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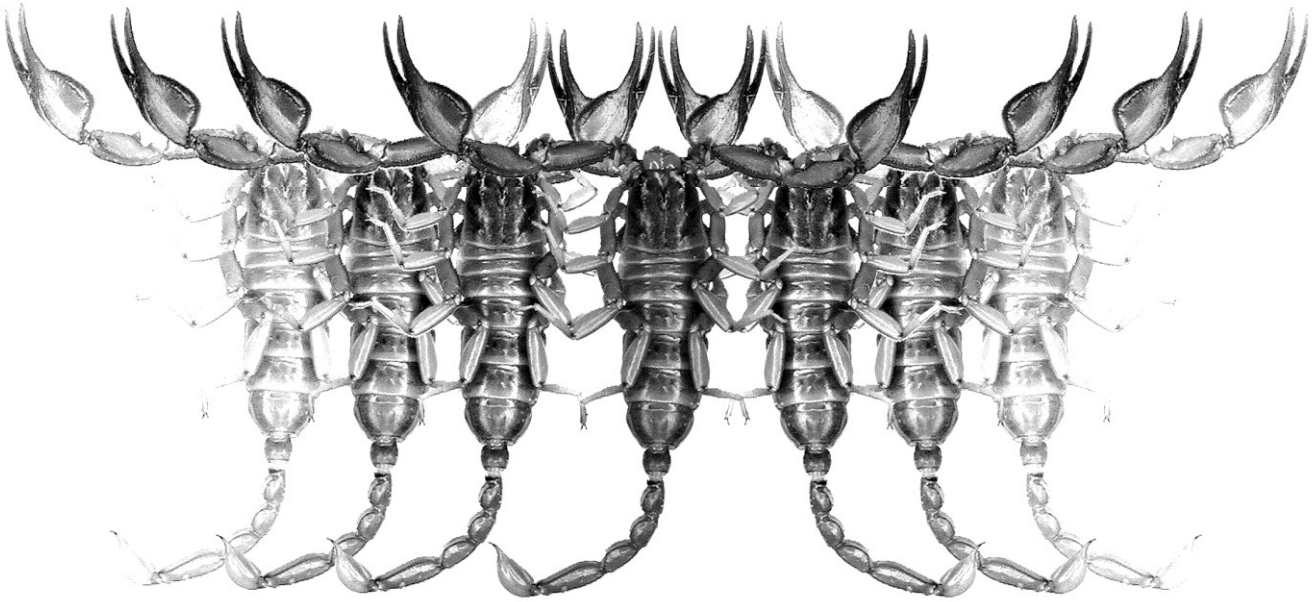

New Species of *Vaejovis* from the Whetstone Mountains, Southern Arizona (Scorpiones: Vaejovidae)

Richard F. Ayrey & Michael E. Soleglad

January 2015 — No. 194

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Publication date: 28 January 2015
http://zoobank.org/urn:lsid:zoobank.org:pub:B5D24928-5D29-40D8-8448-4953099A75EB

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

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http://zoobank.org/urn:lsid:zoobank.org:pub:B5D24928-5D29-40D8-8448-4953099A75EB

Summary

A new scorpion species, *Vaejovis troupi* **sp. n.**, is described and placed in the "*vorhiesi*" group of the genus *Vaejovis*. Based on a recent molecular analysis of Bryson et al. (2013), this species is shown to be related to *V. vorhiesi* and *V. grahami*. Two of three diagnostic characters found in this new species are the presence of six inner denticles (*ID*) on the pedipalpal fixed and movable fingers, and a unique arrangement of trichobothria on the external surface of the pedipalp patella. This species was found in an isolated montane habitat in the Whetstone Mountains, Cochise County, Arizona.

Introduction

Herbert Stahnke (1940) named the first species to be placed in the "vorhiesi" group of *Vaejovis*, all from Arizona: *V. vorhiesi*, *V. lapidicola*, and *V. jonesi*. Soleglad (1973: figs. 24–25) named the next species placed in this group, *V. paysonensis*, and was the first author to use the number of inner denticles (*ID*) of the chelal movable finger as a diagnostic character. Since then, including the new species described in this paper, fourteen additional species have been described and placed in the "*vorhiesi*" group. The number of *ID* on the movable finger is still used today to partition the many species in this group into two subgroups, which in general complies with distinct geographic areas. In total, there are now eighteen "*vorhiesi*" group species spanning Arizona, New Mexico, and Sonora, Mexico.

The Whetstone Mountains are one of the "sky islands" found in southeastern Arizona, close to the Huachuca and Santa Rita mountain ranges, and contain ideal habitat for "*vorhiesi*" group scorpions. Indeed, a single "*vorhiesi*" group scorpion was collected in the Whetstone Mountains by Robert Troup in October of 2009. However, after numerous attempts to collect additional specimens from this area, none have been found.

In this study, we examined the specimen from the Whetstone Mountains and compared it to two species from nearby sky islands: *V. vorhiesi*, from the Huachuca Mountains and *V. grahami*, from the Santa Rita Mountains. Our analysis identified three morphology-based diagnostic characters that differentiate the specimen from the Whetstone Mountains. In addition, in a recent phylogeographic analysis of "*vorhiesi*" group scorpions (Bryson et al., 2013), *V. vorhiesi* and *V. grahami* form a monophyletic group with the specimen from the Whetstone Mountains, and appears to have diverged from these two species as early as the Miocene. Based on this combination of genetic and morphological distinctiveness, we herein describe the specimen from the Whetstones as a new species.

Materials and Methods

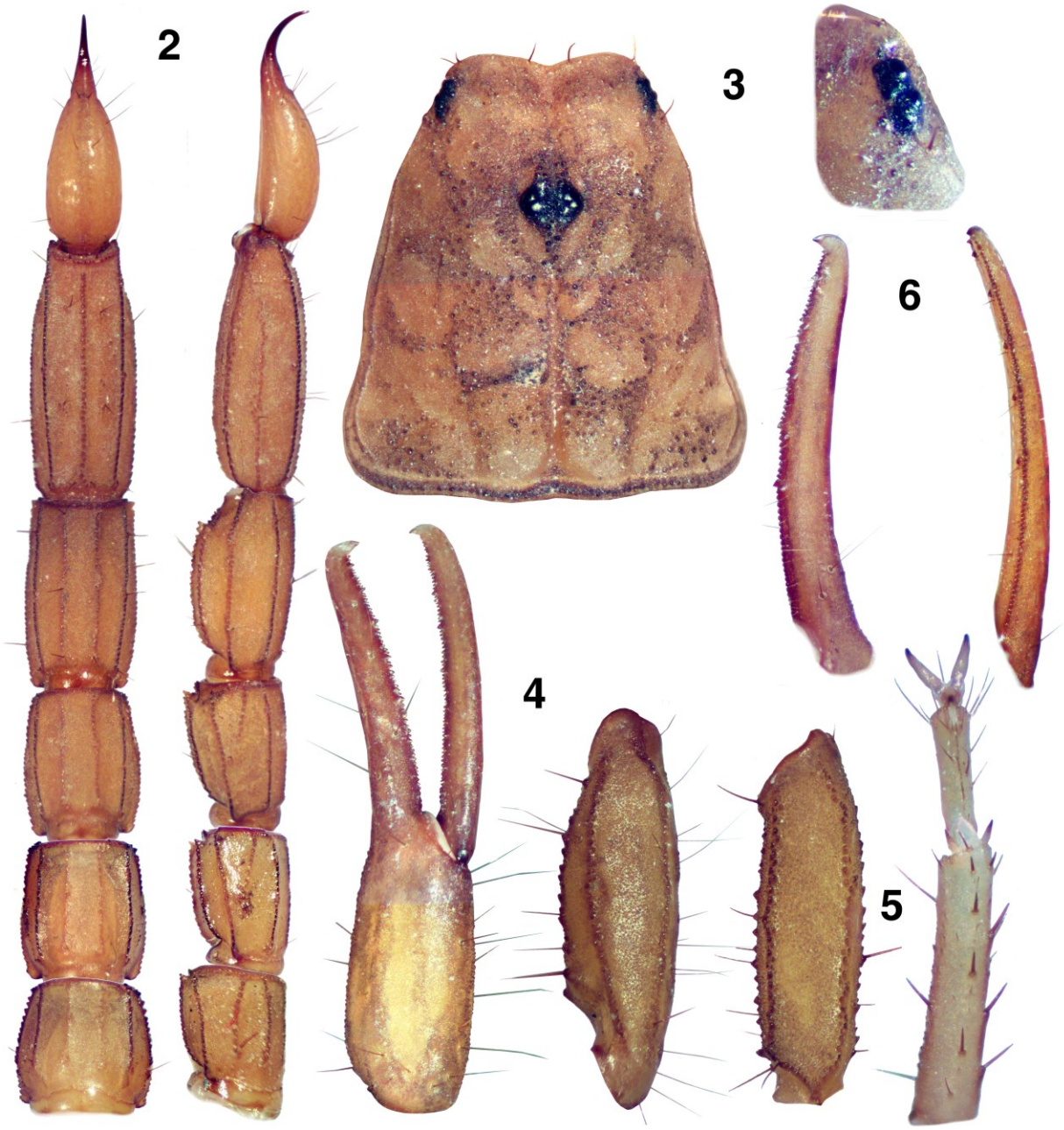
Terminology and conventions

Measurements are as described in Stahnke (1970), trichobothrial patterns are as in Vachon (1974), pedipalp finger dentition follows Soleglad & Sissom (2001), and sternum terminology as described in Soleglad & Fet (2003). The holotype was sequenced for the phylographic analysis of "*vorhiesi*" group scorpions by Bryson et al. (2013).

Abbreviations

RFA, personal collection of Richard F. Ayrey, Flagstaff, Arizona, USA; and USNM, United States National Museum, Smithsonian Institution, Washington, DC, USA.

Figure 1: *Vaejovis troupi* **sp. n.**, female holotype. In natural habitat (top) and on a leaf (bottom).



Figures 2-6: *Vaejovis troupi* **sp. n**., female holotype. **2.** Metasoma and telson, ventral and lateral views. **3.** Carapace and close-up of lateral eyes. **4.** Pedipalp chela, external view, patella and femur, dorsal views. **5.** Right leg III basitarsus and tarsus, ventral view. **6.** Chelal fixed and movable fingers, each exhibiting six inner denticles (*ID*).

Material

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

Vaejovis grahami Ayrey et Soleglad, 2014. USA: Arizona: Cochise Co.: Madera Canyon, Santa Rita Mountains, 12 May 2013, leg. R.F. Ayrey, ♀ holotype (USNM); 22 June 2009, leg. R. F. Ayrey, 1 ♀ (RFA); 4 September 2008, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂ (RFA); 3 October 2010, leg. R. F. Ayrey, 1 ♂ (RFA); Mount Hopkins, Santa Rita Mountains, 2 August 2010, leg. R. F. Ayrey, 1 ♀ 1 ♂ (RFA).

Vaejovis vorhiesi Stahnke, 1940. USA: Arizona: Cochise Co.: Miller Canyon, Huachuca Mountains, 24 May 2011, leg. R. F. Ayrey & M. M. DeBoer-Ayrey, 3 ♀ from type locality (RFA).

	V. troupi female holotype	*V. grahami* female holotype	*V. grahami* female paratype	*V. grahami* female paratype	*V. vorhiesi* female lectotype	*V. vorhiesi* female	*V. vorhiesi* female	*V. vorhiesi* female
	Whetstone Mountains	Santa Rita Mountains			Huachuca Mountains			
		Madera Canyon		Mt. Hopkins	Miller's Canyon			
Total length	25.70	26.90	26.30	23.85	24.28	24.80	25.05	28.25
Carapace length	3.40	3.45	3.45	3.30	3.36	3.50	3.30	3.45
Mesosoma length	7.10	7.90	7.55	6.15	10.00	7.70	7.90	10.50
Metasoma length	11.90	12.15	11.95	11.20	10.92	10.70	10.75	11.10
Segment I length/width	1.65/1.80	1.75/2.05	1.60/2.10	1.45/1.95	1.53/1.91	1.45/1.85	1.40/1.80	1.50/1.85
Segment II length/width	1.90/1.75	1.85/1.95	1.85/1.95	1.75/1.85	1.67/1.81	1.65/1.75	1.60/1.70	1.70/1.75
Segment III length/width	2.00/1.70	1.95/1.85	1.95/1.90	1.85/1.80	1.79/1.76	1.80/1.70	1.80/1.65	1.85/1.70
Segment IV length/width	2.70/1.60	2.70/1.80	2.65/1.85	2.55/1.65	2.52/1.65	2.40/1.55	2.45/1.55	2.50/1.55
Segment V length/width	3.65/1.50	3.90/1.65	3.90/1.75	3.60/1.65	3.41/1.53	3.40/1.55	3.50/1.50	3.55/1.55
Telson length	3.30	3.40	3.35	3.20	3.03	2.90	3.10	3.20
Vesicle length	2.15	2.25	2.25	2.00	1.95	1.70	1.85	2.00
width/depth	1.10/0.90	1.20/0.95	1.20/0.90	1.10/0.85	1.06/0.89	1.00/0.85	1.05/0.90	1.10/0.95
Aculeus length	1.15	1.15	1.10	1.20	1.08	1.20	1.25	1.20
Pedipalp length	11.65	11.40	11.00	10.90	10.73	10.65	10.55	11.00
Femur length/width	3.05/0.90	2.90/0.85	2.80/0.95	2.70/0.80	2.82/0.92	2.75/0.90	2.65/0.90	2.80/0.90
Patella length/width	3.35/1.05	3.45/1.15	3.25/1.15	3.25/0.95	2.99/1.06	3.10/1.00	3.10/1.00	3.20/1.05
Chela length	5.25	5.05	4.95	4.95	4.92	4.80	4.80	5.00
Palm length	2.15	2.15	2.00	2.05	2.00	2.00	1.90	2.00
width/depth	1.10/1.25	1.15/1.30	1.20/1.30	1.15/1.10	1.18/1.18	1.00/1.10	1.00/1.10	1.10/1.15
Fixed finger length	2.75	2.90	2.65	2.60	2.54	2.45	2.50	2.50
Movable finger length	3.35	3.35	3.15	3.00	3.08	2.90	3.00	3.05
Pectines teeth	11-12	13-12	14-14	13-12	13-13	13-13	12-13	12-12

Table 1: Morphometrics (mm) of *Vaejovis troupi* **sp. n.**, Whetstone Mountains, Cochise County, Arizona, USA, *V. grahami*, Madera Canyon, Santa Rita Mountains, Pima County, Arizona, USA (after Ayrey & Soleglad, 2014: tab.1, in part), and *V. vorhiesi* lectotype, Miller's Canyon, Huachuca Mountains, Cochise County, Arizona, USA (after Graham, 2007: 3–4, in part).

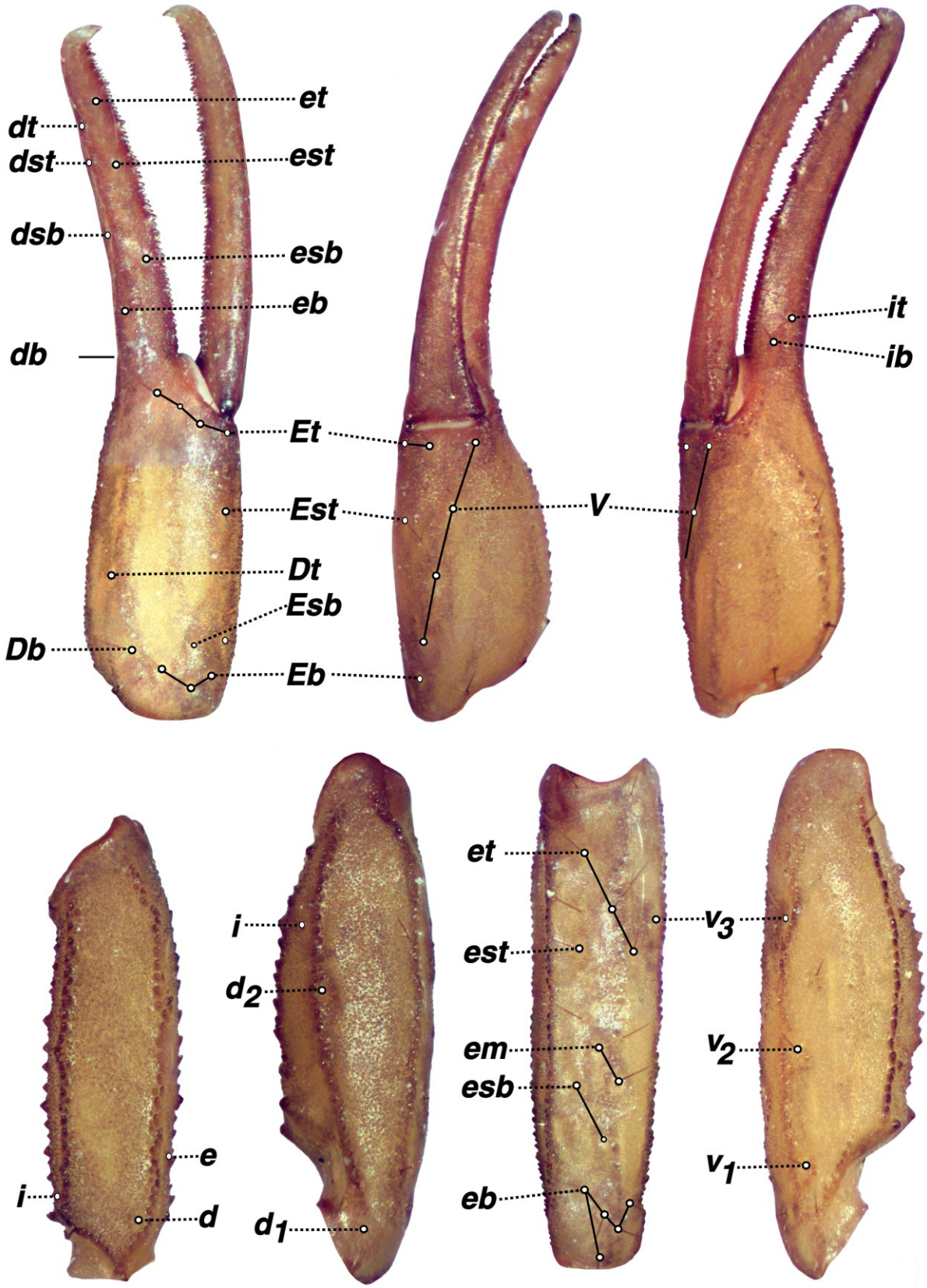


Figure 7: *Vaejovis troupi* **sp. n**., female holotype. Trichobothrial pattern.

Systematics

Family Vaejovidae Thorell, 1876
Subfamily Vaejovinae Thorell, 1876
Genus ***Vaejovis*** Thorell, 1876

Vaejovis troupi Ayrey et Soleglad, sp. n.

Figs. 1–7, 10; Tables 1–2
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References:

Vaejovis sp. cf. *vorhiesi*: Ayrey, 2013a: 3; Ayrey, 2013b: 2; Ayrey, 2014: 3; *Vaejovis* sp., *vorhiesi* group: Bryson et al., 2013: 5.

Diagnosis: Medium sized species, 26 mm in length (only female known); light brown in color with variegated patterns on the carapace, lighter mottlings on the mesosoma, pedipalps, and legs. Pectinal tooth counts 11–12. Chelal fingers with six inner denticles (*ID*) on both the movable and fixed fingers. Patellar external trichobothria *est–et*$_3$*–v*$_3$ form an angle, *et*$_3$ occurring more proximally.

Etymology. This species is named in honor of Robert Troup who found the only specimen.

Distribution. Known only from the type locality, Whetstone Mountains, Cochise County, Arizona, USA.

Type material. Holotype female, Whetstone Mountains, Cochise County, Arizona, USA (31.81093, -110.39370; 1607 m asl), 14 October 2009, leg. R. Troup, specimen #RA223, deposited in USNM.

FEMALE. Description based on holotype female. See Table 1 for measurements.

COLORATION. Color is medium brown, slightly lighter on the legs, telson orange. Weak underlying mottling is visible on the carapace, mesosoma, pedipalps, and legs.

CARAPACE (Fig. 3). Anterior margin of carapace with a conspicuous wide emargination. Carapace moderately granular occurring primarily in the subtle mottled areas. Three lateral eyes on each side, the most proximal the smallest. Ratio of median eyes position from anterior edge/carapace length 0.340; carapace length/width at median eyes 1.442.

MESOSOMA. Tergites moderately granular on proximal half on segments I–VI. Tergite VII with strong crenulated median and lateral carina. Sternites III–VI smooth. Sternite VII with rough surface with weak ventral lateral carinae. 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.

PECTINES. With three anterior lamellae, 8/8 middle lamellae, and 11/12 teeth. Sensorial areas present on all teeth and fulcra are present.

METASOMA (Fig. 2). Segments I–IV: dorsal and dorsolateral carinae strong and serrate with distal denticle of I–III enlarged and spinoid, and spinoid on the dorsal carinae and expanded and flared on the dorsolateral carinae for segment IV. Lateral carinae strong and serrate on I, present on posterior 2/3 of II, posterior 1/3 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. Anal arch with approximately 16 small denticles. Dorsal intercarinal spaces irregularly granular.

TELSON (Fig. 2). Smooth with several setae on ventral surface. Vesicular tabs with one to two small pointed granules. Subaculear tubercle present but small. LAS present exhibiting 5–6 serrations.

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

PEDIPALP (Figs. 4, 6–7). 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 and ventrointernal carinae 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 14 serrated granules. **Chela.** Digital (*D1*) carina weak, with small irregularly placed granules, 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 with pointed granules, ventroexternal (*V1*) and ventromedian (*V2*) carinae rounded and smooth, ventrointernal (*V3*) rounded with

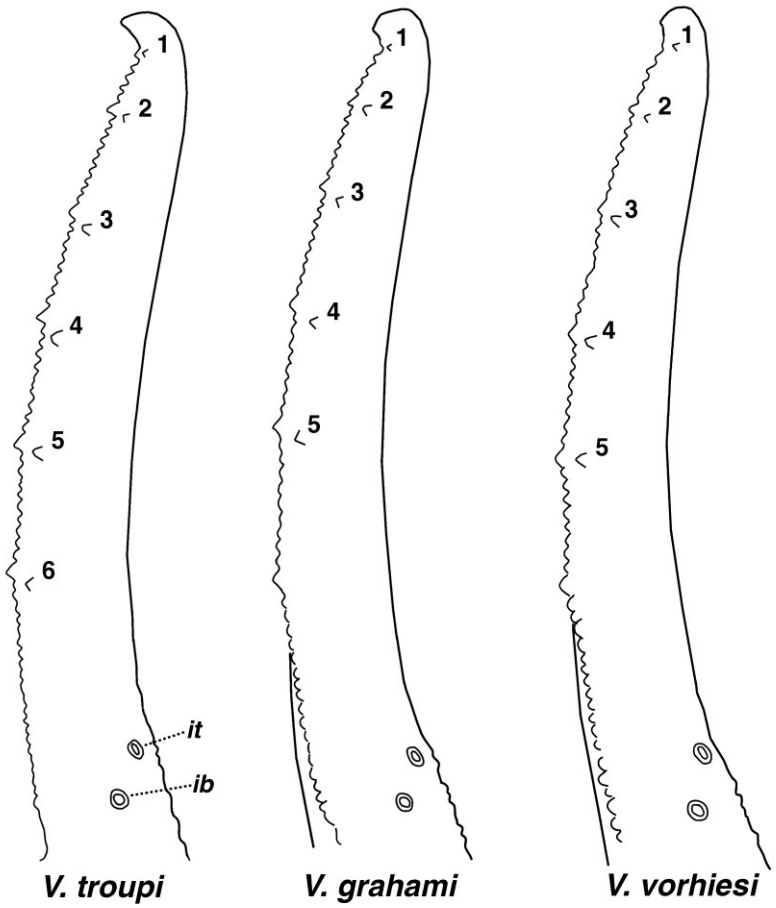

Figure 8: Chelal fixed finger dentition showing the number of inner denticles (*ID*). **Left.** *Vaejovis troupi* **sp. n.**, holotype female (left fixed finger, reversed). **Center.** *V. grahami*, Madera Canyon, Santa Rita Mountains. **Right.** *V. vorhiesi*, Miller's Canyon, Huachuca Mountains. Of particular interest, note that *V. troupi* has six *ID* denticles whereas the other two species exhibit only five *ID* denticles. Internal trichobothria *ib* and *it* are shown.

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 6 *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 7). 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. Trichobothrium et_3 is located proximal of a line connecting *est* and v_3.

LEGS (Fig. 5). Ventral surface of tarsomere II with single median row of spinules terminating distally with one spinule pair.

Reproduction. This species is not represented in the *Vaejovis* "vorhiesi" group study (Ayrey, 2013a) but is presumed to have behavior similar to the rest of the group. The "vorhiesi" group average clutch size is 22.87 first instars (n=100 births, 2,287 first instars). Being one of the larger species it would have a relatively large clutch size, estimated to be approximately 25 first instars. Birth and postpartum behavior would be as described in Ayrey (2013a).

Comparison of Species

With the description of *Vaejovis troupi* presented herein, 18 species are now currently placed in the "*vorhiesi*" group of *Vaejovis*. Morphologically, these species are roughly partitioned into two presumably phylogenetic groups, those with seven inner denticles (*ID*) on the chelal movable finger (seven species), found primarily in central to northern Arizona, and those with six *ID* (eleven species) located primarily in southeastern Arizona, southwestern New Mexico, and northern Mexico (see Map in Fig. 11).

In this contribution we compare *V. troupi* to two other species, *V. grahami* and *V. vorhiesi*, both which are found in adjacent sky island mountain ranges in southeastern Arizona. The choice of these two species is based, in part, on the recent phylogenetic analysis based on molecular considerations (see Bryson et al., 2013), which suggests that these two species are the closest relatives of *V. troupi* (see below).

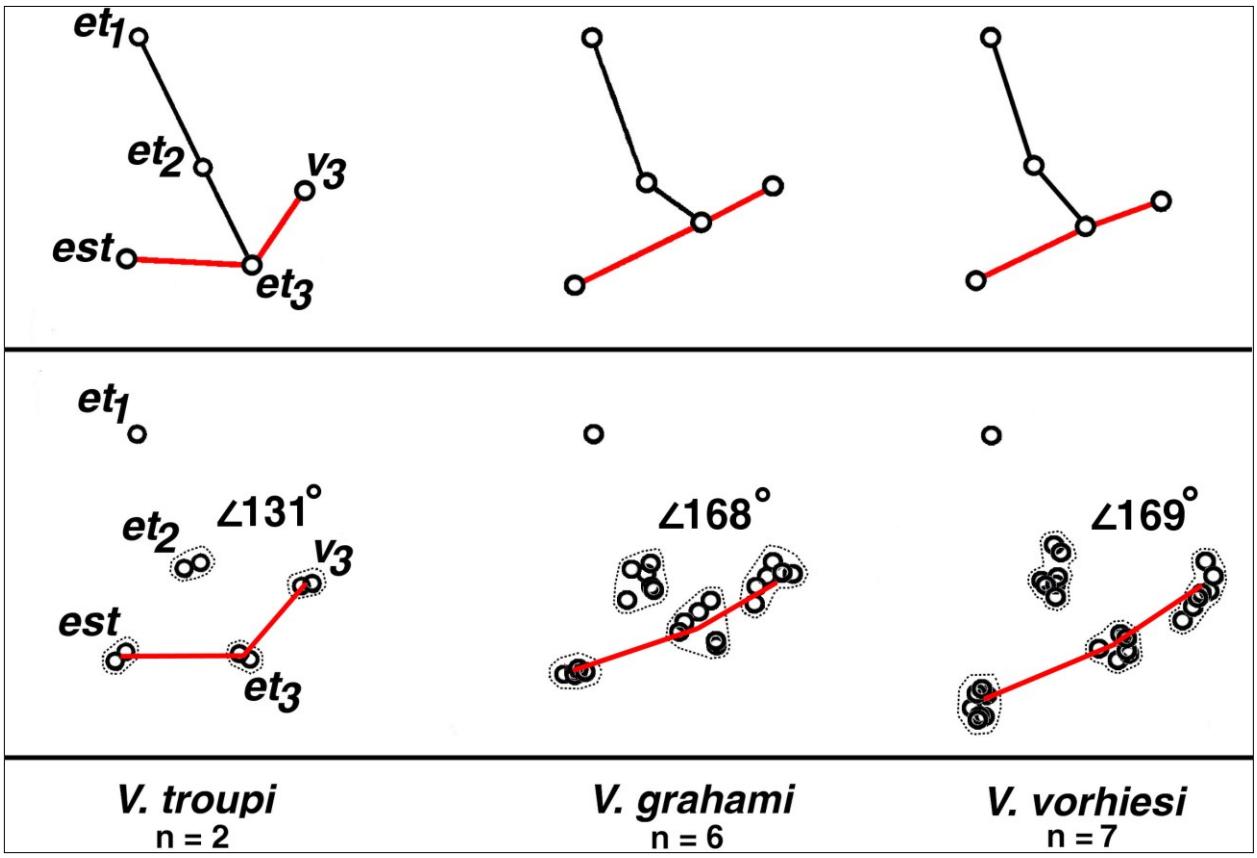

Figure 9: Comparison of the relative positions of five patellar trichobothria et_1–et_3, *est*, and v_3 of species *Vaejovis troupi* **sp. n.**, *V. grahami*, and *V. vorhiesi*. **Top.** Trichobothria positions of the three female type specimens. *Red lines* indicate the angle formed by trichobothria *est–et3–v3*, contrasting *V. troupi* from the other two species. **Bottom.** Each individual pattern for a pedipalp patella is anchored at trichobothrium et_1 while other trichobothria are plotted at their relative locations forming clusters. *Red lines* indicate the *average* angle formed by trichobothria *est–et3–v3*. Patterns of left patellae were reversed for these plots which are shown from a right-patella perspective. Only adult female specimens were used in these plots. Number below species name indicates the number of pedipalp patellae considered. Information for *Vaejovis vorhiesi* and *V. grahami* lectotype/holotype females was extracted from Graham (2007: fig. 9) and Ayrey & Soleglad (2014: fig. 11).

Geological considerations. Weldon Heald (1951) coined the term "Sky Islands" to describe the distinct isolated groups of Madrean pine-oak woodlands found at higher elevations in a complex of small mountain ranges in southern and southeastern Arizona, southwestern New Mexico, and northwestern Mexico. These "Sky Islands" are surrounded at lower elevations by the Sonoran and Chihuahuan Deserts thus essentially being isolated by different extreme xeric climates and different micro-habitats. Here we use an expanded definition that includes all isolated, high elevation habitats in Arizona, New Mexico and Mexico. Many habitats in northern Arizona and northern New Mexico are high elevation habitats isolated by the intervening Colorado Plateau. Graham (2007: 1) states: "...Faunas adapted to these isolated mountain environments are therefore disconnected from similar habitat on adjacent mountain ranges by extreme climates of xeric lowlands. ...". This paper applies to the isolated, elevation habitats on the Colorado Plateau as well as it does the Madrean pine-oak woodlands of the south.

These three species are found in three separate geographically close, but distinctly isolated, mountain ranges, *V. troupi* found in the Whetstone Mountains, *V. grahami* from the Santa Rita Mountains, and *V. vorhiesi* from the Huachuca Mountains (see Fig. 10). These three isolated mountain ranges are situated quite close to each other, only 45 – 66 km separate the type localities of these three species. The Huachuca Mountains are the most southern and highest, their Miller's Peak reaching 2878 m. It extends roughly 32 km in a north to southeast direction reaching Mexico. The Santa Rita Mountains are the largest mountain range, extending roughly 42 km, with its highest point Mount Wrightson at 2863 km. The Whetstone Mountains, which are located directly north of the Huachuca Mountains, is the smallest range, only 18 km long in a north to south direction, its highest point is the Apache Peak at 2346 m. Figure 10 states the

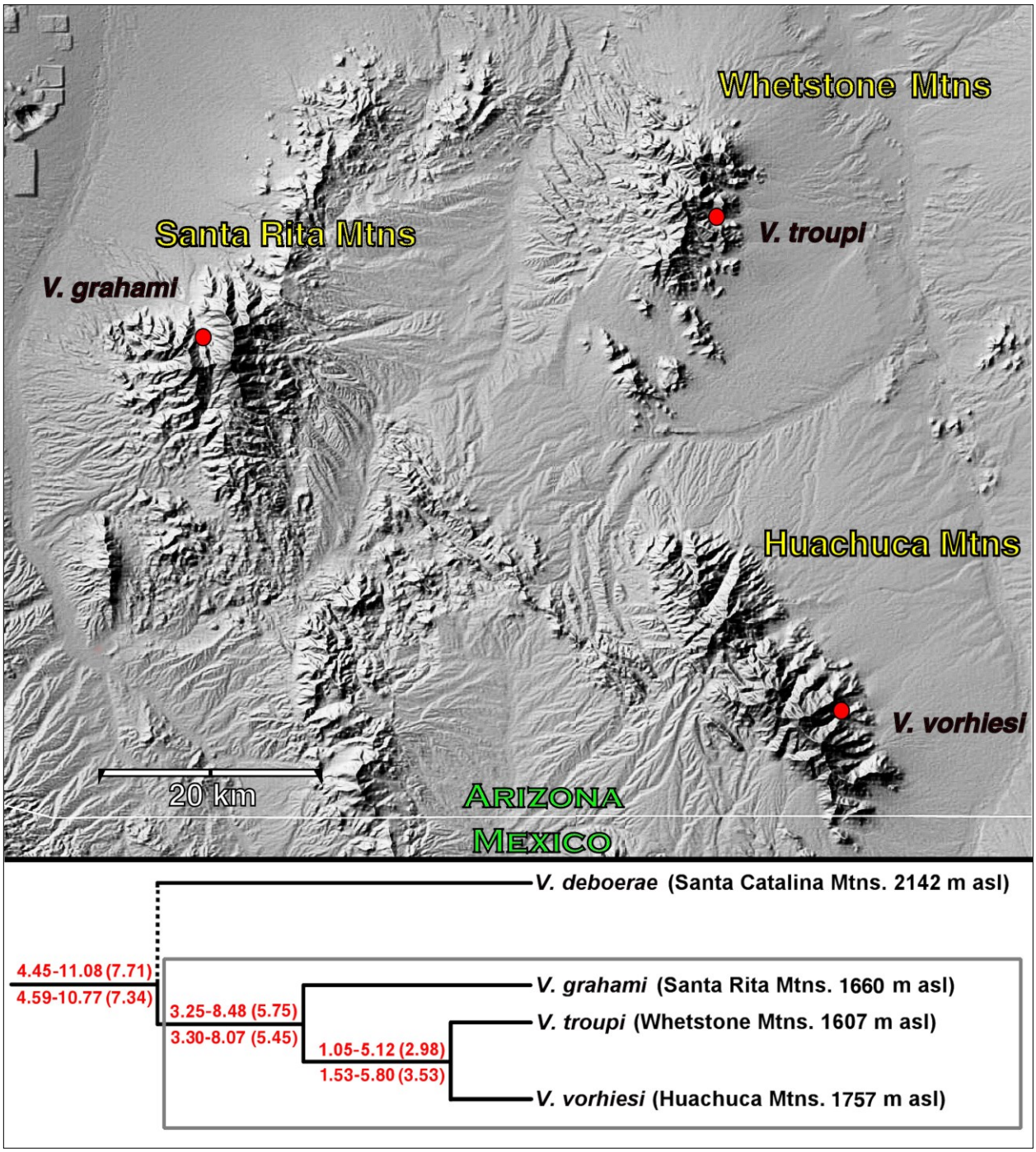

Figure 10: Proposed geographic and molecular relationships of "sky island" species *Vaejovis troupi* **sp. n.**, *V. grahami*, and *V. vorhiesi*. **Top.** Close-up of southeastern Arizona showing the type localities of the three species and the distinct, isolated "sky island" mountain ranges in which they occur, Whetstone, Santa Rita, and Huachuca Mountains, respectively. **Bottom.** A partial chronogram based on molecular data showing proposed phylogenetic relationships based on evolutionary time (red numbers). Red numbers above branch indicate estimates for a multilocus species tree, bottom numbers represent a mtDNA gene tree. Means and 95% highest posterior densities are shown for each node. Red numbers indicate proposed minimum, maximum, and mean Mya. Information is from Bryson et al. (2013: fig. S2). Gray rectangle delineates the three species discussed in this paper. Altitude data is that of the type localities.

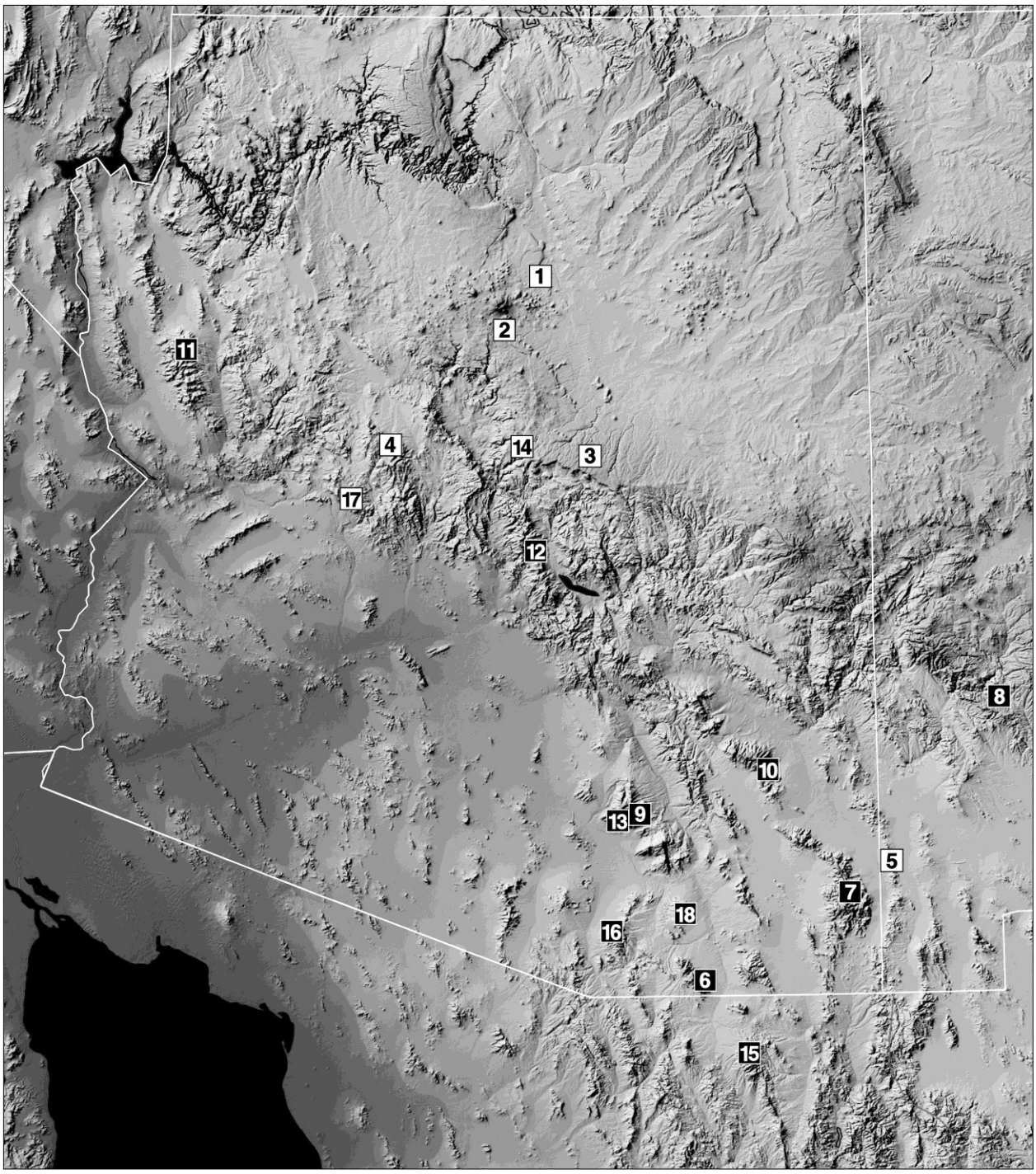

Figure 11: Map of Arizona, extreme western New Mexico and northern Sonora (Mexico) showing the type locality of all 17 *Vaejovis* "vorhiesi" group species, including new species *Vaejovis troupi*. Localities are divided into those species exhibiting seven inner denticles (*ID*) on the chelal movable finger (white rectangles with black lettering) and those with primarily six, or five *ID* denticles (black rectangles with white lettering). **Seven *ID*s: 1** = *V. jonesi*, **2** = *V. lapidicola*, **3** = *V. paysonensis*, **4** = *V. crumpi*, **5** = *V. bigelowi,* **14** = *V. trinityae*, **17 =** *V. grayae*. **Six *ID*s: 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,* **16** = *V. grahami*, and **18** = *V. troupi* **sp. n**.

	V. troupi	*V. grahami*	*V. vorhiesi*
Seg-I: L/W	0.917 > △16.6, 15.6 %	0.744–0.854 (0.787) (±0.059) [3]	0.778–0.811 (0.794) (±0.015) [4]
Seg-II: L/W	1.086: >△14.6, 15.0 %	0.946–0.949 (0.948) (±0.002) [3]	0.923–0.971 (0.945) (±0.020) [4]
Seg-III: L/W	1.176: >△13.5, 10.6 %	1.026–1.054 (1.036) (±0.016) [3]	1.017–1.091 (1.064) (±0.034) [4]
Seg-IV: L/W	1.688: >△13.1, 7.7 %	1.432–1.545 (1.492) (±0.057) [3]	1.527–1.613 (1.567) (±0.038) [4]
Seg-V: L/W	2.433: >△7.7, 7.6 %	2.182–2.364 (2.258) (±0.094) [3]	2.194–2.333 (2.262) (±0.062) [4]

Table 2: Comparison of morphometric ratios of the metasoma based on the measurements of female specimens presented in Table 1. In these ratios, *Vaejovis troupi* **sp. n.** exhibits the more slender metasoma when compared to the other two species (as indicated by a larger ratio value), ranging from 8 to over 16 percent mean value difference (MVD). Statistical data group: minimum–maximum (mean) (±standard deviation) [number of samples]. Seg = metasomal segment, L = length, W = width.

altitudes of the type localities of the three species found in these three mountain ranges.

Molecular considerations. In an important study conducted by Bryson et al. (2013) using multilocus data (mtDNA and two nuclear genes), they explored the phylogeographic structure of the "*vorhiesi*" group. The dataset was generated from 63 samples of "*vorhiesi*" group scorpions including 11 of the then described species as well as many other populations. Important to this paper, the dataset included species *V. vorhiesi* and specimens from two populations, the Santa Rita Mountains, now named *V. grahami*, and the Whetstone Mountains, the location of *V. troupi*, the new species described in this paper. In their study divergence times were estimated across the mtDNA dataset and the multilocus species tree, and the temporal distribution of divergence events was modeled across southwestern North America. The result of their study placed *V. grahami*, *V. troupi*, and *V. vorhiesi* in a terminal clade, implying that they were the most closely related. Both the multilocus species tree and mtDNA gene tree analyses supported this result. Their chronograms (Bryson et al., 2013: fig. S2) showed the estimated divergence times (in millions of years, Mya) as follows: for the multilocus species tree, 3.25–8.48 (5.75) Mya for *V. grahami* and *V. vorhiesi* + *V. troupi*, and for the mtDNA gene tree, 3.3–8.07 (5.45) Mya for *V. grahami* and *V. vorhiesi* + *V. troupi*. Similarly, multilocus species tree, 1.05–5.12 (2.98) Mya for *V. vorhiesi* and *V. troupi*, and mtDNA gene tree, 1.53–5.80 (3.53) Mya for *V. vorhiesi* and *V. troupi*.

It should also be noted that the Bryson et al. (2013) study placed species *V. deboerae* and *V. tenuipalpus* in the same basic clade as our three subject species, but earlier chronologically, exhibiting 4.45–11.08 (7.71) Mya and 8.07–18.19 (12.78) Mya, respectively.

Morphological considerations. We have isolated three morphology-based characters that distinguish *V. troupi* from species *V. grahami* and *V. vorhiesi*: 1) number of inner denticles (*ID*) on the chelal fingers; 2) comparative positions of certain patellar trichobothria; and 3) morphometric ratios of the metasomal segments. Of course, it must be emphasized here that only one specimen of *V. troupi*, a female, is currently available for examination, and the male is unknown. Therefore, some variability should be expected as more specimens are collected and studied.

All three species exhibit six *ID* on the chelal movable finger, also common to eight other species in the "*vorhiesi*" group (see map in Fig. 11). Unusual, however, are the six *ID* also found on the fixed finger in *V. troupi* (found on both chelae), somewhat unusual in this species subgroup that only have six *ID* on the movable finger. In contrast, *V. grahami* and *V. vorhiesi*, on an average, only have five *ID* on the fixed finger (see Fig. 8). Other species contained in the species set with six *ID* on the movable finger, only *V. tenuipalpus*, Sissom et al. (2012: fig. 4D) and *V. electrum* Hughes (2011: fig. 8d) match *V. troupi* with six *ID* on the fixed finger, as these authors illustrated for the type specimens. It should be stated here, however, that variability does occur on the number of *ID* found on the fixed finger for "vorhiesi" group species. For example, Sissom (2012: 12) reported 4–6 (5.732) [56] for *V. tenuipalpus*; for *V. grahami*, six specimens, we encountered significant variability, 5–6 (5.417) [12]; however, in stark contrast, *V. vorhiesi* exhibited 5 *ID* on the fixed finger for four specimens (including lectotype as described by Graham (2007: 6)).

We compared the relative positions of five external patellar trichobothria et_1–et_3, *est*, and v_3 in species *V. troupi*, *V. grahami*, and *V. vorhiesi* (see Fig. 9). Both patellae of *V. troupi* and thirteen patellae of *V. grahami* and *V. vorhiesi* were included in this analysis, demonstrating little variability in the relative positions of these five trichobothria. In Figure 9 we plotted the five trichobothria by anchoring each patellar pattern to trichobothrium et_1, allowing the other trichobothria to form clusters. It is apparent that these trichobothria in general form fairly tight clusters, thus demonstrating minimal variability in their relative positions. In Figure 9, we see

that et_3 in *V. troupi* is noticeably proximal to a line connecting *est* and v_3, forming an angle of approximately 130 degrees. In the other two species et_3 is essentially located in this connecting line, thus the angle is quite obtuse, over 165 degrees. This difference in the relative pattern can be attributed to a couple of observations. In general the distance between et_1 and et_2 is approximately the same as between et_2 and et_3 in *V. troupi*. For the other two species, the distance between et_2 and et_3 is shorter. Trichobothria et_1–et_3 are essentially in a straight line in *V. troupi*, whereas et_3 is out of line, closer to the ventral edge in the other two species. Based on the analysis of published trichobothrial patterns of other sky island species which exhibit six *ID* on the movable finger, we see that species *V. deboerae* and *V. halli* have patterns similar to that described for *V. troupi* (see Ayrey, 2009: fig. 14; and Ayrey, 2012: fig. 10).

We compared several morphometric ratios between the *V. troupi* female and *V. grahami* (three females) and *V. vorhiesi* (four females, including the lectotype measurements contained in Graham (2007: 3–4)). These measurements are presented in Table 1. The *V. troupi* female has a relatively thinner metasoma than female *V. grahami* and *V. vorhiesi* (see Table 2), ranging from 8 to over 16 percent mean value differences (MVD). In particular, the basal segments I–III exhibit the largest differences.

Acknowledgments

We would like to thank Robert Troup and Tom Miscione for joining RA on eight field trips to the Whetstone Mountains, Victor Fet for his useful comments, and two anonymous reviewers.

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