

Abstract

A giant Antarctic deep-sea barnacle *Hexelasma antarcticum* BORRADAILE, obtained by the Japanese Antarctic Research Expedition research ship SÔYA and her consort UMITAKA-MARU of the Tokyo University of Fisheries during the cruises of 1957 and 1958 respectively was described in detail.

In connection with this, all the known species of the genus *Hexelasma* were chronologically reviewed and systematically discussed.

I. INTRODUCTION

The Japanese Antarctic Research Expedition brought home only a few specimens of the giant deep-sea barnacle *Hexelasma antarcticum* BORRADAILE during the cruises of 1957 and 1958. None of the other cirripeds previously known to occur in the Antarctic territory was obtained in these cruises.

The author had an opportunity to study the collection through the courtesies of Dr. Riozo YOSHII of the Yoshida College, Kyoto University, aboard the R. S. SÔYA, and Dr. Jiro SENÔ of the Tokyo University of Fisheries, aboard the T. S. UMITAKA-MARU, to whom the author is greatly indebted.

II. LOCALITIES OF COLLECTIONS

1957, UMITAKA-MARU Stations.

- 1) St. 4. Gunnerus Bank, off Cape Cook, 67°48.5'S, 33°41.0'E, 790 m.
Bottom: Angular gravel, coarse sand, fine sand, organism. 7 Feb. 1957.
(One living specimen without carinolaterals, rostrum and base.)
- 2) St. 6. Off Cape Cook, 67°51.5'S, 33°13.5'E, 630-680 m.
Bottom: Angular gravel, organism. 7 Feb. 1957.
(A large number of loose compartments and valves of dead animals deposited in the bottom sediments.)

1958, SÔYA Stations.

- 3) St. 4. Braid Bay, 68°29.7'S, 32°02.7'E, 590 m. 31 Jan. 1958.
(A few small shell remains.)
- 4) St. 6. Gunnerus Bank, 68°10.0'S, 34°04.0'E, 620 m. 27 Jan. 1958.
(A scutum of living animal and numerous shell remains.)
- 5) St. 7. Off Cape Cook, 68°09.7'S, 34°34.0'E, 830 m. 26 Jan. 1958.
(A large number of loose compartments and valves of dead animals, totalling about 53.)

III. DESCRIPTION OF MATERIALS

Hexelasma antarcticum BORRADAILE, 1916

- 1916 *Hexelasma antarcticum* BORRADAILE, British Antarctic ("Terra Nova") Expedition, Nat. Hist. Report, Zoology, Vol. III, no. 4, p. 132, fig. 7.
- 1924 *Hexelasma antarcticum* WITHERS, N. Z. Geol. Survey Brit. Palaeont. Bull. No. 10, p. 22 (cited only).
- 1938 *Hexelasma antarcticum* BAGE, Australasian Antarctic Exped., Sci. Reports, Ser. C-Zool. and Bot., Vol. 2, pt. 7, p. 8, pls. V-VIII.

Materials: The materials hereby examined are fragmentary, represented only by one imperfect living specimen and a large number of shell remains most of which are badly broken, as stated above and figured in Plates. However, it is beyond doubt that they belong to a deep-sea barnacle *Hexelasma antarcticum* which was described and figured rather briefly by two authors (BORRADAILE and BAGE).

Description: Out of the loose compartments which may belong to different specimens, either living or dead, the carina, carinolaterals, laterals and rostrum are represented respectively by relatively complete ones. All of these compartments are solid and very thick (about 4 mm in the carina). The membranous base is not preserved.

The outer surface of the compartments is marked with broad transverse ridges, and when living, it is covered by a primrose-yellow epidermis which is deciduous for the most part; when dead, the shell is wholly white and the epidermis is entirely lost. The opercular valves are also white under a similar epidermis.

Internally, the sheath in all compartments is distinctly striate transversely; it is the widest in the carina and the narrowest in the rostrum. In the rostrum, the lateral stripes which are prominent on both sides of the sheath extend to the base, though obscured downwards. The inner surface below the sheath is wholly smooth as in other members of Chthamalidae.

The scutum is very thick, elongate triangular, with an apex bent back. The occludent sutural edge on the inner side is provided with oblique lines extending from the outer growth-lines. The articular ridge is conspicuously developed, and the adductor ridge is unusually distinct, as separated from the former by a shallow longitudinal furrow extending from the apex and ending in a triangu-

lar pit for the depressor muscle at the base. The pit for the adductor muscle is distinct but shallow.

The tergum is elongate triangular, longer than wide. A distinct ridge runs

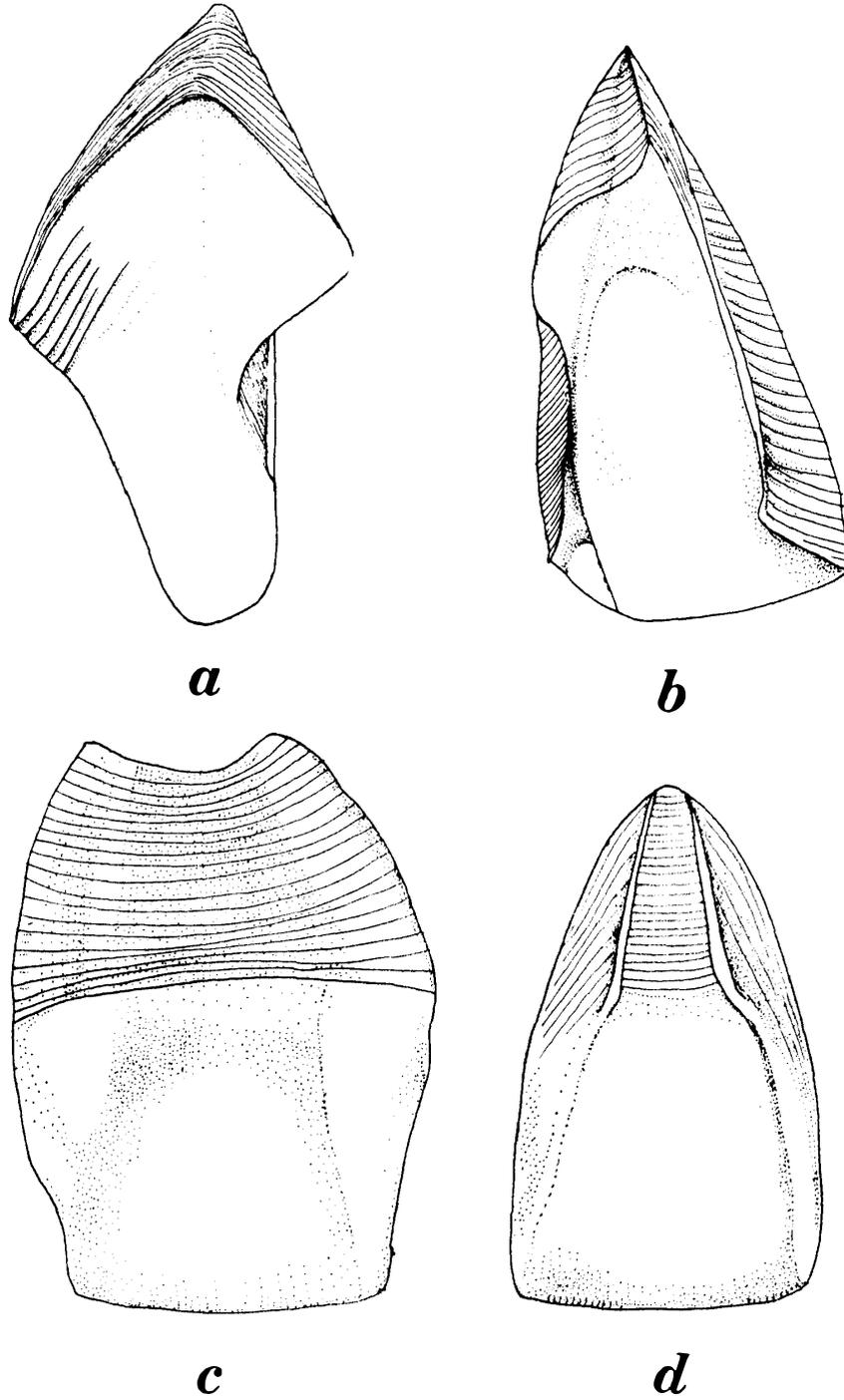


Fig. 1. Opercular valves and compartments.

- a. Tergum, inner view. ×2 b. Scutum, inner view. ×2*
c. Carina, inner view. ×1.5 d. Rostrum, inner view. ×1.5

from the apex to the basiscutal angle at the end of the spur, along the straight scutal margin, parallel to the spur fasciole. The spur is distinct, with rounded end and the carinal base joining the basal margin of the valve. The carinal margin is almost straight, as long as about 2/3 of the scutal margin. Internally, the articular ridge is prominently developed, much protruding beyond the scutal margin. The inner sutural surface at the apex is very broad, flat and closely striate obliquely. Besides, there are 6 long prominent crests for the depressor muscles.

Mouth-parts: Labrum is bullate, with a median concavity on the free margin. There is no notch, and no teeth nor hairs can be traced.

Palp is elongate oval in outline and provided with many long hairs.

Mandible has 4 sharply pointed teeth and a rounded lower angle. The upper margin of the lower angle is almost straight but slightly dentate.

Maxilla I with a broad but shallow notch below a single stout spine and supports a few spinules at the bottom of the notch. The frontal margin below the notch is slightly convex and bears many slender spines subequal in length. The apophysis is about 2/3 the length of the blade.

Maxilla II is broad, roughly quadrangular in a lateral view, and the frontal margin is distinctly bilobed, being divided by a non-spinose notch.

Cirri: The first pair is short, with the rami subequal in length; each segment is short and protuberant anteriorly. The second pair with the rami very unequal in length; the anterior ramus is about 2/3 the length of the posterior one. Each segment of the lower portion of the rami bears a brush of setae on the protuberant anterior surface and a few setae on the posterior distal corner, while in the distal portion each segment is narrow, elongate and bears only distal semicircles of erect setae. The third pair has the anterior ramus a little shorter than the posterior one. The lower segments are likewise short and protuberant anteriorly with a brush of setae, while the distal segments are very slender, somewhat flagellate in appearance.

The posterior three pairs (IV-VI) are all flattened and curled. They have long rami of nearly equal size. The segments in both rami bear almost without exception 4-7 pairs (mostly 6) of very long, stiff setae, diminishing gradually down-wards in size, and a tuft of slender setae at the posterior distal corner.

Table 1. Length and number of segments of the cirri.

Cirrus	I	II	III	IV	V	VI
Maximum length (mm)	20	22	28	30	30	30
Anterior ramus	15	27	47	31	37	32
Posterior ramus	12	39	55	34	36	37

In general, the three anterior pairs (I-III) with unequal rami (excepting only Cirrus I) are shorter than the posterior pairs (IV-VI) and the shape of each segment and its armature are quite different between the anterior and

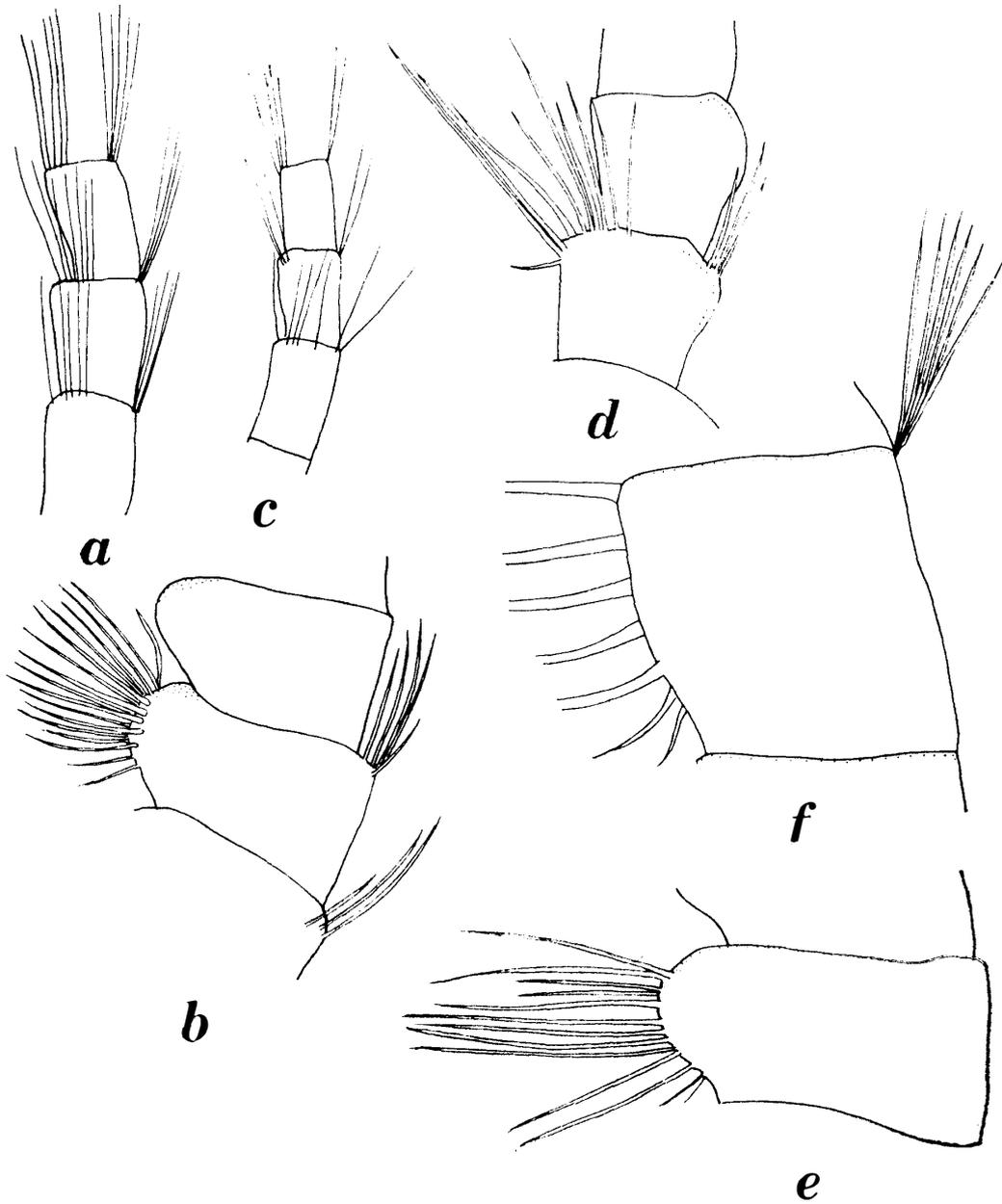


Fig. 3. Segments of cirri.
 a. Upper segments of Cirrus II.
 b. Lower segments of Cirrus II.
 c. Upper segments of Cirrus III.
 d. Intermediate segments of Cirrus III.
 e. Lower segments of Cirrus III.
 f. Intermediate segment of Cirrus IV,
 showing the typical setation in posterior pairs.

All $\times 33$

posterior pairs. Therefore, HOEK's statement "Third pair of cirri resembling more those of the fourth than of the second pair", characterizing the genus, cannot be applied to this species. This character may vary with species of the genus. There is no trace of the caudal appendage.

The *penis* is rather long, about $2/3$ the length of the last cirri, when extended, and delicately annulated except for the proximal broader portion and the narrower terminal portion. The annulated middle portion bears only a few hairs, and 2 tufts of long hairs are seen around the extremity.

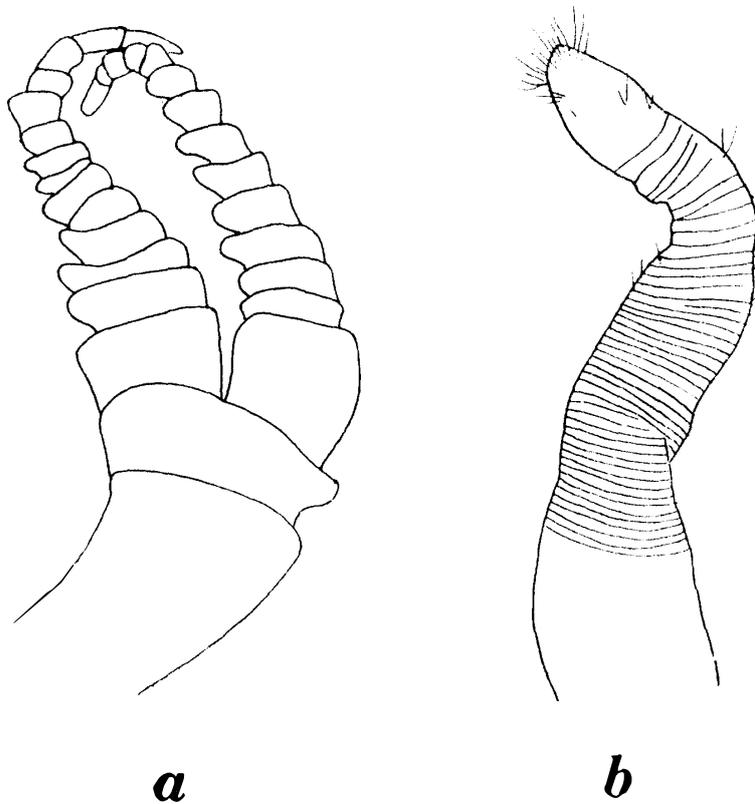


Fig. 4. a. Cirrus 1, setae on segments being removed. $\times 12$
b. Distal portion of penis. $\times 21$

IV. SIZE OF SPECIMENS

The actual size of the specimens can be assumed from the following measurements (Tables 2 and 3).

Table 2. Measurements of compartments and scutum of a living specimen obtained by the T. S. UMITAKA-MARU.

Compartments and valve	Length (mm)	Width (mm)	Illustration
Carina	33	21	Pl. I, Fig. 2
Paries of carina	33	19	
Sheath of carina	15	20	
Laterals	35	27	Pl. J, Fig. 1
Scutum	28	16	

Table 3. Measurements of large-sized compartments among shell remains.

Compartments	Length (mm)	Width (mm)	Source
Carina	112	24	UMITAKA-MARU coll. (Pl. I, Fig. 8)
Carinolateral	70	26	" (Pl. I, Fig. 4)
Carinolateral	53	21	" (Pl. I, Fig. 5)
Rostrum	46	28	SÔYA coll.
Rostrum	43	19	"
Rostrum	29	16	"
Carina	32	14	"
Carina	29	12	"

V. CHRONOLOGICAL REVIEW OF *HEXELASMA*

In connection with a discussion on this Antarctic cirriped, a chronological review of the genus *Hexelasma*, with all the known species belonging to the genus, is given below.

1. ***Hexelasma corolliforme*** (HOEK, 1883)
 = *Balanus corolliformis* HOEK, 1883, Challenger Report, Zoology, 8, p. 155, pl. VI, figs. 21-22; pl. XIII, figs. 1-7.
 ----- Between Kerguelen and Heard Islands, south of Indian Ocean, 150 fathoms.
2. ***H. hirsutum*** (HOEK, 1883)
 = *Balanus hirsutus* HOEK, 1883, Challenger Report, Zoology, 8, p. 158, pl. XIII, figs. 8-15.
 ----- Farøe Channel (59°40'N, 7°21'W), 516 fathoms.
3. ***H. aucklandicum*** (HECTOR, 1888)
 = *Scalpellum aucklandicum* HECTOR, 1888, p. 440.
 = *Pollicipes? aucklandicus* BENHAM, 1903, p. 111.
 ----- Miocene Waitemata beds, Motutapu Is., Auckland Harbour, New Zealand (fossil).
4. ***H. callistoderma*** (PILSBRY, 1911)
 = *Balanus callistoderma* PILSBRY, 1911, p. 78, figs. 9-10; pl. XII, fig. 5; pl. XV, figs. 3-7.
 ----- Suruga Gulf, Japan (*Albatross* St. 5068), 77 fathoms.
 = *Balanus corolliformis* KRÜGER, 1911, p. 78, figs. 9-10; pl. XII, fig. 5; pl. XV, figs. 3-7. (Not HOEK, 1883)
 ----- Off Misaki, Sagami Bay, Japan.
5. ***H. velutinum*** (HOEK, 1913)
 = *Balanus velutinus* (nom. nudus) HOEK, 1912, p. 407.
 = *Hexelasma velutinum* HOEK, 1913, Siboga-Expeditie, Mon. 31b, p. 246, figs. 1-2; pl. 26, figs. 1-16.
 ----- Malay Archipelago (*Siboga* Sts. 59, 105, 251), 204 to 390 meters.
6. ***H. arafuræ*** (HOEK, 1913)
 Siboga-Expeditie, Monogr. 31b, p. 123, pl. 25, figs. 12-16.
 ----- Malay Archipelago (*Siboga* St. 262), 560 meters.

7. *H. americanum* PILSBRY, 1916
 PILSBRY, 1916, p. 330, text-fig. 98, pl. 69, figs. 1-3a.
 Off South Carolina, N. America (*Albatross* St. 2663), 421 fathoms.
8. *H. callistoderma* (PILSBRY, 1911)
 = *H. callistoderma* PILSBRY, 1916, p. 332, fig. 99.
 Suruga Gulf, Japan (*Albatross* St. 5068), 77 fathoms; Ose Zaki.
 Japan (*Albatross* St. 3741), 63-68 fathoms.
9. *H. antarcticum* BORRADAILE, 1916
 British Antarctic ("Terra Nova") Exped. Nat. Hist. Rep. Zool., 3(1)
 p. 132, fig. 7.
 Evans Cove, Terra Nova Bay, Victoria Land. [In glacier, 30
 feet above sea level.]
10. *H. hirsutum* (GRUVEL, 1920, Rés, Camp. Sci. Prince de Monaco, 53, p. 55,
 pl. I, figs. 13-14).
 Azores Islands (1895 Cruise St. 584), 845 meters.
11. *H. aucklandicum* (WITHERS, 1924, p. 18, text-figs. 7-8, pl. IV, figs. 1-4; pl.
 V, fig. 1)
 Miocene Waitemata beds, Motutapu Is., Auckland Harbour, New
 Zealand (fossil).
12. *H. corolliforme* (NILSSON-CANTELL, 1930, Discovery Reports, 2, p. 252, figs.
 11-12)
 Bransfield Straits, South Shetlands (*Discovery* St. 175), 200 meters.
13. *H. velutinum* (BROCH, 1931, p. 53)
 Malay Archipelago, 245 to 290 meters.
14. *H. velutinum* (HIRO, 1933, p. 70, pl. III, fig. 2)
 Naer Muroto-zaki, Kôti Pref., Sikoku, Japan (*Sôyô-Maru* St. 232),
 269 meters.
15. *H. antarcticum* (BAGE, 1938, Australasian Antarctic Exped., Sci. Rep. Ser.
 C, 2 (7), p. 8, pls. 5-8)
 Commonwealth Bay (Australasian Antarctic Exped. St. 3), 157
 fathoms.

The genus *Hexelasma* was first established by HOEK (1913) who previously (1883) regarded it as representing a special section G of the genus *Balanus*. He diagnosed this genus as follows:—

"Compartments six; carina, carinolateral and lateral compartments with alae, but without radii, the rostrum being neither radii nor alae. Parietes not porose and without longitudinal ribs on their inner surfaces; basis membranous. Opercular valves subtriangular. Mouth with the labrum not notched in the middle; mandibles with 4 to 5 sharply pointed teeth; maxillae with numerous spines beneath the notch; third pair of cirri resembling more those of the fourth than of the second pair. No caudal appendages. Species living in deep water."

These diagnostic characters are generally those of the family Chthamalidae.

So its close affinity to Chthamalidae, not to Balanidae, was already affirmed by PILSBRY (1916). But later BAGE (1938) became somewhat skeptical about the affinity of the genus whether to Balanidae or Chthamalidae for *H. antarcticum*.

As far as the present author's examination of the internal body of this cirriped is concerned, the mouth-parts agree well with those of other members of Chthamalidae, while the cirri resemble, unexpectedly much more those of Balanidae than those of *Chthamalus*. However, BAGE's statement "the genus is somewhere between the two families" is unreasonable.

As to some representatives of *Hexelasma*, some additional comments are made in the following.

Balanus corolliformis identified by KRÜGER (1911) may possibly be the same as *Hexelasma callistoderma* (PILSBRY, 1911) simultaneously described from Suruga Gulf, Japan. The fifth species *H. velutinum* HOEK (1913) is newly designated herein as the type species of the genus.

The third and eleventh *H. aucklandicum* (HECTOR, 1888) is probably the largest barnacle among the group except for *Balanus psittacus* (MOLINA) occurring along the Pacific coast of South America which has been known to attain a length of 263 mm and a diameter of 78 mm (VAYSSIÈRE, 1905). *H. antarcticum* BORRADAILE is thus ranked as the next (see Table 4).

Table 4. Record of measurements of the largest compartments in some large-sized species of *Hexelasma*.

Species	Compartment	Height	Source
<i>H. aucklandicum</i>	Lateral	187 mm	WITHERS, 1924
<i>H. antarcticum</i>	Carina	90	BORRADAILE, 1916
"	Lateral & carinolateral	80	BAGE, 1938
"	Carinolateral	70+	Present paper
<i>H. corolliforme</i>	From tip of opercular valves to base	45	HOEK, 1883
<i>H. callistoderma</i>	Wall	32	PILSBRY, 1911
<i>H. americanum</i>	Carina	21	PILSBRY, 1916

The twelfth specimen obtained by the Discovery Expedition from Bransfield Straits, South Shetlands was regarded by NILSSON-CANTELL (1930) as *Hexelasma corolliforme* (HOEK), but it may be an undescribed species or a young form of *H. antarcticum* BORRADAILE, judging from that the tergum is much narrower, with the narrow spur extending to the basiscutal angle in parallel to the scutal margin, and the rostralateral overlapping portion of the rostrum is extremely narrow and extend to the base.

References

- BAGE, Freda (1938): Cirripedia. Australasian Antarctic Exped. 1911-14, Sci. Rep. Ser. C—Zool. and Bot., 2, pt. 7, 1-14, pls. V-VIII.
- BENHAM, W. (1903): On some remains of a gigantic fossil cirripede from the Tertiary rocks of New Zealand. Geol. Mag., dec. iv, 10, 110-119, pls. IX-X.
- BORRADAILE, L. A. (1916): Crustacea. Part III—Cirripedia. British ("Terra Nova") Exped., 1910, Nat. Hist. Rep. Zool., 3, no. 4, 127-136.
- BROCH, Hjalmar (1931): Indomalayan Cirripedia. Vidensk. Medd. fra Dansk naturh. Foren., 91, 1-146.
- GRUVEL, A. (1905): Monographie des Cirrhipèdes ou Thécostraces. 472 pp. Paris.
- (1920): Cirrhipèdes provenant des campagnes scientifiques de S. A. S. le Prince de Monaco (1885-1913). Rés. Campagnes Sci. Prince de Monaco, 53, 1-88, pls. I-VII.
- HECTOR, J. (1888): Specimens of a large fossil stalked Cirripedia. Trans. N. Z. Inst., 20 (1887), 440.
- HIRO, Fujio (1933): Report on the Cirripedia collected by the surveying ships of the Imperial Fisheries Experimental Station on the continental shelf bordering Japan. Rec. Oceanogr. Wks. Japan, 5, No. 1, 11-84, pls. I-III.
- HOEK, P. P. C. (1883): Report on the Cirripedia collected by H. M. S. "Challenger" during the years 1873-6. Challenger Report, Zoology, 8, 1-169, 13 pls.
- (1912): On the species of the genus *Balanus* collected in the Malay Archipelago during the cruise of the Dutch man-of-war 'Siboga'. Rep. 81th Meeting British Ass. Adv. Sci. 1911, Section D, 407-408.
- (1913): The Cirripedia of the Siboga Expedition. Part II. Cirripedia Sessilia. Siboga-Expeditie, Monogr. 31b, 1-275, pls. 1-27.
- KRÜGER, P. (1911): Beiträge zur Cirripedenfauna Ostasiens. Beiträge zur Naturgeschichte Ostasiens. Abhandl. math.-phys. Kl. K. B. Akad. Wiss. II. Suppl.-Bd. 6, Abhandl. 72 pp., 4 pls. München.
- NIINO, Hiroshi (1958): On the bottom deposits of the sea around Cape Cook, Prins Harald Coast, Antarctic region. Jour. Tokyo Univ. Fisheries, Special ed., 1, No. 3, 250-254. (In Japanese.)
- (1961): On the soundings from the sea bottom at the offing of Cape Cook, Prince Harald Coast, Antarctic Continent. Antarctic Record, No. 11, 45-47, 2 pls. (In Japanese.)
- NILSSON-CANTELL, C. A. (1930): Thoracic cirripedes collected in 1925-1927. Discovery Reports, 2, 223-260, pl. I.
- PILSBRY, Henry A. (1911): Barnacles of Japan and Bering Sea. Bull. Bur. Fisheries, 29, 61-84, pls. VIII-XVII.
- (1916): The sessile barnacles (Cirripedia) contained in the collections of the U. S. National Museum: Including a monograph of the American species. U. S. Nat. Mus. Bull. 93, i-xi, 1-366, pls. 1-76.
- VAYSSIÈRE, A. (1905): Description de quelques specimens géants du *Balanus psittacus*, Molina, appartenant au Musée d'Histoire Naturelle de Marseille. Annales Fac. Sci. de Marseille, 15, No. 5, 161-170, pl. I.
- WITHERS, T. H. (1913): Some Miocene cirripedes of the genera *Hexelasma* and *Scalpellum* from New Zealand. Proc. Zool. Soc. London, 1913, 937-948, pls. 94-95.
- (1924): The fossil cirripeds of New Zealand. N. Z. Geological Survey Branch, Palaeont. Bull. No. 10, 1-47, pls. I-VIII, 1 map.

- WITHERS, T. H. (1928): Catalogue of fossil Cirripedia in the Department of Geology. Vol. I. Triassic and Jurassic. British Museum (Natural History), London. 132 pp., 12 pls.
- (1953): Catalogue of fossil Cirripedia in the Department of Geology. Vol. III. Tertiary. British Museum (Natural History), London. 396 pp., 64 pls.

(Manuscript received February 1, 1965)