



Taxonomy and systematics

A new *Pilogalumna* (Acari: Oribatida: Galumnidae) from Mexico

Una nueva Pilogalumna (Acari: Oribatida: Galumnidae) de México

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Received 23 May 2014; accepted 11 March 2015

Available online 24 August 2015

Abstract

A new species of *Pilogalumna* from the Ecological Reserve Pedregal de San Ángel, Mexico City is described from adult specimens of both sexes, this being the eighth Galumnidae species recorded from Mexico. *Pilogalumna rosauraruizae* sp. nov. is characterized by a combination of lamellar setae longer than other prodorsal setae, sensillum lanceolated with capitulum slightly barbulated, postanal porose area present, pseudolamellae absent, and 20 setae on the first tarsus. Additionally, the 18S rRNA partial sequence is reported, and an identification key for worldwide species of this genus is provided.

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Keywords: Taxonomy; Morphology; Taxonomic key; 18S rRNA

Resumen

Se describe una nueva especie de *Pilogalumna* de la Reserva Ecológica del Pedregal de San Ángel, Distrito Federal, México, a partir de ejemplares adultos de ambos sexos, siendo la octava especie de Galumnidae registrada para México. *Pilogalumna rosauraruizae* sp. nov. se caracteriza por la combinación de la seda lamelar más larga que las demás sedas prodorsales, sensilo lanceolado con capítulo ligeramente barbulado, área porosa postanal presente, ausencia deseudolamela y 20 sedas en el primer tarso. Adicionalmente, se registra la secuencia parcial 18S rRNA y se proporciona una clave de identificación para las especies del género en el mundo.

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Palabras clave: Taxonomía; Morfología; Clave taxonómica, 18S rRNA

Introduction

Galumnidae (Jacot, 1925) includes 34 genera, 9 subgenera, 470 species, and 33 subspecies worldwide (Subías, 2014). Nevertheless, only 7 species in 6 genera have been cited from Mexico (Palacios-Vargas & Iglesias, 2004), of which only 2 (Villagomez & Palacios-Vargas, 2013; Wharton, 1938) were described from Mexican specimens. *Pilogalumna* was erected by Grandjean (1956), with the type species *P. ornatula*

Grandjean, 1956. Currently this genus comprises 11 valid species and 6 subspecies (Subías, 2014); however, an updated taxonomic revision is needed.

The most detailed descriptions were done by Engelbrecht (1972a, 1972b) for *P. bloemfonteinensis*, *P. kimberleyensis*, and *P. variabilis* from South Africa. Nevin (1975) described *P. cozadensis* from the United States of America, performed a simple analysis that suggested that *P. binadalares* is a valid species, and gave measurements for several members of the genus. Finally Liu and Wu (2013) described *P. minima* from China including leg chaetotaxy.

Subías (2014) reported *P. ornatula ornatula* Grandjean, 1956 from the Mediterranean region and also from Mexico. In the original description (Grandjean, 1956), it is mentioned

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Peer Review under the responsibility of Universidad Nacional Autónoma de México.

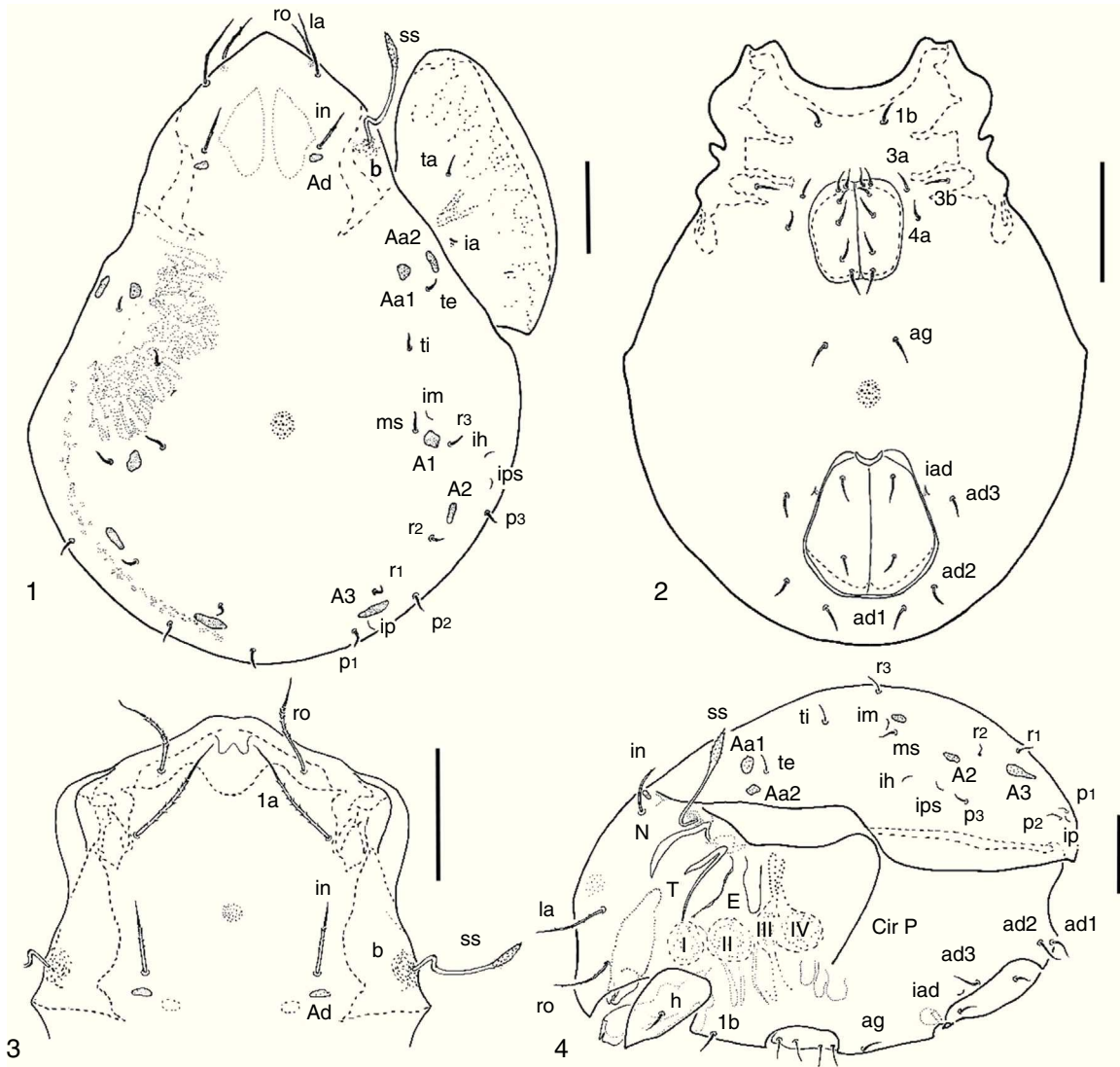
that this species is distributed only in France and Spain. All the synonyms of this species (*Galumna adareata* Mihelčič, 1957, *Galumna decipiens* Mihelčič, 1956, *Allogalumna molensis* Mihelčič, 1957, and *Allogalumna pterata* Mihelčič, 1957) have been reported from Spain, mainly Madrid, Cercedilla, and Los Molinos (Mihelčič, 1956, 1957). Later, Vázquez and Prieto (2001) reported *P. ornatula* from Quintana Roo, Mexico for the first time.

In this work, we describe the 8 new species of winged mites from Mexico based on adult males and females. This contribution is the first to include the morphological description of a Galumnidae Oribatid mite along with its nuclear small subunit rRNA sequence (18S rDNA). This molecular marker has proven to be a good species identifier of mites along with Cytochrome c oxidase 1 and has been shown to resolve adequately the phylogenetic relationships of this group (Dabert, Witalinski, Kazmierski, Olszanowski, & Dabert, 2010). A taxonomic key for all species of the genus is also provided.

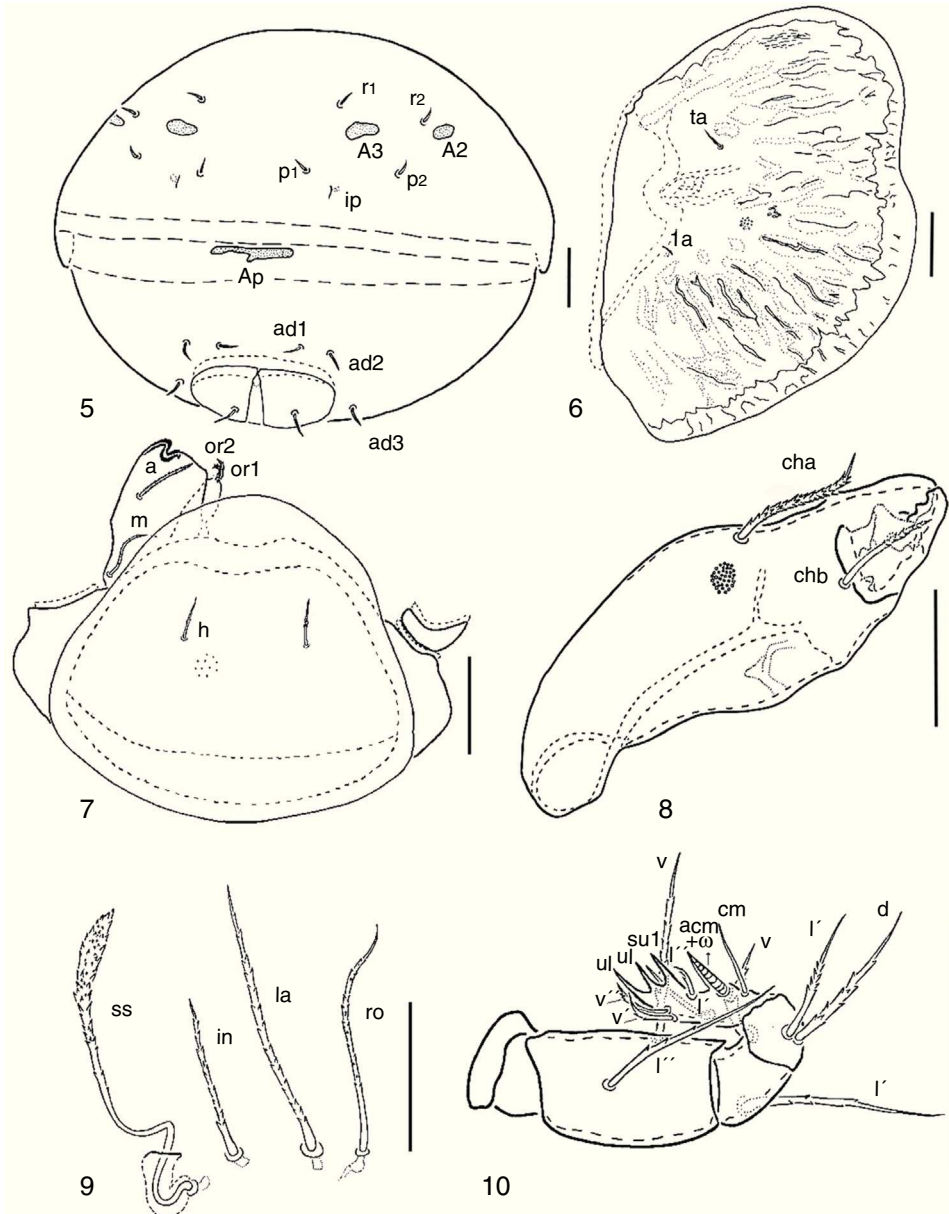
Materials and methods

During the study of temporal variation of community structure of soil microarthropods associated with *Pittocaulon* (*Senecio*) *praecox* in El Pedregal de San Ángel Ecological Reserve, in southern México City (Razo-González, Castaño-Meneses, Callejas-Chavero, Pérez-Velázquez, & Palacios-Vargas, 2014), 61 specimens of a new species of *Pilogalumna* (Oribatei: Galumnidae) were found.

Mites were extracted from soil samples using Berlese–Tullgren funnels and preserved in 75% ethanol. Then they were mounted under slides in Hoyer's solution. Observations and measurements were made using a Carl Zeiss Axiostar Plus phase contrast microscope with a drawing tube adapted to the microscope. In the description, all measurements are in micrometers (μm) and indicated in brackets after each morphological character. Cheatotaxy follows Engelbrecht (1972), except for the adalar porose areas, which are named



Figures 1–4. *Pilogalumna rosauraruizae* sp. nov. 1, notogaster; 2, ventral plate; 3, rostrum; 4, lateral region. Scale bar 100 μm .



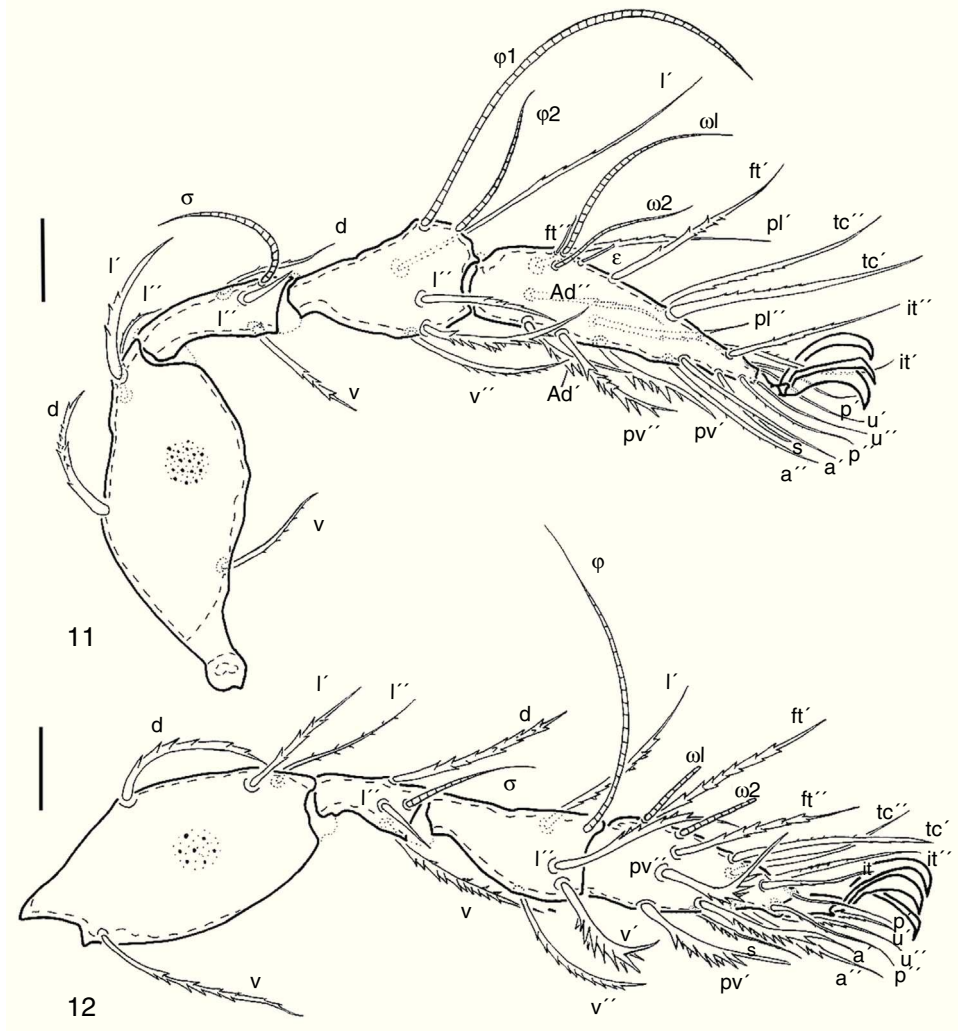
Figures 5–10. *Pilogalumna rosauraruizae* sp. nov. 5, posterior region; 6, pteromorpha; 7, hypostoma; 8, chelicera; 9, prodorsal setae; 10, pedipalp. Scale bar 50 μ m.

Aa1 and *Aa2*, instead of *Aai* and *Aae*. Figures were edited in Photoshop CS5.

Extraction, amplification, and sequencing

Eight specimens were fixed in 96% ethanol and stored at -20°C . DNA was extracted from a single specimen with a commercial kit using enzymatic methods and precipitation (MasterPure™ Complete DNA and RNA Purification Kit, Illumina Inc., Madison, WI, USA). DNA was amplified with VENTR™ DNA polymerase (New England Biolabs, Ipswich, MA, USA) and following the protocols suggested by Dabert et al. (2010), with some modifications: 6 μ l (0.06 unit/ μ l) of Red Taq Ready Mix, 2 μ l (10 μ M) of the forward primer Fw1230

(5' TGAAACTTAAAGGAATTGACG 3'), 2 μ l (10 μ M) of the reverse primer Rev18S (5' TGATCCTTCCGCAGGTTACCT 3'), and 2 μ l of the purified DNA sample were used. Final extracts were 25 μ l with a total DNA concentration of ≥ 100 ng per 25 μ l. PCR cycling parameters included 35 cycles of denaturation at 94°C for 45 s, annealing at 54°C for 45 s, and extension at 72°C for 90 s. Sequencing reactions were performed with BigDye Terminator v. 3.1 reagents (Life Technologies, Foster city, California, USA). The final product was sequenced with an Applied Biosystems® 3500xL Dx Genetic Analyzer (Life Technologies™ Foster City, CA, USA) at the Laboratorio de Secuenciación Genómica de la Biodiversidad y de la Salud, Instituto de Biología, Universidad Nacional Autónoma de México. The sequences were edited using BioEdit v7.2.5. software (Hall, 1999).



Figures 11–12. *Pilogalumna rosauraruizae* sp. nov. 11, leg I, paraxial view; 12, leg II, paraxial view. Scale bar 20 μ m.

The partial 18S rRNA sequence of 686 base pairs for this new species was deposited in GenBank (Accession number KJ423065). It will be used for future analysis of the phylogeny of Galumnidae.

Description

Pilogalumna Grandjean, 1956

Type species. *Pilogalumna ornatula*

Grandjean, 1956

Diagnosis

Prodorsal lines *L* and *S* lacking; with true porose areas; 10 pairs of notogastral setae that might be reduced to alveoli; dorsosejugal suture interrupted, setae *ta* and marginal *p1*–*3* always present; pteromorphs never foveolate, with a notch and setae *ta* usually well developed; lamellar setae between lines *L*; notogaster rounded, never foveolate; adanal lyrifissures adjacent to genital plate margins; tridactylus legs (Balogh, 1958; Balogh & Balogh, 1992).

P. rosauraruizae sp. nov. (Figs. 1–14).

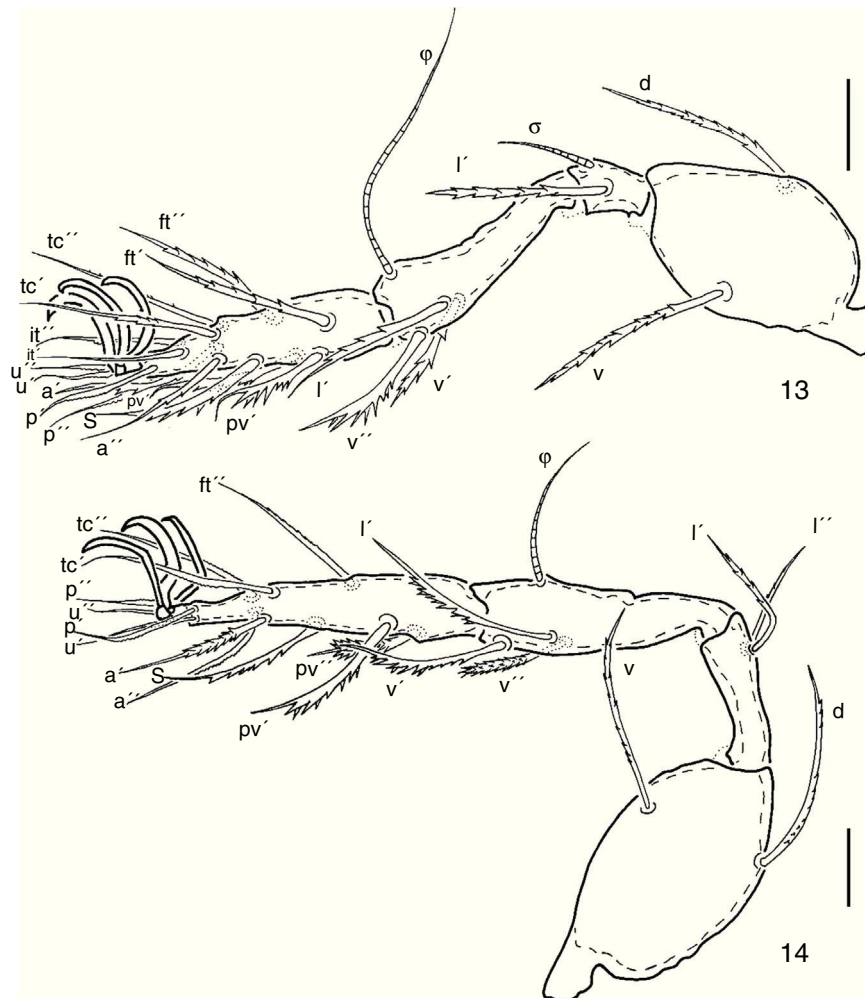
Adult. ($N = 10$). Length 650 (621–709), width 483 (453–512). Color from dark brown to reddish brown.

Sensillum clavate, with capitulum barbulate. Cuticular ornamentation slightly punctate on prodorsum, notogaster and ventral plate. All prodorsal setae present and slightly barbulate, interlamellar setae short and erect; all notogastral porose area present, *Aa* duplicate; 10 pairs of short notogastral setae; no dorsosejugal suture, no median pore; 6 pairs of genital setae, 2 pairs of anal setae; lyrifissure *iad* close to anal plate; 1 pair of aggenital and 3 pairs of adanal setae; postanal porose area present; no ornamentation on genital and anal plates; no gastronomic or ventral granular belt.

Prodorsum (Figs. 1, 3 and 4). Surface slightly punctuated, no dorsosejugal suture, lines *L* and *S* lacking, dorsosejugal porose area (*Ad*) (15 \times 13) oval and smaller than notogastral porose areas. All prodorsal setae present and slightly barbulate (Fig. 9) interlamellar setae (*in*) short and erect (54), lamellar setae (*la*) longer than others (91), rostral setae (*ro*) of average size (76) but more curved.

Key for the species of *Pilogalumna* (males and females).

- 1a. Sensillar capitulum lanceolate, apex acuminate; vertex pointed 2
- 1b. Sensillar capitulum flattened, apex truncate; vertex square *P. binadalares* (Jacot, 1929) (USA)
- 2a. Prodorsum with pseudolamella, postanal porose area almost threefold size of anal plates *P. ornatula* Grandjean, 1956 (Spain, France, and Mexico)
- 2b. Prodorsum without pseudolamella, postanal porose area of normal size or absent 3
- 3a. Vertex elongated and sharp, setae *in* diminutive, hardly visible 4
- 3b. Vertex not elongated, setae *in* always well discernible 6
- 4a. Prodorsum rounded, with a line or a transversal fold between setae *la* and *ro*, sensillum barbulated *P. steinmanni* Aoki, 1975 (Korea)
- 4b. Prodorsum triangular, without transversal fold between setae *la* and *ro*, sensillum smooth 5
- 5a. Lamellar seta subequal to rostral setae, body length more than 550 μm *P. tenuiclava* Berlese, 1908 (Italia)
- 5b. Lamellar seta shorter than rostral setae, body length less than 410 μm *P. minima* Liu and Wu, 2013 (China)
- 6a. Interlamellar setae shorter than lamellar setae 7
- 6b. Interlamellar setae subequal or longer than lamellar setae 8
- 7a. Seta *ti* reduced to 1 alveolus, lyrifissure *iad* posterior to setae *ad3*, tarsus I with 19 setae *P. cozadensis* Nevin, 1975 (USA)
- 7b. Seta *ti* always present, lyrifissure *iad* anterior to *ad3*, tarsus I with 20 setae *P. rosauraruizae* sp. nov. (Mexico)
- 8a. Interlamellar setae subequal to lamellar setae 9
- 8b. Interlamellar setae longer than lamellar setae 10
- 9a. Porose area A2 short and smaller than A3, body length more than 700 μm *P. arabica* Bayoumi and Al-Khalifa, 1968 (Arabic Peninsula)
- 9b. Porose area A2 elongated, similar to A3 in shape and size, body length less than 550 μm *P. crassiclava* (Berlese, 1914) (Italia)
- 10a. Sensillum smooth, notogastric setae short (<30 μm) 11
- 10b. Sensillum barbulated, notogastric setae long (>40 μm). *P. bloemfonteinensis* Engelbrecht, 1972 (South Africa, USA?)
- 11a. Sensillum very elongated and thin, rostral setae subequal to lamellar setae *P. kimberleyensis* Engelbrecht, 1972 (South Africa)
- 11b. Sensillum not elongated and thick, rostral setae shorter than lamellar setae *P. variabilis* Engelbrecht, 1972 (South Africa and India)



Figures 13–14. *Pilogalumna rosauraruizae* sp. nov. 13, leg III, paraxial view; 14, leg IV, paraxial view. Scale bar 20 μm .

Table 1
Comparison of setae and solenidia from legs I to IV of *Pilogalumna rosauraruizae* sp. nov., with *P. ornatula*, *P. bloemfonteinensis*, *P. cozadensis*, and *P. variabilis*. () denotes paired setae.

<i>Pilogalumna rosauraruizae</i> sp. nov.				
<i>Pilogalumna ornatula</i> Grandjean, 1965				
Setal formulae. Fe: 4-4-2-2; Ge: 3-3-1-2; Ti: 4-4-3-3; Ta: 20-15-15-12				
Solenidial formulae. Fe: 0-0-0-0; Ge: 1-1-1-0; Ti: 2-1-1-1; Ta: 2-2-0-0				
Leg I	<i>d</i> , <i>v</i> , (<i>l</i>)	<i>l'</i> , <i>v</i> , <i>d</i> , σ	(<i>l</i>), (<i>v</i>), $\varphi 1$, $\varphi 2$	(<i>ft</i>), ε , (<i>tc</i>), (<i>it</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , (<i>pv</i>), (<i>Ad</i>), (<i>pl</i>), $\omega 1$, $\omega 2$
Leg II	<i>d</i> , <i>v</i> , (<i>l</i>)	<i>l'</i> , <i>v</i> , <i>d</i> , σ	(<i>l</i>), (<i>v</i>), φ	(<i>ft</i>), (<i>tc</i>), (<i>it</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , (<i>pv</i>), $\omega 1$, $\omega 2$
Leg III	<i>d</i> , <i>v</i>	<i>l'</i> , σ	<i>l'</i> , (<i>v</i>), φ	(<i>ft</i>), (<i>tc</i>), (<i>it</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , (<i>pv</i>)
Leg IV	<i>d</i> , <i>v</i>	(<i>l</i>)	<i>l'</i> , (<i>v</i>), φ	<i>ft'</i> , (<i>tc</i>), (<i>p</i>), (<i>u</i>), (<i>a</i>), <i>s</i> , (<i>pv</i>)
<i>Pilogalumna bloemfonteinensis</i> Engelbrecht, 1972				
<i>Pilogalumna cozadensis</i> Nevin, 1975				
Setal formulae. Fe: 4-4-2-2; Ge: 3-3-1-2; Ti: 4-4-3-3; Ta: 19-15-15-12				
Solenidial formulae. Fe: 0-0-0-0; Ge: 1-1-1-0; Ti: 2-1-1-1; Ta: 2-2-0-0				
Leg I	Tarsi lacking <i>Ad''</i>			
<i>Pilogalumna variabilis</i> Engelbrecht, 1972				
Setal formulae. Fe: 4-3-2-2; Ge: 3-2-1-2; Ti: 4-4-2-3; Ta: 19-15-15-12				
Solenidial formulae. Fe: 0-0-0-0; Ge: 1-0-1-0; Ti: 2-1-1-1; Ta: 2-2-0-0				
Leg I	Tarsi lacking <i>Ad''</i>			
Leg II	Femur lacking <i>l''</i> ; genua lacking <i>d</i> and solenidia σ			
Leg III	Tibia lacking <i>v''</i>			

Sensillum (SS) (85) slightly curved (Figs. 1, 3, 4 and 9), stalk thin and the insertion in the shape of “S”, capitulum fusiform, thick close to apical region, with barbulations and punctuations. Chelicerae normal (185 length and 69 width) (Fig. 8), setae *cha* (49) longer than *chb* (37), both very barbulated.

Notogaster (Figs. 1 and 4). Integument slightly punctate from middle to posterior region, fine irregular ornamentation between *Aa1* and *A1*; 10 pairs of setae (20, except *ta*) in normal position, no double alveoli, no medial pore; porose areas semi-circular (except *A3*), with little variation in form to slightly oval. *Aa* divided in *Aa1* (18 × 6) orientated to sagittal line and *Aa2* (15 × 5), between them setae *te*, under it there are setae *ti* and *ms*, and between them the lyrifissure *im*.

Porose area *A1* (22 × 12) semicircular, irregular ornamentation between setae *ms* and *r3* in the posterior margin, *A2* oval (15 × 8) posterior to *r3*; *A3* oval (39 × 6) being the biggest and located between setae *r1* and lyrifissure *ip*, anterior to setae *p1* and *p2*, setae *p3* at the side at level of *A2*.

Pteromorpha bilobed (325 × 217) (Fig. 6), with 3 types of ornamentation, slight and superficial at margin, also with some striations, profuse at middle region, with a granular ornamentation on most of the surface except margins; it has a central notch near articulation zone to notogaster; setae *ta* (18) anterior to notch and posterior lyrifissure *ia* directed slightly toward the hinge.

Ventral plate (Fig. 2). Integument finely punctated, epimeral setae *1b*, *3a*, *4a*, and *3b* present (17 μ m); genital plates smooth (94 length × 103 width), 6 genital setae (23), 2 in the anterior margin of each plate and another in a slightly curved row; anal plate smooth (156 length × 131 width), 2 pairs of anal setae (23); 1 pair of aggenital setae (21); 3 pairs of adanal setae subequal

in size (20), *ad1* and *ad2* inserted posterior to anal plate, *ad3* in the medial zone, anteriorly lyrifissure *iad*; postanal porose area present, elongated (74 × 9), irregular shape, only visible at posterolateral view in a caudal preparation (Fig. 5).

Lateral region (Fig. 4). Lines *L* and *S* absent, *in* between position of lines *L*, circumpedal line present, thin, posterior to fourth acetabulum, rostrum slightly sharp.

Hypostome (Fig. 7). 165 length × 197 width. One pair of hypostomal setae (*h*) thin and barbed (20), camerostoma with setae *a* (32) slightly longer than *m* (29), *or1* and *or2* (13) short and barbulated.

Pedipalp (Fig. 10). Setal formula 9-3-1-2. Femur with 2 setae, ventral longest, genua with only setae *l'*, tibia with 3 setae, only *v* ventral, tarsus with 1 pair of ventral setae, 1 pair of lateral setae and the culminal (*cm*), anteroculminal eupatidium (*acm*) fused to solenidium ω .

Legs. All the legs are tridactylous with small punctuation on femora.

Chaetotaxy. (Table 1) Leg I (Fig. 11) setae *l''* shorter than *l'* on femur; solenidium σ on genua similar to $\omega 2$ of tarsus; $\varphi 1$ on tibia dorsal, about twice the length of $\varphi 2$; *l'* of tibia as long as solenidium $\varphi 1$; fastigial setae *ft''* of tarsus short and thin, anterior to $\omega 1$, $\omega 2$ about half the size of $\varphi 1$; famulus (ε) very short and blunt tip; setae *Ad''* and *Ad'* Present. Leg II (Fig. 12), setae *l''* and *l'* of femur similar in length and shape, slightly barbulate; solenidium σ of genua similar to leg I; tibial φ long; $\omega 1$ and $\omega 2$ of tarsus similar in length and shape, with blunt tips. Leg III (Fig. 13) solenidium σ shorter than those of legs I and II; φ about 3 times as long as σ . Leg IV (Fig. 14). Only 1 solenidium, φ on tibia, ventral tibial *v''* shorter and more barbulate than *v'*.

Taxonomic summary

Type locality. Ecological Reserve Pedregal de San Ángel, Universidad Nacional Autónoma de México (UNAM), Distrito Federal, Mexico. 19°19′07.44″ N, 99°11′43.85″ W, 2330 m.a.s.l.

Type material. Female holotype deposited as slide, 09/05/2008, Mexico. Distrito Federal. Reserva Ecológica del Pedregal de San Ángel, Ciudad Universitaria. E. Catalán y F. Villagomez Coll., (catalog number #1555); 40 more paratypes with same data, of which 10 are deposited as slides (7 females, 3 males) and 30 in ethanol (22 females, 8 males) at 75% (# 1556); 11 specimens as additional material from type locality with collecting data 28/07/2013 (# 1554). This material is deposited in the collection of Laboratorio de Ecología y Sistemática de Microartrópodos (LESM), Facultad de Ciencias, UNAM. Additionally, 5 paratypes (catalog numbers CNAC00 9002 to CNAC00 9006) with the same data as the other paratypes, are deposited as slides in the Colección Nacional de Ácaros (CNAC), Instituto de Biología, UNAM.

Distribution. This species is only known from the type locality.

Etymology. This new species is dedicated to Dr. Rosaura Ruiz Gutiérrez, Director of the Facultad de Ciencias, UNAM, for supporting the development of science in Mexico.

Natural history. The specimens were collected from soil and litter under shrubs and small trees of *Senecio (Pittocaulon) prae-cocox*.

Remarks

Setal and solenidial morphology of legs provide important information for the identification of *Pilogalumna* species as suggested by Nevin (1975) and Engelbrecht (1972). Nevertheless, there is a lack of information for most of the species, as only 5 of 11 valid species (Subías, 2014) have detailed leg chaetotaxy reported (Engelbrecht, 1972a, 1972b; Grandjean, 1956; Liu & Wu, 2013; Nevin, 1975). Tarsi I vary from 19 to 20 setae, and tibiae of legs III can present 2 or 3 setae, genua of legs II also have 2 or 3 setae, and femora II 3 or 4 setae. This variation in the number of setae on leg articles has been overlooked, but it is important, as in *P. variabilis* Engelbrecht, 1972, that possesses a unique leg chaetotaxy. The morphology of solenidia might be relevant as well. It is a character that has been found to be variable between species and could be used for species discrimination.

P. rosauraruizae sp. nov. is very similar to *P. ornatula* but differs in lacking the pordorsal pseudolamella between *la* setae, the position of setae *ti*, and lirisfisure *im* in the same axis between *Aa2* and *A1*. Presence of postanal porose area elongated as long as ventral plate, but never threefold longer. Finally, *P. rosauraruizae* sp. nov. is smaller, reaching a maximum of 709 in adults, while *P. ornatula* can reach a maximum of 735 in males and 770 in females. The new species differs from *P. binadalares* in the shape of sensillus and vertex. Leg chaetotaxy is also different from *P. variabilis*, *P. cozadensis*, and *P.*

bloemfonteinensis, which have 19 setae on tarsus I, versus 20 setae in *P. rosauraruizae* sp. nov.

Acknowledgments

The authors thank Dr. Gabriela Castaño Meneses for donation of the mites (project PAPIIT-IN208508, DGAPA, UNAM). Dr. Hugo H. Mejía-Madrid provided financial and technical support (Project PAPIIT IA 202713-2, DGAPA, UNAM) for the molecular analyses and reviewed the manuscript. M.Sc. Laura M. Márquez Valdelamar (Instituto de Biología, UNAM), M.Sc. Andrea R. Jiménez Marín (Instituto de Biología, UNAM), and M.Sc. Fabiola Ramírez (Facultad de Ciencias, UNAM) provided technical assistance for molecular sequencing and amplification techniques. Dr. Roy A. Norton shared important literature for this study. This work is part of a master's thesis on the species delimitation in Galumnidae Oribatid mites from Mexico, where the relationships between species and genera within the family are being described. We thank to the Posgrado en Ciencias Biológicas, UNAM and Conacyt for the scholarship received.

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