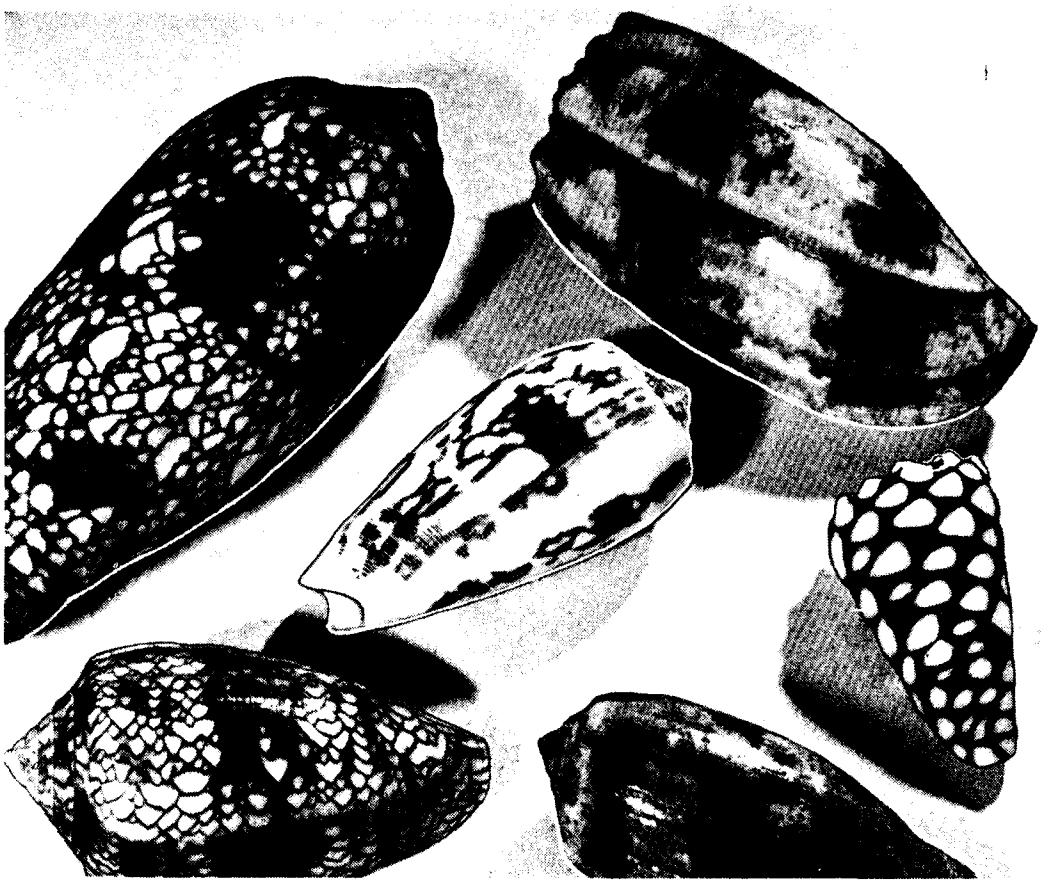
Technical Paper No. 144

POISONOUS GASTROPODS OF THE CONIDAE FAMILY FOUND IN NEW CALEDONIA

and the Indo - Pacific



René Sarramégna

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SOUTH PACIFIC COMMISSION
TECHNICAL PAPER No. 144

POISONOUS GASTROPODS OF THE CONIDAE FAMILY FOUND IN NEW CALEDONIA

and the Indo-Pacific

By

René SARRAMEGNA

Graduate of the *Ecole Supérieure de Biologie,* Paris
Assistant at the *Institut Pasteur,* Nouméa

VOLUME I

POISON APPARATUS AND POISON

Investigation undertaken at the *Institut Pasteur,* Nouméa, New Caledonia

SOUTH PACIFIC COMMISSION
NOUMEA, NEW CALEDONIA
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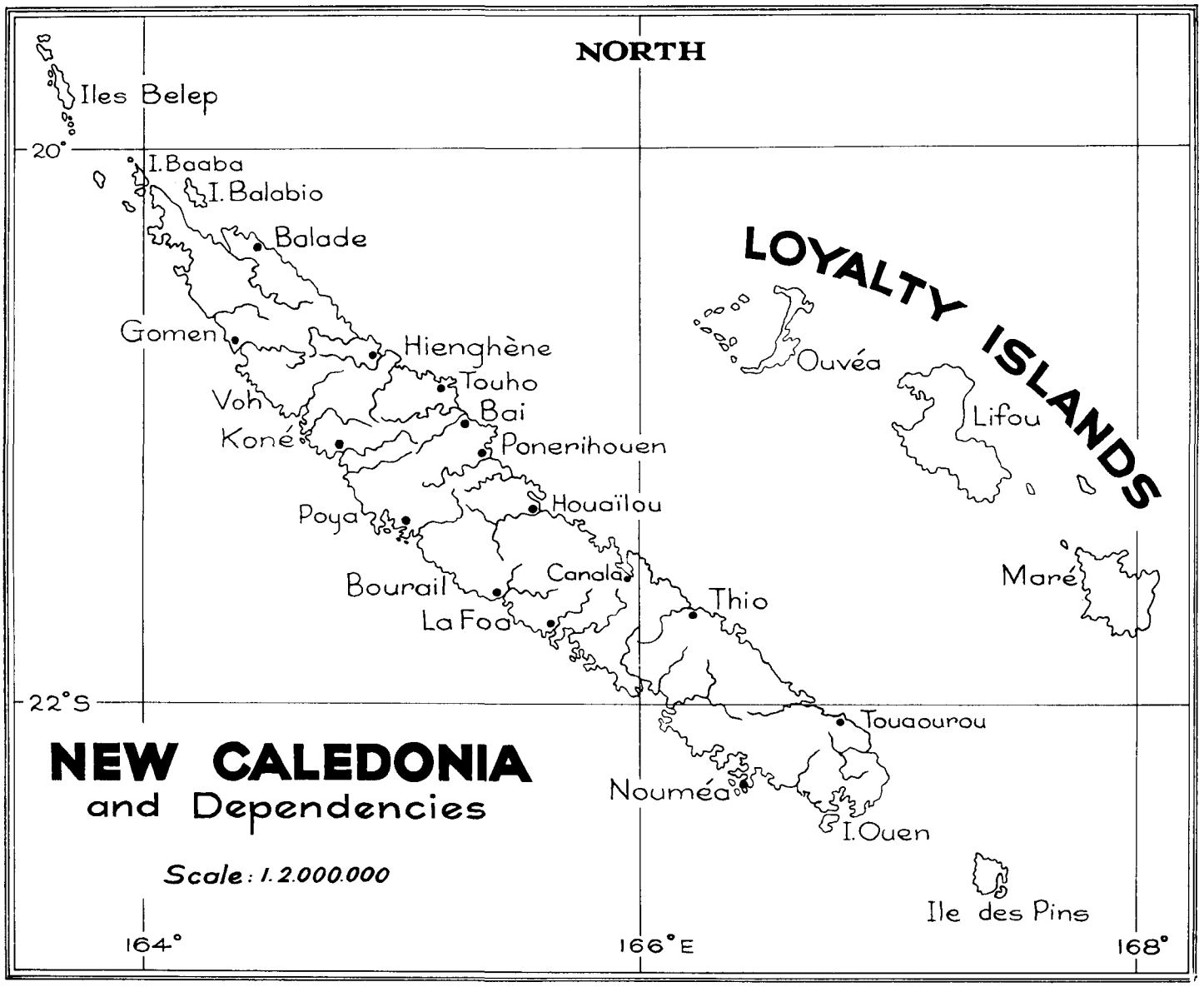
COVER PHOTOGRAPH

Centre: *Conus striatus.*

Outside, beginning top left and proceeding clockwise: *Conus aulicus* (court cone), *Conus geographus* (geographus cone), *Conus marmoreus* (marble cone), *Conus tulipa* (tulip cone), and *Conus textile* (cloth-of-gold).

(Photo: Rob Wright)



This report, originally written in French, is published as general information by the South Pacific Commission, which accepts no responsibility for any statements made therein.

Manuscript received 15th September, 1963.

PREFACE

In the programme of the Health Section of the South Pacific Commission there is a section headed "Research Grants." This relates to funds allotted to research projects which might be of practical value to several South Pacific territories.

In October, 1962, it was decided to grant a request made by the *Institut Pasteur*, Nouméa, the Director of which was anxious to have a study made of the poisons of the *Conidae*. These latter are molluscs which have caused a number of deaths in New Caledonia.

The task was entrusted to Mr René Sarramégna, laboratory research worker at the *Institut Pasteur*.

The South Pacific islanders have always known that certain cone shells are dangerous to handle; but newcomers have to be warned of the danger, and this is one of the purposes of the present publication. In it, the author describes the gastropods and their poison organs. A second volume, now under way, will deal with toxicity tests made on *Conidae* poisons and will describe the efforts made to evolve an antiserum. There can be no doubt that such a serum, if effective, would save lives. The Pacific islands attract tourists from all over the world, and among them, as among the islanders themselves, underwater fishing is becoming steadily more popular. Shells are being exchanged and sold, made into necklaces, trinkets, and souvenirs, and shell-collecting has become something of an industry.

The South Sea islands are celebrated alike for the good nature of their peoples and their scarcity of dangerous fauna. The traditional idyllic picture is not seriously affected by the existence of a few poisonous species of mollusc, and what danger there is would, in any case, almost completely disappear if people knew what to look out for.

The document now published by the South Pacific Commission does not, of course, attempt to list all the fatal accidents attributable to *Conidae*. In many islands there is no doctor, and it may well be that not all doctors have published their findings. A typical instance which happens to have come to the notice of the author of this preface is that of a 23-year-old Vietnamese, resident in the New Hebrides, who, in December, 1962, was successfully treated by Dr Campana in Vila (New Hebrides). This young man, in the course of a fishing expedition, had picked up a *Conus geographus* and tucked it into his shirt.

Two unexplained deaths which occurred near Sydney this year are thought to have been due to *Conidae* poisoning.

Cone poisoning in this part of the world thus achieves a certain sporadic notoriety. The Commission itself has published an article of a popular kind in its SOUTH PACIFIC BULLETIN of January, 1963. The following study by Mr Sarramégna, published as an S.P.C. Technical Paper, deals with the same problems. As we have said, it represents merely the first stage in a process of research, to the outcome of which the Commission will be happy to feel it has contributed.

GUY LOISON, M.D., M.P.H.,
Executive Officer for Health.

Nouméa,
New Caledonia,
October, 1963.

INTRODUCTION

Among the numerous shell fish found on the reefs of the New Caledonian lagoon, cone shells are prominently represented. Roughly 25 per cent of all known species are found there.

These shell fish are remarkable because of their variegated colouring. Their flesh is also good to eat, and hence it is only natural that they should be much sought after by native divers, who eat them, barter them, or sell them to shell collectors.

Cone shells are also much in favour among underwater swimmers and hunters who readily stop to pick them up.

Unhappily, when placed for convenience of transport inside a bathing suit, or when carried in the hand, these timid, apathetic molluscs often prove dangerous, and may even cause death.

So much so, in fact, that they have achieved an unenviable reputation among the South Sea islanders, and although underwater fishermen fear these molluscs less than they do sharks, they tend to view them with much distrust.

It is observed that the *Conidae* are not the only poisonous gastropods; there are other toxic prosobranchial molluscs, such as the *Turridae* and the *Terebridae,* which certain authors have combined into a sub-group, the "Toxoglossa," or "poison tongues" of the English-speaking world. It seems, however, that *Turridae* and *Terebridae* have caused no harm to humans, so that, in what follows, we shall confine ourselves to the *Conidae.*

However, just as some snakes are poisonous while others are not, and some snakes are more poisonous than others, so some cones are more dangerous than others.

The native peoples boast of knowing which cones are dangerous by empirical means, in which it is unwise, we feel, to place too much confidence, since there have been cases in which the price of rashness has been death. It is often no easy matter to tell one kind of cone shell from another in their natural setting, and hence all cone shells should, in our view, be regarded with circumspection.

Although certain species appear harmless to man, all are equipped to administer poison—a fact we should always keep very much in mind.

Without wishing to sound unduly alarming, the author does consider it opportune to utter a word of warning with regard to these shells, which are much sought after by collectors, and fetch a good price among the ever-increasing numbers of tourists attracted to the South Pacific.

Hence, he will begin by a succinct description of the general characteristics of cone shells, followed by a description of those species most often found along the coasts of New Caledonia.

He will then examine in some detail the processes and organs whereby these gastropods produce and secrete their toxins.

He will describe toxicity tests on the poisons extracted from a number of species.

In addition, he will consider the possibility of evolving a suitable antidote by the usual means, namely, immunization from some suitable animal.

The task will be by no means easy. It is difficult enough, in the first place, to collect sufficient cone shells of various species so as to obtain poison samples large enough for test purposes, and even more so if, for the sake of quantity, we concentrate on the larger species.

The author is confident, nevertheless, that the many obstacles which beset his path will be overcome, thanks to the assistance of all those who—however remotely—are interested in this problem.

René Sarramégna

ACKNOWLEDGEMENTS

The author wishes to acknowledge a debt of gratitude to the following—

—Dr Guy Loison, Executive Officer for Health, South Pacific Commission, for unfailing encouragement and support;

—Dr Cavallo, for the interest taken in the author's labours and for much valuable advice;

—The *Institut Pasteur,* Nouméa, which financed the shell collecting and has always provided the author with working facilities; and

—The South Pacific Commission, which offered the author the free run of its library and enabled him to assemble much valuable information.

The author is also grateful to—the South Pacific Commission, for financial assistance towards the cost of publishing this paper;

—Mr Traica, draughtsman with the Marine Works Department of New Caledonia, for assistance received; and

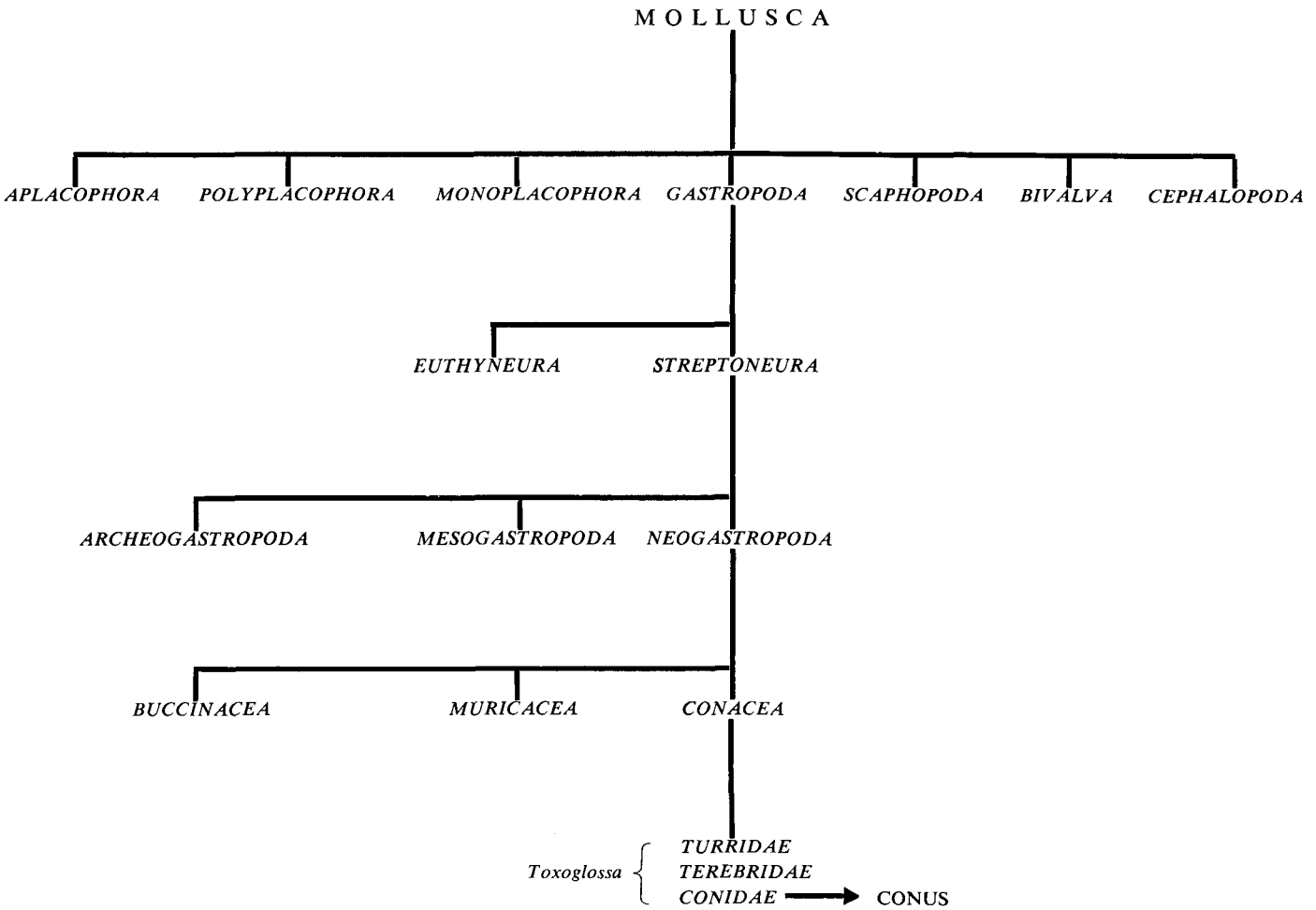
—Mr and Mrs. Revercé, who very kindly made their collection of shells available to the author.

Finally, the author thanks all those collectors and skin divers who continue to give him their assistance.

I: THE GENUS CONUS

Classification

The shell fish of the genus *Conus* belong to the family of the *Conidae*—super-family *Conacea*—order *Neogastropoda*—sub-class *Streptoneura* (or *Prosobranchia*)—class *Gastropoda*—*Phyllum mollusca.*



The genus *Conus,* Linnaeus (1758) has been divided by Swainson and Mörch into numerous sub-genera, which have now been reduced to four—

1. *Sub-genus Conus:* these are all conic in shape and have narrow apertures with sub-parallel edges.

   Varieties: Rhombus, Montfort (1810)
   Puncticulis, Swainson (1840)
   Coronaxis, Swainson (1840)
   Dendroconus, Swainson (1840)
   Leptoconus, Swainson (1840)
   Lithoconus, Mörch (1850)
   Stephanoconus, Mörch (1850)
   Rhizoconus, Mörch (1852)
   Chelyconus, Mörch (1852)
   Virroconus, Iredale (1930)
   Cleobula, Iredale (1930).

2. *Sub-genus Hermes:* roughly cylindrical shell with transverse striation; high obtuse whorl; straight narrow aperture (*Hermes clavus,* Linnaeus).

   Varieties: Asprella, Schaufus (1869) (*Asprella orbignyi,* Audouin)
   Leporiconus, Iredale (1930) (*Hermes* (*Leporiconus*) *mitratus,* Bruguière).

3. *Sub-genus Cylindrus:* smooth, roughly conical shell; sharp whorl; last gyrus bulging in the middle; aperture flared out at fore-end.

   Varieties: Darioconus, Iredale (1930) (*Darioconus textile,* Linnaeus)
   Regiconus, Iredale (1930) (*Regiconus aulicus,* Linnaeus).

4. *Sub-genus Gastridium:* roughly cylindrical shell; whorl short but sharp; sinuous columella; aperture flared out at fore-end.

   Varieties: Rollus, Montfort (1810) (*Rollus geographus,* Linnaeus)
   Tuliparia, Swainson (1840) (*Tuliparia tulipa,* Linnaeus).

II: GENERAL CHARACTERISTICS

The *Conidae* constitutes a very large family found in all the warm seas of the world, predominantly in the Indo-Pacific area.

At present, more than 300 species are known, which differ greatly both in size and in colour and colour patterns. Furthermore, fossil species, not exceeding 150 in number, have been found in tertiary layers.

Their length is variable, but usually lies between 2 and 4 inches. Some species reach a length of over 6 inches; those shorter than four-fifths of an inch are rare.

Most of them emerge only at night, when they are frequently encountered at low tide on reefs and shores covered only at high tide. In the daytime, they hide in the crags of coral masses, under rocks, or in the sand.

All of them hunt all kinds of moving prey such as small coral fish, marine worms, and molluscs (including other cone shells) which they capture alive.

"They are predatory animals which seize their victims and draw their sustenance therefrom," says Clench.

This somewhat vivid description is quite accurate. In fact, cone shells feed on prey which they first paralyze by means of a very efficient poison apparatus. Their radula, considerably modified, is armed with small needle-like teeth which end in a hook. Each tooth can be thrust out separately with sufficient force to harpoon the victim. At the same time, a poison secreted by a complex glandular system is injected into the wound.

The *Conus* is also able to use this poison apparatus to protect itself against its natural enemies, which occasionally include man.

Hence, although these gastropods are timid and withdraw into their shells at the approach of the slightest danger, it is nevertheless prudent not to handle them carelessly.

Collectors should always grasp them by the dorsal part of the shell; the opening should be held away from the body. They should then be dropped into a small linen or plastic bag which should always be carried on a collecting expedition.

Description

(a) *The shell*

Before we begin our study of the cone shell, a few words should be said about our interpretation of the words "base or spire," "anterior tip" and "apex."

In most gastropod molluscs, the tip is the summit of the shell where the whorls originate. The base is the wide part; example: *Terebridae.*

In the *Conidae,* the apex is the raised cone in the centre of the wide part or base of the shell, while the tapering part is the anterior tip or fore-end (Figure 1).

As their name suggests, the gastropods of the *Conidae* family all have a shell shaped like a cone—a hollow, calcareous cone arranged in a spiral shape around an axis called the columella. The internal whorls are partially masked (Figure 2).

The whorls have a right-hand thread, i.e., they turn clockwise if the shell is held with the apex towards the observer. The whorls, which vary in number (usually six or seven), lie against one another, at first tightly packed and then, spreading out into broad bands, they either do not jut out at all (apex not very distinct) or jut out only slightly (projecting apex).

The base may be studded with knobs corresponding to the different stages of growth of the whorls. The striae separating the growth bands are distinctly visible in certain species.

The outer lip or peristoma is a narrow, straight cleft, with parallel or sub-parallel edges, which extends from the base to the tip of the cone where it may be flared out (*Rollus geographus*).

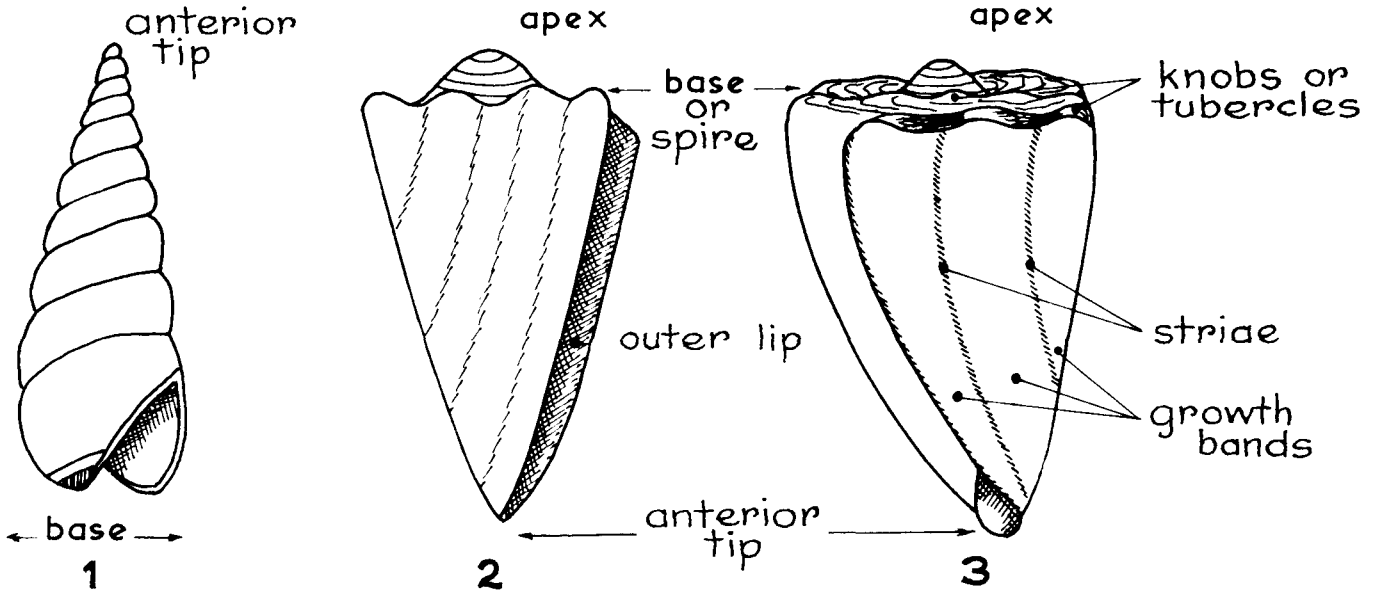


Figure 1—(1) Terebridae, (2) and (3) Conidae.

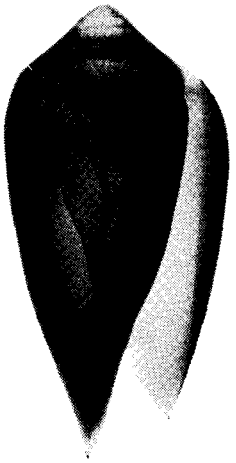


Figure 2—X-ray photograph of the shell of Darioconus textile.
(Photo: Dr Mauvais)

The shells show striking patterns and colours, which are different for each species. They constitute an essential characteristic for the identification of a *Conus*. It should, however, be noted that under natural conditions the surface of the shell is usually covered by a fibrous coating which masks its characteristics. Lime deposits on the shells are also frequent.

The cone shells, as a rule, do not show the porcelain lustre which we see on so many other shells and on which a number of factors such as light, temperature, and diet appear to exert a considerable influence.

The purity of the water also has a considerable effect on the glaze and colouring of the shells; shells found near beaches in the vicinity of factories which discharge fuel oil and waste products have a sombre, dull appearance.

(b) *The operculum*

Most prosobranchial molluscs have a calcareous or horny operculum fixed to the foot, with which the animal can close its shell and so protect itself from danger.

In the cone shells, an unguiform operculum, with a saw-tooth edge, is found on the posterior surface of the foot. This horny proliferation, much smaller than the opening, no longer really serves as a stopper but acts as an organ of locomotion and prehension. The animal uses it to cling fast when in a difficult situation, to burrow in the sand, or to drag large food particles towards it.

(c) *The animal out of its shell*

It is sufficient to break the shell and to detach the animal's insertions at the level of the first whorl. We find—

(1) the viscero-dorsal mass, rolled up spiral fashion and covered by a thin tegument, the mantle. In the anterior and dorsal region the mantle delimits the palleal cavity. Its fore border usually lies against that of the shell; and

(2) the "head-foot" combination which is visible outside the shell when the animal emerges. It is covered with a thick, tough tegument.

The well-developed, rather broad foot is truncated in front and blunt at the back. In the female it is pierced by a pore in its fore portion. The male has a well-developed lateral spicule.

The cephalic extremity is prolonged by a fleshy sheath connected with the oral orifice. It hides the proboscis, a projectable organ which the animal sometimes unfolds when it is moving. On either side of this sheath, two thin tentacles are visible; they are roughly cylindrical in shape, with eyes near the tips on the outside.

The elongated syphon projects out of the shell (Figure 3).

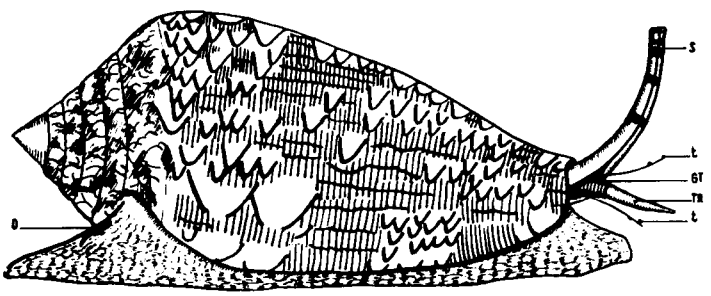


Figure 3—Darioconus textile, Linnaeus—

S = Syphon
TR = Proboscis
GT = Proboscis sheath
t = Tentacles
O = Operculum

(Drawing: A. Traica — Photo: Boixo)

III: POISONOUS PROPERTIES OF CONUS

History

The poisonous properties of *Conus* appear to have been known for a long time. As early as 1705, the Dutch naturalist, G. E. Rumphius, reported a fatal case on the island of Banda, in the Moluccas Archipelago:

> A native woman kept this shell in her hand after she had picked it up when hauling in the seine at sea. As she went to the beach she felt a faint tickling sensation in the hand which crept slowly through her entire body—she died on the spot.

This story is related in the RUMPHIUS MEMORIAL VOLUME (1959), by W.S.S. Van Benthem Jutting, and it seems likely that the species in question was that now known by the name of *Darioconus textile,* Linnaeus.

We have then to wait for more than a century before we find another report of a case of poisoning by a *Conus* bite. This report is included in the story of the voyage of H.M.S. *Samarang,* by A. Adam in 1848. In the second volume on page 356 we find the following paragraph:

> At the little island of Mayo, in the Moluccas, Sir Edward Belcher was bitten by a *Conus aulicus,* which suddenly inserted its proboscis as he took it out of the water with his hand, and he compares the sensation he experienced to that produced by the burning of phosphorous under the skin. The instrument which inflicted the wound, in this instance, I conceive must have been the tongue, which in these molluscs is long and armed with two ranges of sharp-pointed teeth.

Between 1850 and 1911, a number of accidents due to *Conus* bites are reported, and in 1912, Dr J. Burton Cleland, then connected with the Government Bureau of Microbiology in Sydney, lists them in an important article in the AUSTRALIAN MEDICAL GAZETTE of 14th and 21st September under the title "Injuries and Diseases of Man in Australia Attributable to Animals."

The complete text of this article follows here—

1860—McGillivray, J.—Zoological Notes from Aneitum, New Hebrides. "The Zoologist," 18, pp. 7136-7138.

On a poisonous property attributed to *Conus textile*:

On my first visit to Aneitum I was told of a shell fish which, on being incautiously handled, is said to eject a poison, causing, if it comes in contact with the hand, an immediate and peculiar sensation, then numbness of the hand and arm, followed by intense pain, usually severe illness, and not infrequently death. The native name is *intrag,* and the mollusc in question is the well-known *Conus textile.* Having frequently handled this shell fish . . . without having sustained any injury from it, I was naturally somewhat incredulous in the matter; yet as the general belief . . . was against me, I yielded to it so far as afterwards to handle with caution any live specimen I saw . . . The *intrag* is not usually considered dangerous unless the animal be touched . . . but some of the natives say that it can "blow" the poisonous influence upon the hand of an intruder from the distance of several inches.

On the 9th June of the present year . . . I had brought to me a young man . . . who was said to have recently been poisoned by the *intrag,* and appeared to suffer intense pain. . . . He had been looking . . . for shell fish and had picked up in the shallow water something which he did not see distinctly. Immediately on touching it . . . he felt a sensation as if some very cold water had been "blown" on the palm of his right hand, and dropped the object, which he saw was an *intrag.* Not long afterwards he went home, and soon began to complain of numbness in the whole of his right arm and hand. . . . A bandage was tied tightly round the sufferer's arm at a little below the shoulder, and when I saw him the arm was cold and much swollen and the pulse about 50 and very feeble. I administered an enormous dose of the solution of muriate of morphia, as he was suffering excruciating pain. . . .

Meanwhile, a man experienced in such matters had been sent for. On arrival he prepared a knife of two strips of bamboo, and made two deep incisions in the upper part of the arm, one in front, another behind, below the ligature, which had been slackened. About half a pint of blood was obtained. Next morning I found that the morphia had produced sound sleep during the night and that the bandage had been removed according to my suggestion. The right arm was swollen and felt rather cold, but the pulsation was equally strong at each wrist, sixty-three beats to the minute. . . . All pain, except from the incisions, had disappeared and in the course of about a week the patient recovered his usual health. With regard to this case it is right to mention that although satisfied by the circumstantial evidence that contact with an *intrag* had produced extraordinary effects, yet I could not separate them satisfactorily from those attributable to the ligature. No pain was felt before the bandage was applied.

A case which terminated fatally may now be mentioned. On 28th May, 1859, I went along with the Rev. J. Geddie to see a sick woman, who 14 days before was believed to have been poisoned by her hands having accidentally come in contact with an *intrag* while collecting shell fish on the reef. The whole right hand and arm . . . were in a state of gangrene . . . I could see that numerous small but deep incisions had been made in the arm. . . . In this case I learned that a tight bandage had been kept on for several days, probably of itself sufficient to induce mortification even in a healthy limb.

These two cases are the only ones of which I can say anything from personal observation, and I shall make no further comment than merely to observe that as I cannot find any special apparatus in the animal of *Conus textile,* or see any anatomical difference between it and *Conus arenatus* (which is known to be innocuous) after examining both, I feel great reluctance in subscribing even to the universal popular belief on this island of the power of the *intrag* to cause injury to man in the manner ascribed to it. A jet from the siphon of the animal might partially account for the first sensation experienced. . . .

1874—Crosse, H., and Marie, E.—"Journal de Conchyliologie," 22, p. 353.

Conus textile and *tulipa* are very common in New Caledonia and are both reputed to be venomous.

The fact mentioned before by several English naturalists, that the bite of *C. textile is* venomous, was confirmed in New Caledonia. According to an eye witness, a native of Pouébo, after being stung on the hand, suffered a considerable swelling of this hand and the corresponding arm, with very sharp pain. The swelling persisted for some time. However, the mistake was made in that country of blaming the operculum of the *Conus* for what was caused by the teeth of the tongue.

1877—Father Montrouzier—"Journal de Conchyliologie," 25, p. 99.

At Maré, one of the Loyalty Islands, *Conus marmoreus,* which is abundant there, cannot be handled carelessly without the risk of causing accidents through the sting of its tongue. In the New Hebrides, accidents due to the sting of *C. textile* are said to be rather frequent.

1878—Garrett, A.—Annotated Catalogue of the Species of Conus Collected in the South Sea Islands—"Quarterly Journal of Conchology," 1, p. 365.

Under *Conus tulipa* Linn., he has the following notes:

Somewhat plentiful; under clumps of coral on reefs. When collecting at the Tuamotu, I found three examples of this species and held them in my hand while searching for other shells, when one suddenly threw out its long slender proboscis and punctured one of my fingers, causing sharp pain not unlike the sting of a wasp.

1884—Cox, J. B.—"Poisonous Effects of the Bite Inflicted by Conus geographus," Linn. Proc. Linnean Soc. N.S.W., 9, p. 944-946.

Dr Cox received the following letter from Mr B. H. Hinde, R.N. Surgeon on H.M.S. *Diamond.*

H.M.S. *Diamond*
at sea, Lat. 10° 14′ S., Long. 155° 44′ E.

A native of Nodup, New Britain, seeing me with a specimen of *C. geographus* in my hand, remarked "suppose he bite he kill man." . . . He added that it always killed people if they did not cut themselves to let the blood run all round the place bitten. . . .

Some time afterwards being in conversation with a New Britain cotton planter, I inquired if he knew anything of this man's statement about this *Conus.* He told me that he believed it to be perfectly true, and that he had written about it to someone in Sydney.

I should have taken no more notice of the statement but for the fact, that *I saw myself,* a native, on the Island of Matupi, Blanche Bay, New Britain, who had been bitten by one, and who had at once cut small incisions with a sharp stone

all over his arm and shoulder from which the blood had flowed freely, and he explained to me that if he had not taken these precautions that he would have died. . . .

To stop the bleeding of the numerous cuts in his arm and shoulder, hot wood ashes had been put on them, and the arm seemed to be stiff and useless for the time. But whether this was the effect of the *bite* or the *cure* I really am unable to state. . . .

Hoping that these few observations may be of use either as information, or confirmation to conchologists generally.

1902—Corney, R. G.—"Nature," 65, p. 198.

I notice that doubt is cast on the opinion held by some authorities that the bite of certain species of *Conus* is poisonous and as a case has now occurred here in a European subject whose intelligence places her account of it beyond question, I think it may be useful to represent the corroborative evidence thus obtained. . . .

The victim, Mrs B., was fishing in the harbour of Levuka (Fiji) with her family and a native servant. The latter had collected a number of shell fish for bait among which there was a *Conus geographus*. He broke the shell of the latter and gave it to Mrs B. who proceeded to dislodge the animal with a finger. At that moment she felt a curious sting in her finger, near the nail.

Soon afterwards, she felt her hand and arm becoming numb. The condition grew rapidly worse and the paralysis extended to her whole body.

She was immediately taken home and seen by a doctor. This doctor compared the symptoms to those of curare poisoning. Utterance was thick and difficult. The patient did not, however, lose consciousness, and was clearly aware of what was going on. The heart and lungs were quite equal to their task.

The worst was past in about six hours and the next day most of the symptoms had become much attenuated. The numbness of the hand, however, persisted considerably longer. Mrs B. also experienced disturbances of vision which she attributed to the same cause.

Medical Department, Fiji, September, 1901.

In later years, more cases of poisoning due to *Conus* bites have been reported, of which we quote a few:

1932—Hermitte, L. D. C.—"Venomous Marine Molluscs of the Genus Conus," Transactions of the Royal Society of Tropical Medicine and Hygiene, p. 485.

In June, 1932, a white Seychellois of French descent, Monsieur Frédérique de Lafontaine, 32 years of age, residing at Ile-aux-Cerfs, Seychelles, was wading at low tide in the shallow water of the lagoon not far from the shore of the island, in search of shell fish, when he found and picked up a medium-sized living male specimen of *Conus geographus*.

As the shell of the mollusc was covered with a slimy growth of marine algae, he proceeded to clean it up by holding the shell in his left hand, aperture towards the palm, and scraping the shell with a pocket knife. He had hardly started scraping when he felt a sharp sting in the palm of his left hand, followed immediately by a burning sensation. Turning the shell over quickly to look at the part of the animal visible in the aperture, he saw the "mouth" of the animal just retracting into the shell, and noticed at the same time what he described as a "fine sharp needle" protruding from a narrow tongue-like organ which was gradually withdrawn out of sight into the mouth before the latter had completely retracted into the shell. When once the animal had completely retracted itself into the shell, neither the needle nor the tongue-like organ were any more to be seen.

The wound itself was so tiny as to be almost invisible. The burning sensation soon gave rise to numbness, and within a few minutes he felt his left arm tingling and gradually becoming numb. Then, feeling his head getting "queer" he decided to regain the shore and go home. . . . Within an hour the whole of his body was numb, his sight was impaired, he had marked dizziness and nausea, he became completely paralyzed and could not move his limbs or sit up, and speech was difficult. . . .

After five or six hours he began to improve a little and asked to be taken to my surgery at Mont Fleuri on the main island of Mahé. . . .

The accident had occurred at 9 a.m. and he was brought by canoe to my surgery at 6 p.m. . . . He was still giddy and unable to stand, with a feeling of general weakness in all four limbs.

On examination there was nothing to see at the site of the sting. . . . His knee reflexes could not be elicited but his pupils reacted normally to light and to accommodation. The pulse rate and respiration were normal. . . . His temperature was also normal.

These were obviously symptoms of some form of neurotoxic poisoning and the only treatment I considered might be of any use was, after a hypodermic injection of strychinine hydrochloride (1/60 grain), to send him home to bed with a strychnine mixture and recommendation that he should be given general massage in addition. . . . In spite of this, it took three days for the weakness to disappear completely.

When he was brought to my surgery on the day of the accident he had, fortunately, ordered the mollusc also to be brought alive in a vessel containing fresh sea water and sand, and as I was at the same same indulging, in my spare time, in the fascinating hobby of collecting and classifying the marine shells of Seychelles, the species was easily diagnosed as *Conus (Gastridium) geographus* Linn. . . . It was not a large specimen, measuring only 8.5 cm. in length.

1935—Allan, Joyce—"Poisonous Shell Fish," The Medical Journal of Australia, 2, pp. 554-555.

A young man, on board a ship anchored near the Whitsunday Group, was holding a *Conus geographus* which he had picked up on Hayman Island. He was scraping the shell with a knife when he was suddenly stung in the hand.

Severe symptoms came on quickly and it was necessary to bring him ashore immediately.

The patient fell into a coma on the way and died before he reached hospital.

1936—Flecker, H.—"Cone Shell Mollusc Poisoning, with a Report of a Fatal Case," The Medical Journal of Australia, 1, pp. 464-466.

(This is the same case as that reported by Allan, J.)

C.H.G., a male, aged 27 years, landed at Hayman Island (Great Barrier Reef) on 27th June, 1935, and picked up a live cone shell (since identified by Mr M. A. Longman of the Queensland Museum, as *Conus geographus*). According to an eye witness, it was gripped in the palm of one hand, with the open side downwards in contact with the skin, whilst with the other hand he proceeded to scrape with a knife the epidermis, that is a thin cuticle covering the hard part of the shell. It was during this operation that he was stung in the palm of the hand. . . . Local symptoms of slight numbness started almost at once. . . . Ten minutes afterwards there was a feeling of stiffness about the lips. At 20 minutes the sight became blurred, with diplopia; at 30 minutes the legs were paralyzed, and at 60 minutes unconsciousness appeared and deepened into coma. . . .

Just before death, the pulse became weak and rapid, with slow, shallow respiration. Death took place five hours after the patient was stung.

1954—Petrauskas, L. E.—"A Case of Cone Shell Poisoning by 'Bite' in Manus Island," Papua and New Guinea Medical Journal, Vol. 1, No. 2, p. 67.

On the 27th August, 1954, a little native girl, about eight years of age, the daughter of one of our hospital orderlies, suddenly collapsed while playing on the beach. This occurred about midday. On examination, slurred speech, shallow breathing (thoracic variety), complete palsy and absence of reflexes in lower limbs, arms, and neck, with partial affection of hand muscles and complete freedom of face muscles were encountered. The heart rate increased. Temperature not elevated. While further examinations were being prepared for, complete paralysis of respiratory muscles ensued. At first the breathing was maintained by Sylvester's method, then an endotracheal tube was introduced and further oxygenation carried out by means of a portable anaesthetic machine. 100 mg. of Vit. B1 and 200,000 U. of Penicillin Proc. was given. The pulse, which had begun to give some concern, improved.

About two hours later the patient recovered consciousness; this was soon followed by signs of re-establishing diaphragmatic respiration. About four hours after commencement of the treatment, artificial respiration could be discontinued. . . . The following morning the patient was in full control of all her faculties. After having recovered the power of speech the girl told us that she had been bitten by a "Nunus" (pronounced noonoos)—vernacular for a cone shell—in this case *Conus omaria*. The "bite" was in the thenar region, appearing as a black spot surrounded by a moderately swollen area not occupying the entire palm. In retrospect it appears that if the possibility of cone shell poisoning is kept in mind one should not have any difficulty in arriving at a correct diagnosis without being told the story. . . . In our case the issue was somewhat confused by a few cases of flaccid palsy of different muscle

groups that occurred some time before the case under discussion, and which might have well been mild cases of acute poliomyelitis.

1960—Dr Duron—"Compte-rendu No. 32," 17th October, 1960.—Circonscription Médicale de Koumac, New Caledonia.

On 11th October, 1960, around noon, a Melanesian, Theophile Gnaie, who had caught a number of *Conus* at Tana (Pouébo, New Caledonia), returned to his boat when he felt a bite in the palm of the left hand. He told this to Mr M. with whom he was out fishing, and showed him the shell that had bitten him.

Very soon afterwards, a syndrome of intoxication developed with vertigo and dyspnœa. The patient was brought to the hospital where he arrived an hour later, at which time he presented:

Pulse: 54
Arterial pressure: max. 5
Voluntary movements: impossible
Complexion: ashen.

Treatment with phenergan, coramine, and syncortyl brought no improvement but rather the contrary—complete paralysis without unconsciousness.

Death at 2 p.m.

Nothing could be learned from the post-mortem examination.

The shell in question was sent to the Institut Pasteur, Nouméa for examination; it was found to be a *Rollus geographus*, Linnaeus.

1963—Rob Wright—"Cone Shells Can Be Killers," South Pacific Bulletin, Vol. 13, No. 1, January, 1963, South Pacific Commission, Nouméa, New Caledonia.

But there are others more versed in the ways of cones who sometimes make mistakes. Take Ron Pahl's experience. He is a young Australian living in Fiji, an expert diver and spear fisherman, but his greatest hobby is shell collecting. . . .

While fishing on a reef about a mile from the Samoan shore, he found a nest of seven tulip shells, *Conus tulipa*. It was a veritable goldmine for a collector to find in one spot. Not anticipating such good fortune he had neglected to bring his collecting equipment from the ship and in his eagerness to gather them before they spread, he tried to handle too many at the one time. . . .

Finding one of the shells sliding off his left hand, he flicked it with his finger. The shell fish flicked back—with its tiny lethal spear. There was no sting and no pain, but the poison took effect immediately. The hand became as numb as though a local anaesthetic had been used. Hastily a tourniquet was devised from the head strap of a diving mask and wrapped around the arm above the elbow and then with as much haste as possible over the coral, the journey to shore commenced.

During the 25 minutes it took to get from the reef to the township, the whole arm became numb and a feeling of constriction was felt in the chest. The young man was rushed to hospital where the Medical Officer, Dr Fisher, and his wife—also a doctor—prepared a possible antidote. Neither had had experience with shell fish poisoning, but as the symptoms were similar to those of snake bite, they tried a remedy which had been used successfully for this.

Into the afflicted member they injected an anti-histamine.

This was followed by an injection of adrenalin into the other arm. The constriction in the chest, which had grown steadily worse, vanished immediately and, after a period of observation, the patient was allowed to proceed on his way. The hand and arm were still paralyzed, but two days later he was able to move both the third and little fingers slightly. After a fortnight, feeling began slowly to return to the arm and hand, but it was three months before he finally recovered full use of them. Even today, nearly six months after the incident, there is still a feeling of tightness in the muscles.

IV: POISON APPARATUS OF CONUS

The study of the poison apparatus of *Conus* was first undertaken by Bouvier in 1887, and continued by Bergh in 1895.

However, it is mainly since the Second World War that this subject has received the special attention of investigators.

The landings of allied troops in the Pacific led to a renewed interest in these deadly shells, which up to then were very little known outside their own area.

Nowadays, with the development of underwater sports and of shell collecting, everyone knows that these shell fish are really poisonous and that this is not just a native legend.

The most recent studies concerning the poison apparatus of the gastropods are those carried out by Hermitte in 1946 and by Hinegardner in 1958.

Anatomy

The poison apparatus of cone shells consists of a large gland connected with a long sinuous canal which enters the pharynx. As an adjunct, it has a sort of sac studded with tiny teeth. This is the radula sheath or sac, which also enters the pharynx.

To the pharynx is connected the proboscis, which has the form of a fleshy projection, generally of a pink colour, with transverse striation, and tapering off at the tip.

This proboscis is, in fact, the beginning of the digestive tract. It is through this organ that the animal sucks in its food. It may be extended out of the mouth, its maximum length approximating three-quarters the length of the shell. When retracted, it is reduced to a small pad on the front part of the pharynx, not more than one-eighth of an inch in length.

As we shall see, because of a special property of the proboscis it can also be used as a weapon. It is from this organ that the radula teeth are shot to paralyze prey animals.

1. THE VENOM BULB (Leiblin gland)

The Leiblin gland is the most prominent organ. It varies in size from that of a cucumber seed to a large white bean. Its appearance is that of a transparent pulp. It is sausage-shaped, with convex sides.

It is situated obliquely in relation to the fore-aft axis of the animal and lies dorsally just in front of the oesophagus (Figure 4).

This gland was long regarded as the source of the venom, but Hermitte (1946) concluded from histological studies that this was unlikely.

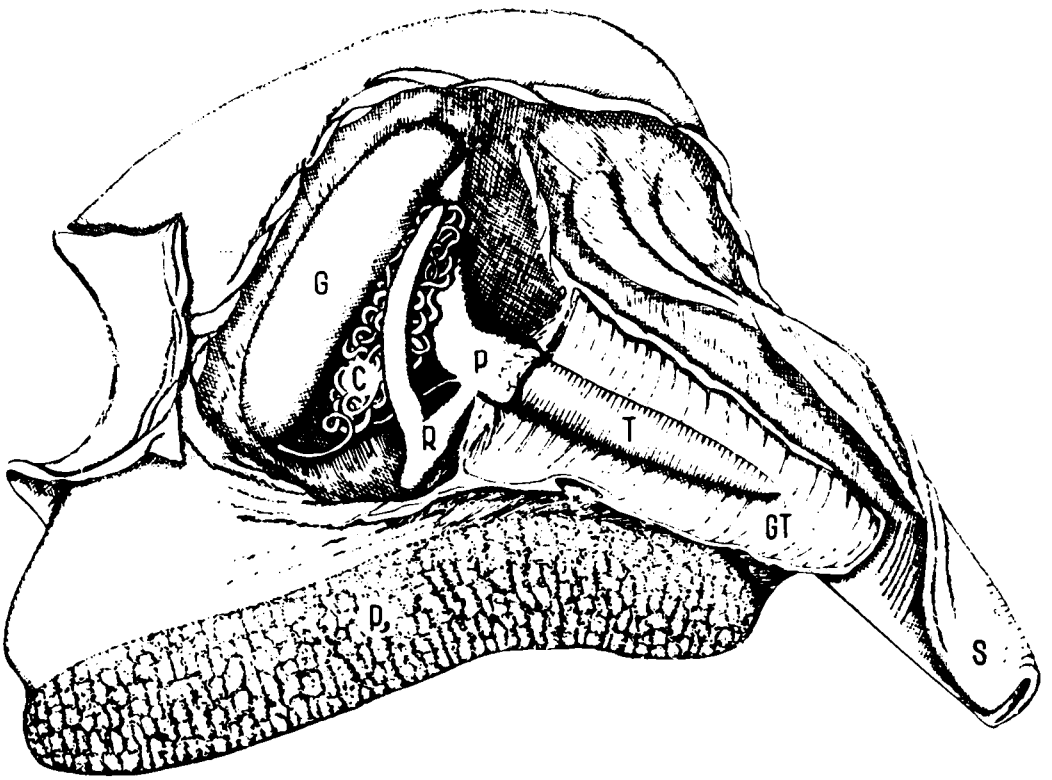


Figure 4—Anatomy of venom apparatus of a cone shell (Darioconus textile, Linn.)

G = Venom bulb or Leiblin gland
R = Radula sheath
T = Proboscis
S = Siphon
C = Venom duct
P = Pharynx
GT = Proboscis sheath
P, = Foot

(Drawing: A. Traica—Photo: Boixo)

A transverse section of the poison bulb clearly shows three thick layers of muscle:

—a longitudinal inner layer,
—an annular middle layer, and
—a longitudinal external layer.

The internal layer is lined with a single layer of epithelial cells resting on a thin membrane; the epithelial lining shows no secretion and the lumen of the gland appears to be empty (Figures 5 and 6).

Hermitte concluded that the hollow muscular organ known as the "Leiblin gland" had a storage function. This surmise is attractive, but, unfortunately, the homogeneous contents that can be extracted from this supposed reservoir are less toxic than the granular secretion which fills the pharynx.

It may well be, of course, that the fluid only acquires full potency by some enrichment process during its passage through the long poison duct. This interpretation is difficult to examine, but in any case it suggests that the poison duct probably does more than merely act as an excretory conduit.

Personally, I believe that the Leiblin gland plays a mechanical part, and acts more or less as a pump, bringing about the ejaculation of the poison towards the proboscis by its powerful contractions.

Such a function, which would be perfectly compatible with its structure, would explain the mechanism of the spontaneous ejections of poison by the animal when alarmed.

2. The Venom Duct

The canal is the second important part of the poison apparatus. It is a long, irregularly coiled tube lodged in the body cavity. Its distal portion lies along the œsophagus and enters the pharynx.

Its length may reach 8 to 10 inches, i.e., three to four times the length of the shell (Figure 4).

Bergh (1895) and Shaw (1914) believed the duct canal functioned only to transport the poison to the proboscis. Hermitte (1946) concluded that it was the source of the poison. This is my opinion, too, and the histological and toxicological findings reported below support this conclusion.

A transverse section shows that the venom duct is a tube with a very wide lumen, lined with a single-layer epithelium consisting of cubical cells resting on a dense connective chorion. These cells contain a granular secretion product which fills the lumen of the gland (Figures 7 and 8).

The wall of the duct consists of an annular smooth muscle.

In brief, all the evidence suggests that the poison is produced in the venom duct and not in the Leiblin gland; the histological characteristics suggest a tubular gland, which, although it has a regular lumen, has a greatly increased secretory surface due to the extreme length of the duct.

3. The Radula

The highly modified radula apparatus of *Conus* is contained in an L- or Y-shaped organ—the radula sheath—varying in size but clearly visible to the naked eye.

The longer arm is free and ends blindly. It contains a cluster of about twenty teeth oriented with the points directed towards the blind end.

The shorter arm enters the pharynx just anterior to the entrance of the venom duct. It contains a smaller bundle of teeth, which have their points directed towards the opening into the pharynx.

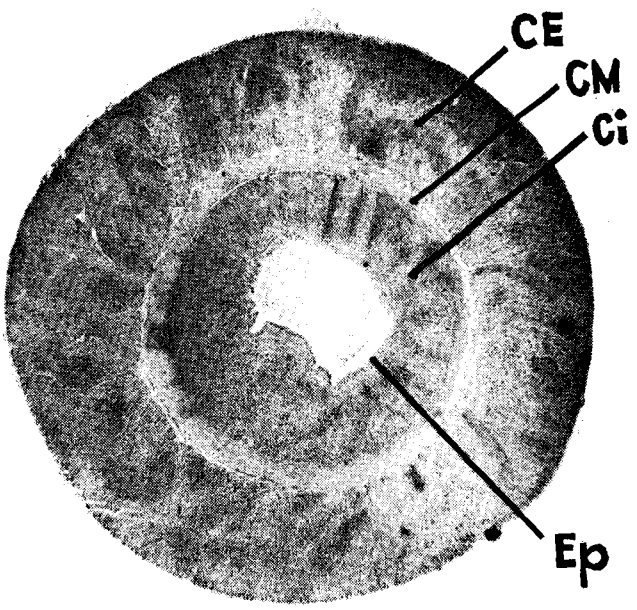


Figure 5—Transverse section of the Leiblin gland.
CE = External layer
CM = Middle layer
CI = Inner layer
Ep = Cuboidal epithelium
(Photo: Inst. Pasteur, Paris)

Kohn states that it is likely that the teeth are produced in the long arm, where they are found in various stages of development, and are then moved into the shorter arm when fully formed.

The teeth are between 5 and 10 mm. long. They are very fine and the tops end in a harpoon, the lateral barbs of which are open. There is a bulge at the base where a ligament is attached which fixes the tooth to the wall of the sheath (Figure 9).

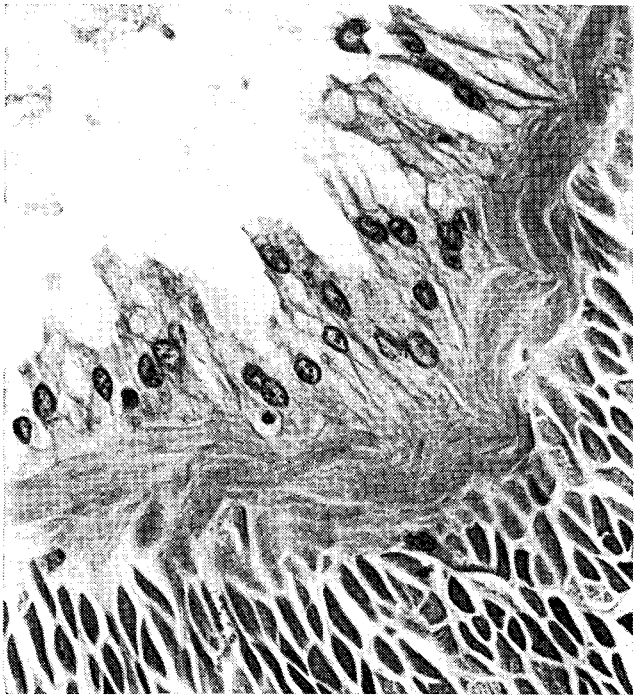


Figure 6—Cuboidal epithelium greatly magnified.
(Photo: Inst. Pasteur, Paris)

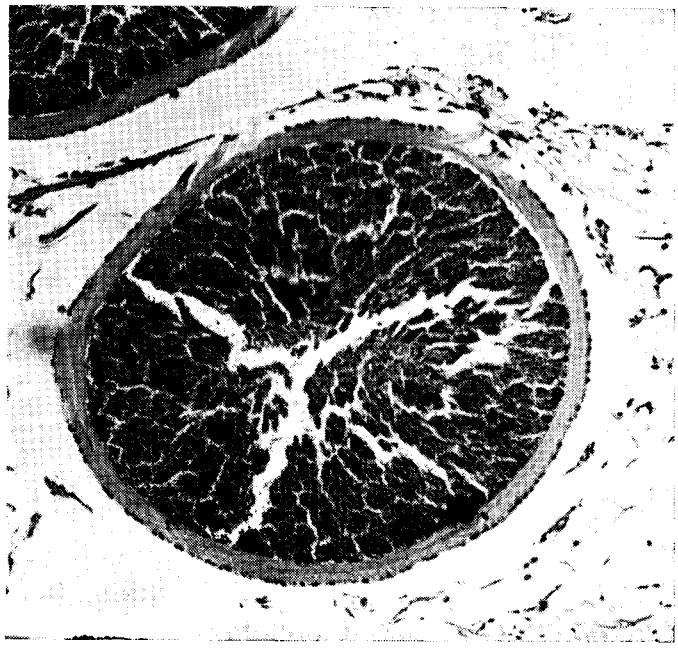


Figure 7—Transverse section of the canal. The lumen is filled with an *abundant secretion product.*
(Photo: Inst. Pasteur, Paris)

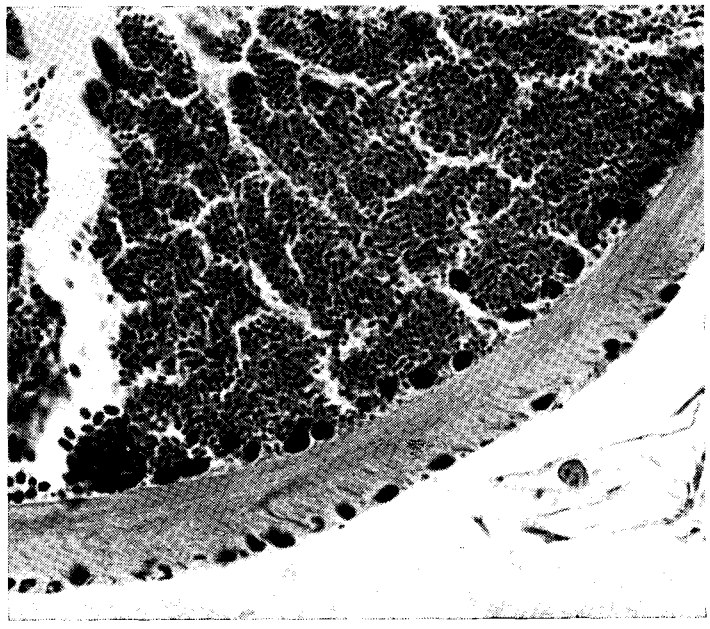


Figure 8—Cuboid epithelium, greatly magnified. Note the secretion granules in the foreground.
(Photo: Inst. Pasteur, Paris)

In cross-section, the tooth shows as a hollow, crystalline tube which is not closed, the edges of which are sometimes studded with barbs. The lumen of the tooth freely communicates with the surrounding medium and its groove-shaped structure satisfactorily accounts for the movements of the poison. There is no specific anatomical connexion between the radula and the glandular apparatus (Figure 10).

The teeth are not themselves poisonous; they become filled with poison only as they pass into the proboscis.

When the shell fish is hunting, one tooth is engaged in the proboscis. The animal is "armed" and it is then dangerous.

When necessary, the proboscis is suddenly and violently projected with sufficient force to bury the tooth it harbours into the victim.

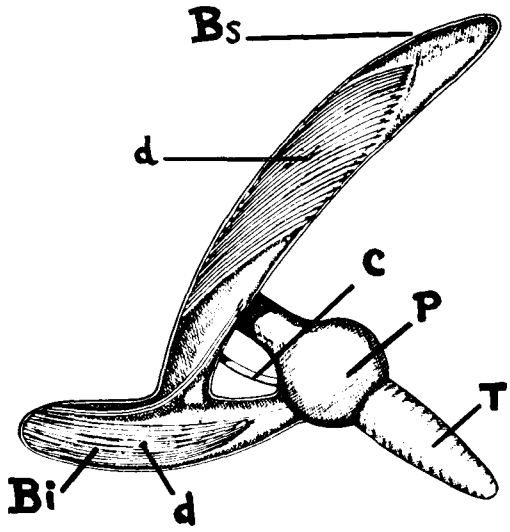


Figure 9—Section of the radula:

Bs = Upper arm
Bi = Lower arm
d = Bundles of teeth
C = Venom duct
P = Pharynx
T = Proboscis

(Drawing: A. Traica — Photo: Boixo)

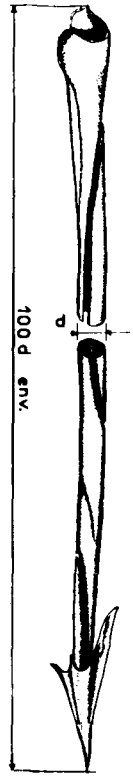


Figure 10—Sketch of a tooth of Darioconus textile.
(Drawing: A. Traica — Photo: Boixo)

Simultaneously with this extension of the proboscis, the Leiblin gland contracts and this, as we have seen, facilitates the ejection of the poison. This fluid then fills the hollow cylinder of the tooth. The poison oozes out through the spiral cleft of the tooth as it penetrates the victim's tissues.

We still do not know exactly how the teeth are transferred from the radula into the proboscis.

Hermitte proposed a retraction of the proboscis followed by invagination of its anterior portion until it comes into contact with the connecting orifice of the radula.

At that moment, it is believed, the sheath of the radula, or the pharynx itself, is the seat of muscular contractions which cause the teeth to point through the orifice. One of the teeth is then seized by the proboscis and after rupture of its ligament it is propelled outward.

Only one tooth is engaged at a time, and during dissection its point can frequently be seen at the extremity of the proboscis (Figure 11).

After each "shot," the tooth remains buried in the tissues of the prey; it is not taken back by the animal (aquarium observation). It is replaced by another tooth by the same mechanism.

The Poison

Upon exerting a slight pressure along the poison duct, a milky-white poison emerges; subsequently it becomes yellower and more viscous. No more than one or two drops can be thus obtained.

Microscope examination shows the poison to consist of ovoid granules of various sizes, dark reddish brown in colour. They are frequently interspersed with cellular debris. The fresh poison has a Ph oscillating between 7.8 and 8.2.

Chemical Composition

The chemical composition of the poison of *Conus* was studied by Kohn in 1960. In addition to the glucoproteins evidenced by Molish reaction, the chromatographic adsorption method reveals the presence of quaternary ammonium compounds: N. methylpyridinium, homarine, and gamma-butyrobetaine.

J. H. Welsh (1958) has noted the presence of indole amino-derivatives, but has carried out no further attempts at identification.

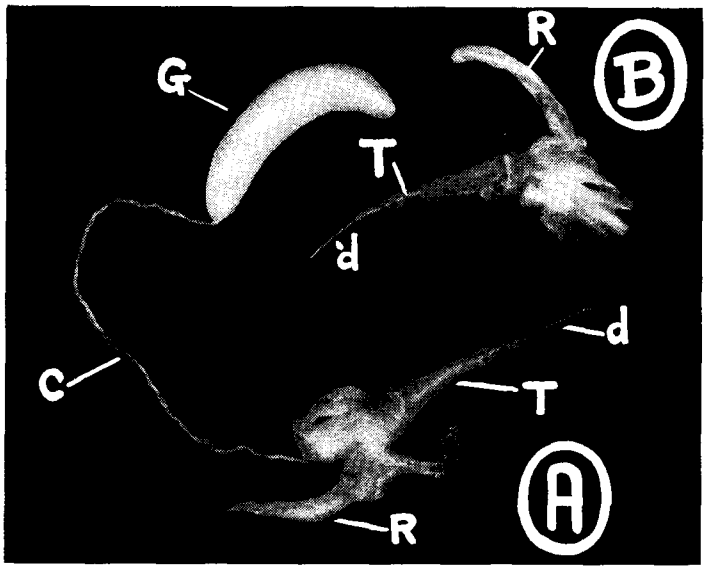


Figure 11—Projection of a tooth of the radula. Enl. = 1.5 x (Dendroconus striatus, Linnaeus)

G = Leiblin gland
T = Proboscis
R = Radula
d = Tooth (note the barbed extremity at B)

(Photo: Boixo)

Craig (1948) called attention to the curariform activity of N. methylpyridinium; he appears to be of the opinion that this factor plays an important part in the toxicity of the venom. However, injection of N. methylpyridinium, gamma-butyrobetaine, and homarine separately into crustaceans (*Uca pugilator*) did not induce experimental paralysis (Welsh and Prock, 1958).

It is possible, however, that the toxicity of the venom is not due to any individual element, but to a mixture of bases.

As noted by Kohn, the venom of *Conus textile* and *Conus striatus* is rich in quaternary ammonium derivatives, whereas the venom of *Conus litteratus, Conus marmoreus,* and *Conus magus* contain no gamma-butyrobetaine, but only N. methylpyridinium and traces of homarine. It should be noted that the first two species, in which the poison apparatus is well developed, are listed among the dangerous cone shells.

V: TOXICITY EXPERIMENTS ON ANIMALS

How the Poison Was Extracted

For this purpose we used the following technique: The poison duct was first cut out at the level of the pharynx and then placed on a very clean glass plate. By exerting continuous pressure along the whole length of the canal, the poison which appeared at the end could easily be collected.

The substance obtained in this manner was divided into two portions:

1. One-half was diluted in a suitable volume of normal saline solution to obtain a final concentration of fresh venom of 1 : 10, and

2. The other half was dried in an incubator at 97.8°F. for 24 hours.

The dilution of fresh poison in normal saline solution was rapidly injected into animals in volumes ranging from 0.1 to 0.2, and even 0.5 cc.

In order to test the contents of the Leiblin gland, this was removed directly by aspiration with a micro-pipette.

Tests on Mice

White mice of approx. 20 g. were used as laboratory animals in all the tests.

As many groups of mice were used as there were specimens to be tested. Each animal was given only one injection in order to eliminate any possible phenomenon of immunization.

In most cases the venom was injected by the subcutaneous route. However, with the weak venoms of certain species, intraperitoneal administration was used and, also, but more rarely, intravenous administration.

(a) *Dilution of the fresh poison in normal saline solution*—

(Dilution to 1 : 10 prepared immediately before use)

This dilution was injected subcutaneously in quantities of 0.1, 0.2 and 0.5 cc.

The purpose of these initial injections was to identify the particularly poisonous species, i.e., those which under the conditions described were capable of bringing about a fatal paralytic syndrome in the assay animal.

When the first test produced a negative result, injections were repeated using the intraperitoneal and the intravenous routes.

(b) *Dilution of the dried extract in normal saline solution*—

After 24 hours in the incubator at 97.8°F., the desiccated extract was diluted in different concentrations in normal saline solution and the solution was then centrifuged to eliminate any cellular debris in suspension.

The supernatant was injected into mice by the subcutaneous and intraperitoneal routes.

(c) *The contents of the Leiblin gland*—

The contents of the Leiblin gland were aspirated directly with a micro-pipette and totally injected into a mouse.

Results of Particular Experiments on Mice

On the basis of the first series of toxicity tests, we classified the cones into three categories:

1. Species capable of killing a mouse within a period of 10 to 80 minutes after a first injection of fresh diluted poison. Example: *Dendroconus striatus,* Linnaeus.

2. Species capable of killing a mouse in a much longer period (18 to 24 hours) with very high concentrations prepared from the dried extract. Example: *Darioconus textile,* Linnaeus.

3. Species which were not toxic for mice, regardless of the dose injected. Example: *Cleobula quercinus,* Solander.

We deliberately selected *Dendroconus striatus* because, although it has never caused accidents in human beings, it has nevertheless proved to be particularly dangerous.

From toxicity tests carried out with this species, we obtained valuable information on the properties of the poison. For instance, we found that toxicity was in no way altered by extraction or desiccation.[1]

With the large doses of duct extracts mentioned above, after subcutaneous injection death ensues in 10 to 30 minutes. The predominant symptom is muscular hypotonia, which quickly spreads to the entire musculature. First of all, the animal loses its balance and slumps on its belly with the head drooping, and is incapable of movement. It shows a pronounced dyspnœa and dies soon afterward from paralysis of the respiratory muscles.

Post-mortem examination reveals no abnormalities at the site of the inoculation. The liver, spleen, and kidneys are normal. The lungs are hæmorrhagic and infarcted.

After subcutaneous injection of the contents of the Leiblin gland death occurs in 14 to 18 hours. The first symptom is paresis of the hind limbs, which begins within an hour. This condition grows worse and at the end of the second hour paralysis affects the forepaws. The animal can crawl only with difficulty. It is wreaked by convulsions and its breathing is laboured.

Within six hours the animal lies on its side in a coma heralding death.

A — *DENDROCONUS STRIATUS, Linnaeus*

Material injected	Injection route	Volume injected	Number of mice injected	Number of deaths
Fresh extract of duct content diluted to 1 : 10 in normal saline solution	Subcutaneous	0.1 cc.	3	3
Dried extract restored to its initial volume and diluted to 1 : 10 in normal saline solution	Subcutaneous	0.1 cc.	2	2
Contents of Leiblin gland	Subcutaneous	0.05 cc.	1	1
Contents of Leiblin gland diluted to 1 : 10 in normal saline solution	Subcutaneous	0.1 cc.	1	0

[1] The failure of numerous toxicity tests had been attributed by certain authors to rapid oxidation of the poison on exposure to air.

B — *DARIOCONUS TEXTILE, Linnaeus*

Material injected	Injection route	Volume injected	Number of mice injected	Number of deaths
Fresh extract of the duct diluted to 1 : 10 in normal saline solution	Subcutaneous	0.1 cc.	5	0
	Subcutaneous	0.2 cc.	5	0
	Subcutaneous	0.5 cc.	5	0
	Intra-peritoneal	0.1 cc.	5	0
	Intra-peritoneal	0.2 cc.	3	0
	Intravenous	0.1 cc.	2	0
Dried extract in normal saline solution (1 mg. per cc.) ...	Subcutaneous	0.1 cc.	4	0
	Subcutaneous	0.5 cc.	4	0
	Intra-peritoneal	0.2 cc.	2	0
Dried extract in normal saline solution (5 mg. per cc.) ...	Subcutaneous	0.5 cc.	2	2
	Intra-peritoneal	0.2 cc.	1	1
Contents of Leiblin gland ...	Subcutaneous	0.1 cc.	5	0

These species cannot easily be regarded as poisonous as their venom affects the assay animal only in the above-mentioned high concentrations. Obviously, such conditions can only be realized experimentally, and if we nevertheless publish the results obtained with *Darioconus textile,* this is only because *Dariconus textile* has been responsible for a number of accidents, two of which have been fatal.

If we presume that man and mouse have an equal sensitivity to the *Conus* poison, we may surmise the existence of an intermediate category of "potentially dangerous" molluscs, between the species that are very toxic for animals, such as *Conus striatus,* and those known to be harmless, such as *Cleobula quercinus,* mentioned below.

If this hypothesis were to be proved, it would explain how it is that although so many specimens are collected every year, accidents are so few and far between.

Our researches will be continued in this direction, and if we do succeed in finding a *Darioconus textile* as lethal for mice as *Conus striatus,* the results reported below would assume a wholly different significance.

C — *CLEOBULA QUERCINUS, Solander*

Material injected	Injection route	Volume injected	Number of mice injected	Number of deaths
Fresh extract of the duct diluted to 1 : 10 in normal saline solution	Subcutaneous	0.1 cc.	3	0
	Subcutaneous	0.2 cc.	3	0
	Subcutaneous	0.5 cc.	3	0
	Intra-peritoneal	0.1 cc.	2	0
	Intra-peritoneal	0.2 cc.	2	0
Dried extract in normal saline solution (1 mg. per cc.) ...	Subcutaneous	0.1 cc.	3	0
	Subcutaneous	0.5 cc.	3	0
Dried extract in normal saline solution (5 mg. per cc).	Subcutaneous	0.5 cc.	2	0
	Subcutaneous	1 cc.	1	0
	Intra-peritoneal	0.2 cc.	1	0
Contents of Leiblin gland	Subcutaneous	0.1 cc.	2	0

Even in very large doses, the venom of *Cleobula quercinus* did not have any toxic action on mice.

D — *ROLLUS GEOGRAPHUS, Linnaeus*

A REDOUBTABLE SPECIES

The toxicity of *R. geographus,* whether observed accidentally or experimentally, deserves a special mention which I am the more inclined to accord it in that, when writing this chapter, I had the opportunity of testing a specimen that had caused a fatal accident.

The Conus *R. geographus,* the sting of which is always very serious, is generally well known by the natives, for whom it is synonymous with "death."

Skin divers are no less afraid of it and many of them now refuse to touch what they call the "deadly shell."

Unfortunately, many reckless fishermen and children are unaware of this danger and it is therefore not surprising that the list of accidents due to stings by *R. geographus* is constantly increasing.

1963—Dr Feurion, Chief Medical Officer, Ponérihouen District, New Caledonia, "Account of a Fatal Case of Sting by R. Geographus," (hitherto unpublished):

> On 14th September, 1963, at approximately 11.30 a.m. a little native girl, Pomo Dassa Poapie, aged 9, in perfect health, was fishing for shell fish in the company of two friends on the reef near the area of the Paama tribe, at Poidimié.
>
> She had picked up a *R. geographus* when she felt a sharp pain in the hand. She threw the shell away and cried out to her playmates that she had been bitten.
>
> At the site of the bite on the inside of the thenar eminence of the left hand there immediately appeared an erythematous spot associated with slight oedema.
>
> After a few minutes, a brief fainting fit.
>
> Thereafter, convulsions with severe muscular tremors.
>
> Polypnœa and death approximately 40 minutes after the sting.
>
> Examination of the victim revealed no particular phenomena, except three small black spots at the site of the sting on the thenar eminence of the left hand. No autopsy could be performed.

Dr Feurion concludes: "Here, then, is a case of death from *R. geographus.* The severity of the symptoms and the speed with which they developed show how potent was the neurotoxic effect of the poison in question."

The lethal shell fish was sent to me by Dr Feurion and I was able to extract some venom and carry out some toxicity tests.

TESTS ON MICE

Material injected	Injection route	Volume injected	Number of mice injected	Number of deaths
Fresh extract of the duct diluted to 1 : 10 in normal saline solution	Subcutaneous	0.1 cc.	2	2
Dried extract restored to its original volume and diluted to 1 : 10 in normal saline solution	Subcutaneous	0.1 cc.	1	1
Contents of Leiblin gland	Subcutaneous	0.05 cc.	1	1

After injection of duct extract, the mouse died within a minute. The animal became agitated, developed convulsions in less than 30 seconds, and died with gaping mouth and eyes staring from their sockets.

Post-mortem examination revealed some congestion of the lungs.

After injection of the contents of the Leiblin gland, the same symptoms were observed but they took longer to develop. An element to be noted was a paralysis of the hind paws which appeared within the first two minutes.

Death occurred five to six minutes after the injection.

Post-mortem examination, here also, revealed some pulmonary congestion.

VI: COMMENTS AND PROSPECTS

It is still difficult to draw up a complete list of all poisonous cone shells. Toxicity tests on animals are insufficient because the degree of toxicity may vary within each species.

The frequently observed discrepancy between the results of an accidental sting and those of the experimental test necessitates even greater caution; hence, all the gastropods of the large *Conidae* family should be regarded as suspect.

Not until we have tested a very large number of specimens of every species will we be justified in regarding as definitely reliable the toxicity determinations of the various venoms which are now being studied.

Furthermore, as Barme said in connexion with snakes, "if it could be verified that the antigenic properties of these poisons are similar, we might consider the preparation of a polyvalent serum effective against the sting of different cones."

POISONOUS CONE SHELLS OF NEW CALEDONIA

On the basis of our present knowledge, and subject to the results of further investigations, we might list as dangerous the following six species (most of which have already claimed human victims)—

1. *Rollus geographus,* Linnaeus
   — 2 deaths
   — 3 serious accidents followed by recovery.
2. *Tuliparia tulipa,* Linnaeus
   — 1 serious accident followed by recovery
   — 1 mild accident.
3. *Darioconus textile,* Linnaeus
   — 2 deaths
   — 2 serious accidents followed by recovery.
4. *Darioconus omaria,* Bruguière
   — 1 serious accident followed by recovery.
5. *Regiconus aulicus,* Linnaeus
   — 1 mild accident.
6. *Dendroconus striatus,* Linnaeus
   — No accident reported.

PLATE I

Fig. 1

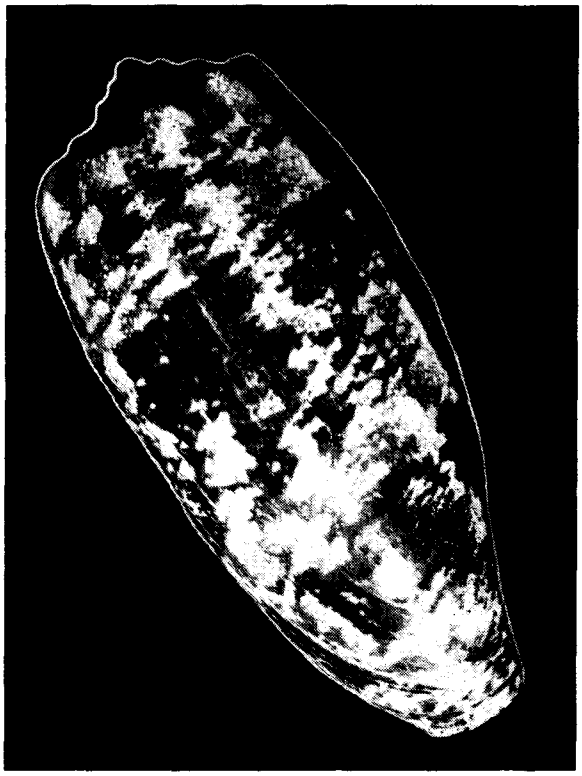
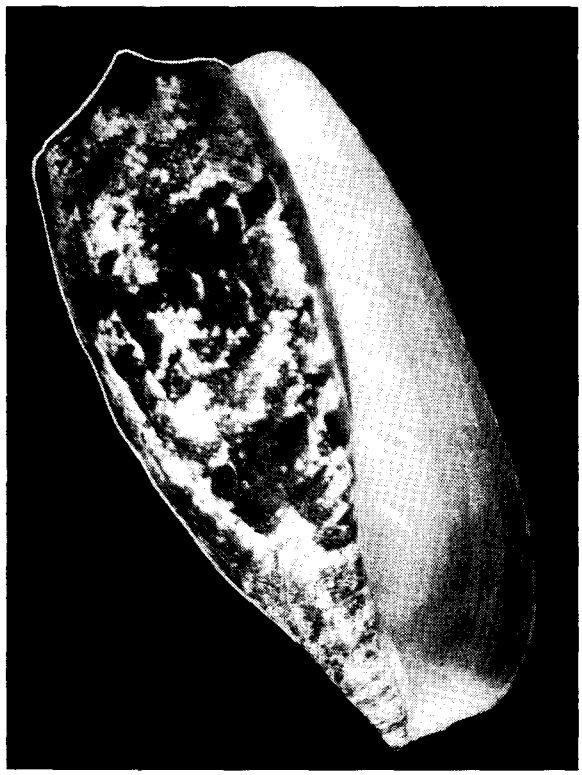


Fig. 2



Figures 1 and 2—Rollus geographus, **Linnaeus**

The shell is light, thin, and of a fragile texture. The colour is light brown with pink and white shades, and dark-brown or reddish-brown clouds.

The whorls do not overlap and are studded with projecting tubercles. The apex is pink. The aperture is very large and flared out at the anterior tip.

The animal emerges at night, and in the daytime hides in the sand or in the cracks between rocks or coral masses.

Length: 4-2/5 to 6-4/5 inches.

Distribution: all over the Indo-Pacific, without precise limits: *inter alia* Ceylon, the Philippines, northern Australia, and the east coast of New Caledonia.

Fig. 3

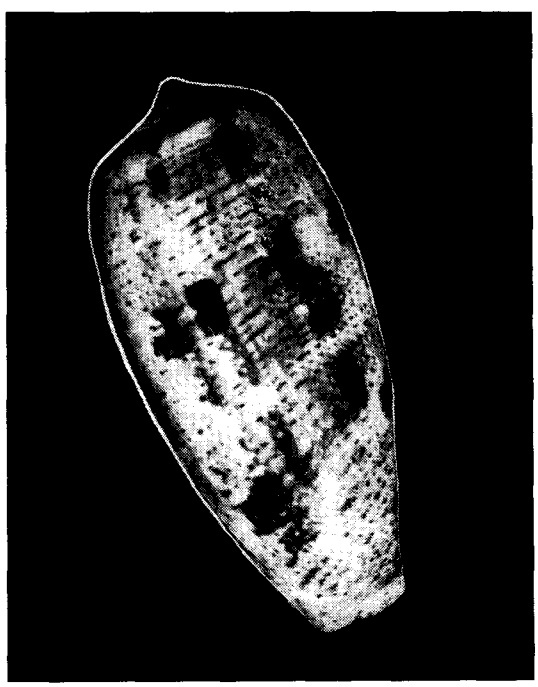
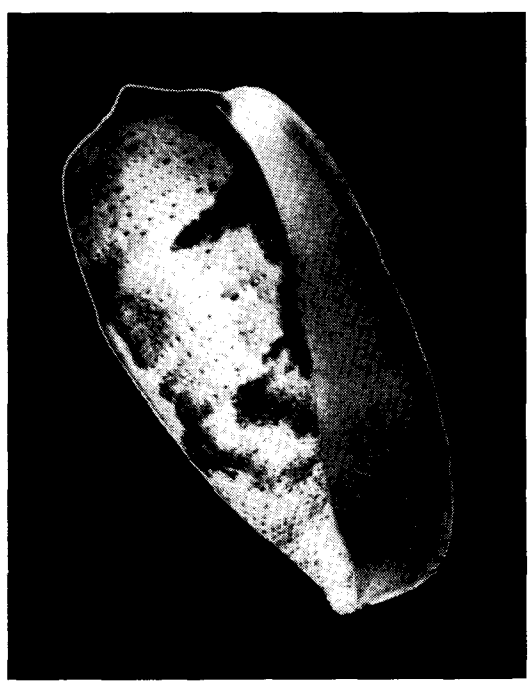


Fig. 4



Figures 3 and 4—Tuliparia tulipa, **Linnaeus**

Its delicately coloured shell is light and fragile. It may be confused with *Rollus geographus*, but closer observation reveals mahogany-brown or dark-chestnut brown cloud patterns over a bluish-white background, with rows of tiny dark-brown dots masked in places by the darker patches.

The overlapping whorls are practically smooth. The apex is pink.

The aperture is wide and markedly flared out; it has a purplish glow.

Length: roughly 2-2/5 inches.

Distribution: north-east of New Caledonia, northern Australia, and the Philippines.

(Photos: Boixo)

PLATE II

Fig. 5

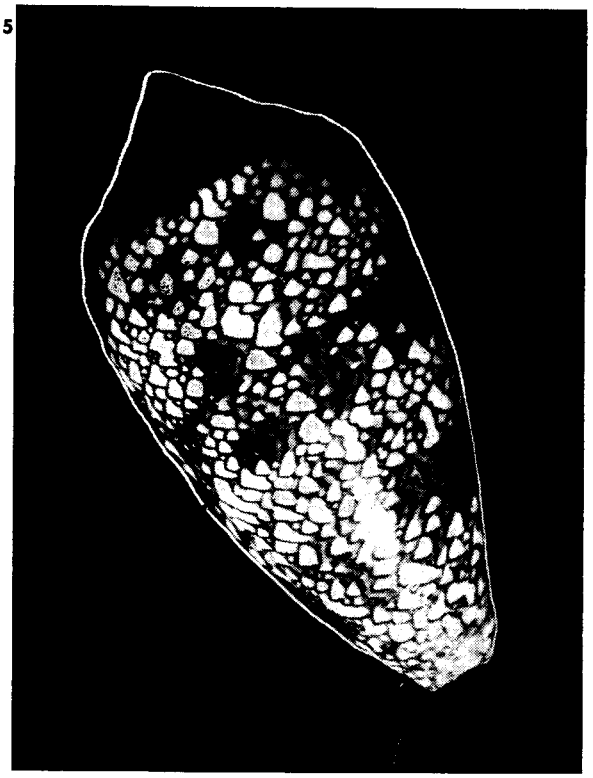
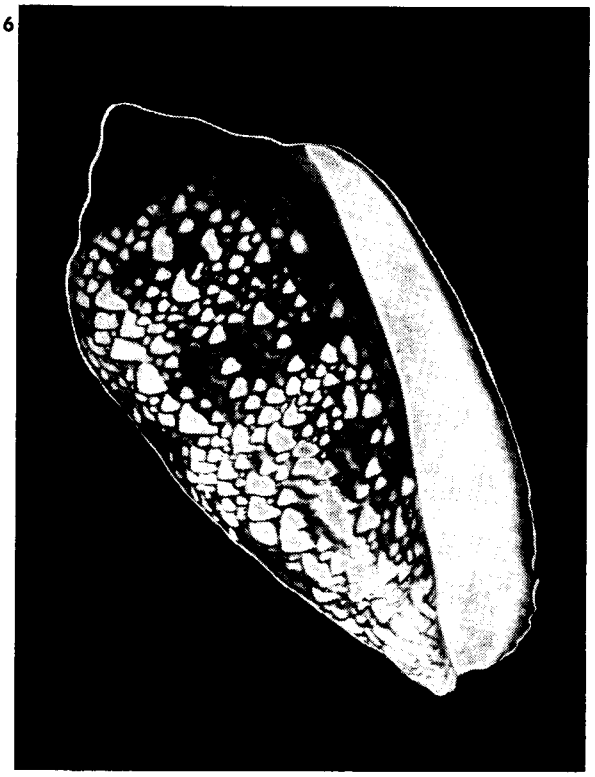


Fig. 6



Figures 5 and 6—Darioconus textile, **Linnaeus**

This is a delicately marked shell, of heavy construction; the colour is a yellowish brown with wavy intersecting lines, forming an irregular mesh pattern and defining a mosaic of white triangular scales.

The whorls distinctly overlap and the apex is tall and pointed.

Length: 2-4/5 to 6-2/5 inches.

The animal can be found in the daytime under coral or rocks; at night it comes out on the sand.

Distribution: New Caledonia and other islands of the South Pacific, off the east coast of India, and in the Red Sea.

Fig. 7

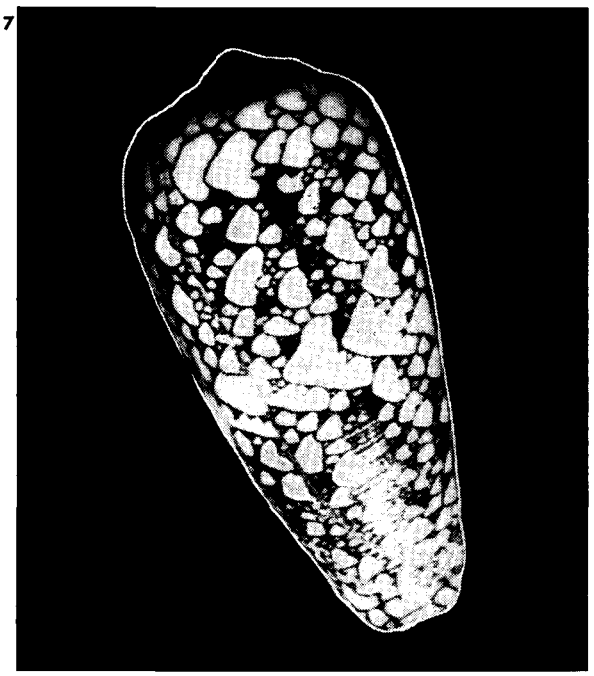
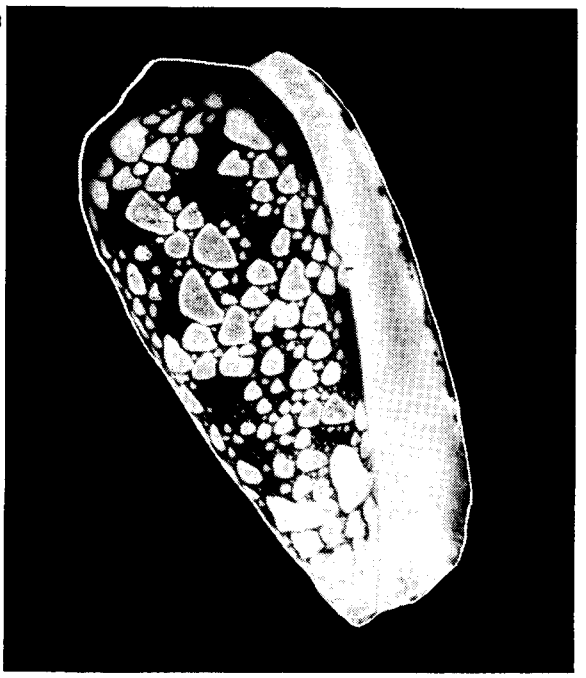


Fig. 8



Figures 7 and 8—Darioconus omaria, **Bruguiere**

Covered all over with white triangles on a dark-brown background, it greatly resembles *Conus aulicus*. The shell is less elongated but is more markedly conical. The apex is not tall; the shell is smaller and is on the average about 2-2/5 inches long.

Distribution: the Moluccas, and several islands of the South Pacific including New Caledonia.

(Photos: Boixo)

PLATE III

Fig. 9

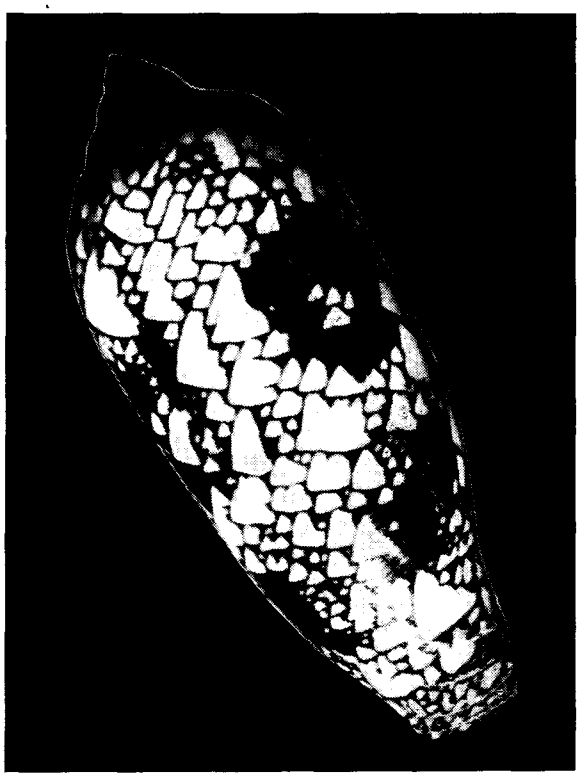
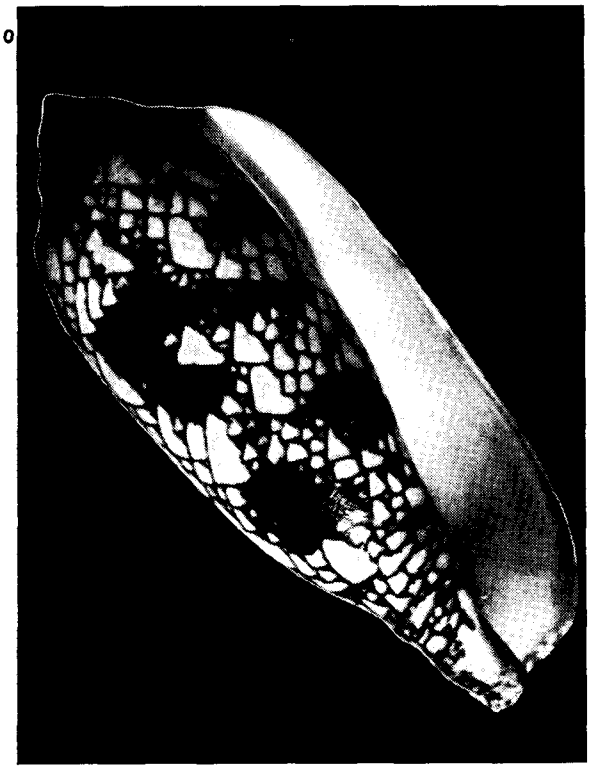


Fig. 10



Figures 9 and 10—Regiconus aulicus, **Linnaeus**

An elongated shell of robust construction. The chestnut or mahogany-brown surface is filled up by numerous white triangular spots of varying sizes.

The whorls overlap and the apex is spindle-shaped.

This shell should not be confused with *D. textile* which is much more compact and rounded.

Length: 2-4/5 to 6 inches.

Distribution: Indo-Pacific, north coast of Australia, and islands of the South Pacific.

Fig. 11

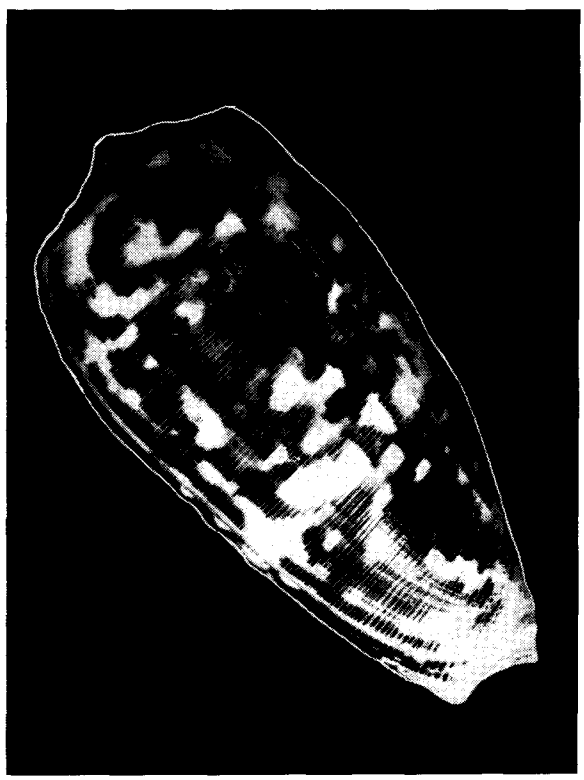


Fig. 12

Figures 11 and 12—Dendroconus striatus, **Linnaeus**

The thick shell is covered with brown blotches on a pinkish-white background.

The entire surface is densely sculptured by grooved spiral threads, clearly and distinctly visible in the darker-coloured parts and apparent to the touch.

The overlapping whorls leave the pink apex clearly visible.

Length: 2-4/5 to 3-3/5 inches.

This animal can easily be identified by the presence of raised grooves on a pinkish-white colour.

This mollusc emerges at night and hides by day under coral or in sand.

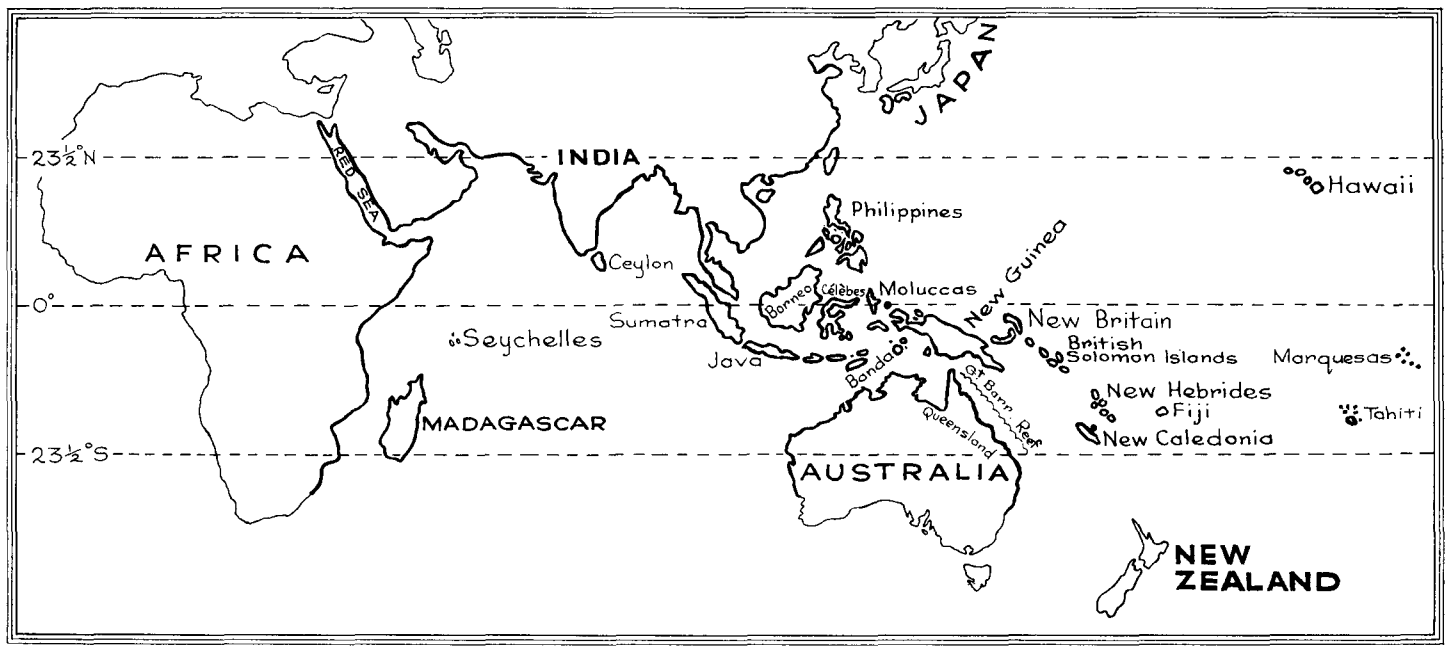
Distribution: South Pacific, east of India, and from the Indian Ocean to the Red Sea.

(Photos: Boixo)

THE INDO-PACIFIC ZONE

(after P. Fischer)

This immense marine area extends from the east coast of Africa and the Red Sea in the west to the Sandwich Islands, the Marquesas Islands, and Easter Island in the east, and from the north and east coasts of Australia to southern Japan. It covers 45 degrees of latitude and three-quarters of the circumference of the globe.



Non-poisonous species and species the toxicity of which has not yet been demonstrated

Fig. 1

Fig. 2

PLATE IV

Figure 1—Coronaxis marmoreus, **Linnaeus**

The marbled cone shell is undoubtedly the best known of the genus. It is common in New Caledonia where it can be found in the daytime among seaweed near beaches.

The thick shell is marbled black-brown, and roughly marked with white triangular scales.

The slightly overlapping whorls are studded with tubercles.

It varies in length from 2 to 4 inches.

It is widely distributed in the Indo-Pacific.

Figure 2—Conus (s.s.) crosseanus, **Fischer**

Its whole surface is covered with dark-brown wavy bands which are joined in many places. The ground colour of the shell appears in many parts as white triangular areas.

The whorls are studded with tubercles: the base is almost flat.

It varies in length between 2 and 2-4/5 inches.

This shell occurs in New Caledonia and does not appear to have been reported elsewhere.

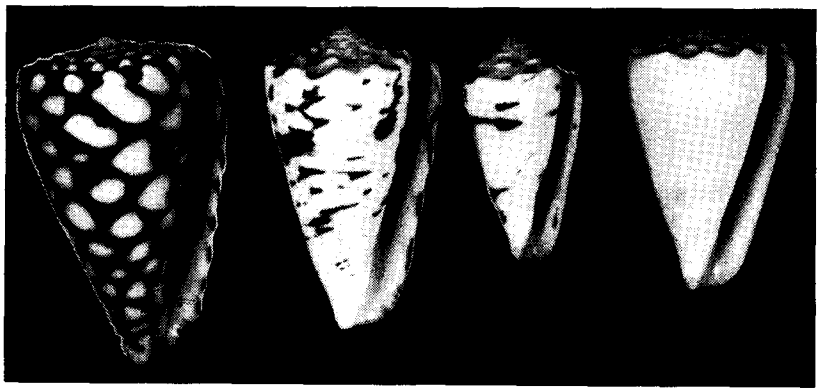


Fig. 3 Fig. 4 Fig. 5 Fig. 6

Figures 3, 4, 5, and 6—Coronaxis marmoreus, **albino forms**

This is probably the same species as that described by Linnaeus, from which it differs, however, in that the colours are much less pronounced and sometimes completely absent.

This variant of *C. marmoreus* is found in the area of Bourail (New Caledonia) and does not appear to have been found elsewhere.

Fig. 7

Figure 7—Conus (s.s.) chenui, **Crosse**

The thick shell shows an ivory background on which can be distinguished longitudinal brown bands, separated at the base and towards the middle. It has a transverse striation of lighter dots.

The whorls are smooth and the apex is protruding.

Length varies between 2 and 2-4/5 inches.

Found in New Caledonia, where it is probably an endemic species.

Figure 8—Lithoconus litteratus, **Linnaeus**

The smooth, porcelain-like shell bears numerous oblong black spots, reminiscent of print. They are often confused with *Lithoconus millepunctatus*, but it is smaller, never exceeding 4 inches in length.

It lives near reefs in sandy places.

Found on the South Pacific islands, north of Australia, and south of India.

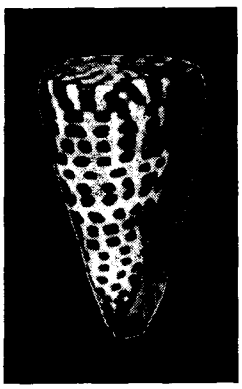


Fig. 8

(Photos: Studio-Boixo, Nouméa)

(Collection: P. Revercé, Nouméa)

PLATE V

Fig. 9

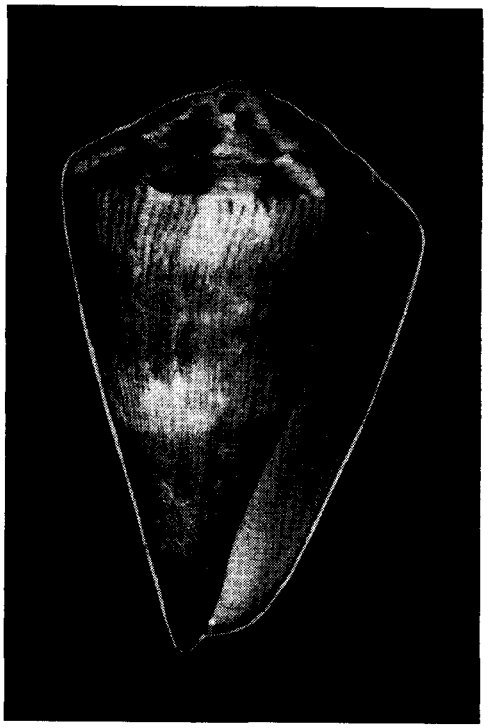


Figure 9—Rhizoconus vexillum, **Gmelin**

The shell is wide and massive and of a solid texture, of a brownish-yellow or caramel colour, intersected towards the centre by a white streak.

The opening is very large and has a pearly lustre.

The smooth whorls overlap and have white spots at the spire extremity.

Normally the shell is between 3-3/5 to 4 inches long, but it may grow to a length of more than 6 inches.

This species, very widespread in the Indo-Pacific, is particularly frequent in northern and Western Australia and on most of the Pacific islands.

Fig. 10

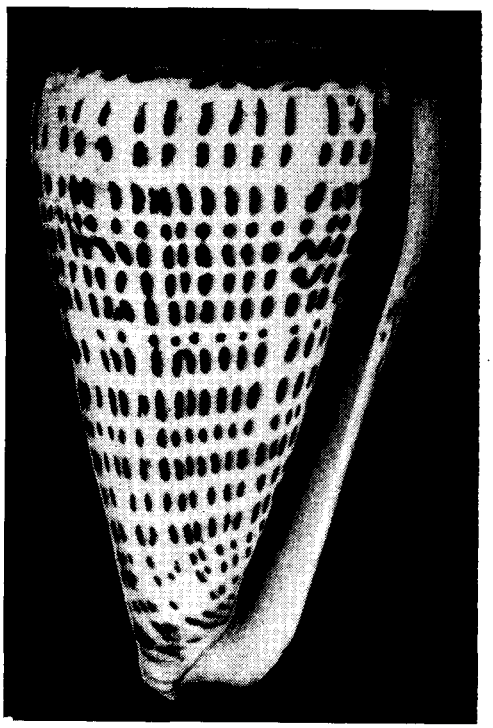


Figure 10—Lithoconus millepunctatus, **Lamark**

The shell is very wide and massive, of a light-ivory colour flecked with many dark-brown bars parallel to the main axis, arranged in spirals somewhat reminiscent of the characters of the alphabet.

The whorls do not overlap and the spire is flat.

This is the largest species; it frequently exceeds 6 inches in length. In the Bishop Museum, Hawaii, there is a specimen 8-3/5 inches long weighing more than 4 lbs.

It lives on reefs or buried in the sand.

Found in the Indo-Pacific, mainly in northern Australia and on the islands of the South Pacific.

Fig. 11

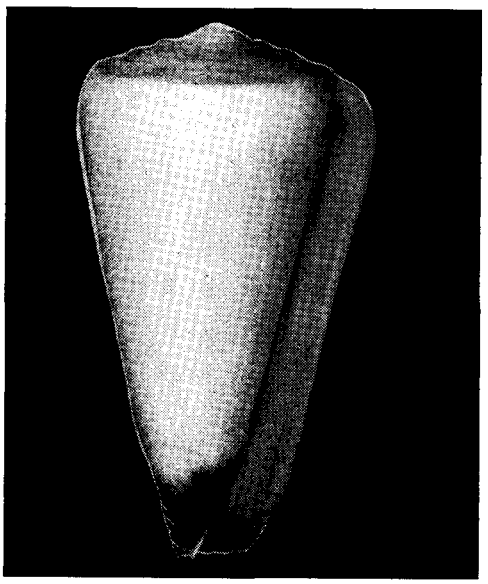


Figure 11—Virgiconus virgo, **Linnaeus**

A stoutly built shell of a pale-yellow colour, with smooth, slightly overlapping whorls and an almost flat base.

The fore-end is of a deep violet colour, affecting also the outer lip in this area.

Length: usually about 4 inches, but may be as much as 6 inches.

Found on reefs in the Indo-Pacific.

Fig. 12

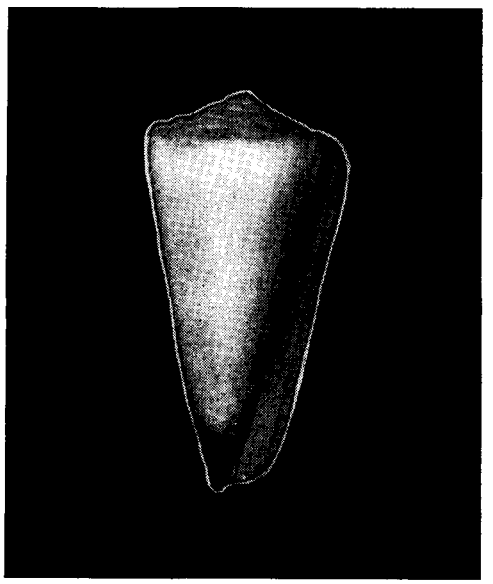


Figure 12—Virgiconus pastinaca, **Sowerby**

This shell, too, is of a pale-yellow colour, and greatly resembles *Virgiconus virgo*. However, the violet spot at the anterior tip is lighter and does not extend to the outer lip, which is pearly white throughout. The apex is taller and has a violet sheen.

The average size is 2-4/5 inches.

It is found on several South Pacific islands including New Caledonia.

PLATE VI

Fig. 13

Figure 13—Leptoconus generalis, Linnaeus

This slender shell is of a dark-brown or yellowish-brown colour. At the shoulder, near the middle and at the point, there are three white bands with the brown colour of the shell encroaching upon them here and there.
The spire is flat and the apex pointed.
The pearly aperture is darker near the fore-end.
The size varies between 2 and 4 inches.
Habitually encountered in northern Australia and on the islands of the South Pacific, including New Caledonia.

Fig. 14

Figure 14—Rhombus imperialis, Linnaeus

This elongated shell has a white ground surface with many spiral rows of brownish dots and bars.
Two brown or greenish-grey bands of a more or less regular shape also encircle the surface of the body whorl.
The whorls do not overlap; they are studded with numerous tubercles.
The aperture has a pearly sheen and is dark brown at the anterior tips.
The length varies, as a rule, between 2 and 3-1/5 inches.
Frequently found in the Indo-Pacific. Encountered near the Hawaiian Islands, in southern and eastern Polynesia, in Melanesia, and in the Indian Ocean as far as the African coast.

Fig. 15

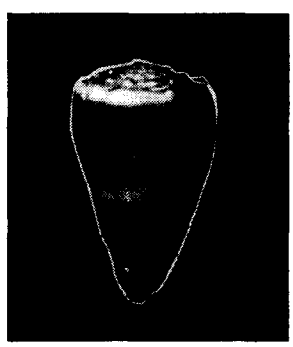


Figure 15—Stephanoconus lividus, Bruguiere

This small shell has overlapping whorls studded with projecting white knobs clearly outlined against the caramel colour of the shell. The lower third shows fine spiral threads dotted with white granules.
On the middle part of the body whorl there is a lighter band which may even be completely white.
The aperture is purplish.
The average length is 2 inches.
Found in the South Pacific, the Indian Ocean, and the Red Sea.

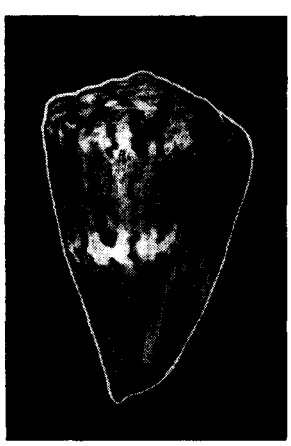


Fig. 16

Figure 16—Rhizoconus capitaneus, Linnaeus

The shell is small with a very wide base; it has a yellow- or caramel-coloured surface and is encircled near the shoulder and middle by two white bands edged with black.
The body whorl is scattered with dotted lines.
The whorls are smooth and overlap slightly.
The aperture has a bluish sheen.
The size varies between 2 and 3-1/5 inches.
Lives on reefs in the Indo-Pacific, mainly off the north coast of Australia.

Figure 17—Leptoconus ammiralis, Linnaeus

This shell, of sturdy construction, has an ivory ground colour, with chestnut-coloured bands dotted with many irregular white spots.
Fine wavy lines cover the surface of the body whorl.
The whorls overlap and leave the very pointed apex quite clear.
The opening has a pearly white sheen.
Length: approximately 2-4/5 inches.
Found from the south of Japan to Melanesia.

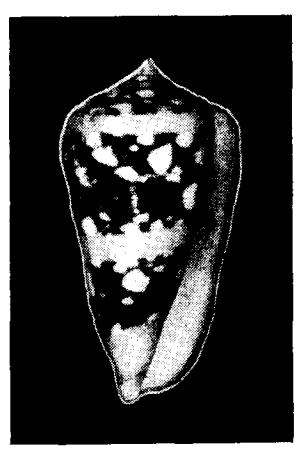


Fig. 17

(Photos: Studio-Boixo, Nouméa)

(Collection: P. Revercé, Nouméa)

PLATE VII

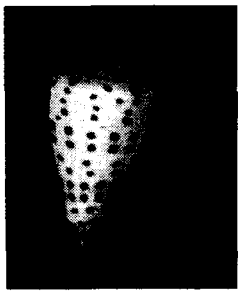


Fig. 18

Figure 18—Lithoconus eburneus, Bruguière

This small shell has a white surface with dark-brown bars of varying thickness, separated by two or three yellow stripes.
The whorls are smooth and the spire is practically flat, except at the centre, where a very pointed apex protrudes.
Hardly ever more than 2 inches long.
Lives on reefs and sand banks in the Indo-Pacific.

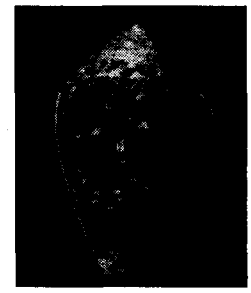


Fig. 19

Figure 19—Virroconus coronatus, Gmelin

The shell shows pink shades with dark-brown patches and the entire surface bears rows of alternating white and brown dots.
The overlapping whorls delineating the spindle-shaped apex and small granules give the spire a crown-like aspect.
The average length is 1-1/5 inches.
The species is mainly found off the north coast of Australia and in New Caledonia.

Fig. 20

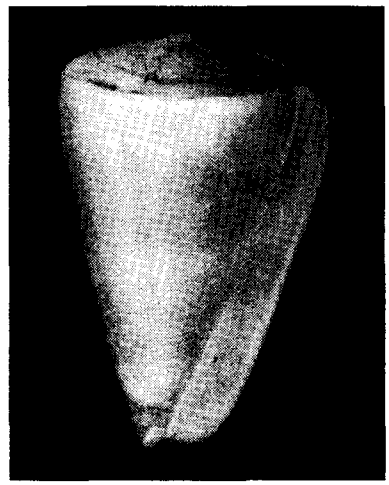


Figure 20—Cleobula quercinus, Solander

A lemon-yellow shell of heavy texture. The spire is rather wide and the fore-end short, which gives the shell a stocky appearance.
The whorls are smooth and slightly overlapping.
The apex is very sharp. The aperture is of a pearly white colour.
Length: varies between 2-4/5 and 4 inches.
In many publications this species has been described under the name of *Conus cingulum*, Martyn.
Found throughout the Indo-Pacific area.

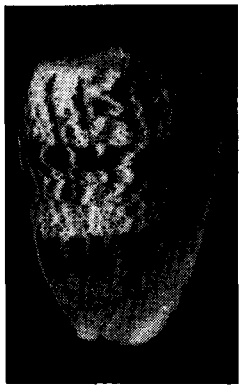


Fig. 21

Figure 21—Puncticulis arenatus, Bruguière

The shell has a shagreen-like appearance; the whole surface is covered by countless minute dark-brown dots arranged in spiral rows. These spiral rows are denser towards the upper third and at the fore-end, where they form two dark zones clearly contrasting with the lighter background of the shell.
The whorls are carinated at the shoulder.
The aperture is of a pearly white colour.
Length: varies between 1-3/5 and 2-4/5 inches.
Found on the shores of islands of the South Pacific.

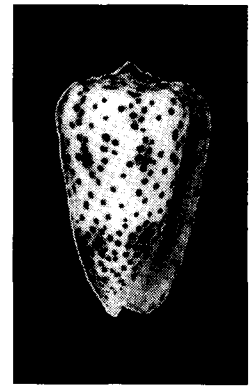


Fig. 22

Figure 22—Puncticulis pulicarius, Bruguière

The shell has a porcelain-white appearance with many scattered dark-brown bars.
The overlapping whorls are studded with tubercles on the shoulder.
The apex is pointed.
The size varies between 1-3/5 and 2-2/5 inches.
This species is found on South Pacific islands, south of Japan, and east of India.

(Photos: Studio-Boixo, Nouméa)

(Collection: P. Revercé, Nouméa)

PLATE VIII

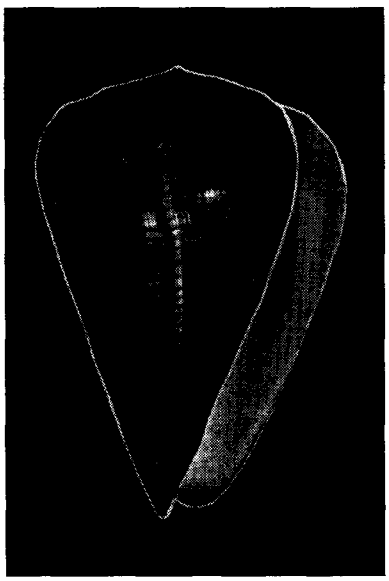


Fig. 23

Figure 23—Cleobula figulinus, **Linnaeus**

This light chestnut-coloured shell is encircled from tip to shoulder by darker lines of varying width.
The whorls are smooth. The spire is rather flat and dark.
The apex is very pointed.
The aperture is of a pearly white colour.
Length: varies between 1-3/5 and 3-1/5 inches.
Appears to be present throughout the Indo-Pacific area.

Figure 24—Rhizoconus miles, **Linnaeus**

The shell is of variable size and densely covered by wavy, longitudinal, brown lines contrasting with the white ground colour of the shell.
Two chocolate-coloured bands encircle the middle and anterior parts. Spiral threads are raised near the fore-end.
The whorls overlap and the apex is well marked.
Length: varies between 2-2/5 and 4-4/5 inches.
Found over wide areas of the Indo-Pacific, in the Hawaiian Islands, in southern and eastern Polynesia, in the Philippines, south of Japan, and in the Indian Ocean as far as the coast of Africa.

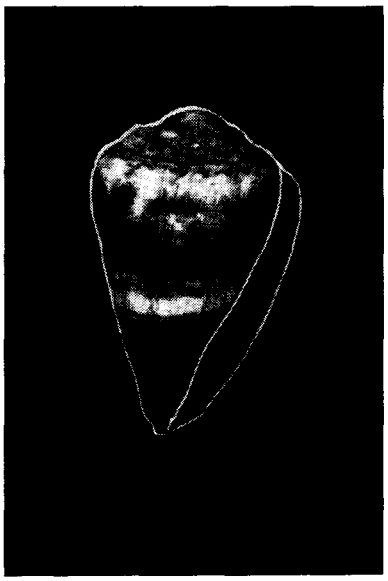


Fig. 24

Figure 25—Virroconus ebraeus, **Linnaeus**

The white surface bears black, quadrilateral scales arranged in three or four transverse rows.
The slightly overlapping whorls are surmounted by faint tubercles.
The pearly aperture shows shades of dark brown corresponding to external scales.
Length: varies between 4/5 inch and 2 inches.
Found on all islands of the South Pacific, east of India, and on the African coast.

Fig. 25

Figure 26—Conus scabriusculus, **Chemnitz**

A strong shell, coloured white with dark-brown patches. It bears transverse striations.
The whorls are smooth and overlapping.
The average length is 1-1/5 to 1-3/5 inches.
It is found in New Caledonia and apparently nowhere else.

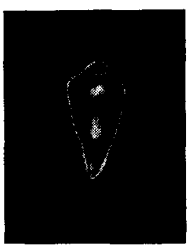


Fig. 28

Figure 27—Stephanoconus balteatus, **Sowerby**

This shell is of a caramel-brown colour, with dark, transverse lines.
The whorls, studded with tubercles, are white at the shoulder.
The aperture is violet.
Length: approximately 1-1/5 inches.
So far this species has been found only in New Caledonia.

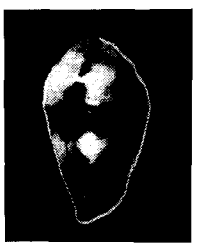


Fig. 26

Figure 28—Conus cabriti, **Bern**

The shell is of a light structure and of a blackish colour with white blotches. The apex is well marked.
The aperture is dark.
The size hardly ever exceeds 4/5 inch.
This species has been reported only in New Caledonia.

Fig. 29

Figure 29—Hermes coccineus, **Gmelin**

The shell is of an orange-yellow colour and has a granular appearance. At the middle there is a white band flecked with black.
The apex protrudes.
Length: approximately 4/5 inch.
This species has been reported only in New Caledonia.

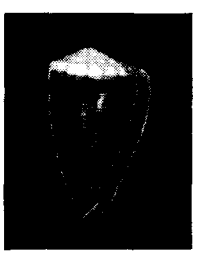


Fig. 27

Figure 30—Conus sponsalus, **Chemnitz**

The shell is a globular shape; on its upper half it bears dark, longitudinal bands. The lower part shows transverse striations.
The whorls are studded with tubercles.
The aperture is more or less black near the fore-end.
Length: approximately 4/5 inch.
This species is endemic to New Caledonia.

Fig. 30

(Photos: Studio-Boixo, Nouméa)

(Collection: P. Revercé, Nouméa)

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