



Three new species of land flatworms and comments on a complex of species in the genus *Geoplana* Stimpson (Platyhelminthes: Continenticola)

SILVANA VARGAS DO AMARAL, SIMONE MACHADO DE OLIVEIRA & ANA MARIA LEAL-ZANCHET
Instituto de Pesquisas de Planárias and Programa de Pós-Graduação em Biologia, Universidade do Vale do Rio dos Sinos, 93022-000 São Leopoldo, Rio Grande do Sul, Brazil

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Abstract

Three new species of *Geoplana* Stimpson, 1857 from south Brazil, *Geoplana ficki* **sp. nov.**, *G. carbayoi* **sp. nov.**, and *G. baptistae* **sp. nov.**, with dark, nearly homogeneous dorsum, reddish or orange venter, and eyes spreading over the dorsum, are described. The three can be included in the Graff group of “large, broad and flat species”, designated the *G. applanata*-group by C. G. Froehlich (1967). The first described species presenting this pattern was *G. rufiventris* Schultze & Müller, 1857. Later, several other authors described various species exhibiting the “dark dorsal surface and orange or reddish ventral side” pattern. These species constitute an assemblage which will be here designated the *G. rufiventris*-complex. Apart from presenting a similar pattern, a further considerable difficulty in differentiating these taxa from the other large, broad and flat species of the genus *Geoplana* which were included in Froehlich’s original *G. applanata*-group, resides in their possessing a very homogeneous copulatory apparatus. Characteristics of their external and internal morphology are here discussed to simplify the differentiation of sub-groups and comparison of species.

Key words: Geoplaninae, taxonomy, land planarians, triclads

Introduction

When commenting on certain Neotropical land planarians, notably in specific reference to a group of large, broad and flat species, Graff (1899) designated *G. rufiventris* as its “type”. *Geoplana rufiventris* Schultze & Müller, 1857, first described on the basis of external morphology of specimens from Blumenau, south Brazil, has a dark dorsal surface and an orange or reddish ventral side. In his analysis of specimens from various provenances in south Brazil, Argentina and Paraguay, Graff (1899) appears to have been misled by the similarities of these external morphological characters, and considered his heterogeneous material as conspecific with *Geoplana rufiventris*

Schultze & Müller. In addition, he considered *Geoplana marmorata* Schultze & Müller, 1857 as synonymous with *G. rufiventris* (Froehlich, 1959).

Later, Bresslau in Riester (1938, p.53), in accord with Graff's information, attempted to find "die häufigste Art in Mittel-Brasilien" (the most common species in mid-Brazil). After identifying various specimens as *G. rufiventris* in his notes, Bresslau reached the point where the eye pattern in his specimens proved to be different from that of Graff's (Riester, 1938). After analyzing Bresslau's specimens, Riester (1938) concluded that *G. rufiventris* sensu Graff could not be considered a single species, but that Graff's heterogeneous material possibly belonged to at least two or three species. Later, several authors, such as Schirch (1929), Riester (1938), Marcus (1951) and Froehlich (1959), among others, described various species with the pattern, "dark dorsal surface and orange or reddish ventral side". These species actually constitute a species complex, here designated as the *G. rufiventris*-complex. Apart from presenting the same basic pattern, their extremely homogeneous copulatory apparatus poses a further and considerable difficulty in differentiating between these and other large, broad and flat species of the genus *Geoplana* in general.

On studying the land planarian fauna from various localities in south Brazil (state of Rio Grande do Sul), the occurrence of various species of the *G. rufiventris*-complex was noted. Three species of this complex are described here, and their position among the large, broad and flat species of the genus *Geoplana* Stimpson, 1857, discussed.

Material and methods

Specimens of *G. ficki* **sp. nov.** were collected from São Francisco de Paula (National Forest of São Francisco de Paula) (29°23'–29°27'S; 50°23'–50°25'W), located in the state of Rio Grande do Sul, and Cambará do Sul and Praia Grande (National Park of Aparados da Serra) (29°05'–29°15'S, 50°00'–50°15'W), respectively, in the states of Rio Grande do Sul and Santa Catarina, Brazil. Sampling took place in areas of Mixed Ombrophilous Forest in both conservation units, as well as in areas of Dense Ombrophilous Forest in the National Park, areas with *Pinus* plantations, and in the neighborhood of man-made buildings in the National Forest. Specimens of *G. carbayoi* **sp. nov.** were collected in areas of Caducifolious Forest, and in the neighborhood of man-made buildings in the State Park of Turvo (27°00'–27°20'S; 53°40'–54°10'W), located in Derrubadas, state of Rio Grande do Sul, Brazil. Specimens of *G. baptistae* **sp. nov.** were collected in areas of Caducifolious Forest at two sites in Santa Maria county, namely the "Campo de Instrução do Exército—CISM" (29°43'–29°44'S; 53°42'–53°44'W), in the district of São Valentin, and Três Barras (29°41'S; 53°44'W), Arroio Grande, located 20 km to the northeast of the county-seat, in the state of Rio Grande do Sul, Brazil. Most of the specimens were collected by direct sampling in soil-litter, under and inside fallen logs and branches, and under stones. However, the holotype was captured in a pitfall trap with drift-fences, comprising a buried 100-liter container, with the open top on a level with the surface (Castro & Leal-Zanchet, 2005), in an area of man-disturbed native grassland at Santa Maria, in the district of Pains, located ca. 10 km from the county-seat (29°44'S; 53°44'W). This specimen was immediately fixed in formaldehyde.

Methods described by Froehlich and Leal-Zanchet (2003) were used for histological processing of material and analysis of external and internal characters. The material was sectioned at 5–7 µm.

The ratio of the height of the cutaneous musculature to the height of the body (mc:h index in Froehlich, 1955) was determined in the median region of a transverse section of the pre-pharyngeal region. Mesenchymatic muscle fibers were counted in transverse sections of the same region. Colour descriptors, based on the uptake of dyes of particular colours, were used for classifying secretions with trichrome methods: erythrophil (red-loving), xanthophil (orange-loving) and cyanophil (dark blue-loving). The term cyanophil also applies to secretions which have an affinity for the green dye of Goldner's Masson.

Type-material was deposited in the following reference collections: Museu de Zoologia da Universidade do Vale do Rio dos Sinos (MZU), São Leopoldo, Rio Grande do Sul, Brazil, and the Helminthological Collection of Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, São Paulo State, Brazil.

Taxonomic part

Family Geoplanidae Stimpson, 1857

Subfamily Geoplaninae Stimpson, 1857

Geoplana Stimpson, 1857

Geoplana ficki sp. nov. Amaral & Leal-Zanchet

Geoplana sp. 8: Leal-Zanchet & Carbayo, 2000

Geoplana sp. 6: Fick, Leal-Zanchet & Vieira, 2006

Geoplana sp. 6: Baptista, Fick, Matos & Leal-Zanchet, 2006

Etymology. the specific name is in honor of MSc. Israel Alberto Fick and his collaboration in collecting various specimens of land planarians which were deposited in the scientific collection of the Instituto de Pesquisas de Planárias (UNISINOS).

Type material. Holotype: MZUSP PL.01146: I. A. Fick, *leg.* 12.VIII.1999, São Francisco de Paula, RS, Brazil—anterior tip: transverse sections on 151 slides; anterior region at the level of the ovaries: sagittal sections on 175 slides; pre-pharyngeal region 1: transverse sections on 48 slides; pre-pharyngeal region 2: transverse sections on 127 slides; pharynx: sagittal sections on 212 slides; copulatory apparatus: sagittal sections on 60 slides.

Paratypes: MZU PL.00101: M. Cardoso, *leg.* 03.IV.1998, São Francisco de Paula, RS, Brazil—anterior tip: transverse sections on 60 slides; anterior region at the level of the ovaries: sagittal sections on 29 slides; posterior region to ovaries: sagittal sections on 120 slides; pre-pharyngeal region; transverse sections on 32 slides; pharynx: sagittal sections on 139 slides; copulatory apparatus: sagittal sections on 50 slides; MZU PL 00102: A. M. Leal-Zanchet, coll. 04.V.1998, São Francisco de Paula, RS, Brazil—pre-pharyngeal region; transverse sections on 29 slides pharynx: sagittal sections on 61 slides; copulatory apparatus: sagittal sections on 40 slides; MZU PL.00103: I. A. Fick, *leg.* 02.IX.1998, São Francisco de Paula, RS, Brazil—copulatory apparatus: horizontal sections on 117 slides; MZU PL.00104: I. A. Fick, *leg.* 29.XI.1999, São Francisco de Paula, RS, Brazil—preserved in ethanol 70°; MZU PL.00105: I. A. Fick, *leg.* 26. III. 2000: Cambará do Sul, RS, Brazil—anterior tip: sagittal sections on 106 slides; MZU PL.00106: I. A. Fick, *leg.* 24.X.2000, Praia Grande, SC, Brazil—anterior tip: transverse sections on 47 slides; anterior region at the level of the ovaries: sagittal sections on 23 slides; pharynx: sagittal sections on 92 slides; copulatory apparatus: sagittal sections on 71 slides; MZU PL.00107: I. A. Fick, *leg.* 11.XII.2000, Cambará do Sul, RS, Brazil—pre-pharyngeal region; transverse sections on 112 slides; pharynx: sagittal sections on 178 slides; copulatory apparatus: sagittal sections on 244 slides; MZU PL.00108: I. A. Fick, *leg.* 11.XII.2000, Cambará do Sul, RS, Brazil—preserved in ethanol 70°; MZU PL.00110: A. M. Leal-Zanchet, coll. 06.VIII.2002, São Francisco de Paula, RS, Brazil—preserved in ethanol 70°; MZU PL.00111: P. K. Boll, *leg.* 24.II.2010, São Francisco de Paula, RS, Brazil—anterior tip: transverse sections on 68 slides; anterior region at the level of the ovaries: transverse sections on 82 slides; posterior region to ovaries: transverse sections on 117 slides; copulatory apparatus: horizontal sections on 185 slides.

Type locality. São Francisco de Paula, state of Rio Grande do Sul (RS), Brazil.

Distribution. Santa Catarina (Praia Grande) and Rio Grande do Sul (Cambará do Sul, São Francisco de Paula), Brazil.

Diagnosis. body broad and flat, anterior end pointed, posterior end gradually narrowed. Live specimens with dorsum brown or greenish-brown to the naked eye and venter orange to light brown with dark contour. Eyes dorsal, with inconspicuous clear halos; sensory pits in the first third of the body; conspicuous glandular margin with three types of secretory cells; mc:h, 8%–11%; pharynx collar-form; very short esophagus; esophagus: pharynx ratio, 2%–7%; anteriormost testes anterior to ovaries, most posterior ones near to root of pharynx; sperm ducts open laterally into anterior end of prostatic vesicle; prostatic vesicle tubular, mainly extrabulbar, consisting of two portions, a forked and short proximal portion and an unpaired distal portion which loops dorsally and posteriorly, entering the bulbar muscular coat; male atrium short, with the entire cavity occupied by the conical penis papilla which extends into the female atrium; straight ejaculatory duct opens through the tip of the almost symmetrical papilla; ovovitelline ducts emerging, dorsally and laterally displaced, from posterior third of ovaries, and ascending behind

gonopore; common glandular ovovitelline duct short; vagina as a dorso-anteriorly curved ental portion of female atrium; female atrium elongate, with ample lumen; male atrium shorter than female atrium; length of female atrium, 123% that of male one; straight gonopore canal; no folds separating male and female atria.

Description. External morphology: Body broad and flat, anterior end pointed, posterior end gradually narrowed (Figs. 1–2). When crawling, maximum length reaches 231 mm (Table 1). Mouth distance from anterior tip varies from 52% to 77%; gonopore between 70% and 88%, relative to body length (Table 1).

Live specimens with brown dorsum, sometimes greenish-brown, usually seeming homogeneous to the naked eye. Some specimens with pale greenish-gray dorsum, with numerous fine black spots under moderate magnification (Fig. 1–3). In preserved specimens dorsal colour fades, becoming light brown. Under the stereomicroscope, dorsal ground-colour pale brown or greenish gray covered by dense dark-brown or black pigmentation. Venter orange to light brown with dark contour, becoming grayish or pale brown in preserved specimens.

Eyes uniserially surround anterior tip, becoming large and irregular in distribution immediately after the tip. Approximately after 0.5 mm and 1 mm from the tip (about 1% and 2% of body length), respectively, they form two and three series. After 3 mm or 4 mm (about 5% or 7% of body length), they also extend slightly dorsad and are surrounded by inconspicuous halos, being more abundant about 15 mm from the tip in paratype MZU PL.00110 (ca. 25% of body length). They occupy the maximum width of 3 mm on each side of the body (about 33% of body width in paratype MZU PL.00110) (Fig. 4). Towards posterior end, they become less numerous.

Internal morphology. Anterior region: Sensory pits, as simple invaginations, about 35 μ m to 65 μ m deep, contouring anterior tip, occurring initially at intervals of approximately 25 μ m, posteriorly become gradually sparser until they disappear approximately 30 mm from anterior tip (30% of body length in paratype MZU PL.00111). Eyes contour the anterior tip in a single row, then run along both sides of the body (two to three eyes on each side). Eyes 28 μ m to 48 μ m diameter. Cutaneous musculature arrangement similar to that of pre-pharyngeal region (see next section), but thinner close to the tip; longitudinal fibers absent or very weak on first 0.4 mm of body length. Mesenchymal musculature, poorly developed on anterior tip, mainly comprising crossed fibers between ventral cutaneous musculature and margins of body; transverse sub-intestinal layer, together with some transverse supraintestinal and dorsoventral fibers appear about 0.4 mm after anterior tip. Rhabditogen cells absent on first 260 μ m of body length. Ventral epidermis receives weakly stained cyanophil cells with granular secretion, abundant erythrophil cells with granular secretion, and numerous xanthophil cells with granular secretion. Dorsal epidermis receives weakly stained cyanophil cells with amorphous secretion and sparse rhabditogen cells on first 1.1 mm of body length (1% of body length in paratype MZU PL.00111). Secretory cells absent on sensorial border, except cyanophil cells. Xanthophil and erythrophil cells become more numerous on body margins, forming the glandular margin, approximately 0.4 mm from tip.

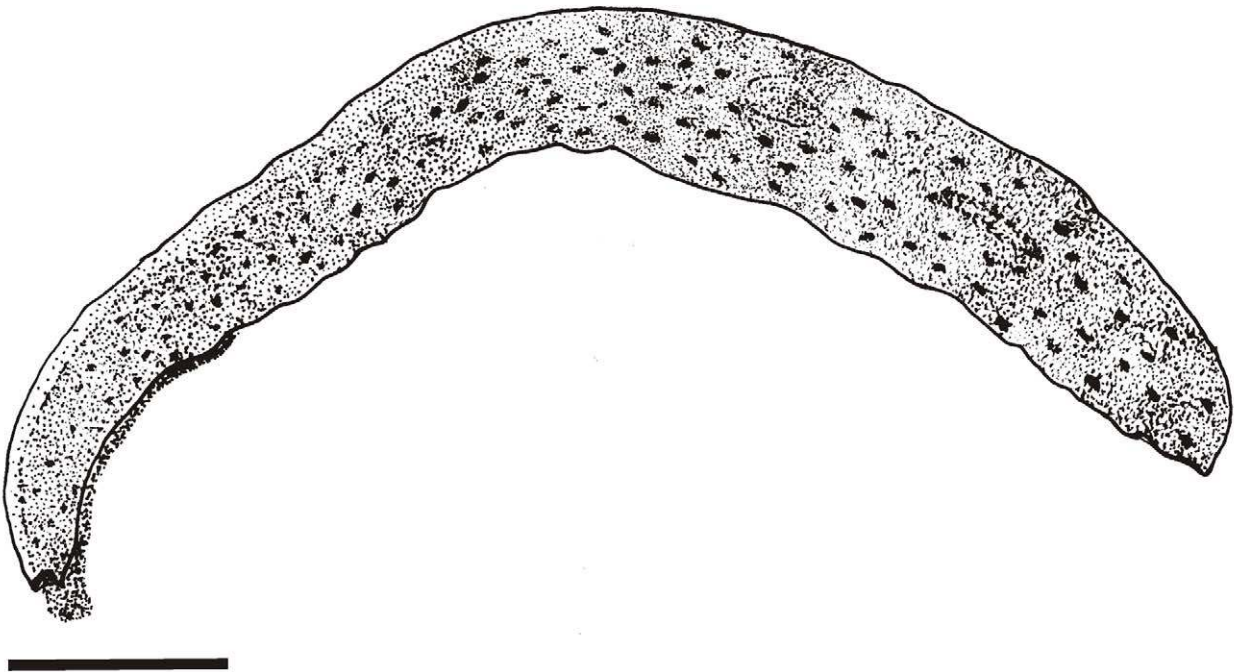
Epidermis and musculature at pre-pharyngeal region (Fig. 5): Creeping sole broad, occupying 82% to 90% of body width (Table 1). Three types of secretory cells open through dorsal epidermis and body margins: (1) numerous rhabditogen cells with xanthophil secretion and less frequent (2) weakly cyanophil cells with fine granular secretion and (3) erythrophil cells with fine granular secretion. Creeping sole receives abundant cells with weakly cyanophil amorphous secretion, rhabditogen cells, and erythrophil cells with fine granular secretion, less numerous. Glandular margin conspicuous, comprising numerous cells with coarse granular erythrophil secretion and cells with coarse granular xanthophil secretion; cells with coarse granular cyanophil secretion, cells with fine erythrophil secretion, as well as cells with mixed secretion (periphery cyanophil with a central erythrophil core) less numerous.

Cutaneous musculature tripartite (circular, oblique and longitudinal muscle layers), longitudinal layer with thick bundles. Mc:h 8% to 11% (Table 2).

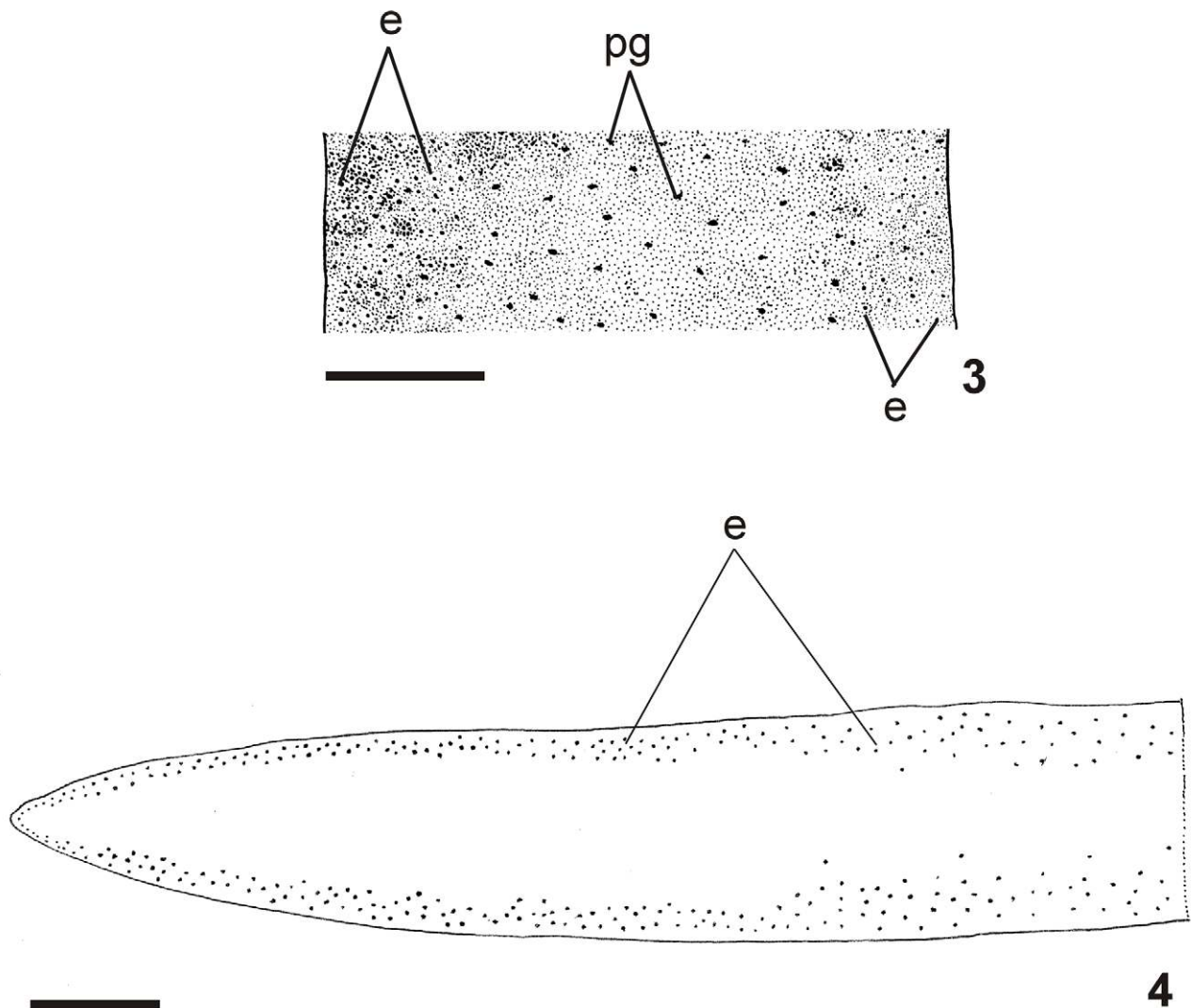
Mesenchymal musculature comprised mainly of transverse, oblique, and dorsoventral fibres. Supra-intestinal and sub-intestinal muscle layers, each about 5–6 fibres thick, comprised of transverse muscle fibres. Longitudinal fibers are indiscernible.

TABLE 1. Measurements, in millimeter, of specimens of *Geoplana ficki* sp. nov. -: not measured; --: gonopore absent; *: After fixation; **: Specimens with damaged anterior tip (lost or regenerating); DG: distance of gonopore from anterior end; DM: distance of mouth from anterior end; DMG: distance between mouth and gonopore; DPVP: distance between prostatic vesicle and pharyngeal pouch. The numbers given in parentheses represent the position relative to body length.

	Holotype MZUSP PL.01146 **	Paratype MZU PL.00101 **	Paratype MZU PL.00102 **	Paratype MZU PL.00103 **	Paratype MZU PL.00104 **	Paratype MZU PL.00105 **	Paratype MZU PL.00106 **	Paratype MZU PL.00107 **	Paratype MZU PL.00108 **	Paratype MZU PL.00109 **	Paratype MZU PL.00110 **	Paratype MZU PL.00111 **
Maximum length in extension	231	120	95	145	51	128	182	-	-	45	-	135
Maximum width in extension	18	8	6	9	2	7.5	6	-	-	5	-	15
Length at rest	120	70	65	100	32	62	59	110	-	73	65	100
Width at rest	22	9-11	10	12	4	9	8	11	-	7	9	18
Length*	144	92	65	80	53	92	90.3	125	65	41	60	100
Width*	19	11	9	17	7	11	8	7	11	6	11	15
DM*	99	55	41	42 (52.5)	31	71	56	79	55	31	43	58
	(69)	(60)	(63)		58.5	(77)	(62)	(63)	(15.5)	(75.5)	(71.5)	(58)
DG*	118	67.5	50	58	46	81	70	88 (70)	--	--	--	71
	(82)	(73.5)	(77)	(72.5)	(87)	(88)	(77)					(71)
DMG*	19	12.5	9	16	15	10	14	9	--	--	--	13
DPVP*	5	3	3	-	-	-	2.5	3.2	--	--	--	-
Creeping sole %	82	90	85	-	-	-	-	85	-	-	-	-
Ovaries	21	9.5	-	-	-	-	-	-	-	-	-	24
	(14)	(10)										(24)
Anteriormost testes	17	11	-	-	-	-	-	-	-	-	-	22
	(12)	(11)										(22)
Posteriormost testes	95	44	-	-	-	-	-	-	-	-	-	-
	(66)	(48)										
Prostatic vesicle (forked portions)	0.2	0.2	0.1	0.1	0.2	-	0.2	0.2	-	-	-	0.2
Prostatic vesicle (unforked portion)	1.8	1.2	0.7	1.2	-	-	0.9	1.1	-	-	-	0.9
Penis papilla	3.7	2.2	0.9	2.6	-	-	1.6	2.1	-	-	-	0.9
Male atrium	2.2	1.3	0.7	2.0	-	-	1.4	2.2	-	-	-	1.4
Female atrium	2.7	2.3	0.7	2.0	-	-	1.2	2.9	-	-	-	1.6
Vagina	0.2	0.2	0.1	0.1	-	-	0.2	0.2	-	-	-	0.1
Common oviduct	0.1	0.2	0.1	0.2	-	-	0.1	0.2	-	-	-	0.1



FIGURES 1–2. *Geoplana ficki* sp. nov.: (1) photograph of a live specimen (paratype MZU PL.00111) in dorsal view; (2) colour pattern of a live specimen (paratype MZU PL.00111) in dorsal view. Scale bar: 15 mm.



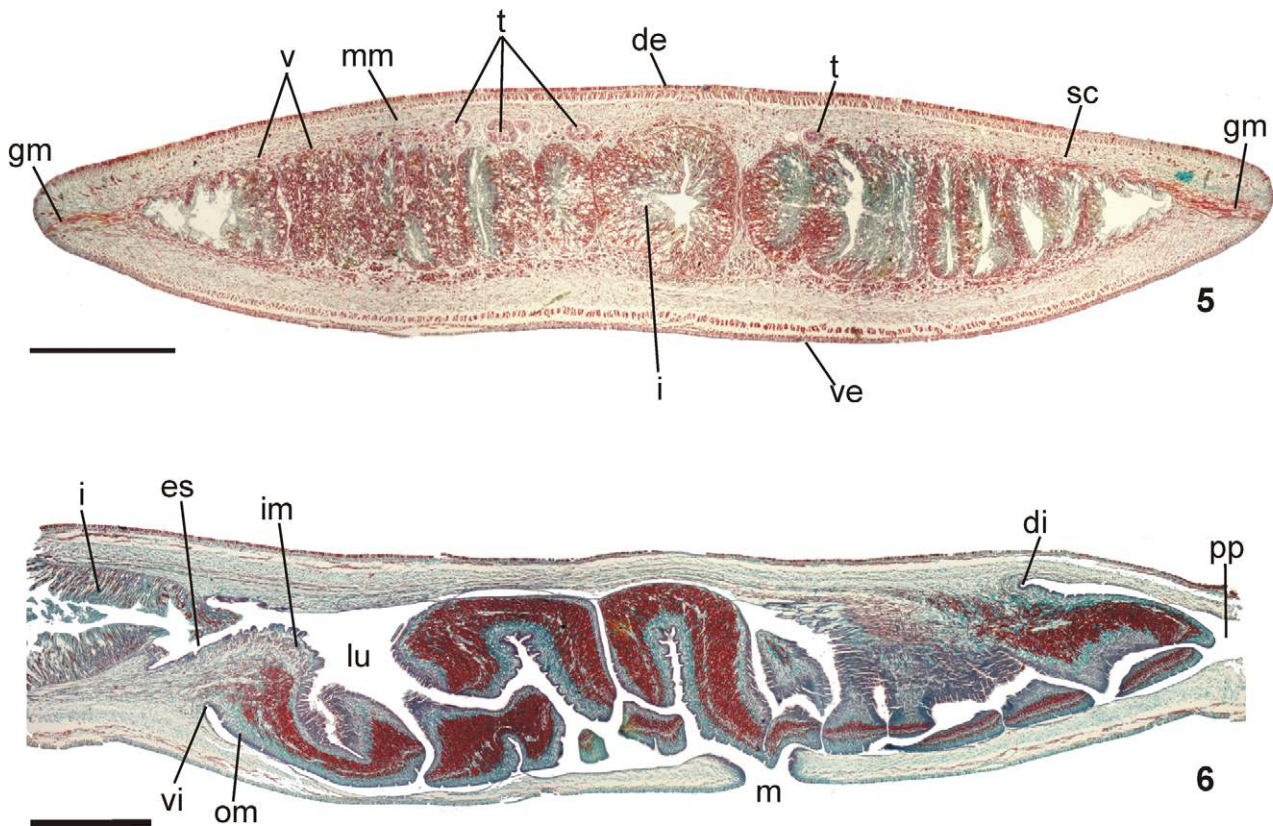
FIGURES 3–4. *Geoplana ficki* **sp. nov.**: (3) detail of colour pattern of preserved specimen (paratype MZU PL.00111) in dorsal view; (4) detail of eyes pattern in the anterior body half of a preserved specimen (paratype MZU PL.00110) in dorsal view. (e) eyes, (pg) pigmentation. Scale bar: 5 mm.

TABLE 2. Cutaneous musculature and body height, in micrometer, in the median region of a transverse section of the pre-pharyngeal region, and ratio of the height of cutaneous musculature to the height of the body (mc:h index) of specimens of *Geoplana ficki* **sp. nov.**

	Holotype	Paratype MZU PL.00101	Paratype MZU PL.00102	Paratype MZU PL.00106	Paratype MZU PL.00107
Dorsal musculature	92	77	66	82	62
Ventral musculature	100	88	68	76	63
Body height	2495	1593	1718	1390	1543
Mc:h (%)	8	10	8	11	8

Pharynx (Fig. 6): Pharynx collar-form. Mouth located in mid-third of pharyngeal pouch. Esophagus very short, lined with ciliated columnar epithelium presenting some insunk nuclei and cyanophil secretory cells with cell bodies in mesenchyme; with muscularis of interwoven circular and longitudinal fibers. Esophagus: pharynx ratio, 2%–7%. Pharyngeal glands with cell bodies located in mesenchyme, mainly anteriorly to pharyngeal pouch. Three secretory cell types: (1) cells with fine granular erythrophil secretion (1 μ m); (2) cells with cyanophil amorphous secretion, and (3) less numerous cells with fine granular xanthophil secretion. Pharyngeal outer musculature (ca. 65

μm thick) comprised of thin subepithelial layer of longitudinal muscles, followed by a thicker circular one, mixed internally with few longitudinal fibers. Circular and longitudinal muscle layers become very thin towards pharyngeal margins. Inner pharyngeal musculature (ca. $110\ \mu\text{m}$ thick) comprises a thick circular subepithelial layer, mixed with some longitudinal fibers. Inner musculature gradually thins down towards pharyngeal tip.



FIGURES 5–6. *Geoplana ficki* sp. nov.: (5) pre-pharyngeal region of paratype MZU PL.00107 from Cambará do Sul in transverse section; (6) pharynx of paratype MZU PL.00102 from São Francisco de Paula in sagittal section. (de) dorsal epidermis, (di) dorsal insertion, (es) esophagus, (i) intestine, (im) internal musculature, (lu) pharyngeal lumen, (m) mouth, (mm) mesenchymatic muscles, (om) outer musculature, (pp) pharyngeal pouch, (sc) secretory cells, (t) testes, (ve) ventral cutaneous musculature, (vi) ventral insertion. Scale bar: 1 mm.

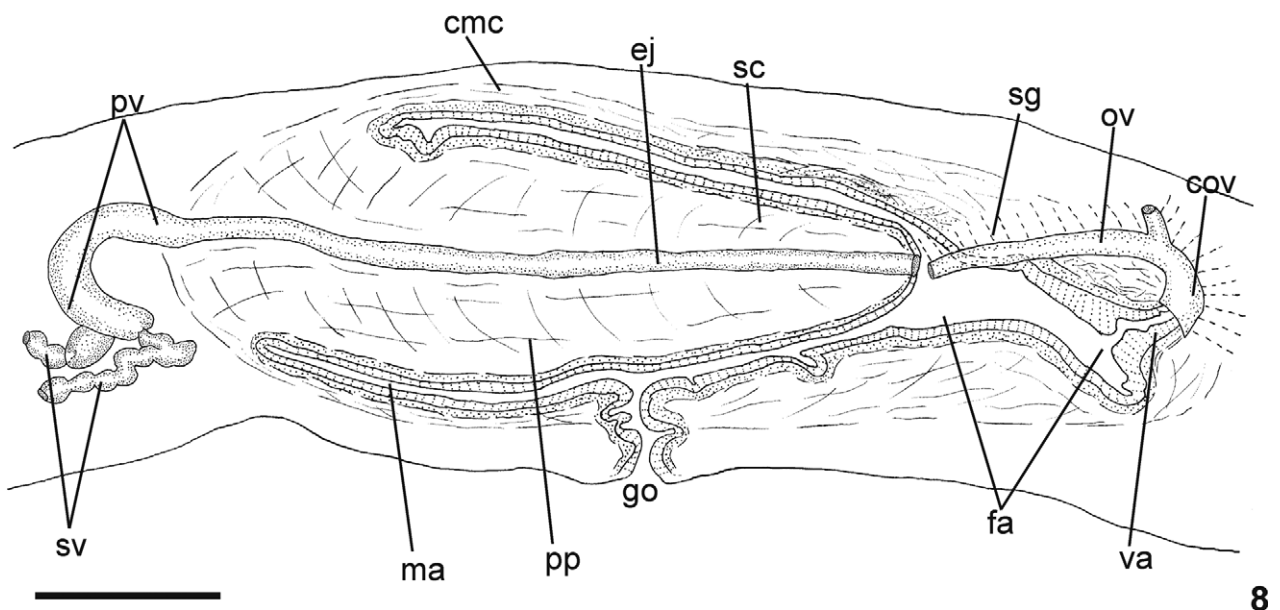
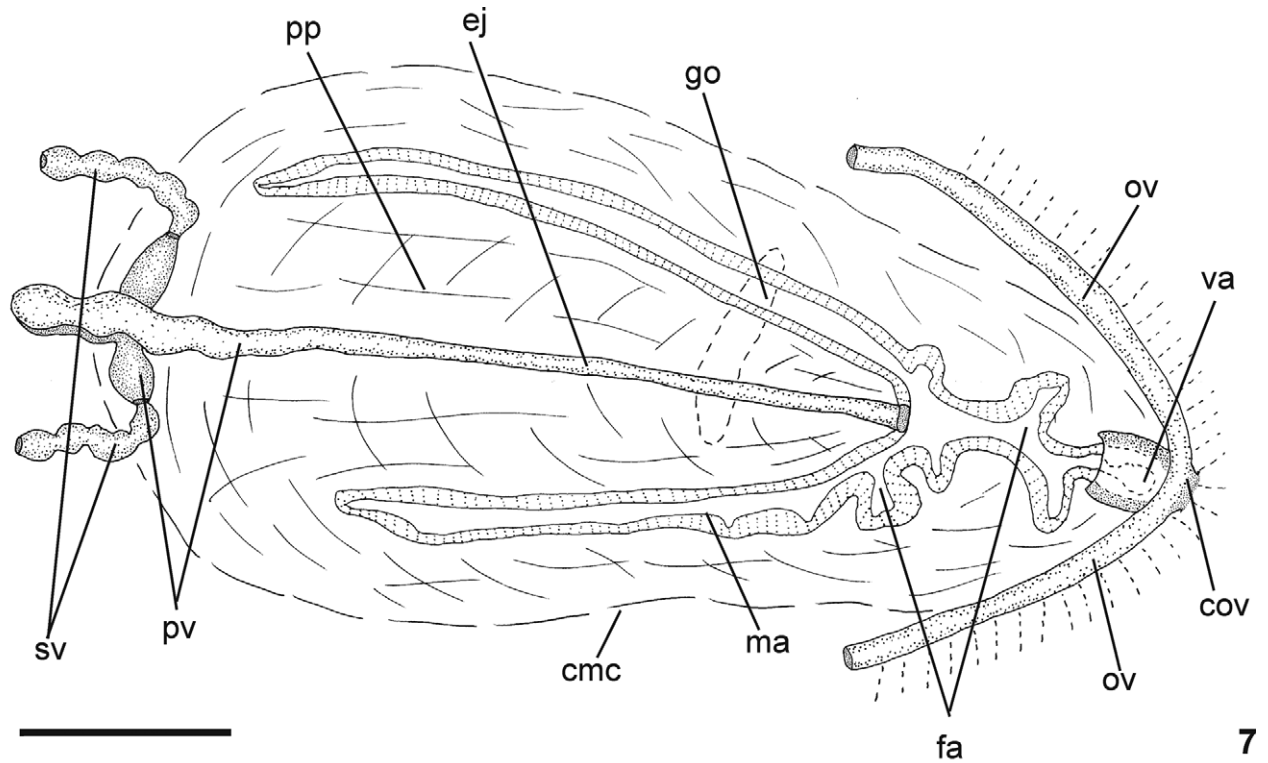
Reproductive apparatus: Testes in two irregular rows dorsal to the intestinal branches, on each side of the body extend from anterior of the ovaries to just anterior of the pharynx (Table 1, Fig. 5). Pre-pharyngeally, sperm ducts, subdivided in two or three ductules, dorsal to ovovitelline ducts, medianly displaced. Lateral to pharynx these form spermiducal vesicles, opening laterally into anterior end of prostatic vesicle (Figs. 7, 8, 14).

Prostatic vesicle of two portions: a short, tubular and forked proximal portion, and an unpaired distal portion which loops dorsally and then posteriorly, then enters the bulbar muscular coat and continues into the ejaculatory duct (Figs. 11, 13, 14). Ejaculatory duct traverses the long, almost symmetrical penis papilla to open through its tip. Male atrium oval-elongate, with the entire cavity occupied by the penis papilla which extends into female atrium (Table 1, Figs. 7–12).

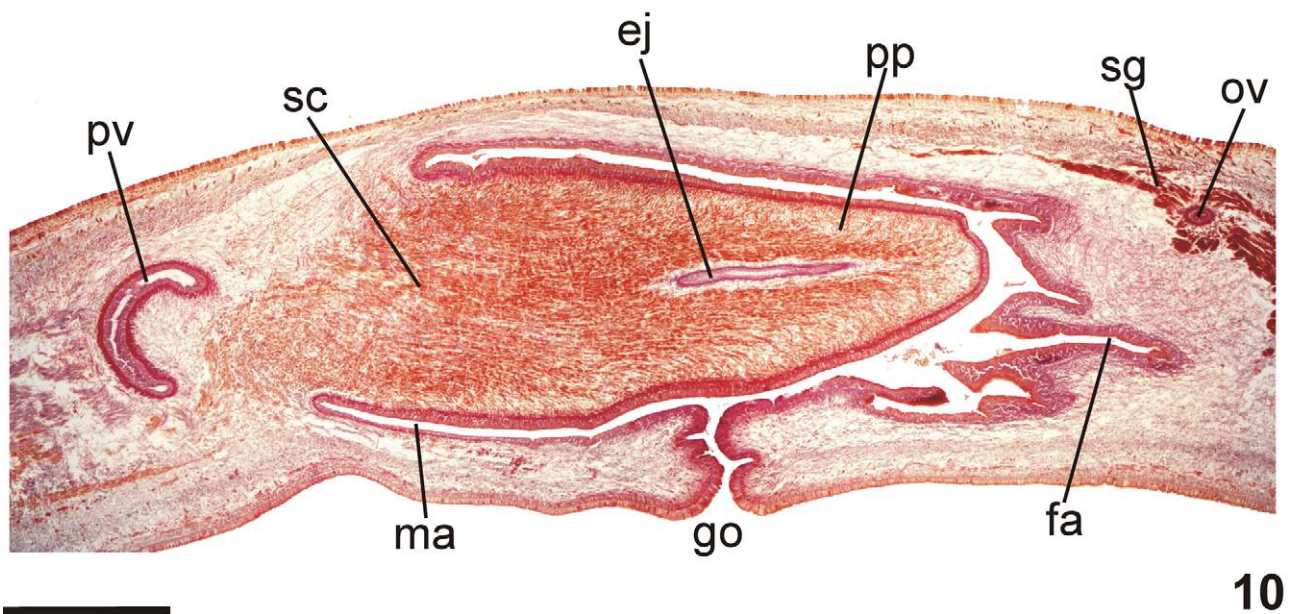
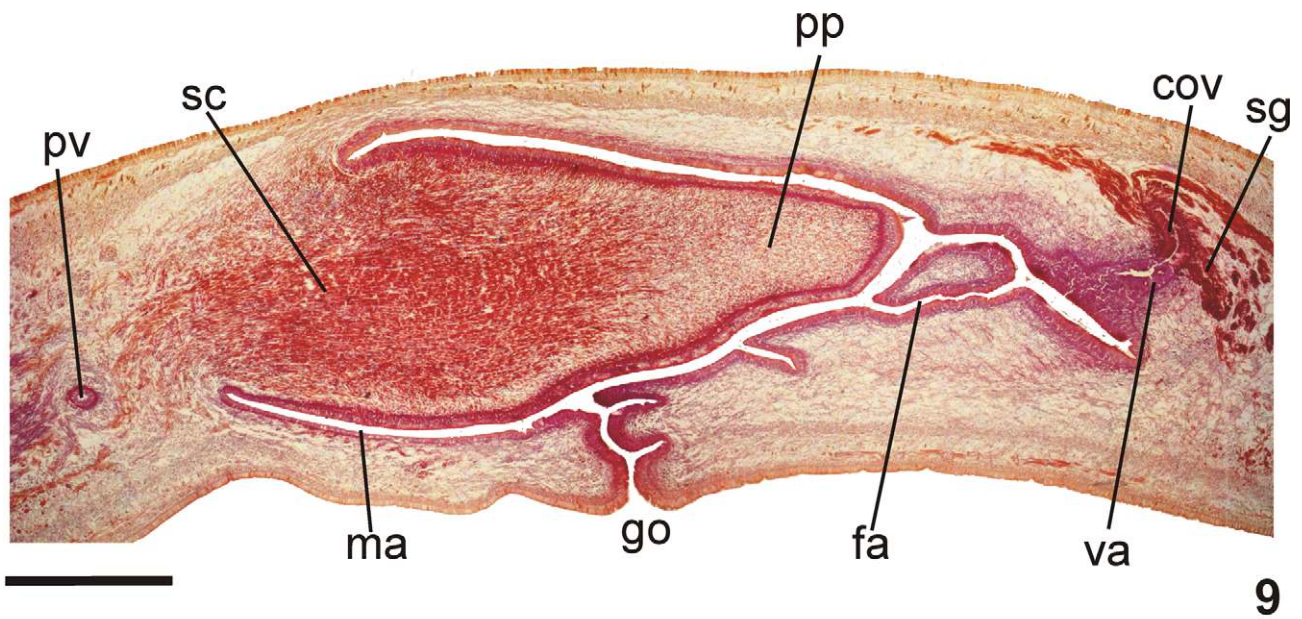
Sperm ducts lined by ciliated cuboidal epithelium, with thin muscularis (ca. $10\ \mu\text{m}$ thick) comprised mainly of circular fibers. Prostatic vesicle lined with ciliated pseudostratified epithelium. Numerous weakly cyanophil cells with amorphous secretion and less abundant xanthophil cells with granular secretion, both with bodies lying in mesenchyme, mainly around vesicle, open into both portions of vesicle. Muscularis of vesicle ($25\text{--}40\ \mu\text{m}$) comprised of interwoven circular and longitudinal fibers.

Ejaculatory duct lined with ciliated columnar epithelium, receiving numerous openings from secretory cells with amorphous, weakly cyanophil secretion and bodies in the surrounding mesenchyme. Muscularis (ca. $10\ \mu\text{m}$ thick) comprised mainly of circular fibers. Penis papilla lined with columnar, non-ciliated epithelium, diminishing very slightly in height towards its tip. Three types of secretory cells run longitudinally in papilla, with numerous openings through its lining epithelium: (1) numerous cells with fine densely arranged granular erythrophil secre-

tion; (2) less numerous cells with granular mixed secretion (cyanophil peripheral part and erythrophil central core); and (3) cells with cyanophil amorphous secretion. Erythrophil cells with cell bodies external to common muscle coat; cells with mixed secretion and cyanophil secretion, with intrabulbar or intrapapillar cell bodies. Muscularis (50 μ m) composed of a circular subepithelial layer and a longitudinal subjacent layer; thinner towards the tip of papilla. Longitudinal, radial and oblique muscle fibers cross papilla.



FIGURES 7–8. *Geoplana ficki* sp. nov.: (7) diagrammatic horizontal composite reconstruction of the copulatory apparatus of paratype MZU PL.00103; (8) sagittal composite reconstruction of the copulatory apparatus of the holotype. (cmc) common muscle coat, (cov) common glandular ovovitelline duct, (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (ov) ovovitelline ducts, (pp) penis papilla, (pv) prostatic vesicle, (sg) shell glands, (sv) spermiducal vesicle, (va) vagina. Scale bar: 1 mm.

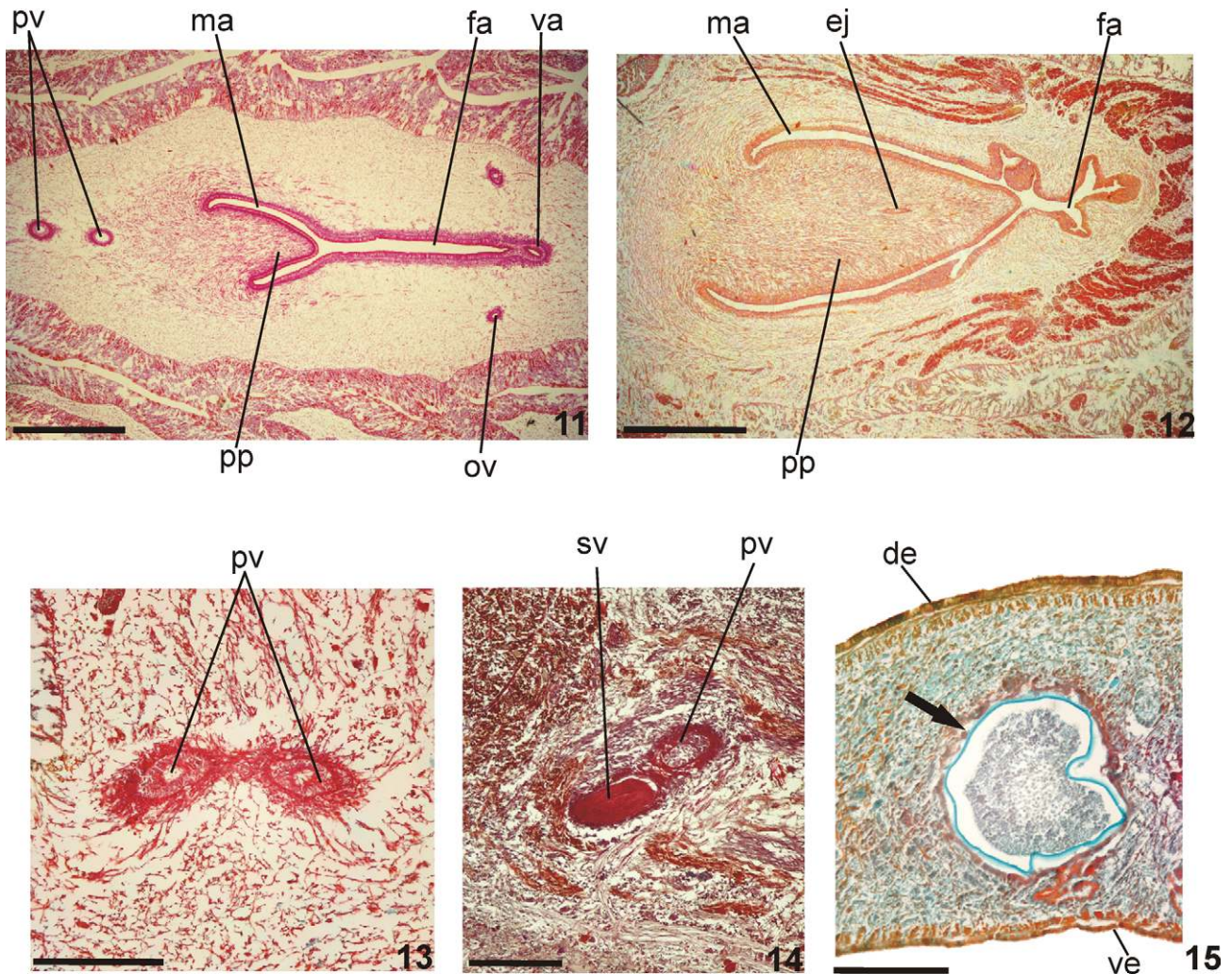


FIGURES 9–10. *Geoplana ficki* sp. nov.: copulatory apparatus in sagittal sections (holotype). (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (ov) ovovitelline ducts, (pp) penis papilla, (pv) prostatic vesicle, (sc) secretory cells, (sg) shell glands, (va) vagina. Scale bar: 1 mm.

Epithelial lining of male atrium, columnar (30 μ m), non-ciliated, becoming ciliated ventrally near to gonopore. Epithelial cells with xanthophil apical secretion, higher distally. Three types of secretory cells, with cell bodies internal to common muscle coat, empty through the epithelium: cells with cyanophil amorphous secretion, cells with granular mixed secretion (cyanophil peripheral part and erythrophil central core), and cells with fine granular xanthophil secretion. Muscularis (40 μ m) comprised of circular subepithelial fibers and subjacent longitudinal fibres.

Ovaries oval-elongate with a long posterior projection, measuring 1.0 mm anterior-posteriorly and 0.15 mm dorso-ventrally in the holotype. Ovovitelline ducts emerge dorsally and laterally displaced from posterior third of ovaries, then recurve immediately dorsal to nerve plate. Behind gonopore, ovovitelline ducts ascend posteriorly and medially inclined, to unite dorsally to the ental part of female atrium (proflex dorsal approach), thus forming a

short common glandular ovovitelline duct. Ental portion of female atrium presents a short, dorso-anteriorly curved diverticulum (vagina) (Table 1). Female atrium oval-elongate in shape (Figs. 7–12). Length of female atrium 123% of male atrium length in the holotype (Table 1).



FIGURES 11–15. *Geoplana ficki* sp. nov.: (11) copulatory apparatus of paratype MZU PL.00103 from São Francisco de Paula in horizontal section; (12) copulatory apparatus of paratype MZU PL.00111 from São Francisco de Paula in horizontal section; (13) detail of paired portions of the prostatic vesicle of paratype MZU PL.00103 from São Francisco de Paula in horizontal section; (14) opening of spermiducal duct into one of the paired portions of prostatic vesicle in sagittal section (holotype); (15) encysted stage of a parasite (arrow), possibly metacercariae, in paratype MZU PL.00106. (de) dorsal epidermis, (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (ov) oviduct, (pp) penis papilla, (pv) prostatic vesicle, (sv) spermiducal vesicle, (va) vagina. Scale bar: 0.5 mm.

Paired ovovitelline ducts and common oviduct lined with ciliated columnar epithelium, with muscularis comprising mainly circular fibers with some interposed longitudinal fibers. Shell glands with xanthophil secretion open into distal ascending portion of paired ovovitelline ducts and common glandular ovovitelline duct.

Female atrium lined with very thick epithelium, with multilayered aspect, irregular in height (Figs. 9, 10, 12), up to 150 μ m, reducing in height in vagina (maximum 95 μ m), changing to a ciliated columnar epithelium in its ental portion. Epithelial cells of female atrium and vagina with xanthophil apical secretions. Secretions within female atrium derived from numerous cells with granular xanthophil secretion, less numerous secretory cells with cyanophil amorphous secretion, together with cells with a granular mixed secretion (cyanophil peripheral part and erythrophil central core). Epithelium of vagina receives three secretions: abundant cyanophil and mixed (peripheral cyanophil with erythrophil central core) secretions from cells external to the common muscularis, and xanthophil secretions from subepithelial glands. Muscularis of female atrium and vagina of similar thickness (20–45 μ m) to that of the male atrium, comprising interwoven circular and longitudinal fibers.

Gonopore canal approximately vertical in sagittal plane. Male and female atria with ample communication, without folds separating them (Figs. 8–10). Gonopore canal lined with ciliated columnar epithelium with numerous openings of rhabditogen cells, cells with cyanophil amorphous secretion, and scattered cells with granular erythrophil secretion. Muscularis of circular fibers with subjacent longitudinal fibers.

Common muscle coat thin with circular, longitudinal and oblique fibers surrounding male and female atria, separated from the atrial muscularis by a poorly developed stroma with variously oriented muscle fibers.

Vitellaria, situated between intestinal branches, open into the ovovitelline ducts.

Remarks. The dorsum in paratypes MZU PL.00102 and MZU PL.00111 was olivaceous-brown covered with abundant, irregular dark-grey spots. Vitellaria, well-developed in the holotype and paratype MZU PL.00103, were, together with the shell glands, inconspicuous in paratypes MZU PL.00101, MZU PL.00102 and MZU PL.00106, thereby indicating incomplete maturity in these specimens. Although the testes in paratype MZU PL.00107 were small, the vitellaria and shell glands were well-developed. Testes were small in paratypes MZU PL.00102 and MZU PL.00106. In the former these began posterior to the ovaries, probably through incomplete development. Although the female and male atria in four specimens (MZU PL.00102, MZU PL.00103, MZU PL.00106, and MZU PL.00111) were of almost the same length, this was not so in the holotype and two other paratypes (MZU PL.00101 and MZU PL.00107, see table 1). The holotype and paratype MZU PL.00106 show pathological features (Fig. 15) represented by encysted stages of a parasite, possibly metacercariae.

***Geoplana carbayoi* sp. nov. Oliveira & Leal-Zanchet**

Geoplana sp. 3: Baptista, Oliveira & Leal-Zanchet, 2010

Geoplana sp. 3: Baptista & Leal-Zanchet, 2010

Etymology. the specific name honours Dr. Fernando Carbayo Baz and his collaboration in collecting several specimens of land planarians deposited in the scientific collection of the Instituto de Pesquisas de Planárias (UNISINOS).

Type material. Holotype: MZUSP PL.01147: I. Fick, *leg.* 23.VII.1999, Derrubadas (State Park of Turvo), RS, Brazil—anterior tip in three parts: (1) transverse sections on 13 slides, (2) transverse sections on 95 slides, and (3) sagittal sections on 75 slides; anterior region at the level of the ovaries: transverse sections on 81 slides; pre-pharyngeal region: transverse sections on 101 slides; pharynx: sagittal sections on 95 slides; copulatory apparatus: sagittal sections on 96 slides.

Paratypes: MZU PL.00112: M. Cardoso, *leg.* 20.VII.1999, Derrubadas (State Park of Turvo), RS, Brazil—pre-pharyngeal region: transverse sections on 74 slides; pharynx: sagittal sections on 104 slides; copulatory apparatus: horizontal sections on 74 slides. MZU PL.00113: F. Carbayo *leg.* 21.VI.1999, Derrubadas (State Park of Turvo), RS, Brazil—pre-pharyngeal region: transverse sections on 35 slides; pharynx: sagittal sections on 67 slides; copulatory apparatus: horizontal sections on 44 slides; MZU PL.00114: F. Carbayo, *leg.* 21.VI.1999, Derrubadas (State Park of Turvo), RS, Brazil—preserved in ethanol 70°; MZU PL.00115: F. Carbayo, *leg.* 26.VII.1999, Derrubadas (State Park of Turvo), RS, Brazil—anterior tip: transverse sections on 35 slides; anterior region at the level of the ovaries: transverse sections on 68 slides; copulatory apparatus: sagittal sections on 106 slides.

Type locality. Derrubadas, state of Rio Grande do Sul (RS), Brazil.

Distribution. Rio Grande do Sul (Derrubadas), Brazil.

Diagnosis. Body broad and flat, anterior end pointed, posterior end gradually narrowed. Live specimens with dorsum homogeneously black to the naked eye and venter orange with dark borders. Eyes dorsal, with clear halos; sensory pits in the first third of the body; conspicuous glandular margin; mc:h, 5%–6%; pharynx bell-form; very short esophagus; esophagus: pharynx ratio, 4%–9%; anteriormost testes anterior to ovaries, most posterior ones anterior to pharynx; sperm ducts open into lateral expansions of prostatic vesicle; tubular prostatic vesicle, mainly extrabulbar, consisting of two portions, a laterally expanded T-shaped ental portion, ventrally located, and a sinuous, almost vertically disposed, unpaired ectal portion, with its most distal sinuous part entering the bulbar muscle coat; male atrium relatively short, occupied by dorsal folds of its wall and entally by the truncate, obliquely disposed penis papilla; curved ejaculatory duct opening through the ventral surface of the penis papilla; ovovitelline ducts emerging dorsally and laterally displaced from anterior third of ovaries, and ascending behind gonopore; common glandular ovovitelline duct dorsal to the most ental part of female atrium; vagina as a terminal dorsally

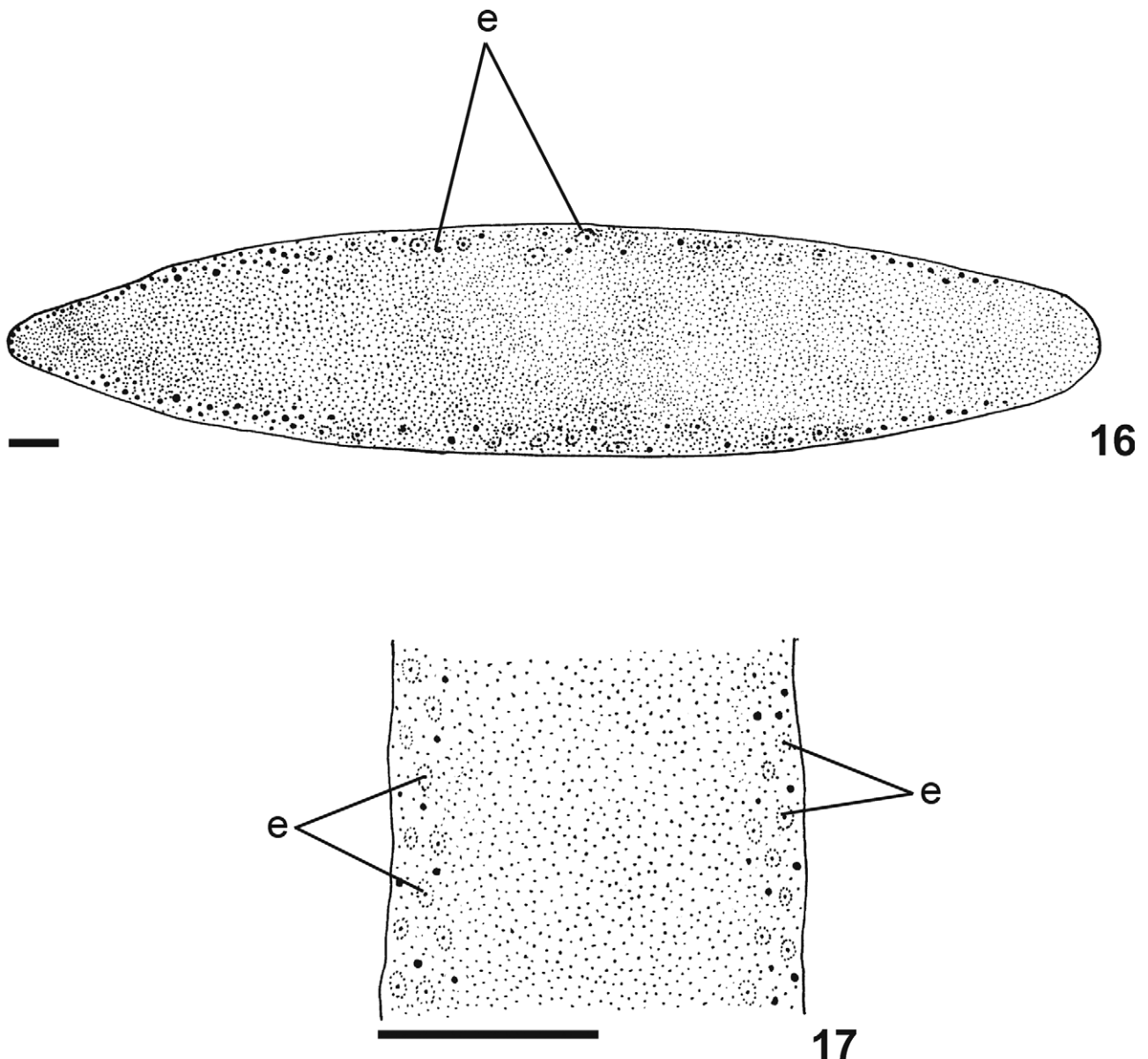
directed diverticulum of female atrium; female atrium, oval-elongate, relatively long, and highly folded; length of female atrium, 156% that of male one; gonopore canal posteriorly inclined; no folds separating male and female atria.

Description. External morphology: Body broad and flat, anterior end pointed, posterior end gradually narrowed. When creeping, maximum length may reach 141 mm (Table 3). Mouth distance from anterior tip varies from 60% to 65% relatively to body length, gonopore from 72% to 79% (Table 3). Live specimens with homogeneously black dorsum. In preserved specimens dorsal colour fades, becoming dark brown. Under the stereomicroscope, dorsal ground-colour light-brown homogeneously covered by dark-brown, dense pigmentation; anterior tip lighter than the rest of the dorsum. Venter orange with dark borders, becoming grayish cream after fixation.

TABLE 3. Measurements, in millimeter, of specimens of *Geoplana carbayoi* **sp. nov.** -: not measured; *: After fixation; **: Specimens with damaged anterior tip (lost or regenerating); DG: distance of gonopore from anterior end; DM: distance of mouth from anterior end; DMG: distance between mouth and gonopore; DPVP: distance between prostatic vesicle and pharyngeal pouch. The numbers given in parentheses represent the position relative to body length.

	Holotype MZUSP PL.01147**	Paratype MZU PL.00112	Paratype MZU PL.00113**	Paratype MZU PL.00114**	Paratype MZU PL.00115**
Maximum length in extension	130	112	91	141	141
Maximum width in extension	11	12	8	15	13
Length at rest	93	76	55	78	70
Width at rest	15	16	12	18	18
Length*	104	78	66	117	114
Width*	15	14	12	15	19
DM*	62 (60)	50 (64)	43 (65)	72 (62)	69 (61)
DG*	75 (72)	60 (77)	52 (79)	87 (74)	82 (72)
DMG*	13	10	9	15	13
DPVP*	3	1.8	1.5	-	-
Creeping sole %	97	-	91	-	-
Ovaries	28 (27)	-	-	-	-
Antermost testes	26 (25)	-	-	-	-
Posteriormost testes	56 (54)	-	37 (56)	-	-
Prostatic vesicle (forked portions)	0.2	0.2	0.5	-	0.3/0.4
Prostatic vesicle (unforked portion)	1.2	0.9	1.7	-	1.7
Penis papilla	0.9	0.7	1.8	-	2.2
Male atrium	1.6	1.4	2.0	-	1.6
Female atrium	2.5	2.0	2.4	-	2.5
Vagina	0.4	-	-	-	0.4
Common oviduct	0.5	-	-	-	0.3

Eyes, initially marginal and uniserial, surround the anterior tip. In paratype MZU PL.00114 they become larger about 1 mm from the tip, forming two series intercalated with smaller eyes, between approximately 2 mm and 5 mm (ca. 2% and 4% of body length, respectively). Between 5 mm and 15 mm (ca. 4% and 12% of body length, respectively), they form two to three series and, after that, the eyes become smaller and appear dorsal with clear halos (Figs. 16, 17), occupying the maximum width of 2.5 mm in paratype MZU PL.00114 (about 18% of body width on each side of the body). After 55 mm from anterior tip (approximately 46% of body length), they become gradually sparser (Fig. 16).

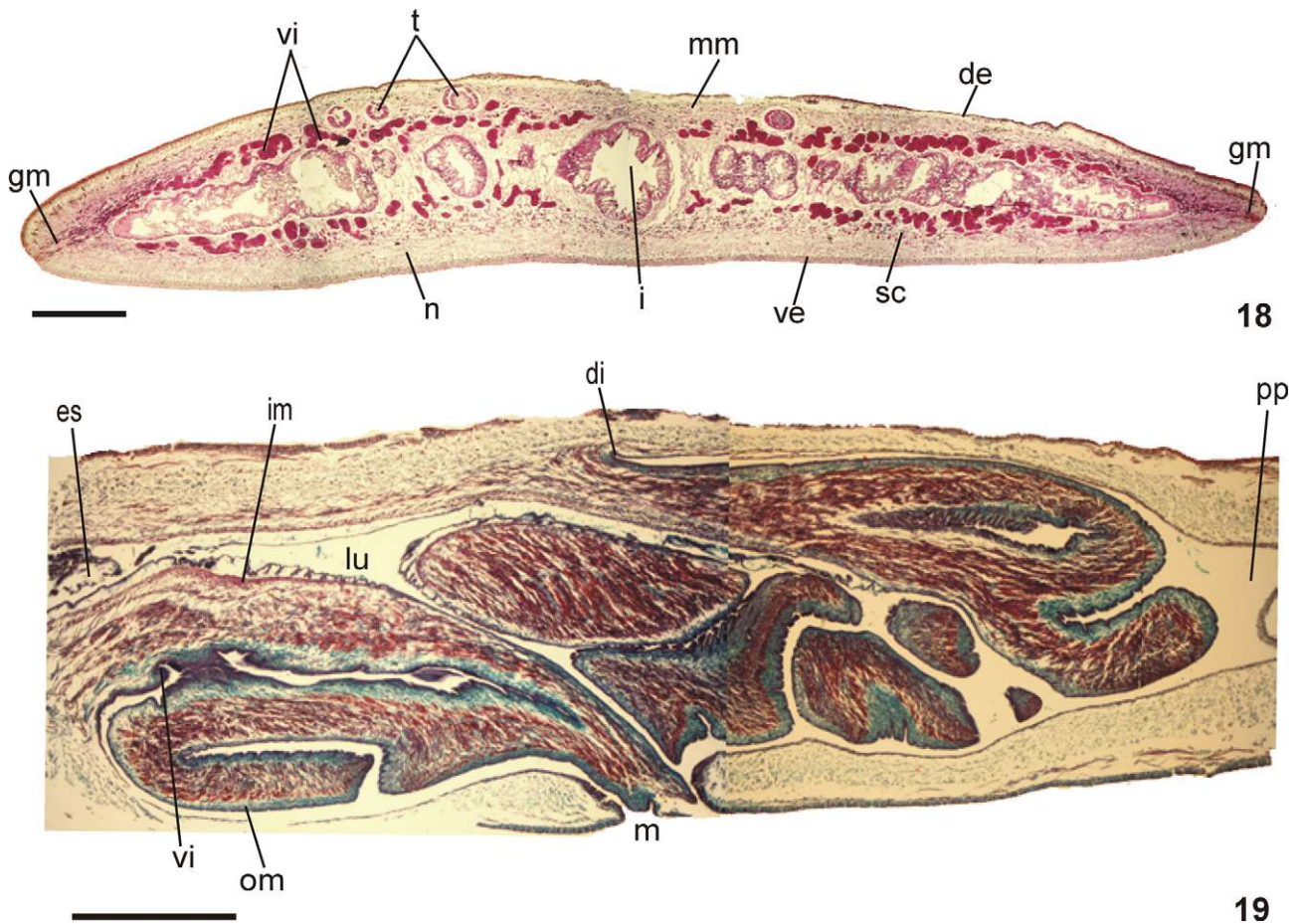


FIGURES 16–17. *Geoplana carbayoi* sp. nov.: (16) colour pattern and (17) detail of eyes pattern of a preserved specimen (paratype MZU PL.00114) in dorsal view. (e) eyes. Scale bar: 5 mm.

Internal morphology. Anterior region: Sensory pits, as simple invaginations, about 35 μm to 48 μm deep, contouring anterior tip, occurring initially at intervals of approximately 25 μm to 35 μm , posteriorly become gradually sparser until they disappear approximately 26 mm from anterior tip (approximately 23% of body length in paratype MZU PL.00115). Eyes (30 μm to 40 μm) initially contour the anterior tip in a single row, and then run along both sides of the body (one or two on each). Cutaneous musculature tripartite, similar to that of pre-pharyngeal region (see next section), but thinner close to the tip; ventral longitudinal fibers absent or very weak in first 0.5 mm of body length. Mesenchymal musculature poorly developed on the anterior tip, with fibers in various directions. Transverse sub-intestinal and supra-intestinal layers appear approximately 1 mm after anterior tip. Rhabditogen cells are rare and sparsely distributed on first 0.5 mm of body length. Three types of secretory cells open through dorsal and ventral epidermis: weakly stained cyanophil cells with amorphous secretion; rhabditogen cells, and erythrophil cells with granular secretion. Only cyanophil cells open through body margins (sensorial border). Small concentrations of erythrophil cells, representing the beginning of the glandular margin, occur ventrally to sensorial border, about 3 mm from the tip (approximately 2.6% of body length in paratype MZU PL.00115).

Epidermis and musculature at pre-pharyngeal region (Fig. 18): Creeping sole broad, 97% of body width, in the holotype. Three types of secretory cells discharge through dorsal epidermis and body margins: (1) abundant

rhabditogen cells with xanthophil secretion (2); few cells with fine xanthophil secretion; (3) few cells with cyanophil amorphous secretion. Glandular margin (Fig. 18) with abundant erythrophil cells with coarse secretion and cyanophil cells amorphous secretion. Creeping sole receives necks of few rhabditogen cells and numerous cells with amorphous cyanophil secretion.

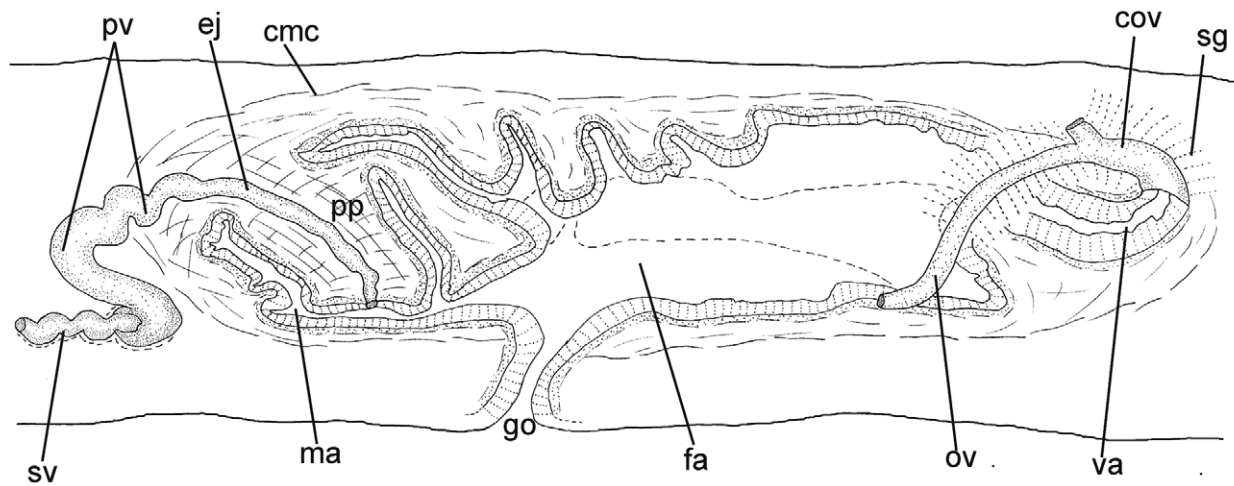


FIGURES 18–19. *Geoplana carbayoi* sp. nov.: (18) pre-pharyngeal region of the holotype in transverse section; (19) pharynx of the holotype in sagittal section. (de) dorsal epidermis, (di) dorsal insertion, (es) esophagus, (gm) glandular margin, (i) intestine, (im) internal musculature, (lu) pharyngeal lumen, (m) mouth, (mm) mesenchymatic muscles, (om) outer musculature, (n) nerve plate, (pp) pharyngeal pouch, (sc) secretory cells, (t) testes, (v) vitellaria, (ve) ventral epidermis, (vi) ventral insertion. Scale bar: 1 mm.

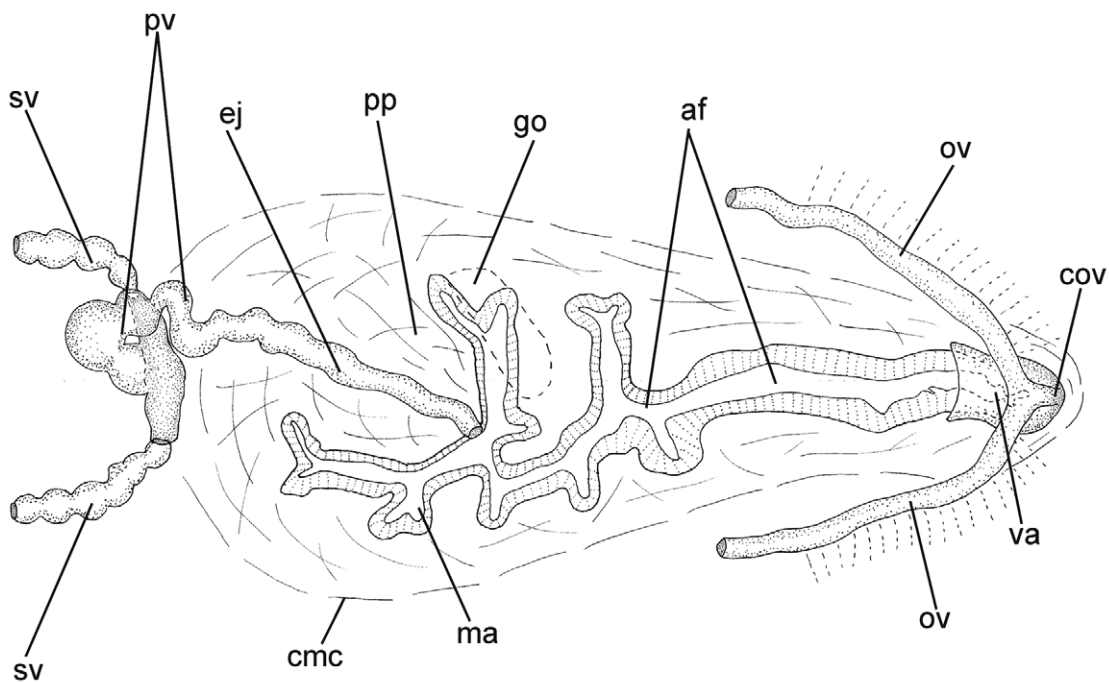
Cutaneous musculature tripartite; longitudinal layer with thick bundles, approximately twice height of circular and diagonal muscle layers. Ventral cutaneous musculature slightly thicker than dorsal musculature at the sagittal plane and paramedianly, but progressively lower towards body margins. Mc:h 5% to 6% (Table 4).

TABLE 4. Cutaneous musculature and body height, in micrometer, in the median region of a transverse section of the pre-pharyngeal region, and ratio of the height of cutaneous musculature to the height of the body (mc:h index) of specimens of *Geoplana carbayoi* sp. nov. Pre-pharyngeal region of the holotype shows artefacts.

	Holotype	Paratype MZU PL.00112
Dorsal musculature	44	63
Ventral musculature	55	68
Body height	1790	2215
Mc:h (%)	5	6



20



21

FIGURES 20–21. *Geoplana carbayoi* sp. nov.: (20) diagrammatic sagittal composite reconstruction of the copulatory apparatus of the holotype; (21) diagrammatic horizontal composite reconstruction of the copulatory apparatus of paratype MZU PL.00112. (cmc) common muscle coat, (cov) common glandular ovovitelline duct, (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (ov) ovovitelline ducts, (pp) penis papilla, (pv) prostatic vesicle, (sv) spermiducal vesicle. Scale bar: 1 mm.

Mesenchymal musculature poorly developed composed of three layers: dorsal subcutaneous with oblique fibers variously oriented (ca. 2–3 fibers thick); supra-intestinal transversal (about 3 fibers thick); and sub-intestinal transversal (ca. 4 fibers thick). In addition, scattered subneural transversal and ventral subcutaneous oblique fibers, as well as dorsoventral ones are present. If existent, longitudinal fibers are indiscernible, few and very scattered.

Pharynx (Fig. 19): Pharynx bell-form with folded margins. Mouth at the level of dorsal insertion in median third of pharyngeal pouch. Esophagus, very short, lined with ciliated columnar epithelium with a few insunk nuclei, receiving some openings of erythrophil secretory cells with granular secretion and bodies located in mesen-

chyme, with muscularis comprising a mainly circular layer and some interposed longitudinal fibers. Esophagus: pharynx ratio, 4%–9%. Pharynx and pharyngeal lumen lined with ciliated columnar epithelium showing several insunk nuclei. Pharyngeal glands with cell bodies located in mesenchyme, mainly anterior and posteriorly as well as lateral to pharyngeal pouch. Three secretory cell types present: cells with coarse granular xanthophil secretion, cells with fine granular erythrophil secretion, and cells with cyanophil amorphous secretion. Outer musculature of pharynx (ca. 40 μm thick) comprises a thin longitudinal subepithelial layer, followed by a thicker circular one, mixed internally with few longitudinal fibers. Towards pharyngeal tip, circular layer becomes as thin as longitudinal one. Inner pharyngeal musculature comprises a thick circular subepithelial layer mixed mainly externally with some longitudinal fibers (135 μm thick). Inner musculature gradually tapers outwards and dorsomedially.

Reproductive apparatus: Testes in two to three irregular rows beneath the dorsal transversal mesenchymatic muscles dorsally to the intestinal branches on each side of the body (Fig. 18) extend from anterior of the ovaries to just anterior of the pharynx. Sperm ducts, pre-pharyngeally subdivided in two or three ductules, dorsal to ovovitelline ducts, at least two ductules medially displaced; post-pharyngeally right and left sperm ducts form spermiducal vesicles, and open into lateral expansions of the vesicle (Figs. 20–22).

Prostatic vesicle tubular, mainly extrabulbar, of two portions, a laterally expanded T-shaped ental portion, ventrally located, and a sinuous, almost vertically disposed, unpaired ectal portion, with the distad sinuous part entering the bulbar muscle coat and continuing into the curved ejaculatory duct which opens through the ventral surface of the penis papilla (Figs. 24, 25). This is a truncate, obliquely disposed ental circular fold which posteriorly communicates with dorsal folds of the male atrium (Figs. 20, 21, 24, 25). Male atrium relatively short (Table 3), occupied by dorsal folds of its wall and entally by the penis papilla.

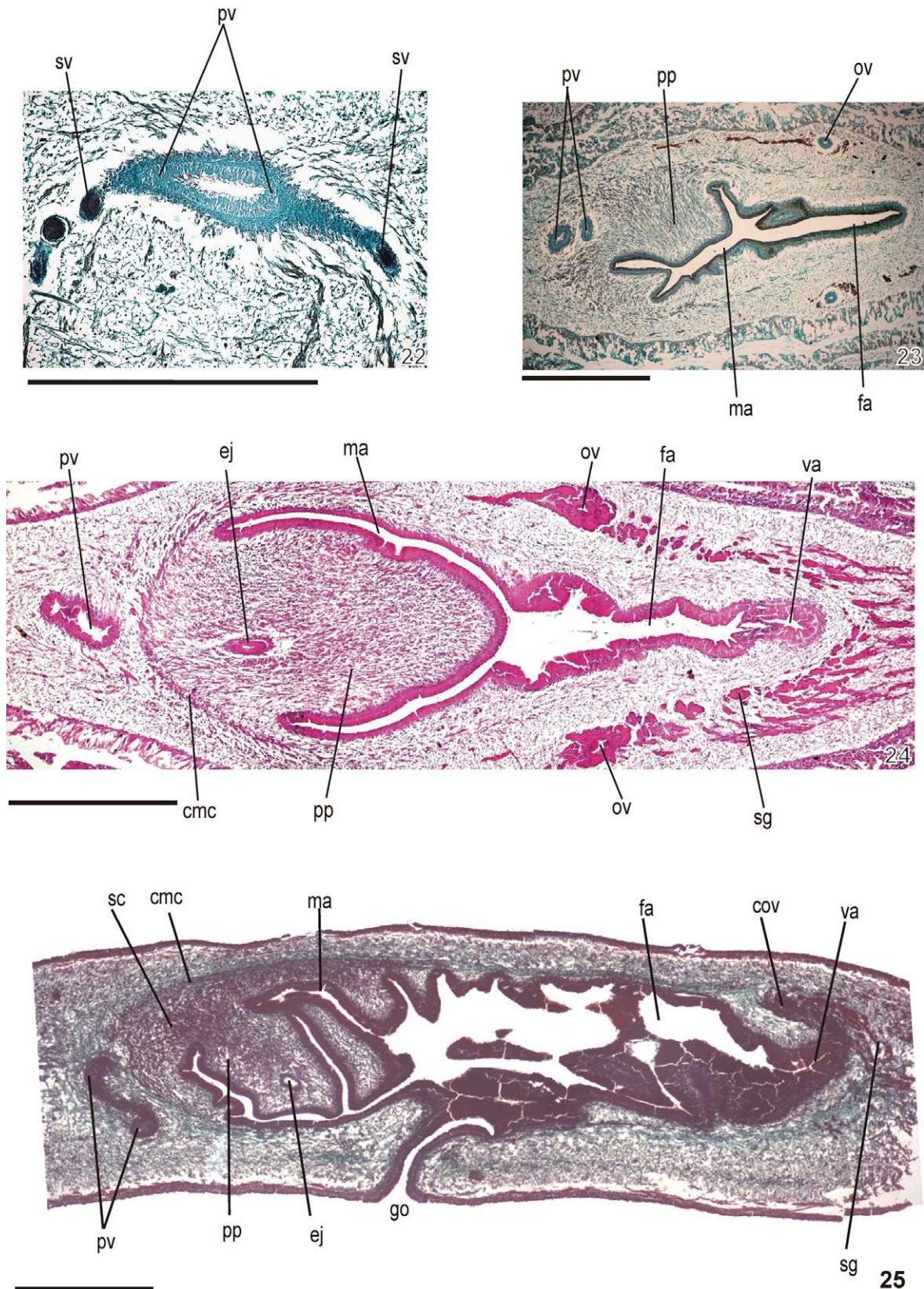
Sperm ducts lined with ciliated cuboidal epithelium; thin muscularis (ca. 4 μm thick) mainly comprised of circular fibers. Prostatic vesicle lined with ciliated tall columnar epithelium, receiving abundant erythrophil granular secretion and coarse granular cyanophil secretion, both from secretory cells with bodies lying in mesenchyme, mainly around vesicle. Muscularis of vesicle mainly comprised of circular fibers, thicker in the ental portion (20–30 μm thick) than the ectal portion (10–20 μm).

Ejaculatory duct lined with ciliated columnar epithelium, receiving openings from secretory cells with amorphous, cyanophil secretion and subepithelial bodies as well as from some intra-papillary cells with erythrophil granular secretion. Muscularis of ejaculatory duct (5–10 μm thick) comprised of mixed circular and longitudinal fibers. Penis papilla lined with non-ciliated columnar epithelium with apical xanthophil layer. Three types of secretory cells run longitudinally in the papilla, with numerous openings into the male atrium through its lining epithelium: (1) cells with granular xanthophil secretion; (2) cells with granular erythrophil secretion; and (3) cells with cyanophil amorphous secretion. Erythrophil and cyanophil cells present cell bodies external to common muscle coat; xanthophil cells, intrapapillary, mainly subepithelial cells bodies. Muscularis (10–15 μm) mainly composed of circular fibers with some mixed longitudinal fibers.

Male atrium with the same lining epithelium as the penis papilla. Three types of secretory cells empty through the epithelium: (1) cells with granular xanthophil secretion and subepithelial cell bodies; (2) cells with granular erythrophil secretion; and (3) cells with cyanophil amorphous secretion. Erythrophil and cyanophil cells present cell bodies external to common muscle coat. Muscularis well developed (15–35 μm) of a circular subepithelial layer, underneath by a longitudinal layer.

Ovaries ovoid in shape, measuring 0.4 mm anterior-posteriorly and 0.25 mm dorso-ventrally in the holotype. Ovovitelline ducts emerge dorsally and laterally displaced from the end of anterior third of ovaries, lead backwards immediately dorsal to nerve plate; behind gonopore, ascend posteriorly and medially, to unite dorsally with the female atrium (proflex condition with dorsal approach), to form the common glandular ovovitelline duct. The latter, dorsal to the most ental part of female atrium, recurves anteriorly to communicate with the vagina a terminal dorsally directed diverticulum of female atrium (Table 3). Female atrium, oval-elongate in shape, relatively long, and highly folded (Figs. 20, 21, 23–25). Length of female atrium, 156% of male atrium length in the holotype (Table 3).

Paired ovovitelline ducts lined with ciliated cuboidal epithelium; near to the copulatory apparatus this grades into a ciliated columnar epithelium that also lines the common glandular ovovitelline duct. Paired ovovitelline ducts and common glandular ovovitelline duct with muscularis comprising mixed circular and interposed longitudinal muscle fibres. Abundant shell glands with xanthophil secretion empty into distal third of ascending portion of paired ovovitelline ducts, besides into common glandular ovovitelline duct (Figs. 20, 21, 24, 25).



FIGURES 22–25. *Geoplana carbayoi* sp. nov.: (22) detail of paired portions of the prostatic vesicle of paratype MZU PL.00112 in horizontal section; (23) copulatory apparatus of paratype MZU PL.00112 in horizontal section; (24) copulatory apparatus of paratype MZU PL.00113 in horizontal section; (25) copulatory apparatus of the holotype in sagittal section. (cmc) common muscle coat, (cov) common glandular ovovitelline duct, (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (pp) penis papilla, (pv) prostatic vesicle, (sc) secretory cells, (sg) shell glands, (sv) spermiducal vesicle, (va) vagina. Scale bar: 1 mm.

Female atrium and vagina lined by tall columnar to pseudostratified epithelium with strongly xanthophil cytoplasm, and exhibiting irregular height and multilayered aspect in some places (Fig. 25). Entally, epithelial lining of vagina ciliated. Vagina and female atrium receive abundant xanthophil granular and cyanophil amorphous secretions. Cell bodies of cyanophil glands are located between fibers of the atrial stroma or external to the common muscle coat and those of xanthophil cells are internal to the common muscle coat. Muscularis (15–20 µm) composed mainly of circular fibers mixed with some longitudinal fibers.

Gonopore canal posteriorly inclined. Male and female atria with ample communication, without separating folds (Figs. 20, 25). Common muscle coat with circular, longitudinal and oblique fibers, thickest entally and along dorsal wall of male, thinner around female atrium. A stroma with sparse mixed muscle fibres separates the atrial muscularis and common muscle coat.

Vitellaria, situated between intestinal branches, open into the ovovitelline ducts.

Remarks. Vitellaria were well developed in the holotype, although in maturation in paratypes MZU PL.00112 and MZU PL.00113. In paratype MZU PL.00113, length of female atrium relatively to male atrium is shorter (95%, see table 3). Paratypes MZU PL.00113 and MZU PL.00114 were found in copulation.

Geoplana baptistae sp. nov. Leal-Zanchet & Oliveira

Geoplana sp. 3: Castro & Leal-Zanchet, 2005

Etymology. The specific name honours MSc. Vanessa dos Anjos Baptista and her collaboration in collecting several specimens of land planarians which were deposited in the scientific collection of the Instituto de Pesquisas de Planárias (UNISINOS).

Type material. Holotype: MZUSP PL.01148: K. A. Kopp, *leg.* 04.VII.2001, Santa Maria, RS, Brazil—anterior region in three parts: transverse sections on 140 slides; pre-pharyngeal region: transverse sections on 13 slides; pharynx: sagittal sections on 46 slides; copulatory apparatus: sagittal sections on 30 slides.

Paratypes: MZU PL.00116: D. Cechin, *leg.* 19.XI.2000, Santa Maria, RS, Brazil—preserved in ethanol 70°; MZU PL.00117: V. S. Lemos, *leg.* 13.I.2001, Santa Maria, RS, Brazil—pre-pharyngeal region: transverse sections on 18 slides; pharynx: sagittal sections on 17 slide; copulatory apparatus: sagittal sections on 52 slides; MZU PL.00118: R. A. Castro *leg.* 13.I.2001, Santa Maria, RS, Brazil—preserved in ethanol 70°; MZU PL.00119: A. L. R. Seitenfus *leg.* 13.I.2001, Santa Maria, RS, Brazil—preserved in ethanol 70°; MZU PL.00120: R. A. Castro, *leg.* 31.III.2001, Santa Maria, RS, Brazil—anterior tip: transverse sections on 41 slides; anterior region at the level of the ovaries: transverse sections on 23 slides; pre-pharyngeal region: transverse section on 13 slides; pharynx: transverse sections on 40 slides; copulatory apparatus: sagittal sections on 22 slides; MZU PL.00121: R. A. Castro *leg.* 31.III.2001, Santa Maria, RS, Brazil—preserved in ethanol 70°; MZU PL.00122: I. Fick, *leg.* 21.VII.1999, Santa Maria, RS, Brazil—preserved in ethanol 70°. MZU PL.00123 R. A. Castro, *leg.* 26.VII.2001, Santa Maria, RS, Brazil—preserved in ethanol 70°; MZU PL.00124: V. A. Baptista, *leg.* 29.IX.2001, Santa Maria, RS, Brazil—pre-pharyngeal region: transverse sections on 51 slides; pharynx: sagittal sections on 80 slides; copulatory apparatus: sagittal sections on 142 slides; MZU PL.00125: V. M. Dias *leg.* 06.IV.2002, Santa Maria, RS, Brazil—anterior tip: transverse sections on 71 slides; anterior region at the level of the ovaries: transverse sections on 26 slides; pre-pharyngeal region: transverse section on 16 slides; pharynx: sagittal section on 31 slides; copulatory apparatus: transverse sections on 15 slides; MZU PL.00126: L. B. Matos *leg.* 15.XII.2002, Santa Maria, RS, Brazil—preserved in ethanol 70°.

Type locality. Santa Maria, state of Rio Grande do Sul (RS), Brazil.

Distribution. Rio Grande do Sul (Santa Maria), Brazil.

Diagnosis. Body rather elongate, with almost parallel margins, broad and flat, anterior end pointed, posterior end gradually narrowed. Live specimens with dorsum dark-brown to the naked eye and venter orange to light brown. Eyes dorsal, with inconspicuous clear halos; sensory pits restricted to the proximity of anterior tip; poorly developed glandular margin with three types of secretory cells; mc:h, 6%–11%; pharynx bell-form; very short esophagus; esophagus: pharynx length, 7% to 9%; anteriormost testes anterior to ovaries, most posterior ones near to root of pharynx; sperm ducts open laterally into proximal part of diverticula of prostatic vesicle; prostatic vesicle, mainly extrabulbar, tubular, consisting of two portions, a laterally expanded T-shaped ental portion, ventrally

located, and a sinuous, mainly horizontally located distal portion which enters the bulbar muscular coat; male atrium relatively short, with the entire cavity occupied by the conical penis papilla; straight ejaculatory duct opens through the tip of the symmetrical papilla; ovovitelline ducts emerge dorsally from end of anterior third or median third of ovaries, and ascending behind gonopore; common glandular ovovitelline duct short; vagina as a dorsally curved ental portion of female atrium; female atrium oval-elongate, with an ample lumen, a little narrower in the ental third, lined by an high columnar to pseudostratified epithelium with lacunae; male atrium shorter than female atrium; length of female atrium, 164% that of male one; straight gonopore canal; no folds separating male and female atria.

Description. External morphology. Body rather elongate, with almost parallel margins, broad and flat, anterior end pointed, posterior end gradually narrowed. When crawling, maximum length reaches 120 mm (Table 5). Mouth distance from anterior tip varies from 58% to 72%; gonopore between 71% and 83%, relative to body length (Table 5). Live specimens with dark brown dorsum to the naked eye (Fig. 26). In preserved specimens dorsal colour fades, becoming light brown with darker margins; anterior extremity lighter than the rest of the dorsum. Under the stereomicroscope, dorsal ground-colour brown or gray covered by dense dark-brown pigmentation. Venter orange to light brown, becoming grayish in preserved specimens.

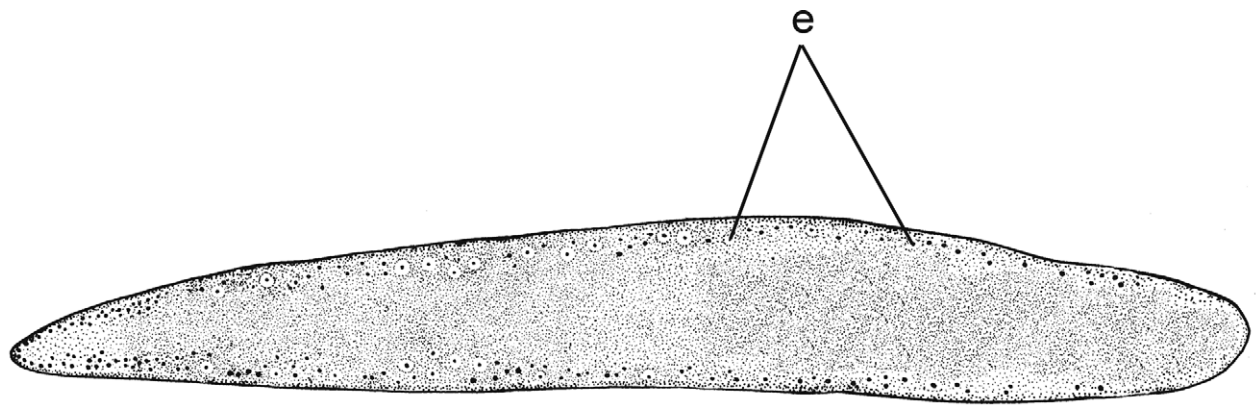


FIGURE 26. *Geoplana baptistae* sp. nov.: photograph of a live specimen (paratype MZU PL.00124) in dorsal view. Scale bar: 30 mm.

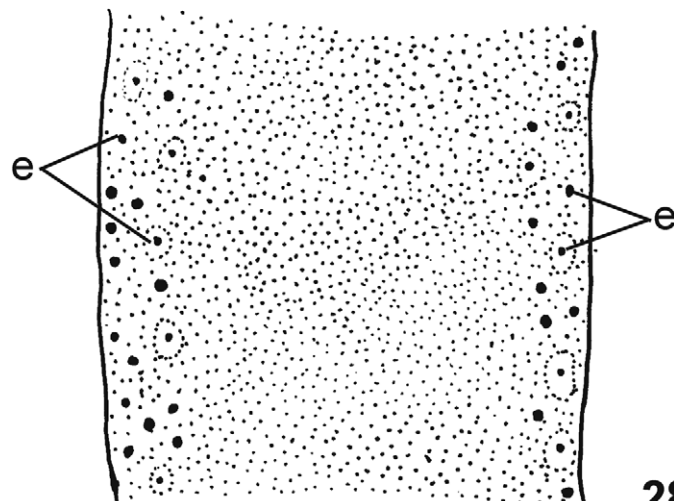
Eyes uniserially surround anterior tip, becoming pluriserial after 1 mm from the tip in paratype MZU PL.00124 (about 1% of body length). Initially, they form two series, the more dorsal comprising the largest eyes. Between 4 mm and 12 mm (approximately 5% and 15% of body length) behind anterior end, these form three to four series near to body margins. After that, they become more dorsal and surrounded by inconspicuous clear halos (Figs. 27, 28). Approximately after 28 mm from anterior tip (about 35% of body length), they form a lateral band on each side of the dorsum, occupying the maximum width of 2 mm on each side of the body (18% of body width on each side of the body). Towards posterior end, they become less numerous (Fig. 27).

Internal morphology. Anterior region: Sensory pits, as simple invaginations, about 30 μ m to 47 μ m deep, contouring anterior tip, occurring initially at intervals of about 25 μ m, posteriorly becoming gradually sparser until

they disappear approximately at 10 mm from anterior tip (approximately 14% of body length in the holotype). Eyes (20 μ m to 38 μ m) contour the anterior tip in a single row; after that run along both sides of the body (two or three on each side). Cutaneous musculature tripartite, similar to that of pre-pharyngeal region (see next section), poorly developed close to the tip. Ventral cutaneous longitudinal muscles gradually become more developed laterally, reaching the same thickness than medially, about 0.4 mm after the tip. Mesenchymal musculature poorly developed in anterior tip with fibers in various directions. Transversal sub-intestinal mesenchymal layer comprising oblique fibres, together with some traverse fibers aggregate ventrally, about 1.4 mm after the anterior tip. Openings of rhabditogen cells and erythrophil cells are absent on first 100 μ m of body length. Weakly stained cyanophil cells with amorphous secretion open throughout the anterior tip. After that, three types of secretory cells open through dorsal and ventral epidermis: weakly stained cyanophil cells with amorphous secretion; rhabditogen cells, and erythrophil cells with granular secretion. There are only openings of cyanophil cells through body margins (sensorial border). Small concentrations of erythrophil cells, representing the beginning of the glandular margin, appear approximately 10 mm from the anterior tip (about 14% of body length in the holotype).



27

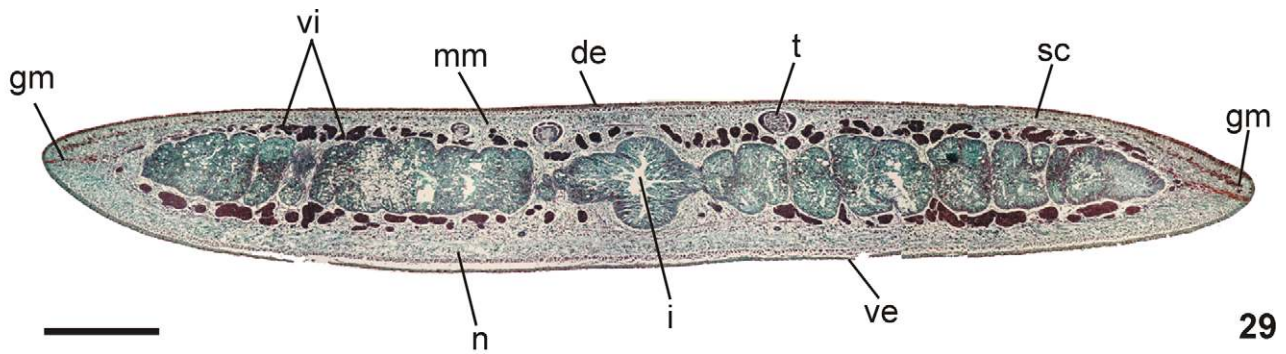


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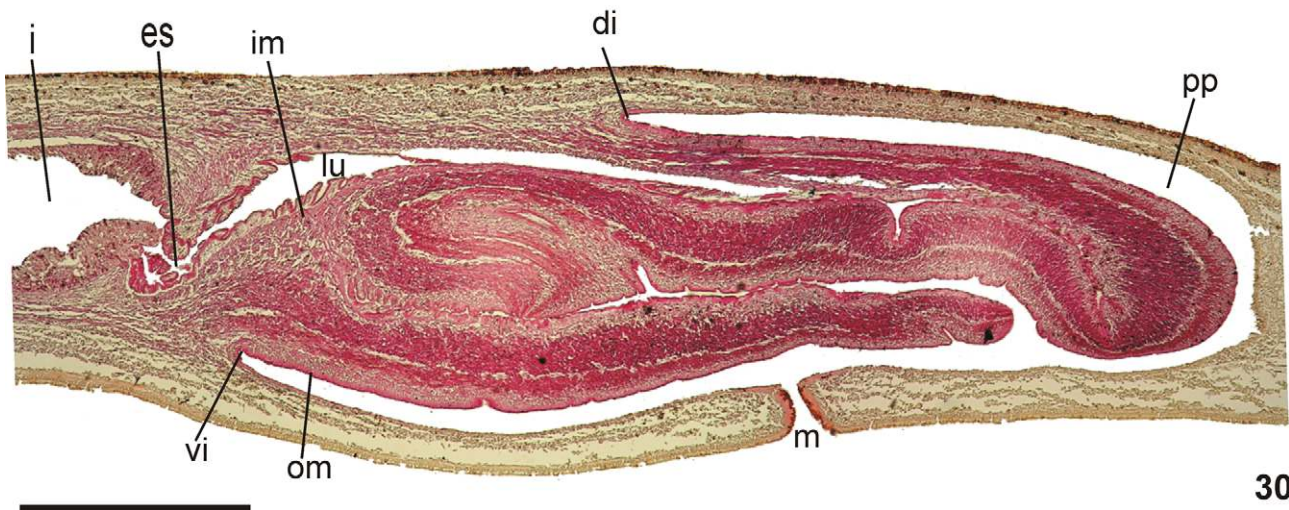
FIGURES 27–28. *Geoplana baptistae* sp. nov.: (27) colour pattern of a preserved specimen (paratype MZU PL.00122) in dorsal view; (28) detail of eyes pattern of a preserved specimen (paratype MZU PL.00124) in dorsal view. (e) eyes. Scale bar: 5 mm.

TABLE 5. Measurements, in millimeter, of specimens of *Geoplana baptistae* sp. nov. -: not measured; *: After fixation; **: Specimens with damaged anterior tip (lost or regenerating); DG: distance of gonopore from anterior end; DM: distance of mouth from anterior end; DMG: distance between mouth and gonopore; DPVP: distance between prostatic vesicle and pharyngeal pouch. The numbers given in parentheses represent the position relative to body length.

	Holotype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype
	MZU	MZU	MZU	MZU	MZU	MZU	MZU	MZU	MZU	MZU	MZU	MZU
	PL.001148	PL.001116	PL.001117	PL.001118	PL.001119	PL.00120	PL.00121	PL.00122	PL.00123	PL.00124	PL.00125	PL.00126
	**	**	**	**	**	**	**	**	**	**	**	**
Maximum length in extension	-	65	120	70	70	55	-	70	31	85	70	50
Maximum width in extension	-	4	8	5	8	5	-	8	5	12	5	4
Length at rest	-	45	70	40	60	43	-	50	17	60	25	30
Width at rest	-	8	10	6	10	6	-	10	8	15	10	5
Length*	72	42	97	55	50	43	28	62	30	80	53	47
Width*	10	8	10	7	6	7	6	7	7.5	13	8	5
DM*	42	27	62	32	34	31 (72)	19	40.5	20	50	32	29
	(58)	(64)	(64)	(58)	(68)	(68)	(68)	(65)	(67)	(63)	(60)	(62)
DG*	53	33	73	39	41	34	23	49	25	59	41	38
	(74)	(79)	(75)	(71)	(82)	(79)	(82)	(79)	(83)	(74)	(77)	(81)
DMG*	9	9	9	7	7	3	4	8.5	5	9	9	9
DPVP*	1.5	-	2	-	-	1	-	-	-	2.5	2	-
Creeping sole %	94	-	99	-	-	99	-	-	-	99	-	-
Ovaries	11.5 (16)	-	-	-	-	-	-	-	-	-	13 (25)	-
Anterior most testes	8.7 (12)	-	-	-	-	-	-	-	-	-	10 (19)	-
Posterior most testes	40	-	59 (61)	-	-	-	-	-	-	29 (55)	28 (53)	-
	(55)											
Prostatic vesicle (forked portions)	0.1	-	0.1	-	-	0.1	-	-	-	0.2	0.3	-
Prostatic vesicle (unforked portion)	1.2	-	1.5	-	-	0.6	-	-	-	1.5	1.5	-
Penis papilla	1.5	-	1.3	-	-	0.7	-	-	-	1.2	2	-
Male atrium	1.1	-	1.5	-	-	0.3	-	-	-	1.1	1.9	-
Female atrium	1.8	-	1.7	-	-	0.9	-	-	-	2.1	1.0	-
Vagina	0.2	-	0.3	-	-	0.1	-	-	-	0.3	0.1	-
Common oviduct	0.3	-	0.3	-	-	0.1	-	-	-	0.2	0.2	-



29



30

FIGURES 29–30. *Geoplana baptistae* sp. nov.: (29) pre-pharyngeal region (paratype MZU PL.00124) in transverse section; (30) pharynx of paratype MZU PL.00120 in sagittal section. (di) dorsal insertion, (es) esophagus, (i) intestine, (im) internal musculature, (lu) pharyngeal lumen, (m) mouth, (mm) mesenchymatic muscles, (n) nerve plate, (om) outer musculature, (sc) secretory cells, (t) testes, (v) vitellaria, (vi) ventral insertion. Scale bar: 1 mm.

Epidermis and musculature at pre-pharyngeal region (Fig. 29): Creeping sole broad, occupying 94% to 99% of body width (Table 5). Three types of secretory cells open through dorsal epidermis and body margins: (1) abundant rhabditogen cells with xanthophil secretion and less frequent (2) cyanophil cells with fine granular secretion, (3) erythrophil cells with fine granular secretion, and (4) xanthophilous cells with coarse granular secretion. Creeping sole receives abundant cells with cyanophil coarse granular secretion, as well as less numerous rhabditogen cells and erythrophil cells with fine granular secretion. Poorly developed glandular margin (Fig. 29) comprising cells with coarse granular, densely packed xanthophil secretion and cells with coarse granular, loosely disposed erythrophil secretion, plus a few cells with coarse granular cyanophil secretion.

Cutaneous musculature with the usual three layers, longitudinal layer with thick bundles, being approximately at least double the height of the other two. Laterally to the sagittal plane, the cutaneous musculature remains thick, and close to the body margins, it becomes progressively lower. Mc:h 6% to 11% (Table 6).

Mesenchymal musculature mainly composed of transversal, oblique, and dorsoventral fibres, the former ones constitute a supra-intestinal transversal (3–4 fibers thick) and a sub-intestinal transversal layer (2–3 fibers thick). Oblique fibers constitute a dorsal, subcutaneous layer (4–6 fibers thick). Longitudinal fibers were indiscernible.

Pharynx (Fig. 30): Pharynx bell-form with folded walls; dorsal insertion approximately at the same transverse level as the mouth, both located in the middle third of pharyngeal pouch. Esophagus short, partially projected ventrally to intestine, lined with ciliated cuboidal epithelium mainly presenting insunk nuclei and with some erythrophil secretory cells with granular secretion and cell bodies in the mesenchyme; esophageal muscularis comprises a circular muscle layer with longitudinal interposed fibers. Esophagus: pharynx length, 7% to 9%. Pharynx and pharyngeal lumen lined with ciliated columnar epithelium exhibiting insunk nuclei. Pharyngeal glands with cell bodies

located in mesenchyme, mainly anteriorly to pharyngeal pouch. Three secretory cell types: (1) cells with fine granular erythrophil secretion; 2) cells with mixed cyanophil and erythrophil fine granular secretion and (3) less numerous cells with cyanophil amorphous secretion. Outer musculature of pharynx (ca. 23 μm thick) with a thin longitudinal subepithelial layer, followed by a thicker circular one, mixed internally with few longitudinal fibers. Towards pharyngeal tip, circular layer becomes as thin as longitudinal one. Inner pharyngeal musculature (ca. 50 μm thick) of thick circular subepithelial layer, mixed with some longitudinal fibers. Inner musculature gradually diminishes towards pharyngeal tip.

TABLE 6. Cutaneous musculature and body height, in micrometer, in the median region of a transverse section of the pre-pharyngeal region, and ratio of the height of cutaneous musculature to the height of the body (mc:h index) of specimens of *Geoplana baptistae* **sp. nov.** * Specimen collected in a pitfall trap and directly fixed in formaldehyde.

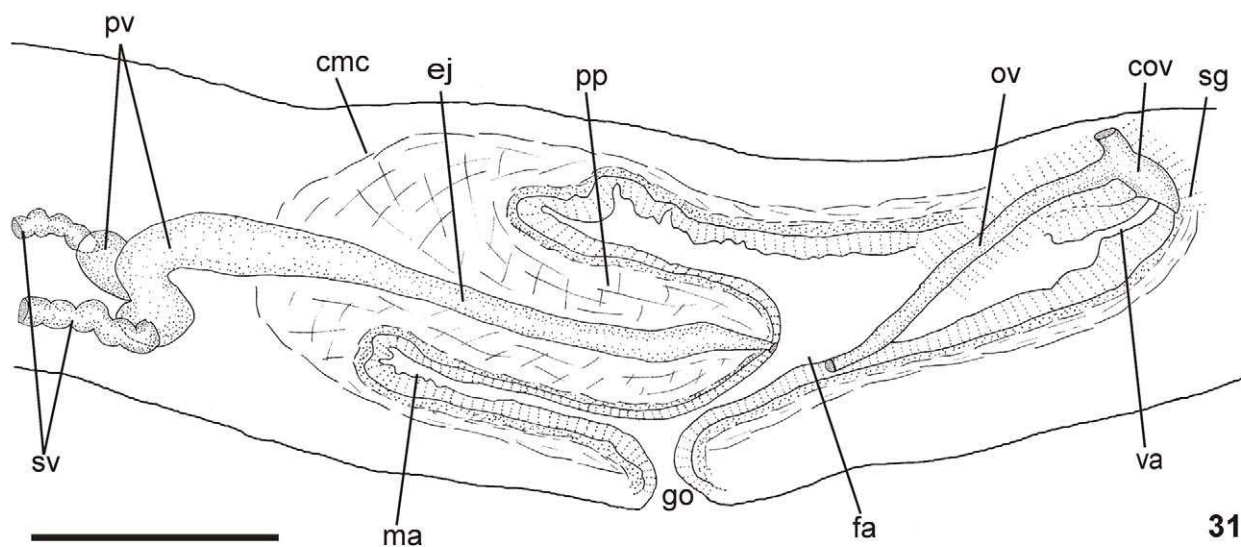
	Holotype*	Paratype MZU PL.00117	Paratype MZU PL.00124	Paratype MZU PL.00125
Dorsal musculature	49	35	49	31
Ventral musculature	80	46	58	53
Body height	1140	1340	1660	1250
Mc:h (%)	11	6	6	7

Reproductive apparatus: Testes beginning anteriorly to ovaries and extending up to the same transverse level as the ventral insertion of the pharynx (Table 5), comprising one or two irregular rows, dorsal to the intestinal branches on each side of the body (Fig. 29). Pre-pharyngeally, sperm ducts, subdivided in two or three ductules, dorsal to ovovitelline ducts, at least one ductule laterally displaced. Laterally to the posterior third of pharynx, these form spermiducal vesicles, opening laterally into proximal part of diverticula of prostatic vesicle (Figs 31, 32). Prostatic vesicle, mainly extrabulbar, tubular, of two portions, a laterally expanded ental portion, ventrally located, and a mainly horizontally located distal portion which enters the bulbar muscular coat, continuing into the ejaculatory duct. The latter traverses the conical and symmetrical penis papilla to open through its tip. Male atrium oval-elongate, relatively short, with few, low folds and with the entire cavity occupied by the conical penis papilla which may extend into the female atrium (Table 5; Figs. 31–36, 38).

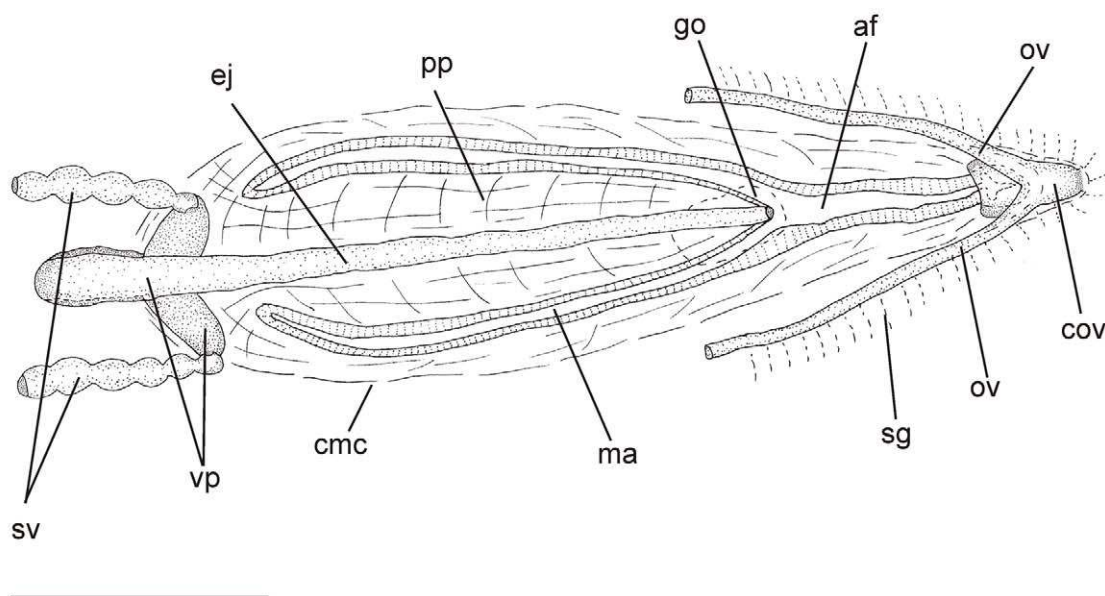
Sperm ducts lined with ciliated cuboidal epithelium; thin muscularis (ca. 3 μm thick) mainly comprised of circular fibers. Prostatic vesicle lined with irregular ciliated columnar to ciliated pseudostratified epithelium, gradually diminishing its height towards ejaculatory duct. Erythrophil cells with granular secretion and bodies lying in mesenchyme, mainly around and anteriorly to the vesicle, show numerous openings into vesicle. Muscularis of proximal and distal portions of vesicle 20–25 μm thick and 15 μm thick in diverticula comprising interwoven circular, oblique, and longitudinal fibers.

Ejaculatory duct lined with ciliated columnar epithelium, receiving numerous openings from secretory cells with amorphous, cyanophil secretion and subepithelial bodies. It is coated with a muscularis (ca. 5 μm thick) of circular fibers interposed with some longitudinal ones. Penis papilla lined with non-ciliated columnar epithelium. Three types of secretory cells run longitudinally in the papilla, with numerous openings through its lining epithelium: (1) cells with fine densely arranged granular heavily stained erythrophil secretion; (2) cells with granular xanthophil secretion; and (3) cells with cyanophil amorphous secretion. Erythrophil and cyanophil cells present cell bodies external to common muscle coat; xanthophil cells, subepithelial cells bodies. Muscularis (8–25 μm) mainly of circular layer with some mixed longitudinal fibers; thinner towards the tip of the papilla. Longitudinal, radial and oblique muscle fibers cross the papilla.

Epithelial lining of male atrium, columnar (about 40–50 μm), non-ciliated, showing xanthophil apical secretion. Two types of secretory cells, empty through the epithelium: abundant cells with cyanophil amorphous secretion and cells with fine granular xanthophil secretion, both with cell bodies internal to common muscle coat. In addition, there are some cells with fine granular erythrophil secretion and cell bodies external to common muscle coat. Muscularis well developed (40–80 μm) throughout male atrium, comprising circular subepithelial fibers and subjacent longitudinal ones.



31

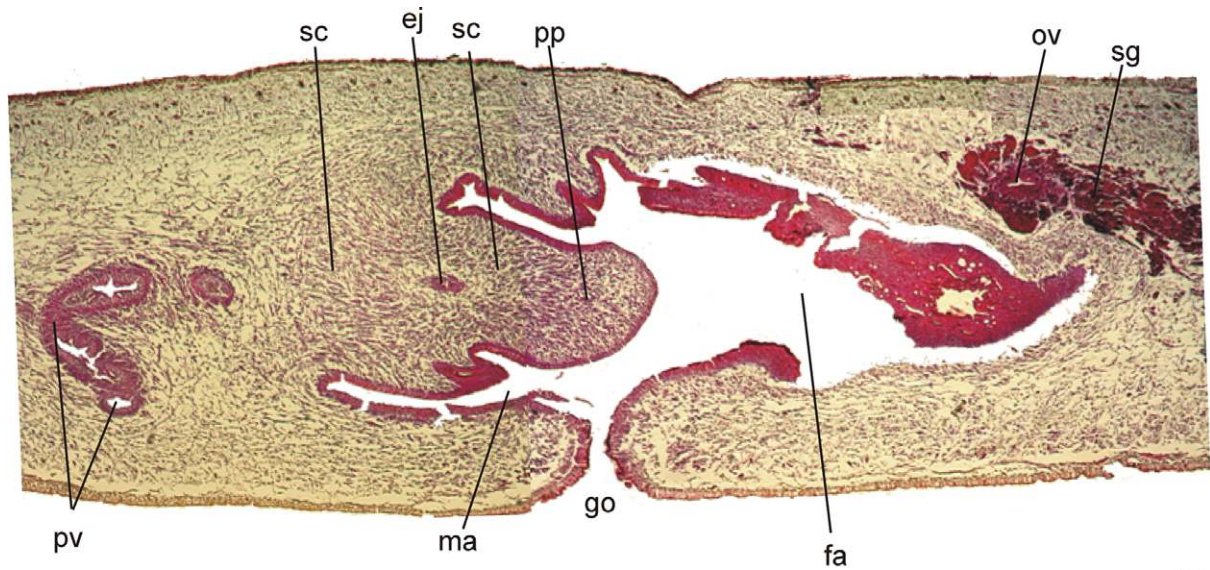


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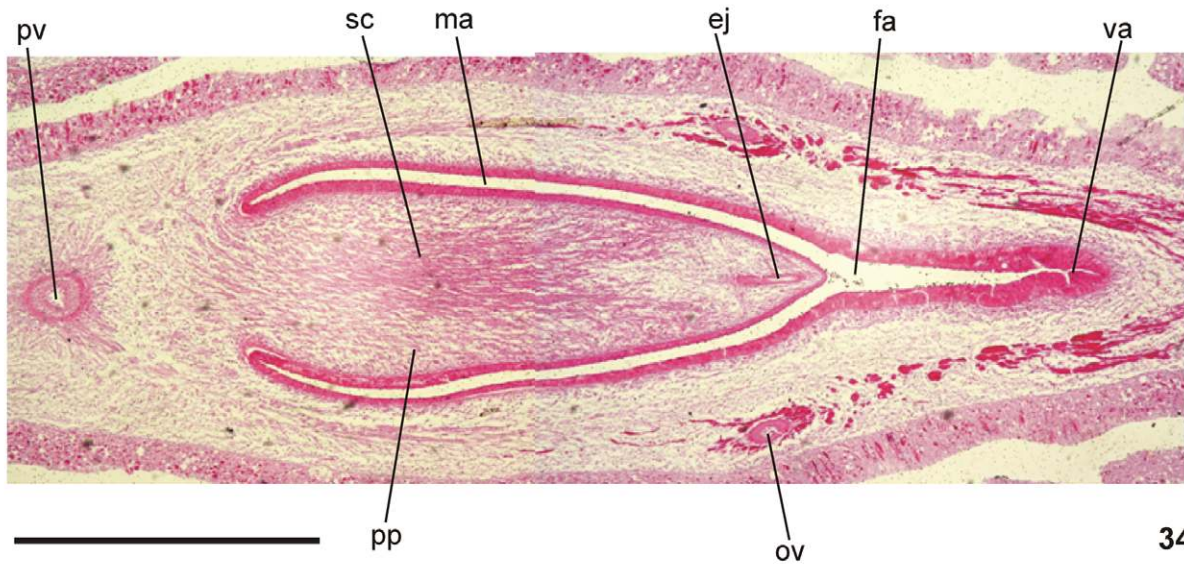
FIGURES 31–32. *Geoplana baptistae* sp. nov.: (31) diagrammatic sagittal composite reconstruction of the copulatory apparatus of the holotype; (32) diagrammatic horizontal composite reconstruction of the copulatory apparatus of paratype MZU PL.00125. (cmc) common muscle coat, (cov) common glandular ovovitelline duct, (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (ov) ovovitelline ducts, (pp) penis papilla, (pv) prostatic vesicle, (sc) secretory cells, (sv) spermiducal vesicle, (va) vagina. Scale bar: 1 mm.

Ovaries oval-elongate in shape, 0.5 mm long anterior-posteriorly and approximately 0.2 mm dorso-ventrally in the holotype. Ovovitelline ducts emerging dorsally from end of anterior third or median third of ovaries, then leading backwards immediately dorsal to nerve plate. Behind gonopore, ovovitelline ducts ascend posteriorly and medially inclined, to unite dorsally to the female atrium (proflex condition with dorsal approach), thus forming the common glandular ovovitelline duct. A conspicuous common glandular ovovitelline duct opens into ental portion of female atrium. Female atrium oval-elongate in shape, with a spacious lumen, a little narrower in the ental third, with elongate lateral folds arising from its floor. Length of female atrium, 164% of male atrium length (Table 5). Ental portion presents a dorsally directed diverticulum (vagina) (Table 5, Figs. 31, 32, 34–36).

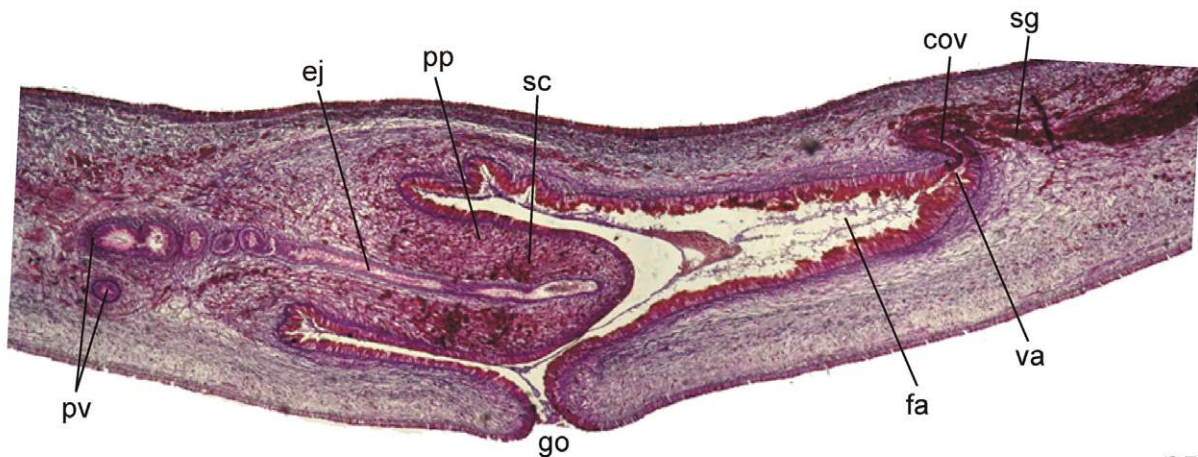
Paired ovovitelline ducts lined by ciliated cuboidal to columnar epithelium; muscle coat of paired and common ovovitelline ducts mainly comprising circular fibers and some interposed longitudinal fibers. Shell glands with xanthophil secretion opening into distal ascending portion of paired ovovitelline ducts, and also into common glandular ovovitelline duct (Figs. 31–33, 35).



33

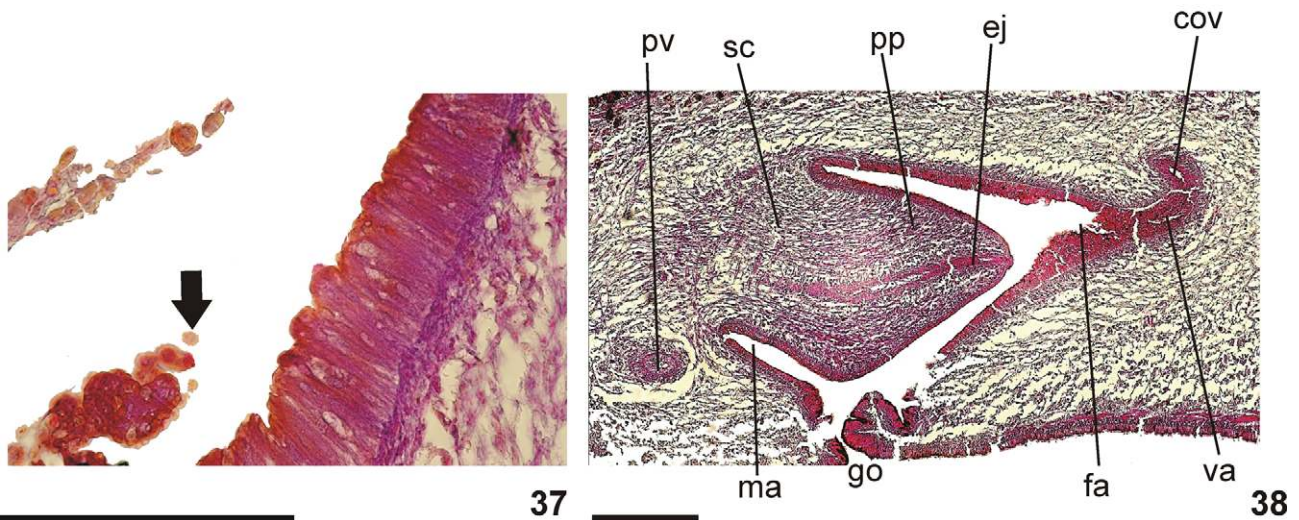
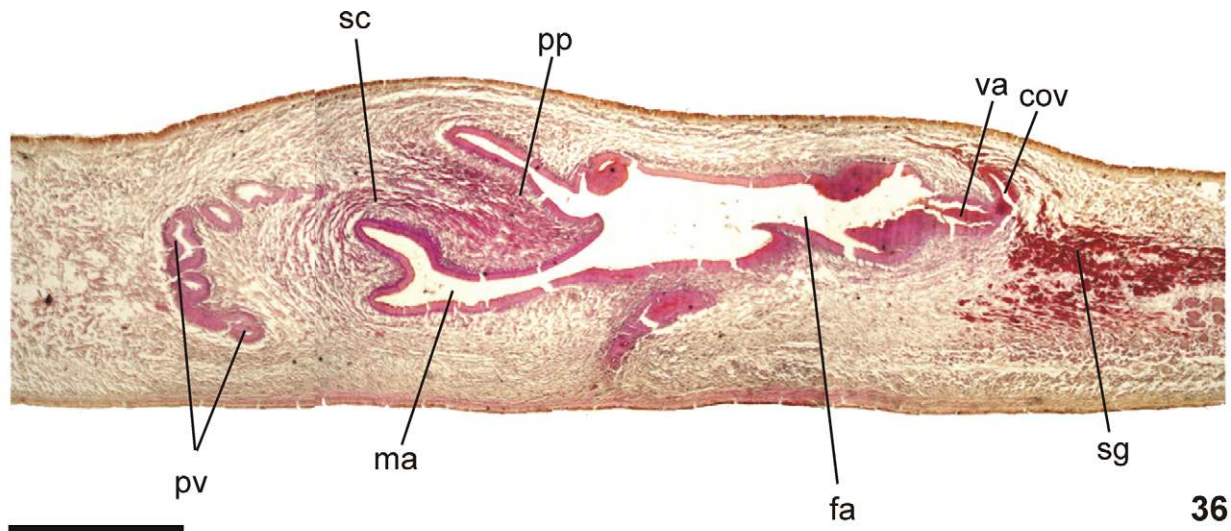


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FIGURES 33–35. *Geoplana baptistae* sp. nov.: (33) copulatory apparatus of paratype MZU PL.00124 in sagittal section; (34) copulatory apparatus of paratype MZU PL.00125 in horizontal section; (35) copulatory apparatus of the holotype in sagittal section. (cmc) common muscle coat, (cov) common glandular ovovitelline duct, (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (pp) penis papilla, (pv) prostatic vesicle, (sc) secretory cells, (sg) shell glands, (va) vagina. Scale bar: 1 mm.



FIGURES 36–38. *Geoplana baptistae* sp. nov.: (36) copulatory apparatus of paratype MZU PL.00120 in sagittal section; (37) detail of epithelial lining of the female atrium of paratype MZU PL.00120 in sagittal section; (38) copulatory apparatus of paratype MZU PL.00117. (cmc) common muscle coat, (cov) common glandular ovovitelline duct, (ej) ejaculatory duct, (fa) female atrium, (go) gonopore, (ma) male atrium, (pp) penis papilla, (pv) prostatic vesicle, (sv) spermiducal vesicle, (va) vagina. The arrow indicates apocrine secretion in the female atrium. Scale bars: 1 mm (Figs. 36; 38); 0.1 mm (Fig. 37).

Lining epithelium of vagina and female atrium columnar (approximately 50 μ m) with lacunae, irregular in height, becoming pseudostratified in various parts of female atrium (100–160 μ m) (Figs. 33, 35, 37); non-ciliated in female atrium and ciliated in vagina. Three types of secretory cells empty through the epithelium: abundant cells with cyanophil amorphous secretion and cell bodies external to common muscle coat; cells with fine granular xanthophil secretion and cell bodies internal to common muscle coat; and cells with fine granular erythrophil secretion and cell bodies external to common muscle coat. Female atrium with muscularis of interwoven circular and longitudinal fibers, thinner (15–25 μ m) than in male atrium. Muscularis of vagina mainly of circular fibers with some interposed longitudinal fibers (5–8 μ m).

Gonopore canal approximately vertical in sagittal plane. Male and female atria with ample communication, without folds separating them (Figs. 31–36, 38). Gonopore canal lined with ciliated columnar epithelium with numerous openings of cells with xanthophil amorphous secretion, rhabditogen cells, and cells with granular erythrophil secretion. Muscularis of circular fibers with some interposed as well as subjacent longitudinal fibers.

Common muscle coat thin with circular, longitudinal and oblique fibers. Between atrial muscularis and common muscle coat, a poorly developed stroma with muscle fibers variously oriented.

Vitellaria, situated between intestinal branches, open into the ovovitelline ducts.

Remarks. Vitellaria were well developed in paratypes MZU PL.00124, MZU PL.00125, and MZU PL.00117, and in maturation in the holotype. Paratype MZU PL.00120 was incompletely mature, thus presenting small testes, and inconspicuous vitellaria and shell glands. Apart from the abundant apocrine secretion produced by cells of the epithelial lining of the female atrium in paratype MZU PL.00117, there were also xanthophil granules and cyanophil amorphous secretion in both lacunae of this epithelium and the atrial lumen (Fig. 37). A small amount of secretion was also present in the male atrium. The holotype, from an open area in a native field, was darker than specimens from forested areas, the dark-brown colour due to dense, dark pigmentation covering the dorsal ground colour. It was directly fixed after falling into a pitfall, and showed an everted pharynx, and a very distended copulatory apparatus. In the paratype MZU PL.00125, the female atrium is relatively shorter (53%, see table 5) than is the male, when compared to other mature specimens.

Discussion

The three new species described here and their affinities with other taxa and historical groupings are considered as follows: the historical background and the *G. applanata*-group, the *G. ladislavii*-group, the *G. assu*-group, the *G. rufiventris* species complex, the affinities of the new species described in this paper and their differential diagnosis.

Historical background and the *G. applanata*-group. The three new species described herein may be included in the Graff group of those ‘large, broad and flat’, originally containing 29 species (Graff, 1899). When studying Brazilian species of the genus *Geoplana* sensu Stimpson, 1857, E.M. Froehlich (1955) included the “large, broad and flat” ones in her “A” group. On analysing Neotropical land planarians, C.G. Froehlich (1967) proposed the name “*G. applanata*” for this group. The species of this group are always provided with a (permanent) penis papilla, there is no separation between male and female atria, and the female canal emerges from the dorsal side. Besides 18 species occurring in Brazil, C.G. Froehlich (1967) also included 7 registered in Peru and 3 in Colombia in his *G. applanata* group.

Among the species of Froehlich’s *G. applanata*-group, it is possible to differentiate species that may reach maturity with a length of approximately 50 mm than can be placed together in what is termed here the ***G. ladislavii*-group**, from those presenting mature specimens of at least 100 mm in length that may be placed together in what is called here the ***G. assu*-group**.

The *G. ladislavii*-group. This includes the following species: *G. argus* Graff, 1899, *G. aymara* Du Bois-Reymond Marcus, 1951, *G. burmeisteri* Schultze & Müller, 1857, *G. carrierei* Graff, 1897, *G. dictyonota* Riester, 1938, *G. itaiyana* Schirch, 1929, *G. ladislavii* Graff, 1899, *G. leucophryna* Marcus, 1951, *G. marmorata* Schultze & Müller, 1857, *G. notocelis* Bresslau, 1930, *G. notophthalma* Riester, 1938, and *G. quichua* Du Bois-Reymond Marcus, 1951. Although some specimens of *G. ladislavii*, *G. leucophryna* and *G. marmorata* are capable of reaching 100 mm when creeping, most mature specimens are smaller. *Geoplana notocelis*, *G. notophthalma*, and *G. leucophryna* were not included in the *G. applanata*-group by Froehlich (1967), probably because he considered them as synonymous with other species.

The *G. assu*-group. In many species of *G. applanata*-group, there are mature specimens capable of stretching to more than 100 mm when creeping. There are even very long specimens that may reach approximately 300 mm, such as *G. polyophthalma* Graff, 1899 and *G. eudoximariae* Ogren & Kawakatsu, 1990, or 200 mm in *G. eudoxiae* Ogren & Kawakatsu, 1990. In other species, the largest specimens range from 110 mm to 160 mm. This group may be called the ***G. assu*-group**, and includes at least 16 species (*G. apeva* Froehlich, 1959, *G. applanata* Graff, 1899, *G. arpi* Schirch, 1929, *G. assu* Froehlich, 1959, *G. blaseri* Schirch, 1929, *G. braunsi* Graff, 1899, *G. carinata* Riester, 1938, *G. divae* Marcus, 1951, *G. duca* Marcus, 1951, *G. eudoxiae*, *G. eudoximariae*, *G. fryi* Graff, 1899, *G. glieschi* Froehlich, 1959, *G. majori* Fuhrmann, 1914, *G. polyophthalma*, and *G. rufiventris* Schultze & Müller, 1857). Although *G. apeva*, with incompletely mature specimens, and *G. duca*, were smaller when creeping (85 mm and 100 mm, respectively), they were included in the *G. assu*-group, since specimens would become larger when fully mature. In addition, eight other species (*G. bimbergi* Fuhrmann, 1914, *G. cantuta* Du Bois-Reymond Marcus, 1951, *G. catharina* Hyman, 1957, *G. chalonga* Du Bois-Reymond Marcus, 1951, *G. chulpa* Du Bois-Reymond Marcus, 1951, *G. gabriellae* Du Bois-Reymond Marcus, 1951, *G. lareta* Du Bois-Reymond Marcus, 1958, and *G. tamboensis* Fuhrmann, 1914), which are commented below, may also be tentatively included in this group.

Among the Colombian species described by Fuhrmann (1914), *G. mayori*, reaching 150 mm in length when creeping, clearly belongs to the *G. assu*-group. The other two species, *G. bimbergi* and *G. tamboensis*, tentatively included in the same group, were known from smaller specimens (60 mm and 71 mm, respectively). The pattern in the three species is almost striped with one or two broad and dark lateral bands on the dorsum.

Seven species described by Du Bois-Reymond Marcus (1951, 1958) and *G. catharina* were known exclusively from fixed specimens, reaching between 43 mm and 85 mm in length. Some had been described based on a single specimen, and some were immature. *Geoplana cantuta* Du Bois-Reymond Marcus, 1951, *G. gabriellae* Du Bois-Reymond Marcus, 1951, *G. aymara* and *G. lareta* Du Bois-Reymond Marcus, 1958 have each distinctive dorsal patterns. *Geoplana cantuta* has a striped pattern on the anterior third of its body, with the rest covered by small dots, *G. gabriellae* two black lateral stripes and three yellowish orange bands, *G. aymara* a black median-stripe bordered by two yellowish orange stripes and black body margins, and finally, *G. lareta* a grayish dorsal surface, sometimes mottled with darker stripes, or with only the darker stripes. On the other hand, *G. chalonga*, *G. chulpa* and *G. quichua* all have a black dorsum (mottled black in *G. quichua*) and a yellowish or grayish ventral surface. *Geoplana quichua* and *G. aymara*, which were represented by the smallest specimens (43 mm and 45 mm in length, respectively), are included in the *G. ladislavii*-group. *Geoplana cantuta*, *G. catharina*, *G. chalonga*, *G. chulpa*, *G. gabriellae* and *G. lareta* are possibly part of the *G. assu*-group.

Geoplana arpi, *G. blaseri*, *G. duca*, *G. eudoxiae*, and *G. polyophtalma* were not included in the *G. applanata*-group by Froehlich (1967). The former two species were known exclusively by their external morphology and both reach a length of 160 mm. *Geoplana blaseri* shows an almost homogeneous black dorsum, whereas *G. arpi* a striped pattern on the dorsal surface. The original description of *G. polyophtalma* was also based on the external aspects of medium-sized specimens (35 mm). Later, C.G. Froehlich (1956) re-described the species based on specimens which are between 100 mm and 300 mm long.

The *G. rufiventris* species-complex. Most species of the *G. assu*-group may constitute a species-complex distinguished by a dark, nearly homogeneous dorsum, a reddish, orange, or even sometimes brown, venter, and eyes dispersed over the dorsum. This reddish or orange colour can be observed, however, only in live specimens. Since the first species described as presenting this aspect was *G. rufiventris*, this complex will be called the *G. rufiventris*-complex. Other species to be included therein are *G. apeva*, *G. applanata*, *G. assu*, *G. braunsi*, *G. divae*, *G. duca*, *G. eudoximariae* and *G. glieschi*. *Geoplana apeva* may be distinguished from other species of the *G. assu*-group, with the exception of *G. catharina* and *G. arpi*, by having a light median dorsal stripe bordered by black. In *G. braunsi*, the ventral surface has been described by Graff (1899) as yellowish tending towards reddish, and in specimens analyzed by Marcus (1951), as greenish gradually becoming black on the anterior part of the body.

Two species described by Schirch, 1929, viz., *G. blaseri* and *G. arpi*, as well as *G. carinata*, although in the *G. assu*-group, are not included in the species-complex, through presenting a different pattern on the venter, i.e., mottled on a usually grayish background, with, in the case of *G. arpi*, a clear median line.

Three species which clearly belong to *G. ladislavii*-group, viz. *G. leucophryna*, *G. notophtalma*, and *G. notocelis*, may be confused with species of the *G. rufiventris*-complex. Mature specimens of *G. leucophryna* show lengths between 45 mm and 110 mm (Marcus, 1951, p. 88). Specimens of *G. notophtalma* have the maximal length of about 50 mm after fixation (Riester, 1937, p. 53). Mature specimens of *G. notocelis* reach the maximal length of 90 mm (Bresslau, 1933, p. 159). In *G. leucophryna*, the ventral colour is brownish-red and in *G. notophtalma*, yellowish-red or yellowish. Specimens of *G. notocelis* may have a reddish ventral colour (Riester, 1937, p. 52). Certain species of the *G. assu*-group, viz., *G. applanata*, *G. eudoximariae*, and *G. eudoxiae*, are distinguished by a mottled or marbled dorsal pattern.

Pharyngeal anatomy and morphology of the copulatory apparatus in species of the *G. ladislavii* and *G. assu*-groups. Regarding pharyngeal anatomy, in most species of the *G. assu*-group, viz., *G. apeva*, *G. assu*, *G. braunsi*, *G. cantuta*, *G. carinata*, *G. chalonga*, *G. divae*, *G. eudoximariae*, *G. gabriellae*, and *G. rufiventris* sensu Graff, the pharynx is collar-form. In *G. applanata*, *G. catharina*, *G. duca*, *G. fryi*, *G. glieschi* and *G. polyophtalma* this is cylindrical, and in *G. chulpa* and *G. lareta*, bell-form. Although described as cylindrical in *G. chulpa* (Du Bois-Reymond-Marcus, 1951, p. 227), it would be more appropriate to regard it as a bell-form pharynx because its dorsal pharyngeal wall is inserted in the second third of the pharyngeal pocket, a key criterion for the bell-form pharynx. The pharynx of *G. catharina* was described as a cylindrical type after observations under the stereomicroscope.

In relation to pharyngeal anatomy of species of the *G. ladislavii*-group, in *G. argus*, *G. aymara*, *G. carrierei*, *G. dictyonota*, *G. itatiayana*, *G. ladislavii*, *G. leucophryna*, *G. marmorata*, and *G. notophthalma*, the pharynx is cylindrical, with a folded margin in *G. argus* (cf. Graff, 1899, p. 297), *G. aymara*, *G. carrierei*, *G. itatiayana*, *G. leucophryna* and *G. marmorata*. In contrast, *G. quichua* shows a bell-form pharynx.

There is no description of the pharynx anatomy for *G. arpi*, *G. bimbergi*, *G. blaseri*, *G. burmeisteri*, *G. eudoxiae*, *G. mayori*, *G. notocelis*, and *G. tamboensis*.

The anatomy of the copulatory apparatus appears to be very homogeneous in the species of both the *G. ladislavii* and *G. assu*-groups. In most, there is a prostatic vesicle with a usually tubular, extrabulbar portion located close to the bulbar musculature, with ental, short-forked expansions, a conical penis papilla filling the male and sometimes invading the female atria, an ample female atrium lined by a high columnar secretory epithelium, without separation between the male and female atria, and usually a distinctive female canal and common glandular ovovitelline duct. Five species, viz., *G. divae*, *G. mayori*, *G. polyophthalma* and *G. rufiventris* sensu Graff, as well as *G. dictyonota*, constitute an exception by possessing an exclusively intrabulbar prostatic vesicle. In addition, the prostatic vesicle of *G. applanata*, *G. eudoximariae*, *G. gabriellae* and *G. rufiventris* sensu Graff is ovoid or globous. Notwithstanding, in the description of *G. argus*, *G. bimbergi*, *G. braunsi*, *G. cantuta*, *G. dictyonota*, *G. eudoxiae*, *G. fryi*, *G. itatiayana*, *G. mayori*, and *G. rufiventris* sensu Graff, there was no mention of ental-forked expansions of the prostatic vesicle. The penis papilla of *G. applanata*, *G. cantuta*, *G. carrierei*, *G. chalonga*, *G. dictyonota*, *G. gabriellae*, *G. ladislavii*, *G. marmorata*, *G. notophthalma*, and *G. quichua* has a posteriorly located dorsal insertion. There is no description of the morphology of the copulatory apparatus of *G. arpi*, *G. blaseri*, *G. burmeisteri*, *G. notocelis*, and *G. tamboensis*.

Affinities of the new species in this paper. *Geoplana ficki* and *G. carbayoi* clearly belong to the *G. assu*-group, since the specimens, with less than 100 mm, were incompletely developed. As mature *G. baptistae* specimens are smaller and more elongate than the larger and broader specimens of the other two species, *G. baptistae* belongs to the *G. ladislavii*-group.

The three species described herein differ, as do most species of *G. assu* and *G. ladislavii*-groups, from the striped specimens of *G. apeva*, *G. arpi*, *G. aymara*, *G. bimbergi*, *G. cantuta*, *G. catharina*, *G. gabriellae*, *G. lareta*, *G. mayori*, and *G. tamboensis*.

Geoplana ficki and *G. carbayoi* evidently belong to the *G. rufiventris*-complex by having dark dorsal surface and orange venter. Some specimens of *G. ficki* presented a mottled dorsal pattern, whereas in those of *G. carbayoi* and *G. baptistae*, this was almost homogeneous. In *G. carbayoi*, the dorsum is the darkest among the three new species. As with *G. leucophryna*, *G. notocelis*, and *G. notophthalma*, *G. baptistae* is represented by specimens with orange or reddish venter, the mature specimens of which are too small to be included into the *G. assu*-group. However, considering the ventral colour of the body, *G. baptistae* is similar to species of the *G. rufiventris*-complex.

As regards eye distribution, in *G. ficki* these are more dispersed on the dorsum, whereas in *G. carbayoi* and *G. baptistae* they are more restricted to the lateral parts thereof (about 18% of body width), which is similar to the maximum width of the eyes in *G. glieschi* (one seventh or 14% of body width according to Froehlich, 1959, p. 222). Clear halos were observed in live specimens of *G. carbayoi* and in some specimens of *G. baptistae* and *G. ficki*. After fixation, although inconspicuous, halos could still be observed. This is in accordance with Marcus' comment (1951), when describing *G. carinata*, in that clear halos are no confident character for comparing species, at least in specimens with dark and dense pigmentation over the dorsum.

Geoplana ficki, presenting a collar-form pharynx, differs from *G. applanata*, *G. catharina*, *G. chulpa*, *G. duca*, *G. glieschi*, *G. lareta*, *G. polyophthalma*, as well as *G. carbayoi*. The shape and/or position of the prostatic vesicle in *G. ficki* distinguishes the species from the following species of the *G. assu*-group: *G. divae*, *G. eudoximariae*, *G. gabriellae*, *G. mayori*, and *G. rufiventris* sensu Graff, as well as *G. applanata* and *G. polyophthalma*. Also the presence of the forked prostatic vesicle in *G. ficki* distinguishes the species from *Geoplana bimbergi*, *G. braunsi*, *G. cantuta*, *G. eudoxiae*, *G. fryi*, *G. mayori*, and *G. rufiventris* sensu Graff. Regarding copulatory apparatus anatomy as well as colour pattern, distribution of eyes, and pharyngeal anatomy, *G. ficki* is similar to *G. assu* and *G. carinata*. However, mature specimens of *G. ficki* are larger, at maturity reaching at least lengths of 140 mm, whereas a mature specimen of *G. assu* reaches a length of 84 mm (Froehlich, 1959), as well as is the case of *G. carinata*, the larger specimens of which reach 120 mm (Marcus, 1951). In addition, the ventral side of *G. carinata* is grayish and spotted.

Geoplana carbayoi, presenting a bell-form pharynx, differs from most species of *G. assu*-group. Similar to *G. carbayoi*, the pharynx of *G. chulpa* and *G. lareta* is bell-form, but the homogeneous pattern of *G. carbayoi* is distinct from the stripped pattern of both species. *Geoplana carbayoi* shows a relatively short male atrium, occupied by dorsal folds of its wall and entally by the truncate, obliquely disposed penis papilla as a distinctive feature of its copulatory apparatus anatomy.

Geoplana baptistae shows a bell-form pharynx, thus differing from most species of the *G. ladislavii*-group, except *G. quichua*. In addition, *G. baptistae* may be distinguished from *G. argus*, *G. dictyonota*, and *G. itatiayana* by its forked prostatic vesicle. *Geoplana baptistae* also differs from *G. carrierei*, *G. ladislavii*, *G. marmorata*, *G. notophthalma*, and *G. quichua* by its conical and symmetrical penis papilla with a straight ejaculatory duct opening through the tip of the papilla, whereas the afore mentioned species show their penis papilla with a posteriorly located dorsal insertion.

In addition, the three new species described herein may be distinguished from each other by details of the anterior region of the body, such as the distribution of the sensory pits, the position where ovovitelline ducts emerge from ovaries, as well as the relative position of anteriormost testes in relation to ovaries. These characteristics may be useful to distinguish species especially when they show a relatively homogeneous copulatory apparatus.

Comments on some species of the *G. rufiventris*-complex. The species described by Schultze and Müller (1857), and contemplated in the present discussion (*G. rufiventris* and *G. burmeisteri*), deserve additional comments. As stated in the introduction, Graff (1899) re-described *G. rufiventris* based on heterogeneous material from various provenances in south Brazil, Argentina and Paraguay (Riester, 1938; Froehlich, 1955, 1959). A similar situation occurred with *G. burmeisteri*, also re-described by Graff (1899) based on specimens from the same regions (Marcus, 1951). As the material studied by Graff has, as yet, not been re-analysed, both Schultze & Müller species remain known only by their external morphology. On considering the provenance and morphological characteristics, Froehlich (1959) considered *G. leucophryna* as a synonym of *G. burmeisteri*.

Furthermore, C. G. Froehlich (1955) considered certain species of the *G. rufiventris*-complex, viz., *G. rufiventris* sensu Schirch, *G. notocelis* and *G. notophthalma*, as synonymous with *G. applanata*. However, on considering the number of species with a similar pattern, but otherwise distinguishable by a combination of characters of internal morphology, we think it very likely that they constitute different species. A re-description of the type-material, considering other characteristics of the internal morphology, as well as re-sampling of new material in the type-localities for combined molecular and morphological analysis, would improve the differentiation of these sibling species.

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