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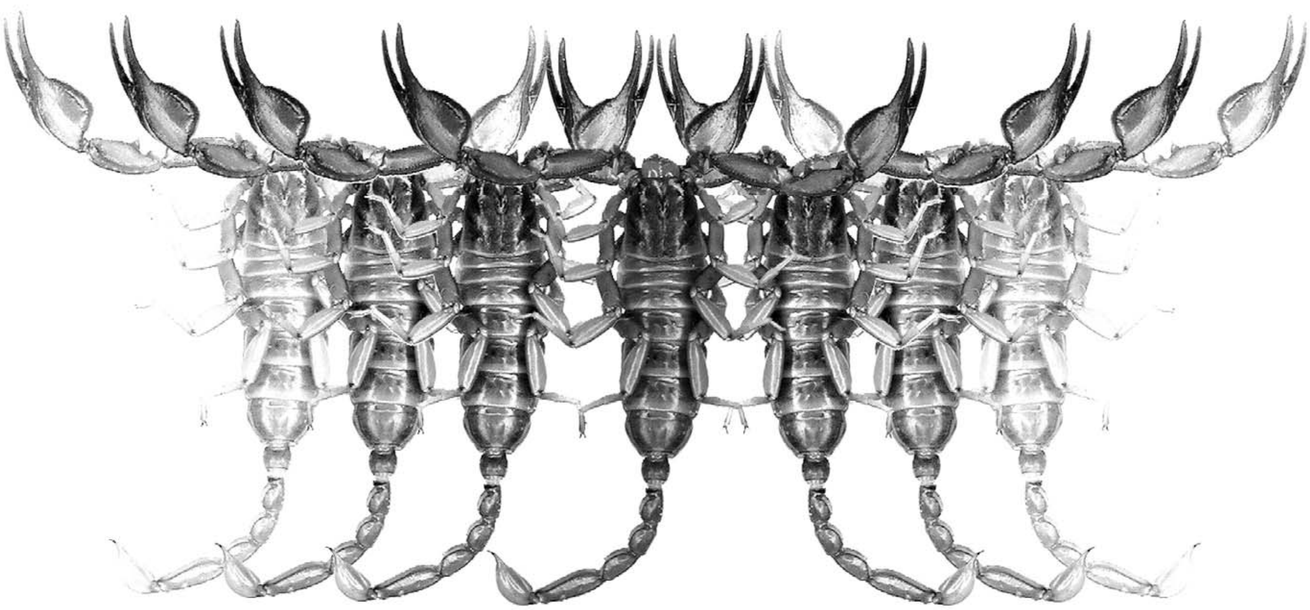

Catalinia, a New Scorpion Genus from Southern California, USA and Northern Baja California, Mexico (Scorpiones: Vaejovidae)

Michael E. Soleglad, Richard F. Ayrey, Matthew R. Graham and Victor Fet

October 2017 – No. 251

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Publication date: 26 October 2017
http://zoobank.org/urn:lsid:zoobank.org:pub:EEE5FEE0-58F1-40A4-B1E3-4B66CDFB706E

Catalinia minima (Kraepelin, 1911), female lectotype, San Pedro, California (declared in 1970 by Willis J. Gertsch). Photo courtesy of František Kovařík.

Catalinia minima (Kraepelin, 1911), male and female paratypes, San Pedro, California. Photo courtesy of František Kovařík.

Euscorpius — Occasional Publications in Scorpiology. 2017, No. 251

Catalinia, a new scorpion genus from southern California, USA and northern Baja California, Mexico (Scorpiones: Vaejovidae)

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Summary

Genus *Catalinia*, **gen. nov.** (Scorpiones: Vaejovidae) is described from southern California, USA and Baja California, Mexico. The genus is composed of four species formerly placed in *Pseudouroctonus*: *Catalinia minima* (Kraepelin, 1911), **comb. nov.** (type species), *C. andreas* (Gertsch et Soleglad, 1972), **comb. nov.**, *C. castanea* (Gertsch et Soleglad, 1972), **comb. nov**., and *C. thompsoni*, **comb. nov**. (Gertsch et Soleglad, 1972). Major diagnostic characters of *Catalinia* include a carapace with a very weak anterior indentation, a very stout metasoma with little or no tapering from segment I to V, and a mating plug with two partial bases. Evidence is presented suggesting that *Catalinia* is closely related to the "*apacheanus*" species group of *Pseudouroctonus*.

Introduction

Gertsch & Soleglad (1972: 598–603; tab. 10–11, figs. 136–144) described in detail two closely related scorpion taxa that they placed as subspecies under the Kraepelin's species *Pseudouroctonus minimus* (= *Vejovis minimus* 1911), *P. m. castaneus* and *P. m. thompsoni*. In their analysis, the original Kraepelin's types of *P. m. minimus* were analyzed and a female lectotype was declared (see photo of same in the front plate). In addition, in this same paper, Gertsch & Soleglad (1972: 587–589; tab. 7) named a small species *P. andreas* (= *Uroctonus andreas*). These four taxa are found in the more mesic, rocky chaparral in coastal habitats of the Peninsular Ranges (coastal northern Baja California, Mexico, and coastal southern California, USA) and the Channel Islands (California, USA).

In this paper, all four of these taxa are moved as separate species to a new genus, *Catalinia*. This genus is comprised of small scorpion species with a wide metasoma and reduced pectinal tooth counts, 9–12 males and 7–11 females. Diagnostic of *Catalinia* is its weak anterior indentation of the carapace, a very heavy metasoma exhibiting little or no tapering, and a hemispermatophore mating plug with two partial bases, as well as other characters involving the pedipalp patella and the leg basitarsus. Figure 1 provides a dorsal view of all four species.

We refer to the set of species that were originally placed in genus *Pseudouroctonus* by Stockwell (1992: 409–410) as the "*Pseudouroctonus* clade". This is necessary since we are currently revising this clade and have removed several species and placed them into their own genera: *Kovarikia* and *Graemeloweus*, and in this paper, *Catalinia*, accounting for 10 species. Previously, Williams & Savary (1991) named the genus *Uroctonites* moving three species to it as well as adding a new species, four species in all. As for the remaining species in the *Pseudouroctonus* clade we see at least three species groups: 1) the "*apacheanus*" group which is comprised of *P. apacheanus*, *P. santarita*, *P. brysoni*, *P. kremani*, *P. chicano*, *P. savvasi*, and *P. rufulus*; 2) the "*lindsayi*" group which is monotypic, *P. lindsayi*; and 3) the "*reddelli*" group for species *P. reddelli*, *P. sprousei*, *P. cazieri*, and *P. peccatum* (note, the placement of the latter two species is tentative, requiring further analysis). Therefore, as of now, the *Pseudouroctonus* clade contains 26 species.

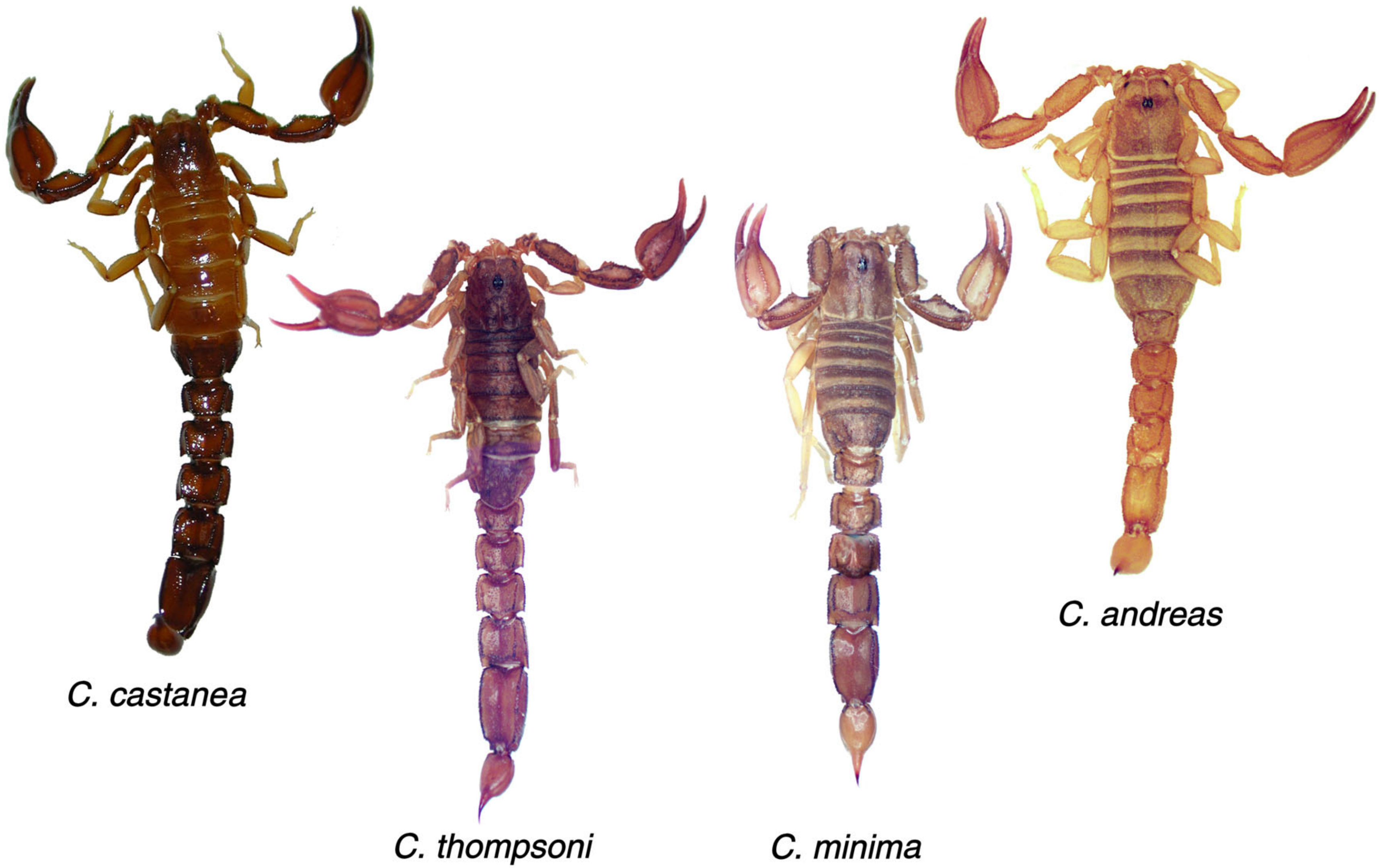

Figure 1: Dorsal view of species of genus *Catalinia*. *C. castanea*, male, Vista, San Diego Co., California, USA. *C. thompsoni*, male, Santa Cruz Island, Santa Barbara Co. California, USA. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. *C. andreas*, male, Escondido, San Diego Co., California, USA.

We use the biogeographical work of Bryson et al. (2013) in this paper as a supplementary guide to the morphology-based analysis presented in this effort. In addition to biogeographical considerations, Bryson et al. (2013) also supplies a molecular-based foundation using four genetic markers for their results. In general the results we present in this paper are consistent with those of the above work.

In this paper we present a detailed discussion and illustrations of *Catalinia*'s morphology, including the carapace, metasoma and telson, hemispermatophore and mating plug, the pedipalp, leg III basitarsus, the sterno-pectinal area, chelicerae, and trichobothrial patterns. A key to the four species and a map showing their distribution is provided. Taxonomic data are presented showing the close relationship *Catalinia* has with the "*apacheanus*" species group. Data on the reproduction of *C. minima* in captivity are reported. Biogeographical considerations are discussed for this genus. Three Appendices are provided: Appendix A, illustrations of the four trichobothrial patterns; Appendix B, supplementary statistical data supporting the morphometric analysis presented in this paper; and Appendix C, a detailed list of all reported localities for the four species of genus *Catalinia*, with latitude/longitude/altitude data. It must be noted here that the systematics as established in this paper (i.e., species identification and a new genus) is used in these character descriptions; see **Systematics** section for a formal statement of these emendations.

Methods and Material

Abbreviations

List of depositories: MES, Personal collection of Michael E. Soleglad, Winchester, California, USA; MRG, Personal collection of Matthew R. Graham, Willimantic, Connecticut, USA; RA, Personal collection of Richard F. Ayrey, Flagstaff, Arizona, USA; ZMH, Zoologisches Museum, Universität Hamburg, Hamburg, Germany.

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

Terminology and conventions

The systematics adhered to in this paper follows the classification as established in Fet & Soleglad (2005) and as modified by Soleglad & Fet (2008). Terminology describing trichobothria follows that described in Vachon (1974); pedipalp chelal finger dentition follows that described and illustrated in Soleglad & Sissom (2001); that of the sternum follows Soleglad & Fet (2003a); cheliceral dentition, the metasomal and pedipalp carination, and leg tarsus armature follows Soleglad & Fet (2003b); and the hemispermatophore terminology follows Soleglad & Fet (2008), Soleglad, Fet & Graham (2014), Ayrey & Soleglad (2015), and Soleglad et al. (2016).

Map generation software package

Map was generated by Earth Explorer 6.1, with positional and altitude data compiled through Google Maps.

Material Examined

Catalinia andreas **(Gertsch et Soleglad, 1972):** *USA, California*: San Diego Co., Escondido, California, USA, 2006, 1 ♂, 1 ♀, leg. M.R. Graham (MRG); San Diego Co., Chariot Canyon, 4.3 mi. S. Banner (HWY-78), California, USA, 30 August 1997, 4 ♂, 3 ♀, leg. M.E. Soleglad (MES); 3 ♀ (RA).

Catalinia castanea **(Gertsch et Soleglad, 1972):** *USA, California*: San Diego Co., Vista, August 2003, 5 ♂ (MES); Carlsbad, 1 ♀ (RA).

Catalinia minima **(Kraepelin, 1911):** *USA, California*: Los Angeles County: Hermit Trail, Avalon, Santa Catalina Island, 22–23 August 2016, 4 ♂, leg. R. A. Ayrey (RA); Los Angeles County: San Pedro, 1 ♀ (lectotype), 1 ♀, 1♂ (paralectotypes) (ZMH).

Catalinia thompsoni **(Gertsch et Soleglad, 1972):** *USA, California*: Santa Barbara Co., Santa Cruz Island, June 2011, leg. Unknown, 2 ♂, 3 ♀, (MRG); 1 ♂ (RA); 2 ♀ (MES).

Graemeloweus glimmei **(Hjelle, 1972):** *USA, California*: Lake Co., Cache Creek, 27 April 2016, 1 ♂, 2 ♀, leg. R.F. Ayrey (RA).

Graemeloweus iviei **(Gertsch et Soleglad, 1972):** *USA, California*: Trinity Co., 2 mi. E. Del Loma, Little French Creek, 6 April 1960, 1 ♂, 1 ♀, leg. W.J. Gertsch, W. Ivie, R. Schrammel (MES); El Dorado Co., American River, 28 April 2016, 2 ♂, 2 ♀, leg. R.F. Ayrey (RA).

Graemeloweus maidu **(Savary et Bryson, 2016):** *USA, California*: El Dorado Co., American River, 28 April 2016, 1 ♀, leg. R.F. Ayrey (RA).

Kovarikia angelena **(Gertsch et Soleglad, 1972):** *USA, California*: Ventura Co., Yerba Buena Canyon, 19 October 1991, 1 ♂, leg. B. Hebert (BH).

Kovarikia bogerti **(Gertsch et Soleglad, 1972):** *USA, California*: San Diego Co., Palomar Canyon, June 2013, 1 ♂, 1 ♀, leg. M.R. Graham (MRG).

Kovarikia williamsi **(Gertsch et Soleglad, 1972):** *USA, California*: San Diego Co., Santa Ysabel Preserve, 2 ♂, 1 ♀, leg. USGS pitfall trap (MES).

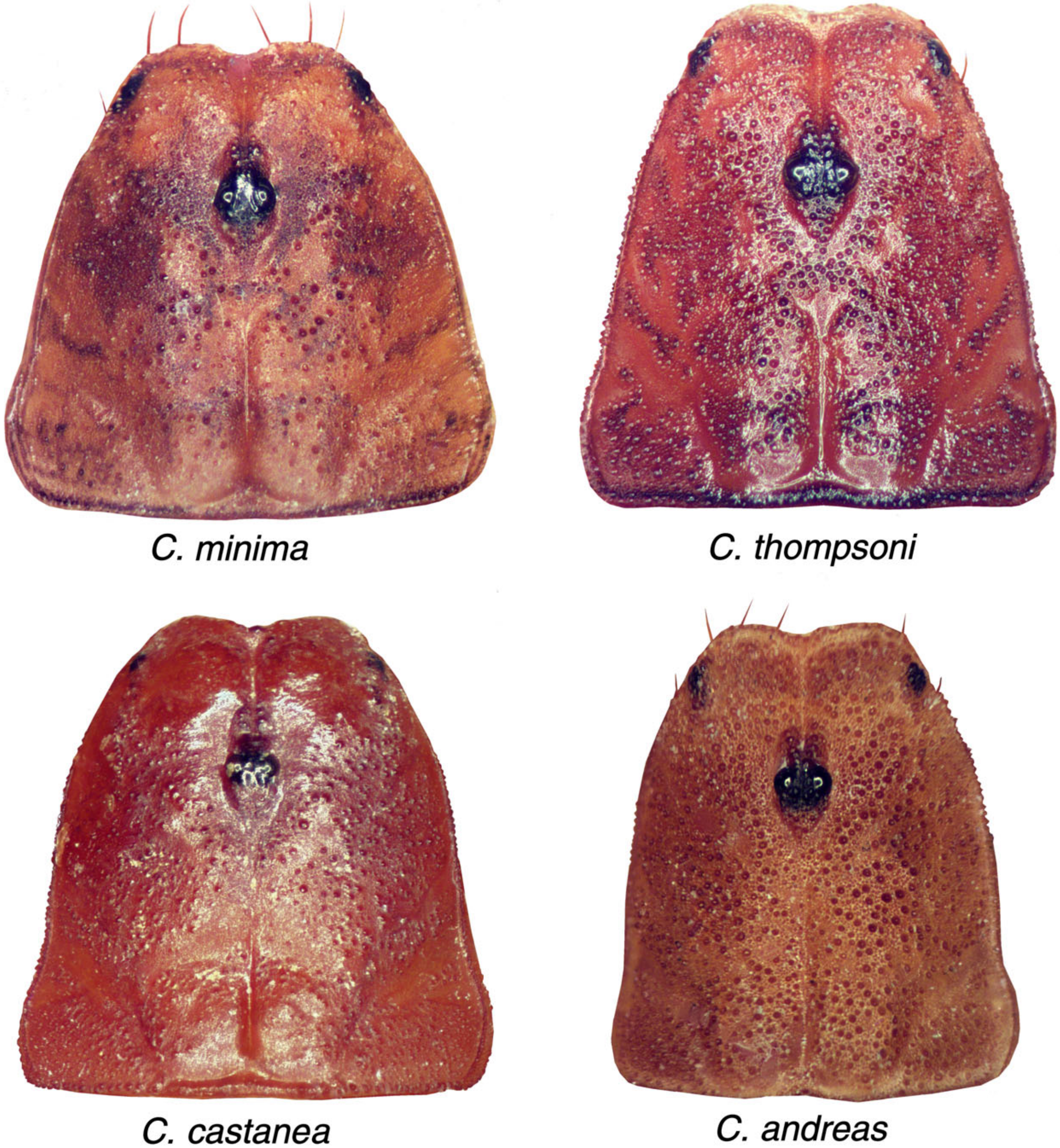

Figure 2: Carapace of species of genus *Catalinia*, all adult male specimens. Note, some of the anterior setae are missing in these figures. *C. minima*, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, Santa Barbara, Santa Cruz Island, California, USA. *C. castanea*, Vista, San Diego Co., California, USA. *C. andreas*, ABDSP, Chariot Canyon, San Diego Co., California, USA.

***Pseudouroctonus apacheanus* (Gertsch et Soleglad, 1972):** *USA, Arizona*: Chiricahua Mountains, Rucker Canyon, 5 September 2008, 1 ♂, leg. R. F. Ayrey, (RA836, RFA).

***Pseudouroctonus brysoni* Ayrey et Soleglad, 2017:** *USA, Texas*: Jeff Davis Co., Musquiz Canyon, 6 August 2016, ♂, leg. R. Bryson (RA).

***Pseudouroctonus kremani* Ayrey et Soleglad, 2015:** *USA, Arizona*: Pima Co., Molino Basin, Santa Catalina Mountains, 19 August 2012, 1 ♂, leg. R.F. Ayrey (RA1110).

***Pseudouroctonus santarita* Ayrey et Soleglad, 2015:** *USA, Arizona*: Santa Cruz Co., Madera Canyon, Santa Rita Mountains, 28 May 2012, 1 ♂, leg. R. F. Ayrey, (RA1104).

***Pseudouroctonus reddelli* (Gertsch et Soleglad, 1972):** *USA, Texas*: Comal Co., Gem Cave, 1 ♀, leg. T. Barr, J. Reddell, (MES).

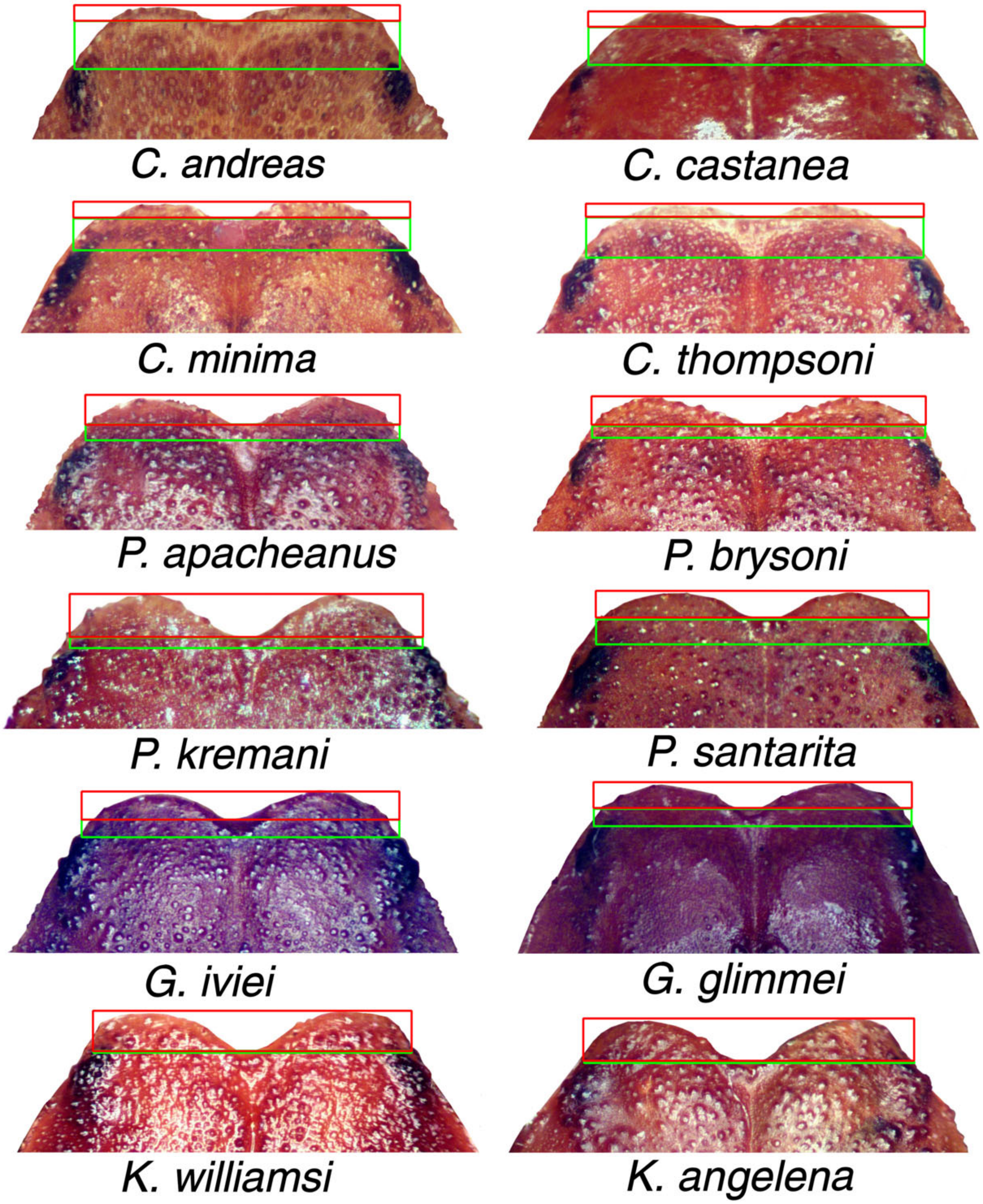

Figure 3: Anterior edge of the carapace for genus *Catalinia* and select species of the "*apacheanus*" group, *Graemeloweus*, and *Kovarikia*. The *RED* rectangle shows the depth of the anterior indentation and the *GREEN* rectangle shows the distance between the anterior indentation and the distal lateral eye. The *GREEN* triangle in *Catalinia* is considerably larger than its *RED* rectangle, whereas in the other species, the *RED* rectangle is larger. This clearly indicates a more shallow indentation in *Catalinia*. *Catalinia andreas*, ABDSP, Chariot Canyon, San Diego Co., California, USA. *C. castanea*, male, Vista, San Diego Co., California, USA, *C. minima*, Avalon, Santa Catalina Island, California, USA, *C. thompsoni*, male, Santa Barbara, Santa Cruz Island, California, USA, *Pseudouroctonus apacheanus*, male, Chiricahua Mountains, Rucker Canyon, Arizona, USA, *P. brysoni*, male, Musquiz Canyon, Jeff Davis Co., Texas, USA, *P. kremani*, female, Seven Cataracts Overlook, Santa Catalina Mountains, Pima Co., Arizona, USA, *P. santarita*, female, Madera Canyon, Santa Cruz Co., Arizona, USA, *Graemeloweus iviei*, female, American River, El Dorado Co., California, USA, *G. glimmei*, female, Cache Creek, Lake Co.,California, USA, *Kovarikia williamsi*, female, Santa Ysabel Preserve, San Diego Co., California, USA, *K. angelena*, male, Yerba Buena Canyon, Ventura Co., California, USA. Some of the photographs are, in part, after Ayrey & Soleglad (2015: figs. 4, 18; 2017: fig. 2) and Soleglad et al. (2016: fig. 6).

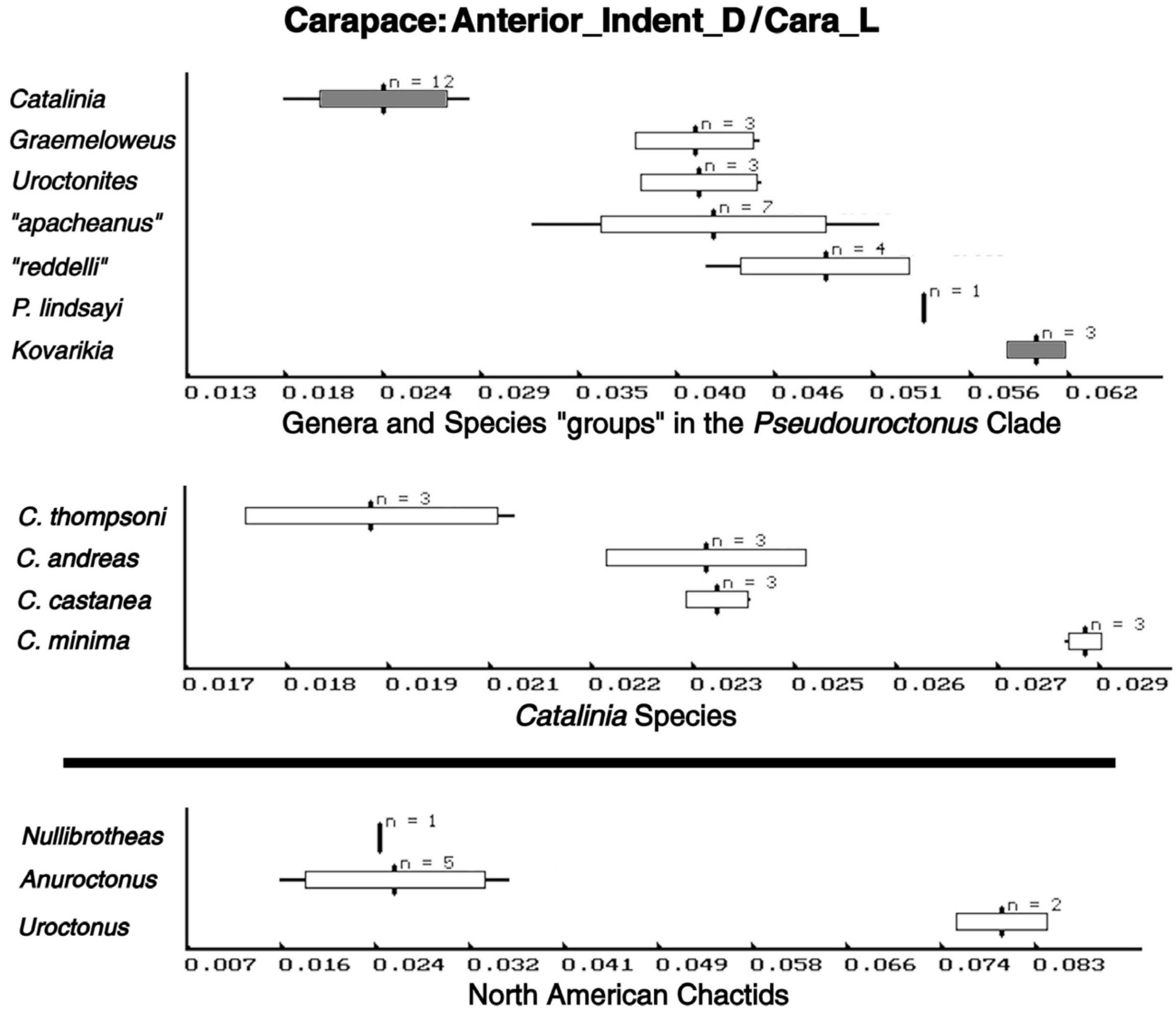

Figure 4: Histograms depicting morphometric ratio "carapace anterior indentation depth / carapace length". The histogram on the top shows the relatively shallow anterior indentation of genus *Catalinia* exhibiting complete separation from the other proposed clades in the *Pseudouroctonus* group. Also evident in this histogram is the relatively deep anterior indentation found in genus *Kovarikia*. Both are considered diagnostic of these two genera. In the middle histogram the four species of genus *Catalinia* are shown for this ratio, species *C. thompsoni* with the most shallow anterior indentation and *C. minima* with the relatively deepest indentation. The histogram on the bottom presents this ratio for the three North American chactid genera which includes subspecies and multiple specimens in some cases. See Appendix B for more detailed data pertaining to these histograms.

Nullibrotheas allenii **(Wood, 1863):** *MEXICO*, *Baja California Sur*: Los Planes, 20 Dec 1958, 1 ♂, leg. A. Leviton (MES).

Structure Analysis

Major diagnostic structures discussed in this section are the reduced anterior indentation of the carapace, the very wide metasoma, exhibiting little or no tapering from segment I to V, and the short metasomal segments IV and V. Other important structures discussed in detail are the hemispermatophore and its mating plug, the pedipalp patella dorsal patellar spur (*DPSc*) carina, the external carinae *EMc* and *SEMc* of the patella, and the setation of the leg basitarsus. Other less defining structures are also discussed fully, such as the chelicerae, pectines, and trichobothrial patterns of all four species.

Carapace

Carapace anterior edge. Unique to the species of *Catalinia* is the reduction of the anterior indentation of the carapace. The reduced anterior indentation is quite apparent in the carapace illustrations shown in Figure 2. In particular, this reduction of the indentation is significant since in the other genera and species groups comprising the *Pseudouroctonus* clade, this indentation is significant and is one of its defining characters. To further emphasize this character, Figure 3 shows the carapace anterior edge of select species of genera *Graemeloweus* and *Kovarikia*, and species of the "*apacheanus*" group for comparison with *Catalinia*. In these figures, we emphasize the shallowness of the anterior indentation in *Catalinia* by comparing the distance from the carapace anterior edge to the bottom of the indentation (indicated by a *RED* rectangle) to the distance from the indentation bottom to the most anterior lateral eye (indicated by a *GREEN* rectangle). The *RED* rectangle in *Catalinia* is considerably smaller than the *GREEN* rectangle, at least twice as small. In the other species, the *RED* rectangle is larger than the *GREEN* rectangle in size. For genus *Kovarikia*, the anterior indentation is so deep that the *GREEN* rectangle is essentially obsolete; i.e., the anterior indentation's bottom is parallel to the anterior lateral eye.

To quantify the relative depth of the anterior indentation in major genera and species groups now comprising the *Pseudouroctonus* clade, we constructed a morphometric ratio comparing the depth of the indentation to the carapace length. In Figure 4 we show histograms of this ratio for all components of the *Pseudouroctonus* clade as well as the three North American chactids, *Uroctonus*, *Anuroctonus*, and *Nullibrotheas*. It is clear from the top histogram that this ratio is considerably smaller in *Catalinia* (indicating a shallow indentation) than in the other *Pseudouroctonus* clade components. Complete plus-minus standard error separation (and absolute separation for that matter) is shown for genus *Catalinia*. When comparing the MVD percentage differences, *Catalinia* exhibits considerable difference, ranging from 74 to 155 %. The close relative of *Catalinia*, the "*apacheanus*" group, showed a 78 % difference. The genus *Kovarikia* exhibited the deepest indentation which was mentioned as a diagnostic character for this genus by Soleglad, Fet & Graham (2014: 9, figs. 6). This result is also supported by the comparisons discussed above for Figure 3.

In Figure 4 we also show the anterior indentation ratio histogram for the four species of *Catalinia*. We see here that *C. thompsoni* has the shallowest indentation whereas *C. minima* has the deepest. In *Catalinia andreas* and *C. castanea*, indentation ratio is roughly the same.

The North American chactids span the spectrum for this indentation ratio, genera *Anuroctonus* and *Nullibrotheas* with modest indentations and *Uroctonus* with a deep indentation.

Note, these histograms are based on both male and female specimens since the carapace indentation doesn't exhibit sexual dimorphism. See Appendix B for more data and the identity of species/sources involved in these histograms.

Lateral eyes. Scorpions of genus *Catalinia* are in general small and consequently the number of lateral eyes varies within a species, the posterior eye reduced or sometimes missing altogether. This observation is also supported by Gertsch & Soleglad (1972: 588, 598, 600, 603) who report: for *C. andreas*, "… Lateral eyes three or two; posterior eye small, often missing …", for *C. minima*, "… Lateral eyes three; posterior eye smaller than front pair, in some cases obsolete. …", for *C. castanea*, "… Lateral eyes two; posterior eye obsolete or nearly so …", and for *C. thompsoni*: "… Lateral eyes three; posterior eye small, rarely obsolete. …". Thus, we can conclude that species of *Catalinia* have 2 to 3 lateral eyes and can be variable within a species.

Metasoma and telson

Since all *Catalinia* species are quite small and stocky in overall proportions, the metasoma provides us with several diagnostic characters for this genus. Figure 5 shows the dorsal view of the *C. castanea* metasoma and three views of segment V for all four species of *Catalinia*. Besides exhibiting a somewhat wide stocky metasoma, we also detected an interesting characteristic of this metasoma: there is essentially *no tapering* of the segments, the width of segments I–V are roughly the same width, which is highly unusal for scorpions of family Vaejovidae. In general, segment I is much wider than segment V, thus exhibiting a gradual tapering from segment I to segment V. Also of diagnostic importance, all metasoma segments are relatively wider than found in the other *Pseudouroctonus* clade components, in particular segments IV and V. We present a detailed discussion of these diagnostic characters below. Also refer to Appendix B for the detailed statistical data used in the analysis and constructing relevant histograms.

Metasoma tapering quotient. The "metasoma tapering quotient" is calculated as follows: |segI_W – segV_W| / segV_W. This formula determines the presence or absence of any tapering of the metasoma. If no tapering is present, then the result is zero. Of course, tapering also involves all five segments of the metasoma, but only segments I and V are considered here, since in a large majority of vaejovid species, segment I is the widest and segment V is the thinnest.

In Figure 6 we show two histograms (for male and female) that compare the tapering quotient for *Catalinia*, the "*apacheanus*" group, and genera *Graemeloweus* and *Kovarikia*. It is clear from these histograms that *Catalinia* exhibits minimal tapering, showing complete plus-minus standard error separation. Also predictable, we see that genus *Kovarikia* has the most tapering. The MVD differences between *Catalinia* and the other genera/groups is quite significant, exhibiting 334 to 531 percent for the males and 246 to 450 percent for the females.

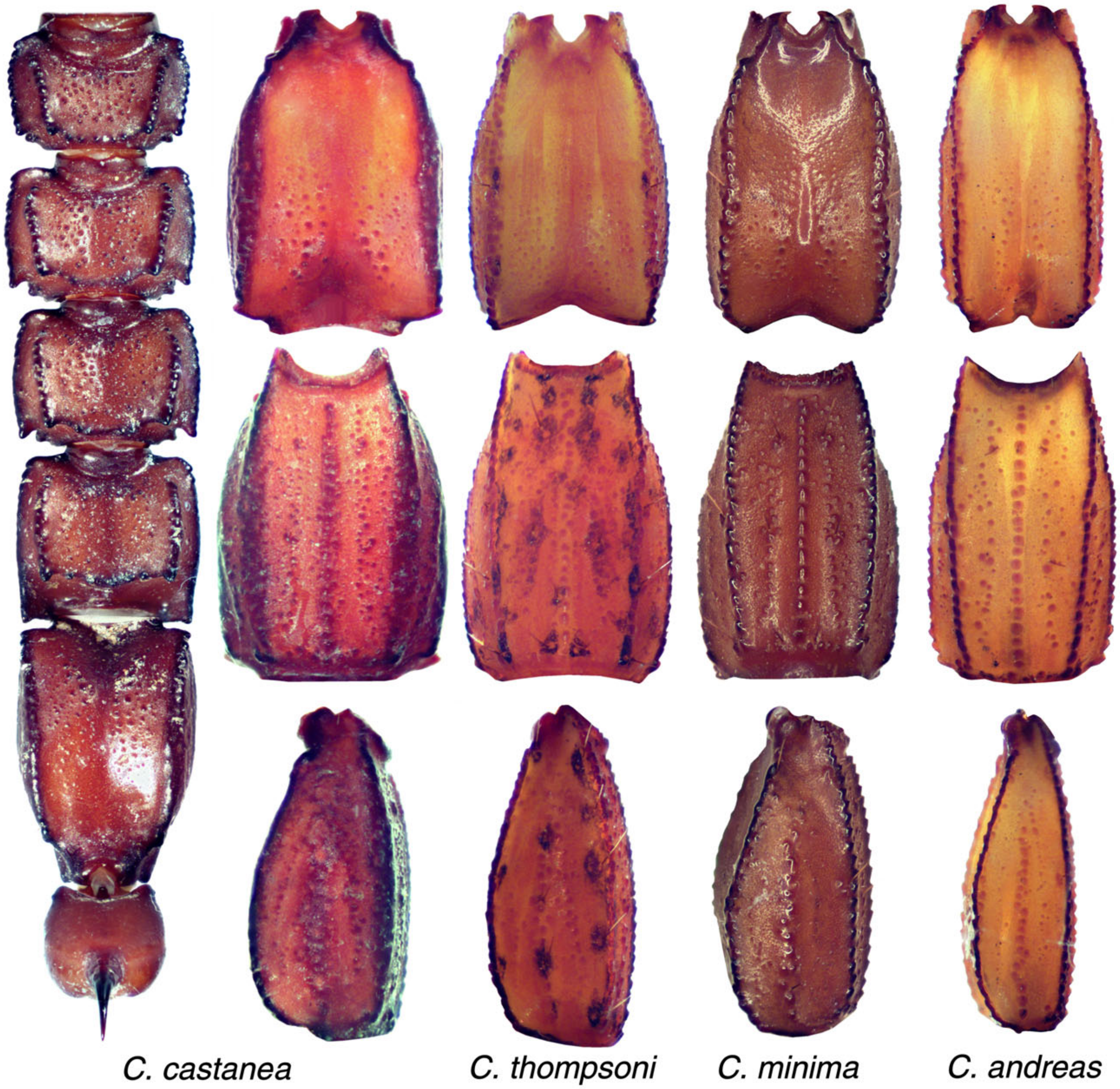

Figure 5: Metasomal segments of genus *Catalinia*. *C. castanea*, male, Vista, San Diego Co., California, USA. Dorsal view of metasoma and telson, and dorsal, ventral, and lateral views of segment V. *C. thompsoni*, male, Santa Cruz Island, Santa Barbara Co., California, USA. Dorsal, ventral, and lateral views of segment V. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. Dorsal, ventral, and lateral views of segment V. *C. andreas*, male, Chariot Canyon, ABDSP, San Diego Co., California, USA. Dorsal, ventral, and lateral views of segment V.

Segment IV–V proportions. We compared the width to the length of the five metasomal segments comprising the *Pseudouroctonus* clade. In histograms presented in Figure 8, we see that metasomal segments IV–V of *Catalinia* are considerably stouter than they are in the "*apacheanus*" group and genera *Graemeloweus* and *Kovarikia*. These histograms also show the "*reddelli*" group, which in this case includes species *P. reddelli* and *P. sprousei* (male only). Note, although segments IV and V are the most stout in the metasoma, all segments of *Catalinia* species are stouter than in the other groups, see Appendix B for more data.

Of the five metasomal segments, segments IV and V exhibited the most separation. For these two segments, the plus-minus standard error ranges were non-overlapping between *Catalinia* and the other genera/groups. The MVD differences for segment IV between genus *Catalinia* and the other genera/groups ranged 27 to 109 % for males and 19 to 98 % for females. For segment V, the MVD differences ranged 29 to 93 % for

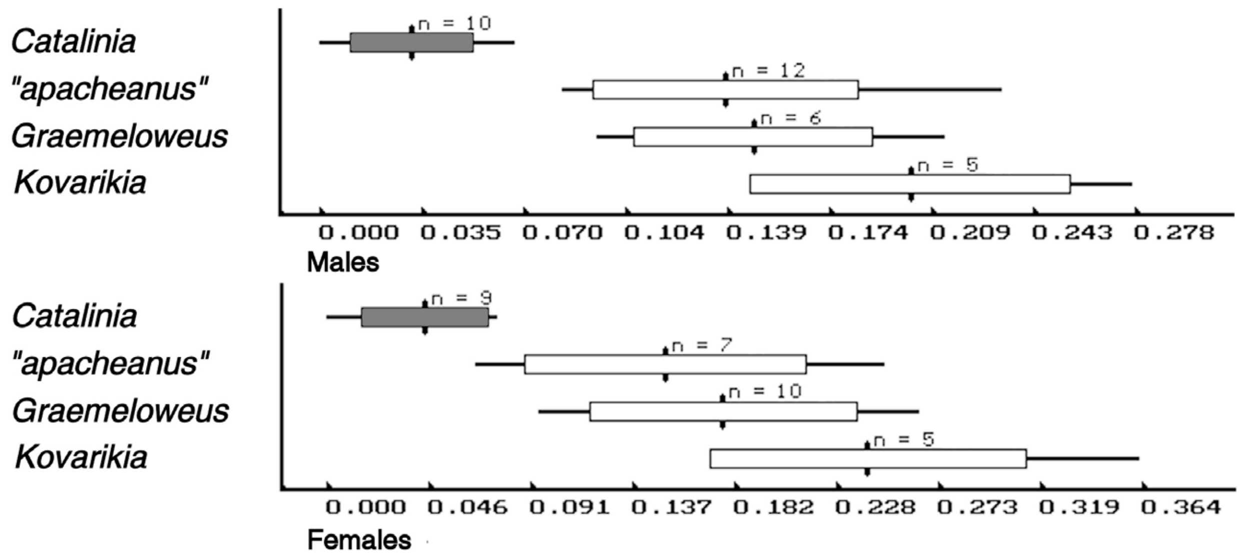

Figure 6: Histograms depict the metasomal "tapering quotient", |segI_W – segV_W| / segV_W. These histograms show that genus *Catalinia* has marginal tapering as compared to the other genera or "groups", and genus *Kovarikia* exhibits the most metasomal tapering. See Appendix B for more detailed data pertaining to these histograms.

males and 29 to 85 % for females. Figure 7 illustrates the proportional differences in segment V of adult male species for *Catalinia*, "*apacheanus*" group, and select species of *Graemeloweus* and *Kovarikia*. In this Figure it is clear just how proportionally wide segment V is in *Catalinia*.

Metasomal carinae. Dorsal, dorsolateral, and lateral carinae of segments I–IV prominent, provided with heavy, rounded granules to give crenulate to serrate appearance, those at posterior ends of series slightly larger. The ventral and ventromedian carinae well developed and coarsely granulated. Intercarinal spaces with numerous small granules. The carinae of segment V less developed, rounded, with fewer heavy granules.

Telson. The telsons of all four species of *Catalinia* are shown in Figure 9, both lateral and dorsal views. All four telsons exhibit the same overall shape with a somewhat elongated and flat vesicle from the lateral view, and a wide vesicle from the dorsal perspective. The aculeus/vesicle juncture is not well delineated, the aculeus with a shallow curve. The subaculear setal pair is located at this juncture. As in most vaejovids, a distinct subaculear tubercle is not present in *Catalinia* (note, genus *Wernerius*, which exhibits a distinct tubercle, is a notable exception). The dorsal surface of the male vesicle lacks the *linear patch* seen in genus *Kovarikia* (see Soleglad, Fet & Graham, 2014: 8, fig. 5).

Hemispermatophore and mating plug

Hemispermatophore. The hemispermatophore of *Catalinia* is structured the same in all four species. Figures 10–13 show several views of the hemispermatophore of these species, including the dorsal, internal and ventral views. The lamina edges are subparallel, the terminus is truncated *without* a distal crest on the dorsal side. The lamellar hook is elongated, distinctly bifurcated, and originates from the dorsal trough. A secondary lamellar hook and basal constriction are absent. Note: the secondary lamellar hook, a very unique structure, is found in genera *Graemeloweus* and *Kovarikia*, but it is absent both in *Catalinia* and the "*apacheanus*" group of *Pseudouroctonus*. The lamellar hook length to lamina length ratio ranges 0.414–0.507 (0.458) and the trough difference to lamellar hook length ratio ranges 0.394–0.452 (0.413). See Appendix B for the breakdown of these ratio values for each species.

In Figure 14 we show a spermatophore of *C. minima* after insemination of the female. The spermatophore is composed of the right (left side) and left (right side) hemispermatophores partially "fused" together on their ventral surfaces. The view shown in Figure 14 is from the internal side, where both lamellar hooks, the internal edges of the dorsal troughs, and the lamina termini are visible.

Mating plug. In Figures 10–13 we present the mating plug of all four species, showing several views including the dorsal and ventral aspects. Also shown is the mating plug embedded in the ventral side of the hemispermatophore just below the ventral trough for all species. All four species exhibit the same overall structure in the plug. The mating plug in genus *Catalinia* has a simplistic barb with one tine longer than the other and exhibits a smooth edge. The barb's edge is located on the dorsal side of the mating plug. The barb itself is attached to the distal end of the primary stem, its smooth edge adjacent to the stem's convexed side.

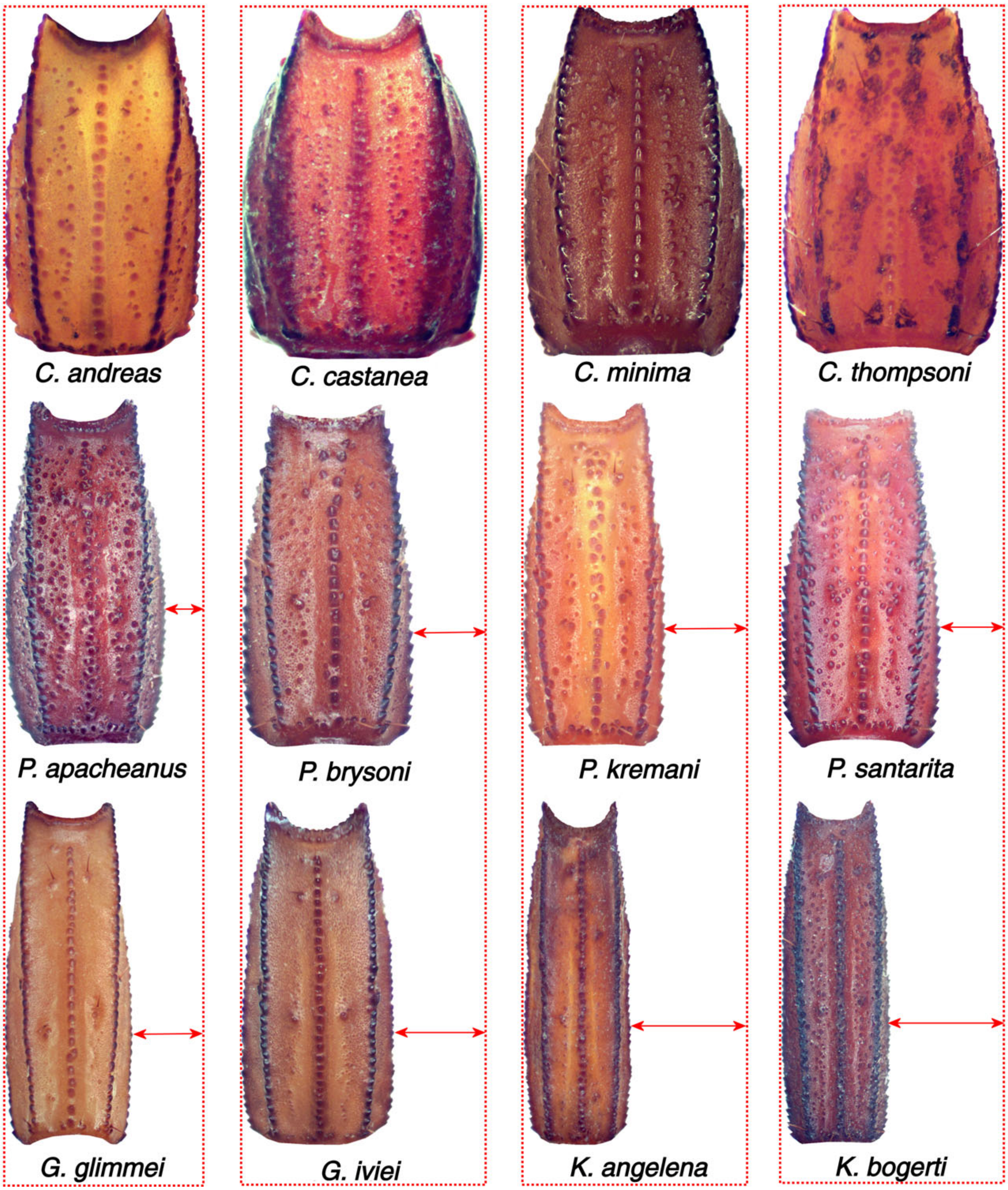

Figure 7: Metasomal segment V of adult male, ventral view, for genus *Catalinia*, "*apacheanus*" group, and select species of *Graemeloweus* and *Kovarikia*. Note, each segment is shown at the *same* length in order to emphasis the exceptional stockiness of *Catalinia*'s metasomal segment V. The *red dotted rectangles* and *arrows* illustrate the wideness of this segment in comparison to the other species. Also the slender metasoma segment V of genus *Kovarikia* is quite apparent. *Catalinia andreas*, Chariot Canyon, ABDSP, San Diego Co., California, USA, *C. castanea*, Vista, San Diego Co., California, USA, *C. minima*, Avalon, Santa Catalina Island, California, USA, *C. thompsoni*, Santa Cruz Island, Santa Barbara Co., California, USA, *Pseudouroctonus apacheanus*, Rucker Canyon, Chiricahua Mountains, Arizona, USA, *P. brysoni*, Musquiz Canyon, Jeff Davis Co., Texas, USA, *P. kremani*, Seven Cataracts Overlook, Santa Catalina Mountains, Pima Co., Arizona, USA, *P. santarita*, Santa Rita Mountains, Santa Cruz Co., Arizona, USA, *Graemelowues glimmei*, Cache Creek, Lake Co., California, USA, *G. iviei*, American River, El Dorado Co., California, USA, *Kovarkia angelena*, Yerba Buena Canyon, Ventura Co., California, USA, *K. bogerti*, Palomar Mountain Road, San Diego Co., California, USA.

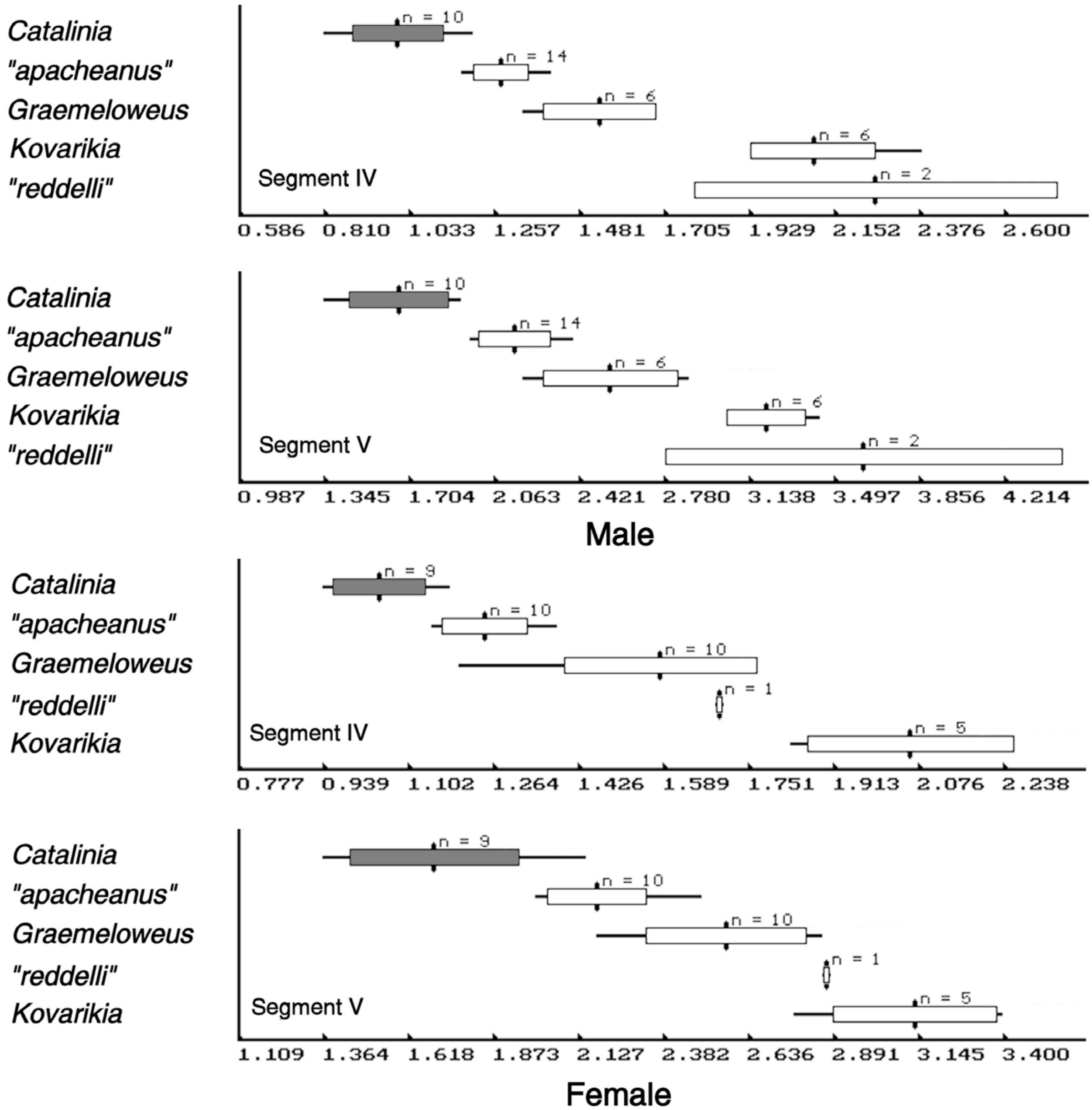

Figure 8: Histograms depict metasomal morphometric ratios for segments IV and V (segment length / segment width). These histograms show that genus *Catalinia* has the stoutest segments IV and V and, in contrast, genus *Kovarikia* and the two species comprising the "*reddelli*" group (out of four) with the thinnest. See Appendix B for more detailed data pertaining to these histograms.

Very unusual in the mating plug of *Catalinia*, however, is its double base and two stems. In the diagrammatic view of the mating plug shown in Figure 15, we see the coupling of the primary base to a smaller secondary base by way of a short flared secondary stem. In this figure the view is from a ventrointerior view (i.e., the barb is closer to the viewing plane). This view therefore emphasizes the coupling of the two bases, thus exposing the primary base's *convex* top. The secondary stem projects from the primary base, the stem's base quite wide which then tapers considerably as it connects to the secondary base (i.e., to its bottom). The secondary base has two elongated projections, the longer of the two located on the distal aspect of the plug (i.e., pointing to the hemispermatophore lamina) and the other on the proximal side (i.e., pointing to the hemispermatophore base). From these two projections the secondary base immediately tapers considerably forming the base of the primary stem which leads to the barb. In Figure 15 the concaved side of the primary stem is visible, its con-

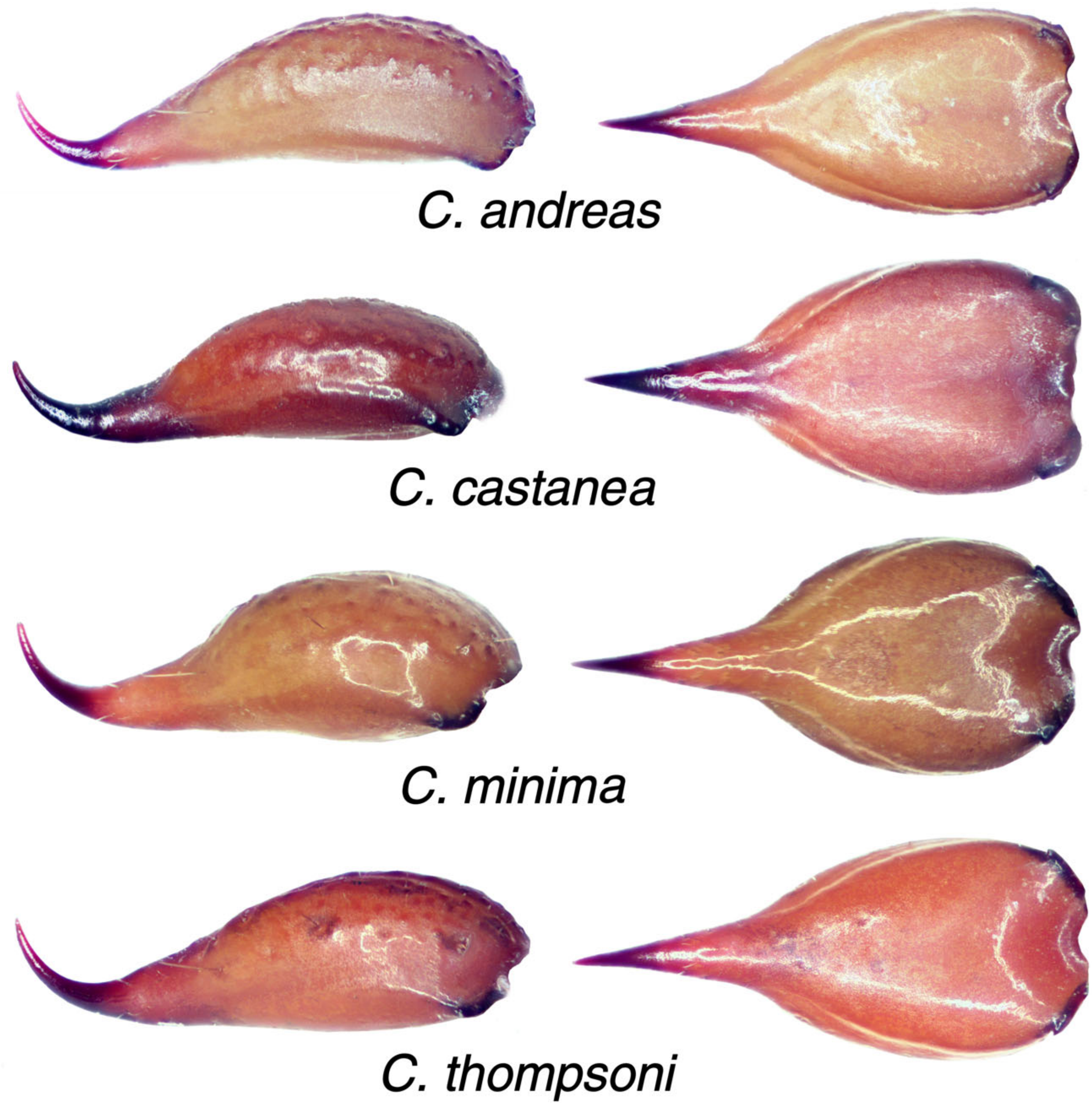

Figure 9: Telson, lateral and dorsal views of genus *Catalinia*. *C. andreas*, female, Chariot Canyon, ABDSP, San Diego Co., California, USA. *C. castanea*, male, Vista, San Diego Co., California, USA. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, male, Santa Cruz Island, Santa Barbara Co., California, USA.

vexed side on the other side, in alignment with the barb's smooth edge.

The secondary base's position relative to the primary base is variable on individual mating plugs, depending on whether it is situated close to the primary base thus hiding the secondary stem, or raised (as shown in Fig. 15), thus exposing the secondary stem. The double base configuration is visible for all species of *Catalinia* to one degree or another (Figures 10–13), the most exaggerated in the images shown for species *Catalinia castanea* and *C. thompsoni*. We hypothesize here that the secondary base position variability is due to its ability to raise up from the primary base and therefore *does not* imply a difference in the substructures. We have examined multiple plugs where this is the case.

In Figure 16 we identify all the mating plug substructures using colored identifiers. This nomenclature allows one to follow individual substructures as they appear (if visible) in the multiple views shown. The mating plug is highly three-dimensional, as overall

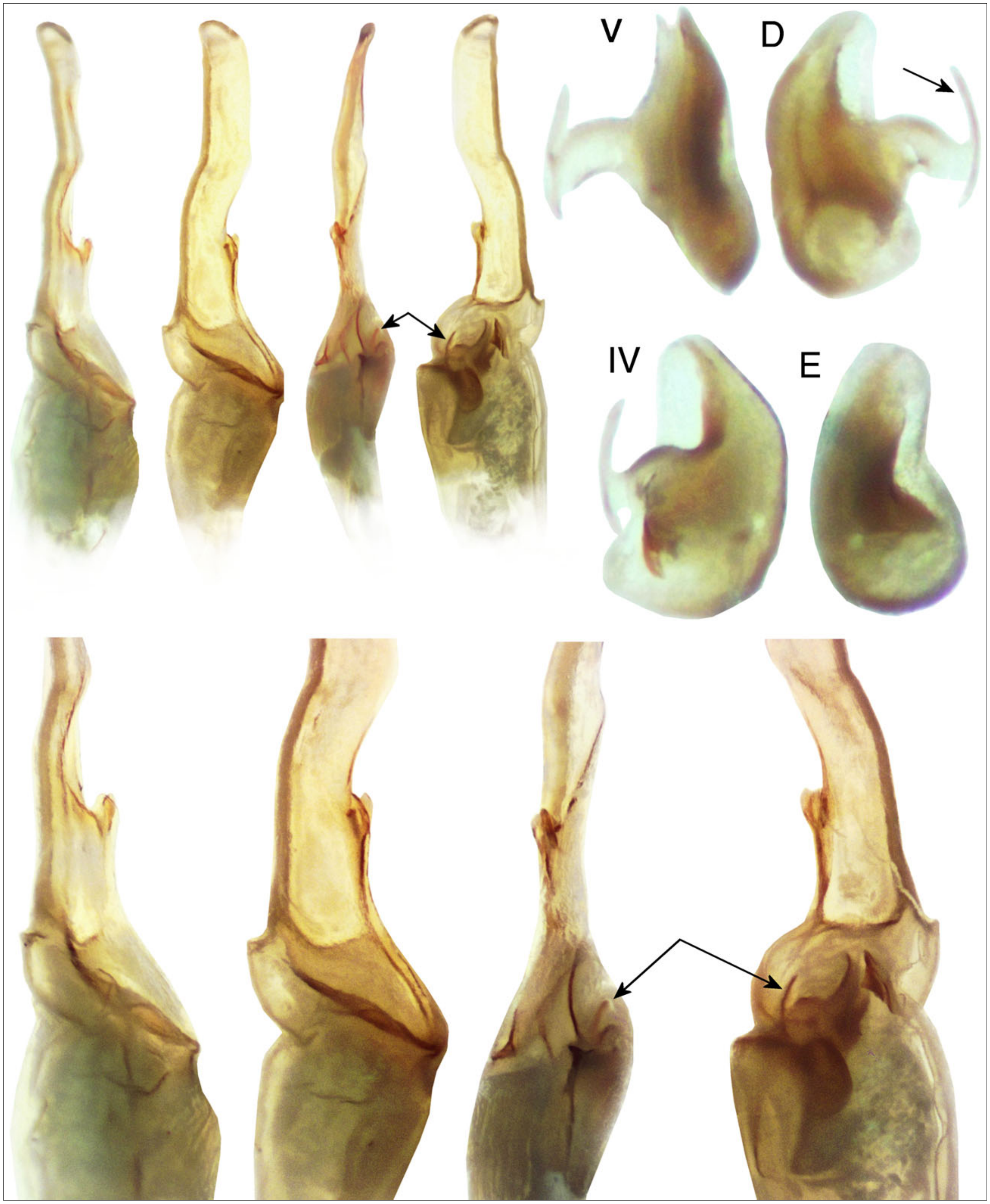

Figure 10: *Catalinia andreas*, ABDSP, Chariot Canyon, San Diego Co., California, USA. Left hemispermatophore and mating plug dissected from two different specimens (reversed, photographed submerged in alcohol). **Upper Left.** Hemispermatophore, exterodorsal, dorsal, internal, and ventral views. Note, the proximal half of the trunk is partially intact. **Lower.** Close-up of median area, exterodorsal, dorsal, internal, and ventral views, showing the construction of the lamellar hook. The mating plug embedded in the median area is visible in the ventral and internal views (indicated by *arrows*). **Upper Right.** Mating plug, ventral (V), dorsal (D), interoventral (IV), and external (V) views. Note the smooth barb edge is indicated by an *arrow*.

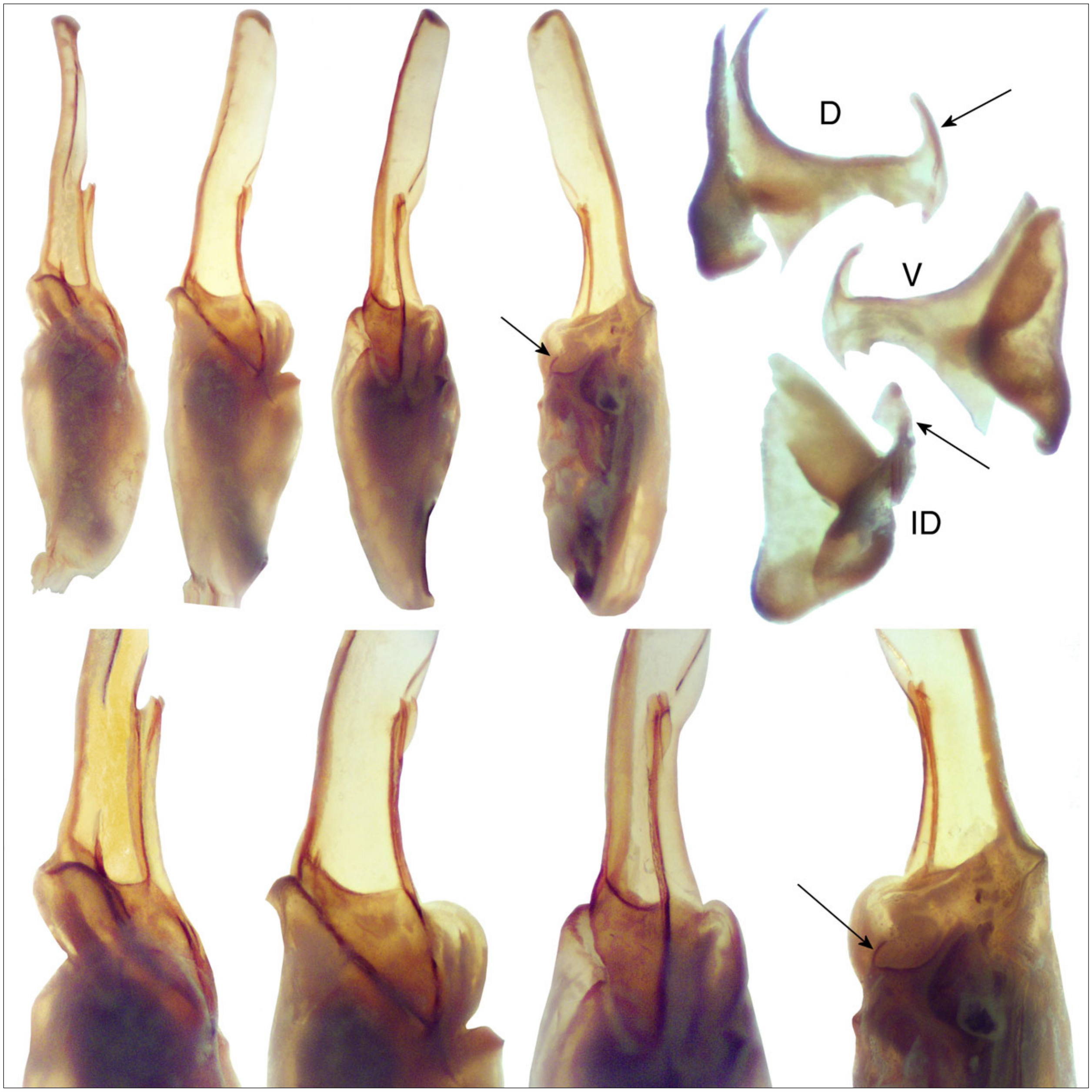

Figure 11: *Catalinia castanea*, Vista, San Diego Co., California, USA. Hemispermatophore and mating plug (photographed submerged in alcohol). **Upper Left.** Right hemispermatophore, exterodorsal, dorsal, internal, and ventral views. **Lower.** Right hemispermatophore, closeup of median area, exterodorsal, dorsal, internal, and ventral views, showing the construction of the lamellar hook. The mating plug, embedded in the median area, is visible in the ventral view (indicated by *arrows*). **Upper Right.** Mating plug (from left hemispermatophore, reversed) dorsal (D), ventral (V), and interodorsal (ID) views. *Arrows* point to barb's smooth edge.

appearance of this substructure can change radically based on a subtle angle change caused by a different view.

Of taxonomic importance, we consider this unique mating plug configuration described for *Catalinia* to be the same as that described/illustrated for the "*apacheanus*" group species *Pseudouroctonus santarita* (see Ayrey & Soleglad, 2015: figs. 14). In the description presented above we provided additional information on this mating plug. See below for a further discussion of this mating plug with respect to other species of the "*apacheanus*" group and its potential taxonomic significance.

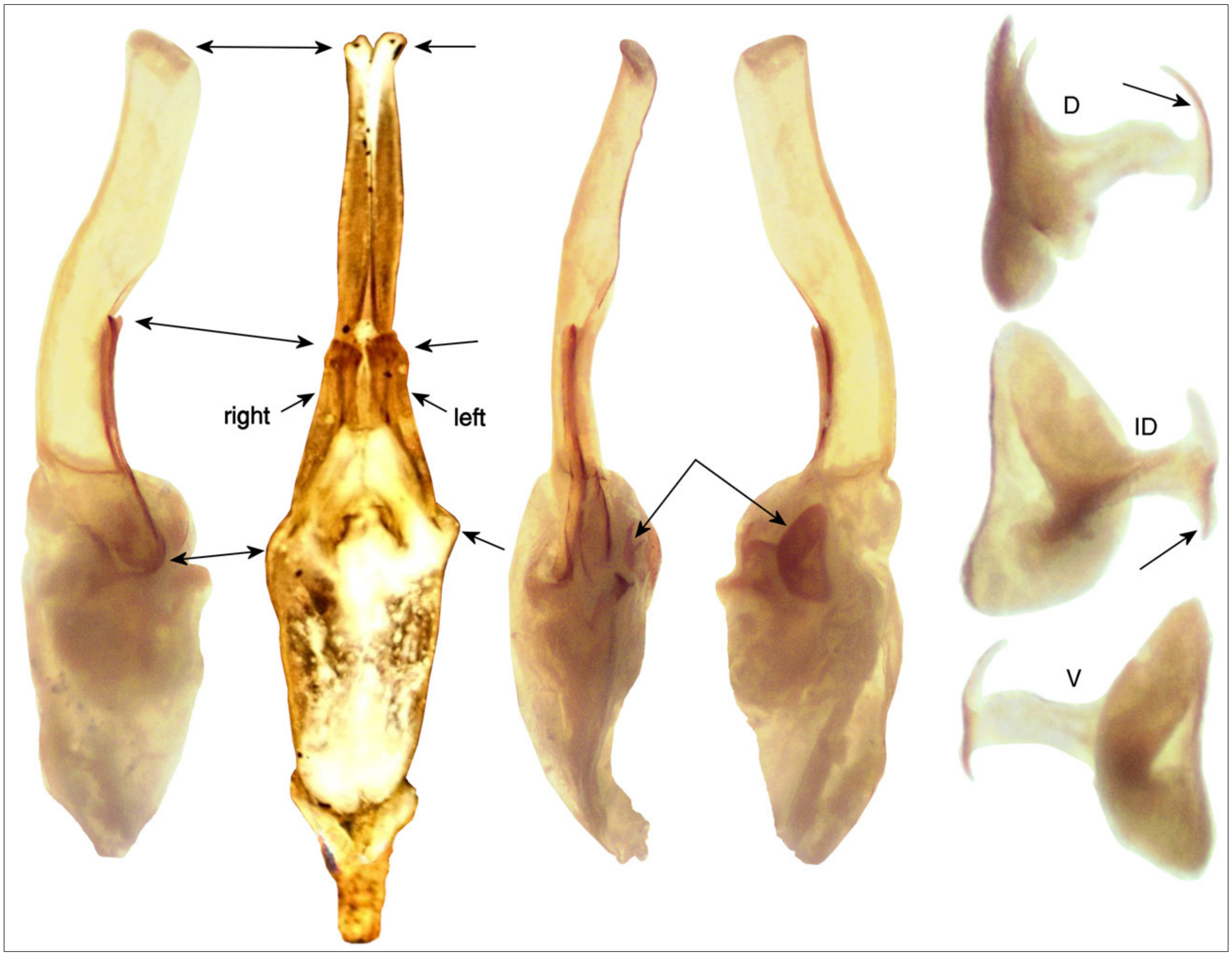

Figure 12: *Catalinia minima*, Avalon, Santa Catalina Island, California, USA. Spermatophore, hemispermatophore, and mating plug (photographed submerged in alcohol). Spermatophore affixed to a rock after insemination of the female. Right and left hemispermatophores indicated. Internal view showing pairs of lamellar hooks, edges of dorsal trough, and lamina termini (indicated by *arrows*). Right hemispermatophore dorsal, internal, and ventral views. *Arrows* point to embedded mating plug. Mating plug dorsal (D), interodorsal (ID), and ventral (V) views. *Arrows* point to barb's smooth edge.

Pedipalp carinal development

Chela carinae. The carinal structure of the pedipalp chela is important in scorpion systematics. It was discussed in detail in Soleglad et al. (2016: fig. 3) where the presence of a well-developed ventromedian (*V2*) carina was shown to exist in genus *Graemeloweus*. The prescence of this carina was counter to that found in other species in the *Pseudouroctonus* clade. In Figure 17 we illustrate the ventral surface of the chelal palm for the four species of *Catalinia*. Also in this figure we show a distal view of the chela for two species emphasizing the somewhat flat chelal palm that is present in this genus. This is caused in most part by the obsolescence of *V2* and the somewhat flattening of *D3*. It is clear that *Catalinia* does not have a developed *V2* carina.

Finger dentition. In Figure 18 we illustrate the dentition of the movable and fixed fingers for the four species of *Catalinia*. As common in the vaejovids the median denticle (*MD*) rows are continuous, each group separated by an outer denticles (*OD*) and flanked internally by inner denticles (*ID*). Accessory denticles are absent in this genus. There are six *ID* on the fixed finger and either six or seven on the movable finger. *Catalinia andreas* and *C. minima*, the smallest species in the genus, exhibit only six *ID* on the movable finger. This is consistent with Gertsch & Soleglad (1972: 589, 598) who report: for *C. andreas*, "…Keels on movable and fixed fingers flanked by six supernumerary teeth …" and for *C. minima*, "… movable finger with six supernumerary teeth …".

Patella *DPSc*. The dorsal patella spur carina (*DPSc*) was discussed in detail in Soleglad & Fet (2003: 52–58). It was shown that it is present to one degree or another in all vaejovids. Both Stockwell (1981: fig. 251), character 41: state = 0, and Soleglad & Fet (2003: fig.

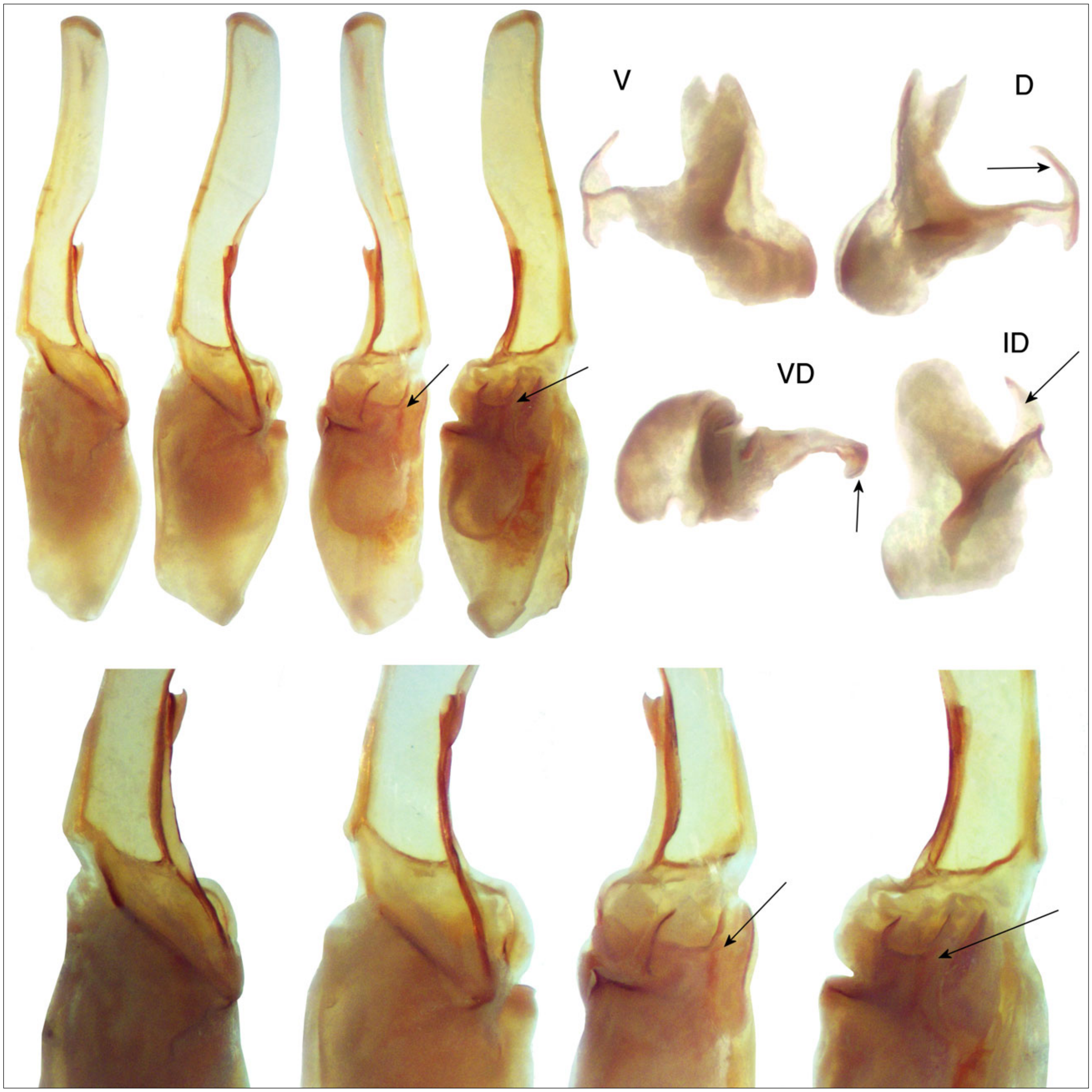

Figure 13: *Catalinia thompsoni*, Santa Cruz Island, Santa Barbara Co. California, USA. Right hemispermatophore and mating plug from two different specimens (photographed submerged in alcohol). **Upper Left.** Hemispermatophore, dorsoexternal, dorsal, interoventral, and ventral views. **Lower.** Closeup of median area, dorsoexternal, dorsal, interoventral, and ventral views, showing the construction of the lamellar hook. The mating plug embedded in the median area is visible in the interoventral and ventral views (indicated by *arrows*). **Upper Right.** Mating plug, ventral (V), dorsal (D), distal view from the lamina (VD), and interodorsal (ID) views. Note, the smooth barb edge is indicated by *arrows*.

116), character 96: state = 1, consider the presence of the *DPSc* as a synapomorphy for family Vaejovidae. However, Stockwell (1981: fig. 257), character 42, state = 1, considered the *DPSc* to be highly reduced to absent in his definition of the genus *Pseudouroctonus*, as well as in genera *Uroctonites* and *Uroctonus* (i.e., Stockwell considered this a "loss" of this carina). Soleglad & Fet (2003: 58) disagreed with this stating that the *DPSc* was present in *Pseudouroctonus* and *Uroctonites*. They did agree with *Uroctonus*, however, which lacks this carina, but stated "…we propose that the *DPSc* carina was not lost in *Uroctonus* since it was never present in this genus in the first place …". Of course, these authors demonstrated that *Uroctonus* was a North American chactid as were genera *Anuroctonus* and *Nullibrotheas*.

We studied the relative development of the *DPSc* in genus *Catalinia* as well as in the "*apacheanus*" group, and genera *Graemeloweus* and *Kovarikia*. Figure 19

Figure 14: *Catalinia minima*, Avalon, Santa Catalina Island, California, USA. Spermatophore affixed to a rock after insemination of the female (photographed submerged in alcohol). Right and left hemispermatophores are visible from their internal views showing the lamellar hooks and lamina termini. See Figure 12 for comparison to the hemispermatophore.

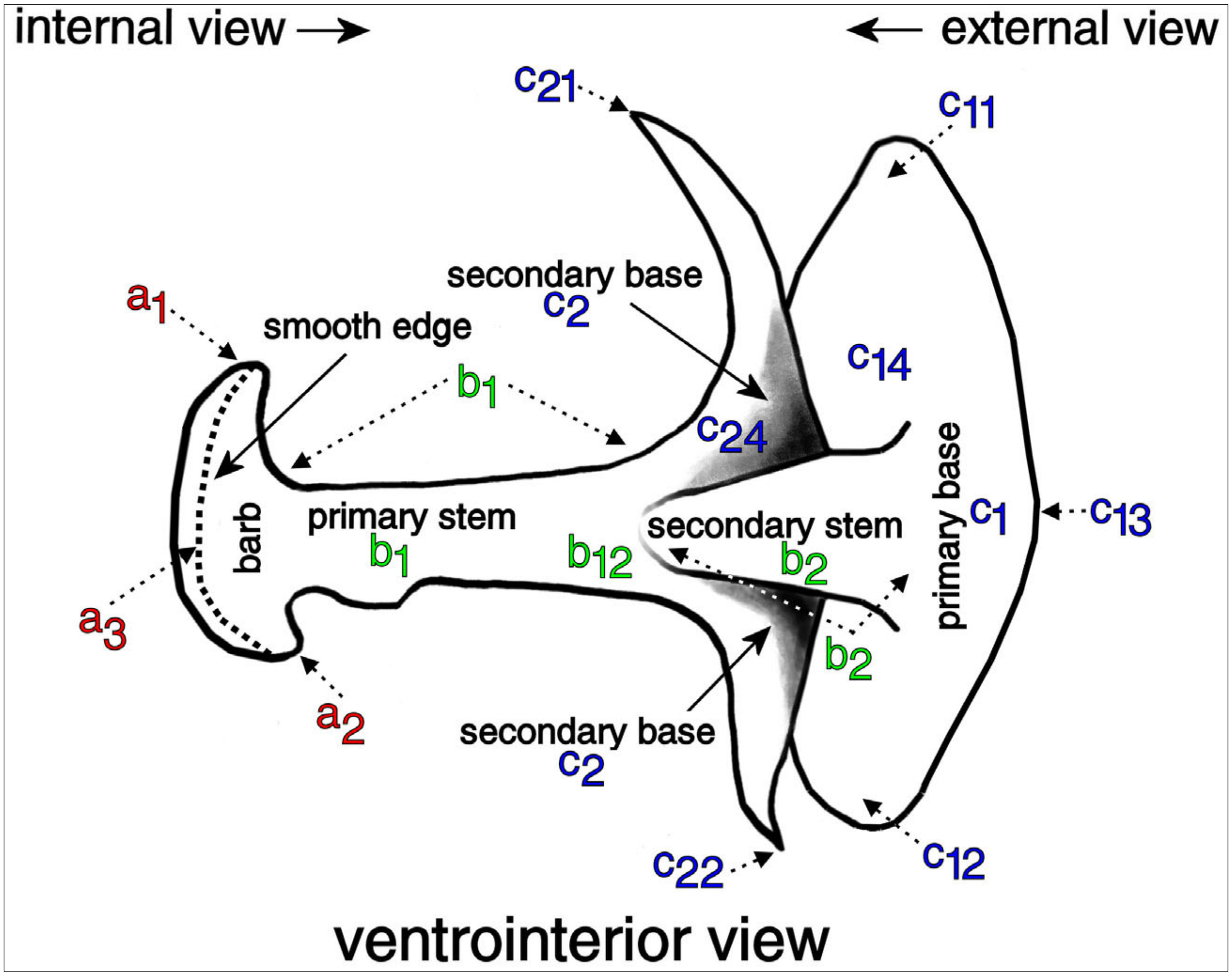

Figure 15: Diagrammatic outline of the mating plug of genus *Catalinia*. This view is from a ventrointerior perspective (i.e., the barb is closer to the viewing plane) which emphasizes the unusal coupling of the secondary base (c_2) to the primary base (c_1) by way of a secondary stem (b_2). The primary base's convexed top portion (c_{14}) is visible. Finally, the smooth barb edge (a_3), which is located on the dorsal side, is depicted by a *dotted line*, indicating it is visible from the ventral side. **Barb** (**a: red**): a_1 = long tine, a_2 = short tine, a_3 = edge; **Stem** (**b: green**): b_1 = primary stem, b_{11} = convexed side, b_{12} = concaved side, b_2 = secondary stem; **Base** (**c: blue**): c_1 = primary base, c_{11} = long vertex, c_{12} = short vertex, c_{13} = base vertex, c_{14} convexed top, c_{15} = concaved bottom, c_2 = secondary base, c_{21} = long projection, c_{22} = short projection, c_{23} = convexed top, c_{24} = concaved bottom. See Figure 16 for additional view perspectives of the mating plug.

shows the patellar *DPSc* for all species of *Catalinia* as well as select species of the other groups and genera. The *DPSc* is clearly reduced in *Catalinia* and the "*apacheanus*" group, unlike that seen in the other two genera, which exhibit a long consistenly serrated carina. These differences can be attributed, in part, to the relatively stout patella found in *Catalinia* and the "*apacheanus*" group, clearly not as elongate as seen in the other two genera.

We analyzed these differences by counting the major granules in the *DPSc* as well as construct a morphometric ratio based on the length of the *DPSc* as compared to the length of the dorsal external carina (*DEc*) of the patella. The length of the *DPSc* is the distance from the *DPS* to the last major granule in the carina. The *DEc* length is a straight line from the carina's origin (proximal of the d_2 trichobothrium) to the distal end of the carina. The number of granules in the *DPSc* ranged 2–5 (3.25) for *Catalinia*, 1–4 (2.75) for the "*apacheanus*" group, 5–10 (7.67) for *Graemeloweus*, and 5–8 (6.00) for *Kovarikia*. *Catalinia* and the "*apacheanus*" group exhibited the least number of granules. For the morphometric ratio comparing the *DPSc* length to the *DEc* length, we see good separation of *Catalinia* from the other genera and species groups, in particular genera *Graemeloweus* and *Kovarikia*. The following ratio ranges: 0.063–0.259 (0.141) for the "*apacheanus*" group, 0.123–0.210 (0.165) for *Catalinia*, 0.246–0.372 (0.297) for *Kovarikia*, and 0.261–0.570 (0.417) for *Graemeloweus*. The "*apacheanus*" group has the rel-

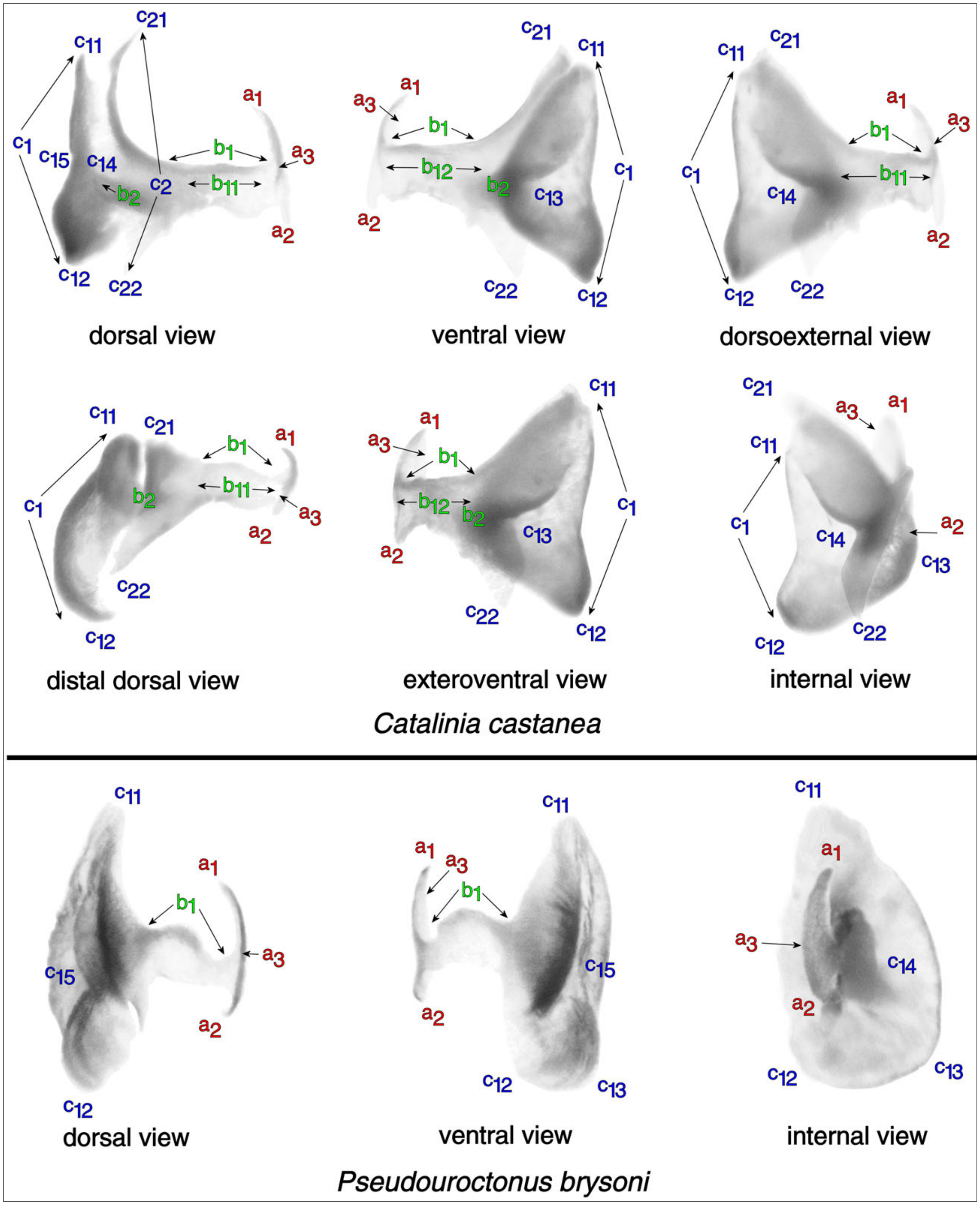

Figure 16: Detailed comparison of the mating plugs of species *Catalinia castanea* and *Pseudouroctonus brysoni*. **Barb** (**a: red**): a_1 = long tine, a_2 = short tine, a_3 = edge; **Stem** (**b: green**): b_1 = primary stem, b_{11} = convexed side, b_{12} = concaved side, b_2 = secondary stem; **Base** (**c: blue**): c_1 = primary base, c_{11} = long vertex, c_{12} = short vertex, c_{13} = base vertex, c_{14} convexed top, c_{15} = concaved bottom, c_2 = secondary base, c_{21} = long projection, c_{22} = short projection, c_{23} = convexed top, c_{24} = concaved bottom. Note, due to the semi-translucency of the mating plug, some substructures may be visible from the opposite side.

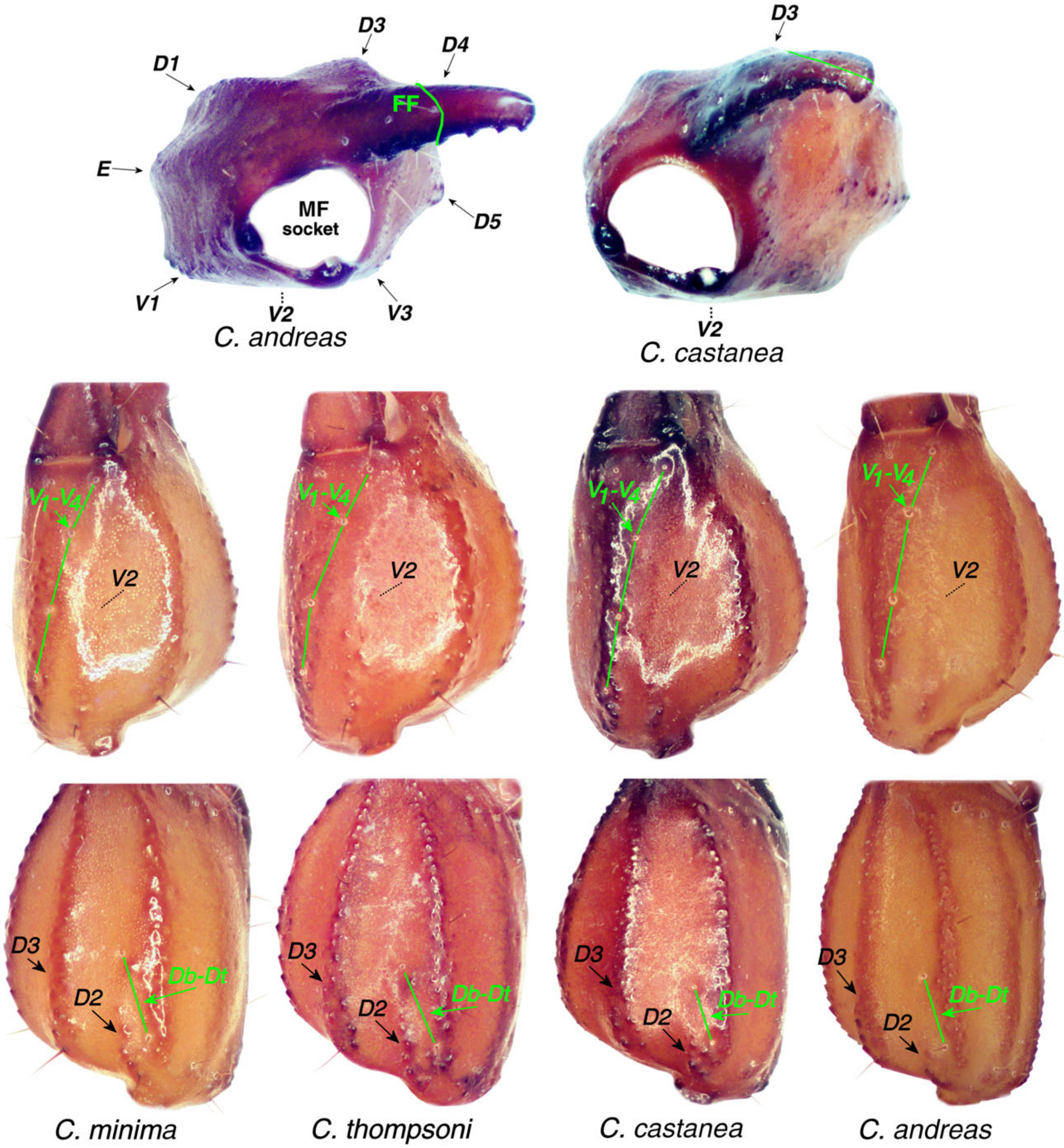

Figure 17: Pedipalp chelae of genus *Catalinia* showing carinal configurations (all male). *C. minima*, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, Santa Cruz Island, Santa Barbara Co., California, USA. *C. castanea*, Vista, San Diego Co., California, USA. *C. andreas*, Chariot Canyon, ABDSP, San Diego Co., California, USA. **Top.** Distal perspective of the right pedipalp chela showing the carinal configuration of two species of *Catalinia*. Note, green lines indicate the *D3* or *D4* carina which are blocked or partially blocked from view by the fixed finger terminus. MF = movable finger, FF = fixed finger, *D1* = digital carina, *D3* = dorsosecondary carina, *D4* = dorsomarginal carina, *D5* = dorsointernal carina, *V1* = ventroexternal carina, *V2* = ventromedian carina, *V3* = ventrointernal carina, and *E* = exterosecondary carina. Note, the subdigital carina (*D2*), which is vestigial in most species, is not shown. **Middle-Bottom.** Right chela showing diagnostic carinae of all species of *Catalinia*. Middle images show essentially obsolete ventromedian (*V2*) carinae with slight traces found proximally (indicated by *dotted line*). Bottom images show a somewhat weak to medium developed subdigital (*D2*) carina. Carinae are indicated with black arrows and relevant trichobothrial series V_1–V_4 and *Db–Dt* indicated with green arrows.

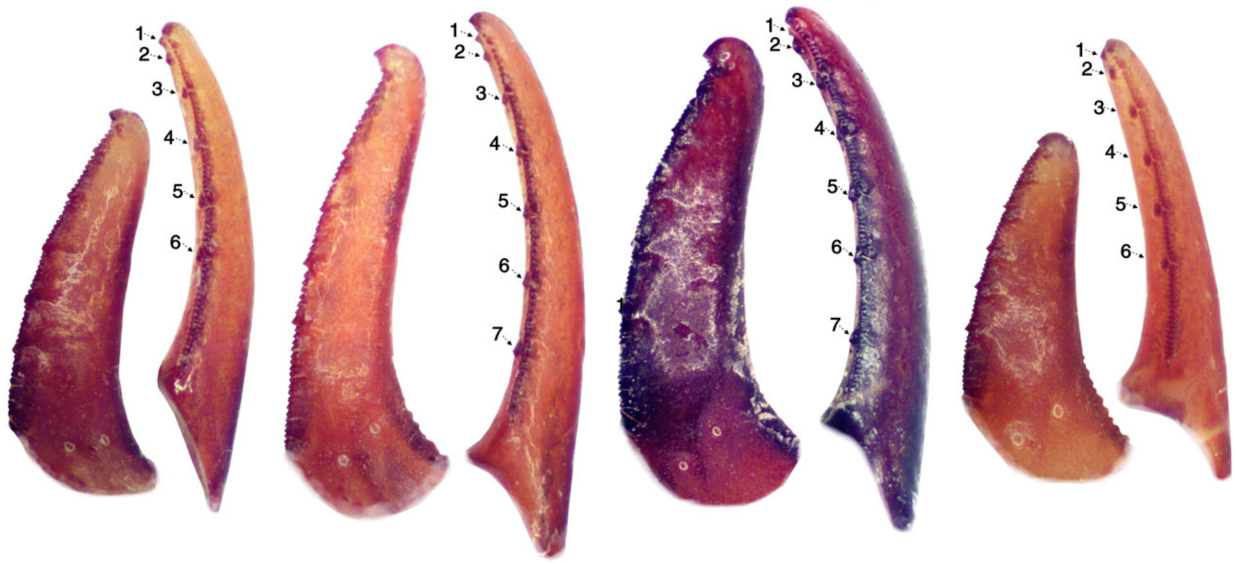

Figure 18: Chelal fixed and movable fingers of genus *Catalinia* showing dentition. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, male, Santa Cruz Island, Santa Barbara Co., California, USA. *C. castanea*, male, Vista, San Diego Co., California, USA. *C. andreas*, male, Chariot Canyon, ABDSP, San Diego Co., California, USA. Of special interest, species *C. minima* and *C. andreas* have six inner denticles (*ID*) on the movable whereas the other two species have seven (i.e., indicated with *arrows* for each species). Note internal trichobothria *ib* and *it* are visible on the base of the fixed finger.

atively shortest *DPSc*, exhibiting a MVD of 17 % difference from *Catalinia*, and 111 to 196 % from the other two genera. *Catalinia* also showed large MVD from these two genera, 80 to 153 %. All species defined for these genera and species group were used in these calculations. See Appendix B for more detailed information of this *DPSc* analysis.

Patella external carinae. The exteromedian carina (*EMc*) for genus *Catalinia* is present for most of the patella length but weakens considerably on the proximal half, exhibiting some granulation (see Figure 20). The secondary median carina (*SEMc*) is essentially absent, with some minor scattered rounded granulation in the area.

The *EMc* and *SEMc* exhibited by *Catalinia* are the weakest of the four *Pseudouroctonus* clades discussed in this paper: genus *Kovarikia* has a strong, straight, and highly granulated *EMc* and the *SEMc* is strong and granulated for most of the patella's length (see Soleglad, Fet & Graham, 2014: fig. 4), *Graemeloweus* also has a strong, straight, and granulated *EMc* with the *SEMc* only represented by three granulated areas of the patella (see Soleglad et al., 2016: fig. 5), and the four species currently defined for the "*apacheanus*" group all consistently exhibit a strong, straight and highly granulated *EMc* but with little trace of a *SEMc*.

Leg basitarsus and tarsus

Basitarsus setation and morphometrics. The basitarsus of the right leg III (see Figure 21 for a diagrammatic view) has shown to be diagnostic for genus *Catalinia*. In particular, two series of setae emanating from enlarged areolae have been studied in this analysis. This includes both their number and their overall composition. Also, the morphometric analysis of the basitarsus's width as compared to its length has proved to be diagnostic as well. Finally, of note, the basitarsus as analyzed herein shows the close relationship between *Catalinia* and the "*apacheanus*" group. Likewise, it also shows their distance from genera *Graemeloweus* and *Kovarikia*, which share striking similarity in these substructures.

Basitarsus setation. We have isolated two series of setae on the basitarsus that show considerable consistency in their composition as well as in their number. The primary ventral setae (PVS) are located on the ventral edge of the basitarsus, visible from both the external and internal views. We have isolated only those ventral setae that are large, emanate from a stout areola, located basally or terminally from the basitarsus midpoint, and are essentially evenly spaced. The second series, the primary exteroventral setae (PEVS), are located on the external surface and are positioned above the PVS. These setae, which also emanate from large areola, are somewhat smaller than those found in the PVS.

In Figures 22–23 we show the basitarsus of the right leg III for all species of *Catalinia* and select species of the "*apacheanus*" group, *Graemeloweus*, and *Kovarikia*. In these figures, we show both the external and internal views. For genus *Catalinia* we see two somewhat con-

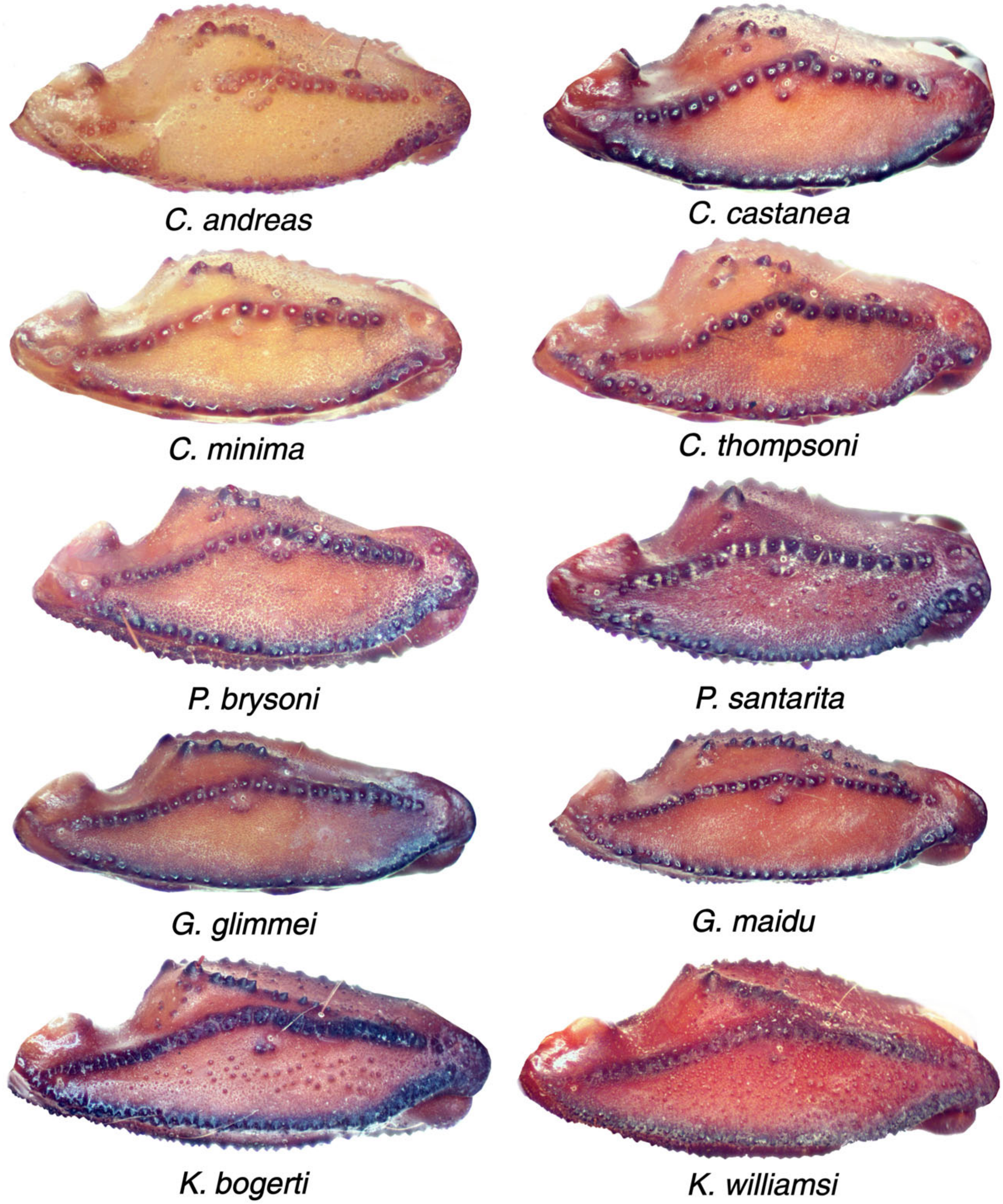

Figure 19: Comparison of the Dorsal Patellar Spur Carina (*DPSc*) of genus *Catalinia* to select species of genera *Pseudouroctonus*, *Graemeloweus*, and *Kovarikia*. Note, the patella of the right pedipalp is slightly tilted in an external direction in order to show the layout of the *DPSc*. ***Catalinia*:** *C. andreas*, female, ABDSP, Chariot Canyon, San Diego Co., California, USA. *C. castanea*, male, Vista, San Diego Co., California, USA. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, male, Santa Barbara, Santa Cruz Island, California, USA. ***Pseudouroctonus* "*apacheanus*" group:** *P. brysoni*, male, Musquiz Canyon, Jeff Davis Co., Texas, USA. *P. santarita*, male, Madera Canyon, Santa Cruz Co., Arizona, USA. ***Graemeloweus*:** *G. glimmei*, female, Cache Creek, Lake Co., California, USA. *G. maidu*, female, American River, El Dorado Co., California, USA. ***Kovarikia*:** *K. bogerti*, male, Palomar Mountain Road, San Diego Co. California, USA. *K. williamsi*, female, Santa Ysabel Preserve, San Diego Co., California, USA.

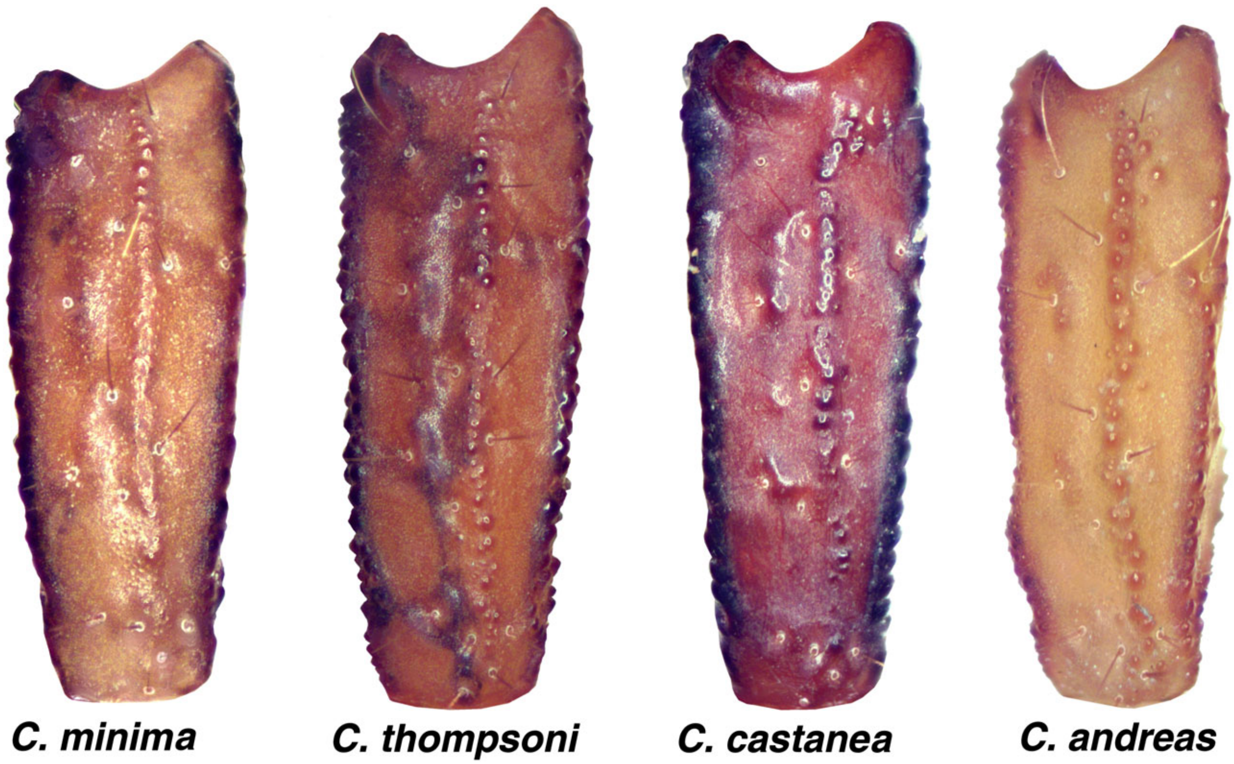

Figure 20: Pedipalp patella, external view, of genus *Catalinia* showing external carinae. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, male, Santa Cruz Island, Santa Barbara Co., California, USA. *C. castanea*, male, Vista, San Diego Co., California, USA. *C. andreas*, female, Chariot Canyon, ABDSP, San Diego Co., California, USA.

spicuous enlarged setae in both the PVS and PEVS series. In the "*apacheanus*" group we also see generally the same number/composition of the setae in these series also, with a few exceptions in *P. apacheanus* and *P. kremani* with a third reduced setae in the PVS. For genera *Graemeloweus* and *Kovarikia*, we see a more elongated basitarsus (see below) with larger numbers of setae in the PVS and PEVS. The genus *Graemeloweus* has 4 and 3 setae in the PVS and PEVS series, respectively. These setae are elongate and slender, conspicuously different from those seen in *Catalinia* and the "*apacheanus*" group. The genus *Kovarkia* has 5 and 4 setae in the PVS and PEVS series. As in *Graemeloweus*, the setae are elongate and slender. See Appendix B where data for all species in these genera and species group is presented.

Since we see a major difference in the stoutness of the PVS and PEVS setae between these genera and species group, we constructed a "stoutness" morphometric for the setae in the PVS of the ten species shown in Figures 22–23. The "stoutness" morphometric is calculated by dividing the width of each PVS seta by its length. The width is the cross section of the seta at the areola/seta juncture and the length is taken from the areola/seta juncture to its distal tip. For the four *Catalinia* species we see a "stoutness" factor ranging 0.119–0.165 (0.139) exhibiting the stoutest setae (i.e., the largest ratio number). However, close to this range seen in *Catalinia* is the "*apacheanus*" group with a range of 0.074–0.144 (0.120), exhibiting a 15.8 % MVD. For genera *Graemeloweus* and *Kovarikia*, there are large differences from the other two ranges, exhibiting 0.050–0.092 (0.075) and 0.044–0.075 (0.055), respectively. For the MVD, the percentages are quite significant, ranging from 60.0 to 152.7 %. *Catalinia*'s MVD range from the other three groups ranges 15.8 to 152.7 %.

Basitarsus morphometrics. During our analysis of the basitarsus of the third leg we noted that the basitarsus is stouter in genus *Catalinia* than it is in the "*apacheanus*" group and genera *Graemeloweus* and *Kovarikia*. The morphometric constructed compares the basitarsus's basal width to its length. Figure 21 shows how this morphometric is calculated. For *Catalinia*, the morphometric ranges 0.261–0.293 (0.278) [4] across its four species. In the "*apacheanus*" group the morphometric ranges 0.220–0.254 (0.240) [4], four species considered. And for genera *Graemeloweus* and *Kovarikia*, we have 0.223–0.225 (0.224) [3] and 0.211–0.235 (0.225) [4], respectively. *Catalinia* has a stouter basitarsus than the other three groups/genera (a ratio with a larger number), exhibiting MVDs ranging from 15.8 to 24.1 %.

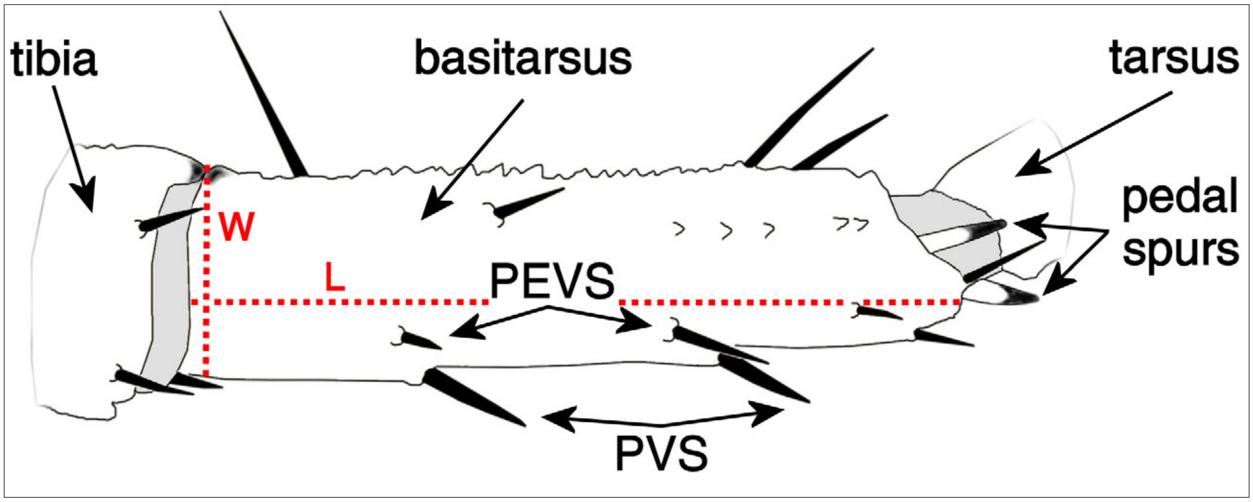

Figure 21: Diagrammatic drawing of the basitarsus of right leg III, exterolateral view. Of particular importance to this study are two series of primary setae identified as the primary ventral setae (PVS) and primary exteroventral setae (PEVS). PVS is located on the basitarsus ventral edge and is visible from either the exterolateral or interolateral views. PEVS are somewhat smaller setae located above the PVS on the exterolateral side. However, setae from both series emanate from large areolae. The number and composition of the setae in these two series are of diagnostic importance, showing consistency within genera and species groups. The basitarsus width and length (*red dotted lines*) are used for morphometric analysis.

Note, in Appendix B, we show all detailed statistical data from all species of these genera and species groups, as discussed above.

Tarsus. In Figure 24 we show the leg III tarsus for species *Catalinia thompsoni*, *C. castanea*, and *C. minima*. Species in this genus have the ventral surface of the tarsus with a median row of short spinules terminating distally with two–three pairs of spinules (i.e., 4–6 spinules). The unguicular spine is well-developed and pointed. McWest (2009: 38) reported 4–6 (4.33) individual spinules in the ventral distal group for *C. thompsoni*.

Chelicerae

In Figure 25 the chelicerae of all four *Catalinia* species are illustrated. The dentition exhibited in *Catalinia* is typical of most vaejovids: the movable finger's dorsal edge has two subdistal (*sd*) denticles, its ventral edge is smooth lacking ventral accessory (*va*) denticles. Serrulae is present on the distal half of the movable finger's ventral edge, numbering at least 20 tines. The dorsal distal denticle (*dd*) is considerably shorter than its ventral counterpart (*vd*). The fixed finger's median (*m*) and basal (*b*) denticles form a bicuspid. Ventral accessory (*va*) denticles are lacking on the fixed finger's ventral surface.

Sternopectinal area

In Figure 26 the sternopectinal area is shown for *C. minima* and the pecten of all four species are shown in Figure 27. The sternum in *Catalinia*, type 2, is wider than long in all species, exhibiting a range of 0.69–0.89 (0.783) for the ratio length / width (see Table 1). The sclerites of the genital operculum in the male are separated for most of their length, modest genital papillae are visible proximally. In the female, the genital operculum is modestly separated for one-fifth of the proximal area. The pectines of the genus *Catalinia* is a complex structure with three anterior lamellae, multiple middle lamellae numbering up to eight, fulcra, and seven to twelve teeth, all with sensorial areas. The terminal tooth is rounded lacking any angling on its sides. Appendix B presents pectinal tooth count data for all four species, indicating that *C. andreas* and *C. minima* have the smallest number of teeth and are also the smallest species in the genus, 16–26 mm.

Trichobothrial patterns

The trichobothrial pattern of genus *Catalinia* is Type C, orthobothriotaxic. Appendix A illustrates these patterns for all four species of this genus. Below we highlight trichobothria positions for this genus across all four species, and contrast it to those found on the "*apacheanus*" group, and genera *Graemeloweus* and *Kovarikia*.

The *ib–it* series is located on the fixed finger/palm juncture, *it* is located at this juncture and *ib* is found below on the palm, next to the articular membrane. The *eb–et* series is located on the basal two-thirds of the fixed finger. In *Catalinia andreas* and *C. castanea*, the series is slightly more basal with trichobothrium *eb* located on the distal aspect of the palm. In *Catalinia minima* and *C. thompsoni*, *eb* is located at the fixed finger/palm juncture. The *db–dt* series is located on low-

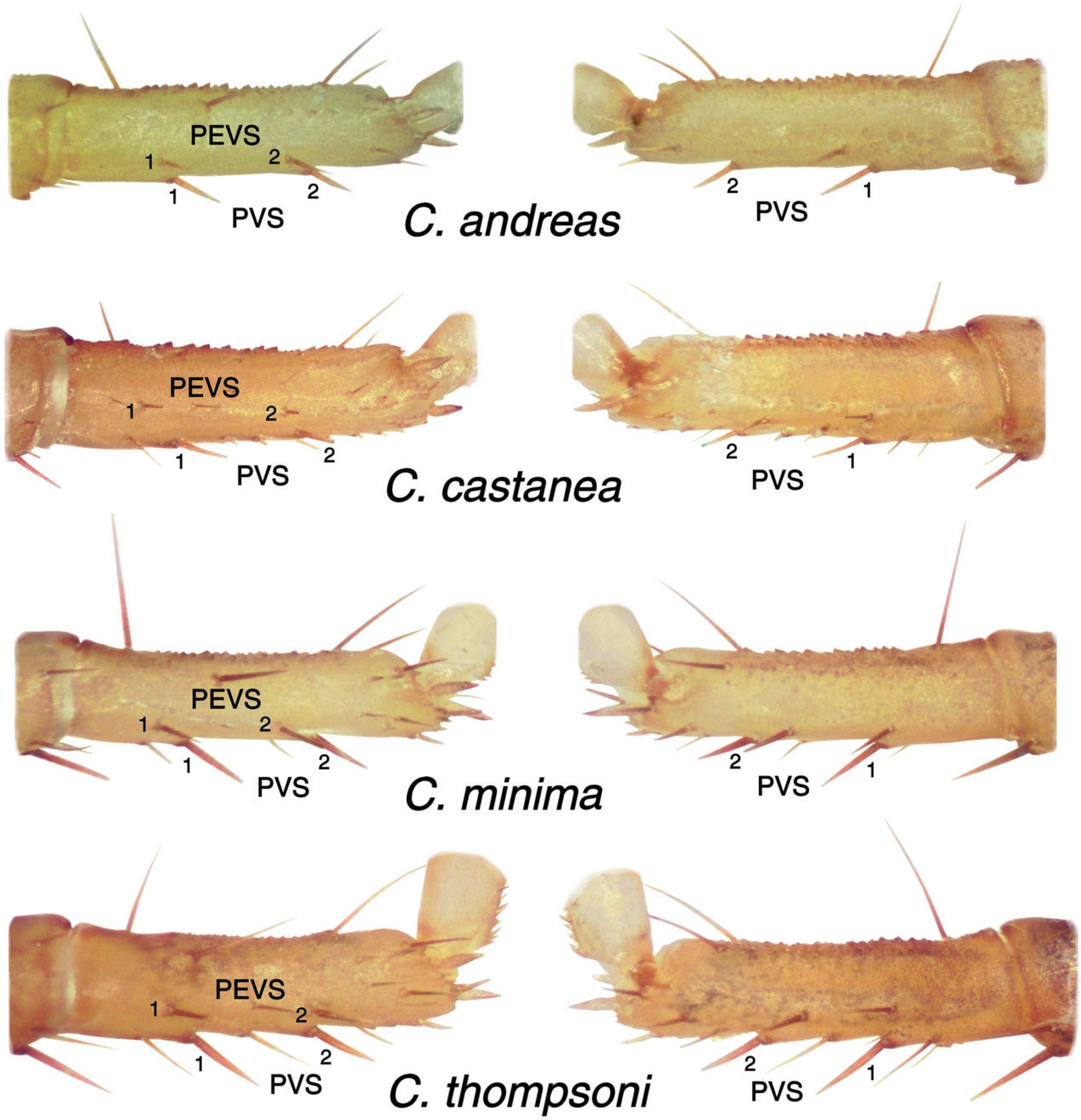

Figure 22: Basitarsus of right leg III of genus *Catalinia*, exterolateral (left) and interolateral (right) views. *C. andreas*, female, Chariot Canyon, ABDSP, San Diego Co., California, USA. *C. castanea*, male, Vista, San Diego Co., California, USA. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, male, Santa Cruz Island, Santa Barbara Co., California, USA. PVS = primary ventral setae, PEVS = primary exteroventral setae.

er on the fixed finger than *eb–et*, with basal trichobothrium *db* found well on the distal half of the palm. Again, as with the *eb–et* series, the *db–dt* series is more basal in *Catalinia andreas* and *C. castanea* than it is *Catalinia minima* and *C. thompsoni*. Trichobothria Et_1 and V_1 form a line essentially parallel to the movable finger articulation membrane and trichobothrium V_4 is located in a depression on carina *V1*. On the patella, trichobothrium v_3 is located on the external surface and is either adjacent or slightly distal of et_3.

In general the trichobothria positions in *Catalinia* are the same as those found in genus *Graemeloweus* and the "*apacheanus*" group. With respect to genus *Kovarikia*, however, we find the following differences: in *Kovarikia* the *V* series of the chela contains 1–2 (1) accessory trichobothria; the line formed by Et_1 and V_1 is not parallel to the movable finger articulation membrane, V_1 slanting downwards; trichobothrium V_4 is located on the ventral surface, not on the *V1* carina; and trichobothrium *Dt* is positioned more distally on the palm.

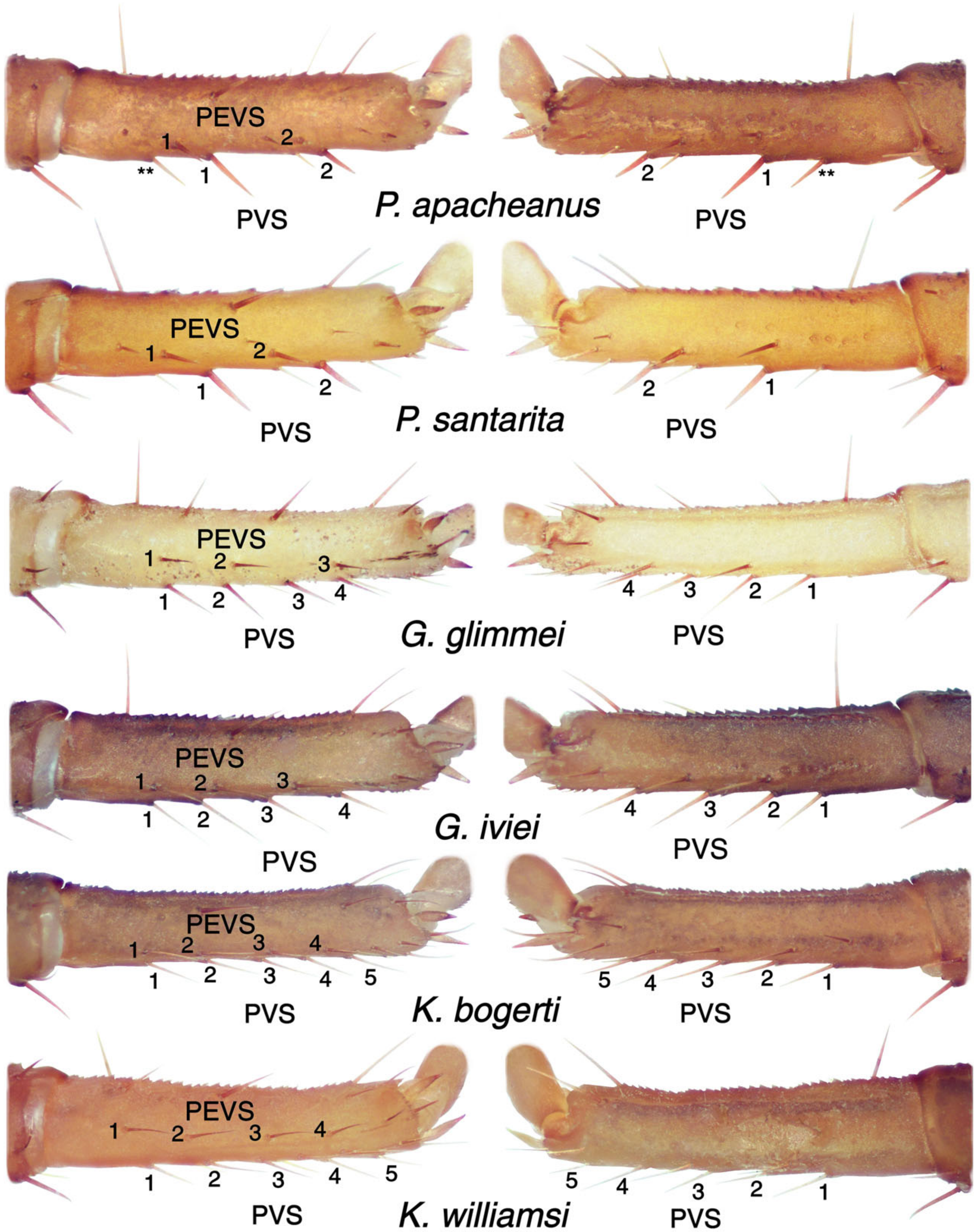

Figure 23: Basitarsus of right leg III of select species of the "*apacheanus*" group, *Graemeloweus*, and *Kovarikia*, exterolateral (left) and interolateral (right) views. *P. apacheanus*, male, Rucker Canyon, Chiricahua Mountains, Arizona, USA. *P. santarita*, male, Madera Canyon, Santa Rita Mountains, Santa Cruz Co., Arizona, USA. *G. glimmei*, female, Cache Creek, Lake Co., California, USA. *G. iviei*, male, American River, El Dorado Co., California, USA, *K. bogerti*, female, Palomar Mountain Road, San Diego Co., California, USA. *K. williamsi*, female, Santa Ysabel Preserve, San Diego Co., California, USA. PVS = primary ventral setae, PEVS = primary exteroventral setae. ** reduced primary ventral seta.

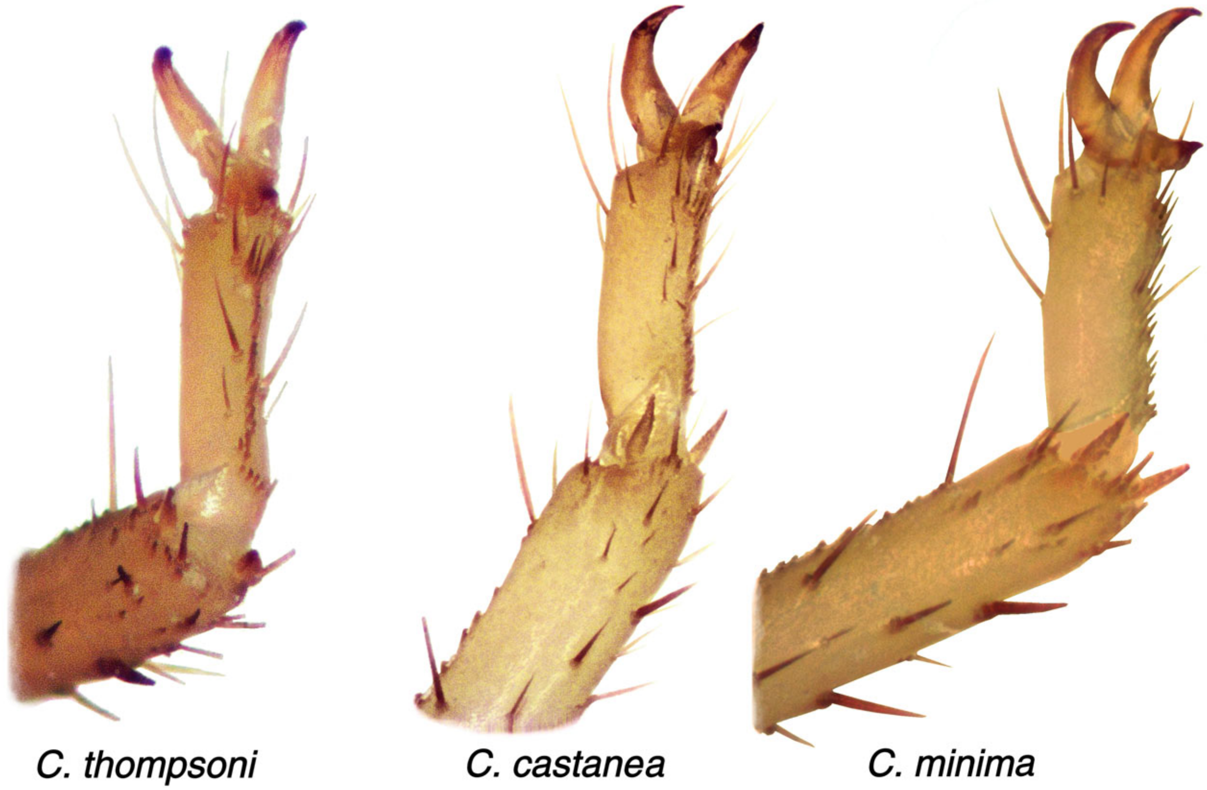

Figure 24: Leg tarsus of select *Catalinia* species, exteroventral views. *C. thompsoni*, female (left leg III, reversed) Santa Cruz Island, Santa Barbara Co. California, USA. *C. castanea*, male (right leg III) Vista, San Diego Co., California, USA. *C. minima*, male (right leg III) Avalon, Santa Catalina Island, California, USA.

Systematics

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
Subfamily Vaejovinae Thorell, 1876

Genus *Catalinia* Soleglad, Ayrey, Graham et Fet gen. nov.
Figures 1–27, 30–34; Tables 1–2
http://zoobank.org/urn:lsid:zoobank.org:act:3ED5D120-7B3A-408C-AC2F-2DC849287190

Type Species. *Catalinia minima* (Kraepelin, 1911), **comb. nov.** [= *Vejovis minimus* Kraepelin, 1911], designated here.

Composition. This genus contains four species: *Catalinia minima* (Kraepelin, 1911), **comb. nov.** [= *Pseudouroctonus minimus minimus* (Kraepelin, 1911)] (type species); *C. andreas*, **comb. nov.** [= *Pseudouroctonus andreas* (Gertsch et Soleglad, 1972)]; *C. castanea*, **comb. nov.** [= *Pseudouroctonus minimus castaneus* (Gertsch et Soleglad, 1972)]; *C. thompsoni*, **comb. nov.** [= *Pseudouroctonus minimus thompsoni* (Gertsch et Soleglad, 1972)].

Distribution. Southern California, USA (Los Angeles, Riverside, Santa Barbara, San Diego, and Ventura Counties) and Baja California, Mexico. See map in Figure 28.

Diagnosis. Small scorpions, adults 16–34 mm in length; pectinal tooth counts 9–12 males, 7–11 females. Orthobothriotaxic; carapace anterior indentation considerably reduced; metasoma quite stocky, in particular segments IV and V; all segments are essentially the same width, exhibiting no tapering from segment I to V. Hemispermatophore terminus lacks a distal crest, lamellar hook bifurcated; secondary lamellar hook not present; mating plug barb smooth; plug base is divided into partial bases, connected by a short secondary stem. Chelal carina *V2* is essentially obsolete, *D3* is reduced, somewhat flat; on the patella the exteromedian carina (*EMc*) is developed but is weak to obsolete proximally, the secondary external median (*SEMc*) is lacking altogether; telson lacking vesicular ridges, subaculear setal pair located on vesicle/aculeus juncture, dorsal surface

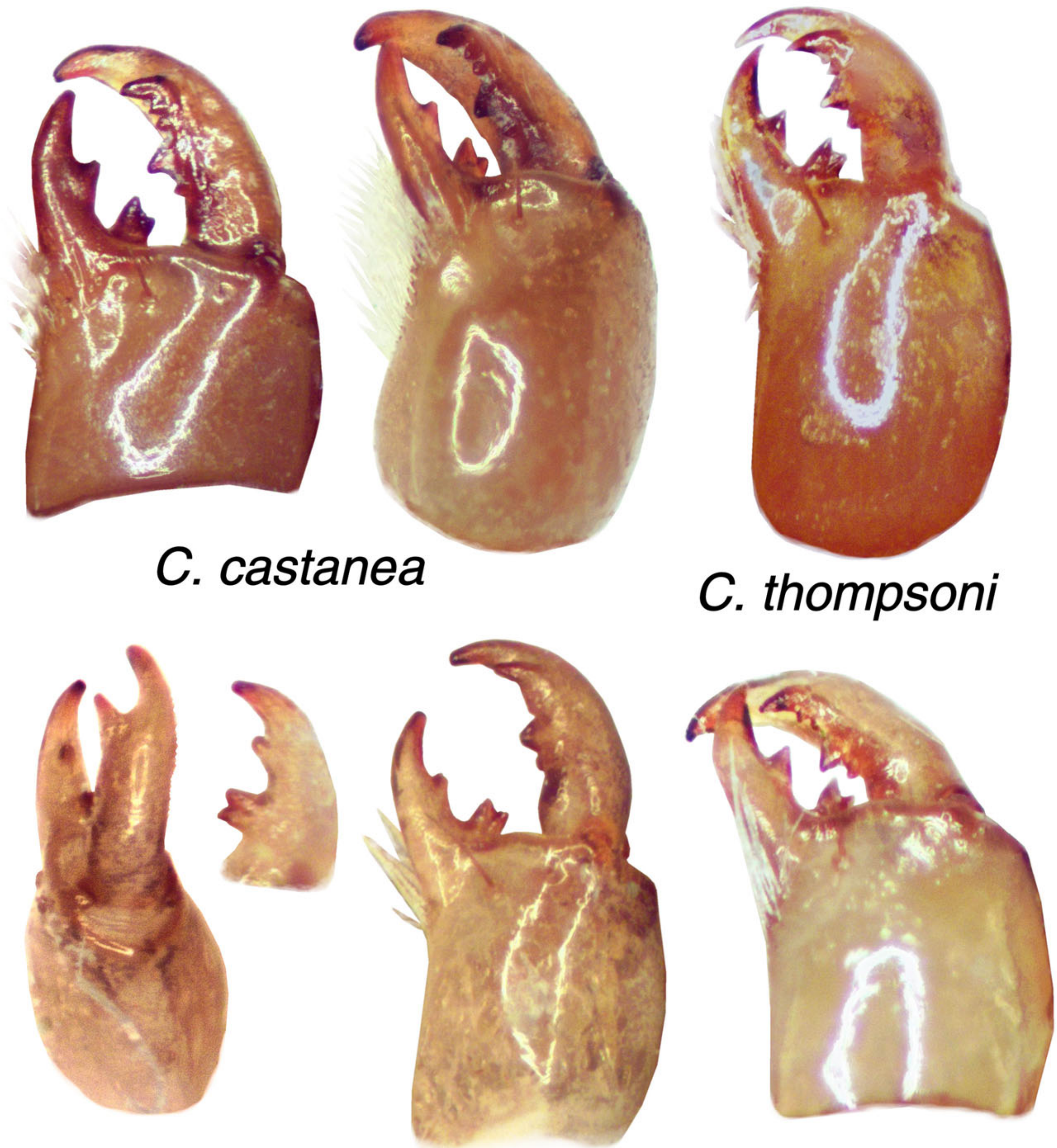

Figure 25: Right chelicera of *Catalinia* species (all male) showing diagnostic dentition of fixed and movable fingers: the movable finger dorsal edge has two subdistal (*sd*) denticles and the ventral edge is smooth, lacking ventral accessory (*va*) denticles; the fixed fingers median (*m*) and basal (*b*) denticles are formed as a bicuspid and its ventral surface lacks *va*. *C. castanea*, Vista, San Diego Co., California, USA. Dorsal and interodorsal views. *C. thompsoni*, Santa Cruz Island, Santa Barbara Co., California, USA. Dorsal view. *C. minima*, Avalon, Santa Catalina Island, California, USA. External view showing the length differences between the dorsal and ventral distal denticles (*dd* and *vd*), ventral view of the fixed finger, and a dorsal view (note, in this specimen the denticles are somewhat reduced due to wear, in particular, the two subdistal denticles (*sd*) are not detectable). *C. andreas*, ABDSP, Chariot Canyon, San Diego Co., California, USA. Dorsal view.

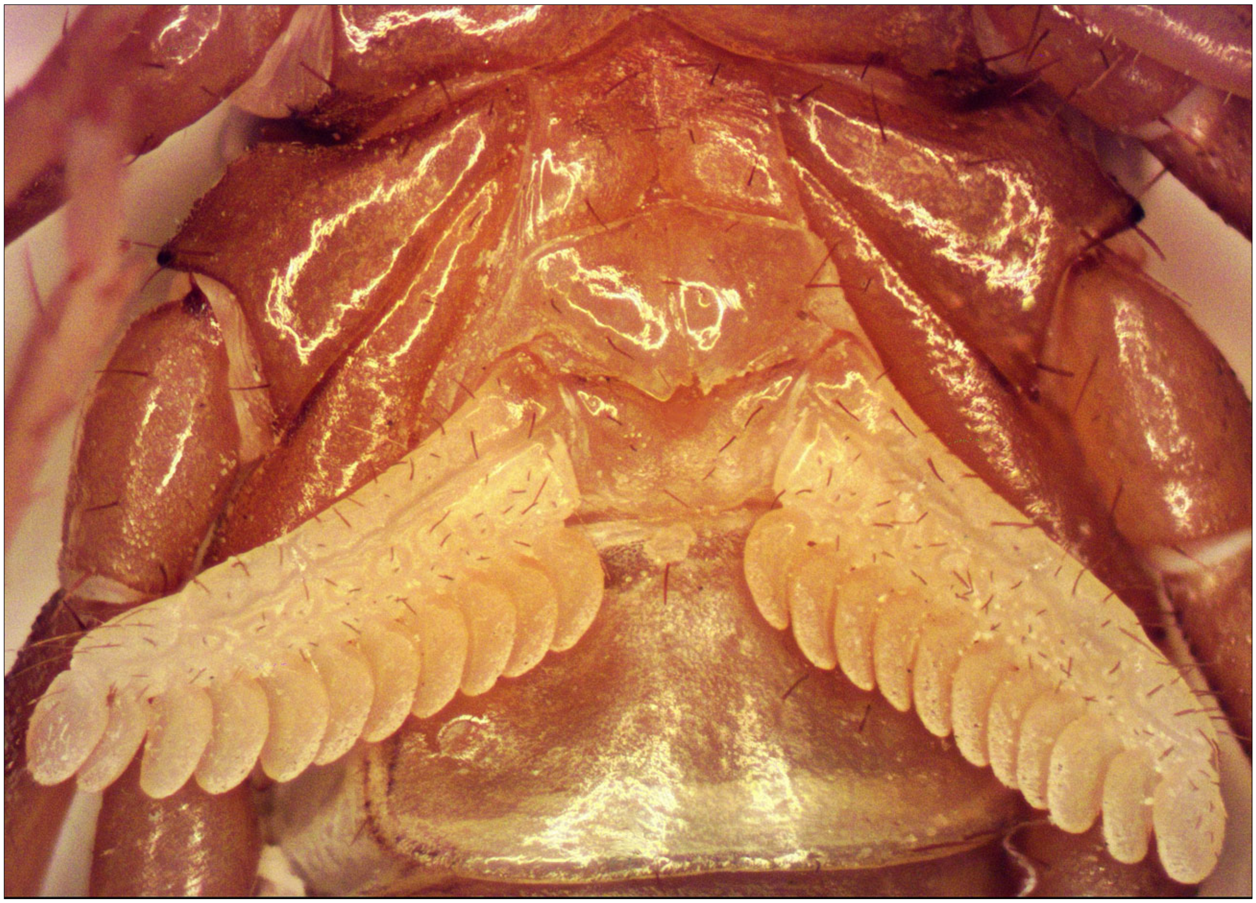

Figure 26: Sternopectinal area of *Catalinia minima*, male, Avalon, Santa Catalina Island, California, USA. See individual pectines of the four *Catalinia* species in Figure 27.

of the male's vesicle lacks a linear patch; basitarsus of leg III with two stout primary ventral setae (PVS) and two stout primary exteroventral setae (PEVS) emanating from large areolae. Cheliceral movable and fixed fingers lack ventral accessory (*va*) denticles.

Etymology. This genus (feminine in gender) is named after Santa Catalina Island, California, USA where *Catalinia minima* can be found.

Key to Species of *Catalinia*

1 — Metasomal segments IV and V of males are relatively short, length compared to width 0.92–0.99 and 1.38–1.65 respectively; chelal fingers relatively elongate, fixed finger and movable finger lengths compared to palm length 0.78–0.98 and 1.08–1.25, respectively ……………………..…………………………………….…. **2**

■ — Metasomal segments IV and V of males are relatively elongate, length compared to width 1.12–1.21 and 1.91–1.93 respectively; chelal fingers relatively short, fixed finger and movable finger lengths compared to palm length 0.64 and 0.84 respectively …………..... ……….. ***Catalinia andreas* (Gertsch et Soleglad, 1972)**

2 — Chelal movable finger with 7 inner denticles (*ID*) ……………………………….……………….....…… **3**

■ — Chelal movable finger with 6 inner denticles (*ID*) ..…………..……... ***Catalinia minima* (Kraepelin, 1911)**

3 — Chelal fixed finger relatively elongate with exaggerated tip curved inward, length compared with palm length 0.98; ventral aspect of metasoma mottled with spots..***Catalinia thompsoni* (Gertsch et Soleglad, 1972)**

■ — Chelal fixed finger relatively short with normal tip, length compared with palm length 0.81; ventral aspect of metasoma not mottled with spots ………………..……... …...…. ***Catalinia castanea* (Gertsch et Soleglad, 1972)**

Table 2 presents statistical data that is used in the species key above.

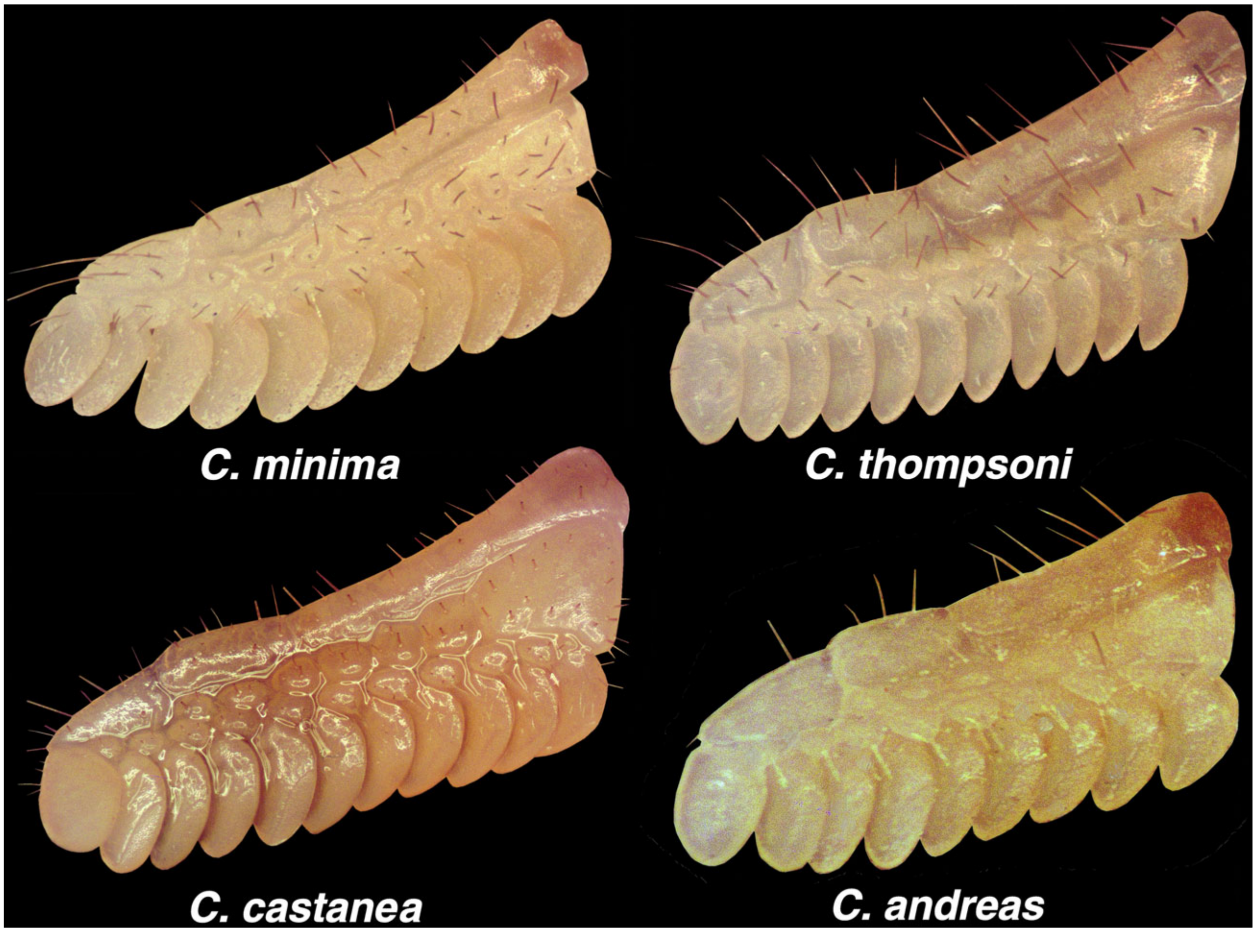

Figure 27: Right pecten of species of genus *Catalinia*. *C. minima*, male, Avalon, Santa Catalina Island, California, USA. *C. thompsoni*, female, Santa Barbara, Santa Cruz Island, California, USA. *C. castanea*, male, Vista, San Diego Co., California, USA. *C. andreas*, male, Escondido, San Diego Co., California, USA.

Discussion

Mating plug. As discussed in detail above, the base of the mating plug in *Catalinia* is divided into two partial bases connected by a short secondary stem. We observed variability in this coupling in the ability of the two partial bases to pull away from each other to a certain degree. Interestingly, this type of mating plug is similar to that described for the *Pseudouroctonus apacheanus* group species *P. santarita* (see Ayrey & Soleglad, 2015). The other three species of the "*apacheanus*" group, for which the mating plug have been described exhibit a single base, but with traces of the two bases, referred to as "braces" in Ayrey & Soleglad (2015).

As stated in the Introduction, in this paper and other papers by Ayrey & Soleglad (2015, 2017) we have referred to the molecular work of Bryson et al. (2013: fig. 3) as a guide for the discovery of new species in the "*apacheanus*" group. In their work they referenced material from the Quinlan Mountains of Arizona which geographically are close to the area where *P. santaritia* originates (i.e., Santa Rita Mountains). In addition, from a molecular perspective, the Quinlan population and *P. santarita* form a clade separate from the other potential members of the "*apacheanus*" group. However, within this clade Bryson et al. (2013: fig. 3) estimate a 12.28 Mya separation between the two (based on a mean estimate).

We have examined material from the Quinlan Mountains (Ayrey & Soleglad, in progress) and have verified that its hemispermatophore mating plug is the same as that found in species *P. santarita* and the genus *Catalinia*. Therefore, based on our current understanding of this mating plug and data so far available on relevant species, we have constructed a charogram (see Figure 29) depicting the evolution of the presence/absence of the secondary base. Note, this charogram is derived from a partial chronogram based on molecular data from Bryson et al. (2013: fig. 3). However, it must be stated here that the mating plug of species *P. rufulus*, *P. chicano*, and *P. savvasi* have not been examined (note:

	Catalinia andreas		***Catalinia castanea***		***Catalinia minima***		***Catalinia thompsoni***	
	Banner, CA	**Female Banner, CA**	**Mal ta,**	**Male ista, CA**	**Male Catalina Isl., CA**	**Male Catalina Isl., CA**	**Male S. Cruz Isl., CA**	**Female S. Cruz Isl., CA**
Total length	20.45	21.85	33.90	26.70	20.05	15.85	21.85	25.15
Carapace length	2.75	2.90	4.50	3.80	2.70	2.30	2.90	3.10
Mesosoma length	5.00	7.70	10.50	7.40	6.00	4.00	6.50	9.50
Metasoma length	9.55	8.25	14.10	11.65	8.45	7.05	9.35	9.40
Segment I length/width	1.30/1.70	1.10/1.60	2.00/3.10	1.60/2.60	1.05/1.80	0.95/1.45	1.20/1.95	1.25/2.10
Segment II length/width	1.50/1.80	1.30/1.55	2.30/3.25	1.85/2.75	1.30/1.85	1.10/1.50	1.40/1.90	1.35/2.05
Segment III length/width	1.55/1.75	1.35/1.60	2.30/3.30	2.00/2.80	1.40/1.85	1.15/1.50	1.50/2.00	1.50/2.00
Segment IV length/width	2.05/1.70	1.70/1.50	3.00/3.25	2.50/2.75	1.80/1.85	1.50/1.50	2.00/2.05	2.00/2.05
Segment V length/width	3.15/1.65	2.80/1.50	4.50/3.20	3.70/2.75	2.90/1.80	2.35/1.50	3.25/2.00	3.30/2.00
Telson length	3.15	3.00	4.80	3.85	2.90	2.50	3.10	3.15
Vesicle length	2.25	2.00	3.20	2.50	1.80	1.50	1.95	2.00
width/depth	1.30/0.95	1.30/1.00	2.00/1.50	1.85/1.30	1.35/0.95	1.10/0.80	1.30/1.00	1.50/1.05
Aculeus length	0.90	1.00	1.60	1.35	1.10	1.00	1.15	1.15
Pedipalp length	9.00	8.60	14.60	12.05	8.25	7.25	8.80	9.45
Femur length/width	2.20/0.90	2.10/0.85	3.60/1.40	3.00/1.20	2.00/0.80	1.80/0.70	2.10/0.85	2.25/0.90
Patella length/width	2.50/1.00	2.40/1.05	3.80/1.70	3.20/1.30	2.35/0.95	2.00/0.80	2.50/1.05	2.60/1.10
Chela length	4.30	4.10	7.20	5.85	3.90	3.45	4.20	4.60
Palm length	2.50	2.40	3.80	3.05	2.00	1.80	2.00	2.10
width/depth	1.50/1.75	1.40/1.60	2.60/3.00	2.20/2.50	1.40/1.65	1.15/1.35	1.65/1.70	1.40/1.65
Fixed finger length	1.60	1.60	3.00	2.50	1.55	1.40	1.95	2.10
Movable finger length	2.10	2.00	4.10	3.30	2.20	1.90	2.50	2.80
Pectines teeth	10-10	9-9	11-11	x-x	11-11	11-11	11-11	10-11
middle lamellae	6-x	5+-5+	7-7	x-x	5+-6	7-7	6+-7	7-7
Sternum length/width	0.70/0.90	0.80/0.90	1.00/1.45	0.90/1.10	0.65/0.85	0.55/070	0.70/0.95	0.80/1.00

Table 1: Morphometrics (mm) of genus *Catalinia,* California, USA.

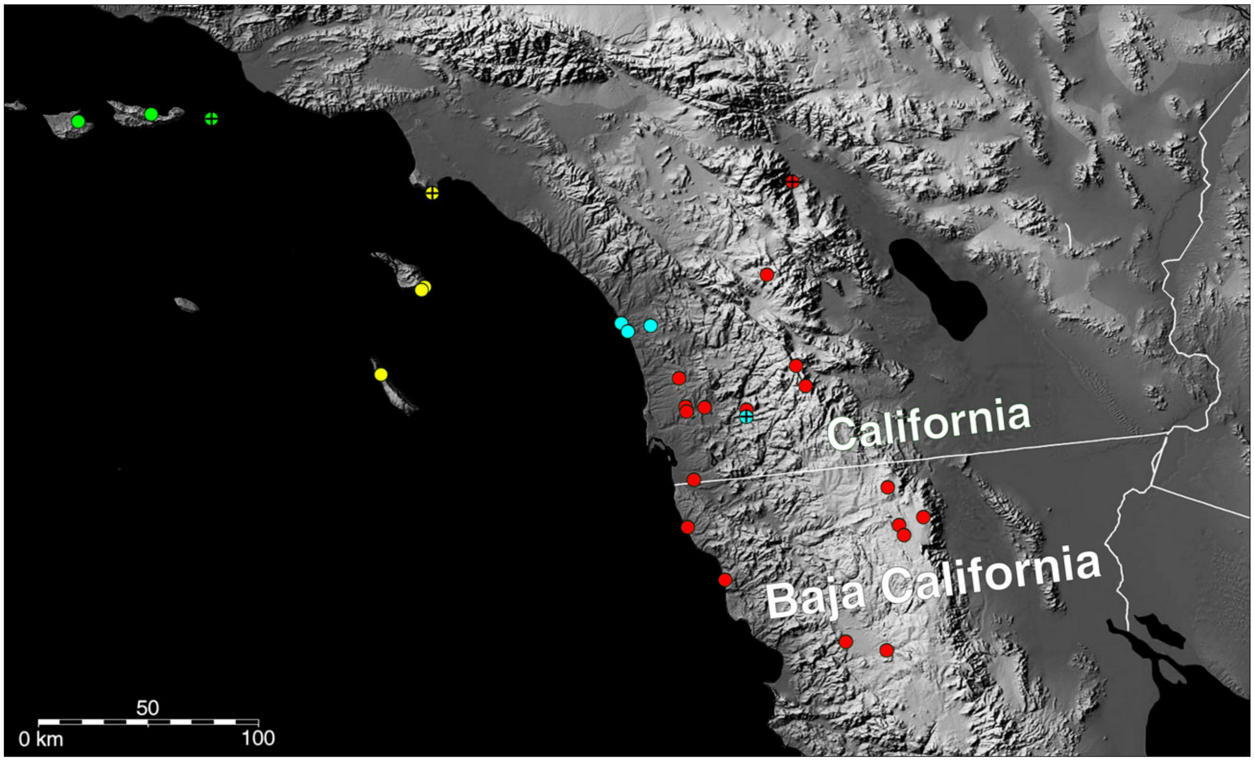

Figure 28: Distribution of genus *Catalinia* in southern California, USA and Baja California, Mexico. Individual localities based on Gertsch & Soleglad (1972: 589, 598–603), Bryson et al. (2013: fig. 2), and material examined. *Catalinia minima*, yellow icons; *C. thompsoni*, green icons; *C. castanea*, turquoise icons; and *C. andreas*, red icons. Type localities indicated with a **'+'**.

the mating plug for *P. savvasi* was illustrated by Francke, 2009: fig. 4, but only as an "outline", so there is little information that can be derived from this illustration). Therefore, the exact location in the chorogram where the secondary base is lost is not known. According to Bryson et al. (2013: fig. 3), the derivation of these three species occurred somewhere between species *P. santarita* + "Quinlan population" (which have a secondary base as in *Catalinia*) and *P. brysoni* (which lacks a secondary base). The loss of the secondary base appears to have occurred at least 14.5 Mya, and probably is a synapomorphy for the clade containing *P. brysoni*, *P. kremani*, and *P. apacheanus*.

Genus-level differences. Table 3 lists major structural differences between *Kovarikia*, *Graemeloweus*, *Catalinia*, and the "*apacheanus*" species group (accounting for 17 species in the *Pseudouroctonus* clade). The table groups some of the structures into aggregates, which we propose might represent two larger clades within the *Pseudouroctonus* clade. As stated elsewhere in this paper, *Catalinia* and the "*apacheanus*" group appear to be closely related, and likewise exhibit a more distant relationship from *Kovarikia* and *Graemeloweus,* which appear to also represent a distinct clade.

Clade *Kovarikia* + *Graemeloweus* has a secondary lamellar hook and a complex double-base mating plug with a crescent-shaped barb, which is quite unusual in the vaejovid scorpions. We consider these to be major taxonomic structures. In Table 3 we refer collectively to these two mating plugs as "C" with "C1" and "C2" furthering breaking them down into two subtypes found in these two genera. Also, this clade has a strong elongated *DPSc* on the patella and 4–5 and 3–4 PVS and PEVS, respectingly, on the leg III basitarsus. In addition, the PVS are quite thin and elongated.

For clade *Catalinia* + "*apacheanus*" group, the secondary lamellar hook is not present and the mating plug has a simpler base divided into one or two parts, and the barb is not crescent-shaped. As with *Kovarikia* + *Graemeloweus*, we assign "B" to this plug type and break it down into "B1" and "B2" to delineate two partial bases versus one base. The secondary external median carina of the patella (*SEMc*) is essentially obsolete and the *DPSc* is quite short. Additionally, there are two PVS and PEVS setae of the leg III basitarsus, which are quite short and stout.

Reproduction

One adult female *Catalinia minima* was kept alive, in captivity, to enable observations of her giving birth and to count the number of first instar juveniles. She was found with 17 first instars on her back on the 10 September, 2016. It is assumed that they had been born several days earlier. The 1st instar behavior was similar

Diagnostic Characters Separating *Catalinia* Species					
	Meta_Seg IV (L/W)	**Meta_Seg V (L/W)**	**Fixed_FL/ Palm_L**	**Movable_FL/ Palm_L**	**Number of Movable_Finger *ID***
C. andreas	**1.155^{L}**	**1.924^{L}**	**0.640^{S}**	**0.840^{S}**	6
C. castanea	**0.916^{S}**	**1.376^{S}**	0.805	1.080	7
C. minima	0.927	1.609	0.776	1.078	6
C. thompsoni	0.988	1.646	**0.975^{L}**	**1.250^{L}**	7
MVD	0.169–0.261	0.169–0.398	0.211–0.523	0.157–0.488	-

Table 2: Key diagnostic character comparisons for differentiating the four species of genus *Catalinia*. For the morphometric ratios, we indicate the largest (L) and smallest (S) values. The mean value difference (MVD) percentages (%) are presented as a range. *ID* = inner denticles.

to that described by Ayrey (2013a) for the "*vorhiesi*" group of the genus *Vaejovis* and Ayrey & Soleglad (2015: 14, 24; figs. 15, 30) for the genus *Pseudouroctonus*. The lineup on the mother's back was non-random (Figure 30). They were facing anteriorly with the prosoma down and the metasoma raised over the prosoma of the juvenile immediately posterior to them (Ayrey, 2012: 9; 2013b: fig. 13). The instars began to molt into second instars beginning the 18 September, 2016. In the process of molting, the instars left their 1st instar exuvia attached to the mother's back. This is frequently seen in the family Vaejovidae (Ayrey, 2013a; Ayrey & Soleglad, 2015). After molting, the 2nd instars began moving about on the back of the mother. Within one more week, they had all left the mother's back and were moving about freely in the enclosure. Feeding, on pinhead crickets, began once they were off the mother and living freely.

Ecological Observations

The habitat of all four species of the new genus *Catalinia* is California Chaparral. The climate there is mild wet winters and hot dry summers. RA collected all specimens of *Catalinia minima* using a blacklight at night at Santa Catalina Island, California. During a visit there in August of 2016 by RA, the area had been suffering a drought which began in December of 2011. The habitat photo, Figure 31, shows the dry conditions prevalent on the island at that time. According to local residents, many of the numerous dead trees seen in the vicinity had died that year. The mammals seen, deer and ground squirrels, were malnourished with their ribs and leg bones prominent. Even given this extreme drought situation, the scorpion population seemed to be holding its own. Twelve specimens of *Catalinia minima* were observed, by black light at night, in approximately 20 minutes. Figures 30−34 show live photos and/or habitats of species of genus *Catalinia*.

Biogeography

A multi-locus analysis of the *Pseudouroctonus minimus* complex revealed two distinct clades estimated to have diverged in the Paleogene at least 28 Ma (Bryson et al., 2014): a Southeast Clade from the northern Sierra Madre Occidental, southwestern Sky Island region, and adjacent Chihuahuan Desert and a Northwest Clade which was herein named *Catalinia*. Divergence among the *Catalinia* species was estimated to have occurred during the Miocene, a time when coastal southern California and the Channel Island region underwent pronounced tectonic activity. The four northern Channel Islands were originally thought to have historical affinities with the mainland as a linear connection with the Santa Monica Mountains (e.g. Valentine & Lipps, 1967). However, geological data and sea level reconstructions have not found any evidence of a land bridge (Junger & Johnson, 1980). *Catalinia thompsoni* occurs on at least three of the four northern islands, but not the Santa Monica mountains, further supporting the idea that the islands were not connected to the mainland, at least in this region. Paleogeographic reconstructions tell a different story, one that partially explains the otherwise odd distribution of *Catalinia*, which we outline below.

Prior to the Miocene, the Channel Islands and southern California were all part of mainland Sonora. Mesozoic and early to middle Cenozoic subduction of the Farallon Plate under the North American plate in the area produced a series of volcanos inland of the plate boundaries. Clastic rock from one of these volcanos in present-day Sonora was carried westward to the Pacific Coast by the ancient Ballena River during the Eocene. Today these rocks (cobbles of rhyolite in a sandstone matrix), called "Poway" clasts, can be found in Sonora, San Diego County, and the northern Channel Islands, a disjointed distribution caused by a legacy of extreme geologic evolution in this region since the Eocene.

	Kovarikia	*Graemeloweus*	*Catalinia*	"*apacheanus*" Group
Neobothriotaxy	**Yes (chela, *V*)**	No	No	No
Chelal Carina *V2*	Obsolete	**Developed**	Obsolete	Obsolete
Secondary Lamellar Hook	**Yes**	**Yes**	**No**	**No**
Primary Lamellar Hook	Bifurcated	**Non-bifurcated**	Bifurcated	Bifurcated
Mating Plug Type	**C1**	**C2**	**B1**	**B1, B2**
Carapace Anterior Indentation	Deep	Deep	**Shallow**	Deep
Metasomal Tapering	Yes	Yes	**No**	Yes
Metasomal Segment IV–V Stoutness	Thin	Medium	**Very Stout**	Medium-Stout
Telson Vesicular Ridges	**Yes**	No	No	No
Telson Subaculear Setal Pair Location	**Aculeus base**	Acuelus/Vesicle juncture	Acuelus/Vesicle juncture	Acuelus/Vesicle juncture
Telson Vesicular Linear Patch (Male)	**Yes**	No	No	No
Patellar *EMc* Carina	Strong, granulated	Strong, granulated	**Medium**	Strong, granulated
Patellar *SEMc* Carina	**Strong**	Weak, medium	**Near obsolete**	**Near obsolete**
Patellar *DPSc* Carina	**Strong**	**Strong**	**Weak**	**Weak**
Leg III Basitarsus PVS Count	**5**	**4**	**2**	**2**
Leg III Basitarsus PEVS Count	**4**	**3**	**2**	**2**
PVS Development	**Thin**	**Thin**	**Stout**	**Stout**
Pectinal Tooth Counts	10–14 males, 11–12 females	10–12 males, 9–11 females	9–12 males, 7–11 females	10–12 males, 8–11 females
Adult Size (mm)	36–45 males, 51–62 females	27–41 males, 35–41 females	16–34 males, 18–36 females	20–27 males, 25–32 females

Table 3: Major structures that contrast genera *Kovarikia*, *Graemeloweus*, *Catalinia*, and species of the "*apacheanus*" group. *Shaded bold items* indicate a major diagnostic character for a genus or species group. If two shaded areas are enclosed in a heavy border, it indicates a major diagnostic character for clades '*Kovarikia* + *Graemeloweus*' or '*Catalinia* + "*apacheanus*" group'. B1, B2, C1, and C2 are "labels" assigned to mating plug types and subtypes, see hemispermatophore discussion in paper.

Between 27 and 18 Ma, the Poway clasts began to separate as the Pacific Plate collided with the North American Plate, breaking off pieces of mainland and producing the San Andreas plate boundary (Atwater, 1998). The Transverse Ranges block, which contained the present-day northern Channel Islands, was oriented in a north-south direction, but began to slip away with the Pacific plate and rotated a remarkable 90–110° clockwise (see animations at http://emvc.geol.ucsb.edu/). We hypothesize that the common ancestor of

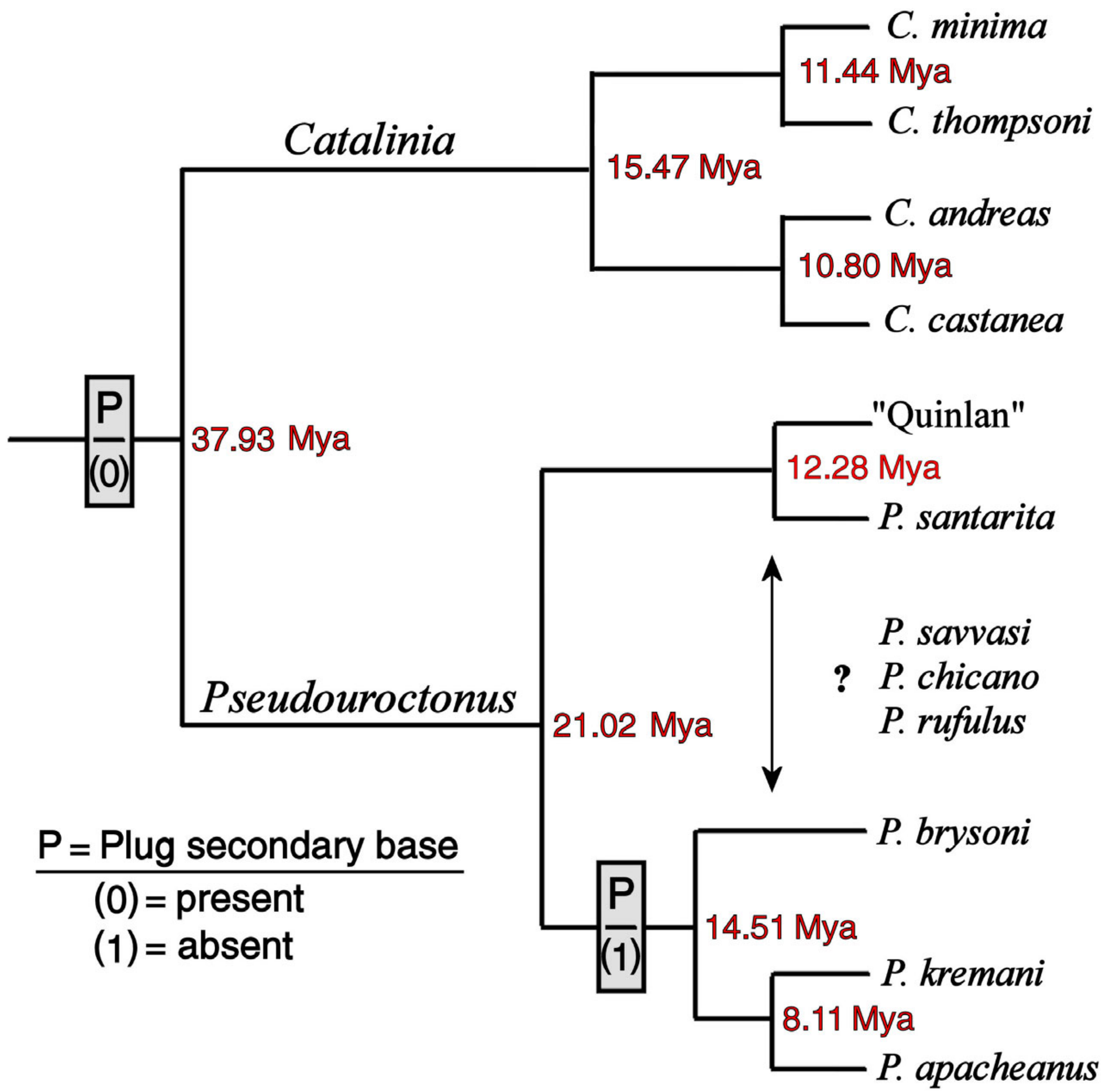

Figure 29: A partial charogram depicting the presence/absence of the hemispermatophore mating plug's secondary base. These data are based on species so far examined including the four species of genus *Catalinia*, four species currently placed in the "*apacheanus*" group of genus *Pseudouroctonus*, and another population from Quinlan Mountains of Arizona. Note, the mating plug of species *P. savvasi*, *P. chicano*, and *P. rufulus* are not known. The charogram branching is taken from a partial chronogram based on molecular data showing proposed phylogenetic relationships based on evolutionary time indicating estimates for a multilocus species tree (red numbers depict Mya means). This information is from Bryson et al. (2013: fig. 3).

Catalinia diverged as the Transverse Range block rotated away from the mainland, taking new island populations with it. Molecular clock estimates suggest that the island and mainland lineages diverged approximately 20 to 12 Ma, a timeframe consistent with our hypothesis.

Genetic samples are needed from additional populations, especially some of the islands, before we can determine if tectonic events are also responsible for species level diversification within *Catalinia*, but the distribution of the genus is interesting (Fig. 28). The northern Channel Islands each harbor the same species, *C. thompsoni.* This is what we should expect given the history of these islands. While sea levels were low (i.e. 120 m below the present level during the last glacial maximum) the northern islands were joined together as the larger Santarosae Island. This would have allowed opportunities for gene flow among populations on dif-

Figure 30: *Catalinia minima*, Avalon, Santa Catalina Island, California, USA. **Top.** Gravid female and *third* instar. **Bottom.** Females with *first* instars.

Figure 31: *Catalinia minima*, Avalon, Santa Catalina Island, California, USA. **Top.** Male in natural habitat. **Bottom.** Natural habitat.

Figure 32: *Catalinia minima*, Avalon, Santa Catalina Island, California, USA. Females in life.

Figure 33: Top. *Catalinia andreas*, San Diego Co., California, USA. Female in life. **Bottom.** *Catalinia castanea*, Carlsbad, San Diego Co., California, USA. Female in life.

Figure 34: *Catalinia minima* natural habitat, Santa Catalina Island, California, USA. Avalon Harbor, where the specimen locality canyon empties into the Pacific Ocean.

ferent islands, thereby maintaining a single species. Although there was always a marine channel between Santarosae Island and the mainland, at times the channel may have been as narrow as 6 km (when sea levels were at their lowest). This allowed some terrestrial animals to cross the channel, such as island foxes (*Urocyon littoralis;* Hofman et al., 2015) and the famous pygmy mammoths (*Mammuthus exilis*; Torben et al., 2012), which colonized the islands from mainland populations. Other animals, like *Catalinia*, were already on the islands and either could not disperse across the channel or could never establish mainland populations once they did cross.

We also find it intriguing that the distribution of *C. minima* on Santa Catalina Island, San Clemente Island, and the Palos Verdes Peninsula form a nearly linear north-south orientation. All three regions are the result of localized uplift, and the Palos Verdes Peninsula existed as an island until it joined the mainland during the Pleistocene. Santa Catalina and San Clemente islands were never connected to the mainland. Curiously, each island is thought to have emerged in the Late Pliocene or Early Pleistocene (Rowland, 1984; Conrad & Ehlig, 1987; Ward & Valensise, 1996), a timeframe inconsistent with the divergence date estimate. According to Bryson et al. (2014), *C. minima* diverged from its sister taxon *C. thompsoni* much earlier in the Miocene (11.4 Ma). But how could this occur if the islands and peninsula did not yet exist? We propose that additional genetic sampling might hold the answer, and that *Catalinia* would be an ideal taxon for investigating the impact that dramatic landscape reconfigurations can have on regional arthropod diversity.

Acknowledgments

Thanks goes to Melinda DeBoer-Ayrey for accompanying RA on two field trips to Southern, CA and Catalina Island. We are grateful to Danilo Harms (Zoologisches Museum Universität Hamburg, Hamburg, Germany) for the loan of Kraepelin's types of *Catalinia minima*, and a very special thanks to František Kovařík who borrowed and photographed this type material (see the two Front Plates).

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Appendix A
Trichobothrial Patterns of *Catalinia* Species

This Appendix presents the trichobothrial patterns of the four species of genus *Catalinia*, *C. andreas*, *C castanea*, *C minima*, and *C thompsoni*. The pattern for *C minima* is presented here for the first time, the other three patterns are from, in part, Ayrey & Soleglad (2015: figs. A-1, A-2, and A-3).

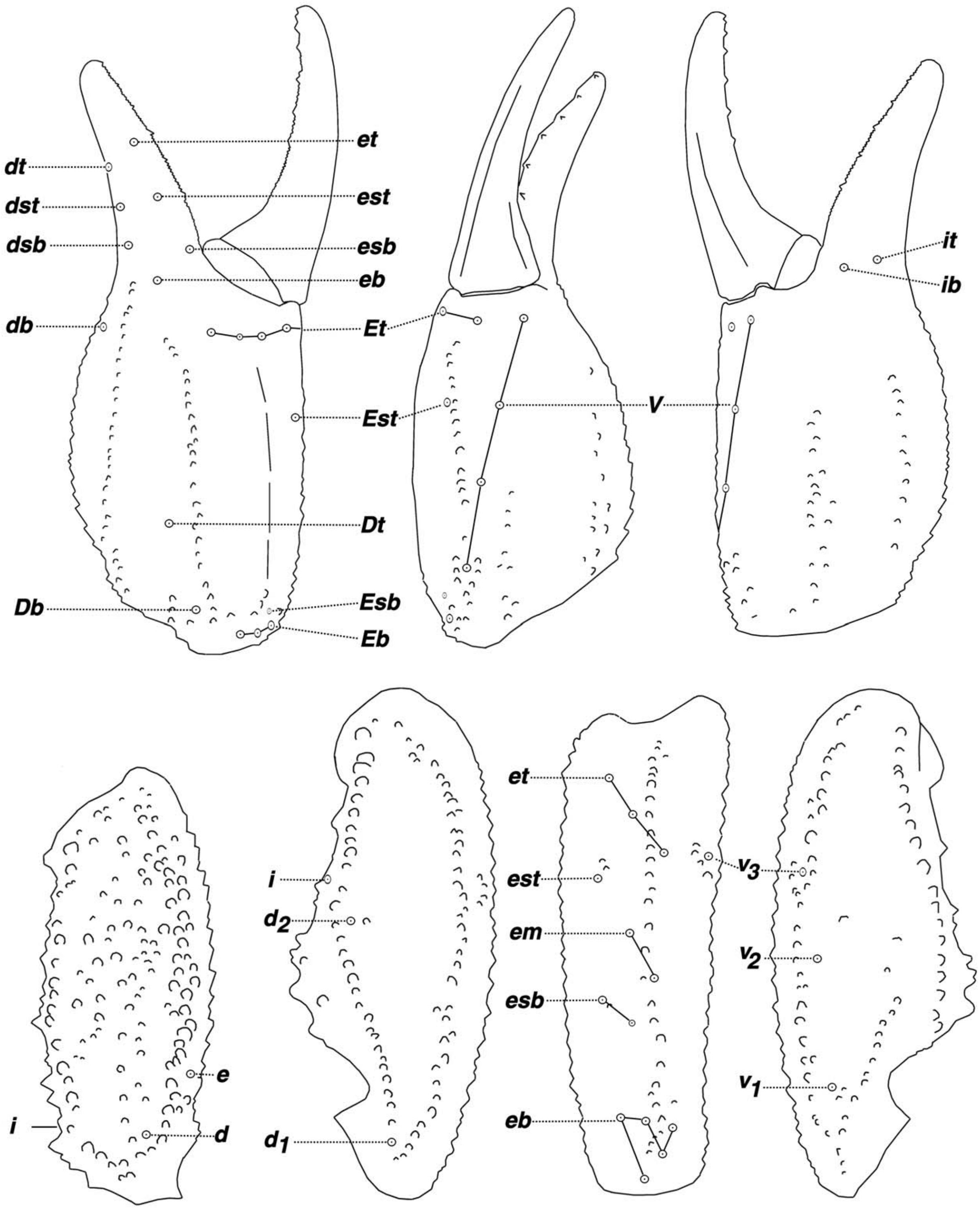

Figure A-1: *Catalinia andreas*, male, Chariot Canyon, ABDSP, San Diego Co., California, USA. Trichobothrial pattern.

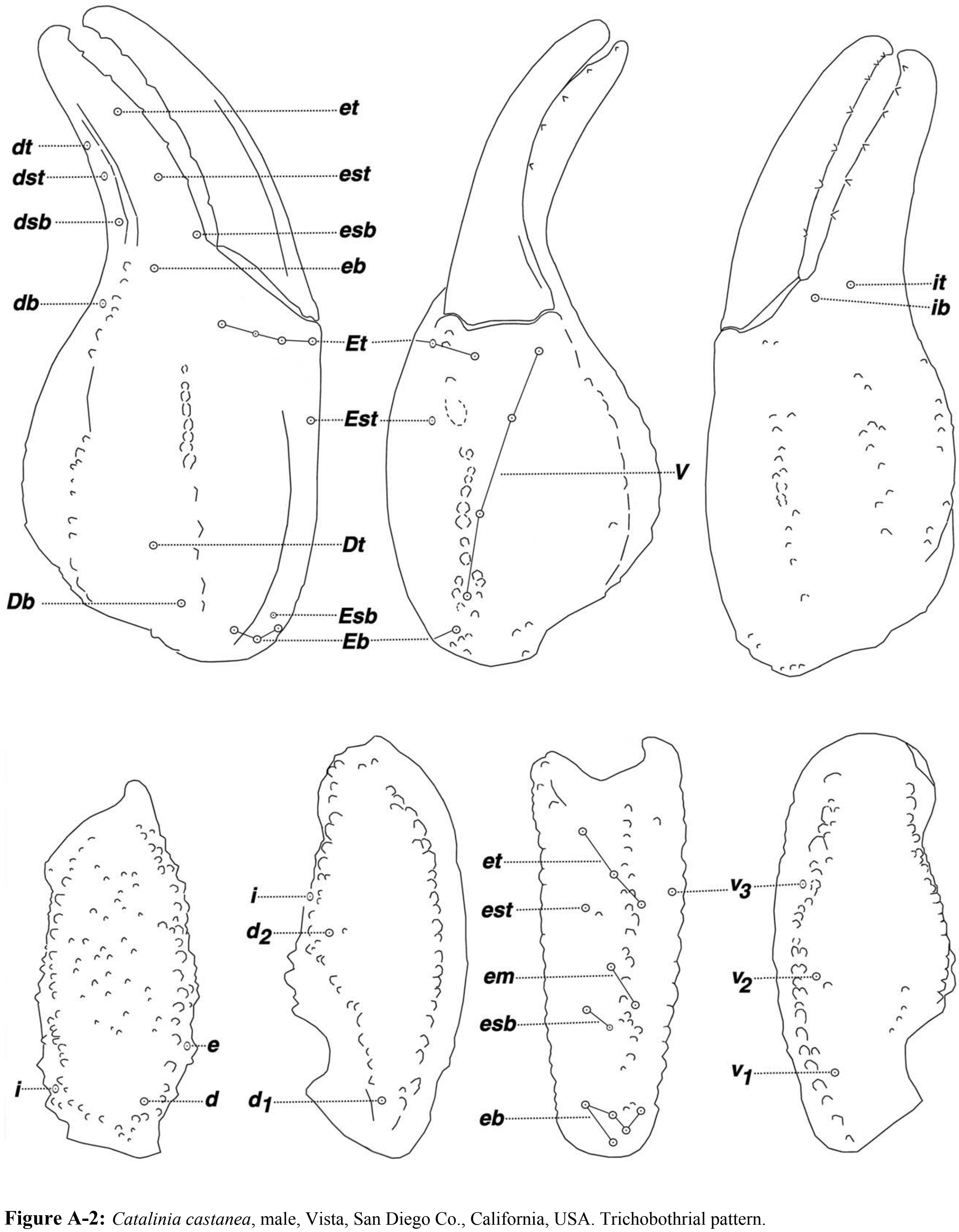

Figure A-2: *Catalinia castanea*, male, Vista, San Diego Co., California, USA. Trichobothrial pattern.

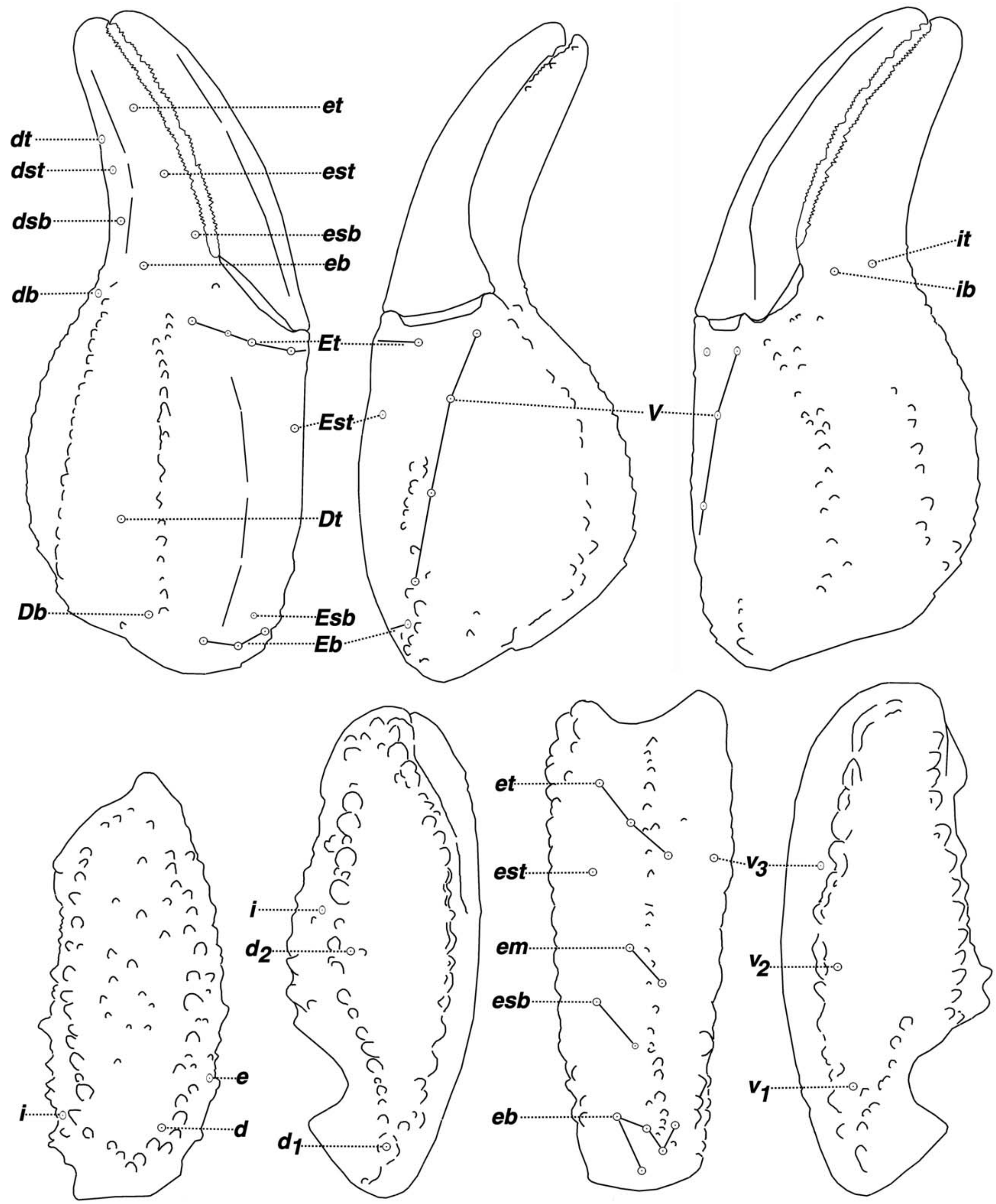

Figure A-3: *Catalinia minima*, male, Avalon, Santa Catalina Island, California, USA. Trichobothrial pattern.

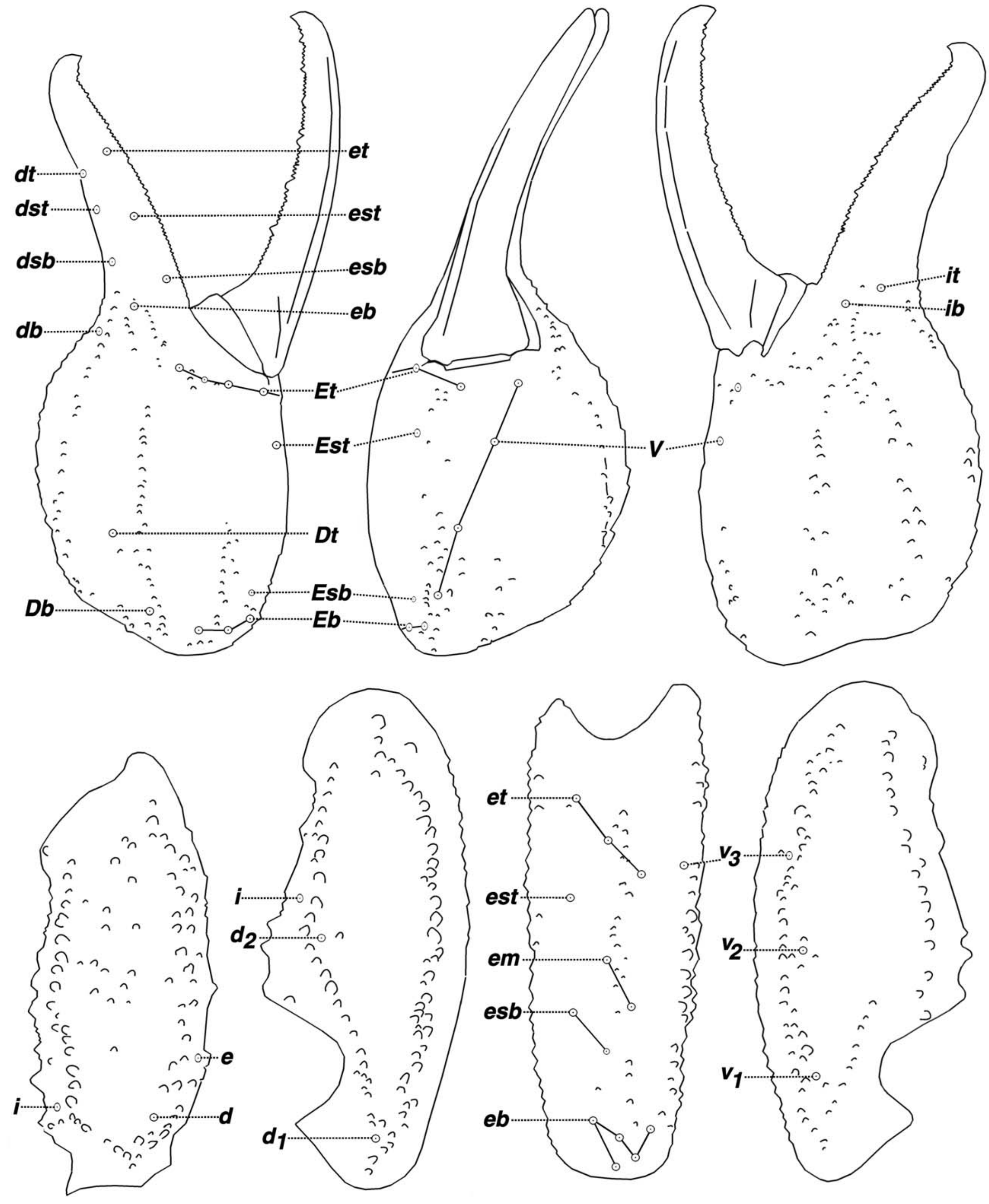

Figure A-4: *Catalinia thompsoni*, male, Santa Cruz Island, Santa Barbara Co., California, USA. Trichobothrial pattern.

Appendix B

Data used to construct the statistical results of the morphometric ratio and meristic analysis conducted in this paper are presented in this appendix. Data are presented as follows: minimum–maximum (mean) (±standard deviation) [number of samples] {mean: minus–plus standard deviation} (coefficient of variability). Mean Value Differences (MVD) are presented as percentages. The carapace anterior indentation, the metasomal segment "tapering quotient" and length/width ratios, *DPSc* ratios, basitarsus ratio and setal counts, pectinal tooth counts, and key measurements of the hemispermatophore are presented in this Appendix.

The data presented herein is from specimens examined and the following publications: Gertsch & Soleglad (1972), Hjelle (1972), Francke & Savary (2006), Francke (2009), Bryson et al. (2013), Tate et al. (2013), Soleglad, Fet & Graham (2014), Ayrey & Soleglad (2015), Savary & Bryson (2016), Soleglad, Fet, Graham & Ayrey (2016), and Ayrey & Soleglad (2017).

Carapace Anterior Indentation Depth

This section presents the data used in the construction of the histograms in the body of this paper that presented the morphometric ratio Cara_Ant-Ind_D / Cara_L.

Pseudouroctonus "group"

Catalinia: 0.018–0.029 (0.024) (±0.004) [12] {0.020–0.027} (0.149)
C. andreas: 0.022–0.025 (0.024) (±0.001) [3] {0.022–0.025} (0.055)
C. castanea: 0.023–0.024 (0.024) (±0.000) [3] {0.023–0.024} (0.017)
C. minima: 0.028–0.029 (0.029) (±0.000) [3] {0.028–0.029} (0.008)
C. thompsoni: 0.018–0.021 (0.019) (±0.002) [3] {0.018–0.021} (0.084)
Based on 12 specimens spanning four species, *C. andreas*, 1 ♂ and 2 ♀, *C. castanea*, 3 ♂, *C. minima*, 3 ♂, and *C. thompsoni*, 2 ♂ and 1 ♀.
Graemeloweus: 0.039–0.045 (0.041) (±0.003) [3] {0.038–0.044} (0.079)
Based on three species, *G. glimmei* ♀, *G. iviei* ♀, and *G. maidu* ♀.
Kovarikia: 0.059–0.062 (0.060) (±0.002) [3] {0.059–0.062} (0.027)
Based on three species, *K. angelena* ♂, *K. bogerti* ♀, and *K. williamsi* ♀.
Uroctonites: 0.039–0.045 (0.041) (±0.003) [3] {0.038–0.046} (0.079)
Based on three species, *U. giulianii* ♀, *U. huachuca* ♀, and *U. montereus* ♂.
"*apacheanus*" group: 0.032–0.052 (0.042) (±0.006) [7] {0.036–0.049} (0.149)
Based on seven species, *P. apacheanus* ♂, *P. brysoni* ♂, *P. kremani* ♀, *P. santarita* ♀, *P. chicano* ♀, *P. rufulus* ♀, after Gertsch & Soleglad (1972: fig. 130), and *P. savvasi* ♂, after Francke (2009: fig. 11).
"*reddelli*" group: 0.042–0.053 (0.048) (±0.005) [4] {0.044–0.053} (0.098)
Based on four species, *P. cazieri* ♀, after Gertsch & Soleglad (1972: fig. 131), *P. reddelli* ♀, *P. sprousei* ♂, after Francke & Savary (2006: fig. 1), and *P. peccatum* ♀, after Tate et al. (2013: fig. 4).
Pseudouroctonus lindsayi: ratio value = 0.054
Based on ♀, after Gertsch & Soleglad (1972: fig. 127).

North American Chactids

Anuroctonus: 0.016–0.036 (0.026) (±0.008) [5] {0.018–0.034} (0.304)
Based on two species and 2 subspecies all ♂: two specimens of *A. phaeodactylus*, one specimen of *A. pococki pococki*, and two specimens of *A. pococki bajae*. After Soleglad & Fet (2004: figs. 38–42).
Nullibrotheas allenii: ratio value = 0.025.
Based on ♂ specimen.
Uroctonus: 0.077–0.083 (0.080) (±0.004) [2] {0.076–0.084} (0.050)
Based on two species, *U. grahami* ♀ and *U. m. mordax* ♀, after Gertsch & Soleglad (1972: figs. 3 & 15).

MVD (%) between *Catalinia* and *Kovarikia* from other *Pseudouroctonus* Clade Components

	Kovarikia	***Graemeloweus***	***Uroctonites***	**"*apacheanus*" grp.**	**"*reddelli*" grp.**	***P. lindsayi***
Catalinia	**154.6**	**73.7**	**74.7**	**78.3**	**104.6**	**127.9**
Kovarikia	-	46.6	45.7	42.8	24.5	11.7

Metasoma Morphometrics

This section presents the data used in the construction of the histograms in the body of this paper that analyzed the morphometric ratios of the metasomal segments I–V, length / depth and the *tapering quotient* of these segments.

Metasoma "Tapering Quotient": In many scorpions the metasoma's width, segment by segment, reduces from segment I to segment V, thus causing a "tapering effect". Sometimes, segment V may be fatter due to exaggerated carinal development, etc. However, in the *Pseudouroctonus* clade, we do in most cases see a tapering from segment I to segment V due to a decrease in each segment's width and likewise lengthing of the segment. The reason we are considering the "tapering" of the metasoma is because in genus *Catalinia*, the metasoma does *not* taper, all five segments are essentially the same width (see Table 1).

In order to quantify the "tapering effect" we apply the following technique as follows:

Subtract the width of segment V from the width of segment I and divide the absolute value by the width of segment V:

|segI_W – segV_W| / segV_W

In theory if all segments are the same width we will have a result of zero ("0"). The more tapering we see in a metasoma the result will be greater than zero, the larger the result, the more tapering exhibited by the scorpion, thus an indicator of the degree of tapering.

Males:

C. andreas:	0.030, 0.034, 0.067
C. castanea:	0.031, 0.055
C. minima:	0.000, 0.033, 0.000
C. thompsoni:	0.025, 0.042
***Catalinia*:**	**0.000–0.067 (0.032) [10]**
G. glimmei:	0.156, 0.150
G. iviei:	0.118, 0.095
G. maidu:	0.214, 0.156
***Graemeloweus*:**	**0.095–0.214 (0.148) [6]**
K. angelena:	0.191, 0.235
K. bogerti:	0.152, 0.278
K. williamsi:	0.152
***Kovarikia*:**	**0.152–0.278 (0.202) [5]**
P. apacheanus:	0.132, 0.176
P. brysoni:	0.108, 0.121, 0.125, 0.083, 0.125, 0.097
P. chicano:	-
P. kermani:	0.233
P. rufulus:	0.100
P. santarita:	0.176
P. savvasi:	0.190
***"apacheanus"* group:**	**0.083–0.233 (0.139) [12]**
P. cazieri:	0.150
P. peccatum:	-
P. reddelli:	0.286
P. sprousei:	0.286
"*reddelli*" group:	

Females:

C. andreas:	0.067, 0.074, 0.077
C. castanea:	0.000
C. minima:	0.000, 0.050
C. thompsoni:	0.050, 0.038, 0.043
***Catalinia*:**	**0.000–0.077 (0.044) [9]**
G. glimmei:	0.095, 0.174
G. iviei:	0.104, 0.217
G. maidu:	0.125, 0.265, 0.200, 0.165, 0.165, 0.261
***Graemeloweus*:**	**0.095–0.265 (0.177) [10]**
K. angelena:	-
K. bogerti:	0.364, 0.190
K. williamsi:	0.233, 0.200, 0.222
***Kovarikia*:**	**0.190–0.364 (0.242) [5]**
P. apacheanus:	0.139, 0.176
P. brysoni:	-
P. chicano:	0.067
P. kermani:	0.206
P. rufulus:	0.118
P. santarita:	0.105
P. savvasi:	0.250
***"apacheanus"* group:**	**0.067–0.250 (0.152) [7]**
P. cazieri:	0.087
P. peccatum:	0.058, 0.085
P. reddelli:	0.290
P. sprousei:	-
"reddelli" group:	

“Slender” species (females)

“*Syntropis*”:		**0.478–0.528 (0.508) [3]**
S. williams:	0.478	
S. aalbui:	0.528	
S. syntropis:	0.519	
H. viscaenensis	0.208	

After Soleglad, Lowe & Fet (2007: tab. 1) and Williams (1970:tab. 5).

Metasoma “Tapering Quotient”

	MVD % Males		
	“apacheanus”	***Graemeloweus***	***Kovarikia***
Catalinia	**334.4**	**362.5**	**531.3**
Pseudouroctonus	-	6.5	45.3
Graemeloweus	-	-	36.5

	MVD % Females		
	“apacheanus”	***Graemeloweus***	***Kovarikia***
Catalinia	**245.5**	**302.3**	**450.0**
Pseudouroctonus	-	16.4	59.2
Graemeloweus	-	-	36.7

Genus *Catalinia*’s MVD percentage in the tapering quotient is quite significant, exceeding 246 to 531 percent from the other genera/species groups compared.

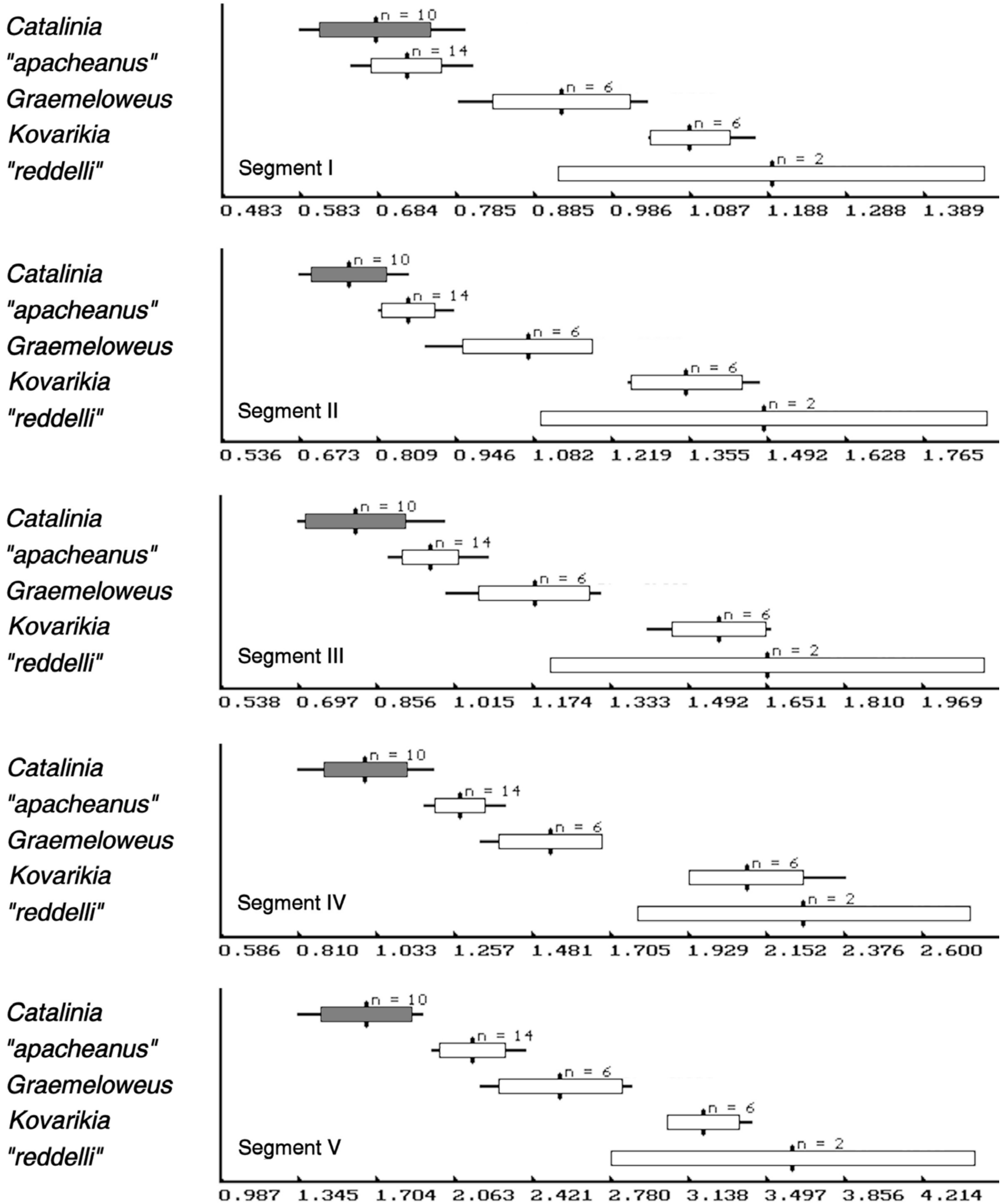

Figure B-1: Histograms depict metasomal morphometric ratios "segment length / segment width" for adult male specimens. The histograms for all five metasomal segments show that genus *Catalinia* has the most stout metasoma and genus *Kovarika* and the two species comprising the "*reddelli*" species group (out of four) with the thinnest. See Appendix B for more detailed data pertaining to these histograms.

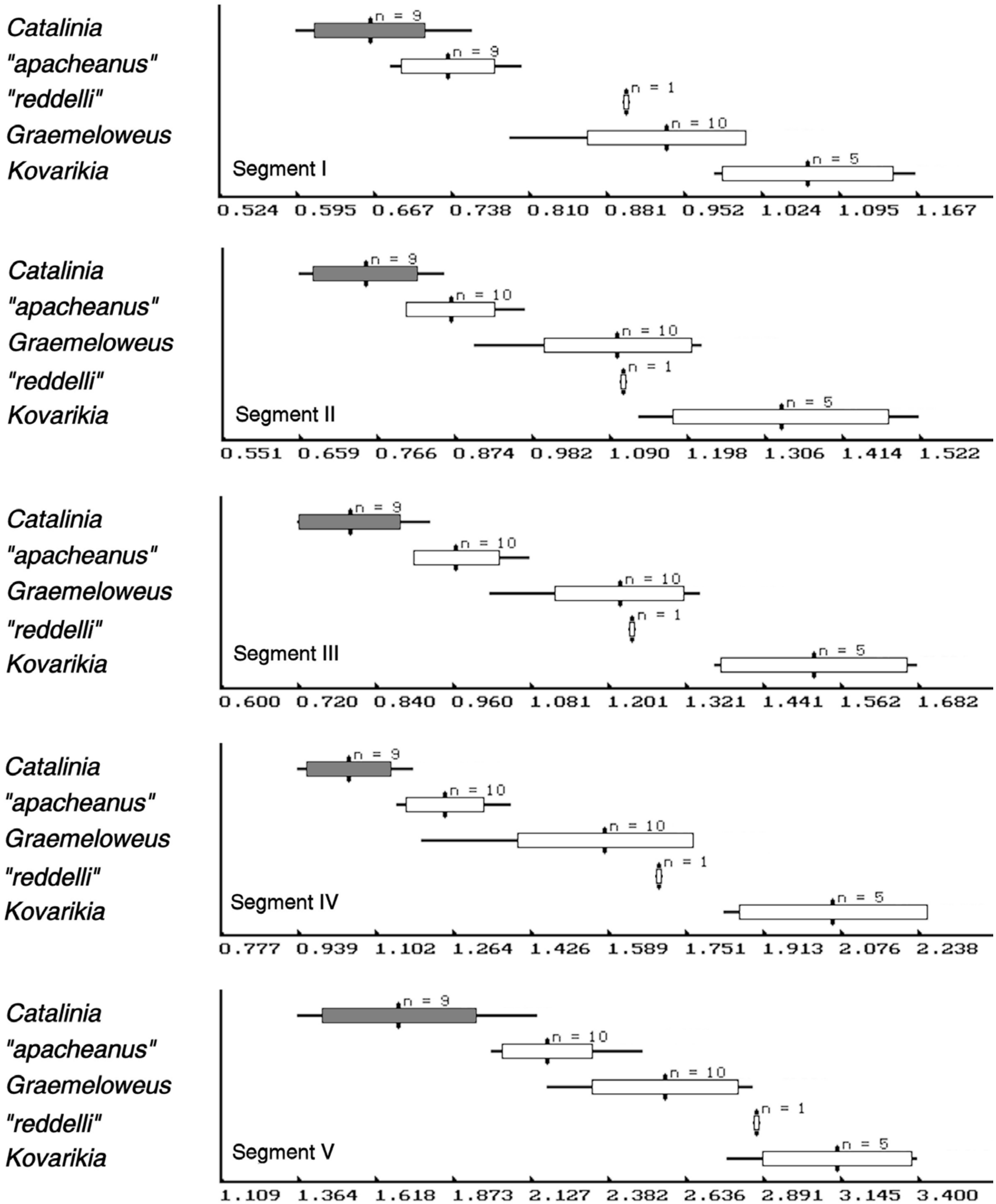

Figure B-2: Histograms depict metasomal morphometric ratios "segment length / segment width" for adult female specimens. The histograms for all five metasomal segments show that genus *Catalinia* has the most stout metasoma and genus *Kovarika* and a species comprising the "*reddelli*" species group (out of four) with the thinnest for segments II–V. See Appendix B for more detailed data pertaining to these histograms.

Histograms metasomal segments I–V length / width for genus *Catalinia*

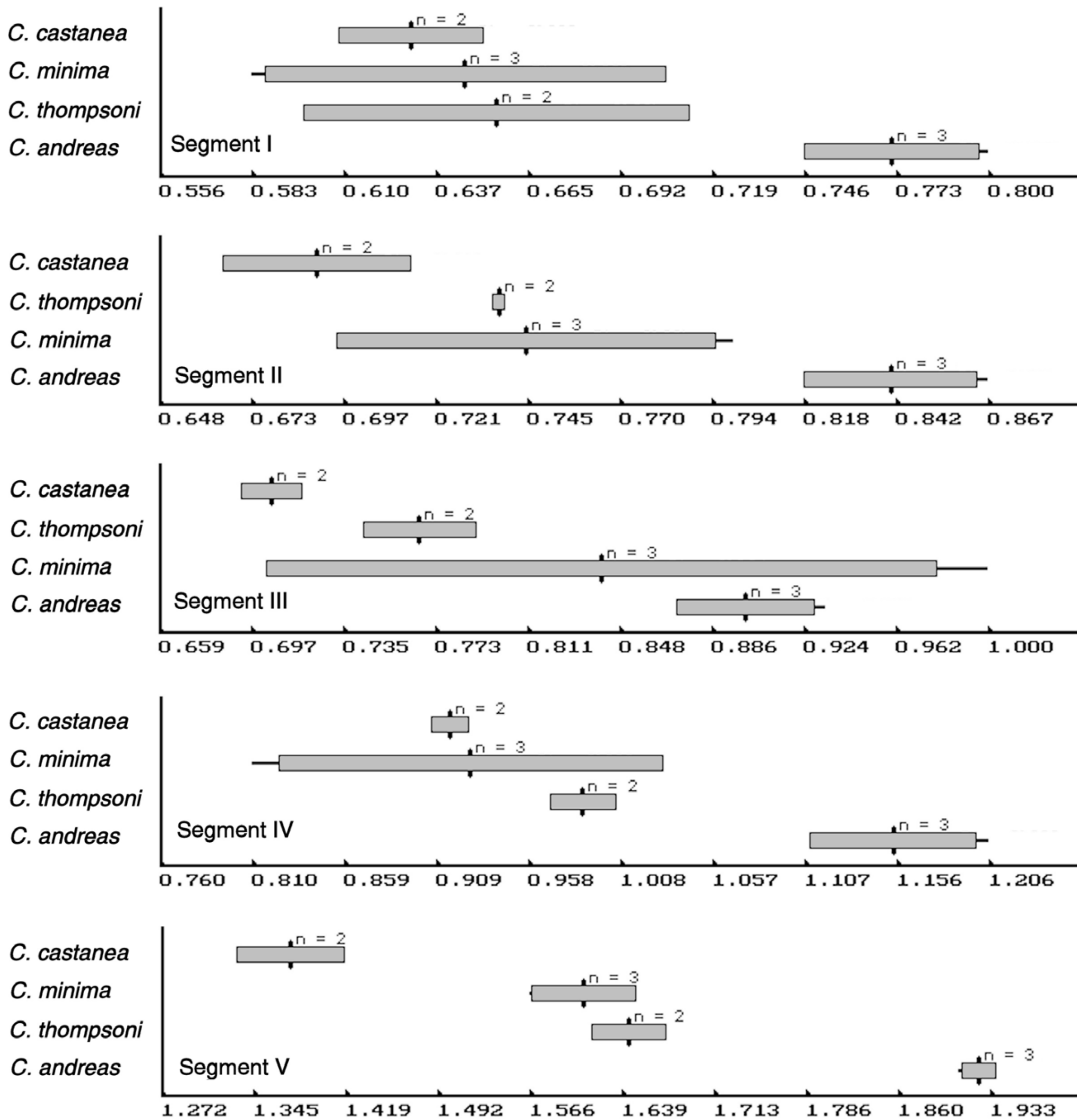

Figure B-3: Histogram showing the metasomal segments I–V length / width for male species of genus *Catalinia*.

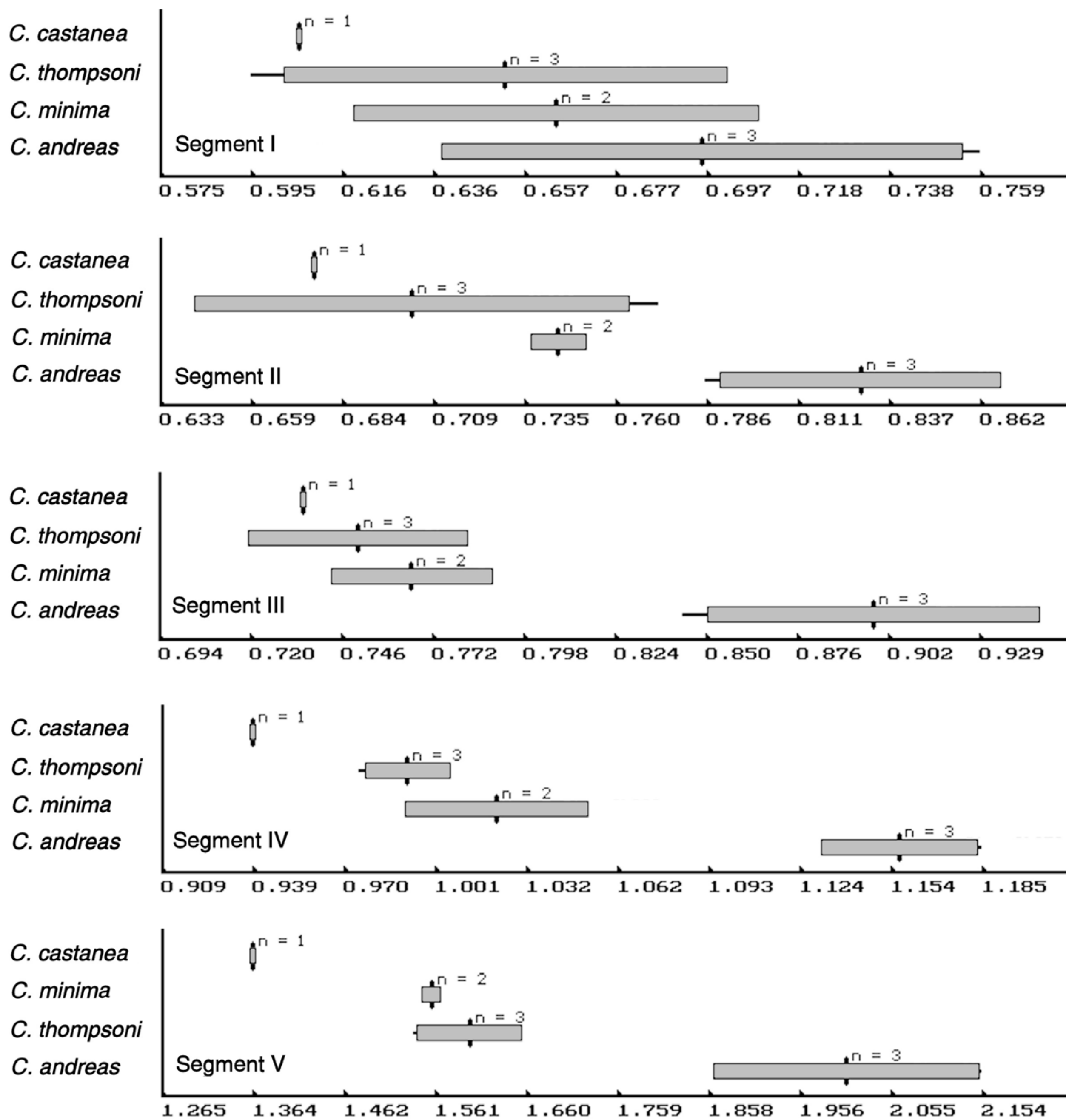

Figure B-4: Histogram showing the metasomal segments I–V length / width for female species of genus *Catalinia*.

Metasoma Segments, Length / Width. We present here detailed morphometric data for the four species of genus *Catalinia* by gender, spanning 19 specimens.

	C. andreas	*C. castanea*	*C. minima*	*C. thompsoni*
Males:				
Seg I:	0.750–0.800 (0.772) (±0.026) [3]	0.615–0.645 (0.630) (±0.021) [2]	0.583–0.700 (0.646) (±0.059) [3]	0.615–0.696 (0.656) (±0.057) [2]
Seg II:	0.824–0.867 (0.841) (±0.023) [3]	0.673–0.708 (0.690) (±0.025) [2]	0.703–0.800 (0.745) (±0.050) [3]	0.737–0.739 (0.738) (±0.002) [2]
Seg III:	0.882–0.933 (0.900) (±0.029) [3]	0.697–0.714 (0.706) (±0.012) [2]	0.757–1.000 (0.841) (±0.138) [3]	0.750–0.783 (0.766) (±0.023) [2]
Seg IV:	1.125–1.206 (1.155) (±0.044) [3]	0.909–0.923 (0.916) (±0.010) [2]	0.810–1.000 (0.927) (±0.103) [3]	0.976–1.000 (0.988) (±0.017) [2]
Seg V:	1.909–1.933 (1.924) (±0.013) [3]	1.345–1.406 (1.376) (±0.043) [2]	1.567–1.650 (1.609) (±0.042) [3]	1.625–1.667 (1.646) (±0.029) [2]
Females:				
Seg I:	0.643–0.759 (0.696) (±0.058) [3]	0.606–0.606 (0.606) (±0.000) [1]	0.632–0.696 (0.664) (±0.045) [2]	0.595–0.682 (0.652) (±0.049) [3]
Seg II:	0.786–0.862 (0.829) (±0.039) [3]	0.676–0.676 (0.676) (±0.000) [1]	0.739–0.750 (0.745) (±0.008) [2]	0.659–0.773 (0.704) (±0.061) [3]
Seg III:	0.844–0.929 (0.898) (±0.047) [3]	0.735–0.735 (0.735) (±0.000) [1]	0.750–0.783 (0.766) (±0.023) [2]	0.720–0.783 (0.751) (±0.031) [3]
Seg IV:	1.133–1.185 (1.157) (±0.026) [3]	0.939–0.939 (0.939) (±0.000) [1]	1.000–1.043 (1.022) (±0.031) [2]	0.976–1.000 (0.992) (±0.014) [3]
Seg V:	1.867–2.154 (2.007) (±0.144) [3]	1.364–1.364 (1.364) (±0.000) [1]	1.550–1.565 (1.558) (±0.011) [2]	1.538–1.650 (1.599) (±0.056) [3]

Mean Value Difference of Metasoma Segments IV and V, Length / Width

	MVD % Males		
	"*apacheanus*" group	***Graemeloweus***	***Kovarikia***
Segment IV			
Catalinia	**26.9**	**53.0**	**108.9**
Pseudouroctonus	-	20.6	64.6
Graemeloweus	-	-	36.5
Segment V			
Catalinia	**29.4**	**53.6**	**93.2**
Pseudouroctonus	-	18.7	49.3
Graemeloweus	-	-	25.8

	MVD % Females		
	"*apacheanus*" group	***Graemeloweus***	***Kovarikia***
Segment IV			
Catalinia	**19.2**	**51.2**	**97.8**
Pseudouroctonus	-	26.9	65.1
Graemeloweus	-	-	30.1
Segment V			
Catalinia	**28.6**	**51.4**	**84.7**
Pseudouroctonus	-	17.7	43.5
Graemeloweus	-	-	22.0

The metasoma of genus *Catalinia* is more stocky than it is in "*apacheanus*" group, *Graemeloweus*, and *Kovarkia*, as shown in the histograms in Figs. B-1–B-2. In particular metasomal segments IV–V exhibit the largest differences, showing complete plus-minus standard error separation from the other two genera and species group. This is further supported above by the MVD, *Catalinia* exhibiting 26.9–108.9 % and 29.4–93.2 % differences in segments IV and V for the males; and 19.2–97.8 % and 28.6–84.7 % for the females. Also, separation from the "*apacheanus*" group, ranging 19.2–29.4 %, is noteworthy since this group and *Catalinia* appear to be sister clades. The data for these two clades is based on 19 samples of *Catalinia* and 24 samples of the "*apacheanus*" group.

Patellar Carinae Special Morphometrics

<u>Ratios and method of measurement:</u>

ratio-1: *DPSc*_L / *DEc*_L & number of major granules in *DPSc*

ratio-2: (*DIc*|*DEc* / *DEc*_L)

DIc|*DEc* = its widest width, *DPSc*_L = *DPS* to last major denticle; *DEc*_L = distal of trichobothrium d_1 to end of carina.

	Ratio-1	***Ratio-2***
***Catalinia*:**		
C. andreas	0.196, 5	0.318
C. castanea	0.130, 3	0.340
C. minima	0.123, 2	0.292
C. thompsoni	0.210, 3	0.340
	0.123–0.210 (0.165); 2–5 (3.25)	0.292–0.340 (0.325)
“*apacheanus*” group:		
P. apacheanus	0.132, 4	0.325
P. brysoni	0.108, 2	0.333
P. kremani	0.259, 4	0.304
P. santarita	0.063, 1	0.313
	0.063–0.259 (0.141); 1–4 (2.75)	0.304–0.333 (0.319)
***Graemeloweus*:**		
G. glimmei	0.261, 5+	0.270
G. iviei	0.420, 8+	0.239
G. maidu	0.570, 10+	0.290
	0.261–0.570 (0.417); 5–10 (7.67)	0.239–0.290 (0.266)
***Kovarikia*:**		
K. angelenus	0.246, 5+	0.288
K. bogerti	0.372, 8+	0.310
K. williamsi	0.274, 5+	0.327
	0.246–0.372 (0.297); 5–8 (6.00)	0.288–0.327 (0.308)

MVD % Ratio 1

	“*apacheanus*” group	***Graemeloweus***	***Kovarikia***
Catalinia	17.02	**152.72**	**80.00**
“*apacheanus*” group	-	**195.74**	**110.64**
Graemeloweus	-	-	40.40

Note, ratio-1 is very important, showing that *Catalinia* and the “*apacheanus*” group definitely have a reduced *DPSc*, showing significant MVD from the other two genera. The number of *DPSc* granules supports this result as well. Ratio-2 also supports the reduced *DPSc* but the MVD differences are negligible and therefore this ratio is not considered important.

Basitarsus (Leg III) Morphometrics

<u>Ratio = width/length</u>

Method of measurement (taken from exterolateral view, see Figure 21):
Width = base width, adjacent to tibia (next to articulation membrane).
Length = ventral length, adjacent to tibia (next to articulation membrane) to terminus below internal pedal spur.
Number of primary ventral setae (PVS) and primary exteroventral setae (PEVS) and their composition.

***Catalinia*:**

C. andreas: 0.261, 2; 2
C. castanea: 0.293, 2; 2
C. minima: 0.268, 2; 2
C. thompsoni: 0.288, 2; 2
0.261–0.293 (0.278) PVS = 2, short and stout; PEVS = 2, short and stout.

"*apacheanus*" group

P. apacheanus: 0.240, 3, 2, 3, 3, 2 (2.6); 2 Note, third PVS is reduced in size.
P. brysoni: 0.254, 2; 2
P. kremani: 0.220, 2; 2 (3?)
P. santarita: 0.245, 2; 2
0.220–0.254 (0.240) PVS = 2-3 (2), short and stout; PEVS = 2, short and stout.

***Graemeloweus*:**

G. glimmei: 0.225, 4; 3
G. iviei: 0.223, 4; 3
G. maidu: 0.224, 4; 3
0.223–0.225 (0.224) PVS = 4, elongated and thin; PEVS = 3, elongated and thin.

***Kovarikia*:**

K. angelenus: 0.211, 5; 5
K. bogerti: 0.230, 5; 4
K. williamsi: 0.235, 5; 4
0.211–0.235 (0.225) PVS = 5, elongated and thin; PEVS = 4–5, elongated and thin.

MVD %	"*apacheanus*" group	*Graemeloweus*	*Kovarkia*
Catalinia	**15.8**	**24.1**	**23.6**
"*apacheanus*" group	-	7.1	6.7
Graemeloweus	-	-	0.4

Catalinia mean value separation from the other three genera is significant, ranging from 15.8 to 24.1 percent.

Basitarsus PVS Stoutness Factor

Below we present data that establishes the *relative stoutness* of the setae comprising the primary ventral setae (PVS) of the genera and species groups discussed in this paper. The stoutness factor is calculated by dividing the base width of the seta by its length. All setae are considered as shown in Figures 22–23. We present the stoutness factor for each species and also combined for each genus and species group. Finally, the MVD percentage is shown between the genera and species groups.

Catalinia

C. andreas: 0.158–0.165 (0.161) (±0.005) [2]
C. castanea: 0.119–0.119 (0.119) [1]
C. minima: 0.123–0.150 (0.137) (±0.019) [2]
C. thompsoni: 0.127–0.133 (0.130) (±0.005) [2]
***Catalinia*: 0.119–0.165 (0.139) (±0.018) [7]**

"*apacheanus*" Group

P. apacheanus: 0.074–0.144 (0.109) (±0.049) [2]
P. santarita: 0.120–0.143 (0.131) (±0.016) [2]
***P.* "*apacheanus*" group: 0.074–0.144 (0.120) (±0.033) [4]**

Graemeloweus

G. glimmei: 0.082–0.092 (0.087) (±0.004) [4]
G. iviei: 0.050–0.083 (0.063) (±0.0142) [4]
***Graemeloweus*: 0.050–0.092) (0.075) (±0.016) [8]**

Kovarikia

K. bogerti: 0.044–0.058 (0.053) (±0.006) [5]
K. williamsi: 0.050–0.075 (0.058) (±0.010) [5]
***Kovarikia*: 0.044–0.075 (0.055) (±0.008) [10]**

	MVD %		
	"*apacheanus*" group	***Graemeloweus***	***Kovarkia***
Catalinia	**15.8**	**85.3**	**152.7**
"*apacheanus*" group	-	60.0	118.2
Graemeloweus	-	-	36.4

This data shows that *Catalinia* and the "*apacheanus*" group clearly have the stoutest setae in the PVS series exhibiting a MVD range of 60 to 153 %. *Catalinia* has the stoutness setae of the two, showing a 15.8 MVD %. Clearly, the PVS setae are much longer and thinner in genera *Graemeloweus* and *Kovarikia*.

Pectinal Tooth Count Ranges

	Male	Female
C. andreas:	9–11 (9.900) (±0.738) [10]	7–9 (8.583) (±0.669) [12]
C. castanea:	10–12 (11.000) (±0.535) [8]	10–10 (10.000) (±0.000) [2]
C. minima:	10–11 (10.500) (±0.535) [8]	9–10 (9.500) (±0.577) [4]
C. thompsoni:	10–11 (10.833) (±0.408) [6]	10–11 (10.071) (±0.267) [14]

The pectinal tooth count data presented above are based on specimens examined as well as data reported by Gertsch & Soleglad (1972).

Hemispermatophore Morphometrics

Morphometric Ratios

	Lamellar_Hook_L / Lamina_L	Trough_Diff / Lamellar_Hook_L
C. andreas:	0.414	0.397
C. castanea:	0.507	0.407
C. minima:	0.473	0.394
C. thompsoni:	0.437	0.452
Catalinia	**0.414–0.507 (0.458)**	**0.394–0.452 (0.413)**

See Soleglad & Fet (2008: fig. 40) for methods of measurement of the three substructures used in the morphometric ratios.

Appendix C
Genus *Catalinia* Locality and Altitude Data

This Appendix presents the data used in the construction of the *Catalinia* map in Figure 28. The locality descriptions are from Gertsch & Soleglad (1972), Bryson et al. (2013), and field trips by Ayrey, Graham, and Soleglad. It must be noted that in many cases, the latitude/longitude (and derived altitudes from these positions) were based solely on the locality descriptions as provided by the authors, in particular Gertsch & Soleglad (1972) who provided a large majority of the locality data.

Latitude, longitude, and altitude (meters/feet) are presented as follows: (latitude, -longitude/meters, feet).

Data from Gertsch & Soleglad (1972: 589, 600, and 603)

C. minima: TYPE DATA: Female lectotype and male and female paratypes from San Pedro, Los Angeles County, California, (33.718, -118.298/73.399, 240.812) in the zoologisches Museum, Universitat Hamburg, Hamburg, Germany. California: Los Angeles County: Avalon, Santa Catalina Island, July 24, 1961 (V. and B. Roth), male: (33.342, -118.327/5.619, 18.435); San Clemente Island: April 10, 1923 (P. Needham), two males, three females, November 17, 1962 (D. Sanchez), male from Indian midden, August 11, 1968 (D. G. Marqua) (32.980, -118.540/16.523, 54.208) female from Nots Pier area, February, 1969 (T. Cooke), eight males. (32.980, -118.540/16.523, 54.208).
C. thompsoni: TYPE DATA: Female holotype from Anacapa Island, Ventura County, California, (34.005, -119.393/28.414, 93.222) April 11, 1968 (M. Thompson), in the American Museum of Natural History.
RECORDS: California: Ventura County: Anacapa Island: (34.005, -119.393/28.414, 93.222) April 11, 1968 (M. Thompson), male, immature; July 18, 1968 (M. Thompson), female. Santa Barbara County: Santa Cruz Island: (34.019, -119.684/65.591, 215.194) August 17, 1968 (M. Thompson), male; August 20, 1968 (M. Thompson), male; no further data, female in San Diego Museum of Natural History; Prisoner's Harbor, (34.019, -119.684/65.591, 215.194) March 14, 1969 (J. T. Doyen), male, two females from under bark; Canada de la Cuesta, (unknown) March 15, 1969 (J. Powell), female from under oak bark; Santa Rosa Island, (33.987, -120.050/ 211.130, 692.684) female in San Diego Museum of Natural History.
C. castanea: TYPE DATA: Female holotype from Santee, San Diego County, California, (32.835, -116.973/106.760, 350.263) January 28, 1965 (Marion Keaher), from house, in San Diego Natural History Museum. OTHER RECORD: California: San Diego County: Vista, (33.180, -117.232/174.629, 572.929) April, 1965 (Mrs. Philip Sampson), female.
C. andreas: TYPE DATA: Female holotype from Andreas Canyon, off Palm Canyon, 4 mi. S Palm Springs, Riverside County, California, (33.763, -116.537/178.702, 586.292) March 26, 1960 (W. J. Gertsch, W. Ivie, R.Schrammel), in the American Museum of Natural History.
RECORDS: California: San Diego County: Mission Gorge, 1 mi. W Padre Dam, (32.839, -117.064/184.720, 606.036), July 7, 1969 (S. C. Williams, V. F. Lee), male, female; 1 mi. E San Ysidro, (32.555, -117.028/149.977, 492.049) near sea level, December 31, 1966 (S. C. Williams), male from under rock on chaparral hillside; 25 mi. E San Diego, off highway 8, (32.840, -116.772/593.293, 1946.499) August 23, 1970 (M. Soleglad), males, females; 1 mi. N Santee, (32.850, -116.973/106.069, 347.995) September, 18, 1970 (C. S. and M. E. Soleglad, J. and J. Springer), two females. Riverside County: Andreas Canyon, off Palm Canyon, 4 mi. S Palm Springs, (33.763, -116.537/178.702, 586.292) March 26, 1940 (W. J. Gertsch, W. Ivie, R. Schrammel), three males, 15 females, some not fully mature. Baja California: 1 mi. W La Rumarosa, (32.520, -116.091/1294.953, 4248.535) 4800 ft., July 17, 1969 (S. C. Williams), male, 6 mi. N La Mission, (32.149, -116.887/93.043, 305.258) 200 ft., July 14, 1969 (S. C. Williams), male, female; 16 mi E Ensenada, (31.892, -116.305/694.580, 2278.804) 2000 ft., July 15, 1969 (S. C. Williams), female; 11 mi. SE Ojos Negros, (31.856, -116.102/914.914, 3001.687) 3500 ft., July 15, 1969 (S. C. Williams, V. F. Lee), female. Sierra Juarez: (32.396,-115.924/1477.358, 4846.976), 9 mi. N Rancho El Topo, (32.362, -116.034/1450.172, 4757.781), July 16, 1969, female; 5 mi. N Rancho El Topo, (32.324, -116.013, 1479.976, 4855.565), male; 6 mi. N Rancho El Topo, (32.324, -116.013/1479.976, 4855.565) July 16, 1969, female (all S. C. Williams, V. F. Lee).

Bryson et al (2013: fig. 2)

C. castanea: Oceanside, CA: (33.194, -117.376/24.242, 79.534), Carlsbad, CA: (33.158, -117.346/16.689, 54.753).

C. andreas: Banner Canyon, CA: (33.015, -116.528/1109.344, 3639.578), Mission Trails, CA, (32.828, -117.061/126.142, 413.853), Penasquitos, CA, (32.967, -117.100/193.587, 635.130), Rosarito, Baja, (32.364, -117.062/16.609, 54.491).

R. F. Ayrey Field Trips

C. minima: Hermit Trail, Avalon, Santa Catalina Island, California, (33.329, -118.342/256.525, 841.619).

M. R. Graham Field Trips

C. andreas: Escondido, CA, (33.188, -117.080/203.234, 666.778).

M. E. Soleglad Field Trips

C. castanea: Vista, San Diego Co., California, USA, (33.180| -117.232/174.629, 572.929).
C. andreas: ABDSP: LaGuna Mountains, Kwaaymii Point, 0.1 mi. off S1, (32.935, -116.483/1669.693, 5477.994), ABDSP: Chariot Canyon, 4.3 mi. S. Banner (HWY-78), (33.015, -116.528/1109.344, 3639.578), ABDSP: Pacific Crest Trail off Chihuahua Road, 11.1 mi. E. HWY-79, (33.386, -116.665/1313.860, 4310.566).