

Fossil barnacles from the Pleistocene Miyata Formation

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(With 1 Table and 1 Plate)

宮田層 (洪積世) 産化石フジツボ類について

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三浦半島南部・津久井浜駅西方 50 m の崖に露出する宮田層の中粒ないし粗粒砂中より多くの軟体動物と共にフジツボ類の化石を多数得た。そのうち三種類のフジツボ, *Balanus* (*Megabalanus*) *tintinnabulum* *rosa* PILSBRY (アカフジツボ), *B. rostratus* HOEK (ミネフジツボ) と *B. (Semibalanus) cariosus* (PALLAS) (チシマフジツボ) について記載した。このうち *B. (S.) cariosus* は寒流系種として知られ, その現生標本の南限は現在までのところ 女川湾付近までしか知られていないが宮田層堆積時には三浦半島付近まで分布していたことが知られた。この研究は横須賀市博物館が行なった宮田層に関する総合研究の一部をなすものである。

As it is seen from the table 1, the fossil barnacles are found commonly in the Neogene and Quaternary formations throughout Japan. However, they have not been studied in detail.

Table 1.

Author, Year	Species	Formation
MATSUMOTO, H. (1920)	<i>Balanus porcatus</i> DA COSTA <i>B. bisulcatus</i> DARWIN <i>B. flosulcatus</i> DARWIN var. <i>orientalis</i> MATSUMOTO	Taihaku Fm. (Miocene)
HATAI, K. (1936)	<i>B. rostratus</i> HOEK	Suenomatsuyama Ser. (Pliocene)
NOMURA, S. & HATAI, K. (1936)	<i>B.</i> sp. <i>B. nubilis</i> DARWIN <i>B. cariosus</i> (PALLAS)	Tanagura Beds (Miocene)
HATAI, K. H. (1938)	<i>B. rostratus</i> HOEK <i>B. cariosus</i> (PALLAS) <i>B. nubilis</i> DARWIN <i>B.</i> sp. <i>Coronula diadema</i> (LINNAEUS)	Tanagura Beds (Miocene)
YABE, H. & HATAI, K. (1941)	<i>C. Balanus diadema</i> (LINNAEUS) <i>tintinnabulum rosa</i> PILSBRY	Shimaziri Beds (Pliocene)
SHIKAMA, T. (1954)	<i>B. nubilis</i> DARWIN <i>B.</i> sp.	Nukuta Fm. (Miocene)
OZAKI, H. (1958)	<i>B. rostratus</i> HOEK <i>B.</i> cf. <i>tintinnabulum volcano</i> PILSBRY <i>Tetraclita squamosa stalactifera</i> (LAMARCK) <i>Coronula diadema</i> (LINNÉ) <i>Balanus</i> sp.	Katori Fm. (Pleistocene)
OHARA, S. (1969)	<i>B. amphitrite</i> DARWIN <i>B. rostratus</i> HOEK	Semata Fm. (Pleistocene)
IWAI, T. & SIOBARA, T. (1969)	<i>B. rostratus</i> HOEK	Numasaki Mud (Pleistocene)

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Three species of barnacles, *Balanus* (*Megabalanus*) *tintinnabulum* *rosa* PILSBRY, *B. rostratus* HOEK and *B. (Semibalanus) cariosus* (PALLAS) are found from the medium to coarse grained sand of the Pleistocene Miyata Formation, exposed at the cliff 50m west of Tsukui-hama tramway station, Miura Peninsula (139°40'E., 35°11'N.). The sand is loose, rich in fine pumice and scoria, and slightly cross-laminated. Barnacles occur clustered in a fossiliferous bed of approximately 4 m in thickness, and associated with molluscs, brachiopods, foraminifers, corals, bryozoans and others. Among these fossils, molluscs and barnacles are particularly rich.

Most of the barnacles are found as the disjointed elements. The elements are worn out and or broken fragments. In spite of the fact that *B. (M.) tintinnabulum* *rosa* are particularly fragmental in comparison with *B. (S.) cariosus* and *B. rostratus*, yet, in detail, *B. (M.) tintinnabulum* *rosa* as well as *B. (S.) cariosus* are found very rarely but in complete specimens. This is probably due to the difference of structural coherence between the compartment of these species. *B. rostratus* are found always

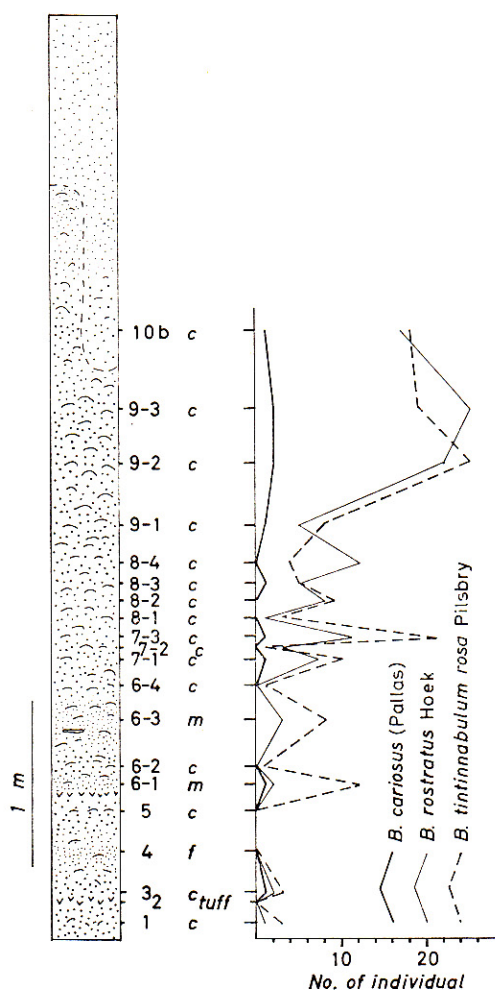


Fig. 1. Columnar section at the fossil locality, showing the sampling horizons, frequency of occurrence of three species and nature of sediments. f: fine sand, m: medium sand, c: coarse sand. (modified from ARAI and others (1971) and KANIE (1971))

as disjointed elements. This is probably due to the differences of the shell structure and or the long distance of the transportation.

Individual number of each species in the sand of 5 kilograms at the various stratigraphic horizons are shown in fig. 1. Because most barnacles are found disjointed, it is impossible to calculate the real individual number exists in a sample. However, the minimum individual number can be calculated through the number of the same kind of element. The figures thus obtained attain 151 for *B. (M.) tintinnabulum rosa* and 124 for *B. rostratus*. *B. (S.) cariosus* is a rare species and only 10 individuals in total are collected. *B. (M.) tintinnabulum rosa* occurs from the most horizons but their number is smaller in the lower horizon and becomes larger toward the upper. Descriptions of the three species mentioned above are given below.

Mr. Yasumitsu KANIE of the Yokosuka City Museum provided the specimens at the writer's disposal. Professor Huzio UTINOMI read the manuscript and gave the writer invaluable advices. Professor Fuyuji TAKAI, Drs. Tetsuro HANAI, Kiyotaka CHINZEI and Yasuhide IWASAKI of the University of Tokyo, Professor Tokio SHIKAMA of the Yokohama National University and Dr. Noriyuki IKEYA of the Shizuoka University also gave the writer helpful advices.

Family Balanidae LEACH, 1817

Subfamily Balaninae LEACH, 1817

Genus *Balanus* DA COSTA, 1778

Subgenus *Megabalanus* HOEK, 1913

Balanus (Megabalanus) tintinnabulum rosa PILSBRY

(Pl. I, Figs. 1-7)

Balanus (Megabalanus) tintinnabulum rosa PILSBRY, 1916, p. 61.

Balanus tintinnabulum rosa PILSBRY, NILSSON-CANTELL, 1932, p. 16, text-fig. 6, pl. 1, fig. 3., HIRO, 1932a, p. 549, text-fig. 3., HIRO, 1937, p. 431, text-fig. 19 B., YABE and HATAI, 1941, p. 78.

Description of fossil specimens: General shape: Shell conical, smooth, large, rather thick. Color purplish red or pink gray. Radii smooth and wide. Summit of radii parallel to the base. Orifice large, wide, acutely ovate or rhomboidal.

Opercular valves: Scutum with prominent and downwardly imbricated ridges of growth. Color of scutum purplish red to pink in external and white in internal surface. Articular ridge prominent and reflexed. Articular furrow narrow and shallow. Adductor ridge blunt and not very prominent. Pit for adductor muscle and lateral depressor muscle wide and deep. Tergum triangular, broad, with the ridges of growth. Color of tergum white but purplish pink along the carinal margin. Spur furrow deep and closed. Spur long and its width nearly equal to the distance between anterior side of spur and basiscutal angle. Articular ridge long, prominent and acute, running from apex toward basiscutal angle. Scutal edge high and acute. Longitudinal ridges at carinal side of articular ridge very weak but numerous and paralleled to articular ridge. Crests for depressor muscle very weak.

Compartments: Parietes conical. Longitudinal tubes with transverse septa in the uppermost portion. Under certain circumstances number of longitudinal ribs and tubes increase with growth. Surface of inner lamina slightly ribbed or smooth. Radii porous, with septa, denticulated on both sides. External surface of radii smooth, often with many slight horizontal stripes reflecting existence of septa. Sheath smooth, purplish red to white.

Basis: Base calcareous, thick, porous, and flat or irregular cupform.

Remarks: The external and/or internal surface of disjointed and fragmental elements are often covered by bryozoans or bored by the unknown animals.

Subgenus *Balanus* DA COSTA, 1778

Balanus rostratus HOEK

(Pl. I, Figs. 8–13)

Balanus rostratus HOEK, 1883, p. 152, pl. 13, figs. 16–22., PILSBRY, 1916, p. 138, pl. 36, figs. 1–2a., HIRO, 1933, p. 71., HIRO, 1935, p. 217, pl. 10, figs. 1–2., HATAI, 1936, p. 73., HATAI, 1938, p. 97., CORNWALL, 1955, p. 38, figs. 30–31., OZAKI, 1958, p. 175, pl. 10, figs. 15–16., ŌHARA, 1968, p. 316., IWAI and SIOBARA, 1969, p. 5, pl. 3, fig. 21.

Balanus sp., OZAKI, 1958, p. 176, pl. 22, fig. 23.

Description of fossil specimens: *General shape:* Shell conical, rather thick and strong, with smooth external surface. Color yellowish white to light gray. Orifice ovate, small, with irregular teeth.

Opercular valves: Scutum narrow, with very prominent ridges of growth, superimposed over very fine growth lines. Color of scutum yellowish white. Ridges of growth imbricating downward, and divided into squarish beads by longitudinal striation. Articular ridge long, but not very prominent. Articular furrow narrow and shallow. Adductor ridge weak. Pit for adductor muscle rather deep. Tergum yellowish to gray, flat, with weak ridges and growth lines. Spur wide at base, obliquely truncated at end. Spur furrow absent. Articular ridge moderate. Ridge running toward basiscutal angle. Scutal margin concave. Crests for depressor muscle weak.

Compartments: Parietes yellowish white to light gray, conical and smooth with longitudinal tubes having transverse septa. Rostrolateral well developed. Carinolateral narrow. Radii narrow, deeply sunken from parietes. Sheath extending lower than the middle of compartment. Longitudinal ribs prominent, in some cases weak. Surface of sheath with growth lines and very weak longitudinal lines.

Basis: Base calcareous, thin and solid.

Remarks: Pit for adductor muscle of this species well develops in the specimens from the Miyata Formation. According to the HOEK's original description, crests for depressor muscle are invisible in this species whereas they are weak but visible in the present specimens.

Subgenus *Semibalanus* PILSBRY

Balanus (Semibalanus) cariosus (PALLAS)

(Pl. I, Figs. 14–17)

Balanus cariosus (PALLAS), DARWIN, 1854, p. 273, pl. 7, figs. 3a–e., GRUVEL, 1903, p. 140, pl. 4, fig. 13., PILSBRY, 1921, p. 112, pl. 20, figs. 3 & 6., HIRO, 1932b, p. 472, text-fig. 3., NOMURA and HATAI, 1936, p. 152, pl. 15, figs. 19a–b., HATAI, 1938, p. 96., HENRY, 1940, p. 13, pl. 1, figs. 1–4., HENRY, 1942, p. 102, pl. 1, figs. 4–6., CORNWALL, 1955, p. 26, figs. 19–20.

Balanus (Semibalanus) cariosus (PALLAS), PILSBRY, 1916, p. 189, pl. 46, figs. 1–9, pl. 47, figs. 1a–c., CORNWALL, 1925, p. 472, text-fig. 1A–F & L, pl. 1, figs. A–E, pl. 2, figs. A–B, pl. 3, figs. E–H., HIRO, 1935, p. 223, text-fig. A, pl. 10, fig. 3.

Description of fossil specimens: General shape: Shell white to light gray, conical, with ovate orifice. Shell surface covered by longitudinal plaits with many spines. Plaits numerous, narrow, extremely prominent, imbricated downward. Raddi very narrow.

Compartments: Parietes very thick with tubes. The tubes irregularly arranged. Form and size of tubes variable, having transverse septa. Sheath well developed, smooth with faint growth lines, in some cases extends nearly to the base. Surface of inner lamina with irregularly branched wrinkles. Interspace of sheath and inner lamina filled up solidly. Alae conspicuous, but radii very narrow.

Basis: Without calcareous base.

Remarks: Opercular valve is not found in the specimens at hand.

Discussion

Localities from where the three species *B. (M.) tintinnabulum rosa*, *B. rostratus* and *B. (S.) cariosus* have so far been reported are shown in fig. 2. *B. (M.) tintinnabulum rosa* is a warm water species living between lower tidal line and the depth up to 300 m. The species have been reported

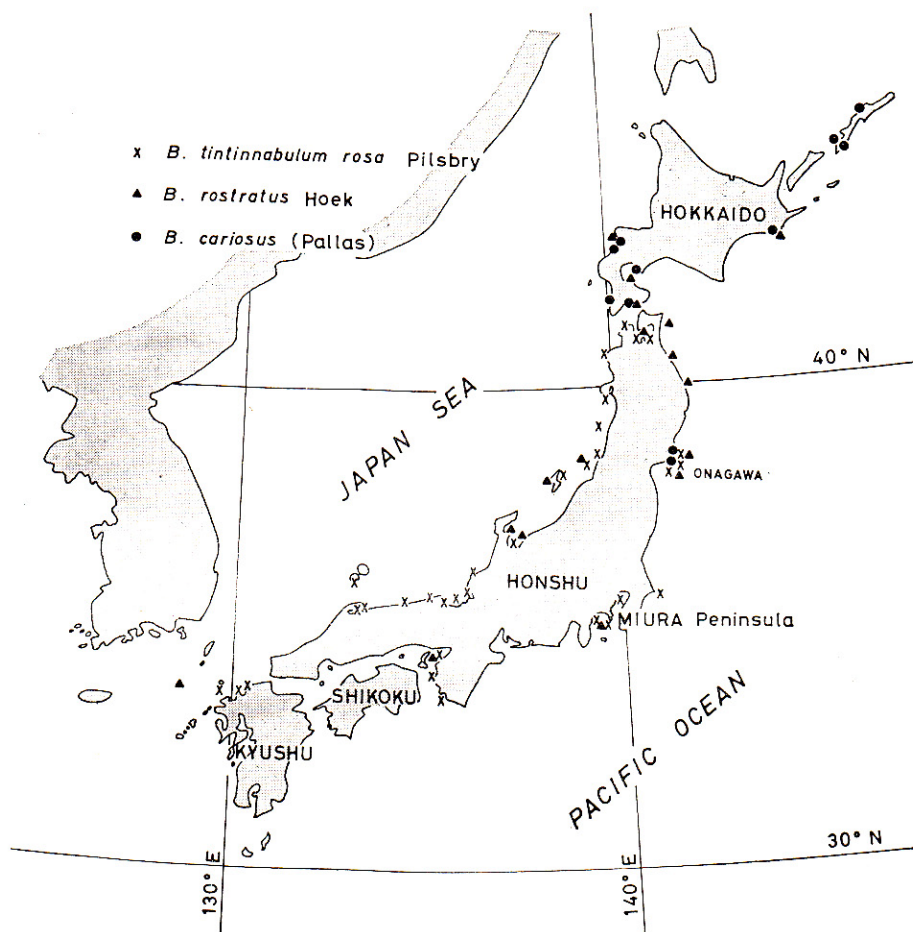


Fig. 2. Distribution of the three species in the recent sea around the Japanese Islands. (compiled from HOEK (1883), HIRO (1932a, 1932b, 1933, 1935, 1937 and 1939) and UTINOMI (1955, 1958 and 1970))

as far north as Tsugaru Straits and down south to Formosa.

Balanus rostratus was originally described from Kobe in the report of expedition of H. M. S. Challenger. The species is a cold water inhabitant and is found from lower tidal line to 170 m in depth. Distribution of the living species ranges between western Japan and Puget Sound of North America, through Kuril Is., Aleutian Is. and the Pacific coast of Alaska and Canada. In Japan, this species extends to the Sagami Bay on the Pacific side, and to the Tsushima Straits, western end of Kyushu on the Japan Sea side. Occurrence of this species in Kobe is inferred to be a result of the intrusion of this cold water species into the Inland Sea of Japan from the Japan Sea.

Balanus (S.) *cariosus* is a cold water form, attached to the rocks, organisms and other solid substances, and found just below the lower tidal line. This species have been reported from northern Japan, Kuril Is., Aleutian Is., Alaska, Canada, and northern California. In Japan, this species extends southward to the Onagawa Bay along the Pacific coast of northern Honshu. This species has so far been unknown from the Japan Sea side of Honshu.

Thus the combined occurrence of three species, *B. (M.) tintinnabulum rosa*, *B. rostratus* and *B. (S.) cariosus* can probably be limited to the area between the Onagawa Bay and the Tsugaru Straits. In fact, the three species are actually found living in the Onagawa Bay and its adjacent areas. Thus, it is an important datum for the paleogeographic discussion on the Japanese Pleistocene that the Miyata Formation, which is located more than 360 km south of the Onagawa Bay, yields the three species mentioned above.

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Postscript: After the manuscript of this paper was submitted to the editor, the writer found that two new localities should be added for *Balanus (Semibalanus) cariosus* (PALLAS). One is Cape Inubo (35°42.3'N., 140°52'E.), and the other is Onahama harbor (36°56.5'N., 140°54.5'E.). Specimens from Cape Inubo were collected by Mr. Inaba and preserved in Seto Marine Biological Laboratory of Kyoto University. Specimens from Onahama were collected by the writer in a cruise, KT 71–5, from May 4 to 13, 1971, of “Tansei-Maru”, a research vessel of the Ocean Research Institute, University of Tokyo.

PLATE I

- Figs. 1-7. *Balanus (Megabalanus) tintinnabulum rosa* PILSBRY, 1 *a, b*, right lateral and posterior views of compartments, horizon no. 9-3, $\times 1$. 2 *a, b*, exterior and interior views of right lateral compartment, horizon no. 6-1, $\times 2$. 3 *a, b*, exterior and interior views of rostrrolateral compartment, horizon no. 7-3, $\times 2$. 4 *a, b*, exterior and interior views of carina, horizon no. 9-3, $\times 2$. 5 *a, b*, exterior and interior views of left carinolateral compartment, horizon no. 8-3, $\times 2$. 6 *a, b*, exterior and interior views of right scutum, horizon no. 8-2, $\times 2.5$. 7 *a, b*, exterior and interior views of left tergum, horizon no. 6-2, $\times 2.5$.
- Figs. 8-13. *Balanus rostratus* HOEK, 8 *a, b*, exterior and interior views of rostrrolateral compartment, horizon no. 9-2, $\times 2$. 9 *a, b*, exterior and interior views of right carinolateral compartment, horizon no. 10b, $\times 2$. 10 *a, b*, exterior and interior views of right lateral compartment, horizon no. 9-1, $\times 2$. 11 *a, b*, exterior and interior views of carina, horizon no. 9-3, $\times 2$. 12 *a, b*, exterior and interior views of right scutum, horizon no. 10b, $\times 2.5$. 13 *a, b*, exterior and interior views of left tergum, horizon approximately correspond to horizon no. 6, $\times 2.5$.
- Figs. 14-17. *Balanus (Semibalanus) cariosus* (PALLAS), 14 *a, b*, posterior and right lateral views of compartments, horizon no. 3, $\times 3$. 15 *a, b*, exterior and interior views of rostrrolateral compartment, horizon no. 8-3, $\times 2$. 16 *a, b*, exterior and interior views of carina, horizon no. 9-3, $\times 2$. 17 *a, b*, exterior and interior views of right lateral compartment, horizon no. 9-3, $\times 2$.

