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Camerobiid mites (Acariformes: Raphignathina: Camerobiidae) inhabiting epiphytic bromeliads and soil litter of tropical dry forest with analysis of setal homology in the genus *Neophyllobius*

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Abstract. A survey of the camerobiid mites living on epiphytic bromeliads and the forest floor of a Mexican tropical dry forest was carried out. We found three new species of the genus *Neophyllobius*, which are described in this paper; the first two, namely *N. cibyci* sp. nov. and *N. tepoztlanensis* sp. nov., were both found inhabiting bromeliads (*Tillandsia* spp.) and living on two tree species (*Quercus obtusata* and *Sapium macrocarpum*); the third, *N. tescalicola* sp. nov., was found in soil and litter under *Q. obtusata*. These three new species can be differentiated from other species in the genus by a combination of morphological characters in adult females, mainly those setae on femora and genua I. The idiosoma and leg setal ontogeny of a camerobiid mite is presented for the first time in this paper, illustrating chaetotaxic notations and their relative positions in *N. cibyci* sp. nov. larva, protonymph and adults (female and male), and establishing setal homologies among instars. Setal homology with other species in the cohort Raphignathina is briefly discussed. Additionally, a compilation and an identification key to all known species of camerobiid mites in Mexico is provided.

Keywords. Acari, chaetotaxy, Mexico, predator, Prostigmata, tree canopy, *Tillandsia* spp.

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Introduction

The family Camerobiidae Southcott, 1957 (Acariformes: Prostigmata: Raphignathina: Raphignathoidea) comprises about 161 species in seven genera of predatory mites (Fan & Walter 2011; Zhang *et al*. 2011; Khanjani *et al*. 2012a, 2012b, 2013, 2014; Akyol 2013; Khanjani & Hoseini 2013; Zeity & Gowda 2013; Uluçay & Koç 2014). Camerobiids are usually found in different microhabitats like humus, tree bark, vegetation or inside epiphytes in temperate and tropical ecosystems. Some camerobiid species feed on plant pests such as scale insects (Coccoidea), plant-parasitic mites (Eriophyidae and Tenuipalpidae) and on other small mites that scavenge or feed on fungi on plant surfaces (Tarsonemidae and Tydeidae) (McGregor 1950; De Leon 1967; Bolland 1983; Gerson *et al*. 2003; Walter *et al*. 2009).

Neophyllobius Berlese, 1886 species have world-wide distribution, and the genus is the richest in Camerobiidae with more than 100 species. The genus was revised by Bolland (1991) and later works mainly include species descriptions (e.g., Koç & Ayyildiz 1996; Bolland 2001; Khanjani & Ueckermann 2006; Khanjani *et al*. 2010; Uluçay & Koç 2014). Like many other groups of mites, there is insufficient knowledge regarding their ecology and ontogeny which, in turn, restricts our knowledge of habitat specificity and the identification of homologies among species. Also, many descriptions of camerobiid mites are based on a single specimen because they are usually found singly or in low numbers (Bolland 1986), and rarely is setal nomenclature detailed.

Members of Raphignathoidea generally include four active postembryonic instars: larva, protonymph, deutonymph and adult (Walter *et al.* 2009). However, in *Neophyllobius* it is questioned whether the life cycle includes one nymphal instar instead of two. Protonymphs are frequently found, but deutonymphs have been mentioned briefly only in a few species, for example *N. saxatilis* Halber, 1938, *N. ambulans* Meyer, 1962, *N. gonzali* Zaher & Gomaa, 1979, *N. aesculi* Bolland, 1983, *N. ceratoniae* Bolland, 1991, *N. dichantii* Bolland, 1991, *N. muscantribii* Bolland, 1991 and *N. piniphilus* Bolland, 2001 (Bolland 1983, 1991, 2001). Only the deutonymphs of the last two species has been partially illustrated (Bolland 1983, 1991). Because of the scarcity of specimens the distinction between deutonymph and adult female is not always clear. Besides, two types of protonymphs (male and female) has been recognized at least in *N. piniphilus* (Bolland 2001).

The family Camerobiidae in Mexico comprises 13 species of *Neophyllobius* (Bolland 1991) (Table 1). This number is clearly low, suggesting that the group is under-represented, and shows that camerobiid mites have been reported throughout tropical and northern areas and in a variety of different habitats (inside epiphytes, tree bark or in the forest floor).

Analysis of leg chaetotaxy for different instars in rich groups, like the genus *Neophyllobius*, could provide systematic and phylogenetic clues for a better understanding of the groups at different hierarchical levels (Swift 2001), and may be helpful in distinguishing between lineages (Norton 1977). It is important to homologize the setal organs in the different species and among different instars because to ignore the homology and only take into account the numerical formulas in descriptions of new taxa is not phylogenetically informative. In the Camerobiidae, Grandjean's idiosomal chaetotaxy system was firstly applied by Kethley (1990), whereas the leg chaetotaxy system was implemented in adult females belonging to *Acamerobia inflatus* Fan & Walter, 2011 (Fan & Walter 2011). However, leg chaetotaxy is frequently omitted in most recent species descriptions, with a few noteworthy exceptions (e.g., Khanjani *et al*. 2013, 2014).

In this paper, we provide descriptions of three new species of *Neophyllobius*: two that have been found exclusively on epiphytic bromeliads and one on soil litter in Mexico. An identification key to females of all the species of *Neophyllobius* in Mexico is provided. The ontogeny of idiosoma and leg setation, setal notations (chaetotaxy) and their relative positions on the podomeres are presented and illustrated for one of these new species.

Table 1. Species of *Neophyllobius* Berlese, 1886 recorded in Mexico.

SPECIES	LOCALITY	HABITAT	REFERENCE	REMARKS
N. mexicanus McGregor, 1950	Mexico, intercepted at Brownsville, TX	On avocado budwood	McGregor (1950)	Unknown locality
N. quadrisetosus De Leon, 1958	SONORA: Guaymas, intercepted at Nogales	Soil from cactus	De Leon (1958)	
N. trisetosus De Leon, 1958	OAXACA: Oaxaca	*Quercus* sp.	De Leon (1958)	
	OAXACA: Siete Cabrillas	*Quercus* sp.		
	OAXACA: Tamazulapan	Unknown tree		
	MICHOACAN: near Quiróga			
	NAYARIT: Santa María del Oro			
	NAYARIT: Ixtlán del Río			
N. farrieri De Leon, 1958	OAXACA: Puenta [*sic*] de Nejapa	Spanish moss	De Leon (1958)	The common name "Spanish moss" is commonly used to refer to *Tillandsia usneoides* (L.) L.
N. inequalis De Leon, 1958	VERACRUZ: Veracruz	*Erythrina* sp., *Terminalia catappa* L.	De Leon (1958)	
N. equalis De Leon, 1958	NAYARIT: Navarrete	*Guazuma* sp.	De Leon (1958)	According to De Leon (1958) and Bolland (1991), it is open to doubt whether the specimens recorded in San Luis Potosí belong to this species
	SAN LUIS POTOSI: near Valles			
N. consobrinus De Leon, 1958	CHIAPAS: Tuxtla Gutiérrez	*Jaquinia pungens* A.Gray	De Leon (1958)	
N. lobatus De Leon, 1958	NAYARIT: San Blas	From "guasamolleta"	De Leon (1958)	On *Guasa molleta* sensu Bolland (1991)
N. marginatus De Leon, 1958	NAYARIT: Ixtlán del Río	Asteraceae	De Leon (1958)	
	NAYARIT: nine miles west of Tepic	*Quercus* sp.		
N. longulus De Leon, 1958	OAXACA: Matías Romero	*Calophyllum* sp.	De Leon (1958)	
N. curtipilus De Leon, 1958	CHIAPAS: Tuxtla Gutiérrez	*Cordia dentata* Poir., *Guazuma tomentosa* Lam., *Rhus schideana* Schltdl., *Lonchocarpus rugosus* Benth., *Quercus* sp., and avocado	De Leon (1958)	De Leon first (1958) named this species as *N. curtipilus* (p. 175, 178, 180), but later the name was misspelled as *N. curtipilis* (p.181) Also, Bolland (1991) misspelled it as *N. curtipilis*
N. spatulus De Leon, 1958	NAYARIT: Tepic	Two undetermined species of Asteraceae	De Leon (1958)	The type specimens are lost (Bolland 1991)
	OAXACA: km post 666, Route 190 north of Tehuantepec	A Malpighiaceae shrub		

SPECIES	LOCALITY	HABITAT	REFERENCE	REMARKS
N. deleoni Bolland, 1991	JALISCO: route 35, 18 miles southeast of Guadalajara	Unknown	Bolland (1991)	Originally described as *Neophyllobius horridus* by De Leon (1958) but as the name was preoccupied, Bolland (1991) re-named it
DOUBTFUL AND UNDETERMINED SPECIMENS				
Neophyllobius spp.	CAMPECHE: Calakmul	Soil litter	Vázquez *et al.* (2011)	
	CAMPECHE: Zoh-Laguna	Soil litter		
	QUINTANA ROO: Reserva de la Biósfera de Sian Ka'an	Soil litter		
	QUINTANA ROO: Bahía de Chetumal	Leaf litter and mangrove	Vázquez-González (2008)	
	MORELOS: Mpio. Tepoztlán: "derrame lávico del volcán Chichinautzin"	*Tillandsia* spp.	This study	See comments about *Camerobia* sp.
Camerobia sp.	MORELOS: Mpio. Tepoztlán: "derrame lávico del volcán Chichinautzin"	*Tillandsia* spp.	Palacios-Vargas (1982)	All the species of *Camerobia* Southcott, 1957 are not distributed throughout the Americas. We reviewed six adult specimens from this series (CNAC009249–009254) and they are *Neophyllobius*
Camerobiidae gen. et sp.	MORELOS VERACRUZ	*Tillandsia prodigiosa* (Lemaire) Baker	Hoffmann & López-Campos (2000)	Undetermined genus and species

Material and methods

This research was carried out in the tropical dry forest about 1 km south of San Andres de la Cal, Tepoztlán, Morelos, México (18.95617° N, 99.11394° W, 1495 m a.s.l.). Mean annual temperature is about 20.5°C and mean annual precipitation is 1091.8 mm. The tropical dry forest in the study area has an open canopy with short tree species (maximum 16 m in hight); two forest units can be identified by plant composition and the parent rock of the soil (Cortés-Anzúres 2015; Vergara-Torres *et al*. 2010).

Sampling was done in the forest unit emerged on a lava flow; here, epiphytes are abundant (25 species) and the dominant tree species are *Sapium macrocarpum* Müll.Arg. (Euphorbiaceae), *Ipomoea pauciflora* M.Martens & Galeotti (Convolvulaceae) and *Quercus obtusata* Bonpl. (Fagaceae), which together comprise 46% of tree individuals. The most abundant epiphytes are widespread bromeliads *Tillandsia hubertiana* Matuda and *T. schiedeana* Steud. (Bromeliaceae), which comprise 76% of all adult individuals (Cortés-Anzúres 2015).

Camerobiid mites were collected from two species of epiphytic plants (Bromeliaceae): *Tillandsia hubertiana* and *T. schiedeana*. Both bromeliads are xerophytic, but *T. schiedeana* has been deemed an atmospheric epiphyte (gray, narrow leaves that do not form an impounding tank) whereas *T. hubertiana* is a tank epiphyte (green, wide leaves that do form an impounding tank) (Ruiz-Cordova *et al*. 2014). *T. hubertiana* is endemic to Mexico (Espejo-Serna *et al*. 2004). Both bromeliads were collected from

trunks or branches of two tree species: *Quercus obtusata* and *Sapium macrocarpum*. *Quercus obtusata* is an oak species endemic to Mexico (Arizaga *et al*. 2009). Additionally, soil litter samples were collected from around the base of the trunk of both *Q. obtusata* and *S. macrocarpum*.

Mites were extracted from soil litter samples and bromeliads with Berlese-Tullgren funnels and preserved in 80% ethanol; previously, the bromeliad leaves were cut into small pieces. Then mites were observed under a stereoscopic microscope (Olympus SZ) and were cleared in potassium hydroxide (KOH) solution. Microscope slides were made using Hoyer's medium as a preserver for observation and illustration using a drawing tube adapted to a compound microscope (Nikon Optiphot-2). Additional observations were made with an optic microscope (Nikon Labophot-2). Line drawings were edited using the GNU Image Manipulation Program (GIMP) (The GIMP team 2014). Holotype and paratype specimens are deposited in the "Colección Nacional de Ácaros" (CNAC) kept at the "Instituto de Biología, Universidad Nacional Autónoma de México" in Mexico City, and three paratype specimens in the "Colección de Insectos de la Universidad de Morelos" (CIUM) at the "Centro de Investigación en Biodiversidad y Conservación, Universidad Autónoma del Estado de Morelos", in Cuernavaca, Morelos, Mexico.

The nomenclature for describing palp and leg chaetotaxy follows Grandjean (1944, 1946) and Fan & Walter (2011), and the terminology of idiosomal chaetotaxy follows Kethley (1990) and Fan & Walter (2011). In descriptions of male, protonymph and larva, only specific features that were found to be different from those of females are mentioned. All measurements are given in micrometres (µm).

Results

Subclass Acari Sundevall, 1833
Superorder Acariformes Zakhvatkin, 1952
Order Trombidiformes Reuter, 1909
Suborder Prostigmata Kramer, 1877
Supercohort Eleutherengonides Oudemans, 1909
Cohorte Raphignathina Kethley, 1982
Superfamily Raphignathoidea Kramer, 1877
Family Camerobiidae Southcott, 1957
Genus *Neophyllobius* Berlese, 1886

Neophyllobius cibyci sp. nov.
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Figs 1–4; Table 2

Diagnosis

This species is unique due to a combination of following characters: female with dorsal setae reaching setae immediately behind, femur II with three setae (*d*, *v'* and *v''*), femur III with two setae (*d* and *v'*), setae *d* on genua I–IV reaching tibiae, short setae (about ⅙ of podomere length) on femur I, setae *l'* and *d* on femur I nearly located horizontally at same level, dorsal setae *c1* and *d1* distinctly longer than distance between setae *c1–d1* and *d1–e1* respectively, idiosomal setae *d1* longest, and setae *d* and *l'* on palpal femur heavily spinose.

Etymology

The specific name incorporates the acronym of the "Centro de Investigación en Biodiversidad y Conservación" (CIByC) at the "Universidad Autónoma del Estado de Morelos" in recognition of its work on biological conservation.

Type material

Holotype

MEXICO: ♀, CNAC009229, ex *Tillandsia hubertiana* at 2.5 meters (m) on *Quercus obtusata*. Collected from the type locality on 12 Mar. 2014, O. Cortés and R. Paredes coll. (RPL1219).

Paratypes

MEXICO: 1 ♀, CNAC009230, ex *T. schiedeana* at 3 m on *Q. obtusata* (RPL1220); 1 ♀, CNAC009231, ex *T. schiedeana* at 3.05 m on *Q. obtusata* (RPL1223); 1 ♀, CNAC009232, 1 L, CNAC009243, ex *T. hubertiana* at 2.1 m on *Q. obtusata* (RPL1225); 1 ♀, CNAC009233, ex *T. hubertiana* at 2.7 m on *Sapium macrocarpum* (RPL1237); 1 ♀, CNAC009234, ex *T. schiedeana* at 2.7 m on *S. macrocarpum* (RPL1238); 1 ♀, CIUM, ex *T. schiedeana* at 2.7 m on *S. macrocarpum* (RPL1241); 1 ♀, CNAC009235, ex *T. schiedeana* at 2.9 m on *Q. obtusata*, 22 Aug. 2014, S. Gómez and R. Paredes coll. (RPL1295); 1 ♀, CNAC009236, ex *T. schiedeana* at 2.6 m on *S. macrocarpum*, 22 Aug. 2014, S. Gómez and R. Paredes coll. (RPL1304); 1 ♀, CNAC009237, on soil litter of *S. macrocarpum*, 23 Oct. 2014, R. Reyes and R. Paredes coll. (RPL1341); 1 ♂, CNAC009238, ex *T. hubertiana* at 3.6 m on *Q. obtusata* (RPL1222); 1 ♂, CNAC009239, ex *T. hubertiana* at 2.7 m on *S. macrocarpum*, 30 Apr. 2014 (RPL1276); 1 ♂, CNAC009240, ex *T. schiedeana* at 2.4 m on *S. macrocarpum*, 22 Aug. 2014, S. Gómez and R. Paredes coll. (RPL1301); 1 PN, CNAC009241, ex *T. hubertiana* at 3.4 m on *Q. obtusata*, 30 Apr. 2014 (RPL1255); 1 L, CNAC009242, same data as holotype (RPL1219); 1 L, CNAC009244, ex *T. hubertiana* at 2.6 m on *S. macrocarpum*, 30 Apr. 2014 (RPL1279). All collected from the type locality, with same data as holotype except where noted.

Type locality

MEXICO: Morelos, Tepoztlán, 1 km S of San Andrés de la Cal, 18.94305° N, 99.11786° W, 1490 m a.s.l.

Description

Female (n = 10) (Figs 1, 3A–D, 4A–D)

Holotype female (followed in parentheses by range of holotype and nine paratype females).

Gnathosoma. 87 (81–98) long and 93 (77–93) wide. Subcapitulum with subcapitular setae *m* 28 (28–31) and two pairs of adoral setae *Or1* 11 (9–14) and *Or2* 9 (8–13); these three pairs are nude and slender, *m* longest (Fig. 1B); distance *m–m* 25 (21–25). Chelicerae 38 (30–44) long. Palp, five-segmented with following setal distribution: trochanter without setae; femur with two serrate setae, *d* 20 (17–20) and *l'* 39 (31–39); genu with one long, slender, nude dorsal (*d*) seta 39 (33–39); tibia with three tactile setae (*l'*, *l''* and *d*) and one claw (sword-like seta); tarsus with two eupathidia (*acmζ* and *sulζ*), two simple setae (*ba* and *va*) and one small solenidion (*ω*) (Fig. 1A). Setae *elcp* present.

Idiosoma. Longer than wide, 280 (270–350) long (gnathosoma excluded), 235 (195–320) wide. Cuticle striated, except on coxae and attenuated between setal pairs *c1*, *d1*, *e1* and *f1* (Fig. 1C). *Dorsum*. With 15 pairs of serrated setae set on small tubercles; all setae are long, *d1* longest and *h2* shortest; all setal pairs are longer than distance to setal pairs immediately behind. Two pairs of eyes are positioned between setae *sci* and *sce*. Length of setae: *vi* 58 (47–58), *ve* 50 (42–56), *sci* 46 (40–53), *sce* 46 (42–52), *pdx* 67 (55–71), *c1* 80 (66–83), *c2* 70 (53–70), *d1* 82 (64–82), *d2* 52 (43–54), *e1* 77 (60–77), *e2* 52 (45–57), *f1* 67 (54–72), *f2* 41 (36–43), *h1* 35 (34–39), *h2* 34 (29–34). Distances between setae: *vi–vi* 66 (45–66), *ve–ve* 96 (70–100), *vi–ve* 26 (26–32), *sci–sci* 115 (91–120), *sce–sce* 145 (125–150), *sci–sce* 45 (35–45), *c1–d1* 45 (34–58), *d1–d1* 16 (10–16), *d1–d2* 83 (82–94), *d1–e1* 42 (39–46), *ve–sci* 22 (15–22), *pdx–pdx* 23 (13–24), *pdx–c1* 27 (22–37), *c1–c1* 16 (11–17), *c1–c2* 98 (86–100), *c2–c2* 185 (155–190), *e1–e1* 14 (11–16), *e1–f1* 46 (37–59), *f1–h1* 50 (39–57), *e1–e2*

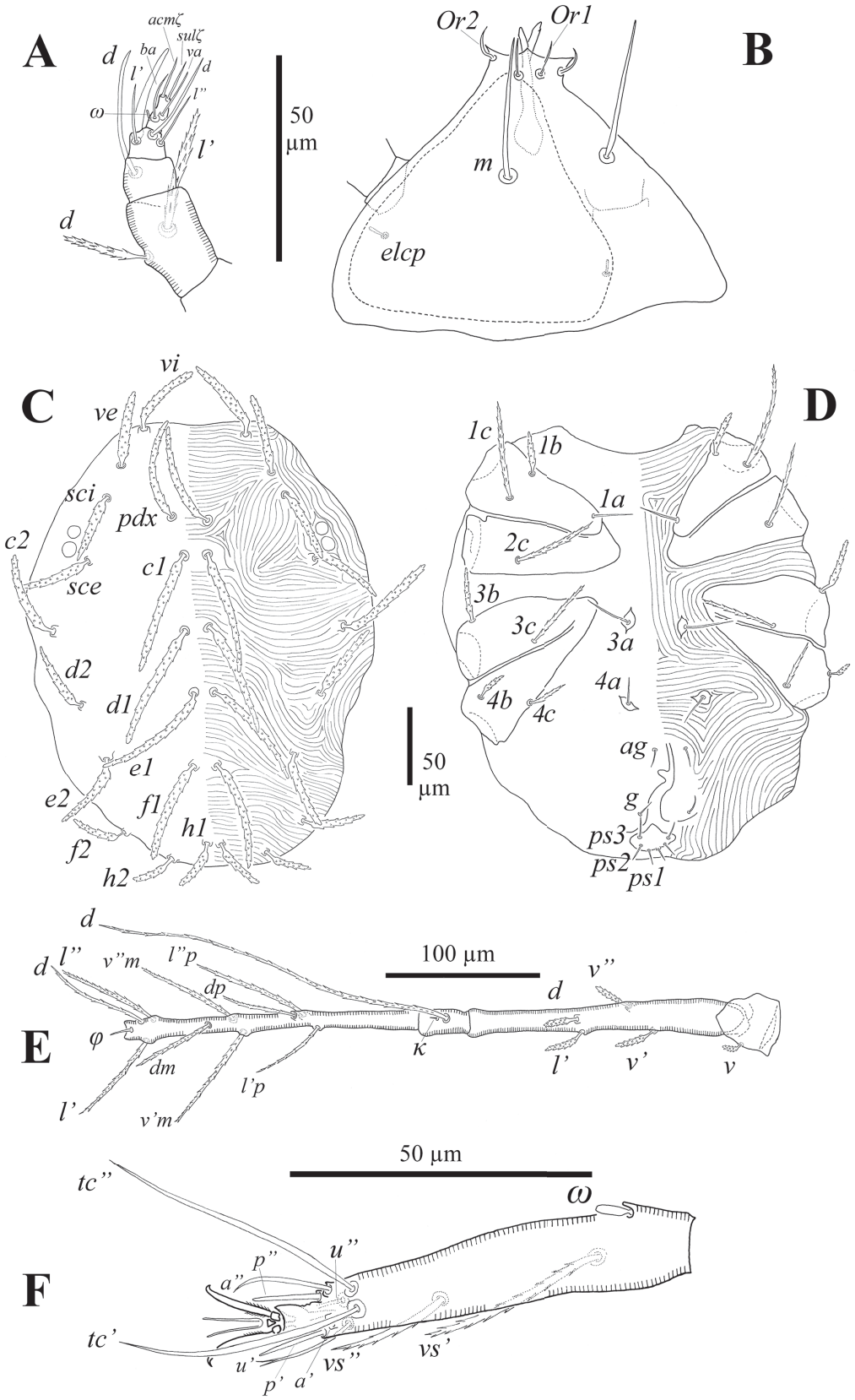

Fig. 1. *Neophyllobius cibyci* sp. nov., ♀, holotype. **A**. Palp. **B**. Subcapitulum. **C**. Dorsal idiosoma. **D**. Ventral idiosoma. **E**. Trochanter–tibia of leg I. **F**. Tarsus I.

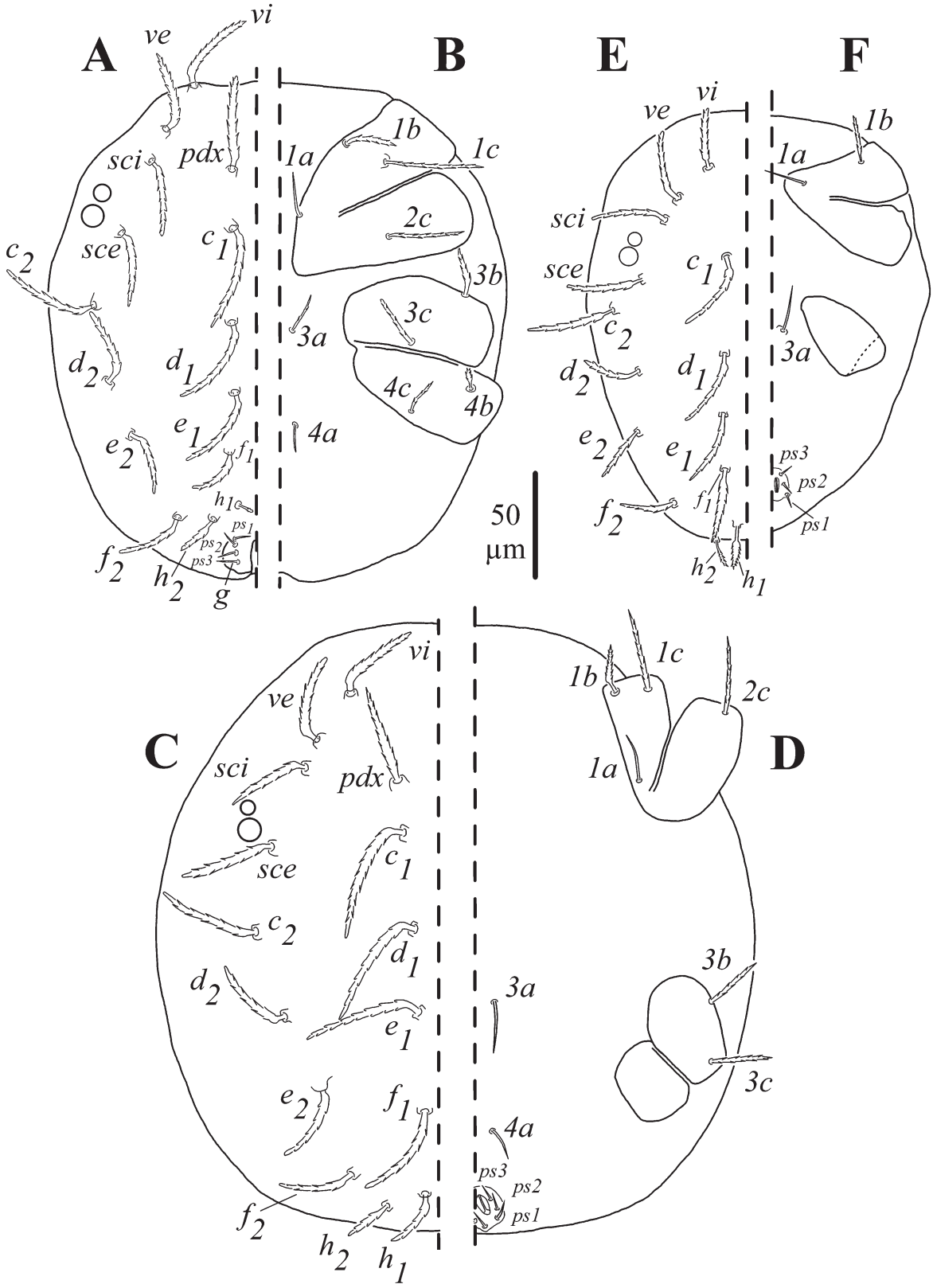

Fig. 2. *Neophyllobius cibyci* sp. nov. **A–B**. ♂, paratype (CNAC009238). **A**. Dorsal idiosoma. **B**. Ventral idiosoma. **C–D**. Protonymph, paratype (CNAC009241). **C**. Dorsal idiosoma. **D**. Ventral idiosoma. **E–F**. Larva, paratype (CNAC009242). **E**. Dorsal idiosoma. **F**. Ventral idiosoma.

66 (56–70), *d2–e2* 42 (39–45), *f1–f1* 14 (9–14), *f1–f2* 66 (46–66), *f2–f2* 115 (105–125), *e2–f2* 42 (33–71), *h1–h1* 10 (6–11), *h1–h2* 30 (21–30), *h2–h2* 61 (50–68), *f2–h2* 33 (29–40). *Venter.* Coxal setae thinner than dorsal setae. Setal pairs *1a*, *3a*, *4a*, *ag*, *g*, *ps1*, *ps2* and *ps3* nude and short. Setae *1b*, *1c*, *2c*, *3b*, *3c*, *4b* and *4c* serrated. Setae *1c* longest and *ps1–3* shortest. Setal pairs *3a* and *4a* located on individual platelets. Genito-anal valves with one pair of genital setae (*g*). Coxa I grouped with coxa II, and coxa III with IV but not completely fused (Fig. 1D). Length of setae: *1a* 26 (25–29), *1b* 29 (22–30), *1c* 69 (53–69), *2c* 54 (33–56), *3a* 34 (33–38), *3b* 37 (25–40), *3c* 49 (34–50), *4a* 18 (18–26), *4b* 21 (17–22), *4c* 30 (22–31), *ag* 15 (15–19), *g* 10 (10–15), *ps1* 12 (10–14), *ps2* 12 (10–14), *ps3* 12 (9–12).

Legs. Slender and long, leg I and IV longest. Lengths (excluding ambulacra): leg I 565 (480–565), leg II 495 (440–500), leg III 475 (465–530), leg IV 550 (510–590). Podomere lengths: femur I 180 (155–180), femur II 145 (125–145), femur III 145 (130–145), femur IV 165 (135–165), tibia I 185 (165–185), tibia II 160 (135–160), tibia III 185 (165–190), tibia IV 195 (180–200), tarsus I 62 (60–70), tarsus II 69 (60–70), tarsus III 71 (59–71), tarsus IV 71 (64–76). Leg setae as indicated in Figs 1E–F, 3A–D and 4A–D. Tarsus I with five setal pairs: *vs* serrated, *tc*, *a*, *p* and *u* slender and nude, *u* bifurcated at tip. Setae *tc* longest (Fig. 1F). Setae lengths: *v'* on femur I 26 (21–27), *v''* on femur I 27 (20–30), *l'* on femur I 28 (21–30), *d* on femur I 24 (19–24), dorsal seta on genu I 250 (210–265), dorsal seta on genu II 275 (210–280), dorsal seta on genu III 335 (230–340), dorsal seta on genu IV 360 (215–360), solenidion ω on tarsus I 6 (6), ω on tarsus II 5 (4–5). All tarsi with ambulacrum bearing a pair of claws and an empodium with two rows of tenent hairs. Counts of setae on legs I–IV, indicating additional solenidia in parenthesis: coxae: 3–1–2–2, trochanters 1–1–1–1, femora 4–3–2–2, genua 1(κ)–1(κ)–1–1, tibiae 9(φ)–8(φ)–8(φ)–7(φ), tarsi 10(ω)–10(ω)–8–8.

Male (Figs 2A–B, 3E–H, 4E–H), range of three paratypes

Gnathosoma. 72–81 long and 65–72 wide. Subcapitular setae *m* 25–26, setae *Or1* 9, *Or2* 8–9, distance *m–m* 17–19. Chelicerae 20–24 long. Length of palpal setae: femur *d* 18–20 and *l'* 33–34, and genu *d* 35.

Idiosoma. 195–210 long (gnathosoma excluded), 170–180 wide. *Dorsum* (Fig. 2A). Setae shorter than those of females, *c1* longest and *h1* shortest. Length of setae: *vi* 35–38, *ve* 42, *sci* 38–42, *sce* 37–38, *pdx* 42–44, *c1* 51–53, *c2* 47, *d1* 40, *d2* 40–41, *e1* 45–46, *e2* 34–35, *f1* 24–25, *f2* 30, *h1* 9–10, *h2* 22. Distances between setae: *vi–vi* 40–45, *ve–ve* 65–69, *vi–ve* 20–25, *sci–sci* 80–87, *sce–sce* 105–112, *sci–sce* 10–11, *c1–d1* 39–44, *d1–d1* 8–10, *d1–d2* 55–59, *d1–e1* 30–33, *ve–sci* 15–17, *pdx–pdx* 9–10, *pdx–c1* 25–31, *c1–c1* 9–10, *c1–c2* 65–75, *c2–c2* 124–133, *e1–e1* 8, *e1–f1* 32–35, *f1–h1* 22–25, *e1–e2* 48–50, *d2–e2* 26–31, *f1–f1* 8, *f1–f2* 35–42, *f2–f2* 63–66, *e2–f2* 40–43, *h1–h1* 8, *h1–h2* 14–15, *h2–h2* 34–38, *f2–h2* 15–16. *Venter* (Fig. 2B). Agenital setae (*ag*) absent. Genital seta (*g*) very close to *ps3*. Length of setae: *1a* 16–18, *1b* 20–23, *1c* 44–47, *2c* 35–37, *3a* 17–18, *3b* 22–24, *3c* 25, *4a* 12–13, *4b* 12–13, *4c* 16–21, *ps1* 9, *ps2* 9, *ps3* 9, *g* 10.

Legs. Leg IV longest. Lengths (excluding ambulacra): leg I 465–475, leg II 405–410, leg III 440–450, leg IV 475–485. Podomere lengths: femur I 150–155, femur II 115–125, femur III 120, femur IV 130–135, tibia I 155, tibia II 125–130, tibia III 155–160, tibia IV 155–160, tarsus I 58–60, tarsus II 58–60, tarsus III 60, tarsus IV 65. Tibia I with two solenidia (φ and φ2), and all tarsi with one long basal solenidion (ω) (Fig. 4E–H). Leg setae as indicated in Fig. 3E–H and 4E–H. Setae lengths: *v'* on femur I 21–22, *v''* on femur I 25–27, *l'* on femur I 22, *d* on femur I 24–25, dorsal seta on genu I 110–125, dorsal seta on genu II 130, dorsal seta on genu III 185–195, dorsal seta on genu IV 215–230, solenidion ω on tarsus I 27–28, ω on tarsus II 30, ω on tarsus III 30, ω on tarsus IV 27–28. Counts of setae on legs I–IV, indicating additional solenidia in parenthesis: coxae: 3–1–2–2, trochanters 1–1–1–1, femora 4–3–2–2, genua 1(κ)–1(κ)–1–1, tibiae 9(φ, φ2)–8(φ)–8(φ)–7(φ), tarsi 10(ω)–10(ω)–8(ω)–8(ω).

Protonymph (Figs 2C–D, 3I–L, 4I–L)

Gnathosoma. 70 long and 65 wide. Subcapitular setae *m* 20, setae *Or1* 5, *Or2* 6, distance *m–m* 14. Chelicerae 24 long. Length of palpal setae: femur *d* 13 and *l'* 28, and genu *d* 27.

Idiosoma. 295 long (gnathosoma excluded), 230 wide. *Dorsum* (Fig. 2C). Setae shorter than those of females, *c1* longest. Length of setae: *vi* 41, *ve* 40, *sci* 38, *sce* 43, *pdx* 46, *c1* 60, *c2* 46, *d1* 56, *d2* 39, *e1* 56, *e2* 40, *f1* 50, *f2* 35, *h1* 30, *h2* 22. Distances between setae: *vi–vi* 48, *ve–ve* 83, *vi–ve* 18, *sci–sci* 97, *sce–sce* 130, *sci–sce* 39, *c1–d1* 42, *d1–d1* 11, *d1–d2* 69, *d1–e1* 38, *ve–sci* 14, *pdx–pdx* 17, *pdx–c1* 26, *c1–c1* 10, *c1–c2* 78, *c2–c2* 150, *e1–e1* 11, *e1–f1* 45, *f1–h1* 38, *e1–e2* 54, *d2–e2* 36, *f1–f1* 11, *f1–f2* 44, *f2–f2* 86, *e2–f2* 42, *h1–h1* 5, *h1–h2* 18, *h2–h2* 35, *f2–h2* 23. *Venter* (Fig. 2D). Setal pairs *4b*, *4c*, *ag* and *g* absent. Length of setae: *1a* 21, *1b* 23, *1c* 35, *2c* 34, *3a* 26, *3b* 27, *3c* 11, *4a* 14, *ps1* 9, *ps2* 9, *ps3* 9.

Legs. Leg I longest. Lengths (excluding ambulacra): leg I 375, leg II 340, leg III 315, leg IV 325. Podomere lengths: femur I 130, femur II 95, femur III 100, femur IV 100, tibia I 115, tibia II 95, tibia III 115, tibia IV 105, tarsus I 55, tarsus II 55, tarsus III 55, tarsus IV 55. Leg setae as shown in Figs 3I–L and 4I–L. Setae lengths: *v''* on femur I 21, *l'* on femur I 20, *d* on femur I 18, dorsal seta on genu I 185, dorsal seta on genu II 205, dorsal seta on genu III 240, dorsal seta on genu IV 210, solenidion *ω* on tarsus I 5, *ω* on tarsus II 4. Counts of setae on legs I–IV, indicating additional solenidia in parenthesis: coxae:

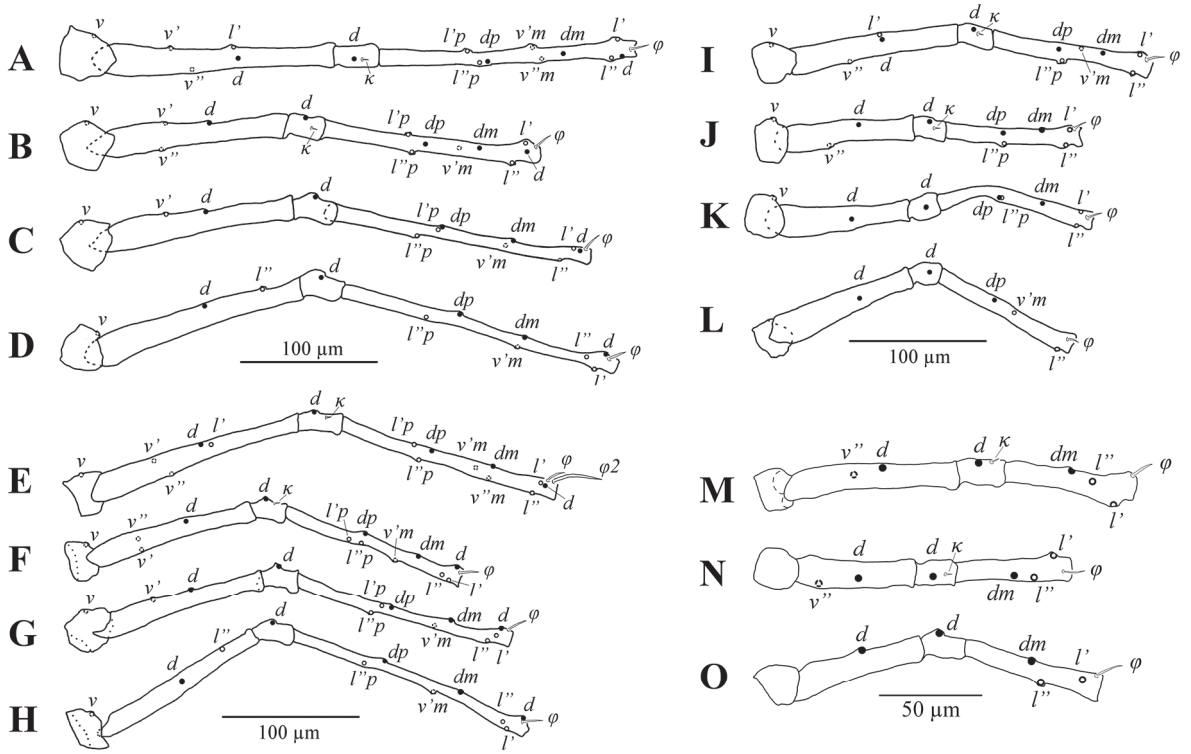

Fig. 3. Schematic leg setations of *Neophyllobius cibyci* sp. nov. **A–D**. ♀, holotype. **A**. Trochanter–tibia of leg I. **B**. Trochanter–tibia of leg II. **C**. Trochanter–tibia of leg III. **D**. Trochanter–tibia of leg IV. **E–H**. ♂, paratype (CNAC009238). **E**. Trochanter–tibia of leg I. **F**. Trochanter–tibia of leg II. **G**. Trochanter–tibia of leg III. **H**.Trochanter–tibia of leg IV. **I–L**. Protonymph, paratype (CNAC009241). **I**. Trochanter–tibia of leg I. **J**. Trochanter–tibia of leg II. **K**. Trochanter–tibia of leg III. **L**. Trochanter–tibia of leg IV. **M–O**. Larva, paratype (CNAC009242). **M**. Trochanter–tibia of leg I. **N**. Trochanter–tibia of leg II. **O**. Trochanter–tibia of leg III.

3–1–2–0, trochanters 1–1–1–0, femora 3–2–1–1, genua 1(*κ*)–1(*κ*)–1–1, tibiae 6(*φ*)–5(*φ*)–5(*φ*)–3(*φ*), tarsi 9(*ω*)–9(*ω*)–7–5.

Larva (Figs 2E–F, 3M–O, 4M–O), range of three paratypes

Gnathosoma. 45–50 long and 60 wide. Subcapitular setae *m* and palpal femur seta *d* absent, setae *Or1* 88, *Or2* 8. Chelicerae 20–22 long. Length of palpal setae: femur *l'* 20–21 and genu *d* 20.

Idiosoma. 165–180 long (gnathosoma excluded), 130–135 wide. *Dorsum* (Fig. 2E). Setae shorter than those of females, *c2* longest. Setal pair *pdx* absent. Length of setae: *vi* 28–29, *ve* 30–34, *sci* 34, *sce* 34, *c1* 35–38, *c2* 42–43, *d1* 32–34, *d2* 28, *e1* 35–36, *e2* 25–27, *f1* 30–34, *f2* 23–24, *h1* 17–18, *h2* 15. Distances between setae: *vi–vi* 30–35, *ve–ve* 58–60, *vi–ve* 18–20, *sci–sci* 65–68, *sce–sce* 85, *sci–sce* 28–29, *c1–d1* 43–46, *d1–d1* 10, *d1–d2* 37–38, *d1–e1* 25–27, *ve–sci* 10–11, *vi–c1* 35–41, *c1–c1* 10, *c1–c2* 55–60, *c2–c2* 105–110, *e1–e1* 10, *e1–f1* 25–30, *f1–h1* 22–24, *e1–e2* 35–39, *d2–e2* 37–40, *f1–f1* 9–10, *f1–f2* 25–26, *f2–f2* 50–55, *e2–f2* 30–32, *h1–h1* 8, *h1–h2* 9, *h2–h2* 20–22, *f2–h2* 22–24. *Venter* (Fig. 2F). Setal pairs *1c*, *2c*, *3b*, *3c*, *4b*, *4c*, *ag* and *g* absent. Length of setae: *1a* 20–24, *1b* 22–23, *3a* 25, *ps1* 7, *ps2* 7, *ps3* 8.

Legs. Leg I longest. Lengths (excluding ambulacra): leg I 260–265, leg II 240, leg III 250–255. Podomere lengths: femur I 80, femur II 60, femur III 70–75, tibia I 60–65, tibia II 55, tibia III 65–70, tarsus I 45, tarsus II 45, tarsus III 45. Leg setae as indicated in Figs 3M–O and 4M–O. Setae lengths: *v"* on femur I 32–34, *d* on femur I 22, dorsal seta on genu I 43–45, dorsal seta on genu II 33, dorsal seta on genu III 45, solenidion *ω* on tarsus I 3, *ω* on tarsus II 3. Counts of setae on legs I–III, indicating additional solenidia in parenthesis: coxae: 2–0–0, trochanters 0–0–0, femora 2–2–1, genua 1(*κ*)–1(*κ*)–1, tibiae 3(*φ*)–3(*φ*)–3(*φ*), tarsi 7(*ω*)–7(*ω*)–5.

Intraspecific variation

In the case of *Neophyllobius cibyci* sp. nov., we observed that leg setation teratologies are relatively rare, but include the following: 1) adult specimens with certain setae in different locations; for example, female right femur I with *v"* distal to *d* instead of proximal (CNAC009236), female right femur I with *l'* positioned before *d* (CNAC009234), female left femur I with *l'* positioned before *d* (CNAC009233), female tibiae I with seta *dm* between *v'* and *v"* (CNAC009231 and CNAC009235) instead of distal, female right tibia I with *dm* between *v'* and *v"* (CNAC009232) instead of distal, and male right tibia I with *l'p* distal to *l"p* instead of proximal (CNAC009238); 2) female specimens without setae on left or right legs, for example left femur I without *l'* (CIUM), left femur I without *v"* (CNAC009236), and left tibia I without *v"* (CNAC009236 and CIUM).

Remarks

Neophyllobius cibyci sp. nov. resembles *N. farrieri* De Leon, 1958 collected on "Spanish moss" (probably *Tillandsia usneoides*) in Oaxaca, Mexico. In both species, dorsal setae on genua I–IV are very long, extending beyond the tip of the tarsus, setae on femur I are short (about ⅙ of podomere length), and setae *l'* and *d* on femur I are nearly located at the same level. These species can be differentiated by the following characters: in *N. cibyci* sp. nov., dorsal setae *c1* and *d1* are distinctly longer than the distance between setae *c1–d1* and *d1–e1* respectively, setae *d1* are the longest of the dorsal setae, and setae *d* and *l'* on palpal femur are heavily spinose. In *N. farrieri*, the lengths of dorsal setae *c1* and *d1* are the same as the distance between setae *c1–d1* and *d1–e1* respectively; setae *e1* are the longest of the dorsal setae, and setae *d* and *l'* on palpal femur are weakly spinose.

Neophyllobius cibyci sp. nov. includes at least three postembryonic instars (larva, protonymph and adult). We found only one nymphal instar (protonymph) which resembles the female type proposed by Bolland (2001).

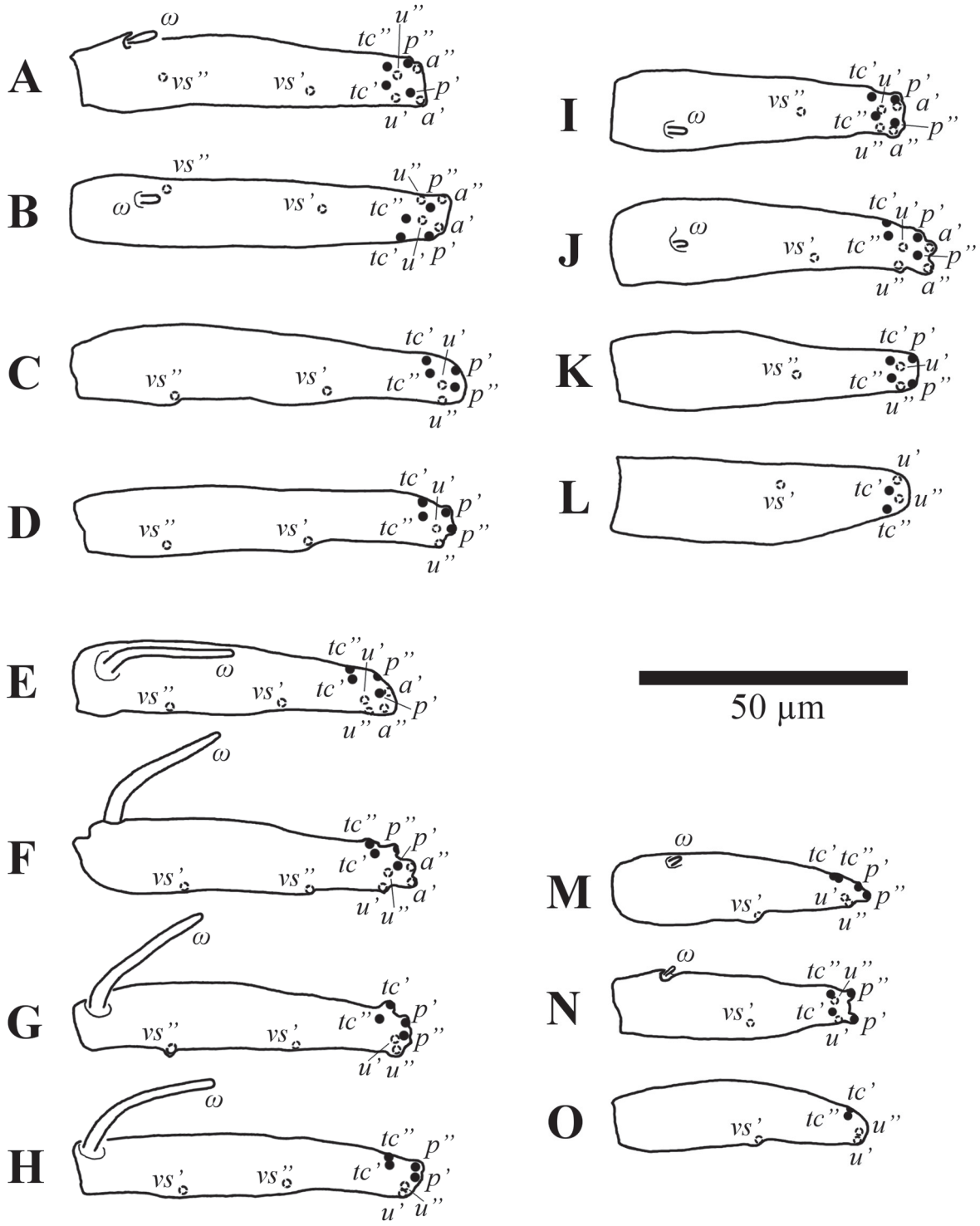

Fig. 4. Schematic tarsal setations of *Neophyllobius cibyci* sp. nov. **A–D**. ♀, holotype. **A**. Tarsus I. **B**. Tarsus II. **C**. Tarsus III. **D**. Tarsus IV. **E–H**. ♂, paratype (CNAC009238). **E**. Tarsus I. **F**. Tarsus II. **G**. Tarsus III. **H**. Tarsus IV. **I–L**. Protonymph, paratype (CNAC009241). **I**. Tarsus I. **J**. Tarsus II. **K**. Tarsus III. **L**. Tarsus IV. **M–O**. Larva, paratype (CNAC009242). **M**. Tarsus I. **N**. Tarsus II. **O**. Tarsus III.

Ecology

Neophyllobius cibyci sp. nov. was the most abundant camerobiid species with 17 specimens, most of which (76.5%) were collected in dry season (March and April). This species is deemed to be an inhabitant of the tree canopy because most specimens (94%) were collected on epiphytic bromeliads at 2.8 m (± 0.4) and only one female specimen (CNAC009237) was found on soil litter. *Neophyllobius cibyci* sp. nov. was found in low numbers, usually one specimen per sample, except for two samples which had two specimens each. The closely resembling species, *N. farrieri*, also inhabits epiphytic bromeliads of the genus *Tillandsia*.

Distribution

This species is only known from San Andrés de la Cal, Morelos, Mexico. The type locality of *N. cibyci* sp. nov. is about 440 km as the crow flies from the known distribution of *N. farrieri* (Puenta [*sic.*] de Nejapa, Oaxaca, Mexico).

Setal homology among *Neophyllobius cibyci* sp. nov. instars

The collection of different instars provides material for study and suggests the ontogenetic development pattern of gnathosoma, idiosoma and leg chaetotaxy. Although, Grandjean's idiosomal and leg chaetotaxy systems were previously applied to camerobiid mites (Kethley 1990; Fan & Walter 2011), this is the first study of complete chaetotaxy (on gnathosoma, idiosoma and legs) involving three different instars (larva, protonymph and adult) of a camerobiid mite species. Swift's (2001) study of leg chaetotaxy of Caligonellidae (Raphignathina: Raphignathoidea), included one larva and one adult female of an undetermined species of *Neophyllobius*. We found only one nymphal instar (protonymph); for this reason and because the presence of deutonymph is questionable in *Neophyllobius*, we prefer not to hypothesise the presence of setae in this particular instar (deutonymph).

There are different concepts about the leg chaetotaxy. Fundamental setae are those present when the appendages in question are first formed, that is on legs I–III in the larva or on leg IV in the protonymph. Accessory setae are any which are formed during subsequent moults (Grandjean 1941; Norton 1977; Swift 2001). Setal priority for each podomere refers to a list of setal organs that appear at the beginning of ontogeny (fundamental setae) and have greater priority, or force, than organs than develop later (accessory setae), which suggests that these setal organs are less susceptible to evolutionary regression (Norton 1977; Swift 2001). Setae of equal priority are listed together within parentheses as proposed by Norton (1977).

Gnathosoma. Larvae have *Or1* and *Or2*. Setal pattern on palps is consistent across larva, protonymph and adults, except that dorsal seta (*d*) on femur do not appear until the protonymphal instar; count of setae from palp coxa to tarsus: 1 (*elcp*), 0, 2, 1, 3 + 1 claw, 4 + ω. Setal pair *m* on subcapitulum do not appear until the protonymphal instar.

Idiosoma. The dorsal chaetotaxy in larvae includes 14 setal pairs: *vi*, *ve*, *sci*, *sce*, *c1*, *c2*, *d1*, *d2*, *e1*, *e2*, *f1*, *f2*, *h1* and *h2* (Fig. 2E). Setal pair *pdx* appears in protonymph (Fig. 2C). The ventral chaetotaxy in larvae includes six setal pairs: *1a*, *1b*, *3a*, *ps1*, *ps2* and *ps3* (Fig. 2F). Setal pairs *1c*, *2c*, *3b*, *3c* and *4a* are added in protonymph (Fig. 2D). Setal pairs *4b* and *4c* are added in adults (Figs 1D, 2B). Setal pair *ag* is present only in adult females (Fig. 1D).

Legs (Table 2). Setae *v* are absent on trochanters I–III in larva (Fig. 3M–O), and do not appear until the protonymphal instar (Fig. 3I–K). Seta *v* on trochanter IV does not appear until adulthood (Fig. 3D, H). Femora I–II of the larva with setae *v''* and *d* (Fig. 3M–N), femur III of the larva (Fig. 3O) and femur IV of the protonymph (Fig. 3L) only with seta *d*. Seta *l'* is added on femur I of the protonymph (Fig. 3I). Setae *v'* on femora I–III (Fig. 3A–C, E–G), and *l''* on femur IV (Fig. 3D, H) are added in adults. The setal

Table 2. Setal leg ontogeny of *Neophyllobius cibyci* sp. nov., parentheses represent a setal pair and square brackets indicate additional setae in ♂.

LEG	INSTAR	TROCHANTER	FEMUR	GENU	TIBIA	TARSUS
I	Larva	0	*d*, *v''*	*d*, *κ*	*dm*, (*l*), *φ*	*vs'*, (*tc*), (*p*), (*u*), *ω*
	Protonymph	*v*	*d*, *v''*, *l'*	*d*, *κ*	*dm*, (*l*), *φ*, *dp*, *l''p*, *v'm*	*vs''*, (*tc*), (*p*), (*u*), (*a*), *ω*
	Adult	*v*	*d*, (*v*), *l'*	*d*, *κ*	*d*, (*l*), (*vm*), *dp*, (*lp*), *dm*, *φ*, [*φ2*]	(*vs*), (*tc*), (*p*), (*u*), (*a*), *ω*
II	Larva	0	*d*, *v''*	*d*, *κ*	*dm*, (*l*), *φ*	*vs'*, (*tc*), (*p*), (*u*), *ω*
	Protonymph	*v*	*d*, *v''*	*d*, *κ*	*dm*, (*l*), *φ*, *dp*, *l''p*	*vs'*, (*tc*), (*p*), (*u*), (*a*), *ω*
	Adult	*v*	*d*, (*v*)	*d*, *κ*	*d*, (*l*), *v'm*, *dp*, (*lp*), *dm*, *φ*	(*vs*), (*tc*), (*p*), (*u*), (*a*), *ω*
III	Larva	0	*d*	*d*	*dm*, (*l*), *φ*	*vs'*, (*tc*), (*u*)
	Protonymph	*v*	*d*	*d*	*dm*, (*l*), *φ*, *dp*, *l''p*	*vs''*, (*tc*), (*p*), (*u*)
	Adult	*v*	*d*, *v'*	*d*	*dm*, (*l*), *φ*, (*lp*), *dp*, *d*, *v'm*	(*vs*), (*tc*), (*p*), (*u*), [*ω*]
IV	Protonymph	0	*d*	*d*	*dp*, *v'm*, *l''*, *φ*	*vs'*, (*tc*), (*u*)
	Adult	*v*	*d*, *l''*	*d*	*dp*, *v'm*, (*l*), *φ*, *d*, *l''p*, *dm*	(*vs*), (*tc*), (*p*), (*u*), [*ω*]

priorities on femora I and II for *Neophyllobius cibyci* sp. nov. are: (*d*, *v''*), *l'*, *v'*. Priorities on femora III and IV are: *d*, *l''*, *v'*. Genua I–II in all instars with seta *d* and *κ* (Fig. 3A–B, E–F, I–J, M–N), and genu III only with *d* (Fig. 3C, G, K, O). Genu IV of the protonymph and adults only with seta *d* (Fig. 3D, H, L).

Tibiae I–III of larva with setae *dm*, *l'*, *l''* and *φ* (Fig. 3M–O). Tibia IV of the protonymph with setae *dp*, *v'm*, *l''* and *φ* (Fig. 3L); *dp* and *l''p* are added to tibiae I–III (Fig. 3I–K) of the protonymph. Seta *v'm* is added to tibia I (Fig. 3I) of the protonymph. Setae *l'p*, and *d* are added to tibiae I–II of adults (Fig. 3A–B, E–F). Seta *v''m* appears only on tibiae I of adults (Fig. 3A, E). Setae *l'p* and *v'm* are added to tibia III of adults (Fig. 3C, G). Setae *l'*, *dp*, *l''p* and *d* are added to tibia IV of adults (Fig. 3D, H). Tibia I of males with *φ*2 (Fig. 3E). The setal priorities for tibiae I and II in *Neophyllobius cibyci* sp. nov., are: (*dm*, *l'*, *l''*), (*dp*, *l''p*, *v'm*), (*d*, *l'p*, *v''m*). Priorities on tibiae III and IV are similar except *v''m* is not formed.

Tarsi I–II of the larva with *vs'*, (*tc*), (*p*), (*u*) and *ω* (Fig. 4M–N), tarsus III with *vs'*, (*tc*), (*u*) and *ω* (Fig. 4O). In tarsi I–II of protonymph, setal pair *a* is added (Fig. 4I–J). Seta *vs'* is lost on tarsi I and III of protonymph but *vs''* appears (Fig. 4I, K). Tarsus IV of the protonymph with *vs'*, (*tc*) and (*u*) (Fig. 4L). Setae *vs'* reappears in tarsi I and III of adults (Fig. 4A, C, E, G). Seta *vs''* appears on tarsi II and IV (Fig. 4B, D, F, H). Setal pair *p* is added in tarsus IV of the adults (Fig. 4D, H). Tarsi III–IV of males with *ω* (Fig. 4G–H). The setal priorities for tarsi I and II are: (*tc'*, *tc''*, *u'*, *u''*, *vs'*, *p'*, *p''*), (*a'*, *a''*, *vs''*). Priorities on tarsi III and IV are: (*tc'*, *tc''*, *u'*, *u''*, *vs'*), (*p'*, *p''*, *vs''*).

Neophyllobius tepoztlanensis sp. nov.
urn:lsid:zoobank.org:act:A8A8CE4B-824C-40D7-A435-45A8E4401A4D
Fig. 5A–F

Diagnosis

This species is characterized as follows: dorsal setae reaching setae immediately behind, seta *d* on femur I positioned in front of *l'*, femur II with three setae (*d*, *v'* and *v''*), femur III with two setae (*d* and *v'*), setae *d* on genua I–IV slightly less than half as long as tibiae I–IV respectively, dorsal seta *d1* less than half as long as width of body; dorsal setae *c1* as long as setae *d1*, setae *v''* on femora I–II positioned distinctly in front of *v'*.

Etymology

The specific name makes reference to the municipality Tepoztlán, where the type locality is situated. The name of the municipality derives from two words in the náhuatl language, "Tepoztecatl" (a nahua divinity) and "tlan" (beside), so its meaning is "in the company of Tepoztécatl".

Type material

Holotype

MEXICO: ♀, CNAC009245, ex *Tillandsia schiedeana* at 2.4 m on *Sapium macrocarpum*. Collected from the type locality on 12 Mar. 2014, O. Cortés and R. Paredes coll. (RPL1232).

Paratypes

MEXICO: 1 ♀, CIUM, ex *T. hubertiana* at 3.2 m on *S. macrocarpum*, 30 Apr. 2014 (RPL1267); 1 ♀, CNAC009246, ex *T. hubertiana* at 2.6 m on *S. macrocarpum*, 22 Aug. 2014, S. Gómez and R. Paredes coll. (RPL1303). Both specimens collected from the type locality, with same data as holotype except where noted.

Type locality

MEXICO: Morelos, Tepoztlán, 1 km S of San Andrés de la Cal, 18.94408° N, 99.11924° W, 1478 m a.s.l.

Description

Female (n = 3) (Fig. 5A–F)

Holotype female (followed in parentheses by range of holotype and two paratype females).

Gnathosoma. 68 (68–79) long and 77 (71–82) wide. Subcapitulum with subcapitular setae *m* 20 (20–24) and two pairs of adoral setae *Or1* 9 (9) and *Or2* 10 (8–10); these three pairs nude and slender, *m* longest (Fig. 5B); distance *m–m* 20 (20–21). Chelicerae 40 (27–40) long. Palp, five-segmented with following setal distribution: trochanter without setae; femur with two serrated setae, *d* 19 (17–19) and *l'* 31 (27–31); genu with one long, slender, nude dorsal (*d*) seta 31 (30–32); tibia with three tactile setae (*l'*, *l''* and *d*) and one claw (sword-like seta); tarsus with two eupathidia (*acmζ* and *sulζ*), two simple setae (*ba* and *va*) and one small solenidion (*ω*) (Fig. 5A). Setae *elcp* present.

Idiosoma. Longer than wide, 285 (225–285) long (gnathosoma excluded), 230 (200–235) wide. Cuticle striated, except on coxae and attenuated between setal pair *e1* (Fig. 5C–D). *Dorsum*. With 15 pairs of serrated setae set on small tubercles; each setal pair just reaching next setal pairs (in transversal row), *c2* longest and *h2* shortest. Two pairs of eyes are positioned between setae *sci* and *sce*. Length of setae: *vi* 48 (48–53), *ve* 46 (46–48), *sci* 43 (43–50), *sce* 46 (46–48), *pdx* 46 (46–53), *c1* 50 (50–54), *c2* 63 (53–63), *d1* 51 (50–56), *d2* 40 (40–44), *e1* 53 (53–56), *e2* 46 (40–46), *f1* 50 (50–54), *f2* 30 (30–32), *h1* 34 (32–34), *h2* 28 (27–28). Distances between setae: *vi–vi* 40 (40–50), *ve–ve* 82 (64–94), *vi–ve* 28 (24–30), *sci–sci* 98 (80–110), *sce–sce* 130 (115–140), *sci–sce* 40 (34–40), *c1–d1* 46 (42–52), *d1–d1* 15 (14–15), *d1–d2* 70 (62–78), *d1–e1* 40 (38–43), *ve–sci* 19 (19–21), *pdx–pdx* 12 (11–12), *pdx–c1* 31 (29–31), *c1–c1* 15 (14–15), *c1–c2* 77 (70–86), *c2–c2* 160 (140–170), *e1–e1* 12 (10–12), *e1–f1* 42 (34–42), *f1–h1* 56 (38–56), *e1–e2* 54 (52–62), *d2–e2* 34 (34–37), *f1–f1* 11 (9–12), *f1–f2* 53 (43–53), *f2–f2* 91 (83–94), *e2–f2* 50 (30–50), *h1–h1* 8 (8–11), *h1–h2* 25 (23–25), *h2–h2* 57 (54–57), *f2–h2* 42 (26–42). *Venter*. Coxal setae slenderer than dorsal setae. Setal pairs *1a*, *3a*, *4a*, *ag*, *g*, *ps1*, *ps2* and *ps3* nude and short. Setae *1b*, *1c*, *2c*, *3b*, *3c*, *4b* and *4c* serrated. Setae *1c* longest and *g* shortest. Setal pairs *4a* and *ag* located on individual platelets. Genito-anal valves with one pair of genital setae (*g*). Coxa I grouped with coxa II, and coxa III with IV but not completely fused (Fig. 5D). Length of setae: *1a* 32 (27–32), *1b* 22 (21–22), *1c* 50 (42–50), *2c* 42 (35–42), *3a* 37 (34–37), *3b* 30 (25–30), *3c* 31 (30–31), *4a* 19 (19–30), *4b* 18 (14–18), *4c* 20 (19–20), *ag* 16 (12–16), *g* 9 (9–12), *ps1* 14 (9–15), *ps2* 11 (10–12), *ps3* 12 (10–14).

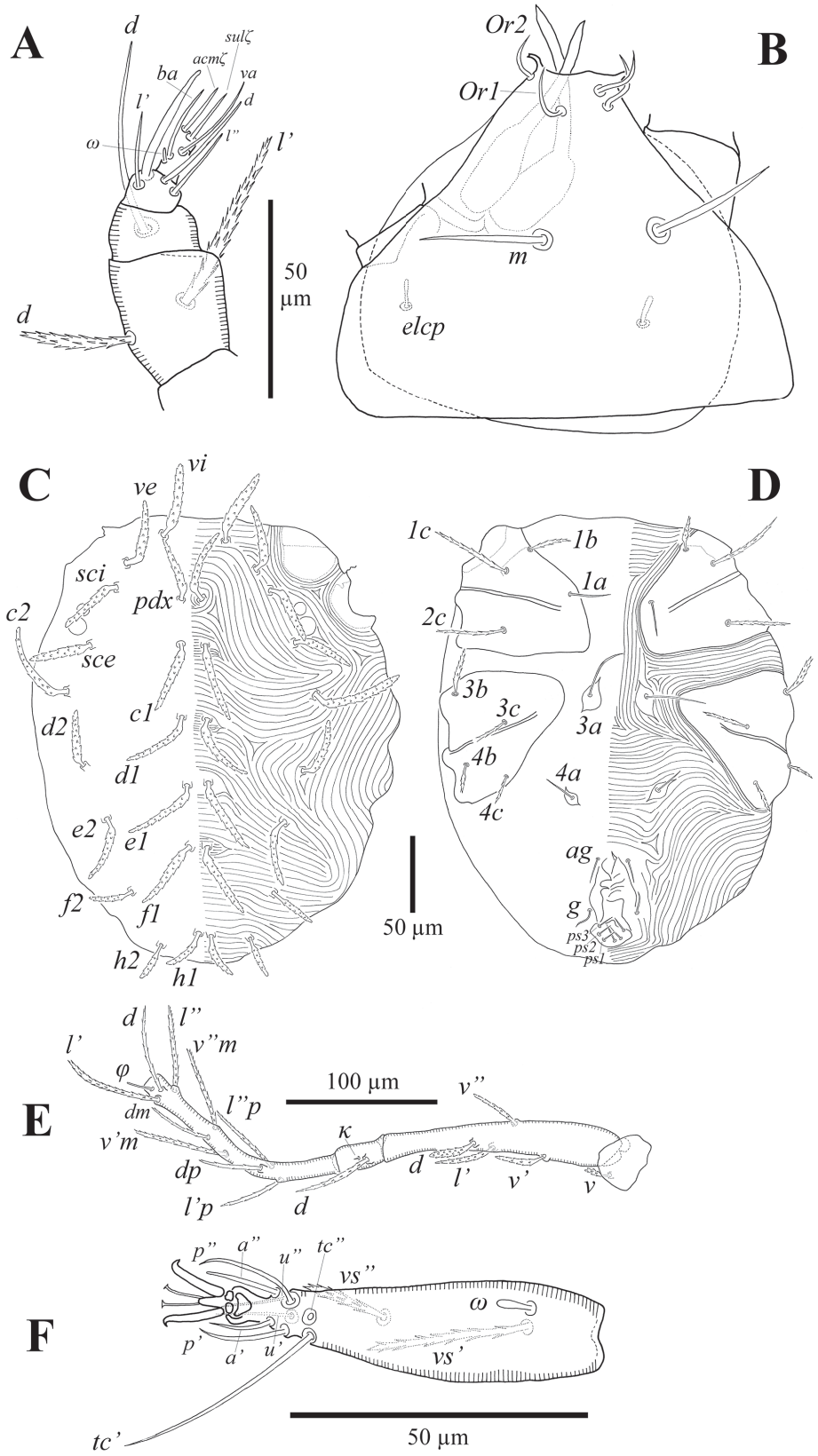

Fig. 5. *Neophyllobius tepoztlanensis* sp. nov., ♀, holotype. **A**. Palp. **B**. Subcapitulum. **C**. Dorsal idiosoma. **D**. Ventral idiosoma. **E**. Trochanter–tibia of leg I. **F**. Tarsus I.

Legs. Slender and long, leg IV longest. Lengths (excluding ambulacra): leg I 500 (420–510), leg II 415 (390–450), leg III 455 (417–485), leg IV 505 (470–530). Podomere lengths: femur I 160 (160–165), femur II 120 (110–130), femur III 125 (115–135), femur IV 140 (130–155), tibia I 145 (135–160), tibia II 115 (110–125), tibia III 130 (130–165), tibia IV 165 (155–175), tarsus I 59 (54–61), tarsus II 58 (56–61), tarsus III 60 (57–66), tarsus IV 66 (62–66). Leg setae as indicated in Fig. 5E–F. Tarsus I with five setal pairs: *vs* serrated, *tc*, *a*, *p* and *u* slender and nude, *u* bifurcated at tip. Setae *tc* longest. Setae lengths: *v'* on femur I 34 (30–34), *v''* on femur I 34 (30–37), *l'* on femur I 38 (31–38), *d* on femur I 31 (30–31), dorsal seta on genu I 54 (48–54), dorsal seta on genu II 45 (39–45), dorsal seta on genu III 45 (42–47), dorsal seta on genu IV 71 (68–71). All tarsi with ambulacrum bearing a pair of claws and an empodium with two rows of tenent hairs. Counts of setae on legs I–IV, indicating additional solenidia in parenthesis: coxae: 3–1–2–2, trochanters 1–1–1–1, femora 4–3–2–2, genua 1(κ)–1(κ)–1–1, tibiae 9(φ)–8(φ)–8(φ)–7(φ), tarsi 10(ω)–10(ω)–8–8.

Remarks

Neophyllobius tepoztlanensis sp. nov. resembles *N. marginatus* De Leon, 1958 collected from an undetermined composite plant and *Quercus* sp. in Nayarit, Mexico. In both species, the dorsal setae on genua I–IV are short, less than half as long as tibiae I–IV; the setae on femur I are short (about a quarter of the length of the podomere). These species can be differentiated by the following characters: in *N. tepoztlanensis* sp. nov., dorsal setae *c1* as long as setae *d1*, and setae *v''* on femora I–II positioned distinctly in front of *v'*. In *N. marginatus*, dorsal setae *c1* about half as long as seta *d1*, and setae *v'* and *v''* on femora I–II are positioned horizontally on nearly the same level.

Ecology

Neophyllobius tepoztlanensis sp. nov. is deemed to be an inhabitant of the tree canopy and was found on *Tillandsia schiedeana* and *T. hubertiana* at 2.7 m (± 0.4) on *Sapium macrocarpum.*

Distribution

This species is only known from San Andrés de la Cal, Morelos, Mexico. The type locality of *N. tepoztlanensis* sp. nov. is about 600 km from Ixtlán del Río, Nayarit, Mexico and 660 km from Tepic, Nayarit, the two known localities of *N. marginatus*.

Neophyllobius tescalicola sp. nov.
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Fig. 6A–F

Diagnosis

This species is unique due to a combination of following characters: dorsal setae reaches setae immediately behind, femur II with three setae (*d*, *v'* and *v''*), femur III with two setae (*d* and *v'*), setae *d* on genua I–IV passing tibiae, long setae (about ⅓ of podomere length) on femur I; setae *d* on femur I positioned behind setae *l'*, dorsal idiosomal setae *pdx* and *c1* grouped on small and finely-striated platelet.

Etymology

The specific name refers to the parent rock of the soil (lava flow) in which soil litter, the habitat of this mite species, is deposited. The word "tescal" in the náhuatl language means covered basalt stone from ancient volcanic eruptions or volcanic lava field, and the latin suffix "cola" means inhabitant (one who inhabits). So, *tescalicola* means "inhabitant of volcanic lava fields".

Type material

Holotype

MEXICO: ♀, CNAC009247, on soil litter of *Quercus obtusata*. Collected from the type locality on 12 Mar. 2014, O. Cortés and R. Paredes coll. (RPL1224).

Paratypes

MEXICO: 2 ♀♀, CNAC009248, 1 ♀, CIUM, on soil litter of *Quercus obtusata*, 23 Oct. 2014, R. Reyes and R. Paredes coll. (RPL1317). All collected from the type locality, with same data as holotype except where noted.

Type locality

MEXICO: Morelos, Tepoztlán, 1 km S of San Andrés de la Cal, 18.94329° N, 99.11784° W, 1485 m a.s.l.

Description

Female (n = 3) (Fig. 6A–F)

Holotype female (followed in parentheses by range of holotype and two paratype females).

Gnathosoma. 88 (85–90) long and 82 (80–85) wide. Subcapitulum with subcapitular setae *m* 24 (24–27) and two pairs of adoral setae *Or1* 15 (12–15) and *Or2* 8 (8); these three pairs nude and slender, *m* longest (Fig. 6B); distance *m–m* 22 (20–23). Chelicerae 24 (23–25) long. Palp, five-segmented with following setal distribution: trochanter without setae; femur with two serrated setae, *d* 16 (15–16) and *l'* 27 (25–28); genu with one long, slender, nude dorsal (*d*) seta 37 (35–38); tibia with three tactile setae (*l'*, *l''* and *d*) and one claw (sword-like seta); tarsus with two eupathidia (*acmζ* and *sulζ*), two simple setae (*ba* and *va*) and one small solenidion (*ω*) (Fig. 6A). Setae *elcp* present.

Idiosoma. Longer than wide, 340 (330–345) long (gnathosoma excluded), 305 (300–310) wide. Cuticle striated, except on coxae and attenuated between setal pairs *pdx*, *c1* and *d1* (Fig. 6C–D). *Dorsum*. With 15 pairs of serrated setae set on small tubercles; all setal pairs longer than distance to setal pairs immediately behind, *e2* longest and *h2* shortest. Two pairs of eyes are positioned between setae *sci* and *sce*. Setal pairs *pdx* and *c1* associated in a small and weakly striated platelet (Fig. 6C). Length of setae: *vi* 81 (80–81), *ve* 77 (76–77), *sci* 70 (70), *sce* 77 (75–80), *pdx* 71 (70–73), *c1* 80 (80–83), *c2* 84 (84–85), *d1* 77 (75–77), *d2* 74 (74–75), *e1* 84 (84–85), *e2* 87 (85–90), *f1* 84 (83–84), *f2* 40 (39–41), *h1* 45 (43–45), *h2* 36 (35–36). Distances between setae: *vi–vi* 53 (50–53), *ve–ve* 99 (99–100), *vi–ve* 36 (35–36), *sci–sci* 120 (120–125), *sce–sce* 160 (160–165), *sci–sce* 42 (40–43), *c1–d1* 53 (50–53), *d1–d1* 19 (18–19), *d1–d2* 88 (85–90), *d1–e1* 54 (53–54), *ve–sci* 20 (18–20), *pdx–pdx* 20 (20), *pdx–c1* 26 (25–28), *c1–c1* 19 (18–20), *c1–c2* 91 (90–95), *c2–c2* 185 (180–185), *e1–e1* 12 (11–12), *e1–f1* 37 (36–38), *f1–h1* 53 (53–55), *e1–e2* 67 (65–67), *d2–e2* 54 (54–55), *f1–f1* 12 (12), *f1–f2* 56 (55–56), *f2–f2* 70 (70–73), *e2–f2* 68 (65–70), *h1–h1* 9 (9), *h1–h2* 23 (20–25), *h2–h2* 42 (40–43), *f2–h2* 28 (27–28). *Venter.* Coxal setae slenderer than dorsal setae. Setal pairs *1a*, *3a*, *4a*, *ag*, *g*, *ps1*, *ps2* and *ps3* nude and short. Setae *1b*, *1c*, *2c*, *3b*, *3c*, *4b* and *4c* serrated. Setae *1c* longest and *ps2* shortest. Setal pairs *3a* and *4a* located on individual platelets. Genito-anal valves with one pair of genital setae (*g*). Coxa I grouped with coxa II, and coxa III with IV but not completely fused (Fig. 6D). Length of setae: *1a* 29 (28–29), *1b* 19 (15–20), *1c* 58 (55–58), *2c* 51 (50–55), *3a* 21 (20–21), *3b* 27 (27–30), *3c* 30 (30), *4a* 22 (20–22), *4b* 26 (25–27), *4c* 30 (30), *ag* 20 (20), *g* 14 (13–14), *ps1* 14 (13–14), *ps2* 12 (11–12), *ps3* 14 (13–14).

Legs. Slender and long, leg IV longest. Lengths (excluding ambulacra): leg I 660 (650–665), leg II 570 (565–580), leg III 660 (660–675), leg IV 750 (745–765). Podomere lengths: femur I 215 (210–215), femur II 170 (170–180), femur III 185 (185), femur IV 225 (220–230), tibia I 215 (210–220), tibia II 185 (180–190), tibia III 235 (230–235), tibia IV 265 (260–270), tarsus I 80 (80), tarsus II 82 (80–83), tarsus III 83 (81–84), tarsus IV 86 (86–90). Leg setae as indicated in Fig. 6E–F. Tarsi I with five setal

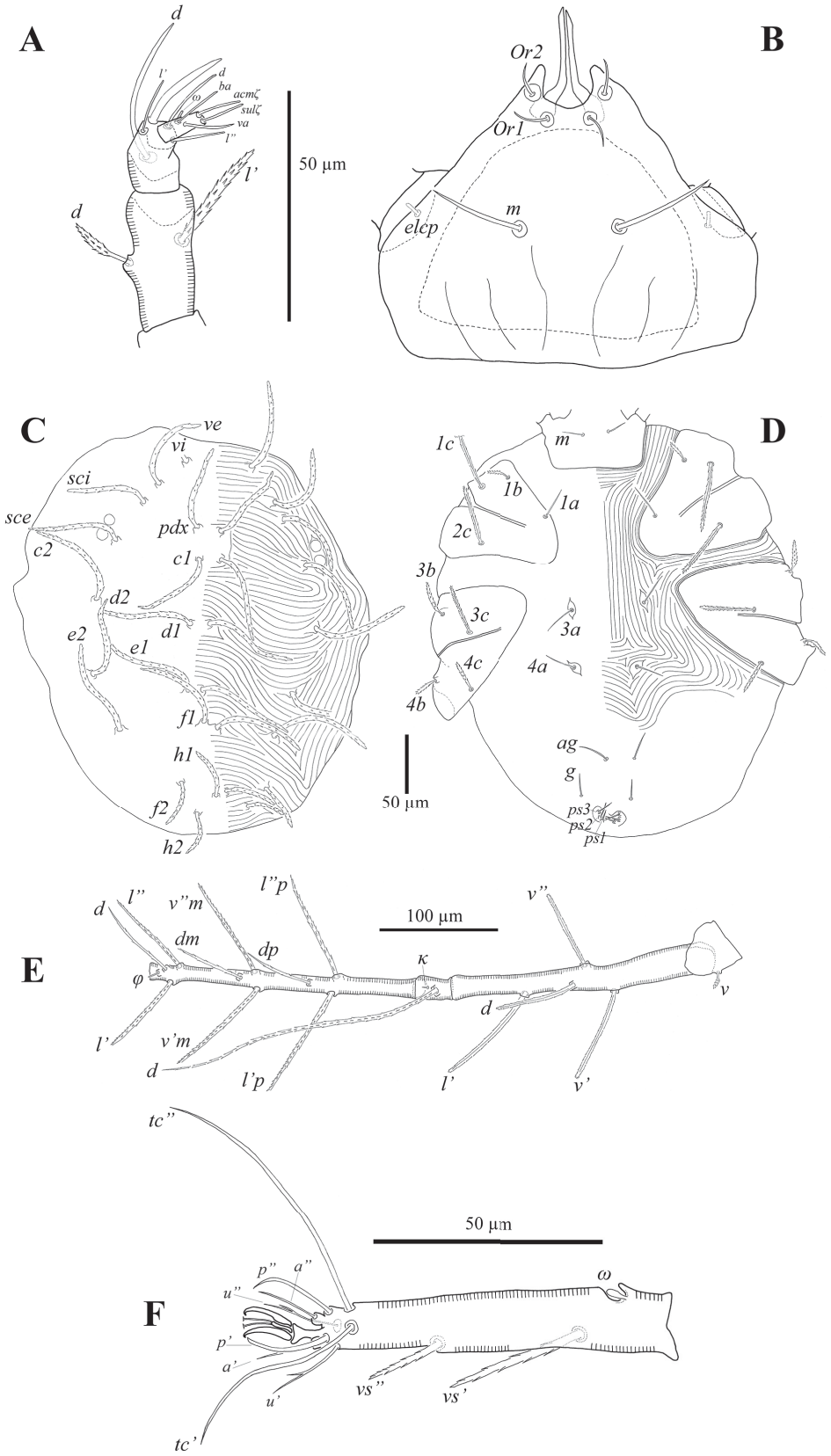

Fig. 6. *Neophyllobius tescalicola* sp. nov., ♀, holotype. **A**. Palp. **B**. Subcapitulum. **C**. Dorsal idiosoma. **D**. Ventral idiosoma. **E**. Trochanter–tibia of leg I. **F**. Tarsus I.

pairs: *vs* serrated, *tc*, *a*, *p* and *u* slender and nude, *u* bifurcated at tip. Setae *tc* longest. Setae lengths: *v'* on femur I 80 (75–85), *v''* on femur I 67 (65–70), *l'* on femur I 94 (94–98), *d* on femur I 68 (65–70), dorsal seta on genu I 250 (245–250), dorsal seta on genu II 250 (250), dorsal seta on genu III 285 (280–290), dorsal seta on genu IV 341 (340–345). All tarsi with ambulacrum bearing a pair of claws and an empodium with two rows of tenent hairs. Counts of setae on legs I–IV, indicating additional solenidia in parenthesis: coxae: 3–1–2–2, trochanters 1–1–1–1, femora 4–3–2–2, genua 1(κ)–1(κ)–1–1, tibiae 9(φ)–8(φ)–8(φ)–7(φ), tarsi 10(ω)–10(ω)–8–8.

Remarks

Neophyllobius tescalicola sp. nov. resembles *N. farrieri* and *N. cibyci* sp. nov. In these three species, the dorsal setae on genua I–IV are very long, extending beyond the tip of the tarsus. These species can be differentiated by the following characters: in *N. tescalicola* sp. nov., setae on femur I are long, about ⅓ of podomere length, setae *d* on femur I is positioned behind setae *l'*, dorsal idiosomal setae *pdx* and *c1* are grouped on a small and finely-striated platelet. In *N. farrieri* and *N. cibyci* sp. nov., setae on femur I are short, about a sixth of the length of the podomere, setae *l'* and *d* on femur I are nearly positioned horizontally at same level, and dorsal idiosomal setae *pdx* and *c1* are not joined on a platelet.

Ecology

Neophyllobius tescalicola sp. nov. inhabits soil litter of *Quercus obtusata*, and was collected in dry (March) and in rainy seasons (October).

Distribution

This species is only known from the type locality.

Key to the species of the genus Neophyllobius *in Mexico*

Based on females, updated from De Leon (1958).

1. Dorsal setae *c1*, *d1*, *e1* and *f1* not reaching setae immediately behind ..... ***Neophyllobius mexicanus*** McGregor, 1950
– At least one of these dorsal setae *c1*, *d1*, *e1* and *f1* reaching or extending beyond the seta immediately behind 2

2. Femur II with four setae ..... ***N. quadrisetosus*** De Leon, 1958
– Femur II with three setae 3

3. Femur III with three setae ..... ***N. trisetosus*** De Leon, 1958
– Femur III with two setae 4

4. Seta *d* on genu IV longer than or about as long as tibia 5
– Seta *d* of genu IV distinctly shorter than tibia IV 10

5. Setae *d* of genua III–IV extending beyond ends of respective legs 6
– Setae *d* of genua III–IV not extending beyond ends of respective legs 8

6. Femur I with long setae, about ⅓ of podomere length; setae *l'* on femur I positioned before setae *d*; dorsal idiosomal setae *pdx* and *c1* grouped on a small and finely striated platelet ..... ***Neophyllobius tescalicola*** sp. nov.
– Femur I with short setae, about ⅙ of podomere length; setae *l'* and *d* on femur I positioned horizontally nearly at same level; dorsal idiosomal setae *pdx* and *c1* not joined on a platelet 7

7. Length of dorsal setae *c1* and *d1* same as distance between setae *c1–d1* and *d1–e1* respectively; setae *e1* longest of dorsal setae; setae *d* and *l'* on palpal femur, weakly spinose....***N. farrieri*** De Leon, 1958
– Dorsal setae *c1* and *d1* distinctly longer than distance between setae *c1–d1* and *d1–e1* respectively; setae *d1* longest of dorsal setae; setae *d* and *l'* on palpal femur, heavily spinose ....***Neophyllobius cibyci*** sp. nov.

8. Seta *d* of genu III distinctly shorter than tibia III .....***N. inequalis*** De Leon, 1958
– Seta *d* of genu III longer than or about as long as tibia III 9

9. Seta *d* on genu II shorter than tibia II, seta of genu III about as long as tibia III ....***N. equalis*** De Leon, 1958
– Setae *d* on genua II and III distinctly longer than respective tibiae... ***N. consobrinus*** De Leon, 1958

10. Striae of dorsum consisting chiefly of broken striae; posterior margins of femora I–IV, highly serrulate.....***N. lobatus*** De Leon, 1958
– Striae of dorsum consisting chiefly of unbroken striae; posterior margins of femora, not highly serrulate.....11

11. Dorsal setae *d1* more than half as long as width of body; seta *d* on genu III about two-thirds as long as tibia III.....***N. deleoni*** Bolland, 1991
– Dorsal setae *d1* less than half as long as width of body; seta *d* on genu III about one-half (or less) as long as tibia III..... 12

12. Seta *d* on genu II distinctly longer than genu II..... 13
– Seta of genu II about as long as or shorter than genu II 15

13. Seta *d* on genu II nearly as long as seta of genu III and about half as long as seta of genu IV..... 14
– Seta *d* on genu II about half as long as seta of genu III and about one-third as long as seta *d* on genu IV .....***N. longulus*** De Leon, 1958

14. Dorsal setae *c1* as long as setae *d1*; setae *v"* on femora I–II distinctly in front of *v'*..... .....***Neophyllobius tepoztlanensis*** sp. nov.
– Dorsal setae *c1* about half as long as setae *d1*; setae *v* on femora I–II positioned horizontally on nearly same level .....***N. marginatus*** De Leon, 1958

15. Genual setae coarse, setiform, distinctly spinose .....***N. curtipilus*** De Leon, 1958
– Genual setae linear (seta of genu II is slightly obovate), very faintly spinose ....***N. spatulus*** De Leon, 1958

Discussion

Some patterns of setal ontogeny found in *Neophyllobius cibyci* sp. nov. have also been found in other Raphignathina. For example, the presence of setae *v* on trochanters I–III, retarded until the protonymphal instar, was also reported in Caligonellidae (Swift 2001) and Pterygosomatidae (Paredes-León & Guzmán-Cornejo 2015).

The larva of *N. cibyci* sp. nov. bears the setal pair *p* (i.e., *p'* and *p"*) on tarsus I instead of only *p'* as in *Neophyllobius* sp. (Swift 2001). Also, tarsus IV in females of *N. cibyci* sp. nov. has one more seta (i.e., eight instead of seven like *Neophyllobius* sp.); however, Swift (2001) didn't mention the nomenclature of these seven setae, making the comparison with *N. cibyci* sp. nov. difficult. Another difference between both species is the presence of iteral setae (*it*) on tarsi I–IV located anterodorsal to (*tc*) (Swift 2001). Based on the location (anterodorsal to *tc*), we consider setae *it* to be absent in *N. cibyci* sp. nov., but setal

pair *p* to be present instead. The same condition (i.e., presence of setal pair *p* on tarsi I–IV instead of setal pair *it*) was reported by Fan & Walter (2011) for *Acamerobia inflatus* (Camerobiidae).

The presence of setal pair *it* has been reported anterodorsal to setal pair *p* and *a* for some pterygosomatid mites (Pterygosomatidae) only in tarsus I (Bochkov *et al*. 2008; Paredes-León *et al*. 2012; Paredes-León & Guzmán-Cornejo 2015). According to Khanjani *et al*. (2014), setal pair *it* is also absent in *Neophyllobius ostovani* Khanjani, Hoseini, Yazdanpanah & Masoudian, 2014, and in *N. lorestanicus* Khanjani, Hoseini, Yazdanpanah & Masoudian, 2014 adults. Compared with these latter species, *Neophyllobius cibyci* sp. nov. has both setae of pair *p* (i.e., *p'* and *p''*) on tarsi I–II, whereas *N. ostovani* has only one (*p'*) on tarsi I–II. *N. lorestanicus* has both setae *p* on tarsus I but only *p'* on tarsus II.

In many other species of the genus *Neophyllobius* the counts of setae in adults, from coxa to tarsus, appears to be consistent with that found in *Neophyllobius cibyci* sp. nov. (coxae: 3–1–2–2, trochanters 1–1–1–1, femora 4–3–2–2, genua 1(κ)–1(κ)–1–1, tibiae 9(φ)–8(φ)–8(φ)–7(φ), tarsi 10(ω)–10(ω)–8–8), such as *N. lachishensis* Bolland, 1998, *N. piniphilus*, *N. demirsoyi* Akyol & Koç, 2006 and *N. quercus* Uluçay & Koç, 2014, among others (Bolland 2001; Akyol & Koç 2006; Uluçay & Koç 2014).

Leg setation teratologies similar to that shown by *N. cibyci* sp. nov. has also been reported in other camerobiid mites, for example in *N. consobrinus* (Bolland & Swift 2000), *Tycherobius stramenticola* Bolland, 1986 and *T. polonicus* Bolland, 1986 (Koç & Akyol 2007). In the last two species, abnormal disposition of setae are also found in dorsal and ventral idiosoma (Koç & Akyol 2007).

Due to the lack of setal notations, and because many descriptions of camerobiid mites are based on single specimens, it is very difficult to establish a homology hypothesis among instars and even among species. Notwithstanding this fact, our data suggest a hypothesis to how leg setae appear at different life stages on the podomeres of legs I–IV of larva, protonymph and adult. However, a detailed examination of the leg chaetotaxy of taxa in Camerobiidae will have to be conducted to establish homologies within the family and with the other raphignathoids.

The results presented here clearly show that the species richness of the family Camerobiidae in Mexico is under-represented, and that systematic surveys sampling different components of vegetation are needed. The species recorded had different habitat preferences, two of them inhabiting epiphytic bromeliads on two tree species at an average height of 2.8 m (± 0.4), and one inhabiting soil litter of one tree species. This suggests that habitat diversity determines the richness of the group but it needs to be studied in greater detail.

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