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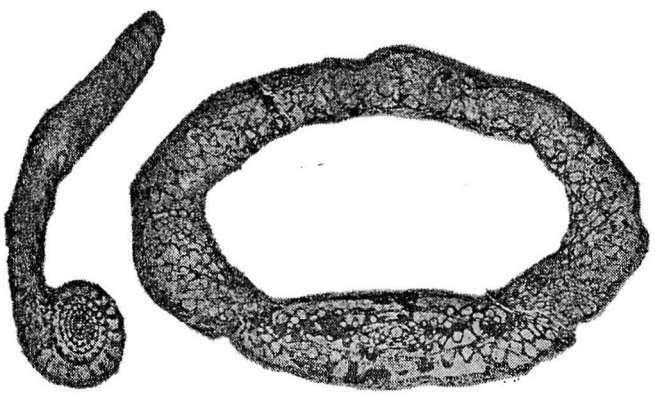

日本古生物学会

Palaeontological Society of Japan
December 30, 1979

Officers for 1979—1980

The fossil on the cover is *Nipponitella explicata* HANZAWA, an aberrant uncoiled fusulinacean from the Lower Permian Sakamotozawa Formation, southern Kitakami, Northeast Japan.

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708. *KIDOA*, EINE NEUE DIATOMEEN-GATTUNG AUS DEN OBERNEOGENEN KOITOI SCHICHTEN, TENPOKU, HOKKAIDO*

SEIICHI KOMURA

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Abstract. *Kidoa graviarmata*, n. gen., n. sp. (araphid diatom) is described from the Koitoi Formation (Upper Neogene) in the Tenpoku district, Japan.

Einleitung

Bei der Untersuchung der marinen Mikrofossilien aus den neogenen Ablagerungen, die im Nordtenpoku Gebiet umfangreich verbreitet sind, im Zusammenhang mit der Suche von Erdöl und -gas hat der Verfasser eine neue bogenförmige Kieselalge, die von den bereits bekannten Gattungen vollständig unterschieden werden kann, neulich gefunden.

In dieser Arbeit beschreibt und illustriert der Verfasser die neue Gattung, *Kidoa*, die zur Familie Fragilariaceae gehört. Viele gut erhaltene Exemplare aus den in den Aufbissen gesammelten Materialien wurden für die Diagnose und Beschreibung der neuen Gattung und Art verwendet. Alle Exemplare, die in den Präparaten durch Pleurax eingebetteten wurden, werden im Technischen Institut von JAPEX aufbewahrt.

* Received May 26, 1978; revised manuscript received Sept. 11, 1979; read June 18, 1977 at Shizuoka.

Systematische Beschreibung

Ordnung Pennales SCHÜTT, 1896

Familie Fragilariaceae SCHÜTT, 1896

Gattung *Kidoa*, n. gen.

Namengebung: Herrn Hideo KIDO, Direktor von Sakhalin Oil Development Corporation Co., Ltd. in Verehrung gewidmet.

Typusart: *Kidoa graviarmata*, n. sp.

Diagnose: Theken in Valvarebene mit Apikalachse gewölbt, in Gürtelansicht linear-rechteckig, mit den am Pol stehenden derben Fortsätzen, ohne Zwischenbänder und Septen; Schalen dorsoventral, mit stärker gewölbtem Rückenrand, linear-lanzettlich im Umriß, unsymmetrisch zur Apikalebene, mit randständige Stacheln und regelmäßig geordneten transapikalen Streifen; Apikalarea vorhanden aber Zentralarea fehlend.

Bemerkungen: Die bilaterale Strukturanordnung und das Fehlen des Raphensystems rechtfertigen die Gehörigkeit dieser neuen Gattung zur Familie Fragilariaceae. Diese Gattung besitzt

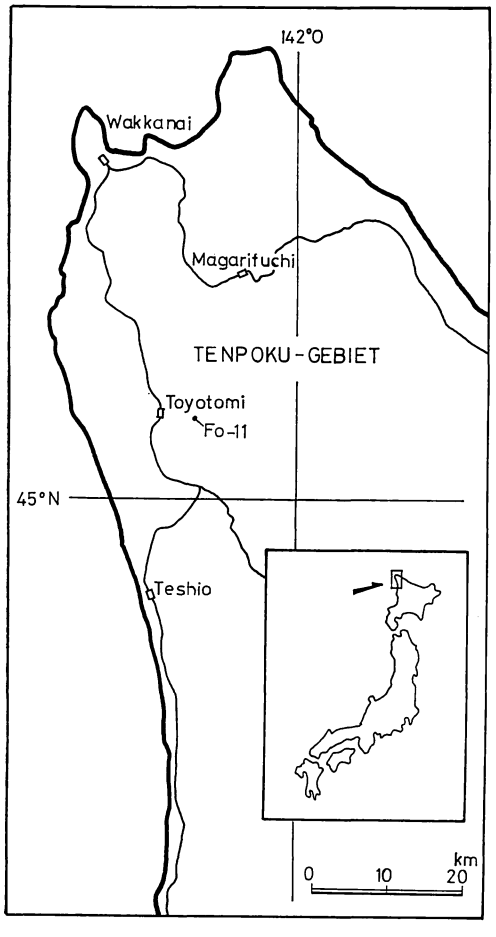

Abb. 1. Lage des Fundpunktes

vier folgende Eigentümlichkeiten: 1) derbe Fortsätze am Pol, 2) dichtstehende Stacheln am Rande, 3) krammerförmiger Schalenumriß und 4) kurze Streifen auf der Oberfläche. Sie besteht im wesentlich in nächster Verwandtschaft mit der Gattung *Campylosira*, die drei erstere Charakteristiken besitzt und sich von ihr durch die regelmäßig punktierte Ornamente unterscheidet.

Aus Analogie mit den ähnlichen Genera mit Fortsätzen und Stacheln läßt sich vermuten, daß die lebende Zelle in derselben Weise wie die Arten von *Campylosira* GRUNOW (vgl. HUSTEDT, 1927-64, S. 128) *Cymatosira* GRUNOW (vgl. HUSTEDT, *op. cit.*, S. 123) durch Bildung der bandförmig geschlossenen Kolonien leben mußte.

Kidoa graviarmata, n. sp.

Tafel 24, Fig. 1-8; Abb. 2, Fig. 1-6

Namengebung: gravis (lateinisch, adv.) =wichtig+armo (lat.)=bewaffnen, nach den durch viererlei Strukturelementen ganz ausgerüsteten Theken.

Holotypus: Präparat Nr. JAPEX Fo-11(34)=14.1×78.5(Fm15636, 15635, 15634), Taf. 24, Fig. 1, Abb. 2, Fig. 1.

Paratypen: Präparat Nr. JAPEX Fo-11(31)=18.3×90.3(Fm15630, 15631), Taf. 24, Fig. 2, Abb. 2, Fig. 2; Präparat Nr. JAPEX Fo-11 (23) = 19.0 × 90.2 (Fm 15645, 15644), Taf. 24, Fig. 3, Abb. 2, Fig. 6; Präparat Nr. JAPEX Fo-11(25)=13.2×89.8(Fm15642, 15640), Taf. 24, Fig. 4; Präparat Nr. JAPEX Fo-11(14)=8.6×86.0 (Fm 15628), Taf. 24, Fig. 5; Präparat Nr. JAPEX Fo-11(34)=7.2×92.9(Fm15633, 15632), Taf. 24, Fig. 6; Präparat Nr. JAPEX Fo-11(40) =9.1×83.0(Fm15626), Taf. 24, Fig. 7, Abb. 2, Fig. 3; Präparat Nr. JAPEX Fo-11(70) =5.3×132.0 (Fm 16958), Abb.2, Fig. 4; Präparat Nr. JAPEX Fo-11(68)=11.0× 138.3(Fm16988), Abb. 2, Fig. 5.

Material: 10 Exemplare.

Typusfundort: Fo-11, Bodenaufschluß (Abb. 1), etwa 3,8 km südöstlich von Toyotomi (Breitengrad 45°5′14″N, Längengrad 141°19′17″O).

Typusschichten: Aschenreicher Kieselgur der Koitoi-Schichten, Oberstmiozän (vgl. MINATO et al., 1956; NAGAO, 1960).

Beschreibung: Theken in Gürtelansicht eng-linear, mit großen derben pedalähnlichen an den Polen stehenden Fortsätzen, die in der schrägen Valvarlage

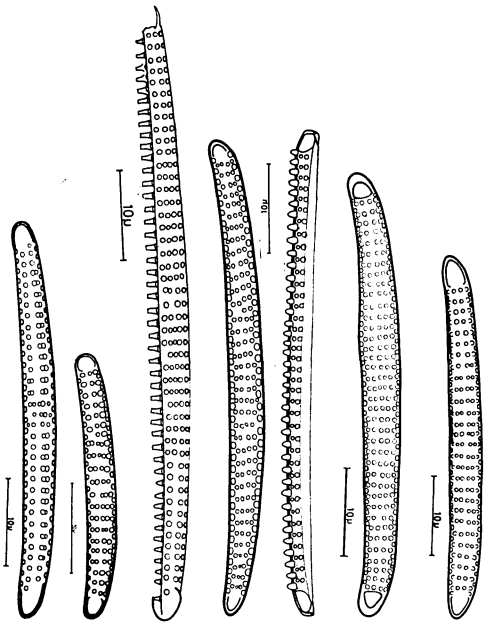

Abb. 2. *Kidoa graviarmata*, n. sp.

best sichtbar sind und in der Gürtellage als ungebuckelte Schrägfläche erscheinen (Taf. 24, Fig. 7 u. Abb. 2, Fig. 4b); Schalen verlängert, eng-linear bis linear-lanzettlich, dorsoventral, gegen den Polenden allmählich verschmälert, flach in Axialrichtung doch im Querschnitt etwas gewölbt, mit stumpf bis scharf gerundeten, nicht geschnäbelten, doch selten etwas kopfig geschwollenen Apikalenden und auch mit geraden oder wenig konkavem Bauchrand und stärker, vor den Polenden plötzlich noch stärker konvexem Rücken, 29-69 μ lang, 4-5 μ breit; marginale Stacheln entlang Schalenrand, in der Valvarlage als ob Punkt erscheinend, gleichentfernt und dicht liegend, mit transapikalen Streifen abwechselnd, 8-9 in 10 μ; Streifen sehr kurz, punktiert, aus 1-3 Punkten bestehend, zur Apikalachse senkrecht und daher etwas konvergent, über die ganze Oberfläche außer dem hyalinen Apikalfeld verbreitet, von Pseudoraphe unterbrochen, 8-9 in 10 μ; Axialarea oder Pseudoraphe sehr eng, fadenähnlich jedoch deutlich, in der Mittellinie verlaufend.

Bemerkungen: Die vorliegende Art zeigt eine bedeutende Regelmäßigkeit und Einheitlichkeit in der Anordnung der Streifen und Stacheln, wie die mikrophotographischen Aufnahmen (Taf. 24, Fig. 5 und 7) deutlich zeigen. Sie tritt selten oder zwar meistens als Bruchstück in den Tenpoku-Materialien auf, aber sie kann durch ihre bogenförmigen Schalen mit den unnachahmlichen Stacheln leicht aufgefunden werden.

Danksagung

Der Verfasser ist Herrn Dr. Y. IKEBE, Vizepräsident von JAPEX, für seine Erlaubnis dieser Veröffentlichung und Herrn F. AKIBA von JAPEX für seine fruchtbare Diskussionen zu großem Dank verpflichtet.

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北海道天北上部新第三系声問層産珪藻新属 *Kidoa*: この新属は中間帯・隔壁・縦溝がなく，下記の4つの構造要素をそなえていることを特徴とする：弓なりに彎曲した殻形・両極端にある密質のコブ状突起・両側端に列生するトゲ・頂軸に直角に整列する条線。既知属のなかでは *Campylosira* GRUNOW が上記のうちのはじめの3つの特徴をもっているので，新属 *Kidoa* はこの属にもっとも近縁である。しかし *Campylosira* は殻面上の点紋が不規則に分布するのに対して，*Kidoa* は頂軸の両側に規則的に配列するので，この点で両者は区別される。この新属は上記の諸特性からみて，*Campylosira* のように中心目におかれる可能性はなく，明らかに羽状目に，従って Fragilariaceae にぞくすることになる。これは現在までのところ単模式的で，天北の試料中ではごく稀に，多くは破片となって出現する。

なおこの属の名称はサハリン石油開発協力（株）技術部長 城戸秀夫氏にちなむ。

小 村 精 一

Koitoi 声問, Toyotomi 豊富, Tenpoku 天北

Erklärungen zur Tafel 24 (Plate 24)

Fig. 1-8: *Kidoa graviarmata*, n. gen., n. sp.

Fig. 1. Holotypus. Präparat Nr. JAPEX Fo-11 (34)=14.1×78.5 (Fm 15636, 15635, 15634). Koitoi-Schichten. Oberstmiozän. a: hohe, b: mittlere, c: tiefe Einstellung.

Fig. 2. Paratypus. Präparat Nr. JAPEX Fo-11 (31)=18.3×90.3 (Fm 15630, 15631). Ebenda. a: hohe, b: tiefe Einstellung.

Fig. 3. Paratypus. Präparat Nr. JAPEX Fo-11 (23)=19.0×90.2 (Fm 15645, 15644). Ebenda. a: tiefe, b: hohe Einstellung.

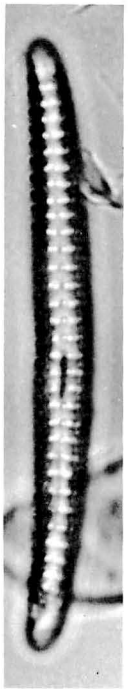
Fig. 4. Paratypus. Präparat Nr. JAPEX Fo-11 (25)=13.2×89.8 (Fm 15642, 15640). Ebenda. a: tiefe, b: hohe Einstellung.

Fig. 5. Paratypus. Präparat Nr. JAPEX Fo-11 (14)=8.6×86.0 (Fm 15628). Ebenda.

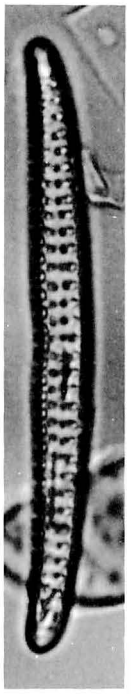
Fig. 6. Paratypus. Präparat Nr. JAPEX Fo-11 (34)=7.2×92.9 (Fm 15633, 15632). Ebenda. a: hohe, b: tiefe Einstellung.

Fig. 7. Paratypus. Präparat Nr. JAPEX Fo-11 (40)=9.1×83.0 (Fm15626). Ebenda. Schräge Valvarlage.

Fig. 8. Paratypus. Präparat Nr. JAPEX Fo-11 (27)=5.4×89.6 (Fm 15638). Ebenda. Schräge Valvarlage.



1 a



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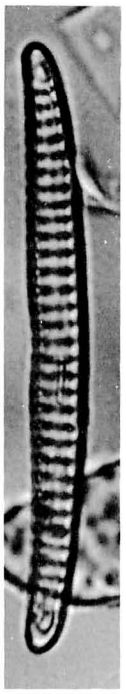

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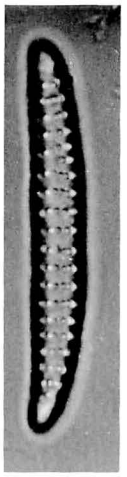
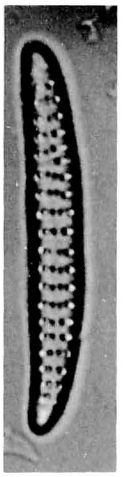


2 a



2 b

3 a

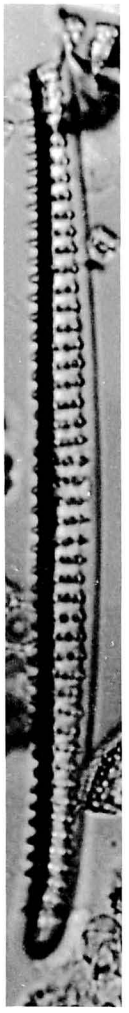
3 b

4 a

4 b

5

6 a



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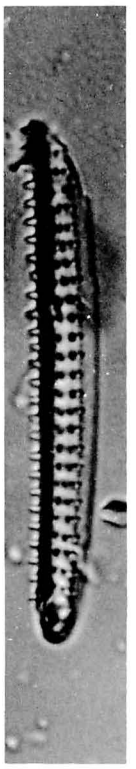
6 b



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

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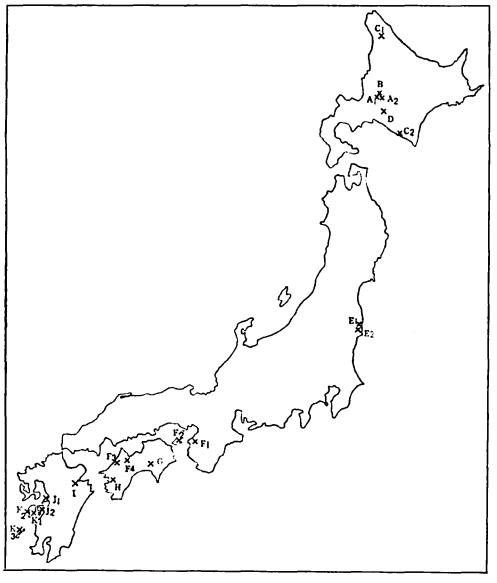
Abstract. The present work is a taxonomic revision of the so-called pennatae trigoniids from Japan, with an attempt to explain the evolutionary parallelism between *Heterotrigonia* and *Apiotrigonia*. 16 species belonging to the pennatae trigoniids are known from various localities of the Upper Cretaceous in Japan. They are classified into two genera (*Apiotrigonia* and *Heterotrigonia*) and four subgenera (*Apiotrigonia* s. str., *Heterotrigonia* s. str., *Microtrigonia* and *Nakanotrigonia* nov.). I propose Apiotrigoniinae nov. as a new subfamily of the Trigoniidae on these genera and subgenera together with several other genera and subgenera outside Japan, such as *Columbitrigonia*, *?Quoiecchia*, *Dampietrigonia* nov. and *Turkestanella* nov. Apiotrigoniinae nov. is mainly composed of the *Heterotrigonia* trunk and the *Apiotrigonia* trunk which were probably derived from a common ancestor in the Lower Cretaceous. The evolutionary tempo of the *Heterotrigonia* trunk is more rapid than that of the *Apiotrigonia* trunk. *Microtrigonia* is an off-shoot of *Apiotrigonia*, whereas *Nakanotrigonia* nov. is that of *Heterotrigonia*. 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 in Southwest Japan. 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

* Received July 13, 1979; read Oct. 20, 1979 in Nagoya.



Text-fig. 1. Map showing the localities of the pennatae trigoniids in Japan.
A: Middle Yezo Group; A1. Shimo-katsurazawa, A2. Katsurazawa. B: Mikasa Formation (Turonian part) (Pombetsu). C: Upper Yezo Group; C1. Saku, C2. Urakawa. D: Hakobuchi Group (Tomiuchi=Hetanai). E: Futaba Group; E1. Hirono, E2. Ashizawa. F: Izumi Group; F1. Izumi Mountains, F2. Awaji island, F3. Matsuyama, F4. Yuasa. G: Sotoizumi Group (Kaiisako Formation) (Monobe). H: Uwajima Group (Uwajima). I: Onogawa Group (Inukai). J: Lower Himenoura Subgroup; J1. Uto Peninsula, J2. Amakusa-Kamishima Island. K: Upper Himenoura Subgroup; K1. eastern coast of Amakusa-Shimojima Island, K2. western coast of Amakusa-Shimojima Island, K3. Shimo-koshikijima Island.

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 trigonians 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 Trigoniids

Systematic Description

Order Trigonioida

Superfamily Trigoniacea

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 HOEPEN, 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 concentriccos tae. 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 *Frenguelliella* LEANZA, 1942, and *Rutitrigonia* VAN HOEPEN, 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 intermadiate forms between the Apiotrigoniinae and the group of *Rutitrigonia*. Many species of *Rutitrigonia*, e.g., *Trigonia pseudoindica* ARCHANGELSKI (1916), from the Cenomanian of Turkestan, *T. weaveri* STOYANOW (1949), from the Aptian of Texas, *Rutitrigonia yeharai* 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 HOEPEN (1929) established the subfamily Rutitrigoniinae (Laevitrigoniinae, SAVELIEV, 1958; Fren-

guelliellinae NAKANO, 1960) based on his genus *Rutitrigonia* VAN HOEPEN), 1929 (type-species: *Rutitrigonia peregrina* VAN HOEPEN). NAKANO (1963) amended Rutitrigoniinae to which he referred *Frenguelliella, Geratrigonia* KOBAYASHI, 1954, *Latitrigonia* KOBAYASHI, 1954, *Ibotrigonia* KOBAYASHI, 1954, *Laevitrigonia* LEBKÜCHNER, 1933, *Linotrigonia* COX, 1952, *Psilotrigonia* COX, 1952, *Nipponitrigonia* COX, 1952, and *Rutrigonia*. HAYAMI (1975) listed, however, *Frenguelliella, Geratrigonia, Latitrigonia, Nipponitrigonia, Ibotrigonia* and *Rutitrigonia*, as members of the subfamily Trigoniinae LAMARCK, 1819. In my opinion, the Rutitrigoniinae, 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. Apiotrigoniinae nov. are also added to them as one of the members of this group. The Apiotrigoniinae are most closely related to the Rutitrigoniinae, but discriminated by its subradial costae on the posterior part of the disk.

List of genera and subgenera.—
Genus *Apiotrigonia* COX, 1952
  Subgenus *Apiotrigonia* COX, 1952; *Microtrigonia* NAKANO, 1957; *Dampietrigonia* nov.; *Turkestanella* 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, Turkestan, Japan, Sakhalin, Kamchatzka, Cordillera of North America, southern part of the interior province of North America, Central America, western Australia, Patagonia, Chile and South Africa.

Genus *Apiotrigonia* COX, 1952

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

Diagnosis.—Shell medium to small for trigoniids but large to small for the Apiotrigoniinae; 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., *Apiotrigonia* (*Apiotrigonia*) *obsoleta* NAKANO, *A.* (*A.*) *crassoradiata* NAKANO, *A.* (?*A.*) *dubia* nov. and *A.* (*Microtrigonia*) *imutensis* (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., *Apiotrigonia* (*Apiotrigonia*) *minor* (YABE and NAGAO), *A.* (*A.*) *utoensis* TASHIRO, *A.* (*A.*) *undulosa* NAKANO, *A.* (*A.*) *obsoleta* NAKA-

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, Kamchatzka, 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 sulcataria* 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) crassified *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

Trigonia newcombei PACKARD, 1921; 'Middle Cretaceous' of British Columbia

Apiotrigonia obsoleta NAKANO, 1957; Santonian and Campanian of Japan

Trigonia pennata SOWERBY, 1819; Cenomanian of England

Apiotrigonia (Apiotrigonia) progonos (PAULCKE) in REYES and PEREZ (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

Apiotrigonia utoensis TASHIRO, 1972; Lower Campanian of Japan

A. undulosa NAKANO, 1957; Coniacian of Japan

Trigonia condoni PACKARD, 1921 was referred to *Megatrigonia (Apiotrigonia)* 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.

Apiotrigonia (Apiotrigonia) minor (YABE and NAGAO)

Plate 25, Figs. 18-20, Text-fig. 2

1923. *Trigonia subovalis* JIMBO: YEHARA, *Japan. Jour. Geol. Geogr.*, vol. 2, no. 3, p. 78, pl. 11, figs. 4-8.
1925. *Trigonia subovalis* JIMBO var. *minor* YABE and NAGAO, *Sci. Rept. Tohoku Imp. Univ.*, ser. 2, vol. 7, no. 4, p. 116.
1930. *Trigonia subovalis* var. *minor* YABE and NAGAO: NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 1, no. 1, p. 18.
1954. *Apiotrigonia subovalis minor* (YABE and NAGAO): KOBAYASHI, *Japan. Jour. Geol. Geogr.*, vol. 25, nos. 1-2, p. 77.
1957. *Apiotrigonia minor* (YABE and NAGAO): NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 110, pl. 8, fig. 4, non. figs. 1-3.
1957. *Apiotrigonia obliquecostata* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 113, pl. 8, figs. 9-10.
1962. *Apiotrigonia minor* (YABE and NAGAO): SAITO, *Bull. Fac. Arts and Sci. Ibaraki Univ., Nat. Sci.*, no. 13, p. 63, pl. 1, figs. 8-9.
1962. *Apiotrigonia ashizawaensis* SAITO, *Bull. Fac. Arts and Sci. Ibaraki Univ., Nat. Sci.*, no. 13, p. 63, pl. 1, fig. 6.
1967. *Apiotrigonia minor* (YABE and NAGAO): MAEDA and KAWABE, *Prof.* H. SHIBATA *Mem. Vol., Tokyo*, p. 423, pl. 1, figs. 10-25.
1967. *Apiotrigonia futabaensis* MAEDA and KAWABE, *Prof.* H. SHIBATA *Mem. Vol., Tokyo*, p. 421, pl. 1, figs. 5-6.
1967. *Apiotrigonia hironoensis* MAEDA and KAWABE, *Prof.* H. SHIBATA *Mem. Vol., Tokyo*, p. 422, pl. 1, figs. 7-8.
1967. *Apiotrigonia orikiensis* MAEDA and KAWABE, *Prof.* H. SHIBATA *Mem. Vol., Tokyo*, p. 423, pl. 1, figs. 1-4.
1972. *Apiotrigonia minor* (YABE and NAGAO): TASHIRO, *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 86, text-figs, 1-b, 3-c, 4 and 6-a, pl. 40, figs. 1-17 (compare, not described).
1975. *Apiotrigonia (Apiotrigonia) minor* (YABE and NAGAO): HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 114.
1975. *Apiotrigonia (Apiotrigonia) obliquecostata* 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 Wadanohana of Ryugadake-machi, Amakusa Kamishima Island, Kyushu. KSG 2048-2049, from the same subgroup at Hinoshima islet of Amakusa Kamishima Island; KSG 2053-2054, plaster casts from the Furushiro-yama Formation of

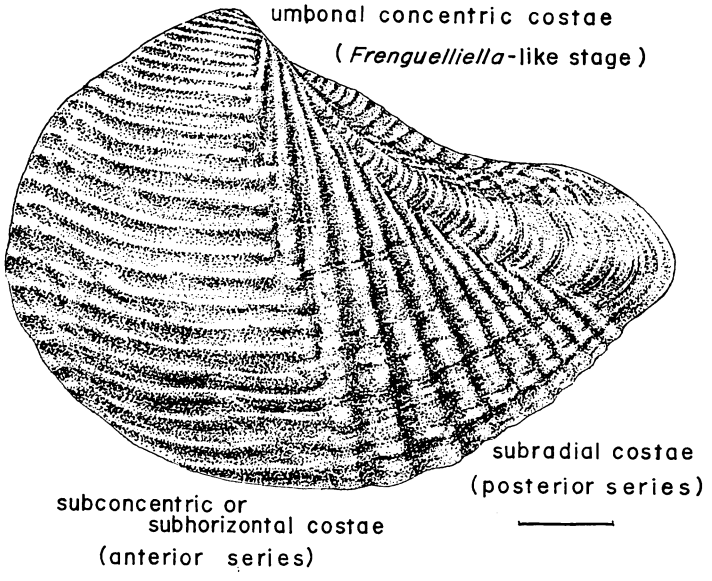
the Uwajima Group of Furushiro, Hiromi-machi, Uwajima City, Ehime Pref. KSG 2055-2058 are collected from the Lower part of the Futaba Group of Hirono-machi and Iwaki City, Fukushima Pref.

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).—

Specimen	Length	Height	Thickness
KE 1904, left valve	30.7	22.0	6.4
KE 1905, left valve	28.5	19.6	6.5
KE 1906, left valve	22.8	17.3	5.5
KE 1907, right valve	31.1	20.6	7.0
KE 1910, right valve	20.3	15.7	5.8
KE 1909, left valve	31.0	25.6	9.0
KSG 2053, left ex. mould	15.8	10.5	3.2
KSG 2054, right ex. mould	33.0	24.9	5.6
KSG 2055, right ex. mould	24.0	18.0	6.6
KSG 2056, left ex. mould	24.0	16.5	4.5

Remarks.—YABE and NAGAO (1925) established *minor* as a variety of *Trigonia subovalis* JIMBO, based on many syntypes



Text-fig. 2. Illustration and terminology of the costae on the disk of the pennatae trigonian, based on *Apiotrigonia* (*Apiotrigonia*) *minor* (YABE and NAGAO), scale 5 mm.

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 Prefecrure; 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-*

icus Zones; Santonian; Upper Urakawan.

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

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

1915. *Trigonia* cf. *subovalis* JIMBO: YEHARA, *Sci. Rept. Tohoku Imp. Univ.*, ser. 2, vol. 2, no. 2, p. 42, pl. 1, figs. 14-17.
1957. *Apiotrigonia minor* (YABE and NAGAO): NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 110, pl. 8, fig. 1, non. figs. 2 and 3.

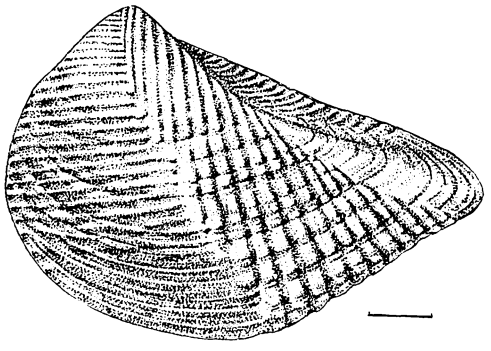
Material.—Holotype KSG 2061, is a right valve from the Ponbetsu (Loc. IK 2016), Mikasa area, Hokkaido; KSG 2068-2070 (paratypes), from the same locality as the holotype; GK. H6910-6913 (paratypes), from Ponhorokabetsu, Yubari dome, Hokkaido (Loc. Yb 67r, see MATSUMOTO and HARADA, 1964) (Masato HARADA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

Description.—Shell medium in size, moderately inflated; test rather thin; anterior margin semi-circular, ventral margin broably 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).—

Specimen	Length	Height	Thickness
KSG 2068, right valve	19.0	14.3	3.0
KSG 2061, right valve	17.9	14.0	3.3
GK.H 6910, right valve	34.8	22.1	6.5
GK.H 6912, left valve	33.2	24.5	6.2
GK.H 6913, left valve	31.2	20.5	5.0

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



Text-fig. 3. *Apiotrigonia* (*Apiotrigonia*) *mikasaensis* sp. nov., scale 5 mm.

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 costellae 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.*) *hetonaiana* 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 costellae 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, (IK 2016), Mikasa City, Hokkaido; *Inoceramus hobetsuensis* Zone. Sandstone of the Middle Yezo Group at Yonnosawa of Ponhorokabetsu, Yubari (Yb 67r, see, MATSUMOTO and HARADA, 1964), Hokkaido. This species is probably restricted to the Upper Gyliakian (Turonian).

Apiotrigonia (*Apiotrigonia*) *undulosa* NAKANO

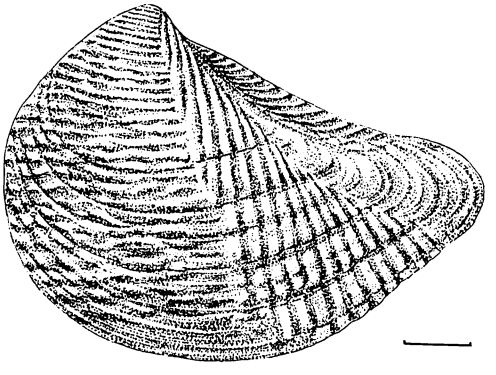
Plate 25, Figs. 7-10, Text-fig. 4

1957. *Apiotrigonia undulosa* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 112, pl. 8, fig. 8.
1972. *Apiotrigonia undulosa* NAKANO: TASHIRO, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 86, pl. 40, figs. 18-19, text-figs. 1-a and 2-B (compare, not described).
1975. *Apiotrigonia* (*Apiotrigonia*) *undulosa* NAKANO: HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 115.

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 Kajisako of Otochi, 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.



Text-fig. 4. *Apiotrigonia* (*Apiotrigonia*) *undulosa* NAKANO, scale 5 mm.

Measurements (in mm).—

Specimen	Length	Heigth	Thickness
KSG 2072, right ex. mould	23.0	16.0	—
KSG 2073, left ex. mould	12.0	11.0	1.8
KSG 2074, left ex. mould	9.0	7.2	—
KSG 2062, left valve	19.0	14.2	2.9
KSG 2063, left valve	14.0	11.0	—
KSG 2064, left valve	14.0	11.0	—

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

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 Furushiroyama 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, Oriki, Hirono-machi, Futaba-gun, 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

1938. *Trigonia subovalis* JIMBO, 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, fig. 9, non figs. 7 and 8.
1957. *Apiotrigonia crassoradiata* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 113, pl. 8, figs. 9 and 10.
1975. *Apiotrigonia* (*Apiotrigonia*) *crassoradiata* NAKANO: HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 115.
1976. *Apiotrigonia crassoradiata* NAKANO: TASHIRO, *Palaeont. Soc. Japan, Spec. Pap.*, no. 19, p. 57, pl. 7, figs. 4-6.
1978. *Apiotrigonia crassoradiata* NAKANO: TASHIRO, *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 112, pp. 428-431, Text-figs. 3-5, pl. 54, fig. 5.

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).—

Specimen	Length	Height	Thickness
KSG 2075, right ex. mould	42.0	32.2	9.9
KSG 2076, right in. mould	43.3	29.0	—
KSG 2077, left ex. mould	36.5	25.5	9.0
KSG 2078, left ex. mould	25.0	26.0	7.8
KSG 2079, right ex. mould	32.5	27.5	7.3
KSG 2086, right valve	24.0	23.0	7.0

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 silitstone 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 (Hetonai), 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.

1978. *Apiotrigonia hetonaiana* TASHIRO, *Trans. Proc. Palaeont. Soc. Japan*, N.S., no. 112, pp. 425-428, text-fig. 2, pl. 54, figs. 1-4.

Material.—KE 2776-2782, see TASHIRO, 1978.

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, disapperance 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 Hetonaian). 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*) *schmidti* Zone or uppermost part of the *Inoc.* (*Sphenoc.*) *schmidti* Zone; Lower Maastrichtian or Uppermost Campanian?; Lowest Upper Hetonaian or uppermost Lower Hetonaian. The holotype (KE 2776) was collected at Panketosano-sawa, Tomiuchi. This species presumably ranges from the uppermost Campanian to Maastrichtian.

Apiotrigonia (*Apiotrigonia*) *utoensis* TASHIRO

1972. *Apiotrigonia utoensis* TASHIRO, *Trans. Proc. Palaeont. Soc. Japan*, N.S., no. 86, p. 333, text-fig. 7, pl. 41, figs. 9-11.
1975. *Apiotrigonia* (*Apiotrigonia*) *utoensis* TASHIRO: HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 115.

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.*) *postonodosa* 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 Oda-machi, Uto City, Kumamoto Pref.; *Inoc.* (*Sphenoceramus*) *orientalis nagaoi*, *Heterotrigonia* (*Nakanotrigonia*) *himenourensis* (subgen. nov.), and *Diplomoceras*? sp. occurred together with this species. The bed is probably Lower Campanian (Lowest Hetonaian) 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

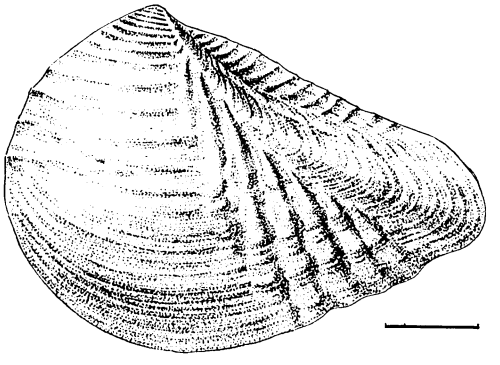
Text-fig. 5

1957. *Apiotrigonia obsoleta* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 114, pl. 9, figs. 5-7.
1957. *Apiotrigonia minor* var. *nankoi* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 112, pl. 9, figs. 1-4.
1972. *Apiotrigonia obsoleta* NAKANO: TASHIRO, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 86, p. 331, pl. 41, figs. 1-8, non figs. 12 and 13.
1975. *Apiotrigonia* (*Apiotrigonia*) *obsoleta* NAKANO: HAYAMI, *Univ. Mus., Univ. Tokyo, Bull*, no. 10, p. 115.

Material.—KE 1891-1903, from Okoshiki beach of Oda-machi, Uto City, Kumamoto

Prefecture.

Description.—Shell small; test rather thin; umbo small, slightly prominent, a little opisthogyrous, located at a third to a fouth 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 broably 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*) *obsoleta* 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.*) *hetonaiana* (text-fig. 17). It resembles *Trigonia maudensis* WHITEAVES (PACKARD, 1921) from the Haida Formation of Queen Chalotte 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 Wadanohana of Takado, Ryugadake-machi, Amakusa-gun, Kumamoto Pref.; *Inoceramus japonicus* Zone; Upper Urakawan (Santonian). Holotype and paratypes 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.

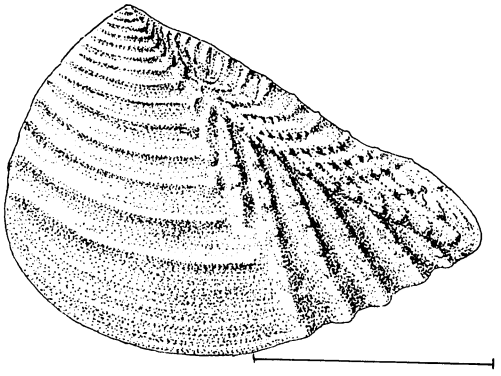
Apiotrigonia (?*Apiotrigonia*) *dubia* sp. nov.

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

1972. *Apiotrigonia* aff. *obsoleta* NAKANO: TASHIRO, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 86, pl. 41, figs. 12 and 13.

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 opisthogyrous, located at the fourth to fifth from the front of valve; anterior margin semicircular; ventral margin weakly arched; siphonal margin narrow, rostrated 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.



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

Measurements (in mm).—

Specimen	Length	Height	Thickness
KSG 2087, left ex. mould	9.5	6.5	1.6
KSG 2088, right ex. mould	11.9	8.0	1.9
KSG 2089, left in. mould	10.0	7.0	—
KSG 2090, left ex. mould	10.5	7.8	1.2
KE 1935, left ex. mould	11.0	7.5	—
KE 1936, left ex. mould	15.0	9.5	—

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 costellation on the area, but is distingushable 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 Hetonaian (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

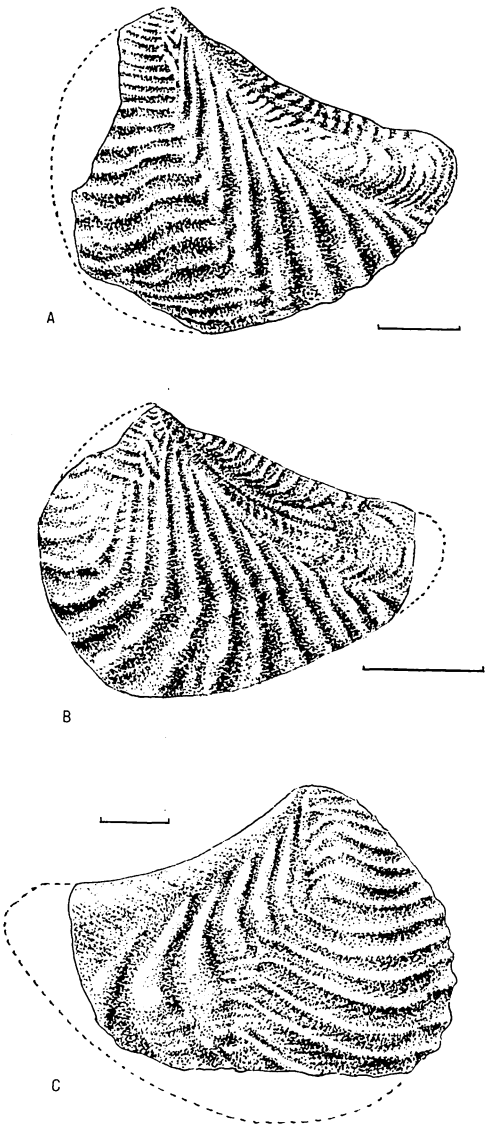
Type-species: *Microtrigonia amanoi* NAKANO, 1957; Upper Himenoura Subgroup in Southwestern Japan. Upper Campanian (Lower Hetonaian).

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 malform. *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 from *Apiotrigonia* s. str. in its tuberulated



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* (*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., *Turkestanella* 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*) *dampierensis* SKWARKO have fine radial striae, and *Apiotrigonia* (*Turkestanella*) *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., *Turkestanella* 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 pennatae trigoniids. I think that these four taxa, *Apiotrigonia* s. str., *Turkestanella* nov., *Dampietrigonia* nov. and *Microtrigonia*, can not be distinguished generically. I regard *Microtrigonia* as a subgenus of *Apiotrigonia* s. l. *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.*) *minima* (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

1957. *Trigonia subovalis* var. *minor* YABE and NAGAO: AMANO, *Kumamoto Jour. Sci.*, ser. B, vol. 2, no. 2, p. 57, pl. 1, fig. 19.

1957. *Microtrigonia amanoi* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 117, pl. 9, figs. 21 and 22.

1957. *Apiotrigonia tuberculata* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 115, pl. 9, figs. 15 and 16.

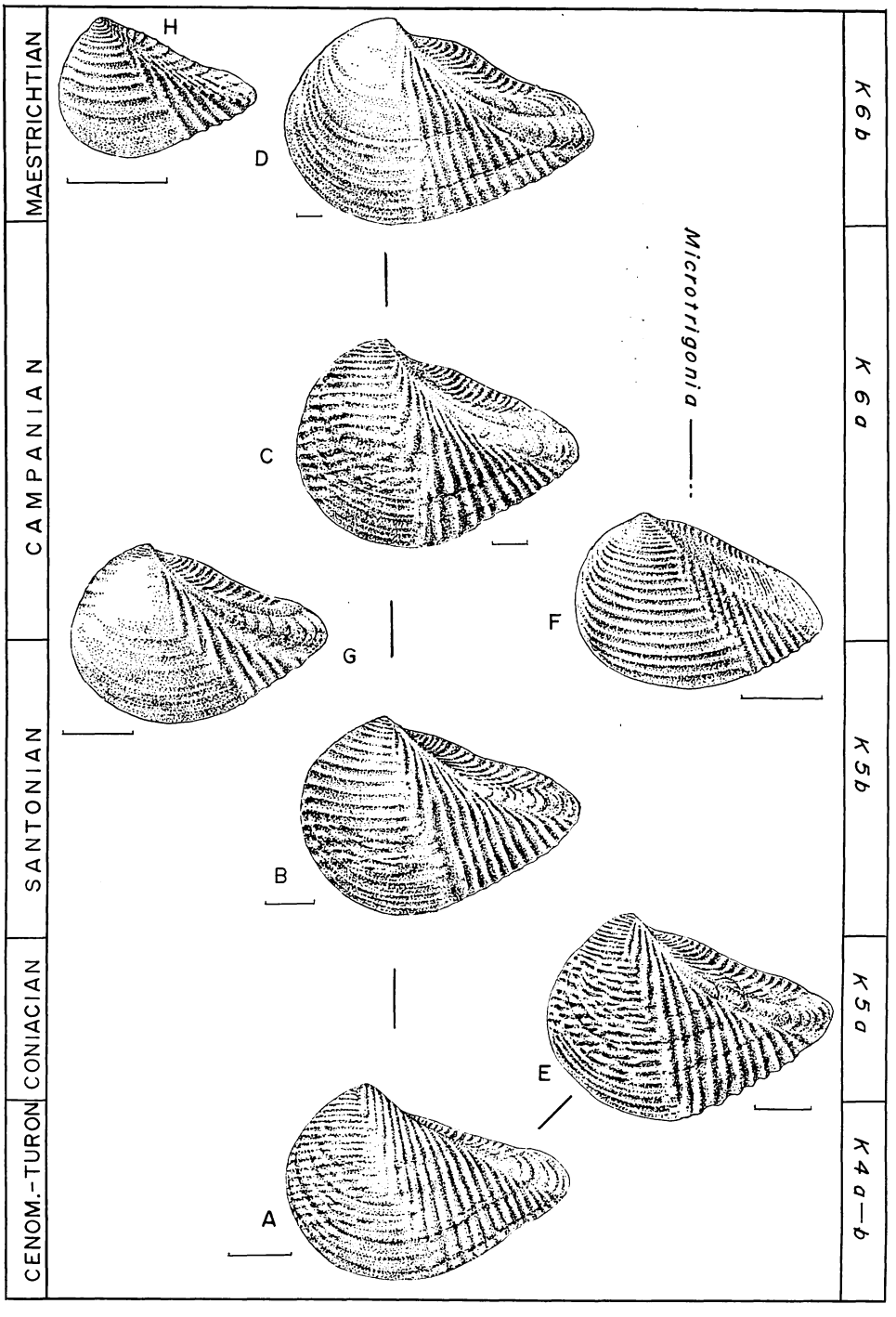
1972. *Microtrigonia amanoi* NAKANO: TASHIRO, *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. 86, pl. 40, figs. 26 and 27 (without description).

1975. *Microtrigonia amanoi* NAKANO: HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 116.

1975. *Microtrigonia tuberculata* (NAKANO): HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 116.

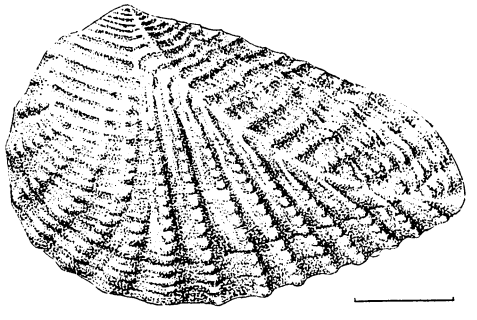
1976. *Microtrigonia amanoi* NAKANO: TASHIRO, *Palaeont. Soc. Japan Sp. Pap.* no. 19, p. 57, pl. 7, figs. 10-14.

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


CENOM.-TURON
CONIACIAN
SANTONIAN
CAMPANIAN
MAESTRICHTIAN
K4a—b
K5a
K5b
K6a
K6b
Microtrigonia
A
B
C
D
E
F
G
H

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; umbo 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 lenght 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 postero-marginal 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; postero-marginal carina distinctly angulated, weakly concave; median groove of the area indistinct; inner surface smooth; inner posterior ventral margin broadly crenulated; in the



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

Text-fig. 8. Diagram showing the stratigraphical occurrences and the presumed line of descent in *Apiotrigonia* s. str. from Japan. A: *Apiotrigonia* (*Apiotrigonia*) *mikasaensis* sp. nov., B: *A.* (*A.*) *minor* (YABE and NAGAO), C: *A.* (*A.*) *crassoradiata* NAKANO, D: *A.* (*A.*) *hetonaiana* TASHIRO, E: *A.* (*A.*) *undulosa* NAKANO, F: *A.* (*A.*) *utoensis* TASHIRO, G: *A.* (*A.*) *obsoleta* NAKANO, H: *A.* (?*A.*) *dubia* sp. nov., 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).—

Specimen	Length	Height	Thickness
KSG 2095, right ex. mould	18.0	14.0	3.3
KSG 2096, left valve	14.5	10.8	1.9
KSG 2097, left ex. mould	12.3	8.5	1.7
KSG 2098, right ex. mould	11.9	9.2	1.7
KSG 2093, right ex. mould	12.5	8.9	2.5
KSG 2092, left ex. mould	8.5	6.3	1.6

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 latio of length to height is variable between 4/5 and 3/5.

This species shows gradual changes in outline and surface sculptures in accordance with the stratigraphic sequence, in which three representative forms are recognizable. They are called here the "rostrate", the "typical" and the "tuberculate" 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 *Apiotrigonia* (*Microtrigonia*) *postonodosa* NAKANO, in its features of costae on the disk, but differs in its weak and more distinctly tuberculate costae of the posterior series. The *Frenguelliella*- or *Rutitrigonia*-like stage is more distinct in the tuberculate form and more persistent than in *A.* (*M.*) *postonodosa*. *Apiotrigonia tuberculata* 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-IIb), 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-IIa) 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*) *schmidti* Zone. Campanian and probably also an uncertain part of the Maastrichtian.

Apiotrigonia (*Microtrigonia*) *imutensis* (TASHIRO)

Plate 26, Figs. 7-12

1972. *Microtrigonia imutensis* TASHIRO, *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. 86, p. 335, text-fig. 9, pl. 40, figs. 24 and 25.
1975. *Microtrigonia imutensis* TASHIRO: HAYAMI, *Univ. Mus., Univ. Tokyo Bull.* no. 10, p. 116.
1976. *Microtrigonia imutensis* TASHIRO: TASHIRO, *Palaeont. Soc. Japan, Sp. Pap.* no. 19, pl. 7, figs. 7 and 8 (for comparison).

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).—

Specimen	Length	Height	Thickness
KSG 2102, right valve	25.0	17.0	4.0
KSG 2103, right valve	17.0	12.2	3.0
KSG 2104, left ex. mould	16.7	12.5	2.8
KSG 2105, right ex. mould	24.0	15.0	4.0
KSG 2106, right ex. mould	22.4	16.5	3.9
KSG 2107, left ex. mould	18.4	14.7	4.0
KSG 2108, left ex. mould	11.2	9.3	2.6
KSG 2109, left ex. mould	13.2	12.5	3.0

Remarks.—This species is clearly distinguished from *Apiotrigonia* (*Microtrigonia*) *amanoi* (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 aredis criminated: pseudo-*utoensis* 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 *Frenguelliella*-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 postonodosa* (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, Kumamoto 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 Himezuka of Dogo, Matsuyama City, Ehime Pref., occurring together with *Inoceramus* (*Sphenoceramus*) *schmidti*. Another locality of the radiate form is the sandstone of the Lower Member of the Middle Formation of the Upper Himenoura Subgroup (Member U-IIa) 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 Hetonaian); *Inoceramus* (*Sphenoceramus*) *orientalis orientalis* Zone and *Inoc.* (*Sphenoc.*) *schmidti* Zone.

Apiotrigonia (*Microtrigonia*) *postonodosa* NAKANO

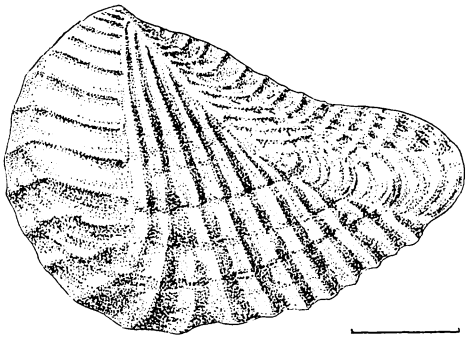
Plate 26, Figs. 13-17, Text-fig. 10

1957. *Apiotrigonia postonodosa* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 114, pl. 9, figs. 8-14.
1972. *Apiotrigonia postonodosa* NAKANO: TASHIRO, *Trans. Proc. Palaeont. Soc. Japan*, N.S., no. 86, pl. 40, figs. 20-23, text-figs. 5 and 1-c, 3-d, and 6-B.
1975. *Apiotrigonia postonodosa* NAKANO: HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 115
1976. *Apiotrigonia postonodosa* NAKANO:

TASHIRO, *Palaeont. Soc. Japan, Sp. Pap.*, no. 19, pl. 7, figs. 1-3.

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; umbo slightly opisthogyrous, not prominent, located at about one-third to one-fifth from the front of the valve; anterior margin well rounded; ventral margin long, broadly arched; siphonal margin narrow, rounded, somewhat rostrated to the posterior; postero-dorsal margin straight or weaklyc oncave, occupying about a half length of the valve; ratio of length to height about two-thirds in the adult stage but larger in younger stages; disk ornamented with two series of costae: the anterior and the subradial series, those of the former concentric, plain, widely spaced, somewhat narrower than their interspaces; 5 or 6 costae on the umbonal region distinct for about 4 mm in distance from the umbo towards the venter; the succeeding several costae gradually weakened and broadly spaced, and connected with the subradial series of costae on the anterior part; and finally those on the ventral part of the adult stage, over 10 mm or so in length, become nearly indistinct; the subradial series of costae very strong, but narrower than their interspaces, finely tuberculated; about 10 costae from the rear of the valve extended from the postero-ventral carina towards the ventral margin, nearly straight, occupying about three-fourths in length of the disk; 7 or more costae on the anterior part short, surrounded by the outskirts of the anterior series, bi- or trifurcate near the antero-ventral part; *Frenguelliella*-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 weaked 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).—

Specimen	Length	Height	Thickness
KE 1927, left ex. mould	18.4	13.3	3.0
KE 1928, right ex. mould	12.5	10.5	2.6
KSG 2110, right in. mould	13.3	9.7	2.7
KSG 2112, right ex. mould	13.4	9.4	2.4
KSG 2113, left ex. mould	14.8	9.8	2.3
KSG 2114, right ex. mould	12.3	10.8	3.2
KSG 2119, left ex. mould	14.9	9.5	3.6

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, Miharagun, Awaji Island. As the specimens from the Izumi Group in my collection are very small, it is questionable whether they are referrable 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 *Frenguelliella*-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-IIIa), at Yotsuinosako of Kamihira, Ono of Hongo, Keijigahama and Nodden, all in Miyanokawachi, Kawaura-machi, Amakusa-gun, Kumamoto Pref. The type locality by NAKANO (1957) (Nodden of Miyanokawachi) 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-IIIa of the Upper Himenoura Subgroup may be referrable 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 postero-ventral 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).—

Specimen	Length	Height
KSG 2120, right valve	7.8	5.6
KSG 2123, left in. mould	15.0	11.7

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 Hetonaian).

Apiotrigonia (*Microtrigonia*) *minima* (NAKANO)

1957. *Microtrigonia minima* NAKANO, *Japan. Jour. Geol. Geogr.* vol. 28, nos. 1-3, p. 119, pl. 9, figs. 21 and 22.
1975. *Microtrigonia minima* NAKANO: HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 116.

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

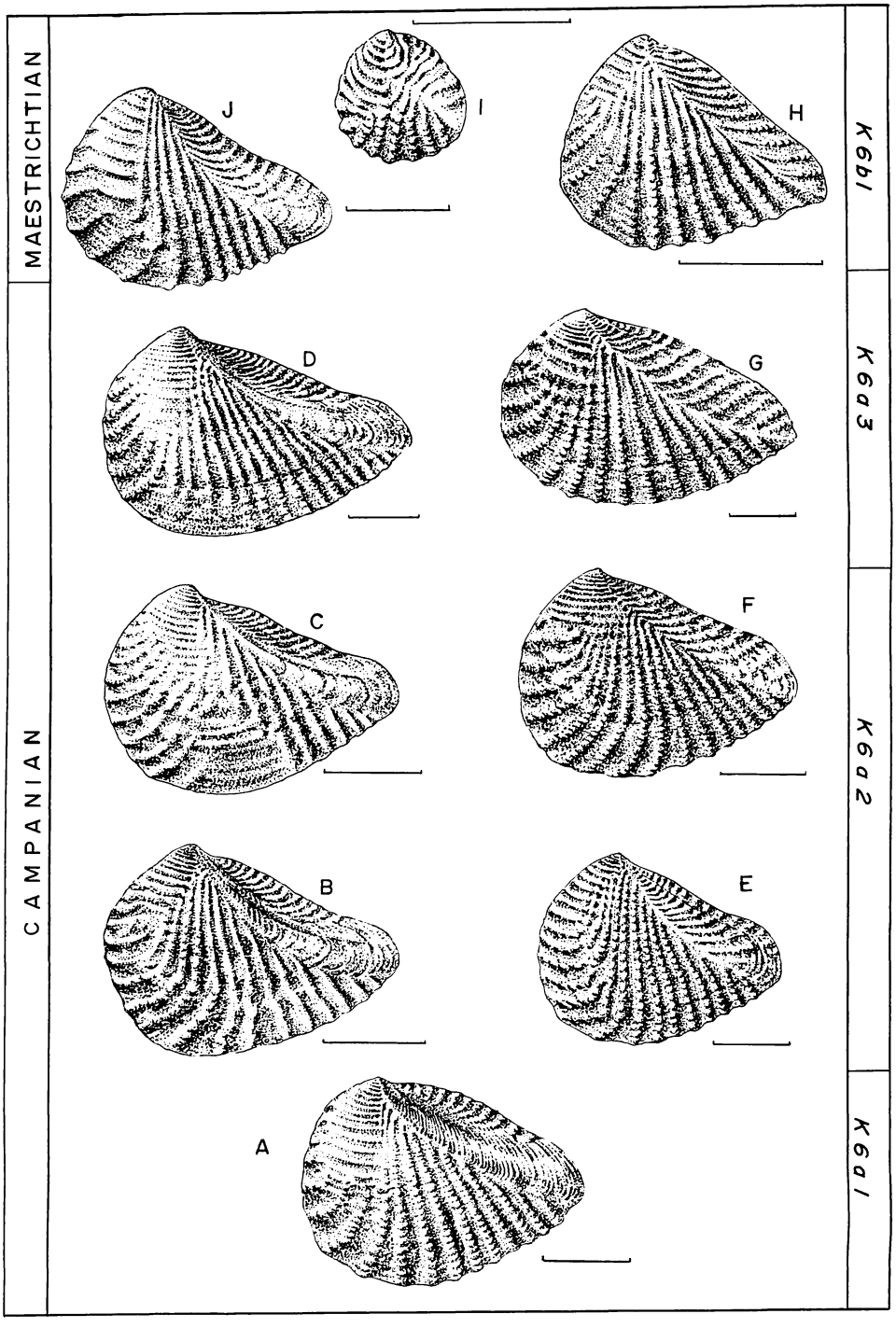
Age and distribution.—Campanian and Maastrichtian (Hetonaian): Shichi Shale and Kitaama Sandstone of the Izumi Group in Awaji Island (NAKANO, 1957).

Subgenus ***Dampietrigonia*** nov.

Type-species: *'Apiotrigonia' dampierensis* SKWARKO, 1969; Aptian; Western Australia.

Diagonosis.—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' dampierensis* 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;


MAESTRICHTIAN
CAMPANIAN
K6b1
K6a3
K6a2
K6a1
A
B
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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 *Heterotrigonia*, 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. *Microtrigonia, Nakanotrigonia* 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 [=*Megatrigonia* (*Apiotrigonia*) *turkestanensis*: POJARKOVA, 1978]; Cenomanian; Turkestan.

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

Remarks.—This new subgenus is similar to *Microtrigonia* 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 *Heterotrigonia* COX, 1952

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

Diagnosis.—Shell small to large, pyriform and trigonally ovate; umbo opithogyrous, 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.—*Heterotrigonia* 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

Text-fig. 11. Diagram showing the stratigraphical occurrence and possible lines of descent in *Apiotrigonia* (*Microtrigonia*) from Japan. A-D: *Apiotrigonia* (*Microtrigonia*) *imutensis* (TASHIRO), A. pseudo-*utoensis* form, B. and C. radiate form, D. typical form; E-H: *Apiotrigonia* (*Microtrigonia*) *amanoi* (NAKANO), E and F. rostrate form, G. typical form, H. tuberculate form (=*Microtrigonia tuberculata* NAKANO), I: *Apiotrigonia* (*Microtrigonia*) *minima* (NAKANO), J: *Apiotrigonia* (*Microtrigonia*) *postonodosa* NAKANO, scale 5 mm.

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).

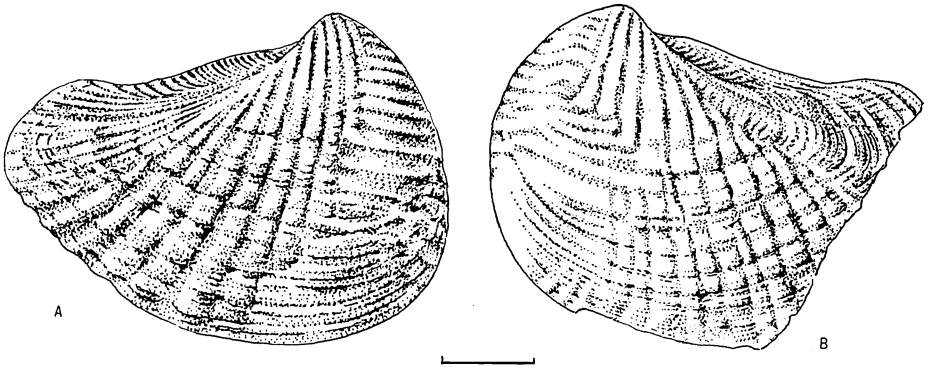
Heterotrigonia (*Heterotrigonia*) *subovalis* (JIMBO)

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

1894. *Trigonia subovalis* JIMBO, *Pal. Abh., N.F.* Bd. 2, Ht. 3, pp. 188-189, pl. 8, figs. 5 and 5a.
1923. *Trigonia sawatai* YEHARA, *Japan. Jour. Geol. Geogr.*, vol. 3, p. 80, pl. 10, fig. 9.
1954. *Heterotrigonia sawatai* (YEHARA): KOBAYASHI, *Japan. Jour. Geol. Geogr.*, vol. 25, nos. 1-2, p. 77.
1957. *Apiotrigonia jimboi* NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 115, pl. 8, figs. 5-7.
1957. *Heterotrigonia subovalis* (JIMBO): NAKANO, *Japan. Jour. Geol. Geogr.*, vol. 28, nos. 1-3, p. 118, pl. 8, figs. 13-15.
1961. *Heterotrigonia subovalis* (JIMBO): NAKANO, *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. 42, p. 57, pl. 9, figs. 1-14.
?1960. *Megatrigonia* (*Apiotrigonia*) *subovalis* (JIMBO): LIVEROVSKAJA, *Palaeont. Bull., 2, Leningrad*, pp. 251-252, pl. 5, figs. 1-3.
1975. *Apiotrigonia* (*Heterotrigonia*) *subovalis* (JIMBO): HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 115.

Material.—KSG 2125-2128, external and internal moulds from Keirinbashi 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,



Text-fig. 12. Diagramatic sketches showing two shapes of *Heterotrigonia* (*Heterotrigonia*) *subovalis* (JIMBO). A: radiate form (form of *Trigonia sawatai*), B: typical form, scale 5 mm.

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).—

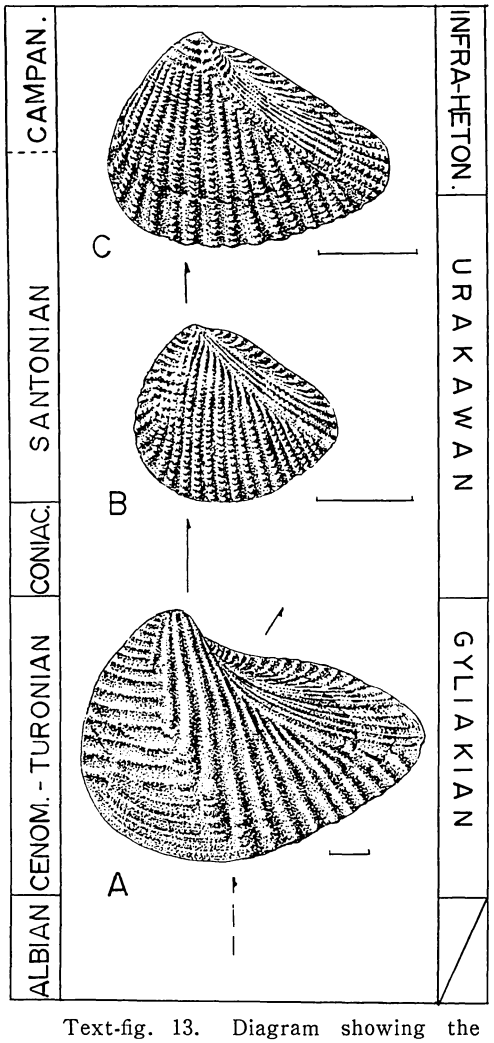
Specimen	Length	Height	Thickness
KSG 2127, right ex. mould	32.0	24.1	8.4
GK. H6051 left valve	43.2	33.3	10.8
GK. H6055, right valve	48.9	38.2	12.0

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 *Apiotrigonia 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.*) *himenourensis* 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 *Aiotrpigonia* (*Apiotrigonia*) *mikasaensis* nov. of the same locality in its less numerous costae on the disk.

Occurrence.—Sandstone of the Mikasa Formation at Keirinbashi of Shimokatsurazawa, 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 Ponbetsu (Ik 2016); Turonian. Sandstone of the upper part (IId) of the same formation at an abandoned quarry, NWW of the Katsurazawa-dam, Ikushunbetsu; Turonian.

Subgenus ***Nakanotrigonia*** nov.

Type-species: *Heterotrigonia himenourensis* 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 umbonal part and subradial, tuberculated ones extending to the outer part of the outskirt of the umbonal 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 umbonal 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 tubrculated posterior series. *Microtrigonia* is, however, devoid of the radial costellae on the area.

List of species.—
Heterotrigonia (*Nakanotrigonia*) *granosa*

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, *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. 86, p. 334, pl. 41, figs. 14-16, text-fig. 8.

1975. *Apiotrigonia (Heterotrigonia) himenourensis* (TASHIRO): HAYAMI, *Univ. Mus., Univ. Tokyo, Bull.* no. 10, p. 116.

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 Hetonaian.

Heterotrigonia (Nakanotrigonia) granosa NAKANO

1957. *Heterotrigonia granosa* NAKANO, *Japan. 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) amanoi* (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 *Quoiecchia* CRICKMAY, 1932

Type-species: *Quoiecchia aliciae* CRICKMAY, 1932.

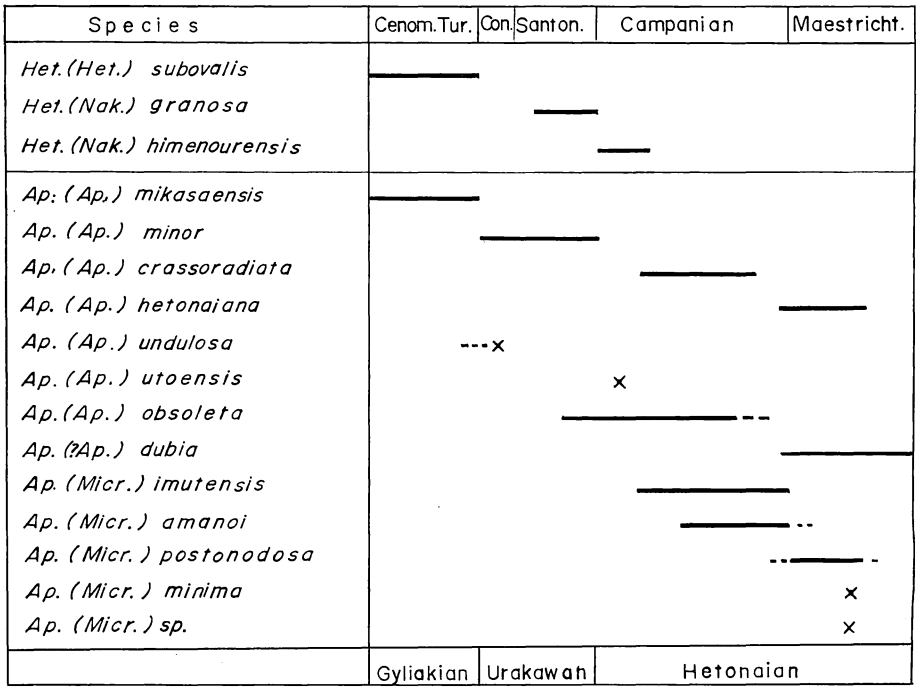
Remarks.—This genus is debatable as to its taxonomic position. It was referred to the Laevitrigoniinae by SAVELIEV (1958), but to the Myophorellinae by POULTON (1977). It is characterized by subvertical or subradial costae on the posterior part of the disk where the costae extend from the postero-ventral 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 opisthogyrate umbo and less angulated postero-ventral ridge are

also similar to those of the pennatae trigoniids.

Age and distribution.—Lower Cretaceous, British Columbia.

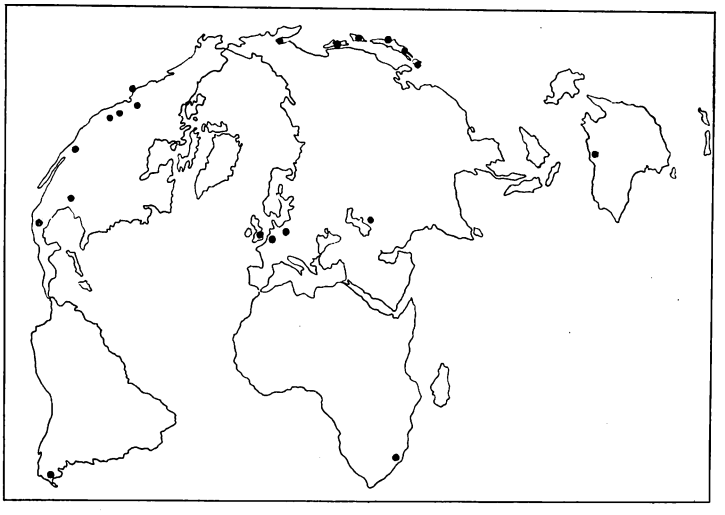
Evolutionary changes of the subfamily Apiotrigoniinae

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 *Frenguelliella*- or *Rutitrigonia*-like regularly spaced and plain concentric costae. Such a *Frenguelliella*- 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 *Heterotrigonia* s. l., which flourished extensively in the Cretaceous period.

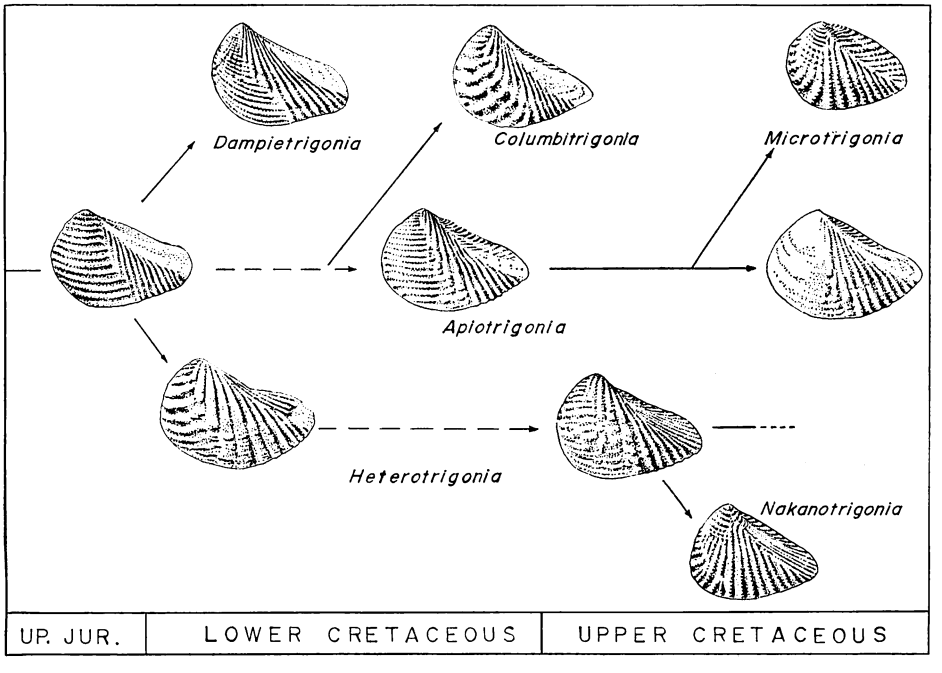


Text-fig. 14. The stratigraphic ranges of the pennatae trigoniid species from Japan.

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 pennatae trigoniids in the world.



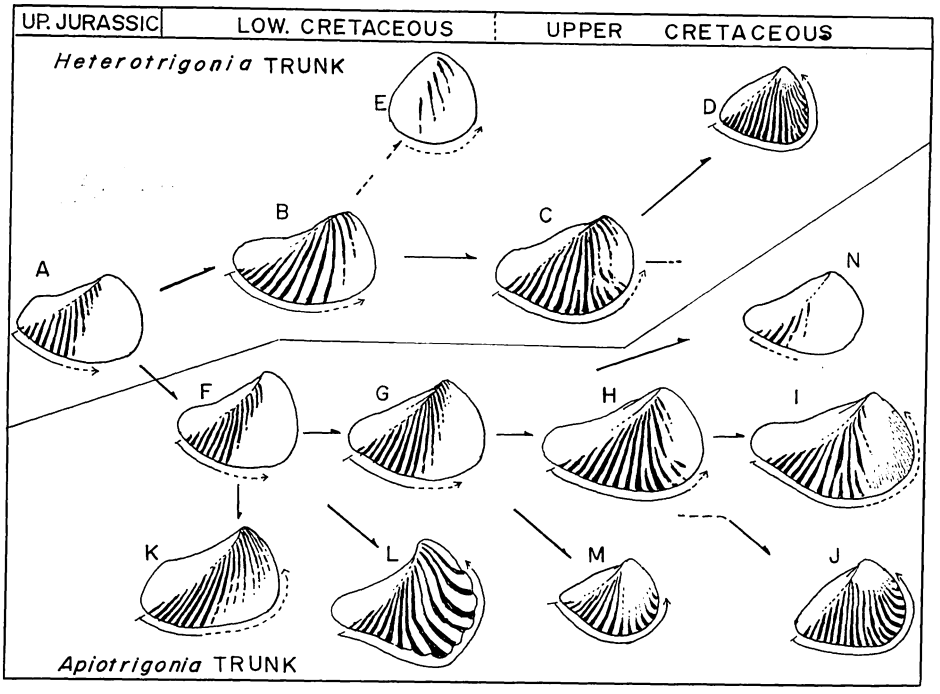
Text-fig. 16. Possible lines of descent of the pennatae trigoniids.

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 newcombei*" (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 costellae 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. newcombei*", as has already been pointed out by NAKANO (1961, 1971). Text-fig. 13 diagramatically 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 '*Apoitrigonia*' *dampierensis* 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.

Apiotrigonia s. str. is the most flourished group in the pennatae trigoniids (Apiotrigoniinae), characterized by the absence of radiating costellae on the area. The earlier representatives of *Apiotrigonia* are several species from the Lower Cretaceous of Central America and South America (STOYANOW 1949, ANDERSON 1938, STANTON 1901). The latest one is represented by *Apiotrigonia* (*Apiotrigonia*) *hetonaiana*, from the Maastrichtian (K6b1) of Japan. Some species of *Apiotrigonia* 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 *Apiotrigonia* 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 *Apiotrigonia* 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 *Apiotrigonia* s. str. of the Lower Cretaceous, e. g., *A.* (*A.*) *cragini*, *A.* (*A.*) *kitchini* and *A.* (*A.*) *kayana* from North America, and *A.* (*A.*)



Text-fig. 17. Diagram showing the directionally increasing radial ornaments on the disk of the pennatae trigoniids and the evolutional parallelism between trunks of *Heterotrigonia* and *Apiotrigonia*. A: *Heterotrigonia* (*Heterotrigonia*) *calderoni*; B: *H.* (*H.*) *diversicostata*; C: *H.* (*H.*) *subovalis*; D: *H.* (*Nakanotrigonia*) *himenourensis*; E: *Quoiecchia aliciae*; F: *Apiotrigonia* (*Apiotrigonia*) *pennata*; G: *A.* (*A.*) *mikasaensis*; H: *A.* (*A.*) *crassoradiata*; I: *A.* (*A.*) *hetonaiana*; J: *A.* (*Microtrigonia*) *amanoi*; K: *A.* (*Dampietrigonia*) *dampierensis*; L: *Columbitrigonia columbiana*; M: *A.* (*Turkestanella*) *turkestanensis*; N: *A.* (*A.*) *obsoleta*.

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 *Apiotrigonia* and *Heterotrigonia*.

In sofar as I know, the origin of *Apiotrigonia* s. str. was probably in the Lower Cretaceous of Central America, as that of *Heterotrigonia* s. str. *Apiotrigonia* s. l. expanded its distribution into three directions. One was the same as in the case of *Heterotrigonia* 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.*) *progonos* (PAULCKE) (REYES and PÉREZ, 1978) from Chile and *A.* (*A.*) *concardiformis* (KRAUSS)

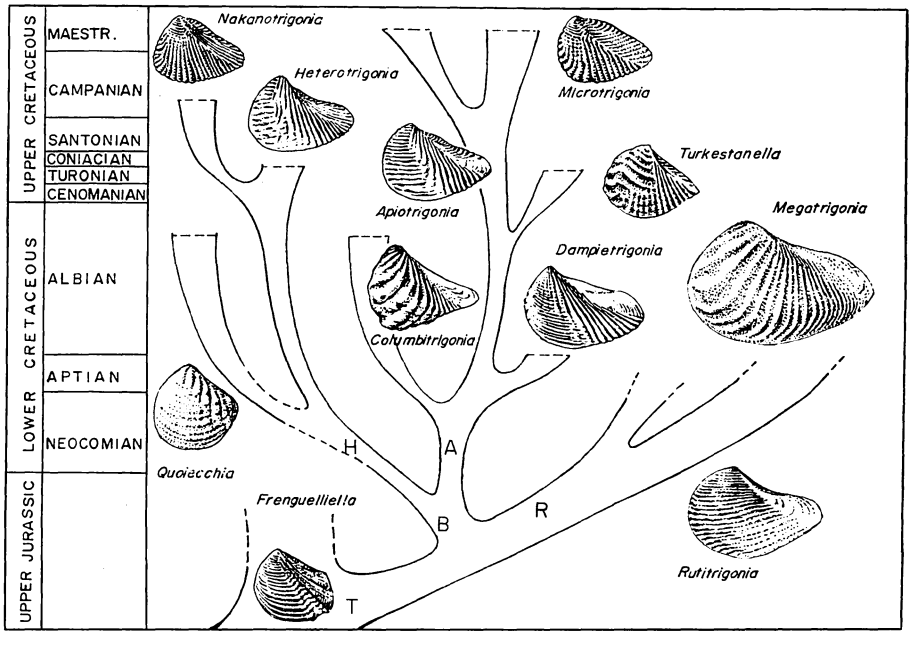
from South Africa (KITCHIN 1913).

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.

Quoiecchia 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 *Heterotrigonia* trunk.

Microtrigonia NAKANO, 1957, from Japan, is undoubtedly derived from *Apiotrigonia* s. str., with *Apiotrigonia* (*Apiotrigonia*) *utoensis* as its presumable ancestor. *Microtrigonia* 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. *Microtrigonia* is the latest branch from the *Apiotrigonia* trunk, as *Nakanotrigonia* is so from the *Heterotrigonia* trunk. *Microtrigonia* appears, however, later than *Nakanotrigonia* (*Microtrigonia* 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.



Text-fig. 18. Presumed phylogenetic relations in the subfamily Apiotrigoniinae nov. T: Trigoniinae, B: Apiotrigoniinae, R: Rutitrigoniinae and Megatrigoiinae; A: *Apiotrigonia* trunk, H: *Heterotrigonia* trunk.

The *Apiotrigonia* trunk ranges from the lowest Cretaceous to the uppermost Cretaceous, accompanied with several branches, e. g., *Columbitrigonia* in the Neocomian, *Dampietrigonia* in the Aptian, *Turkestanella* 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 *Quoiecchia*(?) in the Lower Cretaceous and *Nakanotrigonia* in the Santonian (see Text-fig. 18).

In my opinion, the phylogenetic evolution of the pennatae trigoniids (Apiotrigoniinae) 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 *Apiotrigonia* and *Heterotrigonia* in parallel with each other, and also in several branches which offshooted from the both trunks. The evolutional tempo in each branch or trunk was not constant.

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Explanation of Plate 25

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

Fig. 1: GK. H6910; right valve, ×1; loc. Yonnosawa, 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 Tomiuchi (Hetonai), 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.


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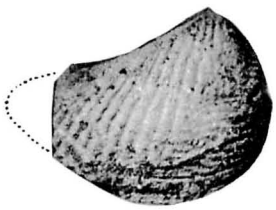
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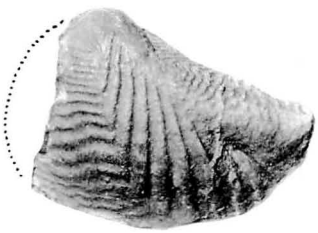
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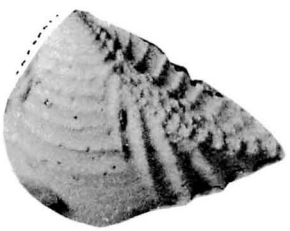
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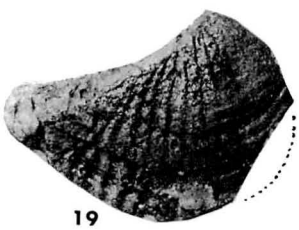
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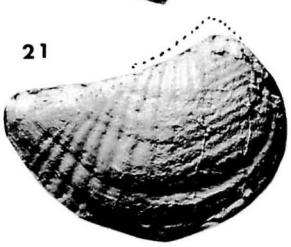
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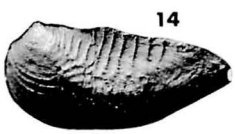
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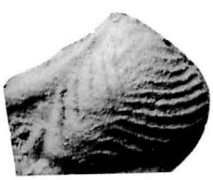
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Amakusa 天草, Amakusa-Kamishima 天草上島, Amakusa-Shiimojima 天草下島, Ashizawa 足沢, Awaji 淡路, Azenotani 畦ノ谷, Chinomigawa 乳呑川, Dogo 道後, Fukaushi 深牛, Fukkireura 吹切浦, Furushiroyama 古城山, Futaba 双葉, Futamado 二間戸, Goshonoura 御所浦, Hakobuchi 函淵, Hanzanji 半山寺, Hetonai 辺富内, Hidaka 日高, Himedo 姫戸, Himenoura 姫浦, Himezuka 姫塚, Hinoshima 樋之島, Hiraiwa 平岩, Hiromi 広見, Hirono 広野, Hongo 本郷, Iburi 胆振, Ikushunbetsu 幾春別, Imuta 蘭牟田, Inukai 犬飼, Iwaki イワキ, Izumi 和泉, Kajisako 猪佐古, Kamihira 上平, Kashima 鹿島, Katsurazawa 桂沢, Kawaura 河浦, Keirinbashi ケイリン橋, Keiji 越路, Kitaana 北阿那, Kita-uwa 北宇和, Kugushima 椚島, Masuno 増野, Mihara 三原. Mikasa 三笠, Minato 湊, Miyanokawachi 宮野河内, Nodden 乗田, Oda 網田, Oe 大江, Okoshiki 御輿来, Omagari 大曲, Oniki 魚貫, Ono 大野, Onogawa 大野川, Onsen 温泉, Otochi 大栃, Oriki 折木, Oshima 大島, Panketosanosawa パンケトサノ沢, Ponbetsu ポンベツ, Ponhorokabetsu ポンホロカベツ, Ryugadake 竜ケ岳, Sakai 堺, Saku 佐久, Sakuradani 桜谷, Satsuma 薩摩, Shichi 志知, Shimokatsura 下桂, Shimo-Koshiki 下甑, Taikorin タイコリン, Takado 高戸, Takinoike 滝ノ池, Teshionakagawa 天塩中川, Tomiuchi 富内, Ukimizu 浮水, Urakawa 浦川, Ushibuka 牛深, Uto 宇土, Uwajima 宇和島, Wadanohana 和田鼻, Yachi 谷地, Yezo エゾ, Yokohama 横浜, Yotsuinosako 肆井ノ迫, Yonnosawa 四ノ沢, Yuasa 湯浅, Yubari 夕張.

日本産 "pennatae trigoniids" の研究：本研究は，本邦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，セノマニアン～マストリヒシアンに出現し，16種（2新種）が確認される。これらは *Heterotigonia* と *Apiotrigonia* に属するものとに大別できる。*Heterotrigonia* に属するものは *Heterotrigonia* s. str. の1種と新亜属 *Nakanotrigonia* の2種の計3種があり，*Heterotrigonia* s. str. はセノマニアン～チュロニアンにかぎられ，*Nakanotrigonia* はサントニアン～カンパニアンに出現する。*Apiotrigonia* には *Apiotrigonia* s. str. と亜属 *Microtrigonia* がある。*Apiotrigonia* s. str. はチュロニアン～マストリヒシアンまでに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*Dampietrigonia*（新亜属）や中央アジアの *Turkestanella*（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. と共通の先祖をもっていると思われる。またカナダの *Quoiecchia* は *Heterotrigonia* に共通した表面装飾を持ちその系統的関連性が予想される。以上の属・亜属をもとに新亜科 Apiotrigoniinae を設定した。本新亜科には *Apiotrigonia* trunk と *Heterotrigonia* trunk の二系列が認められ，前者はおそらく下部白亜紀において後者から分枝したと思われ，また両者間には平行した定向的な形態変化が認められる。本新亜科は，おそらくジュラ紀後期に *Frenguelliella* かあるいは類似の三角具を起源として中央アメリカ付近を起点にして分散していったと思われる。また本亜科は，Rutitrigoniinae とも密接な関係があると思われる。

田代正之

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 (*Dampietrigonia*) *dampierensis* (SKWARKO)

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

Fig. 22: CPC 7729; ditto.

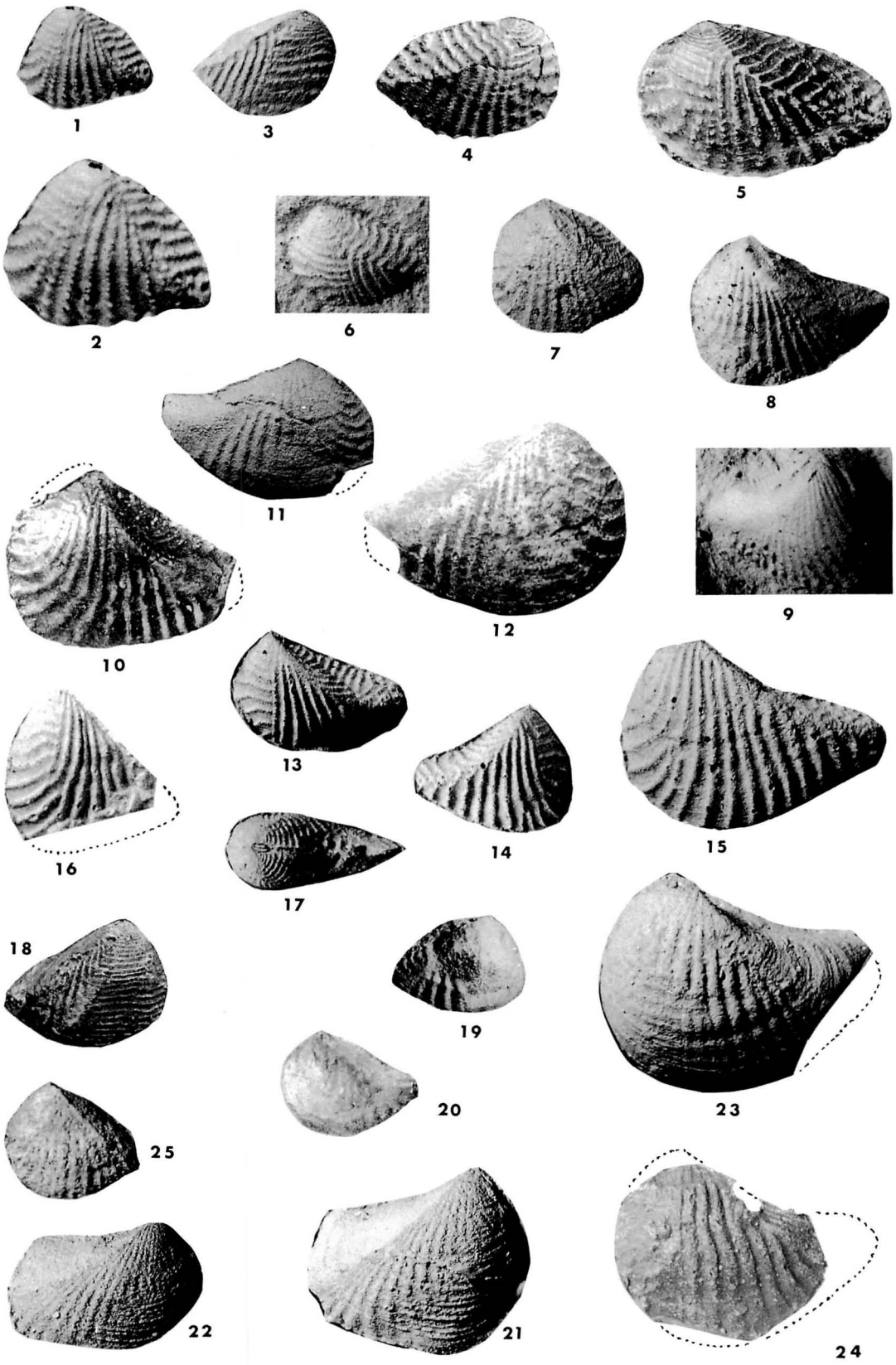
Heterotrigonia (*Heterotrigonia*) *subovalis* (JIMBO)

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.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710. SOME NEW BIVALVE SPECIES FROM THE LOWER GYEONGSANG GROUP, KOREA*

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Abstract. Two new bivalvian species from the Yeonhwadong Formation, the lowermost formation of the Gyeongsang Group are described here. *Trigonioides* (*Koreanaia*) *bongkyuni* sp. nov. is ornamented with large angled V-shape subradial ribs of *Koreanaia* type and possesses fine crenulated hinge teeth of *Wakinoa* type. On account of the stratigraphic relation as well as the morphologic characters, *T.* (*K.*) *bongkyuni* is reasonably interpreted as a link-species between *T.* (*K.*) *cheongi* and some species of *T.* (*Wakinoa*) in the evolutionary lineage. The other new one, *Pseudohyria matsumotoi*, may be considered to be an ancestor of other species of *Pseudohyria* reported from the continental side of Asia in respect of the stratigraphic occurrences.

Introduction

Many species referred to the family Trigonioididae have been reported from the Lower Cretaceous formations in the Asian Continent including the Koreo-Japanese region since the genus *Trigonioides* was first established by KOBAYASHI and SUZUKI (1936) from the Nagdong Subgroup, Korea. They have been known as indices in the non-marine Cretaceous formations of Asia. But, for further precise correlation and the appropriate allocation of their taxonomic position, the construction of their phylogeny is indispensable. The formations yielding these species, unfortunately, are separately distributed here and there, and thus the phylogenetic relations among them have not yet been definitely constructed as mentioned previously (YANG, 1978a).

OTA (1963) regarded *Trigonioides* (s.s.) as a derivative from *Wakinoa* observing the degree of the development of median cardinal teeth in the two subgenera. HAYAMI (in HAYAMI and ICHIKAWA, 1965) considered that *Wakinoa* was a common ancestor of *Trigonioides* (s. s.) and *Nippononaia* or that *Trigonioides* (s.s.) was derived from *Nippononaia* through *Wakinoa* with regard to the hinge structure and other morphologic characters. After that, I revised the evolutionary lineage such as *Koreanaia—Wakinoa Nippononaia—Trigonioides* (s. s.)—*Kumamotoa* from the stratigraphic relations and their morphologic characters and presented the *Koreanaia cheongi* as an ultimate ancestor of the trigonioidid species (1976, 1978b). The evolutionary trend was also supported from the comparison of the *T.* (s. s.) *kodairai* and *T.* (s. s.) *paucisulcatus* (YANG, 1978a).

Recently, I discovered a new fossil locality from the lowermost formation of the Gyeongsang Group, Korea. Among the collection, a new trigonioidid species described below presents a fairly inter-

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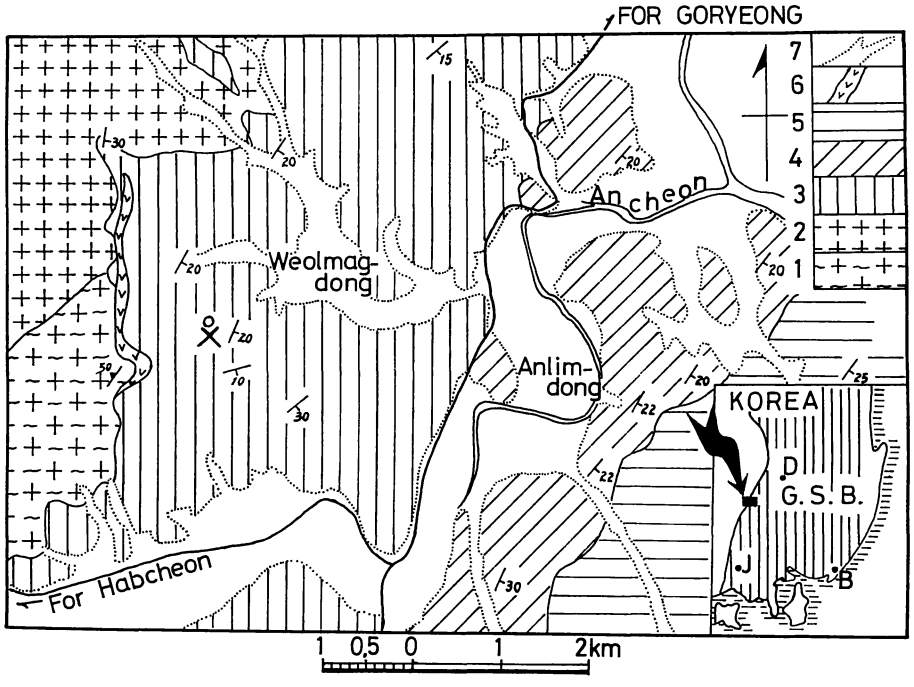


Text-figure 1. Geologic map around the fossil locality (generally after S.O. CHOI and Y.I. KWON, 1970). 1. Pre-Gyeongsang gneiss, 2. Pre-Gyeongsang granite, 3. Yeonhwadong Formation, 4. Hasandong Formation, 5. Dongmyeong Formation, 6. Acidic dyke, 7. Alluvium. ⚹ Fossil locality. In the index map at the lower right corner, D: Daegu, J: Jinju, B: Busan, G.S.B.: Gyeongsang Main Basin.

esting feature certainly considered to be intermediate between *K. cheongi* and *W. wakinoensis*. This is supported also by the stratigraphic evidence.

The other new species is referred to *Pseudohyria*, which has not been reported from Koreo-Japanese region. From the stratigraphic occurrence, the new species of *Pseudohyria* is possibly an ancestor of various species of *Pseudohyria* reported from the Asian Continent.

This is to report systematically the two new species with some brief notes on the stratigraphy of the Gyeongsang Group.

Acknowledgements—I would like to express my sincere gratitude to Emeritus Professor Tatsuro MATSUMOTO of the Kyushu University for his kind encouragement and also critical reading of this paper, and to Miss Gumja LEE of the Kyungpook National University for her assistance on field and laboratory works.

This study was financially supported by the Korea Science & Engineering Foundation (KOSEF).

Stratigraphic Notes

There have been different proposals about the stratigraphic subdivision of the Gyeongsang Group by several authors, but I do not give any comments on them in this paper. In this paper, the current scheme of subdivision is used as shown in Table 1.

The Gyeongsang Group is nonconformably underlain by a complex gener-

ally composed of gneisses and granites, but in one small area of the northern margin of the Gyeongsang Basin, the group is in contact with the possibly upper Jurassic Myogog Formation with angular unconformity, from which *Koreanaia cheongi* was described (YANG, 1976). Assuming that the Yeonhwadong Formation next above the regional unconformity is almost of the same age throughout the basin, *K. cheongi* must be chronologically earlier than the present species.

The relation of the two subgroups, the Nagdong and the Sinla, is apparently observed as conformable at least near the type-section. The ruditic rock of the Paldal Formation shows a gradual change from the arenites of the Chilgog Formation lying below generally in the northern area of the basin. However, in the southern area, an abrupt lithologic change at the boundary is observed, which leads us to regard the relation as disconformable. The two subgroups are fairly well distinguishable from each

Table 1. Current scheme of subdivision of Gyeongsang Group.

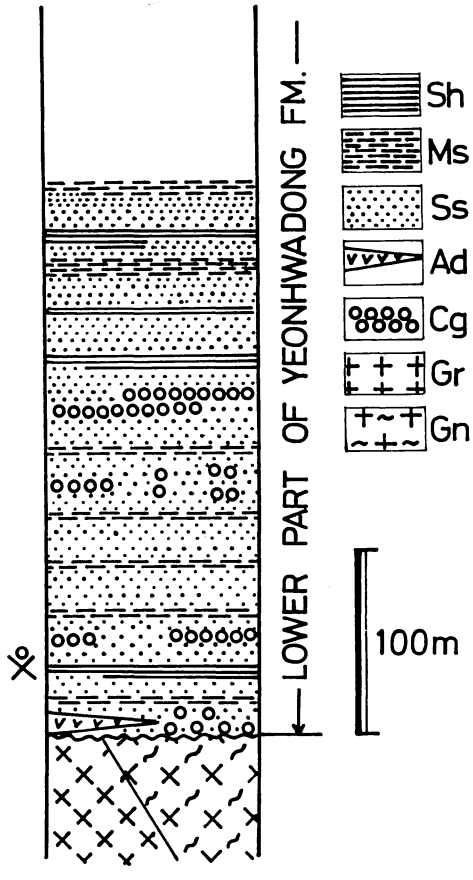
GYEONGSANG GROUP		Bulgugsa intrusives	
		— intrusive	
	Sinla Subgroup	Jusasan andesites	
		Geoncheonri Fm.	*T.* (s.s.) *paucisulcatus* or Jindong Fm.
		Chaeyagsan basalts	
		Banyaweol Fm.	
		Haman Fm.	
		Hagbong basalts	
		Paldal Fm.*	
		— conformity (or disconformity)	
	Nagdong Subgroup	Chilgog Fm.	
		Dongmyeong Fm.*	
		Hasandong Fm.—*T.* (s.s.) *kodairai*	
		Yeonhwadong Fm.*—*Nippononaia ryosekiana*, *T.* (*K.*) *bongkyuni*, *Ps. matsumotoi*	
		— unconformity	
Pre-Gyeongsang complex (granites, gneisses) or Myogog Fm.—*T.* (*K.*) *cheongi*			

In spite of CHANG's withdrawal (1975) of his own proposal (1966) of *Yeonhwadong and *Dongmyeong formations for Nagdong and Jinju formations, respectively, I prefer to use the Yeonhwadong and Dongmyeong formations, as the name Nagdong has been familiar to geologists broadly meaning the lower part of the Gyeongsang Group such as Nagdong flora and Nagdong fauna since YABE (1905), and above all, the Nagdong is also used to the subgroup, and the name Jinju is derived from the remote distance from the type-section. The *Paldal formation has been occasionally used for the Sinla conglomerate since SUZUKI (1943), and seems more desirable than the latter on the same reason as above. The Paldal is derived from the Paldal-gyo (Paldal bridge) at the type-locality near Daegu.

other by different lithology, that is, the Nagdong is composed of rudites, arenites and lutites, while the Sinla contains predominantly lutites and subordinately arenites besides the basal conglomerate of the Paldal Formation. Therefore, it seems to be more reasonable to divide the group into the two subgroups than any other schemes of subdivision. And there is no problem in stratigraphic comparison between Geoncheonri Formation (with *T.* (s. s.) *paucisulcatus*) and Hasandong Formation (with *T.* (s. s.) *kodairai*).

The subgroups are divided into formations generally on the grounds whether the reddish beds are intercalated or not. However, on account of discontinuity of the reddish beds, they can not be considered as appropriate key beds (YANG, 1972). Therefore, it is quite difficult to draw chronology in detail from the lithologic units, formations, especially in correlation of the two areas of a great distance aparts. For instance, no one can say, in the present state of knowledge, whether the lower Lower Yeonhwadong Formation near Goryeong be in fact lower than the middle Lower Yeonhwadong Formation near Waegwan. And so the locality of *Nippononaia ryosekiana* near Waegwan is hardly comparable with that of the present fossil locality. However, the Lower Yeonhwadong Formation and the Middle Hasandong Formation can be compared with each other with some chronologic sense. The present locality falls under the Lower Yeonhwadong Formation. While the occurrences of *T.* (s. s.) *kodairai* are confined to the Middle Hasandong Formation even though the fossils occur very sporadically. Thus, the present locality can be said to be stratigraphically lower than those of *T.* (s. s.) *kodairai*.

The geology around the present fossil locality was mapped by CHOI and KWON (1975), and Text-figure 1 is adapted from their geological map with some modification made by me. The area is located on the western margin of the central part of the Gyeongsang Basin and consists of the pre-Gyeongsang complex, the lower part of the Gyeongsang Group and the acidic dyke as illustrated in Text-figure 1.



Text-figure 2. Columnar section of lower part of the Yeonhwadong Formation, showing the stratigraphic horizon of the fossil locality. Sh: shale, Ms: mudstone or siltstone, Ss: sandstone, Ad: acidic dyke, Cg: conglomerate, Gr: granite, Gn: gneiss.

Systematic Description

Superfamily Unionacea

Family Trigonioididae COX, 1952

Subfamily Trigonioidinae COX, 1952

Genus *Trigonioides* KOBAYASHI & SUZUKI, 1936

Subgenus *Koreanaia* YANG, 1976

Type-species—Koreanaia cheongi YANG, 1976.

Remarks—Koreanaia was originally proposed as an independent genus on account of its large angle of the V-sculptures on the median part and lamellar hinge teeth. Such a combination of characters had been unknown in the trigonioidid genera, i.e., *Trigonioides, H offetrigonia, Nippononaia* and *Wakinoa*. However, a new species described below is certainly referred to *Koreanaia* on account of its similar surface ornamentation and outline, but the hinge teeth are not lamellar but finely crenulated like *Wakinoa*. It can be regarded as a member of *Koreanaia* with dentition of *Wakinoa* or a member of *Wakinoa* with sculpture of *Koreanaia*. Therefore, it is considered as an intermediate species between *Koreanaia* and *Wakinoa*, that is, a link-species in the lineage from *Koreanaia* to *Wakinoa*. If *Wakinoa* is considered as one of the subgenera of *Trigonioides* (OTA, 1975; HAYAMI, 1975), it is reasonable to treat *Koreanaia* also as another subgenus of *Trigonioides*.

Subgeneric diagnosis (emend.)—Hinge plate moderate in breadth, provided with opisthocline pseudocardinal and postero-lateral teeth; the pseudocardinal ones two or three in left valve, two in right valve, and the postero-lateral teeth two in left valve, one in right valve. The hinge teeth typically lamellar but may be crenulated in some species. Other characters same as the original diagnosis (YANG, 1976, p. 320).

Trigonioides (Koreanaia) bongkyuni, sp. nov.

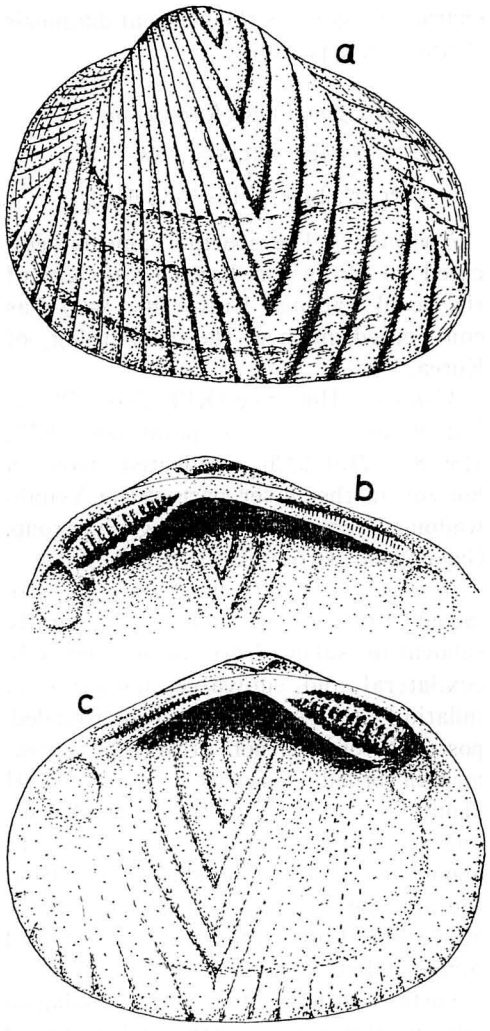
Pl. 27, Figs. 1-12; Text-fig. 3

Etymology—The specific name is dedicated to Professor Bong Kyun KIM of the Seoul National University who has contributed much to the paleontology of Korea.

Material—Holotype (KPE 2190, Pl. 27, Fig. 9) and forty six paratypes (KPE 2180-89, 2191-2226), collected from a horizon in the lower part of the Yeonhwadong Formation, Nagdong Subgroup, Gyeongsang Group (Coll. S.Y. YANG).

Description—Shell medium in size (about 10-60 mm in length) generally suboval or subquadrate in outline subequilateral and equivalve, moderate in inflation; anterior margin well rounded, posterior one rather straight, ventral margin broadly arcuate; ratio of L/H about 1.3; test of moderate thickness; umbo slightly prosogyrous, placed at about two-fifths of the shell length from the anterior extremity, projected slightly above the hinge line; escutcheon and lunule indistinct.

Surface ornamented with V-shaped ribs in the median part and reversed V-ribs on both of the anterior and the posterior sides. The angles of the median V-ribs about 30-45 degrees and those of the reversed V-ribs on both sides about 50-60 degrees. The line linking the apices of the median V-ribs prosocline, forming about 80 degrees with the ventral margin. The ribs and grooves on the posterior half stronger and wider than those on the anterior half; the former ones run downward and gently curved forward, while the latter ones run rather



Text-figure 3. *Trigonioides (Koreanaia) bongkyuni*, sp. nov. a: surface ornametation and the outline of left valve, b: internal structure of right valve, c: internal structure of left valve. The sculpture impressed on the internal surface is probably due to the erosion of the inner layer.

straightly downward. The median ribs number more than 13 in the anterior half and 9 in the posterior half of the large specimens. The whole surface ornamented also with fine numerous concentric growth-lines of irregular interval and prominence. Posterior ridge running from the umbo to the postero-ventral corner.

Hinge plate moderate in breadth, provided with pseudocardinal and postero-lateral teeth; the pseudocardinal ones two on each valve, the postero-lateral ones one on right valve, two on left valve, forming the following dental formula;

$$\frac{5 \quad 3 \quad \text{PIII}}{4 \quad 2 \quad \text{PII} \quad \text{PIV}}$$

where 5: narrow and elongated with fine transverse crenulations on the ventral (lower) side only, parallel to the antero-dorsal margin,

3: stout and high, with fine transverse crenulations on both sides, subparallel to the anterodorsal margin,

PIII: narrow and elongated, with very fine transverse crenulations on both sides, parallel to the postero-dorsal margin,

4: stout and high, with fine transverse crenulations on both sides, parallel to the antero-dorsal margin,

2: narrow and low, with fine transverse crenulations on dorsal (upper) side only, subparallel to the antero-dorsal margin,

PII: narrow and elongated, with very fine transverse crenulations on dorsal side only, parallel to the postero-dorsal margin,

PIV: narrow and elongated, more or less lower and shorter than PII, with very fine transverse crenulations on ventral side only, parallel to the postero-dorsal margin.

Two adductor scars subequal in size; anterior one semicircular, strongly impressed, accompanied with a minute distinct pedal scar; posterior one subcircular and larger, but not so distinct. The internal mould provided with impression of V-shaped ornaments on the flank and with crenulations around the ventral margin. Umbonal cavity moderately deep.

Observation—The holotype (KPE 2190) is an external mould of right valve. The paratypes are also external or inter-

nal moulds. The tests were mostly dissolved out. The internal structures can be observed on some internal moulds. Among the type-specimens, seven are conjoined, twenty four are right valves and fifteen are left valves. The specimens at hand are mostly deformed to some extent. Besides the type-specimens, many fragmentary specimens were collected.

Occurrence—The specimens described here were collected from the black shale at Weolmagdong, Ssangrim-myeon, Goryeong-gun, Gyeongsangbug-do, Korea (see Text-figure 1). The black shale contains abundantly the following molluscan species besides the described one and fragmental remains of plants.

Nippononaia ryosekiana (see YANG, 1978a)
Nagdongia cf. *soni* YANG
Pseudohyria sp. (described below)
Micromelania? katoensis SUZUKI
Viviparus sp.

Measurements (in mm)—

Specimens	Length	Height
Right valve (KPE 2180)	15.3+	13.1+
Left valve (KPE 2182)	56.2+	42.9+
Left valve (KPE 2183)	17.0+	9.6+
Right valve (KPE 2184)	28.7+	22.2
Right valve (KPE 2185)	25.9+	19.0+
Conjoined valves (KPE 2187)	57.6	—
Right valve (KPE 2189)	33.9	24.2+
Right valve (KPE 2190)*	56.6	38.1+
Left valve (KPE 2192)	38.8+	31.3
Right valve (KPE 2202)	43.4	32.3+
Right valve (KPE 2220)	10.8	6.3+

* holotype

Comparison—The present species is similar to *Koreanaia cheongi* YANG, 1976 in the surface ornamentation and outline, but its ribs and grooves are much stronger and wider than those of the latter. The subradial ribs of the present species number about 13 in the anterior half and 9 in the posterior, while those of *K. cheongi* number 17 in the anterior half and 13 in the posterior. Above all, the hinge teeth of the present species are clearly crenulated, while those of *K. cheongi* are not crenulated, rather lamellar. The crenulations of the hinge teeth are quite similar to those of *Wakinoa wakinoensis*, but the surface ornametation distinctly differs from that of the latter. In short, the present species may be comparable with *Wakinoa* in the hinge while it resembles *Koreanaia* in the surface ornamentation, especially in the large angle of the V-sculptures. In other words, the present species belongs neither to typical *Wakinoa* nor to typical *Koreanaia*. But it is rather reasonable to assign the present species to one of the two subgenera than to propose another independent genus or subgenus. In this case it is practically more convenient to classify the fossil species on the basis of the surface ornamentation rather than the internal structures for the future identification.

Hoffetrigonia diversicostatus (HOFFET, 1937) and *H. robusta* (KOBAYASHI, 1968) are similar to the present species in the large angle of V-sculpture on the median surface, but differ in their opisthogyrous umbo, finer subradial ribs on the anterior half and stronger inflation.

If the phylogenetic series of *Koreanaia-Wakinoa-Trigonioides* (s. s.)-*Kumamotoa* is assumed (OTA, 1963; HAYAMI and ICHIKAWA, 1965; and YANG, 1976), the present species can be inserted between *K. cheongi* and *W. wakinoensis*.

Subfamily Pseudohyriinae
KOBAYASHI, 1968

Genus *Pseudohyria* MACNEIL, 1936

Type-species — Pseudohyria gobiensis MACNEIL, 1936

Pseudohyria matsumotoi, sp. nov.

Pl. 28, Figs. 1-8, Text-fig. 4

Etymology—The specific name is dedicated to Professor Tatsuro MATSUMOTO of the Kyushu University who has greatly contributed to the Cretaceous stratigraphy.

Material—Holotype (KPE 2163, Pl. 28, Fig. 1) and twenty eight paratypes (KPE 2151-62, 2164-79), collected from the lower horizon of the Yeonhwadong Formation, Nagdong Subgroup, Gyeongsang Group, Korea (Coll. S.Y. YANG).

Description—Shell fairly large in size (about 60-85 mm in length), trigonally suboval or suborbicular in outline, fairly inflated; subequilateral and equivalve; anterior margin well rounded, postero-dorsal one rather straight, postero-ventral corner rather angulate, ventral margin broadly arcuate; ratio of L/H about 1.2; umbo fairly high and prominent, slightly prosogyrous, situated nearly centrally, escutcheon and lunule indistinct; test moderately thick.

Surface ornamented with radial costae and concentric growth-lines; the costae indistinct near the umbo and on the anterior half, but becoming gradually prominent toward postero-ventral side. The costae on the postero-dorsal periphery being widely separated tangentially from the posterior ridge. The radial costae number 13 or more. Posterior ridge fairly prominent.

Hinge plate moderate in breadth, provided with opisthocline pseudocardinal teeth and postero-lateral teeth; the pseudocardinal ones three or four on right valve, three on left valve, the postero-lateral teeth one on right valve, two on left valve, forming the following dental formula:

(5)	3	1a	1b	PIII
4	2	1'a	PII	PIV

where 5: narrow and elongated, parallel to the antero-dorsal margin, occasionally indistinct,

3: stout and high, subparallel to the antero-dorsal margin,

1a: low and short, immediately below the umbo, nearly vertical,

1b: low and short, smallest in the right valve, immediately below the umbo, nearly vertical,

PIII: distinct and elongated, parallel to the postero-dorsal margin,

4: stout and prominent, parallel to the antero-dorsal margin,

2: stout and high, subparallel to the antero-dorsal margin,

1'a: low and short, nearly vertical,

PII and PIV: narrow and elongated, parallel to the postero-dorsal margin.

These hinge teeth neither crenulated nor striated, but rather lamellar.

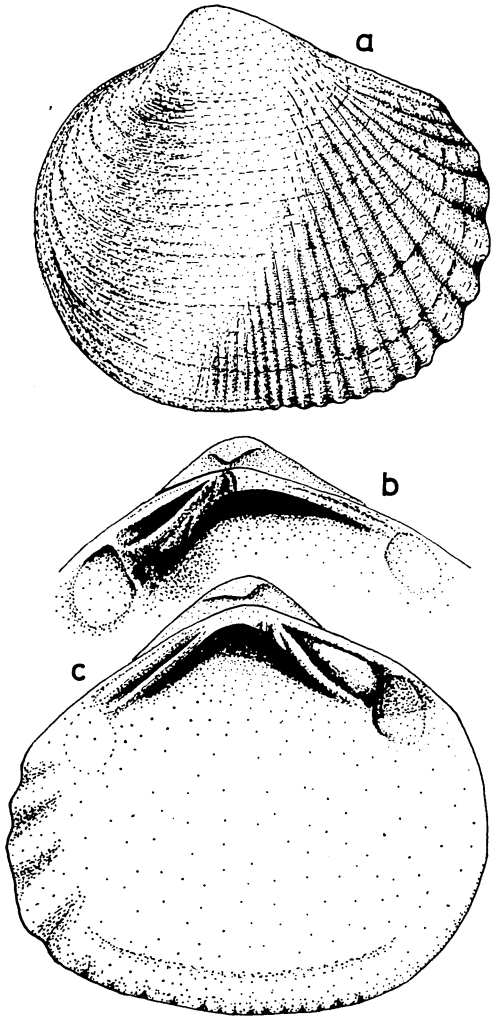
Two adductor scars subequal in size; anterior one semicircular, strongly impressed, accompanied with a minute but distinct pedal scar, posterior one subcircular and larger, but not so distinct. The internal mould provided with impression of the surface radial costae on the flank, especially distinct on the posterial part. Ventral crenulation on the inner side not so distinct. Umbonal cavity moderately deep.

Measurements (in mm)—

Specimens	Length	Height
Left valve (KPE 2151)	67.7+	58.3+
Right valve (KPE 2152)	30.1+	26.4+
Right valve (KPE 2153)	75.5+	60.6+
Right valve (KPE 2154)	85.5+	—
Left valve (KPE 2160)	80.2+	62.2+
Left valve (KPE 2163)*	69.3+	52.7+
Left valve (KPE 2166)	12.0+	10.9+
Right valve (KPE 2174)	65.1+	55.7+

* holotype

Observation—The holotype (KPE 2163) is an internal mould of left valve. Many of the other specimens are also



Text-figure 4. *Pseudohyria matsumotoi*, sp. nov. a: surface ornamentation and outline of left valve, b: internal structure of right valve, c: internal structure of left valve.

internal or external moulds and fragments. Thererefore, the description is supplemented by the paratypes.

The immature small specimens are generally suborbicular in outline, but gradually become trigonally suboval with growth. The posterior costae or plications are not distinct in the small specimens but become distinct with growth.

Occurrence—Same as described above (*Koreanaia bongkyuni*).

Comparison—At a glance, the present species looks similar to some species of *Plicatotrigonioides* from U.S.S.R.(MARTINSON, 1965, pl. 3, fig. 6) and from Thailand (KOBAYASHI, 1968, pl. 20, fig. 1) in the trigonally suboval outline and surface ornamentation. But those species are generally ornamented with rather strong costae nearly on the whole surface, and the costae on the postero-dorsal part start directly from the last posterior radial costa which runs from the umbo to the postero-ventral corner. The ventral crenulation on the inner margin is rather regular and subquadrate in that genus (MARTINSON, 1965, pl. 6, fig. 2) unlike other trigonioidid species.

The present species is very similar to *Pseudohyria cardiiformis ferganensis* MARTINSON in the surface ornamentation and internal structures. But in the latter the radial costae climb up to near the umbo, and are well developed even on the anterior half. So far as the illustration is relied upon (MARTINSON, 1965, pl. 2, fig. 2), *P. c. ferganensis* possesses two or three pseudocardinal teeth on the right valve, while the present species possesses three or four ones on the right valve. With respect to the surface ornamentation, the present species is rather similar to *P.* cf. *cardiiformis* (MARTINSON, 1965, pl, 2, fig. 4) from U.S.S.R., but the latter is more elongated laterally, and not so high.

Remarks—Many species referred to the genus *Pseudohyria* have been reported from Southeastern U.S.S.R. and China. They are generally of upper Cretaceous as illustrated in Table 2, while the present species is probably of lower Cretaceous (see YANG, 1978b).

Table 2. Stratigraphic occurrences of *Pseudohyria* spp.
(original data after MARTINSON, 1965, 1969; KU, 1976)

	Pseudohyria SPECIES	NEOC.	APT.	ALB.	CEN.	TUR.	SAN.-DAN.
U.S.S.R.	*P. javanica*			———			
	P. babatagensis			———			
	P. mujanica			———			
	P. plicatensis			———			
	P. kysylkumaensis				———		
	P. k. aralica			———			
	P. ferganensis				———		
	P. mongolensis radiatus				———		
	P. tachtamyshensis				———		
	P. gobiensis itemirica				———		
	P. triangularis						———
CHINA	*P. tuberculata*	K 1			———	K 2	
	P. obliqua				———		
	P. cardiiformis				———		
	P. gobiensis				———		
	P. sinkiangensis				———		
	P. aralica				———		
	P. songhuaensis				———		
K.	*P. matsumotoi, sp. nov.*	———					

Explanation of Plate 27

Figures 1-12. *Trigonioides* (*Koreanaia*) *bongkyuni*, sp. nov.

1. Left valve (KPE 2197), internal mould, 1a; side view, showing the impression of the surface ornaments, 1b; dorsal view, showing the crenulated hing teeth.

2. Left valve (KPE 2182), internal mould, side view, showing the crenulation on the antero-ventral margin, the impression of V-shaped ornaments on the posterior flank, the muscle scars and the crenulated hinge teeth partly, the postero-ventral part broken out.

3. Right valve (KPE 2220), internal mould, showing the impression of V-shaped ornaments and the hinge teeth, immature specimen. ×2.

4. Left valve (KPE 2186), internal mould, showing the crenulated pseudocardinal hinge teeth and the muscle scars.

5. Left valve (KPE 2191), external mould of the postero-dorsal part.

6. Left valve (KPE 2192), external mould, showing the crenulated pseudocardinal hinge teeth.

7. Right valve, clayey cast of the external mould (KPE 2184).

8. Right valve (KPE 2194B), antero-dorsal part broken out, 8a; external mould, 8b; clayey cast.

9. Right valve, clayey cast of the external mould (KPE 2190), holotype.

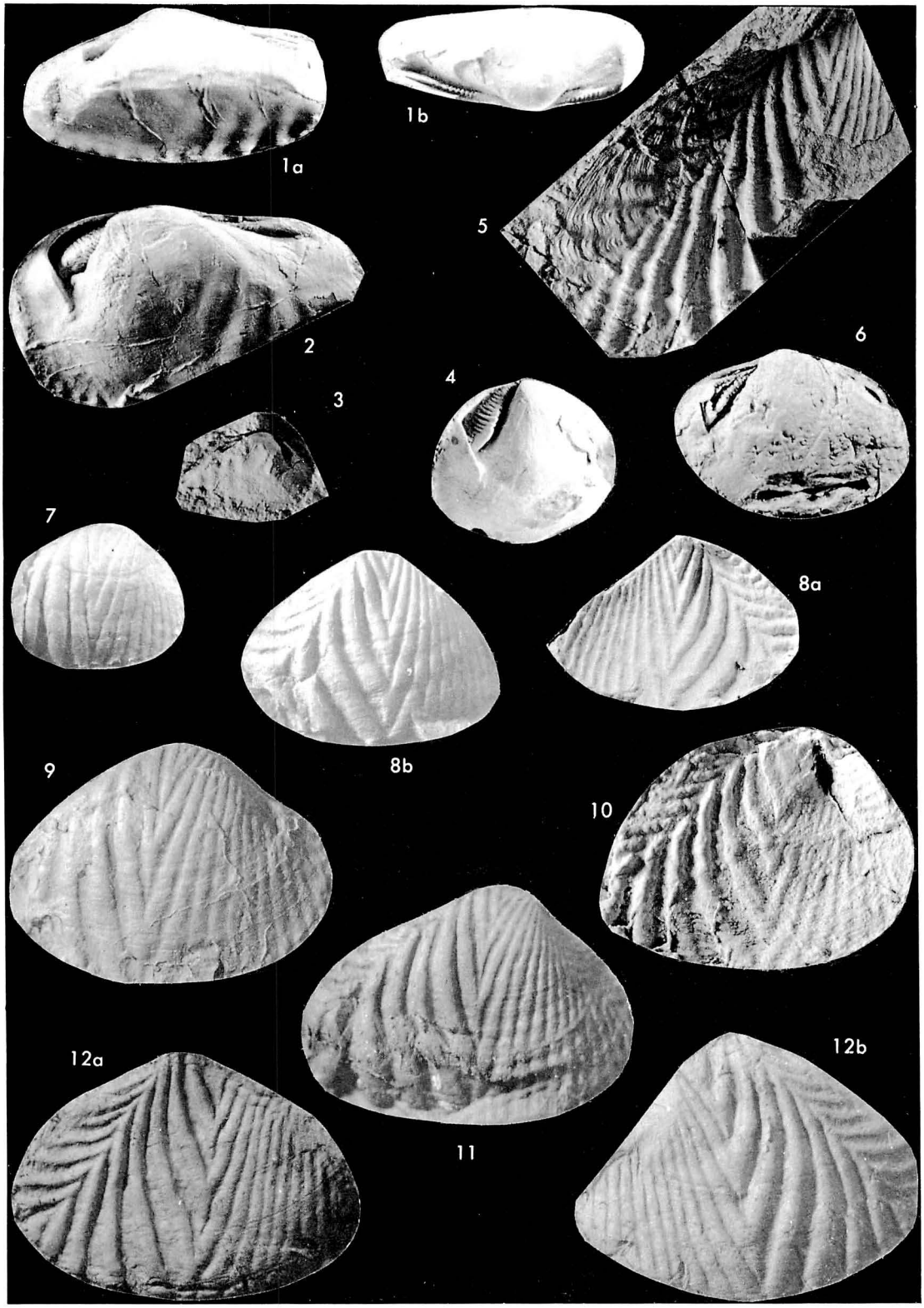
10. Left valve (KPE 2196), external mould, strongly compressed laterally.

11. Right valve, clayey cast of external mould (KPE 2188).

12. Conjoined valve (KPE 2187), external mould, antero-dorsal part broken out, 12a; clayey cast of right valve, 12b; clayey cast of left valve.

All figures are approximately of natural size, unless otherwise stated.

Loc.: Weolmagdong, Ssangrim-myeon, Goryeong-gun, Gyeongsangbug-do, Korea (see Text-figure 1).


1a
1b
2
3
4
5
6
7
8a
8b
9
10
11
12a
12b

The hinge teeth of the upper Cretaceous species of *Pseudohyria*, that is, *P. aralica*, *P. tuberculata*, *P. cardiiformis* and *P.* aff. *gobiensis*, are more or less distinctly crenulated and are similar to those of *Wakinoa* and *Plicatounio*, but somewhat different from the regularly crenulated teeth of the species of *Trigonionioides* (*T.*) and *Kumamotoa*. Up to now, *Pseudohyria* is first found from the Lower Cretaceous formation in Far East Asia, and the hinge teeth of *P. matsumotoi* are not crenulated but lamellar as described above. As the phylogenetic relation can be read in the hinge teeth in the series *Koreanaia-Wakinoa-Trigonioides* (s. s.)-*Kumamotoa*, a similar transformation of hinge teeth may be expected in the phylogeny of the Pseudohyriinae.

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Ancheon 安川, Anlimdong 安林洞, Banyaweol 半夜月, Bulgugsa 仏国寺, Chaeyagsan 採薬山, Chilgog 漆谷, Daegu 大邱, Dongmyeong 東明, Geoncheonri 乾川里, Goryeong 高霊, Gujeong 九汀, Gyeongsang 慶尚, Habcheon 陜川, Hagbong 鶴峰, Haman 咸安, Hasandong 霞山洞, Jinju 晋州, Jusasan 朱砂山, Myogog 卯谷, Nagdong 洛東, Paldal 八達, Sinla 新羅, Ssangrim-n.yeon 双林面. Waegwan 倭館, Weolmagdong 月幕洞, Yeonhwadong 蓮花洞.

韓国下部慶尚層群産二枚貝新種化石について：慶尚層群最下部層である蓮花洞層から産出した軟体動物化石中二枚貝2新種を記載する。その中，*Trigonioides* (*Koreanaia*) *bongkyuni*, n. sp. はその表面装飾は *Koreanaia* 型を鉸歯の構造は *Wakinoa* 型を示している。これらの形質と層序学的関係から判断して，この新種は典型的な *Koreanaia* から *Wakinoa* または *Trigonioides* (s.s.) に進化する系列の中間型と解釈される。*Pseudohyria matsumotoi*, n. sp. はその層序学的関係を考えて，今までアジア大陸から報告された *Pseudohyria* spp. の祖先になる可能性がある。

梁 承 栄

Explanation of Plate 28

Figures 1-8. *Pseudohyria matsumotoi* sp. nov.

1. Left valve (KPE 2163), internal mould, holotype. 1a; side view, showing the pseudocardinal teeth, the muscle scars, and the impression of radial plicae on the posterior part. 1b; dorsal view, showing the hinge teeth, 1c; rubber cast, showing the internal structures.

2. Right valve (KPE 2169), internal mould, posterior part broken out, 2a; dorsal view, showing the pseudocardinal hinge teeth, 2b; rubber cast, showing the pseudocardinal teeth and the muscle scars.

3. Left valve (KPE 2166), internal mould, showing the hinge teeth and the muscle scar, immature specimen. ×1.6.

4. Left valve (KPE 2152), internal mould, showing the pseudocardinal tooth.

5. Left valve (KPE 2173), internal mould, dorsal view, showing the hinge teeth.

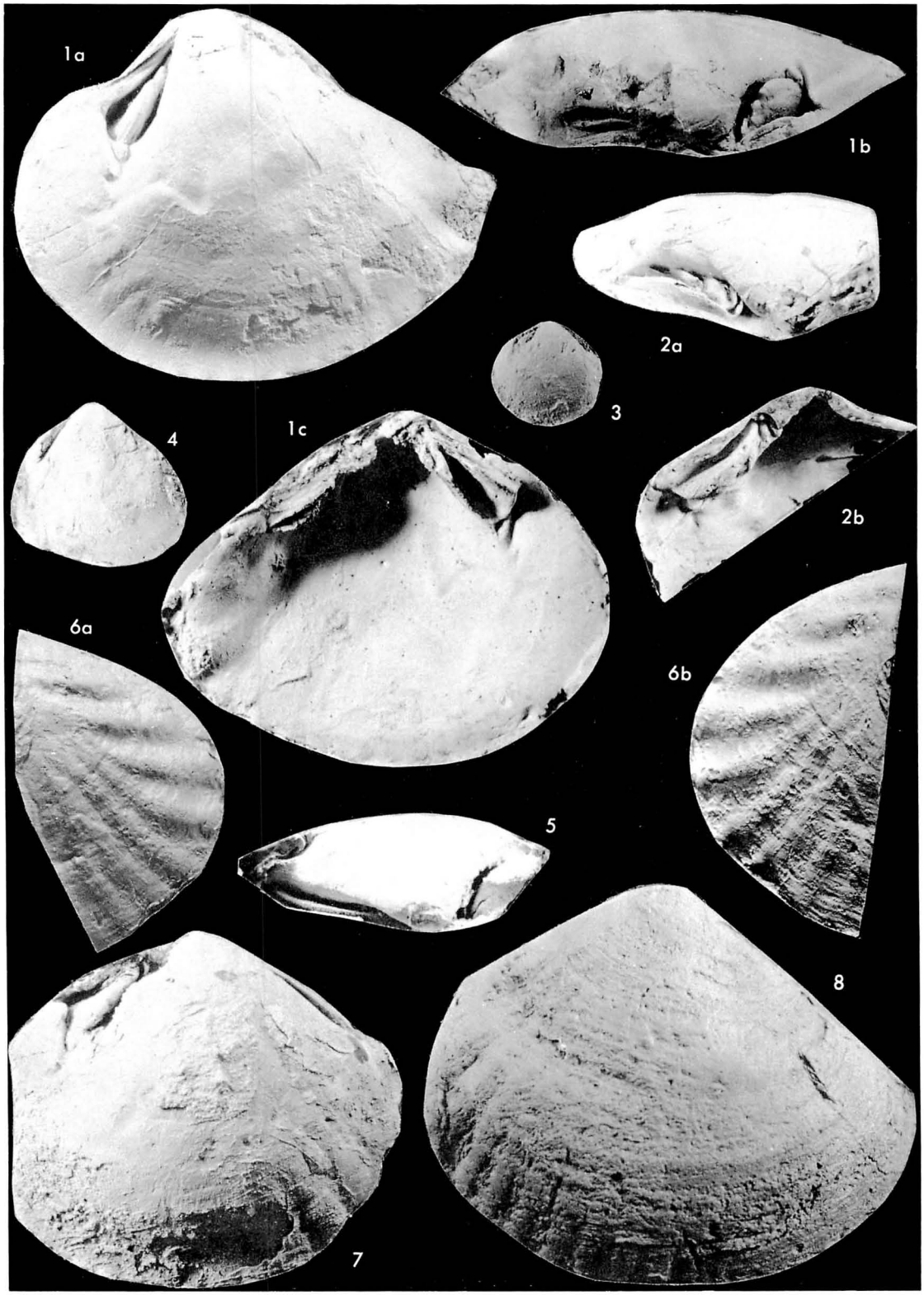
6. Left valve (KPE 2157), posterior part only, 6a; external mould, showing the radial plicae on the posterior part, 6b; clayey cast.

7. Left valve (KPE 2151), internal mould, showing the hinge teeth, the muscle scar and the impression of posterior plicae.

8. Right valve, clayey cast of KPE 2153, showing the radial plicae antero-dorsal and postero-ventral parts broken out.

All figures are approximetely of natural size, unless otherwise stated.

Loc.: Weolmagdong, Ssangrim-myeon, Goryeong-gun, Gyeongsangbug-do, Korea (see Text-figure 1).


1a
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1c
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6a
6b
5
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7

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

学会記事

日本古生物学会第124回例会は1979年10月20日に名古屋大学理学部において開催された（参会者74名）。

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1980年総会・年会	筑波大学	1980年1月25・26日	1979年11月25日
第125回 例会	高知大学	1980年6月29日	1980年4月29日

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

6月29日（日）の第125回例会ではシンポジウム「四万十帯の生層序学の現状と今後の問題点」が，6月30日（月）には高知県佐川地方への巡検が予定されている。

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