THE OPISTHOBRANCH PSEUDOVERMIS FROM BRAZIL

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(with 5 plates)

When we during our stay at the island of São Sebastião in march 1952, together with Professor Dr. ADOLF REMANE-Kiel, found the first two specimens of sand-dwelling Acochlidiacea, this outstanding zoologist foresaid that we ought to find *Pseudovermis* at the same biotope. He drew a sketch of the characteristic features that was very useful for us later on. Professor Remane had seen this strange slug for the first time in the spring of 1926 at the zoological station of Naples, where his attention was called to the odd creature by his and our ever remembered Teacher KARL HEIDER. Later Professor Remane had found a *Pseudovermis*-spec. near Heligoland at 6-8 m. depth (Jaeckel 1952, p. 253).

Remane's prophecy proved to be certain. The next time my husband and I came to the island of São Sebastião, in november 1952, we found three *Pseudovermis* in coarse sand of the lower tidal zone, sheltered behind a boulder. They belong to a new species that I call *Pseudovermis salamandrops* because of its aspect (Fig. 1).

In 1891 Sophia Pereyaslawzewa, known by her monograph of the Turbellaria of the Black Sea, published a note in russian on a marine slug, *Pseudovermis paradoxus*, found at Sevastopol. As the Travaux de la Société des Naturalistes à l'Université Impériale de Kharkow (v. 25, p. 267 ; quoted from S. A. Neave 1940, Nomenclator Zoologicus v. 3, p. 1010) are little spread, *Pseudovermis* became really known only ten years later through Kowalevsky's monograph (1901). To Professor REMANE and his staff, Zoological Institute of the University of Kiel, I owe a beautiful copy of this indispensable work. Kowalevsky described *Pseudovermis paradoxus* from the original locality thoroughly. He added (p. 19) *P. papillifer*, under the name *papillifera*, not *papillosa* as the Zoological Record indicates, and a not named species (p. 22) from Mytilene in the Aegean Sea. All these species live in sand, that from Sevastopol in coarse sand in 10-16 m. depth (Graff 1904, p. 191).

While in *P. paradoxus* and the not denominated form from Mytilene the cerata are small, button-like and retractile, those of *P. papillifer* and the new brazilian species are long, finger-shaped and can not be retracted. The european species, of which Remane drew a sketch from memory, possesses small, button-like papillæ. Besides the differences mentioned in the following description of *P. salamandrops* some more striking features allow a rapid separation of the species of *Pseudovermis*:

1 Papillæ small, button-like, retractile 2

— Papillæ long, finger-like, not retractile 3

2 Seven to eight pairs of papillæ ; inner border of mandible as in Fig. 12 and 13 (Plate 2) .... *paradoxus* Pereyas.

— Thirteen pairs of papillæ ; inner border of mandible as in Fig. 15 (Plate 2).... .... not named species from Mytilene.

3 Central plate of radula with 5 denticles on each side of the median tooth ; anterior border of mandible smooth (Kowalevsky 1901, f. 55) ; inner border as in Fig. 14 (Plate 2). Eyes present ; cephalic cilia interrupted dorsally and laterally .... *papillifer* Kowal.

— Central plate of radula with 4 denticles on each side of the median tooth ; anterior border of mandible dentate ; inner border as in Fig. 11 (Plate 2). No eyes ; cephalic cilia developed around the entire head.... *salamandrops*, sp. n.

As Kowalevsky (1901, p. 1) informs, already Sophia Pereyaslawzewa understood the systematic position of *Pseudovermis* correctly, and he himself called (p. 18) *P. paradoxus* a reduced Aeolid, developed in a special direction. He frequently compares *Pseudovermis* with *Tergipes*. Also in Thiele's synopsis (1931, p. 453-454) the families Pseudovermidæ Pelseneer (1906, p. 179) and Tergipedidæ are treated one after the other. The diagnosis of the family Pseudovermidæ that coincides with that of the genus *Pseudovermis* Pereyaslawzewa 1891 can be given in the terms of Thiele (l. c.) with some modifications :

Animals small, less than 10 mm., slender, without tentacles and rhinophores. Head little separated from the body, foot weakly developed, but characterized by ciliated sole and two rows of pedal glands. On each side of the body a series of retractile cnidosacs or short cerata, that are united with either the stomach or the liver. Buccal cavity with a pair of mandibles, the anterior border of which is dentate in most species, and the interior border of which is thickened. Radular formula 1-1-1×33-36; central plate concave in front, posteriorly with a bigger median tooth and 4-5 lateral long denticles on each side ; lateral plates narrow, pointed. Statocyst with one statolith. Salivary glands are developed. A long, tubular liver extends from the stomach to the hind end and does not enter the cerata. Kidney sac-shaped, lying above the rectum. Anus on the right side behind the genital apertures ; ovotestis beneath the liver.

Pseudovermis salamandrops, spec. nov. (Fig. 1-11, 16-23)

The living specimens attain 6 mm. length when they are creeping (Fig. 1), preserved they contracted to 2-3 mm. (Fig. 2). In life they are more or less transparent white with a yellow liver stippled with black. In sections these stipples appear as yellow, refractive, intracellular granules (Fig.

22, re). There are no eyes. The anterior end is a little broadened, then the body narrows and increases towards the middle, tapering to the tail. The biggest diameter of the living animal is 0,5 mm.; the dorso-lateral cerata are 0,2 mm. long in the sections. The distribution of these tegumentary papillæ in the present three preserved specimens is shown in Fig. 2. In the drawing made from the living animals (Fig. 1) there are 6 papillæ on the left and 5 on the right side. The cerata of both sides except the first pair are disposed on different transverse levels.

The foot is not set off, it is recognizable by a band of cilia (so) and two rows of glands (x). On the head the epidermis is 17 micra high and ciliated (Fig. 4, 17, ci). Farther backwards it measures 7-8 micra, on the creeping sole 8 micra with 4 micra long cilia. The breadth of the sole is 0,15 mm. in sections, that is about one fifth of the circumference. The cyanophil glands (x), that flank the sole as in Kowalevsky's fig. 8, are small though composed of several cells. In the anterior region (Fig. 4) there are blue glands scattered on all sides, especially numerous around the outer mouth opening (mo). Also at the hind tip the foot glands increase and form a kind of adhesive pad. In the rest of the body there are scarce blue epidermal glands, only near the genital apertures (g) on the middle of the right side they are heaped.

In *P. paradoxus* Per. Kowalevsky describes (p. 4) the foot glands and cilia as beginning behind the outer mouth opening. The ciliated area of the head of *P. papillifer* (Kowalevsky f. 53) is interrupted on the back and sides, so that there are two latero-dorsal patches that resemble flattened tentacles (ibid., p. 20, 28). Single tufts of epidermal cilia occur in various parts of the body (Fig. 23, ic) of *Pseudovermis salamandrops*.

The dorso-lateral conical papillæ contain only cnidosacs (Fig. 18, cn) with nematocysts. They communicate with the exterior by a terminal pore and with the underlying liver (r) by narrow canals (ca) with very small and flat cells. The first pair of cerata (Fig. 18) is united with the stomach (t), not with the liver, as they are situated on the level of the former (Fig. 3). In *Pseudovermis paradoxus* Per. only the first left ceras is in connection with the stomach (Kowalevsky p. 12), while to the right a long canal comes from the liver (ibid., f. 38-40). The liver tube has a smooth surface and does not enter the cerata with cæca.

The nematocysts are arranged in groups in the epithelium of the cnidosac (cn) very similar to the aspect of the batteries on the hydrozoan tentacles. The nematocysts of the present slugs belong to two different types, larger ones that are nearly as broad (5 micra) as high (7 micra) and small slender ones 5 micra long and 2 micra in diameter. In two of my specimens there are several exploded nematocysts on the tip of the papillæ. "Les poils raides" that Kowavesky described (p. 12, 13) and figured (f. 48, 49) from the tip of the cnidosac-button of *Pseudovermis paradoxus* Per. were not seen in the present species.

Hoffmann (1926, p. 50), evidently under the impression of Henneguy's deliberations (1925, p. 426), still considers it probable that the epithelium of the cnidosacs or cnidocystic sacs is able to produce nematocysts. But I agree that "it may be taken as proved that all æolid nematocysts are derived from their coelenterate food" (Graham 1938, p. 296).

There are not many Cnidaria in the sand (Remane 1951, p. 331). At first I thought it possible that *Pseudovermis salamandrops* feeds on the Ceriantharian, probably *Ceriantheomorphe brasiliensis* Carlgren 1931, a big specimen of which lived on the finding place. It served as mark for the place where we took our samples with other sand-Opisthobranchia (Marcus 1953), so that we know this sand anemone was available for *Pseudovermis*. But the cnidocysts of that Ceriantharian are much bigger, 18,3-70 micra (Carlgren 1952, p. 170), than those in the cnidosacs of *P. salamandrops*. The Trachymedusa *Olindias sambaquiensis* Fr. Müller (see Vannucci 1951, p. 72) that is frequent on the beach of the island of São Sebastião, and the torn tentacles of which sometimes abound in the tidal zone, has about 40 micra long nematocysts on its tentacles (Fritz Müller 1861 in A. Möller 1915, p. 133), so that it neither can have served as food-source for *P. salamandrops*. However shape and measurements of the nematocysts of *Psammohydra nanna* E. Schulz 1950, not those of *Halammohydra* Remane 1927, agree completely with those in the cnidosacs of *Pseudovermis salamandrops*. We did not yet, it is true, see *Psammohydra* in the sand of the littoral of the island of São Sebastião, but this may be due to our collecting method, as we chiefly applied the inclined dish (Corrêa 1949, p. 5 t. 1 f. 3). Of course I do by no means want to pretend that the nematocysts in *Pseudovermis salamandrops* must come from *Psammohydra*, there are many other Hydrozoa with cnidocysts of the same size, but the biotope suggests this possibility.

The dermal annular and longitudinal muscles form thin layers. The peritoneum consists of rather numerous cells. There are small vacuolized ones with eosinophilous contents and others of phagocytic character. The latter are most frequent in the hind end. Similar free phagocytes of Doridomorph and Æolidomorph Nudibranchs have been described by Cuénot (1914, p. 286), Agersborg (1923, p. 554), Millott (1937, p. 191), Fretter (1939, p. 608 f. 5, am) and others. They occur in the body cavity, the blood, and the liver. Besides these amœboid cells, though not seen in the present species, exist the resembling special connective tissue cells (Hecht 1895, p. 661-662 t. 3 f. 19, x; Henneguy 1925, p. 422-425) that are not loose (Evans 1922, p. 446 t. 11 f. 6).

The central nervous system (Fig. 4, 16) is highly concentrated like in the other Nudibranchia that are all notoneural (Lacaze-Duthiers 1898, p. 364). It lies behind the buccal bulb and is similar to the type that occurs in Tritonoidea (Hanström 1928, f. 169), Doridoidea (Pelseneer 1906, f. 159; Hanström 1929, f. 3), and Æolidoidea (MacFarland 1909, t. 19). The coalescence of the cerebro-pleural complex (ce) of each side is complete, and also the pedal ganglia (d) belong to the dorsal half of the body. The pedal commissure runs horizontally under the œsophagus (e) behind the buccal bulb (b), and the statocyst (o) is apposed to the cerebro-pedal connective. Like in the former subfamily Tergipedinæ Bergh (1890, p. 32) there is only one statolith in the statocyst. The buccal, bulbo-œsophageal (Guiart 1901, p. 90), or stomato-gastric ganglia (bu) lie between the buccal bulb and the œsophagus. Several branched nerves (Fig. 4, ne) provided with a scarce revestment of nerve-cells go out from the anterior border of the cerebro-pleural mass. Some sensory subepithelial cells are developed in the fore end, but neither the foliaceous groups of *P. paradoxus* Per. (Kowalevsky, p. 16 f. 4), nor retina cells (ibid., p. 17).

The outer mouth (mo) lies on the ventral side behind the tip of the head (Fig. 4) surrounded by numerous cyanophil glands. The buccal cavity is expanded by a folded cuticular ring (di), 21 micra in diameter. This ring is mug-shaped, and its concavity is directed backwards (Fig. 6). This structure, the "Lippenscheibe" of Bergh (1890, p. 17), corresponds to the inner lips in *Eolidina alderi* (Graham 1938, p. 270 f. 1).

The buccal bulb (b) is 0,26 mm. long and 0,12 mm. in diameter. It is supported by two lateral mandibles, the anterior borders of which bear a row of about 10 sharp teeth each (Fig. 7). The inner borders of the jaws are bent upwards and thickened. Their transverse section is characteristic for the species (Fig. 11). Their hind buts serve for the insertion of muscles. I cannot see their likeness with Kowalevsky's "soie des Annélides" (p. 5), as they are stiffenings of the mandibular blade (Fig. 5, j). The muscle fibres of the buccal bulb are principally longitudinal and of very different diameter (Fig. 17).

The radula has 33-34 series of three plates each (Fig. 8); about 10-11 series belong to the lower limb. The broad central plate is 16 micra broad and 12 micra high, concave on the anterior border and provided with a strong median (mt) tooth and four lateral teeth on either side. These increase in size from the innermost to the border. The slender lateral plates (la) are pointed triangles.

The salivary glands (es) are very little balls in the smallest of the present specimens; in the others they are also distinctly paired but more tubular. They open into the œsophagus, not as Kowalevsky indicated (p. 9), into the pharynx. The œsophagus (e) is a short tube that winds S-shaped from the end of the buccal bulb through the nerve collar to its dorsal entrance into the stomach (t). The latter is a wide sac with ciliated walls that contains rests of the cœlenterate food. Dorso-caudally the intestine (i) goes out from the stomach; ventro-caudally the liver (r) opens into it.

This intestinal gland differs from the states in which Kowalevsky (p. 10) found it in *Pseudovermis paradoxus* Per. In the specimens of the latter observed in winter (ibid., f. 34) the liver occupies nearly the entire body cavity, while in summer (f. 36) the intestinal gland is smaller, and more than half of the body cavity is occupied by the gonad and its accessory glands. In the first case the liver cells are stuffed with fine granulations, in the last the cells and their nuclei are clearly visible.

In *Pseudovermis salamandrops* however the intestinal gland is in an intermediate state (Fig. 22, 23), the cells are high and contain various vacuoles, but leave a more or less ample central lumen free, in which there is coagulated juice and now and then a nematocyst. The contents of some little liver cells (re) situated basally between the cylindrical digestive cells are yellowish refringent corpuscules that appear as black stipples in the living animal. After Henneguy (1925, p. 417, 455) such inclusions are frequent in the Æolidomorpha; he also found them in *Elysia*, probably *E. viridis* Mont.

The intestine (i) after leaving the stomach runs as a thin tube in the dorsal mid-line. On the level of the genital openings (g) it turns to the right side and forms a curve. The anal opening (ar) lies immediately beside the renal pore (ni) and dorso-laterally to the genital apertures, 0,13 mm. from the latter.

The kidney (k) is a spacious sac on the right side between the intestine (i) and the anus (ar). It opens with a short duct immediately beside and over the latter (Fig. 23). A little in front of the renal pore a ciliated reno-pericardial communication (sc) leaves the kidney and runs to the ventral side (Fig. 22). This canal is smooth as in *Fiona nobilis* Ald. & Hanc. (Henneguy 1925, f. 24 on p. 450) and not folded as in many other Æolidomorpha.

In *Pseudovermis paradoxus* Per. the reno-pericardial duct is directed towards the dorsal mid-line, where some parenchymatic elements dorsally to the liver were interpreted as a heart (Kowalevsky 1901, p. 13-14 f. 34-35).

In *Pseudovermis salamandrops* however the pericardial sac (c) extends in ventral direction, and its cavity widens ventrally and in front of the genital apertures (g). It is the only trace of the circulatory system in the present species. Muscle fibres surround the pericardial sac, the endothelium of which is not ciliated (Fig. 19). The basement membrane of the lower wall of the sac is strongly cuticularized and assumes a peculiar form that resembles a mug (Fig. 20). In both sectioned specimens this structure is alike. The cuticular mug is 40-50 micra in diameter. The mug-shaped organ bears high epithelial cells that after origin and localization might be called a pericardial gland (y).

After Strohl (1924, p. 462) there are not many structures known in Nudibranchs that deserve the term pericardial gland. What Hecht (1895) p. 655-656) treated as pericardial gland of *Æolis papillosa* (L.) is as little excretory in character as the perhaps homologous structure of *Pseudovermis salamandrops*. The heart-body of certain Polychætes, as described by Picton (1898), offers an acceptable comparison. It is likewise connected with the wall (p. 271) and consists of an endothelium (p. 272), and inside there are chitinous bodies (p. 278). Picton assumes that it has a valvular function (p. 271).

The gonad (Fig. 21, z) lies ventrally to the liver in the posterior part of the body. In the young specimen (Fig. 3) it is a simple tube, in the older ones there are three follicles, two of which form only ovocytes, while the third is purely male in one animal and contains young female cells between the masculine ones in the other. Protandry that is frequent in Æolidomorphs does not seem to occur in *Pseudovermis salamandrops*. The hermaphrodite duct (h) begins with an ampulla (u) as it was termed by Bergh (1890, p. 23), and continues narrow and ciliated. From the ciliated course a duct goes to the female accessory glands, that are besides connected with one another. Connections between albumen gland and nidamental gland independent of the oviduct are already known from Doridomorph (Pohl 1905, p. 441) and Æolidomorph (Evans 1922, p. 448-452) Nudibranchia. As f. ex. in *Polycera quadrilineata* (Müll.) also in *Pseudovermis salamandrops* the albumen gland (a) and the mucous (nidamentary) gland (m) are not appendages of the oviduct (v), but parts of the latter (Pohl 1905, p. 446).

From the mucous gland the oviduct runs to the right side in front of the anal (ar) and renal (ni) pore and opens to the exterior immediately below the male aperture.

The following description of the male apparatus is based on the biggest of the three animals, the only one that is completely mature. The middle-sized slug that contains masses of ripe sperm and yolk-laden ovocytes shows only a distal swelling full of sperm in the spermiduct in front of the genital apertures. Prostate and eosinophilous granular secretion are not developed, as little as a cuticular penis and the antral glands.

A short distance ectally (distally) to the exit of the female duct from the hermaphrodite duct there is a quite distinct communication (f) from the male duct to the kidney (k). From this point outwards the male duct (se) is glandular and filled with red granules, many of which are seen spreading into the renal cavity (Fig. 23). This connection between the spermiduct and the kidney appeared quite extraordinary to me, therefore I have examined it with special attention.

The narrow and glandular spermiduct runs forward for a long way (0,45 mm.) on the right side of the body. It turns backwards with a sudden bend 0,3 mm. in front of the genital apertures (g). The following part is a 0,24 mm. long wide prostata (pr), a muscular sac storing eosinophilous granules. It ends with a tubular, winding, cuticular penis (p). Such is also known from the genus *Capellinia* Trinchese.

The penial tube is 40 micra long and projects into a wide penis-sheath (s), the walls of which are beset with numerous cyanophilous and eosinophilous gland cells (an). The sheath is separated by a fold from the more tubular male antrum (n) that has a strong basilar membrane. The antrum opens by the male aperture that lies dorsally to the female opening in the same transverse plane.

Resumo

O gênero *Pseudovermis* Pereyaslawzewa 1891, que se tornou conhecido pela monografia de Kowalevsky (1901), representa a família Pseudovermidæ Pelseneer 1906, evidentemente relacionada com as Tergipedidæ (Opisthobranchia, Nudibranchia, Æolidiacea). Além de *Pseudovermis paradoxus* Pereyaslawzewa, do Mar Negro, com curtos cnidosacos retracteis, e *P. papilifer* Kowal., do Mar Egeu, com cerata digitiformes, ainda figuram duas espécies não denominadas na literatura, uma do Mar Egeu, com cnidosacos curtos (Kowalevsky 1901), e outra do Mar do Norte (Jaeckel 1952). Segundo informação verbal do Professor Dr. A. REMANE-Kiel, *Pseudovermis* ocorre também no Golfo de Nápoles. Três indivíduos de uma nova espécie dêste gênero, *Pseudovermis salamandrops*, sp. n., foram encontrados na areia grossa do litoral da ilha de São Sebastião, na zona inferior das marés. Os animais esbeltos (Fig. 1-3) são de 3-6 mm., ao comprido.

Ausência de olhos, bordo anterior da mandíbula com dentes (Fig. 7), bordo interno da mesma com forma específica (Fig. 11), sòmente 4 dentículos de cada lado do dente médio da placa central da rádula (Fig. 8), menor número de papilas laterais, e cílios ao redor da cabeça inteira (Fig. 4) distinguem *P. salamandrops* de *P. papillifer*. *P. paradoxus* é mais distante da nova espécie.

A glândula do intestino médio não entra nas papilas (Fig. 3). As cápsulas urticantes nos cnidosacos correspondem às de *Psammohydra nanna*

E. Schulz 1950, hidrozoo, é verdade, ainda não verificado no litoral brasileiro. Os dutos do ovotestis da nova espécie são diáulicos, com aproximação dos orifícios masculino e feminino (Fig. 22, g), como em geral nos Æolidomorpha. O órgão copulador masculino é armado (Fig. 21, p).

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Explanation of lettering

a — albumen gland
an — glands of penis sheath and antrum
ar — anus
b — buccal bulb
bu — buccal ganglia
c — pericardial cavity
ca — canal of cnidosac
ce — cerebro-pleural ganglia
ci — ciliated area
cn — cnidosac
d — pedal ganglia
di — buccal disc
e — oesophagus
es — salivary gland
f — connection between spermiduct and kidney
g — genital apertures
h — hermaphrodite duct
i — intestine
ic — tuft of epidermal cilia
j — jaw
k — kidney
la — lateral plate of radula
m — mucous gland
mo — outer mouth
mt — median tooth of central radular plate
n — antrum
ne — anterior nerves
ni — renal pore
o — statocyst
p — penis
pr — prostata
q — radular sheath
r — intestinal gland
re — refrative granules of intestinal gland
ri — retractor of buccal bulb
s — penis sheath
sc — reno-pericardial connection
se — spermiduct
so — ciliated sole
t — stomach
u — ampulla of hermaphrodite duct
v — oviduct
w — oral (vestibular) tube
x — pedal glands
y — so-called pericardial gland
z — gonad (ovotestis, hermaphrodite gland)

PLATE 1

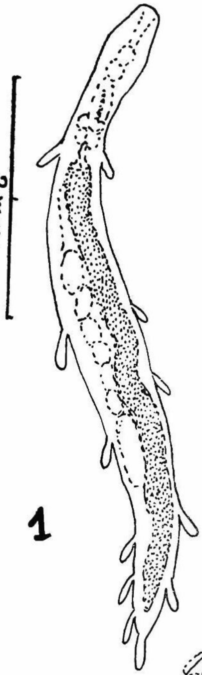
Pseudovermis salamandrops, sp. n.

Fig. 1 — Sketch of living worm.

Fig. 2 — Outlines of the 3 specimens in oil of cloves.

Fig. 3 — The youngest specimen stained and clarified.

Fig. 4 — Head of same.



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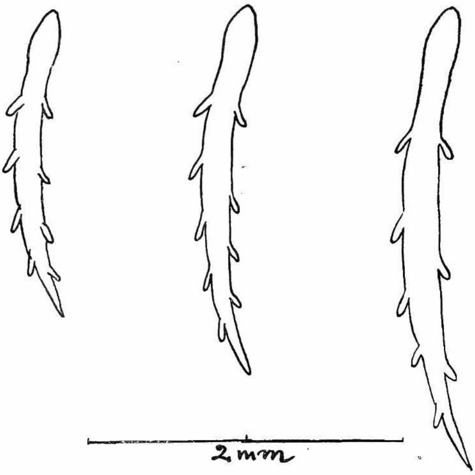

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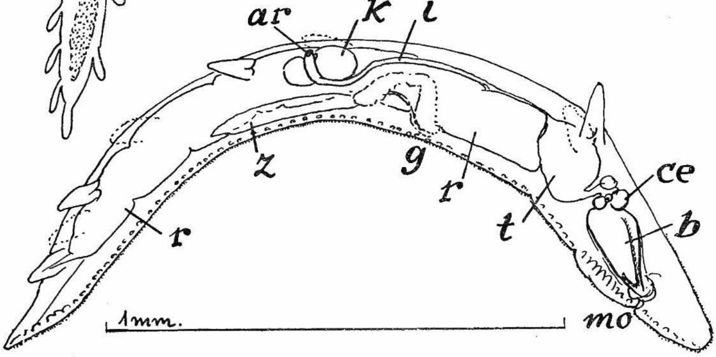

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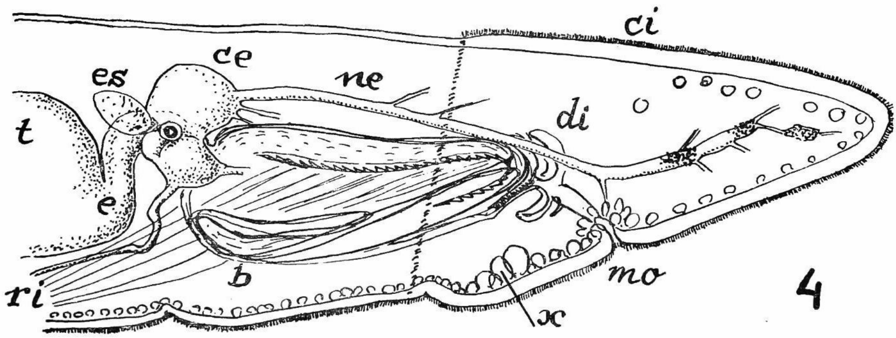

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PLATE 2

Pseudovermis salamandrops, sp. n., Fig. 5-11, 16

Fig. 5 — Buccal sclerites.

Fig. 6 — Cuticular disc of inner lips.

Fig. 7 — Teeth of jaws.

Fig. 8 — One row of radular plates.

Fig. 9 — Central plate of radula from below.

Fig. 10 — Three rows of radular plates in lateral view.

Fig. 11 — Transverse section of inner border of mandible.

Fig. 12 — Same in *Pseudovermis paradoxus* Per. (Kowalevsky 1901, f. 16).

Fig. 13 — Same in *P. paradoxus* Per. (Kowalevsky f. 17).

Fig. 14 — Same in *P. papillifer* Kow. (Kowalevsky f. 53).

Fig. 15 — Same in *P. spec.* from Mytilene (Kowalevsky f. 58).

Fig. 16 — *Pseudovermis salamandrops*, sp. n., central nervous system.

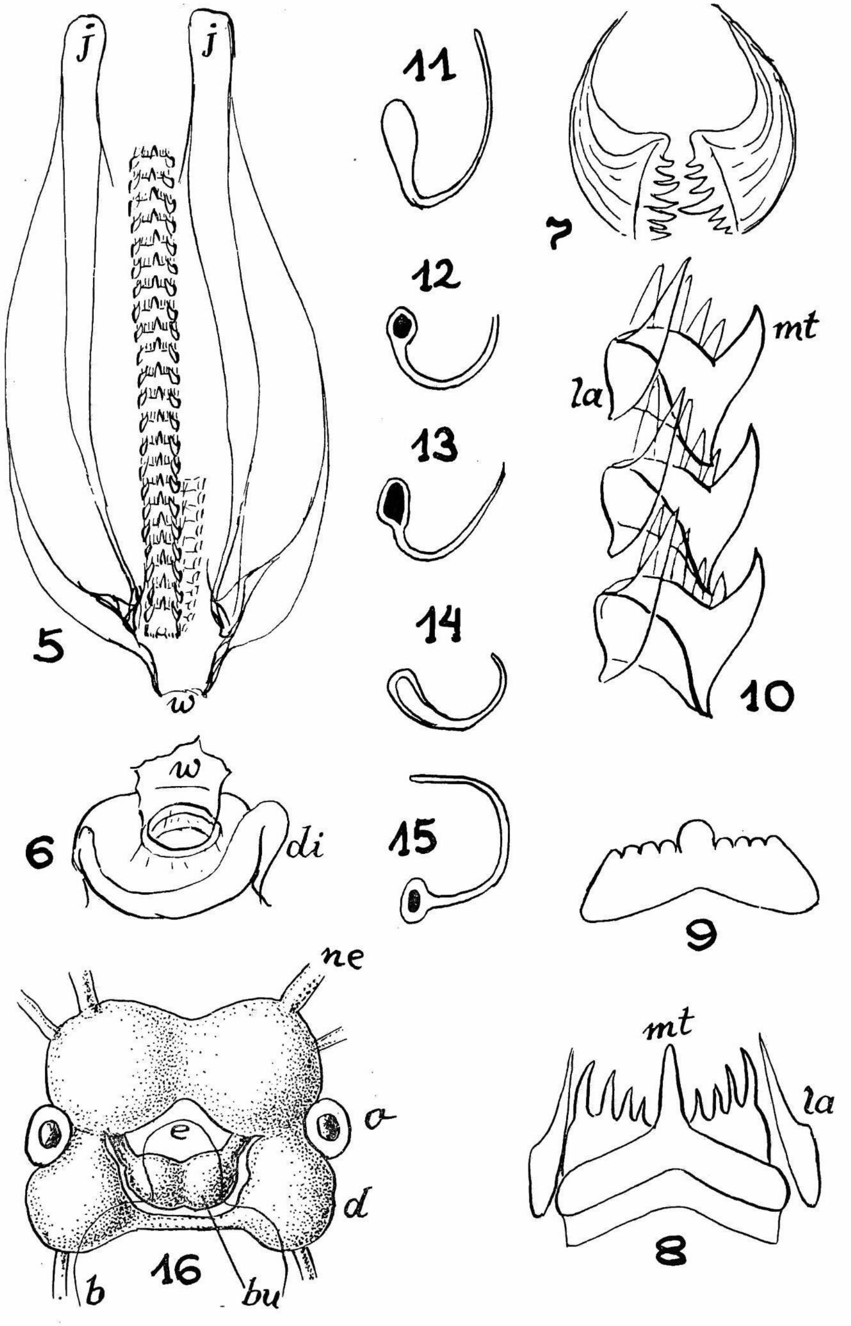
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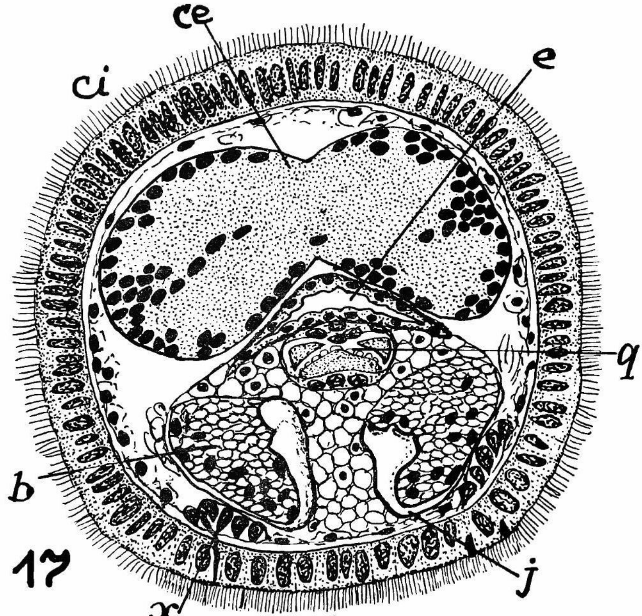
PLATE 3

Pseudovermis salamandrops, sp. n.

Fig. 17 — Transverse section on level of cerebral ganglia (ce).

Fig. 18 — Combined transverse section on level of first papillæ, salivary glands (es), and stomach (t).



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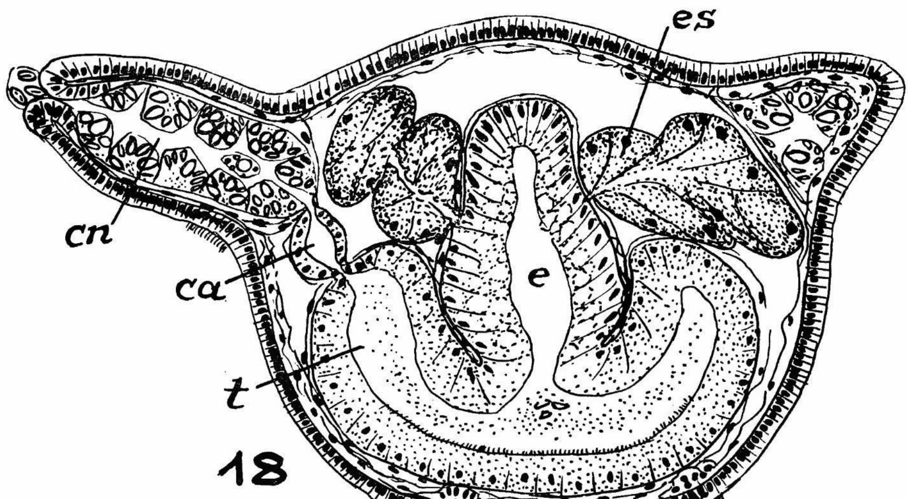

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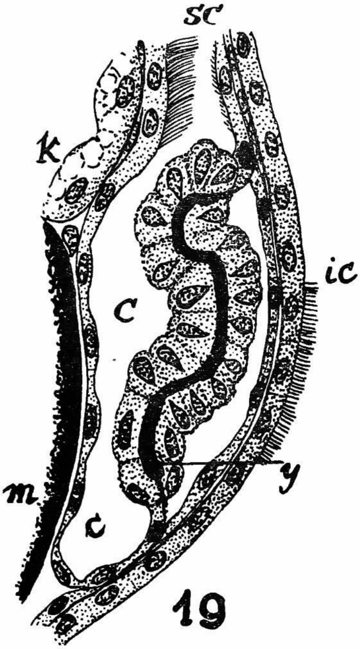
PLATE 4

Pseudovermis salamandrops, sp. n.

Fig. 19 — Pericard (c) with gland (y) from transverse section.

Fig. 20 — Cuticular mug of pericardial gland, reconstruction of one half.

Fig. 21 — Diagram of reproductive organs.



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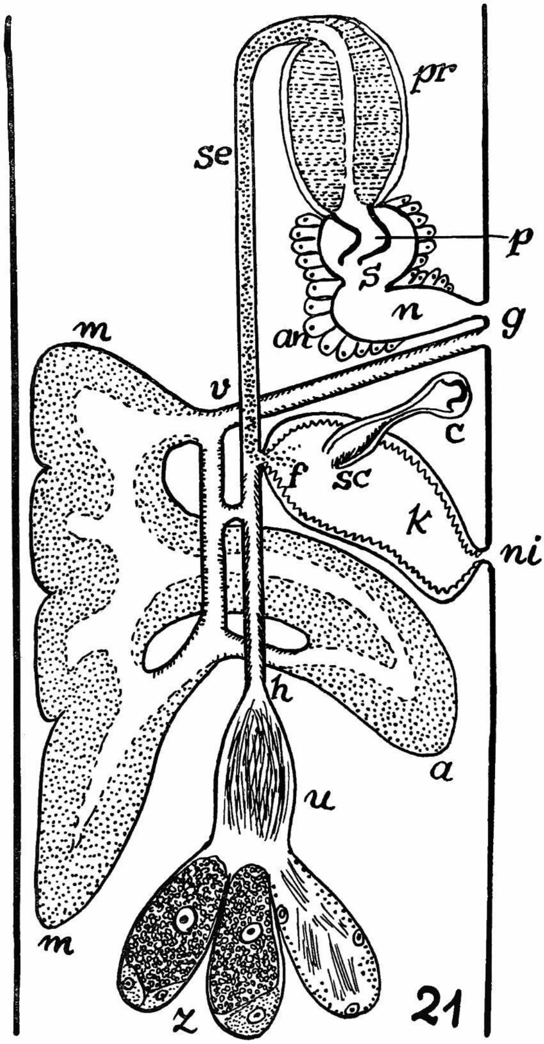

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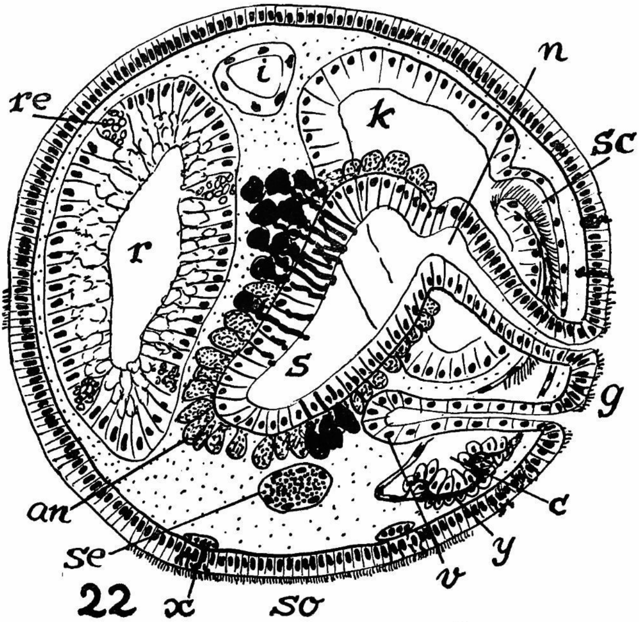
PLATE 5

Pseudovermis salamandrops, sp. n.

Fig. 22 — Transverse section on level of genital openings (g).

Fig. 23 — Transverse section on level of communication (f) from spermiduct (se) to kidney (k), renal pore (ni), and anus (ar), combined.



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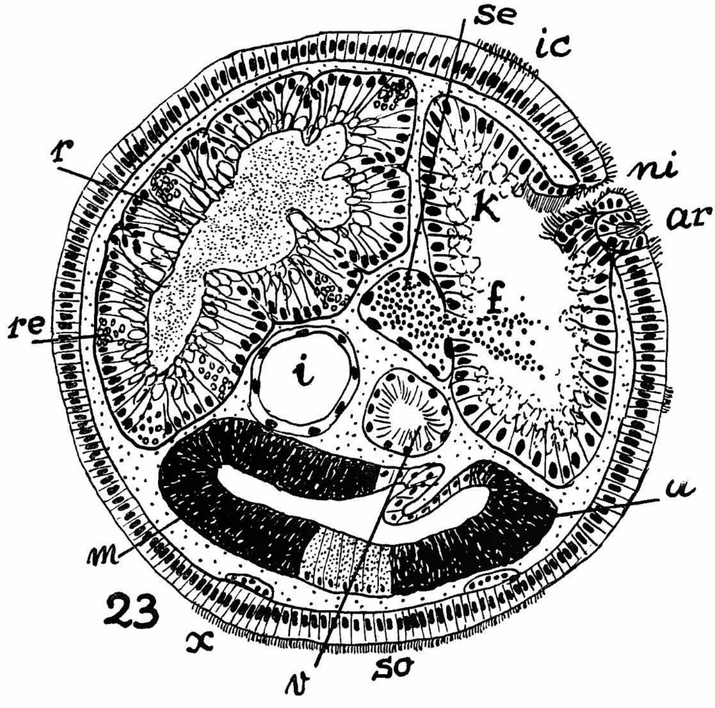

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