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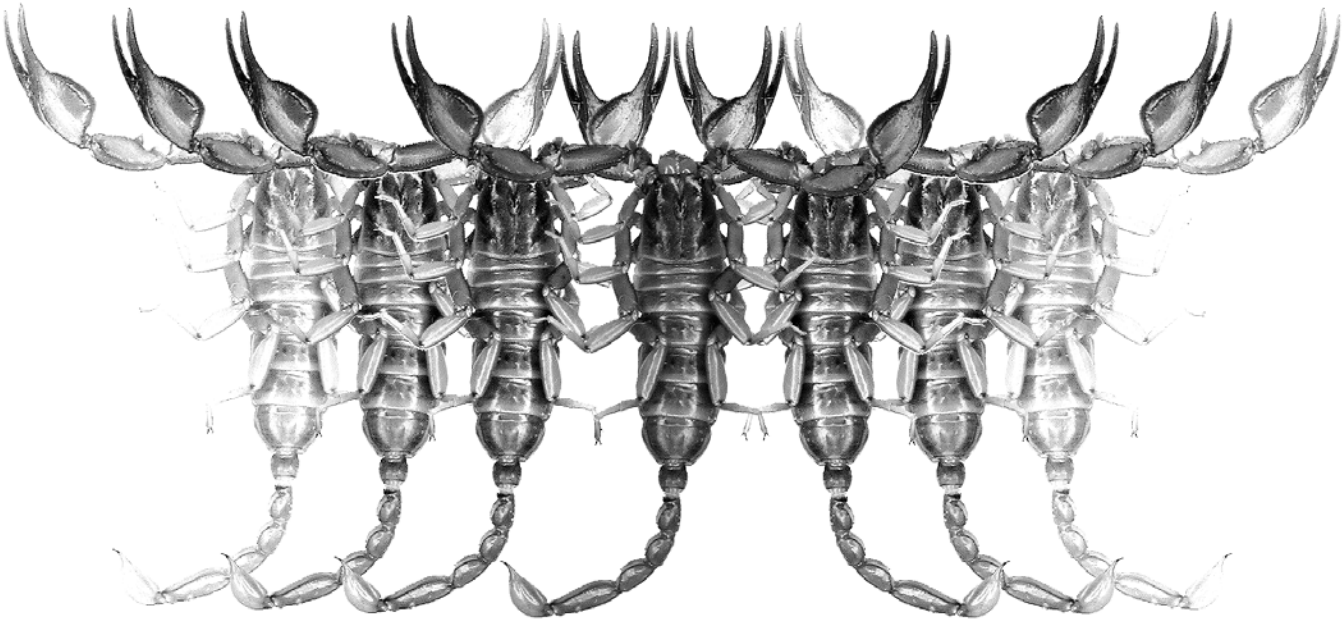

Sky Island *Vaejovis*: A New Species (Scorpiones: Vaejovidae)

Richard F. Ayrey

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Summary

A new scorpion species, *Vaejovis deboerae,* **sp. nov**., is described and placed in the "mexicanus" group of the genus *Vaejovis*. They are small light yellowish brown scorpions found in the Santa Catalina Mountains, one of the sky islands of southern Arizona. They are closely related to *V. vorhiesi* Stahnke. The original description of *V. vorhiesi* Stahnke, 1940 and redescription (Graham, 2007), state that they are found in the Huachuca and Santa Catalina Mountains of southern Arizona. No specimens from the Santa Catalina Mountains were included in the redescription based on the lack of adequate material. The redescription stated "…the Santa Catalina Mountains scorpions definitely warrant further study if specimens become available." This description of a new species is based on ample specimens now being available.

Introduction

The "Sky Island" region of the Madrean Archipelago (located between the northern Sierra Madre Occidental in Mexico and the Colorado Plateau/Rocky Mountains in the Southwestern United States) is an area of exceptional biodiversity and has become an important study area for geoecology, biology, and conservation management (Coblentz, 2005; Graham, 2007). The area is characterized by large areas of low lying desert interspersed with high elevation (1,496-3,267 m a.s.l.) mountain ranges (Masta, 2000).

Isolation of scorpion populations on these high elevation mountain ranges has led to allopatric speciation (Graham, 2007). Upon close examination of several scorpion specimens collected at an elevation of 2,142 m in the Santa Catalina Mountains of southern Arizona, they were found to be a different species than those currently known from the immediate area, in particular, the Huachuca Mountains where *V. vorhiesi* is found. *V. deboerae* is another member of the "*vorhiesi*" subgroup of the "*mexicanus*" group, including species *V. vorhiesi*, *V. cashi* Graham, 2007, *V. feti* Graham, 2007, and *V. paysonensis* Soleglad, 1976 (Graham, 2007; Fet & Soleglad, 2007: 261).

Methods and Materials

Terminology and conventions

The systematics adhered to in this paper is current and therefore follows the classification as established in Fet & Soleglad (2005) and as modified by Soleglad & Fet (2006), Graham & Soleglad (2007), Fet & Soleglad (2007), Soleglad et al. (2007), and Soleglad & Fet (2008). Measurements are as described by Stahnke (1970), trichobothrial patterns are as in Vachon (1974), and pedipalp finger dentition follows Soleglad & Sissom (2001).

Material

Besides type material listed below under new species description, the following additional specimens from the author's collection were examined:

Vaejovis deboerae, **sp. nov.**, 6 ♂, 21 ♀ topotypes, Mt. Lemmon, Santa Catalina Mountains, Pima Co., Arizona.

Vaejovis vorhiesi Stahnke, 1940. 4 ♂, 13 ♀ topotypes, Miller Canyon, Huachuca Mountains, Cochise Co., Arizona.

Systematics

Order **SCORPIONES** C. L. Koch, 1850
Parvorder Iurida Soleglad et Fet, 2003
Superfamily Chactoidea Pocock, 1893
Family Vaejovidae Thorell, 1876
Subfamily Vaejovinae Thorell 1876
"*mexicanus*" group

***Vaejovis deboerae* Ayrey sp. nov.**
Figures 1–15, Table 1

Diagnosis. Small high elevation scorpions of the Santa Catalina Mountains of southern Arizona. This is the lar-

Figure 1: Paratype *Vaejovis deboerae* **sp. nov.** as it appears in life. The photograph was taken on light sand substrate to best show subject.

gest of the southern Arizona sky island scorpions, total length of holotype female 33. Color is light yellowish brown with pedipalps, legs and metasoma lighter yellowish brown. Pectinal tooth counts range 11–13 (18) for female and 14 for male. Subaculear tubercule of telson is well developed. Chelal palm is relatively elongated as compared to the chela and its fingers. Six *ID* denticles are present on the chelal movable finger. The carapace is shorter than the fifth metasomal segment.

Type material. Holotype ♀, Mt. Lemmon, Santa Catalina Mountains of Pima County, Arizona, USA, (32°23'13"N, 110°41'45"W, intersection of Willow Canyon Circle and Catalina Highway), 2,142 m a.sl., 25 August 2008 (leg. R. F. Ayrey) specimen #119 (permanently deposited in the California Academy of Sciences (CAS), San Francisco, California, USA).

Paratypes: Mt. Lemmon, Santa Catalina Mountains of Pima County, Arizona, USA, (same as holotype), 25 August 2008, 1 ♂, specimen #121, 1 ♀, specimen #120 (leg. M. DeBoer-Ayrey); same locality, 25 April 2009, 1 ♀, specimen #181 (leg. R. F. Ayrey) (CAS).

Etymology. This species was named in honor of Melinda DeBoer-Ayrey, for collecting the specimens.

Distribution. Known only from the type locality, Mt. Lemmon of the Santa Catalina Mountains of Pima County, Arizona, USA.

Measurements (in mm). Holotype (female): total length 33.14; carapace length 4.21; mesosoma length 11.17; metasoma length 13.98; Metasoma: segment I length/width 1.82/2.48; segment II length/width 2.14/2.19; segment III length/width 2.39/2.31; segment IV length/width 3.31/2.23; segment V length/width 4.32/1.95. Telson: length 3.78; vesicle length/width/depth 2.51/1.52/1.29; aculeus length 1.29. Pedipalps: total length 13.71; femur length/width 3.29/1.14; patella length/width 4.08/1.32; chela length 6.34; palm length/width/depth 3.09/1.52/1.29; movable finger length 3.84; fixed finger length 3.09.

Paratype (male) #121: total length 25.47; carapace length 2.95; mesosoma length 7.82; metasoma length 11.28; Metasoma: segment I length/width 1.66/1.92; segment II length/width 1.82/1.80; segment III length/width 2.08/1.69; segment IV length/width 2.48/1.73;

	V. deboerae	*V. vorhiesi*	*V. cashi*	*V. feti*
Total Length	31.72 (3)	27.31 *	21.96	22.36
Metasoma L / Carapace L	3.42 (3)	3.25	2.73	2.48
Metasomal Segment I (L/W)	0.73	0.80	0.72	0.69
Metasomal Segment II (L/W)	0.98	0.92	0.83	0.78
Metasomal Segment III (L/W)	1.03	1.02	0.94	0.90
Metasomal Segment IV (L/W)	1.48	1.53	1.36	1.39
Metasomal Segment V (L/W)	2.22	2.23	2.06	1.95
Palm L/Chela L	0.49	0.41	0.43	0.43
Palm L/Palm W	2.03	1.69	1.82	1.68
Palm L/Movable Finger L	0.80	0.65	0.69	0.81
Palm L/Fixed Finger L	1.00	0.79	0.87	0.90
Chela L/W	4.17	4.17	4.29	3.86
Femur L/W	2.89	3.07	3.06	2.90
Patella L/W	3.09	2.82	2.83	-
Fixed Finger L/Carapace L	0.73	0.76	0.71	0.60
Telson W/D	1.18	1.19	1.28	1.32
Carapace L	4.13 (3)	3.36	2.96	3.65
Pectinal Tooth Counts (females)	11.890 (18)	12.389 (18)	11.000 (4)	10.000 (12)
Total L/Pect. Tooth Count	2.67 (3–18)	2.204	1.996	2.236

Table 1: Comparison of morphometric ratios and meristic data of *Vaejovis deboerae* **sp. nov.** with other members of the "*vorhiesi*" subgroup. All ratios calculated using holotype female data unless sample size is noted in parentheses. L = length, W = width, D = depth. * includes the telson.

segment V length/width 3.35/1.62. Telson: length 3.42; vesicle length/width/depth 2.71/1.09/1.02; aculeus length 0.74. Pedipalps: total length 10.08; femur length/ width 2.63/0.91; patella length/width 2.97/1.06; chela length 4.48; palm length/width/depth 2.09/1.12/1.00; movable finger length 2.91; fixed finger length 2.42.

Paratype (female) #120: total length 32.21; carapace length 4.38; mesosoma length 9.14; metasoma length 14.67; Metasoma: segment I length/width 1.95/2.48; segment II length/width 2.19/2.11; segment III length/ width 2.48/2.32; segment IV length/width 3.41/2.13; segment V length/width 4.67/1.92. Telson: length 4.02; vesicle length/width/depth 2.36/1.43/1.11; aculeus length 1.18. Pedipalps: total length 13.84; femur length/ width 3.32/1.21; patella length/width 4.13/1.42; chela length 6.39; palm length/width/depth 2.69/1.41/1.38; movable finger length 4.04; fixed finger length 3.32.

Description. Based on holotype female, see Figures 2–3 for dorsal and ventral views. Table 1 contrasts *V. deboerae* with other "*vorhiesi*" subgroup species from the immediate area.

Color. Light yellowish brown scorpion with some darker mottling on the carapace and tergites. Pedipalps, legs and metasoma are lighter yellowish brown.

Carapace. Anterior margin of carapace moderately emarginated, posterior margin slightly emarginated. Carapace moderately granular. Three lateral eyes on each side. Median furrow moderate and traverses entire length of carapace. Ratio of median eyes location from anterior edge/carapace length 0.35; carapace length/ width at median eyes 1.27. Carapace is shorter than metasomal segment V and longer than pedipalp movable finger**.** See Figure 4.

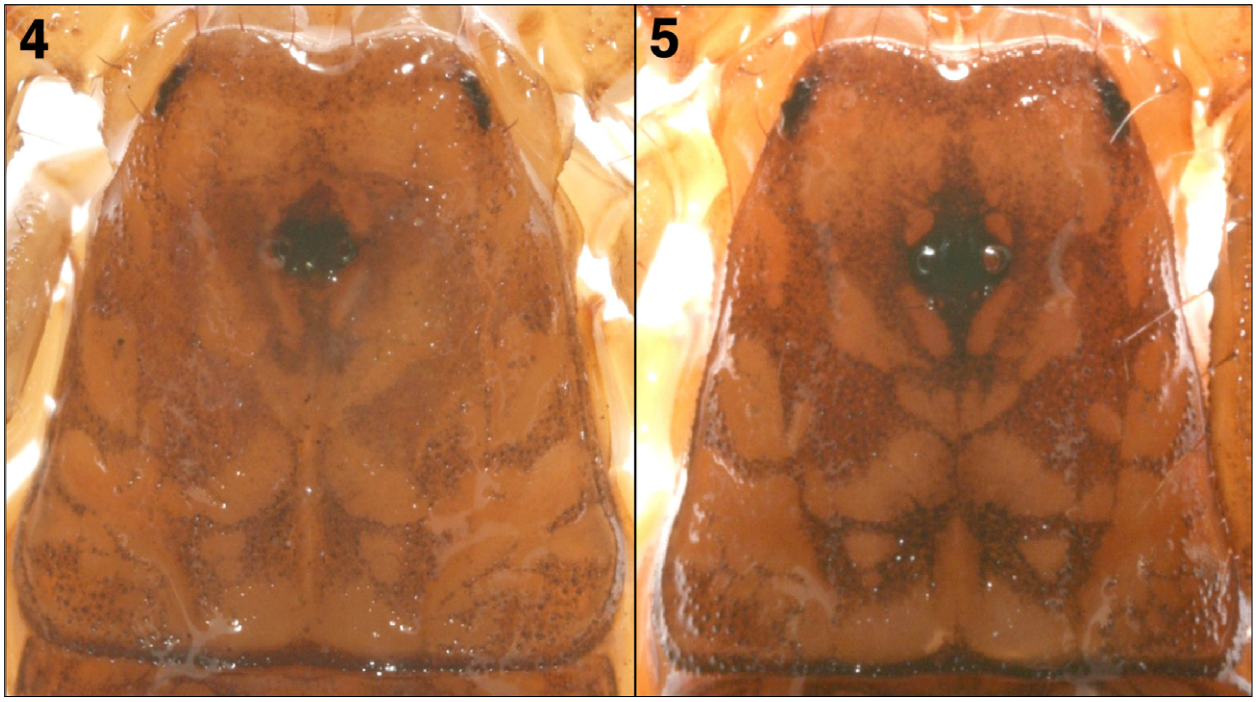
Mesosoma. Tergites coarsely granular with weak median carina on tergites I–VI. Tergite VII with weak median carina on anterior half and strong dorsal lateral and lateral supramedian granular carinae. Sternites III–VI finely granular and without carinae. Sternite VII with granular ventral lateral carinae on middle third. Pre-sternites smooth. Spiracles ovoid, with median side rotated 35º from posterior sternite margin. Sternites with variable number of microsetae.

Figures 2–3: *Vaejovis deboerae* **sp. nov.** holotype female. **2.** Dorsal view. **3.** Ventral view.

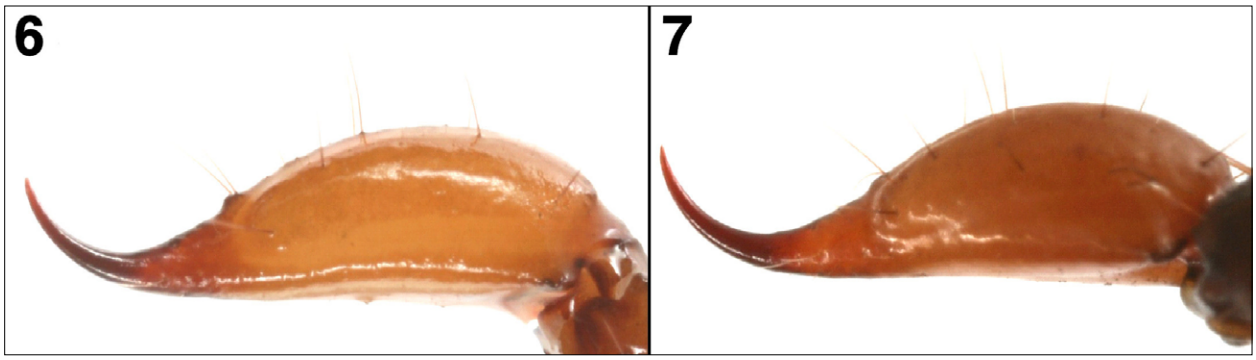
Genital Operculum. Sclerites separated on posterior one-fifth.

Pectines. Pectinal tooth counts for adult females are 12/13 [1], 12/12 [6], 11/12 [1], and 11/11 [1] with a mean of 11.89 [18] and standard deviation of 0.47 for females, and 14/14 for the male paratype. All pectinal teeth, including the most proximal, have exterodistal angling with large sensorial areas. Middle lamellae 7/7. Fulcra are present and number one less than the pectinal tooth count, holotype female 11–12. Fulcra with one central seta each.

Metasoma. Carapace shorter than fifth metasomal segment. Ratio of segment I length/width 0.73; of segment II length/width 0.98; of segment III length/width 1.03; of segment IV length/width 1.48, of segment V length/width 2.22. Segments I–IV: dorsolateral carinae strong and granular with distal denticle of I–IV enlarged and spinoid. Lateral supramedian carinae I–IV strong and granular with enlarged spinoid distal denticle.



Figures 4–5: Carapace. **4.** Paratype *Vaejovis deboerae* **sp. nov. 5.** Female topotype *Vaejovis vorhiesi* Stahnke, 1940.



Figures 6–7: Telson, lateral view. **6.** Paratype *Vaejovis deboerae* **sp. nov. 7.** Female topotype *Vaejovis vorhiesi* Stahnke, 1940.

Lateral inframedian carinae moderately granular on segment I, posterior 4/5 of II, 3/5 of III, and weak on 2/5 of IV. Ventrolateral carinae on I weak and granular; on II–III moderate, granular; on IV strong, granular. Ventral submedian carinae granular. Dorsal and lateral intercarinal spaces very finely granular. Segment I–IV ventral submedian setae 3/3. Segment V: Dorsolateral carinae moderate, distally crenulate, basally granular. Lateromedian carinae moderate and granular on basal 3/5, obsolete on distal 2/5. Ventrolateral and ventromedian carinae strong. Intercarinal spaces finely granular. Segment V ventrolateral setae 5/5.

Telson. Smooth with 4 pairs of large setae on the ventral surface, 4 large setae along both lateral edges of the vesicle along with numerous smaller setae. Subaculear tubercle well developed. See Figure 6.

Chelicerae. Dorsal edge of movable cheliceral finger with two subdistal (*sd*) denticles. Ventral edge is smooth, with well developed serrula on distal half.

Pedipalps. Trichobothrial pattern type C (Vachon, 1974), see Figure 14. Pedipalp ratios: chela length/width 4.17; femur length/width 2.89; patella length/width 3.09; fixed finger length/carapace length 0.73.

Figures 8–9: Chela, ventral view. **8.** Paratype *Vaejovis deboerae* **sp. nov. 9.** Female topotype *Vaejovis vorhiesi* Stahnke, 1940.

Chela. Carinae weak. Median (*MD*) denticles of fixed finger aligned and divided into six subrows by five outer (*OD*) denticles. Movable finger with six subrows, five *OD* denticles and six *ID* denticles. See Figure 8.

Femur. Carinae strong and crenulate. See Figure 10.

Patella. Carinae strong and crenulate. Internal surface with very large granules on the *DPS*c carina. See Figure11.

Legs. Ventral surface of tarsus with single median row of spinules terminating distally with one spinule pair.

Comparison of species

V. deboerae **sp. nov**. can be distinguished from the related species *V. vorhiesi* Stahnke, *V. cashi* Graham, and *V. feti* Graham by the following: **Larger size:** Holotype female 33.14, 21% larger than lectotype female *V. vorhiesi* Stahnke 27.31, previously the largest,

Figures 10–13: Pedipalp femur and patella, dorsal view. **10–11.** Paratype *Vaejovis deboerae* **sp. nov.**, **12–13. F**emale topotype *Vaejovis vorhiesi* Stahnke, 1940.

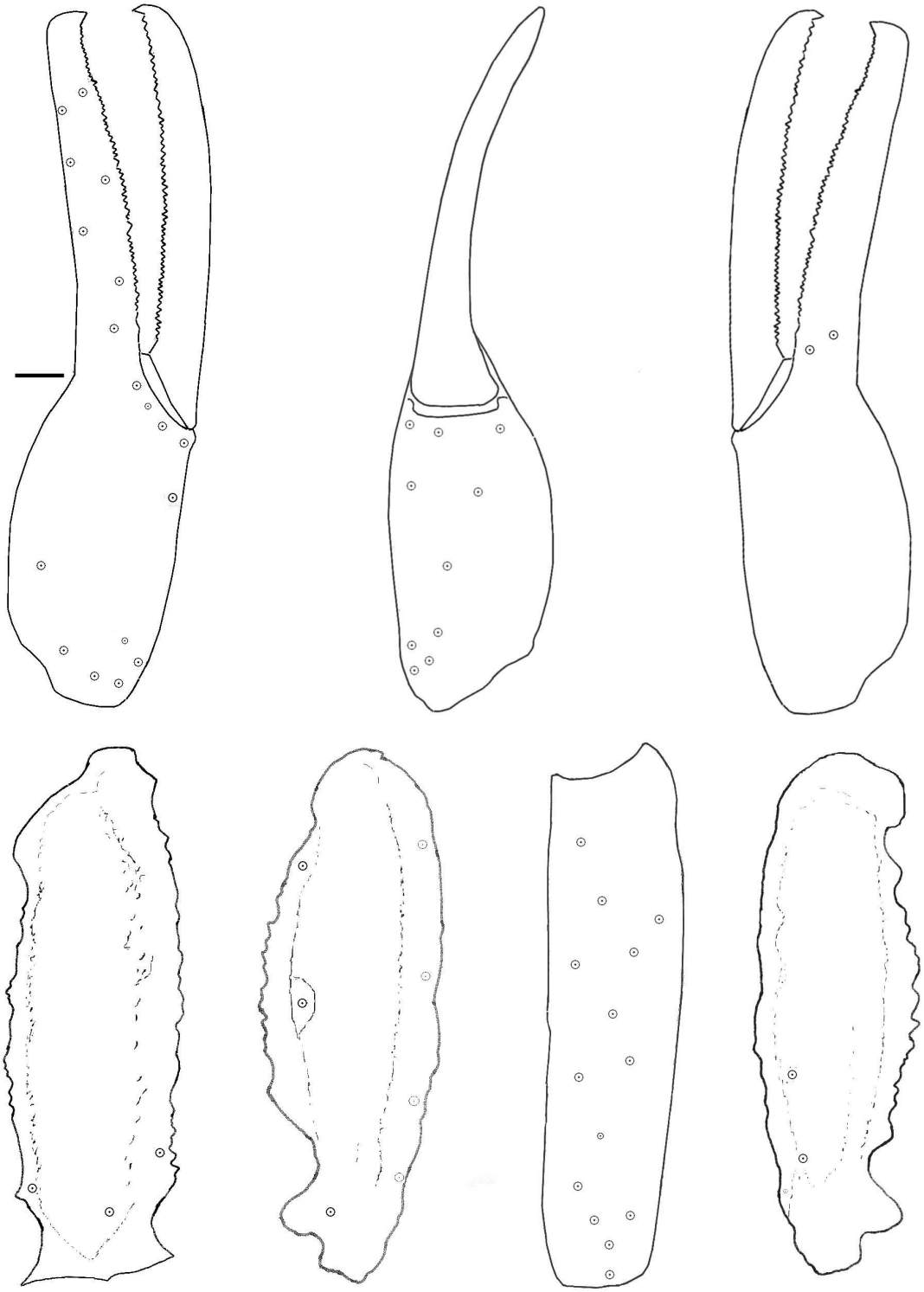


Figure 14: *Vaejovis deboerae* **sp. nov.** holotype female. Trichobothrial pattern.

51% larger than *V. cashi* Graham 21.96, and 48% larger than *V. feti* Graham 22.36. **Morphometrics:** Chelal palm is proportionally longer in *V. deboerae* than in *V. vorhiesi* as indicated by the following mean value differences (as reflected in Figs. 8–9): Chelal palm length (PL)/chelal length = 11.7 %, PL/palm width = 16.3 %, PL/movable finger length = 13.2 %, and PL/fixed finger length = 15 %. **Coloration and granulation:** Color yellowish brown with lighter legs, metasoma and pedipalps; carapace and tergites moderately granular vs. smooth to finely granular. Metasomal segment I dorsolateral carinae enlarged and

Figure 15: *Vaejovis deboerae* **sp. nov.** with first instar juveniles.

spinoid, metasomal segment IV carinae with enlarged spinoid distal denticle, metasomal segments II–III lateral inframedian carinae longer and present on distal 2/5 of IV. **Pectinal tooth counts:** Female pectinal tooth counts for *V. deboerae* **sp. nov.** are 11.89 [18], while *V. vorhiesi* Stahnke is 12.39 [18]; unpaired *t*-test comparing female pectinal tooth counts for *V. vorhiesi* Stahnke and *V. deboerae* **sp. nov.** is statistically significant with two-tailed P value equals 0.0041. Female pectinal tooth counts for *V. cashi* Graham are 11.00 [4], unpaired *t*-test comparing female pectinal tooth counts for *V. cashi* Graham and *V. deboerae* **sp. nov.** is statistically significant with two-tailed P value equals 0.0014. Female pectinal tooth counts for *V. feti* Graham are 10.00 [12], unpaired *t*-test comparing female pectinal tooth counts for *V. feti* Graham and *V. deboerae* **sp. nov.** is extremely statistically significant with two-tailed P value equals 0.0001.

Other disjunct related species: *V. deboerae* **sp. nov.** is distinguished from *V. paysonensis* by having 7 *ID* denticles on the movable finger (Soleglad 1973) whereas *V. deboerae* exhibits 6 *ID* denticles; *V. deboerae* **sp. nov.** is also widely allopatric with *V. paysonensis*.

Geographic affinities

V. deboerae habitat is mixed conifer forest with a substrate of decomposing Ponderosa pine needles, oak leaves, and plant debris (see Figure 16). All four type specimens were found under rocks while many of the other specimens were collected under pine logs and bark.

V. deboerae, as described herein, is known only from the Santa Catalina Mountains. *V. vorhiesi* range is now limited to the Huachuca Mountains, though originally Stahnke (1940) reported *V. vorhiesi* from the Huachuca and Santa Catalina Mountains, and Tucson. *V. cashi* Graham is known only from the Chiricauhua Mountains of Arizona, and *V. feti* Graham is known only from the Black Mountains of New Mexico (see map in Figure 17).

Other taxonomic groups exhibit disjunct distributions within the Santa Catalina Mountains from the Santa Rita and Huachuca Mountain ranges. First Lowe (1992) and then Swann, Mau-Crimmins and Stitt (2005) have shown this in reptile and amphibian populations, separating them into the Rocky Mountain taxa (includes the Santa Catalina Mountains) and the Madrean taxa (includes the Santa Rita and Huachuca

Figure 16: Mt. Lemmon, Santa Catalina Mountains, Arizona, locality of *Vaejovis deboerae* **sp. nov.**

Mountains). *V. deboerae* **sp. nov.** appears to be a distinct part of the Rocky Mountain taxa, while *V. vorhiesi* and *V. cashi* appears to belong to the Madrean taxa

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I am very grateful for the work of Jillian Cowles who created photographs presented in Figures 4–13. I would like to thank my wife Melinda DeBoer-Ayrey who went on the field trip to find these scorpions and encouraged me to write this paper, and Abigail Rankin for contacting me about finding these scorpions in her home. I would also like to thank Victor Fet, Michael Soleglad, and Kathryn A. Munro, as well as an anonymous reviewer, for reviewing the manuscript.

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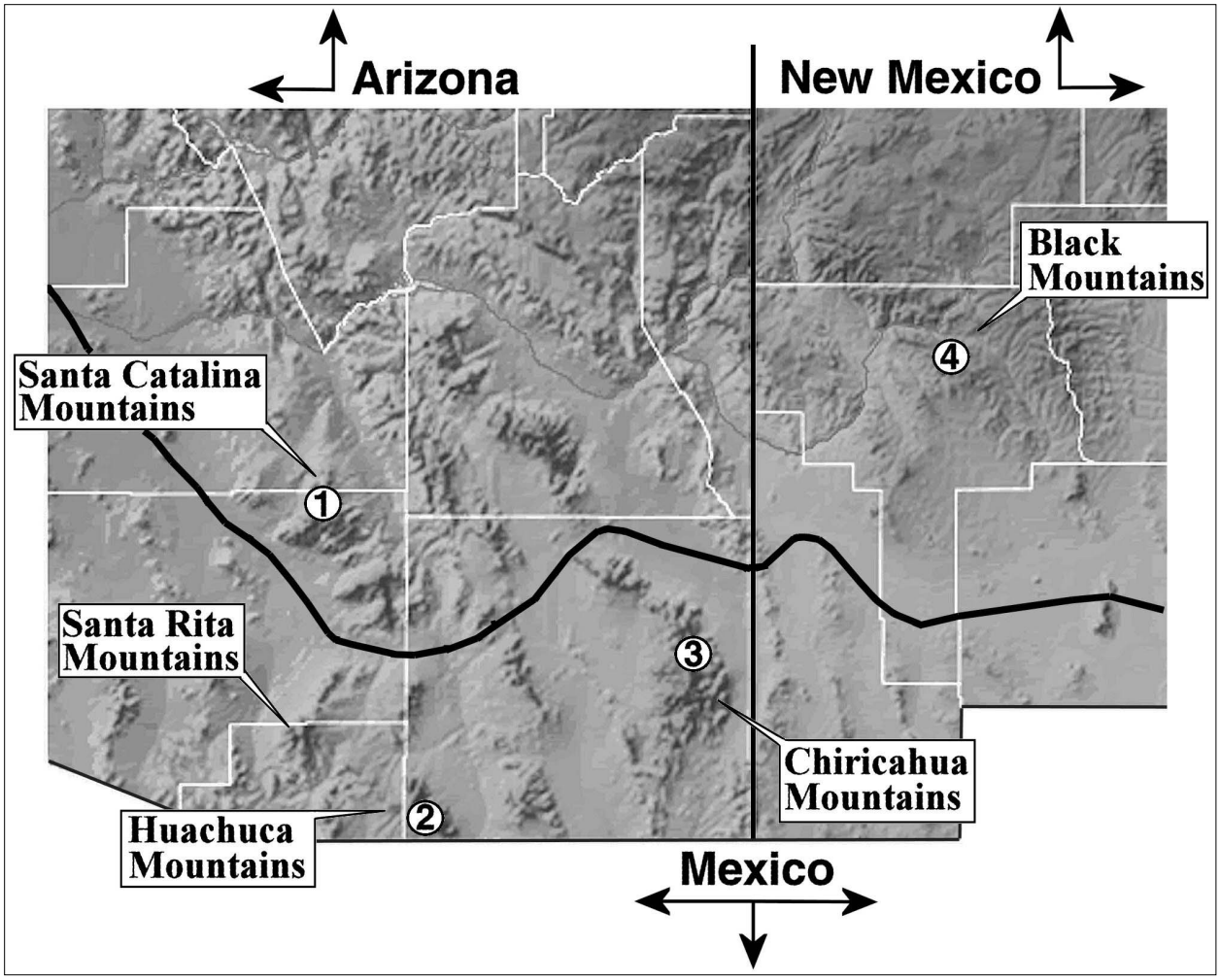

Figure 17: Extreme southeastern corner of Arizona and adjoining New Mexico showing "sky island" mountain ranges germane to the *Vaejovis* "vorhiesi" subgroup. Circled numbers indicate type localities of 1) *Vaejovis deboerae* **sp. nov.**, 2) *V. vorhiesi*, 3) *V. cashi*, and 4) *V. feti*. Santa Catalina, Santa Rita, Huachuca, and Chiricahua Mountains (Arizona), and Black Mountains (New Mexico) are indicated. Interstate Highway 10 is indicated by heavy black line and essentially represents the proposed Madrean Line as discussed by Lowe (1992).

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