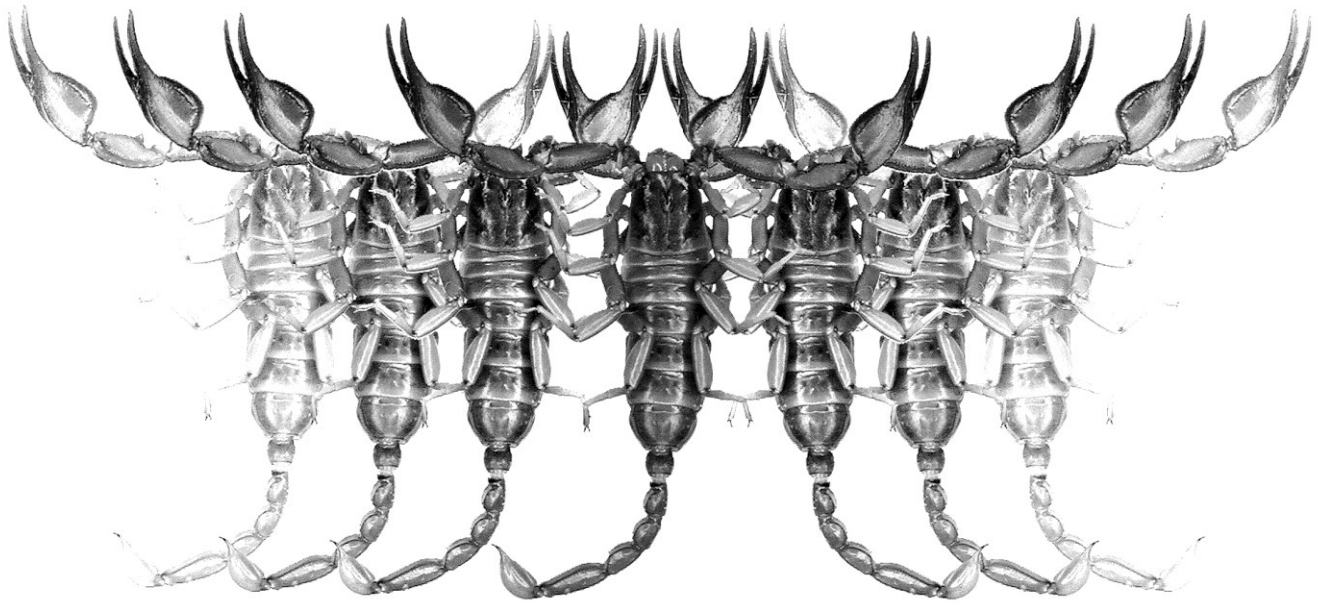


Euscorpius

Occasional Publications in Scorpiology



**Reproduction and Birth in the “Vorhiesi” Group of the
Genus *Vaejovis* (Scorpiones: Vaejovidae).
Part I. Clutch Size**

Richard F. Ayrey

September 2013 — No. 166

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: 16 September 2013

<http://zoobank.org/urn:lsid:zoobank.org:pub:F7B35A40-4437-472E-921F-C0F62278680E>

Reproduction and birth in the “vorhiesi” group of the genus *Vaejovis* (Scorpiones: Vaejovidae). Part I. Clutch size

Richard F. Ayrey

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

<http://zoobank.org/urn:lsid:zoobank.org:pub:F7B35A40-4437-472E-921F-C0F62278680E>

Summary

A total of 2,287 newborn scorpions were counted and photographed on 100 females of all 12 described species of the “vorhiesi” group of the genus *Vaejovis* (Scorpiones: Vaejovidae) found in Arizona, USA, and several undescribed species. Average clutch size for the “vorhiesi” group and for each individual species is reported. The data clearly shows that the larger species have more young, per parturition, than the smaller species. Representative photographs are presented for each species discussed.

Introduction

There exists some confusion about the reproductive characteristics of the “vorhiesi” group of the genus *Vaejovis*. Much of the available biological literature about the genus, summarized by Gary A. Polis in 1990, includes information on scorpions that have since been placed in other genera (Soleglad & Fet, 2008).

Beginning with *Vaejovis deboerae* Ayrey, many recent Vaejovidae species descriptions have included some reproductive information and photographs of females with newborn (Ayrey, 2009, 2011, 2012; Ayrey & Soleglad, 2011; Ayrey & Webber, 2013). Presented here is information on all of the currently described species of the “vorhiesi” group found in the state of Arizona, as well as several additional undescribed species. Clarification of other aspects of the reproductive biology of this group, such as iteroparity, gestation period, etc. is also presented.

Materials and Methods

Terminology and conventions

Undescribed species are listed with the locality names assigned to them in Bryson et al. (2012). A chart was drawn with the help of software available at chartgo.com.

Abbreviations

RFA, personal collection of Richard F. Ayrey, Flagstaff, Arizona, USA; MES, personal collection of Michael E. Soleglad, Winchester, California, USA;

CNAN, Colección Nacional de Arácnidos, Instituto de Biología, Universidad Nacional Autónoma de México, Mexico, D.F.; UANL, Universidad Autónoma de Nuevo León, San Nicolás de los Garza, Nuevo León, Mexico; USNM, United States National Museum, Smithsonian Institution, Washington, DC, USA.

Material

The following species and specimens were examined:

Vaejovis bandido Graham, Ayrey et Bryson, 2012.

Mexico: Sonora: Sierra de los Ajos Mountains, 12–13 October 2010, 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 Highway near Seven Cataracts Vista, Santa Catalina Mountains, 16 March 2012, R.W. Bryson Jr., 1 ♂, 7 ♀ (RFA). Same locality, 5 April 2012, R.W. Bryson Jr. & D. Hartman, 8 ♀ (RFA). Same locality, 18 August 2012, R. F. Ayrey & M. DeBoer-Ayrey, 8 ♀ (RFA).

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

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

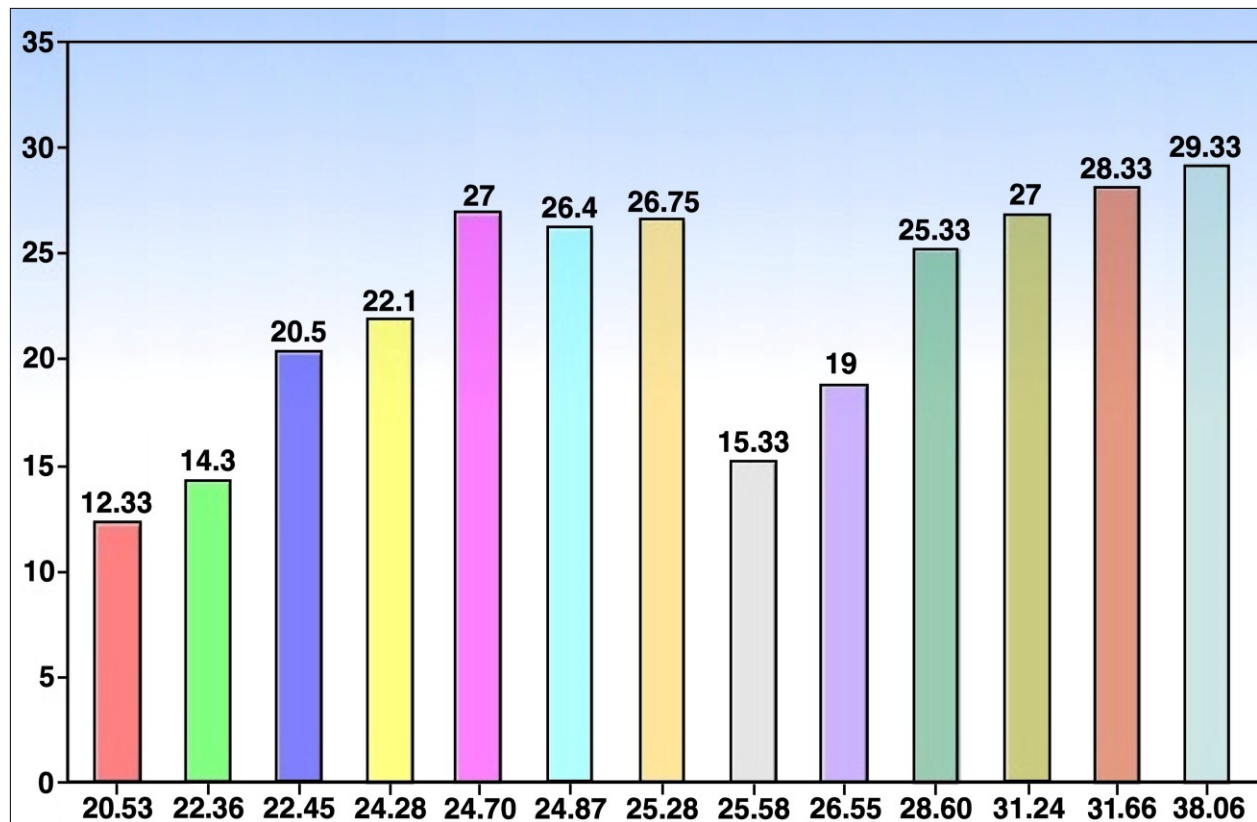


Figure 1: Clutch size compared to average adult female length, by species. The y-axis shows the average clutch size and the x-axis shows the average adult female length. Refer to average adult size on bottom of graph bars with Table 1 to determine the species.

- 2010, 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, R. F. Ayrey & M. M. DeBoer-Ayrey, 3 ♂, 5 ♀ (RFA). Same locality, 29 August 2011, R. F. Ayrey & M. M. DeBoer-Ayrey, 4 ♂, 4 ♀ (RFA).
- Vaejovis electrum* Hughes, 2011. USA: Arizona: Graham Co.: Upper Arcadia Campground, Mount Graham, 17 July 2009, R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 6 ♀ (RFA). USA: Arizona: Graham Co.: 9415 feet a.s.l., Mt. Graham Hwy., Mt. Graham, 18 July 2009, R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 4 ♀ (RFA).
- Vaejovis feti* Graham, 2007. USA: New Mexico: Meadow Creek, Black Mountains, 6 July 1978, M. H. Muma, 4 ♂, 3 ♀ (MES).
- Vaejovis halli* Ayrey, 2012. USA: Arizona: Gila Co.: Mount Ord, 11 September 2010, R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 6 ♀, paratypes (RFA). Same locality, 2 May 2011, R. F. Ayrey & M. M. DeBoer-Ayrey, 3 ♂, 5 ♀, paratypes (RFA).
- Vaejovis jonesi* Stahnke, 1940. USA: Arizona: Coconino Co.: near Wupatki National Monument, 1 April 2011, R. F. Ayrey, 1 ♀ from type locality (RFA).
- Vaejovis lapidicola* Stahnke, 1940. USA: Arizona: Coconino Co.: Red Sandstone Quarry, Flagstaff, 1 June 2011, R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 7 ♀ from type locality (RFA).
- Vaejovis* sp. cf. *lapidicola* "Strawberry". USA: Arizona: Coconino Co., along the Mogollon Rim, 1924 m a.s.l., 31 August 2008, R.F. Ayrey, 1 ♂, 4 ♀ (RFA). Same locality, 31 May 2009, R. F. Ayrey & M. DeBoer-Ayrey, 8 ♀ (RFA). Same locality, 14 August 2010, R. F. Ayrey & M. DeBoer-Ayrey, 8 ♀ (RFA). Same locality, 16 September 2011, R. F. Ayrey & M. DeBoer-Ayrey, 2 ♂, 6 ♀ (RFA). Same locality, 17 October 2011, R. F. Ayrey & M. DeBoer-Ayrey, 1 ♀ (RFA). Same locality, 18 May 2012, R. F. Ayrey & M. DeBoer-Ayrey, 2 ♂, 2 ♀ (RFA).
- Vaejovis paysonensis* Soleglad, 1973. USA: Arizona: Coconino Co.: Control Road, 25 miles E of Payson, 5 July 2011, R. F. Ayrey & M. M. DeBoer-Ayrey, 1 ♂, 7 ♀ from type locality (RFA). Same locality, 6 July 2011, R. F. Ayrey & M. M. DeBoer-Ayrey, 2 ♂, 6 ♀ (RFA).

Species	Clutch Size	Average Adult Female Length (mm)
<i>Vaejovis brysoni</i>	20–32 (26.75) (± 5.737) [4] (0.214)	25.28
<i>Vaejovis cashi</i>	10–15 (12.33) (± 2.517) [3] (0.204)	20.53
<i>Vaejovis crumpi</i>	17–21 (19.00) (± 2.000) [3] (0.105)	26.55
<i>Vaejovis deboerae</i>	21–35 (28.33) (± 7.024) [3] (0.248)	31.66
<i>Vaejovis electrum</i>	23–31 (26.40) (± 3.209) [5] (0.122)	24.87
<i>Vaejovis feti</i>	13–16 (14.30) (± 1.527) [3] (0.107)	22.36
<i>Vaejovis halli</i>	17–24 (20.50) (± 3.512) [4] (0.171)	22.45
<i>Vaejovis jonesi</i>	23–33 (29.33) (± 5.507) [3] (0.188)	38.06
<i>Vaejovis lapidicola</i>	21–33 (25.33) (± 3.674) [9] (0.145)	28.60
<i>Vaejovis</i> sp. “Strawberry”	21–34 (27.00) (± 6.557) [3] (0.243)	24.70
<i>Vaejovis paysonensis</i>	13–18 (15.33) (± 1.861) [6] (0.121)	25.58
<i>Vaejovis tenuipalpus</i>	18–30 (27.00) (± 4.647) [6] (0.172)	31.24
<i>Vaejovis vorhiesi</i>	14–31 (22.10) (± 5.021) [10] (0.227)	24.28

Table 1: Statistical data on “vorhiesi” group species clutch size and adult female length. Data presented as: minimum–maximum (mean) (\pm SD) [N] (cv).

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

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

Vaejovis sp. cf. *vorhiesi* “Santa Rita”. USA: Arizona: Cochise Co.: Madera Canyon, Santa Rita Mountains, 11 June 2010, R. F. Ayrey & M. M.

DeBoer-Ayrey, 1 ♂, 7 ♀ (RFA). Mount Hopkins, Santa Rita Mountains, 6 October 2009, R. F. Ayrey, T. Miscione & R. Troup, 2 ♂, 6 ♀ (RFA).

Vaejovis sp. cf. *vorhiesi* “Whetstone”. USA: Arizona: Cochise Co.: French Joe Canyon, Whetstone Mountains, 14 October 2009, R. Troup, 1 ♀ (RFA).

Results and Discussion

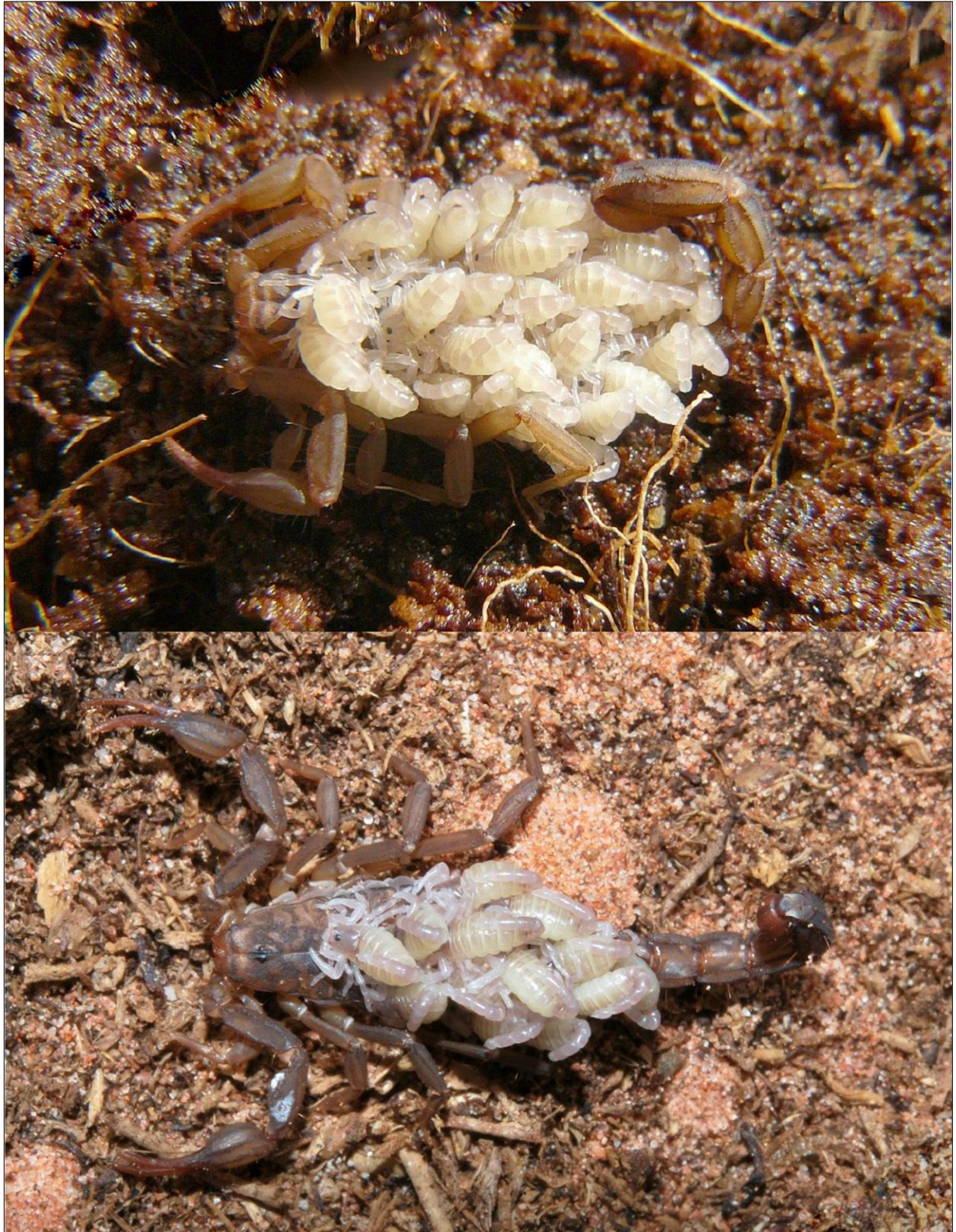
Several females of each Arizona “vorhiesi” group species were kept alive in the laboratory, without males, in order to observe parturition and to determine the gestation period and clutch size of these apoikogenic scorpions. Most of the 100 females gave birth in July and August of the year they were collected. This period coincides with the “Monsoon” season in Arizona, when the temperature and humidity are high. Those collected during or after the “Monsoon” season and kept without males, gave birth the following year during the same



Figures 2–3: **2 (top).** *Vaejovis brysoni* Ayrey & Webber, 2013, paratype female with newborn. **3 (bottom).** *Vaejovis cashi* Graham, 2007, female with newborn, Cave Creek, Arizona.



Figures 4–5: 4 (top). *Vaejovis crumpi* Ayrey et Soleglad, 2011, female from type locality with newborn. **5 (bottom).** *Vaejovis deboerae* Ayrey, 2009, female from type locality with newborn.



Figures 6–7: 6 (top). *Vaejovis electrum* Hughes, 2011, female with newborn. 7 (bottom). *Vaejovis feti* Graham, 2007, female with newborn.



Figures 8–9: 8 (top). *Vaejovis halli* Ayrey, 2012, paratype female with newborn. **9 (bottom).** *Vaejovis jonesi* Stahnke, 1940, female with newborn.



Figures 10–11: 10 (top). *Vaejovis lapidicola* Stahnke, 1940, female from type locality with newborn. 11 (bottom). *Vaejovis paysonensis* Soleglad, 1973, female from type locality with newborn.



Figures 12–13: 12 (top). *Vaejovis tenuipalpus* Sissom et al., 2012, female with newborn. 13 (bottom). *Vaejovis vorhiesi* Stahnke, 1940, female from type locality with newborn.



Figure 14–15: 14 (top). *Vaejovis* sp. cf. *lapidicola* “Strawberry”, female with newborn. 15 (bottom). *Vaejovis* sp. cf. *vorhiesi*, Madera Canyon, female with newborn.



Figure 16–17: 16 (top). *Vaejovis* sp. female with newborn that moved anteriorly after a few days. 17 (bottom). *Vaejovis cashi* Graham, 2007, gravid female, Cave Creek, Arizona.



Figure 18–19: 18 (top). *Vaejovis crumpi* Ayrey et Soleglad, 2011, gravid female from type locality. 19 (bottom). *Vaejovis vorhiesi* Stahnke, 1940, female from type locality with juveniles after the first ecdysis.



Figure 20–21: 20 (top). *Vaejovis brysoni* Ayrey et Webber, 2013, paratype female with some juveniles after the first ecdysis remaining and visible exuvia from juveniles that have dispersed. **21 (bottom).** *Vaejovis* female with exuvia remaining on her back, after juveniles’ dispersal.



Figure 22: *Vaejovis brysoni* Ayrey et Webber, 2013, paratype female well after juveniles' dispersal with one exuvium remaining.

season. This establishes the time of mating as the "Monsoon" season, and a gestation period of approximately one year. This is confirmed by the authors repeated observations of mating behavior in the field during July and August. Many females were kept alive for several additional years, up to four, and none of those females had subsequent broods ($n=150$). This precludes iteroparity in the "vorhiesi" group of the genus *Vaejovis*. Iteroparity was reported for the genus *Vaejovis* by Polis (1990), however, these observations appear to have been related to the species now classified in other genera of Vaejovidae, such as *Hoffmannius* or *Kochius*.

Litter size for scorpions is varied and has been reported to range between 1 and 105, with the average for the order Scorpiones about 26 (Polis, 1990). This is consistent with observations of the "vorhiesi" group of *Vaejovis* with the average for this group 22.87 newborn (first instars) ($n=100$; total number of newborn 2,287). See Table 1 for clutch size for the "vorhiesi" group by species.

The newborn's orientation on the mother's back was non-random, as is seen with many other species of *Vaejovis* (Hjelle, 1974). They face anteriorly with the prosoma down and the mesosoma raised over the

prosoma of the newborn immediately posterior to them (Ayrey, 2012). This nonrandom orientation is not immediate (Fig. 12), and it takes a number of hours for the first instars to settle into their positions (Figs. 1–4, 6–10 & 14). Many, after three to six days, will spread out anteriorly (Fig. 15). This appears to be a response to awareness that there are no other siblings to make room for. They still maintain their nonrandom orientation. Just prior to molting into second instars, they begin to move about (Fig. 11).

After molting (first ecdysis) in 7 to 10 days, the second instars juveniles appear randomly situated on the backs of the mothers (see figure 17), until they disperse. Dispersal takes place between 11 and 15 days. Exuvia are frequently visible on the mesosoma of the mother, for several days (Figs. 18–20).

As can be seen in Fig. 1, the trend, in general, is for the larger species to have higher numbers of offspring. However, species *V. paysonensis* and *V. crumpi* are noticeable exceptions. This observation has not been previously documented. Also of interest, the range of the clutch size for most species is quite large, exhibiting large coefficients of variability (0.105–0.243), see Table 1. This is not necessarily a fall-out from small sample

sizes, we see that *V. vorhiesi*, where ten clutches have been observed, the coefficient of variability is over 20 %, the maximum clutch size more than doubles that of the minimum clutch size. Possibly, female nutritional status is the most likely cause of this variability.

Acknowledgments

I would like to thank Melinda DeBoer-Ayrey for her patience and her willingness to assist me with the keeping of these scorpions. I would also like to thank Victor Fet and two anonymous reviewers for their comments on the manuscript.

References

- AYREY, R. F. 2009. Sky island *Vaejovis*: A new species (Scorpiones: Vaejovidae). *Euscorpius*, 86: 1–12.
- AYREY, R. F. 2011. *Serradigitus miscionei* (Scorpiones: Vaejovidae), a new species from southern Arizona. *Euscorpius*, 111: 1–13.
- AYREY, R. F. 2012. A new *Vaejovis* from the Mogollon Highlands of northern Arizona (Scorpiones: Vaejovidae). *Euscorpius*, 148: 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.
- 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., AYREY, R. F. & R. W. BRYSON, JR. 2012. Multivariate methods support the distinction of a new highland *Vaejovis* (Scorpiones: Vaejovidae) from the Sierra de los Ajos, Mexico. *Journal of Arachnology*, 40: 281–290.
- GRAHAM, M. R. & R. W. BRYSON, JR. 2010. *Vaejovis montanus* (Scorpiones: Vaejovidae), a new species from the Sierra Madre Occidental of Mexico. *Journal of Arachnology*, 38: 285–293.
- HJELLE, J. T. 1974. Observations on the birth and post-birth behavior of *Syntropis macrura* Kraepelin (Scorpiones: Vaejovidae). *Journal of Arachnology*, 1: 221–227.
- POLIS, G. A. (ed.) 1990. *The Biology of Scorpions*. Stanford, CA: Stanford University Press.
- SOLEGLAD, M. E. & V. FET. 2008. Contributions to scorpion systematics. III. Subfamilies Smeringurinae and Syntropinae (Scorpiones: Vaejovidae). *Euscorpius*, 71: 1–115.
- 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 (Ph.D. dissertation abstract).