

ON GOLFINGIA (NEPHASOMA) CONFUSA (SLUITER, 1902), SIPUNCULA

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ABSTRACT

The Sipunculan worm Golfingia (Nephasoma) confusa (Sluiter, 1902) is redescribed upon dissection of 52 specimens. This study calls attention to the wide variation of the external as well as of internal systematic features in the phylum Sipuncula. The species Golfingia (N.) cinerea (Gerould, 1913) is submerged as a synonym of G. confusa.

RESUMO

Com base na dissecação de 52 espécimes redescreve-se Golfingia (Nephasoma) confusa (Sluiter, 1902). Através deste estudo salientamos a ampla variação morfológica externa e interna de características usadas na sistemática do filo Sipuncula. A espécie Golfingia (N.) cinerea (Gerould, 1913) é considerada sinônimo de G. confusa.

INTRODUCTION

During our studies on the developmental biology of some shallow water sipunculans from the northern coast of the State of São Paulo, Brazil we came across representatives of a small species very commonly found in a variety of protected situations. The animals are quite small and so far were not properly described. This prompted us to redescribe the species.

Apart from the original description by Sluiter (1902) based on 9 specimens collected from two stations of the Siboga Expedition, at Malaysia, only Murina (1957, 1972, 1974, 1978) had a chance to restudy the species from a few worms dredged in the Antarctic Ocean.

The fairly large number (106) of worms upon which this paper is based, allowed us to make a study of the variations of internal as well as external features of the species. Additional information on its biology is presented.

MATERIAL AND LOCALITIES

From a sample of 43 worms collected from 1957 to 1967, by one of us (ASFD), 10 specimens were selected for dissections. From another group comprising 54 animals col-

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lected by Mr. L. F. L. Duarte and Miss E. H. Morgado, University of Campinas, during 1975 and 1976, we dissected 34 worms. Finally, we studied 9 specimens collected by ourselves at the end of 1979. Usually, specimens with a trunk 4 mm or less were not dissected, unless they showed by transparency to be adult animals.

The worms not dissected were measured and checked for hooks and number of tentacles whenever the introverts were fully expanded.

The area from where these animals came includes the beaches of Codó, Lamberto, and Saco da Ribeira, at Ubatuba (23° 30' S, 45° 07' W) and the beaches of Araçá, Pitangueiras, and Segredo at São Sebastião (22° 50' S, 45° 20' W), both localities on the northern coast of the State of São Paulo, Brazil. A detailed description of the physical conditions at the Ubatuba region can be found on the report by Amaral (1979).

Collections 1957-1967

02.IX.1957, 1 spec.; 30.VII.1958, 1 spec.; 30.VIII.1958, 1 spec.; 02.IX.1959, 2 specs.; 19.I.1960, 1 spec., Praia do Araçá, S. A. Rodrigues coll.
 04.II.1965, 1 spec.; Praia Pitangueiras; 07.II.1966, 1 spec.; 12.XII.1966, 1 spec.; 10.I.1967 5 specs., Praia do Segredo, all under *Ascidia nigra* at 1.5-2.0 m depth, A. S. F. Ditadi coll.
 17.III.1966, 16 specs., Praia do Segredo, among the corallum of *Porites* sp. 5 m depth, A. S. F. Ditadi coll.
 01.IX.1966, 2 specs.; 02.XII.1966, 7 specs.; 29.III.1967, 2 specs., Praia do Segredo, among the corallum of *Mussismilia* sp. depth 4-5 m, A. S. F. Ditadi coll.
 23.I.1967, 1 spec., Ubatuba, under rocks, P. Montouchet coll.
 27.VII.1960, 1 spec., S. Sebastião, coll. ?

Collections 1975-1976

24.V.1975, 6 specs.; 08.VI.1975, 10 specs.; 08.VII.1975, 2 specs.; 05.IX.1975, 2 specs.; 28.X.1975, 3 specs.; 17.II.1976, 15 specs.; 14.IV.1976, 1 spec.; 13.VI.1976, 1 spec.; 24.IX.1976, 1 spec.; 21.XII.1976, 4 specs., Praia do Lamberto, all under the skeleton of the bryozoan *Schizoporella unicornis*, 05.IX.1975, 1 spec.; 13.VI.1976, 1 spec., Praia do Lamberto, in the blue sponge *Zygomycala parishii*.
 13.VIII.1976, 2 specs.; 19.XI.1976, 1 spec., Praia do Codó, in *Schizoporella unicornis*.
 21.XII.1976, 3 specs., Praia do Codó, in *Zygomycala parishii*.
 17.I.1976, 1 spec., Praia do Araçá, under *Schizoporella unicornis*.
 Mr. L. F. L. Duarte & Miss E. H. Morgado coll.

Collection 1979

13-15.XII.1979, 9 specs., Praia do Segredo, among the corallum of *Mussismilia*, A. S. F. Ditadi & A. E. Migotto coll.

DESCRIPTION OF *GOLFINGIA CONFUSA*

External features: Of the 106 worms gathered in the three collections, only 23 remained completely relaxed after fixation; of these, 14 (= 60%) presented in a ratio between trunk and introvert lengths of 2:1, while 6 (= 26%) had a ratio of 3:1, and 3 (= 14%), a ratio of 1:1. The length of the sausage-shaped trunk (Fig. 1 f) ranged from 2.5 mm to 25.0 mm, in most animals (75%) from 4.0 mm to 12.0 mm.

The transition from trunk to introvert is not sharply marked, and the proboscis tapers gradually towards its tip. (Fig. 1a). The thin skin is covered all over by skin bodies, low in the middle region of the trunk, similar to tiny fingers at the anterior end of the proboscis (Fig. 1e). In a few specimens the skin bodies located near the base of the introvert, as well as those at the distal trunk, may have a dark brown cuticle.

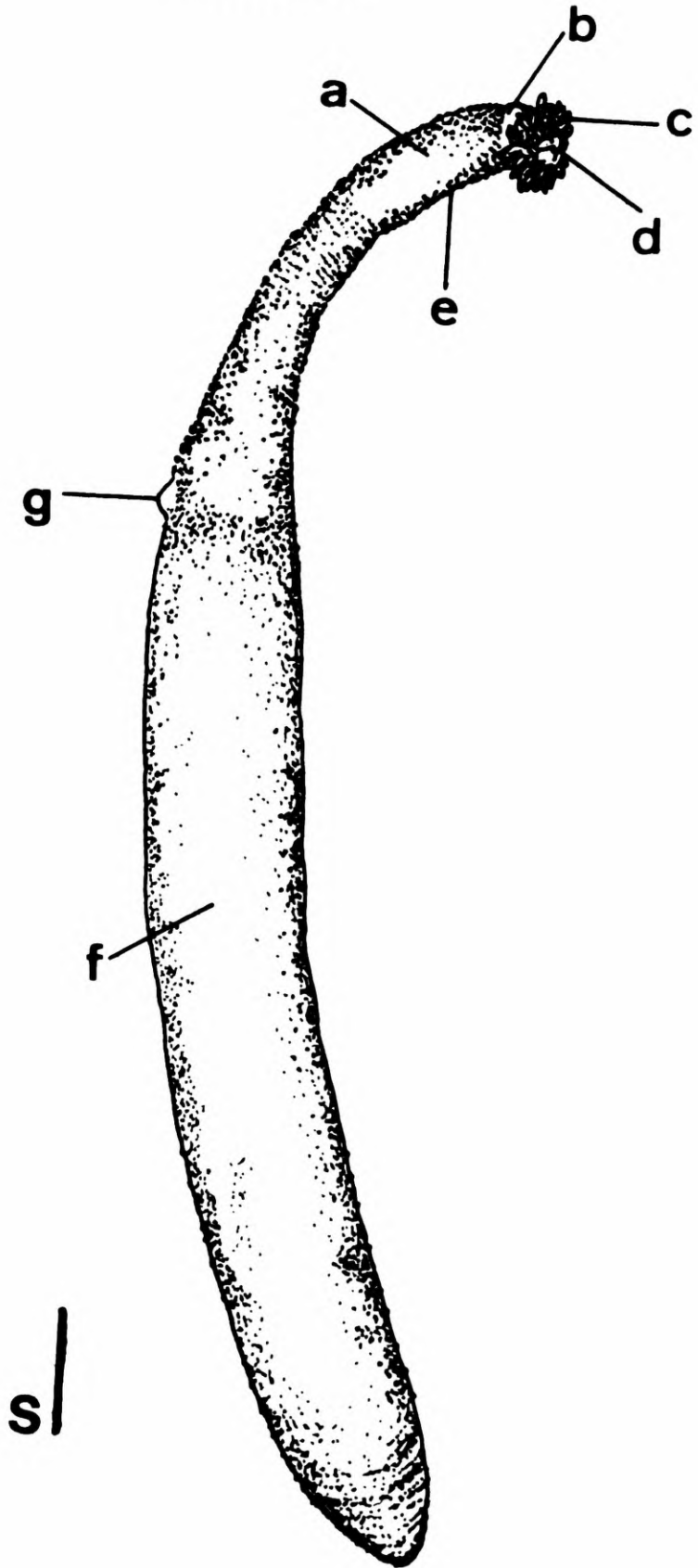


Figura 1. *Golfinia confusa*. Whole animal. a = introvert, b = bare zone, c = tentacle, d = mouth, e = skin bodies, f = trunk, g = anus (S = scale 2 mm).

At the distal end of the introvert, among the tall skin bodies there is an undefined number of minute hooks, scattered and difficult to see, specially when they are pale gold-ish in color resembling the general buffy tone of the skin. They do not seem to be arranged in rows (Fig. 2h), though in one worm they were ordered in three, and in another, in five irregular rows. The hooks are simple-pointed, some slightly curved at the tip and reinforced with a rim of chitin on the distal portion (Figs. 4 h₁ - h₅); the largest measured 73 μ in height by 30 μ in width, the smallest 30 μ by 35 μ .

Between the tentacular crown and the hooks is a bare narrow zone, only seen in fully distended specimens. (Fig. 1b, 2b).

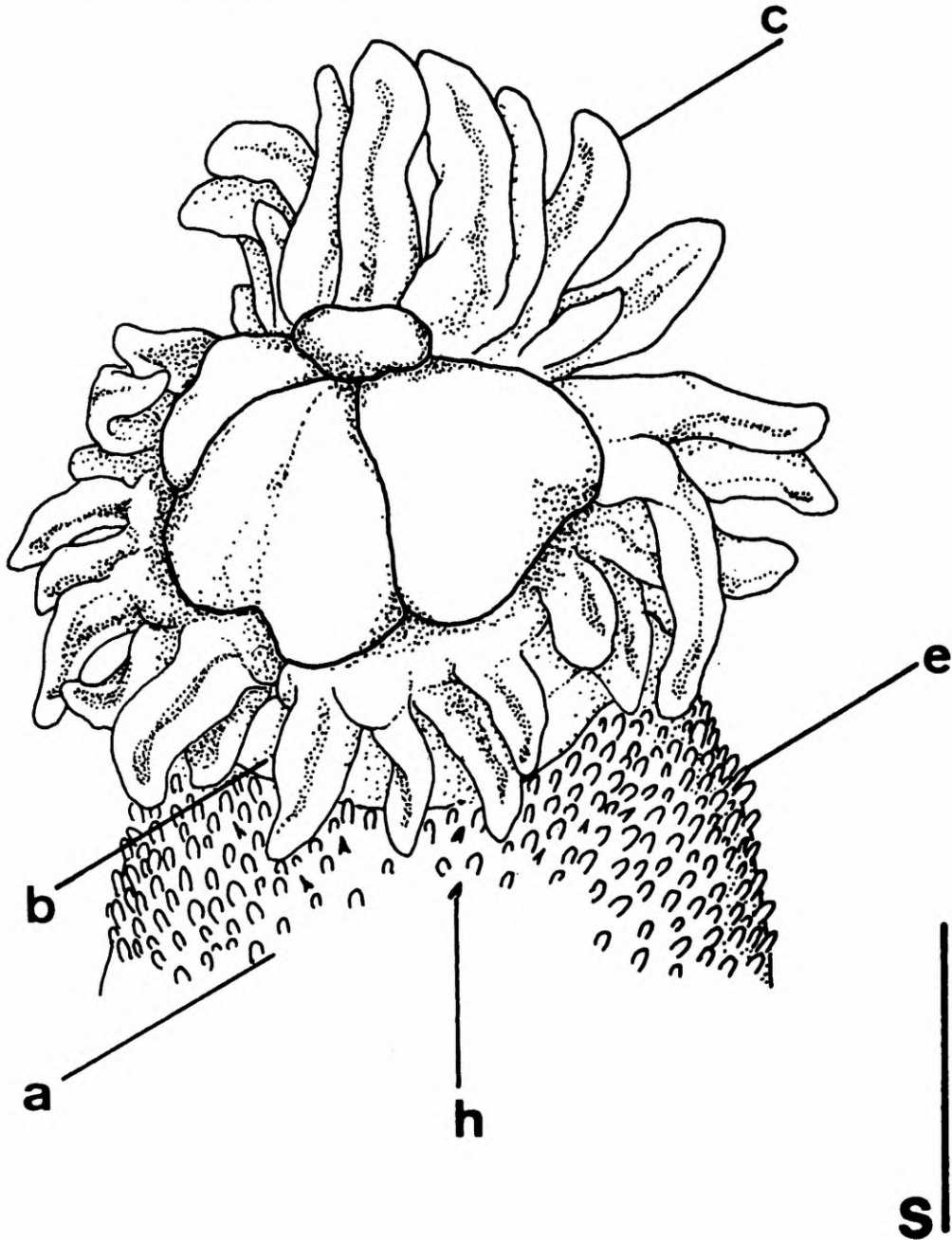


Figure 2. *Golfinigia confusa*. Tip of introvert showing: a = introvert, b = bare zone, c = tentacle, e = skin body, h = hook (S = scale 0,5 mm).

The tentacular crown (Figs. 1c, 2c) consists of a double row of thick, finger-like, medially grooved tentacles; from 18 to 42 in a group of twenty worms, fifteen of which presented 20-30 tentacles. The number of tentacles seems to be related to size, the largest, a 25.0 mm long worm had 42 tentacles. The nuchal organ, located outside the tentacular crown, is very similar to those figured for many other *Golfingia* species.

Living worms are buff or cream in color, becoming light grey when preserved in alcohol and greyish pink, preserved in formalin.

Internal anatomy: The mouth (Fig. 1d) is situated at the center of the tentacular crown. Behind the pharynx, concealed by the proboscis retractor muscles, comes an oesophagus (Fig. 3k) which makes a conspicuous curve before entering the intestine. The oesophagus, is firmly attached to the proboscis retractor muscles by mesenteries. The intestine (Fig. 3o) forms 16 to 60 coils; their number is directly related to the animal's size (or age). Most of the worms ranged from 4.0 mm to 12.0 mm, and had 20 to 30 intestinal coils. The coils, usually filled with fine sand, are loose at the posterior end and often also in the middle of the intestine. A small rounded, whitish or transparent caecum lies in the internal curvature of the last intestinal ascending turn, though in a few cases it is on the proximal rectum (Fig. 3p) or even in the interior of the next to last intestinal winding.

The longitudinal muscles of the body wall form a continuous sheath. A pair of retractor muscles (Fig. 3m) is inserted between the middle trunk and the beginning of the last third of the body; in small animals, at the last third, and in large animals, in the middle of body. It is difficult to tell whether these muscles are thick or thin since this depends on the way the worms were preserved; obviously, contracted animals show stronger muscles than well distended ones. The number of fastener muscles is variable, most commonly there are five fasteners (Fig. 3, F₁-F₅). Table I shows the distribution of these muscles in the 52 dissected worms. F₁ anchors the oesophagus either on its curve area or on its distal segment to the longitudinal muscle sheath. F₂ to F₅, and eventually F₆ and F₇, fas-

Table I. Occurrence of fastener muscles in *G. confusa*

Number of fasteners	1	2	3	4	5	6	7
Number of animals	1	4	6	11	27	2	1

ten the last intestinal coil and frequently the next to last intestinal coil to the body wall. Fastener muscles of the last intestinal coil are usually inserted to the body wall, but between the retractors of the proboscis. The fasteners vary in thickness; all may be thick, all may be thin, or part may be ribbon-like and part thread-like; there seems to be no rule for this peculiarity. A strong spindle muscle (Fig. 3q) is also present; it is inserted anteriorly in front of the terminal rectum, or, in a few worms, on its side, beneath the wing muscle. On emerging from the intestinal coils the spindle muscle has its insertion on the base of the caecum, not attaching posteriorly. A strong wing muscle (Fig. 3r) spreads at each side of the distal rectum.

As a rule, the nephridia (Fig. 3l) open slightly behind the anus; in a few worms they lie more backward and in others they open practically at anus level. In most specimens they are light brick in color, this color persisting even in alcohol-preserved animals. Anteriorly they are somewhat inflated, tapering suddenly to the end. Usually they reach the base of the retractors; sometimes one nephridium has this length, while the other is completely contracted.

The dorsal contractile vessel (Fig. 3j), the only vessel found, was visible to the oesophagus curve, where it ends; it is devoid of villi.

The animal shown in Fig. 3 had the introvert (a) mostly retracted. It shows, as nearly all dissected worms do, a pair of bright reddish eye-spots (Fig. 3i). The red color of the

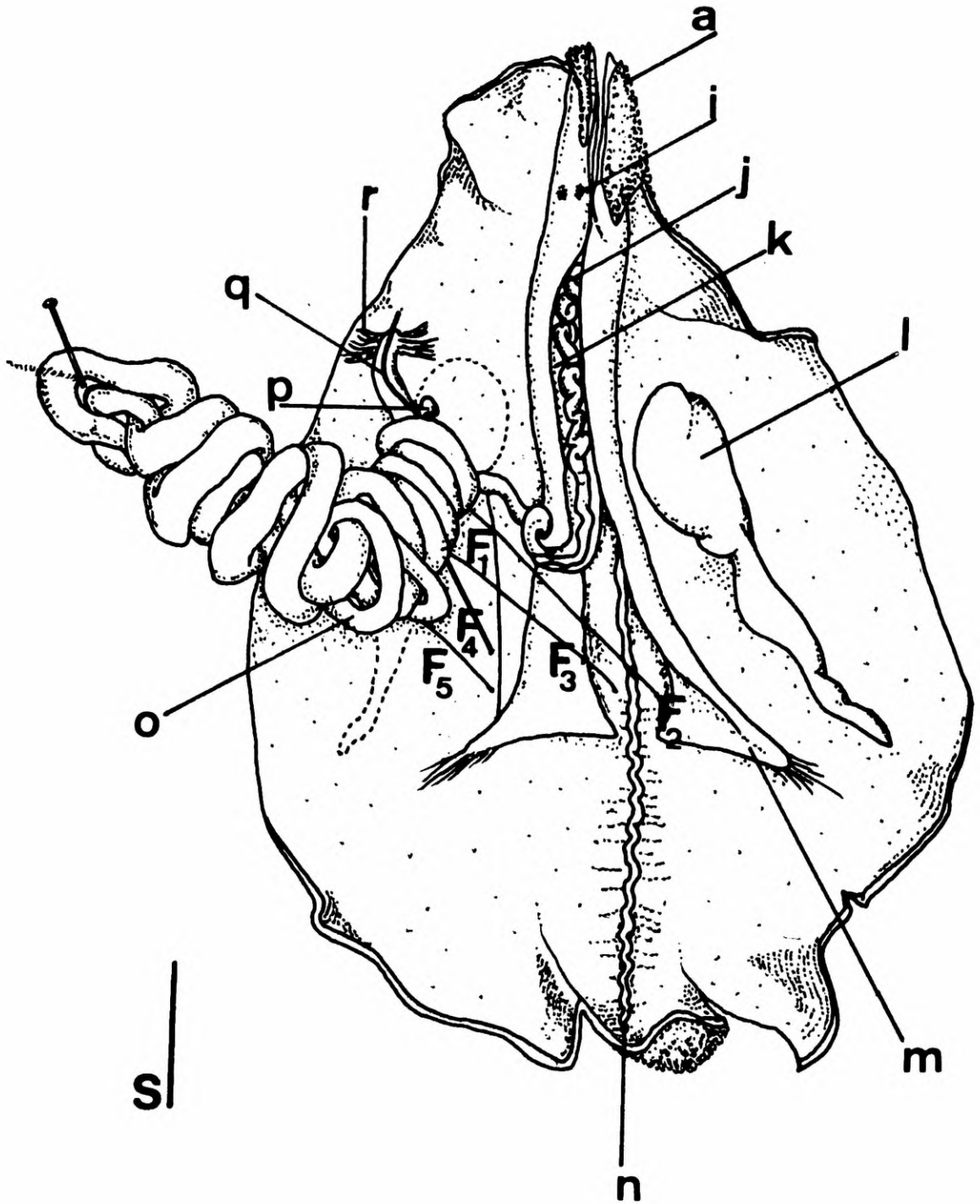


Figure 3. *Golfinhia confusa*. Internal anatomy. a = introvert, i = eye-spot, j = contractile vessel, k = oesophagus, l = nephridium, m = retractor muscle of proboscis, n = nerve cord, o = intestine, p = caecum, q = spindle muscle, r = wing muscle, F₁ to F₅ = fastener muscles (S = scale 2 mm).

eye-spots keeps in preserved animals freshly killed; in old museum specimens they become dark brown or even lose their color completely. The nerve cord (Fig. 3n) is conspicuous in all animals.

DISCUSSION OF *GOLFINGIA CONFUSA*

Golfingia confusa belongs to the subgenus *Nephasoma* Pergament, 1940, the largest subgenus of *Golfingia*.

As pointed out by Sluiter (1902), a very characteristic feature of this species is the chitinous reinforcement of the hooks, a trait we have also found and show in Fig. 4 h₄. *G. confusa* from Brazil carries also other types of hooks figured in Fig. 4, h₁, h₂, h₃, h₅. In our specimens, some of those hooks (h₁, h₃, h₅) are reinforced with a complete rim of chitin, being more common than types h₂ and h₄, only partially reinforced. Hence, the so called "diagnostic character" of Stephen & Edmonds (1972) is not as distinctive as it appears. We quote Gerould (1913) who called attention to the remarkable variety of characters used in distinguishing species of sipunculans, saying "hooks, even though of some service in classifying these species, are unreliable, for in the same species they may be present or absent". Also in Cutler's review (1979) one finds abundant examples of changes in the hook shapes, according to the age of the worms. These statements enhance our finding of other hooks, not yet figured by Sluiter (loc. cit.), and Gerould (loc. cit.), on describing *G. cinerea*. So, on account of the hook structure our material belongs to *confusa* as well as to *cinerea*.

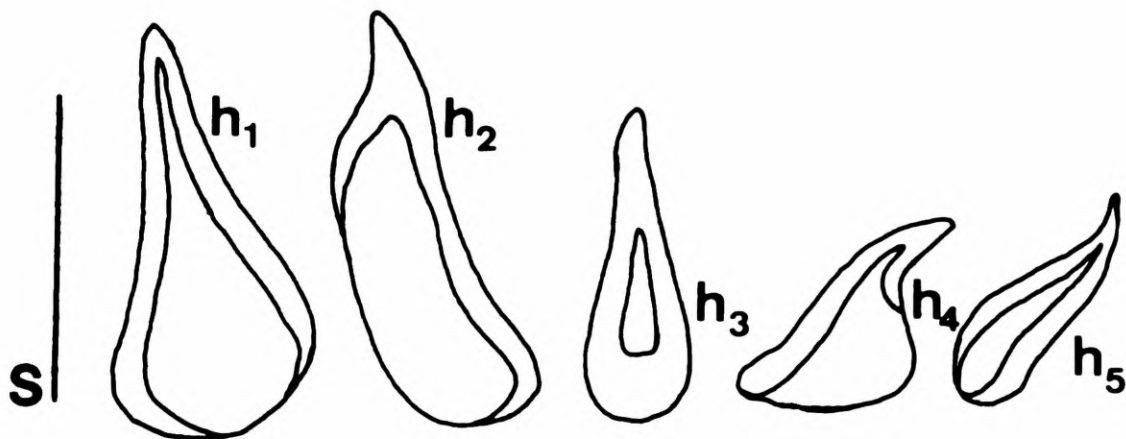


Figure 4. *Golfingia confusa*. h₁ - h₅ = introvert hooks (S = scale 50 m μ).

Another feature, which at the same time joins and separates our *G. confusa* from Gerould's *G. cinerea* is the presence of papillae. This seems to be more a question of semantics rather than of systematics, since Sluiter (loc. cit.) stated that *G. confusa* is devoid of papillae over all its body (= trunk plus introvert). However, Stephen & Edmonds (loc. cit.) translated the "Hautkörperchen" (= skin bodies) of Sluiter to papillae, hence *G. confusa* became a papillae bearing species. On the other hand, Gerould (loc. cit.) described, but did not figure, similar "papillae" for *G. cinerea*; since he did not mention chitinous platelets for the papillae of *cinerea*, one can infer he was actually working with skin bodies. In the Brazilian specimens we found rounded, ovate, and tiny finger-like skin bodies; this trait is common to both Sluiter's *confusa* and Gerould's *cinerea*.

Of the external morphology neither Sluiter nor Gerould mention the tentacular arrangement, nor the number of tentacles for their species. From a set of twenty worms we observed a variation from 18 to 42 tentacles. In a large number of animals Gibbs (1973)

was able to demonstrate a direct relationship between number of tentacles and body length for *G. rimicola*, a conclusion also valid for *G. confusa* from Brazil.

The internal anatomy of *G. confusa* from Brazil also presents intermediate features between Sluiter's *confusa* and Gerould's *cinerea*.

The level of nephridial openings is a trait used as a clear cut alternative in Stephen & Edmonds' Key (1902), though our study of 52 dissected worms does not provide grounds for a similar statement. Indeed, in the description part of this report we showed that nephropores are usually placed behind the anal opening; however, in a few cases they occur almost at the same level as the anus. Besides, when the anterior ends of the nephridia are inflated, the "nephridia grow forwards", rendering an accurate localization of the nephropores difficult.

A second feature is the presence of five fastener muscles instead of one, as stated by Sluiter (1902), or two fixing muscles, as described by Gerould (1913). As demonstrated in our Table I, this is also a variable character; moreover, some of the worms with 2, 3, and 4 fasteners would best be classified as having 5 fastener muscles. The reason for this is that some fasteners are extremely fine and susceptible to rupture. Once broken it is very difficult, if not impossible, to detect their origin or insertion from the satiny lustrous longitudinal muscle sheath. Notwithstanding, some specimens could be said to have only, 1, 2, 3 or 4 fasteners. In this respect the species closest to the Brazilian *G. confusa* is the Pacific *G. elachea* (Fisher, 1952), from which it is readily separated by the hooks, absent in *elachea*. Variation of number and anchorage site of fastener muscles was also reported in *Themiste dyscrita* by Fisher (1952).

Neither Sluiter (1902) nor Gerould (1913) mention the presence of a rectal caecum in their species. This probably reflects the peculiar position of the caecum in *G. confusa*, usually hidden in the internal curvature of the last intestinal coil.

Finally, Gerould (1913) stated that *G. cinerea* has no eye-spots, probably due to the 40 plus years his specimen remained in the preservative. As we noted here, worms preserved for a long time show color changes in eye-spots, to complete bleaching.

G. confusa and *G. cinerea* belong to the group of fifteen species whose validity was questioned by Cutler and Murina (1977). They pointed out the variable appearance of *G. confusa*, a fact we demonstrate here. Our material shows external variable appearance if we compare thin body wall worms with those in process of shedding; the first allow a rough inspection of internal anatomy without dissection, while the others have a thick and opaque body wall.

Our anatomical study lead us to the conclusion that *Golfingia* (N.) *confusa* (Sluiter, 1902) is a senior synonym of *Golfingia* (N.) *cinerea* (Gerould, 1903), so that its geographic and bathymetric ranges are considerably extended (see further). The geographical range is actually extended even more, since Cutler (personal communication) found one specimen of *G. confusa* off South Australia at 242 m depth.

The customary brief descriptions by Sluiter have produced a lot of inaccurately described species, as claimed by Cutler (1970), throwing much confusion into the modern systematics of Sipuncula. Hence we agree with Cutler & Murina's suggestion (1977) to consider those species as populations rather than as distinct species. On the other hand we would not hesitate to describe a new worm upon a single, though well preserved, specimen, if only one is found. Our suggestion to whom would describe a species based on a single specimen is to document it as much as possible with drawings, in order to make further identifications of new specimens easier. An example which supports our suggestion is *Aspidosiphon albus*, described by Murina (1967) from a single worm from Cuba; later, Ditadi (1979) found the species again in Brazil, the precise drawings and description by this Russian author being extremely valuable for a safe identification.

REMARKS

G. confusa is a species of opportunistic habitat, since it is found in any protected situation. In Southern Brazil it occurs among the skeleton of white corals (*Mussismilia*, *Porites*), under the skeleton of the giant bryozoan *Schizoporella unicornis*, under the base of the tunicate *Ascidia nigra*, in oyster beds in the colonies of the blue sponge *Zygomysale parishii*, and under rocks. Sluiter (1902) reports mud plus molluscan shells, or fine mud, and Gerould (1913), coral sand as the substratum from which their species were collected.

In Malaysia, *G. confusa* was found between 289 and 567 meters deep; in Florida, *G. cinerea* was collected at 81 meters, while Murina obtained her worms from between 70 and 4.737 meters. In Brazil, *G. confusa* has been collected, until now, from the lowest intertidal to a depth of 5 meters. There is no disagreement in finding a species from 5 to 4.700 meters deep. Support for this possibility is given by Cutler (1977), who listed new and until then "unusual" bathymetric distributions for a long series of specimens.

The worms collected in the blue sponge have a huge amount of monoaxonic spicules in their oesophagus and proximal intestine, though the bulk of the intestinal contents is fine sand; the spicules also traverse the thin oesophageal wall, and are found floating in the coelomic fluid.

Worms of 4.0 mm length can be adult animals since ova or spermatozoa are found in their coelomic fluid. The sex ratio was roughly estimated as 1:1 from a sample of 37 worms sacrificed for developmental studies. Natural spawning was observed in the first fortnight of January 1980.

Apart from the "normal" variation of some features of the internal and external anatomy of *G. confusa*, we report the following teratological aspects seen in the sample of 52 dissected worms: One worm with a single retractor muscle (the right one), two worms with a single nephridium (one on the right, one on the left side), one worm with a fastener muscle holding the left nephridium, and one worm with three nephridia (one left and two right!).

No large parasites were seen in our *Golfingia*; however a not yet identified bivalve mollusc was found firmly attached to the outer body wall of one worm.

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