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Studies on the Cirripedian Fauna of Japan

IV. Cirripeds of Formosa (Taiwan), with Some Geographical and Ecological Remarks on the Littoral Forms

By

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With 16 Text-figures

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Introduction

Although the investigations of the land fauna of Taiwan or Formosa were commenced more than half a century ago, they were restricted largely to vertebrates and certain groups of insects. Recently the inland water fauna has received considerable attention from some Japanese hydrobiologists. The marine, especially littoral, fauna of the island, however, has been practically unconsidered.

The cirripeds in this island, which represent the most predominant elements of the littoral fauna, has remained almost unknown until now. So far as I know, only a few odd references to the cirripeds of Formosa have been made by former authors. WELTNER (1897) first recorded *Balanus amphitrite* from Tansui in his Catalogue of the Cirripedia. KRÜGER (1911) recorded four forms: *Heteralepas* (*Heteralepas*) *quadrata* from Making, Pescadores (=Makô, Bôko-tô), Tansui and Takao; and *Balanus amphitrite niveus* (=*B. amphitrite krügeri*), *Tetraclita porosa nigrescens* (=*T. squamosa formosana* here described) and *Tetraclita porosa viridis* (=*T. squamosa viridis*) from Making, Pescadores. In addition, two deepwater forms, *Calantica scorpio* and *Octolasmis orthogonia*, were reported from the Formosa Channel by NILSSON-CANTELL (1921) and also by BROCH (1931). Very recently, I described a new form of *Balanus amphitrite* based on materials of Formosa collected by Dr. MIYADI and Mr. SATÔ (HIRO, 1938).

Hoping to elucidate the littoral cirripeds of Formosa, I made a trip to the island in the early summer of 1938, and thus was able to collect many specimens at the localities shown in the appended map (Fig. 16). This collection comprises, as listed in the following, 18 species and 12 subspecies, three of which appear to be new to science. The number is by no means large in comparison to the number of the species obtained from adjacent regions. Still the collection is of some interest from the zoogeographical and ecological view-point.

The present paper establishes a new subgenus *Tetraclitella*, to which *Tetraclita purpurascens* and its allied forms are referred, emendates the character of the genus *Octomeris*, and adds *Chthamalus moro*, *Chthamalus malayensis*, *Balanus tintinnabulum tintinnabulum*, *Balanus tintinnabulum zebra* and *Tetraclita divisa* to the list of hitherto described Japanese fauna. A general discussion on the zoogeographic and faunistic features of the littoral cirripeds in this island is also given.

Before proceeding further, I wish to express my appreciation to the Japan Society for the Promotion of Scientific Research whose grant made the present investigation possible. My thanks are also due to Messrs. H. SATÔ (Sendai), D. MIYADI (Seto), S, MIYAKE (Hukuoka), Y. YOGI and S. MAKI (Kiirun), T. KURODA and K. TAN (Taihoku), A. YAMAGUTI (Giran), Z. TURU (Makô), S. HAGIHARA (Takao), S. TUMORI (Heitô), M. GIMA (Ryûkyû-syo) and I. DENDA (Garanbi) for their kindness in contributing valuable specimens and facilities. For indispensable aid in many ways I am indebted to Professors K. HIRASAKA and I. HARADA of the Taihoku Imperial University.

List of the Species

Systematic Account of the Collection

LEPADOMORPHA

Family SCALPELLIDAE PILSBRY

Genus *Mitella* OKEN

1. *Mitella mitella* (LINNÉ)

Occurrence in Formosa: Suô. July 31, 1928; I. HARADA *leg.* A few specimens.

Kizan. May 29, 1938. On coastal rocks.

Kiirun. July 19, 1928; I. HARADA *leg.* Several specimens.

Distribution: Indo-Pacific in the littoral.

Remarks: It is significant that the occurrence of *Mitella mitella* (LINNÉ) is restricted only to the coast around the northeastern region in Formosa, though it is widely distributed in Japan and the Malayan waters. Its scarcity or absence in the southern part of the island is probably due to the fact that the coast is mostly surrounded by raised coral reefs.

Family OXYNASPIDAE (GRUVEL) NILSSON-CANTELL

Genus *Oxynaspis* DARWIN

2. *Oxynaspis pacifica* HIRO

Oxynaspis pacifica, HIRO, 1931, 1937b.

Occurrence in Formosa: Formosa Channel. Date unknown. Some specimens attached to the stem of *Antipathes* sp. These are preserved in the Fisheries Experimental Station of the Government of Formosa at Syaryô-tô, Kiirun.

Distribution: Pacific coast of Japan. On antipatharians.

Family LEPADIDAE (DARWIN) NILSSON-CANTELL

Genus *Lepas* LINNÉ

3. *Lepas anserifera* LINNÉ

Occurrence in Formosa: Kiirun. February 25, 1934; the late Sadae TAKAHASHI's collection, no. 551. Numerous specimens, old and young.

Taihanratu. July, 1934; the late Sadae TAKAHASHI's collection, no. 291. Numerous young specimens on floating algae.

Distribution: Pelagic, chiefly in tropical and temperate seas.

Genus *Conchoderma* OLFERS

4. *Conchoderma auritum* (LINNÉ)

Occurrence in Formosa: Taihanratu. Date unknown; the late Sadae TAKAHASHI's collection, no. 292, 294. Several specimens from *Coronula diadema.*

Distribution.: Cosmopolitan and pelagic, usually on *Coronula* attached to whales.

5. *Conchoderma virgatum* (SPENGLER)

Occurrence in Formosa: Suô. December 5, 1931; I. HARADA *leg.* Several specimens on *Penella* obtained from *Makaira* aff. *marlina.*

Distribution: Cosmopolitan and pelagic, usually on *Penella* and sometimes on the bottom of ships or driftwood.

Family HETERALEPADIDAE NILSSON-CANTELL

Genus *Heteralepas* PILSBRY

6. *Heteralepas* (*Heteralepas*) *quadrata* (AURIVILLIUS)

Occurrence in Formosa: This species had already been recorded by KRÜGER (1911) as a commensal of various lobsters from the following three stations in Formosa:

Making, Pescadores (=Makô, Bôko-tô) (on *Panulirus versicolor*); Tansui near Kiirun (on *Scyllarus sieboldi*); Takao (on *Panulirus dasypus*).

I obtained numerous specimens attached to *Panulirus versicolor* at the Giran Fish Market (Taihoku Province).

Distribution: Japan, Java Sea, (?) California coast--on crabs and lobsters.

Family TRILASMATIDAE NILSSON-CANTELL (=POECILASMATIDAE ANNANDALE)

Genus *Octolasmis* GRAY

7. *Octolasmis scuticosta* HIRO

Octolasmis scuticosta, HIRO, 1939b.

Occurrence in Formosa: Giran Fish Market (probably from off Suô). May 29, 1938. Several specimens on maxillipeds of *Ranina ranina*.

Distribution: The Pacific coast of southern Japan and Formosa.

Remarks: I very recently described this peculiar form of *Octolasmis*, invariably attached to the outer face of the maxillipeds of *Ranina ranina* (LINNÉ). My original description is based on specimens from Seto on the Pacific coast of Honsyû (*vide* HIRO, 1939 b).

BALANOMORPHA

Family CHTHAMALIDAE DARWIN

Genus *Chthamalus* RANZANI

8. *Chthamalus moro* PILSBRY

Chthamalus moro, PILSBRY, 1916; BROCH, 1922, 1931; NILSSON-CANTELL, 1934; HIRO, 1937a.

Chthamalus challengeri f. *krakatauensis*, BROCH, 1931.

Occurrence in Formosa: Suô. May 30, 1938. A few specimens on coastal rocks.

Kiirun. July 19, 1928; I. HARADA *leg.* Two dry specimens.

Hattosi near Kiirun. May 27, 1938. A few specimens.

Takao. June 3, 1938. A few specimens on *Octomeris sulcata* and numerous specimens on moles at low tide.

Kaikô. June 16, 1938. A few specimens on moles.

Kankau. June 15, 1938. Numerous specimens on coastal rocks.

South China Sea. June, 1938; Y. TOKUOKA *leg.* On the bottom of ships.

Distribution: Malay and Philippine Archipelagoes, Palao Islands and Formosa.

Remarks: This small chthamalid seems to be prevalent on the Formosan coast, because it has been obtained at various spots of the northern and southern regions. Specimens from Suô and Kaikô are rather conical and strongly ribbed, while those from Takao are more or less depressed and somewhat feebly ribbed. They are generally small, being less than 5 mm in carino-rostral diameter.

The normal conic form of *Chthamalus moro* most closely resembles *Chthamalus challengeri*. At a glance they are almost indistinguishable, but there are many internal dissimilarities. The marked differences between the two species, beside those stated by PILSBRY (1916), are found in the presence of the distinct lateral depressor muscle pit and also in the almost uniformly flattened internal surface of the opercular valves of *Chthamalus moro*. In *Chthamalus challengeri*, however, the internal scutal border of the tergum usually develops into a strong ridge. *Chthamalus challengeri* f. *krakatauensis*, presented by BROCH (1931) from Krakatau, comes nearer to *Chthamalus moro* in this respect than to the typical form of *Chthamalus challengeri*. The internal body, which he describes as characteristic of his forma, is of no systematic significance, because it is in many cases subject to considerable variations.

Furthermore, it is noteworthy that all the *Chthamalus* found in Formosa, i. e. *C. moro*, *C. malayensis* and *C. intertextus*, belong to the tropical species, probably originated in the Malayan waters. *Chthamalus challengeri*, which is very common in the Japanese islands, is not found anywhere in Formosa, though occasionally recorded from the Malayan waters (NILSSON-CANTELL, 1921, 1932 b), and also from the Indian Ocean (BROCH, 1927; NILSSON-CANTELL, 1938). The southernmost point of occurrence of *Chthamalus challengeri* in the Japanese waters is, according to data so far obtained, the Yaeyama Islands of the Ryûkyû Group nearest to Formosa. NILSSON-CANTELL (1925) also recorded this from the Ogasawara Islands. It seems probable that, as suggested by the distribution of *Chthamalus* given above, *Chthamalus challengeri* originated in the temperate regions of Japan.

9. *Chthamalus malayensis* PILSBRY

(Fig. 1)

Chthamalus malayensis, PILSBRY, 1916; BROCH, 1931; NILSSON-CANTELL, 1938.

Occurrence in Formosa: Suô. May 30, 1938. Prevalent on rocks on the beach.

Kizan. May 29, 1938. Prevalent on rocks on the beach.

Distribution: Malay Archipelago, Indian Ocean and the northeastern coast of Formosa.

Description and remarks: This species is very prevalent in Nanpô-ô Port near Suô, but curiously it is not found elsewhere. The numerous specimens growing on the coastal rocks of this locality seem to be identical with PILSBRY's *Chthamalus malayensis* from the Malay Peninsula.

Externally, the young specimen is hardly distinguishable from *Chthamalus challengeri* owing to its conic shape, but the larger ones are quite different. The measurements of the type specimens are not mentioned by PILSBRY, but, judging from the present material, this species is rather large in comparison to others: the carino-rostral diameter of the largest of the collection was 16 mm, the height about 4 mm. The external characteristics correspond to the description given by PILSBRY, but there is a slight difference in the dentation of the mandible. According to him: "In place of the even, fine, comblike pectination of the space below the fourth tooth of the mandible, which many species of *Chthamalus* have, there is a series

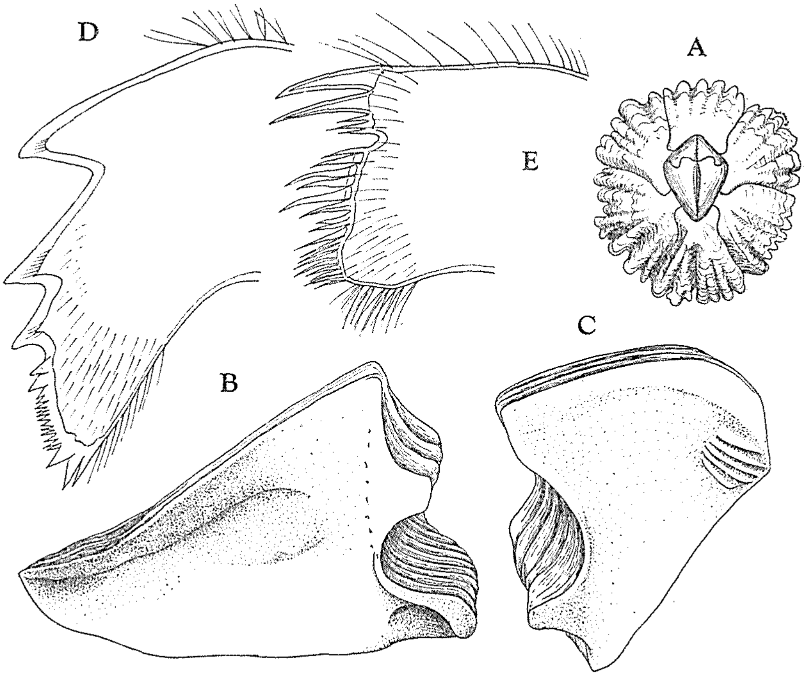

Fig. 1. *Chthamalus malayensis* PILSBRY. A, specimen in upper view. B, internal side of scutum. C, internal side of tergum. D, mandible. E, maxilla I. [A ×2, B-C ×16, D-E ×146].

of coarse teeth" (6 in number in his figure). In the present specimens, however, these denticles below the fourth tooth are generally small and 10 to 15 in number, not differing greatly from those of the other species of *Chthamalus*. The number of spines at the lower angle varies from 3 to 5. PILSBRY seems to have considered the state of the mandible shown by his specimen to be an important specific character, as cited above, yet it seems clear that this form is not a race of *Chthamalus stellatus* or *C. challengeri*, but a distinct species, because other important peculiarities are found in the opercular valves.

In the scutum, the basitergal angle protrudes more than the articular ridge, and there is a rather broad and deep pit for the lateral depressor muscle near the basitergal corner; the adductor ridge is rudimentary. The articular ridge of the tergum is broadly reflexed and the basal margin is straight, the spur being quite indistinguishable.

10. *Chthamalus intertextus* DARWIN

(Fig. 2)

Chthamalus intertextus, DARWIN, 1854: (?) HOEK, 1913; PILSBRY, 1916.

Occurrence in Formosa: Kaikô. June 16, 1938. Several specimens on moles.

Daizyubô. June 14, 1938. Several specimens on the underside of rocks, together with *Octomeris brunnea.*

Distribution: Philippine Archipelago, Hawaiian Islands, Ryûkyû Islands (HIRO, 1937 b, p. 389) and the southern coast of Formosa.

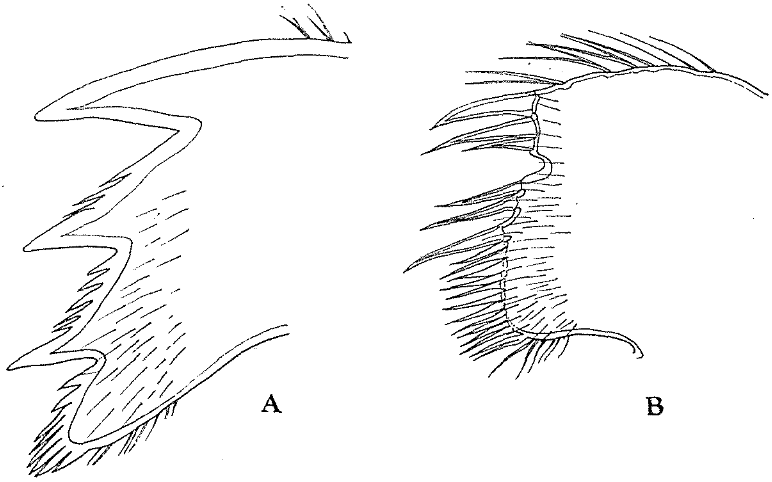

Fig. 2. *Chthamalus intertextus* DARWIN. A, mandible. B, maxilla I. [×208].

Remarks: This species is characterized by many peculiarities: The shell is depressed, with smooth or slightly folded walls, and the interior of the wall is a beautiful pansy violet. The base is membranous in the median part, but surrounded by a calcareous layer formed by the ledge of the inner basal edges of the wall which is inflected rectangularly inwards. The scutum and tergum are firmly calcified together, a trace of suture remaining on only the lower half. In the scutum the inner surface is punctured with small holes and the adductor pit is very shallow without any trace of the adductor ridge; the pit for the lateral depressor muscle is absent.

Genus *Octomeris* SOWERBY

11. *Octomeris brunnea* DARWIN

(Figs. 3, 4, 6 A–B)

Octomeris brunnea, DARWIN, 1854; WELTNER, 1897; GRUVEL, 1903, 1905; NILSSON-CANTELL, 1921, 1930; HIRO, 1932.

Octomeris intermedia, NILSSON-CANTELL, 1921, 1938.

Occurrence in Formosa: Takao. June 3, 1938. Numerous specimens on moles of the outer port.

Kaikô. June 16, 1938. Several specimens on moles.

Daizyubô. June 14, 1938. Under sandstone rocks on the beach, together with *Chthamalus intertextus.*

Distribution: Indian Ocean, Philippine and Malay Archipelagoes, Miyake-zima (south of Sagami Bay) and the southern coast of Formosa.

Description and remarks: *Octomeris brunnea* has been fully described by DARWIN (1854) and NILSSON-CANTELL (1921), so that there is not much to be added. A few remarks concerning the affinity of *Octomeris intermedia,* placed as a separate species by the latter author, however, seems to be necessary.

NILSSON-CANTELL (1921, p. 299; 1932, pp. 13-14) has given a key to distinguish his *Octomeris intermedia* from *Octomeris brunnea:* "Schale mit gröberen Längsfalten, unbedeutend abgeplattet. Orificium weit. Scutum mit geradem Margo basalis. Articularkiel in der Mitte hervorstehend. Margo basalis des Tergums nicht in einem Winkel gebogen. Sporn undeutlich abgesetzt." He further mentions that *Octomeris intermedia* shows a closer external resemblance to *Octomeris angulosa* SOWERBY, though the internal parts are identical with those of *O. brunnea.*

A closer comparison between the present material and his descriptions and drawings does not speak in favour of his statement. Numerous specimens of the present collection and my observations in the field give a good idea of the variations of this species; namely, the surface of the wall as well as the size of the orifice is highly variable, and the shape of the opercular valves varies in accordance with the external deformation. In general, all these variations seem to depend upon the age of the individuals.

In young or flawless specimens, the compartments and the opercular valves show the typical appearance of *Octomeris brunnea,* as described and drawn by DARWIN (1854): The surface of the eight separate compartments is regularly and narrowly ridged in longitudinal lines. The orifice is rather narrow, rounded and toothed by the pointed apices of the compartments. The suture of joint between the scutum and tergum is nearly straight when viewed from above (Fig. 4 A).

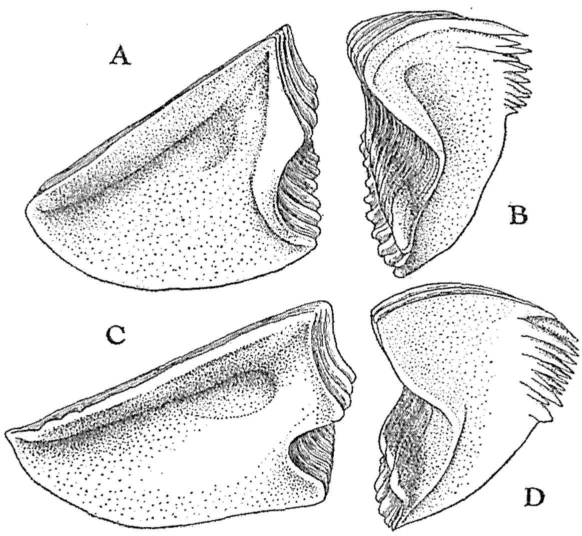

Fig. 3. *Octomeris brunnea* DARWIN. A, B, internal side of scutum and tergum in the typical form from Kaikô. C, D, internal side of scutum and tergum in the corroded specimen from Daizyubô showing its affinity to NILSSON-CANTELL's *intermedia.* (×10).

In more grown and larger specimens, the external surface is subject to deep erosion, as is usual in most littoral barnacles. In those, the orifice is relatively large and quadrangular, because the apices of the compartments are deeply worn off. The suture of the articulation between the scutum and tergum is, accordingly, strongly sinuous; it is apparently varied according to the grade of corrosion of the valves (Figs. 4, B–C).

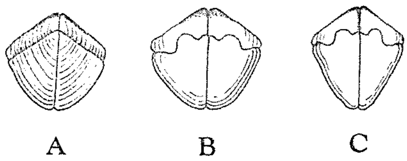

Fig. 4. *Octomeris brunnea* DARWIN. A, upper view of opercular valves in a perfect specimen. B, the same in a corroded specimen. C, the same in a specimen, showing the intermediate stage between figs. A and B; the scutum somewhat elongated. (×2.5).

The scutum, in the typical form, is triangular with a somewhat rounded basal margin; when fully developed, it tends to grow transversely and therefore the basal margin becomes almost straight. The strength of the articular ridge is also variable in accordance with the corroded state of the exterior. In the tergum, the basal margin is slightly arched, no trace of the spur existing. Apparently the "spur", which is mentioned by NILSSON-CANTELL, is in reality the pointed basitergal angle and also his "basiscutalen Ecke" of the tergum is the protruded end of a part of the articular furrow in contact with the deepest part of the articular furrow of the scutum (cf. Fig. 3).

As I have said before, it is beyond doubt that *Octomeris intermedia* is nothing but an old and deeply corroded form of *Octomeris brunnea*. This identity is moreover strengthened by the ecological and geographical evidences, both of NILSSON-CANTELL's 'species' being found together attached to *Mitella mitella* from Java*. The present collection from the three localities of Formosa mentioned below includes specimens in every stage of development. For comparison the dimensions of the specimens showing the appearance referable to the two forms are given below:

	Diameter of base	Diameter of orifice
'*intermedia*' form	17–18 mm	6 mm
'*brunnea*' form	12–14 mm	3.5–3.8 mm.

12. *Octomeris sulcata* NILSSON-CANTELL
(Figs. 5 A, 6 C–D)

Octomeris sulcata, NILSSON-CANTELL, 1932a; HIRO, 1936b.

Occurrence in Formosa: Seisiwan beach near Takao. June 3, 1938. Abundant on limestone rocks in the littoral zone.

Distribution: Japan (Kobe, Seto, Tomioka, Nezugaseki) and Formosa (Takao).

Remarks: Numerous specimens found on the coastal rocks at Seisiwan

*) Erroneously mentioned as "Südlicher Atlantischer Ozean" in his original paper. Exact locality is to be found in NILSSON-CANTELL's (1925, p. 1).

beach near Takao exactly correspond to *Octomeris sulcata* NILSSON-CANTELL which was originally described from Kôbe, Japan. This species has been collected by me at several localities in Japan. Prior to NILSSON-CANTELL's original description, I was rather inclined to refer this species to the genus *Pachylasma* owing to the perfect concrescence of the rostrum and rostrolatera; but the habitat is more like that of the genus *Octomeris*, living in the littoral.

As NILSSON-CANLELL has pointed out, this species holds the intermediate position between the genera *Octomeris* and *Pachylasma*. Indeed, DARWIN (1854, p. 487) said, speaking of the allied genus *Catophragmus*, that with the one great exception of the exterior whorls of the valves, there is hardly a single generic character by which it can be separated from *Octomeris* and *Pachylasma*. A similar view can be applied to the relationship between *Octomeris* having eight separate compartments, and *Pachylasma* having six separate ones, because the present *Octomeris sulcata* as well as *Pachylasma* has the external appearance of the wall consisting of only six compartments, but it is in fact composed of eight ones which are rather distinctly separate at an early stage. Therefore, structurally there is no regular feature to differentiate the two genera. The only marked difference is the habitat, *Octomeris* occurring on the coastal rocks while *Pachylasma* lives in the deep water.

The morphological affinity of this species to the other species of *Octomeris* and also to the genus *Pachylasma* may be seen in the following table:

	O. brunnea & *O. angulosa*	*O. sulcata*	*Pachylasma*
Shape of shell	somewhat conical or depressed	somewhat depressed	distinctly conical
Surface of wall	extremely rugged or ridged	strongly ridged	nearly smooth
Thickness of wall	extremely or moderately thick	very thick	moderately thick
Radii	present, very narrow	present, much developed	wanting or very narrow
Alae	developed in the upper half	developed in the upper half	very wide, extending from tip to base
Sutural edge of plate	neatly toothed	smooth	smooth
Interior of parietes	smooth	roughened by tubercles below	smooth or roughened by tubercles below
Rostrum and rostrolatera	separated	united by linear sutures	united by linear sutures or perfectly fused
Sheath of rostrolatera	present	rudimentary	absent
Base	membranous	thickly calcareous	membranous or thinly calcareous
Opercular valves	*Chthamalus*-type	*Pachylasma*-type	
Caudal appendage	wanting	present, multiarticulate	present, multi- or uniarticulate, or rudimentary

Of these morphological characters of *Octomeris sulcata* listed in the above table, half show resemblances to the characteristics of the other species of *Octomeris*, while the remaining half come nearer to those of the genus *Pachylasma*. It is particularly noteworthy that this species has an entirely calcareous base which is solid, very thick and without any regular structure as in *Pachylasma*—this is a feature not described by NILSSON-CANTELL. Furthermore, it is impossible to regard the absence of the caudal appendage as a generic characteristic of the genus *Octomeris*. In the allied genus *Catophragmus*, which seems to be more primitive than *Octomeris*, the base is either calcareous or membranous, the caudal appendage is present in two species (*C. imbricatus* and *C. Pilsbryi*) and absent in one (*C. polymerus*). In *Pachylasma*, the base is essentially calcareous but partially or wholly membranous owing to its extreme thinness, and the caudal appendage is usually present and multiarticulate, with the exception of *Pachylasma darwinianum* PILSBRY (1912) and *P. ecaudatum* HIBO (1939 a) whose caudal appendage is uniarticulate or rudimentary. At any rate, it seems probable that these two characters are of phylogenetic significance rather than of systematic value.

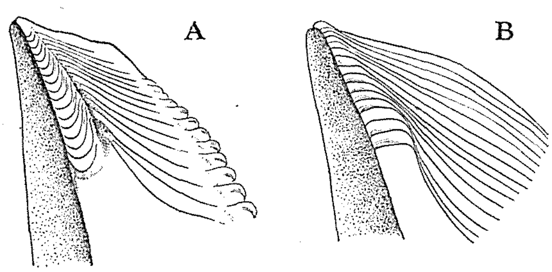

Fig. 5. Internal side of the apex of rostrolateral plate in *Octomeris sulcata* NILSSON-CANTELL (A) and *Pachylasma japonicum* HIRO (B).

Furthermore, it is interesting to compare the rostrum and rostrolatera with those of the other species of *Octomeris* and *Pachylasma*. In respect to the concrescense of the rostrum and rostrolatera, *Octomeris sulcata* closely resembles all the species of *Pachylasma*, but differs in the presence of a sheath, though quite rudimentary, on the inside of the rostrolatera. The sutural lines between the sheath of the rostrum and that of the rostrolatera are, when jointed together, hardly distinguishable, while the sutures between the sheath of the rostrolatera and that of the lateral compartment are more noticeable. In the rostrolatera of *Pachylasma* (f. inst. *P. japonicum* HIRO) however there is no distinct sheath but an extremely narrow area at the corresponding part where the growth-lines running from the inner sutural face are slightly inflected, obliquely on the upper half and rectangularly on the lower. In *Octomeris brunnea*, and probably in *O. angulosa* which I have not seen, a distinct but narrow sheath is present inside the rostrolatera. Thus the tendency towards a reduction of the sheath of the rostrolatera points to *Octomeris sulcata* as a link between the other species and *Pachylasma*. Nevertheless, in *Octomeris brunnea* as well as in *Pachylasma*, the sutural face of the rostrolatera, which is in contact with the alae of the lateral compartment, is wholly visible from the inside,

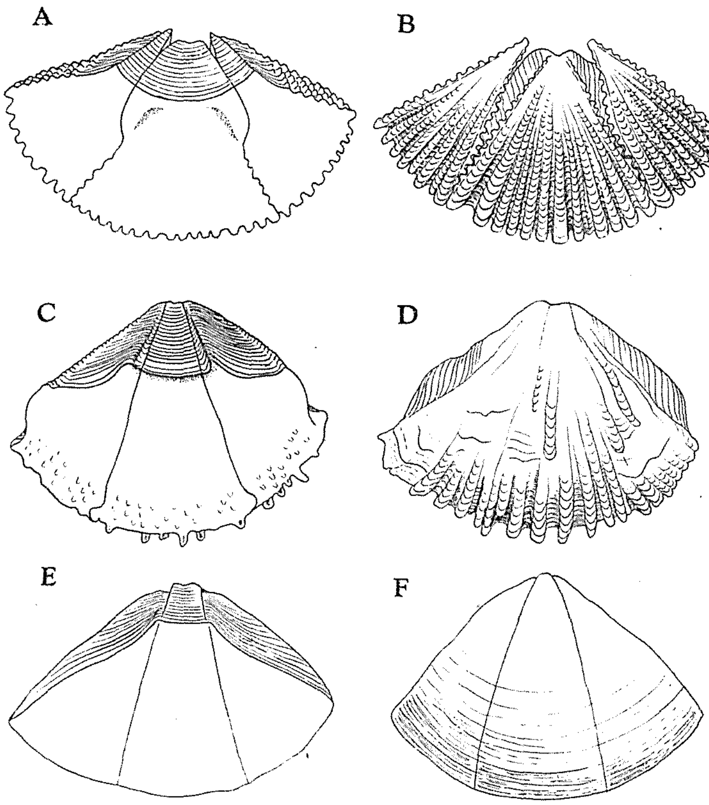

Fig. 6. Rostrum and rostrolatera articulated together in *Octomeris brunnea* DARWIN (A, B), *Octomeris sulcata* NILSSON-CANTELL (C, D) and *Pachylasma japonicum* HIRO (E, F). [A, C, D, internal view; B, D, F, external view].

while in *Octomeris sulcata* it is only partly visible. This is due to the marked development of the radii in the latter species (Figs. 5-6).

As should be clear from the above statements, it seems necessary to modify the definition of the genus *Octomeris* which was given by DARWIN and used by later authors. DARWIN described this genus briefly as follows: "Compartments eight, radii with their edges crenated, basis membranous". As far as his definition is concerned, the present species is apparently not a species of *Octomeris*. The following is an emended definition of *Octomeris*:

Chthamalidae with eight compartments, in which the rostrum and rostrolatera are perfectly separate or united by linear sutures; Surface of wall strongly ribbed or rugged; Radii and alae present; Sheath of rostrolatera narrow or rudimentary; Base membranous or calcareous; Scutum without an adductor ridge; Mandible with three teeth; Caudal appendage present or absent; Lives on shore.

Family BALANIDAE GRAY

Subfamily BALANINAE DARWIN

Genus *Balanus* DA COSTA

Subgenus *Megabalanus* HOEK

13. Balanus tintinnabulum tintinnabulum (LINNÉ)

(Fig. 7)

Lepas tintinnabulum, LINNÉ, 1758.
Balanus dilatatus, SCHLÜTER, 1838.
Balanus tintinnabulum var. *communis*, DARWIN, 1854; GRUVEL, 1903, 1905; BROCH, 1931.
Balanus tintinnabulum tintinnabulum, PILSBRY, 1916; NILSSON-CANTELL, 1931, 1938.

Occurrence in Formosa: Seisiwan near Takao. June 3, 1938. Abundant on coastal rocks and on moles, just below the low tidal mark.

Distribution: Malay Archipelago (the coast around the South China Sea), Indian and Atlantic Oceans and the Mediterranean. Also known as frequent migrants on ships.

Description: Numerous specimens obtained from Takao may be referred to *Balanus tintinnabulum tintinnabulum* which is called var. *communis* by DARWIN, though a slight difference on the external coloration exists. According to DARWIN, this subspecies is "conic or tubulo-conic, smooth or moderately ribbed longitudinally; colors varying from purplish pink to blackish purple, often in obscure longitudinal stripes". The specimen drawn by PILSBRY seems to be analogous with DARWIN's description. The present specimens do not strictly correspond to it but resemble his figure of this form (DARWIN, Pl. I, fig. a).

The shell is large and conical, sometimes tubuloconical. The compartments have deep purplish pink, narrow, longitudinal stripes, with somewhat obscure horizontal bands of the same color; the surface, without distinct ribs, is quite smooth. The walls are not very thick and their outer laminae bear many short lamellae on the inner edge between the septa. The interior is white and slightly ribbed near the base. The sheath is stained with dark slate purple. The orifice is large, rounded, and quadrangular. The radii are wide with horizontal summits, the surface transversely grooved and varies from dull bluish violet to dark purple in color.

Measurements of largest normal specimens (in mm).

Carino-rostral diameter	Height
35	35
32	22.

The opercular valves are similar to the description given by PILSBRY (Fig. 7).

Mouth-parts.—The labrum with two or three minute teeth on each side of the median narrow notch. The palpus is club-shaped, with bristles on the inner edge and at the rounded tip. The mandible has five teeth, of which the second and third are bifid, and a lower angle. Maxilla I has spines arranged in the usual three groups on the rather straight frontal edge; 3 spines on the upper part above a small notch, 9 in the middle and 15 smaller ones on the lower angle.

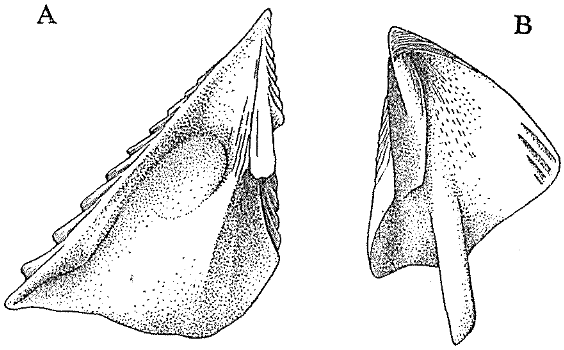

Fig. 7. *Balanus (Megabalanus) tintinnabulum tintinnabulum* (LINNÉ). A, internal side of scutum. B, internal side of tergum. 〔×3〕.

Cirri I to III are shorter than cirri IV to VI as is usual in this genus. In cirrus I, the posterior ramus is about 2/3 as long as the anterior, while in cirrus II, the rami are subequal in length. Cirrus III has the anterior ramus which is a little longer than the posterior. In cirri IV to VI, which appear almost the same, each segment bears three long and one short ventral spines. The following is the number of segments of the cirri in a specimen dissected:

I		II		III		IV		V		VI	
20	16	14	14	16	13	48	46	53	57	54	52

A short, nodular basi-dorsal point is present at the base of the penis.

Several specimens harbored boring cirripeds belonging to the Acrothoracica.

Remarks on distribution: The previous descriptions of this subspecies *tintinnabulum* have mostly been based upon specimens from the bottom of ships, as is usually the case with other forms of *Balanus tintinnabulum*. The geographical distribution of this subspecies thus remains uncertain. According to NILSSON-CANTELL (1931, 1938), "definitely known from the Mediterranean, Atlantic and Indian Oceans. (Exact distribution unknown)". In Takao of the southwestern coast of Formosa where the present specimens were obtained, this subspecies is very prevalent on coastal rocks just below the low tidal level. I examined a lot of specimens referable to this subspecies which were taken from a ship which had arrived at Yokosuka from the South China Sea. PILSBRY's drawings of this subspecies, based on specimens taken from a ship which arrived at Philadelphia from Hongkong and Java, are also given. Thus it seems certain that the natural habitat of this subspecies *tintinnabulum* is the coast around the South China Sea, as is the case with the other two forms described below.

14. *Balanus tintinnabulum zebra* DARWIN

Balanus tintinnabulum var. *zebra*, DARWIN, 1854; WELTNER, 1897; GRUVEL, 1905.

Balanus tintinnabulum zebra, PILSBRY, 1916.

Occurrence in Formosa: Daizyubô. June 14, 1938. One dry specimen.

Distribution: Philippine Archipelago, South China Sea. WELTNER (1897) records it from Walfisch Bay, southwest Africa.

Remarks: The single dry specimen, measuring 45 mm in carino-rostral diameter and 30 mm in height, covered wholly by coral limestone, has no opercular valves. It can, however, be easily identified with the subspecies *zebra* by the shell alone, which is conical, broadly ribbed and a pale rose. The radii are wide, transversely striated and rose-tinted toward the adjoining parietes. The sheath has the remarkable madder-brown color peculiar to this subspecies.

15. *Balanus tintinnabulum occator* DARWIN

Balanus tintinnabulum var. *occator,* DARWIN, 1854; BORRADAILE, 1900.
Balanus tintinnabulum occator, PILSBRY, 1916; NOMURA, 1938; NILSSON-CANTELL, 1938.

Occurrence in Formosa: Kizan. May 29, 1938. One specimen on a coastal rock.

Kankau. June 15, 1938. Several specimens on coastal rocks.

Distribution: Indo-Pacific—Mindanao, Fiji Islands (after PILSBRY), Bonin Islands (HIRO, 1937, p. 430), Indian Ocean (after NILSSON-CANTELL) and the eastern coast of Formosa.

NOMURA (1938) recently recorded this race with *Tetraclita squamosa* from the Lower Miocene of Kume-zima, Ryûkyû Islands.

Remarks: The compartments are tinted a light purplish drab, with close-set narrow white longitudinal ribs of which the lower half carries many sharp spines projecting toward the base. The sheath is generally white but tinged with pale purple inside the rostrum and lateral compartments.

In the young forms the spur of the tergum is separated with an interspace of more than its own width from the basiscutal angle; in older ones, however, the interspace is about the same width as the spur or less.

The internal parts do not differ much from those of the other subspecies of *B. tintinnabulum* described above.

Measurements (in mm).

Localities	Carino-rostral diameter	Height
Kizan	12	8
Kankau	32	15
,,	19	15
,,	15	11.

Subgenus *Balanus* DA COSTA

16. *Balanus amphitrite hawaiiensis* BROCH

Balanus amphitrite hawaiiensis, BROCH, 1922; HIRO, 1937b, 1938; NILSSON-CANTELL, 1938.
Balanus amphitrite, PILSBRY, 1928.

Occurrence in Formosa: Suô. May 30, 1938. On the wall of the pier of Nanpô-ô Port. Very prevalent in the intertidal region.

Kiirun. July 19, 1928; I. HARADA *leg.* On *Tetraclita squamosa viridis* and on *Styela plicata.*

Tansui. July 12, 1928; I. HARADA *leg.* A few specimens.

Takao. June 3, 1938. Abundant in the intertidal region. A lot of specimens from a ship in port.

Makô, Bôko-tô. September, 1938; Z. TURU *leg.* Several specimens on submerged iron-plates.

Distribution: Hawaiian Islands, Philippine Islands, Japan, Formosa and the Persian Gulf.

Remarks: This race is very prevalent on coastal rocks, on walls of piers and on moles in the intertidal zone. Its habitat in Formosa is thus identical with that in the Hawaiian Islands; PILSBRY (1928) says that it is very abundant between tides on the Anomia Reef (Hawaii). In the mainland of Japan, however, it does not occur on coastal rocks, though frequently found on the bottom of ships in harbours which are protected from the open sea, as already noticed by HIRO (1937 b p. 433; 1938, p. 311).

17. *Balanus amphitrite albicostatus* PILSBRY

(Fig. 8)

Balanus amphitrite f. *formosanus,* HIRO, 1938.

Occurrence in Formosa: Tôi near Kiirun. June 22, 1938. A few specimens.

Tansui Estuary. January 13, 1937; D. MIYADI *leg.* June 22, 1938. On stones.

Rokukô. April 10, 1936; H. SATÔ *leg.* June 21, 1938. On stones and submerged woods.

Gosei. April 11, 1936; H. SATÔ *leg.* A colony on a stone.

Takao. June 3, 1938. Abundant on the mole.

Distribution: Japan, South China and the western coast of Formosa.

Description and remarks: This Formosan race of *Balanus amphitrite* is widely distributed on the west coast facing the Strait of Formosa, but not found on the east coast. In a previous paper (HIRO, 1938), I dealt with the Formosan specimens merely as a local form of *Balanus amphitrite* showing the most affinity to the Japanese subspecies *albicostatus.* Having now studied a large series collected at several localities in Formosa, it was revealed that the distinction between *albicostatus* and *formosanus* is too slight to separate them into subspecies, but that the latter should be considered as a local form of the former.

In the typical form from Japan proper, the surface of the parietes is strongly ribbed and the interspace between these ribs is usually wider than the rib. In a lot of specimens from Formosa, the parietes are almost smooth and have relatively wide white longitudinal stripes; these stripes are sometimes barely or moderately raised but not as much as in the typical form.

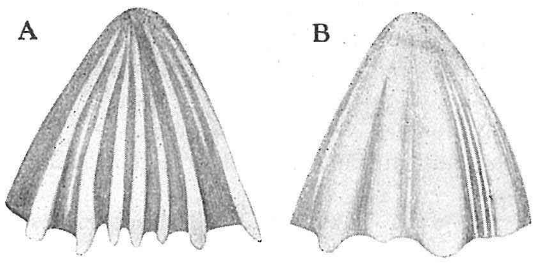

Fig. 8. *Balanus (Balanus) amphitrite albicostatus* PILSBRY. A, parietal area of the wall showing distinct narrow ribs in the typical form from Japan. B, parietal area of the wall showing rather obscure broad ribs in the Formosan form. [×6].

The white ribs thus formed are usually rounded and wider than the purplish interspace between them. Sometimes several white longitudinal stripes are raised to form a single rib together (Fig. 8). A comparison of the number of white stripes (including those which are distinct ribs) on the typical form and Formosan form is given in the following table:

Localities	Carina	Carinal latera	Lateral	Rostrum
(Typical form) Japan	5 (5) 6 (6) 7 (4) 8 (6)	2 (1) 2 (2) 4 (2) 3 (2)	9 (8) 9 (7) 8 (7) 15 (7)	13 (8) 7 (5) 10 (8) 13 (8)
Mean	7 (5)	3 (2)	10 (7)	11 (8)
Takao	6 (3) 7 (4) 8 (5) 11 (3)	3 (1) 2 (1) 3 (1) 4 (1)	9 (4) 9 (3) 8 (4) 9 (2)	12 (4) 13 (3) 11 (7) 14 (2)
Rokukô	5 (5) 8 (3) 9 (1) 14 (0)	3 (1) 2 (1) 4 (0) 3 (0)	8 (2) 6 (4) 12 (0) 12 (0)	5 (2) 9 (6) 14 (0) 19 (0)
Tansui	8 (0) 8 (2) 11 (0) 11 (3)	3 (0) 4 (1) 2 (1) 3 (1)	12 (0) 10 (4) 13 (3) 8 (3)	11 (0) 15 (2) 14 (2) 14 (2)
Mean	9 (2)	3 (1)	9 (2)	13 (3)

The numbers in brackets indicate those white stripes which are distinct ribs.

18. Balanus amphitrite cirratus DARWIN

Balanus amphitrite var. *cirratus,* DARWIN, 1854; WELTNER, 1897; GRUVEL, 1903, 1905.
Balanus amphitrite cirratus, NILSSON-CANTELL, 1921, 1931, 1932b, 1934a, 1934b, 1938; HIRO, 1938.

Occurrence in Formosa: Rokukô. June 21, 1938. On oysters.

Anpin. June 2, 1938. On oysters.

Reitiryô near Takao. Date unknown; A. YAMAGUTI *leg.* On the small mussel, *Aloides fava.*

Takao Port. June 3, 1938. On submerged wood at the Hagihara Dock Co.

Distribution: Indian Ocean, Australia, Malay Archipelago, South China, Formosa and Southern Japan.

19. *Balanus amphitrite krügeri* NILSSON-CANTELL

Balanus amphitrite krügeri, NILSSON-CANTELL, 1932; HIRO, 1938.
Balanus amphitrite niveus, KRÜGER, 1911 (nec DARWIN).

Occurrence in Formosa: A large number of specimens taken from the bottom of a ship which arrived at Takao from Kanton, South China can be identified with *Balanus amphitrite krügeri*, which is identical with *B. amph. niveus* recorded by KRÜGER (1911) from Making, Pescadores.

These clustered specimens are cylindrical and have large orifices. The parietes are smooth with light purplish longitudinal stripes which are nearly white in some of them. Internally, the tergum is very prominent, having a very long and strongly pointed spur; the basal margin at the carinal side is deeply notched.

Distribution: Japan, Korea, Pescadores (Bôko-tô) and South China Sea.

20. *Balanus amphitrite communis* DARWIN

Occurrence in Formosa: A few specimens were mixed with *Balanus amphitrite hawaiiensis* and *B. amph. cirratus* collected from a ship in Takao Port. Judging from its scarcity it appears to be merely a migrant on ships in Formosa, though very common in the mainland of Japan.

Distribution: West Indies, European Seas, Mediterranean, West and South Africa, Indian Ocean, Malay Archipelago, New South Wales and Japan.

21. *Balanus amphitrite poecilotheca* KRÜGER

Balanus poecilotheca, KRÜGER, 1911.
Balanus amphitrite poecilotheca, HIRO, 1937b, 1938.

Occurrence in Formosa: Makô, Pescadores. September, 1938; Z. TURU *leg.* A small specimen attached to *Ostrea* (*Lopha*) *crenulifera.*

Distribution: Japan, Sulu Archipelago, South Africa, Pescadores Islands.

22. *Balanus trigonus* DARWIN

Occurrence in Formosa: Kiirun. July 19, 1928; I. HARADA *leg.* A specimen on *Styela plicata.*

Distribution: Pacific, Atlantic and Indian Oceans.

Subgenus *Chirona* GRAY

23. *Balanus taiwanensis* n. sp.

(Figs. 9, 10)

Occurrence in Formosa: Suô. May 30, 1938. Six specimens on stones in the littoral.

Takao. June 3, 1938. One specimen attached to *Balanus tintinnabulum tintinnabulum.*

Description: The specimens are depressed-conical, rather patelliform, with the apical aperture small, triangularly ovate and not very toothed. The surface of the wall is dirty white, smooth and covered with a pale yellowish epidermis, which is marked with minute growth-striae fringed with fine hairs. The opercular valves are white under a similar epidermis. The compartments are thick, solid and only weakly cemented together but cling firmly to the base. The carina is narrow, about two-thirds as wide as the lateral compartment, and usually recurved outwards at the apex. The carinolaterals are extremely narrow, less than one-fourth as wide as the laterals. The rostrum is very broad, about twice as wide as the laterals, and much depressed. The parietes of these compartments are smooth, only having slight growth-striae; the inside is longitudinally ribbed throughout.

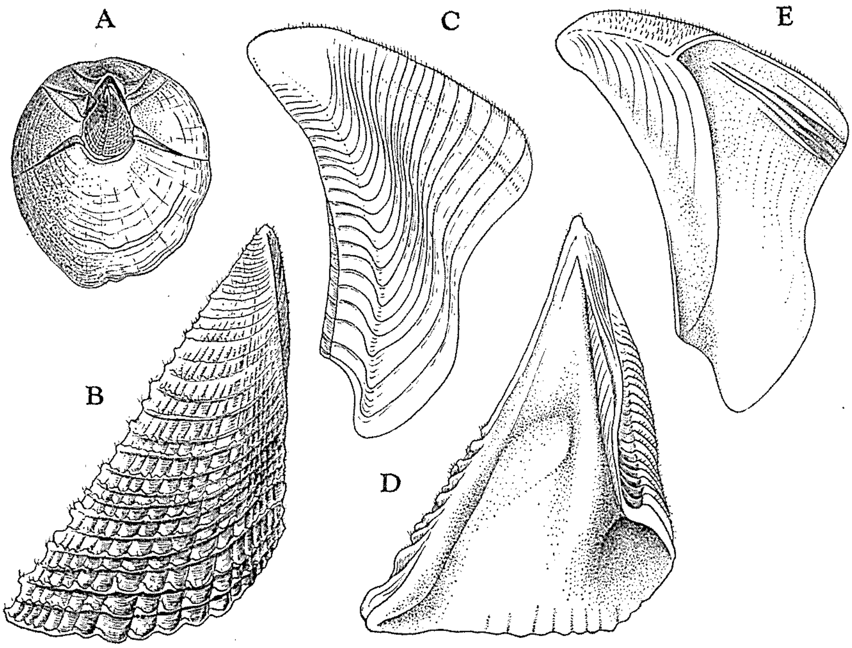

Fig. 9. *Balanus (Chirona) taiwanensis* n. sp. A, type-specimen from Suô in upper view. B, external side of scutum. C, external side of tergum. D, internal side of scutum. E, internal side of tergum. [A ×2.5, B-E ×27].

The radii are very narrow, only the upper half being visible from the outside; the sutural edges are denticulate, and those of the parietes along the alae are likewise denticulate. The sheath is prominently ridged transversely and its lower edge is overhanging. The base is flat, calcareous and not porous.

Measurements (in mm).

	Carino-rostral diameter	Height
Holotype (from Suô)	13	6
Paratype (from Takao)	7	4

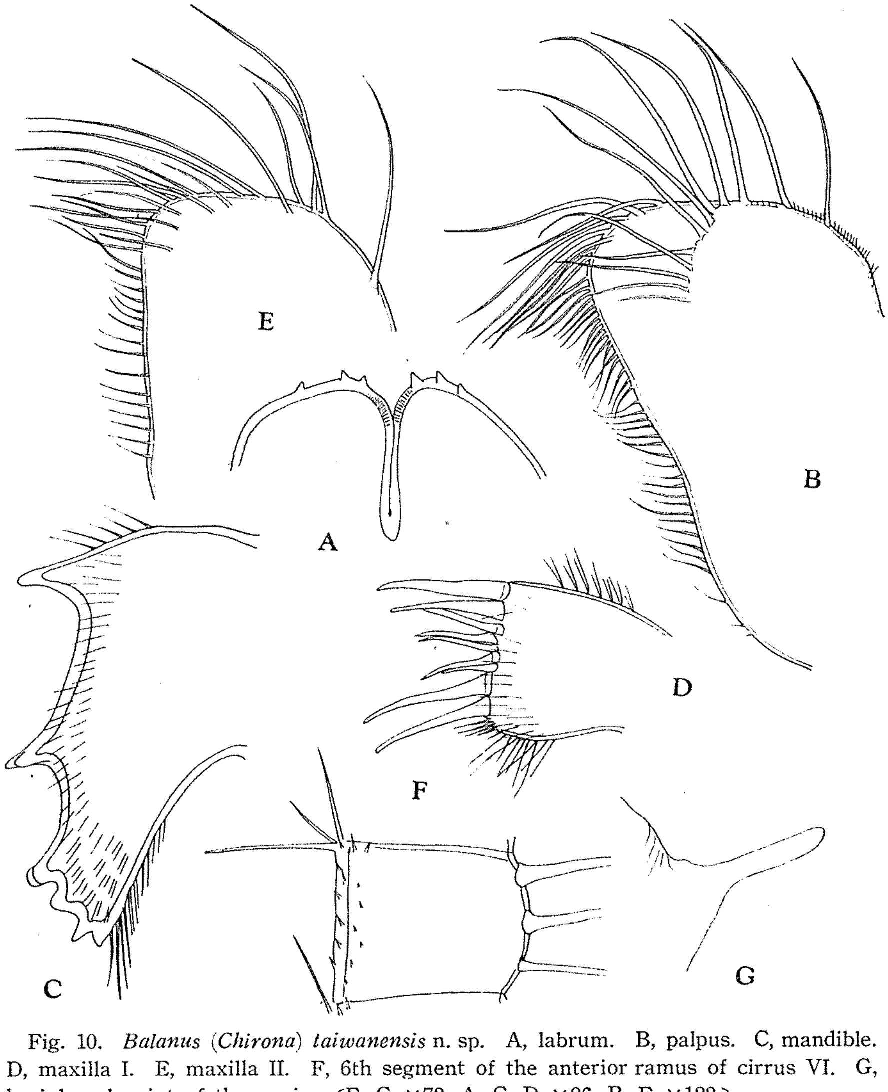

Fig. 10. *Balanus (Chirona) taiwanensis* n. sp. A, labrum. B, palpus. C, mandible. D, maxilla I. E, maxilla II. F, 6th segment of the anterior ramus of cirrus VI. G, basi-dorsal point of the penis. [E, G ×72, A, C, D ×96, B, F ×122.]

The scutum is flat or slightly concave outside, having close growth-ridges fringed with hairs and cut by deeply engraved longitudinal striae. Inside there is a rather low articular ridge four-fifths as long as the tergal margin, with a narrow articular furrow along it. The adductor ridge is broad, though not acute, and separated by a narrow distinct groove from the articular ridge. Adductor and depressor muscle impressions are broad and shallow.

The tergum is externally flat and regularly marked with growth-striae; no groove is present on the spur-fasciole. The spur is short and wide, about half of the width of the valve, and truncate at the end. The interior is smooth and nearly flat, except for the crests for the depressor muscles which are long and 4 in number. The articular ridge is not prominent; the articular furrow is wide and shallow.

The labrum has three strong teeth on each side of the median deep notch. The palpus is typically club-shaped. The mandible has five distinct teeth of which the second and third are bifid; the lower angle is minutely and shortly pointed. Maxilla I has a nearly straight edge, bearing spines, the upper two and the lower two of which are larger, the middle five smaller. Besides these, a tuft of minute spines are planted at the lower angle. Maxilla II is oval and rather densely covered with long hairs.

Cirri.—In cirrus I, the anterior ramus is a little longer than the posterior, while in all the posterior ones the rami are subequal. In cirri IV to VI, each segment is usually somewhat broader than long, and has two larger and one smaller pairs of ventral spines; the dorsal side of the segments has a few erect spinules. The number of segments in each cirri is as follows:

I		II		III		IV		V		VI	
13	11	10	10	12	11	17	17	20	20	23	23

The penis is as long as the sixth cirrus and has the usual basi-dorsal point.

Remarks: The present species undoubtedly belongs to the group of *Chirona*, indicating its affinity to *Balanus bimae* HOEK and *B. krügeri* PILSBRY. The narrow carinolateral compartment and longitudinally striated scutum are features in common with both of them; however, the present species differs from them in the shape of the tergum. More peculiar is the habitat which is intertidal and hypobiotic, as is the case with the species of *Tetraclitella* mentioned below. Most of the species grouped in *Chirona* have been recorded from the deep waters, with the exception of *B. amaryllis* which is, according to PILSBRY (1916), a real littoral species.

Subgenus *Conopea* SAY

24. *Balanus granulatus* HIRO

Balanus granulatus, HIRO, 1937b.

Occurrence in Formosa: Formosa Channel. Date unknown. Several specimens attached to antipatharians preserved in the Fisheries Experimental Station of the Government of Formosa at Kiirun.

Distribution: Japan to Formosa, attached to antipatharians.

Genus *Acasta* LEACH

25. *Acasta spinosa* n. sp.

(Figs. 11, 12)

Occurrence in Formosa: Suô. May 30, 1938. Numerous specimens imbedded in a very hard and tough sponge collected from a tide pool.

Description and remarks: At first sight these specimens from Suô recall some known species of *Acasta,* such as *Acasta sulcata* LAMARCK, *A. cyathus* DARWIN, *A. conica* HOEK and *A. serrata* HIRO. As is indicated by the structure of the opercular valves, they possibly belong to the same group as the one which I formerly named A-type. The beaded growth-ridges of the scuta and terga as well as the long spines on the shell, however, differ so strikingly from all species hitherto known that it cannot be identified with any of them.

The entire shell is round, or like a hazel nut, white with a pale purplish tinge toward the apex. The compartments are thin and solid, their surface provided with some calcareous projections which are long and extremely pointed. The inner surface of the compartments below the sheath is smooth except for the lower half where definite but short ribs are present; these do not reach the basal margin of the valve. The basal margin of the sheath stands freely from the inner face of the wall. The radii and alae are very broad; the former extends down to the base but the latter does not. The orifice is rather large and strongly toothed, the tips of the compartments being pointed and the summits of the radii as well as alae very oblique. The tip of the rostrum is curved inwards much more than that of other compartments. The carinolateral compartment is moderately narrow, about 1/5 to 1/6 as wide as the lateral one.

The compartments as well as the basal cup show no trace of canaliculation. The basal cup is not very deep but distinctly conical. Its upper margin is almost smooth.

Measurements (in mm).

	Carino-rostral diameter	Height	Depth of basal cup
Holotype	5.4	7.9	3.0
Paratype	5.4	7.8	2.7
Paratype	5.0	7.7	2.6

The scutum has a nearly straight basal margin, with a rounded basitergal corner. The outer surface is furnished with prominently beaded growth-ridges crossed by slight longitudinal striae. Internally, the articular ridge is moderately developed, terminating gradually toward the bottom; it is about two-thirds as long as the tergal border. The adductor ridge is more or less distinct. The cavity for the lateral depressor muscle is likewise distinct, but that of the adductor muscle is shallow.

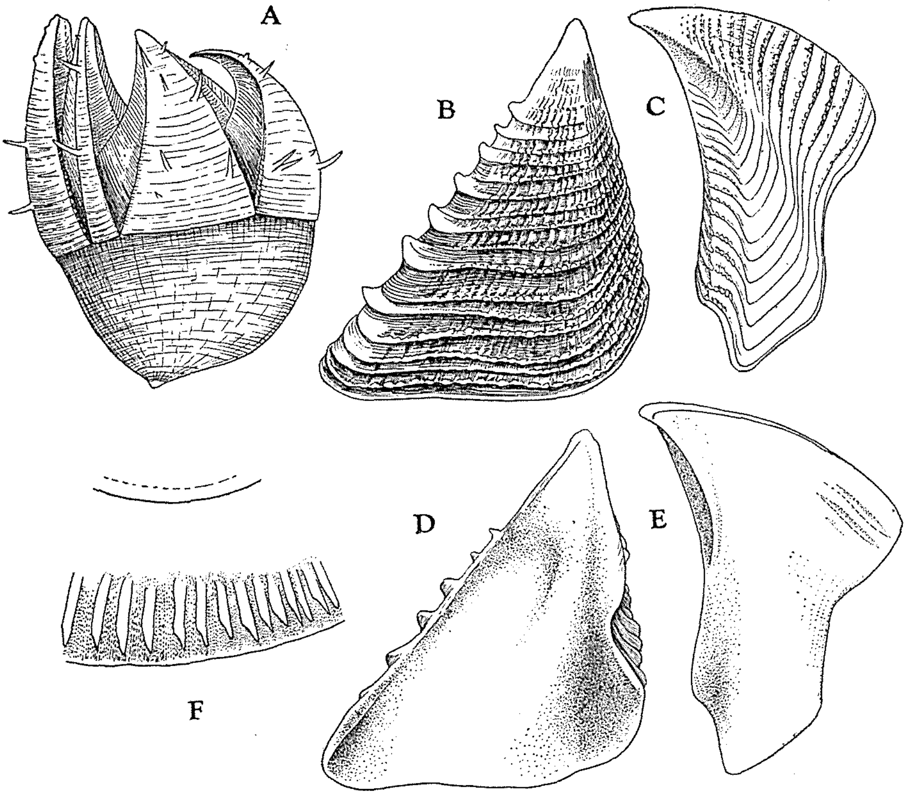

Fig. 11. *Acasta spinosa* n. sp. A, type-specimen in side view. B, external side of scutum. C, external side of tergum. D, internal side of scutum. E, internal side of tergum. F, internal side of a part of the wall, showing a row of internal ribs. [A ×7, F ×10, B-E ×16].

The tergum is rather thin, somewhat beaked at the apex, with low growth-ridges. The growth-ridges are all beaded, though not as prominently as in the scutum, except on the surface of the depression which leads from a little below the apex into the spur. The spur is about half as broad as the entire plate and its end is obliquely cut off. The almost smooth interior is white, though tinged with blackish purple toward the apex. Two or three crests for the depressor muscles can hardly be made out.

Mouth-parts.—The labrum with three minute teeth on each side of the median notch. The palpus is of ordinary shape. The mandible has five teeth of which the second to fourth are bifid; the lower angle is pointed. Maxilla I has almost straight frontal edge, though a notch under the upper pair of larger spines can hardly be distinguished. A row of 6 spines of about the same length is arranged between the upper and lower pairs of spines. The lower angle is armed with three minute spines.

In cirrus I, the anterior ramus is a little longer than twice the posterior.

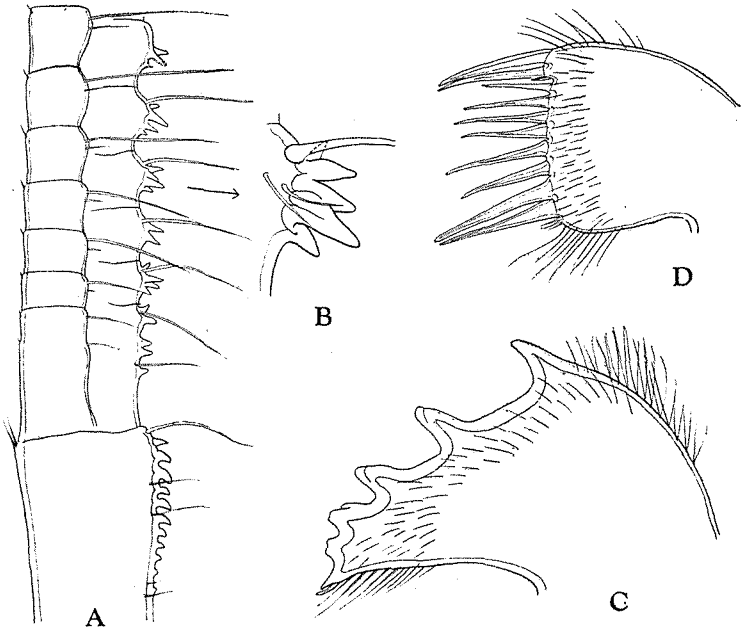

Fig. 12. *Acasta spinosa* n. sp. A, basal segments of cirrus IV. B, a row of teeth on the frontal face of the sixth segment of the anterior ramus of cirrus IV. C, mandible. D, maxilla I. [A, C, D, ×96, B ×335].

Cirrus II has rami of almost similar length. In cirrus III, the anterior ramus is a little longer than the posterior. The armature of cirrus IV seems to be characteristic, the anterior ramus bears two to five strong, conical teeth on the frontal face of each segment; these teeth are close-set and unrecurved, instead of being arranged as usual in a row and recurved downwards. The protopodite bears about 10 somewhat recurved teeth on the frontal face of the upper half of the proximal segment. The pairs of cirri V and VI are almost equal, with about 30 to 35 segments, each of which bears one long and two shorter pairs of ventral spines. The number of segments of these in the specimen dissected is as follows:

I		II		III		IV		V		VI	
17	7	11	9	13	11	27	30	31	34	34	35.

The penis is long, slender and annulated all over; its distal part is covered sparsely with hairs. No basi-dorsal point is present.

Subfamily TETRACLITINAE NILSSON-CANTELL

Genus *Tetraclita* SCHUMACHER

The genus *Tetraclita* in its DARWINian limits comprises species in diverse stages of evolution, as in the case of the genus *Balanus*. According to DARWIN's definition of this genus, it is a Balanidae " with four compartments, sometimes externally calcified together, parietes permeated by pores, generally forming several rows; base flat, irregular, calcareous or membranous." PILSBRY (1916) divided the genus into two groups, *Tetraclita* s. str. and *Tesseropora*, according to a distinct difference in the canaliculation of the compartments. In respect to the other characters, however, both groups are closely allied to each other.

DARWIN has already recognized the difference between *Tetraclita purpurascens* and *T. costata*, and all the other species in the structure of the radii, but he did not make any sectional division concerning the porosity of the radii. As far as the structure of the radii and the opercular valves are concerned, it seems to be rather unnatural to subdivide *Tetraclita*, because there are the intermediate forms such as *T. radiata* (KRAUSS) and *T. darwini* PILSBRY. If the other characteristics indicated in *T. purpurascens* (WOODS) and its allies are combined, however, their affinities would become more obvious by placing them into a separate subgroup i. e. *Tetraclitella*. But I believe that the differences between the two subdivisions are adaptive in accordance with their mode of life. All of the species included in *Tetraclitella* have the hypobiotic habit.

Subgenus *Tetraclita* (SCHUMACHER) emend.

Supplementary diagnosis: Shell steeply conical or somewhat depressed; usually dark colored. Compartments four, sometimes externally calcified together; parietes permeated, forming many irregular rows. Radii generally obsolete, poreless, with oblique summits. Orifice oval to rounded trigonal or rhomboidal. Base calcareous or membranous. Scutum longer than wide, with distinct crests for depressor muscles. Tergum elongate, with a strongly developed spur. Mandible with four teeth, followed by an even, comblike row of spinules towards the lower angle. Maxilla I generally with more than 10 spines below the upper notch.

Type.—*Tetraclita squamosa* (BRUGUIÈRE).

Distribution and habitat: All of tropical and warm temperate seas; living attached to intertidal rocks and shells, usually exposed to surf.

Remarks: The newly established *Tetraclita* includes species such as *Tetraclita squamosa* (BRUGUIÈRE) (=*T. porosa* (GMELIN)), *T. serrata* DARWIN, *T. vitiata* DARWIN, *T. coelurescens* (SPENGLER), *T. alba* NILSSON-CANTELL and (?) *T. radiata* (DE BLAINVILLE) DARWIN. The last-named *T. radiata* known from the West Indies may hold an intermediate position between the two subgroups; in this species, according to DARWIN, the radii are broad, with slightly oblique summits, and their sutural edges are formed by ridges having many denticles all very much alike; the interspaces between the main ridges more or less terminate in tubes. The other characters however indicate a closer affinity to the species of the subgenus *Tetraclita* than to those of *Tetraclitella*.

The following two races of *Tetraclita squamosa* are represented in my collection from Formosa:

26. *Tetraclita squamosa viridis* DARWIN

Syn. HIRO, 1937a.

Occurrence in Formosa: Suô. May 30, 1938. Rather rare on coastal rocks.

Kizan. May 29, 1938. Very rare.

Syaryô-tô in Kiirun. May 27, 1938. Very abundant on coastal rocks.

Kiirun. July 19, 1928; I. HARADA *leg.*

Sekimon. April 2, 1933; the late S. TAKAHASHI *leg.*

Tôi. June 22, 1938. Several specimens on rocks.

Makô, Pescadores. September, 1938; Z. TURU *leg.* Very abundant.

Kaikô. June 16, 1938. Common on moles.

Garanbi. June 12-13, 1938. Very rare on raised coral reefs.

Kankau. June 15, 1938. Rare on raised coral reefs.

Distribution: From Malay Archipelago northward to South China and South Japan, and southward to Australia, and westward to the Indian Ocean. Also recorded from Panama (BROCH, 1922) and from West Africa (PILSBRY, 1916).

Remarks: This well-known Malayan race of *Tetraclita squamosa* lives on any rocky coast of Formosa. It is of zoogeographical interest, however, to observe the fact that it is very abundant on the northern coast and also in the Pescadores Islands but very rare in the southernmost region.

In a large collection of specimens from the Pescadores I found two specimens referable to the subspecies *japonica* which is characterized by the deep purplish-gray coloration of the shell and by the presence of two to four occludent teeth in the scutum. I nevertheless doubt the natural existence of this Japanese race in that locality. I therefore hesitate to treat it as a member of the Formosan fauna.

27. *Tetraclita squamosa formosana* n. subsp.

(Fig. 13)

Occurrence in Formosa: Suô. May 30, 1938. Very abundant on coastal rocks.

Kizan. May 29, 1938. Very abundant on coastal rocks.

Syaryô-tô in Kiirun. May 27, 1938. Rather rare.

Seisiwan near Takao. June 3, 1938. Abundant on coastal rocks.

Kaikô. June 16, 1938. Abundant on the mole, together with *T. s. viridis.*

Garanbi. June 12-13, 1938. A few on raised coral reefs.

Kankau. June 15, 1938. Very abundant on coastal rocks.

Distribution: Northeastern and southern coasts of Formosa.

Description and remarks: Another form of *Tetraclita squamosa* prevalent on the Formosan coast is so closely allied to the Japanese race, *T. s. japonica* particularly in the structure of the opercular valves that I at first thought them identical. Several characters of the Formosan form, however, especially the coloration of the shell and scutum, are not identical with the Japanese form.

In the Japanese form, as PILSBRY (1916) says, the surface of the wall is a dark purplish-gray or deep mouse-gray, the sheath ranging from vinaceous slate to dull violet black and the inside of the scutum from dark slate purple to dusky madder violet. In the Formosan form, the surface of the wall is reddish purple or Vernonia purple, the sheath dull purplish black and the inside of the scutum is nearly white, tinged with pale Vernonia purple. The inside of the tergum is almost white, not bicolored as in *T. s. japonica*.

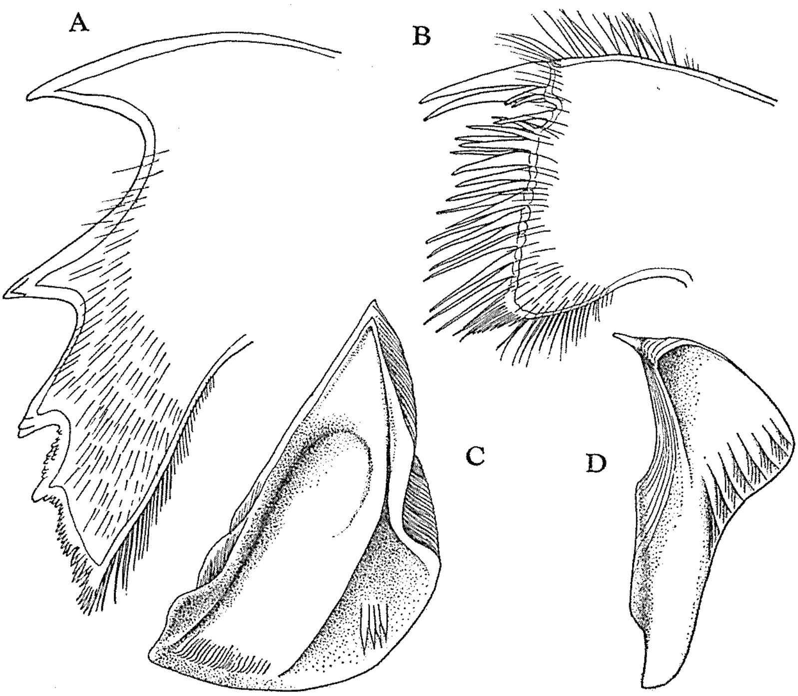

Fig. 13. *Tetraclita* (*Tetraclita*) *squamosa formosana* n. subsp. A, mandible. B, maxilla I. C, internal side of scutum. D, internal side of tergum. [C–D ×4.5, A–B ×55].

The external difference between the above-mentioned two races is readily recognized because of the brighter color of the Formosan form which is a contrast to the dusky color of the Japanese form. So far as my experience goes, no specimens have been found, showing an intermediate coloration.

In adult specimens, the four compartments are united, the sutures usually obliterated. The surface is wholly eroded and roughened, exposing the filling of the parietal tubes, though not so densely as in *T. s. japonica*. The wall is thick with pores of medium size or larger. The orifice is usually wide and oval.

Measurements of the holotype (in mm).

Carino-rostral diameter	Height
40	25.

The scutum, like that of *T. s. japonica,* has two or three strong oblique teeth on the lower half of the occludent border. Inside, the adductor ridge is long and removed from the articular ridge by a narrow furrow.

The tergum is elongate with a spur which is pointed at the basiscutal end and more or less wider than in *T. s. japonica.* There are 7 or 8 crests for the depressor muscles.

The internal body was dissected, but it showed no important difference from all the other races.

T. squamosa perfecta, which was described by NILSSON-CANTELL (1931) from Santuao, Fukien of South China, which is not far from Formosa, seems to be a peculiar form distinct from the present Formosan and other forms, though no account has been given of the coloration of the shell and of the opercular valves.

Subgenus *Tetraclitella* nov.

Diagnosis: Shell of small size, depressed and whitish. Compartments four, usually separate; parietes rather thin, permeated. Radii broad with horizontal summits, permeated radially by pores like those of parietes. Orifice rhomboidal. Base membranous or thinly calcareous. Scutum generally transversely elongated with an external median depression; no crest for depressor muscles. Tergum not elongate, with short broad spur. Mandible with five teeth, a few spinules and a spine-like lower extremity. Maxilla I with 6 to 7 spines below the upper notch.

Type.—*Tetraclita purpurascens* (WOODS).

Distribution and habitat: Indo-Pacific waters. Hypobiotic, under stones or littoral shells.

Remarks: This group contains the following three species: *Tetraclita purpurascens* (WOODS), *T. divisa* NILSSON-CANTELL, *T. costata* DARWIN. The last-named one *T. costata* is not represented in the present collection, but has been known from the Malay, Philippine and Hawaiian Archipelagoes. It has characters common to the other two species, except for the scutum which is not transversely elongated.

Tetraclita darwini PILSBRY, which is known from Japan only, is a most peculiar form of the genus *Tetraclita,* differing in the articulation of the compartments. In this species, the radii as well as the alae are perforated by pores like those of the parietes, but the opercular valves indicate intermediate feature between those of *T. squamosa* and *T. purpurascens.* Though I have placed it in this group for the time being, it shows a close affinity to *T. radiata* which is a member of the subgenus *Tetraclita.*

28. *Tetraclita purpurascens chinensis* NILSSON-CANTELL
(Fig. 14)

Occurrence in Formosa: Suô. May 30, 1938. Attached to the sheltered underface of stones within the tidal limit, together with *T. darwini*, *T. divisa* and *Balanus taiwanensis*.

Kankau. June 15, 1938. Attached to sheltered underface of shore rocks, together with *Chthamalus moro* and *T. divisa*.

Distribution: Typical form—New Zealand, Australia, Java, Madagascar. Forma *chinensis* (incl. *nipponensis*)—China, Formosa, Southern Japan.

Remarks: *Tetraclita purpurascens*, together with its subspecies, has been described fully by some authors so that any further description is scarcely needed. Some remarks on its varied forms which I have sometimes met on identifying specimens, however, would not be useless.

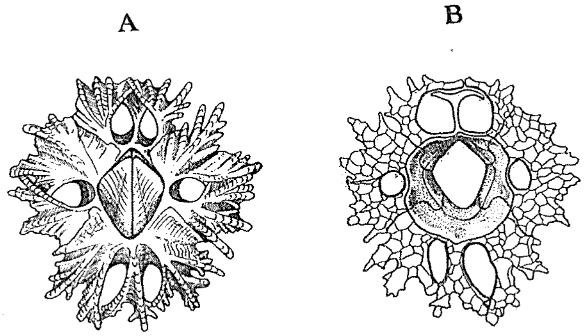

Fig. 14. *Tetraclita* (*Tetraclitella*) *purpurascens chinensis* NILSSON-CANTELL. A, specimen in upper view. B, shell seen from base. 〔×2.〕

As has already been mentioned in connection with *T. purpurascens nipponensis*, the structure of the shell and the opercular valves of this species are very variable (HIRO, 1932). In younger specimens, which are found sometimes attached to *Mitella mitella* and other littoral cirripeds, the shell is small, about 4 to 8 mm across, and rather tubuloconic in shape, somewhat like that of *Chthamalus challengeri*; the ribs on the parietes are sometimes few, sometimes numerous, and the radii are at times obliterated. In each plate, three of these ribs on the parietes are usually distinct.

In older and depressed specimens the compartments are sometimes perforated with large hollows, as NILSSON-CANTELL (1921) mentioned; usually the lateral compartment has two hollows and the rostrum as well as the carina has one. It is difficult to say why these hollows are formed, yet it seems unlikely that they are made by another creature or some other external agent, since they are not found in any other cirriped. I consider them parietal tubes which became larger by successive corrosion because of the weakness of the wall of the interspace between the prominent ribs on the outer lamina. DARWIN did not mention such a feature as this in describing the typical form of *T. purpurascens* from Australia and New Zealand, the surface of the wall of which is granulated by disintegration, the sutures united and obliterated (cf. DARWIN, 1854, pl. 11, fig. Ia; GRUVEL, 1903, pl. 4, fig. 8). In the oriental form here described, however, there has not been found any specimen showing such disintegration. If these differences prove constant, the oriental form is a distinct subspecies.

The scutum is transversely elongated and furnished externally with a longitudinal median depression, the occludent border being raised above the level of the remaining surface. The basal margin is thus notched at the end of the external depression. The strength of the notch varies, generally being stronger in specimens from China and Formosa than in those from Japan. The adductor ridge is also variable; it is usually distinct but sometimes indistinct, as NILSSON-CANTELL said it is "weak". The tergum is not very different from that of the typical form.

If these differences in character found between the Japanese and Formosan specimens are variations by development, *T. p. nipponensis* may turn out to be a mere variant of *T. p. chinensis.*

T. purpurascens f. *breviscutum* BROCH (1922), recorded from Auckland Island, New Zealand, does not exhibit identity to any form of *purpurascens.* It is certainly not a form of *T. purpurascens* as might be inferred from the scutum figured by BROCH which has distinct crests for the depressor muscles.

T. purpurascens var. *multicostata* NILSSON-CANTELL (1930), recorded from Jeffi, Misoöl Archipelago, is, according to him, not much different from those described earlier, except that "the tubes (of the wall) are regularly formed, which is perhaps also a character distinguishing this from the more typical ones." His description is based on one specimen.

29. *Tetralita divisa* NILSSON-CANTELL
(Fig. 15)

Tetraclita divisa, NILSSON-CANTELL, 1921.

Occurrence in Formosa: Suô. May 30, 1938. Attached to sheltered stones within the tidal limit, together with *Tetraclita darwini, T. purpurascens chinensis* and *Balanus taiwanensis.*

Kankau. June 15, 1938. Common on sheltered tidal rocks.

Distribution: Sumatra, Java and the eastern coast of Formosa.

Description: Numerous specimens found in association with *Tetraclita purpurascens* and other littoral barnacles on the east coast seem to be identical with *Tetraclita divisa* NILSSON-ÇANTELL (1921). This species was first described from Sumatra and from Java Sea but has never been rediscovered. From mere superficial examination it is difficult to differentiate it from *Tetraclita purpurascens*, but it differs markedly from the latter in the shape of the tergum, which is not as variable as in *T. purpurascens.*

The shell is dirty white or pale purple, much depressed and almost rounded in outline; the ends of the ribs, in most cases, do not project around the margin. The four compartments, of almost the same size, are furnished with close, imbricated horizontal lines of growth with minute fringes of fine chitinous hairs, and each has three longitudinal ribs ending indiscernibly toward the margin; these ribs are not as prominent as in *T. purpurascens* and *T. costata.* The parietes are rather thin, semitranslucent and internally made up of two to four rows of parietal tubes; these tubes are mostly four- to six-cornered in cross-section. The radii are broad, square at their summits and furnished with growth-lines, like those of the parietes,

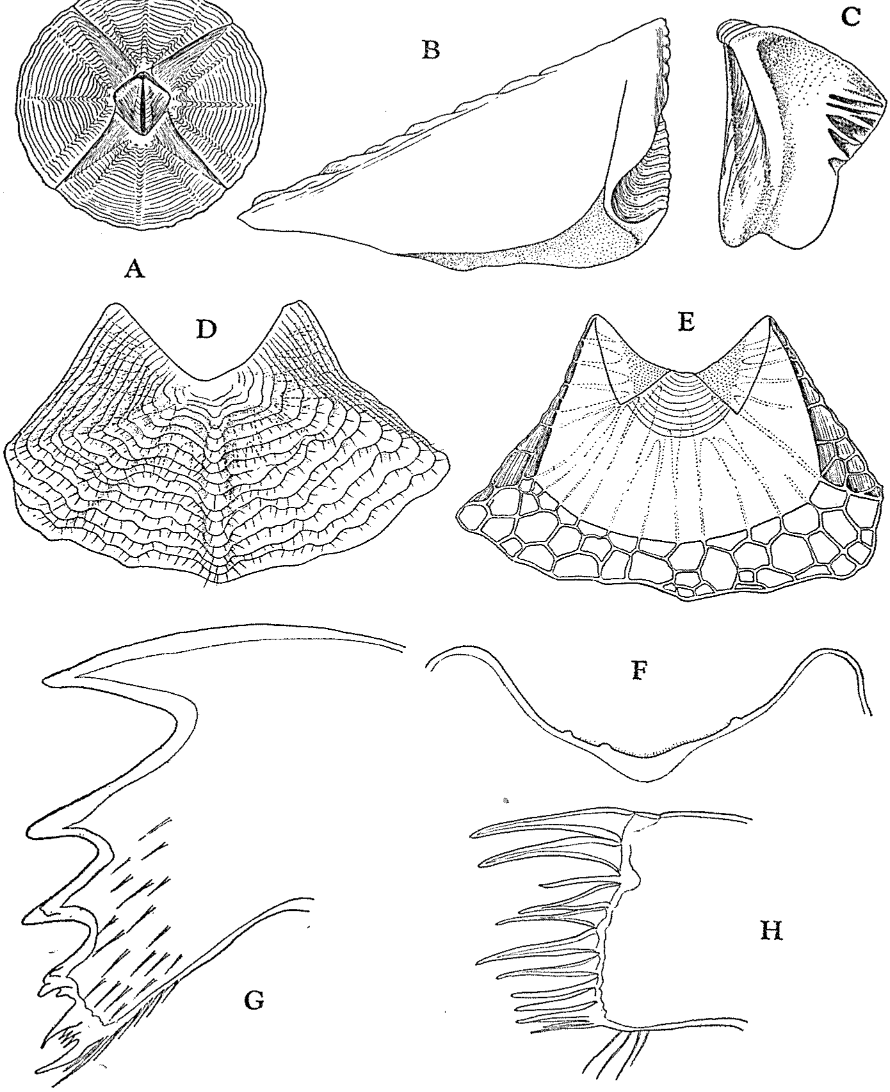

Fig. 15. *Tetraclita* (*Tetraclitella*) *divisa* NILSSON-CANTELL. A, specimen in upper view. B, internal side of scutum. C, internal side of tergum. D, external side of rostrum. E, internal side of rostrum. F, labrum. G, mandible. H, maxilla I. [A ×3, B-C ×27, D-E ×10, F ×146, G-H ×208].

running obliquely to the base; internally, large tubes like those forming the parietes run radially in one or two rows. The alae are triangular, thin and not perforated. The inside of the wall is smooth except for the sheath. The orifice, about 1/4 as broad as the whole shell, is diamond-shaped. The base is usually membranous, but often thinly calcareous at the bottom of the wall; the central part remains membranous.

The scutum is transversely elongated with a broad median depression on the outer surface. Inside, the adductor ridge is present but often obsolete. There is no crest for the rostral and lateral depressor muscles. The articular ridge and furrow are prominent.

The tergum is broad and short, with a wide, short, rounded spur which is separated by a distance of half of its own width from the basiscutal angle. 5 or 6 strong crests for the carinal depressor muscles are present, though NILSSON-CANTELL says they are "schwach".

The mouth-parts, as figured here, do not differ much from NILSSON-CANTELL's description.

The number of segments in the cirri is as follows:

I		II		III		IV		V		VI	
10	6	8	7	7	6	11	12	14	14	14	14

In cirrus I the posterior ramus is a little longer than half the anterior. In cirri II and III, both rami are similar in length and armed with feathered spines at the end. Each segment of the posterior three longer cirri carries two longer and one shorter pairs of spines on the frontal face.

No basi-dorsal point is present at the base of the penis.

Metanauplius and cypris-larvae, as figured by NILSSON-CANTELL (1921, fig. 8), are often found in the mantle cavity—usually 20 to 30 larvae in one individual.

30. *Tetraclita darwini* PILSBRY

Tetraclita darwini, PILSBRY, 1928; NILSSON-CANTELL, 1931; HIRO, 1937b.

Occurrence in Formosa: Suô. May 30, 1938. A few specimens on the sheltered underface of stones in the littoral.

Distribution: Japan and Formosa.

Some Geographical and Ecological Remarks on the Littoral Forms

When we look at the previous papers dealing with the biogeography of marine animals, we at once detect the obvious fact that the littoral cirripeds have in most cases been left out of consideration, notwithstanding they represent an important group of marine biocoenoses. Most students of biogeography seem to have overlooked the following facts: Although most of the littoral forms seemingly have a more limited distribution than the species inhabiting the deeper waters, yet several of them show a world-wide distribution. In most cases, however, such widely distributed species obviously tend to split up into local races, as evinced in detail by PILSBRY (1916): f. inst. *Balanus tintinnabulum, Balanus amphitrite, Tetraclita squamosa* and so on have many local races each of which plays a predominant part in the littoral community of its particular region. Thus they often serve as biogeographically important forms.

Here I shall discuss some zoogeographical features of the littoral area of Formosa with particular reference to the Cirripedia represented by the present material. A list of the littoral species of Cirripedia occurring in Formosa, appended with notes on their geographical distribution and habitats, is given below:

List of the littoral cirripeds of Formosa

Name of the species	Localities outside Formosa	Habitat*
Mitella mitella ((LINNÉ)	Malay Arch., Japan, Hawaii, Madagascar, Samoa.	Upper and lower littoral, mainly hypobiotic.
Chthamalus moro PILSBRY	Malay Arch., South Sea Is.	Upper and lower littoral, epibiotic.
C. malayensis PILSBRY	Malay Arch., Indian Ocean.	Upper and lower littoral, epibiotic.
C. intertextus DARWIN	Malay Arch., Hawaii, Ryûkyû Is.	Lower littoral, hypobiotic.
Octomeris brunnea DARWIN	Malay Arch., Mergui Arch., Miyake-zima (S. Japan).	Upper and lower littoral, hypobiotic.
O. sulcata NILSSON-CANTELL	Japan.	Lower littoral, epibiotic.
Balanus tintinnabulum tintinnabulum (LINNÉ)	Malay Arch., Indian Ocean, Mediterranean, Atlantic Ocean.	Submerged littoral, epibiotic.
B. tintinnabulum zebra DARWIN	Malay Arch. esp. South China Sea coast.	Submerged littoral, epibiotic.
B. tintinnabulum occator DARWIN	Malay Arch., Fiji Is., Bonin Is., Indian Ocean.	Submerged littoral, epibiotic.
B. amphitrite hawaiiensis BROCH	Malay Arch., Hawaii, Japan, Indian Ocean.	Upper and lower littoral, epibiotic.
B. amphitrite albicostatus PILSBRY	Japan, South China.	Upper and lower littoral, epibiotic.
B. amphitrite cirratus DARWIN	Malay Arch., Indian Ocean, Australia, China, South Japan.	Submerged littoral and sublittoral, epibiotic.
B. amphitrite communis DARWIN	All tropical and temperate seas.	Sumerged littoral and sublittoral, epibiotic.
B. amphitrite krügeri NILSSON-CANTELL	Japan, S. China.	Lower littoral, epibiotic.
B. taiwanensis HIRO	. . .	Lower littoral, hypobiotic.
Tetraclita squamosa viridis DARWIN	Malay Arch., Indian Ocean, S. China, S. Japan, Australia, South Sea Islands.	Lower littoral, epibiotic.
T. squamosa formosana HIRO	. . .	Lower littoral, epibiotic.
T. purpurascens chinensis NILSSON-CANTELL	S. China, S. Japan.	Lower littoral, hypobiotic.
T. divisa NILSSON-CANTELL	Malay Arch.	Lower littoral, hypobiotic.
T. darwini PILSBRY	Japan.	Lower littoral, hypobiotic.

GISLÉN's terminology (1930) is followed here.

As might be well expected by the subtropical situation of the island, the cirripedian fauna of Formosa is in general composed of common Indo-Pacific forms showing a mixture of the Japanese and Malayan elements, although the latter particularly characterizes the Formosan fauna, no boreal form occurring there. Of the 20 littoral forms listed here, three are widely distributed in the Malayan and Japanese waters. They are: *Mitella mitella, Balanus amphitrite hawaiiensis* and *Balanus amphitrite communis*. The following six species, which have their distributional centre in the Malay Archipelago, spread into the southern region of Japan proper due to the influence of the warm current, though their occurrence is mostly restricted to small areas: *Chthamalus intertextus, Octomeris brunnea, Balanus tintinnabulum occator, Balanus amphitrite cirratus, Tetraclita squamosa viridis* and *Tetraclita purpurascens chinensis.*

This region is inhabited also by the true tropical species, such as *Chthamalus moro, Chthamalus malayensis, Balanus tintinnabulum tintinnabulum, Balanus tintinnabulum zebra* and *Tetraclita divisa* which are so far unknown, except as migrants on the bottom of ships as in the case of *Balanus tintinnabulum,* from other than the Indo-Malayan region. Thus Formosa appears to be the northern limit of these tropical forms mentioned above.

The occurrence of only 4 Japanese forms, namely *Octomeris sulcata, Balanus amphitrite albicostatus, Balanus amphitrite krügeri* and *Tetraclita darwini*, also suggests a zoogeographical affinity, although far less than with the Philippine and Malayan regions, with the Japanese waters. These 4 forms have their distributional centre in the Japanese waters, although they may essentially be of tropical origin.

There are many other littoral species characteristic of the Indo-Malayan waters which are not found on the coast of Formosa. It is notable that I could not succeed in finding the two genera, *Lithotrya* and *Ibla.* Although this must be a problem left to future investigators, it may be said at present that the range of distribution of the former genus extends northward in accordance with the presence of the raised coral reefs or rocky limestone coasts, and that the latter may occur as far north as the Pacific coast of central Japan, sometimes in association with *Mitella mitella;* their distribution must be aided by favourable oceanic currents and greatly depends on their adaptability to the biophysical conditions. So the absence of *Ibla cumingi* in Formosa may be due to the astonishing scarcity of *Mitella mitella,* as suggested by the fact of their usual occurrence together in regions where *Mitella mitella* lives abundantly (HIRO, 1936 and unpublished data). *Chthamalus challengeri* also seems to belong to the same category, since it is commonly found in Japan and also in the Malayan waters but not in Formosa as far as I know.

If we look at a map of Formosa, we at once notice a striking contrast in the topographical and biophysical conditions between the east and west coasts. The west coast of the island which is fringed with sandy beaches, save along the northernmost and southernmost parts, is 170 kilometers from

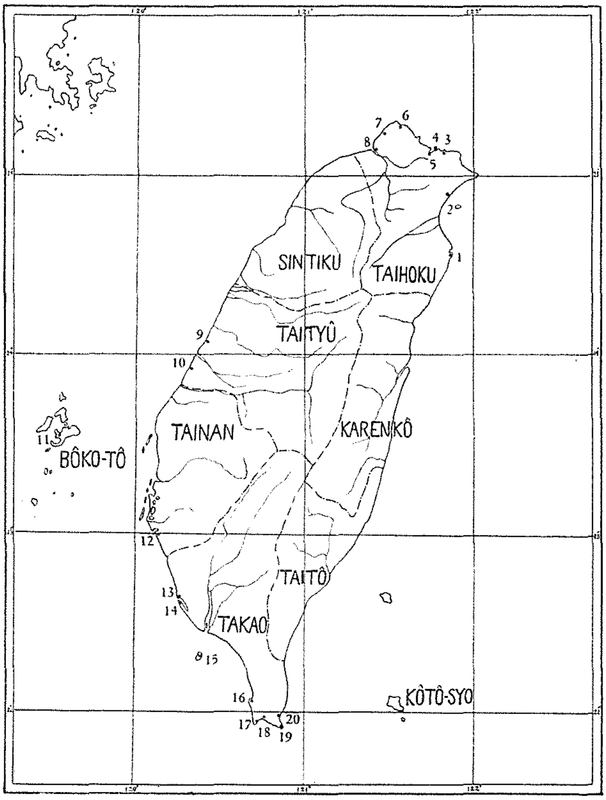

Fig. 16. Map of the Island of Formosa (Taiwan) showing the places where specimens were collected. 1. Suô (蘇澳). 2. Kizan (龜山). 3. Hattosi (八斗子). 4. Syaryôtô (社寮島). 5. Kiirun (基隆). 6. Sekimon (石門). 7. Tôi (頭圍). 8. Tansui (淡水). 9. Gosei (梧棲). 10. Rokukô (鹿港). 11. Makô (馬公). 12. Anpin (安平). 13. Takao (高雄). 14. Kigo (旗後). 15. Ryûkyû-syo (琉球嶼). 16. Kaikô (海口). 17. Daizyubô (大樹房). 18. Taihanratu (大板埒). 19. Garanbi (鵞鑾鼻). 20. Kankau (港口).

the nearest shore of South China, the Strait of Formosa, less than 100 m deep, lying between them. The east coast, however, consists mainly of precipices or rocky beaches, and its submarine slope is extremely steep; moreover there are the raised coral reefs, especially along the southernmost part, viz. Kôsyun Peninsula.

Such physiographical difference between the east and west coasts naturally affects the distribution of the shore barnacles. On the west coast the littoral barnacles, being represented only by 5 forms of *Balanus amphitrite*, are comparatively few in accordance with the scarcity of the hard substratum. Of these *albicostatus* is most prevalent on the northern region, while *cirratus* is more abundant in the south; both *albicostatus* and *krügeri* have their homes in Japan proper, and *communis* is very common in the Japanese waters (HIRO, 1937 b, 1938). On the east coast, however, there is apparently only one form, viz. *hawaiiensis*, which has a wide range of distribution in the Indo-Pacific region. The southward extension of such Japanese forms to the north and west coast of Formosa can probably be attributed to the southward flow of the cold current to form a southerly offshoot of the Tusima current, which enters into the East China Sea from the Sea of Japan along the coast of the Yellow Sea. A record of the true boreal species, *Balanus crenatus* from South China (NILS-

SON-CANTELL, 1931), if it is correct, may offer another evidence for the close relationship among the littoral fauna of South China, the west coast of Formosa, and that of the temperate region of Japan proper. NOMURA (1934) upon studying the molluscs which inhabit the coast of Amoy, South China, and TAN (1935) who worked in those of Formosa came to the same conclusion; they found many species known from the mainland of Japan, although so far unknown from the Ryûkyû Islands and their adjacent waters.

The southern part of the west coast is, on the contrary, more like the east coast of the island, possibly because it is favoured by the influence of a branch of the warm current, Kurosio, flowing into the Pescadores Channel. As examples of such similarity we can name *Chthamalus moro, Balanus taiwanensis* and *Tetraclita squamosa.* It is to be noted in this connection that *Mitella mitella* seems to be lacking from the southern region of the island.

On the east coast of the island there are large number of littoral species mostly belonging to the genera *Chthamalus* and *Tetraclita.* To these may be added the forms of *Balanus tintinnabulum* inhabiting the sections washed by strong surfs; two subspecies, *tintinnabulum* and *zebra,* live along the southern region only, this possibly being the northern limit of their distribution. *Chthamalus intertextus* and *Octomeris brunnea* too are found only in the southern part; but their range extends northward to the southern islands of Japan proper, viz. Ryûkyû Islands and Miyake-zima.

Concerning the littoral cirripeds the northeast coast of the island is especially noteworthy. Here the warm subtropical water meets the southerly flow of the cold Yellow-Sea water, the latter occupying a deeper layer than the former. Here *Chthamalus malayensis, Tetraclita squamosa viridis* and *Tetraclita squamosa formosana* flourish on coastal rocks; the former species is not found elsewhere. Furthermore, *Mitella mitella,* which is a species common in the Japanese and Malayan waters, seems to be restricted, in Formosa, to this region.

Turning now to the habitat of these littoral cirripeds found in Formosa, we find that several of them, like *Octomeris sulcata, Chthamalus malayensis* and *Balanus tintinnabulum tintinnabulum,* seemingly have a very limited habitat, being found in only one or two localities stated above, although having a wider distribution on other parts of the world. But if taking here those species which have been gathered in several localities as examples of leading forms characterizing the littoral fauna of Formosa according to their habitat lying on different tidal levels, we at once detect an obvious difference from those of the temperate region of the Japanese waters. To clarify the difference of the two regions the table in the next page has been prepared.

In connection with this, it should be noted that the specimens of *Balanus amphitrite hawaiiensis* which I collected at several localities in Formosa, are all from the intertidal (or littoral) zone; thus the habitat coincides with BROCH's (1922) and PILSBRY's (1928) accounts of the specimens of the

Comparison of the main littoral forms at different levels in Formosa and Japan proper.

Habitat	Formosa Island	Mainland of Japan
Below high tide level	*Chthamalus moro*	*Chthamalus challengeri*
About mean tide level	*Balanus amphitrite albicostatus*	*Balanus amphitrite albicostatus*
Above low tide level	*Tetraclita squamosa formosana*	*Tetraclita squamosa japonica*
About lowest tide level	*Balanus tintinnabulum occator*	*Balanus tintinnabulum volcano*
Below low tide level	*Balanus amphitrite cirratus*	*Balanus amphitrite communis*

Hawaiian and Philippine waters. In the temperate region, e. g. the mainland of Japan and the Yellow Sea, however, this form lives under water and is always found, according to my experience, on the bottom of ships or on submerged objects with *Balanus amphitrite communis*, but not on shore rocks. This means that this form, which is typically intertidal in the tropical and subtropical seas, can endure transportation on ships to the waters of temperate regions, but probably can not, like most of the littoral cirripeds, establish itself in the littoral region there, owing to the unsuitable bio-physical conditions. Furthermore, it seems likely that the typically intertidal form, which always submerged by the unusual attachment to the bottom of ships, are subject to a great deal of structural variation (HIRO, 1938).

Next, we must consider these littoral barnacles from the ecological or zoo-sociological view-point. It is possible to classify the barnacles according to their habitats into "epi-, hypo-, and endobiotic forms" (terminology given by GISLÉN, 1930). To the last-named I refer the rock-boring *Lithotrya* occurring in the littoral, and *Acasta, Membranobalanus, Creusia* and *Pyrgoma* of the sublittoral regions, the former two genera living in sponges and the latter two in reef corals. *Lithotrya*, which is a littoral form of the pedunculate group, is abundant in the tropical seas but lacking from the Formosan fauna. It therefore seems unnecessary to say much about the endobiotic species.

As far as I am aware, detailed investigation of the intertidal barnacles with reference to the nature of the substratum, are very scarce. GISLÉN (1930, 1931) has put all the barnacle associations—at least the *Balanus amphitrite*- and *Tetraclita squamosa*-association, under the epibioses. Most of the littoral cirripeds are, of course, found living on the exposed rocks or stones, but a few demanding little water motion, as *Balanus amphitrite albicostatus*, seem to be more abundant in sheltered places.

Investigators frequently overlook the fact that there are some littoral cirripeds forming the community on the underside of stones or in rock-crevices. As examples of such species we can name *Chthamalus intertextus, Octomeris brunnea, Balanus taiwanensis*, and *Tetraclita*-species belonging to the subgenus *Tetraclitella.* These may be regarded as a special type of the epibioses probably demanding more moisture than others during the ebb tide. Indeed, empty and dead specimens of *Tetraclita purpurascens* and *Tetraclita darwini* attached to the exposed underside of stones which remain overturned by wave or artificial agencies, are not rare. But the shell of those on *Mitella mitella* is perfect in most cases. I, therefore, prefer to treat the *Mitella*-association, found as clans in crevices of rocks, also as one of the hypobioses, although it may sometimes be found on a rock-surface exposed to the sweep of tides.

On the other hand, all the races of *Balanus amphitrite* as well as those of *Balanus tintinnabulum* and *Tetraclita squamosa* evidently form the epibiotic association everywhere. The former species in most cases, however, is confined to rather calm waters, such as a gulf or a harbour which is protected from strong waves, while the latter two species are found exclusively on the open shore or at a spot exposed to strong tides; thus those cirripeds represent dominant forms on different tidal levels. The fact that *Balanus amphitrite* is abundant on the west coast of Formosa, while the east coast is more fitted for such species as *Balanus tintinnabulum* and *Tetraclita squamosa* can be deduced from such ecological evidences too.

It may be interesting to study the larval biology of these littoral cirripeds of which little is known, because the hypobiotic habitat which is indicated by some littoral cirripeds might possibly be referred to the peculiarities in the larval life. *Tetraclita divisa,* for instance, has the developed metanauplius- or cypris-larvae in the mantle cavity, as is the case in most of the deep-sea cirriped *Scalpellum* (cf. NILSSON-CANTELL, 1921, p. 101); the other littoral species, however, do not show such a peculiarity in their larval development so far as we know. Thus, thorough ecological and embryological studies are greatly needed not only on adult stages, but also on larval stages.

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