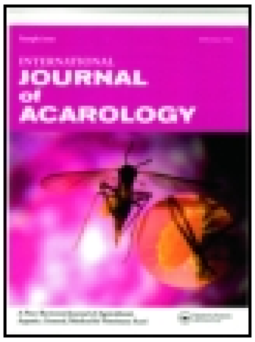

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Daidalotarsonemus and Excelsotarsonemus species (Acari: Tarsonemidae) found in shaded cacao plantations in Brazil, with a description of a new species

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Daidalotarsonemus and *Excelsotarsonemus* species (Acari: Tarsonemidae) found in shaded cacao plantations in Brazil, with a description of a new species

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ABSTRACT

Mites of the family Tarsonemidae (Acari: Prostigmata) exhibit a great diversity of feeding habits including fungivorous, algivorous, plant feeders, and predatory of other mites, as parasitoids and parasites are kinds of symbionts of other insects. They also have a considerable diversity of morphological structures, including the shape and structure of the mouthparts and specialized tactile organs, particularly the setae on the body and legs. The Atlantic Forest remnant is considered to be a very diverse tropical biota. Samples were collected on *Theobroma cacao* and *Artocarpus heterophyllus* trees in *cabruca* agroforest systems located in Ilhéus, Bahia State, Brazil. A new species, *Excelsotarsonemus cabrucae* Sousa, Lofego & Ochoa, sp. n. is described and illustrated. Six *Daidalotarsonemus* and three *Excelsotarsonemus* species were identified in the same area. A key to the species of *Daidalotarsonemus* of Brazil and a key to the species of *Excelsotarsonemus* of the world are presented. The findings emphasize the importance of conducting mite surveys in rainforests to better understand the mite diversity which inhabits this biome.

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Atlantic Forest; *cabruca*; taxonomy; systematic; Tarsonemoidea

Introduction

The Tarsonemidae (Acari: Prostigmata) currently consists of 43 genera (Lin and Zhang 2002; Magowski et al. 2005; Lofego and Feres 2006; Lofego et al. 2015, 2016; Khaustov and Abramov 2017). They exhibit a great diversity of feeding habits including fungivorous, algivorous, plant feeders, and predatory of other mites, as parasitoids and parasites are kinds of symbionts of other insects (Lindquist 1986). They also have a considerable diversity of morphological structures, including the shape and structure of the mouthparts and specialized tactile organs, particularly the setae on the body and legs (Lindquist 1986). The genus *Daidalotarsonemus* De Leon consists of 37 described species recorded from all of the continents except Antarctica (Lindquist 1986; Lin and Zhang 2002); of these, 8 have been recorded from Brazil (Lin and Zhang 2002; Lofego et al. 2005; Sousa et al. 2014; Rezende et al. 2015a, 2015b, 2015c). The genus *Excelsotarsonemus* Ochoa & Naskrecki consists of five species only reported from Central and South America (Ochoa et al. 1995; Ochoa and OConnor 1998; Rezende et al. 2015a). Both genera are considered to be fungivorous and algivorous, two food sources commonly found on plants located in humid areas (Ochoa et al. 1995; Ochoa and OConnor 1998; Rezende et al. 2015a).

The southern coastal region of the Bahia state, in Brazil, contains a significant part of the remaining Atlantic Forest and one of the most diverse tropical biotas of the world (Mittermeier et al. 2004; Faria et al. 2006, 2007). Local farmers cultivate the cacao tree, *Theobroma cacao* L. (Malvaceae), under the rainforest canopy, in shaded cacao plantations called *cabrucas* (Johns 1999; Schroth et al. 2011; Sambuichi et al. 2012). This agroforest is characterized by high levels of humidity and temperature, favouring the presence of a great diversity of microorganisms and microarthropods (Joly et al. 2014). Although the species diversity of Tarsonemidae in the *cabruca* is believed to be very great, only three species, *Daidalotarsonemus oliveirai, Excelsotarsonemus caravelis*, and *E. tupi*, have been recorded from this habitat (Rezende et al. 2015a). The present paper presents new records of *Daidalotarsonemus* and *Excelsotarsonemus* species and describes a new species of *Excelsotarsonemus* from a *cabruca* agroforest in Brazil.

Materials and methods

Samples of branches, leaves, buds, and stem bark of cacao trees and leaves of jackfruit trees (*Artocarpus heterophyllus* Lam: Moraceae), which form the dense canopy of the *cabruca*, were collected from May to December 2016 on the campus of the Universidade Estadual de Santa Cruz (UESC) (14°47′47″ S and 39° 10′15″ W), Ilhéus, Bahia. The climate of the region is classified as "Af" (tropical rainforest climate) of Köppen, due to its high annual temperature (±24°C) and the high rainfall index (±2200 mm annually) (Canty et al. 2008).

Tarsonemids were extracted from the samples, examined under a Leica EZ4 stereomicroscope, and stored in 70% ethyl alcohol. The mites were analysed using three different microscopy techniques: phase contrast (PC), differential interferential contrast (DIC), and scanning electron microscopy (SEM). For PC and DIC, some specimens were mounted on slides using Hoyer's medium and analysed under a Zeiss Axioscope™. For the SEM, specimens were dehydrated in an ascending ethanol series (70–100%) followed by a similar ascending series utilizing pentane (25–100%), dripped onto stubs and left to dry. The stub preparations were coated with gold using an SCD 050 sputter coater. SEM analyses were performed at the Centro de Microscopia Eletrônica (CME) of UESC using a FEI Quanta 250 microscope with Microscope Control software for image capturing.

The terminology used in this paper follows Lindquist (1986), except for the gnathosomal setae *dgs* and *vgs* (Suski 1967; Magowski et al. 1998). For each structure, measurements are given

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in micrometres (μm), with the holotype value in bold, followed by the average measurement and the respective range in parentheses based on all specimens, including the holotype. The legs were measured from the base of the trochanter to the apex of the tarsus, excluding the pretarsus. The following abbreviations are used for the acarological collections where the type specimens are deposited: Departamento de Zoologia e Botânica, Universidade Estadual Paulista (UNESP), São José do Rio Preto, São Paulo, Brazil [AC-DZSJRP]; Universidade Estadual de Santa Cruz (UESC), Ilhéus, Bahia, Brazil [AC-UESC]; Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ), Universidade de São Paulo, Piracicaba, São Paulo, Brazil [AC-ESALQ]; and United States National Museum of Natural History (USNM), Smithsonian Institution, hosted in Beltsville, Maryland, USA [AC-USNM]. Vouchers of the other *Daidalotarsonemus* and *Excelsotarsonemus* species reported herein are deposited at AC-DZSJRP and AC-UESC.

Results

Data for the six *Daidalotarsonemus* and three *Excelsotarsonemus* species identified in the study are presented below.

Daidalotarsonemus annonae Sousa, Lofego and Gondim Jr 2014: 430.

Material examined

A. heterophyllus leaves: 16-II-2016 (3); *T. cacao* branches: 15-III-2016 (1); *T. cacao* leaves 03-V-2016 (1), 14-IX-2016 (1), 07-XII-2016 (1).

Daidalotarsonemus esalqi Rezende, Lofego & Ochoa 2015: 436.

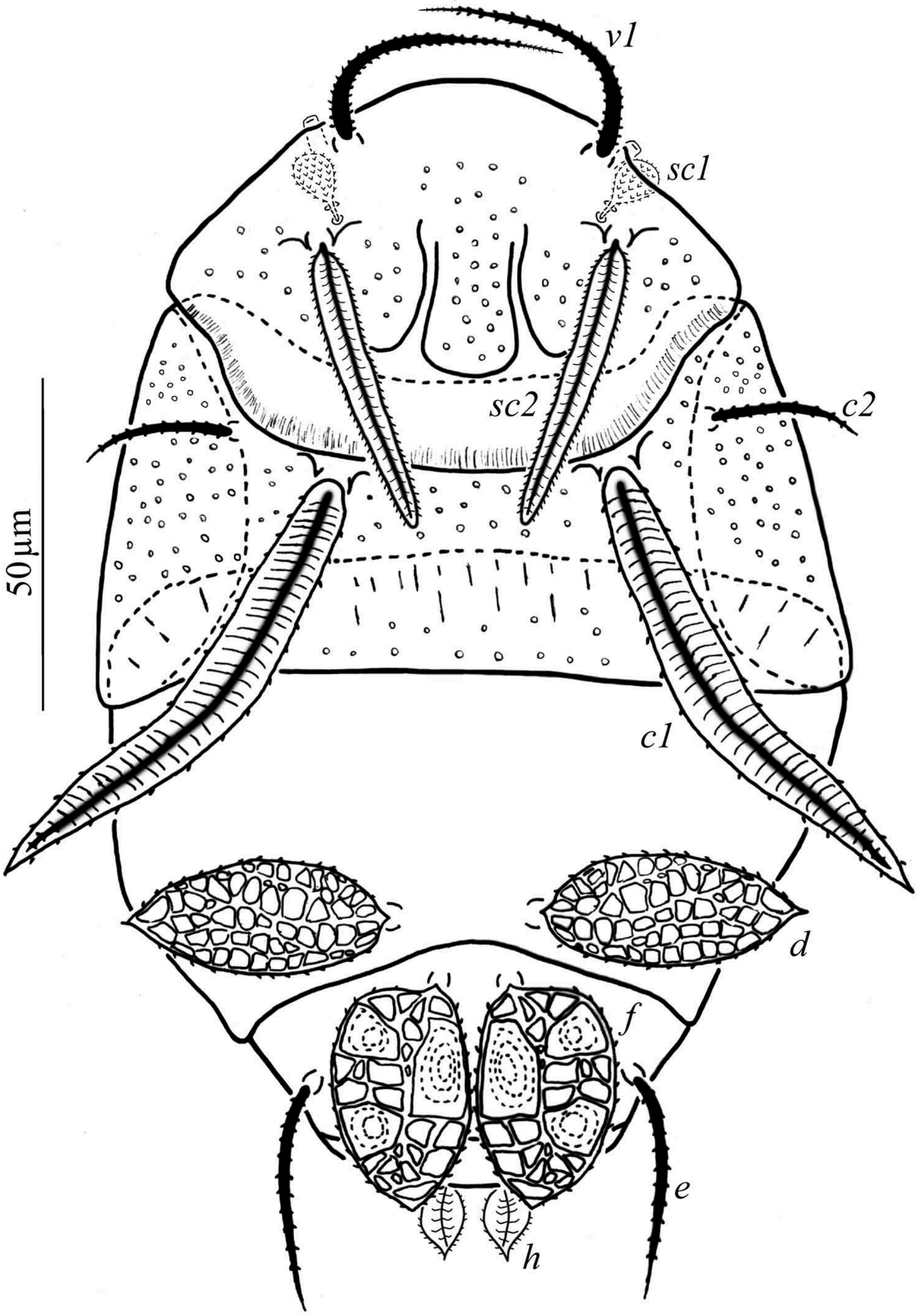

Figure 1. *Excelsotarsonemus cabrucae* sp. n. (female). Dorsal surface.

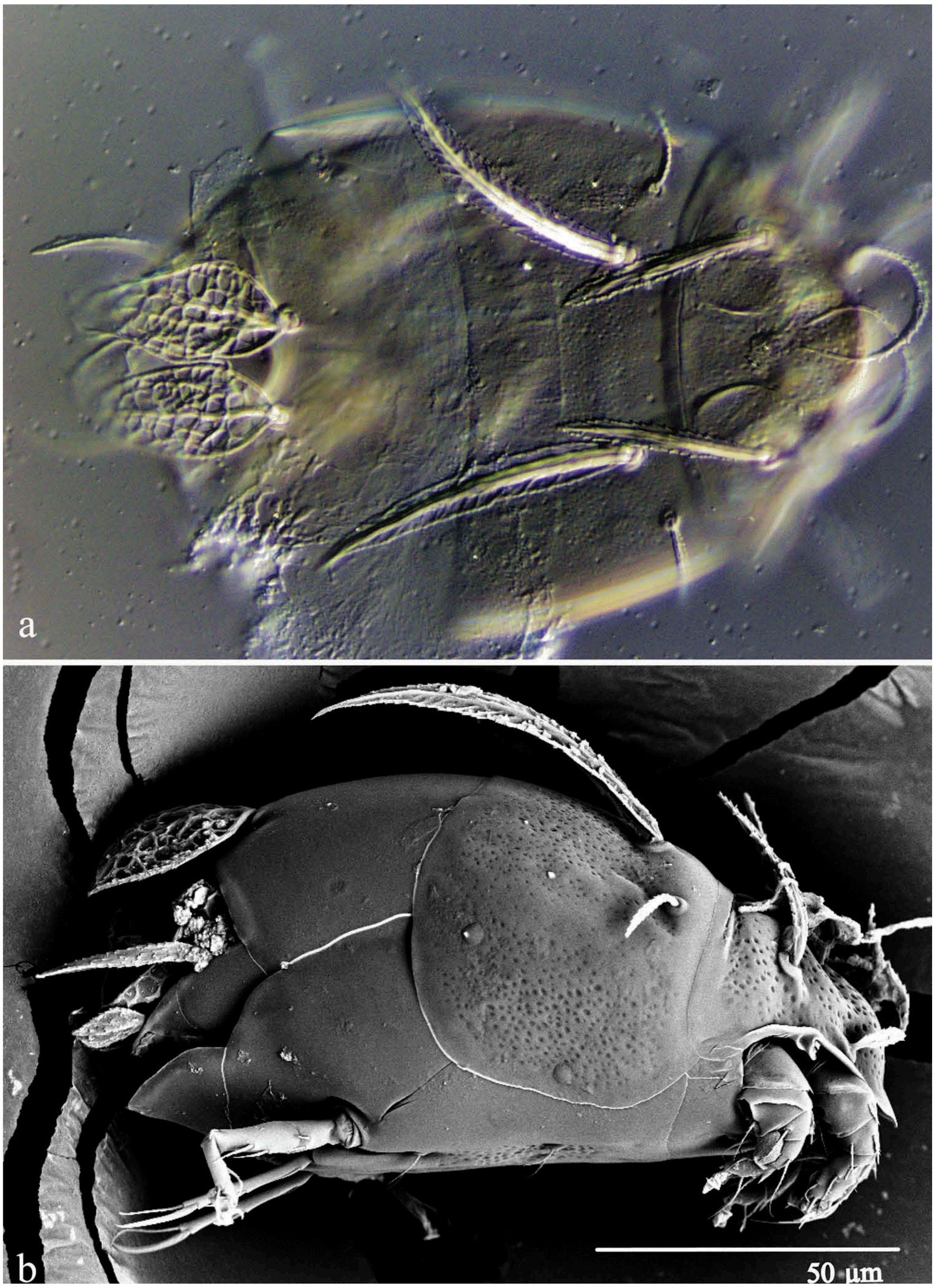

Figure 2. *Excelsotarsonemus cabrucae* sp. n. (female). Dorsal and lateral micrographs: (a) differential interference contrast and (b) scanning electron microscopy.

Material examined

A. heterophyllus leaves: 16-II-2016 (1); *T. cacao* bark: 03-V-2016 (2); *T. cacao* leaves: 03-V-2016 (4); *T. cacao* branches: 07-VI-2016 (2); *T. cacao* leaves: 14-IX-2016 (2).

Daidalotarsonemus lini Ochoa, Rezende & Lofego 2015: 25

Material examined

T. cacao leaves: 14-IX-2016 (1), 09-XI-2016 (3), 07-XII-2016 (1).

Remarks

This represents the first record of this species in the South America.

Daidalotarsonemus maryae Ochoa, Rezende & Lofego 2015: 33.

Material examined

T. cacao branches: 15-III-2016 (1), 14-VIII-2016 (2), 09-XI-2016 (3).

Remarks

This represents the first record of this species in the South America.

Daidalotarsonemus oliveirai Rezende, Lofego & Ochoa 2015: 3.

Material examined

A. heterophyllus leaves: 16-II-2016 (4), 19-X-2016 (7); *T. cacao* leaves: 16-II-2016 (10), 15-III-2016 (10), 03-V-2016 (9), 14-VIII-2016 (1), 14-IX-2016 (19), 19-X-2016 (48), 09-XI-2016 (13), 07-XII-2016 (85).

Daidalotarsonemus savanicus Ochoa, Rezende & Lofego 2015: 441.

Material examined

T. cacao leaves: 18-I-2016 (1), 14-IX-2016 (3), 07-XII-2016 (1).

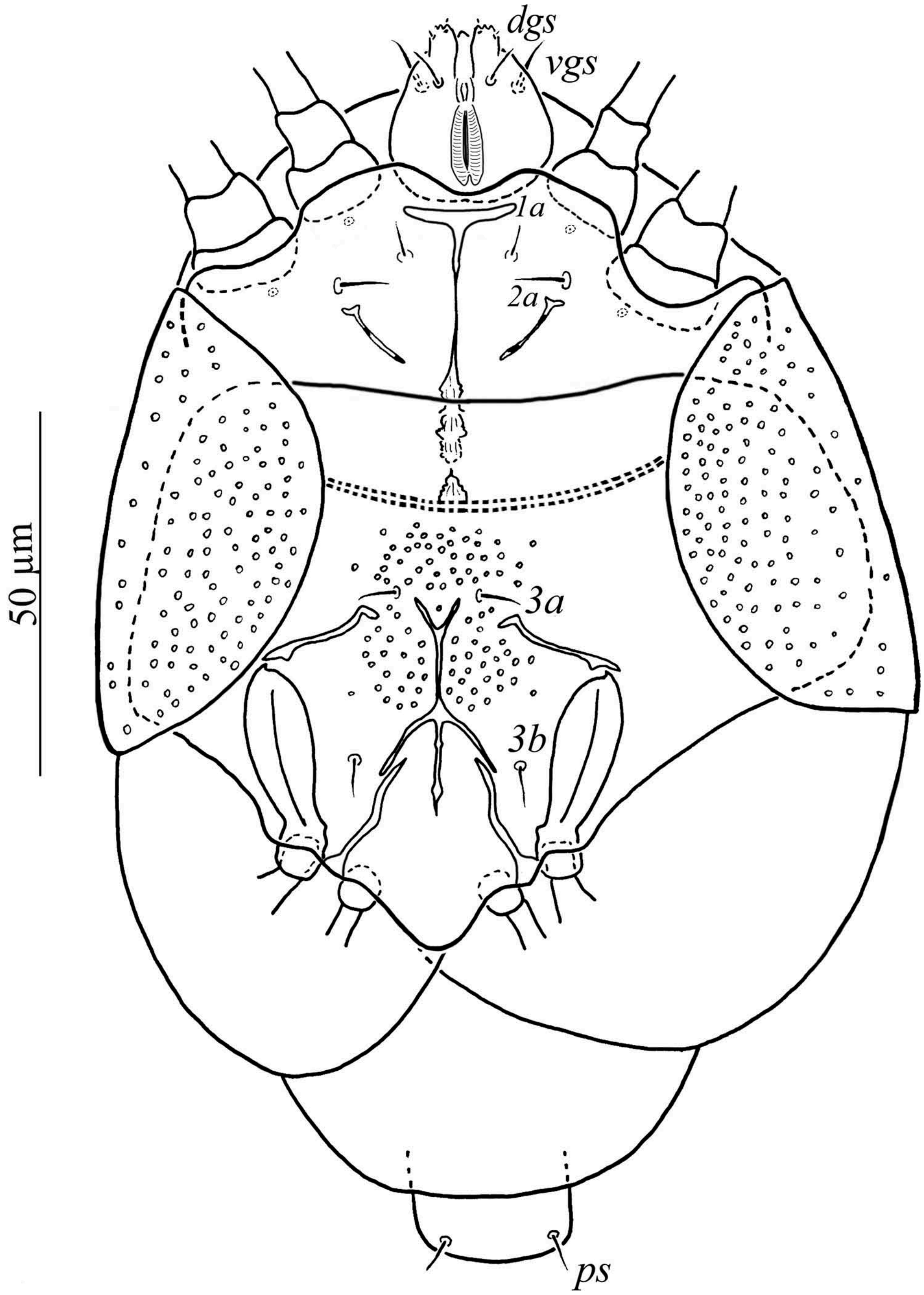

Figure 3. *Excelsotarsonemus cabrucae* sp. n. (female). Ventral surface.

Excelsotarsonemus caravelis Rezende, Lofego & Ochoa 2015: 18.

Material examined

A. heterophyllus leaves: 16-II-2016 (1), 12-IV-2016 (1), 14-VIII-2016 (7), 19-X-2016 (22); *T. cacao* leaves: 03-V-2016 (13), 14-VIII-2016 (127), 19-X-2016 (132), 09-XI-2016 (1), 07-XII-2016 (15);

Excelsotarsonemus tupi Rezende, Lofego & Ochoa 2015: 25.

Material examined

T. cacao leaves: 26-V-2016 (2), 07-VI-2016 (1), 19-X-2016 (1).

Excelsotarsonemus cabrucae Sousa, Lofego & Ochoa, **sp. n.** (Figures 1–7).

Material examined

A. heterophyllus leaves: 14-VIII-2016 (4); *T. cacao* leaves: 18-I-2016 (1), 16-II-2016 (1), 15-III-2016 (1), 07-XII-2016 (1).

Diagnosis

Excelsotarsonemus cabrucae sp. n. has apodeme 4 extending diagonally from the middle portion of the poststernal apodeme nearly to the base of femorogenu III and base of trochanter IV, whereas in *E. tupi* and *E. kaliszewskii*, apodeme 4 extends diagonally from the middle of the poststernal apodeme to base of seta *3b*.

Differential diagnose

Females of the new species *Excelsotarsonemus cabrucae* are similar to those of *E. kaliszewskii* Ochoa & Naskręcki (Ochoa et al. 1995) and *E. tupi* Rezende, Lofego & Ochoa (Rezende et al. 2015a), based on the similar shape of setae *c1* and *d*. However, the shape of setae *sc2* in *Excelsotarsonemus cabrucae* sp. n. is lanceolate,

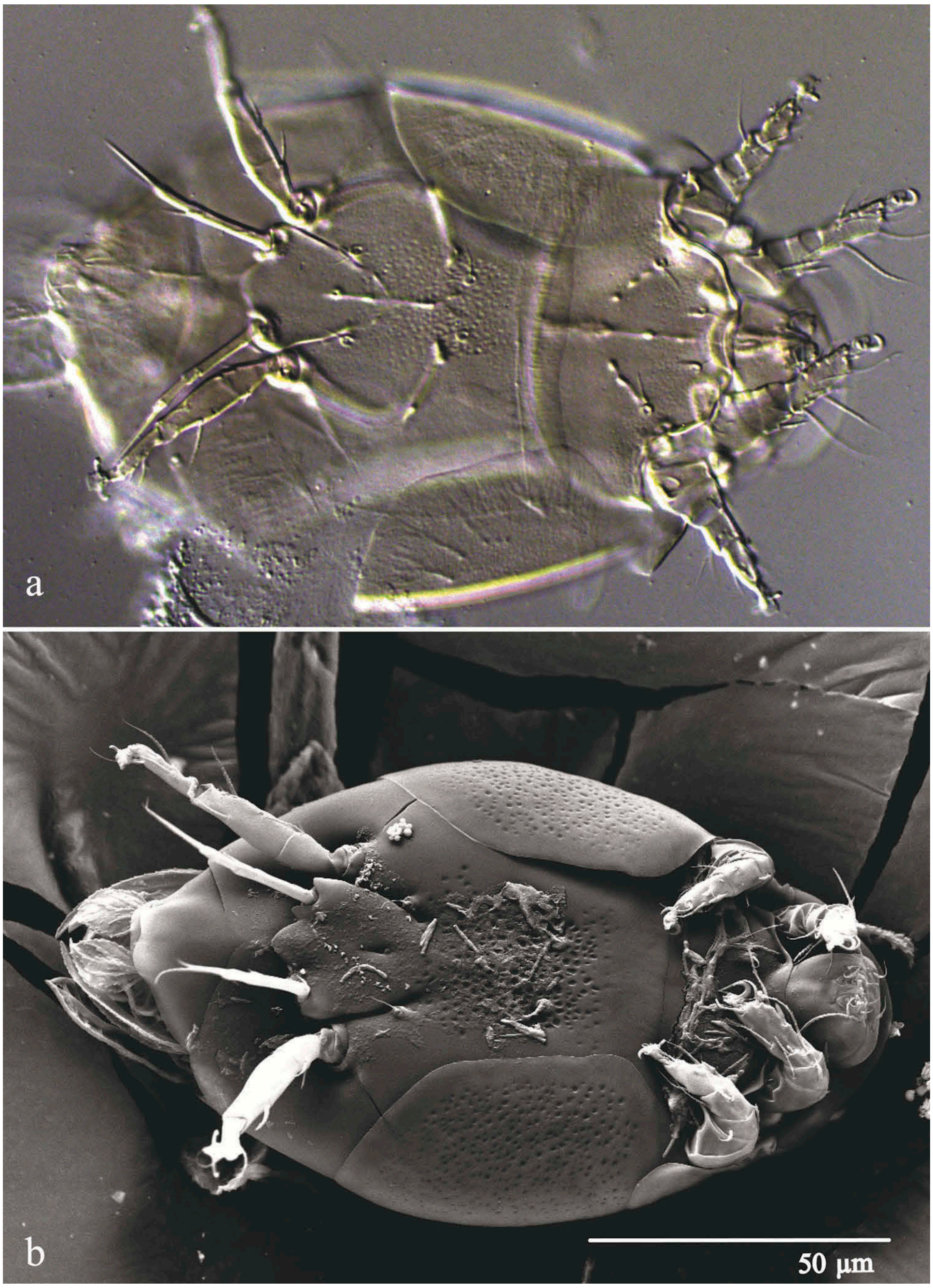

Figure 4. *Excelsotarsonemus cabrucae* sp. n. (female). Ventral micrographs: (a) differential interference contrast and (b) scanning electron microscopy.

whereas that of *E. tupi* and *E. kaliszewskii* are oblong and elongate.

Adult female (N = 7). Gnathosoma (Figures 3 and 4). completely covered by the prodorsum and subtriangular in ventral view, length **24**, 25 (23–26), maximum width **23**, 23 (20–25). Setae *dgs* **8**, 8 (7–11) and *vgs* **7**, 7 (5–7) smooth. Palps moderately long **7**, 7 (7–8), with 2 small subterminal setae and terminal projections. Pharynx fusiform **15**, 14 (12–15) long and **6**, 5 (5–6) wide at maximum width.

Idiosoma – dorsum (Figures 1, 2, and 6). length of all dorsal plates **165**, 168 (165–170), width at level of *c1* **108**, 105 (100–110). Stigma inserted proximally at the lateral notch of the prodorsal shield, near to base of setae *v1*. Lengths of the setae: *v1* **47**, 45 (40–47), *sc1* **14**, 15 (14–16), *sc2* **42**, 43 (40–45), *c1* **70**, 71 (65–75), *c2* **18**, 19 (18–24), *d* **35**, 38 (31–43), *e* **35**, 33 (30–37), *f* **35**, 35 (32–39), and *h* **15**, 16 (14–18). Maximum width of expanded setae: *sc2* **5**, 5 (4–5), *c1* **9**, 9 (8–9), *d* **20**, 19 (17–22), *h* **3**, 4 (3–4), and *f* **18**, 22 (18–25). All dorsal setae serrated. Bothridial seta *sc1* capitate. Setae *v1, c2*, and *e* setiform and slightly widened; *c1* and *sc2* lanceolate; *d, f*, and *h* ovate. Distances between dorsal setae: *v1–v1* **37**, 36 (34–39), *sc2–sc2* **43**, 45 (43–47), *v1–sc2* **18**, 18 (17–19), *c1–c1* **42**, 41 (40–42), *c2–c2* **67**, 66 (63–68), *c1–c2* **15**, 14 (13–15), *d–d* **19**, 21 (19–22), *f–f* **15**, 15 (14–15), *e–f* **18**, 19 (18–20), and *h–h* **10**, 11 (10–11). Seta *sc2* located laterally to *sc1*. Dorsal shield with tergite D longer than tergite C covered with tiny dimples, each around 0.3 (0.2–0.5) in diameter.

Idiosoma – venter (Figures 3, 4, 6, and 7). setae *1a* **5**, 5 (4–5), inserted on tubercles posteriad of apodemes 1; *2a* **8**, 8 (7–10), on anterior margins of apodemes 2; alveolar remnants of setae *1b* and *2b* present; *3a* **8**, 8 (7–9) near anteromedial margins of apodemes 3; *3b* **9**, 8 (7–9) on posterior margins of apodemes 4. Apodemes 1 conspicuous, fused to anterior end of prosternal apodeme. Apodemes 2 short and not fused to prosternal apodeme. Prosternal apodeme not clearly joined with sejugal apodeme, conspicuous from apodemes 1 to level of apodemes 2, ending in a diffuse area that reaches sejugal apodeme. Sejugal

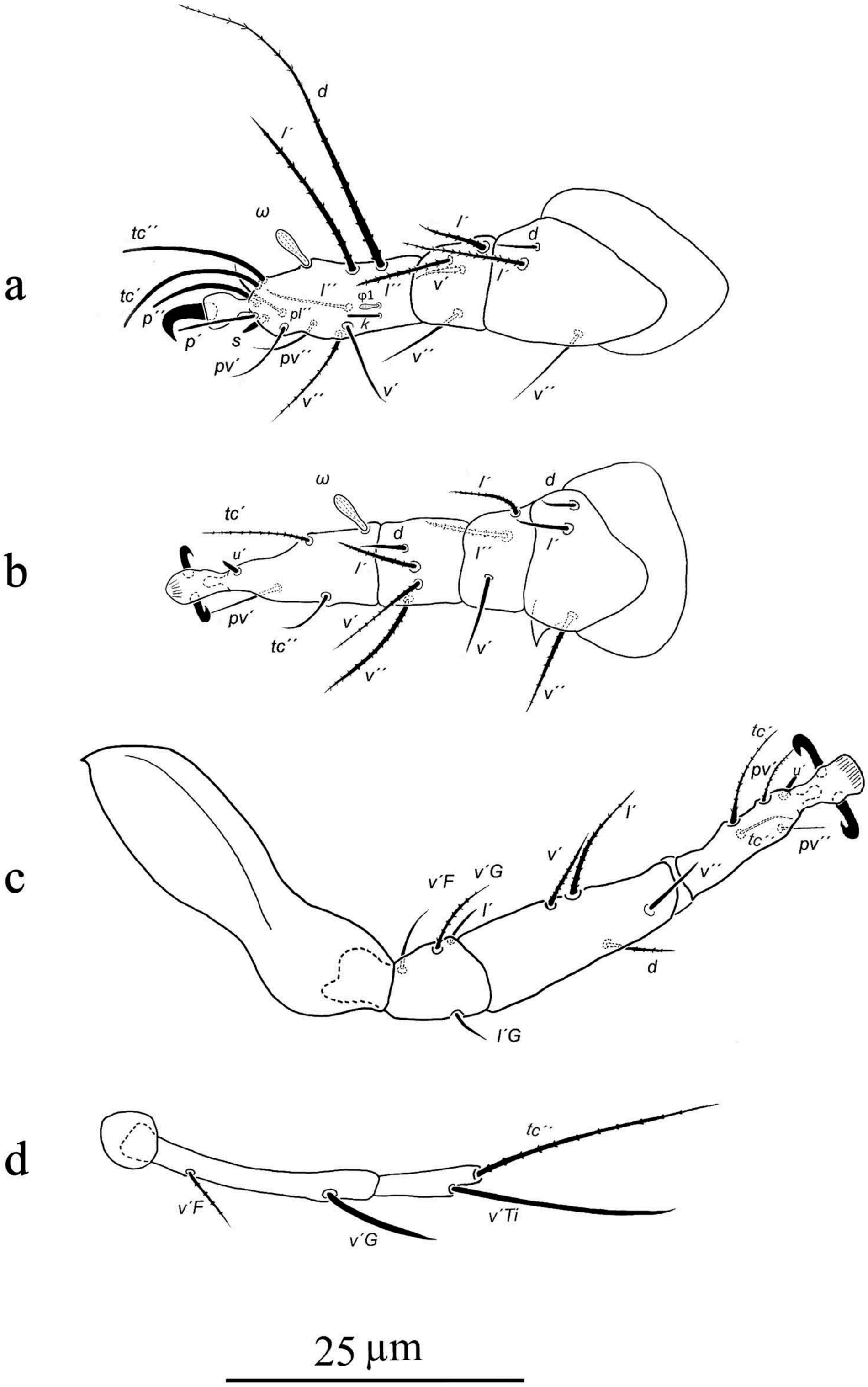

Figure 5. *Excelsotarsonemus cabrucae* sp. n. (female): (a) leg I, (b) leg II, (c) leg III, and (d) leg IV.

apodeme uninterrupted. Apodemes 3 with a constriction near trochanter III; apodemes 4 extending diagonally from middle of poststernal apodeme to base of seta *3b*. Fissures on coxisternal plate IV overlapping apodemes 4, reaching the anterior level of femorogena III and IV. Coxisternal plates covered with tiny dimples, each around 0.3 (0.2–0.5). Tegula wide **13**, 13 (13–15) and short **7**, 7 (7–8), with posterior margin slightly convex. Seta *ps* **4** smooth.

Legs (Figures 5 and 6). lengths: leg I **45**, 44 (42–47), leg II **41**, 43 (40–45), leg III **75**, 72 (70–75), leg IV **32**, 31 (30–33). Number of setae (solenidia in parentheses) on femur, genu, tibia, and tarsus, respectively: leg I: 3-4-6(1)+8(1), leg II: 3-3-4-4(1), leg III: 1+3-4-5, leg IV: 0-2-2. Claws medium-sized, hook-like, empodium in form of subcircular pad; pretarsal stalk expanded at bases of claws. Empodia of legs I, II, and III about the same size or slightly smaller compared to respective basal stalks. Tarsal solenidion *ω* of tibiotarsus I 5, stout, wider medially. Sensory cluster of tibia I incomplete, solenidion *φ*1 **2**, slender, capitate; famulus *k* **4**, 4 (3–4); both inserted approximately at the same level (Figure 6(a)). Seta *d* of tibia I **32**, 32 (32–34), serrate. Solenidion *ω* of tarsus II proximally inserted **5**, 5 (4–5) long, stout, wider medially. Seta *d* of tibia II **5**, 6 (5–6), smooth. Femorogenu IV **23**, 23 (22–24); tibiotarsus IV **8**, 8 (7–9). Length of leg IV setae: *v´* F **5**, 5 (5–7), *v´* G **9**, 9 (8–10), *v´* Ti **16**, 16 (14–18), and *tc*" **20**, 19 (17–20); setae *v´* Ti and *tc*" smooth; *v´* Ti falcate.

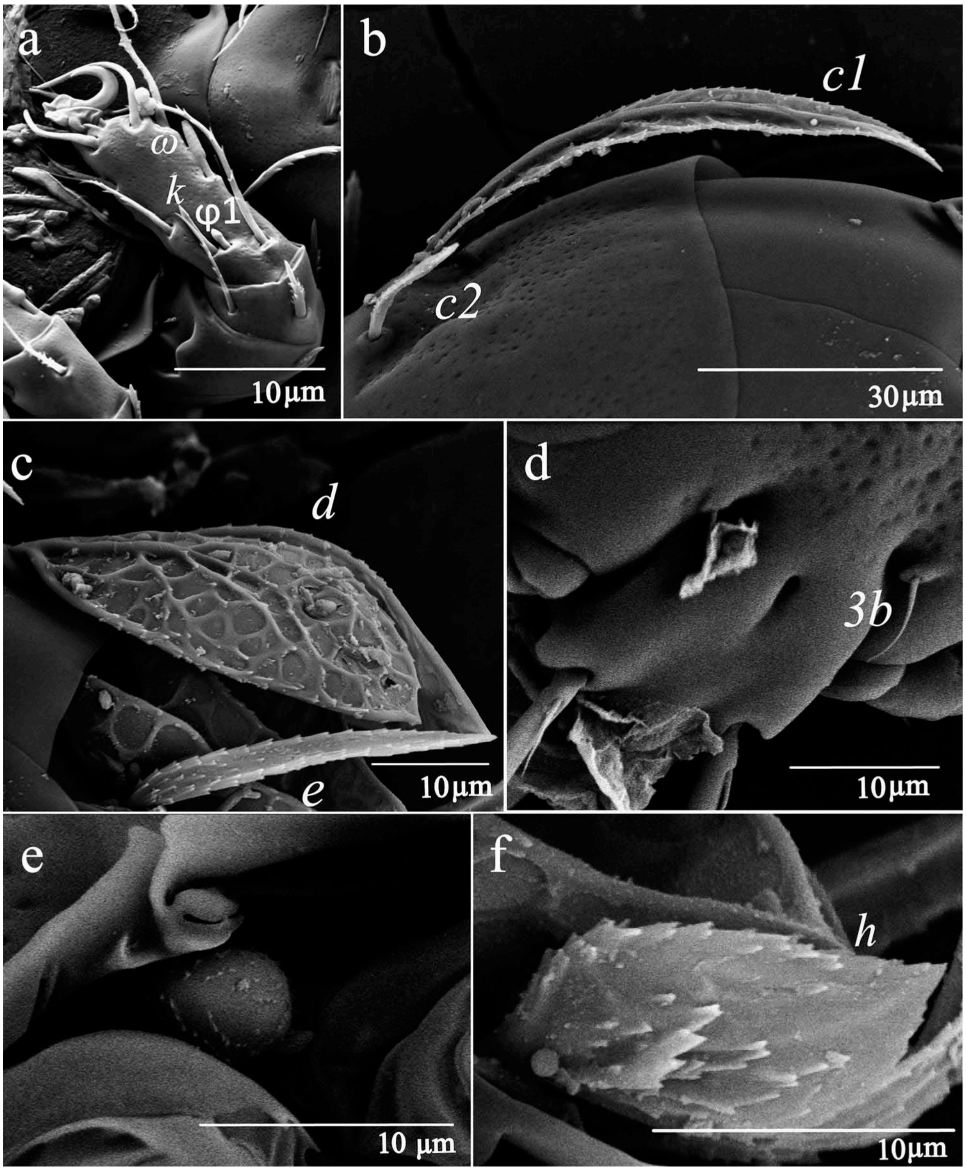

Figure 6. *Excelsotarsonemus cabrucae* sp. n. (female): (a) sensorial cluster of tibia I, (b) lateral view of the setae *c1* and *c2*, (c) lateral view of the setae *d* and *e*, (d) details of the tegula, (e) bothridial seta and stigma, and (f) details of the setae *h*.

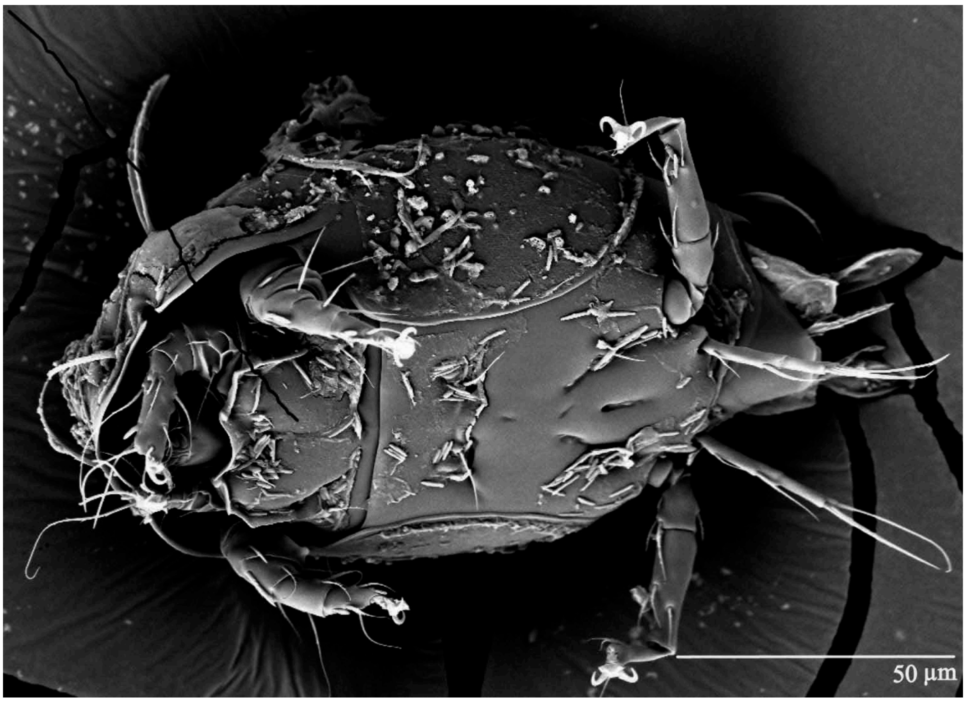

Figure 7. Presence of fungi and bacteria on part of lateral and ventral surface of the *Excelsotarsonemus cabrucae* sp. n.

Figure 8. *Excelsotarsonemus cabrucae* sp. n. Differential interference contrast micrograph of setae *d, f, e*, and *h*.

Adult male and larva. Unknown.

Type material

All female specimens were collected by André Silva Guimarães Sousa. Holotype and two paratypes on *Artocarpus heterophyllus* Lam and four paratypes on *Theobroma cacao* L., 14°47′47″ S and 39°10″15″ W, Ilhéus, Bahia, Brazil, 14-VIII-2016, 18-I-2016, 16-II-2016, 15-III-2016 E 07-XII-2016). Holotype and one paratype deposited in the Acari Collection of the Departamento de Zoologia e Botânica (DZSJRP), São José do Rio Preto, State of São Paulo, Brazil [AC-DZSJRP], two paratypes deposited at United States National Museum of Natural History, Smithsonian Institution, hosted in Beltsville, Maryland, USA, two paratypes deposited at Acari Collection of the Entomology Laboratory, in Universidade Estadual de Santa Cruz, Ilhéus, State of Bahia, Brazil [AC-UESC], and one paratype deposited at Escola Superior de Agricultura "Luiz de Queiroz," ESALQ, Universidade de São Paulo, Piracicaba, São Paulo, Brazil [AC-ESALQ].

Etymology

The species name *cabrucae* comes from the *cabruca* agrosystem which contains cacao trees in association with the jackfruit trees and other plants in the tropical forest. This agricultural system can be found in Brazil, mainly in the coastal region of the state of Bahia, where this mite species was found.

Remarks

Excelsotarsonemus cabrucae has a fissure which appears to extend from between bases of legs III and IV to level of seta *3b* where it overlaps slightly with posterolateral end of apodeme 4 and poststernal apodeme bifurcated anteriorly; similar structures are present in *Daidalotarsonemus puntarenensis* Rezende, Ochoa & Lofego and *Daidalotarsonemus serratus* Rezende, Ochoa & Lofego (Rezende et al. 2015c). Besides the genera *Excelsotarsonemus* and *Daidalotarsonemus*, such fissures overlapping apodemes 4 have also been observed in the genus *Metatarsonemus* (Attiah 1970; Lindquist 1985;

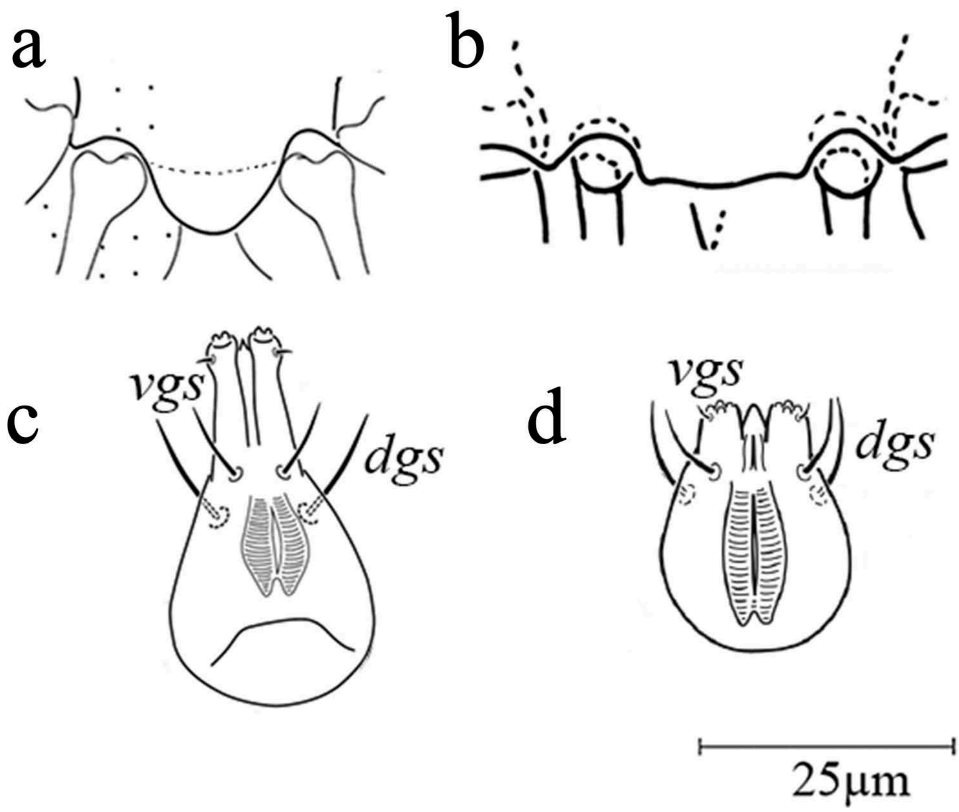

Figure 9. (a,b): Tegula of *D. annonae* and *D. maryae*, respectively; (c,d): Gnathosoma of *D. esalqi* and *D. oliveirai*, respectively.

Lofego et al. 2005). The dorsal shield has tergite D longer than tergite C, smooth, covered with tiny dimples, each around 0.3 (0.2–0.5) in diameter; setae *c1, c2, d, f*, and *e* are distinctly elongate. Setae *h* is short (±3°µm) and ovate shape, setae *sc2* and *c1* are lanceolate, and setae *f* has internal cavities and veins (Figure 8). The fissures on coxisternal plate IV overlapping apodemes 4 extend to the anterior level of femorogena III and IV. Females of the genus *Excelsotarsonemus* have most of their dorsal setae very wide and with intricate folding patterns (Rezende et al. 2015a).

Key to the species of *Daidalotarsonemus* from Brazil (based only on females):

1. Setae *c1* inserted near posterior border of tergite C; tegula rounded apically 2
– Setae *c1* inserted in the middle of the tergite C or near anterior margin of this plate; tegula truncated apically........ 4
2. Posterior dorsal setae *d* and *f* elliptical with two serrate veins; setae *sc2* falcate 3
– Posterior dorsal setae *d* and *f* ovate; setae *sc2* setiform ***D. annonae*** **Sousa, Lofego & Gondim Jr**. (Figures 9(a) and 10(a))
3. Setae *e* lanceolate; setae *c1* long (±30 µm); setae *d* narrower (±7 µm) and length (±31 µm).................... .. ***D. lini*** **Ochoa, Rezende & Lofego** (Figures 9(b) and 11(d))
– Setae *e* elliptical; setae *c1* long (±18 µm); setae *d* wider (±10 µm) and length (±25°µm);..... ***D. maryae*** **Ochoa, Rezende & Lofego** (Figures 9(c), 10(b), and 11(e))
4. Tergite C without rows of reticula. 5
– Tergite C with at least one row of reticula.................... 6
5. Setae *c1* elongate (±24 µm); setae *e* filiform.................... .... ***D. folisetae*** **Lofego & Ochoa** (Figures 9(g) and 11(a))
– Setae *c1* short (±11 µm); setae *e* cordate.............. ***D. oliveirai*** **Rezende, Lofego & Ochoa** (Figures 9(d), 10(d), and 11(b))
6. Setae *e* lanceolate (±3 µm); palps long (±17 µm)........................ ***D. esalqi*** **Rezende, Lofego & Ochoa** (Figures 9(e) and 10(c))
– Setae *e* broad (±15 µm); palps short (±9 µm).. 7
7. Setae *c1, c2* setiform.................... ***D. savanicus*** **Rezende, Lofego & Ochoa** (Figures 9(f) and 11(c))

Key to the species of *Excelsotarsonemus* of the world (based only on females):

1. Setae *sc2* setiform 2
– Setae *sc2* elliptical.... 3
2. **2** Setae *e* symmetrical, orbicular, and smooth; surface of tergite C smooth; absence of fissure flanking the tegula.......... .... ***E. kimhansenae*** **Ochoa & OConnor**
– Setae *e* asymmetrical; surface of tergite C with a U-shaped pattern; presence of fissure flanking the tegula .... ***E. caravelis*** **Rezende, Lofego & Ochoa**
3. Setae *d* symmetrical and elliptical in shape 4
– Setae *d* asymmetrical, bilobate, and heavily sculptured............ .... ***E. mariposa*** **Ochoa & OConnor**
4. Setae *c2* lanceolate; setae *e* slightly falcate and very elongate (±66 µm)............... .... ***E. kaliszewskii*** **Ochoa & Naskrecki**
– Setae *c2* setiform; setae *e* setiform and not very elongate (±30°µm) 5
5. **5** Setae *sc2* serrate oblong; without a fissure flanking the tegula.................. .... ***E. tupi*** **Rezende, Lofego & Ochoa**
– Setae Rezende, Lofego *sc2* lanceolate; with a fissure flanking the tegula .... ***Excelsotarsonemus cabrucae*** **sp. n.**

Discussion

In recent years, five different genera of tarsonemid have been found in the tropical forests of Brazil (*Excelsotarsonemus, Biscutulumnemus, Kaliszewskia, Ochoanemus*, and *Daidalotarsonemus*) (Ochoa et al. 1995; Ochoa and OConnor

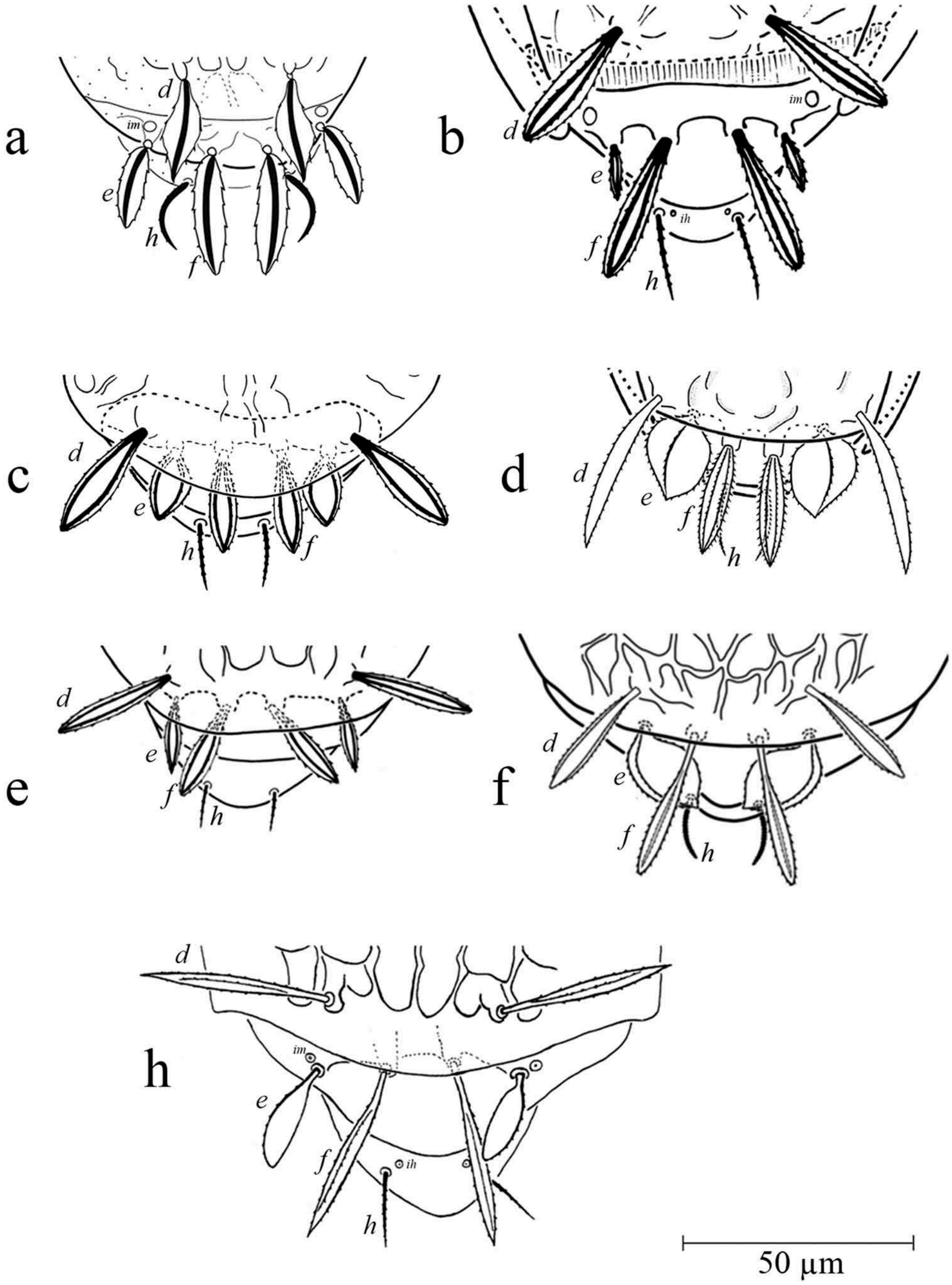

Figure 10. Shape of the posterior setae d, e, f, and h: (a) D. annonae, (b) D. lini, (c) D. maryae, (d) D. oliveirai, (e) D. esalqi, (f) D. savanicus, and (g) D. folisetae.

1998; Lofego and Feres 2006; Lofego et al. 2015, 2016; Rezende et al 2015a, 2015b; 2015c). *Daidalotarsonemus* and *Excelsotarsonemus* are among the most diverse tarsonemid genera in this biome, with several species recorded on cocoa trees (Ochoa et al. 1995; Ochoa and OConnor 1998; Rezende et al. 2015a). The species *D. lini* and *D. maryae* are recorded for the first time in Brazil in this study, as they were first described in Costa Rica (Rezende et al. 2015c). Both species were collected from the tropical forests in Costa Rica and Brazil.

In the rainforest, cocoa trees act as a host-trap for the adult female mites falling from the canopies, indicative of a closer association with the climate and general environment rather than a host plant association. The females found are possibly being trapped while in the stage of the wind dispersion from canopy host plants using their large erect setae on the top of their body like sails (Ochoa and OConnor 1998). In the future, the canopy plants need to be better investigated to find males, larvae, and eggs. Oliveira and Sousa observed some adult females of these genera, in particular *Daidalotarsonemus*, living on the bark of the trunk and the surface of the branches maybe indicating dietary associations with the saprophytic fungi and lichen.

These genera are commonly collected with fungi and bacteria present on the dorsal tergites and some modified setae (*e* and *f*). Possibly, they may be feeding on fungi, algae, or lichen in the different canopy ecosystems, and the wind dispersal of the mites with these organisms is in need of research (Ochoa et al. 1995; Ochoa and OConnor 1998; Rezende et al. 2015a). This is important because of the potential association of these mites with fungal and bacterial diseases in this ecosystem (Johns 1999). Therefore, although in this paper we do not intend to document direct mite associations with fungi and bacteria, some species of these genera might be useful indicators of biodiversity in stable environments since many species found in *cabruca* have been previously found only in undisturbed environments. The high

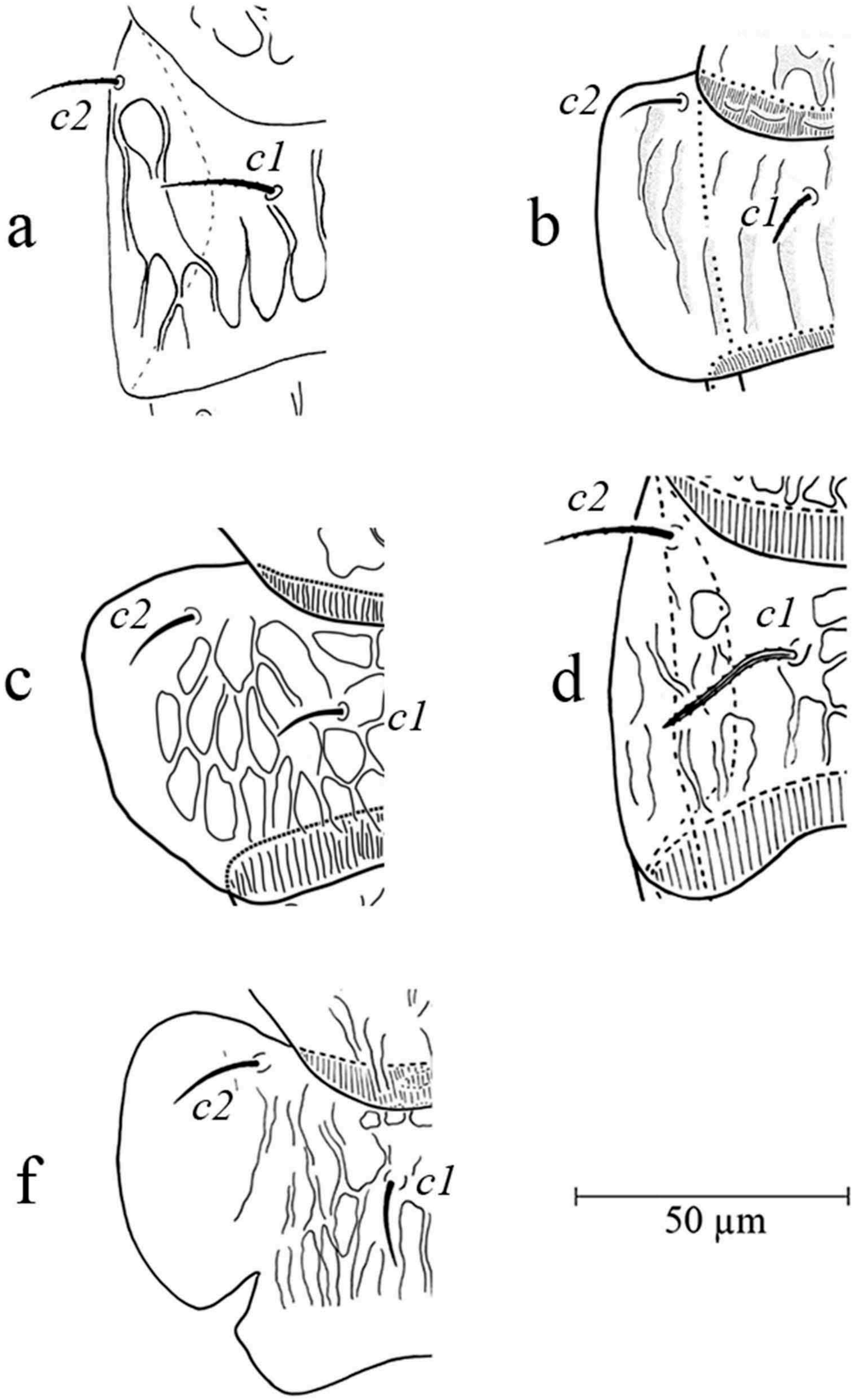

Figure 11. Shape of the dorsal setae *c1* and *c2*: (a) *D. folisetae*, (b) *D. oliveirai*, (c) *D. savanicus*, (d) *D. lini*, and (e) *D. maryae.*

number of tarsonemid species observed inhabiting this ecosystem shows the importance of preserving the *cabruca* system and its unique biodiversity. The great biodiversity present in this ecosystem is not limited to just tarsonemids but includes other animal groups as well (Faria et al. 2006, 2007). Future research in this work area presents a unique opportunity to observe interactions between these diverse mite communities to gain insight into their relations between other mite families that was also found in the same biome (de Carvalho et al. 2017). The *cabruca* system has been shown to be a balanced production system that contributes to the biodiversity conservation, since it is a low-impact economic activity that retains moisture, soil quality, biotic waste, and stable temperature.

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