Stratigraphic Occurrences of the Cretaceous Trigoniids in the Japanese Islands and their Faunal Significances

By

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with 19 Tables and 8 Plates

ABSTRACT: In this paper, the writer discussed briefly on the Trigoniid faunas of the Mesozoic era, especially Cretaceous period, in the Japanese Islands.

In Japan, Trigoniids appeared already in the Carnian of Southwest Japan and prospered in the Jurasssic to the Cretaceous. They are, however, completely lacking in the Cenozoic. Now, they are classified into 79 species and 10 subspecies in 21 genera in addition to 7 subgenera in 8 subfamilies.

The salient facts obtained through this study are as follows:

1. Although Trigoniids were rare in the Upper Triassic, some forms of *Minetrigonia* and *Frenguelliella* have hitherto been reported from several places in Southwest Japan. Triassic fauna may be related to one of the Arcto-Pacific region by the presence of *Minetrigonia*.

2. The Japanese Jurassic is characterized by abundant Vaugoniinae and Myophorellinae. The former flourished in the Lower to the Middle Jurassic and the latter in the Upper Jurassic. Jurassic fauna is probably connected to that of European rather than North American and Indian provinces because of the presence of common genera and subgenera as shown on Pl. 26, but *Haidaia* CRICKMAY, a subgenus of *Myophorella*, is characteristic in the Upper Jurassic of the Pacific regions.

3. Strongly carinate Trigoniids, i.e. *Vaugonia* s.l. and *Myophorella* s.l. etc., already disappeared in the Cretaceous when the Pterotrigoniinae and the Quadratotrigoniinae etc. took their place.

4. Cretaceous Trigoniids most flourished in the Gyliakian when many genera, subgenera, and species occurred in various localities. In the Gyliakian, *Heterotrigonia*, *Apiotrigonia*, and *Yeharella* of *Steinmannella* inhabited in the Yezo geosynclinal region including Hokkaido and Sachalin, but they have hitherto been undiscovered from Southwest Japan.

5. In Japan proper, especially Southwest Japan, the Trigoniid assemblages of the Cretaceous were different distinctly in 3 series, i.e. Lower, "Middle", and Upper Cretaceous. The Neocomian is characterized by several forms of *Nipponitrigonia*, *Rutitrigonia*, and *Pterotrigonia* s.s., while *Apiotrigonia* and *Yeharella* of *Steinmannella* flourished and restricted to occur in the Senonian s.l. Numerous Trigoniids are known in the "Middle Cretaceous" when 3 genera and 1 subgenus of the Pterotrigoniinae were existent. *Scabrotrigonia* and *Acanthotrigonia* are the most characteristics in this time.

6. In the Yezo geosynclinal region, Trigoniids are abundant in the Gyliakian formation of Ikushumbetsu in Central Hokkaido where *Pterotrigonia* s.s., *Scabrotrigonia*, *Acanthotrigonia*, *Steinmannella* (*Yeharella*), *Apiotrigonia*, and *Heterotrigonia* are co-occurrenced. In the Senonian s.l. the former three vanished but latter three survived.

7. The Lower and the "Middle" Cretaceous Trigoniids of Southwest Japan were allied probably to those of the Indo-African region rather than the North American because of the presence of *Pterotrigonia* s.l., *Acanthotrigonia*, and *Rutitrigonia*. While, the Upper Cretaceous ones were similar to those of the West Coast in North America.

8. KOBAYASHI's Trigoniinae are quite variable in surface costation on the flank and the area the latter of which is provided with radial or concentric costae near the umbo. With reference to the costation on the area Trigoniinae em. and Frenguelliellinae nov. can be distinguished from KOBAYASHI's proposal. The latter typified by *Frenguelliella* LEANZA, ranges from the Carnian to the Senonian, but the former ranges the Anisian to the Senonian (?). The former flourished and inhabited in the Upper Jurassic to the Senonian of the Indo-African region, but the latter prospered and was prolific in the Middle Jurassic to the "Middle Cretaceous" of Eurasia.

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I. INTRODUCTION

The Cretaceous formations distributied widely in Japan and the adjacent areas contain fairly abundant fossils and, therefore, have been studied stratigraphically and palaeontologically in considerable detail by a lot of authors.

With regard to the Cretaceous stratigraphy of Japan and the adjacent areas Trigoniidae are one of the most important fossils as well as Ammonoidea and Inoceramid, because of their abundant occurrences and peculiar forms. In view of these facts, since 1891, YOKOYAMA had described 3 species of Trigoniid from the Cretaceous rocks in Shikoku, a number of new species and varieties were added and reported by JIMBO (1894), YEHARA (1915, 21, 23a-b, 27), YABE and NAGAO (1925, 28), NAGAO (1930) and others. Among them, the useful and excellent works for Trigoniids were established by YEHARA who had first divided the Cretaceous formations in Japan into 4 series by their faunal characters (1923b). At present, the knowledges for the horizontal and vertical distributions of the Cretaceous Trigoniids are fairly well known by the publication of "The Cretaceous System in the Japanese Islands" (MATSUMOTO et al. 1954).

The above-mentioned authors treated *Trigonia* in broad sense and divided it into some groups. While, KOBAYASHI (1954) discussed the evolution and phylogeny of the Jurassic Trigoniids in Japan, based on the modern classification which was recently proposed by COX (1952b). At the same time, KOBAYASHI also disputed briefly on the Cretaceous ones. Subsequently, KOBAYASHI and AMANO (1955) argued *Steinmannella* CRICKMAY, 1930, and considered that some 7 forms of Japan and the adjacent areas are to be comprised in this genus. Succeedingly, KOBAYASHI (1957a) discussed minutely *Nipponitrigonia* and *Rutitrigonia*.

Since 1947, on the other hand, the writer engaged in study on the Cretaceous Trigoniids under the guidances of Professor Sotoji IMAMURA of the Hiroshima University and Professor Teiichi KOBAYASHI of the University of Tokyo, and collected a number of specimens from various localities. In 1957, the writer divided the Pennatae Trigoniids in Japan into 3 genera. Jointly with KOBAYASHI, the writer (1957) revised the Pterotrigoniinae van HOEPEN, 1929 into 3 genera and 1 subgenus. Still more, the writer described 3 species of *Scabrotrigonia* and a note on the migration of Japanese *Steinmannella* (*Yeharella*). At the same time, the writer has carried out the bio-stratigraphical studies on the Cretaceous Trigoniids in the important places, such as, Goshonoura-jima in Western Kyushu, Katsuuragawa, Ryoseki-Monobegawa and Sakawa basins in Shikoku, Miyako district in Northeast Japan, and Ikushumbetsu district of Central Hokkaido etc. Therefore, the stratigraphical and palaeontological data for the Cretaceous Trigoniids were rapidly increased at least a few years.

In this paper, the writer summarized the faunal characters of the Mesozoic Trigoniids in the Japanese Islands, especially Cretaceous ones, based on the present knowledges.

In Japan, Trigoniids appeared already in the Carnian of the Upper Triassic and they were developed in the Jurassic to the Cretaceous. They were, however, lacking

in the Cenozoic. *Minetrigonia* and *Frenguelliella* have been collected and reported from the Upper Triassic of Southwest Japan. Jurassic was characterized by the presence of the strongly carinate forms of the Vaugoniinae and Myophorellinae. The former was abundant in the Lower to Middle Jurassic, but the latter flourished in the Upper Jurassic when *Haidaia* CRICKMAY, a subgenus of *Myophorella*, was characteristic in the Pacific regions. In the Cretaceous, strongly carinate Trigoniids, i.e. *Vaugonia* s.l., *Myophorella* s.l. etc., vanished already and the Pterotrigoniinae, Quadratotrigoniinae, etc. took the positions of the prosperities from the Jurassic ones. Neocomian, i.e. Kochian to Aritan, was characterized by the occurrence of several forms of *Nipponitrigonia*, *Rutitrigonia*, and *Pterotrigonia* s.s., but *Apiotrigonia* and *Steinmannella* s.l. flourished and were prolific in the Senonian s.l., i.e. Urakawan to Hetonaian. Roughly speaking, Miyakoan to Gyliakian, i.e. Aptian to Turonian, was marked by the abundant occurrence and the co-existence of the Neocomian and the Senonian Trigoniids. In this epoch *Scabrotrigonia* and *Acanthotrigonia* were the most characteristics. Trigoniids most flourished and reached the acme in the Gyliakian (Cenomanian-Turonian) when the Yezo geosynclinal region was characterized by the occurrence of the early representatives of *Heterotrigonia*, *Apiotrigonia*, and *Steinmannella* (*Yeharella*). They are, however, absent in Southwest Japan at the same time.

On the fossil contents of the Japanese Mesozoic Trigoniids, Triassic fauna was connected to one of the Arcto-Pacific region by the abundance of *Minetrigonia*, while the Jurassic one was probably related to that of the European region rather than those of the North American and Indian provinces, because of the presence of the common genera and subgenera in the both regions as shown on Pl. 26. But, in the Upper Jurassic *Haidaia* is a characteristic in the Pacific regions. Neocomian to Turonian ones of Southwest Japan were allied possibly to those of the Indo-African region, but the Senonian one, especially Gyliakian Trigoniids in the Yezo geosynclinal region, was connected to that of West Coast in North America.

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III. Stratigraphical Notes of the Trigoniid-bearing Cretaceous Formations in the Japanese Islands

The Trigoniid specimens discussed in this paper collected from the Cretaceous deposits of Japan and the adjacent areas, distributed from Sachalin to the islands of Western Kyushu. In this chapter the stratigraphy of the rocks from which the examined specimens have briefly described hereunder. Trigoniid-bearing strata are marked with sign "×".

Regarding the general outline of the Cretaceous stratigraphy of Japan and the adjacent areas, the reader is requested to refer to the following papers:

YABE, H. (1927): Cretaceous Stratigraphy of the Japanese Islands. *Sci. Rep. Tohoku Imp. Univ., 2nd Ser., Vol. 11, No. 1.*

MATSUMOTO, T. et al. (1954): The Cretaceous System in the Japanese Islands. *Japan. Soc. Prom. Sci. Research, Tokyo.*

Yezo geosynclinal Region

1) Near Alexandrovsk, North Sachalin

This area was investigated by YABE and SHIMIZU (1924). They clearified the following stratigraphic succession of the Cretaceous deposits (Thickness not reported).

- Cape de la Jonquierère group
  - Upper formation···Sandstone and shale in thin alternation, with plant remains and coal seams.
  - Middle formation
    - Upper member···Dark shale with nodules, containing marine fossils.
    - Middle member···Greenish sandstone containing Hetonaian *Inoceramus schmidti*, *Pattella gigantea* etc.
    - Lower member···Grey shale with nodules, containing *In. schmidti*, *P. gigantea* etc.
  - Lower formation···Sandstone and shale in thin layered alternation with plant remains.
- Werblude group
  - Upper formation···Sandstone with thick conglomerate and thin sandy shale layers at some places, containing Gyliakian fossils, such as, *Apiotrigonia minor* and *Pterotrigonia hokkaidoana* etc. (Cape Khoi beds ×).
  - Lower formation···Sandstone and shale in alternation with plant fossils.

2) Keton-Hoè region, South Sachalin

This region located at the northern part of South Sachalin, was investigated by OISHI and MATUMOTO (1937). The stratigraphy of the district is summarized as follows:

Palaeogene Tertiary

~~~~~~ unconformity ~~~~~~

- Hoè formation
  - Upper member···Mudstone with thin sandstone layers, containing a number of marine fossils. (100 m.+)
  - Middle member···Sandstone with coaly shale and coal, containing Hetonaian marine fossils. (150 m.±)
  - Lower member···Mudston with sandstone layers at some places, containing *Gaudryceras denseplicatum*, *Inoceramus naumanni* etc. (200–300 m.)
- Aton formation···Sandstone with sandy shale, containing *In. uwajimensis*, *Apiotrigonia minor* etc. (×). (300 m.±)
- Keton formation···Shale with occasional intercalation of thin sandstone layers, containing *In.* cf. *hobetsensis*, *In.* aff. *yabei*, *Steinmannella* (*Yeharella*) *lymani* etc. (×). (1,700 m.±)
- Keton formation···Tuff and tuffaceous sandstone with conglomerate and sandy shale. (400 m.±)

3) Abeshinai district, Teshio Prov., Northern Hokkaido

The stratigraphy of the area is recently established by TAKAHASHI (1958).

Neogene Tertiary

~~~~~~ unconformity ~~~~~~

- Yasukawa group (=Hakobuchi group)
  - Y_5···Variegated sandstone (60 m.±).
  - Y_5···Fine-grained sandstone and siltstone (20 m.±).
  - Y_4···Bluish, silty, fine-grained sandstone, containing Maestrichtian *Metaplacenticeras substriatum* (45 m.±).
  - Y_3···Variegated sandstone with thin conglomerate layers at some places (40 m.±).
  - Y_2···Bluish grey, silty, medium-grained sandstone (40 m.±).
  - Y_1···Variegated conglomeratic sandstone (70 m.±).

~~~~~~ unconformity ~~~~~~

- Upper Yezo group
  - Osoushinai formation (Usoushinai formation)
    - O_5···Bluish grey, sily, fine- to medium-grained sandstone, containing *Neopuzosia* sp., *Epigoniceras* sp., *Inoceramus* cf. *orientalis* etc. (215–500 m.).
    - O_4···Sandy siltstone containing lower Hetonaian *Canadoceras kossmati*, *In. schmidti* etc. (250 m.±).
    - O_3···Sandstone and tuff in alternation with thin shale layers (70 m.±)
    - O_2···Siltstone with huge nodules containing *Damesites damesi*, *In. ezoensis* etc. (350 m.).
    - O_1···Dark grey, siltstone with thin tuff layers (400 m.).
  - Omagari formation···Sandstone and shale in alternation (100 m.±).
  - Nishichirashinai formation···Shale with tuff (120m.±).
~~~~~~

According to TAKAHASHI, KUBOTA's *Trigonia deckeina*, i.e. *Steinmannella* (*Yeharella*) *deckeina*, occurred probably in Y_4 or Y_5 member of the district.

4) Horombetsu district, Kitami Prov., Northern Hokkaido

Trigoniid-bearing Cretaceous strata under the name of Horombetsu formation were recently reported by IMANISHI (1956) from this district. The Horombetsu formation exposured at a small and isolated area surrounded by the Tertiary rocks. The formation consists mainly of sandstone and conglomerate with subordinate sandy mudstone. From conglomeratic sandstone of the formation, *Scabrotrigonia imanishii* NAKANO, *Neithea* cf. *morrisi* (PICTET and RENEVIER), *Cucullaea acuticarinata* NAGAO, *Natica* cf. *importuna* NAGAO etc. were found. Judging from the fossil contents, the Horombetsu formation is considered probably by the writer (1958b) to the Miyakoan (Aptian-Albian) in age.

5) Ikushumbetsu district, Ishikari Prov., Central Hokkaido

In this district, a great number of Trigoniid specimens occur in the socalled "*Trigonia* Sandstone" (=Mikasa formation), and are associated with shallow sea type Pelecypods and the pelagic Ammonoids the latter of which are the most important for chronologic classification.

The stratigraphy of this district is summarized as follows:

Hakobuchi Sandstone···Coarse-grained sandstone and conglomerate.

Upper Ammonites Beds	Upper member (160 m.+)	···Mudstone with thin tuff and sandstone layers at several horizons, containing marine fossils.
	Middle member (80 m.±)	···Sandy mudstone with thin sandstone layers, containing marine fossils.
	Lower member (130m. ±)	···Sandy mudstone with thin sandstone layers, containing marine fossils.
"*Trigonia* Sandstone" (=Mikasa formation)	Upper member (185 m.)	···Medium- to coarse-grained sandstone with conglomerate and sandy shale, containing marine fossils (×).
	Middle member (70 m.)	···Sandy mudstone with a thin sandstone layer at the middle, containing marine fossils.
	Lower member (190m.)	···Dark grey, fine- to medium-grained sandstone with sandy shale, containing marine fossils (×).
Lower Ammonites Beds	Upper member (40 m.)	···Sandy shale with sandstone layers at several horizons, containing marine fossils.
	Midde member (85 m.)	···Fine- to medium-grained sandstone with sandy shale, containing marine fossils.
	Lower member (300 m.+)	···Mudstone with thin sandstone layers, containing marine fossils.

In summers of 1957 and 58, the writer engaged in study on the Cretaceous rocks in this area and collected numerous Trigoniid specimens from various horizons. As a result, some additional notes are described briefly as follows:

Generally speaking, as suggested by several authors, the Cretaceous strata form an anticlinal structure ("Ikushumbetsu anticline") and the clastic materials of the "*Trigonia* Sandstone" of the western wing are much coarser than those of the eastern

TABLE 1. Stratigraphic Succession of the Cretaceous Formations in the Vicinity of the Katsurazawa dam-site area, Ikushumbetsu, Mikasa-city, Central Hokkaido (Eastern Wing).

Stratigraphic division					Thickness in M.	Lithologic character	Fossil Trigoniids	Associated important Fossils	Stage	
Upper Yezo Group	Upper Ammonites Beds	Lower			130	Sh. & ss. in alternation		*Inoceramus teshioensis*	Upper Gyliakian	(Upper)
Middle Yezo Group	"*Trigonia* Sandstone"	Upper	U_7		30	Silty, m. ss.	*Heterotrigonia subovalis* *Apiotrigonia minor*	*In. hobetsensis*		(Middle) Turonian
			U_6		20	M.~f. ss. with sdy sh. at the upper part	*H. subovalis*, *Ap. minor* *Scabrotrigonia kobayashii*	*In. hobetsensis*		
			U_5		20	Cg. & cross-laminated c. ss. in alternation	*H. subovalis*, *Ap. minor*, *Steinmannella* (*Yeharella*) *ainuana*, *Pterotrigonia hokkaidoana*, *Sc. kobayashii*	*In. hobetsensis*		
			U_4		45	Ss. & sdy sh. in alternation with cg. layer at the base	*Ap. minor* *St.* (*Y.*) *ainuana* *Sc. kobayashii*	*In. hobetsensis*		
			U_3		10	Greenish grey, m. ss. with sdy sh.	*Ap. minor*, *St.* (*Y.*) *ainuana*, *P. hokkaidoana*	*In.* cf. *labiatus*		(Lower)
			U_2		15	Sdy sh. with f. ss.				
			U_1		45	Greenish grey, m.~f. ss. with sdy sh.				
		Middle	M_2		40	Sdy sh. with thin ss. layer at the base			Lower Gyliakian	(Upper) Cenomanian
			M_1		30	Sdy sh.				
		Lower	L_{10}		55	Greenish grey, silty, f. ss.	*Acanthotrigonia longiloba*	*In. concentricus* var. *nipponicus*, *Desmoceras* (*Pseudouhligella*) *japonicus*		
			L_9		5	Sdy sh.				
			L_8		40	Greenish grey, silty, m.~f. ss.	*H. subovalis*	*In. c.* var. *nipponicus*, *In. yabei*, *Calycoceras asiaticum*, *Calyc. orientale*		(Middle)
			L_7		20	Greenish grey, silty, m.~f. ss.	*H. subovalis*, *St.* (*Y.*) *ainuana*, *Pterotrigonia brevicula*, *Ac. longiloba*	*In. c.* var. *nipponicus*, *In. yabei*, *Calyc. asiaticum*, *Calyc. orientale*		
			L_6		10	Sdy sh.				
			L_5		5	Greenish grey, silty, m.~f. ss.				
			L_4		15	Dark greyish blue, silty, f. ss.	*Ap. minor*, *P. brevicula*, *P. hokkaidoana*, *Sc. kobayashii*, *Ac. longiloba*, *Ac. pustulosa*	*Mantelliceras* sp., *Hyppoturrilites komotai*		
			L_3		5	Sdy sh.				
			L_2		25	Dark grey, f. ss.	*P. hokkaidoana* ?	*Desmoceras kossmati*, *D.* (*P.*) *japonicum*	Infragyliakian	(Lower)
			L_1		10	Dark grey, silty, f. ss. with tuff				
	Lower Ammonites Beds	Upper			40	Sh. with thin ss. layers			Upper Miyakoan	Albian
		Middle			85	Ss. with sh.				
		Lower			300+	Sh.				

TABLE 2. Stratigraphic Succession of the Cretaceous Formations along the Pombetsu River in Ikushumbetsu, Mikasa-city, Central Hokkaido (Western Wing).

Stratigraphic division				Thickness in M.	Lithologic character	Fossil Trigoniids	Associated important Fossils
Upper Yezo Group	Upper Ammonites Beds			130+	Sdy sh. with thin ss.		
Middle Yezo Group	"*Trigonia* Sandstone"	Upper	U_5	20	Conglomeratic ss.	*St. (Y.) ainuana*	
			U_4	50	Conglomeratic ss. with thin cg. layers.		
			U_3	30	Cg. & ss.	*St. (Y.) ainuana*	*Gaudryceras ?* sp., *In. hobetsensis*
			U_2	120	Conglomeratic ss. with cg. layers.		
			U_1	30	Cg. & ss.		
		Middle	M_2	50	Ss. with sdy sh.		
			M_1	15	Cg. & ss.		
		Lower	L_3	100	C. ss. with thin cg. layers.		
			L_2	20	Dark grey, m. ss.	*H. subovalis, St. (Y.) ainuana, P. brevicula, Ac. longiloba*	*Desmoceras japonicum, Calycoceras ?* sp.
			L_1	20	Dark grey, m. ss.		
	Lower Ammonites Beds	Upper		100+	Sdy sh.		

TABLE 3. The List of Fossil Trigoniids from the "*Trigonia* Sandstone" in the Hokkaido (Eastern Wing).

Specific name / Stratigraphic division / Horizon	Lower Ammonites Besds	"*Trigonia* Lower						
		L_1	L_2	L_3	L_4	L_5	L_6	L_7
Heterotrigonia subovalis								C
Apiotrigonia minor					VR			
Steinmannella (Yeharella) ainuana								VR
Pterotrigonia brevicula					A			?
P. hokkaidoana			?		VR			
Scabrotrigonia kobayashii					C			
Acanthotrigonia longiloba					C			C
Ac. pustulosa					R			

VA...Very abundant; A...Abundant; C...Common;

TABLE 4. The List of Gyliakian Trigoniids from Ikushumbetsu district, Central Hokkaido.

Specific name \ Horizon	Western Wing			Eastern Wing		
	Lower member	Middle member	Upper member	Lower member	Middle member	Upper member
Heterotrigonia subovalis	×			×		×
Apiotrigonia minor				×		×
Steinmannella (Yeharella) ainuana	×		×			×
Pterotrigonia brevicula	×			×		
P. hokkaidoana				×		×
Scabrotrigonia kobayashii				×		×
Acanthotrigonia longiloba	×			×		
Ac. pustulosa				×		

Vicinity of the Katsurazawa dam-site area, Ikushumbetsu, Mikasa-city, Central

Sandstone"												Upper Ammonites Beds
			Middle		Upper							
L_8	L_9	L_{10}	M_1	M_2	U_1	U_2	U_3	U_4	U_5	U_6	U_7	
R									C	C	VR	
							C	C	R	R	VR	
							A	VA	VA			
							VR		VR			
							R	C	C	R		
		R										

R...Rare; VR...Very rare;

one. As illustrated on Tab. 1 and 2, the fine materials of the off-shore origin are more dominant in the eastern part than in the western one where the *Desmoceras kossmati* and *Mantelliceras* zones of the lower member are not yet well recognized.

Trigoniids occur only in the so-called "*Trigonia* Sandstone" which is subdivided into the lower, middle and upper members by litho-facies. The upper member consists mainly of greenish grey, medium- to coarse-grained sandstone and sometimes with conglomerate layers at the upper part, while the lower member is composed chiefly of dark grey, muddy, fine- to medium-grained sandstone. Cross-bedding, ripple marks, and sand-pipes are recognized occasionally in several horizons of the upper member, but absent or seldom found in the lower member. The middle member consists of massive sandy mudstone or sandy shale with thin sandstone layers at the middle part. A number of Trigoniid specimens were collected from the lower and the upper member, and are associated with Pelecypods, Echinoids, Crinoids, Brachiopods, single corals, fish scales and teeth, pelagic Ammonoids and Nautiloids etc. These fossils are usually crowded and they form the so-called "fossil beds". The lower member produces single corals, fish scales and teeth, Echinoids, Brachiopods, Crinoids, pelagic Ammonoids and Nautiloids, *Inoceramus*, *Pecten* (*Synclonema*), *Pinna*, *Anthonya*, *Thetironia* etc. While, the upper member is characterized by the occurrence of *Gervillia* (*Pseudoptera*), "*Callista*", "*C.*" (*Pseudamiantis*), *Glycymeris*, *Ostrea* etc. and the lacking or scarceness of single corals, Echinoids, Crinoids, Brachiopods, fish scales and teeth etc. The lower member is rather rich in thin-tested bivalve, while the thick-tested ones are more abundant in the upper member. From the both members, the writer has not yet discovered the data indicating the Pelecypods inhabited *in situ*. It is an interesting fact that in the lower member a number of Pelecypod-valves are closed in condition and not so damaged in many cases, but in the upper member a fairly amount of shells are free and destroyed. Judging from the above-mentioned facts, the upper member indicates probably the littoral environment of open sea where the current was fairly strong. While, the lower member may be the products under the calm water of the neritic environment in open sea.

As illustrated on Tab. 4, a number of Trigoniids were collected from the eastern wing, although some authors noted that Trigoniids were more abundant in the western wing than in the eastern part. *Heterotrigonia subovalis* (JIMBO) and *Apiotrigonia minor* (YABE and NAGAO) or *Pterotrigonia hokkaidoana* (YEHARA) and *P. brevicula* (YEHARA) have some resemblances with each other in surface costation and shell form. These allied forms are seldom associated with each other in the same shell bed. In many cases, the quite different forms, such as, *Pterotrigonia brevicula* and *Heterotrigonia subovalis* etc., occur in the same horizon and the other associated Trigoniids are very poor in certain horizon where some species is abundant.

In this district, a number of Trigoniid-valves are usually closed in condition and the commissures of their valves are almost parallel or slightly oblique to the bedding. In the oblique condition, the siphonal margin of the valve is directed upward and the antero-ventral one is pointed to the lower part of the stratum. This phenomenon

is occasionally well observed in burial of *Steinmannella* (*Yeharella*) *ainuana* (YABE and NAGAO). In this species, the oblique angle ranges about 10 to 30 degrees.

6) Hetonai district, Iburi Prov., Central Hokkaido

The upper Senonian Hakobuchi group is well developed in this area, has been investigated by many workers because of the abundant interesting and important fossils.

The stratigraphy of the district is summarized as follows:

Hakobuchi group
- Upper sandy siltstone (30 m.+): Sandy siltstone with a thick sandstone layer at the middle part, containing upper Hetonaian *Inoceramus shikotanensis* etc. (×)
- Fukaushi formation (150–160 m.)
  - Upper member: Medium-grained, greenish sandstone with thin shale layers at the middle part, containing *In. shikotanensis* etc. (×)
  - Middle member: Sandy siltstone containing marine fossils.
  - Lower member: Conglomeratic sandstone and medium-grained sandstone with thin shale layers at the lower part, containing *In. shikotanensis* etc. (×).
- Lower siltstone (300 m.): Siltstone with fine-grained sandstone at the uppermost part, containing *In. shikotanensis* etc. (×).
- Tomiuchi formation (280 m.±)
  - Upper member: Sandstone and shale with thin conglomerate and tuff layers at the lower part and coal seams at the upper.
  - Middle member: Conglomeratic sandstone and sandstone with shale in the middle part, containing *In. orientalis* etc. (×).
  - Lower member: Conglomeratic sandstone and sandstone with thin shale layers, containing Campanian *In. orientalis* etc.

Upper Yezo group: Shale with thin tuff layers, containing marine fossils.

In this district, a single representative of Trigoniid, *Apiotrigonia minor* (YABE and NAGAO) (= *Trigonia subovalis* var. *minor*), is abundant through the all members of the Hakobuchi group (upper Campanian-Maestrichtian).

Japan Proper

Northeast Japan

7) Miyako district, Rikuchu Prov., Iwate Pref.

The fossiliferous Cretaceous deposits named under the Miyako group outcropped at several small and isolated areas, have been studied by a lot of geologists and palaeontologists. In 1958, the writer visited to this area and engaged in study on the Cretaceous strata. In this occasion, some additional notes are described hereunder.

Though there is a considerable variation of rock-facies, the stratigraphy of this district is summarized as follows:

Shimohei formation
- Hideshima sandstone (80m.+): Sandstone with thin sandy shale and conglomerate layers at several places (×).
- *Orbitolina*-bearing shell-sandstone (30 m.+): Yellowish brown, medium-grained sandstone with *Orbitolina* and marine shells (×).
- Hiraiga calcareous sandstone (35 m.±): Greyish, medium-grained sandstone with marine shells (×).
- Tanohata conglomeratic sandstone (60 m.±): Cross-laminated, conglomeratic sandstone and sandstone with marine shells (×).

Raga conglomerate···Boulder conglomerate with several thin red shale layers at some places. (0–20 m.)

Raga conglomerate overlies the basement Palaeozoic formation and granitic rocks with an unconformable surface of remarkable relief. This member yields calcareous sponge, Hexacorals, *Exogyra* sp., *Spondylus* sp. etc. in the vicinity of Hideshima, but Trigoniids have hitherto been undiscovered. Tanohata conglomeratic sandstone overlies the preceding conformably and the lateral changes of rock-facies are rather remarkably. Roughly speaking, the lateral changes of rock-facies are rather remarkable in the lower two members, i.e. Raga conglomerate and Tanohata conglomeratic sandstone, but somewhat constant in the upper parts.

The group contains a great number of fossils of good preservation, such as, Ammonoids, Trigoniids, and other Pelecypods etc. as described and reported by some authors. In 1931, SHIMIZU described 7 species of Ammonoids from the Hiraiga sandstone and 1 species from the Hideshima sandstone and he considered the former to be the Aptian plus the lower Albian and the latter to be the middle Albian. Trigoniids are fairly abundant, and produce at several horizons. *Nipponitrigonia kikuchiana* (YOKOYAMA) is collected from the Tanohata and Hiraiga members, and is associated with long ranged forms, such as, *Exogyra* sp., *Limatula ishidoensis* (YABE and NAGAO), *Astarte miyakoensis* NAGAO, and *Praecaprotina yaegashii* (YEHARA) etc. On the other hand, *Pterotrigonia hokkaidoana* (YEHARA) occurs in various horizons of this district, and is accompanied usually with *Spondylus decorata* NAGAO, *Astarte subomalioides* NAGAO, *Astarte minor* NAGAO, *Semisolarium incrassatum* (NAGAO), *Natica importuna* NAGAO, *Tylostoma miyakoensis* NAGAO etc., but seldom associated with *Praecaprotina yaegashii* (YEHARA). The other forms of Trigoniids, i.e. *Pterotrigonia datemasamunei* (YEHARA), *P. kotoi* (YEHARA), and *P. yokoyamai* (YEHARA), are very rare. The latter two once occurred in the Tanohata member, but the former came out from the Tanohata and the *Orbitolina* sandstone member.

8) Island of Oshima, offing Kesennuma, Rikuzen Prov., Miyagi Pref.

This small island has been investigated by many authors. The stratigraphy of the district is summarized as follows:

Oshima formation···Black shale with thin sandstone, conglomerate and lenticular limestone layers at some places, containing *Pterotrigonia hokkaidoana* and *P. pocilliformis* etc. (×). (370 m.±)

Oshima effusive rocks···Lavas and pyroclastics of andesite and basalt, interbedded with "*Corbicula*"-bearing black shale.

conformity

Shishiori group

Kogoshio formation (300 m.±)

- Upper member···Black shale with Jurassic *Myophorella* (*Promyophorella*) *orientalis* and *M.* (*P.*) *obsoleta* etc. (×). (200 m.±)
- Middle member···Fine-grained sandstone and shale.
- Lower member···White, coarse-grained sandstone with shale.

Mone formation (480 m.±)

- Upper member···Shale with lenticular conglomerate at some places, containing plant fossils.
- Lower member···Conglomerate. (230 m.±)

According to SATO (1958), Ammonoids occurred in the upper member of the Kogoshio formation indicate Berriasian in age. The writer is, however, of oppinion that the Kogoshio formation is probably belonged to the Upper Jurassic as can be judged from the stratigraphy of the district and the occurrence of *Myophorella* (*Promyophorella*) which has hitherto been undiscovered from the Cretaceous rocks of Japan.

In Ofunato region, the Ofunato formation approximately equivalent to the Oshima formation produces *Nipponitrigonia kikuchiana* (YOKOYAMA)?, *Pterotrigonia pocilliformis* (YOKOYAMA) and the Monobegawa fauna indicating the Aritan epoch (Barremian-Hauterivian).

9) Futaba district, Iwaki Prov., Fukushima Pref.

The Senonian rocks distributed narrowly in the northern part of the Joban coal-field, was discovered by TOKUNAGA.

The stratigraphy of the district is summarized as follows:

Palaeogene Tertiary

unconformity

Futaba group	Upper formation (220 m.)	Coarse-grained sandstone and conglomerate with local intercalation of sandy shale, containing marine fossils.
	Middle formation (120 m.)	Soft, bluish grey mudstone with coarse-grained sandstone at some places.
	Lower formation (270 m.)	Upper member···Sandstone and sandy shale with marine fossils (×).
		Lower member···Bluish, coarse- to medium-grained sandstone with conglomerate layers at some places (×).

unconformity

Paleozoic group, Granitic rocks

Trigoniids have been collected from the lower formation, and are associated with the lower Urakawan fossils, such as, *Inoceramus uwajimensis* YEHARA, *Bostrychoceras indicum* (STOLICZKA), *Baculites* (*Lechites*) *yokoyamai* TOKUNAGA and SHIMIZU, *Yabeiceras orientale* TOKUNAGA and SHIMIZU etc. *Steinmannella* (*Yeharella*) *kimurai* (TOKUNAGA and SHIMIZU) had been collected from the lower member of this formation. On the other hand, *Apiotrigonia minor* (YABE and NAGAO) and *Ap. undulosa* NAKANO were obtained by the writer from the lower and the upper member of the formation

10) Choshi peninsula, Choshi-ctiy, Kazusa Prov., Chiba Pref.

The Trigoniid-bearing Cretaceous rocks outcrop at a small and isolated area in the Choshi peninsula.

The stratigraphy of the Cretaceous strata studied by the writer is summarized as follows:

Neogene Tertiary

unconformity

Choshi group	C_3 formation	Greenish coarse-grained sandstone, containing Aptian *Hypophylloceras* aff. *onoense*, *Ancyloceras choshiense* etc.
	C_2 formation	Sandstone and shale in alternation (×).
	C_1 formation	Conglomerate and sandstone.

unconformity

Palaeozoic group

Because of its complicated structure, thickness of the Choshi group is uncertain. *Pterotrigonia pocilliformis* (YOKOYAMA) is abundant in C_2 formation in which *Nipponitrigonia kikuchiana* (YOKOYOMA) is rarely found.

11) Sanchu graben, Kwanto mountainland

The region was investigated by many workers because of the abundance of marine and plant fossils. In 1959, the writer had a chance to study on the Cretaceous formation distributed in Nakasato- and Ueno-mura districts in Tano-gun, Kamitsuke Prov., Gumma Pref. There are the considerable variations of litho- and bio-facies between the northern and the southern wing and the eastern and the western area. It is, however, well recognized that there are 3 major cycles of sedimentation in the Cretaceous strata which form a synclinal structure.

The stratigraphy of the district is summarized as follows:

Upper formation (350 m.+)		Sandy shale with thick conglomerate layers at the base and thin sandstone layers in the middle part, containing marine fossils.
Middle formation (500-550m.)	Upper member	Sandy shale with thin sandstone layers, containing Trigoniids and Ryoseki type fauna etc.(×)
	Middle member	Sandy shale with wedge-shaped sandstone layers, containing Ryoseki fauna and flora.
	Lower member	Greyish-blue, coarse- to medium-grained sandstone with conglomerate at the base.
Lower formation (150 m. ±)	Upper member	Sandy shale containing Trigoniids and Ryoseki type fauna (×).
	Lower member	Conglomerate and sandstone with thin shale layers, containing Ryoseki fauna and flora.

fault

Palaeozoic group, Jurassic group

In Shiroi, the western part of the district, many so-called brackish fossil shells, i.e. Ryoseki fauna, produce from the upper member of the lower formation which is approximately equivalent to YABE and NAGAO's Shiroi formation, but Trigoniid is absent. While Trigoniid is fairly rich in the same member near Sebayashi of the eastern part where *Pterotrigonia pocillifomis* (YOKOYAMA) and *P. hokkaidoana* (YEHARA) are associated or alternated with Ryoseki fauna, such as, "*Corbicula*" *sanchuensis* YABE and NAGAO, *Aloides pseudotruncata* YABE and NAGAO, and others. On the other hand, the middle formation (=YABE and NAGAO's Ishido formation) in Shiroi area is rich in characteristic marine fauna, such as, *Pterotrigonia pocilliformis* (YOKOYAMA) and *P. hokkaidoana* (YEHARA) etc., but Ryoseki fauna and flora are abundant in the vicinity of Sebayashi.

Rutitrigonia yehara KOBAYASHI, *R. sanchuensis* (NAKANO), and *Nipponitrigonia kikuchiana* (YOKOYAMA) are abundant in the vicinity of Ohinata, Saku-machi, Minamisaku-gun, Nagano Pref. The rocks containing these fossils are probably corresponded to the middle member of the middle formation.

Southwest Japan

12) Todai district, Akaishi mountainland

The Cretaceous rocks of the district distributed in the narrow area, are in fault contact with the metamorphic and the non-metamorphic Palaeozoic formation on the west and the east part. The Cretaceous formation is highly disturbed, and consists mainly of massive, greenish grey, coarse-grained sandstone with subordinate conglomerate and shale. According to YEHARA (1923b), *Nipponitrigonia kikuchiana* (YOKOYAMA), *N. naumanni* (YEHARA), *Pterotrigonia pocilliformis* (YOKOYAMA), and *P. kotoi* (YEHARA) were found at Todai. Among them, *P. kotoi* is known and characteristic in the Miyakoan (Aptian-Albian) formation of Miyako district in Northeast Japan.

13) Misakubo district, Akaishi mountainland

The Cretaceous deposits named under the Misakubo formation outcropped at a small area along the Median Tectonic Line, have been studied by TATSUMI and YOSHIMURA (1938) and KIMURA (1959) etc.

The stratigraphy of this district is summarized as follows:

Misakubo formation	Upper member (750 m.±)	Sandy shale with sandstone layers at some horizons.
	Middle member (400 m.±)	Greyish green, medium- to coarse-grained sandstone with thin sandy shale and conglomerate, containing marine fossils (×).
	Lower member (350 m.±)	Bluish to greenish coarse-grained sandstone and conglomerate with thin sandy shale at some places.
unconformity		
Palaeozoic group		

TATSUMI and YOSHIMURA collected *Cucullaea* sp., *Ostrea* sp., *Pterotrigonia hokkaidoana* (YEHARA), *Acanthotrigonia dilapsa* (YEHARA), *Anthonya japonica* MATUMOTO, "*Callista*" (*Pseudamiantis*) *crenulatus* MATUMOTO, *Lucina* sp., *Solarium* cf. *berthoni* PERVINQ. etc. from this formation. This faunal contents are quite similar to those of the IIb member of the middle formation in the Goshonoura group, Western Kyushu. Therefore, the Misakubo formation may be referable to the Lower Gyliakian.

14) Yuasa district, Kii Prov., Wakayama Pref.

The Cretaceous formation distributed in this area lies unconformably on the folded Palaeozoic group, and there are the considerable varitions in litho- and biofacies between those of the northern and the southern (*) wing.

The stratigraphy of the Cretaceous formations is summarized as follows:

Soto-Izumi group	Toyajo formation (=Futakawa* f.)	Upper member (130+ -300 m.)	Sandstone with shale, containing marine fossils.
		Lower member (700-1,000 m.)	Sandy shale with thin sandstone layers, containing Hetonaian *Didymoceras awajiense*, *Inoceramus schmidti* etc.
	Goryo formation (=Matsubara f.)	Upper member (60-100 m.±)	Sandstone with thin conglomerate and shale layers.
		Middle member	Sandy shale with thin sandstone layers, containing *In. uwajimensis*, *Polyptychoceras* cf. *obstrictum* etc.
		Lower member (80-150 m.±)	Sandstone and conglomerate, with *In. uwajimensis* etc.

Kanaya formation···Sandstone with shale and conglomerate layers at several horizons, containing, Cenomanian *Sharpeiceras* aff. *naviculare*, *In.* sp. etc.
(=Kamimatsubara f.) (100-400 m.)

? disconformity

Monobegawa group

Nishihiro formation (=Izeki f.)
- Upper member···Sandstone and shale with marine and plant fossils (×). (200m.±)
- Mddle member···Shale with brackish shells. (50-150m.)
- Lower member···Conglomerate and sandstone with thin shale layers, containing brackish shells. (70-190m.)

disconformity

Arita formation
- Upper member···Shale with thin sandstone layers at some places, containing *Heteroceras* aff. *astieri*, *Cymatoceras* aff. *neokomiense*, Trigoniids etc. (×) (60+-120m.+)
- Middle member···Greyish, silty, coarse- to fine-grained sandstone, containing Barremian *Shasticeras nipponicum*, *Barremites* cf. *pseudodifficile* etc. (×). (70m.±)
- Lower member···Conglomerate and sandstone with plant fossils. (0-80m.)

Ryoseki group

Yuasa formation (=Kitadani f.)
- Upper member···Sandstone and shale containing brackish shells and plant fossils. (30-120m.)
- Lower member···Conglomerate and sandstone. (10-30m.)

Generally speaking, the rocks of the Monobegawa and the Ryoseki group distributed in the northern wing are much coarser than those of the southern one, but in the Soto-Izumi group the fine materials of the off-shore origin are more dominant in the northern wing than in the southern one.

TABLE 5. The List of Fossil Trigoniids from the Northern Part of Yuasa district, Kii Prov., Wakayama Pref.

Specific name \ Formation	Ryoseki Group		Monobegawa Group						Soto-Izumi Group		
	Yuasa formation		Arita formation			Nishihiro formation			Kanaya formation	Goryo formation	Toyajo formation
	Low.	Up.	Low.	Mid.	Up.	Low.	Mid.	Up.			
Nipponitrigonia kikuchiana			C	R	VR			R			
N. k. var. *plicata*			R	VR							
N. naumanni				VR							
Pterotrigonia pocilliformis				A	R			C			
P. hokkaidoana				VR				VR			

On the bio-facies of the Ryoseki and the Monobegawa group, marine fossils are more abundant in the southern part than in the northern area where the brackish Ryoseki fauna are sometimes associated or alternated with the marine fossils, such as, Trigoniids and others. On the other hand, in the Soto-Izumi group the pelagic Ammonoids and Inoceramids are more rich in the northern wing than in the southern

region. Trigoniids are somewhat abundant in the Monobegawa group of the northern wing, but they have hitherto been undiscovered from the rocks of the Soto-Izumi group.

From this district, as tabulated on Tab. 5, *Nipponitrigonia kikuchiana* (YOKOYAMA), *N. k.* var. *plicata* KOBAYASHI and NAKANO, *N. naumanni* (YEHARA), *Pterotrigonia pocilliformis* (YOKOYAMA), and *P. hokkaidoana* (YEHARA) were collected by the writer. *Pterotrigonia* is common in the district, but *Nipponitrigonia* is rare. The ratio of the specimen number of *Pterotrigonia* to *Nipponitrigonia* is about 3 : 1 to 10 : 1.

15) Katsuuragawa basin, Awa Prov., Tokushima Pref., Shikoku

Although there are many works on the Cretaceous stratigraphy of the area, the observations of many authors somewhat disagree with one another because of the complicated geologic structure. Recently, the writer with NUMANO surveyed the Yokosetatsukawa area, the western part of the Katsuuragawa basin, and recognized that there are 3 major cycles of the sedimentation in the Cretaceous formation which lies unconformably on the Palaeozoic group in the central part but they are in fault contact in the northern and southern parts. Generally speaking, the Cretaceous group forms a homoclinal structure, dipping toward north, having major two synclines and an anticline and their axes are almost E-W.

The stratigraphy of the Cretaceous group in this area is summarized as follows:

Fujikawa formation	Upper member (200 m.+)	Sandy shale with sandstone layers at the base, containing *Desmoceras kossmati*.
	Lower member (200 m.±)	Sandstone with thin conglomerate layers at the base and thick sandy shale at the upper.
Hoji formation	Upper member (170–200m.)	Thick medium-grained sandstone and thin sandy shale in alternation with coal seams at the uppermost, containing marine fossils (×).
	Lower member (140–200m.)	Conglomeratic to coarse-grained sandstone with subordinate sandy shale in the lower and the upper part, intercalating with thin conglomerate layers in the lower part and thin coal seams at the uppermost (×).
Hanoura formation (350m.±)		Sandstone and sandy shale in alternation with thin conglomerate layers in the lower and thin coal seams at the uppermost, containing *Phyllopachyceras infundibulum*, *Barremites pseudodifficile* etc. (×).
Tachikawa formation	Upper member (140–350m.)	Conglomerate, sandstone and shale in alternation with brackish shells and plant fossils.
	Lower memder (60–200m.)	Conglomerate and sandstone in alternation with thin sandy shale layers, containing brackish shells.

unconformity

Palaeozoic group

Desmoceras kossmati MATSUMOTO was collected recently from the Fujikawa formation. Therefore, the Fujikawa formation may be the lowest Cenomanian, i. e. Japanese uppermost Miyakoan in age.

In this district, Trigoniids were obtained from the Aritan Hanoura and the Miyakoan Hoji formation the latter of which can be subdivided into 2 members by litho- and bio-facies. The lower member of the Hoji formation consisting chiefly of conglomeratic to coarse-grained sandstone and subordinate with sandy shale, produces

many specimens of *Nipponitrigonia*, such as, *Nipponitrigonia kikuchiana* (YOKOYAMA), *N. k.* var. *plicata* KOBAYASHI and NAKANO, and *N. naumanni* (YEHARA), but *Pterotrigonia pocilliformis* (YOKOYAMA) is very rare. It is an interesting fact that in this district *Nipponitrigoniae* were all collected from this member and they were sometimes associated or interbedded with the remains of *Ostrea* sp. which form so-called "*Ostrea* bank." On the other hand, the upper member consists of alternating layers of thick, medium-grained sandstone and thin sandy shale, and contains a lot of specimens of *Pterotrigonia pocilliformis* (YOKOYAMA) accompanying with *Gervillia forbesiana* d'ORBIGNY, *Glycymeris* sp., Crinoid stem etc. *Pocilliformis* forms by itself the fossil banks. Judging from the above mentioned facts, the lower member of the Hoji formation may be the products under the littoral environment, but the upper member indicates probably the environment under somewhat off-shore and calm water than in the lower member.

TABLE 6. The List of Fossil Trigoniids from Katsuuragawa basin, Awa Prov., Tokushima Pref., Shikoku.

Formation / Specific name	Tachikawa formation		Hanoura formation	Hoji formation		Fujikawa formation		Miyakura formation
	Low.	Up.		Low.	Up.	Low.	Up.	
Nipponitrigonia kikuchiana				A				
N. k. var. *plicata*				C				
N. naumanni				A				
Apiotrigonia minor								R
A. minor var. *nankoi*								R
Pterotrigonia pocilliformis			R	VR	VR			
P. hokkaidoana					VR			

Senonian Miyakura formation is well developed in the small isolated hills at Miyakura, about 20 km. east from Yokosetatsukawa district. This formation is always in fault-relation with the Lower Cretaceous formations, and is composed mainly of medium- to fine-grained sandstone and with sandy shale and conglomerate layers at several horizons. From this formation, *Nanonavis* cf. *sachalinensis* SCHMIDT, *Apiotrigonia minor* (YABE and NAGAO), *Ap. m.* var. *nankoi* NAKANO, *Inoceramus balticus* var. *toyajoanus* NAGAO et MATUMOTO, *In. schmidti* MICHAEL, *Astarte* sp., *Pattella gigantea* (SCHMIDT), *Didymoceras* cf. *awajiense* (YABE), and *Washiaster* (?) sp. etc. were found. Therefore, Miyakura formation is probably the upper Campanian or Japanese lower Hetonaian.

16) Nagase district in Monobegawa basin, Tosa Prov., Kochi Pref., Shikoku

The presence of the Upper Cretaceous formations were recently reported by KATTO and SUYARI (1956) from this district situated at about 30 km. east from Kochi-city.

The stratigraphy of the Cretaceous formations is described as follows:

Stratigraphic Occurrences of the Cretaceous Trigoniids in the Japanese Islands

Soto-Izumi group

- **Kajisako formation**
  - Upper member (80–130m.+) — Sandy shale with sandstone, containing Urakawan *Inoceramus japonicus*, *In. naumanni* etc.
  - Middle member (20–70m.) — Sandstone with tuffaceous sandstone and shale.
  - Lower member (20–100m.) — Grey, coarse-grained sandstone with marine fossils (×).
- **Nagase formation**
  - Upper member (100m.+) — Sandstone and shale in alternation, containing Cenomanian Ammonoids.
  - Lower member (100m.+) — Silty, medium-grained sandstone with conglomerate layers, containing Cenomanian *Mantelliceras* sp., *Anagaudryceras sacya*, Trigoniids etc. (×).

fault

Monobegawa group

- **Hibihara formation**
  - Upper member (400m.+) — Shale with thin sandstone layers, containing Albian *Pachydesmoceras denisoni*, *Puzosia* sp., *Mortoniceras* sp. etc.
  - Lower member (300m.) — Arkose sandstone with conglomerate, containing marine fossils (×).
- **Yunoki formation**
  - Upper member (200m.) — Shale and subordinate sandstone, containing marine fossils.
  - Lower member (200m.) — Silty, medium-grained sandstone with conglomerate and sandy shale, containing marine fossils (×).

Ryoseki group

- Upper member (150m.±) — Sandstone and sandy shale in alternation with brackish shells.
- Lower member (250m.±) — Conglomerate and conglomeratic sandstone with sandy shale containing brackish shells.

The Cretaceous strata of the district are much disturbed by minor folds and numerous faults along which the Jurassic and the Palaeozoic group are sometimes squeezed out.

According to KATTO and SUYARI, *Acanthotrigonia dilapsa* (YEHARA) occurred in the lower member of their Urakawan Kajisako formation. Because *dilapsa* is a characteristic form of the Gyliakian Trigoniids, the lower member of the Kajisako formation may be excluded better from the Urakawan formation. Recently, the writer collected *Acanthotrigonia pustulosa* (NAGAO), accompanied with *Mantelliceras* sp., *Anag-*

TABLE 7. The List of Fossil Trigoniids from Nagase district in Monobegawa basin, Tosa Prov., Kochi Pref. Shikoku.

Specific name \ Formation	Ryoseki Group		Monobegawa Group				Soto-Izumi Group				
			Yunoki formation		Hibihara formation		Nagase formation		Kajisako formation		
	Low.	Up.	Low.	Up.	Low.	Up.	Low.	Up.	Low.	Mid.	Up.
Nipponitrigonia kikuchiana					×						
Pterotrigonia pocilliformis			×		×						
P. hokkaidoana			×		×		×				
Acanthotrigonia dilapsa									×?		
Ac. moriana					×						
Ac. pustulosa							×				

audryceras sacya (YOKOYAMA) and others, from silty, medium-grained sandstone in the lower member of the Nagase formation at the Nagase dam-site in Nagase. A single imperfect specimen of *Acanthotrigonia moriana* (YEHARA) was also obtained from the lower member of the Hibihara formation in the vicinity of Inono.

In Hagino, about 10 Km. west from the district, *Nipponitrigonia naumanni* (YEHARA) and *Acanthotrigonia moriana* (YEHARA) are known from the Miyakoan Hagino formation.

17) Sakawa basin, Tosa Prov., Kochi Pref., Shikoku

The Cretaceous system of the district has been surveyed by many authors, such as, NAUMANN and NEUMAYR (1890), YEHARA (1923b, 27), KOBAYASHI (1931,32,41), and others.

Although there is a considerable variation of rock-facies, the stratigraphy of the district is summarized as follows:

Miyanohara Sandstone···Grey, muddy, medium-grained sandstone with thin sandy shale layers, containing Cenomanian marine fossils (×). (100m.+)

Monobegawa group

Upper Monobegawa group

- Upper member (500m.)···Black shale and siltstone with *Desmoceras* sp., *Mortoniceras* sp. etc.
- Middle member (50m.)···Grey, muddy, medium-grained sandstone with marine fossils (×).
- Lower member (30m.)···Conglomerate sometimes replaced by conglomeratic or coarse-grained sandstone.

unconformity

Lower Monobegawa group

- Upper member (100m.)···Black shale with marine fossils.
- Middle member (10m.±)···Greenish blue, muddy, medium-grained sandstone with marine fossils (×).
- Lower member (20m.)···Conglomerate.

disconformity

Ryoseki group

- Upper member (100+-150m.)···Shallow sea facies, shale with thin sandstone, but sometimes represented by brackish facies (×).
- Lower member (50-100m.)···Shallow sea facies, conglomerate and sandstone in alternation with sandy shale, partly represent by brackish facies (×).

partial disconformity

Torinosu group (70-300m.)···Shale and sandstone in alternation with thin conglomerate and limestone layers at some horizons, containing Upper Jurasric marine fossils and sometimes plant fossils (×).

The Cretaceous Ryoseki group lies disconformably on the Upper Jurassic Torinosu group in the northern part of the district, but their relation is transitional in the southern area where they are distinct in fossil contents. The former is quite variable in litho- and bio-facies, and produces so-called brackish Ryoseki fauna and marine shells. The marine Ryoseki group distributed in the southern area once produced *Nipponitrigonia kikuchiana* (YOKOYAMA), *N. naumanni* (YEHARA), *Rutitrigonia yeharai* KOBAYASHI, *Pterotrigonia pocilliformis* var. *yamanokamiensis* KOBAYASHI and NAKANO, and a cyrenid etc. On the other hand, subjacent Torinosu group contains *Nipponitri-*

gonia sagawai (YEHARA), *Myophorella* (*Haidaia*) *gracilenta* KOBAYASHI, *M.* (*H.*) *pulex* TAMURA, *Linotrigonia toyamai* (YEHARA), *Perisphinctes* (*Aulacosphinctes*) aff. *steigeri* SHIMIZU etc. On the Trigoniid fauna, *Myophorella* (*Haidaia*) and *Linotrigonia* are all collected from the Upper Jurassic, while *Pterotrigonia* and *Rutitrigonia* are known from the Neocomian to the Turonian or to the Albian, respectively.

TABLE 8. The List of Fossil Trigoniids from Sakawa basin, Tosa Prov., Kochi Pref., Shikoku.

Formation / Specific name	Torinosu Group	Ryoseki Group		Upper Monobegawa Group			Lower Monobegawa Group			Miyanohara Sandstone
		Low.	Up.	Low.	Mid.	Up.	Low.	Mid.	Up.	
Nipponitrigonia kikuchiana		×						×		
N. naumanni		×								
N. sagawai	×									
Rutitrigonia yeharai		×								
Myophorella (*Haidaia*) *gracilenta*	×									
M. (*H.*) *pulex*	×									
Linotrigonia toyamai	×									
Pterotrigonia pocilliformis					×			×		
P. p. var. *yamanokamiensis*		×								
P. hokkaidoana										×
Acanthotrigonia longiloba										×
Ac. pustulosa										×

Gyliakian Miyanohara formation produces a number of marine fossils, such as, *Pterotrigonia hokkaidoana* (YEHARA), *Acanthotrigonia longiloba* (JIMBO), *Ac. pustulosa* (NAGAO), *Anthonya japonica* MATUMOTO, "*Callista*" (*Pseudamiantis*) *crenulatus* MATUMOTO, *Pholadomya* sp., *Glycymeris* sp., "*Cerithium*" *piramidaeformis* NAGAO, *Desmoceras* sp., "*Mantelliceras*" sp., *Calycoceras* (*?*) sp., *Sharpeiceras* sp. etc. *Acanthotrigonia dilapsa* (YEHARA), and *N.* (*?*) *sakamotoensis* (YEHARA) were reported by MATSUMOTO et al. (1954, p.53) and KOBAYASHI (1957, pp.55-56) from this formation, but they are not recognized in the writer's collection.

18) Uwajima district, Iyo Prov., Ehime Pref., Shikoku

The Cretaceous rocks well developed in this area, have been studied by YEHARA (1924), SUZUKI (1936), KUDO (1949, 50) and others. On account of complicated geologic structure, the observations of these authors somewhat disagree with one another. Recently, the writer investigated stratigraphically and palaeontologically this area and collected numerous Trigoniid specimens from various localities. Speaking generally, the Trigoniid-bearing Cretaceous formation, i. e. Uwajima group, forms a synclinorium structure. Although litho- and bio-facies are fairly variable in horiz-

ontl distribution, the stratigraphy of the Cretaceous rock is summarized as follows:

Uwajima group	Makinoyama formation	Upper member (350m.+)	Conglomerate and coarse-grained sandstone.
		Lower member (100m.±)	Sandstone and shale in alternation with several conglomerate layers, containing *Polyptychoceras haradanum*, *Inoceramus naumanni* etc. (×).
	Furushiroyama formation (800m.±)		Sandy shale sometimes with thin sandstone and red shale layers, containing *Anagaudryceras limatum*, *Bostrychoceras indicum*, *In. uwajimensis* etc. (×).
	Ishibiki formation	Upper member (600m.+)	Coarse-grained sandstone with conglomerate and shale layers, containing *Archaeozostera*; ripple mark and cross-bedding well observed.
		Lower member (800m.+)	Thick sandstone and thin shale in alternation.
	Narukawa formation	Upper member (400m.±)	Sandy shale with thin sandstone layers, containing *In. uwajimensis* etc.
		Lower member (600m.±)	Sandstone with thin shale layers, containing *In. uwajimensis* etc. (×).
fault ?			
Shimonada group		Upper member (400m.±)	Sandy shale with sandstone and thin acidic tuff layers, containing *In.* aff. *cripsi*.
		Middle member (400m.±)	Sandstone and shale in alternation.
		Lower member (1,000m.±)	Shale with sandstone and lenticular limestone, containing *Pterophyton* cf. *miyakoensis* etc.
fault ?			
Shimantogawa Complex			

In this district, the writer collected many specimens of *Apiotrigonia minor* (YABE and NAGAO) from the Furushiroyama formation and the lower member of the Makinoyama formation in Uwajima-city. In the former, it is associated with *Anagaudryceras limatum* (YABE), *Bostrychoceras indicum* (STOLICZKA), *Inoceramus uwajimensis* YEHARA, *In. akamatsui* YEHARA etc., while in the latter it is associated with *Polyptychoceras haradanum* (YOKOYAMA) and *In. naumanni* YOKOYAMA etc. At Tenjinzaka near Narukawa in Uwajima-city, the same form was recently obtained from the lower member of the Narukawa formation in which *Anagaudryceras limatum* (YABE), *Inoceramus uwajimensis* YEHARA and *In. akamatsui* YEHARA were found in the vicinity of Shimizu. From fossil evidences, the Makinoyama formation is probably the upper Urakawan, approximately equivalent to the European Santonian, and the Furushiroyama, Ishibiki, and Narukawa formations are possibly the lower Urakawan, i.e. Coniacian, in age.

According to YABE (1927) and KUDO, *Inoceramus* aff. *cripsi* MANTELL and *Pterophyton* cf. *miyakoensis* YABE were reported from the upper and the lower member of the Shimonada group, respectively. Tentatively, the Shimonada group may most resonably be assigned to the Gyliakian to the Miyakoan.

The Lower Cretaceous Kikunodani formation containing *Nipponitrigonia kikuchiana* (YOKOYAMA), *N. naumanni* (YEHARA), and *Pterotrigonia pocilliformis* (YOKOYAMA), is

narrowly developed in Kikunodani of Kurosegawa-mura, about 20 Km. northeast of Uwajima-city.

19) Izumi belt, Southwest Japan

The upper Senonian strata, i.e. Izumi group, well developed and run along the northern side of the Median Tectonic Line. This group distributed in the southern half of Awaji-island has been studied stratigraphically and palaeontologically in considerable detail by many workers because of abundant occurrences of interesting and important fossils.

The stratigraphy of the Izumi group in this island is summarized as follows:

h) Shimonada sandstone (250m.+)···White, medium- to coarse-grained sandstone with thin tuff, conglomerate, and shale layers at several horizons, containing upper Hetonaian *Inoceramus vwajiensis* etc.

g) Shimonada fine sandy siltstone (370m.+)···Sandy shale with thin sandstone and conglomerate layers at some places, containing *In. awajiensis*, *Pachydiscus subcompressum* etc.

fault

f) Nada sandstone and conglomerate (1,100m.±)···Sandstone and sandy shale in alternation with thin conglomerate, containing marine fossils (×).

e) Kitaama sandstone and shale
- Upper member (800m.±)···Sandstone and shale in alternation with thin tuff layers, containing *In. shikotanensis* etc. (×).
- Lower member (2,500m.±)···Sandstone and shale in alternation with tuff, containing *In. shikotanensis* etc.

d) Shichi shale (400m.±)···Fossiliferous shale with thin sandstone layers at several horizons, containing *Didymoceras awajiense*, *In. balticus* var. *toyajoanus* etc.(×).

c) Yoroizaki sandtone (1,400m.±)···Thick sandstone and thin sandy shale in alternation with thin tuff layers at some places.

b) Minato shale (500m.±)···Fossiliferous shale with thin sandstone layers at several horizons, containing *Didymoceras awajiense*, *Pravitoceras sigmoidale* etc. (×).

a) Tsui conglomerate (200-400m.±)···Conglomerate and sandstone, sometimes with thin tuff layers.

unconformity

Granitic rocks

It is an interesting fact in this island *Apiotrigonia* and allied members are all dwarf forms and they were collected mainly from various horizons and localities of the lower half in this group. They occur commonly in fine-grained sandstone to sandy shale. *Steinmannella* (*Yeharella*) has hitherto been undiscovered from this island, though they are common in the upper Senonian of Southwest Japan. Judging from the occurrence of the important fossils, such as, Ammonoids and Inoceramids etc., upper four formations are probably upper Hetonaian (Maestrichtian) in age and the lower half is possibly corresponded to the lower Hetonaian (upper Campanian).

The Izumi group is, also, well developed in the Izumi mountain-range of Kinki district and the northern part of Shikoku. In Shikoku, *Steinmannella* s.l. is fairly abundant in the basal part of the Izumi group corresponding approximately to the Tsui mebmer of Awaji, but *Apiotrigonia postonodosa* NAKANO and *Ap. minor* var. *nankoi* Nakano are collected rarely from the lowest part (≒Minato shale) of the Hiketa shale

TABLE 9. The List of Fossil Trigoniids from the Izumi group in Awaji-island, Awaji Prov., Hyogo Pref.

Specific name \ Geological Age / Formation	Lower Hetonaian				Upper Hetonaian				
	a	b	c	d	e Low.	e Up.	f	g	h
Apiotrigonia minor var. *nankoi*		×		×		×	×		
Ap. obsoleta		×		×					
Ap. postonodosa		×		×					
Ap. tuberculata				×					
Microtrigonia minima				×		×	×		

member in Kagawa Pref. *Steinmannella* (*Setotrigonia*) *shinoharai* KOBAYASHI and AMANO, *Steinmannella* (*Yeharella*) *kimurai* (TOKUNAGA and SHIMIZU) and its subspecies *sanukiensis* NAKANO are found in Kagawa Pref. In the vicinity of Matsuyama-city in Ehime Pref., *Apiotrigonia crassoradiata* NAKANO, *Steinmannella* (*Yeharella*) *japonica* (YEHARA) and *St.* (*Y.*) *kimurai* (TOKUNAGA and SHIMIZU) are associated with lower Hetonaian *Inoceramus schmidti* MICHAEL.

In Izumi district, *Apiotrigonia minor* var. *nankoi* NAKANO is also rarely found in the Asenotani shale (≒ Minato shale) near Shintachi in Izumi-Sano-city, but *Steinmannella* (*Yeharella*) has hitherto been undiscovered.

20) Onogawa basin, Bungo Prov., Oita Pref., Kyushu

The stratigraphy of the Cretaceous formations in this district was established by MATUMOTO (1936), and is summarized as follows:

- Onogawa group
  - Upper Onogawa group
    - Amabe formation (3,000m.)
      - Upper member···Sandstone and shale in alternation with thin conglomerate and acidic tuff.
      - Lower member···Sandstone and shale in alternation with conglomerate and acidic tuff, containing *Polyptychoceras* cf. *haradanum* etc.
    - Yoshinotsuru formation (5,000m.?)
      - Upper member···Conglomerate, sandstone and shale.
      - Middle member···Shale and thin sandstone, containing *Bostrychoceras* cf. *indicum*, *Polyptychoceras* sp., *Inoceramus naumanni* etc.
      - Lower member···Conglomerate and sandstone with shale, containing *Apiotrigonia undulosa* etc. (×)
    - Tonoe formation (3,000m.±)···Sandstone and shale with conglomerte, containing *In. uwajimensis*, *In. akamatsui* etc.
  - Lower Onogawa group
    - Nakakawarauchi formation (1,3000m.)
      - Upper member···Sandstone.
      - Lower member···Conglomerate, sandstone and shale.
    - Okukawarauchi formation (1,350m.)
      - Upper member···Bluish grey siltstone.
      - Middle member···Sandstone with conglomerate and shale, containing Turonian *In. hobetsensis* etc.
      - Lower member···Conglomerate with sandstone and shale.

Ryozen formation (3,000m.±)
- Upper member···Shale with subordinate sandstone, containing *In. hobetsensis*, *Pterotrigonia datemasamunei* var. etc. (×).
- Middle member···Conglomerate with subordinate sandstone.
- Lower member···Fanglomerate.

unconformity

Palaeozoic group

In Haidateyama region, the Albian Haidateyama formation is well developed and it produces *Pterotrigonia datemasamunei* (YEHARA) and P. *hokkaidoana* (YEHARA).

21) Mifune district, Higo Prov., Kumamoto Pref., Kyushu

The Cretaceous formation named under the Mifune group is somewhat variable in litho- and bio-facies on the southern and northern parts, and contains a number of molluscan fossils of the shallow sea and the brackish environment.

The stratigraphy of the group established by MATUMOTO (1939) is summarized as follows:

Mifune group
- Upper formation···Variegated sandstone and shale (700-750m.)
- Middle formation···Sandstone with sandy shale, containing marine or sometimes brackish shells (450-750m.) (×).
- Lower formation···Conglomerate with coarse-grained sandstone. (50-300m.)

unconformity

Palaeozoic group

As already discussed by MATSUMOTO et al. (1954), a number of molluscan fossils from the group are common with those of the Goshonoura group. Recently, *Pterotrigonia* (*Rinetrigonia*) sp. nov. were obtained by H. OKADA only from the middle formation in the vicinity of Miyanomoto, Mifune-machi.

22) Yatsushiro district, Higo Prov., Kumamoto Pref., Kyushu

Recently, the following stratigraphy is summarized by MATSUMOTO and KANMERA (1949).

Tomochi formation
- Upper member···Sandy shale with thin sandstone layers. (100m.±)
- Middle member···Medium-grained sandstone with sandy shale layers. (280m.)
- Lower member···Sandy shale contains Cenomanian *Mantelliceras*, *Marshallites*, *Kossmaticeras*, (170m.) Trigoniids etc. (×).
- Basal member···Conglomerate and cross-laminated conglomeratic sandstone with sandy shale. (100-200m.)

unconformity

Yatsushiro formation
- Upper member···Sandstone with sandy shale and thin limestone layers, containing brackish (150m.) shells and plant fossils.
- Middle member··· Conglomeratic to medium-grained sandstone at the lower and sandy (180m.) shale in the upper, containing Albian Ammonoids and shallow sea shells. (×).
- Lower member···Conglomerate and conglomeratic sandstone with sandy shale, containing (250m.) plant fossils.

unconformity

Hinagu formation	Upper member (200m.)	Sandy shale sometimes with lenticular limestone, containing marine shells.
	Middle member (250m.)	sandstone and sandy shale in alternation with thin conglomerate, containing marine fossils (×).
	Lower member (270m.)	Sandstone and sandy shale in alternation, containing Aptian Ammonoids.
	Basal member (80m.)	Conglomerate and coarse-grained sandstone with thin sandy shale, containing brackish shells.

disconformity

Hachiryuzan formation	Upper member (250-280m.)	Sandy shale with sandstone layers at the upper, containing Trigoniids, *Crioceras*, *Toxoceras*, *Leptoceras* etc (×).
	Lower member (75-100m.)	Conglomerate and sandstone with sandy shale, containing brackish shells in some places.
Kawaguchi formation	Upper member (140m.)	Sandstone and shale in alternation, with brackish shells and plant fossils.
	Middle member (130-100m.)	Arkose, conglomeratic to coarse-grained sandstone with sandy shale.
	Lower member (70-100m.)	Sandstone and shale in alternation with brackish shells and plant fossils.
	Basal member (50m.±)	Conglomerate and coarse-grained sandstone.

unconformity

Upper Jurassic Sakamoto formation

In this region, Trigoniids were collected commonly from rather silty, medium-grained sandstone in which *Pterotrigonia* s. s. is usually dominant than *Nipponitrigonia*. *Rutitrigonia* is a rare and peculiar form of the Japanes Cretaceous Trigoniids, and is known from the Yatsushiro formation in the vicinity of Shimofukamizu, Simomatsukuma-mura. This is associated with *Pterotrigonia*, *Nipponitrigonia*, and Pelecypod fossils of the shallow sea nature. In this locality, *Rutitrigonia* is rather abundant and its number of the specimen is almost equivalent to that of *Nipponitrigonia*. As mentioned before, *Pterotrigonia* is abundant in the locality and the ratio of the specimen number of *Pterotrigonia* to *Nipponitrigonia* plus *Rutitrigonia* is about 5: 4. It is an important fact that *Pterotrigonia* (*Rinetrigonia*) sp. *a* and *b* were reported from the Aptian Hinagu formation near Yatsushiro-city (KOBAYASHI and NAKANO, 1958).

23) Islands of Amakusa, Western Kyushu

The fossiliferous Cretaceous strata are widely distributed in the islands of Amakusa including Amakusa-kamishima, -shimoshima and others, and they have been investigated by a lot of geologists and palaeontologists.

The Cretaceous rocks underlying the Lower Tertiary formation are classified into the Gyliakan Goshonoura group and the overlying Senonian Himenoura group. The Goshonoura group is well developed in Goshonoura-jima in Kumamoto Pref. and Shishi-jima in Kagoshima Pref., and its type area is Goshonoura-jima where the group contains a considerable amount of coarse clastic sediments and many molluscan fossils of brackish or paralic and shallow sea nature. On the other hand, the

TABLE 10. The List of Fossil Trigoniids from Yatsushiro district, Higo Prov., Kumamoto Pref., Kyushu.

Horizon / Specific name	Kawaguchi formation				Hachiryuzan formation		Hinagu formation				Yatsushiro formation			Tomochi formation			
	Bas.	Low.	Mid.	Up.	Low.	Up.	Bas.	Low.	Mid.	Up.	Low.	Mid.	Up.	Bas.	Low.	Mid.	Up.
Nipponitrigonia kikuchiana									×			×			×		
N. k. var. *plicata*					×							×			×		
N. quadrata												×					
Rutitrigonia sanchuensis												×					
Pterotrigonia hokkaidoana					×				×			×			×		
P. (*Rinetrigonia*) spp.									×								
Acanthotrigonia ogawai															×		

TABLE 11. The List of Fossil Trigoniids from the Cretaceous formations in Goshonoura-jima, Amakusa-gun, Higo Prov., Kumamoto Pref., Kyushu.

Horizon / Specific name	Goshonoura Group										Himenoura Group		
	Lower formation		Middle formation					Upper formation			Lower formation	Middle formation	Upper formation
	a	b	a	b	c	d	e	a	b	c			
Nipponitrigonia kikuchiana			×	×									
Apiotrigonia minor												×	×
Ap. obliquecostata													×
Pterotrigonia hokkaidoana			×	×			×						
P. sakakurai			×	×	×		×			×			
P. (*Rinetrigonia*) *yeharai*, n. sp.				×									
Scabrotrigonia obsoleta				×									
Acanthotrigonia dilapsa			×	×			×						
Ac. ogawai			×	×			×						
Ac. pustulosa			×	×			?						

Himenoura group overlied conformably on the Goshonoura group, is characterized by the predominance of marine shale which contains Ammonoids and Inoceramids etc.

In this island, the stratigraphy of the Cretaceous starata surveyed by MATUMOTO (1938) are summarized as follows:

Himenoura group		Upper member (300m.±)	Sandy shale with thin fine-grained sandstone layers at several horizons, containing *Inoceramus, Gaudryceras, Polyptychoceras, Texanites* etc. (×).
		Middle member (60–75m.)	Massive, bluish-grey, fine-grained sandstone, containing *Inoceramus, Gaudryceras, Polyptychoceras* etc. (×).
		Lower member (20–50m.)	Conglomerate and sandstone.
conformity			
Goshonoura group	Upper formation (Deltaic deposits)	IIIc member (60m.±)	Coarse- to medium-grained sandstone with thin sandsy shale layers, containing marine fossils (×).
		IIIb member (90m.±)	Coarse- to fine-grained sandstone with red shale layers at some places.
		IIIa member (50m.±)	Coarse-grained, cross-laminated sandstone.
	Middle formation (Shallow sea deposits)	IIe member (120–150m.)	Massive and well-sorted medium-grained sandstone, containing *Desmoceras (Pseudouhligella) japonicum, Marriella, 'Anisoceras'*, Trigoniids etc. (×).
		IId member (50m.±)	Sandstone and sandy shale in alternation, with thin red shale.
		IIc member (60–70m.)	Cross-laminated, coarse-grained sandstone with conglomerate (×).
		IIb member (180–200m.)	Greenish or bluish, silty, medium- to fine-grained sandstone, containing *Desmoceras kossmati, Baculites, Inoceramus* aff. *anglicus*, Trigoniids etc.(×).
		IIa member (100m.±)	Conglomerate, conglomeratic and coarse-grained sandstone (×).
	Lower formation (Deltaic foreset deposits)	Ib member (80m.±)	Conglomeratic to fine-grained sandstone with sandy shale
		Ia member (120m.±)	Conglomerate, conglomeratic and coarse-grained sandstone with red shale beds at some places.

Since 1954, the writer had visited occasionally to this region and engaged in collection work of fossil Trigoniids. So, the palaeontological and stratigraphical data for Trigoniids were fairly accumulated at late some years. A great number of Trigoniid specimens occur in the middle formation of the Goshonoura group. As already pointed out by MATUMOTO (1938), IIb and IIe member consist mainly of dark greenish to bluish, silty, medium- to fine-grained sandstone and sometimes with thin conglomerate layers at several horizons. In these members, Trigoniids are associated usually with *Cucullaea, Glycymeris, Inoceramus, Pholadomya, Cercomya, Anthonya*, Ammonoids, *Archaeozostera* (*?*) etc. On the other hand, IIa, IIc, and IId members are composed mainly of coarse-grained sandstone and conglomerate, and cross-bedding and contemporaneous erosions are sometimes well observed. Fossil Trigoniids are very rare in these members, but rather common in the medium sandstone layers of the IIa member near Momonokisako of the east coast in the island. Trigoniids are accompanied sometimes with *Anomya, Cyprina, Astarte, Cyrena, Pseudasaphis, Aloides,*

"*Cerithium*" etc. It is an interesting fact that *Pterotrigonia sakakurai* (YEHARA) is common in these members and the other forms are fairly rare. Judging from the litho- and bio-facies, IIb and IIe members may be the deposits of the neritic environment, while the others indicates the littoral facies.

On the fossil Trigoniids, it is recognized that *Pterotrigonia sakakurai* (YEHARA) is more abundant in conglomeratic to coarse-grained sandstone than in silty medium-grained sandstone. *Acanthotrigonia pustulosa* (NAGAO) and *Ac. ogawai* (YEHARA) were collected usually from silty medium-grained sandstone, and they are prolific in the upper and the lower of IIb member, respectively. *Nipponitrigonia kikuchiana* (YOKOYAMA) is rather common in IIa member, but rare in IIb. It has hitherto been not known from the IIc to IIe member and the upper formation. *Scabrotrigonia obsoleta* NAKANO and *Pterotrigonia* (*Rinetrigonia*) n. sp. are very rare, and they were collected only from silty medium-grained sandstone layers of IIb member. *Acanthotrigonia dilapsa* (YEHARA) is larger than *Ac. ogawai* (YEHARA) in shell form, and is always associated with the latter. It rarely occurs in silty medium grained sandstone.

On the other hand, *Apiotrigonia minor* (YABE and NAGAO) and *Ap. obliquecostata* NAKANO were collected from medium- to coarse-grained sandstone layers of the Himenoura group in which *Nipponitrigonia* and the Pterotrigoniinae are entirely lacking. *Apiotringonia* are not yet collected from the Goshonoura group.

Good displays of the Himenoura group are, also, well recognized in Amakusa-kamishima, -shimoshima, and Koshiki-jima etc. In Amakusa-kamishima, the writer collected *Apiotrigonia minor* (YABE and NAGAO), *Ap. m.* var. *nankoi* NAKANO, *Ap. obliquecostata* NAKANO, *Ap. obsoleta* NAKANO, and *Heterotrigonia granosa* NAKANO at Wadanohana in Ryugatake-mura. They are associated with *Gaudryceras tenuiliratum* YABE, *Polyptychoceras obstrictum* (JIMBO), *Inoceramus amakusensis* NAGAO et MATUMOTO etc. The geological age may be the upper Urakawan approximately corresponding to the European Santonian.

According to YEHARA (1923a–b), *Trigonia japonica* YEHARA occurred in the Santonian formation near Oe-mura in Amakusa-shimoshima. KOBAYASHI and AMANO (1955) revised this form, and considered that this is a varietal form of *Steinmannella* (*Yeharella*) *japonica* (YEHARA). In the vicinity of Noriden, Miyanokouchi-mura in Amakusa-shimoshima, the writer (1957a) collected *Apiotrigonia postonodosa* NAKANO accompanying with *Inoceramus balticus* BOEHM and others. This species is characterized and abundant in the lower half of the Izumi group in Awaji-island.

Recently, the writer visited to Koshiki-jima in Kagoshima Pref., and obtained *Apiotrigonia tuberculata* NAKANO, *Microtrigonia amanoi* NAKANO, and *Steinmannella* (*Yeharella*) *japonica* var. *obsoleta* KOBAYASHI and AMANO. The latest one occurred in the Taira formation probably uppermost Urakawan (lower Campanian). The others are collected from the Imuta formation, and they are associated with lower Hetonaian *Inoceramus balticus* BOEHM, *In. ezoensis* YOKOYAMA, and *Glyptoxoceras* sp. etc.

Mitsuo NAKANO

IV. FAUNAL SIGNIFICANCE OF THE CRETACEOUS TRIGONIIDS IN THE JAPANESE ISLANDS

1. Outline of the Geographical and Geological Distributions of the Trigoniidae

Already pointed out by several authors, it is probable that the Mesozoic Trigoniids were derived polyphyletically from some forms of the Myophoriids in the Middle to the Upper Triassic. In the Triassic, 6 genera of the Trigoniids, differing remarkably in surface costation, were reported from various places of the world.

The Minetrigoniinae KOBAYASHI, 1954 having cancellate costation on the flank, includes *Minetrigonia* KOBAYASHI and KATAYAMA, 1938 and *Myophorigonia* COX, 1952. They are typified respectively by *Trigonia hegiensis* SAEKI, 1925 from the Carnian in Kyoto Pref. of Japan and *Myophoria paucicostata* JAWORSKI (1922, p. 126, pl.5, figs.9-11) from the Upper Triassic of Peru, and inhabited mainly in the Arcto-Pacific region of the Upper Triassic. Some forms of *Myophorigonia*, i. e. *Trigonia parcinoda* LYCETT (1872, p. 46, pl. 36, fig. 8, text-fig.) and *Myophoria* sp. by KRUMBECK (1905, p. 114, pl.12, fig. 4) are, however, known from the Inferior Oolite of England and from the Upper Jurassic limestone of Syria, respectively. The Prosogyrotrigoniinae KOBAYASHI, 1954 characterized by the presence of a weak marginal carina and concentric costation on the flank, comprises *Prosogyrotrigonia* KRUMBECK, 1924 and *Prorotrigonia* COX, 1952. The former typified by *Prosogyrotrigonia timorensis* KRUMBECK, flourished in the Upper Triassic of Indonesia and Indo-China, but a single species, *Trigonia inouyei* YEHARA (1921, p.8, pl. 15, figs. 1-2), occurred in the Lias of Yamaguchi Pref., Southwest Japan. The latter is monotypic and typified by *Trigonia seranensis* KRUMBECK (1923, p. 211, pl. 4, figs. 4-8) from the Upper Triassic of Ceram.

As already mentioned by KOBAYASHI (1954), it is probable that the almost of the Mesozoic Trigoniids flourished in the Jurassic to the Cretaceous were derived from Kobayashi's Trigoniinae which are main Trigonian trunk whence several branches issued. As already discussed by Kobayashi and Mori (1955), the sculptures on the flank and the area and the shell form are variable in this subfamily. It is an important fact that the obsoletion of the carinae and the surface costation and the complication of the ornamentation are observed in each genus and species of the subfamily. The area is, however, ornamented with radial or transverse costellae which are sometimes evanescent in the later stages. With reference to the sculpture on the area, Kobayashi's Trigoniinae can be separable into two groups called the Trigoniinae em. and the Frenguelliellinae nov. Trigoniinae em. and Frenguelliellinae nov. have morphologically some resemblances with each other, except the costation on the area. The area of the former is radially costellate but sometimes evanescent in the later stages. On the other hand, the latter has a transversely or concentrically costellate area on which costation is often obsolete later. They are typified respectively by *Trigonia* BRUGIÈRE, 1789 and *Frenguelliella* LEANZA, 1942. The former is a long ranged genus, the oldest of which is *Trigonia* (*Trig.*) *tabacoensis* BARTHEL (1958, pp. 353-356, pl.

19, figs.1-8, text-fig. 1) from the possibly middle or even lower Anisian formation of Chile. The latter is a cosmopolitan and persistent genus from the Upper Triassic to the Upper Cretaceous, and its earliest representative is *Frenguelliella* (*Kumatrigonia*) *tanourensis* TAMURA (1959, pp. 213–215, pl. 2, figs. 1—6, text-fig. 2) from the Carnian of Kumamoto Pref., Kyushu, Japan. Trigoniinae em. flourished in the Middle Jurassic to the Lower Cretaceous of cosmopolitan and a number of interesting derivatives were issued from the main trunk. The Jurassic derivatives including *Indotrigonia* DIETRICH, 1933, *Eselaevitrigonia* KOBAYASHI and MORI, 1954, and *Opisthotrigonia* Cox, 1952, appeared and were prolific in the Upper Jurassic of India, but the former two continued into exist till the Lower Cretaceous of South Africa and the "Middle Cretaceous" of New Zealand, respectively. The Cretaceous ones inhabited and flourished in the Pacific sides, though *Sphenotrigonia frommurzei* (RENNIE) and *Pleurotrigonia blanckenhorni* (NEWTON) are known from the Neocomian and the Albian of South Africa, respectively. It is an interesting fact that the Upper Cretaceous derivatives or representatives of the subfamily, such as, *Pacitrigonia*, *Heterotrigonia* and others, were restricted to the Pacific sides and they were especially abundant in the Southern Pacific region (See Pls. 25–27).

On the other hand, Frenguelliellinae nov. were very abundant in the Jurassic of Europe and Japan, but lacking in the Jurassic of North America. This subfamily declined in the Cretaceous but the Senonian forms are known only from India. *Nipponitrigonia* and *Rutitrigonia* are the smooth Trigoniids belonging to this subfamily. The former was prolific in the Lower to the "Middle" Cretaceous of Japan, but the latter was abundant and widely distributed in the Lower to the "Middle" Cretaceous of cosmopolitan except for the austral region.

The Myophorellinae KOBAYASHI, 1954 flourished in the Upper Jurassic when all genera and subgenera of the subfamily were existent, but this subfamily hitherto been undiscovered from India. This subfamily fell off in the Cretaceous. *Linotrigonia* van HOEPEN, 1929 and *Oistotrigonia* Cox, 1952 are the members of the subfamily, and have the obliquely costellate area. They appeared propably from the Upper Jurassic of Japan, flourished in the "Middle" to the Upper Cretaceous except for Japan.

The Vaugoniinae KOBAYASHI, 1954 appeared in the Hettangian from Japan and survived into till the Upper Cretaceous. The strongly carinate genera of the subfamily, such as, *Vaugonia* s. l. and *Orthotrigonia* etc., prospered and were prolific in the Middle to Upper Jurassic, but declined already in the Cretaceous. In the Cretaceous, the other genera of the subfamily having no strong carinae, i. e. *Apiotrigonia*, *Buchotrigonia* etc., appeared and flourished. *Apiotrigonia* Cox, 1952 inhabited in the upper Albian (?) to the Maestrichtian of the Northern Pacific, Turkestan and Western Europe and *Buchotrigonia* DIETRICH, 1938 were common in the Cretaceous of Spain, Gulf region, and South America. The distributions of the other Cretaceous genera of the subfamily were limited to the narrow regions, and they were absent in the Cretaceous of the Indo-African region.

Megatrigoniinae van HOEPEN 1929, Pterotrigoniinae van HOEPEN 1929, and Quad-

ratotrigoniinae SAVELIEV, 1958 em. appeared in the Upper Jurassic and flourished in the Cretaceous. The former one including *Megatrigonia* van HOEPEN 1929 and *Iotrigonia* van HOEPEN, 1929 were the most abundant in the Upper Jurassic to Lower Cretaceous of South Africa, South America, and India etc. Some forms of *Iotrigonia* are, however, known from the "Middle Cretaceous" of North America, South Africa, Europe, Turkestan and others, but absent in Japan. The latter two subfamilies were very abundant and widely distributed in the all stages of the Cretaceous in the world, but they were rare in the austral region. Pterotrigoniinae most prospered in the "Middle Cretaceous" but declined in the Upper Cretaceous when the members of the subfamily were survived in Europe, Asia Minor, North America, and austral region. Quadratotrigoniinae em. comprises *Quadratotrigonia* s.l. and *Steinmannella* s.l., etc. The former were prolific in Europe from the Lower to "Middle" Cretaceous. While, the latter flourished in the other regions from the Lower to the Upper Cretaceous. The Upper Cretaceous representatives were limited to occur in the Northern Pacific.

In the Cenozoic, the Trigoniidae have been only found from Australia where the Neotrigoniinae KOBAYASHI, 1954 including *Neotrigonia* COSSMANN, 1912 and *Eotrgonia* COSSMANN, 1912 are well known. The latter ranges from the Eocene to the lower Miocene, but the former is upper Miocene to Recent.

2. Brief Notes of the Rise and the Fall of the Mesozoic Trigoniids in the Japanese Islands

A great number of Trigoniid specimens have been collected and reported by many authors from various localities and horizons of the Mesozoic areas in the Japanese Islands. Now, the Mesozoic Trigoniids are classified into 79 species and 10 subspecies in 21 genera in addition to 7 subgenera in 8 subfamilies. (See Tab. 12)

Some forms, i. e. *Pterotrigonia hokkaidoana* (YEHARA), *Apiotrigonia minor* (YABE and NAGAO), *Nipponitrigonia sagawai* (YEHARA) and others, have the broad distributions, while the most others of Trigoniid are restricted to occur in the narrow areas. This fact suggests that Trigonian-lives were controled strongly by the environments of the sedimentary basins in the Mesozoic time. Still more, the vertical distributions of them were fairly short in many common forms, but the widely spread species, such as, *Nipponitrigonia sagawai* (YEHARA), *N. kikuchiana* (YOKOYAMA), *Vaugonia niranohamensis* KOBAYASHI and MORI, *Apiotrigonia minor* (YABE and NAGAO), and *Pterotrigonia hokkaidoana* (YEHARA) etc., had somewhat long ranges.

In Japan, the Trigoniids appeared in the Carnian and they continued into exist till the late Cretaceous. They flourished and were prolific in the Jurassic to the Cretaceous, but they have hitherto been undiscovered from the Cenozoic formations.

In the Triassic, the following forms are known:

Subfamily Minetrigoniinae KOBAYASHI, 1954
Genus *Minetrigonia* KOBAYASHI and KATAYAMA, 1938
Trigonia hegiensis SAEKI, 1925
Trigonia (*Minetrigonia*) *katayamai* KOBAYASHI and ICHIKAWA, 1949

Minetrigonia katayamai obsoleta NAKAZAWA, 1956
Subfamily Frenguelliellinae nov.
Genus *Frenguelliella* LEANZA, 1942
Frenguelliella (*Kumatrigonia*) *tanourensis* TAMURA, 1959

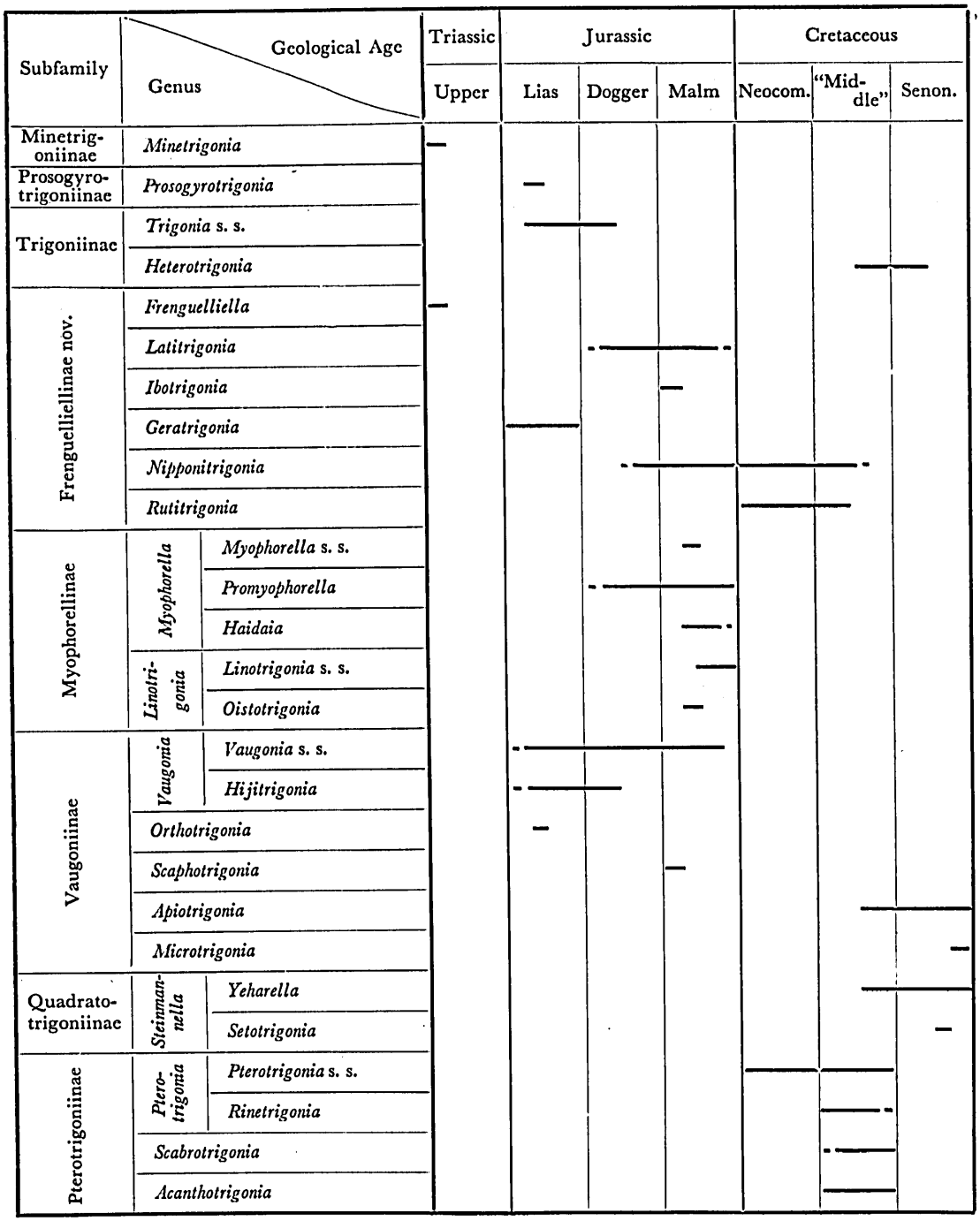
Trigonia hegiensis is the type species of *Minetrigonia* which inhabited in the Upper Triassic of the Pacific sides, such as New Zealand, Chile, Peru, British Columbia etc. This form and *katayamai obsoleta* are reported from the Carnian of Heki and Nabae districts in Kyoto Pref. *Katayamai* is well known in the Carnian formations of Kyowa district in Nariwa region of Okayama Pref., Mine district in Yamaguchi Pref., and Sakuradani and Sakawa districts in Shikoku. *Tanourensis* is the earliest representative of *Frenguelliella* ranging from the Carnian to the Senonian. In Northeast Japan, the Upper Triassic Trigoniids have hitherto been unknown, though *Minetrigonia* and *Frenguelliella* occur in several places of Southwest Japan. In the Triassic, the Trigoniid fauna was probably related to that of the Arcto-Pacific region by the occurrence of *Minetrigonia.*

As already discussed by KOBAYASHI and co-workers (1959), a number of Trigoniids are known from the Jurassic of Japan and they consist of 38 species and 3 subspecies in 11 genera in addition to 4 subgenera in 4 subfamilies.

They are as follows:

Subfamily Prosogyrotrigoniinae KOBAYASHI, 1954
Genus *Prosogyrotrigonia* KRUMBECK, 1924
Trigonia inouyei YEHARA, 1921
Subfamily Trigoniinae KOBAYASHI, 1954 em.
Genus *Trigonia* BRUGUIÈRE, 1789
Trigonia senex KOBAYASHI and MORI, 1954
Trigonia (*Lyriodon*) *sumiyagura* KOBAYASHI and KASENO, 1947
Subfamily Frenguelliellinae nov.
Genus *Latitrigonia* KOBAYASHI, 1957
Latitrigonia orbicularis KOBAYASHI, 1957
Latitrigonia pyramidalis KOBAYASHI and TAMURA, 1957
Latitrigonia tetoriensis KOBAYASHI, 1957
Latitrigonia unicarinata KOBAYASHI and TAMURA, 1957
Latitrigonia unituberculata KOBAYASHI and TAMURA, 1957
Genus *Ibotrigonia* KOBAYASHI, 1957
Ibotrigonia masatanii KOBAYASHI and TAMURA, 1957
Genus *Geratrigonia* KOBAYASHI, 1954
Trigonia hosourensis YOKOYAMA, 1904
Geratrigonia hosourensis var. *convexa* KOBAYASHI, 1954
Geratrigonia kurumensis KOBAYASHI, 1957
Geratrigonia lata KOBAYASHI, 1954
Genus *Nipponitrigonia* COX 1952
Trigonia sagawai YEHARA, 1926
Subfamily Vaugoniinae KOBAYASHI, 1954
Genus *Vaugonia* CRICKMAY, 1930
Subgenus *Vaugonia* s. s.
Vaugonia awazuensis KOBAYASHI, 1957
Vaugonia kodaijimensis KOBAYASHI and MORI, 1955
Vaugonia namigashira KOBAYASHI and MORI, 1955

TABLE 12. Geological Ranges of the Mesozoic Trigoniids in the Japanese Islands.



Vaugonia niranohamensis KOBAYASHI and MORI, 1955
Vaugonia yambarensis KOBAYASHI, 1956
Vaugonia yokoyamai KOBAYASHI and MORI, 1955
Vaugonia yokoyamai forma *gracillis* KOBAYASHI and MORI, 1955
Subgenus *Hijitrigonia* KOBAYASHI, 1955
Vaugonia (*Hijitrigonia*) *geniculata* KOBAYASHI and MORI, 1955
Vaugonia (*Hijitrigonia*) *kojiwa* KOBAYASHI and MORI, 1955
Genus *Orthotrigonia* COX, 1952
Orthotrigonia corrugata KOBAYASHI and MORI, 1955
Orthotrigonia midareta KOBAYASHI and MORI, 1955
Genus *Scaphotrigonia* DIETRICH, 1933
Scaphotrigonia somensis KOBAYASHI and TAMURA, 1957
Subfamily Myophorellinae KOBAYASHI, 1954
Genus *Myophorella* BAYLE, 1878
Subgenus *Myophorella* s. s.
Myophorella (*Myophorella*) *dekaiboda* KOBAYASHI and TAMURA, 1955
Subgenus *Promyophorella* KOBAYASHI and TAMURA, 1955
Myophorella (*Promyophorella* ?) *hashimotoi* KOBAYASHI, 1956
Myophorella (*Promyophorella* ?) *imamurai* KOBAYASHI, 1956
Myophorella (*Promyophorella*) *sigmoidalis* KOBAYASHI and TAMURA, 1955
Myophorella (*Promyophorella*) *sugayensis* KOBAYASHI and TAMURA, 1955
Myophorella (*Promyophorella*) *sugayemsis* var. *geniculata* KOBAYASHI and TAMURA, 1955
Myophorella (*Promyophorella*) *obsoleta* KOBAYASHI and TAMURA, 1955
Myophorella (*Promyophorella*) *orientalis* KOBAYASHI and TAMURA, 1955
Subgenus *Haidaia* CRICKMAY, 1930
Myophorella (*Haidaia*) *crenulata* KOBAYASHI and TAMURA, 1955
Myophorella (*Haidaia*) *crenulata* var. *lunulata* KOBAYASHI and TAMURA, 1955
Myophorella (*Haidaia*) *gracilenta* KOBAYASHI, 1956
Myophorella (*Haidaia*) *ohmachii* TAMURA, 1959
Myophorella (*Haidaia*) *subcircularis* KOBAYASHI and TAMURA, 1955
Myophorella (*Haidaia*) *pulex* TAMURA, 1959
Genus *Linotrigonia* van HOEPEN, 1929
Subgenus *Linotrigonia* s. s.
Trigonia toyamai YEHARA, 1923
Subgenus *Oistotrigonia* COX, 1952
Oistotrigonia prima KOBAYASHI and TAMURA, 1955

Among them, Infra-Hettangian *Geratrigonia*, a genus of Frenguelliellinae nov., is the oldest and peculiar form and its type species is *Trigonia hosourensis* YOKOYAMA (1904, pl. 1, figs. 3a-c) from the Niranohama formation of Shizukawa district in Miyagi Pref. This genus survived till the upper Lias of the Kuruma group in Central Japan. *Latitrigonia* and *Ibotrigonia* are two aberrant genera from the Bajocian to the Tithonian in Eurasia or Japan, are probably the derivatives from *Frenguelliella*. *Nipponitrigonia* typified by *Trigonia kikuchiana* YOKOYAMA from the Cretaceous of Shikoku, is a smoothened genus of Frenguelliellinae nov., ranging from the Bathonian (?) to the Cenomanian of Japan and the Neocomian (?) of Phillippine. Jurassic *sagawai* is a single representative of the genus. *Prosogyrotrigonia* is well represented in the Upper Triassic of Indonesia and Indo-China, but in Japan a single form of the genus, i. e. *Trigonia inouyei* YEHARA, occurs in the Liassic Higashinagano formation in Yamaguchi Pref. *Trigonia* s. s. is rare in the Jurassic of the Northern Pacific, although

they are abundant in the Middle to the Upper Jurassic of Europe. *Trigonia senex* KOBAYASHI and MORI and *Trigonia sumiyagura* KOBAYASHI and KASENO were two representatives of the genus, and were collected respectively from the Hettangian and the Bajocian of Kitakami region. (See Pl. 28)

Vaugonia s. s. appeared in the Hettangian from Japan, and flourished in the Lower to the Middle Jurassic of cosmopolitan, especially European region, but declined suddenly in the Neocomian when *Trigonia progonos* PAULCKE and others are known as the relics. In Japan, *Vaugonia* s.s. is common in the Lower to the Middle Jurassic but in the Upper Jurassic Kimmeridgian *Vaugonia yambarensis* KOBAYASHI is collected only from the Yambara formation of Kuzuryu district in Central Japan. *Hijitrigonia* of *Vaugonia* is characterized by the geniculate costation on the flank, and is known in the Lower to the Middle Jurassic of Japan. The character of the subgenus is recognized in some forms, i. e. *Trigonia litterata* YOUNG and BIRD and *Trigonia lycetti* GOTTSCHE etc., from the Lower to the Middle Jurassic of Europe and South America. *Orthotrigonia* is well known in the Dogger to the Malm of Europe and India, but a solitary form, i. e. *Clavotrigonia discordans* HENNIG, is collected from the Neocomian of Tendaguru district, Southeast Africa. In Japan it is represented by two species from the Hettangian of Shizukawa district in Miyagi Pref., Northeast Japan. *Scaphotrigonia* is a peculiar genus which inhabited mainly from the upper Lias to the Turonian (?) of Europe, but a single form, i. e. *Trigonia naviformis* HYATT is reported from the Upper Jurassic of California. Callovian Yamagami formation of Soma district in Northeast Japan produces *Scaphotrigonia somensis* KOBAYASHI and TAMURA.

On the other hand, in Japan *Myophorella* s. l. ranges from the Bajocian to the Tithonian, though in Europe and South America the genus is known from the Lias to the Neocomian. *Myophorella* (*Promyophorella*) *sigmoidalis* KOBAYASHI and TAMURA is the oldest of the genus in Japan, and were collected from the Bajocian Aratozaki sandstone of Shizukawa region, Miyagi Pref., Northeast Japan. This genus developed explosively in the Upper Jurassic when a number of species and varieties were existent in the rocks from Northeast Japan to Southwest Japan. *Haidaia* CRICKMAY, 1930 is a characteristic form of the Middle Jurassic to the Neocomian in Pacific regions, while *Myophorella* s. s. flourished in the Upper Jurassic of Europe. *Linotrigonia* s. l. appeared probably in the Kimmeridgio-Oxfordian from Japan, and they prospered in the Cretaceous of the world excluding Japan.

As mentioned before, the Japanese Upper Jurassic is characterized by the abundant Myophorellinae, while Vaugoniinae rich in the Lower to the Middle Jurassic. *Geratrigonia*, *Prosogyrotrigonia*, and *Orthotrigonia* are known only from the Lower Jurassic. On the fossil contents, the Lower to the Middle Jurassic of Japan may be connected to European region by the abundant occurrence of the Vaugoniinae among which *Hijitrigonia* plus *Orthotrigonia* fauna is restricted to occur in Eurasia, while the Upper Jurassic is probably related to North America by the occurrence of *Haidaia* which is characteristic and flourished in the Upper Jurassic of the Pacific regions.

In the Cretaceous, a number of Trigoniids are also collected and reported from

various horizons and localities from Western Kyushu to Sachalin and they are classified into 39 species and 5 subspecies in 8 genera in addition to 3 subgenera in 5 subfamilies. As compared with the Jurassic fauna, the Cretaceous is characterized by the presence of the Pterotrigoniinae, Quadratotrigoniinae, *Rutitrigonia*, *Apiotrigonia*, *Heterotrigonia* etc. and the absence of the strongly carinate Trigoniids, such as, *Trigonia* s. s., *Vaugonia* s. l., *Myophorella* s. l. etc., though *Nipponitrigonia* is common in the both periods.

Generally speaking, Neocomian is characterized by the occurrence of several forms of *Pterotrigonia* s. s., *Rutitrigonia*, and *Nipponitrigonia*, while *Steinmannella* s. l., *Apiotrigonia* and others flourished in the Senonian s. l. The Cretaceous Trigoniids prospered and were prolific in the Aptian to the Turonian, i. e. so-called "Middle Cretaceous," when a number of species and genera were existent. *Scabrotrigonia* and *Acanthotrigonia* are the most characteristics in the "Middle Cretaceous," and they were associated with the members of *Nipponitrigonia*, *Rutitrigonia*, and *Pterotrigonia* s. l. In the Gyliakian (Cenomanian-Turonian) of the "Middle Cretaceous," the fossil contents of Trigoniids were somewhat different between the Yezo geosynclinal region and Japan proper, especially Southwest Japan, because *Apiotrigonia*, *Heterotrigonia*, and *Steinmannella* (*Yeharella*) are known in the former region but lacking in the latter. (See Tab. 13)

3. Cretaceous Trigoniid Fauna in the Japanese Islands

3a. Summarized Classification and List of Localities of the Cretaceous Trigoniids in the Japanese Islands

As already discussed before, a number of Trigoniids were collected and reported from various localities and horizons from Sachalin to Kyushu and they are classified and summarized as follws:

Subfamily Trigoniinae KOBAYASHI, 1954 em.

Genus *Heterotrigonia* COX, 1952

1. *Heterotrigonia granosa* NAKANO, 1957. Middle Himenoura group (Santonian) at Wadanohana, Ryugatake-mura, Amakusa-gun, Higo Prov., Kumamoto Pref.
2. *Trigonia subovalis* JIMBO, 1894. "*Trigonia* Sandstone" (Cenomanian-Turonian) of Ikushumbetsu district in Mikasa-city, Central Hokkaido; Urakawan formation (Coniacian-lower Campanian) from South Sachalin.

Subfamily Frenguelliellinae nov.

Genus *Nipponitrigonia* COX, 1952

3. *Trigonia kikuchiana* YOKOYAMA, 1891. Ryoseki formation (lower Neocomian) at Yamanokami of Nagano near Sakawa-machi in Tosa Prov., Kochi Pref.; Aritan formation (upper Neocomian) from Shingai near Tosa-Yamada in Tosa Prov. of Kochi Pref., the vicinity of Yuasa-machi in Kii Prov. of Wakayama Pref., the vicinity of Ohinata, Saku-machi, Minamisaku-gun, Shinano Prov., Nagano Pref., and (?) Ofunato district of Rikuzen Prov. in Iwate Pref.; Miyako series (Aptian-Albian) from the Yatsushiro district in Higo Prov. of Kumamoto Pref., (?) Kikunodani in Kurosegawa-mura near Uwajima-city of Iyo Prov. in Ehime Pref., Katsuuragawa basin of Awa Prov. in Tokushima Pref., the vicinities of Sakawa and Ryoseki-Monobegawa basins of Tosa Prov. in Kochi Pref., Yuasa region of Kii Prov. in Wakayama Pref., Todai district in

Akaishi mountainland of Central Japan, Choshi peninsula in Choshi-city of Kazusa Prov. in Chiba Pref., and Miyako area of Rikuchu Prov. in Iwate Pref.; lower Gyliakian (Cenomanian) from Goshonoura-island and Yatsushiro district of Higo Prov., Kumamoto Pref.

4. *Nipponitrigonia kikuchiana* var. *plicata* KOBAYASHI and NAKANO, 1958. Upper Neocomian near Yuasa-machi of Kii Prov. in Wakayama Pref. and at Shimofukamizu, Shimomatsukuma-mura, Yatsushiro-gun, Higo Prov., Kumamoto Pref.; Aptian lower Hoji formation at Yanagidani in Katsuuragawa basin of Awa Prov. in Tokushima Pref.; Albian Yatsushiro formation at Shimofukamizu in Shimomatsukuma-mura near Yatsushiro-city of Higo Prov. in Kumamoto Pref.; Cenomanian Tomochi formation at Naraki near Yatsushiro-city of Higo Prov. in Kumamoto Pref.
5. *Trigonia naumanni* YEHARA, 1923. Lower Neocomian at Yamanokami of Nagano near Sakawa-machi of Tosa Prov. in Kochi Pref.; upper Neocomian at Shingai near Tosa-Yamada of Tosa Prov. in Kochi Pref. and Yuasa region of Kii Prov. in Wakayama Pref.; Miyakoan (Aptian-Albian) at Soyama, Nishitani and Hagino in Ryoseki-Monobegawa basin and Hirano and Sendatsuno near Ochi-machi in Sakawa basin of Tosa Prov. in Kochi Pref., (?) Kikunodani in Kurosegawa-mura near Uwajima-city of Iyo Prov. in Ehime Pref., at Yanagidani in Katsuuragawa basin of Awa Prov. in Tokushima Pref., at Todai in Shinano Prov. of Nagano Pref., and (?) at Shakain, Kuriki-mura, Yatsushiro-gun, Higo Prov., Kumamoto Pref.
6. *Nipponitrigonia quadrata* KOBAYASHI and NAKANO, 1958. Albian Yatsushiro formation at Shimofukamizu, Shimomatsukuma-mura, Yatsushiro-gun, Higo Prov., Kumamoto Pref.
7. *Trigonia sakamotoensis* YEHARA, 1921. Hoji formation (Aptian-Albian) at Sakamoto in Katsuuragawa basin, Awa Prov., Tokushima Pref.; (?) Miyanohara sandstone (Cenomanian) at Miyanohara near Ochi-machi in Sakawa basin, Tosa Prov., Kochi Pref.

Genus *Rutitrigonia* van HOEPEN, 1929

8. *Psilotrigonia sanchuensis* NAKANO, 1957. Upper Neocomian Ishido formation at Ishido, Ohinata, Saku-machi, Minamisaku-gun, Shinano Prov., Nagano Pref.; Albian Yatsushiro formation at Shimofukamizu, Shimomatsukuma-mura, Yatsushiro-gun, Higo Prov., Kumamoto Pref.
9. *Rutitrigonia yeharai* KOBAYASHI, 1957. (= *Trigonia neumayri* YEHARA, 1923b) Lower Neocomian Ryoseki formation at Yamanokami of Nagano near Sakawa-machi, Tosa Prov., Kochi Pref.; Ishido formation (upper Neocomian) at Ishido, Ohinata, Saku-machi, Minamisaku-gun, Shinano Prov., Nagano Pref.

Subfamily Vaugoniinae KOBAYASHI, 1954

Genus *Apiotrigonia* COX, 1952

10. *Apiotrigonia crassoradiata* NAKANO, 1957. Basal conglomerate and sandstone member (Campanian) of the Izumi group (upper Campanian-Maestrichtian) at Aonami of Yuyama-machi in Matsuyama-city, Iyo Prov., Ehime Pref.
11. *Apiotrigonia minor* var. *nankoi* NAKANO, 1957. Santonian Middle Himenoura group at Wadanohana, Ryugatake-mura, Amakusa-gun, Higo Prov., Kumamoto Pref.; Campanian formation from Mutsuo of Shintachi-machi in Izumi-Sano-city, Izumi Prov., Osaka Pref., in the vicinity of Hiketa-machi, Okawa-gun, Sanuki Prov., Kagawa Pref., and at Miyakura near Tokushima-city, Awa Prov., Tokushima Pref.; Campanian-Maestrichtian formations from Awaji-island, Awaji Prov., Hyogo Pref.
12. *Apiotrigonia obliquecostata* NAKANO, 1957. Middle Himenoura group (Santonian) at Wadanohana, Ryugatake-mura, Amakusa-gun, Higo Prov., Kumamoto Pref.
13. *Apiotrigonia obsoleta* NAKANO, 1957. Santonian formation at Wadanohana, Ryugatake-mura, Amakusa-gun, Higo Prov., Kumamoto Pref,; Minato and Shichi shale formations of the Izumi group (Campanian-Maestrichtian) in Awaji-Island, Awaji Prov., Hyogo Pref.
14. *Apiotrigonia postonodosa* NAKANO, 1957. Campanian formation in Awaji-island, Awaji Prov., Hyogo Pref., Hiketa-machi in Sanuki Prov. of Kagawa Pref., and in the vicinity of Noriden, Miyanokouchi-mura, Amakusa-gun, Higo Prov., Kumamoto Pref.
15. *Trigonia subovalis* var. *minor* YABE and NAGAO, 1925 (= *Apiotrigonia minor*). Gyliakian (Cenomanian-Turonian) formations in the vicinities of Ikushumbetsu and Yubari coal-fields of Central Hokkaido and the Werblude group in Alexandrovsk region of North Sachalin; lower Urakawan

(Coniacian) formations from Hoé-river region of South Sachalin, Oriki of Hirono-machi, Futaba-gun, Iwaki Prov., Fukushima Pref., and Uwajima-city area of Iyo Prov. in Ehime Pref.; upper Urakawan (Santonian) formation at Wadanohana, Ryugatake-mura, Amakusa-gun, Higo Prov., Kumamoto Pref., uppermost Urakawan to Hetonaian formations (Campanian-Maestrichtan) from Miyakura near Tokushima-city of Awa prov. in Tokushima Pref. and Hetonai district of Iburi Prov. in Central Hokkaido.

16. *Apiotrigonia tuberculata* NAKANO, 1957. Shich shale (uppermost Campanian or lowest Maestrichtian) of the Izumi group at Hanzanji of Shichi-mura in Awaji Prov. and Shimokoshiki-island, Satsuma Prov., Kagoshima Pref.
17. *Apiotrigonia undulosa* NAKANO, 1957. Lower Urakawan (Coniacian) at Taikorin of Oriki in Hirono-machi, Futaba-gun, Iwaki Prov., Fukushima Pref. and in the vicinity of Inukai-machi, Ono-gun, Bungo Prov., Oita Pref.

Genus *Microtrigonia* NAKANO, 1957

18. *Microtrigonia amanoi* NAKANO, 1957. Hetonaian formation (uppermost Campanian or Maestrichtian) in Shimokoshiki-island, Satsuma Prov., Kagoshima Pref.
19. *Microtrigonia minima* NAKANO, 1957. Shichi shale (uppermost Campanian or lowest Maestrichtian) and Kitaama sandstone (lowest Maestrichtian) of the Izumi group in Awaji-island, Awaji Prov., Hyogo Pref.

Subfamily Quadratotrigoniinae SAVELIEV, 1958 em.

Genus *Steinmannella* CRICKMAY, 1930

Subgenus *Yeharella* KOBAYASHI and AMANO, 1955

20. *Trigonia ainuana* YABE and NAGAO, 1925. "*Trigonia* Sandstone" (Cenomanian-Turonian) in Ikushumbetsu and Yubari coal-fields in Central Hokkaido.
21. *Trigonia deckeina* KUBOTA, 1952. Upper Hetonaian (Maestrichtian) Yasukawa group from Abeshinai district, Teshio Prov., Northern Hokkaido.
22. *Trigonia japonica* YEHARA, 1923. Basal member of the Izumi group at Kitadani of Omi-mura in Sanuki Prov., Kagawa Pref. and at Aonami of Yuyama-machi in Matsuyama-city, Iyo Prov., Ehime Pref.
23. *Steinmannella* (*Yeharella*) *japonica* var. *obsoleta* KOBAYASHI and AMANO, 1955. Santonian formation from Oe-mura in Amakusa-shimoshima, Higo Prov., Kumamoto Pref.; upper Campanian formation in Shimokoshiki- and Taira-islands of Satsuma Prov., Kagoshima Pref.
24. *Trigonia kimurai* TOKUNAGA and SHIMIZU, 1926. Lower Futaba group (Coniacian) from Oriki, Hirono-machi, Futaba-gun, Iwaki Prov., Fukushima Pref.; basal member of the Izumi group from Aonami in Yuyama-machi, Matsuyama-city, Iyo Prov., Ehime Pref. and the same member at Tsubasayama of Hiketa-machi, Okawa-gun, Sanuki Prov., Kagawa Pref.
25. *Steinmannella* (*Yeharella*) *kimurai sanukiensis* NAKANO, 1958. Basal member of the Izumi group at Kamikashihara, Sogisho-mura, Ayauta-gun, Sanuki Prov., Kagawa Pref.
26. *Steinmannella* (*Yeharella*) *lymani* KOBAYASHI and AMANO, 1955. "*Trigonia* Sandstone" from Ikushumbetsu and Yubari coal-fields of Central Hokkaido and Hoé-river region of South Sachalin.

Subgenus *Setotrigonia* KOBAYASHI and AMANO, 1955

27. *Steinmannella* (*Setotrigonia*) *shinoharai* KOBAYASHI and AMANO, 1955. Basal member of the Izumi group in the vicinity of Tsubasayama in Hiketa-machi, Okawa-gun, Sanuki Prov., Kagawa Pref.

Subfamily Pterotrigoniinae van HOEPEN, 1929

Genus *Pterotrigonia* van HOEPEN, 1929

Subgenus *Pterotrigonia* s. s.

28. *Trigonia brevicula* YEHARA, 1915. Lower "*Trigonia* Sandstone" (Cenomanian) from Ikushumbetsu district in Mikasa-city, Central Hokkaido.
29. *Trigonia datemasamunei* YEHARA, 1915. Miyakoan (Aptian-Albian) series from Miyako district in Rikuchu Prov. of Iwate Pref. and in the vicinity of Sukubo in Kawanobori-mura, Ono-gun, Bungo Prov., Oita Pref.
30. *Trigonia datemasamunei* YEHARA var. by YEHARA 1923b. Upper Gyliakian at Kofuji-mura in

Bungo Prov., Oita Pref.

31. *Trigonia hokkaidoana* YEHARA, 1915. Lower Neocomian (?) in the vicinity of Sebayashi in Nakasato-mura, Tano-gun, Kamitsuke Prov., Gumma Pref.; Upper Neocomian in the vicinity of Yuasa-machi in Kii Prov. of Wakayama Pref., in the vicinity of Toba-city in Ise Prov. of Mie Pref., Sanchu graben in Kwanto mountainland, Oshima district of Rikuzen Prov. in Iwate Pref., and Yatsushiro district of Higo Prov. in Kumamoto Pref.; Miyakoan formation (Aptian-Albian) from Yatsushiro district in Higo Prov. of Kumamoto Pref., Kawanobori area of Bungo Prov. in Oita Pref., Ryoseki-Monobegawa basin of Tosa Prov. in Kochi Pref., Katsuuragawa basin in Awa Prov. of Tokushima Pref., Sanchu graben in Kwanto mountainland, and Miyako district of Rikuchu Prov. in Iwate Pref.; Gyliakian formation (Cenomanian-Turonian) of Goshonoura-island in Higo Prov. of Kumamoto Pref., Miyanohara near Ochi-machi in Sakawa basin of Tosa Prov. in Kochi Pref., Misakubo district of Akaishi mountainland, Ikushumbetsu region of Central Hokkaido, and Alexandrovsk region of North Sachlin.
32. *Trigonia kotoi* YEHARA, 1915. Miyakoan (Aptian-Albian) formation from Miyako district of Rikuchu Prov. in Iwate Pref. and Todai district of Shinano Prov. in Nagano Pref.
33. *Trigonia pocilliformis* YOKOYAMA, 1891. Lower Neocomian (?) in the vicinity of Sebayashi in Nakasato-mura, Tano-gun, Kamitsuke Prov., Gumma Pref.; upper Neocomian from Sakawa and Ryoseki-Monobegawa basins of Tosa Prov. in Kochi Pref., Katsuuragawa area of Awa Prov. in Tokushima Pref., Yuasa region of Kii Prov. in Wakayama Pref., Sanchu graben in Kwanto mountainland, Ofunato and Oshima districts of Rikuzen Prov. in Miyagi Pref.; Miyakoan series from Choshi peninsula in Choshi-city of Kazusa Prov. in Chiba Pref., Sanchu graben in Kwanto montainland, Yuasa district of Kii Prov. in Wakayama Pref., Katsuuragawa region of Awa Prov. in Tokushima Pref., Ryoseki-Monobegawa and Sakawa basins of Tosa Prov. in Kochi Pref., and (?) Kikunodani of Kurosegawa-mura near Uwajima-city of Iyo Prov. in Ehime Pref.
34. *Pterotrigonia pocilliformis* var. *yamanokamiensis* KOBAYASHI and NAKANO, 1957. Lower Neocomian at Yamanokami of Nagano near Sakawa-machi of Tosa Prov., Kochi Pref.; Masakidani formation (Barremio-Valangian) at Okiyadani, Miyahama-mura, Naka-gun, Awa Prov., Tokushima Pref.
35. *Trigonia sakakurai* YEHARA, 1923. Gyliakian formation (Cenomanian-Turonian) from Goshonoura-island, Higo Prov., Kumamoto Pref.
36. *Trigonia yokoyamai* YEHARA, 1915. Miyakoan (Aptian-Albian) formation of Miyako district in Rikuchu Prov. of Iwate Pref.

Subgenus *Rinetrigonia* van HOEPEN, 1929

37. *Pterotrigonia* (*Rinetrigonia*) *yeharai*, sp. nov. Lower member (Cenomanian) of the middle formation of the Goshonoura group at Enokuchi in Goshonoura-island, Higo Prov., Kumamoto Pref.
38. *Pterotrigonia* (*Rinetrigonia* ?) sp. *a* and *b* by KOBAYASHI and NAKANO, 1958. Aptian Hinagu formation in Koda-mura near Yatsushiro-city, Higo Prov., Kumamoto Pref.
39. *Pterotrigonia* (*Rinetrigonia*) sp. nov. Middle Mifune group (Cenomanian) at Miyanomoto, Mifune-machi, Kamimasuki-gun, Higo Prov., Kumamoto Pref.

Genus *Scabrotrigonia* DIETRICH, 1933

40. *Scabrotrigonia imanishii* NAKANO, 1958. Miyakoan (Aptian-Albian) (?) at Horombetsu, Utanobori-mura, Esashi-gun, Kitami Prov., Northern Hokkaido.
41. *Scabrotrigonia kobayashii* NAKANO, 1i958. "*Trigonia* Sandstone" (Cenomanian-Turonian) of Ikushumbetsu district in Mikasa-city, Central Hokkaido.
42. *Scabrotrigonia obsoleta* NAKANO, 1958. Lower member (Cenomanian) of the middle Goshonoura group at Kurosaki and Enokuchi in Goshonoura-island, Higo Prov., Kumamoto Pref.

Genus *Acanthotrigonia* van HOEPEN, 1929

43. *Trigonia dilapsa* YEHARA 1923. Middle formation of the Goshonoura group in Goshonoura-island of Higo Prov. in Kumamoto Pref., (?) Miyanohara sandstone (lower Cenomanian) at Miyanohara near Ochi-machi in Sakawa basin of Tosa Prov. in Kochi Pref., (?) Nagase formation (lower Cenomanian) at Nagase in Monobegawa basin of Tosa Prov. in Kochi Pref., and the Misakubo formation of Misakubo district in Akaishi mountainland of Central Japan.

44. *Trigonia longiloba* JIMBO, 1894. Lower member (lower- middle Cenomanian) of the "*Trigonia* Sandstone" in Ikushumbetsu district of Mikasa-city, Central Hokkaido and Miyanohara sandstone (lower Cenomanian) in the vicinity of Ochi-machi in Sakawa basin, Tosa Prov., Kochi Pref.
45. *Trigonia moriana* YEHARA, 1926. Miyakoan formation from Hagino of Mirafu-mura and Inono of Nagase-mura in Monobegawa basin and the vicinity of Kochi-city in Tosa Prov., Kochi Pref.
46. *Trigonia ogawai* YEHARA, 1923. Gyliakian Goshonoura group in Goshonoura-island and Miyaji of Miyaji-mura near Yatsushiro-city in Higo Prov., Kumamoto Pref.
47. *Trigonia pustulosa* NAGAO, 1930. Gyliakian members from Goshonoura-island of Higo Prov. in Kumamoto Pref., Miyanohara in Ochi-machi near Sakawa-machi and Nagase in Monobegawa basin of Tosa Prov., Kochi Pref., and Ikushumbetsu district in Mikasa-city of Central Hokkaido.

3b. Rise and Fall of the Cretaceous Trigoniids in the Japanese Islands

At a glance, the Grabrae and the Aliformis group inhabited in the Kochian (Berriasian-Valangian) to the Gyliakian (Cenomanian-Turonian) and their survivors were not recognized entirely in the Senonian s. l., i. e. Japanese Urakawan to Hetonaian. The former is distributed widely from Kyushu to Miyako district, but unknown from the Yezo geosynclinal region including Hokkaido and Sachalin districts. On the other hand, the Pseudoquadratae and the Pennatae section appeared in the Yezo geosynclinal region of the lower Gyliakian (Cenomanian) when no one came out from Southwest Japan. Both sections existed into till the Senonian s. l., and flourished chiefly in the Campanian-Maestrichtian of Southwest Japan. The Miyakoan (Aptian-Albian) to the Gyliakian, i. e. "Middle Cretaceous", is characterized by the abundant occurrence of Trigoniids. The Gyliakian rocks of the Yezo geosynclinal region produces a number of Aliformis, Pseudoquadratae, and Pennatae groups.

More precisely, the Neocomian, i. e. Kochian (Berriasian-Valangian) to Aritan (Barremian-Hauterivian), is marked by the inhabitants of several forms of *Nipponitrigonia*, *Rutitrigonia*, and *Pterotrigonia* s. s., such as, *Nipponitrigonia kikuchiana* (YOKOYAMA), *N. k.* var. *plicata* KOBAYASHI and NAKANO, *N. naumanni* (YEHARA), *Rutitrigonia sanchuensis* (NAKANO), *R. yeharai* KOBAYASHI, *Pterotrigonia hokkaidoana* (YEHARA), *P. pocilliformis* (YOKOYAMA), and *P. p.* var. *yamanokamiensis* KOBAYASHI and NAKANO.

Pterotrigonia s. s. is well represented in the Cretaceous of cosmopolitan, and flourished in the "Middle Cretaceous" but declined in the Senonian s.l. Senonian forms are known from North America, Western Europe, and New Zealand etc. In Japan, this subgenus appeared in the lower Neocomian at Yamanokami of Nagano near Sakawa-machi, Kochi Pref., Shikoku, and survived till the late Gyliakian. This subgenus prospered and were extensively developed in the Miyakoan to the Gyliakian from Sachalin to Kyushu. It declined already in the late Gyliakian, leaving *Pterotrigonia datemasamunei* (YEHARA) var., *P. hokkaidoana* (YEHARA), and *P. sakakurai* (YEHARA) as three relics. *Nipponitrigonia* was restricted to the Dogger (?) to the Cenomanian of Japan excluding Yezo geosynclinal region and the Neocomian (?) of Philippine. It prospered in the Miyakoan when all forms were existent, but suddenly

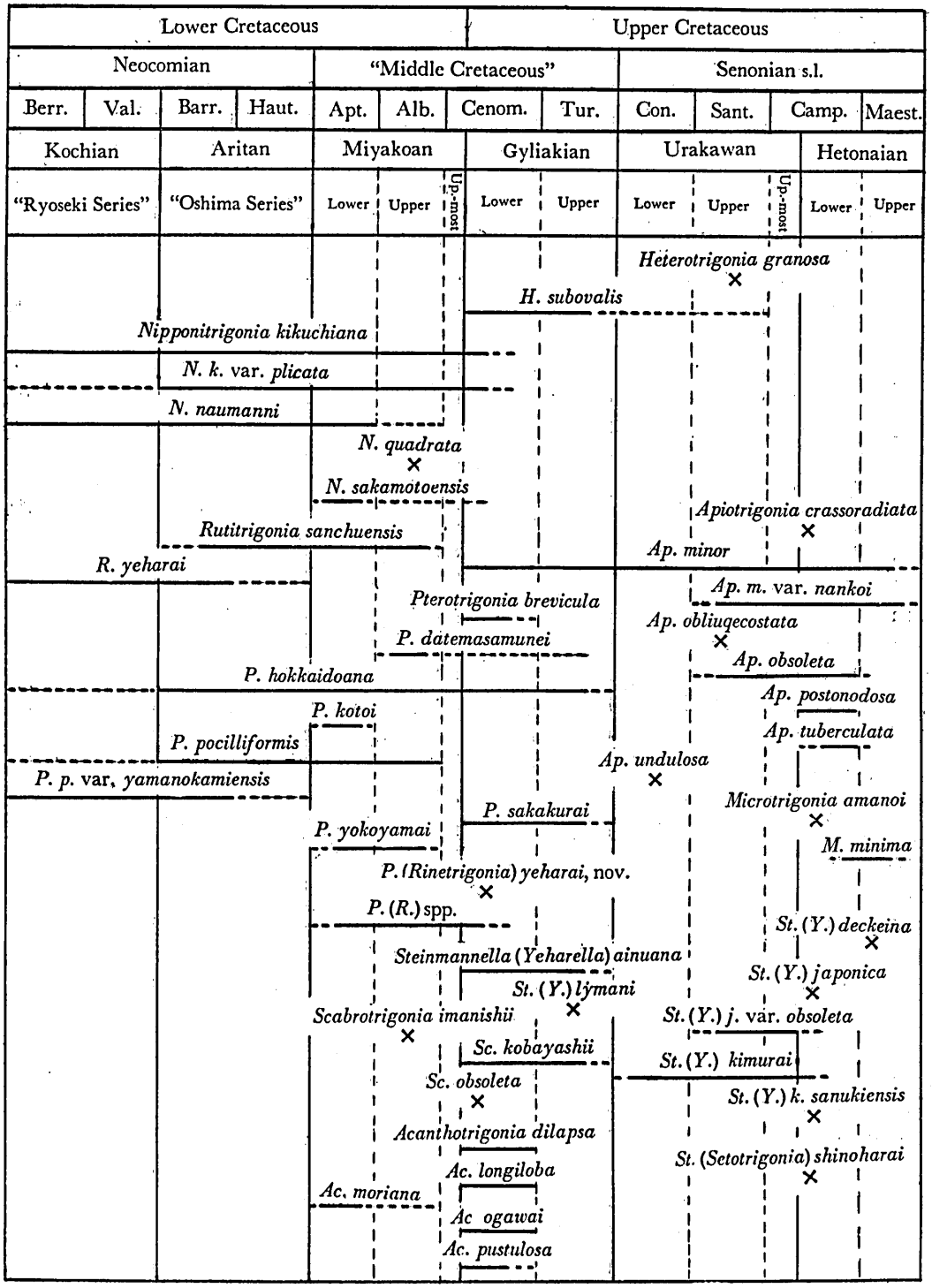
TABLE 13. The List of Gyliakian Trigoniids from Japan and the adjacent areas.

Specific name \ Locality	Yezo Geosynclinal Region			Southwest Japan						
	Sachalin				Shikoku		Kyushu			
	Near Alexandrovsk	Keton-Hoé Region	Ikushumbetsu district	Misakubo district	Nagase district	Sakawa basin	Onogawa basin	Yatsushiro district	Mifune district	Islands of Amakusa
Heterotrigonia subovalis			×							
Nipponitrigonia kikuchiana								×		×
N. k. var. *plicata*								×		
Apiotrigonia minor	×		×							
Steinmannella (*Yeharella*) *ainuana*			×							
S. (*Y.*) *lymani*		×	×							
Pterotrigonia brevicula			×							
P. datemasamunei var.							×			
P. hokkaidoana	×		×	×		×		×		×
P. sakakurai										×
P. (*Rinetrigonia*) *yeharai*, n. sp.										×
P. (*R.*) sp. nov.									×	
Scabrotrigonia kobayashii			×							
S. obsoleta										×
Acanthotrigonia dilapsa				×	×?	×?				×
Ac. longiloba			×			×				
Ac. ogawai								×		×
Ac. pustulosa			×		×	×				×

declined in the Gyliakian. *Rutitrigonia* is an effaced and rostrate genus, is rare in the Kochian to the Miyakoan of Southwest Japan including Kwanto mountainland. While the genus was common in the Lower to "Middle" Cretaceous of the world, it was most prolific in the Neocomian of Europe, South Africa, and South America.

In the Senonian s. l., *Heterotrigonia*, *Apiotrigonia*, *Steinmannella* (*Yeharella*), *Steinman-*

TABLE 14. Geological Ranges of the Cretaceous Trigoniids in the Japanese Islands.



nella (*Setotrigonia*), *Microtrigonia* took the positions of the prosperities from the old ones. As already mentioned above, the former three were arisen in the lower Gyliakian of the Yezo geosynclinal region, and were broadly spread out in the later stages from Kyushu to Sachalin. The latter two had the short durations, and inhabited only in the Campanian-Maestrichtian of Southwest Japan. These genera and subgenera reached the second acme in the Campanio-Maestrichtian of Southwest Japan.

Apiotrigonia inhabited in the Northern Pacific, West Europe, and Turkestan regions from the upper Albian (?) to the Maestrichtian, and most flourished in the Campanio-Maestrichtian of Southwest Japan where a number of interesting forms, such as, *Apiotrigonia obsoleta* NAKANO, *Ap. postonodosa* NAKANO, and *Ap. tuberculata* NAKANO etc. were collected. In the Maestrichtian, *Microtrigonia* typified by *Microtrigonia amanoi* NAKANO from the Hetonaian of Koshiki-island in Western Kyushu, was derived probably from small tuberculate Apiotrigonian in Southwest Japan. *Heterotrigonia* having the radial costae on its area, appeared probably from the upper Albian (?) of British Columbia. This is one of the most characteristic Trigoniids in the Northern Pacific. In Japan, *Heterotrigonia subovalis* (JIMBO) was reported and collected from the "*Trigonia* Sandstone" (Cenomanian-Turonian) in Ikushumbetsu, Mikasa-city, Central Hokkaido and upper Urakawan formation of South Sachalin. While, *Heterotrigonia granosa* NAKANO having a small shell and tuberculate costation, occurred in the Middle Himenoura group (Santonian) at Wadanohana in Ryugatake-mura, Amakusa-gun, Kumamoto Pref., Kyushu. It is the most important fact that *Steinmannella* (*Yeharella*) is characteristic in the Cenomanian to the Maestrichtian of the Northern Pacific. In Japan, this appeared in the early Gyliakian of the Yezo geosynclinal region as stated above, and prospered and were abundant in the uppermost Urakawan or the lower Hetonaian of Southwest Japan. *Steinmannella* (*Setotrigonia*) is monotypic and typified by *S.* (*S.*) *shinoharai* KOBAYASHI and Amano, is known only from the Campanian of Kagawa Pref., Shikoku.

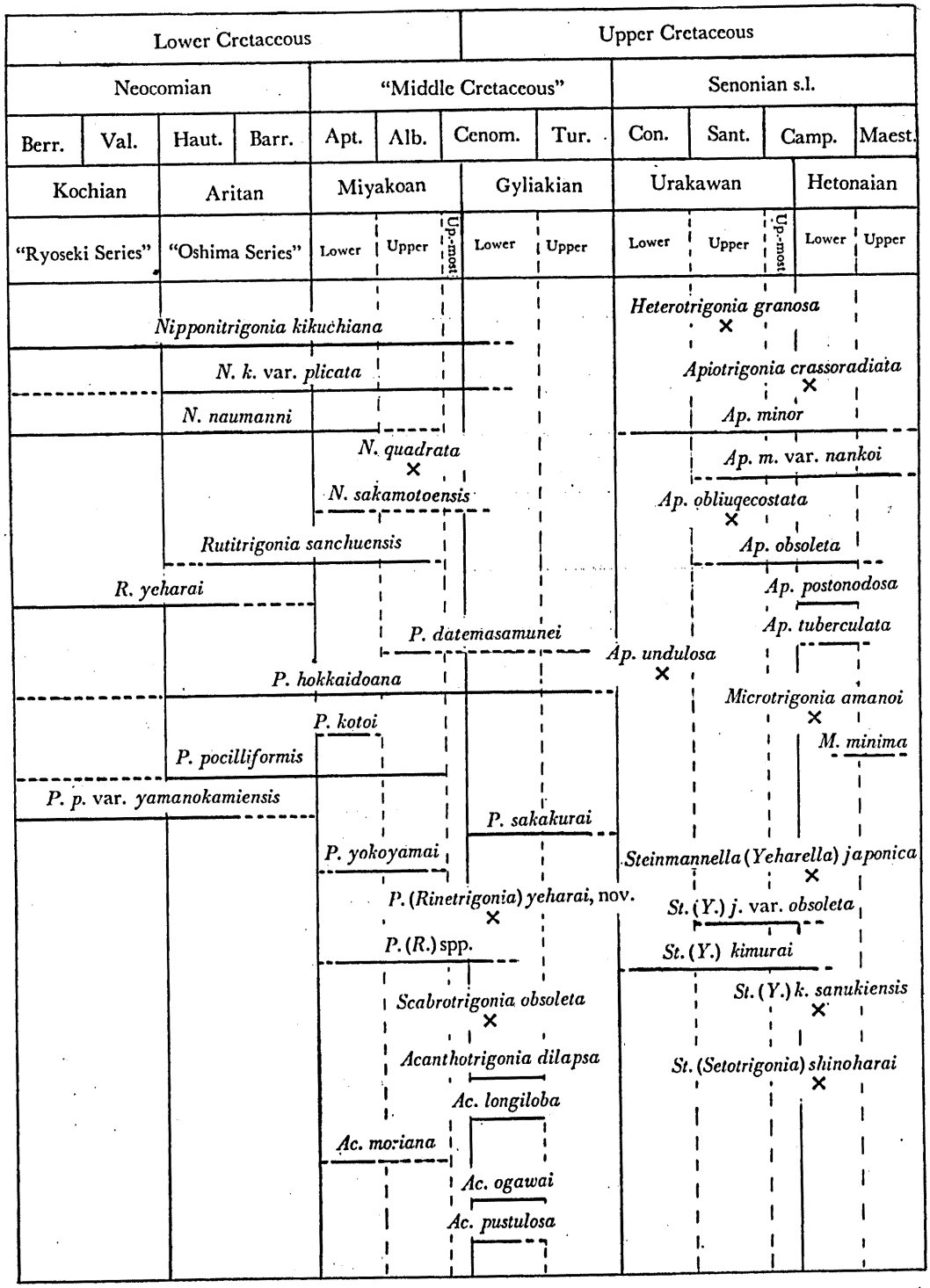
The Japanes Cretaceous Trigoniids flourished in the Miyakoan to the Gyliakian and their faunal assemblages were thoroughly changed through this time. The old survivors and the pioneers of the new forms were co-existed in these stages. *Acanthotrigonia* and *Scabrotrigonia* are the most characteristics and important genera, because they range from Miyakoan to the Gyliakian and they have the wide distributions from Kyushu to Hokkaido. They were, however, most developed in the Gyliakian.

Acanthotrigonia is common in the "Middle Cretaceous" of Eurasia and Africa, but lacking in North and South America. While, *Scabrotrigonia* is common in the "Middle" to the Upper Cretaceous of North America and Europe. It is the most significant fact that some forms of *Rinetrigonia* of *Pterotrigonia* were collected from the Miyakoan and Gyliakian rocks of Western Kyushu. This subgenus is a characteristic Trigoniid of the Indo-African region from the Tithonian to the "Middle Cretaceous".

As already mentioned before, it is recognized that there were the differences of the Trigonian faunules between the Yezo geosynclinal region and Japan proper, esp-

Stratigraphic Occurrences of the Cretaceous Trigoniids in the Japanese Islands

TABLE 15. Geological Ranges of the Cretaceous Trigoniids in Japan Proper



ecially Southwest Japan. Because, in the Gyliakian *Nipponitrigonia* is absent in the former region where the Senonian forms in Southwest Japan are associated with the old ones. On the other hand, the characteristic Senonian Trigoniids, such as, *Heterotrigonia*, *Apiotrigonia*, and *Steinmannella* (*Yeharella*), are not yet collected from Southwest Japan, although the marine Gyliakian formations are scattered at several places of Southwest Japan. In Japan proper, the Cretaceous may be arranged into 3 series by the Trigonian assemblages.

TABLE 16. The List of Trigonian Assemblages of the Cretaceous System in Japan proper

System	Subsystem	Series	Genera and Subgenera	Correlation to the European Standard	
Cretaceous	Upper Cretaceous	Hetonaian	*Apiotrigonia, Microtrigonia, Steinmannella (Yeharella)*	Maestrichtian	Senonian s.l.
				Campanian	
		Urakawan	*Heterotrigonia, Apiotrigonia, Steinmannella (Yeharella), St. (Setotrigonia)*	Santonian	
				Coniacian	
		Gyliakian	*Nipponitrigonia, Pterotrigonia* s. s., *P. (Rinetrigonia) Scabrotrigonia, Acanthotrigonia*	Turonian	"Middle Cretaceous"
	Lower Cretaceous			Cenomanian	
		Miyakoan	*Nipponitrigonia, Rutitrigonia Pterotrigonia* s. s., *P. (Rinetrigonia), Scabrotrigonia, Acanthotrigonia*	Albian	
				Aptian	
		Aritan	*Nipponitrigonia, Rutitrigonia, Pterotrigonia* s. s.	Barremian	Neocomian
				Hauterivian	
		Kochian	*Nipponitrigonia, Rutitrigonia, Pterotrigonia* s. s.	Valangian	
				Berriasian	

Neocomian, i. e. Lower Cretaceous, was characterized by the occurrence of some forms of *Rutitrigonia*, *Nipponitrigonia*, and *Pterotrigonia* s. s. In the Aptian to the Turonian, i. e. "Middle Cretaceous", the Pterotrigoniinae flourished and were abundant. Among them, *Scabrotrigonia* and *Acanthotrigonia* are the most characteristics and the both genera were reported from various localities, accompanying with the forms of *Nipponitrigonia*, *Rutritrigonia*, and *Pterotrigonia* s.l. *Rutitrigonia* has hitherto been not known from the Gyliakian formations. In the Senonian s. l., the Trigoniid faunules were reformed perfectly and they are characterized by the occurrence of *Heterotrigonia*, *Steinmannella* s. l., *Apiotrigonia*, and *Microtrigonia*.

On the other hand, in the Yezo geosynclinal region the occurrence of Trigoniids are known mainly from the "*Trigonia* Sandstone" of Ikushumbetsu district in Central Hokkaido. Already mentioned before, it is an interesting fact that the "*Trigonia* Sandstone" in Ikushumbetsu produces a number of Trigoniids, such as, *Pterotrigonia* s. s., *Scabrotrigonia*, *Acanthotrigonia*, *Heterotrigonia*, *Apiotrigonia*, and *Steinmannella* (*Yeharella*), because the same assemblage is lacking in Japan proper, especially in Southwest Japan. This fact may be one of the most important omen of the revolution on the faunal aspects of the Japanese Cretaceous Trigoniids. In the Senonian s. l., Trigoniids from the Yezo geosynclinal region are very poor, but their aspects are

Stratigraphic Occurrences of the Cretaceous Trigoniids in the Japanese Islands

TABLE 17. Geological Ranges of the Cretaceous Trigoniids in the Yezo geosynclinal Region

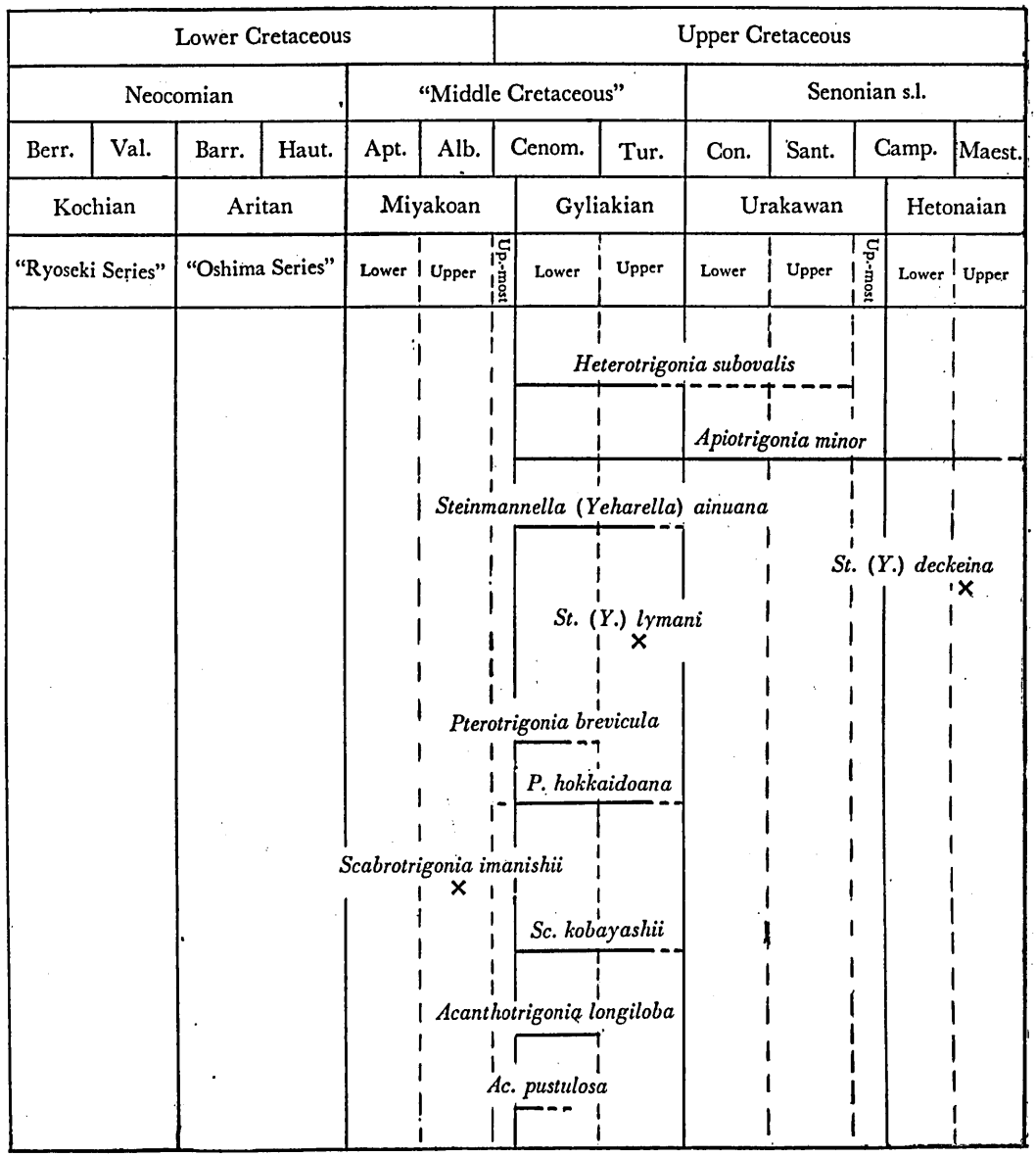


TABLE 18. The List of Trigonian Assemblages of the Cretaceous System in the Yezo Geosynclinal Region

Syst-em	Subsy-stem	Series	Genera and Subgenera	Correlation to the European Standard	
Cretaceous	Upper Cretaceous	Hetonaian	*Apiotrigonia, Steinmannella* (*Yeharella*)	Maestrichtian	Senonian s.l.
				Campanian	
		Urakawan	*Heterotrigonia, Apiotrigonia, Steinmannella* (*Yeharella*)	Santonian	
				Coniacian	
		Gyliakian	*Heterotrigonia, Apiotrigonia, Steinmannella* (*Yeharella*), *Pterotrigonia* s. s., *Scabrotrigonia, Acanthotrigonia*	Turonian	"Middle Cretaceous"
				Cenomanian	
	Lower Cretaceous	Miyakoan	*Pterotrigonia* s. s., *Scabrotrigonia*	Albian	
				Aptian	
		Aritan	Fossils non	Barremian	Neocomian
				Hauterivian	
		Kochian	Fossils non	Valangian	
				Berriasian	

quite similar to those of Southwest Japan.

On the specific ranges, the early representatives of the Cretaceous Trigoniids have usually the longer life-periods than those of the later ones. The Neocomian Trigoniids have the long durations from about 2 to 3 epochs and most of them were existed into till the "Middle Cretaceous". On the other hand, the Upper Cretaceous forms have the shorter durations than those of the Neocomian ones. Their ranges are nearly 1 to 1.5 epoch or less, although the forerunners of the Senonian forms, such as, *Apiotrigonia minor* (YABE and NAGAO) and *Heterotrigonia subovalis* (JIMBO), have the long life-periods. In the "Middle Cretaceous", the longer and shorter ones are recognized together, but the most members appeared in this series have the short ranges which are almost 1 epoch or sometimes limited to the very short time.

In summarizing above, the writer is of oppinion that the Cretaceous System of Japan proper, especially Southwest Japan, may be divided into 3 series as can be judged from the faunal assemblages of Trigoniids. So far as the generic assemblages of Trigoniids are concerned, however, the boundary between the Kochian (Berriasian-Valangian) and the Aritan (Barremian-Hauterivian) epoch is obscure and some doubtful relations are suspended, because they are, also, not easy to separate by the stratigraphical and palaeontological studies on the typical localities. The "Middle Cretaceous" is characterized by the abundant occurrence and co-existence of the old and new forms of Trigoniids and it may be subdivided into 2 epochs by the faunal assemblages of them. *Acanthotrigonia, Scabrotrigonia,* and *Pterotrigonia* (*Rinetrigonia*) are limited to this time. In the Gyliakian of the "Middle Cretaceous", *Heterotrigonia, Apiotrigonia,* and *Steinmannella* (*Yeharella*), appeared in the Yezo geosynclinal region, but they have hitherto been undiscovered from Southwest Japan. With respect to the faunal contents of the Cretaceous Trigoniids, the Lower and the "Middle" Cret-

aceous ones of Japan proper, especially Southwest Japan, may be closely allied to those of the Indo-African region, while in the Senonian s. l. of Southwest Japan or the Cenomanian to the Maestrichtian of the Yezo geosynclinal region the affinities are recognized in those of West Coast in North America.

3c. Faunal Relationships between the Cretaceous Trigoniids in the Japanese Islands and West Coast in North America

As already suggested by YEHARA (1915, 23b) and PACKARD (1921), the faunal characters of the Cretaceous Trigoniids in the Japanese Islands were closely allied to those of West Coast in North America, because same genera were common in the both regions. It is, however, recognized that the differences of the Trigoniid assemlages of the both regions are discussed hereunder. According to GABB (1869), WHITEAVES (1876), STEPHENSON (1923, 41), ANDERSON (1938, 59), STOYANOW (1949), JONES (1960a–b) and others, the following forms were now well known from various horizons and localities in North America.

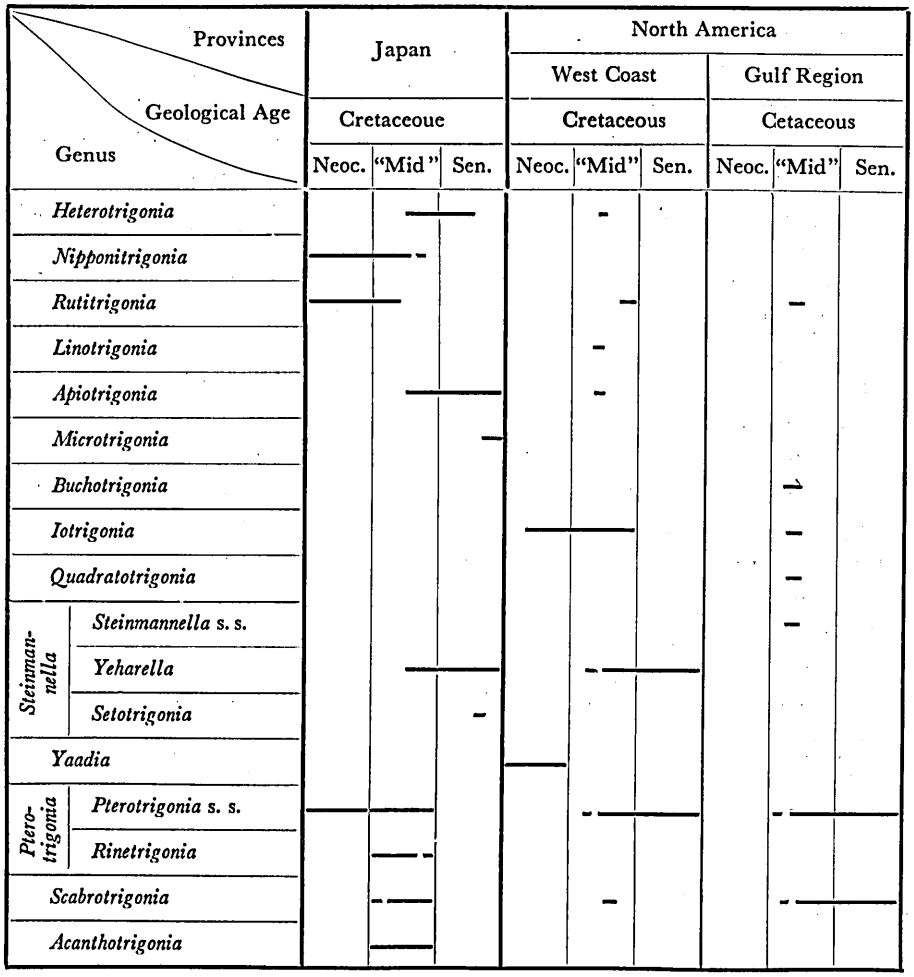
Subfamily Trigoniinae KOBAYASHI, 1954 em.
  Genus *Heterotrigonia* COX, 1952
    Trigonia diversicostata WHITEAVES, 1876. Haida formation (upper Albian ?) of Queen Charlotte series; British Columbia.
Subfamily Frenguelliellinae nov.
  Genus *Rutitrigonia* van HOEPEN, 1929
    Trigonia jacksonensis PACKARD, 1921. Turonian; California and Oregon.
    Trigonia weaveri STOYANOW, 1949. Upper Aptian; Arizona.
Subfamily Myophorellinae KOBAYASHI, 1954
  Genus *Linotrigonia* van HOEPEN, 1929
    Subgenus *Linotrigonia* s. s.
      Trigonia charlottensis PACKARD, 1921. Haida formation (upper Albian ?) of Queen Charlotte series; Maude Island, British Columbia.
Subfamily Vaugoniinae KOBAYASHI, 1954
  Genus *Apiotrigonia* COX, 1952
    Trigonia maudensis WHITEAVES, 1884. Haida formation (upper Albian ?) of Queen Charlotte series; British Columbia.
    Trigonia newcombei PACKARD, 1921. Haida formation of Queen Charlotte series; British Columbia.
  Genus *Buchotrigonia* DIETRICH, 1938
    Trigonia reesidei STOYANOW, 1949. Upper Aptian; Arizona
Subfamily Megatrigoniinae van HOEPEN, 1929
  Genus *Iotrigonia* van HOEPEN, 1929
    ? *Trigonia aequicostata* GABB, 1869. Cenomanian; California and Oregon.
    ? *Trigonia condoni* PACKARD, 1921. Upper Cretaceous Chico group; California and Oregon.
    Trigonia cragini STOYANOW, 1949. Upper Albian; Arizona.
    Trigonia flexicostata BURWASH, 1913. Haida formation of Queen Charlotte series; British Columbia.
    Trigonia kayana ANDERSON, 1938. Valangian-Hauterivian; California.
    Trigonia kitchini STOYANOW, 1949. Upper Albian; Arizona.
Subfamily Quadratotrigoniinae SAVELIEV, 1958 em.
  Genus *Quadratotrigonia* DIETRICH, 1933
    Subgenus *Quadratotrigonia* s. s.
      Trigonia dumblei STOYANOW, 1949. Upper Aptian; Arizona.
      Trigonia guildi STOYANOW, 1949. Upper Aptian; Arizona.

Trigonia mearnsi STOYANOW, 1949. Upper Aptian; Arizona.
Trigonia resoluta STOYANOW, 1949. Upper Aptian; Arizona.
Genus *Steinmannella* CRICKMAY, 1930
Subgenus *Steinmannella* s. s.
Trigonia gordoni WHITNEY, 1952. Albian; Texas.
Subgenus *Yeharella* KOBAYASHI and AMANO, 1955
Trigonia branneri ANDERSON, 1959. Lower Turonian; California.
Trigonia californiana PACKARD, 1921. Turonian; California and Oregon.
Trigonia colusaensis ANDERSON, 1959. Cenomanian; California.
Trigonia fitchi PACKARD, 1921. Turonian; Oregon.
Trigonia hemphilli ANDERSON, 1959. Senonian s. s.; California.
Trigonia leana GABB, 1876. Turonian; California and Oregon.
Trigonia leana var. *whiteavesi* PACKARD, 1921. Haida formation of Queen Charlotte series; British Columbia.
Trigonia perrinsmithi ANDERSON, 1959. Cenomanian; California.
Trigonia tryoniana Gabb, 1864. Campanian; Vancouver Island, British Columbia.
Genus *Yaadia* CRICKMAY, 1931
Yaadia lewisagassizi CRICKMAY, 1930. Neocomian; British Columbia.
Subfamily Pterotrigoniinae van HOEPEN, 1929
Genus *Pterotrigonia* van HOEPEN, 1929
Subgenus *Pterotrigonia* s. s.
Trigonia bartrami STEPHENSON, 1923. Coniacian; North Carolina.
Trigonia bowersiana ANDERSON, 1959. Upper Cretaceous; California.
Trigonia columbiana PACKARD, 1921. Haida formation of Queen Charlotte series; British Columbia.
Trigonia evansana MEEK, 1869. Coniacian-Campanian; British Columbia, Oregon, California etc.
Trigonia evansana var. *oregana* PACKARD, 1921. Upper Albian- lower Cenomanian; Oregon and California.
Trigonia klamathonia ANDERSON, 1959. Turonian; California and Oregon
Trigonia marionensis STEPHENSON, 1923. Coniacian; North Carolina.
Trigonia melhasei ANDERSON, 1959. Turonian; California.
Trigonia stollegi HILL, 1893. Upper Aptian; Arizona and Texas.
Trigonia wendlei WHITNEY, 1952. Albian; Texas.
Trigonia whitneyi WHITNEY, 1952. Albian; Texas.
Genus *Scabrotrigonia* DIETRICH, 1933
Trigonia anglicostata GABB, 1876. Maestrichtian; Missouri, Georgia, Alabama etc.
Trigonia castrovillensis STEPHENSON, 1941. Upper Maestrichtian; Texas.
Trigonia clavigera CRAGIN, 1893. Cenomanian; Texas.
Trigonia emoryi CONRAD, 1857. Lower Cenomanian; Texas and Mexico.
Trigonia eufaulensis GABB, 1850. Campanian; Alabama, Texas, North and South Carolina, Georgia etc.
Tirgonia eufaulensis var. *gabbi* STEPHENSON, 1941. Lower Maestrichtian; Texas.
Trigonia eufaulensis var. *moorei* STEPHENSON, 1941. Upper Maestrichtian; Texas.
Trigonia guadalupae BÖSE, 1910. "Middle Cretaceous"; Mexico.
Trigonia haynensis STEPHENSON, 1923. Upper Campanian; North Carolina.
Trigonia mooreana GABB, 1861. "Middle Cretaceous"; California, Texas, Mexico etc.
Trigonia plicatocostata NYST y GALEOTTI, 1840. Aptian ?; San Juan Raya, Mexico.
Trigonia stantoni STEPHENSON, 1941. Lower Maestrichian; Texas.
Trigonia thoracia MORTON, 1834. Maestrichtian; New Jersey, Alabama, Texas, Tennessee, Missouri etc.

Roughly speaking, the Neocomian of the Japanese Islands is characterized by the abundant occurrence of *Nipponitrigonia*, *Rutitrigonia*, and *Pterotrigonia* s. s., while Trig-

oniids are very rare in North America where *Iotrigonia* and *Yaadia* are reported from the Pacific side. Trigoniids flourished and were prolific in the "Middle Cretaceous" when some genera were common in the both regions, and there were some similarities on the faunal assemblages. In the Japanese Islands, Pterotrigoniinae were prolific and prospered in the "Middle Cretaceous" when all genera and subgenera were existent. The early representatives of *Heterotrigonia*, *Apiotrigonia*, and *Steinmannella* (*Yeharella*) appeared from the Cenomanian of the Yezo geosynclinal region, but they were absent in Southwest Japan of the same age. *Nipponitrigonia* and *Rutitrigonia* appeared in the Neocomian, and died out in the Cenomanian and the Albian, respectively. On the other hand, the "Middle Cretaceous" of North America was characterized by the presence of a number of genera and subgenera some of which are known in the Japanese Islands and limited to this period. *Steinmannella* (*Yeharella*), *Pterotrigonia*, and *Scabrotrigonia* prospered and were prolific in the "Middle" to the Up-

TABLE 19. Geological Ranges of the Cretaceous Trigoniids of Japan and North America.



per Cretaceous, but *Iotrigonia* was evanescent already in the late "Middle Cretaceous". In the Senonian s. l., *Steinmannella* (*Yeharella*) and *Apiotrigonia* were developed in the Japanese Island, while *Steinmannella* (*Yeharella*) and *Pterotrigonia* s. s. were prolific in West Coast and *Pterotrigonia* s. s. and *Scabrotrigonia* flourished in the Gulf region.

Many forms of *Apiotrigonia* and *Heterotrigonia* inhabited in the Senonian s. l. of the Japanese Islands, but 3 forms of them, i. e. *Apiotrigonia maudensis*, (WHITEAVES), *Ap. newcombei* (PACKARD), and *Heterotrigonia diversicostata* (WHITEAVES), are recognized only from the Haida formation (probably upper Albian) of the Queen Charlotte series of British Columbia in West Coast of North America. As pointed out by some authors, the Senonian *evansana* group of *Pterotrigonia* s. s. in West Coast is closely allied to the *pocilliformis* group from the Neocomian to the Turonian of the Japanese Islands and *Pterotrigonia columbiana* (PACKARD) from the Haida formation looks similar to *Pterotrigonia sakakurai* (YEHARA) from the Gyliakian of Goshonoura-island in Western Kyushu, Japan. *Pterotrigonia* s. s. in the Japanese Islands ranges from the Neocomian to the Turonian, and it declined and vanished in the Senonian s. l. While, in North America it inhabited in the Aptian to the Senonian s. l. and it has hitherto been undiscovered from the Neocomian. *Acanthotrigonia* inhabited mainly in the "Middle Cretaceous" of Japan, Indo-Africa, and Europe, but lacking in North America. As already discussed by the writer (1958b), *Scabrotrigonia* are collected from the "Middle Cretacenus" of the both regions, but in the Senonian s. l. they prospered and were most prolific in the Gulf region. Although they are lacking in North America, in the "Middle Cretaceous" Japan has some forms of *Rinetrigonia* of *Pterotrigonia* which is a characteristic form of the Indo-African region from the Tithonian to the "Middle Cretaceous". Comparing with the occurrence of *Rutitrigonia*, Japan yields it from the Neocomian to the Albian, while in North America *Rutitrigonia jacksonensis* (PACKARD) and *R. weaveri* (STOYANOW) are reported respectively from the Turonian of Oregon and the upper Aptian of Arizona. *Steinmannella* s. l. comes out from the Upper Jurassic Malone formation of Texas, and they are recognized in the "Middle" to the Upper Cretaceous of West Coast and in the "Middle Cretaceous" of the Gulf region. They most prospered in the Upper Cretaceous of West Coast. On the other hand, it appeared in the Cenomanian of the Yezo geosynclinal region in the Japanese Islands, and flourished in the Senonian s. l. of Southwest Japan. *Nipponitrigonia* and *Microtrigonia* are the characteristic genera of Japan, and they have no distribution in North America. In West Coast, *Linotrigonia* and *Iotrigonia* are known and the former is represented by *Trigonia charlottensis* PACKARD from the Haida formation of British Columbia. The latter comprises *Trigoina flexicostata* BURWASH, *T. kayana* ANDERSON, *T. cragini* STOYANOW, and *T. kitchini* STOYANOW etc. The former two were collected respectively from the Haida formation of British Columbia and from the upper Paskenta group and the Cottonwood formation of California. The rest members were reported from the upper Albian formation of Arizona. These two genera are lacking in the Japanese Cretaceous. *Yaadia* is an aberrant genus, and is monotypic and typified by *Yaadia lewisagassizi* CRICKMAY from the Neocomian of British Colum-

bia. In 1949, STOYANOW described *Trigonia reesidei* and some forms of Quadratae from the Aptian of Arizona. The former is a typical *Buchotrigonia* which distributes in the Cretaceous of Spain and South America etc. While, the latter forms belonging to *Quadratotrigonia* s. s. mainly inhabited in the Upper Jurassic to the "Middle Cretaceous" of Europe and Caspian regian

In summarizing above, the writer is of oppinion that the faunal assemblage of the Japanese "Middle Cretaceous", especially Gyliakian of the Yezo geosynclinal region, may be closely related to the "Middle Cretaceous" one of West Coast in North America, though some differences on the faunal contents are recognizable (See Tab. 19). In the Senonian s. l., Trigoniids of the Japanese Islands are characterized by the abundant occurrence of *Apiotrigonia* and *Steinmannella* (*Yeharella*) etc., while in West Coast *Steinmannella* (*Yeharella*) and *Pterotrigonia* s. s. prospered and were prolific and in the Gulf region *Scabrotrigonia* and *Pterotrigonia* s. s. were abundant. In the Neocomian the common genera are entirely absent between the Japanese Islands and North America, but in the Senonian *Steinmannella* (*Yeharella*) is common in the both regions and it inhabited only in the Northern Pacific. In North America, Cretaceous Trigoniids of the Gulf region are somewhat different in those of West Coast and its affinities are known in the European or the South American region.

3d. Faunal Relationships between the Cretaceous Trigoniids in the Japanese Islands and the Indo-African Region

As mentioned before, the Trigonian assemblage of the Japanese Neocomian is quite different from that of West Coast in North America, because the same genera are lacking in the both regions. It is an interesting fact that the Trigonian contents of the Neocomian to the Turonian in Southwest Japan are probably related to those of the Indo-African region (See Pl. 27).

In the Indo-African region, the following genera, subgenera, and species were reported from various horizons and localities by FORBES (1845), STOLICZKA (1871), KITCHIN (1914), LANGE (1914), van HOEPEN (1929), RENNIE (1936), and others.

Subfamily Trigoniinae KOBAYASHI, 1954 em.
- Genus *Indotrigonia* DIETRICH, 1933
  - *Trigonia beyschlagi* MÜLLER, 1900. Barremian-Aptian; Tendaguru, East Africa.
  - ? *Trigonia matapuana* KRENKEL, 1910. Neocomian; Tendaguru, East Africa.
- Genus *Pleurotrigonia* van HOEPEN, 1929
  - *Trigonia blanckenhorni* NEWTON, 1908. Albian; Zululand, South Africa.
- Genus *Sphenotrigonia* RENNIE, 1936
  - *Trigonia* (*Sphenotrigonia*) *frommurzei* RENNIE, 1936. Neocomian; Zululand, South Africa.

Subfamily Frenguelliellinae nov.
- Genus *Frenguelliella* LEANZA, 1942
  - *Trigonia indica* STOLICZKA, 1871. Arriyalur group; South India.
  - *Trigonia minuta* STOLICZKA, 1871. Arriyalur group; South India.
  - *Trigonia orientalis* FORBES, 1845. Arriyalur group; South India and (?) Madagascar.
- Genus *Rutitrigonia* van HOEPEN, 1929
  - *Trigonia bornhardti* MÜLLER, 1900. Barremian-Aptian; Tendaguru, East Africa.

Trigonia dietrichi LANGE, 1910. Neocomian; Tendaguru, East Africa.
Trigonia janenschi LANGE, 1914. Neocomian; Tendaguru, East Africa.
Trigonia niongalensis LANGE, 1910, Neocomian; Tendaguru, East Africa.
Rutitrigonia peregrina van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Trigonia pongolensis RENNIE, 1936. Neocomian; Zululand, South Africa.
Trigonia schwarzi MÜLLER, 1900. Aptian; Tendaguru, East Africa.
Trigonia semiculta FORBES, 1845. Trichinopoly group; South India.

Subfamily Myophorellinae KOBAYASHI, 1954
Genus *Linotrigonia* van HOEPEN, 1929
Subgenus *Linotrigonia* s. s.
Linotrigonia linifera van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Linotrigonia venusta van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Subgenus *Oistotrigonia* COX, 1952
Trigonia crenulifera STOLICZKA, 1871. Arriyalur group; South India.
Trigonia spinosa PARKINSON in BASSE, 1932. Maestrichtian; Madagascar.

Subfamily Vaugoniinae KOBAYASHI, 1954
Genus *Orthotrigonia* COX, 1952
Clavotrigonia discordans HENNIG, 1933. Neocomian; Tendaguru, East Africa.

Subfamily Megatrigoniinae van HOEPEN, 1929
Genus *Megatrigonia* van HOEPEN, 1929
Trigonia conocardiiformis KRAUSS, 1847. Aptian; Uitenhage, South Africa.
Megatrigonia obesa van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Trigonia staffi LANGE, 1914. Neocomian; Tendaguru, East Africa.
Genus *Iotrigonia* van HOEPEN, 1929
Iotrigonia crassitesta van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Trigonia haugtoni RENNIE, 1936. Neocomian; Zululand, South Africa.
Iotrigonia inconstans van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Trigonia stowi KITCHIN, 1913. Aptian; Uitenhage, South Africa.
Trigonia vau SHARPE, 1852. Aptian; Uitenhage, South Africa.

Subfamily Quadratotrigoniinae SAVELIEV, 1958 em.
Genus *Steinmannella* CRICKMAY, 1930
Subgenus *Steinmannella* s. s.
Trigonia hennigi LANGE, 1914. Neocomian; Tendaguru, East Africa.
Trigonia herzogi HAUSMANN, 1834. Upper Neocomian; Natal, South Africa.
Trigonia holubi KITCHIN, 1913. Upper Neocomian; Sundy river, South Africa.

Subfamily Pterotrigoniinae van HOEPEN, 1929 em.
Genus *Pterotrigonia* van HOEPEN, 1929
Subgenus *Pterotrigonia* s. s.
Ptilotrigonia bullen-newtoni van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Trigonia cricki NEWTON, 1908. "Middle Cretaceous"; Zululand, South Africa.
Ptilotrigonia cricki var. *constans* van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa,
Trigonia ethra COQUAND, 1869. Cenomanian; Congo.
Pterotrigonia jubata van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Ptilotrigonia lauta van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Ptilotrigonia lauta var. *sparsicostata* van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Ptilotrigonia plebeia van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
? *Trigonia rogersi* KITCHIN, 1913. Aptian; Uitenhage, South Africa.
Trigonia scabra (pars) LAMARCK in STOLICZKA, 1871. Trichinopoly group; South India.
Pterotrigonia setosa van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Subgenus *Rinetrigonia* van HOEPEN, 1929
Trigonia kraussi KITCHIN, 1913. Neocomian; Natal, South Africa.
Pisotrigonia salebrosa van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Trigonia tuberculifera STOLICZKA, 1871. Trichinopoly group; South India.

Trigonia ventricosa KRAUSS, 1847. Neocomian; East Africa and India.
Genus *Scabrotrigonia* DIETRICH, 1933
Trigonia scabra LAMARCK in BASSE, 1932. Turonian-Coniacian; Madagascar.
Genus *Acanthotrigonia* van HOEPEN, 1929
Trigonia crenulata LAMARCK, 1819. Cenomanian; Congo
? *Trigonia elegans* BAILY, 1885. "Middle Cretaceous"; Natal, South Africa.
Trigonia forbesii LYCETT, 1875. "Middle Cretaceous"; Cutch, India.
Linotrigonia plumosa van HOEPEN, 1929. "Middle Cretaceous"; Zululand, South Africa.
Trigonia scabra (pars) LAMARCK in STOLICZKA, 1871. Trichinopoly group; South India
Trigonia sheptonei GRIESBACH, 1871. "Middle Cretaceous"; Natal and Zululand in South Africa and Madagascar.

In the Indo-African region, Trigoniids prospered and were prolific in the Neocomian to the "Middle Cretaceous" but suddenly declined in the Senonian s. l. when 3 species of *Frenguelliella* and two forms of *Oistotrigonia* are known from the Arriyalur group of South India and the Maestrichtian of Madagascar as the relics.

In the Neocomian, *Indotrigonia*, *Sphenotrigonia*, *Rutitrigonia*, *Orthotrigonia*, *Megatrigonia*, *Iotrigonia*, *Steinmannella* s. s., and *Pterotrigonia* s. l. are well represented in East and South Africa. Among them, *Indotrigonia*, *Orthotrigonia*, *Megatrigonia*, *Iotrigonia*, and *Steinmannella* s. s. were succeeded from the Jurassic in this region and they are lacking entirely in the Cretaceous of the Japanese Islands. *Sphenotrigonia* is an aberrant and elongate genus derived from *Trigonia* s. s. or Trigoniinae em. stock. *Indotrigonia*, *Megatrigonia*, and *Iotrigonia* survived till the "Middle Cretaceous," but *Sphenotrigonia*, *Orthotrigonia*, and *Steinmannella* s. s. were restricted to occur in the Neocomian. *Rutitrigonia* and *Pterotrigonia* are two cosmopolitan genera in the Cretaceous. In the Neocomian, their occurrences are limited to the eastern hemisphere excluding the Australian region. *Rinetrigonia*, a subgenus of *Pterotrigonia*, is an austral subgenus, and appeared in the Tithonian of Cutch in India. It is well represented in the Lower to the "Middle Cretaceous" in this region. In the "Middle Cretaceous", its distributions are known also in Manghyschlack and Western Kyushu in Japan.

Pleurotrigonia, *Linotrigonia* s. s., *Scabrotrigonia*, and *Acanthotrigonia* are collected from the "Middle Cretaceous". *Pleurotrigonia* is monotypic and an interesting form issued from *Trigonia* s. s., occurred in the Albian of Zululand in South Africa. *Linotrigonia* s. s. was arisen in the Upper Jurassic of Japan, but it is unrepresented in the Japanese Cretaceous. Many forms of *Acanthotrigonia* were known from the "Middle Cretaceous" of India and Africa. This genus was widely distributed in the "Middle Cretaceous" of the eastern hemisphere excluding the Australian region where *Trigonia waiparensis* WOODS, possibly a member of the genus, is known from the Senonian of New Zealand. *Scabrotrigonia* is somewhat rare in the "Middle Cretaceous" of the Japanese Islands, but a single form of the genus is, also, reported by BASSE (1932) from Madagascar.

As mentioned before, in this region Cretaceous Trigoniid genera and subgenera almost appeared in the Jurassic, and flourished in the Lower to the "Middle Cretaceous. *Pleurotrigonia*, *Sphenotrigonia*, *Rutitrigonia*, *Pterotrigonia* s. s., *Scabrotrigonia*, and *Acanthotrigonia* are the characteristics in the Cretaceous. The former two are restricted to occur in this region, but the latter three are cosmopolitan in the Cretaceous. *Rine-*

trigonia is an austral subgenus of *Pterotrigonia*, inhabited in the Tithonian to the "Middle Cretaceous".

On the fossil contents, in the Neocomian *Rutitrigonia* plus *Pterotrigonia* s. s. fauna is well represented and widely distributed in Eurasia or the eastern hemisphere excepting for the Australian region. *Rinetrigonia* plus *Acanthotrigonia* fauna may be characteristic in the "Middle Cretaceous" of the Indo-African region including Caspian sea and the Japanese Islands. Therefore, the Trigoniid fauna of the Lower to "Middle Cretaceous" in the Japanese Islands, especially Southwest Japan may be closely related to that of the Indo-African region.

V. CONCLUDING REMARKS

As a conclusion from the above discussion, the faunal assemblages of the Japanese Mesozoic Trigoniids are quite different in each period.

The Upper Triassic fauna is characterized by the presence of *Minetrigonia* and *Frenguelliella*, and is connected probably to one of the Arcto-Pacific region because of abundant *Minetrigonia*.

In the Jurassic, the Vaugoniinae and the Myophorellinae took the positions of the prosperities from the Triassic ones and they have commonly the strong carinae on their surface. The former was abundant and flourished in the Lower to the Middle Jurassic, but the latter prospered in the Upper Jurassic. The Trigoniid assemblage of the Japanese Jurassic may be related to that of the European rather than the North American or Indian province bacause of the presence of the common genera and subgenera, but in the Upper Jurassic *Haidaia* CRICKMAY is chracteristic in the Pacific regions.

The Cretaceous is characterized by the presence of the Pterotrigoniinae and Quadratotrigoniinae etc., and the carinae on their shells are usually absent or weak. The Cretaceous Trigoniids most flourished in the Gyliakian (Cenomanian-Turonian) when *Heterotrigonia*, *Apiotrigonia*, and *Steinmannella* (*Yeharella*) inhabited only in the Yezo geosynclinal region and they have hitherto been undiscovered from Southwest Japan. In Japan proper, especially Southwest Japan, the Cretaceous may be arranged into 3 series by the fossil contents of the Trigoniids. The Neocomian, i. e. Lower Cretaceous, is characterized by some forms of *Pterotrigonia* s. s., *Rutitrigonia*, and *Nipponitrigonia*. In the Aptian to the Turonian, i. e. "Middle Cretaceous", the Pterotrigoniinae prospered and were abundant. Among them, *Acanthotrigonia* and *Scabrotrigonia* are the most characteristics, and were co-existent with some of *Nipponitrigonia*, *Rutitrigonia*, and *Pterotrigonia* s. l. *Rutitrigonia* has hitherto been unknown from the Gyliakian formations. In the Senonian s. l., i. e. Upper Cretaceous, the Trigonian aspect was reformed perfectly and the members of *Heterotrigonia*, *Steinmannella* s. l., *Apiotrigonia*, and *Microtrigonia* were developed, but *Nipponitrigonia*, *Rutitrigonia*, and the Pterotrigoniinae are lacking. In the Yezo geosynclinal region, the Cretaceous Trigoniids are reported and collected from the Miyakoan (Aptian-Albian) to the Hetonaian (uppermost Campanian-Maestrichtian) formations, and are most abundant

in the "*Trigonia* Sandstone" of the Ikushumbetsu district of Central Hokkaido. The Ikushumbetsu collection comprises *Pterotrigonia* s. s., *Acanthotrigonia*, *Scabrotrigonia*, *Heterotrigonia*, *Apiotrigonia*, and *Steinmannella* (*Yeharella*) the latter three of which are the characteristics in the Senonian s. l. of Southwest Japan where the Senonian forms are not always associated with the Pterotrigoniinae, *Rutitrigonia*, and *Nipponitrigonia*. This fact is probably one of the most important omen of the revolution on the Trigonian aspect of the Japanese Cretaceous. In the Senonian s. l., Trigoniids in the Yezo geosynclinal region were very rare, but their faunal aspect is similar to that of Southwest Japan.

On the faunal contents, the Neocomian to the Turonian Trigoniids in Japan proper have some resemblances to those of the Indo-African rather than West Coast of North America, because *Rutitrigonia*, *Pterotrigonia* s. l., and *Acanthotrigonia* are the characteristics and most flourished in the same age of the Indo-African province. On the other hand, the Senonian fauna, especially Gyliakian fauna of the Yezo geosynclinal region, is closely allied to that of West Coast in North America.

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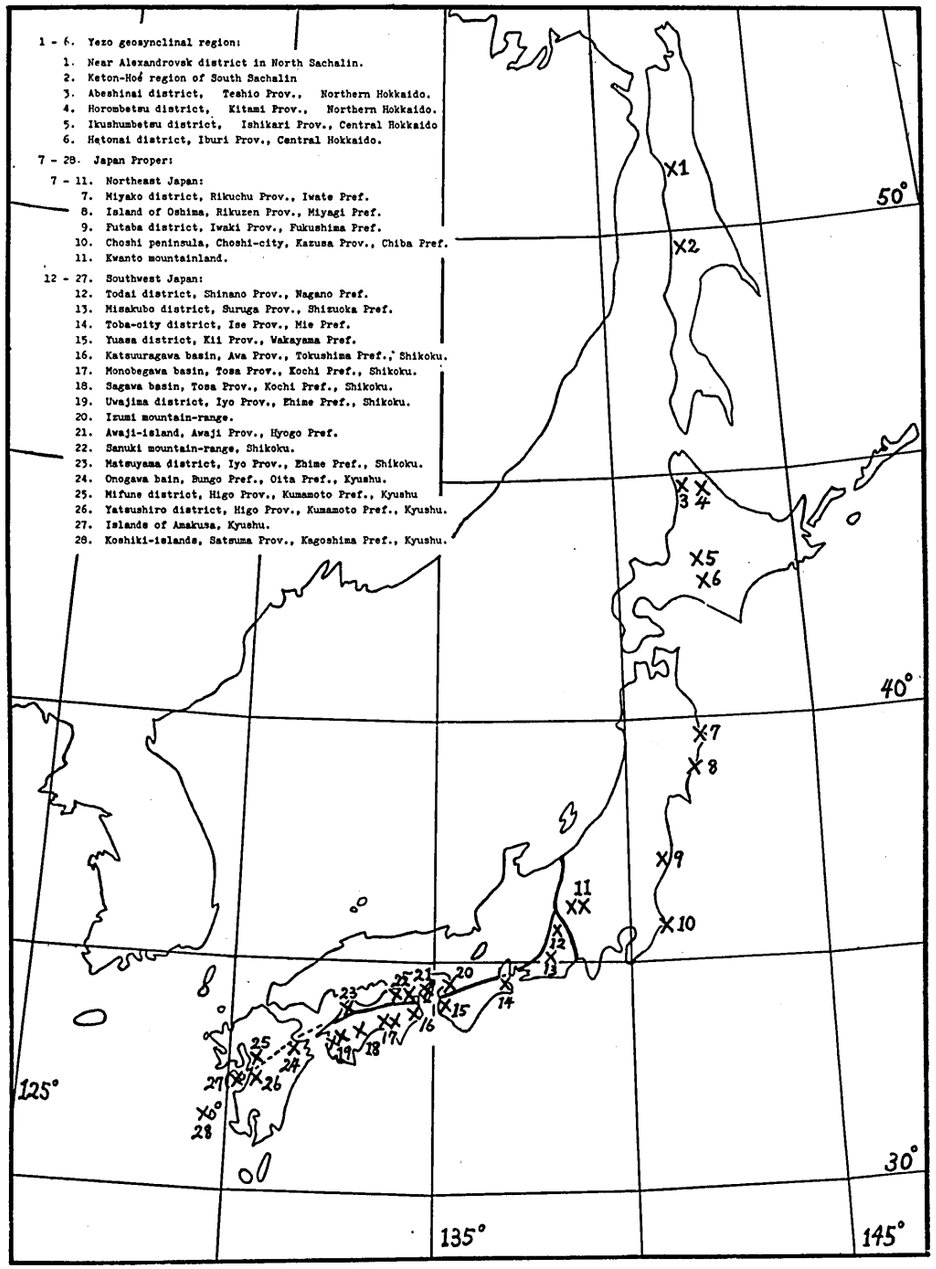


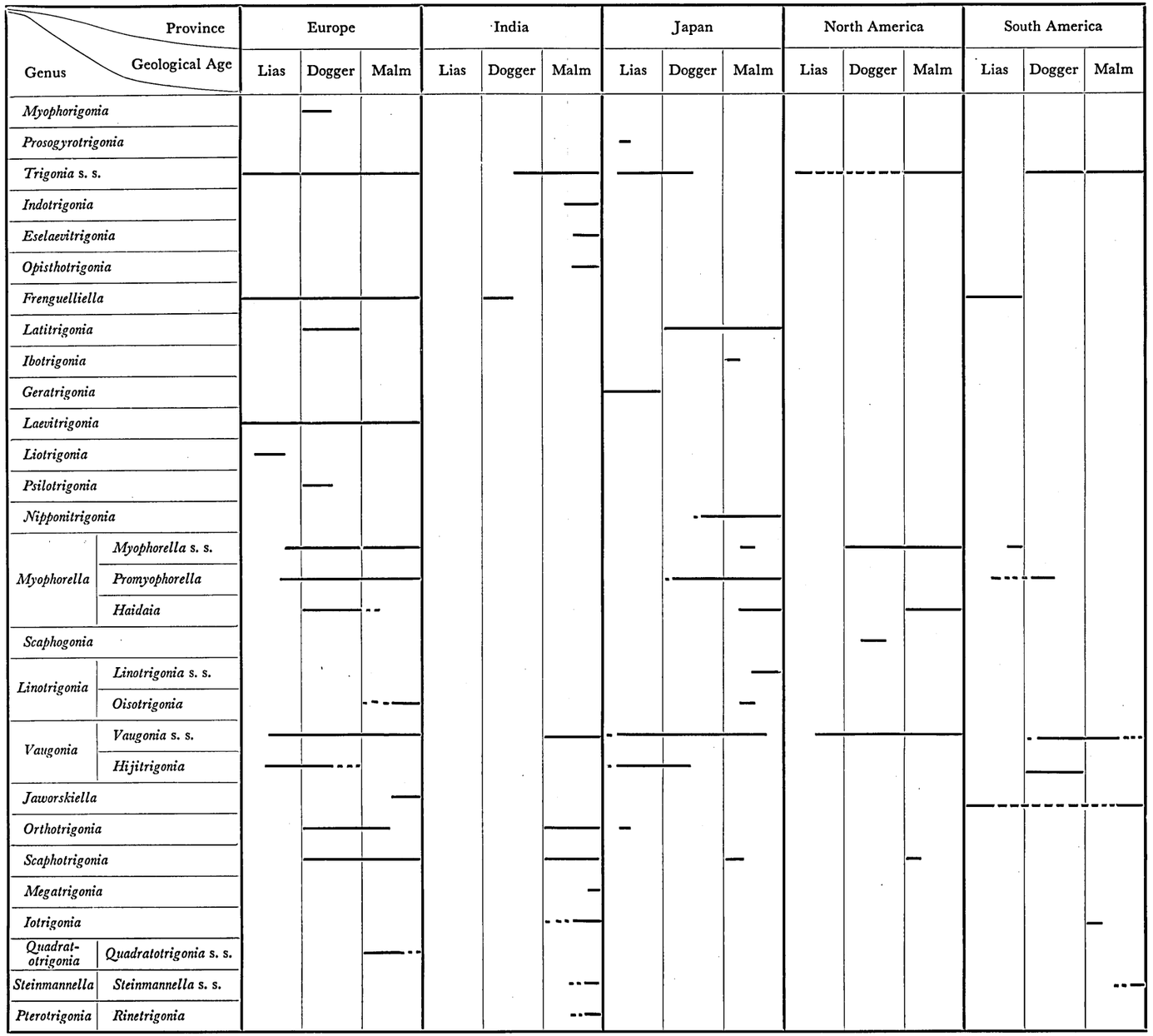
Map showing the distributions and the localities of the Cretaceous Trigoniids in the Japanese Islands.

Specific name \ Horizon	Eastern Wing																			Western Wing
	Lower										Middle		Upper							Lower
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	M_1	M_2	U_1	U_2	U_3	U_4	U_5	U_6	U_7	
Solemya angusticaudata NAGAO											×	×								×
Acila (*Truncacila*) *hokkaidoensis* (NAGAO)												×								
Nuculana ? sp.				×	×															
Cucullaea aff. *truncata* GABB	×	×	×	×										×						
C. ezoensis YABE and NAGAO	×	×	×		×	×				×	×	×								
Nanonavis sachalinensis (SCHMIDT)	×	×	×	×		×				×	×	×		×				×	×	×
Glycymeris hokkaidoensis NAGAO															×	×	×			
Pinna saitoi NAGAO				×	×						×									
P. sp. cf. *P. breveri* GABB	×	×	×																	×
Gervillia (*Pseudoptera*) *acuticarinata* NAGAO													×	×			×			
Ostrea sp.														×	×		×			×
Pecten (*Synclonema*) cf. *ovatus* STOLICZKA				×	×		×	×	×		×	×								×
Propeamussium cooperi var. *yubarensis* YABE and NAGAO				×	×	×							×					×		×
Anomia linensis WHITEAVES	×		×																	
Astarte (*Dorzyia*) aff. *striata* SOWERBY													×		×					
Thetironia affinis var. *japonica* YABE and NAGAO					×															×
"*Callista*" *pseudoplana* YABE and NAGAO	×		×							×			×	×	×	×	×			
"*C.*" *p.* var. *alata* YABE and NAGAO													×	×	×	×	×			
"*C.*" *p.* var. *elongata* YABE and NAGAO													×	×		×	×			
"*C.*" (*Pseudamiantis*) *crenulatus* MATUMOTO													×	×		×	×			
Anthonya japonica MATUMOTO		×	×	×	×															×
A. apicalis NAGAO		×	×	×																×
Panope sp.					×									×		×	×			

The List of Pelecypod Fossils from the "*Trigonia* Sandstone" in Ikushumbetsu district, Central Hokkaido (excluded Inoceramid and Trigoniid).

Subfamily	Genus	Subgenus	Triassic: Mid.	Triassic: Up.	Jurassic: Lias	Jurassic: Dogger	Jurassic: Malm	Cretaceous: Neoc.	Cretaceous: "Middle"	Cretaceous: Senon.	Tertiary: Paleogene	Tertiary: Neogene	Recent
Minetriogoniinae	*Minetrigonia*			—									
	Myophorigonia			- -	—	—	— - -						
Prosogyrotrigoniinae	*Prosogyrotrigonia*			—	- -								
	Prorotrigonia			—									
Trigoniinae em.	*Trigonia* s. s.		—	—	—	—	—	—	—	— - -			
	Pacitrigonia								—	—			
	Nototrigonia							—	—				
	Heterotrigonia								- —	—			
	Indotrigonia						—	—	—				
	Eselaevitrigonia						—	—	—				
	Pleurotrigonia								—				
	Sphenotrigonia							—	—	— - -			
	Opisthotrigonia						—						
Frenguelliellinae nov.	*Frenguelliella*			—	—	—	—	—	—	—			
	Latitrigonia					—	—						
	Ibotrigonia						—						
	Geratrigonia				—	—							
	Laevitrigonia				—	—	—						
	Liotrigonia				—								
	Psilotrigonia					—							
	Nipponitrigonia					-	-	-	-				
	Rutitrigonia							—	—	—			
Myophorellinae	*Myophorella*	*Myophorella* s. s.				—	—	—	—				
		Promyophorella				—	—	—					
		Haidaia				—	—	—					
	Scaphogonia					—							
	Linotrigonia	*Linotrigonia* s. s.					—	—	—	—			
		Oistotrigonia					-	—	—	—			
Vaugoniinae	*Vaugonia*	*Vaugonia* s. s.			—	—	—	—	—				
		Hijitrigonia			—	—							
	Jaworskiella				—	—	—	—					
	Orthotrigonia				—	—	—	—					
	Scaphotrigonia					—	—	—	—	- -			
	Apiotrigonia								-	—			
	Microtrigonia									—			
	Buchotrigonia							—	—	—			
	Syrotrigonia								—				
	Asiatotrigonia								—				
	Korobkovitrigonia								-				
Megatrigoniinae	*Megatrigonia*						—	—	—				
	Iotrigonia						-	—	—				
Quadratotrigoniinae	*Quadratotrigonia*	*Quadratotrigonia* s. s.					—	—	—				
		Leptotrigonia						—					
	Litschkovitrigonia							—	—				
	Steinmannella	*Steinmannella* s. s.					-	—	—				
		Yeharella							-	—			
		Setotrigonia								—			
	Yaadia							—	—				
Pterotrigoniinae	*Pterotrigonia*	*Pterotrigonia* s. s.						—	—	—			
		Rinetrigonia						-	—	—			
	Scabrotrigonia								—	—			
	Acanthotrigonia								—	— - -			
Neotrigoniinae	*Neotrigonia*											—	—
	Eotrigonia										— - -	—	

Geological Ranges of the Trigoniidae



Geographical and Geological Distributions of the Jurassic Trigoniids

Genus \ Province		Europe			Near and Central Asia			Indo-Africa			Japan			North America			South America			Australia		
		Necom.	"Middle"	Senon.	Necom.	"Middle"	Senon.	Necom.	"Middle"	Senon.	Necom.	"Middle"	Senon.	Necom.	"Middle"	Senon.	Necom.	"Middle"	Senon.	Necom.	"Middle"	Senon.
Trigonia s. s.																						
Pacitrigonia																						
Nototrigonia																						
Heterotrigonia																						
Indotrigonia																						
Eselaevitrigonia																						
Pleurotrigonia																						
Sphenotrigonia																						
Frenguelliella																						
Nipponitrigonia																						
Rutitrigonia																						
Myophorella	*Myophorella* s. s.																					
	Promyophorella																					
	Haidaia																					
Linotrigonia	*Linotrigonia* s. s.																					
	Oistotrigonia																					
Vaugonia																						
Jaworskiella																						
Orthotrigonia																						
Scaphotrigonia																						
Apiotrigonia																						
Microtrigonia																						
Buchotrigonia																						
Syrotrigonia																						
Asiatotrigonia																						
Korobkovitrigonia																						
Megatrigonia																						
Iotrigonia																						
Quadratotrigonia	*Quadratotrigonia* s. s.																					
	Leptotrigonia																					
Litschkovitrigonia																						
Steinmannella	*Steinmannella* s. s.																					
	Yeharella																					
	Setotrigonia																					
Yaadia																						
Pterotrigonia	*Pterotrigonia* s. s.																					
	Rinetrigonia																					
Scabrotrigonia																						
Acanthotrigonia																						

Geographical and Geological Distributions of the Cretaceous Trigoniids

Geological Age / Specific name	Infra-Hettangian	Lias				Dogger			Malm			
		Hettangian	Sinemurian	Pliesbachian	Toarcian	(Aalenian)	Bajocian	Bathonian	Callovian	Oxfordian	Kimmeridgian	Tithonian
Prosogyrotrigonia inouyei		×										
Trigonia senex		×										
T. sumiyagura							×					
Latitrigonia orbicularis											×	
L. pyramidalis							×					
L. tetoriensis											×	
L. unicarinata								×	×			
L. unituberculata									×			
Ibotrigonia masatanii									×			
Geratrigonia hosourensis	×											
G. h. var. *convexa*	×											
G. kurumensis					×							
G. lata	×											
Nipponitrigonia sagawai								×	×	×	×	×
Vaugonia awazuensis								×				
V. kodaijimensis							×					
V. namigashira		×			×		×					
V. niranohamensis		×										
V. yambarensis											×	
V. yokoyamai		×					×					
V. y. forma *gracilis*		×										
V. (Hijitrigonia) geniculata							×					
V. (H.) kojima		×					×					
Orthotrigonia corrugata		×										
O. midareta		×										
Scaphotrigonia somensis									×			
Myophorella (Myophorella) deckaiboda										×		
M. (Promyophorella ?) hashimotoi											×	
M. (P. ?) imamurai											×	
M. (P.) sigmoidalis							×					
M. (P.) sugayensis								×	×			
M. (P.) s. var. *geniculata*									×			
M. (P.) obsoleta											×	
M. (P.) orientalis											×	×
M. (Haidaia) crenulata										×	×	
M. (H.) c. var. *lunulata*											×	
M. (H.) gracilenta											×	×
M. (H.) ohmachii												×
M. (H.) subcircularis										×		
M. (H.) pulex											×	×
Linotrigonia toyamai											×	×
L. (Oistotrigonia) prima										×		

Vertical Distributions of the Japanese Jurassic Trigoniids

Specific name \ Locality	Yezo geosynclinal Region						Japan proper																					
							Northeast Japan					Southwest Japan																
	Sachalin		Hokkaido									Akaishi mountainland			Shikoku				Izumi belt				Kyushu			
	Near Alexandrovsk	Keton-Hoé region	Abeshinai district	Horombetsu district	Ikushumbetsu district	Hetonai district	Miyako district	Island of Oshima	Futaba district	Choshi peninsula	Sanchu graben	Todai district	Misakubo district	Yuasa district	Katsuuragawa basin	Nagase district	Sakawa basin	Uwajima district	Near Matsuyama city	Sanuki mountain-range	Awaji-island	Izumi mountain-range	Onogawa basin	Mifune district	Yatsushiro district	Islands of Amakusa
Heterotrigonia granosa																										×
H. subovalis					×																					
Nipponitrigonia kikuchiana							×	×?		×	×	×		×	×	×	×	×							×	×
N. k. var. *plicata*														×	×										×	
N. naumanni												×		×	×	×	×	×							×	
N. quadrata																									×	
N. sakamotoensis															×		× ?									
Rutitrigonia sanchuensis											×														×	
R. yeharai											×						×									
Apiotrigonia crassoradiata																			×							
Ap. minor	×	×			×	×			×						×			×								×
Ap. m. var. *nankoi*															×					×	×	×				×
Ap. obliquecostata																										×
Ap. obsoleta																					×					×
Ap. postonodosa																				×	×					×
Ap. tuberculata																					×					×
Ap. undulosa									×														×			
Microtrigonia amanoi																										×
M. minima																					×					
Steinmannella (Yeharella) ainuana					×																					
St. (Y.) deckeina			×																							
St. (Y.) japonica																			×	×						
St. (Y.) j. var. *obsoleta*																										×
St. (Y.) kimurai									×										×	×						
St. (Y.) k. sanukiensis																				×						
St. (Y.) lymani		×																								
St. (Setotrigonia) shinoharai																				×						
Pterotrigonia brevicula					×																					
P. datemasamunei							×																			
P. datemasamunei var.																							×			
P. hokkaidoana	×				×		×	×			×		×	×	×	×	×								×	×
P. kotoi							×					×														
P. pocilliformis								×		×	×	×		×	×	×	×	×								
P. p. var. *yamanokamiensis*																	×									
P. sakakurai																										×
P. yokoyamai							×																			
P. (Rinetrigonia) yeharai, sp. nov.																										×
P. (R.) sp. a & b																									×	
P. (R.) sp. nov.																								×		
Scabrotrigonia imanishii				×																						
Sc. kobayashii					×																					
Sc. obsoleta																										×
Acanthotrigonia dilapsa													×			×?	×?									×
Ac. longiloba					×												×									
Ac. moriana																×										
Ac. ogawai																									×	×
Ac. pustulosa					×											×	×									×

The List of the Localities of the Cretaceous Trigoniids in the Japanese Islands

Tentative Correlation of the Cretaceous Deposits in the Important Places of the Japanese Islands

Time-Stratigraphic Classification

Series	Subseries	Stage	Japanese stage	Substage
Lower Tertiary				
Upper Cretaceous	Senonian s. l.	Maestrichtian	Hetonaian	Upper Hetonaian
		Campanian		Lower Hetonaian
			Urakawan	Uppermost Urakawan
		Santonian		Upper Urakawan
		Coniacian		Lower Urakawan
	"Middle Cretaceous"	Turonian	Gyliakian	Upper Gyliakian
		Cenomanian		Lower Gyliakian
			Miyakoan	Uppermost Miyakoan
Lower Cretaceous		Albian		Upper Miyakoan
		Aptian		Lower Miyakoan
	Neocomian	Barremian	Aritan	"Oshima Series"
		Hauterivian		
		Valangian	Kochian	"Ryoseki Series"
		Berriasian		
Upper Jurassic				

Yezo geosynclinal Region (Sachalin: Near Alexandrovsk, Keton-Hoé region; Hokkaido: Abeshinai, Horombetsu, Ikushumbetsu, Hetonai districts)

Time-Stratigraphic Classification	Near Alexandrovsk	Keton-Hoé region	Abeshinai district	Horombetsu district	Ikushumbetsu district	Hetonai district
Lower Tertiary					Ishikari group	
Maestrichtian (Upper Hetonaian)	Cape de la Jonquière group	(+)	Yasukawa group 21	Basement rocks	Hakobuchi group	Hakobuchi group 15
Campanian (Lower Hetonaian)			Osoushinai form.	(+ ?)		
Campanian (Uppermost Urakawan)		Hoé form.			Upper Yezo group: Upper Ammonites Beds	Upper Yezo group
Santonian (Upper Urakawan)			Omagari form.; Nishichirashinai form.			
Coniacian (Lower Urakawan)		Aton form. 15				
Turonian (Upper Gyliakian)	Werblude group 15, 31.	Keton form. 26			Middle Yezo group: "*Trigonia* Sandstone" 2, 15, 20, 28, 31, 41, 44, 47.	
Cenomanian (Lower Gyliakian)		Koton form.				
Cenomanian (Uppermost Miyakoan)	?	?				
Albian (Upper Miyakoan)				Horombetsu form. 40	Lower Ammonites Beds	
Aptian (Lower Miyakoan)						
Barremian						
Hauterivian						
Valangian						
Berriasian						
Upper Jurassic						

Japan Proper — Northeast Japan; Southwest Japan (Akaishi-mountainland, Yuasa)

Time-Stratigraphic Classification	Miyako and Oshima districts	Futaba district	Choshi peninsula	Sanchu graben	Todai district	Misakubo district	Yuasa district
Lower Tertiary	(–)	Shiramizu group	(–)	(–)	(–)	Wada form.	(–)
Maestrichtian (Upper Hetonaian)	Basement rocks	(+)		(Not yet identified)		Basement rocks	(+)
Campanian (Lower Hetonaian)	(–)	Futaba group 15, 17, 24.				(+ ?)	Toyajo form.
Campanian (Uppermost Urakawan)							
Santonian (Upper Urakawan)							Goryo form.
Coniacian (Lower Urakawan)							
Turonian (Upper Gyliakian)		Basement rocks	(–)			Misakubo form. 31, 43.	Kanaya form.
Cenomanian (Lower Gyliakian)							
Cenomanian (Uppermost Miyakoan)						Basement rocks	? ; Nishihiro form. 3, 31, 33.
Albian (Upper Miyakoan)	Miyako group: Shimohei f. 3, 29, 31, 32, 36. Raga cg.		Choshi group 3, 33.	? ; Upper form. (Kawarazawa f.)	Todai form. 3, 5, 32, 33.		
Aptian (Lower Miyakoan)							
Barremian	Basement rocks		Basement rocks	Middle form. (Ishido f.) 3, 8, 9, 31, 33.			Arita form. 3, 4, 5, 31, 33.
Hauterivian	Oshima form. 3?, 31, 33.						
Valangian	Oshima effusives			Lower form. (Shiroi f.) 31, 33.			Yuasa form.
Berriasian							
Upper Jurassic	Shishiori group			Miyakozawa Onozawa form.			Basement rocks

Southwest Japan — Shikoku; Izumi belt

Time-Stratigraphic Classification	Katsuuragawa basin	Nagase district	Sakawa basin	Uwajima district	Izumi belt
Lower Tertiary	(–)	(–)	(–)	(–)	(–)
Maestrichtian (Upper Hetonaian)	(+)	(+)	(+)	(+)	Izumi group 10, 11, 13, 14, 16, 19, 22, 24, 25, 27.
Campanian (Lower Hetonaian)	Miyakura form. 11, 15.				
Campanian (Uppermost Urakawan)	(Not yet identified)			?	Basement rocks
Santonian (Upper Urakawan)		Soto-Izumi group: Kajisako form. 43 ?		Uwajima group: Makinoyama f. 15; Furushiroyama f. 15; Ishibiki f.; Narukawa f. 15	
Coniacian (Lower Urakawan)					
Turonian (Upper Gyliakian)		Nagase form. 31, 47.		? ; Shimonada group	
Cenomanian (Lower Gyliakian)			Miyanohara sandstone 7?, 31, 43?, 44, 47.		
Cenomanian (Uppermost Miyakoan)	Fujikawa f.	Monobegawa group: Hibihara form. 3, 5, 31, 33, 45.	Monobegawa group: Upper Monobegawa group 3, 33		
Albian (Upper Miyakoan)	Hoji form. 3, 4, 5, 31, 33.			?	
Aptian (Lower Miyakoan)				? ; Kikunodani form. 3, 4, 5, 33	
Barremian	Hanoura form. 33.	Yunoki form. 31, 33	Lower Monobegawa group 33.	Basement rocks	
Hauterivian					
Valangian	Tachikawa form.	Ryoseki group	Ryoseki group 3, 5, 9, 34.		
Berriasian					
Upper Jurassic	Basement rocks	Basement rocks	Torinosu group		

Southwest Japan — Kyushu

Time-Stratigraphic Classification	Onogawa basin	Mifune district	Yatsushiro district	Islands of Amakusa
Lower Tertiary	(–)	(–)	(–)	Akazaki group
Maestrichtian (Upper Hetonaian)	(+)	(+)	(+)	(+)
Campanian (Lower Hetonaian)				Himenoura group 1, 11, 12, 13, 14, 15, 16, 18, 23,
Campanian (Uppermost Urakawan)	Onogawa group: Amabe form.			
Santonian (Upper Urakawan)	Yoshinotsuru f. 17			
Coniacian (Lower Urakawan)	Tonoe form.			
Turonian (Upper Gyliakian)	Nakakawarauchi f.; Okukawarauchi f.	Mifune group 39	Tomochi form. 3, 4, 31, 46.	Goshonoura group 3, 31, 35, 37, 42, 43, 46, 47,
Cenomanian (Lower Gyliakian)	Ryozen form. 30.			
Cenomanian (Uppermost Miyakoan)	Basement rocks	Basement rocks	Yatsushiro form. 3, 4, 6, 8, 31.	Basement rocks
Albian (Upper Miyakoan)	Haidateyama form. 29. 31			
Aptian (Lower Miyakoan)			Hinagu form. 3, 31, 38.	
Barremian			Hachiryuzan form. 4, 31.	
Hauterivian				
Valangian			Kawaguchi form.	
Berriasian				
Upper Jurassic			Sakamoto form.	

〰〰 Unconformity — Basement rocks (hatched) — ～～ Disconformity

(+) Eroded away (–) Lacking originally

Numbers correspond to those in the specific list (IV – 3a).