INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

IX. CIRRIPEDIA[1)2)]

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With 2 Text-figures

The collection of Cirripedia from the Tokara Islands includes three pelagic and nine littoral species, all of which have been recorded previously from the adjacent regions (HIRO, 1939; UTINOMI, 1949). The Tokara Islands, in particular Takarazima, are surrounded partly by a narrow raised coral reef, so the Cirripedian fauna in the intertidal zone is rather poor despite the subtropical situation of that islands, as represented only by small number of species in the present collection.

The cirripeds represented here are mostly well-known species, so that they call for no special description and have been given with notes on distribution. Lastly, a general account on the geographical distribution of the intertidal barnacles in the Ryukyu Islands is given, together with a list of the species recorded from the neighbouring regions.

Family Scalpellidae PILSBRY

1. *Mitella mitella* (LINNÉ)

Jap. Name. Kamenote.
Material. Five specimens from Nakanosima (TK. No. 483).
Distribution. Widespread in the warm Indo-Pacific.

Family Lepadidae (DARWIN) NILSSON-CANTELL

2. *Lepas anserifera* LINNÉ

Jap. Name. Karu-ebosi.
Material. Two specimens from Nakanosima (TK. No. 484). Eight specimens from Takarazima (TK. No. 485).

1) Scientific Survey of the Tokara Islands, Report No. 11.
2) Contributions from the Seto Marine Biological Laboratory, No. 235.

Distribution. Pelagic in tropical and temperate seas.

3. *Lepas pectinata* SPENGLER

Jap. Name. Ruri-ebosi.

Material. Several small specimens on a pumice stone from Takarazima, together with *Lepas fascicularis* (TK. No. 486).

Distribution. Pelagic in all seas.

4. *Lepas fascicularis* ELLIS et SOLANDER

Jap. Name. Uki-ebosi.

Material. One small specimen on a pumice stone from Takarazima, together with *Lepas pectinata* (TK. No. 486).

Distribution. Pelagic, chiefly in tropical and temperate seas.

Family Chthamalidae DARWIN

5. *Chthamalus malayensis* PILSBRY

(Fig. 1)

Chthamalus malayensis PILSBRY, 1916, p. 310, pl. 72, figs. 5, 5 a ; BROCH, 1931, p. 55 ; NILSSON-CANTELL, 1938, p. 31 ; HIRO, 1939, p. 250.

Chthamalus moro PILSBRY, 1916, p. 311, pl. 72, figs. 6, 6a, 6b ; BROCH, 1931, p. 56 ; NILSSON-CANTELL, 1934, p. 50 ; HIRO, 1937, p. 49 ; HIRO, 1939, p. 249.

Chthamalus challengeri f. *krakatauensis* BROCH, 1931, p. 53.

Jap. Name. Minami-iwahuzitubo. (nom. nov.)

Material. Numerous specimens from Nakanosima (TK. No. 487). Several specimens on stones and *Tetraclita squamosa* from Takarazima (TK. No. 488).

A lot of *Chthamalus* from the Tokara Islands caused much trouble. The specimens are strongly ribbed and depressed, except only those seated on *Tetraclita* which are conic in form. At first I was inclined to regard some larger specimens selected from the material as typical *Chthamulus malayensis*, but after studying the opercular valves I found such a close resemblance to PILSBRY's description that there can be no doubt that most of the specimens belong to *Chthamalus moro*. This led me to re-examine the many representatives of *Chthamulus* collected from Palao and from Formosa, which I have recorded in the past as either *Ch. moro* or *Ch. malayensis*.

According to a key given by PILSBRY (1916, p. 297) and NILSSON-CANTELL (1938, p. 30), *Ch. malayensis* is clearly distinguishable from *Ch. moro* by the differences of the opercular valves, as follows :—

Tergum triangular, very narrow at the lower end, with nearly straight basal margin ; tergal margin of scutum decidedly shorter than the basal, with a pro-

minent articular ridge about median or above, its lower end gradually sloping. ..... *Ch. malayensis.*

Tergum nearly of the same width above and below, with broad rounded spur at base; tergal margin of scutum nearly as long as the basal, with a rather weak articular ridge below the middle, its lower end abruptly truncate.....*Ch. moro.*

In a large series of specimens from Formosa, these differences in the opercular valves are more or less clearly defined so as to refer them to either of the two species. In the present collection, however, I have found that all the points of difference specified as cited above are present in varying degree in individual specimens taken from the same rock face, and that no clear lines of demarcation could be drawn between the two species on the basis of these characters in the opercular valves.

For comparison some drawings of the opercular valves are given here, one showing good agreement with PILSBRY's figures of *Ch. malayensis*, while the others with those of *Ch. moro*. Doubt is thus raised as to the validity of the differentiation.

The general outline of the opercular valves combined together coincides well with the shape of the orifice, which is rhomboidal as seen from above. In fairly grown and more depressed specimens, the orifice often tends to lengthen rostrad. Therefore, the scutum becomes more elongate triangular and eventually the basal margin of the tergum becomes nearly straight. The suture between the scutum and tergum, which is typically simple as in *moro*-form, becomes more zigzag, showing varying degree of development of the articular ridge, as I have already commented on the similarity of *Octomeris brunnea* to NILSSON-CANTELL's *Octomeris intermedia* (HIRO, 1939). The strength of the articular ridge as well as the articular furrow is apparently varied partly in accord with the growth of valves, hence the sutural edges increasing in thickness. All the specimens showing such variation of opercular valves are indistinguishable externally.

I therefore conclude that *Ch. malayensis* and *Ch. moro* are synonymous and that such differences as found in the opercular valves are merely individual. If this suggestion be accepted, it should be named *Ch. malayensis*, since the latter is preceded to *Ch. moro* by page priority.

But it may be objected from the several alleged internal disparities between the two, in particular with regard to details of the mandible and terminal segments of cirrus II. According to previous descriptions of *Ch. malayensis* by PILSBRY and by NILSSON-CANTELL, the mandible has about 6 coarse spines only in place of a comblike row of smaller spines below the fourth, and cirrus II has no large-toothed spines on the terminal segment. In the present collection, however, the mandible has a series of fine comblike pectination as in many species of the genus. Similar feature is found also in specimens from Palao and Formosa. Cirrus II has finely serrate spines on the terminal segments but without large-toothed spines, as in specimens from Palao. In specimens recorded as *Ch. malayensis* from Suô, Formosa, however, cirrus

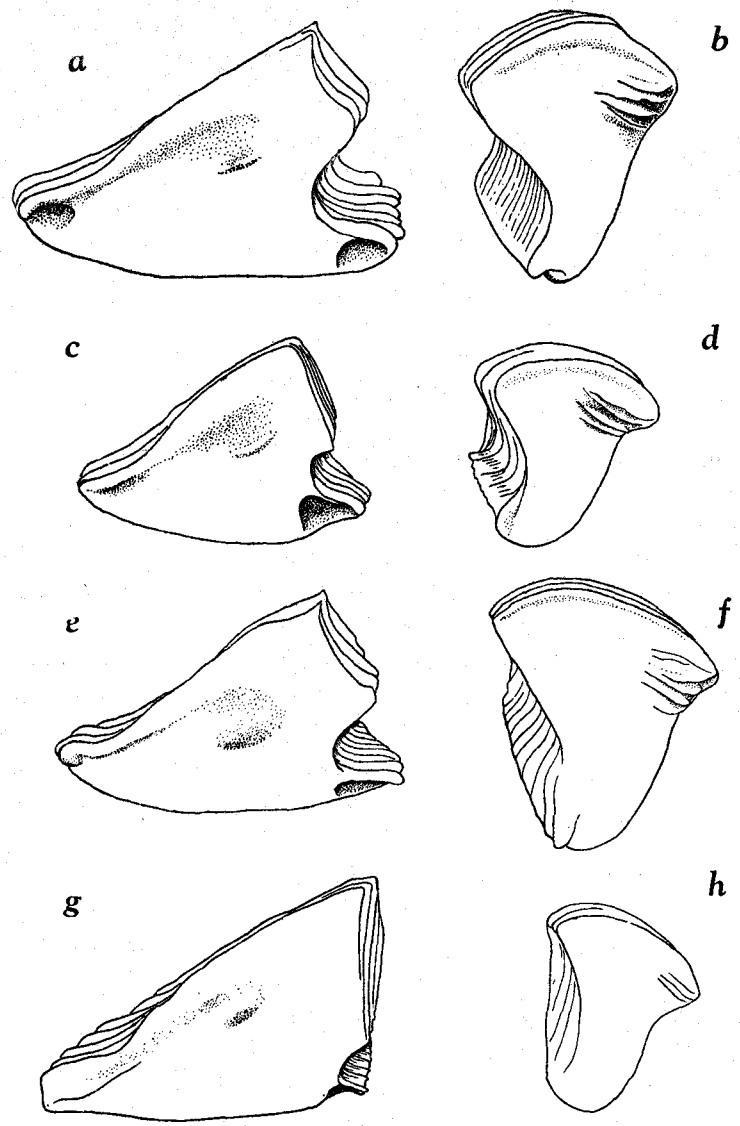

Fig. 2. *Chthamalus malayensis* PILSBRY. Inside of scutum (*a*, *c*, *e*, *g*) and tergum (*b*, *d*, *f*, *h*). *a*, *b*, from Tokara Islands (typical form). *c*, *d*, from Tokara Islands (*moro*-form). *e*, *f*, from Palao Islands (typical form). *g*, *h*, from Palao Islands (*moro*-form). (All ×14)

II has two coarse teeth a little below the serrate portion among the terminal spines.

Whether these differences in the cirri and mandibles are constant everywhere so as to have specific or racial significance remains to be investigated. Probably, these internal characters also may be in many cases subject to considerable variation.

The major morphological characters of the opercular valves common to the two forms *malayensis* and *moro* are as follows:—In the scutum, the adductor ridge is very weak or rudimentary, though the adductor pit rather deep, and the pit for lateral depressor muscle is very deep and prominent. In the tergum, the interior is evenly flattened, the articular ridge not distinctly delimiting from the rest of inner face, and the basal margin is slightly notched just below the short crests for carinal depressor muscle which are usually 4 in number.

At any rate, it seems justified to regard these specimens as a single species and to refer them to *Ch. malayensis*, as identical with *Ch. moro*.

Distribution. Northeast of Indian Ocean, Malay Archipelago, Palao, Philippines and Formosa.

6. *Chthamalus pilsbryi* HIRO

(Fig. 2)

Chthamalus pilsbryi HIRO, 1936, p. 227; UTINOMI, 1949, p. 21.

Jap. Name. Ô-iwahuzitubo.

Material. About thirty specimens from Nakanosima (TK. No. 489).

This species, apparently endemic to Southern Japan, occurs on rocks near the high tide mark. This is easily distinguishable from other chthamalids living together by its relatively large size and by the complicately interlocked opercular valves.

Among a lot of specimens, curiously enough I found an unusual example with

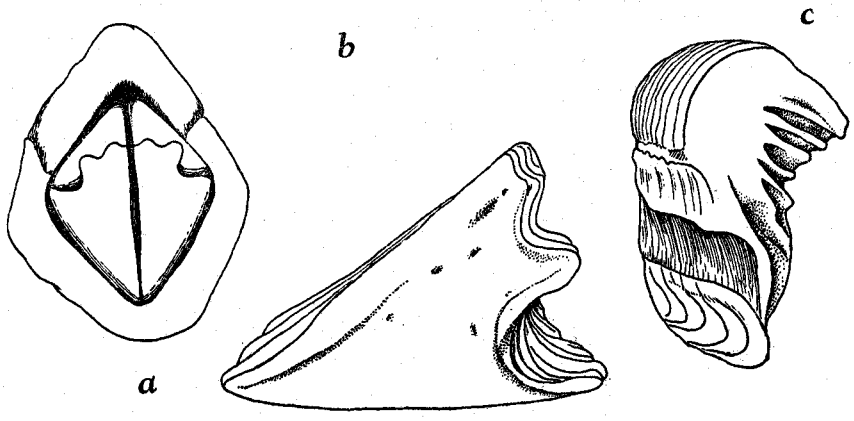

Fig. 2. *Chthamalus pilsbryi* HIRO.
a, Abnormal specimen, with compartments fused together.
b, Inside of scutum. *c*, Inside of tergum. (a ×4; b, c ×22)

the shell composed of only two plates (Fig. 2a). One of the plate is undoubtedly the carina, whilst the other large one is the remaining compartments coalesced togetner, sutures between them being completely obliterated even on the inside. The opercular valves, however, are typical for the species, as figured here. The interior of the scutum is much punctured with small holes, but no pits or scars for the adductor and depressor muscles are visible. The tergum is extremely thick, with prominent crests for depressor muscle, 5 or 6 in number, all along the basal margin.

Distribution. Kii coast, Murotozaki, Aosima, Amakusa Is., and Tanegasima, all along the surf-washed coast under the influence of 'Kurosio'.

7. *Chthamalus intertextus* DARWIN

Chthamalus intertextus DARWIN, 1854, p. 467, pl. 19, figs. 1a, 1b; PILSBRY, 1916, p. 324; HIRO, 1939, p. 251; UTINOMI, 1949, p. 29.

Jap. Name. Utimurasaki-iwahuzitubo. (nom. nov.)

Material. Numerous specimens from Nakanosima (TK. No. 490) and from Takarazima (TK. No. 491).

This species is, according to TOKIOKA (1953), more prevalent in the mid-tidal zone below the littorinid zone than *Ch. malayensis*, and epibiotic in habitat. The shell is largely corroded and dirty white externally, but beautiful violet within. The suture between the scutum and tergum is usually obsolete externally by the fusion of the valves, but rarely distinct.

Distribution. Hawaii, Philippines, Formosa, and Ryukyu Islands.

8. *Octomeris brunnea* DARWIN

Octomeris brunnea DARWIN, 1854, p. 484; HIRO, 1939, p. 252 (for synonymy and references).

Jap. Name. Kiku-huzitubo. (nom. nov.)

Material. Several specimens from Nakanosima (TK. No. 492).

This is characterized by the remarkably depressed wall formed of 8 closely-ribbed compartments with serrate sutural edges. The largest specimen in the collection is 24 mm in carino-rostral diameter, with a height of 4 mm.

Distribution. Indian Ocean, Malay Archipelago, Philippines, and Formosa. The northermost locality so far recorded is Miyakezima (34°5′ N., 139°32′ E.), about 200 km south of Tokyo (HIRO, 1932).

Family Balanidae GRAY

9. *Balanus tintinnabulum occator* DARWIN

Balanus tintinnabulum occator HIRO, 1939, p. 260 (with references).

Jap. Name. Minami-akahuzitubo. (nom. nov.)

Material. Six specimens from Takarazima, attached to coral limestone (TK. No. 493).

The specimens are rather small, the largest one being 18 mm in carino-rostral diameter and 12 mm in height. The shell is dirty white, tinged with dull purplish drab. Parietes are broadly ribbed and often with downward-directing spines on the lower half.

This species is a typical inhabitant of coral reefs, so that it is often overgrown by the coral (KOLOSVÁRY, 1950).

Distribution. Indo-Pacific only: Zamboanga (Mindanao), Pulu Tusa near Halmahera Is. (Malay Archipelago), Fiji Islands, Bonin Islands, and Formosa.

10. *Tetraclita squamosa viridis* DARWIN

Jap. Name. Minami-kurohuzitubo. (nom. nov.)

Material. Numerous specimens from Nakanosima (TK. No. 494).

This well known Malayan race, which is characterized by the bluish green colouration, is very abundant in the lower tidal zone in both the islands, Nakanosima and Takarazima. The wall is often covered with a cluster of *Chthamalus malayensis* or/and *Vermetus reniscatus*, a small coiling gastropod.

Distribution. Widespread in the Indo-Pacific.

11. *Tetraclita squamosa formosana* HIRO

Tetraclita squamosa formosana HIRO, 1939, p. 271; UTINOMI, 1949, p. 23.

Jap. Name. Taiwan-kurohuzitubo. (nom. nov.)

Material. Numerous specimnes from Nakanosima (TK. No. 495) and from Takarazima (TK. No. 496).

This Formosan race of the reddish colouration is also plentiful in the intertidal zone of the Tokara Islands as on the Formosan coasts.

Distribution. Formosa, Tanegasima, and Kii coast.

12. *Tetraclita (Tetraclitella) chinensis* (NILSSON-CANTELL)

Tetraclita purpurascens chinensis HIRO, 1939, p. 273.
Tetraclita (Tetraclitella) chinensis UTINOMI, 1949, p. 36.

Jap. Name. Mutuana-hirahuzitubo. (nom. nov).

Material. One specimen without opercular valves from Nakanosima (TK. No. 497).

Distribution. Hongkong, Formosa and Southern Japan, as far north as Sagami Bay.

Zoogeographical Remarks

The Ryukyu Islands Group, lying just between Kyusyu and Taiwan (Formosa),

has been considered as an actual bridge for the mixture or extension of ranges of both temperate and tropical forms, and offers many possibilities for faunal comparisons. But there are to date very few published records for barnacles as well as other intertidal faunas. The reason for the dearth of information lies largely in the fact that the islands are too remote and rather hard to explore thoroughly on various islands, mostly cliffed around the coasts, and zoogeographers merely consider that the marine fauna as a whole is representative of the Taiwan-Ryukyu province predominated by the tropical Indo-Malayan elements. In my opinion, however, the extensive ranges of intertidal barnacles together with the isolation of populations on various islands offer many possibilities for the study of speciation and ecological adaptations.

While the survey made on the Tokara Islands (actually worked at only two isles, Nakanosima and Takarazima, at the northern and southern ends), cannot be said to be complete, a lot of specimens of the intertidal barnacles here described should present a fairly adequate idea as to the distributional ranges of the tropical and temperate forms, in connection with their occurrence in Formosa and Japan proper which I have confirmed myself.

Of the nine species or subspecies of intertidal barnacles taken in the Tokara Islands, only one *Chthamalus pilsbryi* is limited to Japanese waters and the remaining eight are truly the southern forms. Of the latter, however, five extend by the aid of the 'Kurosio' Current to more northern parts of Japan, viz., *Mitella mitella* extending to southern Hokkaido, *Tetraclita squamosa viridis* and *T. chinensis* to Sagami Bay, *T. squamosa formosana* to Kii coast and *Octomeris brunnea* to Miyakezima, about 200 km south of Sagami Bay, though the last two only rarely found there.

At the northern end of Tanegasima at which I made a collection of intertidal barnacles during my short stay in 1943, the following five species were found to occur commonly. Namely, *Chthamalus pilsbryi*, *Ch. challengeri*, *Tetraclita squamosa japonica*, *T. squamosa viridis*, *T. squamosa formosana*, *T. chinensis* and *Octomeris sulcata*. Most of them have their homes in Japanese waters, excepting *formosana* in Formosa and *viridis* in more southern warm waters. Among three subspecies of *Tetraclita squamosa*, *viridis* was predominant, while *formosana* and *japonica* were not so abundant. None of the species of *Chthamalus* excepting *Ch. pilsbryi*, which are common in the Tokara Islands, were found there.

To these may be added the subspecies of *Balanus tintinnabulum* inhabiting on surf-washed rocky coasts in the lower tidal zone or sublittoral (or infralittoral) fringe. Specimens found at Tanegasima belong to the Japanese race *volcano*, while those obtained at Takarazima is the Malayan race *occator*, ranging from the Bonin Islands to the South Pacific or to the Indian Ocean.

An analysis of these data on the distribution of intertidal barnacles in the northern part of Ryukyu Islands shows that in general their occurrence is consistent with the provinces designated by NOMURA and HATAI (1936) based mainly on molluscs

Distribution of intertidal sessile barnacles on various islands between Kyusyu and Taiwan.

Latitude N. (approximately)	←31°	31°	30°	29°	28°	27°	25°	25°→
Islands (from N. to S.)	Kyusyu	Tanegasima	Nakanosima	Takarazima	Amami-ôsima	Okinawazima	Isigakizima	Taiwan
Chthamalus pilsbryi	←	—	—	—				
Chthamalus challengeri	←	—	—				?	
Chthamalus intertextus			—	—	.....	—	.....	—→
Chthamalus malayensis			—	—	.....	.....	.....	—→
Tet. squamosa japonica	←	—	—				?	
Tet. squamosa viridis	←	—	—	—	.....	—	—	—→
Tet. squamosa formosana	←.....	—	—	—	.....	.....	.....	—
Tetraclita chinensis	←	—	—	.....	.....	.....	—	—→
Octomeris sulcata	←	—	.....	.....	.....	.....	—	—
Octomeris brunnea			—	.....	.....	.....	.....	—→
B. tintinnabulum volcano	←	—	—				?	
B. tintinnabulum occator				—	.....	.....	.....	—→

Arrow indicates further extension of range to its direction. Bold and dotted lines indicate actual and probable occurrence respectively.

and brachiopods. Further work on the distribution of barnacles in the neighbouring islands or localities will undoubtedly extend many ranges, but at present the most pronounced faunal break is in the vicinity of Nakanosima, approximately the latitude 30°N., as can be clarified in the accompanying table. In an earlier paper (UTINOMI, 1949), I have suggested that a wide gap between Tanegasima and Amami-ôsima, where the Tokara Islands are located, may interrupt or control the further extension of ranges of the northern and southern forms. All the evidence thus points to the fact that most of the common intertidal barnacles along the Formosan coasts, in accord with earlier observations, do not extend as far north as Tanegasima.

On the other hand, the faunal difference for intertidal barnacles between Nakano- and Takarazima is very slight in comparison with that between Tanegasima and Nakanosima. A striking physiographical difference is the existence of the raised and recent fringing reef all around the coast of Takarazima, against the other islands concerned where the coral reef is considerably less developed. The dominancy of *Ch. intertextus* and the occurrence of *B. tintinnabulum occator* at Takarazima are probably correlated with the presence of raised coral reefs. The same may be said for the absence of *Mitella mitella* and various races of *Balanus amphitrite* there, since they are rather confined to sheltered habitats such as harbours and moles. Furthermore it may be worth mentioning that *Ch. moro*, recorded as such, seems to

be an inhabitant of rather calm waters, as shown by earlier records mostly from mangrove trees or submerged barks, and it may be variant of the typical *Ch. malayensis*, adapted to sheltered habitat.

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