

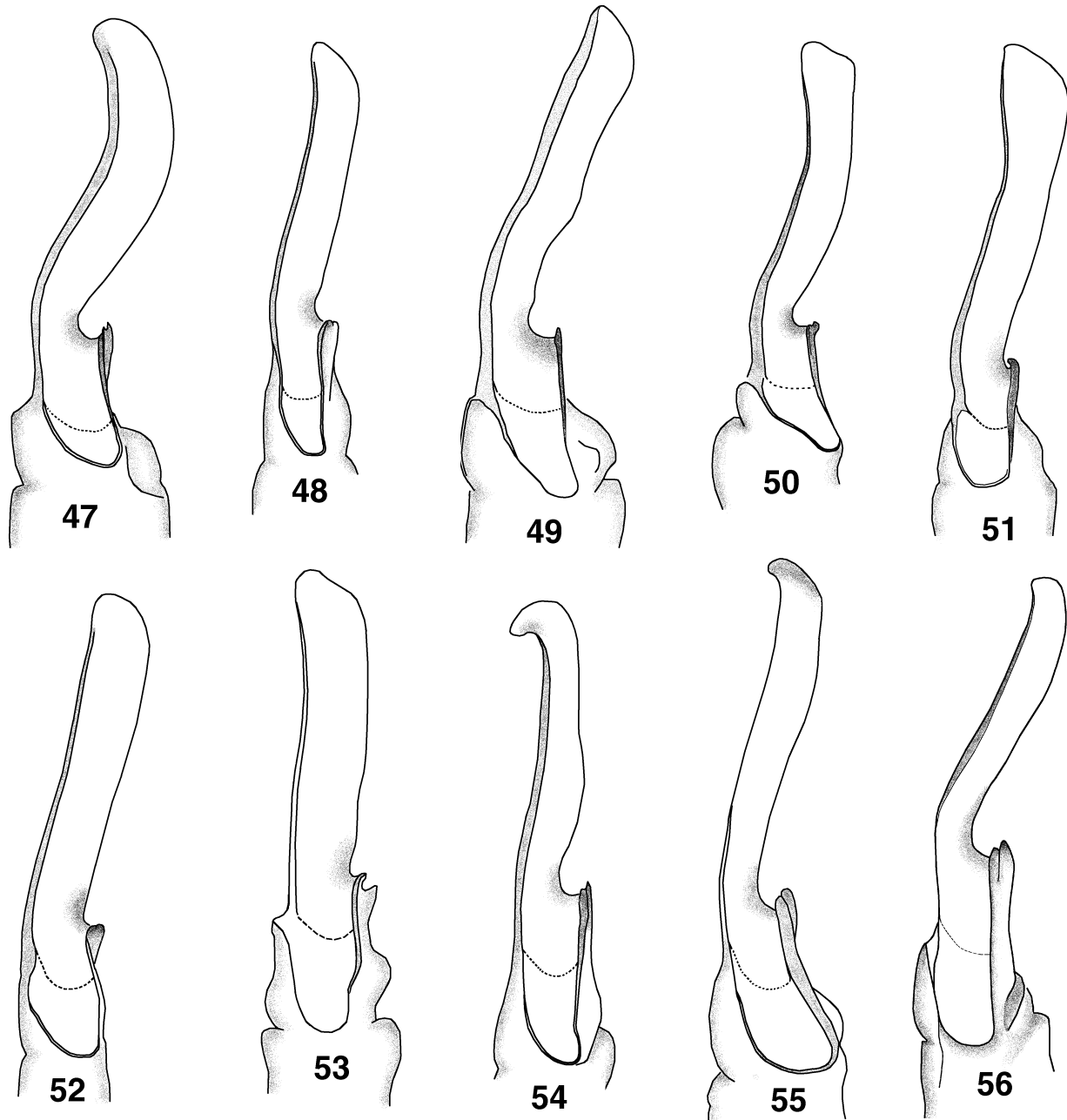
Figures 44–46: Right hemispermatophore of *Kochius punctipalpi* *punctipalpi*, Los Aripes, Baja California Sur, Mexico. **44.** Dorsal view; dotted line indicates position of ventral trough, see Fig. 46. **45.** Internal view showing partial view of embedded mating plug and close-up of bifurcated lamellar hook. **46.** Ventral view showing embedded mating plug partially visible on distal aspect, barb on left pointing inwards into capsular area. See Fig. 76 for extracted mating plug, dorsal view (barb pointing outward), showing toothed (12 teeth) distal barb.

by both troughs or just the dorsal trough; its length and degree of sclerotization and terminus arrangement (intact, grooved or bifurcated); the position of the lamellar hook with respect to the ventral trough; the relative ratio of the lamellar hook length compared to the lamina length; the presence or absence of a secondary lamellar hook; the presence or absence of an internal protuberance on the lamina base; and the composition of the mating plug barb, which can be smooth or toothed. Of secondary importance is the shape of the lamina terminus: blunted clip-like, narrow and curved, or exhibiting a slight groove (i.e., a distal crest). As to the orientation of the hemispermatophore, we opted to use the terms dorsal and ventral as opposed to external and internal.

Syntropinae. Figures 41–43, 44–46, 47–56 illustrate several hemispermatophores of seven genera in subfamily Syntropinae (see Sissom, 1993, figs. 12–14, for an example of the *Wernerius* hemispermatophore). Figures 41–43 and 44–46 illustrate three views of a hemispermatophore showing some detail of the capsular area for species *Thorellius cristimanus* and *Kochius punctipalpi*, respectively. In these figures we can see that the formation of the lamellar hook is derived from both the dorsal and ventral troughs, characteristic of this subfamily. All of these hemispermatophores have an enlarged lamellar hook whose distal tip is exaggerated

by a conspicuous basal constriction of the lamina. In most cases, the distal tip of the lamellar hook is at least partially bifurcated if not completely separated forming two hooks (Figs. 41–42, 45, 47, 50, 53–56). The ratio constructed from the lamellar hook length / lamella length (using the dorsal trough as the proximal base of both measurements) ranges from 0.292 – 0.450 (0.366), based on 21 species (see Table 2). Thus we can see that it is well developed exhibiting considerable length, roughly one-third of the lamina length. Also of importance is that the distal tip is considerably distal of the ventral trough, as indicated in Table 2, where the trough difference as compared to the hook length is 0.241–0.508 (0.426).

Comparing hemispermatophores of subtribe Thorelliina (represented by *Thorellius cristimanus*, *T. intrepidus*, *Kochius punctipalpi*, *K. hirsuticauda*, and *K. cazieri*; Figs. 41–43, 44–46, 47–49) with those of subtribe Syntropina (represented by *Hoffmannius eusthenura*, *H. waeringi*, *H. puritanus*, and *Syntropis macrura*; Figs. 50–53), we see little difference in the shape of the lamina terminus, and a general consistency in the strong development of the lamellar hook. For tribe Stahnkeini (represented by *Serradigitus wupatkiensis*, *Stahnkeus subtilimanus*, and *Gertschius crassicorpus*; Figs. 54–56), the lamina appears to be slightly thinner with the distal tip sometimes curving externally, but



Figures 47–56: Right hemispermaphore, dorsal view, of genera of subfamily Syntropinae showing well developed lamellar hook. Dotted line indicates position of ventral trough. Tribe **Syntropini**: **47.** *Kochius hirsuticauda*, Indian Gorge Canyon, ABDSP, California, USA. **48.** *Kochius cazieri*, Cuatro Ciénegas, Coahuila, Mexico. **49.** *Thorellius intrepidus*, Mexico. **50.** *Hoffmannius eusthenura*, Cabo San Lucas, Baja California Sur, Mexico. **51.** *Hoffmannius waeringi*, Vallecito Creek, Carrizo Badlands, ABDSP, California, USA. **52.** *Hoffmannius puritanus*, Jasper Trail, ABDSP, California, USA. **53.** *Syntropis macrura* (after Stockwell, 1989: fig. 218, in part). Tribe **Stahnkeini**: **54.** *Serradigitus wupatkiensis*, Wupatki Ruins, Wupatki National Monument, Arizona, USA. **55.** *Stahnkeus subtilimanus*, Vallecito Creek, Carrizo Badlands, ABDSP, California, USA. **56.** *Gertschius crassicornis*, paratype, Navojoa, Sonora, Mexico (after Graham & Soleglad, 2007: fig. 10, in part).

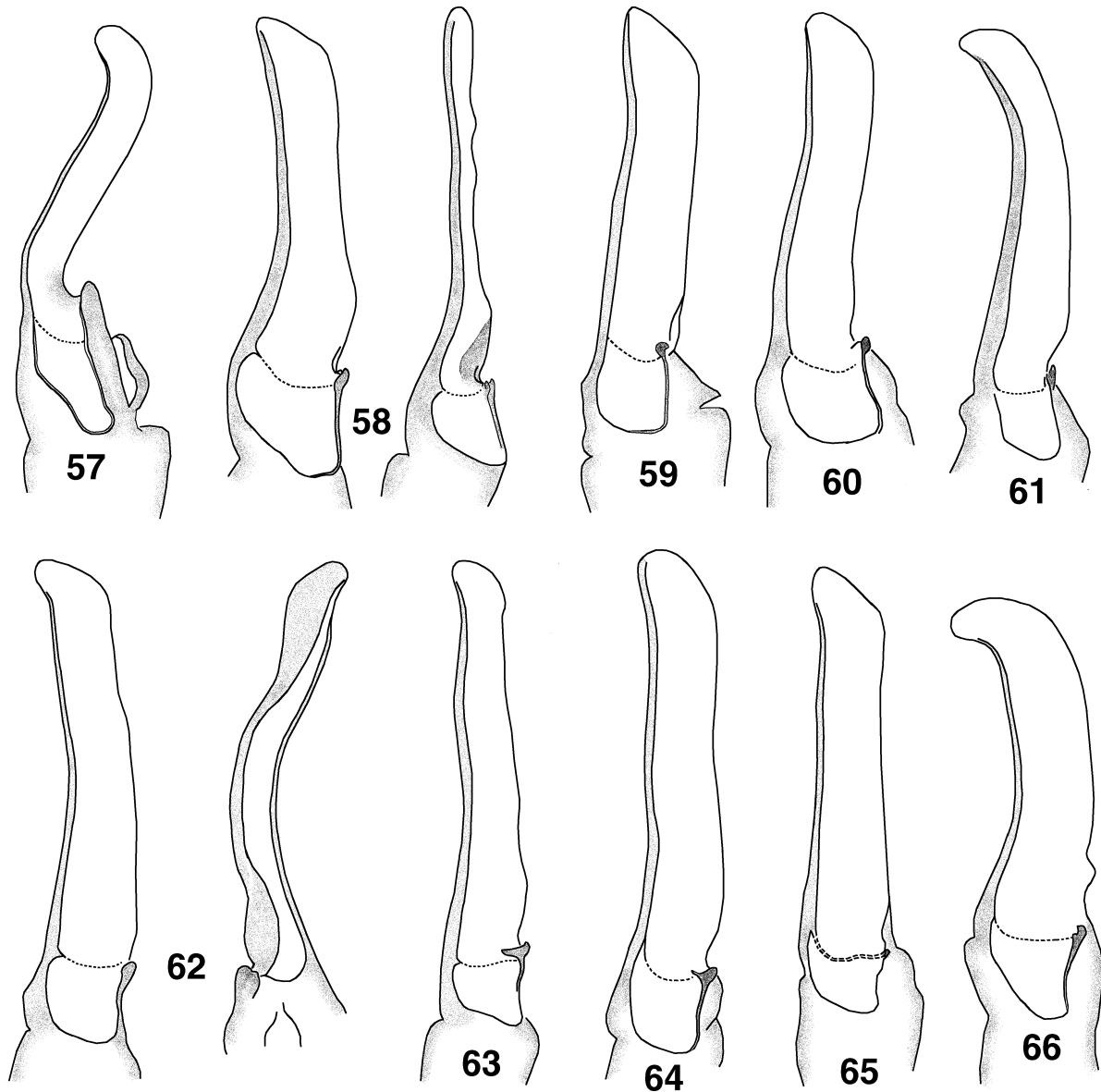
generally the lamellar hook development and strong basal constriction are consistent with those in sister tribe Syntropini.

Sissom (1991: 26–27, 1993: 68) was the first to report this well developed lamellar hook (*broad flange* in his terminology) where he correctly attributed it to

Serradigitus (now tribe Stahnkeini) and the three *Vaejovis* groups now comprising subfamily Syntropinae (as illustrated in Figs 41–43, 44–46, 47–56). Sissom (1991) contrasted this hemispermaphore with that of seven species in the “nigrescens” group of *Vaejovis*. Although the lamellar hook/lamella ratio is smaller in

	Hook L / Lamella L	Trough D / Hook L	Basal Constriction	Lamellar Hook Terminus	Secondary Lamellar Hook	Mating Plug Barb
<i>Gertschius</i>	0.340–0.450 (0.395) [2]	0.406–0.434 (0.420) [2]	Strong	Bifurcated	Absent	Smooth
<i>Serradigitus</i>	0.385 [1]	0.468 [1]	Strong	Bifurcated	Absent	Smooth
<i>Stahnkeus</i>	0.360–0.397 (0.381) [3]	0.462–0.474 (0.470) [3]	Strong	Bifurcated	Absent	Smooth
<i>Wernerius</i>	0.433 [1]	Not available	Strong	Bifurcated	Absent	Smooth
<i>Stahnkeini</i>	0.340–0.450 (0.393) [7]	0.406–0.474 (0.453) [6]	Strong	Bifurcated	Absent	Smooth
<i>Kochius</i>	0.321–0.400 (0.348) [4]	0.267–0.412 (0.355) [3]	Strong	Bifurcated	Absent	Toothed
<i>Hoffmannius</i>	0.292–0.409 (0.331) [4]	0.452–0.518 (0.490) [3]	Strong	Bifurcated	Absent	Toothed
<i>Syntropis</i>	0.345 [1]	0.580 [1]	Strong	Bifurcated	Absent	Toothed
<i>Thorellius</i>	0.323–0.441 (0.376) [5]	0.241–0.505 (0.355) [4]	Strong	Bifurcated	Absent	Toothed
<i>Syntropini</i>	0.292–0.441 (0.353) [14]	0.241–0.580 (0.412) [11]	Strong	Bifurcated	Absent	Toothed
Syntropinae	0.292–0.450 (0.366) [21]	0.241–0.508 (0.426) [17]	Strong	Bifurcated	Absent	Variable
<i>Paravaejovius</i>	0.366 [1]	0.616 [1]	Strong	Whole	Absent	Toothed
<i>Paravaejovini</i>	0.366 [1]	0.616 [1]	Strong	Whole	Absent	Toothed
<i>Paruroctonus</i>	0.210–0.242 (0.219) [4]	0.680–0.782 (0.748) [4]	Absent	Whole	Absent	Smooth
<i>Smeringurus</i>	0.138–0.169 (0.162) [4]	0.857–1.000 (0.872) [4]	Absent	Whole	Absent	?
<i>Vejovoidus</i>	0.221 [1]	0.833 [1]	Absent	Whole	Absent	?
<i>Smeringurini</i>	0.138–0.242 (0.194) [9]	0.680–1.000 (0.813) [9]	Absent	Whole	Absent	Smooth (?)
Smeringurinae	Variable	0.616–1.000 (0.793) [10]	Variable	Whole	Absent	Variable
<i>Franckeus</i>	0.237 [1]	Not available	Absent	Bifurcated	Absent	Smooth
<i>Pseudouroctonus</i>	0.269–0.527 (0.422) [12]	0.360–0.603 (0.474) [12]	Absent	Bifurcated	Present, in part *	Smooth
<i>Uroctonites</i>	0.038–0.076 (0.057) [3]	Not applicable	Medium	Whole	Absent	Non-sclerotized ***
<i>Vaejovius “mexicanus”</i>	0.121–0.458 (0.242) [9]	0.375–0.769 (0.576) [6]	Variable	Variable	In part (?) **	Variable
<i>Vaejovius “nigrescens”</i>	0.200–0.314 (0.257) [10]	0.500–0.654 (0.577) [2]	Absent	Bifurcated	Absent	Smooth
Vaejovinae	Variable	Variable	Variable	Variable	Present, in part	Smooth

Table 2: Hemispermatophore characteristics and morphometrics for family Vaejovidae based on, in part, 66 species. See Fig. 40 for terminology and method of measurement. Hook L = lamellar hook length (distal tip to dorsal trough), Lamella L = lamella length (distal tip to dorsal trough), Trough D = vertical distance between dorsal and ventral troughs, P = present, A = absent, n = number of samples. Based on specimens examined and illustrations from literature. * Present in species *P. williamsi*, *P. angelensis*, *P. bogerti*, *P. iviei*, and *P. glimnei*. ** Some species (e.g., *Vaejovis chisos*, Jarvis et al., 2004: figs. 1–2) exhibit a non-sclerotized cleft on the internal edge of the lamellae. This cleft is probably not homologous to the secondary lamellar hook seen in some *Pseudouroctonus* species. *** After Williams & Savary (1991).

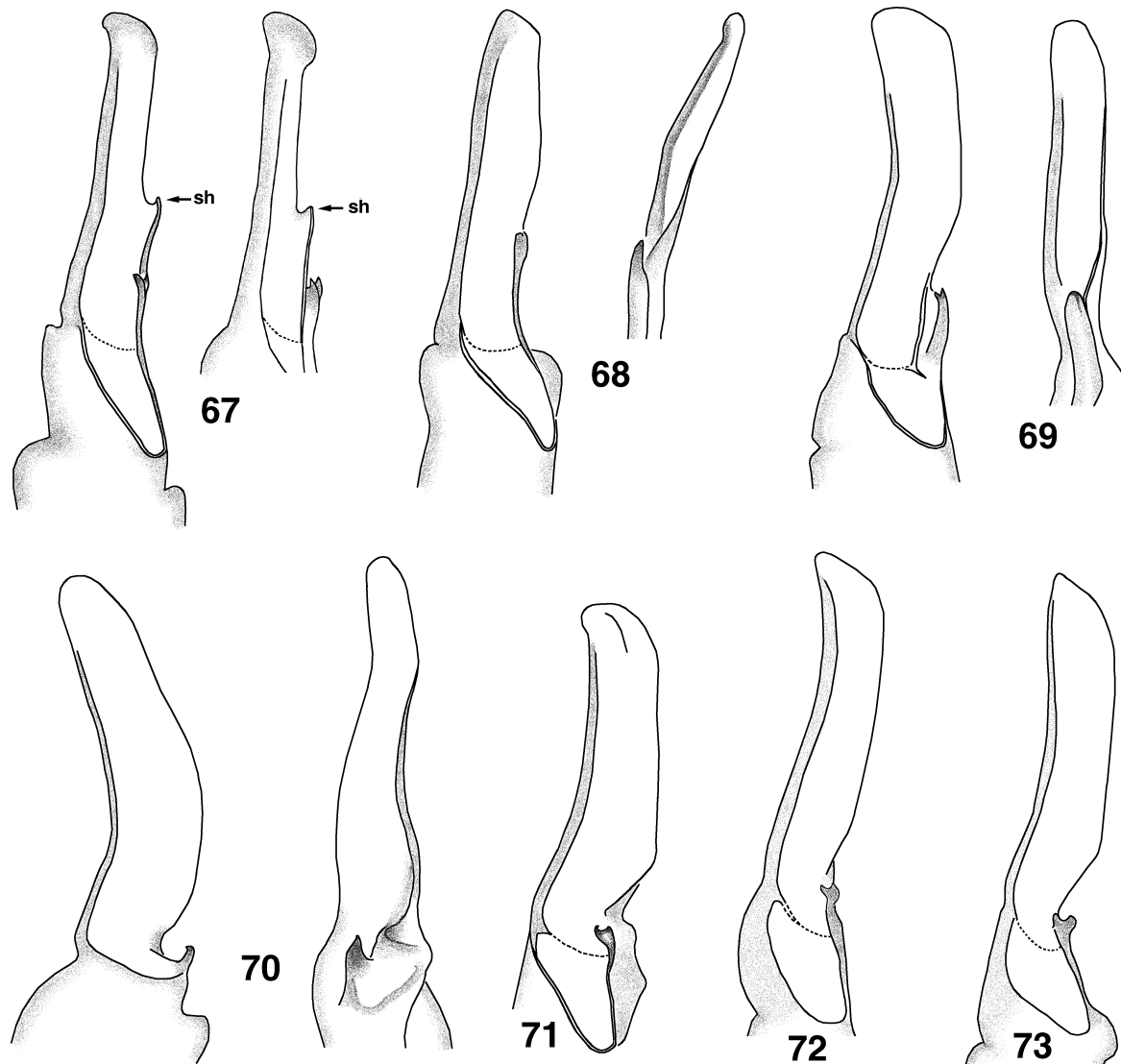


Figures 57–66: Right hemispermaphore, dorsal view, of genera of subfamily Smeringurinae. Dotted line indicates position of ventral trough. Tribe **Paravaejovini**: 57. *Paravaejovis pumilis*, Ciudad Constitución, Baja California Sur, Mexico. Tribe **Smeringurini**: 58. *Paruroctonus boreus*, Mercury, Nevada, USA, dorsal and dorsoexternal views. 59. *Paruroctonus gracilior*, Lajitas, Brewster Co., Texas, USA. 60. *Paruroctonus silvestrii*, Chihuahua Road, ABDSP, California, USA. 61. *Paruroctonus utahensis*, Bluff, Utah, USA. 62. *Smeringurus mesaensis*, Borrego Springs, California, USA, dorsal and internoventral views. 63. *Smeringurus aridus*, Palo Verde Wash, ABDSP, California, USA. 64. *Smeringurus vachoni immanis*, 1000 Palms, California, USA. 65. *Smeringurus grandis*, Oakies Landing, Baja California, Mexico. 66. *Vejovoidus longiunguis*, Las Bombas, Baja California Sur, Mexico.

the “nigrescens” group (0.200–0.314 (0.257) [10], see Table 2), it is our opinion that the basal constriction contributes considerably to the exaggerated lamellar hook seen in Syntropinae, whereas in the “nigrescens” group (see our Fig. 73 of *Vaejovis janssi*; Sissom, 1991: figs. 71–84) this constriction is essentially absent. The vertical distance between the dorsal and ventral troughs

is also significant in Syntropinae, roughly 40 % of the lamellar hook length.

This well developed lamellar hook with a conspicuous basal constriction is also illustrated by other authors for species *Thorellius occidentalis* and *T. subcristatus* (Sissom, 1989b: figs. 1–4), *Kochius atenango* (Francke & González Santillán, 2007: fig. 1), and



Figures 67–73: Right hemispermaphore of genera of subfamily Vaejovinae. Dotted line indicates position of ventral trough. **67.** *Pseudouroctonus williamsi*, Santa Ysabel Reserve, San Diego Co., California, USA, dorsal and dorsoexternal views. Note secondary lamellar hook (sh) (indicated by arrow). **68.** *Pseudouroctonus minimus castaneus*, Vista, San Diego Co., California, USA, dorsal and internal views. **69.** *Pseudouroctonus reddelli*, Gem Cave, Comal Co., Texas, USA, dorsal and internal views. **70.** *Uroctonites huachuca*, Huachuca Mountains, Cochise Co., Arizona, USA, dorsal and internal views. **71.** *Vaejovis lapidicola*, Williams, Coconino Co., Arizona, USA, dorsal view. **72.** *Vaejovis carolinianus*, Athens, Georgia, USA. **73.** *Vaejovis janssi*, Isla Socorro, Mexico.

Hoffmannius glabrimanus (Sissom & Hendrixson, 2005: fig. 9).

Smeringurinae. The hemispermaphore structure is quite interesting in subfamily Smeringurinae. In the tribe Paravaejovini (Fig. 57), lamellar hook is well developed, exaggerated by a conspicuous basal constriction, and its distal tip is considerably distal of the ventral trough, essentially identical to the hemispermaphore seen in Syntropinae. In stark contrast, tribe Smeringurini exhibits a very reduced lamellar hook whose distal tip is essentially in line with the ventral trough exhibiting roughly only 20 % of the lamina length (see Table 2). A basal constriction is essentially

absent in this tribe. The hook itself is quite small and weakly sclerotized and is formed by the dorsal trough. The reduction in the lamellar hook length is further emphasized when the hook length is compared to the dorsal and ventral trough distance, roughly 80 % of its length. Figures 58–65 show that the hemispermaphores are very similar across the two genera: *Paruroctonus*, as illustrated in species *P. boreus*, *P. gracilior*, *P. silvestrii*, and *P. utahensis*, and *Smeringurus*, species *S. mesaensis*, *S. aridus*, *S. vachoni immanis*, and *S. grandis*. The lamina itself is straight, with its distal aspect somewhat blunted. In the genus *Vejovoidus* (Fig. 66), the lamina is a little heavier,

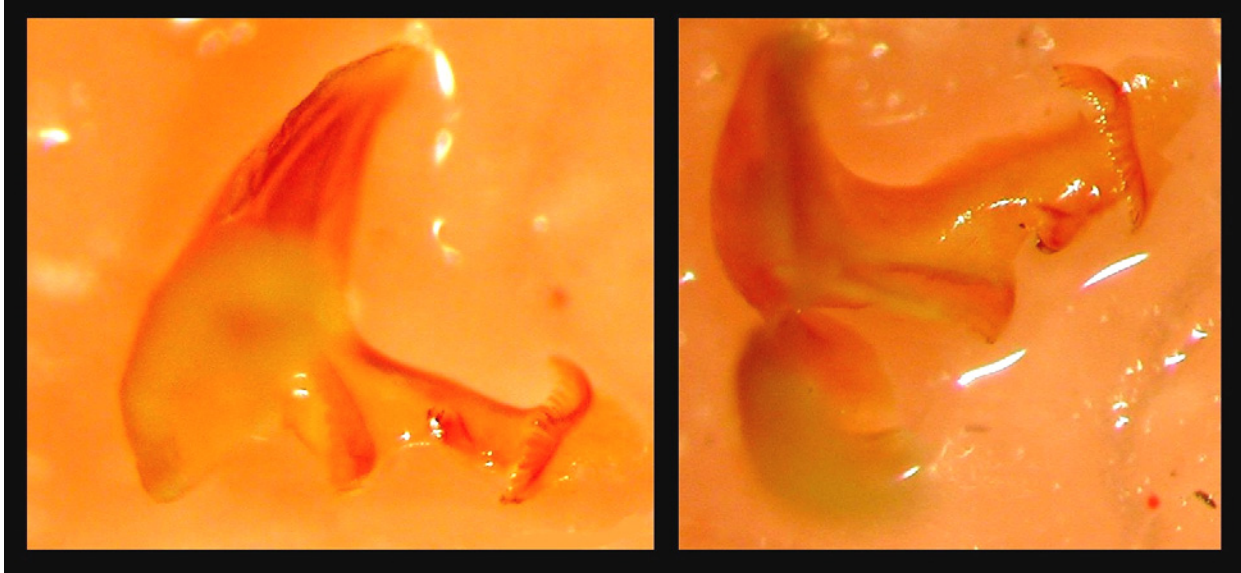


Figure 74: Photographs of hemispermaphore mating plug of *Thorellius cristimanus*, Autlán, Jalisco, Mexico. Distal barb is seen on right side of images, showing delicate curved teeth which face inwards when embedded in the hemispermaphore capsular area, the ventral side.

shorter, and distally curved. In addition, on the internal base of the lamina there is a slight protuberance (this was observed in two specimens), although its lamellar hook is marginally developed and is adjacent to the ventral trough typical of the tribe.

Other hemispermaphores of subfamily Smeringurinae were illustrated by Francke & Soleglad (1981: figs. 50–52) for *Paruroctonus utahensis*, and Stockwell (1989: figs. 220–221, 222–223) for *Paravaejovis pumilis* and *P. utahensis*.

Vaejovinae. There is a lot of diversity in the construction of the hemispermaphore in subfamily Vaejovinae. In our Figures 67–73, which illustrate species in three vaejovine genera and both groups of *Vaejovis*, we observe three basic types:

- (1) a distally placed highly reduced lamellar hook formed from the dorsal trough only, usually moderately bifurcated, that barely extends from the lamina internal edge as emphasized by an essentially obsolete basal constriction, genus *Pseudouroctonus* (Figs. 67–69);
- (2) a very short, proximally positioned lamellar hook, non-bifurcated, emphasized by a mediumly developed basal constriction in genus *Uroctonites* (Fig. 70); and
- (3) a medium length lamellar hook, usually bifurcated, with a weak basal constriction, in genera *Franckeus* and *Vaejovis* (Figs. 71–73), exhibited in both the “mexicanus” and “nigrescens” groups.

Sissom (see the many references above) illustrated the hemispermaphore of many species of genus *Vaejovis*

and *Franckeus*. Most of these illustrations are consistent with those illustrated in our Figures 71–73, representing species *V. lapidicola*, *V. carolinianus* (both members of “mexicanus” group), and *V. janssi* (member of “nigrescens” group). Comparison of morphometrics (Table 2) shows that the length of lamellar hook in *Vaejovis* and *Franckeus* is roughly 25 % of the lamina length (based on 20 samples). This length is intermediate between the very short hook exhibited in tribe Smeringurini (19 % of lamina length) and the long lamellar hook of subfamily Syntropinae (37 % of lamina length). This intermediate position shown by *Vaejovis* and *Franckeus* is also supported by the percentage of the trough difference when divided by the lamellar hook length, 58 % as compared to 81 % in tribe Smeringurini and 43 % in subfamily Syntropinae.

Williams & Savary (1991) contrasted the hemispermaphores of their new genus *Uroctonites* with, at that time, the “minimus” group of *Vaejovis* (now placed in genus *Pseudouroctonus*). They made the important observation that the lamellar hook was situated more basally in *Uroctonites* than in *Pseudouroctonus* species, whose hook is positioned considerably distally on the lamella, roughly at midpoint (0.269–0.527 (0.422) [12], see Table 2). Common to both genera, however, is a weakly developed lamellar hook, construction similar to that seen in Smeringurini, and the lack of a conspicuous basal constriction. Our Figure 67 of *Pseudouroctonus williamsi* demonstrates that a *secondary lamellar hook* is present, situated above the major lamellar hook, which is bifurcated, and is formed by the ventral trough. This secondary hook is also visible in the illustrations provided by Williams & Savary (1991: figs. 26–29) for

Pseudouroctonus bogerti, *P. angelenus*, *P. iviei*, and *P. glimmeri*. The secondary hook may be of taxonomic importance since it is clear that some of these species are closely related, especially *P. williamsi*, *P. bogerti*, and *P. angelenus*, which also share other unique characters (e.g., neobothriotaxy of the chela, see Fig. 13).

Other, less defined tendencies in the hemispermaphore morphology are apparent in the shape and width of the lamina in subfamily Syntropinae: the lamella is quite curved in genera *Kochius* and *Thorellius* with a rounded distal tip (Figs. 41–43, 44–46, 47–49), in contrast to *Hoffmannius* with a more straight lamina and a wider blunted distal tip (Figs. 50–52); the lamella appears thinner with a sharper tip in tribe Stahnkeini (Figs. 54–55). Species of *Pseudouroctonus* also exhibit a blunted distal tip (Figs. 67–69). However, there are exceptions to many of these trends. Many more species need to be investigated to see if these more localized characteristics are consistent and therefore diagnostic.

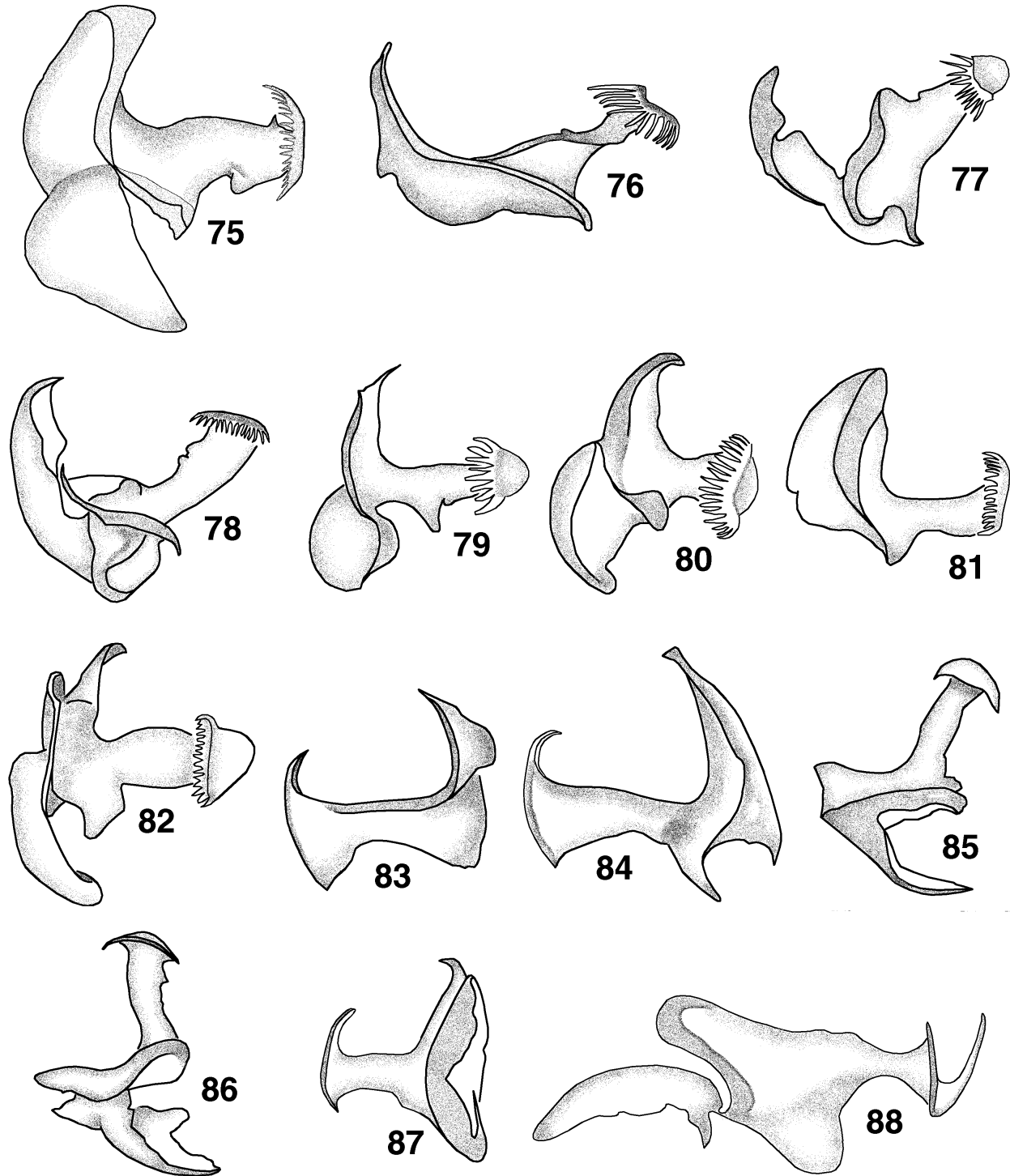
Mating plug composition. Stockwell (1989) first illustrated the mating (= sperm) plug of several species of scorpions, including *Syntropis macrura* (replicated in this paper, Fig. 82). Interestingly, Stockwell's (1989: fig. 228) illustration of *Syntropis* shows an extracted mating plug thus exposing the somewhat complicated base of the plug. Similar illustrations of extracted mating plugs were published for *Stahnkeus* and *Serradigitus* (Sissom & Stockwell, 1991), *Wernerius spicatus* (Sissom, 1993), *Vaejovis pequeno* (Hendrixson, 2001), and *Pseudouroctonus sprousei* (Francke & Savary, 2006). Figures 74, 75–88 illustrate several extracted mating plugs across all three subfamilies, although most are from Syntropinae genera where they are relatively large and sclerotized. In Figs. 29–30 we show post-insemination mating plugs as they protrude from the genital aperture of a female *Pseudouroctonus williamsi*.

This tiny structure has a complex arrangement of partially sclerotized components: the *base*, *stock*, and *barb* (see Fig. 40). The base of the mating plug is quite complex being composed of irregularly attached asymmetric highly convex/concave petal-like thin plates. The appearance of this complicated base is completely different depending on the angle and/or perspective viewed. For example, in Fig. 74, two slightly different perspectives of the mating plug of *Thorellius cristimanus* are shown. Note the significant differences in the base in these two views. Emanating from the base is a somewhat thick asymmetric stock, with or without smaller protuberances present. The stock, which is roughly as long as the base is wide, terminates into the barb. The barb is a thin component which is situated perpendicular to the stock and is asymmetric, folding lengthwise over to one side. Its length is roughly twice that of the thickness of the stock. With an embedded mating plug, the sharp edge of the barb faces into the hemispermaphore capsular area when viewed from the

ventral aspect (see Figs. 42–43 and 45–46 where the mating plug is embedded in the hemispermaphore). The sharp edge of the barb can be smooth or it can be lined with long delicate curved “teeth”. The toothed condition is sometimes referred to as the “crown”. The number of “teeth” on the barb varies, probably based on the species, but this has not been established. In our extracted mating plugs (Figs. 74, 75–82) that exhibited “teeth”, we counted 10–16 teeth. This toothed barb itself is similar in appearance to the terminus of the ental channel found in the euscorpiid genera *Euscorpius* and *Megacormus* (see Soleglad & Sissom, 2001: figs. 119–122; Fet & Soleglad, 2002: 37–38, figs. 65–67). This structure in *Euscorpius flavicaudis*, with its “crown” lacking “teeth”, is similar to the smooth mating plug barb. However, the ental channel is a substantial structure that emanates from the hemispermaphore base, thus much larger and located in a different area than the much smaller mating plug of the vaejovids. Whether these two structures are homologous between the two families remains to be seen.

As of now, the barb is the only taxonomically important component of the mating plug in Vaejovidae: is it either *smooth* or *toothed*. This distinction has proven to be an excellent diagnostic character for subfamily Syntropinae, where tribe Stahnkeini has a smooth barb (Figs. 83–84) and tribe Syntropini, a “toothed” barb (Figs. 75–82). So far, based on the species examined and reported in literature, there are no exceptions. The “toothed” barb appears to be derived for tribe Syntropini since it has only been reported in one other vaejovid genus, *Paravaejovis*, a member of Smeringurinae (Stockwell, 1989; see note below). We suspect that the base of the mating plug, with its complex structure, may also provide diagnostic characters. Figures 83–84 show that the base appears to be less complicated in Stahnkeini than it is in Syntropini, and highly complicated in vaejovine genus *Pseudouroctonus* (or at least for *P. williamsi*, Fig. 88) but this must be carefully examined; exact images of the mating plug base must be taken from several perspectives in order to adequately quantify its structure.

In subfamily Smeringurinae, the dichotomy of “toothed” versus “smooth” is also present. Stockwell (1989: fig. 221) shows that the mating plug barb of *Paravaejovis pumilis* is toothed. In tribe Smeringurini, it appears that the barb is smooth based on Stockwell's cladistic analysis and our preliminary results. Our preliminary investigations (Soleglad & Fet, in progress) have verified that genus *Paruroctonus* has a smooth mating plug barb; see Figs. 85–86 for *Paruroctonus boreus* and *P. silvestrii* and Stockwell's (1989: fig. 229), illustration of *P. utahensis*. However, many more species need to be investigated, and, as Stockwell (1989) states, the mating plug can be “greatly reduced, or absent,” making this determination all the more difficult.



Figures 75–88: Representative hemispermaphore mating plugs of subfamilies Syntropinae, Smeringurinae, and Vaejovinae. Tribe **Syntropini**, note *toothed* terminus. **75.** *Thorellius cristimanus*, Autlán, Jalisco, Mexico. **76.** *Kochius punctipalpi punctipalpi*, Los Arípes, Baja California Sur, Mexico. **77.** *Kochius hirsuticauda*, Indian Gorge Canyon, ABDSP, California, USA. **78.** *Kochius cazieri*, Cuatro Ciénegas, Coahuila, Mexico. **79.** *Hoffmannius eusthenura*, Cabo San Lucas, Baja California Sur, Mexico. **80.** *Hoffmannius puritanus*, Jasper Trail, ABDSP, California, USA. **81.** *Hoffmannius confusus*, Mesa, Arizona, USA. **82.** *Syntropis macrura* (after Stockwell, 1989: fig. 228, in part). Tribe **Stahnkeini**, note *smooth* terminus. **83.** *Serradigitus wupatkiensis*, ventral view, Wupatki Ruins, Wupatki National Monument, Arizona, USA. **84.** *Stahnkeus subtilimanus*, ventral view, Vallecito Creek, Carrizo Badlands, ABDSP, California, USA. Tribe **Smeringurini**, note *smooth* terminus. **85.** *Paruroctonus silvestrii*, Chihuahuah Road, ABDSP, California, USA. **86.** *Paruroctonus boreus*, Mercury, Nevada, USA. Subfamily **Vaejovinae**, note *smooth* terminus. **87.** *Pseudouroctonus minimus castaneus*, Vista, San Diego Co., California, USA. **88.** *Pseudouroctonus williamsi*, Santa Ysabel Reserve, San Diego Co., California, USA.

In subfamily Vaejovinae, only a smooth barb has been reported for those species exhibiting a sclerotized mating plug (see Figs. 87–88), primarily in genus *Franckeus* and the “nigrescens” group of *Vaejovis* (Sissom, 1991: figs. 72, 74, 76, 78, 80, 82, 84). Stockwell (1989) stated that species in the “mexicanus” group (in part, and referred to as *Vaejovis* in his unpublished revision) do not have a sclerotized mating plug, which instead is gelatinous (see his cladistic character 117).

Note: Stockwell (1989: 204), in a diagnosis of his (unpublished) tribe “Paruroctonini”, which included genera *Paruroctonus*, *Smeringurus*, *Vejooidus*, and *Paravaejovis*, stated “... sclerotized mating plug of hemispermaphore well developed, greatly reduced, or absent; distal barb margin bearing teeth ...”. With respect to the “distal barb ... teeth” phrase, Stockwell (1989: tab. 6, fig. 257) contradicts this statement in his cladistic analysis, which reflects only *Paravaejovis* of this assemblage with a toothed barb. This is also shown in his cladograms where the toothed barb (character 119) is derived twice, once for *Paravaejovis* and once for our tribe Syntropini.

Leg Basitarsus and Tarsus

Diagnostic value: Leg basitarsus and tarsus setal and spinule configurations are used to differentiate subfamilies in Vaejovidae, tribes in subfamily Syntropinae, and genera (in part) in subfamily Vaejovinae.

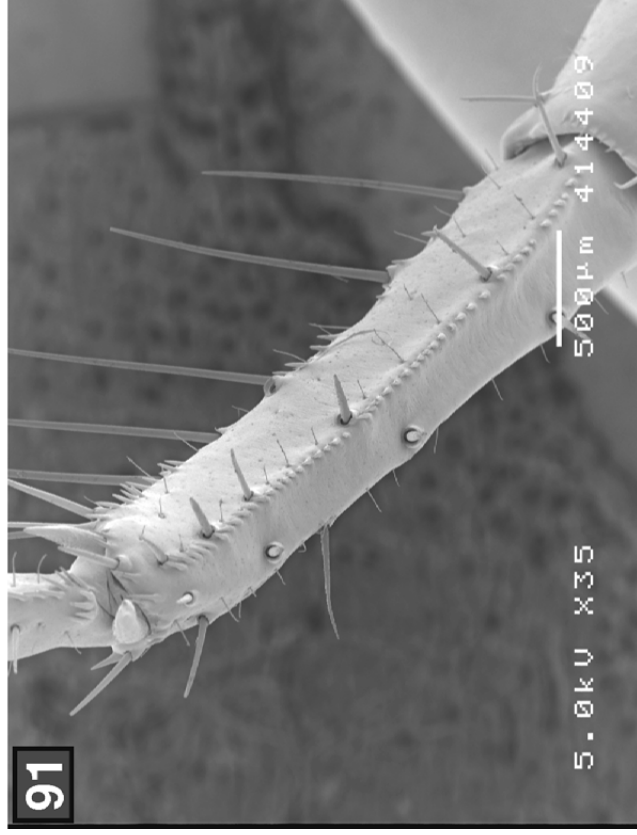
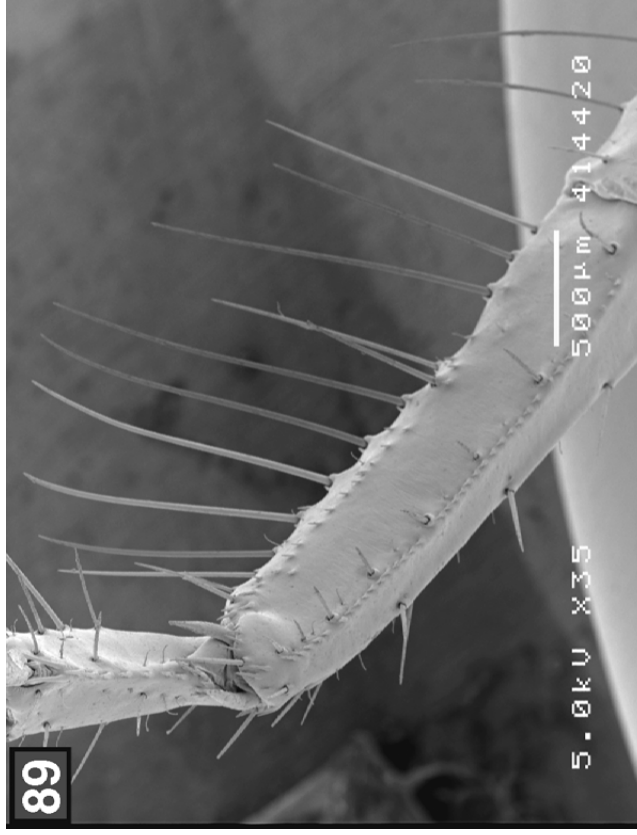
We (Soleglad & Fet, 2003b) categorized the setal and spinule configurations of the ventral surface of the leg tarsus for Recent scorpions into five types, combining parvorders Buthida and Chaerilida as type 2. Since then, after having examined additional species of *Chaerilus*, Fet et al. (2004: 17–18) expanded on type 2 indicating that the chaerilids tarsus configuration was different from Buthida, breaking them into types 2a and 2b. Superfamily Chactoidea, which includes Vaejovidae, is assigned to type 5: two lateral rows of small to medium setae with small sockets and a median row of spinules. Family Vaejovidae conforms to the chaetoid type 5, exhibiting both irregular seta pairs and a median spinule row on the leg tarsus. Note, in contrast, that in some chactids, namely subfamily Brotheinae, the median ventral spinule row is vestigial and the lateral setal rows are more developed forming distinct parallel rows (see Soleglad & Fet, 2003b: 39). Both the leg basitarsus and tarsus are of diagnostic value for the subfamilies in Vaejovidae.

Smeringurinae. In the subfamily Smeringurinae we find a “setal comb” on the dorsal margin of the basitarsus. A “setal comb” is an evenly arranged series of somewhat elongated setae located on dorsal margin of the leg basitarsus, most exaggerated on legs I–III.

Haradon (1983, 1984a, 1984b, 1985) used the configuration of the “setal comb” (which he termed *superior setae*) on the basitarsus extensively in his diagnoses of species in *Smeringurus* and the several “infra-” and “microgroups” defined for genus *Paruroctonus*. Stockwell (1989: fig. 257) considered the “comb-like” configuration of the dorsomarginal setae of the basitarsus a synapomorphy (his character 99) for his tribe Paruroctonini (= subfamily Smeringurinae). Figures 89–92, 93–96, 97, and 100 illustrate several setal combs spanning all four genera of Smeringurinae. It is interesting to see the difference in the density of the individual setae in these combs, presumably based on the species degree of adaptation as a psammophile (Fet et al., 1998). Our Figs. 89–92 illustrate two species of *Smeringurus*, *S. mesaensis*, an ultrapsammophile, and *S. grandis*, a fossorial species. *Smeringurus mesaensis* exhibits about twice as many setae than *S. grandis*. Similarly, for genus *Paruroctonus* (Figs. 93–94), the psammophile *P. utahensis* has more proportionally longer setae in the comb than the fossorial species *P. silvestrii*. Genus *Paravaejovis* (Fig. 97) is also equipped with a well developed setal comb on the basitarsus, the setae being extremely long compared to the leg basitarsus. The ultrapsammophile genus *Vejooidus* is equipped with an extraordinary array of setal arrangements (Figs. 100–102): the setal comb on the basitarsus is very well developed with elongated setae, and the tarsus is covered laterally and ventrally with a large cluster of setae essentially obscuring its ventral row of spinules.

The ventral surface of the leg tarsus in subfamily Smeringurinae has a ventral median row of spinules along its surface terminating distally with a single pair of spinules. Figures 90, 92, 94, 96, 99, 102 illustrate this single ventral spinule pair for all four genera. In genera *Paravaejovis*, *Paruroctonus*, and *Smeringurus*, the spinules are well developed and stout, the distal spinule pair straight and usually longer than the spinules in the median row. In genus *Vejooidus* (Fig. 102), the ventral median spinule row and distal pair of spinules is difficult to detect due to the high density of the setal cluster covering the ventral surface; therefore, in Fig. 102 the spinules are indicated with arrows, (black for the median row spinules and white for the distal pair). The distal pair is quite elongated, as in the other smeringurine genera.

Syntropinae. The dorsomarginal setae of the leg basitarsus are not arranged into a comb-like configuration in subfamily Syntropinae. The spinule configuration of the leg tarsus ventral surface, however, is diagnostic for the two tribes comprising this subfamily. As in Smeringurinae, tribe Stahnkeini has a single distal spinule pair on the leg tarsus, as shown in Figs. 111–113 for species *Serradigitus wupatkiensis*, *S. adcocki*, and *Stahnkeus subtilimanus*. This pair of



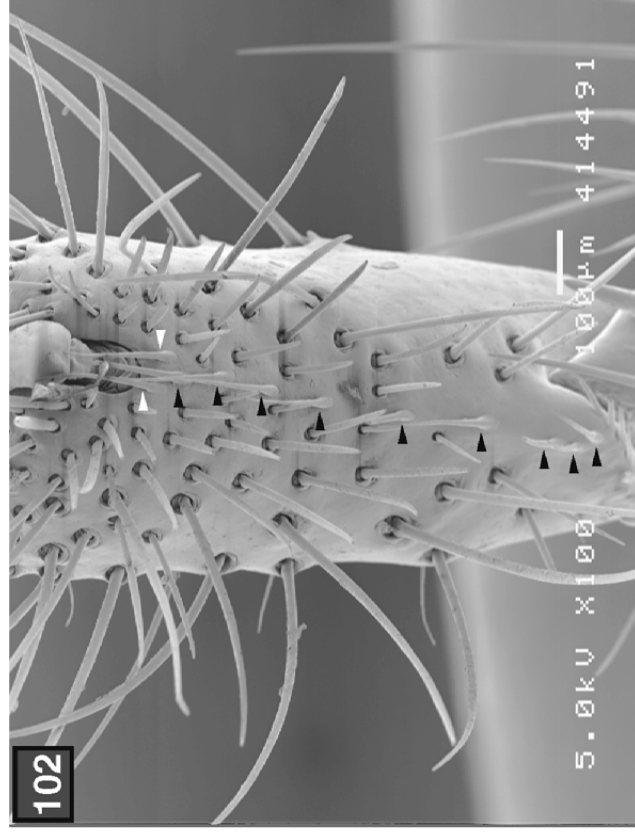
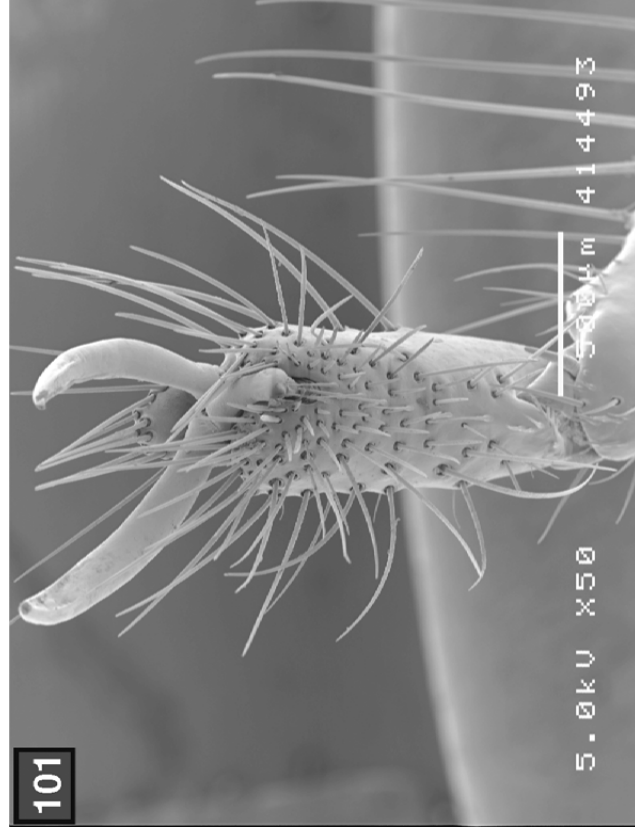
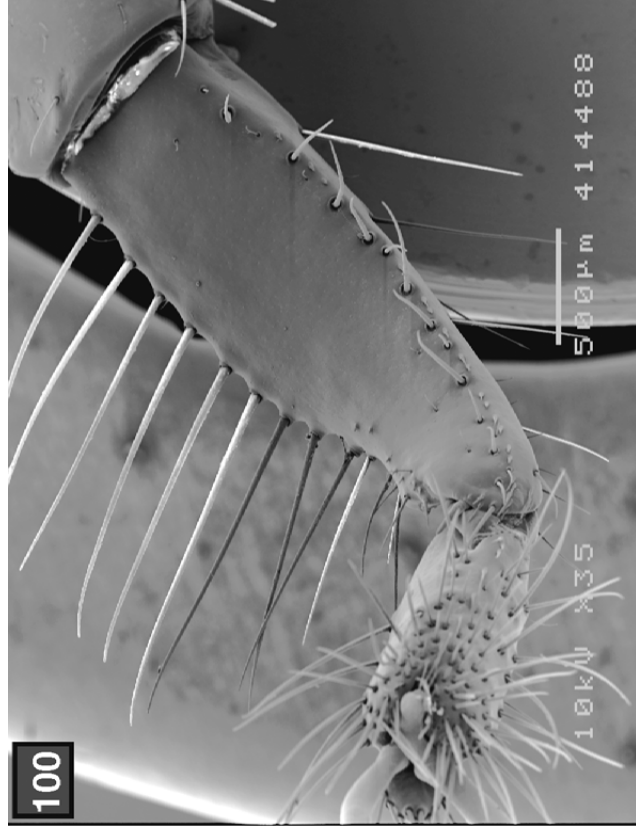
Figures 89–92: Leg III of *Smeringurus* species. **89 & 90.** *Smeringurus mesaensis*, female, Palo Verde Wash, ABDSP, California. **89.** Ventral view of basitarsus showing “setal combs”. **90.** Ventral view of tarsus showing median spinule row and single pair of distal spinules. **91 & 92.** *Smeringurus grandis*, male, Oakies Landing, Baja California, Mexico. **91.** Ventral view of basitarsus showing “setal combs”. **92.** Ventral view of tarsus showing median spinule row and single pair of distal spinules.



Figures 93–96: Leg III of *Paruroctonus* species. **93 & 94.** *Paruroctonus utahensis*, male, Kermit, Winkler Co., Texas. **93.** Ventral view of basitarsus and tarsus, showing “setal combs” on basitarsus. **94.** Ventral view of tarsus showing median spinule row and single pair of distal spinules. **95 & 96.** *Paruroctonus sierrae*, male, Chihuahua Road, ABDSP, California. **95.** Ventral view of basitarsus and tarsus, showing “setal combs” on basitarsus. **96.** Ventral view of tarsus showing median spinule row and single pair of distal spinules.



Figures 97–99: Right leg III of *Paravaejovis pumilis*, male, Ciudad Constitución, Baja California Sur, Mexico. **97.** Ventral view of basitarsus, tarsus, and epitarsus, showing “setal combs” on basitarsus. **98.** Lateral view of tarsus showing median spinule row. **99.** Ventral view of tarsus showing median spinule row and single pair of distal spinules.



Figures 100–102: Right leg III of *Vejovoidus longiunguis*, female, Vizcaino Desert, Baja California, Mexico. **100.** Ventral view of basitarsus, tarsus, and epitarso, showing “setal combs” on basitarsus. **101.** Ventral view of tarsus and epitarso showing highly populated cluster of elongated curved setae on tarsus, the elongated asymmetric unguis of the epitarso, and the reduced somewhat blunted unguicular spine. **102.** Close-up of ventral view of tarsus showing setal cluster and median spinule row. Note that spinule median row and single pair of distal spinules are hidden in the setal cluster, median spinules indicated by *black* arrows and single distal setal pair indicated by *white* arrows.