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A new species of land planarian (Platyhelminthes: Tricladida: Geoplanidae) from the Amazonian lowlands, Peru

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ABSTRACT

Notogynaphallia urku sp. nov. is here described from the north-east region of Peru, in the Amazonian lowlands. Specimens of the new species are flattened, up to 120 mm long, and characterised by their dorsal colouration consisting of a median band of melon yellow, on which run two irregular longitudinal stripes formed by tiny jet black dots; cephalic region with two para-median stripes forming a 'V'; two green beige lateral bands with jet black pigment covering a large part of these bands, in the form of large circular or irregular spots that reach the posterior end of the body; marginal stripes with antique pink pigment; ventral surface ivory with antique pink margins, except for the cephalic region, whose margins are jet black. This species represents the second record of *Notogynaphallia* in Peru and exhibits some similarities regarding external features and internal anatomy to species found in Paraguay and Argentina, with which it is compared.

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Introduction

The biodiversity of land planarians (Platyhelminthes: Geoplanidae) in Peru is poorly known, with 35 recorded species (Negrete et al. 2012). This number seems small considering that this country, mostly its mountainous region, is part of the Tropical Andes biodiversity hotspot (Myers et al. 2000). In fact, most of the known land planarian species from Peru were described in different localities along the Andes Mountains (between 1600 and 3600 m.a.s.l.) during the 1950s (du Bois-Reymond Marcus 1951, 1953; Hyman 1955, 1957, 1958). These species, except for *Bipalium kewense* Moseley, 1878, appear to be endemic to Peru. However, many of them are currently listed as *incertae sedis* because their morphology is insufficiently known or their identification is doubtful (Carbayo et al. 2013). New species have been described more recently (Negrete et al. 2010, 2012), although the lack of native specialists and of studies extended over time is a taxonomic impediment for this group of flatworms.

In this contribution, we describe a new species of land planarian found in the north-east region of Peru, in the Amazonian lowlands (~410 m.a.s.l). This new entity, assigned to *Notogynaphallia* Ogren and Kawakatsu, 1990, represents the second record of the genus for this country. We also include some comments on the genus *Notogynaphallia* given the features of this new taxon and other species of this genus.

Materials and methods

Specimens were found in Centro Urku (-6.459°S, -76.351°W; ~410 m.a.s.l), located in the surroundings of the city of Tarapoto, Department of San Martín, Peru. Urku, a rescue centre for threatened species, is part of the non-profit organisation 'Asociación Estudios Amazónicos', dedicated to conservation, environmental education, research and the recognition of ancestral Amazonian knowledge. Land planarians were collected by hand during night sampling along native forest trails. The animals were photographed alive using a camera with flash and their external appearance was recorded. They were killed by pouring boiling water over them, fixed in 10% formalin and preserved in 70% ethanol. Before fixation, the posterior tip was cut off, fixed in 100% ethanol, and preserved at -4°C for molecular analysis. Specimens were sectioned into different parts, namely (1) cephalic region, (2) anterior region at the level of the ovaries and the anterior-most testes, (3) pre-pharyngeal region, (4) pharynx and (5) copulatory apparatus. These tissue fragments were dehydrated in an ascending series of ethanol, cleared in n-butanol, infiltrated and embedded in Paraplast®. Sagittal, transverse and horizontal sections (6–8 µm thick) of these fragments were cut with a microtome and stained with a modified version of Masson's trichrome method (Negrete et al. 2019). The RAL colour standard chart (<http://www.ralcolor.com>) was used to describe the pigment of the dorsal and ventral surface of the body more accurately. The type material was deposited in the Invertebrate Collection at Museo de La Plata (MLP), Argentina.

Figure abbreviations

cc, circular cutaneous muscle layer; **cod**, common ovovitelline duct; **cs**, cyanophil secretion; **dc**, diagonal cutaneous muscle layer; **de**, dorsal epidermis; **di**, dorsal insertion of pharynx; **dp**, dorsal parenchymatic muscle layer; **dvp**, dorso-ventral parenchymatic muscle layer; **e**, oesophagus; **es**, erythrophil secretion; **fa**, female atrium; **fc**, female canal; **go**, gonopore; **i**, intestine; **lc**, longitudinal cutaneous muscle layer; **ma**, male atrium; **mb**, muscular penis bulb; **mo**, mouth; **n**, nervous plate; **od**, ovovitelline duct; **ov**, ovary; **pg**, prostatic glands; **ph**, pharynx; **pl**, pharyngeal lumen; **pp**, pharyngeal pouch; **pv1**, prostatic vesicle, proximal portion; **pv2**, prostatic vesicle, distal portion; **rb**, rhabditogen glands; **sbp**, sub-intestinal parenchymatic muscle layer; **sd**, sperm duct; **sg**, shell glands; **sm**, sensory margin; **spp**, supra-intestinal parenchymatic muscle layer; **t**, testes; **ve**, ventral epidermis; **vi**, ventral insertion of pharynx; **vt**, vitellaria.

Figures showing sagittal sections are arranged with the anterior body region to the left. Figures showing longitudinal sections are oriented with the anterior body region upward.

Systematics

Order TRICLADIDA Lang, 1881

Family GEOPLANIDAE Stimpson, 1857

Subfamily GEOPLANINAE Stimpson, 1857

Genus *Notogynaphallia* Ogren and Kawakatsu, 1990

Notogynaphallia urku sp. nov.

Material examined

Holotype. MLP He-7982. 28 July 2019, Tarapoto, Peru (-6.464°S, -76.352°W); Milton F. Ubeda Olivas coll.; cephalic region: transverse sections (6 µm thick) on 30 slides; anterior region at the level of the ovaries: longitudinal sections (6 µm thick) on 40 slides; posterior region to the ovaries: sagittal sections (8 µm thick) on 88 slides; pre-pharyngeal region: transverse sections (6 µm thick) on 10 slides; pharynx: sagittal sections (8 µm thick) on 75 slides; copulatory apparatus: sagittal sections (8 µm thick) on 90 slides.

Paratype 1. MLP He-7983. 7 March 2020, Tarapoto, Peru (-6.464°S, -76.352°W); Leyli Vega Tuesta coll.; cephalic region: transverse sections (6 µm thick) on 28 slides; anterior region at the level of the ovaries: sagittal sections (8 µm thick) on 50 slides; pre-pharyngeal region: transverse sections (6 µm thick) on 10 slides; pharynx: sagittal sections (8 µm thick) on 52 slides; copulatory apparatus: sagittal sections (6 µm thick) on 60 slides.

Paratype 2. MLP He-7984. 19 February 2020, Tarapoto, Peru (-6.464°S, -76.351°W); Leyli Vega Tuesta coll.; whole specimen preserved in 80% ethanol.

Diagnosis. Species of *Notogynaphallia* with a colour pattern of the dorsal surface consisting of a median band of melon yellow, on which run two irregular longitudinal stripes formed by tiny jet black dots; cephalic region with two para-median stripes forming a 'V'; two green beige lateral bands with jet black pigment covering a large part of the lateral bands, in the form of large circular or irregular spots which reach the posterior end of the body; marginal stripes with antique pink pigment; ventral surface ivory with antique pink margins, except in the cephalic region, whose margins are jet black. Monolobulated and trilobulated eyes spreading onto the dorsum, with clear halos. Glandular margin present. Pharynx collar-shaped. Prostatic vesicle intrabulbar, with two regions: a tubular proximal portion, entally forked, and a globose distal portion. Female atrium almost as long as the male one.

Type locality. Tarapoto, Department of San Martín, Peru.

Etymology. The specific name *urku*, which in the native language Quechua means mountain or hill, is dedicated to Centro Urku, where the specimens of this new species were collected.

Description

External features. Body elongated, broad and flat. Anterior body region gradually narrows towards the rounded anterior tip; posterior portion of the body abruptly narrows, ending in a point (Figure 1(a–d)). When creeping, the maximum length reached ~120 mm. After fixation, maximum length was 96–112 mm, maximum width 11–12 mm, and maximum height 2.1–2.4 mm. Mouth and gonopore distance from anterior tip 53–57%, and 68–72% relative to body length.

The colour pattern of the dorsal surface of the specimens (Figure 1(a–c)) consists of a median band of melon yellow (RAL 1028) (~60% of body width), whose outer limits are fuzzy, on which run two irregular longitudinal stripes (~10% of body width each) formed by tiny jet black (RAL 9005) dots. Behind the pharyngeal region, black dots are scarcer and more diffuse, so these stripes are somewhat paler. The cephalic region shows two para-median stripes that arise near the cephalic tip, without connecting to each other; they run backward obliquely forming a 'V'. On the sides of the median band are two green beige (RAL 1000) lateral bands (~15% of body width each) that merge near the cephalic tip and at the posterior end of the body. In the cephalic region, these lateral bands are externally bordered by minute jet black dots linked together forming a fine stripe. In the body fragment comprising approximately 15–30% of the body length, the jet black pigment extends to cover a large part of the lateral bands, on which the clear halos of the eyes can be observed (see below). Posteriorly, this black pigment spreads over the lateral bands in the form of large circular or irregular spots that reach the posterior end of the body. Externally to the



Figure 1. External aspect of *Notogynaphallia urku* sp. nov. (A, C) Dorsal view of live specimens (A, holotype; C, paratype 1); (B) dorsal view after fixation (holotype); (D) ventral view of live specimen (holotype). The arrowheads indicate the region of the body that was damaged in the holotype and the arrows show the position of the mouth and gonopore, respectively. In Figures A, B, and D the anterior body region is on the left. In Figure C, the anterior body region is upwards. Scale bars: 10 mm.

green beige lateral bands extend fine marginal stripes (~5% of body width each) with antique pink (RAL 3015) pigment.

The ventral surface (Figure 1(d)) is ivory (RAL 1014) with antique pink (RAL 3015) margins, except for the cephalic region, whose margins are jet black (RAL 9005).

Monolobulated eyes, uniseriably arranged, surround the anterior tip. Immediately behind the anterior tip, they become pluriserial with small clear halos, arranged on the body margins (Figure 2(a)). After one-tenth of the body, eyes are also pluriserial (monolobulated on the margins and dorsally trilobulated), surrounded by noticeable clear halos spreading over the dorsal surface of the body (Figure 2(a–c)). Eyes show their maximum extension at one-third of the body, occupying two lateral bands each with ~35% of body width (Figure 2(a)). They are progressively more dispersed on the dorsum, reaching the posterior end.

Sensory organs, epidermis and body musculature. Sensory pits on the cephalic region, as simple invaginations (40 µm deep), are distributed ventromarginally in a single row on either side of the body. The creeping sole occupies 95–100% of the body width at the pre-pharyngeal region. Three gland types discharge through the epidermis of the pre-pharyngeal region: rhabditogen cells with xanthophil secretion, abundant erythrophil glands with fine granular secretion, and less abundant cyanophil glands with fine granular

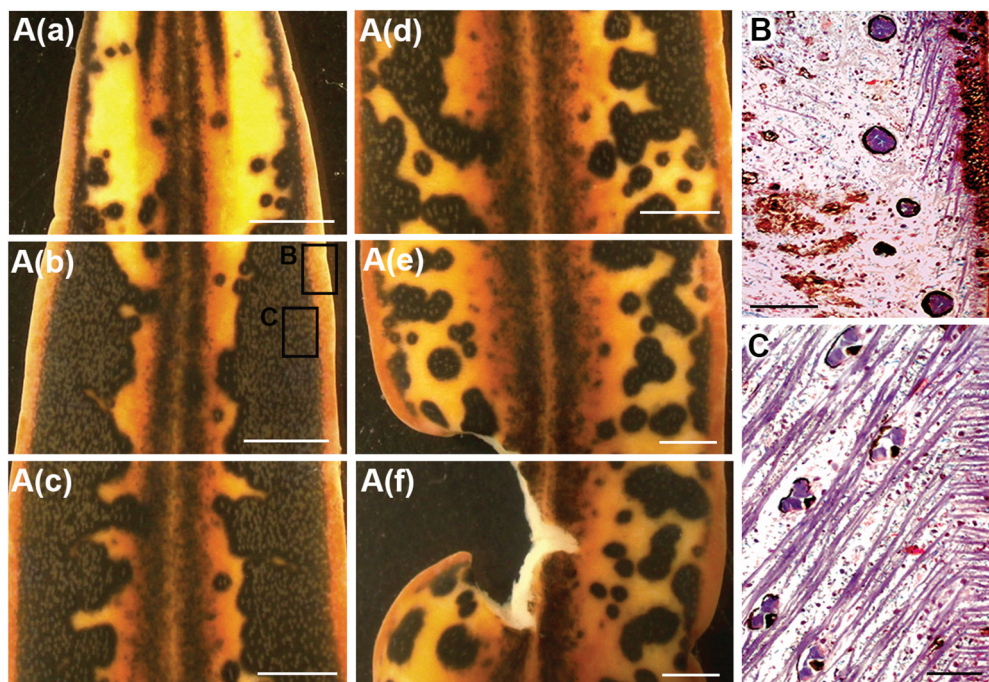


Figure 2. Eyes of *Notogynaphallia urku* sp. nov. (holotype). (A) Photographs (a–f) showing the clear halos spreading from the anterior body region to the pre-pharyngeal region. (B, C) Longitudinal sections at the anterior body region, showing the monolobulated (B) and trilobulated (C) eyes. The boxes in Fig. A(b) indicate the approximate body region from which histological sections (B and C) were made. Scale bars: A(a–f) = 2 mm; B, C = 100 µm.

secretion (Figure 3(a–c,e)). Small rhabdites occupy the creeping sole (Figure 3(c)). The glandular margin is composed of two types of glands, discharging fine granules of cyanophil and erythrophil (Figure 3(e)). Glands discharging through the cephalic region are similar to those of the pre-pharyngeal region.

The cutaneous musculature shows the typical three muscle layers of Geoplaninae: circular, diagonal and longitudinal layers, the last one being the thickest and organised in discrete bundles (Figure 3(c)). The ventral musculature (100–125 μm thick) is slightly thicker than the dorsal musculature (90–100 μm thick). The thickness of the cutaneous musculature represents $\sim 9\%$ of the body height. The parenchymatic musculature is composed of three layers, but not forming discrete bundles (Figure 3(b,d)): a dorsal layer with decussate fibres (100–150 μm thick), a supra-intestinal transverse layer (200–300 μm thick), and a sub-intestinal transverse layer (125–150 μm thick). Additionally, some dorsoventral fibres run among intestinal branches (Figure 3(b)). The cephalic region lacks any muscular-glandular specialisation, and the parenchymatic musculature arrangement is similar to that of the pre-pharyngeal region.

Digestive system. The pharynx is collar-shaped (5–9% of body length) (Figure 4(a,b)). It occupies 60–80% of the pharyngeal pouch (10.6–11 mm in length). The mouth opens in the middle third (Figure 4(b)) or the posterior third of the pharyngeal pouch (Figure 4(a)). The oesophagus is present (Figure 4(a)); oesophagus:pharynx ratio varies from 8% to 13%. The pharynx is lined with cuboidal ciliated epithelium. The outer musculature comprises a longitudinal subepithelial layer (5 μm thick) followed by a circular layer (10–25 μm thick). The pharyngeal lumen is lined with ciliated, columnar epithelium. The inner musculature (125–200 μm thick) is formed by a circular layer interspersed with some longitudinal fibres. Three gland types discharge through the pharyngeal epithelium: abundant glands

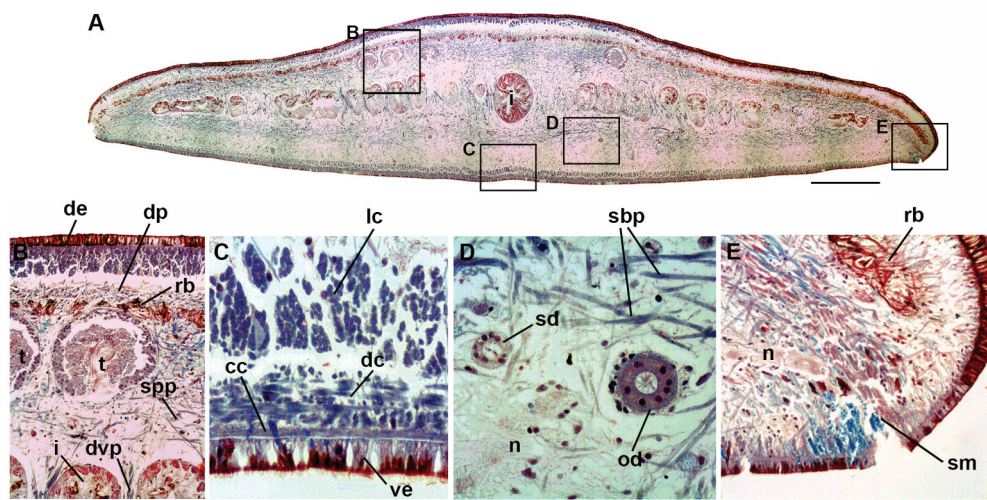


Figure 3. Pre-pharyngeal region of *Notogynaphallia urku* sp. nov. (holotype). Transverse section (A) and details (B–E): dorsal to the intestine (B); ventral to the intestine (C); the sperm and ovovitelline ducts (D); and body margin (E). Scale bars: A = 1 mm; B = 250 μm ; C = 50 μm ; D, E = 100 μm .

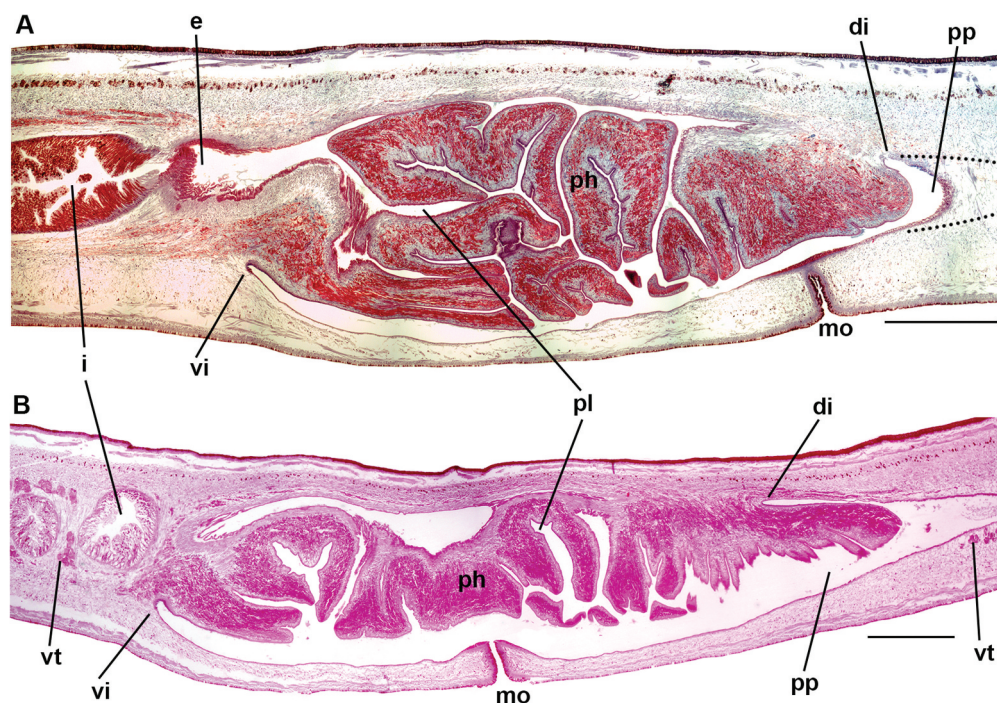


Figure 4. Pharynx of *Notogynaphallia urku* sp. nov. Sagittal sections of the holotype (A) and paratype 1 (B). Scale bars: 1 mm.

with fine granular erythrophil and cyanophil secretion, and scarce glands with amorphous erythrophil secretion.

Male reproductive system. The testes are arranged in at least three irregular rows on either side of the body, located among the supra-intestinal parenchymatic muscle fibres (Figure 3(a,b)). They arise behind the ovaries in the holotype (21% relative to body length) and before them in paratype 1 (18% relative to body length). The testes extend posteriorly and reach the level of the root of the pharynx (50–55% relative to body length). The sperm ducts are slightly dorsal to ovovitelline ducts, medially displaced (Figure 3(d)). Laterally to the pharynx, the sperm ducts are dilated and full of spermatozoa, forming spermiducal vesicles. Distally, they are located laterally to the proximal part of the penis bulb. At this point, the sperm ducts' lumen decreases, and the ducts turn anterior-medially and traverse the bulb to open into very short (~100–130 μ m in length) lateral branches of the proximal region of the prostatic vesicle (Figure 5). This intrabulbar vesicle consists of a proximal tubular and sinuous portion (proximally bifurcated) (pv1 in Figures 5 and 6) and a distal, unpaired portion (pv2 in Figures 5 and 6). The latter is somewhat globose with folded walls and opens into the bottom of the male atrium (Figures 6 and 8(a)). The male atrium is a large chamber, whose lumen is narrow owing to its richly folded walls (Figures 5 and 6). It is longer (5.2–6.2 mm) than the female atrium (4.7–5.2 mm).

The lining epithelium of the sperm ducts is cuboidal and ciliated, surrounded by a circular muscle layer (5 μ m thick). The distal part of the spermiducal vesicles is lined

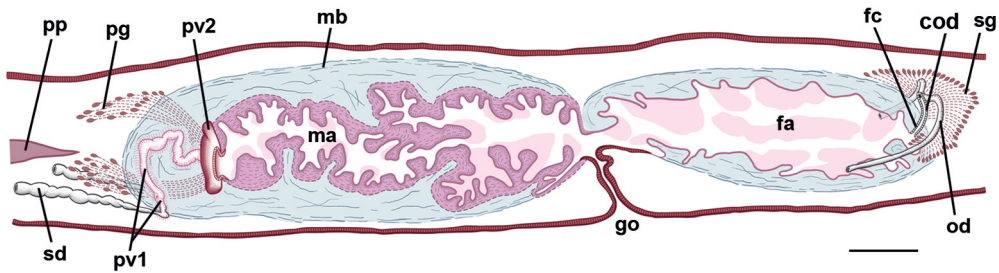


Figure 5. Schematic reconstruction, in sagittal view, of the copulatory apparatus of *Notogynaphallia urku* sp. nov. (holotype). Scale bar: 1 mm.

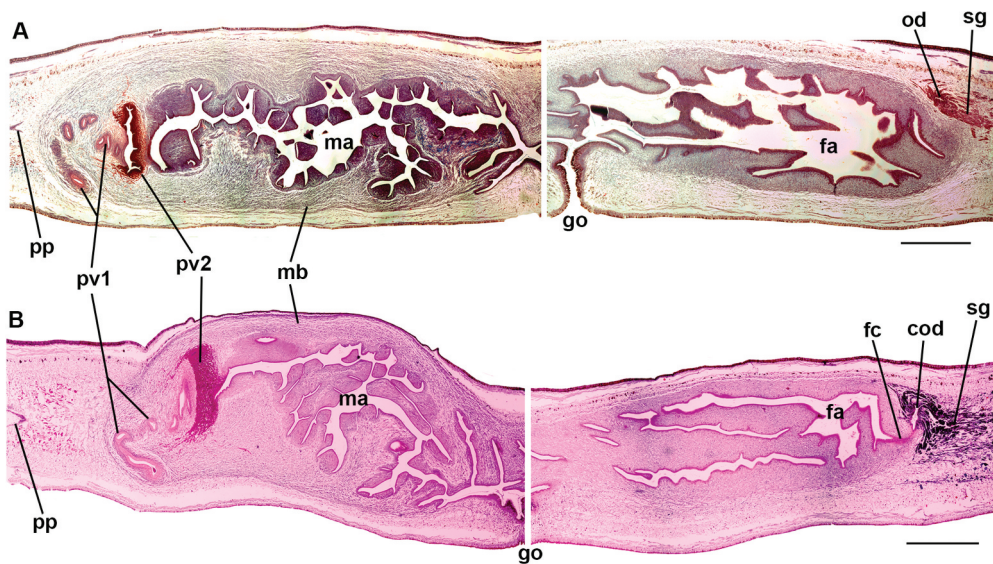


Figure 6. Copulatory apparatus of *Notogynaphallia urku* sp. nov. Sagittal sections of the holotype (A) and paratype 1 (B). Scale bars: 1 mm.

with ciliated, columnar epithelium, covered by circular and oblique fibres (25 μ m thick). The proximal region of the prostatic vesicle, both paired and unpaired, is lined with ciliated, columnar epithelium, which receives a fine granular, weakly stained erythrophil secretion (Figure 7(a–d)). The epithelium of the distal part of the vesicle, ciliated and columnar, is pierced by abundant coarse, granular, heavily stained erythrophil secretion (Figure 7(a,b,e,f)). The muscle coat of the prostatic vesicle (40–60 μ m thick) is composed of interwoven longitudinal, circular, and oblique fibres. The male atrium is mostly lined with non-ciliated columnar epithelium, although some parts exhibit cuboidal epithelium (Figure 7(g,h)). Two types of glands open through the surface of the male atrium: cells with fine granular erythrophil secretion (Figure 7(g)) and cells with fine granular cyanophil secretion (Figure 7(h)). The muscle coat of the male atrium (25–100 μ m thick) includes, in some parts, a circular layer with a subjacent longitudinal layer, but in other regions, the circular fibres are interspersed with some longitudinal muscle fibres. The thick muscular penis bulb (~500–600 μ m thick) that

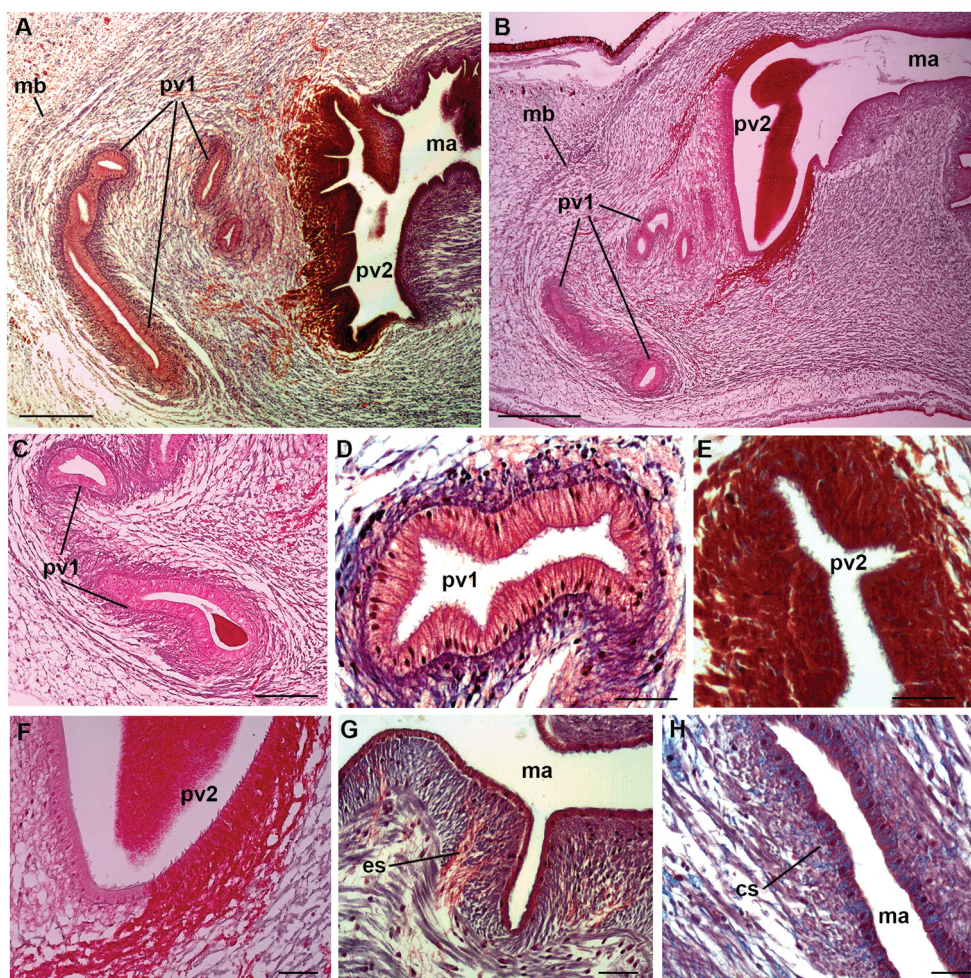


Figure 7. Details of the male organs of the copulatory apparatus of *Notogynaphallia urku* sp. nov. in sagittal sections of the holotype (A, D, E, G, H) and paratype 1 (B, C, F). (A, B) Prostatic vesicle and proximal part of the male atrium; (C, D) proximal portion of the prostatic vesicle; (E, F) distal portion of the prostatic vesicle; (G, H) male atrium. Scale bars: A–C = 500 μ m; D–H = 100 μ m.

surrounds the male atrium and the prostatic vesicle consists of longitudinal, oblique and circular intermingled fibres (Figures 5, 6, and 7(a,b)).

Female reproductive system. The ovaries are oval-elongate in shape (Figure 8(a,b)), three or four times longer than wide. In the holotype, they are located at a distance from the anterior tip of 15% relative to body length (paratype 1 at 20%). The ovaries are found immediately above the nerve plate (Figure 8(b)). The ovovitelline ducts arise dorsally from the median third of the ovaries (Figure 8(b)). They run posteriorly above the sub-intestinal parenchymatic muscle layer (Figure 3(d)). After running laterally to the distal portion of the female atrium (Figures 5 and 8(c)), the ovovitelline ducts gradually ascend to finally turn to the sagittal plane (Figure 5). They dorsally converge in a short common ovovitelline duct

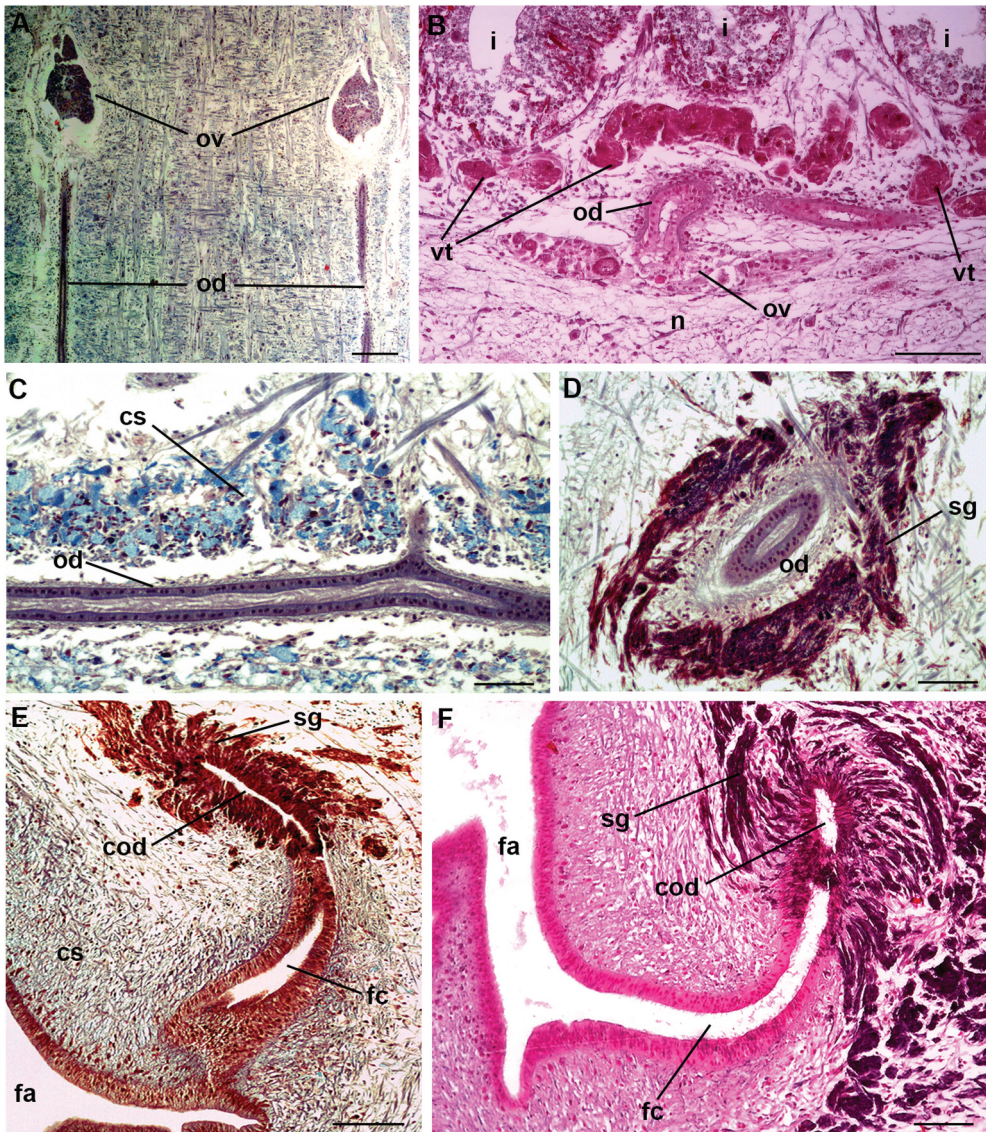


Figure 8. Details of the female organs of the copulatory apparatus of *Notogynaphallia urku* sp. nov. in longitudinal (A) and sagittal (B–F) sections. (A, C – E) holotype; (B, F) paratype 1). (A, B) ovaries; (C, D) ovovitelline ducts: lateral to the female atrium (C) and distal ascending portion (D); (E, F) distal portion of the female reproductive system. Scale bars: A, C–F = 100 μ m; B = 200 μ m.

(250–300 μ m in length), posteroventrally inclined or slightly vertical (Figures 5, 6(b), and 8(e,f)), to open into a female canal (~500 μ m in length). The female canal turns anteroventrally and opens into the female atrium, which is a long oval-elongate cavity with highly folded walls that reduce its lumen (Figures 5, 6, and 8(e,f)).

The ovovitelline ducts, in the pre-pharyngeal region, are lined with ciliated, cuboidal epithelium, followed by a thin muscle coat (5 μ m thick) consisting of intermingled longitudinal and circular fibres (Figure 3(d)). Their distal portions are lined with ciliated,

columnar epithelium and coated with the same arrangement of muscle (~20 µm thick) (Figure 8(c,d)). Abundant shell glands, with coarse granular erythrophil secretion (heavily stained in paratype 1), open into the distal sections of the ovovitelline ducts as well as the common ovovitelline duct (Figures 5, 6, and 8(d–f)). The latter and the female canal are lined with columnar, ciliated epithelium followed by circular and some oblique and longitudinal interspersed muscle fibres (20–25 µm thick). The female canal receives abundant fine granular erythrophil secretion and scarce fine cyanophil granules (Figure 8(e,f)). The lining epithelium of the female atrium is columnar and non-ciliated, receiving abundant fine granular cyanophil secretion and scarce granular erythrophil secretion from glands whose cell bodies are located in the parenchyma surrounding the atrium (Figure 8(c)). The female atrium is wrapped in a thick subepithelial muscle coat (~50–100 µm thick) (Figure 6), which consists of circular fibres with some interspersed longitudinal and oblique ones. This muscle coat is independent of the muscular bulb that envelops the male atrium and the prostatic vesicle. There is no common muscle coat. Vitellaria are scarce in the holotype and abundant in paratype 1. However, both specimens are mature.

Discussion

Among the known genera in the subfamily Geoplaninae, the new species here described fits with the definition of the genus *Notogynaphallia* Ogren and Kawakatsu, 1990 (Carbayo et al. 2013).

This genus was named by Ogren and Kawakatsu (1990) to group land planarians mainly found in Brazil (in addition to some species recorded in Colombia, Panama, Paraguay and Peru) characterised by a medium-sized body, absence of penis papilla, male atrium with folded walls, and female genital canal opening dorsally into the female atrium. Carbayo et al. (2013) amended and restricted its diagnosis, under a molecular phylogenetic framework, and added other morphological features, such as the presence of monolobulated eyes along body margins, cylindrical pharynx, and the characteristics related to the copulatory apparatus already mentioned by Ogren and Kawakatsu (1990). Later, Negrete et al. (2015) included some characteristics to the diagnosis, like eyes sometimes spreading dorsally and pharynx cylindrical or bell-shaped, among others.

The new species here described, *Notogynaphallia urku*, will be discussed along with the seven species of *Notogynaphallia* recognised by Carbayo et al. (2013) plus two species described subsequently, *Notogynaphallia nawei* Negrete et al., 2015 and *Notogynaphallia fortuita* Negrete et al., 2019. We also include *Notogynaphallia garua* (du Bois-Reymond Marcus, 1951) in the comparative discussion because it is the only species of *Notogynaphallia* found in Peru, even though it has been categorised as *incertae sedis* due to poor knowledge of its internal anatomy (see Carbayo et al. 2013).

Externally, the striking pigmentation pattern on the dorsum of *N. urku* easily differentiates this new entity from the rest of the species of *Notogynaphallia*. They may show a striped pattern [*Notogynaphallia froehlichae* Ogren and Kawakatsu, 1990, *N. garua*, *Notogynaphallia modesta* (Graff, 1899), and *Notogynaphallia sexstriata* (Graff, 1899)], a well-defined banded pattern [*Notogynaphallia mourei* (Froehlich, 1956) and *Notogynaphallia parca* (Froehlich, 1955)] or a homogeneous dark pattern [*N. fortuita*, *N. nawei*, and the type species *Notogynaphallia plumbea* (Froehlich, 1956)] (Graff 1899; Froehlich 1955, 1956). Only the

pigmentation pattern of *Notogynaphallia biseminalis* (Riester, 1938) is unknown. Concerning the eye pattern, the species of *Notogynaphallia* exhibit monolobulated eyes along the body margins (Carbayo et al. 2013). *Notogynaphallia urku* also has numerous eyes along the dorsum, especially in the first third of the body. This trait was also recorded in other species, such as *N. fortuita*, *N. froehlichae*, *N. garua*, *N. modesta* and *N. nawei* (see Riester 1938; Carbayo 2003; Negrete et al. 2015, 2019). Species with only marginal eyes have been found in Brazil, except for *N. froehlichae*. The remaining species with dorsal eyes were recorded in Argentina, Paraguay and Peru. Interestingly, like the new species herein described, Carbayo (2003) observed in *N. modesta* the presence of trilobulated eyes spreading dorsally in the ovarian region. This information (the occurrence or not of mono- and trilobulated eyes) is not available for *N. froehlichae* and *N. garua*, while for *N. fortuita* and *N. nawei*, Negrete et al. (2015, 2019) did not make these observations. However, a re-analysis of the histological sections of these latter species (LN, personal observation) allowed us to discriminate trilobulated dorsal eyes at least in *N. nawei*, since in *N. fortuita* we observed only monolobulated eyes.

The collar-shaped pharynx of the new species distinguishes it from all other species of *Notogynaphallia*, which have a cylindrical pharynx, except *N. modesta*, with a bell-shaped pharynx (Carbayo 2003; Negrete et al. 2015).

Concerning the reproductive organs, *N. urku* resembles, in their gross anatomy, *N. fortuita* and *N. nawei*, both species found in Argentina, and *N. modesta*, recorded in Paraguay. Similarly to these three species, the prostatic vesicle of *N. urku* has two portions, which are differentiated by (1) their anatomy: proximally tubular and distally globose with richly folded walls; and (2) the glandular secretions they receive, with the proximal region receiving fine granular secretion, and the globose distal part being pierced by coarse granular secretion, heavily stained. Also, the new species shares with *N. fortuita* and *N. nawei* the presence of a voluminous female atrium with folded walls, although in *N. nawei*, the folds are not as conspicuous as in *N. urku* and *N. fortuita*. Conversely, in *N. modesta*, the female atrium is funnel-shaped, a feature that appears to be the most widespread within the genus.

Accordingly, it is worth noting the similarity – mainly concerning the general anatomy of the copulatory apparatus – between the new species here described and *N. fortuita*, *N. nawei* and, to some extent, *N. modesta*, none of which have been recorded in Brazil. It would be possible to hypothesise that these species form a lineage that was split from the species present in Brazil. New approaches will corroborate this, or not. With respect to the other species of Peru, *N. garua*, any comparison with all species discussed above must be taken with some reserve, given that the specimens revised by Carbayo (2003) were not fully mature.

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Disclosure statement

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