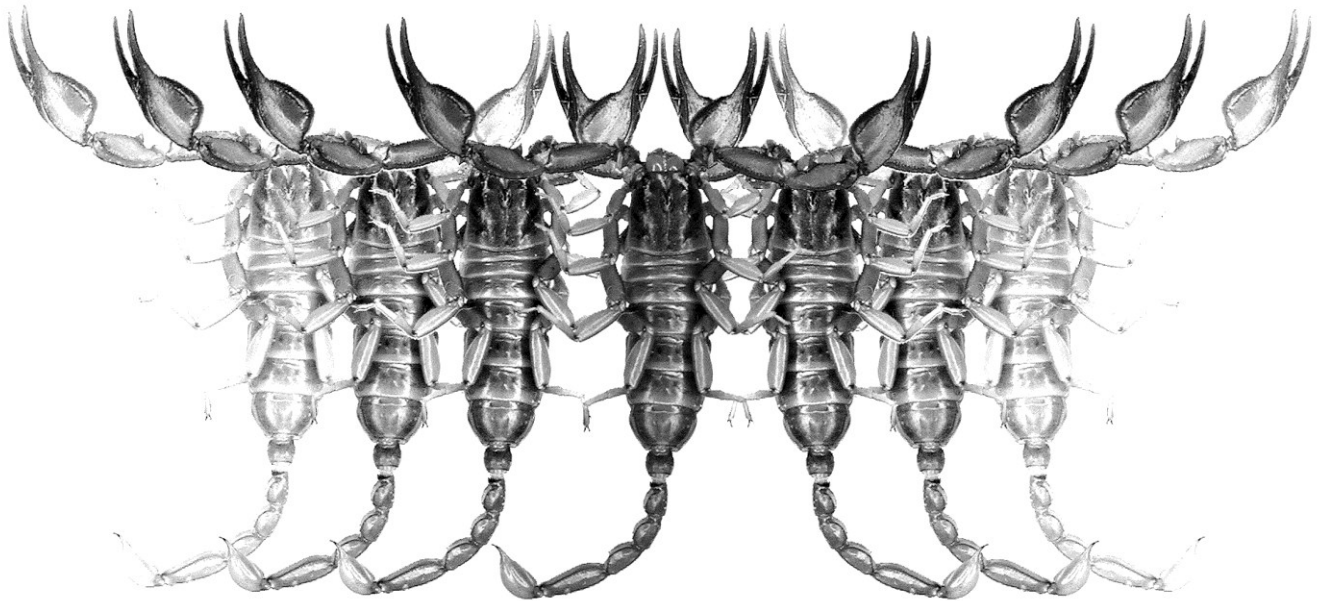


Euscorpium

Occasional Publications in Scorpiology



**New Species of *Vaejovis* from the Santa Rita Mountains,
Southern Arizona (Scorpiones: Vaejoidea)**

Richard F. Ayrey & Michael E. Soleglad

March 2014 — No. 183

Euscorpius

Occasional Publications in Scorpiology

EDITOR: Victor Fet, Marshall University, 'fet@marshall.edu'
ASSOCIATE EDITOR: Michael E. Soleglad, 'soleglad@znet.com'

Euscorpius is the first research publication completely devoted to scorpions (Arachnida: Scorpiones). *Euscorpius* takes advantage of the rapidly evolving medium of quick online publication, at the same time maintaining high research standards for the burgeoning field of scorpion science (scorpiology). *Euscorpius* is an expedient and viable medium for the publication of serious papers in scorpiology, including (but not limited to): systematics, evolution, ecology, biogeography, and general biology of scorpions. Review papers, descriptions of new taxa, faunistic surveys, lists of museum collections, and book reviews are welcome.

Derivatio Nominis

The name *Euscorpius* Thorell, 1876 refers to the most common genus of scorpions in the Mediterranean region and southern Europe (family Euscorpiidae).

Euscorpius is located at: <http://www.science.marshall.edu/fet/Euscorpius>
(Marshall University, Huntington, West Virginia 25755-2510, USA)

ICZN COMPLIANCE OF ELECTRONIC PUBLICATIONS:

Electronic ("e-only") publications are fully compliant with ICZN ([International Code of Zoological Nomenclature](#)) (i.e. for the purposes of new names and new nomenclatural acts) when properly archived and registered. All *Euscorpius* issues starting from No. 156 (2013) are archived in two electronic archives:

- **Biotaxa**, <http://biotaxa.org/Euscorpius> (ICZN-approved and ZooBank-enabled)
- **Marshall Digital Scholar**, <http://mds.marshall.edu/euscorpius/>. (This website also archives all *Euscorpius* issues previously published on CD-ROMs.)

Between 2000 and 2013, ICZN did not accept online texts as "published work" (Article 9.8). At this time, *Euscorpius* was produced in two identical versions: online (*ISSN 1536-9307*) and CD-ROM (*ISSN 1536-9293*) (laser disk) in archive-quality, read-only format. Both versions had the identical date of publication, as well as identical page and figure numbers. Only copies distributed on a CD-ROM from *Euscorpius* in 2001-2012 represent published work in compliance with the ICZN, i.e. for the purposes of new names and new nomenclatural acts.

In September 2012, ICZN Article 8. *What constitutes published work*, has been amended and allowed for electronic publications, disallowing publication on optical discs. From January 2013, *Euscorpius* discontinued CD-ROM production; only online electronic version (*ISSN 1536-9307*) is published. For further details on the new ICZN amendment, see <http://www.pensoft.net/journals/zookeys/article/3944/>.

Publication date: 31 March 2014

<http://zoobank.org/urn:lsid:zoobank.org:pub:77325392-1754-4F52-AAE5-BA4F13FDE8F1>

New species of *Vaejovis* from the Santa Rita Mountains, southern Arizona (Scorpiones: Vaejovidae)

Richard F. Ayrey¹ & Michael E. Sologlad²

¹ P.O. Box 2236, Flagstaff, Arizona 86003, USA; email: flagrich@azscorpion.com

² 32255 Safflower St., Winchester, California 92596, USA; email: soleglad@znet.com

<http://zoobank.org/urn:lsid:zoobank.org:pub:77325392-1754-4F52-AAE5-BA4F13FDE8F1>

Summary

A new scorpion species, *Vaejovis grahami* sp. nov. is described. This small, dark brown species is found in the Santa Rita Mountains, Santa Cruz County, Arizona, USA. It is most similar to *V. vorhiesi* Stahnke and *V. deboerae* Ayrey. The pedipalp fixed finger usually has 5 inner denticles (*ID*) and the movable finger has 6, like in most other southern Arizona *Vaejovis*.

Introduction

Including the new species described in this paper, from the Santa Rita Mountains of Arizona, there are now 16 “vorhiesi” group species. The population described here as *Vaejovis grahami* was known already to Herbert Stahnke and included in his original description of *Vaejovis vorhiesi* Stahnke. Since that description was written, 75 years ago, most scorpologists have assumed the designation was correct. This was in spite of the obvious geographic separation between the Huachuca and Santa Rita Mountains. After the publication of the species description of *Vaejovis deboerae* Ayrey, 2009, the first author thought about the possibility, but dismissed it until the recent publication of the “vorhiesi” group DNA paper (Bryson et al., 2013). Those specimens collected by Stahnke, from the Santa Rita Mountains, are now referred to *Vaejovis grahami*. As of this publication, only the specimens from the Huachuca Mountains are still considered *Vaejovis vorhiesi*.

The recent DNA evidence (Bryson et al., 2013) is consistent with the morphometric evidence and confirms that *Vaejovis grahami* is a new species. Based on the DNA, it is most closely related to *V. vorhiesi* and *V. deboerae* and its lineage has been isolated from lineages leading to those species for approximately 5.45 and 7.34 million years (Bryson et al., 2013).

Materials and Methods

Terminology and conventions

The systematics adhered to in this paper follows the classification as established in Fet & Sologlad (2005) and Sologlad & Fet (2008).

Measurements are as described in Stahnke (1970), trichobothrial patterns are as in Vachon (1974), pedipalp finger dentition follows Sologlad & Sissom (2001), and sternum terminology as described in Sologlad & Fet (2003).

Abbreviations

CNAN, Colección Nacional de Arácnidos, Instituto de Biología, Universidad Nacional Autónoma de México, D.F., Mexico; MES, personal collection of Michael E. Sologlad, Winchester, California, USA; RFA, personal collection of Richard F. Ayrey, Flagstaff, Arizona, USA; UANL, Universidad Autónoma de Nuevo León, San Nicolas de los Garza, Nuevo León, Mexico; and USNM, United States National Museum, Smithsonian Institution, Washington, DC, USA.

Material

Besides type material listed below under new species description, the following additional specimens were examined:

Vaejovis grahami sp. nov. USA: Arizona: Cochise Co.: Madera Canyon, Santa Rita Mountains, 11 June 2010, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 5 ♀ (RFA); Mount Hopkins, Santa Rita Mountains, 6 October 2009, leg. R. F. Ayrey, T. Miscione & R. Troup, 2 ♂, 6 ♀ (RFA).

Vaejovis bandido Graham, Ayrey et Bryson, 2012. Mexico: Sonora: Sierra de los Ajos Mountains, 12–13 October 2010, leg. R.W. Bryson, Jr., 3 ♂ (1 CNAN, 2 UANL), 3 ♀ (1 CNAN, 2 UANL).

Vaejovis brysoni Ayrey et Webber, 2013. USA: Arizona: Pima Co.: above Molino Basin on Catalina



Figure 1: *Vaejovis grahami* sp. nov., paratype female in natural habitat.

Highway near Seven Cataracts Vista, Santa Catalina Mountains. 16 March 2012, leg. R.W. Bryson, Jr., 1 ♂, 7 ♀ (RFA); 5 April 2012, leg. R.W. Bryson, Jr. & D. Hartman, 8 ♀ (RFA); same locality, 18 August 2012, leg. R. F. Ayrey & M. DeBoer-Ayrey, 8 ♀ (RFA).

Vaejovis cashi Graham, 2007. USA: Arizona: Cochise Co.: Cave Creek Canyon, Chiricahua Mountains, 2 August 2008, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 4 ♂, 4 ♀ (RFA); same locality, 23 August 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 3 ♂, 4 ♀ (RFA).

Vaejovis crumpi Ayrey et Soleglad, 2011. USA: Arizona: Yavapai Co.: near Lynx Lake, Prescott, 14 August 2008, R. F. Ayrey & M. M. DeBoer-Ayrey, 3 ♂, 5 ♀ from type locality (RFA); same locality, 14 September 2009, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 4 ♂, 4 ♀ (RFA); same locality, 8 August 2010, leg. R. F. Ayrey & M. M. DeBoer-Ayrey 3 ♂, 5 ♀ (RFA).

Vaejovis deboerae Ayrey, 2009. USA: Arizona: Pima Co.: Rose Canyon Campground, Santa Catalina Mountains, 28 August 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 3 ♂, 5 ♀ (RFA); same locality, 29 August 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 4 ♂, 4 ♀ (RFA).

Vaejovis electrum Hughes, 2011. USA: Arizona: Graham Co.: Upper Arcadia Campground, Mt. Graham. 17 July 2009, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 6 ♀ (RFA); Mt Graham Hwy, Mt. Graham, 9415 feet asl, 18 July 2009, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 4 ♀ (RFA).

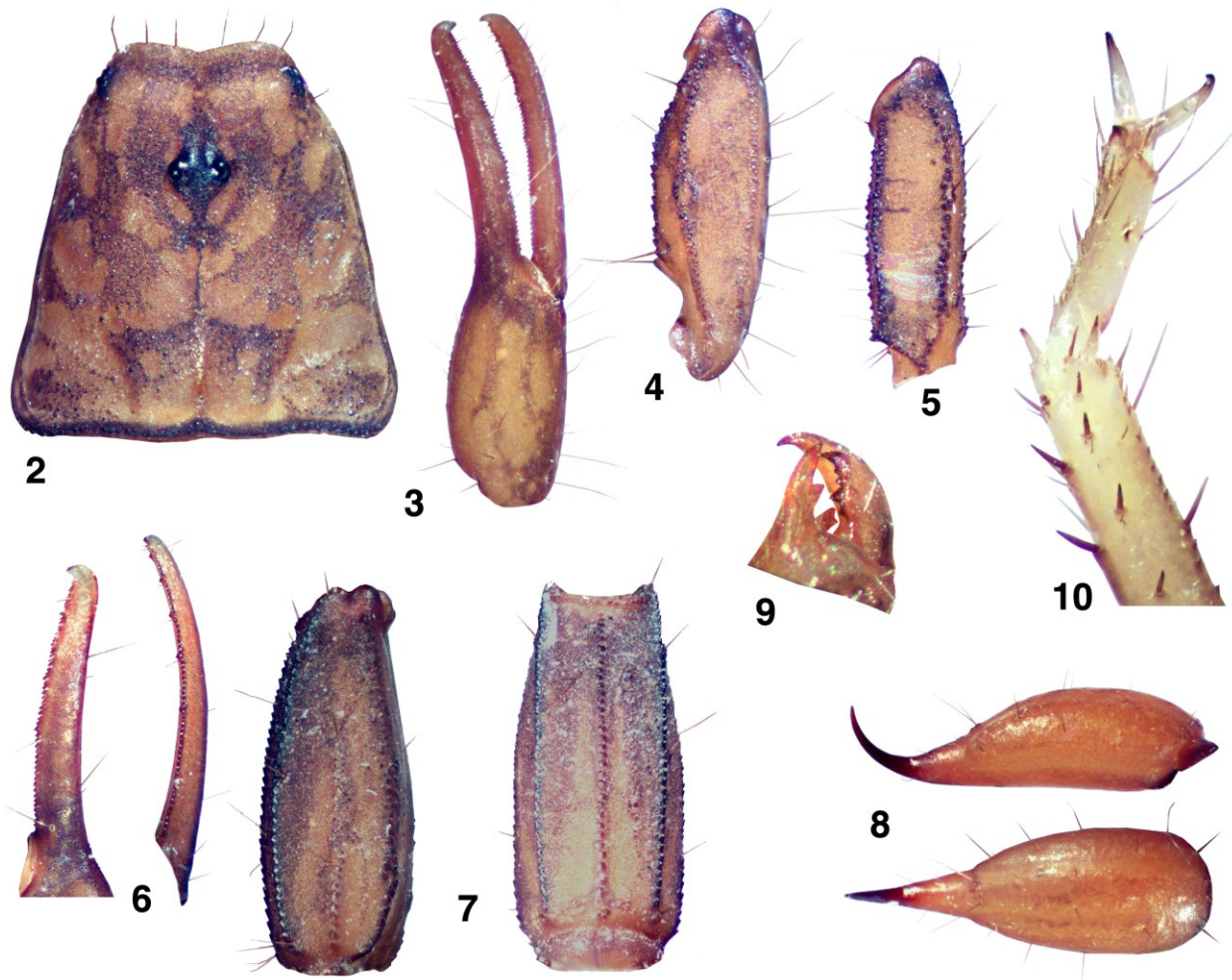
Vaejovis feti Graham, 2007. USA: New Mexico: Meadow Creek, Black Mountains, 6 July 1978, leg. M. H. Muma 4 ♂, 3 ♀ (MES).

Vaejovis halli Ayrey, 2012. USA: Arizona: Gila Co.: Mount Ord, 11 September 2010, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 6 ♀, paratypes (RFA); same locality, 2 May 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 3 ♂, 5 ♀, paratypes (RFA).

Vaejovis jonesi Stahnke, 1940. USA: Arizona: Coconino County: near Wupatki National Monument, 1 April 2011, leg. R. F. Ayrey, 1 ♀ from type locality (RFA).

Vaejovis lapidicola Stahnke, 1940. USA: Arizona: Coconino County: Red Sandstone Quarry, Flagstaff, 1 June 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 7 ♀ from type locality (RFA).

Vaejovis paysonensis Soleglad, 1973. USA: Arizona: Coconino County: Control Road, 25 miles E of Payson, 5 July 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 7 ♀ from type locality (RFA); same locality,



Figures 2–10: *Vaejovis grahami*, **sp. nov.**, Madera Canyon, Santa Rita Mountains, Pima County, Arizona, USA. 2–8. Female holotype. 9. Male paratype. 10. Female paratype. 2. Carapace. 3. Chela, external view. 4. Patella, dorsal view. 5. Femur, dorsal view. 6. Fixed and movable finger dentition. 7. Metasomal segment V, lateral and ventral views. 8. Telson, lateral and ventral views. 9. Chelicera, dorsal view. 10. Left leg III, tarsus and basitarsus (partial), exteroventral view.

6 July 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 6 ♀ (RFA).

Vaejovis tenuipalpus Sissom et al., 2012. USA: Arizona: Mojave Co.: Getz Peak, Hualapai Mountains, 9 August 2009, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 7 ♀ (RFA).

Vaejovis trinityae Ayrey, 2013. USA: Arizona: along the Mogollon Rim, Coconino County, Arizona (N34.5201°, W111. 5074°), 1924 m asl, 31 August 2008, leg. R.F. Ayrey, 1 ♂, 4 ♀ (RFA); same locality, 31 May 2009, leg. R. F. Ayrey & M. DeBoer-Ayrey 8 ♀ (RFA); same locality, 14 August 2010, leg. R. F. Ayrey & M. DeBoer-Ayrey, 8 ♀ (RFA); same locality, 16 September 2011, leg. R. F. Ayrey & M. DeBoer-Ayrey. 2 ♂, 6 ♀ (RFA); same locality, 17 October 2011, leg. R. F. Ayrey & M. DeBoer-Ayrey. 1 ♀ (RFA); same lo-

cality, 18 May 2012, leg. R. F. Ayrey & M. DeBoer-Ayrey. 2 ♂, 2 ♀ (RFA).

Vaejovis vorhiesi Stahnke, 1940. USA: Arizona: Cochise Co.: Miller Canyon, Huachuca Mountains, 24 May 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 7 ♀ from type locality (RFA); Carr Canyon, Huachuca Mountains, 5 October 2008, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 6 ♀ (RFA); Garden Canyon, Huachuca Mountains, 26 August 2011, leg. R. F. Ayrey, 4 ♂, 6 ♀ (RFA); Lutz Canyon, Huachuca Mountains, 27 March 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 2 ♀ (RFA); Ash Canyon, Huachuca Mountains. 24 May 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♀ (RFA).

Vaejovis sp. cf. *vorhiesi* (“Whetstone” population in Bryson et al., 2013). USA: Arizona: Cochise Co.:

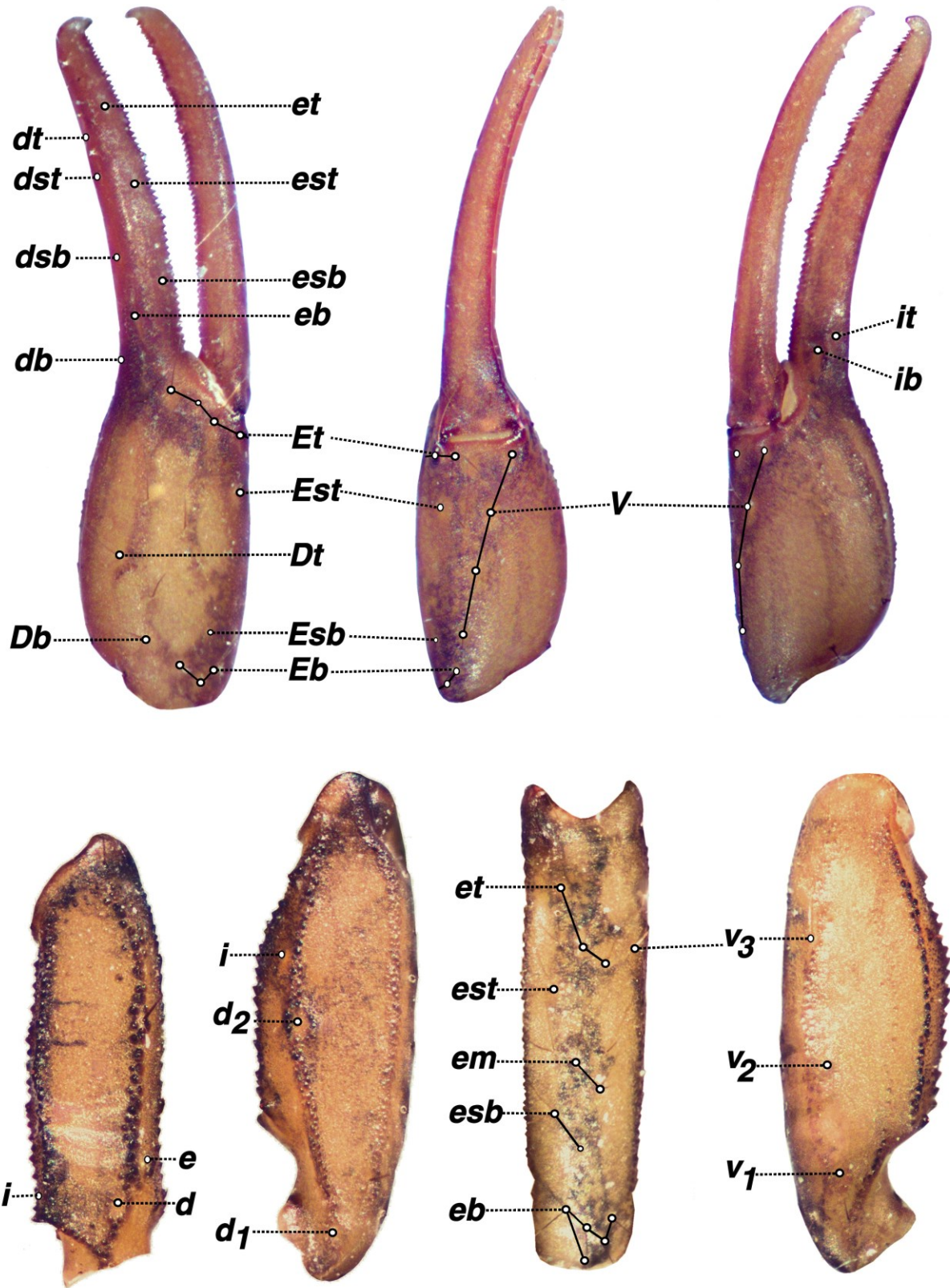


Figure 11: *Vaejovis grahami*, sp. nov., female holotype, Madera Canyon, Santa Rita Mountains, Pima County, Arizona, USA. Trichobothrial pattern.

<i>Vaejovis grahami</i>					
Santa Rita Mountains, Pima County, Arizona, USA					
	Madera Canyon				Mt. Hopkins
	Female Holotype #896	Female Paratype #897	Male Paratype #898	Male Paratype #144	Paratype Female #900
Total length	26.90	26.30	20.45	21.40	23.85
Carapace length	3.45	3.45	2.60	2.70	3.30
Mesosoma length	7.90	7.55	5.10	5.60	6.15
Metasoma length	12.15	11.95	10.10	10.30	11.20
Segment I length/width	1.75/2.05	1.60/2.10	1.40/1.60	1.40/1.60	1.45/1.95
Segment II length/width	1.85/1.95	1.85/1.95	1.50/1.55	1.60/1.50	1.75/1.85
Segment III length/width	1.95/1.85	1.95/1.90	1.75/1.50	1.75/1.50	1.85/1.80
Segment IV length/width	2.70/1.80	2.65/1.85	2.20/1.45	2.25/1.50	2.55/1.65
Segment V length/width	3.90/1.65	3.90/1.75	3.25/1.25	3.30/1.40	3.60/1.65
Telson length	3.40	3.35	2.65	2.80	3.20
Vesicle length	2.25	2.25	1.90	1.95	2.00
width/depth	1.20/0.95	1.20/0.90	0.85/0.70	0.95/0.80	1.10/0.85
Aculeus length	1.15	1.10	0.75	0.85	1.20
Pedipalp length	11.40	11.00	8.75	9.15	10.90
Femur length/width	2.90/0.85	2.80/0.95	2.35/0.75	2.40/0.75	2.70/0.80
Patella length/width	3.45/1.15	3.25/1.15	2.50/0.80	2.70/0.85	3.25/0.95
Chela length	5.05	4.95	3.90	4.05	4.95
Palm length	2.15	2.00	1.60	1.75	2.05
width/depth	1.15/1.30	1.20/1.30	0.75/0.85	0.85/0.95	1.15/1.10
Fixed finger length	2.90	2.65	1.85	2.05	2.60
Movable finger length	3.35	3.15	2.15	2.50	3.00
Pectines teeth	13-12	14-14	15-16	15-x	13-12
middle lamellae	9-8	9-9	10+-11	9+-x	8-8

Table 1: Morphometrics (mm) of *Vaejovis grahami*, sp. nov.

French Joe Canyon, Whetstone Mountains, 14 October 2009, leg. R. Troup, 1 ♀ (RFA).

Systematics

Order **SCORPIONES** C. L. Koch, 1850
 Infraorder Orthosterni Pocock, 1911
 Parvorder Iurida Soleglad et Fet, 2003
 Superfamily Chactoidea Pocock, 1893
 Family Vaejovidae Thorell, 1876
 Subfamily Vaejovinae Thorell, 1876
 Genus *Vaejovis* Thorell, 1876

Vaejovis grahami Ayrey et Soleglad, sp. nov.

Figures 1–12, 14; Tables 1–2

<http://zoobank.org/urn:lsid:zoobank.org:act:7B3B672F-1130-4E42-9B92-B80115D122B2>

Diagnosis: Small scorpion, 21–27 mm in length, color medium to dark brown, lighter on the legs and telson with underlying mottling on carapace, mesosoma, and pedipalps. Pectinal teeth 15–16 in male and 12–14 in female. Pedipalp movable finger with 6 *ID* denticles and fixed finger with 5 *ID*. Carapace is shorter than length of fifth metasomal segment, in a ratio of 0.88 for females, 0.80 to 0.82 for males. Ventral surface of tarsomere II with single median row of spinules terminating distally with one spinule pair. Hemispermaphore with short bifurcated lamellar hook emanating from the dorsal trough, modest distal crest on lamina terminus, and slightly sclerotized mating plug with smooth barb.

Distribution: Known only from the Santa Rita Mountains of Arizona, USA. See map in Fig. 15 for type locality.

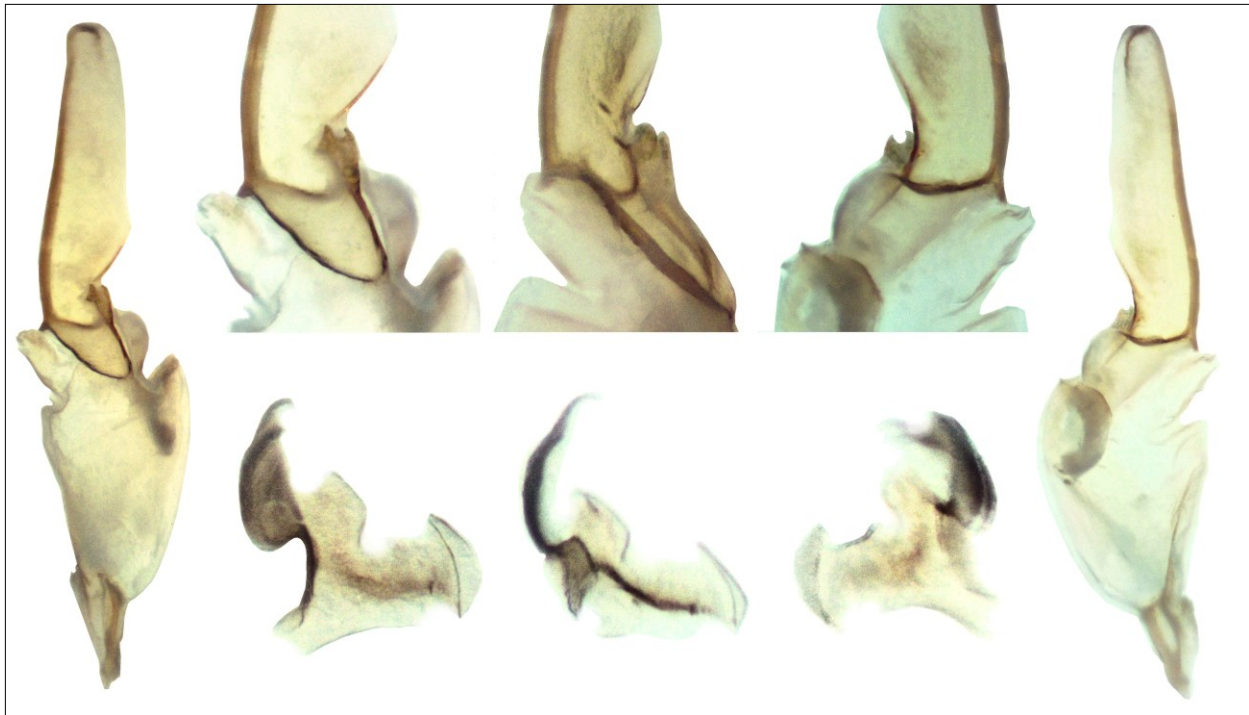


Figure 12: *Vaejovis grahami*, **sp. nov.**, Madera Canyon, Santa Rita Mountains, Pima County, Arizona, USA. Male paratype, left hemispermatophore and mating plug (reversed, photographed submerged in alcohol). **Left.** Dorsal view. **Right.** Ventral view. **Upper.** Close-up of median area, dorsal, exterodorsal, and ventral views. The bifurcated lamellar hook originates entirely from the dorsal trough edge. **Bottom.** Mating plug, dorsal view, two perspectives, and ventral view, showing smooth barb (visible in dorsal views). Note, mating plug was removed prior to the photographs taken of the hemispermatophore. Due to the translucency of the lamina and mating plug, the ventral trough edge is visible from the dorsal view and the smooth barb edge is visible from the ventral view.

Etymology: This species is named in honor of Matthew R. Graham for his contributions to scorpion systematics and biogeography. Matt was the first to recognize the importance of the isolated mountain ranges of southern Arizona and New Mexico which formed insular “sky island” habitats for scorpion species.

Type material: Holotype female, Madera Canyon, Santa Rita Mountains, Pima County, Arizona, USA, 12 May 2013, leg. R.F. Ayrey, specimen #RA896, deposited in USNM. Paratype female, same locality, 22 June 2009, leg. R.F. Ayrey, specimen #RA897 (RFA). Paratype male, same locality, 3 October 2010, R.F. Ayrey, specimen #RA898 (USNM). Paratype female, Mount Hopkins, Santa Rita Mountains, Pima County, Arizona, USA, 02 August 2010, leg. R.F. Ayrey, specimen #RA900 (RFA).

FEMALE. Description based on holotype female except where noted. See Table 1 for measurements of holotype female, and two female and male paratypes.

COLORATION. Color is medium to dark brown, lighter on the legs, telson orange with dark brown stripe

medially on ventral surface. Underlying mottling on the carapace, mesosoma, pedipalps, and legs.

CARAPACE (Fig. 2). Anterior margin of carapace with a conspicuous wide emargination. Carapace moderately granular occurring primarily in the mottled areas. Three lateral eyes on each side, the most proximal the smallest. Ratio of median eyes position from anterior edge/carapace length 0.327; carapace length/width at median eyes 1.359.

MESOSOMA. Tergites moderately granular on proximal half with vestigial median carina on Tergites I–VI. Tergite VII with strong median and lateral carina. Sternites III–VI smooth. Sternite VII rough surface with weak ventral lateral carinae on middle third. Stigma small and ovoid with median side rotated 35 degrees from posterior sternite margin.

STERNUM. Sternum conforms to type 2, lateral lobes and apex subtly defined. Sclerite is wider than long.

GENITAL OPERCULUM. Sclerites separated on posterior one-third. See comparison to male below.

Adult Females (N)	<i>V. grahami</i> (3)	<i>V. bandido</i> (5)	<i>V. brysoni</i> (8)	<i>V. cashi</i> (3)	<i>V. deboerae</i> (3)	<i>V. electrum</i> (3)	<i>V. feti</i> (3)	<i>V. halli</i> (3)	<i>V. tenuipalpus</i> (3)	<i>V. vorhiesi</i> (3)
Total Length	23.85–26.90	24.65–27.75	22.88–27.50	20.90–22.10	29.64–33.14	24.48–25.38	22.00–23.46	21.87–23.43	28.38–31.24	24.62–26.55
Cara_L	3.30–3.45	3.12–3.38	2.88–3.75	2.86–3.11	3.79–4.38	3.48–3.60	3.01–3.19	2.90–3.18	3.52–3.71	3.21–3.39
Cara_L/M5_L	0.88–0.92	0.97–0.98	0.88–1.03	0.96–1.14	0.89–0.97	1.02–1.13	0.96–1.05	0.98–0.99	0.93–0.98	0.98–1.06
M1_L/M1_W	0.76–0.85	0.73–0.78	0.93–1.00	0.61–0.66	0.72–0.79	0.65–0.68	0.69–0.73	0.70–0.77	0.90–0.94	0.68–0.73
M2_L/M2_W	0.95	0.88–0.94	0.90–1.03	0.74–0.80	0.98–1.03	0.68–0.89	0.69–0.73	0.79–0.87	1.09–1.18	0.85–0.92
M3_L/M3_W	1.03–1.05	0.96–1.04	1.00–1.09	0.89–0.92	1.02–1.14	0.93–0.98	0.93–1.13	0.94–1.00	1.29–1.36	0.96–0.98
M4_L/M4_W	1.43–1.55	1.35–1.44	1.34–1.61	1.28–1.39	1.48–1.60	1.33–1.46	1.35–1.60	1.27–1.50	1.74–1.83	1.39–1.62
M5_L/M5_W	2.18–2.36	2.02–2.16	2.15–2.82	2.05–2.15	2.10–2.32	1.81–1.91	2.07–2.24	1.79–2.11	2.49–2.52	2.08–2.22
Ves_L/Ves_W	1.82–1.88	1.59–1.69	1.60–2.06	1.56–1.71	2.22–2.43	1.45–1.62	1.62–1.87	1.68–1.85	1.60–1.77	1.63–1.72
Fem_L/Fem_W	2.95–3.41	2.86–3.07	2.87–3.22	2.74–3.02	2.74–2.90	2.78–3.19	2.89–3.41	2.83–3.33	3.81–3.83	2.87–3.22
Pat_L/Pat_W	2.83–3.42	2.83–3.21	2.47–3.29	2.86–3.03	2.91–3.16	2.86–2.94	2.53–2.66	2.89–3.63	3.72–3.85	3.12–3.19
Che_L/Che_W	4.13–4.39	4.09–4.48	3.71–4.55	3.84–4.52	4.17–4.53	3.74–4.19	3.59–3.91	4.33–4.79	5.05–5.43	4.57–5.30
FF_L/Cara_L	0.77–0.84	0.65–0.69	0.68–0.83	0.68–0.73	0.71–0.77	0.68–0.69	0.69–0.80	0.67–0.77	0.83–0.87	0.72–0.81
FF_L/Che_L	0.53–0.57	0.48–0.49	0.51–0.56	0.47–0.49	0.48–0.52	0.47–0.51	0.48–0.50	0.46–0.53	0.50–0.51	0.47–0.54
Pectinal Teeth	12–14 (13.00) [19]	11–12 (11.10) [10]	11–12 (11.50) [16]	10–12 (11.20)[8]	12–13 (12.17) [6]	11–12 (11.33) [6]	10 (10.00) [6]	11–13 (11.94) [16]	11–12 (11.00) [6]	12–13 (12.38) [8]

Table 2: Morphometric statistical comparisons between *Vaejovis grahami* sp. nov. and other species exhibiting six inner denticles (*ID*) on the chelal movable finger. Shaded entries indicate *non-overlapping ranges*. Cara_L = carapace length, M1-5_L(W) = metasomal segment I-V length (width), Ves_L(W) = telson vesicle length (width), Fem_L(W) = pedipalp femur length (width), Pat_L(W) = pedipalp patella length (width), Che_L(W) = pedipalp chela length (width), FF_L = chelal fixed finger length.



Figure 13: *Vaejovis grahami* sp. nov. habitat. **Top.** Madera Canyon. **Bottom.** Photo taken from the Santa Catalina Mountains, showing Madera Canyon in the Santa Rita Mountains (V-notch in the background).

PECTINES. With three anterior lamellae, 9/8 middle lamellae, and 13/12 teeth. Sensorial areas present on all teeth and fulcra are present.

METASOMA (Fig. 7). Segments I–IV: dorsal and dorsolateral carinae strong and serrate with distal denticle of I–IV enlarged and spinoid. Lateral carinae strong and serrate on I, present on posterior 3/4 of II, posterior 1/2 of III, and obsolete on IV. Ventrolateral carinae strong and serrate, ventromedian moderately granular on I and crenulate to serrate on II–IV. Segment V: Dorsolateral carinae strong and irregularly granulate. Lateral carinae granular on basal 3/5. Ventrolateral and ventromedian carinae serrate. Dorsal intercarinal spaces irregularly granular.

TELSON (Fig. 8). Smooth with several setae on ventral surface. Subaculear tubercle present but small. LAS present with 4–6 serrations.

CHELICERAE (Fig. 9, paratype male). Dorsal edge of movable cheliceral finger with two subdistal (sd) denticles. Ventral edge is smooth, with well-developed serrula on distal half.

PEDIPALP (Figs. 3–6, 11). Femur. Dorsointernal and dorsoexternal carinae serrated, and ventrointernal crenulated, ventroexternal rounded. Dorsal and ventral surfaces very rough, internal surface with scattered granules, and external with line of serrated granules. **Patella.** Dorsointernal carina serrated, ventrointernal crenulated, dorsoexternal and ventroexternal carinae granulated. Dorsal patellar (*DPS*) and ventral patellar (*VPS*) spurs formed with a pointed granule, *DPS*_c carina well developed with approximately 16 serrated granules. **Chela.** Digital (*D1*) carina weak, irregularly granulate, subdigital (*D2*) represented with a single rounded granule, dorsosecondary (*D3*) rounded with slight median granules, dorsomarginal (*D4*) rounded with scattered granules, dorsointernal (*D5*) rounded and irregularly granulated, ventroexternal (*V1*) and ventromedian (*V2*) carinae rounded and smooth, ventrointernal (*V3*) rounded with minor granulation, and external (*E*) carina weak to obsolete. Chelal finger median denticle (*MD*) rows in straight line. Fixed finger median denticles (*MD*) divided into 6 groups by 5 outer (*OD*) denticles, and 5 *ID* denticles are found on the inner edge. Movable finger with 6 *MD* groups, 5 *OD* denticles and 6 *ID* denticles. Trichobothrial pattern type C orthobothriotaxic (see Figure 11). Chelal *ib* and *it* trichobothria located at fixed finger's base, considerably proximal of sixth *ID* denticle; *Dt* on chela is proximal of palm midpoint; *dt* and *dst* are proximal to *et* and distal of *est*; patellar *v*₃ is located on external surface and positioned distally of *et*₃.

LEGS (Fig. 10, female paratype). Ventral surface of tarsomere II with single median row of spinules terminating distally with one spinule pair.

HEMISPERMATOPHORE (Fig. 12, paratype male). The left hemispermatophore is 3.69 mm in length with the lamina and trunk 1.98 each. The hemispermatophore is lightly sclerotized with a somewhat centrally wide lamella that tapers slightly at its terminus. A modest distal crest is present on the inner distal aspect of the lamella, which is also visible from the ventral surface. The lamellar hook is sclerotized, relatively short, emanating from the dorsal trough, and is widely bifurcated. The lamellar hook is short, exhibiting a 0.264 ratio of its length to the lamellar length. The trough difference (i.e., the vertical distance between the ventral and dorsal troughs) also indicates the hook's shortness when compared to the lamellar hook length, a ratio of 0.543. The truncal flexure is visible on the external aspect of the trunk/lamella juncture. A small slightly sclerotized mating plug was located on the ventral surface. Its stock is somewhat short and thick, and the barb's edge is smooth.

Variability between male and female. Pectinal teeth are longer and more angled in the male than in the female, the basal tooth is located closer to the pectinal base. Pectinal tooth counts range 15–16 for the male and 12–14 for the female. The genital operculum is larger and longer in the male, the sclerites disconnected for most of their length, genital papillae protruding proximally. The metasomal segments are slightly thinner in the male, mean value differences of length to width ratios ranging from 2.9 % to 12.2 % (based on two males and females).

Variability in meristic data. Variability of pectinal tooth counts 12/13 [n=1], 13/12 [n=1], x/13 [n=1], 13/13 [n=6] and 14/14 [n=1], with a mean of 13.00 [n=19], standard deviation 0.47 for females and 14/15 [n=1], 15/15 [n=1], and 15/16 [n=1], with a mean of 15.00 [n=6], standard deviation 0.63 for males. There was no variability of fixed finger ID denticle count noted in *V. grahami* [n=25], while variability is usually seen in other species of *Vaejovis* (Ayrey, 2012, 2013b; Ayrey & Webber, 2013).

Type Locality Description. The type specimens were found, using a blacklight at night in Madera Canyon, Santa Rita Mountains, Pima County, Arizona (N31.71339°, W110.87296°) at an elevation of 1665 m asl. and Mount Hopkins Santa Rita Mountains, Pima County, Arizona (N31.67455°, W110.88337°) at an elevation of 2082 m asl. The vegetation type is mesic Ponderosa Pine and mixed evergreen oak woodland, see



Figure 14: *Vaejovis grahami* sp. nov. holotype with first instar juveniles.

Figure 5. *Uroctonites huachuca* and *Pseudouroctonus apacheanus* were found syntopically with *V. grahami* during 12 field trips to the Santa Rita Mountains.

Behavior and reproduction. This species is found, in Madera Canyon, from approximately 50 m higher in elevation than the highest elevation where *Centruroides sculpturatus* and *Hoffmannius spinigerus* are found in that canyon. The authors presume predation from these species is the limiting factor establishing the lowest elevation for this species. Birth and postpartum behavior are as described in Ayrey (2013a).

Comparison of Species

Map in Fig. 15 shows the type localities of the 16 currently described species of *Vaejovis* from Arizona, western New Mexico and Sonora, Mexico. Comparisons are made to all species with emphasis on *V. vorhiesi* Stahnke and *V. deboerae* Ayrey according to recent DNA comparisons (Bryson et al., 2013).

Vaejovis jonesi, *V. lapidicola*, *V. paysonensis*, *V. bigelowi*, *V. trinityae*, and *V. crumpi* all exhibit 7 inner denticles (*ID*) on the chela movable finger, not 6 which is found on most southern Arizona “vorhiesi” group

scorpions, including *Vaejovis* Santa Rita. Based on recent DNA analysis, *V. grahami* has been isolated from the above species for 15.37 to 14.31 million years, excluding *V. bigelowi* for which DNA data is unavailable.

***Vaejovis bandido*:** differs from *V. grahami* by 6 important morphometric ratios (see Table 2). Based on recent DNA analysis, *V. bandido* has been isolated from *V. grahami* for 16.26 million years. It is also widely allopatric with *V. grahami*.

***Vaejovis brysoni*:** differs from *V. grahami* by metasomal segment 1 L/W ratio (see Table 2). Although total length is the same, males differ by having a longer carapace and metasoma, and by all 12 important morphometric ratios used in table 2. This is the only southern Arizona species for which there is no DNA data available at this time.

***Vaejovis cashi*:** differs from *V. grahami* by 9 important morphometric ratios (see Table 2). Based on recent DNA analysis, *V. cashi* has been isolated from *V. grahami* for 16.26 million years. It is also widely allopatric with *V. grahami*.

***Vaejovis electrum*:** differs from *V. grahami* by 8 important morphometric ratios (see Table 2). *V. electrum* has been isolated from *V. grahami* for 16.26 million years. It is also widely allopatric with *V. grahami*.

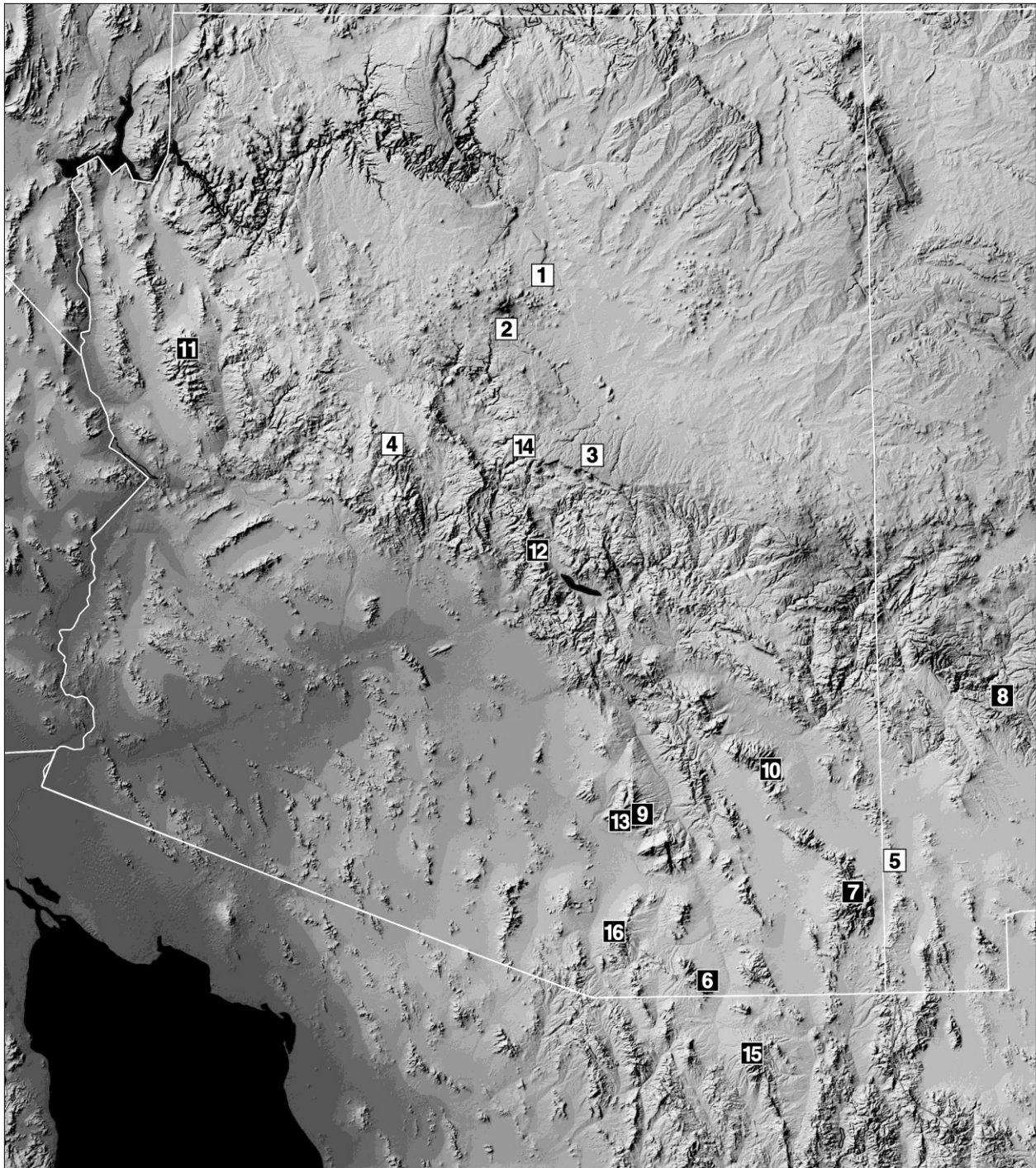


Figure 15: Map of Arizona, extreme western New Mexico and northern Sonora Mexico showing the type locality of all 16 *Vaejovis* “vorhiesi” group species, including new species *Vaejovis grahami*. Localities are divided into those species exhibiting seven inner denticles (ID) on the chelal movable finger (white rectangles with black lettering) and those with primarily six, or five ID denticles (black rectangles with white lettering). **Seven IDs:** 1 = *V. jonesi*, 2 = *V. lapidicola*, 3 = *V. paysonensis*, 4 = *V. crumpi*, 5 = *V. bigelowi*, 14 = *V. trinityae*. **Six IDs:** 6 = *V. vorhiesi*, 7 = *V. cashi*, 8 = *V. feti*, 9 = *V. deboerae*, 10 = *V. electrum*, 11 = *V. tenuipalpus*, 12 = *V. halli*, 13 = *V. brysoni*, 15 = *V. bandido*, and 16 = *V. grahami* sp. nov.

Vaejovis feti: differs from *V. grahami* by having a lower pectinal tooth count and 7 important morphometric ratios (see Table 2). Based on recent DNA

analysis, *V. feti* has been isolated from *V. grahami* for 16.26 million years. It is also widely allopatric with *V. grahami*.

Vaejovis halli: differs from *V. grahami* by 6 important morphometric ratios (see Table 2). Based on recent DNA analysis, *V. halli* has been isolated from *V. grahami* for 15.37 million years. It is also widely allopatric with *V. grahami*.

Vaejovis tenuipalpus: has 6 *ID* denticles on both the fixed and movable fingers while *V. grahami* usually has 6 *ID* denticles on the movable finger and 5 on the fixed finger. *V. tenuipalpus* is also larger and differs from *V. grahami* by 11 important morphometric ratios (see Table 2). Based on recent DNA analysis, *V. grahami* has been isolated from *V. tenuipalpus* for 11.61 million years. *V. tenuipalpus* is also widely allopatric with *V. grahami*.

Vaejovis deboerae: differs from *V. grahami* by being larger and by 5 important morphometric ratios (see Table 2). Based on recent DNA analysis, *V. deboerae* has been isolated from *V. grahami* for 7.34 million years.

Vaejovis vorhiesi: differs from *V. grahami* by 8 important morphometric ratios (see Table 2). Based on recent DNA analysis, *V. vorhiesi* has been isolated from *V. grahami* for 5.45 million years.

Acknowledgments

We would like to thank Melinda DeBoer-Ayrey for joining the first author on twelve field trips to the Santa Rita Mountains. We would also like to thank Robert Bryson, Jr. for his assistance with the analysis, and two anonymous reviewers for their critical reviews.

References

- AYREY, R. F. 2009. Sky island *Vaejovis*: A new species (Scorpiones: Vaejovidae). *Euscorpius*, 86: 1–12.
- AYREY, R. F. 2012. A new *Vaejovis* from the Mogollon Highlands of northern Arizona (Scorpiones: Vaejovidae). *Euscorpius*, 148: 1–13.
- AYREY, R. F. 2013a. Reproduction in the “vorhiesi” group of the genus *Vaejovis* (Scorpiones: Vaejovidae). Part I. Clutch size *Euscorpius*, 166: 1–15.
- AYREY, R. F. 2013b. A new *Vaejovis* from the Mogollon Rim of northern Arizona (Scorpiones: Vaejovidae). *Euscorpius*, 176: 1–13.
- AYREY, R. F. & M. E. SOLEGLAD. 2011. A new species of *Vaejovis* from Prescott, Arizona (Scorpiones: Vaejovidae). *Euscorpius*, 114: 1–15.
- AYREY, R. F. & M. M. WEBBER. 2013. A new *Vaejovis* C. L. Koch, 1836, the second known *vorhiesi* group species from the Santa Catalina Mountains of Arizona (Scorpiones: Vaejovidae). *ZooKeys*, 270: 21–35.
- BRYSON, R. W., B. R. RIDDLE, M. R. GRAHAM, B. T. SMITH & L. PRENDINI. 2013. As old as the hills: montane scorpions in Southwestern North America reveal ancient associations between biotic diversification and landscape history. *PLoS ONE*, 8: 1–11.
- FET, V. & M. E. SOLEGLAD. 2005. Contributions to scorpion systematics. I. On recent changes in high-level taxonomy. *Euscorpius*, 31: 1–13.
- GRAHAM, M. R. 2006. Redescription and lectotype designation of *Vaejovis lapidicola* Stahnke (Scorpiones: Vaejovidae). *Euscorpius*, 46: 1–6.
- GRAHAM, M. R. 2007. Sky island *Vaejovis*: two new species and a redescription of *V. vorhiesi* Stahnke (Scorpiones: Vaejovidae). *Euscorpius*, 51: 1–14.
- GRAHAM, M. R., R. F. AYREY & R. W. BRYSON, JR. 2012. Multivariate methods support the distinction of a new highland *Vaejovis* (Scorpiones: Vaejovidae), from the Sierra de los Ajos, Mexico. *The Journal of Arachnology*, 40: 281–290.
- SOLEGLAD, M. E. & V. FET. 2003. The scorpion sternum: structure and phylogeny (Scorpiones: Orthosterni). *Euscorpius*, 5: 1–34.
- SOLEGLAD, M. E. & V. FET. 2008. Contributions to scorpion systematics. III. Subfamilies Smeringurinae and Syntropinae (Scorpiones: Vaejovidae). *Euscorpius*, 71: 1–115.
- SOLEGLAD, M. E. 1973. Scorpions of the Mexican group of the genus *Vaejovis*. *Wasmann Journal of Biology*, 31(2): 351–372.
- SOLEGLAD, M. E. & W. D. SISSOM, 2001. Phylogeny of the family Euscorpiidae Laurie, 1896: a major revision. Pp. 25–111 in Fet, V. & P.A. Selden (eds). *Scorpions 2001. In memoriam Gary A. Polis*. Burnham Beeches, Bucks: British Arachnological Society.
- STAHNKE, H. L. 1939. *The Scorpions of Arizona* (Ph.D. Dissertation, unpublished). Iowa State College, 184 pp.
- STAHNKE, H. L. 1940. The scorpions of Arizona. *Iowa State College Journal of Science*, 15(1): 101–103 (dissertation abstract).

STAHNKE, H. L. 1970. Scorpion nomenclature and mensuration. *Entomological News*, 81: 297–316.

VACHON, M. 1974. Etude des caractères utilisés pour classer les familles et les genres de Scorpions

(Arachnides). 1. La trichobothriotaxie en Arachnologie. Sigles trichobothriaux et types de trichobothriotaxie chez les Scorpions. *Bulletin du Museum National d'Historie Naturelle*, Paris, (Ser. 3), 140 (Zool. 104): 857–958.