709. A STUDY OF THE "PENNATAE TRIGONIIDS" FROM JAPAN*

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Abstract. The present work is a taxonomic revision of the so-called pennatae trigoniids from Japan, with an attempt to explain the evolutionary parallelism between *Heterotrignia* and *Apiotrigonia*. 16 species belonging to the pennatae trigoniids are known from various localities of the Upper Cretaceous in Japan. They are classified into two genera (*Apiotrigonia* and *Heterotrignia*) and four subgenera (*Apiotrigonia* s. str., *Heterotrignia* s. str., *Microtrignia* and *Nakanotrigonia* nov.). I propose *Apiotrigoniinae* nov. as a new subfamily of the Trigonidae on these genera and subgenera together with several other genera and subgenera outside Japan, such as *Columbitrignia*, *Quoiechcia*, *Dampiotrigonia* nov. and *Turkestanella* nov. *Apiotrigoniinae* nov. is mainly composed of the *Heterotrignia* trunk and the *Apiotrigonia* trunk which were probably derived from a common ancestor in the Lower Cretaceous. The evolutionary tempo of the *Heterotrignia* trunk is more rapid than that of the *Apiotrigonia* trunk. *Microtrignia* is an off-shoot of *Apiotrigonia*, whereas *Nakanotrigonia* nov. is that of *Heterotrignia*. The apparently directional changes of characters are recognized in both trunks in parallel with each other.

Introduction

Many species belonging to the so-called "pennatae trigoniids" (pennatae group, AGASSIZ, 1841; pennata group, LYCETT, 1872–1879; pinnate forms, NEWELL and BOYD, 1975, excluding *Iotrigonia* and *Vaugonia*) have been described from various localities of the Upper Cretaceous in Japan by elder authors.

A biostratigraphic study of the Cretaceous trigonians in Japan was comprehensively treated by NAKANO (1960). The stratigraphical positions of pennatae trigonian species which were listed in NAKANO (1957, 1960, 1961) are incorrect in certain parts, especially regarding the species from the Himenoura Group. Since UEDA and FURUKAWA (1960) reported the biostratigraphy of the Himenoura Group, several authors, e.g., HATAE (1959, 1960), AMANO (1960a, 1960b, 1962, 1963), UEDA (1962), YAMAMOTO and HAYAMI (1971), TANAKA and TERAOKA (1973), TASHIRO and NODA (1973), TASHIRO (1976), and TASHIRO and OTSUKA (1978), restudied the Himenoura Group. As a result the stratigraphic knowledge of the Himenoura Group was much improved, and consequently the stratigraphic ranges of pennatae trigonian species were also clearly determined. I once described the evolutionary change of characters in the pennatae trigoniids on the basis of the material from the Himenoura Group (TASHIRO, 1972). Subsequently more materials have been obtained, and my previous work should be revised and enlarged in the light of

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Text-fig. 1. Map showing the localities of the pennatae trigoniids in Japan.

up-to-date knowledge.

In this paper I offer revised taxonomic classification of the pennatae trigoniids from Japan, and attempt to discuss the origin and evolution of this group.

Repository

The specimens treated in this paper are stored in the following three institutions, with abbreviated indication by prefix.

GK: Department of Geology, Faculty of Science, Kyushu University (Fukuoka 812)
KE: Faculty of Education, Kumamoto University (Kumamoto 860)
KSG: Department of Geology, Faculty of Science, Kochi University (Kochi 780)

Acknowledgements

Before going further, I wish to express my sincere thanks to Emeritus Professor Tatsuro MATSUMOTO of Kyushu Univ. for his kind encouragements, critical reading of the first draft and supplying me with valuable information and several specimens from the Upper Cretaceous of Hokkaido. My sincere gratitude is extended also to Professor Minoru TAMURA of Kumamoto Univ., for his valuable suggestions and encouragements, to Dr. Mitsuo NAKANO and Dr. Itaru HAYAMI, for their kind advice. Thanks are due to Mr. Katsukichi YAMAMOTO, for the supplying me several pennatae trigoniids from the Izumi Group, to Mr. Iwane MIZUNO, from the Uwajima Group, to Mr. Masao OTSUKA, from the Himenoura Group, and to Mr. Makoto OKAMURA from the Upper Yezo Group. My thanks are extended to Dr. D. H. POULTON of the Geological Survey of Canada, for his kind advice and Dr. S. K. SKWARKO of the Bureau of Mineral Resources, Geology and Geophysics of Australia for his kind supply of the Australian specimens.

Revised Classification of the Pennatae Trigioids

Systematic Description
Order Trigonioida

Superfamily Trigoniaceae

Family Trigoniidae LAMARCK, 1819

Subfamily Apiotrigoniinae nov.

Diagnosis.—Shell usually small, pyriform or trigonally ovate; umbo normally opisthogyrous, but nearly orthogyrous in a few groups, located more anteriorly than the mid-point of the valve length; disk ornamented with two sorts of costae: the concentric or subhorizontal ones, occupying the umbonal and anterior parts of the disk and the subradial ones, developed usually on the posterior half of the disk, but often also on the anterior part of the disk; area ornamented with oblique or radial costellae, or smooth; escutcheon narrow, ornamented with oblique costellae or smooth; dorsal and marginal carinae weak or indistinct except near the umbo; median groove weak or obscure.

Remarks.—Some genera, e.g., Apiotrigonia and Heterotrigonia, of this new subfamily resemble Vaugonia CRICKMAY, 1932, and Iotrigonia VAN HOEPPEN, 1929, in having the reverse L-shaped costae which are formed by two sorts of costae on the disk. Vaugonia, however, differs from them, in having its distinct marginal and dorsal carinae, and transversely laminated costellae on the area. The L-shaped costae of Vaugonia and Iotrigonia were probably originated step by step from the concentric costae. Therefore, the costae on the anterior part of the disk in Vaugonia and Iotrigonia usually cut across the growth lines from upper to lower. On the other hand, the L-shaped costae of the genera belonging to Apiotrigoniinae, appear suddenly at an early stage of growth, on account of the appearance of the subradial costae which transversely cross the umbonal concentric costae. The subhorizontal costae on the anterior part of the disk generally cut across the growth lines from lower to upper. A young shell or umbonal part of some genera of this subfamily resembles Frenquelliguilla LEANZA, 1942, and Rutitrigonia VAN HOEPPEN, 1929, in their surface ornamentation and their outline of a valve as already mentioned by TASHIRO (1972). Trigonia sydariensis ARCHANGELSKI (1916), from the Cenomanian of Turkestan, is characterized by feeble subradial costae on the posterior part and concentric costae on the anterior part. NAKANO (1957) suggested that Trigonia sydariensis is referable to Rutitrigonia. Rutitrigonia cfr. laeviscula (LYCETT) (SAVELIEV, 1958), from the Lower Cretaceous of Turkmenia, is similar to the species of the Apiotrigoniinae in its features of concentric costae on the disk. Since the Turkmenian species lacks distinct subradial costae, numerous short costae appear under the marginal carina. I think, those two species may represent intermediate forms between the Apiotrigoniinae and the group of Rutitrigonia. Many species of Rutitrigonia, e.g., Trigonia pseudo-indica ARCHANGELSKI (1916), from the Cenomanian of Turkestan, T. weaveri STOYANOW (1949), from the Aptian of Texas, Rutitrigonia yeharae KOBAYASHI (1954; HAYAMI, 1968) and Rutitrigonia amagensis KOBAYASHI (1956) from the Jurassic of Mindoro, are characterized by a pyriform outline and plain subhorizontal costae which are obscured on the posterior part. Though they have no subradial costae, they resemble the species of this subfamily in their features of the outline and the ornamentation of anterior part. VAN HOEPPEN (1929) established the subfamily Rutitrigoniinae (Laevitrugoniinae, SAVELIEV, 1958; Fren-

Hayami (1975) listed, however, *Frenguelliiella, Geratrigonia, Latitrigonia, Nipponitrigonia, Ibotrigonia* and *Rutigrigonia*, as members of the subfamily Trigoniinae Lamark, 1819. In my opinion, the Rutitrigniinae, the Trigoniinae (Kobayashi, 1954; Nakano, 1961) and the Nototrigoniinae Skwarko (1963) are closely related to one another, and they form a group under the Trigoniidae. *Apiotrigniinae* nov. are also added to them as one of the members of this group. The Apiotrigniinae are most closely related to the Rutitrigniinae, but discriminated by its subradial costae on the posterior part of the disk.

**List of genera and subgenera.**

Genus *Apiotrignonia Cox*, 1952

Subgenus *Apiotrignonia Cox*, 1952; *Microtrigonia Nakano*, 1957; *Dampietrigonia* nov.; *Turkesianella* nov.

Genus *Heterotrigonia Cox*, 1952

Subgenus *Heterotrigonia Cox*, 1952; *Nakanotrigonia* nov.

Genus *Columbitrigonia Poulton*, 1977

?Genus *Quoiecchia Crickmay*, 1932

**Age and distribution.**—Upper Jurassic and Cretaceous; Western Europe, Turkistan, Japan, Sakhalin, Kamchatka, Cordillera of North America, southern part of the interior province of North America, Central America, western Australia, Patagonia, Chile and South Africa.

Genus *Apiotrignonia Cox*, 1952

Type-species: *Trigonia sulcata* Lamark, 1819.

**Diagnosis.**—Shell medium to small for trigoniids but large to small for the Aapiotrigniinae; umbo more or less prominent, located anteriorly; disk ornamented with two sorts of costae: the concentric or subhorizontal costae, generally appear on the umbonal part and the anterior part of the disk, and the subradial ones covering the posterior part of the disk but sometimes present on the anterior part of the disk; area smooth or ornamented by oblique or concentric costellae; escutcheon depressed, ornamented by oblique or horizontal costellae, or smooth; escutcheon carina almost invisible except near the umbo; marginal carina distinctly angulated near the umbo but gradually changing into rounded ridge on the posterior part; median groove weak or indistinct.

**Remarks.**—The outline of the valve is rather constant in each species of this genus. The anterior costae of the disk (anterior series) are variable in number, strength and appearance in each species. The posterior subradial costae (posterior series) are, however, rather constant in number and strength in each species but for several species, e.g., *Apiotrignonia (Apiotrignonia) obsoleta Nakano, A. (A.) crassoradiata Nakano, A. (?A.) dubia* nov. and *A. (Microtrigonia) imatensis* (Tashiro). The costae of the anterior series are plain, narrower than their interspaces and regularly spaced on the umbonal region. A very narrow marginal sulcus is recognizable on a portion closest to the umbo in some species, e.g., *Apiotrignonia (Apiotrignia) minor* (Yabe and Nagao), *A. (A.) utoensis* Tashiro, *A. (A.) undulosa* Nakano, *A. (A.) obsoleta* Nak-
NO, A. (?A.) dubia nov., A. (Microtrigonia) amanoi (NAKANO), A. (M.) imutensis (TASHIRO) and A. (Turkestanella) turkestanensis (ARCHANGELSKI) (subgen. nov.). TASHIRO (1972) has already illustrated the umbonal characters of several species of this genus.

**Age and distribution.**—Cretaceous; Western Europe, Turkestan, Japan, Sakhalin, Kamchatka, Cordillera of North America, southern part of the interior province of North America, western Australia, Patagonia, Chile and South Africa.

Subgenus Apiotrigonia Cox, 1952

Type-species: *Trigonia sulcata* LAMARCK, 1819.

**Diagnosis.**—Shell large to medium for Apiotrigoniinae, pyriform, longer than high; umbo weakly prominent, opisthogyrous or nearly orthogyrous in a few species; disk ornamented by two series of costae; anterior ones concentric or subhorizontal, very often weakly inclined or undulated, sometimes vanished, located on an anterior half or more limited anterior part of the disk; posterior ones subradial, sometimes tuberculated, occupying about a posterior half of the disk; area rather narrow, ornamented with oblique or subhorizontal costellae, sometimes sculptured with concentric costellae; fine concentric plain costellae regularly spaced on umbonal area in some species; escutcheon narrow, deeply depressed, ornamented by oblique or subhorizontal costellae, or smooth on some foreign species; median groove shallow.

**Remarks.**—This subgenus resembles *Heterotrigonia* s. str. in the two series of costae, but differs clearly from the latter in its less-developed radial costellae on the area. *Trigonia calderoni* (CASTILLO and AGUIERA), from the Upper Jurassic of Mexico and Texas (CRAGIN, 1905; STOYANOW, 1949), is the oldest species belonging to Apiotrigoniinae nov. SKWARKO (1970) referred *T. calderoni* to *Apiotrigonia*. NAKANO (1971) reclassified *T. calderoni* in *Heterotrigonia*, because of its radial costellae on the area. I think that *T. calderoni* was a common ancestor of the species of *Apiotrigonia* s.l. and *Heterotrigonia* s.l. I list here, *Trigonia calderoni* as a member of *Heterotrigonia* s. str., following NAKANO’s classification. COX (1952) and NAKANO (1957) referred many species to *Apiotrigonia* s.l. The species undoubtedly referable to *Apiotrigonia* s. str. are as follows.—

*Trigonia buchi* GEINITZ, 1872; Middle Cretaceous of Sachsen

*T. concardiformis* (KRAUSS) in KITCHIN (1913); Lower Cretaceous of South Africa

*T. condoni* PACKARD, 1921; Aptian of British Columbia

*T. cragini* STOYANOW, 1949; Aptian of Texas

*Apiotrigonia crassoradiata* NAKANO, 1957; Campanian of Japan

A. (?A.) dubia sp. nov.; Maastrichtian of Japan

*Trigonia heterosculpta* STANTON, 1901; Lower Cretaceous of Patagonia

*Apiotrigonia hetonaiana* TASHIRO, 1978; Maastrichtian of Japan

*Trigonia kayana* ANDERSON, 1938; Aptian of California

*T. kitchini* STOYANOW, 1949; Aptian of Texas

*T. maudensis* WHITEAVES, 1876; Upper Cretaceous of British Columbia

*T. subovalis* var. *minor* YABE and NAGAO, 1925; Senonian of Japan and Sachalin

*Apiotrigonia (Apiotrigonia) mikasaensis* sp. nov.; Cenomanian and Turonian
of Japan and Sachalin
Trigonias newcombei PACKARD, 1921; 'Middle Cretaceous' of British Columbia
Apionotrigonia obsoleta NAKANO, 1957;
Santonian and Campanian of Japan
Trigonia pennata SOWERBY, 1819;
Cenomanian of England
Apionotrigonia (Apionotrigonia) progonos
(PAULCKE) in REYES and PÉREZ (1978); Neocomian and Aptian of Chile
T. pumila NILSON in HÄGG (1954);
Cenomanian of Germany
T. sulcataria LAMARCK, 1819 (COX, 1952); Cenomanian of France
T. turkmenensis ARCHANGELSKI, 1916;
Cenomanian of Turkestan
Apionotrigonia utensis TASHIRO, 1972;
Lower Campanian of Japan
A. undulosa NAKANO, 1957; Coniacian of Japan
Trigonia condoni PACKARD, 1921 was referred to Megatrigonia (Apionotrigonia) by JONES (1960), but to Columbitrigonia by POULTON (1977).
Age and distribution.—Cretaceous;
Western Europe, British Columbia, Texas, California, Patagonia, Chile, Turkestan, South Africa, Sachalin and Japan.

Apionotrigonia (Apionotrigonia) minor
(YABE and NAGAO)
Plate 25, Figs. 18-20, Text-fig. 2

1923. Trigonia subovalis JIMBO: YEHARA,
1925. Trigonia subovalis JIMBO var. minor
YABE and NAGAO, Sci. Reppt. Tohoku
1930. Trigonia subovalis var. minor YABE and
NAGAO: NAGAO, Jour. Fac. Sci.,
1, p. 18.
1954. Apionotrigonia subovalis minor (YABE
and NAGAO): KOBAYASHI, Japan. Jour.
1957. Apionotrigonia minor (YABE and NAGAO):
NAKANO, Japan. Jour. Geol. Geogr.,
vol. 28, nos. 1-3, p. 110, pl. 8, fig. 4,
nom. figs. 1-3.
1957. Apionotrigonia obliquecostata NAKANO,
1-3, p. 113, pl. 8, figs. 9-10.
1962. Apionotrigonia minor (YABE and NAGAO):
SAITO, Bull. Fac. Arts and Sci. Ibaraki
Univ., Nat. Sci., no. 13, p. 63, pl. 1,
figs. 8-9.
Fac. Arts and Sci. Ibaraki Univ., Nat.
Sci., no. 13, p. 63, pl. 1, fig. 6.
1967. Apionotrigonia minor (YABE and NAGAO):
MAEDA and KAWABE, Prof. H. SHIBATA
Mem. Vol., Tokyo, p. 423, pl. 1, figs.
10-25.
1967. Apionotrigonia futabaensis MAEDA and
KAWABE, Prof. H. SHIBATA Mem. Vol.,
Tokyo, p. 421, pl. 1, figs. 5-6.
1967. Apionotrigonia hironoensis MAEDA and
KAWABE, Prof. H. SHIBATA Mem. Vol.,
Tokyo, p. 422, pl. 1, figs. 7-8.
1967. Apionotrigonia orikiensis MAEDA and
KAWABE, Prof. H. SHIBATA Mem. Vol.,
Tokyo, p. 423, pl. 1, figs. 1-4.
1972. Apionotrigonia minor (YABE and NAGAO):
Japan, N.S., no. 86, text-figs. 1-b, 3-c,
4 and 6-a, pl. 40, figs. 1-17 (compare,
not described).
1975. Apionotrigonia (Apionotrigonia) minor
(YABE and NAGAO): HAYAMI, Univ.
Mus., Univ. Tokyo, Bull. no. 10, p. 114.
1975. Apionotrigonia (Apionotrigonia) oblique-
costata NAKANO: HAYAMI, Univ. Mus.,
Univ. Tokyo, Bull. no. 10, p. 115.

Material.—KSG 2050-2052, 2059-2060
and KE 1904-1910, collected from the
Lower Himenoura Subgroup at Wadano-
hana of Ryugadake-machi, Amakusa
Kamishima Island, Kyushu. KSG 2048-
2049, from the same subgroup at Hino-
shima islet of Amakusa Kamishima
Island; KSG 2053-2054, plaster casts
from the Furusihio-yama Formation of
the Uwajima Group of Furushiro, Hiromimachi, Uwajima City, Ehime Pref. KSG 2055-2058 are collected from the Lower part of the Futaba Group of Hironomachi and Iwaki City, Fukushima Pref.

Description.—Shell medium in size, moderately inflated; test rather thick; anterior margin semi-circular, passing gradually into broadly arched ventral margin; posterior dorsal margin weakly concave, as long as about a half length of the valve; siphonal margin somewhat broad, well rounded; umbo large but a little elevated from the dorsal margin, slightly opisthogyrous, located at about two-fifths of the length from the front of the valve; disk ornamented with two series of costae; a boundary between the anterior series and the posterior series extending nearly straight from a little posterior of the umbo to the nearly mid-point of the ventral margin; the costae of the anterior series plain, narrower than their interspaces, 10 or more costae on umbonal region concentric, regularly spaced, next about 10 costae on the median part of the series broadly spaced, horizontal or concentric in general, but sometimes oblique, the rest costae of the anterior series on the anterior ventral part very variable in strength, subhorizontal, concentric, oblique, undulated, irregularly waved, bended in V shape, or disappearing (see, TASHIRO 1972, p. 329, text-fig. 4, pl. 40, figs. 1-13); the costae of posterior series strong, broader than their interspaces, countable between 10 and 13 in the adult specimens, the first 6 or so of the series narrow on the upper side but soon become sturdy on the lower side, not reaching the ventral margin, of which the first one begins to appear on a little posterior of umbo, the other costae somewhat narrower than those of the anterior ones, reaching subradially the ventral margin; escutcheon broad, strongly depressed, ornamented with subhorizontal or slightly oblique numerous plain costellae; area broad, ornamented with two sorts of plain costellae; one of them occupying nearly the full surface of the area except near the siphonal margin, subhorizontal or oblique, each of which is conjoined with a costella on the escutcheon; the other sort of costellae are concentric or transverse, generally developed near the marginal carina crossing the other sort of costellae; escutcheon carina scarcely visible only near the umbo; marginal carina distinct near the umbo but gradually changing posteriorly into broadly rounded ridge; median groove shallow; inner surface smooth; inner anterior margin and posterior part of the inner ventral margin broadly crenulated.

Measurements (in mm).—

<table>
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<th>Specimen</th>
<th>Length</th>
<th>Height</th>
<th>Thickness</th>
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<td>30.7</td>
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</tr>
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<td>KE 1905, left valve</td>
<td>28.5</td>
<td>19.6</td>
<td>6.5</td>
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<tr>
<td>KE 1906, left valve</td>
<td>22.8</td>
<td>17.3</td>
<td>5.5</td>
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<tr>
<td>KE 1907, right valve</td>
<td>31.1</td>
<td>20.6</td>
<td>7.0</td>
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<tr>
<td>KE 1910, right valve</td>
<td>20.3</td>
<td>15.7</td>
<td>5.8</td>
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<tr>
<td>KE 1909, left valve</td>
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<td>9.0</td>
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<td>33.0</td>
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<td>5.6</td>
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<td>KSG 2055, right ex. mould</td>
<td>24.0</td>
<td>18.0</td>
<td>6.6</td>
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<tr>
<td>KSG 2056, left ex. mould</td>
<td>24.0</td>
<td>16.5</td>
<td>4.5</td>
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</table>

Remarks.—YABE and NAGAO (1925) established minor as a variety of Trigonia subovalis JIMBO, based on many syntypes
from several localities of Hokkaido, North Sachalin, Northeast Japan and Southwestern Kyushu, but Nakano (1957) ranked it up as a distinct species of Apiotrigonia and designated a specimen as the lectotype which was collected from the lower part of the Futaba Group of Northeast Japan (Yabe, 1927, pl. 7, fig. 4). A form represented by the specimens from Hokkaido (Yehara, 1915, pl. 1, figs. 14-17) belongs to Apiotrigonia (Apiotrigonia) mikasaensis nov., because its foremost costa of the series is more numerous than those of this species. The specimens from the lower part of the Uwajima Group (pl. 25, figs. 9-10), which were collected by Mr. I. Mizuno, are small and characterized by more numerous costae of the posterior series than those of this species. They are probably immature shells of Apiotrigonia (Apiotrigonia) undulosa Nakano, which is characterized by strong costae of the posterior series and irregular arrangement of costae of the anterior series (see, Tashiro 1972). The variable costae are also shown in the illustrations of the specimens from the Futaba Group by Maeda and Kawabe (1967).

Occurrence.—Siltstone of the lower part of the Futaba Group at Oriki of Hirono-machi, Futaba-gun, and Ashizawa of Yachi, Iwaki City, Fukushima Prefecture; Inoceramus uwajimensis Zone; Coniacian; Lower Urakawan. Sandstone of the upper part of the Furushiroyama Formation of the Uwajima Group, at Furushiroyama of Hiromi-machi, Ehime Prefecture; Santonian; Urakawan. Black siltstone of the Lower Formation of the Lower Himenoura Subgroup at Hinoshima, Goshonoura island and Futamado of Himedo, Amakusa-Kaminoshima area. Black siltstone of the Middle Formation of the same subgroup at Wadanohana and Kugujima of Takado, Amakusa-Kamishima area, Kumamoto Prefecture. Inoceramus amakusensis and Inoc. japon-
icuZ Zones; Santonian; Upper Urakawan.

*Apiotrigonia* (*Apiotrigonia*)
*mikasaensis* sp. nov.

Plate 25, Figs. 1-6, Text-fig. 3


**Material.**—Holotype KSG 2061, is a right valve from the Ponbetsu (Loc. IK 2016), Mikasa area, Hokkaido; KSG 2068-2070 (paratypes), from the same locality as the holotype; GK. H6910-6913 (paratypes), from Ponhorokabetsu, Yubari dome, Hokkaido (Loc. Yb 67r, see **Matsumoto** and **Harada**, 1964) (Masato **Harada** coll.)

**Description.**—Shell medium in size, moderately inflated; test rather thin; anterior margin semi-circular, ventral margin broadly arched on the anterior part but nearly straight on the posterior; dorsal margin long, weakly concave; siphonal margin somewhat narrow but well rounded; umbo small, a little prominent, opisthogyrous, located at about a third or a fourth of the length from the front of the valve; disk with two series of costae; anterior series plain, narrower than their interspaces, 5 or more costae on the umbonal region concentric, regularly spaced, next 15 or more on the median part of the series subhorizontal but sometimes weakly waved; on the anterior ventral part of the adult specimens, the anterior series generally obscured or become irregularly flexous; the costae of the posterior series number 17 or more, plain, a little wider than their interspaces, the first 5 or so of the same series short, subvertical, not reaching the ventral margin, of which the first one begins to appear under the umbo, the other 12 or so subradial, occupying the posterior half of the disk; escutcheon strongly depressed, narrow but elongated with about a half length of the valve, ornamented with narrow, plain, subhorizontal costellae; area narrow, ornamented with oblique and narrow costellae, which are conjoined with the costellae of the escutcheon near the umbonal or anterior half of the area, but on the posterior half of the area the costellae are obscured and shown only by fine growth lines; escutcheon carina obscure; marginal carina distinct near the umbo, moderately angulated, but soon weakened and changing into rounded ridge on the posterior part of the valve; median groove very weak; inner surface weakly impressed by the subradial ribs of the posterior series.

**Measurements** (in mm).—

<table>
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<th>Specimen</th>
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<th>Thickness</th>
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<td>KSG 2068, right valve</td>
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<td>3.0</td>
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<td>GK. H 6910, right valve</td>
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<td>31.2</td>
<td>20.5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Remarks.**—This species is one of the oldest species of *Apiotrigonia* s. str. from Japan. The specimens which have hitherto been called "*Trigonia subovalis* var. minor **Yabe** and **Nagao**" or "*Apiotrigonia minor* (**Yabe** and **Nagao**)" from the Mikasa Formation and the Middle Yezo Group in Hokkaido can be mostly referred to this species. The specific name is derived from the Mikasa Formation of central Hokkaido, in which
this species occurs commonly.

*Apiotrigonia (Apiotrigonia) minor* (YABE and NAGAO) is discriminated from this species by its less numerous and stronger subradial costae of the posterior series, less numerous and more irregular costae of the anterior series, distinct and widely spaced costella on the area, and more posterior location of the foremost (i.e. the first) costa of the posterior series. *Apiotrigonia (Apiotrigonia) undulosa* NAKANO is closely similar to this species in its numerous costae of the posterior series and finely waved costae of the anterior series. The foremost costa of the posterior series in this species is, however, located more anteriorly than that in *A. (A.) undulosa* NAKANO. Other specimens belonging to *Apiotrigonia* s. str. in Japan, e.g., *Apiotrigonia (Apiotrigonia) crassoradiata* NAKANO, *A. (A.) sexonana* TASHIRO, *A. (A.) utoensis* TASHIRO, *A. (A.) obsoleta* NAKANO and *A. (? A.) dubia* sp. nov. are clearly discriminated from this species in their less numerous costae of the anterior and posterior series, and more posterior locations of the foremost costa of the posterior series. *Heterotrigonia (Heterotrigonia) subovalis* (JIMBO), radiate form, (see, p. 210), resembles this species in its foremost costae which begins to appear under the umbo, but differs in its distinct radial costella which are one of the important characters in *Heterotrigonia* s. l., and its less numerous costae of the anterior and posterior series.

**Occurrence.**—Sandstone of the Mikasa Formation of Ponbetsu, (JK 2016), Mikasa City, Hokkaido; *Inoceramus hobetsuensis* Zone. Sandstone of the Middle Yezo Group at Yonosawa of Ponhorokabetsu, Yubari (Yb 67r, see, MATSUMOTO and HARADA, 1964), Hokkaido. This species is probably restricted to the Upper Gyliakan (Turonian).

*Apiotrigonia (Apiotrigonia) undulosa* NAKANO

Plate 25, Figs. 7-10, Text-fig. 4


**Material.**—KSG 2071-2072 and KE 1925-1926, imperfect specimens from Sakuradani, Hirono-machi, Fukushima Pref.; KSG 2073-2074, external moulds collected from Hiromi-machi, Uwajima City, Ehime Pref. by Mr. I. MIZUNO; KSG 2062-2067, from Kajisaka of Ootochi, Kami-gun, Kochi Pref.

**Description.**—Shell medium in size, weakly inflated; anterior margin well arched and nearly semi-circular, ventral margin long, broadly arched; posterior dorsal margin elongated and weakly concave; siphonal margin narrow and
well rounded; umbo small, slightly elevated from the dorsal margin, a little opisthogyrous, located at a fourth of length from the front of valve; disk ornamented with two series of costae except near the umbo; the costae of the anterior series, which occupy about a half of the disk, plain, narrower than their interspaces, densely crowded and concentric near the umbo, irregularly undulated or wavy on the main part, and on the antero-ventral part gradually obsolete to be represented by growth lines only; the costae of the posterior series fairly broader than the anterior ones, broader than their interspaces number about 20, of which the first 10 or so do not reach the ventral margin, and the first short costa begins to appear at a point a little posterior to the umbo; about 10 succeeding costae stretch from the postero-ventral carina to the ventral margin; escutcheon narrow but elongated, ornamented with about 20 or more subhorizontal and plain costellae; area somewhat broad, ornamented with numerous wavy subconcentric costellae near the umbo, and with numerous subhorizontal costellae which are connected with the costellae of escutcheon on the anterior half of the area except for near the umbo; posterior half of the area nearly smooth except for fine growth lines; escutcheon carina indistinct; posterior carina angulated near the umbo but gradually changing into roundly elevated ridge; median groove of the area very weak.

**Measurements (in mm).**

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<th>Thickness</th>
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<tr>
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**Remarks.**—Many specimens are collected from the Futaba Group of Northeast Japan and the Uwajima Group of Shikoku, although some of them are imperfect external moulds. The specimens (pl. 25, figs. 7–10) from Hiromi-machi of Uwajima and Kajisako of Otochi both in Shikoku, represent the immature stage of this species. Mature specimens are generally about 40 mm or more in length. This species is characterized by the strongly undulated costae of the anterior series. Such costae generally appear on some species of Apiotrigonia s. str., e.g., A. (A.) minor (YABE and NAGAO) and A. (A.) crassoradiata NAKANO. In this species, the undulate costae are somewhat crowded and occupy the majority of the anterior series. This species closely resembles A. (A.) minor, but it has undulated costae in the anterior series and less numerous subradial costae of the posterior series. This species is similar to A. (A.) mikasaensis sp. nov. in

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Text-fig. 4. *Apiotrigonia (Apiotrigonia) undulosa NAKANO*, scale 5 mm.
having numerous costae of the posterior series, but differs in the foremost costa of the posterior series which appears later in that species. It is probably a derivative from *A. (A.) mikasaensis* sp. nov. *A. (A.) utoensis* TASHIRO resembles this species in the wavy concentric costellae near the umbo on the area, but clearly differs in the plain subradial costae of the posterior series and its undulated costae of the anterior series.

*Occurrence.*—Examined specimens are from the lower sandstone of the Futaba Group at Sakuradani, Hiromi-machi, Futaba-gun, Fukushima Pref., from the sandstone of the lower part of the Furushiroya Formation of the Uwajima Group at Hiromi, Kitauwa-gun, Ehime Pref. and fine-grained sandstone of the Kajisako Formation of the Sotoizumi Group at Kajisako of Otochi, Kami-gun, Kochi Pref. This species is also reported from the Inukai Formation of the Onogawa Group in Oita Pref. by TERAOKA (1970). The holotype designated by NAKANO (1957) was described from Taikorin, Orik, Hirono-machi, Futabagun, Fukushima Pref. This species is probably restricted to the Turonian (upper part of the Kajisako Formation) and Coniacian (lower part of the Uwajima Group and the Inukai Formation of the Onogawa Group). *Inoceramus hobetsuensis* Zone and *I. uwajimensis* Zone.

*Apiotrigonia (Apiotrigonia)*

*crassoradiata NAKANO*

Plate 25, Figs. 21 and 22


1957. *Apiotrigonia crassoradiata NAKANO,*

*Japan, Jour. Geol. Geogr.*, vol. 28, nos. 1–3, p. 113, pl. 8, figs. 9 and 10.


*Material.*—KSG 2077–2085, internal and external moulds from Fukkireura of Shimo-koshikijima Island, Kagoshima Pref., KSG 2075–2076 and KE 2783, external moulds from Omagari of Tomiuchi (Hetonai), Iburi District, Hokkaido. KE 2127 and KSG 2086, from Himezuka of Dogo, Matsuyama City, Ehime Pref.

*Measurements* (in mm).—

<table>
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<tr>
<td>KSG 2078, left ex. mould</td>
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</tr>
<tr>
<td>KSG 2079, right ex. mould</td>
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<td>7.3</td>
</tr>
<tr>
<td>KSG 2086, right valve</td>
<td>24.0</td>
<td>23.0</td>
<td>7.0</td>
</tr>
</tbody>
</table>

*Remarks.*—This species is characterized by its entirely smooth area, bi- or trifurcated subradial costae in the posterior series in some adult specimens, variable ornamentation of the anterior series and somewhat large size for *Apiotrigonia* s. str. The subradial costae, about 12 in number, are variable in the strength on the median part of the disk, as already mentioned in my previous
paper (TASHIRO, 1978). The first costa of the posterior series begins to appear more posteriorly than that of Apiotrigonia (Apiotrigonia) minor (YABE and NAGAO). The posterior carina is distinctly angulated on the earlier half of the valve, but it rapidly becomes blunt on the later half.

Occurrence.—Holotype of this species was described by NAKANO (1957) from the basal part of the Izumi Group at Yuasa of Onsen-gun, Ehime Pref. The specimens in my hand were collected from several localities as mentioned below.

Black siltstone of the basal part of the Izumi Group at Himezuka of Dogo, Matsuyama City, Ehime Pref.; Inoceramus (Sphenoceramus) schmidti Zone; Middle Campanian. Sandstone of the Lower Member of the Middle Formation (Member U-IIa) of the Upper Himenoura Subgroup, at about 500 m south of Fukkireura, and about 200 m north of Fukkireura, Kashima-mura, Satsuma-gun, Kagoshima Pref. Sandstone of Member U-IIa of the same subgroup at Yokohama of Oe, Amakusa-machi, Amakusa-gun, Kumamoto Pref.; Inoceramus (Sphenoceramus) sachalinensis Zone; Middle Campanian. Fine grained sandstone of the Hakobuchi Group, at Omagari, Tomiuchi (Hetonaia), Iburi District, Hokkaido; Inoceramus (Sphenoceramus) orientalis orientalis Zone; Lower Campanian. A specimen collected by Mr. Makoto OKAMURA of Kumamoto Univ. from the Upper Yezo Group at Saku, Teshionakagawa-gun, Hokkaido (Inoceramus (Sphenoceramus) schmidti Zone), is identified with this species.

This species is probably restricted to Lower and Middle Campanian (Lower Hetonaian).

Apiotrigonia (Apiotrigonia) hetonaiana TASHIRO

1938. Trigonia subovalis var. minor YABE and NAGAO; NAGAO and OTATUME, Jour. Fac. Sci., Hokkaido Imp. Univ., ser. 4, vol. 4, nos. 1–2, p. 42, pl. 1, figs. 7–8, non fig. 9.


Remarks.—Since this species was referred to Trigonia subovalis var. minor YABE and NAGAO, by NAGAO and OTATUME (1938), it has been listed as Apiotrigonia minor (YABE and NAGAO) by NAKANO (1957), SAITO (1961), MAEDA and KAWABE (1967) and HAYAMI (1975). Recently TASHIRO (1978) discriminated this species from Trigonia subovalis var. minor YABE and NAGAO, and described in detail as a distinct species of Apiotrigonia, A. hetonaiana TASHIRO.

This species is large for Apiotrigonia s. str., and characterized by smooth and broad area, disappearance of the anterior series, finely crenulated inner anterior margin and numerous radial striae on the subinternal surface of the anterior half of the disk. The subradial costae of the posterior series are generally weaker than in several resembling species, e.g., A. (A.) minor (YABE and NAGAO), A. (A.) mikasaensis sp. nov., and A. (A.) crassoradiata NAKANO. This species is similar to Apiotrigonia (Apiotrigonia) obsoleta NAKANO, in having its smooth area and obscured costae of the anterior series, but clearly differs in its larger size of the valve and more numerous subradial costae of the posterior series than that of A. (A.) obsoleta (12 or more in this species; 4–7 in A.
(A.) obsoleta). This species is probably closely related to Apiotrigonia (Apiotrigonia) crassoradiata Nakano.

Occurrence.—Fukaushi Sandstone of the Hakobuchi Group at Panketosano-sawa of Tomiuchi (Hetonai), Iburi District, Hokkaido; Maastrichtian (Upper Heteronai). Sandstone of the uppermost part of the Chinomigawa Formation of the Upper Yezo Group, at Chinomigawa of Urakawa, Hidaka District, Hokkaido, which is somewhat younger than the Inoceramus (Sphenoceramus) schmidtii Zone or uppermost part of the Inoc. (Sphenoc.) schmidtii Zone; Lower Maastrichtian or Uppermost Campanian?; Lowest Upper Heteronai or uppermost Lower Heteronai. The holotype (KE 2776) was collected at Panketosano-sawa, Tomiuchi. This species presumably ranges from the uppermost Campanian to Maastrichtian.

Apiotrigonia (Apiotrigonia) utoensis TASHIRO


Material.—The specimens at my disposal are KE 1881 and 1882 which were described in my previous study (TASHIRO, 1972, pl. 41, figs. 9 and 10).

Remarks.—This species is discriminated from the other species of Apiotrigonia s. str. in its numerous transverse striae on the area and the subradial costae which are finely tuberculated on the anterior region of the posterior series. This species resembles Microtrigonia spp., e.g., Apiotrigonia (Microtrigonia) amanoi (NAKANO), A. (M.) postomoda NAKANO, and A. (M.) imutensis (TASHIRO), in its tuberculated subradial costae on the posterior series. Apiotrigonia (Microtrigonia) imutensis (TASHIRO) is closely related to this species in having its transverse striae on the area. This species, however, differs from these species of Microtrigonia in its less developed subradial costae on the anterior part of the disk.

Occurrence.—Black siltstone of the lower part? of the Upper Formation of the Lower Himenoura Subgroup (Formation L-III) at Okoshiki beach of Odamachi, Uto City, Kumamoto Pref.; Inoc. (Sphenoceramus) orientalis nagaai, Heterotrigonia (Nakanostrigonia) himenourensis (subgen. nov.), and Diplomoceras? sp. occurred together with this species. The bed is probably Lower Campanian (Lowest Heteronai) in age. Black siltstone of the Middle Formation of the same subgroup, at the western beach of Kugujima islet, Takado, Ryugadake-machi, Amakusa-gun, Kumamoto Pref.; Inoceramus japonicus Zone; Upper Santonian (Uppermost Urakawan).

Apiotrigonia (Apiotrigonia) obsoleta NAKANO

Text-fig. 5


Material.—KE 1891–1903, from Okoshiki beach of Odamachi, Uto City, Kumamoto
Prefecture.

Description.—Shell small; test rather thin; umbo small, slightly prominent, a little opisthogyrous, located at a third to a fourth from the front of valve; anterior margin well rounded passing gradually into broadly arched ventral margin; siphonal margin narrow, well rounded, somewhat rostrated to posterior; posterior margin nearly straight, postero-dorsal margin gently concave; the costae of the posterior series occupy about a third of the disk; about 10 of the costae of the anterior series concentric near the umbo, regularly spaced and crowded; those on the succeeding median part of the same series broadly spaced, narrower than their interspaces, nearly subhorizontal, gradually weakened towards venter and posterior, and generally effaced on the median part of the disk; those on the ventral part of the same series nearly obsolete; the costae of the posterior series very weak, broadly spaced, 4 to 8 in number, of which 3 or so on the anterior region do not reach the ventral margin; the first costa of the series begins to appear at a point about 5 mm distant from the umbo towards the posterior; area nearly smooth except for several concentric costellae which are conjoined with the costellae of the escutcheon near the umbo; escutcheon depressed, rather broad, ornamented with 10 or less than 10 oblique costellae; escutcheon carina indistinct; postero-ventral carina obtusely angulated near the umbo, but soon changing into low and broadly rounded ridge; median groove of the area very shallow, but distinct; smooth marginal sulcus extended along the boundary between the costate disk and the smooth area; inner surface smooth; inner posterior ventral margin broadly crenulated on some specimens.

Text-fig. 5. Apiotrigonia (Apiotrigonia) obsolete Nakano, scale 5 mm.

Measurements.—(see, Tashiro, 1972)

Remarks.—The subradial costae of the posterior series are variable in number, between 4 and 8. The costae of the anterior series are generally obscure in the majority of the specimens on the central and anterior ventral part of the disk; but occasionally discernible as weak costellae in some specimens. The latter was once called Apiotrigonia minor var. nankoi by Nakano (1957), but there is gradation between it and the smoothish form in a fossil population from one and the same locality.

This species distinctly differs from other species of Apiotrigonia s. str. from Japan, in its less numerous, and low and weak costae on the disk. It may have been derived from the main lineage ranging from A. (A.) mikasaensis to A. (A.) helonaiana (text-fig. 17). It resembles Trigonum maudensis Whiteaves (Packard, 1921) from the Haida Formation of Queen Charlotte Island, British Columbia, in having less numerous subradial costae of the posterior series and somewhat weak costation on the disk. That species, however, lacked the costellae on the escutcheon.

The specimens from the Himenoura Group of Kyushu are larger in size and
less triangular in outline than those from the Izumi Group of Awaji Island. These differences could not be regarded as specific but may be due to the changes with growth.

Occurrence.—Black siltstone of the Upper Formation (Formation L-III) of the Lower Himenoura Subgroup, on Okoshiki beach and Hiraiwa beach of Oda-machi, Uto City, Kumamoto Pref.; Lowest Hetonaian (Lower Campanian). Black siltstone of the Middle Formation (Formation L-II) of the same subgroup, at Wadanoana of Takado, Ryugadake-machi, Amakusa-gun, Kumamoto Pref.; Inoceramus japonicus Zone; Upper Ura-
kawan (Santonian). Holotype and para-
types by Nakano (1957) were described from the Shichi shale (Uppermost Campanian) and Minato shale (Upper Campanian) of the Izumi Group of Awaji Island, Kinki District. This species ranges probably from Upper Santonian to Campanian.

_Apiotrigonia (?Apiotrigonia) dubia_ sp. nov.

Plate 25, Figs. 11-17, Text-fig. 6


Material.—Holotype KSG 2087, is a left valve, from Azenotani, Sakai City, Izumi Mountains; KSG 2089 and KE 1935–1936 (paratypes), from the same locality of holotype; KSG 2090–2091 (paratypes) from Masuno, Ushibuka City (Amakusa-Shimojima Island), Kumamoto Pref. The specimens are external and internal moulds.

Description.—Shell small, pyriform to trigonal ovate, longer than high; umbo small, slightly prominent, a little opis-

athygourous, located at the fourth to fifth from the front of valve; anterior margin semicircular; ventral margin weakly arched; siphonal margin narrow, rosted to posterior; posterior margin nearly straight; the costae of the posterior series occupy about a half or less of the disk; the costae of the posterior series strong but narrow, broadly spaced, finely tuberculated near the postero-

ventral carina, 7 to 10 in number, of which 3 or 4 on the anterior region do not reach the ventral margin; the first costa of the series begins to appear at a point about 2 mm distant from the umbo towards the posterior; about 8 or so costae of the anterior series concentric near the umbo, closely spaced, connected with the costellae of escutcheon and area, forming _Rutitrigonia_ or _Frenguelliella_-like concentric ornamentation; those on the median part of the same series broadly spaced, narrower than their interspaces, nearly horizontal, about 5 in number, gradually weakened towards ventral and posterior; those on the ventral part of same series nearly obsolete; area ornamented with two sorts of costellae; subhorizontal costellae occupy nearly full surface of the area except for the siphonal part, conjoined with the costellae of escutcheon; subvertical costellae also occupy nearly full surface of the area except the siphonal part, conjoined with the subradial costae on the posterior series of the disk; those two sorts of costellae cross each other, forming fine tuberculations; escutcheon rather broad, lanceolated, ornamented with 8 or more tuberculated subhorizontal costellae; postero-ventral carina well remarked; escutcheon carina and median groove of the area nearly invisible; inner posterior ventral margin broadly crenulated; growth lines very weak or almost invisible.
709. Pennatae trigoniids from Japan

Text-fig. 6. Apiotrigonia (?Apiotrigonia) dubia sp. nov., scale 5 mm.

Measurements (in mm).

<table>
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<th>Thickness</th>
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<td>—</td>
</tr>
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<td>—</td>
</tr>
<tr>
<td>KE 1936, left ex. mould</td>
<td>15.0</td>
<td>9.5</td>
<td>—</td>
</tr>
</tbody>
</table>

Comparison.—This species resembles Apiotrigonia (Apiotrigonia) obsoleta Nakano in ornamentation of the disk, but differs in its tuberculated sculpture on the area and the finely tuberculated subradial costae in the posterior series. It is similar to Apiotrigonia (Apiotrigonia) utoensis Tashiro in its finely tuberculated subradial costae, but differs clearly in that the latter has transverse costellae on the area and numerous concentric costae in the anterior series. It resembles Apiotrigonia (Microtrigonia) amanoi (Nakano) in the same type of costelation on the area, but is distinguishable from that species in having less developed subradial costae on the disk. It is also similar to Apiotrigonia (Microtrigonia) postonodosa Nakano in the finely tuberculated subradial costae in the posterior series and the features of the ornamentations on the area, but is not characterized by so strong and so well developed subradial costae of the posterior series as in that species. The subgeneric assignment of this species to Apiotrigonia (s. str.) is provisional, since it has some characters which recall us Microtrigonia.

Occurrence.—Fine-grained sandstone of the Azenotani Shale of the Izumi Group at Azenotani, Sakai City, Izumi Mountains. Fine-grained sandstone of the same formation at Takinoike, Izumi-Sano City, Izumi Mountains. Sandstone of the Middle Member (Member U-IVb, Tashiro and Otsuka, 1978) of the Upper Himenoura Subgroup, at about 400 m west of Masuno (roadside exposure), Oniki-machi, Ushibuka City, Kumamoto Pref.; Upper Hetonian (Maastrichtian). This species is restricted probably to the uppermost Campanian and Maastrichtian, being one of the latest species of the pennatae trigoniids.

Subgenus Microtrigonia Nakano, 1957

Type-species: Microtrigonia amanoi Nakano, 1957; Upper Himenoura Subgroup in Southwestern Japan. Upper Campanian (Lower Hetonian).

Diagnosis.—Shell small, roundly subtriangular or pyriform; umbo weakly opisthogyrous, located anteriorly; disk ornamented with two sorts of costae: the concentric plain costae on umbonal part and the subradial ones tuberculated generally, appearing on the outer side of outskirts of the former; escutcheon
narrow with tuberculated oblique or transverse costellae; area broad with or without oblique tuberculated costellae which conjoined with the costellae of the escutcheon; dorsal carina indistinct; postero ventral carina rather distinct, angulated near the umbo; median groove of the area weak or indistinct.

Remarks.—Microtrigonia was established by Nakano (1957) as a distinct genus. It was considered as a derivative from Apiotrigonia s. str. by Nakano (1957) and Tashiro (1972). The intimate relationships between certain species of Apiotrigonia s. str. and Microtrigonia are suggested by many features. For instance, a specimen of Apiotrigonia (Microtrigonia) imutensis (Tashiro) (pl. 26, fig. 10), shows the subradial costae of the posterior series, like those of Apiotrigonia (Apiotrigonia) minor (Yabe and Nagao) (pl. 26, fig. 18) and A. (A.) crassoradiata Nakano (pl. 26, figs. 21, 22) (see Text-figs.). This specimen may, however, be a malformed. Apiotrigonia (Microtrigonia) imutensis (Tashiro) is closely related to Apiotrigonia (Apiotrigonia) utoensis Tashiro in the features of the area and the tuberculated costae of the posterior series. The immature stage of Microtrigonia is nearly identical with that of Apiotrigonia s. str. in the Frenguelliella- or Rutitrigonia-like concentric plain costae of the umbonal region (see Tashiro, 1972, text-fig. 1). A younger shell of Apiotrigonia (Microtrigonia) postonodosa Nakano does not show the typical characters of Microtrigonia but has fine tuberculate costae of the posterior series and less developed subradial costae on the anterior part of the disk. This suggests that A. (M.) postonodosa may have descended from some species of Apiotrigonia s. str..

Microtrigonia is distinguished 2° from Apiotrigonia s. str. in its tuberculated

Text-fig. 7. Examples showing the relationships between Apiotrigonia s. str. and Microtrigonia. Note the “common zigzag ribbing” appearing on the disks on three different species of the pennatae trigoniids. A: Apiotrigonia utoensis (Apiotrigonia) minor (Yabe and Nagao); B: A. (Microtrigonia) imutensis (Tashiro); C: A. (A.) crassoradiata Nakano, scale 5 mm.
subradial costae which are developed on a certain part of the disk. Several species of Apiotrigonia s. str., Turkestanaella nov. and Dampietrigonia nov., have subradial sculptures on the anterior part of the disk. For instance, Apiotrigonia (Apiotrigonia) hetonaiana TASHIRO have subinternal striae on the part, Apiotrigonia (Dampietrigonia) dampieriensis SKWARKO have fine radial striae, and Apiotrigonia (Turkestanaella) turkestanensis (ARCHANGELSKI) is characterized by the Microtrigonia-like subradial costae. Apiotrigonia (Apiotrigonia) minor (YABE and NAGAO) and A. (A) crassoradiata NAKANO are very often characterized by the obliquely costated anterior series. Such subinternal or external subradial sculptures and oblique costations on the anterior part of the disk, appearing in Apiotrigonia s. str., Turkestanaella nov. and Dampietrigonia nov., are probably suggested the relationships between them and Microtrigonia. And the subradial elements probably indicate one of the common characters in the pennateae trigoniids. I think that these four taxa, Apiotrigonia s. str., Turkestanaella nov., Dampietrigonia nov. and Microtrigonia, can not be distinguished generically. I regard Microtrigonia as a subgenus of Apiotrigonia s.1. Microtrigonia is as yet unknown from the foreign Cretaceous sediments. Its known occurrence is restricted to the Campanian and Maastrichtian of Japan. It seems likely that Microtrigonia is one of the end members of the trigoniid lineages, which became extinct by the end of Cretaceous.

The following species from Japan are referable to the subgenus Microtrigonia:

A. (M) amanoi (NAKANO, 1957); Upper Campanian (type-species of Microtrigonia)
A. (M) minimata (NAKANO, 1957); Maastrichtian

A. (M) imutensis (TASHIRO, 1972); Campanian
A. (M) postonodosa NAKANO, 1957; uppermost Campanian or Maastrichtian
A. (M) sp.; Maastrichtian (this paper)

Distribution.—Campanian and Maastrichtian (Hetonaian) of Japan. Examples outside of Japan have not yet been confirmed.

Apiotrigonia (Microtrigonia) amanoi (NAKANO)

Plate 26, Figs. 1–6, Text-fig. 9


Material.—KE 1933, 1934, 2130 and 2131, external moulds, collected from Ukimizu, Shimo-Koshikijima Island, Kagoshima Pref. (type locality by NAKANO, 1957). KE 2134, external mould, from Oe of Amakusa-machi, Amakusa-shimojima Island, Kumamoto Pref. KE 2132–2133, from Himezuka of Dogo, Matsuyama City, Ehime Pref. KSG 2092–2094, internal
709. *Pennatae trigoniids from Japan*

and external moulds, from Azenotani, Sakai City, Izumi Mountains. KSG 2095–2098, internal and external moulds, from Fukkireura of Shimo-Koshikijima Island. KSG 2099–2100, external moulds, from Hanzanji, Awaji Island, Hyogo Pref. KSG 2101, external mould, from Hirono of Awaji Island. The specimens registered as KE, were already described by TASHIRO (1976).

*Description.*—Shell trigonally ovate, moderately inflated; umbro slightly opisthogyrous or nearly orthogyrous, small, a little elevated from the dorsal margin, located at about two-fifths from the front of the valve; anterior margin semicircular; ventral margin broadly arched; siphonal margin obliquely truncated, occupying about a half length of the height of the valve; postero-dorsal margin nearly straight or slightly convex but a little concave near the umbo; antero-siphonal margin bluntly angulated; disk ornamented with two sorts of costae; concentric plain ones, narrower than their interspaces, regularly spaced, about 10 in number, occupying umbonal region which is about one fourth in height from the umbo; several imperfect concentric costae which are crossed by the other sort of costae, forming tuberculations, recognizable under the umbonal concentric costae, weakened and broadend towards the venter; the other element of costae subradial, strong, tuberculated, broader than their interspaces, occupying the main part of the disk outside the umbonal region, about 9 costae of posterior extended from the posteromarginal carina to the ventral margin, the other 6 or more costae appearing on the anterior marginal part and the anterior part of ventral margin, oblique or nearly vertical on the middle part on the ventral, soon bended obliquely on the ventral part; escutcheon very narrow with 10 or more oblique and tuberculated costellae; area broad, elongated triangular; 7 or so plain and concentric costellae which conjoined with the costae of the disk, crowded near the umbo of the area; 10 or so tuberculated and oblique costellae, which conjoined with the costellae of the escutcheon, widely spaced, narrower than their interspaces, occupying the other part of the area; escutcheon carina distinct near the umbo, but obscure on the posterior; the boundary of the area and escutcheon visible only as a depressed line of the escutcheon; posteromarginal carina distinctly angulated, weakly concave; median groove of the area indistinct; inner surface smooth; inner posterior ventral margin broadly crenulated; in the

![Image](image_url)

Text-fig. 9. *Apionotrigonia (Microtrigonia) amanoi* (NAKANO), scale 5 mm.

umbonal region a marginal sulcus-like narrow band runs under the postero-
ventral carina; the band ornamented with fine plain vertical costae which conjoined
with the concentric costae of the disk of umbonal region, forming reverse L
shape.

Measurements (in mm).—

<table>
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<tr>
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<td>1.7</td>
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<tr>
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<td></td>
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</tr>
<tr>
<td>mould</td>
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</tbody>
</table>

Remarks.—The holotype (GKU, MA. 00001) designated by NAKANO (1957) from
the Upper Member of the Middle Formation of the Upper Himenoura Subgroup
(Member U-IIb), at Ukimizu of Imuta, Kashima-mura, Shimo-Koshikijima Island,
Kagoshima Pref. (=Imuta Formation at Ukimizu of Imuta by AMANO, 1957, and
NAKANO, 1957), is small (11.6 mm in length). It seems to represent a young
stage, being probably a umbonal fragmental specimen. The largest specimen
(KE 1934; see TASHIRO, 1976) in my collection from the type locality is measured about 25 mm in length. The ratio of length to height is variable
between 4/5 and 3/5.

This species shows gradual changes in outline and surface sculptures in ac-
cordance with the stratigraphic sequence, in which three representative forms are
recognizable. They are called here the “rostrate”, the “typical” and the “tubercu-
culate” forms (see Text-fig. 11). They are, however, not clearly discriminated
specifically or subspecifically, since the intermediate specimens are usually found
between them. The rostrate form generally occurs in the Lower Campanian or
the lowest part of the Upper Campanian of the Izumi Group and the Upper
Himenoura Subgroup. The typical form is found from the Upper Campanian and
Lowest Maastrichtian? of the Upper Himenoura Subgroup, the tuberculate form
from the Maastrichtian and the uppermost Campanian of the Izumi Group of
Awaji Island and the Izumi Mountains. The features of each form are as
follows.—

Rostrate form:—Shell pyriform and roundly subtriangular; area narrow than
in the typical form; umbonal concentric costae less numerous and occupy a
narrower area.

Typical form:—Shell subtriangularly ovate; umbo improminent; area broader
than in the rostrate form; escutcheon very narrow.

Tuberculate form:—Shell trigonally ovate, much inflated.

The rostrate form somewhat resembles Apiotrigonia (Microtrigonia) imutensis
(TASHIRO) in its rostrated posterior siphonal part, but differs in its costellae
on the area and less numerous costae of the anterior and posterior series. The
tuberculate form is similar to Apiotri-
gonia (Microtrigonia) postonodosa NAKA-
NO, in its features of costae on the disk,
but differs in its weak and more dis-
tinctly tuberculate costae of the posterior
series. The Frenguellieilla- or Rutitrigonia-
like stage is more distinct in the tuber-
culate form and more persistent than in
A. (M.) postonodosa. Apiotrigonia tuber-
culata NAKANO (1957) is identical with
the tuberculate form. What was listed
under “Apiotrigonia tuberculata” by TANAKA and TERAOKA (1973), and MAEDA and KAWABE (1967) from Shimo-Koshikijima Island, Kagoshima Pref., is probably better to be transferred to typical form.

Occurrence.—Black siltstone of the Upper Member of the Middle Formation of the Upper Himenoura Subgroup (Member U-Ilb), at Ukimizu of Kashima, Satsuma-gun, Kagoshima Pref. Black silty sandstone of the Lower Member of the Middle Formation of the Upper Himenoura Subgroup, at Fukkireura of Kashima. Fine-grained sandstone of the Lower Member of the Middle Formation of the Upper Himenoura Subgroup (Member U-Ila) at Yokohama of Oe, Amakusa-machi, Amakusa-gun, Kumamoto Pref. Black siltstone of the basal part of the Izumi Group at Himezuka of Dogo, Matsuyama City, Ehime Pref. Fine-grained sandstone or siltstone of the Azenotani shale of the Izumi Group at Azenotani, Sakai City, Izumi Mountains. Silty sandstone of the Shichi shale of the Izumi Group at Hirono, Awaji Island, Hyogo Pref.; Inoceramus (Sphenoceramus) schmidtì Zone. Campanian and probably also an uncertain part of the Maastrichtian.

_Apiotrigonia (Microtrigonia) imutensis_ (TASHIRO)

Plate 26, Figs. 7-12


Material.—Holotype is KE 1887 (TASHIRO, 1972) from Ukimizu of Imuta, Kashima-mura (Shimo-Koshikijima Island), Satsuma-gun, Kagoshima Pref. KSG 2102–2104, from Fukkireura of Imuta, Kashima-mura. KSG 2105–2106 from Yokohama of Oe, Amakusa-machi, Amakusa-gun, Kumamoto Pref. KSG 2107 from Himezuka of Dogo, Matsuyama City, Ehime Pref. KSG 2108–2109 from Oshima islet of Ushibuka City, Amakusa-Shimojima, Kumamoto Pref.

Description.—See TASHIRO, 1972, p. 335.

Measurements (in mm).—

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<td>17.0</td>
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<td>KSG 2104, left ex. mould</td>
<td>16.7</td>
<td>12.5</td>
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<tr>
<td>KSG 2105, right ex. mould</td>
<td>24.0</td>
<td>15.0</td>
<td>4.0</td>
</tr>
<tr>
<td>KSG 2106, right ex. mould</td>
<td>22.4</td>
<td>16.5</td>
<td>3.9</td>
</tr>
<tr>
<td>KSG 2107, left ex. mould</td>
<td>18.4</td>
<td>14.7</td>
<td>4.0</td>
</tr>
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<td>KSG 2108, left ex. mould</td>
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<tr>
<td>KSG 2109, left ex. mould</td>
<td>13.2</td>
<td>12.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Remarks.—This species is clearly distinguished from _Apiotrigonia (Microtrigonia) amanoï(NAKANO) in its smooth area, finer tuberculations of the subradial costae and more numerous and more crowded concentric costae on the disk. This species shows changes in the arrangement of the surface ornamentation in accordance with the stratigraphic sequence. Three representative varieties are thus crinimated: pseudo-atoennis form (Text-fig. 3-A), radiate form (Text-fig. 3-B and C) and the typical form (Text-
fig. 3-D). Since an intermediate form usually occur in every case, these three forms are not treated as subspecies. The features of the three forms are as follows.—

pseudo-utoensis form:—Area ornamented with fine but distinct concentric or transverse striae, as in Apiotrigonia (Apiotrigonia) utoensis TASHIRO; subradial costae somewhat less numerous (about 15) and more distinctly tuberculated than in the other two forms; siphonal margin moderately rostrated.

radiate form:—Siphonal margin rostrated; subradial costae well developed on almost the entire surface of the disk, except for the umbonal concentric Rutitrigonia or Frenguellia-like series; the tubercles of the subradial costae very fine.

typical form:—Area broader than in the other two forms; siphonal margin somewhat truncated; the subradial costae about 25, being more numerous than in other forms.

The radiate form was sometimes listed erroneously as Trigonia ogawai (YEHARA, 1923) or Apiotrigonia postonososa (HATAE, 1959, 1960; MIKI, 1972) from the Lower Member of the Middle Formation of the Upper Himenoura Subgroup at Yokohama of Oe. "Trigonia" sp. (n. sp.) of AMANO (1962), from the same member at Oe, is probably another example of this radiate form.

Occurrence.—The holotype came from the black siltstone of the Upper Member of the Middle Formation of the Upper Himenoura Subgroup at Ukimizu of Imuta, Kashima-mura, Satsuma-gun, Kagoshima Pref. (Shimo-koshikijima Island) (TASHIRO, 1972). The pseudo-utoensis form occurs in the black siltstone of the Lower Formation of the Upper Himenoura Subgroup (Formation U-I) at Oshima islet of Ushibuka City, Kuma-moto Pref. (Amakusa-Shimojima Island), and from the same formation at Fukkireura of Kashima-mura (Shimo-koshikijima Island). Inoceramus (Sphenoceramus) orientalis orientalis is known from the locality of Oshima islet. While Inoceramus (Sphenoceramus) elegans pseudosulcatus was collected from the locality of Fukkireura. The radiate form is known from the black siltstone of the basal part of the Izumi Group at Himenezuka of Dogo, Matsuyama City, Ehime Pref., occurring together with Inoceramus (Sphenoceramus) schmidtii. Another locality of the radiate form is the sandstone of the Lower Member of the Middle Formation of the Upper Himenoura Subgroup (Member U-Ila) at Yokohama of Oe, Amakusa-machi, Amakusa-gun, Kumamoto Pref. (Amakusa-Shimojima Island), and the sandstone of the same member at Fukkireura of Kashima-mura, Shimo-Koshikijima Island. Inoceramus (Sphenoceramus) sachalinensis is known from the same locality as this form in Amakusa-Shimojima Island. This species is probably restricted to occur in the Campanian (Lower Hetonaiian); Inoceramus (Sphenoceramus) orientalis orientalis Zone and Inoc. (Sphenoc.) schmidtii Zone.

Apiotrigonia (Microtrigonia) postonososa NAKANO

Plate 26, Figs. 13-17, Text-fig. 10


1976. Apiotrigonia postonososa NAKANO:
709. Pennatae trigoniids from Japan


Material.—KE 1927-1931 and KSG 2113-2114, from Yotsuinosako of Kamihira, Miyanokawachi, Kawaura-machi, Amakusa-Shimojima Island; KE 2117-2119, from Ono of Hongo, Miyanokawachi; All the specimens are internal and external moulds.

Diagnosis.—Shell medium for Microtrigonia but small for Apiotrigonia s.l., pyriform to rounded subtrigonal, fairly inflated; umbonal region limited only with a few concentric plain costae; escutcheon depressed, very narrow, ornamented with 10 or more transverse costellae which are finely tuberculated, narrower than their interspaces, and conjoined with the costellae of the area; area broad, ornamented with horizontal or oblique costellae which are finely tuberculated, narrower than their interspaces, number about 15, of which 3 or so near the siphonal margin somewhat weakened and irregularly waved; escutcheon carina indistinct except near the umbo; postero-ventral carina angulated on a half length of itself from the umbo but soon changing into roundly angulated ridge on the posterior half; median groove on the area indistinct; inner surface smooth; posterior inner ventral margin broadly and strongly crenulated; inner adductor scars and hinge structures are strongly impressed for pennatae trigoniids.

on the anterior part short, surrounded by the outskirts of the anterior series, bi- or trifurcate near the antero-ventral part; Frenquelliella-like stage of the umbonal region limited only with a few concentric plain costae; escutcheon depressed, very narrow, ornamented with 10 or more transverse costellae which are finely tuberculated, narrower than their interspaces, and conjoined with the costellae of the area; area broad, ornamented with horizontal or oblique costellae which are finely tuberculated, narrower than their interspaces, number about 15, of which 3 or so near the siphonal margin somewhat weakened and irregularly waved; escutcheon carina indistinct except near the umbo; postero-ventral carina angulated on a half length of itself from the umbo but soon changing into roundly angulated ridge on the posterior half; median groove on the area indistinct; inner surface smooth; posterior inner ventral margin broadly and strongly crenulated; inner adductor scars and hinge structures are strongly impressed for pennatae trigoniids.

Text-fig. 10. Apiotrigonia (Microtrigonia) postonodosa NAKANO, scale 5 mm.
Measurements (in mm).—

<table>
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</table>

Remarks.—This species was referred to *Apiotrigonia* s. str. by NAKANO (1957). As the holotype (GH. NM.00004) and the paratypes (GH. NM.00005–6, GK. H.6021) are small, the subradial costae which are characteristic to *Microtrigonia* are not shown in these type specimens. Judging from the specimens which I collected from the same stratigraphic unit in Amakusa, the type specimens undoubtedly represent the younger stage of this species. The largest specimen in my collection is about 20 mm in length.

Besides the material from the Himenoura Group, this species was also described by NAKANO (1957) from the Shichi shale of the Izumi Group at Hanzanji, Mihara-gun, Awaji Island. As the specimens from the Izumi Group in my collection are very small, it is questionable whether they are referable to this species or to the tuberculate form of *Apiotrigonia* (*Microtrigonia*) amanoi (NAKANO). In fact, this species is closely related to the tuberculate form of *A. (M.) amanoi*, in having the tuberculated subradial costae and the oblique costellae on the broad area, but differs in its finer tubercles on the costae, more rostrated siphonal margin and the more restricted *Fennguellia*-like stage on the umbonal part. The rostrate form of *Apiotrigonia* (*Microtrigonia*) imutensis (TASHIRO) somewhat resembles this species in its rostrated outline, but clearly discriminated by its smooth area and more numerous subradial costae of the posterior series.

Occurrence.—Fine sandstone of the Lower Member of the Upper Formation of the Upper Himenoura Subgroup (Member U-IIla), at Yotsuinosako of Kanihira, Ono of Hongo, Keijigahama and Nodden, all in Miyakawachi, Kawauna-machi, Amakusa-gun, Kuma-moto Pref. The type locality by NAKANO (1957) (Nodden of Miyakawachi) is of nearly the same horizon as the four localities of this paper. ?Siltstone of the Shichi shale of the Izumi Group, at Hanzanji, Shichi-mura, Mihara-gun, Hyogo Pref. (Awaji Island); The geological age of Member U-IIla of the Upper Himenoura Subgroup may be referable to the uppermost Campanian or Lower Maastrichtian. The Shichi Shale of the Izumi Group was assigned to the Uppermost Campanian.

*Apiotrigonia* (*Microtrigonia*) sp. indet.

Plate 26, Figs. 19, 20

Material.—Three imperfect specimens (KSG 2120–2122) and two internal moulds (KSG 2123–2124), from Panketosanosawa of Tomiuchi (Hetonai), Iburi District, Hokkaido.

Description.—Shell small, roundly triangular, longer than high, fairly strongly inflated; umbo slightly opisthogyrous, less prominent; anterior margin semicircular; ventral margin broadly arched; siphonal margin small, somewhat angu-
lated; posterior dorsal margin nearly straight but a little concave near the umbo; disk ornamented with two series of costae; the subradial costae of the posterior series tuberculated, of which 8 or more extended from the posteroventral carina to the ventral margin, occupying the posterior half of the disk, whereas several others appear on the antero-ventral part, short, extending from a point at some distance from the umbo to the ventral margin; concentric costae of the anterior series plain; area broad with oblique costellae; escutcheon very narrow with numerous transverse costellae; escutcheon carina indistinct; postero-ventral carina angulated near the umbo, but roundly elevated on its posterior half; inner surface smooth; inner posterior ventral margin broadly crenulated, numbering about 6; inner posterior dorsal margin crenulated, about 12; inner siphonal median ridge distinct.

Measurements (in mm).—

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<tr>
<td>KSG 2123, left in. mould</td>
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Remarks.—Although the details of surface ornamentation of the available specimens are not clear, this species resembles *Apiotrigonia (Microtrigonia) postonodosa* Nakano rather than other species of *Microtrigonia*, in its inflated valve and less numerous subradial costae. *A. (M.) postonodosa*, differs from this species in its strong costae in both series on the disk. So far it is only known species of *Microtrigonia*, from the Cretaceous of Hokkaido.

Occurrence.—Fukaushi Sandstone of the Hakobuchi Group at Panketosanosawa of Tomiuchi (Hetonai), Iburi District, Hokkaido. The part immediately below the Zone of *Inoceramus (?Sphenoceramus) hetonaianus*; Maastrichtian (Upper Hetonaijan).

*Apiotrigonia (Microtrigonia) minima* (Nakano)


Remarks.—There is no example of this species in my collection. I indicate it only for completing the list of species.


Subgenus *Dampietrigonia* nov.

Type-species: ‘*Apiotrigonia’ dampieriensis* Skwarko, 1969; Aptian; Western Australia.

Diagnosis.—Shell pyriform; umbo opisthogyrous, located anteriorly; disk ornamented with two series of costae; subradial costae occupying on the whole surface of the disk but weak on the anterior half, generally tuberculated; concentric costae plain, appear on the anterior half of the disk; area and escutcheon smooth; escutcheon and postero-ventral carinae weak or indistinct except near the umbo; median groove of the area weak.

Remarks.—This new subgenus is proposed on the basis of ‘*Apiotrigonia’ dampieriensis* Skwarko, 1969, from the MelliGo Quartzite of Dampier Peninsula, Western Australia. It is characterized by the smooth area and escutcheon, and the subradial costae which cover the whole surface of the disk including the anterior part. *Trigonia calderoni* (Castillo and Aguilera) (Cragin, 1905;
STOYANOW, 1949; SKWARKO, 1970), from the Jurassic formation of Mexico and Texas, is similar to this type-species in its smooth escutcheon. While SKWARKO (1970) referred *T. calderoni* to *Apiotrigonia*, NAKANO (1971) classified *T. calderoni* as a member of *Heterotrignia*, because of the presence of weak radial costellae on the area of *T. calderoni*. A few Albian species, *Trigonia newcombei* PACKARD (1921) and *Trigonia maudensis Whiteaves* by PACKARD (1921) from the Haida Formation (Albian) of Queen Charlotte Island, resemble the type-species in having the smooth escutcheon and area. *Dampietrigonia* is, however, distinguishable from them in that its subradial costae extend to the anterior part. *Microtrignia*, *Nakanotrignia* nov. and *Turkestanella* nov. are characterized by the subradial costae which appear on the anterior part of the disk. The subradial costae of them are, however, stronger than those of this new subgenus, and do not develop near the umbo.

*Distribution.*—Aptian; Western Australia.

**Subgenus Turkestanella** nov.

*Type-species:* *Trigonia turkestanensis* ARCHANGELSKI, 1916 [= *Megatrignia* (*Apiotrigonia*) turkestanensis: POJARKOVA, 1978]; Cenomanian; Turkestan.

*Diagnosis.*—Shell trigonal-ovate; umbo small, less prominent, slightly opisthogyrous, located anteriorly; disk ornamented with *Microtrignia*-like costae; area and escutcheon ornamented with oblique costellae; postero-ventral carina distinct; escutcheon carina obscure.

*Remarks.*—This new subgenus is similar to *Microtrignia* in its subradial costae which develop on the anterior part of the disk, but differs in its broader and less numerous subradial costae, and less numerous concentric costae on the disk.

*Distribution.*—Cenomanian; Turkestan.

**Genus Heterotrignia** COX, 1952

*Type-species:* *Trigonia diversicostata* WHITEAVES, 1876; Albian; British Colombia.

*Diagnosis.*—Shell small to large, pyriform and trigonally ovate; umbo opisthogyrous, located anteriorly; disk ornamented with two series of costae; subradial ones developed generally on the posterior part of the disk; extending sometimes to the anterior part; the costae of the other series appear on the anterior part of the disk, generally subhorizontal but may be variable in the arrangement and intensity; area ornamented with radial costellae; escutcheon ornamented with oblique or subhorizontal costellae, or smooth; postero-ventral carina and escutcheon carina weak except near the umbo; median groove of the area very weak or indistinct.

*Remarks.*—*Heterotrignia* was established as a distinct genus by COX (1952) on the basis of *Trigonia diversicostata Whiteaves*, from the Haida Formation of the Queen Charlotte Islands, British

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Columbia. It is distinguishable from *Apiotrigonia* in its radial costellae on the area.

**Distribution.**—Upper Jurassic to Upper Cretaceous; Northern Pacific region.

Subgenus *Heterotrigonia* Cox, 1952

Type-species: *Trigonia diversicostata* Whiteaves, 1876.

**Diagnosis.**—Shell pyriform, umbo prominent, opisthogyrous; disk ornamented with two series of costae; anterior ones plain, concentric near the umbo, but horizontal, oblique, waved or obsolete on the antero-ventral part, occupying about the anterior half or less of the disk; posterior costae plain, occupying the posterior half or so of the disk; area ornamented with plain radial costellae; escutcheon narrow, smooth or ornamented with oblique or subhorizontal costellae; postero-ventral and escutcheon carinae indistinct except near the umbo.

**Remarks.**—Three species, e.g., *Trigonia diversicostata* Whiteaves, from the Albian of British Columbia, *Trigonia calderoni* (Castillo and Aguilera), from the Upper Jurassic of Mexico and Texas, and *Trigonia subovalis* Jimbo, from the Cenomanian of Japan, are referable to this subgenus. It resembles closely *Apiotrigonia* s. str. in its ornamentations of the disk and the escutcheon, and its pyriform outline of the valve. Unless the area is observable, it may be difficult to discriminate *Heterotrigonia* s. str. from *Apiotrigonia* s. str.

**Distribution.**—Upper Jurassic and Cretaceous; Northern Pacific region, Central America (Mexico and Texas).

*Heterotrigonia (Heterotrigonia) subovalis* (Jimbo)

Plate 26, Figs. 23-24, Text-fig. 12


**Material.**—KSG 2125-2128, external and internal moulds from Keirnbashi of Shimo-Katsurazawa, Mikasa City, Hokkaido; KSG 2129-2130 from the Ponbetsu River (Loc. near Ik 2016), Mikasa City, Hokkaido; GK. H6051 and 6055, collected at Ik 2021, on the Ponbetsu River, by T. Matsumoto.

**Description.**—Shell large, pyriform, moderately inflated, longer than high; test rather thick; umbo slightly prominent, located at about one third or one fourth of length from the front of the valve; anterior margin well rounded; ventral margin moderately arched; siphonal margin weakly rounded or somewhat truncated obliquely, slightly rostrate; posterior dorsal margin weakly concave; disk ornamented with two series of costae: anterior ones plain, generally weak, of which several on the umbonal region are concentric, those on the anterior ventral part nearly obsolete,
and those on the median part generally subhorizontal, variable in the arrangement, oblique, wavy and sometimes disappear; the costae of posterior series subradial, generally weak, broadly spaced, numbering about 10 or more, of which 2 or so near the umbo do not reach the ventral margin and the next 2 or so are very often bi- or trifurcated near the ventral margin; area ornamented with radial costellae which are very variable in number and strength and sometimes effaced; escutcheon depressed, narrow, ornamented with fine and plain horizontal or oblique costellae; escutcheon carina indistinct; posterior carina distinct near the umbo but later changing into roundly elevated and concave ridge; median groove on the area very shallow.

**Measurements (in mm).**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Length</th>
<th>Height</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
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<td>32.0</td>
<td>24.1</td>
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</tr>
<tr>
<td>GK, H6051, left valve</td>
<td>43.2</td>
<td>33.3</td>
<td>10.8</td>
</tr>
<tr>
<td>GK, H6055, right valve</td>
<td>48.9</td>
<td>38.2</td>
<td>12.0</td>
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**Remarks.**—This species was described in detail by Nakano (1957, 1961). It is variable in the features of the surface ornamentation. *Trigonia sawatai* Yehara, 1923, and *Apotrigonia jimboi* Nakano, 1957, are here regarded as synonyms of *Heterotrigonia (Heterotrigonia) subovalis*. However, two forms are represented in the same fossil population of this species.

Radiate form (form of *T. sawatai*):—Subradial costae of the posterior series appear distinctly under the umbo; anterior series irregularly waved on the anterior ventral part; radial costellae on the area numerous and distinct.

“Typical form”:—Subradial costae weak, less numerous than in the radiate form; costae of the anterior series nearly disappear on the anterior ventral part; radial costellae on the area very weak and discernible only on the umbonal region; umbonal angle somewhat broader than in the radiate form.

This species differs from *Heterotrigonia (Heterotrigonia) calderoni* (CASTILLO and AGUILERA) from the Upper Jurassic of Mexico and Texas, and *H. (H.) diversicostata* (WHITEAVES) from the Albian of British Columbia, in its distinct costellae on the escutcheon. Two imperfect speci-
Text-fig. 13. Diagram showing the stratigraphical occurrences and the presumed line of descent in Heterotrigonia s.l. from Japan. A: Heterotrigonia (Heterotrigonia) subovalis (Jimbo); B: H. (Nakanotrigonia) granosa Nakano; C: H. (N.) himenoureensis Tashiro, scale 5 mm.

mens (KSG 2129 and 2130) of the present species are in my collection from a higher part of the Mikasa Formation (Inoceramus hobetsensis Zone; Middle Turonian), (Ik 2016). They do not show clearly the characters of the area. They differ from Aiotrigonia (Apiotrigonia) mikasaensis nov. of the same locality in its less numerous costae on the disk.

Occurrence.—Sandstone of the Mikasa Formation at Keirinbashi of Shimokatsuura, Ikushunbetsu, and on the Pombetsu River (Ik 2021), both in Mikasa, Central Hokkaido; Middle Cenomanian. Sandstone of the upper part of the Mikasa Formation of Pombetsu (Ik 2016); Turonian. Sandstone of the upper part (Ild) of the same formation at an abandoned quarry, NWW of the Katsurazawa-dam, Ikushunbetsu; Turonian.

Subgenus Nakanotrigonia nov.

Type-species: Heterotrigonia himenoureensis Tashiro, 1972; Lower Campanian.

Diagnosis.—Shell small, trigonal-ovate, a little longer than high; umbo small, less prominent, slightly opisthogyrous; disk ornamented with two sorts of costae; the plain, concentric ones on umbalonal part and subradial, tuberculated ones extending to the outer part of the outskirt of the umbalonal concentric ones; area rather broad, ornamented with several tuberculate radial costellae; escutcheon very narrow, with numerous tuberculate, oblique costellae; escutcheon carina indistinct; postero-ventral carina rather angulated; median groove indistinct; Frenguelliella-like stage of umbalonal region distinct.

Remarks.—This subgenus differs from Heterotrigonia s. str. in having the tuberculated costae and costellae on the surface, and the well developed subradial costae of the posterior series. It is similar to Microtrigonia in its well developed and tuberculated posterior series. Microtrigonia is, however, devoid of the radial costellae on the area.

List of species.—Heterotrigonia (Nakanotrigonia) granosa
709. *Pennatae trigoniids from Japan* 211

Nakano, 1957; Santonian; Japan.  
*H. (N.) himenourensis* Tashiro, 1972;  
Lower Campanian; Japan.  
*Distribution.*—Santonian and Lower Campanian; Japan. No species has been known outside Japan.

**Heterotrigonia (Nakanotrigonia)**  
himenourensis Tashiro  
Plate 26, Fig. 25

1972. *Heterotrigonia himenourensis* Tashiro,  
no. 86, p. 334, pl. 41, figs. 14-16, text-fig. 8.  

*Description and Measurements.*—(see Tashiro, 1972).

*Remarks.*—This species differs from *Heterotrigonia (Nakanotrigonia) granosa* Nakano in its distinct postero-ventral carina, well developed subradial costae of the posterior series, and bi- or trifurcate subradial costae on the antero-ventral part of the disk.

*Occurrence.*—Black siltstone of the Upper Formation of the Lower Himenoura Subgroup (Formation L-III) at Okoshiki and Hiraiwa beaches of Oda, Uto City, Kumamoto Pref. (Uto Peninsula); lower Lower Campanian; Lowest Heteronai.

**Heterotrigonia (Nakanotrigonia)**  
granosa Nakano

*Jour. Geol. Geogr.*, vol. 28, nos. 1-3,  
p. 119, pl. 8, fig. 16.  
1975. *Apiotrigonia (Heterotrigonia) granosa*  
(Nakano): Hayami, Univ. Mus., Univ.  
Tokyo, Bull. no. 10, p. 116.

*Remarks.*—This species resembles *Apiotrigonia (Microtrigonia) amanoii* (Nakano), in its suboval outline and tuberculated costae and costellae on the disk and escutcheon, but clearly differs in its distinct radial costellae on the area.

*Occurrence.*—Black siltstone of the Middle Formation of the Lower Himenoura Subgroup (Formation L-II), at Wadanohana of Takado, Ryugadake-machi, Amakusa-gun, Kumamoto Pref.; *Inoceramus japonicus* Zone; Santonian (Upper Urakawan).

Genus *Columbitrigonia* Poulton, 1977

*Type-species:* *Trigonia columbiana* Packard, 1921.

*Remarks.*—This genus is characterized by well developed subradial costae of the posterior series. In young stage it shows the surface ornamentations of typical *Apiotrigonia*. Poulton (1977) referred it to *Megatrigoniinae* van Hoepen, together with *Apiotrigonia*.

*Age and distribution.*—Albian, southwestern British Columbia.

?Genus *Quoiechichia* Crickmay, 1932

*Type-species:* *Quoiechichia aliciae* Crickmay, 1932.

*Remarks.*—This genus is debatable as to its taxonomic position. It was referred to the *Laevitrigoniinae* by Saveliev (1958), but to the *Myophorellinae* by Poulton (1977). It is characterized by subvertical or subradial costae on the posterior part of the disk where the costae extend from the postero-ventral ridge to the ventral margin. Its costae resemble more closely to those of the posterior series of *Apiotrigonia* s. str. or *Heterotrigonia* s. str. than the costation of *Myophorella* and *Laevitrigonia*. Its less opisthogryrate umbo and less angulated postero-ventral ridge are
also similar to those of the pennatae trigoniids.

*Age and distribution.*—Lower Cretaceous, British Columbia.

**Evolutionary changes of the subfamily Apiotrigoniinae**

The earliest species of pennatae trigoniids is represented by *Trigonia calderoni* (CASTILLO and AGUILERA) (CRAGIN, 1905; STOYANOW, 1949; SKWARKO, 1970), from the Upper Jurassic of Mexico and Texas. *T. calderoni* is characterized by its smooth escutcheon and finely radiating area as mentioned by SKWARKO (1970) and NAKANO (1971). The disk of *T. calderoni* is ornamented with subhorizontal plain costae on the anterior part, subradial or subvertical costae on the posterior, and fine regular concentric costae on the umbonal part. Such a costation on the disk is one of the important characters of pennatae trigoniids. The anterior subhorizontal costae (anterior series) meet with the posterior subradial ones (posterior series) usually on the central part of the disk, forming the reversed L sculptures. As illustrated by STOYANOW (1949, pl. 14, figs. 1 and 2), the umbonal region of *T. calderoni* is characterized by Frenguellia- or Rutitrigonia-like regularly spaced and plain concentric costae. Such a Frenguellia- or Rutitrigonia-like stage is generally observable on the umbonal region of numerous species in pennatae trigoniids, as has already been mentioned by TASHIRO (1972). *T. calderoni*, is probably a common ancestor of many species belonging to *Apiotrigonia* s.l. and *Heterotrignia* s.l., which flourished extensively in the Cretaceous period.

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Text-fig. 14. The stratigraphic ranges of the pennatae trigoniid species from Japan.
Heterotrigonia is known from the Cenomanian and Turonian (Gyliakian) of Hokkaido in Japan. It is represented by Trigonia subovalis Jimbo (1894), which is characterized by numerous radial costellae on the area. T. subovalis is very changeable in the number and strength of the costae and costellae. The subradial

Text-fig. 15. Map showing the distributions of the pennate trigoniids in the world.

Text-fig. 16. Possible lines of descent of the pennate trigoniids.
costae are weakened or bi- or trifurcate on the ventral part, and the subhorizontal costae are weakened, irregularly waved or sometimes disappearing in the mature or late aged specimens. *Heterotrigonia* s. str. began to appear, probably in the Upper Jurassic, as shown by the occurrence of *Trigonia calderoni* in Central America, and disappeared in the Middle Turonian (K4b2) by Matsumoto, 1977) of Japan, with the downfall of *Trigonia subovalis*. The distribution of *Heterotrigonia* was shifted from Central America to Japan along the North Pacific Coast, passing through British Columbia, where *Heterotrigonia diversicostata* and radiating “*Trigonia newcombii*” (Nakano, 1961, 1971), are known.

*Heterotrigonia* s. str. is undoubtedly succeeded by *Nakanotrigonia* nov., which occurs in the Santonian and Lower Campanian (K5b and K6a1) of Japan. *Nakanotrigonia* is characterized by tuberculate radial costae on the area and tuberculate subradial costae which occupy nearly the whole surface of the disk except for the narrow umbonal part, crossing to plain concentric costae. *Nakanotrigonia* is probably a branch which offshooted from the *Heterotrigonia* trunk represented by the successive species from *T. calderoni* to *T. subovalis* by way of *T. diversicostata* and “*T. newcombii*”, as has already been pointed out by Nakano (1961, 1971). Text-fig. 13 diagrammatically illustrates the three species of *Heterotrigonia* s. l. from Japan, showing the successive change with age. Also text-fig. 12 shows two varied forms of *Heterotrigonia* (*Heterotrigonia*) subovalis.

*Dampietrigonia* nov., based on *‘Aポイトリジオニア’ lampierensis* Skwarko (1969) from the Aptian of Western Australia, is characterized by the smooth area and escutcheon, and numerous subradial costae which invade into the anterior part of the disk. *Dampietrigonia* was probably derived from *Trigonia calderoni* or some other pennatae trigoniids in the Early Cretaceous. The close relationship between *T. calderoni* and *Dampietrigonia* is shown by their smooth escutcheon and somewhat truncated siphonal margin.

*Aポイトリジオニア* s. str. is the most flourished group in the pennatae trigoniids (*Aポイトリジオニイナェ*), characterized by the absence of radiating costellae on the area. The earlier representatives of *Aポイトリジオニア* are several species from the Lower Cretaceous of Central America and South America (Stoyanow 1949, Anderson 1958, Stanton 1901). The latest one is represented by *Aポイトリジオニア(Aポイトリジオニア)* hetonaiana, from the Maastrichtian (K6b1) of Japan. Some species of *Aポイトリジオニア* s. str. from the Lower Cretaceous, are generally characterized by the regularly arranged costae of the anterior series and the escutcheon without costellae. On the other hand, the species of *Aポイトリジオニア* s. str. from the Upper Cretaceous are characterized by the variable arrangement of the anterior series and the costellate escutcheon. The Campanian and Maastrichtian species, such as A. (A.) hetonaiana and A. (A.) crassoradiata, probably represent the last phase of the evolutionary trend in the main trunk of *Aポイトリジオニア* s. str., as shown by their extraordinarily bi- or trifurcate subradial costae of the posterior series and the irregularly waved or effaced costae of the anterior series. Similar features are also observable in *H. (H.) subovalis*, the latest species of *Heterotrigonia* s. str. On the other hand, the earlier species of *Heterotrigonia*, e.g., *H. (H.) calderoni* and *H. (H.) diversicostata*, are similar to the earlier ones of *Aポイトリジオニア* s. str. of the Lower Cretaceous, e.g., A. (A.) cragini, A. (A.) kitchini and A. (A.) kayana from North America, and A. (A.)

Newcombei and *A. (A.) condoni* from British Columbia, in their regularly arranged costae of the both series on the disk. These similarities in successive changes with geological age imply the evolutionary parallelism between *Apiotrignia* and *Heterotrignia*.

Insofar as I know, the origin of *Apiotrignia* s. str. was probably in the Lower Cretaceous of Central America, as that of *Heterotrignia* s. str. *Apiotrignia* s.l. expanded its distribution into three directions. One was the same as in the case of *Heterotrignia* s. str., extending from Central America to Japan along the North Pacific coast. The second route was from Central America to Central Asia (Turkestan), passing Texas, England and France, along the northern coast of the Tethys Sea. The third one was presumably from the native home to western Australia passing through South America and South Africa, along the South western Pacific coast. This is suggested by the subgenus *Dampietrigonia* from Australia by way of *A. (A.) heterosculpta* (Stanton, 1909) from Patagonia, *A. (A.) progono* (Paulcke) (Reyes and Pérez, 1978) from Chile and *A. (A.) concordiformis* (Krauss)
from South Africa (KITCHIN 1913).

*Columbitrigonia* POULTON (1977), from the Lower Cretaceous (Barremian to Albian) of British Columbia, is characterized by extraordinarily developed subradial costae of the posterior series. It is undoubtedly derived from *Apiotrigonia* s. str., because the immature shell has distinctly the *Apiotrigonia*-type costae as illustrated by POULTON (1977, pl. 2, figs. 22, 24, 28, 29, 30, 33, 38, 41, 42 and 43; pl. 3, figs. 22 and 23). *Columbitrigonia* probably offshooted from the *Apiotrigonia* trunk in an early Cretaceous time.

*Quoiechia* CRICKMAY (1932), from the Lower Cretaceous of British Columbia, is doubtful in the systematic position. For the reasons which I mentioned in p. 212, I regard it as a member of the pennatae trigoniids (*Apiotrigoniinae*), presumably a branch from the *Heterotrignia* trunk.

*Microtrignia* NAKANO, 1957, from Japan, is undoubtedly derived from *Apiotrigonia* s. str., with *Apiotrigonia* (*Apiotrigonia*) *utoensis* as its presumable ancestor. *Microtrignia* closely resembles *Nakanotrigonia* and *Turkestanella* in the ornamentation of the disk, but differs from *Nakanotrigonia* in its less developed radial costellae on the area, and from *Turkestanella* in its more numerous costae of the posterior and anterior series. *Microtrignia* is the latest branch from the *Apiotrigonia* trunk, as *Nakanotrigonia* is so from the *Heterotrignia* trunk. *Microtrignia* appears, however, later than *Nakanotrigonia* (*Microtrignia* in the Lower Campanian as compared with *Nakanotrigonia* in the Santonian) (see Text-figs. 16, 18).

*Turkestanella*, from the Cenomanian of Turkestan, may also be a derivative from the *Apiotrigonia* trunk.

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(Text-fig. 18. Presumed phylogenetic relations in the subfamily *Apiotrigoniinae* nov.

T: Trigoniines, B: *Apiotrigoniinae*, R: *Rutitrigenous* and *Megatrigenous*; A: *Apiotrigonia* trunk, H: *Heterotrignia* trunk.)
709. Pennatae trigoniids from Japan

The *Aiptotrigonia* trunk ranges from the lowest Cretaceous to the uppermost Cretaceous, accompanied with several branches, e.g., *Columbritrigonia* in the Neocomian, *Damprietrigonia* in the Aptian, *Turkjestanella* in the Cenomanian and *Microtrigonia* in the Campanian. The *Heterotrigonia* trunk probably ranges from the Upper Jurassic to the lower Lower Campanian, accompanied with the branches of *Quoiecia(na)* in the Lower Cretaceous and *Nakanotrigonia* in the Santonian (see Text-fig. 18).

In my opinion, the phylogenetic evolution of the pennatae trigoniids (*Aiptotrigoniinae*) probably took place systematically in a definite direction which is manifested by the development or increase of the subradial costae, the so-called posterior series, and the degeneration of the concentric or subhorizontal costae, the so-called anterior series (see Text-fig. 17). The directional evolution proceeded on the trunks of *Aiptotrigonia* and *Heterotrigonia* in parallel with each other, and also in several branches which offshooted from the both trunks. The evolutionary tempo in each branch or trunk was not constant.

References


— (1975): A systematic survey of the


—— (1956) : Studies on the Jurassic trigonians in Japan, part 5, Some Jurassic trigonians from central and west Japan. Ibid., vol. 27, no. 1, p. 1-8, pl. 1.


Masayuki TASHIRO


Explanation of Plate 25

_Apiotrigonia_ (Apiotrigonia) _mikasaensis_ sp. nov.

Fig. 1: GK. H6910; right valve, ×1; loc. Yonosawa, Ponporokabetsu, Yubari, Hokkaido.
Fig. 2: GK. H6912; left valve, ×1; loc. ditto.
Fig. 3: GK. H6913; left valve, ×1; loc. ditto.
Fig. 4: GK. H6911; left and right valves, ×1; loc. ditto.
Fig. 5: KSG 2061; right valve, ×1.2; loc. Ponbetsu, Mikasa City, Hokkaido.
Fig. 6: KSG 2070; a cluster of specimens, ×1; loc. ditto.
_Apiotrigonia_ (Apiotrigonia) _undulosa_ NAKANO

Fig. 7: KSG 2064; gum cast of left external mould, ×2; loc. Kajisako of Monobe, Kochi Pref., Shikoku.
Fig. 8: KSG 2065; gum cast of left external mould, ×2; loc. ditto.
Fig. 9: KSG 2073; gum cast of left external mould, ×3; loc. Hiromi, Uwajima City, Ehime Pref., Shikoku.
Fig. 10: KSG 2074; gum cast of left external mould, ×2; loc. ditto.
_Apiotrigonia_ (?) _Apiotrigonia_ _dubia_ sp. nov.

Fig. 11: KSG 2087; gum cast of left external mould, ×5; loc. Azenotani, Sakai City, Izumi Mountains.
Fig. 12: KSG 2088; gum cast of right external mould, ×2.5; loc. ditto.
Fig. 13: KE 1935; gum cast of left external mould, ×2; loc. ditto.
Fig. 14: KE 1936; gum cast of left external mould, ×2; loc. ditto.
Figs. 15, 16: KSG 2090; gum cast of left external mould, ×2; loc. Masuno, Oniki-machi, Ushibuka City, Kumamoto Pref., Kyushu.
Fig. 17: KSG 2091; gum cast of imperfect left external mould, ×5; loc. ditto.
_Apiotrigonia_ (Apiotrigonia) _minor_ (YABE and NAGAO)

Fig. 18: KSG 2051; left valve, ×2; loc. Wadanohana of Takado, Amakusa-Kamishima island, Kyushu.
Fig. 19: KSG 2054; gum cast of right external mould, ×1; loc. Furushiroyama, Uwajima City, Ehime Pref., Shikoku.
Fig. 20: KE 1906; left valve, ×2; loc. Wadanohana of Takado, Amakusa-Kamishima island.
_Apiotrigonia_ (Apiotrigonia) _crassoradiata_ NAKANO

Fig. 21: KSG 2075; gum cast of right external mould, ×1; loc. Omagari of Tomiiuchi (Hetonoai), Iburi District, Hokkaido.
Fig. 22: KSG 2085; gum cast of imperfect right external mould, ×1; loc. Fukkireura of Kashima, Shimo-koshikijima island, Kagoshima Pref., Kyushu.
709. Pennatae trigoniids from Japan


日本産 "pennatae trigoniids" の研究：本研究は、日本の上部白亜系から知られる小型三角具 "pennatae trigoniids" に関する形態学的系統 分類学的研究である。本邦では "Pennatae Trigoniids" は、セリマツ高〜マストリヒティアンに出現し、16種（2新種）が確認される。これらは Heterotrigonia と Apiotrigonia に対するものに大別できる。Heterotrigonia に対するものには Heterotrigonia s. str. の1種と新亜属 Nakanotrigonia の2種の計3種があり、Heterotrigonia s. str. はセリマツ高〜チューリヒ高にかぎられ、Nakanotrigonia はサントニアン〜カンパニアンに出現する。Apiotrigonia は、Apiotrigonia s. str. はチューリヒ〜マストリヒティアンまでに8種（2新種）があり、Microtrigonia はカンパニアン以降に出現し、その5種が認められる。オーストラリアのDampiotrigonia（新亜属）や中央アジアのTurkestaneilla（新亜属）は、おそらく下部、中部白亜紀に Apiotrigonia から分枝したものであり、カナダのColumbitrigonia はおそらく Apiotrigonia s. str. と共通の祖先をもついていると思われる。またカナダのQuoitiehia は Heterotrigonia に共通した表面装飾をもつその系統的関連性が予想される。以上の亜属亜亜属をもとに新亜科 Apiotrigoniinae を設定した。本新亜科では、Apiotrigonia trunk と Heterotrigonia trunk の三角具の三角具を三角具として中央アメリカ付近を起点にして分散していたと思われ、または本亜科は、Heterotrigoniinae とも密接な関係があると思われる。
Explanation of Plate 26

*Apiotrigonia (Microtrigonia) amanoi* (NAKANO)

Fig. 1: KSG 2092; gum cast of left external mould, × 2.5; 'tuberculate form'; loc. Azenotani, Sakai City, Izumi Mountains.

Fig. 2: same specimen, × 5.

Fig. 3: KSG 2098; gum cast of right external mould, ×2; 'rostrate form'; loc. Fukkireura of Kashima, Shimo-koshikijima island, Kagoshima Pref., Kyushu.

Fig 4: KE 2130; gum cast of right external mould, ×2; 'typical form'; loc. Ukimizu of Kashima, Shimo-koshikijima island, Kagoshima Pref., Kyushu.

Fig. 5: KE 1934; gum cast of left external mould, ×2; 'typical form'; loc. ditto. Kashima, Shimo-koshikijima island.

Fig. 6: KSG 2097; gum cast of left external mould, ×2; 'typical form'; loc. Fukkireura of Kashima, Shimo-koshikijima island.

*Apiotrigonia (Microtrigonia) imutensis* (TASHIRO)

Fig. 7: KSG 2108; gum cast of left external mould, ×2; 'pseudo-utoensis form'; loc. Oshima of Ushibuka City, Amakusa-Shimojima island, Kumamoto Pref., Kyushu.

Fig. 8: KSG 2104; gum cast of left external mould, ×2; 'radiate form'; loc. Fukkireura of Kashima, Shimo-koshikijima island.

Fig. 9: KSG 2105; right valve, ×1; 'radiate form'; loc. ditto.

Fig. 10: KSG 2107; plaster cast of left external mould, × 2; 'radiate form'; loc. Himezuka of Dogo, Matsuyama City, Ehime Pref., Shikoku.

Fig. 11: KSG 2105; gum cast of right external mould, ×1.5; 'radiate form'; loc. Yokohama of Oe, Amakusa-machi, Amakusa-Shimojima, Kumamoto Pref., Kyushu.

Fig. 12: KSG 2106; gum cast of right external mould, ×2; 'radiate form'; loc. ditto.

*Apiotrigonia (Microtrigonia) postonodosa* NAKANO

Fig. 13: KSG 2117; gum cast of left external mould, ×1.5; loc. Ono of Hongo, Miyanokawachi, Amakusa-Shimojima island, Kumamoto Pref., Kyushu.

Fig. 14: KSG 2118; gum cast of right external mould, ×2; loc. ditto.

Fig. 15: KE 1927; gum cast of left external mould, ×2; loc. ditto.

Fig. 16: KSG 2116; gum cast of imperfect left external mould, ×2; loc. Yotsuinosako of Kamihira, Miyanokawachi.

Fig. 17: KSG 2115; gum cast of conjoined valves, ×1.5; showing the dorsal view; loc. Ono of Hongo, Miyanokawachi.

*Apiotrigonia (Apiotrigonia) utoensis* TASHIRO

Fig. 18: KE 1882; right valve, ×1; loc. Okoshiki of Oda, Uto City (Uto peninsula), Kumamoto Pref., Kyushu.

*Apiotrigonia (Microtrigonia) sp. indet.*

Fig. 19: KSG 2120; right valve, ×2; loc. Panketosanosawa of Tomiuchi (Hetonai), Iburi District, Hokkaido

Fig. 20: KSG 2123; left internal mould, ×1.5.; loc. ditto.

*Apiotrigonia (Damprietrigonia) dampierensis* (SKWARKO)

Fig. 21: CPC 7723; plaster cast of right external mould (see SKWARKO, 1969).

Fig. 22: CPC 7729; ditto.

*Heterotrigonia (Heterotrigonia) subovalis* (JINBO)

Fig. 23: GK. H6056; left valve, ×1; loc. Shimokatsura, Mikasa (IK 2021), Hokkaido; collected by T. MATSUMOTO; 'typical form of subovalis'.

Fig. 24: KSG 2125; plaster cast of imperfect left valve, ×1; loc. Keirinbashi, Shimokatsura, Mikasa, Hokkaido; 'radiate form' (form of *Trigonia sawatai*).

*Heterotrigonia (Nakanotrigonia) himenourensis* TASHIRO

Fig. 25: KSG 2131; left valve, ×2; loc. Hiraiwa of Oda, Uto City, Kumamoto Pref., Kyushu.