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## Description of a new species of *Vaejovis* from Michoacán, Mexico (Arachnida: Scorpiones: Vaejovidae)

### Descripción de una especie nueva de *Vaejovis* de Michoacán, México (Arachnida: Scorpiones: Vaejovidae)

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**Abstract.** *Vaejovis coalcoman* sp. n. from Sierra de Coalcomán, in the northwestern part of the state of Michoacán, Mexico, is described. It belongs to the “mexicanus” group and it is compared with related species from the states of Jalisco and Guanajuato. A map with the known distribution of the related taxa is provided.

Key words: *Vaejovis coalcoman*, “mexicanus” group, biodiversity, endemism.

**Resumen.** Se describe *Vaejovis coalcoman* sp. n. de la sierra de Coalcomán en la parte noroeste del estado de Michoacán, México; pertenece al grupo “mexicanus” y se hace la comparación con las especies relacionadas de los estados de Jalisco y Guanajuato. Se proporciona un mapa con la distribución conocida y la de los taxones relacionados.

Palabras clave: *Vaejovis coalcoman*, grupo “mexicanus”, biodiversidad, endemismo.

## Introduction

In the world there are approximately 2000 species of scorpions described and Mexico has approximately 250 species, being the most diverse country in the world for this order of arachnids (Fet et al., 2000; Ponce-Saavedra and Francke, 2011; Rein, 2013). Vaejovidae are the most diverse scorpion family in North America, with 17 genera and 180 species currently recognized (Rein, 2013), and the genus *Vaejovis* C. L. Koch 1836 is the largest within the family. There is some controversy regarding the diagnosis and the limits of the genus (Sissom, 2000; Prendini and Wheeler, 2005; Soleglad and Fet, 2008), and the number of species included varies from 55 to 80+. The genus traditionally included 5 species groups (Sissom, 2000), and some of these have been elevated to genera (Soleglad and Fet, 2008); this was a taxonomic change not accepted by all scorpologists working with this family, because the monophyly of the proposed genera has not been rigorously tested (Prendini and Wheeler, 2005). The type species of the genus is *V. mexicanus* C. L. Koch 1836, and thus the “mexicanus” group *sensu stricto* has not been moved nomenclaturally. It has been well characterized by at least 3

particular characters: 1) 6 subrows of denticles on the fixed finger of the pedipalp chela, 2) the position of trichobothria *ib - it* at the base of the fixed finger of the pedipalp chela, and 3) the lack of a mating plug in the spermatophore (Santibáñez-López and Francke, 2010). The “mexicanus” group *sensu stricto* is found in the highlands of central Mexico, usually between 1 800-3 000 m asl. Nowadays it comprised by 34 species (Miranda-López et al., 2012), but this is likely to change in the future due to several research projects currently being carried out by several groups of researchers, mainly the REVSYS project, which has the cooperation from several academic institutions like the American Museum of Natural History, the California Academy of Science, the West Texas AandM University and the Instituto de Biología, UNAM.

The state of Michoacán is located in the central-western part of Mexico, with numerous highlands above 1 800 m asl, due to the presence of both the Sierra Madre del Sur and the Transmexican Volcanic Belt (Atlas Geográfico del Estado de Michoacán, 2003). This is an area where several species belonging to the “mexicanus” group have been recently collected (Miranda et al., 2012; in prep.). The Sierra de Coalcomán is an isolated outcrop of the Sierra Madre del Sur, located in the extreme northwestern portion of Michoacán, near the political boundaries with the states of Colima and Jalisco. The scorpions collected in

the Sierra de Coalcomán and deposited at the CNAN were initially identified as *Vaejovis monticola* Sissom 1989, a species described from the Nevado de Colima, which straddles Colima and Jalisco; however, direct comparisons with topotypes of that species disclosed that they are not the same. In the present work the population endemic to the highlands of the Sierra de Coalcomán is described as new, *Vaejovis coalcoman* sp. n., clearly differentiated from *V. monticola*, which is endemic to the highlands of the Nevado de Colima, and both species are undoubtedly geographically isolated from each other.

### Materials and methods

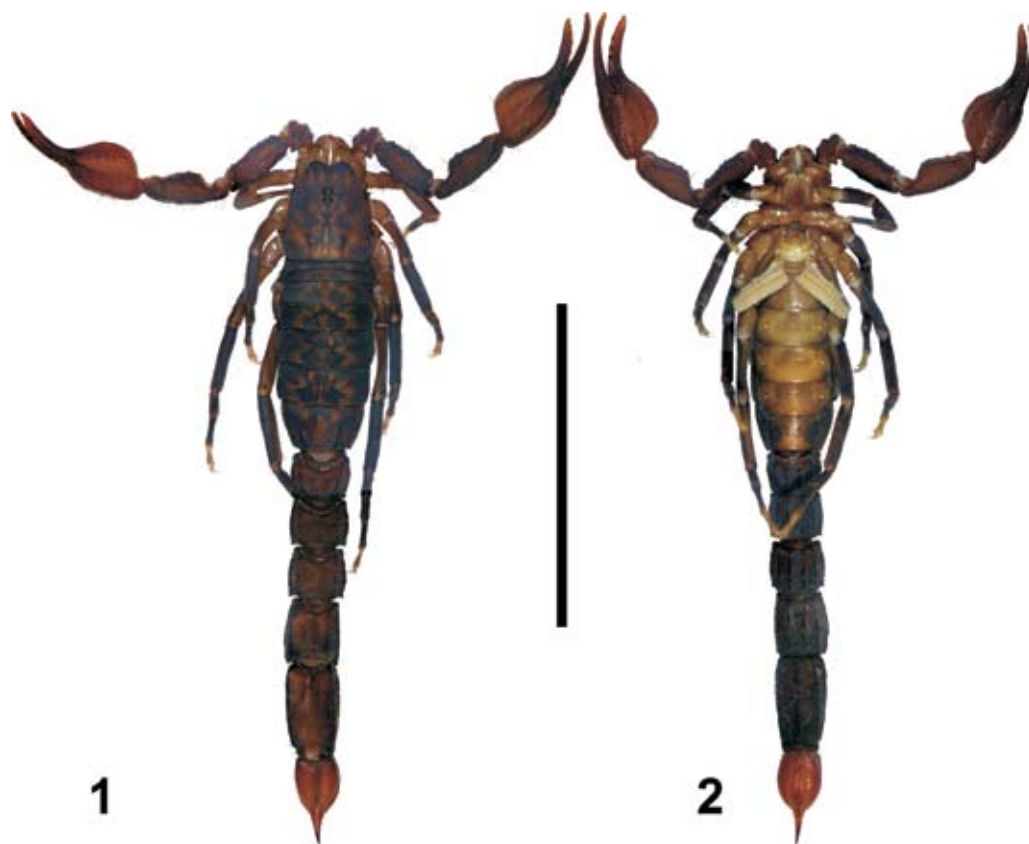
Nomenclature and measurements follow Stahnke (1970), except for trichobothrial terminology after Vachon (1974), metasomal and pedipalpal carinal terminology after Francke (1977), and telotarsal armature after McWest (2010). Surfaces of the pedipalp, carapace, mesosoma and metasoma were observed under ultraviolet light as described in Santibáñez-López and Sissom (2010).

Hemispermatothores were dissected following Vachon (1952), and cleared using the technique of Álvarez and Hormiga (2008). Higher level taxonomy of scorpions follows Coddington et al. (2004) and Prendini and Wheeler (2005). Photographs of the female and male carapace, pedipalp femur, patella and chela under black light follows Prendini (2003) and Volschenk (2005). Measurements were taken with an ocular micrometer calibrated at 10X and are given in millimeters. Abbreviations for depositories: AMNH: American Museum of Natural History, New York; CNAN: Colección Nacional de Arácnidos, Instituto de Biología, UNAM, México, D.F.

### Description

#### *Vaejovis coalcoman* sp. n.

*Description of the holotype male* (Figs. 1, 2). Coloration: pale brown, with a fusco-piceus pattern in the carapace, chelicerae, pedipalps, mesosomal tergites and legs. Anterior margin of the carapace with a dark band, median eyes with a notorious dark coloration and the posterior



**Figure 1.** Habitus of adult male holotype of *Vaejovis coalcoman* sp. n.; dorsal and ventral views. Scale bar= 10 mm.

margin with 2 distinctive whitish brown spots on either side of median furrow and extending to the sides along the posterolateral furrows; the rest of the segment with a fusco piceus pattern. Chelicera dorsally with conspicuous dark line at the anterior margin, with a net-like pattern becoming diffuse basally; the base of the segment is pale; the fixed finger of the chelicerae pale; movable finger with diffuse dark coloration. Mesosomal tergites I -VI, with 2 oval paramedian yellowish brown spots anteriorly, then an irregular pattern of yellowish brown coloration reaching the posterior margin, this yellowish coloration is bordered by dark brown coloration and on segments III-VI, with an irregular, longitudinal yellowish brown band, never reaching the lateral margins. Segment VII with 2 paramedian, oval, yellowish brown spots with diffuse edges, and with a pale triangular pattern shape beginning between the 2 paramedian spots and reaching the posterior margin; the 4 carinae of this segment dark. Prosoma ventrally yellowish brown, and coxae slightly more pigmented along edges; sternum darker. Genital operculum and pectines pale yellow, with diffuse fuscosity; sternites whitish, sides infusate with an irregular whitish line inside the darker coloration. Sternite VII, whitish medially, with 2 darker oval spots paramedially; laterally moderately to densely infusate, with irregular whitish lines on sides. Metasomal segments I-IV dorsally brown along middle, paler along dorsal carinae; segment V shares the same brown coloration, but with 2 paramedian darker lines on anterior half. Ventrally mainly dark brown; segment I, has a pale brown band along anterior margin, ending where submedian carinae begin; segments II-IV have 4 oval pale brown spots, 2 between the submedian and the lateral inframedian carinae, 2 between lateral inframedian and lateral median carinae. Segment V, ventrally, mainly dark brown, with 2 paler bands between median and lateral inframedian carinae, beginning at anterior margin and ending at the middle of the segment, then there are 2 spots subdistally with the same coloration, but well separated from anterior bands. All the carinae in the metasomal segments have a dark coloration. The vesicle is medium brown, with 2 paramedian, lighter, longitudinal bands ventrally. Pedipalp femur dorsally dark brown coloration, with 1 pale spot on basal third; ventrally uniformly reddish brown. Patella: dorsally a dark brown, with paler spots; ventrally uniformly brown. Pedipalp chela is brown, with fingers and carinae darker.

*Prosoma.* Carapace longer than wide (Fig. 3). Frontal margin with moderately deep, rounded notch; smooth, with a few granules and 3 setae on each side; 3 pairs of lateral eyes, subequal in size. Surface densely, minutely granulose.

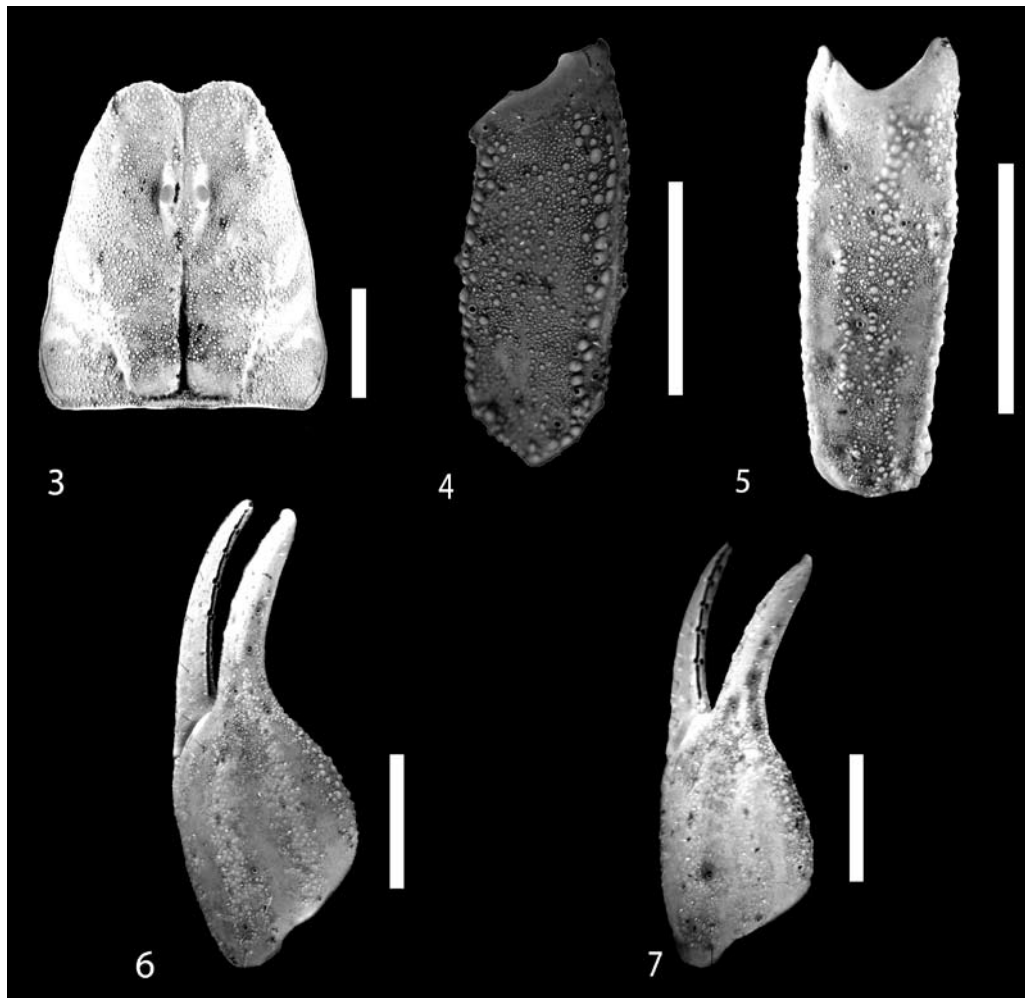
*Mesosoma.* Tergites I-VI, pre-tergites shagreened to weakly

granular, post-tergites minutely granular to granular. Tergite VII shagreened to minutely granular; paramedian carina minutely granular, present distal half; lateral carina serrated, with a big pointed granule on distal end; shorter than paramedian carinae. Sternites III-VI smooth, shiny; stigmata linear. Sternite VII smooth, with 1 pair of weak, sparsely granulose lateral carinae. Pectinal tooth count 15-15.

*Metasoma.* Ventral submedian carinae strong and granular on I-IV, aspect of the granules crenulated on segments I-II, serrated on segments III-IV. Ventral lateral carinae strong, granular and serrated on I-IV. Lateral inframedian carinae strong, granular on I; weak and poorly developed on II-III and absent on IV. Lateral supramedian carinae weak and minutely granular on I; strong, serrated and well-developed on II-IV, with distal granule larger, pointed and darker. Dorsolateral carinae on I-IV weak, sparsely and minutely granular, with distal granule larger, pointed and darker. Metasomal segment V length greater than femur length (Femur length/segment V length= 0.85); ventral median carina weak, serrated and minutely granulated with larger granules basally; ventral lateral carinae strong, granulated, pointed and darker than on other segments; dorsolateral carinae weak, serrated with pointed granules. Setae count on metasoma as follows: Segments I/II/III/IV (right-left sides): dorsal lateral 0-0/0-1/0-0/1-1; lateral supramedian 0-0/0-1/2-2/2-3; lateral median 2-3/1-0/0-0/0-0; lateral inframedian 2-2/3-2/3-3/4-3; ventral submedian 3-3/2-3/3-3/4-3. Segment V: dorsal lateral 3-4; lateral median 3-3; ventral lateral 5-6 and ventral median 6.

*Telson.* Vesicle ventrally smooth, with few small, scattered, rounded granules on ventral surface and few scattered setae; dorsal face flat, smooth, without setae or granules. Basal aculear serrations absent.

*Pedipalp.* Orthobothriotaxic "C". Femur (Fig. 4) wider than deep (width/depth= 2.1); dorsal external carina strong, with few large, pointed granules, not differentiated in colour from rest of femur; dorsal internal carina strong, with a few larger, darker, pointed granules; dorsal face flat, shagreened with scattered pointed granules; ventral surface pale brown, flattened, slightly concave in the middle, shagreened to minutely granular. Patella (Fig. 5): Wider than depth (width/depth= 1.2); dorsal internal carina weak, with 3-4 bigger granules; dorsal median carina darker than the rest of the segment, strong, with few large, flattened granules; dorsal external carina weak, smooth, almost flat and differentiated by darker brown coloration; ventral external carina pale brown, smooth, with elongated, flattened granules; ventral medial carina weak, almost absent, formed by 3-4 large flat granules; ventral internal carina strong, granular and darker than rest of the patella. Chela (Fig. 6): carinae weak and smooth to



**Figure 3-7.** *Vaejovis coalcoman* n. sp.; 3, carapace of the holotype male; 4, dorsal view of the pedipalp femur; 5, external view of the pedipalp patella; 6, external view of the pedipalp chela of paratype female; 7, external view of the pedipalp chela of the holotype male. Scale bars= 1 mm.

faint, except for dorsal marginal carina with large rounded tubercles; other carinae are faint, raised, smooth ridges of the cuticle, with some granules on the internal carinae. Dentate margin of fixed finger with primary row divided into 6 subrows by 5 enlarged denticles and 6 inner denticles. Movable finger with primary row divided into 6 subrows by 5 enlarged outer denticles and 6 inner denticles; distal-most subrow very short, with 2 denticles.

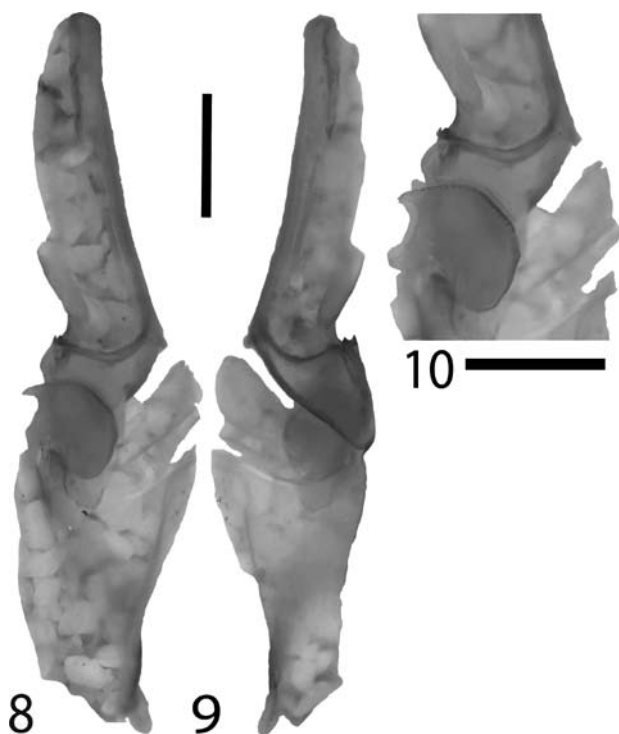
**Legs.** Telotarsus ventrally with 3 distal spinules on segment I, with 2 distal spinules on segments II-IV.

**Hemispermaphore.** (Figs. 8-10) Lamelliform (length 4.5 mm, width 1.0 mm); lamellar hooks basal, with 3 short denticles on the margin; lamella straight, as wide as the capsule, with weak distal crest; no sclerotized hemi-mating plug, but with a large, sclerotized median lobe.

**Diagnosis.** *Vaejovis coalcoman* sp. n. belongs in the “mexicanus” group (Soleglad, 1973; Sissom, 2000; Soleglad and Fet, 2008). Small scorpions with adult total length ranging from 20.6-29.3 mm (average [N= 6]: 25.9 mm) in males and 32 to 25 mm (average [N= 5]: 28.8 mm) in females (Table 1) and carapace length in males from 3.5 to 4.7 mm (average [N= 6]: 4 mm) and in females goes from 4 to 4.7 mm (average [N= 5]: 4.4 mm). The manus on the pedipalp chela (without the fixed finger) is rounded, in males from 3 to 4.1 mm long (average [N= 6]: 3.4 mm) and in females goes from 3.5 to 4mm (average [N= 5]: 3.7 mm). Pectinal tooth count in males 14 - 15 and in females 12 - 13 (variation shown in Table 1).

**Taxonomic summary**

**Distribution.** Only known from Las Nieves, a small



**Figure 8-10.** Right hemispermathophore of *V. coalcoman* sp. n.; 8, mesal view; 9, ectal view; 10, detail of capsular region showing semicircular internal lobe. Scale bars= 1mm.

settlement on the road from Coalcomán to Dos Aguas, in the Sierra de Coalcomán (Fig. 11).

**Habitat.** Most specimens of *V. coalcoman* were collected in a pine forest, at night, with portable U.V. lights; the altitudinal range where this species was collected goes from 2 050 to 2 265 m. We have observed that these scorpions tend to rest at the base of the pine trees, although the bark is firmly attached and offers little cover.

**Etymology.** The specific epithet refers to the mountains where the type locality of this species is found, and it is used as a noun in apposition.

**Types.** One ♂ holotype Michoacán: municipio Coalcomán, Las Nieves (18°49.070' N, 103°02.653' W, 2 246 m asl), 10.VII.2005. O. Francke, J. Ponce, M. Córdova, A. James, G. Francke and V. Capovilla (CNAN-T0738). Paratypes: Michoacán: municipio Coalcomán, Las Nieves (18°49.070' N, -103°02.653' W, 2 246 m asl), 10.VII.2005. O. Francke, J. Ponce, M. Córdova, A. James, G. Francke and V. Capovilla 2♂♂, 2♀♀. (CNAN-T0740) 3♂♂, 3♀♀ (AMNH). Michoacán: municipio Coalcomán, Las Nieves, 28.V.1988. A. Cadena and L. Cervantes. 1♂ (CNAN-T0739).

**Other specimens examined:** municipio Coalcomán, Las Nieves (18°49' 5.8" N, 103° 02' 40.6" W, 2 265 m asl)

7.VIII.2003. O. Francke, E. González and S. Reynaud. 4♂♂, 4♀♀ (CNAN-SV0094). Michoacán: municipio Coalcomán: km 27 along the road Coalcomán-Dos Aguas, Las Nieves. 10.XI.1988. H. Brailovsky. 2♀♀ (CNAN-S0919). Michoacán: municipio Coalcomán: Las Nieves. (2 050 m asl) 6.V.1983. E. Marino. 1♂, 1♀ (CNAN-S01241).

#### Remarks

**Intraspecific variation.** *Vaejovis coalcoman* sp. n. shows sexual dimorphism, the males are slightly darker than females; the shape of the chela differs between males (slender; average length/depth= 1.5 [N= 6]) and females (deeper; average length depth= 1.7 [N= 6]), with more strongly developed and more granulose carinae on males. Pectinal tooth count variation as follows: Males-12 combs with 14 teeth, 10 with 15, 6 with 13 and 2 with 16 teeth; Females-15 combs with 13 teeth, 9 with 12, 6 with 14 and 2 with 15 teeth. Metasomal setae counts are presented in Table 2.

*Vaejovis coalcoman* sp. n. is similar to *V. monticola* Sissom, 1989 in size and colour and is geographically close; both species can be separated because the frontal notch in the carapace is distinct and U-shaped in *V. coalcoman* sp. n., whereas in *V. monticola* it is vestigial to absent in (anterior margin nearly straight); the pedipalp femur is proportionately longer in *V. coalcoman* sp. n. (Femur length/Carapace length ratio= 0.81 average; males and females have the same average) than in *V. monticola* (Femur Length/Carapace length ratio= 0.75 average in males, and in females the average is slightly lower 0.74); *V. coalcoman* sp. n. has the ventral carinae of sternite VII more developed and the carinae on the pedipalp chela with well-differentiated granules; whereas *V. monticola* has weaker carinae on sternite VII, and smooth carinae on the chela. Another species similar to *V. coalcoman* sp. n. and also belonging to the "mexicanus" group is *V. dugesi* Pocock, 1902 from Guanajuato, which is well separated geographically and has a larger size as adult than *V. coalcoman* sp. n.; these 2 species are well-differentiated by the coloration, which is yellowish in *V. dugesi* and dark brown in *V. coalcoman* sp. n. The manus on the pedipalp chelae on *V. dugesi* females is slender (Length= 4 mm, Width= 1.9 mm; L/W= 2.1 on average, males are unknown), whereas in *V. coalcoman* sp. n. it is relatively wider (L/W= 1.6 on average on males and 1.7 on females); the ventral submedian and ventral lateral carinae of the first 3 metasomal segments are crenulated in *V. dugesi*, whereas in *V. coalcoman* sp. n. they are distinctly serrated. *Vaejovis mexicanus* is another related species to *V. coalcoman* sp. n., but the telson is lighter in color in *V. coalcoman* sp. n. and is darker in *V. mexicanus*; in *V. mexicanus* the frontal margin of the carapace is straight and in *V. coalcoman* sp.

**Table 1.** Measurements of selected specimens (in mm)

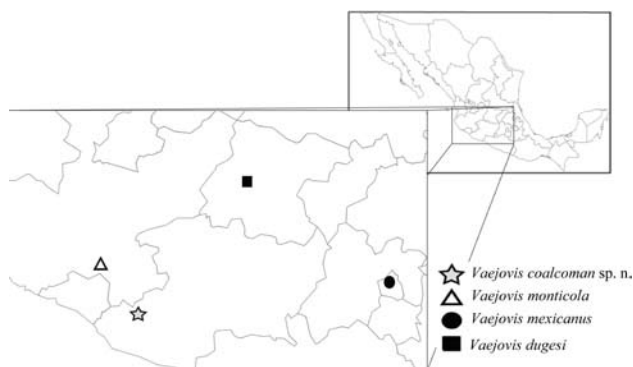
	<i>Holotype male</i>	<i>Paratype male</i>	<i>Paratype male</i>	<i>Paratype female</i>	<i>Paratype female</i>	<i>Paratype female</i>
Total length	20.6	21	29	29.5	27.1	25
Carapace length/width	4.3/2.1	4/2.1	4/2.2	4.7/2.5	4.4/2.3	4.6/2.6
Tergite I length	0.5	0.6	0.5	0.8	0.9	0.6
Tergite II length	0.5	0.7	0.7	1	1	1
Tergite III length	1.1	1.2	1.1	1.4	1.2	1.3
Tergite IV length	1.1	1.4	1.3	1.7	1.7	1.4
Tergite V length	1.6	1.5	1.6	2	1.9	1.8
Tergite VI length	1.7	1.5	1.7	2.3	2.1	2.2
Tergite VII length	2.2	2.2	2.2	2.5	2.5	2.8
Mesosoma length	6.6	6.7	12.0	11.7	10	9.0
Metasoma I length	1.7	1.5	1.6	1.8	1.5	1.7
Metasoma II length	2	1.8	1.8	2	1.8	1.9
Metasoma III length	2.2	2	2	2.6	2.1	2.2
Metasoma IV length	2.5	2.3	2.4	2.6	2.4	2.4
Metasoma V length	4	3.8	3.8	4.1	4	4.3
Metasoma total length	10.5	10.6	12.6	13.1	12.2	12.1
Telson length	1	0.8	1	5.3	1	0.5
Vesicle length/width	3.5/2	3.2/1.8	3.2/1.6	4.3/2.1	3.3/2	3.8/2.2
Pedipalp femur length/ width/ depth	3.5/1.2/0.9	3.2/0.9/0.8	3.3/1.1/0.9	3.8/1.4/1.1	3.6/1.3/1	3.8/1.3/0.9
Pedipalp patella length/ width/ depth	4/1.3/1.2	3.5/1.3/1.2	3.6/1.3/1.1	4.1/1.6/1.4	4/1.4/1.2	4.1/1.5/1.3
Manus length/ width/ depth	3.3/2.3/2.7	3.3/2/2.2	3.5/2/2.3	4/2.2/2.1	3.8/2.2/2.5	4/2.2/2.1
Movable finger length	4	3.2	3.4	3.6	3.5	3.8
Fixed finger length	2.3	2.5	2.6	2.8	2.9	3
Pectinal tooth count	14-14	14-14	16-16	13-13	13-13	13-12

**Table 2.** Variation in the metasomal setae count in selected specimens. For segments I-IV the carinae order is: 1<sup>st</sup> ventral submedian, 2<sup>d</sup> lateral inframedian, 3<sup>d</sup> lateral median, 4<sup>th</sup> lateral supramedian and 5<sup>th</sup> dorsal lateral; and for segment V, the order is: 1<sup>st</sup> dorsal lateral, 2<sup>d</sup> lateralmedian, 3<sup>th</sup> ventral lateral and last ventral media; x when the carinae is absent

	<i>Metasomal segment</i>				
	<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>	<i>V</i>
Holotype ♂	0-1/0/3/2/3	1/2/2/3/3-4	1/2/2/3/3	2/4/x/4/3	6-7/4/7/5
Paratype #f	1/0-1/3/2/3	1/1/2/3-4/3	1/2/2/3/3	2/3/x/3/4	5/4/7-6/5
Paratype ♂	0/0/3/2/3-2	1/2/2/3-2/4	1/2-1/2/4-3/3	2/4/x/4/4	5/4/7/5
Paratype #f	0/0/3-2/2/3	1/2/2/4/3	1/2/1/4-3/4-3	2/3/x/5/3-4	5/5-4/6/5
Paratype ♂	0/0/2/3-2/3	1/2/2/4/4	2/2/2/4/4	2/3/x/5-4/4	6/4/7/5
Paratype #f	0/1-0/2/2/3	1/1/2/3/3	1/1/1/4-3/3	2/4/x/4/4-3	5/4-3/6/9

n. it has a U-shaped notch; the carinae of the chelae are more strongly developed in *V. mexicanus* and formed by bigger, pointed granules than in *V. coalcoman* sp. n. which

has smaller, rounded granules on the chelae. The pectinal tooth count in males of *V. coalcoman* sp. n. is 13-16 (N= 15, mode= 14), and in females it is 12-15 (N= 16, mode



**Figure 11.** Known distribution of *V. coalcoman* sp. n. (star), *V. monticola* (triangle), *V. dugesi* (square) and *V. mexicanus* (circle).

13); in *V. dugesi* females it is 13-14 (N= 4, mode= 13); in *V. mexicanus* in males it is 17-20 (N= 6, mode= 18), in females is 15-17 (N= 6, mode= 16) and in *V. monticola* in males it is 13-15 (N= 4, mode= 15) and in females it is 10-13 (N= 4, mode= 12).

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