SIPUNCULIDS OF MADAGASCAR

by

Edward B. CUTLER *

RESUME

Cet article est un compte-rendu sur les Sipunculides dans la région de Nosy-Bé, Madagascar. Ils ont été réunis par l'auteur pendant sa participation à l'Expédition Internationale dans l'Océan Indien, du 24 juin au 10 septembre 1964. Neuf espèces y sont enre-

[redacted]

losoma nigrescens, *P. scolops*, *P. dentigerum*, *Aspidosiphon corallicola* et *Cleosiphon aspergillum*. Aucune de ces espèces n'est nouvelle pour la science, mais cinq d'entre elles sont nouvelles pour cette région, faisant un total de 13 espèces maintenant connues à Madagascar. Une discussion quant à leur habitat préféré et leurs relations commensales est présentée en supplément à une brève discussion relative à chaque espèce. Une clé illustrée des 13 espèces connues est également jointe.

ABSTRACT

This paper is a report of the sipunculids in the region of Nosy Be, Madagascar. They were collected by the author during his participation in the International Indian Ocean Expedition from 24 June to 10 September 1964. There are nine species recorded :

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grescens, *P. scolops*, *P. dentigerum*, *Aspidosiphon corallicola*, and *Cleosiphon aspergillum*. None of these are new to science but five are new to this country, making a total of thirteen species now known from Madagascar. A discussion of their habitat preference and commensal relationships is presented in addition to a brief discussion of each species. An illustrated key to the thirteen known species is also included.

INTRODUCTION

The information presented in this paper is based on collections I made as a participant in the U.S. Program in Biology of the International Indian Ocean Expedition. Most of the specimens were collected in the vicinity of Nosy Bé, Madagascar, between 24 June 1964 and 24 July 1964. A few specimens were collected at Tuléar, Madagascar, during a stopover of the R/V «Anton Bruun» from 8-10 August 1964.

The sipunculid fauna has been described from surrounding areas (Figure 1): Mauritius (**Wesenberg-Lund** 1959), Zanzibar (**Lanchester** 1905; **Stephens** & **Robertson** 1952), Mozambique (**Kalk** 1958, 1962), South Africa (**Stephens** 1942; **Wesenberg-Lund** 1963), and Australia (**Edmonds** 1955, 1956). In **Herubel** (1908) six species are listed from Madagascar. **Hammerstein** (1915) added two more to this list, each represented by only one specimen and one of these (*Dendrostomum signifer*) was in poor condition. In the material I collected were nine species, none new

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to science but five previously unreported from Madagascar. The collection has been deposited in the U.S. National Museum, Washington, D.C.

LIST OF MADAGASCAR SIPUNCULIDS

Sipunculus indicus - He, pp
Sipunculus robustus - pp
Siphonosoma cumanense - He, pp
Siphonosoma australe - pp
Phascolosoma nigrescens - He, Ha, pp
Phascolosoma scolops - He, Ha, pp
Phascolosoma dentigerum - pp
Phascolosoma asser - He
Phascolosoma lobostomum - Ha
Dendrostomum signifer - Ha

Cleosiphon aspergillum - pp

He - Herubel (1908)
Ha - Hammerstein (1915)
pp - the present paper

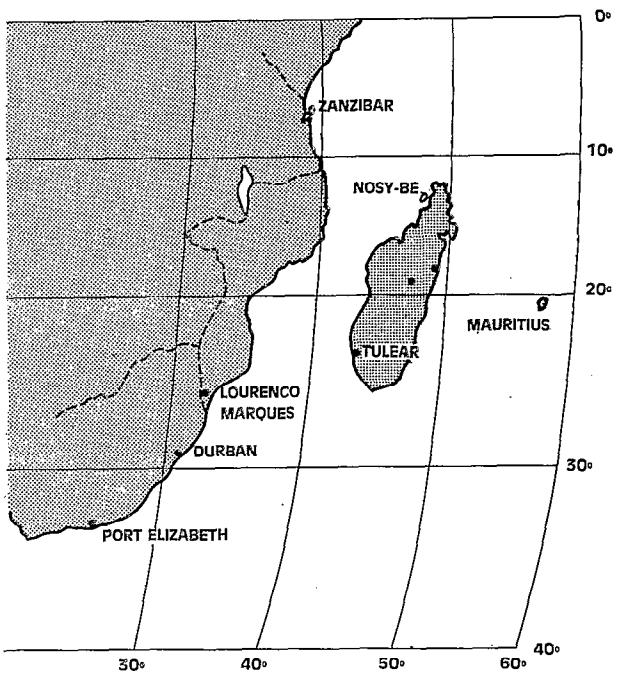


Fig. 1 - The southwestern Indian Ocean showing localities where sipunculids have been collected.

THE AREAS AND STATIONS

The island of Nosy Bé lies off the northwestern coast of Madagascar at 13° 20' S and 48° 15' E (Figure 1). Located on the southeastern corner of the island is the Centre de l'Océanographie et des Pêches which is operated by the Office de la Recherche Scientifique et Technique Outre-Mer. This served as the headquarters for the American IIOE program on Madagascar.

The climate is tropical with a warm rainy season from October to April and a cool dry season from May to September. The total average rainfall is 2244 mm with a maximum recorded in January of 462 mm and a minimum of 37 mm in July. The air temperature ranges from 34.8°C in November to 15.0°C in June. The surface water temperature ranges from 25.2°C in August-September to 31.3°C in January-February and the salinity from 35.57 ‰ in August-October to 29.05 ‰ in January. The average tide differential is 2.2 m but may increase to 4.4 m at spring tides (Centre records). There is a wide variety of habitats within easy reach of the Centre ranging from coral islands through sand and mud flats to mangrove swamps.

Tulear is about 900 miles south of Nosy Be just north of the Tropic of Capricorn at 23° 20' S and 43° 40' E. Along the shore is a broad muddy sand flat and off shore lies a large fringing reef which is partially exposed at low tide. As time and equipment were limited these collections were not extensive.

The stations where collections were made are described in Appendix I and shown in Figure 2.

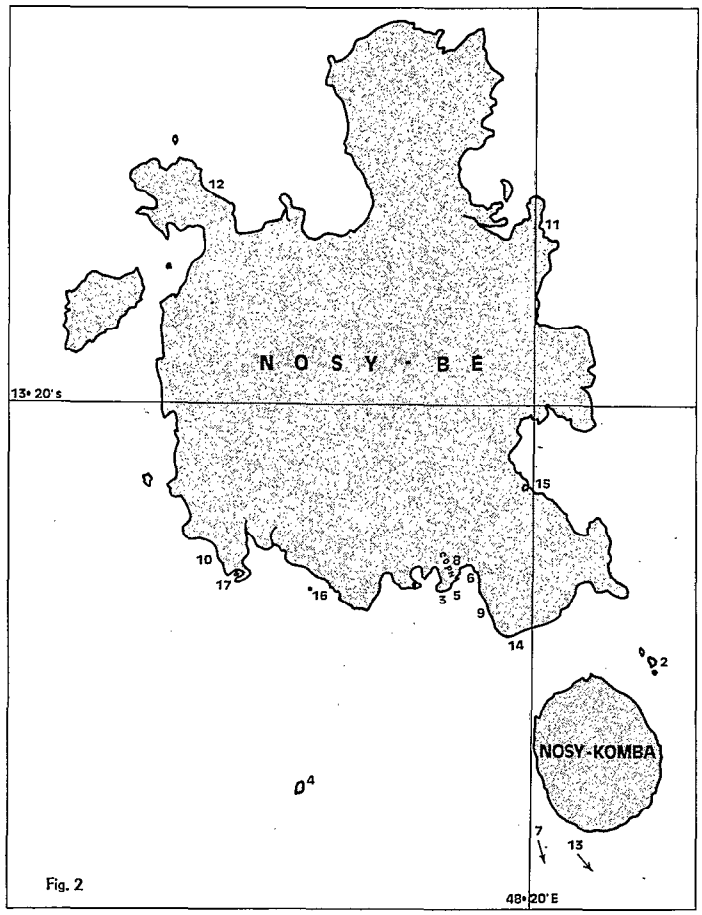


Fig. 2 - Map of Nosy Be, Madagascar, showing stations where collections for this study were made. (For the descriptions of the stations see Appendix I).

ECOLOGICAL RELATIONSHIPS

A clear-cut pattern of habitat preference emerged from this study. From the information summarized in Table 1 and Appendix 1, I was able to make the following observations.

Most of the coral formations (Stations 10, 14, 16, 17 and 20) were inhabited by a complex of four species. The most numerous and cosmopolitan was *Phascolosoma nigrescens*. The

other *Phascolosoma (P. dentigerum* and *P. scolops)* were found here as well as *Cleosiphon asperigillum.* Most of the *Cleosiphon* were found in *Millipora.* The *Phascolosoma* spp. were also found in the peculiar rock-like clay (hardened, indurated, muddy sand) at Station 5. The fact that one mass of material about 25 cm in diameter yielded sixteen specimens indicates the unusually high density in this material. A few specimens were found under rocks in tide pools in this same area (Station 3). Only *P. nigrescens* was found in the coral from the two small islands (Stations 2 and 4). Possibly more extensive collecting would have produced other forms.

This information leads to the conclusion that these four species prefer a hard, rock-like environment where they can live in holes and cracks, either of their own construction or abandoned works of other organisms. Additional evidence was supplied by the following experiment: Two *P. nigrescens* from Station 5 were placed in an aquarium containing two inches of sand with a piece of *Tubipora* at one end. One worm worked its way into the *Tubipora* and the second (which was at the other end, 5 or 6 inches away) buried itself in the sand. When checked six hours later, both individuals were located in the *Tubipora.* In addition to the four sipunculids mentioned there were numerous polychaetes, crustaceans, pelecypods *(Rocellaria* and *Lithophaga),* ophiuroids, holothurians, and tunicates present at these stations.

A unique commensal relationship, which appears to be obligatory, exists between the *Aspidosiphon corallicola* and two genera of solitary coral. A bivalve mollusc is sometimes a third member of this complex. This association has been previously reported by **Bovier** (1894), **Bourne** (1906), **Sluiter** (1902), and **Stephens** and **Robertson** (1952). In this instance the corals were *Heteropsammia* (cf) *geminale* and *Heterocyanthus* (cf) *rouseanus,* the former being more numerous. On the trunk of two of the worms within *Heteropsammia* there were several

Harvard University, it was decided they were members of the genus *Jousseaumiella* and probably *J. heteropsammia* (family Montacutidae).

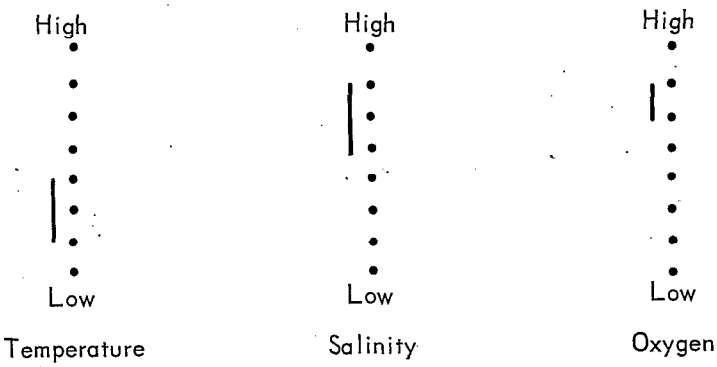
The question of how this relationship comes into being has been discussed at length but no experimentation has been done nor has an indisputable answer been given. The most reasonable idea seems to be **Sluiter**'s (1902) suggestion that the young worm inhabits an empty gastropod shell which is then covered by the coral, the shell being subsequently absorbed or dissolved. The relationship seems to be beneficial to both the worm (provides protection) and the coral (keeps it upright and provides locomotion to more desireable habitats).

A third type of habitat was preferred by the two species of *Sipunculus (S. indicus* and *S. robustus).* They were found at widely separated points but at both stations (12 and 13b) there was a very low tide and clean, white, apparently well oxygenated, coarse sand. There was no apparent mixing of these two populations.

The two members of *Siphonosoma* were also segregated from one another, but a different substrate preference was apparent. All of the *S. cumanense* came from a rather homogenous, muddy sand (Stations 6, 11, 13, 15, 19). The *S. australe* were found in a more heterogenous substrate, mostly firm, muddy sand but also containing larger particles such as pebbles, mangrove roots, etc. (Stations 8, 9). It would have been illustrative had I made a transect between Stations 6 and 8 to see if there was a distinct separation or how much overlap of species occurred at the border area.

These *Siphonosoma* stations all differed from the *Sipunculus* stations in that the former were exposed with almost every low tide. This information about these two genera *(Siphonosoma* and *Sipunculus)* is interesting because of the physiological implications. Without doing any laboratory experiments one could predict that the *Siphonosoma* are much more tolerant with regard to at least three parameters: temperature, salinity, and oxygen (Figure 3).

Fig. 3 -
Hypothetical relative tolerance limits
for *Sipunculus* (——) and *Siphonosoma* (• • •)



This also has interesting evolutionary-phylogenetic implications if it is true that *Siphonosoma* does have more of a capacity to acclimate (as reflected by wider tolerance limits). The evolutionary significance of the capacity to acclimate is based on the assumption that genetic adaptation is selection acting upon genetic variation. Therefore, genetic adaptation is a primary mechanism of evolution (**Kinne** 1963), i.e. the more capacity to acclimate, the more genetic adaptation which is, in a sense, evolution. As yet, within the sipunculids, no attempt has been made to establish any taxa between genus and phylum. The foregoing ideas may be helpful when such an attempt is made.

Habitats which consistantly yielded no specimens were those areas composed of soft, fine, silty mud. This probably was a very unstable situation and not suitable for worm burrows of any sort.

I. Coral, rock, hard clay
Phascolosoma scolops, P. nigrescens, P. dentigerum and *Cleosiphon aspergillum*
II. Within base of solitary corals
Aspidosiphon corallicola
III. Clean, white, coarse sand; exposed rarely
Sipunculus indicus and *S. robustus*
IV. Homogenous, muddy sand; exposed
Siphonosoma cumanense
V. Firm, muddy sand with pebbles, stones, roots, etc.
Siphonosoma australe

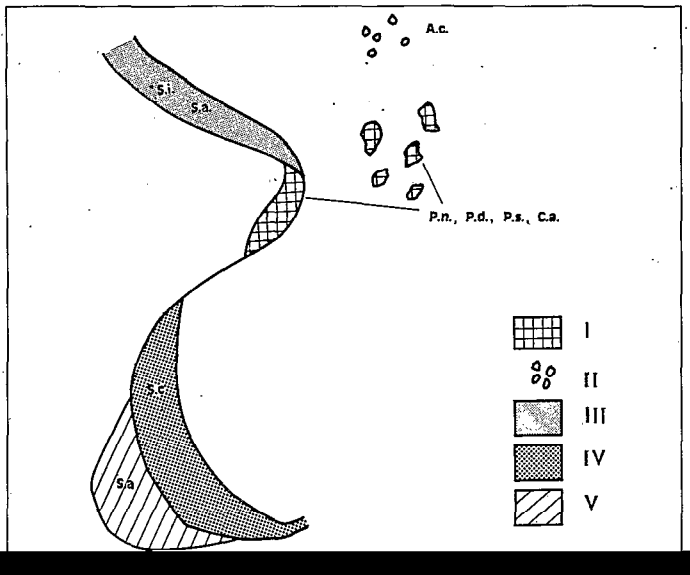


Fig. 4 - Diagramatic, pictoral summary of habitat preference

DISCUSSION OF SPECIES

Sipunculus indicus PETERS, 1850

8 specimens. Length ranged from 165-510 mm; diameter 7-11 mm; color, white.

These animals were very abundant at this station but apparently quite restricted. There are many interesting similarities between the situation here and that reported on Zanzibar by **Stephen** and **Robertson** (1952). When we arrived at Antsakoabe, there was a fisherman collecting the animals for bait by inserting a square, straight stick, which was «burred» on the end, into the burrow and exerting just the proper amount of pressure so that as the animal retracted the introvert it pulled the stick down inside immobilizing itself. The native then dug down in the sand next to the worm with his hand, loosened the sand around the worm, got a firm grasp and pulled it out more or less intact. Even though it looked easy I was unable to obtain any in this manner, finally gave up, and purchased some from the fisherman.

Sipunculus robustus KEFERSTEIN, 1865

1 specimen. Size 185 mm × 13 mm; color, grey.

This individual was found moving along the surface of the sand. As the tide was very low and the sun was hot that day, its micro-habitat might have become intolerable causing it to move to a better location. Although Dr. **Humes** had seen them there on previous occasions, I was unable to locate any more. When found, it was covered with a layer of sand and mucus. After returning to the laboratory it was placed in an aquarium but was not very active. It did produce, however, copius amounts of mucus, much of it apparently coming from the posterior bulb. This species closely resembles *S. angasi* Baird, but lacks the tufted organs near the rectum.

Siphonosoma cumanense (KEFERSTEIN, 1866)

54 specimens. Length ranged from 35-245 mm (average 120 mm); color, pinkish when alive, dirty white to pale yellow preserved.

These individuals are common and fit published descriptions quite well. **Edmonds** (1955) uses the terms «skin bodies» and «**papillae**» as synonyms to describle the multicellular epidermal glands present in this form. **Gerould** (1913) uses «epidermal organs». It should be pointed out that these are quite different from the papillae in the *Phascolosoma* which protrude as well-defined «warts» or «knobs» that remain after the underlying muscle layers are stripped off. In *Siphonosoma*, however, when the muscle layer is removed there is left only a thin piece of skin with holes which were the pores of the glands. The glands themselves remain attached to the muscle layer. As the term papillae suggests well-developed protuberances, it could be misleading to a person to look for them on the smooth-skinned *Siphonosoma*. Therefore, in this species I suggest that the term multicellular epidermal glands be used rather than papillae, skin bodies, or epidermal organs.

An interesting example of autotomy occurred when one individual, damaged while being dug out, pinched off the posterior damaged quarter of the trunk within 24 hours after it was collected. This portion contained part of the digestive tract but no other organs. I have been unable to find any previous record of this for the sipunculids.

Siphonosoma australe (KEFERSTEIN, 1865)

17 specimens. Length ranged from 45-210 mm (average 105 mm); color, yellow (straw) to dark brown; 50-20 rows of hooks.

One noteworthy feature of this group is the variability of color. Some were a uniform dark brown, others mottled, some uniform yellow with a darker introvert, and one, small, damaged specimen had an almost white trunk but retained the brown introvert. On examination this color proved to be a transient, superficial layer, probably due to the animals' environment. This color can be rubbed off exposing an irridescent bluish-grey color similar to *Siphonosoma cumanense*. Attached by byssal threads to the posterior end of one specimen was a small bivalve which looked very similar to the *Jousseaumielle* found on the *Aspidosiphon* (page 5).

Phascolosoma nigrescens KEFERSTEIN sensu STEPHEN

44 specimens. Because of the varied states of contraction the size measurements are not very meaningful. The approximate range is from 25-120mm, most between 40-80mm in length. The color varied from dark to very pale brown; most with, but some without, the alternating dark and light cross bands on the introvert. In a few the skin was very loose and easily removed.

This species is common in this region of the world and has been reported by several authors. There does exist, however, a good deal of variation in the descriptions, and the distinction between *P. nigrescens* and *P. puntarenae* is not always clear. Many structures such as the hooks, papillae, segmental organs, etc. are quite variable and it may be that these two species are the same (**Edmonds** 1956, page 289; **Wesenberg-Lund** 1963, page 129 and table 1; **Fisher** 1952, page 430). **Wesenberg-Lund's** (1963) description of *P. nigrescens* is particularly confusing for several reasons and seems to more closely agree with other descriptions of *P. puntarenae* (e.g. caecum and contractile vessel villi). The material I have is *P. nigrescens* based on Dr. **Stephen's** criteria, **Selenka's** (1883) figure 130, and comparison to specimens of both species from the United States National Museum as identified by **W.K. Fisher.**

One characteristic which is sometimes reported is the hook dimensions. On the assumption that this might be important I measured the height and width of 152 hooks from thirteen *P. nigrescens* and fifteen hooks from the one *P. puntarenae* (Figure 5 and Appendix 3). At first it looked as though there was a positive correlation between body size and hook size, but as I measured more hooks, the correlation was not always consistent. It is difficult to say anything more than: as the hook size of *P. nigrescens* is variable it should not be used as a taxonomic character. In most of the specimens, which are between 40 and 80mm long, the width of the hook (at the base) is between 70 and 80 μ.

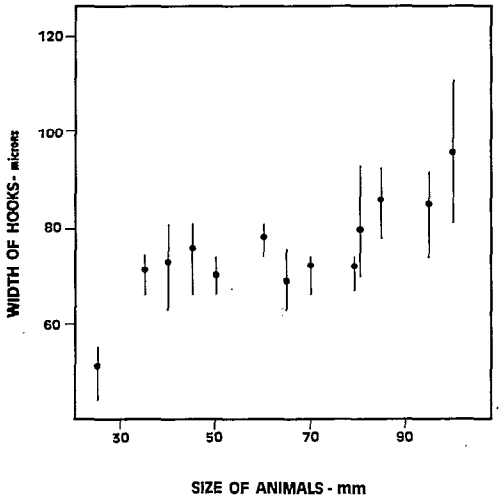


Fig. 5 - The hook size of *Phascolosoma nigrescens*

These two forms, *P. nigrescens* and *P. puntarenae* are a good example of a situation where analysis of specimens from around the world should be carried out. Either a better distinction between the two should be made or the two should be combined as one species.

Phascolosoma scolops (SELENKA and DE MAN, 1883)

These two specimens (60 and 15 mm respectively) represent another common Indo-Pacific form. It is perhaps noteworthy that only two were found. On the Zanzibar-Mozambique-South Africa coast they generally comprise a large percentage of the total. They have not been reported, however, from Mauritius. This apparent decrease in frequency with distance from

the continent may be significant. This species, together with *P. agassizi*, *P. japonicum* and others form another complex of *Phascolosoma* with very similar hooks and the internal anatomy exhibiting only minor differences. This species differs from *P. agassizi* by the absence of a rectal caecum. The nature of the papillae platelets separates it from *P. japonicum*.

Phascolosoma dentigerum (SELENKA and DE MAN, 1883)

20 specimens. The trunks ranged in length from 20-52 mm. The expanded introverts were all at least half as long and some as long as the body. The largest individual was 77 mm overall. Most of these individuals had a very pale body with the tall, conical, preanal papillae oriented posteriorly and the introvert showing the reddish-brown bands or blotches which characterize this species.

Aspidosiphon corallicola SLUITER, 1902

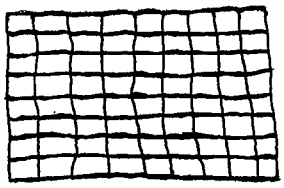
11 specimens. I am indebted to Dr. **M. Pichon** for pointing these out to me in the bases of the solitary corals. The anal shields fit **Stephen's** (1952) description very well. They are dark red-brown and composed of longitudinal furrows next to the anus changing to rounded granules anteriorly. The caudal shield is not deep red-brown, however, but a rather pale tan becoming somewhat darker towards the center. The secondary tooth on the hook is quite variable in size but usually present.

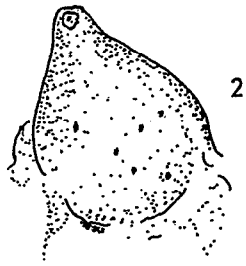
Cleosiphon aspergillum (QUATREFAGES 1865)

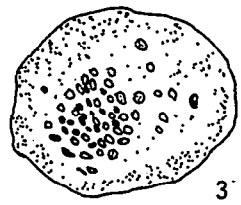
15 specimens. Most of these were an ivory color but a few were a rather dark brown. These are unique animals with their white, compound, acorn-like cap or knob at the anterior end of the trunk through which the introvert protrudes. The hooks differ slightly from **Edmonds** (1956, Figure 21) in that the secondary tooth is even more strongly developed as in **Selenka** (1883) Figure 216. The size of the trunk ranged from 30-75 mm. The average was 48 mm. These were very difficult to obtain intact as they were most abundant in very hard *Millipora*.

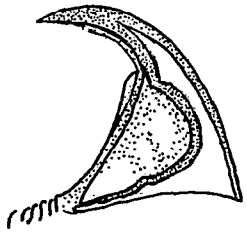
KEY TO THE KNOWN SPECIES OF SIPUNCULIDS OF MADAGASCAR

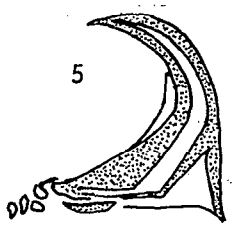
1 a. Horny or calcareous shields absent from both ends of the trunk 2
1 b. Above shields present at one or both ends of trunk 10
2 a. Longitudinal muscles gathered into a number of bands 3
2 b. Longitudinal muscles form a continuous sheath 12
3 a. Skin divided into numerous rectangles or squares (Figure 6-1) 4
3 b. Skin not divided into rectangles or squares 5
4 a. 24-30 strong longitudinal muscle bands . . . . . *Sipunculus robustus*
4 b. 41-43 weak longitudinal muscle bands . . . . . *Sipunculus indicus*
5 a. Skin papillae complex; made up of numerous platelets (Figure 6-2 & 3) 6
5 b. Protruding and complex skin papillae absent 9
6 a. Hooks present on introvert 7
6 b. Introvert without hooks . . . . . *Phasyolosoma asser*
7 a. Clear streak of hook merged with basal, triangular clear space (Figure 6-4) . . . . . *Phascolosoma nigrescens*
7 b. Clear streak of hook separate from triangular clear space (Figure 6-5 & 6) 8
8 a. Introvert with reddish bands and tall, conical, preanal papillae oriented somewhat posteriorly (Figure 6-7) . . . . . *Phascolosoma dentigerum*
8 b. Papillae smaller and not as above . . . . . *Phascolosoma scolops*
9 a. Introvert with hooks . . . . . *Siphonosoma australe*
9 b. Introvert lacking hooks . . . . . *Siphonosoma cumanense*
10 a. A white pineapple-like cap at the anterior end of trunk (Figure 6-8) . . . . . *Cleosiphon asperigillum*
10 b. Corrugated shields at both ends of trunk. The caudal shield is pale with radiating grooves 11
11 a. Grooves of anal shield run from ventral edge to margin . . . . . *Aspidosiphon truncatus*

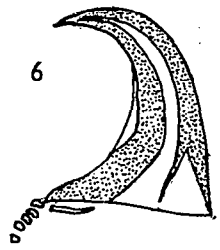


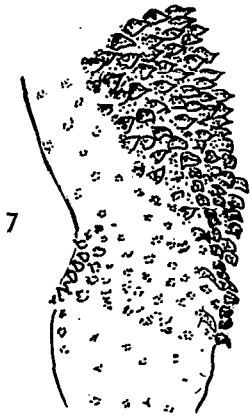


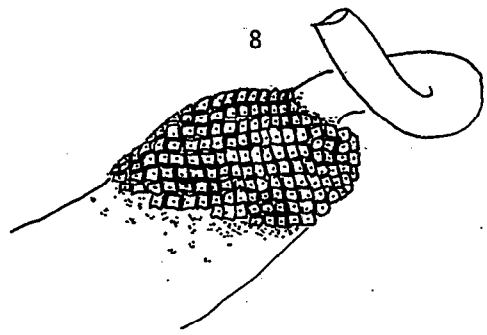


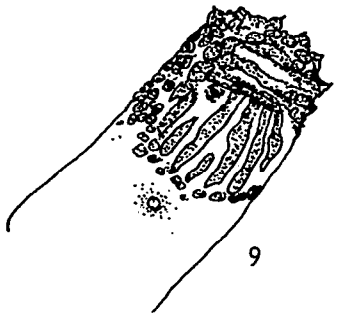












1. Generalized appearance of body surface in *Sipunculus*.
2-3. Two views of a complex *Phascolosoma* papillae covered with numerous small platelets.
4. Hook of *Phascolosoma nigrescens;* clear streak merged with triangular clear space.
5-6. *Phascolosoma* hook with separate triangular clear space (*P. scolops* and *P. dentigerum*).
7. Base of introvert of *Phascolosoma dentigerum* showing tall, conical, pre-anal papillae.
8. Anterior end of *Cleosiphon aspergillum* showing complex "cap".
9. Anal shield of *Aspidosiphon corallicola*.

Fig. 6 - Morphological features to assist in identifying the known sipunculids of Madagascar.

11 b. Anal shield with two distinct areas; longitudinal grooves posteriorly, granules near introvert (Figure 6-9) . . . . . *Aspidosiphon corallicola*

12 a. Tentacles dendritic . . . . . *Themiste signifer* (formerly *Dendrostomum*)

12 b. Tentacles filiform or digitiform; complicated hooks present . . . . *Fisherana lobostomum* (formerly *Phascolosoma*)

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TABLE I

DISTRIBUTION OF SIPUNCULID SPECIES AT EACH STATION

SPECIES	STATIONS																		Total no. of each sp.
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	
Sipunculus indicus											8								8
Sipunculus robustus												b1							1
Siphonosoma cumanense					7					14		a12		3			18		54
Siphonosoma australe							16	1											17
Phascolosoma nigrescens	4	5	3	20					1				5		3	2		1	44
Phascolosoma scolops				1									1						2
Phascolosoma dentigerum				1					2				9		4	4			20
Aspidosiphon corallicola						11													11
Cleosiphon aspergillum													5		4	2		4	15
Total no. of individuals at each station	4	5	3	22	7	11	16	1	3	14	8	12 &1	20	3	11	8	18	5	172

APPENDIX I

Station List

2. Nosy Ambariobe; 25 June 1964; 2.3 m tide; coral masses.
3. Shore south of laboratory; 25 June 1964; tide pools under rocks.
4. Nosy Tanikely; 26 June 1964; 2.3 m tide; coral, dead and living.
5. Shore south of laboratory; 28 June 1964; and 21 July 1964; hardened, muddy sand (indurated) appeared like rock but with the consistency of hard clay.
6. Ambanoro Bay; 30 June 1964, 1 & 9 July 1964; 3.1 m, 3.5 m, 1.3 m tides; north end of bay; muddy sand flats with some rocks.
7. Southwest of Nosy Komba; 13° 30' S 48° 20' E; 2 July 1964; dredged in 20 m; bottom - sand, shell fragments, and solitary corals.
8. A Kirintsa, mangrove at north end of Ambanoro Bay; 5 & 19 July 1964; firm sandy mud, stones, and roots.
9. Ampasindava, east side of Ambanoro Bay; 6 July 1964; mostly rocks, few sandy patches with underlying pebbles and stones.

10. Ambatoloaka; 8 July 1964; 1.9 m tide; coral, sandstone.
11. Antafianambitry; 10 July 1964; 0.9 m tide; collected by R. Maddocks; extensive black, muddy sandflats.
12. Antsakoabe; 12 July 1964; 0.9 m tide; clean, white, coarse, well-oxygenated sand.
13. Ankifi, east of coffee factory; 11 & 14 July 1964;
    13a. sand with «grasses» and some organic material;
    13b. clean, barren sand.
14. Lokobe Point; 13, 16 & 17 July 1964; 1.4 m, 4.0m, 4.7 m tides; coral.
15. Ambatozavavy; 16 July 1964; coarse, muddy sand.
16. Ilot Ambariotsimaramara; 20 July 1964; coral heads.
17. Crater Lake; flooded extinct volcanic crater with one side somewhat open to sea; 22 July 1964; 3.4 m tide; coral.
19. Tulear; 8 & 9 August 1964; sandy mud flats south of pier.
20. Tulear; 10 August 1964; coral reef.

APPENDIX II

Methods and Materials

The collecting methods were of two general types: (1) digging and sifting sand and/or mud; and (2) snorkeling in the coral areas, breaking off large pieces of coral, and subsequently fragmenting these with a hammer to obtain the enclosed organisms.

Several types of relaxing agents were tried, but menthol crystals generally gave the best results. Other substances tried less successfully were propylene phenoxetol, $MgCl$, and slow addition of ethanol. All the specimens were preserved in 70 per cent ethanol, but the larger ones were first injected with formalin to prevent deterioration of the internal structures.

APPENDIX III

Data on *Phascolosoma nigrescens* Hook Size

Animal	Size (in mm)	Number of Hooks measured	Average height (in microns)	Average width at base (in microns)
s-12	25	12	48	51
t-1	35	12	74	73
s-13	40	14	66	73
USNM-1	45	5	72	76
s-124	50	9	74	70
s-15	60	9	74	79
s-9	65	10	71	69
s-157	70	10	67	72
s-165	80	10	62	72
s-5	80	23	68	80
s-150	85	16	87	86
s-8	95	10	84	85
s-1	100	12	92	96