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A new species of *Centruroides* (Scorpiones: Buthidae) from the northern mountain range of Oaxaca, Mexico

Una especie nueva de *Centruroides* (Scorpiones: Buthidae) de la sierra norte de Oaxaca, México

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Abstract. *Centruroides serrano* sp. nov. from the Sierra Juárez of Oaxaca (Villa Alta District) is described. This is the eleventh species of the genus reported from Oaxaca and the first one reported from this area. It occurs from 500 m to 1 500 m. It is compared to *C. baergi* Hoffmann, 1932, *C. nigrovariatus* Pocock, 1898 and *C. hoffmanni* Armas, 1996 due to its overall similarity. To separate these 4 species, a principal component analysis was conducted. A list of the species of this genus from Oaxaca is provided.

Key words: scorpions, diversity, principal components analysis, multiple correlation analysis, one way analysis of variance.

Resumen. Se describe *Centruroides serrano* sp. nov. de la sierra Juárez de Oaxaca (distrito de Villa Alta). Es la onceava especie del género reportada para Oaxaca y la primera reportada para el área. Se distribuye en elevaciones desde los 500 a los 1 500 m. Se compara con *C. baergi* Hoffmann, 1932*, C. nigrovariatus* Pocock, 1898 y *C. hoffmanni* Armas, 1996 por su parecido morfológico. Para separar estas 4 especies, se llevó a cabo un análisis de componentes principales. Finalmente, se incluye una lista de las especies del género presentes en Oaxaca.

Palabras clave: alacranes, diversidad, análisis de componentes principales, correlación múltiple, análisis de varianza de una vía.

Introduction

Mexico harbors one of the world's largest scorpiofaunas, with more than 200 species and subspecies in 7 families and 24 genera (Fet et al., 2000; Lourenço and Sissom, 2000; Sissom and Hendrixson, 2006). The family Buthidae is represented in the country by 2 genera: *Tityopsis* Armas, 1974, with 1 species in the Isthmus of Tehuantepec (*T. aliciae* Armas and Martín-Frías, 1998); and *Centruroides* Marx, 1890, with 30 species distributed throughout the country (Lourenço and Sissom, 2000; Ponce and Barajas, 2005; Armas et al., 2003).

García-Mendoza et al. (2004) consider the state of Oaxaca as one of the most biodiverse in México. The Sierra Juárez (from now on referred to as the "Northern mountain range") is one of the most important regions of the state for conservation. It has been poorly studied from the point of view of its arthropods, although it has been considered an important area for conservation due to its high plant endemism (Lorence y García-Mendoza, 1989). There are no published records of any species of *Centruroides* for this area. Currently the scorpiofauna of the area is being studied as part of the master's degree research of the senior author. In the present contribution, a new species of *Centruroides* is described from the District of Villa Alta.

Centruroides is one of the best studied scorpion genera in the country due to the high toxicity of some species, but still remains poorly sampled (Ponce-Saavedra and Francke, 2004) and the status of several species is unclear. It was divided into 3 major groups by Hoffmann (1932), modified into 4 major groups by González-Santillán (2001) and subsequently accepted by Ponce and Barajas (2005): a) *C. gracilis* species group: species with 9 denticle rows

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on the fingers of the pedipalp chelae (see Capes, 2002); b) *C. thorelli* species group: small species with variegated fuscous patterns not consisting of 2 longitudinal rows dorsally along the opisthosoma; c) *C. bertholdii* species group: species with 8 denticle rows on the fingers of the pedipalp chelae (this group is not well characterized and a better delimitation is required); and d) the striped ones: all the species with 8 denticle rows in the fingers of the pedipalp chela and with 2 dark longitudinal bands along the mesosoma with 1 yellow band between them. The "striped" group is divided into 2 subgroups: the *C. elegans-limpidus* subgroup (species with longitudinal bands along the carapace; 2 longitudinal bands along the mesosoma with spots on the pretergite and the postergite) and the *C. infamatus-nigrovariatus* (*C. suffusus-infamatus* sensu Ponce and Barajas, 2005) subgroup with variegated fuscous pattern in the carapace and without the longitudinal bands along it, and 2 longitudinal bands along the mesosoma with a well defined spot on the pretergites and another on the median portion of the postergites united by a diffused pigmentation.

Oaxaca is the state with the highest number of species of *Centruroides* in the country, with 10 described species (Table 1) (Beutelspacher, 2000; Fet et al., 2000; Armas et al., 2003; Santibáñez-López et al., 2007). Although Fet et al. (2000) reported *C. elegans* Thorell, 1876 on the coast of Oaxaca (a misidentification; it corresponds to *C. meisei* Hoffmann, 1938, see Armas and Martín-Frías, 1998) and there have been some records of *C. limpidus* Karsch, 1879 along the boundaries of the state with Guerrero and Puebla, there are no other records of medically important species in Oaxaca. Thus, additional collections are necessary.

The taxonomy of the "striped" group in the genus is complicated because it is largely based on morphometric characters and coloration patterns, which are characters that show high intraspecific variation; according to Ponce (2003) this often leads to misidentification. Ponce et al. (1999) and Ponce and Barajas (2005) indicate that the morphometric variables can be tested in a multivariate analysis and then it is possible to select the variables with the lowest intraspecific variability and the highest interspecific variability for a numerical taxonomy approach to this complex problem. These multivariate techniques have been used to separate sympatric species of the genus *Euscorpius* Thorell, 1876 (Euscorpidae) in Italy (Vignoli et al., 2005), species of the genus *Centruroides* in Michoacán, México (Ponce and Francke, 2004), and to show intraspecific and interspecific variability within the genus *Mesobuthus* Vachon, 1950 (Buthidae) in Turkey (Karatas, 2007). A multivariate analysis was conducted to strengthen the separation of the new species from the northern mountain range of Oaxaca from its close relatives.

Table 1. Annoted list of the species of *Centruroides* Marx, 1890 from Oaxaca, Mexico (modified from Beutelspacher, 2000; Fet et al., 2000; Lourenço and Sissom, 2000; González-Santillán, 2001; Armas et al., 2003; Santibáñez-López et al., 2007)

Species	*Distribution*
C. baergi Hoffmann, 1932	Valley of Cuicatlan, Oaxaca
C. flavopictus flavopictus (Pocock, 1898)	Southern Oaxaca (Santa María Chimalapas, Matías Romeo)
C. fulvipes (Pocock, 1898)	Coast of Oaxaca (Pinotepa Nacional, Puerto Escondido, San Juan Cacahuatepec, Bahías de Huatulco)
C. gracilis (Latreille, 1804)	Papaloapam basin (Tuxtepec, San Miguel Quetzaltenango Mixes, Santiago Choapam)
C. hoffmanni Armas, 1996	Isthmus of Tehuantepec (Santo Domingo Tehuantepec, Ciudad Ixtepeji, Salina Cruz)
C. limpidus (Karsch, 1879)	Mixteca region (Huajuapam de León, Silacayoapan, Mariscal de Juárez, San Miguel Amatitlan, San Agustín Atenango, Santiago Chazumba)
C. meisei Hoffmann, 1932	Coast of Oaxaca (Pinotepa Nacional)
C. nigrescens (Pocock, 1898)	Southern mountain range (Magdalena Mixtepec)
C. nigrimanus (Pocock, 1898)	Wide range (Santa Cruz Xoxocotlán, Salina Cruz, Pochutla, Tehuantepec, San Juan Juquila Mixes, San Pedro Juchatengo)
C. nigrovariatus (Pocock, 1898)	Central valley of Oaxaca (Oaxaca city, Monte Albán, San Pablo Etla); Northern mountain range at the Ixtlán de Juárez district (La Cumbre Ixtepeji, Ixtlán de Juárez, Santa Catarina Ixtepeji)
C. serrano sp. nov.	Northern mountain range at the Villa Alta district (San Francisco Cajonos, San Melchor Betaza, San Andrés Yaa, San Juan Tabaa, San Andrés Zoolaga, Villa Alta)

Material and methods

Fieldwork. A trip to the District of Villa Alta, in the northern mountain range in Oaxaca, Mexico in June-July 2007, allowed us to collect scorpions under rocks and other objects on the ground during daylight, and at night using UV light detection (Sissom et al., 1990). A preliminary examination of the specimens indicated strong similarities with *C. nigrovariatus*, *C. baergi* and *C. hoffmanni*. These 3 taxa plus the unidentified material from the Villa Alta district were included in the analysis. Additional material was obtained from other collection trips (see taxonomic summary).

Statistical analysis. A statistical analysis was conducted to obtain a better resolution among the morphometric variables and their importance as diagnostic characters. First, we selected 31 morphometric variables and 15 morphometric ratios to test their usefulness as characters for multivariate analysis. This dataset was tested with multiple correlation analysis to select the variables with the lowest redundancy values. With the reduced dataset, a principal component analysis (PCA) was carried out to evaluate the variables with the highest contribution to the explained variance contained in the 3 principal components. This procedure was repeated until we found a group of characters with high interspecific variation and the lowest possible intraspecific variation. Finally, the variables were used to perform one way analysis of variance (ANOVA) followed by the Tukey-Kramer procedure to determine which pairs of means had statistically significant differences. All analyses were performed with the JMP v. 6.0 statistical software (SAS Institute).

Five males and 5 females of each species were measured. A Student's t-test was undertaken after the ANOVA because 2 species remained with unclear status: *C. baergi* and *C. serrano.*

Measurements and counts. Carapace length, mesosoma length, pectinal tooth count (right pectine), pedipalp chelae: fixed finger length, fixed finger external accessory denticle count, fixed finger internal accessory denticle count, movable finger length, movable finger external accessory denticle count, movable finger internal accessory denticle count, chela length, femur length, patella length, patella width, subaculear tubercle (multistate character: 0=obsolete or weak, 1=moderate developed and 2=strong and well developed), metasoma length, segment I length, segment I width, segment II length, segment II width, segment III length, segment III width, segment IV length, segment IV width, segment V length, segment V width, segment V depth, vesicle length, vesicle width, vesicle depth, aculeus length, total length.

Morphometric ratios. Total length / metasoma length, metasoma length / carapace length, carapace length / metasomal segment V length, carapace length / movable finger length, patella length / width, vesicle length / width, vesicle length / aculeus length, fixed finger length / movable finger length, aculeus length / total length, movable finger length / patella length, patella length / vesicle length, carapace length / chela length, movable finger length / chela length, patella length / metasomal segment V depth, metasomal segment V length / metasomal segment I length.

Description. Nomenclature and measurements follow Stahnke (1970), except for trichobotrial terminology after Vachon (1974) and metasomal carinal terminology after Francke (1977). Measurements were taken with an ocular micrometer calibrated at 10X and are given in millimeters. The picture was obtained with a Nixon Coolpix S10 VR camera supported on a Nikon SMZ800 stereoscope. Abbreviations for depositories: AMNH—American Museum of Natural History, New York, USA; and CNAN—Colección Nacional de Arácnidos, Instituto de Biología, Universidad Nacional Autónoma de México, Mexico, D. F.

Results

In the PCA, the cumulative variance for the first 3 principal components (70%) split the species into 2 groups: small species (*C. nigrovariatus* and *C. hoffmanni*) and large species (*C. baergi* and the Villa Alta population). We eliminated the 2 smaller species from the subsequent analyses because they are clearly distinguished by size and other characters (see comparative description for full details). With the large-size group, we ran the multiple correlation procedure and 26 characters were eliminated due their high correlation levels, and then a PCA was performed. The variance explained by the first 3 principal components was lower (66.7%) than in the first analysis, but a better separation was observed. A third multiple correlation analysis was made and 9 additional characters were eliminated from the dataset, and a new PCA was performed. From this analysis, the first component separated the 2 species and the explained variance was better than in the previous (73.63%). From this final PCA, we found 3 variables (the fixed finger internal accessory denticle count, the movable finger external accessory denticle count, and the vesicle width) with the highest eigenvalues and the highest contribution to the explained variation. Also the state of the subaculear tubercle is an important character to separate both species. None of the 15 ratios included in the analysis had high values in the first principal component. However, in the second principal component there are 3 ratios: the carapace length / segment V length; the vesicle length / aculeus length and the movable finger length / patella length which contribute significantly to the variation under analysis.

The ANOVA allowed us to select 3 characters with statistically significant differences ($p<0.05$) (all morphometric, see Appendix 1 and comparative description) that separate the 2 large-sized species. The Student's t-test allowed the separation of these 2 species from each other (Table 2). Also, this analysis provided 2 morphometric ratios with statistically significant differences and they characterize the sexual dimorphism in these 2 species (see remarks).

Centruroides serrano sp. nov. (Figs. 1-5, 9)

Diagnosis. Scorpions of moderate size, adults 51-59 mm long (x=56.4 mm +/-S.D.= 2.88, n=10) belonging to the *C. infamatus-nigrovariatus* subgroup (within the striped group). Carapace with diffuse fuscosity but without distinct longitudinal black color bands along it. Two pigmented rows along tergites conformed by a dark spot on postergite only. Pectinal tooth count in males 23 to 27 (mean=24 +/-S.D.=1.12; n=20) and in females 20 to 23 (mean=22 +/-S.D.=1.04; n=20). Internal accessory denticle count of pedipalp movable finger 30 to 38 (only adults; mean=38 +/-SD=4.67; n=24) and external accessory denticle count of movable finger 31 to 46 (also only adults; mean=39 +/-SD=3.9; n=24). Subaculear tooth well developed and it points towards the middle of aculeus. Vesicle 1.5 times deeper than wide.

Table 2. Characters with the highest interspecific variability. * marks the characters useful for separating *Centruroides serrano* sp. nov. from *C. baergi*

Character	*t-test*	*P<t*
*Fixed finger inner accessory denticle count	6.9279	0.0038
*Movable finger outer accessory denticle count	6.4451	0.0051
*Movable finger inner accessory denticle count	7.4201	0.0028
Vesicle width	2.9874	0.0645
Aculeus length	1.6542	0.2193
*Carapace length / segment V length	46.0223	<.0001
Carapace length / movable finger length	0.0675	0.9763
Vesicle length / aculeus length	2.8582	0.0721
*Movable finger length /patella length	13.7847	0.0001
Patella length / segment V depth	0.3533	0.7874

Male holotype (Figs. 1-2; measurements in Table 3). Coloration: Base color pale yellow brown above with faint to moderate dusky markings on chelicerae, pedipalps, legs and tergites. Coloration fairly uniform except as follows: coxosternal region light orange, pectines very pale yellow, metasomal segment V and telson dark orange to reddish; cheliceral teeth and tip of aculeus dark reddish brown. Granulation on the pedipalp fingers dark red.

Prosoma: carapace coarsely granulose (Fig. 3); anterior median furrow moderately deep; posterior median furrow shallow anteriorly, deeper posteriorly; ocular tubercle

Table 3. Measurements of *Centruroides serrano* sp. nov. (in millimeters)

	Holotype male	*Paratype female*
Carapace length	5.5	6.0
Mesosoma length	16.6	18
Metasoma length	33.7	26.8
Segment I length	5.5	4.1
Segment I width	3.2	2.8
Segment II length	6.2	5
Segment II width	3.1	2.7
Segment III length	6.7	5.3
Segment III width	3.1	2.6
Segment IV length	7	6
Segment IV width	3.3	2.7
Segment V length	8.3	6.4
Segment V width	3.4	3
Segment V depth	3.3	3
Telson length	6.4	6.1
Vesicle length	3.3	3
Vesicle width	2.3	2.1
Vesicle depth	2.6	2
Aculeus length	3.1	3.1
Pedipalp length	24	21.6
Femur length	6.2	5
Femur width	1.2	1.2
Patella length	6.8	6.1
Patella width	1.5	1.7
Chela length	11	10.5
Fixed finger length	5.6	6
Movible finger length	7	6.7
Total length	55.8	50.8

dark, granulose. Lateral margins finely serrate. Carapacial carinae inconspicuous, indicated by small granules. Anterior median notch moderately deep.
Mesosoma: two pigmented rows along the tergites formed by a dark spot only on postergite. Lateral margin of tergites I-VI with a dark serrate carina. Pretergites and postergites separated by a feebly granulose carina. Postergite posterior margin with moderate size, sparse granules. Tergal median carinae on I-VI weak to obsolete on anterior portion; moderate on posterior portion. Tergite VII: median carina moderately granulose; submedian carinae moderate, granulose; lateral carinae moderate, serrate. Sternites III-VI smooth, VII with submedian carinae weak, weakly granulose; lateral carinae moderate, serrate. Pectinal basal piece twice wider than long; posterior margin slightly rounded. Pectinal tooth count 23-23.
Metasoma: dorsolateral carinae: on I-III moderate, serrate; on IV strong, serrate. Lateral supramedian carinae: on I-III strong, serrate; on IV moderate, serrate. Lateral inframedian carinae: on I strong, serrate; on II-IV vestigial. Ventrolateral carinae: on I moderate, feebly crenate to serrate; on II-IV moderate, serrate. Ventral submedian carinae: on I-IV moderate, crenate. Intercarinal spaces shagreened. Segment V (Fig. 4): Dorsolateral carinae weak, sparsely granulose. Ventrolateral carinae moderate, granulose. Ventromedian carina weak to vestigial. Intercarinal spaces shagreened. Vesicle of telson elongate oval in shape. Ventral aspect with row of small granules leading to the subaculear tooth; subaculear tooth well developed, conical, its point towards middle portion of aculeus.
Pedipalp (Figs. 5-7): orthobothriotaxy type “A” (Vachon, 1974); femur with alpha configuration of dorsal trichobotria (Vachon, 1975). *Femur*. Dorsointernal, dorsoexternal and ventroexternal carinae strong, serrate. Ventrointernal carina moderate to weak, sparsely granulose. Dorsal face moderately granulose. *Patella*. Dorsointernal carina moderate, serrate. Dorsomedial and dorsoexternal carinae moderate to weak, feebly crenate. Ventrointernal carina weak, weakly granulose. Internal face with 4 large subconical granules. *Chela*. Dorsomarginal carina weak to moderate, feebly crenate, dorsal secondary carina weak, granulose. Digital carina weak, smooth, other carinae weak, smooth. Right chela fixed finger with 8 oblique rows of granules flanked by 30 inner accessory denticles and 37 outer accessory denticles (right pedipalp chela). Right chela movable finger with 8 oblique rows of denticles flanked by 35 internal accessory denticles and 45 outer accessory denticles.
Male intraspecific variation. Pectinal tooth counts (n=20 pectines): 23 teeth (6 pectines), 24 (9), 25 (3), 26 (1) and 27 (1). Fixed finger outer accessory denticles (both pedipalp chelae) (n=20): 25 denticles (1 finger), 26 (1), 28 (3), 29 (4), 30 (3), 31 (2), 32 (2), 33 (1), 34 (1) and 35 (1). Fixed finger inner accessory denticles (both pedipalp chelae) (n=20): 32 denticles (1 finger), 33 (2), 34 (1), 35 (5), 36 (4), 37 (2), 38 (1), 39 (1), 40 (2) and 41 (1). Movable finger outer accessory denticles (both pedipalp chelae) (n=20): 31 dentices (1 finger), 32 (1), 33 (1), 37 (2), 38 (3), 39 (4), 41 (1), 42 (1), 43 (1), 44 (1), 45 (2), 46 (1) and 52 (1). Movable finger inner accessory denticles (both pedipalp chelae) (n=20): 30 denticles (1 finger), 31 (1), 32 (3), 33 (2), 34 (4), 35 (3), 36 (2), 37 (1) and 38 (3).
Female: Carapace longer than male; basal pectinal piece with a shallow depression in the middle portion, which is absent on males (Fig. 9): anterior margin straight; posterior margin weakly bilobed; 22-22 pectinal teeth; inner accessory denticles on the fixed finger 35; on movable finger 36; outer accessory denticles on fixed finger 37; on movable finger 41.
Female intraspecific variation. Pectinal tooth counts (n=19): 20 teeth (4 pectines), 21 (4), 22 (7) and 23 (4).

Taxonomic summary

Type data. Holotype male from 6 km S San Andrés Zoolaga, district of Villa Alta, Oaxaca, Mexico (1119 m) 21/07/2007, N 17° 15.472’; W 96° 14.393’, cols. O. Francke, A. Ballesteros, H. Montaño, C. Santibáñez y A. Valdez, CNAN-T0348. Paratype female (CNAN-T0349) and paratype male (AMNH) from San Melchor Betaza, Villa Alta, Oaxaca, México (1 415 m) 18/12/2006 N 17° 15.061’ W 96° 09.188’, cols. C. Santibáñez and H. Jara.
Other material (Fig. 13). *Centruroides serrano* sp. nov. 1♂, 6♀ (CNAN) 1 km NE de San Andrés Yaa, Villa Alta, Oaxaca, México (1 506 m) 21/07/2007, N 17° 18.086’ W 96° 09.180’, cols. O. Francke, A. Ballesteros, H. Montaño, C. Santibáñez and A. Valdez. 1♀ (CNAN) 6 km S de San Juan Tabaa, Villa Alta, Oaxaca, México (1 734 m) 21/07/2007, N 17° 16.697’ W 96° 13.481’, cols. O. Francke, A. Ballesteros, H. Montaño, C. Santibáñez and A. Valdez. 2♂, 1♀ (CNAN) San Francisco Cajonos, Villa Alta, Oaxaca, Mëxico (1 678 m) 20/06/2007, N 17° 10.125’ W 96° 14.671’, cols. A. Valdez and C. Santibáñez. 5♂, 1♀ (CNAN) Km 101 carretera Díaz Ordaz-Villa Alta, Villa Alta, Oaxaca, México (992 m) 21/06/2007 N 17° 13.463’ W 96° 09.124’, cols. A. Valdez and C. Santibáñez.

Centruroides nigrovariatus. 1♂, 1♀ (CNAN) Camino a Santa Catarina Ixtepeji, Ixtlán de Juárez, Oaxaca, México (1 951 m) 17/06/2007, N 17° 16.778’ W 96° 32.686’, cols. A. Valdez and C. Santibáñez. 1♂, 1♀ (CNAN) Km 9 carretera Díaz Ordaz - San Antonio Cuajimoloyas, Ixtlán de Juárez, Oaxaca, México (2 363 m) 01/04/2007 N 17°

02.394' W 96° 28.267', cols. C. Santibáñez and H. Jara. 2♂, 3♀ (CNAN) Campamento Tatachinto, Santiago Xiacuí, Ixtlán de Juárez, Oaxaca, México (2 278 m) 13/11/2005 N 17° 17.244' W 96° 25.069', cols. O. Francke, M. Córdoba, A. Jaimes, G. Montiel and C. Santibáñez. 5♂ subadult, 5♀ (CNAN) Km 45.8 carretera federal 175 tramo Oaxaca-Ixtlán de Juárez, Oaxaca, México (2 003 m) 14-15/06/07 N 17° 17.834' W 96° 32.582', cols. A. Valdez and C. Santibáñez.

Centruroides baergi. 1♀ subadult (CNAN) Paraje 5. Mezquites 8 km S Zinacatepec, Puebla, México (1075 m) 08/11/2005, N 18° 18.147' W 97° 12.918', cols. O. Francke, M. Córdoba, A. Jaimes and G. Montiel. 2♂, 1♀ (CNAN) Road to Ixcatlan, 5 km N Cuicatlán, Oaxaca, México (702 m) 08/11/2005 N 17° 48.914' W 97° 00.323', cols. O. Francke, M. Córdoba, A. Jaimes and G. Montiel. 2♀ (CNAN) Road Cuicatlán-Oaxaca 33 km S Cuicatlán, Oaxaca, México (1 574 m) 09/11/2005 N 17° 34.914' W 96° 56.928', cols. O. Francke, M. Córdoba, A. Jaimes and G. Montiel. 1♀ (CNAN) Zapotitlán de las Salinas (botanical garden), Puebla, México (1 497 m) 30-31/10/2003 N 18° 20' 1.4'' W 97° 27' 7.5'', col. R. Paredes. 3♂ (CNAN) Cuicatlán, Oaxaca, México (620 m) 23/07/1998 N 17°47'55" W 96°57'35", col. S. Zaragoza.

Centruroides hoffmanni. 1♀ (CNAN) Microwave station 9 Puntas, road Oaxaca-Tehuantepec, Oaxaca, México 09/09/1979 (55 m) N 16° 19' 28" W 95° 14' 20" col. C. Márquez. 1♀ (CNAN) Morro Mazatán, Oaxaca, México 14/03/1990 (20 m) N 16° 05' 53" W 95° 22' 46" col. E. Barrera and A. Cadena. 1♂ (CNAN) Road to Nizanda, Ixtepeji, Oaxaca, México 12/08/2002 (100 m) N 16° 39' 28" W 95° 00' 42" col. R. Paredes. 1♂ (CNAN) Ixaltepec, Huiditou, Oaxaca, México 26/12/2000 (neither altitude nor georeference available) col. E. Cabrera. 3♂, 3♀ (CNAN) 5 km west of San Miguel Tenango 02/11/2004 (1 571 m) N 16° 13' 30.9'', W 95° 35' 57.2'', col. O. Francke, G. Villegas and R. Paredes.

Etymology. The specific Spanish epithet "serrano", that means "belonging to the mountain range", is used as a noun in apposition.

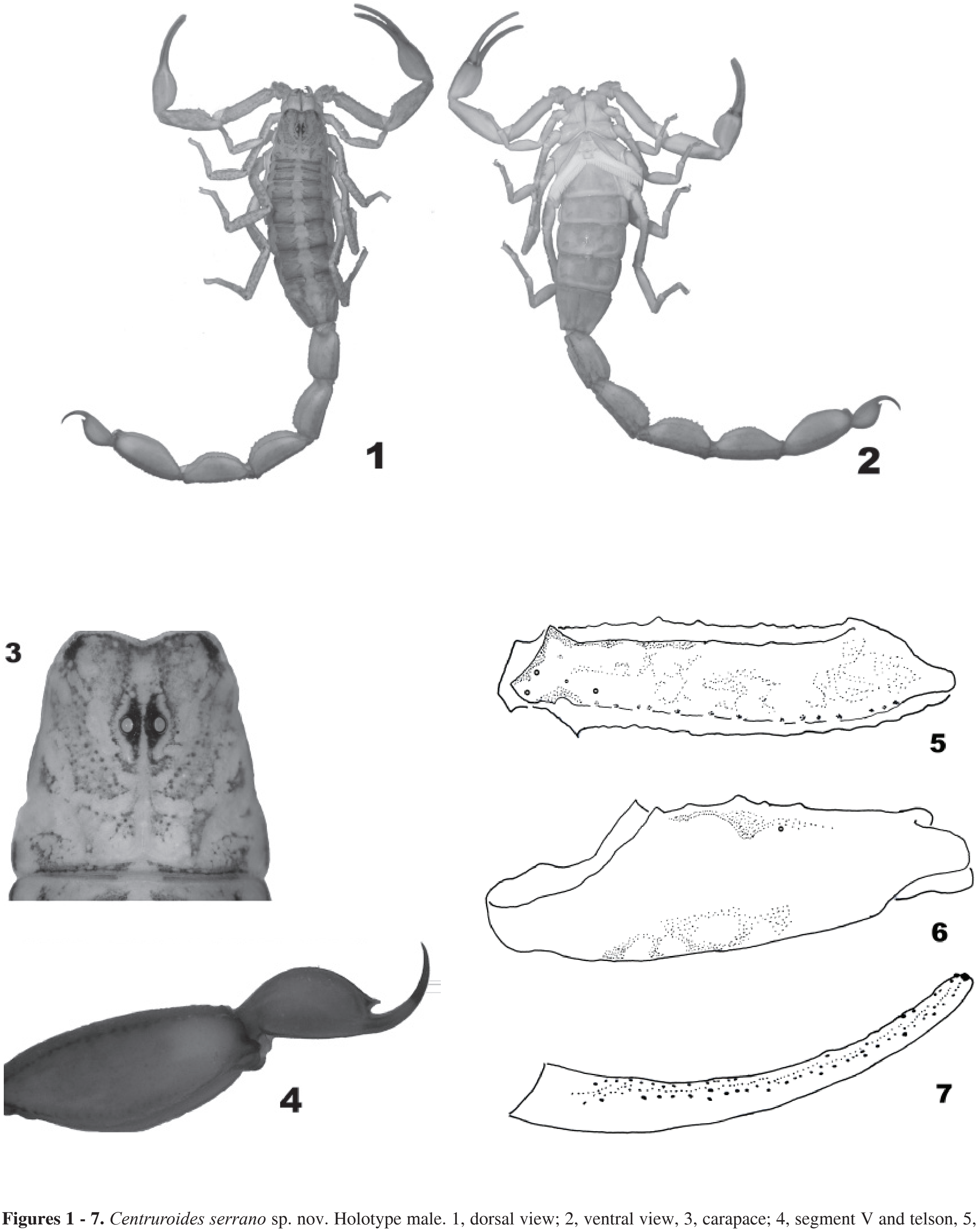
Remarks

Sexual dimorphism: the pectinal tooth count is higher in males and the carapace longer in adult females. The carapace length/segment V length ratio is 0.70 times on males whereas on females it is 0.86; the vesicle length/aculeus length ratio is 1.16 times on males whereas on females it is 1.02.

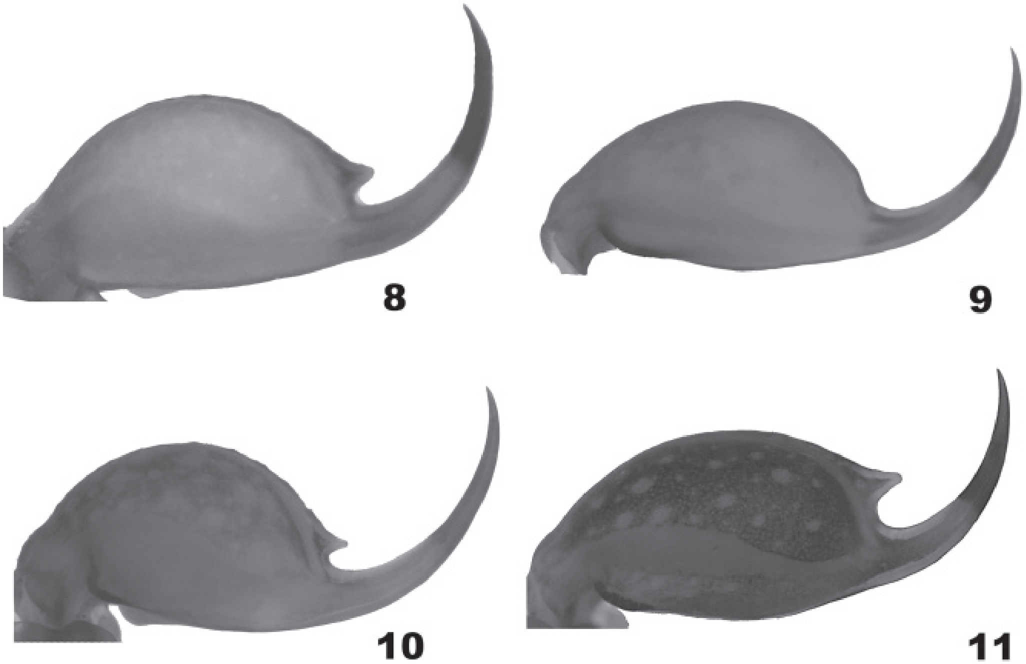
Centruroides serrano sp. nov. is related to *C. baergi* on account of their similar size, but it is clearly distinguished by the following characters: on *C. serrano* the subaculear tooth is well developed, whereas it is very small or obsolete on *C. baergi* (Figs. 8-9). A higher pectinal tooth count on *C. serrano* (male=23 to 27, Mode=24, n=20 and female= 20 to 23, Mode=22, n=19) whereas on *C. baergi* it is lower (male= 21-23, Mode=23, n=20 and female= 18-22, Mode=20, n=20); the anterior margin of the basal pectinal piece on *C. baergi* is straight and the posterior margin is rounded whereas on *C. serrano* it is not (Figs. 12-13); the inner accessory denticle count of the pedipalp movable finger (only in adults, males and females) is higher on *C. serrano* (30 to 46, Mode=35, n=10) than on *C. baergi* (28 to 34, Mode=30, n=10); the outer accessory denticle count of the pedipalp movable finger (only on adults, males and females) is also higher on *C. serrano* (31 to 45, Mode=37, n=10) than on *C. baergi* (31 to 38, Mode=33, n=10).

Centruroides serrano sp. nov. is related also to *C. nigrovariatus* on account of the shape of the subaculear tubercle but it is clearly distinguished by differences in a variety of features. Most conspicuous of these differences is overall size, with *C. nigrovariatus* adults, at 38-52 mm being conspicuously smaller than those of *C. serrano* (51-59 mm). Likely associated with its larger size is the higher pectinal tooth count in *C. serrano* (male= 23-27, Mode=24, n=20; female= 20-23, Mode=22, n=19) as compared to that of *C. nigrovariatus* (male = 19-22, Mode=21, n=10 and female = 17-20, Mode=19, n=10). Similarly, the inner accessory denticle count of the pedipalp fixed finger (only in adults, males and females) is higher in *C. serrano* (25 to 39, Mode=29, n=20) than in *C. nigrovariatus* (20 to 29, Mode=24, n=10). The outer accessory denticle count of the pedipalp fixed finger (only in adults) is also higher on *C. serrano* (31 to 41, Mode=35, n=20) than on *C. nigrovariatus* (22 to 31, Mode=31, n=10). A distinguishing feature that is not as clearly size-related is the orientation of the subaculear tubercle, which points towards the base of the aculeus in *C. nigrovariatus* whereas in *C. serrano* it points toward the middle of the aculeus (Figs. 8 and 10).

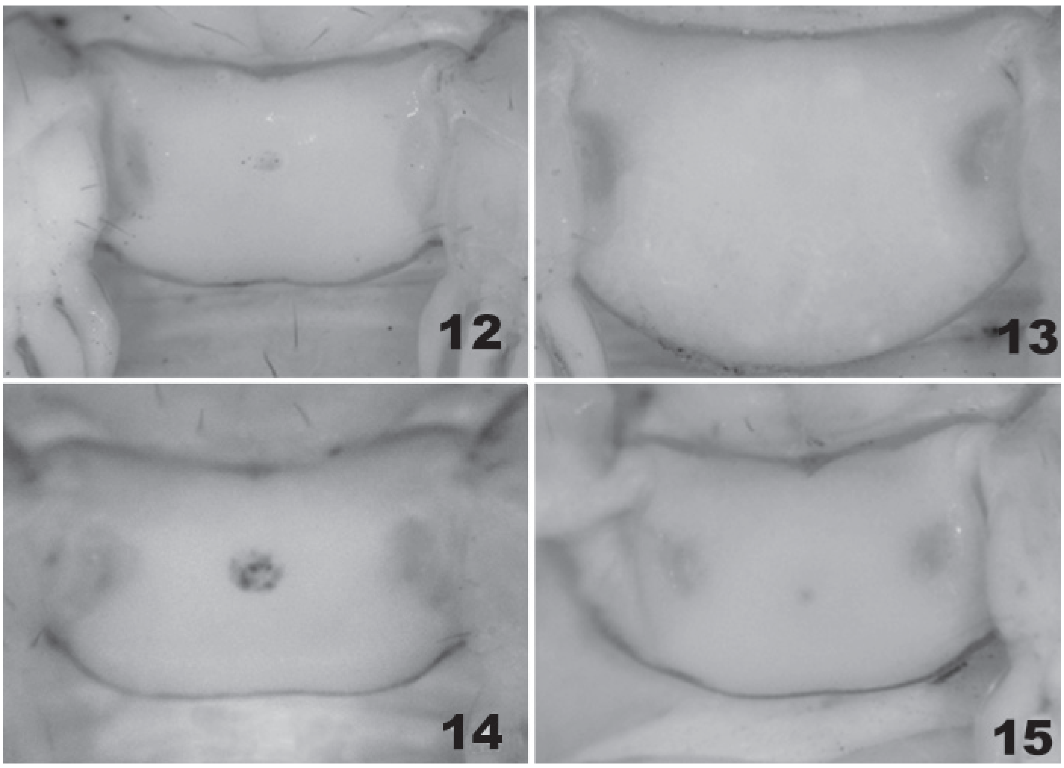
Centruroides serrano sp. nov. is also related to *C. hoffmanni* on account of the shape of the subaculear tubercle (Figs. 8 and 11) and with similar pectinal tooth counts on males and females. The 2 species can be separated by the following characters: males of *C. hoffmanni* are smaller (36 to 49 mm, following Armas et al., 2005; whereas on *C. serrano*=54 to 59 mm), and the metasomal segment V is wider than the segment I on males of *C. serrano* (1.1 times wider) whereas on males of *C. hoffmanni* the segment V is narrower than segment I (ratio= 0.8).



Figures 1 - 7. *Centruroides serrano* sp. nov. Holotype male. 1, dorsal view; 2, ventral view, 3, carapace; 4, segment V and telson, 5, femur, dorsal view; 6, patella, dorsal view; 7, movable finger inner accessory denticles.



Figures –8 - 11. Comparisons between the telson of the species of the *C. infamatus-nigrovariatus* subgroup from Oaxaca. 8, *Centruroides serrano* sp. nov.; 9, *C. baergi*; 10, *C. nigrovariatus;* 11, *C. hoffmanni*.



Figures 12 - 15. Comparisons between the female basal pectinal pieces. 12, *Centruroides serrano* sp. nov.; 13, *C. baergi;* 14, *C. nigrovariatus;* 15, *C. hoffmanni*.

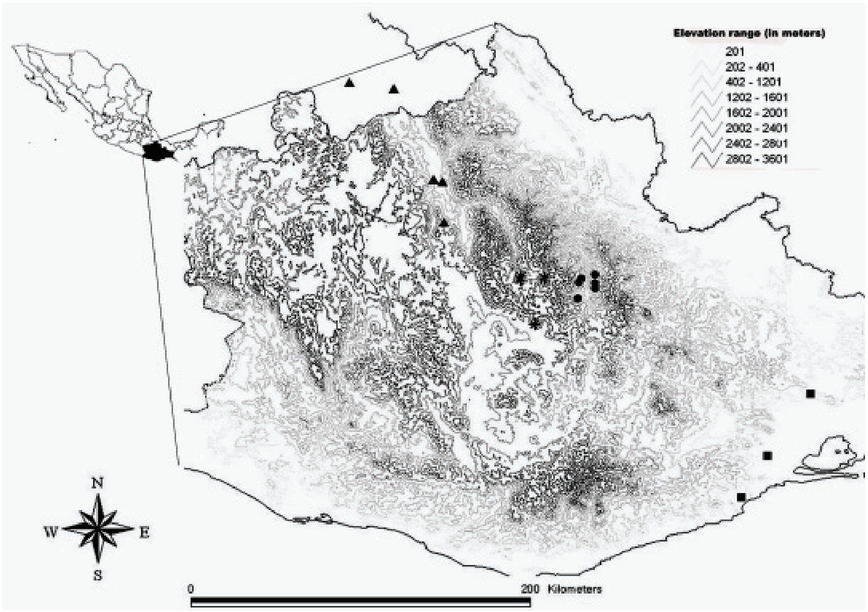


Figure 16. Known distribution of *Centruroides baergi* (triangles, northern Oaxaca and southern Puebla), *C. nigrovariatus* (asterisks, central valleys of Oaxaca), *C. hoffmanni* (squares, Isthmus of Tehuantepec), and *C. serrano* sp. nov. (circles, Sierra Juárez). Elevation ranges in meters. Map base taken from CONABIO (Available at:http://www.conabio.gob.mx/metacarto/metadatos.pl).

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Appendix 1. Morphometric measurements of males and females of *C. serrano, C. baergi*, *C. nigrovariatus*, and *C. hoffmanni*.

Males	*C. serrano*		*C. baergi*		*C. nigrovariatus*		*C. hoffmanni*	
	Mean	± STD	Mean	± STD	Mean	± STD	Mean	± STD
Carapace length	5.55	0.34	5.02	0.43	4.38	0.13	4.44	0.84
Mesosoma length	15.43	1.07	13.30	2.59	12.90	0.84	13.34	2.18
Vesicle width	2.35	0.18	1.91	0.23	1.80	0.07	1.87	0.26
Metasomal segment V length	7.93	0.44	7.79	0.79	5.98	0.23	6.59	1.31
Metasomal segment V width	3.42	0.16	2.27	0.28	2.22	0.16	2.22	0.27
Metasomal segment V depth	2.86	0.09	2.45	0.24	2.16	0.13	1.99	0.20
Total length	57.73	2.20	54.76	6.18	44.46	1.64	46.84	8.28
Carapace length / Metasomal segment V length	0.70	0.03	0.65	0.01	0.73	0.01	0.67	0.07
Carapace length / Pedipalp movable finger length	0.81	0.03	0.82	0.02	0.82	0.04	0.86	0.07
Vesicle length / Aculeus length	1.13	0.33	1.31	0.10	1.16	0.08	1.53	0.26
Pedipalp movable finger length / patella length	1.03	0.06	1.06	0.02	1.01	0.06	1.03	0.07
Patella length / Metasomal segment V depth	2.33	0.04	2.36	0.05	2.45	0.15	2.50	0.21

Appendix 1. Continues

Females	*Centruroides serrano* sp. nov.		*Centruroides baergi*		*Centruroides nigrovariatus*		*Centruroides hoffmanni*	
	Mean	± STD	Mean	± STD	Mean	± STD	Mean	± STD
Carapace length	5.79	0.40	5.28	0.76	4.44	0.43	4.59	0.33
Mesosoma length	17.66	0.98	15.86	2.09	13.99	1.53	13.57	2.74
Vesicle width	2.19	0.47	1.79	0.38	1.68	0.13	1.72	0.21
Metasomal segment V length	6.68	0.53	6.36	0.99	4.81	0.59	5.43	0.46
Metasomal segment V width	3.32	0.28	2.22	0.38	2.19	0.22	2.29	0.17
Metasomal segment V depth	2.72	0.15	2.40	0.38	1.97	0.26	2.11	0.36
Total length	54.54	2.88	49.61	6.29	40.66	4.34	42.54	4.61
Carapace length / Metasomal segment V length	0.87	0.03	0.83	0.05	0.92	0.03	0.84	0.06
Carapace length / Pedipalp movable finger length	0.82	0.03	0.82	0.05	0.83	0.03	0.83	0.05
Vesicle length / Aculeus length	1.02	0.11	1.00	0.06	0.94	0.22	1.17	0.09
Pedipalp movable finger length / patella length	1.14	0.04	1.16	0.01	1.11	0.05	1.15	0.06
Patella length / Metasomal segment V depth	2.28	0.12	2.32	0.17	2.46	0.22	2.30	0.35