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MARINE SPONGES FROM AN ISLAND CAVE ON SAN SALVADOR ISLAND, BAHAMAS

by

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ABSTRACT

Dixon Hill Lighthouse Cave, about 800 m (0.5 miles) inshore on San Salvador Island, Bahamas, was found to hold populations of three sponge species new to science, viz. *Pellina penicilliformis* n. sp., *Prosuberites geracei* n. sp., and *Cinachyra subterranea* n. sp. The new species are described and figured, and compared with Caribbean congeneric species. The geological history of the cave is described and its implication for ideas on speciation rates in sponges is discussed.

RÉSUMÉ

Dans la Dixon Hill Lighthouse Cave (île San Salvador des Bahamas, à 800 m environ de la côte) des populations de trois espèces de Spongiaires, nouvelles pour la science, ont été découvertes; il s'agit de *Pellina penicilliformis* n. sp., *Prosuberites geracei* n. sp. et *Cinachyra subterranea* n. sp. Les espèces nouvelles sont décrites et figurées; elles sont comparées avec des espèces congénériques des Caraïbes. L'histoire géologique de la grotte est décrite et l'on fait des commentaires sur les implications de cette histoire sur les idées concernant les rythmes de spéciation chez les spongiaires.

INTRODUCTION

The Bahamas consist of 29 major islands, over 700 "cays", and 2300 rocky shoals. This recently independent island nation extends from latitude 20°50'N to 27°25'N, and longitude 72°37'W to 80°32'W, on the Atlantic side of Florida and Cuba. San Salvador Island, previously called Guanahani and Watling Island (24° N 74°25'W), was the landfall for the first voyage of Columbus on 11-14 October 1492 (cf. Morison, 1942); it serves as the locus of the present study as well.

Dixon Hill Lighthouse Cave was discovered by Dr. Donald Gerace, director of the San Salvador Field Station. The cave contains fully marine water and by its position 800 m (0.5 miles) inland, without an obvious connection with the sea, immediately attracted attention from visiting scientists from the U.S.A. and other countries.

During the Amsterdam Expeditions to the West Indian Islands in 1979, the fauna of the cave appeared to contain a.o. three sponges new to science; the prime purpose of the present paper is to provide description of them.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. D. F. Gerace for bringing the problem to their attention, providing facilities while on San Salvador Island, and permission to read and use the then unpublished manuscripts of Dr. John Mylroie of Murray State University, Ky., and Dr. Robert W. Adams of S.U.N.Y. Brockport, N.Y.

Prof. Dr. J. H. Stock and Dr. S. Weinberg (Institute of Taxonomic Zoology, University of Amsterdam) and Dr. Rudy Prins of W. Kentucky University and several of his students were helpful in obtaining both specimens and pictures of the sponges. The fieldwork of Stock c.s. has been supported by grants of the Netherlands Foundation for the Advancement of Tropical Research (WOTRO), The Hague, by the Landbouw Hogeschool Fonds, Wageningen, and by the Beyerinck-Popping Fonds, Amsterdam.

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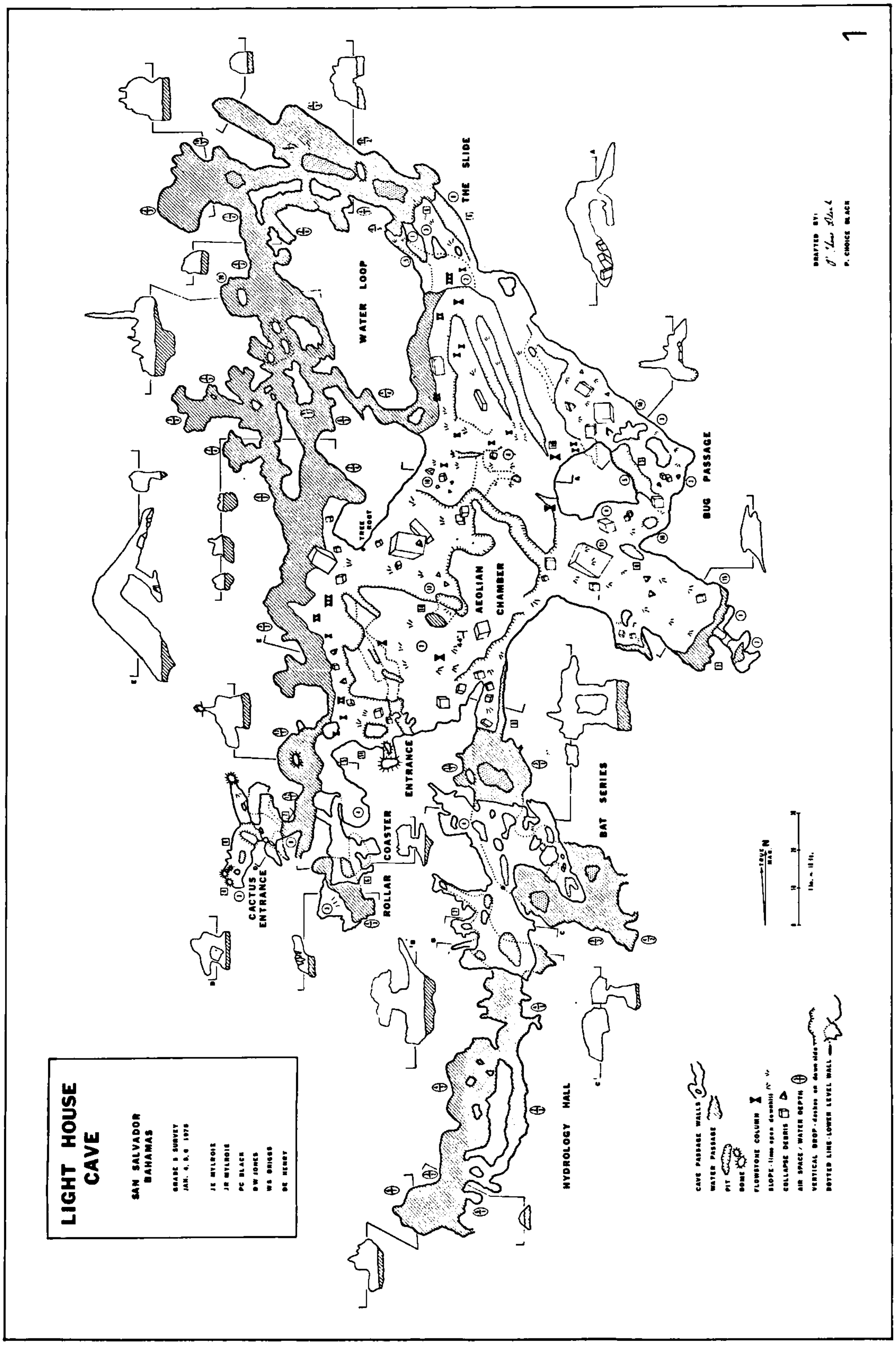

Fig. 1. Map of Lighthouse Cave and its system of galleries, passageways and pools (after Mylroie, 1980).

GEOMORPHOLOGY OF SAN SALVADOR

San Salvador is located near the eastern margin of a marine platform which (Adams, 1980) represents an accumulation of approximately 6,000 meters of Upper Cretaceous and Tertiary carbonates on a basement of unknown origin. Topographically the island appears to consist of a succession of arcuate hills separated by intervening lakes. The terrain has been interpreted as a succession of arrested wind-blown dunes with the interdune areas at or near sea level. Almost without exception, the surficial rocks are calcarenites which can be differentiated as to origin.

The most common characteristics of the rocks above the coastal margins are those associated with the activity of the wind. Adams (1980) shows many examples of these which he calls "aeolianites". Their stabilization was probably due to the rapid dolomitization of the constituent grains, and surficial fixation by the rapid succession of vegetation-processes which are accelerated in the tropics.

All of the constituents of the carbonate facies on the island have chemical or biochemical origins. In the first case, the supersaturation of the warm shallow marine seas with calcium carbonate resulted in the accumulation of massive quantities of aragonitic lime muds as minor changes took place in the geochemistry of the water. Plants and animals can also extract the essential ions from the waters they inhabit to construct carbonate skeletons or shells. The carbonate precipitates, regardless of origin, are returned to the sea in solution or temporarily "stored" on land or sea as beach rock, dunes, etc.

Both meteoric and marine waters have begun the process of reducing the rock bastions of San Salvador to their basic elements. Adams (1980) has recorded the various terranes created by the processes of erosion; prominent among them is a resulting relief called karstification. The karstification or solution terrane varies from simple surface depressions a few centimeters across, to subsurface caverns many meters in depth and of considerable linear extent. The deeper penetration of percolating waters mainly originated in the Pleistocene, when the sea level was low and the effective relief large (Fairbridge et al., 1975). The Dixon Hill Lighthouse Cave is a premier example of a major karstification feature on San Salvador.

DESCRIPTION OF LIGHTHOUSE CAVE

Dr. John Mylroie of Murray State University, Kentucky, and his students have examined Lighthouse Cave and prepared a map of it (fig. 1). An edited version of their description (1980: 74) follows:

"The cave is entered by a collapse modified solution pit that enters the cave's large central room, Aeolian Chamber (fig. 1). The cave is a series of rooms connected by tubular conduits, and despite the large, open expansion of these chambers, breakdown and collapse are a minor feature in the cave... The cave trends north-south, and the solution sculpture is well-developed on walls, floors and ceiling. Directional flow markings are difficult to find and interpret, and the flow direction of the water through the cave during its formation has not been positively established. The cave formed below the saturated (phreatic) zone of the limestone, probably at an earlier, higher sea level. The cave has since been drained, and water percolating into the cave (vadose water) has cut small canyons and pits into the cave floor. In a few areas, this vadose water has formed fluted domepits, as in the entrances and in Bug Passage (fig. 1). The vadose water has also produced secondary calcite deposition (speliothems) in the form of stalactites, stalagmites, flowstones, etc. Most of this secondary calcite deposition is no longer active, indicating a change in conditions... The lowest passages in the cave contain water, which is slightly hypersaline. The water level fluctuates with the tides, and water flow can be seen during these fluctuations in the Cactus Entrance of the cave. The water containing passages generally have bedrock floors, and water depths over 8 feet (2.4 m) have not been recorded. The water containing passages are suspected to continue laterally away from the cave as flooded passages, but their existence has not been documented. The tidal fluctuation within the cave does indicate a connection to the sea...

From the entrance, the large Aeolian Chamber trends north for 120 feet (36.5 m) as a broad chamber varying from 20 to 2 feet (6-0.6 m) in height. The floor of the room is bedrock and scattered breakdown, with small vadose passages and pits cut into the higher parts of the floor. Immediately east of the entrance, a narrow passage leads down to waterflooded passages called the Bat Series. Numerous bats make exploration here unpleasant, but crawling up into any of a number of domes leads to a clear dry upper level that drops in turn into Hydrology Hall, a water flooded passage that leads south for 100 feet (30.5 m) to the southernmost portion of the cave; Hydrology Hall ends in a blank wall, and no obvious continuation exists. From the junction of Bat Series with Aeolian Chamber, proceeding 50 feet (15.2 m) north along the east wall of Aeolian Chamber leads downslope to a room and a pool. North from here a passage, Bat Passage, loops around and rejoins Aeolian Chamber... Following the wall of Aeolian Chamber to the north and northwest leads to the Slide, an inclined series of crawls that lead down to a complex of flooded passages called the Water Loop. These passages exist under the west wall of Aeolian Chamber from the Entrance to the Slide. Water depth varies with the tide,

> but generally some swimming is needed to traverse this area. Solutional sculpture is exceptionally well-developed, including walls, floor and ceiling. Several phreatic domes lead up to 20 feet (6.1 m) above the water passages, but end in blind pockets..."

Gerace (pers. comm.) and Carpenter (pers. comm.) have observed that oceanic tidal fluctuations apparently effect the water level in the cave and that the differences between high and low tidal levels may fluctuate from 20″ to 24″ (50-60 cm) twice daily. These differences match those of the nearby ocean but lag behind the oceanic fluctuations by a factor of two hours.

Carpenter (1981) reports that water samples, taken between 1978 and 1980, had salinities of approximately 3.5% (as measured by hydrometer) which coincides with the salinity of the adjacent ocean water. Stock & Weinberg (pers. comm.) found a chlorinity of 21.264 mg/l. Cave water temperature is usually 25° C in summer which is a bit cooler than the 30° C measured in the nearby ocean. The few chemical tests of cave water quality indicate a dissolved oxygen content of approximately 8 ppm.

Mylroie (1980) and Carpenter (pers. comm.) have noted the existence of a substantial fauna in the cave. The non-aquatic elements include bats, land crabs, hermit crabs, cockroaches, and scorpions (Carpenter is currently working on a detailed inventory of the fauna which apparently includes forms new to science). The aquatic elements of the fauna include a new cirolanid isopod, phoronid worms, sponges, ostracods, gastropods, harpacticoids, amphipods, oligochaetes, foraminiferids, and polychaetes.

In the pools in the cave several sponge species occur, among them *Tethya* spec., and three sponges new to science, though belonging to wide-spread marine genera. The latter were most abundant in Mylroie's Hydrology Hall (cf. fig. 1).

SYSTEMATIC DESCRIPTIONS

Order HAPLOSCLERIDA

Family OCEANAPIIDAE

Pellina penicilliformis n. sp.

Pl. I figs. 2-4, text-fig. 2.

Material. — Holotype: Zoological Museum Amsterdam (ZMA), cat. no. POR 4579 (now fragmented), Dixon Hill Lighthouse Cave, San Salvador, Bahamas, 23/24-XI-1979, coll. S. Weinberg & J. H. Stock (Amsterdam Expeditions to the West Indian Islands, sta. 79/186).

Paratypes: National Museum of Natural History, Washington, D.C. (USNM), cat. no. 31744-45, same locality as holotype, coll. D. B. Sass.

Description. — Shape, size and consistency: Creeping "stolons" with upright branches, infrequently and irregularly anastomosing. Branches thin-walled, hollow, up to 25 cm long, up to 1 cm in diameter; lateral expansion indefinite. Consistency slightly brittle, extremely fragile; it is impossible to lift it out of the water without fragmenting it. No apparent oscules found.

Colour: Straw-coloured.

Ectosome: A typical three-dimensional reticulation of single spicules supported by longitudinal spicule tracts of about 7 spicules in cross section, bound by a very small amount of spongin. Dermal pores 70-120 µm.

Choanosome: What could be found of the choanosomal skeleton consisted of a single spicule reticulation.

Spiculation: Robust, long oxea: 342-*368.1*-390 by 9-*11.1*-13 µm. These constitute a major diagnostic character, as *Pellina* species with such long spicules are unknown up to now.

Habitat. — At bottom of pools on rocks and on rather soft sediment; always submerged, more frequent at some depth (2-3 m).

Etymology. — *penicilliformis* = in the form of a hair-pencil.

Discussion. — The genus *Pellina* Schmidt, 1870, so far was represented in the West Indies by two species (cf. Van Soest, 1980): *P. nodosa* (George & Wilson, 1919) and *P. carbonaria* (Lamarck, 1813). Of these *P. nodosa* (synonyms *P. coela* De Laubenfels, 1950, and *P. coeliformis* Hechtel, 1965) is obviously quite close to the above described new species, but it is smaller (up to 10 cm high, 0.5 cm in branch-diameter), more brittle and the spicules are about half as long as those of *P. penicilliformis*. *P. carbonaria* deviates strongly from both in habit, consistency, colour (black); it may not be a *Pellina* after all.

Elsewhere, *Pellina* is represented by five names

TABLE I

Species recognized as belonging into *Pellina* sensu Van Soest, 1980, with specific characters and distribution.

Species	Distribution	Spicule size	Size of fistules	Colour	Consistency
Pellina semitubulosa	Mediterr.-Atlantic	75-*150*-220/1.5-*4.5*-6.5	2-10/0.5 cm	white	fragile
Pellina fistulosa	Mediterr.-Atlantic	85-*122*-152/2.5-*3.5*-6.8	0.7/0.2 cm	white-yellow	fragile
Pellina nodosa	West Indies	82-*129*-165/3-*4.8*-6.5	fewer 4.5/0.3-0.5 cm	white	fragile
Pellina carbonaria	cosmotropic?	127-*188*-260/3.6-*8.1*-13	? /1 cm	black	brittle-tough
Pellina penicilliformis	West Indies	342-*368.1*-390/9-*11.1*-13	25/1 cm	straw-white	extr. fragile
Pellina polysiphonia	Indian Ocean	140/4	4.5/0.2-0.3 cm	grey-white	fragile-spongy
Pellina eusiphonia	? Australia	330/12-19	(1.2)/0.3-0.4 cm	? grey-white	fragile
"*Adocia semitubulosa*"	Chatham Islands	100-180/6	0.6-3/0.4-0.7 cm	yellow-white	fragile
Pellina "*semitubulosa*"	California	50-130/2-5-10	2.5/0.3-0.4 cm	white	fragile
Pellina pinella	Palau Islands	98/3	1.1/0.3 cm	white	fragile
Pellina cioniformis	Indian Ocean	120-130/6	small	grey-yellow	fragile

from the Mediterranean-Atlantic region (cf. Griessinger, 1972): *P. semitubulosa* (Lieberkühn, 1859), the type-species of the genus (somewhat less fragile, but otherwise quite like *P. nodosa* and *P. penicilliformis*), *P. parietalis* (Topsent, 1893; redescriptions by Topsent & Olivier, 1943, and Griessinger, 1972), which seems an untypical, doubtful *Pellina*, *P. magna* (Vacelet, 1959), which seems to be a *Reniera*, not a *Pellina* in the sense of Van Soest (1980), *P. fistulosa* (Bowerbank, 1866), a rare but typical *Pellina* originally described from British waters.

In Indo-Pacific waters at least six clear representatives of *Pellina* are known, viz. *P. polysiphonia* (Dendy, 1922) (originally described in *Phloeodictyon*), which seems the vicariant species of *P. nodosa* with only subtle, minor differences; *P. eusiphonia* Ridley, 1884, which seems morphologically closest to *P. penicilliformis* by virtue of its large fistules and robust spicules (330 by 12-19 μm); "*Adocia semitubulosa*" Bergquist, 1961, from subtropical waters near New Zealand, which seems indeed close to Mediterranean *P. semitubulosa*; *Pellina* "*semitubulosa*" Dickinson, 1945, from Californian waters, which undoubtedly represents a vicariant species of *P. nodosa*; *P. pinella* De Laubenfels, 1954, from Palau, which seems also close to *P. nodosa*; and *P. cioniformis* Lévi, 1956, from Madagascar, which seems a somewhat separate species.

Other species described in the literature under *Pellina* or related generic names at a closer scrutiny belong to *Oceanapia* or *Reniera*, or are suspected synonyms. The distribution of the genus, from this provisional, probably incomplete survey (for a summary cf. table I), thus seems to be typically tropical-subtropical, with an occasional wandering into temperate waters.

Order HADROMERIDA

Family SUBERITIDAE

Prosuberites geracei n. sp.

Pl. II fig. 1, text-fig. 3.

Material. — Holotype: ZMA cat. no. POR 4580, Dixon Hill Lighthouse Cave, San Salvador, Bahamas, 23/24-XI-1979, coll. S. Weinberg & J. H. Stock (Amsterdam Expeditions to the West Indian Islands, sta. 79/186).

Paratype(s): USNM cat. no. 31746, same locality as holotype, coll. D. B. Sass.

Description. — Shape, size and consistency: Thinly (less than 1 mm) encrusting calcareous rocks and limestone cave walls, superficially smooth. Lateral expansion indefinite. Consistency soft, easily damaged. No evident oscules.

Colour: Blue or greyish blue, alive and in spirit.

Ectosome: Thin, organic, microhispid with single, projecting spicules.

Choanosome: Due to the heavily pigmented organic and calcareous debris on which the sponge thrives, difficult to study. Spicules stand erect on the substrate, points up, singly or in small groups. No clear palissade or plumose brushes.

Spiculation: Exclusively tylostyles with prominent rounded knobs, of widely varying sizes: 190-*340.5*-555 by 3.5-*8.5*-18 μm.

Habitat. — On rocks and vertical walls, barely covered at low tide.

Etymology. — The species is named after Dr. Donald Gerace, the discoverer of the cave.


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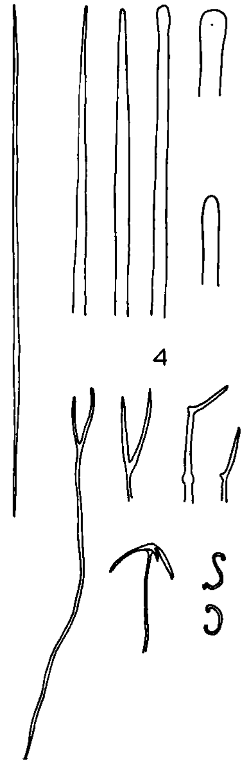
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Fig. 2. *Pellina penicilliformis* n. sp., spicule.
Fig. 3. *Prosuberites geracei* n. sp., spicules.
Fig. 4. *Cinachyra subterranea* n. sp., spicules.

Discussion. — *Prosuberites* is known from the West Indies by only a few records. *Alcyonium epiphytum* Lamarck, 1813 (redescribed as *P. epiphytum* by Topsent, 1933), said to be cosmopolitan, is reported from the West Indies (Topsent, 1933: 34), although sufficient evidence for this record was not given. Specimens from Holland (cf. Van Soest, 1977) and Curaçao, referable to this genus do not seem to be conspecific. The latter may perhaps be identical with De Laubenfels' (1936a) *Prosuberites microsclerus* described from Florida. Both Topsent (l.c.) and De Laubenfels (l.c.) made some partly or wholly erroneous statements.

Lamarck's material is "probablement originaire des mers d'Amérique", which in practice means that it could have come from anywhere, that is: anywhere with a vegetation of fucoid algae (cf. Ridley, 1884: 465, who saw the type-specimen too, and found it to encrust fucoid algae). Topsent further claims to have seen the species in material from the Gulf of Campêche, but refrains from giving substance to his statement. De Laubenfels (1936a) erected a new species, *P. microsclerus* on account of its "exceedingly small" spicules (125-250 by 2 μm); this is not exceedingly small as compared to European *P. epiphytum* (Holland: 90-340 by 0.5-5.5 μm), or the type-specimen of *Alcyonium epiphytum*: 250 by 6 μm. However, the erection of *P. microsclerus* is probably correct, as it is unlikely that the type-specimen of *Alcyonium epiphytum* was of West Indian origin. Specimens described from Australia by Ridley (1884) are very similar to both, with typical, rather small pin-shaped spicules, encrusting habit and yellow colour.

It is clear that the present material by its colour and robust tylostyles represents a new species of this insufficiently known genus. The genus *Prosuberites* needs to be compared to the genus *Terpios* Duchassaing & Michelotti, 1864, a common West Indian genus, with, admittedly, elaborate, often erect or branched habit, but starting out as thin encrustations not unlike *Prosuberites.*

Order SPIROPHORIDA
Family TETILLIDAE

Cinachyra subterranea n. sp.

Pl. II fig. 2, text-fig. 4.

Material. — Holotype: ZMA cat. no. POR 4581, Dixon Hill Lighthouse Cave, San Salvador, Bahamas, 23/24-XI-1979, coll. S. Weinberg & J. H. Stock (Amsterdam Expeditions to the West Indian Islands, sta. 79/186).

Description. — Shape, size and consistency: Hispid, globular sponge of 2 cm in diameter. Porocalyces 8 in number, distributed irregularly over entire sponge. Attachment to the rock not by a root of spicules but by a smooth, flat, disklike part. Porocalyces are surrounded by a palissade of megascleres protruding 5 mm or more beyond the ectosome. Consistency fairly soft, easily damaged. No pseudoscules.

Colour: Grey-white, alive and in spirit.

Ectosome: A cortex consisting of a palissade of large megascleres cemented by large amounts of microscleres.

Choanosome: Radiate architecture, rather open with a fair proportion of organic mass. Skeleton of the usual *Cinachyra* type: large radiating megascleres with large numbers of microscleres.

Spiculation: The peculiarities of the spiculation constitute the major specific character. Megascleres are predominantly oxeote forms and prodiaenes. Among the oxeote forms the number of tylote modifications is striking and peculiar. Promonaenes (not known from West Indian *Cinachyra* species so far) and especially anatriaenes are quite rare. Protriaenes absent. Sigmaspires numerous. Sizes of the spicules are:

oxeotes:	1800-2500	by	15-30	µm.
prodiaenes:	1100-2300	by	4-8	µm.
promonaenes:	1300-2350	by	4-10	µm.
anatriaenes:	1400	by	7	µm, cladomes 70 µm.
sigmaspires:	10-13 µm.			

Habitat. — On vertical wall and floor of the cave; some individuals are exposed at low tide.

Etymology. — Named after its subterranean occurrence.

Discussion. — Table II summarizes all West Indian *Cinachyra* records. Possibly some of Schmidt's (1870) *Craniella* species are also *Cinachyra* but we will have to await redescriptions from the type preparations present in the British Museum (Natural History). A total of eight names (including the new species described above) is available. A comparison of the descriptions makes a few preliminary conclusions possible, although ultimately we will have to await a proper revision based on re-examination of as much specimens as possible.

According to Wiedenmayer (1977), De Laubenfels' 1949, 1950 and 1953 material described as *C. cavernosa* (Lamarck, 1814) is all referable to *C. alloclada* Uliczka, 1929; the same applies to Wells, Wells & Gray's (1960) *C. cavernosa* and De Laubenfels' (1936a) *C. alloclada*. If we combine all the descriptions with those of Uliczka (1929) and Wiedenmayer (1977), this species has the following characters: globular, 2-8 cm in diameter; yellow, ochre-yellow or yellow-orange; strongly hispid surface in smaller, much smoother in larger specimens; porocalyces distributed mostly along a belt around the equator of the specimens; pseudoscules present on the apex; abundant oxea 1000-7000 by 3-50 µm (possibly in two size categories); no promonaenes; protriaenes and prodiaenes fairly rare (sometimes prodiaenes are absent), 3000-6600 by 5-20 µm with clads of 30-185 µm; anatriaenes 1000-5200 by 1-20 µm with clads of 10-300 µm; normally without small oxea (although Wiedenmayer found rare oxea 75-197 by 2-3.5 µm, which may not be proper); sigmaspires 7-20 µm. Although certain details are not described, De Laubenfels' (1936b) account of his alleged *C. apion* Uliczka, 1929, reminds strongly of *C. alloclada* too.

C. apion Uliczka, 1929, is here upheld as a separate species, in spite of the lack of unequivocal recent redescriptions, by virtue of its two sizes of protriaenes and evenly distributed porocalyces. *C. rhizophyta* Uliczka, 1929, seems very close to the latter, also having two sizes of protriaenes and prodiaenes; the small differences (smaller clads in the protriaenes) between the two might be infraspecific variation.

C. kuekenthali Uliczka, 1929, is recently redescribed by Wiedenmayer (1977). The species is sharply differentiated from the preceding ones by its possession of small microhispid or crenulated oxea, possibly in two size categories: 47-100 by 1.5-3 µm and 285-370 by 5-10 µm. Furthermore the species is larger, up to 20 cm in diameter, yellow or orange, and tends to have a smoother, less hispid appearance; porocalyces are distributed evenly over the specimen, except for the top which holds some pseudoscules; spicules comprise the usual abundant, large oxea: 1320-4320 by 3-40 µm, rare triaenes of which sometimes a category is lacking: 960-3920 by 3-12 µm with clads of 10-72 µm, microscleres 7-20 µm.

C. schistospiculosa Uliczka, 1929, seems to be quite close to *C. kuekenthali*, the only noteworthy difference being the split nature of part of the oxeote megascleres, a freak incidence of little significance in our opinion. Protriaenes were not reported for this species, but this also seems to be of less importance, since Wiedenmayer's (1977) material did not contain anatriaenes.

For this reason, too, we think it quite likely that *Trachygellius cinachyra* De Laubenfels, 1936a (second record and redescription by Wells, Wells & Gray, 1960) also belongs in *Cinachyra*, possibly one of the above given species. It is difficult to tell which one, since no triaenes are known from this material. Other details such as habit (including porocalyces), size of megascleres and sigmaspires, make it quite likely that they belong in *Cinachyra*; for the time being they are best left as a separate species.

The new species described above differs clearly from all West Indian *Cinachyra* species, in the absence of pseudoscules, in the many tylote modifications of the oxeote megascleres, and in the presence of numerous promonaenes. In other details it is close to *C. alloclada*.

REMARKS ON SPECIATION RATE

The past geologic record of Pleistocene sea level changes reportedly of ca. 120 m (Bloom et al., 1974) must have created conditions whereby fresh and salt waters were alternatively factors in the cave's development. Recent fluctuations in sea level in excess of 6 m above the present would indicate that the penultimate erosion factor was marine. In fact, modified erosional buttresses and recesses in the Aeolian Chamber (pl. I fig. 1) could mark the tidal fluctuations of encroaching marine waters. The sequence of beach rock in the cave wall below the aeolinite would further confirm the complexity of the origin of the cave matrix.

Gerace (pers. comm.) has reported the discovery of a West Indian top shell in the beach rock wall of the cave. Radio carbon dating of the shell at the University of Miami laboratories has produced a date of ca. 23,000 years B.P. This would establish a base line date for the accumulation of the cave matrix sediment, additional data related to the cave's origin is being accumulated via the $^{16}O/^{18}O$ analysis of a stalactite from the cave roof.

Gerace (pers. comm.) also reports that the major surficial openings of the Dixon Hill Lighthouse Cave occur consistently at ca. 6 m above present mean tide level. It is entirely possible that the caves started with fresh water erosion during a low stand of the sea. In due course the island was inundated and in the process, for a while, there were fresh water lenses as long as a portion of the last parts of the island were above sea level. At this stage the caves and their passageways may have had the appearance of "blue holes". Upon complete submergence and the elimination of fresh water, the sponges could have invaded the caves. With re-emergence (or by caving in of the cave entrances) the sponges (and some other organisms) were trapped. It seems likely that the cave situation can be classed in one of Riedl & Ozretič's (1969) stages of development of "marginal caves".

It seems a reasonable assumption that the three new sponge species are limited in their distribution to the cave area, although the West Indian sponge fauna is by no means well known. A striking form like *Pellina penicilliformis* would have been noticed had it been distributed elsewhere. At least two of the three species seem closely related to common West Indian forms: *P. penicilliformis* seems a huge form of *P. nodosa* (George & Wilson, 1919) (common in mangrove forests and shallow bays), and *Cinachyra subterranea* seems only marginally distinct from *C. alloclada* Uliczka, 1929 (from reefs and lagoons).

The above cited data on the history and age of the cave make it a defendable hypothesis, that the new sponge species originate from marooned populations of marine shallow-water species of at least 23,000 years ago. Such a rate of speciation seems quite high, when compared to the evidence of slow evolution in tropical sponges, as accumulated by Wiedenmayer (1977: 241-242). On the other hand, the cave situation very likely speeded up the development of morphological changes due to inbreeding. Possibly the data of the top shell are misleading, because the shell might have reached the caves from land (Indians, hermit crabs) at a later stage than the sponges.

Specimens of another sponge species, *Tethya* cf. *maza* Selenka, 1893, were found both in the cave and in Snow Bay outside in fully marine surroundings. One might well ask, why in this case no (obvious) morphological changes took

TABLE II

West Indian *Cinachyra* records with summarized descriptions and tentative taxonomic conclusions (spicule sizes in μm).

Species	Surface	Colour	Size	Oxeote
C. rhizophyta Uliczka, 1929	hispid, oval porocalyces	grey-yellow (spirit)	—	3200-3800/25-43
C. alloclada Uliczka, 1929	hispid, porocalyces only on sides	grey (spirit)	up to 7 cm	3500-5200/32-42
C. alloclada; De Laubenfels, 1936a	hispid-smooth, small porocalyces	yellow	—	3000-4000/24-40 abundant
C. alloclada; Wiedenmayer, 1977	hispid-smooth, porocalyces 2-7 mm on sides, pseudoscules on top	yellow-orange	6 cm	1320-4480/3-50 very abundant
C. apion Uliczka, 1929	hispid, porocalyces equally distributed	—	pear-shaped	3420-4330/35-46
C. apion; De Laubenfels, 1936b	extremely hispid, porocalyces 1-3 mm	yellow	—	3000/30 very abundant
C. kuekenthali Uliczka, 1929	slightly hispid, porocalyces shallow, 6 mm in diameter	—	11 cm	2000-3000/8-40
C. kuekenthali; Wiedenmayer, 1977	smooth, porocalyces numerous, pseudoscules on top	orange	20 cm	1320-4320/3-40 abundant
C. schistospiculosa Uliczka, 1929	hispid, numerous porocalyces	grey (spirit)	3.5 cm	2000-3500/5-36 thin forms split
C. cavernosa; De Laubenfels, 1949	strongly hispid	golden yellow	—	abundant
C. cavernosa; De Laubenfels, 1950	extremely hispid, porocalyces 5-8 mm, pseudoscules on apex	ochre-yellow	8 cm	a. 3500-7000/35-50 b. 1000/3
C. cavernosa; Wells, Wells & Gray, 1960	hispid, porocalyces only on sides, pseudoscules on top	yellow-orange	2-2.5 cm	3500-4000/30-35
C. subterranea n. sp.	hispid, few porocalyces, distributed evenly	grey-white	2.5 cm	1800-2500/15-30 abundant, many tylote modifications
Trachygellius cinachyra De Laubenfels, 1936a	smooth, oval porocalyces	ochre-yellow		3000-4000/4-40
Trachygellius cinachyra Wells, Wells & Gray, 1960	smooth, oval porocalyces	ochre-yellow		2000-4000/4-40

TABLE II

Continuation of previous page.

Promonaenes	Prodiaenes	Protriaenes	Anatriaenes	Small oxea	Sigmaspires	Conclusion
absent		a. 3090-6050/4-9 clad. 43-70 b. 330-2100/2-4 clad. 17-43	2700-4800/4-7 clad. 24-42	absent	8-12	? syn. *C. apion*
absent		3500-6600/5-10 clad. 35-185	2650-4350/6-10 clad. 30-119	absent	12-18	*C. alloclada*
absent		a. ?/32 clad. ? b. ?/? clad. 15	1000/1-3 chord. 75 very abundant	absent	7-10	*C. alloclada*
absent		?/5-10 clad. 30-100 rare	3530-5200/3-5 clad. 10-50 chord. 75-90 abundant	75-197/2-3.5	7-19	*C. alloclada*
absent	absent	a. 1360-7280/5-12 clad. 28-147 b. 520-1010/1-2 clad. 5-13	1870-5780/5-8 clad. 18-60	absent	9-12	? syn. *C. rhyzophyta*
absent	absent	3000	3000	absent	10	*C. alloclada*
absent		1700-2600/5-7 clad. 52-72	960-1500/3-4 clad. 10-20	55-65/2.5-3	10-18	*C. kuekenthali*
absent		3480-3920/6-12 clad. 30-65 chord. 35-45	absent	a. 47-100/1.5-2 b. 285-370/5-10	7-20	*C. kuekenthali*
absent	absent	absent	1900-2500/3-5 clad. 22-36	90-150/2-5	12-18	*C. kuekenthali*
absent	absent	few	few	absent	15-20	*C. alloclada*
absent		?/10 clad. 56	?/5 clad. 50	absent	10	*C. alloclada*
absent	absent	3000/8-20 clad. 50-300	3000/8-20 clad. 50-300	absent	10	*C. alloclada*
1100-2350/4-10 common	common	absent	1400/7 clad. 70 rare	absent	10-13	*C. subterranea*
absent	absent	absent	absent	absent	6-11	? *C. cinachyra*
absent	absent	absent	absent	absent	6-11	? *C. cinachyra*

place in the cave population. Possibly, the reason is to be found in the absence of sexual reproduction in the cave population, since asexual bud formation is a common mode of reproduction in *Tethya*. Occasional influx of larvae into the cave by way of an unknown underwater passage is another possibility.

Although sponges do not constitute a normal element in marginal caves, there is no reason to assume that their speciation in Dixon Hill Lighthouse Cave is different from that of other large organisms as decapods and fishes in similar situations (cf. Riedl & Ozretič, 1969).

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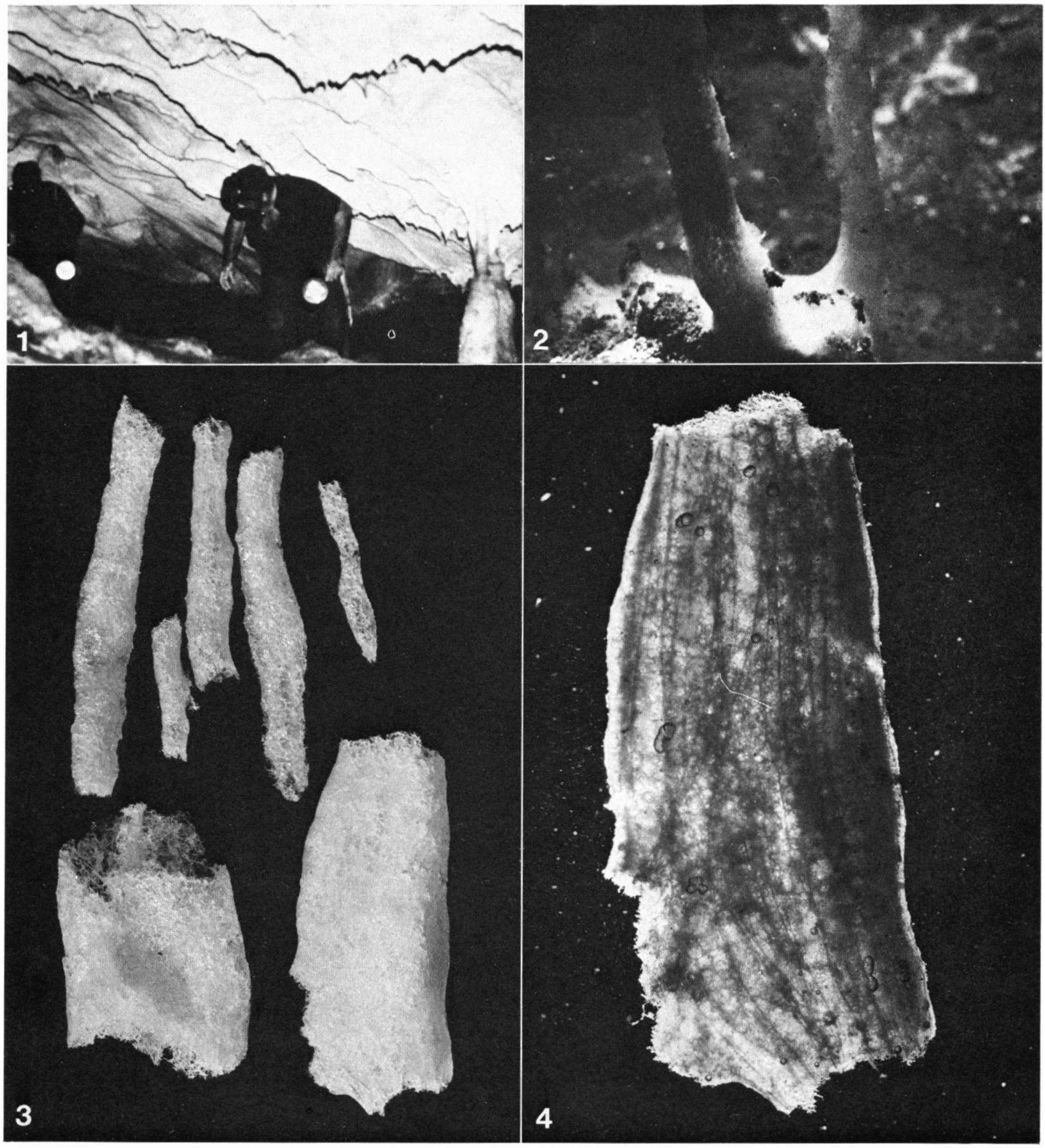


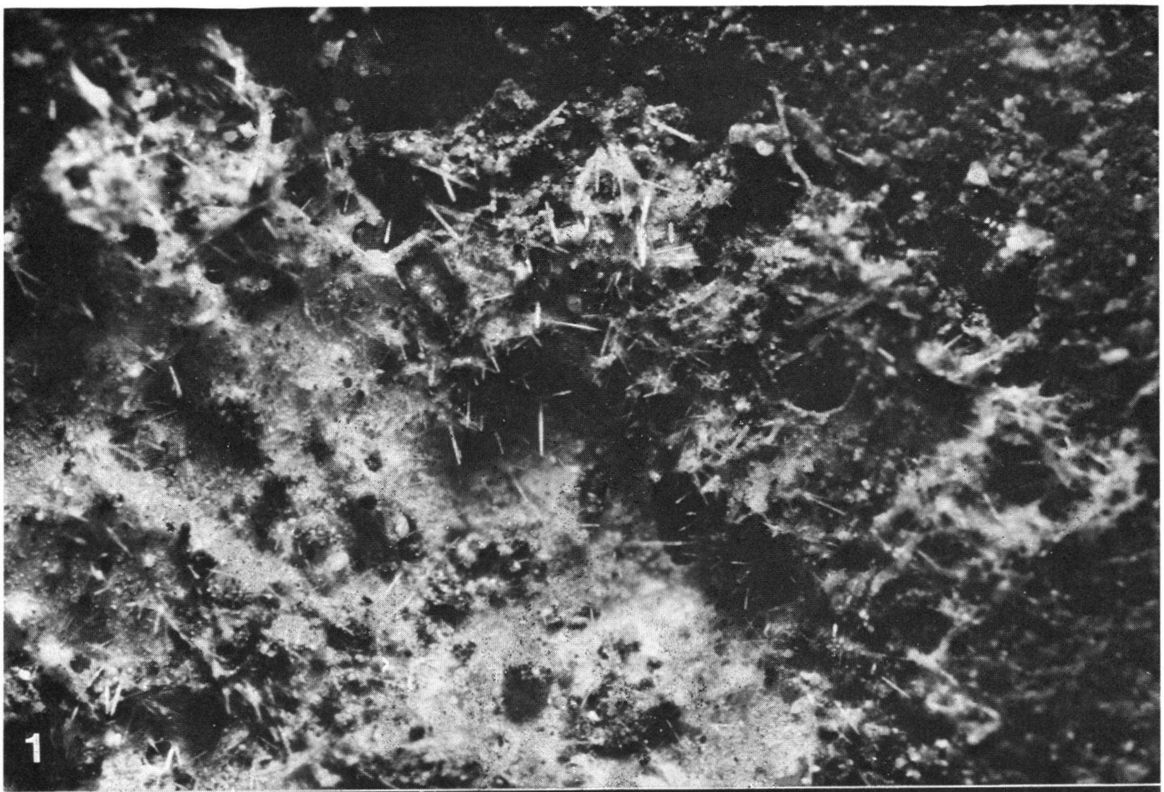
PLATE I

1, Cave explorers passing from the Water Loop into the Aeolian Chamber. The solution sculpture on the ceiling is well defined and may represent marine erosion during a higher tidal stand. (Photo D. B. Sass.)

2, A close-up of the branching mode of *Pellina penicilliformis* n. sp. in situ (× 1.0). (Photo R. Prins.)

3, *Pellina penicilliformis* n. sp., holotype fragments (× 2.5). (Photo L. A. van der Laan.)

4, *Pellina penicilliformis* n. sp., holotype fragment in transparent light to show the subdermal supporting system of longitudinal spicule tracts (× 4.5). (Photo L. A. van der Laan.)



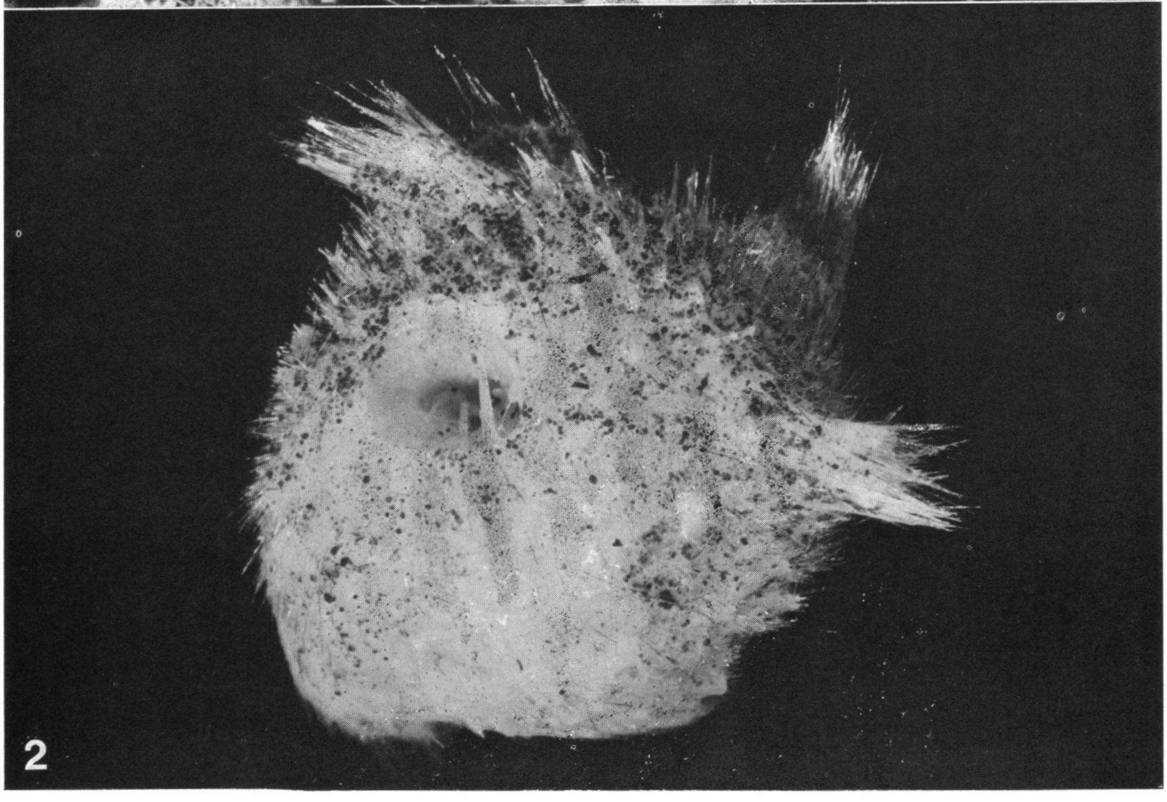


PLATE II

1, *Prosuberites geracei* n. sp., detail of surface of holotype (× 30). (Photo L. A. van der Laan.)
2, *Cinachyra subterranea* n. sp. (× 3.8). (Photo L. A. van der Laan.)