STUDIES ON THE FAUNA OF CURAÇAO AND OTHER CARIBBEAN ISLANDS: No. 163

THE CIRRIPEDIA OF TRINIDAD

by

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INTRODUCTION

The cirripede fauna of the island of Trinidad has been little investigated. SOUTHWARD (1962) recorded five species collected in north-west Trinidad for experimental studies; he listed *Chthamalus fragilis* Darwin on mangroves, *Balanus amphitrite* var. on mangroves and harbour piles, *B. tintinnabulum* Linnaeus on piles and *Tetraclita radiata* Blainville and *T. squamosa* Bruguière on rocks. The determinations for all these species have been revised recently (SOUTHWARD, 1975).

Specimens of *Newmanella radiata* Blainville from the collections described below were included by Ross (1969) in his revision of the genus *Tetraclita*. A provisional list of the Trinidad cirripedes was given in an appendix to a report on a local swamp (BACON, 1970a) and reports have also been published on the fouling of mangrove oysters by barnacles (BACON, 1970b), barnacles commensal on leatherback turtles nesting in Trinidad (BACON, 1970c), the seasonal occurrence of cirripede larvae in local estuarine plankton (BACON, 1971a) and the ecology of *B. eburneus* Gould in a west coast mangrove area (BACON, 1971b). Barnacles from the mangrove areas assigned provisionally in these reports to "*B. amphitrite*" and "*C. fragilis*" required further taxonomic study.

The north coast of Trinidad was reported as one locality for the recently described species *B. subalbidus* (HENRY, 1973), and SOUTHWARD's report on the Intertidal and Shallow Water Cirripedes of the Caribbean includes further material from Trinidad.

The report which follows is mostly concerned with species not recorded by other authors, together with further data on the distribution and general ecology of the Trinidad cirripedes.

I am indebted to Drs. E. L. BOUSFIELD, National Museum of Canada; A. Ross, San Diego Natural History Museum; V. A. ZULLO, California Academy of Sciences, and H. G. STUBBINGS, British Admiralty Materials Laboratory, for assistance with determinations during the early stages of this study. Special thanks are due to Dr. A. J. SOUTHWARD, Marine Biological Association Laboratory, Plymouth, for making available his manuscript on the Caribbean cirripedes and for many helpful suggestions during the preparation of this report.

I am grateful to the many persons who assisted with the collection of specimens, especially Professor J. S. KENNY, Messrs. D. RAMSAROOP and S. ALLICK, Department of Biological Sciences, University of the West Indies, Trinidad, and to Mr. P. PERCHARDE, Trinmar Ltd. Professor KENNY kindly provided salinity data for Salybia Reef and the directors of the Trinidad and Tobago Electricity Commission made available barnacles fouling the water cooling system of their Port of Spain plant.

Specimens of *C. rhizophorae* from Panamá were provided by Dr. C. BIRKLAND and Dr. P. BOXSHALL kindly allowed me access to the cirripede collections of the British Museum.

Thanks are due also to Mrs. S. RATTAN, University of the West Indies, and to Miss G. THOMPSON, University of Reading, for assistance with the laboratory work.

DESCRIPTION OF THE AREA

The Caribbean coast of Trinidad is dominated by steep cliffs and headlands formed by the limestones and schists of the northern range mountains. Fringing coral reefs are developed, particularly in the east near Galera Point, and some of the sheltered bays have small patches of mangrove at the river mouths. This topography is continued throughout the north western peninsula and the islands of Monos, Huevos and Chacachacare.

South east of Port of Spain the coast is formed by the mangrove swamps and, mudflats of the Caroni delta, interrupted north of Pointe-a-Pierre by firmer Tertiary sediments with occasional cliffs. South of San Fernando is a further low lying area of the South Oropuche Swamp, after which tertiary sand cliffs and rocky reefs dominate the coast to Icacos Point. Cliffs behind sand and pebble beaches continue along the south coast to Galeota Point. These soft Tertiary rocks are eroding rapidly, whereas the south west peninsula is actively accreting.

The east coast presents a long line of sand beaches exposed to the rough surf of the Atlantic Ocean. This is interrupted by promontories where the central range hills reach the sea and passes into rocky coastline north of Matura. Steep cliffs and rocky reefs formed by the eastern extension of the northern range dominate the coast to Galera Point.

ANDEL & POSTMA (1954) and GADE (1961) have described the water movements and marine conditions around Trinidad. The surface water is of variable origin,

predominately south Atlantic except for the dry season, during the first four to five months of the year, when north Atlantic waters dominate. The south Atlantic water enters the area from the east as the Guianas Current and divides into one stream passing east and north of Trinidad and another which enters the Gulf of Paria. In the Gulf the currents are generally north going but a clockwise eddy exists. During the dry season when these currents are minimal, some Caribbean water enters at the surface from the north into the Gulf of Paria, while it is present at depth in the Bocas, between the western islands, throughout the year.

The surface waters of the Guianas Current are influenced by precipitation and run off from the Orinoco and other South American rivers. This mixes vertically with the higher salinity water beneath and horizontally with the north equatorial current. Annual surface salinities range from 2–20‰ in the wet season to 35‰ in the dry season in the eastern Gulf of Paria and from 33‰ to 36‰ on the east and north coasts of Trinidad.

The coast of Trinidad has a varied rock type and topography which produces a wide range of habitats for barnacle colonisation. However, the predominately low salinity conditions of the coastal environment, particularly in the Gulf of Paria, might be expected to restrict the numbers and distribution of the cirripedes.

MATERIALS AND METHODS

The material described was mostly collected at intervals from 1965 to 1974. A few older specimens from the collections of the University of the West Indies are included also. The collection localities are shown in Figure 1 and, unless otherwise stated, all collections contained at least 10 animals.

The descriptions follow widely accepted terminology. Where reference is made to types of setae on the appendages these are as shown in Figure 2. HENRY (1973) used similar terms to describe the setae but did not distinguish pectinate setae with basal guards. In this type two large spines are present at the base and separated by a short space from the pectinated part of the seta (Fig. 2e). Pectinate setae with basal guards were found only in some Chthamalids.

The barnacle collections described here contain 26 taxa, 4 Lepadomorpha, 21 Balanomorpha and 1 sacculinid.

References under species synonymy have been reduced by omission of earlier ones listed in the monographs of DARWIN (1854) and PILSBRY (1916) or listed in more recent major reviews, such as those

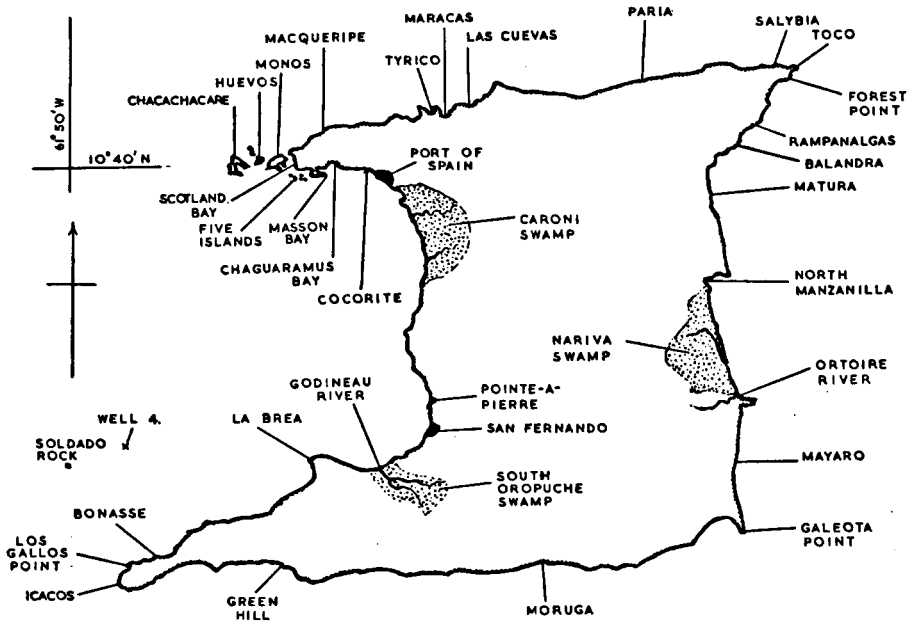

Fig. 1. Map of the island of TRINIDAD, showing collection localities.

dealing with *Balanus amphitrite* (Harding, 1962) and *B. trigonus* (Werner, 1967).

The specimens figured in this report are deposited in the British Museum (Natural History), London at BM (NH) Registration numbers 1975: 981 to 1054. The remaining material from which localities and other general data were obtained are deposited in the Department of Biological Sciences, University of the West Indies, Trinidad.

Family LEPADIDAE Darwin

Genus **Lepas** Linnaeus

1. **Lepas anatifera** Linnaeus

Lepas anatifera, DARWIN, 1854, p. 73, pl. 1 fig. 1; PILSBRY, 1907, p. 79; 1927, p. 37; NILSSON-CANTELL, 1939, p. 3; WELLS, 1966, p. 88; SOUTHWARD, 1975, p. 3; ZEVINA, 1975, p. 234.

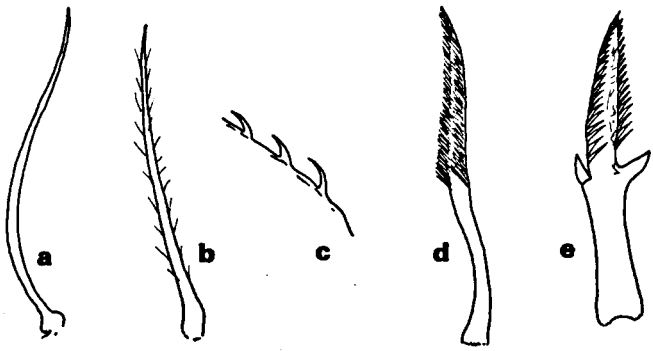

Fig. 2. Types of cirral setae: a – simple; b – pinnate; c – hooked; d – pectinate; e – pectinate with basal guards.

On beach drift, Manzanilla, 1965; on driftwood and plastic flotsam, Matura, March 1973; on fishing float, Matura, Feb. 1974.

This species is abundant on beach drift on the east coast and is commonly associated with the polychaete *Amphinome rostrata* (Pallas) and amphipods.

2. **Lepas hillii** Leach

Lepas hillii, DARWIN, 1854, p. 77, pl. 1 fig. 2; PILSBRY, 1907, p. 80.

On beach drift, Rampanalgas, Apr. 1974.

3. **Lepas anserifera** Linnaeus

Lepas anserifera, DARWIN, 1854, p. 81, pl. 1 fig. 4; PILSBRY, 1907, p. 80; NILSSON-CANTELL, 1933, p. 504; 1939, p. 3; SOUTHWARD, 1975, p. 3; ZEVINA, 1975, p. 234.

On driftwood, Matura, May, 1967.

Seven specimens of this uncommon species from Trinidad are in the collections of the National Museum of Canada (NMC. No. 67–373).

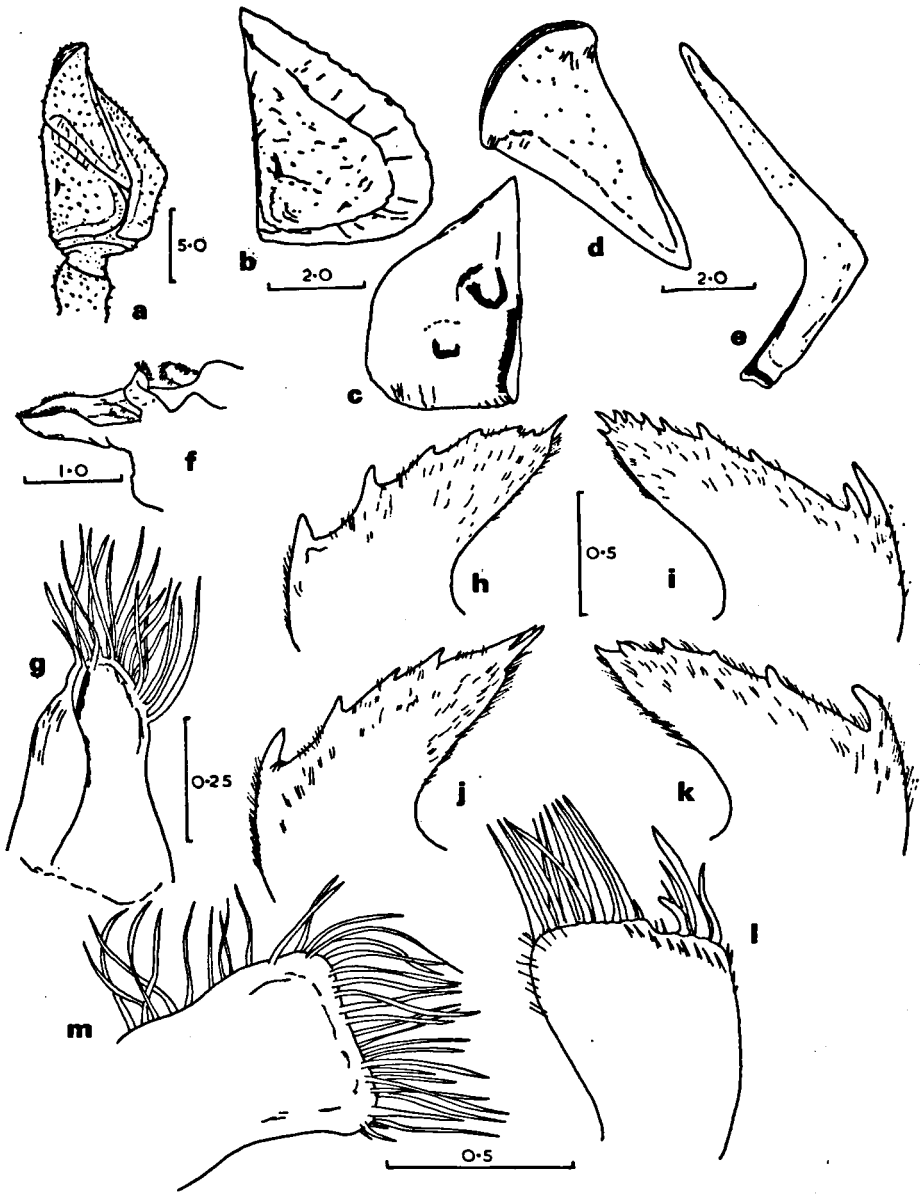

Fig. 3. *Oxynaspis hirtae*, from Chacachacare Bay. a – external features; b – external view of scutum; c – internal view of scutum; d – external view of tergum; e – carina; f – labrum and palps; g – labral palp; h to k – left and right mandibles of two specimens; l – first maxilla; m – second maxilla. (Scale on all figures in mm).

Genus **Oxynaspis** Darwin

4. **Oxynaspis hirtae** Totton

Oxynaspis celata var. *hirtae*, TOTTON, 1940, p. 474, figs. 10 & 11.

17 Specimens attached to antipatharian at 30 m deep, Chacachacare Bay, Oct. 1972.

The external features and details of the opercular valves are shown in Fig. 3. The size of the largest individual was as follows – length of capitulum – (apex of tergum to base of carina) 14.0 mm, width of capitulum (maximum) – 8.5 mm, length of peduncle (sheath to base of scutum) – 2.6 mm.

The scutum (Figs. 3b, c) was smooth externally, between the short spines, and the umbo was indistinct. There was evidence of slight ribbing towards the tergal and carinal margins. Internally there were two pits, a large one for the adductor muscle and a smaller one closer to the basal margin. The occludent margin was slightly incurved near the base. The apex of the tergum (Fig. 3d) was thickened and recurved and the basal angle was from 30–40°. Internally the valve was smooth except for a roughening near the apex. The carina (Fig. 3e) was angled at about 110°, with the distal limb nearly twice as long as the basal.

The labrum (Fig. 3f) was tongue-like with a row of short, dense setae on the crest. The palps were small, conical with medium sized setae at the apex (Fig. 3g). There was considerable variability in the number of teeth on the mandibles in different individuals and on either side of the mouth. The majority had 4–5 large teeth, the first sometimes possessing a smaller, secondary tooth, grading into a number of smaller teeth at the lower angle (Fig. 3h–k). The mandibles were covered with short, dense setae. The first maxilla (Fig. 3l) possessed 3 large spines at the upper angle, one of which was characteristically short and hook-like. Below this was a step, rather than a notch, so that the lower part, which carried approximately 25 long spines, was a raised flat area. The second maxilla was oblong, with setae of equal length on the end and outer side (Fig. 3m).

All the cirri were darkly pigmented dorsally with unpigmented,

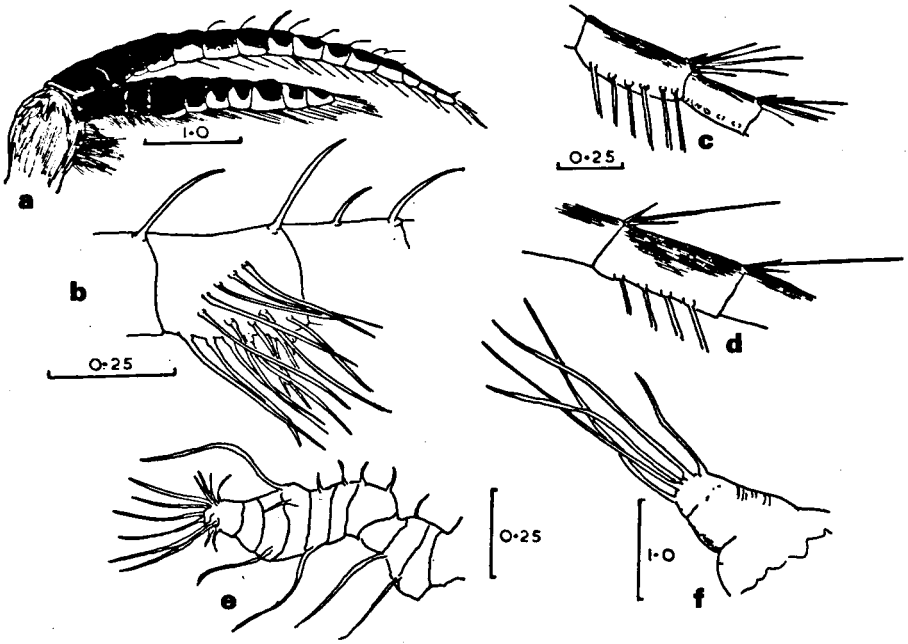

Fig. 4. *Oxynaspis hirtae*. a – cirrus I, showing pigmentation; b – median segment of cirrus I; c – median segment of cirrus II; d – segment of cirrus VI; e – distal end of penis; f – caudal appendage.

clear setae (Fig. 4a), the first pair separated widely from the others. The first cirrus carried a few pinnate setae and many pectinate setae near the tip of both rami. The long ramus had 14–15 segments, the short one 9, the segments bearing a large group of setae ventrally and 1 or 2 setae on the dorsal side (Fig. 4b). Cirrus II had rami of 15 and 16 segments, with pinnate setae only. The segments normally with 6 long ventral setae and a tuft of about 6 thinner setae dorsally (Fig. 4e). Cirri III to V were longer and had simple setae and a few pinnate setae only and carried 3–4 long setae on each segment. The short and long rami of cirri III to V with 16/17, 18/18 and 19/20 segments respectively. Cirrus VI had 21–23 segments each of which carried 4 long setae ventrally with a tuft of 1 long and 2 short setae dorsally (Fig. 4d). The penis (Fig. 4e) was annulated throughout its

length and covered with long and short sparse setae. The tip had a tuft of about 10 long setae.

A single pair of filamentary appendages were present, one at the base of each first cirrus. The caudal appendages were conical and carried 5 long setae at the tip (Fig. 4f).

The specimens described above are similar to *O. celata* Darwin (1854) except for the presence of a pair of filamentary appendages and the shape of the opercular valves. The tergum has a longer occludent margin, almost in line with that of the scutum, and the distal end forms an acute angle. The distal limb of the carina is nearly twice as long as the proximal limb and the base is in line with the base of the scutum. In these characters it approximates most closely to *O. celata* var *hirtae* described by TOTTON (1940) from the West Indies. Unfortunately TOTTON did not describe the internal anatomy of his var. *hirtae*, but the material investigated here differs further from *O. celata* Darwin in the absence of a notch in the first maxilla, the numbers of ventral setae on the cirri and the presence of only 5 setae on the caudal appendages. Although the Trinidad specimens were all considerably larger than TOTTON's material of *O. celata* var *hirtae* in the British Museum they cannot be separated satisfactorily without further details of the internal anatomy. However, insofar as *O. celata* var *hirtae* is readily separable from *O. celata* on taxonomic and geographic grounds it clearly warrants recognition at the specific level.

The few other records of *Oxynaspis* in the West Indian region include *O. patens* from Anguilla Island (AUROVILLIUS, 1894) and the Bahamas (PILSBRY, 1907), *O. gracilis* from "the West Indies" (TOTTON, 1940) and *O. floridanum* from Florida (PILSBRY, 1953). These species are all sub-littoral and probably endemic to the region (ZEVINA, 1975).

Family BALANIDAE Gray

Genus **Balanus** E. da Costa

Subgenus *Megabalanus* Hoek

1. **Balanus tintinnabulum antillensis** Pilsbry

Balanus tintinnabulum antillensis PILSBRY, 1916, p. 63, pl. 13 figs. 1-2e; 1927, p. 38; NILSSON-CANTELL, 1928, p. 31; 1939, p. 4; OLIVIERA, 1941, p. 14; PILSBRY, 1953, p. 24; SOUTHWARD, 1975, p. 4; ZEVINA, 1975, p. 234.
Balanus tintinnabulum, SOUTHWARD, 1962, p. 163.

Pipeline, Oil Field, Gulf of Paria, Feb. 1924; Well No. 4, Trinmar Oil Field, Gulf of Paria, May, 1968, sub-tidal; on rocks, Damien Bay, Jan. 1972, 3 m deep; on *Purpura patula*, bay between Damien and Las Cuevas, April, 1973; on rocks, Macqueripe Bay, Sep. 1973; on rocks and *Perna perna*, Tyrico Bay, Oct. 1973; on base of *Gorgonia flabellum*, Macqueripe Bay, at 10 m deep, Apr. 1974.

Common on jetty of Monos Island (SOUTHWARD, 1975).

This species is most common sub-tidally and extremely abundant on the marine structures of the Gulf of Paria oil fields. The collections of *B. tintinnabulum* from the north and west coasts contained small numbers of specimens in a good state of preservation. Most of these could be assigned to PILSBRY's subspecies *antillensis* on their external features alone. Two individuals of 28 mm and 32 mm diameter respectively from the Gulf of Paria and other smaller specimens from Tyrico Bay showed the strong white ribs and dark brown sheath characteristic of *B. t. zebra* Pilsbry, although they were indistinguishable from the other form on dissection of their mouthparts and cirri. Further individuals differed on individual characters, such as the number of teeth on the labrum or of segments on the cirri, although externally similar to *B. t. antillensis*.

Unfortunately, neither DARWIN (1854) nor PILSBRY (1916) gave sufficient detail of the internal anatomy to differentiate the several subspecies and varieties of *B. tintinnabulum* and later descriptions of *B. t. tintinnabulum* and *B. t. antillensis* (NILSSON-CANTELL, 1928; OLIVIERA, 1941) do not agree in some details. PILSBRY (1953) later revised his description of *B. t. antillensis*, but was then of the opinion

that "the recognition of this antillean race of *tintinnabulum* appears of doubtful utility" and that the antillean form has probably interbred with ship borne oriental species. Furthermore, a specimen from Curaçao which PILSBRY (1927) cited and figured as *B. t. antillensis* is probably *B. stultus* Darwin (ROSS, 1968) and SOUTHWARD (1975) has found the colour of the tergo-scutal flaps of little value in distinguishing the subspecies of *B. tintinnabulum.*

It is obvious that a revision of the varieties of *B. tintinnabulum* is required which will include details of the internal anatomy. Meanwhile, the Trinidad material has been assigned provisionally to *B. t. antillensis* until it is possible to examine more extensive collections.

Subgenus *Balanus* Da Costa

2. **Balanus eburneus** Gould

Balanus eburneus, DARWIN, 1854, p. 248, pl. 5 figs. 4a–d; PILSBRY 1916, p. 80; GRAVE, 1933, p. 378; HENRY, 1954, p. 443; GERLACH, 1958, p. 671; MOORE & FRUE, 1959, p. 421; TABB & MANNING, 1961, p. 592; WELLS, 1966, p. 84; BACON 1970b, p. 187; SOUTHWARD, 1975, p. 5; ZEVINA, 1975, p. 234.

On *Rhizophora mangle*, Caroni Swamp, Aug. 1966; on *R. mangle*, South Oropuche Swamp, Aug. 1967; on driftwood, Los Gallos Point, Sep. 1967; on bamboo driftwood, Chatham Beach, near Bonasse, Nov. 1970; on *R. mangle*, Mouth of the Caroni River, Caroni Swamp, March 1974.

Common off Port of Spain and on mangroves at Monos Island (SOUTHWARD, 1975).

The largest populations of *B. eburneus* in Trinidad occur on mangroves in estuaries and swamp lagoons on the Gulf of Paria coast. This is the habitat for the species in other parts of the western Atlantic (GERLACH, 1958; TABB & MANNING, 1961; WELLS, 1966).

A permanent population of this species is maintained throughout the year in Caroni Swamp, despite annual salinity variation from below 5‰ in the wet season to nearly 30‰ in the dry season (BACON, 1971b). The adults showed a wide salinity tolerance and adapted to local salinity conditions while the tolerance of the larvae varied at different times of year as this depended on the salinity experienced during the pre-liberation period.

Individuals of *B. eburneus* known to be less than one year old attained a carino-rostral length of 24 mm, spawning and larval settlement occurred throughout the year and newly settled animals could reach maturity in about two weeks.

Balanus eburneus was confined to the rhizophores between high and low water neap tide marks where it comprised about 60% of the total cirripede settlement in association with *B. reticulatus* and *B. improvisus assimilis*.

3. Balanus improvisus assimilis Darwin

Balanus improvisus, DARWIN, 1854, p. 250, pl. 6 figs. 1a–c, with var. *assimilis*, p. 250; PILSBRY, 1916, p. 84; NILSSON-CANTELL, 1928, p. 33; McDOUGALL, 1943, p. 343; MOORE & FRUE, 1959, p. 421; ROSS, 1962, p. 14; ZULLO, p. 235; SOUTHWARD, 1975, p. 6.

On *Rhizophora mangle*, Caroni Swamp, May 1967, NMC No. 67–373; on *R. mangle* and *B. a. amphitrite*, Godineau River, S. Oropuche Swamp, Aug. 1967; on *B. tintinnabulum antillensis* and *Newmanella radiata*, sub-tidal, Well No. 4, Trinmar Oil Field, Gulf of Paria, May 1968; on rocks, Icacos, Nov. 1970; on *R. mangle*, Caroni Swamp, Oct. 1971; on rocks, Vessigny, La Brea, March 1974; on *Mytella falcata* on pier pilings, Vessigny, La Brea, Apr. 1974; on *M. falcata*, South Trunk Road Sea Wall, Mosquito Creek, Apr. 1974; on *M. falcata*, Point Sable, La Brea, June 1974.

Balanus improvisus Darwin was not found. The specimens of *B. improvisus* reported from "Maraca Bay, Trinidad", probably Maracas Bay, by HENRY (1973) were not examined but no representatives of this species were collected by the author in that area.

Barnacles referable to DARWIN's variety *"assimilis"* with hyaline stripes, off ships from Trinidad, were recorded at several localities, although they were nowhere common.

The size of the largest specimen found, from the Trinmar Oil Field, was 7.3 mm carino-rostral length, 6.2 mm maximum width, 3.2 mm carinal height. The parietes were white and smooth, slightly ridged, distinguished by hyaline lines opposite the septa. A single row of almost square pores was present at the base. The radii were oblique

Fig. 5. *Balanus improvisus assimilis*. a – internal view of scutum of specimen from Trinmar Oil Field; b to d – internal views of terga of specimens from b – Trinmar Oil Field, c – Godineau River, d – Vessigny; e to g – labra of specimens from e – Vessigny, f – Icacos, g – Godineau River; h – labral palp of specimen from Icacos; i – mandible of specimen from Godineau River and j – from Icacos; k – first maxilla of specimen from Godineau River; l – second maxilla of specimen from Icacos; m – posterior ramus of cirrus I of specimen from Icacos; n and o – basal and median segment of cirrus III and p – median segment of cirrus VI of specimen from Vessigny.

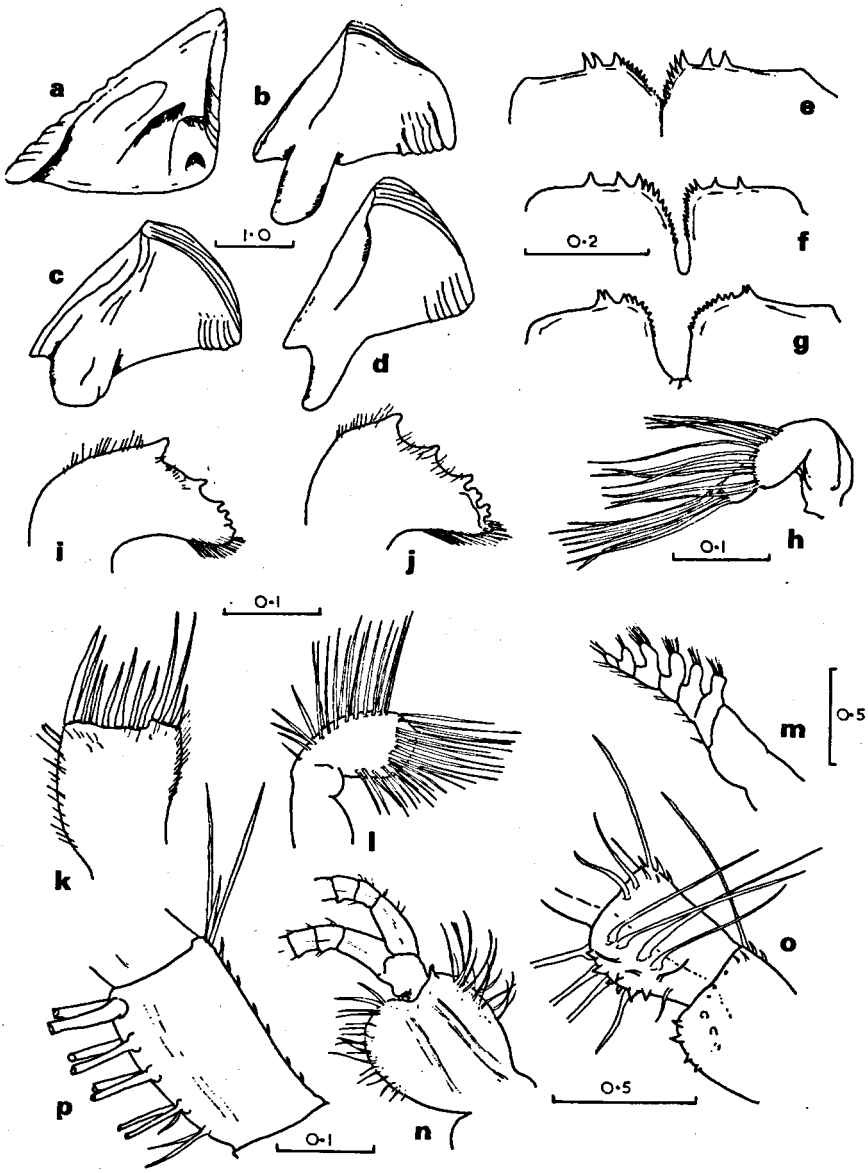
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TABLE 1

NUMBERS OF SEGMENTS IN THE CIRRI OF *Balanus improvisus* VAR. *assimilis* FROM VESSIGNY

CIRRUS	I	II	III	IV	V	VI
1. R.	14/16	13/15	11/12	18/19+	26/28	24/25
L.	14/15	13/15	11/12	20/22	26/28	24/25
2. R.	14/16	12/13	13/13	18/19	24/19+	20/22
L.	14/15	11/12	10/14	19/20	24/25	21/23
3. R.	14/16	12/13	11/13	23/25	27/29	20/21
L.	14/16	12/13	12/14	20/21	27/28	19/20

and the upper edge of the rostrum was rounded and overlapping the ends of the scuta.

Externally the scuta and terga showed fine growth lines. Internally, the articular ridge of the scutum (Fig. 5a) occupied a little over half the tergal margin, but did not project beyond it. The lower end was abruptly truncated. The adductor ridge was strong, but low and the pits for the adductor and lateral depressor muscles were distinct, the latter frequently deep. The tergum (Figs. 5b–d) was triangular with the articular ridge strong and curved. The spur was long and blunt ended in most specimens, although very short and thick in some individuals from the Godineau River (Fig. 5c), and about ½ its own width from the scutal margin. The basal margin was straight with 6 deeply incised muscle crests.

The edge of the labrum was broadly square with a total of 26 to 28 teeth (Fig. 5e–g). On each side there were two large teeth, either together or slightly separated, followed by 11 to 12 teeth which decreased in size down the edges of the groove. The palps were small and bilobed (Fig. 5h), having a lower lobe with a line of long setae and a smaller terminal lobe with approximately 10 very long setae. The mandibles had 3 large teeth and 3 to 4 smaller, blunt ended teeth at the lower angle followed by a dense group of setae (Fig. 5i–j). The first maxilla had 2 large spines at the upper end followed by 6 short spines medially. The lower angle, which carried 2 long and 1 short spines, was raised above the flat end of the upper regions (Fig. 5k). Long setae covered the oval shaped second maxilla (Fig. 5l).

The numbers of segments in the cirri is given in Table 1 for 3 specimens from Vessigny. The rami of the first cirrus were slightly unequal, the shorter ramus very protuberant in front (Fig. 5m). The terminal segments carried simple and pinnate setae as did those of cirrus II. The rami of the second cirrus were almost equal in length and the segments were less protuberant. The lower segments had a few small hooked setae dorsally. The rami of cirrus III were narrow and sparsely setose and had a conspicuously rounded basal segment (Fig. 5n) bearing long setae. The terminal segments carried simple and pinnate setae and from 5 to 20 teeth were present on the ventral side of the other segments, particularly on the middle and proximal thirds (Fig. 5o). Up to 4 small hooked setae were present dorsally on all segments except the lower ones which had a larger number. Numerous smaller teeth were present on cirrus IV, which had 4 pairs of long setae ventrally and 3 to 4 short ones dorsally. Cirrus V was longer and had a greater number of segments than cirrus VI, although the individual segments were similar. Cirrus VI had 4 to 5 pairs of ventral setae, with the proximal pair very small, and 2 to 3 short dorsal setae. Hooked setae were present on most segments (Fig. 5p). The penis was sparsely setose throughout with a ring of setae at the tip.

The presence of teeth on the lower segments of cirrus III and IV was not mentioned by DARWIN (1854), but PILSBRY (1916) described specimens from South Carolina with "a few short spines on and adjacent to the anterior margin" of the longer ramus of cirrus III. Although these spines may be equivalent to the teeth found on the Vessigny specimens, the shape of the segment of the cirrus figured by PILSBRY (1916, p. 87, Fig. 17f) is quite different. Furthermore, there are minor differences in the shape of the tergal spur, the labral palps and the number of segments in cirrus VI suggesting a local form of *B. improvisus assimilis*. That there should be local races showing minor differences is not surprising in a species which ranges from Nova Scotia to Patagonia, although in the absence of detailed descriptions of this species from other parts of the Caribbean and eastern South America no definite conclusions can be drawn.

4. **Balanus amphitrite amphitrite** Darwin

Balanus amphitrite amphitrite, HARDING, 1962, p. 274, pl. 1 & 2; ZULLO, 1966, p. 232; WELLS, 1966, p. 83; UTINOMI, 1967, p. 200; NEWMAN et al., 1967, p. 168; STUBBINGS, 1967, p. 271; SOUTHWARD, 1975, p. 6.

On *Rhizophora mangle*, Godineau River, S. Oropouche Swamp, Aug. 1967; on rocks, near Vessigny, La Brea, March 1974; on rocks, mouth of the Godineau River, Apr. 1974; on *Mytella falcata* on pier pilings, Vessigny, La Brea, Apr. 1974.

Intake screens to power station at Port of Spain, several, Dec. 1970 (SOUTHWARD, 1975).

Balanus a. amphitrite is an uncommon species in Trinidad found in association with *B. eburneus* and *B. improvisus assimilis* in brackish water localities. It appears to be confined to the intertidal zone.

5. **Balanus pallidus** Darwin

Balanus pallidus pallidus, HARDING, 1962, p. 278, pl. 3.
Balanus pallidus stutsburi, HARDING, 1962, p. 281, pl. 4; SOUTHWARD, 1975, p. 9.
Balanus pallidus, STUBBINGS, 1967, p. 277; ZEVINA, 1975, p. 234.

On driftwood, Matura, July 1967, dead shells only; on fruits of *Mauritia setigera* in beach drift, Los Gallos Point, Sep. 1967; on driftwood and coconut stumps, Green Hill, Dec. 1967; on bamboo driftwood, Moruga, Dec. 1970; on driftwood and fruits of *M. setigera*, Balandra, July 1972; on driftwood, Erin, Dec. 1973; on driftwood, Mayaro, June 1974.

Nariva River mouth on *Rhizophora* and pilings in brackish water (SOUTHWARD, 1975).

SANDISON (1962) and STUBBINGS (1967) consider that the separation of *B. pallidus pallidus* Darwin and *B. p. stutsburi* Darwin on the basis of colour differences is of no systematic significance. The Trinidad material has, therefore, been assigned to the former, although SOUTHWARD (1975) has placed specimens from the mouth of the Nariva River in *B. p. stutsburi*.

There was wide variation in the colour of the parietes in the Trinidad material among specimens collected from the same localities. Only very young animals were completely white, however, adult specimens all showing some purple colouration. This varied from

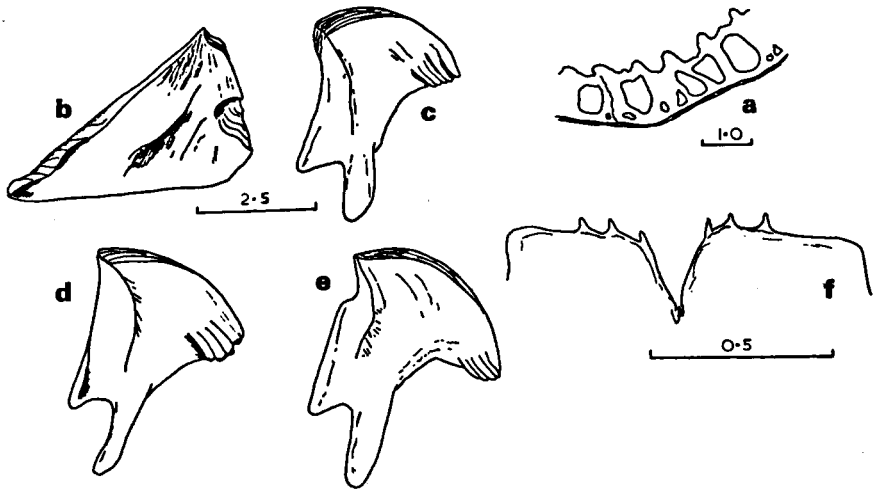


Fig. 6. *Balanus pallidus*. a – parietal pores; b and c – internal views of scutum and tergum from Moruga; d – internal view of tergum and labrum – f, from Balandra; e – internal view of tergum from Los Gallos Point.

faint purple colour on the edges of the parietes to thick, dark stripes, especially near the centre. The stripes were normally darker on the lower part and, although most specimens exhibited a large number of stripes, those collected at Moruga had only one deep purple stripe on the parietes. The scuta, and to a lesser extent the terga, had a dark, triangular patch externally.

The parietal pores were arranged in two rows, one of large almost square holes and the other, smaller ones irregularly placed, but mostly opposite the septa (Fig. 6a). The scuta and terga are shown in Figure 6b–e, and were within the range of variation for this species described by HARDING (1962), SANDISON (1962) and STUBBINGS (1967). The labrum had three teeth on each side (Fig. 6f) and the cirri were as figured by HARDING (1962).

Apart from the few specimens collected on rooted coconut stumps at Green Hill on the south coast, and SOUTHWARD's (1975) material from Nariva, all the specimens of *B. pallidus* were taken from floating debris. Those on palm fruits and driftwood at Los Gallos Point and Moruga almost certainly came from the South American mainland and it is probable that this is the origin of most of the others also. There are few records of this species in the western Atlantic region. Some of DARWIN's material probably came from the West Indies (HARDING, 1962), SOUTHWARD (1975) reports

this species washed up at Bonaire and from the brackish waters of Lake Maracaibo and ZEVINA (1975) recorded specimens from the Magdalena Delta, Colombia. It is not known whether *B. pallidus* is confined to brackish water habitats, as it appears to be in West Africa (STUBBINGS, 1967), but the occurrence of this species in the Nariva River and on flotsam derived from the Orinoco drainage system suggests a brackish water origin for the Trinidad material.

6. **Balanus venustus venustus** Darwin

Balanus amphitrite var. (2) *venustus*, DARWIN, 1854, p. 240, pl. 5 fig. 2a.
Balanus venustus venustus, HARDING, 1962, p. 283, pl. 6; STUBBINGS, 1967, p. 280.

> Seven specimens on scallop shells, dredged from a muddy bottom in 60 m depth by S.S. Eastward, Feb. 1973, between Trinidad and the coast of Guyana. Collected by S. Allick.

The locality data for these specimens is incomplete but, even though they may have come from outside Trinidad's territorial waters, the record of the species in this area is of interest. *Balanus v. venustus* is common in West and South Africa, Ceylon, and India (HARDING, 1962) but has not been reported from the western Atlantic. As it appears to be confined to the open sea (STUBBINGS, 1967) it is probably less easily collected. A description of the few specimens follows.

The size of the largest specimen was 10.2 mm carino-rostral length, 8.9 mm maximum width and 5.0 mm height of carina. The shell was an off-white, almost pink colour, with bands of pink-purple opposite the septa. These bands were equidistant from one another and of the same thickness. The radii were narrow and oblique. The compartments were smooth or finely ribbed.

Externally the opercular plates had a dark purple patch on the scutum and a lighter patch on the tergum. Both valves showed coarse growth lines. The internal features are shown in Figure 7a–b. The scutum was thick, with the articular ridge occupying over half the tergal margin, reflexed over the articular furrow and obliquely truncated at the base. The adductor ridge was strong, but short. Pits for the adductor and lateral depressor muscles were deep and distinct. The tergum was thick, flat and roughly triangular with the broad spur occupying about 1/3rd of the basal margin. The articular furrow was broad and deeply concave. Four distinct crests were developed for the depressor muscles and these projected slightly

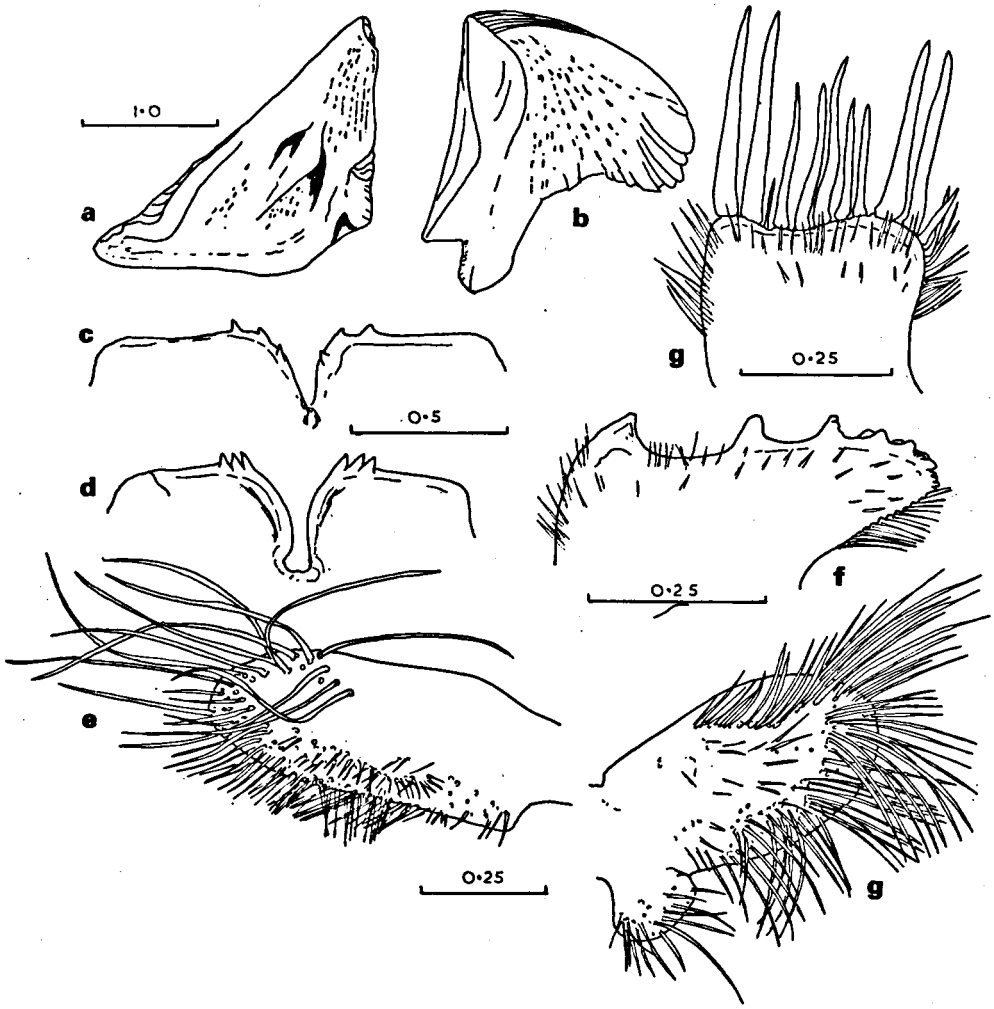


Fig. 7. *Balanus venustus venustus*, dredged off Trinidad. a and b – internal views of scutum and tergum; c and d – labra of two specimens; e – labral palp; f – mandible; g – first maxilla; h – second maxilla.

beyond the basal margin. The internal surface of both valves exhibited finely tuberculated striations, particularly on the tergum.

The labrum (Fig. 7c–d) had three teeth, either grouped or more widely spaced near the inner edge, and the groove was smooth. The

palps are shown in Figure 7e. There were 3 large teeth on the mandibles, the second bifid in one animal, and the lower third carried 2–3 medium sized and several small, rounded teeth. Below these was a group of short, thick setae (Fig. 7f). The first maxilla had 2 large upper spines, 5–6 smaller median spines and 2 large spines below. The biting edge was almost straight and a tuft of small spines and stout setae was present at the lower angle (Fig. 7g). The second maxilla was broadly oval, with a small lower lobe. The whole appendage was covered with long setae (Fig. 7h).

The cirri were as figured by HARDING (1962) except that a few short, curved setae were present on the inner and outer faces of basal segments in cirrus III. The mouthparts and cirri were otherwise almost identical with material of *B. v. venustus* described from West Africa by STUBBINGS (1967).

7. **Balanus reticulatus** Utinomi

Balanus reticulatus UTINOMI, 1967, p. 216, figs. 9–12, pl. 6 figs. 7–8; SOUTHWARD, 1975, p. 11.

Balanus amphitrite var., SOUTHWARD, 1962, p. 163; BACON, 1970a, p. 64; 1970b, p. 273; 1971b, p. 189.

Dredged in 10 m, Gulf of Paria off Caroni Swamp, Aug. 1966; on *Pteryia colymbus*, dredged off Caroni Swamp, March 1967; on rocks, Monos Island, May 1967; on *Rhizophora mangle*, Caroni Swamp, May 1967, NMC. No. 67–373; on *B. tintinnabulum antillensis*, Well No. 4, Trinmar Oil Field, Gulf of Paria. sub-tidal, May 1968; on driftwood, Cocorite Swamp, Aug. 1968; on concrete water cooling system culverts, Trinidad & Tobago Electricity Commission power station, Port of Spain, Dec. 1969; on *R. mangle*, Caroni Swamp, Nov. 1971; on *R. mangle*, Cocorite Swamp, Jan. 1972; on *R. mangle*, mouth of Tucker Valley River, Chaguaramus Bay, Apr. 1973; on *Panopeus herbstii*, Caroni Swamp, March 1974; on rocks, Masson Bay, March 1974.

Port of Spain, near generating station and on intake filters, on Yacht Club jetty and near Five Islands and Monos Island (SOUTHWARD, 1975).

The specimens referred to "*B. amphitrite*" by BACON (1970a, 1970b) from mangroves in Caroni Swamp are *B. reticulatus*. The "*B. amphitrite* var." reported by SOUTHWARD (1962) on mangroves and harbour piles in the Port of Spain area is also *B. reticulatus* (SOUTHWARD, 1975).

Balanus reticulatus was abundant in the middle and lower tidal zones in the Caroni and Cocorite swamps and at the T. & T.E.C. power station. It was also found sub-tidally in the Gulf of Paria.

8. **Balanus subalbidus** Henry

Balanus amphitrite pallidus, HENRY (not Darwin, 1854), 1954, p. 443; 1959, p. 192, pl. 1 fig. 4, pl. 3 figs. 7–8.
Balanus subalbidus HENRY, 1973, p. 968, figs. 1–2.

HENRY (1973) listed "Trinidad: Maraca Bay" among the localities for her new species *B. subalbidus*. The locality should be corrected to Maracas Bay, but specimens referable to this species were not found by the author in that Bay.

9. **Balanus trigonus** Darwin

Balanus trigonus DARWIN, 1854, p. 223, pl. 3 figs. 7a–f; PILSBRY, 1916, p. 111; WERNER, 1967, p. 64; SOUTHWARD, 1975, p. 14; ZEVINA, 1975, p. 234.

On *Pteryia colymbus*, dredged in 10 m, Gulf of Paria off Caroni Swamp, March 1967; on *B. t. antillensis*, Well No. 4, Trinmar Oil Field, Gulf of Paria, subtidal, March 1968; on concrete culverts, water cooling system, T. & T.E.C. power station, Port of Spain, Dec. 1969; on carapace of *Caretta caretta*, Toco Fishing Depot, March, 1972; on *Pseudoplexaura*, sub-tidal, Tyrico Bay, Oct. 1972; on *Pteryia*, *Murex* and *Conus*, sub-tidal, Cyril's Bay, Feb. 1973; on base of gorgonian, Escondido Cove, Dec. 1973; on *Telesto*, 17 m deep, Balata Bay, Jan. 1974; on *Panulirus*, mouth of the First Boca, Jan. 1974; on *Ellisiella elongata*, 17 m deep, Mirimar Bay, Jan. 1974; on *P. colymbus* on base of *E. elongata*, 18 m deep, Huevos Island, March 1974; on *Gorgonia flabellum* and on *P. colymbus* on the gorgonian base, on *Muriceopsis flavida*, on *Muricea elongata* and attached *P. colymbus* and on *Syphomia*, on *G. flabellum*, 10 m deep, Macqueripe Bay, Apr. 1974; on *Manicina*, Grand Fond Bay, Monos Island, Apr. 1974; on cowrie shell, Mirimar Bay, 30 m deep, May 1974.

Port of Spain, off Five Islands, common, and Los Gallos Point (SOUTHWARD, 1975).

The distribution of *B. trigonus* in Trinidad agrees closely with that given by WERNER (1967) who found this completely sub-tidal form attached to a wide variety of substrata, particularly other animals, in the western Atlantic from Florida, through the West Indies, to Brazil.

10. **Balanus calidus** Pilsbry

Balanus spongicola, var. with the walls slightly folded longitudinally, DARWIN, 1854, p. 225, pl. 4 fig. 1d.
Balanus calidus PILSBRY, 1916, p. 118, figs. 30a, 32a–f, pl. 25 figs. 1–1c; NILSSON-CANTELL, 1939, p. 6; HENRY, 1954, p. 443; Ross *et al.*, 1964, p. 312; ZULLO, 1966, p. 235; WELLS, 1966, p. 83; ZEVINA, 1975, p. 234.

On test of *Clypeaster*, sub-tidal, Cyril's Bay, Feb. 1973.

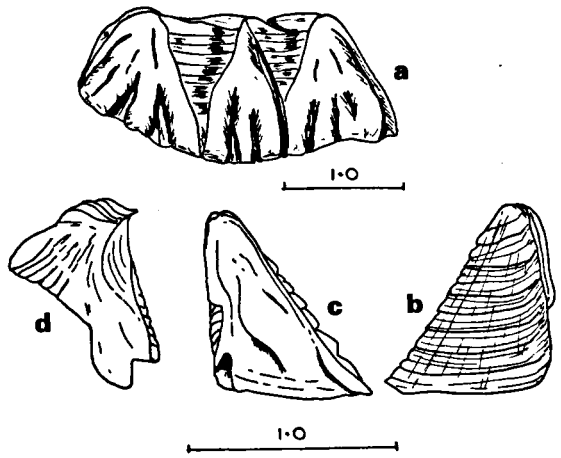


Fig. 8. *Balanus calidus*, from Cyril's Bay. a – external view of shell; b – external view of scutum; c and d – internal views of scutum and tergum.

The largest individual in the group of 10 measured only 3 mm from carina to rostrum. The shell (Fig. 8a) was white on the thick ridges and pink to dark red in the hollows and on the radii. The scutum (Fig. 8b–c) showed numerous distinct growth lines but few fine radial striations. Internally, the articular ridge was inflected and distinct, occupying about one half the tergal margin and ending in a free point. The adductor ridge was distinct, as was the pit for the lateral depressor muscle. The tergum (Fig. 8d) had a broad spur which was almost straight on both sides. Six distinct muscle crests were present. There were no soft parts.

This record considerably extends the southern distribution of recent *B. calidus*, known previously from Cape Hatteras to St. Vincent (PILSBRY, 1916; ZULLO, 1966), although this species has been reported as a fossil in Colombia (NILSSON-CANTELL, 1939).

Subgenus *Conopea* Say

11. **Balanus galeatus** (Linnaeus)

Balanus galeatus, DARWIN, 1854, p. 220, pl. 3 figs. 4a–c; PILSBRY, 1907, pl 7 figs. 5–6, pl. 9 figs. 8–11; 1916, p. 236, figs. 75a–c, pl. 56 fig. 1; 1927, p. 38; NILS-

SON-CANTELL, 1939, p. 1; MCDOUGALL, 1943, p. 343; PILSBRY, 1953, p. 25; HENRY, 1954, p. 443; ROSS, 1962, p. 31; ZULLO, 1966, p. 237; WELLS, 1966, p. 84; ZEVINA, 1975, p. 234.

On *Leptogorgia*, Mirimar Bay, 25 m deep, Jan. 1974.

Two small specimens were collected from the base of the gorgonian, the sizes of which were, carino-rostral length – 9.0 mm and 7.2 mm, carinal height – 7.0 mm and 5.1 mm respectively. The external appearance is illustrated in Figure 9a–b. The shell and basis was not much elongated as the rostral end was not produced as a sharp point. The shell below the encrusting gorgonian was white with yellow brown longitudinal banding and faint vertical striations. The summits of the radii were irregular. The opercular valves (Fig. 9c–d) were as described by DARWIN (1854), with the characteristically truncated tergum, although in one specimen the lateral depressor muscle pit was barely discernable.

According to DARWIN (1854) this species has 2 teeth on each side of the labrum. The smaller specimen had 3 teeth on each side and the other only one on one side and teeth absent from the other side, although in both specimens there were short dense setae present (Fig. 9e–f). In the larger number of labral teeth one individual resembles the closely related species *B. merrilli* (ZULLO, 1966) but it is possible, as the small size suggests, that both are juveniles in which the final adult tooth number has not developed. The palps (Fig. 9g) were oblong, slightly concave and with a row of sparse setae around the margin. The mandibles (Fig. 9h–i) had 5 main teeth. A large number of subsidiary teeth was present in one specimen and the other had tooth no. 4 bifid and a group of 4 subsidiary teeth at the lower angle. Traces of a notch, which carried 2 small spines on its edges, was visible below the upper pair of large spines on the first maxilla (Fig. 9j). The median section with 3 moderately long spines and 2 large spines was followed by a group of 6 small spines forming a tuft at the lower angle. The second maxilla had two lobes (Fig. 9k), the smaller basal one with a few short, pinnate setae and the distal lobe oval and with long, dense setae on the superior and posterior margins.

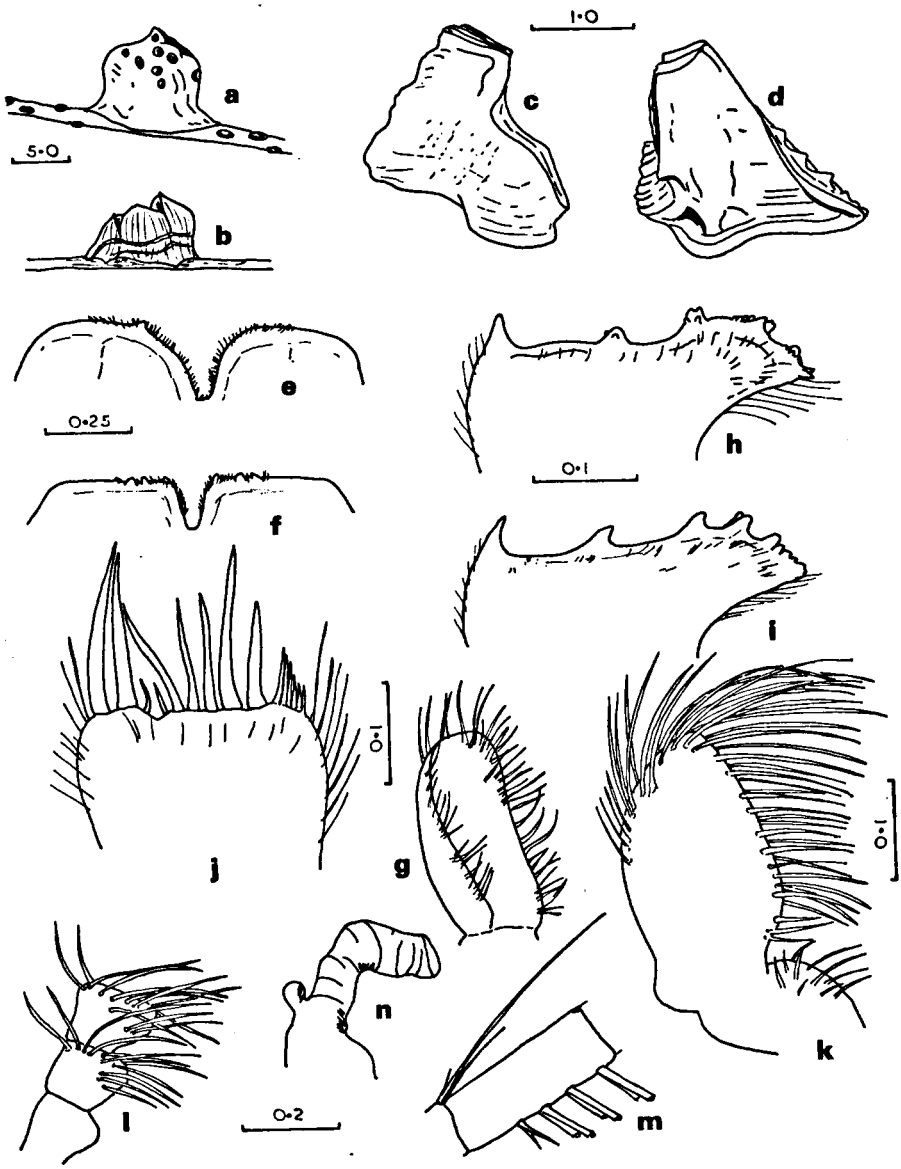


Fig. 9. *Balanus galeatus*, from Mirimar Bay. a – external form with encrusting gorgonian; b – external features with gorgonian removed; c and d – internal views of tergum and scutum; e and f – labra of two individuals; g – labral palp; h and i – mandibles of two individuals; j – first maxilla; k – second maxilla; l – median segment of cirrus III; m – median segment of cirrus IV; n – basidorsal point of penis.

Cirrus I with rami of 7 and 12 segments, the anterior ramus nearly twice as long as the posterior. Simple or sparsely pinnate setae were present on both rami and on cirrus II. The latter with 8 and 12 and 9 and 12 segments. Cirrus III had 11 and 12 segments with a ring of setae at the distal end of each segment (Fig. 9l). Cirri IV to VI were slightly damaged in both specimens, but each with approximately 20 segments. Cirri IV and V with 4 pairs of ventral setae and 3 dorsally, one of which was longer than the segment (Fig. 9m). The middle segments of cirrus VI had 5 pairs of setae, the proximal pair very short, and had one long and one short seta dorsally. The penis had a distinct basi-dorsal projection, rounded rather than pointed (Fig. 9n), and sparse setae along the appendage with 1 or 2 pairs of small setae at the tip.

Although the apically truncated opercular valves are characteristic of *B. galeatus*, slight differences are noteworthy. The mouthparts differ from those described by DARWIN (1854), the number of segments and their setae in cirri II to VI is greater than those described by PILSBRY (1916) and the oval shell shape is similar to that of specimens from Curaçao (PILSBRY, 1927). In the absence of further material, however, it is best to regard the Trinidad specimens as belonging to this species.

Balanus galeatus occurs on *Leptogorgia virgulata* in Carolina and on gorgonians through Central America and the West Indies (ZULLO, 1966). The West Indian locality of the type material is not known (PILSBRY, 1916), but the present record is probably the most southern locality for this species in the western Atlantic.

Genus **Tetraclita** Schumacher

12. **Tetraclita stalactifera** (Lamarck)

Tetraclita porosa var. *communis*, DARWIN, 1854, in part, p. 329, pl. 10 figs. 1a, i.
Tetraclita squamosa stalactifera, PILSBRY, 1916, p. 254, pl. 59 figs. 1a–b; OLIVIERA, 1940, p. 138; 1941, p. 7; HENRY, 1954, p. 444; 1958, p. 224; ROSS, 1962, p. 31.
Tetraclita porosa stalactifera, NILSSON-CANTELL, 1933, p. 508; 1939, p. 5.

Tetraclita squamosa, SMITH *et al.*, 1950, p. 134; SOUTHWARD, 1962, p. 163; WERNER, 1967, p. 70.
Tetraclita stalactifera, PILSBRY, 1927, p. 38; ROSS, 1968, p. 8; SOUTHWARD, 1975, p. 16; ZEVINA, 1975, p. 234.

Dredged in 10 m depth, Gulf of Paria off Caroni Swamp, Aug. 1966; on rocks, Monos Island, May 1967; on rocks, Soldado Rock, Oct. 1967; on rocks, Balandra, 1968; Well No. 4, Trinmar Oil Field, Gulf of Paria, sub-tidal, May 1968; on rocks, Icacos, Nov. 1970; on rocks, Chacachacare Island, Dec. 1970; on rocks, Forest Point, Toco, Dec. 1973; on rocks, Salybia Reef, Toco, May 1974.

As reported by SOUTHWARD (1962) this is the common species of *Tetraclita* on rocks on all coasts of Trinidad. It is more common, however, on the north and east where suitable hard rock substratum exists. This species occurred in the lower tidal zone and sub-tidally.

Genus *Tetraclitella* Hiro

13. **Tetraclitella divisa** (Nilsson-Cantell)

Tetraclita divisa NILSSON-CANTELL, 1921, p. 93, 362, figs. 8 & 83, pl. 3 fig. 11; STUBBINGS, 1967, p. 291; ROSS, 1968, p. 13.
Tetraclitella divisa, ROSS, 1969, p. 237; SOUTHWARD, 1975, p. 18.

On rocks, Soldado Rock, Oct. 1967; on rocks, Forest Point, Toco, Dec. 1973.

This uncommon species was found in the two localities on the underside of boulders, on sheltered rock surfaces and in small caves in the lower tidal zone.

Genus **Newmanella** Ross

14. **Newmanella radiata** (Bruguière)

Tetraclita radiata, DARWIN, 1854, p. 343, pl. 11 figs. 5a–d; PILSBRY, 1916, p. 259, pl. 61 figs. 3–3c, 4; 1927, p. 38; NILSSON-CANTELL, 1939, p. 5; PILSBRY, 1953, p. 27; SOUTHWARD, 1962, p. 163; ROSS, 1968, p. 18.
Newmanella radiata, ROSS, 1969, p. 242, figs. 3–4; SOUTHWARD, 1975, p. 17.

Drilling rig in south Trinidad, Feb. 1924; on rocks, Monos Island, May 1967; Well No. 4, Trinmar Oil Field, Gulf of Paria, sub-tidal, on *B. t. antillensis*, May 1968; on *Perna perna*, Tyrico Bay, Oct. 1973; on base of *Gorgonia flabellum*, in 10 m depth, Macqueripe Bay, Apr. 1974.

10 specimens on marine structures, Shell Oil Field, Gulf of Paria, May 1968 (Ross, 1969).
Monos Island and Gaspare Grande, common to abundant (SOUTHWARD, 1975).

Newmanella radiata was common in the lower tidal zone and sub-tidally on the north coast and in the Gulf of Paria.

Genus **Ceratoconcha** Kramberger-Gorjanovic

15. **Ceratoconcha quarta** Kolosváry

Creusia spinulosa var. 4., DARWIN, 1854, p. 378, pl. 14 fig. 6i, k–l.
Ceratoconcha quarta KOLOSVÁRY, 1947, p. 426; ROSS & NEWMANN, 1973, p. 167; NEWMANN & LADD, 1974, p. 393.

In *Siderastrea radians*, Salybia coral reef, Toco, intertidal and subtidal, Nov. 1971; in *Porites porites*, subtidal at 5 m depth, Tyrico Bay, June 1972.

Externally the barnacles were completely covered with the coral matrix which was cemented to the shells up to and overhanging the aperture. The aperture was oblong and placed to one side of a circular, slightly raised area, approximately 6.0 mm in diameter, which identified the position of the barnacle in the coral. The barnacles were embeded in the coral skeleton to a depth of 5–6 mm (Fig. 10a).

Internally the shell was white, with 4 plates, wide radii and simple sutures. The walls were ribbed internally and had rows of irregularly placed small pores which continued to the cup-shaped base (Fig. 10b). The scutum and tergum are shown in Figure 10c–f. Externally the scutum showed strong concentric growth lines. The valve was triangular and thick, and internally the occludent margin showed a line of rounded projections. The articular ridge occupied about 3/4 the tergal margin and was rounded at the base. A long, strong adductor ridge extended to cut the basal margin about the middle. The pits for the adductor and lateral depressor muscles were distinct. The tergum had strong growth lines externally and the edges of the furrow curved inwards so that the furrow was nearly closed along the spur. The spur was narrow, being about 1/6th the width of the basal margin and with its free end about 1/2 as long as the rest of the

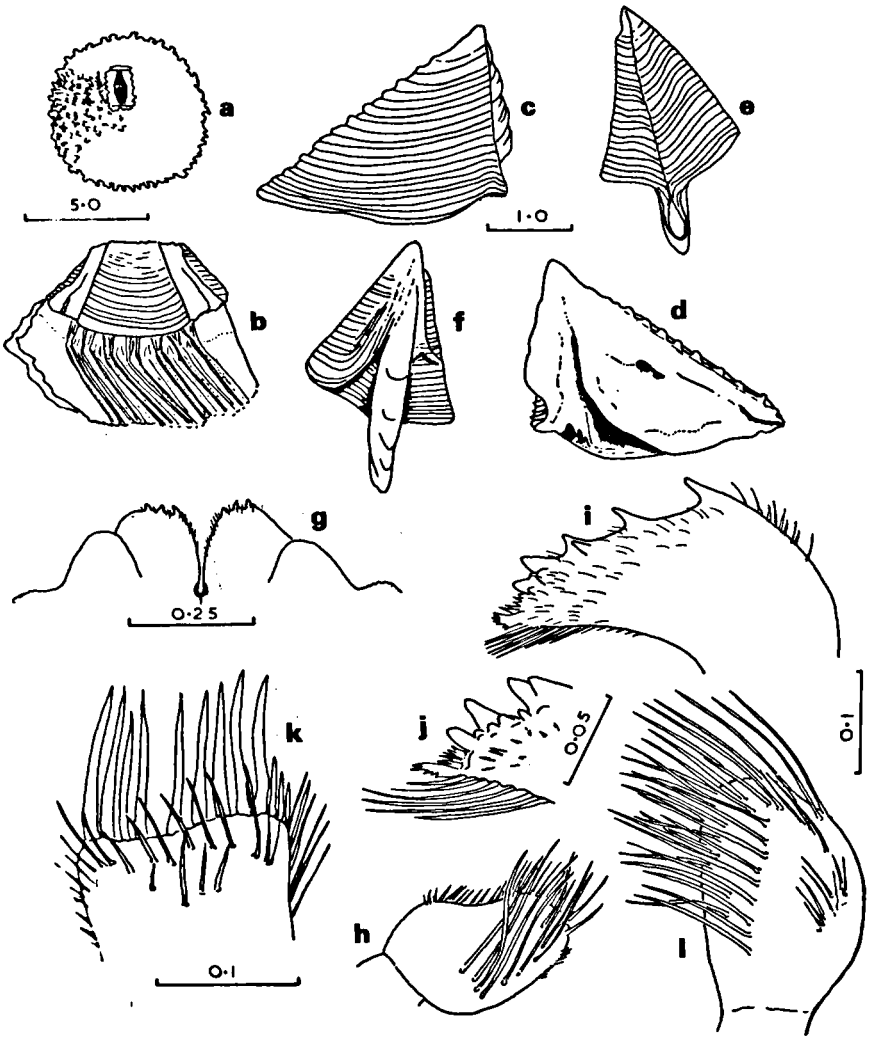


Fig. 10. *Ceratoconcha quarta*, from Tyrico Bay. a – plan view of shell with encrusting *Porites*; b – internal view of pariete; c and e – external views of scutum and tergum; d and f – internal views of scutum and tergum; g – labrum; h – labral palp; i – mandible; j – lower third of mandible of another specimen; k – first maxilla; l – second maxilla.

TABLE 2

NUMBER OF SEGMENTS IN THE CIRRI OF *Ceratoconcha quarta* FROM SALYBIA REEF

CIRRUS	I	II	III	IV	V	VI
1. R.	6/14	6/8	8/9	13/15	15/16	17/18
L.	7/15	7/8	9/10	12/15	15/17	14/14+
2. R.	8/16	7/8	9/10	14/16	15/16	17/19
L.	8/15	6/9	9/10	13/14	16/17	17/19
3. R.	8/16	7/8	9/10	14/16	10+/19	19/20
L.	7/15	7/8	8/9	14/16	10+/18	16/19
4. R.	7/15	7/8	9/10	13/15	16/17	18/19
L.	6/14	7/8	9/10	11+/15	15/16	17/19
5. R.	7/14	6/8	8/9	15/16	18/19	19/20
L.	6/14	7/8	9/10	15/17	18/19	19/20
6. R.	7/14	7/8	9/10	16/17	18/19	18/20
L.	7/15	7/8	9/10	15/17	17/18	18/19
Range	6–16	6–9	8–10	12–17	15–19	14–20

valve. A broadly oval, raised area occupied the occludent side of the valve in the absence of crests for the depressor muscles.

The labrum bore 3 teeth and setae on each side of the upper part of two rounded projections with the setae extending into the groove (Fig. 10g). The palps were broadly oval, slightly concave on the anterior side which had short setae. Longer setae were present on the posterior side (Fig. 10h). The mandibles (Fig. 10i–j) had 4 large, widely spaced teeth, the third and fourth either bifid or with subsidiary cusps. The lower angle carried a group of smaller teeth, the lowest of which was the largest and most complex. Below this was a tuft of about 6 long setae. The first maxilla (Fig. 10k) had the leading edge broadly concave with 9 equal sized, long spines. At the lower edge was a group of 3 smaller spines and below these long setae. The second maxilla was oval with long setae on the anterior side and apex and a group of short setae about midway down the posterior side (Fig. 10l).

The number of segments in the cirri is shown in Table 2. The short ramus of cirrus I carried groups of long, pinnate setae on the protu-

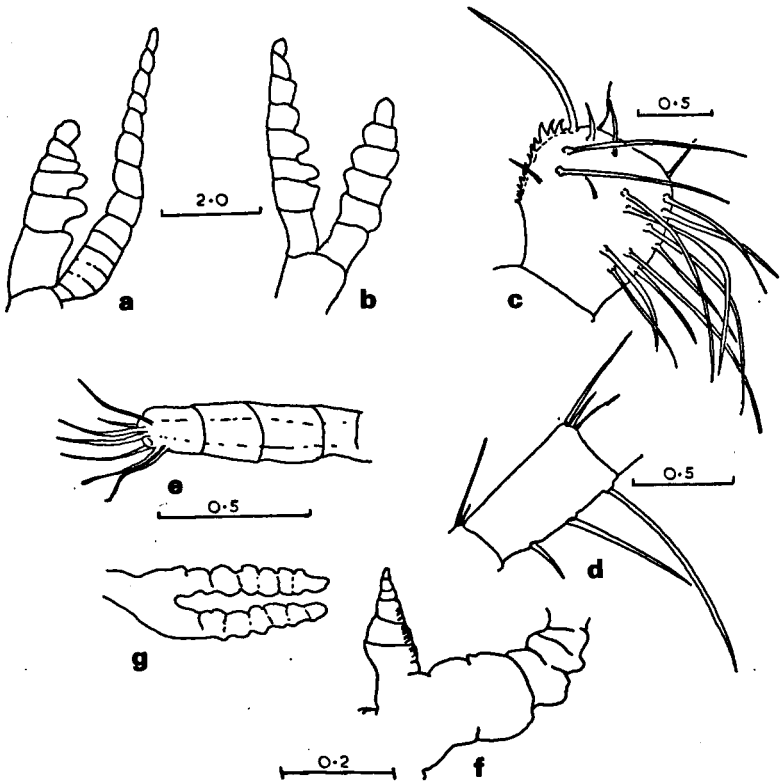


Fig. 11. *Ceratoconcha quarta*. a – cirrus I; b – cirrus II; c – proximal segment of cirrus III; d – median segment of cirrus IV; e – distal end of penis; f – basidorsal point of penis; g – caudal rami.

berant segments and longer setae on the basal segments. The other ramus was almost twice as long (Fig. 11a) and thickly clothed with long setae, most of which were pinnate. Cirrus II had a group of long setae on the projections of the inner side of both rami (Fig. 11b). Pectinate setae without basal guards were present on the tip of the short ramus. The third cirrus was much thinner and with pinnate setae on the tip of both rami. Small teeth were present on the anterior side of the segments (Fig. 11c). There were about 10–15 of these on the lower segments with a large number of long and short setae. The number of teeth and setae decreased towards the tip. The

segments of cirri IV to VI were longer than broad and with 3 pairs of setae (Fig. 11d). The dorsal side carried 1 long and 1 short seta. The penis (Fig. 11e) was slightly pigmented, annulated and with sparse setation. The setae became more numerous in the distal third and a tuft of 6 setae was present at the tip. A conical dorsal point was present at the base of the penis (Fig. 11f). The caudal appendages had rami of 7 and 8 segments (Fig. 11g).

Although several fossil species of *Ceratoconcha* have been described from Trinidad and other parts of the Caribbean (NEWMANN & LADD, 1974), only 3 recent species are known from this region. *Ceratoconcha domingensis* Des Moulins (1866) is known in *Porites astreoides* from Haiti and is probably the species reported in *P. astreoides* from Bermuda and Florida by ZULLO *et al.* (1972). It is closely similar to *C. quarta* Kolosváry (1947) (= *Creusia spinulosa* var. 4. DARWIN, 1854, p. 378, also from the West Indies) reported in *Colpophyllia natans*, but the original description by DES MOULINS is inadequate. A third species, *C. floridanum*, was reported in *Meandrina areolata* by PILSBRY (1931) from the Gulf of Mexico. Although the appendages were not described by DES MOULINS or PILSBRY, the shape of the opercular valves alone separates the Trinidad material from *C. domingensis* and *C. floridanum* and places it with *C. quarta*.

KOLOSVÁRY (1947) did not describe the appendages of *C. quarta* and DARWIN (1854) stated only that "in the characters derived from the mouth and cirri, there are no generic differences" between "*Creusia*" and the related commensal genus *Pyrgoma* whose appendages he did describe. The internal anatomy of the present material agrees generally with DARWIN's description of the appendages of these genera, but more detailed descriptions are required before satisfactory separation of the three known West Indian species is possible.

ZULLO *et al.* (1972) suggested that the Bermudan and Floridan specimens mentioned above were *C. domingensis* as this species had been described originally in *P. astreoides*. ROSS & NEWMANN (1973) do not consider this genus to be host specific, however, and the Trinidad material, which was found in two coral species, supports the idea that the coral host may be of little value in taxonomic studies on *Ceratoconcha*.

The corals of the Salybia Reef, Toco, contained large numbers of *C. quarta*, particularly in the reef flat lagoon. Some environmental data are available from 1972 for this reef (J. S. KENNY, personal communication). The water was highly turbid throughout the year and water temperatures at the reef front varied from 25.5°C in March to 27.9°C in September. Salinities at the reef front were highest in February and March and low in August and September, being 33–26‰ respectively, but in the lagoon near the outfall of a small stream salinities fell to 5‰ in September. Living *C. quarta* have been noted at all seasons indicating that this species is able to survive a wide range of salinities which are below normal oceanic values throughout the year.

Genus **Chelonibia** Leach

16. **Chelonibia testudinaria** (Linnaeus)

Chelonibia testudinaria, DARWIN, 1854, p. 392, pl. 14 figs. 1a–d, 5, pl. 15 fig. 1; PILSBRY, 1916, p. 264, pl. 62 figs. 1–4; NILSSON-CANTELL, 1939, p. 5; WELLS, 1966, p. 86.

On carapace of *Caretta caretta*, Toco Fishing Cooperative Depot, March 1972.

Two specimens, 30 and 52 mm diameter, were found in a group of *Ch. caretta* on the Loggerhead Turtle.

17. **Chelonibia caretta** (Spengler)

Chelonibia caretta, DARWIN, 1854, p. 394, pl. 14 fig. 2; PILSBRY, 1916, p. 267, pl. 63 figs. 5, 5a; WELLS, 1966, p. 86.

On carapace of *Caretta caretta*, Toco Depot, March 1972; on carapace of *C. caretta*, Toco Depot, May 1973.

Genus **Platylepas** Gray

18. **Platylepas hexostylos** (O. Fabricius)

Platylepas bisexlobata DARWIN, 1854, p. 428, pl. 17 figs. 1a–d.
Platylepas hexostylos, PILSBRY, 1916, p. 285, pl. 67 figs. 1–1c, 3; WELLS, 1966, p. 87.
Platylepas sp., BACON, 1970, p. 215.

On carapace of *Dermochelys coriacea*, Paria Bay, June 1968; on carapace, neck and fore limbs of *D. coriacea*, Matura Bay, May 1972.

Platylepas was found frequently on leatherback turtles nesting on Trinidad beaches (BACON, 1970c) but has not been seen on other species, although reported on *C. caretta* and *Eretmochelys imbricata* by PILSBRY (1916) and on *C. caretta* by WELLS (1966). HUGHES (1974) found *Platylepas* sp. on leatherbacks in South-East Africa, but the only other commensal cirripede recorded previously on *Dermochelys* is *Stomatolepas elegans* (O.G. Costa) from turtles caught in Europe, Canada and New Zealand (HOLTHUIS, 1969; MCCANN, 1969).

In addition to the specimens of *Chelonibia* and *Platylepas* found on turtles, *Balanus trigonus* was found on *C. caretta* at Toco in March, 1972, and a *Lepas* sp. was seen, but not collected, on *E. imbricata* at Monos in June, 1974.

Family CHTHAMALIDAE Darwin

Genus **Chthamalus** Ranzani

1. **Chthamalus bisinuatus** Pilsbry

Chthamalus stellatus bisinuatus PILSBRY, 1916, p. 306, pl. 71 figs. 6, 6a; OLIVIERA, 1941, p. 24; GERLACH, 1958, p. 670; WELLS, 1966, p. 88.
Chthamalus fragilis, PILSBRY, 1916, 229; NILSSON-CANTELL, 1933, p. 505, 1939, p. 4; SOUTHWARD, 1962, p. 163; BACON, 1971b, p. 189; ZEVINA, 1975, p. 234.
Chthamalus bisinuatus, SOUTHWARD, 1975, p. 28.

On rocks, Soldado Rock, Oct. 1967; on rocks, North Manzanilla, Feb. 1968; on *Laguncularia racemosa*, Monos Island, June 1969; on rocks, Icacos, Nov. 1970; on rocks, Rampanalgas, Jan. 1971; on *Crassostrea rhizophorae*, Cocorite, Sep. 1971; on *Rhizophora mangle*, Caroni Swamp, Oct. 1971; on *C. rhizophorae* on mangrove roots, Caroni Swamp, Jan. 1972; on rocks, east coast near Toco, Apr. 1972; on *R. mangle*, Chaguaramus Bay, Apr. 1973; on rocks, Erin, Dec. 1973; on rocks, Escondido Bay, Jan. 1974; on rocks, Scotland Bay, March 1974; on rocks, Masson Bay, March 1974; on *Brachidontes exustus* on rocks, near Vessigny, La Brea, March 1974; on *Mytella falcata* on pilings, Vessigny, Apr. 1974; on rocks, mouth of Godineau River, South Oropuche Swamp, Apr. 1974; on driftwood, Mayaro Beach, June 1974; on *M. falcata*, Point Sable, La Brea, June 1974.

Port of Spain, Monos Island, Galera Point and Balandra Bay, Dec. 1970; Mouth of Nariva River on pilings, Jan. 1964; Maracas Bay on sandy rock, Jan. 1955; common to abundant at all localities (SOUTHWARD, 1975).

Chthamalus bisinuatus is the common chthamalid on rocks on all four coasts. It occurs occasionally on driftwood, red and white mangroves and on oysters. In the estuarine areas, such as Caroni Swamp, it settles during the dry season but may be absent during the wet season.

Populations of *C. bisinuatus* which had settled on *Rhizophora* in Caroni Swamp and Chaguaramus Bay possessed thin, smooth shells

when adult which were similar superficially to juvenile *Chthamalus rhizophorae*. Examination of the opercular valves readily separated the two species, but the valve plates of these *C. bisinuatus* were more delicate than those of specimens living on rocks on the open coast.

Chthamalus fragilis Darwin

This species was not present in the collections examined. SOUTHWARD's (1962) specimens from mangroves on Monos Island and the Diego Martin River were probably juvenile *C. bisinuatus* Pilsbry, as were those from mangroves in Caroni Swamp (BACON, 1971b) which resembled *C. fragilis* in shell form and the shape of tergum and scutum. Earlier reports of *C. fragilis* in the southern Caribbean at Curaçao, Bonaire and Venezuela (PILSBRY, 1927; NILSSON-CANTELL, 1939) are possibly erroneous also.

2. **Chthamalus angustitergum** Pilsbry

Chthamalus stellatus angustitergum PILSBRY, 1916, p. 305, figs. 85–86, pl. 71 figs. 5, 5a–5b; 1927, p. 37; NILSSSON-CANTELL, 1933, p. 506; KOLOSVÁRY, 1939, p. 161; HENRY, 1954, p. 444; WELLS, 1966, p. 92.

Chthamalus stellatus, SMITH, WILLIAMS & DAVIS, 1950, p. 143; WERNER, 1967, p. 70.

? *Chthamalus fragilis* PILSBRY, 1916, p. 299; NILSSON-CANTELL, 1933, p. 505; PILSBRY, 1927, p. 37.

? *Chthamalus stellatus thompsoni*, HENRY, 1958, p. 220.

Chthamalus angustitergum, ROSS, 1968, p. 2; SOUTHWARD, 1975, p. 20; ZEVINA, 1975, p. 234.

On rocks, Rampanalgas, Jan. 1971; on rocks, Galera Point, Jan. 1971; on rocks, Mirimar Bay, Jan. 1974; on rocks, Masson Bay, March 1974; on *Laguncularia racemosa*, Scotland Bay, March 1974.

Galera Point, few specimens near high tide level, Dec. 1970 (SOUTHWARD, 1975).

This species was abundant in a few localities but not as widespread as *C. bisinuatus*.

Mature specimens could be distinguished from *C. bisinuatus* by the shape of the opercular suture, the tergum and scutum (Fig. 12a–g) as listed in Table 3. The crests for the depressor muscles were on a distinct mound in *C. bisinuatus*, although there were 4–5 crests

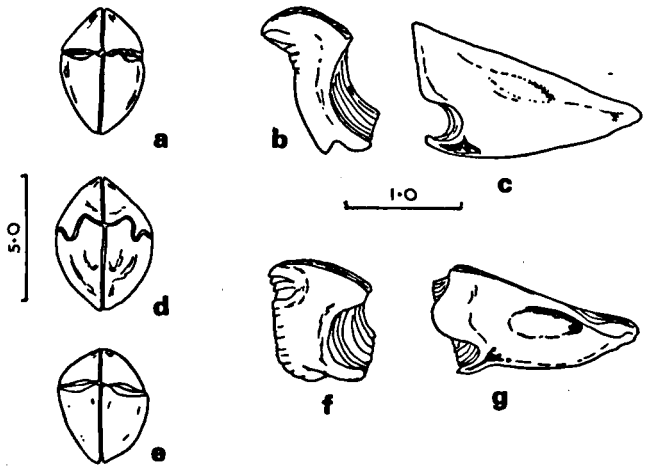


Fig. 12. a – opercular valve suture of *C. angustitergum* from Rampanalgas. b and c – internal view of tergum and scutum of same specimen; d – valve suture of *C. bisinuatus* from Rampanalgas; f and g – internal views of tergum and scutum of same specimen; e – valve suture of thin walled specimen of *C. bisinuatus* from Caroni Swamp.

TABLE 3

CHARACTERS OF THE SCUTUM AND TERGUM OF *C. angustitergum* AND *C. bisinuatus*

Character	*angustitergum*	*bisinuatus*
SCUTUM		
Height	1/2 width	1/3 width
articular ridge	3/5 tergal margin straight	2/3 tergal margin curved and projecting
adductor muscle scar	narrow, shallow	oval, deep
TERGUM		
height	twice width	slightly greater than width
spur	narrow, clearly delimited	less distinct
depressor muscle crests	4–5 no mound	4–5 distinct mound

in both species, as reported by SOUTHWARD (1975). Ross's record (1968) of 5–7 crests in *C. angustitergum* is probably an error as he states in the same paper that 5 crests is the characteristic number. Juvenile animals of the two species were separable only after examination of the mouthparts and cirri. The absence of basal guards on the pectinate setae of cirrus I and II in *C. angustitergum*, as noted by ROSS (1968) and SOUTHWARD (1975), appears to be the most reliable criterion for separating this species from *C. bisinuatus*. SOUTHWARD has suggested that there are differences in the teeth of the pectinated part of the mandible as follows:

C. bisinuatus – pectinate part with 11 – 17 small teeth (mean 13), then 3, sometimes 4, larger teeth, the second two often fused together.

C. angustitergum – pectinate part with 14–23 small teeth (mean 20), then 1 large tooth and 1 or 2 smaller teeth.

However, ROSS (1968) stated earlier that in *C. angustitergum* the inferior angle bears 3–4 spines, above which is a comb containing about 22–28 spinules. Most of the Trinidad material agreed with SOUTHWARD in the presence of one large and 2 smaller teeth, but several specimens were found with dissimilar mandibles. In one *C. angustitergum* from Scotland Bay the left mandible had one large and 2 small teeth, whereas the right had 3 equal sized large teeth. The number of small teeth or spinules in the comb was highly variable, although it generally exceeded 20. The use of the dentition of the mandibles to differentiate the two species may be occasionally of little value therefore.

3. **Chthamalus rhizophorae** Oliviera

Chthamalus rhizophorae OLIVIERA, 1940, p. 379, pl. 1; 1941, p. 26, pl. 6 figs. 1–4; 1953, p. 511; GERLACH, 1958, p. 670; ROSS, 1968, p. 6; SOUTHWARD, 1975, p. 32.

not *Chthamalus rhizophorae*, LONGHURST, 1958, p. 32, 59, 85.

Chthamalus fragilis, BACON, 1970a, p. 36, fig. 16, pl. 11; 1970b, p. 270.

On *Laguncularia racemosa*, Monos Island, June 1969; on *Rhizophora mangle*, mouth of Tucker Valley River, Chaguaramus Bay, Apr. 1973; on *R. mangle*, Caroni Swamp, March 1974; on *R. mangle*, Godineau River, few on rocks also, Apr. 1974; on *R. mangle* and few on driftwood, Bonasse, Apr. 1974.

The largest population of *C. rhizophorae* in Trinidad was found on mangrove roots in the Caroni Swamp (BACON, 1970a, 1970b). The description which follows is based on dissections of a long series of individuals from this area, although the few animals present in other localities fitted within the range of form found in the Caroni population. With the exception of a few *C. rhizophorae* found on the white mangrove, *Laguncularia racemosa*, at Monos and on driftwood at Bonasse, this species appears to be confined to prop roots of the red mangrove, *R. mangle*.

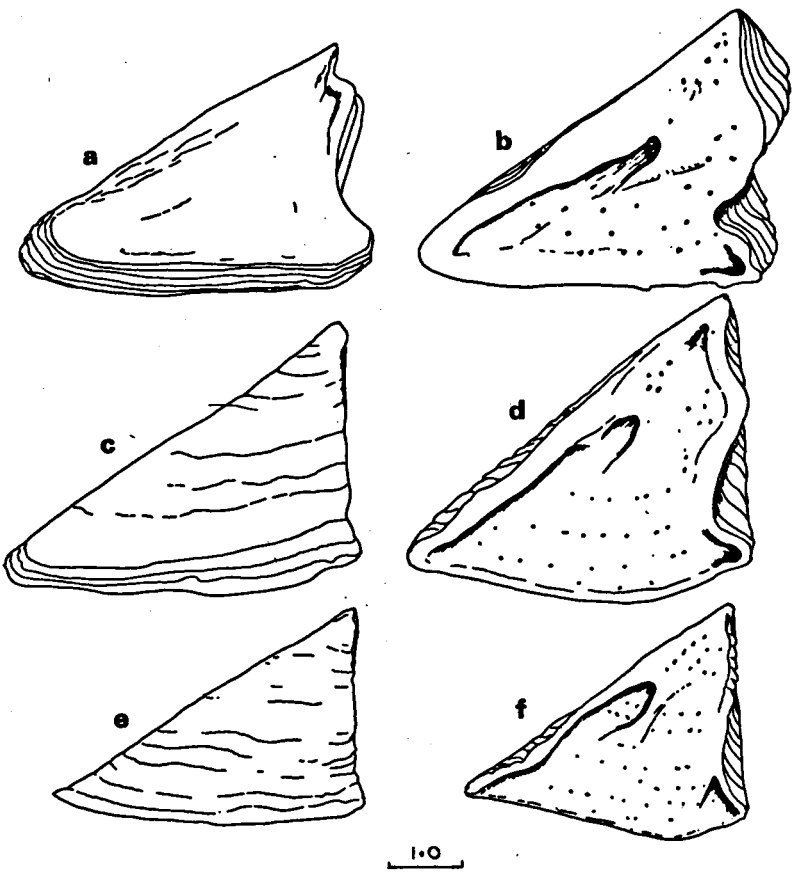


Fig. 13. *Chthamalus rhizophorae*, from Caroni Swamp. External and internal views of scutum of three specimens.

The external form was as described by OLIVIERA (1940, 1941). The colour varied from yellow-brown in young individuals to dirty white in large adults. The largest specimen seen measured 21 mm carino-rostral length, 7.2 mm carinal height. The capital Psi (Ψ) shaped articulation of the opercular valves was shown by most individuals over 10 mm carino-rostral length. This shape or a slight curvature was frequently present in very young individuals. An almost straight line of articulation was present, however, in some animals of sizes up to 15 mm carino-rostral length and in many of the immature ones. As a result, barnacles of approximately equal size could show a Psi-shaped, slightly curved or straight articulation which influenced the general form of the scuta, and to a lesser extent the terga, as

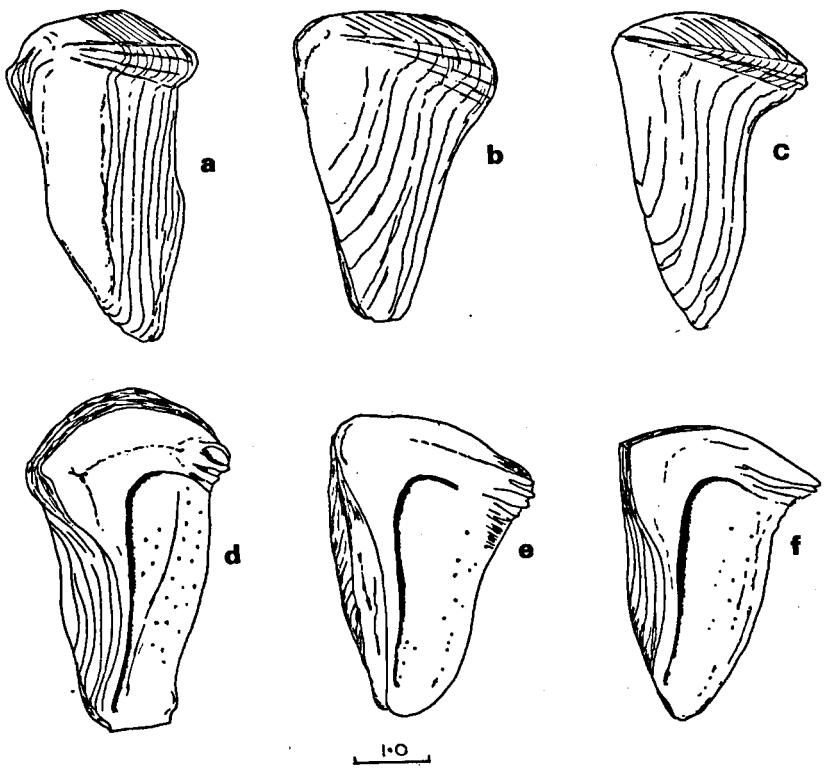


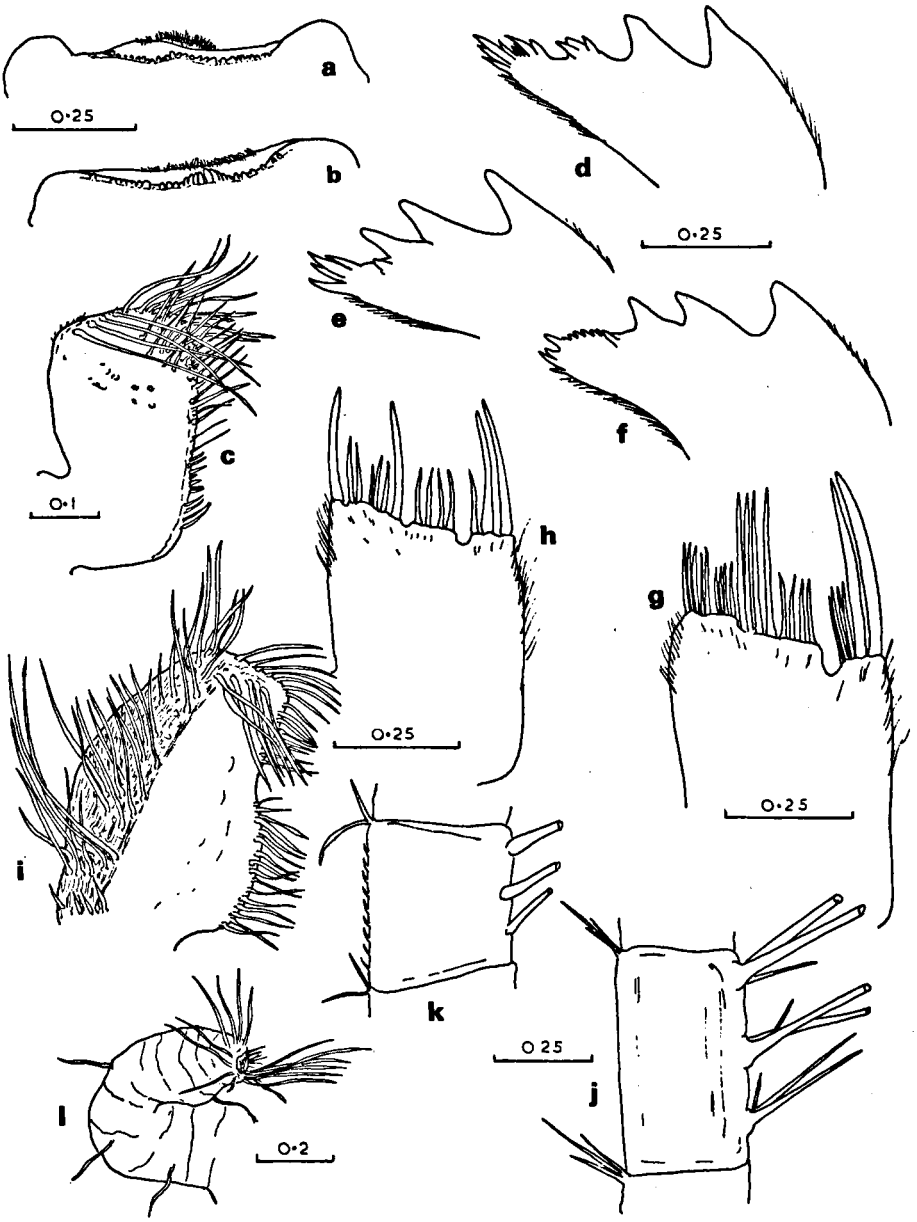
Fig. 14. *Chthamalus rhizophorae,* from Caroni Swamp. External and internal views of tergum of three specimens.

shown in Figures 13 and 14. The opercular valves were of variable thickness, those with the straight articulation being thinnest and possibly from the youngest individuals. In all the scuta of the three forms the articular ridge projected over the tergal margin at the centre, even in specimens showing the straight tergal margin in external view (Fig. 13e–f). Pits for the adductor muscles were elongated and deep, those for the lateral depressor muscles were deep also. A large number of distinct pits were present on the inner surface of all the scuta examined. The terga showed similar pitting, but the less numerous pits were confined to the moderately deep articular furrow. The number of depressor muscle crests varied from 3–4, mostly 3, and these were deeply incised. The lower part of the valve was narrow, almost pointed in some cases while almost square in others. There was no separate spur present.

The labrum (Fig. 15a–b) was broadly concave with a long, straight row of small peg-like teeth grading into smaller denticles laterally. There were from 30–40 teeth and denticles on most labra. A row of short, coarse setae was associated with the teeth. In many adult specimens a number of the largest teeth were grouped at the centre (Fig. 15b). The palps were rectangular, with the longest setae on the upper margin (Fig. 15c). Three large teeth were present on the mandible, with the third tooth carrying subsidiary cusps in some individuals. The lower pectinated angle had from 4–9 teeth of different sizes (Fig. 15d–f), the number being different frequently in the two mandibles of one animal.

The first maxilla had two large upper spines followed by 2–4 small spines above a distinct notch. The median section was slightly raised and carried 7–8 large and small spines and the lower third protruded further and bore about 10 large and small spines (Fig. 15g–h). Maxilla II was oval, with a slightly concave anterior and convex posterior margins. The anterior margin has a row of setae interrupted centrally, and longer setae on the apex and posterior side (Fig. 15i).

The numbers of segments on the cirri are given in Table 4. Cirrus I carried numerous pinnate setae at the tip of the long ramus, fewer on the short. Cirrus II had pectinate setae without basal guards on both rami on the terminal and lower segments. Cirri III to IV were


a
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j
l
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TABLE 4

NUMBER OF SEGMENTS IN THE CIRRI OF *Chthamalus rhizophorae*, FROM CARONI SWAMP

CIRRUS	I	II	III	IV	V	VI
1. R.	8/9	10/11	21/22	25/26	27/28	31/33
L.	8/9	10/11	20/22	25/26	27/29	31/33
2. R.	8/9	9/10	22/23	25/25	27/28	32/33
L.	8/9	9/10	22/23	25/26	29/30	29/33
3. R.	8/9	9/10	24/24	24/26	28/31	33/34
L.	8/9	8/9	24/25	25/26	28/31	33/34
4. R.	7/9	8/8	25/26	30/30	31/32	34/36
L.	7/8	8/8	28/28	28/30	31/32	35/36
5. R.	8/9	9/9	30/31	31/32	33/33	36/37
L.	8/9	9/9	30/32	31/32	32/33	35/36
6. R.	8/9	9/9	25/26	32/33	35/36	35/36
L.	8/9	9/9	25/25	32/33	35/37	35/37
Range	7–9	8–11	20–32	24–33	27–37	29–37

longer and similar in shape with the segments almost as broad as long. They carried 3 pairs of setae ventrally, the proximal pair nearly always shorter than the other two pairs. The longer setae were about three times the length of the segments and usually had a single short seta between their bases. The dorsal side possessed a group of 3–4, mostly 3, short setae distally (Fig. 15j). The proximal segments of cirrus III to VI possessed small, hooked spines dorsally (Fig. 15k). The penis was annulated and pigmented proximally, with sparse setae distally. A circle of short and a tuft of longer setae was present at the tip (Fig. 15l).

POPE (1965) noted the close similarity in shell form and shape of the opercular plates between *C. withersi* Pilsbry and *C. rhizophorae*

Fig. 15. *Chthamalus rhizophorae*, from Caroni Swamp. a and b – labra; c – labral palp; d to f – mandibles of three specimens; g and h – first maxilla of two specimens; i – second maxilla; j – median segment of cirrus IV; k – proximal segment of cirrus VI; l – distal end of penis.

Oliviera. She considered, in the absence of details of the soft parts of the latter, that the species were probably synonymous. In describing the related species, *C. aestuarii*, STUBBINGS (1963, 1967) stated that the three species could be distinguished on the shape of the scutum alone. The articular ridge of the scutum does not project beyond the tergal margin in *C. withersi*, projects only at the apex in *C. aestuarii* and projects at the centre in *C. rhizophorae*. Although there appeared to be similarities in the mouth appendages, the first maxilla of *C. aestuarii* was distinguishable from the other species by the almost straight edge. STUBBINGS (1963) found the maxilla of *C. rhizophorae* stepped in the middle and lower thirds, although this was not mentioned by OLIVIERA (1940, 1941), and that of *C. withersi* distinct in its prominent lower third. Further details of the appendages of *C. rhizophorae* were not available. Table 5 lists the differences between the three species from the available literature (PILSBRY, 1916; POPE, 1965; STUBBINGS, 1963, 1967; OLIVIERA, 1940, 1941). The Trinidad material from Caroni Swamp is listed for comparison and shown to be *C. rhizophorae*. It is distinguished from *C. withersi* by the opercular plates, greater number of teeth on the labrum, stepped surface of the first maxilla, absence of a notch on the second maxilla, presence of pectinated setae on cirrus II and the greater number of segments in the cirri, especially cirrus VI. The medially projecting articular ridge and irregularly pitted surface of the scutum, the V-shaped articular furrow, pitted surface and flattened shape of the tergum, the stepped maxilla with large spines in the lower third, the closely packed labral teeth, the more rounded pectinated portion of the mandible and the greater number of segments in the cirri, separate this species from *C. aestuarii* also. Hooked spines on the basal segments of the cirri have not been reported in *C. withersi* or *C. aestuarii*.

The Caroni Swamp specimens with the straight edged opercular plate articulation were indistinguishable externally from *C. aestuarii* from West Africa (BM. cat. no. 1956.1.7.3) except by their more flattened form. Although not reported by STUBBINGS (1967), this material had a few pectinated setae on the second cirrus. Cirri III to V were generally thinner than the Trinidad specimens of *C. rhizophorae* and also tapered markedly distally. The internal features of

TABLE 5

COMPARISON OF THE CHARACTERS OF *C. withersi*, FROM AUSTRALIA, *C. aestuarii* FROM AFRICA, *C. rhizophorae* FROM BRAZIL WITH *C. rhizophorae* FROM TRINIDAD

Character	*C. withersi* (Australia, POPE, 1965; PILSBRY, 1916)	*C. aestuarii* (W. Africa, STUBBINGS, 1963, 1967)	*C. rhizophorae* (Brazil OLIVIERA, 1940, 1941)	*C. rhizophorae* (Trinidad)
1. PSI-SHAPED ARTICULATION	no	yes, except young	yes, except young	yes, majority
2. SCUTUM				
articular ridge & furrow	shallow	strong	strong	strong
articular ridge projecting beyond margin	no	at apex	at centre	at centre
adductor muscle pit	shallow	oval, deep	elongated, deep	elongated, deep
latr. depr. muscle pit	shallow	deep	shallow	deep
pitted surface	no	no	yes	yes
3. TERGUM				
apex	pointed	rounded	rounded	rounded
articular furrow	deep, V-shaped	flat, wide	wide	wide, V-shaped
depress. muscle crests	4	1–3	3–4	3–4
pitted surface	yes	no	yes	yes
4. LABRUM				
shape	flattened	broadly concave	n/g	broadly concave
no. teeth	18–28, central	n/g	n/g	30–40
5. MANDIBLE				
no. major teeth	3(4)	3	3	3
pectinated part	8	9	n/g	4–9
6. MAXILLA I				
surface	prominent lower edge	straight	stepped	stepped
no. notches	2	1	1	1
7. MAXILLA II				
anterior margin	wide notch	concave	n/g	concave
8. CIRRI				
pectinated setae on I or II	no	no	n/g	yes on II
max. no. segments				
cirrus I	8–9	6–9	9–11	7–9
cirrus II	7–9	8–9	11–13	8–11
cirrus III	19	16–19	n/g	20–32
cirrus IV	n/g	19–21	n/g	24–33
cirrus V	n/g	21–22	n/g	27–37
cirrus VI	23	22–23	32–34	29–37
9. PENIS				
setation	sparse	sparse	n/g	sparse
terminal tuft	yes	yes	n/g	yes
10. CAUDAL APPENDAGES	no	n/g	n/g	no

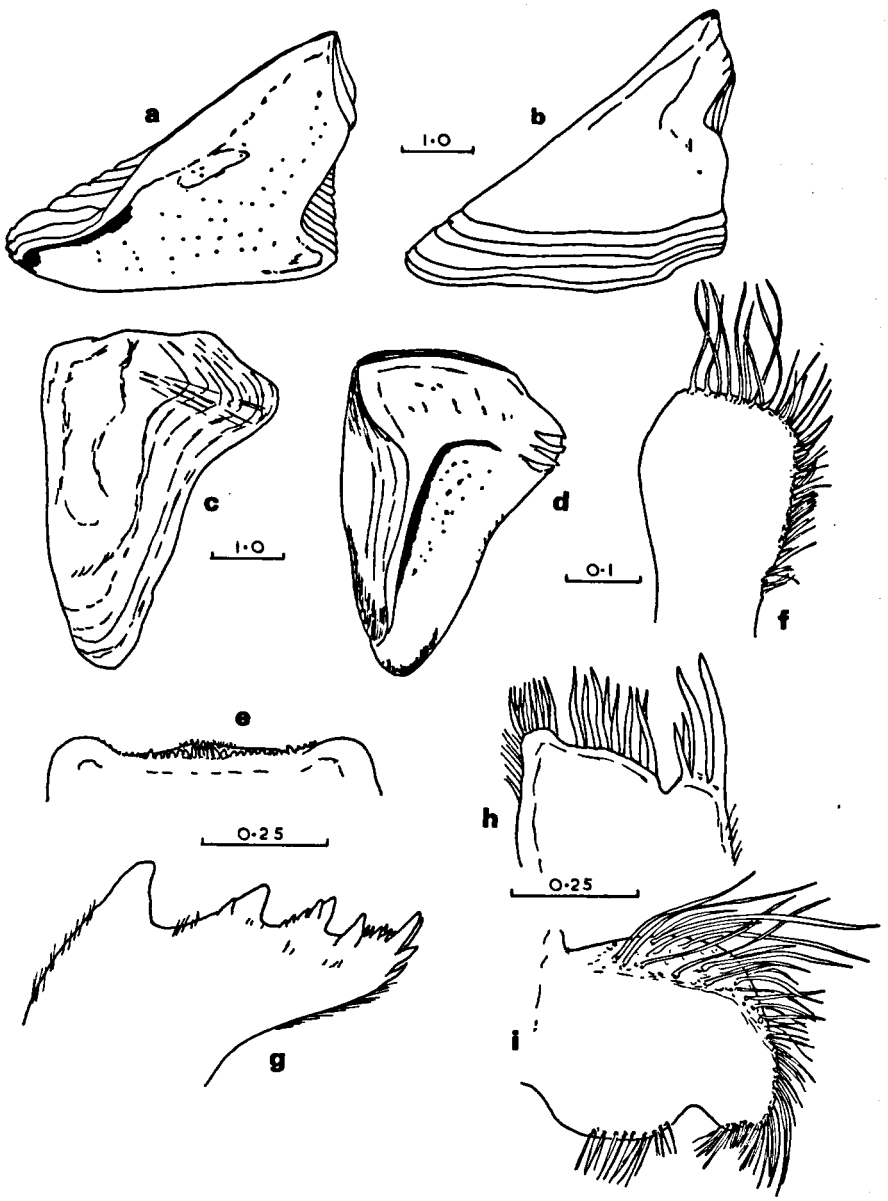

Fig. 16. *Chthamalus rhizophorae*, from Galeta, Panama. a and b – internal and external views of scutum; c and d – external and internal views of tergum; e – labrum; f – labral palp; g – mandible; h – first maxilla; i – second maxilla.

TABLE 6

NUMBERS OF SEGMENTS IN CIRRI OF TWO *Chthamalus rhizophorae* FROM GALETA, PANAMA

CIRRUS	I	II	III	IV	V	VI
1. R.	9/9	8/10	25/27	28/29	28/30	29/31
L.	9/9	9/10	25/26	27/28	30/32	29/19+
2. R.	9/9	10/11	25/26	28/29	32/34	35/36
L.	9/9	10/11	25/26	27/29	33/34	31/39

the straight-edged Trinidad form of *C. rhizophorae* distinguished this species as clearly as the more typical specimens. Further investigation of the variation in shell form of the Trinidad populations of *C. rhizophorae* might show the effects of differing habitats and seasonal growth conditions similar to those found by SANDISON (1962) influencing colour in *B. pallidus* in West Africa.

One of POPE's (1965) early objections to separate specific status for *C. rhizophorae* was that the type, and only, locality for OLIVIERA's species was the port of Rio de Janeiro, to which *C. withersi* could have been transported on ships. The species has now been reported from the Bahamas (ROSS, 1968) and material examined by the author from mangroves on the Atlantic coast of Panama agrees with OLIVIERA's description (1941) and with the Trinidad material. The Galeta, Panama, specimens are illustrated for comparison in Figure 16 and Table 6.

Chthamalus rhizophorae is, therefore, widespread in the western Atlantic in the habitat occupied by *C. aestuarii* in West Africa. Both species occur commonly on mangrove rhizophores whereas *C. withersi* is more often found on rocks and marine pilings (POPE, 1965).

In the Caroni Swamp, *C. rhizophorae* was found only on *R. mangle*, being absent from neighbouring *Avicennia germinans* and *Laguncularia racemosa*. The barnacle was confined to the upper part of the mangrove rhizophores between the mean highest high water level and that of extreme high water of spring tides, a vertical range of approximately 30 cms. *Chthamalus rhizophorae* survived desiccation on the laboratory bench for 30 days, a period in excess of exposure time at low water under natural conditions, and commenced feeding 15 minutes after reimmersion. The *hembeli* group of the genus *Chthamalus*, to which this species is related, is known to be tolerant of desiccation.

The only other species competing for settlement space on the upper part of the roots were the algae *Bostrychia radicans* and *Caloglossa leprieurii* and, on occasions during the dry seasons, *C. bisinuatus*. Because of the general lack of competition, *C. rhizophorae* was extremely abundant throughout the swamp. It was found in the estuaries up to the freshwater limit of *R. mangle*. Laboratory experiments showed that *C. rhizophorae* could survive immersion in salinities from 6 to 40‰. Feeding, ecdysis and spawning behaviour appeared to be unaffected by gradual salinity changes within this range, but released nauplii survived less well at salinities below 10‰.

Family SACCULINIDAE Darwin

Genus **Ptychascus** Boschma

1. **Ptychascus glaber** Boschma

Ptychascus glaber BOSCHMA 1967, p. 311.

On *Sesarma* (*Holometopus*) *miersi*, mouth of Marianne River, Blanchisseuse Bay, Feb. 1966. S. Hill Colln.

STONLEY (1975) considers that *S. miersi* does not occur in Trinidad and that the host crab on which the two specimens of the parasitic barnacle were found is *S.* (*Holometopus*) *americanum* De Saussure.

BACON (1970a) found sacculinid parasites on *Aratus pisoni* in estuaries of the Caroni Swamp and it is possible that these may belong to the genus *Ptychascus*.

DISCUSSION

Trinidad is situated close to the South American mainland at the south eastern end of the Caribbean and could derive its barnacle fauna from both regions. The relationships of this cirripede fauna to that of neighbouring regions is obscured, however, by the fragmentary knowledge of the barnacles of South and Central America.

Table 7 shows the known distribution in the Western Atlantic, from the literature quoted in the bibliography, of 17 of the species collected in Trinidad. *Balanus v. venustus*, which has not been recorded previously in this area, is excluded, as are the species of *Lepas*, *Chelonibia* and *Platylepas* which were attached to floating objects and turtles. *Balanus reticulatus* probably occurs over a wider

TABLE 7

DISTRIBUTION IN THE WESTERN ATLANTIC OF 17 SPECIES OF CIRRIPEDES RECORDED IN TRINIDAD

SPECIES	Faunal Province			
	Eastern U.S.A. (N. Carolina – Florida)	Gulf of Mexico	Caribbean	Eastern S. America (Guyana – Brazil)
B. eburneus	×	×	×	×
B. i. assimilis	×	×	×	×
B. a. amphitrite	×	×	×	×
B. trigonus	×	×	×	×
T. stalactifera	×	×	×	×
B. calidus	×	×	×	·
B. galeatus	×	×	×	·
N. radiata	·	×	×	·
C. angustitergum	·	×	×	·
C. bisinuatus	·	×	×	×
O. hirtae	·	·	×	·
B. reticulatus	·	·	×	·
T. divisa	·	·	×	·
C. quarta	·	·	×	·
B. t. antillensis	·	·	×	×
B. pallidus	·	·	×	×
C. rhizophorae	·	·	×	×

area than shown, as its abundance and wide habitat tolerance in Trinidad suggest, but is has been confused previously with other species of the *Balanus amphitrite*-complex (UTINOMI, 1967) so that the distribution data are unsatisfactory. There are many reports of *C. fragilis* from northern South America and the West Indies which almost certainly refer to *C. bisinuatus*, such as the recent report of this species in Colombia and Venezuela (ZEVINA, 1975). SOUTHWARD (1975) considers that *C. fragilis* does not occur south of Florida and has extended the range of the South American species *C. bisinuatus*, once thought to be uncommon north of Brazil. Similarly, *B. calidus* may occur further south than Trinidad, where it is now reported, as STUBBINGS (1967) considers that some tropical American material recorded as *B. spongicola* Brown should be assigned to this species. Further work on the commensal and deep water cirripedes of the

region might extend the known range of *C. quarta* and *O. hirtae*, although these are limited by their association with corals and antipatharians.

Table 7 shows that 17 of the species found in Trinidad occur in other parts of the Caribbean, 9 of these are reportgd in eastern South America and 7 from the eastern United States. Five of the species are found from Florida to Brasil and none of them is confined to either North or South America. From a comparison of the barnacles of the Carolinian, Gulf of Mexican and West Indian faunal provinces, ZULLO (1966) found a continuity between the three regions and suggested that there was little possibility of recognising provincial elements. It would appear from Table 7 that this continuity extends to eastern South America also. If, as ZEVINA (1975) has concluded, cirripede distribution in the Caribbean region is determined mainly by migration in ocean currents, the direction of flow of the major currents in the tropical western Atlantic would account for the close similarities in the cirripede faunas of South America, the Caribbean, Gulf of Mexico and the eastern U.S.A., and also for the slightly greater number of South American barnacle species in Trinidad.

Although ZEVINA (1975) found no connection between the cirripedes of both sides of the Panama Isthmus, *B. galeatus* has been collected in the eastern Pacific (PILSBRY, 1907; HENRY, 1954). As in Trinidad, it is known only sub-tidally, suggesting an older deep water fauna common to both areas. The clearer affinities with the Old World fauna are supported by the occurrence around Trinidad of *B. a. amphitrite*, *B. v. venustus* and *B. pallidus*. The latter has been reported also from scattered localities in northern South America (SOUTHWARD, 1975; ZEVINA, 1975) and Brazil (STUBBINGS, 1967) and its occurrence in Trinidad mainly on driftwood suggests a possible means of dispersal to the area.

The Trinidad cirripede fauna has affinities, therefore, with that of the whole tropical and sub-tropical Atlantic. When considering barnacle distribution, DARWIN (1854) proposed a North Atlantic cirripede province but thought that "even the West Indies, the coast of Brazil, and equatorial West Africa might have been added". The collections described here give further support to this view.

The importance of shipping serving Port of Spain and the Trinidad oil fields cannot be overlooked, however, in discussions of local cirripede geography. Pacific varieties of *B. tintinnabulum* may be present with *B. t. antillensis* in the Gulf of Paria, and according to SOUTHWARD (1975) the Old World species, *B. a. amphitrite*, may be a recent ship-borne introduction to Trinidad. The survival of introduced species, or immigrants from neighbouring regions, depends on the availability of suitable habitat. Some cirripedes showed specific substratum or host requirements, while others appeared to have adapted to a variety of habitats. *Chthamalus rhizophorae*, for example, was found only on red mangrove rhizophores. The reasons for this substratum preference are unknown and require further investigation, as does the effect of colonisation of mangroves on the shell form of *C. bisinuatus*. Differences in cirral setation between rock and mangrove dwelling populations of Caribbean chthamalids have been noted by SOUTHWARD (1975). These are probably related to the sheltered conditions under which the mangroves grow than to the special nature of the substratum.

Although *C. quarta* was abundant in the reef corals, *Boscia madreporarum* (Bosc.) was not found, even though it was reported from Klein Bonaire by SOUTHWARD (1975) and its normal host occurs in Trinidad. *Boscia* may not be able to survive under the low salinity conditions experienced by *C. quarta* at some seasons on the north coast of Trinidad. A distinct estuarine or brackish water cirripede fauna has been reported for other areas (OLIVIERA, 1940; SMITH *et al*, 1950; TABB & MANNING, 1961; WELLS, 1966) which includes *B. eburneus*, *B. i. assimilis* and *B. a. amphitrite*. These species, together with *C. rhizophorae*, dominate estuaries in Trinidad, although they are not confined to them. Although *B. pallidus* is abundant in brackish waters in West Africa, it does not appear to have displaced *B. eburneus* from this habitat in Trinidad or in adjacent regions which would indicate that it is a recent arrival in the western Atlantic. Brackish water cirripedes are common in Trinidad but it is of interest that in the predominately low salinity environment of this island more typically marine, open coast species are present also. Some are able to survive in deeper water where salinities approach oceanic values, but the inter-tidal species, *B. reticulatus*, *T. sta-*

lactifera, *T. divisa*, *C. angustitergum* and *C. bisinuatus*, must tolerate a wider salinity range with rapid salinity changes.

The successful adaptation of species not normally found in estuaries to a variety of substrata under brackish water conditions indicates that the number of barnacle species which occur in Trinidad is not related entirely to the types of habitat available. The composition of the fauna must be determined largely, therefore, by the ability of individual species to migrate to the island from neighbouring regions.

REFERENCES

ANDEL, Tj. VAN & POSTMA, H., 1954. Recent sediments of the Gulf of Paria. Reports of the Orinoco Shelf Expedition, I. *Verh. Kon. Ned. Akad. Wetensch. 20* (5): 240 pp.

AURIVILLIUS, C. W. S., 1894. Studien über Cirripeden I. Morphologie und Systematik neuer oder wenig bekannter Cirripeden. *Kon. Svenska Vetensk. Akad. Handl. 26* (7): 38–41.

BACON, P. R., 1970a. *The ecology of Caroni Swamp, Trinidad.* Spec. Publ. Central Stats. Office, 68 pp.

BACON, P. R., 1970b. Studies on the biology and cultivation of the mangrove oyster in Trinidad with notes on the other shellfish resources. *Tropical Science 12* (4): 265–278.

BACON, P. R., 1970c. Studies on the Leatherback Turtle, Dermochelys coriacea (L.), in Trinidad, West Indies. *Biological Conservation 2* (3): 213–217.

BACON, P. R., 1971a. Plankton studies in a Caribbean estuarine environment. *Carib. J. Sci. 2* (1–2): 81–89.

BACON, P. R., 1971b. The maintenance of a resident population of Balanus eburneus (Gould) in relation to salinity fluctuations in a Trinidad mangrove swamp. *J. Exp. Mar. Biol. Ecol. 6*: 187–198.

BOSCHMA, H., 1967. On two specimens of the rhizocephalan parasite Ptychascus glaber Boschma from the island of Trinidad. *Proc. Kon. Ned. Akad. Wetensch.* (C) 70 (3): 321–323.

DARWIN, C., 1851. *A monograph of the sub-class Cirripedia. The Lepadidae; or pedunculated cirripedes.* Ray Society, London, 400 pp.

DARWIN, C., 1854. *A monograph of the sub-class Cirripedia. The Balanidae* etc. Ray Society, London, 684 pp.

DES MOULINS, C., 1866. Liste des principaux fossiles receuillis par les membres de la Société a Cazeneuve dans le Calcaire de Bazas pendent l'excursion de la 50e Fête Linnéenne. *Actes Soc. Linn. Bordeaux 26* (3) 6: 293–344.

GADE, H. G., 1961. On some oceanographic observations in the Southeastern Caribbean Sea and the adjacent Atlantic Ocean with special reference to the influence of the Orinoco River. *Bol. Inst. Oceanogr. Univ. Oriente. 1* (2): 287–342.

GERLACH, S. A., 1958. Die Mangroveregion tropischer Küsten als Lebensraum. *Ztschr. Morph. Oekol. Tiere 46*: 636–730.

GRAVE, B. H., 1933. Rate of growth, age at sexual maturity, and duration of life of certain sessile organisms, at Woods Hole, Massachusetts. *Biol. Bull. Mar. Biol. Lab. Woods Hole. 65*: 375–386.

HARDING, J. P., 1962. Darwins type specimens of varieties of Balanus amphitrite. *Bull. Brit. Mus. (N.H.) Zool. 9* (79): 273–296.

HENRY, D. P., 1954. Cirripedia: The barnacles of the Gulf of Mexico. In GALTSOFF, ed. *The Gulf of Mexico: its origin, waters, and marine life.* Fish. Bull. U.S. Fish. Wildl. Serv. *55* (89): 443–446.

HENRY, D. P., 1958. Intertidal barnacles of Bermuda. *J. Mar. Res. 17*: 215–234.

HENRY, D. P., 1973. Descriptions of four new species of the Balanus amphitrite-complex (Cirripedia, Thoracica). *Bull. Mar. Sci. Gulf & Carib. 23* (4): 964–1001.

HOLTHUIS, L. B., 1969. Enkele interessante Nederlandse Crustacea. *Zool. Bijdr. Leiden 11*: 34–48.

HUGHES, G. R., 1974. The sea turtles of South-East Africa. II. The biology of the Tongaland loggerhead turtle, Caretta caretta L. *Invest. Report 36, Oceanogr. Res. Inst. S. African Assoc. Mar. Biol. Research*: 1–96.

KOLOSVÁRY, G. VON, 1939. Ueber die Variabilität der Cirripedien-Unterart C. stellatus stellatus (Poli). *Zool. Anz. 127*: 159–169.

KOLOSVÁRY, G., 1947. A study of the cirripedes associated with corals in the collection of the Hungarian National Museum. *Proc. Zool. Soc. Lond. 117* (2–3): 425–428.

LONGHURST, A. R., 1958. An ecological survey of the West African marine benthos. *Colonial Office, Fish. Publ. 11*: 1–20.

MCCANN, C., 1969. First Southern Hemisphere record of the platylepadine barnacle Stomatolepas elegans (Costa) and notes on the host Dermochelys coriacea (L.). *New Zealand J. Mar. Freshw. Res. 3*: 152–158.

MCDOUGALL, K. D., 1943. Sessile marine invertebrates of Beaufort, North Carolina. *Ecol. Monogr. 13:* 321–374.

MOORE, H. B. & FRUE, A. C., 1959. The settlement and growth of Balanus improvisus, B. eburneus and B. amphitrite in the Miami area. *Bull. Mar. Sci. Gulf & Caribb. 9*: 421–440.

NEWMANN, W. A. & LADD, H. S., 1974. Origin of coral-inhabiting Balanids (Cirripedia, Thoracica). *Verh. Natur. Gesell. Basel. 84* (1): 381–398.

NILSSON-CANTELL, C. A., 1928. Studies on cirripeds in the British Museum (Nat. Hist.). *Ann. Mag. Nat. Hist. 10* (2): 1–39.

NILSSON-CANTELL, C. A., 1933. Cirripedes from Bonaire. *Zool. Jahr. (Syst.). 64*: 503–508.

NILSSON-CANTELL, C. A., 1939. Recent and fossil balanids from the north coast of South America. *Cap. Zool. 8* (4^3): 1–7.

OLIVIERA, L. P. H. DE, 1940. Sobra uma nova especie de Crustacea Chthamalus rhizophorae n. sp. (Chthamalidae: Cirripedia). *Mem. Inst. Oswaldo Cruz. 35*: 379–380.

OLIVIERA, L. P. H. DE, 1941. Contribuição ao conhecimento dos crustáceos do Rio de Janeiro, subordem "Balanomorpha" (Cirripédia: Thoracica). *Mem. Inst. Oswaldo Cruz. 36*: 1–31.

OLIVIERA, L. P. H. DE, 1953. Levantamento biogeográfico de Baía de Guanabara. 11. Crescimento do manguezal na Ilha do Pinheiro. *Mem. Inst. Oswaldo Cruz. 51*: 503–524.

PILSBRY, H. A., 1907a. Hawaiian and west American cirripedes. *Bull. Bureau of Fisheries. 26*: 179–204.

PILSBRY, H. A., 1907b. The barnacles (Cirripedia) contained in the collections of the U.S. National Museum. *Bull. U.S. natn. Mus. 60*: 122 pp.

PILSBRY, H. A., 1916. The sessile barnacles (Cirripedia) contained in the collections of the U.S. National Museum; including a monograph of the American species. *Bull. U.S. natn. Mus. 93*: 366 pp.

PILSBRY, H. A., 1927. Cirripedia of Curaçao. *Bijdr. Dierk. 25*: 37–38.

PILSBRY, H. A., 1931. The cirriped genus Pyrgoma in American waters. *Proc. Acad. Nat. Sci. Philad. 83*: 81–83.

PILSBRY, H. A., 1953. Notes on Floridan barnacles (Cirripedia). *Proc. Acad. Nat. Sci. Philad. 105*: 13–28.

POPE, E. C. A., 1965. A review of Australian and some Indo-Malayan Chthamalidae (Crustacea: Cirripedia). *Proc. Linn. Soc. N.S.W. 90:* 10–77.

ROSS, A., 1968. Bredin-Archbold-Smithsonian Biological Survey of Dominica, 8 The intertidal balanomorph Cirripedia. *Proc. U.S. natn. Mus. 125* (3663): 1–22.

ROSS, A., 1969. Studies on the Tetraclitidae (Cirripedia: Thoracica). Revision of Tetraclita. *San Diego Soc. Nat. Hist. Trans. 15* (15): 237–251.

ROSS, A. & NEWMANN, W. A., 1973. Revision of the coral-inhabiting barnacles (Cirripedia, Balanidae). *San Diego Soc. Nat. Hist. Trans. 17* (12): 137–173.

SANDISON, E. E., 1962. The populations of Balanus amphitrite var. stutsburi on the Guinea Coast. *Proc. Zool. Soc. Lond. 138*: 517–542.

SMITH, F. G. W. & WILLIAMS, R. H. & DAVIS, C. C., 1950. An ecological survey of the subtropical inshore waters adjacent to Miami. *Ecology 31* (1): 119–146.

SOUTHWARD, A. J., 1962. On the behaviour of barnacles. IV. The influence of temperature on cirral activity and survival of some warm water species. *J. Mar. Biol. Assoc. U.K. 42*: 163–177.

SOUTHWARD, A. J., 1975. Intertidal and shallow water Cirripedia of the Caribbean. *Studies on the Fauna of Curaçao 46*: 1–53.

STONLEY, J. M., 1975. *A monograph of the crabs of Trinidad.* M.Sc. Thesis of the University of the West Indies, Trinidad, 402 pp.

STUBBINGS, H. G., 1963. Cirripedia of the tropical South Atlantic coast of Africa. *Expéd. Oceanogr. Belge Eaux Cotières africaines de L'Atlantique Sud (1948–1949), Res. Sci. 3* (10): 1–39.

STUBBINGS, H. G., 1967. The cirripede fauna of tropical West Africa. *Bull. Brit. Mus. (Nat. Hist.) 15* (6): 229–319.

TABB, D. C. & MANNING, R. B., 1961. A checklist of the fauna and flora of Northern Florida Bay. *Bull. Mar. Sci. Gulf & Caribb. 2* (4): 552–649.

TOTTON, A. K., 1940. New species of the cirripede genus Oxynaspis commensal with antipatharians. *Ann. Mag. Nat. Hist. Ser. (2) 6*: 465–486.

UTINOMI, H., 1967. Comments on some new and already known cirripedes with amended taxa, with special reference to parietal structure. *Publ. Seto. Marine Biol. Lab. 15* (3): 199–236.

WELLS, H. W., 1966. Barnacles of the north eastern Gulf of Mexico. *Quart. Journ. Florida Acad. Sci. 29* (2): 81–95.

WERNER, W. E., 1967. The distribution and ecology of the barnacle Balanus trigonus. *Bull. Mar. Sci. Gulf & Caribb. 17*: 64–84.

ZEVINA, G., 1975. Thoracic Cirripedia of the American mediterranean. *Trudy Inst. Okeanol. 100*: 233–258.

ZULLO, V. A., 1966. Thoracic cirripedia from the continental shelf of Southern Carolina, U.S.A. *Crustaceana, 2*: 229–244.

ZULLO, V. A. & BEACH, D. B. & CARLTON, J. T., 1972. New barnacle records (Cirripedia; Thoracica). *Proc. Calif. Acad. Sci.* (*4*) *39* (6): 65–74.