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ORIGINAL ARTICLE

Integrative taxonomy reveals a hidden diversity: Redescriptions and new records of Rhizoecidae (Sternorrhyncha: Coccomorpha) in Germany

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Abstract. The scale insect family Rhizoecidae in Germany has historically been documented as comprising six species from two genera: *Rhizoecus albidus* Goux, 1942, *Rhizoecus cacticans* (Hambleton, 1946), *Rhizoecus franconiae* Schmutterer, 1956, *Ripersiella caesii* (Schmutterer, 1956), *Ripersiella halophila* (Hardy, 1868), and *Ripersiella hibisci* (Kawai & Takagi, 1971). To assess changes in this biodiversity, we collected 37 samples from potted plants across the botanical gardens of Berlin, Bonn, Frankfurt, Hamburg, and Munich. Species identifications were conducted using integrative taxonomy, combining morphological analysis of slide-mounted specimens, molecular data from the COI region, and ecological information. Our study identified eight species: *Geococcus coffeae* Green, 1933, *Rhizoecus arabicus* Hambleton, 1976, *Rh. cacticans*, *Rhizoecus dianthi* Green, 1926, *Rhizoecus nemoralis* (Hambleton, 1946), *Rhizoecus falcifer* Kunckel d'Herculais, 1878, *Rhizoecus simplex* (Hambleton, 1946) and *Ripersiella aloes* (Williams & Pellizzari, 1997). Except for *Rh. cacticans*, all are newly recorded for Germany, increasing the total German Rhizoecidae fauna to 13 species across three genera. We provide detailed morphometric redescriptions for *Rh. arabicus*, *Rh. franconiae*, *Rh. simplex*, and *Ri. caesii* based on type material, along with morphological notes for the other species. The study also resolves nomenclatural issues for *Rh. franconiae* and *Ri. hibisci* designating Lectotypes and reports 61 new host records for eight species. We present a taxonomic key for the updated list of Rhizoecidae species recorded in Germany. This research significantly revises the understanding of rhizoecid diversity in the country, revealing that the fauna is more than twice as rich as previously known.

INTRODUCTION

According to the ScaleNet database, the family Rhizoecidae comprises 226 species grouped into 16 genera (García Morales et al., 2016). Its phylogenetic position is still under review: it is sometimes treated as a subfamily within the Pseudococcidae, but recent studies recognise it as a family category (Hodgson, 2012). Morphologically, the main characters of this family for adult females are the absence of cerarii, antenna with six or fewer segments, presence of bi- or tritubular ducts, and their hypogeal habit (Hodgson, 2012). At the genus level, the highest diversity is concentrated in tropical regions, primarily in the Neotropics and Oriental regions (Kozár & Konczné Benedicty, 2007).

Currently, six species of Rhizoecidae have been recorded in Germany, in the genera *Rhizoecus* Kunckel d'Herculais, 1878, and *Ripersiella* Tinsley, 1899. *Rhizoecus albidus* Goux, 1942 has been recorded in 11 European countries, four Asian and one African country; it is associated with 29 plant species in 12 families (Williams, 1962; Ben-Dov, 1994; Fetykó et al., 2010; Moghaddam, 2013; Jansen & Westenberg, 2015; Gavrilov-Zimin, 2016). The record for Germany corresponds to Bayern (localities of Regnitz and Keuper), feeding on *Agrostis vulgaris* L., 1753, *Festuca ovina* L., 1753, *Arrhenatherum elatius* (L.) P. Beauv., 1819, *Corynephorus canescens* (L.) P. Beauv., 1812, *Holcus lanatus* L., 1753, and *Deschampsia flexuosa* (L.) Trin., 1820 (Poaceae) (Schmutterer, 1952). *Rhizoecus cacticans* (Hambleton, 1946) is considered a cosmopolitan and polyphagous species, recorded in 26 countries and associated with more than 60 botanical species (Kozár & Konczné Benedicty, 2007). There are two records for Germany, the first one corresponds to an unidentified species of *Mammillaria* Haw., 1812 (Cactaceae) intercepted in the United States, without further origin information besides the coun-

try (Hambleton, 1946); the second record was in Stuttgart, associated with greenhouse plants of *Crassula arborea* Medik., 1783, *C. tetragona* L., 1753 (Crassulaceae) and *Euphorbia lactea* Haw., 1812 (Euphorbiaceae) (Schmutterer, 1956). *Rhizoecus franconiae* Schmutterer, 1956 has been recorded only in Germany; its plant host associations include *Achillea millefolium* L., 1753, *Pilosella officinarum* F.W. Schultz & Sch. Bip., 1862, *Tanacetum vulgare* L., 1753 (Asteraceae) and *Corynephorus canescens* (L.) P. Beauv., 1812 (Poaceae) (Schmutterer, 1956). Apparently, there are no further records since its original description (García Morales et al., 2016).

Ripersiella caesii (Schmutterer, 1956) has been recorded in Germany and Hungary, associated with *Dianthus gratianopolitanus* Vill., 1789 (Caryophyllaceae) (Schmutterer, 1956; Kozár et al., 2013). *Ripersiella halophila* (Hardy, 1868) is restricted to the Palearctic region, having been recorded in 10 countries and is associated with nine plant species. The species was recorded in Germany for the first time in Hamburg, associated with roots of *Pilosella officinarum* (Asteraceae) (Lindinger, 1939). Although it is mentioned by several authors (Schmutterer, 1980; Kosztarab & Kozár, 1988; Ben-Dov, 1994), they refer solely to the first record and it seems there are no new direct collections related to the species. *Ripersiella hibisci* (Kawai & Takagi, 1971) was intercepted by phytosanitary authorities associated with *Callistemon* plants in the states of Hessen and Baden-Württemberg (Julius Kühn-Institut, 2022).

Root-feeding insects, including Rhizoecidae species, are primarily introduced through the movement of plant material, and their subterranean habit makes their detection particularly challenging. German botanical gardens, as regular importers of plants, could inadvertently facilitate the spread of non-native scale insects. To provide basic information about species that could represent potential risks to local vegetation, the aim of this research is to contribute to the knowledge of Rhizoecidae species diversity in the country through direct sampling of specimens, a literature review, and an analysis of type material. Our results include new taxonomic information for easier identification of the group, and an update of the species present in Germany.

MATERIAL AND METHODS

Samplings were carried out in the botanical gardens of Bonn, Hamburg, Munich, Frankfurt am Main, and Berlin (Germany) (detailed list of collecting data in Supplement S1) and preserved in 96% Ethanol for posterior analyses. Scientific names of plants were reviewed according to the database of the Royal Botanic Gardens, Kew (POWO, 2026). A tripartite interaction network graph was created to facilitate the visualisation of the large volume of collection data. It was developed from two matrices: one comprising scale insect species (columns) interacting with host plants (rows), and the other comprising scale insect species (columns) interacting with localities (rows). The graph was generated using the "bipartite" package (Dormann et al., 2008) in R version 3.5.2 (R Development Core Team, 2019).

Morphological analysis

Permanent mounting slides were prepared following the protocol of Sirisena et al. (2013), and they are preserved in the Bavarian State Collection for Zoology (Zoologische Staatssammlung München – ZSM). The type material of *Rh. arabicus*, *Rh. franconiae*, *Rh. simplex*, and *Ri. caesii* was studied. Measurement of labium corresponds to apical + medial segments; total length of leg excludes coxa. Measurement data are given as average, standard deviation, range in parentheses and holotype measurements in square brackets. Taxonomic drawings follow the usual half dorsum-venter scheme; all figures were prepared with Adobe Creative Cloud. Morphometric image analysis and measurement data were acquired with the phase-contrast and differential interference contrast microscope Leica DM6 B and the LAS X Life Science Microscope v 3.10 software.

Molecular analysis

DNA was isolated from 26 specimens with the DNAeasy Tissue kit (Qiagen, Inc., Valencia, CA) according to the manufacturer's protocol and stored at –20°C; specimens were recovered and preserved in 70% ethanol for morphological analysis. PCR products were obtained from partial COI using the primers C1-J-2183 aka "Jerry" 5'-CAA CAT TTA TTT TGA TTT TTT GG-3' (Simon et al., 1994) and C1-N-2568 aka "BEN3R" 5'-GCW ACW ACR TAA TAK GTA TCA TG-3' (designed by T.R. Schultz, Smithsonian Institution). The PCR reaction components and final concentrations were 2.5 mM $MgCl_2$, 0.1 mM dNTPs, 0.2 µM each primer, 2.5 units of Taq DNA polymerase with the appropriate buffer (Qiagen, Venlo, The Netherlands), and 3 µl of DNA template in a final volume of 20 µl. The PCR cycling protocol for COI was as follows: 95°C for 7 min, followed by 40 cycles of 95°C for 1 min, 45°C for 1 min, and 72°C for 1 min 30 s, with a final extension at 72°C for 5 min. PCR products were purified and sequenced in both directions at a contract sequencing facility (IONTEK, İstanbul, Turkey). DNA extract products are preserved in the Hemiptera collection of ZSM.

Double-stranded sequences were assembled using CodonCode Aligner v. 3.7.1 (CodonCode Corp.), and multiple alignments were performed by using ClustalW in BioEdit v. 7.7 (Hall, 1999). Each alignment was controlled visually, and ambiguous parts were removed. All the new sequences were verified using web BLAST to evaluate and confirm that they corresponded to the target group. Detailed voucher information, taxonomic classifications, photos, DNA barcode sequences, used primer pairs and trace files (including their quality) are publicly accessible through the public data set "(Dataset code: COCCO)" on the Barcode of Life Data Systems workbench (BOLD; www.boldsystems.org) (Ratnasingham & Hebert, 2007) and in Supplement S2. The analysis tools of the BOLD workbench were employed to calculate the nucleotide composition of the sequences and distributions of Kimura-2-parameter K2P distances (Kimura, 1980) within and between species. A neighbour-joining cluster analysis based on K2P model was performed with MEGA 12.0.9 (Kumar et al., 2024), with a non-parametric bootstrap analysis of 1000 replicates (Felsenstein, 1985). The resulting topology serves no phylogenetic purpose but rather provides a graphical visualisation of DNA species clustering; it means that molecular information for taxonomic identification at the species level is still not possible.

Entomological collections

USNM – United States National Entomological Collection, U.S. National Museum of Natural History, Washington, D.C., USA. SDEI – Senckenberg Deutsches Entomologisches Institut, Müncheberg, Germany. ZSM – Staatlichen Naturwissenschaftli-

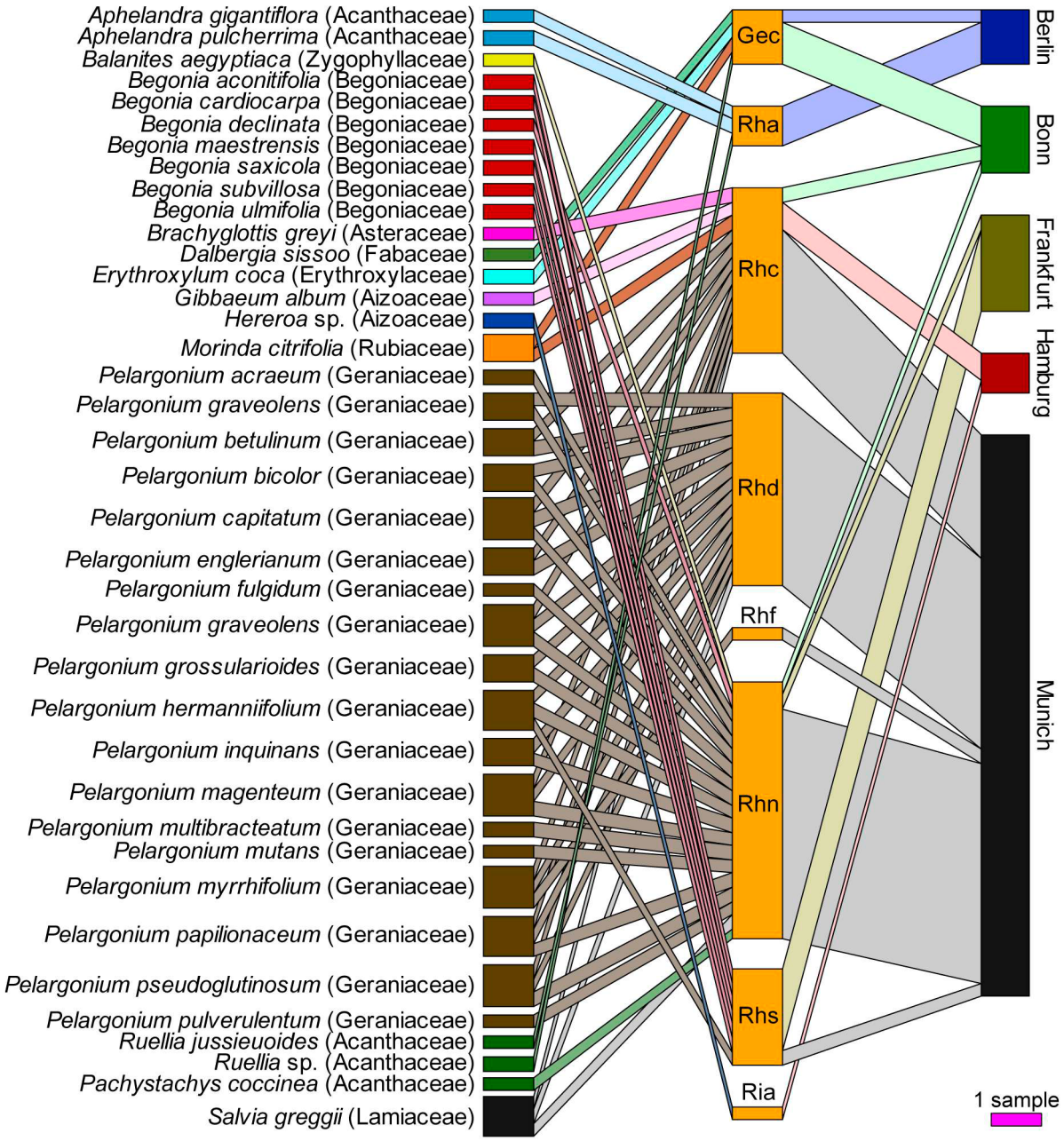

Fig. 1. Network diagram of interaction between plant host, insect species and locality. The colour for the plant host is designated by family. The width of each box and link corresponds to the number of samples between each component. Gec – *Gecococcus coffeae*; Rha – *Rhizoecus arabicus*; Rhc – *Rhizoecus cacticans*; Rhd – *Rhizoecus dianthi*; Rhf – *Rhizoecus falcifer*; Rhn – *Rhizoecus nemoralis*; Rhs – *Rhizoecus simplex*; Ria – *Ripersiella aloes*.

chen Sammlungen Bayerns, Zoologische Staatssammlung München, Germany.

RESULTS AND DISCUSSION

A total of eight species of three genera were identified from 238 analysed specimens: *Geococcus coffeae* Green, 1933, *Rhizoecus arabicus* Hambleton, 1976, *Rh. cacticans*, *Rh. dianthi* Green, 1926, *Rh. falcifer* Kunckel d'Herculais, 1878, *Rh. nemoralis* (Hambleton, 1946), *Rh. simplex* (Hambleton, 1946) and *Ripersiella aloes* (Williams & Pellizzari, 1997) (Full collection data on Supplement S1). Except for *Rh. cacticans*, the remaining seven species are new records for Germany. Additionally, 61 new host records were discovered for the eight species; the details of plant hosts and localities per species are presented in Fig. 1 and Table 1.

Rhizoecus nemoralis and *Rh. cacticans* are the most relevant species in terms of host association and geographical distribution. *Rhizoecus nemoralis* was found in the botanical gardens of Frankfurt, Bonn, and Munich, where it is associated with 19 plant species (Table 1 and Fig. 1, Rhn). Its distribution is concentrated in Guatemala, El Salvador, Mexico and the Netherlands (Williams & Granara de Willink, 1992; Kozár & Konczné Benedicty, 2007; Jansen & Westenberg, 2015). We consider these last two records dubious. The publication that recorded it in Mexico is based

Table 1. Matrix of association between host plants (rows) and the scale insects (columns) *Geococcus coffeae*, *Rhizoecus arabicus*, *Rhizoecus cacticans*, *Rhizoecus dianthi*, *Rhizoecus falcifer*, *Rhizoecus nemoralis*, *Rhizoecus simplex* and *Ripersiella aloes* found in botanical gardens of Germany.

Plant host	Family	*G. coffeae*	*Rh. arabicus*	*Rh. cacticans*	*Rh. dianthi*	*Rh. falcifer*	*Rh. nemoralis*	*Rh. simplex*	*Ri. aloes*	Total
Aphelandra gigantiflora	Acanthaceae		1							1
Aphelandra pulcherrima	Acanthaceae		1							1
Pachystachys coccinea	Acanthaceae						1			1
Ruellia jussieuoides	Acanthaceae		1							1
Ruellia sp.	Acanthaceae	1								1
Gibbaeum album	Aizoaceae			1						1
Hereroa sp.	Aizoaceae								**1**	1
Brachyglottis greyi	Asteraceae			1						1
Begonia aconitifolia	Begoniaceae							1		1
Begonia cardiocarpa	Begoniaceae							1		1
Begonia declinata	Begoniaceae						1			1
Begonia maestrensis	Begoniaceae							1		1
Begonia saxicola	Begoniaceae							1		1
Begonia subvillosa	Begoniaceae							1		1
Begonia ulmifolia	Begoniaceae							1		1
Erythroxylum coca	Erythroxylaceae	1								1
Dalbergia sissoo	Fabaceae	1								1
Pelargonium acraeum	Geraniaceae						1			1
Pelargonium graveolens	Geraniaceae				1		1			2
Pelargonium betulinum	Geraniaceae			1	1					2
Pelargonium bicolor	Geraniaceae				1		1			2
Pelargonium capitatum	Geraniaceae			1	1		1			3
Pelargonium englerianum	Geraniaceae			1	1					2
Pelargonium fulgidum	Geraniaceae						1			1
Pelargonium graveolens	Geraniaceae			1	1		1			3
Pelargonium grossularioides	Geraniaceae				1		1			2
Pelargonium hermanniifolium	Geraniaceae				1		1	1		3
Pelargonium inquinans	Geraniaceae				1		1			2
Pelargonium magenteum	Geraniaceae			1	1		1			3
Pelargonium multibracteatum	Geraniaceae						1			1
Pelargonium mutans	Geraniaceae						1			1
Pelargonium myrrhifolium	Geraniaceae			1	1	1				3
Pelargonium papilionaceum	Geraniaceae			1	1		1			3
Pelargonium pseudoglutinosum	Geraniaceae			1	1		1			3
Pelargonium pulverulentum	Geraniaceae						1			1
Salvia greggii	Lamiaceae			1	1		1			3
Morinda citrifolia	Rubiaceae	1		1						2
Balanites aegyptiaca	Zygophyllaceae						1			1
Total		4	3	12	14	1	19	7	1	61

on a literature review (Kozár & Konczné Benedicty, 2007). The authors cited in that publication, i.e., Ferris (1953), Hambleton (1976), and Williams & Granara de Willink (1992) placed the species only in El Salvador and Guatemala. The Dutch record was reclassified as *Rhizoecus* cf. *nemoralis* in a recently updated checklist for the country, by the same author who first recorded it (Jansen & Alferink, 2023). Therefore, this could be the first confirmed record of *Rh. nemoralis* for Europe. The host range covers four plant species, each belonging to a different family (Williams & Granara de Willink, 1992; Jansen & Westenberg, 2015). Consequently, the 19 plant species recorded in this study represent new data, extending the known range to include species from the families Acanthaceae, Begoniaceae, Geraniaceae, Lamiaceae, and Zygophyllaceae. *Rhizoecus nemoralis* was found in 10 samples co-occurring with up to three other rhizoecid species: *Rh. cacticans*, *Rh. dianthi*, and *Rh. simplex*.

For *Rh. cacticans*, the distribution in Germany extends to Bonn, Frankfurt, and Munich, associated with 12 plant hosts. This species is considered polyphagous and economically relevant for agriculture (Ramos-Portilla & Caballero, 2022). There is new information for the previously recorded genus *Pelargonium* L'Hér., 1789 (Geraniaceae) and *Salvia* L., 1753 (Lamiaceae), extending the records to eight and two species, respectively; it is recorded for the first time associated with a species of the genus *Morinda* L., 1753 (Rubiaceae) and *Brachyglottis* J.R. Forst. & G. Forst., 1775 (Asteraceae), and for the first time associated with a species of the family Aizoaceae. This species was found in 10 samples co-occurring with up to three other rhizoecid species: *G. coffeae*, *Rh. dianthi*, *Rh. falcifer*, and *Rh. nemoralis*.

Rhizoecus dianthi is associated with 13 Geraniaceae species and one Lamiaceae species, but it was found only in Munich. This species is extended in the Nearctic, Palaearctic (European part) and Australasian bioregions (Zahradník, 1965; Kozarzhevskaya & Reitzel, 1975; Hambleton, 1976; Williams, 1985; Ben-Dov, 1994; Germain et al., 2002; Kozár & Konczné Benedicty, 2007; Danzig & Gavrilov, 2009; Mazzeo et al., 2014). It is a polyphagous species, but the 14 plant records presented here increase its host range, both in the number of species and families. In all the samples, this species was found co-occurring with at least one other scale insect, with up to three of the follow-

ing species: *Rh. cacticans*, *Rh. falcifer*, *Rh. nemoralis* and *Rh. simplex* (Fig. 1).

Rhizoecus simplex was collected in Frankfurt associated with six species of Begoniaceae, and in Munich associated with one species of Geraniaceae. Until now, this species has been restricted to the United States and Brazil (Hambleton, 1946, 1973, 1976; Williams & Granara de Willink, 1992), which makes it the first record for Europe. Regarding the host information, both botanical families are new records, which extends the host range to 22 families and 34 species.

Geococcus coffeae was recorded on four plant species in Berlin and Bonn. It has been recorded in four European countries, with records related to indoor plant sampling in the United Kingdom, Denmark and the Netherlands (Kozarzhevskaya & Reitzel, 1975; Malumphy & Badmin, 2012; Jansen & Westenberg, 2015). Despite the large list of associated plants (>50 species), the four hosts presented here are new records, including the first record of the Erythroxylaceae family.

Rhizoecus arabicus was associated with three botanical hosts and observed only in Berlin. This species has only one record for the Palaearctic, which corresponds to Spain, from specimens collected in an indeterminate plant in outdoor conditions (Szita et al., 2022). This species has been associated with *Chloris radiata* (L.) Sw., 1788 (Poaceae), *Coffea arabica* L., 1753 (Rubiaceae) and *Pilea microphylla* (L.) Liebm., 1851 (Urticaceae) (Hambleton, 1976; Williams & Granara de Willink, 1992; Matile-Ferrero & Étienne, 2006), therefore, the new information presented here extends the host range to the Acanthaceae family, totalling six species.

Finally, the less frequent species were *Rhizoecus falcifer* and *Ripersiella aloes*. On one hand, *Rh. falcifer* was found on *Pelargonium myrrhifolium* (L.) L'Hér., 1789 (Geraniaceae) in Munich. The species was originally described from specimens collected in greenhouse plants from France and has spread throughout Europe (Künckel D'Herculais, 1878; Kozár & Konczné Benedicty, 2007). It has been recorded on *Pelargonium* previously (McKenzie, 1967), but without species-level information. On the other hand, one specimen of *Ri. aloes* is associated with an undetermined species of *Hereroa* (Schwantes) Dinter & Schwantes, 1927 (Aizoaceae) in Hamburg. The records of *Ri. aloes* in Europe are limited to specimens collected from indoor plants, associated with *Aloe glauca* Mill., 1768 and an undetermined species of *Gasteria* Duval, 1809 (Asphodelaceae) in England and Russia, respectively (Williams & Pellizzari, 1997; Gavrilov-Zimin & Gapon, 2016).

Integrative taxonomy Rhizoecidae species in Germany

I. Taxonomic redescriptions

Rhizoecus arabicus Hambleton, 1976

Figs 2 and 3

Rhizoecus eloti Giard, 1897: 585. Nomen oblitum.
Rhizoecus arabicus Hambleton, 1976: 13.

Morphological redescription

Slide-mounted adult female (n = 19; 14 German specimens + holotype + 4 paratypes). **Body** oval-elongated, 1.1 ± 0.2 (0.7–1.6) [1.5] mm long and 0.6 ± 0.1 (0.3–0.8) [0.8] mm wide (Figs 2, 3A). **Anal lobes** not protruding, with three flagellate setae not uniformly distributed, either two on venter and one on dorsum, or two on dorsum and one on venter; the longest seta always in ventral surface 58.9 ± 8.4 (40–72) µm long, remaining setae each one of 39.6 ± 4.9 (26–47) µm long, and 0–1 associated trilocular pores.

Dorsum: Ostioles, both anterior and posterior, are evident but unsclerotised, with lips not projecting, aperture of anterior ostioles of 36.7 ± 5.7 (24–43) µm wide and posterior ostioles of 44 ± 8.7 (35–59) µm wide, no flagellate setae or associated trilocular pores over the lips. **Anal ring** 57.6 ± 2.7 (54–63) [57] µm transversal diameter (Figs 2A, 3B), with six flagellate setae, each 81.6 ± 7.9 (63–95) µm long; external row with 26.5 ± 2.6 (22–31) [22] cells, oval to subtrapezoidal, with evident spicules; inner row with 13.9 ± 1.5 (11–16) [14] cells, elongated, mostly subtriangular with sinuous edges. **Tritubular ducts** of one size 4.7 ± 0.5 (4–6) µm wide and 8.1 ± 0.6 (7–9) µm long, without accompanying setae, with tubules protruding from cuticle about half of its length, each 8–9 µm long and 1 µm wide in the narrowest part (Figs 2B, 3C); asymmetric distribution but present as a transversal row on margin, lateral and medial areas, number per segment detailed in Table 2. **Tubular ducts** numbering 55 ± 7.1 (50–60) [not counted] on whole body, each duct 4–5 µm long and 1–2 µm wide on dorsum and venter, 4–5 µm long and 2 µm wide, about half a trilocular pore, not projecting from the cuticle (Figs 2C, 3D, td); dorsum with 27.5 ± 4.9 (24–31) ducts, without symmetrical arrangement, numbering 0–2 [not counted] on head, 3–9 [not counted] on thorax, 2–5 [not counted] on abdominal segment I, 2–3 [not counted] on segment II, 3–5 [not counted] on segment III, 1–2 [not counted] on segment IV, 2–3 [not counted] on segment V, 1–4 [not counted] on segment VI, 2 [not counted] on segment VII, 1–3 [not counted] on segment VIII, totalling 20.5 ± 0.7 (20–21) ducts on abdomen. **Multilocular pores** absent. **Trilocular pores** 3–4 µm wide, evenly distributed on the surface (Figs 2D, 3D, tr). **Microtrichia** are present on the dorsum and venter and are abundant in the last four abdominal segments. **Body setae**, flagellate, 8–30 µm long, evenly distributed, the longest setae >20 µm long present on the median area of the head and the margin of the abdominal segment VII.

Venter: Antenna with six segments (Fig. 3E), total length 153.7 ± 11.1 (129–167) µm; segment I 32.8 ± 2.8 (29–38) µm long and 44.9 ± 5 (39–58) µm wide, segment II 21.2 ± 1.8 (16–24) µm long and 26.6 ± 2.8 (22–31) µm wide, segment III 29.4 ± 4 (23–42) µm long and 23.7 ± 3.5 (20–30) µm wide, segment IV 14.8 ± 2.6 (12–19) µm long and 23.9 ± 3.3 (20–30) µm wide, segment V 16.1 ± 2 (12–19) µm long and 21.6 ± 3.7 (18–30) µm wide, segment VI 41.8 ± 3.1 (34–47) µm long and 24 ± 4.2 (21–31) µm wide. Chaetotaxy as follows (Fig. 10A): segment I with four flagellate setae, segment II with three flagellate setae plus one

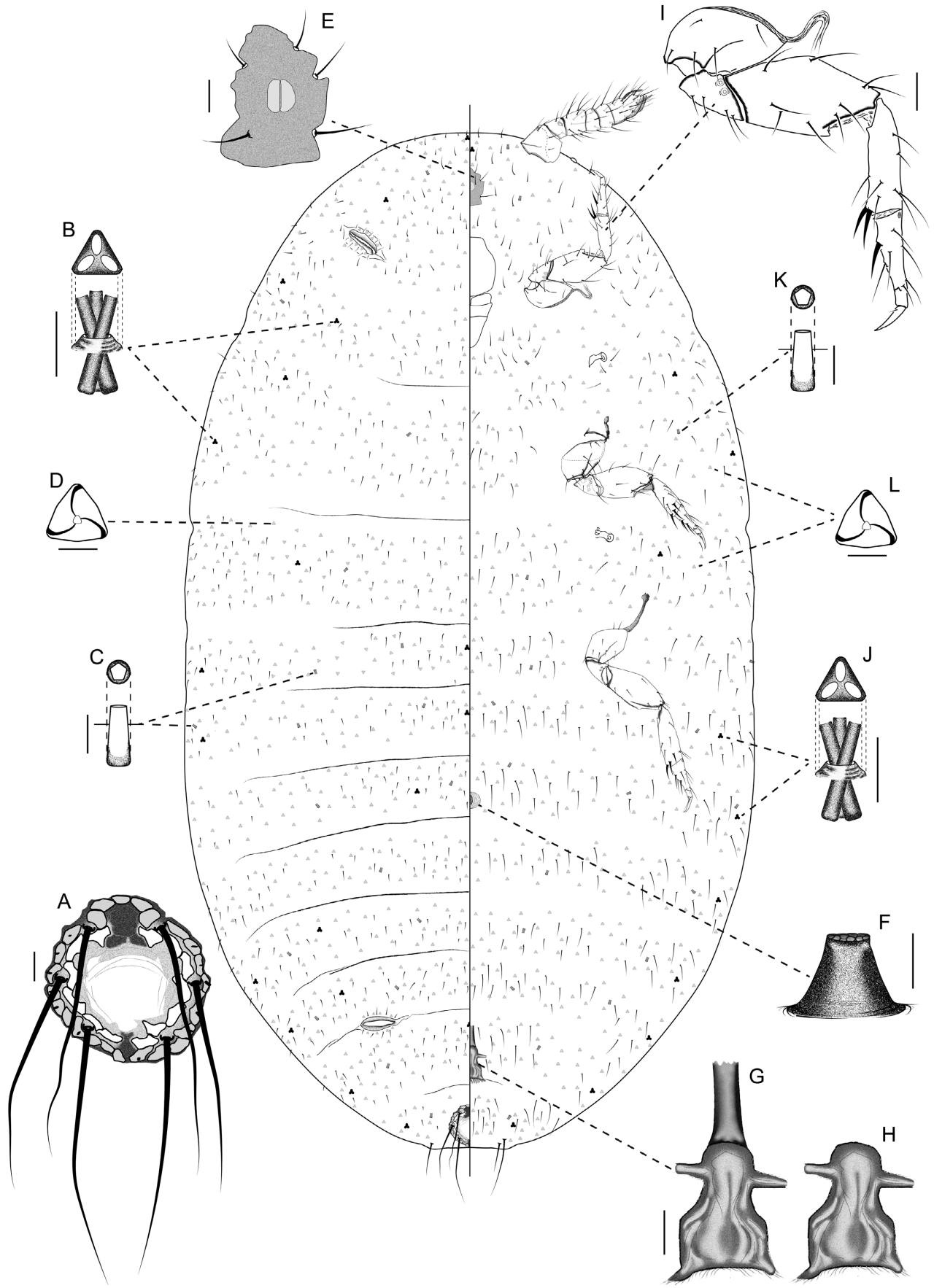

Fig. 2. Taxonomic illustration of *Rhizoecus arabicus* with body divided in dorsum (left side) and venter (right side). A – anal ring, B – dorsal tritubular duct, C – dorsal tubular duct, D – trilocular pore, E – cephalic plate with central vacuoles, F – circulus, G – genital chamber with anterior area, H – genital chamber without anterior area, I – anterior leg, J – ventral tritubular duct, K – ventral tubular duct, L – trilocular pores. Scale bars: A, G, H = 10 µm; B, F, J = 5 µm; C, D, K, L = 2 µm; E, I = 20 µm.

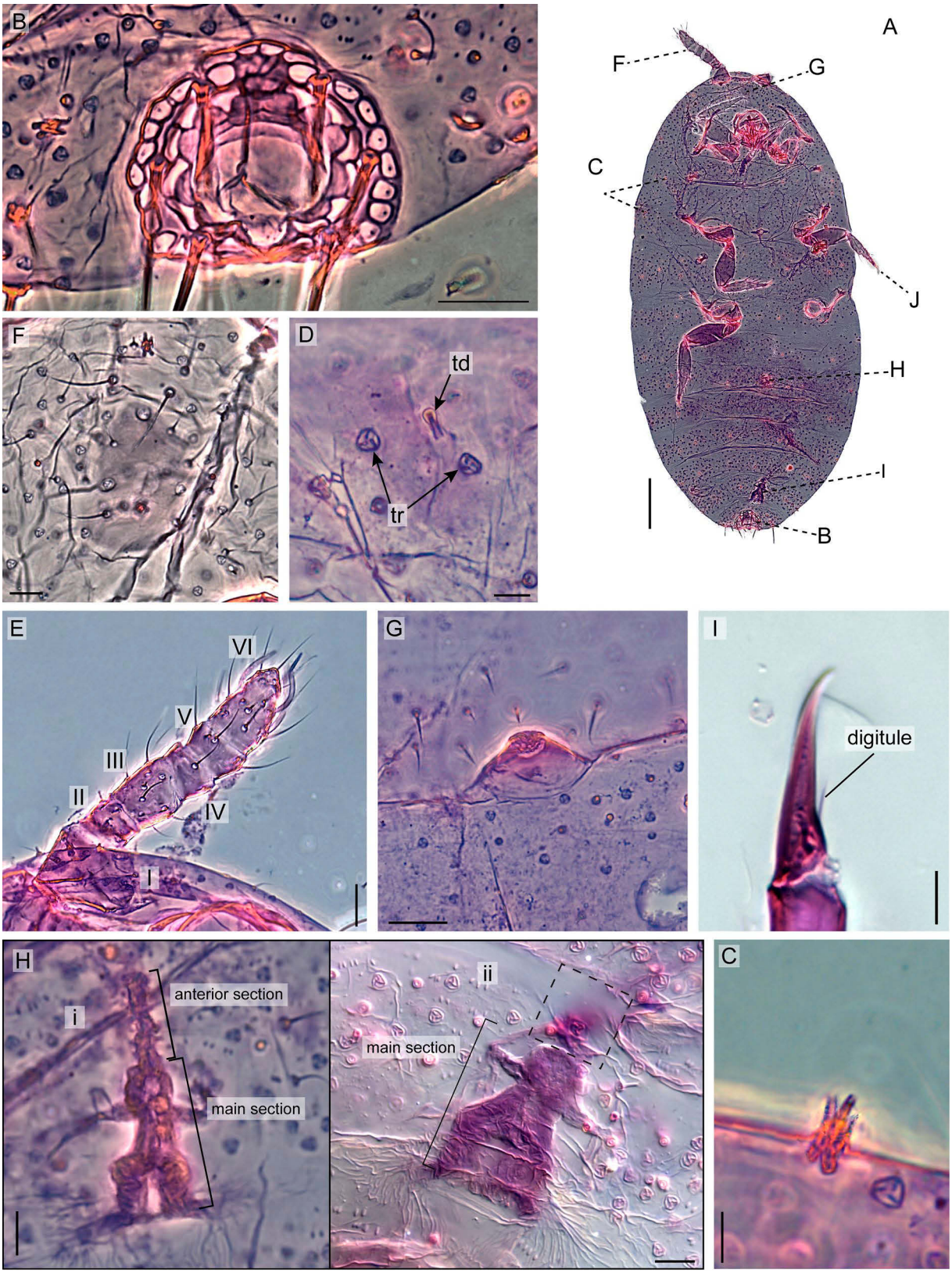

Fig. 3. Microphotographs of anatomical structures from *Rhizoecus arabicus*, slide-mounted adult female. A – body, B – anal ring, C – tritubular duct in lateral view, D – tubular duct (td) and trilocular pore (tr), E – antenna with segments indicated with roman numbers, F – cephalic plate, G – circulus, H – genital chamber with variations of the anterior section i) present, ii) absent. Scale bars: A = 100 µm; B, E = 20 µm; F–H = 10 µm; C, D, I = 5 µm.

placoid sensillum of 3–4 µm wide, segment III with 9–11 flagellate setae arranged in two rows, segment IV with five flagellate setae, segment V with five flagellate setae plus one falcate sensillum of 15–20 µm long, segment VI with 15–19 flagellate setae plus three falcate sensilla, the basal sensillum with 29–35 µm long, medial and distal sensilla

Table 2. Information on number and distribution of tritubular ducts for *Rhizoecus arabicus*, *Rh. dianthi*, *Rh. franconiae*, *Rh. nemoralis*, *Rh. simplex*, and bitubular ducts for *Ripersiella caesii*. Data organised by surface and body segmentation, with mean, standard deviation (SD), minimum (Min), maximum (Max), and holotype (Ht). Abd_seg_# corresponds to the abdominal segment number.

	Parameters	Head			Thorax			Abd_seg_1			Abd_seg_2			Abd_seg_3			Abd_seg_4			Abd_seg_5			Abd_seg_6			Abd_seg_7			Abd_seg_8			Abdomen			Total		
		dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	total	dorsum	venter	body
Rh. arabicus	Mean	3.9	1	4.8	12.3	4.0	18.4	2.2	0.3	2.4	3.4	0.5	3.9	2.6	1.8	4.3	3.3	0.6	4.3	2.3	1.9	4.2	3.5	1.2	4.9	3.2	1.9	5	2	2	4	20.6	9.2				
	SD	0.3	0.5	0.4	4.7	1.7	2.4	0.9	0.7	0.9	1	0.7	0.7	0.8	0.4	0.5	1.3	0.8	1.0	1.3	1	1	1.4	1.1	0.7	0.4	0.3	0.4	0	0	0	7.6	4.1	2.8	13.1	5.8	4.8
	Min	3	0	4	0	0	14	0	0	0	2	0	3	2	1	4	1	0	3	0	0	3	2	0	4	3	1	4	2	2	4	0	0	28	0	0	47
	Max	4	2	5	17	6	22	3	2	4	5	2	5	4	2	5	5	2	6	5	4	7	5	3	6	4	2	6	2	2	4	28	15	38	48	22	63
	Ht	4	1	5	9	5	14	2	0	2	3	0	3	2	2	4	3	0	3	2	1	3	4	0	4	4	1	5	2	2	4	22	6	28	35	12	47
Rh. dianthi	Mean	2.1	1.0	3.1	9.1	2.7	11.9	0.9	0.0	0.9	2.1	0.6	2.7	2.0	0.0	2.0	1.0	0.6	1.6	2.3	1.7	4.0	0.6	1.1	1.7	2.0	0.7	2.7	0.0	0.0	0.0	10.9	4.7	15.6	22.1	8.4	30.6
	SD	0.4	0.6	0.4	1.9	1.0	1.7	0.7	0.0	0.7	1.5	1.1	1.1	0.8	0.0	0.8	0.6	0.8	0.5	0.8	0.5	0.8	0.8	0.9	0.8	0.0	0.8	0.8	0.0	0.0	0.0	3.7	2.1	3.7	5.2	1.8	5.4
	Min	2	0	3	7	2	10	0	0	0	0	0	1	1	0	1	0	0	1	1	1	3	0	0	1	2	0	2	0	0	0	7	2	11	16	7	24
	Max	3	2	4	12	4	14	2	0	2	4	3	4	3	0	3	2	2	2	3	2	5	2	2	3	2	2	4	0	0	0	17	9	21	31	11	38
Rh. franconiae	Mean	5	3	8	17.6	18	35.6	4.9	1.9	6.7	4.3	3.6	7.9	5	4.1	9.1	5.6	4.1	9.7	4.7	4.6	9.3	4.6	3.6	8.1	3.1	3.1	6.3	2	0	2	34.1	25	59.1	57	46	103
	SD	2	1	2	3	3.2	6	0.7	1.3	1.7	1.1	0.5	1.2	1.5	0.7	2	0.8	1.5	1.3	1	0.8	1.5	1	0.5	1.1	0.4	0.4	0.5	0	0	0	3.8	3.2	6.8	7.7	6.4	13.9
	Min	3	2	5	13	14	28	4	0	5	3	3	6	3	3	7	5	1	7	4	4	8	3	3	7	3	3	6	2	0	2	29	21	50	47	38	85
	Max	7	4	10	23	23	46	6	4	9	6	4	10	7	5	12	7	5	11	6	6	12	6	4	9	4	4	7	2	0	2	39	30	68	68	54	122
	Ht	3	3	6	16	14	30	4	1	5	3	4	7	3	4	7	6	1	7	4	4	8	4	3	7	3	4	7	2	0	2	29	21	50	48	38	86
Rh. nemoralis	Mean	1.7	1.3	3	5.6	4.1	9.7	0	0	0	1.7	0.1	1.9	1	0.1	1.1	0.4	0	0.4	2.3	0.4	2.7	0	1.6	1.6	2	0.1	2.1	0	0	0	7.4	2.4	9.9	14.7	7.9	22.6
	SD	0.5	0.5	0	1.3	1.1	0.5	0	0	0	0.5	0.4	0.4	0.6	0.4	0.7	0.8	0	0.8	0.8	0.8	0.5	0	0.5	0.5	0	0.4	0.4	0	0	0	0.8	0.8	0.7	1.8	1.6	0.8
	Min	1	1	3	3	3	9	0	0	0	1	0	1	0	0	0	0	0	0	1	0	2	0	1	1	2	0	2	0	0	0	6	2	9	12	6	22
	Max	2	2	3	7	6	10	0	0	0	2	1	2	2	1	2	2	0	2	3	2	3	0	2	2	2	1	3	0	0	0	8	4	11	17	10	24
Rh. simplex	Mean	4	1	4.9	12	4.7	18	2	0.1	2.2	2.4	0.8	3.3	2	1.6	3.8	3.6	2.4	6	3.2	1.8	4.6	4	1.3	5.3	2.9	1.6	4.5	2	2	4	22	11	33.7	37	17	56.1
	SD	1	0	1	3.4	1.2	2.5	0.5	0.4	0.8	0.9	1.1	0.7	0	0.9	0.6	1.1	1.5	1.1	1.3	0.4	1.2	1.2	1	1.3	0.4	0.7	1	0	0	0	2.1	2.6	2.8	5.1	2.6	5
	Min	3	1	4	7	4	11	1	0	1	1	0	2	2	0	2	2	1	4	2	1	3	2	0	2	2	0	2	2	2	4	20	8	28	31	13	44
	Max	5	1	6	15	7	20	3	1	4	3	2	4	2	2	4	5	5	7	5	2	7	5	2	7	3	2	5	2	2	4	25	15	37	44	20	61
	Ht	4	1	5	7	4	11	3	1	4	2	2	4	2	0	2	3	1	4	4	2	6	2	0	2	2	0	2	2	2	4	20	8	28	31	13	44
Ri. caesii	Mean	3.0	0.5	2.6	6.5	2.2	6.5	1.7	0	1.3	1.0	0.2	0.9	1.7	0.3	1.5	2.3	1.2	2.6	1.0	1.7	2	2	2.2	3.1	2.3	1.8	3.1	1.8	0	1.4	13.8	7.3	15.9	23.3	10	25
	SD	0.6	0.5	1.7	1.2	1.7	4.3	0.5	0	0.9	0.9	0.4	1.1	1.2	0.5	1.4	0.5	1	1.8	0.9	0.8	1.7	0.6	0.4	2.1	0.8	0.4	2.2	0.4	0	0.9	3	2.2	10.2	3.8	3.7	16
	Min	2	0	0	5	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	1	0	1	2	0	1	1	0	1	0	0	10	5	0	19	6	0
	Max	4	1	4	8	5	12	2	0	2	2	1	3	3	1	3	3	2	5	2	3	5	3	3	6	3	2	5	2	0	2	19	11	26	30	17	42
	Ht	3	1	4	8	0	8	2	0	2	2	0	2	3	0	3	3	0	3	2	1	3	2	2	4	3	2	5	2	0	2	19	5	24	30	6	36

with 21–28 µm long, erect sensillum 17–22 µm long. **Eyes** always present, diameter 9.4 ± 1.1 (8–12) µm. **Cephalic plate** visible only on 4 out of 20 specimens, 39–49 µm long and 26–40 µm wide, with 4–6 flagellate setae surrounding the plate and two discal oval vacuoles (Figs 2E, 3F). **Clypeolabral shield** oval, larger than labium, 84.7 ± 5 (74–93) [86] µm long. **Labium** with 63.8 ± 5 (49–71) [66] µm long and 43.9 ± 3.8 (38–51) [not available] µm wide; basal segment membranous with six flagellate setae; medial segment sclerotised, 22.6 ± 2.9 (17–29) [21] µm long, with two setae; apical segment sclerotised, 41.4 ± 4.8 (32–52) [45] µm long, with 18 flagellate setae. **Spiracles** anterior and posterior pairs with similar size, 25.7 ± 2.6 (21–32) µm long and peritreme 11.8 ± 0.9 (10–14) µm wide. **Circulus** conical, apex truncated and papilliform, on posterior margin of abdominal segment III, basal diameter 22.7 ± 8.4 (15–48) [18] µm, apical diameter 10.1 ± 1.7 (7–14) [8] µm (Figs 2F, 3G). **Genital chamber** present on 7 out of 20 analysed specimens; the shape shows variations in the most anterior section, where some specimens exhibit a long and narrow extension in the distal section (Figs 2G, 3H, i), or such extension is missing (Figs 2H, 3H, ii), 44.8 ± 6.5 (39–57) µm long and 29.5 ± 4.7 (22–35) µm wide at the base.

Anterior leg 236.2 ± 15.3 (212–262) µm long (Fig. 2I). Length and chaetotaxy per segment as follow: coxa 30.9 ± 3.2 (23–38) µm long and 62.3 ± 5.1 (53–70) µm wide, with 7–9 flagellate setae; trochanter 27.4 ± 2.4 (22–31) µm long and 32.1 ± 2.5 (28–36) µm wide, with 5–6 flagellate setae, and four placoid sensilla; femur 83.7 ± 6.8 (70–98) µm long and 40.7 ± 3.6 (34–46), with 9–10 flagellate setae; trochanter + femur length 107.8 ± 6.8 (97–119) µm; tibia 61.8 ± 3.5 (57–70) µm long and 21.2 ± 1.3 (19–24) µm wide, with 6–7 flagellate setae and two spine-like setae in the internal distal area; tarsus 51.3 ± 6.5 (41–65) µm long, with 8 flagellate setae and one spine-like setae, plus one placoid sensillum 4–5 µm wide; tibia + tarsus length 107.7 ± 7.1 (94–118) µm; claw 22.5 ± 1.8 (19–25) µm long, with short setose digitule 4–6 µm (Fig. 3I). **Mid leg** 228 ± 17 (190–253) µm long. Length and chaetotaxy per segment as follow: coxa 35.7 ± 2.5 (32–43) µm long and 59.5 ± 5.8 (46–70) µm wide, with 9–11 flagellate setae; trochanter 28.9 ± 4.6 (23–41) µm long and 28.5 ± 3.5 (21–33) µm wide, with 5–6 flagellate setae plus four placoid sensilla; femur 80.9 ± 6 (71–95) µm long and 37 ± 3 (33–43) µm wide, with 7–8 flagellate setae; trochanter + femur length 106.3 ± 6.9 (96–117) µm; tibia 56.6 ± 4.2 (48–68) µm long and 21.1 ± 1.4 (18–23) µm wide, with 6–8 flagellate setae and three spine-like setae in the internal margin; tarsus 47.8 ± 4.2 (35–56) µm long, with 6 flagellate setae and 2 spine-like setae, plus one placoid sensillum; tibia + tarsus length 101.2 ± 8.4 (76–112) µm; claw 22.8 ± 1.3 (19–24) µm long, with short setose digitule 4–6 µm long. **Posterior leg** 273.8 ± 19.6 (239–308) µm long. Length and chaetotaxy per segment as follow: coxa 35.1 ± 4.1 (26–41) µm long and 56 ± 5.4 (46–65) µm wide, with 9–11 flagellate setae; trochanter 29.1 ± 4.4 (20–34) µm long and 29.5 ± 3.3 (23–35) µm wide, with 5–8 flagellate setae plus four placoid sensilla; femur 94.6 ± 6.9 (84–109) µm long and 40.8 ± 3.4 (35–47) µm wide, with 6–8 flagellate setae; trochanter + femur length 122 ± 8.7 (107–135) µm; tibia 82.1 ± 5 (75–95) µm long and 22.5 ± 2.1 (19–26) µm wide, with

eight flagellate setae and three spine-like setae, plus 0–2 macules; tarsus 55.3 ± 3 (51–62) µm long, with 6–7 flagellate setae, one or two spine-like setae, plus one placoid sensillum; tibia + tarsus length 133.8 ± 6.8 (123–146) µm; claw 23.4 ± 2.5 (16–27) µm long, with short setose digitule of 4–5 µm long.

Tritubular ducts similar in size to those on the dorsum (Fig. 2J), distributed and restricted to marginal or submarginal areas, with a few exceptions: the medial area of the mesothorax, abdominal segment II, and the lateral area of abdominal segment V; number per segment detailed in Table 2. **Tubular ducts** similar size to those in dorsum (Fig. 2K); venter with 27.5 ± 2.1 (26–29) ducts, without symmetrical arrangement, numbering 2 [not counted] on head, 2–5 [not counted] on thorax, 2 [not counted] on abdominal segment I, 1–2 [not counted] on segment II, 3 [not counted] on segment III, 4 [not counted] on segment IV, 4–5 [not counted] on segment V, 1–4 [not counted] on segment VI, 2–3 [not counted] on segment VII, 2 [not counted] on segment VIII, totalling 22 ± 4.2 (19–25) ducts on abdomen. **Multilocular pores** absent. **Trilocular pores** 3–4 µm wide, evenly distributed on both dorsum and venter (Fig. 2L). **Microtrichia** are present along the surface, abundant in the last four abdominal segments. **Body setae** with a similar type and distribution to those on the dorsum; the largest setae are present on the head and abdominal segments V and posterior segments.

Comments

The morphological analysis shows that the closest species recorded in Germany could be *Rh. simplex* and *Rh. cacticans*. *Rhizoecus arabicus* differs from *Rh. simplex* by having a setose short digitule and the larger apical diameter of the circulus (7–14 µm); *Rh. simplex* presents a long capitate digitule and a shorter apical diameter of the circulus (4–6 µm). On the other hand, the digitule length and type differentiate *Rh. arabicus* from *Rh. cacticans*. Nevertheless, this character is affected by the preservation level pre- and during slide mounting, due to the digitule can easily break. The morphometric analysis based on the German specimens indicates that *Rh. arabicus* can be differentiated from *Rh. cacticans* for fore femur characters and its proportions with tibia + tarsus. The following data corresponds to *Rh. arabicus*; femur length, in its external margin, 40.7 ± 3.6 (34–46) µm; trochanter + femur length 83.7 ± 6.8 (70–98); ratio length/width femur 1.3 ± 0.1 (1.1–1.4); ratio trochanter + femur length / tibia + tarsus length 0.76 ± 0.02 (0.71–0.80). *Rhizoecus cacticans* presents femur length 92.6 ± 9.7 (79–118) µm; trochanter + femur length 119.9 ± 12.9 (102–148); ratio length/width femur 2 ± 0.2 (1.7–2.5); ratio trochanter + femur length / tibia + tarsus length 1.01 ± 0.03 (0.96–1.10).

As a note for the morphology of the species, the shape of the genital chamber varies within the analysed population and differs from Kozar's drawing (see Fig. 58, page 155 of Kozár & Konczné Benedicty, 2007). This structure does not appear to be a reliable indicator of species.

Material examined. Holotype, ♀ adult, COLOMBIA: Caldas, Chinchiná, ex *Coffea arabica* (Rubiaceae), iv.1956, S.E. Flanders leg., (USNM). Paratypes, COLOMBIA, 1♀ adult, Caldas, same collection data as for holotype, (USNM); 1♀ adult, same collection data as for holotype except host, ex Poaceae species, (USNM); COSTA RICA, 1♀ adult, Coto, ex soil, 20.v.1945, E.B. Dixon leg., (USMN).

Additional material. USA, 1♀, adult, Florida, Sarasota, ex undetermined species of *Stenostephanus* Nees, 1847 (Acanthaceae), 22.xi.1982, D. Culbert leg., (USNM); GERMANY, 10♀ adults, Berlin, Botanischer Garten; 52.455948°N 13.307338°E, 59 m, 29.xi.2023, ex roots of *Aphelandra gigantiflora* Lindau, 1895 (Acanthaceae), A. Caballero leg., (SNSB-ZSM); 1♀ adult, same collection data as for preceding, ex roots of *Ruellia jussieuoides* (Acanthaceae), A. Caballero leg., (SNSB-ZSM); 3♀ adults, same collection data as for preceding, ex roots of *Aphelandra pulcherrima* (Jacq.) Kunth, 1818 (Acanthaceae), A. Caballero leg., (SNSB-ZSM).

***Rhizoecus franconiae* Schmutterer, 1956**

Figs 4 and 5

Rhizoecus franconiae Schmutterer, 1956: 519.

Nomenclatural correction

The original description does not mention a holotype explicitly, as the International Code of Zoological Nomenclature orders in Chapter 4, Article 16.4 (ICZN, 1999). The syntype slide marked as "Type" by the descriptor holds two specimens, and it is not possible to determine which one corresponds to the possible holotype. Therefore, we designate as Lectotype of *Rh. franconiae* the specimen on the left side of the slide, as it best represents the original description, and it is preserved in good condition. The other specimen on the upper right side of the slide, as well as the remaining seven syntypes, become paralectotypes.

Morphological redescription

Slide-mounted adult female (n = 8). **Body** elongated oval to broadly oblong, length 885.8 ± 31.8 (832–920) [856] µm, width 569 ± 47.2 (507–647) [542] µm (Figs 4, 5A). **Anal lobes** not developed, without sclerotisation; two blunt setae on dorsum of each lobe, 40.3 ± 3.8 (33–46) µm long (Fig. 5B); one flagellate seta on venter of each lobe, 51.1 ± 5.8 (40–57) µm long (Fig. 5C), the flagellate seta is longer than the blunt setae.

Dorsum: Ostioles, both anterior and posterior, are visible but unsclerotised, lips not projected, without setae or trilocular pores, aperture of 24–29 µm long. **Anal ring** 32 ± 07 (31–33) [32] µm transversal diameter (Fig. 4A), with six flagellate setae of 46 ± 5.3 (33–59) µm long; external cell row numbering 9–12 [not counted] cells, narrow and elongated, with spicules; inner row numbering 10 [not counted] cells, elongated, mostly subtriangular with sinuous edges; space between internal and external rows less than an external cell. **Tritubular ducts** on dorsum of 6.8 ± 0.9 (5–8) µm wide and 8.6 ± 0.7 (7–10) µm long (Figs 4B, 5D); tubules protruding from cuticle about one third of its length, each tubule 8–9 µm long 2–4 µm wide; distribution on head and thorax in marginal, lateral and medial areas, on abdomen as transversal rows along each segment;

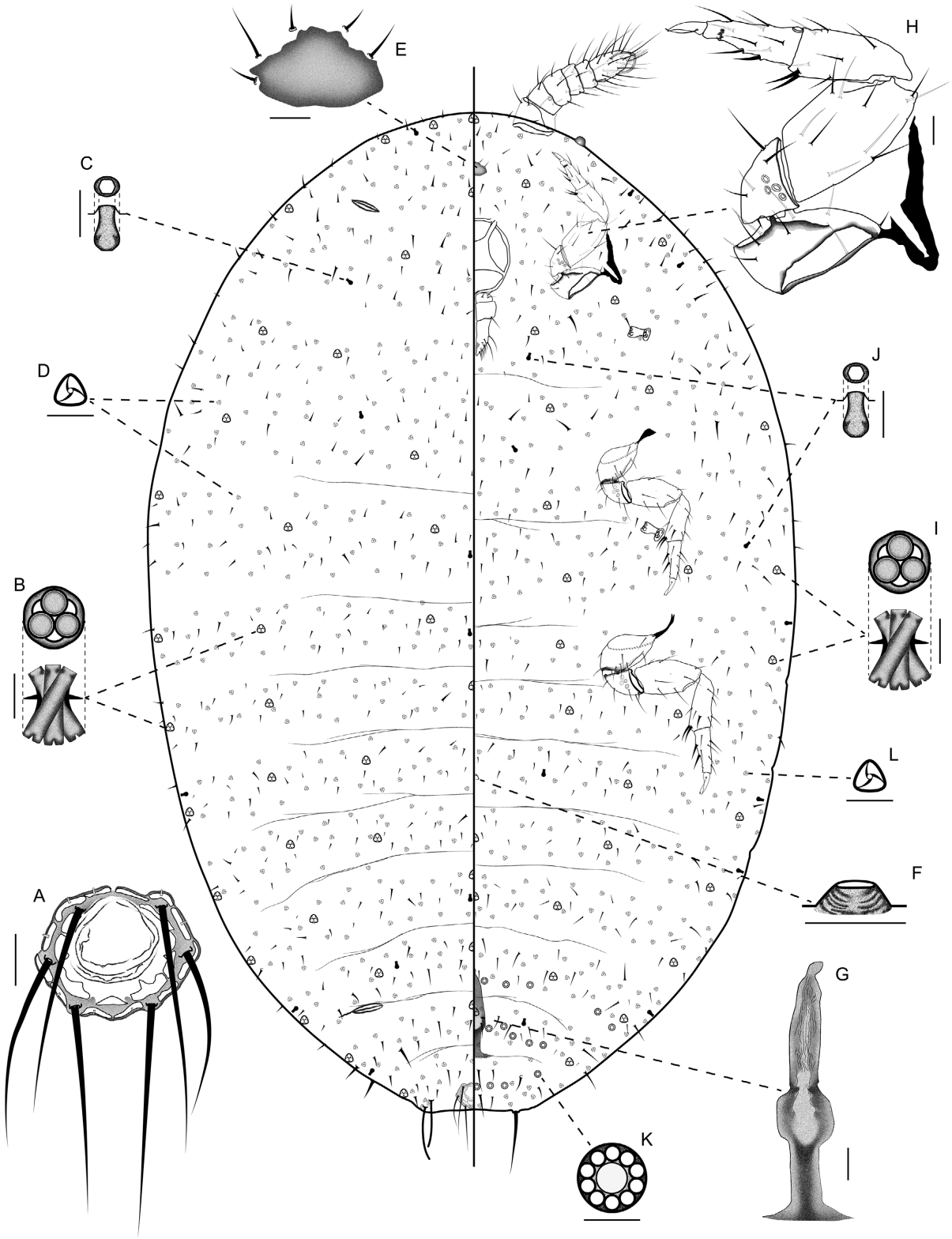

Fig. 4. Taxonomic illustration of *Rhizoecus franconiae* with body divided in dorsum (left side) and venter (right side). A – anal ring, B – Ddorsal tritubular duct, C – dorsal tubular duct, D – trilocular pore, E – cephalic plate, F – circulus, G – genital chamber, H – anterior leg, I – ventral tritubular duct, J – ventral tubular duct, K – multilocular disc pore, L – trilocular pore. Scale bars: A, E, G, H = 10 µm; B–D, F, I–L = 5 µm.

number per segment detailed in Table 2. **Tubular ducts** numbering 11.8 ± 5.3 (5–16) on whole body, each duct 4–6 µm long, slightly protruding from cuticle, with the external section narrower than the internal section, each section of 2 µm and 3 µm respectively (Figs 4C, 5E); dorsum with 5.2 ± 2.8 (2–9) [9] ducts, without defined symmetrical pattern but usually on submarginal, lateral or medial areas, numbering 0–1 [1] on head, 0–3 [0] on thorax, 0–2 [2] on each abdominal segment I and II, 0–1 [1] on segment III, absent on segment IV, 0–1 [0] on segments V, 0–1 [1] on

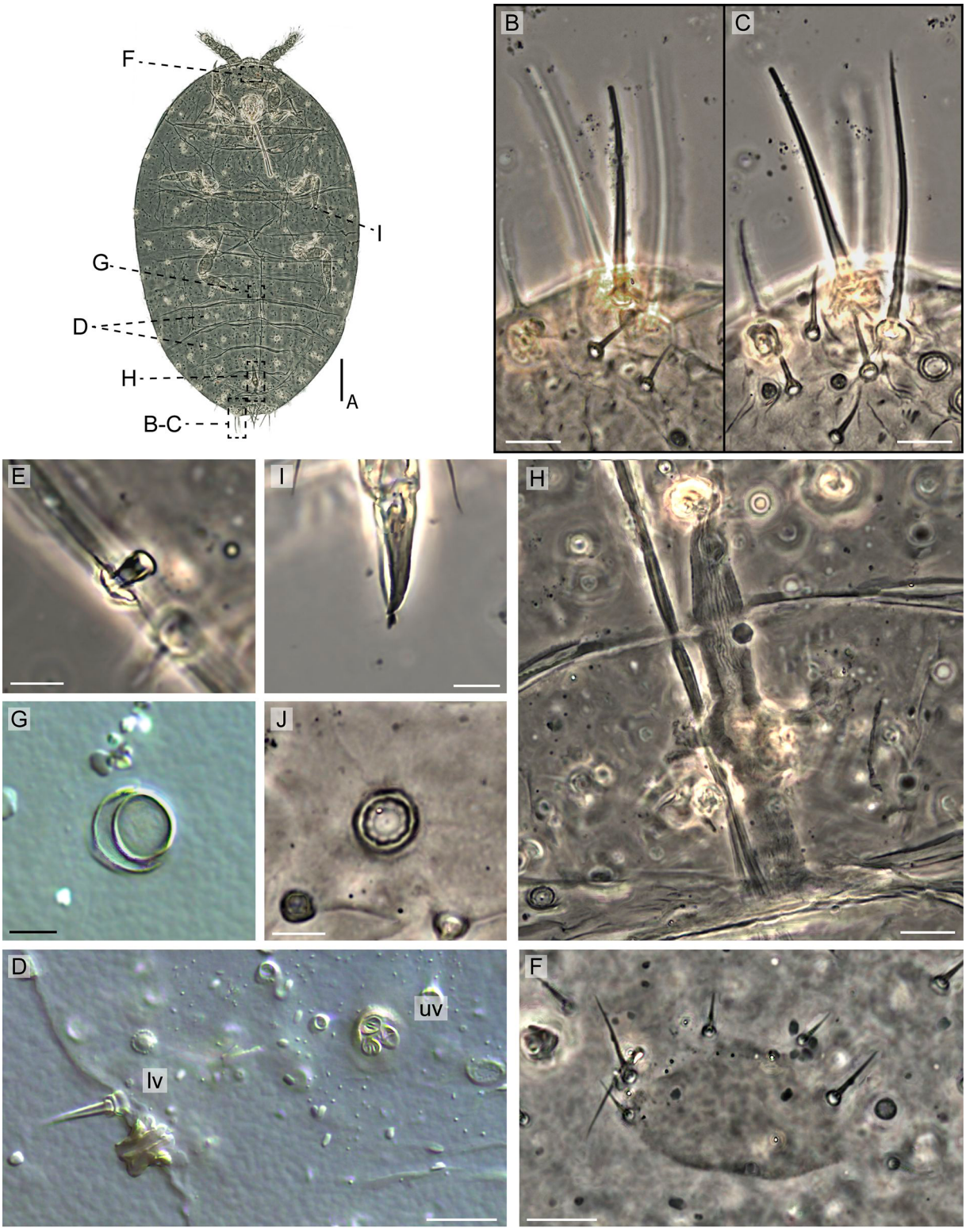

Fig. 5. Microphotographs of anatomical structures from *Rhizoecus franconiae,* slide-mounted adult female. A – body, B – dorsal surface of anal lobe, C – ventral surface of anal lobe, D – tritubular ducts on upper view (uv) and lateral view (lv), E – tubular duct in lateral view, F – cephalic plate, G – circulus, H – genital chamber, I – claw of hind leg, J – multilocular disc pore. Scale bars: A = 100 µm; B–D, F, H = 10 µm; E, G, I, J = 5 µm.

segment VI, 0–2 [2] on segment VII and absent on segment VIII, totalling 3.2 ± 2.9 (1–8) [8] on abdomen. **Multilocular pores** absent. **Trilocular pores** 3 µm wide (Fig. 4D), evenly distributed throughout the surface. **Microtrichia** present on the dorsum on thorax and abdomen and abundant on the last two abdominal segments. **Body setae** flagellate, dorsal setae 10–40 µm long, the longest setae >25 µm long present as a small group in the median area of the head and singly along the margin of the posterior abdominal segments.

Venter: Antenna with six segments, total length 121.9 ± 8.7 (112–136) [121] µm; length segment I 26.5 ± 2.1 (23–29) [27] µm, segment II 17.6 ± 3.6 (13–23)[20] µm, segment III 18.6 ± 1.8 (16–22) [17] µm, segment IV 12.5 ± 2 (9–16) [11] µm, segment V 12.1 ± 1.2 (10–14) [12] µm, segment VI 34.5 ± 1.7 (33–38) [34] µm. Chaetotaxy as follows (Fig. 10B): segment I with four flagellate setae, segment II with three flagellate setae and one placoid sensillum, segment III to V with five flagellate setae, additionally segment V present one fleshy seta of 12–15 µm long, segment VI with 20–21 flagellate setae plus three falcate sensilla of 23–31 µm long and one erected sensillum of 17–22 µm. **Eyes** are always present, with a diameter of 8–11 µm. **Cephalic plate** (Figs 4E, 5F), present in 2 out of 8 studied specimens, 19–26 µm long and 31–37 µm at the widest point, with 3–5 flagellate setae located on the borders of the plate; no vacuoles were observed. **Tentorium** oval, 67 ± 4.3 (59–72) [66] µm long. **Labium** 47.4 ± 3.9 (42–55) [45] µm long and 40 ± 4.2 (33–47) [43] µm wide, basal segment membranous, with six flagellate setae, medial segment sclerotised with two flagellate setae, apical segment sclerotised with 16 flagellate setae. **Spiracles**, anterior and posterior pairs of similar size, 22 ± 2.2 (18–25) µm long and diameter of peritreme 11 ± 1.1 (9–13) µm. **Circulus** dome-shaped, located near to the posterior margin of abdominal segment III, basal diameter 7.8 ± 1.4 (5–9) [5] µm, apical diameter 2 µm (Figs 4F, 5G). **Genital chamber** present in 6 out of 8 studied specimens, 71.3 ± 16 (42–88) [79] µm long, basal section with bell-shaped and posterior section with parallel borders (Figs 4G, 5H). **Anterior leg** 165.3 ± 7.3 (153–174) µm (Fig. 4H); length and chaetotaxy per segment as follow: coxa 27 ± 2.9 (22–31) µm long and 39.4 ± 5.8 (29–47) µm wide, with 8–9 flagellate setae; trochanter (52–61) µm long and 30.1 ± 3.4 (26–36) µm wide, with 8–10 flagellate setae; trochanter + femur 75.1 ± 4.6 (69–81) µm long; tibia 41.8 ± 2.4 (38–46) µm long and 16.5 ± 1.4 (15–19) µm in the widest section, with 5–6 flagellate setae plus two spine-like setae located in the internal distal margin; tarsus 35.6 ± 1.4 (34–38) µm long, with 7–8 flagellate setae plus one spine-like setae and one placoid sensillum; tibia + tarsus length 76.7 ± 3.4 (73–82) µm; claw 14.6 ± 1.9 (12–18) µm, with flagellate capitate digitule 12.1 ± 0.9 (11–13) µm, reaching the tip of the claw. **Medial leg** 155.7 ± 11 (141–167) µm; length and chaetotaxy per segment as follow: coxa 27.5 ± 3.5 (22–32) µm long and 34.3 ± 3 (29–38) µm wide, with 9–11 flagellate setae; trochanter 19.8 ± 2.7 (15–23) µm long and 22.6 ± 2.9 (18–26) µm wide, with 4–6 flagellate setae; femur 52.6 ± 2.7 (49–56) µm long and 27.8 ± 3 (25–33) µm wide, with 6–11 flagellate setae; trochanter + femur length 70.9 ± 4.3 (65–77) µm; tibia 38.9 ± 1.7 (36–41) µm long and 15.8 ± 2.3 (13–20) µm in the widest section, with 5–7 flagellate setae and three preapical spine-like setae; tarsus 33.4 ± 2.1 (30–36) µm long, with 5–6 flagellate setae plus 2–3 spine-like setae and one placoid sensillum; tibia + tarsus length 71.7 ± 4.3 (66–76) µm; claw 15.1 ± 1.3 (13–17) µm long, with flagellate capitate digitule 12.6 ± 1.3 (11–15) [21] µm long, reaching the tip of the claw (Fig. 5I). **Posterior leg** 185 ± 9.9 (171–195) µm long; length and chaetotaxy per segment as follow: coxa 28.7 ± 3.4 (24–34) µm long and 38.5 ± 4.4 (35–48) µm wide, with 9–10 flagellate setae; trochanter 20.8 ± 1.8 (18–23) µm long and 21.9 ± 2.4 (18–25) µm wide, with 4–6 flagellate setae; femur 59 ± 3.6 (54–64) µm long and 30.1 ± 3 (26–35) µm wide, with 6–8 flagellate setae; trochanter + femur length 78.8 ± 4.6 (73–85) µm; tibia 51.8 ± 3.6 (48–58) µm long and 16.1 ± 2 (14–20) µm in the widest section, with 5–6 flagellate setae and three spine-like setae; tarsus 40 ± 2.4 (36–43) µm, with 5–6 flagellate setae plus two spine-like setae and one placoid sensillum; tibia + tarsus length 90.4 ± 4.5 (84–98) µm; claw 16 ± 2.3 (13–19) µm long, with flagellate capitate digitule 13 ± 0.7 (12–14) µm long, reaching the tip of the claw.

Tritubular ducts 6.1 ± 0.8 (5–8) µm wide and 8.2 ± 1.2 (6–9) µm long, ducts without accompanying setae nor pores (Fig. 4I); tubules protruding from cuticle about one third of its length, each tubule 8–9 µm long 2–4 µm wide; dorsal distribution on head and thorax in marginal, lateral and medial areas, on abdomen as transversal rows along each segment; ventral distribution similar to dorsum but absent on abdominal segment VIII; number per segment and surface detailed in Table 2. **Tubular ducts** with similar size to those on dorsum (Fig. 4J); venter with 6.4 ± 4.2 (2–12) [2] ducts, without symmetrical distribution but usually on marginal or lateral areas, numbering 0 [0] on head, 0–2 [0] on thorax, 0–2 [1] on each abdominal segment I, 0–2 [0] on each segment II to VI, 0–2 [1] on segment VII, and absent on segment VIII, totalling 5.4 ± 3.8 (1–10) [2] on abdomen. **Multilocular pores** of 5–7 µm wide (Figs 4K, 5J), restricted to abdominal segments VI to VIII, numbering 10.5 ± 2.1 (6–13) [11] on segment VI, 10.4 ± 2.4 (7–14) [11] on segment VII, 7.8 ± 0.9 (6–9) [8] on segment VIII, totalling 28.6 ± 4.3 (22–36) [30]. **Trilocular pores** similar in size and distribution to dorsal pores (Fig. 4L). **Microtrichia** with a similar distribution to the dorsum. **Body setae** flagellate, slightly longer than dorsal setae, 15–54 µm long, the largest setae are distributed as the dorsal setae.

Comments

This species is quite distinguishable from other species recorded from Germany. The closest species are *Rh. nemoralis* and *Rh. dianthi* by the presence of multilocular disc pores, but *Rh. franconiae* presents tubular ducts on the dorsum and venter, presents a circulus, and has two spur-like setae in the internal distal margin of the tibia. In contrast, *Rh. nemoralis* lacks circulus, and the setae in the internal distal margin are flagellate. Those same characters apply to *Rh. dianthi*, plus the lack of tubular ducts.

Material examined. Lectotype, ♀ adult, GERMANY: Bavaria, Erlangen, Bubenreuth, ex *Pilosella officinarum* (Asteraceae), 16.viii.1949–1.ix.1949, H. Schmutterer leg., (SDEI). The specimen shares the slide with another specimen; the lectotype is located on the bottom-left side of the glass, marked with the letter A. Paralectotypes, GERMANY: 3♀, adults, Bavaria, same collection data as for lectotype; one of the specimens shares slide with the lectotype and is located in the upper right side of the glass, marked with the letter B, (SDEI); 1♀ adult, same collec-

tion data as for lectotype except for host, ex *Achillea millefolium* L., 1753 (Asteraceae), (SDEI); 1♀ adult, same collection data as for lectotype, ex roots of *Achillea* L., 1753 / *Tanacetum* L., 1753 / *Hieracium* L., 1753 (Asteraceae), (SDEI).

Additional material. GERMANY: 2♀, adults, Bavaria, surroundings of Lake Obersee near Berchtesgaden, ex roots of undetermined species of Poaceae, 12.viii.1954, H. Schmutterer leg., (SDEI).

Rhizoecus simplex (Hambleton, 1946)

Figs 6 and 7

Ripersiella simplex Hambleton, 1946: 73.
Rhizoecus simplex (Hambleton, 1946); (Hambleton, 1973): 69. Change of combination.

Morphological redescription

Slide-mounted adult female (n = 10; 9 German specimens + Lectotype). **Body** oval-elongated, 1.2 ± 0.1 (0.97–1.3) [1.2] mm long and 0.5 ± 0.1 (0.4–0.6) [0.5] mm wide (Figs 6, 7A). **Anal lobes** not developed, without sclerotisation; dorsal surface with one flagellate seta on each lobe, 27.7 ± 5.3 (14–32) µm long, without associated trilocular pores; ventral surface with two flagellate setae on each lobe, the longest seta with 40.9 ± 2.5 (34–43) µm long, shortest seta 28 ± 3.3 (23–33) µm long.

Dorsum: Ostioles anterior are less evident than posterior, both unsclerotised, with lips not projecting, aperture of 37.4 ± 6.2 (27–47) µm wide, without flagellate setae or trilocular pores over the lips. **Anal ring** 44.6 ± 2.6 (42–49) [42] µm transversal diameter (Figs 6A, 7B), with six flagellate setae of 53.7 ± 4.3 (45–62) µm long, longer than the anal ring diameter; external row numbering 18.8 ± 1.5 (17–22) [18] cells, with short spicules at least on lateral cells; inner row numbering 11.9 ± 1.1 (11–14) [not fully visible] cells, larger than the external cells, mostly subtriangular with sinuous edges. **Tritubular ducts** of one size 4.6 ± 0.6 (4–6) µm wide and 6.9 ± 0.5 (5–8) µm long (Figs 6B, 7C), without accompanying setae; tubules protruding from cuticle about half of its length, each one 7 µm long and 1 µm wide in the narrowest part; dorsal distribution usually symmetric on margin, lateral and medial areas as transversal rows on each segment; number per segment and surface detailed in Table 2. **Tubular ducts** 4 µm long and 2 µm wide, not projecting from the cuticle (Figs 6C, 7D); 3–5 on most of the segments, absent on head, 14 on thorax, and 3–5 in each abdominal segment, distributed without pattern, around 40 ducts along the surface. **Multilocular disc pores** absent**. Trilocular pores** 3 µm wide, evenly distributed along the surface (Fig. 6D). **Microtrichia** present on abdomen, more abundant in the last two segments. **Body setae** flagellate, 7–21 µm long, the longest setae present singly along the margin of the posterior abdominal segments.

Venter: Antenna with six segments (Fig. 7E), total length 127.6 ± 6.8 (116–139) µm; segment I 29.3 ± 2.4 (26–32) µm long and 34 ± 2.6 (30–38) µm wide, segment II 17.1 ± 1.1 (15–19) µm long and 21.3 ± 2.2 (19–25) µm wide, segment III 23.7 ± 3.3 (18–28) µm long and 19.6 ± 2.1 (17–23) µm wide, segment IV 16 ± 2.5 (10–19) µm long and 17.8 ± 2.3 (14–21) µm wide, segment V 15.1 ± 1.6 (11–17) µm long and 17.5 ± 1.9 (16–23) µm wide, segment VI 35.5 ± 2.2 (30–38) µm long and 18.8 ± 1 (18–21) µm wide. Chaetotaxy as follow (Fig. 10C): segment I with four flagellate setae, segment II with three flagellate setae and one placoid sensillum, segment III with 7–12 flagellate setae arranged in two rows, segment IV with five flagellate setae, segment V with 5 flagellate setae and one falcate sensillum seta of 15 ± 1.1 (13–17) µm long, segment VI with 17–19 flagellate setae, one or two short setae 5–7 µm long, basal falcate sensillum with 29.7 ± 2.1 (25–33) µm long, medial and subapical falcate sensilla with 24 ± 2.1 (19–27) µm long and an apical erect sensillum 16.6 ± 1.3 (14–18) µm long. **Eyes** always present, diameter 7.1 ± 0.6 (6–8) µm. **Cephalic plate** visible in 3 out of 7 specimens, 32.3 ± 6.6 (27–40) [31] µm long and 38.3 ± 6.4 (32–45) [38] µm wide, with 4–6 flagellate setae usually in the margins of the plate, and two discal oval vacuoles (Figs 6E, 7F). **Clypeolabral shield** oval, larger than labium, 75 ± 4.1 (66–79) [66] µm long. **Labium** with 52.1 ± 4.4 (45–58) [45] µm long and 37 ± 3.8 (30–42) [no data] µm wide; basal segment membranous, with six setae; medial segment sclerotised, 18.1 ± 2 (15–21) [15] µm long, with two flagellate setae; apical segment sclerotised, 34.4 ± 2.3 (30–38) [30] µm long, with 18 flagellate setae. **Spiracles** both anterior and posterior with similar size, 21.3 ± 1.6 (19–24) µm long and peritreme 10.1 ± 0.6 (9–11) µm wide. **Circulus** conical, apex truncated and papilliform, located in posterior margin of abdominal segment III, basal diameter 13.8 ± 1.5 (11–16) [12] µm, apical diameter 5.2 ± 0.7 (4–6) [5] µm (Fig. 7G). **Genital chamber** presents only in one specimen, not visible in holotype, 75 µm long; the basal third shaped as bell, 25 µm long and 15 µm wide, the remaining two thirds with parallel borders, 50 µm long and 5 µm wide (Figs 6F, 7H).

Anterior leg 179 ± 15.9 (143–192) µm (Fig. 6G). Length and chaetotaxy per segment as follow: coxa 24.8 ± 3.3 (18–28) µm long and 45.5 ± 3.2 (40–50) µm wide, with 7–10 flagellate setae; trochanter 20.6 ± 2.1 (19–25) µm long and 24.1 ± 3.7 (16–29) µm wide, with 4–5 setae and one placoid sensillum 4–5 µm wide; femur 65 ± 3.6 (58–69) µm long and 31.8 ± 2.3 (27–34) µm wide, with 7–10 flagellate setae; trochanter + femur length 85.3 ± 4.2 (79–91) µm; tibia 46.1 ± 3 (40–51) µm long and 15.3 ± 0.8 (14–16) µm wide, with seven flagellate setae and two preapical spine-like setae; tarsus 38.8 ± 3.3 (31–42) µm long, with 6–7 flagellate setae, two spine-like setae and one placoid sensillum of 4 µm wide; tibia + tarsus length 85.8 ± 3.8 (80–93) µm; claw 15.4 ± 0.7 (14–16) µm, with two capitate digitule 11.9 ± 1 (10–13) µm long, as long as the claw. **Middle leg** 166.5 ± 13.2 (133–180) µm. Length and chaetotaxy per segment as follow: coxa 26.4 ± 3.4 (22–31) µm long and 43.7 ± 3.5 (39–49) µm wide, with 9–11 flagellate setae; trochanter 20.9 ± 2.3 (16–24) µm long and 24.7 ± 1.8 (22–27) µm wide, with five flagellate setae and one placoid sensillum 4 µm wide; femur 59.4 ± 3.9 (51–65) µm long and 29.7 ± 2.6 (25–34) µm wide, with 5–8 flagellate setae; trochanter + femur length 79.7 ± 5 (72–88) µm; tibia 42 ± 2.9 (36–46) µm long and 16.4 ± 2 (14–20) µm

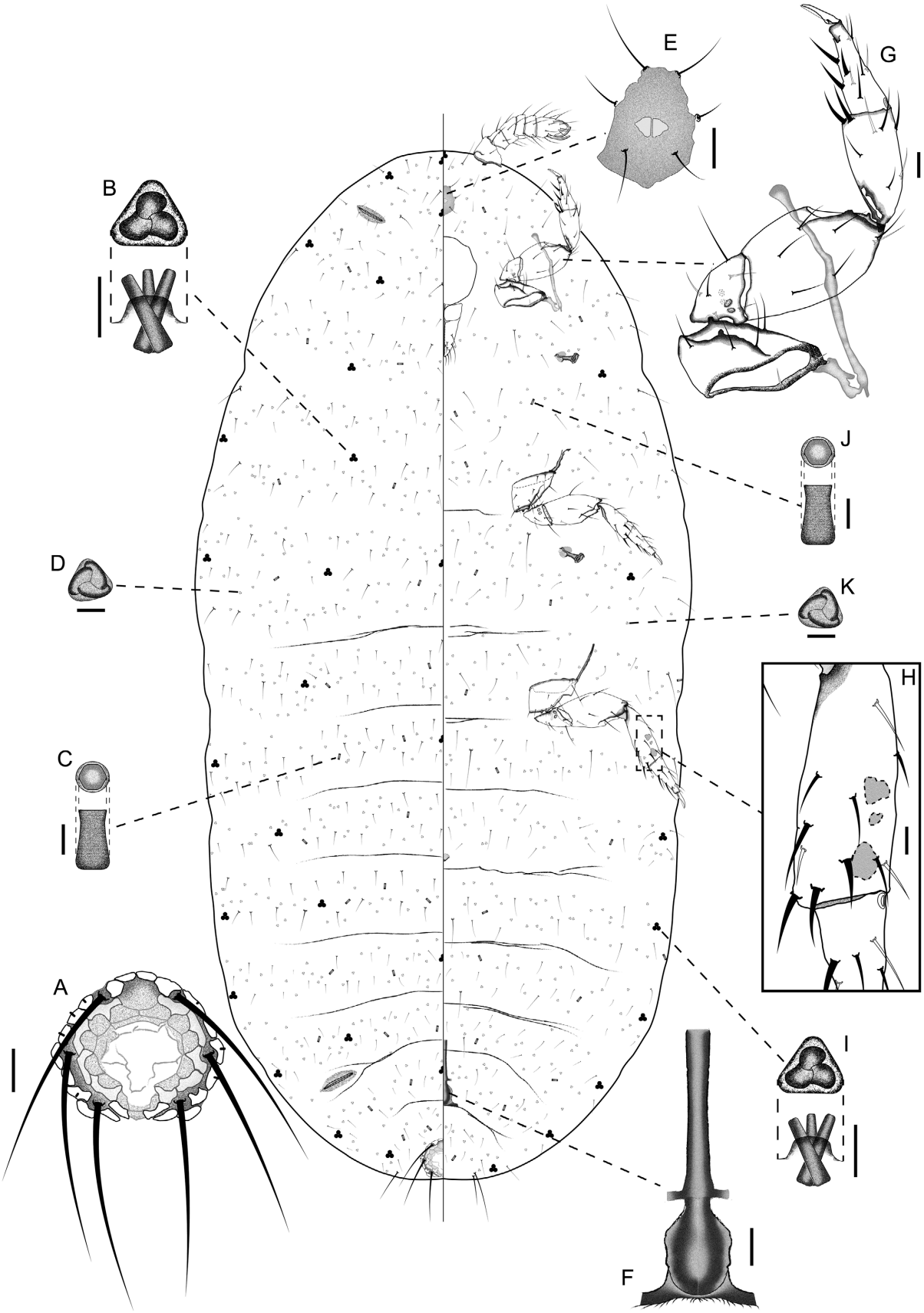

Fig. 6. Taxonomic illustration of *Rhizoecus simplex* with body divided as dorsum (left side) and venter (right side). A – anal ring, B – dorsal tritubular duct, C – dorsal tubular duct, D – dorsal trilocular pore, E – cephalic plate with central vacuoles, F – genital chamber, G – anterior leg, H – hind tibia with macules, I – ventral tritubular duct, J – ventral tubular duct, K – ventral trilocular pore. Scale bars: A, E–H = 10 μm; B, I = 5 μm; C, D, J, K = 2 μm.

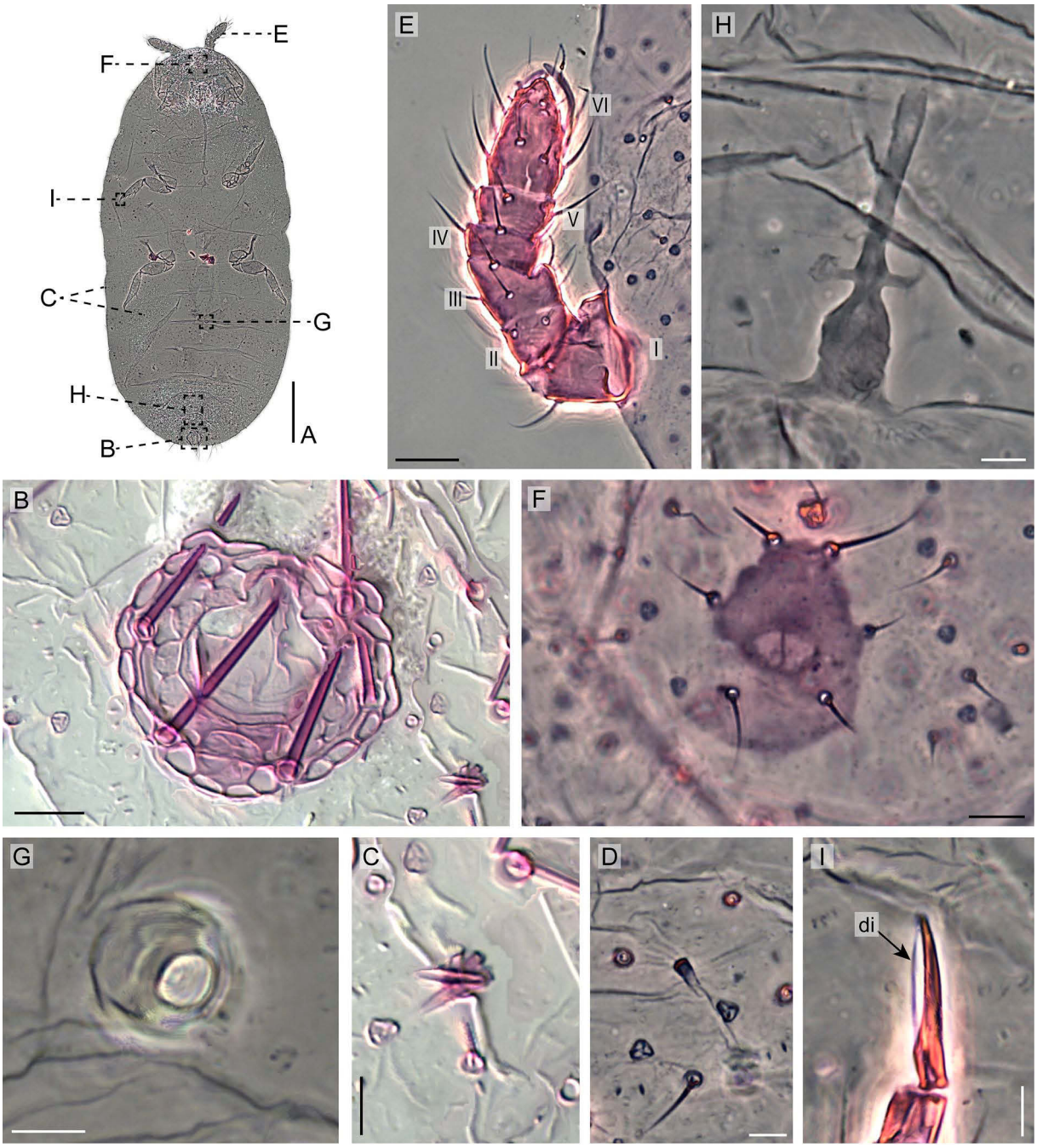

Fig. 7. Microphotographs of anatomical structures from *Rhizoecus simplex,* slide-mounted adult female. A – body, B – anal ring, C – tritubular duct, D – tubular duct, E – antenna with segments indicated by roman numerals, F – cephalic plate with central vacuoles, G – circulus, H – genital chamber, I – claw of hind leg with digitule (di). Scale bars: A = 100 µm; B, F, H = 10 µm; C, D, G, I = 5 µm; E = 20 µm.

wide, with six flagellate setae and three preapical spine-like setae; tarsus 36.1 ± 2.2 (31–39) µm long, with six flagellate setae, two spine-like setae and one placoid sensillum of 4 µm wide; tibia + tarsus length 79.5 ± 4.6 (73–88) µm; claw 15.1 ± 1.3 (13–18) µm, with two capitate digitule 11.7 ± 0.7 (10–13) µm long, as long as the claw (Fig. 7I). **Hind leg** 201 ± 18.7 (163–217) µm. Length and chaetotaxy per segment as follow: coxa 27.1 ± 2.1 (25–30) µm long and 44.6 ± 3.5 (41–50) µm wide, with 8–10 flagellate setae; trochanter 23.6 ± 2.2 (22–29) µm long and 22.4 ± 3.9 (14–27) µm wide, with five flagellate setae and one placoid sensillum 4 µm wide; femur 67.3 ± 7.7 (51–75) µm long and 31.8 ± 2.8 (26–35) µm wide, with seven flagellate setae; trochanter + femur length 92.2 ± 3.4 (88–97) µm; tibia 60.1 ± 5.5 (51–67) µm long and 17.7 ± 2 (13–20) µm wide, with 7–8 flagellate setae, three preapical spine-like setae, and some specimens with one or two macules (Fig. 6H); tarsus 40.5 ± 2.5 (35–43) µm long, with five flagellate setae, two spine-like setae and one placoid sensillum of 4 µm wide; tibia + tarsus length 102.1 ± 5.7 (89–107) µm; claw 17.1 ± 1.1 (16–19) µm long, with digitules 12.4 ± 1.1 (11–14) µm long, as long as the claw, flagellate with capitated apex.

Tritubular ducts of one size 4.4 ± 0.4 (4–5) µm wide and 6.7 ± 0.3 (6–7) µm long (Fig. 6I), without accompany-

ing setae; tubules protruding from cuticle about half of its length, each one 7 µm long and 1 µm wide in the narrowest part; dorsal distribution usually symmetric on margin, lateral and medial areas as transversal rows on each segment; ventral distribution restricted to marginal or submarginal areas with a few exceptions on medial area of mesothorax, absent on abdominal segment I; number per segment and surface detailed in Table 2. **Tubular ducts** similar in size and shape to dorsal ducts (Fig. 6J); 0–1 on head, 11 on thorax, 2–4 on each abdominal segment, totalling around 33 along the surface. **Multilocular disc pores** absent**. Trilocular** pores 3 µm wide, evenly distributed on dorsum (Fig. 6K). **Microtrichia** are present along the metathorax and abdomen and are more abundant in the last abdominal segments. **Body setae** flagellate, similar in length and distribution to the dorsal setae.

Comments

Morphologically, *Rh. simplex* is similar to *Rh. cacticans* by having long capitate digitules, the presence of circulus, and a similar number and distribution of tritubular ducts. However, *Rh. simplex* differs from *Rh. cacticans* by having an anal ring with fewer than 20 cells in the external row and a diameter less than 50 µm, and the length of the labium is shorter than 60 µm. In contrast, *Rh. cacticans* has an anal ring with more than 25 cells in the external row and a diameter larger than 50 µm; the length of the labium is also larger than 60 µm. The molecular analysis shows a single cluster for the morphologically identified specimens, and a specimen lost during the molecular process (ZSM250). That sample has only *Rh. simplex* specimens, and we assume the cluster is composed of a single species. The genetic distance between *Rh. simplex* specimens and the nearest species, *Rh. cacticans*, is 5.5% for ZSM491, 5.9% for ZSM167 and 7.9% for ZSM479.

Material examined. Lectotype, ♀ adult, BRAZIL: Sao Paulo, ex roots of *Oxalis debilis* Kunth, 1822 (Oxalydaceae), 10.iv.1935, B.L. Ribeiro & E.J. Hambleton leg., (USNM).

Additional material. GERMANY: 1♀, adult, Bavaria, Munich, Botanischer Garten, 48.16267°N 11.50219°E, 515 m, 10.xi.2023, ex roots of *Pelargonium hermanniifolium* (Geraniaceae), A. Caballero leg. (SNSB-ZSM); 3♀ adult, Hessen, Frankfurt am Main, Palmengarten, 50.12375°N 8.65739°E, 111 m, ex roots of *Begonia maestrensis* Urb., 1925 (Begoniaceae), 17.i.2024, A. Caballero leg., (SNSB-ZSM); 5♀ adults, same collection data as for preceding, ex roots of *Begonia cardiocarpa* Liebm., 1852 (Begoniaceae), A. Caballero leg., (SNSB-ZSM).

Ripersiella caesii (Schmutterer, 1956)

Figs 8 and 9

Rhizoecus caesii (Schmutterer, 1956): 516.
Ripersiella caesii (Schmutterer, 1956); (Tang, 1992): 65. Change of combination.
Rhizoecus caesii Schmutterer, 1956; (Ben-Dov, 1994): 447. Revived combination.
Ripersiella caesii (Schmutterer, 1956); (Kozár & Konczné Benedicty, 2003): 236. Revived combination.

Nomenclatural correction

The original description does not explicitly mention a holotype, as specified in Chapter 4, Article 16.4 of the International Code of Zoological Nomenclature (ICZN, 1999). There are 18 slides in the SDEI collection, but only one matches the collection and publication dates (collection data: 19.v.1955). Therefore, the type material consists of a single specimen, which we designate as the Lectotype, as it is the sole representative of the original species description.

Morphological redescription

Slide-mounted adult female (n = 7). **Body** oval-elongated, 1.7 ± 0.4 (1.3–2.5) [1.3] mm long and 1.0 ± 0.4 (0.7–1.6) [0.7] mm wide (Figs 8, 9A). **Anal lobes** slightly developed; dorsal surface with three flagellate setae on each lobe, with three sizes, shorter size 37.2 ± 5.8 (31–44) µm long, mid-size 49.8 ± 8.7 (35–58), longest size 58.8 ± 6.7 (50–67), only one associated trilocular pore; ventral surface without setae.

Dorsum: Ostioles, both anterior and posterior, are barely visible, with lips not projected, unsclerotised, anterior ostioles 27–35 µm wide, 0–2 flagellate setae and 0–2 trilocular pores associated with lips. **Anal ring** with 52 ± 3.5 (48–56) [49] µm transversal diameter (Figs 8A, B), with six flagellate setae, each 68.2 ± 8.1 (57–89) µm long; external cell row with 13–18 [14] cells, narrow rectangular in shape, most cells with thick spicules 2–4 µm long; inner row with 10–13 [12] cells, elongated, irregular shaped; space between external and internal rows similar to width of an external cell. **Bitubular ducts** of one size 4 ± 0.4 (3–5) µm wide and 8.5 ± 0.5 (8–9) µm long, without accompanying setae nor pores; tubules protruding from cuticle about two third of its length (Figs 8B, 9C), each tubule 9 µm long and 1 µm wide; ducts distributed as transversal rows in most of the segments, numbers detailed in Table 2. **Tubular ducts** numbering 47.3 ± 6.8 (41–57) [45] on whole body, 4–5 µm long and 2–3 µm wide, protruding from cuticle about half of its length (Figs 8C, 9D); dorsum with 28.3 ± 8.6 (22–41) [25] ducts, distributed on marginal, lateral and medial areas without symmetrical arrangement, numbering 2.3 ± 0.5 (2–3) [2] ducts on submargin of head, 3.6 ± 0.5 (6–7) [6] ducts on margin and submargin of meso- and metathorax, 1–3 [2] on abdominal segment I, 0–3 [3] on segment II, 1–5 [3] on segment III, 3–5 [3] on segment IV, 1–4 [2] on segment V, 2–4 [2] on segments VI, 2–5 [2] on segment VII, 0–2 [0] on segment VIII, totalling 20.3 ± 7.2 (16–31) [17] ducts on abdomen. **Multilocular disc pores** numbering 296.8 ± 55.4 (224–368) [262] on whole body, each pore 6–7 µm wide, with 9–12 loculi (Figs 8D, 9E); dorsum with 113.8 ± 15.1 (96–132) [102] pores, numbering as 10.6 ± 3.9 (6–15) [7] pores on head, 67.8 ± 11.9 (55–78) [55] pores on thorax, 35.4 ± 9 (23–44) [40] on abdomen, distributed on each segment as follow: I 8–16 [10], II 13–18 [14], III 10–21 [10], IV 11–26 [11], V 15–30 [21], VI 8–23 [21], VII 15–26 [18], absent on VIII. **Trilocular pores** 3–4 µm wide (Fig. 8E), evenly distributed on the surface. **Body setae** evenly distributed, flagellate, dorsal setae of 13.9 ± 4.6 (7–25) µm long, the longest one on median, lateral and marginal areas; ventral setae evenly distributed, with 15.1 ± 5.8 (7–28) µm long, the longest setae on marginal and medial areas.

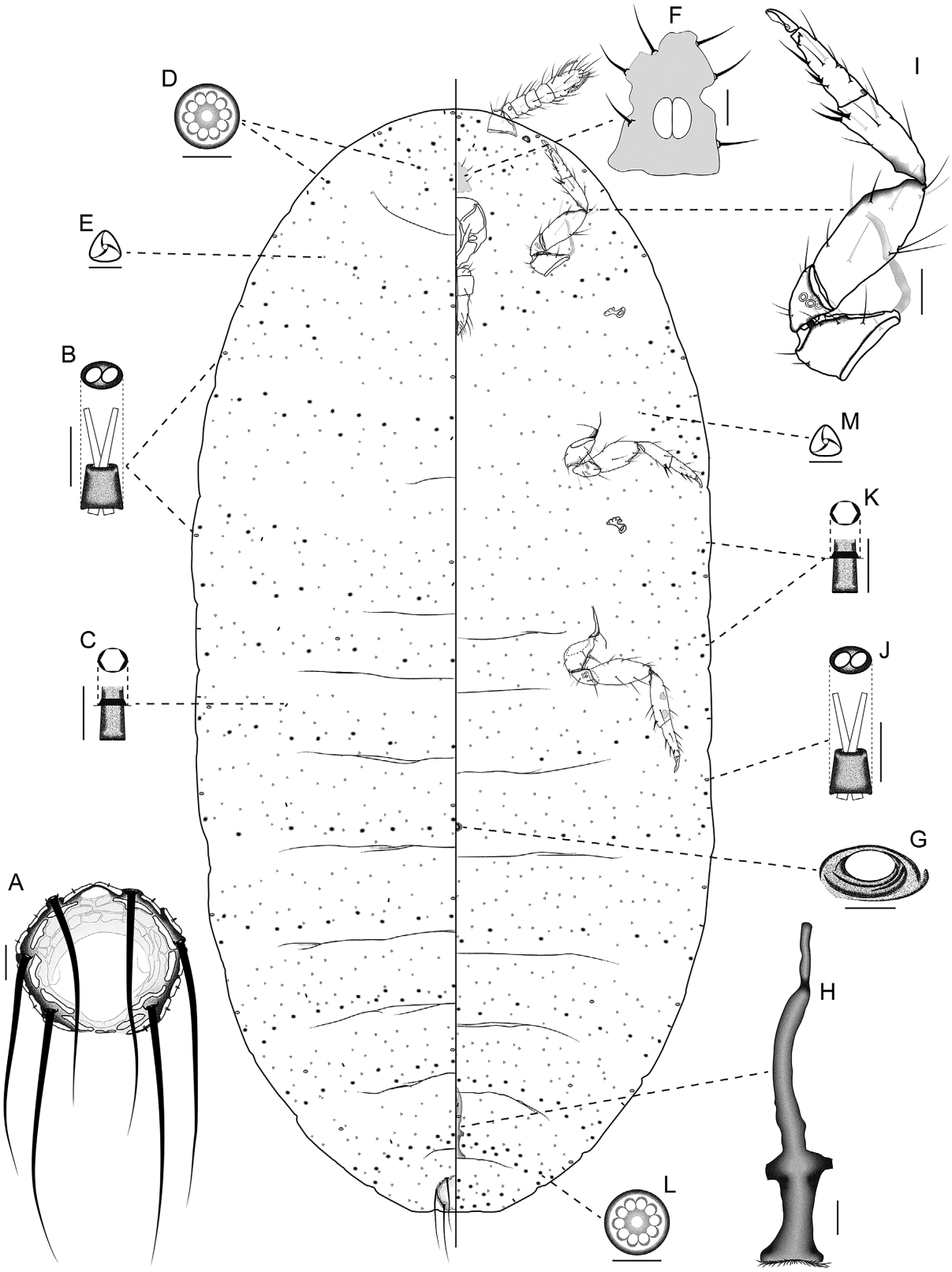

Fig. 8. Taxonomic illustration of *Ripersiella caesii* with body divided in dorsum (left side) and venter (right side). A – anal ring, B – dorsal bitubular duct, C – dorsal tubular duct, D – dorsal multilocular disc pore, F – cephalic plate with central vacuoles, G – circulus, H – genital chamber, I – anterior leg, J – ventral bitubular duct, K – ventral tubular duct, L – ventral multilocular disc pore. Scale bars: A, F–H = 10 µm; B–D, J–L = 5 µm; E, M = 3 µm; I = 20 µm.

Venter: Antenna with six segments (Fig. 9F), total length 137.8 ± 13.6 (120–161) [136] µm; length segment I 31.8 ± 2.9 (28–35) [28] µm, segment II 16 ± 1.8 (14–18) [14] µm, segment III 21.7 ± 4 (15–26) [23] µm, segment IV 15.3 ± 1.8 (15–26) [15] µm, segment V 14.5 ± 2.3 (11–17) [13] µm, segment VI 42.8 ± 2 (40–46) [42] µm. Chae-

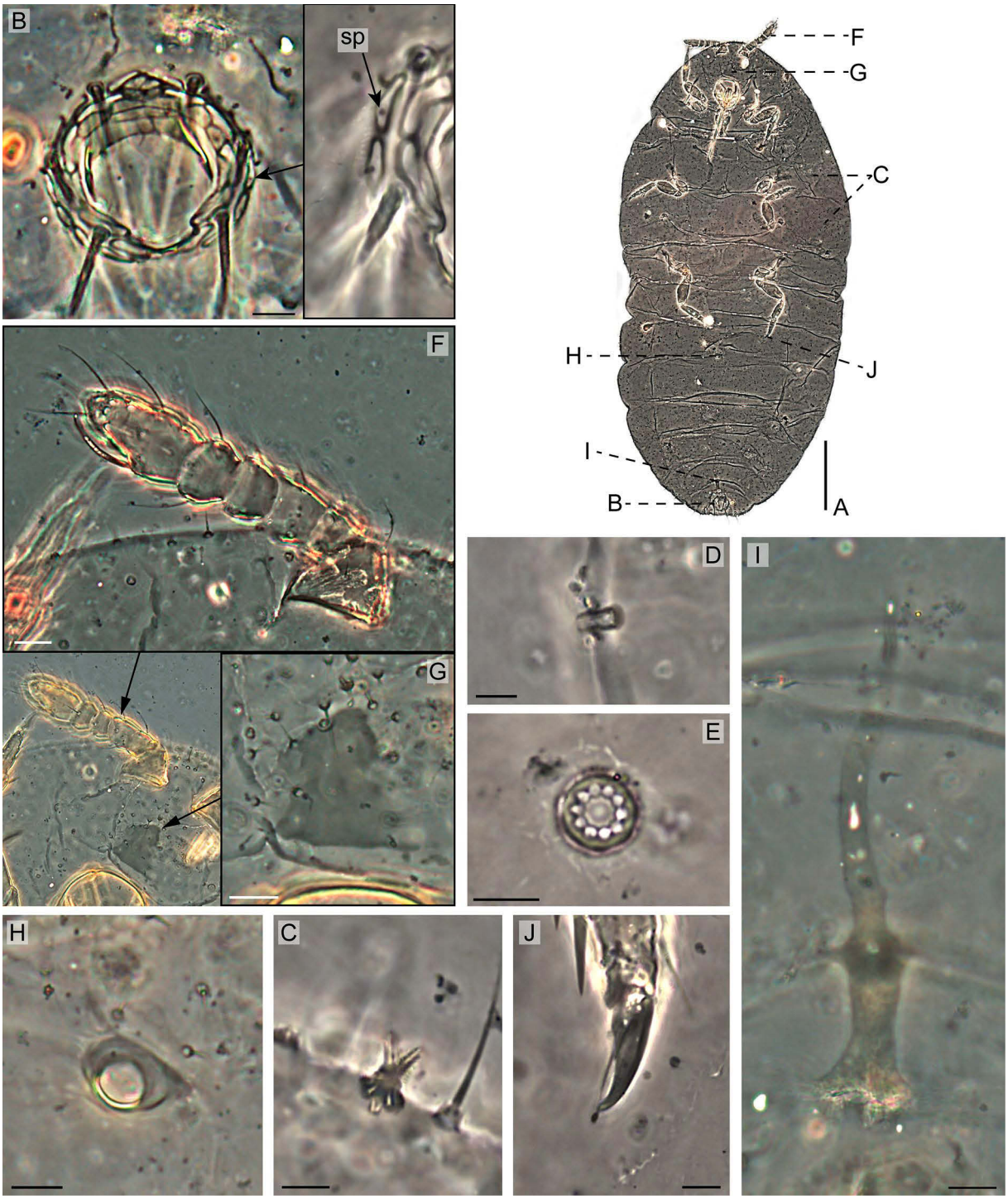

Fig. 9. Microphotographs of anatomical structures of *Ripersiella caesii*, slide-mounted adult female. A – body, B – anal ring with close-up of spicules (sp) on external row of cells, C – tritubular duct, D – tubular duct, E – multilocular disc pore, F – antenna, G – cephalic plate, H – circulus, I – genital chamber, J – claw of the hind leg. Scale bars: A = 200 µm; B, F–I = 10 µm; C–E, J = 5 µm.

totaxy as follow (Fig. 10D): segment I with four flagellate setae, segment II with three flagellate setae and one placoid sensillum, segment III with five or six setae arranged in two rows, segment IV with five flagellate setae, segment V with five flagellate setae and one falcate sensillum of 12–13 µm long, segment VI with 18 long flagellate setae, one short setae 4–6 µm long, three falcate sensilla 26–30 µm long and one erect sensillum with 18–21 µm long. **Eyes** present except on one specimen, diameter 6–8 µm. **Cephalic plate** (Figs 8F, 9G), usually present, 38.4 ± 6.6 (31–49) [38] µm long and 31.8 ± 7 (26–44) [29] µm in the widest section, with 3 to 5 flagellate setae in the borders and one or two oval, discal vacuoles. **Tentorium** oval, 89.5 ± 3.1 (87–94) [88] µm long. **Labium** with 66.7 ± 4.8 (58–72) [69] µm long and 45.5 ± 2.3 (43–49) [43] µm, basal segment membranous, with six setae, medial segment sclerotised with two setae, apical segment sclerotised with 18. **Spiracles**, anterior and posterior pairs with similar size, 24.5 ± 2.2

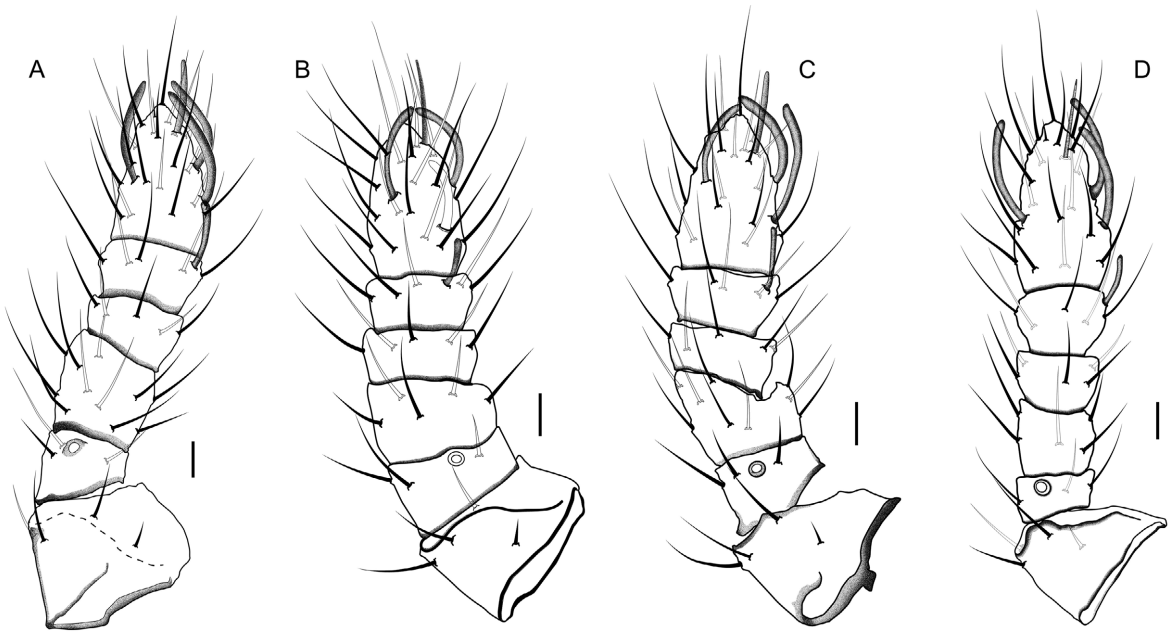

Fig. 10. Taxonomical illustrations of antennae, with detailed chaetotaxy. A – *Rhizoecus arabicus*, B – *Rhizoecus franconiae*, C – *Rhizoecus simplex*, D – *Ripersiella caesii*. Scale bar 10 µm.

(22–29) µm long and peritreme diameter 10.7 ± 1.5 (8–13) µm. **Circulus** dome-shaped, located near to the posterior margin of abdominal segment III, basal diameter 20.4 ± 6.5 (15–31) [20] µm, apical diameter 11.3 ± 2.8 (8–15) [10] µm (Figs 8G, 9H). **Genital chamber** present in 2 out of seven specimens, in holotype total length 110 µm long (Figs 8H, 9I).

Anterior leg 192 ± 6.3 (182–199) µm (Fig. 8I). Length and chaetotaxy per segment as follow: coxa 30.5 ± 7.1 (26–41) µm long and 36.2 ± 3.9 (30–40) µm wide, with 8–9 flagellate setae; trochanter 20.6 ± 0.9 (19–21) µm long and 23.8 ± 1.3 (22–25) µm wide, with 4 flagellate setae, one short erect seta and four placoid sensilla; femur 70.3 ± 6 (63–81) µm long and 29.5 ± 1 (28–31) µm wide, with 8–9 flagellate setae; trochanter + femur 88.2 ± 3.4 (83–92) µm long; tibia 46.4 ± 3 (42–50) µm long and 18 ± 0.7 (17–19) µm wide, with 6 flagellate setae and two spine-like setae in the internal distal area; tarsus length 41.8 ± 1.3 (41–44) µm, with 8 flagellate setae and one spine-like seta, plus one placoid sensillum; tibia + tarsus 87.2 ± 3.6 (81–90) µm long; claw 17.2 ± 1.3 (16–19) µm long, with two flagellate capitate digitules 13–15 µm long, reaching the tip of the claw. **Medial leg** 180.7 ± 8.7 (171–188) [143] µm, coxa 28 ± 3 (25–31) µm long and 36.6 ± 2.5 (33–40) µm wide, with 7–8 flagellate setae and 1–2 spine-like setae; trochanter 20 ± 0.8 (19–21) µm long and 21.8 ± 1.3 (20–23) µm wide, with 6–7 flagellate setae and one spine-like seta; femur 65 ± 3.2 (61–70) µm long and 30.3 ± 1 (29–31) µm wide, with 7–8 flagellate setae; trochanter + femur 85.6 ± 3.7 (81–91) µm long; tibia 47.2 ± 1.9 (44–49) µm long and 17.8 ± 0.8 (17–19) µm wide, with 6–7 flagellate setae and two spine-like setae in the internal margin; tarsus 39.8 ± 1.3 (38–41) µm long, with 5–6 flagellate setae and two spine-like setae, plus one placoid sensillum; tibia + tarsus 83.8 ± 3.6 (79–89) µm long; claw 17.7 ± 1.5 (16–19) µm long, with flagellate capitate digitules 13–14 µm long, reaching the tip of the claw. **Posterior leg** 227 ± 21.6 (203–260) µm long; coxa 31.2 ± 4.9 (26–36) long and 40.8 ± 4.1 (35–46) µm wide, with 7–9 flagellate setae and one or two shot erect setae; trochanter 24.5 ± 6.2 (20–36) µm long and 22 ± 1.1 (21–23) µm wide, with five or six flagellate setae and four placoid sensilla; femur 78.2 ± 7 (69–90) µm long and 32.3 ± 1.9 (30–35) µm wide, with 6–7 flagellate setae; trochanter + femur 100.3 ± 8.8 (89–115) µm long; tibia 70.5 ± 6.4 (63–82) µm long and 19.8 ± 0.8 (19–21) µm wide, with 6–7 flagellate setae and two spine-like setae in distal internal margin, with two macules present; tarsus 47.7 ± 2.3 (45–52) µm long, with 6–7 flagellate setae and one spine-like setae, plus one placoid sensillum; tibia + tarsus 113 ± 8.2 (104–128) µm long; claw 14.4 ± 1.1 (13–16) µm long, with flagellate capitate digitule 12–14 µm long, reaching the tip of the claw (Fig. 9J).

Bitubular ducts of similar size to those in dorsum (Fig. 8J); distributed as follows: central area of head, as transversal row between anterior coxa and anterior spiracle, as marginal clusters between anterior spiracle and abdominal segment I, and transversal rows between abdominal segment II and segment VIII, number per segment detailed in Table 2. **Tubular ducts** size and shape similar to those in dorsum (Fig. 8K); venter with 19 ± 3.8 (16–24) [20] ducts, without symmetrical arrangement, numbering 0.8 ± 1.5 (0–3) [0] on submargin of head, 5.3 ± 1 (4–6) [6] on submargin or margin of thorax, 0–2 [2], II 0–4 [4], III 2–4 [2], IV 1–2 [2], V 0–4 [2], VI 2–4 [2], VII 0–2 [2], VIII 0–2 [0], totalling 13 ± 3.2 (10–17) on abdomen, distributed on medial, lateral or marginal areas. **Multilocular disc pores** similar size and number of loculi to dorsal pores (Fig. 8L); venter with 183 ± 40.9 (128–236) [160] pores, numbering as 10.8 ± 3.6 (7–16) [9] pores on head, 46 ± 2.5 (14–67) [44] pores on thorax, 126.2 ± 23.5 (98–156) [107], distrib-

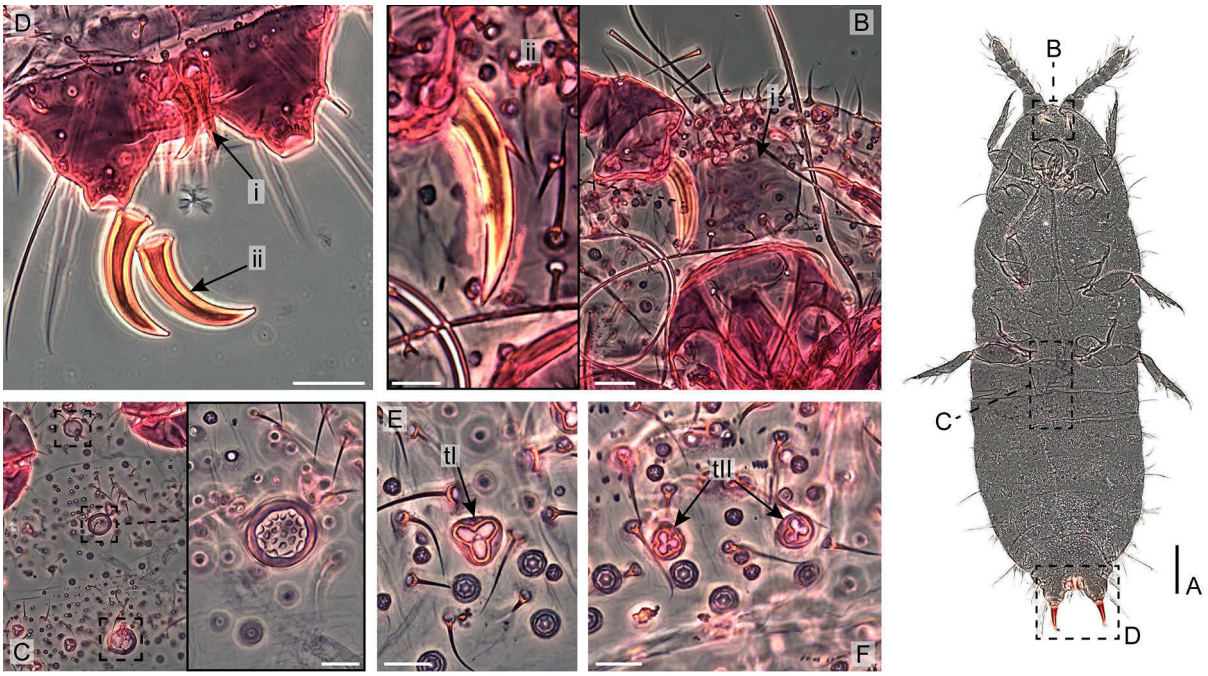

Fig. 11. Microphotographs of anatomical structures of *Gerococcus coffeae*, slide-mounted adult female. A – body, B – interantennal area with cephalic plate (i) on venter and close-up of spur-like seta (ii) on dorsum, C – venter of abdominal segments I to III with close-up of indicated circuli, D – last abdominal segment with interlobular setae (i) and apical setae of anal lobes (ii), E – tritubular duct Type I (tI), F – tritubular duct Type II (tII). Scale bars: A = 100 µm; Bi = 20 µm, Bii = 10 µm; C, E, F = 10 µm; D = 30 µm.

uted on each segment as follow: I 3–9 [6], II 9–19 [10], III 10–12 [12], IV 10–19 [10], V 11–23 [12], VI 15–30 [22], VII 22–32 [22], VIII 12–18 [13]. **Trilocular pores** 3–4 µm wide (Fig. 8M), evenly distributed on the surface. **Microtrichia** present on the venter of the last three abdominal segments, scattered. **Body setae** evenly distributed, flagellate, evenly distributed, with 15.1 ± 5.8 (7–28) µm long, the longest setae on marginal and medial areas.

Comments

This species is easily differentiable from the remaining species recorded in Germany. It can be separated from *Ripersiella hibisci* (Kawai & Takagi, 1971) and *Ri. aloes* by the distribution of the tubular ducts. While *Ri. caesii* has tubular ducts in the venter and dorsum in all segments, *Ri. aloes* lack in the dorsum and venter of the head and thorax, and *Ri. hibisci* lacks such tubular ducts. The main difference with *Ri. halophila* is the presence of bitubular ducts in the venter, while *Ri. halophila* has bitubular ducts restricted to the dorsum.

Material examined. Lectotype, ♀ adult, GERMANY: Rhineland-Palatinate, Bad Kreuznach, Rheingrafenstein, ex roots of *Dianthus gratianopolitanus* Vill., 1789 (Caryophyllaceae), 19.v.1955, H. Schmutterer leg., (SDEI).

Other material examined. GERMANY: 4♀, adults, Rhineland-Palatinate, Sankt Goarshausen, ex roots of *Festuca ovina* L., 1753 (Poaceae), 8.x.1957, H. Schmutterer leg., (SDEI); 2♀ adults, Hesse, Herborn, Amdorf, ex *Festuca ovina* (Poaceae), 5.v.1999, H. Schmutterer leg., (SDEI).

II. Taxonomic notes for the newly recorded species

Geococcus coffeae Green, 1933

Fig. 11

Novel intraspecific variation

Seven specimens were compared with redescriptions of Williams (1958, 2004). **Body** 1.5 ± 0.5 (1–2.3) mm long and 0.6 ± 0.2 (0.4–1.0) mm wide (Fig. 11A). **Antenna** total length 175.8 ± 20.1 (136–190); segment I 38.6 ± 4.3 (34–45) µm long and 54.5 ± 5.9 (45–60) µm wide, segment II 25.3 ± 3.9 (19–28) µm long and 32.1 ± 2.5 (30–37) µm wide, segment III 23.7 ± 3.7 (17–27) µm long and 28.3 ± 3 (24–32) µm wide, segment IV 19 ± 3.8 (15–24) µm long and 25.7 ± 3.1 (22–30) µm wide, segment V 18.3 ± 3.1 (16–24) µm long and 28.8 ± 2.6 (26–33) µm wide, segment VI 57.4 ± 6.1 (45–61) µm long and 32 ± 5 (28–42) µm wide. **Cephalic plate** visible in 2 out of 9 specimens, 43.3 ± 4.9 (40–47) µm long and 66 ± 6.6 (61–71) µm wide, with 5–6 setae in the margins of the plate, no vacuoles observed (Fig. 11B, i). **Clypeolabral shield** 111.1 ± 7.6 (101–118) µm long. **Labium** 74.5 ± 3.5 (72–77) µm long and 49.4 ± 3.2 (47–52). **Cephalic spur-like setae** each 42.3 ± 4.4 (33–47) µm long (Fig. 11B, ii). **Spiracles**, anterior and posterior pairs with similar size, 28.1 ± 3.3 (25–34) µm long and peritreme diameter 15 ± 0.7 (14–16) µm. **Circulus** on abdominal segment I, apical diameter of 9–13 µm wide and basal diameter 16–20 µm wide; circulus on abdominal segment II, apical diameter 18–21 µm wide and basal diameter 20–27 µm wide; and circulus on abdominal segment III apical diameter 17–22 µm wide and basal diameter of 23–27 µm wide (Fig. 11C). **Anal ring** on venter, with 45.8 ± 1.5 (44–47) µm transversal diameter, with six flagellate setae of 37.9 ± 3.8 (31–42) µm long. **Interlobular spur-like setae**, on dorsum of abdominal segment VIII, 39.4 ± 3 (35–45) µm long (Fig. 11D, i). **Anal lobe spur-like setae** with 63.2 ± 1.8 (61–66) µm long (Fig. 11D, ii). **Tritubular**

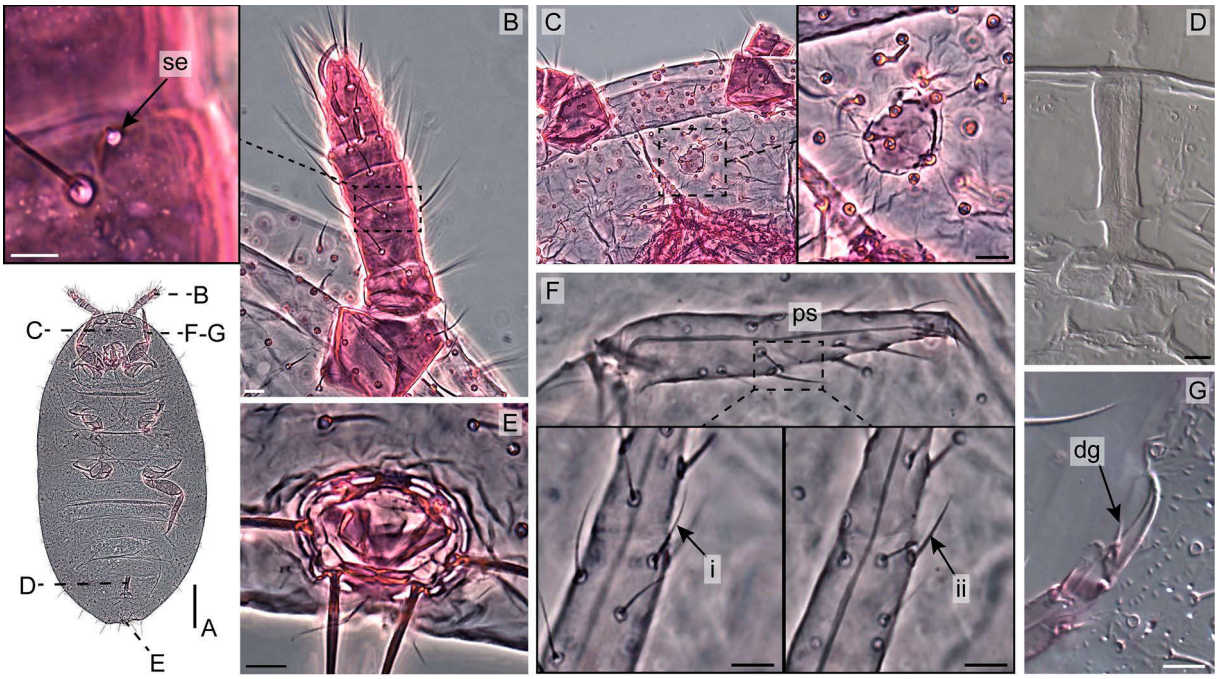

Fig. 12. Microphotographs of anatomical structures of *Rhizoecus dianthi*, slide-mounted adult female. A – body, B – antenna with close-up of the third segment indicating a tiny sensillum (se), C – ventral of the interantennal area with a close-up of the cephalic plate, D – genital chamber, E – anal ring, F – foreleg with close-up of distal area of tibia with flagellate setae in the internal face (i and ii), G – fore claw with short setose digitule (dg). Scale bars: A = 160 µm, B antenna = 10 µm and close-up = 5 µm, C–F = 10 µm.

ducts of two types: type 1 is large, triangular shape, 9.6 ± 1.1 (9–11) µm wide, present in dorsum and venter (Fig. 11E, tI); type 2 is smaller, rounded shape, 7.3 ± 0.9 (6–9) µm wide, restricted to venter of abdominal V to VIII (Fig. 11F, tII). **Anterior leg** total length 269.9 ± 8.1 (259–277) µm; coxa 36.8 ± 1.3 (35–38) µm long and 63.3 ± 3.8 (60–68) µm wide; trochanter 29.5 ± 2.7 (26–32) µm long and 33.5 ± 3.1 (31–38) µm wide; femur 96.8 ± 3.9 (91–99) µm long and 45.2 ± 2.5 (42–48) µm wide; trochanter + femur length 124.8 ± 4.8 (118–128) µm; tibia 58.9 ± 3.0 (55–62) µm long and 22.2 ± 1.1 (21–23) µm wide, with two spur-like seta in the inner distal margin; tarsus 59.1 ± 2.1 (56–61) µm long; tibia + tarsus length 117.6 ± 4.4 (111–121) µm; claw 29 ± 2 (27–31) µm, with two short setose digitule 7 ± 0.8 (6–8) µm long. **Middle leg** total length 254.9 ± 5.5 (249–262) µm; coxa 42.7 ± 4.7 (36–48) µm long and 63.7 ± 2.3 (60–65) µm wide; trochanter 29.2 ± 2.2 (26–31) µm long and 32.2 ± 2.3 (30–35) µm wide; femur 89.2 ± 2 (86–91) µm long and 41.9 ± 2.2 (40–44) µm wide; trochanter + femur length 117 ± 3.3 (114–120) µm; tibia 56 ± 2.5 (52–58) µm long and 22.2 ± 1.2 (21–24) µm wide; tarsus 58 ± 1.3 (57–59) µm long; tibia + tarsus length 113.4 ± 3.6 (108–116) µm; claw 28.9 ± 2.3 (27–32) µm, with two short setose digitule 7.6 ± 0.9 (7–8) µm long. **Hind leg** total length 293 ± 11.5 (282–307) µm; coxa 45 ± 3.2 (41–48) µm long and 62.2 ± 2.9 (59–66) µm wide; trochanter 32.3 ± 1.7 (30–34) µm long and 32.9 ± 3 (30–36) µm wide; femur 103 ± 2.6 (100–107) µm long and 46 ± 1.6 (45–48) µm wide; trochanter + femur length 133.1 ± 3.8 (130–138) µm; tibia 68.4 ± 2.2 (65–70) µm long and 24.3 ± 1.1 (23–25) µm wide; tarsus 67 ± 2 (64–69) µm long; tibia + tarsus length 135.1 ± 5.3 (127–139) µm; claw 31.6 ± 3.5 (28–36) µm, with two short setose digitules, each 7 µm long.

Comments

This is the first species of *Geococcus* to be recorded in Germany. *Geococcus coffeae* is quite recognisable by the presence of the spine-like setae on the dorsum of the head and the interlobular spine-like setae. The molecular analysis marks an intraspecific distance of 0.31% between the specimen associated with *Ruellia* sp. collected in Berlin (ZSM300) and the specimen associated with *Dalbergia sissoo* Graham, 1831 (Fabaceae) from Bonn (Fig. 16). This molecular difference seems not to be reflected in the morphology of the specimens, but a larger population should be analysed in the future to get a better idea of these molecular differences.

***Rhizoecus dianthi* Green, 1926**

Fig. 12

Novel intraspecific variation

Seven specimens of *Rh. dianthi* are contrasted with the information provided by McKenzie (1967), Hambleton (1976), Kozár & Konczné Benedicty (2007), Danzig et al. (2008). **Body** oval-elongated, 1.4 ± 0.3 (1.1–1.9) mm long and 0.8 ± 0.2 (0.5–1.1) mm wide (Fig. 12A). **Antenna** with six segments, total length 180.5 ± 7.9 (168–191) µm; segment I 45.6 ± 3 (40–50) µm long and 60.1 ± 4.4 (54–66) µm wide, segment II 26.1 ± 1.4 (25–28) µm long and 36.5 ± 3.1 (31–41) µm wide, segment III 37.2 ± 2.6 (35–42) µm long and 27.1 ± 2.8 (23–30) µm wide, segment IV 22.1 ± 1.5 (21–25) µm long and 28.2 ± 2.8 (25–33) µm wide, segment V 17.9 ± 2.1 (15–21) µm long and 30 ± 3.8 (25–36) µm wide, segment VI 44.9 ± 1.5 (44–48) µm long and 26.9

± 3.1 (23–33) µm wide. Chaetotaxy as follow: segment I with four flagellate setae, segment II with three flagellate setae plus one placoid sensillum of 5–7 µm wide, segment III with 6–9 flagellate setae arranged in two rows plus a tiny sensorium 1–2 µm wide (Fig. 12B), segment IV with five flagellate setae, segment V with five flagellate setae plus one falcate sensillum of 14–15 µm long, segment VI with 18–19 flagellate setae, one or two short setae of 6–7 µm long, plus three falcate sensilla of similar length, 28–34 µm long, erect sensillum of 24–26 µm long. **Eyes** with a diameter of 8–12 µm. **Cephalic plate** visible only in one specimen, 21 µm long and 26 µm wide, with one flagellate seta and no vacuoles (Fig. 12C). **Clypeolabral shield** 109.9 ± 4.5 (104–116) µm long. **Labium** with 87.4 ± 3.2 (83–92) µm long and 53.5 ± 7.1 (45–61) µm wide; basal segment membranous with six flagellate setae; medial segment sclerotised, 26.7 ± 2.9 (23–30) µm long, with two setae; apical segment sclerotised, 61.2 ± 5.8 (55–73) µm long, with 18 flagellate setae. **Spiracles** anterior and posterior pairs with similar size, 34.1 ± 2.9 (29–39) µm long and peritreme 17.3 ± 1.1 (15–19) µm wide. **Genital chamber** present on 6 out of 7 analysed specimens; 82.1 ± 8.2 (68–89) µm long, base 47.2 ± 6.1 (37–51) µm wide, constricted in the first third, expanded in the second third 18.7 ± 2.3 (15–20) µm wide (Fig. 12D). **Anal lobes** not protruding nor sclerotised, with three flagellate setae: the longest seta always in the ventral surface 80.3 ± 17.1 (50–92) µm long, remaining setae each one of 69.8 ± 10.8 (48–86) µm long, on dorsum. **Anal ring** on dorsum, 47.1 ± 2 (44–50) µm transversal diameter, with six flagellate setae of 58 ± 5.3 (47–65) µm long; external row with 11.3 ± 1.3 (10–13) cells, flat oval, with evident spicules (Fig 12E). **Multilocular disc pores** of 6–8 µm wide, restricted to venter of abdominal segments VI to VIII totalling 14.3 ± 3.1 (9–18), distributed 1.3 ± 0.8 (0–2) on segment VI, 5.4 ± 2.4 (2–8) on segment VII and 7.6 ± 1.4 (6–10) on segment VIII. **Tritubular ducts**, each one 7.1 ± 0.8 (6–8) µm wide and 9.6 ± 0.4 (9–10) µm long, with each ductulus with the inner edge wider than the outer edge, from 3 µm to 2 µm wide and 9–10 µm long; number per segment detailed in Table 2. **Tubular ducts** absent. **Anterior leg** 295.2 ± 14.4 (274–313) µm long. Length per segment as follow: coxa 47.8 ± 3.2 (45–53) µm long and 77.3 ± 8.2 (67–88) µm wide; trochanter 35.7 ± 3.7 (30–39) µm long and 40 ± 4.1 (33–45) µm wide; femur 110.2 ± 3.1 (106–114) µm long and 53.9 ± 4.3 (48–59) µm wide; trochanter + femur length 144.1 ± 6.7 (137–152) µm; tibia 67.1 ± 3.2 (63–71) µm long and 18.7 ± 1.7 (17–21) µm wide, with internal preapical setae as flagellate type (Fig. 12F); tarsus 65.3 ± 2.7 (62–69) µm long; tibia + tarsus length 131.7 ± 6 (124–140) µm; claw 24.7 ± 2.6 (21–28) µm long, with short setose digitule 6–9 µm (Fig. 12G). **Mid leg** 291 ± 16.3 (272–318) µm long. Length per segment as follow: coxa 51.2 ± 3.4 (46–55) µm long and 77.4 ± 7.3 (67–88) µm wide; trochanter 35.4 ± 3 (31–39) µm long and 38 ± 3.4 (33–43) µm wide, femur 108.7 ± 4.8 (104–116) µm long and 49.5 ± 4.6 (43–56) µm wide; trochanter + femur length 142.4 ± 7.8 (133–155) µm; tibia 68.2 ± 3.6 (64–74) µm long and 19.5 ± 2.1 (17–22) µm wide; tarsus 66.1 ± 3.9 (60–71) µm long; tibia + tarsus length 133.4 ± 5.8 (127–144) µm; claw 25.6 ± 2.5 (24–30) µm long, with short setose digitule 7–8 µm long. **Posterior leg** 352 ± 17.4 (327–376) µm long. Length per segment as follow: coxa 53.8 ± 2.5 (50–56) µm long and 77.8 ± 9.3 (62–88) µm wide; trochanter 39.4 ± 2.7 (35–43) µm long and 38.7 ± 3.2 (34–43) µm wide; femur 125.5 ± 5 (120–133) µm long and 51.8 ± 4.2 (45–57) µm wide; trochanter + femur length 164 ± 7.5 (155–175) µm; tibia 85.5 ± 4.9 (77–95) µm long and 20.2 ± 1.1 (18–22) µm wide; tarsus 78.7 ± 2.2 (75–81) µm long; tibia + tarsus length 164.1 ± 7.2 (151–171) µm; claw 26.5 ± 5.4 (17–31) µm long, with short setose digitule of 7–10 µm long.

Comments

Several authors have discussed the resemblance between *Rhizoecus dianthi* and *Rh. nemoralis* from a morphological approach. They both present multilocular disc pores and a similar number and distribution of tritubular ducts; however, *Rh. dianthi* lacks tubular ducts. The molecular topology also indicates that these two species are closely related, with a genetic interspecific distance of 5.5%, which supports the delimitation hypothesis based on the presence/absence of tubular ducts. The topology also shows a specimen (ZSM432) associated with *Salvadora persica* L., 1753 (Salvadoraceae) from Bonn (Fig. 16). Unfortunately, the exoskeleton of the sample did not retain the features necessary for identification after the molecular analysis.

Rhizoecus falcifer **Kunckel d'Herculais, 1878**

Fig. 13

Novel intraspecific variation

Only one specimen was found; it complements the information provided by Hambleton (1946, 1976) and Cox (1978). **Antenna** with five segments (Fig. 13A), total length 256 µm; segment I 59 µm long and 66 µm wide, segment II 27 µm long and 36 µm wide, segment III 46 µm long and 27 µm wide, segment IV 27 µm long and 27 µm wide, segment V 103 µm long and 30 µm wide. Chaetotaxy as follow: segment I with four flagellate setae, segment II with three flagellate setae plus one placoid sensillum of 6 µm wide, segment III with seven flagellate setae arranged in two rows, segment IV with five flagellate setae, segment V with 24 flagellate setae, two of them quite short 9 µm long; four falcate sensilla, the basal one 35 µm long, and the remaining three each 47 µm long; preapical erect sensillum of 39 µm long. **Cephalic plate** slightly sclerotised, 45 µm long and 61 µm wide, with 5 flagellate setae and no vacuoles visible (Fig. 13B). **Clypeolabral shield** 133 µm long. **Labium** 102 µm long and 61 µm wide; basal segment membranous with six flagellate setae; medial segment 30 µm long, with two setae; apical segment 71 µm long, with 18 flagellate setae. **Spiracles** are anterior and posterior pairs with similar size, 45–46 µm long and peritreme 21–24 µm wide. **Anal ring** on dorsum, 55 µm transversal diameter, with six flagellate setae of 98–110 µm long; external row with 11 cells, flat elongated, with evident spicules; internal row with 10 cells (Fig. 13C). **Multilocular disc pores** on dorsum and venter**,** each one 9–10 µm wide, with 6–8 loc-

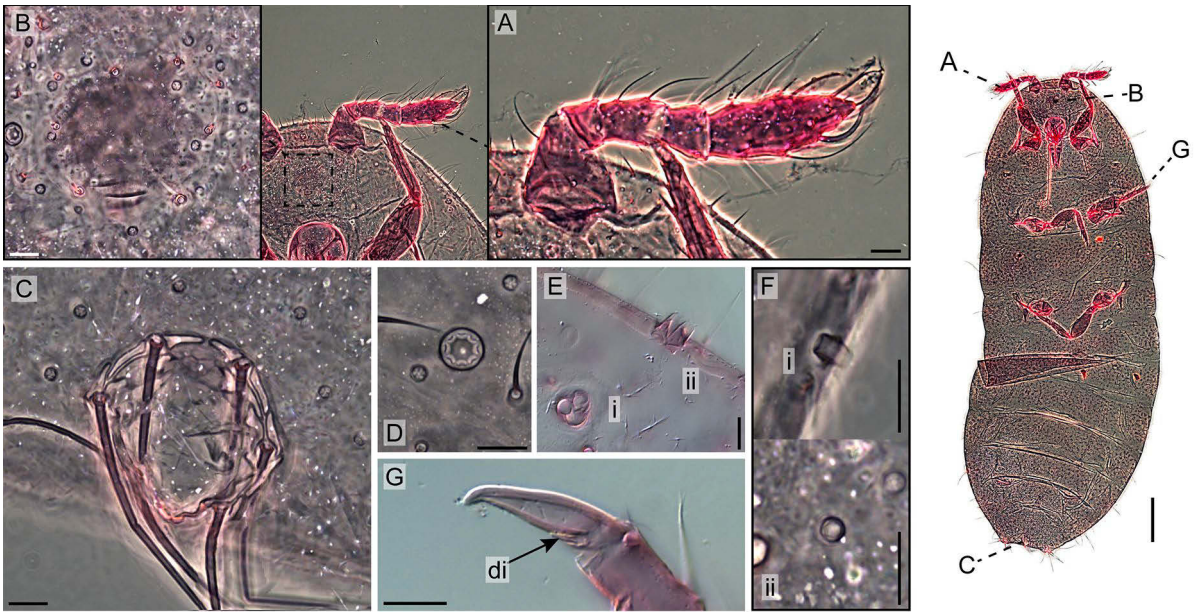

Fig. 13. Microphotographs of anatomical structures of *Rhizoecus falcifer*, slide-mounted adult female. A – antenna, B – cephalic plate, C – anal ring, D – multilocular disc pore, E – tritubular ducts on upper view (i) and lateral view (ii), F – tubular duct in lateral view (i) and upper view, G – claw with short setose digitule (di). Scale bars: Body = 200 µm, A = 20 µm, B–G = 10 µm.

uli (Fig. 13D); dorsum with 76 ducts distributed as follows: 6 on head, 49 on thorax, 6 on each abdominal segment I, 7 on II, 5 on III, 2 on IV, 1 on V, and absent on VI to VIII; venter with 168 ducts distributed as follows: 3 on head, 19 on thorax, 4 on each abdominal segment I, and V, 6 on II, 3 on IV, 22 on VI, 52 on VII, and 51 on VIII. **Tritubular ducts,** of two sizes: the large-type ducts on dorsum, each one 11.6 ± 0.8 (10–13) µm wide and 11.7 ± 0.4 (11–12) µm long (Fig. 13E), the small-type ducts on venter, each one 8 ± 0.8 (7–9) µm wide and 8.1 ± 0.7 (7–9) µm long; dorsum with 74 ducts distributed as follows: 5 on head, 28 on thorax, 5 on each abdominal segment I, II, and VII, 4 on III, 9 on IV, 6 on V, 7 on VI and absent on VIII; venter with 54 ducts distributed as follows: 1 on head, 13 on thorax, 2 on each abdominal segment I, II, and VIII, 3 on III, 9 on each IV and V, 7 on VI, and 6 on VII. **Tubular ducts** 4 µm wide and 5–6 µm long, around half of the ducts protruding from the cuticle (Fig. 13F), present on the dorsum and venter, with at least three ducts per segment. **Anterior leg** 359 µm long. Length per segment as follow: coxa 58 µm long and 88 µm wide; trochanter 37 µm long and 45 µm wide; femur 149 µm long and 63 µm wide; trochanter + femur length 187 µm; tibia 84 µm long and 25 µm wide, with two internal preapical setae as flagellate type; tarsus 77 µm long; tibia + tarsus length 161 µm; claw 30 µm long, with short setose digitule. **Mid leg** 347 µm long. Length per segment as follow: coxa 58 µm long and 89 µm wide; trochanter 39 µm long and 43 µm wide, femur 135 µm long and 57 µm wide; trochanter + femur length 175 µm; tibia 86 µm long and 24 µm wide; tarsus 71 µm long; tibia + tarsus length 156 µm; claw 28 µm long, with short setose digitule 10 µm long (Fig. 13G, di). **Posterior leg** 405 µm long without the claw. Length per segment as follows: coxa 48 µm long and 73 µm wide; trochanter 43 µm long and 40 µm wide; femur 158 µm long and 66 µm wide; trochanter + femur length 199 µm; tibia 117 µm long and 25 µm wide; tarsus 87 µm long; tibia + tarsus length 205 µm; claws broken on the studied specimen.

Comments

This is the only recorded species in Germany with five antennal segments, which facilitates differentiation from other species. While a single specimen is insufficient to establish definitive differences or similarities with populations from Australasia and the New World, it is noteworthy that this specimen has a reduced number of tritubular ducts (totalling 128 on the body), compared to the 175–200 recorded by Hambleton (1976). Additionally, the short size of appendages may represent an important character to consider in future taxonomic studies. Despite the overall body size (data not shown) fitting into the range recorded in the literature, this specimen shows a shorter length of the antenna and hind leg by 15% and 25% respectively, in contrast with Hambleton's records. This suggests the possibility of negative allometry among populations, which should be analysed with additional collections. Here, new information on the chaetotaxy of appendages and on the number and distribution of tritubular ducts and multilocular disc pores is recorded.

Rhizoecus nemoralis **(Hambleton, 1946)**

Fig. 14

Novel intraspecific variation

Eight specimens were analysed and contrasted with information provided by Hambleton (1946), Williams & Granara de Willink (1992), Kozár & Konczné Benedicty (2007) and Jansen & Westenberg (2015). **Body** oval-elongated, 1.6 ± 0.2 (1.3–1.8) mm long and 1 ± 0.1 (0.7–1.1) mm wide (Fig. 14A). **Antenna** with six segments, total length 185.4 ± 10.2 (175–204) µm; segment I 43.4 ± 6.6

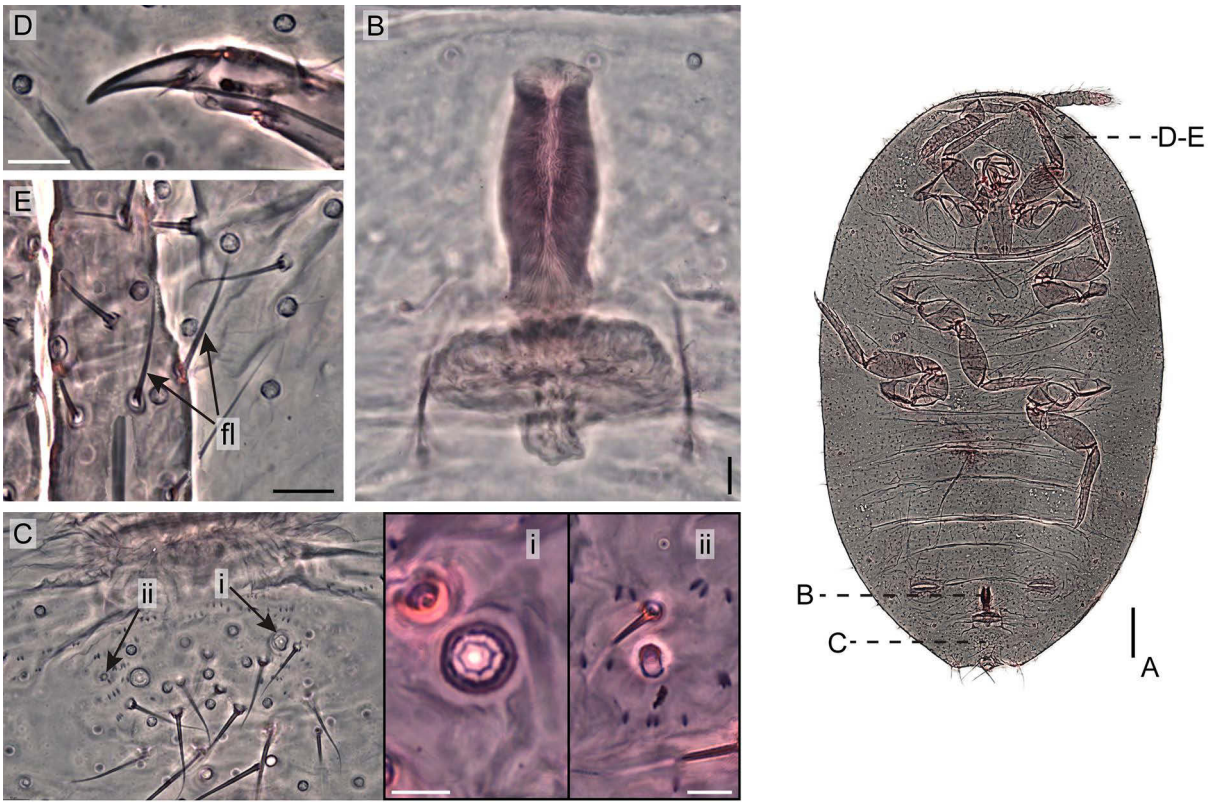

Fig. 14. Microphotographs of anatomical structures of *Rhizoecus nemoralis*, slide-mounted adult female. A – body, B – genital chamber, C – venter of central area of abdominal segment VIII with close-up of multilocular disc pore (i) and tubular duct (ii), D – fore claw, E – internal face of fore tibia with flagellate setae (fl) in the distal section. Scale bars: A = 100 µm; B, D–F = 10 µm; C = 5 µm.

(33–54) µm long and 59.2 ± 5.1 (51–66) µm wide, segment II 26.2 ± 2 (24–29) µm long and 39.1 ± 3.2 (33–43) µm wide, segment III 40.4 ± 3.8 (34–44) µm long and 29.2 ± 2.8 (25–32) µm wide, segment IV 24.5 ± 1.2 (22–26) µm long and 26.8 ± 2.9 (23–31) µm wide, segment V 19.6 ± 2.6 (17–24) µm long and 27.6 ± 4 (23–35) µm wide, segment VI 44.7 ± 2.6 (41–49) µm long and 25.6 ± 4.2 (22–34) µm wide. Chaetotaxy as follow: segment I with four flagellate setae, segment II with three flagellate setae plus one placoid sensillum of 5–6 µm wide, segment III with 7–9 flagellate setae arranged in two rows, segment IV with five flagellate setae, segment V with five flagellate setae plus one falcate sensillum of 17–19 µm long, segment VI with 18.4 ± 1.5 (16–21) flagellate setae plus three falcate sensilla, the basal sensillum with 34–38 µm long, medial and distal sensilla with 27–34 µm long, erect sensillum of 26–31 µm long. **Eyes** always present, diameter 13 ± 1.5 (10–14) µm. **Cephalic plate** not visible. **Clypeolabral shield** oval, larger than labium, 105.2 ± 7.9 (94.9–116) µm long. **Labium** with 92.6 ± 5.2 (82.6–99) µm long and 56.7 ± 3.9 (50–60) µm wide; basal segment membranous with six flagellate setae; medial segment sclerotised, 27.4 ± 7 (21–49) µm long, with two setae; apical segment sclerotised, 64.7 ± 7.8 (52–74) µm long. **Spiracles** anterior and posterior pairs with similar size, 37 ± 3.4 (28–42) µm long and peritreme 20.1 ± 1.8 (17–24) µm wide. **Genital chamber** present on 6 out of 15 analysed specimens; 44.8 ± 6.5 (39–57) µm long, and the aperture 29.5 ± 4.7 (22–35) µm wide, constricted in the first third 15.5 ± 1.5 (14–18) µm wide and expanded in the second third 26 ± 2.8 (24–30) µm wide (Fig. 14B). **Anal lobes** not protruding, unsclerotised, with three flagellate setae, two on the venter and one on the dorsum; the longest seta always in the ventral surface 96.3 ± 8.6 (81–102) µm long, remaining setae each one of 65.7 ± 7.3 (58–77) µm long. **Anal ring** on dorsum, 46.9 ± 2.9 (41–50) µm transversal diameter, with six flagellate setae of 67 ± 5.1 (56–75) µm long; external row with 11.3 ± 1.3 (10–13) cells, flat oval, with evident spicules but not in all the cells. **Multilocular disc pores** of 6.9 ± 0.4 (6–8) µm diameter (Fig. 14C, i), restricted to abdominal segments VII, with 3.9 ± 1 (3–5) pores, and segment VIII, with 2.4 ± 0.7 (2–4) pores; total number of pores 6.3 ± 1.6 (5–9). **Tritubular ducts,** each 7.9 ± 1 (6–10) µm wide and 12 ± 0.6 (11–13) µm long, with each ductulus of 3 µm wide and 12 µm long; number per segment detailed in Table 2. **Tubular ducts** present only on venter of abdomen, each duct of 2.3 ± 0.4 (2–3) µm wide and 5.1 ± 0.6 (4–6) µm long (Fig. 14C, ii), smaller than a trilocular pore; numbering 0.1 ± 0.4 (0–1) on segment III, 1.1 ± 1.1 (0–3) on segment IV, 1.4 ± 0.9 (0–2) on segment V, 2.8 ± 1.3 (0–4) on segment VI, 4.5 ± 1.6 (2–7) on segment VII, and 4.5 ± 0.8 (3–5), totalling 14.4 ± 3.7 (11–21). **Anterior leg** 314.9 ± 13.1 (297–337) µm long. Length per segment as follow: coxa 48 ± 6.8 (36–56) µm long and 79.5 ± 3.9 (73–85) µm wide; trochanter 38.4 ± 3.2 (34–43) µm long and 44.4 ± 3.5 (40–50) µm wide; femur 114 ± 5.5 (107–123) µm long and 61.9 ± 3.5 (57–67); trochanter + femur length 150.6 ± 7.2 (140–160) µm; tibia 72.5 ± 3.6 (67–77) µm long and

22.2 ± 2 (19–26) µm wide, with internal preapical setae as flagellate type (Fig. 14E); tarsus 71.9 ± 3.3 (67–76) µm long; tibia + tarsus length 143.6 ± 6.7 (134–149) µm; claw 25.3 ± 1.9 (22–28) µm long, with short setose digitule 6–7 µm (Fig. 14F). **Mid leg** 313.3 ± 13.5 (290–326) µm long. Length per segment as follow: coxa 57.3 ± 8.3 (42–65) µm long and 74.7 ± 4.9 (70–84) µm wide; trochanter 40.3 ± 2.4 (36–43) µm long and 40.4 ± 2.2 (38–44) µm wide, femur 115.1 ± 5.6 (106–121) µm long and 56.3 ± 2.7 (52–61) µm wide; trochanter + femur length 154.5 ± 7.3 (141–162) µm; tibia 70.6 ± 2.8 (66–73) µm long and 21.5 ± 1.9 (19–24) µm wide; tarsus 68.6 ± 2.7 (64–72) µm long; tibia + tarsus length 138.9 ± 5.4 (131–144) µm; claw 26.3 ± 2.5 (22–29) µm long, with short setose digitule 6–7 µm long. **Posterior leg** 358.5 ± 21 (326–381) µm long. Length per segment as follow: coxa 62.5 ± 6.4 (52–70) µm long and 72.4 ± 6.1 (64–80) µm wide; trochanter 42 ± 3.1 (36–45) µm long and 40.6 ± 3 (36–45) µm wide; femur 127.5 ± 8.2 (113–136) µm long and 59 ± 4.3 (52–65) µm wide; trochanter + femur length 168.8 ± 10.9 (152–179) µm; tibia 88.9 ± 4.6 (82–95) µm long and 20.9 ± 1.5 (19–23) µm wide; tarsus 78.7 ± 4.3 (73–86) µm long; tibia + tarsus length 167.5 ± 8.4 (156–177) µm; claw 28.2 ± 2.7 (25–33) µm long, with short setose digitule of 7–8 µm long.

Comments

Different authors have discussed the similarities among *Rhizoecus nemoralis*, *Rh. cyperalis* (Hambleton, 1946), and *Rh. pauciporus* Hambleton, 1976. The characters used to delimit such species are the labium length, sclerotisation of the anal lobe, number of setae surrounding the tritubular ducts, and the cephalic plate (Hambleton, 1946; Williams & Granara de Willink, 1992; Kozár & Konczné Benedicty, 2007; Jansen & Westenberg, 2015). We do not consider the last two characters useful. The definition of how close these setae are to the tritubular duct is affected by the distension of the cuticle, particularly when the body is producing eggs. The cephalic plate is a structure whose occurrence varies within the same population (evidenced in other species in this paper). The labium length as a discriminating character is not useful, since the literature shows an overlap between them, with 76–90 µm for *Rh. cyperalis*, 88–106 µm for *Rh. nemoralis*, and 103 µm for *Rh. pauciporus*.

Our analyses revealed significant diagnostic differences in the distribution, size, and number of tubular ducts among the studied species. We propose applying these characteristics with temporal limitations pending a comprehensive taxonomic revision of these species, based on morphometric comparisons with the German population and existing descriptions (Hambleton, 1976; Williams & Granara de Willink, 1992; Kozár & Konczné Benedicty, 2007). The morphometric analysis shows that *Rh. nemoralis* has tubular ducts with a diameter shorter than a trilocular pore, always present on the venter of abdominal segments VII and VIII, but could extend until segment III, totalling 14.4 ± 3.7 (11–21), and a minimum of three ducts always present in the central area posterior to the vulvar aperture (Fig. 14C, i). In contrast, *Rh. cyperalis* presents a "few", "small" tubular ducts restricted to the margin of the posterior abdominal segments, whereas *Rh. pauciporus* has tubular ducts on the dorsum and venter of the head, thorax and abdomen, with a diameter larger than a trilocular pore. Moreover, the shape of the genital chamber (Fig. 14B) was constant for all the specimens that preserved it and could be used as an additional character.

Regarding the German records, *Rh. nemoralis*, *Rh. dianthi* and *Rh. franconiae* are the most similar species. The molecular analysis reveals an interspecific distance of 5.5% with *Rh. dianthi* (Fig. 16). The morphological discussion regarding these two species is presented in the redescription of *Rh. franconiae* and the notes on *Rh. dianthi*.

Ripersiella aloes (Williams & Pellizzari, 1997)

Fig. 15

Novel intraspecific variation

Only one specimen was found; it was compared with the information provided by Williams & Pellizzari (1997). **Body** oval-elongated, 1 mm long and 0.3 mm wide (Fig. 15A). **Eyes** with a diameter of 12 µm. **Clypeolabral shield** 102 µm long. **Labium** with 69 µm long and 44 µm wide; basal segment membranous with six flagellate setae; medial segment sclerotised, 27 µm long, with two setae; apical segment sclerotised, 42 µm long, with 18 flagellate setae. **Spiracles**, both anterior and posterior pairs, are of similar size, measuring 30 µm in length and 15 µm in width across the peritreme. **Circulus** on abdominal segment III, with apical diameter of 11 µm and basal diameter of 17 µm (Fig. 15B). **Genital chamber** 51 µm long, base 34 µm wide, constricted in the first third, expanded in the second third 20 µm wide, with round apex, (Fig. 15C). **Anal lobes** not protruding nor sclerotised, with three dorsally flagellate setae, the length of the longest seta 58 µm long, the intermedial seta of 54 µm long, and the shorter seta of 49 µm long. **Anal ring** on dorsum, 56 µm transversal diameter(Fig. 15D), with six flagellate setae of 63–71 µm long; external row of cells numbering 22, flat oval, with large spicules (Fig. 15D, sp), internal row with 11 cells. **Multilocular disc pores** of 6–7 µm wide, with 9–10 loculi (Fig. 15E); distribution restricted to the venter of abdominal segments V to VIII, totalling 80 pores, distributed 9 on segment V, 25 on segment VI, 26 on segment VII and 20 on segment VIII. **Bitubular ducts**, each one 2.3 ± 0.2 (2–3) µm wide and 9.8 ± 0.6 (9–11) µm long, each ductulus with 1 µm diameter, with both apices converging in the external section of the duct and diverging internally, around half of duct protruding from cuticle resembling a conic process (Fig. 15F); dorsum with 114 ducts distributed as follows: 5 on head, 32 on thorax, 10 on abdominal segment I, 9 on each II, III and IV, 14 on V, 11 on each VI and VII and 4 on VIII; venter with 91 ducts distributed as follows: 5 on head, 16 on thorax, 7 on I, 5 on II, 6 on III, 10 in IV, 12 on V, 13 on VI, 9 on VII and 8 on VIII. **Tubular ducts** numbering 61 on the whole body, 4–5 µm long and 2 µm wide (Fig. 15G); dorsum with 29 ducts distributed as follows: absent on head, thorax, and abdominal segment I, 2 on II, 5 on III, 3 on IV, 7 on V, 6 on VI and 3 on each VII and VIII;

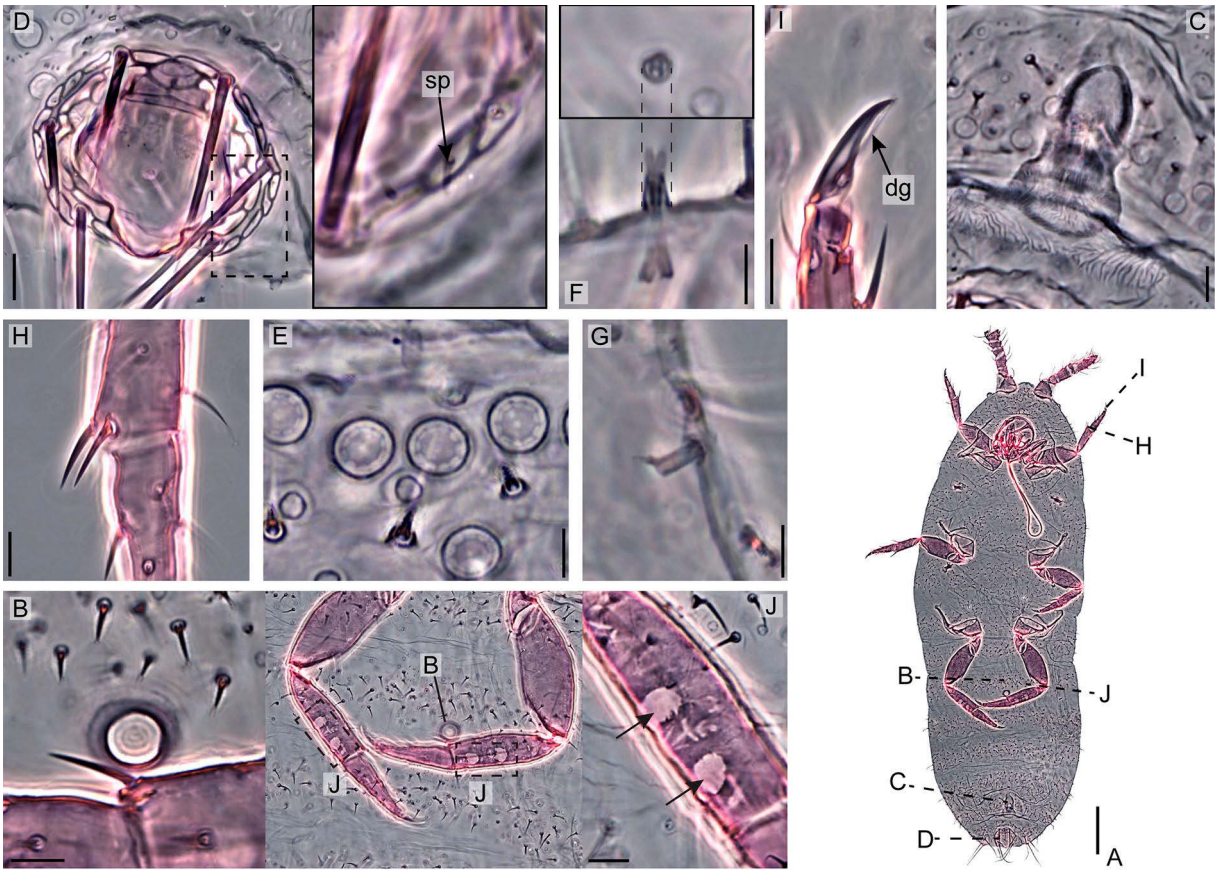

Fig. 15. Microphotographs of anatomical structures of *Ripersiella aloes*, slide-mounted adult female. A – body, B – circulus, C – genital chamber, D – anal ring with close-up of cells in the external row indicating the spicules, E – multilocular disc pores, F – bitubular duct in upper view (upper square) and lateral view (lower box), G – tubular duct in lateral view, H – distal section of the fore tibia with spur-like setae in the Inner margin, I – claw indicating the digitule (dg), J – hind tibia with macules (arrows). Scale bars: A = 100 µm; B–D, H–J = 10 µm; E–G = 5 µm.

venter with 32 ducts distributed as follows: absent on head, thorax, and abdominal segment I, 2 on II, 3 on III, 5 in IV, 7 on V, 9 on VI, 4 on VII and 2 on VIII. **Trilocular pores** on dorsum and venter, scattered distribution, 3 µm wide, larger than bitubular and tubular ducts. **Body seta** flagellate straight; on dorsum 8–29 µm long, the longest setae on the last three abdominal segments; those on venter similar in size, but the largest setae (>15 µm long) are more abundant. **Anterior leg** 249 µm long. Length per segment as follow: coxa 33 µm long and 64 µm wide; trochanter 28 µm long and 32 µm wide; femur 92 µm long and 39 µm wide; trochanter + femur length 118 µm; tibia 64 µm long and 19 µm wide, with two setae on inner distal end as spur type, stouter than other setae of the segment (Fig. 15H); tarsus 54 µm long; tibia + tarsus length 118 µm; claw 20 µm long, with long capitated digitule of 15 µm long, reaching the tip of the claw (Fig. 15I). **Middle leg** 249 µm long. Length per segment as follow: coxa 39 µm long and 58 µm wide; trochanter 26 µm long and 30 µm wide; femur 95 µm long and 40 µm wide; trochanter + femur length 119 µm; tibia 61 µm long and 21 µm wide, with three preapical setae as spur type, stouter than remaining setae of segment; tarsus 56 µm long; tibia + tarsus length 116 µm; claw 21 µm long, with long capitated digitule of 14 µm long, reaching the tip of the claw. **Posterior leg** 317 µm long. Length per segment as follow: coxa 38 µm long and 68 µm wide; trochanter 32 µm long and 30 µm wide; femur 111 µm long and 44 µm wide; trochanter + femur length 138 µm; tibia 89 µm long and 23 µm wide, with three preapical setae as spur type, stouter than remaining setae of segment, plus two macules on each tibia (Fig. 15J); tarsus 67 µm long; tibia + tarsus length 151 µm; claw 22 µm long, with long capitated digitule of 15 µm long, reaching the tip of the claw.

Comments

The main differences between the analysed specimen and the original description of the species are the distribution and size of the multilocular disc pores. Those are present on venter, from abdominal segments V to VIII in a considerably high number, in contrast with the restricted distribution between abdominal segments VI to VIII, with "a few situated between positions of anal lobes" (no detailed information about the number). Williams & Pellizzari (1997) considered the type of bitubular ducts as a differentiating character for grouping *Ri. aloes*, *Ri. geniculata* (James, 1935), *Ri. graminicola* (James, 1935) and *Ri. palestineae* Hambleton, 1946. The lack of morphometric information prevents a full comparison with those species. Nevertheless, the analysed specimen fits better with *Ri. aloes*, based on the characteristic shape of the bitubular ducts, the dis-

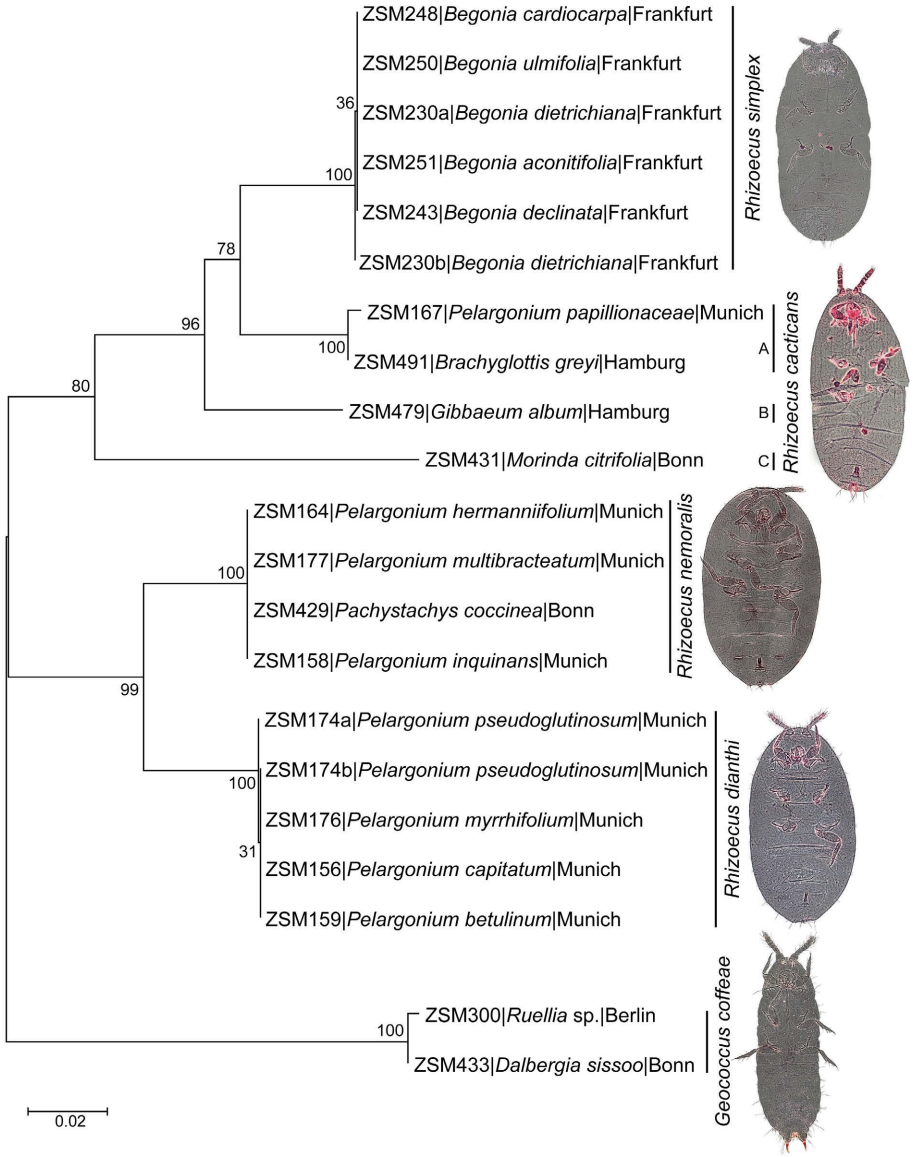

Fig. 16. Neighbour-joining topology based on Kimura 2 parameter distance based on COI gene from 25 sequences of 6 species, with information of collection code (left), plant host (center) and sampling locality (right). The values at nodes represent the bootstrap confidence level (1000 replicates).

tribution and proportions of the tubular ducts, the type of digitule, and the type of setae on the inner distal end of the fore tibia. A redescription including detailed morphometric data of the species should be considered for future work.

III. Taxonomic notes for the previously recorded species

Rhizoecus cacticans (Hambleton, 1946)

A total of 83 specimens were morphologically identified. Several of these specimens exhibit morphological variations that do not align satisfactorily with the original description of *Rh. cacticans*. This is corroborated by our molecular analysis, which reveals a considerable genetic divergence, with sequences distributed across disparate clades of the tree. The minimum genetic distance observed was 0.3% (between samples ZSM167 and ZSM491), while the maximum distance was 15.6% (between ZSM167 and ZSM479) (Fig. 16).

Recent literature provides information to separate *Rh. cacticans* from similar species present in the Netherlands, i.e. *Rh. keysensis* Hambleton, 1979, *Rh. elongatus* Green, 1926 and *Rh. albidus* Goux, 1942 (Jansen & Westenberg, 2015). Nevertheless, German specimens present values on morphometric characters that overlap with the aforementioned species: labium 59–89 µm long, antenna 136–212 µm long, and hind tibia + tarsus 119–177 µm long, anal lobe setae 52–94 µm long and anal ring with 23–43 cells on the outer ring. Despite both studies analysing specimens collected in greenhouses, the phenotypic plasticity affects the current species boundaries. A comprehensive taxonomic revision is necessary to clarify the status and diagnostic criteria of closer taxa. As access to type material was not possible during this study, we have adopted a conservative approach, assigning our specimens to *Rh. cacticans* to preclude the introduction of an unrecorded species (e.g.

Rh. keysensis) into the European fauna without conclusive support.

IV. Taxonomic key for Rhizoecidae species recorded in Germany

1 Anal lobes, each terminating with a robust spine-like seta .... *Geococcus coffeae*
– Anal lobes not terminating with a robust spine-like seta..... 2
2 Bitubular ducts present, tritubular ducts absent..... 3
– Bitubular ducts absent, tritubular ducts present..... 6
3 Multilocular disc pores absent on dorsum..... 4
– Multilocular disc pores present on dorsum..... 5
4 Bitubular ducts present on venter; tubular ducts restricted to abdomen..... *Ripersiella aloes*
– Bitubular ducts absent on venter; tubular ducts present in all head, thorax and abdomen .....*Ripersiella halophila*
5 Tubular ducts present.....*Ripersiella caesii*
– Tubular ducts absent ..... *Ripersiella hibisci*
6 Antenna with five segments.....*Rhizoecus falcifer*
– Antenna with six segments 7
7 Multilocular disc pores absent..... 8
– Multilocular disc pores present.....11
8 Digitule extending no more than half of claw .... *Rhizoecus arabicus*
– Digitule reaching the tip of the claw 9
9 External cell row of anal ring numbering less than 20, if there are more, the labium length is shorter than 60 µm ....*Rhizoecus simplex*
– External cell row of anal ring numbering more than 25, if there are fewer, the labium length is longer than 60 µm 10
10 Tubular ducts absent on venter of thorax... *Rhizoecus albidus*
– Tubular ducts present on venter of thorax ....*Rhizoecus cacticans*
11 Tubular ducts absent .....*Rhizoecus dianthi*
– Tubular ducts present..... 12
12 Circulus absent; preapical setae in fore tibia flagellate ....*Rhizoecus nemoralis*
– Circulus present; preapical setae in fore tibia spine-like..... .....*Rhizoecus franconiae*

CONCLUSION

Our work addresses a significant gap by applying an integrated taxonomic framework to root scale insects, a group where such methods are not yet widely adopted. The findings show that Germany's diversity is greater than expected, and the potential for discovering additional species is high and should be regularly assessed. The study provides evidence that phenotypic plasticity is a factor to consider in Rhizoecidae species, particularly reflected in the size of body structures used as discriminant characters. Additionally, the integrative approach provides evidence that *Rh. arabicus*, *Rh. dianthi*, *Rh. nemoralis* and *Rh. simplex* are taxonomically solid, while *Rh. cacticans* should be analysed both molecularly and morphologically to establish its taxonomic boundaries.

The morphological analyses reveal several taxonomically informative characters within *Rhizoecus* species. The results corroborate the taxonomic reliability of otherwise overlooked characters (e.g., distribution and number of tubular ducts). A key diagnostic feature is found at the inner distal margin of the fore tibia, which clearly distinguishes two species groups: one comprising *Rh. dianthi*, *Rh. falcifer*, and *Rh. nemoralis* is characterised by two flagellate setae, and another including *Rh. arabicus*, *Rh. cacticans*, *Rh. franconiae*, and *Rh. simplex* possessing two spur-like setae. The number and distribution of tritubular ducts provide additional diagnostic value, enabling species-level differentiation as seen between *Rh. nemoralis* and *Rh. dianthi*. Conversely, certain characters proved less reliable for taxonomic purposes. The presence or absence of spicules showed limited diagnostic utility due to their partial occurrence in most species or their usual minute size. Similarly, both the genital chamber and cephalic plate exhibited substantial intraspecific variation, making them unsuitable as consistent diagnostic features. We strongly recommend that future species descriptions incorporate detailed morphometric data, focusing on characterising intraspecific variation, to improve species delineation and taxonomic accuracy.

The diversity of Rhizoecidae in Germany is now updated to 13 species across three genera, supported by 60 new host records for eight species. This study provides new taxonomic information and tools to clarify species delimitation and facilitate the identification of German rhizoecids. We corroborate the presence of *Rh. cacticans* 70 years after its sole previous record in the country, demonstrating a far wider distribution than previously known. Furthermore, we provide the first molecular data for *G. coffeae, Rh. cacticans, Rh. dianthi, Rh. nemoralis,* and *Rh. simplex*.

These findings revealed patterns in the Rhizoecidae ecology. *Rhizoecus cacticans* and *Rh. nemoralis* seem to have a biological advantage over the other species, considering the number of plant species and locations where they were found. We wonder whether this advantage can be reflected in phenotype and whether it favours the establishment of these species in natural niches in Germany. Notably, native (Palaearctic) species such as *Rh. franconiae*, *Ri. caesii*, and *Ri. halophila* were absent from our sampling.

Ultimately, this research highlights the crucial importance of continually updating scale insect diversity records for the country. We strongly encourage phytosanitary authorities to extend this line of investigation through targeted surveys of commercial greenhouses and open-field environments. Such efforts are essential for comprehensively evaluating the diversity associated with cultivated plants and estimating potential threats of Rhizoecidae species to German agriculture.

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Supplement S1. Collection data and museum information of the material analysed for the redescriptions and the new records of scale insects of Germany.

Geococcus coffeae Green, 1933

GERMANY Berlin, Botanischer Garten, 59 m, 52.455948°N 13.307338°E, 29.xi.2023, ex: roots of *Ruellia* sp. (Acanthaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_300/2024] Germany Nordrhein-Westfalen, Bonn, Botanischer Garten, 57 m, 50.725283°N 7.093614°E, 1.vii.2024, ex: roots of *Erythroxylum coca* (Erythroxylaceae), coll. A. Caballero, 5 adult ♀, [SNSB_ZSM_Cocc_428/2024]; Nordrhein-Westfalen, Bonn, Botanischer Garten, 57 m, 50.725283°N 7.093614°E, 3.vii.2024, ex: roots of *Morinda citrifolia* (Rubiaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_431/2024]; same data except ex: roots of *Dalbergia sissoo* (Fabaceae) with ants, coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_433/2024].

Rhizoecus arabicus Hambleton, 1976

Holotype: COLOMBIA, Chinchiná, ex: *Coffea arabica* (Rubiaceae), coll. S.E. Flanders, iv.1956, 1 adult ♀ [56-673; 56-6029 USNM]. **Paratypes:** Same data as holotype except host, ex: *Coffeae* sp. (Rubiaceae) 1 adult ♀; Same data as holotype except host, ex: Poaceae species, 1 adult ♀, [56-676 USNM]; COSTA RICA, Coto, ex: soil, E.B. Dixon leg., 20.v.1945, 1 adult ♀, [5705-19 USNM]. **Additional samples:** EE.UU., Sarasota. Florida, ex: *Stenostephanus* sp. (Acanthaceae), coll. D. Culbert, 22.xi.1982, 1 adult ♀, [126-360 USNM]; GERMANY, Berlin, Botanischer Garten, 59 m, 52.455948°N 13.307338°E, 29.xi.2023, ex: roots of *Aphelandra gigantiflora* (Acanthaceae), coll. A. Caballero, 10 adult ♀, [SNSB_ZSM_Cocc_277/2024]; Berlin, Botanischer Garten, 59 m, 52.455948°N 13.307338°E, 29.xi.2023, ex: roots of *Ruellia jussieuoides* (Acanthaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_295/2024]; Berlin, Botanischer Garten, 59 m, 52.455948°N 13.307338°E, 29.xi.2023, ex: roots of *Aphelandra pulcherrima* (Acanthaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_307/2024].

Rhizoecus cacticans (Hambleton, 1946)

GERMANY; Bayern, Munich, Botanischer Garten, 515 m, 48.16267°N 11.50219°E, 2.xi.2023, ex: roots of *Pelargonium capitatum* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_156/2024]; same data except ex: roots of *Pelargonium graveolens* (Geraniaceae), cod. 1021/0391-1, coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_157/2024]; same data except ex: roots of *Pelargonium betulinum* (Geraniaceae), cod. 1021/0364-1, coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_159/2024]; same data except ex: roots of *Pelargonium englerianum* (Geraniaceae), cod. 1021/0378, coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_163/2024]; same data except ex: roots of *Pelargonium papilionaceum* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_167/2024]; same data except ex: roots of *Pelargonium magenteum* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_169/2024]; same data except: roots of *Salvia greggii* (Lamiaceae), coll. A. Caballero,

3 adult ♀, [SNSB_ZSM_Cocc_171/2024]; same data except ex: roots of *Pelargonium pseudoglutinosum* (Geraniaceae), coll. A. Caballero, 5 adult ♀, [SNSB_ZSM_Cocc_174/2024]; same data except ex: roots of *Pelargonium myrrhifolium* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_176/2024]; Nordrhein-Westfalen, Bonn, Botanischer Garten, 57 m, 50.725283°N 7.093614°E, 3.vii.2024, ex: roots of *Morinda citrifolia* (Rubiaceae), coll. A. Caballero, 8 adult ♀, [SNSB_ZSM_Cocc_431/2024]; Hamburg, Loki Schmidt Garden Botanical of University Hamburg, 23 m, 53.5608°N 9.860388°E, 22.viii.2024, ex: roots of *Gibbaeum album* (Aizoaceae), coll. A. Caballero, 6 adult ♀, [SNSB_ZSM_Cocc_479/2024]; same data except ex: roots of *Brachyglottis greyi* var. "sunshine" (Asteraceae), coll. A. Caballero, 5 adult ♀, [SNSB_ZSM_Cocc_491/2024].

***Rhizoecus dianthi* Green, 1926**

GERMANY Bayern, Munich, Botanischer Garten, 515 m, 48.16267°N 11.50219°E, 2.xi.2023, ex: roots of Pelargonium capitatum (Geraniaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_156/2024]; same data except ex: roots of *Pelargonium graveolens* (Geraniaceae), coll. A. Caballero, 4 adult ♀, [SNSB_ZSM_Cocc_157/2024]; same data except ex: roots of *Pelargonium inquinans* (Geraniaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_158/2024]; same data except ex: roots of *Pelargonium betulinum* (Geraniaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_159/2024]; same data except ex: roots of *Pelargonium graveolens* (Geraniaceae), coll. A. Caballero, 7 adult ♀, [SNSB_ZSM_Cocc_160/2024]; same data except ex: roots of *Pelargonium grossularioides* (Geraniaceae), coll. A. Caballero, 4 adult ♀, [SNSB_ZSM_Cocc_161/2024]; same data except ex: roots of *Pelargonium bicolor* (Geraniaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_162/2024]; same data except ex: roots of *Pelargonium englerianum* (Geraniaceae), coll. A. Caballero, 6 adult ♀, [SNSB_ZSM_Cocc_163/2024]; same data except ex: roots of *Pelargonium hermanniifolium* (Geraniaceae), coll. A. Caballero, 5 adult ♀, [SNSB_ZSM_Cocc_164/2024] same data except ex: roots of *Pelargonium papilionaceum* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_167/2024]; same data except ex: roots of *Pelargonium magenteum* (Geraniaceae), coll. A. Caballero, 7 adult ♀, [SNSB_ZSM_Cocc_169/2024]; same data except ex: roots of *Salvia greggii* (Lamiaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_171/2024]; same data except ex: roots of *Pelargonium pseudoglutinosum* (Geraniaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_174/2024]; same data except ex: roots of *Pelargonium myrrhifolium* (Geraniaceae), coll. A. Caballero, 7 adult ♀, [SNSB_ZSM_Cocc_176/2024].

***Rhizoecus falcifer* Kunckel d'Herculais, 1878**

GERMANY, Bayern, Munich, Botanischer Garten, 515 m, 48.16267°N 11.50219°E, 17.xi.2023, ex: roots of *Pelargonium myrrhifolium* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_176/2024].

***Rhizoecus nemoralis* (Hambleton, 1946)**

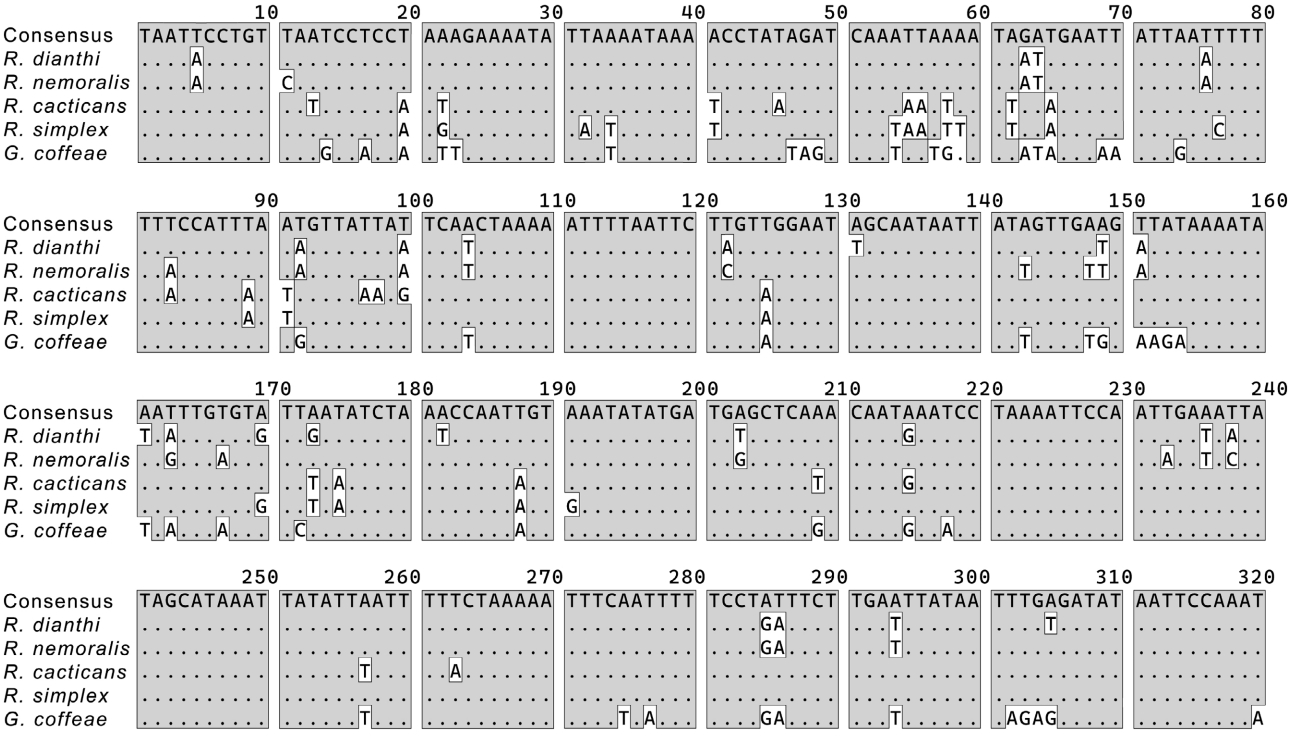
GERMANY, Bayern, Munich, Botanischer Garten, 515 m, 48.16267°N 11.50219°E, 2.xi.2023, ex: roots of *Pelargonium acraeum* (Geraniaceae), coll. A. Caballero, 4 adult ♀, [SNSB_ZSM_Cocc_153/2024]; same data except ex: roots of *Pelargonium capitatum* (Geraniaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_156/2024]; same data except ex: roots of *Pelargonium graveolens* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_157/2024]; same data except ex: roots of *Pelargonium inquinans* (Geraniaceae), coll. A. Caballero, 9 adult ♀, [SNSB_ZSM_Cocc_158/2024]; same data except ex: roots of *Pelargonium graveolens* (Geraniaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_160/2024]; same data except ex: roots of *Pelargonium grossularioides* (Geraniaceae), coll. A. Caballero, 5 adult ♀, [SNSB_ZSM_Cocc_161/2024]; same data except ex: roots of *Pelargonium bicolor* (Geraniaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_162/2024]; same data except ex: roots of *Pelargonium hermanniifolium* (Geraniaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_164/2024]; same data except ex: roots of *Pelargonium papilionaceum* (Geraniaceae), coll. A. Caballero, 11 adult ♀, [SNSB_ZSM_Cocc_167/2024]; same data except ex: roots of *Pelargonium magenteum* (Geraniaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_169/2024]; same data except ex: roots of *Salvia greggii* (Lamiaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_171/2024]; same data except ex: roots of *Pelargonium fulgidum* (Geraniaceae), coll. A. Caballero, 7 adult ♀, [SNSB_ZSM_Cocc_172/2024]; same data except ex: roots of *Pelargonium pulverulentum* (Geraniaceae), coll. A. Caballero, 10 adult ♀, [SNSB_ZSM_Cocc_173/2024]; same data except ex: roots of *Pelargonium pseudoglutinosum* (Geraniaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_174/2024]; same data except ex: roots of *Pelargonium mutans* (Geraniaceae), coll. A. Caballero, 8 adult ♀, [SNSB_ZSM_Cocc_175/2024]; same data except ex: roots of *Pelargonium multibracteatum* (Geraniaceae), coll. A. Caballero, 9 adult ♀, [SNSB_ZSM_Cocc_177/2024]; Hessen, Frankfurt am Main, Palmergarten, 111 m, 50.12375°N 8.65739°E, 17.i.2024, ex: roots of *Begonia declinata* (Begoniaceae) coll. A. Caballero, 8 adult ♀, [SNSB_ZSM_Cocc_227/2024]; Nordrhein-Westfalen, Bonn, Botanischer Garten, 57 m, 50.725283°N 7.093614°E, 3.vii.2024, ex: roots of *Balanites aegyptiaca* (Zygophyllaceae), coll. A. Caballero, 7 adult ♀, [SNSB_ZSM_Cocc_430/2024]; same data except ex: roots of *Pachystachys coccinea* (Acanthaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_429/2024].

***Rhizoecus simplex* (Hambleton, 1946)**

GERMANY, Bayern, Munich, Botanischer Garten, 515 m, 48.16267°N 11.50219°E, 10.xi.2023, ex: roots of *Pelargonium hermanniifolium* (Geraniaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_164/2024]; Hessen, Frankfurt am Main, Palmergarten, 111 m, 50.12375°N 8.65739°E, 17.i.2024, ex: roots of *Begonia saxicola* (Begoniaceae) cod. 9-24233-4, coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_230/2024]; same data except ex: roots of *Begonia subvillosa* (Begoniaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_243/2024]; same data except ex: roots of *Begonia maestrensis* (Begoniaceae), coll. A. Caballero, 3 adult ♀, [SNSB_ZSM_Cocc_247/2024]; same data except ex: roots of *Begonia cardiocarpa* (Begoniaceae), coll. A. Caballero, 5 adult ♀, [SNSB_ZSM_Cocc_248/2024]; same data except ex: roots of *Begonia ulmifolia* (Begoniaceae), coll. A. Caballero, 4 adult ♀, [SNSB_ZSM_Cocc_250/2024]; same data except ex: roots of *Begonia aconitifolia* (Begoniaceae), coll. A. Caballero, 2 adult ♀, [SNSB_ZSM_Cocc_251/2024].

***Ripersiella aloes* (Williams & Pellizzari, 1997)**

Germany Hamburg, Hamburg, Loki Schmidt Garden Botanical of University Hamburg, 23 m, 53.5608°N 9.860388°E, 22.viii.2024, ex: roots of *Hereroa* sp. (Aizoaceae), coll. A. Caballero, 1 adult ♀, [SNSB_ZSM_Cocc_542/2024].



Supplement S2. Molecular characterisation of COI region (320 bp) for *Rhizoecus cacticans*, *Rh. dianthi*, *Rh. nemoralis*, *Rh. simplex* and *Geococcus coffeae*