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Author(s)	Yoshizawa, Kazunori; Souza-Silva, M.; Ferreira, R. L.
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Disjunct occurrence of *Trichadenotecnum s.str*. in southeastern Brazil (Psocodea: "Psocoptera": Psocidae), with description of a new species

K Yoshizawa 1, M Souza-Silva 2, RL Ferreira 2

1 Systematic Entomology, School of Agriculture, Hokkaido Univ, Sapporo, Japan
2 Centro de Estudos em Biologia Subterrânea, Setor de Zoologia Geral, Departamento de Biologia, Universidade Federal de Lavras, Lavras, Brazil

Keywords

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Correspondence

K Yoshizawa, Systematic Entomology, School of Agriculture, Hokkaido Univ, Sapporo 060-8589, Japan; psocid@res.agr.hokudai.ac.jp

Abstract

A new barklouse species belonging to the *Trichadenotecnum s.str.* clade (Psocodea: "Psocoptera": Psocidae) was described from southeastern Brazil (Minas Gerais state). This locality is highly isolated (about 3400 km) from the closest known distributional range of this clade. It also represents the southern-most distributional record of *Trichadenotecnum s.str*. Phylogenetic placement of the species and biogeography of Neotropical *Trichadenotecnum* were briefly discussed. *Trichadenotecnum punctipenne* New, 1972 described from Brazil was synonymized with *T. pardus* Badonnel, 1955.

Introduction

The genus *Trichadenotecnum* is one of the most species-rich and widely distributed barklouse genera (Psocodea: "Psocoptera"). It occurs in South America but, in comparison to the high diversification of the genus in Southeast to eastern Asia (ca. 150 species: Yoshizawa *et al*, 2014; Yoshizawa & Lienhard, 2015a, b) or in Central America (over 35 species: Yoshizawa *et al*, 2008), species richness of *Trichadenotecnum* in South America is quite low (10 species: Yoshizawa *et al*, 2008; Yoshizawa & García Aldrete, 2010). Recent morphological (Yoshizawa *et al*, 2008) and molecular (Yoshizawa *et al*, 2016) phylogenetic analyses showed that most of the South American *Trichadenotecnum* species belong to a single small clade (Neotropical Clade in Fig 1) which is the sister to all the rest of members of the genus (Yoshizawa *et al*, 2008, 2016). Within the major clade of the genus, a conspicuous subclade, *Trichadenotecnum s.str.*, has long been recognized (Fig 1), which is distributed throughout the Oriental and Holarctic Regions and throughout the northern-most part of the Neotropics (Figs 1–2). *Trichadenotecnum s.str.* has its origin in the Old World (probably Oriental), and the occurrence of the species of this clade in the New World is considered to be a result of transcontinental dispersals from the Old World (Yoshizawa *et al*, 2008). Only two species of *Trichadenotecnum s.str.* are known to occur in South America: *T. decui* Badonnel, 1987 from Venezuela and *T. simile* Mockford, 1996, which was originally described as the male of *T. decui* by Mockford (1991) but was later recognized as an independent species, from northern Brazil. Both species have their close relatives in Central America (North, Central, South American Clade in Fig 1: Yoshizawa *et al*, 2008). Extremely low diversification of *Trichadenotecnum s.str.* in South America and its restriction to the northern-most region of the continent have been considered to reflect their recent dispersal to South America, after formation of the Central and South American connection in the Pliocene (ca. 3 Ma) (Yoshizawa *et al*, 2008).

In this paper, we report the occurrence of a species belonging to *Trichadenotecnum s.str.* from southeastern Brazil (Lavras, in southern Minas Gerais state), which is here described as *Trichadenotecnum ufla* n. sp. (Fig 3A). This locality is over 3400 km away from the known localities of the *Trichadenotecnum s.str.* species in South America (Venezuela and Roraima state in northern Brazil) (Fig 2). It also represents the southern-most distributional record of the clade.

Material and Methods

The specimens studied were collected by beating and were freshly killed and stored in 95% ethanol. Examination was made by using a stereoscopic microscope (SZX16: Olympus, Japan) or a compound microscope (Axiophot: Carl Zeiss Microscopy, Germany). The photographs were taken by using a digital camera (OM-D E-M5: Olympus, Japan) attached to SZX 16 (habitus) or Axiophot (forewing). Terminology followed Yoshizawa *et al* (2014).

Taxonomy

Trichadenotecnum ufla Yoshizawa, n. sp. (Figs 3–4)

Description

Female (Fig 3A). Head. White in ground color; vertical markings blackish brown, each marking separated from neighboring marks; orbital markings brown, posterior spots paler; brown marking between vertical and orbital markings; coronal suture white; epicranial suture bordered with brown band, outer part broader; frons with two pair of dark brown markings and medially with small spot; eyes gray, IO/D = 2.1; ocelli white, ocellar field black; gena blackish brown, medially with pale portion; postclypeus with rows of dark brown spots dorsally, spots fused and forming brown marking ventromedially; anteclypeus blackish brown. Scape and pedicel dark brown; flagellum pale brown. Mouthparts blackish brown.

Thorax. Prothorax pale brown. Mesonotum white in ground color, with posterior part of lateral lobe brown; median lobe mostly brown, sutures blackish brown. Metanotum mostly white, brown medially. Meso- and metapleuron blackish brown except for white membranous region.

Legs. Fore- and midlegs mostly white; coxa of midleg blackish; femora with two blackish stripes; tibiae with blackish stripe near distal tip. Hindleg blackish except for white tibia with blackish stripe near distal tip. Tarsi of all legs blackish.

Forewing (Fig 3B). Spots in cell a1 well developed, basal one paler. Opposing spots in cell r apparent, about equal in size, clearly separated. Basal band discontinuous around M–Cu

fork, with broad oval pale region in cell cu. Median spots well developed. Distal band well developed. Spot on roof of cell m3 broad. Submarginal spots well developed, especially in cell r5 expanding distally to marginal cloud. Marginal cloud dark and well developed, with pale region at wing margin of cells r5 and m1 and middle of cell m3.

Abdomen pale yellow with small brown irregular markings dorsally, brown ventrally.

Genitalia (Fig 4). Subgenital plate (Fig 4A) with pair of pointed and basally serrated processes posteriorly; egg guide weakly sclerotized ventrally, widely sclerotized dorsally, posterior margin rounded, narrow and parallel sided in distal half, then gradually broadened to base; body broadly sclerotized with narrow membranous region medially, posterolaterally with wrinkled region just anterior to long processes, and with extended sclerotization anteromedially. Gonapophyses (Fig 4B). Ventral valve long; dorsal valve with long distal process; external valve with broad posterior lobe, internal lobe short. Spermapore plate sclerotized and pigmented as in Fig 4C.

Measurements. Body length 2.1–2.2 mm; forewing length 2.8–2.9 mm; hindwing length 2.0–2.1 mm.

Type material. Holotype: female. S21.223747º, W44.968633º, Campus of the Universidade Federal de Lavras (UFLA), 16.iii.2016, K. Yoshizawa (deposited in ISLA-UFLA) (five sequences, *16S rRNA, 12S rRNA, COI, 18S rRNA* and *Histone 3* genes, of the holotype are deposited in GenBank, under the accession numbers LC185091–5). *Paratypes*. 2 females, same locality as for holotype, 1 collected on 16.iii and 1 collected on 17.iii.2016 (deposited in ISLA-UFLA and Hokkaido University)

Etymology. The specific epithet, an invariable combination of letters, is the abbreviation of the type locality, Universidade Federal de Lavras.

Habitat. *Trichadenotecnum ufla* was collected in a secondary forest (Fig 5A: of about 7.56 ha) predominantly formed by trees of *Anadenanthera peregrine*, with an understory of diversified vegetation (at least 25 families and 66 plant species) (Fig 5B). This forest resulted from a shading experiment of coffee trees (*Coffea arabica*) started in 1943, currently in a permanent preservation area of UFLA (Nascimento *et al*, 2009). This forest is surrounded by

Eucalyptus plantations, public roads, forest nurseries, coffee plantations, and buildings of the Coffee Research Centre (Fig 5A).

The local climate has rainy and hot dry summers and cold winters, with average annual rainfall above 1400 mm (ranging from 15 to 3000mm) and average monthly temperatures from 15 to 23ºC (Dantas *et al*, 2007). The rains occur between November and February (Dantas *et al*, 2007; INMET 2016).

Remarks. This species belongs to *Trichadenotecnum s.str.* and resembles the species of the *alinguum* group distributed in the Oriental Region (not presented in Fig 1: see Yoshizawa & Lienhard, 2015b and Yoshizawa *et al*, 2016 for the morphology and placement of the species group) in having long and pointed processes on the subgenital plate. However, preliminary molecular phylogenetic analysis (Yoshizawa *et al*, unpublished) shows that this species is closely related to the New World species of the genus (see below). Among the New World species of *Trichadenotecnum*, nothing similar is known.

T. simile Mockford, 1996 is known to occur in Brazil (Roraima, Rio Uraricoera, Ilha de Maraca), the female of this species has not been recorded to date. However, the forewing markings of *T. ufla* (Fig 3B) differ significantly from those of *T. simile* in the following points (see Mockford, 1991: fig. 287): opposing spots in cell r are about equal in size in *T. ufla* whereas the posterior spot is much smaller in *T. simile*; the submarginal spot in cell m3 is distinct in *T. ufla* whereas it is fused to the marginal cloud and m3 roof spot so that is obscure in *T. simile*; marginal cloud is discontinuous in cell m2 in *T. ufla* whereas it is continuous in *T. simile*. The forewing marking condition is quite stable at least among the three individuals of *T. ufla* examined here. Forewing length of *T. simile* (2.2 mm) is much smaller than that of *T. ufla*, although such variation can sometimes be seen even within the same species.

Discussion

Of two known species of the South American *Trichadenotecnum s.str.* clade, *T. decui* is known from both sexes whereas *T. simile* is known only from a male. Therefore, there is a possibility that the present species, known so far only from females, may be conspecific with *T. simile*. However, from the differences in the forewing markings (see *Remarks* above) and great geographical isolation with climate differences (Fig 2), we concluded that these

specimens represent different species. Description of a *Trichadenotecnum* species based only on the females may be criticized, but DNA sequences (five genes, including a partial mitochondrial *COI*, the commonly used marker for DNA barcoding) of the holotype are available from the public database (see above for GenBank accession number) so that future identification of the conspecific male is warranted.

The subgenital plate of *T. ufla* is characteristic in having a pair of long and narrow processes, unknown in any other New World *Trichadenotecnum* species. Similar structures, however, can be seen in some species of the Oriental *Trichadenotecnum* (the *alinguum* group and a couple of Nepalese species of the *spiniserrulum* group: Yoshizawa *et al*, 2007; Yoshizawa & Lienhard, 2015b). Therefore, at least three independent origins of such processes can be assumed. The function of the processes is unknown to date.

Preliminary molecular analyses (Yoshizawa *et al*, unpublished) placed this species to the basal branch of the *slossonae* group (Fig 1), in which *T. simile* is classified (Yoshizawa *et al*, 2008). The morphology-based phylogenetic analysis supported sister group relationship between the *slossonae* and *decui* groups (Fig 1), but no species of the *decui* group was sampled in the molecular analyses. Therefore, as to the species-group placement of *T. ufla*, these two species groups are both probable. Here, we tentatively assign this species to the *slossonae* group because of the similarity of the spermapore plate structure of this species with that of *T. slossonae* Banks, 1903. The subgenital plate of *T. slossonae* possesses weakly projecting parts on the posterior margin, which probably represent the ancestral condition of the well-developed processes on the subgenital plate of *T. ufla*.

Although *Trichadenotecnum s.str.* is quite diversified in Central America, with a total of 35 species classified into seven species groups (North, Central, South American Clade in Fig 1), all three South American species of *Trichadenotecnum s.str.* belong to a single clade (the *slossonae* + *decui* clade). This may reflect the biogeographical history of *Trichadenotecnum s.str.* in Central and South America, but further phylogenetic and biogeographic analyses are needed to uncover when *Trichadenotecnum s.str.* colonized South America, why South American species are restricted to a single clade, and how they expand their distributional range in the continent. The widely disjunct distribution of *Trichadenotecnum s.str.* in South America is interesting because it potentially reflects the Quaternary refugia (Brown *et al*, 1974; Dietz, 1994). However, it may be just due to poor faunal investigation of Psocoptera in South America. Further investigation of the *Trichadenotecnum* fauna in South America,

especially for the high altitude regions rather than the Amazonian area, is highly desirable, because occurrence of *Trichadenotecnum s.str.* in South America seems to be restricted to mountainous regions (Fig 2).

The present discovery also highlights the importance of preserved forested areas in urban centers (Fig 5A). Unfortunately, during the expansion of many cities, most forested areas are removed, and many habitats (especially microhabitats) of some species can be destroyed. Most forested areas in cities (usually parks or squares) are created to promote recreation for the population, but without the concern of maintaining original habitats for different species. Especially in the Neotropics, with well-known mega diversity, it is crucial to keep forested areas in cities, since they can certainly embrace the main habitat of many species, particularly endemic invertebrates. In the case of the Universidade Federal de Lavras, the preserved areas have already revealed a new species, the amphipod *Hyallela minensis* (Bastos-Pereira & Bueno, 2013).

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Appendix. Identity of *Trichadenotecnum punctipenne* New, 1972

(by K. Yoshizawa)

In addition to the species mentioned in the main text of this paper, one more species, *T. punctipenne* is also known to occur in Brazil (Pernambuco state). Judging from a unique structure on the subgenital plate (lining sclerotisations), this species is apparently close to *T. pardus* Badonnel, 1955 and *T. pardidum* Thornton, 1961. The former is parthenogenetic and is widely distributed worldwide including Brazil (Mockford, 1993; Yoshizawa *et al*, 2008). This wide distribution of the parthenogenetic species is considered to be artificial, introduced from its native area in the Oriental Region, where the sister species of *T. pardus* (i.e., bisexual *T. pardidum*) is distributed.

Judging from the original description, I could not find any difference between *T. punctipenne* and *T. pardus*. All close relatives of *T. punctipenne*, i.e., species of the *spiniserrulum* group (Fig 1), are unknown from the New World. Very isolated occurrence of a native species of the *spiniserrulum* group (distributed in the Oriental and Afrotropical Regions: Fig 1) in Brazil is less likely. Therefore, I conclude here that *T. punctipenne* should be treated as a **new junior synonym** of *T. pardus*.

As mentioned above, *T. pardus* is likely to be artificially introduced to South America. Therefore, its occurrence in central Brazil does not affect the biogeographical discussion made in the main text of this paper.

Figure captions

Fig 1 Phylogenetic relationships among representative species groups of *Trichadenotecnum* (Yoshizawa *et al*, 2008). Note that some Old World species groups (e.g., the *alinguum* group) are not included in the tree (see Yoshizawa *et al*, 2016 for the placement of such groups). Distributional range of each species group (except for artificially introduced ones) is indicated after the group name. AF: Africa; CA: Central America; EP: eastern Palearctic; HA: Holarctic; NA: North America; OR: Oriental; PA: Palearctic; SA: South America; WP: western Palearctic.

Fig 2 Distribution map of the Neotropical species of *Trichadenotecnum s.str.*

Fig 3 *Trichadenotecnum ufla* n. sp. *A* Habitus of paratype female; *B* forewing of the holotype female.

Fig 4 Female genitalia of *Trichadenotecnum ufla* n. sp., ventral view. *A* Subgenital plate; *B* gonapophyses; *C* Spermapore plate.

Fig 5 The type locality of *Trichadenotecnum ufla* n. sp. *A* Satellite view: red broken line indicates the forest area where the species was collected; *B* environment within the forest.

Figure 1

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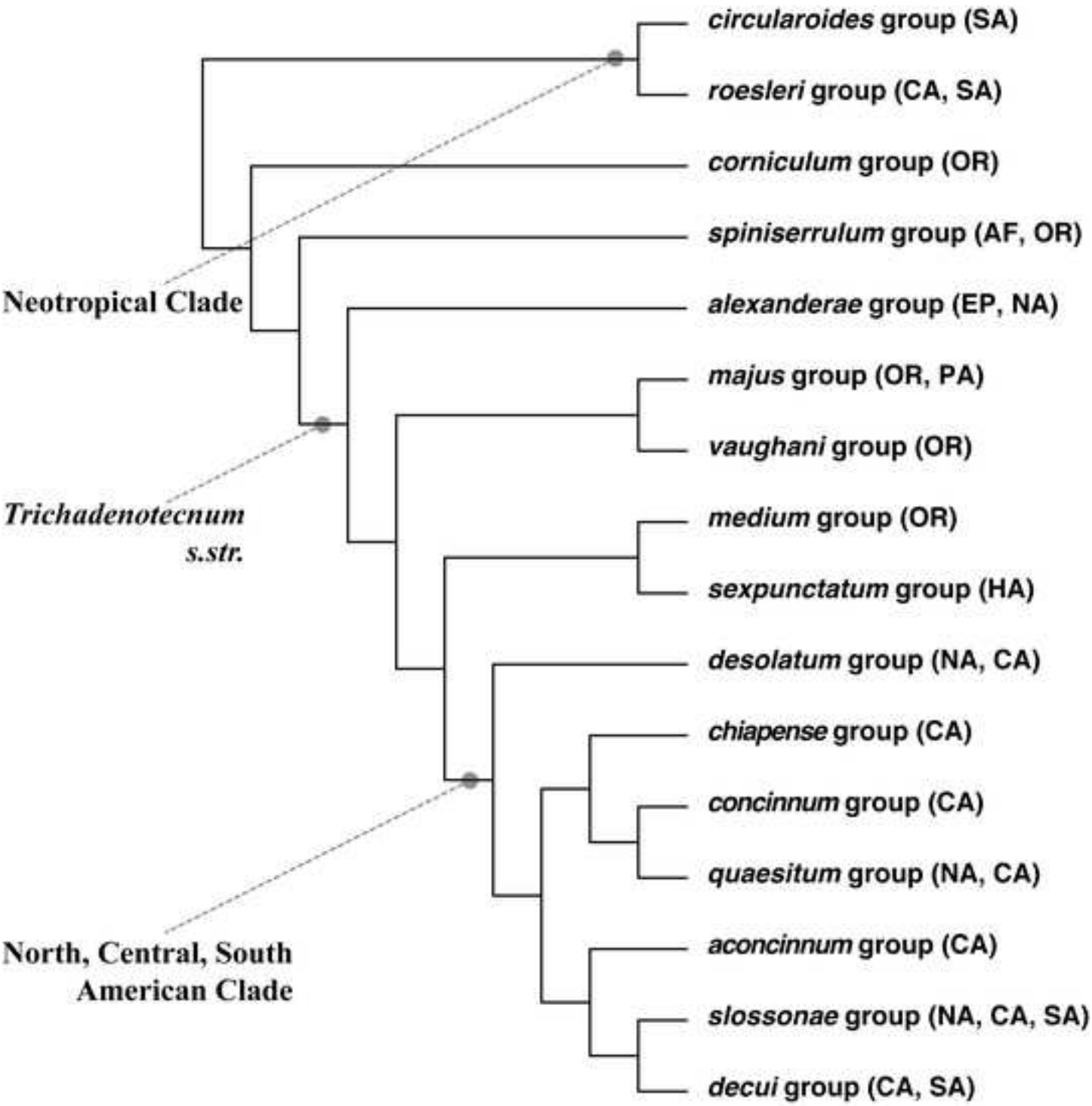

Figure 2

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Figure 3

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Figure 4

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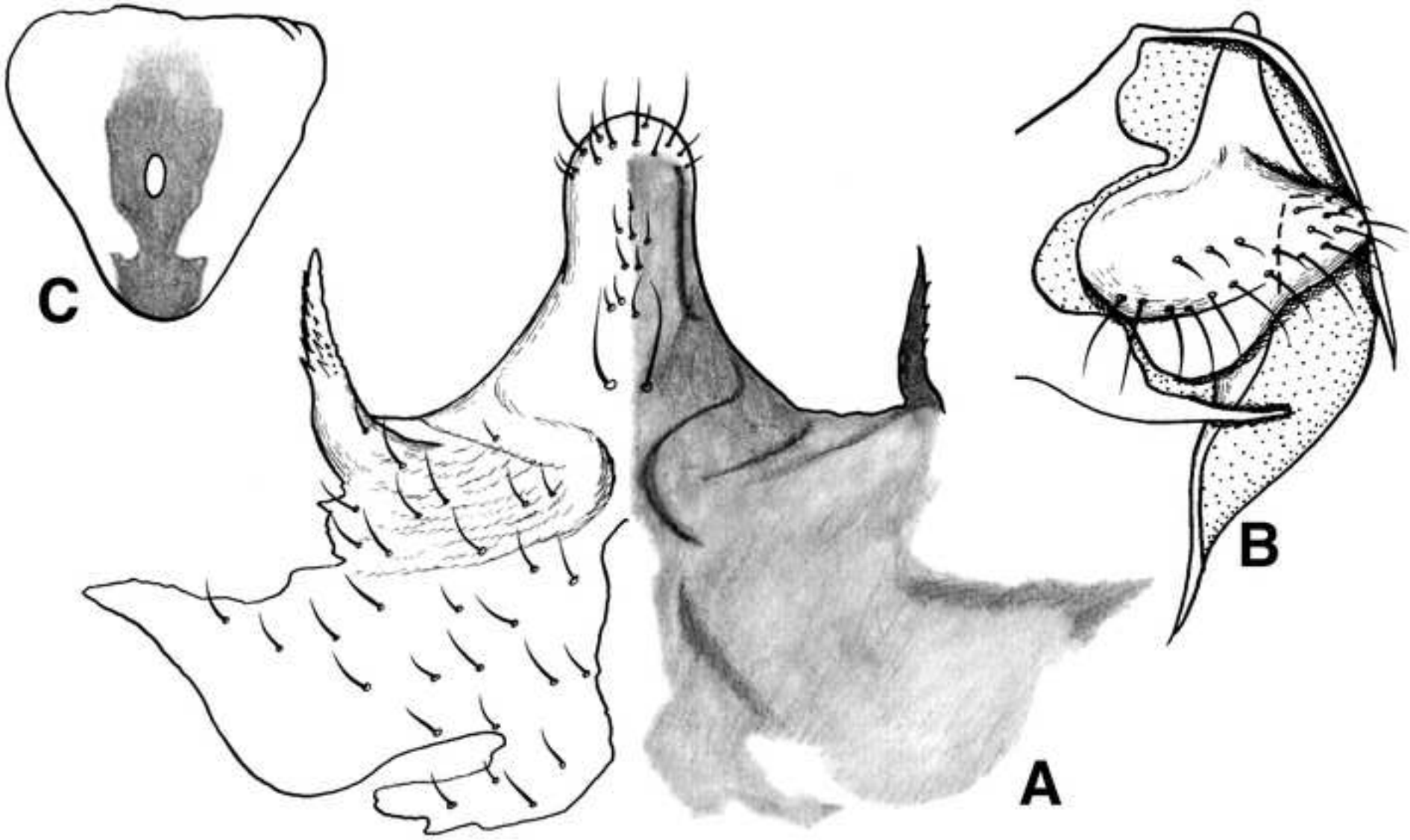

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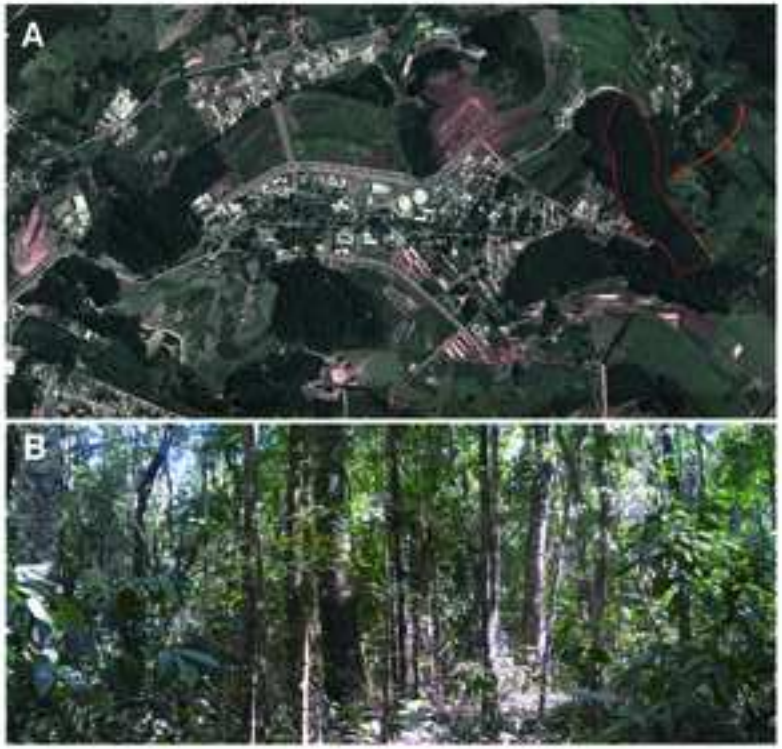
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