CONTRIBUTIONS TO THE NATURAL HISTORY OF BRAZILIAN TURBELLARIA

EVELINE and ERNST MARCUS [*]

Our faunistic studies of Turbellaria published in Portuguese since 1944 aim principally at morphological and systematic knowledge. But they also include observations of living animals, and the examination of the slides led to more or less settled statements referring to the functions of various organs. Moreover some of the morphological findings might be of general interest. In the following notes we try to relate only such selected facts and opinions out to those contained in DIVA D. CORREA's and our papers (see bibliographic list). Many of our results only confirm those of other workers, the publications of which we hope to have quoted carefully in our earlier reports. These citations are not repeated in the present synopsis that does not want to inform about the natural history of the Turbellaria, but only intends to make our notes attainable by arranging them after general points of view.

The minimum sizes we found among Acoela and Alloecoela Cumulata (Holocoela). Of the former our smallest species are *Kuma brevicauda* with living mature worms 0,35 mm. long, and *Haploposthia microphoca* that has less than 0,3 mm. Some measurements of Holocoela (preserved worms) are: *Rosmarium evelinae* (Scleraulophoridae) 0,2 mm.; *Cylindrostoma ibeenum* (Cylindrostomidae) 0,22 mm.; *Monoophorum tigacum* (Cyl.) 0,25 mm., and living *Tuilica evelinae* (Plagiost.) 0,34 mm. Our smallest Polyclads are two species of *Acerotisa*: *A. bituna*, 2 mm. alive; and *A. leuca*, 1,8 mm. in the living state.

Sometimes the size of the body seems to hold proportion to the diameter of the nuclei, as in three species of *Chordarium* (Catenulida), *evelinae, leucanthum,* and *cryptum*. Single zooids of the species are up to 0,8 mm., 0,5-1 mm., and 0,36-0,5 mm. long, respectively. The corresponding diameters of the nuclei (epidermis, gut, parenchyma) are: up to $5\,\mu$ (*evelinae, leucanthum*) and $3\,\mu$ (*cryptum*). The fourth species however, *Ch. philum*, with no more than 0,6 mm. in length, has nuclei of $7\text{-}11\,\mu$ in diameter. Also Acoela and Holocoela furnish examples for the size of the nuclei being a good specific character. In *Paraphanostoma westbladi* (1,5 mm. alive) the rare somatic

[*] Faculty of Philosophy, Sciences, etc. of the University of São Paulo, Brazil. P. O. Box 2926.

nuclei measure 8 µ.; those of the spermatogonia 10-12 µ. In *Paraphanostoma macroposthium* studied by WESTBLAD of likewise 1,5 length the nuclei are 5 µ in diameter and normally disposed. The rareness in *P. westbladi* is due to the big size and resulting small number of the cells. The 0,3 mm. long *Aphanostoma orphinum* (preserved) has somatic nuclei of 3,5 µ and germ-cell nuclei of 8 µ. Thus the nuclei of the germ-cells do not very as much in size as the somatic ones.

Preserved worms of the Cylindrostomid *Thallagus divae* are 0,6 mm. long, and their somatic nuclei less than 1 µ in diameter; another species of the same family, *Cylindrostoma ibeenum* (0,22 mm.), has much bigger ones (3-5 µ).

In some groups, f.ex. in many Typhloplanoida and Kalyptorhynchia, all epidermic nuclei are slightly lobed. In other cases ramification of the nuclei indicates special secretory activity of the corresponding cells, as, f.ex., in those of the penial sac of *Convoluta divae,* where abundant acidophilous secretion is produced; in the ejaculatory duct of *Pistrix thelura* (Monocelididae) the cuticular revestment is furnished by the cells with lobed nuclei. The epidermal cells of the Trigonostomid *Brinkmanniella augusti* have branched nuclei and contain numerous rhabdites. When the small substitutive cells with their relatively volumous and spherical nucleus are inserted between the functioning ones, they grow, their nuclei begin to ramify, and the rhabdites develop on the tips of the nuclear lobes.

Also depressed nuclei and normal, intra-epithelial ones may be understood as more or less intense solicitations for locomotory and secretory functions of the epidermis in one the other species, or in the various regions of the body in one species. This type of mixed, normal and depressed, epithelium occurs among Acoela, Microstomidae, and Proseriata; in Tricladida even the same organ (penis, antrum) may show normal and depressed areas of its covering.

The nuclei with karyosome of *Stenostomum,* that divide within the persisting nuclear membrane, become more numerous when digestion is at its height, and especially in the parts that are growing most intensely. Such growth precedes the development of brains and pharynges in new zooids. In the cephalic region of the chain mitoses are rare, and therefore granular nuclei predominate here.

Besides by intra-epithelial mitoses the epidermis of *Stenostomum* is renewed by immigration of substitutive cells that have divided below the epithelium. This is usual in Turbellaria. *Nematoplana asita* (Proseriata) f.ex., shows blue staining substitutive cells that have recently entered the epidermis, still without rhabdites. Wasted epidermic cells of *Stenostomum* are eliminated into the parenchyma.

Pigment may occur in the epidermis and in the parenchyma. From the latter processes of chromatophores extend into the neuropilema of the brain (*Plicastoma astrum;* Plagiost.) and into the epithelium of the intestine (*Puzostoma evelinae;* Plagiost.). In many cases the pigment is present in all healthy adult specimens, f.ex., the red colour of *Stenostomum matarazzoi,* and the yellow of *Plagiostomum nonatoi,* in both species situated in epidermic cells. In other cases pigment is a sign of age, as the epidermic colour of *Daelja secuta* (Provorticidae) and the parenchymatic pigment of *Microdaly-*

ellia evelinae. Possibly the apicytial dark yellow granules of *Paraproporus xanthus* (Acoela) belong to the same type.

The blue colour of *Amphiscolops evelinae* (Acoela) is localized in the depressed nuclei of the epicytium. One of the most uncommon types of colouring is that of *Alcha evelinae* (Kalyptorhynchia), a worm with white fore- and hind end, yellow in the middle, and with two broad, dark blue or black, transverse stripes. No correlation with the food could be verified in this case, whereas *Pseudoceros evelinae* (Cotylea) shows the same light red colour as the compound Ascidians upon which it feeds. *Stylochoplana aulica* (Acotylea) corresponds in colour either to its food or to the algae between which it lives, but active adaptation was not observed. The latter phenomenon occurs in *Bothromesostoma evelinae*. The melanophores of specimens kept in the dark for an hour (20º C) contract, and expand exposed to daylight in half an hour.

As little as the true eosinophil rhabdites of many Turbellarians the cyanophil rhabdoids of *Stenostomum* have a toxic effect upon its prey. As functions of rhabdites we only observed adhesion of rhamnites secreted by the principally caudal glands of *Mesoda gabriellae* (Proseriata), and the sticky cysts produced by the rhabdites of *Baicalellia evelinae* (Provorticidae), in which the worms stay during digestion. Although the occurrence of rhabdites in the epidermis (dermal rhabdites) and in depressed glands (adenal rh.) is frequently characteristic for the genera, exceptions occur, f.ex., *Stenostomum ventronephrium* has adenal rhabdites, and *Microstomum gabriellae* dermal ones.

In our material cuticulae only occur in the anterior part of the alimentary tract and the reproductive organs. The oral tube, prehensile border ("Greifwulst") of the pharynx (*Schizorhynchoides martae;* Kalyptorhynchia), the outlet of the pharynx, and the oesophagus (*Puzostoma evelinae,* Plagiost.) may be cuticular. Stylet, spines of the cirrus, and lining of the vagina are frequently cuticular. Sometimes a single cell secretes the stylet, as in the Proseriata *Togarma evelinae* and *Tabaota curiosa.* The cuticula of the ejaculatory duct of *Lurus eveliae* (Provorticidae) is also furnished by only one cell. The successive transformation of the blue staining formative cells into red cuticular spines was seen in the cirrus of *Mesoda gabriellae* (Proseriata). Not only epithelial but also parenchymatic cells can produce a cuticula, as is shown by the stylet of *Triadomma evelinae* (Acotylea). Cuticulae with plasmatic inner processes are developed by the non nuclear vaginal epithelium of various Kalyptorhynchia. The elasticity of the cuticula is evidenced by the variability of the shape of the spermatic duct (nozzle of the bursa) in *Convoluta divae.*

Bursa-like organs of the species of *Dolichomacrostomum* contain cuticular structures that migth be capsules produced in the female accessory organs around the sperms.

Cilia may be absent in some parts of the body, as on the caudal adhesive plate of Macrostomida (*Myozona evelinae* and others), Proseriata (*Pistrix thelura* and others), and the back of the Otoplanidae (*Kata, Parotoplana, Philosyrtis*). The free-living Triclad *Nerpa evelinae* has cilia of equal length on the whole body in opposition to *Bdelloura* of the same family that lives upon Xiphosura. In *Microdalyellia evelinae* the cilia can stop beating in some areas of the body and continue later on.

The length of 2,5 mm. is not a limit for swimming. Specially long and comparatively narrow species swim freely although they are longer. Chains of *Catenula lemnae* with 5 mm., *Stenostomum bicaudatum* with up to 7 mm., and *St. grande* f. *megista* up to 10 mm. swim as do individuals of *Nematoplana naia* (3 mm.). An other linear species of the Proseriata, *Meidiama lutheri*, does not swim in the adult stage, whereas the young worms. (0,2 mm.) do. Perhaps it is not only the size that conditions the different type of locomotion. The young of *Kuma brevicauda* (Acoela) swim (0,1 mm.), the adult do not, although they are no more than 0.35 mm. long. Also *Macrostomum delphax* only swims till it reaches 0,8 mm. length. The species of *Suomina* and *Chordarium* (Catenulida) swim sometimes with the tail forward. Some (*Stenostomum uronephrium*) and Proseriata (*Minona evelinae, Nematoplana naia*) stand perpendicularly in the water on the same spot for some time. The species of *Suomina* and some of *Stenostomum* swim and glide over the substratum ventral side up. Strongly stimulated *Zygantroplana henriettae* (Acotylea) curl alternately to the dorsal and ventral side rapidly repeated up to 20 times and propel themselves through the water. This Polyclad, about 10 mm. long. and 2 mm. broad, creeps up to 15 cm. per minute (22ºC.). The also marine *Meidiama lutheri* (Proseriata), up to 4 mm. long and 0,1 mm. in diameter, attains 3 cm. per minute. The slow movements of *Anoplodium evelinae* (Dalyellioida) that sticks to the watch glass when taken out of its host, a Holothuria, contrasts with the elegant swimming of the free-living Dalyellias.

Ditaxic creeping known from Polyclads occurs also in other Turbellaria (*Parotoplana moya, Geocentrophora applanata*), when they move in a thin film of water. As the angle between the surface of the water and the glass is a tactic stimulus for *Zygantroplana henrittae*, other Polyclads, and many species of the remaining Orders, these worms do not notice when they leave the water, as long as they are covered by a film of liquid. Mechanical stimuli interfere with the locomotion of sand-dwellers as Kalyptorhynchia and Proseriata. Among the latter *Vannuccia martae* almost never glides freely between the sand. Nearly always it sticks with one or more areas of its body to one or more grains that it does not let go before having fastened another region of its skin to another grain. The Kalyptorhynchian *Trapichorhynchus tapes* is perhaps the species in our material that shows the highest variability of its shape. Fusiform while swimming, the worm is as flat as a carpet when fastened to a stone.

The cutaneous muscles of such worms are very well developed and may condition an external annulation even in stretched worms (*Schizorhynchoides martae*). Annulated forms also occur among swimmers (*Urastoma evelinae;* Holocoela Combinata). The efficiency of contraction in the smooth muscle fibers of the of *Prosthiostomum cynarium* (Cotylea) can be seen by the diameter of the sucker at rest and in action. In the former stage this is 0,09 mm., in the latter nearly four times more, 0,35 mm., and therewith the sucker is expanded to one fourth of the breadth of the body (1,4 mm.). Striated muscles were found in *Kata evelinae* and *Parotoplana moya* (Proseriata) principally in the anterior region of the body but also in the penis sheath.

The sequence of the annular and longitudinal muscles around the pharynx of some Catenulida (f. ex. *Stenostomum matarazzoi*) and many Microstomids is inverted as compared with the integumentary layers. This makes it difficult to consider the pharynx simplex as originated by a simple invagination of the skin. Its development is only known from larvae of Polyclads and from dividing Catenulids and Microstomids. In the latter Orders the pharynges of new zooids are produced by formative cells in the parenchyma, not by the integument.

The cilia of the pharynx simplex in *Suomina evelinae* (Catenulida) are disposed and developed in such a manner that Protozoa are not only taken in by means of the current but also prevented from escaping. *Stenostomum bicaudatum*, the first species of the genus known from America (figured in a letter from FRITZ MÜLLER - Desterro to MAX SCHULTZE Bonn of March 13, 1864), has six muscular, sticky tentacles in its pharynx that grasp Crustacea and Rotatoria. Also the prehensile border of the bulbous pharynx in some Dayellioida is provided with tentacles (f. ex. *Baicalellia evelinae; Kalyla gabriellae*). The feeding types of Catenulida are: microphagous whirlers and macrophagous engulfers, but some species unite various types. *Stenostomum virginianum* ingests bacteria as a whirler, catches small ciliates as a microphage, swallows other *Stenostomum* without breaking them up as a macrophage, and cuts pieces out of the body of *Stenostomum* by means of combined sucking and biting. It even happens that the oldest zooid of a chain of *Stenostomum* swimming in a circle gulps its own tail at the hind end of the chain.

We only mention a few examples of the various food found in our Turbellaria. Diatoms are frequently eaten by sand-dwellers (*Convoluta vexillaria, C. divae, Dolichomacrostomum lutheri*, and others), not by the Proseriata of the sand. Also inhabitants of algae as *Macrostomum gabriellae* and *Levopharynx triops* (Typhloplanoida) feed principally on Diatoms. *Myozona evelinae* (Macrostomida) that also ingests Diatoms possesses a musculous gizzard appropriate for triturating the foood, whereas the function of a similar organ in *Stenostomum tauricum* that lives on Rotatoria and other small animals could not be verified.

Many Catenulida are bacteriophagous or feed on green flagellates. *Suomina evelinae* could be kept with ground Characeae, the chloroplasts of which it ate. We have only few records of Nematods as food: *Harsa obnixa* from sand with mud and *Itaipusa divae* (both Kalyptorhynchia) that occurs between algae and in sand. The latter species feeds also on other Turbellaria, as do *Amphiscolops evelinae* (Acoela), a 2 mm. long worm that was observed with up to six Kalyptorhynchia in its endocytium. *Microdalyellia evelinae* ingests, besides bacteria and pieces of Naidids, also *Catenula lemnae* that is rarely eaten by other animals. *Plagiostomum evelinae*, the pharynx of which is more than half the length of the body in young and about one third in adult worms, ingests *Prorhynchus stagnalis* that is as long as the *Plagiostomum*. The stylet of *Prorhynchus* proves not always to be an efficient defensive weapon. On the other hand this species itself, and still more a second of the Lecithoepitheliata, *Geocentrophora applanata*,

are, as JEANNETTE CARTER said, ravenous eaters. Turbellaria, **Rotatoria,** Nematoda, Oligochaeta, Copepoda, are devoured by them; *Geocentrophora* attacks the Naidid *Aulophorus superterrenus* that is ten times longer than the Turbellarian, sticks to it by means of secretion of its cephalic gland, tries to fasten itself to the substratum with its adhesive caudal glands, and even dragged along for a while, soon succeeds to cut off some segments of the Annelid. The portion of 16 segments that is as long as the Turbellarian was swallowed within a few minutes. With Naidids (*Dero, Aulophorus*) we also fed *Mesostoma ehrenbergii* in our aquarium. Also preserved specimens from the river Amazon had Naidid setae in their intestine, whereas in Europe the species seems to be rather stenophagous, capturing only Cladocera. These Crustaceans and others (Copepoda, Amphipoda) are eaten by Macrostomida, Kalyptorhynchia, and Polycladida (*Stylochoplana*). Ten individuals of *Chydorus* (Cladoc.) were seen in the gut of one *Macrostomum gigas* that is very greedy and may be deformed by the volume of the prey. Voracious forms exist also among the cancrivorous Acoela: an *Amphiscolops sargassi* that was 0,8 mm. long lodged four Copepods and one Amphipod (0,4 mm.), or six Turbellaria (Holocoela) simultaneously in its endocytium.

The pretense "sucker" of *Convoluta henseni*, that was described as an "adaptation", indeed rather strange for a planctonic species, is in fact an enormous catching pit for Copepods. The prey coiled up in the Turbellarian is nearly as long as the predatory worm. Crustacea and Polychaeta are eaten by many Polyclads, f.ex. *Zygantroplana henriettae* and *Pucelis evelinae* (Acotylea); compound Ascidians by the Cotylea *Pseudoceros evelinae* and *Tysanozoon lagidium* (feeds on Didemnidae). Up to 30 loricae of a species of *Metopidia* (Rotatoria) were counted in the gut of *Stenostomum paraguayense* that is 0,35-0,8 mm. long and also eats Rhizopods (*Arcella*), Phyllopods and Isopods (*Asellus*). *Enterostomula evelinae* (Cylindrostomidae) feeds specially on Bryozoa, and its gut can contain many tentacle-crowns of them, or five and more whole zooids of *Amathia* (Ctenostomata). In the alimentary tract of *Urastoma evelinae* (Holocoela Combinata) we only saw muscle fibers, no whole animals; the probably predacious species seems to suck or to tear them out of its prey in a not yet observed manner.

The Proseriata are chiefly scavengers that live on the animals left on the beach when tide falls, some of them suck in the blood of the gills, others engulf muscles, or fill themselves with the juice of the tissues, as *Meidiama lutheri*, the alimentary tract of which never was seen to contain solid substances. The necrophagy of the Proseriata makes it possible to attract many of them by means of a bait. But the mature stages of some species cannot be obtained by this method, because they do not eat any more during maturation. *Nematoplana naia, N. asita*, and principally *Tabaota curiosa* are such species. Their pharnyx diminishes from 11,2 per cent (*N. asita*) and 2 p. c. (*Tabaota*) of the body length in immature worms, to 3,5 p. c. (*N. a.*) and 0,15 p. c. (*T.*) in mature ones. The number of the pharyngeal nuclei decreases much less than the volume of the cells.

Degeneration of various organs, first the intestine, later on brain and statocyst, occur in the advanced female phase of *Catenula lemnae*. New

glands develop in the tail-region and surround the single egg. The excretory organs are preserved.

In our material there are histological signs both of extracellular and intracellular digestion. Extracellular predigestion of the larger food objects followed by intracellular digestion of the resulting particles occurs in Catenulida (*Stenostomum*), Macrostomida (*M. gigas*), Proseriata (*Promonotus villacae, Pistrix thelura*), Lecithocepheliata (*Prorhynchus* and *Geocentrophora*), and Polycladida (*Zygantroplana henriettae*). The cilia of the intestinal epithelium can disappear during intracellular digestion (*Stenostomum*) or persist (*Dasyhormus*). In the latter Catenulid (from dead leaves on the ground of a wet wood) the gut cells take in spores of fungi by phagocytosis, as do those of *Tabaota curiosa* (Proseriata) erythrocytes of fish. Wasted intestinal cells of *Stenostomum* are eliminated into the lumen before intracellular digestion is on its height. This stage is characterized by the maximum size of the cells that are full of food globules. Soon after food is taken into the gut the intestinal cells secrete a digestive ferment into the lumen of the gut and thereby diminish in height. Immediately after ingestion *Pistrix thelura* is 0,17 mm. in diameter and the intestinal wall is 6 μ high. Later on the lumen of the gut is obliterated by the cells of the wall that increase to 0,05 mm., while the diameter of the worm diminishes to 0,12 mm. Another Proseriate, *Tabaota curiosa*, showed the following measurements: Diameter of body immediately after feeding 0,2 mm., of which 0,176 mm, are the contents of the intestinal lumen, 10μ the walls of the intestine (5μ, each side), 14 μ body walls (7 μ each side). On the height of absorption the diameter of the body is 0,154 mm., of which 0,02 mm. body walls (0,01 mm. each side) so that 0,134 mm. remain for the height of the intestine that has no lumen left (0,067 mm. each side). The cells increase to 13 times their height by absorption of food.

In *Catenula, Microstomum gabriellae, Plagiostomum mirabile*, and *Kata evelinae* (Proseriata) digestion is evidently principally extracellular. The mentioned *Plagiostomum* has densely ciliated gut cells, and the splanchnic muscles are strong; club-shaped cells of Minot, on the whole rare among Holocoela (Cumulata), are wanting, as also in *Catenula* and other species of the Catenulida (*Stenostumum uronephrium*). On the other hand we have clear signs that these cells partake in extracellular predigestion (*Parotoplana moya*, Proseriata).

Certainly the digested substances pass to the adjacent organs through the parenchyma, but sometimes the diverticles of the intestine-function like a gastrovascular system. Although on the whole the species with ramified intestine, the Dendrocoela of EHRENBERG's system, comprehend the species of greater size, the proportion between body size and intestinal diverticles is not constant in every single case. *Philosyrtis eumeca* and *Parotoplana moya* are Otoplanidae (Proseriata) with a ramified gut. The first is very small, the second big. *Kata evelinae* however, of the same family, has a smooth tubular gut and is bigger than *Parotoplana* with a volume thousand times that of *Philosyrtis*.

The organs that furnish the food for the embryo in the egg, the vitellaria, receive the absorbed substances directly from the intestine in many

Holocoela (*Cylindrostoma myfflum, Plagiostomum thelotrichum*, and others), Proseriata, and Tricladida. In the Macrostomida (*Myozona, Dolichomacrostomum*) the growing ovocytes are nourished by the intestine; also those of *Urastoma evelinae* (Holocoela Combinata) are contiguous with the digestive syncytium. *Theama evelinae*, an acotylean Polyclad from sand, has each of its ovocytes inserted between the main gut and two intestinal diverticles. Thus the few ovocytes of this species take the best advantage of the food that is scarce in the sand biotope.

The ovocytes of *Convoluta henseni* seem to incorporate cells of the digestive syncytium (endocytium: WESTBLAD). Also the follicle of the testes penetrate between the intestinal tissue in *Nematoplana asita* and other Proseriata. The highest degree of intestinal ramification in this Order we have seen in *Parotoplana moya*, where the branches of the gut extend between the various organs like nourishing vessels. Often an excess of alien sperms is digested in the intestine which receives them from the bursa communicating with the gut by a duct or a pore, or by syncytial locules, the tissue of which is connected with that of the intestine. The latter type occurs also in Acoela (*Convoluta henseni*). In the two species of *Kata* (Proseriata) exceeding own sperms pass from the male efferent duct to the gut through a special canal. These sperms are digested in intracellular vacuoles of the digestive epithelium.

The evacuation of faecal masses through external pores of the intestinal diverticles of *Cycloporus* (Cotylea) was not seen in our material (*gabriellae*). On the other hand *Tabaota curiosa* (Proseriata) seems to possess a temporary anal opening at its hind end, khere faeces whirl round in a ciliated vesicle of the intestine.

An other transitory dorso-caudal intestinal pore develops in the female phase of *Togarma evelinae*. A cuticular passage apparatus allows alien sperms to pass through this opening. They enter the hind gut that is not digestive in this region and attain the female organs by a genito-intestinal duct. In this case part of the gut assumes the function of a vagina.

The intestine serves for still other purposes. In many of the thread-like Proseriata of the sand it supports, as a solid, not digesting, organ, the head region that has to clear the way through the dense medium. In *Mesoda gabriellae* also the tail is fortified by a compact portion of the gut. In the Prorhynchid *Geocentrophora applanata* the intestinal epithelium lodges the primordial germ-cells. In the Catenulida and possibly in *Myozona evelinae* (Macrostomida) some intestinal cells, the fixed excretophores, store wastes transported to them by amoeboid cells of the parenchyma, the athrocytes or mobile excretophores. These can also evacuate their contents directrly into the lumen of the gut, or entering it are evacuated with the faeces.

The same or a similar type (paranephrocytes) of cells occur ying against the walls of the emunctories that are important for the water content of the body. Emunctories are more numerous in *Promonotus villacae* from brackish water than in marine Proseriata. In our cultures pathological individuals of *Stenostomum* without protonephridia became so distended that they looked like baloons. The ascending and descending canal of the emunctory are grown together or are independent in Catenulids. Their walls are

generally epithelial, exceptionally syncytial, and their lumen is intra- or intercellular. The terminal cells, the occurrence of which has been incorrectly contested for this Order, are without processes directed into the surrounding parenchyma. These cell-processes are known from the figures of the flame-cells in many text-books, but in Catenulids there are only some parenchymatic strands that suspend the terminal cells and may simulate such branching processes. The U-wise curved terminal cells of *Stenostomum grande* f. *megista* also show that they propel the liquid in the canals and do not collect waste matters from the parenchyma. In rich material of three species of *Phaenocora* (Typhloplanoida) neither tufts of propelling cilia ("Treibwimperflammen") nor terminal organs were seen, so that the origin of the current in the canals is not known.

In *Plagiostomum evelinae* the lateral pores of the excretory organs open on the bottom of ciliated pits. The beat of these cilia may produce a current directed outwards that can drain the liquid from the canal.

The slimy vacuoles between the epithelial cells ("wasserklare Räume") have been considered as excretory (BÖHMIG). Perhaps this opinion can be supported by the intra-epithelial processes of the melanophores of *Bothromesostoma evelinae*. Their pigment granules lie in the superficial layer of the ventral and lateral epidermis and may be a sign of superficial intra-cellular excretion.

The nervous system of the Acoela is sometimes a diffuse plexus or neuropile that does not show nerve stems (*Mecynostomum evelinae*). This plexus constitutes the basal part of the epicytium and is connected with a thin layer of nerves around the statocyst. In most other species of the same (Convolutidae) and other families the brain is compact and composed of two pairs or accumulations of nerve cells (ganglia) from which the paired dorsal, lateral, and ventral nerves go out. The number of nerve pairs varies very much among the Turbellaria: *Catenula* has an unpaired anterior sensorial tract and four pairs of nerves, one lateral, two posterior, and one pharyngeal pair. In *Suomina* there are five pairs, because the anterior sensorial tract is double. *Stenostomum* and *Rhynchoscolex* have four anterior and four posterior pairs besides the pharyngeal nerves. In *Microdalyellia bellis* five anterior and five posterior pairs occur, in *Cylindrostoma myfflum* a total of eleven pairs. *Zygantroplana henriettae* (Acotylea) has eight pairs, of which the postero-dorsal one bifurcates immediately behind its origin. *Theama evelinae* of the same Section as *Zygantroplana* is one of the very few sand-dwellers among Polyclads. Its cerebral nerves are less numerous and their anastomoses much simpler than those of the inhabitants of algae. From the nerve cells that revest the brain of *Parotoplana moya* (Proseriata) dorsally, each latero-ventral nerve receives a giant fibre ("neurocord"). Such intra-central conductions over great distances correspond to functional needs of a comparatively long body (up to 7 mm.) that must be very flexible for gliding through the micro-caverns between the sand grains. This species and *Tabaota* (Proseriata) have extra-capsular ganglia that are else only known from Polyclads ("äussere Körnerhaufen"). They are weakly developed in some of them (*Theama, Prosthiostomum*). A cerebral capsule occurs also in

the Macrostomida (*Microstomum ulum*) that are ranked with the lower Orders in KARLING's system (1940). The capsule accompanies the roots of the principal nerves in many Holocoela, and continues along the whole length of the nerves in the Proseriata *Togarma, Nematoplana,* and *Tabaota.*

Flagellate sense cells with depressed cell-bodies (*Convoluta vexillaria* and other Acoela) were also found in *Suomina evelinae* (Catenulida). The sensory cells on the head of many species of *Stenostomum* are metamerically disposed like in *Rhynchoscolex.* The ciliated pits in *Stenostomum* are very mobile but not evertible. A pair of peculiar sensory knobs, each with one nucleus, lie on the top of the head of *Microstomum trichotum.* As they contain a blackish pigment they have a remote resemblance with the epithelial eyes of *Alaurina.* Two tufts of bristle-like sensory cilia supplied by nerves were observed above the cephalic gland of *Tuilica evelinae* (Plagiostomidae), and two more beside the short tail.

The Catenulid *Rhynchoscolex evelinae* and the Provorticid *Lurus evelinae* increase the small number of Turbellaria with two statoliths in the statocyst. *Amphiscolops sargassi* and *A. evelinae* are Acoela without a statocyst. Among our Proseriata *Togarma evelinae,* two species of *Nematoplana,* and *Tabaota curiosa* are sand--dwellers without a statocyst; of these only *Nematoplana* has eyes.

The ligth-refracting bodies ("schüsselförmige Organe") present in many species of *Stenostomum* are photo-receptors of the type of visual cells with a phaosoma. The vesicle of the "body" is a cell and the refractive unit a cytoplasmatic differentiation of this cell. The phobic negative phototaxis shown by species with such "bodies" corresponds to a photo-receptor that can distinguish increase and decrease of light-intensity, but not the direction from which the light enters the optic cell. The photo-receptors of *Tabaota curiosa* (Proseriata) belong to the same type.

It seems that of the so-called "epithelial" eyes described from Acoela do not lie in the epicytium (epidermis, covering layer), but in the ectocytium (superficial parenchyma). The presence of eyes in *Haploposthia microphoca* and also its seal-like body are adaptations to its biotope, algae of the upper littoral. The other species of the genus *Haploposthia* that are benthonic or live in sand, have no eyes, and the shape of their body is broadest behind the middle, different from Phocidae.

The common type of eyes in Turbellaria is the ocellus inverted into a pigmented cup. Where more than one visual cell exists, they may be united in one cup. This is the rule among Plagiostomids, or they form two pairs of eyes, the anterior with one and the posterior with two optic cells (many Combinata). In *Plicastoma carvalhoi* (Plagiostomidae) one or both sides of the body may show united or separated visual cells. In the first case the worm has one pair of eyes, in the latter two pairs or three eyes. Part of the optic cell can be refractive and function as a lens (*Geocentrophora applanata*). When the photo-receptive part of the eye consists of more than one cell, as in *Nerpa evelinae* (Tricladida Maricola) and perhaps *Dinizia divae* of the same group, the dioptric part might be produced by the catoptric part or by the surrounding parenchyma. The latter type cer-

tainly occurs in *Urastoma evelinae* (Holocoela Combinata) and possibly in *Vorticeros cyrtum* (Plagiostomidae). As a rule the so-called cerebral eyes of the Polycladida Acotylea are disposed appropriately for perceiving light from above and below, the tentacular eyes from the front and from behind as well as from the right and left hand. The number of eyes is greatly reduced in *Prosthiotomum gabriellae* that lives in sand. It has four cerebral eyes and four pre-cerebral ones, two at the border and two near the eventral side. In our other sand Polyclad, *Theama evelinae* (Acotylea) the mentioned disposition of the cerebral eyes is indistinct.

Contrary to the negative phototaxis of *Stenostomum* - species with refractive bodies, *Catenula lemnae* that has no photoreceptores behaved indifferently against light, even illuminated suddenly and intensely. As earlier authors mentioned reactions of another species of *Catenula* to strong artificial light, differences in photo-dermatic sensibility seem to exist. The reaction of *Stenostomum* is phobic, not directed, that of *Macrostomum gigas*, *Phaenocora bresslaui*, and *Geocentrophora applanata*, topic, that is directed. The three last species possess inverted ocelli in pigmented cups. The reaction of *G. applanata* that has lenses is the most violent of the three species. *Phaenocora bresslaui* with red pigment in the cup reacts stronger to light than *Ph. evelinae*, in which the cells of the cup contain a substance that looks like guanine. *Ph. chloroxantha* without eyes is indifferent against light. The heterogeneous responses to photic stimuli of the three *Phaenocora* are to a certain degree correlated with the green algae in their parenchyma; these are absent in *Ph. bresslaui*, the most negatively phototactic species. Some examples of species that shun the light among the marine Turbellaria are the sand-dwellers *Vejdovskya suslica* (Dalyellioida), *Trapichorhynchus tapes* (Kalyptorhynchia) that even leaves the water on the side of the watch-glass farthest from the window, and *Nematoplana asita* (Proseriata). It must be said that *V. suslica* combines a body full of brownish green algae with negative phototaxis. This reaction is directed (negative phototropotaxis) in *Zygantroplana henriettae* (Acotylea): the worms go towards the dark even against the incidence of the light (skototaxis). The photokinetic reaction of this species decreases after some time, but can be re-increased by intensified illumination.

Other Turbellaria inhabiting algae like *Zygantroplana* are positively phototactic, f. ex., the marine *Amphiscolops evelinae* (Acoela) and *Urastoma evelinae* (Holocoela Combinata). Also the planctonic *Convoluta henseni* with symbiotic algae belongs to the species that accumulate on the lighter side of a dish. Contrary to what is known from European species of *Bothromesostoma*, our *B. evelinae* swims in full sun-light with the ventral side upward on the surface of permanent pools and temporary plashes. If the worms are pushed downwards by some drops of water, they fall only a short way, and then remain suspended to the surface by a mucous thread like *Mesostoma ehrenbergii*.

Proseriata and other sand-dwellers (*Macrostomum evelinae, Myozona evelinae*) contained in a certain amount of sand heaped on one side of a dish glide out of the sand if the dish is inclined gently. They accumulate

in the water on the deeper side of the dish. The worms are by no means washed out of the sand with the current, although the movement of the water gives the impulse for their gliding downwards. Some minutes after the impulse has passed, the reaction ends. The worms glide about on the walls of the bowl and also creep upwards till they hit the rim of the sand. Immediately they react to this mechanical stimulus and disappear in the sand. Most Proseriata have a statocyst with which they can perceive the change of their position that induces their positive geotactic behaviour; when the stimulus is over they return to geotactic indifference. But as the Macrostomids mentioned above taht have no statocyst, and the Proseriata *Nematoplana ñaia, N. asita,* and *Togarma evelinae* also come out of the sand, the phenomenon becomes less intelligible. It is true that the species without statocyst appear later on the low side of the dish than those with statocyst. Some individuals of *Nematoplana* even remain in the sand. Nevertheless most of them and nearly all worms of the other statocyst-less species glide downwards. As their morphology does not support the idea of a positive geotaxis due to translocation of their inner organs, their behaviour seems to be negatively rheotactic. Such a kind of response to mechanical stimuli provoked by currents is very rare among animals.

Tabaota curiosa reacts to movements of the water (shaking of the dish) by stretching two thirds of its length forth over the surface of the sand. About 20 seconds after the water is calm again the worms withdraw. Also animals with a damaged head come out of the sand, but these do not go back when the stimulus ends.

Most Kalyptorhynchia and Proseriata of the sand behave as "haptic" (REMANE) animals, wthen hit by a current. They curl up, frequently around the grains of sand (*Meidiama lutheri*), or fix themselves with the caudal region (*Pistrix thelura; Nerpa evelinae*) frequently developed as an adhesive plate (*Macrostomum evelinae, Minona evelinae,* and others). *Zygantroplana henriettae,* an inhabitant of algae, only reacts to a strong current that hits the fore end. This species shows the righting reaction clearly and conditioned by a positive thigmotaxis of the ventral side. The tactile or perhaps also chemical stimulus brought about by the calcareous algae inhabited by *Z. henriettae* is specific and can not be substituted by cotton-wool. If however a tuft of these algae is placed in one half of a dish that is exposed to bright sun-light and the other half is left in the dark but without substratum, all worms gather in the dark half. This shows that negative phototaxis, at least with strong light, is superposed to positive thigmotaxis. Much less distinct, but still perceptible, is the precedence of negative phototaxis over positive thigmotaxis if the algae in the light side of the dish are exposed to diffuse daylight.

The mechanical or perhaps also chemical stimulus that may go out from food are responded by *Stenostomum* only if the stimulation attains the anterior region of the body; if the worms touch their usual nutritive bodies with the back or with the tail, they do not react.

Geocentrophora applanata that behaves positively thigmotactic shows this quality also when it lays its eggs. In our aquaria the cocoons were usually laid in places where two leaves of the aquatic plants touched.

The last mentioned species has hermaphroditic individuals with simulta-neous development of eggs and sperms, others are protandrous, and still others protogynous. Protandrous hermaphroditism is very frequent in our Turbellaria, so that we only mention some striking examples: *Catenula lemnae*, the Provorticidae *Baicalellia evelinae* and *Daelja secuta*, the Proseriata *Togarma evelinae*, *Nematoplana naia*, *N. asita* and *Tabaota curiosa*, and many Polyclads: *Latocestus ocellatus*, *Alleena callizona*, *Stylochus martae*, and others. The male and female stage of *Latocestus ocellatus* differ externally; the former is thin and narrow (1,5 mm. broad), the latter thick and broad (4 mm.). The male pore of *Togarma* opens only on the height of the male phase. Later on the copulatory organ, a cuticular stylet, leaves its place while the male organs involve, and can enter the gut from where it is evacuated. Also *Brinkmanniella augusti*, *Daelja secuta* and protandrous hermaphrodites of *Georentrophora applanata* have no stylet in the female stage; possibly the male organ falls off after the last copulation. Only 5-6 worms with male organs were seen among 200 individuals of different ages in *Baicalellia evelinae*, but all middle-sized and full grown worms have sperms in their bursa seminalis. Autogamy may occur in *Dolichomacrostomum mortenseni*, if copulation with a partner is not feasible, at least the course of an accessory male tube can best be explained by this supposition (LUTHER).

Among the simultaneous hermaphrodites of *Convoluta westbladi* some pure females occurred. In these cases an unknown factor has suppressed the male component of the normally hermaphroditic germ-centres. Suppression of the male organs is not restricted to Acoela with hermaphroditic germ-centres. Recently we found a small pure female of *Brinkmanniella augusti*. The normal female phase of this protandrous Trigonostomid may also lack all male organs, but it is twice as large as the worm in question. The herma-phroditic Naidids too have sometimes one sex suppressed. Hermaphroditic germ-centres, from which the spermatocytes and ovocytes grow forth and separate, occur in various of our Acoela, f. ex., *Haploposthia microphoca* and *Mecynostomum pellitum*. *Puzostoma evelinae* (Plagiostomidae) is the first Turbellarian with a pair of true ovariotestes (hermaphrodite glands) enveloped by a tunica propria.

Of the Turbellaria with separate ovaries (germaria) and vitelline glands (vitellaria) only the species of the Nematoplanidae (Proseriata) have more than one pair of ovaries. *Tabaota curiosa* has up to five pairs, *Nematoplana asita* up to ten.

Frenquently the ovaries and vitellaries do not develop simultaneously. The ovaries appear first, f. ex. in *Plagiostomum evelinae* (slightly protan-drous), *Plicastoma phocae* (Plagiostomidae; distinctly prótandrous), and *Mesoda gabriellae* (Proseriata; protandrous). The vitellaria precede the ovaria in *Acmostomum canarium* (Plagiostomidae; slightly protandrous), and *Togarma evelinae* (Proseriata; distinctly protandrous). On the whole ovarial precedence is more frequent.

The number of testes varies very much, even within the same Order (Proseriata): *Philosyrtis eumeca* (Otoplanidae) has one pair, or only one testis, and *Tabaota* (Nematoplanidae) about 600 pairs of follicles. There is

also a great range of variation among the marine Tricladida, where up to 150 pairs occur. In our material we have one pair (*Nerpa evelinae*), 2-3 (*Dinizia divae*) and 3-4 (*Leucolesma corderoi*).

The gonads of *Dugesia tigrina* develop in moving and stagnant waters in the neighbourhood of São Paulo, contrary to what has been stated for North American populations (HYMAN 1939), at least in some regions, where moving water was recognized as an essential environmental factor for the development of sexuality in *D. tigrina*.

The occurrence of only one ovary in sand-living Kalyptorhynchia was explained with the unfavourable conditions in this biotope by MEIXNER. It is clear that MEIXNER only thought of the scarce food, as with regard to competition and enemies the sand seems to be better than the zone of vegetation. We have Polycystididae (*Zuccaria, Pauloroda*) and Koinocystididae (*Itaipusa, Utelga, Alcha*), that live among algae (*Itaipusa* also in sand) and have two ovaries, whereas *Harsa* (Placorhynchidae) and the Schizorhynchia *Trapichorhynchus, Proschizorhynchus*, and *Schizorhynchoides*, living in sand have one ovary. *Rhinolasius martae* (Koinocystididae) inhabits what MEIXNER called: "a not characteristic sand-formation mixed with much organic matter". It has, as is the rule in its family, two ovaries, but growing ovocytes were seen in only one, in the other the female germ cells remained with less than half of their definitive diameter.

The genital ducts, that are of great systematic importance, show some peculiarities that deserve a more ample interest. The wall of each ovary of *Amphiscolops sargassi* continues with a strand that inserts on the ventral body-wall at a spot where the outermost layer, the epicytium, is interrupted. If these strands led out the eggs, they would be the first oviducts known in the Acoela.

In one of our fresh-water Triclads, *Bopsula evelinae*, the male and female pore are separated. Perhaps as an inheritance from ancestors with united male and female antrum, that is the rule in Tricladida, a wide canal unites the female antrum with the lumen of the penis. The bursa copulatrix of *Lurus evelinae* (Provorticidae) has an outlet into the parenchyma, probably with the same function as the above mentioned communications between bursa and gut of other species.

LANG, BOCK, MEIXNER, and others considered the granule vesicle and the penis stylet of Turbellaria primarily as arms that only secondarily united with the testis to lead out the sperms. This idea is supported by the Proseriata *Minona evelinae* and *Peraclistus itaipus*, that have an unarmed ejaculatory duct and a granule vesicle with a stylet independent of it. Also the Catenulid genus *Chordarium* suits well to the mentioned theory. In three species of this genus a penis with granule vesicle occurs in all full grown worms independently of the rarely developed testis (seen only in one species). The penis is often protruded and probably helps to capture the Algae, Rotatoria, and *Aeolosoma*, on which *Chordarium* feeds. In favour of LANG's weapon-theory the authors use to mention cases in which development of the stylet precedes that of the testis. Such occur also in our material, f.ex., in *Gyratrix hermaphroditus* and *Prorhynchus stagnalis*. It must however be abded that in our other Prorhynchid, *Geocentrophora ap-*

planata, the copulatory stylet develops latest in the male state and disappears after this phase is over. In Proseriata and Polycladida the stylet develops late in the male apparatus.

The inversion of the usual sequence of internal seminal vesicle and external granule vesicle, that is a particularity of *Plagiostomum nonatoi,* cannot be explained.

One isolated young *Macrostomum delphax* developed gonads in a month and showed sperms implanted in the cells of the female antrum, that normally harbour the male products waiting for the egg. In young *Mesostoma ehrenbergii* still without functioning penis the spermatozoa leave the testes and fertilize the eggs of the same worm. In *Macrostomum* however the male and female organs have separate pores, and the sperms observed in our isolated *M. delphax* must have been immitted by auto-copulation. After copulation the sperms of *Mecynostum evelinae* (Acoela) lie in the bursa bundled with their tails to one side as they had previously lain the seminal vesicle.

The spermatozoa of the Plagiostomidae, the shape of which is specific, can change their form in the body of the partner and in the female germ cells, or even in the seminal vesicle (*P. nonatoi*) of their producer. In this family hypodermic impregnation is the usual type of copulation. The worms of *Plagiostomum evelinae* protrude the whole male efferent duct including the seminal vesicle in the inverted antrum and feel about with it. We saw how one of the animals touched the hind part of the back of another, fixed its penis there, pulled out a point of the black parenchyma of its partner, and remained in this position for 1-2 minutes. Then the penis was withdrawn, leaving a mark still visible after five minutes. In another copulation the penis pierced the epidermis above the ovary, and the pricked worm contracted so violently that its skin became wrinkled. Also this copulation lasted 1-2 minutes. In both cases the passive worm tried to thrust its male organ into its partner but did not succeed. The spermatozoa, that are introduced by hypodermic impregnation in the Plagiostomids, can be found in the intestinal epithelium, in the brain, in the parenchyma, and in epidermic vacuoles; their chemical orientation is evidently very little efficient.

Prorhynchus stagnalis and *Geocentrophora applanata* copulate, as it seems, repeatedly, and generally the sperms are introduced into the female antrum. In the Polycladida both processes of copulation occur, hypodermic impregnation and immission into the vagina. The first type was found in *Acerotisa bituna,* the second in *Acerotisa leuca.* In the latter some alien sperms were also observed in the parenchyma, where they only can have come by hypodermic impregnation. The two vaginal ducts of *Pentaplana divae* have up to nine diverticles each that open on the ventral side of the hind region. These copulatory pores, in some of which sperms were seen, probably function after one another.

Monospermic insemination of the ovocyte during the growing period or even at its beginning is not rare. As examples *Geocentrophora applanata, Urastoma evelinae,* many Plagiostomidae and Proseriata (*Promonotus villacae, Monocelis tabira,* and *Philosyrtis eumeca*) may be mentioned. The full grown ovocytes of *Urastoma evelinae* have a diameter of 42 μ, but such of 25 μ are

already inseminated. In this species the ovarian parenchyma (stroma) forms a central vacuole, in which spermatozoa are lodged. *Acmostomum canarium* and *Tuilica evelinae* are Plagiostomidae without precocious insemination. The former species is only slightly protandrous, and the latter has a receptaculum seminis; both circunmstances turn a precocicous entrance of sperms into the ovocytes unnecessary. Where full grown female germ cells are inseminated, as those of *Mesoda gabriellae* still within the ovarian tunica, the process precedes the maturation in all our registered cases. But we did not yet see old female phases of *Thysanozoon*. In this genus the sperm is said to enter the egg after the formation of the polocytes. *Pseudoceros evelinae*, of the same family, has sperms in the oviducts near the ovarian follicles inward from the uteri in which the divisions of maturation take place, but only uterine eggs are inseminated.

The transformations of the ooplasm during the growing period that proceed from the nucleus to the periphery are specially distinct in *Nematoplana asita* and some species of the Plagiostomidae (*Plagiostomum kurrum*).

Only in some favourable cases we verified the number of chromosomes and counted in the diploid phase: ca. 40 in *Paraphanostoma westbladi;* 18 in *Pseudoceros evelinae;* 16 in *Convoluta westbladi* and *Mecynostomum pellitum;* 10 in *Mesostoma ehrenbergii;* 8 in *Stylochoplana divae;* 6 in *Macrostomum gabriellae*, *M. gigas*, and *Stylochoplana aulica;* 4 in *Macrostomum delphax* and *Notoplana plecta*. In the systematic discussion of *Macrostomum gabriellae* (against *hustedi* Jones) and *Mesostoma ehrenbergii* (against *wardii* Woodw.) the number of chromosomes was used.

The annual cycle of the last species from the neighbourhood of São Paulo is different from that observed in Europe. In the Alsacian populations already a considerable part of the second generation in the year produces only thick-shelled "winter-eggs", and of the third generation only 40 per cent develop thin-shelled "summer-eggs". In São Paulo worms considered as first generation, that had perhaps already hatched from "summer-eggs", were brought to the laboratory, where still 94 per cent of the third generation of their descendants produced yolk-poor and thin-shelled eggs. In Europe the thick-shelled resting eggs are freed by the death of the mother worm. In São Paulo they are a little smaller (0,29-0,4 mm. in diameter) than the European ones (0,45-0,5 mm.), and are laid off throughout the year after a permanence of 1-6 days in the uterus (average: 3 days 20 hours, at 16-18º C.). Retention of the eggs heaped up in the body is biologically less advantageous than laying them, because all can be eaten at once by one turbellariophagous animal. That the disadvantageous type of reproduction occurs in higher latitudes, suits to HESSE's statement that in colder zones the "struggle for existence" is less intensely fought between the various species than in warmer regions. Also in *Bothromesostoma evelinae* the thick-shelled eggs, up to three of which were observed in each uterus, are freed by the living worm.

Of *Phaenocora evelinae* we obtained six cocoons with one egg each in twelve successive days in the aquarium. The permanence of the eggs in the uterus of *Microdalyellia evelinae* varies very much: sometimes the egg is laid with a still yellow shell, other times with a red-brown or dark brown

one. The capsules are glued to plants or shells of snails (*Australorbis*, Ancylidae). The cocoons of *Plagiostomum evelinae* are pedunculate and contain up to four eggs. In this species the diameter of the capsule equals 60-75 per cent of the greatest breadth of the body; in our Dalyelliidae it is 18-68 per cent. In *Baicalellia evelinae* it is 45-50 per cent. Notwithstanding this species frees its eggs through the intestine, although efferent organs exist, by which the penis comes out and is admitted. The cocoon contains two eggs, and up to six cocoons can be lodged simultaneously in the intestinal tissue Sometimes the capsules are expelled through the mouth, other times the embryos develop while the cocoons are in the gut, and there the young worms hatch. Herewith the species becomes viviparous, as Mesostominae normally are with regard to the young hatching from subitaneous eggs. The developing embyos of *Baicalellia* can survive the death of their mother within their capsules, and become free when the maternal body decays.

The young worms of *Rhynchoscolex evelinae* are larvae, as they prossess two belts of cilia, one before, one behind the brain, and fixed excretophores in the gut, structures that disappear later on. The not yet concentrated pharyngeal glands, the weakly developed sensory cells in the prostomium, and the absence of a statocyst and tactile cilia are juvenile characters, but those mentioned first are true larval provisory organs that undergo retrogressive metamorphosis. One of the larvae of *Cycloporus gabriellae* that we found had male reproductive organs with living sperms. It could not be stated whether such larvae of *C. gabriellae* are unisexual animals or protandrous hermaphrodites. In any case this larval sexual stage, with the primordials of the pharynx, the pharyngeal pocket, and the sucker, can hardly be considered as a definitive animal. Probably it will pass through normal metamorphosis and an immature juvenile phase, as such were found at the same locality, to the full grown worm that becomes mature again. This phenomenon known as dissogony (Ctenophora, some Nereidae) occurs possibly also in one of the Euryleptidae of Monterey Bay, the sexually mature larva of which was described as a neotenic Polyclad (*Graffizoon lobatum*).

The development of the embryo of *Baicalellia evelinae* takes 8-10 days at a temperature of 18° C. Five days hatching the female organ (bursa seminalis) already contained sperm. One mature worm that was isolated produced 14 young in 11 days. The young of *Dugesia arndti* hatched with a length of 3 mm. in our aquarium. Every day the worm received one Chironomid larva but occasionally did not eat it. At a temperature of 20-22° C. the animal was 9 mm. long 19 days after hatching; on the 32. day it was mature with 16 mm. length. As the species attains 18 mm. in its natural surroundings, it became mature when it was full grown. Embryos of *Dugesia tigrina* stayed three weeks in the cocoons (22-26°C.), and the young hatched with 2 mm. Three weeks later they were 8 mm. long, and their copulatory apparatus, the latest part of their reproductive organs, began to develop. The worms continued to grow up to 18 mm. Till now the gonads of the Tricladida Paludicola were known to appear only in full grown animals, but *Dugesia tigrina* in São Paulo is an exception from this rule. Free-living *Dugesia hypoglauca* that we know only from one brook with

rapidly current, relatively cold, not insolated, water, are 8-15 mm. long and 1,2 mm. broad. In the aquarium the worms grew up to 38 mm. in length and 3 mm. in breadth. They were fed daily and generally refused to eat on one out of six days.

The frequently different shape of young and adult Turbellaria is·due to the different growth of the various regions of the body. In the Dalyellioida, Phaenocorinae, and Plagiostomidae, f.ex., the anterior region grows less than the rest of the body during the post-embryonic life. In *Phaenocora chloroxantha* the pharynx grows to thrice its original length from hatching to maturity, the body six times. The brain hardly increases in size during the post-embryonic life of some Macrostomida (*Macrostomum evelinae*), Proseriata (*Meidiama lutheri, Philosyrtis eumeca*, etc.), and Polycladida (*Cycloporus gabriellae, Prosthiostomum*, and others). The brain of young and mature individuals of *Urastoma evelinae* has nearly the same size; also the differences between smaller and bigger adult worms are slight with regard to the dimensions of the brain. Chiefly the development of the copulatory apparatus, and in some cases also that of the gonads and vitellaria causes the greater lengthening of the post-pharyngeal region. The growth of the vitellaria changes the vitellaria changes the cylindrical form of young *Phaenocora evelinae* to a foliaceous shape. The creeping stages of many young Polyclads are proportionally narrower than the mature worms (*Stylochoplana selenopsis; St. leptalea; Pucelis evelinae*, etc.). In other species growth is more harmonious; both in *Zygantroplana henriettae* with the ovaries in part developed in front of the pharynx and in *Enchiridium evelinae* with the entire reproductive apparatus behind.

The sucker of the last species grows to more than twice its diameter from the young to the mature stage. Besides the salient adhesive papillae at the hind end, and the usual, much farther anterior position of the pharynx, young worms of of *Meidiama lutheri* have three girdles of adhesive epidermal knobs, that are irregularly disposed in the adults. The growth of the stylet in *Macrostomum delphax* shows an individual variation that is not correlated with the body-size, nor does it depend on the quantity of food. In eight mature worms that were isolated with stylets of 50 μ length, these grew to 60-96 μ in the course of 13 days with plenty of food. Young *Bipalium kewense* have the typical unate head of the adults. This is an important distinctive feature against young *Dolichoplana feildeni* and *carvalhoi* that have a narrow, black, conical head, and against regenerating fragments of *Bipalium kewense*, that have a pigment free cone of regenerative tissue.

Division is the typical way of reproduction in Catenulids, and is also in Microstomidae more frequent than the sexual process. Among the Tricladida Paludicola and some Terricola (*Bipalium, Dolichoplana*) either of the two reproductive types seems to prevail over the other corresponding to conditions of the medium. *Curtisia schubarti* was hitherto only obtained in rapidly current water or in higher altitudes (up to 1830 m.). In the latter places it has gonads in summer. In our aquarium the species divided by architomy during many weeks; of the North American *C. foremani* (Gir.) no agamic reproduction has been reported. On the other hand, sexual repro-

duction of *Dugesia tigrina* in São Paulo is more frequent and less dependent on the special conditions of the habitat than in many North American localities. *Dugesia hypoglauca* divided during the warm months and with as much food as was accepted in the laboratory. Fed only once a week in winter 20 per cent of our population developed gonads. The worms that divided architomically grew to a much greater size than the sexual ones, that were never obtained at the natural finding place. Some of the sexual worms developed partly multiplied reproductive organs. CHILD considered supernumerary copulatory organs as a morphological proof of the existence of zooids in *Dugesia dorotocephala*. However in our material also ovaries with tubae and ovo-vitelloducts localized in the anterior region of the sexually mature worm are multiplied. Thus the presumed zooids develop prepharyngeal organs characteristic of the anterior end previous to separation, and their morphogenetic powers are not only those of the post-pharyngeal region. Neither in the multiplied copulatory apparatus nor in the gonads can any traces of gradual diversity in histological differentiation be detected, and therefore the sequence of developmental stages characteristic of paratomically dividing chain is wanting. Another argument against CHILD's opinion is that sexual reproduction generally suppresses fission in Triclads, and if it does not, one should expect more brains and pharynges and not only copulatory apparatus and gonads.

Rhodax evelinae continues to divide during the development of the reproductive organs, that were only obtained in the laboratory and in the cold months, as in the preceding species. The type of division is intermediate between architomy and paratomy. We call it precocious paratomy, as the formative cells accumulate in the fission zone before the individualization of the zooids, and a separating constriction is developed about two days before division happens.

The paratomic Oligochaeta *Aeolosoma, Dero*, and at least some species of *Aulophorus*, continue to divide, while they develop gonads to about middle size. In architomical *Nais paraguayensis* however fission ceases immediately when the sexual phase begins. Thus the microdrilous Oligochaeta show paratomy and architomy related with sexual reproduction in the same manner as the Tricladida Paludicola. On the other hand, *Catenula lemnae* generally does not divide any more, when the gonads begin to develop, although its type of division is pure paratomy. Of the true paratomic Paludicola *Planaria fissipara* we received a rich preserved material by courtesy of Dr. Harald Sioli - Belém from the river Amazon. Gonads were not present though the worms had been collected in various months: March to August, November and December. As in the likewise paratomical Catenulida the primordial of the brain precedes that of the pharynx in the zooids of *Planaria fissipara*.

The details of paratomy are different in *Catenula* and *Stenostomum*. The zooids of the former individualize their guts early, because the communication between the intestine of the preceding and that of the following zooid is soon interrupted. All zooids of a chain of *Catenula* with a pervious pharynx feed, and every zooid furnishes the necessary energies for the primordial of its daughter zooid. The typical mode of fission, repeated bi-

partition, occurs with so few irregularities, that probably also absorbed subs-
tances pass along the parenchyma from one zooid to the next, thus com-
pensating differences in the obtaining of food. Chains of up to 20 zooids
were seen. The same repeated bipartition occurs in the asexually reproduc-
ing Macrostomida (*Microstomum, Alaurina*), but these have a continous in-
testine through the whole chain.

In every member of a chain of *Stenostomum* a new series of zooids is
initiated; rhythmic bipartition is exceptional. Such a multiserial division also
occurs in *Aeolosoma* and paratomical Naididae. Our longest observed chain
of *Stenostomum* had 17 zooids. These are all nourished by the food that the
foremost pharynx of the chain, belonging to the oldest zooid, ingests. The
communication between all guts is maintained as long as the chain con-
tinues united.

The intestine of the new *Catenula*-zooid buds from the preceding
(SEKERA) as in *Stenostomum*, not independently ("BRONN"). The pri-
mordial of the brain of *Catenula* that is undivided in the adult stage, begins
with two separate masses of formative cells, thus resembling the embryonic
primordial of the brain in Mesostominae and *Plagiostomum* (BRESSLAU).
The new pharynx with its muscles is also produced by formative cells, but
the glands that surround the anterior border of the pharynx in some species
of *Stenostomum*. These are depressed after their cells are histologically dif-
ferentiated, thus histogenesis precedes morphogenesis. The excretory tube
is lengthened by mitoses of its own cells. In the prostomium of the pos-
terior zooid the ascending and descending canal join, and in the tail of the
anterior zooid the descending canal opens with a pore through the dorsal
epidermis. This individualization of the protonephridium happens in
Catenula, while the chain is still coherent, so that successions of 16 zooids
with eight excretory pores were noted.

In *Stenostomum* the emunctory individualizes during or immediately
after the separation of the zooids. In the last genus the integument grows
constantly, but the alimentary tract does not accompany this growth in the
regions of future division zones. As the body-wall lengthens, these sections
of the gut as distended and narrowed passively, and the gut is torn in two,
when the zooids separate. Later on the prostomial gut is absorbed into the
post-pharyngeal part. The epidermal furrow, that marks the plane of fission
in *Stenostomum*, is due to a local and endogenous loss of muscular tonus.
The septum in the fission zone of *Microstomum* is formed by the epidermic
basement membrane. Violent contractions of the cutaneous muscles in
Stenostomum can produce premature separation. Such are provoked f. ex.
by the prick of a *Prorhynchus stagnalis* that introduces the poisonous
granular secretion with its penial sting. Under natural conditions physiolo-
gical individualization precedes the morphological separation, as is shown
by independent movements of the hinder zooid, often contrary to those of
the anterior one. After fission the distended tail of the latter contracts to
normal length and recovers its normal tonus.

After CHILD the tubular chains of *Stenostomum* are good examples
for the dominance, that the most developed head exercises over the subor-
dinate zooid. Dominance decreases from the head towards the tail in a
linear animal (normal gradient). The farther the first daughter zooid is

removed from the oldest head by growth and develops its own, it becomes more physiologically isolated and finally separates morphologically. When a chain is cut in two on whatever level, the oldest head of every fragment dominates the younger ones. Zooids lying in front of it are absorbed (inversion of the gradient). The hinder zooids behave as in the normal chain and remain subordinate to the new field of dominance till the second in age of the fragment attains physiological isolation.

Our results obtained in reconstitution of hundred cut fragments of various species of *Stenostomum* can be disposed in three groups:

(1) Head dominance with inversion of the gradient occurred in 65 per cent. The zooid with the most developed brain absorbed the younger (subordinate) zooids and the headless portion. In 35 per cent of these cases a head had begun to regenerate at the anterior end of the fragment.

(2) In ten cases the section stimulated premature division in the fragment. Thus younger parts became isolated before they could be absorbed under the influence of the new centre of dominance in the fragment. In seven fragments there was no trace of absorption; in three the anterior zooid was slightly reduced before fission.

(3) In the remaining 25 per cent reconstitution delayed the development of posterior more advanced zooids without any signs of dominance. In all these cases the cut had passed through a zooid, so that the fragments began with a headless trunk. Thirteen times the headless part was absorbed and the foremost youngest zooid was completed. Twelve times the anterior end reconstitued a head. In both groups fission was retarded, and the development of the more advanced zooids was suspended. This proves the presence of a reconstitution-field opposed to the action of the field of dominance.

In opposition to the high regenerative power of the Catenulids the Prorhynchidae *Prorhynchus stagnalis* and *Geocentrophora applanata* lack this quality. They do not reconstitute any lost organs. If up to three eighths of their volume is cut off from the sides or the hind end, the Prorhynchidae survive the loss, but asymetries caused by the injury are permanent. If the oral or pharyngeal region is damaged, the worms die in the course of a few days, during which their body-size diminishes.

Both species are euryhygrous and do not need liquid water. It is true that *Prorhynchus stagnalis* wants at least wet, decayed leaves near water for its life, but *Geocentrophora applanata* is able to remain alive in dried Bromeliaceae with only small rests of moisture. When it rains, the worms leave their mucous cysts. The species also occurs in current, permanent water. Mucous cysts are rapidly secerned by many Catenulids. Those of *Stenostomum tenuicauda* evidently resist to some degree of drying up of the medium. Probably also the worms of *Bothromesostoma evelinae* and *Bothrioplana semperi*, that appear in temporary plashes and ditches in spring, survive the dry times in the subsurface mud. *Dugesia hypoglauca* is a stenothermic cold-water form, that did not thrive during the warm months in our dishes. *Plagiostomum evelinae* however, that lives together with the preceding species, proved to be eurythermic, as it was also found in sunny, shallow ponds and backwaters.

The marine Dalyellioid *Vejdovskya suslica* is an eurythermic and euryhalinous worm that was gathered in tide pools exposed to sun and rain

the corresponding changes of temperature and salinity during low tide. All species of its family (Provorticidae) with an unpaired female gonad live in brackish or fresh water. This statement must not be inverted, because the mentioned biotopes are also inhabited by species with paired gonads. Reductions of the reproductitve organs in fresh water are frequent (HESSE), but they are evidently in various animals brought about by different reasons. Brackish water constitutes a peculiar biotope. From its selective factors, that are similar everywhere, result faunistic similarities in regions far apart from one another. All valid species of *Promonotus* live in brackish water, and so *P. villacae* is related to Sarmatic, also brackish, elements, and *Monocelis scalopura* to the Adriatic mesohalinous *M. cirrifera*. Euryhalinous forms that live in sea-water, brackish water, and pure, or nearly pure, fresh water, are *Macrostomum evelinae*, *Mesoda gabriellae*, and the cosmopolitan *Gyratrix hermaphroditus*, the emunctories of which are known to be largest in fresh water. Especially the Proseriate *Mesoda gabriellae* must be mentioned, as it was found as well under the fin of a dogfish near the high-water line on a sunny day in very salty sand, as in a brooklet, at that time separated from the sea, together with tadpoles and killifishes.

Macrostomum evelinae is a sand-dweller without eyes, but it is true that of this genus also some inhabitants of algae are eyeless. *Itaipusa divae* (Kalyptorhnchia) belongs to the species that live in sand as well as among algae. In the latter biotope, especially under the cushions of calcareous algae (*Jania rubens* L.) that are rather loosely attached to the rock, many Polyclads hide during the day. If such algae are collected and placed in the dark, the worms creep out. The cushions of algae lodge Polyclads of very different configuration. Therefore it is difficult to consider the caudal position of the pharynx with the mouth at its posterior end (BOCK), as it occurs in the three sections of the Acotylea: Craspedommata (*Latocestus*), Schematommata, (*Pucelis*ᴏ, and Emprostommata (*Cestoplana*), as a consequence of similar life-habits. The three mentioned genera are found together with Prosthiostomidae (pharynx in front) and Leptoplanidae (pharynx in the middle). Sand Polyclads of our fauna are *Prosthiostomum gabriellae* with a very reduced number of eyes, and *Theama evelinae*, that we at first confounded with Otoplanids because of its shape.

As a possibly not definitive conclusion we mention the absence of a Lang's vesicle in the three Atlantic species of *Euplana*, while it occurs in the seven Indo-pacific species. Moreover the female duct, that ascends from the ventral pore, slants forward only in the Atlantic species, so that perhaps a geographically distinct group becomes evident.

One of the widely distributed Acoela is *Convoluta henseni*, a planctonic form that contains green algae, and at some times gives a greenish hue to the sea in the canal of São Sebastião. The species was previously found in the tropical Atlantic North of the Equator, and a very closely related species from the Adriatic is know. Also among the littoral Acoela several of our species are morphologically near such that live in similar biotopes on the Scandinavian coast, contrary to what succeeds with the sand-dwellers among the Kalyptorhynchia and Proseriata, in which the differences are very pronunced. On the whole the now known Acoela from the coast of São Paulo are less distant from the European fauna than the marine

"coelate" Turbellaria". This is so much more remarkable as our Acoela must be compared with those of the Scandinavian coast, the only well known fauna (WESTBLAD). Our "Coelata", especially the Polyclads, can be confronted with those from the Mediterranean. Notwithstanding the Acoela of São Paulo differ less from the North Atlantic ones than our Polyclads from those found at Naples (LANG).

The fresh water Turbellarian fauna of the vicinity of São Paulo differs less from the European than from the marine "coelate" Orders. It is true that limnic species identical in Europe and the known region of Brazil are not numerous, but different genera are still more rare. Our present first glance of the subject, although without a complete statistic base, already shows that our fresh water Turbellarian fauna is as little poor as that of the sea. The contrary statement regarding the tropical fauna of aquatic Turbellaria in BRESSLAU's monograph is only due to the difficulty of collecting Turbellaria and preserving them satisfactorily.

Of our hitherto four endemic genera of limnic Turbellaria, *Dasyhormus*, *Chordarium*, *Bopsula*, and *Rhodax*, the two first belong to the Catenulida very rich in species in our region. The Order is certainly old and perhaps developed especially in the lower latitudes among the never frozen moist leaves in the soil of the forests. Cases of wide distribution are frequent in species of Catenulids, f.ex., *Catenula lemnae* was found in South and North America, Europe, Siberia, and Japan; *Suomina turgida* in São Paulo, Finland, Poland, Germany and Austria; *Stenostomum tauricum* in São Paulo, the North American states of Virginia and Georgia, and the Crimea; *Rhynchoscolex simplex* in São Paulo, North America, Central and Eastern Europe. A great number of species in a group, the principal reproduction of which is asexual and therewith disfavorable for specification, combined with various cases of vast distribution although the means for passive transport are only mediocre, can be understood as a sign of high geological age. The scarce material offered to selection in these mostly dividing Turbellaria is largely counterbalanced by their generally euryoecous behaviour. The Aeolosomatidae show the same phenomenon. Fresh-water species with thick-shelled eggs are more appropriate for being transported than most Catenulida. These eggs may be spread embedded in particles of mud sticking to the feet or beak of water birds, or even by the wind. Our *Microdalyellia ornata*, *Mesostoma ehrenbergii*, and *Bothrioplana semperi* belong to this group. The list of foreign localities for *Macrostomum gigas* contains also aquaria, so that the commerce of aquarian fishes accompanied by plants of their habitats must be considered as a way for passive distribution of fresh-water Turbellaria. The geographic range of *Dugesia tigrina* extends from Canada to Southern Brazil. But as long as we have no records from the region between Florida and São Paulo, it is impossible to comment the distribution of this very euryoecous and resistant species. After 1919 it has been imported to Germany unintentionally with *Cabomba*, and already 20 years later free living, dividing worms were found at many localities, even in France. Some slight histological variations of the epithelia that line the penis and bursa can be verified in the various North American and Brazilian lots, so that one character of the worms from São Paulo suits to the material from Massachusetts, Michigan, and Illinois and differs from that of Porto Alegre, while another character of the worms from Porto Alegre agrees

better with the North American ones than with the lot from São Paulo. These facts support Miss HYMAN's opinion that *D. tigrina* is in process of evolution into several species.

The Prorhynchidae *Geocentrophora applanata* from South, Central and North America, and *Prorhynchus stagnalis* that is nearly cosmopolitan and was once also found in brackish water (Falmouth, Mass.) do not have very hard eggs, and their large distribution can hardly be attributed to passive transport, at least not that of *Prorhynchus stagnalis*. Perhaps this species, that has many traces of presumably ancestral character, has penetrated from the sea into continental waters, like the still marine *Gyratrix hermaphroditus*, the Turbellarian with the vastest distribution.

Such euryoecous species as *Macrostomum gigas, Prorhynchus stagnalis*, and *Geocentrophora applanata* can be easily bred in the aquarium. Also endemic species like *Microdalyellia evelinae* thrive in the laboratory, while others, even though euryoecous in nature, do not, f. ex., *Macrostomum delphax*.

If *Convoluta henseni* are kept in a dish for about six hours, their algae begin to wander to the surface of the animals. After some days worms with algae forming compact balls in the endocytium are rare; in most the algae lie under the cutaneous muscles, often gathered around small glands. The same position of the algae occurs, although not often, in free living worms, among which also colourless specimens were found. The granular bright yellow ad refractive contents of these glands seem to be excretory. Possibly the scarcity of food for the worms in the dish and the consequent want of digestive waste in the parenchyma cause the algae to accumulate near the excretory glands. In the Provorticid *Vejdovskya suslica* the algae, that occur also in other parts of its body, are heaped in several volumous depressed glands ventro-laterally to the pharynx. Another of our marine Turbellaria with algae of the type generally called Zooxanthellae is *Amphiscolops sargassi*. The symbionts lie chiefly embedded in the outer parenchyma (ectocytium) of the back and are fastened by cells of the host.

Examples of Brazilian fresh-water Turbellaria with green algae are *Baicalellia evelinae, Microdalyellia thymara, M. acariaia, Phaenocora evelinae*, and *Ph. chloroxantha*. In the former three species the algae lie in the cells of the gut, in the two latter in the parenchyma. One of the localities in which *Phaenocora* was found, a temporary, humic swamp-water, was extremely rich in animals with zoochlorellae, viz. Flagellates, shelled Lobosa, species of *Stentor* and other Ciliates, many *Hydra*, wheel-animalcules, leeches, and Ancylidae.

The parasitic *Euglena leucops* Hall was found in seven species of *Stenostomum, Microdalyellia acariaia, M. tridesma*, and *Mesostoma ehrenbergii*. The worms of *Stenostomum* may be killed by a heavy infection, or their caudal region (*St. arevaloi*) becomes mutilated, so that classification of such infected specimens is difficult. An astomatous Ciliate, *Dogielella minuta* Poljanskij, was abundant in the body cavity of a *Stenostomum grande* without causing a visible effect. Eaten nematocysts, that are known to reach the integument of Microstomidae, Proseriata, and Polyclads actively and passively, also occur in our *Microstomum breviceps* and *M. ulum*. In the latter they lie exclusively in certain rare cells which produce atypical, perhaps adhesive, rhabdites. The nematocysts contained in vacuoles of the intestinal

cells of *Plagiostomum sagax* and *Puzostoma evelinae* of the same family, do not migrate to the skin, they are digested or evacuated.

The egg capsules of *Dalyellia* (s.str.) accumulate in the parenchyma, those of *Microdalyellia* are formed, one at a time, in the uterus. Once we noted a specimen of *M. sawayai* with one cocoon in the uterus and another in the parenchyma. Although probably exceptional, the case represents a transition between the two types of egg-laying. A specimen of *Baicalellia evelinae* had both ovaries cleft longitudinally. Therefore two full-grown ovocytes came simultaneously in contact with the vitellaries on each side, and all the cocoons of this worm contained four embryos. Other examples of duplications in our material are offered by *Monocelis tabira* and *Prosthiostomum gilvum*. In the first species one specimen had two vaginal pores, one beside the other, as normally *M. balanocephala* has. The inner part of the short vagina was unpaired. The mentioned Cotylean had two suckers, one behind the other.

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