



TITLE:

A Study on the Pelecypod-Fauna of the Upper Triassic Nabae Group in the Northern Part of Kyoto Prefecture, Japan (Part 4) : Cardinioides, Homomya, Pleuromya and others, Supplement and Brief Summary

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A Study on the Pelecypod-Fauna of the Upper  
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Cardinioides, Homomya, Pleuromya and others, Supplement  
and Brief Summary.

By

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**Abstract**

This article treats with the remaining species of this series belonging to *Cardinia*, *Cardinioides*, *Homomya*, *Pleuromya*, *Anodontophora* and others as well as the supplementary species of *Neoschizodus*, *Minetrigonia*, and others. As a result of the faunal study at least two faunizones are recognized in the Nabae group through the Maizuru "zone." The two zones are also acceptable in other correlative Sakawan formations in Japan. Accordingly, the Sakawan age (= Carnian) is divisible into two subages available for entire Sakawan formations in Japan. The early Sakawan subage is characterized mainly by the species belonging to *Minetrigonia*, *Palaeopharus* and *Bakevellia*, and the late one by *Tosapecten* spp., *Pseudolimea naumanni*, *Chlamys mojsisovicsi* and others.

**Description of Species**

Family CARDINIIDAE

Genus **Cardinia** AGASSIZ, 1848

**Cardinia misawensis** KOBAYASHI and ICHIKAWA (Pl. 1, Fig. 1.)

1952. *Cardinia misawensis* KOBAYASHI and ICHIKAWA, p. 265, pl. 10, figs. 7-8.

1954 b, *C. misawensis* ICHIKAWA, p. 58, pl. 4, figs. 7, 12-14.

cf. 1955. *C. cf. misawensis* NAKAZAWA, p. 259, pl. 16, fig. 10.

After the writer reported *Cardinia* cf. *misawensis* from the N<sub>2</sub> formation of Kongoin in the preceding paper, he collected several specimens from black shale of the middle part of the N<sub>3</sub> formation. They agree very well with the type-specimens in essential characters, though a little deformed secondarily. The smaller size than the type may have been caused by unfavourable

environments.

*Occurrence*:— Common from middle part of  $N_3$  formation, Nishi-arata, (N. 140) and Higashi-arata (N. 135'), Matsuo. (Reg. Nos. JM. 10340-1).

Genus **Cardinioides** KOBAYASHI and ICHIKAWA, 1952

*Reference*:—KOBAYASHI and ICHIKAWA (1952), p. 65

When KOBAYASHI and ICHIKAWA erected the genus, they referred it provisionally to the family Cardiniidae by the reason of the absence of lateral tooth. The writer could not collect the topotype-specimens, but he obtained many individuals referable to this genus from other localities. Most of them show a marginal thickening or projection at the posterior hinge-margin in the left valve and a corresponding depression in the right, which are regarded as a rudimentary lateral tooth and socket respectively. This fact suggests it reasonable to place the genus in the Cardiniidae.

KOBAYASHI and ICHIKAWA described three new species, one variety and one conferable species from the Heki formation at Heki (Loc. No. N. 705 in this paper), but the distinction needs further examination on more ample topotype-specimens, because they are more or less deformed secondarily. The following identification, therefore, is provisional.

**Cardinioides japonicus** KOBAYASHI and ICHIKAWA (Pl. 1, Fig. 2)

1952. *Cardinioides japonicus* KOBAYASHI and ICHIKAWA, p. 66, pl. 1, figs. 10a-b.

The species is commonly found from the lower part of the  $N_3$  formation at Shinmichi (N. 404, 406, 407), Miuchi (N. 414) and rarely at Saka, in Matsuo (N. 124), aside from type-locality at Heki (N. 705). When the specimen is compressed laterally, it can hardly be distinguished from var. *elongatus* KOBAYASHI and ICHIKAWA (ibid., p. 67, pl. 1, Figs. 8-9). (Reg. Nos. JM. 10401-3, 5, 10442)

**Cardinioides cf. splendis** KOBAYASHI and ICHIKAWA (Pl. I, Fig. 3)

cf. 1952. *Cardinioides splendis* KOBAYASHI and ICHIKAWA, p. 68, pl. 2, figs. 1a-b.

A figured specimen which was obtained from the  $N_3$  formation at Shinmichi (N. 406) is more comparable to *C. splendis* than other described species of the genus in general feature, but is different in the absence of a ventral sinus. (Reg. No. JM. 10404)

**Cardinioides cf. subtriangularis** KOBAYASHI and ICHIKAWA

cf. 1952. *Cardinioides subtriangularis* KOBAYASHI and ICHIKAWA, p. 67, pl. 1, figs. 6-7.

*C. cf. subtriangularis* KOBAYASHI and ICHIKAWA, p. 68, pl. 2, fig. 2.

A single internal mould of a left valve from the same locality of the preceding species is referable to *C. subtriangularis* in the short and subtrigonal outline, but may be a crushed specimen of *japonicus*. (Reg. No. JM. 10406-a)

**Cardinoides** new species, indet. (Pl. 1, Figs. 4-5)

*Description*:— Shell of medium size, thick, rather elongate, roundly subtrigonal in outline, moderately convex; length and height in the proportion of 1.72:1 in the internal left valve. Umbo lying at about one-third of the length from the anterior end; posterior carina obtusely rounded and indistinct. Hinge consisting of a strong pseudocardinal? tooth, relatively small, subtrigonal sockets at the both sides and a rudimental lateral tooth in the left valve; those of the right valve not preserved. Anterior adductor scar just below the anterior socket, oval and deeply incised; posterior one elongate-oval, located below the posterior end of the lateral tooth, not deeply impressed; pedal retractor scar small, but distinctly excavated near the upper margin of the anterior adductor scar; pallial line weak, perfect. Surface covered with rather strong, lamellose, concentric sculptures irregular in strength.

*Observation and Comparison*:— An univalved internal mould and a part of external one are at hand, the former of which is somewhat eroded at the umbonal portion, and the detail of the cardinal hinge cannot be fully examined. External sculptures which is well preserved in the specimen kept in the Ayabe Middle School (Pl. I, Fig. 5), look more like those of *Cardinia* than usual *Cardinoides*, but the hinge-character indicates the species belonging to the latter genus. In the elongate outline, this resembles mostly *Cardinoides japonicus*, but is easily distinguished by the marked concentric sculptures just mentioned and more obtuse umbonal carina.

*Occurrence*:—Rare from the lower part of N<sub>3</sub> formation, Nabae (N. 212). (Reg. Nos. JM. 10407, 10443 (gypsum-cast)).

**Cardinoides?** sp. indet. (Pl. 1, Fig. 6)

*Description*:—Shell of medium size, *Myophoria*-like in outline, longer than high, the length more than one and a half of the height. Umbo located at about one-third of the length from the anterior end, slightly prosogyrate. Posterior carina obtusely rounded, extending to postero-ventral extremity. Hinge consisting of one subtrigonal cardinal tooth in front of the beak and two cardinal sockets at the both sides in the left valve; lateral tooth, if present, very weak. Anterior adductor scar oval, distinct but provided with no myophorous buttress; posterior one weak. Surface nearly smooth, covered with fine concentric growth-lines; neither carina nor furrow being observable

on the posterior area.

*Remarks and Comparison*:—Because of the incomplete preservation it is not sure whether the hinge of the specimen represents the real one. The absence of the myophorous buttress of the anterior scar and the escutcheon on the posterior area, as well as the anterior cardinal tooth of the left valve indicates the species belonging to *Cardinioides* rather than *Neoschizodus* GIEBEL, the smooth myophorian genus. Nevertheless the palivincular ligament-area cannot be seen and the reference to *Cardinioides*, too, is uncertain. The species is similar to *C. japonicus* among the species of the genus, but the umbo is more prominent and the posterior area more sharply defined from the flank.

*Occurrence*:—Common from lower part of N<sub>2</sub> formation, Ashidani, Nabae (N. 223). (Reg. Nos. JM. 10444-5).

#### Family MYTILIDAE

##### Genus *Mytilus* LINNÉ, 1758

##### *Mytilus* cf. *tenuiformis* KOBAYASHI and ICHIKAWA (Pl. 1, Figs. 7 a, b)

cf. 1950. *Mytilus tenuiformis* KOBAYASHI and ICHIKAWA, p. 207, pl. 1, fig. 7.

A pair of valves from the Heki formation at Heki (N. 704) is at hand. It agrees very well with the type-specimen from the Sakawa basin in general aspect and dimensions, but the decision is postponed until more samples will be obtained.

*Dimensions*:—Height=15 mm, length=23.5 mm, breadth=10 mm, apical angle=42°. (Reg. No. JM. 10342).

##### *Mytilus tenuiformis* var. *punctatus* KOB. and ICH. (Pl. 1, Fig. 8)

1950. *Mytilus tenuiformis* var. *punctatus* KOBAYASHI and ICHIKAWA, p. 208, pl. 1, fig. 8.

There are several individuals contained in a same slab, which are identified to *M. tenuiformis* var. *punctatus* by the short, rounded, subtrigonal outline and the obtuse umbo. The apical angle varies between 55°-70°, but this is caused mostly by secondary deformation.

*Occurrence*:—Not common from Heki formation, Heki (N. 704). (Reg. No. JM. 10343)

##### *Mytilus* aff. *tenuiformis* var. *punctatus* KOB. and ICH. (Pl. 1, Figs. 9a, b)

A solitary internal mould of a left valve is at hand, which allies to the preceding species in general outline and ill-defined umbo, but it differs in the much more inflated shell, the larger apical angle and the larger size.

The dimensions are as follows.

Length=21.5 mm, height=18.5 mm, depth=9 mm, apical angle=70°. The acute carina running from the beak to the antero-ventral margin may be due to secondary compression. The species is also similar to "*Modiola*" *klipsteini* BITTNER (1895, p. 47, Pl. 4, Fig. 21) in the highly inflated shell, but is distinguished from the latter by the much larger size and the more expanded outline.

*Occurrence* :—Very rare from Heki formation, Heki (N. 704). (Reg. No. JM. 10344).

#### Subgenus *Falcimylus* COX, 1937

***Mytilus* (*Falcimylus*) cf. *nasai* KOBAYASHI and ICHIKAWA (Pl. I, Fig. 10)**

cf. 1950. *Mytilus* (*Falcimylus*) *nasai* KOB. and ICH., p. 208, pl. 1, figs. 2-3.

1954 a, *Mytilus* (*Falcimylus*) *nasai* ICHIKAWA, p. 46, pl. 1, fig. 11.

A single right valve is 30 mm long, 32 mm high and 4.5 mm deep. At a glance the specimen is very similar to *M. (F.) nasai* var. *nagaiides* KOB. & ICH. (1950, p. 209, Pl. I, Fig. 4; ICHIKAWA, 1954 a, p. 47, Pl. I, Fig. 10) in the slender shape. But it is considered to be compressed dorsoventrally, and consequently the anterior area makes a sharp and acute angle with the flank. So the shell must be wider and more expanded than the present shape, and is referable to *nasai* rather than its variety.

*Occurrence* :—Very rare from N<sub>3</sub> formation, Saka, Matsuo (N. 137). (Reg. No. JM. 10345).

#### *Mytilus* new species?, indet. (Pl. I, Figs. 11-12)

*Description* :—Shell medium in size, oblong, gently convex; anterior margin nearly straight, hinge-margin slightly arcuate upward, continuing gradually to the broadly rounded posterior margin; ventral margin short and acutely rounded. Umbo ill-defined. Hinge perhaps edentulous; ligamental area short and traversed by a feeble ridge. No distinct carina.

*Observations* :—There are a compressed right valve and a flattened left one. The former one (Pl. I, Fig. 11) is 34 mm long, 31 mm high and 8 mm deep and has an apical angle of 45°, while the other one (Pl. I, Fig. 12) is 14 mm long, 23 mm high, 4 mm deep and has an apical angle of 70°. They differ considerably from each other, but are thought to fall into the same species. The outline, especially, of the left valve reminds one of the upper Paleozoic genus *Selenimyalina* NEWELL (1942, p. 63), which was supposed by him to include the lower Triassic "Myalinid" species such as *Myalina schmarae*

BITTNER, *M. vetusta* BITTNER, *M. pluzynotus* WHITE. The specimens in hand are not so satisfactorily preserved for detail examination, but they are apparently lacking in transverse striations on the ligamental area, and seem better to be placed in *Mytilus*. The writer could not find any comparable species of the Triassic *Mytilus*.

*Occurrence*:—Rare from upper part of  $N_3$  formation, Wakizaka, Nabae (N. 215) and Nishi-mitsumatsu (N. 201). (Reg. Nos. JM. 10346-7)

Genus **Volsella** SCOPOLI, 1777

**Volsella** aff. **paronaiformis** KOBAYASHI and ICHIKAWA  
(Pl. I, Figs. 13, 14 B, 15)

cf. 1950. *Volsella paronaiformis* Kob. and Ich., p. 210, pl. 1, fig. 1.

There are many specimens which resemble closely *V. paronaiformis* described from the Sakawa basin. To his regret the exact shape of this species cannot be given because of the remarkable deformation, but the species differs from *paronaiformis* in the straight hinge-margin, the more expanded outline posteriorly and in the more distinctly defined anterior lobe.

*Occurrence*:—Abundant from lower part of  $N_3$  formation, Miuchi (N. 414), very rare from Saka, Matsuo (N. 124) and very rare from  $N_2$  formation, Shinmichi (N. 410). (Reg. Nos. JM. 10348-352)

**Volsella** aff. **paronaiformis**? (Pl. I, Figs. 16-17)

Associated with preceding species are there found several specimens which are distinguished in the mode of umbonal carination. Contrary to the above mentioned species, the umbonal ridge tends to arcuate with the convex side forward making somewhat opisthogyrate umbo. It could not be ascertained whether this is merely due to secondary crustal movement or not. If the difference is a primary one, the species should be separated as a distinct species.

*Occurrence*:—Rare from  $N_3$  formation, Miuchi (N. 414). (Reg. Nos. JM. 10353-4).

**Volsella** new species?, indet. (Pl. I, Figs. 14 A, 18)

*Description*:—Shell elongate, subtrigonal, moderately convex, very inequilateral with subterminal umbo. Anterior lobe small, producing slightly anterior to the beak or not beyond it; umbonal ridge delimiting the anterior area, rounded, more or less distinct; antero-ventral sinus obscure; hinge-margin nearly straight; posterior one broadly arcuate. Hinge edentulous;

hinge-area narrow, extending nearly as long as the dorsal margin and provided with a faint ridge parallel to the periphery.

*Remarks and Comparison*:—The remarkable variation of the shape puzzled the writer to suppose the original one.

Through the courtesy of Mr. TOKUYAMA of Tokyo University, the writer could examine his specimens collected from the Hirabara formation of Yamaguchi Prefecture, which were considered to be referred to the same species under consideration. As a result the specimen figured in Pl. I, Fig. 18 is supposed closest to the original, though the umbonal carina is emphasized secondarily.

This species resembles very much such species as *V. triquetra* (SEEBACH) (1861, p. 599, Pl. 14, Fig. 6), *V. raibliana* (BITTNER) (1895, p. 48, Pl. 5, Figs. 21-22), *V. aff raibliana* (BITTNER) (1901, p. 21, Pl. 7, Figs. 26-27) and *V. minuta* (GOLDFUSS) (MOORE, 1861, p. 505, Pl. 15, Fig. 36; PHILIPPI, 1903, Pl. 6, Fig. 4) in the *Mytilus*-like outline, but is supposed to be less prosocline and consequently to have a broader postero-dorsal part. Whether the species belongs to the upper Paleozoic *Promytilus* NEWELL (1942, p. 37), which has intermediate characters between *Volsella* and *Mytilus*, needs for further scrutiny on more complete samples.

*Occurrence*:—Common from lower part of N<sub>3</sub> formation, Miuchi (N. 414) and Shinmichi (N. 404-5); very rare from Kongoin (N. 104). (Reg. Nos. JM. 10348, 355-6, 357 (?))

#### Family PHOLADOMYIDAE

#### Genus **Homomya** AGASSIZ, 1843

#### **Homomya matsuoensis** NAKAZAWA, new species (Pl. II, Figs. 1a-e, 2a-d)

cf. 1952. *Pleuromya* (?) sp. KOBAYASHI and ICIKAWA, p. 78., pl. 3, fig. 13.

*Description*:—Shell moderate, thin, oblong, very inequilateral, slightly inequivalve?, not so tumid, gaping anteriorly as well as posteriorly; proportion of length to height about 1.8:1 and height to breadth about 1.45:1. Umbo almost contiguous, situated at a little more than one-fourth of the shell-length, nearly orthogyrate, compressed. Antero-dorsal margin straight or slightly concave; anterior side short, acute and the most anterior end well above the midheight; ventral margin very gently arcuate, rising up and forward to posterior margin; umbonal ridge obtusely rounded, running postero-ventrally from the umbo, becoming obsolete towards the rear end. Hinge edentulous; ligament external, opisthodontic, as long as about a half of the hinge-margin; pallial line and adductor scars not impressed. Surface



covered with fine concentric growth-lines and weak plications.

*Observation and Comparison*:—There are six specimens of conjoined valves and several incomplete ones. Though most of them are slightly detached, they are undoubtedly opening at the both sides of the shell except one specimen (JM. 10363) which is apparently closing at the anterior side. In the internal mould of the holotype there can be seen a distinct furrow (that

*Dimensions*:—

Reg. no. \ mm	L (length)	H (height)	B (breadth)	U	L/H	H/B	L/U
JM. 10358 (Holotype)	76	44	26	19	1.73	1.69	4.00
JM. 10359 (Paratype)	61	33	23	18	1.85	1.45	3.81
JM. 10360 ( " )	67	36	24	22	1.86	1.50	3.04
JM. 10362 ( " )	65	31	ca 23	ca 20	2.10	1.35	3.25
JM. 10363 ( " )	52	28.5	22.5	14	1.82	1.28	3.70

U: distance between beak and anterior end.

is, blunt internal ridge in reality) along antero-dorsal margin delimiting the anterior adductor scar, but it is not observed in the rest.

The species is distinguished from *Homomya alberti* (VOLTZ) (GOLDFUSS, 1838, p. 261, pl. 154, Fig. 3; BENDER, 1921, p. 42, pl. 1, Figs. 1-3) from the German Muschelkalk in less and weaker concentric wrinkles, and in the more anteriorly located umbo. It also differs from *Arcomya sansonii* SALMON (1895, p. 172, Pl. 5, Fig. 55), which is most similar in outline, by the larger size and the more inflated shell. The fragmental specimen reported as *Pleuromya* (?) sp. by KOBAYASHI and ICHIKAWA from the Heki formation, is most probably identical to this new species.

*Occurrence*:—Common from N<sub>2</sub> formation, Higashi-arata, Matsuo (N. 122, N. 135), rare from Kongoin (N. 102-3), Sugitani (N. 503); rare from Heki formation, Heki (N. 704). (Reg. Nos. JM. 10358-363)

## Family PLEUROMYIDAE

Genus **Pleuromya** AGASSIS, 1842**Pleuromya wakasana** NAKAZAWA, new species (Pl. III, Figs. 1-3)

*Description*.—Shell of medium size, thin, transversely oblong, very inequilateral, protruded posteriorly, not so tumid; longer than high, proportion of length to height varying between 2.16-1.60. Umbo located at about one-third of the length from the anterior end, not conspicuous, slightly salient above hinge-margin. Anterior side bluntly rounded; ventral side broadly arcuate, continuous with both sides, provided with no sinus; posterior side produced, tapering to acutely rounded extremity; dorsal margin obtusely angulated at the beak; postero-dorsal margin nearly straight. Lunule ill-defined; escutcheon and posterior carina absent. Hinge apparently edentulous aside marginal projection or thickening of postero-dorsal edge; ligament external, opisthodontic. Anterior muscle-scar longitudinally oval, somewhat irregular in outline; posterior one oval, almost contacted with dorsal margin; from the lower margin of the posterior scar running low ridge-like swelling to the umbo; pallial line strongly sinuous as shown in the plate (Pl. III, Fig. 1a). Surface covered with fine concentric growth-lines irregular in strength. Shell-margin closed except posterior side, where it is considered to be slightly gaping.

*Remarks and Comparison*.—There are many specimens at hand. Though all of them are moulds only, the writer could not confirm the presence of any distinct tooth or socket besides slightly projected thickening of the postero-dorsal margin. In eight conjoined valves at hand the right one is lying over the left without exception. This fact coincides with BENDER's observation on *Pleuromya* of Muschelkalk, from which he concluded that the right valve of *Pleuromya* lay over the left by a thin, horizontal projection or thickening of the hinge-margin (BENDER, 1921, p. 39). The remarkable variation of length-height ratio is mostly due to differential crushing, and the ratio is estimated about 1.7-1.8. An internal ridge running irregularly from the beak downward is often seen (Pl., III, Fig. 3), but it is uncertain to be primary or secondary one. The species somewhat resembles *Pleuromya mactroides* (SCHLOTHEIM) (BENDER, *ibid.*, Pl. 4, Fig. 3), but distinguished by less conspicuous and more posteriorly located umbo. It is more like *P. pulchra* ASSMANN (1915, p. 632, Pl. 36, Fig. 11), but much larger than the latter.

*Occurrence*.—Abundant from  $N_1$  formation, Nishi-mitsumatsu (N. 222). (Reg. Nos. JM. 10364-372, except 10371)

**Pleuromya wakasana** new subspecies? (Pl. II, Fig. 3)

Two internal moulds are present, which are distinguished from the preceding species by more elongate outline and more anteriorly located umbo. The proportion of length to umbonal distance from the anterior end varies between 2.6-3.3 in the type-specimens, while it attains even 4.7 in these ones. Therefore they should be separated subspecifically if they are saved from strong deformation.

*Occurrence* :—Very rare, associated with preceding species. (Reg. No. JM. 10371)

**Pleuromya** (?) aff. **forsbergi** (BOHM) **nipponica** KOBAYASHI and ICHIKAWA (Pl. III, Figs. 4-5)

cf. 1950. *Pleuromya forsbergi* (BOHM) *nipponica* Kob. & Ich., p. 235, pl. 4. Figs. 8 a-c.

The species is undoubtedly closely allied to *P. forsbergi nipponica*, but the umbo lies more anteriorly, the posterior carina more distinct and the postero-ventral margin more acutely protruded. The species also resembles *Anodontophora* (?) *alberti* (ASSMANN) (1915, p. 617, Pl. 34, Figs. 8-12) and *A. münsteri* (WISSMANN) (BITTNER, 1895, p. 9, Pl. 1, Figs. 22-25), but differs from the former in the presence of the posterior carina and from the latter in the more rounded postero-ventral extremity and the weaker adductor impression.

*Occurrence* :—Common from lower part of N<sub>3</sub> formation, Kuredani (N. 126) and Tsukigoshi (N. 114) in Kichisaka, and Miuchi (N. 414). (Reg. Nos. JM. 10416-418, ? 10425)

## ? Family ANTHRACOSIIDAE

Genus **Anodontophora** COSSMANN, 1897**Anodontophora** (?) cf. **trapezoidalis** MANSUY (Pl. III, Figs. 6-7)

cf. 1919. *Anodontophora trapezoidalis* MANSUY, p. 13, pl. 2, figs. 11a-d; pl. 3, figs. 1a-c.

*A. tonkinensis* MANSUY (pars.), *ibid.*, p. 12, 10a, b, f, k, i, l. (non, c, d, e, g, h, j).

*A. myophorioides* MANSUY, *ibid.*, p. 13, pl. 2, fig. 13.

1926. *A.* (?) *trapezoidalis* PATTE p. 66, pl. 10, figs. 38-43; pl. 11, figs. 1-4.

Three crushed specimens of very thin shell are at hand. One of them (Pl. III, Fig. 6) is much similar to the *Myophoria*-like form of *A.* (?) *trapezoidalis* (PATTE, 1926, Pl. 10, Fig. 38) and *A. myophorioides* (MANSUY, 1919, Pl. 2, Fig. 13), while another one (Pl. III, Fig. 7) can hardly be distinguished from the trapezoidal form of *trapezoidalis* (PATTE, *ibid.*, pl. 11, Fig. 4 a) and the remaining one (not illustrated) is comparable with one of *A. tonkinensis*

(MANSUY, *ibid.*, pl. 2, Fig. 10 A). All the specimens here compared with are regarded as the same species, *A. (?) trapezoidalis* after PATTE. So the species under consideration may be identified with *trapezoidalis*, though exact comparison is almost impossible.

*Occurrence*:—Rare from lower part of  $N_3$  formation, Wakizaka, Nabae (N. 208). (Reg. Nos. JM. 10414-5)

**Anodontophora (?) aff. minima** MANSUY, (Pl. III, Fig. 8)

cf. 1919. *Anodontophora minima* MANSUY, p. 13, pl. 3, fig. 3

There are several specimens which have small, thin shells of nearly isosceles triangle in outline. Illustrated one is compressed laterally by deformation and is actually taller than it. Anterior and posterior carinae are both acutely rounded, but the rear end is more projected at the posterior corner than at the anterior.

The species resembles especially *Anodontophora (?) minima* from the Carnian of Tonkin in many respects, but the latter one seems to be more convex and rising more steeply at the anterior side.

*Occurrence*:—Rare from lower part of  $N_3$  formation, Tsukigoshi, Kichisaka (N. 114). (Reg. Nos. JM. 10427-8)

**Anodontophora (?) aff. manmuensis** REED (Pl. III, Figs. 9-11)

cf. 1927. *Anodontophora manmuensis* REED, p. 235, pl. 19, figs. 5-6.

*Description*:—Shell small in size, very thin, elongate posteriorly, suboval in outline, inequilateral, equivalve; length about twice the height. Anterior side bluntly rounded; ventral one slightly arcuate with no sulcation; posterior one rather acutely rounded; dorsal margin nearly straight on both sides of the beak, where they are conjunct with each other with very obtuse angle. Umbo situated at a little more than one-third of the length from the anterior end, slightly salient. Hinge and musculature unknown. Surface covered with fine concentric growth-lines and weak plications.

*Remarks and Comparison*:—As all the specimens are strongly crushed, the above stated description was induced from many samples. The transversely elongated form of them (Pl. III, Fig. 10) resembles very much *Anodontophora (?) elisabethae* PATTE (*ibid.*, p. 160, Pl. 9, Figs. 32-33), but the alliance is supposed to be superficial. The species seems to be particularly allied to *A. manmuensis* REED, from the upper Triassic of Yunnan. *A. cf. ovalis* (REED, *ibid.*, p. 236, Pl. 19, Fig. 4) can hardly be distinguished from the latter species judging from the figure, if the number of the plate is not misspelling, though he separated the species by the subcentral umbo.

*Occurrence*:—Abundant from lower part of  $N_3$  formation, Tsukigoshi, Kichisaka (N. 114) and common from Miuchi (N. 412, 414). (Reg. Nos. JM. 10419-426, 10441)

“**Anodontophora**” sp. indet. (Pl. III, Fig. 12)

*Description*:—Shell of small size, suboval in outline, inequilateral, equi-valve, longer than high, inflated; umbo rather slender, curved inward and forward; in front of it indistinct lunule-like depression being observable. Ligament external, opisthodontic. Below the beak of the internal mould of a right valve, a small depression and a projection are seen, which are supposed to be a rudimental tooth and a socket respectively. Lateral tooth perhaps absent. Surface almost smooth.

*Comparison*:—*Anodontophora lettica* (QUENST.), the genotype of the genus, has a thick, blunt cardinal tooth in the right valve and a long lateral tooth in the left after KOENEN (1881, p. 680). The present species seems different from the genotype in the dentition and may belong to other genus.

It is similar to *Anodontophora* sp. nov.? KOBAYASHI and ICHIKAWA (1950, p. 233, Pl. 4, Fig. 7) in outline, but differs in the absence of mesial sinus.

*Occurrence*:—Common from lower part of  $N_3$  formation, Shinmichi (N. 404) and Kuredani (N. 126), rare from Miuchi (N. 414). (Reg. Nos. JM. 10429-433).

Family CUSPIDARIIDAE

Genus **Cuspidaria** NARDO, 1840

“**Cuspidaria**” **ayabensis** NAKAZAWA, new species (Pl. III, Figs. 13-14)

*Description*:—Shell of medium size, subtrigonal, inequilateral, equivalve, longer than high, moderately convex, acutely rounded anteriorly, broadly rounded ventrally provided with a slight sinus at the front of posterior corner; posterior area relatively broad, depressed or slightly concave delimited by a very sharply projected posterior carina, perhaps gaping posteriorly; umbo lying anteriorly (?) to the center, acutely curved inward and downward and a little prosogyrate. Chondrophore internal?; external ligamental area (or lithodesma?) short, excavated. Surface covered with close-set concentric growth-lines, which sometimes develop into relatively regular concentric costae on the flank, but usually smooth on the posterior area. Tooth seems to be absent; pallial line and adductor scars not impressed.

*Observation and Comparison*:—There are apparently two kinds of specimens,

in one of which the umbo situated remarkably posteriorly and the shell is expanded anteriorly as shown in the holotype (Pl. III, Fig. 13), and in another one the umbo is located anteriorly and the shell is more symmetrical than the former, as shown in the paratype (Pl. III, Fig. 14). The writer considers them nothing but the same species, of which differences are mainly due to secondary deformation. The impression of the chondrophore is generally not preserved, and a doubtful one can be seen in only a single internal mould of a right valve (Reg. No. JM. 10387), so the generic reference is tentative. The sharply projected carina is a marked character of this species, and the writer could not find any comparable species of Triassic *Cuspidarias*. *Cuspidaria alpis civicae* BITTNER (1895, p. 5, Pl. 1, Figs. 1-9) is mostly allied species among them, but is easily distinguished by the much longer posterior half and the mode of carination.

*Occurrence* :—Common from lower part of N<sub>3</sub> formation, Kuredani (N. 126), Shinmichi (N. 405), Miuchi (N. 412, 414); not common from N<sub>2</sub> formation, Higashi-arata (N. 122, N. 135), Sugitani (N. 503) and Monobe (N. 601); rare from Heki formation, Heki (N. 701). (Reg. Nos. JM. 10384-8).

#### Family LUCINIDAE

#### Genus *Schafhütli* COSSMANN, 1897.

#### *Schafhütli* cf. *astartiformis* (MÜNSTER) (Pl. III, Figs. 15, 16, 17?)

cf. 1841. *Isocardia astartiformis* MÜNSTER, p. 87, pl. 8, fig. 24. (Complete synonymic list is found in Fossilium Catalogus, Pars 19 et 51, by Diener and Kutassy, 1923-1931)

*Description* :—Shell of medium size, suborbicular, equivalve, subequilateral, considered to be slightly longer than high, moderately convex; maximum convexity lying slightly lower than the center. Umbo lying mesially or slightly anteriorly, rounded, incurved and pointed downward, somewhat prosogyrate. Lunule and escutcheon lacking. Hinge unknown. Surface covered with fine concentric growth-lines and somewhat lamellose striae.

*Comparison* :—The specimens of transversely elongate form are similar to *Sch. mellingi* (HAUER) var *balatonica* (FRECH) (1907, p. 58, Pl. 8, Fig. 9) or *Sch. cf. astartiformis* (BOHM) (1903, p. 48, Pl. 5, Figs. 10-11), and those of longitudinally oval form to *Sch. ovata* (STOPPANI) (1860, p. 85, Pl. 17, Fig. 7), but the alliance is superficial caused by secondary deformation. The species is rather referable to *Sch. mellingi* (HAUER) or *Sch. astartiformis* (MÜNSTER) and especially to the latter one, because the umbo is lying anterior to the center. The species seems to differ from *astartiformis* in the position of the

maximum convexity which lies lower than the latter. There is a bivalved specimen having a strong cardinal tooth in the right valve (Pl. III, Fig. 17), but it is not sure whether it is conspecific with the specimens under consideration.

*Occurrences* :—Abundant from lower part of  $N_3$  formation, Tsukigoshi (N. 114), rare from Takaya, Monobe (N. 602). (Reg. Nos. JM. 10373-7).

**Schafhäutlia** (?) sp. indet. (Pl. III, Fig. 18, Pl. IV, Figs. 1-3.)

*Description* :—Shell large, rather thin, suborbicular, longer than high, inflated. Umbo lying a little anteriorly, strongly curved inward and downward, slightly prosogyrate. Lunule and escutcheon absent. Hinge not clearly seen in the specimens at hand. Musculature not impressed. Surface ornamented with distinct concentric costae.

*Comparison* :—It is uncertain to refer the species to *Schafhäutlia*, because the shell is rather thin in the genus and the dentition seems to be rudimental unlike the genus, though not well preserved. Among the species of the genus, *Sch. americana* COX (1949, p. 31, Pl. 2, Figs. 1-2) from the upper Triassic of Peru resembles this species in the large size and the strong concentric sculpture, but differs in the more inflated shell and the stronger prosogyrate umbo. *Sch.*? sp. ICHIKAWA (1950, p. 253, Pl. 5, Fig. 14) is another similar species, but the shell is much smaller and less convex.

*Occurrence* :—Common from  $N_2$  formation, Kongoin (N. 192, 103), very rare from Saka, Matsuo (N. 141); ? very rare from Heki formation, Heki (702). (Reg. Nos. JM. 10378-382, 10447)

## Supplements

**Parallelodon** sp. indet. (Pl. IV, Figs. 10 a—c)

*Description* :—Shell small in size, elongate transversely, trapezoidal, moderately convex, very inequilateral. Anterior side well rounded with the extremity lying above the midheight; ventral margin almost straight parallel to the hinge-margin, conjoining with slightly arcuate posterior margin making rounded acute angle. Umbo depressed, situated at anterior one-third of the shell-length; posterior carina rounded, well defined. Hinge consisting of a short, horizontal anterior tooth and a socket, and a long slender posterior tooth and a socket parallel to the hinge-margin in each valves; vertical denticles between them not preserved as well as ligamental area. Surface apparently smooth, but on the posterior part of the posterior area faint, close-set radial striae being recognizable.

*Remarks and Comparison*.—A single specimen of both valves in apposition is 40 mm long, 12 mm high and 5 mm deep in the external mould of the right. But it is strongly compressed laterally and must be considerably different from the original one. The species is similar to *Parallelodon monobensis* NAKAZAWA (1955, p. 253, Pl. 16, Fig. 17; Pl. 16, Figs. 1-3) in general outline, but differs in the much weaker dentition and sculpture and in the absence of ventral sinus. It is more like *Cucullaea (Parallelodon?) Tschapitana* BROILI (1904, p. 205, Pl. 24, Figs. 34-35), but the anterior side is more regularly rounded, continuing gradually to the dorsal margin, while in the latter species it meets at nearly right angles to the dorsal margin.

*Occurrence*.—Upper part of  $N_3$  formation, Nishi-mitsumatsu (N. 201). (Reg. No. JM. 10383)

***Neoschizodus (Okunominetania) kawarensis* NAKAZAWA, new species**  
(Pl. IV, Figs. 11-15)

*Description*.—Shell fairly large, subtrigonal, thick, moderately convex, longer than high, proportion of length to height about 1.4:1. Umbo located almost mesially or a little anteriorly to the center, orthogyrate, not so prominent. Marginal carina angular near the umbo, becoming round and obscure towards the rear end; posterior area provided with a faint median furrow and defined from the narrowly excavated escutcheon by a sharp external carina.

Hinge *Myophoria*-type; in the right valve anterior cardinal tooth (3a) strong, trigonal; posterior one (3b) slender, subparallel to the periphery and crenulated on the anterior side; anterior one (4a) of the left relatively broad with depressed anterior part; mesial one (2b) strong, trigonal, crenulated on the posterior side; posterior one (4b) long, slender, parallel to the shell-margin. Ligament external, opisthodetic; adductor scars strongly impressed; pallial line entire. Surface almost smooth.

*Remarks and Comparison*.—It is very difficult to show the accurate shape because of the strong deformation. The reconstruction inserted in the plate (Pl. IV, Fig. 15) was inferred from many samples. The species is referred to *Okunominetania* ICHIKAWA (1954 b, p. 62), the subgenus of *Neoschizodus*, by having crenulated cardinal tooth and socket on their lateral surfaces, but is distinguished from the type-species *O. okunominetaniensis* (ICHIKAWA) (1954 b, p. 62, Pl. 4, Figs. 1-3) by a much larger size and stronger dentition. Moreover the crenulation is seen only on 2b (right valve) and 3b (left), while it develops on both 4a and 2b in the right valve of the type-species.



*Occurrence* :—Abundant from N<sub>2</sub> formation, Kongoin (N. 103). (Reg. Nos. JM. 10389–398)

**Minetrigonia hegiensis** (SAEKI) **obsoleta** NAKAZAWA, new subspecies  
(Pl. IV, Figs. 5–9)

This subspecies coincides very well with *hegiensis* in the outline and dentition, but differs in smaller number of radial ribs, that is, the number varies between 2 and 8, scarcely over 8 and the apex of the distribution-curve lying at 6, while the latter one between 5 and 18 with the apex lying at 8 (NAKAZAWA, 1955, p. 253). Furthermore radials of this subspecies usually grow obsolete towards the ventral margin and is hardly recognizable in full grown stages. It differs also in the concentric sculptures, which become obscure backwards and usually more indistinct on the posterior half of the flank than those of *hegiensis*. Moreover the concentric costae are finer and the interspaces are broader than *hegiensis*.

*Occurrence* :—Abundant from N<sub>2</sub> formation, Higashi-arata (N. 122, 135) and Kurodani, Hirubatake, Takahama City (formerly Aonogo-mura) (N. 127), rare from N<sub>2</sub> formation, Ashidani, Nabae (N. 220); not associated with *hegiensis*. (Reg. Nos. JM. 10408–413).

**Minetrigonia katayamai** KOBAYASHI and ICHIKAWA (Pl. IV, Fig. 4)

1928. *Trigonia (Minetrigonia) hegiensis* KOBAYASHI and KATAYAMA, p. 188, text-figs. 1–2.

1945. *Minetrigonia katayamai* KOBAYASHI and ICHIKAWA p. 184.

1954. b. *Minetrigonia katayamai* ICHIKAWA, p. 63, pl. 4, figs. 9–10a, b.

Recently the writer found many specimens from the conglomeratic sandstone of the N<sub>2</sub> formation which belong undoubtedly to *Minetrigonia katayamai*. This species distributes widely in Kochi, Tokushima, Yamaguchi and Okayama Prefectures, but had not been discovered in the Maizuru zone. It is noticeable that the species does not accompany the intimate species *M. hegiensis* like in other localities.

*Occurrence* :—Abundant from N<sub>2</sub> formation, Kurodani, Takahama city (formerly Aonogo-mura) (N. 132). (Reg. Nos. JM. 10399–400)

**Oxytoma pulchra** KOBAYASHI and ICHIKAWA (Pl. IV, Fig. 16)

1950. *Oxytoma pulchra* KOB. & ICH., p. 244, Pl. 3, fig. 4.

1954a. *Oxytoma pulchra* ICHIKAWA, p. 49, pl. 2, figs. 6–11, ?12.

An external mould of a left valve is kept in the Ayabe Middle School. The surface is ornamented with 12 primary radial ribs, alternating secondaries with the former and two or three fine tertiary striae between the higher

orders. Though the specimen is compressed dorso-ventrally, it agree quite well with *O. pulchra* described from Sakawa and the Sakuradani areas in its outline, feature of both ears and mode of ornamentation.

*Occurrence*:—Very rare from upper part of  $N_3$  formation, Nabae (N. 216). (Reg. No. JM. 10446 (Gypsum cast)).

### Brief summary

Detailed scrutiny and discussion on the faunules and zoning of the Nabae group will be given in another paper, and brief summary is stated below.

The Nabae group including the Heki formation extends over 57 km from east to west in the Nabae, Matsunoodera, Terada, Oyogi, Monobe and Yakuno districts. The lowest  $N_1$  formation composed of sandstone, shale and conglomerate associated with thin, meagre coal seams is more than 70 m in thickness, and distributed only in the Nabae district and the northern part of the Matsunoodera. The formation is poor in fossils, and contains such species as *Minetrigonia* cf. *hegiensis obsoleta*, *Bakevellia subhekiensis* at the uppermost horizon at Nabae and *Ostrea*? sp. at Matsunoodera. The  $N_2$  formation consisting mainly of fine to medium, sometimes conglomeratic, quartzose sandstone is fairly continuous and traceable from Nabae westward to Monobe for about 30 km, and attains 520 m in maximum thickness. At Arakura in the southern part of the Matsunoodera district it overlies disconformably the Arakura formation, which is now considered as the lowest upper Triassic. Fossils are found mostly in sandy shale beds intercalated in the formation, and show a small horizontal variation in the faunal assemblage. The main fossils are *Minetrigonia hegiensis*, *Lima yataensis*, *Lima yataensis* var. *kuredaniensis*, *Velata maizurensis*, *Palaeopharus maizurensis*, *Bakevellia matsushitai*, *Cardinia triadica*, *Homomya matsuoensis*, etc. About the  $N_3$  formation consisting mostly of shale and sandy shale are recognizable two provinces by the facies and fossil-contents, i. e., the Nabae and the other. The formation in the Nabae province is entirely lacking in coal seams, rich in marine fossils through the formation, suggesting the open sea deposits. The lower part about 60 m thick is characterized by the *Halobia* faunule composed of *Halobia kawarai*, *H.* cf. *austriaca*, *H.* sp.; in addition to Halobiids ammonite (*Cyrtopleurites* sp.) is rarely found. On the other hand the upper part occupying the main portion of the formation contains a different faunule represented by *Tosapeecten nabaensis*, *Chlamys mojsisovicsi*, *Pseudolimea naumannii*, *Oxytoma* sp. and brachiopods such as *Mentzeliopsis* spp. and *Psioidea* sp., though the upper part highly resembles

the lower one in lithic aspect. Anmonites (*Cyrtopleurites* cf. *sakawanus*, *Paratrachyceras*? sp., *Dimorphites*? sp.), Halobiids (*Halobia* n. sp., *H. sp. a*) and bryozoans are also found from the upper part and small taxodont pelecypods (*Nuculana* sp., *Palaeoneilo* sp.) occur through the formation. The  $N_3$  formation in the remaining districts intercalates several coal seams, some of which were once in production, and is divisible into two parts. The lower one is predominant in marine pelecypod fossils and is about 100 m thick, while the upper one consisting the main portion of the formation, is common in plant remains instead of marine animal ones. The fossil assemblage of the lower part is not different essentially from that of the  $N_2$  formation in spite of the marked difference of lithic characters between them, but *Minetrigonia hegiensis*, *Homomya matsuoensis* and *Bakevellia matsuhitai* are very scarce and *Bakevellia monobensis*, *B. hekiensis*, "*Cuspidaria*" *ayabensis* become more predominant. *Velata maizurensis*, *Lima yataensis* and *Palaeopharus maizurensis* are the commonest species through both fossil beds. In the upper part, marine animal fossils are very limited in both kinds and quantities, and occur sporadically. *Palaeopharus maizurensis*, *Cardinia misawensis*, *Pseudolimea naumanni*, *Mentzeliopsis* sp. are these rare members. The uppermost  $N_4$  formation mainly constituted by fine to medium quartzose sandstone is distributed only in the Nabae and Monobe districts. The thickness is no less than 360 m in the Nabae district. At the horizon 90 m above the base fossiliferous bands are met with, crowded with *Pleuromya wakasana* and *Neoschizodus semicostatus*.

The Heki formation distributed in the Yakuno, the westernmost district of Kyoto Prefecture, coincides very well with the  $N_2$  formation and the lower part of the  $N_3$  formation in the fossil-contents.

Among the representative fossils of the  $N_3$  formation in the Nabae district, *Tosapecten* and *Halobia* are rarely found in the Matsunoodera and Terada districts, and recently *Pseudolimea naumanni* and *Mentzeliopsis* sp. have been discovered at Monobe. They are useful in correlation between two provinces.

From the faunal and stratigraphical studies it is surely concluded that the  $N_1$ - $N_3$  formation are regarded as Sakawan (=Carnian) in age, although the  $N_4$  formation remains uncertain because of the lack of the species common to other areas. Furthermore it is reasonable to subdivide the Sakawan age into two subages, early and late ones. ICHIKAWA (1950 b) has already proposed three subages, but his late subage cannot be separated clearly from his middle one by the present knowledge. The late subage here proposed includes his middle and late ones. The writer expects, however, the faunal change, which subdivides the late subage, in the Aso formation in Yamaguchi

Table 1. Correlation of the Sakawan formations in Japan

		"Maizuru Zone"					Okayama	Yamaguchi	Shikoku							
		Nabae	Matsunoodera-Oyogi	Monobe	Yakuno	Fukamoto	Kyowa <sup>2)</sup>	Miné <sup>3)</sup>	Sakawa <sup>4)</sup>	Sakuradani <sup>5)</sup> -Kito						
Early Sakawan	Nabae	N <sub>1</sub> f.	Palaeopharus-Lima yataensis Zone	Halobia Zonule	Palaeoph. Anodontoph. Z.	Bakevella-"Cuspidaria" Zonule	Kyowa formation	Mine group	Lower Kochigatani subgroup	Oxytoma-Mytilus beds	Lower formation					
				Palaeoph.-Lima yataensis Zonule	Minetrigonia-Homomya Zonule							Palaeopharus Minetrigonia Zone				
		N <sub>2</sub> formation	Palaeopharus-Lima yataensis Zone	Bakevella subhekiensis "Zonule"	Ostrea ? sp.	Palaeopharus-Lima yataensis Zone	Palaeopharus Minetrigonia Zone					Kyowa formation	Hirabara formation	H <sub>I</sub>	H <sub>I</sub>	Upper formation
		N <sub>3</sub> formation		Tosapecten-Pseudolimea naumanni Zone									Tosap. -Pseudol. naumanni Zonule	Cardinia misawensis, Palaeoph. maizurensis, and plant fossils	non-fossil	
Late Sakawan	Group	N <sub>4</sub> f.						Aso formation	A <sub>III</sub>	Myoconcha beds ?	Upper formation					
									A <sub>II</sub>							
									A <sub>I</sub>							

1) NAKAZAWA, SHIKI, SHIMIZU (1952),

2) NAKANO, M. (1952),

3) HASÉ, A. (1951)

4) KOBAYASHI and ICHIRAWA (1950),

5) ICHIKAWA, K. (1954)

Prefecture, the type formation of Ichikawa's late subage, though the detailed study on the faunules as well as stratigraphy of the formation is needed.

Finally the writer has tried the correlation of the Sakawan formations in Japan as shown in table 1.

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### Explanation of Plate

#### Plate I.

- Fig. 1. *Cardinia misawensis* KOBAYASHI and ICHIKAWA .....p. 231  
External mould of a right valve, boulder from upper part? of the N<sub>3</sub> formation, loc. Higashi-arata, Mastuo, (N. 121), x 1.5. (Reg. No. JM. 10340)
- Fig. 2. *Cardinioides japonicus* KOBAYASHI and ICHIKAWA .....p. 232  
Internal mould of a bivalved specimen, L: left valve, R: right valve, lower part of the N<sub>3</sub> formation, loc. Miuchi (N. 414), x 1.5. (Reg. No. JM. 10401)
- Fig. 3. *Cardinioides cf. splendis* KOBAYASHI and ICHIKAWA .....p. 232  
Internal mould of a right valve, lower part of the N<sub>3</sub> formation, loc. Shinmichi (N. 406), x 1.5. (Reg. No. JM. 10404)
- Fig. 4-5. *Cardinioides* new species, indet. ....p. 233  
fig. 4. Internal mould of a left valve, lower part of the N<sub>3</sub> formation, Nabae (N. 212), x 1.5, (Reg. No. JM. 1047)  
fig. 5. Gypsum-cast of the external mould of a right valve, lacking of the umbonal portion, lower part? of the N<sub>3</sub> formation, Nabae, x 1. (Reg. No. JM. 10443, gypsum-cast)
- Fig. 6. *Cardinoides* ? sp. indet. ....p. 233  
Clay-cast of the external mould of a right valve, lower part of the N<sub>3</sub> formation, Ashidani, Nabae (N. 223), x 1.5. (Reg. No. JM. 10444.)
- Figs. 7a, b. *Mytilus cf. tenuiformis* KOBAYASHI and ICHIKAWA .....p. 234  
Internal mould of a bivalved specimen, a: lateral view of a left valve, b: dorsal view of both valves, Heki formation, Heki (N. 704), x 1. (Reg. No. JM. 10342)
- Fig. 8. *Mytilus tenuiformis* var. *punctatus* KOBAYASHI and ICHIKAWA .....p. 234  
Internal moulds of several individuals, loc. ditto, x 1. (Reg. No. JM. 10343)

- Figs. 9a, b. *Mytilus* aff. *tenuiformis* var. *punctatus* KAB. and ICH. ....p. 234  
Internal mould of a left valve, a: lateral view, b: anterior view, loc. ditto., x 1. (Reg. No. JM. 10344)
- Fig. 10. *Mytilus* (*Falcimylus*) cf. *nasai* KOBAYASHI and ICHIKAWA .....p. 235  
External mould of a right valve, dotted portion being broken, the N<sub>3</sub> formation, exact horizon unknown, loc. Saka, Matsuo (N. 137), x 1. (Reg. No. JM. 10345)
- Fig. 11. *Mytilus* new species?, indet .....p. 235  
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All specimens here illustrated are kept in the Geological and Mineralogical Institute, University of Kyoto.

Arrows show apparent directions of compression by deformation.

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