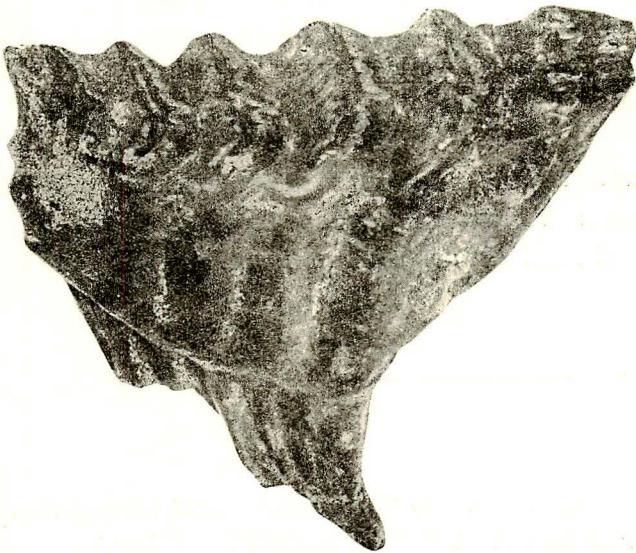


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586. THE GENERA *NEPHROLEPIDINA* AND *EULEPIDINA*  
FROM NEW ZEALAND

KUNITERU MATSUMARU

Department of Natural Science, Saitama University, Urawa, Japan

ニュージーランドから産出するネフロレピディナ属とユーレピディナ属：ニュージーランドの北島・南島両島の中新世の地層から産出した *lepidocyclinas* を検討した結果、次の一新種を含む四種 *Nephrolepidina orakeiensis* (KARRER), *N. hornibrooki* MATSUMARU, sp. nov., *N. howchini* CHAPMAN and CRESPIN, *Eulepidina dilatata dilatata* (MICHELOTTI) を識別した。このうち、*Nephrolepidina* 属に関しては、日本およびオーストラリアの中新世の地層から産出する *Nephrolepidina* と比較検討し、種の水準で、各々の系統関係を明らかにした。

松丸 國照

### Introduction

The classification of the family *Lepidocyclinidae* has been established mainly on the structure of the embryonic chambers. Recently, with the progress of study on the *lepidocyclinas*, the structure of the embryonic chambers has been classified into the *isolepidine* to *nephrolepidine* types or the *nephrolepidine* to *trybliolepidine* types, and their degree of variation within a species has also been studied. As the result, the *lepidocyclinas* with the *isolepidine*, *nephrolepidine* or *trybliolepidine* types of embryonic chambers should be reconsidered from the species level.

The stratigraphic distributions of the two genera, *Lepidocyclina* with *isolepidine* type and *Nephrolepidina* with *nephrolepidine* type and with *trybliolepidine* type embryonic chambers, are known to have restricted ranges, but with overlapping one another.

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Recently, VAN DER VLERK (1959, 1963) proved biometrically that there is a tendency of the deuteroconch to enclose the protoconch with advance of age, that is to say, from the lower horizon to the younger. This tendency was designated as embryonic acceleration of the *lepidocyclinas*, and is important for studies on the phylogeny of the *lepidocyclinid* species.

The writer examined some specimens of *lepidocyclinas* from the Otaian, top Altonian/basal Clifdenian and Waiauian stages of New Zealand for evaluation of the classification and evolution of the family *Lepidocyclinidae*. In this article, the New Zealand *Nephrolepidina* and *Eulepidina* are described in the systematics and some species of the former genus from Japan and Australia are compared with one another to interpret their phylogenetic interrelationship.

### Acknowledgments

Deep appreciation is expressed to Dr. N. de B. HORNIBROOK of the New Zealand

Geological Survey, for his kind offer of New Zealand lepidocyclinas from the Otaian, top Altonian/basal Clifdenian and Waiauan stages and to Prof. Kotora HATAI of the Institute of Geology and Paleontology, Tohoku University, for his kind helping in various ways and for reading of the manuscript, to Prof. Emeritus Dr. Shoshiro HANZAWA, Prof. Kiyoshi ASANO and Associate Prof. Tamio KOTAKA of the same Institute, Tohoku University, for their kind advice and criticism during the present study.

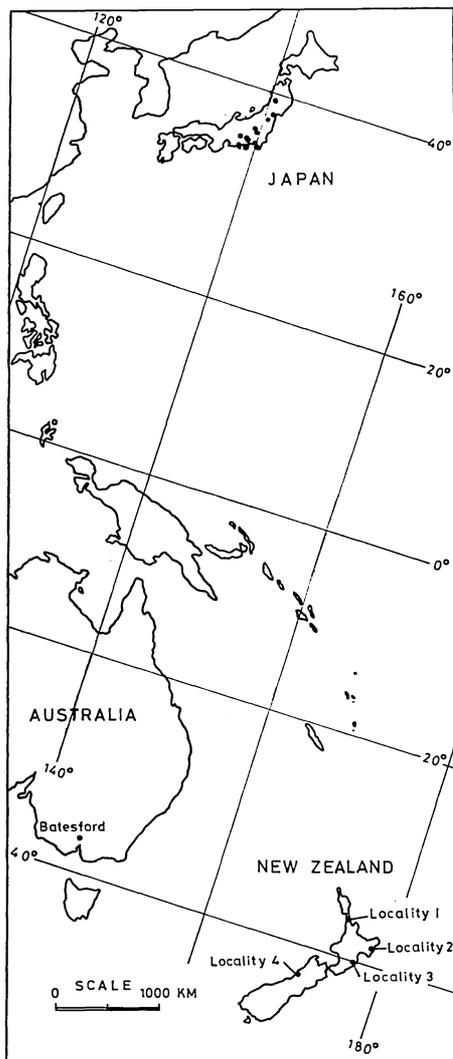
#### Localities, stratigraphic Positions and Ages

The lepidocyclinas treated in this study are from four localities (Text-fig. 1). The descriptions of the larger foraminifers, stratigraphic position and age of each locality are according to FINLAY (1947) and HORNIBROOK (personal communication).

Locality 1. N18/569 (=GS733, same locality, but different collection times), south head of Hokianga Harbour on the west coast, north of Auckland, North Island. The larger foraminifers from the "Orbitolite" bed at this locality are *Eulepidina* sp., *Nephrolepidina orakeiensis*, *Miogypsina* cf. *irregularis* and *Amphistegina lessoni*. This bed belongs to the Otaian stage and has been correlated with the Aquitanian of the European standard stages. The bed has yielded such planktonic foraminifers as *Globotrifarina dehiscens*, *Catapsydrax dissimilis* and *Globigerina woodi*.

Locality 2. N80/825, Whakoau Stream, north of Gisborne on the east coast of the North Island. The larger foraminifers from the sandstone at the base of the massive mudstone (Otaian), at this locality are *Eulepidina* sp., *Nephrolepidina*

*orakeiensis*, sp. nov., *Trybliolepidina* aff. *howchini*, *Miogypsina* cf. *irregularis* and *Amphistegina lessoni*. The planktonic foraminifers from this locality belong to the range zone of *Catapsydrax dissimilis*.



Text-fig. 1. Index map showing the localities of New Zealand lepidocyclinas. 1: Auckland, 2: Gisborne, 3: Greymouth, 4: Pourere. The localities of *Nephrolepidina* from Japan and Australia are shown by solid dots.

Locality 3. S44/559, Alexander St., Greymouth on the west coast of the South Island. The larger foraminifers from the base of the Blue Bottom Formation at this locality are *Nephrolepidina* sp., *Trybliolepidina* aff. *batesfordensis*, *Heterostegina* 2 spp., *Cycloclypeus* cf. *posteidae dodekaseptus*, *Gypsina* cf. *howchini* and *Amphistegina lessoni*. The age of this formation is at the boundary between the New Zealand top Altonian and basal Clifdenian stages, corresponding almost to the base of the Langhian and at or just below the earliest occurrence of *Globigerinoides glomerosus*.

Locality 4. F5938, Pourerere, east coast of Dannevirke, North Island. The larger foraminifers from the fine sandstone conglomerate and green sandstone comprise *Trybliolepidina* n. sp. aff. *rutteni*, *Heterostegina* 2 spp., *Cycloclypeus indopacificus* var. *terhaari*, *Operculina* cf. *victoriensis* O. sp., O. n. sp. aff. *complanata* and *Amphistegina lessoni*. The planktonic foraminifer from this locality of the Waiauian stage is *Globorotalia mayeri mayeri*, and corresponds to the upper stage of Indonesia.

#### Notes on the Geology

The marine Tertiary of New Zealand is distributed in the North Island in the Auckland and Hamilton region, the east coast region of Gisborne, Hawke's bay region and the southwest coast of Wanganui. In the South Island, they are mainly distributed in the east coast region of Canterbury, the west coast region of Greymouth and the south coast region of Clifden.

Many stages have been proposed for Tertiary rocks, and these comprise the stratigraphical scale of New Zealand (FINLAY and MARWICK, 1940, 1947). According to HORNIBROOK (1958), the New

Zealand lepidocyclinas occurred from the Otaian, Altonian, Clifdenian and Waiauian stages.

JENKINS (1966) established planktonic foraminiferal zones and judging from his zoning, the Otaian, Altonian, Clifdenian and Waiauian stages are represented by *Globigerina woodi connecta*, *Globigerinoides trilobus trilobus*, *Globigerinoides glomerosa curva* and *Globorotalia mayeri mayeri* zones, respectively. HORNIBROOK (1967, fig. 4) correlated the New Zealand planktonic foraminiferal zones of JENKINS with the Caribbean planktonic foraminiferal zones of BOLLI and BLOW. The New Zealand stages from their respective planktonic foraminiferal zones and occurrences of lepidocyclinas are correlated with Zone N. 4, Zone N. 7, Zone N. 8 and Zone N. 12 (?) to Zone N. 13 of the proposed zonal series of BLOW (1969).

#### Lepidocyclinas studied

The lepidocyclinas from the four localities stated above are of two types. One type is a small shell, less than 3.3 mm in diameter of the megalospheric form and less than 5.4 mm in diameter of the microspheric form, with less than 62 percent in the deuteroconch enclosure of the protoconch (=factor A). The other type is a large shell, more than 6 mm in diameter and with more than 70 percent in factor A value. The former type belongs to the genus *Nephrolepidina* and the latter to *Eulepidina*. The genus *Nephrolepidina* is used in this paper, when the structure of the embryonic chambers is the nephrolepidine type and the number of specimens possessing such type exceeds 80 percent of the total number of specimens from one locality.

The following four species were identified from the four localities.

- Locality 1. *Nephrolepidina orakeiensis*  
(KARRER)  
*Eulepidina dilatata dilatata*  
(MICHELOTTI)
- Locality 2. *Nephrolepidina orakeiensis*  
(KARRER)
- Locality 3. *Nephrolepidina hornibrooki*  
MATSUMARU, sp. nov.
- Locality 4. *Nephrolepidina howchini*  
CHAPMAN and CRESPI

It is important to examine the embryonic acceleration of the specimens to interpret the evolutionary development of the New Zealand lepidocyclinas. The embryonic acceleration is represented by factor A value and the biometrical analysis of the specimens is as follows.

1. *Nephrolepidina orakeiensis*  
(KARRER)  
Factor A (%)=35.90; 44.19; 45.24.  
3 specimens from locality 1 and  
locality 2.
2. *Eulepidina dilatata dilatata*  
(MICHELOTTI)  
Factor A (%)=71.05; 75.50; 74.68;  
74.77; 75.00.  
5 specimens from locality 1.
3. *Nephrolepidina hornibrooki*  
MATSUMARU, sp. nov.  
Factor A (%),  $m^* \pm s^{**}$  = 49.77  $\pm$  4.80.  
16 specimens from locality 3.
4. *Nephrolepidina howchini*  
CHAPMAN and CRESPI  
Factor A (%)=53.70; 55.38; 58.70;  
61.36.  
4 specimens from locality 4.

Though sufficient conclusions can not be gained from these data, it appears that the factor A values of *Nephrolepidina orakeiensis*, *N. hornibrooki* and *N. howchini* show an increase in acceleration.

From the factor A data of *Nephrolepidina howchini* from Australia, and *Nephrolepidina japonica* and *N. angulosa* from many localities in Japan, the relationship of their embryonic acceleration was examined. The factor A values of *Nephrolepidina hornibrooki* from New Zealand and *N. howchini* from Australia are judged to be of normal distribution from the examination of  $\chi^2$  test ( $P^* > 0.05$ ,  $\nu^{**} = 2$ ), and the statistical significance of the difference between the means of factor A of those species is tested by calculating the statistic t according to the formula (SIMPSON, ROE and LEWONTIN, 1960).

$$t = \frac{(m_1 - m_2) \sqrt{N_1 N_2 / (N_1 + N_2)}}{\sqrt{\frac{(N_1 - 1) s_1^2 + (N_2 - 1) s_2^2}{N_1 + N_2 - 2}}}$$

*N. hornibrooki*:

$$N_1 = 16, m_1 \pm s_1 = 49.77 \pm 4.80.$$

*N. howchini* :

$$N_2 = 31, m_2 \pm s_2 = 51.64 \pm 8.43.$$

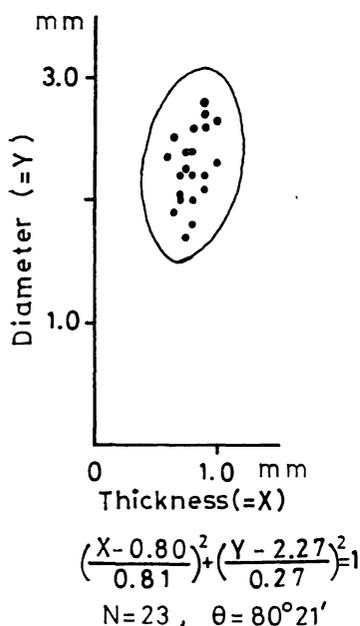
The difference is judged to be non-significant at the 5 percent level and 45 degrees of freedom ( $\nu = N_1 + N_2 - 2$ ). This means that the factor A of the populations of both species actually does not differ from one another. Thus, it is concluded that the *Nephrolepidina hornibrooki* bearing rock facies at the top Altonian/basal Clifdenian stages can be correlated with the *Nephrolepidina howchini* bearing limestone of the Batesfordian stage in Australia. And, *Nephrolepidina howchini* from Australia (MATSUMARU, 1971) can be correlated with the lower to middle part of the zoning of the three form groups based upon factor A of the Japanese *Nephrolepidina*.

The shells of many generations of *Nephrolepidina hornibrooki* from their

$m^*$  = mean,  $s^{**}$  = standard deviation.

$P^*$  = probability,  $\nu^{**}$  = degrees of freedom.

diameter (=Y) and thickness (=X) are included in the following rejection ellipse (Text-fig. 2).



Text-fig. 2. Rejection ellipse showing the position and variation of *Nephrolepidina hornibrooki* MATSUMARU, sp. nov. based upon the diameter and thickness parameters of the shell.

*Nephrolepidina howchini* (MATSUMARU, 1971) fall in the following ellipse.

$$\left(\frac{X-0.99}{1.96}\right)^2 + \left(\frac{Y-3.12}{0.26}\right)^2 = 1, \theta = 76^\circ 15'$$

From the ellipses it is proved that *hornibrooki* is smaller than *howchini* and that both species have essentially different shells. The species identification in lepidocyclinas is by the size and ontogenetic development of the shell. The characters of the shell through ontogeny are represented by the half diameter and half thickness of the first to last volutions of the lateral chambers. From the measurements of the New Zealand *Ne-*

*phrolepidina*, the allometric equation of  $Y=bX^\alpha$  is calculated as follows (Text-fig. 3):

*Nephrolepidina orakeiensis* (KARRER):

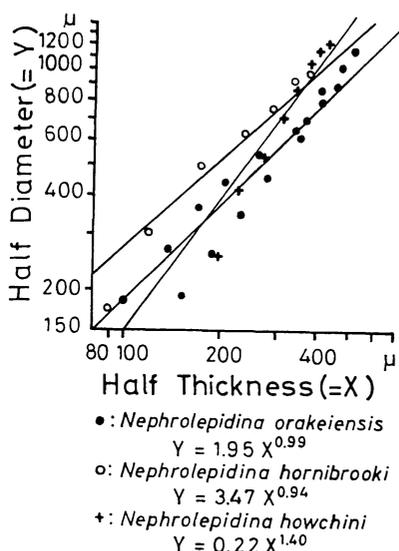
$$Y = 1.95X^{0.99}, n = 17$$

*Nephrolepidina hornibrooki* MATSUMARU, sp. nov.:

$$Y = 3.47X^{0.94}, n = 7$$

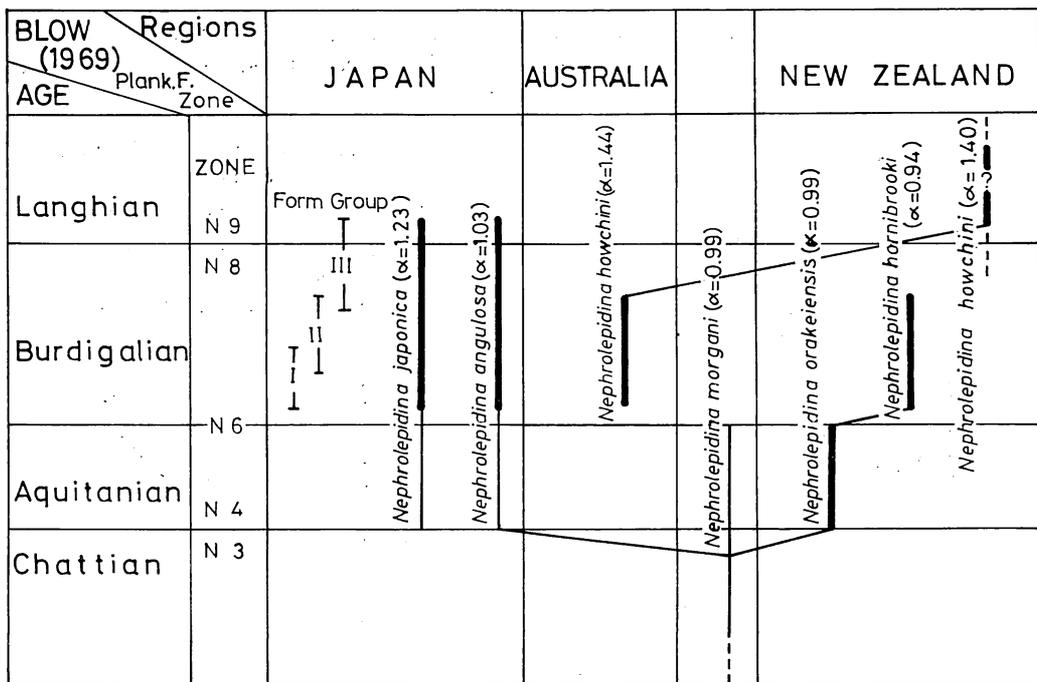
*Nephrolepidina howchini* CHAPMAN

and CRESPIN:  $Y = 0.22X^{1.40}, n = 8$



Text-fig. 3. Relationship between the half diameter and half thickness of the shell through ontogeny of *Nephrolepidina orakeiensis*, *Nephrolepidina hornibrooki* and *Nephrolepidina howchini*.

Though some variation is noticed in the characters stated above among the individuals, in the case of the Japanese *Nephrolepidina*, there are no remarkable differences in the relation between the value of the exponent  $\alpha$  of many individuals and that of only one individual. Though  $\alpha$  of the three *Nephrolepidina* species from New Zealand was not calculated for many individuals, it is considered that the data of *Nephrolepidina orakeiensis* ( $\alpha = 0.99$ ), *N. hornibrooki* ( $\alpha =$



Plank. F. = Planktonic Foraminifera

Text-fig. 4. Supposed phylogenetic trends of the genus *Nephrolepidina* from Japan, Australia and New Zealand.

0.94) and *N. howchini* ( $\alpha=1.40$ ) are representative of each species.

The evolutionary development of the embryonic acceleration of factor A and allometry through ontogeny of the individuals of *Nephrolepidina*, and their stratigraphic occurrences, the following supposed phylogenetic tribes can be constructed (Text-fig. 4).

**Description of Species**

Family Lepidocyclinidae SCHEFFEN, 1932

Genus *Eulepidina* H. DOUVILLÉ, 1911

*Eulepidina dilatata dilatata* (MICHELOTTI)

Pl. 22, figs. 28-38

1861. *Orbitoides dilatata* MICHELOTTI, *Études sur le mioc. inf.*, p. 17, pl. 1, figs. 1-2.

1968. *Eulepidina dilatata dilatata* (MICHELOTTI), LANGE, *Inaugural-Dissertation, Ludwig-Maximilians-Univ.*, p. 51-55, pl. 3, fig. 1.

Shell lenticular or elongate lenticular in shape, outline polygonal, generally with pillars and pseudopillars distributed on general surface of shell. Shell diameter 5.85\* to 8.80 mm, thickness at central portion 1.30 to 1.60 mm.

Embryonic chambers in equatorial section of eulepidine type, bilocular; protoconch large, 505 to 760 microns in diameter, 430 to 715 microns in height, deuteroconch large 1035 to 1255 microns in diameter, 250 to 430 microns in height, embraces protoconch along its outer

5.85\*: This specimen is not a perfect form, but a erosive one.

circumference. Ratios of protoconch diameter to deutoconch diameter 1.39 to 2.04. Factor A of degree of deutoconch to enclose protoconch 71.1 to 75.0 percent in five specimens. Partition between two embryonic chambers 15 to 35 microns in thickness. Embryonic chambers ellipsoidal in general, extend towards periphery.

Equatorial chambers arranged in sub-circular to polygonal rings in equatorial section, vary ontogenically in shape from arcuate through ogival to spatulate.

Lateral chambers large, subcircular to subreniform in shape in transverse section, more or less spacious, especially wide in tiers over embryonic chambers, but narrow in tiers just above embryonic chambers.

*Remarks:* The present species resembles *Eulepidina eodilatata* H. DOUVILLÉ in shell form, but differs in the larger embryonic chambers and larger enclosure of deutoconch to protoconch. *Eulepidina dilatata dilatata* differs in general shell shape from *Lepidocyclina (Eulepidina) ephippioides* (JONES and CHAPMAN) from the Kamanga grit, at the base of the Tanakau group and from the basal part of the Betilonga Limestone of Guadalcanal, British Solomon islands (COLEMAN, 1963).

*Depository:* New Zealand Geological Survey, Lower Hutt, New Zealand.

Genus *Nephrolepidina* H. DOUVILLÉ, 1911

*Nephrolepidina orakeiensis* (KARRER)

Pl. 22, figs. 1-27

1864. *Orbitoides orakeiensis* KARRER, *Novara Exped., Geol. Theil*, vol. 1, p. 86, pl. 16, fig. 21.
1926. *Miogypsina orakeiensis* KARRER, CHAPMAN, *N.Z. Geol. Surv., Pal. Bull.*, no.

♀, p. 94, pl. 1, fig. 21, pl. 18, figs. 6a-b, pl. 20, fig. 2.

Shell of moderate size, measuring 2.0 to 3.2 mm in diameter and 0.6 to 1.1 mm in thickness. Shell lenticular to inflated, outline polygonal or rounded, sometimes with conical pillars on top of central boss of inflated shell, and a narrow peripheral portion composed only of equatorial chamber layer. Bilocular embryonic chambers of nephrolepidine type. Factor A of degree of the deutoconch to enclose the protoconch varies from 35.90 to 45.24 percent. Protoconch small, 245 to 255 microns in diameter and 160 to 220 microns in height, deutoconch large, 320 to 365 microns in diameter and 120 to 185 microns in height. Ratios of protoconch diameter to deutoconch diameter 1.29 to 1.42. Partition between protoconch and deutoconch solid and thin, 9 to 11 microns in thickness. Embryonic chambers ellipsoidal in general and extend towards periphery. Allometry of half diameter to half thickness through ontogeny given in Text-fig. 3.

Equatorial chambers of a single layer, of arcuate form in nepionic stage, changing from ogival to hexagonal in neanic stage through ontogeny, polygonal or often circular in arrangement in equatorial section, gradually increasing thickness of roofs and floors of equatorial chambers from embryonic chambers to periphery.

Lateral chambers large, subcircular to subreniform in shape, characteristic pillars with one concentric ring in transverse section, more or less spacious, arrangement of lateral chambers from narrow in tiers just above embryonic chambers to wide in tiers over embryonic chambers. Eight or nine layers of lateral chambers per tier over embryonic chambers in adult specimens.

*Remarks:* The species was originally described on the specimens from Orakei Bay, Auckland by KARRER in 1864. According to CHAPMAN (1926), KARRER's original description of this species is as follows: "The shell is 2 mm to 5 mm in diameter, circular in outline, somewhat wavy on the tapering edge, which is usually broken; somewhat compressed, convex towards the centre and generally more so on one face; both sides ornamented with irregular excrescences which cover the surface with a network". CHAPMAN describes this species as "the shell shows a median layer of angular cell, which are apparently arranged with regularity one another; this layer occupies about one tenth of the thickness of the shell at the centre; upon this the layers of the greater portion of the shell have cells longer than broad and 6 to 7 in number; they are apparently separated by strong walls, of long rectangular form, apparently dissimilar, and sloping upon the axis of the median shell layer; the shells of the median layer are of similar size, rounded, or pentagonal and regular; the embryonic cell is very much larger than the remainder, and enclosed on one side by two similarly larger, crescentic cells". CHAPMAN more or less doubts whether KARRER's species belongs to *Miogypsina* (=the writer thinks to be *Miolepidocyclina*) or to *Lepidocyclina* but places his species in *Miogypsina*.

FINLAY (1947) notes this species to be a lepidocyclinid. The writer puts this species in the genus *Nephrolepidina* based upon the nephrolepidine structure of the embryonic chambers and identified it with *Orbitoides orakeiensis*.

*Nephrolepidina orakeiensis* resembles *N. morgani* in shell form, but differs in the allometry and the tendency of the deutoconch to enclose the protoconch.

*Depository:* New Zealand Geological Survey, Lower Hutt, New Zealand.

*Nephrolepidina hornibrooki*

MATSUMARU, sp. nov.

Pl. 23, figs. 12-37

Shell of moderate size, measuring 1.80 to 2.80 mm in diameter and 0.60 to 1.00 mm in thickness. Position and variation of diameter and thickness of shell given in Text-fig. 2. Shell lenticular or sometimes inflated, outline steroid in megalospheric forms and polygonal or rounded in microspheric forms. narrow peripheral portion composed only of equatorial chamber layer. Some conical pillars distributed on central part of megalospheric shell surface and stout conical pillars on general surface of microspheric shell surface.

Embryonic chambers of nephrolepidine to trybliolepidine type of bilocular embryonic chambers. Factor A of degree

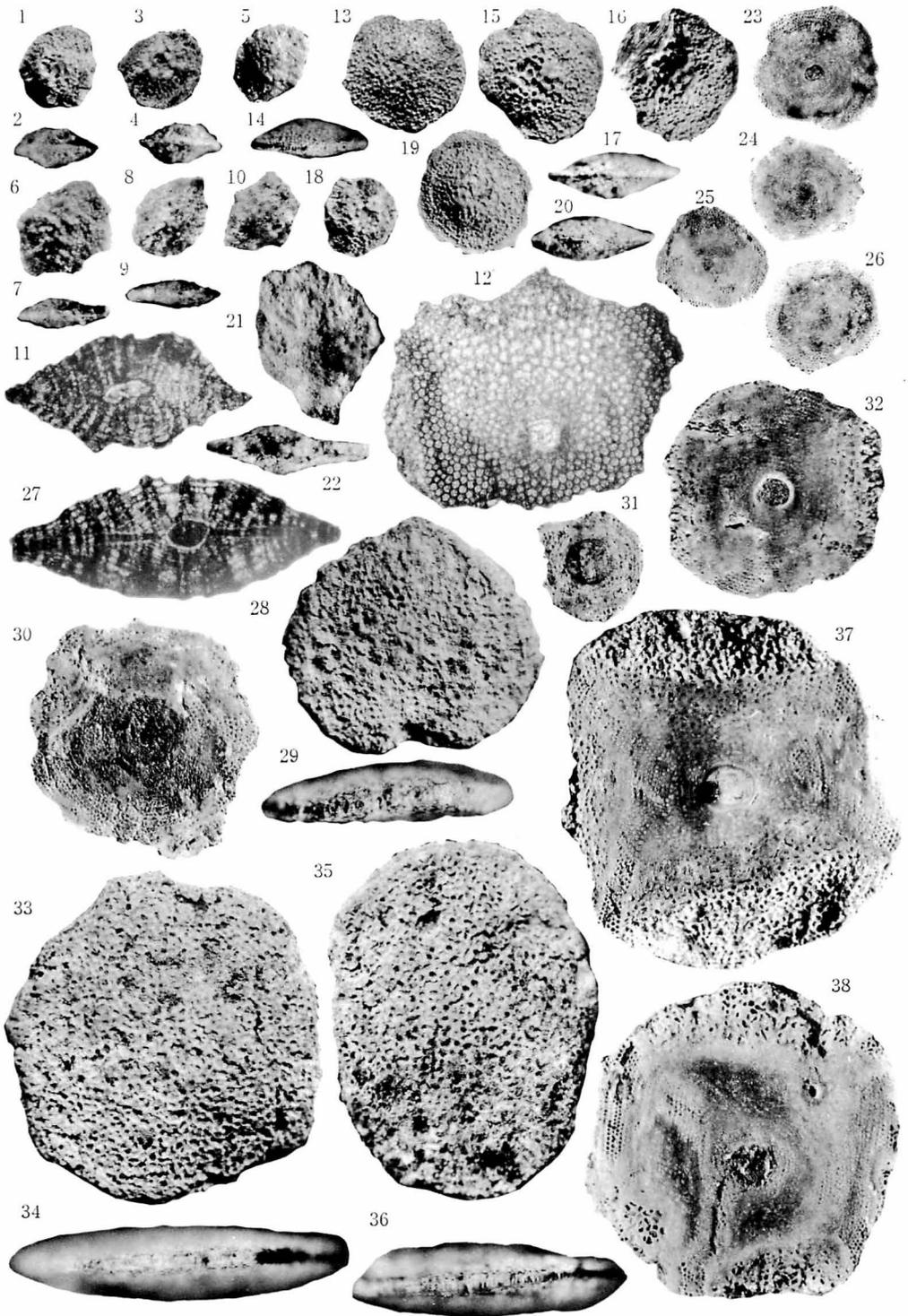
Explanation of Plate 22

Figs. 1-27. *Nephrolepidina orakeiensis* (KARRER).

1, 3, 5-6, 8, 10, 13, 15-16, 18-19, 21: equatorial view; 2, 4, 7, 9, 14, 17, 20, 22: vertical view; 11: vertical section; 12: centered oblique section; 23-25: equatorial plane; 26: nearly centered transverse section; 27: vertical section; 1-12: Locality 2; 13-27: Locality 1; 1-10:  $\times 7.5$ ; 11:  $\times 19.5$ ; 12:  $\times 20.0$ ; 13-26:  $\times 7.5$ ; 27:  $\times 20.5$ .

Figs. 28-38. *Eulepidina dilatata dilatata* (MICHELOTTI).

28, 33, 35: equatorial view; 29, 34, 36: vertical view; 30-32, 37-38: equatorial plane; 28-32: Locality 1; 33-38: Locality 2; 28-38:  $\times 7.5$ .



MATSUMARU and KUMAGAI photo.

of deuteroconch to enclose protoconch ranges from 43.08 to 60.42 percent, and mean value and standard deviation in 16 equatorial sections,  $49.77 \pm 4.80$ . Protoconch small, 150 to 335 microns in diameter and 115 to 205 microns in height, deuteroconch large, 265 to 420 microns in diameter and 80 to 150 microns in height. Ratios of protoconch diameter to deuteroconch diameter 1.15 to 1.90. Partition between protoconch and deuteroconch solid and thin, 3 to 14 microns in thickness. Embryonic chambers ellipsoidal, extend towards periphery, allometry of half diameter to half thickness through ontogeny given in Text-fig. 3.

Equatorial chambers arcuate in nepionic stage near embryonic chambers, through ogival to hexagonal form in neanic stage through ontogeny in equatorial section, polygonal in arrangement in equatorial section, increasing thickness of roofs and floors of equatorial chambers from embryonic chambers to peripheral portion in vertical section.

Lateral chambers large, subcircular to subreniform in shape in transverse section, more or less spacious, arrangement of lateral chambers from narrow in tiers just above embryonic chambers to wide in tiers over embryonic chambers. Number of lateral chambers per tier over embryonic chambers seven lateral layers in adult.

*Remarks:* The present new species resembles *Nephrolepidina orakeiensis* in the allometry, but differs in the outline of the megalospheric shell form and the tendency of the deuteroconch to enclose the protoconch. It resembles *Nephrolepidina howchini* in shell form, but differs from the latter in the allometry and the tendency of the deuteroconch to enclose the protoconch.

*Depository:* New Zealand Geological Survey, Lower Hutt, New Zealand and

IGPS\* coll. cat. no. 91691 (Holotype).

*Nephrolepidina howchini* CHAPMAN  
and CRESPIN

Pl. 23, figs. 1-11

1932. *Lepidocyclus howchini* CHAPMAN and CRESPIN, *Canterbury Mus., Rec.*, vol. 3, p. 94, pl. 13, figs. 18-19.
1943. *Lepidocyclus gippslandica* CRESPIN, *Proc. Roy. Soc. Vic. (N.S.)*, vol. 55, pt. 2, p. 165-168, pl. 3, figs. 1-7, pl. 6, figs. 22-28.
1943. *Lepidocyclus batesfordensis* CRESPIN, *Ibid.*, p. 170-173.
1964. *Lepidocyclus howchini* CHAPMAN and CRESPIN, CARTER, *Geol. Surv. Vic. mem. no. 23*, p. 137-140, pl. 17, figs. 290-292.

Shell of moderate size, measuring 2.30 to 3.25 mm in diameter and 0.60 to 0.90 mm in thickness. Shell lenticular, outline polygonal or steroid, moderate peripheral portion composed only of equatorial chamber layer.

Embryonic chambers of nephrolepidine to trybliolepidine type. Factor A values from 53.70 to 61.36 percent. Protoconch small, 220 to 365 microns in diameter and 170 to 295 microns in height. Ratios of protoconch diameter to deuteroconch diameter 1.74 to 2.23. Partition between protoconch and deuteroconch solid and thin, 11 to 26 microns in thickness.

Embryonic chambers ellipsoidal extend toward periphery. Allometry of half diameter to half thickness through ontogeny given in Text-fig. 3.

Equatorial chambers arcuate in nepionic stage near embryonic chambers, through ogival to hexagonal form in

IGPS\*=Abbreviation for Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai.

neanic stage through ontogeny, polygonal or often circular in arrangement in equatorial section.

Lateral chambers, subcircular to sub-reniform in shape in transverse section, more or less spacious, 8 layers per tier over embryonic chambers in adult.

*Remarks:* The New Zealand specimens show more steroidal outline in shell shape than the Australia specimens, but the ontogenetic developments of diameter to thickness both in the former and the latter agree with each other. Judging from the factor A values, the former may be from a horizon younger than the latter, although the former is based upon the factor A values of only four specimens.

*Depository:* New Zealand Geological Survey, Lower Hutt, New Zealand.

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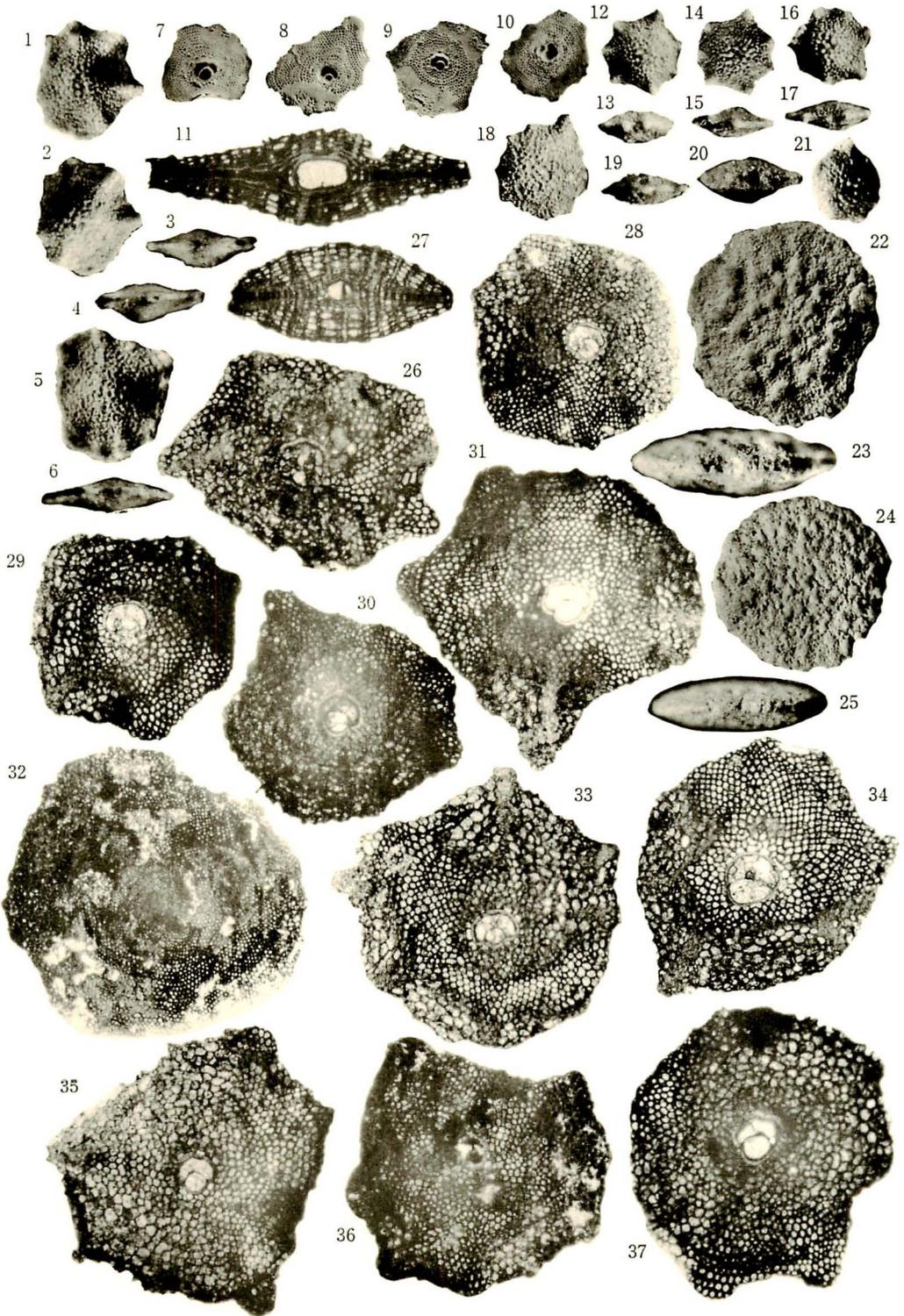
#### Explanation of Plate 23

Figs. 1-11. *Nephrolepidina howchini* CHAPMAN and CRESPIN.

1-2, 5: equatorial view; 3-4, 6: vertical view; 7-10: equatorial plane; 11: vertical section; 1-11: Locality 4; 1-10:  $\times 7.5$ ; 11:  $\times 19.5$ .

Figs. 12-37. *Nephrolepidina hornibrooki* MATSUMARU, sp. nov.

12, 14, 16, 18, 21: equatorial view; 22, 24: equatorial view of microspheric form; 13, 15, 17, 19-20: vertical view; 23, 25: vertical view of microspheric form; 26, 28 (Holotype, IGPS coll. cat. no. 91691), 29-31, 33-37: equatorial section; 32: equatorial section of microspheric form; 27: vertical section; 12-37: Locality 3: 1-25:  $\times 7.5$ ; 26-37:  $\times 20.0$ .



MATSUMARU and KUMAGAI photo.

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587. THE DISCOVERY OF THE CYCAD-LIKE LEAFLETS WITH  
TOOTHED MARGIN FROM THE LOWER CRETACEOUS  
ITOSHIRO SUB-GROUP, THE TETORI GROUP,  
CENTRAL HONSHU, JAPAN

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and

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手取層群, 石徹白亜層群 (下部白亜紀) から葉縁に棘のあるソテツ状葉の発見: 筆者らは 1965 年, 手取川支流日附谷川上流に露出する桑島砂岩・頁岩互層相当層から, 葉縁にいちじるしい棘のあるソテツ状葉標本 2 個を採集した。現生ソテツ類において, とくにいちじるしい棘のある属は *Encephalartos* であるとされているが, 全縁の種もあり, また *Stangeria*, *Bowenia*, *Zamia*, *Macrozamia* および *Microcycas* などにも棘または鋸歯のあるものが多く, 棘や鋸歯があるというだけで属を識別する根拠とはならない。しかし化石ソテツ状葉で棘や鋸歯のある例は少なく, 筆者らの標本は, 1962 年, VAKHRAMEEV によってヤクーツク付近の下部白亜系から報告・記載された *Neozamites* 属に一致する。この属は沿海州やレナ川中流地域の下部白亜系から 3 種が知られているが, ここに記載する標本はそのどれとも一致しないので, *Neozamites elongata* sp. nov. として報告する。この属はシベリア植物群の主要要素とされている。

木村 達明・関 戸 信 次

In the past year, we and our co-workers found two fragments of the cycad-like frond bearing pinnate leaflets with specially toothed margin on their both sides, from the equivalent of the Lower Cretaceous Kuwashima sandstone-shale alternation member, the Itoshiro Sub-Group, the Tetori Group, located along the upper course of the Mekkodani, Ozo, Oguchimura, Ishikawa-gun, Ishikawa Prefecture.

We here describe the above specimens

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as a new species under the name of *Neozamites* originally established by V. A. VAKHRAMEEV (1962).

We should like to thank the staffs of the Komatsu City Museum, who co-operated for us in collecting material, and to thank Dr. T. KOIWA who kindly co-worked with us in reading the articles written in Russian. Our thanks are also extended to Drs. T. M. HARRIS, V. A. VAKHRAMEEV, N. D. VASSILEVSKAJA and V. A. KRASSILOV, who sent us their valuable articles continuously, which have been indispensable to the present study.

The recent development of our knowledge regarding the living Cycads owes much to the studies conducted by C. J. CHAMBERLAIN, J. SCHUSTER and P. GREGUSS. Among the above, for the study of fossil members, more useful is GREGUSS's recent work (1968) with the detail description in which most species of living Cycads were done respectively in their xylotomy, leaf-morphology and also leaf-epidermis.

So far as leaf-margin is concerned, it has been known that spinose margin is characteristic feature of living *Encephalartos*, but is not always so; in most species, margin is markedly spinose on one or both sides and at the apex, but in a few species perfectly entire as in *E. humilis*, *E. eximius*, *E. lehmanni* and etc.

Besides this African genus *Encephalartos*, there are considerable numbers of species belonging to various genera represented by the leaflets with toothed, spinose or serrate margin; *Stangeria eriopus*, *Dioon spinulosum*, *Bowenia serrulata* have toothed or serrate margin; *Bowenia spectabilis*, *Stangeria paradoxa* both show deeply dissected margin; most species of *Zamia* and *Macrozamia fawcettii* show toothed or serrate margin in the apical half or only at the apex of lamina; moreover in *Microcycas* there are some species with finely dentate margin at the apex or whole around.

In case of fossil, these cycad-like leaflets with spinose or toothed margin being encountered, they used to have been christened calling the name from *Encephalartos* based only upon the marginal character.

FONTAINE described some cycad-like leaflets with serrate margin and with *Ctenis*-type nervation forming meshes under the name of *Encephalartopsis nervosa* (1889, p. 174, Pl. LXX, fig. 4; Pl. LXXI, figs. 3-4; Pl. LXXII, figs. 3-4), which he

considered to be an original type of the recent *Encephalartos*. As was stated by SEWARD (1917, p. 508), however, its direct relation not only to *Ctenis* but also to recent *Encephalartos* without net-worked nervation, can not be made clear because of lacking the point of attachment to the rachis. It seems to be impossible to compare unexpectedly or directly between the Cretaceous leaflets and the recent cycadean genera depending only on having toothed or serrate margin.

*Ctenis exilis* originally described by HARRIS (1964) exceptionally shows the leaflets with roughly toothed margin.

#### Genus *Neozamites* VAKHRAMEEV, 1962

In 1962, V. A. VAKHRAMEEV established two new genera, *Neozamites* and *Encephalartites*, based on the cycad-like pinnae with particularly toothed leaf-margin from the Lower Cretaceous deposits near Yakutsk, East Siberia, and also described two new species in *Neozamites* and a single new species in *Encephalartites*, they were *Neozamites verchojanensis* (type-species), *N. lebedevii* and *Encephalartites leipzigii*. The following generic diagnosis of *Neozamites* was given (freely translated) by VAKHRAMEEV; "frond pinnate; pinnae comparatively long and narrow, attached to the both sides of the upper surface of rachis, narrowing gradually towards the apex with several spinous teeth; pinna base more or less auriculate and sometimes cordate; margin spinously toothed asymmetrically, each tooth directed forwards as well as the direction of apical teeth; nerves diverging dichotomously forking near the margin." Moreover based on the cuticles obtained from some specimen of *N. lebedevii*, he stated "epidermal cell walls conspicuously sinuous; stomata bennettitalean." It was also

mentioned by him that "among these described, both characters, toothed pinna margin and cordate and asymmetrical pinna base were distinct from those of other cycad-like genera already known, such as *Sphenozamites* and *Otozamites*." Both of which are close in outline, especially in the nervation, to the present genus. In *Sphenozamites*, pinnae are asymmetrical oval or rhomboidal in form with contracted or cuneate bases. *Sphenozamites*, as was stated by SEWARD (1917, p. 587), was established only on the outline of pinnae for the purpose of convenience in case of description. In *Otozamites* pinnae are varied oblong, ovate or sword-like in shape, usually representing auriculate projection only at the upper basal margin. Among all species belonging to both *Sphenozamites* and *Otozamites*, the toothed pinnae have not been illustrated but *S. belli* SEWARD (1917, p. 588, fig. 629) in which the lower margin of pinna was drawn as loosely undulated and some *Otozamites* from Primorie to be stated later.

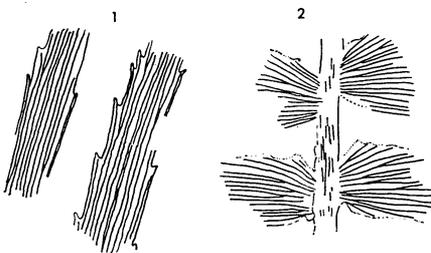
Another new genus *Encephalartites* was diagnosed by VAKHRAMEEV as well; frond pinnate; pinnae long and narrow, ribbon-like with somewhat contracted

base and attached to both sides of upper surface of rachis with their whole bases; margin spinose on both sides; nerves being sent off not radially from a point of attachment of leaflet as seen in *Neozamites*, but in parallel, about 12 in number at base, lateral nerves forking dichotomously, one of which reaching the tip of each spines respectively, as shown in Text-figs. 1 and 2 (after VAKHRAMEEV).

*Neozamites elongata* KIMURA  
et SEKIDO, sp. nov.

Pl. 24, figs. 1-4; Text-figs. 3-4

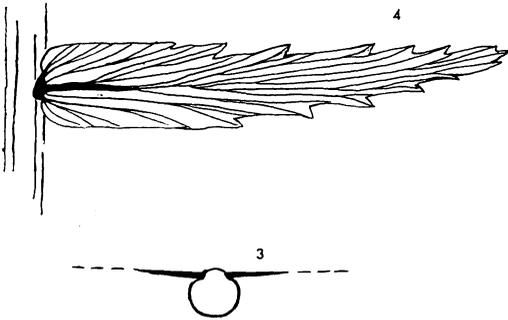
*Description of species:* Frond pinnate, more than 11.5 cm long, 13.5 cm or more wide at the widest, tapering gradually towards the anterior; pinnae long and narrow, ribbon-like, the largest more than 7 cm long, 1.1 cm wide measured at 1 cm distance from its base, tapering gradually towards the apex, somewhat asymmetrical, slightly cordate at base, attached to both sides of upper surface of the rachis with narrower central portion and suboppositely with wide angle, getting smaller in size towards the anterior and with acute angle, about 50 degrees to the rachis; margin asymmetrically toothed, having 5-6 pairs of conspicuous spines; the apex of leaflet dissected into 3-5, each spine sharply pointed, directed forward, the rest of margin loosely undulated; nerves originate radially from the narrower pinna base, then generally parallel to the direction of leaflet, about 12 in number at the portion of 1 cm distance from the base, often dichotomously forking but not anastomosed, one at the median part thick, looking like a mid-nerve, in posterior half or one-third, but not appearing in smaller leaflets, outside nerves reaching each spine. Any of epidermal cells have not been prepared be-



Text-figs. 1-2. *Encephalartites leipzigii*  
VAKHRAMEEV.

1: Toothed margin and the nervation ( $\times 1$ )  
2: Mode of Attachment of leaflets ( $\times 1$ )

Both after VAKHRAMEEV (1962, p. 128, Fig. 1a-b).



Text-figs. 3-4: *Neozamites elongata*  
KIMURA et SEKIDO sp. nov.

- 3: Model of traverse section of a frond ( $\times 1$ )  
4: Model of the outline of a leaflet ( $\times 1$ )

cause of impression alone. Fructification not known.

*Description of specimens:* Two fragments of frond have been obtained. Pl. 24, fig. 1 may show the middle portion of a frond in which pinnae are attached to both sides of upper surface of rachis suboppositely with the central point of cordate base as seen in recent species of *Encephalartos*, *Ceratozamia* and etc. The distorted pose in the present figure is not natural but due to the deformation in its preservation. Pl. 24, fig. 2 shows the thickened median nerve and Text-figs. 3 and 4 show the models of traverse section of a frond and the shape of leaflet respectively. Pl. 24, figs. 3-4 show respectively an apical portion of a frond and partly enlarged one in which the thickened median nerve failed to be noticed. Judging from both Pl. 24, fig. 1 and fig. 3, a frond may have reached more than 30 cm in length.

*Remarks and comparison:* Though, taking the recent knowledge regarding the cycadean leaflets into consideration, there might remain some doubts in establishing some new genera only based upon the leaflets with spinose or toothed margin, it is clear that the present specimens

in outline agree closely with the diagnosis of VAKHRAMEEV's genus *Neozamites* in representing spinose margin and somewhat cordate base, the central part of which sticks to both sides of the upper surface of rachis, sending off nerves radially, not anastomosed.

At first the present specimens should be compared with the type specimen, *N. verchojanensis* described originally by VAKHRAMEEV from the Lower Cretaceous Batilifsk, Ekseniatsk formations and their equivalents near Yakutsk and by VASSILEVSKAJA (1966) from the equivalent of the above, East of the Lena. The specimens derived from the bank of the Rampeska (VAKHRAMEEV, 1962, Pl. XII, fig. 1) resemble closely the present ones in both outline and size, but the former is more strongly asymmetrical and conspicuously toothed and each itself dissected more into 2-3 spines. Another illustrated specimen of *N. verchojanensis* (Ibid., figs. 2-4; VASSILEVSKAJA, 1966; Pl. III, figs. 1-2) have short pinnae and abnormally dissected tips, from which the present ones are clearly distinguishable in outline.

We have also been informed of the occurrence of this species from the Lena basin by KIRITCHKOVA but we couldn't refer her article (1966) to the present study for want of her paper.

The specimens derived from the Lower Cretaceous at the bank of the Vilyuy under the name of *Neozamites lebedevii* (VAKHRAMEEV, Pl. XIII, figs. 1-3), should be, at second, compared with the present ones. The former shows that the leaf-bases are conspicuously auriculated, spinose margin also marked, very sharply pointed at apices, and nerves are radial and evenly distributed, no midnerve-like thickening as seen in some leaflets in *N. verchojanensis* (Ibid., Pl. XII, fig. 1) and in the present ones, can be noticed at all.

So *N. lebedevii* is clearly distinguishable from both *N. verchojanensis* and the present new species.

At third, KRYSHTOFOVICH and PRINADA (1932, p. 369) reported some specimens under the name of *Otozamites denticulatus* originally but not illustrated, from the Lower Cretaceous of Southern Primorie. VAKHRAMEEV (1962) renamed the above *Neozamites denticulatus* (KRYSHTOFOVICH & PRINADA), depending on the information by F. N. CHERNISHEVA who had observed this specimen deposited at the Leningrad Museum of Natural History. According to VAKHRAMEEV, *N. denticulatus* shows that leaflets are very short in length with symmetrical base and with less toothed margin.

KRASSILOV (1967, p. 151, Pl. XL, fig. 1) described the similar but more elongate specimens from the Lower Cretaceous Galenkov Series, Southern Primorie. His single illustration shows pinnate habit and the pinnae elongate-oblong in outline, 4 cm long, 1 cm wide at the widest with loosely undulated margin and with contracted base in both sides. These *N. denticulatus* are easily distinguishable in outline of leaflet from the other.

As is stated above, since the present specimens might be distinct from those of any other species already described, so we have hereby made them a new species to give the name of *Neozamites elongata*.

Of course, the present species is also

distinguishable from *Encephalartites leipzigii* in the nature of the leaf-base and its nervation. Besides the Potomac specimens by FONTAINE in question of their attribution, spinose or toothed cycad-like leaflets such as *Neozamites* and *Encephalartites*, seem to be limited in their distribution geographically to Far East of Eurasia and in age to the Lower Cretaceous.

*Locality and geological horizon:* Equivalent of the Kuwashima sandstone-shale alternation member (Lowest of Lower Cretaceous), the Itoshiro Sub-Group, the Tetori Group, near Nijidaki (another name; Benidaki), a branch of the Tetori, Ozo, Oguchi-mura, Ishikawa Prefecture.

*Occurrence:* Rare.

*Reg. Nos.:* KM-N-1 (Pl. 24, fig. 1: Holotype) and KM-N-2 (Pl. 24, fig. 3: Paratype); Both type specimens have been deposited at the Komatsu City Museum, Ishikawa Prefecture.

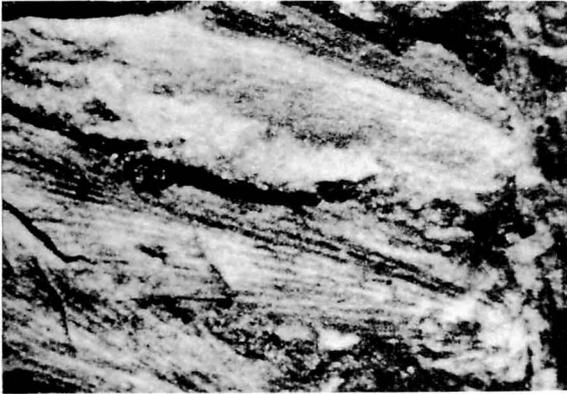
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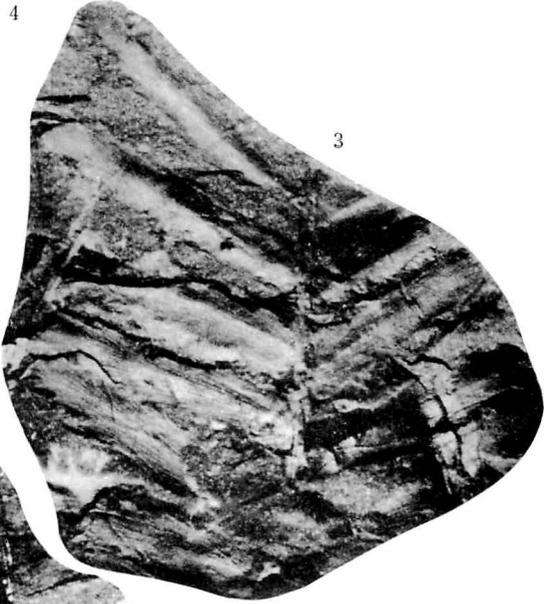
### Explanation of Plate 24

Figs. 1-4. *Neozamites elongata* KIMURA et SEKIDO sp. nov.

- Fig. 1: Holotype (Reg. No. KM-N-1)  $\times 1$   
 Fig. 2: Enlarged (partly) of holotype,  $\times 4$   
 Fig. 3: Paratype (Reg. No. KM-N-2)  $\times 1$   
 Fig. 4: Enlarged (partly) of paratype,  $\times 3$



4



3



1



2

- with a description of their leaves and epidermis. *Ibid.*, pp. 1-260, 185 pls., 80 text-figs.
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Ishikawa-gun 石川郡  
 Itoshiro 石徹白  
 Komatsu 小松  
 Kuwashima 桑島  
 Mekkodani 目附谷

Nijidaki (Benidaki) 虹滝(紅滝)  
 Oguchi-mura 尾口村  
 Ozo 尾添  
 Tetori 手取

588. ON SOME BRYOZOA FROM NEAR NAMIOKA-CHO, MINAMI-TSUGARU-GUN, AOMORI PREFECTURE, JAPAN

TOMOKO HAYAMI

Institute of Geology and Paleontology, Faculty of Science,  
Tohoku University, Sendai, Japan

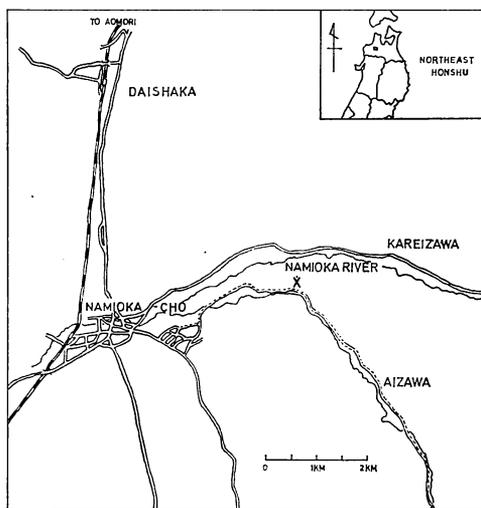
青森県南津軽郡浪岡町付近のこけ虫化石：弘前盆地浪岡町付近の大釈迦層からこけ虫化石を得たので報告する。9属11種を識別し記載した。古環境、地史については、従来の貝類、腕足類化石の研究結果と何ら矛盾しない結論に達した。速水 俱子

**Introduction and Acknowledgments**

The fossil bryozoans described in the present article were collected by the writer in September, 1970 from a single locality of a roadside cliff near Aizawa, southeast of Namioka-cho (Text-fig. 1). These form the second fossil record of the group from the younger Tertiary rocks of Aomori Prefecture and contribute to our knowledge of the fossil bryozoan fauna of northeast Japan.

At this place the writer expresses her thanks to Professor Kotora HATAI of the Institute of Geology and Paleontology, Tohoku University, for his kindness and guidance throughout the course of the present work. Thanks are due to Professor Takehiko IWAI of the Department of Geology, Faculty of Education of the Hirosaki University, for his kind guidance to the fossil locality and information on the geology of the area. Acknowledgments are also due to Miss Hiroko UNO of the Hakodate School of the Hokkaido University of Education for her

assistance in the field.



Text-fig. 1. Locality map of fossil Bryozoa.

**Stratigraphic position and geological age of the fossil bryozoans**

The locality of the fossil bryozoan specimens treated in this article is the roadside cliff near Aizawa, northeast of Namioka-cho (Text-fig. 1). At this locality, there is exposed fossiliferous dark gray

Received January 14, 1971; read November 22, 1970, at the Hiroshima University, Hiroshima.

tuffaceous siltstone intercalated with rounded pebbles and cobbles of andesite and soft rocks. The fossils are abundant but most are rather fragile, and comprise balanids, brachiopods, gastropods, fragments of spine and carapace of echinoids, foraminifers, and bryozoans, etc. According to IWAI (1965a), this outcrop is one of the prolific fossil localities of the Daishaka Formation.

The Daishaka Formation is distributed rather widely around the type locality which is near the Daishaka Tunnel of the main Ôu railway, Minami-Tsugaru-Gun, Aomori Prefecture. The formation in the northeastern part of the Hirosaki Basin has yielded many fossils such as foraminifers (ASANO, 1938), molluscs (NOMURA and HATAI, 1935; IWAI, 1960, 1962, 1965b), brachiopods (NOMURA and HATAI, 1935; HATAI, 1940; KOTOH, 1957), spines of echinoids, bryozoans (KATAOKA, 1957), and calcareous algae, etc.

The stratigraphic position of the Daishaka Formation is shown in Text-fig. 2.

Age	Formation
Pliocene	Tsurugasaka Formation
	Daishaka Formation
Miocene	Otakizawa Member of Ka. Fm.
	Kareizawa Formation
	Toyamori Formation
	Umanokamiyama Formation
Pre-Tertiary	

Text-fig. 2. The stratigraphic position of the Daishaka Formation, after IWAI (1965a).

### The fossil bryozoans

The bryozoan specimens occur as broken stems and as branches or fragments

of encrusting forms. The bryozoans identified amount to 11 species distributed among nine genera, and these are listed in Table 1.

The bryozoan species listed in Table 1, comprise several types, among which the Cellariiform type represented by such genera as *Microporina*, *Diatosula* and *Myrizoum* is the most abundant. The next common is the Reteporiform type which is characterized by *Reteporellina* and *Schizoretepora*, and only very few incrusting zoaria of the Membraniporiform type are found in the fauna. The fauna contains species that have been recorded living along the coast of Alaska, Aleutian Islands, Queen Charlotte Island, and from Hokkaido, all in the North Pacific.

In comparison with the fossil bryozoans recorded by KATAOKA (1957) from the type locality of the Daishaka Formation, there are only two species in common, namely, *Microporina articulata* and *Myrizoum subgracile*.

The fossil bryozoan fauna described in this article comprise species which are typically northern in distribution. The fauna is characterized by the dominance of Cellariiform and Reteporiform types and an assemblage of this kind of types is characteristic of rather shallow water (STACH, 1936; LAGAAIJ and GAUTIER, 1965). The thermal conditions of the sea in which the fauna once lived is thought to have been cold as is inferred from the distribution of the living counterpart species. The conditions were probably similar to the present day east coast of Hokkaido to northeast Aomori Prefecture. This inference seems to be in good agreement with the results obtained by ASANO (1938) from the foraminifers, by NOMURA and HATAI (1935) from the molluscs, and by KATAOKA (1957) from his studies on the bryozoans

Table 1. Bryozoan species identified from Namioka-cho.

Genus and species	Distribution
<i>Microporina articulata</i> (FABRICIUS)	Recent, Japan Sea; Off Torishima and Paramushir Island; California; Greenland and Queen Charlotte Island. Pliocene, Sado (Niigata Pref., Japan); Miocene, Ishikawa Pref., and Hokkaido.
<i>Tricellaria</i> sp.	
<i>Diatosula marionense</i> (BUSK)	Recent, Prince Edward Island (80-150 fms); Off Heard Island (75 fms); Off Marion Island (50-75 fms).
<i>Schizobrachiella subhexagona</i> (ORTMANN)	Recent, Sagami Bay.
<i>Cystisella midwayanica</i> CANU & BASSLER	Eocene, North America.
? <i>Cystisella americana</i> CANU & BASSLER	Recent, Gulf of Mexico (32 fms); Porto Rico.
<i>Schizoretopora tumescens</i> (ORTMANN)	Recent, Paramushir Island and Hokkaido; Sagami Bay (40 fms) and (200-230 fms).
<i>Costazia rota</i> (MACGILLIVRAY)	Recent, Juan Fernandez (35 m); Australia; Cape Horn and East Africa; and Gulf of Manaar.
<i>Schismopora chrysalis</i> CANU & BASSLER	Recent, Philippine Region (20 fms).
<i>Myriozoum subgracile</i> D'ORBIGNY	Recent, Japan (shallow water); Kara Sea (35-127 m) and Mourmane Sea (90 m); Paramushir Island; and Alaska (15-25 fms) and (13-22 fms).
<i>Myriozoum coarctatum</i> (SARS)	Recent, Pacific Coast of Canada (Juneau 20 fms); Alaska and Off Washington; and Queen Charlotte Island.

of the Daishaka Formation.

The geological age of the Daishaka Formation based upon the molluscs (NOMURA and HATAI, IWAI), the brachiopods (NOMURA and HATAI, HATAI), and the bryozoans (KATAOKA), is Early Pliocene.

#### Descriptions and Remarks on the Bryozoa

Order Cheilostomata BUSK, 1852

Family Calpensiidæ CANU  
and BASSLER, 1923

Genus *Microporina* LEVINSEN, 1909

*Microporina articulata* (FABRICIUS, 1821)

1905. *Cellaria borealis* (BUSK), ROBERTSON,

p. 287, pl. 14, fig. 86; pl. 16, fig. 102.

1929. *Microporina japonica* CANU and BASSLER, p. 139, pl. 14, figs. 9-11.

1933. *Cellaria borealis* BUSK, OKADA, p. 214.

1936. *Microporina articulata* (FABRICIUS). SAKAKURA, pp. 259-267, pl. 15, figs. 1-9.

1950. *Microporina borealis* (BUSK), OSBURN, p. 106, pl. 11, fig. 2.

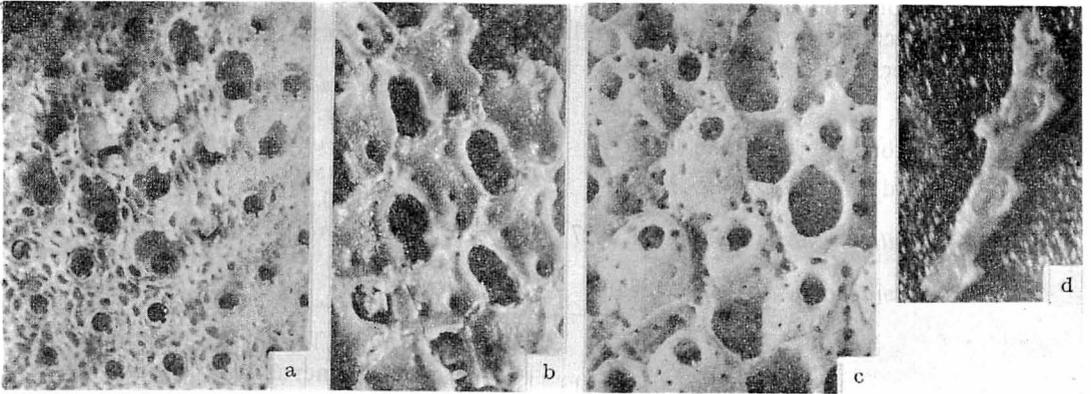
1956. *Microporina articulata* (FABRICIUS), MAWATARI, p. 120.

1958. *Microporina articulata* (FABRICIUS), ANDROSOVA, p. 125, text-fig. 40.

1965. *Microporina articulata* (FABRICIUS), MAWATARI, p. 603, figs. 62a, b.

1970. *Microporina articulata* (FABRICIUS), HAYAMI, p. 325, pl. 35, figs. 1, 2.

*Description:* Zoarium erect, cylindrical, of jointed segments, branching formed of 9-10 rows of zooecia. Zooecia large, elongate, alternate, surrounded by a raised



Text-fig. 3. Bryozoa from Namioka-cho.

- a. *Diatosula marionense* (BUSK),  $\times 30$ , showing ordinary and broken ovicelled zooecia.  
 b. ? *Cystisella americana* CANU and BASSLER,  $\times 30$ .  
 c. *Schismopora chrysalis* CANU and BASSLER,  $\times 30$ , showing a portion of large, massive, and multilamellar zoarium.  
 d. *Tricellaria* sp.,  $\times 30$ .

thread; frontal very porous. Aperture semicircular. Avicularia distal, distributed at irregular intervals; rostrum triangular, pointing downward.

*Measurements* (in mm): Zooecia: Lz = 0.72-1.28, Wz = 0.28-0.36.

*Depository*: IGPS\* coll. cat. no. 86809.

*Remarks*: ROBERTSON (1908) noted that *Microporina articulata* is a species strictly northern in distribution and stated that it has not been reported south of the Queen Charlotte Islands.

*Distribution*: Recent, Paramushir Island and Hokkaido (MAWATARI, 1956); Paramushir Island (OKADA, 1933); Saghalien 20.5-66 m (ANDROSOVA, 1958); Alaska 14 fms (OSBURN, 1950); Japan Sea (CANU and BASSLER, 1929). Fossil, Pliocene, Sado (Niigata Pref.) (SAKAKURA, 1936); Miocene, Hokkaido (HAYAMI, 1970).

#### Family Scrupocellariidae LEVINSEN, 1909

IGPS\*=abbreviation for Institute of Geology and Paleontology, Tohoku University, Sendai.

#### Genus *Tricellaria* FLEMING, 1828

##### *Tricellaria* sp.

Text-fig. 3-d

*Description*: Only a fragmental zoarium, uniserial (?). Zooecia large, elongate; opecium oval larger than half as long as front. Lateral avicularia large, triangular rostrum hooked at tip; frontal avicularia wanting. Trace of two spines at distal part of mural rim, and one of scutum located almost at middle of lateral mural rim.

*Measurements* (in mm): Zooecia: Lz = 0.60-0.72, Wz = 0.40; Opecia: lop = 0.40, wop = 0.32.

*Depository*: IGPS coll. cat. no. 86810.

*Remarks*: As no complete zoarium was found in the collection it could not be determined whether it was uniserial or biserial. However, the reference of the present specimens to *Tricellaria* seems to be without doubt, because there are no vibracula or avicularia on the dorsal surface. This species may represent an

undescribed form, but naming is avoided at present because of the lack of well preserved specimens.

Family Stomachetosellidae CANU  
and BASSLER, 1917

Genus *Diatosula* CANU and BASSLER, 1927

*Diatosula marionense* (BUSK, 1884)

Text-fig. 3-a

1884. *Myriozoum marionense* BUSK, p. 171, pl. 23, fig. 6.  
1929. *Diatosula marionense* (BUSK), CANU and BASSLER, p. 293.  
1953. *Diatosula marionense* (BUSK), BASSLER, p. 200, text-fig. 150-4.

*Description*: Zoaria free, branches sub-cylindrical. Zooecia immersed, lines of separation not visible; frontal wall with large irregular pores. Orifice rounded above and lower margin possessing U-shaped sinus. A pair of small avicularia, slightly prominent, present above orifice; ovicell when present occur on each side of orifice. Ovicell subimmersed, large, round. Interzooecial avicularia large, long triangular, its tip pointed proximally.

*Measurements* (in mm): Orifice: lor=0.20, wor=0.18; Interzooecial avicularia: lav=0.48, wav=0.28.

*Depository*: IGPS coll. cat. no. 86811.

*Remarks*: CANU and BASSLER (1929) designated *Myriozoum marionense* BUSK, 1884, as the genotype of *Diatosula*.

*Distribution*: Recent, Prince Edward Island 80-150 fms, Marion Island 50-75 fms, Off Heard Island 75 fms (BUSK, 1884). Fossil, this is the first record.

Family Schizoporellidae JULLIEN, 1903

Genus *Schizobrachiella* CANU  
and BASSLER, 1920

*Schizobrachiella subhexagona*  
(ORTMANN, 1890)

1890. *Schizoporella subhexagona* ORTMANN, p. 51, pl. 4, fig. 3.  
1957. *Schizobrachiella subhexagona* (ORTMANN), HARMER, p. 1026, pl. 74, figs. 17, 19, 24-26.  
1965. *Schizobrachiella subhexagona* (ORTMANN), MAWATARI, p. 615, text-figs. 107a-c.

*Description*: Three fragmental specimens. Zoaria incrusting; zooecia quin-cuncial, somewhat flat, short. Frontal wall with many rather large pores which extend around distal side of orifice. Orifice with a low, thin peristome; proximal margin nearly straight at both ends, with wide and slightly rounded sinus. No avicularia.

*Measurements* (in mm): Zooecia: Lz=0.80, Wz=0.68.

*Depository*: IGPS coll. cat. no. 86812.

*Distribution*: Recent, Sumbawa, 69-73 m (HARMER, 1957); Japan (ORTMANN, 1890). Fossil, this is the first record.

Family Smittinidae LEVINSEN, 1909

Genus *Cystisella* CANU and BASSLER, 1927

*Cystisella midwayanica* CANU  
and BASSLER, 1920

1920. *Cystisella midwayanica* CANU and BASSLER, p. 479, pl. 8, figs. 5, 6.

*Description*: Only four fragmental zooecia; zoarium incrusting. Zooecia separation not visible, but interior subhexagonal; frontal somewhat convex and finely granulated. Peristome thin, little salient in distal part; with 6 to 8 stout spines. Two small cardelles present at low position of peristome. Avicularia form long chamber, median and conical;

its orifice turned toward aperture.

*Measurements* (in mm): Zooecia (interior): Lz=0.32-0.40, Wz=0.30-0.36.

*Depository*: IGPS coll. cat. no. 86813.

*Distribution*: Recent, unknown. Fossil, Eocene, North America (CANU and BASSLER, 1920).

? *Cystisella americana* CANU  
and BASSLER, 1928

Text-fig. 3-b

Compared with:

1928. *Cystisella americana* CANU and BASSLER, p. 113, pl. 15, figs. 7, 8.

1940. *Cystisella americana* CANU and BASSLER, OSBURN, p. 439.

*Description*: Zoarium incrusting, bilamellar or multilamellar. Zooecial separation not visible, but interior large and long. Frontal fine granulated, two to three pores present at marginal part. Aperture large, semielliptical. Avicularian chamber with a pair of glands, large and long, almost occupying frontal. Avicularia very large, as large as aperture; its shape somewhat elliptical, and narrower at distal part. Ovicell not found.

*Measurements* (in mm): Zooecia (interior): Lz=0.80-1.20, Wz=0.44-0.46; Aperture: lap=0.32-0.36, wap=0.28-0.32.

*Depository*: IGPS coll. cat. no. 91692.

*Remarks*: The present species resembles *C. americana* CANU and BASSLER, 1928, in some aspects, but differs from it in having a longer zoecium, in the orifice touching the avicularium, in larger apertural dimensions, and by the presence of some marginal pores.

*Distribution*: Recent, Gulf of Mexico 32 fms (CANU and BASSLER, 1928); Porto Rico (OSBURN, 1940). Fossil, this is the first record.

Family Reteporidae SMITT, 1867

Genus *Schizoretepora* GREGORY, 1893

*Schizoretepora tumescens*  
(ORTMANN, 1890)

1890. *Retepora tumescens* ORTMANN, p. 34, pl. 2, fig. 20.

1956. *Schizoretepora tumescens* (ORTMANN), MAWATARI, p. 131, figs. 14a-g.

1958. *Retepora imperati* var. *tumescens* (ORTMANN), ANDROSOVA, p. 175, text-fig. 106.

*Description*: Fragmental zoaria, rather thick. Zooecia facing one side, elongate-subhexagonal, convex, smooth with two to six small pores. Orifice circular with shallow sinus. Frontal avicularia of two kinds, one very large and prominent, other small and not salient, sometimes wanting. A pair of spines on distal corner of peristome. Dorsal vibices a little salient, separated, elongate quadrate or irregular. Dorsal avicularia small, somewhat acute, elliptical, variable in numbers.

*Measurements* (in mm): Zooecia: Lz=0.80-0.84, Wz=0.28-0.40.

*Depository*: IGPS coll. cat. no. 91693.

*Distribution*: Recent, Kurile Islands and Hokkaido (MAWATARI, 1956); Sagami Bay 40 fms, 200-300 fms (ORTMANN, 1890); Saghalien (ANDROSOVA, 1958). Fossil, this is the first record.

Family Celleporidae BUSK, 1852

Genus *Costazia* NEVIANI, 1895

*Costazia rota* (MACGILLIVRAY, 1885)

1929. *Costazia rota* (MACGILLIVRAY), CANU and BASSLER, p. 431, fig. 3.

*Description*: Only two fragmental zoecia; zoarium incrusting. Zooecial some-

what elliptical. Frontal wall smooth with irregular pores at marginal part. Aperture round distally, and with round, wide sinus proximally. Peristome thin not prominent. A pair of avicularia, prominent distally, rather large, in peristome each side. Ovicell not found.

*Measurements* (in mm): Zooecia (interior): Lz=0.76, Wz=0.56; Aperture: lap=0.24, wap=0.20.

*Depository*: IGPS coll. cat. no. 91694.

*Distribution*: Recent, Philippine region 20 fms (CANU and BASSLER, 1929); Juan Fernandez 35m and Bass Strait (MARCUS). Fossil, this is the first record.

Genus *Schismopora* MACGILLIVRAY, 1888

*Schismopora chrysalis* CANU  
and BASSLER, 1929

Text-fig. 3-c

1929. *Schismopora chrysalis* CANU and BASSLER, p. 430, pl. 62, figs. 11, 12.

*Description*: Zoarium very large, multi-lamellar. Zooecia rather erect, orbicular; frontal granular and surrounded by scattered areolar pores. Aperture round distally, and straight with wide, shallow sinus proximally. Peristome thin; a pair of avicularia present at both sides, sometimes wanting. Interzooecial avicularia sporadic, very few; its shape somewhat elliptical. Ovicell not found.

*Measurements* (in mm): Zooecia: Lz=0.80, Wz=0.40; Peristome (with sinus): lper=0.24, wper=0.24.

*Depository*: IGPS coll. cat. no. 91695.

*Distribution*: Recent, Philippine region 20 fms (CANU and BASSLER, 1929). Fossil, this is the first record.

Family Myriozoidae SMITT, 1867

Genus *Myriozoum* DONATI, 1750

*Myriozoum subgracile* D'ORBIGNY, 1852

1908. *Myriozoum subgracile* D'ORBIGNY, ROBERTSON, p. 296, pl. 21, fig. 5.

1929. *Myriozoum subgracile* D'ORBIGNY, CANU and BASSLER, p. 512, pl. 65, figs. 9-13.

1935. *Myriozoum subgracile* D'ORBIGNY, SAKAKURA, p. 36.

1952. *Myriozoum subgracile* D'ORBIGNY, OSBURN, p. 514, pl. 64, figs. 3, 4.

1956. *Myriozoum subgracile* D'ORBIGNY, MAWATARI, p. 132, fig. 15f-i.

1958. *Leieschara subgracilis* (D'ORBIGNY), ANDROSOVA, p. 145, text-fig. 72.

1965. *Leieschara subgracilis* (D'ORBIGNY), MAWATARI, p. 624, text-figs. 143a-c.

*Description*: Zoaria free, branches cylindrical. Zooecia immersed, its separation not visible. Frontal wall punctate with rather large pores. Orifice higher than broad, sometimes broader than high, proximal margin straight with a well marked sinus. A pair of small avicularia, occasionally only one avicularium, lateral or above each zooecium, and mandible directed obliquely downward.

*Measurements* (in mm): Orifice: lop=0.16, wop=0.12.

*Depository*: IGPS coll. cat. no. 91696.

*Distribution*: Recent, Puget Sound and Baffins Bay (ROBERTSON, 1908); Japan Sea (CANU and BASSLER, 1929); Alaska 13-25 fms (OSBURN, 1952); Aleutian Islands and Japan (MAWATARI, 1956, 1965); Aleutian Islands 10-100 m (ANDROSOVA, 1958). Fossil, Pleistocene, Chiba Pref. (Japan) (SAKAKURA, 1935).

*Myriozoum coarctatum* (SARS, 1850)

1908. *Myriozoum coarctatum* (SARS), ROBERTSON, p. 295, pl. 21, figs. 55-57.

1952. *Myriozoum coarctatum* (SARS), OSBURN, p. 513, pl. 64, figs. 5, 6.

*Description*: Zoarium free, branches cylindrical. Zooecia indistinct, no lines

of separation; frontal a very thick tremocyst with large irregular pores. Orifice longer than wide, rounded distally, straight at sides, proximal border transverse with a narrow sinus. Avicularia wanting.

*Measurements* (in mm): Orifice: lor=0.22, wor=0.20.

*Depository*: IGPS coll. cat. no. 91697.

*Distribution*: Recent, Off the coast of Oregon and Washington 152 fms (OSBURN, 1952); Alaska (ROBERTSON, 1908). Fossil, this is the first record.

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Aizawa            相 沢  
 Kareizawa        王余魚沢  
 Otakizawa        大滝沢  
 Tsurugasaka     鶴ヶ坂

Daishaka         大 釈 迦  
 Namioka-cho     浪 岡 町  
 Toyamori         都 谷 森  
 Umanokamiyama 馬ノ神山

589. *AMUSSIOPECTEN* FROM NORTH AMERICA  
AND NORTHERN SOUTH AMERICA\*

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北米および南米北部の *Amussiopecten*: *Amussiopecten* は SACCO (1897) によって提唱されて以来、世界各地の第三系から多くの種が報告された。しかし、北米および南米からはその存在が既に予想されていたのにも拘らず (COX, 1942), 従来 *Amussiopecten* の報告は全くなかった。

今回筆者は、COX の予想に基づき、北米・中米・南米の Pectinidae について詳しく検討した結果、*Amussiopecten* が Late Oligocene から Middle Miocene にかけて、南北アメリカ大陸に広く分布していたことを確認することができた。すなわち、既知種ではカリフォルニアの *Pecten vanvlecki* ARNOLD (1907), 西インド諸島の *Pecten antiguensis* BROWN (1913), コスタ・リカの *Pecten preglyptus* OLSSON (1922), ベネズエラの *Pecten churuguarensis* F. and H. HODSON (1927) などが、明らかに *Amussiopecten* に属するものであることが判った。さらに、*Amussiopecten* の新種をプエルト・リコ、トリニダードおよびメキシコから 3 種発見した。この中、メキシコからの 1 種は個体数が少なく、保存も余り良好でないので新種の記載は差控えた。

*Amussiopecten* は *Flabellipecten* に属するものであると考えている学者がヨーロッパには少なくないので、その分類の混乱は甚しい。しかし、両者は画然と区別されるべきものであると筆者は考えている。

本論文では *Amussiopecten* の特徴を詳しく論じたほか、類似属との関連、既知種および新種の記載と相互の関連、および *Amussiopecten* の古生物学的意義を論じた。

増田孝一郎

Introduction

Since *Amussiopecten* was established by SACCO 1897, it has been frequently recorded from various localities of Neogene and Paleogene formations in South and Central Europe, the Mediterranean Region, Iran, East Africa, Southeast Asia and East Asia, and believed to represent a tropical or subtropical pectinid. *Amussiopecten* assumes such varied morphological characteristics that it has been frequently confused with related pectinids. Some species refer-

able to *Amussiopecten* have been described under other genera or subgenera, such as *Pecten*, *Amusium*, or *Aequipecten*, as will be pointed out below. Therefore, *Amussiopecten* can be considered to be one of the most significant and important pectinids among the Cenozoic Pectinidae of the world, particularly from the view point of its world wide but locally limited geographical distribution, more or less restricted geological range and intimate relationships with certain other pectinids.

The name *Amussiopecten* has not been used in describing any American species. However, COX (1942) has already pointed

\* Received January 24, 1971: read January 24, 1971 at Tokyo.

out that a well known Miocene form, *Pecten vanvlecki* ARNOLD (1907) described from the Vaqueros Formation in Central to Southern California might be referable to *Amussiopecten*, but this has not been up to now confirmed. Moreover, it is reasonable to assume that some species referable to *Amussiopecten* should have been distributed to the area extending from the North America to South America during the Tertiary period.

The writer has examined numerous specimens preserved in the Department of Geology of Stanford University; Museum of Paleontology, University of California in Berkeley; U.S. Geological Survey in Menlo Park; U.S. National Museum in Washington, D.C.; California Academy of Sciences in San Francisco; Academy of Sciences of Philadelphia; and Paleontological Research Institution in Ithaca. The results of these examinations lead the writer to conclude that several species described from the Miocene or Oligocene formations of the West Coast of North America, Central America, Caribbean Region, and northern South America should be referred to the genus *Amussiopecten*. Two species new to science are described in the present article.

In the present article the writer wishes to describe the morphological characteristics of some species referable to *Amussiopecten* and two new species of *Amussiopecten*, and to discuss the relationship among the species. Moreover, paleontological significance of the genus *Amussiopecten* is given.

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#### Historical Review of *Amussiopecten*

*Amussiopecten* was established by SACCO in 1897 as a subgenus of *Pecten* based upon *Pecten burdigalensis* LAMARCK, an important Miocene pectinid in Europe, and at the same time he described two subspecies of *P. burdigalensis*. Subsequently, UGOLINI (1907, 1908) raised *Amussiopecten* to generic rank, as did many later authors, and he transferred eight species known from the Miocene formations in Italy to this genus. Thenceforth, many species or subspecies of *Amussiopecten* were described from Miocene formations in Central and Southern Europe (SCHAFFER, 1910, COSSMAN and PEYROT, 1914, TELEGD-ROTH, 1914, VON TEPPNER and DREGER, 1918, EAMES and COX, 1956, and others). In 1922 VON TEPPNER summarized the classification of the Tertiary Pectinidae in his "Fossilium Catalogus" and included 18 species and seven subspecies of pectinids in the subgenus *Amussiopecten* of the genus *Philippia*.

On the other hand, DEPÉRET and ROMAN (1910, 1912) did not use the *Amussiopecten* as either genus or subgenus, but they raised *Flabellipecten*, which was also established as a subgenus of *Pecten* at the same time as *Amussiopecten* by SACCO (1897), to generic rank, and moreover, they included the type species of *Amussiopecten*, *Pecten (Amussiopecten) burdigalensis* which was originally designated by SACCO, and the other species of *Amussiopecten*, in the genus *Flabellipecten*.

Subsequently, some authors in Europe (ROGER, 1939, VEIGA, 1954, ACCORDI, 1955, CSEPREGHY-MEZNERICS, 1960, ČTYROKÝ, 1969, etc.) followed the classification of DEPÉRET and ROMAN, and they did not use the taxon *Amussiopecten* but assigned all known species and subspecies of *Amussiopecten* to *Flabellipecten*.

From the Miocene formations de-

veloped in Iran, East Africa and Mediterranean Region several species of *Amussiopecten* were described by COX (1927, 1939), DOUGLAS (1928), and EAMES and COX (1956). Also from an Oligocene formation in Iran *Amussiopecten* cf. *labadyei* (d'ARCHIAE and HAIME) was recorded by COX (1936). In 1927 COX pointed out that *Vola singkirensis* and *Volagendinganensis* described by MARTIN (1909) from the Neogene formations in Java, Indonesia, might also be referable to *Amussiopecten*.

In the Far East part of Asia several species referred to *Amussiopecten* were described from the Neogene formations in Japan and Taiwan (YOKOYAMA, 1922, 1928, NOMURA, 1933, OTUKA, 1934, SHUTO, 1955, AKIYAMA, 1957, MASUDA, 1962a). Recently, CHANG (1967) also reported the occurrence of *Amussiopecten* sp. from Early Miocene formation in Taiwan. Among the species known from East Asia, *Amussiopecten praesignis* (YOKOYAMA) has been frequently reported from the Early Pliocene formations in the Pacific Borderland of Southern Japan and Taiwan (MASUDA, 1962b).

No species has hitherto been described and recorded under *Amussiopecten* either a genus or subgenus from either North America or South America. In 1969 HERTLEIN alluded to the occurrence of *Amussiopecten* in North and South America, but he did not give any details. Thus, *Amussiopecten* in North and South America has remained unknown.

#### Notes on *Amussiopecten*

In 1897 SACCO gave so simple diagnosis to the subgenus *Amussiopecten* that some confusion arose between *Amussiopecten* and *Flabellipecten*, as mentioned above. Later COSSMAN and PEYROT

(1914, p. 272) gave a better diagnosis of the subgenus *Amussiopecten*, as follows: "Shell generally large, a little arched, with a little gape; both valves convex, but left valve a little less convex than right valve; auricles a little elevated and rather long; byssal notch not very conspicuous; ornamentation takes like *Pecten* s. s., but more or less obsolete in full adult specimens (Translation)". The following diagnosis of *Amussiopecten* as a subgenus of *Pecten* was presented by COX (1927): "Shell orbicular, equilateral, inequivalve, the right valve more inflated than the left; ears fairly large, subequal, the sinus below the right anterior one scarcely developed; right valve sculptured with broad, depressed radial ribs, left valve with a rather smaller number of much narrower radial ribs; ribs frequently becoming obsolete towards the ventral margin; internal ornament sometimes consisting of broad ribs (corresponding in position to the external interspaces) concave in cross section, with prominently raised margins, and sometimes of paired narrow ribs (as in *Amusium*), each pair obviously representing the margins of one of the broader ribs, the central portion of which is undeveloped; ligament-pit deep; cardinal crura fairly well developed, three in the right valve and two in the left; auricular crura strong, tuberculiform". In 1956 EAMES and COX raised *Amussiopecten* to generic rank and at the same time they also used *Flabellipecten* as a subgenus of *Pecten*.

Although PHILIPPI (1900) concluded that the genus *Amusium* may belong to a different lineage from that of *Amussiopecten*, it is considered that *Amusium* is related to *Amussiopecten* in general features except for the smooth surface, equally inflated valves, and rather thin shell. Also as pointed out by MACNEIL

(1961), the present genus is closely related to the genus *Pecten* and is believed to form a continuous lineage between *Pecten* and *Amusium*.

#### *Amussiopecten* from North and South America

So far as examined, among numerous specimens collected from the Tertiary strata in North America, Central America, West Indies and South America the following species and subspecies which have been described under other generic taxa such as *Pecten*, *Amusium* and *Aequipecten* can be considered to be referable to the genus *Amussiopecten*. Also it appears that some species referable to the present genus have frequently been recorded as *Amusium* from the Oligocene and Miocene formations. For example: *Pecten* (*Pecten*) *vanvlecki* ARNOLD (1907), *Pecten* (*Amusium*) *antiguensis* BROWN (1913), *Pecten* (*Aequipecten*) *preglyptus* OLSSON (1922), *Pecten* (*Pecten*) *hawleyi* HERTLEIN (1925) and *Pecten* *antiguensis churuguarensis* F. and H. HODSON (1927). Among them *Pecten* (*Pecten*) *hawleyi* HERTLEIN can be considered to be a synonym of *Amussiopecten vanvlecki* (ARNOLD) as discussed later. Moreover, two new species from Oligocene and Miocene formations in Puerto Rico, Trinidad and Mexico, and one undescribed species from the Miocene of Mexico have been found, but the latter specimens are unfortunately so poorly preserved that they are not named.

The following species of *Amussiopecten* are confirmed by the writer from the geological formations ranging from the Late Oligocene to Middle Miocene in North America, Central America, West Indies and northern South America.

1. *Amussiopecten vanvlecki* (ARNOLD) from the Early to Middle Miocene in Southern to Central California, U. S. A.
2. *Amussiopecten antiguensis* (BROWN) from the Late Oligocene of Antigua Island, West Indies.
3. *Amussiopecten preglyptus* (OLSSON) from the Middle Miocene in Costa Rica.
4. *Amussiopecten churuguarensis* (F. and H. HODSON) from the Late Oligocene in Venezuela and Puerto Rico, West Indies.
5. *Amussiopecten harrisi* MASUDA, new species from the Late Oligocene in Puerto Rico and Mexico.
6. *Amussiopecten woodringi* MASUDA, new species from the Late Oligocene in Puerto Rico and Early Miocene in Trinidad.
7. *Amussiopecten* species from the Early Miocene in Mexico.

### Description

Family Pectinidae

Subfamily Amusiinae

Genus *Amussiopecten* SACCO, 1897

*Amussiopecten* SACCO, 1897, p. 53.

*Type-species* (original designation):—*Pecten burdigalensis* LAMARCK, 1809. Miocene (Burdigalian), France.

*Geological range*:—Oligocene to Pliocene.

*Geographical distribution*:—Central and South Europe, Mediterranean, North and East Africa, Iran, India, Indonesia, Taiwan, Japan, West Indies, North America, Central America and northern South America.

*Remarks*:—This genus is characterized by its medium to rather large, medium thick, slightly inflated, nearly equivalved shell; right valve always a little more inflated than slightly inflated left valve;

rather large, angulated auricles with wide and shallow byssal notch; surface of right valve with broad, low, square sided or flatly rounded radial ribs which usually tend to become obsolete towards ventral and lateral margins; left valve with rounded, low radial ribs and raised, regularly spaced, fine incremental lines; radial ribs usually narrower than their interspaces in younger stage but usually tending to become broad and obsolete towards ventral margin; interior surface with distinct paired internal ribs which are more prominent near ventral margin; hinge with simple cardinal crura having a rather distinct provinculum and distinct auricular crura which terminate distally in a distinct oblong denticle at each extremity.

The present genus can be distinguished from *Flabellipecten* in having slightly inflated, nearly equivalved shell, squarish or flatly rounded, low radial ribs which tend to become obsolete towards ventral and lateral margins, and rather large, angulate auricles in the right valve; left valve with rounded radial ribs tending to become broad and obsolete towards the ventral and lateral margins; hinge with rather simple cardinal crura provided with a rather distinct provinculum. Moreover, *Amussiopecten* is never provided with intercalary threads in either valve but *Flabellipecten* usually has intercalary threads in the left valve.

Although from the morphological characteristics DEPÉRET and ROMAN (1910) concluded that *Amussiopecten* should be referred to *Flabellipecten*, the writer believes that from the above mentioned morphological characteristics *Amussiopecten* should be ranked as a genus as did UGOLINI (1907) and EAMES and COX (1956). Also that *Flabellipecten* should be placed as a subgenus of *Pecten*, because *Flabellipecten* has characteristics

very similar to those of the genus *Pecten*, except for the greatly inflated right valve, flat or sometimes concave left valve, and rather smaller number of distinctly squarish, high radial ribs in *Pecten* s. s.

*Amussiopecten vanvlecki*

(ARNOLD, 1907)

Pl. 25, figs. 1a-b, 2, 3, 4

1907. *Pecten* (*Pecten*) *vanvlecki* ARNOLD, *Smiths. Misc. Coll.*, Vol. 50, p. 428, pl. 53, figs. 1, 2.
1907. *Pecten* (*Pecten*) *vanvlecki* ARNOLD, ARNOLD and ANDERSON, *U.S. Geol. Surv., Bull.*, 322, pl. 17, figs. 1, 2.
1925. *Pecten* (*Pecten*) *hawleyi* HERTLEIN, *South. Calif. Acad. Sci., Bull.*, 24, pt. 2, p. 40, pl. 4, figs. 4, 5.
1932. *Pecten* (*Pecten*) *hawleyi* HERTLEIN, LOEL and COREY, *Univ. Calif. Publ., Bull. Dept. Geol. Sci.*, Vol. 22, no. 3, p. 194, pl. 20, fig. 1 (not fig. 2).
1932. *Pecten* (*Pecten*) *vanvlecki* ARNOLD, LOEL and COREY, *Ibid.*, p. 195, pl. 20, figs. 3, 5.
1932. *Pecten vanvlecki* ARNOLD, BREMNER, *Santa Barbara Mus. Nat. Hist., Occ. Paper* No. 1, pl. 2, fig. 6.

*Holotype*:—U. S. Natl. Mus., Coll. No. 165305.

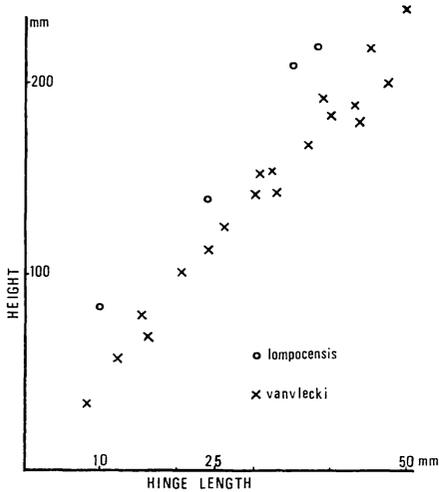
*Remarks*:—From the study of many specimens of *A. vanvlecki* the writer considers that the following features must be added to the original description: Shell slightly inflated, subequivalve, though right valve a little more convex than slightly inflated left valve which is sometimes nearly flat in younger stage but tends to become slightly inflated with growth; radial ribs of right valve flatly round-topped, more or less squarish in profile, rather distinctly separated from their interspaces and varying in number from about 13 to 18,

as pointed out by LOEL and COREY (1932). Hinge with simple cardinal crura with a distinct provinculum and distinct cardinal crura terminating distally in an oblong denticle. Paired internal ribs well developed near ventral margin.

*Comparison*:—*Pecten* (*Pecten*) *hawleyi* was described by HERTLEIN (1925) from the same formation containing *P. vanvlecki*, and was based upon one small left valve and one small, poorly preserved right valve. However, according to the re-examination of type specimens (Stanford University Type Coll. Nos. 19, 20) it seems that *P. hawleyi* is a synonym of *P. vanvlecki*, that is to say, *P. hawleyi* has features characteristic of *P. vanvlecki*, such as slightly inflated left valve with rounded radial ribs that tend to become flatter and lower towards ventral margin, distinct, raised, regularly spaced incremental lines and distinct paired internal ribs. Thus, it appears that *P. hawleyi* represents an immature form of *P. vanvlecki*. Also *P. hawleyi* was recorded by LOEL and COREY (1932) from the Vaqueros Formation at Santa Ynez Mountains in Southern California. However, according to the writer's study of their type specimens (Museum of Paleontology, Univ. Calif. Berkeley, Coll. Nos. 31718, 31719), the left valve can be identified with *P. vanvlecki* but the right valve can be considered to be referable to *Aequipecten andersoni* (ARNOLD).

*Pecten vanvlecki* has frequently been confused with *Pecten* (*Amusium*) *lompoensis* ARNOLD (1906), described from the Temblor Miocene in Southern California, as already pointed out by LOEL and COREY (1932), but the former is easily distinguishable from the latter by its rather thick shell, squarish, low, flatly round-topped radial ribs tending to become obsolete towards the ventral and

lateral margins, paired internal ribs developed at lower part and larger and angulate auricles. The relations between the shell height and hinge length are shown in Text-fig. 1. However, because of the state of preservation sometimes the two can not be distinguished from one another.



Text-fig. 1. Graph showing the relationship between the height and hinge length of shell.

*Dimensions (in mm):—*

Valve R-L	R	R	R	L	L	L
Height	95	105	92	78	120	80
Length	98	110	92	ca. 76	125	82
Depth	15*	—	7	—	ca. 8	ca. 6

\*—thickness

*Type locality:*—Mouth of Ballard Canyon, 2 miles south of Santa Ynez, Santa Barbara County, California. Vaqueros Formation. Early Miocene.

*Distribution:*—Santa Ynez and Fox Mountains, Santa Barbara County; Oak Ridge, Ventura County; Santa Cruz Island, Santa Lucia Mountains, and western foot hills from northern San Luis Obispo quadrangle, railroad cutting

near Paso Robles, Templeton quadrangle and Nipomo quadrangle southwest across the Paso Robles quadrangle to central western Adelaide quadrangle, San Luis Obispo County; Orange County: Early to Middle Miocene.

*Amussiopecten antiguensis*

(BROWN, 1913)

Pl. 26, figs. 4, 5

1913. *Pecten (Amusium) antiguensis* BROWN, *Proc. Acad. Nat. Sci. Philadelphia*, p. 613, pl. 18, figs. 1, 2, 3, 5.

1919. *Pecten (Amusium) antiguensis* BROWN, COOKE, *Carnegie Inst. Washington Publ.*, 291, p. 143, pl. 13, figs. 6, 7.

*Holotype:*—Acad. Nat. Sci. Philadelphia, Coll. No. 1648.

*Remarks:*—This species was first described by BROWN (1913) from the Antigua Limestone of Antigua Island, West Indies, based upon several poorly preserved specimens and then it was described from the type locality by COOKE (1919). Also it was reported by HARRIS (1926) from the Oligocene formation in Trinidad.

The type specimens and the topotype specimens (U. S. Natl. Mus., Coll. No. 197139) are unfortunately not well preserved but this species is characterized by the following features: Shell medium in size and thickness, compressed; sub-equivalve, but right valve a little more inflated than left valve, forming an angle of 120° or a little more at apex. Right valve slightly inflated, with about 16 very low, flatly round-topped radial ribs tending to become obsolete towards ventral and lateral margins and fine incremental lines; radial ribs broader than their interspaces; auricles rather large, somewhat angulate, with fine concentric lines; anterior auricle with wide

and shallow byssal notch. Left valve slightly inflated, with very low, rounded radial ribs tending to become obsolete and broad towards ventral margin, and regularly spaced, raised, fine incremental lines. Hinge with simple cardinal crura with fine provinculum; auricular crura terminate distally in a distinct denticle at each extremity. Interior surface with distinct paired internal ribs near ventral margin.

BROWN (1913) stated that the radial ribs of this species are about 13 in number but the writer finds that they are about 16 in number.

According to the writer's study of the hypotype specimen preserved in the Paleontological Research Institution (Coll. No. 25058) which was illustrated by HARRIS (1926) as *Pecten antiguensis* BROWN from the Adivinanza quarry, east of Princes Town, Trinidad, it seems that HARRIS's specimen can not be referred to *P. antiguensis*; that is to say, the specimen, consisting of a right valve, differs from the present species in having a smaller apical angle and larger number of more elevated radial ribs, which are more rectangular in profile and broader than those of *P. antiguensis*. Therefore, this can be considered to represent a new form of *Amussiopecten* described in the present paper.

*Comparison*:—*Amussiopecten antiguensis* differs from *A. vanvlecki* by its smaller shell, larger apical angle and very low radial ribs.

*Dimensions (in mm)*:—

Valve	R*	L*	L*	L*	R**	R**	L**
Height	61	63	55	—	—	64	40
Length	—	—	55	53	65	64	40
Depth	ca. 5	ca. 5	ca. 4	—	—	ca. 7	ca. 4

\*—cotype specimens,

\*\*—topotype specimens

*Type locality*:—Hodges Bay, Antigua Island, West Indies. Antigua Limestone. Late Oligocene.

*Distribution*:—Known only from the type locality.

This species has been reported from the Early Miocene of Venezuela by HARRIS (1926, p. 107) but it has not been authenticated.

*Amussiopecten preglyptus*

(OLSSON, 1922)

1922. *Pecten (Aequipecten) preglyptus* OLSSON, *Bull. Amer. Paleont.*, Vol. 9, no. 39, p. 202, pl. 17, figs. 2, 7.

*Holotype*:—Paleont. Res. Inst., Coll. No. 21140.

*Remarks*:—As this species was based upon a poorly preserved left valve, its detailed morphological features remained unknown. It is characterized by its rather small shell, slightly inflated left valve, about 16 rounded, very low radial ribs which tend to become obsolete towards ventral and lateral margins and narrower than their interspaces in younger stage but tend to become nearly equal to their interspaces in breadth with growth; fine, regularly spaced incremental lines; distinct auricular crura terminating distally in an oblong denticle at each extremity; distinct paired internal ribs near ventral margin; and simple cardinal crura.

This species was described under the subgenus *Aequipecten* but from the above mentioned morphological characteristics it is evident that it can not be referred to that subgenus but to *Amussiopecten*. Unfortunately the characteristics of the right valve remain unknown.

*Comparison*:—This species can be distinguished from *A. vanvlecki* by its smaller shell, indistinct low radial ribs, and smaller auricles. *Amussiopecten*

*preglyptus* also is related to *A. antiguensis*, but it differs in the smaller apical angle, the incremental lines not raised, and oblong denticles at each extremity of the hinge.

*Dimensions (in mm)*:—Height 50, length 50, depth ca. 5.

*Type locality*:—Upper Cocles Creek, Limón Province, Costa Rica. Gatun Formation. Middle Miocene.

*Distribution*:—Known only from the type locality.

*Amussiopecten churuguarensis*

(F. and H. HODSON, 1927)

Pl. 26, figs. 6, 7

1927. *Pecten antiguensis churuguarensis* F. and H. HODSON, *Bull. Amer. Paleont.*, Vol. 13, no. 49, p. 35, pl. 20, figs. 1, 3, 4, pl. 22, fig. 2.

*Holotype*:—Paleont. Res. Inst., Coll. No. 21965.

*Remarks*:—The specimens studied enable the presentation of the following description: Shell rather small to medium in size, thin, orbicular in outline, compressed, subequivalve but right valve more inflated than left valve; valves smooth but radiately ribbed and forming an angle of about 110° at apex. Right valve slightly inflated, with about 14 very low, flatly round-topped radial ribs tending to become obsolete towards ventral and lateral margins and regularly spaced, fine incremental lines; radial ribs broader than their interspaces; auricles extremely angulated, nearly equal to each other, with wide and shallow byssal notch below anterior auricle and with rugose, fine concentric lines. Left valve slightly inflated, with very low, rounded radial ribs that are nearly equal to their interspaces in younger stages, but tend to become obsolete and broad towards ventral and

lateral margins; and regularly spaced raised incremental lines; auricles straight, with distinct concentric lines. Hinge with simple cardinal crura and distinct auricular crura. Interior surface with paired internal ribs.

Although this species was originally described as a subspecies of *P. antiguensis*, it is evident from the morphological characteristics above mentioned that it should be raised to a species.

*Comparison*:—*Amusium ocalanum* (DALL) from the Eocene Ocala Limestone in Florida (HARRIS, 1951) can be distinguished from the present one by its oblique, thin shell, left valve little more inflated than right valve, complicated cardinal crura, faint radial ribs, rather deep byssal notch and ctenolium. *Amusium ocalanum* is considered to be a significant species in clarifying the relationship between *Amusium* and *Amussiopecten*. Need for a detailed study is evident.

This species can be distinguished from other species of *Amussiopecten* by its extremely angulate auricles.

*Dimensions (in mm)*:—

Valve	R*	R	R	R	L	L	L	L
Height	42	50	35	28	45	37	24	21
Length	45	56	38	30	45	37	26	21
Depth	ca. 5	6	4	3.5	5	—	ca. 2	2

\*—holotype

*Type locality*:—Districts of Petit, Miranda, Federación and Buchivacoa, State of Falcón, Venezuela. Churuguara Formation. Late Oligocene.

*Distribution*:—Churuguara Formation, Venezuela; San Sebastián Formation, Puerto Rico: Late Oligocene.

*Amussiopecten harrisi*

MASUDA, n. sp.

Pl. 26, figs. 1a-b

*Holotype*:—U. S. Natl. Mus., Coll. No. 646476.

*Description*:—Shell medium in size, rather thin, compressed, subequivalve; right valve a little more inflated than left valve; valves radiately ribbed and forming an angle of about 110° at apex. Right valve slightly inflated, with about 16 low but rather distinct, perpendicular sided, flatly round-topped radial ribs tending to become obsolete and broad towards ventral and lateral margins, and faint, fine incremental lines; radial ribs broader than their interspaces, which are flatly round bottomed; auricles somewhat angulate, with fine concentric lines and faint, fine radial threads. Left valve slightly inflated, with low, rather flatly rounded radial ribs, which tend to become obsolete towards ventral and lateral margins, crossed by regularly spaced, raised, faint, fine incremental lines; radial ribs nearly equal to their interspaces in breadth at younger stage but tending to become broader than their interspaces with growth; auricles straight, with fine, faint radial threads and concentric lines. Hinge with simple cardinal crura provided with a distinct, fine provinculum, wide and shallow resilial pit, and distinct auricular crura terminating distally in a distinct denticle at each extremity. Interior surface with distinct paired internal ribs near ventral margin.

*Dimensions (in mm)*:—Holotype, height 57, thickness 12.5; paratype, right valve, height 28, length 29, depth, ca. 4; right valve, height 45, length 45.

*Remarks*:—This species is named in honor of Late Prof. Gilbert D. HARRIS who greatly contributed to the paleontological studies of Central and South America and founded the Paleontological Research Institution in Ithaca, New York.

*Comparison*:—*Amussiopecten vanvlecki*

can be distinguished from the present new species by its larger shell, nearly flat left valve in younger stage that tends to become slightly inflated with growth, the more distinct, high radial ribs in right valve, and distinct radial ribs narrower than their interspaces and raised, rugose, fine incremental lines in the left valve.

The present species also is related to *A. antiguensis* but it differs from the latter in having distinct, perpendicular sided radial ribs in right valve and the left valve with distinct, flatly rounded, broad radial ribs. It differs from *A. preglyptus* in having left valve with flatly rounded radial ribs that are nearly equal to their interspaces in younger stage, auricles with radial threads and distinct denticle at each extremity of hinge.

Several poorly preserved specimens referable to the present species are known from an unnamed formation of Late Oligocene in Mexico.

*Type locality*:—U. S. Geol. Surv., Loc. No. 19780. San Sebastián quadrangle, west of San Sebastián, Puerto Rico. San Sebastián Formation. Late Oligocene.

*Distribution*:—San Sebastián Formation, Puerto Rico; Simojovel, Camino Carretero, Chiapas, Mexico (Univ. Calif. Berkeley, Loc. No. B8267): Late Oligocene.

*Amussiopecten woodringi*

MASUDA, n. sp.

Pl. 26, figs. 2a-b, 3a-b

1926. *Pecten antiguensis* BROWN, HARRIS, *Johns Hopkins Univ., Stud. Geol.*, No. 7, p. 107, pl. 19, fig. 4 (non BROWN, 1913).

*Holotype*:—U. S. Natl. Mus., Coll. No. 646474.

*Description*:—Shell medium in size, rather thin, compressed, orbicular in outline, equilateral, subequivalve; right valve a little more inflated than left valve; valves radiately ribbed and forming an angle of about 115° at apex. Right valve slightly inflated, with about 21 very low, roundly flat-topped radial ribs and fine incremental lines; radial ribs somewhat broader than their interspaces in younger stage but tend to become broader and obsolete towards ventral and lateral margins; auricles rather large, angulate, subequal to each other, with somewhat raised, rugose, fine concentric lines; anterior auricle with shallow and wide byssal notch. Left valve slightly inflated, with very low, rounded radial ribs tending to become obsolete towards ventral and lateral margins with growth and rather distinct, regularly spaced, fine incremental lines; radial ribs narrower than their interspaces in younger stage but tending to become nearly equal to or a little broader than their interspaces with growth; auricles straight, with rugose, fine concentric lines and faint, fine radial threads. Hinge with simple cardinal crura provided with fine provinculum and wide and shallow resilial pit; auricular crura distinct, terminate distally in a distinct denticle at each extremity. Interior surface with distinct paired internal ribs near ventral margin.

*Dimensions (in mm)*:—

Valve	R-L*	R-L	R	R	L
Height	50	70	63	57	45
Length	52	70	63	—	45
Depth	10**	ca. 11**	ca. 5	ca. 4	ca. 3

\*—holotype, \*\*—thickness

*Remarks*:—This species is named in honor of Dr. Wendell P. WOODRING of the Smithsonian Institution, who has greatly contributed to the stratigraphical

and paleontological studies in the Central America and South America.

*Comparison*:—*Pecten antiguensis* illustrated by HARRIS (1926) from the Ste. Croix Formation in Trinidad can be referred to the present new species, because the type specimen (Paleont. Res. Inst., Coll. No. 25058) has radial ribs showing characteristics similar to those of the present species but it differs from *antiguensis* in several particulars. Although HARRIS (1926) described this specimen as an Oligocene species, the locality of this specimen at present is considered to belong to the Early Miocene Ste. Croix Formation.

This new species can be distinguished from *A. antiguensis* (BROWN) by its smaller apical angle at the apex and the larger number of very low radial ribs. Also *A. harrisi* MASUDA differs from the present one in having a smaller number of perpendicular sided radial ribs in the right valve and distinctly broader radial ribs in the left valve.

*Type locality*:—U. S. Geol. Surv., Loc. No. 19775. Central La Plata quadrangle, northeast of Central La Plata, Puerto Rico. Lares Limestone. Late Oligocene.

*Distribution*:—Lares Limestone, Puerto Rico; Ste. Croix Formation, Trinidad; Late Oligocene to Early Miocene.

*Amussiopecten* sp.

Pl. 25, figs. 5a-c

Three rather poorly preserved specimens from the Early Miocene Tuxpan Formation in Vera Cruz, Mexico are at hand. They are in the collections of Smithsonian Institution and in the California Academy of Sciences. They may be characterized as follows: Shell rather large, medium in thickness, compressed, subequivalve; right valve a

little more inflated than left valve; valves radiately ribbed and forming an angle of about  $115^\circ$  at apex. Right valve slightly inflated, with about 18 very low, perpendicular sided radial ribs tending to become obsolete towards ventral and lateral margins, and fine incremental lines; radial ribs broader than their interspaces; auricles rather large, somewhat angulate, subequal, with rugose, fine concentric lines. Left valve slightly inflated, with flatly rounded, low radial ribs and regularly spaced fine incremental lines; radial ribs nearly equal to their interspaces in breadth, tending to become obsolete towards ventral and lateral margins; auricles straight, subequal, with rugose, fine concentric lines. Hinge with simple cardinal crura and fine provinculum; auricular crura distinct. Interior surface with paired internal ribs.

Several fragmental specimens from the Early Miocene Aguada Formation in Puerto Rico (U. S. Geol. Surv., Loc. No. 19710) seem also to belong here, and are included with some hesitation.

These specimens apparently represent an unnamed species, but naming is withheld until better specimens are collected.

From *A. woodringi* this form is distinguishable by its larger shell, more or less squarish and smaller number of radial ribs in the right valve, and the left valve with low radial ribs which are nearly equal to their interspaces in breadth. *A. harrisi* also is related to the present one but differs in having a smaller shell, rather distinct, squarish radial ribs in the right valve, the left valve with distinct radial ribs that are broader than their interspaces, and auricles provided with radial threads and concentric lines.

*Dimensions (in mm)*:—Height ca. 100,

Length 100, thickness 17 (U. S. Natl. Mus., Coll. No. 646478); length 100; height 42, length 45, thickness 10 (Calif. Acad. Sci., Loc. No. 41035).

*Locality*:—"Hill A" in City of Tuxpan, Vera Cruz, Mexico. Tuxpan Formation. Early Miocene.

*Distribution*:—Tuxpan Formation, Mexico; Aguada Formation, Puerto Rico: Early Miocene.

### Paleontological Significance

In the present study the following species referable to the genus *Amussiopecten* are recognized from the Late Oligocene to Middle Miocene formations in North America, Central America, West Indies and northern South America: *Amussiopecten vanvlecki* (ARNOLD), *A. antiguensis* (BROWN), *A. preglyptus* (OLSSON), *A. churuguarensis* (F. and H. HODSON), *A. harrisi* MASUDA, n. sp., *A. woodringi* MASUDA, n. sp. and *A. sp.*

Judging from the descriptions and figures the writer considers that the following species and subspecies in Europe and the Mediterranean Region can be referred to the genus *Amussiopecten*.

*Amussiopecten burdigalensis* (LAMARCK, 1809): Oligocene to Miocene

*A. burdigalensis elongata* (MYLIUS, 1891): Miocene

*A. burdigalensis spinosella* (SACCO, 1897): Miocene

*A. burdigalensis minor* (v. ROTH, 1914): Oligocene

*A. galloprovincialis* (MATHERON, 1842): Miocene

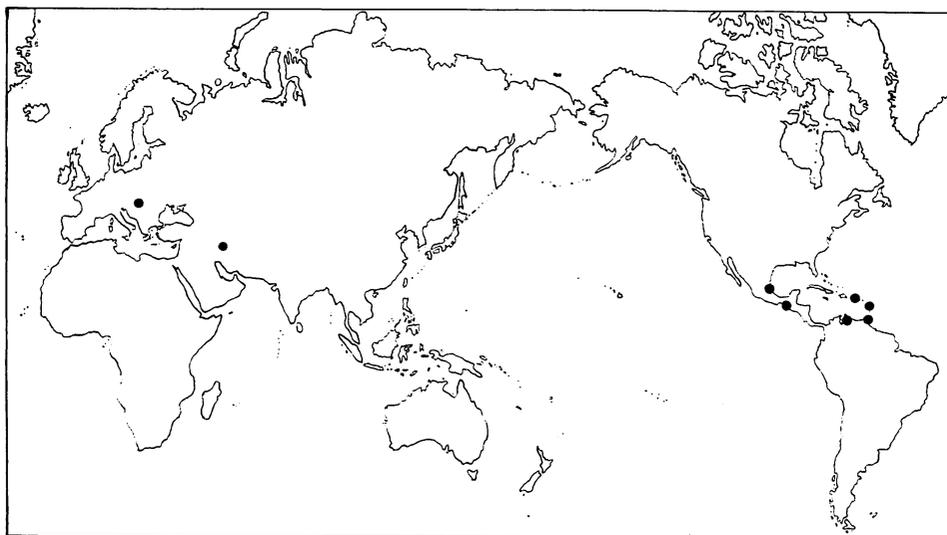
*A. pasinni* (MENECHINI, 1857): Miocene

*A. koheni* (FUCHS, 1876): Miocene

*A. vinassai* (UGOLINI, 1899): Miocene

*A. ugolinii* (DEPÉRET and ROMAN, 1912): Miocene

*A. guebhardi* (DEPÉRET and ROMAN,

Text-fig. 2. Distribution of Oligocene *Amussiopecten*.

1912): Miocene

*A. benoisti* (COSSMAN and PEYROT, 1914): Miocene

The geological age of *Amussiopecten* in Europe and Mediterranean Region ranges from the Late Oligocene to Middle Miocene. However, in Europe there is so much confusion in the classification of this group that a detailed study seems necessary to clarify the biostratigraphical relations of *Amussiopecten*.

The following species are known from the Late Oligocene to Early to Middle Miocene formations in Iran, and East and North Africa.

*Amussiopecten burdigalensis* (LAMARCK, 1809): Oligocene to Miocene

*A. gregoryi* (COX, 1927): Miocene

*A. africanus* (COX, 1927): Miocene

*A. cf. labadyei* (D'ARCHIAC and HAIME, 1854): Oligocene (COX, 1936)

*A. sp.*, EAMES and COX (1956): Miocene

In Indonesia the following species have been described from the Early Miocene and Early Pliocene formations.

*Amussiopecten singikirensis* (MARTIN,

1909): Miocene

*A. gendinganensis* (MARTIN, 1909): Pliocene

From Japan and Taiwan the following species are known from the Early Miocene to Early Pliocene formations.

*Amussiopecten praesignis* (YOKOYAMA, 1922): Pliocene

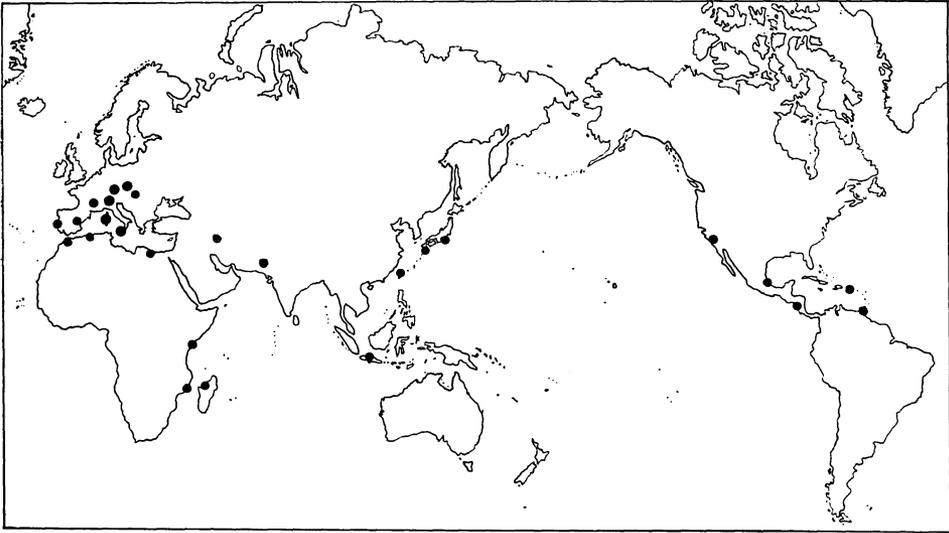
*A. yabei* (NOMURA, 1933): Pliocene

*A. iitomiensis* (OTUKA, 1934): Miocene

*A. akiyamae* MASUDA, 1962: Miocene

*A. sp.*, CHANG (1967): Miocene

From the species listed above it is evident that the geological range of *Amussiopecten* is from the Late Oligocene to Early Pliocene. The Oligocene species are known from Europe (CSEPREGHY-MEZNERICS, 1964, ČTYROKÝ, 1969, etc.), Iran (COX, 1936), Puerto Rico and Antigua Island in West Indies, Venezuela and Mexico, and also the Pliocene species are known from Japan, Taiwan (MASUDA, 1962b) and Indonesia (MARTIN, 1909). The other species are all known from the Early to Middle Miocene formations in world wide distribution. That is to



Text-fig. 3. Distribution of Miocene *Amussiopecten*.

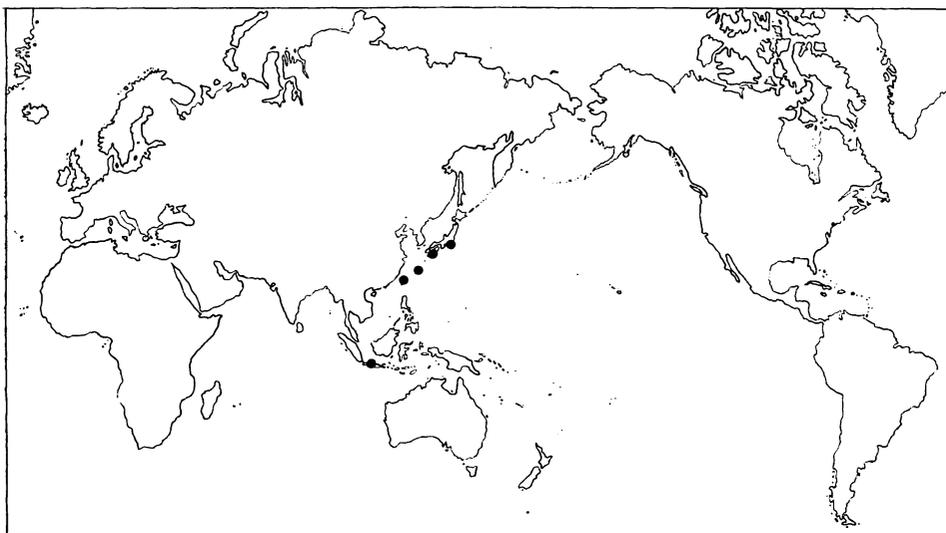
say, it is evident that the *Amussiopecten* group, except for a few species of East Asia, became extinct at the end of Middle Miocene time. The stratigraphical and geographical distributions of the genus *Amussiopecten* is shown in Text-figs. 2-4. It is interesting to notice that (1) the genus *Amussiopecten* appeared in the Late Oligocene and was dispersed from Central Asia to Central America, (2) in the Early to Middle Miocene *Amussiopecten* expanded its range to world wide and many species appeared, and (3) in the Early Pliocene only a few species lived in southern East Asia and they became extinct at the end of Early Pliocene.

All species of *Amussiopecten* in Europe and America became extinct at the end of Middle Miocene, but in East Asia three species survived to the end of Early Pliocene. In general, the decrease in number of species with time can be explained by the changes of oceanographic environmental conditions. The water temperature generally became

gradually lower from the Late Oligocene to the latest Neogene. Therefore, it can be considered that as the result of changes in the oceanographic conditions with time all species of *Amussiopecten* in Europe and America became extinct at the end of Middle Miocene but in East Asia three species were able to survive to the Early Pliocene. That is to say, the environmental conditions in South East Asia did not change extremely during the later Tertiary and have been rather stable than those of the other areas from the Early Miocene to Early Pliocene.

From the accounts given above it appears that the distribution of *Amussiopecten* has been dependent upon the changes of oceanographic conditions progressively during its geological age. Therefore, world wide occurrences of *Amussiopecten* are considered to be very significant for interregional correlation.

The Late Oligocene to Middle Miocene pectinid faunas in North America are usually composed of European elements



Text-fig. 4. Distribution of Pliocene *Amussiopecten*.

such as *Pecten*, *Flabellipecten*, *Amusium*, *Amussiopecten*, *Argopecten*, *Lyropecten*, *Aequipecten*, etc., but the Late Miocene to Pliocene pectinid fauna in the northern West Coast of North America generally contains a mixture of Asian elements such as *Swiftpecten*, *Mizuhopecten*, *Yabepecten*, *Fortipecten* and others (MASUDA and ADDICOTT, 1970, MASUDA, 1971), the survivors of Miocene pectinids such as *Pecten*, *Argopecten*, *Lyropecten*, *Aequipecten* and endemic genera such as *Patinopecten* and *Lituyapecten*. But in the southern West Coast of North America, East Coast of North America, and West Indies, the pectinid faunas differ greatly from those in the northern West Coast since the Late Miocene. In the southern West Coast the Pliocene pectinid fauna reveals a quite different aspect from those of northern part: these faunal provinces indicate geographic differentiation. These facts can be explained by changes of oceanographic conditions as a result of paleogeographical changes in North and South America

(DURHAM, 1961, WHITMORE and STEWART, 1965, WOODRING, 1966). The North American continent may have been connected with the South American continent at least in the Late Miocene to Early Pliocene.

In 1967 MACNEIL stated that most of molluscan stock in North America has older representatives in Japan and they in turn are immigrants from East Asia. However, as far as now known, it is evident that the *Amussiopecten* group and others such as *Amusium*, *Argopecten*, *Lyropecten*, *Aequipecten*, etc. have moved from the West Indies to North America. Therefore, it can be considered that the older stocks of Oligocene to Miocene pectinids in North America should have been present in the Tethys Sea. Of course, it is evident that *Amussiopecten* in North and South America did not come from East Asia.

Furthermore, from the view point of morphological characteristics of *Amussiopecten* it can be stated that the older the geological age, the smaller the shell.

Thus, the latest species of *Amussiopecten*, *A. praesignis* from the Early Pliocene of Japan, has the largest shell (max. about 140 mm in length); but the Oligocene species are always smaller (max. about 70 mm in length in *A. woodringi*), and moreover, the Miocene species are medium in size (max. 125 mm in length in *A. vanvleeki*). Therefore, it seems quite possible and reasonable to determine the geological age of *Amussiopecten* bearing formations and to correlate geographically isolated geological formations based upon the morphological characteristics of this genus.

The life history of *Amussiopecten* is unknown but judging from morphological characters such as auricular crura which terminate distally in a very conspicuous, rounded, oblong denticle at each extremity of the hinge; the circular, equilateral, compressed, rather polished, thin shell, and characteristic paired internal ribs, it appears that *Amussiopecten* may have been adapted for active swimming habits. Moreover, judging from the occurrences of *Amussiopecten*,—they are usually found in rather well sorted, very coarse to medium-grained sandstone or impure limestone—, it is considered that the life environment of *Amussiopecten* may have been influenced by rather strong currents on shallow sea bottoms.

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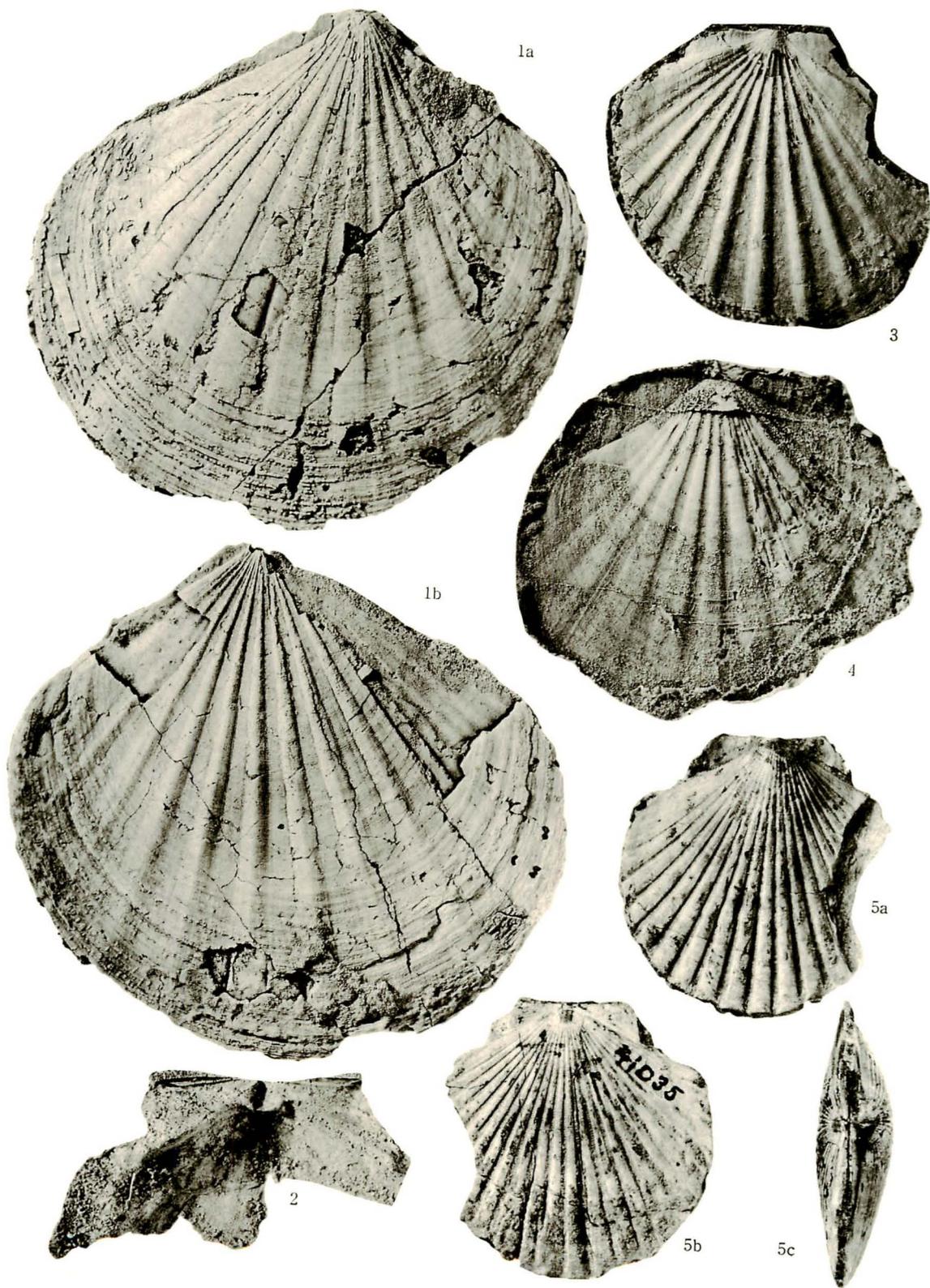
### Explanation of Plate 25

(Natural size)

Figs. 1a-b, 2, 3, 4. *Amussiopecten vanvlecki* (ARNOLD).

1a, right valve. 1b, left valve. U.S. Natl. Mus., Coll. No. 646495. Loc.:—U.S. Geol. Surv., Loc. No. M2418; about 1.5 miles north of Santa Barbara Canyon Ranch, Fox Mountain Quadrangle, Santa Barbara County, California. Saltos Shale Member of Monterey Shale. Middle Miocene. 2, hinge area of right valve. U.S. Natl. Mus., Coll. No. 646498. Loc.:—U.S. Geol. Surv., Loc. No. M2417; about 1.3 miles southwest of the Drill hole near Big Pine Road in Santa Barbara Canyon, Fox Mountain Quadrangle, Santa Barbara County, California. Branch Canyon Formation. Middle Miocene. 3, left valve. U.S. Natl. Mus., Coll. No. 646496. Loc.:—U.S. Geol. Surv., Loc. No. M2458; about 1.4 miles southwest of Willow Campground in Santa Barbara Canyon, Fox Mountain Quadrangle, Santa Barbara County, California. Branch Canyon Formation. Middle Miocene. 4, plaster cast of right valve. U.S. Natl. Mus., Coll. No. 646497. Loc.:—U.S. Geol. Surv., Loc. No. M3044; about 0.8 miles west of the Spring in Alamo Canyon, Fox Mountain Quadrangle, Santa Barbara County, California. Branch Canyon Formation. Middle Miocene.

Figs. 5a-c. *Amussiopecten* sp. a, right valve. b, left valve. c, upper view of 5a. Loc.:—Calif. Acad. Sci., Loc. No. 41035; Tuxpan, Vera Cruz, Mexico. Tuxpan Formation. Early Miocene.



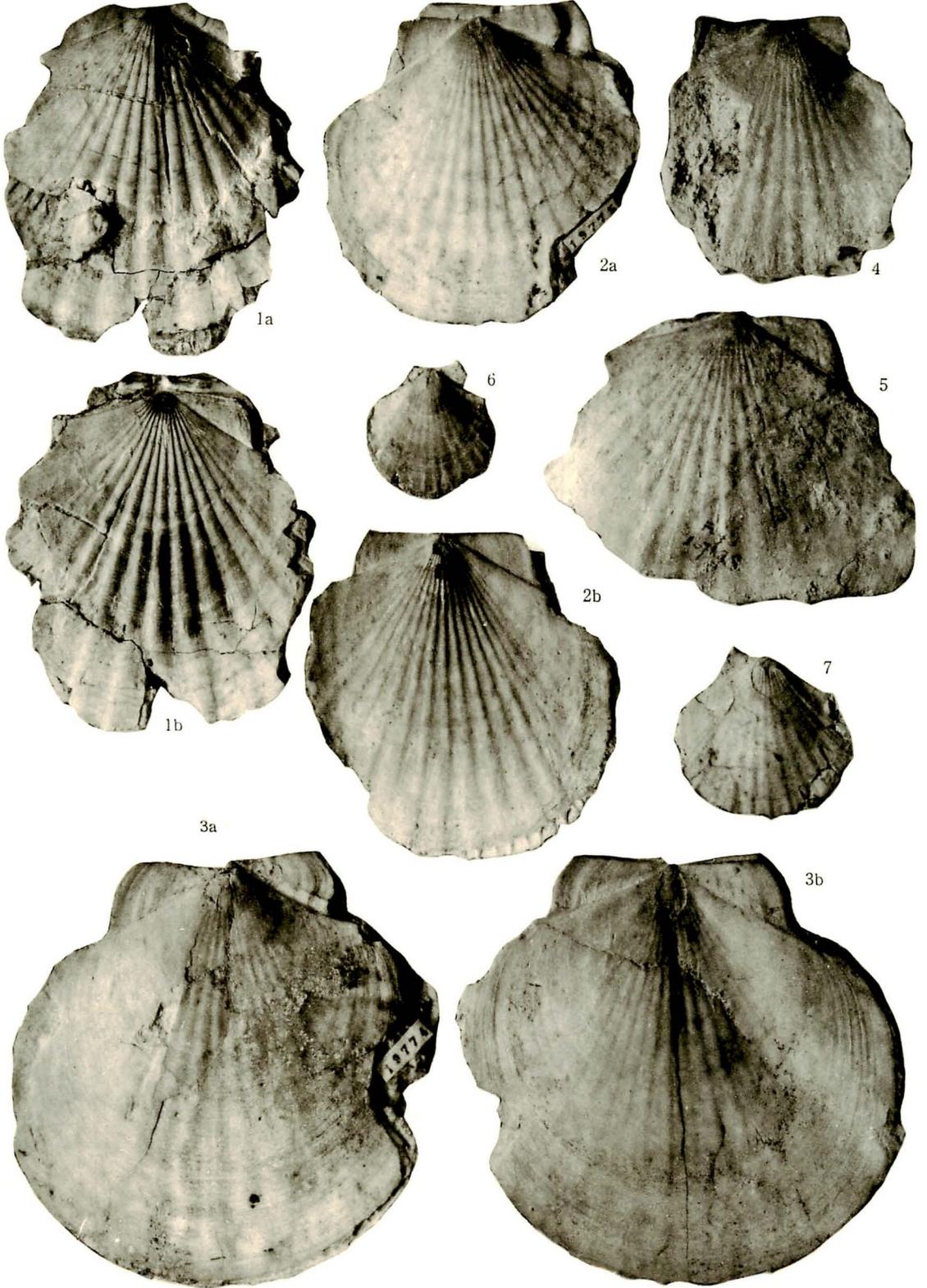
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Explanation of Plate 26

(Natural size)

- Figs. 1a-b. *Amussiopecten harrisi* MASUDA, n. sp. Holotype, U.S. Natl. Mus., Coll. No. 646476. a, right valve. b, left valve. Loc.:—U.S. Geol. Surv., Loc. No. 19780, San Sebastián Quadrangle, Puerto Rico. San Sebastián Formation. Late Oligocene.
- Figs. 2a-b, 3a-b. *Amussiopecten woodringi* MASUDA, n. sp. 2a, right valve. 2b, left valve. Holotype, U.S. Natl. Mus., Coll. No. 646474. 3a, right valve. 3b, left valve. Paratype, U.S. Natl. Mus., No. 646475. Loc.:—U.S. Geol. Surv., Loc. No. 19775, Central La Plata, Puerto Rico. Lares Limestone. Late Oligocene.
- Figs. 4, 5. *Amussiopecten antiguensis* (BROWN). 4, right valve. 5, left valve. Topotype, U.S. Natl. Mus., Coll. No. 167136. Loc.:—Hodges Bay, Antigua Island, West Indies. Antigua Limestone. Late Oligocene.
- Figs. 6, 7. *Amussiopecten churuguarensis* (F. and H. HODSON). Right valve, U.S. Natl. Mus., Coll. No. 646477. Loc.:—U.S. Geol. Surv., Loc. No. 17253, Moca Quadrangle, Puerto Rico. San Sebastián Formation. Late Oligocene.



## 590. UPPER CRETACEOUS GLYCYMERIDS IN JAPAN

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日本の上部白亜系産グリキメリスについて： これまでに記載されてきた本邦白亜系産の *Glycymeris* を系統分類学的立場より再検討し、4 亜属 9 種を識別した。 *Hanaia* 亜属は下部白亜系～上部白亜系に特徴的であり、その産出時代に応じて定向的な形態変化が著しく、その変化は上部白亜紀の種の成長過程において再現される。日本における *Glycymerita* 亜属は、上部白亜紀浦川世以後に出現している。熊本県の御船層群産の *Pseudoveletuceta*, nov. は、 *Hanaia* より分かれた特徴的な glycymerid である。熊本県の姫浦層群、福島県双葉層群産の *Glycymeris amakusensis* は、 *Glycymeris* (s. str.) の *Veletuceta* group に属し、古第三系産の種に類似する。おそらく現棲種を含めた *Veletuceta* group の起源的な形態の一つと思われる。

田代正之

### Introduction and acknowledgments

The family Glycymerididae is a well known marine bivalve family which commonly occurs from the Lower Cretaceous to Recent. The Cretaceous species have been described by many authors from the several localities in Japan: YABE and NAGAO (1928) and NAGAO (1932) in Hokkaido, NAGAO (1934) and SAITO (1962) in Honshu, NAGAO (1930) and AMANO (1956, 1957) in Kyushu and ICHIKAWA and MAEDA (1958) in Shikoku. Recently HAYAMI (1965) established a subgenus *Hanaia* based upon *Glycymeris densilineata* NAGAO and added *Glycymeris* (*Glycymerita* ?) *haipensis* as a new species from the Miyako group.

As I discovered many interesting facts on morphological changes of glycymerids through ages during my Upper Cretaceous fossil hunting in Kyushu, I further visited several localities of Upper Cretaceous glycymerids in Japan. I also

observed some glycymerids from Miyako, Hokkaido and California at the Department of Geology of the Kyushu University (GKH). As a result of this study the Upper Cretaceous *Glycymeris* in Japan is classified into four subgenera, *Glycymeris* (s. str.), *Glycymerita* FINLAY and MARWICK, *Hanaia* HAYAMI and *Pseudoveletuceta*, new subgenus. *Hanaia* is the oldest subgenus in *Glycymeris* and the other three subgenera may be derivatives of *Hanaia*. *Glycymerita* was prosperous in the late Cretaceous in Japan. Japanese Upper Cretaceous glycymerids are listed below:

*Glycymeris* (*Glycymeris*) *amakusensis*  
NAGAO

*Glycymeris* (*Glycymerita*) *japonica* TASHIRO, new species

*Glycymeris* (*Glycymerita*) *himenourensensis*  
TASHIRO, new species

*Glycymeris* (*Glycymerita*) *multicostata*  
NAGAO

*Glycymeris* (*Hanaia*) *solida* NAGAO

*Glycymeris* (*Hanaia*) *matsumotoi* TASHIRO, new species

Received October 7, 1970; read November 29, 1969 at Kagoshima.

*Glycymeris (Hanaia) katsurazawensis*  
TASHIRO, new species

*Glycymeris (Hanaia) hokkaidoensis*  
(YABE and NAGAO)

*Glycymeris (Pseudoveletuceta) mifunensis*  
TASHIRO, new subgenus, new species

*Limopsis kogata* (ICHIKAWA and MAEDA)

Before proceeding further I wish to express my sincere thanks to Emeritus Prof. T. KOBAYASHI of the University of Tokyo for his reading the manuscript and for criticism. I am also much indebted to Dr. M. TAMURA of the Kumamoto University for his kind guidance and reading the manuscript. I thank Prof. T. MATSUMOTO and Dr. I. HAYAMI of the Kyushu University for their continuing encouragement and supply of glycymerid specimens. I am also grateful to Prof. M. AMANO of the Kumamoto University, Prof. K. ICHIKAWA of the Osaka City University, Dr. K. MASUDA of the Miyagi University of Education and Dr. I. OBATA of the National Science Museum of Tokyo for their kind help to my study.

The specimens here treated as KE are kept in the Faculty of Education, Kumamoto University.

### Systematic descriptions

Family Glycymerididae NEWTON, 1922

Subfamily Glycymeridinae

NEWTON, 1922

Genus *Glycymeris* DA COSTA, 1778

*Type-species*:—*Arca orbicularis* DA COSTA, 1778, (*Arca glycymeris* LINNÉ, 1758).

Subgenus *Glycymeris* DA COSTA, 1778

Several reports have been issued on taxonomy of the Upper Cretaceous

glycymerids (FRENEIX, 1959; NICOL, 1945, 1950; HAYAMI, 1965). Recently NEWELL (1969) in *Treatise on Invertebrate Paleontology* summarized above mentioned works except for FRENEIX's. I agree with NEWELL's general classification of glycymerids. It seems, however, necessary for me to study further on the Cretaceous glycymerid taxonomy. *Veletuceta* IREDALE is treated as a synonym of *Glycymeris* by NEWELL (1969). Although the discrimination between *Veletuceta* and *Glycymeris* is difficult, the *Veletuceta* group is distinct for its shape and prosperous in Upper Cretaceous and Palaeogene ages. The umbo of *Veletuceta* is prosodetic and its beak is prosogyrate or orthogyrate. The umbo of *Glycymeris*, on the other hand, is orthodetic or opisthodetic and its beak is opisthogyrate. For the reasons mentioned above, I wish to leave *Veletuceta* as a valid group, if not as a subgenus. I have an opinion that recent *Glycymeris* may be a derivative of the Cretaceous or Tertiary *Veletuceta*.

*Glycymeris (Glycymeris)*

*amakusensis* NAGAO

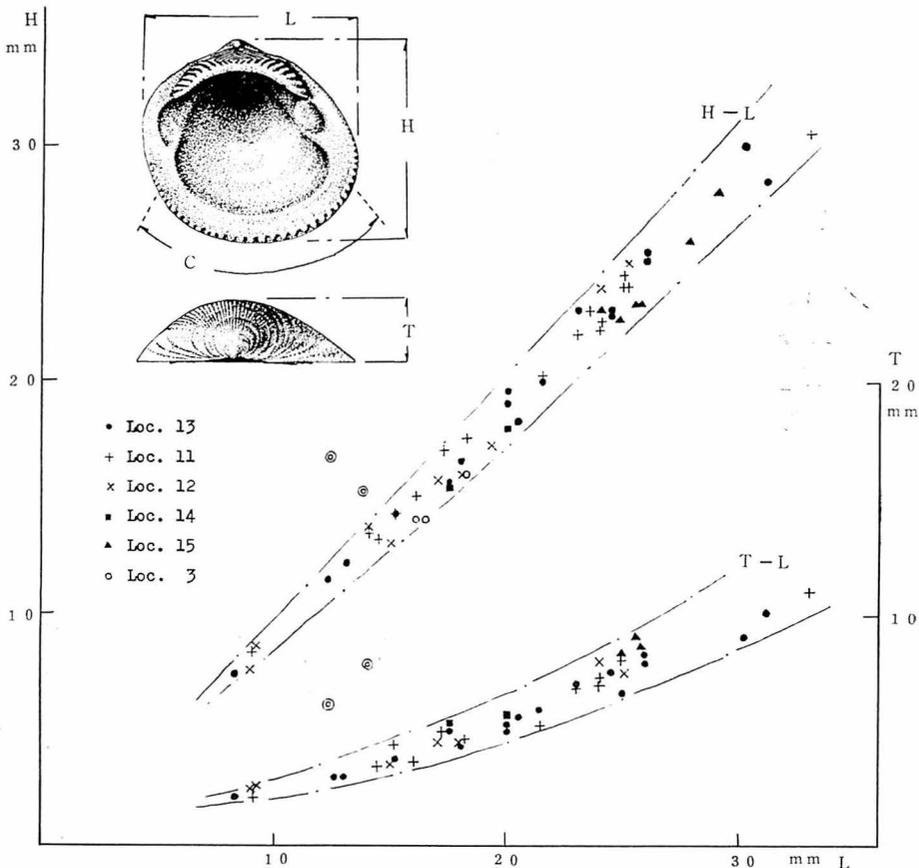
Plate 27, figs. 1-16, Text-figs. 1, 2

1930. *Glycymeris amakusensis* NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, Vol. 1, No. 1, p. 15, pl. 2, figs. 4-7.  
1957. *Glycymeris* sp., AMANO, *Kumamoto Jour. Sci., Sect. 1*, Vol. 2, No. 2 p. 55, pl. 1, fig. 22.  
1962. *Glycymeris multicostata*, SAITO, *Bull. Fac. Arts and Sci., Ibaraki Univ., Nat. Sci.*, No. 13, pp. 62, 63, pl. 1, figs. 2, 3.

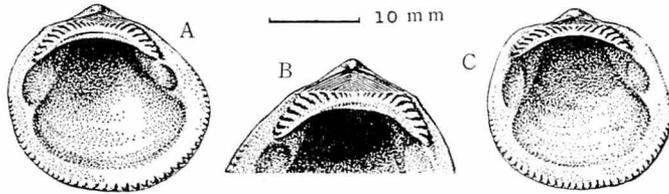
*Observation and Remarks*:—The specific name of *amakusensis* has been used for the Upper Cretaceous glycymerids of Japan. I collected about 300 specimens from many localities of the Himenoura group in Kyushu and the Futaba group

in Fukushima Pref. to confirm its shape. The result of measurement is shown in Text-fig. 1. The number of ventral crenules (see Text-fig. 1, abbrev. C) is about 25. The surface is ornamented with numerous flat-topped radial ribs, each of which is a bundle of 7 or 8 threads. The interspace between every two ribs is very narrow. Generally fully matured specimens exceeding about 20 mm. in length and the specimens from the sandstone at Locs. 14, 15 and 16 are

thick in test of shell. The radial ribs in these specimens are more elevated than in thin-shelled or younger specimens. Consequently growth lines make such crenulated appearance as described by NAGAO (1930). In mature stage two fairly distinct patterns of shape are observable as shown in Text-fig. 2. As the intermediate forms are present, these two groups can not be distinguished specifically. UEDA and FURUKAWA (1959) discriminated 3 varieties of the species



Text-fig. 1. Scatter diagrams of Height against Length, and Thickness against Length of *Glycymeris* (s. str.) *amakusensis* NAGAO (KE1799-KE1853). H: Height, L: Length, T: Thickness, C: Number of ventral crenules, ⊙: *Glycymeris* (*Glycymerita*) *himenourensensis* TASHIRO, n. sp. from Loc. 13 (for comparison). Positions of measurements are also shown.



Text-fig. 2. *Glycymeris (Glycymeris) amakusensis* NAGAO, A: Subtriangular form, B: Ligamental view of adult specimen, C: Subquadrate form.

with no description. The umbonal and median part of an immature valve is dark and other part encircling the above mentioned part is yellowish colored. This dark part fades away in mature form. Some specimens (Pl. 27, fig. 5) show concentric color pattern as observable in some individuals of the recent species.

*Occurrence*:—Locs. 1, 11-16.

Subgenus *Glycymerita* FINLAY  
and MARWICK, 1937

*Type-species*:—*Glycymeris concava* MARSHALL, 1917.

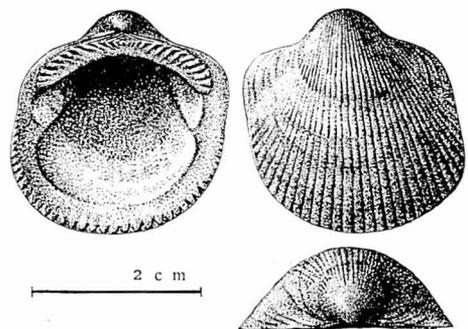
This subgenus is characterized as follows: 1) The shell is subquadrate and well inflated; 2) the umbo is big and prominent; 3) both sides of the umbo are strongly depressed and remarkably shouldered; 4) the hinge plate is long and stout; 5) the teeth on both lateral sides are long and extend horizontally; 6) the radial ribs on the external surface are strong and the radial threads are weak or invisible.

*Glycymeris (Glycymerita) japonica*  
TASHIRO, new species

Plate 27, figs. 17-22, Text-fig. 3

*Description*:—Shell small, well inflated, subquadrate in outline, height and length

approximately equal to each other, posterior margin slightly sinuous, obliquely truncated, ventral margin broadly arched and gradually changing into anterior margin; umbo large, prominent, and located almost medially; beak orthogyrous, incurved and situated slightly posterior to middle of dorsal margin; both sides of umbo remarkably shouldered and strongly depressed; surface ornamented with stout and flat-topped radial ribs; ligament area narrow, triangular, provided with several chevrons; hinge plate slightly arched, very long about four-fifths of length; about 24 teeth symmetrically disposed, long and subhorizontal on both lateral sides, short and diagonal below beak; inner margin with crenules about 20 in number.



Text-fig. 3. *Glycymeris (Glycymerita) japonica* TASHIRO, new species.

Measurements (in mm.):—

Specimen		<i>G. (Glycymerita) japonica</i>		
		Length	Height	
KE 1786	Right internal mould	27.0	25.0	Holotype
KE 1787	Left internal mould	22.0	22.2	Paratype
KE 1788	Left internal mould	22.5	22.4	Ditto
KE 1789	Left internal mould	21.0	18.5	Ditto
KE 1790	Right internal mould	25.5	25.5	Ditto

*Observation and Remarks:*—In this species the ratio of thickness/length of shell is about 0.8. The crenulation of the inner margin is frequently effaced near both lateral sides. The threads on the radial ribs are almost invisible or very delicate. The width of flat-topped radial ribs is nearly equal to the width of the interspaces in ventral side of adult specimens. The width of interspaces in the umbonal part of immature specimens, however, is very narrow.

*Comparison:*—This species is similar to the typical *Glycymerita* in general features except for its small size and narrow ligament area. *Glycymeris (Glycymerita) veatchii* (GABB) from the Chico group in California (Pl. 27, Fig. 33) is more inflated than this species and the radial ribs of *veatchii* are stronger than those in the present species. *G. apletos* DAILAY and POPENOE (1964) from the Jalama formation in California is somewhat akin to this species in its subquadrate and well inflated shell. *G. apletos*, however, differs from this species in the large shell and conspicuously incurved beak. *G. apletos* may be a member of subgenus *Glycymerita*.

*Occurrence:*—Locs. 17 and 18.

Measurements (in mm.):—

Specimen		<i>G. (Glycymerita) himenourensensis</i>			
		Length	Height	Thickness	
KE 1779	Left valve	13.0	14.2	4.0	Holotype
KE 1780	Left valve	12.3	17.5	6.0	Paratype
KE 1781	Left valve	7.0	7.7	2.0	Ditto.
KE 1782	Right valve	10.7	11.2	7.5	Ditto.
KE 1784	Left valve	13.8	15.2	7.8	Ditto.

*Glycymeris (Glycymerita) himenourensensis*  
TASHIRO, new species

Plate 27, figs. 23–27, Text-fig. 4

*Description:*—Shell very small for *Glycymerita*, orbicularly subquadrate, higher than long, anterior and posterior margins obliquely truncated and shouldered at junctions with antero- and postero-dorsal margins; ventral margin rounded; both sides of umbo depressed; umbo moderately large, prominent, located almost at mid-length; surface ornamented with numerous and flat-topped radial ribs which are broader than their interspaces; ligament area triangular, narrow, provided with several chevrons; hinge plate long, moderately arched; teeth symmetrically disposed, short and diagonally bifurcated below beak, long and subhorizontal in both sides of hinge plate; inner ventral margin densely crenulated (about 30).

*Observation and Remarks:*—The umbonal part of this species is black and shows the similar color pattern observed in the immature stage of *Glycymeris* (s.

Locality Maps

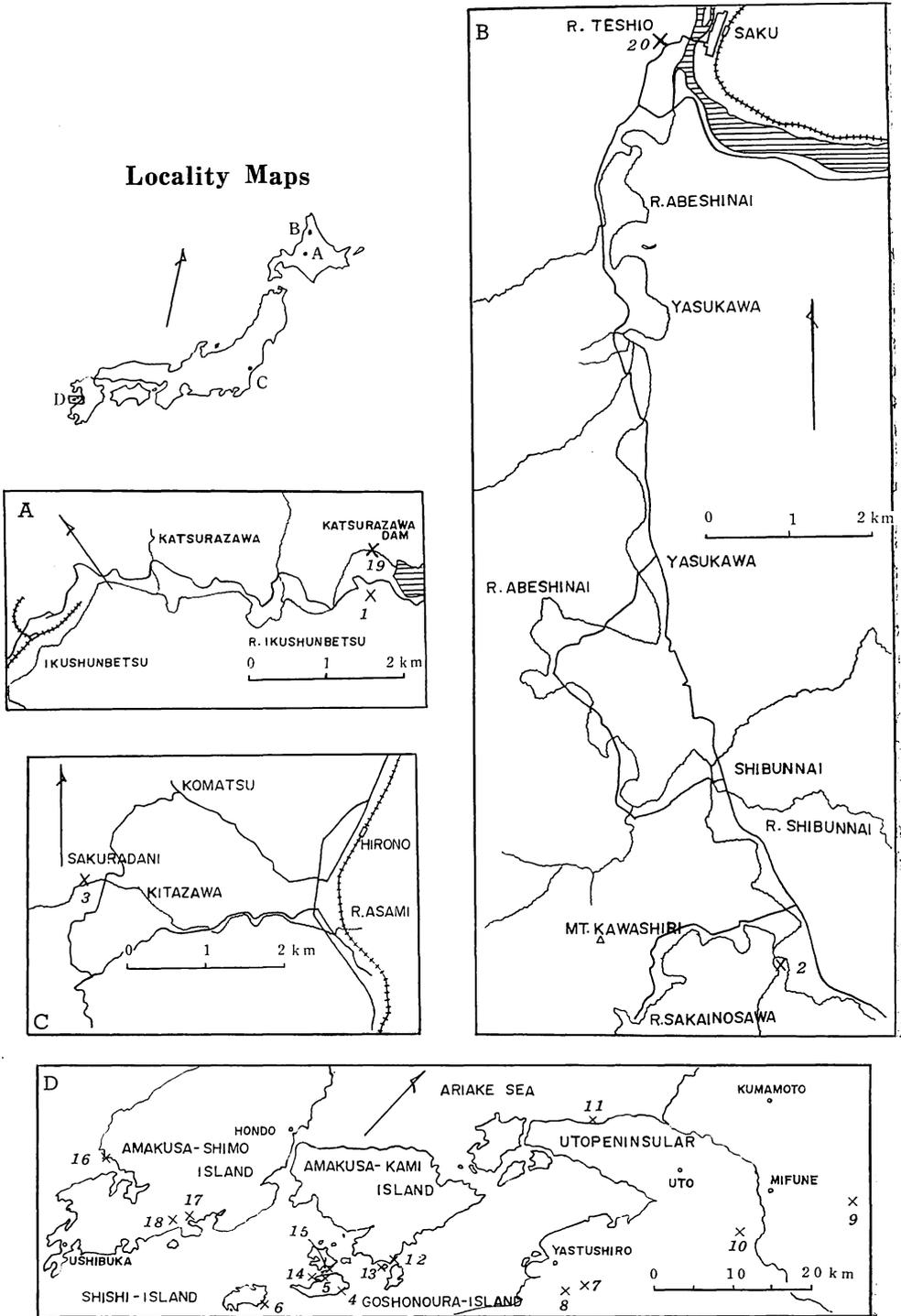
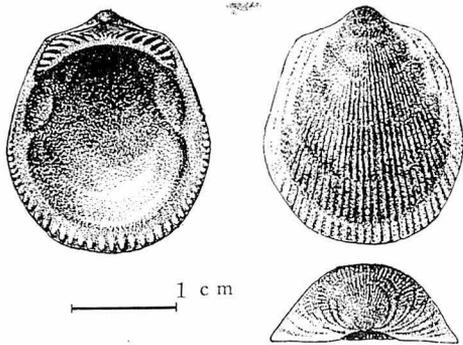


Table 1. Fossil localities.

Mikasa sandstone			A
Loc. 1	Turon.	s.s.	About 500 m south of the Katsurazawa-dam, Ikushunbetsu, Hokkaido.
Loc. 19*	"	"	The coast of the waterway near the Katsurazawa-dam, Ditto.
Upper Yezo Group			B
Loc. 2	Santon.	s.s.	The Sakainosawa river, Kyowa, Teshio prov., Hokkaido.
Loc. 20**	"	"	The Gakkonosawa river, Nakagawa-machi, Teshio prov., Ditto.
Futaba Group			C
Loc. 3	Coniac.	silt s.	The Sakuradani river, Hirono-machi, Futaba Co. Fukushima Pref.
Goshonoura Group			D
Loc. 4	Up. Alb.	s.s.	Enokuchi, Goshonoura-machi, Amakusa Co. Kumamoto Pref.
Loc. 5	L.L. Cenoman.	s.s.	Karakizaki, Ditto.
Loc. 6	"	"	Shirahama, the Shishi-island, Izumi Co. Kagoshima Pref.
Miyaji formation			D
Loc. 7	Up. Alb.?	s.s.	Tani, Miyaji-machi, Yatsushiro city, Kumamoto Pref.
Loc. 8	*	"	Naraki, Kôda-machi, Ditto.
Mifune Group			D
Loc. 9	Turon.	sh.	Asanoyabu, Mifune-machi, Kamimashiki Co. Kumamoto Pref.
Loc. 10	"	"	Nishiyama, Katashida-machi, Shimomashiki Co.
Himenoura Group			D
Loc. 11	Santon.	sh.	Okoshiki, Ôda-machi, Uto city, Komamoto Pref.
Loc. 12	"	"	Wadanohana, Takado-machi, Amakusa Co., Ditto.
Loc. 13	"	"	The Kugu-island, Takado-machi, Ditto.
Loc. 14	"	s.s.	Karakizaki, Goshonoura-machi, Ditto.
Loc. 15	"	"	The Mayu-island, Ditto.
Loc. 16	"	"	Ôe, Amakusa-machi, Ditto.
Loc. 17	Campan.	"	Hongo, Kawaura-machi, Ditto.
Loc. 18	"	"	Kamihira, Ditto.

\*Loc. 19: IK 981 of Kyushu Univ. \*\*Loc. 20: by HAYAMI of Kyushu Univ.



Text-fig. 4. *Glycymeris (Glycymerita) himenourensensis* TASHIRO, new species.

str.) *amakusensis*. The number of chevrons at the ligament area changes through growth and they are about 6 in the adult stage.

*Comparison*.—This species is distinguished from *Glycymeris (Glycymerita) japonica* from the upper formation of the same group by the high and smaller shell. *G. umbonatus* (SOWERBY) from the Greensand at Blackdown in England is somewhat akin to this species in the well inflated and high shell. *G. umbonatus* differs from this species in its small umbo and its asymmetrical hinge plate. *G. umbonatus* is probably a member of subgenus *Hanaia*. *G. sachalinensis* (YABE and NAGAO) (1925) is somewhat similar to this species in the stout ribs of the surface and the large and prominent umbo. *G. sachalinensis* differs from the

present species in having the orbicular outline and the smaller number of the radial ribs on the surface.

*Occurrence*.—Loc. 13.

*Glycymeris (Glycymerita)*  
*multicostata* NAGAO

Plate 27, figs. 28–32

1932. *Glycymeris hokkaidoensis* var. *multicostata* NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, Vol. 2, p. 34, pl. 5, figs. 10, 11.

*Observation and Remarks*.—On some adult specimens the surface ornamentation is worn away but the subinternal and elevated radial ridges can be seen. The number of the chevrons in ligament area is about 8 in the adult stage. The immature specimen is very similar to the subtriangular form of *Glycymeris* (s. str.) *amakusensis* in its outline, external ornamentation and the structure of the hinge plate. The variegated color patterns appear on the umbonal surface of an immature shell. The species is characterized by its orbicularly subquadrate and well inflated shell, large and prominent umbo, elongated and stout hinge structure and flat-topped radial ribs without threads on them. These features are characteristics of *Glycymerita*.

*Measurements* (in mm.):—

<i>G. (Glycymerita) multicostata</i>			
Specimen	Length	Height	Thickness
KE 1858 Left valve	26.0	25.5	9.8
KE 1861 Left valve	25.2	25.0	9.6
KE 1860 Left valve	24.9	24.7	9.0
KE 1863 Left valve	23.1	23.0	8.5
KE 1864 Left valve	20.8	19.5	6.5
KE 1866 Right valve	15.0	14.0	4.2
GKH 6990 Right valve	25.8	25.8	9.5
GKH 6992 Left valve	20.8	19.0	5.2
GKH 6993 Left valve	24.0	23.4	9.5

Occurrence:—Locs. 2 and 19.

the subgenus *Hanaia*.

Subgenus *Hanaia* HAYAMI, 1965

*Type-species*:—*Glycymeris densilineata* NAGAO.

*Hanaia* is characterized with round-topped radial ribs which are composed of a bundle of fine radial threads on surface as already stated by HAYAMI (1965). The species of *Hanaia* changes its shape of shell through geological ages. This morphological change is shown in Text-fig. 5. This phylogeny of *Hanaia* from morphological standpoint is observed in the ontogeny of lower Lower Cenomanian species of *G. (H.) solida*. On the basis of the morphological change, it seems possible that I can estimate the age of species of *Hanaia*. NICOL (1950) included *G. malurensis* (LEYMERIE) from the Neocomian of Europe and *G. sublaevis* (SOWERBY) from the Aptian of England into subgenus *Glycymerita*. *G. haipensis* HAYAMI from the Aptian of Japan was placed in *Glycymerita*? by HAYAMI (1965). Above mentioned Lower Cretaceous glycymerids, however, differ from the typical *Glycymerita* in their small and pointed umbo, asymmetrical hinge structure and the distinct radial threads on the ribs of the external surface. It seems for me that these species may belong to

*Glycymeris (Hanaia) solida* NAGAO

Plate 28, figs. 1-8, Text-fig. 5

1930. *Glycymeris amakusensis* var. *solida* NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, Vol. 1, pp. 16, 17, pl. 2, figs. 13 and 14.
1958. *Glycymeris* aff. *amakusensis*, AMANO, *Dept. Geol., Fac. Sci., Kumamoto Univ.* pp. 68, 69, pl. 1, figs. 22-25.

*Observation and Remarks*:—This species was described as a variety of *Glycymeris amakusensis* by NAGAO (1930) because of its more inflated shell and its thicker test. In this species the chevrons on the ligament area are countable 6 or more at the adult stage. The narrow and fine radial ridges appear frequently on the internal surface near the umbo but they are obscure on both sides and in the ventral border. Radial threads on a rib are about 8 in number.

Occurrence:—Locs. 4, 5 and 6.

*Glycymeris (Hanaia) matsumotoi*

TASHIRO, new species

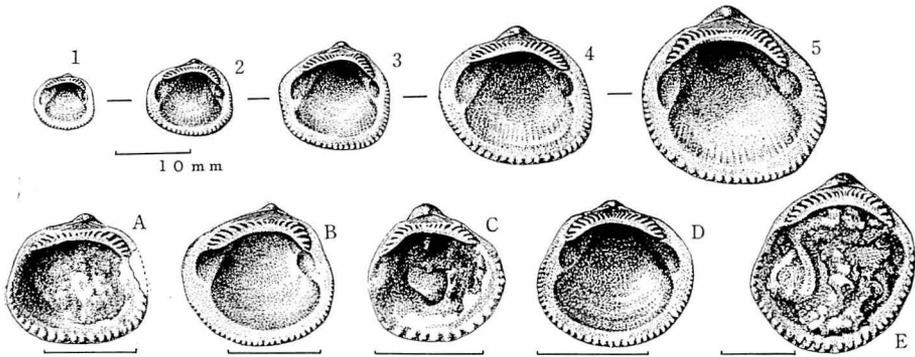
Plate 28, figs. 17-21

*Description*:—Shell small, asymmetrically subquadrate, longer than high, well inflated; anterior margin rounded and passing gradually into arcuate

*Measurements* (in mm.):—

Specimen	Length	Height
KE 1760 Left internal mould	28.5	25.0
KE 1765 Left internal mould	27.0	23.2
KE 1761 Left internal mould	23.5	21.1
KE 1762 Left internal mould	23.1	18.0
KE 1768 Left internal mould	18.0	17.0
KE 1767 Left internal mould	16.0	14.3
KE 1763 Left internal mould	13.0	12.9

*G. (Hanaia) solida*



Text-fig. 5. Growth and geological changes of subgenus *Hanaia*.

1-5, The morphological change through growth of *Glycymeris (Hanaia) solida* NAGAO (Lower Cenomanian).

A-E, Adult shells of different species in successive geological ages showing the morphological change. A: *G. (H.) haipensis* HAYAMI, (Aptian) (after HAYAMI, 1965). B: *G. (H.) sublaevis* (SOWERBY), (Aptian) (after WOODS, 1877-1913). C: *G. (H.) densilineata* NAGAO (Albio-Aptian), (after HAYAMI, 1965). D: *G. (H.) matsumotoi* TASHIRO, n. sp. (Albian?). E: *G. (H.) katurazawensis* TASHIRO, n. sp. (Turonian).

ventral margin; posterior margin obliquely subtruncated; umbo small, situated fairly posterior to mid-point of length, beak orthogyrous, situated posterior to the mid-point of dorsal margin; surface ornamented with numerous round-topped radial ribs each of which is a bundle of 7 or so threads; ligament area narrow, provided with several chevrons; hinge plate asymmetrical, subhorizontal in anterior half but oblique in posterior half; teeth subvertical and small below umbo, stout and weakly hooked in both lateral areas on the hinge plate; inner ventral margin moderately crenulated as

many as about 25; growth lines on surface weak.

*Observation and Remarks*:—MATSUMOTO (1953) listed *Glycymeris elongata* (MS) from the Loc. 8. The morphological change through growth is observable in this species as seen in *G. (H.) solida* except for its last stage (Text-fig. 5-5). The number of ligament chevrons is about 5.

*Comparison*:—This species is distinguishable from *G. (H.) densilineata* by the more abundant crenules on the inner ventral margin and the elongate outline. *G. (H.) haipensis* is similar to this species

*Measurements* (in mm.):—

Specimen	<i>G. (Hanaia) matsumotoi</i>			
	Length	Height	Thickness	
KE 1869 Right external mould	12.4	11.0	3.8	Holotype
KE 1870 Right internal mould	10.5	9.9	—	Paratype
KE 1871 Left internal mould	10.8	9.2	—	Ditto.
KE 1872 Left external mould	10.0	9.0	3.0	Ditto.
KE 1873 Left internal mould	13.2	12.5	—	Ditto.

in the asymmetrical hinge plate and the asymmetrically subquadrate outline. In *G. (H.) haipensis* the hinge teeth are, however, more stout and more primitive than in this species.

*Occurrence*:—Locs. 7 and 8.

*Glycymeris (Hanaia) katurazawensis*

TASHIRO, new species

Plate 25, figs. 9-15

*Description*:—Shell large for *Hanaia*, well inflated, higher than long, orbicularly subtriangular; anterior and ventral margin rounded, posterior margin obliquely subtruncated; umbo prosogyrous, prominent, located anterior to mid-length; beak nearly orthogyrous, situated a little posterior to mid-point of dorsal margin; surface ornamented with round-topped radial ribs each of which bears fine radial threads (about 9); a triangular dark colored area on posterior umbonal part extends about 7 mm. from apex; ligament area narrow and triangular; hinge plate fairly long, symmetrically arched but angularly bending at both lateral sides; teeth small and subvertical below umbo stout and hooked to diagonal on both lateral parts; inner margin

crenulated and 22 or so in number; upper margin of hinge plate close to dorsal margin of valve.

*Observation and Remarks*:—The umbonal part of this species resembles closely shell characters of *G. (H.) densilineata*. Consequently it seems for me that this species was derived from *G. (H.) densilineata*. This species represents the last stage of morphological change of sub-genus *Hanaia*.

*Comparison*:—This species is distinguished from *G. (H.) hokkaidoensis* with the anterior location of umbo to the shell-length and the more abundant threads on the ribs.

*Occurrence*:—Locs. 1 and 20.

*Glycymeris (Hanaia) hokkaidoensis*

(YABE and NAGAO)

Plate 28, figs. 16a-16c

1928. *Pectunculus hokkaidoensis* YABE and NAGAO, *Sci. Rept. Tohoku Imp. Univ., 2nd Ser.*, Vol. 9, No. 3, pp. 82, 83, pl. 17, fig. 22.

*Observation and Remarks*:—The shell is asymmetrically subquadrate and the umbo is located posterior to the mid-length. The round-topped radial ribs of

*Measurements (in mm.)*:—

Specimens	<i>G. (Hanaia) katurazawensis</i>			
	Length	Height	Thickness	
KE 1854 Left valve	24.0	24.8	9.8	Holotype
KE 1855 Left valve	25.0	26.7	10.6	Paratype
KE 1856 Left valve	23.5	26.0	10.0	Ditto
GKH 6980 Left valve	25.8	25.9	9.5	Ditto
GKH 6981 Left valve	24.0	24.0	8.0	Ditto
GKH 6982 Right valve	21.0	21.1	—	Ditto

Specimen	<i>G. (Hanaia) hokkaidoensis</i>		
	Length	Height	Thickness
GKH 6984a Right valve	24.5	23.5	8.6
GKH 6984b Left valve	25.0	24.0	9.0

this species are similar to those in *G. (H.) katurazawensis* except for the number of threads (about 7 in this species). *G. (H.) matsumotoi* is similar to this species in the outline and the external sculpture, but differs from this species in the smaller size and numerous ribs on the surface. The shape of middle aged stage of *G. (H.) solida* (3 and 4 in Text-fig. 5) is akin to this shape. The surface is, however, far stouter in this species than in *G. (H.) solida*.

*Occurrence*:—Sandstone of the Saku formation at the lower reaches of the Kotosawa, Abeshinai district, Hokkaido (Loc. T-453p, by MATSUMOTO).

#### Subgenus *Pseudoveletuceta*

TASHIRO, new subgenus

*Type-species*:—*Glycymeris (Pseudoveletuceta) mifunensis* TASHIRO, new species.

*Diagnosis*:—Shell small, orbicular, more or less inflated, inequilateral; umbo small, prosogyrous, located anterior to middle; apex of ligament-triangle anterior to the base; ligament area with a few chevrons; surface almost smooth except for fine radial threads; hinge plate moderately arched with taxodont teeth; inner margin densely crenulated.

*Remarks*:—The characteristics of this subgenus are as follows: 1) the anterior location of beak, 2) the prosogyrous umbo which is located remarkably anterior to the mid-length, 3) the crowded

fine radial threads forming no bundle;

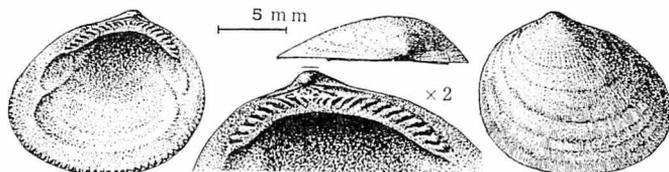
*Pectunculina* D'ORBIGNY is similar to this subgenus in its prosogyrous umbo, ventral crenulation and hinge structure. *Pectunculina*, however, has a triangular ligament pit in the central part of ligament. This is of the Limopsidae. *Protarca* STEPHENSON is similar to this subgenus in having a prosogyrous umbo which is not detected in other genera of the Glycymeridinae referred to NICOL (1945) and NEWELL (1969). I include this subgenus into *Glycymeris*, for it has ventral crenulations, arched hinge structure and triangular ligament area with chevron grooves.

#### *Glycymeris (Pseudoveletuceta) mifunensis*

TASHIRO, new species

Plate 28, figs. 24-30, Text-fig. 6

*Description*:—Shell very small, longer than high, orbicular in outline, moderately inflated; anterior margin rounded; posterior margin obliquely expanded to posterior; ventral margin broadly arched; umbo small and pointed, prosogyrous, located about two-fifths from front; beak situated anteriorly; surface ornamented with numerous fine radial threads; hinge plate rather narrow, moderately arcuated; teeth subvertical and short below umbo, weakly hooked to diagonal on both lateral sides; inner margin crenulated about 30 in number; growth-lines weak.



Text-fig. 6. *Glycymeris (Pseudoveletuceta) mifunensis* TASHIRO, new subgenus and new species.

Measurements (in mm.):—

		<i>G. (Pseudoveletuceta) mifunensis</i>			
Specimen		Length	Height	Thickness	
KE 1774	Right internal mould	15.0	13.0	—	Holotype
KE 1769	Left external mould	12.6	11.0	3.4	Paratype
KE 1776	Right internal mould	16.0	13.0	—	Ditto
KE 1777	Right internal mould	13.5	10.0	—	Ditto
KE 1770	Left internal mould	12.8	9.0	—	Ditto
KE 1771	Right internal mould	7.5	6.3	—	Ditto

*Observation and Remarks:*—There are round-topped radial ribs in immature specimens, and position of the beak and umbo is nearly at the middle of length. Three chevron shaped ligament grooves in adult stage cross their junctions and make tubercles in some cases. In the valves longer than 12 mm. in length the radial threads are crowded and countable about 8 in number in the distance of 1 mm.

*Comparison:*—This is similar to *G. (s. str.) amakusensis* in the outline and the hinge structure, but this differs from *G. (s. str.) amakusensis* in the anteriorly situated beak and the surface without radial ribs. Round-topped radial ribs and median location of umbo and beak are seen in immature specimens. These features are characteristics in adult of the species of *Hanaia*.

*Occurrence:*—Locs. 9 and 10.

Family Limopsidae DALL, 1895

Genus *Limopsis* SASSI, 1827

*Type-species:*—*Arca aurita* BROCCHI, 1814.

*Limopsis kogata* (ICHIKAWA and MAEDA)

Measurements (in mm.):—

		<i>Limopsis kogata</i>	
Specimen		Length	Height
KE 1877	Left internal mould	5.0	6.0
KE 1878	Right internal mould	5.3	6.2

Plate 28, figs. 31-34

1958. *Glycymeris kogata* ICHIKAWA and MAEDA, *Jour. Inst. Polytech. Osaka City Univ., Ser. G. Vol. 4, p. 90-92, pl. 5, figs. 4-7, 10.*

*Observation and Remarks:*—Though the specimens from the Himenoura group are smaller than the specimens from the Izumi group of Awaji-island, the other morphological characters accord between the specimens from the localities. No precise description on ligament area was given by ICHIKAWA and MAEDA (1958). The distinct ligament pit was observed by me in the specimens from the Izumi group (Topotype OCU 0211 by ICHIKAWA and MAEDA) and the Himenoura group. This species is referred to *Limopsis* by the mentioned characteristics.

*Occurrence:*—Locs. 17 and 18.

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## Explanation of Plate 27

*Glycymeris (Glycymeris) amakusensis* NAGAO

- Fig. 1. Right valve, KE1797,  $\times 1$ , Loc.: Okoshiki at Ôda-machi, Uto city, Kumamoto Pref.  
 Fig. 2. Left valve, KE1798,  $\times 1$ , Loc.: Ditto.  
 Fig. 3. Rubber cast of right valve, internal mould, KE1813,  $\times 1$ , Loc.: Ditto.  
 Fig. 4. Right valve, KE1815,  $\times 1$ , Loc.: Ditto.  
 Fig. 5. Immature right valve, KE1805,  $\times 3$ , Loc.: Ditto.  
 Fig. 6. Rubber cast of left internal mould, KE1814,  $\times 1$ , Loc.: Ditto.  
 Fig. 7. Umbonal view of right valve, rubber cast of internal mould, KE1788,  $\times 1.5$ , Loc.: Ditto.  
 Fig. 8. Right valve, KE1836,  $\times 1.5$ , Loc.: Wadanohana at Takado-machi, Amakusa Co.  
 Fig. 9. Right valve, KE1835,  $\times 1.5$ , Loc.: Ditto.  
 Figs. 10a, 10b. Lateral and dorsal views of left valve, KE1817,  $\times 1$ , Loc.: The northwest beach of Kugu island at Takado-machi.  
 Fig. 11. Left valve, KE1819,  $\times 1$ , Loc.: Ditto.  
 Fig. 12. Left valve, KE1816,  $\times 1$ , Loc.: Ditto.  
 Fig. 13. Left valve, KE1818,  $\times 1$ , Loc.: Ditto.  
 Figs. 14a, 14b. Lateral and dorsal view of right valve, KE1822,  $\times 1$ , Loc.: Ditto.  
 Fig. 15. Left valve, KE1820,  $\times 1.5$ , Loc.: Ditto.  
 Fig. 16. Left internal mould, KE1852,  $\times 1$ , Loc.: The Sakuradani valley at Hirono-machi, Futaba Co. Fukushima Pref.

*Glycymeris (Glycymerita) japonica* TASHIRO, new species

- Fig. 17. Internal mould of right valve, KE1786,  $\times 1$ , Holotype, Loc.: Hongo at Kawaura-machi, Amakusa Co. Kumamoto Pref.  
 Fig. 18. Rubber cast of left internal mould, KE1796,  $\times 1$ , Loc.: Ditto.  
 Figs. 19a, 19b. Anterior and lateral views of right valve, rubber cast of external mould, KE1794,  $\times 1$ , Loc.: Ditto.  
 Fig. 20. Rubber cast of right external mould, KE1795,  $\times 1$ , Loc.: Ditto.  
 Fig. 21. Internal mould of right valve, KE1791,  $\times 1$ , Loc.: Ditto.  
 Fig. 22. Internal mould of left valve, KE1792,  $\times 1$ , Loc.: Kamihira at Kawaura-machi, Amakusa Co.

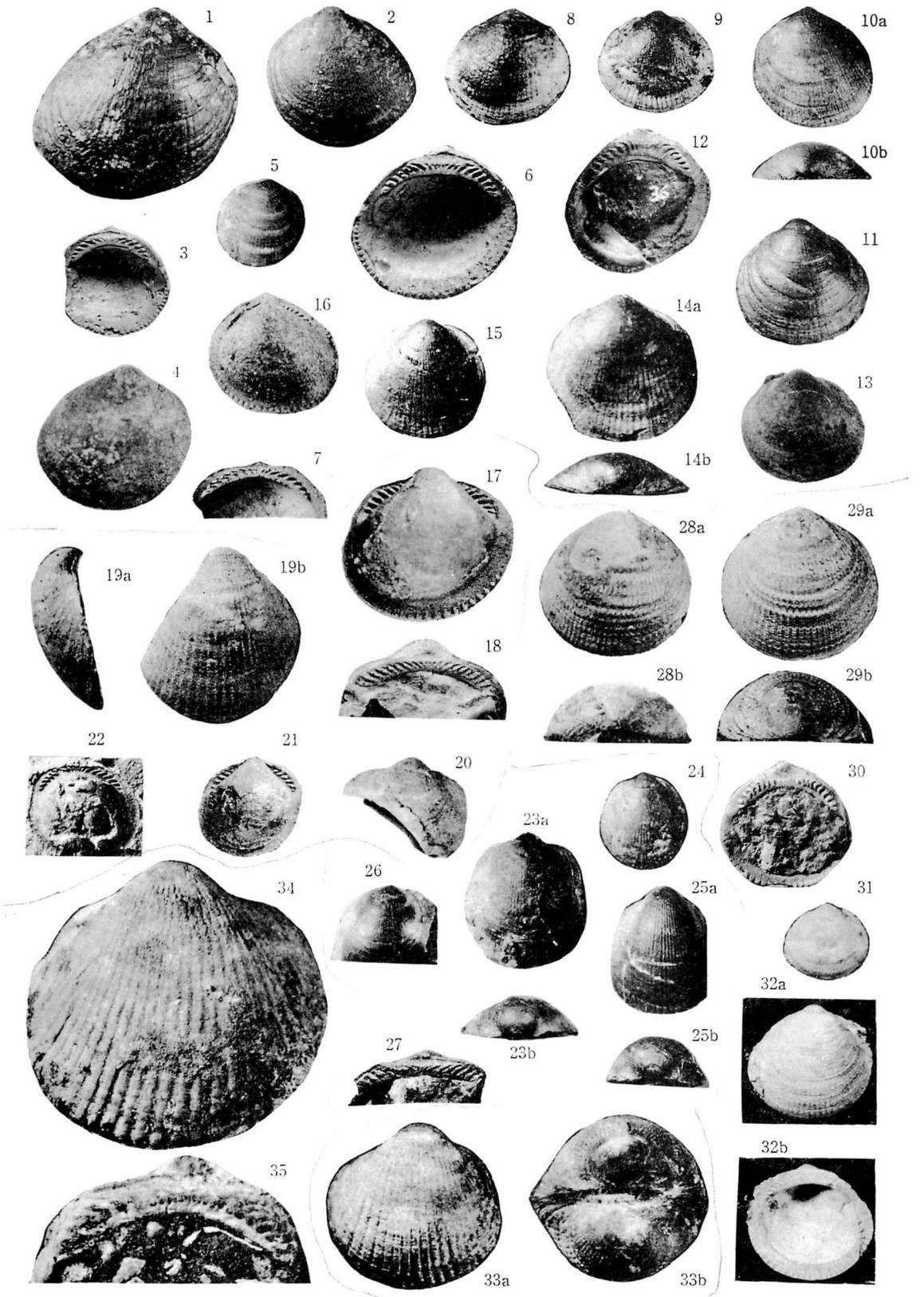
*Glycymeris (Glycymerita) himenourensensis* TASHIRO, new species

- Figs. 23a, 23b. Lateral and dorsal views of right valve, KE1779,  $\times 1.5$ , Holotype, Loc.: The north-west beach of the Kugu island at Takado-machi, Amakusa Co.  
 Fig. 24. Immature left valve, KE1781,  $\times 3$ , Loc.: Ditto.  
 Figs. 25a, 25b. Lateral and dorsal views of imperfect left valve, KE1780,  $\times 1.5$ , Loc.: Ditto.  
 Fig. 26. Umbonal view of right valve, KE1782,  $\times 1.5$ , Loc.: Ditto.  
 Fig. 27. Ligamental view of left valve, KE1783,  $\times 2$ , Loc.: Ditto.

*Glycymeris (Glycymerita) multicostata* NAGAO

- Figs. 28a, 28b. Lateral and dorsal views of left valve, KE1854,  $\times 1$ , Loc.: Sakainosawa, Kyowa, Nakagawa-machi, Teshionakagawa Co., Hokkaido.  
 Fig. 30. Left valve, KE1855,  $\times 1$ , Loc.: Ditto.  
 Fig. 31. Immature right valve, KE1863,  $\times 1$ , Loc.: Ditto.  
 Figs. 29a, 29b. Lateral and dorsal views of left valve, GKH 6990,  $\times 1$ , Loc.: Gakkonosawa at Yasukawa, Nakagawa-machi, Hokkaido.  
 Figs. 32a, 32b. Lateral and internal views of left valve, GKH 6992,  $\times 1$ , Loc.: Gakkonosawa at Yasukawa, Nakagawa-machi, Hokkaido.

(to be continued)



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*Glycymeris (Glycymerita) veatchii* (GABB) (for comparison)\*

Fig. 33a, 33b. Lateral and dorsal views of both valves, 33a, : left valve, GKH 6983, ×1.

*Glycymeris (Glycymerita) aff. apletos* DAILAY and POPENOE (for comparison)\*

Fig. 34. Right valve, GKH 6988, ×1.

Fig. 35. Internal view of right valve, GKH 6989, ×1.

\* *G. (G.) veatchii* and *G. (G.) aff. apletos* are collected by T. MATSUMOTO from the Upper Cretaceous Chico group in California, U.S.A.

## Explanation of Plate 28

*Glycymeris (Hanaia) solida* NAGAO

- Fig. 1. Rubber cast of left internal mould, KE 1760,  $\times 1$ , Loc.: Karakizaki of the Goshonoura island, Amakusa Co., Kumamoto Pref.
- Fig. 2. Rubber cast of left internal mould, KE 1765,  $\times 1$ , Loc.: Shirahama of the Shishi island, Izumi Co. Kagoshima Pref.
- Fig. 3. Rubber cast of left internal mould, KE 1767,  $\times 1$ , Loc.: Ditto.
- Fig. 4. Rubber cast of left internal mould, KE 1768,  $\times 1$ , Loc.: Ditto.
- Fig. 5. Ditto; KE 1762,  $\times 1$ , Loc.: Enokuchi of the Goshonoura island.
- Fig. 6. Imperfect left valve, KE 1761,  $\times 1$ , Loc.: Ditto.
- Fig. 7. Rubber cast of internal mould, immature left valve, KE 1763,  $\times 1$ , Loc.: Ditto.
- Figs. 8a, 8b. Lateral and dorsal views of imperfect left valve, KE 1764,  $\times 1$ , Loc.: Ditto.

*Glycymeris (Hanaia) katsurazawensis* TASHIRO, new species

- Figs. 9a, 9b. Lateral and dorsal views of right valve, GKH 6983,  $\times 1$ , Loc.: The coast of the waterway near the Katsurazawa dam, Ikushunbetsu, Hokkaido.
- Fig. 9c. Umbonal view of GKH 6983,  $\times 1.5$ .
- Figs. 10a, 10b. Lateral and dorsal views of left valve, GKH 6981,  $\times 1$ , Loc.: Ditto.
- Fig. 11. Internal view of right valve, GKH 6982,  $\times 1$ , Loc.: Ditto.
- Fig. 12. Left valve, KE 1855,  $\times 1$ , Holotype, Loc.: About 500 m. south of the Katsurazawa dam, Ikushunbetsu.
- Fig. 13. Internal view of left valve, KE 1855,  $\times 1$ , Loc.: Ditto.
- Fig. 14. Left valve, KE 1856,  $\times 1$ , Loc.: Ditto.
- Fig. 15. Surface ornamentation of left valve, KE 1857,  $\times 4$ , Loc.: Ditto.

*Glycymeris (Hanaia) hokkaidoensis* (YABE and NAGAO)

- Figs. 16a, 16b. Lateral and dorsal views of right valve, GKH 6983,  $\times 1$ , Loc.: The lower reaches of the Kotozawa river, Abeshinai district, Hokkaido.
- Fig. 16c. Surface ornamentation of GKH 6984,  $\times 4$ .

*Glycymeris (Hanaia) matsumotoi* TASHIRO, new species

- Figs. 17a, 17b. Lateral and dorsal view of right valve, rubber cast of external mould, KE 1864,  $\times 2$ , Loc.: Tani of Miyaji-machi, Yatsushiro city Kumamoto Pref.
- Fig. 17c. Surface ornamentation of KE 1864.
- Fig. 18. Rubber cast of left internal mould, KE 1865,  $\times 2$ , Loc.: Ditto.
- Fig. 19a. Ditto, KE 1870,  $\times 2$ , Holotype, Loc.: Ditto.
- Fig. 19b. Umbonal view of Holotype,  $\times 4$ .
- Fig. 20. Rubber cast of right internal mould, KE 1866,  $\times 2$ , Loc.: Ditto.
- Fig. 21. Rubber cast of left internal mould, KE 1869,  $\times 2$ , Loc.: Ditto.

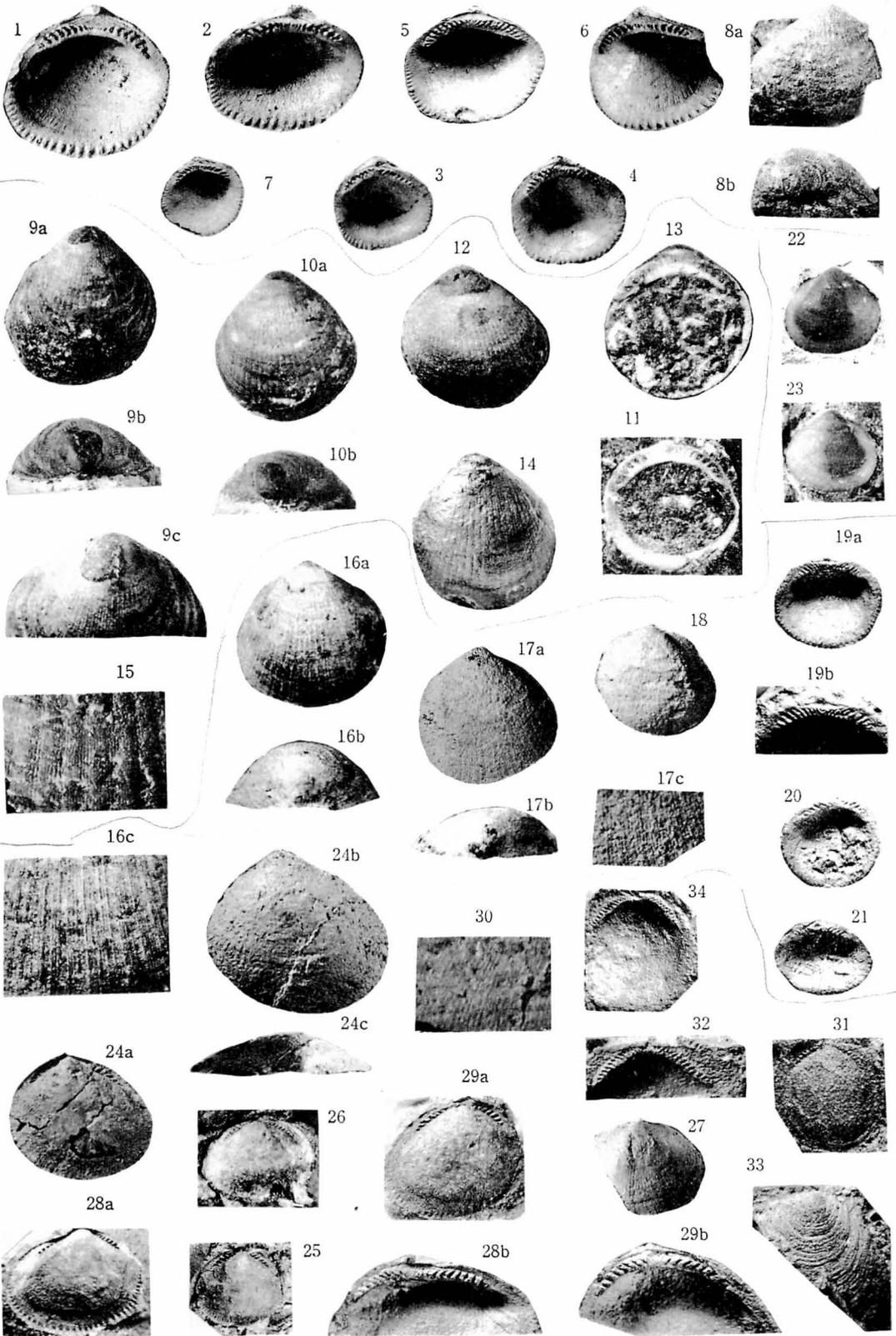
*Glycymeris (Hanaia) densilineata* NAGAO (for comparison)

- Fig. 22. Right valve, GKH 6642a,  $\times 1.5$ , Loc.: Hiraiga of Tanohata village, Iwate Pref. (HAYAMI collect.)
- Fig. 23. Left valve, GKH 6642b,  $\times 1.5$ , Loc.: Ditto. (HAYAMI collect.)

*Glycymeris (Pseudoveletuceta) mifunensis* TASHIRO, new species, new subgenus.

- Fig. 24a. Internal mould of left valve, KE 1769,  $\times 2$ , Loc.: Nishiyama of Katashida-machi, Shimomashiki Co. Kumamoto Pref.
- Figs. 24a, 24b. Lateral and dorsal views of KE 1769, rubber cast,  $\times 3$ .
- Fig. 25. Internal mould of immature right valve, KE 1771,  $\times 3$ , Loc.: Ditto.
- Fig. 26. Internal mould of right valve, KE 1777,  $\times 2$ , Loc.: Ditto.

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(continued from p. 240)

- Fig. 27. External view of immature right valve, rubber cast, KE 1773,  $\times 4$ , Loc.: Ditto.
- Fig. 28a. Internal mould of right valve, KE 1776,  $\times 1.5$ , Loc.: Asanoyabu of Mifune-machi, Kamimashiki Co. Kumamoto Pref.
- Fig. 28b. Rubber cast of KE 1776,  $\times 3$ .
- Fig. 29a. Internal mould of right valve, KE 1774,  $\times 1.5$ , Holotype, Loc.: Ditto.
- Fig. 29b. Ligamental view of Holotype, rubber cast,  $\times 3$ .
- Fig. 30. Surface ornamentation of right valve, rubber cast, KE 1775,  $\times 7$ , Loc.: Ditto.
- Limopsis kogata* (ICHIKAWA and MAEDA)
- Fig. 31. Internal mould of left valve, KE 1877,  $\times 3$ , Loc.: Hongo at Kawaura-machi, Amakusa Co. Kumamoto Pref.
- Fig. 32. Rubber cast of imperfect right valve, ligamental view, KE 1880,  $\times 5$ , Loc. Ditto.
- Fig. 33. Rubber cast of imperfect right? valve, external mould, KE 1875,  $\times 7$ , Loc.: Ditto.
- Fig. 34. Rubber cast of internal mould, OCU 0210,  $\times 2$ , Loc.: The Awaji-island, Hyogo Pref. (ICHIKAWA and MAEDA collect.)

124, 2 pls..

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Hokkaido; Annelida, Gastropoda andLamellibranchiata. *Ibid.*, Vol. 9, No. 3,  
pp. 77-96, pls. 16-17.

Abeshinai	安	部	志	内	Mayu		眉	
Amakusa	天			草	Mifune	御		船
Asanoyabu	浅			藪	Miyaji	宫		地
Enokuchi	江			口	Nakagawa	中		川
Futaba	双			葉	Naraki	奈	良	木
Gakkonosawa	学	校		沢	Nishiyama	西		山
Goshonoura	学	所		浦	Ôda	網		田
Hirono	広			野	Ôe	大		江
Hongo	本			郷	Okoshiki	御	興	来
Ikushunbetsu	幾	春		別	Sakainosawa	界		沢
Izumi	出			水	Sakuradani	桜		谷
Kamihira	上			平	Shimomashiki	下	益	城
Kamimashiki	上	益		城	Shirahama	白		浜
Karakizaki	唐	木		崎	Shishi	獅		子
Katashida	堅	志		田	Takado	高		戸
Katsurazawa	桂			沢	Tani		谷	
Kawaura	河			浦	Teshio	天		塩
Kôda	高			田	Uto	宇		土
Kotozawa	胡	桃		沢	Wadanohana	和	田	鼻
Kugu		櫛			Yatsushiro	八		代
Kyowa	共			和				

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY  
OF JAPAN

日本古生物学会第107回例会は1971年6月27日(日)奈良教育大学教育学部1015教室に於いて開催された(参加者70名)。

個人講演

- 大阪湾央のボーリングコアの花粉分析 ..前田保夫  
宮崎県西部第四紀植物群について(大型・小型化石による検討).....尾上 亨  
On the Upper Cretaceous flora newly found from the Isla Quiriquina, Concepción, Chile. ....KIMURA, T.  
千葉大学南米アンデスの古生物学的研究の経過とその成果.....前田四郎  
チリ産ジュラ紀 Minetrigoniinae の新属 ....前田四郎  
Some Jurassic corals from North Chile....YAMAGIWA, N., MAEDA, S., HAMADA, T. & CHONG, G.  
奈良市南方の藤原層群の双鞭毛藻化石について.....松岡数充  
南西諸島喜界ヶ島・沖繩島・宮古島の新第三系第四系の石灰質超微化石.....西田史朗  
岐阜県犬山市北方鶉沼産の後期中生代型 Spongosaturnalin Radiolariaについて.....八尾 昭・市川浩一郎  
Miocene radiolarian fossils from the Wakura formation in Noto Peninsula, Japan. ....IEDA, K.  
Radiolarian fossils from the Nishiyama formation in the Niigata basin, Japan.....NAKASEKO, K. & IEDA, K.  
新潟県北蒲原地域の新第三系化石放射虫層序について.....菅野耕三・中世古幸次郎  
Radiolarian fossil assemblage of the Yabuta formation in the Niigata basin, Japan..NAKASEKO, K. & SUGANO, K.  
On some species of fossil Radiolaria from the Tobetsu formation in Hokkaido, Japan. ..NAKASEKO, K. & NISIMURA, A.  
和歌山県山良地方立巖石灰岩の石炭紀化石について.....石井健一・八尾 昭  
*Nephrolepidina* from the Shinzaki Green Tuff, Mikasa group, in Shizuoka Prefecture.....MATSUMARU, K.  
*Lepidocyclina* の top datum について.....池辺展生・千地万造  
和歌山県串本町付近の沿岸堆積物の有孔虫遺骸群集に関する二・三の問題.....紺田 功  
関東地方西部の高崎・東松山・秩父・五日市地域に発達する第三系堆積盆地の有孔虫化石について.....栗原謙二  
静岡県相良地域の上部新第三系微化石層序学的研究.....尾田太良  
伊豆半島白浜層の時代について.....高柳洋吉・加藤道雄  
福地石炭紀の *Codium* 化石. Part I. Cylindric *Codium*. 就中その一株の中に14の文献上の諸属と同一の断面構造を見出す.岡村長之助  
佐川盆地七良谷層産のサンゴ化石について.....山際延夫・森本佳子・矢積和子  
山梨県北都留郡丹波村青岩谷産の鳥ノ巣統化石について.....山際延夫・西宮克彦  
Biogeography of early Senonian ammonoids.....MATSUMOTO, T.  
三重県先志摩の洪積世貝類化石群(代読).....糸魚川淳二・小川秀文  
阿武隈山地高倉山層群(ペルム紀)産出の新属三葉虫 *Phillipsiidae* について.....小泉 斉  
Discovery of an Early Triassic *Ichthyosaurus* from Utatsu-cho, Motoyoshi-gun, Miyagi Prefecture.....MURATA, M., BANDO, Y., ISHII, K. & NAKAZAWA, K.  
On *Utatusaurus*, a new genus of Ichthyosauria.....SHIKAMA, T., KAMEI, T. & MURATA, M.  
A Problematica from the Mizuho Tô of Niigata Prefecture(代読).....HATAI, K. & NODA, H.

日本古生物学会第108回例会は、日本地質学会・日本岩石鉱物 鉱床学会・日本鉱山地質学会・日本鉱物学会と共催で、1971年10月22日(金)-24日(日)に九州大学工学部を主会場として開催された。その際に行われた本会々員の参加した古生物学・生物層位学に関する個人講演、及び本会と関連のあるシンポジウム「九州周辺海域の地質学的諸問題」に発表された演題は次の通りである。

## 個人講演

- 屏風ヶ浦層産植物葉化石群について . . . 尾崎公彦  
大船貝層について . . . 松島義章  
琵琶湖底堆積物の花粉学的研究 . . . . .  
. . . . . 藤 則雄・堀江正治  
中海湖底第四紀層中の珪藻遺体 . . . . .  
. . . . . 野口寧世・水野篤行  
沖繩本島南部の“琉球石灰岩”について . . . . .  
. . . . . 土 隆一  
七折坂層産の植物化石群（大型遺体および花粉）  
について . . . . 鈴木敬治・馬場干児・相馬寛吉  
北半球における第三紀植物地理 . . . . . 棚井敏雅  
Middle Triassic pteridosperms from Rio  
Biobio area, Concepción, Chile . . . 木村達明  
石灰藻の新属 *Crassolithon* について . . 石島 涉  
ゴトランド島産シルリア紀層孔虫について . . . . .  
. . . . . 森 啓  
Permian-Carboniferous Endotherozoans from  
Japan, part 2, Tetrataxidae . . . . . 沖村雄二  
Geographic variation in *Lepidolina multi-*  
*septata* (DEPRAT), a Permian foraminifera . . . . . 小沢智生  
Oregon 州中央部より産出する *Eostaffella* に  
ついて . . . . . 佐田公好・DANNER, W. R.  
秋田県能代沖の有孔虫と底質 . . . . . 的場保望  
宮田層の密集型化石層中の有孔虫群集について  
. . . . . 江藤哲人  
満水層の底生有孔虫群集について . . . . .  
. . . . . 吉本裕一・江藤哲人・鹿間時夫  
土佐湾・紀伊水道付近の底質中の石灰質ナノプ  
ラントトン . . . . . 西田史朗  
鹿児島県種子ヶ島産鮮新世海成化石群について  
. . . . . 早坂祥三  
成田層の化石床の形態解析 — 成田層の古環境の  
研究 (1) — . . . 大森昌衛・古環境研グループ  
硬質岩中の穿孔二枚貝の巣穴 . . . . . 増田孝一郎  
*Cryptopecten vesiculosus* の変異と成長 . . . . .  
. . . . . 速水 格・阿久津ヤウ  
二枚貝類の貝殻にみられる交差板構造 (crossed  
lamellar structure) について . . . . . 小林滋雄  
西南日本外帯（四国）におけるコノドント化石  
産地に関する新知見 . . . . . 神戸信和・青木ちえ  
四国佐川盆地地下産の三疊紀こけ虫について . . . . .  
. . . . . 坂上澄夫  
A Late Triassic fauna from Sekkenai,  
Hiranai-cho, Higashi-Tsugaru-gun, Ao-  
mori Prefecture . . . . . 村田正文・永井敏彦  
フタバスズキリュウの発掘とその意義 . . . . .  
. . . . . 長谷川善和・小島郁生  
鹿科 *Elaphurus* 属について . . . . . 大塚裕之

- 富山湾の底質その 4. 珪藻分布の変化 . . . . .  
. . . . . 邑本順亮・武沢 正・藤井昭二  
対馬海峡における浮遊性有孔虫の堆積状況 . . . . .  
. . . . . 氏家 宏  
島根県仁摩町中新世川合累層の貝化石群集 . . . . .  
. . . . . 岡本和夫・高橋由美子・寺地雅美  
長崎県壱岐島の魚類化石とその意義 . . . 林 徳  
衛・小寺春人・友田淑郎ほか壱岐研グループ  
島尻層群の浮遊性有孔虫層序 . . . . .  
. . . . . 名取博夫・石田正夫・福田 理  
中新統産ミオジブシナの時空分布 . . . . 松丸国照  
日本海々底堆積物の marine palynology . . . . .  
. . . . . 島倉巳三郎  
日本海西南部底質中の有孔虫群集 . . . . .  
. . . . . 紺田 功・千地万造  
花粉学データ処理の促進について . . . . .  
. . . . . 徳永重元・藤井敬三  
大阪湾底の堆積物の花粉層序学的研究 . . 前田保夫  
宮古層群の胞子・花粉群集（予報） . . . . 高橋 清  
大和堆北斜面底質中の植物性微化石 . . . . .  
. . . . . 松岡数充・西田史朗・島倉巳三郎  
中部石炭系長岩層の研究 . . 小林文夫・鹿沼茂三郎  
岐阜県舟伏山村付近の地質（その 3） . . . . 石井 醇  
秋吉台南縁部の石灰岩の堆積相と産出化石との  
関係 . . . . .  
. . . . . 高野 修・島山隆三・杉村昭弘・配川武彦  
北海道宗谷地域における白亜系と第三系との関  
係 . . . . . 松本達郎・小原浄之介  
和歌山県由良地域の秩父累帯、とくに古生代石  
灰岩体と中生層の関係について . . . . . 八尾 昭  
宇和島地方の白亜紀層 . . . . . 棚部一成  
鹿児島県久見崎の中生層 . . . . . 橋本 勇・野田直秀

## シンポジウム

## 「九州周辺海域の地質学的諸問題」

- 九州周辺海域の地質学的諸問題を探る . . 奈須紀幸  
九州の新生代地史 . . . . . 高橋良平・首藤次男  
東支那海の海底地質 . . . . .  
. . . . . 加賀美英雄・奈須紀幸・新野 弘  
対馬・五島海域の地質 . . . . . 磯見 博・片田正  
人・長浜春夫・松井和典・服部 仁・鎌田泰彦  
九州西方海域の地質 . . . . .  
. . . . . 水野篤行・海底地質調査技術グループ  
九州西方および尖閣諸島周辺の海底地形 . . . . .  
. . . . . 星野通平・菅野秀文・上砂正一  
東支那海の陸橋 . . . . . 大塚裕之・鹿間時夫  
フィリッピン海の海底 . . . . . 佐藤任弘・青木 斌  
総合討論  
世話人：奈須紀幸・鹿間時夫・星野通平・水野  
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- ◎ 1971 年 8 月にノボシビルスクで開かれた「サンゴ類に関する第 1 回国際古生物シンポジウム」において “International Association of Specialists in Fossil Corals” を設立することができました。最初の行事として関係専門家のリストを作成することとなり、次の要領で情報提供が求められています。なお、第 1 回の Newsletter 発行予定は 1972 年 2 月頃となっています。

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CONTENTS

TRANSACTIONS

586. MATSUMARU, Kuniteru: The genera *Nephrolepidina* and *Eulepidina*  
from New Zealand..... 179
587. KIMURA, Tatsuaki and SEKIDO, Shinji: The discovery of the cycad-like  
leaflets with toothed margin from the Lower Cretaceous Itoshiro  
Sub-group, the Tetori Group, Central Honshu, Japan ..... 190
588. HAYAMI, Tomoko: On some Bryozoa from near Namioka-cho, Minami-  
Tsugaru-gun, Aomori Prefecture, Japan ..... 196
589. MASUDA, Kôichirô: *Amussiopecten* from North America and northern  
South America..... 205
590. TASHIRO, Masayuki: Upper Cretaceous glycymerids in Japan..... 225
- PROCEEDINGS ..... 243