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Five new records of soil scale insects (Hemiptera: Coccomorpha) for Indonesia

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Abstract

Information about soil scale insect (Hemiptera: Coccomorpha) diversity, although fragmented, had been progressively improved for Asia, especially in the southern countries such as Indonesia. Recent works recorded 365 species in the country, 21 of which in below ground habit. In this paper, we contribute to the knowledge of Indonesian scale insect diversity by analyzing specimens collected from rainforest, rubber and oil palm plantations in the Province of Jambi and Sumatra, Indonesia. The results include the new records of *Rhizoecus americanus*, *Rhizoecus omphalius*, *Ripersiella bacorum*, *Ripersiella cryphia* and *Ripersiella sabahica* (Rhizoecidae) with description of new intraspecific variations. *Pseudococcus saccharicola* (Pseudococcidae), *Geococcus coffeae*, and *Rhizoecus pignerator* (Rhizoecidae) were also collected in this study. With these species, the known Indonesian scale insect fauna increases to 370 species.

Keywords Oriental region | Sternorrhyncha | Neococcoidea

1. Introduction

Soil is the physical foundation for supporting life on the planet and many of the processes that occur therein are supported by soil fauna (Cayuela et al. 2020). The study of soil biodiversity is relevant to recogning the participants in such processes, functions, and interactions. Scale insects (Hemiptera: Coccomorpha) are one of the many insect groups that make up such diversity. Knowledge on tropical scale insects is fragmentary, which applies particularly to Southeast Asia (Williams 2004). Indonesia records 365 species, of which 21 have been explicitly recorded from soil samples from the families Pseudococcidae (eight species), Rhizoecidae (eight spp.) and Xenococcidae (six spp.) (Williams 1998, Zarkani et al. 2021). The latter two families contain only obligate soil insects, whereas Pseudococcidae species can be found on both above and below ground plant organs. The current species checklist for the country is in the Table 1. In this paper, we record several soil dwelling Pseudococcidae and Rhizoecidae species for Indonesia and contribute to their existing descriptions providing new information about intraspecific variations.

2. Materials and methods

The specimens were collected in October-November 2016 from 36 sampling sites representing rainforest, rubber, and oil palm plantations in the province of Jambi, Sumatra, Indonesia (Tab. S1). At each site, three soil samples 16 x 16 cm (litter layer + 5 cm of the underlying soil) were taken from subplots a, b and c within a 50 x 50 m plots.

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Materials were transported to the laboratory and extracted using high-gradient Kempson extractors in a 1:1 water:glycol solution and then transferred to ~80% ethanol for storage. The general study design is provided in Drescher et al. (2016) and description of the sampling method is available from Potapov et al. (2021).

The specimens were prepared for microscope slides following the protocol of Sirisena et al. (2013). Collection data and number of analyzed species in the corresponding species section. The identification was done using contrast phase microscopy and the specimens and taxonomic keys and descriptions of Takahashi (1928), Hambleton (1946, 1976), Williams (1958, 1969, 1970, 1996, 2004), Williams & Granara de Willink (1992), Kozár & Konczné Benedicty (2007), Granara de Willink & González (2018), and Kaydan et al. (2019) with the consulted data is presented in brackets. Those measurements without contrasted data in brackets correspond to nova information for the species. The abdominal segments are abbreviated as S_{abd}I for abdominal segment I until S_{abd}VIII for segment VIII; the antennal segments are abbreviated as S_{ant}I for basal segment until S_{ant}## for apical segment. The measurement of labium corresponds to apical and medial segments. The obanal and cisanal setae apply only to *P. saccharicola* and correspond to anterior and posterior pair of setae in the venter of the last abdominal segment, respectively. The morphological information of studied species is available in the Ecotaxonomy database (Potapov et al. 2019) and they are included in the taxonomic key section. Analysed specimens are deposited in Bogor Zoological Museum of Indonesian Institute of Science (LIPI).

Table 1. Checklist of soil scale insects recorded for Indonesia, grouped by families with host data, localities, and literature references.

Species	Host(s)*	Localities	Reference
Pseudococcidae			
Formicococcus lingnani (Ferris, 1954)	*Oryza sativa*	Bogor (Java)	Williams (2004)
Pseudococcus saccharicola Takahashi, 1928	"on root grass"	Bogor (Java)	Williams (2004)
Paracoccus evae Williams, 2004	*Eupatorium* sp. (Asteraceae)	Bandungan, (Java)	Williams (2004)
Paraputo mangiferae (Betrem, 1937)	*Mangifera indica* L., 1753 (Anacardiaceae)	Malang (Java)	Williams (2004)
Planococcus dischidiae (Takahashi, 1951)	*Epipremnum* sp. (Araceae)	Sulawesi	Cox (1989)
Planococcus lilacinus (Cockerell, 1905)	*Coffeae* sp. (Rubiaceae)	Java	Cox (1989)
Pseudococcus pseudocitriculus Betrem, 1937	*Tephrosia vogelii* Hook, 1849 (Fabaceae)	East Java	Williams (2004)
	Coffea robusta L. Linden, 1900 (Rubiaceae)	Central Java	Williams (2004)
Pseudococcus viburni (Signoret, 1875)	*Eupatorium* sp. (Asteraceae)	Bandungan (Java)	Williams (2004)
Rhizoecidae			
Geococcus coffeae Green, 1933	*Nicotiana tabacum* L., 1753 (Solanaceae); in soil	Bogor (Java); Sulawesi	Williams (1969, 2004)
Geococcus hauseri Williams, 2004	"in soil of *Hevea* sp."	Rantau Pandan (Jambi); Sumatra	Williams (1998)
Leptorhizoecus deharvengi Williams, 1998			
Rhizoecus amorphophalli Betrem, 1940	*Amorphophallus variabilis* Blume, 1873 (Araceae)	Java	Williams (2004)
	soil	Sumatra	Williams (2004)
Rhizoecus pignerator Williams, 2004	No data	Sumatra	Williams (2004)
Ripersiella bedosae (Williams, 2004)	No data	Sumatra	Williams (2004)
Ripersiella sumatrensis (Williams, 2004)	No data	Sumatra	Williams (2004)
Ripersiella multiporifera Jansen, 2008	*Sansevieria* sp. (Asparagaceae)	Intercepted in Netherlands from Indonesian ornamental plants	Jansen (2008)
Xenococcidae			
Eumyrmococcus falciculosus Williams, 1998,	No data	Sumatra	Williams (1998)
Eumyrmococcus kruiensis Williams, 1998,			
Eumyrmococcus lanuginosus Williams, 1998			
Eumyrmococcus maninjauensis Williams, 1998			
Eumyrmococcus sulawesicus Williams, 1998		Sulawesi	
Xenococcus acropygae Williams, 1998		Sulawesi; Krakatau (Lampung)	

Notes: (*) The host records corresponding to specimens collected exclusively from roots.

3. Results

3.1 New information for recorded species

Pseudococcus saccharicola (Takahashi, 1928) (Pseudococcidae) (Fig. 1)

Intraspecific variation of 4 adult females, added to information provided by Takahashi (1928), Williams (1970, 2004), and Granara de Willink & González (2018) in square brackets. Antenna with eight segments, 427–469 µm long [335–360 µm long] (Fig. 1A), S_{ant}I 67–74 µm, S_{ant}II 65–76 µm, S_{ant}III 40–52 µm, S_{ant}IV 33–41 µm, S_{ant}V 44–56 µm, S_{ant}VI 30–37 µm, S_{ant}VII 43–47 µm, S_{ant}VIII 100–102 µm. Eyespots 32–35 µm basal diameter without associated pores (Fig. 1B). Labium 112 µm [90–95 µm long]. Foreleg 135–141 µm long: trochanter + femur 296–333 µm, femur 232–268 µm, tibia + tarsus 297–352 µm, tibia 190–242 µm, tarsus 107–110 µm, claw 28–33 µm. Midleg 641–642 µm long: trochanter + femur 299–305 µm, femur 236–244 µm, tibia + tarsus

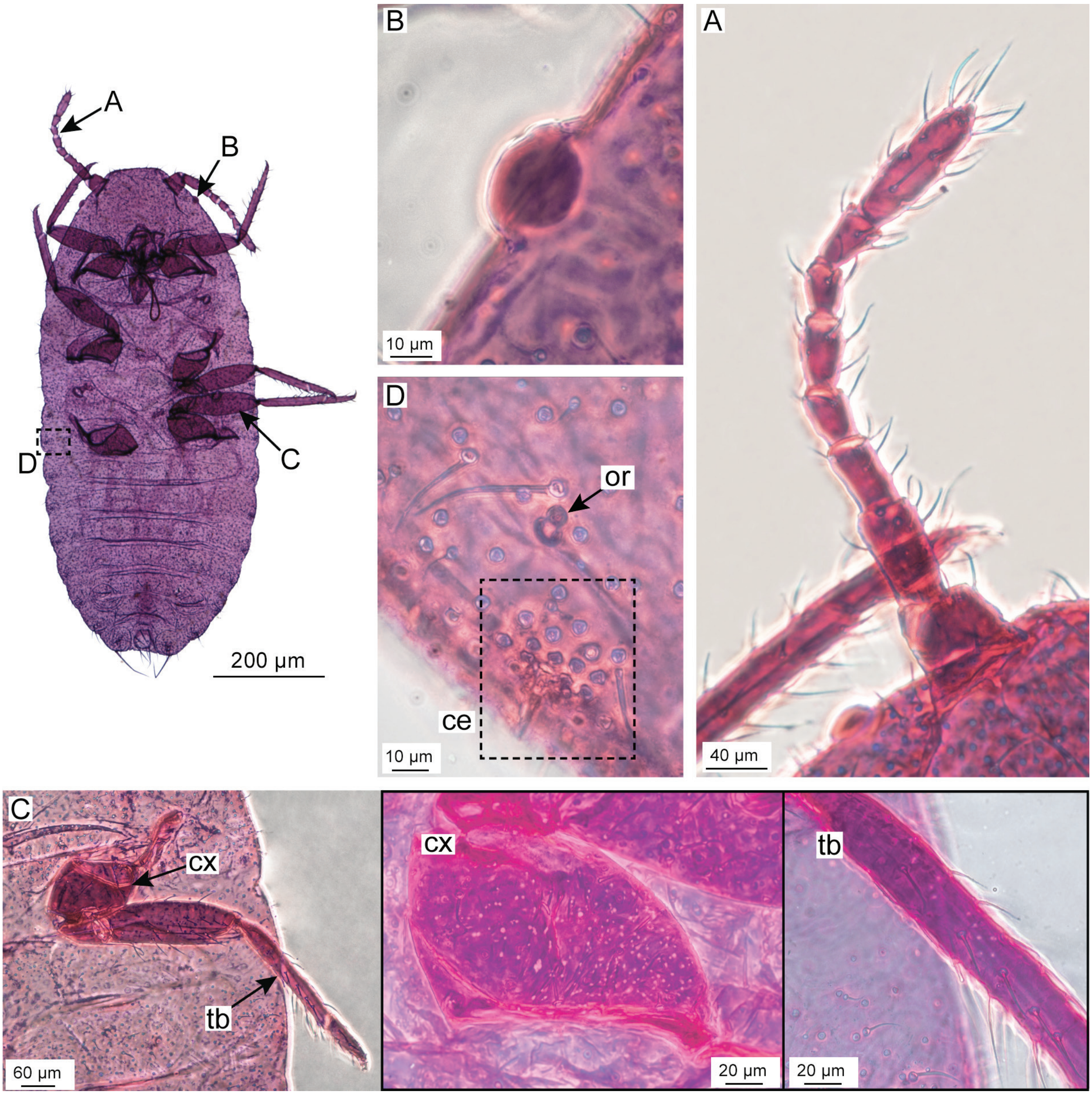

Figure 1. Microphotographs of *Pseudococcus saccharicola* (Takahashi, 1928): (**A**) Eight-segmented antenna. (**B**) Eyespot without pores associated. (**C**) Hind leg with translucid pores in coxa (cx) and tibia (tb). (**D**) section of dorsal marginal area in abdominal segment I with oral rim tubular duct (or) near to cerarious (ce).

311–312 µm, tibia 190–242 µm, tarsus 107–110 µm, claw 28–33 µm. Hind leg 600–737 µm long: trochanter + femur 287–338 µm [265–300 µm], femur 233–273 µm, tibia + tarsus 284–365 µm [310–325 µm], hind tibia 184–249 µm, hind tarsus 100–116 µm, claw 29–34 µm; translucent pores in coxae 98–129 [few pores, as few as 1 or 2, according to Williams (2004); numerous pores over the half or whole surface according to Takahashi (1928) and Williams (1970)] (Fig. 1C, cx) and tibia 13–25 [few pores present on outer edge] (Fig. 1C, tb). Circulus absent on all analysed specimens [present or absent]. Obanal setae 49–54 µm long, cisanal setae 65–87 µm long. Anal lobe setae 190–194 µm long.

Cerarii numbering 16 pairs, C_9, C_{10}, or C_{15} reduced to one slightly conical seta and C_{16} absent. Anal ring 75–80 µm transversal diameter with six anal ring setae 96–116 µm long [6 setae about twice length of diameter of ring]. Multilocular disc pores 8–9 µm diameter [7.5 µm] numbering 133–156, restricted to venter, distributed as follows: absent on head, 5–10 on thorax, absent on S_{abd}I

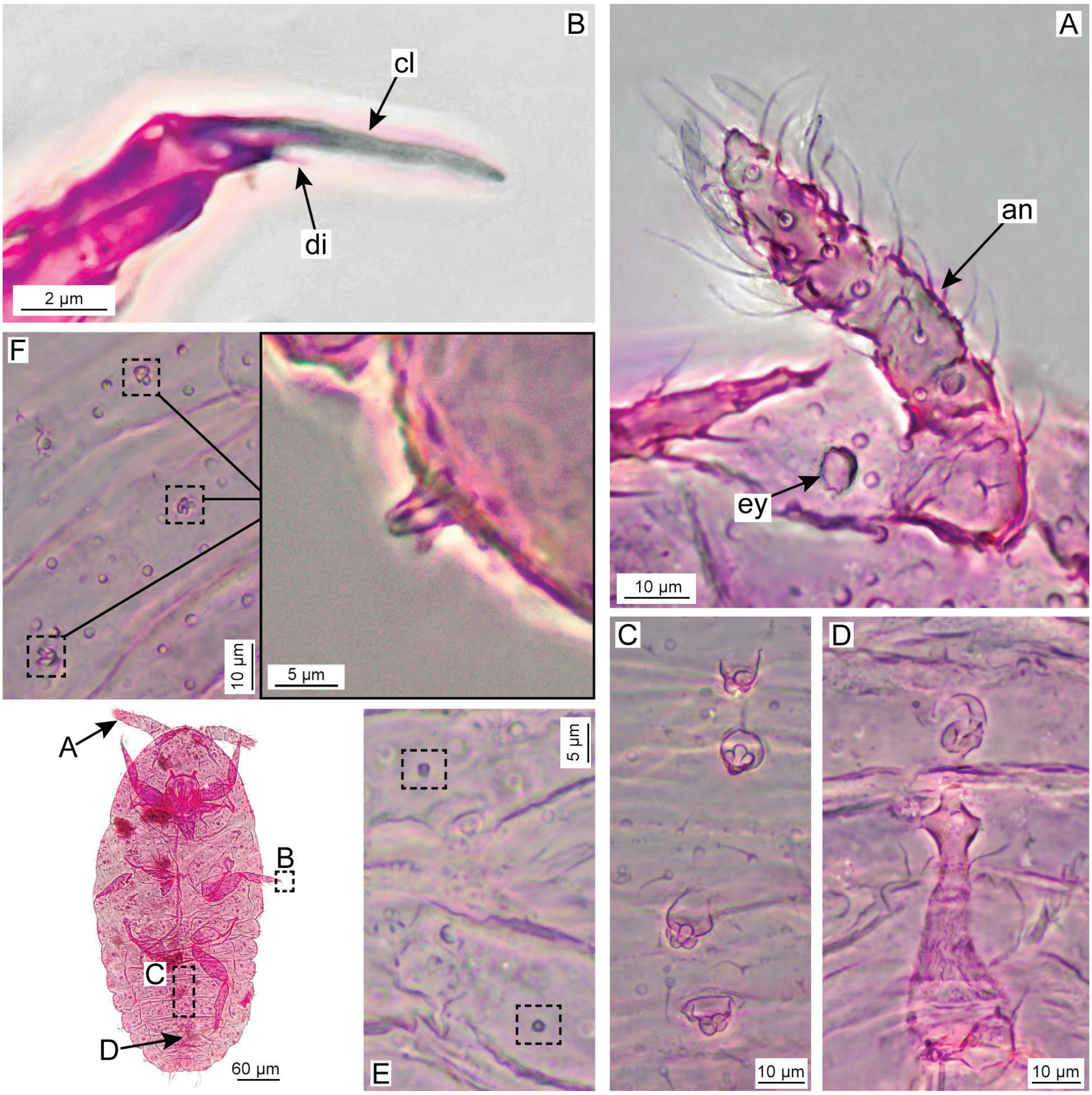

Figure 2. Microphotographs of *Rhizoecus pignerator* Williams, 2004: (**A**) Ventral section of head with six-segmented antennae (an) and eyespot (ey) full developed. (**B**) Claw (cl) with ungual digitule setose (dig). (**C**) Venter of central area of abdominal segments II to IV, each with one circulus. (**D**) Genital chamber covering the abdominal segments V to VII. (**E**) Ventral section of abdomen with oral collar tubular ducts (doted–line box). (**F**) Ventral section of abdomen with ampliation of tritubular ducts.

and S_{abd}II, S_{abd}III 7–12, S_{abd}IV 24–27, S_{abd}V 5–14, S_{abd}VI 17–20, S_{abd}VII 34–49, S_{abd}VIII+IX 32–33. Oral collar tubular ducts restricted to venter, of two sizes: the smallest ones of 2–3 µm in diameter and 6–7 µm long, usually present in mid region along the abdominal segments, the largest ones 3–5 µm in diameter and 7–9 µm long. Ventral oral rim tubular ducts 7–8 µm at widest diameter and 9 µm long (Fig. 1D), numbering 3–5, 0–1 at level of C_{12}, 2 in S_{abd}I, and 1–2 in S_{abd}II. Dorsal oral rim tubular ducts 7–9 µm at widest diameter and 9–12 µm long, numbering 14–17, distributed as follows: 1 posterior to anterior ostiole, 0–1 associated to C_{14}, C_{13}, and C_{11}, C_{10}, 1 in S_{abd}I, 0–2 in S_{abd}II, 2 in S_{abd}IV, 3–4 in S_{abd}V, 1–5 in S_{abd}VI and 1–3 in S_{abd}VII.

Material studied. INDONESIA, Province Jambi, 14 m a.s.l., 01°42'39.6''S 103°17'23.3''E, ex soil of Rubber land-use system (Plot ID HRr4), 2016, 2 ♀♀ adults; Province Jambi, 56 m a.s.l., 02°04'36.1''S 102°46'22.3''E, ex soil of Rubber land-use system (Plot ID BR4), 2016, 2 ♀♀ adults.

Rhizoecus pignerator Williams, 2004 (Rhizoecidae) (Fig. 2)

Intraspecific variation of 4 adult females, added to information provided by Williams (2004), and Kozár & Konczné Benedicty (2007) in square brackets. Antennae 61–98 µm long [100–105 µm], with six segments with length and chaetotaxy as follow (Fig. 2A, an, Fig. 8A), S_{ant}I 17–24 µm and 4 flagellate setae, S_{ant}II 11–16 µm with 3 flagellate setae and 1 sensillum, S_{ant}III 12–17 µm and 7 flagellate setae, S_{ant}IV 7–10 µm and 5–6 flagellate setae, S_{ant}V 6–14 µm 5 flagellate setae and 1 falcate seta [one elongate slender sensory seta], S_{ant}VI 23–26 µm with 19–20 flagellated setae and 4 falcate setae [three stout, falcate sensory seta]. Eyespot 7–9 µm in diameter (Fig. 2A, ey). Labium 50 µm long. Hind tibia + tarsus 83 µm [75 µm], hind femur 57 µm, hind tibia 52 µm, hind tarsus 35 µm, claw 18 µm with short setose digitules (Fig. 2B). Ratio of lengths of hind tibia to tarsus 1.4 [rate 1.1]. Circuli numbering 3–4 on S_{abd}II or S_{abd}III to S_{abd}V (Fig. 2C), one on each segment [three circuli with 1–3 spherical protuberances]. Circulus in S_{abd}II with 7 µm at the base, and two globular protuberances; in S_{abd}III with 10 µm at the base, with four globular protuberances; in S_{abd}IV with 10 µm at the base, and four globular protuberances; in S_{abd}V with 12 µm at the base and two globular protuberances. Genital chamber 74 µm long (Fig. 2D). Anal ring with spicules in the external row of cells. Anal lobe setae, the thickest one 35 µm long with knobbed apex [20–28 µm long], the thinnest setae 30 µm long [40 µm long].

Multilocular disc pores with 8–10 loculi, restricted to venter of abdomen as follow: 0–3 on S_{abd}VI, 2–4 in S_{abd}VII and 3–4 on S_{abd}VIII; total number 5–11 [9–11, around vulva]. Tubular ducts scattered on venter of thorax and abdomen (Fig. 2E). Tritubular ducts 116–130 in whole body (Fig. 2F), in dorsum numbering 68–78, distributed as follows: 5–6 on head, 27–29 in thorax, on abdomen: 7–9 in S_{abd}I, 6–7 on S_{abd}II, 7 on S_{abd}III, 6–7 on S_{abd}IV, 7 on S_{abd}V, 2–3 on S_{abd}VI, 3 on S_{abd}VII, 2 on S_{abd}VIII. Ventral tritubular ducts numbering 46–53. distributed as follows: 3–5 on head, 15–18 on thorax, 2–4 on S_{abd}I, 3 on S_{abd}II, 6 on S_{abd}III, 4–7 on S_{abd}IV, 5–6 on S_{abd}V, 4–5 on S_{abd}VI, 2 on S_{abd}VII, absent on S_{abd}VIII.

Material studied. INDONESIA, Province Jambi, 81 m a.s.l., 02°09'29.4''S 103°20'01.5''E, ex litter of forest land-use system (Plot ID HF2), 2016, 2♀♀ adults ; Province Jambi, 51 m a.s.l., 02°10'30.1''S 103°19'57.8''E, ex soil of forest land-use system (Plot ID HF3), 2016, 1♀ adult; Province Jambi, 61 m a.s.l., 02°11'15.2''S 103°20'33.4''E, ex litter of forest land-use system (Plot ID HF4), 2016, 1♀ adult.

Other species studied: *Geococcus coffeae* was found in this study. The 11 studied specimens agree well with the species descriptions by Williams (1958, 1969) and Kozár & Konczné Benedicty (2007).

Material studied. INDONESIA, Province Jambi, 65 m a.s.l., 02°04'32.0''S 102°47'30.7''E, ex soil of oil palm land-use system (Plot ID BO2), 2016, 3♀♀ adults ; Province Jambi, 52 m a.s.l., 02°04'15.2''S 102°47'30.6''E, ex soil of oil palm land-use system (Plot ID BO3), 2016, 1♀ adult; Province Jambi, 61 m a.s.l., 02°11'15.2''S 103°20'33.4''E, ex litter of forest land-use system (Plot ID HF4), 2016, 1♀ adult; Province Jambi, 63 m a.s.l., 01°53'00.7''S 103°16'03.6''E, ex soil of oil palm land-use system (Plot ID HO2), 2016, 3♀♀ adults; Province Jambi, 58 m a.s.l., 01°51'28.4''S 103°18'27.4''E, ex soil and litter of oil palm land-use system (Plot ID HO3), 2016, 4♀♀ adults.

3.2 New records for Indonesia

Rhizoecus americanus (Hambleton, 1946) (Rhizoecidae) (Fig. 3)

It is a common species in the Caribbean and Central American countries, such as Colombia, Cuba, Mexico, Eastern South of United States, Panama, Puerto Rico (García Morales et al. 2016). Progressively, *R. americanus* has been found in eastern countries, being recorded for the first time in Europe (Italy) in 1992, associated to *Saintpaulia* sp. (Gesneriaceae) (Russo & Mazzeo 1992), later in Asia (Thailand), on

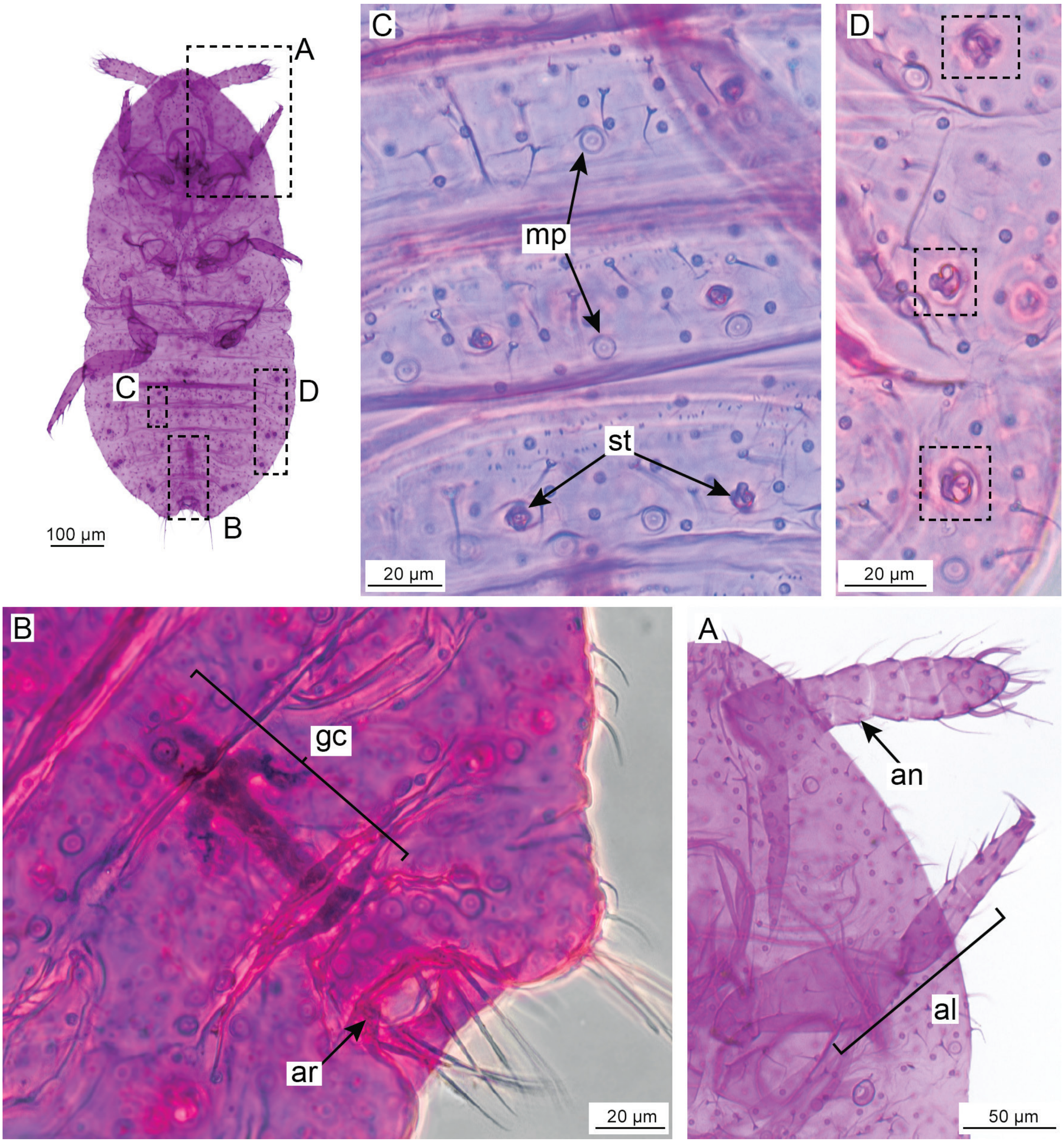

Figure 3. Microphotographs of *Rhizoecus americanus* (Hambleton, 1946): (**A**) Section of head and thorax with antenna (an) and foreleg (al). (**B**) Section of abdomen with genital chamber (gc) and anal ring (ar). (**C**) Ventral section of abdomen with multilocular disc pores (mp) and tritubular ducts (st). (**D**) Submargin of abdomen with tritubular ducts.

roots of *Euphorbia splendens* Bojer ex Hook., 1829 (Euphorbiaceae) in 2004 (Williams 2004).

Intraspecific variations of 14 adult females, added to the information provided by Hambleton (1946, 1976), Williams & Granara de Willink (1992) and Kozár & Konczné Benedicty (2007), in square brackets: Body length 804–1300 µm long [1500–1630 µm long] and 343–654 µm wide [800–890 µm wide]. Antennae 147–168 µm long (Fig. 3A, an): S_{ant}I 33–43 [41] µm long, S_{ant}II 16–23 [20] µm long, S_{ant}III 20–26 [30] µm long, S_{ant}IV 17–21 [23] µm long, S_{ant}V 14–20 [21] µm long, S_{ant}VI 37–45 [48] µm long. Fore leg 344–399 µm long (Fig. 3A, al): trochanter+femur 120–132 µm, femur 93–101 [107] µm, tibia 59–75 [65] µm, tarsus 48–64 [65] µm, claw 19–27 [27] µm. Mid leg 329–361 µm long: trochanter+femur 112–126 µm, femur 83–96 [106] µm, tibia 59–69 [69] µm, tarsus 44–56 [65] µm, claw 22–27 [28] µm. Hind leg 332–436 µm long: trochanter+femur 111–142 µm, femur 86–117 [121] µm, tibia 59–83 [84] µm, tarsus 53–68 [76] µm, claw 21–29 [29] µm. Anal ring transversal diameter 37–48 µm [45–65] (Fig. 3B, ar), with six setae 43–62 µm long. Genital chamber 69–94 µm long (Fig. 3B, gc).

Multilocular disc pores 6–9 µm (Fig. 3C, mp). On dorsum 10–28, absent on head, distributed on thorax 2–9 at level of fore coxa and anterior spiracles, 0–5 at level of anterior spiracles to mid coxa and 0–3 at level of mid coxa to hind coxa, 2–4 on S_{abd}I, 1–5 on S_{abd}II, 0–5 on S_{abd}III, 0–2 on S_{abd}IV and S_{abd}VII, absent on S_{abd}V, 0–1 on S_{abd}VI and S_{abd}VIII. On venter 79–114, distributed on head 1–3, on thorax 9–21 between fore coxa and anterior spiracles, 1–4 on each area between anterior spiracles to mid coxa and between mid coxa to hind coxa, 2 on S_{abd}I, 2–4 on S_{abd}II, 3–7 on S_{abd}III, 4–6 S_{abd}IV, 4–8 on S_{abd}V, 6–11 on S_{abd}VI, 16–25 on S_{abd}VII, and 21–26 on S_{abd}VIII.

Tritubular ducts totaling 31–37 ducts on body; 4–11 µm diameter, increasing size anterior to posterior direction; the smallest ducts on head, thorax and central area of first abdominal segments (Fig. 3C, st); the biggest ducts on margin and submargin of last abdominal segments (Fig. 3D). On dorsum numbering 14–17, distributed one on head, 1–3 at level of fore coxa and anterior spiracles, 2–3 at level anterior spiracles to mid coxa and 0–2 at level mid coxa to hind coxa, 0–1 on S_{abd}I and S_{abd}IV, 0–2 on S_{abd}II and S_{abd}VI, 2–3 on S_{abd}III, 2–4 on S_{abd}V and, 2 on S_{abd}VII, absent on S_{abd}VIII. On venter numbering 16–23, absent on head, distributed 0–1 between fore coxa and anterior spiracles, absent between anterior spiracles to mid coxa and 2 between mid coxa to hind coxa, absent on S_{abd}I, S_{abd}II, S_{abd}III, and S_{abd}VIII, 3–5 on S_{abd}IV, 4–8 on S_{abd}V, 4–6 on S_{abd}VI, 2 on S_{abd}VII.

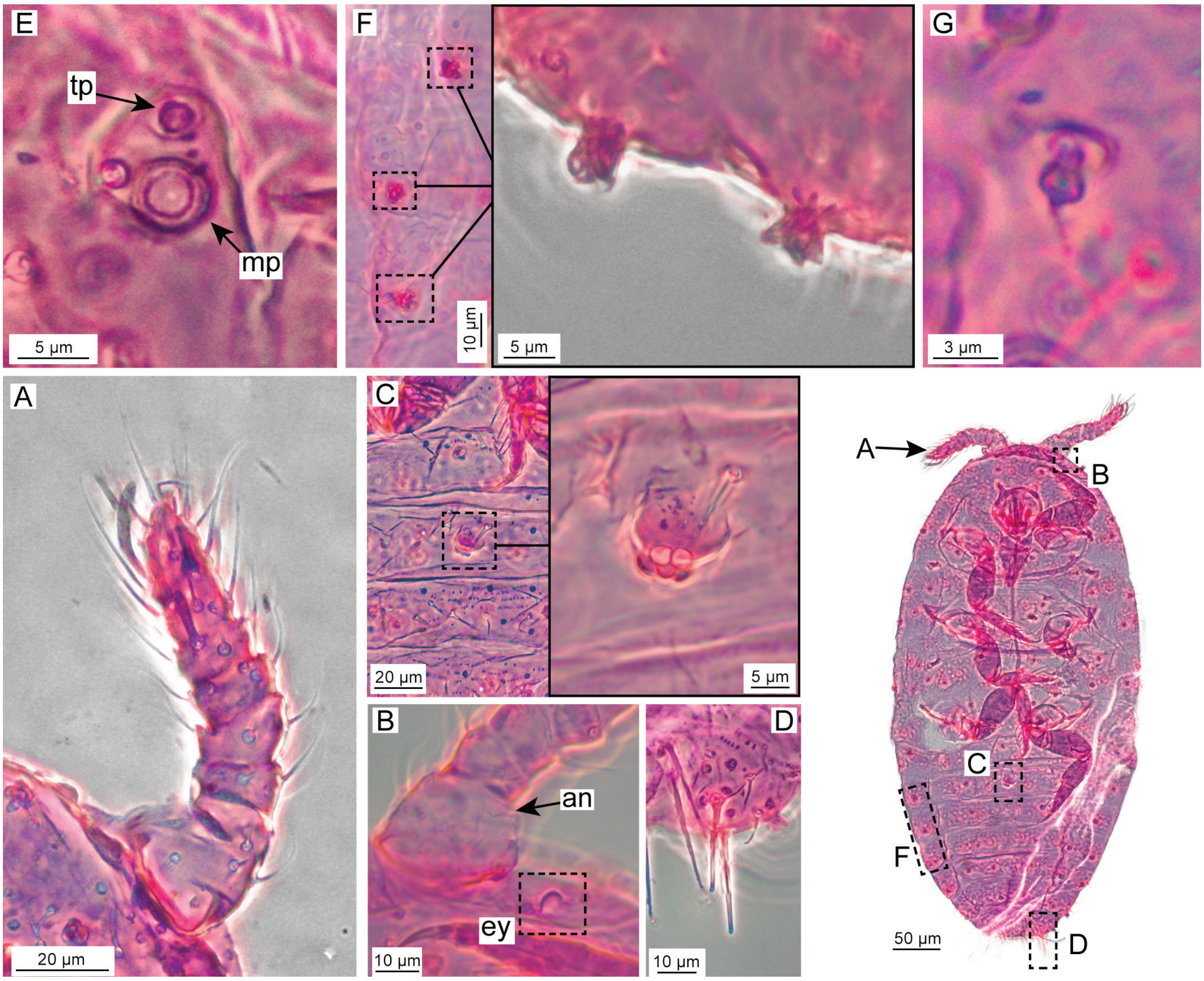

Figure 4. Microphotographs of *Rhizoecus omphalius* Williams, 2004: (**A**) Six-segmented antenna. (**B**) Ventral section of head margin with eyespot full developed (ey) and antennal base (an). (**C**) Venter of abdominal segment III with circulus in the central area. (**D**) Dorsal view of anal lobe with blunt–apex setae. (**E**) Ventral multilocular disc pore (mp) with trilocular pores (tp). (**F**) Submarginal section of venter of abdomen with ampliation of tritubular ducts. (**G**) Oral collar tubular duct.

Material studied. INDONESIA, Province Jambi, 65 m a.s.l., 02°04’32.0’’S 102°47’30.7’’E, ex litter of oil palm land-use system (Plot ID BO2), 2016, 3♀♀ adults; Province Jambi, 43 m a.s.l., 02°03’01.5’’S 102°45’12.1’’E, ex soil and litter of oil palm land-use system (Plot ID BO4), 2016, 8 ♀♀ adults ; Province Jambi, 51 m a.s.l., S 02°10’30.1’’ E 103°19’57.8’’ ex soil of forest land-use system (Plot ID HF3), 2016, 1♀ adult; Province Jambi, 50 m a.s.l., 02°10’51.9’’S 103°20’07.8’’E, ex soil of forest land-use system (Plot ID HFr3), 2016, 1♀ adult; Province Jambi, 14 m a.s.l., 01°54’07.7’’S 103°22’53.3’’E, ex soil and litter of oil palm land-use system (Plot ID HOr1), 2016, 1 ♀ adult.

Rhizoecus omphalius Williams, 2004 (Rhizoecidae) (Fig. 4)

So far, it had only been recorded in Vietnam, associated to *Asplenium nidus* L., 1753 (Aspleniaceae) (Williams 2004).

Intraspecific variation of one adult female, added to information provided by Williams (2004) and Kozár & Konczné Benedicty (2007): Body length 520 µm long and 260 µm wide [1200 µm long and 530 µm wide]. Antennae of six segments (Fig. 4A) 100–103 µm long [160–170 µm long] with length and chaetotaxy per segment as follow (Fig. 8B): S_{ant}I 31–32 µm and 4 flagellate setae, S_{ant}II 11–13 µm with 3 flagellate setae and 1 sensillum, S_{ant}III 11–14 µm and 5 flagellate setae, S_{ant}IV 9–12 µm and 5 flagellate setae, S_{ant}V 9–12 µm with 5 flagellate setae and 1 falcate seta, S_{ant}VI 25–30 µm with 20 flagellate setae and 4 falcate setae. Eyespots 6 µm in diameter (Fig. 4B, ey). Labium 43 µm long and 32 µm wide [80 µm long and 45 µm wide]. Circulus present on S_{abd}III, 13 µm wide at base and 7 µm long [25–30 µm wide at base and 18 µm long], with five spherical protuberances in the top (Fig. 4C). Hind trochanter + femur 75–78 µm [135–140 µm], hind tibia + tarsus 75 µm [135–140 µm], hind femur 55 µm, hind tibia 43, hind tarsus 35 µm claw 18 µm [25 µm]. Genital chamber 18 µm long [“as long as width of two segments”]. Anal ring 25 µm in diameter [48 µm], setae 32–38 µm long [50 µm]; cells in the external row of anal ring with spicules. Anal lobe setae 50–55 µm long [60 µm long], with blunt apex (Fig. 4D). Setae on surface 10–13 µm [10–20 µm] long.

Ventral multilocular disc pores 5–8 µm [6 µm] (Fig. 4E, mp). Tritubular ducts each about 5–6 µm long (Fig. 4F), on dorsum numbering 80, distributed as follows: 9 on head, 34 on thorax, 5 on S_{abd}I, 8 on S_{abd}II, 6 on S_{abd}III, 6 on S_{abd}IV, 6 on S_{abd}V, 2 on S_{abd}VI, 3 on S_{abd}VII, 1 on S_{abd}VIII. Tritubular ducts 116–130 in whole body. On venter, 46 ducts, distributed as follows: 2 on head, 18 on thorax, 2 on S_{abd}I, 3 on S_{abd}II, 3 on S_{abd}III, 4 on S_{abd}IV, 5 on S_{abd}V, 5 on S_{abd}VI, 3 on S_{abd}VII, absent on S_{abd}VIII. Ventral oral collar tubular ducts 3 µm long and 2 µm wide (Fig. 4G).

Material studied. INDONESIA, Province Jambi, 65 m a.s.l., 02°04’32.0’’S 102°47’30.7’’E, ex litter of oil palm land-use system (Plot ID BO2), 2016, 1♀ adult.

Ripersiella bacorum (Williams, 2004) (Rhizoecidae) (Fig. 5)

So far, it has been recorded only in Sri Lanka, but its plant host is unknown (Williams 1996, Kozár & Konczné Benedicty 2007).

Intraspecific variation of two adult females, added to information provided by Williams (1996, 2004): Body 850 µm long, 335 µm wide [1700 µm long and 550 µm wide]. Antenna with five segments, 170 µm long [250 µm long] (Fig. 5A); S_{ant}I 42 µm long, S_{ant}II 23 µm long, S_{ant}III 22 µm long, S_{ant}IV 21 µm long, S_{ant}V 62 µm long. Labium 77 µm long (Fig. 5B). Two circuli (Fig. 5C), one in S_{abd}II, 9 µm diameter at base and 5 µm in the top [12.5 µm in diameter]; circulus on the S_{abd}III 26 µm diameter at base and 17 µm at the top [25 µm in diameter]. Genital chamber 117 µm long (Fig. 5D). Anal ring 47 µm in transversal diameter [50 µm] with six setae 48–64 µm [75 µm]. Anal lobe setae 83 µm long [75 µm long] (Fig. 5E). Multilocular disc pores 7–9 µm in diameter [7.5 µm in diameter], distributed on venter, 22 on thorax (Fig 5F, mt), more than 50 on abdomen (Fig 5F, ma), absent on head. Surface setae in central region 15–25 µm long, those on marginal region 35–40 µm long. Bitubular pores on dorsum and venter, 8 µm long and 6 µm wide (Fig. 5G).

Material studied. INDONESIA, Province Jambi, 65 m a.s.l., 02°04’32.0’’S 102°47’30.7’’E, ex litter of oil palm land-use system (Plot ID BO2), 2016, 2♀♀ adults.

Ripersiella cryphia (Williams, 2004) (Rhizoecidae) (Fig. 6)

It is only recorded in the region of Chiang Mai, Thailand, described from an unknown plant host (Williams 2004, Kozár and Konczné Benedicty 2007).

Intraspecific variation of one adult female, added to information provided by Williams (2004) and Kozár & Konczné Benedicty (2007) in square brackets: Body 664 µm long [850–950 µm long] and 272 µm wide [300–350 µm wide]. Antenna S_{ant}I 29 µm long with 4 flagellate setae, S_{ant}II 19 µm long with 3 flagellate seta and 1 sensillum, S_{ant}III 12 µm long and six flagellate setae,

S_{ant}IV 12 µm long with 4–5 flagellate setae, and S_{ant}V 53 µm long with 20–21 flagellate setae and 5 falcate setae (Fig. 6A, Fig. 8C). Cephalic plate sclerotized, shape of inverted triangle with one seta in the central area [cephalic plate absent] (Fig. 6B). Hind leg 230 µm long; trochanter + femur 104 µm long [105–135 µm], tibia+ tarsus 106 µm long [110–150 µm], claw 20 µm long [25 µm] with setose digitules (Fig. 6C). Circulus on abdominal segment II 18 µm at the base and 9 µm on the top, circulus on abdominal segment III 21 µm at the base and 7 µm on the top [15–25 µm wide] (Fig. 6D). Genital chamber 80 µm long [as long as width of two segments] (Fig. 6E). Anal ring 40 µm in transversal diameter [60 µm], with six setae 38–46 µm long [each about 60 µm long] (Fig. 6F).

Dorsal and ventral multilocular disc pores 8 µm in diameter (Fig. 6G). Bitubular pores totaling 116–130 (Fig. 6H), on dorsum numbering 68–78, distributed as follow: 5–6 on head, 27–29 on thorax, 7–9 on S_{abd}I, 6–7 on S_{abd}II, 7 in S_{abd}III, 6–7 on S_{abd}IV, 7 in S_{abd}V, 2–3 on S_{abd}VI, 3 on S_{abd}VII, 2 on S_{abd}VIII+IX. On venter numbering 46–53 distributed as follow: 3–5 on head, 15–18 on thorax, 2–4 in S_{abd}I, 3 on S_{abd}II, 6 in S_{abd}III, 4–7 on S_{abd}IV, 5–6 in

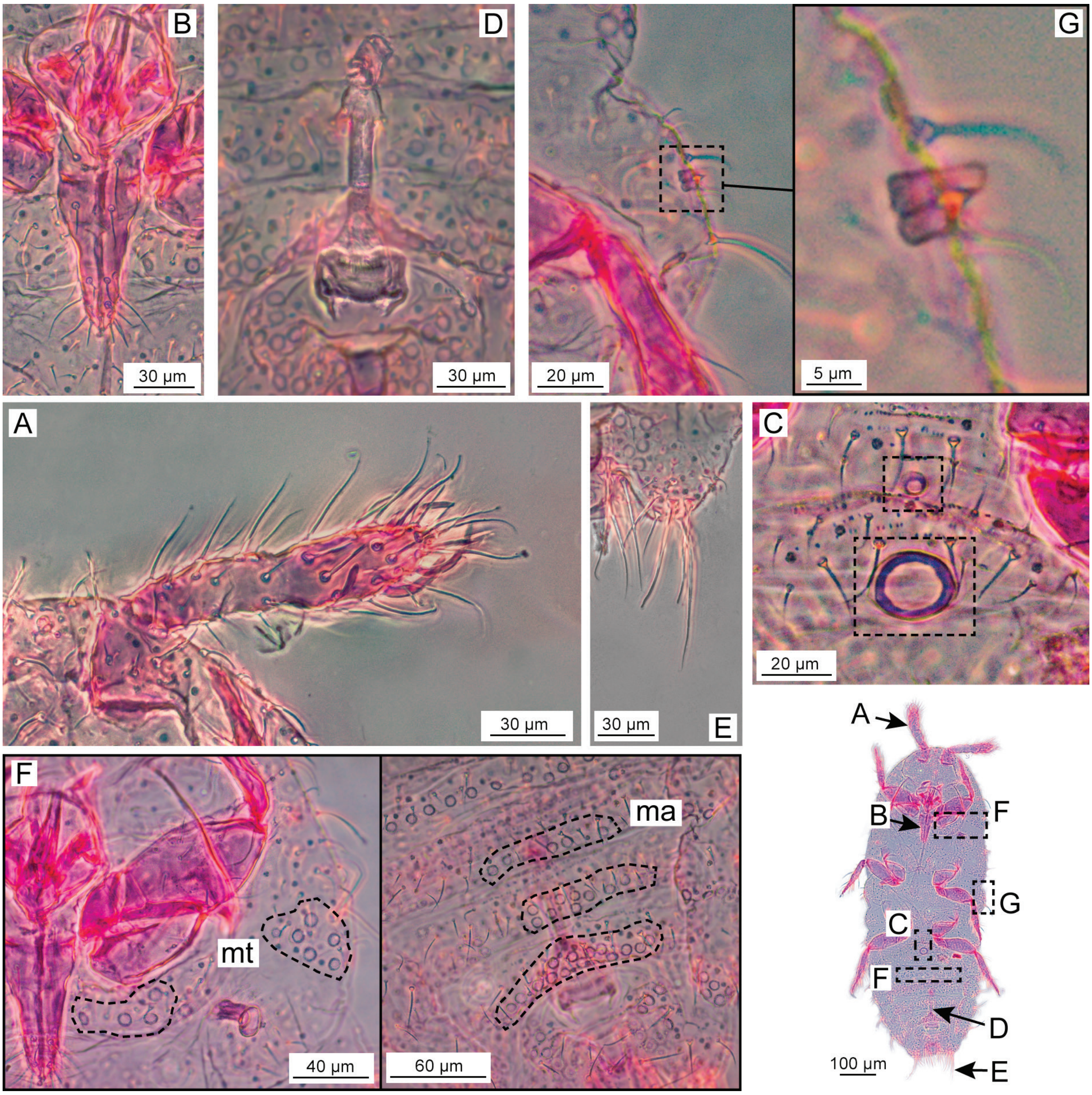

Figure 5. Microphotographs of *Ripersiella bacorum* (Williams, 1996). (**A**) Five-segmented antennae. (**B**) Labium. (**C**) Venter of abdominal segments II and III with circulus in each segment. (**D**) Genital chamber in venter of abdominal segment V to VII. (**E**). Anal lobe with setae flagellated and blunt–apex. (**F**) Multilocular disc pores on venter of thorax (mt) and abdomen (ma). (**G**) Bitubular duct.

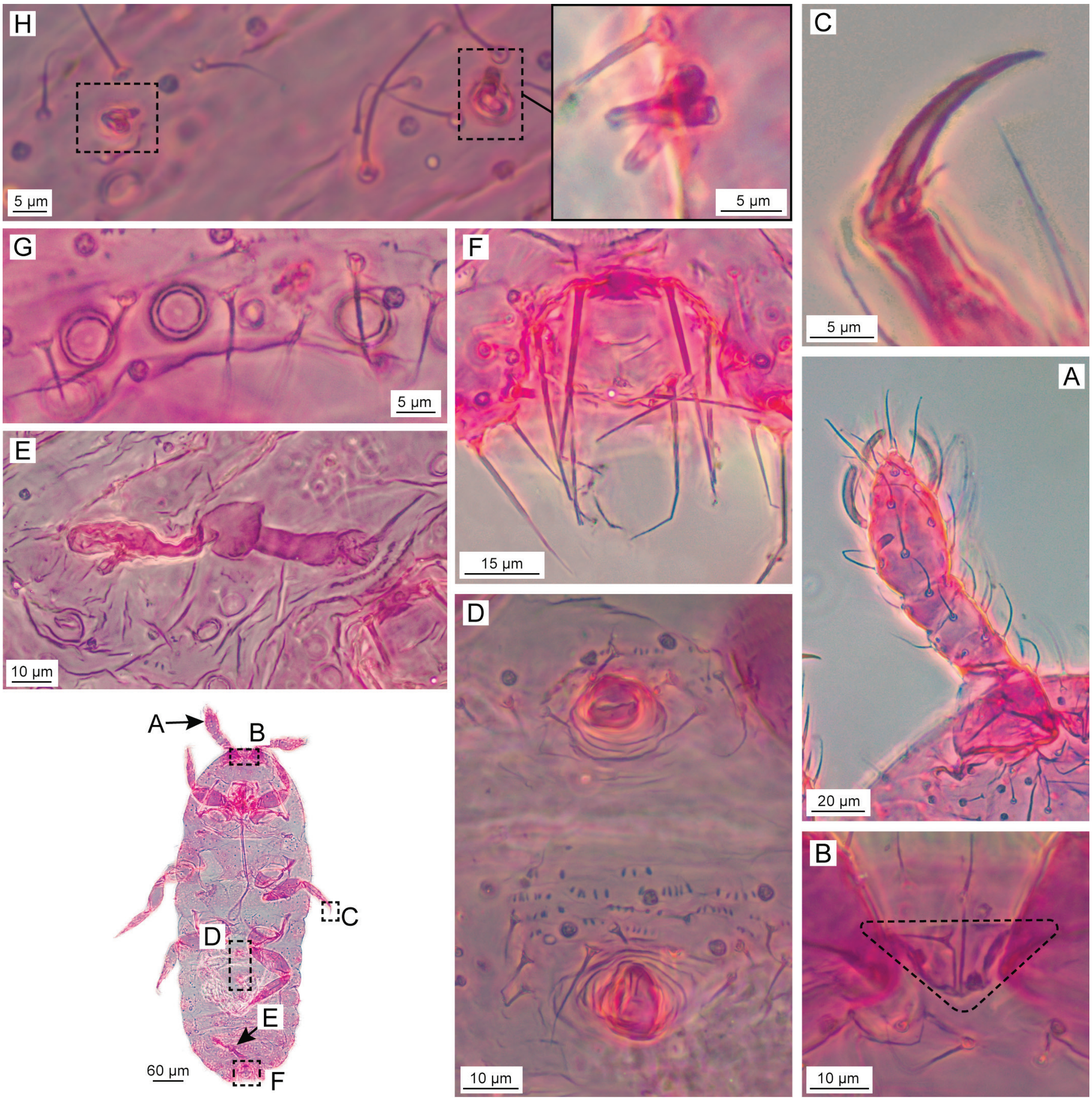

Figure 6. Microphotographs of *Ripersiella cryphia* (Williams, 2004): (**A**) Five-segmented antenna. (**B**) Cephalic plate. (**C**) Claw with ungal digitule setose. (**D**) Venter of abdominal segments II and III with circulus in each segment. (**E**) Genital chamber. (**F**) Anal ring. (**G**) Ventral multilocular disc pores. (**H**) Bitubular ducts.

S_{abd}V, 4–5 on S_{abd}VI, 2 on S_{abd}VII, absent on S_{abd}VIII+IX.

Material studied. INDONESIA, Province Jambi, 50 m a.s.l., 02°10'51.9''S 103°20'07.8''E, ex litter of forest land-use system (Plot ID HFr3), 2016, 1♀ adult.

Ripersiella sabahica (Williams, 2004) (Rhizoecidae) (Fig. 7)

Only recorded in the region of Sabah region, Malaysia, associated host plant unknown (Williams 2004).

Intraspecific variation of two adult females, added to information provided by Williams (2004) and Kozár & Konczné Benedicty (2007): Antenna with 6 segments, 125 µm long [150–180 µm long] (Fig. 7A, an), S_{ant}I 30 µm, S_{ant}II 15 µm, S_{ant}III 22 µm, S_{ant}IV 12 µm, S_{ant}V 13 µm, S_{ant}VI 33 µm. Eyespots present, 8 µm base diameter (Fig. 7A, ey). Labium 43 µm long [80–85 µm] (Fig. 7B). Circulus on S_{abd}III 25 µm at the base, circulus on S_{abd}IV 18 µm [largest about 42, the smallest 20 µm in diameter] (Fig. 7C). Hind leg 209 µm long (Fig. 7D); hind trochanter + femur 90 µm [125–160 µm],

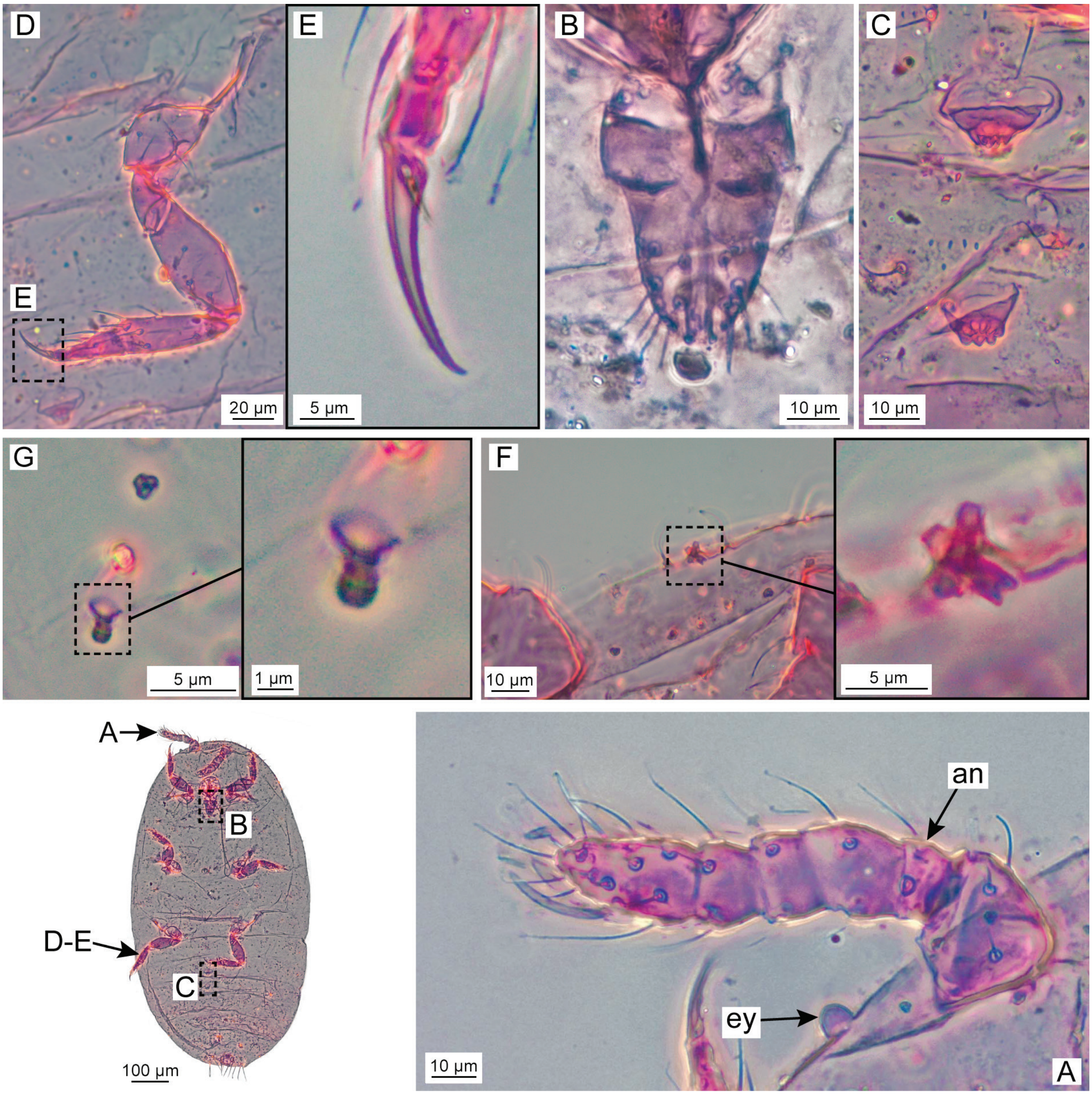

Figure 7. Microphotographs of *Ripersiella sabahica* (Williams, 2004). (**A**) Ventral section of head with six-segmented antennae (an) and eyespot (ey) full developed. (**B**) Labium. (**C**) Ventral abdominal segments III and IV with circulus on each one. (**D**) Hind leg. (**E**) Claw with ungual digitule setose. (**F**) Bitubular duct. (**G**) Oral collar tubular duct.

hind tibia + tarsus 96 µm [138–160 µm], claw 23 µm [35 µm] with digitule shorter than half of the claw (Fig. 7E). Anal lobe setae 37–47 µm long [58–75 µm long]. Anal ring 38 µm in transversal diameter [55 µm] with six setae 43–50 µm [79–92 µm]. Bitubular ducts on dorsum and venter 7 µm long and 5 µm wide (Fig. 7F), tubular ducts on dorsum and venter 5 µm long and 2–3 µm wide (Fig. 7G).

Material studied. INDONESIA, Province Jambi, 61 m a.s.l., 02°11’15.2’’S 103°20’33.4’’E, ex litter of forest land-use system (Plot ID HF4), 2016, 1♀ adult; Province Jambi, 54 m a.s.l., 02°09’51.5’’S 103°22’03.2’’E, ex soil of forest land-use system (Plot ID HFr1), 2016, 1♀ adult.

4. Discussion

The information presented in this study increased the known scale insect fauna of Indonesia to 370, mainly in the family Rhizoecidae (now 16 species) and three

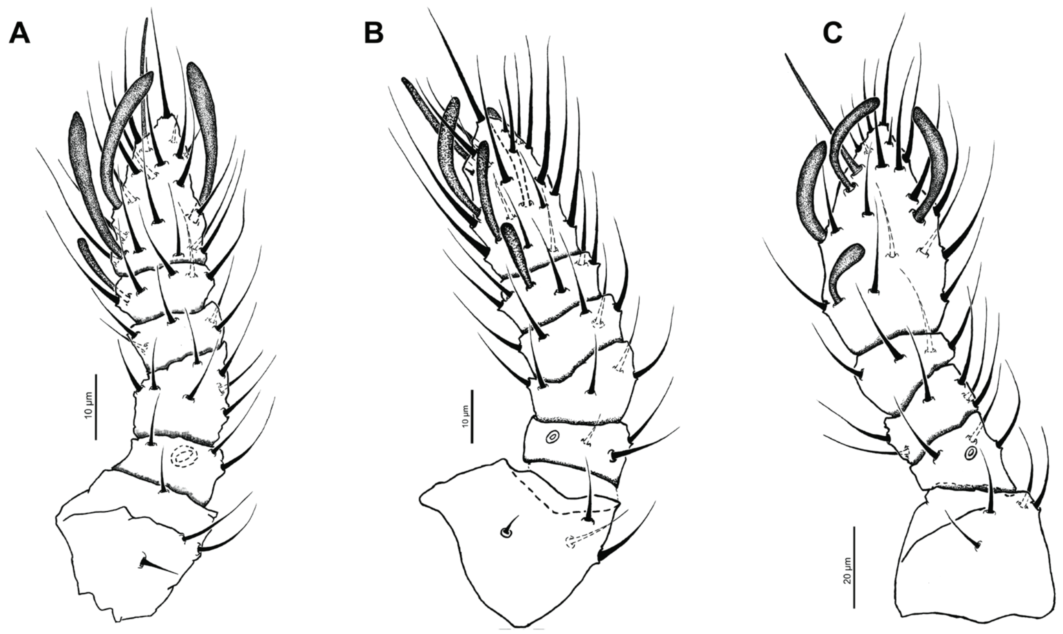

Figure 8. Taxonomic illustrations of antennae of (**A**) *Rhizoecus pignerator* (Williams, 2004), (**B**) *Rhizoecus omphalius* Williams, 2004 and (**C**) *Ripersiella cryphia* (Williams, 2004).

previously recorded species, were confirmed. According to the literature consulted, *Rh. pignerator*, *Ri. bacorum*, *Ri. cryphia* and *Ri. sabahica* have not been recorded in any other location since their descriptions and remain without host association data. Therefore, further sampling should target directly the roots of plants to provide new biological information. Indonesia is the second country in the Oriental region where Rhizoecus americanus is recorded.

New morphological information and intraspecific variations were provided, except for *Geococcus coffeae*. The specimens of *P. saccharicola* analized here show bigger length of antennal and mouth appendices and broad the length range of legs. This species can feed and develop in both aerial and subterrain organs on it host. It could be interesting to analyses the host effect over the morphology of the species, in this case, in the allometry. Considering the taxonomic features for identification of Rhizoecidae species, the most relevant data correspond to genital chamber and antennal chaetotaxy. Kozár & Konczné Benedicty (2007) provided the first approach about genital morphology but, due the difficult to preserve this structure during the mounting process, its use on taxonomic studies is absent. The genital chambers of several species analysed here are consistent with the Kozár & Konczné Benedicty's taxonomic drawings. Therefore, further morphological studies that include other Rhizoecidae species should be driving to establish its value as a taxonomic character useful for differentiation.

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6. References

Cayuela, M. L., J. Clause, J. Frouz & P. C. Baveye (2020): Editorial: Interactive feedbacks between soil fauna and soil processes. – Frontiers in Environmental Science **8**: 14 [https://doi.org/10.3389/fenvs.2020.00014].

Cox, J. M. (1989): The mealybugs genus *Planococcus* (Homoptera: Pseudococcidae). – Bulletin of the British Museum (Natural History) **58**: 1–78.

Drescher, J., K. Rembold, K. Allen, P. Beckschäfer, D. Buchori, Y. Clough, H. Faust, A. M. Fauzi, D. Gunawan, D. Hertel, et al. (2016): Ecological and socio-economic functions across tropical land use systems after rainforest conversion. – Philosophical Transactions of the Royal Society B: Biological Sciences **371**: 20150275 [https://doi.org/10.1098/rstb.2015.0275]

García Morales, M., B. Denno, D. R. Miller, G. L. Miller, Y. Ben-Dov & N. B. Hardy (2016): ScaleNet: A literature-based model of scale insect biology and systematics. – Database **1–5** [https://doi.org/10.1093/database/bav118].

Granara de Willink, M. C. & P. González (2018): Revisión taxonómica de *Pseudococcus* Westwood (Hemiptera: Pseudococcidae) de Centro y Sudamérica con descripciones de especies nuevas. – Insecta Mundi **0673**: 1–117.

Hambleton, E. J. (1946): Studies of hypogeic mealybugs. – Revista de Entomologia. Rio de Janeiro **17**: 1–77.

Hambleton, E. J. (1976): A revision of the New World mealybugs of the genus *Rhizoecus* (Homoptera: Pseudococcidae). – United States Department of Agriculture Technical Bulletin 1522: 1–88.

Jansen, M. G. (2008): A new species of the genus *Ripersiella* Tinsley (Hemiptera: Coccoidea: Pseudococcidae) from import interceptions in The Netherlands. – ISA Press Lisbon, Oeiras, Portugal, Proceedings of the XI International Symposium on Scale Insect Studies: 322

Kaydan, M. B., Z. Konczné Benedicty, T. Kondo, A. A. Ramos-Portilla & É. Szita (2019): Investigations on the genus *Rhizoecus* (Hemiptera: Rhizoecidae) with description of two new species from South America. Neotropical Entomology **48**: 809–821 [https://doi.org/10.1007/s13744-019-00681-w].

Kozár, F. & Z. Konczné Benedicty (2007): Rhizoecinae of the World. – Hungrian Academy of Science, Budapest. Plant Protection Institute, 1st ed. .

Potapov, A., D. Sandmann & S. Scheu (2019): Ecotaxonomy virtual research environment – traits and species [http://ecotaxonomy.org].

Potapov, A., I. Schaefer, M. Jochum, R. Widyastuti, N. Eisenhauer & S. Scheu (2021): Oil palm and rubber expansion facilitates earthworm invasion in Indonesia. – Biological Invasions **23**: 2783–2795 [https://doi.org/10.1007/s10530-021-02539-y].

Russo, A. & G. Mazzeo (1992): *Rhizoecus americanus* (Hambleton) e *Pseudaulacaspis cockerelli* (Cooley) (Homoptera Coccoidea) dannosi alle piante ornamentali in Italia. – Bollettino di Zoologia Agraria e di Bachicoltura **24**: 215–221.

Sirisena, U. G., G. W. Watson, K. S. Hemachandra & H. N. Wijayagunasekara (2013): A modified technique for the preparation of specimens of Sternorrhyncha for taxonomic studies. Tropical Agricultural Research **24**: 139–149.

Takahashi, R. (1928): Coccidae of Formosa. – Philippine Journal of Science **36**: 327–347.

Williams, D. J. (1958): Mealybugs (Pseudococcidae: Homoptera) described by W. M. Maskell, R. Newstead, T. D. A. Cockerell and E. E. Green from the Ethiopian region. – Bulletin of the British Museum (Natural History) **6**: 205–236.

Williams, D. J. (1969): A revision of the genus *Geococcus* Green (Homoptera, Coccoidea, Pseudococcidae). – Bulletin of Entomological Research **59**: 505–517.

Williams, D. J. (1970): The mealybugs (Homoptera, Coccoidea, Pseudococcidae) of sugar-cane, rice and sorghum. – Bulletin of Entomological Research **60**: 109–188 [https://doi.org/10.1017/S0007485300034209].

Williams, D. J. (1996): Four relative species of root mealybugs of the genus *Rhizoecus* from east and southeast Asia of importance at quarantine inspection (Hemiptera: Coccoidae: Pseudococcidae). – Journal of Natural History **30**: 1391–1403.

Williams, D. J. (1998): Mealybugs of the genera *Eumyrmococcus* Silvestri and *Xenococcus* Silvestri associated with the ant genus *Acropyga* Roger and a review of the subfamily Rhizoecinae (Hemiptera, Coccidae, Pseudococcidae). – Bulletin of the British Museum (Natural History) **67**: 1–152.

Williams, D. J. (2004): Mealybugs of southern Asia. – Lumpu, The Natural History Museum Kuala Lumpur: Southdene SDN. BHD.

Williams, D. J. & M. C. Granara de Willink (1992): Mealybugs of Central and South America. – 1st ed. CAB International, London, UK.

Zarkani, A., D. Apriyanto, F. Turanli, C. Ercan & M. B. Kaydan (2021): A checklist of Indonesian scale insects (Hemiptera: Coccomorpha). – Zootaxa **5016**: 151–195 [https://doi.org/10.11646/zootaxa.5016.2.1].

Supplementary materials

Table S1. List of the sampling sites with coordinates and soil characteristics: Percentage of carbone total (C_{total}) and nitogen total (N_{total}), potential of hydrogen (pH).

Plot ID	Riparian	Land-use system	Landscape	Latitude	Longitude	Elevation a.s.l.	C_{total} (%)	N_{total} (%)	pH	Litter (g per cm^2)
BF1	Upland	Forest	BukitDuabelas	S 01°59‘42.5“	E 102°45‘08.1“	58 m	3.41	0.29	3.81	0.250
BF2	Upland	Forest	BukitDuabelas	S 01°58‘55.1“	E 102°45‘02.7“	69 m	3.63	0.41	4.02	0.174
BF3	Upland	Forest	BukitDuabelas	S 01°56’33.9“	E 102°34’52.7“	84 m	3.15	0.20	3.51	0.546
BF4	Upland	Forest	BukitDuabelas	S 01°56’31.0“	E 102°34’50.3“	97 m	3.93	0.24	3.50	0.412
BO2	Upland	Oil palm	BukitDuabelas	S 02°04‘32.0“	E 102°47‘30.7“	65 m	3.47	0.26	4.48	0.187
BO3	Upland	Oil palm	BukitDuabelas	S 02°04‘15.2“	E 102°47‘30.6“	52 m	3.28	0.22	4.95	0.233
BO4	Upland	Oil palm	BukitDuabelas	S 02°03‘01.5“	E 102°45‘12.1“	43 m	3.74	0.30	4.51	0.114
BO5	Upland	Oil palm	BukitDuabelas	S 02°06‘48.9“	E 102°47‘44.5“	54 m	4.35	0.36	4.58	0.097
BR1	Upland	Rubber	BukitDuabelas	S 02°05‘30.7“	E 102°48‘30.7“	69 m	2.52	0.20	5.52	0.076
BR2	Upland	Rubber	BukitDuabelas	S 02°05‘06.8“	E 102°47‘20.7“	72 m	2.77	0.19	5.12	0.205
BR3	Upland	Rubber	BukitDuabelas	S 02°05‘43.0“	E 102°46‘59.6“	66 m	1.71	0.12	5.76	0.259
BR4	Upland	Rubber	BukitDuabelas	S 02°04‘36.1“	E 102°46‘22.3“	56 m	4.11	0.34	4.78	0.099
HF1	Upland	Forest	Harapan	S 02°09‘09.9“	E 103°21‘43.2“	57 m	2.68	0.19	4.69	0.172
HF2	Upland	Forest	Harapan	S 02°09‘29.4“	E 103°20‘01.5“	81 m	5.74	0.38	4.10	0.245
HF3	Upland	Forest	Harapan	S 02°10‘30.1“	E 103°19‘57.8“	51 m	3.76	0.24	4.34	0.243
HF4	Upland	Forest	Harapan	S 02°11‘15.2“	E 103°20‘33.4“	61 m	4.40	0.30	4.49	0.169
HFr1	Riparian	Forest	Harapan	S 02°09‘51.5“	E 103°22‘03.2“	54 m	5.84	0.37	3.62	0.101
HFr2	Riparian	Forest	Harapan	S 02°10‘24.4“	E 103°21‘56.1	45 m	8.42	0.54	3.37	0.245
HFr3	Riparian	Forest	Harapan	S 02°10‘51.9“	E 103°20‘07.8“	50 m	2.64	0.22	3.83	0.112
HFr4	Riparian	Forest	Harapan	S 02°11‘23.9“	E 103°20‘39.5“	57 m	3.85	0.30	3.76	0.120
HO1	Upland	Oil palm	Harapan	S 01°54‘35.6“	E 103°15‘58.3“	75 m	1.13	0.09	4.41	0.078
HO2	Upland	Oil palm	Harapan	S 01°53‘00.7“	E 103°16‘03.6“	63 m	2.77	0.21	4.46	0.158
HO3	Upland	Oil palm	Harapan	S 01°51‘28.4“	E 103°18‘27.4“	58 m	2.20	0.18	4.32	0.141
HO4	Upland	Oil palm	Harapan	S 01°47‘12.7“	E 103°16‘14.0“	47 m	1.46	0.12	4.50	0.127
HOr1	Riparian	Oil palm	Harapan	S 01°54‘07.7“	E 103°22‘53.3“	14 m	3.59	0.30	5.92	0.049
HOr2	Riparian	Oil palm	Harapan	S 01°52‘40.5“	E 103°21‘23.0“	22 m	3.57	0.28	5.48	0.043
HOr3	Riparian	Oil palm	Harapan	S 01°51‘40.2“	E 103°18‘20.2“	42 m	1.67	0.13	5.50	0.075
HOr4	Riparian	Oil palm	Harapan	S 01°42‘39.5“	E 103°17‘31.1“	17 m	3.03	0.23	6.39	0.111
HR1	Upland	Rubber	Harapan	S 01°54‘39.5“	E 103°16‘00.1“	61 m	2.18	0.15	4.06	0.143
HR2	Upland	Rubber	Harapan	S 01°52‘44.5“	E 103°16‘28.4“	71 m	3.03	0.17	3.95	0.125
HR3	Upland	Rubber	Harapan	S 01°51‘34.8“	E 103°18‘02.1“	48 m	2.45	0.15	3.76	0.088
HR4	Upland	Rubber	Harapan	S 01°48‘18.2“	E 103°15‘52.0“	54 m	2.88	0.21	3.89	0.101
HRr1	Riparian	Rubber	Harapan	S 01°44‘18.9“	E 103°18‘50.0“	29 m	1.18	0.07	6.61	0.084
HRr2	Riparian	Rubber	Harapan	S 01°53‘14.3“	E 103°17‘29.2“	46 m	3.28	0.25	5.56	0.116
HRr3	Riparian	Rubber	Harapan	S 01°51‘42.3“	E 103°18‘20.4“	38 m	1.89	0.14	5.42	0.067
HRr4	Riparian	Rubber	Harapan	S 01°42‘39.6“	E 103°17‘23.3“	14 m	2.65	0.18	6.03	0.150