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New morphological data for *Leonseius regularis* (De Leon) (Acari: Phytoseiidae) and a description of a new species of the genus from Brazil

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Abstract

The genus *Leonseius* Chant & McMurtry (Phytoseiidae: Typhlodrominae) was proposed to accommodate *Typhloseiopsis regularis* De Leon, 1965, a species with a troubled taxonomic history that was previously classified in the genera *Typhlodromus* Scheuten, *Diadromus* Athias-Henriot and *Chanteius* Wainstein. Due to its *Amblyseius*-like appearance (long *s4*, *Z4* and *Z5*, most other setae minute; atypical for a typhlodromine), the poor descriptions of reproductive structures (spermatheca, spermatodactyl), and probably also because at the time it was a monotypic genus, researchers over the years have based the species-level identification of *Leonseius regularis* mainly on dorsal and ventral idiosomal chaetotaxy and setal length. In a survey of phytoseiid mites conducted in cacao plantations (*Theobroma cacao* L.: Malvaceae) of the municipality of Ilhéus, Bahia, northeastern Brazil, we identified two distinct morphotypes among specimens initially identified as *L. regularis*. Herein we provide new morphological data for *L. regularis* to complement the original description and previous redescriptions, and then describe *Leonseius elbanhawyi* Carvalho, Ferragut & Oliveira **sp. nov.**, from cacao, distinguishing it from *L. regularis* by its spermatheca and spermatodactyl. Also, the diagnosis of *Leonseius* is amended.

Key words: phytoseiid mites, Typhlodrominae, taxonomy, Neotropical, predatory mites, spermathecae

Introduction

Leonseius regularis (De Leon 1965), the type species of *Leonseius* Chant & McMurtry, 1994, was originally described in the genus *Typhloseiopsis* De Leon, based on the holotype female, although the original description specifies that the type material includes another female and two nymphs collected with the holotype from mango (*Mangifera indica* L.; Anacardiaceae) in Puerto Rico. The male was described from Guyana only a year after the original description of the female, this time as *Diadromus regularis* and accompanied by a complementary description of the female based on specimens from the same country (De Leon 1966). De Leon (1967) reported specimens from Trinidad as *Chanteius regularis*. De Leon (1966) considered that the specimens from Guyana should probably be a separate species because they "have some of the long setae of the dorsal shield and the macrosetae appreciably shorter than do the specimens from Puerto Rico and Trinidad". He stressed

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though that “More specimens, however, and both sexes are needed from all these areas to determine the ranges of variation and to establish limits for the members of the complex”, but provided no information on possible differences in the reproductive structures of *L. regularis*.

There have been several partial redescriptions of *L. regularis* (*e.g.*, Moraes *et al.* 1991, 2013; Denmark *et al.* 1999; Rocha *et al.* 2015; Souza *et al*. 2015), most of which included only measurements. Although reproductive structures, specifically the female spermatheca and the male spermatodactyl, have been used as key characters for species delimitation in Phytoseiidae for over 40 years (Dosse 1958; Schuster & Smith 1960; De Leon 1961; Athias-Henriot 1977), available descriptions of putative examples of *L. regularis* are limited in details for both of these structures. The spermatheca has been illustrated for the type material (De Leon 1965; Chant & Yoshida-Shaul 1983; Chant & McMurtry 1994, 2007) and for female specimens from Guyana (De Leon 1966), Trinidad (De Leon 1967) and Brazil (El-Banhawy 1984). The spermatodactyl has been illustrated for males from Guyana (De Leon 1966) and Brazil (El-Banhawy 1984).

Over these decades of troubled taxonomic history, *L. regularis* has also been classified in the genus *Typhlodromus* Scheuten (Chant & Yoshida-Shaul 1983), before being isolated into a monotypic genus, *Leonseius*, within the subfamily Typhlodrominae, tribe Typhloseiopsini. This species has now been reported from Guadeloupe, Trinidad, Costa Rica, Puerto Rico, Colombia, Guyana and particularly Brazil (Demite *et al*. 2018), where it seems to be widely distributed, with records in the following states: Acre (Nuvoloni *et al.* 2015a), Bahia (Nuvoloni *et al.* 2015b; Souza *et al*. 2015; Argolo *et al.* 2017), Espírito Santo (El-Banhawy 1984), Minas Gerais (Silva *et al.* 2010), Pernambuco (Gondim Jr. & Moraes 2001; Vasconcelos *et al.* 2006; Sousa *et al.* 2015), Rio Grande do Sul (Rocha *et al.* 2015) and São Paulo (Denmark & Muma 1973; Gondim Jr. & Moraes 2001; Castro & Moraes 2010; Moraes *et al.* 2013).

Cacao is widely cultivated in the southeastern region of Bahia state, where the municipality of Ilhéus is located. That large state is located in northeastern Brazil. In a survey of phytoseiid mites conducted in cacao plantations in that municipality, we distinguished two morphotypes within a group of specimens initially identified as *L. regularis*, based on differences in the shape of the spermatheca and the spermatodactyl. It was concluded that the morphotypes corresponded to different species. The objective of this work is to offer new morphological data for *L. regularis* and to describe a new, closely related species. Based on the morphological information obtained, the diagnosis of *Leonseius* is amended.

Materials and methods

Cacao leaves were collected from two plantations in Ilhéus, Bahia, northeastern Brazil: at an experimental area of the ‘Comissão Executiva do Plano da Lavoura Cacaueira’ (CEPLAC), 14°45'35"S, 39º13'49"W, in March 2015, and at the campus of the Universidade Estadual de Santa Cruz (UESC), 14º47'49"S, 39º10'23"W, in August 2016. Leaves were examined under a stereomicroscope (Leica EZ4) in the laboratory. *Leonseius* females and males were mounted in Hoyer’s medium on microscope slides and examined under phase contrast and differential interference contrast microscopy (Leica DM 2500, Nikon Eclipse Ni and Olympus BX50).

Given that initial examinations suggested that those two populations differed in relation to the shape of the spermatheca and spermatodactyl, we selected the 10 best female and five best male specimens (in terms of positions on slides) from each site to assess further those differences. Measurements were taken using a graduated eye-piece. Drawings were prepared with drawing tubes attached to the microscopes. The drawings were scanned and finalized using Adobe Illustrator CC

Series®. Photomicrographs of spermathecae and spermatodactyls were also taken to complement line drawings.

Setal notations follow those of Lindquist and Evans (1965) as applied by Rowell *et al.* (1978) to the dorsal idiosoma of phytoseiids, and Chant and Yoshida-Shaul (1991) for the ventral idiosoma. The formulae used for idiosomal setal pattern follow Chant and Yoshida-Shaul (1992). Notations used for lyrifissures (poroids) and gland openings (solenostomes) are those proposed by Athias-Henriot (1975) and Athias-Henriot (1971) for the dorsal and ventral idiosoma, respectively. Setal formulae of Evans (1963) are used for leg chaetotaxy and notations of Muma *et al.* (1971) for macrosetae. Terminology for the spermathecal apparatus and spermatodactyl follows that described by Beard (2001).

Voucher and type specimens were deposited in the Acarological Collection of Universidade Estadual de Santa Cruz (UESC), Ilhéus, Bahia, Brazil [AC-UESC], of Departamento de Zoologia e Botânica, Universidade Estadual Paulista (UNESP), São José do Rio Preto, São Paulo, Brazil [AC-DZSJRP], and of Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ), Universidade de São Paulo (USP), in Piracicaba, SP, Brazil [AC-ESALQ].

Taxonomy

Family: Phytoseiidae Berlese
Subfamily: Typhlodrominae Wainstein
Tribe: Typhloseiopsini Chant & McMurtry
Genus: *Leonseius* Chant & McMurtry

Type species: *Typhloseiopsis regularis* De Leon

The following revised diagnosis of *Leonseius* is a compilation of the characters presented in the original diagnosis (Chant & McMurtry 1994) and in Chant and McMurtry (2007), supplemented by additional characters observed in specimens examined in this study.

Diagnosis

A member of the Typhlodrominae with the following combination of characters: Female and male dorsal setal patterns 12A:6B, including *s6*, excluding *S2* and *S4*. Female dorsal shield broad, deeply constricted near level of seta *R1*, with podonotal region of dorsal shield 1.04x wider than opisthonotal region; shield margin slightly concave between setae *Z5*. Male dorsal shield oval, not constricted at level of *R1*. Female and male with a combination of elongate (*s4*, *Z4*, *Z5*), moderately long (*j1*, *j3*) and minute (all other) dorsal setae, all of them smooth, except *Z4* and *Z5* slightly barbed; *z4* more or less aligned with *z2–s4* and inserted slightly mesad of *z3–s4* alignment. Female sternal shield with setae *st1–st3*, metasternal platelets with seta *st4* and genital shield with seta *st5*. Male sternogenital shield with setae *st1–st5*. Female and male caudoventral patterns *JV*-4:*ZV* and *JV*-4:*ZV*-1,3, respectively. Ventrianal shield much longer than wide in female, and triangular in male (but fused anteromedially with prolongation of parapodal shields), with four pairs of preanal setae, and a pair of preanal gland openings (*gv3*) posterolaterad of setae *JV2* in female and posteriad of *JV2* in male. Chelicera with fixed digit multidentate. Spermathecal calyx narrowly to broadly tubular, atrium small to large, variously shaped; major duct varying from narrower to as broad as the calyx. Spermatodactyl with foot short, simple and slightly angled relative to shaft, or bearing two short, hook-like projections. One macroseta present on each of genua I–IV, tibiae III–IV, and tarsi II–IV, and two on tibia I, tarsus I and tibia II.

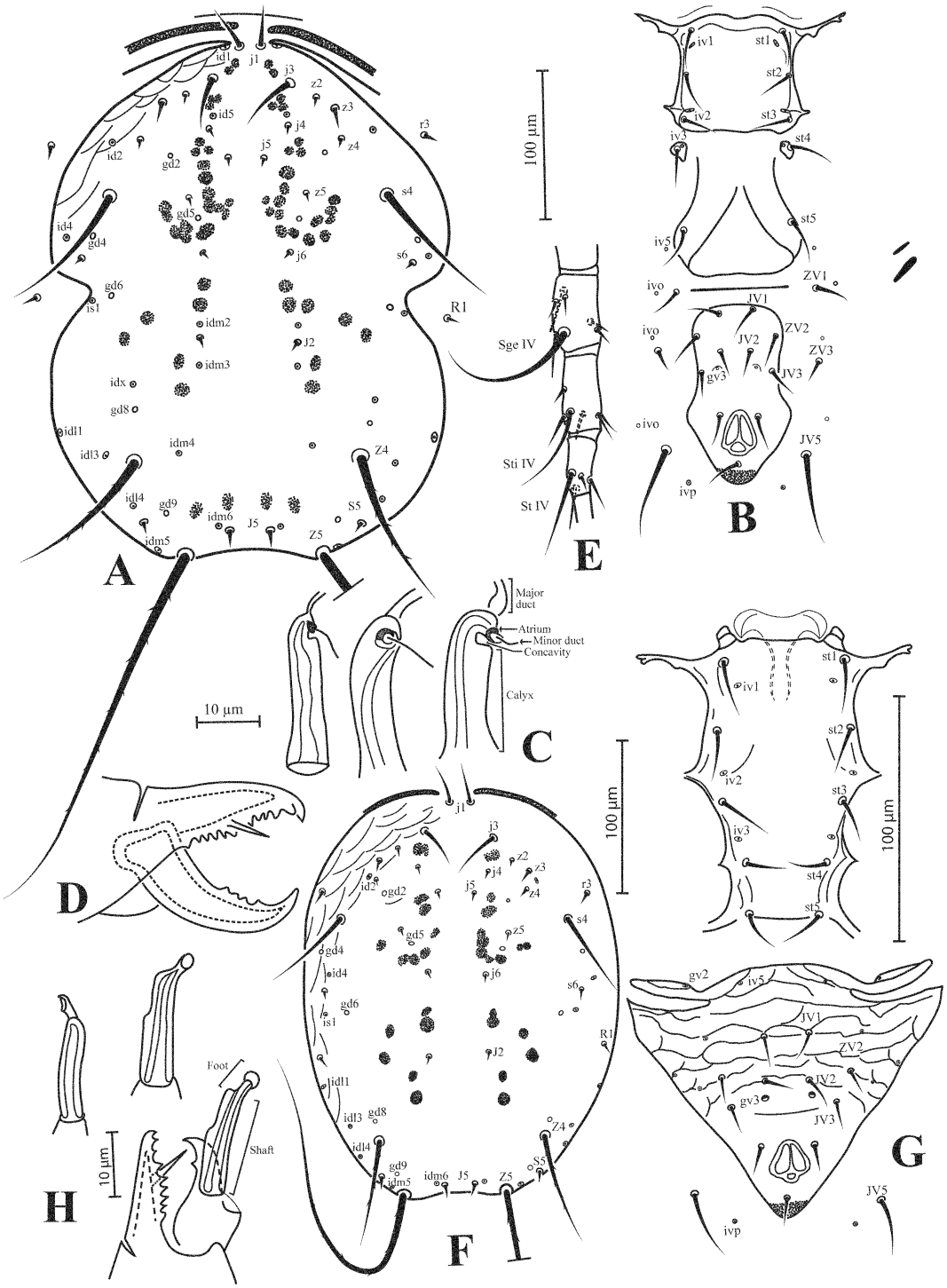

FIGURE 1. *Leonseius regularis*. A. Female dorsal shield. B. Female ventral idiosomal shields. C. Female spermatheca, three different views. D. Female cheliceral digits, antiaxial view. E. Female leg IV, anterolateral view. F. Male dorsal shield. G. Male ventral idiosomal shields. H. Male chelicera and spermatodactyl, three different views. Note: all illustrations drawn from specimens collected in this study.

***Leonseius regularis* (De Leon, 1965)**
(Figs. 1–2)

Typhloseiospsis regularis De Leon, 1965: 122.
Diadromus regularis, De Leon, 1966: 100.
Chanteius regularis, De Leon, 1967: 16.
Typhlodromus regularis, Chant & Yoshida-Shaul, 1983: 1034.

FEMALE (measurements in Table 1; n = 10)

Dorsal idiosoma (Fig. 1A). Dorsal shield lightly sclerotized, with smooth and acuminate setae, except *Z4* and *Z5* slightly barbed. With 14 discernible pairs of dorsal lyrifissures (putatively lacking *id6*, *idm1*) and six pairs of gland openings (*gd2, gd4, gd5, gd6, gd8, gd9*), putatively lacking *gd1*.

Ventral idiosoma (Fig. 1B). All setae smooth and acuminate. Ventral setal pattern *JV*-4:*ZV*. Sternal shield lightly sclerotized, smooth, except for marginal striations, quadrate, with three pairs of setae and posterior margin straight. Seta *st4* on metasternal platelets. Genital shield lightly sclerotized, smooth. Ventrianal shield lightly sclerotized, smooth, vase-shaped, with rounded anterolateral corners, lateral margins concave anteriad of anus; with four pairs of preanal setae (*JV1–3*, *ZV2*) and a pair of preanal gland openings (*gv3*) posterolaterad of *JV2*. Soft opisthogastric cuticle with three pairs of setae (*JV5*, *ZV1*, *ZV3*).

Peritreme (Fig. 1A). Extending to level of *j1*.

Spermatheca (Figs. 1C; 2A–B). Calyx broadly tubular, with a concavity immediately distad of the small atrium. Major duct markedly narrower than calyx and thin-walled.

Chelicera (Fig. 1D). Fixed digit with 10–12 teeth, including one subapical, laterally offset tooth; movable digit with 3–4 contiguous teeth.

Legs (Fig. 1E). Leg chaetotaxy typical for Phytoseiidae (*sensu* Evans 1963 and Rowell & Chant 1979), except for these segments which vary among species: genu II with 7 setae, 2–2/0, 2/0–1; genu III with 7 setae, 1–2/1, 2/0–1. Macrosetae acuminate, one on genua I–IV, tibiae III–IV, and tarsi II–IV, and two on tibia I, tarsus I and tibia II.

MALE (measurements in Table 1; n = 5)

Dorsal idiosoma and *peritreme* (Fig. 1F). Dorsal shield ornamentation, chaetotaxy, setal form, gland openings, lyrifissures and peritreme as in female, except with: *r3* and *R1* captured by the shield; more reticulation anteriorly and laterally due to the larger area covered by the shield; *R1* appears inserted more posteriorly than in female, near level of *J2*; some lyrifissures (*id1*, *id5*, *idm2–4*, *idx*) could not be discerned. Shield and setae moderately smaller/shorter than in female (Table 1).

Ventral idiosoma (Fig. 1G). Setae smooth and acuminate. Ventrianal shield triangular, reticulate anteriad of level of *JV3*; with four pairs of preanal setae (*JV1–JV3* and *ZV2*) and a pair of preanal gland openings (*gv3*) posteriad of *JV2*. Soft opisthogastric cuticle with one pair of setae (*JV5*).

Chelicera (Figs. 1H; 2C). Fixed digit with 8–10 teeth and movable digit with a single tooth. Spermatodactyl short; shaft thick, more or less straight; foot (*i.e.*, attenuate apical portion) short and simple, at slight angle to shaft, bulbous or blunt apically (though can appear concave sometimes, with withered apices; see left image, Fig. 1H).

Legs. Chaetotaxy and macrosetae as in female.

Material examined

27 females and six males collected in 11.III.2015 from *Theobroma cacao* L. (Malvaceae) leaves at Comissão Executiva do Plano da Lavoura Cacaueira (CEPLAC), 14°45'35"S, 39º13'49"W, Ilhéus, Bahia, Brazil, by A.N. Carvalho and P.S. Argolo; mounted in Hoyer's medium. Nine females and two males deposited at AC-UESC, Ilhéus, Bahia, Brazil; nine females and two males deposited at

AC-DZSJRP; nine females and two males deposited at AC-ESALQ. Also examined, holotype female collected on 28.VIII.1963 from *Mangifera indica* at Cayey Montain, Puerto Rico by D. De Leon, remounted in Hoyer's in 1974 (Harvard University Museum of Comparative Zoology Collection of Arachnida, slide number 2103).

TABLE 1. Measurements (micrometers) of different structures of females and males of *Leonseius regularis* and *L. elbanhawyi* **sp. nov.** for specimens collected during this study, for the holotype of *L. regularis* (data taken from Chant & Yoshida-Shaul 1983), and for voucher specimens studied by El-Banhawy (1984) measured by us. Average value is followed by minimum and maximum values (in parentheses).

Characters	*L. regularis* (newly collected)		L. regularis holotype[1]	*L. elbanhawyi* sp. nov. (newly collected)		*L. elbanhawy* sp. nov. specimens of El-Banhawy (1984)	
	♀ (n=10)	♂ (n=5)	♀	♀ (n=10)	♂ (n=5)	♀ (n=4)	♂ (n=1)
DSL	339(329–348)	258(247–285)	343	367(343–380)	257(242–269)	352(323–378)	292
DSW	249(220–270)	186(184–192)	281	262(230–270)	189(176–196)	239(214–252)	165
j1	24(23–26)	20(20–23)	31	28(26–30)	22(20–24)	27(25–29)	–
j3	35(34–38)	28(28–30)	42	37(34–40)	32(30–34)	37(35–40)	30
j4	4(3–5)	3(3–4)	3	4(4–5)	4(3–5)	4(3–4)	3
j5	4(3-4)	3(3–4)	5	4(4–4)	4(4–5)	4(3–4)	3
j6	4(4-5)	5(4–5)	4	5(4–5)	5(5–6)	5(4–5)	–
J2	5(5–6)	5(4–5)	4	6(5–6)	6(5–6)	5(4–6)	5
J5	7(6–7)	6(5–6)	5	8(8–9)	7(6–7)	7(6–8)	7
z2	3(2–3)	3(3–4)	4	4(3–4)	4(3–4)	3(3–4)	–
z3	10(6–13)	8(7–9)	10	11(10–14)	10(9–11)	11(8–12)	–
z4	4(3–4)	5(4–5)	5	5(4–5)	5(5–6)	4(4–5)	3
z5	4(3–4)	4(4–5)	4	4(3–4)	4(3–4)	3 (3–3)	5
Z4	96(93–100)	66(63–68)	106	96(88–100)	66(63–70)	90(86–93)	101
Z5	271(264-277)	200(189–204)	295	271(252–290)	192(176–206)	257(239–270)	188
s4	85(73–99)	53(50–55)	100	80(74–86)	51(45–58)	71(66–75)	55
s6	7(6–10)	6(6–7)	5	8(7–9)	7(6–7)	6(6–7)	9
S5	6(5–6)	5(5–6)	6	6(6–8)	6(4–7)	6(5–6)	–
r3	8(6–9)	8(8–10)	9	10(9–11)	10(10–11)	9(8–10)	–
R1	8(7–8)	7(6–7)	7	9(8–10)	8(7–8)	8(7–9)	7
st1-st3[2]	60(58–63)	–	78	60(60–61)	–	58(55–60)	–
st1-st5[2]	–	110(105–113)	–	–	104(101–106)	–	108, 115
st2-st2[2]	69(65–71)	55(53–57)	76	69(65–72)	54(49–56)	66(62–70)	55
st5-st5[2]	70(68–73)	–	82	74(70–76)	–	72(69–75)	–
JV5	55(47–61)	24(22–25)	66	60(56–63)	29(25–32)	50(30–63)	30
VASL	114(110–118)	109(98–116)	116	114(100–124)	107(95–115)	108(100–115)	90
VASW-ant	57(48–68)	–	58	56(51–62)	143(135–152)	58(55–61)	–
VASW-post	69(65–76)	–	69	72(68–77)	–	70(64–75)	–
VASW-Male	–	139 (131–144)	–	–	143(135–152)	–	115
Calyx[3]	23(20–28)	–	–	13(11–15)	–	–	–
FD[4]	30(29–32)	21(20–22)	–	32(28–35)	23(20–24)	30(30–30)	–
MD[5]	31(28–34)	20(19–21)	28	30(28–33)	20(18–20)	30(30–30)	–
SgeI[6]	50(46–54)	34(33–35)	52	54(52–55)	37(35–38)	51(48–53)	–
StiI[7] *(proximal)*	36(34–38)	28(27–28)	–	38(36–40)	29(26–31)	36(35–38)	–

.....continued on the next page

TABLE 1. (Continued)

Characters	*L. regularis* (newly collected)		L. regularis holotype[1]	*L. elbanhawyi* sp. nov. (newly collected)		*L. elbanhawy* sp. nov. specimens of El-Banhawy (1984)	
	♀ (n=10)	♂ (n=5)	♀	♀ (n=10)	♂ (n=5)	♀ (n=4)	♂ (n=1)
StiI (distal)	54(50–59)	34(36–32)	58	56(53–61)	36(33–39)	55(50–58)	–
StI[8] *(proximal)*	48(45–51)	33 (31–35)	52	52 (46–56)	35 (33–39)	49(45–52)	33
StI (distal)	45(43–50)	31(30–32)	48	48(45–52)	32(30–36)	43(42–45)	–
SgeII	38(36–39)	27(25–28)	43	41(37–43)	31(27–33)	40(38–42)	–
StII	31(28–32)	23(22–25)	–	31(30–33)	25(23–26)	31(30–31)	–
StiII (paraxial)	29(26–31)	22(22–23)	–	31(29–34)	22(22–23)	29(27–30)	–
StiII (antiaxial)	26(24–28)	21(20–22)	–	29(27–32)	22(22–22)	28(26–29)	–
StIII	31(28–35)	24(22–28)	–	33(29–38)	25(24–26)	30(27–33)	27
SgeIII	49(45–53)	34(33–35)	51	50(48–52)	36(33–38)	49(47–51)	34
StiIII	33(30–36)	26(25–28)	41	35(32–37)	28(25–31)	34(32–37)	32
SgeIV	108(101–116)	62(58–66)	109	113(107–124)	66(63–70)	108(103–113)	60
StiIV	56(53–63)	39(35–40)	67	60(57–63)	42(36–47)	58(52–64)	36
StIV	48(46–52)	41(40–43)	52	52(49–55)	43(41–47)	51(49–53)	42
Spermatodactyl shaft	–	20(19–21)	–	–	22(19–23)	–	19
Spermatodactyl foot	–	3(3–4)	–	–	5(4–6)	–	4

DSL: Dorsal shield length, measured along the midline, from *j1* level to the posterior margin of the shield; DSW: dorsal shield width at *s6* level; VASL: ♀, ♂ ventrianal shield length, measured along the midline; VASW-ant: ♀ ventrianal shield width at level of *ZV2*; VASW-post: ♀ ventrianal shield width at level of anterior limit of anus; VASW-Male: ♂ ventrianal shield width at level of anterolateral corners; [1]Chant & Yoshida-Shaul's (1983) measurements were used here because they are more complete than in the original description; [2]distance between setal bases; [3]length of spermathecal calyx; [4]length of fixed cheliceral digit, measured from the dorsal lyrifissure; [5]length of movable cheliceral digit; [6]length of genual macroseta; [7]length of tibial macrosetae; [8]length of tarsal macrosetae.

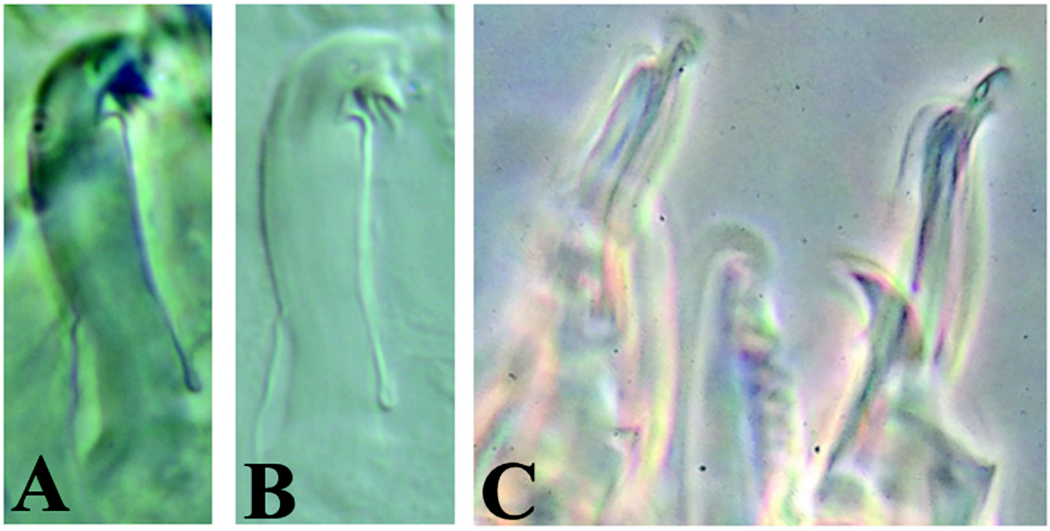

FIGURE 2. *Leonseius regularis*, phase contrast (PH) and differential interference contrast (DIC) photomicrographs of specimens collected in this study. A. Spermatheca, PH. B. Spermatheca, DIC. C. Left and right spermatodactyls, PH.

***Leonseius elbanhawyi* Carvalho, Ferragut & Oliveira sp. nov.**
(Figs. 3–4)

Typhlodromus regularis, El-Banhawy 1984: 139. **Syn. nov.**

Note

Only those character states that differ from *L. regularis* are given. Differences in setal lengths to *L. regularis* are not considered to be diagnostic.

FEMALE (measurements in Table 1; n = 10)

Dorsal and ventral idiosoma, peritreme, chelicera and legs (Fig. 3A, B, D, E).

Spermatheca (Figs. 3C, 4A–B). Calyx narrowly tubular, flaring distally, without a concavity immediately distad of the large atrium. Major duct about as wide as calyx, thick-walled and annulate in some specimens (see left image, Fig. 3C).

MALE (measurements in Table 1; n = 5)

Dorsal and ventral idiosoma, peritreme and legs (Fig. 3F–G).

Chelicera (Figs. 3H, 4C, 5E). Fixed digit with 7–10 teeth; movable digit with a single tooth. Spermatodactyl with shaft thick, straight; foot with two projections, forming together a c-shaped structure when viewed at some angles; the apical projection longer, curved (though can appear flat/truncate and flaring distally; see right image, Fig. 3H), and the subapical projection hook-like.

Etymology

The name of this species is given in honor of E.M. El-Banhawy (School of Biological Sciences, University of Nairobi, Kenya), the first to study specimens of this new species, which he reported as *L. regularis*.

Type material

One female (holotype), 48 females and 22 males (paratypes), collected in 16.VIII.2016 from *Theobroma cacao* L. (Malvaceae) leaves at campus of Universidade Estadual de Santa Cruz (UESC), 14º47'49"S, 39º10'23"W, Ilhéus, Bahia, Brazil, by Rodrigo A. de Souza; mounted in Hoyer's medium. Holotype, 18 female and eight male paratypes deposited at AC-UESC, Ilhéus, Bahia, Brazil; 15 female and seven male paratypes deposited at AC-DZSJRP; 15 female and seven male paratypes deposited at AC-ESALQ.

Other material examined

Six females and a male collected on 20.XI.1976 from undetermined host plant at Sooretama, Espírito Santo state, Brazil by E.M. El-Banhawy (Canadian National Collection of Insects, Arachnids and Nematodes, slide numbers CNC463689, CNC566084, and CNC566086–CNC566090).

Differential diagnosis

Leonseius elbanhawyi **sp. nov.** can be distinguished from *L. regularis* by the following traits of the spermatheca: calyx length (11–15 vs. 20–28) and shape (slender tube, flaring distally vs. broad, parallel-sided; without vs. with concavity near atrium), diameter of major duct (about same as diameter of calyx vs. much narrower) and wall of major duct (sometimes thick vs. always thin), and of the spermatodactyl: foot with two distal hook-like projections vs. a simple, bulbous apical projection.

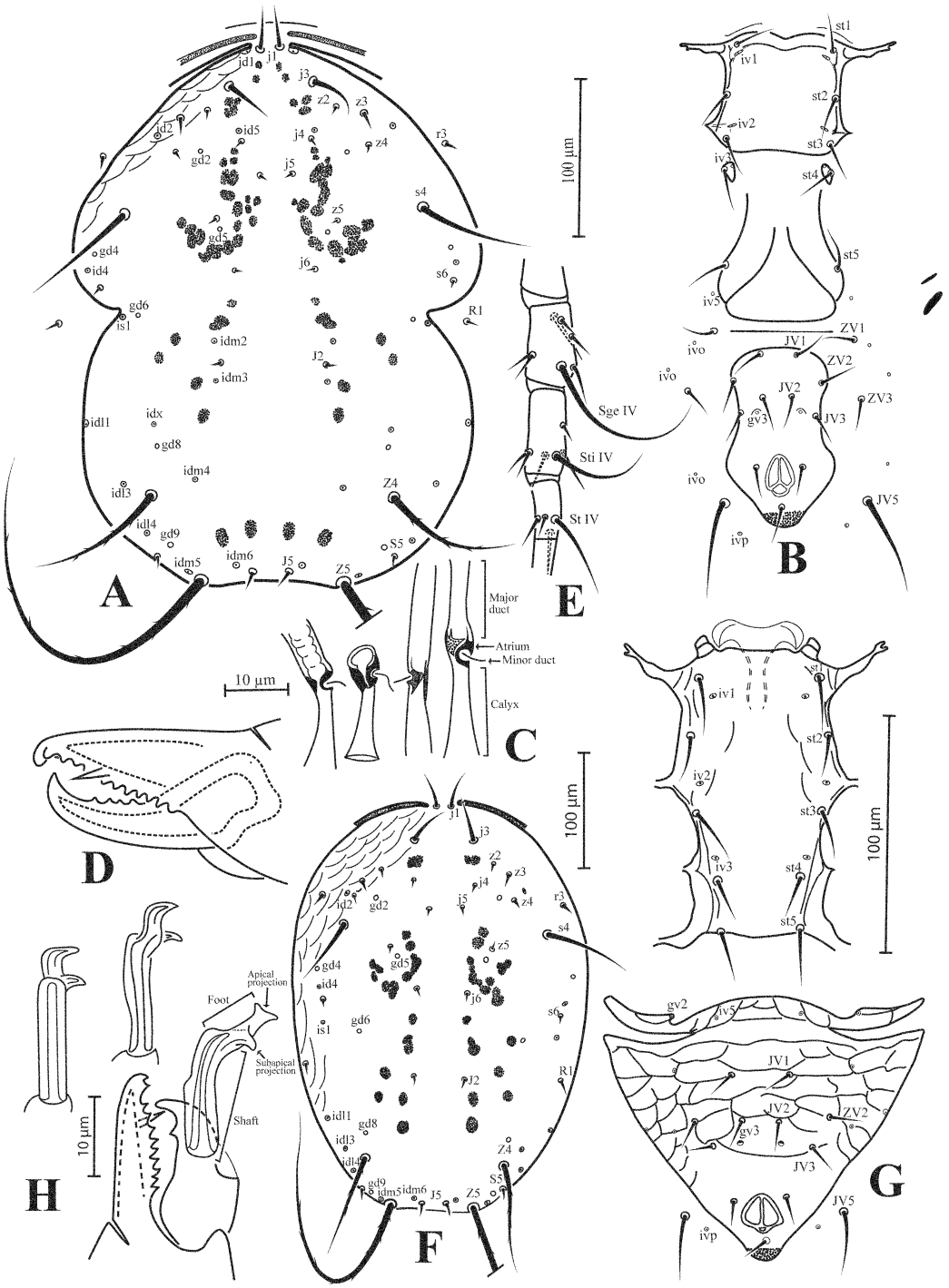

FIGURE 3. *Leonseius elbanhawyi* **sp. nov.** A. Female dorsal shield. B. Female ventral idiosomal shields. C. Female spermatheca, four different views. D. Female cheliceral digits, antiaxial view. E. Female leg IV, anterolateral view. F. Male dorsal shield. G. Male ventral idiosomal shields. H. Male chelicera and spermatodactyl, three different views. Note: all illustrations drawn from specimens collected in this study.

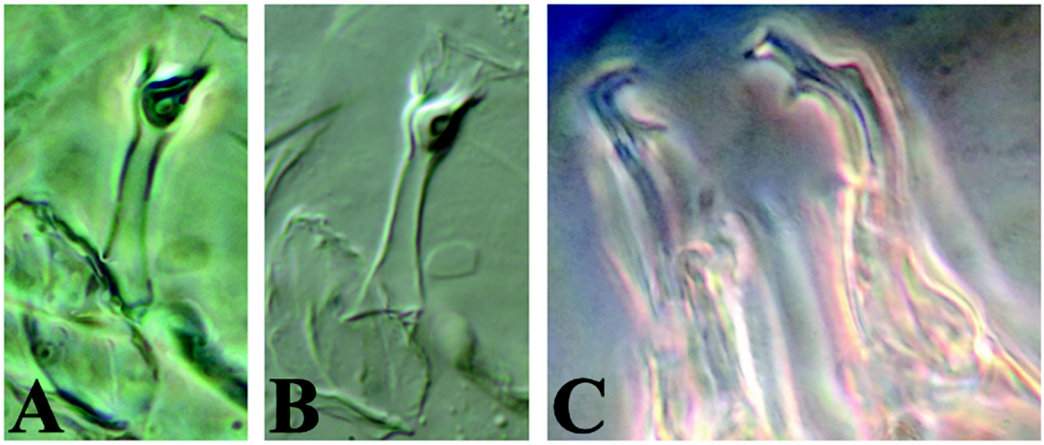

FIGURE 4. *Leonseius elbanhawyi* **sp. nov.**, phase contrast (PH) and differential interference contrast (DIC) photomicrographs of specimens collected in this study. A. Spermatheca, PH. B. Spermatheca, DIC. C. Left and right spermatodactyls, PH.

Discussion

It is surprising that, in our study, two sibling mite species, *L. regularis* and *L. elbanhawyi* **sp. nov.**, were found on the same plant species, cacao, each in a single locality only about 10 km apart from each other. Given the high morphological similarity between the two species, it is plausible that some records of *L. regularis* in the literature actually refer to the new species. This uncertainty hampers any review of the geographical distribution and host plants of each species. Our comparison with the holotype of *L. regularis* allowed us to confirm that specimens of the CEPLAC population were indeed *L. regularis*. Although the holotype is over 50 years old and partially deteriorated, it was nevertheless possible to confirm the broad, parallel-sided calyx, the presence of a concavity adjacent to the atrium and the narrow major duct in comparison to the diameter of the calyx (Figs. 5A–B). Although the concavity close to the atrium and the narrow major duct were not represented in the spermatheca illustrated by Chant and Yoshida-Shaul (1983), their figure was clearly based on the right spermatheca of the holotype, because of the recurved calyx (Fig. 5B).

The morphological account of El-Banhawy (1984), based on specimens misidentified as *L. regularis*, strengthens our concept of *L. elbanhawyi* **sp. nov.** as it shows the same characteristic shape of the spermatheca and the spermatodactyl as those of the specimens collected in this study from UESC. The specimens studied by El-Banhawy were collected about 600 km south of Ilhéus (where we conducted our study), but both sites are rather similar ecologically, *i.e.*, within the Atlantic Forest (Galindo-Leal & Câmara 2003). Although the voucher specimens borrowed from the CNC are not in very good condition, we could still pinpoint the key features typical of the female and male of *L. elbanhawyi* **sp. nov.**, *i.e.*, spermatheca with a swollen, large atrium, a narrowly tubular calyx and a broad major duct (Fig. 5C), and spermatodactyl with two distal hook-like projections (Fig. 5E).

The spermathecae and spermatodactyls are the only morphological characters that we could find to separate the two sympatric species of *Leonseius*. Although we know of few such cases, other sibling species of Phytoseiidae have been distinguished solely based on the spermathecae, such as *Typhlodromus exhilaratus* Ragusa vs. *T. phialatus* Athias-Henriot (Tixier *et al.* 2006). Conversely, spermathecae and/or spermatodactyls are sometimes indistinguishable between close relatives, *e.g.*,

Neoseiulus fallacis (Garman) and *N. californicus* (McGregor) (Tsolakis & Ragusa 2016; Beaulieu & Beard 2018), but in such cases, fortunately, other features of the idiosoma differ. Also, it is common to find morphologically similar species on the same plant individual in the same locality, *e.g.*, *Kampimodromus aberrans* Nesbitt and *K. corylosus* Kolodochka (Kolodochka 2003). In any case, detailed analyses of sexual and non-sexual characters will, hopefully, distinguish most closely related species, sometimes with the help of molecular tools (*e.g.*, Tixier *et al.* 2006). From an applied point of view, vigilance should prevail when discriminating between predatory species, as they may have quite different behaviors and efficacy as biocontrol agents of agricultural pests.

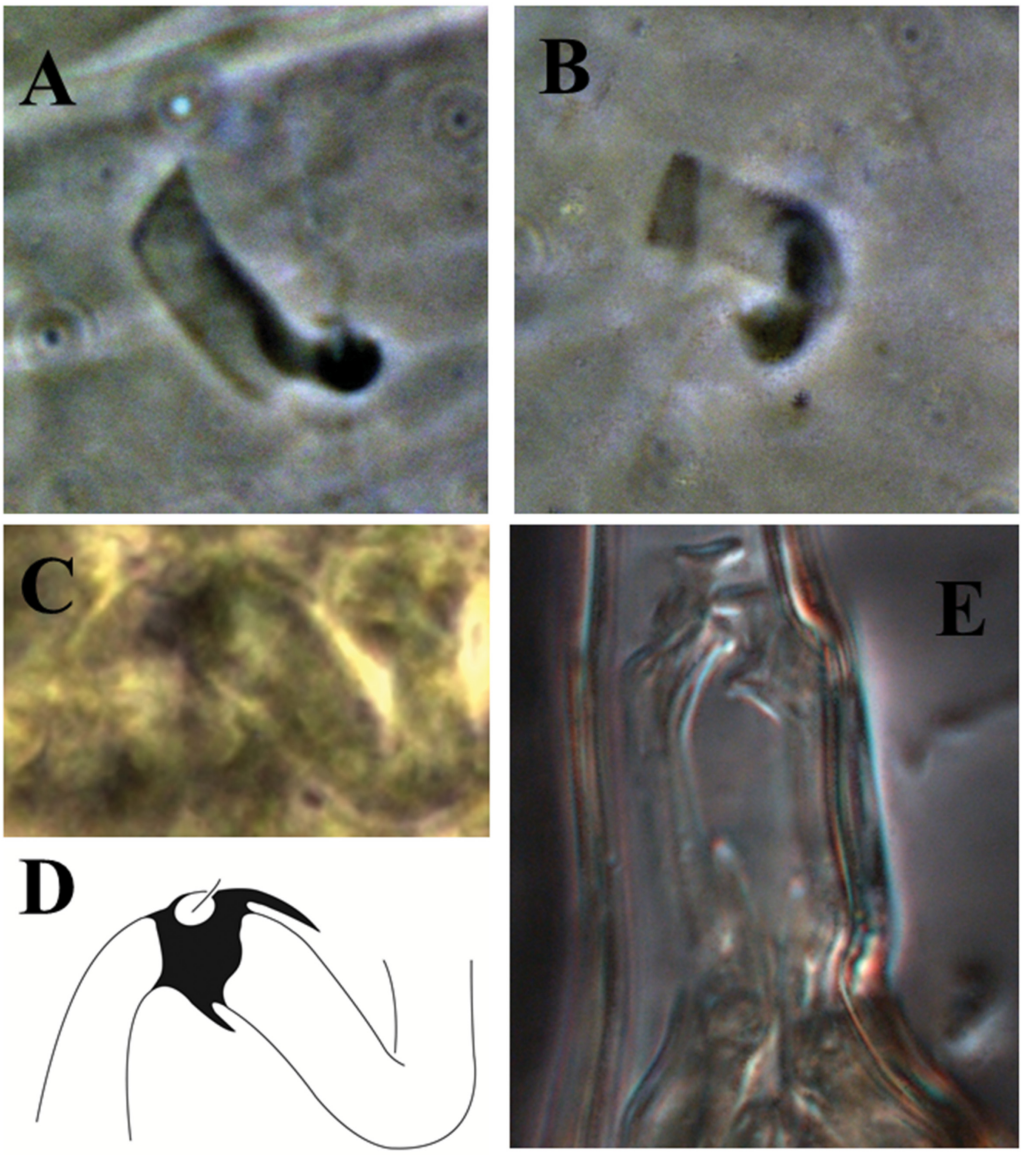

FIGURE 5. *Leonseius regularis* and *Leonseius elbanhawyi* **sp. nov.**, phase contrast photomicrographs. A. Spermatheca of the holotype of *L. regularis*, from Puerto Rico (De Leon 1965), left. B. As in A, right. C. Spermatheca of a female of *L. elbanhawyi* **sp. nov.** from Brazil studied by El-Banhawy (1984). D. as in C, interpreted in line drawing. E. Spermatodactyls of a male of *L. elbanhawyi* **sp. nov.** from Brazil studied by El-Banhawy (1984). Note: specimens in C–E misidentified as *L. regularis* in El-Banhawy (1984).

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