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The Cockle, *Clinocardium nuttallii* (Conrad) in Japan

Frank H. Kilmer*

Abstract

A study of Recent and paleontologic evidence of *Clinocardium nuttallii* (Conrad) from Japan, and that from elsewhere in Asia and western North America, supports the following conclusions (1) *Clinocardium nuttallii* (Conrad) is a valid species in coastal waters of the Kushiro-Akkeshi area, southeastern Hokkaido, (2) there is no valid evidence for *C. nuttallii* in the fossil record of Japan, and (3) *C. nuttallii* probably originated in the northern or northeastern Pacific during Miocene or Pliocene time, dispersing southwestward to Sakhalin and Kamchatka during the Pleistocene and to Japanese shores during the Recent.

INTRODUCTION

The basket cockle, *Clinocardium nuttallii* (Conrad), is a North Pacific bivalve inhabiting bays, sloughs, estuaries and shallow offshore areas between southern California and the Bering Sea (Fitch, 1953). It has also been reported by Dall (1921) to range as far south along the Asiatic coast as northern Japan. The species was described from a locality near the Columbia River mouth by Conrad (1837) as *Cardium nuttallii*, although for many years it was erroneously identified with *corbis* Martyn (1788) and designated variously as *Cardium corbis*, *Laevicardium corbis*, and *Cerastoderma corbis*. Keen (1936) established the genus *Clinocardium* and designated *Cardium nuttallii* as the genotype.

From Japanese waters, *C. nuttallii* has been reported by Smith (1904), Dall (1921), Hirase (1936), Kuroda and Kinoshita (1951), Habe (1955) and others. Keen (1940) considered *C. nuttallii* a "probably valid" species living in Japan based on a comparison of American forms with figured specimens from Japanese literature. However, none of the citations of *C. nuttallii* in Japanese waters have been accompanied by published figures or data directly comparing undoubted specimens of *C. nuttallii* from the northeastern Pacific with those held to be the same species in Japan.

Clinocardium nuttallii has been reported by Japanese paleontologists from Cenozoic deposits of northern Japan and Sakhalin with the earliest occurrence apparently being of Miocene age according to Yokoyama (1926a). However, a study recently undertaken by the author at the Institute of Geology and Paleontology, Tohoku University, casts considerable doubt on the validity of fossil occurrences of *C. nuttallii* in Japanese Cenozoic deposits and it appears more likely that the species did not appear in Japan until the Recent.

The purpose of this paper is (1) to substantiate the living presence of *C. nuttallii* in Japan, (2) to clarify the geological history of *C. nuttallii* in Japan, and (3) to discuss briefly, implications concerning the history of dispersal and possible place of origin of this species.

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A COMPARISON OF RECENT VALVES FROM JAPAN AND AMERICA REFERRED TO *CLINOCARDIUM NUTTALLII* (CONRAD)

Eighteen valves, including five paired sets from Japan and approximately fifty valves, including twenty paired sets from American waters, were personally examined and compared by the author. Principal dimensions of the Japanese specimens and selected American specimens are shown in Table 1. Japanese valves[1] were recovered from coastal waters of the Akkeshi-Kushiro area of southeastern Hokkaido according to Japanese authorities, although no specific locality or ecologic data was available. American valves[2] are from Alaska, Washington, Oregon and California and represent both protected bay and offshore environments.

Japanese and American valves compare closely with respect to size, trigonal outline, rounded anterior and ventral margins, strongly inclined beaks, position and height of umbones, dentition, depressed ligament, arched hinge, and morphology of adductor muscle scars and palial line (Pls. 1–2).

The number of radial ribs for the Japanese varies from 33–38 while in American valves the range is generally the same except that occasionally ribs may number as few as 32 or as many as 41. Rib shapes of Japanese and American valves compare closely in each group the shape ranges from round to squarish (*i.e.* more nearly square than round). Ribs of both groups are crossed by numerous and conspicuous, loop-shaped riblets or nodes. Rib interspaces are relatively narrow, round-bottomed valleys about 1/3 the width of the ribs.

The majority of compared American valves represents protected bay environments including Washington Bay and Bainbridge Island, Puget Sound, Washington; Coos Bay, Oregon; and Humboldt Bay, California. Valves from these and other protected localities generally possess rather small cardinal teeth, have a height/length ratio which is less than 1, and have relatively low umbones. In contrast, valves from an unprotected offshore habitat (14 fathoms) off Eureka, Calif. (G. Collins, pers. comm. 1971), possess more heavily built cardinal teeth, have higher umbones, and have a height/length ratio which ranges from slightly less than 1 to 1 (Fig. 1). With this possible exception, morphologic variation among the American valves does not appear to be great. Japanese valves do not reveal great morphologic variation and such that is evident is generally consistent with that found in American populations of *C. nuttallii* from protected habitats.

Thus on strictly morphologic grounds, American and Japanese valves resemble each other very closely.

[1]Sources of Japanese valves: National Science Museum (Tokyo), Tohoku Univ. (Sendai), Hokkaido Univ. (Sapporo), Kushiro Museum (Kushiro), Akkeshi Marine Biol. Station (Akkeshi) and Akkeshi Natural History Museum (Akkeshi).

[2]American valves: Humboldt State Univ. (Arcata, Calif.).

Table 1. Principal Dimensions (mm).

	Identification	*Height*	*Length*	*Inflation*	*Rib. No.*[3]
Akkeshi-Kushiro	[a]1015-1	78	82	25	36
	[b]1025-1	55	59	19	34
	-2	69	75	23	36
	-3	76	82	26	37
	-4	68	73	22	35
	[c]174	84	86	28	36
	[c]12096	71	73	23	33
	[d]9221	69	72	26	37
	[e]unnumbered	69	71	23	38
	[e]unnumbered	71	76	24	37
	[f]unnumbered	72	76	28	worn
Washington Bay, Wash.	[a]607-1	64	68	20	37
	-2	49	52	18	36
	-3	42	45	15	37
	-4	38	41	13	34
	-5	20	22	6	36
	-6	52	56	17	38
	-7	51	55	16	41
	-8	57	60	18	36
	-9	45	52	16	35
	-10	38	42	14	36
Bainbridge Island, Wash.	[a]615-25	76	29	38	38
	-26	80	27	37	37
	-27	81	28	35	35
	-18	62	21	37	37
	-14	52	20	37	37
	-12	48	17	38	38
	- 5	27	9	35	35
	- 4	23	7	32	32
	- 1	15	5	36	36
	-19	58	21	38	38
	-23	67	25	35	35
Eureka, Calif.	[a]100-A	63	69	26	36
	-B	80	81	31	37
	-C	69	70	27	37
	-D	73	73	28	36
	-E	60	60	22	36

a Humboldt State University (from Akkeshi Natural History Museum)
b Humboldt State University (from Kushiro Museum)
c Hokkaido University
d Tohoku University
e Akkeshi Marine Biological Station
f National Science Museum

FOSSIL RECORD OF *CLINOCARDIUM NUTTALLII* (CONRAD) IN JAPAN

The following evaluation is based upon (1) published information and (2) examinations of specimens from the collections of the Institute of Geology and Paleontology, Tohoku University and the Department of Geology, Hokkaido University.

Honshu. — Yokoyama (1926a, p. 293, pl. 34, figs. 17, 18) identified *Cardium shinjiense* from the Pliocene Sawane Formation of Sado Island (Sea of Japan), and from several other Tertiary deposits of Honshu. Yokoyama (1926b) later designated *C. shinjiense* of Sado under the name *Cardium nuttallii* Conrad based on a resemblance to a

[3] Rib number includes weakly-developed ribs along posterior margin of valve.

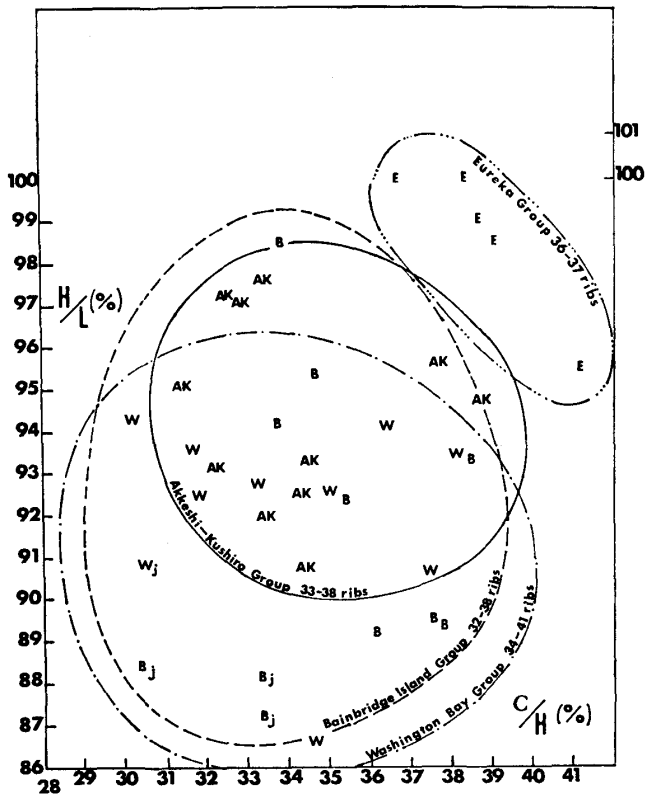

Fig. 1. Estimated morphologic range of valves from four populations of *Clinocardium nuttallii* (Conrad).
(AK) Akkeshi-Kushiro area, Hokkaido, Japan. No ecologic data available.
(B) Bainbridge Is., Wash. Intertidal, muddy substrate, protected bay.
(W) Washington Bay, Wash. " , " , " .
(E) Eureka, Calif. Offshore, 14 fathoms, sandy substrate, unprotected coast.
H, maximum height of valve; **L**, shell length; **C**, maximum inflation of valve; **j**, juvenile specimen. All valves possess ribs which range from squarish to sharply rounded in profile and are crossed by loopshaped riblets or nodes.

form considered by Middendorff (1849) to be a juvenile *C. nuttallii*. However, the roof-shaped ribs and broad, V-shaped interspaces of *C. nuttallii* from Sado clearly separate it from typical *C. nuttallii* which possesses squarish to rounded ribs and round-bottomed interspaces. This conclusion is consistent with that of Nomura (1935a) and of Kotaka (1950) concerning the affinities of the Sado cardiid.

Hokkaido. — Nomura (1935b, p. 34, pl. 4, fig. 11) described and figured *Cardium* (*Cerastoderma*) *nuttallii* Conrad from the Pliocene Takikawa Formation, at the junction of the Ponrurumoppe and the Rumoi rivers. The figured specimen (IGPS coll. cat. no. 55782) is a partially preserved right valve (length 45 mm; height 40 mm) in the collections of the Institute of Geology and Paleontology, Tohoku University. The Takikawa fossil, when compared with valves of undoubted *C. nuttallii* having similar dimensions, reveal important differences. These are (1) although the shapes of the ribs and interspaces are reminiscent of *C. nuttallii*, the ribs are proportionately lower and somewhat flatter and the interspaces proportionately wider, (2) growth lines cross the ribs nearly as straight lines not as well-defined loops as in *C. nuttallii*, (3) although the shell is worn, there is no evidence of arcuate-shaped riblets or nodes on the radial ribs so conspicuous and numerous in *C. nuttallii*, and (4) the beak does not appear as strongly turned forward as in *C. nuttallii*. The exact number of ribs could not be ascertained due to poor preservation but the shell and rib dimensions suggest that the number of ribs probably did not exceed 27–

29. In contrast, the number of radial ribs in *C. nuttallii* usually ranges between 34 and 37. Thus, the above evidence strongly suggests that the Takikawa valve is not referable to *Clinocardium nuttallii*.

Another specimen from the IGPS collections (IGPS coll. cat. no. 64452), also identified as *Cardium nuttallii* Conrad, was examined. This is an incomplete left valve which may be from the Takikawa Formation exposed near Bakai, Teshio Province (H. Noda, pers. comm. 1971). This valve [length 38 mm (approx.); height 35 mm (approx.)] has approximately 29–30 ribs and its general shape resembles that of (IGPS coll. cat. no. 55782). For essentially the same reasons indicated for (IGPS coll. cat. no. 55782) previously, (IGPS coll. cat. no. 64452) is not referable to *Clinocardium nuttallii* (Conrad).

Yokoyama (1929, p. 390, pl. 74, fig. 8) identified *Cardium nuttallii* Conrad from five localities in Sakhalin (or Karafuto) including the Langari, Pohle, Fuhdji, and Kuman rivers and an unnamed locality in south Sakhalin. The figure indicates a poorly preserved left valve (length 28 mm; height 25 mm) differing from typical *C. nuttallii* in that (1) the outline is less trigonal, more elongate, (2) there is no evidence of loop-shaped riblets or nodes, and (3) there appear to be no more than 29–30 ribs. This form has an outline similar to that of *Clinocardium iwashiroense* Nomura (1935 a). It is not assignable to *C. nuttallii*.

Uozumi (1962, p. 531) listed the mollusks characteristic of the Setana Formation and included *Clinocardium ciliatum*, *C. californiense*, and *C. nuttallii*. However, in the checklist (Table II) of the same paper, which shows the geological distribution of fossils in the Setana and other Neogene formations of Hokkaido, both *Clinocardium ciliatum* and *C. nuttallii* are omitted as well as other mollusks cited as being characteristic. Until a better understanding of this paper is obtained and actual specimens and accurate stratigraphic data are available, the author is unable to regard this citation as valid evidence in the present study.

Cardium nuttallii Conrad was reported from a Pliocene (?) deposit at Haboro, Teshio (Yokoyama, 1927, p. 201). In a later paper, Yokoyama (1931) listed *C. nuttallii* from two other Hokkaido localities, including Toppok, Teshio and Piratoriushinai, Hidaka and from a single locality at Noda-gun, Sakhalin. None of these reports were supported by either description or figures. Considering Yokoyama's earlier misconception of *C. nuttallii*, these citations are not herein considered to be valid evidence.

DISCUSSION

Two conclusions are drawn from the foregoing: (1) this study has uncovered no convincing or tangible evidence of *C. nuttallii* in the fossil record of Japan and (2) Recent specimens of *C. nuttallii* from America and those referred to the same species in Japan show very close morphologic resemblance. As to whether the Japanese Recent forms may be safely assigned to the species *C. nuttallii* requires still further comment.

The oldest occurrences of undoubted *C. nuttallii* are from the Pliocene[4] of California (at least 3 localities). From Pleistocene deposits[5] in western North America, the species is known from at least 17 localities, which are distributed from Baja California to Alaska. From the California Tertiary, two species, *Clinocardium pristinum* Keen from the Miocene and *Clinocardium meekianum* (Gabb) from the Pliocene, possess sufficient and significant *C. nuttallii*-like characters to suggest that they are closely related to *C. nuttallii* and may represent possible ancestral stocks.

In Asia, the fossil record of *C. nuttallii* is judged to be two Pleistocene localities, Sakhalin and Kamchatka, based upon figures of *Laevicardium* (*Cerastoderma*) *corbis*

[4] Pliocene loc.: Purisima (2) and Etchegoin (1) fms.; Stanford Univ. collections.

[5] Pleistocene loc.: Baja Calif. Valentine, J.W. & Meade, R.F. (1961): Alaskan R. Baxter. (pers. comm. 1971): intermediate localities from published works and Stanford Univ. collections.

(Martyn) by Slodkewich (1938, part. 2, p. 154, pls. 76, 77, 78). Further an extensive review of Japanese middle and later Cenozoic cardiids, undertaken in the present study, did not reveal a single species or group of species which could be confidently considered as precursors to the Akkeshi-Kushiro cockles. Thus, it appears probable that the Akkeshi-Kushiro cockles did not evolve from any Japanese Cenozoic stock, but rather, from an ancestral stock whose place of origin lies outside Japan.

If this place of origin lay in the northern or northeastern Pacific, can a plausible means of transport be demonstrated which could account for the dispersal of *C. nuttallii* to Sakhalin, Kamchatka, and Japan? In answer to this question we must look at the Recent distribution of *C. nuttallii* in the northwestern Pacific, which, excluding the Akkeshi-Kushiro forms, appears to be only Paramushir, northern Kuril Islands (Kuroda and Koba, 1933). Paramushir lies intermediate between the Akkeshi-Kushiro area and the Bering Sea region, where populations of *C. nuttallii* are relatively abundant. The Oyashio current, which issues from the west side of the Bering Sea, flows southwestward close to Kamchatka, the Kuril Islands, and past the southeast coast of Hokkaido. This current draws from a counterclockwise current in the Bering Sea which in turn draws from waters flowing westward along the southern coast of Alaska (Fig. 2). This system of currents[6] provides a means by which the larvae of *C. nuttallii* from either the northern or the northeastern Pacific could be transported to and distributed along the Asian coast, at least as far south as Hokkaido.

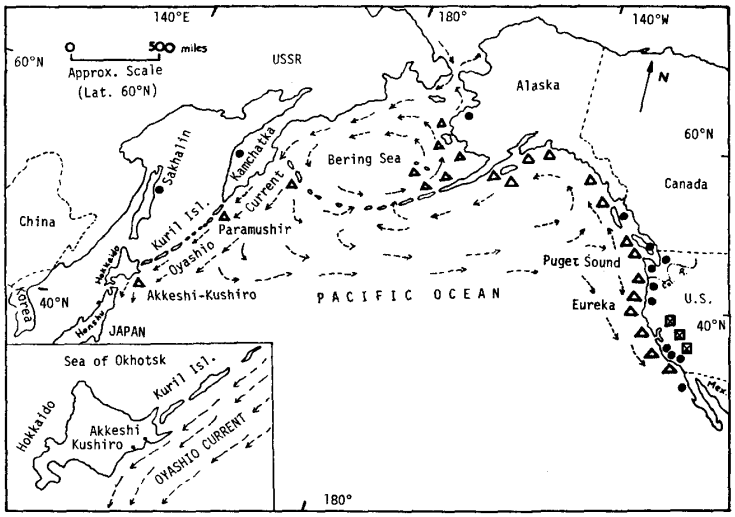

Fig. 2. Recent and Fossil occurrences of *Clinocardium nuttallii* (Conrad).
△ Recent ● Pleistocene ⊠ Pliocene
(Distribution southeast of Alaska is generalized.)
Map adapted from National Geographic Society (Nov. 1960)
Van der Grinter projection

On the basis of the availability of a means of larval transport, geographic proximity to existing populations of *C. nuttallii*, close morphologic resemblance to eastern Pacific *C. nuttallii*, lack of ancestral forms in the Japanese Cenozoic, and recognition in western North America of an extensive fossil record of *C. nuttallii* and possible ancestral forms, it is concluded that the Akkeshi-Kushiro cockles represent a population of *C. nuttallii*, and that *C. nuttallii* probably originated in the northern or northeastern Pacific during Miocene or Pliocene time, dispersing westward to Kamchatka and Sakhalin during the Pleistocene, and to Japan during the Recent.

[6] *Fizikogeograficheskii*, Akademiia Nauk, U.S.S.R. (1964), pls. 50, 51.

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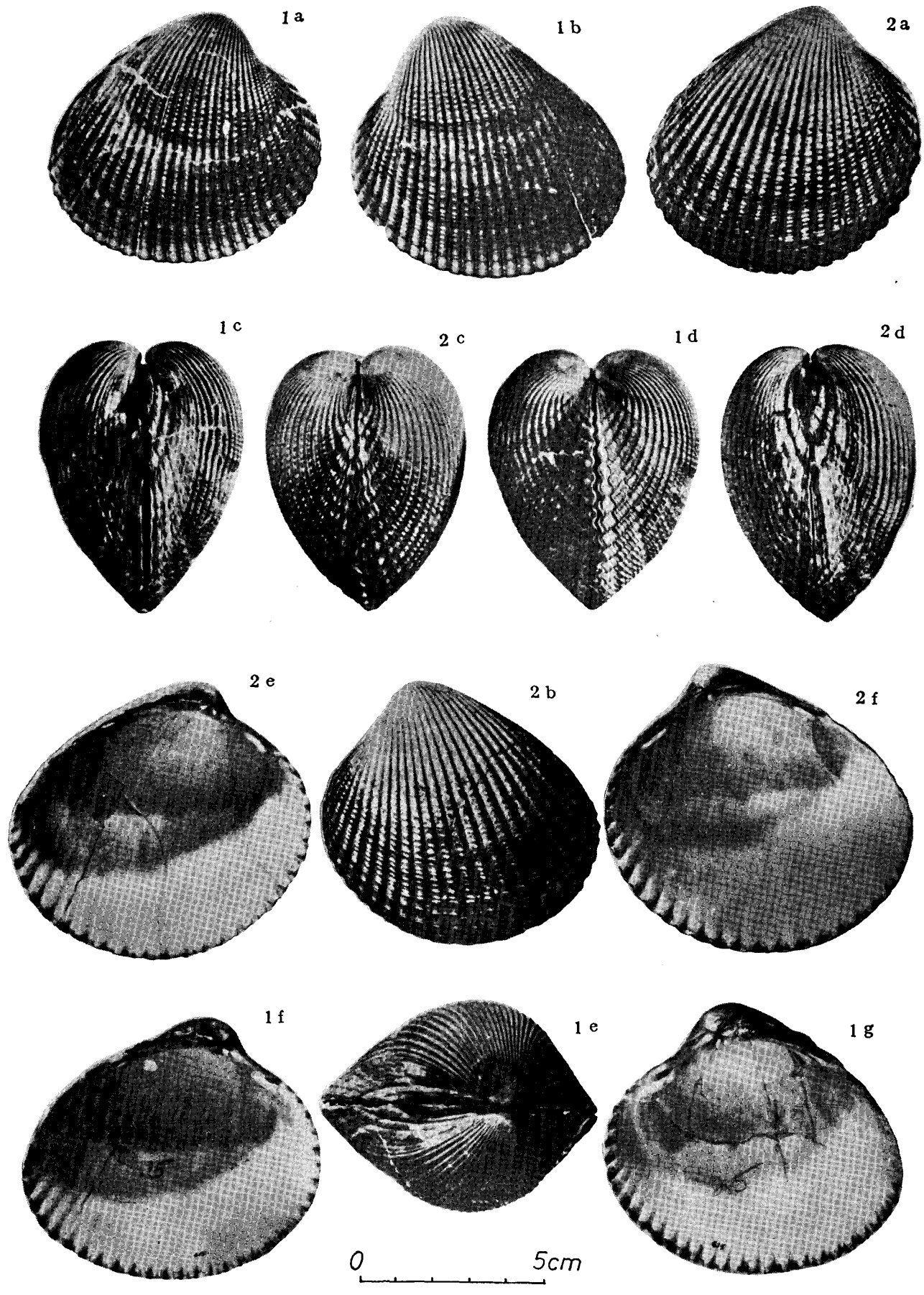
Plate 1

(See size scale in plate)

Figs. 1a-1g, *Clinocardium nuttallii* (Conrad)
Dept. Geol. and Earth Sci., Humboldt State Univ., no. 615–25, Bainbridge Island, Wash., U.S.A., Recent.

Figs. 2a-2f, *Clinocardium nuttallii* (Conrad)
Dept. Geol., Hokkaido Univ., no. 174, Akkeshi, Hokkaido, Japan, Recent.


1a
1b
2a
1c
2c
1d
2d
2e
2b
2f
1f
1e
1g
0
5cm

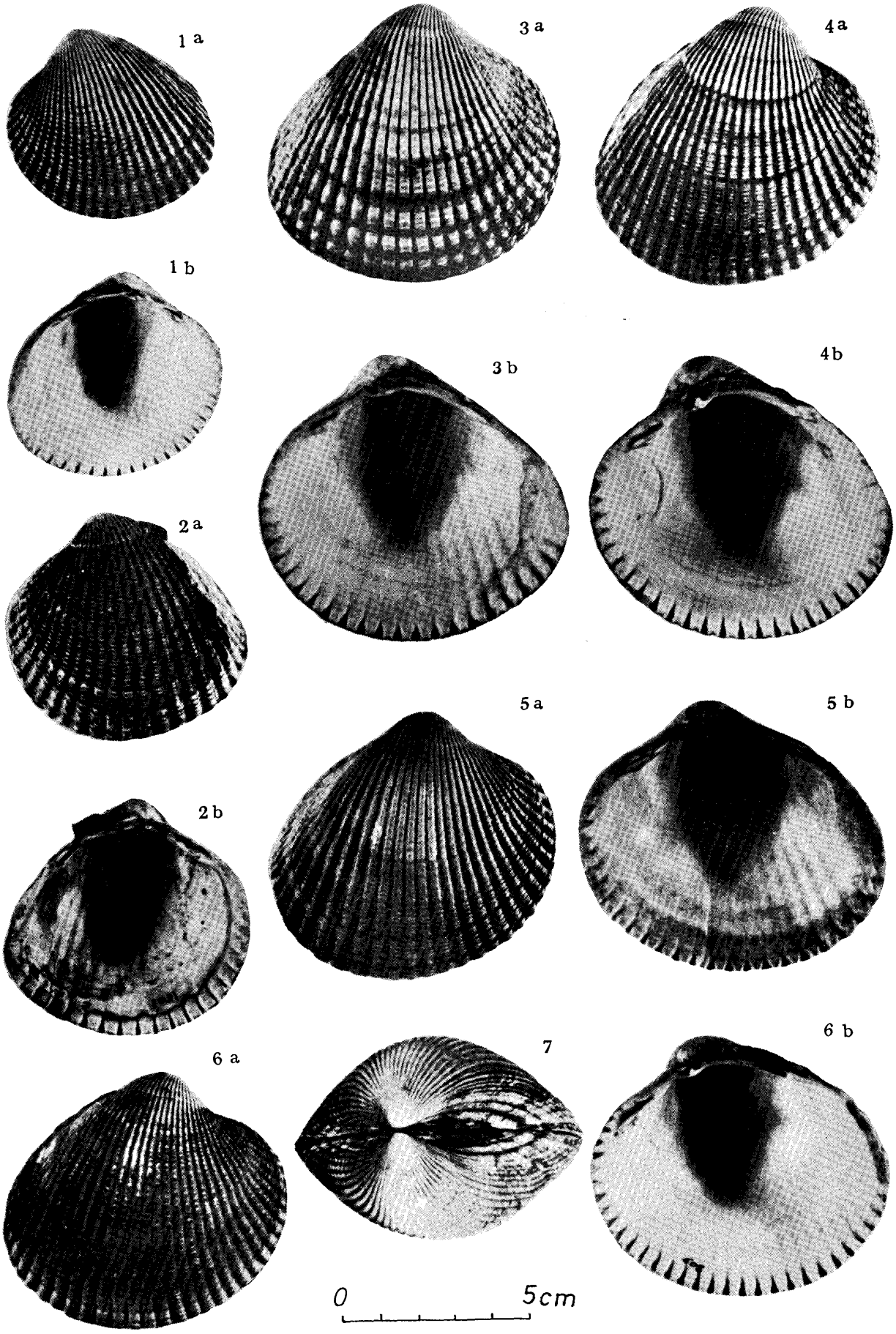

1 a
1 b
2 a
2 b
3 a
3 b
4 a
4 b
5 a
5 b
6 a
6 b
7
0
5cm

Plate 2

(See size scale in plate)

Figs. 1a-1b, *Clinocardium nuttallii* (Conrad)
Dept. Geol. and Earth Sci., Humboldt State Univ., no. 1021, Kushiro, Hokkaido, Japan, Recent.
Figs. 2a-2b, *Clinocardium nuttallii* (Conrad)
Dept. Geol. and Earth Sci., Humboldt State Univ., no. 1031, Hazen Bay, Alaska, Recent.
Figs. 3a-3b, *Clinocardium nuttallii* (Conrad)
Dept. Geol. and Earth Sci., Humboldt State Univ., no. 1015, Akkeshi, Hokkaido, Japan, Recent.
Figs. 4a-4b, *Clinocardium nuttallii* (Conrad)
Dept. Geol. and Earth Sci., Humboldt State Univ., no. 100–B, Eureka, Calif., U.S.A., Recent.
Figs. 5a-5b, *Clinocardium nuttallii* (Conrad)
Dept. Geol. and Earth Sci., Humboldt State Univ., no. 1021, Kushiro, Hokkaido, Japan, Recent.
Figs. 6a-6b, *Clinocardium nuttallii* (Conrad)
Dept. Geol. and Earth Sci., Humboldt State Univ., no. 608, Washington Bay, Wash., U.S.A., Recent.
Fig. 7, *Clinocardium nuttallii* (Conrad)
Dept. Geol., Hokkaido Univ., no. 174, Akkeshi, Hokkaido, Japan, Recent.