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TWO NEW SPECIES OF *PARARRHOPALITES* (COLLEMBOLA: SYMPHYPLEONA: SMINTHURIDAE) IN BRAZIL.

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ABSTRACT

Two new species of springtails (Symphypleona: Sminthuridae), *Pararrhopalites sideroicus* **sp. nov.** and *Pararrhopalites palaciosi* **sp. nov.** are described. The species come from very different environments, the first is a cave dweller in iron caves and the other comes from tropical Atlantic forest leaf litter. They were found only from type localities, in Southeastern and Northeastern Brazil respectively. An identification key is provided for all members of the genus.

Key Words: Taxonomy, Atlantic Forest, Neotropical Collembola, cave and litter fauna, globular springtails

RESUMEN

Se describen dos nuevas especies de colémbolos (Symphypleona: Sminthuridae), *Pararrhopalites sideroicus* **sp. nov.** y *Pararrhopalites palaciosi* **sp. nov.** Ellas provienen de ambientes muy distintos, la primera vive en cuevas de hierro, y la otra en hojarasca de bosque tropical atlántico. Las especies sólo son conocidas de las localidades tipo, en el Sureste y Noreste de Brasil, respectivamente. Se presenta una clave para la identificación de todos los miembros del género.

Palabras Clave: Taxonomía, Bosque Tropical Atlántico, Collembola Neotropicales, Collembola de cuevas y hojarasca, colémbolos globulares

RESUMO

Descrevemos duas espécies novas de colêmbolos (Symphypleona: Sminthuridae), *Pararrhopalites sideroicus* **sp. nov.** e *Pararrhopalites palaciosi* **sp. nov.** As espécies habitam ambientes muito distintos, a primeira vive em cavernas de ferro, e a outra habita o folhiço em floresta tropical Atlântica. As espécies são conhecidas apenas das localidades tipo, no Sudeste e Nordeste brasileiro, respectivamente. Apresentamos uma chave para a identificação de todos os membros do gênero.

Palavras Chave: Taxonomia, Floresta Atlântica, Collembola Neotropicais, Collembola de cavernas e folhiço, colêmbolos globulares

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Pararrhopalites Bonet & Tellez, 1947 was described as follows: Sminthurini; antennae clearly elbowed between Ant. III and IV. Ant. IV subdivided. Ant. III without papilla, setae on basal half sub equal to setae on distal half. Eyes and pigment reduced or lacking. Unguis without tunica; empodial appendages with apical filament, tenant hairs absent. Mucro without mucronal lamina or seta. Collophore sacs large with papillae. No glandular opening on furcal segment. Tenacular rami without lateral appendages. Vertex with lancet like setae. Three pairs of thrichobothria on great abdomen and one pair on genital segment. Body setae slender, short, acuminate, rigid or flexible.

Betsch (1980) complemented the diagnosis of *Pararrhopalites* and remarked on the presence

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of a metathrochanteral spine, dorsal cephalic spines, finely dented macrosetae on great abdomen, female subanal appendages elongated and simple, post antennal organ and dorsal glands absent. Furthermore, he pointed out variable characters as the Ant. IV subdivision (9-14 subsegments), anterior dental formula (3,2,1…1; 3,2,2,1…1; 3,2,2,2,1…1), and number of ommatidia on eyes spots (0-8), extending the definition of the genus to include species with more than 2+2 ommatidia (Bonet & Tellez 1947). The latter made *Neosphyrotheca* Salmon, 1964 a junior synonym of *Pararrhopalites* (Betsch 1980).

The species described here present 2 extreme conditions seen in the genus. One species lacks eyes and pigment while the other has 8+8 eyes and pigment on eyes spots and over the body; the first species occurs in a group of small caves in iron ore lithology and the later one in tropical forest leaf litter. Only 2 species were previously recorded in Brazil, *P. papaveroi* (Zeppelini & Palacios-Vargas 1995) *P. wallacei* (Palacios-Vargas & Zeppelini 1995), both from caves and red-listed in Brazil as endangered (En) and critically endangered (Cr) respectively. This contribution is part of an effort to describe and understand the diversity and distribution of Collembola in Brazil and their conservation status.

Materials and Methods

Dens and posterior cephalic chaetotaxies follow Christiansen (1966) and Christiansen & Bellinger (1998), anterior head, labrum and great abdomen follow Betsch & Waller (1994), anal valves as in Betsch (1997). Apical organ of Ant. III chaetotaxy follows Nayrolles (1991), trichobothria and surrounding setae as in Richards (1968). The abbreviations used along the description are the following: Ant, antennal segment; CD, cephalic diagonal; Th, thoracic segment; Abd, abdominal segment; Ov, oval organ.

Symphypleona Börner, 1901

Sminthuroidea Bretfeld, 1994

Sminthuridae Lubbock, 1862

Sminthurinae Lubbock, 1862

Pararrhopalites Bonet & Tellez, 1947 (= *Neosphyrotheca* Salmon, 1964)

Pararrhopalites sideroicus sp. nov.
(Figs. 1-17, Table 1)

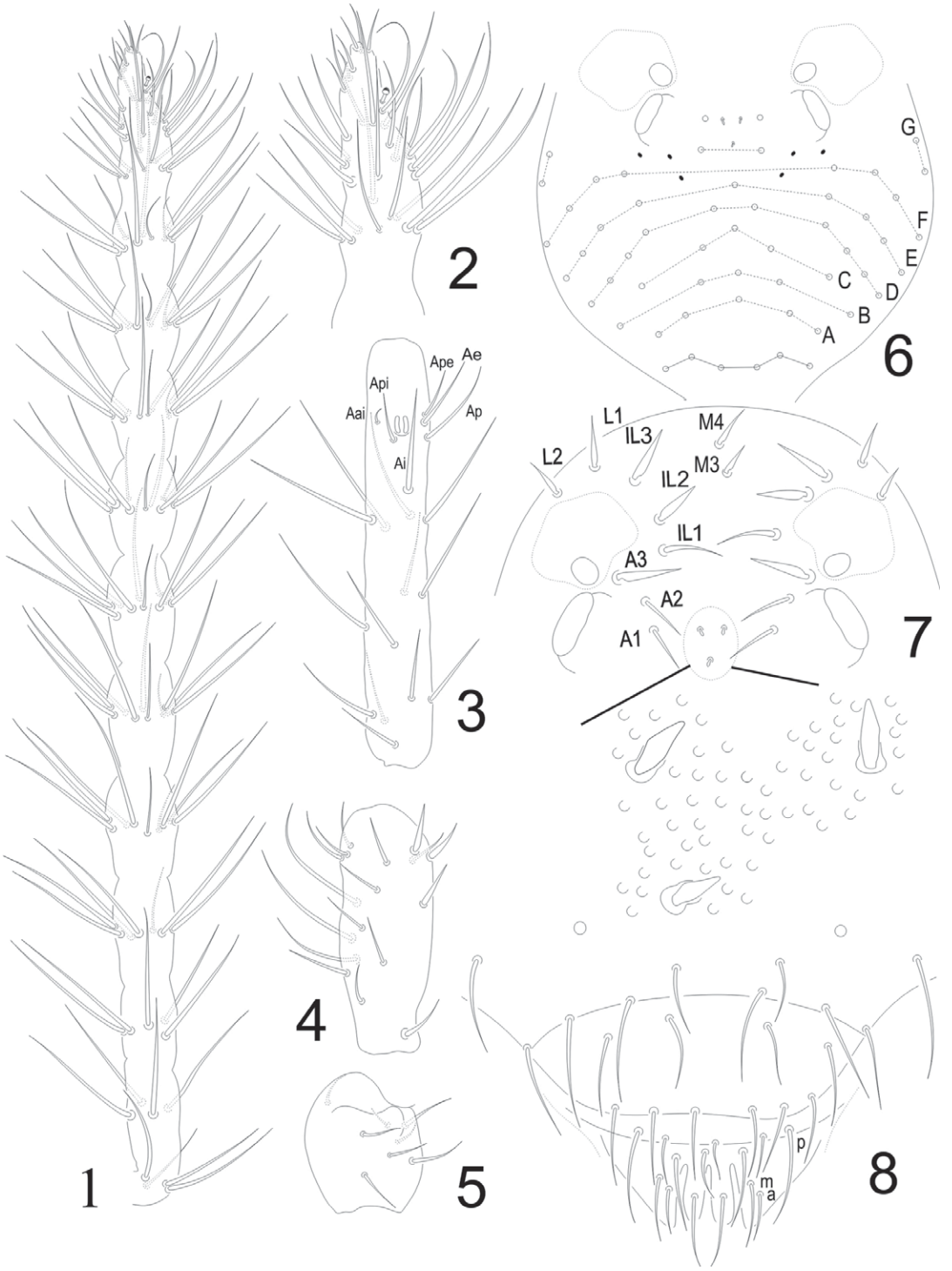
Material Examined

HOLOTYPE: Female, BRAZIL: Minas Gerais, Itabirito, VL-29 cave, 21/24-V-2013, coll. Mascarenhas et al., deposited at Coleção de Referência da Fauna de Solo da Universidade Estadual da Paraíba (CRFS-PB) with the number 5044.

PARATYPES: 3 females, BRAZIL: Minas Gerais, Itabirito, VL-30 cave, 29-III/03-IV-2012 and 03/06-X-2011, coll. Carste et al., deposited at Museu Nacional da Universidade Federal do Rio de Janeiro (MN-UFRJ) under number 2459. 2 females, BRAZIL: Minas Gerais, Itabirito, VL-30 cave, 03/06-X-2011, coll. Carste et al., deposited at Museu de Zoologia da Universidade de São Paulo (MZ-USP), number 0069 and 0070

Description. Pigment and eyes absent, or 1+1 vestigial ommatidia. Body length ~1.0 mm female, ~0.66 mm male (Table 1), habitus sminthuroid. Antennal segments ratio 1:1.8/2.8/8.8. Ant. IV 11(9) subsegmented (Fig. 1), 1.17x longer than CD; basal and apical subsegments slightly longer than intermediate subsegments, each subsegment bear respectively from base to the apex 8,5,6,7,8,8,6,8,8,7,30 setae. Ant. IV subsegment III with 1 sensillum, subsegments IV-VI and VIII-X with 2 sensilla each, subsegment VII with 3 sensilla. Ant. IV apical subsegment bearing a hook like seta and a small bulb shaped sensillum (Fig. 2). Ant. III without basal papilla, apical organ with 2 round sensilla in a single shallow pit. Seta Aai slender, short and acuminated, Api and Ape slender and shorter than Ap and Ae; Ai long and acuminated (Fig. 3). Ant. II with 3 spinelike setae at the apex (Fig. 4), Ant. I with 8 setae (Fig. 5). Dorsal cephalic cuticle heavily granulated with smooth areas around setae IL1 and IL2, frontal region with normal granulation in a hexagonal pattern. Interantennal region with 4 setae and a singular organ formed by 3 sensilla forming a triangle (Figs. 6-7). Anterior to the antennal pit there are 3 structures similar to pseudopores in each side of head (Fig. 6). Dorsal cephalic chaetotaxy with A3, IL2, IL3, L1 and L2 spinelike, other setae normal, M1-2 absent (Fig. 7). Frontal head chaetotaxy as in Fig. 6. Clipeo-labrum formula 4,5,5,6 (Fig. 8). Trochanters I-III with 4,4,5 setae respectivelly, metatrochanteral spine present (Fig. 9). Femora with 14 setae each (Fig. 10). Tibiotarsal FSa absent (Fig. 11). Tunica absent; all unguis with 1 small inner tooth, however, in a few specimens it is lacking in one or all unguis. Unguiculus with apical filament exceeding the unguis tip, corner teeth absent (Fig. 12). Thorax and fore abdominal segments with short setae; posterior part of great abdomen with ~2x longer, finely serrated setae (Fig. 13). Fifth and sixth abdominal segments with normal setae; 5 am setae present; female subanal appendages swollen at the basal half and bristlelike at the apical third (Fig. 14). Tenaculum with 2 apical setae (Fig. 15). Sminthuroid setae absent, furcal basal area with 12+12 setae. Manubrium with 5 posterior setae. Dens with 4(3),2,2,1…1 anterior setae; posterior surface E1-4 and L1 slightly spinelike (Fig. 16). Mucro serrated in both lamellae, at least partially (Fig. 17).

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Figs. 1-8. *Pararrhopalites sideroicus* **sp. nov.** 1, Ant. IV; 2, Apical subsegment of Ant. IV; 3, Ant. III, showing apical organ; 4, Ant. II; 5, Ant. I; 6, Head frontal chaetotaxy; 7, Head posterior dorsal chaetotaxy, sensilla of frontal organ in the detail; 8, Clipeo-labrum chaetotaxy.

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TABLE 1. MEASUREMENTS OF HOLOTYPES BODY PARTS OF *PARARRHOPALITES SIDEROICUS* **SP. NOV.** AND *PARARRHOPALITES PALACIOSI* **SP. NOV.** MEASUREMENTS GIVEN IN M.

Character	*Pararrhopalites palaciosi* **sp. n.**	*Pararrhopalites sideroicus* **sp. n.**
Body	1060	1068
CD	384	393
Ant I	47	51
Ant II	86	94
Ant III	159	147
Ant IV	482	459
Dens	236	231
Mucro	86	100
Tibiotarsus I	211	260
Tibiotarsus II	219	266
Tibiotarsus III	275	344
Unguis I	50	39
Unguis II	47	41
Unguis III	55	28
Unguiculo I	21	23
Unguiculo II	21	23
Unguiculo III	28	22

Etymology

Pararrhopalites sideroicus **sp. nov.** comes from the Greek *Sideros* (ore, metal) and *Oikos* (house), as allusion to the iron ore caves where the species has been collected so far.

Distribution and Habitat

Good's Biogeographic zone 27 (Good 1974; Culik & Zeppelini 2003). The climate according to Köppen's system is As (Koppen 1936; Shear 1966), presenting dry winters and wet summers, average temperatures of 18 °C during winter and 22 °C in summer. The species was found in a group of small caves inserted in a continuous landscape, supposedly connected by the Mesovoid Shallow Substratum (MSS) (Juberthie et al. 1980; White & Culver 2012), in the State of Minas Gerais close to Itabirito (S 20° 15' W 43° 48'), southeastern Brazil. The species seems to be a troglobite which lives in the MSS and the adjacent caves, it was not found in surrounding epigeic environments. The new species is found in sympatry with *Troglobius ferroicus* Zeppelini et al., 2014. The caves where the species were found are inserted in a mining area, with potential threat to the species' conservation.

Remarks

Pararrhopalites sideroicus **sp. nov.** resembles the Brazilian species *P. papaveroi* and *P. wallacei* in the posterior cephalic and anterior dental chaetotaxies, and the presence of only slender setae on the anal valves. The new species can be distinguished from the former by the number of Ant. IV subsegments (11 in the new species and 10 in *P. papaveroi*) and by the absence of internal teeth in all unguis. The apical organ of Ant. III with sensilla Aai slender, curved and acuminated, the dorsal chaetotaxy of dens, most strikingly the plurichaetosis observed in the new species, distinguishes *P. sideroicus* **sp. nov.** from either *P. papaveroi* and *P. wallacei*. Furthermore, *P. sideroicus* **sp. nov.** presents an unique sensory organ in the interantennal area composed of a group of special pseudopores and sensilla, this feature was never seen in other species of the genus. Other species can be differentiated from *P. sideroicus* **sp. nov.** by the features indicated in the identification key below.

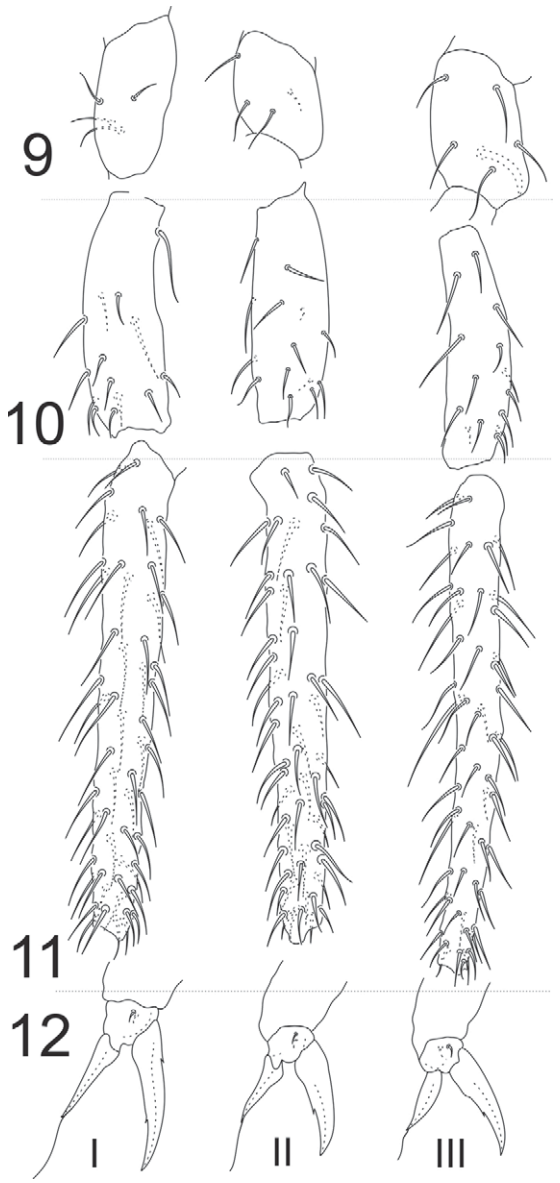
PARARRHOPALITES PALACIOSI **SP. N.**
(Figs. 18-35, Table 1)

Material Examined

HOLOTYPE: Female, BRAZIL: Paraiba, Mamanguape, Biological Reserve Guaribas, SEMA 3 forest, 10-XII-2011, coll. R.A. Brito, deposited at Coleção de Referência da Fauna de Solo da Universidade Estadual da Paraíba (CRFS-PB) under number 5043.

PARATYPES: 3 females, BRAZIL: Paraiba, Mamanguape, Biological Reserve Guaribas, SEMA 1-3 forest, 26-XI-2011, 10-XII-2011 and 26-V-2012, coll. R.A. Brito, deposited at Museu Nacional da Universidade Federal do Rio de Janeiro (MNUFRJ) under number 2460. 2 females, same data label as Holotype, deposited at Museu de Zoologia da Universidade de São Paulo (MZUSP), numbers 0081 and 0082.

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Figs. 9-12. *Pararrhopalites sideroicus* **sp. nov.** 9, Trochanter of legs I-III; 10, Femur of legs I-III; 11, Tibiotarso of legs I-III; 12, Foot complex I-III.

Description. Purple pigments scattered over the dorsum and concentrated in eyes spots. Eyes with 6 large ommatidia and 2 very small each side of head. Body length ~1.0 mm female, ~0,8 mm male (Table 1), habitus sminthuroid. Antennal segments ratio 1:1.8;3.33;10.06. Ant. IV 15 subsegmented (Fig. 18), 1.25x longer than CD; basal and apical subsegments slightly longer than internal subsegments, each subsegment bear respectively from base to the apex 8,7,5,7,8,8,8,8,8,8,8,8,8,7,23 setae. Ant. IV subsegment IV-XIII with 2 sensilla each, subsegments XIV with 3 sensilla. Ant. IV apical subsegment bearing a hook like seta and a small bulb shaped sensillum (Fig. 19). Ant. III without basal papilla, apical organ with 2 elliptical sensilla in a single shallow pit. Seta Aai slender, short and acuminated; Ae and Api slender and acuminated, Ap and Ape slender and shorter than Ae and Api; Ai normal (Fig. 20). Ant. II with 14 setae (Fig. 21), Ant. I with 6 short setae (Fig. 22). Interantennal region with 4 setae and 4 oval organs (Figs. 23 and 24). Anterior to the antennal pit there are 3 structures similar to pseudopores in each side of head (Fig. 23-24). Dorsal cephalic chaetotaxy with A2-3, IL1 and L1 spinelike, other setae normal (Fig. 25). Frontal head chaetotaxy as in Figure 23. Clipeo-labrum formula 4,4,5,6 (Fig. 26). Trochanter I-III with 5 setae each, metatrochanteral spine present (Fig. 27). Femur with 14, 16, 15 setae respectively (Fig. 28). Tibiotarsal FSa absent (Fig. 29). All unguis with an inner tooth, tunica absent. Unguiculus of pro and meso legs with apical filament exceeding the unguis tip, unguiculus of third leg with short apical filament; corner teeth absent (Fig. 30). Mesothorax with short setae a and m, metathorax and anterior segments of abdomen with large lanceolate and finely ciliated spines; posterior part of great abdomen with slender setae (Fig. 31). Fifth and sixth abdominal segments with very large lanceolate and finely ciliated spines on anterior part, setae m1-4 basally swollen, other setae normal; 5 am setae present; female subanal appendages swollen and spinelike (Fig. 32). Tenaculum with 3 apical setae (Fig. 33). Sminthuroid setae absent, furcal basal area with 13+13 setae. Manubrium with 9 posterior setae. Dens with 4(3),2,2,2,2,1,1 anterior setae; all posterior surface setae slender D1-2 longer than others (Fig. 34). Mucro serrated in one lamellae, sometimes the other lamella slightly serrated (Fig. 35).

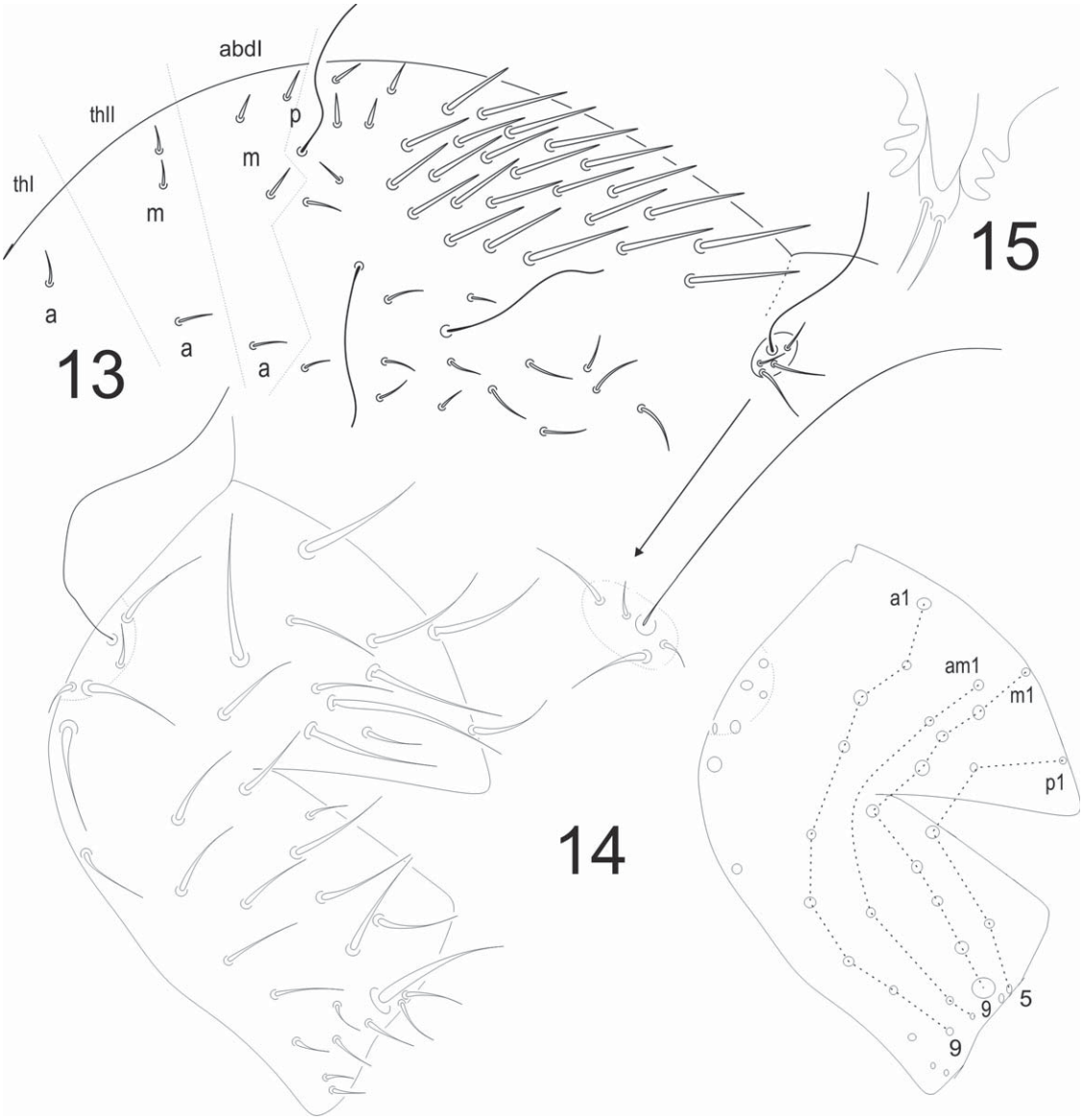
Etymology

Pararrhopalites palaciosi **sp. nov.** is named after Dr. Palacios-Vargas.

Distribution and Habitat

Good's Biogeographic Zone 27 (Good 1974). The species is distributed in northeastern Brazil, the specimens studied were collected in Paraiba State at coordinates S 6° 42' 21" W 35° 7' 30", S 6° 44' 21" W 35° 8' 22" and S 6° 48' 12" W 35° 6' 27". Climate according to Köppen's system is As (Koppen 1936; Shear 1966). The species inhabits leaf litter in Atlantic Forest remnants and spots of savanna, in the wet littoral zone. The litter covering ranges from 1.8 to 3.4 cm deep. Abundance was greater during the late spring, dry season.

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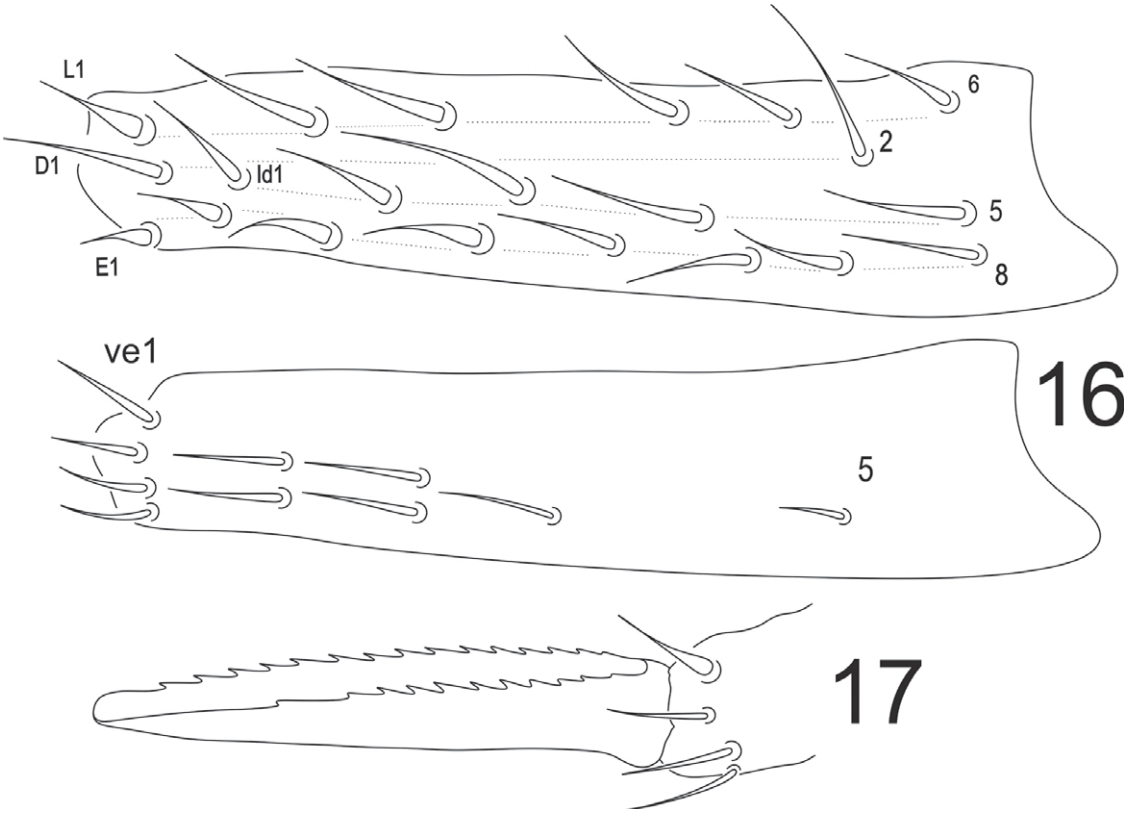


Figs. 13-15. *Pararrhopalites sideroicus* **sp. nov.** 13, Thorax and great abdomen chaetotaxy, trichobothria D in the detail; 14, anal valve chaetotaxy; 15, Tenaculum.

Remarks

Pararrhopalites palaciosi **sp. nov.** can be distinguished from all *Pararrhopalites* by the presence of 4 oval organs in the interantennal area. The new species presents the same type of large and broad spines on abdomen and anal valve as seen in *P. fasciatus* (Salmon, 1951), *P. yinae* Itoh & Zhao, 2000, *P. ecuadorensis* Bretfeld & Trinklein, 2000. These species can be differentiated by the number of subsegments of Ant. IV (15 in *P. palaciosi* **sp. nov.**, 12 in *P. fasciatus* and *P. ecuadorensis*, and 10 subsegments in *P. yinae*), cephalic, anal valve and dens chaetotaxies (Figs. 34 and 35). The new species differs from *P. yinae* and *P. ecuadorensis* by presenting 8+8 eyes and 4(3), 2, 2, 2, 2, 1, 1 setae on anterior side of dens, and lacking oval organs on the tibiotarsus as seen in *P. ecuadorensis*. The species *P. fasciatus* and *P. noonae* (Lawrence, 1968) present 8+8 eyes, and *P. noonae* has the same dental formula as the new species (3,2,2,1…1 in *P. fasciatus*). *P. noonae* can be distinguished from *P. palaciosi* **sp. nov.** by the presence of spines on dorsal surface of dens,

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Figs. 16 and 17. *Pararrhopalites sideroicus* **sp. nov.** 16, Dens chaetotaxy, posterior above and anterior below; 17, Mucro.

mucronal setae, and the size of apical filaments. Both *P. fasciatus* and *P. noonae* were originally described as *Neosphyrotheca*.

KEY FOR THE IDENTIFICATION OF THE SPECIES OF THE GENUS *PARARRHOPALITES*

1. Eyes 4+4 or less 2

—. Eyes 6+6 or more 12

2. Ant. IV with 20 or more subsegments, eyes 3+3, setae on great abdomen normal. . . . . *P. indianus* Baijal & Agarwal, 1972 (India)

—. Ant. IV with less than 20 subsegments (usually 9-15), eyes 2+2 or less 3

3. Body heavily pigmented, Ant. IV 12-14 subsegmented, eyes present, lanceolate setae on abd. V-VI 4

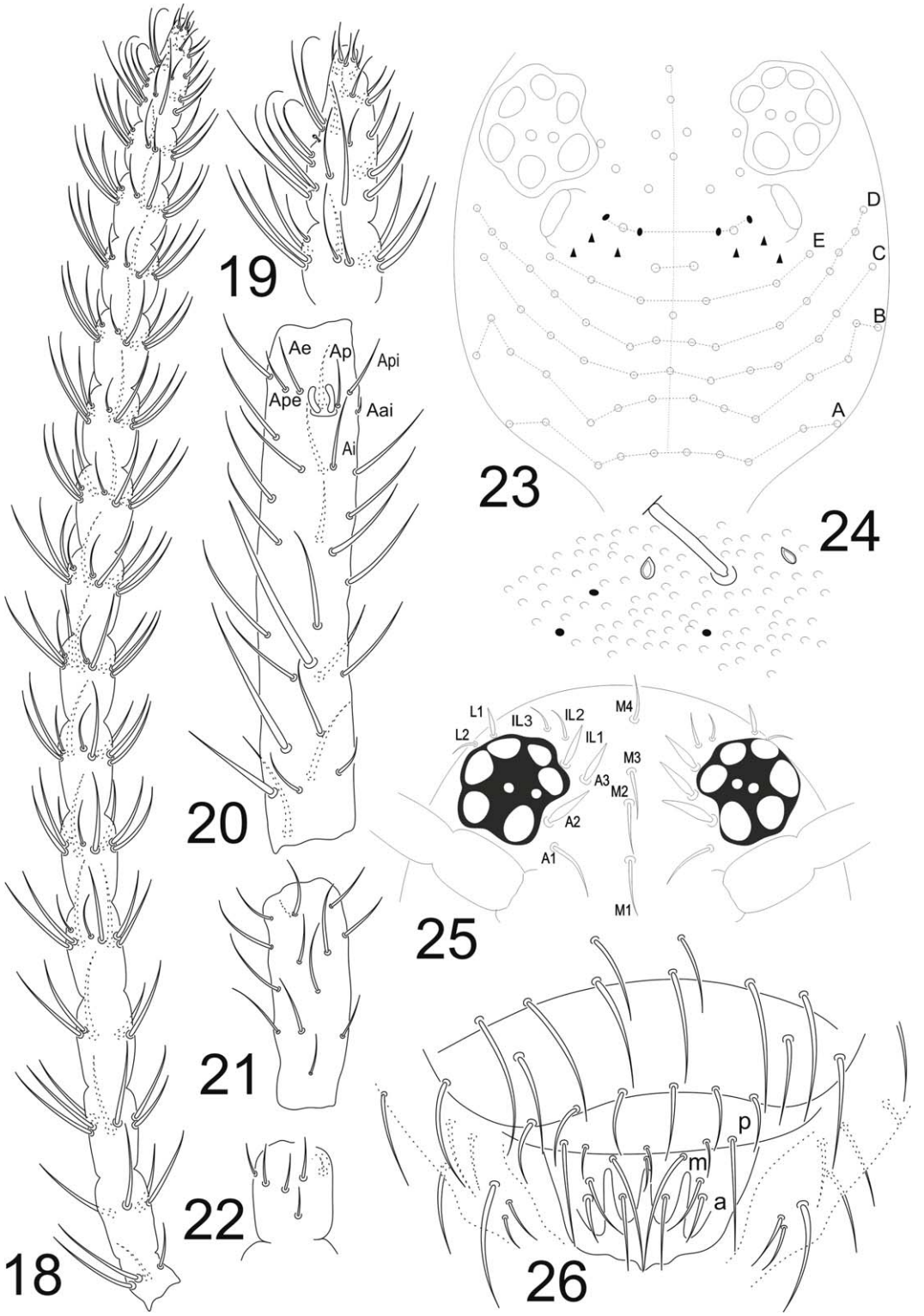
—. Body pigment absent, Ant. IV 9-11 subsegmented, lanceolate setae usually absent from abd. V-VI, 7-9 setae on anterior surface of dens 5

4. Ant. IV 12 subsegmented, eyes 2+2, 10 dorsal cephalic spines, tenaculum with 1 apical seta, dental formula 4,3,2,2,1,(1),1 . . . . . *P. ecuadorensis* Bretfeld & Trinklein, 2000 (Ecuador)

—. Ant. IV 14 subsegmented, eyes 1+1, 9 dorsal cephalic spines, tenaculum with 2 apical setae, dental formula 3,2,2,1...1 . . . . . *P. popei* Lawrence, 1968 (Melanesia and Micronesia)

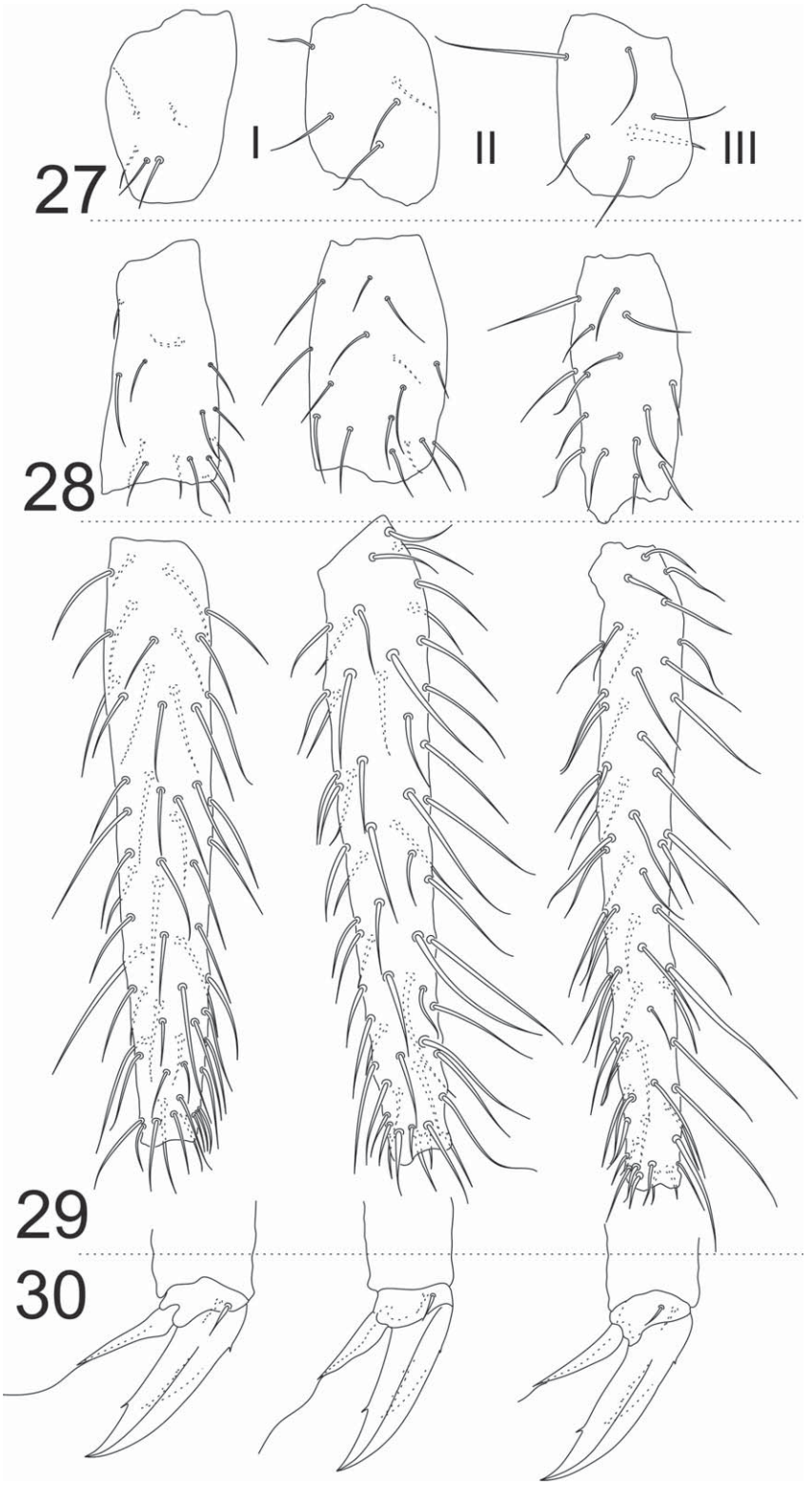
5. Eyes 2+2 6

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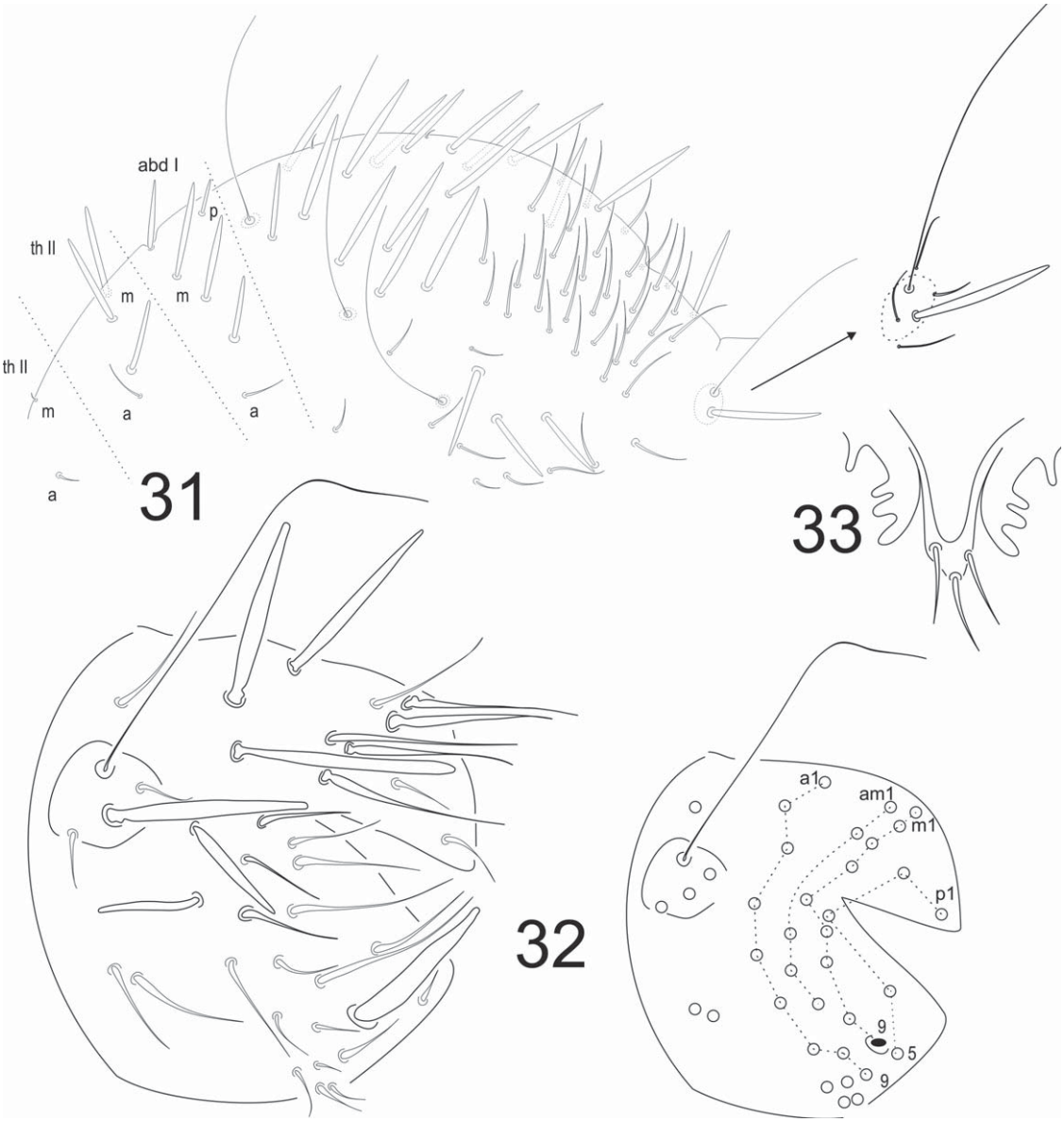
Figs. 18-26. *Pararrhopalites palaciosi* **sp. nov.** 18, Ant. IV; 19, Apical subsegment of Ant. IV; 20, Ant. III, showing apical organ; 21, Ant. II; 22, Ant. I; 23, Head frontal chaetotaxy; 24, Frontal cephalic oval organs; 25, Head posterior dorsal chaetotaxy; 26, Clipeo-labrum chaetotaxy.

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Figs. 27-30. *Pararrhopalites palaciosi* **sp. nov.** 27, Trochanter of legs I-III; 28, Femur of legs I-III; 29, Tibiotarso of legs I-III; 30, Foot complex I-III.

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Figs. 31-33. *Pararrhopalites palaciosi* **sp. nov.** 31, Chaetotaxy of the thorax and great abdomen, trichobothria D in the detail; 14, anal valve chaetotaxy; 32, Anal valve chaetotaxy; 33, Tenaculum.

—. Eyes 1+1 or absent 8

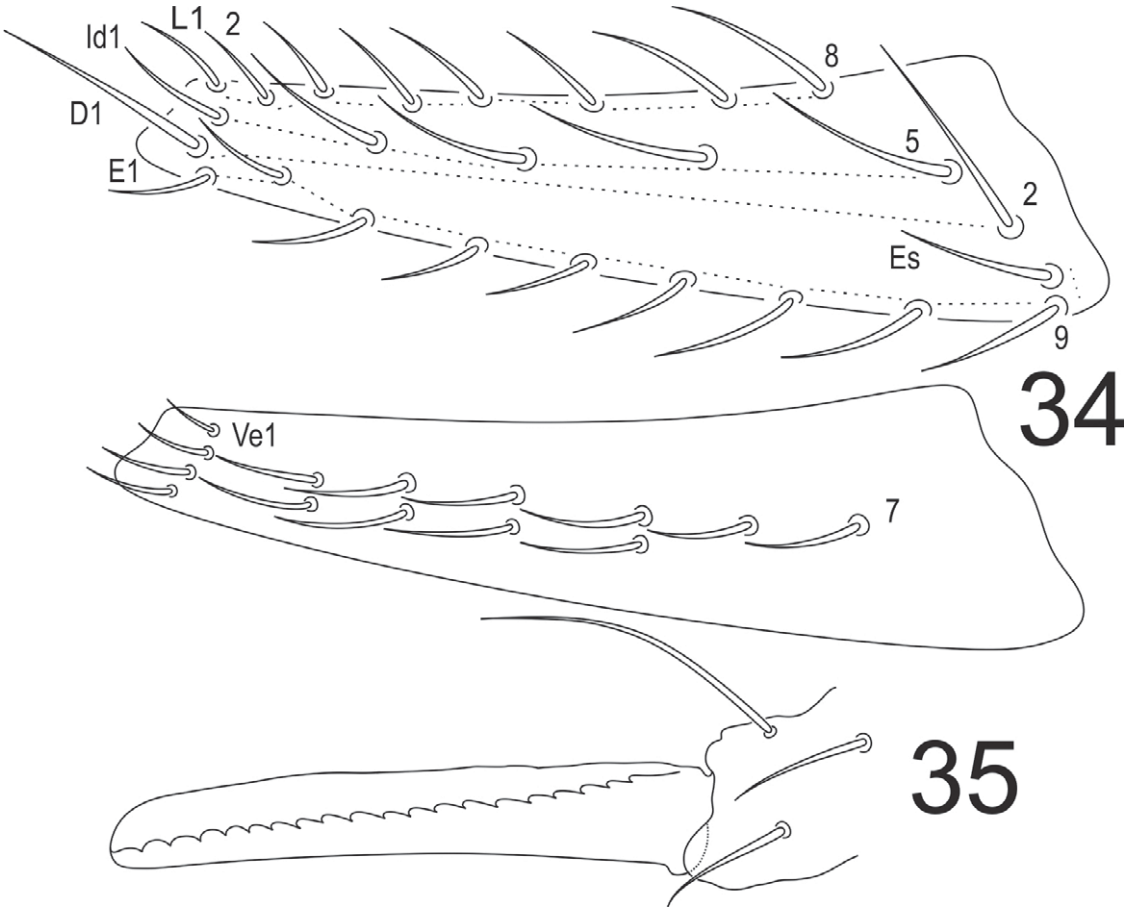
6. Ant. IV 10 subsegmented, 12 dorsal cephalic spines, posterior dens with 17 setae . . . . . *P. oculatus* Bonet & Tellez, 1947 (Mexico)

—. Ant. IV 9 subsegmented, 14 dorsal cephalic spines, posterior dens with 15 setae 7

7. Metatrochanteral spine normal and acuminated, tenaculum with 1 apical setae, dental formula 3,2,1...1 . . . . . *P. hennigi* (Palacios-Vargas & Zeppelini, 1995) (Mexico)

—. Metatrochanteral spine with a membrane, round at the tip, tenaculum with 2 apical setae, dental formula 3,2,2,1...1 . . . . . *P. christianseni* (Palacios-Vargas & Zeppelini, 1995) (Mexico)

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Figs. 34-35. *Pararrhopalites palaciosi* **sp. nov.** 34, Dens chaetotaxy, posterior above and anterior below; 35, Mucro.

8. Eyes absent 9

—. Eyes 1+1 11

9. Ant. IV 11 subsegmented, 6 dorsal cephalic spines, 3 sensilla forming a triangle in the interantennal area, unguiculus without corner tooth, apical filaments exceeding the unguis tip, dental formula 4,2,2,1...1. . . . . *P. sideroicus* **sp. nov.** (Brazil)

—. Ant. IV 10 subsegmented, all unguiculus with corner tooth, unguiculus III apical filament shorter than unguis, less than 10 anterior dental setae 10

10. Tenaculum with 1 apical seta, dental formula 3,2,1...1; posterior dens with 19 setae . . . . . *P. anops* Bonet & Tellez, 1947 (Mexico)

—. Tenaculum with 2 apical setae, dental formula 3,2,2,1...1; posterior dens with 16 setae . . . . . *P. papaveroi* (Zeppelini & Palacios-Vargas, 1999) (Brazil)

11. Head with 9 cephalic spines . . . . . *P. yinae* Itoh & Zhao, 2000 (China)

—. Head with 12 cephalic spines . . . . . *P. wallacei* (Palacios-Vargas & Zeppelini, 1995) (Brazil)

12. Ant. IV 12 or 13 subsegmented, more than 6 cephalic spines, unguis with tunica 13

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—. Ant. IV 15 subsegmented, 6 cephalic spines, tunica absent, dental formula 4,2,2,2,2,1,1 . . . . . *P. palaciosi* **sp. nov.** (Brazil)

13. All unguiculus with corner tooth, apical filament of unguiculus III shorter than unguis . . . . . *P. villiersi* (Delamare Deboutteville & Massoud, 1964) (Angola)

—. Corner tooth absent, apical filament of unguiculus III exceeding the unguis tip 14

14. Head with 16 cephalic spines, unguis III without inner tooth, posterior dens with 22 setae, anterior dental formula 3,2,2,2,2,1,1; mucronal seta present . . . . . *P. noonae* Lawrence, 1968 (Papua New Guinea)

—. Head with 27 cephalic spines, unguis III with inner tooth, posterior dens with 18 setae, anterior dental formula 3,2,1(1)...1 . . . . . *P. fasciatus* (Salmon, 1951) (Malaysia; Melanesia and Micronesia)

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