New Middle Miocene Mollusca from the Katsuta Group at Shinden, Tsuyama City, Okayama Prefecture, Southwest Japan. Part 1. Description of *Perna oyamai* sp. nov. and its Paleoecology

By

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with 1 Table, 2 Text-figures and 2 Plates

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ABSTRACT: One interesting mytilid of the genus *Perna* is newly described from the middle Miocene Katsuta group at Shinden, Tsuyama City, Okayama Prefecture, Southwest Japan. The genus is the first record in Japan. This species, named *Perna oyamai*, may have clustered embedded in muddy substrate in the tidal to neritic zone and is considered to be one of representative indicators of tropical environmental conditions in the earliest middle Miocene of Japan.

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I. INTRODUCTION

Since KANEHARA (1900)'s description of *Mytilus* sp., later identified with *M. giganteus* HOLMBERG by HATAI and NISIYAMA (1952), from Shiobara-machi, Shioya-gun, Tochigi Prefecture, many workers have reported the mytilid species from the Miocene Series of Japan. They are as follows: *Mytilus grayanus* DUNKER (YOKOYAMA, 1925a, 1925b), *M. giganteus* HOLMBERG (YOKOYAMA, 1926), *M. crassitesta* LISCHKE (KURODA, 1931), *M. k-sakurai* NOMURA and HATAI (NOMURA and HATAI, 1936; MIZUNO, 1964), *M. tichanovitchi* MAKIYAMA (UOZUMI, 1953, 1966; MATSUNO, TANAKA, MIZUNO and ISHIDA, 1964; KANNO, OHARA and KAITEYA, 1968), *M. coruscus* GOULD (SHIKAMA, 1973; ITOIGAWA, SHIBATA and NISHIMOTO, 1974; ITOIGAWA, SHIBATA, NISHIMOTO and OKUMURA, 1981), *M.* sp. (KANNO and OGAWA, 1964), *M.* sp. (HAYASHI, 1973), *Septifer* (*Mytilisepta*) *agiensis* ITOIGAWA (ITOIGAWA, 1955; ITOIGAWA, SHIBATA and NISHIMOTO, 1974; ITOIGAWA, SHIBATA, NISHIMOTO and OKUMURA, 1981) and *S.* (*M.*) *virgatus* (WIEGMANN) (ITOIGAWA, SHIBATA, NISHIMOTO and OKUMURA, 1981). Among the specific names determined, *crassitesta*, *giganteus* and *k-sakurai* are invalid according to MAKIYAMA (1958), KANNO, OHARA and KAITEYA (1968) and HABE (1977). I also agree to such opinions. Therefore, the former

two and the last species are considered to belong to *coruscus* and *tichanovitchi*, respectively.

As shown in Fig. 1, the Miocene mytilids mentioned above are limited to occur geographically within central Japan and far north. In this paper, a Miocene mytilid is newly and firstly described from the Katsuta group in Tsuyama City, Okayama Prefecture, Southwest Japan and its paleoecology is discussed.

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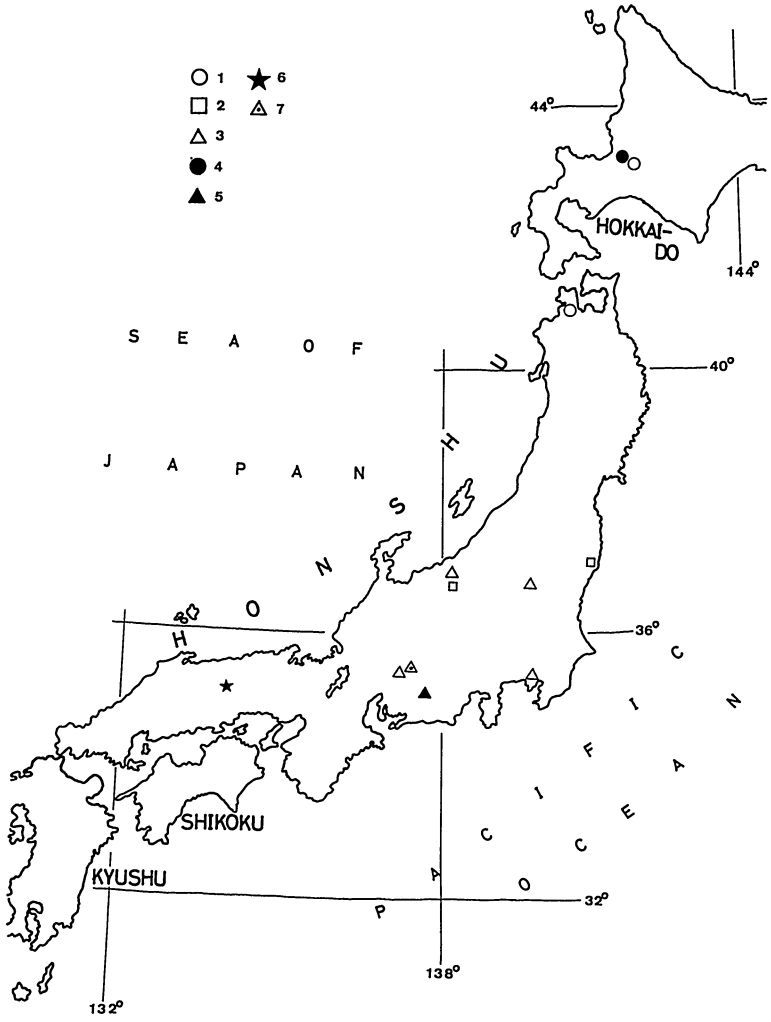

FIG. 1. Distribution of the Miocene mytilids in Japan.

1: *Mytilus tichanovitchi* MAKIYAMA, 2: *M. grayanus* DUNKER, 3: *M. coruscus* GOULD, 4: *M.* sp., 5: *M.* sp., 6: *Perna oyamai* sp. nov., 7: *Septifer* (*Mytilisepta*) *agiensis* ITOIGAWA and *S.* (*M.*) *virgatus* (VIEGMANN).

advice and suggestion. I wish to express my sincere gratitude to Dr. Junji ITOIGAWA, Department of Earth Sciences, Faculty of Science, Nagoya University, for critically reading my manuscript, and to Dr. Katsura OYAMA, Toba Aquarium, for his useful suggestion and kind help. I am especially indebted to Mr. Toshio KANAZAWA, Togoshi Elementary School, for affording me an opportunity to visit Philippines, and to Mr. Tadao OSAFUNE, Katsumada Cultural Properties Protection Commission, for lending precious specimens.

II. LOCALITY AND MATERIAL EXAMINED

A lot of mytilid specimens numbering about a thousand is obtained from Shinden, Tsuyama City, Okayama Prefecture, which is designated as the type locality. The locality (Lat. 35°3′5″N, long. 134°4′1″E) is shown in Fig. 2. Most of the specimens have conjoined valves in a well preservation, although they are more or less deformed or broken. Nine specimens from young to adult state are selected for examination as the type. They are kept in Department of Geology and Mineralogy, Faculty of Science, Hiroshima University, under the registered numbers IGSH-ET 10019–10027.

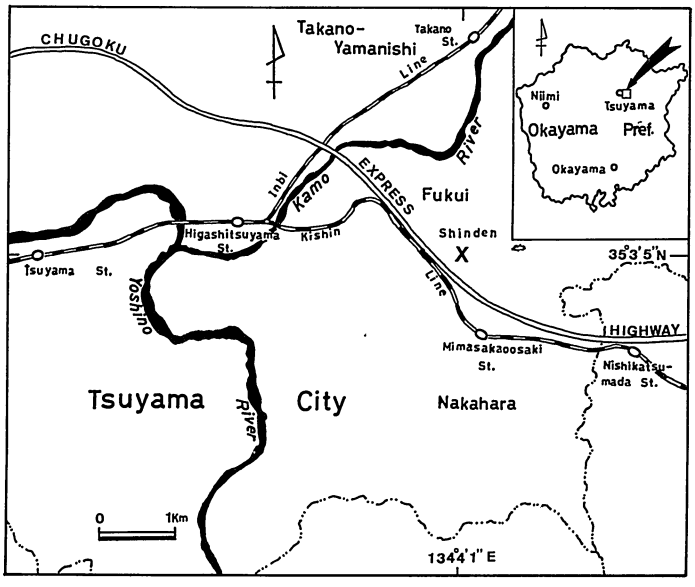

FIG. 2. Fossil locality.

III. DESCRIPTION OF SPECIES

Class Pelecypoda
Subclass Pteriomorphia
Order Mytiloida
Superfamily Mytilacea

Family Mytilidae RAFINESQUE, 1815
Subfamily Mytilinae RAFINESQUE, 1815
Genus *Perna* PHILIPSSON, 1788

Type species: *Perna magellanica* PHILIPSSON, 1788
(=*Mya perna* LINNÉ, 1758); subsequent designation by SOOT-RYEN (1955, p. 29)

Generic examination: According to SOOT-RYEN (1955), genera of mytilids with the pitted resilial ridge are numbered three, namely, *Perna, Mytilus* and *Mytella*; the second has several small teeth, as is seen in *Mytilus edulis* LINNÉ (see present paper, Pl. (8), fig. 3c); the last is characterized by its anterior margin with or without teeth and resilial ridge with the pittings (SOOT-RYEN, 1955, pl. 5, fig. 23); but no detailed account of the first is given.

As a result of an examination of the specimens obtained from Philippines, it is obvious that modern *Perna viridis* (LINNÉ) has a small tooth-like ridge on the resilifer (present paper, Pl. (8), fig. 2c). Such a character is also observed in the fossil specimens examined, as shown in fig. 1c of Pl. (8), and they are thus referred to genus *Perna*.

Perna oyamai sp. nov.
Pl. (8), figs. 1, 4, 5; Pl. (9), figs. 1–6

Diagnosis: Shell large in size, wedge-shaped in young state and elongate ventricose in the adult, moderately thick, more or less swollen; antero-dorsal margin arcuate, passing by obtuse angle into postero-dorsal margin which is broadly rounded but somewhat sinuated anteriorly; posterior end narrowly rounded; ventral margin nearly straight in the younger state, but broadly arcuate or concave in the middle of shell length in the adult; sculpture consisting of regular, smooth concentric lines of growth and irregularly distanced disturbance rings; beak terminal, low, pointed, curved ventrally; main part of the shell from umbo to the posterior end fairly inflated, forming arcuate umbonal ridge; slope of the shell steep ventrally, while making broad wing-like area which is feebly plaited on dorsal side; resilial ridge pitted, with a small, vertical, ventrally situated tooth-like ridge; inner margin smooth.

Dimensions:

Specimen	Length (mm)	Height (mm)	Width (mm)	H/L (%)	W/L (%)
IGSH-ET 10019	ca. 92.2	43.0	22.2+	ca. 64.6	(24.1)
IGSH-ET 10020	138.6+	53.7+	28.8+	(38.7)	(20.7)
IGSH-ET 10021	ca. 74.4	ca. 32.2	19.0	(43.3)	ca. 25.5
IGSH-ET 10022	ca. 66.1	30.8	16.4	ca. 46.6	ca. 24.8
IGSH-ET 10023	ca. 32.6	20.0	10.9	ca. 61.3	ca. 33.4
IGSH-ET 10024	ca. 43.4	ca. 24.4	13.2	(56.2)	ca. 30.4
IGSH-ET 10025	22.5+	ca. 13.6	6.7	(60.4)	(29.8)
IGSH-ET 10026	ca. 84.4	ca. 38.0	ca. 19.7	(44.8)	(23.2)
IGSH-ET 10027	ca. 113.3	48.9–	20.6+	(43.2)	(18.2)

Holotype: IGSH-ET 10019
Paratype: IGSH-ET 10020–10027
Formation: The Yoshino formation of the Katsuta group (KAWAI, 1957)

TABLE 1. STATISTICAL DATA OF MODERN *Perna viridis* (LINNÉ) AND *Mytilus edulis* LINNÉ.

Specific name	Locality	Number of individuals	Height/Length (%) Mean	Height/Length (%) Range	Width/Length (%) Mean	Width/Length (%) Range
Perna viridis	Probably near Cebu island, Philippines	17	41.8	37.3–46.2	24.6	23.0–27.3
Mytilus edulis	Tsutsumigarua, Miyajima-cho, Saeki-gun, Hiroshima Prefecture, Japan	25	55.1	48.7–58.7	40.0	34.2–50.7

Remarks: For the purpose of comparisons, modern *Perna viridis* (LINNÉ) and *Mytilus edulis* LINNÉ are examined statistically as shown in Table 1.

Perna viridis (LINNÉ) living in the lower latitude areas than Philippines such as Indo-Pacific region has an elongate shell with the pitted resilial ridge which has a small, oblique, centrally located tooth-like ridge. In addition, the mean ratio of height to length and of width to length are about 42% and 25%, respectively. The present new species is most akin to *Perna viridis* in having the similar shape in the adult state, the W/L ratio less than ca. 33.4% and a small tooth-like ridge, but is distinguishable therefrom by its higher shell with the lesser angle of wing-like area. This species is related in its edge-shape in the younger state and the H/L mean ratio of nearly 55% and more to *Mytilus edulis* LINNÉ distributed over a shallow sea through the whole world. The former is, however, distinguishable from the latter by having the elongate shape in the adult state, only one tooth-like ridge and the small ratio of width to length (less than ca. 33.4%) in comparison with that of the latter ranging from 34.2 to 50.7%. This is also referred in its shape to *Mytilus chorus* MONILA found in Pacasmayo, Peru, south to Orange Bay, Tierra del Fuego (SOOT-RYEN, 1955, p. 31, text-fig. 5, pl. 2, figs. 7, 8), but the latter differs from the former in its higher shell with the compact resilial ridge and the ventrally arcuate ventral margin.

As for the Miocene mytilids, the present species is distinguishable from *Mytilus conradinus* ORBIGNY (SHIMER and SHROCK, 1949, p. 413, pl. 164, fig. 19) by its higher shell with the shorter antero-dorsal margin and the larger terminal angle.

The specific name is dedicated to Dr. Katsura OYAMA.

IV. REMARKS ON PALEOECOLOGY

In present days the representatives of the family Mytilidae have a wide variety of marine and estuarine habitats. The majority of them attach by means of a strong byssus to firm substrate or live in sandy or soft muddy bottom, and the rests bore in rocks and corals and live a commensal existence embedded in the test of ascidians (WILSON, 1967, p. 279). According to NISHIHIRA (1976, p. 14), for example, *Modiolus demissus* lives embedded in mud, forming a colony, and such a pattern is commonly observed in many mytilid forms.

In the course of the field investigation, I observed that the present new species with conjoined valves from young to adult state is found in the dark grey shale, indicating a dense aggregation, and that they are buried in association with *Vepricardium* sp. and

Tellinella sp. with conjoined valves in a small block. Such a mode of occurrence may represent to be autochthonous in origin. The following molluscs showing autochthonous or semiautochthonous occurrence are associated: *Nipponarca* sp., *Anadara* (*Scapharca*) *abdita, Ostrea denselamellosa, Gari* sp., *Clementia japonica, Lunella* cf. *kurodai, Turritella kiiensis, Vicaryella* spp., *Tateiwaia yamanarii, Terebralia itoigawai, Calyptraea tubura, Euspira meisensis, Sydaphera* sp., *Pugilina sazanami*, etc. Among them, *Terebralia itoigawai* is clearly a tropical element according to HORIKOSHI (1969)'s division of climatic zones of biogeography.

Judging from the ecological information of modern mytilids, the mode of occurrence and the associated forms mentioned above, it is presumed that *Perna oyamai* sp. nov. clustered embedded in muddy substrate in the tidal to neritic zone of tropically conditioned sea.

ITOIGAWA (1978) has synthesized evidence of tropical[1] environment and discussed paleogeography and paleoenvironment in the middle Miocene of Japan. According to him, such fauna and flora as some kind of molluscs, *Aturia*, reef corals, a chelonia, some plants, an insect and others are indicators of tropical environment. Of molluscs, many are at present known as representative of tropical evidence (ITOIGAWA, 1978; OKAMOTO *et al.*, 1978; MATSUOKA, 1979; TAGUCHI *et al.*, 1979; TAGUCHI, 1981; TSUDA, ITOIGAWA and YAMANOI, 1981). They are, for example, as follows: *Isognomon, Maoricardium, Geloina, Batissa, Periglypta, Tectus, Tibia, "Cypraea", Chicoreus* (*Rhizophorimurex*), *Mitra, Oliva, "Conus", "Terebra", Ellobium* and Turridae. These are found concentrated in the horizon ranging from 16 to 15Ma of the earliest middle Miocene of Japan (TSUCHI ed., 1982).

Among the Miocene mytilids, four species have the smooth shell surface, occurring at the horizon mentioned above, and their climatic conditions are described in the following lines. *Mytilus* sp. reported by KANNO and OGAWA (1964) from the Takinoue formation in Takinoue district, Hokkaido, may have lived in a shallow, cold to temperate water. Such an environment is inferred from the ecology of its associated form, *Swiftpecten swiftii* which is distributed from Tohoku district to Alaska in a modern euneritic sea. ITOIGAWA, SHIBATA and NISHIMOTO (1974) first described *Mytilus coruscus* GOULD from several horizons of the Mizunami group, Gifu Prefecture. Based on the ecology of the recent equivalent living in an euneritic sea from Kyushu to South Hokkaido, it is presumed that the fossil species is a temperate to subtropical, shallow water dweller. HAYASHI (1973) reported *Mytilus* sp. from the Nagashino formation in Shidara-gun, Aichi Prefecture. The formation may be settled in the horizon under discussion, judging from such associated forms as *Meretrix* cf. *ogurai, Glycymeris cisshuensis, Ostrea gravitesta, Dosinia kawagensis, Hiatula minoensis, Mya cuneiformis, Modiolus* sp., *Chlamys minoensis, Chlamys iwamuraensis, Ctena minoensis* and *Kawia minoensis*, among which many, if not all, are originally described by ITOIGAWA (1955, 1960) from the Mizunami group. The association may represent a similar environmental conditions to that of the fossil *Mytilus coruscus*. As already mentioned, *Perna oyamai* sp. nov. probably has a shallow sea habitat in the tropical region. Accordingly, a climatic difference among habitats of the mytilids is recognized geographically and latitudinally, and the present new species is the warmest water form.

This conclusion, so far as the mytilids with the smooth shell surface are concerned,

1) In this paper, the word "tropical" is used instead of the word "subtropical", judging from HORIKOSHI (1969).

may clarify that only *Perna oyamai* is added in tropical evidence in the earliest middle Miocene of Japan ranging from 16 to 15Ma.

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EXPLANATION OF PLATE VIII

(All figures in natural size, unless otherwise stated)

Figs. 1, 4, 5. *Perna oyamai* sp. nov.
1a, b: Holotype, IGSH-ET 10019, 1c: Paratype, IGSH-ET 10027, 4: Paratype, IGSH-ET 10022, 5: Paratype, IGSH-ET 10024, 1a, 4a, 5a: lateral view, 1b, 4b, 5b: ventral view, 1c: internal view of hinge area, ×2.

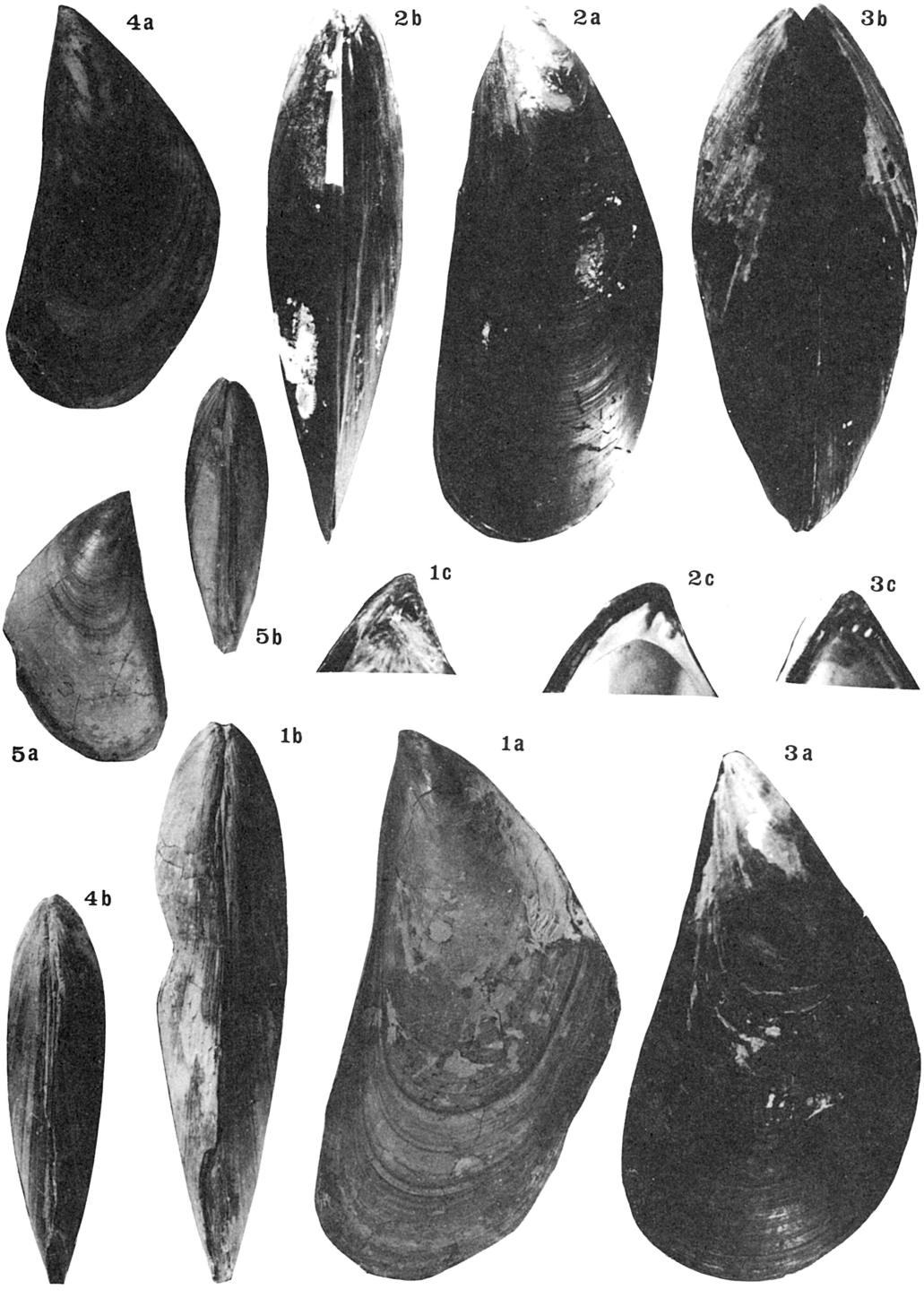
Fig. 2. *Perna viridis* (LINNÉ)
2a: lateral view, 2b: ventral view, 2c: internal view of hinge area, ×2.

Fig. 3. *Mytilus edulis* LINNÉ
3a: lateral view, 3b: ventral view, 3c: internal view of hinge area, ×2.

EXPLANATION OF PLATE IX

(All figures in natural size)

Figs. 1–6. *Perna oyamai* sp. nov.
1: Paratype, IGSH-ET 10026, 2: Paratype, IGSH-ET 10023,
3: Paratype, IGSH-ET 10021, 4: Paratype, IGSH-ET 10027,
5: Paratype, IGSH-ET 10025, 6: Paratype, IGSH-ET 10020,
1a, 2a, 3a, 4, 5a, 6b: lateral view, 1b, 2b, 3b, 5b, 6a: ventral view.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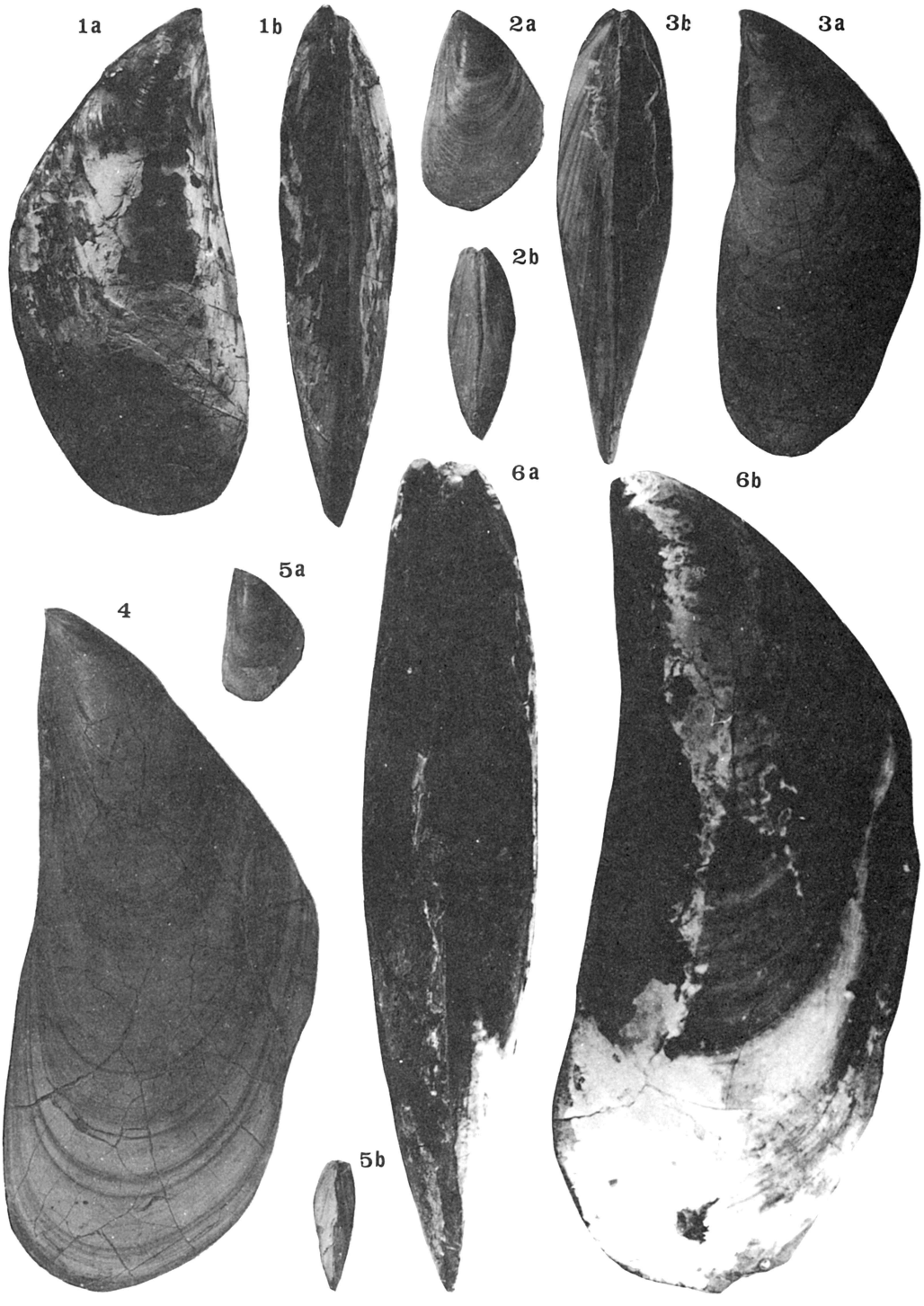
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