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The Hauterivian ammonite and its accompanying bivalve fauna of the Ofunato Group, northeast Japan

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下部白亜系大船渡層群のアンモナイトと二枚貝化石群集

松川正樹 *・柴田健一郎 **・白土　豊 ***

キーワード: ***Balearites* sp.，汽水性二枚貝化石，海底扇状地堆積物，異地性化石，船河原層，失われた船河原層相当層**

Key words: ***Balearites* sp., brackish fossil bivalves, submarine fan deposits, allochthonous occurrences, Funagawara Formation, lost equivalent Funagawara Formation**

The Lower Cretaceous Funagawara Formation of the Ofunato Group, northeast Japan, consists of turbidite sandstones, subaqueous debris flow deposits, and hemi-pelagic mudstones. An ammonite specimen from the Funagawara Formation is described as *Balearites* sp. The *Balearites* sp. Biostratigraphic Horizon is established and it correlates with the *Balearites balearis* Zone of the upper Hauterivian Stage of the Lower Cretaceous ammonite standard zonation for the West Mediterranean Province of the Tethyan Realm. The Funagawara Formation can be assigned to the upper Hauterivian. Bivalve fossil specimens from the Group comprise 19 species of 19 genera, and are described in this paper. A total of 37 species of 29 genera of bivalve fossil specimens show characteristics similar to those of the shallow-marine to brackish-water bivalve faunas of the Lower Cretaceous in the Outer Zone of Southwest Japan. These bivalve fossils are allochthonous, as evidenced by the destruction of shells and the occurrence of single valves. They are thought to have been transported secondarily from shallow-marine to brackish sediments equivalent to the Funagawara Formation.

岩手県南部に分布する大船渡層群船河原層はタービダイト砂岩，水中土石流堆積物，半遠洋性泥岩からなる。船河原層から産出したアンモナイトを *Balearites* sp. として記載した。*Balearites* sp. 生層序層準が設定され，テチス区の西地中海地方の下部白亜系アンモナイト標準生層序帯の *Balearites balearis* 帯 (上部オーテリビアン) に対比される。したがって，船河原層は上部オーテリビアンに対比される。大船渡層群から 19 属 19 種の二枚貝化石を識別し，古生物学的に記載した。合計で 29 属 37 種の二枚貝化石の産出が大船渡層群から認められ，それらは西南日本外帯の下部白亜系における浅海～汽水性の二枚貝動物群の特徴を示す。二枚貝化石は破壊され，離弁した状態で産出するため，異地性を示す。これらの二枚貝化石は，船河原層と同時代の浅海～汽水成堆積物から二次的に供給されたと考えられる。

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INTRODUCTION

The Lower Cretaceous shallow-marine strata that contain ammonites is distributed discontinuously from north to south in Japan. Since these ammonites can used to establish an ammonite zonation in the Lower Cretaceous stages for the circum-northern Pacific rim, it is necessary to carefully identify and describe paleontologically these ammonites.

The Ofunato Group is narrowly distributed in northeast Japan, and contains ammonites and bivalves. The ammonites have been identified as *Crioceratites* (*C.*) *ishiwarai* and *Holcodiscus* sp., and the Group has been assigned to Hauterivian to Barremian (Obata and Matsumoto, 1977; Matsumoto *et al*., 1982). However, descriptions and illustrations of these specimens were not exhibited yet. Bivalves from the Group were described and were regarded as consistent with the representative these ages (Kozai, 1986; Kozai and Tashiro, 1993). Among the bivalve fossil specimens from the Ofunato Group housed at the Ofunato City Museum are some undescribed species.

In this paper, we re-study and describe the ammonite specimen considered as *Crioceratites* (*C.*) *ishiwarai*, and also describe some bivalve species that were not described by Kozai (1986) and Kozai and Tashiro (1993). The geological age of the Ofunato Group is clarified based on the ammonite described, and the species composition and characteristics of the bivalve fauna are shown. Some of the Lower Cretaceous shallow-marine strata in the Japanese archipelago have been subjected to sedimentary studies, and basin development based on paleoenvironment analyzes and their causes have been discussed (e.g., Ito and Matsukawa, 1997). For the Ofunato Group, no such studies have been published, thus we analyze here the depositional environments of the Group.

GEOLOGICAL OVERVIEW OF THE OFUNATO GROUP

The Cretaceous strata consisting of volcanic conglomerates, tuff breccias, tuffs, conglomerates, sandstones, alternating beds of sandstone and mudstone, and mudstones surround the Ofunato Bay. These strata were lithostratigraphically divided into the Ofunato Group, Massaki Group, Hakoneyama conglomerate Formation (Seki and Imaizumi, 1941), and the Ofunato Group (Onuki and Mori, 1961). According to the recent Kawamura and Uchino (2023), the Cretaceous strata are divided into the eastern, central, and western zones, each of which has its own lithostratigraphic division (Fig. 1). In the eastern zone, the lower Ryori Formation is composed of pyroclastic rocks, with sandstone layers occurring in the middle, and the upper Attari Formation is composed tuff, sandstone, and mudstone. In the western zone, the Cretaceous strata unconformably cover the Lower Triassic strata, and are composed of clastic rocks consisting of conglomerates, sandstones, and mudstones in the lower and middle parts, and of predominantly pyroclastic rocks in the upper part. The strata are divided into the Hakoneyama, Funagawara, Hijochi, and Kobosoura formations in stratigraphically ascending order. This stratigraphy is often observed at Yamamagoe along the Suzaki River in Ofunato City (Figs. 2 and 3). The Cretaceous strata in the central zone are undivided layers. Ammonite occurred in the middle part of the Funagawara Formation at Yamamagoe in the western zone. Bivalve fossils were found in the Attari Formation in the eastern zone, undivided layers in the central zone, and the Funagawara and Hijochi formations in the western zone. The bivalves from the Funagawara Formation were described by Kozai (1986) and Kozai and Tashiro (1993). However, for ammonites, only a taxonomic list is shown. Kawamura and Uchino (2023) divided the Cretaceous strata in the western part as the Ofunato Group, and separated the strata in the central and eastern parts from the Ofunato Group, but they did not clearly state the reason for this division. The bivalve fossil assemblages from the western, central and eastern parts that they divided are common to the shallow-marine to brackish assemblages from areas of the outer zone of southwestern Japan, and belong to the same paleobiogeographic province. Accordingly, we follow Onuki and Mori (1961), who classify the Cretaceous strata in whole area as belonging to the Ofunato Group.

SEDIMENTARY ENVIRONMENTS

In order to reveal the sedimentary processes,

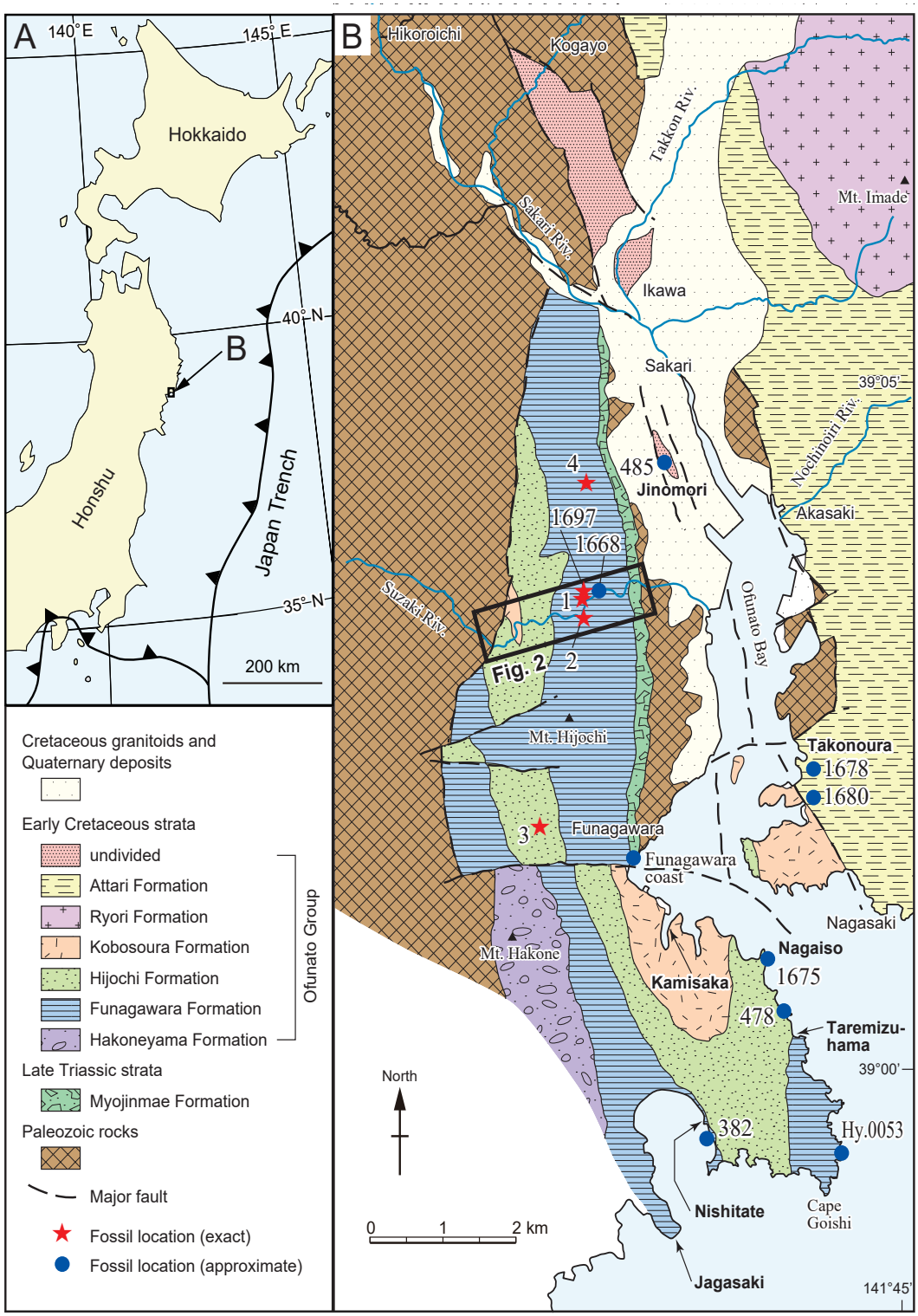

Fig. 1 A: Index map of Ofunato Bay. B: Geologic map around Ofunato Bay. Fossil locations are indicated by red stars for exact locations and blue solid circles for approximate locations. Location numbers 1, 2, 3 and 4 follow Kozai (1986) and Kozai and Tashiro (1993), and Hy0053 follows Hayami (1966). Geological map is based on Kawamura and Uchino (2023).

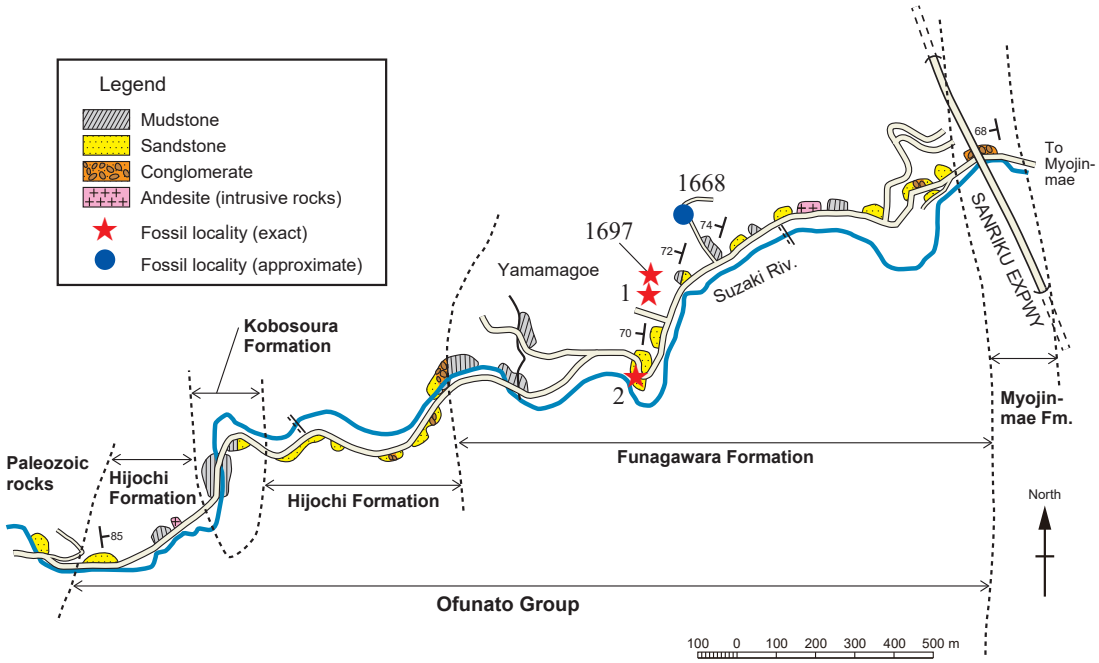

Fig. 2 Investigated route of the Suzaki River (Yamamagoe), Ofunato City. Stratigraphic divisions are after Kawamura and Uchino (2023).

environments, and basin development of the Ofunato Group, a facies analysis was conducted using well-exposed outcrops across five investigated routes and areas: the Suzaki River route (Yamamagoe), Nishitate, Taremizuhama, Kamisaka in Ofunato City, and Jagasaki in Rikuzentakata City, Iwate Prefecture (Fig. 1).

1) Facies and sedimentary processes of the Funagawara Formation

The Funagawara Formation mainly consists of mudstones, sandstones, and conglomerates, and locally includes intrusive andesites. This study identified three types of lithofacies within the Funagawara Formation, based on sedimentary structures and secondary deformed structures. The data for this analysis were collected from the Suzaki River route (Yamamagoe), Nishitate, and Taremizuhama in Ofunato City, and Jagasaki in Rikuzentakata City (Figs. 4 and 5).

Lithofacies A

Description: Lithofacies A comprises very coarse- to very fine-grained sandstones that locally include conglomerates. The thicknesses of these deposits range from 1 cm to 140 cm. The basal surfaces are sharp and erosional. The erosional surfaces locally exhibit concave-up, channel-like forms. The sandstones generally show an upward-fining trend (Fig. 5A), although sandstones with upward-coarsening trends are locally observed. Planar parallel lamination and current ripple cross-lamination (Fig. 4B, C) are common in association with convoluted lamination. In addition, black mudstone clasts with oval or indistinct shapes are locally found within the sandstones (Fig. 5). Stacked sets of lithofacies A form conspicuous thick sandstone layers exceeding 3.5 m in thickness. Lithofacies A is found in Nishitate and Taremizuhama in Ofunato City, and Jagasaki in Rikuzentakata City.

Interpretation: Upward-fining trends are indicative of deposition from waning flows (Pettijohn, 1975; Stow, 2005). The presence of parallel lamination suggests the accumulation of plane beds developed under either lower or upper flow regime (Southard and Boguchwal, 1990). Current ripple cross-lamination suggests the migration of current ripples due to unidirectional flows (Southard and Boguchwal, 1990), and convoluted lamination is interpreted as deformed current ripple cross-lamination,

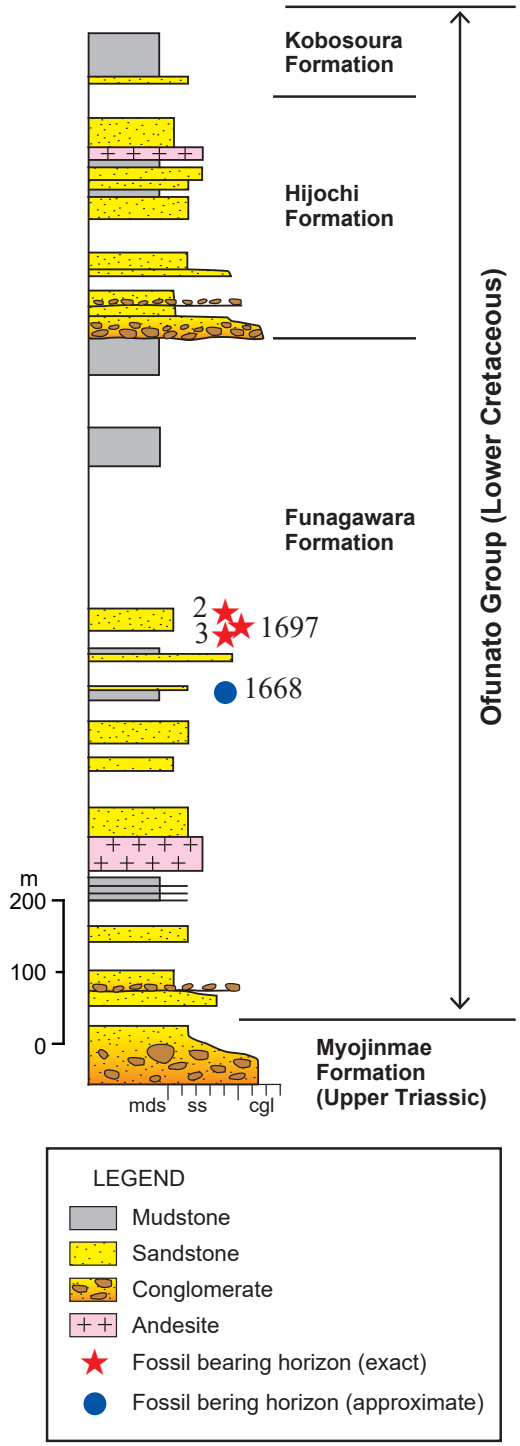

Fig. 3 Columnar section of the Ofunato Group at Suzaki River (Yamamagoe) route, Ofunato City. Stratigraphic divisions are after Kawamura and Uchino (2023).

which occurs in response to pressures within the current or the upward release of pressures (Dzulynski and Smith, 1963; Stow, 2005). Black mudstone clasts are considered to have been eroded and transported from muddy deposits located in proximal settings before accumulating in the sandstones (Pettijohn, 1975). These sedimentary structures, such as erosional basal surfaces, upward-fining trends, planar parallel lamination, current ripple cross-lamination, and convoluted lamination, along with inclusion of mud clasts, are all indicative of turbidites (Bouma, 1962; Lowe, 1982). Based on these features, lithofacies A can be interpreted as turbidite sandstones.

Lithofacies B

Description: Lithofacies B consists of matrix-supported, pebble to boulder-sized conglomerates. The matrix is composed of black mudstones. Thickness is about 1 m. Lithofacies B can be observed in Jagasaki, Rikuzentakata City.

Interpretation: The mudstone matrix indicates that the dominant grain support mechanism was primarily pore pressure, buoyancy, and matrix strength (Mulder and Alexander, 2001). In addition, the absence of sedimentary structures formed from traction loads, such as parallel and cross-lamination, suggests deposition by laminar flow. Therefore, Lithofacies B is interpreted as debris-flow deposits (Middleton and Hampton, 1976; Mulder and Alexander, 2001).

Lithofacies C

Description: Lithofacies C consists of massive black mudstones and includes calcareous nodules. The thickness ranges from 1 cm to more than 25 m. Sporadic molluscan fossils, such as separated bivalves, gastropods, and ammonites, occur locally (Fig. 4F). Generally, these fossils are poorly preserved. Lithofacies C is developed in Nishitate and Taremizuhama in Ofunato City, and Jagasaki in Rikuzentakata City.

Interpretation: Massive mudstones indicate accumulations from suspension loads. The presence of separated bivalves and poorly preserved fossils suggests that these remains were transported from their original habitats before preservation. Lithofacies C is interpreted as hemipelagic mudstones (Bouma, 1962; Stow *et al*., 1998).

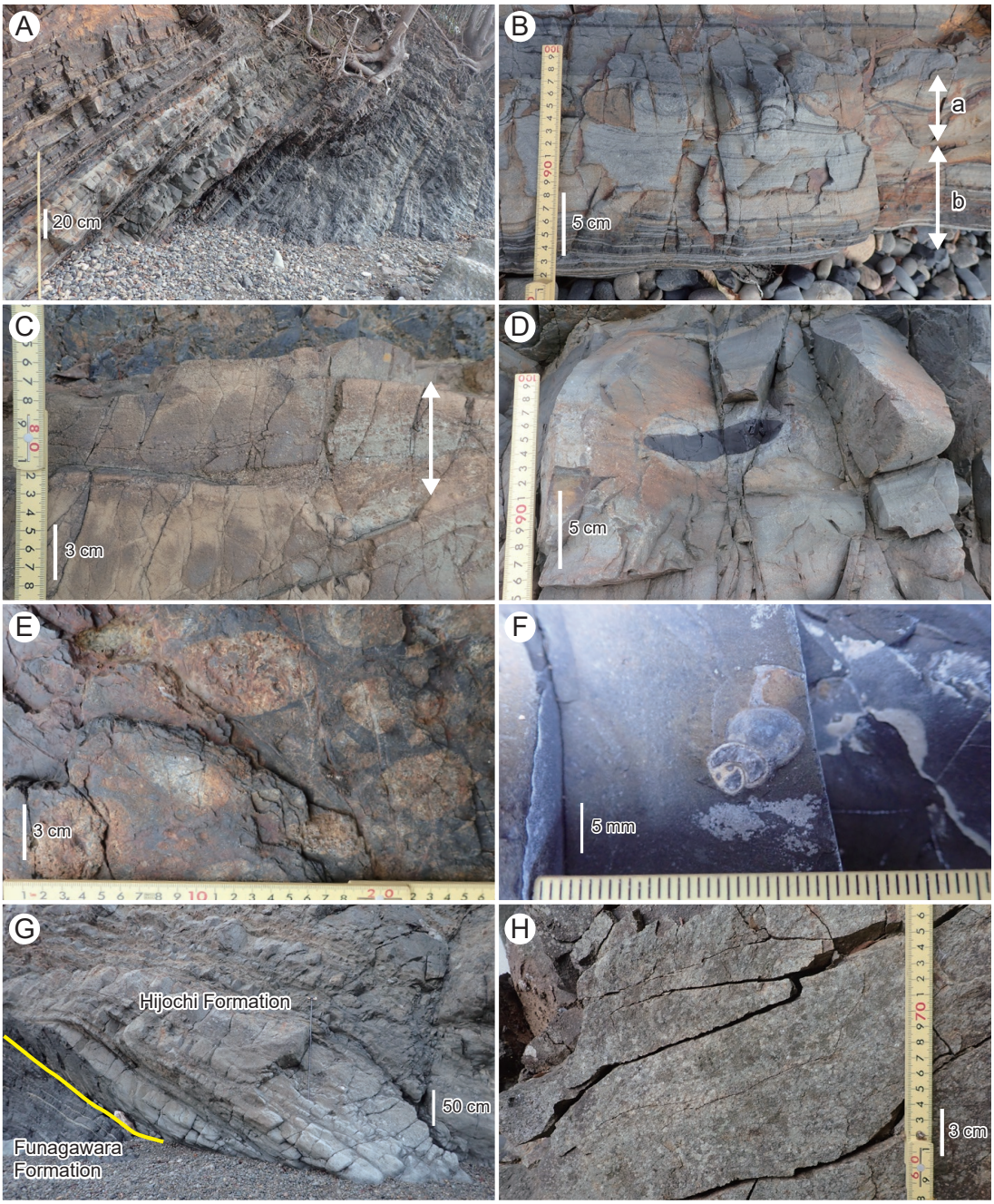

Fig. 4 A: Alternating beds of sandstone (Lithofacies A) and mudstone (Lithofacies C) of the Funagawara Formation. Nishitate, Ofunato City. B: Convolute lamination (a) and planar parallel lamination (b) developed on Lithofacies A. Nishitate, Ofunato City. C: Current ripple cross-lamination developed on Lithofacies A. Nishitate, Ofunato City. D: Black mudstone clast in Lithofacies A. Nishitate, Ofunato City. E: Matrix-supported conglomerate (Lithofacies B) of the Funagawara Formation. Jagasaki, Rikuzentakata City. F: Gastropod in Lithofacies C. Taremizuhama, Ofunato City. G: Boundary between the Funagawara and Hijochi formations. Taremizuhama, Ofunato City. H: Tuff of the Kobosoura Formation. Hosoura, Ofunato City.

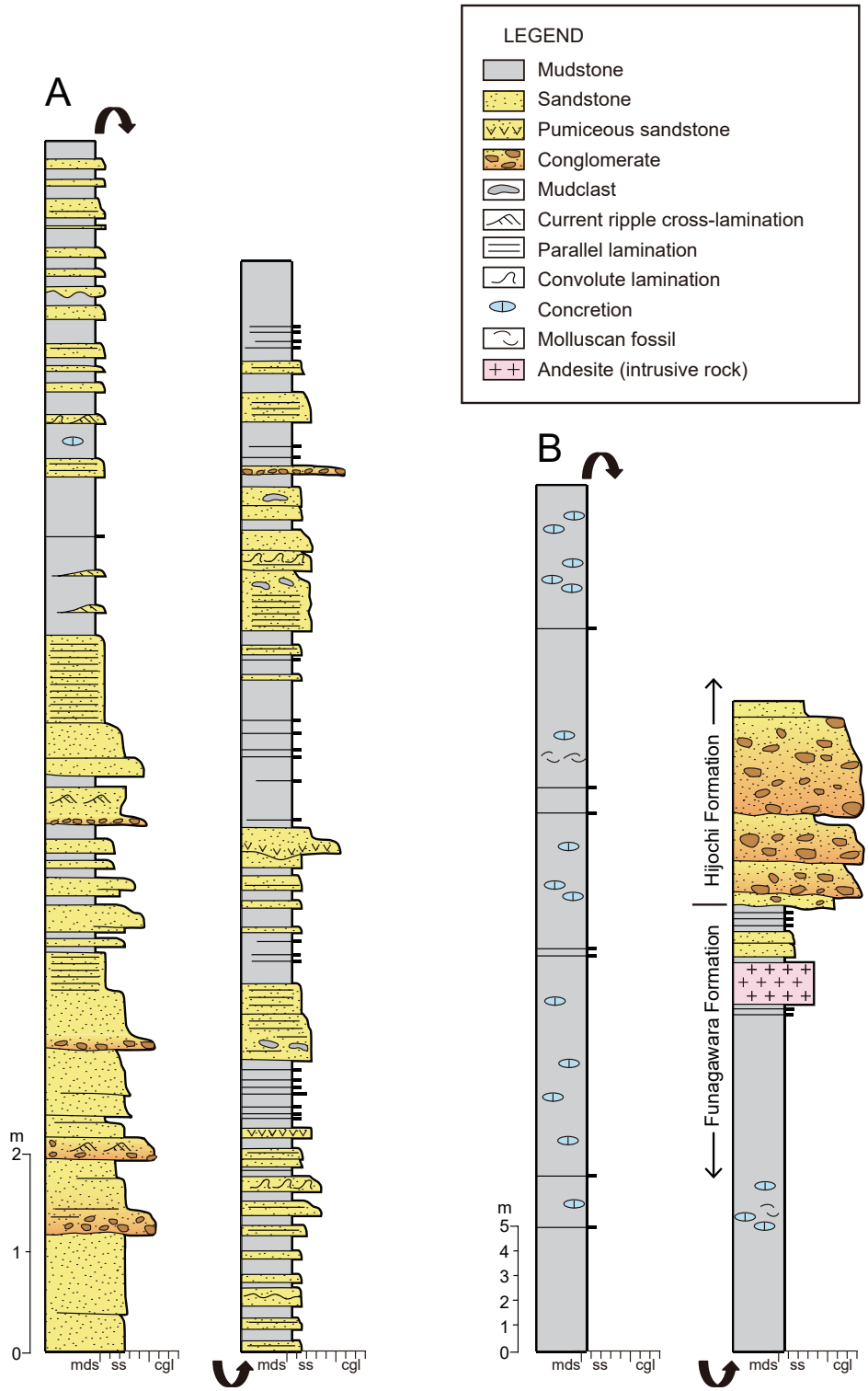

Fig. 5 Measured sections the Funagawara Formation. A: Alternating beds of sandstone (Lithofacies A) and mudstone (Lithofacies C). Upper part of the Funagawara Formation at Nishitate, Ofunato City. B: Uppermost part of the Funagawara Formation dominated by mudstones (Lithofacies C) and basal part of the Hijochi Formation at Taremizuhama, Ofunato City.

2) Sedimentary environments of the Ofunato Group

The Funagawara Formation mainly consists of turbidite sandstones (Lithofacies A) with erosional basal surfaces and black mudstone clasts, and hemipelagic mudstones (Lithofacies C). In addition, the formation locally includes debris flow deposits (Lithofacies B). These lithofacies characteristics resemble those of levee and overbank deposits in the submarine fan model proposed by Posamentier and Walker (2006) and are accordingly ascribed as such. The Funagawara Formation is characterized by an upward decrease in conglomerates, an upward fining of sandstones, an upward thickening of mudstones, and an overall upward-fining trend (Figs. 3 and 5). The upper parts of the formation are considered to have been deposited in more offshore and deep-sea environments, which suggests that the formation was influenced by marine transgression.

The change in the depositional environment of the Ofunato Group is summarized below, based on the lithofacies features the Funagawara Formation described and interpreted above, along with additional insights from previous studies. The Hakoneyama Formation, which forms the base of the Ofunato Group, mainly consists of conglomerates that are interpreted as terrestrial deposits (Kawamura and Uchino, 2023). The boundary between the Hakoneyama Formation and the overlying Funagawara Formation is not observed, leaving their relationship unknown. The Hijochi Formation, which overlies the Funagawara Formation, mainly consists of alternating beds of sandstone, conglomerate, and mudstone. The ratio of sandstones and conglomerates in the Hijochi Formation is higher than that in the Funagawara Formation (Figs. 3 and 4G). The Hijochi Formation is interpreted to have been deposited in a more proximal and shallower environment than the Funagawara Formation sediments. The Kobosoura Formation, the uppermost lithostratigraphic unit of the Ofunato Group, mainly consists of felsic tuff (Fig. 4H), and includes welded tuff, tuffaceous sandstones, and conglomerates. The welded tuff reflects pyroclastic flow deposits, which indicates deposition in a terrestrial environment (Kawamura and Uchino, 2023). Except for the Hakoneyama Formation, whose relationship with the overlying formations is uncertain, the Ofunato Group is interpreted to have been deposited in response to a marine transgression, as indicated throughout the Funagawara Formation, and followed by a regression reflected in the Hijochi and Kobosoura formations.

PALEONTOLOGY

1) Repository of specimens

The specimens described in this paper are kept in the Ofunato City Museum (OCM).We referred some specimens housed in the Tohoku University Museum in Sendai, Miyagi Prefecture (IGPS), and the Saitama Museum of Nature History in Nagatoro, Saitama Prefecture (SMNH-MoF).

2) Conventions

Higher systematic nomenclature follows Cox *et al*. (1969) for bivalves and Wright *et al*. (1996) for ammonite. Descriptive terms (e.g., very small, very large, fairly narrow, and others) for ammonite are those of Matsumoto *et al*. (1988). The following symbols for measurements for ammonite are used; H = the whorl-height; W = the whorl-width; W/H = the width/height ratio; for bivalves are used L = length of shell, H = height of shell, T = thickness of shell, L/H = the Length/Height ratio.

3) Systematic Paleontology

Order Ammonoidea Zittel, 1884
Suborder Ancyloceratina Wiedmann, 1966
Superfamily Ancyloceratacеae Gill, 1871
Family Crioceratitidae Gill, 1871
Genus *Balearites* Sarkar, 1954

Balearites sp.

Figs. 6A, B

Synonymy.

1982 *Crioceratites ishiwarai*, Obata and Matsumoto in Matsumoto *et al*., p. 3, listed.

2023 *Crioceratites ishiwarai*, Kawamura and Uchino, p. 91, listed.

Material. A single specimen, OCM.G.001697 (unknown collector), is a large partial outer whorl of

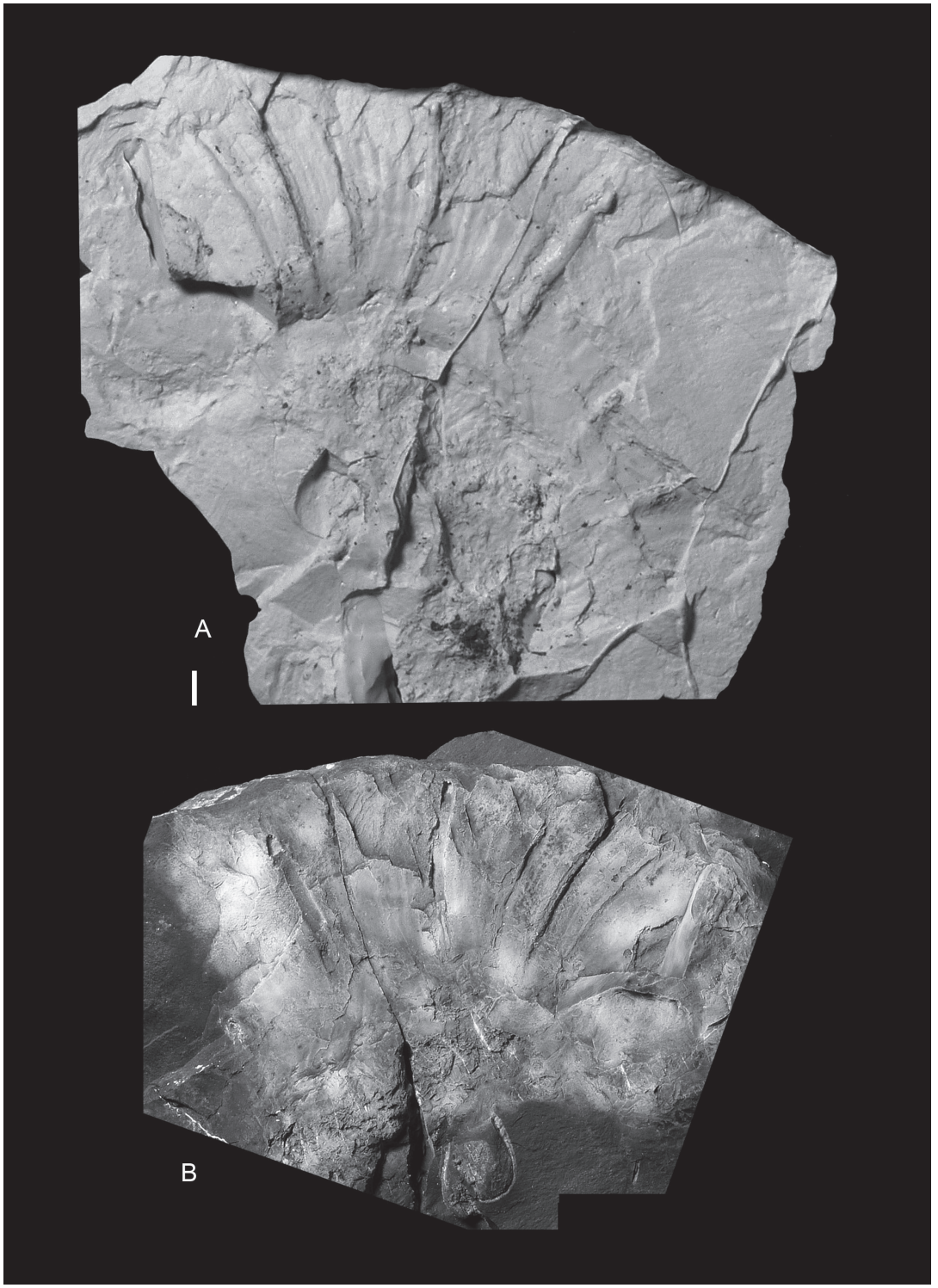

Fig. 6 *Balearites* sp., A and B, OCM.G.001697 (unknown collector), the external mold (B) and its rubber pull (A) from the Funagawara Formation at location the OCM location 1697 in the old quarry in Ofunato-cho, Ofunato City. Scale bar is 1cm.

external mold. The specimen came from the Funagawara Formation at OCM location 1697, where is in an old quarry, along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture.

Dimension (in mm).

Specimen	H	W
OCM.G.001697	64.1	---

Descriptive remarks. The specimen is characterized by large, loosed open plani-spire, compressed, flat side, narrowly oval whorl section which is swollen in its lower part and converges toward the venter, and surface ornamented with dense ribs, which are slightly flexuous in earlier growth whorl and become parabolic in later growth whorl. They consist of thick primary and thin secondary. Two to seven secondary ribs are sandwiched between primary ribs. The secondary ribs emerge from the lower flank, and the interspace between the two ribs becomes wider towards the outer flank. The secondary ribs may have branched into two below the lower flank, although it is not possible to confirm where it arises due to poorly preservation. Its intercalary secondary ribs arise on middle flank. Umbilical bullae and outer lateral tubercles, which form very small projections, are attached on each primary rib. In particular, the projection of the bullae on the primary ribs on the later whorl is very weak. Constriction is absent.

Because of shell with planispiral coiling, compressed whorl section with convex flank, surface ornamented with alternation of primary and secondary flexuous ribs, lateral tubercles and umbilical bullae present, the specimen is assigned to the genus *Balearites* (Matamales and Company, 2019). Hoedemaeker (2013) presented a diagnosis of the genus *Pseudothurmannia* (*Balearites*). The genus *Pseudothurmannia* (*Balearites*) was reclassified as the genus *Balearites* (Szives *et al*., 2024). The presence or absence of constriction was not taken up in the subsequent criteria for this genus (e.g., Company *et al*., 2003). The present specimen has no constriction, so it follows the taxonomic criteria for the genus. The present specimen is only a partial outer whorl of later-growing due to poor preservation. The characteristic that the distance between the primary ribs of the present specimen narrows in the later stage of growth is similar to that of the illustrated specimens of *Balearites balearis*, *B. binelli*, *B. krenkeli*, *B. angulicostatus* from the *Balearites balearis* Zone of the upper Hauterivian of the standard ammonite zonation of the Lower Cretaceous for the Mediterranean Province of the Western Tethyan Realm (Szives *et al*., 2024). It is difficult to compare the present specimen with some specimens of species of the genus *Balearites* described at the species level due to poor partial whorl. Therefore, we describe the present specimen is described as *Balearites* sp.

The specimen differs from the holotype of *Crioceratites* (*C.*) *ishiwarai* (Yabe and Shimizu, 1926) because the tubercles on the primary ribs of the present specimen are two on lower and outer flank, whereas that of *Crioceratites* (*C.*) *ishiwarai* is three, lower, middle and outer. Additionally, a number of secondary ribs between primaries of the present specimen is two to seven, whereas that of *Crioceratites* (*C.*) *ishiwarai* is three to eight.

Occurrence. This genus develops throughout the *Balearites balearis* Zone, which is the third from the bottom of the four zones that divide the upper Hauterivian of the standard ammonite zonation of the Lower Cretaceous for the Mediterranean Province of the Western Tethyan Realm (Szives *et al*., 2024).

Class Bivalvia Linné, 1758
Subclass Pteriomorphia Beurlen, 1944
Order Arcoida Stoliczka, 1871
Superfamily Arcacea Lamarck, 1809
Family Arcidae Lamarck, 1809
Subfamily Arcinae Lamarck, 1809
Genus *Arca* Linné, 1758
Subgenus *Eonavicula* Arkell, 1929

Arca (*Eonavicula*) sp.

Fig. 7A

Material. A single specimen, OCM.G.485 (unknown collector), is a right internal mold of inner shell, and came from the undivided early Cretaceous strata at the OCM location 485, west of the Sakari High School, Jinomori, Ofunato-Cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.485	9.3	5.0	--	1.86

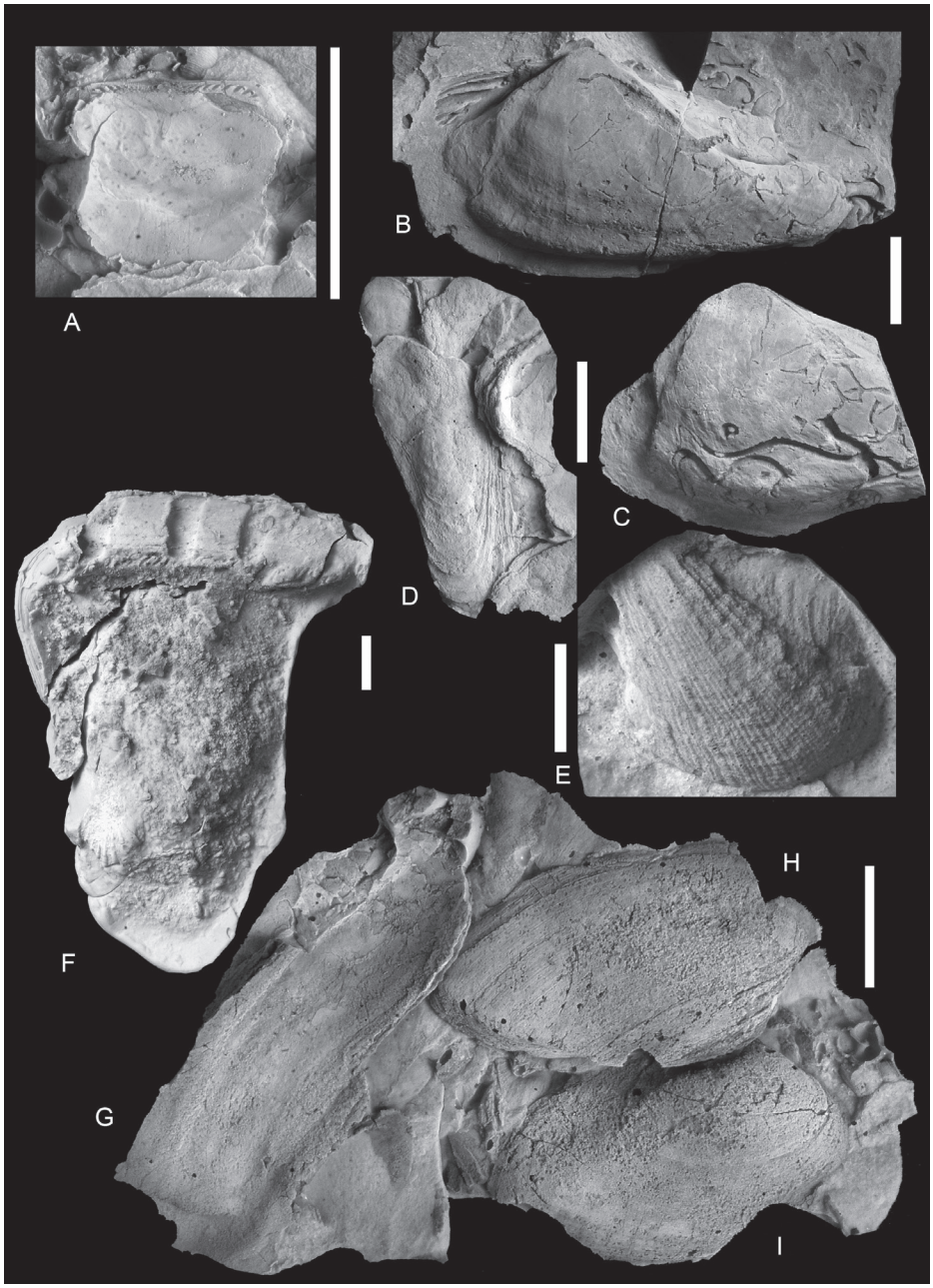

Fig. 7 A; *Arca* (*Eonavicula*) sp, OCM.G.485 (unknown collector), right internal mold of inner shell (rubber pull), from the OCM location 485 in Jinomori, Ofunato-cho. B and C; *Grammatodon* (*Nanonavis*) *yokoyamai*, B, OCM.G.1667A, internal mold, and C, OCM.G.1667B, internal mold of left valve, both came from the OCM location 485. D, Pteriidae gen. et sp. indet., OCM.G.1668S (T. Kikuchi collector), external mod of left valve, came OCM location 1668 in Umamagoe. E; *Gervillaria haradae*, OCM.G.382 (M. Murakami collector), external mold of left valve, came from the OCM location 382 in Nishitate, but the exact location is unknown. F; *Isognomon* (*I.*) cf. *sanchuensis*, OCM.G.002051, (M. Murakami collector), external mold left valve, came from Funagawara coast but exact location is unknown. G; *Gervilla*? sp., OCM.G.1668V (Y. Kikuchi collector), external mold of partial left valve, came from OCM location 1668. H; *Scittila*? sp., OCM.G.1668R (T. Kikuchi collector), an external mold of left valve (rubber pull), came from the OCM location 1668. I; *Modiolus*? sp., OCM.G.1668Q (T. Kikuchi collector), external mold of right valve (rubber pull), came from the OCM location 1668. Scale bars are 1cm.

Descriptive remarks. Because hinge teeth become fine under the umbo, the specimen belongs to the subgenus *Eonavicula* (Cox *et al*., 1969). The specimen is small, and is characterized by a sub-parallelogram, transversely elongated, moderately inflated and inequilateral. A length of shell is nearly twice of height (L/H = 1.86). The umbo is prominent, located at about one-third of shell length from anterior side. A hinge line is nearly straight with about 20 small teeth. These characters are similar to those of the specimens (MoF 2033, 2002, 2004, 2006, 2018, 2029, 2030,2034, 2037, 2042 in the Saitama Museum of Natural History) identified as *Arca* (*Eonavicula*) sp. from the Upper Member of the Sebayashi Formation of the Sanchu Cretaceous in Saitama Prefecture.

Occurrence. A stratigraphic horizon, SA30022, bearing *Arca* (*Eonavicula*) sp. in the Upper Member of the Sebayashi Formation corresponds to the upper Barremian.

Family Parallelodontidae Dall, 1898
Subfamily Grammatodontinae Branson, 1942
Genus *Grammatodon* Meek and Hayden, 1861

Remark. Cox *et al*. (1969) divided the genus *Grammatodon* into five subgroups, *Grammatodon*, *Cosmetodon*, *Indogrammatodon*, *Nanonavis* and *Nordenskjoeldia*. The subgenus *Nanonavis* is defined as trapezoidal, with low, closely spaced costae, umbonal carina sharp, delimiting deeply concave posterodorsal area; hinge plate narrow; teeth serrate, medial and anterior teeth falcate, tangential with dorsal and anterior margins. We follow their criteria of the subgenus.

Subgenus *Nanonavis* Stewart, 1930

Grammatodon (*Nanonavis*) *yokoyamai* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)

Figs. 7B, C

Synonymy.

1890 *Cucullaea* cf. *striatella*, Yokoyama, p. 199, pl. 25, fig. 13.
1926 *Grammatodon yokoyamai* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 45, pl. 12, figs. 12, 13, 15.
1958 *Nanonavis yokoyamai*, Ichikawa and Maeda, p. 67.
1963 *Nanonavis yokoyamai*, Hayami in Matsumoto (ed.), p. 32, pl. 51, fig. 13.
1965a *Nanonavis* (*Nanonavis*) *yokoyamai*, Hayami, p. 238–241, pl. 27, figs. 8–13.
1972 *Nanonavis* (*Nanonavis*) *yokoyamai*, Shikama and Suzuki, pl. 4, fig. 7.
1975 *Grammatodon* (*Nanonavis*) *yokoyamai*, Hayami, p. 29.
1980 *Grammatodon* (*Nanonavis*) *yokoyamai*, Tashiro and Yamamoto, p. 3, pl. 1, fig. 3.
1984 *Nanonavis yokoyamai*, Tashiro and Kozai, p. 14–16, pl. 2, figs. 1-16.
1993 *Nanonavis yokoyamai*, Kozai and Tashiro, p. 25–27, pl. 5, figs. 29, 30.

Material. Two specimens (unknown collector), OCM. G.1667A and OCM.G.1667B, are left internal molds. OCM.G.1667A retains inner shell, but the specimen B retains in mail part of inner shell and lacks its posterior part and dentation. Both specimens came from the undivided early Cretaceous strata at the OCM location 485, west of the Sakari High School, Jinomori, Ofunato-Cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1667A	56.9	29.0	9.9	1.96
OCM.G.1667B	---	29.6	10.4	---

Descriptive remarks. The specimens are characterized by small to medium size species of the genus *Grammatodon* (*Nanonavis*). Shell is sub-rhomboidal shape strongly inflated. Carina is prominent and distinct. Hinge plate is narrow. Hinge teeth are horizontal. These characteristics indicate that the specimens are identified as *Nanonavis yokoyamai* (Hayami, 1965a, p. 238–241) from the Lower Cretaceous deposits in Japan.

Superfamily Mytilacea Rafinesque, 1815
Family Mytilidae Rafinesque, 1815
Subfamily Modiolinae Keen, 1958
Genus *Modiolus* Lamarck, 1799

Modiolus? sp.

Fig. 7I

Material. A single specimen, OCM.G.1668Q (T. Kikuchi collector), is an external mold of right valve. Antero-ventral corner and ventral area are lost. The specimen came from the Funagawara Formation at the OCM 1668 location along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1668Q	31.5	20.8+	3.8	1.51+

Descriptive remarks. The specimen is characterized by Mytiliform, inflated, obtuse umbo being located one-fifth from the anterior end, surface ornamented with concentric growth lines and radial ribs. The umbo of the present specimen is located at one-fifth from the anterior end, whereas the illustrated specimen of *Modiolus* (Fig. G20 in Cox *et al*., 1969) is distinctly behind anterior end. Therefore, we identify the present specimen as *Modiolus*? sp.

Superfamily Pinnacea Leach, 1819
Family Pinnidae Leach, 1819
Genus *Pinna* Linné, 1758
Subgenus *Pinna* Linné, 1758

Pinna sp.

Figs. 8A, B

Material. A single specimen, OCM.G.1665 (unknown collector), is a partial internal mold of conjoined valves opened, and its external mold. The specimen is only left in both left and right anterior shell parts. The lower part of the valves is lost. The specimen came from the undivided early Cretaceous strata at the OCM location 485, west of the Sakari High School, Jinomori, Ofunato-Cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for number of radial rib (N)).

Specimen	L	H	T	N (dorsal area)	N (ventral area)
OCM.G.1665	28.9+	67.2+	5.4	9+	8+

Descriptive remarks. The present specimen is similar to the illustrated specimens of *Pinna* cf. *robinaldina* (Hayami, 1965a, p. 281–282, Pl. 39, figs. 2, 3) from the Ishido Formation of the Sanchu Cretaceous at location Hy. 4011, Ishido, Sakuho-machi, Nagano Prefecture and from the Hinagu Formation at location Km.1832, Tsuzura, Sakamoto Town, Kumamoto Prefecture, in shell outline which is vertically triangle and surface which is covered with distinct radial ribs and concentric growth lines. However, in the present specimen, the narrow concentric lamellae between radial ribs and a sharp median carina, which are characteristics of *Pinna* cf. *robinaldina*, cannot be confirmed, so it is suitable to be identified as *Pinna* sp.

Order Pterioida Newell, 1965
Suborder Pteriina Newell, 1965
Superfamily Pteriacea Gray, 1847
Family Bakevelliidae King, 1850
Genus *Gervillaria* Cox, 1955

Gervillaria haradae (Yokoyama, 1890)

Fig. 7E

Synonymy.

1890 *Avicula haradae* Yokoyama, p. 199, pl. 25, figs. 12a, b.
1926 *Gervilla haradae*, Yabe and Nagao in Yabe, Nagao and Shimizu, p. 58, pl. 13, figs. 1–3, 7; pl. 14, fig. 2.
1934 *Gervilla* cf. *haradae*, Nagao, p. 139, pl. 31, fig. 13.
1963 *Gervillaria haradae*, Hayami in Matsumoto, p. 32, pl. 51, figs. 12a, b.
1965a *Gervillaria haradae*, Hayami, p. 269–271, pl. 35, figs. 3–6; pl. 36, fig. 1; pl. 37, fig. 2.
1986 *Gervillaria haradae*, Tashiro and Matsuda, p. 373–374, p. 75, figs. 1–5, 13.
1986 *Gervillaria haradae*, Tashiro and Kozai, p. 26-27, pl. 1, figs. 10, 12–14; pl. 6, figs. 7, 8; pl. 8, figs. 7, 8.
1996 *Gervillaria haradae*, Tanaka *et al*., p. 20–21, pl. 6, fig. 1.

Material. A single specimen, OCM.G.382 (M. Murakami collector), is an external mold of left valve, and came from the Funagawara Formation or the Hijochi Formation at the OCM location 382 in Nishitate, Massaki-cho, Ofunato City. However, its exact location is unknown. The location of Shirahama coast, which is described the label inside the box containing the specimen, is also unknown.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H

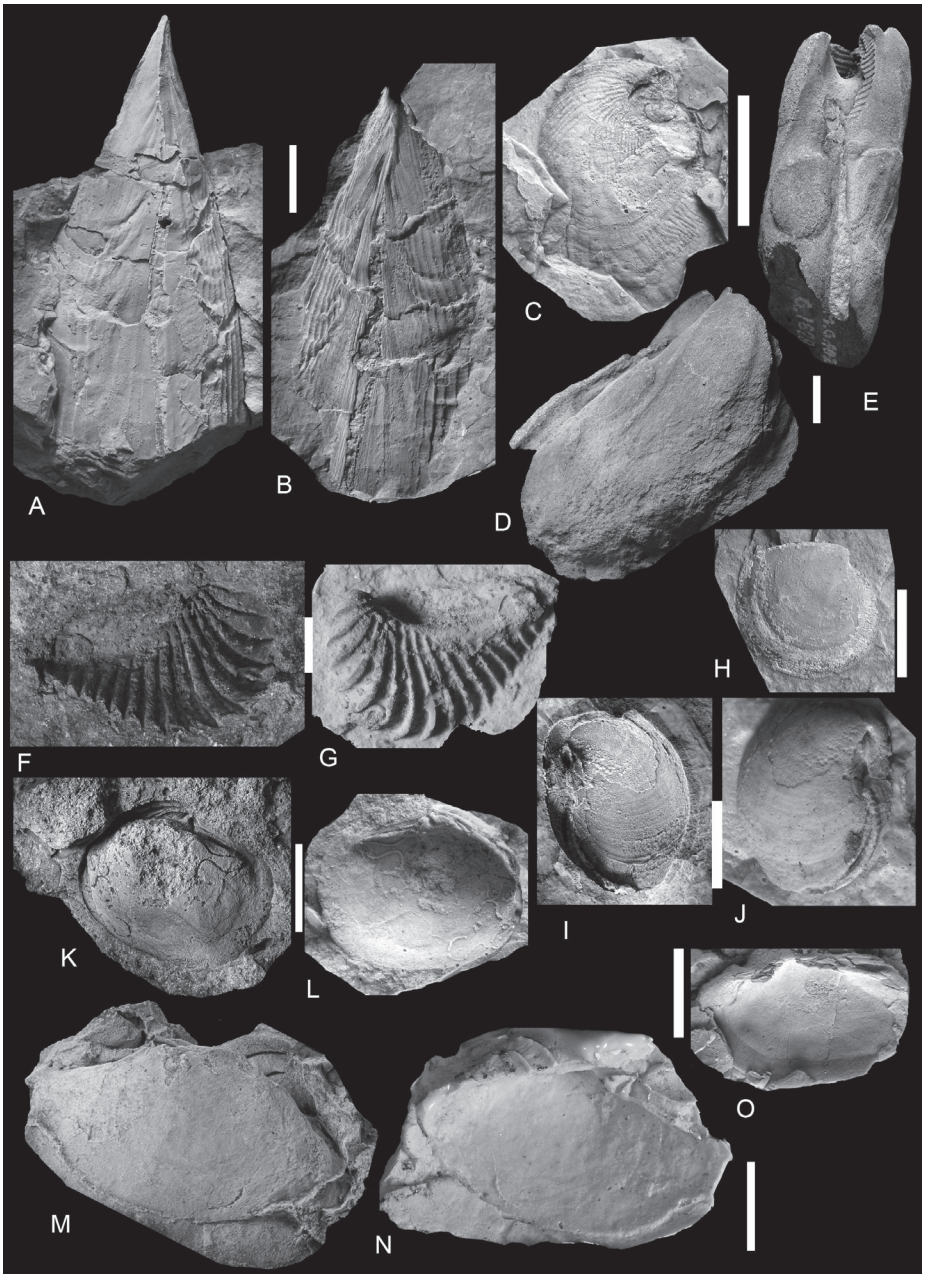

Fig. 8 A and B; *Pinna* sp., OCM.G.1665, a partial internal mold of conjoined valves opened and its external mold, came from the OCM location 485. C; *Placunopsis pseudotrancata*, OCM.G478, external mold of right valve (rubber pull), came from the OCM location 485. D and E; *Nipponitrigonia* sp., OCM.G.1678, internal mold of conjoined valves, came from the OCM location 1678 in Takonoura, but the exact location is unknown. F and G; *Pterotrigonia* (*P.*) *pocilliformis*, OCM.G.1675, internal mold of left valve (F) and its rubber pull (G), came from the OCM location 1675 in Nagaiso. H; *Astarte* (s. str.) cf. *subsenecta*, OCM.G.1666B, right valve, came from the OCM location 485. I and J; *Astarte* (*Yabea*) cf. *shinanoensis*, OCM.G.1666A, conjoined valves, came from the OCM location 485. K-O; *Isocyprina hibiharensis*, K and L, OCM.G.1681, internal mold of right valve (K) and its rubber pull (L), came from the OCM location 1681, Ofunato City, M and N, OCM.G.1680, internal mold of left valve (N) and its rubber pull (M), came from unknown locality in Ofunato City, O, OCM.G.1668F, internal mold of left valve (rubber pull), came from the OCM location 1668. Scale bars are 1cm.

OCM.G.382 24.6 29.3 7.4 0.84

Descriptive remarks. The specimen is medium modioliform consisting of inflated left valve with radial ribs. The left valve consists of main part of shell obliquely strong inflated, small anterior auricle and large posterior auricle. The surface of left vale is ornamented with radial top-projected ribs on main part and undulations on posterior auricle. The radial ribs consisting of the primaries and secondaries pass over the shell and reach to ventral margin. One to six secondary ribs are sandwiched between two primary ribs. Six secondary ribs cover on the most swollen part of the main part of the shell. Spaces of the concentric growth lines become short toward the ventral margin. These characteristics suggest the specimen can be identified as *Gervillaria haradae* (Yokoyama, 1890, p. 199, pl. 25, figs. 12a, b). The specimen differs from the illustrated specimen of *Gervillaria miyakoensis* (Hayami, 1965a, p. 269–273, pl. 36, figs. 2–4; pl. 37, fig. 1) from the upper Aptian Miyako Group, because shell of *Gervillaria miyakoensis* is higher than that of the present specimen. Additionally, the surface of the present specimen is ornamented with distinct radial ribs, whereas *Gervillaria miyakoensis* is ornamented with feeble radial riblets.

Occurrence. The species is reported from the Yatsushiro Formation in Yatsushiro area, Ishido Formation in Sanchu area, Hiraiga Formation of the Miyako Group in Tanohata area (Hayami, 1975) and the Sebayashi Formation in Sanchu area. Those formations are assigned to the Barremian to Aptian.

Genus *Gervilla* Defrance, 1820

Gervilla? sp.

Fig. 7G

Material. A single specimen is an external mold of partial left valve, OCM.G.1668v (T. Kikuchi collector). The specimen came from the Funagawara Formation at the OCM 1668 location along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1668v	40.6+	11.5+	---	3.5+

Descriptive remarks. The specimen is an oblong shell with a curved its lower half, but anterior auricle and ligament area are lack, surface is smooth and is ornamented with concentric growth line. The specimen is similar to *Gervilla forbesiana* from the Upper Member of the Sebayashi Formation (MoF 2066-2074 in the Saitama Museum of Natural History). But the specimen is a partial shell, so it is better to identify as *Gervilla*? sp.

Family Isognomonidae Woodring, 1925

Genus *Isognomon* Lightfoot, 1786

Subgenus *Isognomon* Lightfoot, 1786

Isognomon (*I.*) cf. *sanchuensis* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)

Fig. 7F

Compare.

1926 *Perna sanchuensis* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 57, pl. 12, figs. 1–4.

1965a *Isognomon* (*I.*) *sanchuensis*, Hayami, 278–279.

Material. A single external mold left valve, OCM. G.002051B (M. Murakami collector), came from the Ofunato Group at location Funagawara coast in Ofunato City as a bounding stone. Its exact location is unknown.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H	Obliquity
OCM.G.002051B	67.2	94.7	---	0.71	---

Descriptive remarks. Because of large, vertical rectangle, beak location at anterior end of hinge line, straight posterior dorsal margin with ligament, convex ventral margin, and ligament grooves that are shallow, narrow and subequal, and flat interspace, the specimen is assigned to *Isognomon* (*I.*) *sanchuensis* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926, p. 57, pl. 12, figs. 1–4) from the Lower Member of the Sebayashi Formation of the Sanchu Cretaceous. However, ligamental area of the present specimen differs from that of *Isognomon* (*I.*) *sanchuensis*, because number of grooves of the present specimen is less than that of *Isognomon* (*I.*) *sanchuensis*, and groove and intervals between grooves are wider than these of *Isognomon* (*I.*) *sanchuensis*. So, we identify the specimen as *Isognomon* (*I.*) cf. *sanchuensis*.

Occurrence. The present species is reported from

the Lower Member of the Sebayashi Formation of the Sanchu Cretaceous (Matsukawa, 1983) and the Ofunato Group, Japan. It is an endemic species.

Superfamily Anomiacea Rafinesque, 1815
Family Anomiidea Rafinesque, 1815
Genus *Placunopsis* Morris and Lycett, 1853

Placunopsis pseudotruncata (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926).

Fig. 8C

Synonymy.

1926 *Anomia pseudotruncata* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 62, pl. 12, figs. 26, 27; pl. 13, figs. 27, 28, 36.

1939 *Anomia pseudotruncata*, Kobayashi and Suzuki, p. 219, pl. 13, fig. 19.

1965a *Monia* sp. cf. *M. pseudotruncata*, Hayami, p. 335, pl. 48, fig. 1.

1975 *Placunopsis pseudotruncata*, Hayami, p. 85.

Material. A single specimen of an external mold of right valve, OCM.G.478 (unknown collector), that ventral part is lost. The specimen came from the undivided early Cretaceous strata at the OCM location 485, west of the Sakari High School, Jinomori, Ofunato-Cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.478	19.3	17.5+	---	0.91+

Descriptive remarks. Because of strong inequivalve, circular shell form, wide apical angle, small umbo, and monomyarian, the specimens are assigned to the syntypes of *Placunopsis pseudotruncata* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926, p. 62, pl. 12, figs. 26, 27; pl. 13, figs. 27, 28, 36) from the Shiroi Formation at Bomekizawa gorge in Ohinata Village (present Sakuho-machi Town), Nagano Prefecture. The species is once divided into the genus *Anomia* by Yabe and Nagao in Yabe, Nagao and Shimizu (1926) and moved to the genus *Monia* by Hayami (1965a). These taxa are defined by presence of foramen in valve, but the present specimens do not have the foramen. Therefore, the species belongs to the genus *Placunopsis*.

Occurrence. The species is reported from the Shiroi Formation of the Sanchu Cretaceous in Nagano Prefecture (Yabe and Nagao in Yabe *et al*., 1926), and the Ofunato Group (present study).

Pteriidae gen. et sp. indet.
Fig. 7D

Material. A single specimen, OCM.G.1668S (T. Kikuchi collector), is an external mold of left valve, and came from the Funagawara Formation at the OCM location 1668, along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture.

Dimension (in mm).

Specimen	L	H	T	L/H
OCM.G.1668S	---	28.2	---	---

Descriptive remarks. The specimen is characterized by large anterior auricle, shell protruding to the hinge line, and weak that's bulge. The presence or absence of a posterior auricle is unknown. A posterior auricle must be present because the present specimen has a posterior auricle. Therefore, the present specimen can be assigned to the family Pteriidae (Cox *et al*., 1969).

Order Trigonioida Dall, 1889
Superfamily Trigoniacea Lamarck, 1819
Family Trigoniidae Lamarck, 1819
Genus *Nipponitrigonia* Cox, 1952

Nipponitrigonia sp.

Figs. 8D, E

Material. A single specimen, OCM.G.1678 (unknown collector), is an internal mold of conjoined valves. Most of body of left valve is lost. The specimen is deformed by pressure. The specimen came from muddy fine sandstone of the early Cretaceous strata corresponding Attari Formation at location Takonoura (location 1678), Akasaki-cho, Ofunato City, Iwate Prefecture. A fossil location on the topographic map is unknown.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1678	67.4+	40.0+	11.6	1.69+

Descriptive remarks. The specimen is characterized by

ovately trigonal in outline, short antero-dorsal margin and long postero-dorsal margin, round long ventral margin, gently convex, low posterior carina and trigonacean teeth with crenulation. There are large elliptical muscle scars at middle posterior end in both valves. It is better identification as *Nipponitrigonia* sp., because the dental characteristics support the identification but shell surface characteristics for species identification are not left and original shell form is not preserved due to deformation by pressure.

Genus *Pterotrigonia* Hoepen, 1929

Remarks. Kobayashi and Nakano (1957) designated the genus *Pterotrigonia* van Hoepen (1929) with its diagnosis and regarded the genus *Pterotrigonia* (Hoepen, 1929) and the genus *Notoscabrotrigonia* (Dietrich, 1933) as a synonym of the genus *Pterotrigonia* (Hoepen, 1929) although its reason is not mentioned. We follow the diagnosis of the genus defined by Kobayashi and Nakano (1957).

Subgenus *Pterotrigonia* Hoepen, 1929

Remarks. Hayami (1975) divided the genus *Pterotrigonia* into two subgenera that are *Pterotrigonia* and *Acanthotrigonia* although he did not discuss its reason. Subsequently, Tashiro (1992) defined the criteria of the subgenus *Pterotrigonia* that is characterized by concentric minor ribs parallel to the growth line in the area. Then, he also defined criteria of subgenus *Pterotrigonia*. We follow the criteria of the subgenus *Pterotrigonia* defined by Tashiro (1992).

Pterotrigonia (*P.*) *pocilliformis* (Yokoyama, 1891)

Figs. 8F, G

Synonymy.

1891 *Trigonia pocilliformis* Yokoyama, p. 361, pl. 40, figs. 1–3.

1923 *Trigonia pocilliformis*, Yehara, p. 71, pl. 9, figs. 8–10; p. 10, figs. 4–6.

1927 *Trigonia pocilliformis*, Yabe, pl. 4, fig. 3.

1957 *Pterotrigonia pocilliformis*, Kobayashi and Nakano, p. 229, pl. 16, figs. 1–3.

1957 *Pterotrigonia pocilliformis* var. *yamanokamiensis*, Kobayashi and Nakano, p. 229, pl. 16, figs. 8–10.

1958 *Pterotrigonia pocilliformis*, Kobayashi and Nakano, p. 147, pl. 11, fig. 12.

1964 *Pterotrigonia pocilliformis*, Matoba, pl. 37, figs. 6, 7.

1964 *Pterotrigonia pocilliformis*, Maeda and Kitamura, p. 52, pl. 1, figs. 1–12.

1967 *Pterotrigonia pocilliformis*, Maeda and Kawabe, p. 91, pl. 1, figs. 1–3.

1975 *Pterotrigonia* (*Pterotrigonia*) *pocilliformis*, Hayami, p. 117.

1978 *Pterotrigonia* (*Pterotrigonia*) *pocilliformis*, Tamura, p. 91, pl. 3, figs. 12, 13.

1980 *Pterotrigonia* (*Pterotrigonia*) *pocilliformis*, Hayami in Hayami and Oji, p. 431, pl. 52, fig. 7.

1983 *Pterotrigonia* (*Pterotrigonia*) *pocilliformis*, Tashiro and Matsuda, p. 18, pl. 8, figs. 6–11, text-fig. 3.

1986 *Pterotrigonia* (*Pterotrigonia*) *pocilliformis*, Tashiro and Matsuda, pl. 1, figs. 6–11, text-fig. 3.

1986 *Pterotrigonia* (*Pterotrigonia*) *pocilliformis*, Tashiro, Yanagisawa and Kitamura, pl. 1, figs. 11, 12.

1986 *Pterotrigonia* (*Pterotrigonia*) *pocilliformis*, Tashiro and Kozai, p. 49, 50, pl. 5, figs. 1, 2, 6; pl. 7, figs. 1–11.

Material. A single internal mold of left valve, OCM. G.1675 (unknown collector), came from the early Cretaceous strata corresponding to the Hijochi formation, at the OCM location 1675, Nagaiso, Massaki-cho, Ofunato City, Iwate Prefecture. A fossil location on the topographic map is unknown.

Dimension (in mm except for L/H).

Specimen	L	H	L/H
OCM.G.1675	42.9	26.9	1.60

Descriptive remarks. Because of pterotrigoinan shell being narrower shell and narrow posterior area, the specimen can be identified as *Pterotrigonia pocilliformis* (Tamura, 1978, p. 91, pl. 3, figs. 12, 13).

Occurrence. The species is reported from the Ishido Formation, the Todai Formation, the Arida Formation, the Hanoura and Hoji formations, the Lower Monobegawa Group and the Kikunitani Formation in Kurosegawa area (Hayami, 1975).

Order Veneroida H. Adams and A. Adams, 1856
Superfamily Crassatellacea Férussac, 1822
Family Astartidae Orbigny, 1844
Subfamily Astartinae Orbigny, 1844
Genus *Astarte* J. Sowerby, 1816
Subgenus *Astarte* J. Sowerby, 1816

Astarte (*Astarte*) cf. *subsenecta* Yabe and Nagao in Yabe, Nagao and Shimizu, 1926

Fig. 8H

Compare.

1926 *Astarte subsenecta* Yabe and Nagao in Yabe, Nagao and Shimizu, p.47, pl. 13, fig. 16; pl. 14, fig. 11 (? pl. 13, figs. 14, 15; non pl. 14, fig.10).

1926 *Astarte subsenecta* var. *costata* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 48, pl. 14, fig. 10.

1965 *Astarte* (*Astarte*) *subsenecta*, Hayami, p.81–84, pl. 7, figs. 10–18; pl. 14, figs. 1–5.

1965b *Astarte* (*Astarte*) *costata*, Hayami, p. 85, pl. 8, figs. 1, 2.

1980 *Astarte* (*Astarte*) *subsenecta*, Hayami and Oji, p. 431, pl. 53, figs. 1–6.

1972 *Astarte* (*Astarte*) *subsenecta*, Shikama and Suzuki, pl. 6, fig. 4.

1985 *Astarte* (*Astarte*) *subsenecta*, Tashiro, Matsuda and Tanaka, p.10, pl. 2, fig.16; pl.3 figs.1–3.

1986 *Astarte* (*Astarte*) *subsenecta*, Tashiro and Matsuda, p. 381, pl.75, fig.14; pl.77, figs.17–19, 25, 26.

1988 *Astarte* (*Astarte*) *subsenecta*, Tashiro and Kozai, p. 38–39, pl.1, figs.1, 2.

1992 *Astarte* (*Astarte*) *yatsushiroensis* Tashiro and Tanaka, p. 150–151, pl. 2, figs. 1, 3, 4, 6, 7, 10–12.

2009 *Astarte* (*Astarte*) *subsenecta*, Terabe and Matsuoka, fig. 5, nos. 4a, 4b, 5.

2013 *Astarte* (*Astarte*) *subsenecta*, Murakami, pl. 3, fig. 29.

2021 *Astarte* (*Astarte*) *yatsushiroensis*, Tanaka, Takahashi, Honda, pl. 2, figs. 11–15, 17.

Material. A single specimen, OCM.G.1666B, is right valve, and came from black mudstone beds of the undivided early Cretaceous strata at the OCM location 485, west of the Sakari High School, Jinomori, Ofunato-Cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1666B	18.9	16.9	1.3	1.12

Descriptive remarks. The specimen is characterized by small shell, subovate shell outline which is longer than high, weakly inflated, and prominent small umbo. The surface is ornamented with concentric growth lings. Five concentric ribs are distributed on shell. These intervals become narrow toward outer shell. These characteristics suggest that the specimen can be assigned to *Astarte* (s. str.) cf. *subsenecta* Yabe and Nagao (Hayami, 1965b). However, the present specimen has three strong ribs on outer shell, whereas the topotypes of *Astarte* (s. str.) *subsenecta* from the Sanchu Cretaceous (Yabe *et al*., 1926) has six to twelve and weaken towards the ventral margin. The ribs of the present specimen are weaker than those of then illustrated specimens of *A*. (s. str.) *costata* (Hayami, 1965b, p. 85–86, pl. 8, figs. 1, 2) from the Ishido Formation in Gunma Prefecture. Therefore, we identify the specimen as *Astarte* (s. str.) cf. *subsenecta*.

Occurrence. The species and its related species are reported from the Choshi Group, Ishido Formation, Hanoura Formation, Haidateyama Formation, Yatsushiro Formation in Japan (Hayami, 1975).

Subgenus *Yabea* Hayami, 1965b

Remarks. Hayami (1965b) erected the subgenus *Yabea* into the genus *Astarte*, because characteristics of the cardinal teeth 3a and 5b are closer to the genus *Astarte* (s. str.) than to the genus *Nicaniella* Chavan, 1945, and the genus *Freiastarte* Chavan, 1952, and the subgenus differs from *Nicaniella*, *Freiastarte* and *Neocrassina* by absence of striking concentric sculpture and in the more prosogyrous and more anterior situated umbo. Subsequently, Hayami (1972) designated the subgenus *Yabea* with diagnosis. However, Tashiro (1992) treated the subgenus *Yabea* as the genus *Yabea* without discussion for the rank up. We follow the Hayami (1965b)'s clearly reasons.

Astarte (*Yabea*) cf. *shinanoensis* Yabe and Nagao in Yabe, Nagao and Shimizu, 1926

Figs. 8I, J

Material. A single specimen, OCM.G.1666A, is conjoined valves, consisting of two external molds of left and right valves. The specimen came from black mudstone beds of the Funagawara Formation of the Ofunato Group at the OCM location 485, west of the Sakari High school, Jinomori, Ofunato-town, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1666A	19.6+	18.6+	2.5 b	1.05+

Descriptive remarks. The specimen is characterized by extremely prosogyrous umbo, surface ornamented with very thin concentric ribs, and fine ventral crenulations. These are suggested that the specimen can be assigned to *Astarte* (*Yabea*) *shinanoensis* (Hayami, 1965b), but its dentation is not confirmed. Additionally, the shell swollen of this specimen is weaker than that of the holotype of *A*. (*Y*.) *shinanoensis* (IGCP 22544), which is right internal mold, and the depression under the umbo in antero-dorsal margin of the present specimen is shallower than that of the holotype of *A*. (*Y*.) *shinanoensis* (IGCP 22544). Therefore, we identify this specimen as *Astarte* (*Yabea*) cf. *shinanoensis*.

Occurrence. The present species is reported from the (1) Yatsushiro Formation in Kumamoto Prefecture (Hayami, 1965b), (2) Sebayashi formation, Sanchu Cretaceous, Saitama prefecture (Ichise, 2002; Terabe, Matsuoka, 2009), and the Ofunato Group (This study).

Superfamily Tellinacea Blainville, 1814
Family Icanotiidae Casey, 1961
Genus *Scittila* Casey, 1961

Scittila? sp.

Fig. 7H

Material. A single specimen, OCM.G.1668R (T. Kikuchi collector), is an external mold of left valve, and came from the Funagawara Formation at the OCM location 1668, along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture. The antero-posterior of corner of the is lost.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1666R	31.6	20.5+	3.5	1.54+

Descriptive remarks. The specimen is oblong elliptical shell, umbo that is located about one-third from anterior end, postero-dorsal margin strongly angular, pressing down on the postero-dorsal end. Surface is ornamented with concentric growth lines. A low radial furrow in posterior presents in lower posterior area. These characteristics except for low radial furrow sinuating in ventral margin suggest the specimen is assigned to the genus *Scittila* (Cox *et al*., 1969). Therefore, we identify the specimen as *Scittila*? sp.

Superfamily Arcticacea Newton, 1891
Family Arcticidae Newton, 1891
Genus *Isocyprina* Röder, 1882

Isocyprina hibiharensis Tashiro and Kozai, 1989

Figs. 8K-O

1989 *Isocyprina hibiharensis*, Tashiro and Kozai, p. 119–120, pl. 3, figs. 1–10; text-fig. 3.

Material. Three specimens. OCM.G.1680 (unknown collector), 1681 (unknown collector) and 1668F (T. Kikuchi collector). The specimen OCM.G.1680 is an internal mold of left valve, and came from the early Cretaceous strata corresponding to the Attari Formation at Takonoura, Akasaki-cho, Ofunato City, but exact location is unknown. The specimen OCM.G.1681 is an internal mold of right valve and came from the early Cretaceous strata in Ofunato City, but the exact location is unknown. The specimen 1668F is an internal mold of left valve (rubber pull) and came from the Funagawara Formation at the OCM location 1668, along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1680	37.6	ca.25.6	ca. 6.7	ca.1.47
OCM.G.1681	24.5	19.7	2.8	1.24
OCM.G.1668F	23.5	ca.16.3	1.7	ca.1.44

Descriptive remarks. The specimens are elongated ovata to subelliptical outline, small umbo that is located at little anterior from the center, dental formula being AI?, 1, 3b, PI, PIII in right valve of the OCM.G.1681,

and PII, 2b, 2a in left valve of the OCM.G.1680, these are confirmed. These suggest that the specimens are assigned to *Isocyprina hibiharensis* (Tashiro and Kozai, 1989, p. 119–120; pl. 3, figs. 1–10; text-fig. 3) from the Monobegawa Group in Hibihara, Kochi Prefecture, although very long cardinal tooth 4b, which is one of the characteristics of the present species, is not confirmed. A range of a ratio of shell length and height (L/H) for the present specimen falls almost within the range of the type specimens of the species; a ratio of length and height (L/H) of the present specimen ranges from 1.24 to ca.1.47, and that of the topotype specimen including the type specimen ranges from 1.29 to 1.55. The value of the ratio of length and height (L/H) of the specimen OCM. G.1681 falls within that of *Tosacyprina crenulata* (Tashiro and Kozai, 1989, p. 121–122, pl. 1, figs. 1–4; text-figs. 2D, 4) from the Monobegawa Group in Hibihara, Kochi Prefecture. However, an inner ventral margin of the present specimens is smooth, whereas that of the type specimens of *Tosacyprina crenulate* has very fine crenulation.

Superfamily Corbiculacea Gray, 1847
Family Neomiodontidae Casey, 1955
Genus *Costocyrena* Hayami, 1965b

Costocyrena otsukai (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)

Figs. 9A-D

Synonymy.

1926 *Cyrena otsukai* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 50–51, pl. 13(2), figs. 20–24.
1954 *Polymesoda* (*Isodomella*) *otsukai*, Matsumoto (ed.), p. 63 (Table 16), 110 (Table 20), list only.
1973 *Costocyrena otsukai*, Ohta, p. 256–258, pl. 3, figs. 1–11.
1975 *Costocyrena otsukai*, Hayami, p. 139.
1982 *Costocyrena otsukai*, Ohta, p. 127–129, pl. 7, figs. 13–34.
1983 *Costocyrena otsukai*, Matsukawa, p. 11, fig. 23, pl. 2, figs. 1–3. (list and figure only)
1987 *Costocyrena otsukai otsukai*, Tashiro, p. 100, 102, fig. 1, 26–30.
1987 *Costocyrena otsukai* obsoleta, Tashiro, p. 102–103, fig. 1, 13–37.

Material. Five specimens, OCM.G.1668A, 1668C, 1668L, 1668O, and 1668 U (T. Kikuchi collector), came from the Funagawara Formation at the OCM location 1668, along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture. These are external mold of outer shell.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1668A left	8.8	6.4	2.2	1.38
OCM.G.1668C left	15.0	10.1	3.9	1.50
OCM.G.1668L left	10.6	8.1	---	1.31
OCM.G.1668O left	17.6	13.8	---	1.28
OCM.G.1668U right	11.6 +	11.2	---	1.03+

Descriptive remarks. The specimens are characterized by small shell size, trigonal outline with sometimes posterior ridge and surface that is ornamented with numerous fine concentric growth lines with distinctly prominent concentric ribs. Concentric ribs are decorated by very small studs with almost regular intervals. These characteristics suggest the specimen is assigned to *Costocyrena otsukai* (Matsukawa, 1983, fig. 23, pl. 2, figs. 1-3) from the Shiroi Formation of the Sanchu Cretaceous in Nagao and Gumma prefectures. Although Kozai and Tashiro (1993) identified nine specimens from the Funagawara Formation as *Costocyrena otsukai*, they did not describe the small stud on concentric ribs. The genus *Eomiodon* is distinguished from the genus *Costocyrena* based on the presence or absence of the stud.

Occurrence. The present species is reported from the Idaira Formation, Idaira, Inasa Town, Hamamatsu City, Shizuoka Prefecture, Japan (Tashiro, 1987); from the Yuasa Formation, Nishihiro, Hirokawa Town, Arita County, Wakayama Prefecture, Japan (Ohta, 1973); from the Tatsukawa Formation, Tatsukawa, Katsuura Town, Katsuura County, Tokushima Prefecture, Japan (Tashiro, 1987); from the Ryoseki Formation, Yonemoto, Kochi City, Kochi Prefecture, Japan (Ohta, 1973); from the upper member of the Ryoseki Formation Ikku and Higashikuma, Kochi City, Kochi Prefecture, Japan (Tashiro, 1987); from upper member of the Ryoseki Formation, Suita, Kami City, Kochi Prefecture (Tashiro, 1987); from the Upper member of Koshigoe Formation, Honjyo, Saiki City, Ohita Prefecture, Japan (Ohta, 1982);

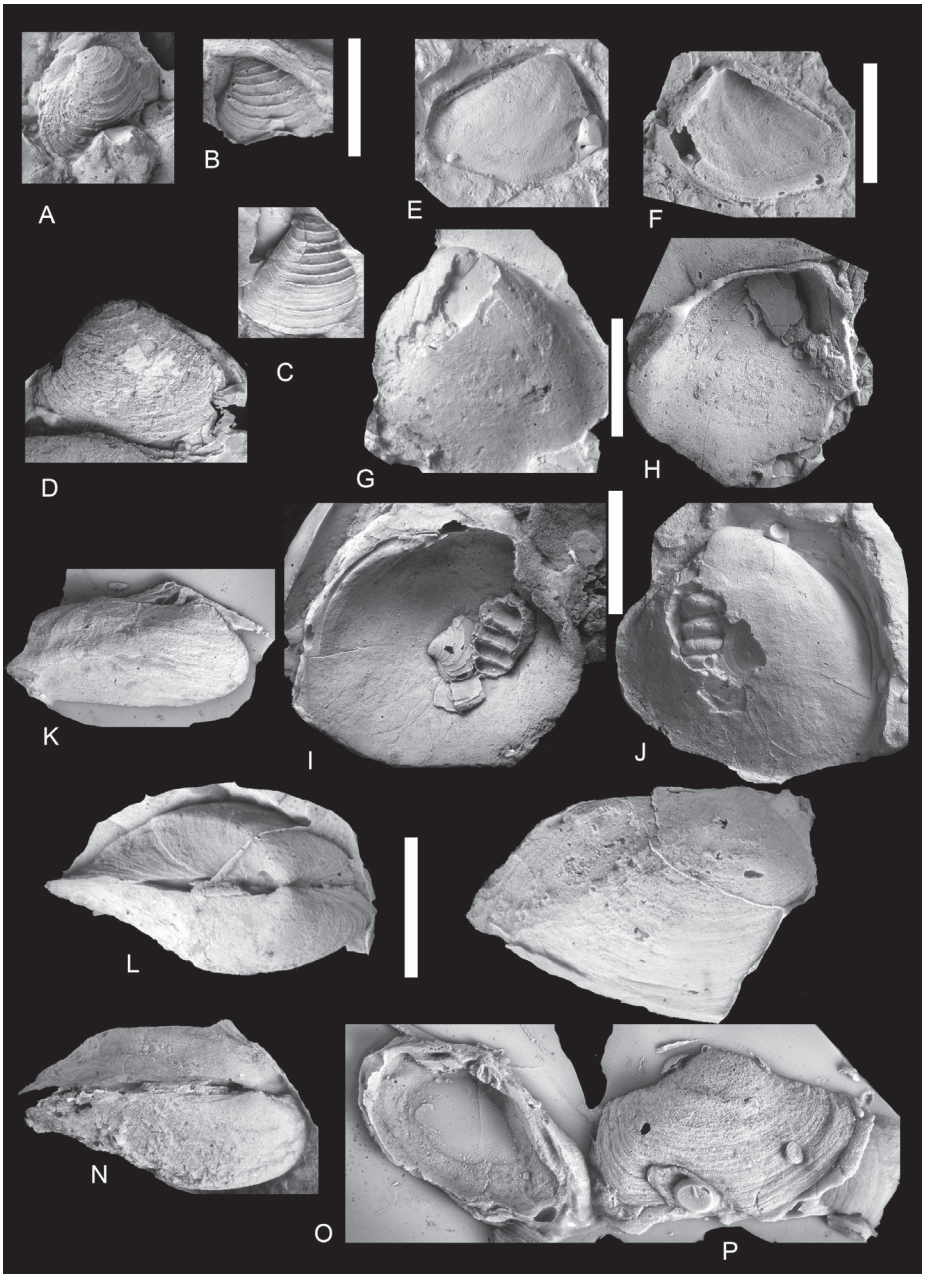

Fig. 9 A-D; *Costocyrena otsukai*, A, OCM.G.1668A (T. Kikuchi collector), left internal vale (rubber pull), B, OCM.G.1668L (T. Kikuchi collector), left internal valve (rubber pull), C, OCM.G.1668U (T. Kikuchi collector), right internal mold (rubber pull), D, OCM.G.1668O (T. Kikuchi collector), left internal mold, all came from the OCM location 1668. E-H; *Isodomella shiroiensis*, E and H, OCM.G.1668H, F, right internal vale (rubber pull), E, its gypsum cast, came from the OCM location 1668, G and H, OCM.G.1668M, left internal vale (H) and its rubber pull (G), came from the OCM location 1668. I and J; *Tetoria sanchuensis*, I, internal mold of left inner shall (rubber pull), J, its gypsum mold, came from the OCM location 1668. K-P; *Filosina* sp., K, OCM.G.478C, external mold of right valve (rubber pull), L, OCM. G.478D, external mold of partial conjoined valves (rubber pull), M, OCM.G.478E, external mold of right valve (rubber pull), N, OCM.G.478F, external mold of conjoined valves (rubber pull), O, OCM.G.478A, internal mold of right valve (rubber pull), P, external mold of left valve (rubber pull). They came from the OCM location 478 in Massaki-cho, but the exact location is unknown. Scale bars are 1cm.

from the upper member of the Koshigoe Formation, Kami-Koshigoe, Honjyo, Saiki City, Ohita Prefecture, Japan (Tashiro, 1987).

Genus *Isodomella* Kobayashi and Suzuki, 1939

Isodomella shiroiensis (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)

Figs. 9E-H

Synonymy.

1926 *Cyrena shiroiensis* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 52, pl. 14, figs. 4–6, 19, 29, 22, 25.

1926 *Cyrena shiroiensis* var. *alata* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 53, pl. 13, fig. 26, pl. 14, figs. 15, 28.

1939 *Polymesoda shiroiensis*, Kobayashi and Suzuki, p. 219, pl. 14, figs. 1–9.

1943 *Polymesoda* (*Geloina*) *shiroiensis*, Suzuki and Oyama, p. 139, 146.

1975 *Isodomella shiroiensis*, Hayami, p.141. (list only)

1983 *Isodomella shiroiensis*, Matsukawa, p.11, pl. 2, figs. 7, 8. (list and figures only).

1993 *Isodomella shiroiensis*, Kozai and Tashiro, p. 31–32, pl. 6, figs. 17–21

Material. Two specimens, OCM.G.1668H and 1668M (both T. Kikuchi collector), came from the Funagawara Formation at the OCM location 1668 along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture. They are internal molds of right inner shell (1668H) and left inner shell (1668M).

Dimension (in mm except for L/H).

Specimen		L	H	T	L/H
OCM.G.1668H	right	15.2	11.4	1.3	1.33
OCM.G.1668M	left	22.3	22.4+	3.7	1.00+

Descriptive remarks. Because of scalene triangular outline, straight posterior margin, protruding umbo and long lateral tooth, specimens are identified as *Isodomella shiroiensis* (Matsukawa, 1983).

Genus *Filosina* Casey, 1955

Filosina sp.

Figs. 9K-P

Material. Six specimens, OCM.G.478A, 478B, 478C, 478D, 478E, and 478F (unknown collector), came from the Funagawara Formation or the Hijochi Formation at the OCM location 478 in Massaki-cho, Ofunato City. The exact location of the specimens is unknown. The specimen 478A is an internal mold of right valve. The specimen 478B is an external mold of left valve. The specimen 478C is an external mold of right valve. The specimen 478D is an external mold of partial conjoined valves. The specimen 478E is an external mold of partial right valve. The specimen 478F is an external mold of conjoined valves.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.478A	18.9	11.3	2.0+	1.67
OCM.G.478B	20.1	13.2	2.9	1.52
OCM.G.478C	16.2	8.2	3.2	2.0
OCM.G.478D	---	14.6+	---	---
OCM.G.478E	---	17.4+	---	---

Description. The specimens are small shell which is inequilateral, elongated triangle with strongly angular at the posterior end and longer than high. Antero-dorsal margin is short and concave. Postero-dorsal margin is straight and long. Ventral margin is smoothly arcuate. Umbo is located on the anterior side from the center. Strong ridge extends from umbonal area to the postero-ventral corner. Escutcheon and lunule are absent. Hinge is the cyrenoid type and dental formula only right valve preserved is AI, 3a, 1, 3b, PI. Lateral teeth are long and straight. Pallial line forms a gentle arch along ventral margin that connects the anterior and posterior adductor scars. The adductor scars form a vertical ovata.

Remarks. Because of cyrenoid type corbiculoid and no escutcheon and lunule, the specimens are assigned to the genus *Filosina* (Cox *et al*., 1969). The present specimens differ from the illustrated specimens of *Filosina jusanhamensis* (Hayami, 1960, p. 15–16, pl. 3, figs. 1–7) from the Tategami and Tsukihama members in Kitakami Village, Monou County, Miyagi prefecture, because the present specimens have distinct ridge extending from umbonal area to pastero-ventral corner, whereas the illustrated specimens of *Filosina*

jusanhamensis do not. Distinct ridge is characteristics of *Crenotrapezium kurumaense* and *C. kitakamiense* from lower Jurassic and the Jurassic – Cretaceous transition in Japan (Hayami, 1957, 1960; Matsukawa *et al*., 2014). However, the genus *Crenotrapezium* is assigned to the lucinoid type corbiculoid, so the present specimens are different from two species of the genus *Crenotrapezium*. The present specimens may be identified as new species. However, the location on the map of the present specimens is unknown. Therefore, it not possible to specify the topotype when describing these specimens as a new species. This conflicts with the ICZN article 76A, so we think it would be better to wait the location of the specimens with the same characteristics as the present specimens is clear before identifying it as a new species.

Genus *Tetoria* Kobayashi and Suzuki, 1937

Tetoria sanchuensis (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)

Figs. 9I, J

Synonymy.

1926 *Corbicula* (*Veloritina*?) *sanchuensis* Yabe and Nagao in Yabe, Nagao and Shimizu, p. 54, pl. 13, figs. 12, 13.

1939 *Corbicula sanchuensis*, Kobayashi and Suzuki, p. 221–222, pl. 14, figs. 10–15.

1965 *Tetoria* (Para*corbicula*) *sanchuensis*, Ota, p. 165–171, pl. 13, fig. 14.

1993 *Corbicula sanchuensis*, Kozai and Tashiro, p. 32–33, pl. 5, figs. 31, 32.

Material. Two specimens, OCM.G.1688D and 1688I (both T. Kikuchi collector), came from the Funagawara Formation at the OCM location 1668, along the Suzaki River, Ofunato-cho, Ofunato City, Iwate Prefecture. Both specimens are internal molds of left inner shell.

Dimension (in mm except for L/H).

Specimen	L	H	T	L/H
OCM.G.1668D left	23.8	23.9	4.1	1.00
OCM.G.1668I left	26.3	23.3+	4.9	1.13

Descriptive remarks. Because of long lateral tooth, prominent umbo, subtrigonal, strong convex shell and deep pallial sinus, the specimens are assigned to *Tetoria sanchuensis* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926) from the Shiroi and Sebayashi formations of the Sanchu Cretaceous in Nagano and Gumma prefectures.

Occurrence. The species is reported from the Early Cretaceous Idaira Formation, Inasa Town, Inasa County, Shizuoka Prefecture, Japan (Komatsu and Ando, 1986), from the Tatsukawa Formation, Tatsukawa, Katsuura County, Tokushima Prefecture. (Tashiro and Ohnishi, 1985), from the Ryoseki Group, Yonemoto, Kochi City, Kochi Prefecture (Ota, 1965), from the Monobe Formation, Okho, Nangoku City, Kochi Prefecture (Tashiro and Kozai, 1989), from the Yoshimo Formation, Yoshimo, Shimonoseki City, Yamaguchi Prefecture (Kobayashi and Suzuki, 1939) and from the Togawa Formation, Togawa, Nishiusuki County, Miyazaki Prefecture (Tashiro *et al*., 1993).

AMMONITE BIOSTRATIGRAPHY OF THE OFUNATO GROUP

The stratigraphic distribution of the ammonite of the Ofunato Group is a single occurrence of species as the stratigraphic horizon.

***Balearites* sp. Biostratigraphic Horizon.** This biostratigraphic horizon corresponds to the lithostratigraphic horizon OCM location 1697 and is characterized by occurrence of *Balearites* sp. in the Funagawara Formation.

Crioceratites (*C.*) *ishiwarai* from the upper part of the Funagawara Formation (Matsumoto *et al*., 1982) and *Holcodiscus* sp. from the top of the Hijochi Formation (Obata and Matsumoto, 1977) are listed, but their paleontological description and photos are not presented. In this study, the specimen with registration number OCM.G.001697, which was obtained from the Funagawara Formation at the OCM location 1697 (Fig. 1) and is housed at the Ofunato City Museum, is described above as *Balearites* sp. Although the specimen can be identified as a member of the genus *Balearites*, a specific determination is not possible due to poor preservation. The genus *Balearites* is employed as an index genus for the upper Hauterivian Stage of the Lower Cretaceous ammonite standard zonation for the West Mediterranean Province of the Tethyan Realm, *Balearites balearis*

Zone (Szives *et al*., 2024). The Funagawara Formation can be assigned to the upper Hauterivian. The specimen and location of the *Holcodiscus* sp. are unknown as of November 30, 2023, and its evaluation has not been possible and is not discussed.

CHARACTERISTICS OF BIVALVE FAUNA

An examination of bivalve fossils was based on 28 specimens collected from eight locations. One specimen classified as *Astarte* (*Astarte*) cf. *subsenecta* and six specimens classified as *Filosina* sp. were found as conjoined, while the other specimens were found as disjointed single valves or destroyed shells. At the location to the west of the Sakari High school in Jinomori, Ofunato-cho town (the OCM location 485), the undivided formation of the Ofunato Group yielded one specimen of *Astarte* (*Astarte*) cf. *subsenecta* found as conjoined valves, but co-occurring specimens of *Arca* (*Eonavicula*) sp. and *Pinna* sp. were found as disjointed single valves or opened valves. All specimens in the Funagawara Formation at Yamamagoe in mid-western part of Ofunato City (the OCM location 1668) occurred as a single valve or shell destroyed. These indicate that they have been washed out of their habitat and moved. On the other hand, at the Massaki-cho in the southwestern part of Ofunato City (the OCM location 478), the specimens of *Filosina* sp., occurred as conjoined valves, have multiple densely stacked shells, which indicates that this species was autochthonous and had an exclusive ecological strategy by building a fossil community in its habitat in brackish waters. Unfortunately, the origin of these specimens are unknown, but the Ofunato Group distributed in Massaki-cho consists of the Funagawara, Hijochi and Kobosoura formations in ascending stratigraphic order, and based on sedimentary facies analysis, this succession formed in an environment during a period of marine regression. Therefore, the origin of these specimens (OCM location 478) is highly likely to be included in the Funagawara to Hijochi formations.

The bivalve specimens are identified as 19 species of 19 genera and are described here. We add one species of one genus collected from the Ofunato Group and identified and described by Hayami (1966), one species of one genus by Kozai (1986), and 22 species of 19 genera by Kozai and Tashiro (1993). Based on these specimens, we discuss the faunal characteristics and paleobiogeographic province using a total of 37 species of 29 genera (Table 1). Although Seki and Imaizumi (1941), Onuki and Mori (1961) and Hayami (1966) listed fossils species from the Ofunato Group, they are excluded from the discussion because they do not provide paleontological descriptions nor photographs of fossils. Bivalve fossil location Loc. 1. in Kozai (1986) and Kozai and Tashiro (1993) is located within the old quarry at OCM location 1967. A specimen of *Balearites* sp. was also found here. However, the relationship between the bivalve fossil horizon and that of the ammonite is unclear.

The 37 species of 29 genera have been reported from the Lower Cretaceous strata in the outer zone of southwest Japan reflecting brackish to shallow-marine environments. In particularly, three species, *Costocyrena otsukai*, *Isodomella shiroiensis* and *Tetoria sanchuensis*, are representative species of the Ryoseki Fauna (Kobayashi, 1983) or Ryoseki-type fauna (e. g., Tashiro, 1994), which is the Early Cretaceous brackish bivalve fauna comprising corbiculoids in the Lower Cretaceous strata distributed in the outer zone of southwest Japan. The fauna had been used as a tool for correlating non-marine strata (e.g., Matsukawa, 1979; Kozai *et al*., 2005).

Kozai (1986) and Kozai and Tashiro (1993) assigned the Ofunato Group to the Hauterivian Stage based on bivalve fossil species, because ammonite species of *Crioceratites ishiwarai* that has been assigned to the upper Hauterivian (Obata and Matsumoto in Matsumoto *et al*., 1982). The Ryoseki fauna is assigned to the upper Hauterivian to lower Barremian stages.

Stage-level chronological indicators for bivalve fossil species, regional teil zone or taxon-range zones for these species in the Early Cretaceous in East Asia, including Japan, have not yet been established. Even if bivalve fossil species are found in strata containing ammonites that have a stage-level chronological indicator, this is only indicates that these species lived in that period, but does not indicate its usefulness as a chronological indicator. Therefore, to evaluate the usefulness of bivalve fossil species as chronological indicators, it is the first necessary to establish bio-zones for bivalve fossil species

Table 1 List of ammonite and bivalve taxonomies from the Ofunato Group. Numbers on the far left indicate the species described systematically in this study.

	Family	Taxonomic name	Location				Ofunato Group						
			This study (OCM location)	Hayami (1966)	Kozai (1986)	Kozai and Tashiro (1993)	Hakone-yama	Funa-gawara	Hijochi	Koboso-ura	Ryori	Attari	undivided
	Crioceratidae	*Balearites* sp.	1697					●					
1	Arcidae	*Arca* (*Eonavicula*) *shinanoensis* Yabe and Nagao in Yabe, Nagao and Shimizu, 1926				2, 3, 4		●					
		A. (*E*.) *minima* Tshiro and Kozai, 1984				4		●					
2		*A*. (*E*.) sp.	485										●
3	Parallelodontidae	*Grammatodon* (*Nanonavis*) *yokoyamai* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)	485			2, 3, 4		●					●
	Mytilidae	*Modiolus* sp.				2		●					
4		*M*.? sp.	1668					●					
5	Pinidae	*Pinna* sp.	485										●
6	Pteriidae	Pteriidae gen. et sp. indet.	1668					●					
	Bakevellidae	*Bakevella* (*Neobakevellia*) *ominensis* Nakazawa and Murata, 1975				2, 4		●					
7		*Gervillaria haradae* (Yokoyama, 1890)	382					← ● →					
		G. hokutoi Tashito and Kozai, 1986				2		●					
8		*Gervilla*? sp.	1668					●					●
9	Isognomonidae	*Isognomon* cf. *sanchueneis* (Yabe and Nagao in Yabe, Nagao and Yabe, 1926)	unknown										
	Pectinidae	*Chlamys tanakai* Kozai and Tashiro, 1993				3, 4		●					
10	Anomiidae	*Placunopsis pseudotrancata* (Yabe and Nago in Yabe, Nagao and Shimizu, 1926)	485			1, 2, 3		●					●
		P. sp.				3		●					
	Ostridae	*Crassostrea* sp.				1, 2		●					
11	Trigoniidae	*Nipponitrigonia* sp.	1678									●	
12		*Pterotrigonia* (*P*.) *pocilliformis* (Yokoyama, 1891)	1675					← ● →					
13	Astartidae	*Astarte* (*Astarte*) cf. *subsenecta* Yabe and Nagao in Yabe, Nagao and Shimizu, 1926	485										●
		A. (A.) costata Yabe and Nagao in Yabe, Nagao and Shimizu, 1926				4		●					
14		*A*. (*Yabea*) cf. *shinanoensis* Yabe and Nagao in Yabe, Nagao and Shimizu, 1926	485										●
	Icanotiidae	*Scittila japonica* Hayami, 1965				2, 4		●					
15		*S*.? sp.	1668					●					
16	Arcticidae	*Isocyprina hibiharensis* Tashiro and Kozai, 1989	1668, 1680, unknown					●				●	
		Tosacyprina crenulata Tashiro and Kozai, 1989				2, 3,4		●					
17	Neomiodontidae	*Costocyrena otsukai* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)	1668			1, 2, 4		●					
18		*Isodomella shiroiensis* (Yabe and Nagao, in Yabe, Nagao and Shimizu, 1926)?	1668			1, 2, 3, 4		●					
19	Corbiculidae	*Filosina* sp.	478					← ● →					
20		*Tetoria sanchuensis* (Yabe and Nagao in Yabe, Nagao and Shimizu, 1926)	1668			1, 2		●					
		Eocallista ofunatoensis Kozai and Tashiro, 1993				2, 4		●					
	Ptychomidae	*Ptychomya densicostata* Nagao, 1934		Hy.0053				●					
	Corbulidae	*Corbula angulata* Kozai, 1986			1, 2, 3	1, 2, 3, 4		●					
		Caestocorbula shikamai Hayami. 1980				2		●					
	Hiatellidae	*Panopea concentrica* Kozai and Tashiro, 1993				3, 4		●					
		P. sp.				1		●					
	Laternulidae	*Plectomya*? sp.				4		●					

in East Asia, including Japan, and then compare them with biostratigraphic zone of ammonites and other fossil species in the standard section of western Europe. Based on ammonite biostratigraphy, the Ofunato Group can be assigned to the Hauterivian Stage, as mentioned above. This supports the opinions of Kozai (1986) and Kozai and Tashiro (1993), but it does not confirm the age of the Ofunato Group using this biostratigraphic procedure for bivalve fossil species.

SEDIMENTARY ENVIRONMENT BASED ON SEDIMENTARY FACIES ANALYSIS AND MOLLUSCAN FAUNAS AND THESE DISCREPANCIES

The Ofunato Group was deposited in response to a marine transgression, as indicated by the Funagawara Formation, then followed by a regressive episode represented by the Hijochi and Kobosoura formations. Bivalves from the Funagawara Formation include brackish corbiculoids as well as shallow-marine species, an extremely rare example of bivalves occurring from deep sea, submarine fan deposits. All of these bivalve specimens, except for specimens of *Filosina* sp., occur as dis-jointed single valve, and or as destroyed shells, which indicates an allochthonous occurrence.

The brackish corbiculoids from the Funagawara Formation contain species that are common in the Ryoseki fauna, which is characteristic of the Lower Cretaceous in the outer zone of southwestern Japan. The bivalve assemblage of the Funagawara Formation would appear to belong to the Ryoseki Fauna (Kobayashi, 1983). The brackish bivalve fossil specimens of the Ryoseki fauna generally occur in conjoined valves and exclusive occurrence, with multiple overlapping single and conjoined shells. The strata containing the Ryoseki fauna are the Lower Cretaceous System of the outer zone of southwest Japan, including the Sanchu Cretaceous, and were all formed in the inner bay during an early transgressive episode (e.g., Matsukawa, 1983). This characteristic differs from that of the Funagawara Formation in which both brackish and shallow-marine species occur allochthonously. It is reasonable to interpret that these bivalve fossil specimens were from inner-bay and/or shallow-marine deposits, which have now disappeared and were age-equivalent to the Funagawara Formation. In the context of the brackish bivalve paleobiogeography in Lower Cretaceous of Japan, the Funagawara Formation represents the northernmost distribution of the Ryoseki fauna.

CONCLUSIONS

1. The Funagawara Formation of the Ofunato Group is composed mainly of sandstone, matrix-supported conglomerate, and mudstone, which are interpreted as turbidite, submarine debris flow deposits, and hemi-pelagic mudstone, respectively. In general, the Funagawara Formation shows upward fining and is thought to have been deposited during marine transgression.
2. An ammonite specimen from the Funagawara Formation of the Ofunato Group is confirmed as *Balearites* sp. We established the *Balearites* sp. Biostratigraphic Horizon that correlates with the *Balearites balearis* Zone of the upper Hauterivian Stage of the Lower Cretaceous ammonite standard zonation for the West Mediterranean Province of the Tethyan Realm. The Funagawara Formation is assigned to the upper Hauterivian.
3. Bivalve fossil specimens were identified into 19 species of 19 genera in this paper. These, in addition taxa already described, comprise a total of 37 species of 29 genera of bivalve fossil specimens, which show characteristics similar to those of the shallow-marine to brackish-water bivalve faunas of the Lower Cretaceous in the outer zone of southwest Japan. The Ofunato Group is considered to the upper Hauterivian to lower Barremian stages, but this is tentative pending further biostratigraphical analyses.
4. The bivalve fossil specimens in the Funagawara Formation include allochthonous brackish and shallow-marine species from inner-bay and/or shallow-marine deposits, which no longer exist. This is different from the Funagawara Formation. The brackish bivalve fossils of the Funagawara Formation represent the northernmost distribution of the Ryoseki fauna.

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