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Redescription of *Diplocentrus zacatecanus* (Scorpiones: Diplocentridae) and limitations of the hemispermatophore as a diagnostic trait for genus *Diplocentrus*

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Abstract. The scorpion *Diplocentrus zacatecanus* Hoffmann (1931) was originally described as a subspecies of *Diplocentrus keyserlingi* Karsch 1880 on the basis of six syntypes and was later elevated to species level. We designate a male lectotype and redescribe the species, including illustrations of the hemispermatophore of a male collected near the type locality. In this genus, the hemispermatophore is poorly sclerotized and lacks elaborate capsular structures, which are taxonomically useful in other genera. We review the variability in the hemispermatophores of males from one population, including five comparisons of the right and left hemispermatophores of the same males. Our results showed asymmetry in the length of the right and left hemispermatophores of the same individual. We also observed the presence of "crenulations" or "spines" in two different hemispermatophores (not complementary ones). We conclude that caution should be used when describing the hemispermatophore of only one male and considering it as diagnostic for the species, because of the high levels of intraspecific variation.

Keywords: Diagnostic character, hemispermatophore, lectotype, taxonomy

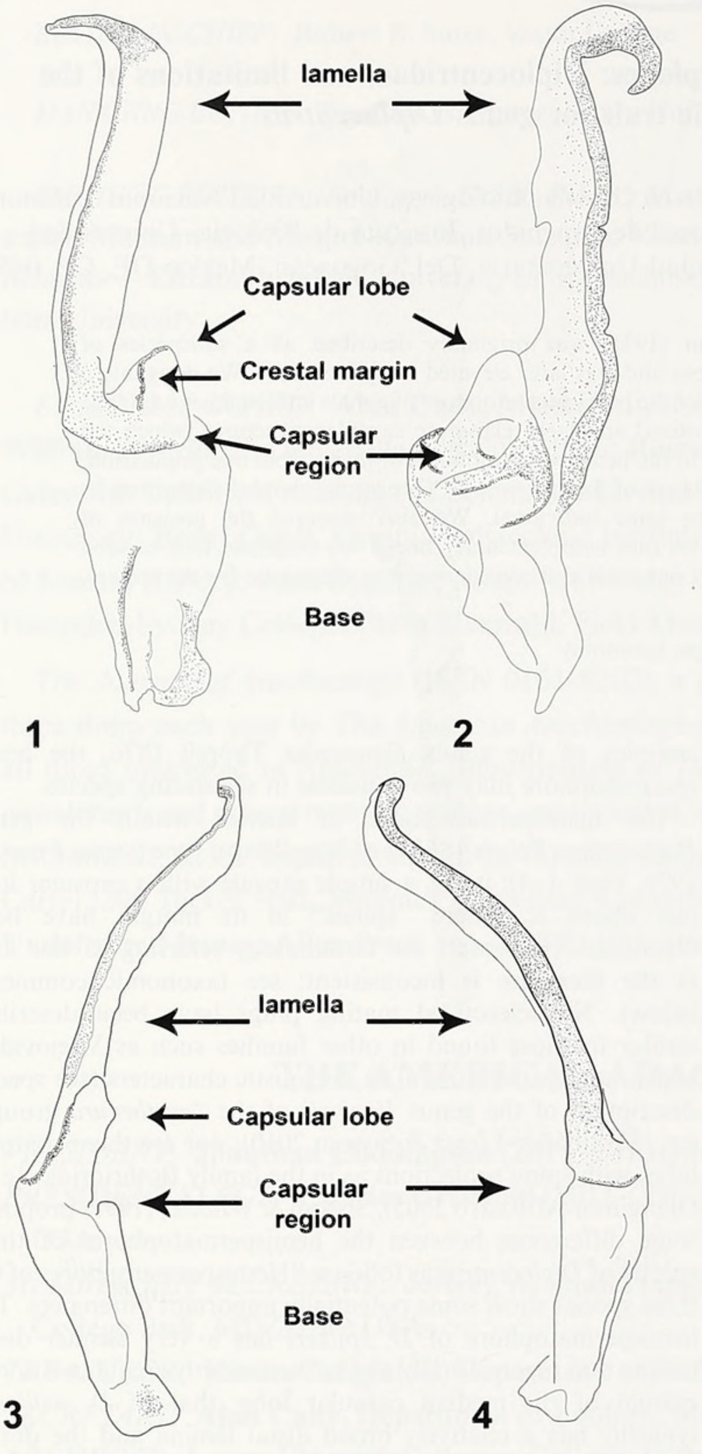
Hoffmann (1931) described three subspecies of *Diplocentrus keyserlingii* Karsch 1880 from Mexico. The nominate subspecies, *D. keyserlingii keyserlingii* Karsch 1880, was originally described from Oaxaca, but Hoffmann (1931) erroneously assigned specimens from Hidalgo to this taxon. The second subspecies, *D. keyserlingii tehuacanus* Hoffman 1931, was described from Tehuacan, Puebla, and the third, *D. keyserlingii zacatecanus* Hoffman 1931, was described based on six specimens from Tepezala, Aguascalientes.

Francke (1977) elevated *D. keyserlingii tehuacanus* to species level and redescribed it based on the holotype. Stahnke (1981) redescribed *D. keyserlingii* and designated a lectotype from Oaxaca. Sissom & Walker (1992) utilized *D. zacatecanus* as a specific epithet but provided no formal nomenclatural or taxonomic indication to justify the change of status. Subsequently, Sissom (1994) formally elevated *D. zacatecanus* to species level based on a comparison with *D. keyserlingii*. Most recently, Ponce *et al.* (2009) enlarged the known geographic distribution of *D. zacatecanus* to include the states of Aguascalientes, Durango, Guanajuato, Hidalgo, Mexico, Michoacan, Queretaro, San Luis Potosi and Zacatecas. However, researchers have undertaken no other taxonomic work on the species. In the present contribution, *D. zacatecanus* is redescribed based on a male lectotype designated herein.

In scorpions, various structures of the hemispermatophore have been used as species-specific diagnostic characters in several genera from different families (e.g., Vachon 1952; San Martín 1963; Koch 1977; Lamoral 1979; Stockwell 1989; Maury 1980; Sissom 1991, 1994a; Williams & Savary 1991; Acosta & Ochoa 2001; Soleglad & Sissom 2001; Ojanguren-Affilastro 2005; Ojanguren-Affilastro & Ramirez 2009; Peretti 2003, 2010; Ochoa & Prendini 2010; Prendini 2006; Prendini & Esposito 2010; Prendini et al. 2006; Francke & Ponce-Saavedra 2010; Santibáñez-López & Francke 2010; Botero-Trujillo & Flórez 2011; Mattoni et al. 2012). However, in other cases, as reported by Jacob et al. (2007) in at least one species complex of the genus *Euscorpius* Thorell 1876, the hemispermatophore may prove useless in separating species.

The hemispermatophore of species within the genus *Diplocentrus* Peters 1861 is of lamelliform type (sensu Francke 1979, Figs. 1–4); it has a simple capsule with a capsular lobe just above it, where "spines" in its margin have been illustrated. (However, the terminology referring to this lobe in the literature is inconsistent: see taxonomic comments below). No sclerotized mating plugs have been described similar to those found in other families such as Vaejovidae, which have proven useful as diagnostic characters (see species description of the genus *Vaejovis* of the "*eusthenura* group," e.g., Santibáñez-López & Sissom 2010); nor are there complex lobes with spiny projections as in the family Bothriuridae (e.g., Ojanguren-Affilastro 2005). Sissom & Wheeler (1995) proposed some differences between the hemispermatophores of three species of *Diplocentrus* as follows: "Hemispermatophores of the three species show some potentially important differences. The hemispermatophore of *D. spitzeri* has a very slender distal lamina that tapers distally and has a distinctly crenulated dorsal margin of the median capsular lobe; that of *D. williamsi* typically has a relatively broad distal lamina and the dorsal margin of the median lobe is weakly crenulated; while that of *D. peloncillensis* bears a very slender distal lamina with a feebly granular dorsal margin on the median lobe." Later, in the "Variation" section of the same work, both authors recognized that a study of hemispermatophore variability is necessary before their full value (or lack thereof) in diplocentrid systematics can be established (Sissom & Wheeler 1995).

The hemispermatophores of at least 17 species of the genus *Diplocentrus* have been described and illustrated (see Stockwell 1988; Sissom 1994; Francke & Ponce-Saavedra 2005; Santibáñez-López & Francke 2008). All reports focused on the presence or lack of "spines", or "crenulations" on the dorsal edge of the capsular lobe. Otherwise no attempt has been made to describe the hemispermatophore in detail and to analyze intraspecific variation. Hence, an additional goal of



Figures 1–4.—Diagrammatic description of the structures present in the hemispermatophores of *Diplocentrus* scorpions. 1. Dorsal view; 2. Ental view; 3, 4. Lateral views. The dorsal margin of the crest on the capsular lobe is the most sclerotized part of the hemispermatophore and it can be crenulated, smooth, or serrated (variation is found, see Figure 12 and text).

this study was to analyze the hemispermatophore morphology of *D. zacatecanus* in order to establish its usefulness as a diagnostic character for the species. We also aimed to explore additional potential taxonomic characters in the genus.

METHODS

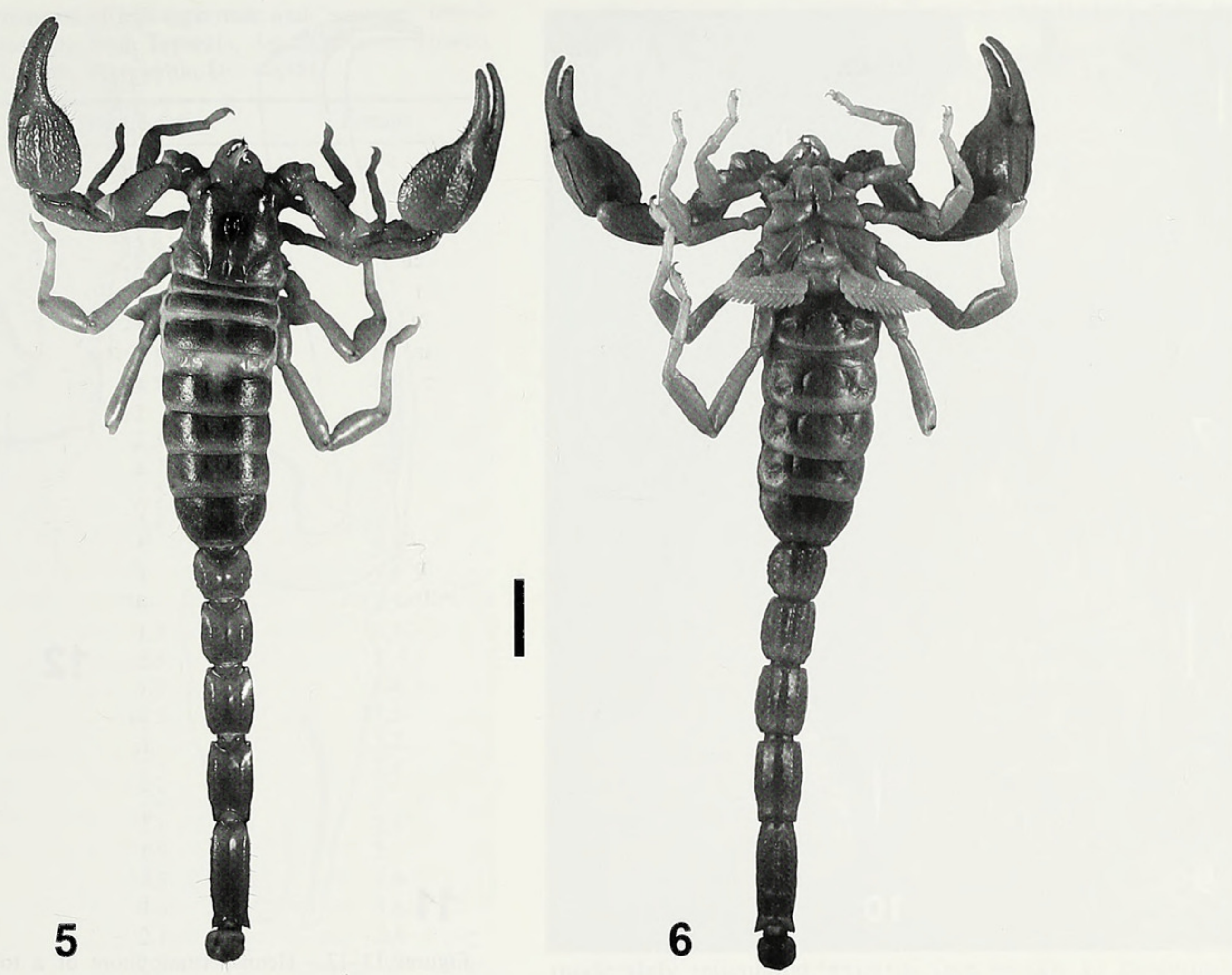
Taxonomy.—Nomenclature and mensuration follow Stahnke (1970), except for trichobothrial terminology after Vachon (1974), and metasomal and pedipalpal carinal terminology after Francke (1977). Surfaces of the pedipalp, carapace, mesosoma, and metasoma were observed under UV light, as in Santibáñez-López & Sissom (2010). Higher-level taxonomy of scorpions follows Coddington et al. (2004) and Prendini & Wheeler (2005). Photography of the female and male carapace, pedipalp femur, patella, and chela under ultraviolet light is according to Prendini (2003) and Volschenk (2005).

Specimens.—The species was redescribed from a lectotype chosen from the syntype series deposited at Universidad Nacional Autonoma de Mexico. Intraspecific variation on pectinal tooth counts and on telotarsal spiniform setae was analyzed on five adult males and five adult female topotypes, along with 15 adult males and one adult female from a different population. Other specimens studied listed below were deposited at the Colección Nacional de Arácnidos, Instituto de Biología, UNAM (CNAN), and at the American Museum of Natural History (AMNH).

Hemispermatophore study.—A series of 45 adult males was collected 1 km SE of Nuevo Alamos, Queretaro, in May 2010. The males were found at night with ultraviolet lights, roaming on the surface in search of females (one couple was found engaged in the courtship dance), and thus all the adult males were judged to be ready for mating and with fully-formed hemispermatophores. The hemispermatophores of ten males from that sample were analyzed as indicated below. Dissections followed Vachon (1952) and Sissom et al. (1990). Three different procedures were followed to clean hemispermatophores: a) manual cleaning, b) immersion in clove oil and c) digestion of the soft tissues of the paraxial organ in pancreatin (as in Álvarez & Hormiga 2007). If manual cleaning is conducted appropriately and carefully, it can be effective. However, if not done properly, manual cleaning can destroy potential structures due to the poor sclerotization of this structure (as it has been described in Francke & Ponce-Saavedra 2005; Santibáñez-López & Francke 2008; Santibáñez-López et al. 2011). Immersion in clove oil reveals the borders of the structures of the hemispermatophore without destroying the surrounding tissues (i.e., the paraxial organ, where the hemispermatophore is formed); however, clove oil hardens those tissues and photographic results are poor. Finally, pancreatin digests soft tissues without causing any apparent damage to sclerotized structures (Álvarez-Padilla & Hormiga 2007); for this reason, it was the preferred method.

Hemispermatophore terminology follows mainly San Martín (1963). We took photographs of the hemispermatophores at the UNIBIO laboratory of photography, at the Instituto de Biologia, UNAM, with a Leica DFC490 camera attached to a Leica Z16 APO-A microscope, and layers were processed with the Leica Application suite program. We took measurements, given in millimeters, with an ocular micrometer calibrated at 10×.

Intraspecific variation: In order to observe intraspecific variation in this structure and to analyze potential diagnostic characters in the same, first we dissected five males and extracted the two hemispermatophores in order to analyze bilateral symmetry or the lack thereof. Secondly, another five males were dissected, but only one hemispermatophore was extracted from each (three right and two left) in order to obtain a larger sample for the comparative analysis. We took



Figures 5–6.—Habitus of the lectotype male of *Diplocentrus zacatecanus* Hoffmann 1931. 5. Dorsal; 6. Ventral.

measurements as follows: Total length (base length plus lamella length), lamella length (from the tip to the capsular region), base length, capsular region width and median lobe depth. The mean, standard deviation and coefficient of variation were calculated for all the structures measured.

Interspecific variation: We selected measurements of six species of *Diplocentrus* from the literature to compare against those from *D. zacatecanus* to observe potential diagnostic characters.

SYSTEMATICS

Family Diplocentridae Karsch 1880
Genus *Diplocentrus* Peters 1861
Diplocentrus zacatecanus Hoffmann 1931
(Figs. 5–10)

Diplocentrus keyserlingii zacatecanus Hoffmann 1931:317–319; Guijosa 1973:145, 150; Francke 1975:116; Vasquez & Zaragoza 1979:583.

Diplocentrus zacatenus (*lapsus calami*): Sissom 1986:256.

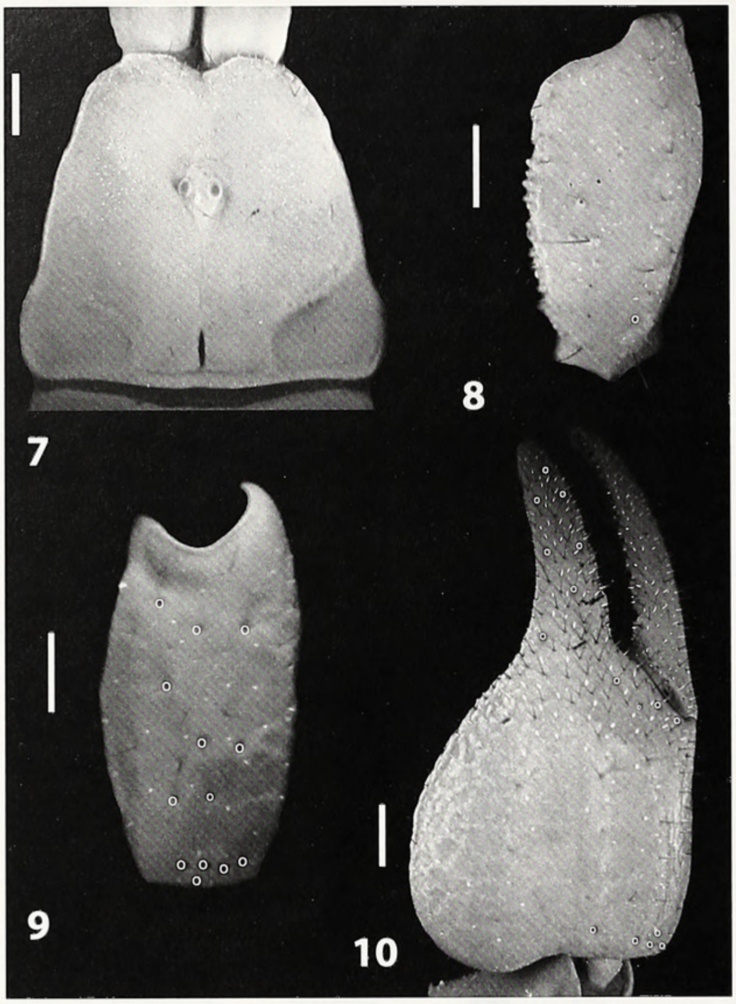
Diplocentrus zacatecanus: Sissom & Walker 1992:130; Sissom 1994b:265; Kovarik 1998:131; Sissom & Fet 2000:344; Kamenz & Prendini 2008:11, 42; Ponce et al. 2009:57–60; Contreras-Félix & Santibáñez-López 2011:62–63.

Diplocentrus keyserlingi (sic) f. *zacatecanus*: Beutelspacher 2000:29.

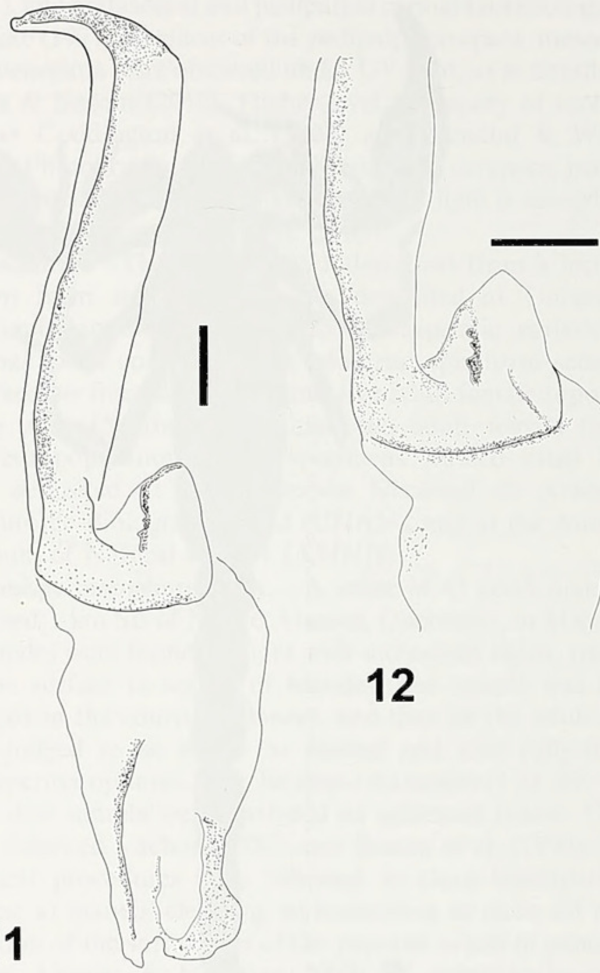
Type specimens.—Lectotype male, MEXICO: *Aguascalientes*: Tepezala (22°13.362′N, 102°10.014′W, 2100 m.), no date, no collector provided (CNAN-T0761). Paralectotypes: 2 males and 1 female (CNAN-T0762), collected with lectotype.

Other material examined.—MEXICO: *Aguascalientes*: Tepezala 1 km N (22°14.348′N, 102°10.467′W, 2048 m), 4 July 2005, O. Francke, J. Ponce-Saavedra, M. Córdova, A. Jaimes, G. Francke and V. Capovilla, 4 males (CNAN-S03075), 2 males (AMNH). *Zacatecas*: Road Sombrerete-Durango, km 179 (23°40.798′N, 103°41.712′W, 2448 m), 9 August 2005, O. Francke, W.D. Sissom, C. Lee, K. McWest, L. Jarvis, C: Dúran, H. Montaño and A. Ballesteros, 3 females (CNAN), 3 females (AMNH).

Diagnosis.—Adults 50 to 60 mm long. Orange brown to reddish brown. Carapacial anterior margin weakly granulose, median notch shallow, V-shaped. Pedipalp femur wider than deep, dorsal surface flat to slightly convex at the middle portion, sparsely granulose medially. On adult males, pedipalp patella dorsal external carina weak, smooth; ventral submedian carina faint; chela digital carina moderate, smooth; dorsal surface moderately reticulate. On females, pedipalp carination weaker and smoother. Basitarsi III and IV without prolateral and retrolateral subterminal spiniform setae. Telotarsal formula: 5/6: 5/6: 6/7: 6/7. Pectinal tooth count on males 12–17 (mode = 13); on females 11–13 (mode = 11–12) as reported by Ponce et al. (2009) from a sample of 71 males and 41 females.



Figures 7–10.—*Diplocentrus zacatecanus* lectotype male photographed under UV light. 7. Carapace dorsal view; 8. Femur, dorsal view; 9. Patella, external view; 10. Chela, dorsoexternal view. Scale bars = 1 mm. White circles highlight trichobothrial positions.



Figures 11–12.—Hemispermatophore of a topotype male of *D. zacatecanus*. 11. Dorsal view; 12. Detail of the capsular region, showing crenulated crest on capsular lobe. Scale bars = 0.5 mm.

Diplocentrus zacatecanus is similar to *D. tehuacanus* in size. The median notch on the anterior margin of the carapace is V-shaped in both species; the femur is wider than it is deep, and both species share similar pectinal tooth counts. However, *D. tehuacanus* has a lower modal telotarsal formula at 4/5:5/5–6:6/6:6/6; on adult males, the pedipalp patella dorsal external carina is obsolete on *D. tehuacanus*, whereas on *D. zacatecanus* it is weak and smooth; on males the chela is rounded in *D. zacatecanus*, whereas on males of *D. tehuacanus* it is slender.

Diplocentrus zacatecanus also resembles *Diplocentrus gertschi* Sissom & Walker 1992 from Nayarit. Both species share a pedipalp femur wider than deep and a similar telotarsal formula. However, *D. zacatecanus* can be clearly distinguished from *D. gertschi* by the punctations on the pedipalps (not present on *D. zacatecanus*). *D. gertschi* adults are colored dark brown, whereas adults of *D. zacatecanus* are reddish brown to orange brown. *D. zacatecanus* is close geographically to *Diplocentrus whitei* (Gervais 1844), sharing similar pedipalp femur proportions (wider than deep). It differs from *D. whitei* by its lighter body coloration (adult *D. whitei* are dark blackish-brown); a higher telotarsal formula in the last two legs in *D. whitei* at 7/8:7/8; by contrast, in *D. zacatecanus* it is 6/7:6/7; and higher pectinal tooth counts are found on males (18–20) and females (14–16), whereas in *D. zacatecanus*, they are 11–17 on males and 11–13 on females.

Description of male lectotype.—*Coloration:* Carapace light brown to pale yellow (old specimen in alcohol), venter pale orange to brown. Pedipalps orange to reddish brown, carinae darker. Mesosoma brown to medium yellow, venter pale brown. Metasoma light brown to orange. Telson orange to reddish brown, uniformly infuscated. Legs pale brown to pale yellow, uniformly infuscated.

Prosoma: Anterior margin "V" shaped, notch shallow, sparsely setose, weakly granulose (Fig. 7). Three pairs of lateral eyes, subequal in size. Carapacial surface shagreened to minutely granulated towards the lateral surfaces.

Mesosoma: Tergites I–VI granulose towards the sides, shagreened at the middle portion. Tergite VII surface shagreened to weakly granulose toward the sides. Sternites III–VI weakly and faintly punctated. Sternite VII with submedian and lateral carinae weak to moderate, crenulated to slightly granulated. Pectinal tooth count: 13–14.

Metasoma: Ventral submedian carinae: on I–II moderate to strong, granulated; on III weak to moderate, granulated; on IV weak to faint, smooth. Ventral lateral carinae: on I–II moderate to strong, crenulated to slightly granulated; on III weak to moderate, crenulated; on IV weak to faint, smooth. Lateral inframedian carinae: on I strong, with large conical granules; on II moderate, granulated; on III weak to faint, smooth; on IV

Table 1.—Measurements of lectotype male and "syntype" female of *Diplocentrus zacatecanus* from Tepezala, Aguascalientes, México. Abbreviations: L= Length, W= width, D= depth.

	Male Lectotype	Female
Total L	42.3	41.4
Carapace L	5.4	5.4
Carapace W	3.4	3.6
Mesosoma L	13.9	13.9
Pedipalp L	17.7	16.6
Femur L	4.3	4
W	1.9	1.8
D	1.5	1.5
Patella L	4.7	4.5
W	2	2
D	2.3	2.2
Chela L	8.7	8.1
W	2.7	3
D	4.8	4.5
Movable finger L	5	5.5
Fixed finger L	4	3.5
Chelicera L	4	3.5
W	1.3	1.3
Movable finger L	2.5	2
Fixed finger L	1.7	1.4
Metasoma L	18.5	17.5
Segment IV L	4	3.7
W	2.5	2.4
Segment V L	5.2	5
W	2.1	2.1
D	1.7	2
Telson L	4.5	4.6
Vesicle L	3.6	3.8
W	2.1	2.4
D	1.7	1.9

faint to obsolete. Lateral supramedian carinae on I–III weak to moderate, crenulated; on IV weak, smooth. Dorsal lateral carinae: on I–II weak, smooth with one or two granules distally; on III–IV weak to moderate, smooth. Segment V 1.2 times longer than pedipalp femur: ventral median carina strong, granulated, with large subconical granules; ventral transverse carina strong, formed by four large subconical granules; ventral lateral carinae strong, granulated with large subconical granules; lateral inframedian carinae faint to obsolete, smooth; dorsal lateral carinae faint to obsolete, smooth. Intercarinal spaces: ventrally on segments I–V smooth; dorsally on segments I–II shagreened, on III–V smooth; laterally on segments I–V smooth; however, on segment V weak punctuation may be appreciate under UV light only.

Telson: Smooth, with granules basally; subaculear tubercle strong, subconical. Vesicle width /length ratio 0.58.

Pedipalp: Orthobothriotaxy type "C"; pattern typical for the genus. Femur wider than deep (Fig. 8). Dorsal internal carina strong, granular. Dorsal external carina weak to moderate, basally granular and smooth, fading out distally. Ventral internal carina moderate, granulose, fading distally. Ventral external carina faint to obsolete. Dorsal face flat to slightly convex medially, central area sparsely granulose with small granules. Ventral face flat, smooth. Internal face densely granulose, with large strong granules.

Patella: (Fig. 9). Dorsal internal carina weak to obsolete, basal tubercle moderately strong, bifurcated. Dorsal median carina strong, smooth. Dorsal external carina weak, smooth. External carina weak, smooth. Ventral external carina faint to obsolete. Ventral median carina faint. Ventral internal carina weak, granular. Dorsal, external and ventral faces smooth. Internal face minutely granular.

Chela: (Fig. 10). Dorsal margin of manus moderately carinated, strongly granular. Digital carina moderate, smooth. Dorsal secondary carina and external secondary carina weak to moderate, smooth. Ventral external carina originating at external condyle of movable finger articulation, converging towards ventral median carina and fading distally, weak, smooth. Ventral median carina strong, smooth to slightly crenulated. Ventral internal carina weak to obsolete, smooth. Three internal carinae originating at the middle portion of chela, all forming a shallow longitudinal depression where chela flexes against patella, weak, smooth. Dorsal face moderately reticulated, external face weakly to moderately reticulated. Fixed finger base: dorsal face smooth, with dense setation, external face flat, internal face feebly concave. Fingers curved.

Legs: Prolateral faces of femora and tibiae smooth. Basitarsi III and IV without prolateral subterminal, retrolateral subterminal and ventral median spiniform setae (Santibañez-Lopéz et al. unpubl. data). Telotarsal spiniform setae formula: 5/6 5/6: 5/6 5/6: 6/7 6/7: 6/7 6/7.

Hemispermatophore: (Extracted from a male collected in 2005; see above) (Figs. 11, 12), 5.5 mm total length; lamellate, weakly sclerotized, lamella 3.3 mm long. Capsular region 1.5 mm wide. Capsular lobe narrow, smooth; no other structures present.

Table 2.—Measurements (mm) of the hemispermatophores of *D. zacatecanus*. Male identifications are given in code. Abbreviations L = length, W = width, D = depth, X = average, STD = standard deviation, CV = coefficient of variation.

Specimen	number	459	450	451	468	469	453	467	456	455	464	X	STD	CV (%)
Right	Hemispermatophore L	4.5	4	4	3.8	4.3	4.8	4.5	-	-	-	4.27	0.35	8.30
	Lamella L	3	3.1	2.8	2.5	2.8	3.1	2.7	-	-	-	2.86	0.22	7.79
	Capsular W	0.9	1	1.2	1.1	0.9	1	0.9	-	-	-	1.00	0.12	11.55
	Median lobe D	0.9	0.9	0.8	1	0.8	0.9	0.8	-	-	-	0.88	0.07	8.13
	Base	1.5	1.3	1.2	1.3	1.5	1.7	1.8	-	-	-	1.47	0.22	15.05
Left	Hemispermatophore L	5.4	4.2	4.1	3.9	4.2	-	-	4.4	5.1	4.3	4.45	0.52	11.71
	Lamella L	3.1	2.5	3.1	2.5	2.8	-	-	3	3.6	2.7	2.91	0.37	12.64
	Capsular W	0.9	0.9	1.1	1.3	1	-	-	1	0.7	1	0.98	0.17	17.64
	Median lobe D	0.8	0.8	0.8	0.8	0.8	-	-	0.7	0.9	0.9	0.81	0.08	10.28
	Base	2.3	1.7	1	1.4	1.4	-	-	1.4	1.5	1.6	1.54	0.37	24.07

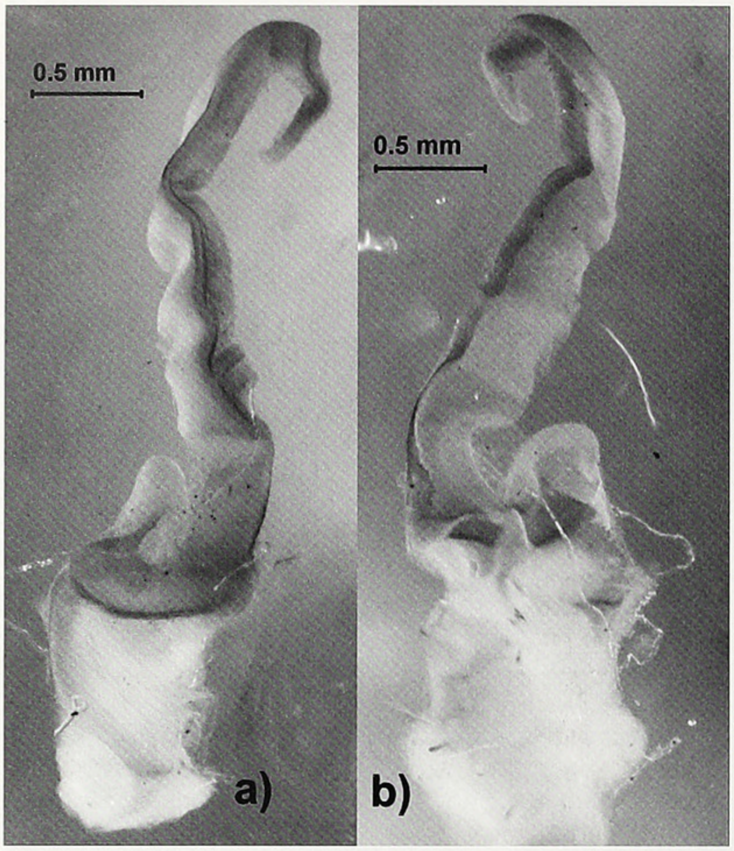


Figure 13.—Right hemispermatophore of male 451. a. Dorsal view; b. Ental view.

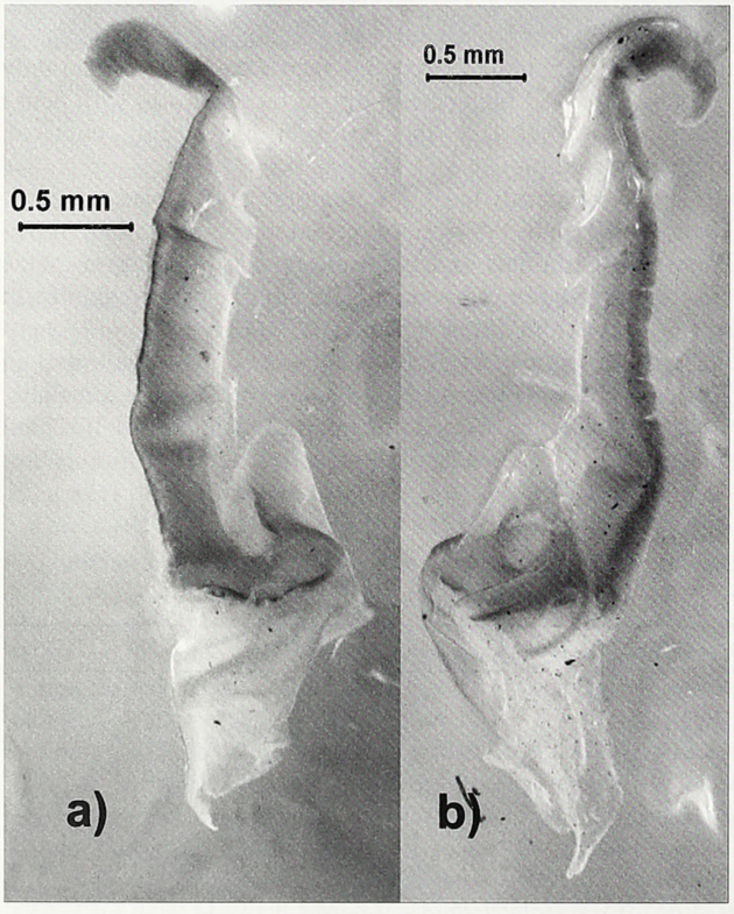


Figure 14.—Left hemispermatophore of male 451. a. Dorsal view; b. Ental view.

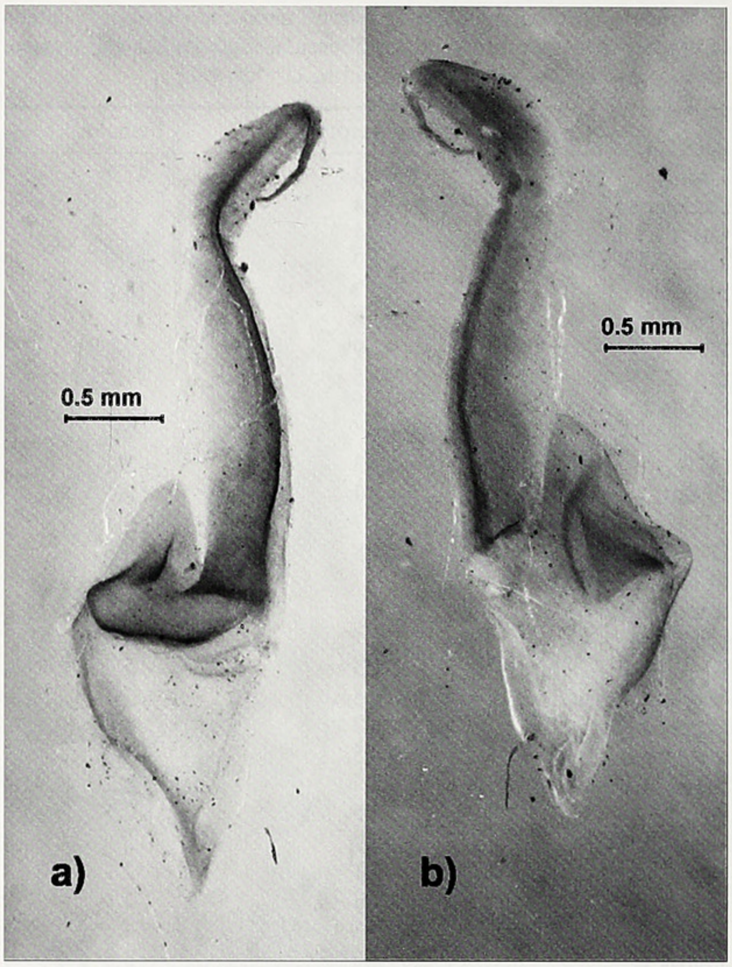


Figure 15.—Right hemispermatophore of male 469. a. Dorsal view; b. Ental view.

Variation (see also Ponce-Saavedra et al., 2009).—*Diplocentrus zacatecanus* exhibits reduced sexual dimorphism compared to other species in the genus. Female differs from the male in some measurements (Table 1) and as follows:

Mesosoma: tergites darker than on male. Pectinal tooth count lower: 11–13.
Metasoma: Carination moderately developed. Telson vesicle width/ ratio: 0.63.
Pedipalp: Chela rounder than on male, digital carina weak, smooth. Dorsal and external faces reticulated, but ridges are weaker than on male.

Pectinal tooth count on males (n = 30): 1 comb with 11 teeth (broken), 10 combs with 12, 3 combs with 13, 7 combs with 14, 6 combs with 15, 2 combs with 16 and 1 comb with 17 teeth. On females (n = 12): 4 combs with 11 teeth, 5 combs with 12 and 3 combs with 13 teeth. The typical telotarsal spiniform setae formula is: 5/6: 5/6: 6/7: 6/7. Telotarsal spiniform setal counts (n = 42):

Leg I prolateral: 1 tarsus with 4 setae, 38 tarsi with 5 and 3 tarsi with 6 setae.
retrolateral: 2 tarsi with 5 setae, 33 tarsi with 6 and 7 tarsi with 7 setae.
Leg II prolateral: 27 tarsi with 5 setae and 15 tarsi with 6 setae.
retrolateral: 24 tarsi with 6 setae and 18 tarsi with 7 setae.

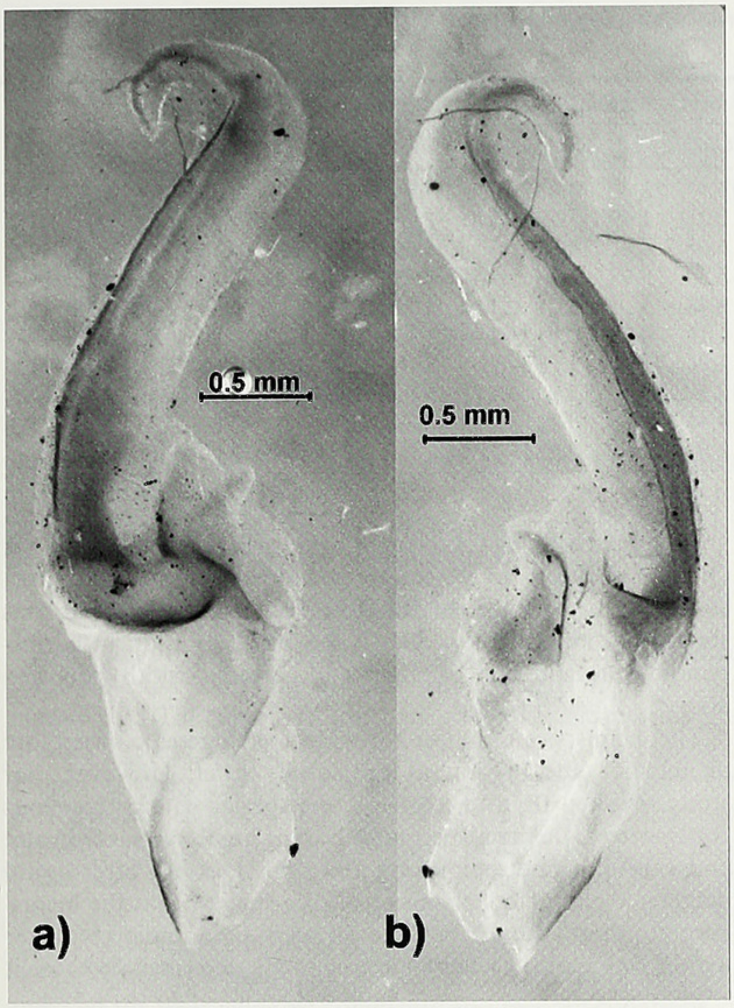


Figure 16.—Left hemispermatophore of male 469. a. Dorsal view; b. Ental view.

Leg III prolateral: 3 tarsi with 5 setae, 32 tarsi with 6 and 7 tarsi with 7 setae.
retrolateral: 7 tarsi with 6 setae, 33 tarsi with 7 and 2 tarsi with 8 setae.
Leg IV prolateral: 35 tarsi with 6 and 6 tarsi with 7 setae.
retrolateral: 2 tarsi with 6; 30 tarsi with 7 and 2 tarsi with 8 setae.

Distribution.—Aguascalientes, Estado de Mexico, Durango, Guanajuato, Hidalgo, Michoacan, Queretaro, San Luis Potosi and Zacatecas (see Ponce-Saavedra et al. 2009).

Analysis of the hemispermatophore in *Diplocentrus zacatecanus*.—*Intraspecific variation:* Measurements of the 15 dissected hemispermatophores showed differences in the total length of the hemispermatophore (Table 2). We found that these differences resulted from the length of the base and not the length of the lamella, because the coefficient of variation in the former is almost twice as large as in the latter (Table 2). The base of the hemispermatophore is often damaged during extraction.

Asymmetry between the right and left hemispermatophores of the five completely dissected specimens is shown in the first five columns of Table 2: all measures of the right hemispermatophore were less variable than the left one. On average, the right hemispermatophore is shorter than the left; however, this could be the result of poor preservation or damage of the

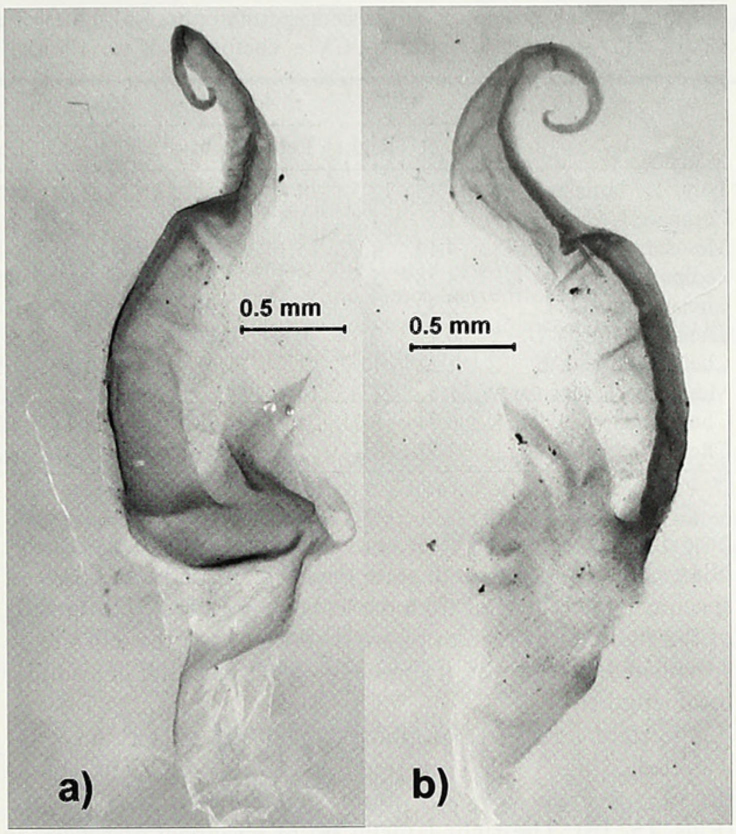


Figure 17.—Right hemispermatophore of male 464. a. Dorsal view; b. Ental view.

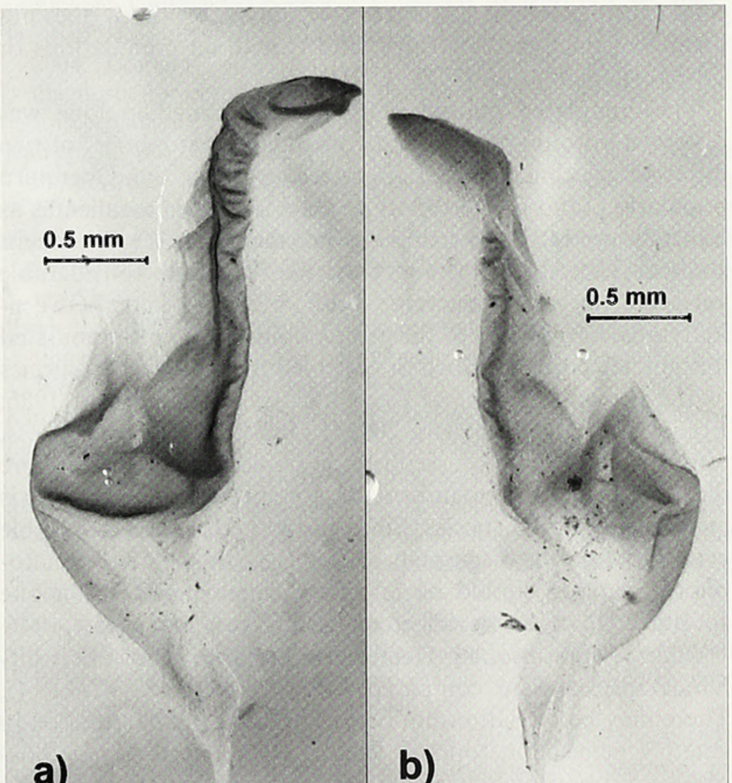


Figure 18.—Left hemispermatophore of male 464. a. Dorsal view; b. Ental view.

Table 3.—Selected ratios of the hemispermatophore of males of *D. zacatecanus*. Abbreviations L = length, W = width, D = depth. X = media, STD = standard deviation, CV = coefficient of variation.

	450		464		451		468		469									
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	453	467	456	455	459	X	± STD	CV %
Total L / lamella L	11.1	13.3	14	13.5	12.4	13.7	16.5	16.5	13.4	13.4	13.4	16.9	13.6	11.8	12.6	13.7	1.7	12.4
Carapace L / lamella L	1.5	1.8	1.85	1.79	1.65	1.82	2.2	2.2	1.79	1.79	1.81	2.25	1.81	1.7	1.74	1.85	0.21	11.4
Mesosoma L/lamella L	4.14	4.97	5.19	5	4.45	4.93	6.08	6.08	4.82	4.82	5	6.29	5.37	4	4.48	5.04	0.68	13.5
Pedipalp L/lamella L	4.58	5.5	5.7	5.5	5.32	5.89	6.84	6.84	5.93	5.93	5.45	7.13	5.56	5.27	5.45	5.79	0.68	11.7
Chela L/lamella L	2.33	2.8	2.89	2.79	2.77	3.07	3.48	3.48	3	3	2.84	3.75	2.89	2.67	2.84	2.97	0.36	12
Chela W/lamella L	0.72	0.87	0.89	0.86	0.9	1	1.16	1.16	0.93	0.93	0.84	1.13	0.93	0.87	0.84	0.93	0.13	13.6
Chela D/lamella L	1.31	1.57	1.74	1.68	1.61	1.79	1.96	1.96	1.68	1.68	1.55	2	1.59	1.5	1.65	1.68	0.19	11.1
Mesosoma L/capsular W	21.3	21.3	14.7	14	12.6	11.5	11.7	13.8	13.5	15	9.12	16.8	8.06	12	15.4	14.1	3.73	26.5
Chela D/capsular W	6.71	6.71	4.95	4.7	4.55	4.17	3.77	4.45	4.7	5.22	2.82	5.33	2.39	4.5	5.67	4.71	1.19	25.3
Chela W/capsular W	3.71	3.71	2.53	2.4	2.55	2.33	2.23	2.64	2.6	2.89	1.53	3	1.39	2.6	2.89	2.6	0.64	24.5

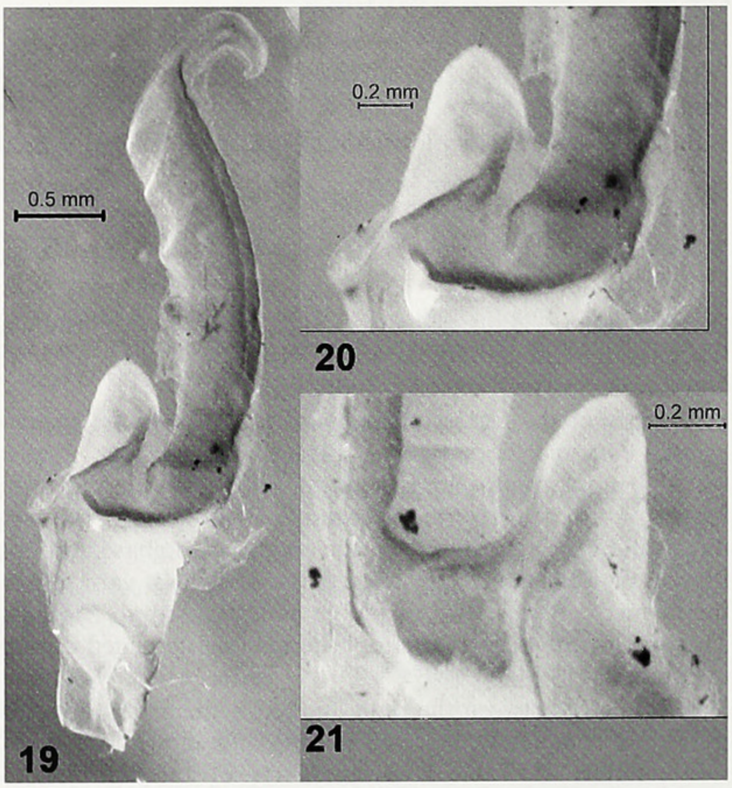
base during extraction. Only one specimen showed considerable bilateral asymmetry in length (right hemispermatophore of specimen 459 is shorter than the left one: Table 2). The lamella of the right hemispermatophore is shorter than the left one on specimen 450; however, its base is shorter, resulting in a similar total length.

The right hemispermatophore lamella tip of specimen 451 was curlier than the left one (see Figs. 13, 14); the right lamella tip of specimen 469 was more slender than the left one (Figs. 15, 16). The right lamella tip of specimen 464 was the curliest of all the hemispermatophores analyzed, whereas the left one was wide and planar (Figs. 17, 18). The chela depth / lamella length ratio (coefficient variation percentage) showed minimum variation, whereas the chela width and capsular region width ratio was more variable (Table 3). No distinct, sclerotized structures were found inside the capsular area; the ectal capsular lobe is distinct and weakly sclerotized, does not form a distinct crest or ridge, and is without crenulations or other ornamentation (Figs. 13–21).

The crenulated margin of crest at the median lobe was observed on only one of the two hemispermatophores of two different specimens of *D. zacatecanus* from the Queretaro population (and in the topotype male from Aguascalientes as well); however, it was missing on the other 13 specimens studied. Therefore, we report for the first time considerable variation in this structure, both bilateral and between-individual asymmetry of the same population. This crenulated margin has been described or observed from at least 10 species in the genus *Diplocentrus* (see Stockwell 1988; Sissom 1986; Francke & Ponce-Saavedra 2005; Francke 2007); nevertheless, most of them were observed on the single hemispermatophore illustrated, and thus no information on intraspecific variation is available for those species. Since this crenulation was variable even in paired hemispermatophores (i.e., the same spermatophore), caution should be taken to examine more than one specimen when it is described or used to compare taxa.

Interspecific variation: Hemispermatophore ratios of six different species were compared to *D. zacatecanus* (Table 4). There may be a relationship between the scorpions' total body length / hemispermatophore length. *Diplocentrus bicolor* possesses a proportionately smaller hemispermatophore compared to its large body, whereas *D. steeleae* has a proportionately larger one compared to its small body. The hemispermatophore of *D. coddingtoni* Stockwell 1988 has a relative wider capsular area compared to its total length, whereas *D. poncei* Francke & Quijano & Ravell 2009 possesses a more slender capsular area compared to its total length. However, all these comparisons should be taken lightly, due to the high variation in corresponding measurements (length and capsular width) reported above in *D. zacatecanus.*

The hemispermatophore provides phylogenetic (therefore diagnostic) information at the family level. However, our study revealed that, at least for one species within the genus *Diplocentrus,* the hemispermatophore is highly variable in size and capsular lobe sculpturing and thus does not offer useful diagnostic characters at this level. We suggest that the hemispermatophore should be ignored as a taxonomic character within *Diplocentrus* when new species are described, because it



Figures 19–21.—Left hemispermatophore of male 459. 19. Dorsal view; 20. Detail of the capsular region, dorsal view; 21. Detail of the capsular region, ental view.

Table 4.—Morphometric ratios of the hemispermatophores of seven species of the genus *Diplocentrus*. All measurements were taken from the literature, except for *D. zacatecanus*, which is from this study.

	Total body length / hemispermatophore length	Hemispermatophore length / capsule width	Capsule width / median lobe depth	Reference
D. coddingtoni	15	2.5	1.5	Stockwell (1988)
D. steeleae	4.17	6	1.43	Stockwell (1988)
D. poncei	7	11.11	1.13	Francke and Quijano-Ravell (2009)
D. churumuco	8.75	5	0.8	Francke and Ponce-Saavedra (2005)
D. bicolor	10.87	5.75	1	Contreras-Félix and Santibáñez-López (2011)
D. tenango	6.23	4.92	1.27	Santibáñez-López and Francke (2008)
D. zacatecanus	16.52	3.45	1.38	This study

lacks significant structures in the capsular region and because it is highly variable. However, additional studies are needed to evaluate the taxonomic value of the hemispermatophore at the generic and subfamilial levels within the Diplocentridae.

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