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On the Rutitrigoniinae

by

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with 1 Table and 1 Plate

ABSTRACT: In this paper, the writer has dealt with the classification and the phyletic relationships of the subfamily Rutitrigoniinae and described and listed a number of genera and species.

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I. INTRODUCTION AND ACKNOWLEDGEMENTS

The writer has discussed the Trigoniid faunas of the Mesozoic era, especially Cretaceous period, in the Japanese Islands and has proposed the Frenguelliellinae nov. which can be separable from KOBAYASHI's Trigoniinae on the basis of the sculpture on the area. Since then, the writer (1961) dealt with the classification of the Trigoniinae and discussed the distributions and the complicated phyletic relationships of the subfamily.

The classification tried by the writer (1961, pp. 79-80) is tentatively summerized as follows:

Subfamily Trigoniinae s.s.

Trigonia section

Genus *Trigonia* BRUGUIÈRE, 1789 (*Venus sulcata* HERMANN, 1781)

? Genus *Pseudomyophorella* nov. (*Pseudomyophorella savelievi* gen. et sp. nov.)

Pacitrigonia section

- Genus *Pacitrigonia* MARWICK, 1932 (*Pacitrigonia sylvesteri* MARWICK, 1932)
 Genus *Nototrigonia* COX, 1952 (*Trigonia cinctuta* ETHERIDGE, 1902)
 ? Genus *Heterotrigonia* COX, 1952 (*Trigonia diversicostata* WHITEAVES, 1876)

Indotrigonia section

- Genus *Indotrigonia* DIETRICH, 1933 (*Trigonia smeei* SOWERBY, 1840)
 Genus *Eselaevitrigonia* KOBAYASHI and MORI, 1954 (*Trigonia meridiana* WOODS, 1916)
 Genus *Opisthotrigonia* COX, 1952 (*Trigonia retrosa* KITCHIN, 1903)
 Genus *Pleurotrigonia* VAN HOEPEN, 1929 (*Trigonia blanckenhorni* NEWTON, 1907)
 Genus *Sphenotrigonia* RENNIE, 1936 (*Trigonia (Sphenotrigonia) frommuerzei* RENNIE, 1936)

Subfamily *Frenguelliellinae* NAKANO, 1960

- Genus *Frenguelliella* LEANZA, 1942 (*Trigonia inexpectata* JAWORSKI, 1916)
 Genus *Geratrigonia* KOBAYASHI, 1954 (*Trigonia hosourensis* YOKOYAMA, 1904)
 Genus *Latitrigonia* KOBAYASHI, 1957 (*Latitrigonia pyramidalis* KOBAYASHI and TAMURA, 1957)
 Genus *Ibotrigonia* KOBAYASHI, 1957 (*Ibotrigonia masatanii* KOBAYASHI and TAMURA, 1957)
 Genus *Laevitrigonia* LEBRÜCHNER, 1931 (*Trigonia gibbosa* SOWERBY, 1821)
 Genus *Liotrigonia* COX, 1952 (*Trigonia lingonensis* DUMORTIER, 1869)
 Genus *Psilotrigonia* COX, 1952 (*Trigonia beesleyana* LYCETT, 1874)
 Genus *Nipponitrigonia* COX, 1952 (*Trigonia kikuchiana* YOKOYAMA, 1891)
 Genus *Rutitrigonia* VAN HOEPEN, 1929 (*Rutitrigonia peregrina* VAN HOEPEN, 1929)

Although *Frenguelliella* seems to be one of the most important trunks of the Trigoniidae and *Rutitrigonia* may represent only a specialized branch, the name of the Rutitrigoniinae van HOEPEN, 1929 antecedes Laevitrigoniinae SAVELIEV, 1958 and *Frenguelliellinae* NAKANO, 1960.

The Rutitrigoniinae comprising 9 genera and a lot of species and varieties, can be divided into 3 sections called the *Frenguelliella*, *Laevitrigonia*, and *Nipponitrigonia* sections, by the sculpture on the flank and the character of the marginal angulation. This subfamily appeared possibly in the Carnian of Japan, and they continued to exist till the Senonian when 3 forms of *Frenguelliella* are known from the Arrialoor group in the "Inde malgasche" region as the relics of the subfamily. They most flourished in the Jurassic of Europe and Japan, but gradually vanished in the Cretaceous. *Frenguelliella* forms a trunk of the subfamily, and prospered in the Malm of Europe but suddenly declined in the Cretaceous. The genera of the *Frenguelliella* section are considered to have been issued from the trunk in East Asia through the Jurassic by the change of the surface ornamentation. In the Jurassic of Europe, the members of the *Laevitrigonia* section were derived probably from the main trunk by the effacement of the carinae and the development of the complicated sculpture which is improminent in many cases. From the Dogger to the Neocomian, the remainders of the subfamily were issued possibly from the trunk in probably Indo-Pacific region by the transfigurations of the shell forms and the obsoletion of the surface sculpture and the marginal angulation.

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ly, the writer is indebted to the Grant in Aid for Scientific Researches from the Ministry of Education in Japan.

II. PALAEOONTOLOGICAL NOTES

Subfamily Rutitrigoniinae van HOEPEN, 1929

(= *Laevitrigoniinae* Saveliev, 1958; *Frenguelliellinae* Nakano, 1960)

Shell trigonal-ovate to ovate or sometimes rostrate posteriorly, inequilateral, usually tripartite distinctly into a flank, an area and escutcheon; umbo rather low, mesial to antero-mesial and opisthogyrous in many forms but often orthogyrous or prosogyrous; costae on the flank plain, concentric to subconcentric, but sometimes undulated, tuberculate or evanescent later; escutcheon transversely costellate or smooth but its presence is rarely uncertain; area bipartite by a median carina or groove, with transverse to oblique costae which are sometimes effaced later; marginal carina and ante-carinal groove distinct, but occasionally not well developed.

The shell outline is fairly constant, while the surface costation and the nature of the marginal angulation vary in this subfamily to a large extent. With reference to the sculpture on the flank and the character of the marginal carina or angulation three sections called the *Frenguelliella*, *Laevitrigonia*, and *Nipponitrigonia* sections can be distinguished in this subfamily.

1) The *Frenguelliella* section comprises *Frenguelliella*, *Latitrigonia*, *Ibotrigonia*, and *Geratrigonia*, and is characterized by the strong marginal carina, broad ante-carinal groove, and fairly distinct and regular costae on the flank. Costellae on the area are arranged transversely and they are sometimes evanescent later. This section is distributed mainly in Eurasia from the Upper Triassic to the Upper Cretaceous, and most flourished in the Jurassic of Japan and Europe.

Frenguelliella having subtrigonal outline, typified by *Trigonia inexpectata* Jaworski (1916, pp. 377-380, pl. 5, figs. 2a-b) from the middle Lias of Patagonia, is a cosmopolitan and persistent genus. Costae on the flank are plain and concentric to subconcentric. Its area is provided with transverse costellae or often smooth in the later representatives. It ranges from the Carnian to the Senonian, but the Neocomian forms have hitherto been missing from the globe. This genus is well known in Europe, and was most abundant in the Malm. On the other region, its existences are reported from the Carnian of Japan, Lias of South America, Dogger of Australia and India, and Senonian of India and Madagascar (?). *Latitrigonia* and *Ibotrigonia* have the small shell, and costae on their flank are parallel to the ventral margin. Their area is ornamented with concentric to transverse costae in juvenalium, but smooth in the later stages. They are typified respectively by *Latitrigonia pyramidalis* Kobayashi and Tamura (1957, pp. 36-37, pl. 1, figs. 8a-b) from the Bajocian of Soma district and *Ibotrigonia masatanii* Kobayashi and TA-

MURA (1957, pp. 38-39, pl. 1, figs. 5-6) from the Callovian of the same region in North Japan. In *Ibotrignia costae* on the flank are broken into tubercles in the later stages, while *Latitrignia* has commonly one or two tubercles on the posterior part of the flank. From the surface sculpture in the early stages, both genera may be the off-shoots derived from *Frenquelliella* by the development of tuberculation on costae and the transfiguration of the shell form. *Latitrignia* distributes in East Asia from the Dogger to the Malm, and *Ibotrignia* occurs in the Callovian of Japan. *Geratrignia* comes out from the Lias of Japan, and its type is *Trignia hosourensis* YOKOYAMA (1904, p. 11, pl. 1, fig. 3) from the Hettangian of Shizukawa district in Miyagi Pref., North Japan. It has a trigonal-ovate outline, and an antecarinal depression is well developed. Costae on its flank are regular and concentric in the early stages, but in the later they become fairly irregular on the posterior part. Area is sculptured with weak transverse costae or striae near the umbo, but smooth in the later stages. It is probably a derivative from *Frenquelliella* by the effacement of the sculpture on the area and the complication of the ornamentation on the flank.

2) The *Laevitrignia* section proposed by KOBAYASHI and MORI (1955), is approximately equivalent to Saveliev's *Laevitrigninae*. This section including *Psilotrignia*, *Liotrignia*, and *Laevitrignia*, is characterized by their ovate to trigonal-ovate outline, obtuse marginal carina, and the development of the fairly prominent and complicated costation on their flank. This section is limited to occur in the Lias to the Malm of Western Europe.

Laevitrignia ranging from the Lias to the Malm, is typified by *Trignia gibbosa* SOWERBY (1821, p. 61, tabs. 235-236) from the Portlandian of Britain whose area is transversely costellate and the flank near the umbo with plain concentric costae. In this aspect, this form is possibly an off-shoot derived from *Frenquelliella*. Monotypic *Psilotrignia* based on *Trignia beesleyana* LYCETT (1874, pp. 91-92, pl. 17, figs. 2-4) from the Inferior Oolite of Britain and Italy, is a specialized ovate Trigniid. The whole surface of the young stage is sculptured with concentric costae and costellae, and three carinae are distinct. While, in the adult stage costellae on the area become oblique and the flank is ornamented with slightly oblique and flexiate costae on its antea portion. From the surface sculpture, this is closely similar to rostrate Cretaceous *Rutitrignia* which has oblique costellae on the area. As already discussed by KOBAYASHI (1957), it is difficult to analyse the phylogeny of the smooth Trigniiids. However, *Psilotrignia* may be an off-shoot derived from *Frenquelliella* or *Laevitrignia* as can be judged from the surface sculpture of the early stage. *Liotrignia* is monotypic and typified by *Trignia lingonensis* DUMORTIER (1861, p. 275, pl. 22, figs. 6-8) from the middle Lias of France and Britain. This is also a peculiar form, and costae on the flank are first weak and concentric but later they become subconcentric wrinkles. Its area is smooth except near the umbo with transverse striae, but marginal angulation and escutcheon carina are well developed. Judging from the shell form and the surface costation, this is probably

a derivative from *Laevitronia* or *Frenguelliella* by the effacement of the sculpture on the surface and the carinae.

3) The *Nipponitronia* section including *Nipponitronia* and *Rutitronia*, has the fairly simple sculpture on the surface and the marginal carina is usually absent or indicated only by an obtuse angulation. The flank is sculptured with concentric to transverse costae which are sometimes effaced later. Costellae on the area are transverse to oblique, and they are in many cases evanescent in the later. Escutcheon is small and transversely costellate in some forms, but it is usually indistinct and not well-defined. *Nipponitronia* is triangularly ovate to ovate in shape, and its type is *Trigonium kikuchiana* YOKOYAMA (1891, pp. 363-365, pl. 40, figs. 4-6) from the Neocomian to the Cenomanian of Japan excluding Hokkaido region. This genus is common in the Dogger to the Cenomanian of Japan. Concentric sculpture presents at the umbonal region, but the rest of the flank is smooth or provided with concentric to transverse costae on the anterior part. As already pointed out by KOBAYASHI (1957), its immature shell is similar to that of *Frenguelliella* because of concentric sculpture and three distinct carinae in the vicinity of the umbo. *Rutitronia* is characterized by its rostrate and pyriform outline and the obliquely costellate area, and costae on the flank are subconcentric to transverse or sometimes slightly oblique. The type is *Rutitronia peregrina* van HOEPEN (1929, pp. 32-33, pl. 7, figs. 13-16) from the Albian of Zululand in South Africa. In 1929, van HOEPEN erected for the Rutitroniinae on *Rutitronia* from his study on the Cretaceous Trigoniids in Zululand. COX (1952) treated it as a subgenus of genus *Megatrigonia* van HOEPEN. KOBAYASHI (1957) ranked it up to the generic rank, and considered that this genus may be a member of his Trigoniinae and an offshoot derived from the Trigoniinae stock. Recently, SAVELIEV (1958) took it for a genus of Megatrigoniinae van HOEPEN. The writer, however, here accepts KOBAYASHI's proposal. This genus is cosmopolitan in the Lower to the "Middle" Cretaceous, but very rare or unknown in Australia and its adjacent regions. The immature form of the genus is sculptured with several concentric costae and costellae and the surface is distinctly tripartite by a weak marginal and escutcheon carinae. Because of its appearance in the early stage, the genus may be a derivative from *Frenguelliella*.

The phylogenetical relation and the distribution of the subfamily are shown on Tab. 1. *Frenguelliella* is a trunk of the subfamily, and appeared possibly in the Carnian of Japan. This genus mainly flourished in the Jurassic of Europe and South America, but suddenly declined in the Cretaceous. The other genera of the *Frenguelliella* section are considered to have been issued from the stock in East Asia through the Jurassic by the change of the surface sculpture. In the Jurassic of Europe, the genera of the *Laevitronia* section were derived from the trunk by the effacement of the carinae and the development of the complicated but improminent sculpture on the surface. The members of the *Nipponitronia* section are possibly the off-shoots issued from the trunk from time to time in probably Indo-

Pacific region by the transfigurations of the shell forms and the effacement of the surface ornamentation and the marginal angulation.

Because the surface ornamentation of their umbonal region is similar to *Frenquelliella*, the Vaugoniinae and the Myophorellinae might be derived from this subfamily.

Genus *Frenquelliella* LEANZA, 1942

Diagnosis:—Shell subtrigonal to triangularly ovate, inequilateral, moderately inflated; umbo prominent and angular; beak opisthogyrous and antero-mesial. Flank sculptured with numerous plain concentric to subconcentric costae; ante-carinal depression distinct but sometimes obscure. Marginal and escutcheon carinae distinct and serrated but indistinct in some forms. Area wide and slightly concave or nearly flat, provided with numerous plain transverse costellae which are sometimes obsolete later; median groove distinct but shallow. Escutcheon depressed and fairly broad, ornamented with transverse costellae or rarely a fine network of radial and transverse costellae which are sometimes evanescent later.

Synonym:—*Kumatrigonia* TAMURA, 1959

Type species:—*Trigonia inexpectata* JAWORSKI, 1916. Mid. Lias; Patagonia.

List of Species:—

- Trigonia belgrandi* MUNIER-CHALMAS, 1882. Portlandian; France.
- Trigonia bicostata* d'ORBIGNY, 1850. Up. Oxfordian; France.
- Trigonia chubutensis* FERUGLIO, 1933. Lias; Patagonia.
- Trigonia clavulosa* RIGAUX et SAUVAGE, 1868. Bathonian; France.
- Trigonia concinna* ROEMER, 1839. Kimmeridgian; Germany.
- Trigonia curvirostris* QUENSTEDT, 1858. Lias; Germany.
- Trigonia cuspidata* SOWERBY, 1826. Great Oolite; Britain.
- ? *Trigonia debilis* LYCETT, 1877. Cenomanian; Britain.
- Trigonia indica* STOLICZKA, 1871. Arrialoor group; India.
- Trigonia minuta* STOLICZKA, 1871. Arrialoor group; India.
- Trigonia modesta* TATE in TROEDSSON, 1951. Sinemurian; Sweden.
- Trigonia monthiersi* MUNIER-CHALMAS, 1882. Low. Portlandian; France.
- Trigonia moorei* LYCETT (pars) in MOOR, 1870. Dogger; Australia.
- Trigonia orientalis* FORBES, 1845. Arrialoor group; India and (?) Madagascar.
- Trigonia painei* LYCETT in GREPPIN, 1888. Great Oolite; Switzerland.
- Trigonia parvula* AGASSIZ, 1840. Low. Malm; Switzerland.
- Trigonia sawagei* de LORIOI, 1874. Mid. Malm; France.
- Trigonia tapiai* LAMBERT, 1944. Lias; Argentina.
- Frenquelliella* (*Kumatrigonia*) *tanourensis* TAMURA, 1959. Carnian; Kumamoto Pref., Kyushu, Japan.
- Trigonia tealei* COX, 1952. Bathonian; Cutch, India.
- ? *Trigonia truncata* AGASSIZ, 1840. Mid.-Up. Malm; Switzerland.
- Trigonia* sp. by FERUGLIO, 1933. Lias; Argentina.

Remarks:—This genus is closely allied to *Trigonia* BRUGUIÈRE in surface sculp-

ture and shell form, but distinct in the absence of the radial costation on the area.

This genus is somewhat constant in shell form, while the surface costation is variable to a fairly large extent. Costae on the area are transverse in many forms, but absent in *indica*. Escutcheon is ornamented with transverse costae in most others, but lacking in *inexpectata*. *Tanourensis* has a fine network of radial and transverse costellae on its escutcheon. In *tapii* and *tanourensis* numerous transverse costae on the area are connected to costae on the flank and costellae on the escutcheon with each another, but they are disconnected in the other forms. Marginal and escutcheon carinae are well developed and serrated in common species, but they are indistinct in 3 Indian forms, i.e. *indica*, *orientalis*, and *minuta*. Antecarinal depression and median groove are indistinct in Indian Cretaceous forms, but distinct in most common species. Beak is as a rule opisthogyrous, but orthogyrous in *tanourensis*.

As mentioned above, Cretaceous Indian species are quite peculiar and aberrant in this genus and they are easily separable from the other forms of the genus.

Distribution:—Carnian to Senonian of cosmopolitan but the Neocomian forms not well known on the globe. This genus appeared possibly in the Carnian of Japan, most flourished in the Jurassic of Europe and South America but suddenly declined in the Cretaceous. In the Senonian, 3 forms are known from the Arrialoor group in the "Inde malgasche" region as the relics.

Genus *Geratrigonia* KOBAYASHI, 1954

Diagnosis:—Shell ovately trigonal, inequilateral, gently inflated; umbo large and prominent; beak orthogyrous or slightly opisthogyrous and located anteriorly. Marginal and escutcheon carinae obtuse but distinct. Flank ornamented with plain regular or partly irregular costae which are often obsolete toward posterior; antecarinal depression shallow but distinct. Area rather narrow, slightly concave, smooth or provided with numerous plain transverse striae; median groove shallow and more or less distinct. Escutcheon narrow, depressed, and not impressed.

Type species:—*Trigonia hosourensis* YOKOYAMA, 1904. Hettangian; Shizukawa district, Miyagi Pref., North Japan.

List of Species:—

Geratrigonia kurumensis KOBAYASHI, 1957. Toarcian; Kuruma district, Central Japan.

Geratrigonia lata KOBAYASHI, 1954. Hettangian; Shizukawa, Miyagi Pref., North Japan.

Remarks:—In its early stage this genus is very similar to *Frenguelliella* in shell form and surface sculpture, because the marginal carina is distinct and the surface is ornamented with regular concentric costae on the flank and weak transverse costellae on the area.

Though a small extent of variation is recognizable, this genus is somewhat constant in surface ornamentation and shell form. In outline, *hosourensis* and *kurumensis* are taller and more trigonal than that of *lata* which has a broader umbo than those of the formers. Marginal angulation and ante-carinal depression are distinct in *lata*, while in *hosourensis* and *kurumensis* they are somewhat indistinct. On costae of the flank, blunt tuberculation on costae of the posterior part of the flank is well observable in *hosourensis* and *lata* but obscure in *kurumensis*. *Lata* has numerous plain transverse striae on its area, but smooth in *hosourensis*.

Distribution:—Lias in Japan.

Genus *Latitrigonia* KOBAYASHI, 1957

Diagnosis:—Shell small in size, subquadrate to subcircular, inequilateral, moderately inflated; umbo rather small; beak opisthogyrous and antero-mesial. Marginal carina fairly prominent in some forms, but indistinct in most others. Area large and smooth except in the vicinity of the umbo where transverse costellae are sometimes well developed; median groove shallow but distinct. Escutcheon depressed, narrow and smooth. Costae on the flank parallel to ventral margin, but sometimes each thickened into a nod at the posterior end where ante-carinal groove is often well developed.

Internally, three radial plications along the carinae well recognized.

Type species:—*Latitrigonia pyramidalis* KOBAYASHI and TAMURA, 1957. Bajocian; Soma district, Fukushima Pref., North Japan.

List of Species:—

Latitrigonia multicostata KOBAYASHI, 1957. Horizon uncertain; Mindoro, Philippine.

Latitrigonia orbicularis KOBAYASHI, 1957. Kimmeridgian; Hida plateau region, Central Japan.

Latitrigonia tetoriensis KOBAYASHI, 1957. Kimmeridgian; Hida plateau region, Central Japan.

Latitrigonia unicarinata KOBAYASHI and TAMURA, 1957. Bathonian-Callovian; Soma district, Fukushima Pref., North Japan.

Latitrigonia unituberculata KOBAYASHI and TAMURA, 1957. Callovian; Soma district, Fukushima Pref., North Japan.

Remarks:—In this genus, its young shell is very close to that of *Frenguelliella* in surface sculpture and shell form.

This genus is fairly variable in outline and surface ornamentation. Its outline is as a rule quadrate, but subcircular in *tetoriensis* and *orbicularis*. Marginal carina is distinct and apparently tuberculate in *pyramidalis* and *unituberculata*, but it is obscure in *multicostata* and *orbicularis*. In *pyramidalis* and *unicarinata* costae on the flank are thickened into a knod at the posterior end, but not well developed in the others. *Tetoriensis* and *unituberculata* have the large area, and they are as wide as the flank. On the other hand, they are half as large as the flank in the other

forms. Area is generally smooth, but transversely costellate in *pyramidalis* and *orbicularis*. Escutcheon carina is tuberculate in *multicostata*, but it is obtuse in the others.

Distribution:—Bathonian to Kimmeridgian of Japan and (?) Philippine.

Genus *Ibotrigonia* KOBAYASHI, 1957

Diagnosis:—Shell subtrigonal to roundly trigonal, inequilateral, moderately inflated. Umbo rather large and with a few plain concentric costae and costellae; beak opisthogyrous and pointed anteriorly. Marginal, median and escutcheon carinae plain or slightly serrated near umbo, but later tuberculate or plain. Escutcheon narrow and smooth. Area rather narrow and smooth. Flank ornamented with concentric to subconcentric costae which are broken into tubercles on the posterior part; ante-carinal groove shallow and relatively broad.

Type species:—*Ibotrigonia masatanii* KOBAYASHI and TAMURA, 1957. Callovian; Soma district, Fukushima Pref., Japan.

List of Species:—

Ibotrigonia masatanii var. by KOBAYASHI and TAMURA, 1957. Callovian; Soma district, Fukushima Pref., North Japan.

Remarks:—This genus shows somewhat remarkable change of characters in ontogeny.

In the early stage, the whole surface is provided with a few plain concentric costae and costellae and distinctly tripartite into a flank, an area and escutcheon by a plain or slightly serrated marginal and escutcheon carinae.

In the later stages, costae on the flank are broken into tubercles on the posterior part and three carinae are tuberculate or plain.

As mentioned above, the shell in the early stage of the genus has some resemblances to that of *Frenguelliella* in surface costation and shell form. Therefore, this genus may be a derivative from *Frenguelliella*. In the adult stage, this genus is, however, quite similar to the earliest forms of some members of Myophorellinae, Vaugoniinae and others in shell form and surface sculpture.

In *masatanii*, three carinae are tuberculate and costae on the flank are well broken into tubercles on the posterior part, while *masatanii* var. has the plain carinae and costae on the flank are not well tuberculate.

Trigonia terquemii BENECKE from the lower Dogger of Germany is morphologically very close to this genus.

Distribution:—Callovian of Japan.

Genus *Laevitrigonia* LEBKÜCHNER, 1931

Diagnosis:—Shell ovate to trigonally ovate, inequilateral and moderately inflated.

ed; umbo broadly rounded and of moderate prominence; beak opisthogyrous and antero-mesial. Marginal, median and escutcheon carinae obtuse, but sometimes marked by a line of tubercles. Area convex and narrow, provided with weak transverse costellae or striae which are sometimes evanescent later. Escutcheon depressed, narrow, smooth or transversely costellate. Flank with several concentric costae near umbo; rest of flank ornamented with plain, more or less irregularly undulated costae or rows of pustules which are often obsolete or obliquely disposed later. Ante-carinal groove distinct and broad, but indistinct in some forms.

Type species:—*Trigonia gibbosa* SOWERBY, 1821. Portlandian; Britain.

List of Species:—

- Trigonia damoniana* de LORIOI, 1866. Portlandian; Britain.
Trigonia edmundi MUNIER-CHALMAS, 1865. Portlandian; France.
Trigonia eudesi BIGOT, 1893. Up. Bathonian; France.
Trigonia manseli LYCETT, 1874. Portlandian; Britain.
Trigonia michelotti de LORIOI, 1866. Portlandian; France.
Trigonia oustaleti MUNIER-CHALMAS, 1866. Low. Kimmeridgian; France.
Trigonia ovidensis LYCETT, 1881. Lias; Spain.
Trigonia primaeva TROEDSSON, 1951. Lias; Sweden.
Trigonia tenuitexta LYCETT, 1875. Portlandian; Britain.
Trigonia variegata CREDNER, 1863. Up. Malm; Germany.

Remarks:—This genus is variable in external characters through growth.

Its immature shell is quite similar to *Frenquelliella*, because the whole surface is sculptured with plain concentric costae and costellae and tripartite distinctly by the sharp carinae into a flank, and area and escutcheon as illustrated by the young forms of LYCETT's *tenuitexta* (pl. 20, figs. 1, 1a) which is a typical member of the genus.

On the other hand, in the adult stage various kinds of the surface sculpture are well developed on the flank and the carinae become obsolete.

While the surface ornamentation varies to a large extent, the shell form is fairly constant in this genus. Costae on the flank are well broken into pustules in common forms, but pustulation is lacking in *michelotti*. They are more or less undulated and concentrically to subconcentrically arranged in most others, but they are obsolete in LYCETT's *gibbosa* (pl. 20, figs. 5-6) and obliquely disposed in *manseli*.

Area is ornamented generally with numerous weak plain transverse costae or striae. *Manseli* has no costation on its area, but costae are coarse and strong in some forms of LYCETT's *damoniana* (pl. 21, fig. 1). Ante-carinal groove is distinct and broad in most common forms, but indistinct in *manseli*. Carinae are marked by a line of tubercles in *manseli*, but indistinct in the others. Escutcheon is transversely costellate in *tenuitexta*, but not impressed in many forms.

Distribution:—Lias to Malm in Western Europe.

Genus *Liotrigonia* Cox, 1952

Diagnosis:—Shell triangularly ovate, inequilateral and fairly inflated; umbo rather narrow and prominent; beak orthogyrous and pointed anteriorly. Marginal, median and escutcheon carinae sharp and well marked in the vicinity of umbo, but obtuse or somewhat rounded in the later; most inflated part of valve approximately coincides with the position of the marginal carina. Area slightly concave and smooth except near umbo where fine concentric costae or striae are recognizable. Escutcheon narrow, depressed, smooth. Flank with plain concentric costae near umbo; rest of flank provided with irregular subconcentric wrinkles which are gradually evanescent toward posterior; ante-carinal groove absent.

Type species:—*Trigonia lingonensis* DUMORTIER, 1869. Mid. Lias; France and Britain.

Remarks:—This genus is monotypic, resembling *Nipponitrigonia* and *Prosogyrotrigonia* in shell form, but distinct in having orthogyrous umbo and weak costation on the surface.

In 1952, Cox (p. 53) suggested that this genus "seems to be descended from the smooth Myophoriids". On the other hand, KOBAYASHI (1957, p. 52) and Saveliev (1958, tab. 8) considered that it may be an off-shoot derived from *Trigonia*.

In the early stage, the whole surface of the type is sculptured with weak concentric sculpture and the carinae are sharp and distinct. In this aspect, this is probably a derivative issued from *Frenquelliella* by the obsolescence of the surface ornamentation and the carinae.

Distribution:—Middle Lias of Western Europe.

Genus *Psilotrigonia* Cox, 1952

Diagnosis:—Shell ovate, compressed and inequilateral; umbo broad, depressed, level with the hinge margin; beak orthogyrous or slightly opisthogyrous and antero-mesial. Thin costae on flank first concentric but later slightly oblique, flexiate and gradually become obsolete posteriorly. Area fairly broad and concave with weak, curved and oblique costae except near umbo where transverse costae are developed. Escutcheon indistinct. Marginal carina sharp and distinct near umbo but obtuse later. Ante-carinal groove and median carina or groove absent.

Type species:—*Trigonia beesleyana* LYCETT, 1874. Inferior Oolite; Britain and Italy.

Remarks:—This genus is monotypic, and has some resemblances to *Rutitrigonia* in surface costation and shell form. It is, however, distinguishable from the latter by a better defined marginal carina and more broader ornamented area.

This genus may be an off-shoot derived from *Frenquelliella* by the obsolescence of the sculpture on the flank and the carinae and development of the diagonal costation on the area, because in the vicinity of the umbo the whole surface is concentrically costate and the marginal carina is distinct and sharp.

Distribution:—Inferior Oolite of Western Europe.

Genus *Nipponitrigonia* Cox, 1952

Diagnosis:—Shell medium or sometimes comparatively large in size, trigonal-ovate to ovate, inequilateral, moderately inflated. Umbo rather narrow, prominent, located anteriorly; beak orthogyrous or slightly opisthogyrous but rarely a little prosogyrous. Marginal carina distinct near umbo, but rounded off later. Escutcheon ill-defined. Flank ornamented with about 3 concentric costae and grooves near umbo; rest of flank smooth or provided with concentric to transverse costae on the anterior part. Area rather narrow and smooth except near umbo where some 3 concentric costae are developed.

Internally, 3 radial plications sometimes well developed along in place of the positions of carinae; inner ventral margin smooth; a short lateral teeth-like ridge and socket recognized respectively on the dorsal margin of the right and the left valve; test rather thick.

Type species:—*Trigonia kikuchiana* YOKOYAMA, 1891. Neocomian-Cenomanian; Japan excluding Hokkaido region.

List of Species:—

Nipponitrigonia kikuchiana var. *plicata* KOBAYASHI and NAKANO, 1958. Up. Neocomian-Cenomanian; Southwest Japan.

Trigonia naumanni YEHARA, 1923. Neocomian-Albian; Southwest Japan.

Nipponitrigonia quadrata KOBAYASHI and NAKANO, 1958. Aptian-Albian; Yatsushiro district, Kyushu, Japan.

Trigonia sagawai YEHARA, 1926. Bathonian-Tithonian; Japan.

? *Trigonia sakamotoensis* YEHARA, 1921. Aptian-(?) Cenomanian; Awa and (?) Tosa in Shikoku of Japan and (?) Neocomian of Philippine.

Remarks:—This genus differs from *Rutitrigonia* in lacking of the oblique sculpture on the area and more ovate outline than the latter. It resembles *Liotrigonia* closely, but the latter has a more prominent umbo and stronger carinae.

Cox (1952, p. 53) established this genus based on *Trigonia kikuchiana* YOKOYAMA, and assigned *T. naumanni* YEHARA to it. Succeedingly, KOBAYASHI (1957, p. 57) accepted it, and referred *Nipponitrigonia convexa* KOBAYASHI, *T. sagawai* YEHARA, and possibly *T. sakamotoensis* YEHARA to this genus. KOBAYASHI's *convexa* (1957, p. 55, pl. 10, fig. 14; pl. 11, figs. 4-7) looks like a member of *Nipponitrigonia*. Its specific validity is, however, dubious, because his *convexa* represented by various

types is a heterogeneous aggregate. Miyako specimen (pl. 10, fig. 14) is moderately convex, and has a fairly small and nearly orthogyrous umbo where 3 concentric costae are observable. This is probably a compressed form of *N. kikuchiana*. Goshonoura form (pl. 11, figs. 7a-c) once called *kikuchiana* by YEHARA (1923a, pp. 9-10, pl. 7, fig. 2; 1923b, pp. 80-81, pl. 11, fig. 1) is incomplete and depressed. Judging from the surface costation and shell form, this resembles the inflated form of *N. kikuchiana*. Sendatsuno specimen on fig. 5 in pl. 11 may be a member of *Pterotrigonia*, because the oblique and diagonal costation is well impressed on its specimen. Yamanokami one (pl. 11, fig. 4) has some resemblances to the internal cast of *Pterotrigonia* as can be judged from its hinge structure. Miyanojima form on fig. 6 in pl. 11 is not well preserved and strongly deformed by secondary deformation. Therefore, its specific determination is very hard for the writer. In this aspects, *convexa* is possibly better excluded from the genus.

This genus presents somewhat remarkable change of characters in ontogeny.

In the immature shell this genus is closely similar to *Frenguelliella*, because its shell is distinctly tripartite by the carinae and the surface is provided with a few to several concentric costae and costellae.

In the next middle growth stages, the carinae are rounded off and represented only by a change of the curvature from the flank to the area and from the area to the escutcheon. Costae on the flank are absent or gradually obsolete posteriorly. Costellae on the area and escutcheon are absent.

In the adult stage of growth the flank except for the umbonal region is smooth or sculptured with transverse costae which are limited to the anterior part. Area is smooth.

As already discussed by KOBAYASHI (1957), the large variations of the surface sculpture and shell form are recognized in this genus. The internal plications may be, however, one of the most important characters, and are well developed in *kikuchiana* var. *plicata* and *sagawai* etc. With reference to the internal plications, 2 groups, i.e. *kikuchiana* and *sagawai* groups, can be distinguished in this genus.

1) The *sagawai* group ranging from the Bathonian to the Cenomanian, includes *Nipponitrigonia kikuchiana* var. *plicata*, *Trigonia naumanni*, *T. sagawai*, and possibly *T. sakamotoensis*. The group has the characteristic plications on its internal cast and its surface sculpture is somewhat variable. About 14 subconcentric to transverse costae are well developed in *naumanni*, but *kikuchiana* var. *plicata* has the smooth surface except for the umbonal region. *Sakamotoensis* is an aberrant and interesting form in the Trigoniids. Its surface is covered by numerous concentric or subconcentric costae on the posterior part of the flank.

On the surface sculpture and the internal character, Cretaceous *naumanni* is closely similar to Jurassic *sagawai*. *Naumanni* has a larger shell and thicker costae on the flank than those of *sagawai*.

2) The *kikuchiana* group including *Trigonia kikuchiana* and *Nipponitrigonia quad-*

rata, inhabited in the Neocomian to the Cenomanian. It is characterized by the absence of the internal plications and its surface is smooth, though its outline varies to a fairly large extent from circular to trigonally ovate. In shell form, *kikuchiana* and *quadrata* are quite similar to each other. The latter has, however, the more quadrate outline and the broader area than the former. The members of the group might be derived from *sagawai* through *kikuchiana* var. *plicata* by the extinction of the sculpture on the flank and the internal plications.

Distribution:—Bathonian to Cenomanian of Japan and (?) Neocomian of Philippine; very abundant in the Aptian to the Cenomanian of Japan excluding Hokkaido region.

Genus *Rutitrigonia* van HOEPEN, 1929

Diagnosis:—Shell trigonal-ovate to pyriform, inequilateral and moderately inflated; umbo broadly rounded, rather improminent, with plain concentric costae and costellae; beak opisthogyrous and antero-mesial. Escutcheon ill-defined, smooth. Area rather narrow, a little concave, sculptured with plain oblique costae which are obsolete later. Flank with plain subconcentric to transverse costae which are sometimes flexiate and slightly oblique and evanescent toward posterior. Carinae sharp and distinct near umbo, but soon become obtuse or obsolete. Ante-carinal groove absent.

Type species:—*Rutitrigonia peregrina* van HOEPEN, 1929. Albian; Zululand, South Africa.

List of Species:—

- Trigonia affinis* SOWERBY, 1818. Cenomanian; Britain and France.
- Trigonia agriensis* WEAVER, 1931. Hauterivian-Barremian; Patagonia.
- Rutitrigonia amagensis* KOBAYASHI, 1957. (?) Low. Cret.; Mindoro, Phillippine.
- Trigonia beyrichi* KRUMBECK, 1906. Low. Turonian; Tripolis, Libya.
- Trigonia beyschlagi* MÜLLER by KRENKEL, 1910. Barremian-Aptian; Tendaguru, East Africa.
- Trigonia bornhardti* MÜLLER, 1900. Barremian-Aptian; Tendaguru, East Africa.
- Trigonia coquandiana* d'ORBIGNY, 1843. Aptian-Turonian; France.
- Trigonia dietrichi* LANGE, 1910. Neocomian; Tendaguru, East Africa.
- Trigonia dunscombensis* LYCETT, 1879. Cenomanian; Britain and France.
- Trigonia excentrica* PARKINSON, 1811. Neocomian; Britain and France.
- Trigonia jacksonensis* PACKARD, 1921. Turonian; California and Oregon.
- Trigonia janenschi* LANGE, 1914. Neocomian; Tendaguru, East Africa.
- Trigonia laeviscula* LYCETT, 1875. Neocomian; Britain.
- Trigonia longa* AGASSIZ, 1840. Valangian-Aptian; Switzerland and France.
- Trigonia longa* var. *undulatostrata* PAULCKE, 1903. Neocomian; Chile.
- Trigonia mesembris* TENISON-WOODS, 1883. (?) Cret.; Queensland, Australia.
- Trigonia niongalensis* LANGE, 1910. Neocomian; Tendaguru, East Africa.
- Psilotrigonia sanchuensis* NAKANO, 1957. Hauterivian-Albian; Sanchu graben in Kwanto district and Yatsushiro area in Kyushu, Japan.

Trigonia schwarzi MÜLLER, 1900. Aptian; Tendaguru, East Africa.

Trigonia semiculta FORBES, 1845. Trichinopoly group; India.

? *Trigonia syrdariensis* (pars) ARCHANGELSKY, 1916. Turonian; Turkestan.

Trigonia weaveri STOYANOW, 1949. Up. Aptian; Arizona.

Rutitrigonia yeharai KOBAYASHI, 1957 (= *Trigonia neumayri* YEHARA, 1923). Low. Neocomian; Tosa, Shikoku, Japan.

Remarks:—In 1952, Cox (p. 59) assigned *Trigonia palaeopatagonia* PIATNITZKY, *T. pongolensis* RENNIE, and *T. pseudoindica* ARCHANGELSKY are referable to be the genus. However, *pongolensis* may be better transferred from this genus to *Megatrigonia* by the presence of the curved diagonal costation on its flank and *pseudoindica* with a fairly sharp marginal carina and a shallow ante-carinal groove, belongs probably to *Apiotrigonia* as can be judged from the surface sculpture.

As already pointed out by the writer (1957, p. 109), *Trigonia syrdariensis* ARCHANGELSKY (1916, pl. 5, fig. 5 only) is possibly a member of *Rutitrigonia* by the aspect of the sculpture on the flank.

Like many other Trigoniids the genus presents somewhat remarkable change of characters in ontogeny.

In the early stage, the whole surface is sculptured with concentric costae and costellae and three carinae are sharp and distinct. In many cases, costae on the area soon become oblique and median and escutcheon carinae are evanescent.

In the later stages, the flank is ornamented with subconcentric to transverse costae which are sometimes undulated and flexiate and they are gradually obsolete toward posterior. Marginal carina becomes rounded or obtuse, and the area is smooth.

This genus varies to a great extent in shell form and surface costation. In outline, the European forms, such as *excentrica*, *affinis* and others, are ovate to trigonal-ovate and not so much rostrate than those of the other regions. In size, *schwarzi* and *semiculta* etc. have the fairly large shell, but they are small in *dietrichi* and *niongalensis*. Costae on the flank are in many cases plain and subconcentric to transverse, and they are gradually obsolete posteriorly. They are, however, slightly oblique and abruptly effaced in *beyschlagi* and *schwarzi* etc. and indistinct nodose costation is observable in *jacksonnensis*. Undulation of costae is well developed in *schwarzi* and *laeviuscula*, but indistinct in the others. Shallow ante-carinal groove is seen in *peregrina* and *longa* var. *undulatostrata* etc., but absent in many others. Marginal carina is not distinct in common forms, but it is distinct in *dietrichi*.

KITCHIN's *recurva* (1903, pl. 8, fig. 6 only) from the Oomia bed in Cutch of India is quite similar to this genus in surface sculpture and shell form, but the rest of the species belongs clearly to *Iotrigonia* van HOEPEN.

Distribution:—Neocomian to Turonian of cosmopolitan. Most flourished in the Neocomian of Western Europe and South Africa.

III. CONCLUDING REMARKS

The followings are summarized as a conclusion from the above discussion. The Rutitrigoniinae van HOEPEN, 1929 can be classified as follows:

Subfamily Rutitrigoniinae van HOEPEN, 1929

Frenguelliella section

- Genus *Frenguelliella* LEANZA, 1942
- Genus *Geratrigonia* KOBAYASHI, 1954
- Genus *Latitrigonia* KOBAYASHI, 1957
- Genus *Ibotrigonia* KOBAYASHI, 1957

Laevitrigonia section

- Genus *Laevitrigonia* LEBKÜCHNER, 1931
- Genus *Liotrigonia* COX, 1952
- Genus *Psilotrigonia* COX, 1952

Nipponitrigonia section

- Genus *Nipponitrigonia* COX, 1952
- Genus *Rutitrigonia* van HOEPEN, 1929

The distributions and the possible phyletic relationships of the genera in the subfamily are as shown on Tab. 1. This subfamily appeared possibly in the Carnian of Japan, and they continued to exist till the Senonian when 3 forms of *Frenguelliella* are known from the Arrialoor group in the "Inde malgache" region as the relics of the subfamily. They most flourished in the Jurassic of Europe and Japan, but gradually vanished in the Cretaceous. *Frenguelliella* forms a trunk of the subfamily, and prospered in the Malm of Europe but suddenly declined in the Cretaceous. The other genera of the *Frenguelliella* section are considered to have been issued from the stock in East Asia through the Jurassic by the change of the surface sculpture. In the Jurassic of Europe, the genera of the *Laevitrigonia* section were derived from the trunk by the effacement of the carinae and the surface costation and the development of the improminent and complicated sculpture. From the Dogger to the Neocomian, the members of the *Nipponitrigonia* section were issued possibly from the trunk in probably Indo-Pacific region by the transfiguration of the shell form and the obsoletion of the surface costation and the marginal angulation.

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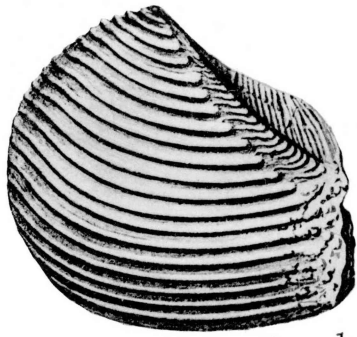
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Postscript

In the midst of printing, the writer read W. G. AITKEN's paper (Geology and Palaeontology of the Jurassic and Cretaceous of Southern Tanganyika. *Bull. Geol. Surv. Tanganyika*, No. 31, 1961), in which he described 4 new *Rutitrigoniae*, i.e. *Megatrigonia (Rutitrigonia) turikirae* sp. nov., *M. (R.) nossae* sp. nov., *M. (R.) nyangensis* sp. nov., and *M. (R.) kigombona* sp. nov., from the Neocomian (?) to the lower Aptian (?) of Southern Tanganyika and noted *Rutitrigonia dietrich* (LANGE) came out from the upper Kimmeridgian (?) to the Tithonian of Southern Tanganyika. AITKEN's *Laevitrigonia curta* derived from the Tithonian of Southern Tanganyika has some resemblances to a member of *Laevitrigonia*, but it may be better transferred to *Eselaevitrigonia* because of the radial sculpture on its area.

EXPLANATION OF PLATE LVI

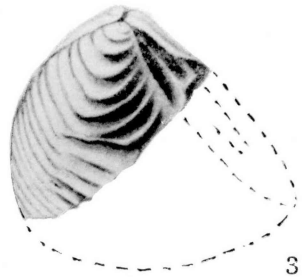
- Fig. 1. *Frenguelliella inexpectata* (JAWORSKI). Middle Lias; Argentina. (After JAWORSKI). $\times 0.9$
- Fig. 2. Same species, showing the sculpture on the area and escutcheon. (After JAWORSKI). $\times 0.9$
- Fig. 3. *Geratrigonia hosourensis* (YOKOYAMA). Hettangian; Shizukawa district, Miyagi Prefecture, North Japan. (After YOKOYAMA). $\times 0.9$
- Fig. 4. *Latitrigonia pyramidalis* KOBAYASHI and TAMURA. Bajocian; Soma district, Fukushima Prefecture, North Japan. (After KOBAYASHI and TAMURA). $\times 4$
- Fig. 5. *Ibotrigonia masatanii* KOBAYASHI and TAMURA. Callovian; Soma district, Fukushima Prefecture, North Japan. (After KOBAYASHI and TAMURA). $\times 1.8$
- Fig. 6. *Psilotrigonia beesleyana* (LYCETT). Inferior Oolite; Britain. (After Cox). $\times 0.7$
- Fig. 7. *Rutitrigonia peregrina* van HOEPEN. Albian; Zululand, South Africa. (After van HOEPEN). $\times 0.9$
- Fig. 8. *Liotrigonia lingonensis* (DUMORTIER). Middle Lias; Britain. (After Cox). $\times 0.9$
- Fig. 9. *Nipponitrigonia kikuchiana* (YOKOYAMA). Neocomian-Cenomanian; Japan excluding Hokkaido region. (After YABE). $\times 0.9$
- Fig. 10. *Laevitrigonia gibbosa* (SOWERBY). Portlandian; Britain. (After SAVELIEV). $\times 0.9$



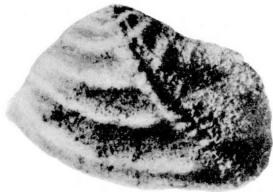
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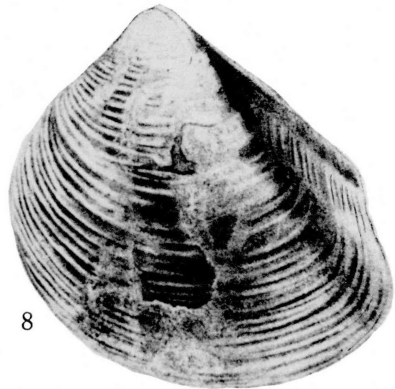
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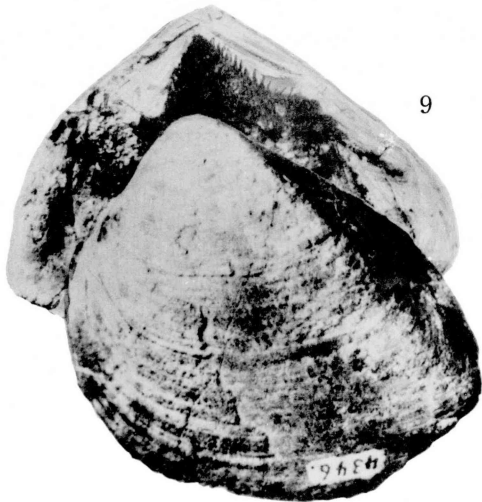
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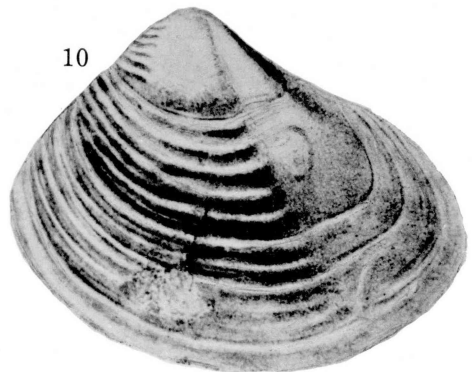
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