

On Some Nerineid Gastropoda in Japan (Preliminary Report)

By

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Introduction	9
History of studies	10
Geological outline of some noteworthy localities	10
Historical view of classification	16
On some taxonomic elements	19
Description of species	20
Paleoecological notes	48
Geological and geographical distributions of Japanese Nerineids	50
Conclusion	54
Literature	55

Introduction

Since 1890 when E. NAUMANN and M. NEUMAYR reported *Nerinea* cf. *visurgis* ROEMER from the Torinosu limestone at Torinosu, Togano-mura, Takaoka-gun, Kôchi Prefecture, some nerineid gastropods have been found at various localities in Japan, but any systematic study of this group was not attempted. Hitherto recorded are eight species and one subspecies of *Nerinea* and two species of *Nerinella*.

These species are very significant from the viewpoints of biostratigraphy, paleogeography, paleoecology and paleoenvironment of Jurassic-Cretaceous biohermic sedimentary areas.

In the summer of 1967, the junior writer collected many nerineids fossils from the Torinosu limestone of the Sakamoto formation in central Kyushu. In the course of the study of these fossils, the writers were able to discern many unreported genera and species occurring in Japanese Mesozoic formations. They also studied the nerineids of the Jurassic formations in the Sakawa district of Shikoku, Southwest Japan and in the Sôma district of the Abukuma mountainland, Northeast Japan, and those of the Lower Cretaceous formations in the Kitakami mountainland, Northeast Japan. They obtained a large number of specimens and discriminated ten genera (one new genus) and twenty-four species (sixteen new species) which are reported in this article. All species of *Nerinella* and *Aptyxiella* and some of *Nerinea*, however, remain undescribed because of the ill preservation and the insufficient material.

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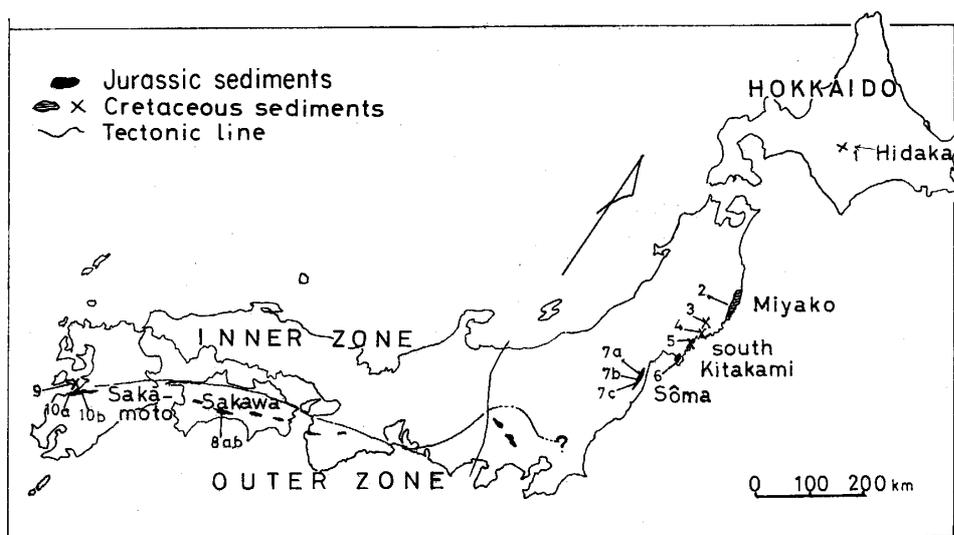
History of studies

Studies of nerineids by Japanese paleontologist date back to 1927 when H. YABE mentioned *Nerinella* sp. from a Lower Cretaceous conglomeratic sandstone in Ôfunato-wan, Miyagi Prefecture. In 1930 T. NAGAO reported *Nerinea* sp. from the Goshonoura formation of the Amakusa area in western Kyushu. In 1934 he also described *Nerinea rigida* NAGAO and *Nerinella* sp. from the Hiraiga sandstone bed of the Aptian to Albian Miyako group in the Miyako district, Iwate Prefecture. In 1940 I. SHIDA mentioned the occurrence of *Nerinea* cf. *rigida* NAGAO, *Nerinea* sp. and *Nerinella* sp. from the Lower Cretaceous (upper Hauterivian-Barremian) Ôshima formation in Ôshima Island, Kesenuma City, Miyagi Prefecture. In 1942 T. SUGIYAMA and S. ASAO made a review of *Nerinea* cf. *visurgis* ROEMER and distinguished two forms of *Nerinea naumanni* SUGIYAMA & ASAO and *N. naumanni neumayri* SUGIYAMA & ASAO.

After World War II, in 1953 A. FUKADA reported *Nerinea hidakaensis* FUKADA from *Orbitolina* limestone of the Aptian Lower Ammonite bed at Sôshubetsu, Hidaka district, central Hokkaido. This huge sized nerineid accompanies *Toucasia carinata* (MATHERON) in a black limestone of bioherm. FUKADA also mentioned the occurrence of *Nerinea* from the Middle Jurassic Tsukinoura formation in Ojika Peninsula, Miyagi Prefecture. In 1961 Y. ONUKI and K. MORI reported *Nerinea* sp. and *Nerinella* sp. from the Hauterivian to Barremian Ôfunato group in Iwate Prefecture. In 1966 K. NAKAZAWA and M. MURATA reported *Nerinea* sp. from a silicified tuff at a horizon a little above Neocomian in the Ômine district, Iwate Prefecture.

Geological outline of some noteworthy localities

Here some notable localities where many nerineids occur are cited. The occurrence and localities of Japanese nerineids reported in this paper are indicated in Text-fig. 1. The localities are listed at the close of this chapter.



Text-fig. 1. Main localities of Japanese nerineids.

I. Hidaka district

According to FUKADA (1953), the thick complex of the Lower Ammonite formation (Aptian to Gault), distributed along the lower course of the Sorachi-gawa and in the Kanayama district, is intercalated with thin lenses of limestone.

FUKADA subdivided the formation into the following five beds in ascending order:

- I) Thin alternation of fine-grained sandstone and silicious shale which is intercalated with two lenses of fossiliferous limestone of 5-6 m thick.
- II) Light bluish-grey coarse-grained sandstone.
- III) Silicious cherty sandstone.
- IV) More or less greenish schalstein.
- V) Schalstein and its agglomerate.

Limestone of bed (I), which yields *Diozoptyxis hidakaensis* (FUKADA), is composed mainly of biosparite, containing numerous bioclastic debris of arenite (0.1-2 mm in size); that is, foraminifer such as *Orbitolina*, coral and algal-stromatorites, etc.

II. Miyako district

The Lower Cretaceous Miyako group, distributed along the Pacific coast of Iwate Prefecture, Northeast Japan, is famous by the occurrence of numerous well-preserved fossils.

This group was studied first by YABE and YEHARA (1913) in detail, and later by HANAI (1953), OGINO (1966, MS) and HANAI et al. (1968).

According to HANAI et al. (1968), the Miyako group is divided into four formations as follows, in ascending order:

- Raga formation (40 m): conglomerate.
 Tanohata formation (70 m); conglomerate, conglomeratic sandstone or sandstone with cross-laminae, and conglomeratic mudstone or muddy sandstone.
 Hiraiga formation (80 m); well-sorted fine- to medium-grained sandstone, highly fossiliferous.
 Aketo formation (30 m); muddy fine-grained sandstone, intercalated with medium-grained sandstone and mudstone.

Nerinea rigida NAGAO and *Nerinella* sp., reported by NAGAO (1934), are found in the calcareous sandstone of the Hiraiga formation (upper part) on the northern coast of Hiraiga, Tanohata-mura, Shimo-hei-gun, Iwate Prefecture. The two nerineids occur in a certain horizon (*Nerinea* zone of NAGAO, 1934), associated with many other pelecypods, gastropods, corals, etc.

III. Ôshima district

According to SHIDA (1940), the Lower Cretaceous Ôshima formation, distributed on the southern coast of Ôshima Island, Kesenuma City, Miyagi Prefecture, Northeast Japan, is subdivided into several beds, as follows, in descending order:

—Eastern wing of syncline—

Black shale	aV	} 370 m
Alternation of sandstone and black shale	aIV	
Black limestone	aIII	
Sandstone, shale and breccia	aII	
Black shale including calcareous nodules	aI	

—Western wing of syncline—

Black limestone intercalated with thin sandstone beds	bVIII, VII=aIV, aV	} =aIII
Black shale including calcareous nodules	bVI	
Dark-colored marly limestone	bV	
Dark-colored tuffaceous impure limestone containing many cobbles of reef-building coral	bIV=aII	
Dark green shale	bIII=aI	
Yellowish-brown sandstone and conglomerate	bII	
Black shale	bI	

Of these beds, aII and bIV are most fossiliferous containing many corals and molluscs occur, as reported by YABE and SHIMIZU (1925), EGUCHI*, HAYAMI (1966), etc, while *Nerinea shiidai* n. sp. and *Phaneroptyxis oshimensis* n. sp. form the aggregated layers of 50-80 cm thick at a few horizon of bVI and bIV beds, but not associate with molluscs or corals.

The Ôshima formation is regarded as Upper Hauterivian-Barremian in age on account of the occurrence of *Paracrioceras ishiharai* (YABE & SHIMIZU) in the upper part of it.

* Quoted from SHIDA (1940).

IV. Sôma district

The Jurassic to Lower Cretaceous complex of the Sôma district is distributed in a narrow zonal area west of Sôma City with a N-S trend.

K. MASATANI (1950) divided the complex into the following formations in ascending order: Hayama sandstone (240 m), Awazu shale (160 m), Sugiyama sandstone (240 m), Tochikubo alternation (300 m), Nakanosawa (180 m), Tômisawa sandstone (400 m) and Koyamada shale (120 m), formations.

The Koyamada formation is regarded as Lower Cretaceous (Ryoseki series). The Nakanosawa formation is subdivided into lower, middle and upper beds. The upper bed is intercalated with the Koike limestone member, which is 15-50 m thick, and is composed of oosparite and biomicrite and their alternation; oosparite is dominant in the lower part of the limestone. M. EGUCHI and R. SHOJI (1965) observed five sedimentary cycles in the limestone.

Nerineid fossils now on hand were collected from a black limestone at Koike, 2 km west of Koyamada and Tochikubo, Sôma City, Fukushima Prefecture. The limestone, where it consists of oosparite, yields *Nerinea somaensis* n. sp., *Cossmannea tahoto* n. sp., *Heteroptygmatis fukushimensis* n. sp., *H. subpyramidalis* n. sp. and *Cryptoplocus abukumensis* n. sp. When it is composed of biomicrite the limestone yields *Nerinea koikensis* n. sp., *Bactroptyxis nobilis* n. sp. and *Heteroptygmatis elegans* n. sp.; *B. nobilis* is aggregated with *N. koikensis* in biomicrite layers.

The Koike limestone is regarded as Kimmeridgian on the basis of occurrence of *Auracosphinctoides* cf. *steigeri* (SHIMIZU), along with stromatoporoids, hexacorals and pelecypods.

V. Sakawa district

The Torinosu group of the Sakawa basin in southern Shikoku, belonging to the Outer Zone of Southwest Japan, has been studied by many stratigraphers and paleontologists such as NAUMANN (1885), HARADA (1890), YEHARA (1926), KOBAYASHI (1932), KURATA (1940-41), KIMURA (1956), and others, from the stratigraphical viewpoints of the Mesozoic orogenic cycle of Japan.

According to KURATA, the Torinosu group of this basin presents three tectonic belts, Kaiseki-yama, Mitoda and Torinosu belts.

The Torinosu belt is the thickest, ranging from Callovian to Tithonian, and is divided into the following six formations, in ascending order; Tsukadani (40-70 m), Yatsuji (160-350 m), Toishiyama (15 m), Irezumizawa (130 m), Kambaradani sandstone (20 m) and Kambaradani shale (50 m) formations. The Yatsuji formation is frequently intercalated with lenses of the so-called Torinosu limestone of various scales.

Two forms of *Nerinea naumanni*, and *N. naumanni neumayri*, established by SUGIYAMA and ASAO in 1942 (the latter is *N. sugiyamai* of the writers) were collected from a massive lenticular limestone exposed at Kamimitsuki, Togano-mura, Takaoka-gun, Kôchi Prefecture.

Dark brown limestone yielding these nerineids is composed mainly of pelsparite and contains highly aggregated pellets with many small foraminifers, fine debris of algae and thin pelecypod shells.

One specimen belonging to the genus *Itieria* was collected from the upper horizon of the Yatsuji formation at a limestone quarry at Shimomitsuki, Togano-mura, Kôchi Prefecture. *Itieria* sp. was found in biolithitic biomicru-dite which contains numerous colonies of hexacoral and stromatoporoid of pebble to boulder size. Although this specimen, only the apical part being preserved, is insufficient for specific identification, it is well comparable with *Itieria japonica* n. sp. from the Sakamoto formation of central Kyushu.

The Yatsuji formation is generally regarded as Upper Callovian to Oxfordian in age because of the occurrence of such ammonoids as *Horioceras mitodaense* KOBAYASHI, *Properisphinctes* aff. *P. bernensis* (LORIO), *Poculispinctes* sp. and *Euaspidoceras* sp.

VI. Sakamoto district

The Upper Jurassic Sakamoto formation in Kumamoto Prefecture was studied by M. TAMURA (1959) in detail. The formation, corresponding to the Torinosu group in the Outer Zone of Southwest Japan, is about 300 m thick and is divided into the upper and lower formations.

The nerineid fossils in question were collected from the lenticular limestone exposed on the sea coast of Igo-misaki, Tanoura-cho, Ashikita-gun, and at about 1 km north of Futami, Yatsushiro City, both in Kumamoto Prefecture. The limestone lens at Igo-misaki is about 15 km thick and is divided

	Lithology	Fossils
Upper Sakamoto Formation	E	Barren
	D	<i>Nerinea higoensis</i> N. sp. <i>Heteroptygmatis orientalis</i> <i>Phaneroptyxis sakamotoensis</i> (<i>Ptygmatis yabei</i>)
	C	Hexacoral, Stromatoporoids
	B	<i>Itieria japonica</i> <i>Cryptoplocus phalloides</i>
	A	Barren

Text-fig. 2. Generalized columnar section of limestone lens at Igo-misaki. A: Black shale. B: Lower layer. C: Middle conglomeratic limestone layer. D: Upper layer. E: Medium grained sandstone and calcareous black shale.

into three layers. The limestone of the upper layer is somewhat dark-colored and is composed of biosparite, containing some algal and coral debris of coarse arenite size, with small amounts of ooids and small foraminifers; *Nerinea higoensis* n. sp. is aggregated in a cluster, accompanied by other nerineids such as *Nerinea* sp., *Cossmannea* sp., *Ptygmatis yabei* n. sp., *Heteroptygmatis orientalis* n. sp. and *Phaneroptyxis sakamotoensis* n. sp. The middle layer is conglomeratic limestone bearing large fragments of corals and stromatoporoids but no nerineids. The limestone of the lower layer is light brownish-grey colored and mainly arenaceous biomicrudite, containing Codiacan algal debris of coarse arenite to rudite size; in this layer, *Itieria japonica* n. sp. and *Cryptoplocus phalloides* n. sp. are sporadically seen.

In the uppermost horizon of the Sakamoto formation *Auracosphinctes* sp. occurs, indicating Tithonian age; limestone lenses intercalated in the lower horizon of the upper Sakamoto formation are assigned to late Oxfordian to early Kimmeridgian age on the basis of the stratigraphic relation and the occurrence of *Diceras* sp. in a marly limestone at Futami.

—The localities and horizons of Japanese nerineids are given in the following list: (Refer to Text-fig. 1.)

- Loc. 1. Upper course of Sôshubetsu-gawa, Shime-kapp-mura, Yûfutsu-gun, central Hokkaido: Lower Ammonite bed of the Sorachi series; Aptian.
- Loc. 2. Northern coast of Hiraiga, Shimo-hei-gun, Iwate Prefecture: Hiraiga formation of the Miyako group; Aptian.
- *Loc. 3. 1 km west (Kanayama-zawa) of Ômine Copper Mine, Yonoshi, Iwate Prefecture: Kamihei group (Aozasa and Kamigo formations of MORI, 1963); Hauterivian to Barremian.
- Loc. 4. West sea coast of Yokonuma of Rikuzen-Ôshima Island, Kesenuma City, Miyagi Prefecture: Middle to upper part of the Ôshima formation; Hauterivian to Barremian.
- *Loc. 5. a: 1.5 km west of Ôfunato Station, Ôfunato City, Iwate Prefecture; Funagawara formation of the Ôfunato group (ONUKI & MORI, 1961); late Hauterivian. *Nerinea* sp. and *Nerinella* sp. were found here.
 b: Nishidate, Suezaki-cho, ibid.; the same horizon as a.
 c: Northern sea coast of Nagaiso, Suezaki-cho, ibid.; Hijôchi formation; early Barremian. *Nerinella* sp. was found.
 d: Ozaki-misaki, Akasaki-cho, ibid.; Takonoura formation; early Barremian. *Nerinea* sp. was found.
- *Loc. 6. Western coast of Benten-jima Island, south of Takenoura, Omae Bay, Miyagi Prefecture: Tsukinoura formation (INAI & TAKAHASHI, 1940); Bajocian.
- Loc. 7. a: 1.5 km west of Koike, Kashima-machi, Sôma City, Fukushima Prefecture; Koike limestone member of the Nakanosawa formation; Kimmeridgian.
 b: 1.5 km west of Koyamada, ibid.; the same horizon as a.
 c: Tochikubo, ibid.; the same horizon.
- Loc. 8. a: 1 km northeast of Togano Station, Kamimitsuki, Togano-mura, Sakawa-cho, Kôchi Prefecture; Torinosu-limestone of the Yatsuji formation (middle part); late Callovian to early Oxfordian.
 b: 1 km north of Togano Station, Shimomitsuki, ibid.; Torinosu-limestone

* Specific determination of nerineids from this locality is omitted in this article.

of the Yatsuji formation (upper part); early Oxfordian.

*Loc. 9. Western coast of Shishi-jima Island, Amakusa-gun, Kumamoto Prefecture: Goshonoura group; Cenomanian. *Nerinea* sp. was found.

Loc. 10. a: About 100 m south and 500 m east of Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture; limestone lens in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.

b: About 2 km north of Futami, Yatsushiro City, Kumamoto Prefecture; the same horizon as a.

Historical view of classification

Nerineacean gastropods have very characteristic internal structure and shell form. Therefore, as the criteria for classification the shape and number of internal folds or columellar plications are as important as shell shape, size, ornaments of surface and apertural form. In general, Nerineacean gastropods are divided into four families; Tubiferidae (=Ceritellidae), Nerineidae, Nerinellidae and Itieriidae. Tubiferidae have no marked internal folds, while the latter three families carry them and are called *Nerinea* group or nerineids.

Since the genus *Nerinea* was proposed by DEFRANCE (1825) and emended by DESHAYES (1927), a number of genera and subgenera of the *Nerinea* group have been described by many paleontologists. In 1898, COSSMANN compiled and classified the families Nerineidae and Itieriidae in his new suborder Entomotaeniata. Subsequently, W. WENZ (1940) revised COSSMANN's classification and proposed the following one.

Family Nerineidae

Genus *Nerinea* DESHAYES, 1827.

Subgenus *Nerinea* s. str.

- " *Acrostylus* COSSMANN, 1896.
- " *Melaniptyxis* COSSMANN, 1896.
- " *Fibuloptyxis* COSSMANN, 1896.
- " *Diozoptyxis* COSSMANN, 1896.
- " *Ptygmatis* SHARPE, 1850.
- " *Laevinerinea* DIETRICH, 1938.
- " *Teleoptyxis* OLSSON, 1934.
- " *Neoptyxis* PCELINZEV, 1934.
- " *Plesioptygmatis* BÖSE, 1906.
- " *Gonzagia* MAURY, 1925.
- " *Aphanoptyxis* COSSMANN, 1896.

Genus *Aptyxiella* P. FISCHER, 1885.

Subgenus *Aptyxiella* s. str.

- " *Nerinoides* WENZ, 1940.
- " *Endiatrachelus* COSSMANN, 1898.
- " *Bactroptyxis* COSSMANN, 1896.

Genus *Aphanotaenia* COSSMANN, 1898.

" *Trochalia* SHARPE, 1850.

Subgenus *Trochalia* s. str.

- " *Cryptoplocus* PICTET & CAMPICHE, 1862.
- " *Endiaplocus* COSSMANN, 1896.

Family Itieriidae

Genus *Itieria* MATHERON, 1842.Subgenus *Itieria* s. str." *Brouzetia* COSSMANN, 1916." *Campichia* COSSMANN, 1896.Genus *Itruvia* STOLICZKA, 1867." ? *Murhilaia* PERVINQUIÈRE, 1912." *Phaneroptyxis* COSSMANN, 1895.Subgenus *Phaneroptyxis* s. str." ? *Favria* COSSMANN, 1916.Genus ? *Curetia* COSSMANN, 1916.

In 1954, L. R. COX examined the earliest diagnosis of *Nerinea* and proposed the subgenus *Eunerinea* under the genus *Cossmannea* PCELINCEV, 1931. In 1954, he also revised generic and specific homonyms, including several new genera and a new subgenus, as follows;

Adiozoptyxis DIETRICH, (1914) 1925.*Carina* COX, 1954.*Eparciella* COX, 1954.*Julesia* COX, 1954, nom. nov. for *Favria* COSSMANN, 1916.*Melanioplocus* COX, 1954.*Nailswarthia* (subgenus of *Nerinella* SHARPE, 1850.)*Pseudotrochalia* COX, 1954.*Trocaliposis* COX, 1954.*Endoplocus* COX, 1954. = *Phaneroptyxis* COSSMANN, 1896.

Adiozoptyxis was first proposed by DIETRICH (1914, 1925)* for the smooth form with its internal character just as defined in COSSMANN's diagnosis of *Diozoptyxis* (1896). He gave it a systematic position as a subgenus of *Nerinea*. COX (1954), however, emended DIETRICH's *Adiozoptyxis*, for the reason of its artificial treatment, and proposed the genus *Adiozoptyxis* with diagnosis for all species which had been referred to *Diozoptyxis*, no matter whether their shells are smooth or tuberculated.

Besides, COX announced that the type species of *Diozoptyxis*, *Nerinea morinifera* D'ORBIGNY, had been referred not to Nerineidae but to Campanilidae by DELPEY (1939)**. At the same time, COX treated *Cryptoplocus* PICTET & CAMPICHE, 1862, as a junior synonym of *Trochalia* SHARPE, 1850. Also as DIETRICH (1925) and WENZ (1940) had erroneously defined *Trochalia* SHARPE, COX proposed his new genera *Pseudotrochalia* and *Trochaliopsis*.

On the other hand, K. YOUNG (1952) considered that genus *Nerinea* and its subgenera in WENZ's classification should comprise the following two groups:

1) Those with three or less folds, such as *Nerinea* s. s., *Fibuloptyxis* COSSMANN, *Diozoptyxis* COSSMANN, *Acrostylus* COSSMANN and *Melanioptyxis*

* Quoted from Cox (1954).

** Gastropodes mesozoïques de la region libanaise, p. 209.

COSSMANN.

2) Those with four or more folds, such as *Ptygmatis* SHARPE, *Laevinerinea* DIETRICH, *Teleptyxis* OLSSON, *Neptyxis* PCELINCEV and *Plesioptygmatis* BÖSE.

He also pointed out that *Gonzagia* MAURY and *Aphanotaenia* COSSMANN do not fit the diagnosis of *Nerinea* or *Ptygmatis* groups.

In 1960, PCELINCEV and KOROBKOV proposed the following classification of Nerineidae, Nerinellidae and Itieriidae, based mainly on the shell form, internal character, and arrangement and number of folds:

Family Nerineidae

Subfamily Nerineinae PCELINCEV

Genus *Nerinea* DEFRANCE, 1825.

- " *Endiatrachelus* COSSMANN, 1850.
- " *Melaniptyxis* COSSMANN, 1896.
- " *Fibuloptyxis* COSSMANN, 1898.
- " *Cossmanea* PCELINCEV, 1898.

Subfamily Ptygmatisinae PCELINCEV

Genus *Ptygmatis* SHARPE, 1894.

- " ? *Teleptyxis* OLSSON, 1934.
- " *Aphanoptyxis* COSSMANN, 1896.

Subfamily Cryptoplocinae PCELINCEV

Genus *Cryptoplocus* PICTET & CAMYICHE, 1861.

- " *Endiaplocus* COSSMANN, 1896.

Subfamily Diozoptyxisinae PCELINCEV

Genus *Diozoptyxis* COSSMANN, 1896. (emend. PCELINCEV, 1931.)

- " *Plesioptygmatis* BÖSE, 1906. (emend. PCELINCEV, 1935.)
- " *Plesioplocus* PCELINCEV, 1953.
- " *Laevinerinea* DIETRICH, 1939.
- " *Neptyxis* PCELINCEV, 1934.

Subfamily Diptyxisinae PCELINCEV

Genus *Diptyxis* OPPENHEIM, 1889.

- " *Oligoptyxis* PCELINCEV, 1953.

Family Nerinellidae

Genus *Nerinella* SHARPE, 1894. (= *Nerinoidea* WENZ, 1938.)

- " *Aptyxiella* FISCHER, 1885. (= *Aptyxis* ZITTEL, 1873; = *Pachystilus* GEMMELLARO, 1878.)
- " *Polyptyxis* PCELINCEV, 1924.
- " *Bactropiyxis* COSSMANN, 1896.
- " *Multiptyxis* PCELINCEV, 1954.
- " *Plesioptyxis* PCELINCEV, 1954.
- " *Aploxus* PCELINCEV, 1954. (= *Aptyxis* PCELINCEV, 1924; non ZITTEL, 1873.)
- " *Triptyxis* PCELINCEV, 1924: aff. ? *Gonzagia* MAURY, 1925; ? *Aphanotaenia* COSSMANN, 1898.

Family Itieriidae

Genus *Itieria* MATHERON, 1842: subgen. *Campichia* COSSMANN, 1896 (= *Campicheia* DIETRICH, 1925); *Brouzetia* COSSMANN, 1916.

- " *Phaneroptyxis* COSSMANN, 1896.
- " *Itruvia* STOLICZKA, 1867. (= *Vernedia* MAZERAN, 1912): aff. ? *Murhilaia* PERVINQUIÈRE, 1912; ? *Favria* COSSMANN, 1916.

The major part of the subgeneric taxa in WENZ's classification were removed to the generic taxa and some new subfamilies were established by them. Their classification seems to be applicable to adjust the Japanese Nerineids in which the internal structure is a useful taxonomic element.

In this article, the writers adopt mainly the classification of PCELINCEV and KOROBKOV (1960) and add one new genus, although there remain a few questions concerning some genera.

On some taxonomic elements

The nerineids are somewhat varied in shell form with some ornaments on the shell surface, but much complicated taxonomic elements exist in internal structure of shell, which are considered by many paleontologists as important for infrageneric classification. The writers admit the importance of their significance.

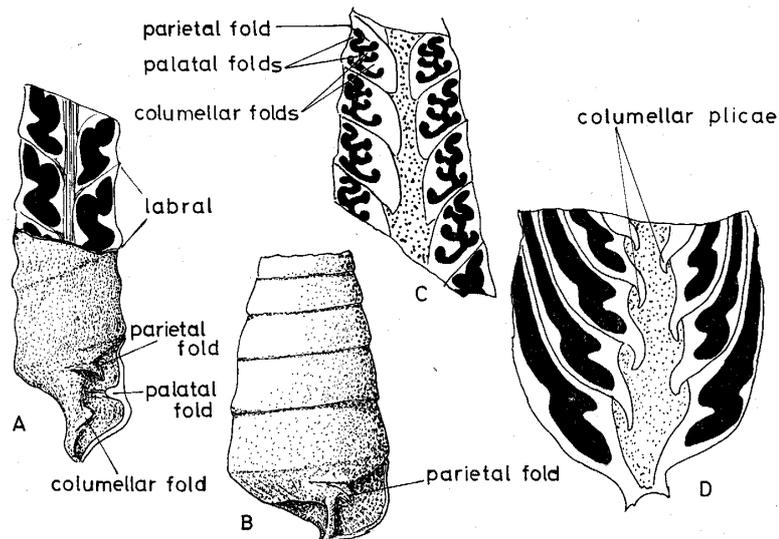
On the inner side of volution there are several projections, which are almost invisible in the other gastropod families. These projections are of delicate and sometimes very complicated construction, as shown in Text-figs. 3, 4, together with their terms.

The morphological terms are found in the glossary by L. R. COX (1955) or by J. B. KNIGHT et al. (1960).

—Arrangement of folds or plications—

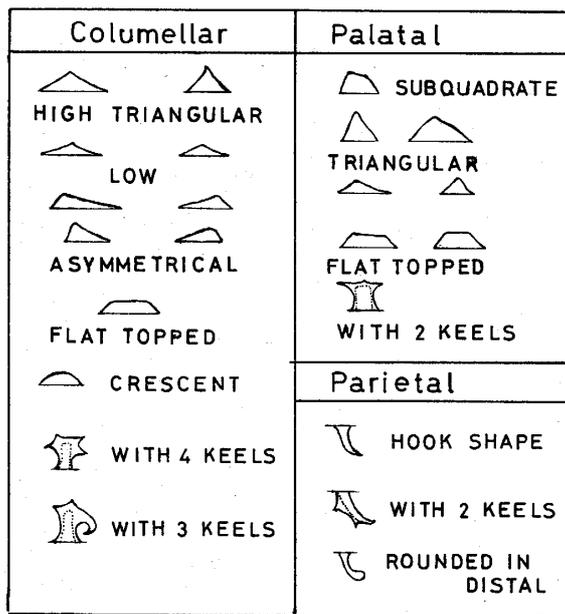
The number and arrangement of internal folds are very important for the infrageneric classification of nerineids.

In Nerineidae, *Nerinea* and *Diozoptyxis* carry one each fold on the columella, parietal lip and labral* (pattern 1-1-1). *Cossmanea* and *Cryptoplocus*



Text-fig. 3. Schematic figures showing the internal structure.
A: *Nerinea*. B: *Cryptoplocus*. C: *Ptygmatis*. D: *Itieria*.

* Outer lip beside basal one (exterior wall of whorl side).



Text-fig. 4. Some shapes of internal folds in nerineids.

carry two and one folds, respectively; the former lacks the parietal fold and the latter both palatal and columellar ones. *Ptygmatis* and *Heteroplygmatis* carry five eminent folds (pattern 2-1-2). In Nerinellidae, *Nerinella* shows the same pattern as *Nerinea*, but *Bactroptyxis* carries five to six or more folds (pattern 3-1-2 or 3).

G. DELPEY (1941) established the grade of folds of nerineids. His grade is based on number, arrangement and strength of folds, ranging from Grade 1 (1a) with one weak

fold to Grade 7 (6a) with four to five folds.

—Shape of folds—

The profile of fold is described by the shape visible on the section along the shell axis. The shape is a very important element for the infrageneric and/or specific taxonomy of nerineids. For instance, the shape is usually simple in *Nerineinae* but very complicated in *Ptygmatisinae*. Several shapes of folds of nerineids are shown in Text-fig. 4.

Description of species

Family Nerineidae ZITTEL, 1873

Subfamily Nerineinae PCELINCEV, 1931

Genus *Nerinea* DEFRANCE, 1825

Type-species:—*Nerinea tuberculosa* DEFRANCE, 1825

Nerinea naumanni SUGIYAMA & ASAO

(Pl. 4, Figs. 7, 8)

1942. *Nerinea* (s.s.) *naumanni* SUGIYAMA & ASAO; Jour. Geol. Soc. Japan., vol. 49, no. 590, pp. 439-442, figs. 3-5. (in Japanese)

Types: Three type specimens illustrated by SUGIYAMA and ASAO are stored at Institute of Geology and Paleontology, Tôhoku University (IGPS nos. 7023, 7371, 65283).

Three specimens (GIYU-M-95-97*) collected from the Torinosu limestone

* Geological Institute, Yokohama National University.

of the Yatsuji formation at Kamimitsuki, Togano-mura, Takaoka-gun, Kôchi Prefecture, are designated as topotypes.

Description: Shell moderate in size, rather high-turreted, consisting of more than twelve whorls. Precise apical angle unknown, but at least 10 to 15 degrees. Spire regularly tapers toward the apex; surface smooth except for two tubercle series on upper and lower sutural regions. Volution rather low, almost twice as wide as high; each volution surface distinctly concave with a deep depression, and rather rapidly elevated toward both supra and infrasutural regions. Suture feebly impressed, narrow and groove-like. Aperture unknown, but whorl profile in longitudinal section is almost rhombic with thick outer lip; basal lip joints at about 60 degrees with columella (axis of shell). Last whorl strongly carinated abaxially. Interior wall consisting of inner and outer lips carries three eminent folds, one each on the columella, parietal lip and labral. The palatal fold highly and stoutly developed, slightly flat-topped, asymmetrical triangular in profile and situated at a little below half of height of labral. The parietal fold rather short, thin and straight, acutely pointed distalward, projecting abaxially downward from the middle portion of parietal lip toward the base of the palatal fold. The columellar fold rather low and wide-based triangular in profile, situated at one-third of height from the base. In spite of each strong fold, the whorl space is not so narrow.

Comparison: SUGIYAMA and ASAO (1942) pointed out the abundant occurrence of the present species from the Torinosu limestone of the Sakawa-Togano Basin. According to them, about ten tubercles of sutural region are observed at the volution diameter of 18 mm, and they are large, conical shaped, 3-4 mm in diameter at base and 2-3 mm in height; distance between distal end of tubercles, is about 4-5 mm. In our specimen, however, tubercles are feebly visible.

The present species is closely allied to *Nerinea tuberculosa* ROEMER which was reported by E. KAYSER from the Upper Jurassic formation of western Europe, but the former is distinguished from the latter by its smaller shell, larger number of tubercles and rather broader volution.

In Japan, the present species is apart from the other Jurassic species of *Nerinea*, i. e. *higoensis*, *sugiyamai* and *somaensis*.

Occurrence: Loc. 8a. Kamimitsuki, Togano-mura, Takaoka-gun, Kôchi Prefecture. Two localities, one near Kohama, Sakawa-cho and another at Hanahata, Togano-mura, both in Kôchi Prefecture, were reported by SUGIYAMA and ASAO to yield the present species.

Geological horizon: Middle part of the Yatsuji formation; late Oxfordian.

Nerinea sugiyamai nom. nov.

(Pl. 4, Figs. 9-11)

1942. *Nerinea* (s.s.) *naumanni neumayri* SUGIYAMA & ASAO; Jour. Geol. Soc. Japan., vol. 49, no. 590, pp. 439-442, figs. 1, 2. (in Japanese)
non 1883. *Nerinea neumayri* DI STEFANO; in DIETRICH, 1925; Gart. Mes. Fam. Nerineidae Foss. Cat. Anim., 31.

Types: IGPS cat. nos. 7024, 65278.

Materials: Five specimens, GIYU-M-98-102. The specimens are cut along longitudinal direction; some whorls at apex and base are not preserved. Two specimens illustrated by SUGIYAMA and ASAO under the subspecific name *Nerinea naumanni neumayri* SUGIYAMA & ASAO, are also referred to.

Description: Shell large, exceedingly high-turreted and rather cylindrical. Whorl number and apical angle unknown; pleural angle of penultimate whorl about 9 degrees. Spire regularly and very slowly tapers toward the apex. Volution rather high, the ratio of the height to the width about 1.1-1.2; each volution surface slightly undulated with two shallow depressions, and swollen at the middle of height; surface rather smooth except for three tubercle series, of which the upper and lower ones situated on supra and infrasutural ridges, respectively, and the middle one at about the middle of height. Each tubercle of the upper and lower series rather low, small conical in profile, while that of the middle one subglobular and eminently projected. Suture deeply depressed. Last whorl, imperfectly preserved, strongly carinated abaxially. Aperture somewhat elongated rhombic with sharp posterior- and narrowly opened anterior ends. Basal lip joints at about 58 degrees with columella (axis of shell). Interior wall carries three eminent folds, two on the inner and one on the outer lips; palatal fold very stout and high, subquadrate or triangular in section, situated at a little below half of height of labral; parietal fold relatively short, thin, hook-shaped and with acutely pointed distal end, projecting abaxially from near parieto-columella corner; columellar fold wide-based triangular in shape, situated at about one-third of height of the columellar lip. Palatal fold so strongly and highly developed that the whorl cavity becomes very narrow between palatal and columellar folds.

Comparison: The present species is somewhat similar to *Nerinea naumanni* SUGIYAMA & ASAO, but the former is clearly distinguished from the latter by its larger shell, higher volution and the presence of three tubercle series. In Japan, no other species of *Nerinea* ornamented with tubercles have been recorded, but some species bear a close resemblance to the present species in internal character. The present species is similar to *N. thiollierei* DUMORTIER & FONTANNES (COSSMANN, 1898) in the general form of shell and in the mode of internal folds, but the former has more eminent and sharp tubercles than those of the latter.

Occurrence: Loc. 8a. Kamimitsuki, Togano-mura, Takaoka-gun, Kôchi Prefecture.

Geological horizon: Middle part of the Yatsuji formation; late Oxfordian.

Nerinea higoensis sp. nov.

(Pl. 3, Figs. 1-5)

Types: Sixteen specimens, GIYU-M-21-36, are designated as syntypes. GIYU-M-21-25, are figured.

Materials: The specimens are cut along longitudinal direction except GIYU-M-25, 26.

Measurements.— (in millimeters)

No.	Height	Width	
GIYU-M-21	85	27	: 4.5 whorls preserved.
GIYU-M-22	135	21	: 15 whorls preserved.

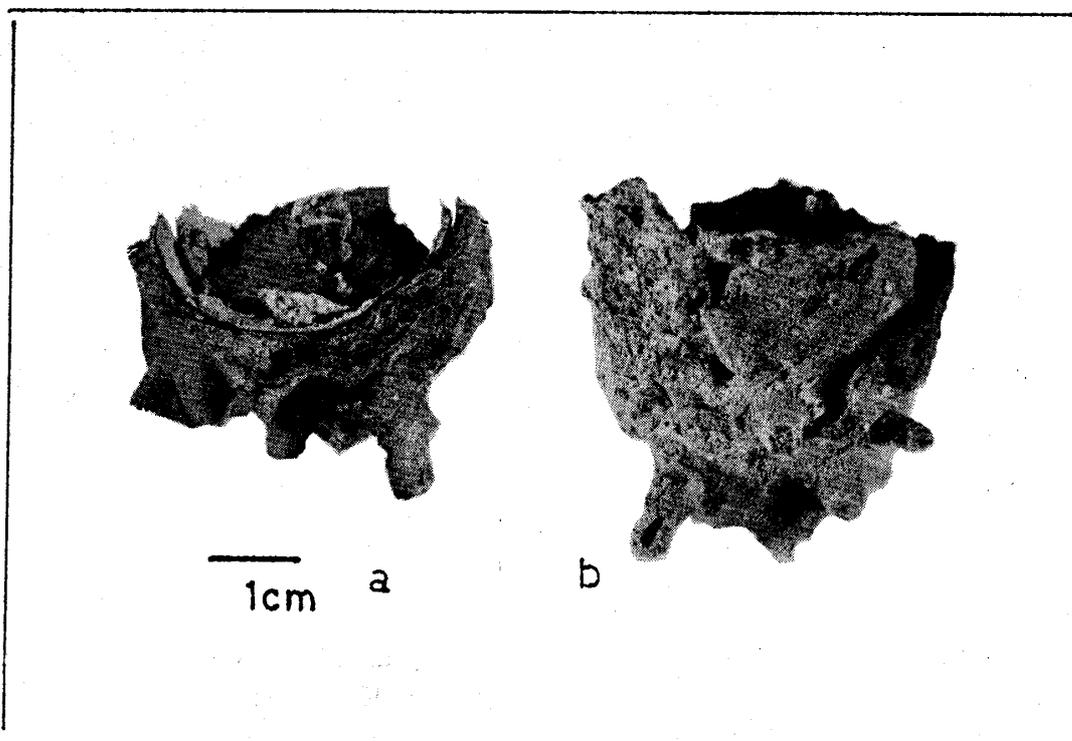
A specimen reaching 270 mm in height and 30 mm in diameter of shell has been observed at the locality.

Description: Shell large, exceedingly high-turreted, subcylindrical, consisting of numerous whorls, apparently twenty or more in number. Apical angle of several early whorls, 7 to 13 degrees but pleural angle of adult stage very small, about 4 degrees. Spire regularly and very slowly tapers toward the apex. Volution rather high, height about eighty percent of width; outer surface of the first several volutions (up to about 10th or less) almost smooth, but in adult stage, gently undulated with two depressions situated at a little above and below the middle height of volution. Suture feebly impressed, lying a little below the middle portion of broad and rounded ridge, formed by elevation of suprasutural part. Last whorl subcarinated below with a short and slightly distorted siphonal canal. Aperture imperfectly preserved, somewhat elongated rhombic with thin outer lip and much narrow posterior end, so far as observed on cross section. Basal lip joints at about 53 degrees with columella. Interior wall, consisting of inner and outer lips, carries three eminent folds, palatal fold high, round-topped and subquadrate in profile, situating at a little below the middle height of labral, projecting adaxially between parieto-columellar folds till the center of whorl chamber; parietal fold thin, acute and hook-shaped, projecting abaxially from the point distant about two-fifths length of parietal lip from parieto-columella corner. Columella thick, solid and carries a comparatively low and wide-based triangular-shaped fold at about one-third of height of columellar lip. In juvenile stage of whorls, folds relatively compressed to each other. Columella and lips grow not so rapidly as volution diameter, hence in adult stages folds become moderately separated from each other, and columella relatively thin compared with that of juvenile stage.

Comparison: The present species is closely allied to *Nerinea sugiyamai* n. nom. from the Torinosu limestone of Sakawa, Kôchi Prefecture, in general form and internal character, but the former is distinguished from the latter by its more slender columella, smaller palatal fold and broader space of whorl chamber and by the absence of tubercles on shell surface. The present

species is also distinguished from *N. tuberculosa* ROEMER (non *N. tuberculosa* DEFRANCE) which was considered by SUGIYAMA and ASAO as akin to *N. naumanni* SUGIYAMA & ASAO, by its larger and slender shell, more eminent palatal fold and by the absence of tubercles. The present species is also similar to *N. bernardiana* D'ORBIGNY from the lower Kimmeridgian of France in general form and aspect, but is distinguished by its more eminently elevated sutural ridge and more prominent palatal fold than in the latter.

Habitat: *Nerinea higoensis* n. sp. occurs in near-reef facies in association with *Ptygmatis yabei* n. sp., *Heteroptygmatitis orientalis* n. sp. and *Phaneroptyxis sakamotoensis* n. sp., besides fine debris of hexacoral, stromatoporoids, calcareous algae and thin shelled pelecypods. High-spined slender shells like this species are usually much concentrated in a layer of several meters thick lying parallel to the bedding; longitudinal axis of shell are arranged in rather random directions with each plane of laminae. On the other hand, all shells are covered by stromatoporoids which are thicker in apical part of shell (see Text-fig. 5). So, they may have attached while these nerineids were alive. These nerineid shells show no sign of breakage or erosion of shell except deformation in rocks. From these facts, the writers suppose that nerineid of this area lived in a near reef frontal region or a channel-like region where the current was rather strong, and they were transported over a small distance after death.



Text-fig. 5. Stromatoporoids, enveloped the shell surface of *Nerinea higoensis*.
a. apical view. b. lateral view.

Occurrence: Loc. 10a, b. Igo-misaki, about 2 kilometers north of Umino-ura, Tanoura-cho, Ashikita-gun, and about 2 kilometers north of Futami, both in Kumamoto Prefecture.

Geological horizon: Limestone lens in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.

Nerinea somaensis sp. nov.

(Pl. 3, Figs. 6, 7)

Types: GIYU-M-37-42 are designated as syntypes. Two specimens (GIYU-M-37, 38) are figured.

Materials: Six specimens mentioned above are preserved as internal moulds with somewhat broken apex and base. GIYU-M-37 is cut along the longitudinal direction.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-37	45+	20+ : 2 whorls preserved.
GIYU-M-38	65	26 : 2 whorls preserved.

Description: Shell large, slender, high-turreted and subcylindrical, consisting of numerous whorls. Pleural angle of median whorls about 7 degrees or less. Surface of shell seems to be smooth, as suggested in section. Lateral margins of spire usually straight. Volution rather high, almost as high as wide, the ratio of the height to the width about 1.09. Surface of each volution almost flat in early stage, but in later stage of penultimate whorl, slightly undulated with two depressions, of which the lower one deep and broad, while the upper one shallow. Suture indistinctly impressed, lying on a little below broad and rounded spiral ridge, formed by a rapid elevation of infra and suprasutural portions of volution surface. Last whorl unknown. Aperture presumably elongated rhombic with acutely pointed posterior end and rather widely notched anterior one, as suggested in longitudinal section along shell axis. Basal lip joints at about 65 degrees with columella. Interior wall carries three weak and acutely pointed folds, two on the inner and one on the outer lips; palatal fold rather thin quadrate in outline, situated at a little below the middle of height of labral, and shortly projects adaxially; parietal fold thin and acute hook-shaped, projecting abaxially from near parieto-columella corner; columellar fold high triangular-shaped, situated at lower than one-third of height of columellar lip, projecting toward an anterior side of palatal fold.

Comparison: In Japan, most of species related to this species are *Nerinea higoensis* n. sp. and *N. sugiyamai* n. nom., but the present species has higher volution, stronger ridge of sutural area, and smaller and weaker folds than in both *higoensis* and *sugiyamai*; moreover the present species has more smooth surface of shell than in *sugiyamai*. Among these species, however,

there are seen slight difference in general aspect. The present species is somewhat similar to *N. contorta* BUVIGNER (COSSMANN, 1898) in general form, but a sufficient comparison of internal character is impossible, because of the lack of internal figure of the latter.

Occurrence: Loc. 8a. Koike, Kashima-machi, Sôma City, Fukushima Prefecture. The shells are aggregated in oosparite, associated with no other molluscs, coral, stromatoporoids or even nerineids.

Geological horizon: Koike limestone member of the Nakanosawa formation; Kimmeridgian.

Nerinea koikensis sp. nov.

(Pl. 3, Fig. 8)

Types: GIYU-M-103 is designated as holotype.

Materials: A single specimen cut along longitudinal direction (slightly oblique section).

Measurements:— (in millimeters)

No.	Height	Width
GIYU-M-103	41+	10

Description: Shell small in size, rather slender, turreted, consisting of eleven or more whorls. Apical angle of several early whorls about 20 or less degrees in measurement of restored shell. Width of spire gradually decreases toward the apex and pleural angle of penultimate whorl about 8 degrees. Volution rather low, almost twice as wide as high. Each volution surface distinctly concave inward by a deep depression at a little below middle of height of labral and gradually elevated toward infrasutural region, forming a broad, rounded and high ridge which has flat and angulated shoulder with inconspicuous suture on its posterior side. Last whorl carries a strong and sharp keel at abaxial margin and a distinct, widely notched anterior canal and rather acutely pointed posterior end, so far as observed on cross section. Aperture presumably rhombic with very thin outer lip. Shell surface seems to have no eminent ornamentations. Basal lip joints at about 65 degrees with columella. Interior wall carries three subequal, low and acutely wedge-shaped folds; two on the inner and one on the outer lips. Parietal fold rather widely based, situated at about one-third portion of parietal lip from parieto-columella corner. Columellar fold situated below one-third of height of columellar lip and palatal one projects adaxially between columellar and parietal folds from a little below the middle of height of labral, which is most deeply depressed inward. The palatal fold disappears or becomes very obsolete at last whorl.

Remarks: Unfortunately the material is deficient for precise determination, but the internal structure and general form of shell of the specimen cut along longitudinal direction may enable us to grasp a general outline of

the species.

The present species is easily distinguished from the other Japanese species of *Nerinea* by its thin test, low and small internal folds and by their arrangement. Upper Jurassic species, such as *N. acreon* D'ORBIGNY (COSSMANN, 1898) from France has somewhat similar aspect, but the present species is clearly distinguished by its smaller size, strongly angulated shoulder, very delicate shell and feebly projected internal folds.

Occurrence: Loc. 8a. Koike, Kashima-machi, Sôma City, Fukushima Prefecture. The immediate associates of this species are *Bactroptyxis nobilis* n. sp., and some pebbles or fine debris of hexacoral, etc. in biomicrite only.

Geological horizon: Koike limestone member of the Nakanosawa formation; Kimmeridgian.

Nerinea shiidai sp. nov.

(Pl. 4, Figs. 1-3)

1940. *Nerinea* sp. cf. *rigida* NAGAO; SHIIDA, I., Geology near Kesenuma, Iwate Prefecture, Part VI, Contr. Inst. Geol. Pal. Tôhoku Univ., no. 33, pp. 51, in list. (in Japanese).

Types: GIYU-M-44-49 are designated as syntype.

Materials: All the six specimens mentioned above lack part of whorls at apex and base, and are deformed in various directions, so that the shell and folds of each specimen are very different in shape.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-44	70±	25± : 4.5 whorls preserved.
GIYU-M-46	85—	/ : 6.5 whorls preserved.

Description: Shell medium in size, exceedingly high-turreted, consisting of numerous whorls, at least twenty. Apical angle precisely unknown owing to deformation, but probably less than 15 degrees. Lateral margins of spire almost straight and very gradually taper toward the apex. Restored volution moderately broader than high; outer surface rather smooth except for numerous and delicate growth lines which run obliquely to suture. Outer margins of each volution almost straight though a little undulated by a shallow and broad depression. Suture very inconspicuous, lying on the middle portion of low sutural ridge. Last whorl and aperture imperfectly preserved, the former carinated abaxially and with short siphonal canal, and the latter presumably subquadrate to rhombic with rather widely opened anterior end. Interior wall carries three eminent folds, one on the outer lip and two on the inner one; parietal fold short, thin and acutely hook-shaped, situated at the middle portion of parietal lip; columellar fold low and almost triangular shaped, situated at a little above columello-basal corner; palatal fold very thick and high, situated at the middle height of labral, projecting adaxially till near

the central portion of whorl chamber. Distal portion of palatal fold expanded with one or rarely two keels, of which the lower one is eminently projected abaxially, while the upper one is feebly projected; the extremity of palatal fold between keels becomes flat and square in profile.

Comparison: The comparison of the species in question with the other species is difficult because of the imperfect preservation of the specimens due to the deformation in rock, but it is distinguished from the foreign species of the lower Cretaceous by its slender shell and flat surface of volution. SHIIDA (1940) reported *Nerinea* cf. *rigida* NAGAO from the middle part of the Ôshima formation, but the present species is easily distinguished from *rigida* NAGAO by its more eminent palatal fold of oblong-shape which is expanded with a keel, the flat surface of volution and by the presence of prominent spiral ridge in sutural portion. The present species is somewhat similar to *Nerinea* sp., reported by NAKAZAWA and MURATA (1966) from the Hauterivian to Barremian of the Ômine Mine area in Iwate Prefecture, but the former has larger shell and stronger internal folds than the latter.

Occurrence: Loc. 4. Northern sea coast of Yokonuma village, Rikuzen-Ôshima Island, Kesenuma City, Iwate Prefecture.

Geological horizon: Middle part of the Ôshima formation; Hauterivian to Barremian.

Nerinea rigida NAGAO

(Pl. 4, Figs. 4-6)

1934. *Nerinea* (s.s.) *rigida* NAGAO; Jour. Fac. Sci., Hokkaido Imp. Univ., ser. IV, vol. II, no. 3, pp. 250-251, pl. 38, figs. 1, 2.

Types: Of the two specimens illustrated by NAGAO (1934), the one in figure 1 was designated as holotype and the other as paratype. Four specimens, GIYU-M-89-92 collected by S. OGINO (1965) from the calcareous sandstone bed of the Hiraiga formation (Zone of his Hn4) at northern coast of Hiraiga, Tanohata-mura, Shimo-hei-gun, Iwate Prefecture, are designated as topotypes.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-89	99	36+ : Anterior 4 whorls.
GIYU-M-90	155	36 : Median 8 whorls.
(Holotype)	93	30 : 5 whorls preserved.

Original description: "Shell large, narrow, extremely high-turreted very gradually tapering toward apex; imperforate. Each whorl moderately broader than high, distinctly concave, the concavity being most exaggerated a little below the mid height. Suprasutural portion of the whorl more convex and more inflated than the infrasutural one; suture distinct. Surface apparently smooth except for crowded and pronounced lines of growth which run obliquely forward and downward. Section of the whorl higher than broad,

with three simple and short plications; of the two columellar plications, the anterior one lying a little below the middle of the columella stronger than the posterior which is situated at the posterior corner of the whorl, the third situated about the middle of the external wall rather low and strong. Test moderately thick."

Remarks: This species is characterized by exceedingly high-turreted shell, strongly depressed volution surface and rather simple internal structure. The palatal fold strongly and highly developed with rounded distal portion, while the columellar and parietal folds developed feebly.

The comparison of this species with the other species was fully discussed by NAGAO. According to him, it is similar to *Nerinea archimedi* D'ORBIGNY from the Lower Aptian of France, *N. vogtiana* DE MORTILLET from the Urgonian and *N. guinchoensis* CHOFFAT from the Valanginian of Portugal, but is distinguished from them by its slight difference in general aspect, whorl profile and by shape of columellar folds. This species is also similar to *N. roemeri* WHITNY from the Aptian (Glen Rose formation of Central Texas), but the former is distinguished from the latter by its more acutely projected palatal fold, and lower and thicker columellar one.

Locality and Geological horizon: Loc. 2. Northern and southern sea coast of Hiraiga, Shimo-hei-gun, Iwate Prefecture; upper part of the Hiraiga formation in the Miyako group; Aptian.

Nerinea sp. indet.

(Pl. 5, Fig. 1)

Materials: Only a fragmentary specimen, GIYU-M-40. About two volutions of near last whorl are preserved, cut along longitudinal direction.

Description: Shell large, presumably high-turreted, and consists of numerous whorls. Volution rather low, about two-thirds as wide as high. Outer margin of each volution carries a deep and broad depression and is rather abruptly elevated both above and below suture, so as to form a broad and rounded sutural ridge. Suture inconspicuous. Surface of shell unknown, but no eminent ornamentations are visible in cross section. Last whorl subcarinated in lower half with well-marked anterior canal. Aperture rather narrow and somewhat elongated rhombic. Interior wall carries three eminent folds, one on the outer lip and two on the inner one; palatal fold the most prominent and the thickest subquadrangular in profile with sharply keeled adapical extremity, situated at lower one-third of height of labral; parietal fold thin and acutely hook-shaped, situated at about one-third of distance from parieto-columella corner, and projects abaxially downward to the base of palatal fold. Columella solid and carries a rather high and wide-based triangular fold at a little below the mid height of columellar lip.

Remarks: The specimen is too fragmentary to discern its general out-

line, so the comparison with the other species is difficult, but this species is similar to *Nerinea higoensis* n. sp. in general form and internal structure. The former, however, is easily distinguished from the latter by having deep depression of volution surface, different shaped palatal fold and lower volution. In comparison with European Jurassic species, this species is somewhat similar to *N. sculpta* DELOR from the early Kimmeridgian of France in general form and aspect, but the sufficient comparison of internal structure is impossible, because the internal figure of the latter could not be observed.

Occurrence: Loc. 10a. South of Igo-misaki, about 2 kilometers north of Uminoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Geological horizon: Limestone lens (upper layer) in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.

Genus *Cossmannea* PCELINCEV, 1931

Type-species.— *Nerinea desvoidyi* D'ORBIGNY

Cossmannea tahoto sp. nov.

(Pl. 6, Fig. 1)

Types: GIYU-M-41-43 are designated as syntypes. GIYU-M-41 is figured.

Materials: Three specimens mentioned above, lack whorls of apex. GIYU-M-41 and 43, are cut along longitudinal direction.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-41	135	42 : 4.5 whorls preserved.

Description: Shell rather thick and very large in size, subcylindrical, high-turreted, consisting of numerous whorls. Apical angle unknown but pleural angle of near last whorl about 8 degrees. Volution rather low, the ratio of the height to the width of it about 0.6. Outer surface of each volution deeply and widely depressed inward and abruptly elevated both above and below suture. Suture shallow but distinctly impressed, lying on the middle portion of rounded and low spiral ridge, formed by the elevation of supra-infrasutural region of volution surface. Last whorl carinated at its abaxial margins, and exterior surface of base carries fine and inconspicuous radial striations with slightly sigmoidal profile. Aperture imperfectly preserved but rather broad and elongated oblong to rhombic with widely notched anterior end, so far as observed on cross section. Basal lip joints at about 69 degrees with columella; it is very thick compared with labral, but becomes thin at near abaxial margin. Interior wall carries two eminent folds, one each on the outer lip and the inner one; palatal fold short and triangular in profile, situated at a little above the mid height of labral, and projects abaxially toward parieto-columella corner. Columella very thick and narrowly hollowed, and carries a low swelling-like fold at a little below the mid height

of columellar lip. These two folds become weaker and lower toward last whorl.

Comparison: The present species is closely allied to type-species *Cossmannea desvoidyi* (D'ORBIGNY) from the Kimmeridgian of France in general form and internal structure, but the former is distinguished from the latter by having deeper depression of volution surface and the different shape of columellar fold. The present species is somewhat similar to *C. imlayi* SOHL from the Bajocian of central and southern Utah of North America, but the former has larger shell and stronger palatal fold than the latter. The present species is also similar to *C. subdesvoidyi* PCELINCEV of Almenia, but the former is distinguished from the latter by its more eminent and sharp internal folds.

Occurrence: Loc. 7b. Koyamada, Kashima-machi, Sôma City, Fukushima Prefecture. The present species occurs in oosparite bed, associated with *Cryptoplocus abukumensis* n. sp..

Geological horizon: Koike limestone member of the Nakanosawa formation; Kimmeridgian.

Cossmannea sp. indet.

(Pl. 6, Fig. 2)

Material: GIYU-M-44. A single specimen; preserved only two whorls of median part of shell. It is cut along longitudinal direction.

Description: Shell large and rather thick, subcylindrical, presumably consisting of numerous whorls. Volution rather broader than high. Outer surface of each volution gently depressed. Surface unknown but probably smooth, so far as observed on cross section. Suture inconspicuous, lying on the middle of swelling, formed by the elevation of supra-infrasutural region of volution side. Last whorl unknown. Interior wall carries two eminent folds, one each on the inner lip and the outer one; palatal fold short and very widely based subquadrate in profile, projected abaxially toward the parieto-columella corner from the mid height of labral. Columella thick and rather narrowly hollowed, and carries a moderately high triangular-shaped fold at a little below the mid height of columellar lip.

Remarks: The specimen is too poor to establish a species, but the shape of internal folds and their arrangement are well observed. This species is closely allied to *Cossmannea tahoto* n. sp. in internal character, but the outer surface of volution is more shallowly depressed than in the latter.

Occurrence: Loc. 10a. East of Igo-misaki, about 2 kilometers north of Uminoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Geological horizon: Limestone lens in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.

Subfamily Ptygmatisinae PCELINCEV, 1931

Genus *Ptygmatis* SHARPE, 1850*Type-species.*—*Nerinea bruntrutana* THURMANN, 1832*Ptygmatis yabei* sp. nov.

(Pl. 7, Figs. 1, 2, Text-fig. 6)

Types: GIYU-M-62, 63 are designated as syntypes.*Materials:* Two specimens mentioned above are cut along longitudinal directions. Whorls of apex and base are not preserved. GIYU-M-63 was collected by Mr. K. TANABE.*Measurements.*— (in millimeters)

No.	Height	Width	
GIYU-M-62	120	42	: 10 whorls preserved.
GIYU-M-63	/	34	

Description: Shell large, umbilicated, stout and spire conical, consisting of about sixteen whorls. Lateral margin of spire almost straight or rarely undulated and comparatively rapidly tapers toward the apex. Apical angle precisely unknown, but at least 18 degrees or more. Volution low about three times as wide as high. Outer surface of each volution shallowly and widely depressed with slightly elevated suprasutural region. Suture inconspicuous. Last whorl and aperture imperfectly preserved; the former sharply carinated abaxially with flat base; a wide umbilicus opening, and aperture presumably narrow rhombic. Interior wall carries five eminent and complicated folds, three on the inner and two on the outer lips; the upper one of the two palatal folds smaller than the lower one; distal portion of the lower fold expanded with three keels, of which median one obsolete, while the other two sharply projected; the upper palatal fold also expanded with three keels, of which the lower two sharply projected; these two palatal folds situated at one-third and two-thirds of height of labral, respectively. The parietal fold rather slender, projected abaxially from the middle portion of parietal lip, expanded with two keels situated at near basal and distal portions of adaxial surface of fold. Two columellar folds strong and robust, situated at one-third and two-thirds of height from the columello-basal corner, respectively; the lower one projected slightly downward, stronger than the



3 cm

Text-fig. 6. Internal structure of *Ptygmatis yabei*, sp. nov. (GIYU-M-62).

upper one and expanded with three keels, of which two situated on the distal portion and one near base; the lowest keel very widely hook-shaped and projected abaxially downward, while the upper two have swelling-like profile. The upper columellar fold expanded with four keels and has almost pentagonal shape. In last whorl all folds become weak and short with no keels, but in those above the penultimate whorl each fold is so elaborate that the space of whorl is very narrowly restricted. Shell axis is penetrated by rather wide umbilicus which is about one-third of whorl diameter. Axial wall of each volution, composing umbilicus, very thick and gently swollen, and carries a short spiral plication (Columellar plicae) which sharply projects abapically from interio-anterior end of volution.

Remarks: The writers place this species in the genus *Ptygmatis* [=subgenus *Nerinea* (*Ptygmatis*) WENZ, 1940] without doubt, by the presence of very wide umbilicus, five complicated folds and by having rather conical shell. The present species is closely allied to *Ptygmatis pseudobruntrutana* GEMMELLARO from the Tithonian of Inwald, Carpathia, but the former is distinguished from the latter by its more complicated folds and wider umbilicus. The present species is also similar to *P. gradata* (MOREAU, non D'ORBIGNY) from the Kimmeridgian of France in general form and aspect, but the latter has more eminent parietal fold and narrower umbilicus.

Occurrence: Loc. 10a. East of Igo-misaki, about 2 kilometers north of Uminoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Geological horizon: Limestone lens in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.

Heteroptygmatis gen. nov.

Type-species.—*Heteroptygmatis orientalis* sp. nov.

Diagnosis: Shell large to moderate in size, slender conical to high-turreted. Volution surface shallowly to deeply depressed. Suture feebly impressed. Last whorl a little larger than penultimate one and carinated at base. Aperture rhombic with short anterior canal. Five eminent folds present, two on the outer, one on the parietal and two on the columellar lips, without basal fold. All folds expanded and complicated with two to four keels except in last whorl and in juvenile stage. Umbilicus not present. Columella thick and partly very narrowly hollowed.

Remarks: In addition to type species from the upper Sakamoto formation in Kumamoto Prefecture, central Kyushu, the following species are surely referable to *Heteroptygmatis*:

Heteroptygmatis abukumensis sp. nov.

H. subpyramidalis sp. nov.

H. elegans sp. nov.

All of the above species occur in the Koike limestone member of the Nakanosawa formation at Sôma City, Fukushima Prefecture, Northeast Japan.

The present genus shows the morphological resembles to genus *Ptygmatis* SHARPE (1850), with type species *Nerinea bruntrutana* THURMANN, 1832, in moderate to large slender conical shell and presence of five internal folds which are expanded and complicated with some keels, but the former is easily distinguished by its more slender shell, more or less deeply depressed volution surface and by absence of umbilicus.

The writers also think that presence or absence of umbilicus is more important taxonomic element than internal character, as discussed before by STANTON (1947) or YOUNG (1952). If this element of umbilicus is considered to be important for infrageneric taxonomy, the present genus must be separated from genus *Ptygmatis*, clearly. The present genus also bears the morphological similarity to some genera of Nerinellidae. Among Nerinellidae, *Multiptyxis* PCELINCEV (1931) with type species *Polyptyxis airigulensis* VOLTZ, 1931, and *Plesioptyxis* PCELINCEV (1954) with type species *Nerinea fleurianus* D'ORBIGNY, 1842, are comparable with the present genus, but *Multiptyxis* is Barremian genus and distinguished from the present genus by having more slender and smaller shell, more smooth lateral slope of spire and by the simpler shape of folds. *Plesioptyxis* is Senonian genus and distinguished from the present genus by having more slender shell, six to seven internal folds (two or three folds weakly appear) and thick outer lip of aperture. Then the writers place the genus *Heteroptygmatis* under *Ptygmatisinae* on the basis of the slender conical and robust shell, presence of five complicated folds and their arrangement.

Heteroptygmatis orientalis sp. nov.

(Pl. 7, Fig. 3)

Types: Holotype, GIYU-M-64, paratype, GIYU-M-65.

Materials: Two specimens mentioned above are cut along longitudinal direction. GIYU-M-64 is almost perfectly preserved except several whorls of apex.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-64	66	19

Description: Shell moderate in size, slender conical consisting of about ten whorls or more. Spire slowly and regularly tapers toward the apex. Pleural angle of penultimate whorls about 7 degrees. Volution rather low, almost twice as wide as high. Outer surface of each volution deeply and broadly depressed to a little below the mid height except in near last whorl where it becomes almost straight or gently depressed. Suture inconspicuous, lying on the swollen and broad ridge. Last whorl strongly carinated at

abaxial margins of its base, with a short siphonal canal. Aperture almost rhombic with rather thin outer lip. Interior wall carries five eminent folds, two on the columellar, one on the parietal and two on the other lips. Of two palatal folds, situated at the upper and lower at one-fourth of height of labral, the upper one acute, small, expanded distally with delicate three keels, and the lower one thick, expanded distally with three keels, of which the median one obsolete, while the other two sharply projected. Two columellar folds situated at one-third and two-thirds of height from columella base, respectively; the upper one shortly projected, expanded distally with four keels and the lower one high, expanded with sharp and delicate three keels, of which the lowest one projects abapically from the middle portion of it, while the other two situated at distal portion. The parietal fold of near parieto-columella corner, high and hook-shaped with two low keels on its anterior surface. All keels of each fold disappear or become obsolete in early and last stages of volution. The upper palatal fold usually weak and the other folds become weaker toward last whorl, hence the space of whorl chambers is rather broad compared with those of preceding whorls.

Comparison: The present species looks like Senonian *Plesioptyxis similis* PCELINCEV (1954) in general form and aspect, but the former is clearly distinguished from the latter by having more smaller and complicated folds. The present species is also comparable with *Ptygmatis bruntrutana* (THURMANN) in the shape of folds and their arrangements. The latter, however, has thicker and stouter shell, more flat side of volution and rather wide umbilicus.

Occurrence: Loc. 10a. South of Igo-misaki, about 2 kilometers north of Uminoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Geological horizon: Limestone lens (upper layer) in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.

Heteroptygmatis fukushimensis sp. nov.

(Pl. 7, Figs. 4-6)

Types: GIYU-M-66-68 are designated as syntypes.

Materials: Three specimens mentioned above are cut along longitudinal direction.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-66	35+	15+ : 3 whorls preserved.
GIYU-M-67	44	10 : 10 whorls of apical part.

Description: Shell moderately in size, turreted, consisting of fifteen whorls or more. Apical angle of several early whorls about 10 degrees. Spire regularly tapers toward the apex and its lateral margins generally straight or slightly concave inward. Volution rather low about two-thirds

as high as wide. Outer surface of each volution gently undulated with two shallow depressions one at mid height and another a little above it. Suture shallow and inconspicuous; sutural region slightly elevated. Last whorl carinated abaxially, with short siphonal canal. Aperture presumably somewhat elongated rhombic. Interior wall carries five eminent folds, two on the outer, one on the parietal and two on the columellar lips. Two palatal folds situated at lower one-third and upper three-fourths height of labral; the lower one very thick and oblong in profile, expanded distally with three keels, of which the median one obsolete, while the other two sharply projected abaxially and adaxially; the upper one fairly smaller than the lower one, distal portion of which expanded with three keels, like that of the lower one. The parietal fold high, acutely hook-shaped with three sharp keels, situated in distal, median, and proximal portions of adaxial surface, and projects toward the base of lower palatal fold from the point at about one-third length of parietal lip from parieto-columella corner. Of two columellar folds, situated at one-third and two-thirds height from the columello-basal corner, respectively, the lower one a little higher than the upper one, expanded with three keels, of which the lowest one projects abaxially downward; the upper one expanded with three keels in distal portion. All keels become weak in penultimate whorl and disappear in last and several early ones.

Remarks: The present species is easily distinguished from the other Japanese species of genus *Heteroptygmatis* by its slender shell and gently depressed volution surface.

Occurrence: Loc. 8a. Koike, Kashima-machi, Sôma City, Fukushima Prefecture. The present species occurs in oosparite bed, associated with some pelecypod shells.

Geological horizon: Koike limestone member of the Nakanosawa formation; Kimmeridgian.

Heteroptygmatis subpyramidalis sp. nov.

(Pl. 7, Figs. 7, 8)

Types: GIYU-M-69, 70 are designated as syntypes.

Materials: Two specimens mentioned above are cut along longitudinal direction. Some whorls of apex and base are not preserved.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-69	108	38 : 6.5 whorls preserved.
GIYU-M-70	76	26 : 8 whorls preserved.

Description: Shell large, rather slender conical, consisting of about fifteen or more whorls. Apical angle of several early whorls about 25 degrees or less. Spire regularly and rather rapidly tapers toward the apex. Volution rather low, about two-thirds high as wide. Outer surface of each volution

deeply and widely depressed and the bottom of depression rather flat, but rapidly elevated both above and below suture, so as to form a high rounded spiral ridge. Suture shallow and inconspicuous. Last whorl strongly carinated abaxially. Aperture rhombic with rather narrow posterior end and widely opened anterior one. Interior wall carries five eminent folds, two on the outer, one on the parietal and two on the columellar lips. The lower one of two palatal folds strong, thick and oblong in profile in last and penultimate whorls, but in preceding whorls, except in early ones, the distal portion of it expanded with three to four keels, of which the median one weakly pointed, while the upper and lower two sharply projected adapically and abaxially downward. The upper palatal fold short and triangular-shaped, expanded with three keels, of which the upper one sharply projected from the middle portion of fold, while the other two weakly pointed at distal. These two palatal folds situated below one-third of height of labral and near posterior end of whorl chamber. Parietal fold situated at about one-third of length of parietal lip from parieto-columella corner, rather thick, hook-shaped with three sharp keels, of which the most distal one thin and high, while the other two weakly pointed at distal and median portions of abapical surface. Of two columellar folds situated at one-third and two-thirds of height from columello-basal corner, the lower one thin and high in last and penultimate whorls, but in preceding ones except in early ones, the distal portion of it carries three keels, of which the lowest one sharply projected adaxially downward, while the upper two projected adapically. The upper columellar fold rather smaller than the lower one, expanded distally with four keels, of which the median two obsolete, while the upper and lower two sharply projected in abapical and adapical directions, respectively. In early whorls all folds are weaker than those in last whorl, and keels are absent.

Comparison: The present species is closely allied to *Heteroptygmatis orientalis* n. sp., but the former is distinguished from the latter by its more stout and conical shell, and by having deeper depression of volution surface.

Occurrence: Loc. 8b. Koyamada, Kashima-machi, Sôma City, Fukushima Prefecture. The present species occurs in oosparite bed, associated with *Cryptoplocus abukumensis* n. sp. and *Cossmannea tahoto* n. sp., but no other fossils are found with these nerineids.

Geological horizon: Koike limestone member of the Nakanosawa formation; Kimmeridgian.

Heteroptygmatis elegans sp. nov.

(Pl. 7, Figs. 9-11)

Types: GIYU-M-71-73, are designated as syntypes.

Materials: Three specimens mentioned above are cut along longitudinal direction.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-71	63	25 : anterior 4 whorls.
GIYU-M-73	43	11+ : 7 whorls of apical part.

Description: Shell moderate to large in size, slender and turreted, consisting of about fifteen whorls. Apical angle about 10 degrees. Spire regularly and slowly tapers toward the apex, volution rather low, the ratio of the height to the width about 0.6. In adult stage, outer surface of each volution deeply depressed and rapidly elevated both above and below suture, so as to form a high and rounded spiral ridge which bears the inconspicuous suture, but the depression is shallower in juvenile stage. Last whorl strongly carinated abaxially with slightly concave and thin base. Aperture rather narrow, elongated rhombic with narrow posterior end and rather long and wide anterior one, and presumably with a short and broad canal, so far as observed on cross section. Interior wall carries five eminent folds, two on the outer, one on the parietal and two on the columellar lips. Two palatal folds situated near posterior end of whorl chamber and below one-third of height of labral; the upper one low and triangular-shaped in last, penultimate and early several whorls, while in median whorls, expanded distally with two sharp and delicate keels, of which the lower one projected adaxially and the upper one adapically. The lower palatal fold thick and oblong to triangular in profile, while in median whorls, expanded to form a flat top with delicate two keels, projected both abapically and adapically. Two columellar folds situated at one-third and two-thirds of height from the columello-basal corner, respectively. The lower columellar fold thin, expanded distally with delicate three keels, separated from each other at about right angles, of which the lowest one hook-shaped and projects adaxially downward to the columello-basal corner. The upper columellar fold smaller than the lower one, but has almost same shape and keels as lower one. Parietal fold high and triangular-shaped, situated at about one-third of length of parietal lip from parieto-columella corner; it carries distally three keels which are separated from each other and project in abaxial, abapical and adaxial directions, respectively. Columella thick and partly hollowed. All folds become very weak in last whorl and keels of each fold disappear in last, penultimate and several early whorls.

Remarks: The shell has almost same form and internal structure as in *Heteroptygmatis subpyramidalis* n. sp., but the writers distinguished the present species from the latter by its slender shell form, smaller shell size, the different shape of internal folds and more delicate keels of each fold.

Occurrence: Loc. 8a. Koike, Kashima-machi, Sôma City, Fukushima Prefecture. The present species occurs in only biomicrite bed, associated with some pebbles of hexacoral and stromatoporoid, and their fragments.

Geological horizon: Koike limestone member of the Nakanosawa forma-

tion; Kimmeridgian.

Subfamily Cryptoplocinae PCELINCEV, 1931

Genus *Cryptoplocus* PICTET & CAMPICHE, 1861

Type-species.—*Nerinea depressa* VOLTZ, 1836

Cryptoplocus abukumensis sp. nov.

(Pl. 5, Fig. 4, Pl. 6, Figs. 3-5)

Types: GIYU-M-45-58 are designated as syntypes. Four syntypes (GIYU-M-45-47 and 51) are figured.

Materials: Fourteen specimens mentioned above lack some whorls of apex. GIYU-M-45, 46 and 48-50 are cut along longitudinal direction, and GIYU-M-51 is of a transverse section.

Measurements.— (in millimeters)

No.	Height	Width	Width of Umbilicus	
GIYU-M-45	120	45	20	: About 7 whorls of apex unpreserved.
GIYU-M-47	/	72	35	: Last whorl preserved.
GIYU-M-48	232	60+	/	

Description: Shell large or gigantic, rather slender conical with wide umbilicus, consisting of usually about fifteen whorls and more than twenty in the largest specimen. Apical angle of several early whorls 25 to 30 degrees. Volution low about three times as wide as high. Outer surface of each volution smooth and moderately concave, but frequently worn out, so as to become straight or to be gently depressed inward. Suture indistinctly impressed and suprasutural region sometimes expanded. Last whorl roundly but strongly carinated abaxially and with a very wide umbilicus opening. Aperture almost rhombic. Interior wall carries an acute and thin fold on the parietal lip. Parietal fold hook-shaped with rounded distal, situating at one-third portion of parietal lip from parieto-columella corner, and projects abaxially downward. Adaxial wall, composing umbilicus, thin in early stage (up to about 9th or 10th volution) but in later stage, rapidly becoming thick, forms a short and rounded spiral ridge at interio-anterior end of volution, hence projects abaxially downward into the umbilicus hole.

Comparison: The present species is closely allied to *Cryptoplocus depressus* (VOLTZ) from the Kimmeridgian of France in general form and aspect, but the former is distinguished from the latter by its more conical and larger shell. The present species is also similar to *C. pyramidalis* MUNSTER from the Kimmeridgian to the Portlandian of France, but the former is distinguished from the latter by its more smooth surface, wider umbilicus and by the different shape of aperture. The present species is also similar to *C. picteti* GEMMELLARO from the Kimmeridgian of France, but the latter has less depressed volution surface, narrower umbilicus and less conspicuous

suture than in the former.

Occurrence: Loc. 10a-c. Common in oosparite beds at Koike, Koyamada and Tochikubo, Sôma City, Fukushima Prefecture.

Geological horizon: Koike limestone member of the Nakanosawa formation; Kimmeridgian.

Cryptoplocus phalloides sp. nov.

(Pl. 5, Figs. 2-4, Text-fig. 7)

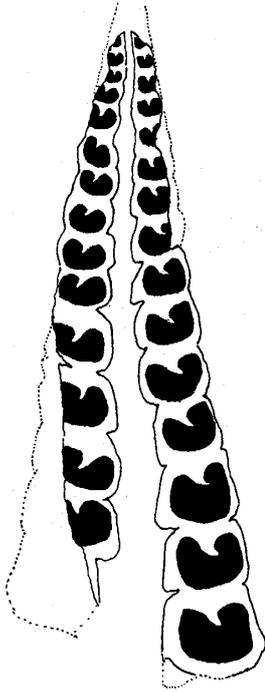
Types: GIYU-M-59-61 are designated as syntypes.

Materials: GIYU-M-60 lacks some whorls of base, and GIYU-M-61 retains only apical part. All specimens are cut along longitudinal direction.

Measurements.— (in millimeters)

No.	Height	Width	Width of Umbilicus
GIYU-M-59	230	70 ?	25±

Description: Shell large or gigantic, slender conical with wide umbilicus, consisting of about twenty-three or more whorls. Apical angle of several early whorls 15 to 20 degrees. Lateral margins of spire almost straight or rarely concave inward in early stage, but slightly concave in later stage. Volution low, usually three times as wide as high. Outer surface of each volution slightly concave, but frequently worn out to become flat or slightly undulated. Suture indistinctly gloove-like. Last whorl roundly carinated abaxially with strongly curved base and widely opened umbilicus which is about one-third of whorl in diameter. Aperture subcircular truncated posteriorly. Interior wall carries a short but stout fold on the middle portion of parietal lip; it gently curves abaxially and widely spreads at base. Adaxial wall, composing umbilicus, very thick and swollen at middle of each volution, and carries a short and strong spiral ridge which projects adaxially from interior-anterior end of volution.



5 cm

Text-fig. 7. Internal structure of *Cryptoplocus phalloides*, sp. nov. (GIYU-M-59).

Comparison: The present species is clearly distinguished from *Cryptoplocus abukumensis* n. sp. by having more slender and thicker shell, a narrower umbilicus and a different shaped parietal fold. Among the several European species reported by COSSMANN (1896), LEVASSEUR (1935), etc., the present species bears close similarity to

C. depressus (VOLTZ) in general form and aspect, but the former is clearly distinguished from the latter by having wider umbilicus, and stronger and thicker parietal fold. The present species is somewhat similar to *C. consobrina* ZITTEL. The former, however, has more slender shell and more curved parietal fold than the latter.

Occurrence: Loc. 10a. South of Igo-misaki, about 2 kilometers north of Uminoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Geological horizon: Limestone lens (lower layer) in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.

Subfamily Diozoptyxinae PCELINCEV, 1931

Genus *Diozoptyxis* COSSMANN, 1896. emend. PCELINCEV, 1931

Type-species.—*Nerinea renauxiana* D'ORBIGNY, 1842

Diozoptyxis hidakaensis (FUKADA)

(Pl. 3, Fig. 9)

1953. *Nerinea* (s.s.) *hidakaensis* FUKADA; Jour. Fac. Sci. Hokkaido Univ., ser. IV, vol. 8, no. 3, pp. 221-216, pls. 12, 13.

Types: Three cotypes were illustrated by FUKADA in 1953. Here two specimens GIYU-M-87, 88, which were collected by the senior writer, are designated as topotypes.

Measurements.— (in millimeters)

No.	Height	Width	
Cotype 1	165	65	: 12th to 18th whorls.
Cotype 2	97	65	: 4 whorls preserved.
GIYU-M-87	132	60±	: 4.5 whorls preserved.

Original description: "Shell thick and test gigantic (roughly estimated to be more than 400 mm in height in one specimen, and about 80 mm in diameter near the body whorl in another incomplete specimen), high turreted, composed of numerous whorls (presumably about 15 whorls to 25 whorls). Several early whorls (up to about ninth whorl) comparatively rapidly taper toward the apex, which is frequently worn out, subsequent whorls increasing more slowly in diameter; consequently the last whorl a little larger than the penultimate one.

Whorls being a little broader than, or almost as broader as, high, without changing the ratio from the anterior to the posterior; surface of the shell is apparently flat and smooth except for the slight convexity in the suprasutural portion of the whorl; in consequence the lateral side of the whorl is slightly concave in the middle of the depth. The thick interior part of the shell being eroded away the interior surface facing the lateral wall is shown, where two spiral, broad ridges in each whorl are recognized; the upper ridge is broad and subangular, and the lower narrow and elevated, the interspaces

being rather deep.

Compared with the distinct unevenness of interior surface, the exterior is almost even and smooth.

Aperture is imperfectly preserved, but presumably rhombic or subquad-rangular with the thin outer lip as is suggested in cross-section. Interior of the shell penetrated by a strong and thick columella which is twisted, hollow, and provided with plications. Of the two columellar plications, the anterior one lying a little below the middle of the columella is stronger than the parietal fold which is situated at the posterior corner of the whorl."

Remarks: As FUKADA described, this species is characterized by gigantic shell, rhombic to subquadrate aperture, exceedingly thick and hollowed columella, and three strong internal fold, of which the columellar one is very high. Here the writers place this species in genus *Diozoptyxis* on the basis of its large cyrtconoidal shell, rather wide umbilicus, rhomboidal aperture and the presence of three simple internal folds and thick columellar plicae (plication).

This species is closely allied to the type species *Diozoptyxis renauxiana* (D'ORBIGNY) from the Neocomian of France in general form and aspect, but the former is distinguished from the latter by its more slender and much larger sized shell. Compared with the Valanginian species *D. coquandi* D'ORBIGNY from Crimea, this species has more smooth and slender spire, and different character of internal structure.

Occurrence: Loc. 1. Upper course of the Sôshubetsu-gawa, Shime-Kapp-mura, Yûfutsu-gun, Hidaka province, central Hokkaido.

Geological horizon: Lower Ammonite bed of the Sorachi series; Aptian.

Family Nerinellidae PCELINCEV, 1931

Genus *Bactroptyxis* COSSMANN, 1896

Types-species.—*Nerinea implicata* D'ORBIGNY, 1894

Bactroptyxis nobilis sp. nov.

(Pl. 7, Figs. 12, 13)

Types: GIYU-M-74, 75 are designated as syntypes.

Materials: Two syntypes, cut along longitudinal direction, lack some whorls of apex and base. Besides, there are many specimens of a transverse section.

Measurements.— (in millimeters)

No.	Height	Width	
GIYU-M-74	75	14	: Anterior 5 whorls preserved.
GIYU-M-75	68	8	: Median 8 whorls preserved.

Description: Shell moderate in size, very slender, claviform, consisting of numerous whorls, apparently more than thirty. Spire exceedingly high

and regularly and very slowly tapers toward the apex. Lateral margins of spire almost straight and smooth, but rarely undulated gently. Volution rather high, almost as broad as high. Suture inconspicuous. Last whorl and aperture imperfectly preserved, the latter presumably narrow and somewhat elongated rhombic to oblong. Interior wall carries six eminent rather simple folds, three on the outer, one on the parietal and two on the columellar lips. The lowest one of three palatal folds oblong in profile, slightly expanded with two keels; between them, the distal portion of fold becomes flat. The median palatal fold a little larger than the upper one, but both are simple in shape, gently curved abapically and rather widely based. Three palatal folds situated at about one-third, middle and three-fourths of height of labral, respectively. Two columellar folds have almost same shape but are smaller than the lowest palatal fold, and projected against the lower two palatal folds. The lower columellar fold a little larger than the upper one, expanded distally with two keels, of which the upper one obsolete, while the lower one sharply projected adapically. Parietal fold rather delicate with two sharp keels at distal, situated at the middle portion of parietal lip.

Remarks: The present species is closely allied to *Bactroptyxis cubanensis* PCELINCEV from the Kimmeridgian of Caucasus in general form and aspect, but the former is distinguished from the latter by its smaller parietal fold and more slender columella.

Genus *Bactroptyxis* occurs in Bajocian to Kimmeridgian, and its geographical distribution is rather wide, and many species are known to occur in Europe and Caucasus.

The present species is found only in biomicrite layer in association with *Nerinea koikensis* n. sp., small gastropoda, and coral and stromatoporoid as a pebble or colony, showing calm environment. On the other hand, the present species has six internal folds which seem to be wasteful for the reinforcement of shell. Therefore the writers think that the internal folds of some nerineids may be a pure taxonomic element which is not affected by environmental factors. But more materials and further observation and biological experiments are necessary before a definite conclusion is reached.

Occurrence: Loc. 8a. Koike, Kashima-machi, Sôma City, Fukushima Prefecture.

Geological horizon: Koike limestone member of the Nakanosawa formation; Kimmeridgian.

Family Itieriidae COSSMANN, 1895

Genus *Itieria* MATHERON, 1842

Type-species.—*Actaeon cabanetiana* D'ORBIGNY, 1841

Itieria japonica sp. nov.

(Pl. 8, Figs. 1-3, Text-fig. 8)

Types: Holotype, GIYU-M-76, paratypes, GIYU-M-77-80.

Materials: Holotype is broken at the median portion of the shell, almost half shell of abaxial part worn out. More or less incomplete paratypes are cut along longitudinal direction.

Measurements.— (in millimeters)

No.	Height	Width	Wl/Ht*
GIYU-M-76	142	84	0.76
GIYU-M-80	191+	87+	0.66

Description: Shell large, robust, typical ovoid, consists of slightly rounded short spire and very large last whorl.

In juvenile stage up to about early 8 volutions, narrow and elongated volutions grow both posteriorly and anteriorly, and abaxial surface of the preceding volution is perfectly enveloped by the next volution, consequently the shell apex holds a shallow conical cavity, reaching about 10 mm wide and about 4 mm deep in the greatest shell.

In adult stage, highly elongated and narrow volutions, decrease slowly their width toward the posterior end, and the greater part of the abaxial surface is enveloped by the next volution, except its distal portion. Outer side of each volution, gently curved, almost smooth with delicate and numerous growth lines, which have exceedingly stretched sigmoidal profile, curved at two portions of infrasutural region and posterior corner of last whorl. Last whorl exceedingly large, occupying about sixty to seventy percent of the total height of shell, and its outer margin broadly and gently subcarinated below anterior part and gently curved posteriorly. Aperture narrow, and crescent-shaped of which the lower one-third portion rhombic and widely open, while the upper portion becomes rapidly narrow wedge-shaped and decreases its width slowly toward the acute posterior end. Outer lip thick, and carries a wide-based and obtuse-topped palatal fold and a smaller fold, which sometimes disappear; the former situated on below one-third of height of outer lip and the latter a little above the former. Inner lip, consisting of obliquely and rather strongly curved parietal lip and a short and thick columella one, carries an eminent fold at mid height of the latter, which is high triangular-shaped with rather sharply pointed distal portion and projected toward the lower base of palatal fold. Axis of shell penetrated by a widely hollowed columella with rather narrow umbilicus, provided with thick plication (columellar plicae) which is gently curved adaxially downward and projected abaxially at its distal.

Comparison: The present species is closely allied to *Itieria cabanetiana* (D'ORBIGNY) from the Kimmeridgian of France in general form and aspect, but the former is distinguished from the latter by its narrower anterior end of whorl chamber and by the presence of two palatal fold. The present

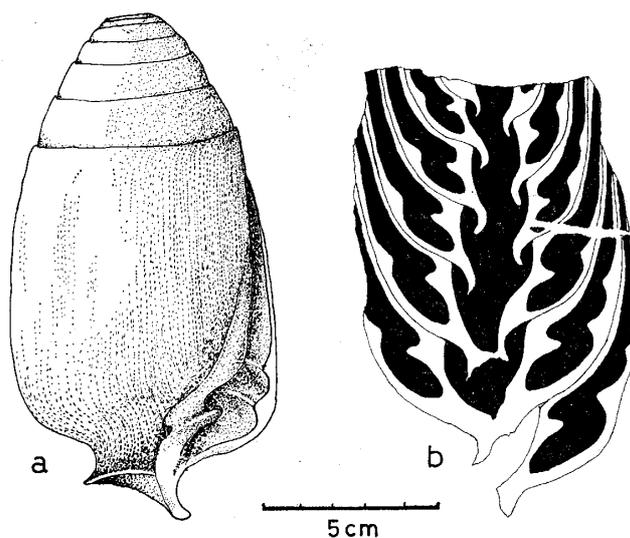
* The ratio of the width of last whorl to the total height of shell.

species is somewhat similar to *I. slaszycii* ZEUSCHNER from the Tithonian of Carpathia in general form, but the former is easily distinguished from the latter by its shorter spire and more simple internal structure.

The specimen (Pl. 5, Fig. 6) collected from the limestone quarry at Shimomitsuki, Takaoka-gun, Kôchi Prefecture, is probably referred to the present species, but their relation cannot be determined before better specimens are obtained.

Occurrence: Loc. 10a. South of Igo-misaki, about 2 kilometers north of Uminoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Geological horizon: Limestone lens (lower layer) in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.



Text-fig. 8. a. Idealized outline of *Itieria japonica*, sp. nov. b. Internal structure of ditto (GIYU-M-80).

Genus *Phaneroptyxis* COSSMANN, 1896

Type-species.—*Nerinea moreana* D'ORBIGNY, 1841

Phaneroptyxis oshimensis sp. nov.

(Pl. 8, Figs. 4, 5)

Types: GIYU-M-81-85 are designated as syntypes.

Materials: Above-mentioned five specimens and several fragmentary specimens. GIYU-M-81 is slightly deformed and the upper surface of shell is lost. GIYU-M-82-85 are cut along longitudinal direction.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-81	45	15
GIYU-M-82	59	17+

Description: Shell moderately small, rather slender fusiform, consisting of about ten whorls or less. Apical angle of several early whorls about 20 or more degrees in restored shell. Each volution with smooth and gently curved surface envelops lower two-thirds portion of abaxial surface of preceding one. Lateral margins of spire gently bent outward and undulated by low swelling of each volution surface, separated by inconspicuous shallow and rounded infrasutural ridge. Last whorl rather large, occupying

about thirty percent of shell height. Aperture imperfectly preserved, narrow, oval with sharply pointed posterior end and a little broader anterior one. Inner lip consists of a long oblique parietal lip and a vertical thick columellar one. The parietal lip carries a high and slender fold, projected abaxially from near parieto-columella corner. Columella rather slender but hollowed narrowly, and carries low and wide-based fold at its mid height. Outer lip almost vertical but gently curved, and carries an eminent high fold, wide-based and almost triangular in profile, projecting abaxially toward the parieto-columella corner from a little below the mid height of outer lip.

Comparison: The present species is closely allied to *Phaneroptyxis angulina* (CASTILLO & BARCENA) from the Barremian of Mexico in general form and internal structure, but the former is distinguished from the latter by its smaller and slender shell. The present species is also similar to *P. clymene* (D'ORBIGNY) and *P. chaperii* COSSMANN, but the shell is larger and thicker than in *chaperii* and the spire is higher and the shell is more slender than in *clymene*.

Occurrence: Loc. 4. Yokonuma village, Rikuzen-Ôshima Island, Kesenuma City, Iwate Prefecture.

Geological horizon: Upper part of the Ôshima formation; Hauterivian to Barremian.

Phaneroptyxis sakamotoensis sp. nov.

(Pl. 8, Fig. 6, Text-fig. 9)

Types: A single specimen GIYU-M-86 is designated as holotype. It is cut along longitudinal direction, and several whorls of apex and a part of base unpreserved. Some part of anterior surface is broken off.

Measurements.— (in millimeters)

No.	Height	Width
GIYU-M-86	108+	50 ?

Description: Shell large, test very thick, cyrtocoid with high conical spire and rapidly narrowed base, consisting of about fifteen or less whorls. Apical angle unknown, but the spire width gradually decreases in full adult stage, and lateral margins of the spire smoothly and gently curved. Outer surface of each volution straight or slightly bent outward and separated by inconspicuous suture. Last whorl occupying about thirty-five percent of shell height, roundly carinated abaxially. Aperture relatively wide-open pyriform with narrow posterior end and rather wide-open anterior one, so far as observed on cross section. Inner and outer lips become very thick anteriorly and probably form acutely projected siphonal fasciole around the narrow umbilicus opening. Shell axis is penetrated by strongly twisted and widely hollowed columella, divided by long and thick columellar plicae, wide-based and projected obliquely downward, at distal curved abapically where it is

acutely pointed or frequently worn out. Inner lip consists of a rather long and curved parietal lip and a succeeding very thick columellar one; the former carries a low wide-based and triangular-shaped fold at a little below the mid height of it and the latter carries almost same but more slender shaped fold as parietal one, at its mid height. Outer lip carries a very large and triangular-shaped fold at a little below the mid height of it. At last and penultimate whorls, all folds become low and weak, and both lips are very thin and chamber broad, compared with those of juvenile stage.

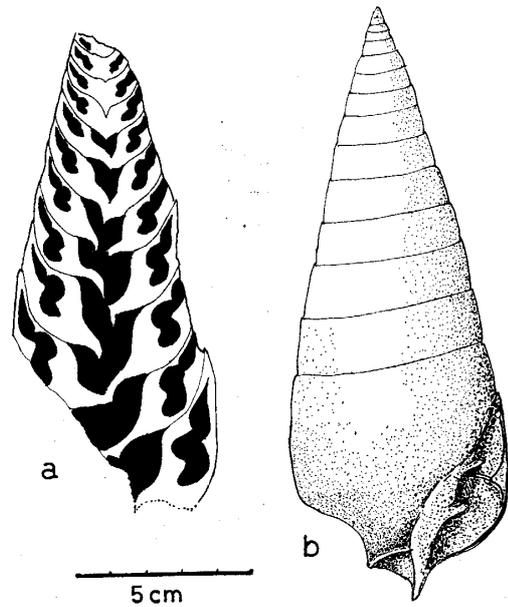
Remarks: According to A. R. KABUL (1967), *Phaneroptyxis* appears first in Bathonian, and *P. choffati* COSSMANN is found continuously; the group of *Phaneroptyxis* reached their acme in Oxfordian and disappear in Urgonian. Genus *Itruvia* may have followed this genus and genus *Itieria* may have appeared in Callovian or Oxfordian.

Compared with the species of *Itieria*, the present species is clearly distinguished by its slender fusiform shell and by the presence of three internal folds. The writers place the present species in the genus *Phaneroptyxis*, though with some misgivings. When compared with the type species *Phaneroptyxis moreana* (D'ORBIGNY), the present species has similar character of shell form, aperture and the mode of internal folds, hence the present species can be put in the range of genus *Phaneroptyxis*, rather than *Itieria* or other nerineids genera.

The present species is somewhat similar to *P. nagreti* (QUIR et OGERIEN) and *P. pupoides* (D'ORBIGNY) from the Kimmeridgian of France, but the spire is higher than in *pupoides* and the volution surface is more straight and the shell is larger and more slender than in *nagreti* and *pupoides*.

Occurrence: Loc. 10a. South of Igo-misaki, about 2 kilometers north of Uminoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Geological horizon: Limestone lens (upper layer) in the upper Sakamoto formation; late Oxfordian to early Kimmeridgian.



Text-fig. 9. a. Internal structure of *Phaneroptyxis sakamotoensis*, sp. nov. (GIYU-M-86). b. Idealized shell of ditto restored.

Paleoecological notes

Nerineid gastropoda of Japan occur almost exclusively in the limestone or limy unit intercalated in normal sediments such as fine- to medium-grained sandstone, mudstone and alternation of them, and the limestone is composed mainly of the reef-building fossil remains, such as calcareous algae, stromatoporoids, hexacorals, etc. It yields also some sponge, small foraminifers, pelecypods and others. In the Jurassic Torinosu series, nerineids commonly occur in the limestone beds or lenses mentioned above. However, in the Sôma area, nerineids-bearing limestone is almost oolitic and/or micritic, including pellet and others in some amount. Besides, it is more or less impure with large amounts of terrigenous materials such as silt, etc. On the other hand, nerineids of Cretaceous in Japan occur in calcareous sandstone or shale, and the Hidaka and Miyako areas corresponding to Urgonian facies are known to yield them. In the Hidaka area, *Diozoptyxis* occurs in more or less sapropelic and impure *Orbitolina* limestone of the middle Sorachi series, associated with rudistids and foraminifers such as *Praeaprotina yaegashii* (YEHARA), *Toucasia carinata* (MATHERON) var. *orientalis* NAGAO, *Orbitolina discoidea-conoidea* var. *ezoensis* YABE & HANZAWA, etc. In the Miyako area, *Nerinea rigida* NAGAO occurs in bluish-grey medium-grained calcareous sandstone of the upper part of the Hiraiga formation, associated with many pelecypods such as *Gervillia miyakoensis* NAGAO, *Exogyra yabei* NAGAO, etc.

Except these two areas, nerineids, in general, are not associated with any megafossils of pelecypod shells, stocks of coral and stromatoporoid, etc. which are common in reef-facies sediments of Jurassic-Cretaceous periods, although their fine fragments are found with them.

In nerineids-bearing limestone, there are several lithologic types, namely biomicritic, pelisparitic, oosparitic and reef biolithic types. In each type of limestone, only one or a few species are known to occur. Moreover, the faunal difference (in generic composition) in different horizons of limestone is observed well in several areas, but these limestone are very similar to each other in a textural sense and differ from each other in a compositional sense. The limestone lens of the upper Sakamoto formation in central Kyushu yields numerous nerineids, there *Nerinea* is aggregated in the upper layer, while *Itieria* and *Cryptoplocus* are sporadically seen in the lower layer (see Text-fig. 2).

Similar mode of occurrence is observed in the Koike limestone member of the Nakanosawa formation and the Torinosu limestone of the Yatsuji formation, both Upper Jurassic in age, and the Ôshima formation of Lower Cretaceous age. Especially in the Sôma area (Koike limestone member), some species of *Nerinea* and *Cryptoplocus* are confined to oosparite and those of *Bactroptyxis*, *Nerinea* and *Heteroptygmatis* in biomicrite. The area of their

distribution is also very limited.

As to the state of preservation, only a slight damage of shell and some erosion of apertural margins and shell surface are observed, but the damage is mostly due to the deformation in rocks after the deposition. This state of preservation may suggest that the nerineid were not so strongly affected by transportation as to break their shell, and their occurrence is probably autochthonous.

WENZ (1938), PCELINCEV (1953) and KABUL (1967) interpreted that the nerineids lived in a turbulent near-reef environment. But no nerineids are found in such facies as conglomeratic limestone which is built by large fragments derived from reefs. This fact suggests an environment near or around reef. Nerineids which have very slender shell or thin test occur even in micritic limestone, indicating a lagoonal environment of calm or slightly agitated condition.

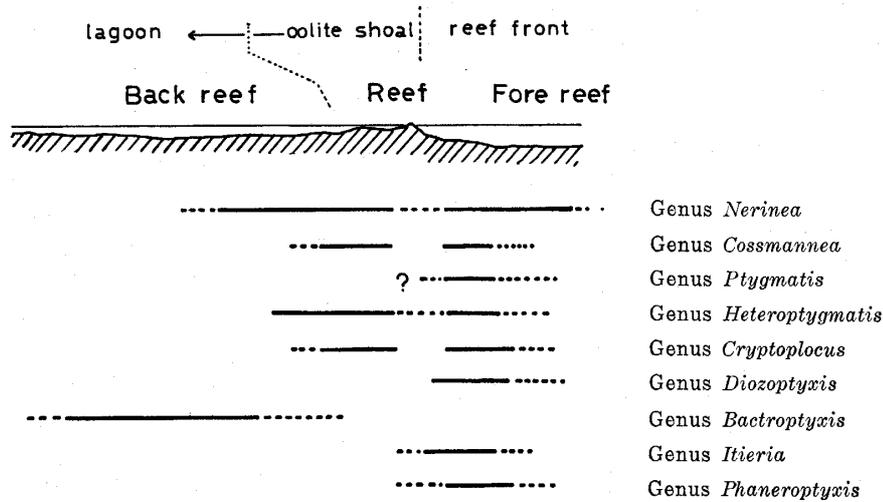
From the junior writer's observation of the litho-facies, the bio-facies, the mode of occurrence of nerineids and their state of preservation, it may be concluded that the habitat of nerineid gastropods is restricted to reef environment and the ecological distribution of the respective genera can be roughly divided into the reef frontal, channel-like, oolite shoal and lagoonal areas. It must be noted that these areas or environments seem to be unfavourable for other kinds of molluscs.

Here the characteristic condition for nerineids occurrence is described. *Nerinea* is common in every rock-facies, from the biomicrite which may suggest the lagoonal facies to the biosparite containing arenite-sized debris, which may suggest the fairly off-shore facies of reef front.

Bactroptyxis, with very slender shell, is restricted in biomicrite which seems to have been deposited in a somewhat calm lagoonal environment. *Nerinea*, with thin test, is also associated with this facies. These nerineids probably could not adapt themselves to a much agitated environment, and the morphological character of these shells seems to be fit to a calm environment. On the other hand, their internal structure is not related to the environmental condition, as recognized especially in *Bactroptyxis* which has more complicated internal folds than other genera of nerineids which may live in a more agitated condition.

Cryptoplocus, *Cossmannea*, *Ptygmatis* and *Heteroptygmatiss* are common in oosparite to biosparite and might have lived in reef channel-like or oolite shoal environment, but *Itieriids* seem to have lived in more special and restricted conditions than other genera of nerineids, e. g., *Itieria* is found in coral reef environment.

The ecological distributions of the above mentioned genera are summarized in Text-fig. 10; a model environment is presumed from the litho-facies of the Jurasso-Cretaceous nerineids-bearing formations. Reef and the surrounding rock facies of Late Jurassic of Japan suggest the sedimentary



Text-fig. 10. Ecological distribution of nerineids genera in Japan.

environment very similar to the recent tropical reef region of shallow sea far from shore, where the muddy bottom is predominant.

Geological and geographical distributions of Japanese Nerineids

The ranges of some nerineid genera are as follow:

<i>Nerinea</i>	Lias to Senonian
<i>Cossmanea</i>	Callovian to Tithonian
<i>Ptygmatis</i>	Bathonian to Barremian
<i>Cryptoplocus</i>	Rauracian to Tithonian
* <i>Diozoptyxis</i>	Tithonian to early Aptian
<i>Nerinella</i>	Lias to Senonian
<i>Bactroptyxis</i>	Bajocian to Kimmeridgian
<i>Itieria</i>	Callovian to Valanginian
<i>Phaneroptyxis</i>	Bathonian to Barremian

The above ranges suggest that the nerineid fauna of the Sôma-Torinosu limestone, accompanied by ammonites and pelecypods must be Upper Jurassic Oxfordian to Kimmeridgian in age.

Bactroptyxis disappears in Kimmeridgian, and *Cossmanea* and *Cryptoplocus* are absent in the formations younger than Jurassic, but other genera have a wider range of chronological distribution, from Middle Jurassic to Lower Cretaceous.

Geological and geographical distributions of Japanese nerineids are summarized in Text-fig. 1, and Table 1.

* The limestone that yields *Diozoptyxis hidakaensis*, belonging to the Sorachi series, is said to correspond to late Aptian to middle Albian, on the basis of occurrence of *Parahoplites* in lower horizon, and of *Oxitropidoceras* in upper horizon. (MATSUMOTO, 1967)

Fossil nerineids are known in various parts of the world, and many genera and species have been reported from Jurassic-Cretaceous sediments of Europe, Crimea, Caucasus and America.

About 25 nerineid species belonging to 10 genera are found in Japan, although all genera except for *Nerinea* are represented by only a few species.

In Jurassic of Japan, more than 20 species of nerineids are found from the so-called Torinosu limestone, intercalated in several horizons of the Torinosu and Sôma groups, extending from the Outer Zone of Southwest Japan to the northern region of the Abukuma mountainland.

The Torinosu group is a sedimentary complex deposited during the period from Callovian to Tithonian, and its depositional belt of predominantly muddy sediments under the shallow warm current has been called the Torinosu Sea.

The Jurassic nerineids do not suggest the distributional patterns of other marine organisms which are most abundant and diversified in the belt of Torinosu and Sôma groups, i. e., pelecypods*, reef-building corals and stromatoporoids, and they are represented only by the Sôma area of Northeast Japan and the Sakawa-Sakamoto areas of the Outer Zone of Southwest Japan (see Table 2).

Table 2. Correlation table of nerineids bearing Sôma-Torinosu Jurassics.

	Area	Outer Zone of S.W. Japan		N.E. Japan		
		Sakamoto	Sakawa	Sôma		
Upper Jurassic	Berriasian	Uminoura f.		Yamanokami f.		
	Tithonian	Sakamoto f.	upper +	Torinosu G.	Kambaradani sh f.	Koyamada f.
	Kimmeridgian				Kambaradani ss f.	Tomisawa f.
					Irezumisawa f.	Nakanosawa f. ⁺
	Oxfordian				lower	Yatsuji f. +
		+ Tsukadani f.	? Yamagami f.			
Middle Jurassic	Callovian					
	Bathonian	Tsurubami f.	Naradani f.		Awazu f.	
	Bajocian	? _____	? _____		Hatsuno f.	

+ occurrence position of nerineid gastropods.

The Sôma area yields such nerineids as *Nerinea somaensis*, *N. koikensis*, *Heteroptygmatitis subpyramidalis*, *H. fukushimensis*, *H. elegans*, *Cryptoplocus abukumensis*, *Cossmannia tahoto*, *Bactroptyxis nobilis* and some indetermined

* According to HAYAMI (1961), most of pelecypods are important facies-indicators in normal sedimentary environment, and significant from the paleogeographical point of view.

species of *Nerinea*, *Nerinella* and *Aptyxiella*.

Nerineids in the Sakamoto and Sakawa areas comprise many species comparable with and related to those of the Sôma area, namely, *Nerinea higoensis*, *Cryptoplocus phalloides* and *Cossmannea* sp. of the Sakamoto area, and *Nerinea sugiyamai* of Sakawa area. Besides these species, *Itieria japonica* occurs in both areas and *Phaneroptyxis sakamotoensis* and *Ptygmatis yabei* in the Sakamoto area.

Although the generic composition of Jurassic nerineids suggest that the Torinosu Sea of the Late Jurassic period must have been under the similar condition belonging to the related paleogeographical province, some environmental difference seems to exist between the Sôma and Torinosu groups, judging from the characteristic occurrence of *Bactroptyxis nobilis* in the Sôma area and *Itieria japonica* in the Sakawa-Torinosu areas, and also from the paleogeographical discontinuity in Central Japan where no nerineids have hitherto been known.

The paleoenvironmental and paleogeographical subdivision, based on the assemblage of Jurassic pelecypods, have been fully discussed by TAMURA (1961a) and HAYAMI (1961).

On the other hand, the Jurassic nerineids from the Sôma-Torinosu group include some comparable forms of species noted by COSSMANN and others from western Europe, as listed below:

Japanese species	Similar European species
<i>Nerinea higoensis</i>	<i>Nerinea bernardiana</i> D'ORBIGNY
<i>Nerinea sugiyamai</i> (<i>Nerinea somaensis</i>)	<i>Nerinea tuberculosa</i> ROEMER
<i>Cossmannea tahoto</i>	<i>Cossmannea desvoydi</i> (D'ORBIGNY)
<i>Ptygmatis yabei</i>	<i>Ptygmatis pseudobruntrutana</i> (GEMMELLARO)
<i>Cryptoplocus abukumaensis</i>	<i>Cryptoplocus depressus</i> (VOLTZ)
<i>Itieria japonica</i>	<i>Itieria cabanetiana</i> (D'ORBIGNY)

Some comparable species are found also in Caucasus and Crimea.

Once, HAYAMI (1961) pointed out the Sôma-Torinosu pelecypods fauna as the migrants of many characteristic genera and species of the pacific region with some Tethyan elements. Nerineids in the Sôma-Torinosu group suggest a close relationship with the shallow sea of Tethyan to Northwest European provinces.

Cretaceous nerineids have been reported from Hokkaido, from southern Kitakami region of Northeast Japan, and from northwestern Kyushu, but their relationship with Jurassic ones cannot be discussed here, because of their poor preservation and sporadic distribution, as well as our meagre knowledge of lower Cretaceous nerineids.

The sporadic distribution of Cretaceous nerineids is probably due to the scarcity of reefal environments under the warm current, like the one represented by the Torinosu Sea or the Urgonian facies which seems much more favourable for nerineids. But the local occurrence of Barremian-Hauterivian nerineids from the neritic calcareous sandy facies in southern Kitakami region may indicate a restricted sedimentary basin somewhat different from the younger basin of the Miyako and Hidaka district, which represents the Aptian-Urgonian facies of Japan.

Conclusion

1. In the process of the research of Japanese nerineid fossils, the writers discriminated more than twenty-four species, belonging to ten genera, from the Jurassic and Cretaceous formations of central Hokkaido, Kitakami, Sôma, Sakawa and Sakamoto (Tanoura) districts. They were usually found in lenticular limestone and limy units of sandy facies. Their geological and geographical distributions are discussed, based mainly on many previous works and the junior writer's field observation. The result is shown in Text-fig. 1 and Table 1.

2. Nerineid fossils are most abundant in the Late Jurassic Sôma and Torinosu groups. They comprise about nineteen species and nine genera, and characterized by the occurrence of related species of *Nerinea*, i. e., *Nerinea higoensis*, *N. sugiyamai* and *N. somaensis*.

Nerineids are relatively rare in the Cretaceous formations of Hokkaido, Kitakami and northwestern Kyushu.

3. Habitats of the Japanese nerineids seem to be restricted in warm shallow sea, like a reef environment, and the ecological distribution of the respective genera may be roughly divided into reef frontal, channel-like, oolite shoal and lagoonal areas. The division is based mainly on the field observation of the mode of occurrence and state of preservation of fossils, the relationship between litho-facies and bio-facies, as well as general lithology. The result is summarized in Text-fig. 10.

4. Just like pelecypods, gastropods and corals, Japanese nerineids are very important for paleogeographical consideration of Jurassic-Cretaceous period, as Japan is situated at the eastern end of the Tethyan province and borders on the Pacific region.

Generic composition of the Japanese nerineids is diverse as in Europe, and many species comparable to the Tethyan and west European provinces are recognized. Several characteristic European genera, which are rare in other regions, are found in Japan.

5. The writers have been studying the systematic position of the Japanese nerineids, but their origins and evolutionary trend remain undecided.

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Explanation of Plate 3

Figs. 1-5. *Nerinea higoensis*, sp. nov.

1. Syntype GIYU-M-23, axial section $\times 1$.
2. Syntype GIYU-M-24, weathered surface of apical part $\times 1$.
3. Syntype GIYU-M-21, axial section $\times 1$.
4. Syntype GIYU-M-22, ditto $\times 1$.
5. Syntype GIYU-M-25, ditto $\times 1$.

Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Figs. 6, 7. *Nerinea somaensis*, sp. nov.

6. Syntype-M-GIYU 38, apertural view of internal mold $\times 1$.
7. Syntype-M-GIYU 37, axial section $\times 1$.

Loc. no. 7a; Koike limestone member of Nakanosawa formation at Koike, Kashima-machi, Sôma-shi, Fukushima Prefecture.

Fig. 8. *Nerinea koikensis*, sp. nov.

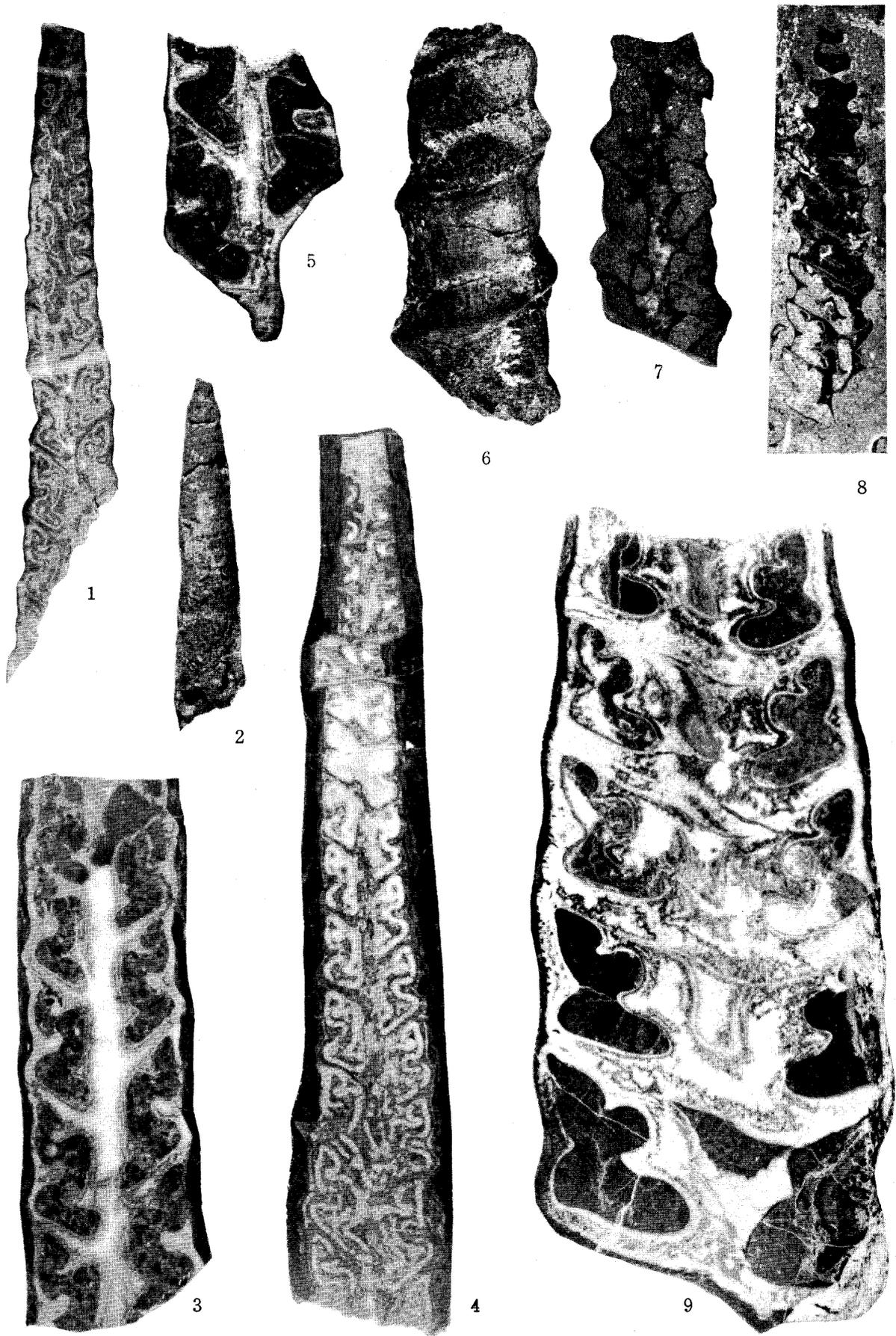
Holotype GIYU-M-103, axial section $\times 1.5$.

Loc. no. 7a; Koike limestone member of Nakanosawa formation at Koike, Kashima-machi, Sôma-shi, Fukushima Prefecture.

Fig. 9. *Diozoptyxis hidakaensis* (FUKADA)

Topotype GIYU-M-87, axial section $\times 1$.

Loc. no. 1; lower Ammonite bed of Sorachi series at Sôshubetsu, Shime-Kapp-mura, Yûhutsu-gun, Hikada, Hokkaido.



YUI photo.

Explanation of Plate 4

Figs. 1-3. *Nerinea shiidai*, sp. nov.

1. Syntype GIYU-M-46, axial section.

2. Syntype GIYU-M-47, ditto.

3. Syntype GIYU-M-44, dorsal view.

Loc. no. 4; middle part of Ôshima formation at Yokonuma, Rikuzen-Ôshima Island, Kesenuma-shi, Iwate Prefecture.

Figs. 4-6. *Nerinea rigida* NAGAO

4-6. Topotype GIYU-M-89, 90, 91, dorsal views and axial section.

Loc. no. 2; calcareous sandstone bed of Hiraiga formation at north of Hiraiga, Shimohei-gun, Iwate Prefecture.

Figs. 7, 8. *Nerinea naumanni* SUGIYAMA & ASAO

7. Topotype GIYU-M-95, axial section.

8. Topotype GIYU-M-96, axial section of apical part.

Loc. no. 8a; Torinosu-limestone lens of Yatsuji formation at Kamimitsuki, Sakawa-cho, Takaoka-gun, Kôchi Prefecture.

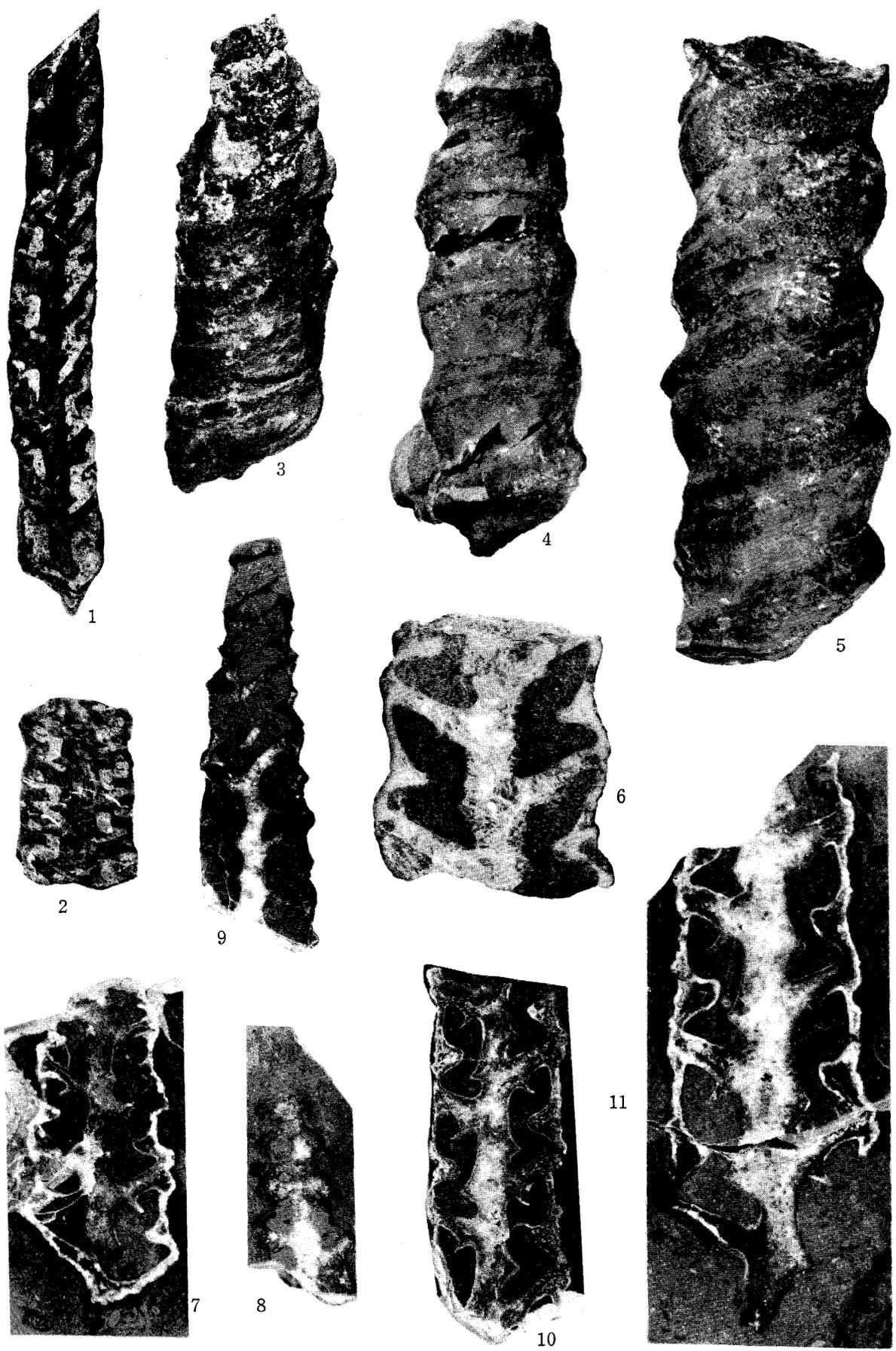
Figs. 9-11. *Nerinea sugiyamai*, nom. nov.

9. Syntype GIYU-M-99, axial section of apical part.

10, 11. Syntype GIYU-M-98, 100, axial section.

Loc. no. 8a; Torinosu-limestone lens of Yatsuji formation at Kamimitsuki, Sakawa-cho, Takaoka-gun, Kôchi Prefecture.

—All in natural size—



YUI photo.

Explanation of Plate 5

Fig. 1. *Nerinea* sp. indet.

GIYU 40, axial section $\times 1$.

Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Figs. 2-4. *Cryptoplocus phalloides*, sp. nov.

2. Syntype GIYU-M-59, axial section of basal part $\times 1$.

3. Ditto, axial section $\times 0.71$.

4. Syntype GIYU-M-60, axial section of apical part $\times 1$.

Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Fig. 5. *Cryptoplocus abukumensis*, sp. nov.

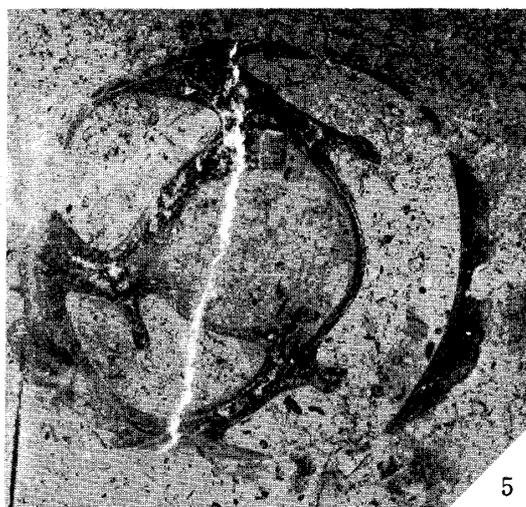
Syntype GIYU-M-59, transverse section of near base $\times 1$.

Loc. no. 7c; Koike limestone member of Nakanosawa formation at Tochikubo, Kashima-machi, Sôma-shi, Fukushima Prefecture.

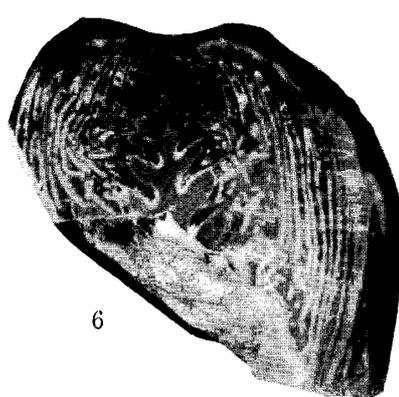
Fig. 6. *Itieria* cf. *japonica* SHIKAMA & YUI

GIYU-M-104, axial section of apical part $\times 1$.

Loc. no. 8b; a quarry of Torinosu-limestone of Yatsuji formation at Shimomitsuki, Sakawa-cho, Takaoka-gun, Kôchi Prefecture.



5



6



4



2



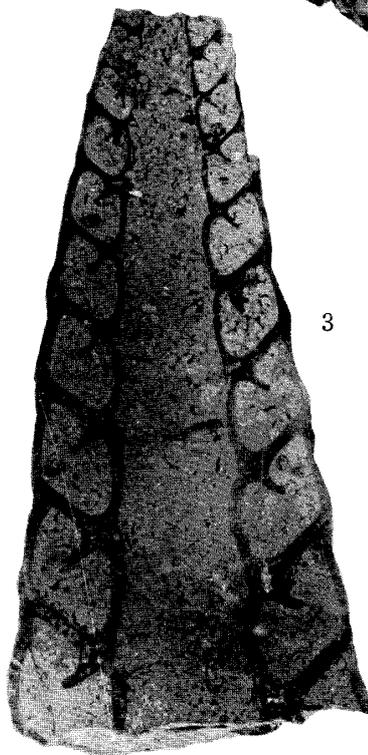
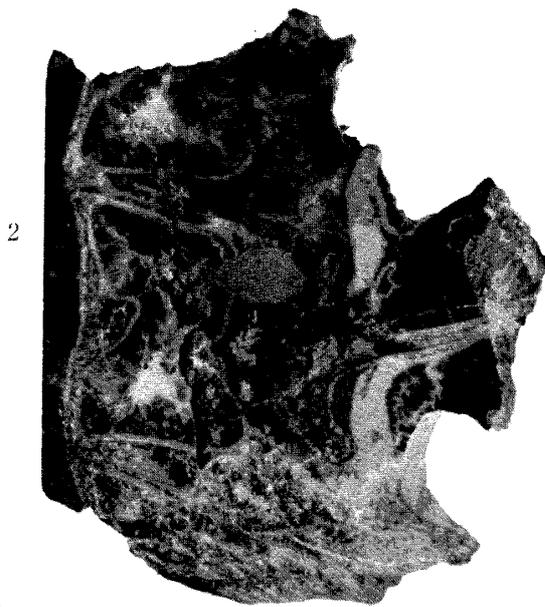
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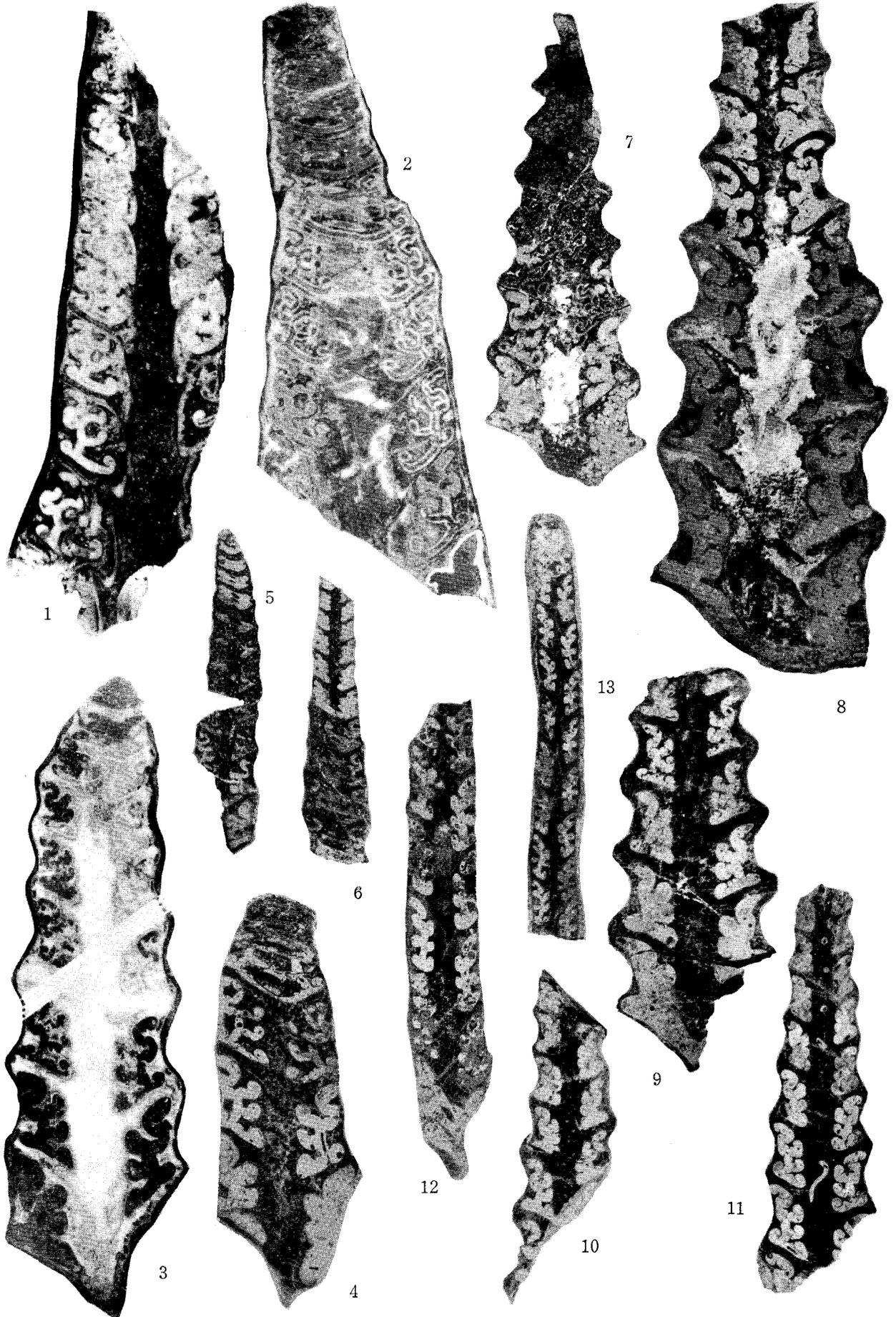
Explanation of Plate 6

- Fig. 1. *Cossmannea tahoto*, sp. nov.
Syntype GIYU-M-41, axial section $\times 1$.
Loc. no. 7b; Koike limestone member of Nakanosawa formation at Koyamada,
Kashima-machi, Sôma-shi, Fukushima Prefecture.
- Fig. 2. *Cossmannea* sp. indet.
GIYU-M-44, axial section $\times 1$.
Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki,
Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.
- Figs. 3-5. *Cryptoplocus abukumensis*, sp. nov.
3. Syntype GIYU-M-46, axial section $\times 1$.
Loc. no. 7b; Koike limestone member of Nakanosawa formation at Koyamada,
Kashima-machi, Sôma-shi, Fukushima Prefecture.
4. Syntype GIYU-M-45, axial section $\times 1$.
Loc. no. 7b; *ibid*.
5. Syntype GIYU-M-47, basal view $\times 1$.
Loc. no. 7c; Tochikubo, Kashima-machi, Sôma-shi, Fukushima Prefecture.



Explanation of Plate 7

- Figs. 1, 2. *Ptygmatis yabei*, sp. nov.
1. Syntype GIYU-M-62, axial section $\times 1$.
2. Syntype GIYU-M-63, axial section (slightly diagonal) $\times 1$.
Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.
- Fig. 3. *Heteroptygmatitis orientalis*, gen. & sp. nov.
Holotype GIYU-M-64, axial section $\times 1.5$.
Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.
- Figs. 4-6. *Heteroptygmatitis fukushimensis*, gen. & sp. nov.
4. Syntype GIYU-M-66, axial section of basal part $\times 1.5$.
5. Syntype GIYU-M-68, axial section of apical part $\times 1$.
6. Syntype GIYU-M-67, ditto $\times 1$.
Loc. no. 7a; Koike limestone member of Nakanosawa formation at Koike, Kashima-machi, Sôma-shi, Fukushima Prefecture.
- Figs. 7, 8. *Heteroptygmatitis subpyramidalis*, gen. & sp. nov.
7. Syntype GIYU-M-69, axial section $\times 1$.
8. Syntype GIYU-M-70, axial section of immature shell $\times 1$.
Loc. no. 7b; Koike limestone member of Nakanosawa formation at Koyamada, Kashima-machi, Sôma-shi, Fukushima Prefecture.
- Figs. 9-11. *Heteroptygmatitis elegans*, gen. & sp. nov.
9. Syntype GIYU-M-71, axial section of basal part $\times 1$.
10. Syntype GIYU-M-72, axial section of apical part $\times 1$.
11. Syntype GIYU-M-73, ditto $\times 1.5$.
Loc. no. 7a; Koike limestone member of Nakanosawa formation at Koike, Kashima-machi, Sôma-shi, Fukushima Prefecture.
- Figs. 12, 13. *Bactroptyxis nobilis*, sp. nov.
12. Syntype GIYU-M-74, axial section of basal part $\times 1$.
13. Syntype GIYU-M-75, axial section $\times 1$.
Loc. no. 7a; Koike limestone member of Nakanosawa formation at Koike, Kashima-machi, Soma-shi, Fukushima Prefecture.



Yui photo.

Explanation of Plate 8

Figs. 1-3. *Itieria japonica*, sp. nov.

1a, b. Holotype GIYU-M-76, a. dorsal view, b. apertural view of weathered surface $\times 0.8$.

2. Paratype GIYU-M-77, diagonal section of apical part $\times 1$.

3. Paratype GIYU-M-78, axial section $\times 0.8$.

Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.

Figs. 4, 5. *Phaneroptyxis oshimensis*, sp. nov.

4. Syntype GIYU-M-82, axial section $\times 1$.

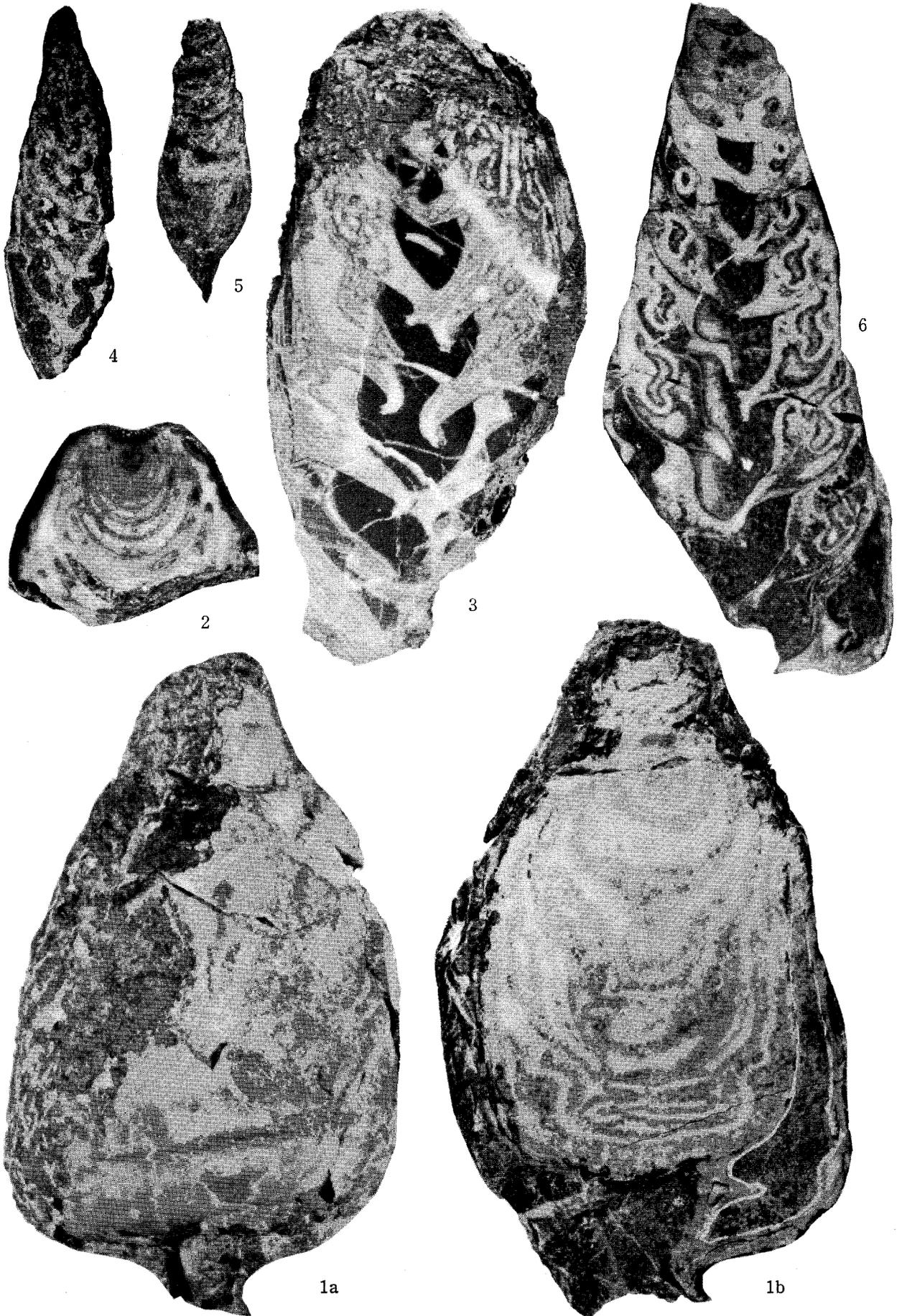
5. Syntype GIYU-M-81, dorsal view $\times 1$.

Loc. no. 4; upper part of Ôshima formation at Yokonuma, Rikuzen-Ôshima Island, Kesenuma-shi, Iwate Prefecture.

Fig. 6. *Phaneroptyxis sakamotoensis*, sp. nov.

Holotype GIYU-M-86, axial section $\times 1$.

Loc. no. 10a; limestone lens of upper Sakamoto formation at Igo-misaki, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture.



YUI photo.