

[Short Report]

First description of left valve of *Chlamys ingeniosa ingeniosa* (Yokoyama) from the Middle Miocene of Japan

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Abstract

Chlamys ingeniosa ingeniosa (Yokoyama) is a fossil pectinid bivalve previously known only from the right valve. Recently, over one hundred well-preserved specimens of this species were collected from the Middle Miocene Nanao Calcareous Sandstone Member of the Akaura Formation distributed at Shirouma-machi, Nanao City, Ishikawa Prefecture, central Japan. In this report, we describe the morphology of its left valve for the first time and note some additional remarks on the species.

Key words : *Chlamys ingeniosa*, Nanao Calcareous Sandstone, Pectinidae, Middle Miocene.

Introduction

Chlamys ingeniosa ingeniosa, an extinct pectinid bivalve, was first described by Yokoyama (1929) as *Pecten (Chlamys) hastatus* Sowerby, var. *ingeniosa* nov., based on a single right valve collected from the vicinity of Nanao City, Ishikawa Prefecture, central Japan. Subsequently, Masuda (1962) and Amano (1994) illustrated the right valve of *C. ingeniosa* from Nanao City. Masuda (1962) reported the occurrence of a left valve from the Miocene Sugota Formation in Akita Prefecture, but he did not illustrate the specimen. Akiyama (1958) and Amano (1994) described another pectinid taxon, *C. ingeniosa tanakai*, from the Pliocene Ogikubo Formation in Nagano Prefecture. Recently, Kurihara and Yanagisawa (2002) reported pectinids from the Miocene Shimotezuna Formation of the Taga Group in Ibaraki Prefecture, and illustrated the right and left valves of *C. ingeniosa ingeniosa*. However, the morphology of the left valve has remained undescribed for this species.

Recently, over one hundred well-preserved specimens of *Chlamys ingeniosa ingeniosa* were collected from the Middle Miocene Nanao Calcareous

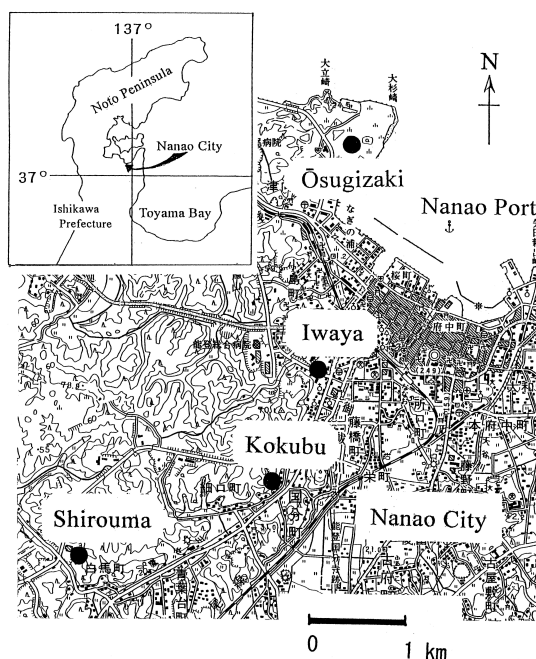


Fig.1. Location map of the study area, based on Geographical Survey Institute of Japan (2005).

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Sandstone Member of the Akaura Formation in Shirouma-machi, Nanao City (Fig. 1). Based on the specimens, we provide the first description of the left valve of this species. We also discuss the occurrence of associated fossil mollusks and their paleoenvironmental conditions. Furthermore, we propose a new Japanese name-“Iwayanishiki” for the species.

Geology and associated fossil mollusks

According to Kaseno (1993), the Neogene series developed in Nanao area was classified into the following formations in ascending order : 1) the Kumabuchi Andesite, 2) the Zyoyama Formation, 3) the Akaura Formation including the Nanao Calcareous Sandstone Member, 4) the Wakura Formation that

includes the Glauconite Sandstone Member, 5) Akasaki Formation, and 6) Kojima Formation (Fig. 2). The Nanao Calcareous Sandstone which yields *Chlamys ingeniosa ingeniosa*, is considered to be interfingering with a non-calcareous sandstone unit of the Akaura Formation in the south Noto Peninsula (Kaseno, 1965). The Nanao Calcareous Sandstone consists of fine to coarse-sized quartz grains including partly andesitic pebbles and is intermittently exposed in four districts in Nanao City : Shirouma-machi, Kokubu-machi, Iwaya Fuzihashi-machi, and Ōsugizaki Tumugi-machi (Fig. 1). This sandstone contains abundant remains of invertebrates, such as foraminiferans, brachiopods, bryozoans, mollusks, and echinoids. Abundant pectinids occur in the coarse sandstone with pebbles at Iwaya (Fig. 3).

Geological Age (Ma)		Stratigraphic Division
2		~~~~~
3.5	Pliocene	Kojima Sandstone
5		~~~~~
9	Late M.	~~~~~
10		~~~~~
13.5		~~~~~
14	Middle Miocene	~~~~~
15		~~~~~
16		~~~~~
17	Early Miocene	~~~~~
20?		~~~~~

Fig.2. Generalized stratigraphical column of Neogene at the Nanao area in Ishikawa Prefecture, Japan (After Kaseno, 1993).

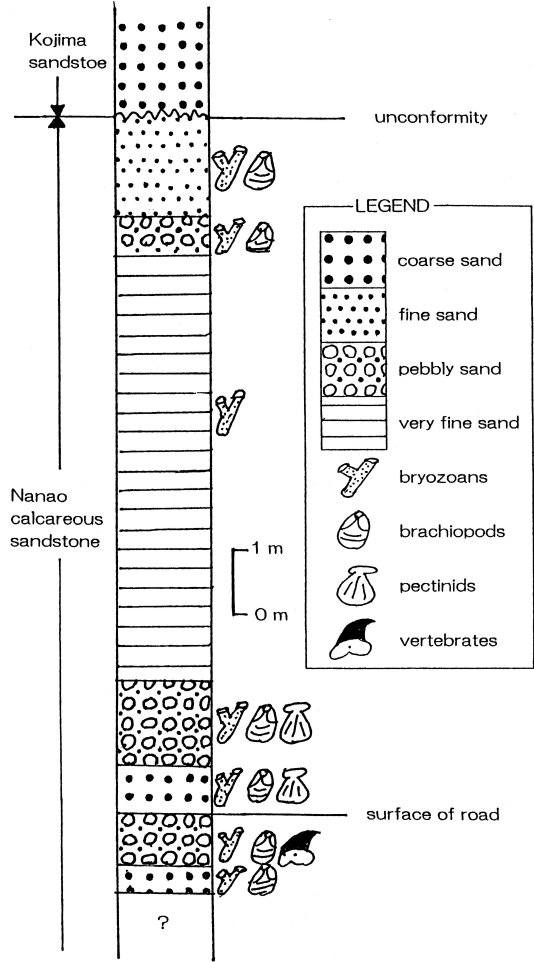


Fig.3. Stratigraphical columnar sections at Iwaya, Nanao City, Ishikawa Prefecture, Japan (After Nomura, 1997).

Concerning the geological age of the Nanao Calcareous Sandstone, Takayama and Kuchida (1979) assigned an age of 14.0 - 13.4 Ma using calcareous nannofossils at Ōsugizaki. Kami et al. (1981) also assigned an age of about 14 Ma based on calcareous nannofossils at Iwaya. Therefore, the stratigraphic unit is considered to be Middle Miocene in age.

The mollusk assemblage of the Nanao Calcareous Sandstone Member consists of three families, six genera, and 14 species (Nomura, 2003). Each species and its frequency of the occurrence at each locality are shown in Table 1. Most pectinid remains are isolated valves arranged parallel with the bedding plane and with their convex side upwards. Over 60 percent of the shells were broken, but the broken valves still remained angular with clear sculptures. Young pectinid individuals are also abundant in the sample. These facts suggest that the pectinids are considered to be indigenous and allochthonous with limited post-mortem transportation.

Table1. Fossil mollusks collected from the Nanao Calcareous Sandstone Member, Nanao City, Ishikawa Prefecture, Japan. S: Shirouma, K: Kokubu, I: Iwaya, O: Ōsugizaki

Specific name	Fossil locality	S	K	I	O
<i>Chlamys cosibensis hanzawae</i>					R
<i>Chlamys ingeniosa ingeniosa</i>		A	C	R	R
<i>Chlamys</i> cf. <i>ingeniosa ingeniosa</i>		R			
<i>Chlamys otukae</i>		R		R	R
<i>Chlamys</i> sp.		R			
<i>Gloripallium crassivenium</i>					R
<i>Nanaochlamys notoensis</i>		A	A	C	R
<i>Swiftopecten swiftii</i>				R	
<i>Kotorapecten kagamianus kagamianus</i>		R		R	R
<i>Kotorapecten kagamianus moniwaensis</i>		A	A		
<i>Kotorapecten kagamianus permirus</i>			R	A	
<i>Nipponopecten akihoensis</i>		C	R	R	R
<i>Crassostrea</i> sp.		R		R	
<i>Epitonium (Boreoscala) nagaminensis</i>		C	R	R	R

A: abundant, C: common, R: rare

Materials and Methods

Our collection of *Chlamys ingeniosa ingeniosa* consists of 106 specimens from Shirouma, many fragments from Kokubu, four specimens from Iwaya, and one specimen from Ōsugizaki. They comprise 51 right valves and 55 left valves. All specimens are deposited in the Nanao Children Science Museum,

Nanao City. We follow Masuda (1962) for the classification of pectinids, Habe (1977) and Masuda (1981) for the morphological terminology, and Sato (1991) for the measurements.

Description

Family Pectinidae Lamarck, 1918

Subfamily Chlamiinae Masuda, 1962

Genus *Chlamys* Röding, 1798

Chlamys ingeniosa ingeniosa (Yokoyama, 1929)

Fig. 4

1929. *Pecten (Chlamys) hastatus* Sowerby, var. *ingeniosa* Yokoyama, *Rep. Imp. Geol. Surv.*, no. 104, pp.5-6, fig. 2.

1962. *Chlamys ingeniosa* (Yokoyama): Masuda, *Tohoku Univ., Sci. Rep., 2nd Ser. (Geol.)*, Vol. 33, no. 2, p. 170, pl. 22, fig. 13.

1994. *Chlamys ingeniosa ingeniosa* (Yokoyama): Amano, *Trans. Proc. Palaeont. Soc. Japan. N. S.*, no. 176, p. 665, figs. 3-5, 8.

2002. *Chlamys ingeniosa ingeniosa* (Yokoyama): Kurihara and Yanagisawa, *Jour. Geol. Soc. Japan*, Vol. 108, No. 7, p. 425, pl. 2, figs. 6, 8, 9.

Shell medium in size, sub-orbicular, moderately thick, equilateral except for auricles; left valve slightly more convex than the right; each valve with approximately 30 radial ribs near the beak where the radial ribs of right valve increase by the bifurcation and those of left by the intercalation; each valve with imbricated radial ribs, and with finely reticulated interspaces, and with fine concentric growth lines, and with an angle of nearly 87° at apex, showing ratio of valve height to width nearly 1.08; intercalary threads present near the ventral margin of both valves at adult stage; both auricles with six to ten riblets and concentric growth lines, anterior auricle much larger than the posterior; inner surface of valve folded corresponding to the ribs and interspaces of the outer surface, and inner ventral margin coarsely crenulated.

Left valve with 16 to 18 original radial ribs and 12 to 14 primary intercalary ribs that appear near the beak; primary intercalary ribs narrower than original radial ribs in breadth; secondary and tertiary intercalations present; increasing number of intercalary threads with growth; tendency of some of original radial ribs to divide two or three riblets by a shallow longitudinal furrow at adult stage;

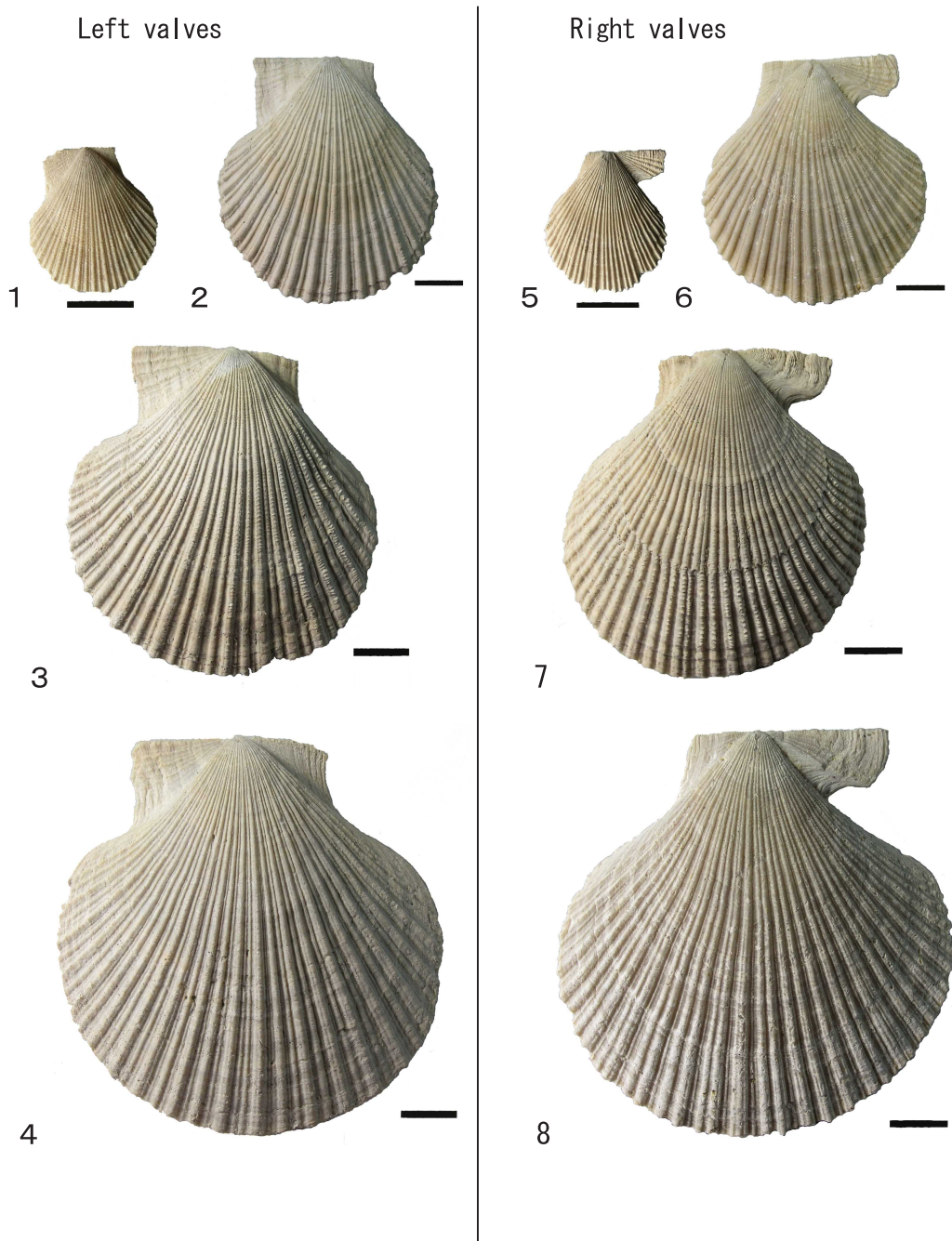


Fig.4. *Chlamys ingeniosa ingeniosa* (Yokoyama). (scale : 1cm).

Table 2. Measurements of the figured specimens

Specimen number of Figure 4	measurement of size (mm)						number of ribs					
	H	L	D	A	P	AA	R	I	B	RM	LM	
1 (left valve)	22.3	19.6	3.7	6.2	4.8	85°	16	14		27	7	
2 (left valve)	51.1	44.8	10.1	15.3	9.4	85°	16	13		30	10	
3 (left valve)	58.6	55.5	12.1	18.2	12.3	87°	16	14		30	13	
4 (left valve)	69.9	67.5	15.1	18.8+	15.8	88°	18	14		33	23	
5 (right valve)	22.6	19.3	3.1	9.1	3.2	85°	15?		29	30	3	
6 (right valve)	50.3	46.2	7.7	17.3	10.4	86°	15?		30	32	9	
7 (right valve)	55.8	51.7	11.8	17.7	12.5	88°	16		31	36	10	
8 (right valve)	69.1	68.9	11.6	21.9	12.5	88°	16		32	34	24	

H : height, L : length, D : depth, A : anterior auricle length, P : posterior auricle length, AA : apical angle, R : numbers of original radial ribs, I : numbers of original intercalary riblets, B : numbers of original branched rib, RM : rib's numbers at the ventral margin, LM : riblet's numbers at the ventral margin

anterior auricle larger than the posterior, and isosceles in shape.

Right valve with approximately sixteen rather distinct radial ribs, that usually divide into two riblets near the beak; intercalary threads present at upper part of disc; tendency of some bifurcated ribs to divide into two or three fine riblets by shallow longitudinal furrows at lower part of disc; anterior auricle much longer than the posterior one; byssal notch deep and distinct with four to seven small ctenoliums.

Measurements. Measurements and number of ribs on specimens (Fig. 4) shown in Table 2.

Remarks. *Chlamys ingeniosa ingeniosa* resembles *C. arakawai* (Nomura) from the Moniwa Formation (Sato, 1991), but the present species is distinguished from *C. arakawai* in larger number of radial ribs, and in narrower width of interspace.

Discussion

The localities of *Chlamys ingeniosa ingeniosa* are limited as following areas; Nanao Calcareous Sandstone, Ishikawa Prefecture (Yokoyama, 1929; this report; Fig. 1); Sugota Formation, Akita Prefecture (Masuda, 1962); Orito Formation, Niigata Prefecture (Masuda, 1962); Shimotezuna Formation, Ibaragi Prefecture (Kurihara and Yanagisawa, 2002). In Nanao City (Fig. 1), *C. ingeniosa ingeniosa* is abundant in the southernmost locality (Shirouma-machi), but tends to decrease northwards (Table 1). This mode of occurrence is similar to that of associated *Nanaochlamys*

notoensis (Table 1). Therefore, it may be considered that their living area was in the southern part of Nanao City and the oceanic currents flowed from the south to the north. Based on the associated pectinids such as *Kotorapecten kagamianus* (Masuda, 1958) and *N. notoensis* (Sato, 1991), it may be inferred that *C. ingeniosa ingeniosa* lived in rocky or sandy bottoms of shallow clean sea influenced by warm thermal water.

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