicus.* Nevertheless, among the American living taxa *B. panamensis* resembles the fossil Japanese *B. sendaicus.*

B. regalis Pilsbry, 1916 [Holotype, USNM 43485] was described from Point Abreojos, west coast of Lower California based on shell wall without opercular valve. Rugged shell with irregularly arranged ribs of various size, extremely narrow radii, and moderately projecting and short adductor ridge of *B. regalis* distinguishes it from *B. sendaicus.* Morphological observation of opercular valves is based on samples obtained through the courtesy of Professor Newman. This species resembles *B. sendaicus* in the nature of spur furrow, parietal tubes of shell wall with transverse septa, and basal margin of tergum.

As mentioned above, the three living taxa distributed along the west coast of USA and central America are morphologically distinct from the fossil Japanese *B. sendaicus.* The morphological difference suggests the species level distinction between *B. sendaicus* and the three living taxa. Among the three living taxa, *B. panamensis* has more characters in common with *B. sendaicus* than the other two species. Thus it can be inferred that, among the living American species of the *B. concavus* group, *B. panamensis* is related to extinct *B. sendaicus.*

In Indo-Pacific area, survival of the infraspecific taxa of *B. concavus* is indicated by only three reports: Broch (1931), Nilsson-Cantell (1932) and Utinomi (1969). Their taxa were included in the *B. c. concavus* of Newman and Ross (1976). According to Newman and Ross (1976), studies on *B. c. concavus* except for the three reports mentioned above are concerned with fossil materials.

In Broch's type specimen of *B. c. sinensis* from Hong Kong, Newman and Southward "have distinguished two species, *B. reticulatus* and *B. variegatus*". "They have concluded that *B. c. sinensis* was a junior synonym of *B. variegatus* and that *B. reticulatus* of Utinomi remains valid (Newman and Southward, pers. comm.)" (Yamaguchi, 1980:1088).

Based on reexamination of Utinomi (1969)'s materials by Newman, *B. c. concavus* from the Persian Gulf reported by Utinomi (1969) is *Chirona* cf. *amaryllis* previously called *B. amaryllis,* because it does not have the parietal tubes in shell wall and has denticular ribs in inner base of parietes (Newman, pers. comm.). Therefore, the decision whether *B. c. concavus* of Newman and Ross (1976) is extant or not should be determined by reexamination of "*B. c. indicus*".

"*B. concavus indicus*" Nilsson-Cantell, 1932 was described based on only one specimen collected from a buoy in Dar-es-Salaam, Tanzania and has been preserved in the Berlin Museum. However, the type specimen can not be found in the Museum (Newman, pers. comm.). Live "*B. c. indicus*" has not been reported since 1932. Name *indicus* is preoccupied by *B. indicus* Withers, 1932. Therefore "*B. c. indicus*" is a homonym of *B. indicus.* However, both are apparently different from each other in morphology, so a replacement name is proposed by Newman (in press, pers comm.). Therefore, "*B. c. indicus*" of taxonomically invalid name is used in this paper.

Before entering to morphological comparison of *B. c. concavus* with "*B. c. indicus*", it will be historically reviewed on taxonomy of *B. c. concavus. B. concavus* was described by Bronn (1831) from the Pliocene of Andona Valley, near Asti, Piedmont, Italy (Pilsbry, 1916). However, the substance of *B. concavus* was not always clear until de Alessandri (1906)'s redescription of topotype materials.

Darwin (1854a) reported three different forms of terga under the name of *B. concavus:* 1) terga of pl. 1, figs. 4g from Coralline Crag, England (fossil) and of pl. 1, fig. 4o from Turin, Italy (fossil) having a narrow spur furrow and basal margin slightly depressed; 2) tergum of pl. 1, fig. 4k from Maryland, USA (fossil) having a very wide spur furrow and a straight basal margin; and 3) tergum of pl. 1, fig. 4m from Portugal (fossil, recent ?) having certainly opened spur furrow and basal margin slightly projected. These morphological differences are usually regarded to represent distinction of species level, therefore, it is not appropriate that those three forms of terga are summarized to a species of *B. concavus.* Darwin (1854b) also reported two different forms in terga under the name of *B. concavus.* Specimens of pl. 4, figs. 4d and 4e and specimen of pl. 4, fig. 4c in Darwin (1854b) are morphologically identical with those of pl. 1, figs. 4g and 4o and that of pl. 1, fig. 4m in Darwin (1854a) respectively.

After Darwin (1854a, b), studies of *B. concavus* have been subjected to his great influence, and three distinct forms have probably been treated as a species of *B. concavus.* This fact seems to be a main cause for the taxonomic confusion of *B. concavus.*

Revision of topotypes (pl. 16, figs. 21–25; pl. 17, figs. 1a–4b) of *B. concavus* Bronn by de Alessandri (1906) seems to be found a clue to solve the taxonomic confusion and pointed out that terga of the real *B. concavus* are identical with those of pl. 1, figs. 4g and 4o in Darwin (1854a) and of pl. 4, figs. 4d and 4e in Darwin (1854b). Therefore, *B. concavus* redescribed by de Alessandri (1906) is called *B. c. concavus* sensu de Alessandri

(1906) in this paper. It is interpreted that *B. c. concavus* of Newman and Ross (1976) contains five or more species of *B. c. concavus* sensu de Alessandri, "*B. c. indicus*", *B. c. sinensis* (=*B. amphitrite* s. l.), and at least two species of *Balanus* (?) eliminated *B. c. concavus* sensu de Alessandri from Darwin (1854a)'s *B. concavus.*

In this paper, *B. concavus* in the following references is considered to be identical with *B. concavus concavus* Bronn in the sense of de Alessandri (1906): Darwin, 1854a, p. 17 (in part), figs. 4g and 4o; Darwin, 1854b, p. 235 (in part), pl. 4, figs. 4d and 4e; de Alessandri, 1895, p. 282, pl. 2, figs. 10a-10e; Pilsbry, 1916, p. 100, pl. 21, figs. 1-1c; Davadie, 1963, p. 52, pl. 24, figs. 8-9, pl. 26, figs. 1-4, pl. 28, figs. 1a-2b; and Menesini, 1965, p. 110, pl. 28, figs. 2-6, pl. 29, figs. 1-9, pl. 30, figs. 1-4, pl. 34, figs. 7-8, pl. 35, figs. 1-2, pl. 41, figs. 3-8, pl. 42, figs. 1-8, pl. 43, figs. 1-3.

"*B. c. indicus*" and *B. c. concavus* sensu de Alessandri (1906) have common morphological characteristics, such as conical shell form, rhomboidal orifice, oblique summits of radii, external scutal surface with longitudinal striations, relative spur width for basal length of tergum, relative position of spur, shape of basal margin of tergum, etc. However, the following morphological differences are present: shell surface is smooth in "*B. c. indicus*", but costated, sulcated, festooned, or with longitudinal ribs in *B. c. concavus.* Parietal tubes of shell wall have not transverse septa in "*B. c. indicus*", but have transverse septa in *B. c. concavus* (Information on this shell structure is by courtesy of Professor Newman, pers. comm.). The adductor ridge is very low and short in "*B. c. indicus*", but prominent, long, clear and slightly curved in *B. c. concavus.* Tergal surface has longitudinal striae on carinal side of "*B. c. indicus*", but is longitudinally and transversally sulcated in *B. c. concavus.* Spur furrow is open in "*B. c. indicus*", but closed in *B. c. concavus.* The morphological resemblances show close relationship between them, however, the morphological distinctions are usually sufficient to recognize them as different species. As mentioned above, *B. c. concavus* sensu de Alessandri (1906) is neither an extant species nor "*B. c. indicus*", therefore, *B. c. concavus* is an extinct species.

B. sendaicus and *B. c. concavus* sensu de Alessandri (1906) closely resemble each other in their morphology. The common characteristics are conical shell shape, rhomboidal and toothed orifice, having transverse septa in parietal tubes of shell wall, striated external surface of scutum, etc. In *B. sendaicus,* shell wall is generally smooth, but occasionally costated in carina and carinolateral. This character resembles that of *B. c. concavus.* The two species, however, differ morphologically in the following characters: high, long and clear adductor ridge of scutum in *B. c. concavus,* but obscure in *B. sendaicus;* long spur length in *B. c. concavus,* but moderately long in *B. sendaicus;* and surface of tergum longitudinally and transverselly sulcated in *B. c. concavus,* but having only weak growth lines in *B. sendaicus.* These morphological differences are sufficient enough to distinguish them as two distinct species. Morphological resemblance, however, suggests their close relationship.

Furthermore, when *B. sendaicus* and "*B. c. indicus*" compared on the basis of morphology, they are found to resemble each other. The conical form, rhomboidal and moderately wide orifice, smooth shell surface (in *B. sendaicus,* carina and carinolateral are often costated, but generally smooth), scutum with well developed growth lines and strong striae on external surface, and crenulation of basal margin of scutum are their common character. However, they have four different characteristics: parietal tubes of shell wall have not transverse septa in "*B. c. indicus*", but have the septa at upper half of shell wall in *B. sendaicus*, though usually secondarily filled up with calcite as result of fossilization; the adductor ridge of scutum is very low and short in "*B. c. indicus*", but obscure in *B. sendaicus;* distance from basiscutal angle to spur of tergum approximately is equal to spur width in "*B. c. indicus*" (Henry and McLaughlin, 1975), but is 2/3 in *B. sendaicus* (average 25 individuals examined); and the spur furrow is open in "*B. c. indicus*", but partially closed in *B. sendaicus*. Thus, morphological distinction is clear and sufficient enough to separate them into two distinct species.

B. sendaicus was described by Hatai *et al.* (1976) based on only one scutum (Holotype). However, the shell walls of *B. sendaicus* were described under the name of *B. rostratus* Hoek, and the tergum was undescribed. Thus, *B. sendaicus* of Hatai *et al.* (1976) clearly does not agree with *B. sendaicus* redescribed here. However, as mentioned above, *B. sendaicus* redefined here is not identical with the already known living species of the *B. concavus* group.

Comparison with the extinct taxa of the *B. concavus* group

B. bloxhamensis Weisbord, 1966 [Holotype, PRI (Paleontological Research Institution) 27408] was described from the late Miocene Choctawhatchee Formation at Jackson Bluff in Leon County, Florida. This species is based on complete shells without opercular valve, and "the V-shaped cut at the summit of the radii, the longitudinal slit dividing the radii, and the vertical ridges transversing the radii, are the distinctive characters of the shell". These characters are distinct from those of *B. sendaicus.*

B. concavus alloplax Pilsbry and Olsson, 1951 [Holotype, ANSP (Academy of Natural Sciences of Philadelphia) 18869] is represented only by opercular valves from the Oligocene age of Playa Rica, Rio Santiago, Ecuador. Shell walls without opercular valves were described from another fossil locality, Posorja, Ecuador. It is difficult whether these shell walls belong to the same subspecies, until more fossil specimens from the type locality are available. The following morphological characteristics of this subspecies are distinct from those of *B. sendaicus;* scutum strongly wrinkled; tergum with "a decidedly sunken spur fasciole"; spur removed "from basiscutal angle by nearly twice width of spur".

B. concavus chesapeakensis Pilsbry, 1916 [Holotype, ANSP 1143] is based on a complete shell having scutum and tergum from the Miocene beds of Maryland. A long and high adductor ridge in its middle part, and lateral depressor muscle pit having a strongly prominent bordering ridge, parallel to adductor ridge in *B. c. chesapeakensis* distinguish it from *B. sendaicus.*

B. concavus coosensis Dall, 1909 [Holotype, USNM 153960] was originally described as a variety of *B. tintinnabulum,* based on four specimens of shell wall without opercular valves from the Miocene of Coos Bay, Oregon. As Pilsbry (1916) poined out, *B. concavus coosensis* having oblique summit radii and no porous radii is not related to *B. tintinnabulum*. Very large specimen attaining 50 mm in greatest diameter and the relatively narrow rostrum typical of *B. concavus coosensis* is not found in *B. sendaicus.*

B. concavus dallonii Davadie-Suaudeau, 1952 is based on a specimen of shell wall from the Astian (late Pliocene) of Aïr Lalla Barta, Algeria. The shell surface having ribs and striations and large orifice distinguishes it from those of *B. sendaicus.*

B. concavus eseptatus Pilsbry, 1924 [Holotype, USNM 352257] was described based on complete shell wall without opercular valve from the Miocene of Haiti. In *B. concavus eseptatus,* the radii are narrower and the orifice is larger than those of *B. sendaicus.*

B. concavus finchii Lea, 1833 was originally described as *B. finchii* Lea from the Miocene of St. Marys, Maryland. Pilsbry (1930: 432) redescribed and illustrated topotype specimens. This subspecies is distinguished from *B. sendaicus* by large orifice, weak growth ridges and a long, moderately well developed adductor ridge in scutum.

B. concavus glyptopoma Pilsbry, 1916 [Syntype, ANSP 1140] was described from the Pliocene Caloosahatchie Formation, Florida. The rather numerous small ribs, sometimes weak or nearly obsolete on the surface of parietes, a strong but rather short adductor ridge, and a short, widely obliquely truncated spur of this subspecies distinguish it from *B. sendaicus.*

B. concavus oligoseptatus Kolosváry, 1961 [Holotype preserved in Coll. Mus. Inst. Syst. Zool. Univ. Szeged] from the upper Oligocene of Kizil-Kum, USSR has level summits radii and large orifice, which are different characteristics from *B. sendaicus.*

B. concavus proteus Conrad, 1834 was described based on specimens from James River, Suffolk, and Yorktown, Virginia. This subspecies is characterized by strong ribs on the external shell wall, and slightly well developed adductor ridge. These morphological characteristics are not present in *B. sendaicus.*

B. concavus raphanoides Moroni-Ruggieri, 1952 [Holotype, Cirr. 342] from the Pliocene of Bagni of Casciana, Italy is represented by an internal mould of shell wall. The characteristic cup-shaped base, cylindrical form and wide orifice of this subspecies are not present in *B. sendaicus.*

B. concavus rariseptatus Pilsbry, 1918 [Holotype, USNM 324292] is based on one cluster of shell walls without opercular valves from the Miocene Gatum Formation of Panama Canal Zone. The slightly longitudinally roughened walls of characteristic of this subspecies are not present in *B. sendaicus.*

B. concavus rubescens Seguenza, 1874 was originally described as a variety of *B. concavus* from the Tertiary formation of the province of Messina, Italy. In *B. concavus rubescens,* the growth ridges of scutum are scarcely detectable and the longitudinal striations on external surface of scutum are weak. These morphological characteristics are distinct from those of *B. sendaicus.*

B. concavus scutorum Seguenza, 1876 was described as a distinct species *B. scutorum* from the province of Messina, Italy. The following morphological characteristics of this subspecies are different from those of *B. sendaicus:* surface of scutum with fine longitudinal striations; spur width nearly equal to 1/3 basal length of tergum; narrow spur furrow; distinctly prominent adductor ridge.

B. indicus Withers, 1923 [Holotype, In. 20233] was reported from the Miocene of Karachi, Mouth of the Indus. This species is distinguished from *B. sendaicus* by rather deeply sunken radii, narrowly spaced and weakly prominent growth ridges on scutum, and spur fasciole in tergum.

B. polyporus Pilsbry, 1924 [Holotype, USNM 352258] from the Miocene of Haiti is represented by only one shell wall specimen. The somewhat roughened wall surface and rostrum notably longer than the other plates distinguish it from *B.*

sendaicus.

B. talquinensis Weisbord, 1966 [Holotype, PRI 27374] was described from the Miocene Choctawhatchee Formation at Jackson Bluff in Leon County, Florida. The following morphological characteristics of *B. talquinensis* are distinct from those of *B. sendaicus:* small beads or nodules are found at the intercepts of the radial riblets with the growth ridges of scutum; adductor ridge of scutum is high and long; spur furrow of tergum is shallow and moderately wide.

B. vadászi Kolosváry, 1949 was reported from the early Miocene of Felsötarkány, Hungary. Compartments with narrow radii and coarse white ridges on surface and scutum without longitudinal striations on external surface of *B. vadászi* are not found in *B. sendaicus.*

In conclusion, as mentioned above, *B. sendaicus* is not identical with any of the already known living and extinct taxa of the *B. concavus* group, and is surely a distinct species as pointed by Hatai *et al.* (1976). However, because *B. sendaicus* based on a single scutum of Hatai *et al.* (1976) is not entirely identical with that of this paper based on complete specimens and description given by Hatai *et al.* (1976) is too brief, *B. sendaicus* is redescribed here.

Systematic Paleontology

Superfamily Balanoidea Leach, 1817
Family Balanidae Leach, 1817
Genus *Balanus* Da Costa, 1778

Balanus sendaicus Hatai, Masuda and Noda, 1976

[Pl. 44, Figs. 1-6, Pl. 45, Figs. 1-9, Pl. 46, Figs. 1-22, Pl. 47, Figs. 1-22, Pl. 48, Figs. 1-3, Text-fig. 1]

Balanus concavus Bronn: Yamaguchi, 1974, p. 218, pl. 67, figs. 9-10.

Balanus rostratus Hoek: Hatai, Masuda and Noda, 1976, p. 14, pl. 2, figs. 1, 2, 13-17, 19-21.

Balanus sendaicus Hatai, Masuda and Noda, 1976, p. 13, pl. 2, figs. 1 (same specimen as fig. 20), 9 (same specimen as fig. 10, Holotype, missing), 10, 14-17, 19, and 20.

Explanation of Plate 44

Balanus sendaicus Hatai, Masuda and Noda, 1976
from the Miocene Moniwa Formation

All specimens were illustrated under the name of *Balanus rostratus* Hoek in plate 2 of Hatai *et al.* (1976) and were deposited in the Saito Ho-on Kai Museum, Sendai, Japan.

[Hatai, *et al.*'s specimens are not accompanied with registration number.]

Fig. 1. 1a-b, shell wall (same specimen as pl. 2, figs. 1 and 20 of Hatai *et al.*) on gravel, ×1.

Fig. 2. 2a-c, shell walls (same specimens as pl. 2, fig. 2 of Hatai *et al.*) on a brachiopod shell of *Coptothyris grayi miyagiensis* Hatai, Masuda and Noda, 2a, ×1. 2b-c, ×2. 2d-k, opercular valves preserved in the shell cavity of shall (left) [These opercular valves were not found by Hatai *et al.*), ×5; 2d-e, right scutum. 2f-g, right tergum. 2h-i, left scutum [morphologically identical with Holotype (missing), pl. 2, figs. 9 and 10 of Hatai *et al.*], 2j-k, left tergum.

Fig. 3. 3a-b, shell wall (same specimen as pl. 2, fig. 14 of Hatai *et al.*) on a brachiopod shell of *Coptothyris grayi miyagiensis*, 3a, ×1. 3b, ×2.

Fig. 4. 4a-b, shell wall (same specimen as pl. 2, fig. 15 of Hatai *et al.*) on a brachiopod shell of *Coptothyris grayi miyagiensis*, 4a, ×1. 4b, ×2.

Fig. 5. 5a-b, shell walls (same specimens as pl. 2, fig. 19 of Hatai *et al.*) on a molluscan shell of *Anomia* sp., 5a-b, ×1.

Fig. 6. 6a-b, shell walls (same specimens as pl. 2, figs. 16 and 17 of Hatai *et al.*) on gravel, ×1.

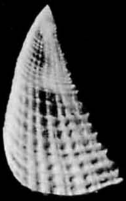

1a

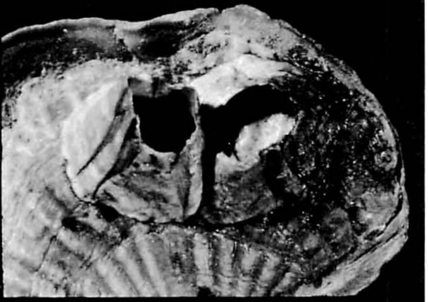

2a

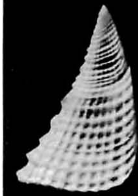

2b


1b


2i


2h


2c


2d


2e


2k

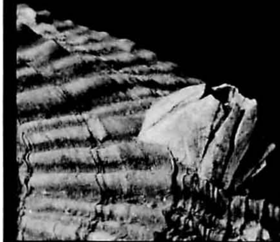

2j

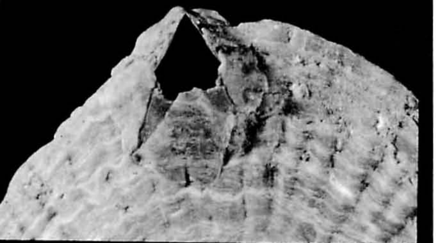

4a


2f


2g

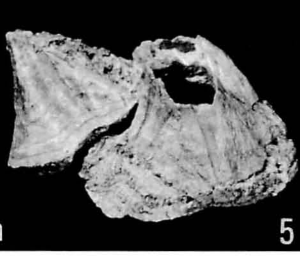

3a


3b

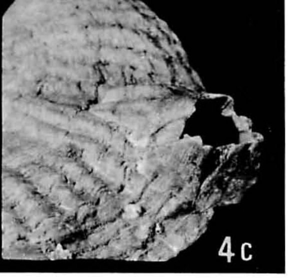

4b


6a


5a


5b


6b


4c

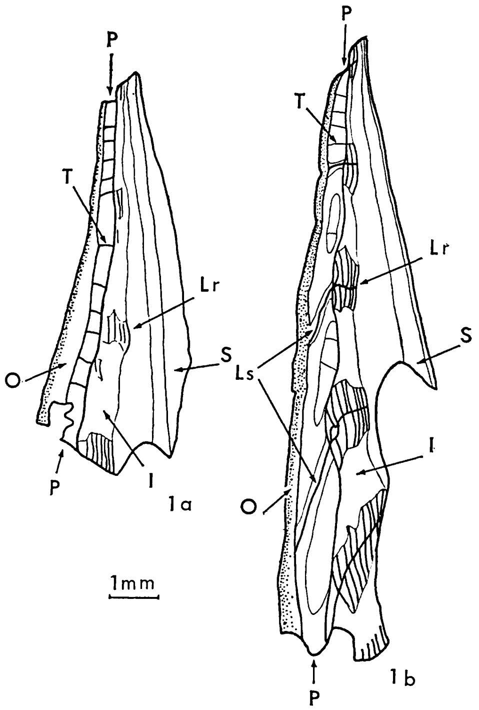
Description.—General appearance.-Shell conical and smooth often with weak longitudinal ribs. Color of shell ivory yellow, frequently with very fine striations of pale reddish purple or tinted with pale reddish purple near orifice or on the shell wall. Orifice toothed.

Compartments.-Parietes very wide in rostrum and lateral. Radii wide in rostrum and lateral, and moderately wide in carinolateral and carina; summits oblique. Sheath solid. Parietal (longitudinal) tubes with transverse septa in upper half of shell wall. Parietal tubes usually secondarily filled up with calcite as the result of fossilization. Those transverse septa usually not found by soft X radiographs (Pl. 48, Figs. 15-19), although, they observable in the longitudinal thin section of shell wall (Text-fig. 1, Pl. 48, Figs. 1-3).

Base.-Calcareous.

Opercular plates.-Scutum slightly concave externally with narrowly inflected tergal segment; basal angle obliquely truncated; external surface with prominent and crenulate growth ridges and moderately prominent longitudinal ridges frequently bifurcated by the weak longitudinal striae; nodes observable at the connection between the ridges; these ridges circumscribing square depressions ("rather coarsely latticed sculpture" as pointed by Pilsbry, 1916:101); color ivory yellow; inner surface smooth on upper part; articular ridge moderately projected, reflexed and greater than 1/2 length of tergal margin; articular furrow narrow and shallow; adductor ridge weak or hardly visible; pit for adductor muscle wide and deep; pit for lateral depressor muscle wide and deep; inner surface of basal margin faintly crenulated.

Tergum flat, moderately wide with a weakly developed beak (Pl. 44, Figs. 2f-g); external surface smooth with fine growth lines; color ivory yellow, tinted with pale reddish purple near apex between spur furrow and carinal margin; basal margin of both sides of spur approximately straight; spur furrow extremely narrow in young specimens or partially closed in large specimens and slightly sunken; spur rounded at end and with several very weak projections on inner surface of basal margin; spur width approximately 1/3 length of basal margin



Text-fig. 1. Shell structures in longitudinal sections of a rostrum (UMUT CA9686) from the Miocene Moniwa Formation (Loc. 4). Photos for Text-figs. 1a-b are shown in Pl. 48, Figs. 1-2. 1a, a parietal tube with transverse septa in a longitudinal section parallel to the parietal (longitudinal) tube. 1b, parietal tubes with transverse septa in an oblique longitudinal section. I: inner lamina, Lr: longitudinal rib, Ls: longitudinal septum, O: outer lamina, P: parietal tube, S: sheath, T: transverse septum.

or less; distance between basiscutal angle and anterior side of spur nearly equal to 1/3 length of spur width; crests for depressor muscle well developed; rest of inner surface smooth.

Stratigraphic and geographic ranges, definition of *B. c. concavus* and habitat

The straigraphic range of each member of the *B. concavus* group summarized by Newman and Ross, 1976 is shown in Table 1. The oldest record is the Oligocene of Nurri, Sardinia Is. and Capo S. Elia, Cagliari, Italy concerning *B. c. concavus* (de Alessandri, 1906), of Pomaz and God, Hungary concerning *B. c. concavus* (Kolosváry, 1943), of Ecuador concerning *B. c. allopax* (Kolosváry, 1943), of Budafork concerning *B. c. chesapeakensis* and *B. c. glyptopoma* (Kolosváry, 1943), and of Kizil-Kum, USSR concerning *B. c. oligoseptatus* (Kolosváry, 1943). The youngest record is the Pleistocene of Monte Mario, Roma; Civitavecchia, Palo; and Sciacca, Sicilia Is., Italy concerning *B. c. concavus* (de Alessandri, 1895, 1906), of Pisa province, Italy concerning *B. c. concavus* (Menesini, 1965), and of Monastir, Tunisia concerning *B. c. concavus* (Davadie 1963), etc. However, most of the fossils were obtained from the Miocene and Pliocene.

There are two critical and important problems of stratigraphic distribution of the *B. concavus* group:

1) Most of *B. c. concavus* reported in the literature appear only as listed occurrence of fossil and/or have only brief morphological description without illustration. Are most of these specimens identical with *B. c. concavus* in the sense of de Alessandri (1906, pl. 16, figs. 21-25; pl. 17, figs. 1a-4b), based on reexamination of topotypes of Bronn (1831)'s *B. concavus?* The writer discussed precisely on *B. concavus* of Darwin (1854a, b) and of de Alessandri (1906) in the preceding line.

2) Geologic age-determination in Neogene and Quaternary were advanced by biostratigraphy based on planktonic microfossils since 1950's and by magnetostra-

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Explanation of Plate 45

Balanus sendaicus Hatai, Masuda and Noda, 1976

All specimens are topotypes from Loc. 4 of the early to middle Miocene Moniwa Formation and preserved in University Museum, University of Tokyo (UMUT).

Fig. 1. a complete shell (UMUT CA9641). 1a-b, a shell wall (conical form), ×1. 1c, four opercular valves articulated, ×2.

Fig. 2. a complete shell (UMUT CA9642). 2a-b, a shell wall (cylindrical form), ×1.5. 2c-j, four opercular valves, ×2.5; 2c-d, right scutum. 2e-f, left scutum. 2g-h, right tergum. 2i-j, left tergum.

Fig. 3. a complete shell (UMUT CA9643). 3a-c, a shell wall (cylindrical form), ×1.5. 3d-k, four opercular valves, ×2.5; 3d-e, right scutum. 3f-g, left scutum. 3h-i, right tergum. 3j-k, left tergum.

Fig. 4. a shell wall (UMUT CA9644). 4a-b, ×1.5 (a single right scutum preserved in shell cavity).

Fig. 5. an aggregation of shell walls (UMUT CA9645), ×1.5.

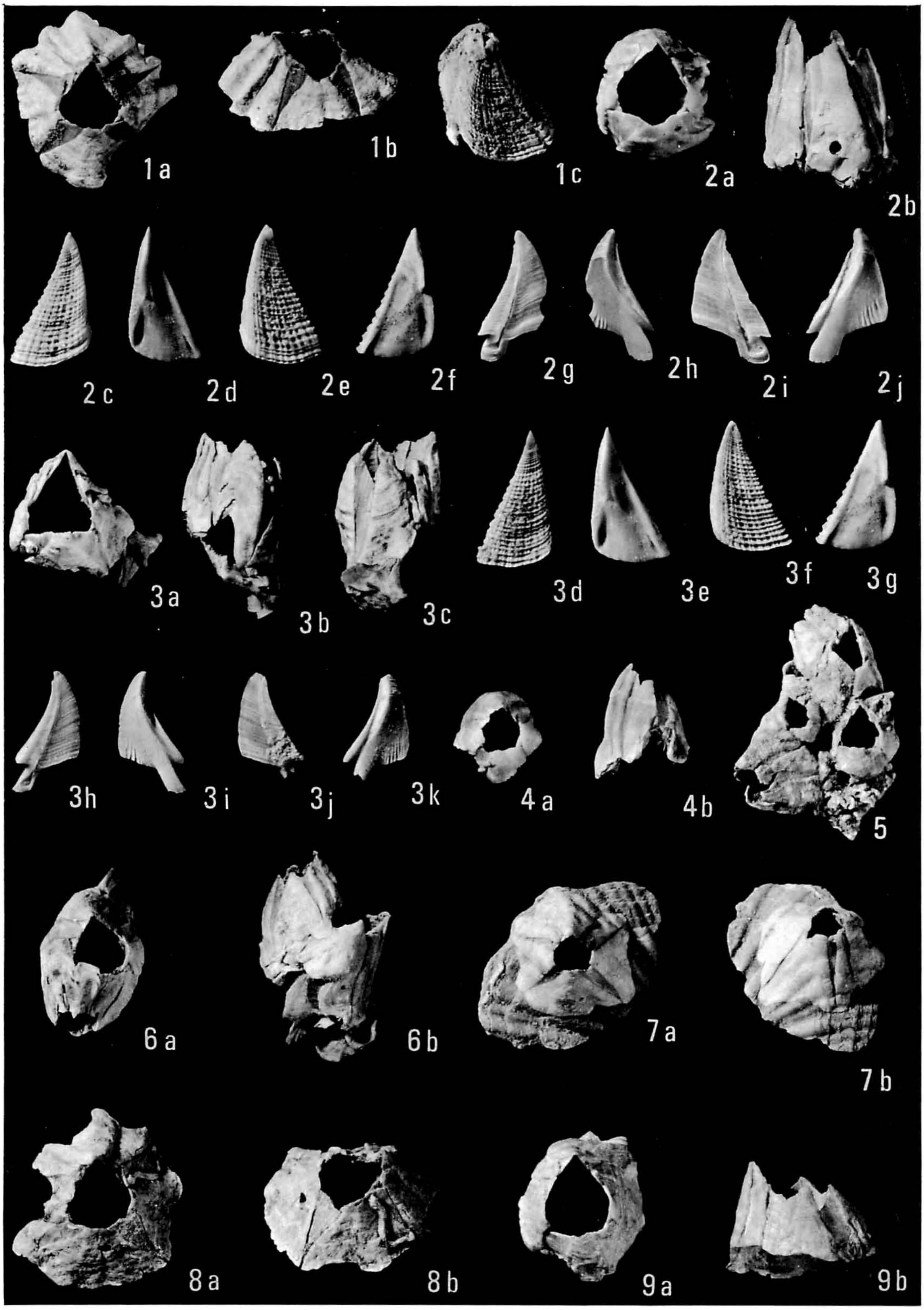
Fig. 6. shell walls (UMUT CA9646). 6a-b, ×1.5.

Fig. 7. a shell wall (UMUT CA9688) on fragment of brachiopod shell. 7a-b, ×1.5.

Fig. 8. a shell wall (UMUT CA9647). 8a-b, ×1.

Fig. 9. a shell wall (UMUT CA9648). 9a-b, ×1.

YAMAGUCHI: Miocene Cirriped Balanus sendaicus *Plate 45*



tigraphy based on paleomagnetic polarity in sediments since 1970's. Determination of the stratigraphic range of *B. concavus* requires knowledge of the precise geologic age of the sampling horizons. However, many previous studies of *B. concavus* did not incorporate the current stratigraphic method mentioned above in age-determination, because they were published before the recent advance of age-determination.

Stratigraphy of Italy, based on modern geologic views, was established after the World War II and thus the geologic ages published before the World War II will have to be compared with the advanced stratigraphy and geologic age.

Therefore, in case where these two important problems of identication or definition of species and geologic age are not concurrently solved, discussion on stratigraphic and evolutionary change of *B. c. concavus* or other members of the *B. concavus* group should be restricted until the precise range of the *B. concavus* group in Mediterranean region is summarized.

The fossils of this group were found in areas surrounding the Mediterranean, corresponding to the western part of Tethys Sea (Oligocene-Pleistocene), England (Pliocene), west Atlantic coast of North and South America (Pliocene), the east Pacific coast from California to Mexico (Miocene-Pliocene), and east Pacific coast of Peru (Pleistocene). One noteworthy result is, as pointed by Pilsbry (1916), that this group had flourished from the Miocene to Pliocene and had lived in the Atlantic and the Mediterranean region until Pleistocene, but is extinct in this region ever since, though its members continuously live on the east Pacific coast of California and Baja Cailfornia at present. The disappearance of this group from the Atlantic and the Mediterranean region in Pleistocene is a mystery.

In the east Pacific region, after the closure of Panama isthmus in the Miocene, three species: *B. gregarius* (=*B. aquila*, a junior synonym of *B. gregarius*), *B. panamensis*, and *B. regalis*, live in the California and Oregonian Provinces from California to Peru-Chile. They are relicts of the Tethys (Newman, 1979). *B. gregarius* is endemic to the narrow Transition Zone (about 4° in latitude) in between California and Oregonian Provinces (Newman, 1979). The nature of this "so-called 4° short-range endemism" is discussed in detail by Newman (1979).

Japanese fossil *B. sendaicus* is the first record of this species group from the western Pacific area. *B. sendaicus* were collected from several localities of northern Honshu, Japan. The geologic age is restricted to the Miocene.

B. sendaicus occurs in association with extinct pectinid *Chlamys kaneharai*, brachiopods and bryozoans from the type locality of this species (Loc. 4). Brachiopods are well preserved, and the majority of them are articulated. Bryozoans have fine and reticulated structure, and are also well preserved. Shells of *B. sendaicus* are chiefly found as fragmental, skeletal elements, however, some of shells are complete shell walls and in some cases opercular valves are preserved in their shell cavities. These facts seem to indicate that those fossils were not transported so far away from their habitat. Those fossils associated indicate the paleoenvironment of moderately strong water agitation. The habitat of *B. sendaicus* is also presumed from the nature of fossil assemblage and sediments at the other fossil localities of *B. sendaicus*.

Conclusion

The description of *Balanus sendaicus*

Hatai, Masuda and Noda (1976) was based on a single scutum, but it could not found out in the Saito Ho-on Kai Museum, Sendai. Study of topotype materials suggests that *B. sendaicus* is conspecific with shell walls incorrectly identified as *B. rostratus* Hoek by Hatai *et al.* (1976). *B. sendaicus,* based on scuta, terga and shell walls, is distinct from the known taxa, and is a good species as proposed by by Hatai *et al.* (1976). *B. sendaicus* is redescribed on the basis of skeletal elements of the topotypes.

B. sendaicus belongs to the *B. concavus* group based on having transverse septa in parietal tubes of shell wall and the characteristic ornamentation of scutum and seems to have derived from the closely related *B. concavus concavus* Bronn sensu de Alessandri (1906) which has mainly lived in the Mediterranean region of Italy and its adjacent areas from the Oligocene to the Pleistocene.

Darwin (1854a, b)'s *B. concavus* includes two or more taxa which are morphologically distinct from true *B. concavus concavus*. Newman (in press) reexamined based on the materials of Darwin (1854a, b), and recognized three taxa including true *B. concavus concavus* (Newman, pers. comm.). It is difficult to decide whether or not extinct infraspecific taxa of *B. concavus* are distinct from the other taxa, judging from their brief descriptions and their incomplete assemblage of skeletal elements. Their taxonomic positions will be valid by the Zoological Nomenclature, however, their holotypes and topotypes are necessary to be reexamined from the modern taxonomic point of view.

Acknowledgments

The author wishes to thank Professor William A. Newman, Scripps Institution of Oceanography, who kindly read the manuscript, and provided with invaluable comments and living American species of the *B. concavus* group for comparative study. The author is also indebted to Professor Elena Menesini for providing invaluable informations of the European *B. concavus*.

Thanks are due to Professor Tetsuro Hanai, University of Tokyo for reading the manuscript and giving valuable advice. I am greateful to Dr. Paul Frydl of our Institute for the reading of the draft

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Explanation of Plate 46

Balanus sendaicus Hatai, Masuda and Noda, 1976

All specimens are topotypes from Loc. 4 of the early to middld Miocene Moniwa Formation and preserved in University Museum, University of Tokyo (UMUT).

Figs. 1-4. rostrum, ×1.2. 1a-b, (UMUT CA9649). 2a-b, (UMUT CA9650). 3a-b, (UMUT CA9651). 4a-b, (UMUT CA9652).

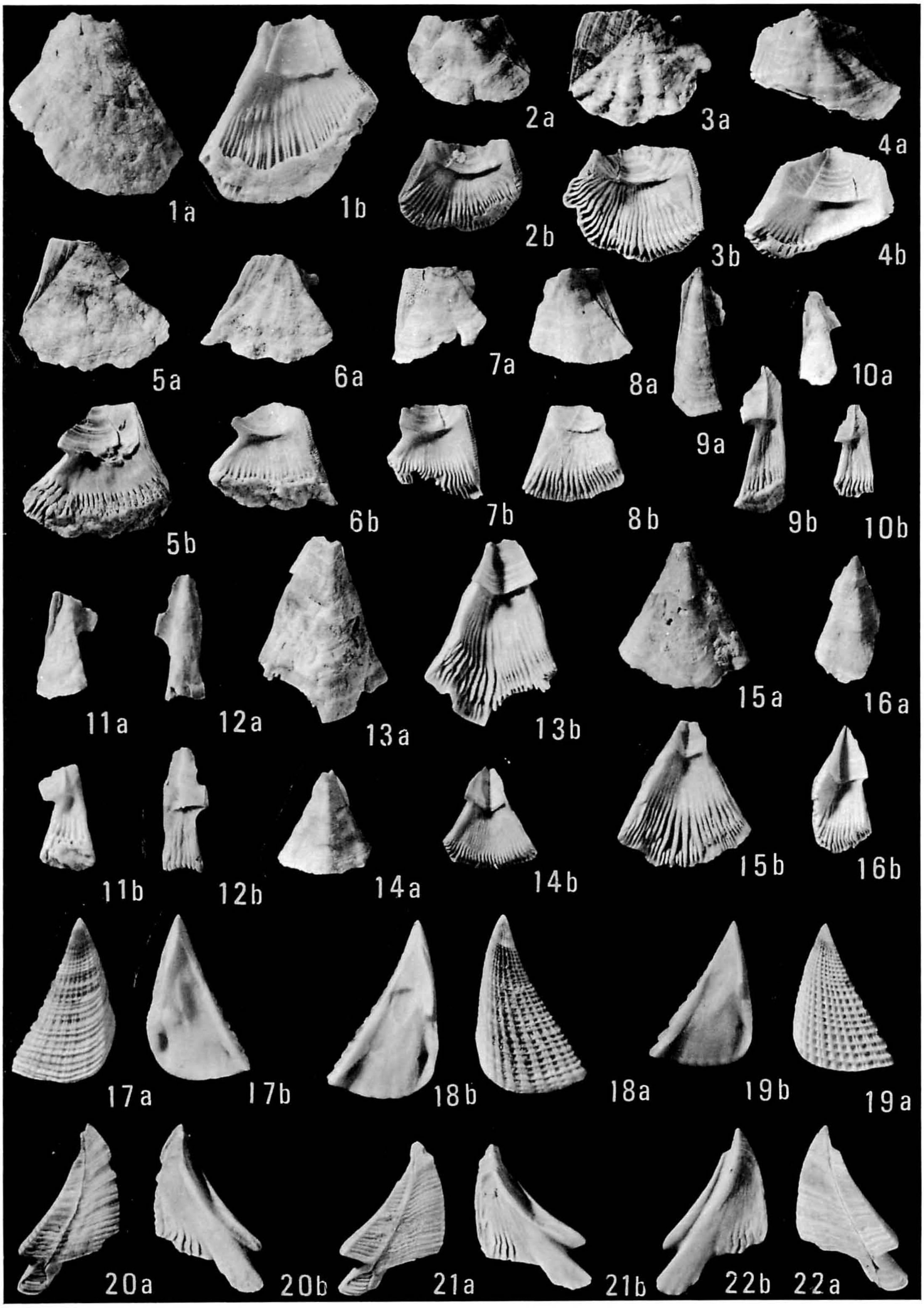
Figs. 5-8. lateral, ×1.2. 5a-b, left, (UMUT CA9653). 6a-b, left, (UMUT CA9654). 7a-b, left, (UMUT CA9655). 8a-b, right, (UMUT CA9656).

Figs. 9-12. carinolateral, ×1.2. 9a-b, left, (UMUT CA9657). 10a-b, left, (UMUT CA9658). 11a-b, left, (UMUT CA9659). 12a-b, right, (UMUT CA9660).

Figs. 13-16. carina, ×1.2. 13a-b, (UMUT CA9661). 14a-b, (UMUT CA9662). 15a-b, (UMUT CA9663). 16a-b, (UMUT CA9664).

Figs. 17-19. scuta. 17a-b, right, (UMUT CA9665), ×3. 18a-b, left, (UMUT CA9666), ×2.5. 19a-b, left, (UMUT CA9667), ×2.5.

Figs. 20-22. terga, ×2.5. 20a-b, right, (UMUT CA9668). 21a-b, right, (UMUT CA9669). 22a-b, left, (UMUT CA9670).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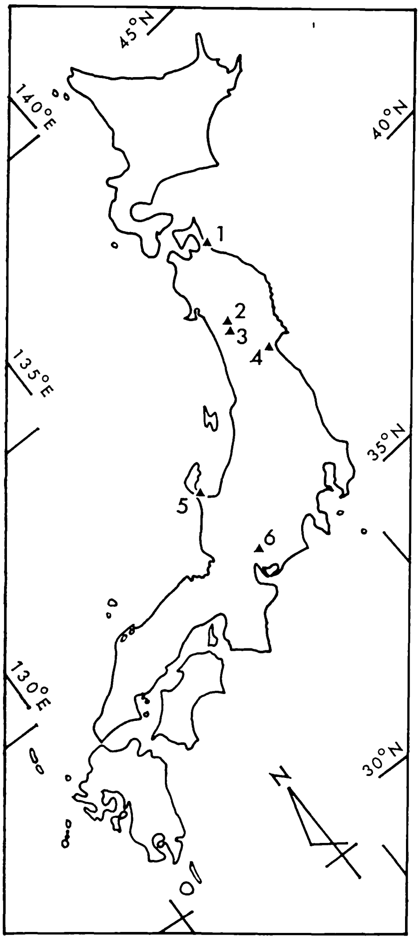


Text-fig. 2. Sampling localities of fossil *Balanus sendaicus*. Details for each site are given in the section Locality.

manuscript. I am indebted to Dr. Koichiro Masuda of Miyagi University of Education and Dr. Sadako Takeuchi of the Saito Ho-on Kai Museum for lending the type materials of Hatai, Masuda and Noda (1976). Thanks are also due to Dr. Junji Itoigawa of Nagoya University and Mizunami Fossil Museum for providing fossil specimens of the Mizunami area. This study was supported in part by Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture, project no. 434042.

Locality

1a-b.—Obuchi: a) cliff (40°58′55.1″N, 141° 21′42.9″E) along the Oippe river, situated about 2.85 km N26°W of Obuchi, Rokkasho-mura, Kamikita-gun, Aomori Pref., cross-laminated coarse shell sand (“coquina”)., b) cliff (40°58′55.1″N, 141°20°49.3″E) along the Oippe river, situated about 3.55 km N44°W of Obuchi; cross-laminated coarse shell sandstone (“conquina”)., a-b) late Miocene Takahoko Formation.

2a-c.—Ohmagari: a) shell quarry at Arasawa (39°24′16.2″N, 140°21′4.2″E), Minami-Soto-mura, Senpoku-gun, Akita Pref.; barnacle shell sand (“coquina”)., b) cliff (39°21′34.1″N, 140°21′42.1″E) at Asizawa Pass of Takinoue, Ohmori-machi, Hiraga-gun, Akita Pref.; massive poorly sorted tuffaceous sandstone containing carbonaceous matter., c) cliff (39° 22′6.5″N, 140°21′42.1″E) of left bank of creak situated about 1 km north of Loc. 2b; massive poorly sorted tuffaceous fine sandstone containing carbonaceous matter., a-c) late Miocene Sugota Formation.

3.—Ukibuta: cliff (39°18′47.8″N, 140°20′41.1″E) situated about 100 m east of Ukibuta Tunnel, Ukibuta, Higashi-Yuri-mura, Yuri-gun, Akita Pref.; poorly sorted, tuffaceous, coarse sandstone; late Miocene Sugota Formation.

4.—Sendai: cliff (type locality of *B. sendaicus*) (38°12′45.4″N, 140°47′26.9″E) situated about 200 m south of the Oide Bridge across the Natori river, Moniwa, Sendai City, Miyagi Pref.; poorly sorted, gravelly, calcareous, medium, shell sandstone; early to middle Miocene Moniwa Formation.

5.—Nanao: cliff (37°2′23.5″N, 136°57′23.4″E) situated about 0.95 km N85°W of Nanao Station, Iwaya-cho, Nanao City, Ishikawa Pref.; cross-laminated conglomeratic coarse shell sandstone containing many bryozoans; late Miocene Nanao Calcareous Sandstone.

6a-b.—Mizunami: a) cliffs (35°23′32.5N″, 137°16′35.6″E) situated about 3.5 km N32°E of Mizunami Station, Dan, Mizunami City, Gifu Pref.; conglomeratic very coarse sandstone., b) cliff (35°22′25.7″N, 137°16′28.6E) situated about 1.95 km N61°E of Mizunami Station, Sakurado, Mizunami City., a-b) late Miocene

Oidawara Formation.

References

Arnold, R. (1907) : New and characteristic species of fossil mollusks from the oil-bearing Tertiary Formation of southern California. *Proc. U.S. Natl. Mus.*, vol. 32, no. 1545, p. 525-546.

Beal, C. (1948) : Reconnaissance of the geology and oil possibilities of Baja California, Mexico. *Geol. Soc. Am. Mem.*, vol. 31, p. 1-138.

Broch, H. (1931) : Indomalayan Cirripedia. Papers from Dr. Th. Mortensen's Pacific Expedition 1914-1916, LVI. *Vidensk. Medd. Dan. naturhist. Foren.*, vol. 93, 146 pp.

Conrad, T.A. (1834) : Description of new Tertiary fossils from the southern states. *J. Acad. Nat. Sci. Philadelphia, ser.* 1, vol. 7, p. 130-157.

—— (1856) : Descriptions of three new genera and twenty three species of middle Tertiary fossils from California, and one from Texas. *Proc. Acad. Nat. Sci. Philadelphia,* vol. 8, p. 315.

Dall, W.H. (1909) : Contributions to the Tertiary paleontology of the Pacific coast. 1. The Miocene of Astoria and Coos Bay, Oregon. *U.S.G.S. Prof. Paper,* no. 59, 142 pp.

Darwin, C. (1854a) : A monograph on the fossil Balanidae and Verrucidae of Great Britain. Palaeontogr. Soc. London, 44 pp.

—— (1854b) : A monograph on the subclass Cirripedia with figures of all the species. The Balanidae, the Verrucidae, etc. Ray, Soc. London, 684 pp.

Davadie, C. (1963) : Étude des Balanes d'Europe et d'Afrique. Systematique et structure des Balanes fossiles d'Europe et d'Afrique. Ed. Centre Natl. Rech. Sci. (C.N.R.S.), Paris, 146 pp.

Davadie-Suaudeau, C. (1952) : Contribution à l'étude des Balanides Tertiaires de l'Algeria. *Bull. Serv. Carte Géol. Alger., sér. 1,*

Explanation of Plate 47

Balanus sendaicus Hatai, Masuda and Noda, 1976

All specimens are from various localities of the Miocene and preserved in University Museum, University of Tokyo (UMUT).

Fig. 1. Specimen from the late Miocene Takahoko Formation (Loc. 1). 1a-b, left scutum (UMUT CA9671), ×2.5.

Fig. 2. Specimen from the late Miocene Sugota Formation (Loc. 2a). 2a-b, left scutum (UMUT CA9672), ×2.5.

Figs. 3-5. Specimens from the late Miocene Sugota Formation (Loc. 2b). 3a-b, left scutum (UMUT CA9673), ×4. 4a-b, left scutum (UMUT CA9674), ×4. 5a-b, right scutum (UMUT CA9675), ×4.

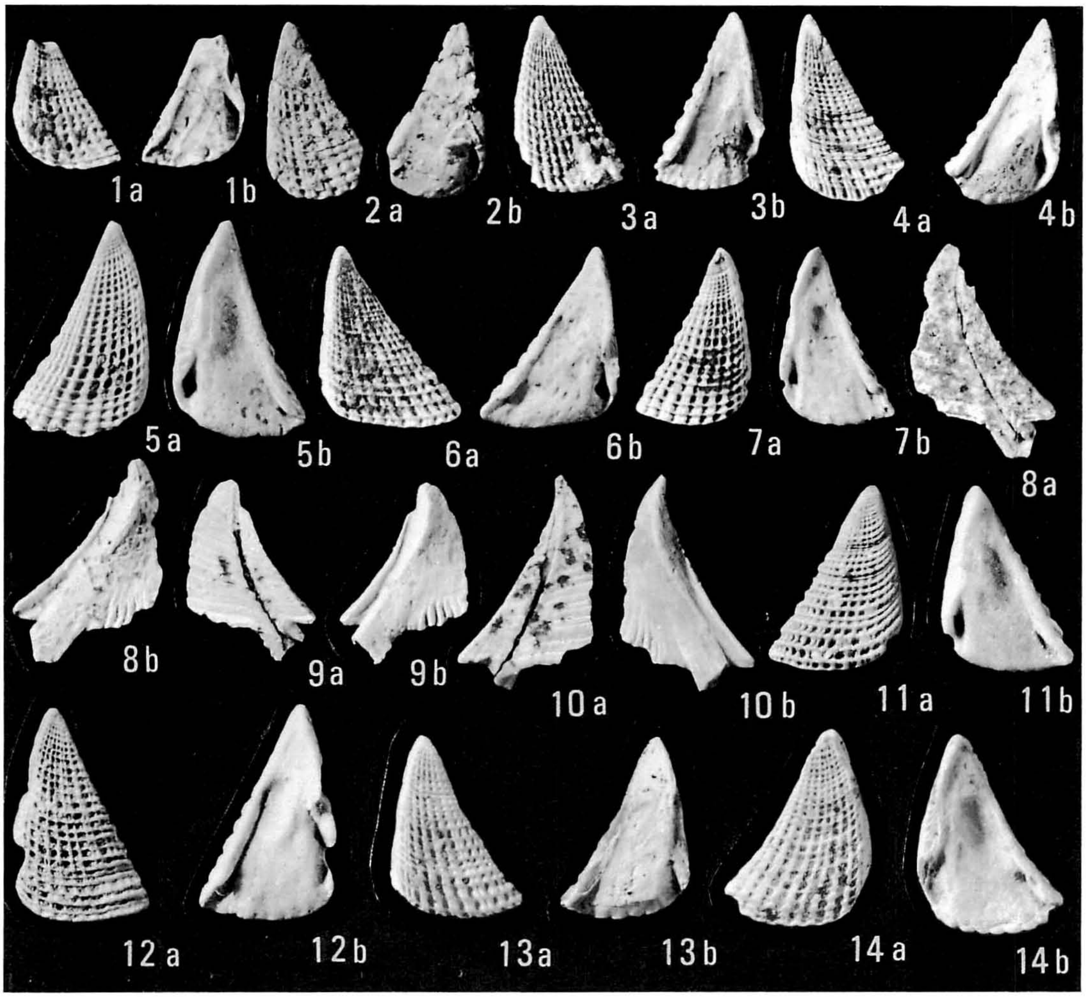
Figs. 6-10. Specimens from the late Miocene Sugota Formation (Loc. 2c). 6a-b, left scutum (UMUT CA9676), ×3. 7a-b, right scutum (UMUT CA9677), ×4. 8a-b, left tergum (UMUT CA9678), ×4. 9a-b, left tergum (UMUT CA9679), ×4. 10a-b, right tergum (UMUT CA9680), ×4.

Figs. 11, 12. Specimens from the late Miocene Nanao Calcareous Sandstone (Loc. 5). 11a-b, right scutum (UMUT CA9681), ×4. 12a-b, left scutum (UMUT CA9682), ×4.

Figs. 13, 14. Specimens from the late Miocene Oidawara Formation (Loc. 6b). Coll. Mizunami Fossil Museum, Mizunami, Gifu Pref. 13a-b, left scutum (UMUT CA9683), ×2.5. 14a-b, right scutum (UMUT CA9684), ×3.

Figs. 15-19. X-radiographs of topotype specimens from the Miocene Moniwa Formation (Loc. 4), ×1. 15, carina (UMUT CA9661). 16, rostrum (UMUT CA9649). 17, rostrum (UMUT CA9651). 18, rostrum (UMUT CA9652). 19, left lateral (UMUT CA9653).

Figs. 20-22. Interlaminate figures observed in thin section parallel to the base of shell wall (Loc. 4). 20, carina (UMUT CA9685). 21, rostrum (UMUT CA9686). 22, left lateral (UMUT CA9687).

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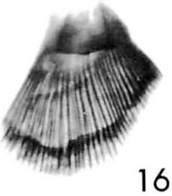
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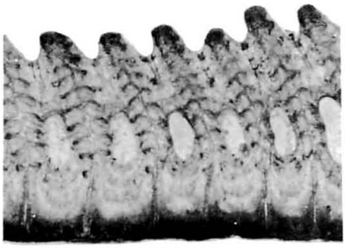
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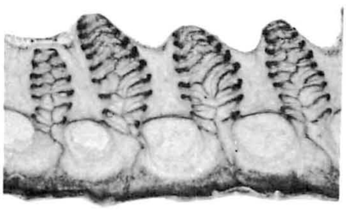
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Paléont., no. 14, p. 8-109.

de Alessandri, G. (1895) : Contribuzione allo studio dei Cirripedi fossili d'Italia. *Soc. Geol. Ital. Boll.*, vol. 13, no. 3, p. 234-314.

—— (1906) : Studi monografici sui Cirripedi fossili d'Italia. *Palaeontogr. Italica*, vol. 12, p. 207-324.

Emerson, W. and Hertlein, L. (1960) : Pliocene and Pleistocene invertebrates from Punta Rosalia, Baja California, Mexico. *Am. Mus. Novit.*, no. 2004, p. 1-8.

Hatai, K., Masuda, K., and Noda, H. (1973) : Marine fossils from the Moniwa Formation distributed along the Natori River, Sendai, Northeast Honshu, Japan. Part 1. Brachiopoda from the Moniwa Formation. *Saito Ho-on Kai Mus. Res. Bull.*, no. 42, p. 9-19.

—— (1974a) : Ditto. Part 2. Problematica from the Moniwa Formation. *Trans. Proc. Palceont. Soc. Japan, n.s.*, no. 95, p. 364-370.

—— (1974b) : Ditto. Part 3. Shark teeth from the Moniwa Formation. *Saito Ho-on Kai Mus. Res. Bull.*, no. 43, p. 9-25.

—— (1947c) : Ditto. Part 4. A new species of *Chlamys*. *Ditto*, no. 43, p. 35-41.

—— (1976) : Ditto. Part 5. Some balanomorphs from the Moniwa Formation. *Ditto*, no. 44, p. 9-21.

Henry, D.P. (1941) : Notes on some sessile barnacles from Lower California and the west coast of Mexico. *Proc. New England Zool. Club*, v. 18, p. 99-106.

—— (1960) : Thoracic Cirripedia of the Gulf of California. *Univ. Washington Publ. Oceanogr.*, vol. 4, no. 4, p. 135-158.

—— and McLaughlin, P.A. (1975) : The barnacles of the *Balanus amphitrite* Complex (Cirripedia, Thoracica). *Zool. Verhandel.*, no. 141, 254 pp.

Kolosváry, G. (1943) : Cirripedia Thoracica in der Sammlung des Ungarishen National-Museums. *Ann. Hist. Nat. Mus. Natl. Hungarici, Zool.*, vol. 36, p. 67-120.

—— (1949) : Új Balanidak a hazai harmadkorból. *Földtani Közlöny*, vol. 79, nos. 1-4, p. 1-8.

—— (1960) : New fossil balanid localities in Hungary. *J. Paleont.*, vol. 34, no. 3, p. 590-591.

—— (1961) : Further fossil balanids from the USSR. *Acta. Biol. Szeged (n. ser.)*, vol. 7, nos. 3-4, p. 149-154.

—— (1962) : New data to the balanida-fauna of the Burdigalien of Karakum. *Ditto.* vol. 8, nos. 1-4, p. 199-202.

Lea, I. (1833) : Description of six new species of fossil shells from the Tertiary of Maryland and New Jersey. (*in* Contributions to Geology). Carey, Lea & Blanchard, Philadelphia, p. 211-220.

Menesini, E. (1965) : Caratteri morfologici e strutture microscopica di alcune specie de Balani neogenici e quaternari. *Palaeontogr. Italica*, vol. 59, p. 85-129.

—— (1966) : I Balani Miocenici delle "Arenarie de Ponsano" (Volterra, Provincia de Pisa). *Ditto*, vol. 60, p. 99-129.

—— (1967) : Osservazioni su alcuni Balani della formazione Langhiana del Arenarie a scutella di manciano (Grosseto). *Atti Soc. Toscana Sci. Nat. Mem., ser. A*, vol. 74, p. 214-220.

—— (1972) : Balani (Cirripedia) Miocenici dell'Ungheria. *Ditto*, vol. 79, p. 36-48.

Moroni-Ruggieri, M.A. (1952) : Ricerche sui Cirripedi fossili italiana. Nota I. *Gior. Geol., Ann. Mus. Geol. Bologna, ser. 2*, vol. 22, p. 66-84.

Newman, W.A. (1979) : Californian transition zone : Significance of short-range endemics. (*in* Historical biogeography, plate tectonics & the changing environment, ed. Gray, J. & Boucot, A.J.). Oregon State Univ. Press, p. 399-416.

—— (in press) : A review of extant taxa of the group of *Balanus concavus* (Cirripedia ; Thoracica) and a proposal for genus-group ranks. *Crustaceana.*

—— and Ross, A. (1976) : Revision of the balanomorph barnacles ; including catalog of the species. *Mem. San Diego Soc. Nat. Hist.*, 9, 108 pp.

Nilsson-Cantell, C.A. (1932) : Neue Balaniden aus Süd- und Ost-Afrika indem Berliner Museum. *Arkiv Zool.*, vol. 24A, no. 6, p. 1-18.

—— (1939) : Recent and fossil balanids from the north coast of South America. *Capita*

Zool., vol. 8, no. 4, p. 3-7.

Nomland, J.O. (1917) : Fauna of the Santa Margarita Beds in the North Coalinga Region of California. *Univ. California Publ. Geol. Sci.*, vol. 10, no. 18, p. 293-326.

Pilsbry, H.A. (1907) : Cirripedia from the Pacific coast of North America. *Bull. Bur. Fish.*, vol. 26, p. 193-204.

—— (1916) : The sessile barnacles (Cirripedia) contained in the collection of the U.S. National Museum; including a monograph of the American species. *Bull. U.S. Natl. Mus.*, no. 93, 366 pp.

—— (1918) : Cirripedia from the Panama Canal Zone. *Ditto*, no. 103, p. 185-188.

—— (1924) : Miocene and Pleistocene Cirripedia from Haiti. *Ditto*, vol. 52, no. 2512, p. 1-3.

—— (1930) : Cirripedia (*Balanus*) from the Miocene of New Jersey. *Proc. Acad. Nat. Sci. Philadelphia*, vol. 82, p. 429-433.

—— and Olsson, A.A. (1951) : Tertiary and Cretaceous Cirripedia from northwestern South America. *Ditto*, vol. 103, p. 197-210.

Rogers, F.L. (1948) : Description of a new species of barnacle from Panama. *Bull. S. Calif. Acad. Sci.*, vol. 47, pt. 3, p. 95-99.

Seguenza, G. (1873) : Ricerche Paleontologiche intorno ai Cirripedi terziari della provincia de Messina. Con appendice intorno ai Cirripedi viventi nel Mediterraneo, e sui fossili terziarii dell'Italia meridionale. Parte I. Fam. Balanidi e Verrucidi. *Atti Accad. Pontaniana*, 102 pp.

—— (1876) : Ditto. Parte II. Terza famiglia Lepadidi Darwin. *Ditto*, 113 pp.

Utinomi, H. (1969) : Cirripedia of the Iranian Gulf. *Vidensk. Medd. Dan. naturhist. Foren.*, no. 132, p. 79-94.

Weisbord, N.E. (1966) : Some late Cenozoic cirripeds from Venezuela and Florida. *Bull. Amer. Paleont.*, vol. 50, no. 225, p. 5-132.

Withers, T.H. (1923) : Revision of some fossil balanomorph barnacles from India and the East Indian Archipelago. *Rec. Geol. Surv. India*, vol. 54, pt. 3, p. 281-295.

Yamaguchi, T. (1974) : On some fossil *Balanus* from the Miocene Mizunami Group. *Bull. Mizunami Fossil Mus.*, no. 1, p. 215-220. [in Japanese].

—— (1980) : A new species belonging to the *Balanus amphitrite* Darwin group (Cirripedia, Balanomorpha) from the late Pleistocene of Japan; An example of peripheral speciation. *J. Paleont.*, vol. 54, no, 5, p. 1084-1101.

Zullo, V.A. (1964) : Re-evaluation of the late Cenozoic cirriped "*Tamiosoma*" Conrad. *Biol. Bull.*, vol. 127, no. 2, p. 360.

—— (1969) : Thoracic Cirripedia of the San Diego Formation, San Diego County, California. *Contrib. Sci. Los Angeles Cty. Mus.*, no. 159, p. 1-25.

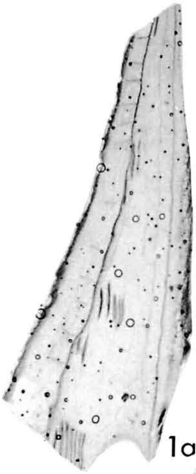
Explanation of Plate 48

Shell structure in longitudinal sections of a rostrum (UMUT CA9686) from the Miocene Moniwa Formation (Loc. 4).

Fig. 1. a parietal tube with transverse septa in a longitudinal section parallel to the parietal (longitudinal) tube. 1a, ×8.4. 1b, ×10.2. 1c, ×42.

Fig. 2. parietal (longitudinal) tubes with transverse septa in an oblique longitudial section (four parietal tubes are found). 2a, ×5.8. 2b, ×10.2. 2c, ×42.

Fig. 3. parietal (longitudinal) tubes with transverse septa in an oblique longitudinal section. 3a, photos by an optical microscope of Replica film (cellulose acetate film), ×10.2. 3b-e, external and internal walls (correspond to the outer and inner laminae) of parietal tubes and transverse septa partially left the original shell structure. Interspace of the parietal tube is secondarily filled up with the calcite which contrasts with the calcite composing the transverse septa in grain size, shape and arrangement. Photos by scanning electron microscope (SEM) of the etched surface. 3b, enlargement of top of fig. 3a, ×42. 3c, ditto, ×128. 3d, ditto, ×290. 3e, ditto, ×728.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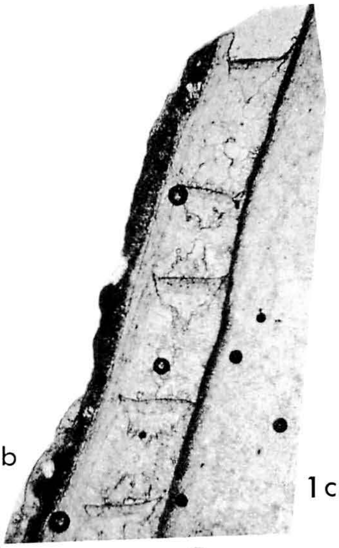
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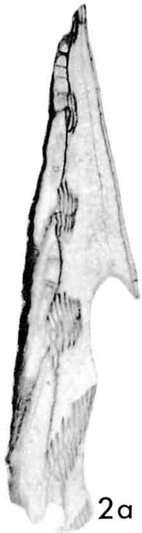
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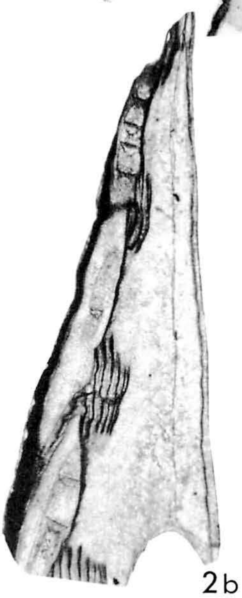
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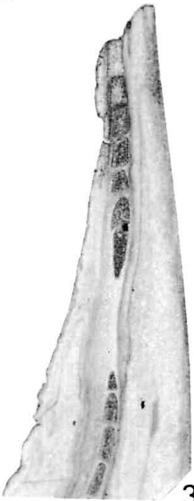
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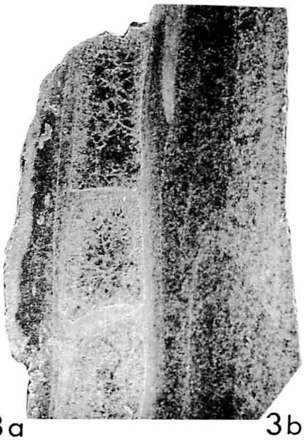
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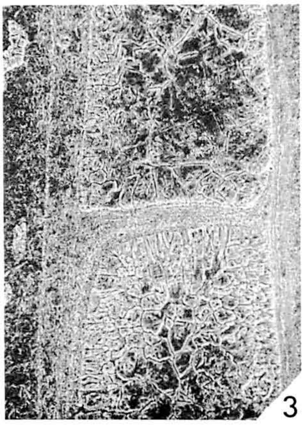
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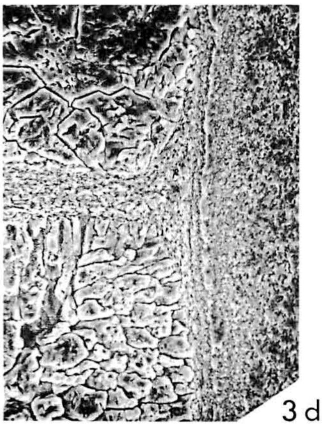
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3e

—— (1979): Thoracican Cirripedia of the Lower Pliocene Pancho Rico Formation, Salinas Valley, Montery County, California. *Ditto*, no. 303, p. 1-13.

Obuchi 尾駮, Oippe 老部, Takahoko 鷹架, Ohmagari 大曲, Arasawa 荒沢, Asizawa 芦沢, Takinoue 滝ノ上, Sugota 須郷田, Ukibuta 浮蓋, Sendai 仙台, Oide 生出, Natori 名取, Moniwa 茂庭, Nanao 七尾, Mizunami 瑞浪, Dan 段, Sakurado 桜堂, Oidawara 生俵

日本の中新世蔓脚類 *Balanus sendaicus* Hatai, Masuda and Noda について——テーチス海の *Balanus concavus* 種群と比較して——: *Balanus sendaicus* は仙台付近に分布する中新世茂庭層から得られた殻の一部分の１つの楯板 (scutum) に基づいて畑井，増田，野田 (1976) により新種として記載された。その標本は仙台の斉藤報恩会博物館に保管されているはずだが，そこには見つけられなかった。その名前のもとに殻の他の部分，背板 (tergum) および周殻 (shell wall)，は記載されなかった。原産地標本 (topotype) および畑井ら (1976) に図示された標本調査で，畑井らが *B. rostratus* として記載・図示した周殻は *B. sendaicus* に属す。それゆえ，本論文では畑井らによって記載されなかった背板を含めて *B. sendaicus* を明確にする。*B. sendaicus* は畑井らの指摘のとうり既知の分類群から異なる。*B. sendaicus* は漸新世から更新世に地中海地域テーチス海に繁栄した de Alessandri (1906) の意味合いでの絶滅種 *B. concavus* と近縁である。*B. sendaicus* は周殻の壁管 (longitudinal または parietal tubes) に直交副隔壁 (transverse septa) を持つことおよび楯板の特徴的な表面装飾によって *B. concavus* に代表される種群に属す。この種群に属す “4 種” が東部太平洋に生息している (Newman, 1979) けれども，大西洋・地中海地域からの *B. concavus* 種群の消滅は Pilsbry (1916) の指摘のようにミステリアスである。化石の日本の *B. sendaicus* は，中新世に限られ，*B. concavus* 種群の東アジアからの最初の化石記録となり，そしてテーチス海と東アジアの間のつながりの存在を指摘する。 山口寿之

Postscript: After submitted, Saito Ho-on Kai Museum of Natural History (SHM) let me know on registration numbers of illustrated specimens in the plate (pl. 2) of Hatai *et al.* (1976). The registration numbers are as follows.

Registration number	figure in Hatai *et al.*	species name in Hatai *et al.*	species name in this paper
SHM, Reg. No. 22069	figs. 1 & 20	*Balanus rostratus*	*B. sendaicus*
22070	figs. 3 & 4	*B. oidensis* (Holotype)	Not studied
22071	figs. 5 & 6	*B. moniwaensis* (Ditto)	Not studied
22072	figs. 7 & 8	*B. natorianus* (Ditto)	Not studied
22073	figs. 11 & 22	*B. miyagiensis* (Ditto)	Not studied
22074	fig. 12	*B. tohokuensis* (Ditto)	Not studied
22075	fig. 18	*B. rikuzenensis* (Ditto)	Not studied
22076	fig. 23	*B.* sp.	Not studied
22077	fig. 2	*B. rostratus*	*B. sendaicus*
22078	figs. 13 & 21	*B. rostratus*	*B. crenatus*
22079	fig. 14	*B. rostratus*	*B. sendaicus*
22080	fig. 15	*B. rostratus*	*B. sendaicus*
22081	figs. 16 & 17	*B. rostratus*	*B. sendaicus*
22082	fig. 19	*B. rostratus*	*B. sendaicus*
22083	figs. 9 & 10	*B. sendaicus* (Holotype, missing)	*B. sendaicus*

Palaeontological Society of Japan Special Papers No. 24
Permian Conodont Biostratigraphy in Japan

By Hisaharu IGO

Issued December 15, 1981, 50 pp., 12 pls.

Price (postage and handling incl.) U. S. $24.00.

Clark and Behenken (1971) summarized "Conodont and biostratigraphy of the Permian" in Symposium on Conodont Biostratigraphy edited by Sweet and Bergström. In this paper, they mentioned that Permian System represents the "last frontier" for conodont research. Permian conodont study was the same situation in Japan.

About ten years ago, Hisaharu Igo initiated to study Permian conodonts and he succeeded to recover numerous specimens from the various sections which were dated by fusulinaceans mainly in central part of Japan. The author clarified stratigraphic as well as geographic distribution of many important species and compared with the range of the previously described species in North America and Europe. Conodonts collected from chert and compound-type are mostly excluded in this volume, but he proposed two conodont faunas and two assemblage zones in the Japanese Permian and described 44 species and subspecies from 14 genera, among which 10 species and 1 subspecies are new to science.

This volume would be indispensable for geological and paleontological libraries as well as workers who may have interests in conodontology and later Paleozoic to early Mesozoic historical geology.

Orders must be accompanied by remittance made payable to Dr. Tsugio Shuto, Editor of the Special Papers, c/o Department of Geology, Faculty of Science, Kyushu University, Hakozaki, Fukuoka 812, Japan.

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

学会記事

○1982年1月22日に東京大学で開かれた評議員会において賞の委員の半数改選を行ない，鎮西清高・長谷川善和の両君がきまった。1982年度賞の委員会は，会長のほか，高柳洋吉，木村達明（幹事）および上記の2名，計5名で構成される。

○同評議員会において，次の諸君の入退会，および特別委員への推薦が認められた（敬称略）。

［入会者］ 竹村厚司（1981年度より），中川登美雄，金 恒黙，吉田 靖，伊藤富夫，西田治文，松岡篤，中川 洋，於保幸正，大矢 仁，中西ゆかり，加藤 進，高木俊男，須田章裕，坪内弘道，国府田良樹，間島隆一，坂本 治（18名）。

［退会者］ 木村方一，石川 正，三谷勝利，平川昌登，長瀬和雄（5名）。出光石油開発株式会社（賛助会員）。

［新特別会員］ 青島睦治，茨木雅子，井上英二，大木公彦，小笠原憲四郎，岡村 真，田沢純一，野原朝秀，松川正樹（9名）。

○1981年中の逝去会員は，奥津春生，中野光雄の両君であった。

○1982年1月23日現在の会員数は，名誉会員10，特別会員193，普通会員394，在外会員45，賛助会員9，計651名である。

○1981年9月に行なわれた地学関係5学会の協議の結果，昭和57年度の科学研究費地質学分科の配分委員候補として，層位古生物学1段委員に，増田孝一郎（本会推薦），地質学一般1段委員に村田正文（本会推薦），歌田 実の諸君が推薦された。なお，2段委員として棚井敏雅，層位古生物1段委員として小畠郁生，沖村雄二，地質学一般に田口一雄の諸君が留任している。

○1981年度日本古生物学会論文賞は，加瀬友喜君の“Early Cretaceous Gastropoda from the Choshi District, Chiba Prefecture, Central Japan（報告・記事118号）に，学術賞は，棚部一成君の“白亜紀アンモナイトの研究”，および松丸国照君の“第三紀大型有孔虫の研究”にそれぞれ授与された。

日本古生物学会1982年年会・総会

日本古生物学会年会・総会が1982年1月23，24日に，千葉大学教育学部を会場として開催された（参加者222名）。

海外学術集会出席報告

第4回サンゴ礁国際会議（I.C.R.S.）(5/18-5/22) .... 小西健二

MCE（白亜紀中期事変）の第7回国際研究集会および MCE 計画ワーキンググループ第6回会議（8/17-8/21，ウプサラ）........松本達郎

Subcommission on Devonian Stratigraphy (7/16-7/29, New York State) ....浜田隆士

XIII IBC（国際植物学会）（8月中旬—9月上旬，Sydney) ....棚井敏雅

IUGS 石炭紀小委員会1981国際集会（8/25-9/3，イギリス・アイルランド）..鳥山隆三・柳田寿一

特別講演

欧米の *Anadara* の分類と古地理的問題 .... 野田浩司

北太平洋域の珪藻層序の現状と将来 ....小泉 格

シンポジウム「アンデスの地質と古生物」
Symposium on “Geology and Palaeontology of the Andes”

世話人 前田四郎・坂上澄夫

コロンビアの白亜系・古第三系花粉層序 .... 徳永重元・大島秀明・伊藤良永

Mesozoic floras in South America ....Kimura, T.

本邦産白亜紀植物と南米産現生植物との比較資料 ....西田 誠

チリ国の第三紀 *Nothofagus* 属葉化石の分類と産出層準 ....棚井敏雅

ボリビア南部タリハ (Tarija) 盆地の第四系と哺乳動物化石の産状 .... 岩崎泰頴・高井冬二・Arozqueta, B.

タリハ盆地発掘哺乳類化石 ....高井冬二
中南米の化石貝類に関する二・三の問題 .... 土 隆一
Jurassic trigoniids from Peru ....Maeda, S., Kawabe, T. & Rangel, C. Z.
Some Jurassic Bivalvia from the Domeyko Range of North Chile.................... .... Hayami, I., Maeda, S. & Chong, G. D.
Stereostylus maedai, a new Permian coral from Colquencha, Bolivia ....Yamagiwa, N., Mukumoto, M. & Urdininea, M.
Some interesting Carboniferous fossils from Huancavelica, Central Peru .... Yamagiwa, N., Ishii, K. & Villavicencio, E.
アンデス中部地域の古・中生界の生物層序学的研究—現地調査報告— ....坂上澄夫・柳田寿一・加瀬友喜・長井孝一・Rangel, C. Z.・Urdininea, M. R.
Copacabana 層群 (二畳系) の堆積相について.. .... 長井孝一
アンデス中部 Abancay 北方地域 Lihuirco-Quisuar ルートのこけ虫化石層序 ....坂上澄夫
ペルー・ボリビア産 Lower Permian 腕足類について ....柳田寿一

個人講演

Paleoscenidiidae の分類的位置と *Nassellaria* の進化に関する考察 ..竹村厚司・中世古幸次郎
Stylosphaerids の殻構造について .... 西村明子・中世古幸次郎
関東山地奥秩父大ガマタ層の微化石と地質時代 .... 指田勝男・滝沢 茂・佐藤 正
一の谷層 (石炭—二畳系) 最上部の有孔虫化石層序の詳細 ....安達修子・猪郷久義
On the Upper Permian *Palaeofusulina-Colaniella* fauna from Khao Doi Pha Phlung, North Thailand ..Sakagami, S. & Hatta, A.
福島県平市北西部の 足沢層の 上部白亜系浮遊性有孔虫群 ....宇田泰子・斎藤常正
Biostratigraphy of the Oligocene—Miocene sequence along Kali Oyo, east of Yogyakarta, central Java .... Saito, T., Kadar, D., Niitsuma, N., Matsuoka, K., Kotaka, T., Tanaka, H., Harada, K., Sudijono, A. F. & Hasibuan, F.
Paleogene Foraminifera from Hokkaido, Japan .... Kaiho, K.
父島の始新世浮遊性有孔虫 ..高柳洋吉・安田尚登
父島の始新世大形有孔虫 ....松丸国照・高柳洋吉
父島の始新世石灰質ナンノプランクトン .... 本田信幸・高柳洋吉
父島の始新世放散虫 ....相田吉昭
Wall ultrastructure of cassiduline Foraminifera..........................Nomura, R.
Internal structure of cassiduline Foraminifera ....Nomura, R.
日本海の現世底棲有孔虫群集の 特徴とその 起源 .... 的場保望
現生底生有孔虫類の微小空間分布について .... 北里 洋・石川 力・小竹信宏・鈴木孝雄・土山 宏・矢野 亨
Remarks on ostracodes from the Ananai Formation.....................Ishizaki, K.
Some Neogene ostracodes from the Ryukyus .... Nohara, T.
Ultrastructure of the ostracod carapace, VI. Parabolic pattern ....Okada, Y.
フジツボ類 *Tetraclita squamosa* の三 "亜種" の種間関係 (予報) ....山口寿之
Outline of the Permian trilobites in Japan ....Kobayashi, T. & Hamada, T.
Genetic control of septal numbers and species problem in a solitary scleractinian coral .... Mori, K. & Minoura, K.
Alcyonarian spiculite について ......小西健二
喜界島の琉球石灰岩より 産出した 単体サンゴの放射年代 ....大村明雄
ウラン系列年代測定法の 信頼性について—USIP プロジェクトの結果から ....大村明雄
海底コアの 研究における 定容サンプリングの 重要性 ....大場忠道・青木三郎
地質調査所の地質標本管理システム (GEMS) における古生物分類について .... 神戸信和・尾上 亨・松江千佐世
東北日本のペルム紀腕足類 — とくにリットニア上科について ....小泉 斉
和歌山県広川流域の寺杣層より 新たに 産出したイノセラムスとアンモナイト .... 松本達郎・吉松敏隆
Growth rate of *Leioceras opalinum*, a Jurassic ammonite ....Hirano, H. & Kennedy, W. J.
Nautilus macromphalus の卵殻の構造とその生化学的検討 ....平野弘道・福田芳生
ミドリシャミセンガイの 外套膜縁剛毛の 機能形態について ....福田芳生・平野弘道
ヒヨクガイ類の形態の地理的変異と時間的変化 .... 速水 格
Selected bivalve fossils from the Cretaceous in the Sakawa Area, Shikoku...........

...............Tashiro, M. & Matsuda, T.

茂庭層産貝化石の古生物学的研究II — *Nipponopecten akihoensis* (Matsumoto) について.. .... 佐藤喜男

茂庭層産貝化石の古生物学的研究 III—*Placopecten nomurai* Masuda について .... 佐藤喜男

岩手県岩泉町茂師より産出した白亜紀前期の脊椎動物化石 ..長谷川善和・花井哲郎・加瀬友喜

福島いわき市産の蛇頸竜化石の追加 .... 長谷川善和・鈴木　直・甲府田良樹

A squalodont whale from the Miocene Ashiya Group, Kyushu ....Okazaki, Y.

珪質鞭毛藻 *Mesocena matuyamai* n. sp. の層位的分布について .... 小林博明・小林和男・古田俊夫

Coccolithus pelagicus (Wallich) Schiller in Plio-Pleistocene time ....Nishida, S.

大阪層群中の珪藻群集 .... 小泉　格・酒勾俊彦・菅野耕三

Fossil pollen grains from the Miocene Takaya plant-bed in Noto Peninsula, Central Japan ....Fuji, N. & Kawai, A.

北海道東部の新第三系の花粉層序 ......佐藤誠司

Review of the Pleistocene Shiobara Flora in Tochigi Prefecture ....Onoe, T.

日本更新世のブナ属の分類について ....南木睦彦

The past distributional history of the genus *Acer* in the northern Pacific region...... .... Tanai, T.

本邦第三系産のフジバシデ属の分類について .. .. 棚井敏雅・植村和彦

山口県美祢層群産トクサ類の一新種 .... 内藤源太郎・高橋文雄

韓国大同層群中の *Neocalamites* (有節類) 群落 .... 木村達明・金　鳳均・大花民子

Coreanophyllum variifolium gen. et sp. nov. —a Mesozoic bipinnate “*Pterophyllum*”, from the Daedong Group, Korea ....Kimura, T. & Kim, B.K.

山中地域白亜系瀬林層産の材化石について .... 大石　徹・西田　誠・田中邦幸

白亜紀木生シダの幹, *Cyathocaulis* Ogura の分類 ....西田治文

北海道産ヘゴ科木生シダの新属 *Protosphaeropteris* の系統学的意義 ....西田治文

Protocedroxylon triassicum Yamazaki et Tsunada の木部柔組織について........... .... 山崎純夫・綱田幸司

中国の Cathaysia flora の起源と進化の段階について ....谷　祖剛 (Gu Zugang)

1981年度日本古生物学会論文賞推薦文

加瀬友喜君：Early Cretaceous Gastropoda from the Choshi District, Chiba Prefecture, Central Japan. *Trans. Proc. Palaeont. Soc. Japan*, N.S., No. 118, pp. 291-324, pls. 34-36, 1980.

本論文は千葉県銚子半島の下部白亜系銚子層群より産した腹足類化石に関する2名の共著者による研究成果で，加瀬君がその古生物学的な記載を行ったものである。

白亜紀中葉は世界的に腹足類の大きな変革期にあたり，その前後の腹足類群の構成には世界中の多くの研究者が深い関心を示している。この分類群の進化史を理解する上に標準地域から遠く離れた我国の資料は重要な役割を果すと考えられる。我国の白亜系には多様な腹足類化石が含まれるが，多くの場合保存状態が十分でなく，分類上の位置を決定するための重要な形質（例えば殻口部の形状）を把握できないことが少くない。特に海生の腹足類については，*Nerinea* 類を除けば，戦前の矢部長克・長尾　巧・松本達郎三氏の研究以後ほとんど発展が見られなかった。

今回加瀬君によって記載された標本は我国の下部白亜系としては稀に見る良好な保存状態を示し，殻口部の形状はもとより，微細な彫刻や棘がよく観察できる。同君はこの恵まれた資料に基づいて世界的な視野から，分類学的研究を進め，Nerithopsidae の1新属2新種や特徴ある Aporrhaidae の3新種を含む11属12種の腹足類化石の分類上の位置を決定し，克明な記載を行った。特に軸唇とふたの構造に着目した Neritopsidae の記載分類は本科の系統進化を考える上に重要な貢献と考えられる。この研究は1地方化石群の記載を主体としているが，全く未知の腹足類群であっただけに鑑定には多大の努力がなされたと考えられ，同様の産出が期待される日本の他地域の海成下部白亜系の古生物の研究に福音をもたらすものである。

加瀬君の研究はまだ緒についたばかりであるが，従来ややもすれば等閑に付されていた我国の中生代腹足類の本格的な研究の第一歩を開くものと評価できる。よって日本古生物学会は加瀬友喜君に今後の一層の研鑚を期待して論文賞を贈る。

1981年度日本古生物学会学術賞推薦文

棚部一成君：白亜紀アンモナイトの研究

棚部君はアンモナイトのパレオバイオロジーを志し，まず北海道産異常巻アンモナイト・スカフィテス類の殻特性の個体発生的アロメトリーを解析し，個体発生的変異と種内変異の研究に個体群概念を併せて機能形態学的アプローチを示し，生活様式の変化との関連を議論した（1975，1977）。

同君および一部協力者との共同研究の業績は数多くあるが，なかでも注目すべき成果を若干挙げてみよう。アンモナイトの生活様式は世界の研究者の間で，浮遊性あるいは底生性と長らく論議の分かれるところであったが，さきの機能形態学的研究ならびに北海道のチューロニアンの浅海ないし中間相における群集古生態学的解析により，連室細管の比較強度の調査と併せて，多種類の分布・産状・保存状態に関する数量的資料から，白亜紀アンモナイトの生活様式は底生性から遊泳性まで多様であることを推論した（1978，1979）。かつ，平滑・弱装飾型は異常巻型や装飾型のものに比し深い環境にあることを実証し，アンモナイト群集の生態分布モデルを提案した。

アンモナイトの発生については，現生頭足類と異なり孵化後幼生期と変態をへて成長するという説がかつて支配的であった。棚部君は共同研究者とともに，多数の属種につき幼期の内部構造の特性と大分類との関連を明らかにし（1979），つづいて現生頭足類の初期の殻形成のデータと比較し，微細構造や組成から，アンモナイトの直接発達を示すモデルを提案した（1980）。また，異常巻類の初期の殻形態を考究し，異常巻類の孵化直後の“正常型”幼体は一時的な浮遊生活を営み，以後底生型の生活に適応したと論じた（1981）。さらに，アンモナイトの連室細管壁ならびに隔壁襟の微細構造と組成を調べ，現生および化石頭足類のそれらと比較し，隔室内液体の移動経路についてのモデルを提唱した（1980，1981）。この種の研究は，現生有殻頭足類の隔室内液体移動の滲透圧機構について示唆を与えるばかりでなく，頭足類進化史を適応戦略の変化として理解する上で，将来の貢献が期待される。

以上を要するに，棚部君は，白亜紀アンモナイトの進化古生物学に大きく寄与し，国の内外で注目されるところとなった。日本古生物学会はここに学術賞を贈り，同君の今後の研究のいっそうの発展を期待する。

松丸国照君：第三紀大型有孔虫の研究

日本における第三紀大型有孔虫化石の研究は，歴史的にかなり古く，20世紀初頭の矢部長克博士による orbitoids の記載に始まる。1920年代に至って矢部博士と半沢正四郎博士の多くの共著論文が発表され，有孔虫研究史上，矢部・半沢時代とも称すべき活動期に入った。その後，半沢博士を主とする大型有孔虫の研究は1960年代まで続いたが，日本列島はもちろん広く東南アジア・太平洋諸島などに関する成果は，今日でも国際的に高く評価されている。このような歴史的背景のもとに，群馬県富岡地域の *Nephrolepidina* の研究（1967）より始めた松丸君は，本州各地から産する本属の詳細な記載・分類を行い，時空的分布と系統発生の傾向を論ずる好著を1971年にまとめた。それ以後，日本列島ならびに周辺諸島の既知の産地のみならず，新産地における大型有孔虫の産出層準を確認し，層位的分布を明らかにする努力を続けた。

このような研究の過程で必然的に国外の特に熱帯亜熱帯地域の有孔虫群との比較研究が必要となるが，このことに早くより関心を抱いた松丸君は，台湾・北米・ニュージーランド産の化石の研究（1968―1971）を行っている。さらに橋本亙君を中心とするフィリピン・インドネシア等の地質古生物の研究グループに1973年より参加し，主として第三系の大型有孔虫の分類学的研究を担当して，このグループの代表作である「フィリピン産大型有孔虫」と題するシリーズをはじめ，多くの共著論文を発表した。

松丸君の研究対象は地理的に広範囲に及び，かつ研究活動ははなはだ精力的であって，1971～1980年の間に大型有孔虫に関するものだけでも30篇を超えている。いうまでもなく，このような成果により西太平洋および東南アジア地域の大型有孔虫に関する多くの貴重な知見がもたらされた。しかし，もう一つ注目されるのは，公表論文中に海外での知見を日本列島の化石の時空的分布の再評価へ還元させる傾向のものが見出せることである。「日本の新生代大型有孔虫群（第1部）」（1980）はまだ化石層位学的問題の一部を取り上げているにすぎないが，今後豊富な資料を用いて，多様な分類学的手法・層位学的手法等を駆使して，より厳密な吟味が行われれば，新生代大型有孔虫学への大いなる寄与となると思われる。よって日本古生物学会はここに学術賞を贈り，今後のいっそうの発展を期待するものである。

日本古生物学会特別号 No. 24

日本古生物学会特別号 No. 24　IGO, Hisaharu: Permian Conodont Biostratigraphy in Japan (50ページ，12図版，1981年12月15日発行）が出版されました（定価3900円，送料300円)。購入申込は特別号の他の号と同じく日本古生物学会特別号編集委員会（福岡市東区箱崎九州大学理学部地質学教室内）（送金先：三和銀行福岡支店普通預金口座12172；振替口座，福岡19014）にお願いします。郵送によらない直接販売は東京大学総合研究資料館（速水格）および国立科学博物館分館（藤山家徳）でも取扱います。なお，特別号バックナンバーの表題・販売価格（国内)・郵送料は本誌121号83ページに示してあります（残部僅少の号もありますので売切れの節は御容赦下さい)。

第6回　パリノロジー国際会議（予告）

4年毎に開催されるパリノロジー国際会議 (IPC) (International Palynological Conference) の第6回大会の第1回予告が到着しましたのでお知らせします。

開催場所：Calgary University, Calgary, Canada

期間：1984・8・24—30

IPC の講演区分・提出論文締切日等については1982年11月発行の第2回予告で示される。講演公式用語は英・仏語。学会に際しては内容要約・野外見学旅行案内書等が刊行される予定。野外見学旅行については下記があげられています。

1. Calgary 中心………Rocky Mountain, Banff 等
2. 航空機利用………Hay River, Norman Well 等
3. 計画中………Nova Scotia, Quebec 等

なお出席希望者の学会内容についてのアンケートなどが付いております。この予告入手希望の向は下記に御連絡下さい。

103　東京都中央区日本橋室町 3-2 CMビル　パリノ・サーヴェイ KK　徳永重元
(Tel 03-241-4566)

第3回太平洋地域第三系国際会議

第15回太平洋学術会議のセクションB固体地球科学と共催で開かれる。

開催場所：Dunedin University, Dunedin, New Zealand

期間：1983年2月2—4日，7日

すべての参加希望者は Pacific Science Congress, P.O. Box 6063, Dunedin, New Zealand に登録されたい。

テーマ：1) 太平洋地域の年代層序体系と対比，2) 地磁気層序と放射年代，3) 生層序，4) 古海洋と古環境，5) 新第三紀の地球的事件（海水準，同位体他），6) 新第三系の諸境界

巡検：会期中2日間 South Island の第三系（130米ドル)，会期後6日間　第三系（700米ドル）

国内問合せ先：東北大学理学部地質古生物学教室　高柳洋吉

環太平洋ジュラ系第1回 Fiele Conference

環太平洋地域のジュラ系に関する共同研究が IGCP の正式プロジェクトとして認められ，第1回 Field Conference が行われる。

開催場所：Calgary University, Canada

期間：1982年8月9日—14日

なおこの現地討論会はモントリオールで計画されている 3rd North American Paleontological Convention の後に接続されるよう計画されている。次の11のトピックに分れて討論される。

A) Ocean floor, continental margins and exotic terrains, B) Palaeogeography of sedimentary basins, C) Eustatic events and their correlations, D) Ocean currents and climatic events, E) Floral biostratigraphy, G) Macrofaunal biostratigraphy, H) Supra-regional standard zones, I) Biogeography

連絡先：Prof. G.E.G. Westermann, Dept of Geology, McMaster University, Hamilton, Ontario, Canada.

国内連絡先：305 茨城県新治郡桜村　筑波大学地球科学系　佐藤　正

行事予定

	開催地	開催日	講演申込締切
第129回 例会	北海道大学	1982年6月26日	1982年5月15日
第130回 例会	三重大学	1982年10月17日	1982年8月17日
1983年年会・総会	東京大学	1983年1月22・23日	1982年11月22日

講演申込先：〒113 東京都文京区弥生 2-4-16 日本学会事務センター 日本古生物学会行事係

お知らせ

○本会名誉会員藤本治義君は昭和57年3月31日に逝去されました。ここに本会の発展に尽された功績を偲び，謹んで哀悼の意を表します。

日本古生物学会

○日本古生物学会では過去5年間経費の節減をはかりながら皆様の会費を据置いてきましたが，昨今の諸物価の高騰により次第に財政が苦しくなって参りました。現在の規模の活動を続けていくには来年度は会費の値上げをお願いしなければならなくなる見通しですので，お含みいただくと共に会費の完納に御協力下さるようお願いいたします。

○日本古生物学会では年会・例会をより魅力あるものにするため，シンポジウムをはじめ各種の新しい形の会合（例えば，テクニックの会合，ポスターセッション，ワークショップ，夜間小集会など）の提案を歓迎します。よい企画がありましたら早目に常務委員会あてお申出下さるようお願いします。

○日本古生物学会刊行の和文誌「化石」を次のように充実させる方向で検討しています。1）B5版の定期的（年2回発行）の刊行物とする〔昭和57年度より実施〕。2）現在の予約購読制を改め，誌代を会費に含め全会員に配布する。3）原著論文を掲載し，内容を一層充実させる。これらの実施につきましては，印刷実費に相当する会費の値上げが伴ないますので，御意見などがありましたら，化石編集部または常務委員会まで早目にお申出下さい。

○1981年度に投稿原稿の校閲者として尽力された諸兄に感謝いたします。

○本年度より賞の委員会委員の半数改選にともない幹事が交代しました。1982年度中の各種の賞に関する問合せ，推薦依頼は鎮西清高（東京大学理学部地質学教室）にお願いします。その他の委員の役割分担と連絡先（本誌122号参照）には変更ありません。

常務委員会

◎ 文部省科学研究費補助金（研究成果刊行費）による。

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CONTENTS

TRANSACTIONS