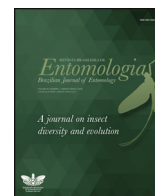




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A new oligolectic bee species of the genus *Rhophitulus* Ducke (Hymenoptera, Andrenidae) from South Brazil



Kelli dos Santos Ramos ^{a,*}, Samuel Siriani-Oliveira ^b, Clemens Schindwein ^c

^a Universidade de São Paulo, Museu de Zoologia, São Paulo, SP, Brazil

^b Universidade Federal de Minas Gerais, Programa de Pós-Graduação em Biologia Vegetal, Belo Horizonte, MG, Brazil

^c Universidade Federal de Minas Gerais, Instituto de Ciências Biológicas, Departamento de Botânica, Belo Horizonte, MG, Brazil

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ABSTRACT

The genus *Rhophitulus* Ducke, 1907 is a large and complex group of bees of the tribe Protandrenini comprising small, slender, mostly black ground-nesting species that are restricted to South America. We describe a new species of *Rhophitulus* from *Parque Nacional São Joaquim*, Urubici, state of Santa Catarina, Brazil. *Rhophitulus ater* sp. nov. is distinctive and easily distinguished from other species of the genus by a unique combination of morphological characters in both sexes, but especially by the following: dull black body, coarsely and densely punctate integument, basal area of metapostnotum depressed and areolate rugose, posterior margin of hind tibia and pygidial fimbria of female with blackish pilosity, and characters of the male genitalia with hidden sterna. The new species is closely associated with *Blumenbachia catharinensis* (Loasaceae), which is restricted to cloud forest of the southeastern rim of Serra Geral. Flowers of *B. catharinensis* are pollen and nectar resources and mating sites for the new species.

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Introduction

Rhophitulus Ducke, 1907 is a bee genus of the tribe Protandrenini, and is exclusively distributed in South America (Schindwein and Moure, 1998, 1999; Michener, 2007; Moure et al., 2007, 2012). Among the genera of Protandrenini, *Rhophitulus* is phylogenetically related to the South American genera *Cephalurgus* Moure & Lucas de Oliveira, *Chaeturginus* Lucas de Oliveira & Moure and *Psaenythisca* Ramos (Ruz and Melo, 1999; Michener, 2007; Ramos and Rozen, 2014; Ramos 2014). Moure (in Schindwein and Moure, 1998) provides a new genus name – *Panurgillus* – for species morphologically similar to *Rhophitulus*. This new genus, however, is a paraphyletic group from which *Rhophitulus s.str.* evolved (Michener, 2007; K.S. Ramos, personal observations). In this paper, *Panurgillus* is employed as junior synonym of *Rhophitulus*.

The genus is defined by the following combination of characters present in both sexes: forewing with two submarginal cells, stigma wider than prestigma, head commonly narrower than mesosoma, lower face convex, tentorial pit at intersection of outer subantennal and epistomal sutures, metapostnotum striate basally, and S2 to S5

with fine pilosity on premarginal areas. In addition, males have the inner orbits parallel or slightly converging below, antennal flagellum longer than head width, metasomal terga with depressed postgradular area compared to their discs, and S8 with slender lateral apodeme. Despite these diagnostic characteristics, the genus has no evident morphological synapomorphies, and thus a phylogenetic study is needed to verify its monophyly in relation to other closely related genera such as *Cephalurgus* (Silveira et al., 2002; Michener, 2007; Ramos, 2014). Males of the genus also have dorsal sclerotization of the membrane in the genital capsule (see Ruz and Melo, 1999: 231; Ascher 2003). This especially interesting structure is only found among other Protandrenini of the genera *Chaeturginus*, *Cephalurgus* and *Psaenythisca* (Moure and Lucas de Oliveira (1962); Ruz and Melo, 1999; Michener, 2007; Ramos and Rozen, 2014).

Rhophitulus currently comprises 32 species that are frequently collected in xeric and temperate areas of Argentina, Brazil, and Paraguay (Schindwein and Moure, 1998, 1999; Moure et al., 2012; Ramos, 2014). Nevertheless, virtually nothing is known about their natural history. Nesting biology and immature stages are known only for *Rhophitulus xenopalpus* Ramos, 2014 and *R. mimus* Ramos, 2014 which are communal, ground nesting and bi- or multi-voltine, and provision their nests with pollen from *Heliotropium* (Boraginaceae, *Rhophitulus xenopalpus*) and Asteraceae (*Rhophitulus mimus*) (Rozen, 2014). Species of *Rhophitulus* seem to be

* Corresponding author.

E-mail: kellisramos@gmail.com (K.S. Ramos).

oligolectic (*sensu* Robertson, 1925) – females provision their nests with pollen from flowers of the same plant family, including Apiaceae, Onagraceae, Oxalidaceae, Cactaceae, and Verbenaceae (Sakagami et al., 1967; Schlindwein and Moure, 1998, 1999; Gimenes, 2003; Gonçalves and Melo, 2005; Martins and Freitas, 2018). Detailed information on their behavior in the host plants and their effectiveness as pollinators, however, is not available.

Here we describe a new species of *Rhopitulus* from South Brazil. The species was discovered in the mountainous region of the state of Santa Catarina, located at the eastern rim of the Serra Geral within the Atlantic Forest domain, during a study of the pollination biology of *Blumenbachia catharinensis* Urb. & Gilg (Loasaceae). The vegetation of the area is characterized as cloud forest (“*matinha nebulosa*”, Rambo, 1956) surrounded by mixed ombrophilous forest dominated by *Araucaria angustifolia* (Bertol) Kuntze (Araucariaceae).

Material and methods

The material examined is deposited in the collection of Departamento de Zoologia, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil (DZMG). Paratypes were also deposited in the American Museum of Natural History, New York, United States (AMNH), Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZSP), Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (MNRJ), and Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Brazil (DZUP). Morphological terminology mainly follows that of Michener (2007), except for the term labral plate to refer to the central part of the labrum characterized by an elevated and glabrous area. The surface-sculpture nomenclature follows Harris (1979). Antennal flagellomeres are referred to as F1 to F11, and metasomal terga and sterna as T1 to T7 and S1 to S8, respectively. Punctuation density and the intervals between punctures are indicated in relation to puncture diameter (pd). The labels of the type specimens were transcribed in the Type material section in the following way: one inverted bar (\) indicates different lines on the label and quotation marks indicate different labels for the same specimen. All measurements are given in millimeters (mm) and are the maximum width/length of the measured structure. For the study of the male genitalia, terminalia were detached from the metasoma, cleared in a 10% KOH solution for 24 h, neutralized in acetic acid and stored in glycerin. Photographs were taken with a Canon EOS Rebel T3i camera equipped with a Canon MP-E 65 mm macro lens connected to a StackShot macro-rail and a Leica videocamera DFC 295 attached to a Leica stereomicroscope M205C employing Leica Application Suite software (LAS V3.6.0). Multi-focal images were produced using the software CombineZP and ZereneStacker version 1.04, and processed with Adobe Photoshop©.

Results

Rhopitulus Ducke, 1907

Rhopitulus ater new species Ramos, Siriani-Oliveira & Schlindwein
(Figs. 1–13 and 15–17)

Diagnosis

The new species has the following diagnostic characteristics in both sexes: integument of body predominantly reticulate between coarse and dense punctures (Figs 1–4), basal area of metapostnotum depressed and areolate rugose (Fig. 5), pronotal lobe black (Figs. 2–4), marginal zone of T1–T2 densely punctate (Figs. 6, 7), mesoscutum with short pilosity (about half the diameter of the

scape), and labral plate sub-rectangular. In addition, the posterior margin of hind tibia and pygidial fimbria of the female with blackish hairs (Fig. 6), female with basal area of fore- and mid tibia black, and clypeus of male with a longitudinal yellow mark (Fig. 3) are features that distinguish the new species among other species of *Rhopitulus*.

Rhopitulus ater sp. nov. is similar to *R. aeneiventris* (Friese, 1908), *R. malvacearum* (Schlindwein & Moure, 1998) (Figs. 22, 23), *R. ogloblini* (Cockerell, 1930), *R. pygidialis* (Vachal, 1909) and *R. reticulatus* (Schlindwein & Moure, 1998) (Figs. 18–21) by the integument surface of head predominantly reticulate between punctures. Despite this, it can be easily distinguished from these species by the predominantly coarsely punctate integument of head and metasomal terga in both sexes. The new species runs to couplet 9 for females of *R. reticulatus* and *R. malvacearum*, and couplet 11 for males with *R. hamatus* (Schlindwein & Moure, 1998) in Schlindwein and Moure's (1999) key. In addition to the features already mentioned, females of *Rhopitulus ater* sp. nov. differs from *R. malvacearum* (males are unknown) (Figs. 22, 23) mainly by the ventral portion of mesepisternum with hooked hairs, labral plate as wide as long and rugulose, and scutellum predominantly smooth between punctures. The new species can be distinguished from *R. reticulatus* (Figs. 18–21) by the following characters in either sex: marginal zone of metasomal terga punctate, basal area of metapostnotum shorter than metanotum length, first labial palpomere as long as the combined length of the three distal palpomeres, and pilosity of mesoscutum shorter than the maximum diameter of the scape. The clypeus of the males of *R. ater* sp. nov. is partly yellow while in *R. reticulatus* it is wholly black (Fig. 20). *Rhopitulus ater* sp. nov. differs from *R. hamatus* (Figs. 24, 25) mainly by the following characters: for either sex – face with dense punctures and reticulate integument, basal area of metapostnotum glabrous, wings with veins and pterostigma blackish; for a female – base of hind and mid tibiae without yellow marks, prepygidial and pygidial fimbria black, and marginal zones of metasomal terga not translucent; for males – mandible and pronotal lobe black, mid tibia and hind femur without yellow marks.

Comments

The new species fits well within the diagnosis of *Rhopitulus* (see Introduction) based on external morphology and hidden sterna. However, the following morphological characteristics of male genitalia differ from what is known for the genus: base of genital capsule without small dorsal sclerite, gonocoxite without deep oblique impression, gonostylus partly fused to gonocoxite, volsella denticulate only on opposable surfaces of digitus and cuspis, and cuspis slightly longer than digitus (Figs. 12, 13). Further studies involving taxonomic revision, phylogenetic analysis and comparative morphological analysis, including the male genitalia, of *Rhopitulus* are needed to provide comprehensive information about morphological variation within the genus.

Description

Holotype female

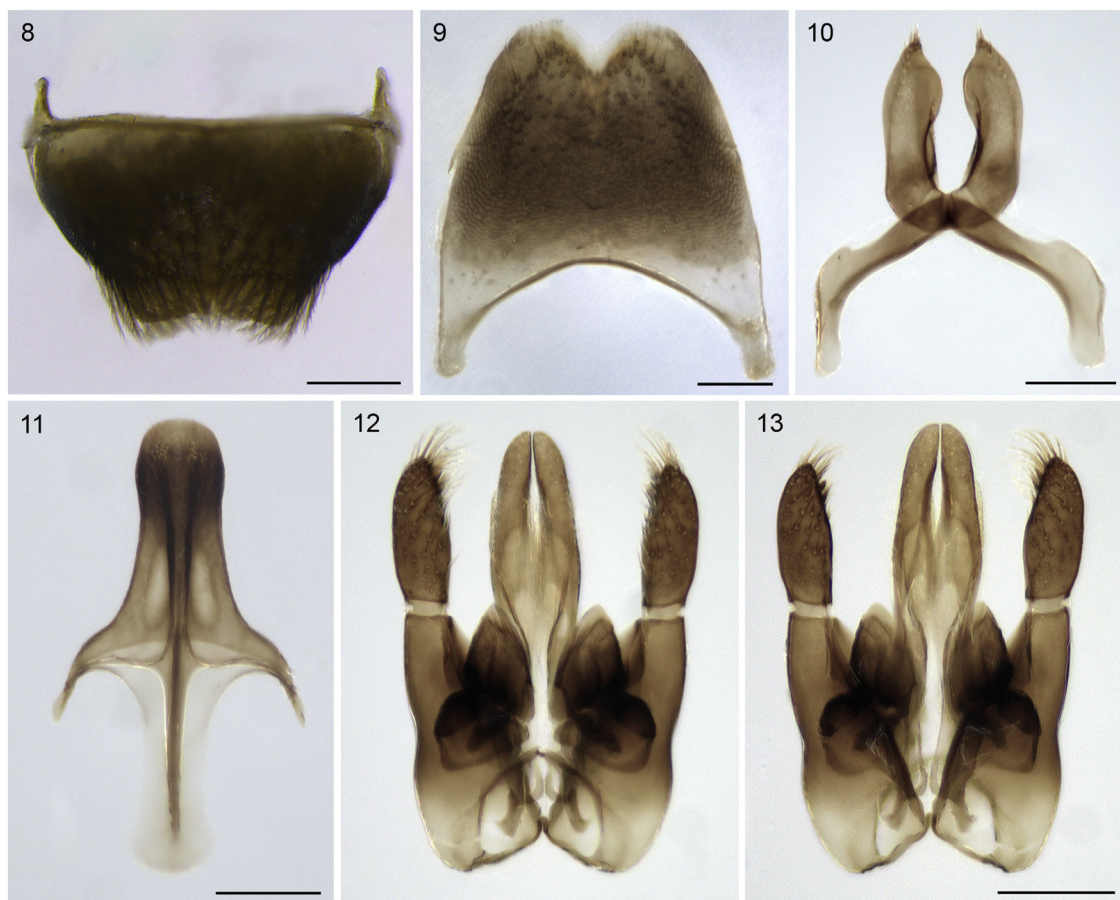
Approximate body length: 6.7 mm; maximum head width: 2.0 mm; intertegular distance: 1.5 mm; forewing length: 5.5 mm; T2 maximum width: 1.9 mm. *Color*. Body predominantly black except as follows: mandible apex dark brown; tegula dark brown, translucent; forewing membrane light brown, translucent, slightly infumated at distal third; veins and pterostigma dark brown; tibial spurs light brown; marginal zone not translucent (Fig. 6). *Pubesence*. Mostly white; ventral portion of basitarsus and tarsi light yellow; basitibial plate, posterior margin of hind tibia, prepygidial and pygidial fimbria blackish. Compound eyes with minute



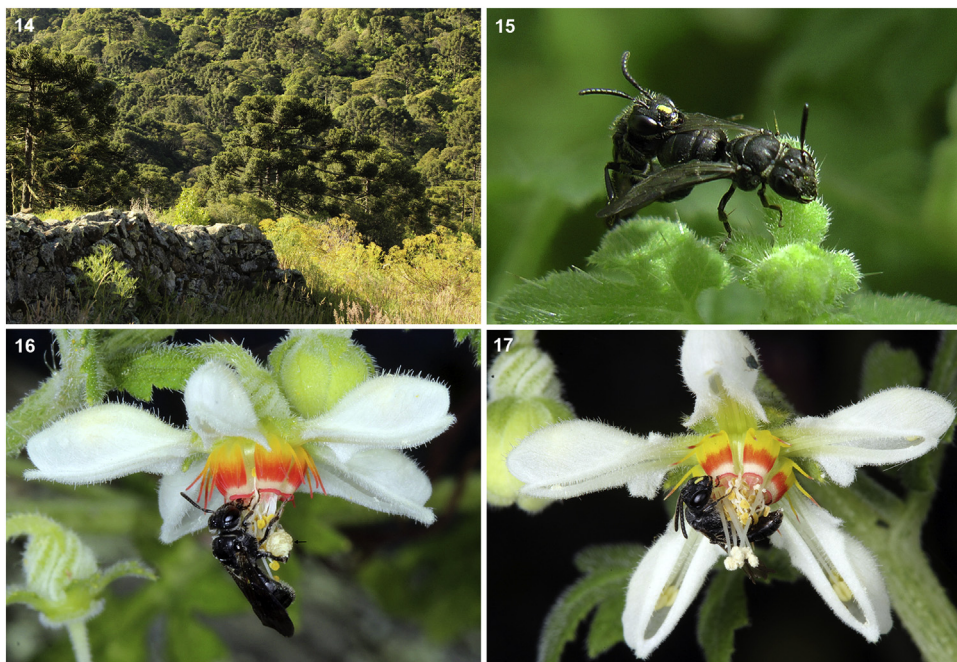
Figs. 1–7. *Rhophitulus ater* sp. nov.: (1) female (holotype), head in frontal view; (2) female (holotype), lateral view; (3) male (paratype), head in frontal view; (4) male (paratype), lateral view; (5) female (paratype), mesosoma in dorsal view; (6) female (paratype), metasoma in dorsal view; and (7) male (paratype), metasoma in dorsal view. Scale bar for figures 1–4 = 1 mm, figures 5–7 = 0.5 mm.

setae, almost inconspicuous; ventral portion of gena and lateral surface of mesepisternum with relatively long (about 0.45 mm), erect and plumose pubescence; tegula with anterior half with decumbent branched hairs and posterior half glabrous; mesoscutum and scutellum with tiny pilosity intermixed with sparse, long and erect branched hairs; pilosity shorter and fine on metanotum; metasomal terga with shorter and fine pilosity on disc, more dense and long on the sides; ventral surface of mesepisternum with simple hooked hairs; dorsolateral portion of propodeum with dense erect plumose hairs (Fig. 5); metapostnotum glabrous. Scola on hind tibia with sparse and simple hairs, longer than maximum tibia width (Fig. 2); hairs on hind basitarsus shorter than those on tibia. Disc of T1–T4 with tiny decumbent hairs, except for glabrous declivous portion of T1 (Fig. 6); premarginal line of T4 with loose fringe of finely branched hairs (Fig. 6); T5 and T6 with prepygidial and pygidial fimbria of plumose hairs (Fig. 6); marginal zone of metasomal terga and sterna glabrous; disc of S1–S5 with long, erect and finely branched pilosity. *Integumental surface.* Predominantly coarsely punctate and reticulate between punctures, except for smooth and shiny surface between punctures on supraclypeal area, posteriorly on disc area of mesoscutum, disc of scutellum, and posterior half of tegula. Labral plate rugulose with one fine median longitudinal carina; clypeus coarsely punctate (Fig. 1); inferior paraocular area moderately densely punctate (about ≥ 1 pd); frons, vertex and genae densely punctate (< 0.5 pd). Mesoscutum, metanotum and dorsolateral portion of propodeum densely punctate, reticulate between punctures (< 1 pd); disc of scutellum with sparse punctures (> 1 pd); posterior surface of propodeum impunctate, strongly reticulate

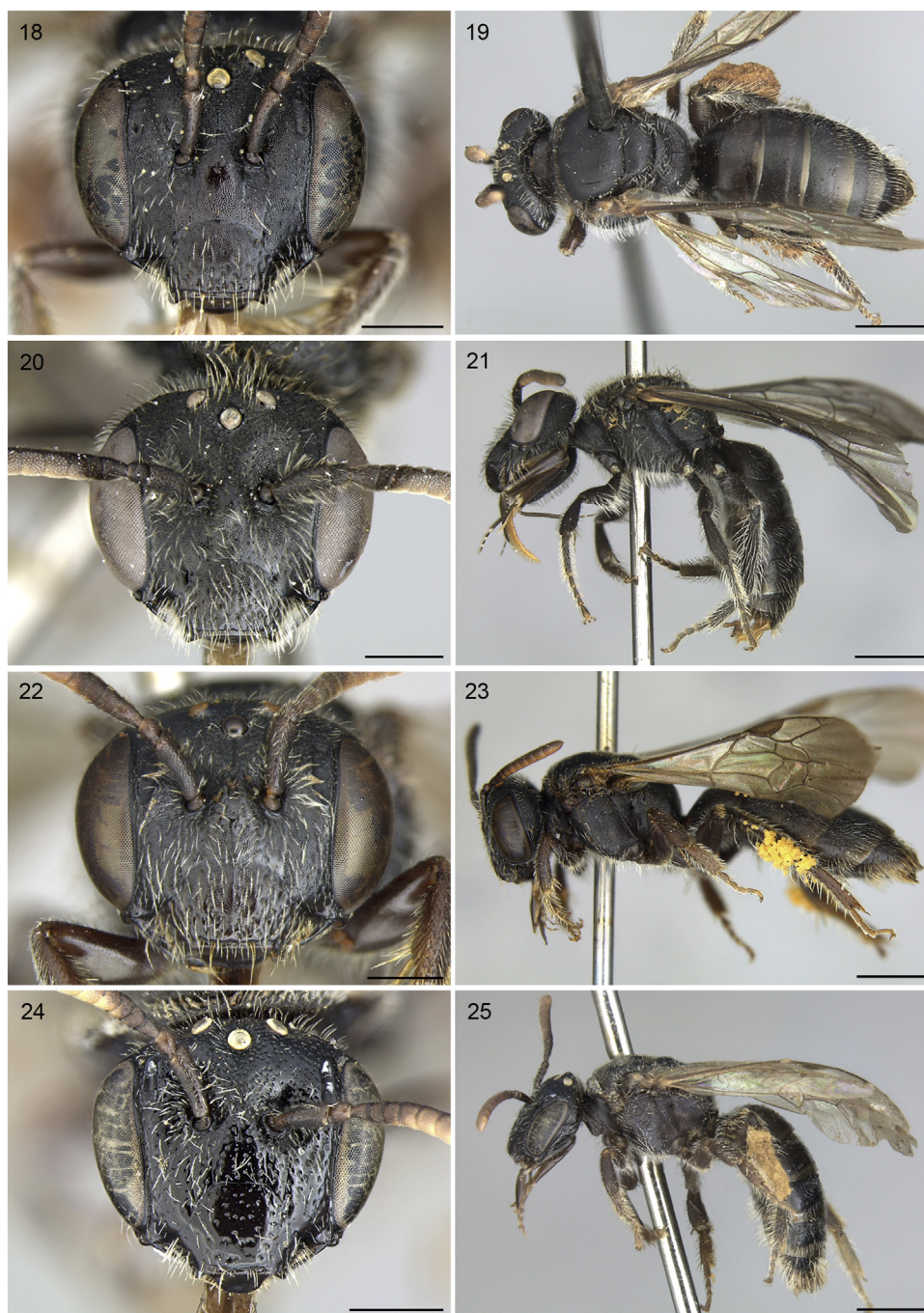
(Fig. 5); basal area of metapostnotum coarsely areolate rugose (Fig. 5). Metasomal terga densely punctate (< 0.5 pd) and lightly reticulate between punctures, except for completely impunctate and shiny declivous portion of T1; marginal zone finely and densely punctate (< 0.5 pd) with smooth, shiny, non-translucent apical margin (Fig. 6); pygidial plate reticulate. *Structure and measurements.* Head approximately $1.2\times$ wider than long (2.0:1.6); first labial palpomere as long as the combined length of the three distal palpomeres; labral plate $1.2\times$ wider than long (0.28:0.26), distal margin weakly emarginate; compound eyes $2\times$ longer than wide (1.2:0.6), inner orbits slightly convergent below (upper distance 1.33, lower distance 1.21) (Fig. 1); clypeus $1.8\times$ wider than long (1.07:0.6); subantennal sutures subparallel; frontal line slightly cariniform in the interalveolar area and grooved to the median ocellus; upper paraocular area slightly inflated; facial fovea narrow and long, $4.7\times$ longer than wide (0.33:0.07); length of the first three flagellomeres 0.21, 0.13, 0.13, respectively; gena in lateral view $0.8\times$ as wide as eye width; parapsidal line impressed and linear, as long as tegula length; median mesoscutal line deeply impressed; first submarginal cell slightly longer than second; 1m-cu reaching second submarginal cell at basal third; hind wing with 9 hamuli; ventral margin of mid femur with pronounced angle but not forming tooth; mid tibial spur finely serrate, $0.8\times$ as long as basitarsus (0.5:0.6); mid basitarsus $3\times$ longer than wide (0.6:0.2); hind tibial spurs similar in length with apex straight; tarsal claws bifid, teeth of similar sizes; basal area of metapostnotum depressed, shorter than scutellum (Fig. 5); anterior portion of T1 strongly declivous; discs of T2–T4 almost flat; T1 and T2 with lateral line; lateral fovea of T2 oval



Figs. 8–13. Male of *Rhophitulus ater* sp. nov. (paratype): (8) T7 in dorsal view; (9) S6 in ventral view; (10) S7 in ventral view; (11) S8 in ventral view; (12) genitalia in ventral view; and (13) genitalia in dorsal view. Scale bar = 0.2 mm.



Figs. 14–17. (14) Type locality of *Rhophitulus ater* sp. nov. in Parque Nacional São Joaquim, Santa Catarina, Brazil. The bees were collected on flowers of *Blumenbachia catharinensis* growing over “Taipas” (old fences built with stones to delimit pasture areas); mixed Araucaria forest in background. (15–17) *Rhophitulus ater* sp. nov. in *Blumenbachia catharinensis*. (15) Male and female in mating position on young leaves. (16) Female foraging on a pendulous flower; the black arrow indicates a hind tibia filled with pollen of *B. catharinensis*. (17) Male sleeping in a flower.



Figs. 18–25. *Rhophitulus* species. (18–19) *R. reticulatus* female paratype, Caçapava do Sul (RS, Brazil): (18) Head in frontal view. (19) Body in dorsal view. (20–21) *R. reticulatus* male, Guarani das Missões (RS, Brazil): (20) Head in frontal view. (21) Body in lateral view. (22–23) *R. malvacearum* female paratype, Caçapava do Sul (RS, Brazil): (22) Head in frontal view. (23) Body in lateral view. (24–25) *R. hamatus* female paratype, Capão da Canoa (RS, Brazil): (24) Head in frontal view. (25) Body in lateral view. Scale bar for figures 18, 20, 22, 24 = 0.5 mm, figures 19, 21, 23, 25 = 0.5 mm.

and slightly depressed; marginal zone of metasomal terga slightly depressed in comparison to disc (Fig. 6); pygidial plate V-shaped, slightly rounded at apex.

Paratype male

Approximate body length: 5.7 mm; maximum head width: 1.5 mm; intertegular distance: 1.2 mm; forewing length: 4.7 mm; maximum T2 width: 1.35 mm. Very similar to female in coloration, pubescence and integumental surface. Body predominantly black except for yellow longitudinal area on central portion of clypeus (Fig. 3) and small yellow spot on basal portion of fore tibia; basal

half of anterior surface of fore tibia and distitarsi light brown. Pubescence mostly white, except for brown hairs on T7; ventral surface of mesepisternum with plumose hairs, apex straight (without hooked hairs); hind tibia with long, sparse and branched hairs, shorter than maximum tibia width (Fig. 4); premarginal line of T4 and T5 with loose fringe of simple or finely branched hairs (Fig. 7); T7 with loose fimbria of plumose hairs; discs of S1–S5 with sparse semidecumbent and finely branched pilosity. Body surface coarsely punctate and reticulate between punctures (Figs. 3, 4); labral plate smooth and shiny on distal half, without longitudinal carina; premarginal line of T1–T2 with very sparse punctures (≥ 3 pd);

marginal zone of T1–T2 densely punctate (<1 pd) (Fig. 7); marginal zone of T3 with dense punctures on basal half (Fig. 7); marginal zone of T4–T7 smooth and shiny (Fig. 7). *Structure and measurements.* Head approximately 1.2× longer than wide (1.8:1.5); labral plate 1.4× wider than long (0.2:0.14), distal margin weakly emarginate; compound eyes 1.8× longer than wide (1.1:0.6), inner orbits convergent below (upper distance 0.73, lower distance 0.61); clypeus 1.2× broader than long (0.6:0.5); subantennal sutures subparallel; frontal line cariniform in the interalveolar area, becoming a weak line up to the median ocellus; facial fovea elliptic, 2× longer than wide (0.14:0.07); length of the first three flagellomeres 0.15, 0.10, 0.13, respectively; gena in lateral view 0.8× as wide as eye width; hind wing with 8 hamuli; ventral margin of mid femur without pronounced angle; mid tibial spur finely serrate, 0.5× as long as basitarsus (0.28:0.52); mid basitarsus about 4× longer than wide (0.52:0.15); hind tibia with toothed posterior margin; anterior portion of T1 declivous; pygidial plate absent; distal margin of T7 slightly emarginate (Fig. 8); S6 with shallow V-shaped emargination distally (Fig. 9); S7 with apical lobes attached to small discal area, constricted basally, with similar width from base to apex and few coarse hairs at apex (Fig. 10); S8 with long apical process, broadly-rounded apically, and basal portion slender compared to distal (Fig. 11); lateral apodeme of S8 basally directed (Fig. 11); genital capsule longer than broad, small dorsal sclerite absent; gonostylus about one half as long as gonocoxite, pilose apically, partly fused to gonocoxite, not reaching apex of penis valve (Figs. 12, 13); penis membranous and not beyond the apex of penis valve; cuspis of volsella slightly longer than digitus (Figs. 12, 13); volsella denticulate only on opposable surfaces of the digitus and cuspis (Figs. 12, 13); apodeme of penis valve hidden by gonocoxite, not surpassing genital capsule opening (Fig. 12).

Variation

The number of hamuli can vary from 7 to 10 in the same individual and in both sexes. The surface between punctures in the supraclipeal area and disc of scutellum can vary from smooth to microreticulate. The frontal line of some males is shorter, not reaching the median ocellus.

Distribution

Brazil, Santa Catarina, known only from the type locality. The species was discovered within the limits of the *Parque Nacional São Joaquim* (São Joaquim National Park) (28°08'30"S, 49°38'07"W), between 1300 and 1500 m elevation. The surrounding vegetation is dominated by mixed *Araucaria* forest and tropical rainforest (Atlantic Forest). Individuals were collected while foraging on flowers of *Blumenbachia catharinensis* growing on humid soil at the edge of the forest or over old fences called "Taipa", which are built with blocks of stones and mainly used to delimit pasture areas (Fig. 14).

Type material

Holotype female (DZMG) (UFMG-IHY-1803416) "PARNA [Parque Nacional] São Joaquim\ Urubucí [Urubici], SC [Santa Catarina]\Brasil 13/12/2016\Samuel Oliveira leg." "L. 320 P.706\Blumenbachia\catharinensis". *Paratypes:* 1 female (DZMG) (UFMG-IHY-1901612) and 3 males (DZMG) (UFMG-IHY-1901605, UFMG-IHY-1901606 and UFMG-IHY-1901607) same data as holotype; 1 female (MZSP 62272) same data as holotype; 1 female (DZMG) (UFMG-IHY-1901610) and 1 male (DZMG) (UFMG-IHY-1901608) same data as holotype except 12/12/2016; 1 male (MZSP 62273), same data except 02/12/2016; 2 females (DZMG) (UFMG-IHY-1901609 and UFMG-IHY-1901611) same data as holotype except 11/11/2016; 1 female (MZSP 62274) and 1 male

(one with terminalia dissected) (MZSP 62275), same data; 1 female and 1 male (DZUP), same data; 1 female and 1 male (AMNH), same data; 1 female and 1 male (terminalia dissected) (MNRJ), same data.

Visited flowers

Blumenbachia catharinensis Urb. & Gilg (Loasaceae). The genus *Blumenbachia* Schrad. is a morphologically quite homogeneous species group of annual stinging herbs (Henning et al. 2015). *Blumenbachia catharinensis* is a rare species with discontinuous occurrence throughout the southeastern border of the Serra Geral Plateau in the states of Santa Catarina and Rio Grande do Sul (Santos and Trinta, 1985). Like most species of Loasaceae, *B. catharinensis* possesses complex floral morphology and a narrow relationship with oligolectic pollinators (Schlindwein and Wittmann, 1997; Siriani-Oliveira et al., 2018). *Rhophitulus ater* sp. nov. was the main floral visitor of *B. catharinensis* during fieldwork for a pollination study carried out between November and December of 2016 to 2018 (Siriani-Oliveira and Schlindwein, not published). A forthcoming study will provide information on the foraging and reproductive behavior of this species and its relationship with its host plant. Females and males rely exclusively on plants of *B. catharinensis* as a food source (pollen and nectar) (Figs. 16, 17), which also provide sleeping places for males (Fig. 17) and mating sites (Fig. 15). No male or female bees of *R. ater* sp. nov. were sampled on other co-flowering plant species in the vegetation surrounding individuals of *B. catharinensis*.

Flight activity

Specimens were collected in November and December.

Etymology

The specific epithet is derived from the Latin 'ater' (= dark, black, gloomy), in reference to the black body of both sexes of this species.

Conflicts of interest

The authors declare no conflicts of interest.

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