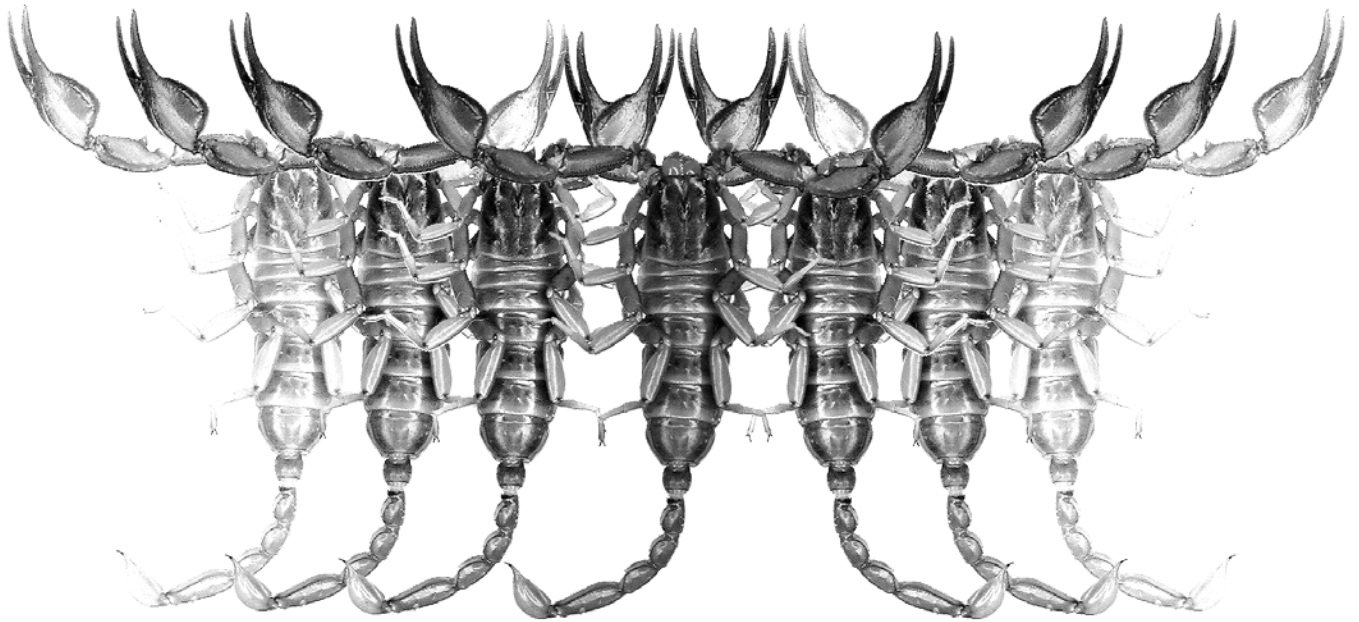


Euscorpius

Occasional Publications in Scorpiology



**Contributions to Scorpion Systematics. II.
Stahnkeini, a New Tribe in Scorpion
Family Vaejoidea (Scorpiones: Chactidea)**

Michael E. Soleglad and Victor Fet

May 2006 — No. 40

Euscorpius

Occasional Publications in Scorpiology

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Contributions to scorpion systematics. II. Stahnkeini, a new tribe in scorpion family Vaejovidae (Scorpiones: Chactoidea)

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“The difference between science and the fuzzy subjects is that science requires reasoning while those other subjects merely require scholarship.”

Robert A. Heinlein

Summary

The diagnostic characters originally established by Herbert L. Stahnke (1940a, 1940b, 1974) in his description of genus *Serradigitus* are studied in detail from several new perspectives. A new genus, *Stahnkeus*, **gen. nov.**, is described based on the presence of inner accessory (*IAD*) denticles on the chelal fingers, unprecedented in family Vaejovidae. Five species of *Serradigitus* are transferred to *Stahnkeus*: *Stahnkeus harbisoni* (Williams, 1970), **comb. nov.** (= *Serradigitus harbisoni*); *Stahnkeus deserticola* (Williams, 1970), **comb. nov.** (= *Serradigitus deserticola*); *Stahnkeus subtilimanus* (Soleglad, 1972), **comb. nov.** (= *Serradigitus subtilimanus*); *Stahnkeus allredi* (Sissom et Stockwell, 1991), **comb. nov.** (= *Serradigitus allredi*); and *Stahnkeus polisi* (Sissom et Stockwell, 1991), **comb. nov.** (= *Serradigitus polisi*). In this revision, a new tribe, Stahnkeini, **trib. nov.** (= *Serradigitus* + *Stahnkeus*), is formally described based on three unambiguous synapomorphies. Issues involving the taxonomic placement of species *Serradigitus baueri*, *S. pacificus*, *S. bechteli* and *S. littoralis* are discussed.

Introduction

This paper is a continuation of a major systematic revision of the family Vaejovidae, and represents the second contribution of several papers in progress (the first being the description of the Mexican genus *Franckeus*, Soleglad & Fet, 2005). As with the first contribution, the foundation of this continued revision is predicated on the original character analysis and subsequent cladistic results presented in the study of high-level systematics and phylogeny of extant scorpions by Soleglad & Fet (2003). We believe that this high-level study provides a relevant up-to-date phylogenetic foundation from which to view the systematics of family Vaejovidae. For example, the systematics of Vaejovidae was clarified considerably in that study when the genus *Uroctonus*, a long time member of Vaejovidae, was shown to be a close relative of genus *Anuroctonus*, and both were moved to family Chactidae forming their own subfamily, Uroctoninae. It was demonstrated that *not one* derived character of Vaejovidae was shared by either of these chactid genera (see Soleglad & Fet, 2004: 83, for additional comparisons between these genera and Vaejovidae).

In this contribution, we revisit the diagnostic characters originally established by Herbert L. Stahnke (1940a, 1940b, 1974) in his description of the vaejovid genus *Serradigitus*. We analyze, quantify and illustrate these characters from several new perspectives, establish new characters, and validate their applicability within the entire species set currently assigned to genus *Serradigitus*. In doing so, we have isolated a new genus, *Stahnkeus*, **gen. nov.**, based on the presence of inner accessory (*IAD*) denticles on the chelal fingers, unprecedented in family Vaejovidae. Consequently, five species of *Serradigitus* are transferred to *Stahnkeus*: *Stahnkeus harbisoni* (Williams, 1970), **comb. nov.** (= *Serradigitus harbisoni*); *Stahnkeus deserticola* (Williams, 1970), **comb. nov.** (= *Serradigitus deserticola*); *Stahnkeus subtilimanus* (Soleglad, 1972), **comb. nov.** (= *Serradigitus subtilimanus*); *Stahnkeus allredi* (Sissom et Stockwell, 1991), **comb. nov.** (= *Serradigitus allredi*); and *Stahnkeus polisi* (Sissom et Stockwell, 1991), **comb. nov.** (= *Serradigitus polisi*).

In this revision, a new tribe, Stahnkeini, **trib. nov.**, encompassing genera *Serradigitus* and *Stahnkeus*, is created and described to accommodate these two genera based on three unambiguous synapomorphies. Issues

involving the taxonomic placement of species *Serradigitus baueri*, *S. pacificus*, *S. bechteli* and *S. littoralis*, which have gone through a somewhat erratic taxonomic history, are discussed in detail with respect to these diagnostic characters. Generalized distribution maps based on material examined and published records are provided for the species of *Serradigitus* and *Stahnkeus*.

Brief taxonomic history

The first accurate description of detailed characteristics of the future tribe Stahnkeini (as described herein) was presented by Herbert L. Stahnke (1940a: 100–102) in his unpublished Ph.D. dissertation where he described new species *Vejovis wupatkiensis* (now placed in genus *Serradigitus*; here and below, we follow original spelling “*Vejovis*” in cases when it was not yet corrected to *Vaejovis*; see Francke, 1977; Sissom, 2000). As is discussed in detail elsewhere in this paper, Stahnke (1940a) called attention to the serrated appearance of the chelal finger dentition as well as the modified basal pectinal teeth of the female (both synapomorphies of our new tribe Stahnkeini), and he did so quite accurately. Interestingly, when Stahnke (1940b) formally published short, “abstract-like” descriptions of the species named in his unpublished thesis, neither of these important characters were mentioned. Instead, Stahnke defined *V. wupatkiensis* based on general carination, carapace features, and coloration:

“... *Vejovis wupatkiensis*. First segment of cauda has weak inferior median keels, but inferior lateral keels distinct and granular. Anterio-median border of the carapace broadly, but not deeply emarginate. Entire body orange yellow to light brown and frequently variegated slightly with darker brown. The specimens were taken at the Wupatki National Monument ...”.

This overly uninformative descriptive style was also applied to other vaejovids in his short summary, thus giving credence to the phrase “the Stahnke inscrutables”.

It was not until 1958 that another species now placed in this tribe was described, *Vejovis baueri*, by Gertsch (1958) (now in genus *Serradigitus*). At the time of this description, Gertsch (1958: 6–9) contrasted *V. baueri* with species in the “mexicanus” group of *Vejovis* (sensu Hoffmann, 1931, not Soleglad, 1973) based on the obsolete ventromedian (VM) carinae of metasomal segment I. This was understandable at the time since Hoffmann’s (1931) monumental work was the most comprehensive treatment of *Vejovis* to date. Williams (1980: 93–95) was the first to recognize that *Vaejovis baueri* belonged to a separate taxonomic group established herein as Stahnkeini.

Williams (1968) described the third species we place in this tribe, *Vejovis gertschi* (now in *Serra-*

digitus). In this paper, Williams contrasted *V. gertschi* with *V. wupatkiensis* implying a close relatedness. This was followed again by Williams (1970a) with two more new species from Death Valley, California, *Vejovis gramenestris* (now placed in *Serradigitus*) and *V. deserticola* (now placed in *Stahnkeus*). Again, these two species were compared to *Vejovis wupatkiensis*. In a large paper describing 11 new species of scorpions from Baja California, Mexico, Williams (1970b) was the first to use the term ““wupatkiensis” group”, in which he named yet two more species, *Vejovis harbisoni* (now placed in *Stahnkeus*) and *V. minutis* (now placed in *Serradigitus*). Hjelle (1970) named a new subspecies, *Vaejovis gertschi striatus*, but did not refer to the “wupatkiensis” group. Soleglad (1972, 1974) followed Williams (1970b) in using terminology of “wupatkiensis” group when he named three additional species, *Vejovis subtilimanus* (now placed in *Stahnkeus*), *V. joshuaensis*, and *V. calidus* (both now placed in *Serradigitus*). The term ““wupatkiensis” group” was in continued use (e.g., Soleglad, 1973) until Stahnke (1974) formally described the genus *Serradigitus* which included all the aforementioned species (with *S. baueri* as the only exception). In Stahnke’s (1974) diagnosis of *Serradigitus*, the two primary characters discussed above were described in detail, with several embellishments (see discussion elsewhere).

Williams (1980), in his large monograph on scorpions of Baja California, Mexico, discussed the characteristics of genus *Serradigitus* and decided to reject its validity. There are several reasons for this stance by Williams, one major reason was that non-*Serradigitus* species were included in his analysis, thus confusing the issue considerably, especially when the consistency of a particular character was considered. Also, as is discussed in detail elsewhere, Williams’s interpretation of the two primary characters used by Stahnke (1974) was not as comprehensive or complete as that originally defined by Stahnke. For example, Stahnke (1974) characterized the unique chelal finger dentition as serrated, uninterrupted by larger denticles, with an enlarged hook-like distal denticle with a whitish patch. Williams (1980) only concentrated on the “uninterrupted by larger denticles” feature of this character and decided it was not consistent. Stahnke (1974) characterized the basal pectinal teeth of the female as “... paddle-like and somewhat larger than the other ...”; at the same time, Williams (1980) only concentrated on their “elongated” appearance of the pectinal teeth, ignoring other details. As a result, any *Serradigitus* species whose basal tooth was shorter or fatter was considered an exception to this character by Williams (1980). In addition, the fact that this condition occurred in one, two, or sometimes three basal teeth, was considered as too much variability by Williams (1980), thus diminishing its importance. This opinion

was somewhat puzzling since earlier Soleglad (1974) had described and illustrated the modified pectinal teeth of the female for several species which included these variable conditions in the character's definition. Incidentally, as will be seen in the present paper, the important aspect of this character is the missing or reduced sensorial areas, which was never discussed by Williams (1980), or for that matter, by Stahnke (1974). Rejecting *Serradigitus* as a valid genus, Williams (1980: 88) resorted to a diluted definition of "wupatkiensis" group, which emphasized, of the original *Serradigitus* diagnostic characters of Stahnke (1974), only the large hook-like distal denticle of the chelal fingers. Consequently, several species not related to Stahnkeini were included in this assemblage, essentially any species with elongated chelal fingers equipped with a hook-like distal denticle. For example, this included species not exhibiting the modified pectinal teeth of the female and whose median denticle row of the chelal fingers were not serrated—i.e., *Vaejovis peninsularis* (now *Franckeus peninsularis*) and *V. janssi*. However, in the important monograph by Williams (1980), nine new species were described under *Vaejovis*, which are all now placed in *Serradigitus*: *V. adcocki*, *V. armadentis*, *V. bechteli*, *V. dwyeri*, *V. gigantaensis*, *V. haradoni*, *V. hearnei*, *V. littoralis*, and *V. pacificus*.

Sissom (1985) within his PhD thesis, provided general comments on vaejovoid systematics, which remained largely unpublished. He followed Williams (1980) in not recognizing *Serradigitus*, and instead listed 20 species under "wupatkiensis" group; however, *Vaejovis peninsularis* (now placed in genus *Franckeus*) and *V. janssi* were excluded and listed under "nitidulus" group (main subject of Sissom's work). Sissom (1985: 264–265) wrote "... I agree with Williams (1980), however, that the elevation of the *wupatkiensis* or any other species group of *Vaejovis* to generic rank is premature ...".

Williams & Berke (1986), in a paper where they described species *Serradigitus torridus*, revisited the status of *Serradigitus* and consequently reestablished it as a valid genus. Their analysis paid more emphasis to the original characters as offered by Stahnke (1974) and they, correctly from the perspective of our present understanding, included under *Serradigitus* the proper species set, with only four exceptions: they excluded *Vaejovis baueri*, *V. bechteli*, *V. littoralis*, and *V. pacificus* (all now placed in *Serradigitus*).

Sissom & Stockwell (1991), in their excellent paper, defined four new species from Sonora, Mexico, *Serradigitus agilis*, *S. yaqui*, *S. allredi*, and *S. polisi* (the latter two now placed in genus *Stahnkeus*). These authors discussed the diagnostic characters of *Serradigitus* and presented for the first time for this genus illustrations of the hemispermaphore. In their interpretation of the characters, Sissom & Stockwell

(1991) emphasized the median denticle groups of the chelal fingers as well as the distal hook of the fingers, but considered the modification of the basal pectinal teeth of the female to be secondary and therefore not a mandatory diagnostic character for the genus. They reestablished some species earlier removed from *Serradigitus* by Williams & Berke (1986), in particular *S. baueri*, *S. bechteli*, *S. littoralis*, and *S. pacificus*. Their reasons for doing so are interesting, however, and we discuss them below.

In this paper, we revisit all diagnostic characters discussed by Stahnke (1940a, 1940b, 1974), Soleglad (1974), Williams & Berke (1986), and Sissom & Stockwell (1991) while we define in detail three unique diagnostic characters (i.e., synapomorphies) for the tribe Stahnkeini.

Scope of study

In our current analysis, specimens of all species of *Serradigitus* as listed by Sissom (2000: 518–526) were analyzed, with the exception of four Mexican species described by Sissom & Stockwell (1991: figs. 1–50, tab. 1). However, these authors provided excellent descriptions and illustrations, covering all the salient diagnostic characters discussed in detail in this paper. Therefore, absence of the original specimens is not considered critical to this analysis. The material examined in this study included four types, four paratypes, several topotypes, and over 140 specimens in total. Although a large majority of the existing species were examined in this study, it is important to stress here that this paper is not a species-level revision of *Serradigitus*. Thus we neither address nor necessarily endorse the validity of the 25 species and subspecies currently placed in tribe Stahnkeini, some of which are based on limited material, or only on a single type specimen. To do such a revision would require an extensive examination of considerable numbers of *newly* collected material. The goal of the present study, however, is to quantify in detail the synapomorphic characters of tribe Stahnkeini as described herein and, as a minimum, to establish that the material examined, involving many types, did indeed comply with these diagnostic characters and therefore belongs to the tribe Stahnkeini.

Methods & Material

Terminology and conventions

Terminology describing pedipalp chelal finger dentition and chelal palm carination follows that described and illustrated in Soleglad & Sissom (2001). Terminology for the pedipalp patella and metasoma follows that described in Soleglad & Fet (2003).

SEM microscopy

To investigate the chelal fingers and pectines, the structures were dehydrated in an ethanol series (50, 75, 95, and two changes of 100%) before being dried and coated with gold/palladium (ca. 10 nm thickness) in a Hummer sputter coater. Digital SEM images were acquired with a JEOL JSM-5310LV at Marshall University, West Virginia. Acceleration voltage (10–20 kV), spot size, and working distance were adjusted as necessary to optimize resolution, adjust depth of field, and to minimize charging.

Abbreviations

List of depositories: AMNH, American Museum of Natural History, New York, New York, USA; BH, Personal collection of Blaine Hébert, Los Angeles, California, USA; CAS, California Academy of Sciences, San Francisco, California, USA; GL, Personal collection of Graeme Lowe, Philadelphia, Pennsylvania, USA; MES, Personal collection of Michael E. Soleglad, Borrego Springs, California, USA; VF, Personal collection of Victor Fet, Huntington, West Virginia, USA.

Other: ABDSP, Anza-Borrego Desert State Park, San Diego and Riverside Counties, California, USA.

Material examined

The following vaejovoid material was examined for analysis and/or illustrations provided in this paper. Refer to this section for locality and gender data of species-level illustrations. The list of material reflects the taxonomic changes established in this paper: *Stahnkeini*, **trib. nov.**, *Stahnkeus*, **gen. nov.**; *Stahnkeus harbisoni* (Williams, 1970), **comb. nov.** (= *Serradigitus harbisoni*); *Stahnkeus deserticola* (Williams, 1970), **comb. nov.** (= *Serradigitus deserticola*); *Stahnkeus subtilimanus* (Soleglad, 1972), **comb. nov.** (= *Serradigitus subtilimanus*); *Stahnkeus allredi* (Sissom et Stockwell, 1991), **comb. nov.** (= *Serradigitus allredi*); and *Stahnkeus polisi* (Sissom et Stockwell, 1991), **comb. nov.** (= *Serradigitus polisi*).

Tribe Stahnkeini. *Serradigitus adcocki* (Williams, 1980), Isla Cerralvo, Baja California Sur, Mexico, ♀ (CAS); *Serradigitus armadentis* (Williams, 1980), Isla Santa Cruz, Baja California Sur, Mexico, ♂ holotype (CAS); *Serradigitus baueri* (Gertsch, 1958), West San Benito Island, Baja California, Mexico, ♂ (CAS); *Serradigitus bechteli* (Williams, 1980), Isla Las Ánimas, Baja California Sur, Mexico, ♀ holotype (CAS); *Serradigitus calidus* (Soleglad, 1974), Cuatro Ciénegas, Coahuila, Mexico, ♀ paratype (MES); *Serradigitus dwyeri* (Williams, 1980), Isla Danzante, Baja California Sur, Mexico, ♂ holotype (CAS); *Serradigitus gertschi* (Williams, 1968), Chariot Canyon, ABDSP,

California, USA, 2 ♀ (MES), Pinyon Mountain Rd., ABDSP, California, USA, 5 ♀ (MES), Tijuana, Baja California, Mexico, 2 ♀ (MES), San Diego, California, USA, ♀ (VF); *Serradigitus gigantaensis* (Williams, 1980), San Jose de Comondú, Baja California Sur, Mexico, ♂ holotype (CAS); *Serradigitus gramenestris* (Williams, 1970), Travertine Spring, Death Valley, California, USA, 11 ♀ ♂ paratopotypes (CAS); *Serradigitus haradoni* (Williams, 1980), Los Aripes, Baja California Sur, Mexico, ♂ paratype (CAS), Isla Santa Catalina, Baja California Sur, Mexico, 2 ♀ (CAS); *Serradigitus hearnei* (Williams, 1980), Loreto, Baja California Sur, Mexico, ♂ paratype (CAS), Punta Trinidad, Baja California Sur, Mexico, 3 ♀ paratypes (CAS); *Serradigitus joshuaensis* (Soleglad, 1972), Cottonwood Springs, Joshua Tree National Monument, California, USA, 11 ♀ topotypes (MES), Indian Gorge, ABDSP, California, USA, 2 ♀ (MES), Pinyon Mountain, ABDSP, California, USA, 2 ♀ (MES), Palm Canyon, ABDSP, California, USA, 5 ♀ (MES), Borrego Springs, California, USA, ♀ (VF); *Serradigitus littoralis* (Williams, 1980), Isla Danzante, Baja California Sur, Mexico, 3 ♀ ♂ (CAS); *Serradigitus minutis* (Williams, 1970), Cabo San Lucas, Baja California Sur, Mexico, 2 ♀ 2 ♂ (MES), Cabo San Lucas, Baja California Sur, Mexico, ♀ (VF), Loreto, Baja California Sur, Mexico, 5 ♀ 2 ♂ (MES); *Serradigitus pacificus* (Williams, 1980), Isla Cedros, Baja California, Mexico, ♂ ♀ (CAS); *Serradigitus torridus* Williams et Berke, 1986, Nine Mile Canyon Rd., Kern Co., California, USA, 4 ♀ ♂ (GL), Jawbone Canyon Rd., Kern Co., California, USA, 2 ♀ ♂ (GL); *Serradigitus wupatkiensis* (Stahnke, 1940), Wupatki National Monument, Coconino Co., Arizona, USA, 2 ♀ 2 ♂ topotypes (MES); *Stahnkeus deserticola* (Williams, 1970), Saratoga Springs, Death Valley, California, USA, 3 ♀ (MES); *Stahnkeus harbisoni* (Williams, 1970), Puertocitos, Baja California, Mexico, ♀ (MES), Oakies Landing, Baja California, Mexico, 2 ♂ 4 ♀ (MES), Isla Smith, Baja California, Mexico, ♀ (VF); *Stahnkeus subtilimanus* (Soleglad, 1972), Picacho Recreational Area, Winterhaven, California, USA, 2 ♀ topotypes (MES), Borrego Springs, California, USA, 2 ♀ ♂ (MES), Borrego Springs, California, USA, ♀ (VF); Split Mountain, ABDSP, California, USA, 4 ♀ 4 ♂ (MES), Vallecito Creek, Carrizo Badlands, ABDSP, California, USA, 6 ♀ 4 ♂ (MES), Hawk's Canyon, ABDSP, California, USA, 2 ♀ ♂ (MES), Palm Canyon, ABDSP, California, USA, ♀ ♂ (MES), Calcite Mine, ABDSP, California, USA, 2 ♀ 3 ♂ (MES), Blow Sand Canyon, ABDSP, California, USA, 3 ♀ 3 ♂ (MES), Indian Gorge Canyon, ABDSP, California, USA, 3 ♀ ♂ (MES), Buttes Pass, ABDSP, California, USA, 3 ♀ ♂ (MES), Ocotillo, California, USA, ♀ (MES).

Additional comparative material. *Franckeus minckleyi* (Williams, 1968) female, Cuatro Ciénegas, Coahuila, Mexico, 2 ♀ ♂ (CAS); *Franckeus*

peninsularis (Williams, 1980), San Raymundo, Baja California Sur, Mexico, ♀ 3 ♂ paratypes (CAS); *Paravaejovis pumilis* (Williams, 1970), Ciudad Constitución, Baja California Sur, Mexico, ♂ (MES); *Paruroctonus arnaudi* Williams, 1972, El Socorro, Baja California, Mexico, ♀ (MES); *Paruroctonus becki* (Gertsch et Allred, 1965), Cottonwood Springs, Joshua Tree National Monument, California, USA, ♀ (MES); *Paruroctonus boreus* (Girard, 1854), Mercury, Nevada, USA, ♂ (MES); *Paruroctonus gracilior* (Hoffmann, 1931), New Mexico, USA, ♂ (MES); *Paruroctonus luteolus* (Gertsch et Soleglad, 1966), Palo Verde Wash, ABDSP, California, USA, ♂ (MES); *Paruroctonus silvestrii* (Borelli, 1909), Chihuahua Road, ABDSP, California, USA, ♂ (MES); *Paruroctonus stahnkei* (Gertsch et Soleglad, 1966), Mesa, Maricopa Co., Arizona, USA, ♂ (MES); *Paruroctonus surensis* Williams et Haradon, 1980, Las Bombas, Baja California Sur, Mexico, ♀ ♂ (MES); *Paruroctonus utahensis* (Williams, 1968), Bluff, San Juan Co., Utah, USA, ♀ ♂ topotypes (MES); *Paruroctonus ventosus* Williams, 1972, El Socorro, Baja California, Mexico, ♂ (MES); *Pseudouroctonus andreas* (Gertsch et Soleglad, 1972), Chihuahua Rd., ABDSP, California, USA, ♂ (MES); *Pseudouroctonus angelenus* (Gertsch et Soleglad, 1972), Ventura Co., California, USA, ♂ (BH); *Pseudouroctonus iviei* (Gertsch et Soleglad, 1972), Little French Creek, Trinity Co., California, ♀ ♂ (MES); *Pseudouroctonus minimus castaneus* (Gertsch et Soleglad, 1972), Vista, California, USA, ♂ (MES); *Pseudouroctonus minimus thompsoni* (Gertsch & Soleglad, 1972), Santa Cruz Island, Santa Barbara Co., California, USA, 2 ♀ 2 ♂ (GL); *Pseudouroctonus reddelli* (Gertsch et Soleglad, 1972), Gem Cave, Conal Co., Texas, USA, ♀ (MES); *Smeringurus aridus* (Soleglad, 1972), Palo Verde Wash, ABDSP, California, USA, ♂ (MES); *Smeringurus grandis* (Williams, 1970), Oakies Landing, Baja California, Mexico, ♀ (MES); *Smeringurus mesaensis* (Stahnke, 1957), Palo Verde Wash, ABDSP, California, USA, ♀ (MES); *Uroctonites giulianii* Williams et Savary, 1991, Lead Canyon, Inyo Co., California, USA, ♂ (CAS); *Uroctonites huachuca* (Gertsch et Soleglad, 1972), Huachuca Mountains, Cochise Co., Arizona, USA, ♀ ♂ (MES); *Uroctonites montereus* (Gertsch et Soleglad, 1972), Hastings National History Reservation, Monterey Co., California, USA, ♂ (MES); *Vaejovis bruneus* Williams, 1970, Loreto, Baja California Sur, Mexico, ♂ (MES); *Vaejovis carolinianus* (Beauvois, 1805), Haralson Co., Georgia, USA, ♀ (MES), Tishomingo State Park, Mississippi, USA, ♀ (VF); *Vaejovis cazieri* Williams, 1968, Cuatro Ciénegas, Coahuila, Mexico, ♂ (MES); *Vaejovis coahuilae* Williams, 1968, Cuatro Ciénegas, Coahuila, Mexico, ♂ (MES); *Vaejovis confusus* Stahnke, 1940, Mesa, Maricopa Co., Arizona, USA, ♀ (MES); *Vaejovis davidi* Soleglad et Fet, 2005, Cuelzalan, Puebla, Mexico,

♀ holotype (AMNH); *Vaejovis decipiens* Hoffmann, 1931, Chinipas, Chihuahua, Mexico, ♀ (MES); *Vaejovis diazi* Williams, 1970, Ciudad Constitución, Baja California Sur, Mexico, ♀ (MES); *Vaejovis eusthenura* (Wood, 1863), Cabo San Lucas, Baja California Sur, Mexico, ♂ (MES), ♀ (VF); *Vaejovis globosus* Borelli, 1915, Zacatecas, Zacatecas, Mexico, ♀ (MES); *Vaejovis granulatus* Pocock, 1898, Hidalgo, Mexico, ♀ (MES); *Vaejovis gravicaudus* Williams, 1970, Santa Rosalia, Baja California Sur, Mexico, ♀ (MES); *Vaejovis hirsuticauda* Banks, 1910, Indian Gorge Canyon, ABDSP, California, USA, ♀ (MES), Indian Gorge Canyon, ABDSP, California, USA, ♀ (VF); *Vaejovis intrepidus* Thorell, 1876, Acatlan, Jalisco, Mexico, ♂ (MES); *Vaejovis lapidicola* Stahnke, 1940, Williams, Coconino Co., Arizona, USA, ♂ (MES); *Vaejovis magdalenensis* Williams, 1971, Baja California Sur, Mexico, ♀ (MES); *Vaejovis mexicanus* (C. L. Koch, 1836), Aculco, Distrito Federal, Mexico, ♀ (MES); *Vaejovis paysonensis* Soleglad, 1973, Payson, Arizona, USA, ♀ topotype (MES); *Vaejovis pococki* Sissom, 1991, Rioverde, San Luis Potosi, Mexico, ♂ (MES); *Vaejovis punctatus* Karsch, 1879, Acatlan, Puebla, Mexico, ♀ (MES); *Vaejovis punctipalpi* (Wood, 1863), Cabo San Lucas, Baja California Sur, Mexico, ♀ (MES); *Vaejovis russelli* Williams, 1971, Deming, Luna Co., New Mexico, USA, ♀ (MES); *Vaejovis solegladi* Sissom, 1991, Cuicuitlan, Oaxaca, Mexico, ♀ (MES); *Vaejovis spinigerus* (Wood, 1863), Alamos, Sonora, Mexico, ♀ (MES); *Vaejovis viscaianensis* Williams, 1970, Las Bombas, Baja California Sur, Mexico, ♀ (MES); *Vaejovis vorhiesi* Stahnke, 1940, Huachuca Mountains, Cochise Co., Arizona, USA, ♀ (MES); *Vaejovis waeringi* Williams, 1970, Indian Gorge Canyon, ABDSP, California, USA, ♂ (MES); *Vaejovoidus longiunguis* (Williams, 1969), Los Bombas, Baja California Sur, Mexico, ♂ (MES), Vizcaino Desert, Baja California, Mexico, ♂ (VF).

Systematics

In the character analysis presented below, species of newly defined tribe Stahnkeini are compared to a large set of vaejovid species (a subset of the species currently being used in our ongoing cladistic analysis of scorpion family Vaejovidae). These species are sometimes referenced by name as well as genus and *Vaejovis* group affiliation. In particular, in Tables 2–3, we compare statistical data of Stahnkeini with that of various vaejovid aggregates comprised of these genera and/or *Vaejovis* groups. Here we state exactly which species are included in these aggregates as used in this paper:

***Serradigitus* + *Stahnkeus* [20 species]:**
Serradigitus adcocki, *S. armadentis*, *S. baueri*, *S. bechteli*, *S. calidus*, *S. dwyeri*, *S. g. gertschi*, *S.*

gigantaensis, *S. gramenestris*, *S. haradoni*, *S. hearnei*, *S. joshuaensis*, *S. littoralis*, *S. minutis*, *S. pacificus*, *S. torridus*, *S. wupatkiensis*, *Stahnkeus deserticola*, *S. harbisoni*, *S. subtilimanus*.

Smeringurus + Paruroctonus + Vejovoidus [14 species]: *Smeringurus aridus*, *S. grandis*, *S. mesaensis*, *Paruroctonus arnaudi*, *P. becki*, *P. boreus*, *P. gracilior*, *P. luteolus*, *P. silvestrii*, *P. stahnkei*, *P. surensis*, *P. utahensis*, *P. ventosus*, *Vejovoidus longiunguis*.

Paravaejovis [1 species]: *Paravaejovis pumilis*.

Franckeus + Vaejovis “nigrescens” group [6 species]: *Franckeus minckleyi*, *F. peninsularis*, *Vaejovis davidi*, *V. decipiens*, *V. pococki*, *V. solegladi*.

Vaejovis “mexicanus” group [6 species]: *Vaejovis carolinianus*, *V. granulatus*, *V. lapidicola*, *V. mexicanus*, *V. paysonensis*, *V. vorhiesi*.

Pseudouroctonus + Uroctonites [9 species]: *Pseudouroctonus andreas*, *P. angelenus*, *P. iviei*, *P. minimus castaneus*, *P. minimus thompsoni*, *P. reddelli*, *Uroctonites giulianii*, *U. huachuca*, *U. montereus*.

Vaejovis “punctipalpi” group [7 species]: *Vaejovis bruneus*, *V. cazieri*, *V. hirsuticauda*, *V. intrepidus*, *V. magdalensis*, *V. punctipalpi*, *V. russelli*.

Vaejovis “eusthenura” group [10 species]: *Vaejovis coahuilae*, *V. confusus*, *V. diazi*, *V. eusthenura*, *V. globosus*, *V. gravicaudus*, *V. punctatus*, *V. spinigerus*, *V. viscainensis*, *V. waeringi*.

Character analysis: tribe Stahnkeini

In this section we discuss in detail characters that distinguish tribe Stahnkeini from the other vaejovids. As a general statement, tribe Stahnkeini can be diagnosed by the specialized serrated chelal finger dentition and the modified basal pectinal teeth of the female. Other diagnostic characters include the variable positioning of the chelal fixed finger trichobothrial series *ib-it* and the relatively large number of pectinal teeth. Other important characters common to tribe Stahnkeini, though not synapomorphic, are listed below in the section on **Taxonomy**.

Chelal finger dentition – general. Soleglad & Sissom (2001: 33–41) established special terminology for the analysis of chelal finger dentition in their revision of chactoid family Euscorpiidae. This was required due to the complex dentition found throughout Euscorpiidae, maybe the most complex denticle arrangements found in Recent scorpions (this is clearly evidenced in Soleglad & Sissom’s (2001) figs. 2–11, 12–21). Though the scope of their terminology was aimed specifically at Euscorpiidae, the authors incorporated in their analysis other closely related families such as Chactidae, Superstitioniidae, and Vaejovidae, as well as the more distant superfamily Iuroidea. The terminology used by Soleglad & Sissom (2001) is adequate for the analysis presented in this paper, since the vaejovids, in general,

exhibit simple denticle patterns, which only contain the basic denticle types of median (*MD*), outer (*OD*), and inner (*ID*) denticles. The denticle groups (*DG*), as determined by intervening *OD* denticles, are aligned in a simple straight row. There is only one known example in Vaejovidae where accessory denticles occur, in this case inner accessory (*IAD*) denticles. This feature is germane to this paper and is discussed below.

Chelal finger dentition – Stahnkeini. As discussed elsewhere in this paper, the unique chelal dentition of *Serradigitus* and *Stahnkeus* has been characterized in various ways by authors over the years, emphasizing different aspects of its structure: denticles serrated; distal denticles of the fingers elongated and “hook-like”; distal denticles with a “whitish patch”; and “primary” denticle row divided into two or three sub-rows. We now discuss these structural issues in detail showing that the serrated finger dentition is indeed unique within this tribe and can be quantified in several ways.

A primary diagnostic character for tribe Stahnkeini is the unusual serrated appearance of the median (*MD*) denticle row and the intervening outer (*OD*) denticles (Fig. 1). Accompanying the derivation of the *MD* and *OD* denticles is the elongated “hook-like” distal denticle of both chelal fingers, their external tips covered with an exaggerated sponge-like “whitish patch” (Figs. 2–3; also see Soleglad & Fet (2005: fig. 8)). It is important to note here that we hypothesize that this modification of the distal denticle, including the “whitish patch”, is *independent* from the serrated condition of the *MD* and *OD* denticles. The same condition is observed in the genus *Franckeus* and the “nigrescens” group of *Vaejovis* whose chelal *MD* and *OD* denticles are developed normally, not exhibiting the serrated condition as seen in Stahnkeini. Therefore, it is more likely that this modification of the chelal finger tips evolved, in part, as an adaptation to their specialized microhabitats, since these two unrelated assemblages are both lithophiles. In addition, the “whitish patch” is found to one degree or another in other vaejovid groups or genera, such as *Pseudouroctonus reddelli* and *Syntropis macrura* Kraepelin, again an association with lithophilic microhabitats.

In our analysis, we see that each *MD* and *OD* denticle is a sharp projection emanating from the cuticle, *flattened*, *elongated*, and *widened* at its base. In addition, unique to this configuration, is the exact inline position of the *OD* denticles in the *MD* denticle row. The serrated appearance of the *MD* and *OD* denticles is not exhibited by the inner (*ID*) denticles of the chelal fingers, which in general, are shaped as those found in other vaejovids. We can see this clearly in Figs. 5–6 for species *Serradigitus g. gertschi* and *Stahnkeus subtilimanus*. In these species, *ID-1*, *ID-2*, *ID-3* and *ID-4* (as shown in *S. g. gertschi*) of the fixed finger exhibit an essentially circular base in contrast to the conspicuous, clearly

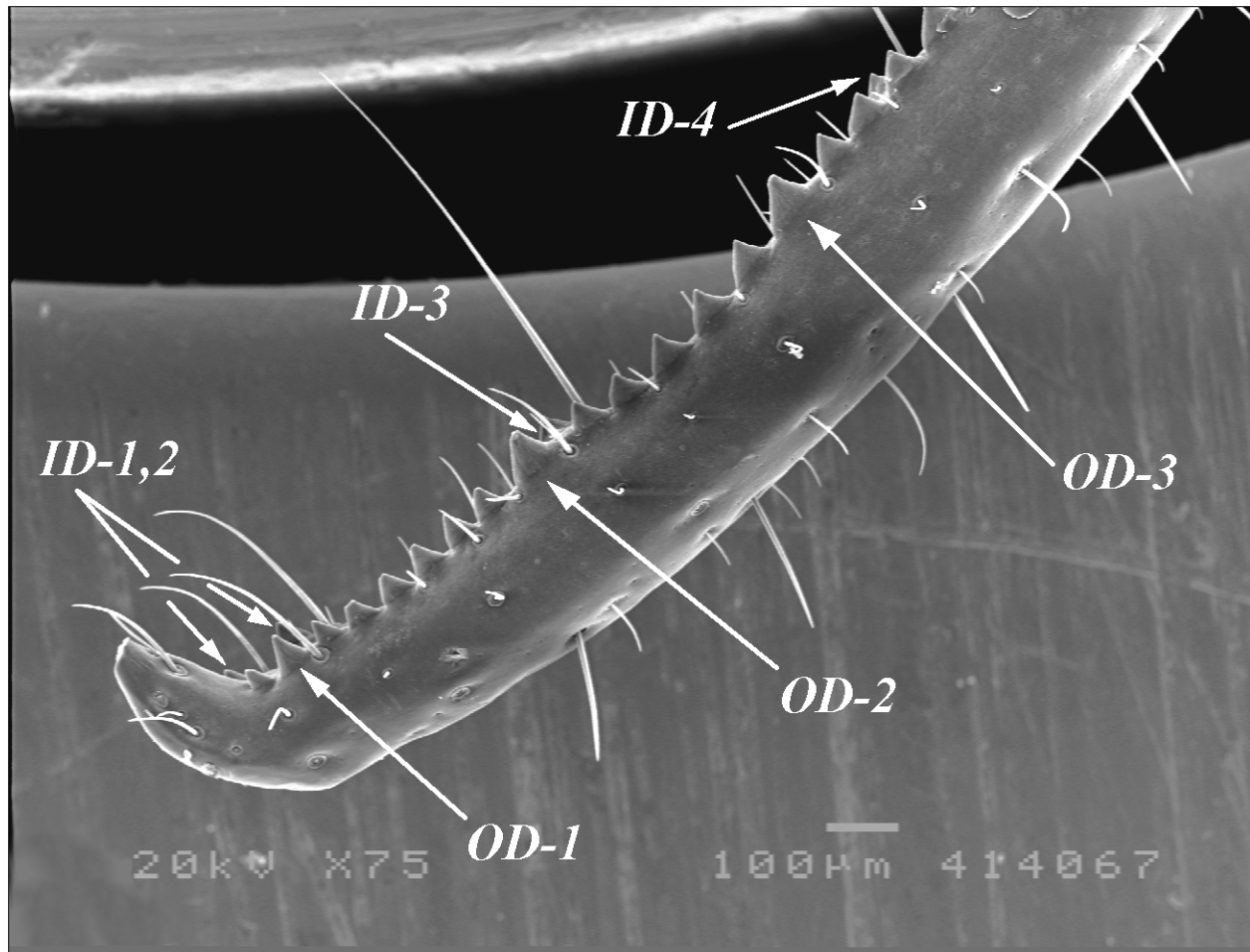
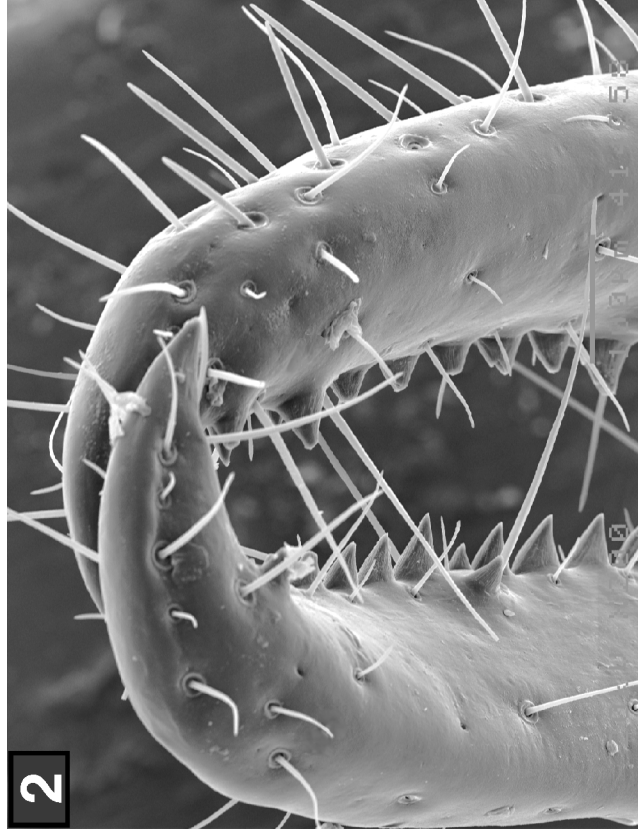


Figure 1: Distal half of movable finger, external view, of female *Serradigitus g. gertschi*, San Diego, California, showing configuration of outer (OD) denticles 1–3 as they relate to MD and inner (ID) denticles 1–4. Typically the only OD denticles discernible in tribe Stahnkeini are 1–3. Distally OD denticles are larger than adjacent MD denticles, but more proximally, the MD denticles, increasing in size, approach the size of the OD denticle thus obscuring their identification. Also note that the OD denticles are directly inline with the MD denticle row exhibiting no outer placement or basal swollenness on the finger externally. The four identified ID denticles are located on the internal aspect of the finger, and therefore are partially hidden by the OD and MD denticles.

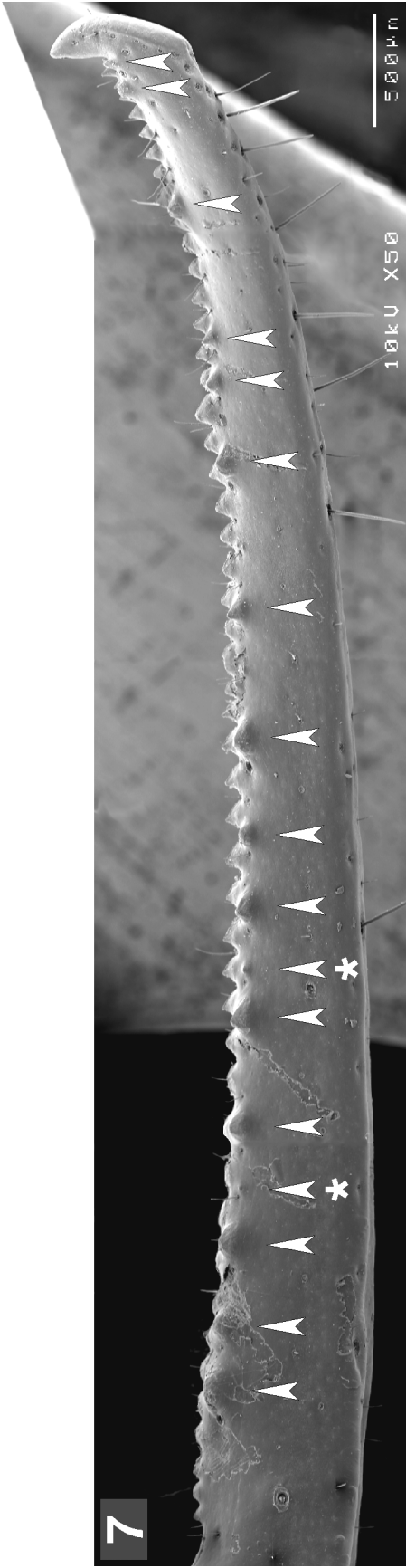
elliptical bases of the surrounding MD and OD denticles, a by-product of the overall flattening of these denticles. Fig. 4 illustrates the elliptical MD denticle bases for species *Serradigitus joshuaensis*.

OD denticle composition. The OD denticle in Stahnkeini is modified into flattened and elongated sharp denticles. Presumably caused by this flattening and elongation, the base of the OD denticle is not swollen thus not exhibiting a slight profile on the external surface of the finger (Fig. 1). In addition, the OD denticles are in direct line with the MD denticles, not slightly external to the MD row (Fig. 1). Typically in other vaejovids (see Figs. 8–11), the OD denticle bases are detectable on the external aspect of the finger and are aligned slightly externally to the MD row. Figures 8–11, which represent several major taxonomic groups in Vaejovidae, show MD denticles positioned slightly

internally from (i.e., “behind”) the OD denticles which are shown from an external perspective. As with all vaejovids, the larger OD divide the MD denticle row into denticle groups (DG). However, in Stahnkeini, as the MD denticles progressively increase in size proximally on the finger, the inline OD denticles become indistinguishable from the MD. Consequently, the typical breakdown of the MD row into denticle groups is not possible in this tribe except for the distal half of the finger. Figure 1 confirms this observation in species *Serradigitus g. gertschi* where the MD denticles adjacent to OD–3 are larger than those adjacent to OD–2. Figure 1 shows the typical configuration of OD denticles of the movable finger in Stahnkeini, with generally only three distal OD denticles being detectable (in *Serradigitus joshuaensis*, only two distal OD are detectable). Also of interest is the consistency (based on the analysis of 20



Figures 2–4: Internal view of chelal fingers showing arrangement of *ID* and *MD* denticles for *Serradigitus joshuaensis*, Borrego Springs, California. **2.** Fixed (left) and movable (right) fingers showing elongated distal denticles. **3.** Distal aspect of fixed finger showing elongated distal denticle. **4.** Interodorsal view of movable finger showing lack of *ID* denticles and the flat *MD* denticles with highly elliptical bases.



Figures 5–7: Internal view of chelal fingers showing arrangement of *ID* and *IAD* denticles in tribe Stahnkeini. White arrows indicate inner denticles. Also note that the “whitish patch” is visible on the distal denticle in all three figures. **5.** *Serradigitus g. gertschi*, San Diego, California, showing cylindrical tooth base of *ID* denticles on distal half of fixed finger. **6.** *Stahnkeus subtilimanus*, Borrego Springs, California, showing cylindrical tooth base of *ID* denticles on fixed finger. **7.** *S. subtilimanus*, Borrego Springs, California, showing 17 *IAD* and *ID* denticles on movable finger; asterisk denotes the beginning of presumably newly formed denticles.

	<i>MD + OD Number</i>	<i>MF_L/Cara_L</i>	<i>MD + OD Density Quotient</i>
<i>Stahnkeus deserticola</i>	43	1.269	34
<i>Stahnkeus harbisoni</i>	50	1.317	38
<i>Stahnkeus subtilimanus</i>	49	1.350	36
<i>Stahnkeus</i>	43–50 (47.333) [3]	1.269–1.350 (1.312)	34–38 (36)
<i>Serradigitus adcocki</i>	39	1.060	37
<i>Serradigitus armadentis</i>	39	1.056	37
<i>Serradigitus baueri</i>	40	1.074	37
<i>Serradigitus bechteli</i>	43	1.086	40
<i>Serradigitus calidus</i>	37	1.030	36
<i>Serradigitus dwyeri</i>	40	1.154	35
<i>Serradigitus g. gertschi</i>	42	1.171	36
<i>Serradigitus gigantaensis</i>	40	0.955	42
<i>Serradigitus gramenestris</i>	40	1.054	38
<i>Serradigitus haradoni</i>	38	1.068	36
<i>Serradigitus hearnei</i>	36	1.086	33
<i>Serradigitus joshuaensis</i>	31	1.018	30
<i>Serradigitus littoralis</i>	36	1.000	36
<i>Serradigitus minutis</i>	37	0.926	40
<i>Serradigitus pacificus</i>	40	1.077	37
<i>Serradigitus torridus</i>	41	1.024	40
<i>Serradigitus wupatkiensis</i>	44	1.209	36
<i>Serradigitus</i>	31–44 (39.000) [17]	0.926–1.209 (1.062)	30–42 (36.824)
Stahnkeini	31–50 (40.250) [20]	0.926–1.350 (1.100)	30–42 (36.700)

Table 1: Statistics of chelal movable finger median (*MD*) and outer (*OD*) denticle numbers for genera *Stahnkeus* and *Serradigitus*. *MD + OD density quotient* is calculated by dividing the number of *MD + OD* by the ratio of *MF_L/Cara_L*. The latter ratio normalizes the movable finger length with respect to the adult scorpion size, represented here by the carapace length. Therefore, the *density quotient* is independent of the length of the movable finger. Since basal to midfinger *ODs* are not distinguishable from *MDs* in these genera, the denticle counts and density quotient include the sum of *MD* and *OD*. Compare the relative low *MD + OD* density of these genera to that of other vaejovoid genera and *Vaejovis* “groups” (see Table 2). Minimum–maximum (mean) [number of samples]; *MD* = median denticle; *OD* = outer denticle; *MF_L* = movable finger length; *Cara_L* = carapace length.

	<i>MD+OD Number</i>	<i>MF_L/Cara_L</i>	<i>MD+OD Density Quotient</i>	<i>Density Increase (%)</i>
<i>Stahnkeus + Serradigitus</i>	31–50 (40.250) [20]	0.926–1.350 (1.100)	30–42 (36.700)	-
<i>Paravaejovis</i>	26 [1]	0.638	41	11.7 %
“punctipalpi” group	43–69 (51.143) [7]	0.813–0.949 (0.887)	52–74 (57.571)	56.9 %
“eusthenura” group	39–66 (53.200) [10]	0.741–1.086 (0.902)	51–68 (59.000)	60.8 %
<i>Smeringurus + Paruroctonus + Vejovoidus</i>	35–96 (62.708) [14]	0.822–1.194 (1.004)	40–82 (66.929)	82.4 %
“mexicanus” group	58–90 (66.833) [6]	0.833–1.029 (0.934)	62–87 (71.333)	94.4 %
<i>Franckeus + “nigrescens” group</i>	64–110 (83.000) [6]	1.055–1.216 (1.101)	59–90 (75.167)	104.8 %
<i>Pseudouroctonus + Uroctonites</i>	60–100 (71.667) [9]	0.733–1.038 (0.881)	66–102 (81.555)	122.2 %

Table 2: Statistics of chelal movable finger median (*MD*) and outer (*OD*) denticle numbers for genera and *Vaejovis* groups of family Vaejovidae. See Table 1 for the method of calculating the *MD + OD density quotient*. *Density increase* is based on the mean value as it relates to genera *Stahnkeus + Serradigitus*. Minimum–maximum (mean) [number of samples]; *MD* = median denticle; minimum–maximum (mean) [number of samples]; *OD* = outer denticle; *MF_L* = movable finger length; *Cara_L* = carapace length.

species) of the alignment of the *ID* and *OD* denticles relatively to intervening *MD* denticles. In the typical configuration, as shown in Fig. 1 (the movable finger),

one small *MD* denticle is aligned with *ID*–1, followed by *OD*–1, which is aligned with *ID*–2; further basad, 4–7 (5.15) *MD* denticles separate *OD*–1 and *OD*–2, which is