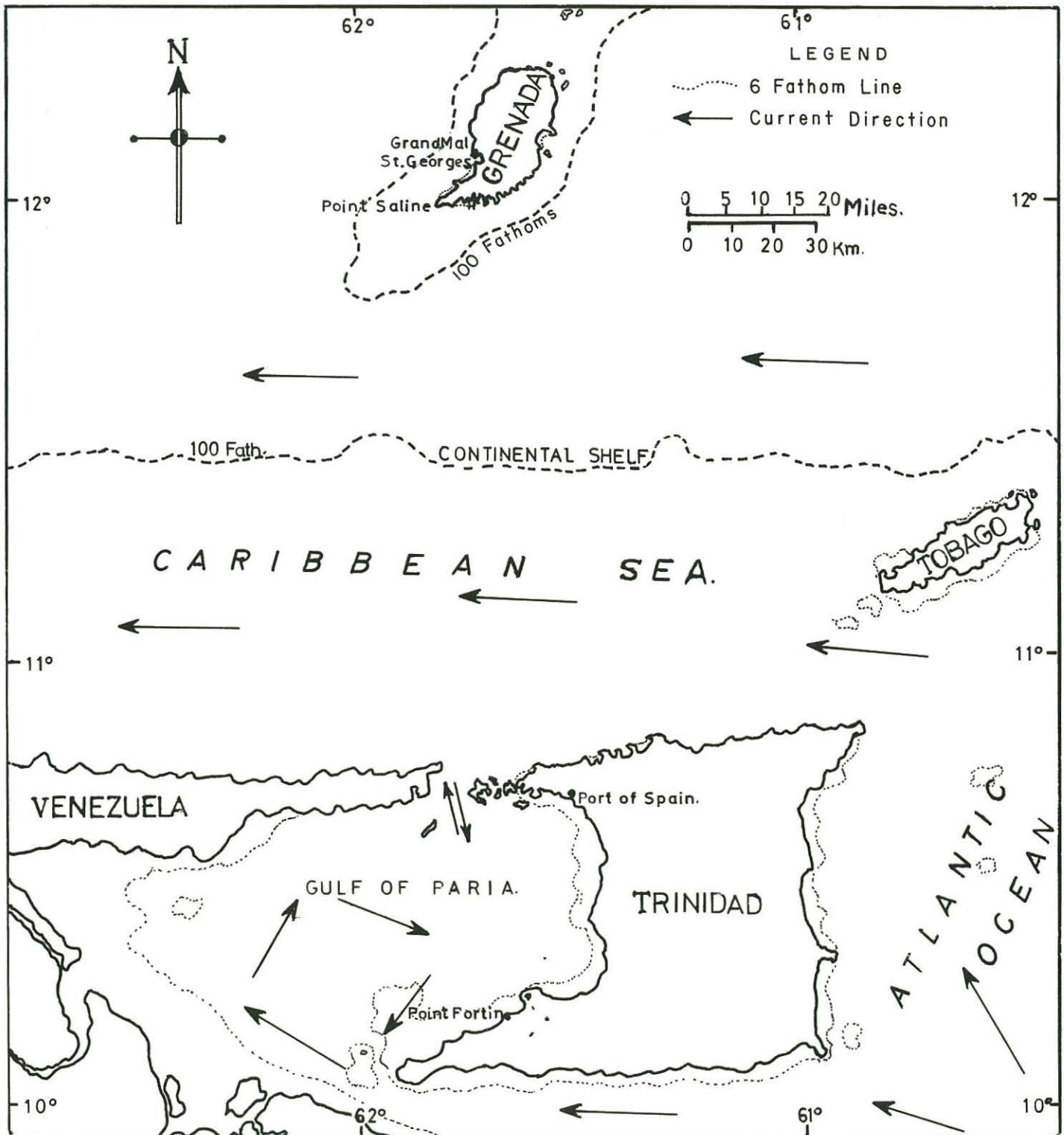


A comparison of the *Strombus* (Mollusca) colonies of Trinidad and Grenada

Figure 1. Map of southern Caribbean Sea.



ABSTRACT

UNDERWATER observations on the genus *Strombus* around the coasts of Trinidad and Grenada show that the same species are common to the two areas but that they are today living under very different conditions. Grenada is surrounded by clear, oceanic water which supports the growth of reef corals while Trinidad, being close to the South American continent and the mouths of the Orinoco River, is surrounded by continental water of variable salinity and carrying much suspended material. In addition, the water at 100 feet depth on the north coast of Trinidad was found to be some 15° F. colder than it is off Grenada due to cold upwelling in the former case. Deep water and strong ocean currents effectively separate *Strombus* colonies in the two islands which lie 90 miles apart.

The ecological differences as they affect the five species involved include the discovery that there is a tendency for colonies to be found considerably deeper in Grenada where the higher water temperatures and better light penetration allow this. Habitat differences illustrated by this study of *Strombus* species point to the care necessary in drawing paleoecological conclusions by extrapolation from the Recent to fossil forms.

INTRODUCTION

It is now recognized that species and aggregations of molluscs which normally are to be found in habitats associated with coral reefs and clear oceanic waters can also be found in habitats on adjacent coasts or around islands situated close to continental areas. These continental waters are rich in suspended terrigenous and nitrogenous material.

Grenada represents a habitat area of clear oceanic water whilst Trinidad is typical of an offshore island with a continental water system.

The islands of Trinidad and Grenada are situated in the southeastern sector of the Caribbean Sea (Fig. 1). Trinidad is the larger island, being 1,864 sq. miles in area, and lies just off the Venezuelan coast.

Trinidad is situated on the continental shelf of South America. The smaller island of Grenada, 120 sq. miles, lies almost ninety miles due north of Trinidad and is separated from the continental shelf, by a 20-mile-wide, deep water channel, 400–500 fathoms in depth (732–914 m). Grenada is mainly of volcanic origin, situated at the southern end of an island chain, whilst Trinidad consists predominantly of Mesozoic and Tertiary sands, clays and shale of continental origin. The waters separating these two islands are strongly influenced by the South Equatorial Current, which sets to the west with an almost constant velocity of 1½–3 knots.

Around the coasts of Trinidad, the waters are often laden with clay and silt; also the salinity varies considerably with the season, owing to the close proximity of the numerous mouths of the Orinoco River system. In consequence, coral reefs are only found near the sister island of Tobago, 18 miles to the northeast of Trinidad. However, small patches of corals do exist around the coasts of Trinidad, and in the past these were quite extensive, as revealed by dredging at Pointe-a-Pierre and Chaguaramas in the Gulf of Paria.

Grenada possesses many areas of both shallow water and deep water coral reefs and many patches of coral heads are to be found off all the coasts of the island. In deeper water the bottom material is a calcareous mud with many areas of coral rubble and grit.

Trinidad has a rich marine molluscan fauna and Grenada is also quite rich with several rare species being reported collected.

In two previous papers on the *Strombus* species of Trinidad and Tobago, the author reported in detail on the ecology, behaviour and habitats of these species (Percharde 1968, 1970).

In July 1972, the author was able to carry out an extensive

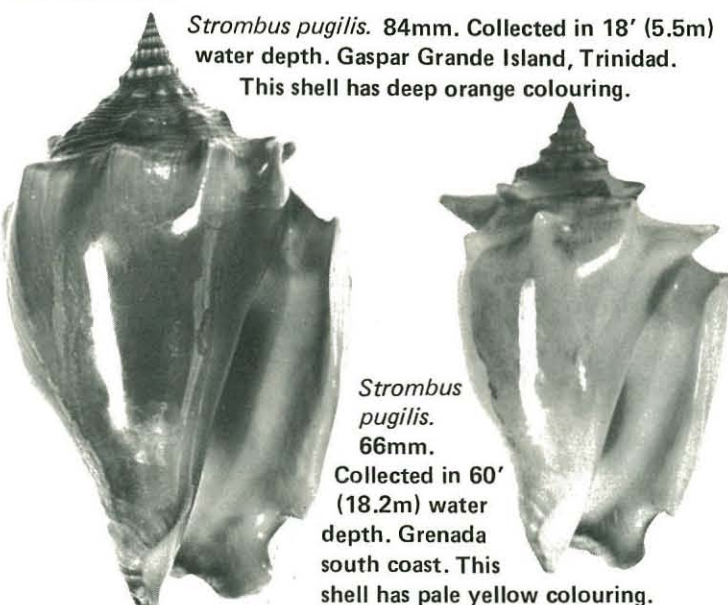
diving survey in the waters of Grenada. Observations made on the *Strombus* colonies and on individual specimens collected, revealed considerable differences in shell morphology, habitat and depth range, as compared to specimens from Trinidad. On the observations made, it is considered by the author that although separated by only eighty to ninety miles, these two molluscan faunas appear to have very little relationship to each other and must have been separated for a considerable period, if indeed any closer relationship or shallow water connection has ever existed between the two.

To the palaeontologist, who uses fossil molluscs as stratigraphic indicators, it is important to be able to relate palaeoecological information to the ecology and behaviour of Recent forms, especially when the depth range of a species is being determined.

This study reveals that considerable variation in shell morphology and depth range of habitat can exist in the same species of molluscs living in these two differing environmental areas.

The Genus *Strombus* in the Caribbean

Of the five widely distributed species of *Strombus* in the Western Atlantic, all five can be found in colonies, small groups or as single individual specimens in both Trinidad and Grenada. These are *Strombus pugilis* Linne, *S. raninus* Gmelin, *S. costatus* Gmelin, *S. gigas* Linne, *S. gallus* Linne. There are also unconfirmed reports of specimens of the endemic Brazilian species *S. goliath* Schroter being found off the south coast of Grenada; the author received this information from conch fishermen divers in Grenada. It is significant that in this same area, the author has collected specimens of the Brazilian species — *Fasciolaria aurantiaca* Lamarck. Neither of these two species has been found in Trinidad waters.



Strombus pugilis

This bright orange, colonial gastropod has been studied in some detail in Trinidad waters by the author, who did not expect to find it in Grenada. However, during dives in the deeply indented bays on the south coast of Grenada, small colonies of *S. pugilis* were found and observed living on a calcareous mud bottom in several locations. Off Calivigny Island and Fort Jeudy small colonies were observed. All specimens were a pale yellow colour as compared to the orange colouration of specimens from Trinidad. They were on average smaller and possessed longer shoulder spines than Trinidad specimens.

The depth range of their habitats was 50–60 feet (15.2m–18.2m) as compared to 20–35 feet (6.1m–10.7m) in Trinidad. All the specimens examined were very active and extensive tracks were found in the substrate of their habitat areas. No specimens were found to be buried and no specimens were observed engaged in oviposition. There were larger patches of algae grow-

ing on the substrate in the habitat areas and the clear water allowed a much better penetration of sunlight, even at this increased depth.

Strombus raninus

This species, which is the most widely distributed and possibly the most adaptable species of the genus in Trinidad waters, was also found in several locations in Grenada. Specimens were collected at Grand Mal Bay on the west coast from both deep water (100 ft., 30.4 m) and shallow locations (15ft., 4.6m) also from several locations on the south coast. No colonies were observed, but a young form with a new thin lip was collected by M.R. Percharde in Grand Mal Bay whilst diving.

One morphological feature was immediately apparent in all the *S. raninus* shells observed and examined in Grenada, as compared to specimens from Trinidad; this was the marked attenuation of the second shoulder, or dorsal spine on all the adult forms (see fig.). Also, the parietal wall of the aperture on many specimens was a bright red, not pink or salmon colour. The spires of most of the specimens examined were quite smooth and lacked the small nodules and varice like ridges of Trinidad specimens. It is considered that that species is not as common in Grenada as it is in Trinidad. In none of the areas examined by the author whilst diving, were any red algae found in Grenada. This red alga is a feature of the habitat areas of *S. raninus* here in Trinidad waters.

Strombus costatus

In Trinidad, this medium-sized member of the genus is very rarely found in true colonies and as mentioned in previous papers on *Strombus* it is usually a shallow water, sand or grit substrate dweller. Consequently, it was with considerable surprise that the author found a very large colony in 120 — 130 feet (36.5 — 39.5m) of water in Grand Mal Bay off the west coast of Grenada. The individuals were all found on a calcareous mud bottom in a deep inlet between two coral reefs. The visibility at this depth was very good and although the author was restricted to a bottom time of twelve minutes on each dive, it was found by counting the specimens comprising the colony, that at least 100 + specimens were living in this habitat area.

Tracks and occasional specimens of *S. costatus* were still being observed when the author was forced to turn back, owing to increasing depth and rising decompression meter reading. Six of the larger and most perfect specimens were collected and whilst cleaning them, the author noted with interest that they comprised three males and three females. In comparison with specimens from Trinidad, they were all much larger and much heavier.

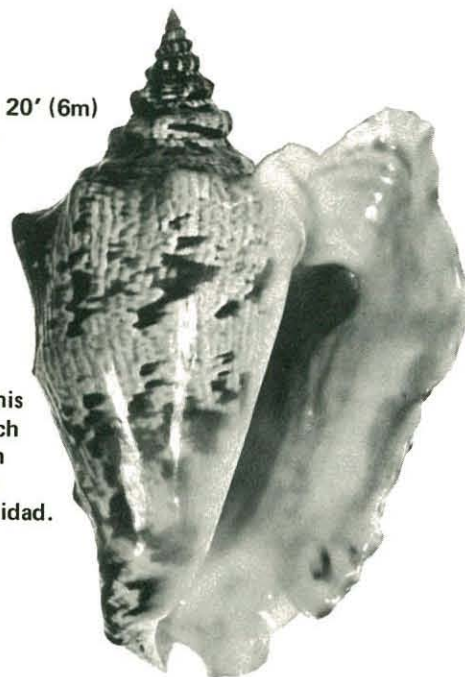
The shells were all in a very good condition, with no growth, barnacles or borer damage whatsoever. Whilst removing the molluscs from their shells, it was also observed that all the opercular "claws" were in perfect condition and unworn, whilst the length and volume of the musculature of the foot appeared to be much greater than in specimens from Trinidad.

Most of the shells possessed the grey aluminium-like glaze of old age on the outer lip and parietal wall of the aperture, but the spires and early whorls were flecked with brown pattern and coloured pink or purple-rose. All references concerning *S. costatus* consider it as a shallow-water species, e.g. Clench and Abbott (1941), Warmke and Abbot (1961). It is now obvious to the author that this species is capable of considerable depth range, possibly depending on water temperature, light penetration of the water and substrate conditions. In Trinidad this species has not been observed below 25 feet (7.6m) and never on a mud substrate.

Strombus gigas

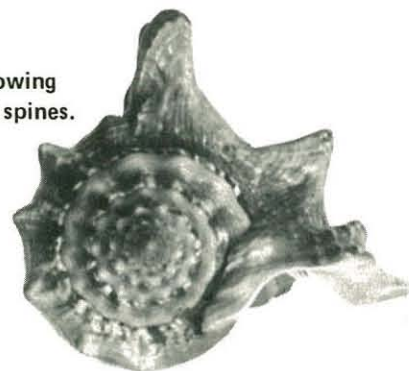
This large edible gastropod is found and fished in very large numbers in the waters of Grenada. It is a source of protein food and in the past the empty shells were stacked up and burnt to form cement. The local conch fishermen call this species "Lambi". This term must have originated from the French early colonists of the island, as today no one appeared to know that

Strombus raninus.
95mm. Collected in 20' (6m)
water depth. North
Coast of Trinidad.



Apertural view
showing typical
nodular spire and
varice-like ridges. This
latter feature is much
more pronounced in
specimens from the
South Coast of Trinidad.

Apical view showing
enlarged dorsal spines.

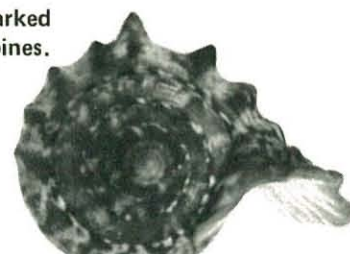


Strombus raninus. 85mm.
Collected in 60' (18m)
water depth. West
coast of Grenada.



Apertural view
showing smooth spire
and bright red
aperture.

Apical view showing marked
attenuation of dorsal spines.



Lambis is the generic name of the Indo-Pacific group of large stromboids. The fishermen call large juveniles "Picket Lambi" and the full adults "Wing Lambi". They do not consider them to be the same species. It is significant that due to the very heavy predation by man and other predators on the adult form most adults are now only found in much deeper water.

Adults were found in large numbers in 70 — 100 feet (21.4 — 30.4m) of water off the south coast and off Point Saline to the west. It is, however, impossible to dive anywhere in the waters of Grenada without finding living or dead specimens of this species; both in deep and shallow water. Most of the adult specimens examined were different from Trinidad specimens. All possessed much longer shoulder spines. In some specimens, the spines on the spire were long and the shoulder spines were quite thick. Jung (1971) reported a fossil species of *Strombus gigas* from the Bowden Formation in Jamaica. Many of the specimens examined in deep water in Grenada were very similar to this form figured by Jung.

The Grenada specimens are much paler in colour even in the living forms. The aperture lacks the purple pinks and the deep colour of the Trinidad specimens. In many specimens the outer lip is a pale yellow without any pink colouration. None of the specimens examined was encrusted with barnacles as many Trinidad specimens are. Many shells of both adult and juvenile forms were observed being utilized by hermit-crabs. These shells were usually pitted by *Cliona* sp. sponge borers and other borers.

Although *S. gigas* is found in large numbers in most of the Caribbean coral water areas, according to P. Jung, they are quite rare in the fossil record. This may be due to the activities of certain species of hermit-crabs. As soon as a fresh shell is available, owing to the death of the mollusc, a hermit-crab will soon occupy the empty shell and transport it down into deep water. Once a shell is occupied by one of these large crustaceans there appears to be some form of attraction or chemical signal which attracts boring and encrusting organisms. Many shells collected and examined by the author in deep water were found to be so badly perforated by molluscan borers as *Cliona* sp. that they had been abandoned by the crustacean, leaving the typical internal erosion marks due to their occupancy. The riddled shell would then soon crumble and decompose, leaving it unlikely to be preserved by fossilization.

Several dead adult shells were observed in shallow water, in the *Thalassia* grass beds occupied by the small cephalopod — *Octopus hummerlincki* Adam. Very small juveniles were only found dead shells in the grass beds, but down the slopes many living small juveniles were found buried in the calcareous grit. It is believed that they emerge at night time to feed. In Trinidad, most female *S. gigas* lay eggs during the latter part of June. No specimens were observed laying eggs and no folded strings of eggs were observed in any of the habitat areas in Grenada.

The total number of specimens of *S. gigas* in Trinidad waters is insignificant when compared with the very large numbers which abound in the waters of Grenada. However, the differing ecological conditions which prevail in Grenada allow colonies of adult *S. gigas* to migrate into deeper water and thus escape the heavy predation by conch fishermen and other predators. Over-collecting by SCUBA divers of the small colonies in Trinidad waters has already had a disastrous effect, as the remaining adults are unable to migrate into deeper water due to two factors — much lower temperatures below 30 feet (9.1m) and much less light penetration of the water. In Tobago the situation is better, but the colonies have been over collected by conch fishermen.

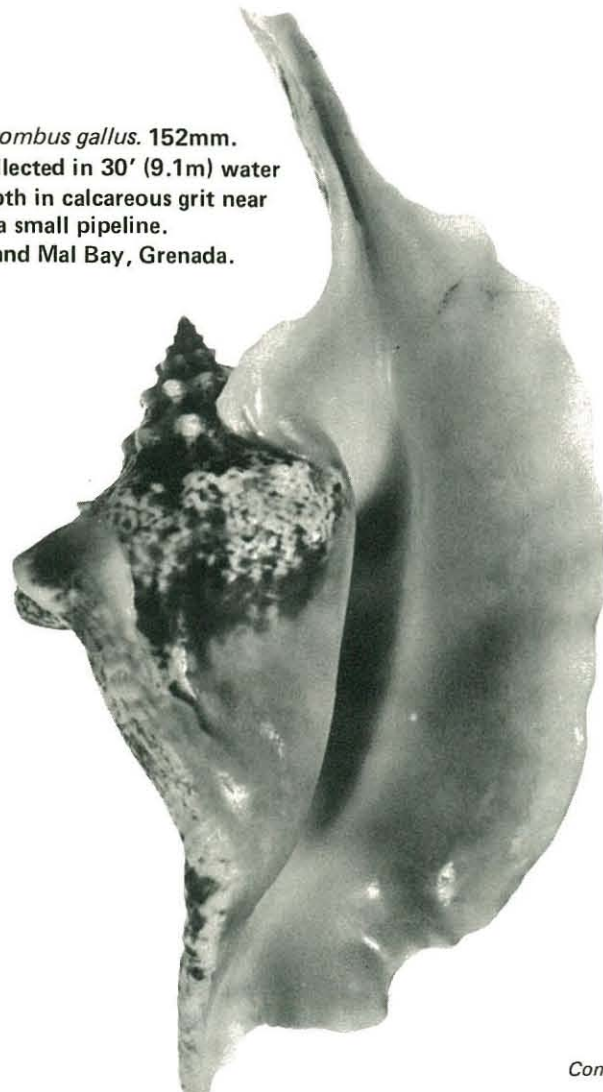
Strombus gallus

Since the publication of the author's first two papers on *Strombus* species (1968 and 1970), a fine specimen of this fairly rare species has been found by the author near a submarine pipeline in the outer harbour at Point Fortin, Trinidad. Whilst exploring the reef areas in Grand Mal Bay, Grenada, the author was again fortunate in collecting another magnificent specimen of this

Strombus gallus. 133mm. Found near a large submarine pipeline, in gritty silt in 50' (15.2m) water depth, Point Fortin, Trinidad.



Strombus gallus. 152mm. Collected in 30' (9.1m) water depth in calcareous grit near to a small pipeline. Grand Mal Bay, Grenada.



species. Although the animal was dead when collected, the shell was in perfect condition with both anterior and posterior siphon extensions of the lip being well preserved and almost fantastically elongated. The shell was found in coarse calcareous grit near to large reef coral heads. Lengthy searching through this grit failed to reveal any additional specimens or any other species of molluscs.

There is a great difference between the Point Fortin specimen and the Grenada specimen (Fig 3). The Point Fortin specimen is much closer in form to *S. raninus* although the wing extension of the lip at the posterior end is very well developed. The Grenada specimen is much more unusual and closely resembles the almost stylized form figured in Swainson's Exotic Conchology.

It is an interesting coincidence that Grand Mal Bay is also a tanker terminal and an oil pipeline was lying on the sea bed only 14 feet from the resting place of the shell.

Although the finding of this specimen is of interest, the author is still unable to determine the true habitat of this species. Three specimens have now been collected in Trinidad; two in grit at 35 feet (10.7 m) depth and one in silt at 50 feet (15.2 m). Two or three specimens have been collected in Tobago all in grit at 35 feet (10.7 m) depth. The specimen from Grenada was dead, collected in grit at 30 feet (9.1 m). It is possible that this species spend most of its life buried in fine grit or slit under the eaves of rocks hence the extension of the siphons on the shell lip. The difficulty of finding or dredging it from such locations may make it seem rarer than it really is.

General observations on the marine environment and the molluscan fauna of Grenada

Large molluscs appear to be very common in the waters of Grenada. The water temperature at 100 feet (30.4 m) was 79° F (26.1° C) whereas in Trinidad, owing to upwelling along the north coast and in the Bocas, the temperature is often 62° — 64° F (16.7° C — 17.8° C) at this depth. The water is much clearer, although at times during rough weather sand and calcareous silt can cause cloudy conditions inshore. Many species of echinoids abound in these waters. *Diadema antillarum*, *Tripneustes*, *Echinocardium* and *Spatangus* are very common.

In consequence, the gastropods *Cassis tuberosa*, *C. madagascariensis* and *Charonia variegata* are quite common (Hughes and Hughes 1971). In the *Thalassia* grass beds *Voluta musica* and *Chione paphia* are quite common, buried in the grit between the roots of the *Thalassia* grass. Very large specimens of *Spondylus americanus* and *Spondylus avicularis* can be found off the south coast and in the harbour at St. Georges. *Conus* and *Cypraea* are not as common as in Trinidad waters.

DISCUSSION

Comparison has been made between the genus *Strombus* from Trinidad and from Grenada. There appears to be little relationship between the two molluscan faunas. Differing environmental and ecological conditions plus a strong current running to the west separating the two islands is effective in isolating the two faunas from each other. Of the five species of the genus *Strombus* compared, all show differences in shell morphology and depth range of habitat.

The specimens in Grenada on average appear to live in much deeper water than in Trinidad. R. Tucker Abbott's division of the Stromboids into "Continental Water" types and "Clear Oceanic Water" types (Abbott 1960) is borne out by these observations and it is obvious to the author that *S. gigas* and *S. costatus* are well established in their natural environment in Grenada, whilst *S. pugilis* and *S. raninus* are struggling to find a foothold. In Trinidad, *S. pugilis* and *S. raninus* are well established, whilst *S. gigas* and *S. costatus* are the struggling species. *Strombus gallus* appears to be a fairly rare species, which can adapt to differing conditions, providing a grit substrate is present and suitable protection from predators can be found.

As mentioned in the introduction, the significance of these observations relates to the fact that so called "Continental Water" molluscs can be found in coral reef areas in clear water. Also, "Clear Oceanic Water" molluscs can be found in muddy continental water habitats. This has resulted in variations in shell morphology and normal depth range of these species.

However, one must apply caution in drawing conclusions. The Archaeogastropod genus — *Pleurotomaria*, which can be found in the Caribbean today (McIntyre 1972) only in deep water habitats 400 — 800 feet (122 — 244 m), is known to have lived in much shallower habitats in the past (Jung 1968, Kanno 1961).

The use of molluscs in the fossil record as stratigraphic indicators must take into account the ecology of recent forms. Comparisons must be made to ascertain whether there have been major changes in habitat and depth ranges of recent and fossil species and genera.

Underwater observations made by the author during the past several years have revealed that many species previously considered to be very deep water species can be found in 100 — 150 feet (30 — 46 m) in the much colder upwelling waters of Trinidad and Tobago. At the same time, many common shallow water molluscs have been found established in small groups or colonies in deep water habitats.

REFERENCES

- Abbot, R.T. (1960). The genus *Strombus* in the Indo-Pacific. Indo-Pacific Mollusca, Vol. 1, No. 2, p. 43.
- Clench W.J. and Abbott, R.T. (1941), The genus *Strombus* in the Western Atlantic. Johnsonia, No. 1, pp. 1 — 15.
- Hughes, R.N. and Hughes, H.P.I. (1971), A study of the gastropod *Cassis tuberosa* (L.) preying upon sea-urchins. J. exp. mar. Biol. Ecol., Vol. 7, pp. 305 — 314.
- Jung, P. (1968), Fossil *Pleurotomaria* and *Halotis* from Barbados and Carriacou, West Indies. Eclog. geol. Helv., Vol. 61, No. 2, pp. 593 — 605.
- Jung, P. (1971), *Strombus gigas* Linnaeus from the Bowden Formation, Jamaica. Nautilus, Vol. 84, No. 4, pp. 129 — 131.
- Kanno, S. (1961), Miocene "*Pleurotomaria*" and its associated fauna from Tochigi Prefecture, Japan. Jap. Journ. Geol. Geogr., Vol. 32, No. 1, pp. 111 — 118.
- Macintyre, I.G. (1972), Submerged Reefs of Eastern Caribbean. Bull. Amer. Assoc. Petr. Geol., Vol. 56, No. 4, pp. 720 — 738.
- Percharde, P.L. (1968), Notes on distribution and underwater observations on the molluscan genus *Strombus* as found in the waters of Trinidad and Tobago. Carib. J. Sci., 8 (1 — 2), pp. 47 — 55.
- Percharde, P.L. (1970), Further underwater observations on the molluscan genus *Strombus* as found in the waters of Trinidad and Tobago. Carib. J. Sci., 10 (1 — 2).
- Warmke, G.L. and Abbott, R.T. (1961), Caribbean Sea shells. Livingston Publishing Co., Narberth, Penn. U.S.A.