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New species of *Coccidella* Hambleton and *Rhizoecus* Kunckel d'Herculais from South America (Hemiptera: Rhizoecidae)

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Abstract

Two new species of root mealybugs (Hemiptera: Rhizoecidae) from South America are described and illustrated based on the morphology of the adult females: *Coccidella advena* Schneider & LaPolla, **sp. nov.** from Peru and *Rhizoecus peripotaro* Schneider & LaPolla, **sp. nov.** from Guyana and Peru. Both species were collected with colonies of *Acropyga* ants (Hymenoptera: Formicidae) but only *R. peripotaro* was found to be trophobiotic; *C. advena* was ignored by the ants and is considered to be free-living. A guide to aid in identification is provided for each species.

Key words: Coccomorpha, Coccoidea, root mealybug, *Acropyga*, taxonomy, trophobiosis

Introduction

This study continues recent work aiming to catalog and describe the diversity of root mealybugs (Hemiptera: Rhizoecidae and Xenococcidae) associated with ants from the genus *Acropyga* Roger (Hymenoptera: Formicidae). Three new species of *Ripersiella* Tinsley (Schneider & LaPolla 2022) and one of *Neochavesia* Williams & Granara de Willink (LaPolla & Schneider 2023) were discovered during recent collecting trips to the Peruvian Amazon. Recent studies by Kaydan *et al.* (2018, 2019) reviewed the Neotropical fauna of *Coccidella* and *Rhizoecus*, providing descriptions of two new species in each genus as well as identification keys to many of the adult females. The present article supplements their work and follows, but does not reiterate, their taxonomic treatments of these genera. We describe two additional new species belonging to *Coccidella* Hambleton from Peru and *Rhizoecus* Kunckel d'Herculais from Guyana and Peru.

Coccidella presently comprises 10 species, all of which are endemic to the Neotropical Region. The species were reviewed in Kaydan *et al.* (2018), which also provided an identification key to the adult females. This article adds *Coccidella advena,* **sp. nov.** and provides a guide to diagnose the species, bringing the total species in *Coccidella* to 11.

Rhizoecus is a large genus, with species located in each major zoogeographical region. At present it comprises 93 species, of which 43 are found in the Neotropical Region (García Morales *et al.* 2016, date of last access 29.viii.2024). Many other root mealybugs have been treated as species of *Rhizoecus* at various times (see for example Ferris 1953; Hambleton 1974; Williams & Granara de Willink 1992). At present, no single identification key covers all the *Rhizoecus* species present in the Neotropics; a combination of resources must be consulted. The family Rhizoecidae requires revision, considering morphological (Hodgson 2012) and molecular (Choi & Lee 2022) lines of evidence now available, and comprehensive identification keys could be included along with such revision. Kozár & Konczné Benedicty (2007) provided the most recent revision of root mealybugs (which they considered as the subfamily Rhizoecinae), based on the morphology of the adult females. At present, the keys to species of *Rhizoecus* by Kaydan *et al*. (2019), Kozár & Konczné Benedicty (2007), and Ramos-Portilla & Caballero (2016) cover all 43 Neotropical species; this article adds *Rhizoecus peripotaro,* **sp. nov.**.

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Materials and methods

Samples in this study were field-collected by the authors from nests of *Acropyga* ants following the protocol of Schneider *et al.* (2022). They were preserved in 95–100% ethanol and stored at −80 °C prior to study. Examined specimens were prepared either by slide-mounting directly or by first extracting DNA and then slide-mounting the cuticle. DNA extractions were performed using a QIAamp DNA Mini Kit (Qiagen, Valencia, California) following the standard protocol; specimen cuticles were removed from the extraction buffer after the initial lysing step and subsequently slide-mounted. DNA-extracted specimens received a unique six-digit alphanumeric identifier (e.g., S0755A); their DNA extractions, preserved at −80 °C, are housed at the USDA ARS Beltsville Agricultural Research Center, Beltsville, Maryland, USA. Individuals that were slide-mounted directly are identified simply by the nest ID number (*e.g.*, JSL130807-01). Specimens were slide-mounted following standard protocols (see Sirisena *et al.* 2013 for example). Associated *Acropyga* ants were identified using LaPolla (2004).

The terminology used in this paper follows Hambleton (1946), Kozár & Konczné Benedicty (2007), and Williams & Granara de Willink (1992). Measurements were made on a Zeiss Axio Imager.M2 (Carl Zeiss Microscopy, LLC, White Plains, NY, USA) microscope with the aid of an AxioCam and AxioVision software. Slide-mounted specimens were examined under phase contrast and differential interference contrast. Illustrations were completed using CorelDRAW X7 (Corel Corporation, Ottawa, Canada) and Krita 5.0.6 (Stichting Krita Foundation, Deventer, Netherlands).

Type depositories are abbreviated as follows: Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru (UNMSM); and Smithsonian National Museum of Natural History, Coccomorpha collection at USDA Agricultural Research Service, Beltsville, Maryland, USA (USNM).

Taxonomy

Coccidella advena Schneider & LaPolla, sp. nov.

Fig. 1

Material examined. ***Holotype***. PERU: 1 adult ♀, Madre de Dios, Las Cruces, Manu Paradise Lodge, from *Acropyga manuense* nest behind lodge, in soil around small rotting branches, -13.0548, -71.5440, 31.v.2019, J.S. LaPolla and S.A. Schneider leg., UNMSM (nest ID PER01-02; prep S0401B).

Paratypes. PERU, all with same data as holotype: 1 adult ♀, USNM (nest ID PER01-02; prep S0401D); 1 adult ♀, USNM (nest ID PER01-02); 1 adult ♀ in poor condition, USNM (nest ID PER01-02).

Description. Adult female (N=4).

Appearance in life. Body white to cream-colored, dusted in powdery white wax.

Description of slide-mounted adult female. Body elongate oval and membranous, 0.92–1.28 mm long, 0.46–0.75 mm wide at widest point near abdominal segment I. Eyes present on head margin. Antennae geniculate, each 5 segmented, situated ventrally on submargin of head; overall length 200–202 µm; segment lengths (in µm): segment I, 57; II, 17–21; III, 30–33; IV, 21–26; and V, 70. Antennal setae mostly flagellate, each 15–42 µm long; longest setae situated on apical segment (V), together with 4 falcate sensory setae. Cephalic plate present and sclerotized. Labium 3 segmented, 107 µm long, 50 µm wide. Anterior and posterior pairs of spiracles each about 16 µm in diameter. Legs well developed, measurements in µm: hind leg 433–446, coxa 59–67, trochanter + femur 171–177, tibia + tarsus 170–171, claw 32; ratio of trochanter + femur / tibia + tarsus 1.0–1.04. Leg setae mostly flagellate, each 15–38 µm long, tarsal digitules spine-like, claw digitules simple and shorter than claw (about 6 µm long). Both pairs of ostioles present and heavily sclerotized, each about 50 µm in diameter across orifice; lips of ostioles bearing multiple setae and trilocular pores. Anal lobes indicated by slight projections at posterior end on either side of anal opening, each lobe bearing 3 distinctly enlarged setae, each about 50 µm long when intact but several broken or missing in type series. Anal ring about 48 µm in diameter, with 2 rows of cells, those in outer ring each containing a spicule; ring bearing 6 setae, each 51–64 µm long. Internal genital organ sclerotized.

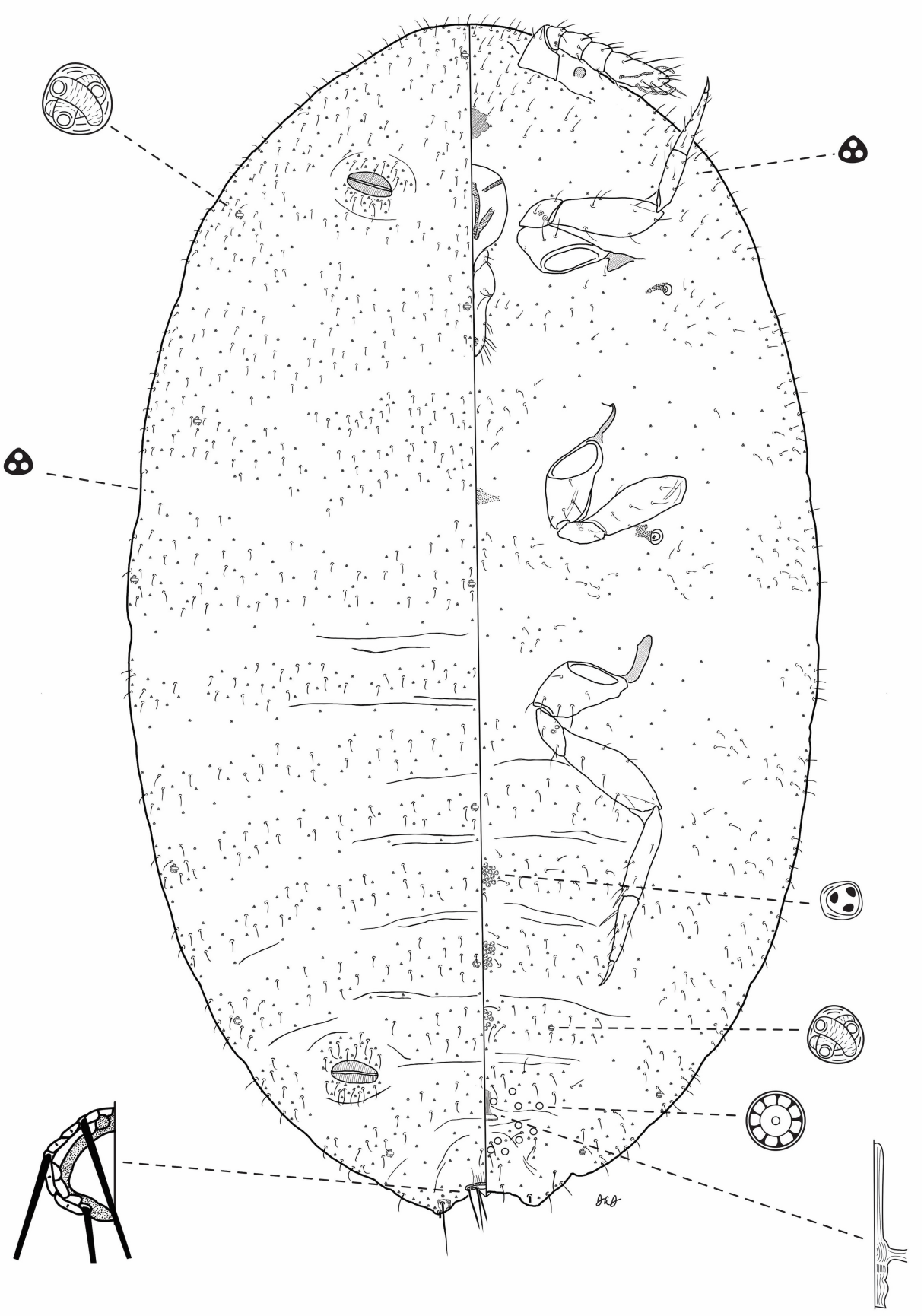

FIGURE 1. *Coccidella advena* **sp. nov.** Adult female, full body view, illustrated from the holotype and paratypes. Illustration by SAS.

Venter. Body setae flagellate, 12–28 µm long on head, 8–16 µm on thoracic segments, 10–19 µm on abdominal segments. Multilocular disc-pores present near vulva, 21 pores situated primarily on segments VII and VIII, in one specimen 2 are present on VI; most pores each apparently with 9 loculi. Tritubular cerores each 8–9 µm in diameter, situated on submargins of abdominal segments VI and VII and with 1 submedial pair on segment VI. Trilocular pores numerous, distributed among body setae, each about 3.5 µm wide. Enlarged trilocular pores, each about 5 µm wide, in medial clusters, with 19–23 pores on abdominal segment IV, 28–30 pores on V, and 13–19 pores on VI. Oral collar tubular ducts absent. Circulus absent.

Dorsum. Body setae flagellate, 9–14 µm long on head, 10–14 µm on thoracic segments, 10–19 on abdominal segments. Multilocular disc-pores absent. Tritubular cerores slightly larger than on venter, each 12–13 µm in diameter, situated on submargins of head, prothorax, mesothorax, metathorax, and abdominal segments III, V, VII; also medial cerores present on prothorax, metathorax, and abdominal segments III, V. Trilocular pores numerous, distributed among body setae, each about 3.5 µm wide. Oral collar tubular ducts absent.

Etymology. The epithet *advena* is a Latin noun meaning "visitor" or "stranger". It signifies that the type collection was collected with an ant colony but was unaffiliated with the ants.

Comments. The new species is placed in the genus *Coccidella* because it possesses characteristic clusters of specialized trilocular pores on the ventral surface of the abdominal segments (Kozár & Konczné Benedicty 2007). *Coccidella advena* is similar in appearance to *C. boliviana* Konczné Benedicty & Kozár but differs from it by having (character states of *C. boliviana* are given in parentheses): no multilocular disc-pores on the thorax (present); enlarged trilocular pores absent on the head (present); and with a ventral submedial pair of tritubular cerores on VI (absent). In a prior publication, *C. advena* was referred to as *Coccidella* near *boliviana* (Schneider *et al.* 2022). The host plant identity is unknown for this species. The type series was collected with a nest of *A. manuense* but was ignored by the worker ants during a period of observation so the species is presumed to have been living freely in the vicinity of the ant colony.

In the key to adult females of *Coccidella* by Kaydan *et al.* (2018), *C. advena* departs from the key at couplet 5 because it has the combination of eyes present and ostiole lips sclerotized. Their key can be modified at this point to accommodate *C. advena* by using the following:

5	Eyes absent	*C. kissbalazsi* Konczné Benedicty & Kozár
-	Eyes present	6
6	Ostiole lips sclerotized	*C. advena* Schneider & LaPolla **sp. nov.**
-	Ostiole lips membranous	6a
6a	Antennae 6 segmented; dorsal setae hair-like	*C. globocula* (Hambleton)
-	Antennae 5 segmented; dorsal setae spine-like	*C. kozari* Kaydan & Szita

Rhizoecus peripotaro **Schneider & LaPolla sp. nov.**

Fig. 2

Material examined. ***Holotype***. GUYANA: 1 adult ♀, Camp on Potaro River at base of Mt. Ayanganna, Dicymbe forest, from *Acropyga goeldii* nest, 5.3033, -59.9113, elev. 695m, 8.x.2002, J.S. LaPolla leg., USNM (nest ID JSL021008-04a-b, prep S0755A).

Paratypes. GUYANA, all with same data as holotype: 1 adult ♀, USNM (nest ID JSL021008-04a-b, prep S0755B); 2 adult ♀♀, USNM (nest ID JSL021008-04a-b); 2 adult ♀♀, USNM (nest ID JSL021008-04a-b); 2 adult ♀♀ and 1 immature in poor condition, USNM (nest ID JSL021008-04a-b); 3 adult ♀♀ and 1 immature in poor condition, USNM (nest ID JSL021008-04a-b).

Non-type material. PERU: all specimens from Cusco, Manu (Villa Carmen) Biological Station, from *Acropyga goeldii* nest, -12.8947, -71.4038, 6.viii.2013, J.S. LaPolla leg.: 1 adult ♀, USNM (nest ID JSL130806-12, prep S0093A); 1 adult ♀, USNM (nest ID JSL130806-12, prep S0093B); 1 adult ♀, 7.viii.2013, USNM (nest ID JSL130807-01, prep S0431A); 4 adult ♀♀ mounted on separate slides, USNM (nest ID JSL130806-12).

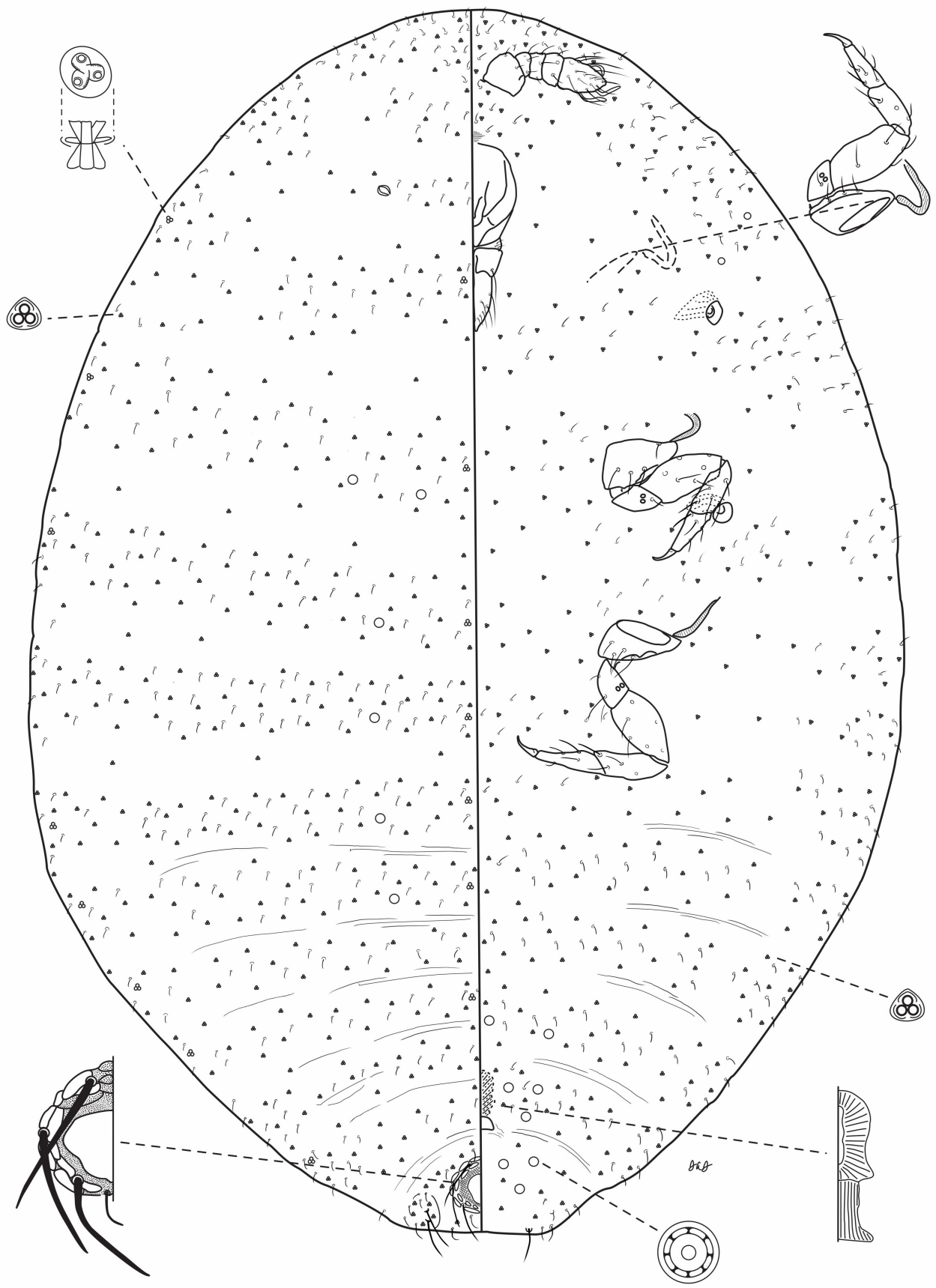

FIGURE 2. *Rhizoecus peripotaro* **sp. nov.** Adult female, full body view, illustrated from the holotype and paratypes. Illustration by SAS.

Description. Adult female (N=11).

Appearance in life not recorded.

Description of the slide-mounted adult female. Body broadly oval to subcircular and membranous, 0.81–0.90 mm long, 0.61–0.69 mm wide at widest point near abdominal segment II. Eyes absent. Antennae geniculate, each 5 segmented, situated ventrally on submedian of head; overall length 103–114 µm; segment lengths (in µm): segment I, 27–33; II, 12–15; III, 12–15; IV, 13–15, and V, 36–41. Antennal setae mostly flagellate, 11–28 µm long, longest setae on the apical segment, together with 3 falcate sensory setae. Cephalic plate present, sclerotized. Labium 3 segmented, 65 µm long, 45 µm wide. Anterior and posterior pairs of spiracles each about 18 µm in diameter. Legs well developed, measurements in µm: hind leg 229–234, coxa 30–34, trochanter + femur 85–91, tibia + tarsus 87–92, claw 19–24; ratio of trochanter + femur / tibia + tarsus 0.92–1.02 (average 0.97). Leg setae mostly flagellate, each 9–27 µm long; tarsal digitules stout flagellate; claw digitules simple and shorter than claw (about 5 µm long). Anterior ostioles present but poorly developed, each 8–11 µm in diameter (average 9.4 µm) with minor sclerotization around rim; posterior ostioles indistinct in type series, if present, weakly developed and without sclerotization. Anal lobes poorly developed, each bearing 3 distinctly enlarged setae, 34–48 µm long. Anal ring about 46 µm in diameter, with 2 rows of cells, all without apparent spicules; ring bearing 8 setae, 6 larger setae 41–49 µm long and 2 smaller setae situated at posterior apex, each about 20 µm long. Internal genital organ heavily sclerotized.

Venter. Body setae flagellate, each 7–10 µm on head, 7–13 µm on thoracic segments, 7–20 µm on abdominal segments. Multilocular disc-pores present: on abdomen, 12–20 pores situated near vulva on segments VI–VIII, with some variation in distribution among type series, 1 specimen also bears 1 submedial disc-pore on each of segments III and V; on thorax: 1 or 2 pores situated near each anterior spiracle but often with lopsided distribution, present on one side of the body only; 1 specimen also bears 1 pore near posterior spiracle on one side; most multilocular disc-pores apparently each with 8 loculi. Tritubular cerores absent. Trilocular pores numerous, each about 3 µm wide, distributed among body setae. Oral collar tubular ducts absent. Circulus absent.

Dorsum. Body setae flagellate, each 7–10 µm long on head, 6–11 µm on thoracic segments, 7–20 µm on abdominal segments. Submedial multilocular disc-pores present, number variable and often asymmetrical in distribution; situated most consistently on mesothorax, metathorax, and abdominal segment I, flanking median tubular cerores but often unpaired or with 2 pores to one side; also occasionally present on segments II or III. Tritubular cerores present, each about 7 µm in diameter; situated on margin of prothorax, mesothorax, metathorax, and abdominal segments II–V and VII; medial cerores present on prothorax, mesothorax, metathorax, and abdominal segments I–III and V. Trilocular pores numerous, each about 3 µm wide, distributed among body setae. Oral collar tubular ducts absent.

Etymology. The epithet is an adjective formed from Potaro, the name of the river basin where it was discovered, combined with the Greek prefix *peri-*, meaning near or around.

Comments. Following Kozár & Konczné Benedicty (2007), the presence of tritubular cerores and the weak development of the anal lobes in *R. peripotaro* places it within their concept of subtribe Rhizoecina, but it cannot be referred to the other genera of this group because it lacks (i) clavate setae, (ii) 5-locular pores, and (iii) groups of pores on the venter or around tritubular cerores. The new species fits within the general description of *Rhizoecus* in having (i) tritubular cerores, on the dorsum only in this case, and (ii) flagellate body setae. It departs from the norm for *Rhizoecus* by possessing 8 anal ring setae—the 6 robust setae typically found in other species, plus 2 additional shorter setae at the posterior apex of the ring.

A distinctive trait of *R. peripotaro* relates to the variable and asymmetrical distribution of multilocular disc-pores, particularly those on the dorsum. Dorsal multilocular disc-pores are present in each specimen of the type series but vary in which segments they occupy (mesothorax through abdominal segment II) and whether they are symmetrically paired or lopsided in distribution around the medial tritubular cerores. For example, one paratype has 1 submedial pore on the mesothorax (unpaired), 2 on the metathorax off to one side, a pair on abdominal segment I flanking the medial ceroris, and 1 (unpaired) on segment II. Multilocular disc-pores located near the spiracles are also asymmetrically distributed, sometimes with 1 or 2 pores located near the anterior spiracle on one side of the body only.

Rhizoecus peripotaro is similar in appearance to *R. compotor* Williams & Granara de Willink. It can be distinguished by having (character states of *R. compotor* are given in parentheses): dorsal multilocular disc-pores present (absent); with 12 or more ventral multilocular disc-pores near the vulva (only 3 in holotype); anterior ostioles with some sclerotization of the rim (anterior ostioles absent); and by lacking spicules in the outer row

of anal ring cells (spicules present). In a previous publication, *R. peripotaro* was referred to as *Rhizoecus* near *compotor* (Sodano *et al.* 2024).

The type series was collected in Guyana in 2002 from a nest of *A. goeldii* and was observed to be actively attended by worker ants. Subsequently, in 2013, another nest of *A. goeldii* from Peru was found containing mealybugs nearly identical to the type series of *R. peripotaro*, the only obvious difference being that their posterior ostioles are more developed and lightly sclerotized than in the type series. We tentatively recognize both samples as members of the same species.

The key to Neotropical adult females of *Rhizoecus* by Kaydan *et al.* (2019) can be modified (at couplet 17) to include *R. peripotaro* by using the following:

17	Anterior pair of ostioles present	18
-	Anterior pair of ostioles absent	*R. granaradewillinkae* Kaydan & Szita
18	Tritubular cerores present on venter	18a
-	Tritubular cerores absent from venter	*R. peripotaro* Schneider & LaPolla **sp. nov.**
18a	Ostioles heavily sclerotized	*R. caladii* Green
-	Ostioles membranous	19

Discussion

Rhizoecus peripotaro was collected from nests of *Acropyga goeldii* Forel and is a trophobiotic species; worker ants were observed actively attending the mealybug colony in the nest, following the protocol of Schneider *et al.* (2022). Repeat collections of these partners, from Guyana and Peru, serve as further evidence they are trophobiotic. Conversely, *Coccidella advena* was collected along with a nest of *A. manuense* LaPolla & Schneider and their trophobionts, *Neochavesia podexuta* Schneider & LaPolla into a nest box for study. Observations of this nest indicated that *N. podexuta* were gathered into a protective cluster and were actively attended by the ants in the nest box, both key indicators that they are directly associated. However, *C. advena* were not involved in the trophobiotic association, living in or near the colony but being ignored by the ants. As such, we consider the species to be free-living. Scale insects may benefit indirectly from living near ant colonies where the ants actively defend a mutualist partner. For example, Prins (1982) noted that populations of an armored scale, *Aonidiella aurantii* (Maskell), benefitted indirectly by the activity of nearby ants defending aphids and soft scales from their natural enemies in exchange for honeydew.

Sodano *et al.* (2024) assessed the morphological traits of scale insects that relate to an obligatory association with ants, finding that myrmecophilic root mealybugs (in comparison to free-living relatives) have smaller bodies, are either pyriform or rotund in shape, are often constricted at the anterior or posterior end, and have ostioles that are reduced in size or have been lost entirely. The study included individuals of *R. peripotaro* and some of the notable traits of this species reflect the overall findings of the study. Specifically, slide-mounted individuals of *R. peripotaro* are relatively small (<1 mm long), have a rounded body, and show significant reduction in the size and development of dorsal ostioles. It was also noted in the study that bi- or tritubular cerores tend to be absent or reduced in obligate myrmecophiles. While *R. peripotaro* possesses tritubular cerores, they are relatively restricted in distribution along the lateral margins and dorsal midline but are absent from the venter.

The morphology of *C. advena* aligns with expectations drawn from the study by Sodano *et al.* (2024) regarding the appearance of free-living root mealybugs. The specimens are elongate oval, tapering evenly at the anterior and posterior apices, and have both pairs of ostioles well developed and sclerotized.

The species of Rhizoecidae that are unequivocally associated with *Acropyga* ants presently include: *Ishigakicoccus shimadai* Tanaka, *Rhizoecus peripotaro*, *Ripersiella campensis* Schneider & LaPolla, *R. colombiensis* (Hambleton), *R. illicians* Schneider & LaPolla, *R. montanae* Schneider & LaPolla, *R. telalia* Schneider, and *Williamsrhizoecus udzungwensis* Schneider & LaPolla (Schneider & LaPolla 2020, 2022; Smith *et al.* 2007; Tanaka 2016). Several additional species may associate with *Acropyga* but the details of how these association records were confirmed are lacking and need to be ascertained (see Schneider & LaPolla 2020; Sodano *et al.* 2024 for further discussion). Probably many more trophobiotic species are yet to be discovered in the nests of *Acropyga* ants.

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