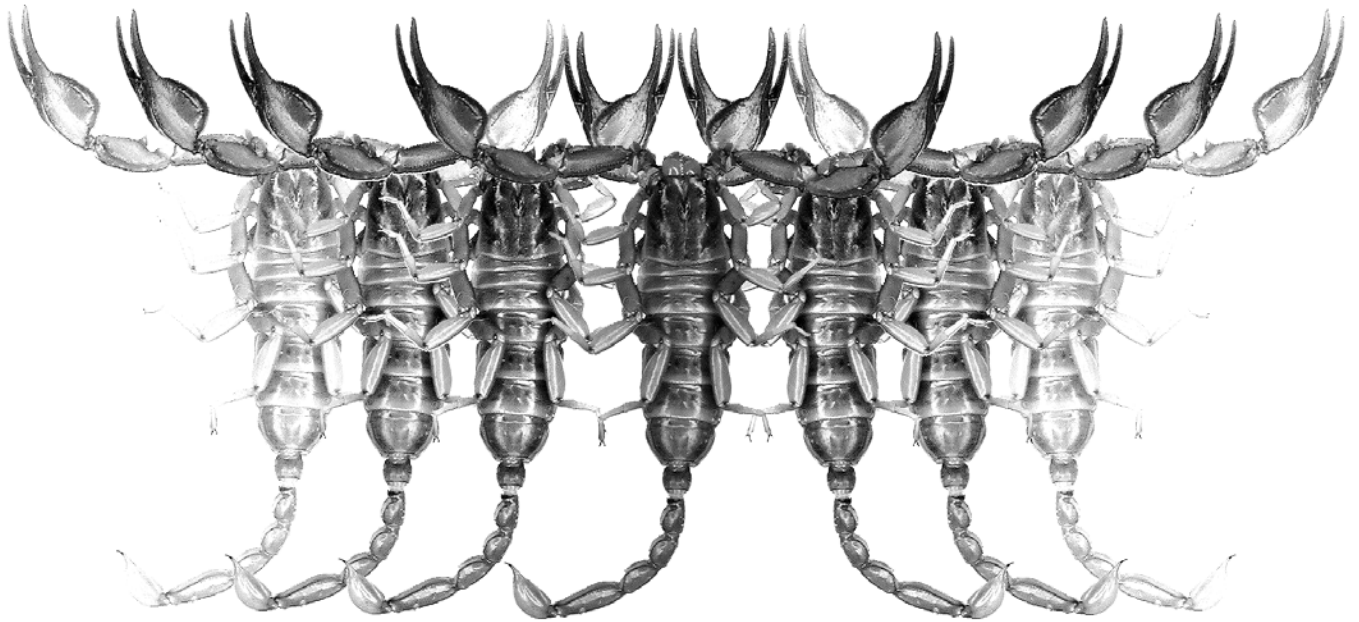


Euscorpium

Occasional Publications in Scorpiology



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

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

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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 Vaejoidea. 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 Vaejoidea, 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 Vaejoidea. For example, the systematics of Vaejoidea was clarified considerably in that study when the genus *Uroctonus*, a long time member of Vaejoidea, 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 Vaejoidea was shared by either of these chactid genera (see Soleglad & Fet, 2004: 83, for additional comparisons between these genera and Vaejoidea).

In this contribution, we revisit the diagnostic characters originally established by Herbert L. Stahnke (1940a, 1940b, 1974) in his description of the vaejoidean 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 Vaejoidea. 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 hemispermatothore. 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 gramenestrus* (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 angeleus* (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 viscainensis* 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

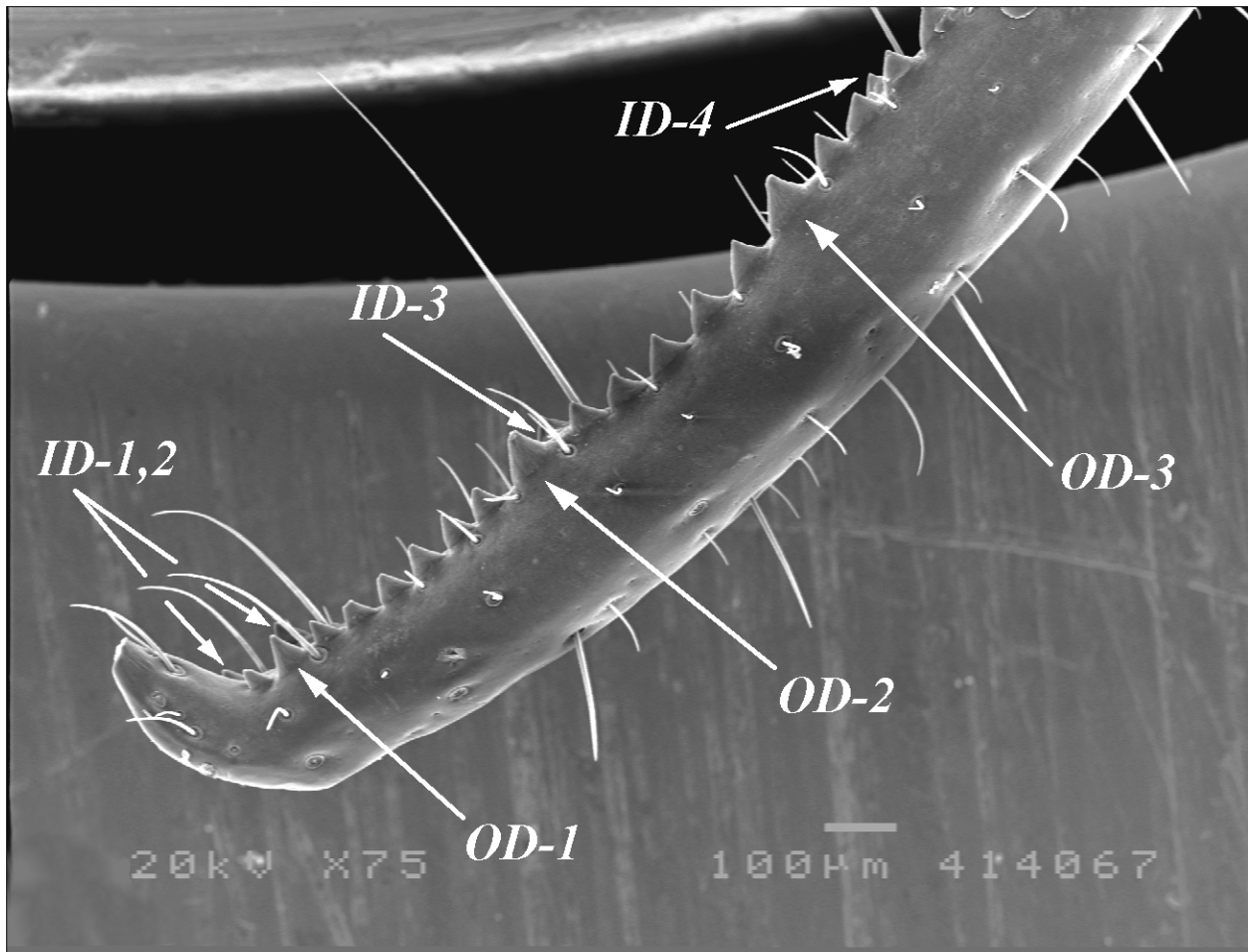
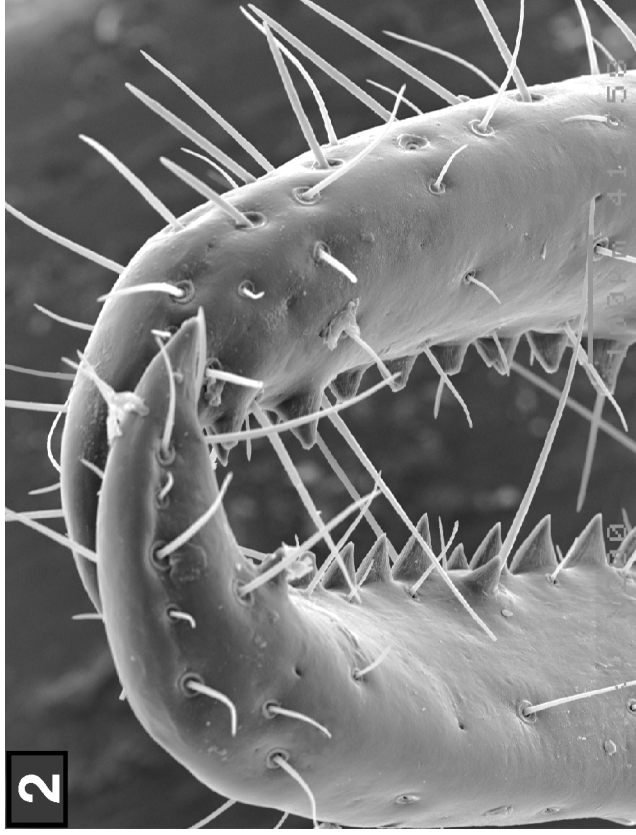


Figure 1: Distal half of movable finger, external view, of female *Serradigitus g. gertschi*, San Diego, California, showing configuration of outer (*OD*) denticles 1–3 as they relate to *MD* and inner (*ID*) denticles 1–4. Typically the only *OD* denticles discernible in tribe Stahnkeini are 1–3. Distally *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 in line 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.

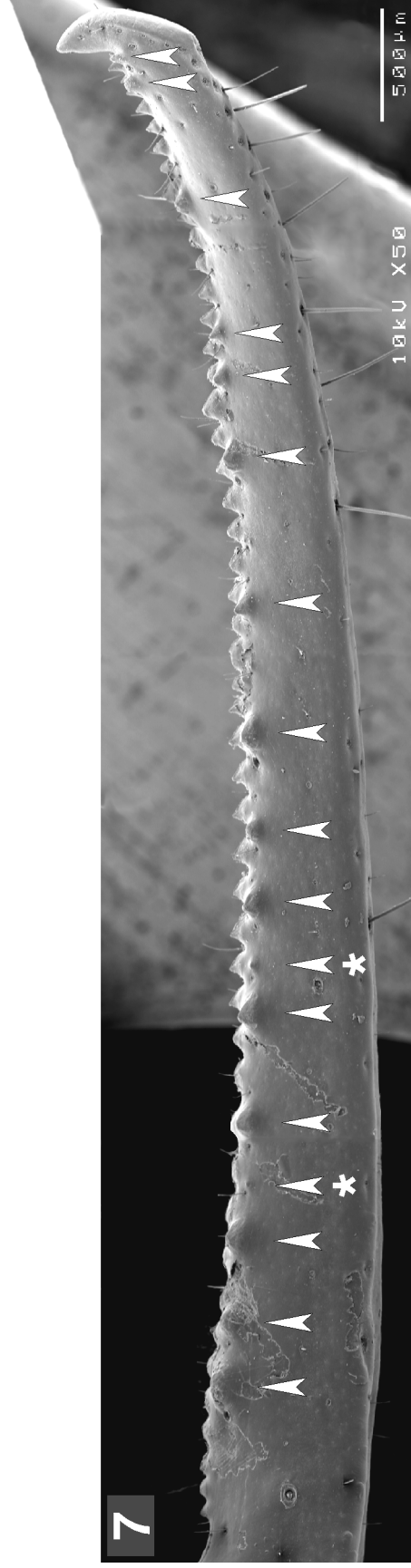
elliptical bases of the surrounding *MD* and *OD* denticles, a by-product of the overall flattening of these denticles. Fig. 4 illustrates the elliptical *MD* denticle bases for species *Serradigitus joshuaensis*.

***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</i> Number | <i>MF_L/Cara_L</i> | <i>MD + OD</i> Density Quotient |
|----------------------------------|----------------------------|----------------------------|---------------------------------|
| <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) |

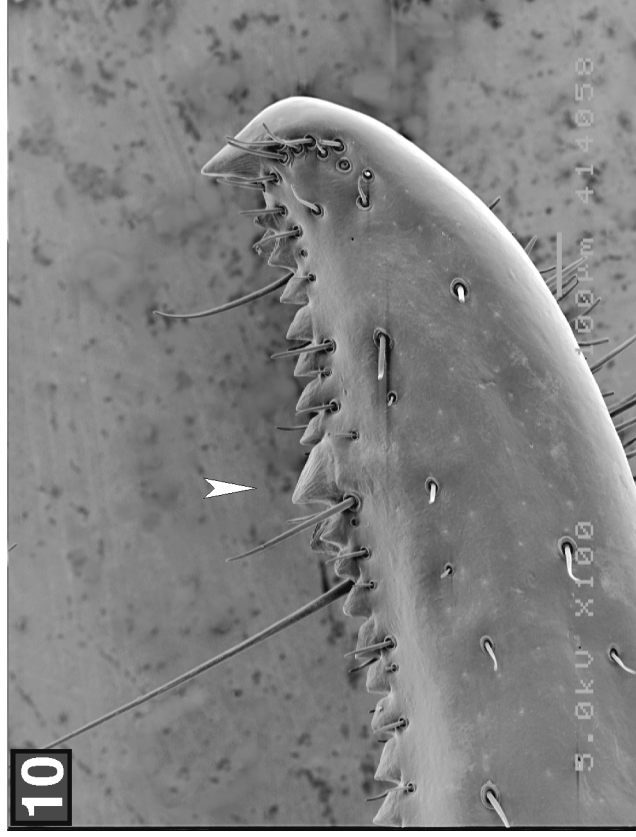
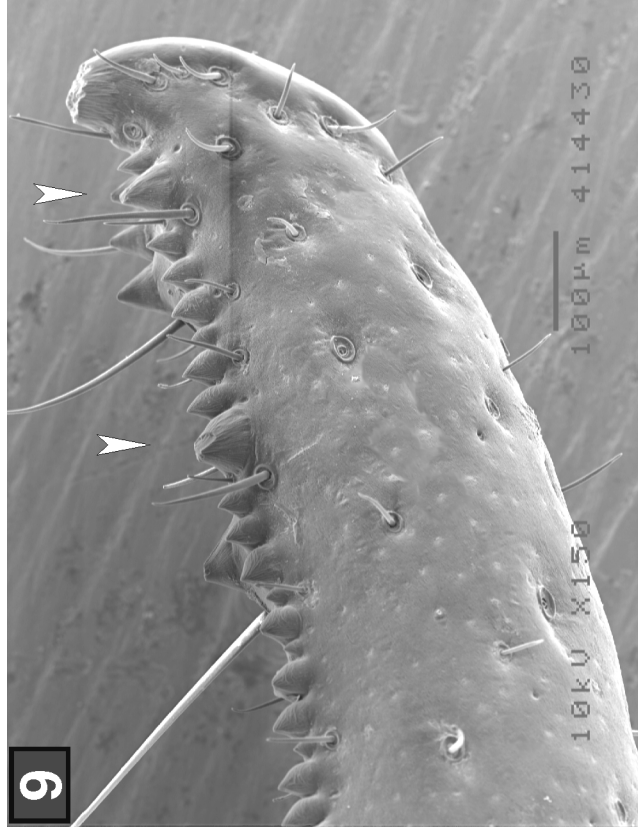
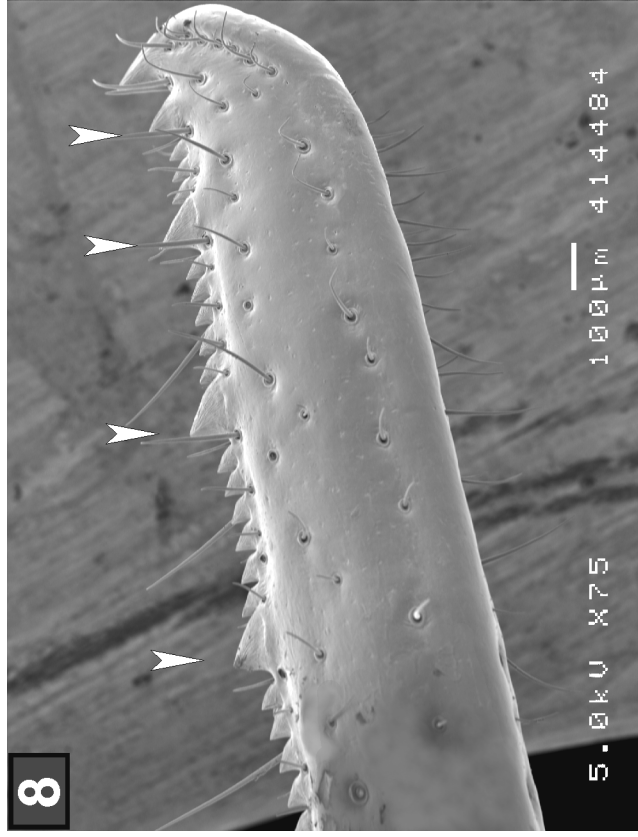
Table 1: Statistics of chelal movable finger median (*MD*) and outer (*OD*) denticle numbers for genera *Stahnkeus* and *Serradigitus*. *MD + OD* density quotient is calculated by dividing the number of *MD + OD* by the ratio of *MF_L/Cara_L*. The latter ratio normalizes the movable finger length with 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</i> Number | <i>MF_L/Cara_L</i> | <i>MD+OD</i> Density Quotient | Density Increase (%) |
|--|---------------------|---------------------|-------------------------------|----------------------|
| <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



Figures 8–11: Distal aspect of movable finger, external view, showing conspicuous differences between OD and MD denticles of select vaejoivids. Note, OD denticles are situated slightly external of MD denticle row. White arrows indicate OD denticles. **8.** *Vaejovis eusthemura*, Cabo San Lucas, Baja California Sur, Mexico. **9.** *Vaejovis carolinianus*, Tishomingo State Park, Mississippi. **10.** *Vaejovoidis longiunguis*, Vizcaino Desert, Baja California, Mexico. **11.** *Vaejovis hirsuitcauda*, Indian Gorge, ABDSP, California.

| | MD L/FF D | % Length Decrease |
|--|---------------------------------|-------------------|
| <i>Stahnkeus deserticola</i> | 0.182 | - |
| <i>Stahnkeus harbisoni</i> | 0.162 | - |
| <i>Stahnkeus subtilimanus</i> | 0.173 | - |
| <i>Serradigitus adcocki</i> | 0.164 | - |
| <i>Serradigitus armadentis</i> | 0.182 | - |
| <i>Serradigitus baueri</i> | 0.118 | - |
| <i>Serradigitus bechteli</i> | 0.173 | - |
| <i>Serradigitus calidus</i> | 0.202 | - |
| <i>Serradigitus g. gertschi</i> | 0.200 | - |
| <i>Serradigitus gramenestris</i> | 0.182 | - |
| <i>Serradigitus haradoni</i> | 0.147 | - |
| <i>Serradigitus hearnei</i> | 0.167 | - |
| <i>Serradigitus joshuaensis</i> | 0.160 | - |
| <i>Serradigitus littoralis</i> | 0.139 | - |
| <i>Serradigitus minutis</i> | 0.159 | - |
| <i>Serradigitus pacificus</i> | 0.179 | - |
| <i>Serradigitus torridus</i> | 0.191 | - |
| <i>Serradigitus wupatkiensis</i> | 0.200 | - |
| <i>Stahnkeus</i> + <i>Serradigitus</i> | 0.118–0.202 (0.171) [18] | - |
| <i>Franckeus</i> + “nigrescens” group | 0.053–0.139 (0.094) [6] | 45.0 % |
| “eusthenura” group | 0.058–0.100 (0.082) [10] | 52.0 % |
| “mexicanus” group | 0.064–0.093 (0.077) [6] | 55.0 % |
| <i>Smeringurus</i> + <i>Paruroctonus</i> + <i>Vejovoidus</i> | 0.059–0.089 (0.071) [14] | 58.5 % |
| <i>Paravaejovis</i> | 0.064 [1] | 62.6 % |
| “punctipalpi” group | 0.053–0.071 (0.063) [7] | 63.2 % |
| <i>Pseudouroctonus</i> + <i>Uroctonites</i> | 0.032–0.057 (0.040) [9] | 76.6 % |

Table 3: Morphometric ratio of chelal fixed finger *median (MD) denticle length/fixed finger depth* of tribe Stahnkeini as it compares to other genera and *Vaejovis* groups. The fixed finger depth is measured at the position of outer (*OD*) denticle three excluding the denticle; *MD* length is calculated from the longest *MD* denticle in close proximity to *OD*–3 from its tip to the juncture of the adjacent denticle (i.e., does not include the denticle base positioned on the finger). *Length decrease* is based on the mean as it relates to genera *Stahnkeus* + *Serradigitus*. Minimum–maximum (mean) [number of samples]; *MD_L* = median (*MD*) denticle length; *FF_D* = fixed finger depth.

aligned with *ID*–3; still further basad, 5–8 (6.11) *MD* denticles separate *OD*–2 and *OD*–3, followed by 1–3 *MD* denticles, the most proximal one aligned with *ID*–4. At this point *OD*–3 and *ID*–4 are not adjacent, the latter being positioned more proximally on the finger. From this point, we cannot reliably detect further basal *OD* denticles. We consider this arrangement generally diagnostic of the serrated condition of these denticles in Stahnkeini. Consequently, the number of denticles groups as discussed by Williams & Berke (1986) and Sissom & Stockwell (1991) is not really an accurate depiction of this character: it is more accurate to talk about *discernable* denticle groups, since the basal *OD* denticles are not absent, but instead are not distinguishable from the surrounding *MD* and therefore the denticle groups are not actually “missing”.

***MD* + *OD* denticle density.** Presumably, due to this flattening as also suggested elsewhere for the *MD* lengthening, individual *MD* denticles are wider at their base (i.e., along the finger length) as would be caused by their highly elliptical bases, thus their numbers are relatively decreased as compared to other vaejovids.

This is particularly interesting observation since the chelal fingers in Stahnkeini, in general, are relatively the longest occurring in family Vaejovidae. Tables 1–2 present statistical data that establishes a *density quotient* of *MD* and *OD* denticles on the chelal movable finger (using the sum of the number of these two denticle types). The *MD* + *OD* density quotient is calculated by dividing the number of *MD* + *OD* by the ratio of the movable finger length divided by the carapace length. 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* presented in Tables 1–2 is essentially independent of the length of the movable finger.

Tables 1–2 provide three groups of interesting information where Stahnkeini is compared to other representative vaejovid genera and *Vaejovis* groups: (1) the movable finger, as compared to the carapace length, is the longest in any vaejovid assemblage, in general the finger being longer than the carapace. Genus *Franckeus* and the “nigrescens” group also exhibit comparable elongated chelal fingers (in the slender monotypic genus

Syntropis, this ratio is 1.291 (after Stahnke, 1965: 261)); (2) from this, we see that the density quotient is a function of the relative finger length (as compared to the carapace length). Since Stahnkeini generally has fingers longer than the carapace, the density value for this group is less than its absolute number of denticles. In contrast, for genera *Pseudouroctonus* and *Uroctonites*, which, in general, have the shortest fingers in the vaejovids, the density value is greater than the actual number of denticles (i.e., the movable finger in this assemblage is in general shorter than the carapace); (3) accompanying the density data are actual counts of *MD* + *OD* of the specimens. The genera *Pseudouroctonus* and *Uroctonites* have some of the highest actual denticle counts in the family due to their somewhat small *MD*. In contrast, tribe Stahnkeini has the smallest numbers of denticles.

It is clear from these data that the tribe Stahnkeini has the lowest denticle density, averaging 37 denticles. Its actual denticle counts are also among the lowest, averaging 40 denticles, only genus *Paravaejovis* has a lower number, 26, but due to its quite short fingers, we calculate a slightly larger density value. Figs. 8–11 depict the distal aspect of the movable finger of several vaejovid genera and groups, illustrating the proportional size of the *MD* denticles as compared to *OD*. These figures reveal the somewhat small, compact *MD* denticles which are in high contrast to the larger slightly externally positioned *OD* denticles.

Elongated *MD* denticle. We hypothesize here that the flattening of the individual *MD* denticle is the probable cause of the lengthening of the denticle. This lengthening, plus its flattening, contributes to the “serrated” appearance of the *MD* denticle row and intervening *OD* denticles. In order to quantify this lengthening, we constructed a morphometric ratio based on the fixed finger depth and the length of a *MD* denticle. Table 3 shows the result of these data and the methods of measurement as compared to a representative set of vaejovid genera and *Vaejovis* groups. What is apparent, even from these limited data, is that Stahnkeini indeed exhibits considerably longer *MD* denticles than any of the other vaejovid genera or *Vaejovis* groups. When compared to other genera and groups, the decrease in *MD* length is even more exaggerated, especially when compared to *Pseudouroctonus* and *Uroctonites*, where we see a decrease of 77 %! It is interesting to note here that these genera happen to exhibit relatively the most dense number of *MD* in the family (see discussion elsewhere), thus explaining their somewhat petite size. Also of interest, in genus *Franckeus* and the “nigrescens” group, an ecological counterpart of Stahnkeini, the *MD* denticle is 45 % shorter than in Stahnkeini. This is an important observation because these two taxonomic assemblages both have elongated slender fingers, thus relatively quite similar in overall morphometrics. This implies that the

slender fingers seen in Stahnkeini are probably not a factor in this *MD* denticle length difference.

History of the character. Stahnke (1940a), in his unpublished thesis, defined this character as follows: “... fingers of the pedipalps bear a longitudinal row of subequal, sharply pointed, tooth-like granules, terminated distad by an extremely large, somewhat curved tooth ...”. As was the case with the modified basal pectinal teeth of the female (discussed elsewhere), Stahnke (1940b) did *not* mention this character in his very brief synopsis of *Vejovis wupatkiensis* (now placed in *Serradigitus*). Therefore, Stahnke’s original description of *V. wupatkiensis* in fact included no diagnostic characters! Thirty-four years later, Stahnke (1974: 130), in his definition of genus *Serradigitus*, described this character: “... inner edge of the pedipalp tarsus has a continuous row of conspicuously serrate, subequal denticles, uninterrupted, or indefinitely so, by larger denticles ... terminal denticle is abnormally large and claw-like and bears on its terminus an elongated whitish cap ... interior lateral, large flanking denticles vary in position and number from six on the type-species up to 16 on other species ...”. This description by Stahnke is quite accurate and, in many aspects, covers some of the more subtle characteristics of the serrated condition discussed in this paper, including, for example, the indistinguishable *MD* denticle groups, as well as the variable number of inner (*ID*) denticles found on the fingers, a distinction now used in this paper to define genus *Stahnkeus*.

It is interesting to compare the depiction of this character throughout the years by other scorpriologists. We divide this comparison into four character components discussed herein: the serrated *MD* denticles, enlarged distal denticle with “whitish cap”, the indistinguishable denticle groups, and the occurrence of *IAD* denticles (the latter applicable to *Stahnkeus* only). Gertsch & Allred (1965) and Johnson & Allred (1972), for species *Vejovis wupatkiensis* (now in *Serradigitus*) did not mention any of these character components. Williams (1968, 1970a, 1970b) and Hjelle (1970) only mentioned the enlarged distal denticle (omitting reference to the “whitish cap”), and ignored the other components. Soleglad (1972) commented on the serrated denticles, enlarged distal tooth and the presence of *IAD* (*Vejovis subtilimanus*, now in *Stahnkeus*) but did not mention the “whitish cap” or indiscernable *MD* groups. Again, Williams (1980), defining several new species now placed in *Serradigitus*, concentrated on the enlarged distal denticle and number of *MD* denticle groups, but ignored the serrated construction of the *MD* row (the *IAD* was discussed and illustrated for *Vaejovis harbisoni*, now placed in *Stahnkeus*). Similarly, Williams & Berke (1986), as they resurrected genus *Serradigitus*, continued with the same depiction as that followed by Williams (1980), again omitting the serrated nature of the *MD* denticle row.

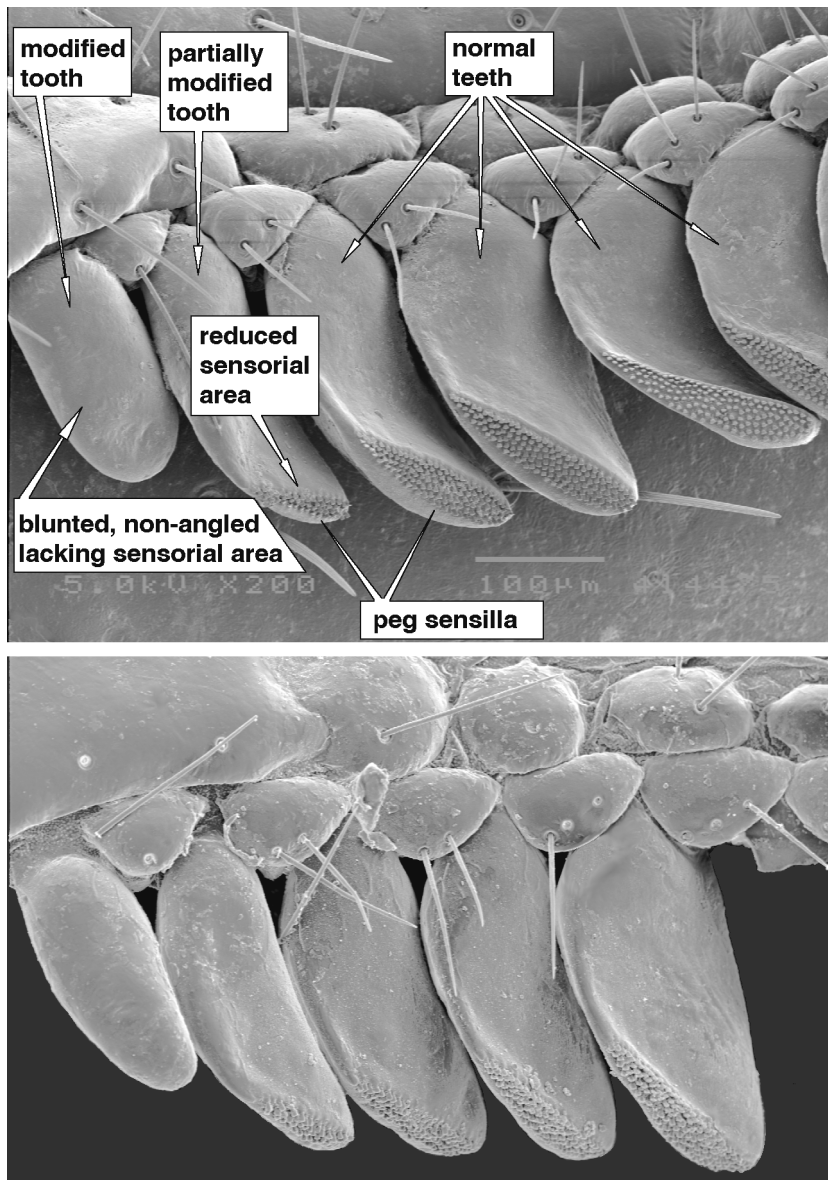


Figure 12: Basal pectinal teeth of female *Serradigitus joshuaensis* (top), Borrego Springs, California, and female *Serradigitus minutis* (bottom), Cabo San Lucas, Baja California Sur, Mexico, showing details of specialized tooth modifications. Note that the basal tooth exhibits *all* modifications: Laterally symmetric, and for these species, blunted in appearance (i.e., not elongated as exhibited in many Stahnkeini species), smooth, thus completely lacking a sensorial area. The second tooth exhibits partial modifications, slight angling and a reduced sensorial area. Note, though reduced in area, the density of the individual peg sensilla is the same as that found in the normal tooth. Other teeth lack these modifications, showing distal angling and a full-sized sensorial area.

Sissom & Stockwell (1991) commented correctly on all components associated with this character, including the *IAD* exhibited in a couple of their new species. Stockwell (1992) only included the indiscernable denticle *MD* groups in his key couplet, ignoring the other character components.

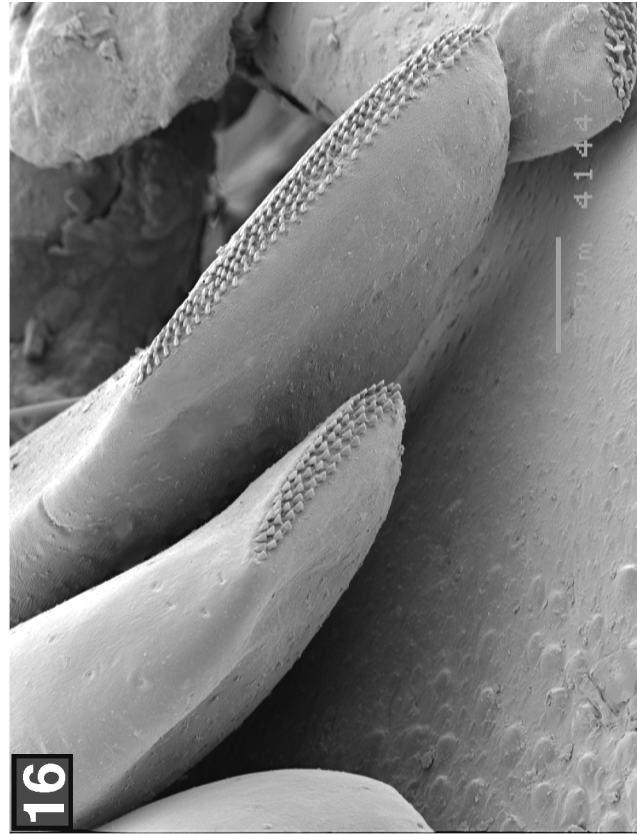
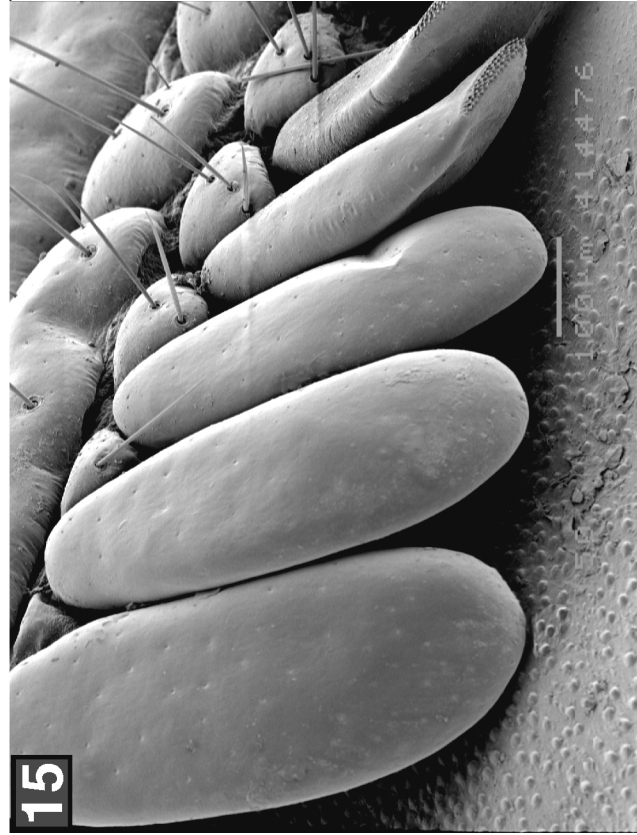
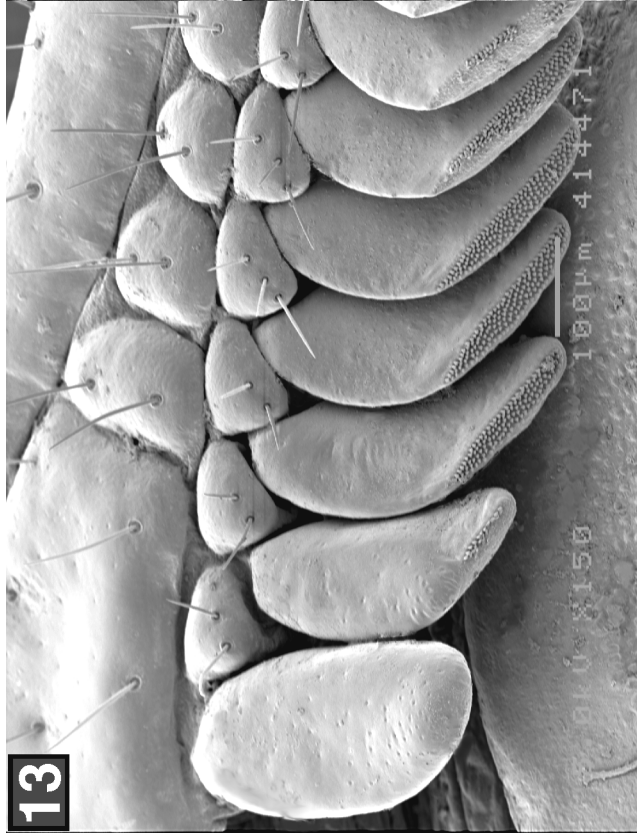
Pectines of the female. The modified basal pectinal teeth of the female in tribe Stahnkeini is quite unique in Vaejovidae. We consider it a primary synapomorphy for this tribe. This character involves three distinct modifications, which are found on at least the basal tooth and may include two, three, or even sometimes four basal teeth:

(1) the tooth is smooth distally, lacking a sensorial area (i.e., the area which contains the peg sensilla);

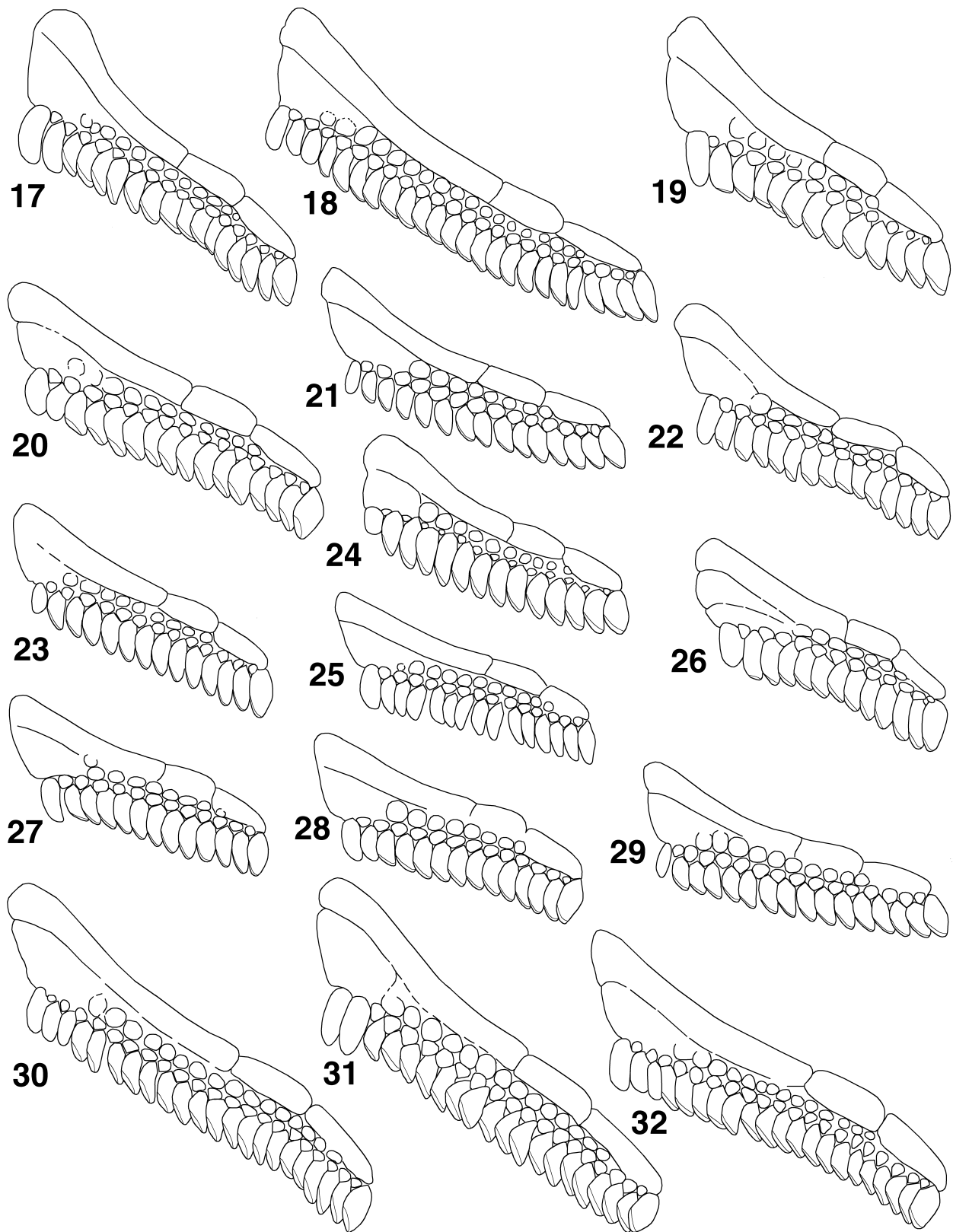
(2) the size and proportion of the individual tooth is usually manifested as a somewhat swollen elongated tooth, but sometimes it is shaped as a shorter and more rounded tooth; and,

(3) the distal aspect of the tooth lacks the exterodistal angling as seen on normal teeth, thus its lateral sides are in most cases nearly symmetric.

Of these three modifications, we consider the absence of the sensorial area to be the most significant. In fact, one could argue that the lack of this sensory area is the cause, in part, of the other two modifications. For example (Fig. 12), the second tooth, which exhibits a greatly reduced sensorial area, does not angle externally as much as the other more distal teeth which have a normally developed sensorial area. Generally, a scorpion's pectinal tooth angles exterodistally to



Figures 13–16: Basal pectinal teeth of female showing the characteristic smooth (i.e., lacking sensorial area), elongated and non-angled teeth of tribe Stahnkeini. **13 & 14** *Serradigitus g. gertschi*, San Diego, California. **15 & 16** *Serradigitus subtilimanus*, Borrego Springs, California.



Figures 17–32: Examples of the female pecten of genera *Serradigitus* and *Stahnkeus* showing the varied configurations of the basal teeth. 17. *Serradigitus wupatkiensis*. 18. *S. adcocki*. 19. *S. torridus*. 20. *S. calidus*. 21. *S. bechteli*. 22. *S. g. gertschi*. 23. *S. minutis*. 24. *S. littoralis*. 25. *S. hearnei*. 26. *S. joshuaensis*. 27. *S. haradoni*. 28. *S. gramenestris*. 29. *S. pacificus*. 30. *Stahnkeus harbisoni*. 31. *S. subtilimanus*. 32. *S. deserticola*. Figs. 20, 22, 26, 30–32 after Soleglad (1974, in part).

| ♀ | Left Pecten | | Right Pecten | |
|----------------------------------|---------------------|-------------------|---------------------|-------------------|
| | Total Teeth | Basal Teeth | Total Teeth | Basal Teeth |
| <i>Stahnkeus allredi</i> | 14–16 | 2 | 14–16 | 2 |
| <i>Stahnkeus deserticola</i> | 20–21 (20.333) [3] | 3* (3.000) [3] | 20–21 (20.500) [2] | 3* (3.000) [2] |
| <i>Stahnkeus harbisoni</i> | 22–24 (23.167) [6] | 2–3 (2.833) [6] | 22–24 (22.667) [6] | 2–3* (2.833) [6] |
| <i>Stahnkeus polisi</i> | 15–21 | 2 | 15–21 | 2 |
| <i>Stahnkeus subtilimanus</i> | 19–23 (21.880) [25] | 2–4* (2.782) [23] | 21–24 (21.954) [22] | 2–3* (2.730) [23] |
| <i>Serradigitus adcocki</i> | 23 (23.000) [1] | 2 (2.000) [1] | 24 (24.000) [1] | 3* (3.000) [1] |
| <i>Serradigitus agilis</i> | 14–15 | 2 | 14–15 | 2 |
| <i>Serradigitus bechteli</i> | 15 [1] | 2* [1] | 15 [1] | 1 [1] |
| <i>Serradigitus calidus</i> | 16–17 (16.500) [2] | 2 (2.000) [2] | 15–16 (15.500) [2] | 1 (1.000) [2] |
| <i>Serradigitus g. gertschi</i> | 15–16 (15.500) [8] | 2* (2.000) [9] | 15–16 (15.571) [7] | 1–3 (2.000) [7] |
| <i>Serradigitus gramenestris</i> | 13–14 (13.800) [10] | 1–2* (1.889) [9] | 13–14 (13.667) [9] | 1–2* (1.750) [8] |
| <i>Serradigitus haradoni</i> | 13–14 (13.500) [2] | 1 (1.000) [2] | 13 (13.000) [2] | 1–2* (1.500) [2] |
| <i>Serradigitus hearnei</i> | 15–16 (15.500) [2] | 1 [1] | 15 (15.000) [2] | 1 (1.000) [3] |
| <i>Serradigitus joshuaensis</i> | 12–14 (12.895) [19] | 1–2* (1.263) [19] | 12–15 (12.944) [18] | 1–2* (1.056) [18] |
| <i>Serradigitus littoralis</i> | 13–14 (13.500) [4] | 1 (1.000) [3] | 13–14 (13.750) [4] | 1 (1.000) [3] |
| <i>Serradigitus minutis</i> | 13–15 (13.875) [7] | 1–2* (1.375) [8] | 13–14 (13.571) [7] | 1–2* (1.143) [7] |
| <i>Serradigitus pacificus</i> | 16 [1] | 1 [1] | 15 [1] | 1* [1] |
| <i>Serradigitus torridus</i> | 13–15 (14.333) [6] | 1–2 (1.667) [6] | 13–15 (14.333) [6] | 1–3* (2.000) [6] |
| <i>Serradigitus wupatkiensis</i> | 16–17 (16.500) [2] | 2 (2.000) [2] | 16–17 (16.500) [2] | 2 (2.000) [2] |
| <i>Serradigitus yaqui</i> | 13–15 | 1–2* | 13–15 | 1–2* |

Table 4: Pectinal tooth data of *female* for genera *Stahnkeus* and *Serradigitus*. *Basal teeth* refer to elongated or shortened, non-angled teeth lacking peg sensilla. Minimum–maximum (mean) [number of samples]. Data based on material examined and Soleglad (1974) for *Serradigitus calidus* (in part), and Sissom & Stockwell (1991) for *Stahnkeus allredi*, *S. polisi*, *Serradigitus agilis* and *S. yaqui*; for the latter species the number of samples or left/right distribution are not available. * indicates that most distal tooth in basal range only partially exhibits tooth modifications.

position the sensorial area parallel to the substrate. In males, whose sensorial area is considerably larger than that of the female, we see a more exaggerated angling to accommodate the larger group of peg sensilla. Finally, one may also argue that the lack of this angling might be the cause of this tooth being more elongated or ovoid in shape, thus symmetric laterally. In summary, without a sensorial area, the tooth need not be positioned parallel to the substrate, thus it is not angled, and therefore essentially symmetric laterally.

This character presents itself in many various configurations. Figures 12–16 depict: a short non-angled, smooth basal tooth (*Serradigitus joshuaensis* and *S. minutis*), one elongated non-angled smooth tooth (*S. g. gertschi*), and three conspicuously elongated non-angled smooth teeth (*Stahnkeus subtilimanus*). The smoothness exhibited on these basal teeth is due to the complete lack of a sensorial area on the distal aspect of

the tooth. It is also important to note in these figures that the second, and with the case of *S. subtilimanus*, fourth tooth, respectively, exhibit a partial modification: in these cases there is a slightly developed sensorial area containing peg sensilla and slight exterodistal angling. The more distal teeth in these four species are normally developed, exhibiting the typical size of sensorial area. On the teeth that have a reduced sensorial area, the peg sensilla show the same density as that of the normally developed tooth, only the area is reduced.

Figures 17–32 illustrate the wide spectrum of configurations of this curious character as it exists in sixteen species of tribe Stahnkeini. These figures show the shortened, rounded basal tooth of species *Serradigitus minutis*, *S. littoralis*, and *S. joshuaensis* (Figs. 23, 24 and 26); a shorter and thinner basal tooth of species *S. bechteli* and *S. pacificus* (Figs. 21 and 29); the two exaggerated elongated basal teeth of *S. wupatkiensis*

(Fig. 17); and three modified basal teeth in *S. adcocki* (Fig. 18), one of the largest *Serradigitus* species. In genus *Stahnkeus*, its three largest species, *S. harbisoni*, *S. subtilimanus* and *S. deserticola*, exhibit two to three modified basal teeth (Figs. 30–32), the average being three.

It is important to note here, as first reported by Soleglad (1974: 108), that these pectinal modifications show variability within the species and even within a specimen, where sometimes one pecten is formed differently than the other with respect to these modifications. For example, a pecten may exhibit a partially modified tooth (as seen in Figs. 12–16) whereas the other pecten may have this tooth completely modified, or, presented as a normally formed tooth lacking any modifications. Table 4 presents statistics of the pectines of a large representative set of Stahnkeini species, where we see asymmetry across the pectines. It is also clear from these data, as well as in Figs. 17–32, that the larger species, thus those exhibiting the overall largest pectinal tooth counts, have a tendency for two or sometimes three modified basal teeth. The smaller species such as *S. minutis*, *S. haradoni*, *S. hearnei*, *S. littoralis* and *S. joshuaensis* exhibiting on an average only a single modified basal tooth. Table 4 also shows, where multiple specimens were available for examination, the occurrence of partially modified basal teeth is somewhat common, as that shown in Figs. 12–16.

History of the character. It is interesting to point out that this character was defined quite accurately as far back as 1940 when Herbert Stahnke (1940a: 102), in his unpublished Ph.D. thesis, described new species *Vejovis wupatkiensis* (now *Serradigitus wupatkiensis*): "... first two teeth on the female are larger, rounder, and smoother looking than the others ...". Stahnke essentially observed the three modifications attributed to this character. This was the most accurate description of this character until Soleglad (1974: 102, figs. 1–6) described and illustrated it in detail for several species of Stahnkeini. Of special interest, when Stahnke (1940b) published an official abstract of the new species described in his unpublished thesis, only a small paragraph was devoted to *S. wupatkiensis* and nothing was mentioned concerning this character. Stahnke (1974), when he officially established the genus *Serradigitus*, described this character as follows: "... female pectines with teeth number one to three more paddle-like and somewhat larger than the others ...". Curiously, he does not mention the smoothness of the teeth, i.e., the lack of a sensorial area. It is interesting to note that this character was sometimes completely ignored by other workers in their descriptions of species of this tribe, including the first author of this paper: Gertsch & Allred (1965), for species now called *Serradigitus wupatkiensis*; Williams (1968), for *S. g.*

gertschi; Williams (1970b, in part), for *S. minutis*; Hjelle (1972), for *S. gertschi striatus*; Soleglad (1972), for *S. joshuaensis* and *Stahnkeus subtilimanus*; Johnson & Allred (1972), for *Serradigitus wupatkiensis*; and Williams (1980), for all Baja California species associated with the "wupatkiensis" group of *Vaejovis*. Williams (1970a) mentioned this character, in part, for two new species (now *Serradigitus gramenestrus* and *Stahnkeus deserticola*), only referring to the "elongated" aspect of the character. Williams (1970b) mentioned this character for *Vejovis harbisoni* (now *Stahnkeus harbisoni*) but ignored it for *V. minutis* (now *Serradigitus minutis*). Presumably, only the "elongated" aspect of the character was recognized, not the loss of the sensorial area or its lack of external angling (the basal tooth of *S. minutis* is small and round (Figs. 12, 23)). As discussed elsewhere, Williams (1980) analyzed this character in his argument for synonymizing *Serradigitus* with *Vaejovis* but limited his depiction of the character only to its shape and decided, because it is found on one, or sometimes two teeth, that it is too variable to be a legitimate character. In his analysis, Williams (1980) completely ignored Soleglad's (1974) detailed description of the character which encompassed the variability of these modifications. This somewhat limited analysis of the character plus the confusion with non-Stahnkeini species, such as *Vaejovis peninsularis* (now placed in *Franckeus*) and *V. janssi*, caused Williams (1980), in part, to synonymize genus *Serradigitus*. However, in 1986, Williams & Berke reconsidered the position of *Serradigitus* and reestablished it as a legitimate genus, but still did not completely describe this character: "... females with proximal teeth 1–3 often more elongate or more swollen than more distal ones ...". Sissom & Stockwell (1991: figs. 1, 14, 27, 36) illustrated this character for four new species. In their depiction of this character they did mention the lack of peg sensilla. Finally, Stockwell (1992: 416, fig. 42) illustrated and described this character in his key "... females with one or more pairs of proximal pectinal teeth ovoid and lacking sensillae ...". Stockwell's description succinctly defines female pectines of the Stahnkeini.

The similar character found in Buthidae. It seems relevant to mention here that the modified basal pectinal teeth in scorpion females are known also in some Old World Buthidae. Such modifications are, to a variable degree, present in all species of the endemic Madagascan genus *Grosphus* Simon, 1880 (e.g. Lourenço, 1996: figs. 3–9) as well as in Afrotropical genus *Uroplectes* Peters, 1861 (e.g. Lamoral, 1979: figs. 229, 230, 268, 284, 291). In some buthids, a single, most basal pectinal tooth can be elongated in a bizarre, saberlike shape (e.g. *Grosphus grandidieri* Kraepelin, 1900; see Lourenço, 1996: fig. 7). Our preliminary SEM data (V. Fet & P. H. Brownell, in progress) show that the

| | $(ib^1/\text{Fixed Finger Length}) = A \mid A/\text{Carapace Length}$ | it Position Relative to Inner Denticles (ID) | ib Position Relative to Inner Denticles (ID) |
|--|---|--|--|
| <i>Stahnkeus allredi</i> | 0.282 0.091 | not determinable | not determinable |
| <i>Stahnkeus deserticola</i> | 0.471 0.091 | not determinable | not determinable |
| <i>Stahnkeus harbisoni</i> | 0.471 0.079 | not determinable | not determinable |
| <i>Stahnkeus polisi</i> | 0.353 0.075 | not determinable | not determinable |
| <i>Stahnkeus subtilimanus</i> | 0.462 0.084 | not determinable | not determinable |
| <i>Serradigitus adcocki</i> | 0.500 0.106 | between $ID-4$ & $ID-5$ | between $ID-4$ & $ID-5$ |
| <i>Serradigitus agilis</i> | 0.216 0.068 | adjacent to $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus armadentis</i> | 0.297 0.082 | between $ID-5$ & $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus baueri</i> ³ | 0.161 0.047 | adjacent to $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus bechteli</i> | 0.313 0.089 | between $ID-5$ & $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus calidus</i> | 0.375 0.114 | between $ID-4$ & $ID-5$ | between $ID-5$ & $ID-6$ |
| <i>Serradigitus dwyeri</i> | 0.255 0.093 | between $ID-5$ & $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus g. gertschi</i> | 0.222 0.072 | between $ID-5$ & $ID-6$ | adjacent to $ID-6$ |
| <i>Serradigitus gigantaensis</i> | 0.215 0.081 | between $ID-5$ & $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus gramenestris</i> | 0.262 0.071 | between $ID-5$ & $ID-6$ | adjacent to $ID-6$ |
| <i>Serradigitus haradoni</i> | 0.253 0.086 | between $ID-5$ & $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus hearnei</i> | 0.327 0.113 | adjacent to $ID-5$ | between $ID-5$ & $ID-6$ |
| <i>Serradigitus joshuaensis</i> ² | 0.208 0.069 | proximal to $ID-4$ ² | proximal to $ID-4$ ² |
| <i>Serradigitus littoralis</i> ³ | 0.152 0.042 | proximal to $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus minutis</i> | 0.316 0.105 | adjacent to $ID-5$ | between $ID-5$ & $ID-6$ |
| <i>Serradigitus pacificus</i> ³ | 0.214 0.055 | adjacent to $ID-6$ | proximal to $ID-6$ |
| <i>Serradigitus torridus</i> | 0.292 0.077 | between $ID-5$ & $ID-6$ | between $ID-5$ & $ID-6$ |
| <i>Serradigitus wupatkiensis</i> | 0.311 0.074 | between $ID-5$ & $ID-6$ | between $ID-5$ & $ID-6$ |
| <i>Serradigitus yaqui</i> | 0.313 0.098 | between $ID-5$ & $ID-6$ | between $ID-5$ & $ID-6$ |

Table 5: Chelal trichobothrial series $ib-it$ relative positioning on fixed finger in relationship to the inner denticles (ID) for genera *Stahnkeus* and *Serradigitus*. The two morphometric ratios illustrate that the relative position of the $ib-it$ trichobothrial series is a function of the species adult size; the larger species exhibit a more midfinger position of these trichobothria and, similarly, smaller species have these trichobothria more proximally on the finger. This is shown by the first ratio ($= A$). The second ratio normalizes the first ratio by dividing it by the carapace length. Note that “not determinable” refers to the presence of inner accessory denticles (IAD) that obscure the identity of individual ID . Data based on specimens examined and from Sissom & Stockwell (1991). ¹ ib position measured from base of fixed finger. ² *S. joshuaensis* exhibits a reduced number of inner (ID) denticles, $ID-4$ is the most proximal denticle. ³ Indicates species with unusually basal $ib-it$ trichobothria.

reduction of the sensorial area and number of peg sensilla takes place on the modified basal tooth in *Uroplectes* in the same fashion as in *Stahnkeini*. In addition, a similar lobe-producing enlargement is known for the proximal median lamella of the pecten, rather than a pectinal tooth, in the African genus *Parabuthus* Pocock, 1890 (e.g. Lamoral, 1979: fig. 108), and in the New World buthid genera *Tityus* C.L. Koch, 1836 and *Tityopsis* Armas, 1974, also in the females. The function of modified basal pectinal teeth or lamellae is not known, but their presence only in females and, moreover, in close proximity to the genital opening

allows to hypothesize this feature as a reproductive adaptation, either for mating or for parturition.

Chelal finger trichobothria ib and it . The “mid-finger” position of chelal internal trichobothria $ib-it$ in *Stahnkeini* was first discussed by Gertsch & Soleglad (1972: 564, figs. 76–79) where they for the first time illustrated the chelal trichobothrial pattern of a member of this tribe (*Vejovis wupatkiensis*, now *Serradigitus wupatkiensis*). In their discussion, they contrasted the midfinger $ib-it$ position of *V. wupatkiensis* with that of *V. gracilis* Gertsch et Soleglad, 1972, whose trichobothria are positioned basally on the finger. The

relatively basal position of chela trichobothrial *ib-it* on the fixed finger was also used by Soleglad (1973: 360) in his definition of the “mexicanus” group of genus *Vaejovis*. Williams (1980: fig. 53A–Q) used this character as well in his monograph on scorpions of Baja California, Mexico, and improved on Soleglad’s (1973) depiction, based solely on finger position (i.e., a ratio), by associating the position of these trichobothria in respect to the *ID* denticles of the finger. Sissom & Francke (1985) also used the position of *ib-it* in their definition of the “nitidulus” group of *Vaejovis* (now genus *Franckeus* + *Vaejovis* “nigrescens” group; Soleglad & Fet, 2005).

Soleglad & Fet (2003: figs. 67–78) illustrated the relative position of trichobothria *ib-it* for 41 scorpion species representing all major genera and *Vaejovis* groups in family Vaejovidae. In this case, the authors were emphasizing the *finger* placement of these trichobothria in Vaejovidae in contrast to the *palm* placement found in families Chactidae and Euscorpiidae. In fig. 67, Soleglad & Fet (2003b) illustrated the position of *ib-it* for five species now placed in tribe Stahnkeini. From this figure, it is clear that the relative position varied within these species. In contrast, other illustrated vaejovid genera and *Vaejovis* groups exhibited the essentially consistent placement of *ib-it* in respect to *ID* locations. This is also verified in the additional species examined during the present study. Soleglad & Fet (2005: 6) commented on this variability of *ib-it* position in the taxa now placed in Stahnkeini suggesting that the position was based, in part, on the adult size of a species: trichobothria *ib-it* are located more mid-finger on larger species of Stahnkeini and likewise, are positioned more basally on smaller species. This observation in general is correct. Table 5 presents data documenting both the *ib-it* position on the fixed finger in respect to their alignment with specific *ID* denticles as well as a ratio based on trichobothrium *ib* position and fixed finger length. The smaller species of Stahnkeini, such as *Serradigitus joshuaensis*, *S. minutis*, *S. gigantaensis*, and *S. gertschi*, exhibit a more proximal placement of *ib-it*, whereas in larger species *S. adcocki*, *Stahnkeus harbisoni*, *S. deserticola* and *S. subtilimanus*, *ib-it* placement is more midfinger, their *ib*/fixed finger length ratio ranging 0.462–0.500 (Table 5). In order to demonstrate that the position of *ib-it* is roughly related to the species adult size, Table 5 employs a second ratio based on the carapace length: (*ib*_position/fixed finger length)/carapace length. The carapace length is used as an indicator of adult size. Our hypothesis here is that if a species is twice the adult size of another species, then the relative distance from trichobothrium *ib* to the fixed finger base would also be twice as large. Using this ratio, we do see overall consistency in tribe Stahnkeini, i.e., the hypothesis is generally correct, except for three species, *Serradigitus littoralis*, *S. baueri*, and *S.*

pacificus. In these species, trichobothria *ib-it* are placed considerably more basally on the fixed finger (as indicated by the somewhat lower second ratio stated in Table 5; 0.042–0.055) considering the reported adult size of the species. We also see in *S. littoralis* that both *ib* and *it* are positioned proximal to the basal *ID* (= *ID-6*); in *S. baueri* and *S. pacificus*, which appear to be closely related (see discussion elsewhere), these trichobothria are positioned closer to *ID-6*.

Relatively large pectinal tooth numbers. Soleglad & Fet (2003: 61–65, figs. 110–113) discussed the number of pectinal teeth as it related to the mature size of the scorpion species, in particular, contrasting the four chactoid families, Chactidae, Euscorpiidae, Superstitioniidae, and Vaejovidae. In is interesting to point out here that this analysis by Soleglad & Fet (2003) was based on the original observation of Soleglad (1973: figs. 13–14) that within closely related species sets (e.g., a genus) the number of pectinal teeth is proportional to the scorpion species adult size; that is, larger species in a related species set will exhibit a larger pectinal tooth count than a smaller species in that same set. And, important to taxonomic analysis, the ratios derived from these comparisons differ across different species sets, thus providing a gross diagnostic indicator. In their analysis, based primarily on published data, Soleglad & Fet (2003) demonstrated that pectinal tooth count in the family Vaejovidae is considerably larger than that found in the other three chactoid families, exhibiting, on an average, an increase well exceeding 100 % (i.e., as it relates to the species mature size). Consequently, a character was established in their cladistic analysis (character 103), where the more developed pectines was shown to be a synapomorphy for family Vaejovidae. See Soleglad & Fet (2003: appendix D) for details and assumptions used in their analysis.

In their analysis, Soleglad & Fet (2003) considered 91 species of the family Vaejovidae, including 16 species now placed in tribe Stahnkeini, the subject of this paper. As originally reported by Soleglad (1973) based on a smaller species set, Soleglad & Fet (2003: fig. D–6) also demonstrated that the assemblage of taxa now placed in Stahnkeini has relatively the largest pectinal tooth counts in the family Vaejovidae, only approached by the genus *Franckeus* and the *Vaejovis* “nigrescens” and “mexicanus” groups, where there is some standard error overlap. In stark contrast, genera *Pseudouroctonus* and *Uroctonites* clearly have the most reduced pectinal tooth numbers in the family.

In this analysis, factoring in the entire species set in tribe Stahnkeini, the Total Length (TL)/Pectinal Tooth Count (PTC) ratio for the *female* is the following: *Serradigitus* = 1.429–2.484 (1.915) [16], *Stahnkeus* = 1.667–2.217 (2.041) [5], and tribe Stahnkeini = 1.429–2.484 (1.945) [21].

Additional comments. Of particular interest for the present study was the examination of species *Serradigitus pacificus*, *S. baueri*, *S. littoralis*, and *S. bechteli*. This interest was precipitated, in part, by several events: (1) these species were considered members of the “wupatkiensis” group by Williams (1980); (2) then they were removed from *Serradigitus* by Williams & Berke (1986); (3) then they were returned (again) to *Serradigitus* by Sissom & Stockwell (1991); and (4) Sissom & Stockwell’s (1991: 198–199) curious statement: “... should be noted that *Vaejovis pacificus* and *V. baueri* [note that they were listed under *Vaejovis* by Williams & Berke, 1986] do not have modified proximal pectinal teeth in females ... *Vaejovis littoralis* has one proximal tooth on each pecten that is elliptical ... and the condition of the female pectinal teeth in *V. bechteli* is not known to us ...”. Taking this statement at its face value, the instability of genus placement of the species, and Williams’s (1980: 95) diagnostic comparisons between *Vaejovis baueri* and *V. pacificus*, which even included *Pseudouroctonus minimus thompsoni* (i.e., presumably implying a close relationship), we suspected that these species could represent a separate, closely related group distinct from *Serradigitus*. Adding to this suspicion was the fact that three of these species shared the same unusual, distally widening metasoma (i.e., segments III and IV sometimes as wide as, or wider than long; see Gertsch & Soleglad, 1972: figs. 141, 144), had elongated curved chelal fingers, and geographically, were isolated on islands off the west coast of southern California and Baja California, Mexico. *Serradigitus baueri* and *S. pacificus* in particular are situated quite close geographically. However, suspicions aside, based on very limited material, and contrary to Sissom & Stockwell’s (1991) comment, we *did observe* modified pectinal basal teeth in species *S. pacificus* (Fig. 29) and *S. bechteli* (Fig. 21, only known from female type specimen). Since only a solitary male of *S. baueri* was available for examination, we were not able to confirm one way or the other Sissom & Stockwell’s (1991) observation as to the female basal pectinal teeth lacking modifications. We suspect, based on this discrepancy with *S. pacificus*, and the qualified description of pectines of *S. littoralis*, that Sissom & Stockwell’s (1991) definition of this character is somewhat restricted, as was the case in Williams & Berke (1986). This probably explains why Sissom & Stockwell (1991) did not consider the modified pectinal base in females to be a mandatory diagnostic character for genus *Serradigitus*. While Sissom & Stockwell (1991) did not have the opportunity to examine *S. bechteli* (i.e., only known from female holotype), we do see that its modified pecten base is quite similar to that seen in *S. pacificus* (Figs. 21 and 29). In addition, with respect to other diagnostic characters, *Serradigitus baueri* and *S. pacificus* exhibited the serrated chelal

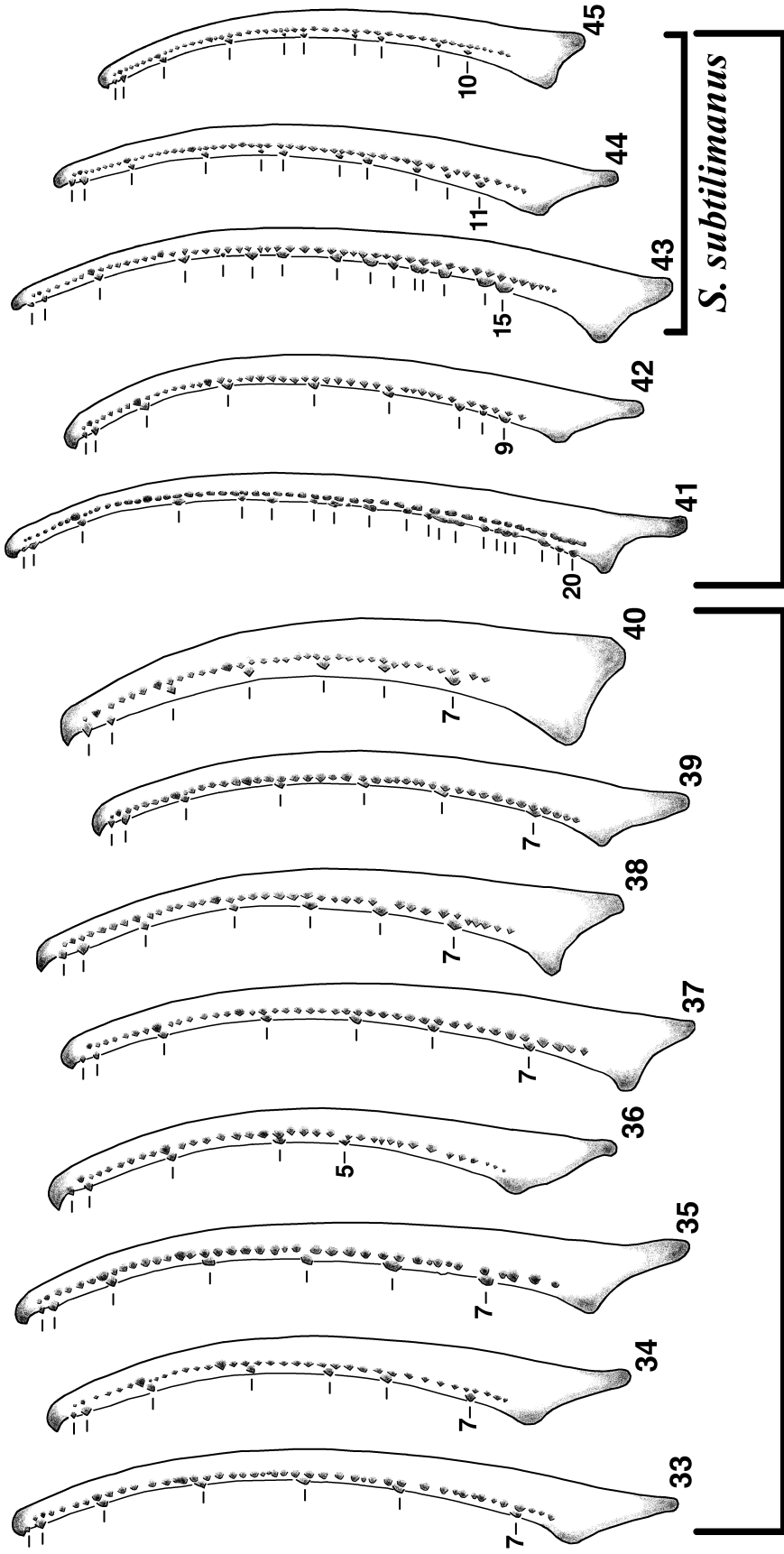
finger denticles as defined in this current study (i.e., low *MD + OD* density, *MD* denticles somewhat elongated, *OD* denticles not discernable proximally), plus they exhibited other characters consistent with tribe Stahnkeini. Interestingly, *S. baueri* and *S. pacificus*, along with *S. littoralis*, do exhibit an unusually basal position of chelal trichobothria *ib–it* in contrast to the other species of Stahnkeini (see Table 5). This is discussed further elsewhere in this paper.

To complete this analysis we even checked species *Pseudouroctonus minimus thompsoni* and concluded, predictively, that it is not related at all to members of tribe Stahnkeini, being more consistent with other members of *Pseudouroctonus*: genital operculum of the female is separated on the posterior one-fifth (it is fused in Stahnkeini), the leg tarsus terminus is equipped with multiple distal spinule pairs (*DSP*) (a single pair is found in Stahnkeini); chelal ventrointernal (*V2*) carina is essentially obsolete (it is present in Stahnkeini); chelal palm trichobothrium *Dt* is located proximally of palm’s midpoint (it is situated at, or distally to midpalm in Stahnkeini); chelal palm trichobothrium *ib* is located at the extreme base of the fixed finger (it is variable in Stahnkeini but never found on the extreme finger base); chelal finger dentition not overly serrated nor reduced in number, exhibiting a *MD + OD* density of 66; pectinal tooth counts are quite low in comparison to length of adult specimens, 10–11 teeth (the pectinal tooth counts are relatively high in Stahnkeini, the highest in Vaejovidae).

As a final comment, it must be noted that species *Serradigitus armadentis*, *S. dwyeri*, and *S. gigantaensis* are based on single male holotypes only, and their females are unknown. Therefore, the state of the basal teeth of the female pectines is not known in these species. Other diagnostic characters discussed in this paper, however, were verified from the single male type specimens to be consistent with *Serradigitus*.

Character analysis: genus *Stahnkeus*

Inner accessory (*IAD*) denticles. Stahnke (1974: 130), in his formal description of genus *Serradigitus*, stated a range of 6–16 for the number of inner (*ID*) denticles found on the movable finger of the chela. This range is unusual for vaejovids in general, since they typically exhibit six and seven *ID* on the fixed and movable fingers, respectively. Of course, there are exceptions to these counts, there are species with six *ID* on the movable finger (e.g., *Uroctonites huachuca*, *Vaejovis vorhiesi*), species with four and five *ID* on fixed and movable fingers (e.g., *Serradigitus joshuaensis*), etc., and, in contrast, genus *Vejovoidus* exhibits eight *ID* on the fixed finger. However, these exceptions as well as the typical counts of six and seven are in general consistent within the species, reflecting



Serradigitus

Stahnkeus

Figures 33–45: Denticle edge of chelal movable finger showing arrangement of inner (ID) and inner accessory (IAD) denticles of genera *Serradigitus* and *Stahnkeus*. Horizontal lines indicate ID and IAD; number specifies the total count of these denticles. **41–45** *Stahnkeus* ID and IAD denticles. **33.** *Serradigitus wupatkiensis*, female, Wupatki National Monument, Arizona. **34.** *S. calidus*, female, Cuatro Ciénegas, Coahuila, Mexico. **35.** *S. adcocki*, female, Isla Cerralvo, Baja California Sur, Mexico. **36.** *S. joshuaensis*, female, Indian Gorge, ABDSP, California. **37.** *S. torridus*, male, Nine Mile Rd., Kern Co., California. **38.** *S. minutis*, male, Cabo San Lucas, Baja California Sur, Mexico. **39.** *S. g. gertschi*, female, Chariot Canyon, ABDSP, California. **40.** *S. littoralis*, female, Isla Danzante, Baja California Sur, Mexico. **41.** *Stahnkeus harbisoni*, female adult, Oakies Landing, Baja California, Mexico. **42.** *S. deserticola*, female adult, Saratoga Springs, Death Valley, California. **43–45.** *S. subtilimanus*, Split Mountain, ABDSP, California. **43.** Male adult. **44.** Male subadult. **45.** Female juvenile.

| | Adult | | Subadult | | Juvenile | |
|-------------------------------|-----------------------|-----------------------|-----------------------|----------------------|----------------------|---------------------|
| | MF | FF | MF | FF | MF | FF |
| <i>Stahnkeus harbisoni</i> | 14–20 (16.83) [6] | 12–18 (14.45) [6] | 12–20 (15.50) [4] | 11–14 (12.25) [4] | 11–13 (12) [4] | 9–11 (10) [4] |
| <i>Stahnkeus subtilimanus</i> | 13–18 (15.31) [35] | 12–17 (14.06) [36] | 10–16 (12.69) [29] | 9–16 (12.07) [29] | 8–12 (10.08) [12] | 7–10 (8.64) [11] |
| <i>Stahnkeus deserticola</i> | 9–12 (10) [4] | 6–10 (7.25) [4] | 8 | 6 | - | - |

Table 6: Numbers of chelal inner (*ID*) and inner accessory (*IAD*) denticles for select species of *Stahnkeus* partitioned into general ontogenetic stages. The denticle numbers are the *sum* of *ID* and *IAD*. Note the increase in *IAD* number as specimens reach maturity. Based on the general stability of the inner (*ID*) denticle counts in the genus *Serradigitus*, we hypothesize here that they most likely equal six and seven in *Stahnkeus* for the fixed and movable fingers, respectively. Minimum–maximum (mean) [number of samples]; MF = movable finger, FF = fixed finger.

little variability. Soleglad (1972: 186) reported 9–15 internal denticles on both fingers of *Vejoavis subtilimanus* (now placed in *Stahnkeus*). This is noteworthy for two reasons; first, the counts are considerably higher than the normal number of *ID* found in Vaejovidae, and second, the counts are variable within the species. Clearly, some of the reported *ID* were inner accessory denticles (*IAD*), which makes Soleglad (1972) the first report of *IAD* denticles in the family Vaejovidae. We consider these accessory denticles for two reasons: first, they are variable in number, their number and overall development increasing with respect to the specimen's ontogenetic development; second, except for *Stahnkeus*, they are not known in any other vaejovid species where in general the number of *ID* is consistent within a species.

These *IAD* denticles occur in no less than five species previously included in the genus *Serradigitus*, now forming the new genus *Stahnkeus*: *Stahnkeus harbisoni*, *S. deserticola*, *S. subtilimanus*, *S. allredi*, and *S. polisi*. The presence of *IAD* in *Stahnkeus* is considered a synapomorphy for the genus. Note that, except for the distal aspect of the finger, *ID* cannot reliably be distinguished from *IAD* denticles, therefore our statistics in Table 6 depict the sum of these inner denticles, *ID* + *IAD*. As stated above, the overall size and number of *IAD* increase as the *Stahnkeus* specimen advances to an adult stage. Figure 7 illustrates a closeup of the movable finger of *S. subtilimanus* showing the somewhat irregular and enlarged *IAD* occurring most frequently on the base of the chelal fingers of adults. Also of interest in this figure are two small granule-like denticles which presumably are *IAD* in the process of developing. In addition, as shown in Table 6 for three *Stahnkeus* species, and supported by the presence of small denticles in Fig. 7, the number of *ID* + *IAD* increases in the specimens developmental stages. We suggest here that the initial *IAD* found in a juvenile increases in size during successive molts as newer small denticles are developed. This is one possible explanation for the larger numbers and somewhat larger irregularly developed *IAD* found on adult specimens (Fig. 7). *S.*

harbisoni, the largest species in genus *Stahnkeus*, averages 17 *ID* + *IAD* on adults for the movable finger, this number decreasing in subadults, showing counts of 16, and in juveniles, showing counts of 12. Similar trends are seen in *S. subtilimanus* and *S. deserticola* (the latter based on limited data), but reflecting smaller *ID* + *IAD* numbers. For species *S. subtilimanus*, where a larger number of specimens were available, the average number of *ID* + *IAD* denticles for adults, subadults and juveniles are 15, 13, and 10, respectively.

Figures 33–45 illustrate the denticle edge of the movable finger of 11 species of *Serradigitus* and *Stahnkeus*, showing the configuration of *ID* and *ID* + *IAD*, respectively. Three developmental stages of *Stahnkeus subtilimanus* (Figs. 43–45) exhibit the number of *ID* + *IAD* as 15, 11, and 10 for adult, subadult and juvenile, respectively. In contrast, for genus *Serradigitus* (Figs. 33–40), we see the typical vaejovid configuration of six and seven *ID* denticles on fixed and movable fingers, respectively. In *Serradigitus joshuaensis* (Fig. 35), however, these fingers have four and five *ID*.

History of *IAD* recognition in *Stahnkeini*. In the earliest descriptions of species now placed in *Stahnkeus* as *S. deserticola* and *S. harbisoni*, Williams (1970a, 1970b) did not discuss internal denticles of the chelal fingers, accessory or otherwise. Soleglad (1972: 186) was the first to report *IAD* in *Stahnkeus* in his description of *Vejoavis subtilimanus*: "... Teeth serrate, flanked by irregular row of supernumerary teeth, numbering 9–15 on both fingers ...". Stahnke (1974) also recognized the occurrence of *IAD* by providing a range when he formally described genus *Serradigitus* "...interior lateral, large flanking denticles vary in position and number from six on the type-species up to 16 on other species ...". Williams (1980: 103, fig. 541) described and illustrated the internal denticle arrangement of species *S. harbisoni* in his monograph on the scorpions of Baja California, Mexico. Sissom & Stockwell (1991: figs. 9, 22) discussed and illustrated the occurrence of multiple inner accessory granules in their descriptions of *Stahnkeus allredi* and *S. polisi*. Sissom & Stockwell (1991) did not distinguish between

inner and inner accessory denticles *sensu* Soleglad & Sissom (2001), but collectively referred to them as “accessory” (= “supernumerary” of Soleglad (1972)). For example, in an important aside, Yahia & Sissom (1996: 86) mentioned that “In all vaejovids except *Serradigitus* Stahnke, pedipalp chela finger dentition has been accepted as a very stable character. Much of the variation in the number of denticle sub-rows and inner accessory denticles appears to be due either to developmental anomalies or to injuries that were improperly repaired during molting. Only in *Serradigitus* spp., is significant ‘normal’ intraspecific variation in these characters observed”. It is important to note here, that Sissom & Stockwell (1991: 202) did suggest the relationship officially established in this paper (i.e., our new genus *Stahnkeus*) in their discussion of species *Serradigitus polisi*: “... is related to *S. harbisoni* (Williams), *S. subtilimanus* (Soleglad), and *S. allredi* ...”. The species *S. deserticola* was not included in their discussion because, until as reported herein, the presence of *IAD* on this species was not known. Soleglad & Sissom (2001: 39, fig. 28) also alluded to this taxonomic group by referring to three of its species as the “harbisoni” group in genus *Serradigitus*.

Inner accessory (*IAD*) denticles in parvorder Iurida. Soleglad & Sissom (2001: 33–41) were the first to differentiate inner (*ID*) denticles from inner accessory (*IAD*) denticles in their revision of chactoid family Euscorpiidae. This distinction was necessary in order to quantify the complex chelal finger dentition arrangements found throughout the euscorpiids. Euscorpiidae is the only known Recent scorpion family where all species exhibit *IAD*, a major synapomorphy for the family. Other than in Euscorpiidae, the presence of *IAD* is quite rare in Iurida. In family Caraboctonidae (superfamily Iuroidea), genus *Hadruroides* exhibits both *IAD* and outer accessory (*OAD*) denticles, most prevalent on mature specimens. This is the primary character separating *Hadruroides* from its sister genus *Caraboctonus* (see key in Fet et al., 2004b: 23). This distinction between these two genera, using accessory denticles, is analogous to that established in the present paper using *IAD* to separate genera *Serradigitus* and *Stahnkeus*. In the family Bothriuridae (superfamily Scorpionoidea), *IAD* are present in two species of *Lisposoma* (subfamily Lisposominae), *L. josehermana* Lamoral, 1979, and *L. haringtoni* (Prendini, 2003). The occurrence of *IAD* separates these closely related species from their sister species, *L. elegans*, which lacks *IAD* (see Fet et al., 2004a, for a detailed discussion and illustrations concerning this character).

Taxonomy & nomenclature

Order SCORPIONES C. L. Koch, 1850
Suborder Neoscorpiones Thorell et Lindström, 1885
Infraorder Orthosterni Pocock, 1911

Parvorder Iurida Soleglad et Fet, 2003
Superfamily Chactoidea Pocock, 1893
Family Vaejovidae Thorell, 1876

Stahnkeini Soleglad et Fet, **trib. nov.**

Type genus. *Stahnkeus* Soleglad et Fet, **gen. nov.**

Composition. This tribe contains two genera, *Stahnkeus* with five species, and *Serradigitus* with 20 species and subspecies.

Distribution. Mexico (Baja California, Baja California Sur, Coahuila, Sonora) and United States (Arizona, California, Nevada, New Mexico, Texas, Utah). See map in Fig. 46.

Diagnosis (*Synapomorphies*). Median (*MD*) and outer (*OD*) denticles of the chelal fingers are flattened and elongated, forming a serrated denticle edge, *OD* 1–3, which are situated directly inline with the *MD*, usually visible, other more basal *OD* denticles indistinguishable; basal pectinal teeth 1, 2, and/or 3 of female with missing or highly reduced sensorial area, exerodistal angling not present or reduced, shape usually elongate and symmetric laterally, but sometimes shorter and fatter; chelal finger trichobothria *ib–it* position on fixed finger is variable, not aligned with a specific inner (*ID*) denticle, located more midfinger in large species and basally in smaller species.

Important characteristics. Sclerites of female genital operculum are completely fused and hinge widely as a single unit; ventral median spinule row of leg tarsus equipped distally with a single pair of spinules; leg basitarsus and tarsus lacking “setal combs”; dorsolateral (*DL*) carinae terminus on metasomal segment IV flared, not coinciding with articulation condyle; ventromedian (*VM*) carinae of metasoma paired on segments I–IV; chelal trichobothrium *Db* positioned ventrally from digital (*DI*) carina; chelal trichobothrium *Dt* positioned at or distally of midpalm; distal ventral edge of cheliceral movable finger equipped with well developed serrula; chelal ventrointernal carina (*V2*) well developed, subdigital carina (*D2*) vestigial; dorsal patellar spur carina (*DPS_c*) well developed, exhibiting many serrated granules; median (*MD*) and outer (*OD*) denticle density quotient of chelal movable finger is low, ranging from 30–42 (36.7); distal margin of sperm plug of hemispermatophore is smooth (after Stockwell, 1989); pectinal tooth numbers large with respect to adult size, TL/PTC ratio for female usually ≤ 2.00 .

Other general characteristics. Carapace exhibits well developed anterior emargination, anteriorly with a subtle median indentation, never straight or convex; chelal fingers elongate, usually as long or longer than carapace, and terminate in an exaggerated distal hook equipped with a conspicuous “whitish patch”; cheliceral dorsal edge of movable finger with two subdistal (*sd*) denticles; cheliceral ventral edge of movable finger



Figure 46: Reported distribution of tribe Stahnkeini. ● = *Serradigitus* (species identified); ○ = *Stahnkeus* (see Map in Fig. 47 for species identifications). Localities based on specimens examined and from the following sources: Stahnke (1940a, 1940b), Gertsch & Allred (1965), Williams (1968, 1970a, 1970b, 1980), Hjelle (1972), Soleglad (1972, 1974), Johnson & Allred (1972), Williams & Berke (1986), Berke (1987, in part) and Sissom & Stockwell (1991).

smooth; vesicular tabs of telson equipped with small “hooked” granule; carinae of leg patellae developed and usually delicately crenulate; most species are lithophilic.

Discussion. From a cladistic point of view, the tribe Stahnkeini clearly forms a solid clade among the generic groups and “*Vaejovis* groups” currently defined in family Vaejovidae, exhibiting multiple unambiguous synapomorphies as detailed in this paper. Based on extensive preliminary cladistic analysis in progress, the choice of tribe level at this time seems the most prudent for this assemblage within the Vaejovidae. The rationale for this choice of taxonomic level will be demonstrated in an upcoming contribution.

Tribe Stahnkeini shares symplesiomorphies with the “punctipalpi” and “eusthenura” groups of *Vaejovis* such as the genital operculum of the female which distinctly operates as a single unit, showing no separation on the proximal edge, the non-basal positioning of chelal trichobothria *ib-it*, and the midpalm to distal position of chelal trichobothrium *Dt*. It differs from these two groups, in addition to the stated synapomorphies discussed above, primarily in exhibiting a single distal spinule pair on the leg tarsus ventral surface, whereas the other two groups have 2–4 pairs, and the smooth edge of the distal aspect of the hemispermatophore sperm plug, not toothed as in the other two groups (after Stockwell, 1989). Other vaejovid assemblages, such as *Pseudouroctonus* + *Uroctonites*, *Vaejovis* “mexicanus” group, *Franckeus* + *Vaejovis* “nigrescens” group, *Paravaejovis*, and *Paruroctonus* + *Smeringurus* + *Vejovoidus*, are proving to be less related to Stahnkeini, especially the last two aggregates, which are quite isolated and distinct in Vaejovidae. These issues will be the subject of other upcoming contributions in the near future.

Serradigitus Stahnke, 1974

Serradigitus Stahnke, 1974: 130–132, fig. 6C, 6D (in part).

Type species. *Vaejovis wupatkiensis* Stahnke, 1940 [= *Serradigitus wupatkiensis* (Stahnke, 1940)].

Diagnosis. Closely related to sister genus *Stahnkeus*, from which it can be distinguished by the following: pedipalp chelal fingers lack inner (*IAD*) accessory denticles, only a fixed number of inner (*ID*) denticles are present, usually six and seven *ID* are found on the fixed and movable fingers, respectively. Otherwise, genus *Serradigitus* exhibits characters of the tribe.

References. *Serradigitus*: Williams & Berke, 1986: 350–351 (in part); Sissom, 1990a: 114; Sissom & Stockwell, 1991: 197–199 (in part); Stockwell, 1992: 409, 416, 419, fig. 40, 42 (in part); Yahia & Sissom, 1996: 86 (in part); Kovařík, 1998: 145 (in part);

Lourenço & Sissom, 2000: 119 (in part); Sissom, 2000: 518–524 (in part); Soleglad & Sissom, 2001: 32, 39 (in part), fig. 28; Soleglad & Fet, 2003: 8, 37, 88, fig. 67 (in part); Sissom & Hendrixson, 2005: 127–128 (in part).

Distribution. Mexico (Baja California, Baja California Sur, Coahuila, Sonora) and United States (Arizona, California, Nevada, New Mexico, Texas, Utah). See Map in Fig. 46.

Species list. The following 20 species and subspecies comprise this genus; general locality data based on specimens examined, Gertsch & Allred (1965), Williams (1968, 1970a, 1970b, 1980), Hjelle (1970), Johnson & Allred (1972), Soleglad (1972, 1974), Williams & Berke (1986), Berke (1987), Sissom & Stockwell (1991), Sissom (2000).

S. adcocki (Williams, 1980), Baja California Sur, Mexico (Figs. 18, 35).

S. agilis Sissom et Stockwell, 1991, southern Arizona, southwestern New Mexico, USA; northeastern Sonora, Mexico.

S. armadentis (Williams, 1980), Baja California Sur, Mexico.

S. baueri (Gertsch, 1958), Baja California, Mexico.

S. bechteli (Williams, 1980), Baja California Sur, Mexico (Fig. 21).

S. calidus (Soleglad, 1974), Coahuila, Mexico (Figs. 20, 34).

S. dwyeri (Williams, 1980), Baja California Sur, Mexico.

S. gertschi gertschi (Williams, 1968), Southern California, USA; Baja California, Mexico (Figs. 1, 5, 13, 14, 22, 39).

S. gertschi striatus (Hjelle, 1970), Central California, USA.

S. gigantaensis (Williams, 1980), Baja California Sur, Mexico.

S. gramenestris (Williams, 1970), Southern California, USA (Fig. 28).

S. haradoni (Williams, 1980), Baja California Sur, Mexico (Fig. 27).

S. hearnei (Williams, 1980), Baja California Sur, Mexico (Fig. 25).

S. joshuaensis (Soleglad, 1972), Southern California, southwestern Arizona, USA (Figs. 2–4, 12, 26, 36).

S. littoralis (Williams, 1980), Baja California, Baja California Sur, Mexico (Figs. 24, 40).

S. minutis (Williams, 1970), Baja California Sur, Mexico (Figs. 12, 23, 38).

S. pacificus (Williams, 1980), Baja California, Mexico (Fig. 29).

S. torridus (Williams et Berke, 1986), Southern California, USA (Figs. 19, 37).

S. wupatkiensis (Stahnke, 1940), Arizona, California, Idaho, Nevada, New Mexico, Utah, USA (Figs. 17, 33).

S. yaqui Sissom et Stockwell, 1991, Sonora, Mexico.

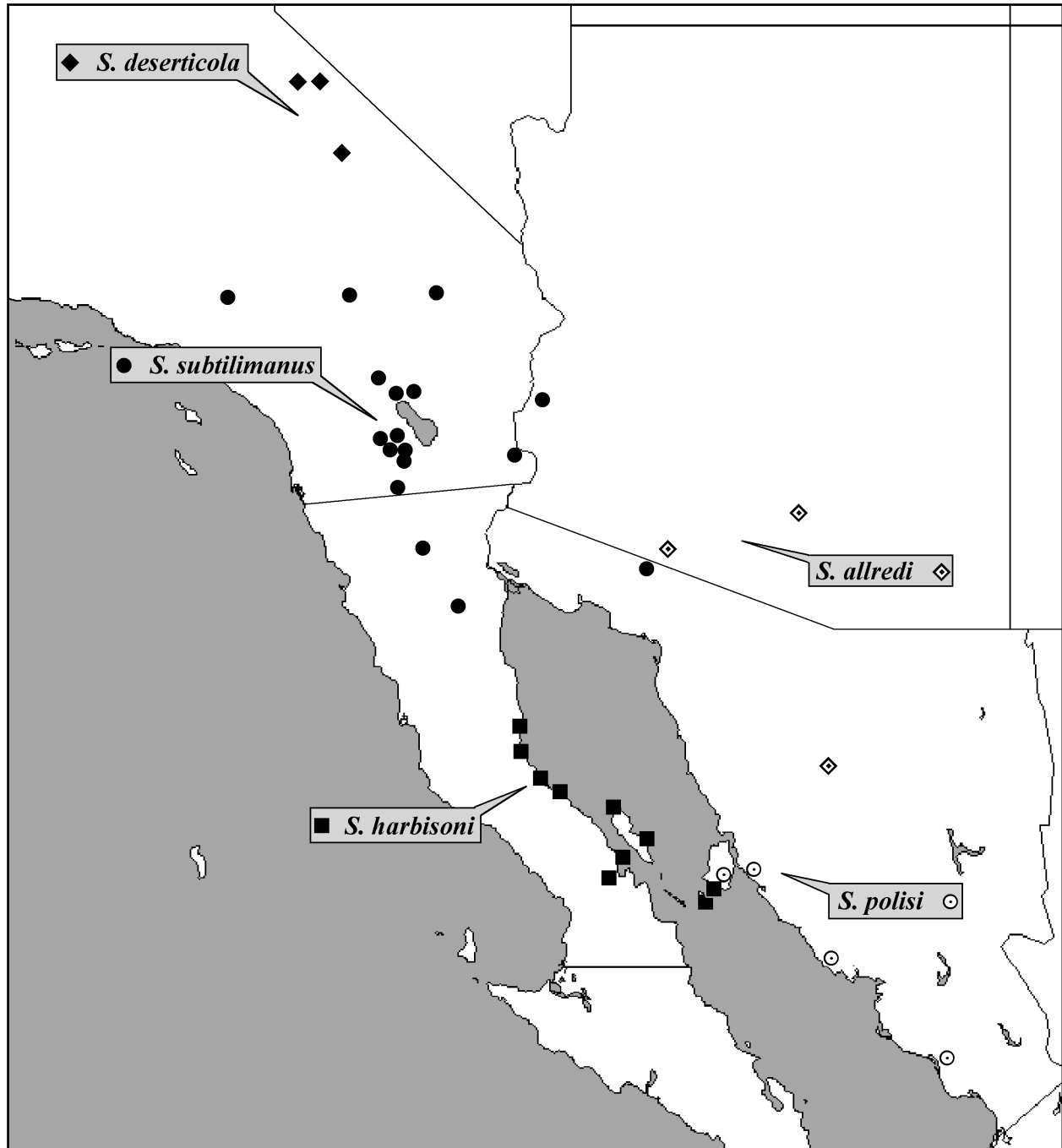


Figure 47: Map showing distribution of genus *Stahnkeus*. Individual localities based on specimens examined, Williams (1970a, 1980: fig. 98, in part), Berke (1987, in part) and Sissom & Stockwell (1991).

Discussion. *Serradigitus* ranges in size from 40 mm (*S. wupatkiensis* and *S. adcocki*) to 23 mm (*S. joshuaensis*), one of the smallest vaejovids known. Its species are found in the southwestern United States and in Mexico (Coahuila, Sonora, Baja California, Baja California Sur) (Fig. 46). In California, *Serradigitus* ranges as far north as Mendocino County (*S. gertschi striatus*), south to San Diego County (*S. g. gertschi*), and

east to Inyo County (*S. gramenestris* and *S. wupatkiensis*). It is found in southern Nevada (*S. wupatkiensis*), northern Arizona (*S. wupatkiensis*), and southeastern Utah (*S. wupatkiensis*). In his paper on scorpions of Idaho, Anderson (1975) did not report *S. wupatkiensis*, but Sissom (2000: 524) reports this species from Idaho as well as New Mexico. The species of *Serradigitus* have been reported as far east as Cuatro



Figure 48: *Stahnkeus subtilimanus*, male, dorsal view, Split Mountain, ABDSP, California, USA.

| | | <i>S. harbisoni</i> | <i>S. subtilimanus</i> | <i>S. deserticola</i> | <i>S. polisi</i> | <i>S. allredi</i> |
|--|------------|---|---|---|---|--|
| Inner Denticles (<i>ID</i> + <i>IAD</i>) (adults) | M | 14–20 (17) | 13–18 (15) | 9–12 (10) | 8–11 | 9–11 |
| | F | 12–18 (14) | 12–17 (14) | 6–10 (7) | 7–9 | 6–11 |
| Carapace length | | 5.4–6.8 | 4.8–5.5 | 5.2 | 3.7–4.7 | 3.0–3.1 |
| Pectinal Tooth Counts | ♂ | 25–27 | 24–26 | 21–22 | 18 | 15–17 |
| | ♀ | 21–24 | 19–23 | 20 | 15–21 | 14–16 |
| Carapace Interocular Area | | smooth | granular | granular | granular | granular |
| Chelal Digital (<i>DI</i>) Carina | | smooth to marbled | granular to marbled | delicately crenulate | weak and smooth | strong and smooth |
| Metasomal Segments Ventral Median (<i>VM</i>) Carinae (♀) | I | smooth | smooth | smooth to crenulate | smooth to crenulate | weak to granulate |
| | II | smooth | smooth, weak to crenulate 1/3 | crenulate | crenulate to serrate | weak to granulate |
| | III | smooth, weak to crenulate 1/5 | crenulate | crenulate | crenulate to serrate | crenulate |
| | IV | smooth, weak to crenulate 1/3 | crenulate | crenulate | crenulate to serrate | crenulate |
| Metasomal Segments (W/L) (♀) | I | 1.03 | 1.13 | 1.18 | 1.29 | 1.46 |
| | II | 0.83 | 1.00 | 1.03 | 1.03 | 1.13 |
| | III | 0.84 | 0.89 | 0.97 | 0.95 | 1.06 |
| | IV | 0.66 | 0.68 | 0.70 | 0.65 | 0.77 |
| Carapace Length/Movable Finger Length (♀) | | 0.95 | 0.75 | 0.79 | 0.89 | 1.03 |
| Trichobothrium <i>ib</i> / Fixed Finger Length * | | 0.471 | 0.462 | 0.471 | 0.353 | 0.282 |
| Geographic Distribution (see Fig. 47) | | central-east Baja California, Mexico | Colorado Desert, southern California, USA; northern Baja California, Mexico | Mojave Desert, southern California, USA | northern Sonora, Mexico | southern Arizona, USA; northern Sonora, Mexico |
| General Coloration (adults) | | dark orange-brown, no variegated patterns on carapace | dark orange-brown, no variegated patterns on carapace | dark orange-brown, no variegated patterns on carapace | yellow-brown, with dusky patterns on carapace | yellow-brown, with dusky patterns on carapace |
| Adult Size (♂/♀) | | 43/51 | 40/48 | 43/45 | 28/36 | 20/18 |

Table 7: Diagnostic characters for species of genus *Stahnkeus*, **gen. nov.** Data for *Stahnkeus allredi* and *S. polisi* after Sissom & Stockwell (1991). * *ib* position measured from base of fixed finger. MF = movable finger, FF = fixed finger.

Cienegas, Coahuila, Mexico (*S. calidus*) and as far south as Cabo San Lucas, Baja California Sur, Mexico (*S. minutis*). In addition, isolated endemic species are only known from small islands off the coast of Baja California, Mexico (*S. armadentis*, *S. baueri*, *S. dwyeri*, and *S. bechteli*). As seen in the map (Fig. 46), there are gaps in the range of this genus; however, we suspect that the interjoining areas are probably inhabited by these specialized scorpions in the microhabitats hospitable to lithophiles. For example, a *Serradigitus* sp. has been reported from the Big Bend National Park in Texas (Sissom & Stockwell, 1991: 197), which bridges considerably the geographical gap as reflected in the map (Fig. 46). Lourenço & Sissom (2000: 119) projected that “a number of new species should be found in northwestern Mexico, especially in the Sierra Madre Occidental”.

Stahnkeus Soleglad et Fet, **gen. nov.**

Type species. *Vaejovis harbisoni* Williams, 1970 [= *Stahnkeus harbisoni* (Williams, 1970)].

Diagnosis. Closely related to sister genus *Serradigitus*, from which it can be distinguished by the following synapomorphic (derived) character: pedipalp chelal fingers exhibit an irregular number of inner (*IAD*) accessory denticles, the number increasing during ontogenetic development; number of *ID* + *IAD* is species-dependent and ranges from 6 to 18 and from 8 to 20 for the fixed and movable fingers, respectively. Otherwise, genus *Stahnkeus* exhibits characters of the tribe.

Etymology. This genus is named after Herbert L. Stahnke for his contributions to scorpion systematics and for being the first to describe a species of *Serradigitus* in 1940 and establishing the genus *Serradigitus* in 1974.

Distribution. Mexico (Baja California, northern Sonora) and United States (Arizona, California). See map in Fig. 47.

Species list. The following five species comprise this genus; general locality data based on specimens examined, Williams (1970a, 1980, in part); Soleglad (1972), Berke (1987, in part), Sissom & Stockwell (1991), Sissom (2000).

- S. allredi* (Sissom et Stockwell, 1991), **comb. nov.** Southern Arizona, USA; northern Sonora, Mexico.
- S. deserticola* (Williams, 1970), **comb. nov.** Death Valley, California, USA (Figs. 32, 42).
- S. harbisoni* (Williams, 1970), **comb. nov.** Central Baja California, Mexico (Figs. 30, 41).
- S. polisi* (Sissom et Stockwell, 1991), **comb. nov.** Sonora, Mexico.
- S. subtilimanus* (Soleglad, 1972), **comb. nov.** Southern California, southwestern Arizona, USA; northern Baja California, northern Sonora, Mexico (Figs. 6, 7, 15, 16, 31, 43–45, 46).

Discussion. In comparison with the broader distribution of *Serradigitus* (Fig. 46), the genus *Stahnkeus* forms roughly a contiguous “horseshoe” pattern around the Sea of Cortez, extending northward to Death Valley, California and southward to central Baja California state in the west and Sonora, Mexico, in the east. In the map (Fig. 47) two northern localities originally reported for species *S. harbisoni* by Williams (1980) have been changed to *S. subtilimanus*, this based on the somewhat disjunct ranges of the specialized microhabitat required by this genus (i.e., they are lithophilic). In addition, the report of *S. harbisoni* from extreme southern Baja California Sur, Isla Cerralvo (Williams, 1980: 103), is unlikely in our opinion, therefore we consider this a locality misidentification.

The five species of *Stahnkeus* can be separated by the characters provided in Table 7. Genus *Stahnkeus* contains the largest species in tribe Stahnkeini, *S. harbisoni*, which reaches lengths of 50 mm. Three species, *S. deserticola*, *S. subtilimanus* and *S. harbisoni*, are closely related, their disjunct distribution forming a north to south pattern from Death Valley, California through the Colorado Desert in southern California, to central-east Baja California state (see map in Fig. 47). All adults of these three species share an attractive yellow-orange coloration of the metasoma, legs and pedipalps with dark mahogany highlights on the pedipalp and metasomal carinae; dusky patterns of the carapace are absent in these species (see Fig. 48 of an adult male *S. subtilimanus*). As typical of large species of tribe Stahnkeini, the trichobothrial series *ib-it* in these three species is located roughly midfinger (Tab. 5). The other two species, *S. allredi* and *S. polisi* from southern Arizona, USA, and Sonora, Mexico, are smaller in size, exhibit dusky patterns on their carapaces, and tricho-

bothria *ib-it* are located more proximally on the fixed finger (after Sissom & Stockwell, 1991).

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