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ECOLOGICAL STUDY OF BRAZILIAN *OTOTYPHLONEMERTES*

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Last year I described two species of Hoplonemertini, *Ototyphlonemertes evelinae* and *O. brevis* (CORREA 1948). At that time I had not compared the Brazilian species with *O. pellucida* Coe (1943, p. 266) from the New England coast, South of Cape Cod. This resembles *O. brevis* in size and composed statoliths. It differs from the latter by the presence of minute cerebral organs, a very slender proboscis with long slender canal in place of the bulblike middle chamber, and stylets marked by a pair of delicate spiral grooves.

By chance I saw the replacement of the stylet in *O. evelinae* (Fig. 1). From BÜRGER (1895, p. 438) to BÖHMIG (1929, p. 23) and FRIEDRICH (1936, p. 24) this process had not yet been observed, but recently COE (1943, pp. 158, 189) has described and figured it in detail. In the anterior chamber of the proboscis and later on in the rhynchodaeum of a specimen of *O. evelinae* floated the discarded old stylet and its basis, and a new stylet was already fastened in the new basis. The wreath of gland cells in the diaphragm (COE 1943, p. 159) was still recognizable by the threads of granular secretion converging towards the new basis like the spikes of a wheel. In the present case the first reserve stylet that was loosened from the pouch did not become implanted, it was found in the rhynchocoelom loose and defective. One of the pouches contained three complete accessory stylets, while in the other two were in formation beside two fully developed ones.

Ototyphlonemertes evelinae and *O. brevis* were found while Professor and Mrs. Marcus and I studied the sand fauna of the beach during several stays on the island of São Sebastião, 100 kms. East of Santos. In 1948 (pp. 9-12) I gave some biological observations.

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The worms showed positive thigmotaxis without preference for coarse (grains of 2-5 mm.) or fine (0,5-0,8 mm.) sand. They have no eyes and no photodermatic sense, and feed upon living (Polychaeta, Crustacea) and dead animals (Fishes and waste of fowl thrown on to the beach). The garbage of a near hotel may condition a certain accumulation of the worms in the restricted area under the pier of the village Ilhabela. The cement pillars of this bridge (graph) enabled me to determine the different places exactly, that were examined for this study. The tides on our coast belong to the half-day and moreover to the mixed form (SCHULZ 1933, pp. 265-266). Therefore such fixed points are even more important than in the Kiel Bight (Baltic) without tides, where REMANE & SCHULZ emphasized their value (1935, p. 399).

In my first paper I did not obtain an univocal proof that the worms are positively geotactic after having received an impulse by the movement of the water. I now employed an arrangement in which the worms did not glide from a drier to a wetter medium, as was the case when I heaped the sand containing the animals on one side of a dish and inclined it. Now I caught the worms with a pipette and put them on to the upper third of an inclined roughened glass-plate in the dish (Fig. 2). The whole plate was covered with water. With exception of a few injured ones all specimens glided downwards, some of them in a straight line to the lower border of the plate, and others obliquely. When the latter came to the side of the plate they released their hold and fell to the bottom of the vessel. They behave in the same way as adult *Convoluta roscoffensis* Graff (GAMBLE & KEEBLE 1904, p. 395). If *Ototyphlonemertes* are kept in a perfectly still dish with sand covered with water, some of the worms come out of the sand and glide on its surface. This behaviour resembles the negative geotaxis of *C. roscoffensis* in still water.

The intense movement of the water caused by the sucking the worms into the pipette and spouting them out of it gives the impulse to their positive geotaxis independent of the tides. Animals collected when the tide was coming in and others when it went out glided downwards in the same manner in my experiences. As I already observed in 1948 (p. 10), the positive geotaxis of the worms ceases some minutes after the impulse has passed. If my original arrangement of the inclined dish with the sand heaped up on the raised side is maintained, the worms accumulate on the bottom of the low side. They glide about without orientation till they hit on to the rim of the sand. Immediately they react to this mechanical stimulus and creep farther into the sand. After about an hour (tem-

perature of the water 23° C.) all uninjured worms have disappeared from the free water.

For the understanding of the worms in their natural habitat chemotaxis must not be forgotten. Not only *O. evelinae* with cerebral organs but also *O. brevis*, the only hitherto known free-living monostyliferous Hoplonemertean without these organs, came to the bait described in my first paper.

The species of *Ototyphlonemertes* belong to the benthonic fauna. Those of the present study are sand-dwellers of the tidal zone in the surf region as defined by MORTENSEN (1921, p. 33). Some of their characters can be considered as adaptations to the life in the sand. The term adaptation designs only the state of being adapted (REMANE 1933, p. 167) without any historical-phylogenetic meaning.

(1) As the length of the Nemertines varies between 2 mm. and 27 m. (MCINTOSH 1874, p. 183), the present species belong to the small forms. This is the rule for the inhabitants of the sand in a given group of animals (l. c., p. 174).

(2) The length-breadth-index, that is the maximal breadth indicated in percent of the length, is low. It is 1 for *O. evelinae* and 5 for *O. brevis*. Such low and even much lower indices are the rule in benthonic Nemerteans of various biotopes; f. ex. *Heterolineus longissimus* (Gunn.) from mud (FRIEDRICH 1936, p. 54) has 0,03. Low indices are also characteristic for the Nematoda that differ only little in the phytal (vegetation biotope), mud, and sand (REMANE 1933, p. 177). An adaptation however exists if the length of *O. evelinae* and *O. brevis* and their indices are considered together. The first species with up to 30 mm. in length is relatively much trinner than the second that only attains 10 mm. The small spaces between the grains of sand require in the first place a small breadth of the body, without which the animals cannot live in the micro-caverns. Greater dimensions of the animals are only possible by lengthening the body without increasing its diameter. The correctness of this simple explanation given by REMANE (1933, p. 179) becomes evident by the correlation between greater length and lower length-breadth-index in *O. evelinae* than those of *O. brevis*.

(3) Eyes are absent, while such occur in most of the Hoplonemertines (BÜRGER 1907, p. 168). Statocysts are developed only in mud- and sand-dwellers among the Nemertini, viz. primitive Palaeonemertini (Tubulanidae; FRIEDRICH 1936, pp. 11, 45, 54) and Ototyphlonemertidae.

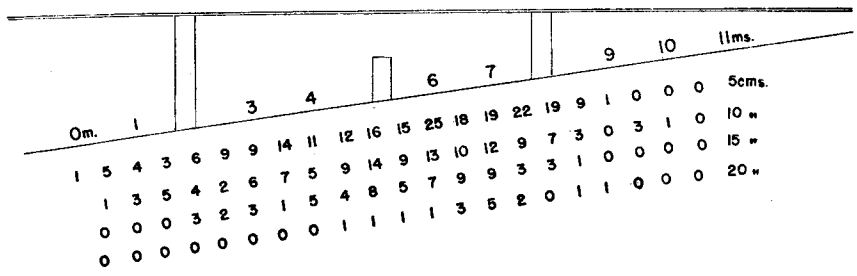
(4) Besides the colour of the food contained in the intestine the worms are whitish, as REMANE (1933, p. 181) verified in more than 95 per cent of the micro-fauna of the sand, and BÜRGER (1907, p. 535) reported for sand-dwelling Nemertines.

(5) If one separates with REMANE (l. c.) the groups of sessile, half-sessile, and motile animals, *Ototyphlonemertes* with the great majority of the Nemertini belongs to the last group. In this group REMANE distinguishes two sub-groups, the haptic animals that react upon a strong stimulus with fixation and the true mobile ones that try to get away from the source of the stimulus. The present species of *Ototyphlonemertes* belong to the first sub-group, that shows a pronounced accumulation in the sand. *O. evelinae* winds around itself like the species of *Saccocirrus* and *Polygordius* (DU BOIS-REYMOND MARCUS 1946; 1948, pp. 1, 11) of the accompanying fauna. *O. brevis* adheres to the sand by means of its caudal plate (CORREA 1948, fig. 11, cp), as many Turbellaria Seriata of the same biotope do (MEIXNER 1938, pp. 134-135; MARCUS 1946, pp. 119, 123; 1948, p. 159). It may be added that *O. evelinae* and *O. brevis* like many other sand-animals which glide by means of cilia do not swim. But as freely swimming Nemertines are hitherto not known in great number (FRIEDRICH 1936, p. 57) apart from the Polystilifera Pelagica, it seems advisable not to consider the type of locomotion exhibited by the present species as a special adaptation to the biotope.

I investigated the details of the distribution of the two species of *Ototyphlonemertes* on the sandy shore of Ilhabela on the island of São Sebastião beneath the above mentioned pier. I always worked on the same spot during the various phases of the tides and thus took my samples in the hours of increasing and diminishing moisture. The extension of the examined area was about 1 m. parallel to the coast and 11 m. in seaward-landward direction. The vertical difference between rise and fall of the tides was about 1 m. during the days of my research. The breeze was faint at that time. The distribution of the worms in the coarse sand outside the pier did not notably differ from the shaded area under the pier, although the latter is less exposed to the drying action of the sun. I began verifying the occurrence of the worms in the center of the described area and proceeded to the lines of mean low tide and mean righ tide. This zone is what DAVENPORT (1903; see FLATTELY & WALTON 1922, pp. 35-36) called the "lower beach".

The graph obtained during my investigation wants some further explanations concerning the method. I prepared a number of diagrams and indicated on the abcissa the distances from the waterline, that is the line of contact between land and sea, which is of course different at different hours. To the right were given the distances on the exposed sand, to the left those in the submerged portion. On the ordinate I marked the depths in the sand down

to 20 cms., below which depth the number of worms diminishes. I always examined the same quantity (125 c.c.) of sand. The samples were taken with a small cup. This cup was emptied into a salad-dish and water added. Fig. 3 shows how the worms were counted. The dish was carefully inclined so that the sand was left in the higher half. The water level touched the sand without covering it and without letting a dry belt between sand and water uncovered. The inclination of the dish causes a movement of the water that makes the worms positively geotactic: they all glide out of the sand and can easily be counted.



Graph showing the distribution of the worms in the sand exposed by the ebbing water.

While I prepared the graphs I became aware of the worms' independence from the movements of the tides. They stayed in their places without great variations, and even if such occurred, they were not correlated with the tidal rhythm. During the regular range of tides and faint winds our Nemerteans are not removed by the shifting line of the water, at least not in a high degree. The worms are occasionally displaced by breakers due to the wind. Struck by the surf they become positively geotactic and go deeper. When the surf has past over their habitat and hits the beach at a higher level, they return to the surface and resist to the less violent movement of the water by their positive thigmotaxis sticking to the sand-grains.

The constancy of the distribution of the worms permits to indicate their occurrence by one graph only. The one reproduced here was begun three hours after a mean high-tide and continued during the ebbing of the water to the following low-tide. The graph shows that the worms chiefly occur in the superficial layer, down to 10 cms. The lines of high-water and low-water have less animals than the zone between them. The region of their accumulation is determined by the positive factor of the organic matter deposited

by the receding tide and the restrictive influence of a long dry period.

As far as I know *Ototyphlonemertes* feeds mainly on the scavengers of the sand. The maximum numbers of individuals of *Ototyphlonemertes* (without discrimination of the two species) in 1000 c.c. of sand was 555 in April 1949 and 320 in June of the same year. This density is much bigger than that of Gastrotricha Macrodasyoidea in sand from the bay of Kiel (REMANE 1933, p. 172). It is true that REMANE counted the population of sand collected without bait. while my samples were taken from a region enriched by regular deposits of garbage.

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Plate I

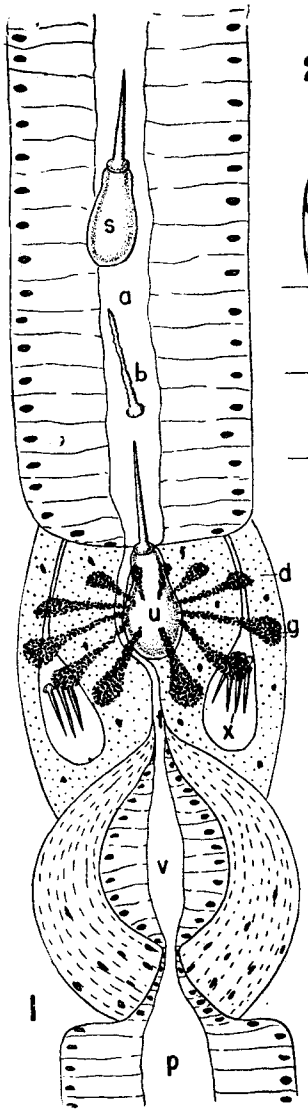
1. Replacement of the stylet in *Ototyphlonemertes evelinae.*

2. Dish with an inclined roughened glass-plate and the traces of three worms placed on its upper border.

3. Inclined dish for the counting of worms.

Significance of the lettering

a, anterior chamber of proboscis. b, defective stylet. d, diaphragm. g, wreath of gland cells. p, posterior chamber of proboscis. s, replaced stylet. t, ejaculatory duct. u, central stylet. v, bulbiform vesicle. x, accessory stylets.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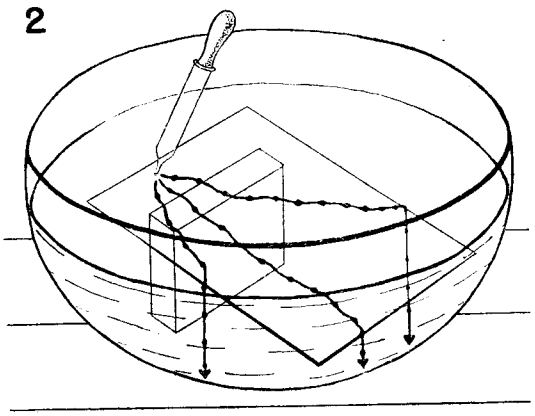
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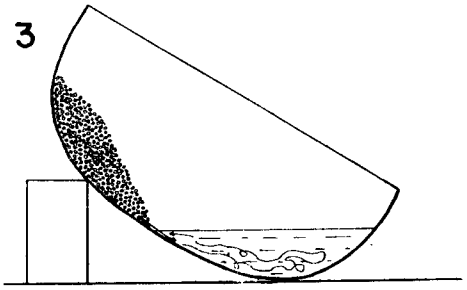
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