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Description of the final-instar larva of *Psaironeura tenuissima* (Odonata: Zygoptera: Coenagrionidae) from Amazonia

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Abstract. The final-instar larva of *Psaironeura tenuissima* is described based on reared specimens from Amazonas and Pará states in the Brazilian Amazon. *Psaironeura* larvae are grouped with *Neoneura* and *Protoneura* larvae by having nodated caudal lamellae, however, they can be differentiated by the number of labial palp setae. *Psaironeura tenuissima* are morphologically compared with *P. angeloi* larvae as well as those of *Neoneura kiautai* and *Protoneura aurantiaca.* The *P. tenuissima* larva can be distinguished from that of *P. angeloi* by the shape of the superior margin of prementum, projections on the prothorax, caudal lamellae apex shape, and the number of setae in the paraproct ventral margin setae.

Key words. Damselfly, dragonfly, exuviae, larval taxonomy, Neotropical

Resumo. A larva de último instar de *Psaironeura tenuissima* é descrita com base em espécimes criados nos estados do Amazonas e Pará, na Amazônia brasileira. As larvas de *Psaironeura* são agrupadas com as larvas de *Neoneura* e *Protoneura* por possuírem lamelas caudais noduladas, no entanto, podem ser diferenciadas pelo número de setas do palpo labial. Comparações morfológicas entre as larvas de *P. tenuissima* e *P. angeloi*, são fornecidas bem como com as larvas de *Neoneura kiautai* e *Protoneura aurantiaca*. A larva de *P. tenuissima* pode ser distinguida da larva de *P. angeloi* pela forma da margem superior do premento, projeções no protórax, forma do ápice da lamela caudal e número de setas na margem ventral do paraprocto.

Palavras-chave. Donzelinha, libélula, exuvia, Neotropico, taxonomia larval

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Data Availability Statement:
All relevant data are within the paper.

Introduction

The genus *Psaironeura* Williamson, 1915 (Coenagrionidae: Protoneurinae) comprises only six species, which distributed from southern Mexico to northern Bolivia (Garrison et al., 2010; Mendoza-Penagos et al., 2022; Tennessen, 2016). Based on adult male cerci morphology, these species are informally arranged in

the *remissa* and the *tenuissima* groups. The former has foliated cerci, while these are filiform in the latter (Garrison, 2004; Tennessen, 2016). Species of this damselfly genus are small (31.5–33.5 mm) and are usually associated with the lower strata of riparian vegetation, being very difficult to observe in the field and scarce in zoological collections (Mendoza-Penagos et al., 2022). For this reason, information about their biology is scarce.

The taxonomy of *Psaironeura* spp. larvae is only at an incipient stage. Of its six species, only the larva of *P. angeloi* Tennessen, 2016 has so far become known (Román-Heráclio et al., 2021). Although the larva of *P. tenuissima* (Selys, 1886) has already been included in several identification keys to genera at larval stage, it has not been formally described (see Lozano et al., 2018; Neiss & Hamada, 2014; Pessacq et al., 2018). In this contribution, we describe the final-instar larva of *P. tenuissima* based on larvae and reared specimens of both sexes collected in the Amazonas and Pará states in the Brazilian Amazon. It is compared to the larva of *P. angeloi*, the only other species in this genus whose larvae are known. Additionally, comparisons with the larvae of *Neoneura kiautai* Machado, 2007 and *Protoneura aurantiaca* Selys, 1886 were made because the larvae of these genera are similar in the shape of their caudal lamellae (Neiss & Hamada, 2012).

Materials and methods

Our descriptions are based on five male final-instar larvae and five exuviae of both sexes collected in the Goianésia, Magalhães Barata and Paragominas municipalities in Pará state and one male exuviae from Presidente Figueiredo, Amazonas state. The larvae were reared in the laboratory until adults emerged so that teneral adults could be used for identification. The exuviae, teneral adults, and final-instar larvae were preserved in 80% ethanol. The mandibular formula follows Watson (1956).

Specimens were analyzed with the aid of a Leica M205 stereo microscope equipped with a Leica DFC 450 camera and processed in Photoshop® software. All measurements were made on Photoshop® software, in millimeters (mm). All the specimens from Pará are deposited in the Odonata collection of the Laboratório de Ecologia e Conservação (LABECO) of the Universidade Federal do Pará (UFPA). The specimen from Amazonas is deposited in the Coleção de Invertebrados do Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Amazonas, Brazil.

Abbreviations used here are as follows: AL, abdomen length (without caudal lamella); CeL, cerci length; F-0, final instar; HtfL, metathoracic femur length; MgL, male gonapophyses length; MsfL, mesothoracic femur length; MtfL, metathoracic femur length; MWh, maximum width of head; Pfl: prothoracic femur length; S1–10, abdominal segments; TL, total length (including caudal lamellae).

Results

Description of the final-instar larva of Psaironeura tenuissima *(Selys, 1886) (Figs 1–4)*

Examined material

Five exuviae (3 ♂, 2 ♀, reared), 5 F-0 larvae (5 ♂). **BRAZIL: Pará state: Goianésia**, Cickel, lateral ponds in stream of the first order (-3.709 S, -48.561 W, elevation 159 m), 03 August 2021 (1 ♂, 1 ♀, emerged 05 September 2021, 10 September 2021, respectively); 08 August 2021 (1 ♀ emerged 08 September 2021) Hamada Neusa, Pes Ana, Desiderio Gleison, da Silva Jeferson, Mendoza-Penagos Cristian, leg.; **Paragominas**, first order stream (-3.086 S, -47.687 W, 50 m), 13 August 2021 (1 ♂, emerged 10 September 2021) Hamada Neusa, Pes Ana, Desiderio Gleison, da Silva Jeferson, Mendoza-Penagos Cristian, leg.; **Magalhaes Barata**, Calafate, stream of first order (-0.863 S, -47.668 W, 20 m), 26 September 2021 (5 ♂ F-0), Mendoza-Penagos Cristian, leg.; **Amazonas state: Presidente Figueiredo**, Uatumã Biological Reserve, next to Balbina village, PPBio grid: N.S. 4–2.600 m, first order stream, larva collected in stack of leaves in a backwater (-1.802 S, -59.246 W, 120 m), 25 September 2009 (1 ♂, emerged 02 October 2009) U.G. Neiss leg.

Description

Larva. Slender, dark brown coloration, legs pale yellow with two dark brown bands on femora. Caudal appendages lamellate, basal part sclerotized, apex membranous (Figs 1a–b).

Head. subpentagonal, elongated transversally, as wide as 1.5 long (Fig. 1a). Labrum ventral margin concave at center, with six spiniform setae; clypeus dark brown with a medial pale spot. Occipital margin concave, occipital lobes rounded and strongly projected laterally with a row of marginal five–six claviform setae. Antennae (Fig. 2a) with seven segments, yellowish with a dark brown spot at base of antennomeres 3th, 4th and 6th; 3rd antennomere the longest, size proportions of antennomeres: 0.40, 0.60, 1, 0.70, 0.50, 0.40, 0.30. Maxilla's (Fig. 2b) galeolacinia with eight teeth, four dorsal teeth slightly incurved, and three ventral teeth varying in size and robustness, maxillary palp gently incurved. Prementum reaching the procoxae, two premental setae on each side of midline; lateral margins slightly concave, each with a row of I–VI setae; distal margin projected and finely serrulated, with a minute tubercle on each side of the midline (Fig. 2c). Labial palp (Figs 2d–e) with 6 setae on the dorsal margin; movable hook slightly curved, sturdy, and sharply pointed; apical lobe truncated, with three small teeth on the basal margin and minute denticles on the distal margin; anterior margin with terminal hook well developed, as long as 0.5 times the length of the movable hook; internal margin slightly serrated. Mandibles (Figs 2f–g) with three setae on the external margin; mandibular formula: L 1'1234 y ab / R 1'1234 y a.

Thorax. Pronotal disk subtrapezoidal (Fig. 1a), lateral pointed projection weakly pronounced. Legs short, posterior tibiae not reaching the margin of S10 (Fig. 1a). Coxae dark brown. Femora pale yellow with two dark brown bands, one submedial and one distal (Fig. 3a). Tibiae pale yellow with a medial dark brown band. Tarsi pale yellow. Femora with concave setae (Figs 3b–e), distributed on the extensor and flexor margins. Tibiae with intercalated trifid (Fig. 3d) and pectinated (Fig. 3e) setae on the distal ventral surface. First and second tarsomeres with four ventral rows of setae (simple, trifid and pectinated, as on tibiae), two medial and two lateral; third tarsomere almost as long as long as the remaining tarsomeres together, with two ventral rows of setae. Tarsal claws simple, thin, and curved apically. Wing pads reaching the median region of S5 (S6 on larval exuviae).

Abdomen. Short and cylindrical; posterior margin armed with setae as follows: S5 laterally, S6–9 increasing dorsally, and S10 completely (Fig. 3f). Male gonapophyses (Fig. 3g) conical, divergent, and sharply pointed, extending beyond the distal margin of S9; their bases separated from each other by a gap matching the length of the gonapophyses. Male cerci globose, apex strongly downcurved (Fig. 3h). Female gonapophyses (Fig. 3i) well developed, extending beyond the posterior margin of S10; lateral valves with acute apexes, central and dorsal valves smooth, shorter than lateral valves. Caudal lamellae (Figs 3j–k) elongated, nine times longer than their widest part, parallel-sided; nodated, divided into two regions: a basal 0.70–0.75 strongly sclerotized, and an apical 0.20–0.25 membranous short, flexible, and foliated apical one with a pale, almost transparent, and entire apex. Epiproct (Fig. 4h) basal 0.70 of dorsal margin with 13–14 strong setae-like spines; basal 0.65 of ventral margin with 19–20 strong setae-like spines, lateral carinae with 14–16 strong spine-like setae. Paraprocts basal 0.70 of dorsal margin with 13 strong setae-like spines, basal 0.75 of ventral margin with 37–43 strong setae-like spines, lateral carinae with 22–26 strong spines.

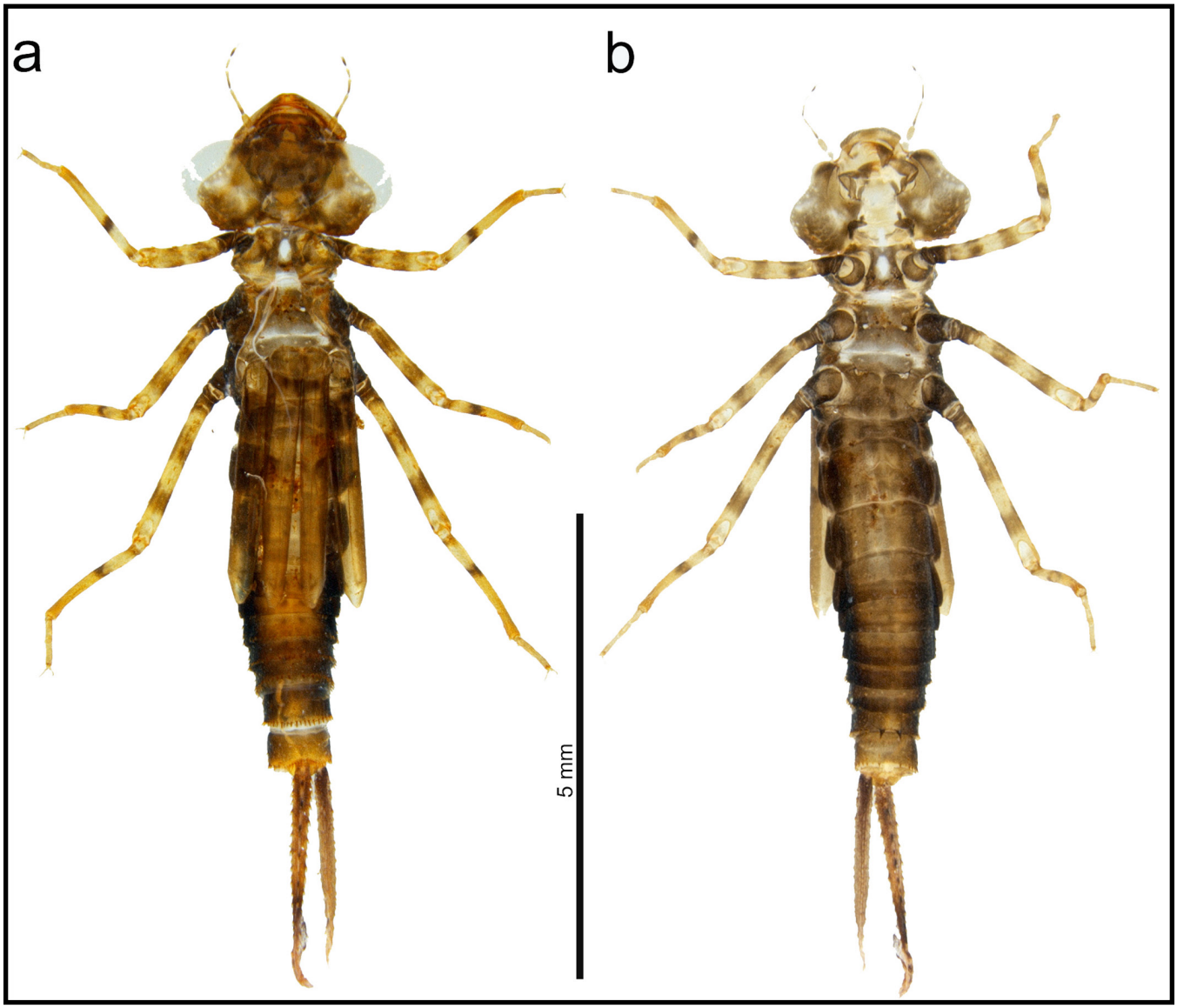

Figure 1. *Psaironeura tenuissima*, habitus, (a) dorsal view; (b) ventral view.

Measurements (mm). TL 9.65–9.67; AL 5.71–5.75; PfL 1.00–1.107; MsfL 1.427; HtfL 1.7; CeL 0.21; MgL 0.18; MLh 1.41; MWh 2.3; epiproct length 2.64, maximum width 0.35; paraproct length 2.28, maximum width 0.35. These measurements apply to both males and females, and no significant differences were found.

Differential diagnosis

Psaironeura can be grouped with *Neoneura* and *Protoneura* on the basis of their nodated caudal lamellae (Neiss & Hamada, 2012). However, they can be differentiated by their numbers of labial palp setae, the ex-

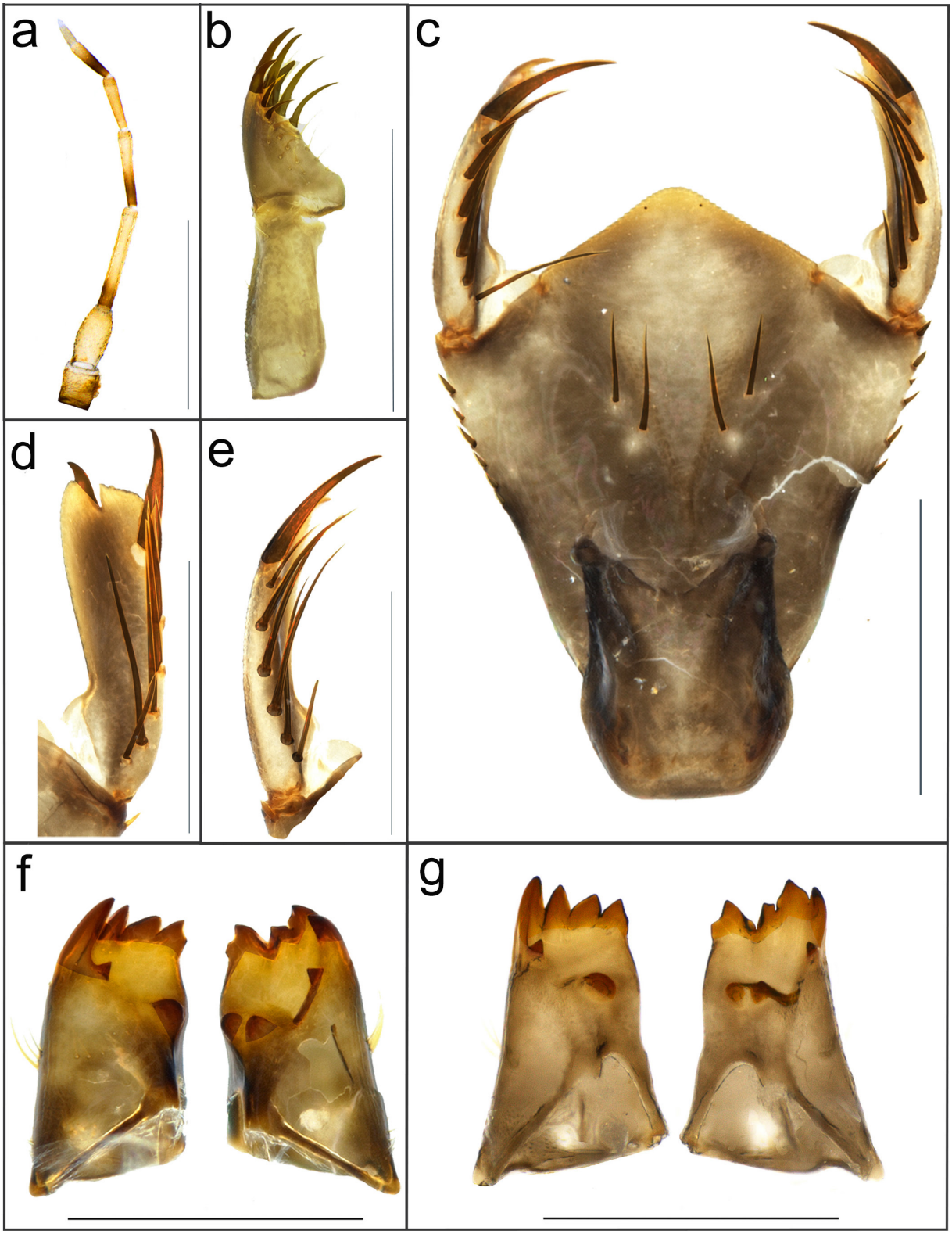

Figure 2. *Psaironeura tenuissima* male last-instar larva: (a) right antenna, dorsal view; (b) right maxilla, ventral view; (c) prementum, dorsal view; (d) right labial palp, ventral view; (e) right labial palp, dorsolateral view; (f) mandibles, ventral view; (g) mandibles, internal view. Scale bar = 1 mm.

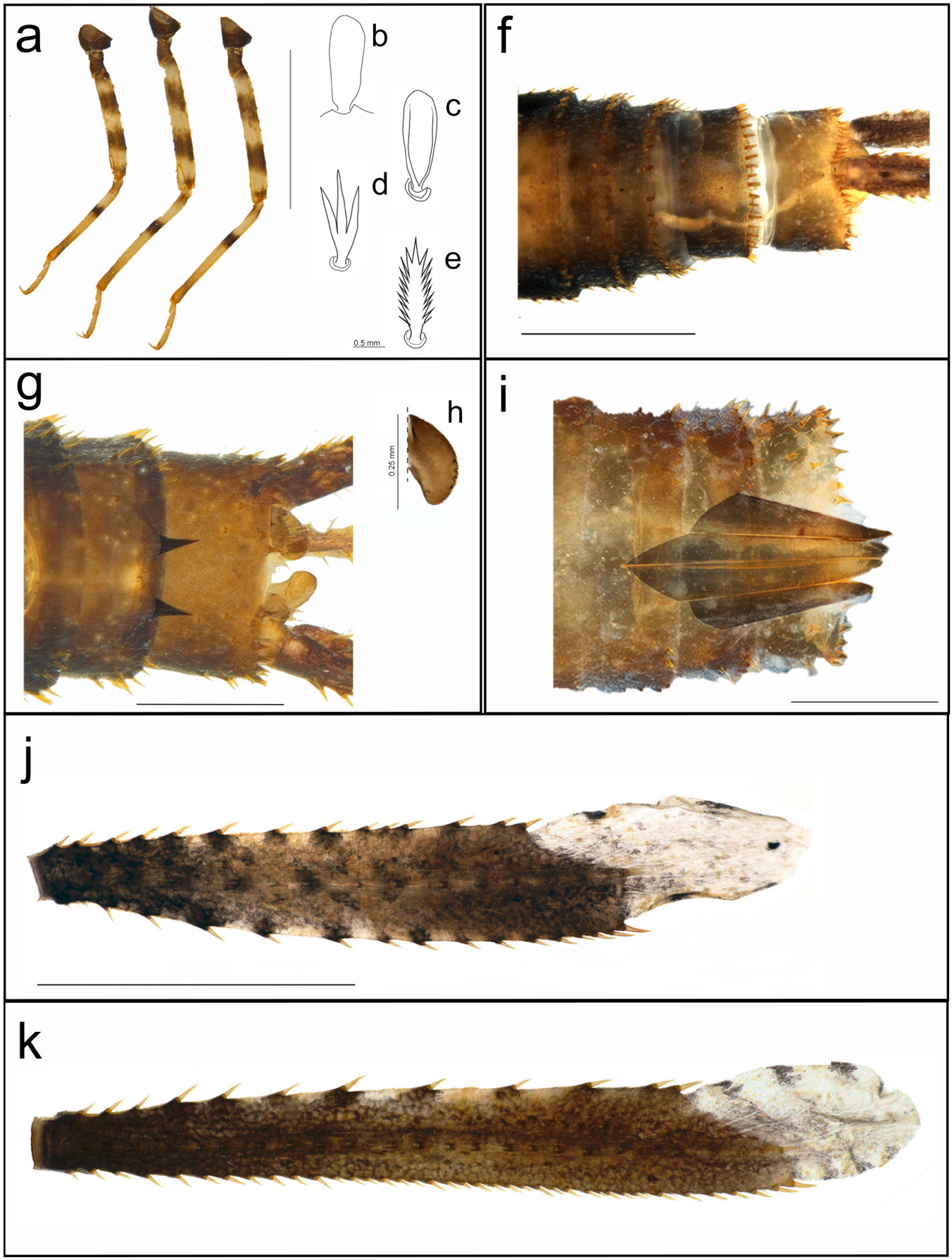

Figure 3. *Psaironeura tenuissima*, male last-instar larva: (a) legs, dorsal view; (b) concave spine with rounded apex, external view; (c) concave spine with rounded apex, internal view; (d) trifid spine; (e) pectinate spine; (f) details of male S6–10, lateral view; (g) male gonapophyses, ventral view; (h) cercus, left lateral view; (i) female gonapophyses, ventral view; (j) epiproct, lateral view; (k) paraproct, lateral view. Scale bar = 1 mm.

Table 1. Diagnostic characters of some Protoneurinae larvae with nodated caudal lamellae (sensu Neiss & Hamada, 2012). ? – character not described. * – character described but not illustrated.

	Psaironeura		***Neoneura***	***Protoneura***
Character	***P. angeloi*** (from Román Heracleo et al., 2021)	***P. tenuissima*** (this contribution)	***N. kiautai*** (from Anjos Santos et al., 2011)	***P. aurantiaca*** (from Novelo Gutiérrez, 1994)
Shape of head	subpentagonal	subpentagonal	semi–oval	trapezoidal
Shape of labrum	rounded	square	rounded	rounded
Shape of prementum	subrhomboidal	subrhomboidal	semi–oval	subrhomboidal
Posterior margin of prementum	weakly pronounced	strongly pronounced	pronounced	pronounced
Premental setae	4	4	4	2
Labial palp setae	6	6	3	5
Galeolacinia dorsal margin teeth	3	4	?	3*
Posterolateral margin of head	concave	concave	concave	concave
Occipital lobes	angulated	angulated	rounded	angulated
Pointed projection of prothorax	strongly acute	weakly pronounced	rounded	absent
Setae on ventral tibia	present	present	absent	absent
Spine–like on distal margin of S5–10	present	present	absent	absent
Paraproct ventral margin setae	22	37–43	25	<20
Caudal lamellae nodus position	about ¾	about ¾	about ½	about ¾
Epiproct apex	trilobate, with terminal filament	entire, without terminal filament	acute, without filament	acute, with filament
Paraproct apex	bilobate	entire	?	acute, with filament

pression of their lateral projections on the prothorax, and the shape of the apexes of their caudal lamellae (Table 1) (Román-Heráclio et al., 2021).

Although the known larvae of the *remissa* and *tenuissima* species groups of *Psaironeura* are morphologically similar to those of *P. angeloi* and *P. tenuissima*, respectively, it is possible to discern some differences between them (*P. angeloi* in parentheses): prementum distal margin strongly pronounced (triangular), reaching half of the labial palp length (slightly pronounced reaching ⅓ of labial palp length); apex of epiproct entire, rounded and without terminal filament (apex trilobate, with a filament on the middle lobe); apex of paraprocts entire, rounded and without filament (apex bilobate, with a filament on the middle lobe); 37–43 (22) spines on the lower margin of paraprocts.

Habitat and Ecology

Psaironeura adults are found in dense forest vegetation, in the lower stratum of the vegetation, and near lateral pools or backwaters (Fig. 4a) (Mendoza-Penagos et al., 2022). The larvae studied here were collected in Amazon lowland forest black-water streams of the first or second orders, among dead leaves and roots in pools adjacent to the main course of streams. These situations matched the habitat described by Román-Heráclio et al. (2021) for *P. angeloi*.

Discussion

Information about Protoneuridae larvae in the Neotropics is scarce, with only about 15% (approximately 17 of 115 spp.) of the larvae being known as yet (Neiss & Hamada, 2014). This indicates that it is necessary to increase sampling efforts, prioritizing studies on larval stages. With regard to the genus *Psaironeura*, which is one of the most widely distributed protoneurid genera in the Neotropics, its first larva was just recently described (Román-Heráclio et al., 2021). This deficient situation may be explained by the fact that, like the adults, these larvae are difficult to collect in the field, since they occur in shallow water cluttered with roots and an abundance of organic matter that provide a multitude of hiding places and an environment that facilitates perfect camouflage, which the larvae make full use of with their small sizes and colorations.

The number of the setae and spines on the prementum and the caudal lamella can be used as diagnostic characters to separate genera in Protoneuridae larvae (De Marmels, 2007; Neiss & Hamada, 2012). Labium morphology seems to be very conservative, with only a few variations in the prementum (e.g., number of palp setae), whereas the number of spines on the caudal lamellae can exhibit a higher degree of variation. For example, the larvae of the two *Psaironeura* species compared here have six setae on the labial palp, while the larva of *N. kiautai* has only three (Anjos-Santos et

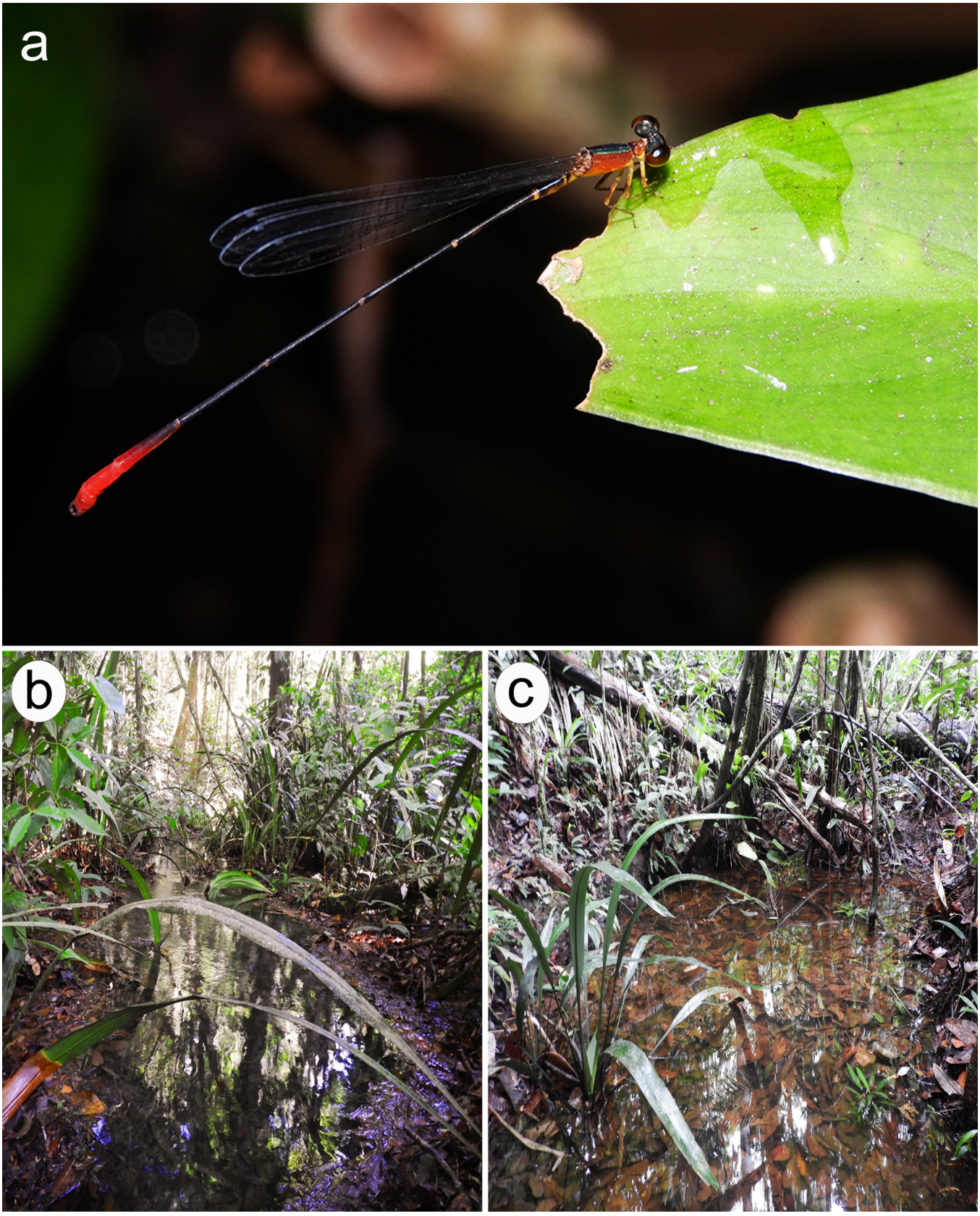

Figure 4. (a) Adult male of *Psaironeura tenuissima*, (b, c) habitat of larvae.

al., 2011) and that of *P. aurantiaca* has five (Novelo-Gutiérrez, 1994). On the other hand, the number of spines on the ventral margin of the paraproct can vary from less than 20 in *Protoneura*, between 12 and 24 in *Neoneura* (De Souza et al., 2012), and between 22 and 43 in *Psaironeura* larvae. This suggests that this variation may be more useful for separating species at larval level within a genus than for separating genera.

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