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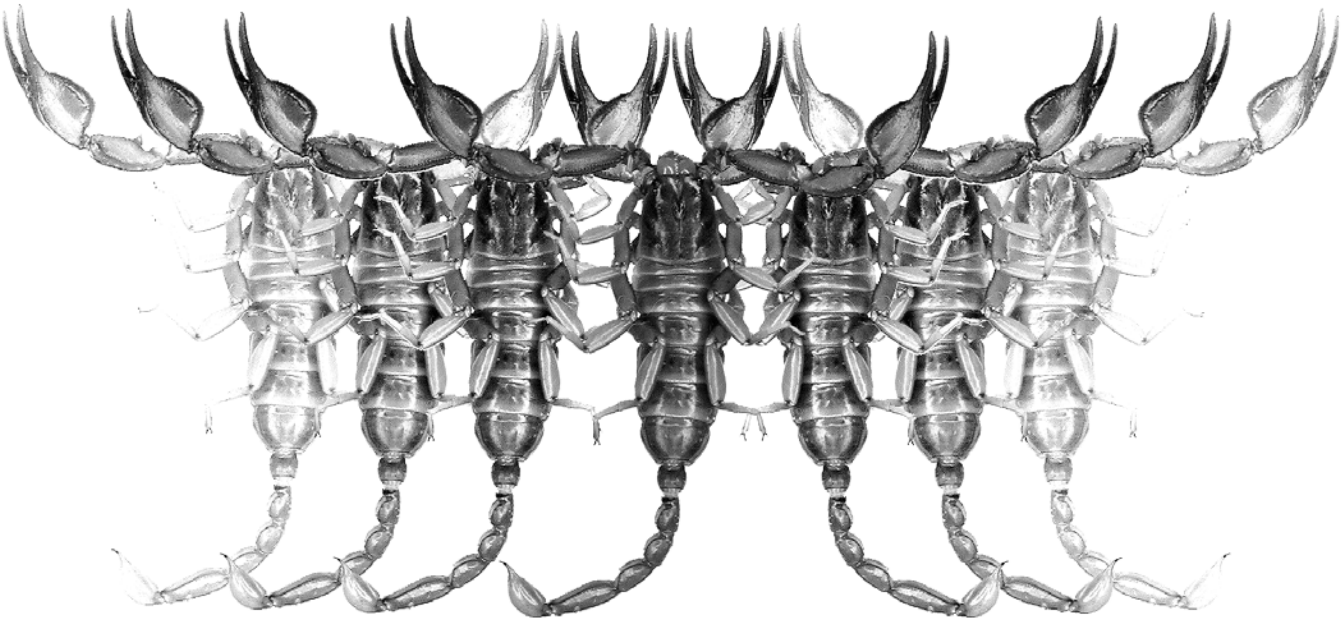

The Genus *Auyantepuia* González-Sponga, 1978 is Confirmed as a Synonym of *Broteochactas* Pocock, 1893 (Scorpiones: Chactidae)

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The genus *Auyantepuia* González-Sponga, 1978 is confirmed as a synonym of *Broteochactas* Pocock, 1893 (Scorpiones: Chactidae)

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Summary

The genus *Auyantepuia* González-Sponga, 1978 is confirmed as a synonym of *Broteochactas* Pocock, 1893 (Scorpiones: Chactidae). It was correctly synonymized with *Broteochactas* by Francke & Boos (1986) and listed as such by Soleglad & Fet (2003) but resurrected by Lourenço & Araújo (2004). We reconfirm that the generic name *Auyantepuia*, based on the type species *Broteochactas scorzai* Dagert, 1957 from Venezuela, is a synonym of *Broteochactas*, based on the type species *Broteochactas nitidus* Pocock, 1893 from Trinidad. All other seven "short-fingered" species from French Guiana and Brazil, classified by Lourenço & Araújo (2004) under *Auyantepuia*, belong to the genus *Neochactas* Soleglad et Fet, 2003, based on the type species *Broteochactas laui* Kjellesvig-Waering, 1966. Additional new information on these genera is provided, based, in part, on the analysis of type specimens of *Broteochactas nitidus* Pocock, 1893, *B. porosus* Pocock, 1900, *B. gollmeri* (Karsch, 1879), *Neochactas parvulus* (Pocock, 1897), and *N. granosus* (Pocock, 1900).

Introduction

In our detailed cladistic revision of the family Chactidae (Soleglad & Fet, 2003), two subtribes of the tribe Brotheini, namely Brotheina and Neochactina, were established on the basis of important trichobothrial characters (*est–esb–eb* patterns on pedipalp chela fixed finger, etc.). When González-Sponga (1978) created genus *Auyantepuia* to distinguish species *Broteochactas scorzai* from other species of *Broteochactas*, he used, in part, the primary diagnostic character of the two Brotheini subtribes. In particular, González-Sponga attributed the pattern we defined, in part, for subtribe Brotheina, to his new, monotypic genus *Auyantepuia*.

Francke & Boos (1986) discussed González-Sponga's result and dismissed it because the character was not consistent across species of *Broteochactas.* They, however, examined several species that belonged to both the Neochactina and Brotheina subtribes (*sensu* Soleglad & Fet, 2003). Francke & Boos's logic for rejecting *Auyantepuia* was not particularly sound here, since González-Sponga created the new genus to accommodate these distinctions. However, whether or not one accepts Francke & Boos's reason for rejecting *Auyantepuia*, the point is mute because the type species of the genus *Broteochactas* Pocock, 1893 is *Broteochactas nitidus* Pocock, 1893. Francke & Boos (1986) redescribed *B. nitidus*, based on a lectotype designated by them. Since this type species exhibited the *same pattern* as attributed to *Auyantepuia* by González-Sponga (and the entire subtribe Brotheina), Soleglad & Fet (2003) regarded *Auyantepuia* indeed as a synonym of *Broteochactas*. This, in turn, required that those species of *Broteochactas* that González-Sponga contrasted with *Auyantepuia* must be placed in a different genus. Soleglad & Fet (2003) achieved this by establishing the new genus *Neochactas*, which becomes the type genus for a monotypic subtribe, Neochactina. Soleglad & Fet (2003) in detail discussed the reallocation of species of the tribe Brotheini necessitated by this change. In fact, most of the former *Broteochactas* species had to be transferred to *Neochactas*. Sissom (2000) listed 37 species under *Broteochactas*. Soleglad & Fet (2003), however, listed only 12 species under *Broteochactas*, while *Neochactas* included as many as 36 species.

Just recently, Lourenço & Araújo (2004) resurrected the genus *Auyantepuia* and listed eight species in this genus (one moved from *Broteochactas*, six from *Neo-*

chactas, and one new species, also a member of *Neochactas*). In addition to the type species, *Auyantepuia scorzai*, Lourenço & Araújo (2004) returned to *Auyantepuia* three species originally described in this genus by Lourenço (1983), namely, *Neochactas gaillardi*, *N. fravalae*, and *N. sissomi*; formally moved to *Auyantepuia* also *N. parvulus* Pocock, 1897 from Brazil; *N. kelleri* Lourenço, 1997 from French Guiana; *N. skuki* Lourenço et Pinto-da-Rocha, 2000 from Brazil; and described a new species, *Auyantepuia mottai* Lourenço et Araújo, 2004 from Brazil.

In making these taxonomic changes, Lourenço & Araújo (2004) ignored the revision of Soleglad & Fet (2003) completely, not addressing *any* of the salient characters used in their revision — characters that must be considered before any revision could be contemplated. Below, we briefly restate the phylogenetic characters germane to this discussion as established originally by Soleglad & Fet (2003) and then analyze, in detail, the "diagnostic" characters offered by Lourenço & Araújo (2004), demonstrating that their resurrection of *Auyantepuia* is clearly without merit.

Brief history of *Auyantepuia*

The severe lack of understanding of the importance of trichobothrial characters (as well as tarsal spination) for systematics of Chactidae has been especially obvious in the past decades. Vachon (1974) illustrated only a few chactid patterns, and did not elaborate on neobothriotaxy. The chactid nature of the important genera *Belisarius*, *Anuroctonus*, and *Uroctonus* has not been understood before the work of Soleglad & Fet (2003). The subfamily/tribe/subtribe division applicable especially to the South American Brotheinae was also first suggested by Soleglad & Fet (2003). At the same time, a number of characters has been applied in the attempts to outline boundaries of genera, often in a non-consistent way, and sometimes even to justify a certain preconceived biogeographic model.

Notwithstanding the synonymy of Francke & Boos (1986), González-Sponga (1996) continued to address *Auyantepuia* as a valid monotypic genus (but *only* as applied to *A. scorzai*, the only species from Venezuela ever listed under this generic name — other species listed under *Auyantepuia* were described from French Guiana and Brazil). The diagnosis and key for *Auyantepuia* given by González-Sponga (1996) appear to be inconsistent with each other, and with the original diagnosis of González-Sponga (1978). In a key to a so-called "*Brotheas*" group of genera from Venezuela, González-Sponga (1996: 59) characterized *Auyantepuia* as having "ventroexternal carina of chela displaced to medioventral position; two rows of setae ventrally on telotarsus; size not larger than 20 mm". These characters had to distinguish *Auyantepuia* from the Venezuelan species of *Broteochactas* and *Taurepania* (the latter genus is now also considered a synonym of *Broteochactas*), which all had a "normal" position of ventroexternal carina of chela, numerous irregular setae ventrally on telotarsus and size larger than 20 mm. Apart from size, which is hardly a generic diagnostic character, *Auyantepuia* was diagnosed in this key only by two characters: position of a carina and telotarsal setation (tarsal in terminology of Soleglad & Fet, 2003). No trichobothrial characters were used in this key.

In the diagnosis of the genus *Auyantepuia* given by González-Sponga (1978: fig. 92; 1996: 60, fig. 104), the partial displacement of the ventroexternal (*V1*) carina to the ventral surface is again given as a diagnostic character. In his fig. 104 we see that the *V1* carina curves a little towards the ventral surface, but there is nothing particularly exceptional in its position as compared to other species: the ventral trichobothria V_3-V_4 and Eb_1 are oriented to this carina as is seen in other related species, and the carina terminates distally to the external condyle of the movable finger, characteristic of this chactid subfamily. *B. scorzai* has extremely short chelal fingers and a somewhat fat and round palm, probably attributing to this perceived character which is clearly a species-level characteristic at most.

The ventral tarsal spination was illustrated for *Auyantepuia* by González-Sponga (1996, figs. 105 and 106) as two clear rows of setae (as stated in the key); however it (probably erroneously) was addressed as "numerous irregular setae" ("abundantes cerdas distribuidas irregularmente"), as opposed to the key statement. In the diagnosis of *Broteochactas*, González-Sponga (1996: 74) repeats the same statement "numerous irregular setae" but his illustrations (figs. 147 and 148) are not convincing: they could as well depict two setal rows. Soleglad & Fet (2003) discussed in detail the tarsal spination across Chactidae, especially since it was a synapomorphy diagnostic for subfamily Brotheinae. Two rows of large setae, with numerical variations, are indeed present not only in all *Broteochactas* and *Neochactas*, but also in *Hadrurochactas*, *Brotheas*, and even *Belisarius* (Soleglad & Fet, 2003, fig. 39).

Note that the trichobothrial pattern of the chela was very well illustrated in González-Sponga, 1996, fig. 109 for *Auyantepuia*; and figs. 150, 153, 156, 159, 162, 165, 168, 171, 174, 177, 180, 183, 186, 189, 192, 195, 198, 201, 203, 207, 210 for not less than 21 species listed under *Broteochactas*! However, no analysis of this trichobothrial pattern was conducted, and no trichobothrial characters were used by González-Sponga (1996) to diagnose *Auyantepuia*. Most of the species listed under *Broteochactas* by González-Sponga (1996) were moved to the new genus *Neochactas* by Soleglad & Fet (2003).

All this confusion indeed made it difficult to apply any definition of the genus *Auyantepuia* to other species, especially in the description of new ones. As demonstrated above, the only character distinguishing *Auyantepuia* in the sense of González-Sponga, 1996 from *Broteochactas* in the sense of González-Sponga, 1996, was allegedly the (apomorphic?) displaced position of ventroexternal carina of chela. The generic name *Auyantepuia* has been used several times between 1978 and 1986 for *Broteochactas scorzai* Dagert, 1957 (González-Sponga, 1980, 1984; Lourenço, 1983).

Moreover, three new species, *Auyantepuia gaillardi*, *A. fravalae*, and *A. sissomi*, were described from French Guiana by Lourenço (1983) and assigned to this genus. Lourenço (1983: 780) indicated that the separation of the genera outlined by González-Sponga (1978) (*Auyantepuia, Broteochactas, Hadrurochactas, Vachoniochactas, Taurepania*) was problematic, but at the same time described three new species assigning them to *Auyantepuia.* As characters distinguishing his three new species from *A. scorzai*, Lourenço (1983) listed: distance between median eyes, number of lateral eyes, carination and granulation of metasoma segments IV and V, and morphometric variation. No trichobothrial patterns were analyzed, although the clearly depicted chela patterns (figs. 34, 40, 49, 56) allowed Soleglad & Fet (2003: 102) to assign all these three species to the genus *Neochactas* (while *Auyantepuia scorzai*, the type species of *Auyantepuia*, was assigned to *Broteochactas*). It is clear from the perusal of Lourenço (1983) that no attempt has been made by this author to investigate the possible validity of *Auyantepuia*. Three species described in 1983 from French Guiana were not characterized by *any* shared characters (synapomorphies), which would qualify them as belonging to a monophyletic group of species, a subgenus, or a genus. Possibly the only resemblance between these three species and *A. scorzai* was their small size and short-fingered chela of the pedipalp.

After the synonymization of *Auyantepuia* by Francke & Boos (1986), Lourenço (1986a, 1986b, 1991, 1997) used the combinations *Broteochactas scorzai*, *B. gaillardi*, *B. fravalae*, and *B. sissomi.* At the same time, he maintained (Lourenço, 1986a, 1986b) that these four species indeed belong to the same informal "group "*Auyantepuia*"" and used this species group name effectively as a systematic unit in discussion of biogeography. He stated (Lourenço, 1986a: 233; 1986b: 564) that the synonymized genera (*Auyantepuia*, *Taurepania*, *Hadrurochactas*, *Vachoniochactas*) "correspond to unique species groups or maybe subgenera". Moreover, Lourenço (1986a: 233; 1986b: 565) listed an additional species in his "*Auyantepuia* group", *Broteochactas parvulus* Pocock, 1897 from Brazil, without any justification and without the listing of *any* characters either pertaining to this species or this species group. Our analysis of the lectotype of *Broteochactas parvulus* show that it belongs to *Neochactas*, as already stated by Soleglad & Fet (2003). Whether this species forms a monophyletic group with three *Neochactas* species described by Lourenço (1983) from French Guiana, remains to be seen.

In the same fashion, Lourenço (1991: 116–117) used the "*Auyantepuia* group" in his review of the Guianan biogeographic province and centers of endemism; this time he included into this group three species from French Guiana only (*B. gaillardi*, *B. fravalae*, and *B. sissomi*) but not *B. parvulus*, which is mentioned on p. 117 without any reference to "*Auyantepuia* group". Lourenço (1997) described a new species from French Guiana, *Broteochactas kelleri*, with a statement (p. 597) that it belongs to the "*Auyantepuia* species group as defined by Lourenço (1986[b])". This statement is, however, misleading, since in 1986 papers Lourenço did not provide any *definition* of this group but only listed five species as belonging to it. From the aside statement in Lourenço (1997: 597) that "this species has a small size as all species of this group" we assume that small size was given a taxonomic value – no other characters were given. Lourenço & Pinto-da-Rocha (2000) described another new species from Brazil, *Broteochactas skuki*, also with a statement (p. 260) that it "can be included in the "*Auyantepuia*" species group as defined by Lourenço (1986[b])". Again, however, this group was never defined.

This usage of "*Auyantepuia* group" and other species groups within *Broteochactas* by Lourenço (1986a, 1986b, 1991, 1997) and especially biogeographic implications of disjunct distribution require independent proof of monophyly for such groups, but this monophyly was never demonstrated. Soleglad & Fet (2003) confirmed the synonymy of *Auyantepuia*, *Taurepania* and *Guyanochactas* with *Broteochactas.* At the same time, they separated many species formerly classified in this genus into *Neochactas*, characterized by a very different trichobothrial arrangement.

Therefore, existence of any natural (monophyletic) groups of species within *Broteochactas* was never investigated or confirmed before the work of Soleglad & Fet (2003). The only attempt to assign species groups in *Broteochactas* was done by González-Sponga (1980: 40) who briefly discussed existence of two groups of *Broteochactas* species in Venezuela, one including six species with punctated tegument (*B. bilbaoi, B. garciai, B. granosus, B. panarei, B. sanmartini*, and *B. santanai*) and another, eight species with smooth tegument (*B. bruzuali, B. eliasilvai, B. efreni, B. gollmeri, B. kjellesvigi, B. orinocensis, B. racenisi* and *B. simarawochensis*). These groups were not mentioned later by González-Sponga (1996). In current terms, these two groups are unequally divided among two genera belonging to two different subtribes: *Broteochactas* and *Neochactas*. Namely, *Broteochactas gollmeri* is the confirmed member of *Broteochactas*; other 13 species belong to *Neo-*

chactas (Soleglad & Fet, 2003: 100, 102). Therefore the variability in punctation does not appear to be a reliable taxonomic character at any level above species.

Methods & Material

Terminology and conventions

Terminology describing pedipalp chelal ornamentation follows that described and illustrated in Soleglad & Sissom (2001). Terminology for the pedipalp patella follows that described in Soleglad & Fet (2003).

Abbreviations

List of depositories: BMNH, Natural History Museum, London, United Kingdom; CAS, California Academy of Sciences, San Francisco, California, USA; MES, Personal collection of Michael E. Soleglad, Borrego Springs, California, USA; MZUF, Museo Zoologico "La Specola" dell'Universita de Firenze, Florence, Italy; VF, Personal collection of Victor Fet, Huntington, West Virginia, USA; WDS, Personal collection of W. David Sissom, Canyon, Texas, USA; ZMB, Museum für Naturkunde der Humboldt-Universität Berlin, Berlin, Germany.

Material examined

The following scorpions of the family Chactidae were examined in this study for either structure analysis and/or illustration. The family assignment is after Soleglad & Fet (2003). The genus assignments presented below, in alphabetical order, are based on Soleglad & Fet (2003) as well as on the taxonomic changes established in this paper. See this section for locality data of species-level illustrations. See the *Taxonomy* section for lectotype designations.

Anuroctonus phaiodactylus (Wood, 1863), Oneida Co., Idaho, USA, ♂ (MES), Beaver Co., Utah, USA, ♂ (MES), Tooele Co., Utah, USA, ♂ and ♀ (CAS); *Anuroctonus pococki bajae* Soleglad et Fet, 2004, Anza-Borrego Desert State Park, California, USA, ♂ (MES); *Belisarius xambeui* Simon, 1879, Vidra, Girona, Catalunya, Spain, ♀ (WDS), Fogars de Monclús, Montseny, Barcelona, Catalunya, Spain, ♀ (VF), Vall d'en Bas, Girona, Catalunya, Spain, ♀ (VF); *Broteochactas gollmeri* (Karsch, 1879), Caracas, Venezuela, 1 ♀ lectotype, 1 ♀ paralectotype (ZMB); *Broteochactas nitidus* Pocock, 1893, Trinidad, ♂ lectotype (BMNH); *Broteochactas porosus* Pocock, 1900, Mt. Roraima, Venezuela [originally listed as British Guiana, now Guyana], 1 ♂ lectotype, 1 ♂ paralectotype (BMNH); *Brotheas granulatus* Simon, 1877, Grande Île, French Guiana, ♀ (MES); *Chactas exsul* (Werner, 1939), Darién, Panama, ♂ and ♀ (MES); *Hadrurochactas schaumii* (Karsch, 1880), Petite Île, French Guiana, ♂ (MES); *Neochactas delicatus* (Karsch, 1879), British Guiana, now Guyana, 1 ♀ lectotype, 1 ♀ paralectotype (ZMB), [=*Broteas panamensis* Thorell, 1894, ♀ holotype, Panama, (MZUF)], [=*Chactas opacus* Karsch, 1894, 1 ♂ lectotype, 1 ♂ paralectotype), Brazil, (ZMB)], Grande Île, French Guiana, ♂ (MES); *Neochactas granosus* (Pocock, 1900), Mt. Roraima, Venezuela [originally listed as British Guiana, now Guyana], ♂ holotype (BMNH); *Neochactas parvulus* (Pocock, 1897), Santarém, Brazil, ♀ lectotype (BMNH); *Nullibrotheas allenii* (Wood, 1863), Cabo San Lucas, Baja California Sur, Mexico, ♂ and ♀ (MES), Los Planes, Baja California Sur, Mexico, ♂ (MES); *Teuthraustes oculatus* Pocock, 1900, Latacunga, Ecuador, ♀ (WDS); *Uroctonus mordax mordax* Thorell, 1876, Yosemite National Park, California, USA, ♂ and ♀ (MES), Weott, California, USA, ♂ (MES); *Uroctonus mordax pluridens* Hjelle, 1972, Santa Clara Co., California, USA, ♂ (MES); *Vachoniochactas* sp., Alto Rio Mavaca, Amazonas, Venezuela (CAS).

Systematics

Soleglad & Fet (2003) conducted a detailed cladistic analysis of Recent scorpions. In particular, this analysis addressed high-level systematics in order to ascertain the phylogenetic placement of the relic scorpion *Pseudochactas ovchinnikovi* Gromov, 1998 (family Pseudochactidae). The result of this analysis was the establishment of four parvorders that partition all Recent scorpions. In addition, a second goal of their analysis was the phylogenetic revision of the chactoid family Chactidae, which is germane to this discussion. We briefly outline the salient results of this analysis which specifically relates to the subject of this paper, the synonymy of *Auyantepuia*.

Current Chactidae *systematics*

With respect to trichobothrial patterns, the clade Euscorpiidae + Chactidae is distinguished (i.e., synapomorphies) by the placement of chelal trichobothrium *it* on the palm and the dorsal (= outer) angling of the *est–esb–eb* juncture (i.e., *eb* situated close to finger inner edge). The latter synapomorphy is of particular relevance to this discussion since it is key, in part, in differentiating the two subtribes of brotheine tribe Brotheini. Figure 1 shows the arrangement of the *eb–et* series of the chelal finger illustrating representative species spanning families Euscorpiidae and Chactidae. As can be seen from the illustrated examples, the *est–esb–eb* juncture forms essentially a right to obtuse angle, trichobothrium *eb* positioned the closest to the fixed finger's inner edge. In the euscorpiids the *eb–et* series is

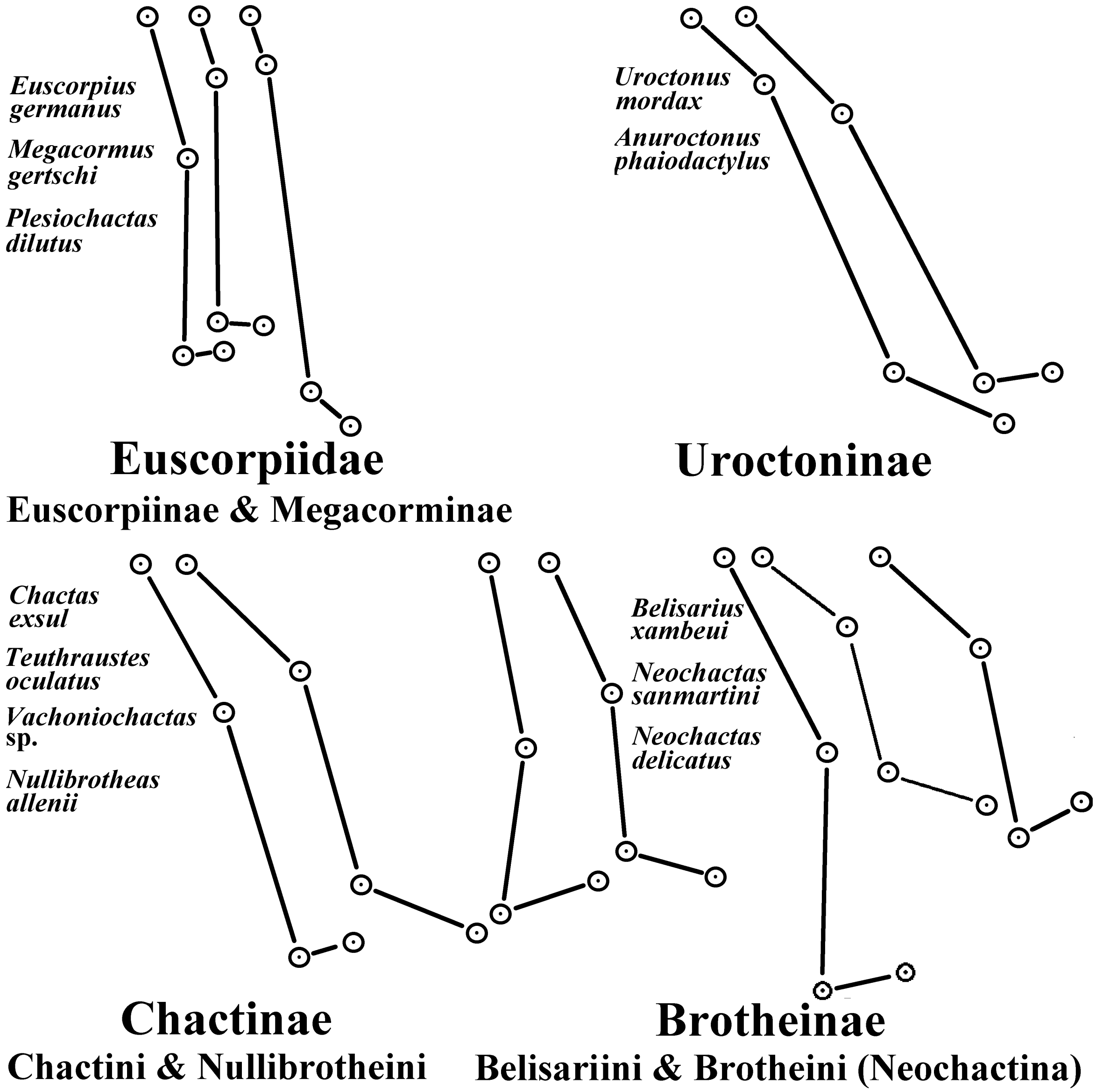


Figure 1: Pedipalp chelal trichobothrial patterns for series *eb–et* for chactoid families Euscorpiidae and Chactidae (in part). These figures illustrate the *est–esb–eb* juncture angling away from the fixed finger edge (i.e., *eb* is closest to the fixed finger edge), a demonstrated *synapomorphy* for Euscorpiidae + Chactidae (Soleglad & Fet, 2003). Specified species name lists are associated, from top to bottom, with patterns, left to right. Figures are from several sources, in part, (Vachon, 1974: fig. 229; Soleglad, 1976: figs. 72, 91; Soleglad & Fet, 2003: figs. 81–88; González-Sponga, 1996: fig. 153).

situated more distally on the fixed finger, while *eb*, although close to the inner finger edge, is not adjacent to the fixed/movable finger juncture. In the three subfamilies of Chactidae, however, *eb* is adjacent to the fixed/movable finger juncture, quite close to the articular membrane of the movable finger. There are three exceptions to this important pattern in the clade Euscorpiidae + Chactidae: (1) in Euscorpiidae (subfamily Scorpiopinae), the *eb–et* series is arranged essentially in a straight line, or, the *est–esb–eb* juncture angles towards the fixed finger edge (see Soleglad & Sissom, 2001: figs. 112–118); (2) in Euscorpiidae (subfamily Megacorminae, tribe Chactopsini), the *eb–et* series is straight and closely arranged on the extreme distal aspect of the fixed finger (see Vachon, 1974: fig. 190); and (3) in Chactidae (subfamily Brotheinae, tribe Brotheini, subtribe Brotheina) the *eb–et* series is arranged essentially in a straight line, or, the *est–esb–eb* juncture angles towards the fixed finger edge (see Soleglad & Fet, 2003: figs. 89–90, 118–123). What is quite interesting about these three separate exceptions to the *et–eb* alignment seen in Euscorpiidae + Chactidae (all considered as separate derivations, by the

	***Dt* / Palm_L**	***Db* / Palm_L**	***Dt* / *Est***
Broteochactas scorzai*	0.842	0.456	0.960
Broteochactas gollmeri*	0.845	0.380	1.000
Broteochactas nitidus*	0.863	0.431	1.000
Broteochactas venezuelensis	1.286	0.714	1.440
Broteochactas porosus	1.102	0.510	1.286
Brotheas cunucunumensis	1.286	0.714	1.440
Brotheas granulatus	1.056	0.472	1.152
Hadrurochactas schaumii	1.013	0.487	1.185
Hadrurochactas odoardoi	1.043	0.522	1.263
Min-max (mean)	0.842–1.286 (1.037)	0.380–0.714 (0.521)	0.960–1.440 (1.192)
Neochactas delicatus	0.825	0.213	0.904
Neochactas parvulus	0.632	0.211	0.774
Neochactas sarisarinamensis	0.607	0.143	0.739
Neochactas laui	0.818	0.273	1.000
Neochactas sanmartini	0.878	0.300	0.975
Neochactas granosus	0.808	0.282	0.984
Min-max (mean)	0.607–0.878 (0.761)	0.143–0.300 (0.237)	0.739–1.000 (0.896)

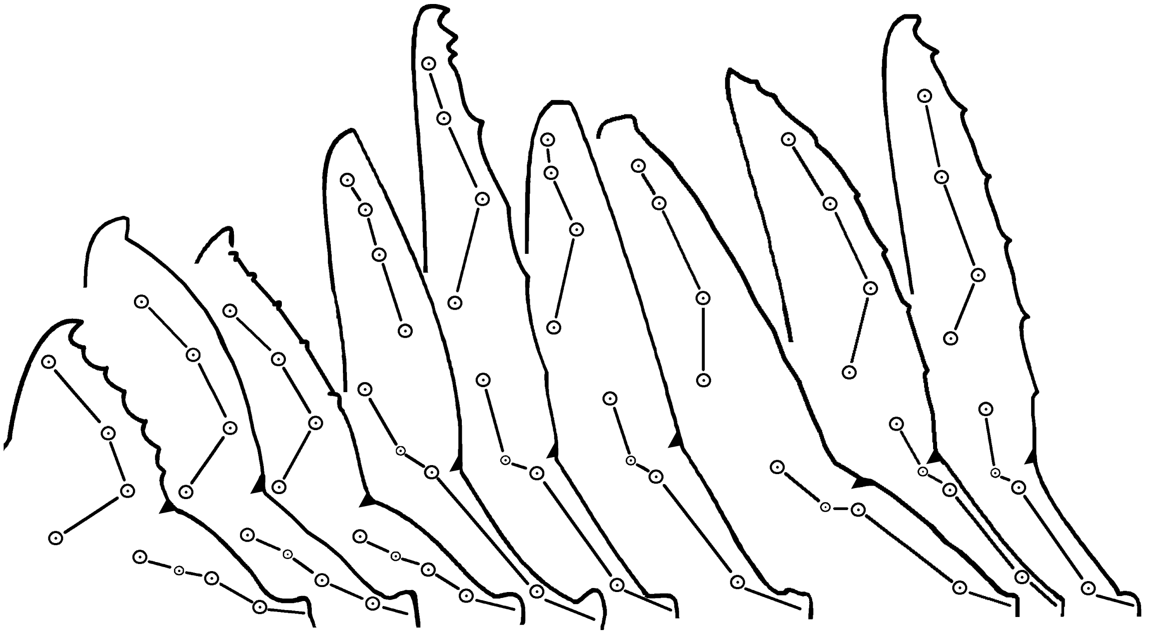
Table 1: Morphometric ratios of chelal trichobothrial series *Db–Dt* and *Est* with respect to the chelal palm length for representatives of subfamily Brotheinae (tribe Brotheini) subtribes Brotheina and Neochactina. *Dt*, *Db* and *Est* distance is measured from the trichobothrium to the proximal edge of the palm. **Note:** in Brotheina (except for short fingered species of *Broteochactas*) *Dt* is located on base of fixed finger, beyond distal edge of palm and distal to *Est*; and, *Db* is located beyond or at midpoint of palm. In contrast, for Neochactina, *Dt* is located on palm, never on fixed finger, and adjacent to or proximal of *Est*; and, *Db* is located considerably proximal of midpoint of palm. Also note, for all species, *Db* is more proximal on palm in Neochactina than *any* species of subtribe Brotheina (i.e., the min-max ranges do *not* intersect). * short fingered *Broteochactas* species.

way) is the tendency for other chelal trichobothria to exhibit a distal repositioning on the segment as well. For example, in the scorpiopines, tribe Scorpiopini, we see an unusual distal placement of trichobothrium Eb_3, which is of diagnostic importance to the genera of this tribe (Soleglad & Sissom, 2001: figs. 113–118). In genus *Chactopsis* (Megacorminae, Chactopini) several chelal trichobothria exhibit drastic distal dislocation, Et_3–Et_5, Eb_2–Eb_3, *Db–Dt*, and *it* (Vachon, 1974: figs. 190,192); and in the brotheines, tribe Brotheini, we see in subtribe Brotheina (all established as synapomorphies by Soleglad & Fet, 2003) that the *eb–et* series, which is situated distally, is either in a straight line or the *est–esb–eb* juncture angles towards the finger inner edge, the Et_2–Et_5 series is situated more distally on the palm, in many cases, Et_5, Et_4, and sometimes Et_3, are found on the fixed finger, and series *Db–Dt* is situated more distally on the palm. Soleglad & Fet (2003: 137) considered these three exceptions to the *eb–et* arrangement as separate derivations from the arrangement illustrated in Fig. 1 (their character-21). From this analysis, it is clear that subtribe Brotheina is the most recently derived lineage in subfamily Brotheinae.

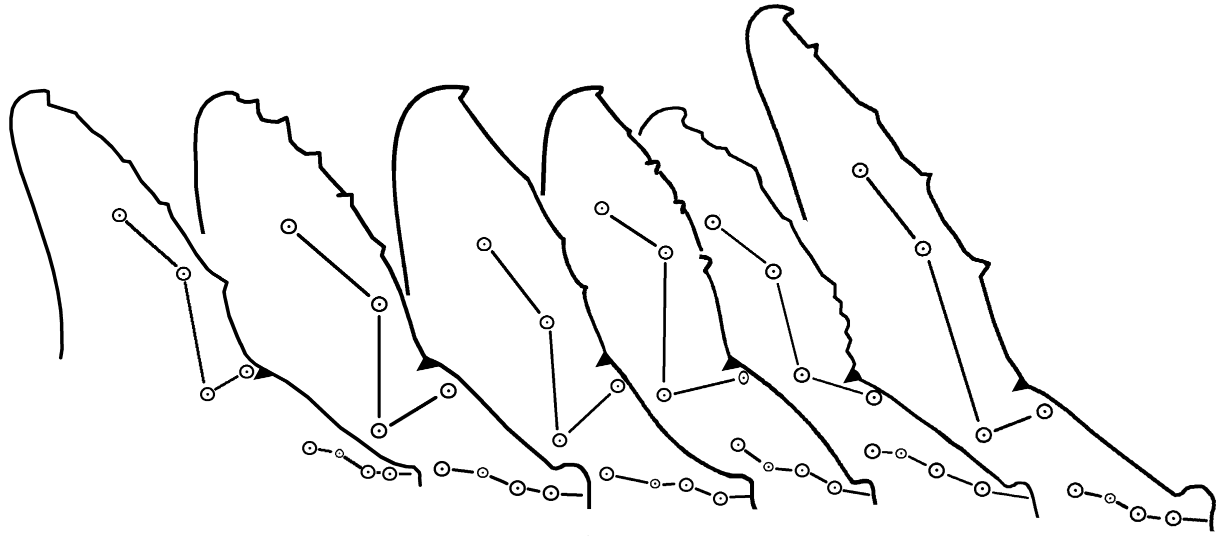
Validity of trichobothrial characters

The three characters contrasting subtribes Brotheina and Neochactina (i.e., characters 19 (state = 5), 21 (state = 1), and 22 (state = 1), Soleglad & Fet, 2003: 137) have been *validated* in a large majority of recognized species in the four genera comprising these two subtribes. Since these characters all deal with trichobothrial patterns, Soleglad & Fet (2003) were able to successfully partition the many species into the two defined subtribes (i.e., in most cases trichobothrial patterns were illustrated). Although much of this verification was based on literature illustrations, Soleglad & Fet (2003) did examine many genera and species spanning the entire Euscorpiidae + Chactidae complex. In this paper additional specimens, most all type specimens, were examined as well. Figures 3–5 illustrate the external aspect of the chela for three additional species spanning both subtribes which further illustrate the legitimacy of these characters; compare to the ample illustrations provided in Soleglad & Fet (2003: figs. 81–90, 118–125).

Fig. 2 and Tab. 1 illustrate these three synapomorphies for subtribe Brotheina as contrasted to Neochactina. Table 1 illustrates the significant positional differences in the *Db–Dt* series between the two subtribes using morphometric ratios. What must be stressed here and is clear from Fig. 2 and Tab. 1 (as was in Soleglad & Fet, 2003), one must factor in the attenuation of the fixed finger when comparing the distal-proximal location of these three trichobothrial series. It is clear that Lourenço & Araújo's (2004) diagnosis of *Auyantepuia* is affected by this attenuation as is seen in species with more elongated appendages (i.e., they only considered species with very short chelal fingers). Clearly, we cannot define genera based on simple morphometric-based characters such as "short fingers". We



Brotheina

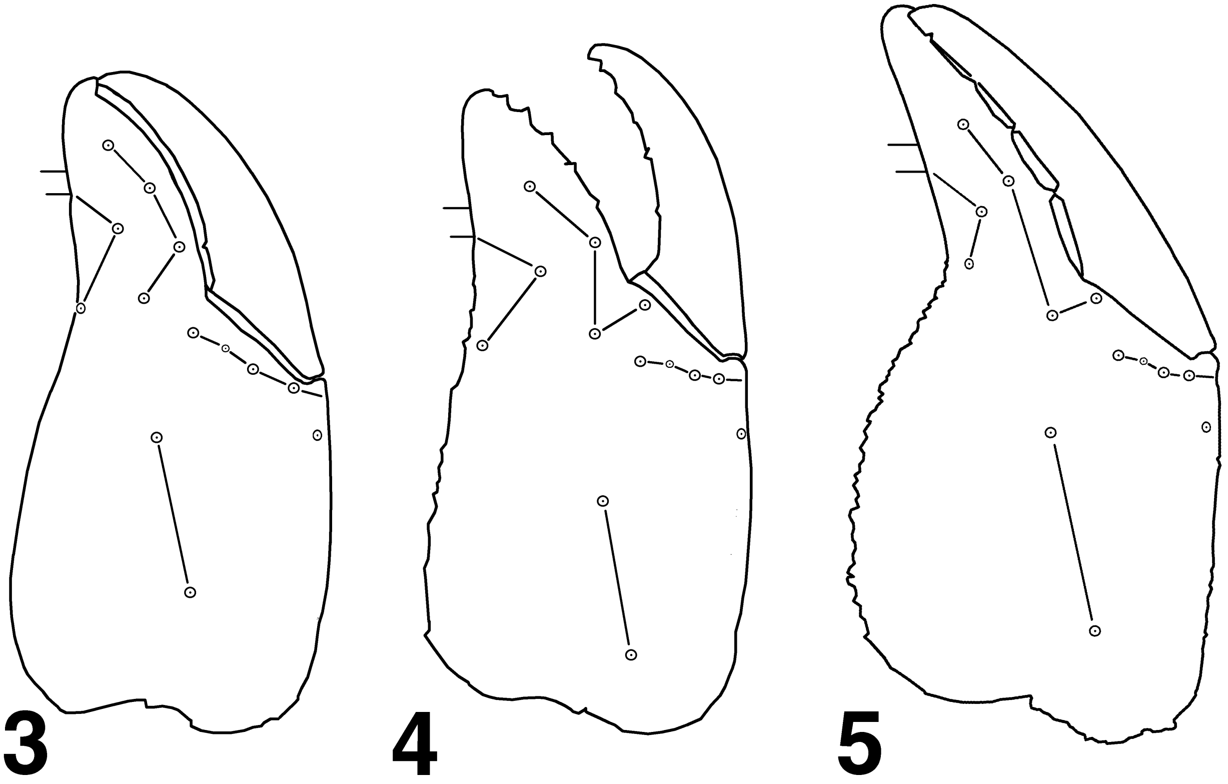


Neochactina

Figure 2: Chelal fixed finger showing the relative alignments of trichobothrial series *eb–et* and Et_2–Et_5 (Et_1 not shown) for subfamily Brotheinae (tribe Brotheini) subtribes Brotheina and Neochactina. **Brotheina,** left to right: *Broteochactas scorzai*, *B. gollmeri*, *B. nitidus*, *B. venezuelensis* and *B. porosus*; *Brotheas cunucunumensis* and *B. granulatus*; *Hadrurochactas schaumii* and *H. odoardoi*. **Neochactina**, left to right: *Neochactas delicatus*, *N. parvulus*, *N. sarisarinamensis*, *N. laui*, *N. sanmartini* and *N. granosus*. Black triangle depicts location of fixed finger/movable finger inner juncture.

see in Fig. 2 the complete spectrum from short fingered species, medium length fingered species, to long fingered species. In this progression, we see characters defined herein becoming more emphasized.

A matter of homology. An important issue for the primary diagnostic character separating the two subtribes of tribe Brotheini is the correct and consistent designation of trichobothria *esb* and *eb*. As stated in



Figures 3-5: Diagrammatic trichobothrial pattern of chela external surface (partial) of Brotheinae tribe Brotheini showing relative positions of trichobothrial series *eb–et*, *db–dt*, *Et*$_2$–*Et*$_5$ *Est* and *Db–Dt* for subtribes Neochactina and Brotheina (other trichobothria are *not* shown). **3.** *Broteochactas gollmeri* (lectotype). **4.** *Neochactas parvulus* (lectotype). **5.** *Neochactas granosus* (holotype).

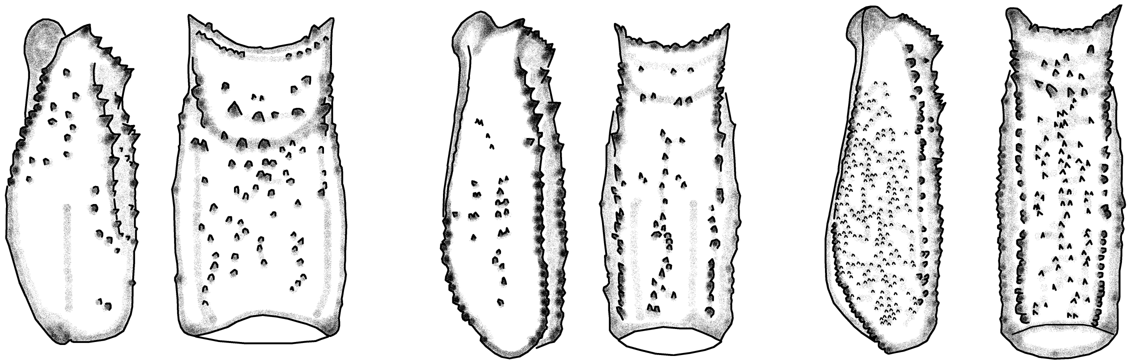
Soleglad & Fet (2003), the first depiction of this important positional difference in *est–esb–eb* alignment between these two subtribes was presented in Vachon (1974: figs. 224–225). Vachon even emphasized these pattern differences by connecting the two trichobothria with a *line*. In these figures, *Brotheas gervaisi* and *Neochactas delicatus* (referred to as *Broteochactas*) were shown, each representing the two subtribes Brotheina and Neochactina, respectively. We accept the designations of *eb* and *esb* as shown by Vachon (1974) for the following reasons: Typically in Type C scorpions, the *eb–et* series is positioned such that it follows the curve of the fixed finger, that is, it is essentially in a straight line or subtly curves proximally towards the dorsal edge of the finger. This is true for most genera in superfamily Scorpionoidea and in Chactoidea families Vaejovidae and Superstitioniidae. This fact alone further emphasizes the validity of the synapomorphy stated for clade Euscorpiidae + Chactidae. Since we see either a straight line between *esb–eb* in a proximal direction or angling towards the dorsal aspect of the fixed finger, we can hypothesize transformations of this angling between closely related species (i.e., as based on other characters). We base these conclusions on the basic assumption that *eb* is the most basal trichobothrium of this series (as its name implies). Analyzing the patterns in Fig. 1, we can see in megacormine genus *Plesiochactas*, a somewhat long fingered genus that, if the homologies of *esb* and *eb* were reversed, we would have an unlikely severe acute angle formed by the *est–esb–eb* juncture, where *esb* would be the most proximal trichobothrium. Since we can dismiss this hypothesized homology in *Plesiochactas* as unlikely, we can then dismiss it likewise in sister genus *Megacormus* where the angle is not acute and the choice of designations is equivocal. Similar arguments can be made in chactid subfamily Uroctoninae, observing that genus *Uroctonus*, as in *Plesiochactas*, exhibits an unlikely acute angle, we can conclude that it is incorrect and therefore can reasonably assume that it would be incorrect in sister genus *Anuroctonus* as well. Same logic can be argued for subfamily Chactinae, using genera *Teuthraustes* and *Nullibrotheas*, which exhibit radical acute angles if we reverse the designations of *esb* and *eb*, we can conclude that other genera, *Chactas* and *Vachoniochactas*, also comply with the proper homology designation. Finally, this same argument can be applied to brotheine subtribe Brotheina (Fig. 2), using the longer fingered species of *Broteochactas*, and, specifically, genera *Brotheas* and *Hadrurochactas*, as a basis, and then addressing the short fingered species. In examples of *Neochactas* (subtribe Neochactina) shown in Figs. 1 and 2 we see that the angle formed by *est–esb–eb* is essentially 90º in most species, but *N. sanmartini* (González-Sponga, 1974) has an acute angle that would make the designation reversal unlikely, consequently we can conclude that other species are correctly designated. Finally, Francke & Boos (1986) also considered these homology designations correct as reflected in their analysis of the validity of González-Sponga's (1978) original definition of genus *Auyantepuia*. We might add here that in many cases, González-Sponga reversed these homologies depending on the species he was describing, thus not necessarily showing consistency in his analysis.

"Auyantepuia" *diagnostic characters*

Lourenço & Araújo (2004: 3), in their resurrection of *Auyantepuia*, listed eight characters in their "revised and simplified" diagnosis, one of which was considered as *diagnostic* of the genus (presumably the other characters are more general in nature):

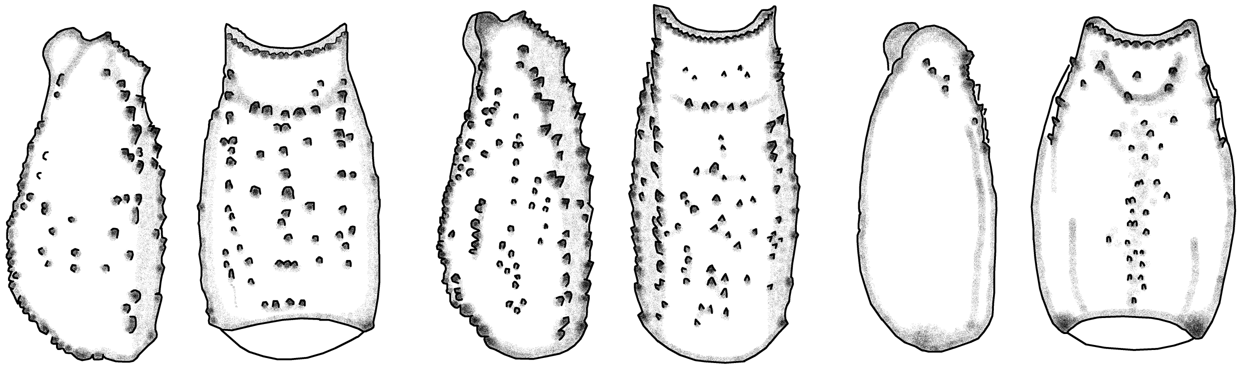
character-1: small species, 24–28 mm.
character-2: generally reddish in color, legs, chelicerae and pedipalps sometimes yellowish
character-3: surface smooth overall and chagrined
character-4: very short fingers when compared to the chelal length
character-5: chelal finger trichobothria *db* and *esb* essentially parallel, sometimes more proximal than Et_3
character-6: "majorante" (i.e. additive) neobothriotaxy
character-7: ventral surface of metasomal segment V with large spiniform granules which form an arc in the posterior region (considered *diagnostic* for the genus)
character-8: pectines reduced in size, with 5 to 8 teeth

Characters 1, 4 and 8 deal with the size of the scorpion (or its organs) or attenuation of the chela only and are certainly not valid diagnostic characters of a genus, in any sense. In addition, there are many species in this tribe excluded from their species set that comply to these characters such as *Broteochactas gollmeri*, *Neochactas santanai* (González-Sponga, 1978), *N. panarei* (González-Sponga, 1980), *N. sarisarinamensis* (González-Sponga, 1985), *N. josemanueli* (González-Sponga, 1992), *N. yekuanae* (González-Sponga, 1984), etc. The same is true for characters 2 and 3 which deal with color and degrees of granulation on the dorsal surface, these certainly are not relevant diagnostic characters for genus-level considerations. Character 6, a statement of general neobothriotaxy, is not definitive as well, there is no indication of the neobothriotaxy type as defined by Soleglad & Fet (2003), e.g., there is significant differences involving both numbers of accessory trichobothria and their relative positions between neobothriotaxy exhibited in tribe Brotheini (type *Ch2*) and subfamily Chactinae (type *Ch1*). Character 5 is quite interesting: if one compares these trichobothria positions between their hypothesized *Auyantepuia* species *Broteochactas scorzai* and *Neochactas parvulus* (or any of the other *Neochactas* species included in their "genus"), one can immediately see a problem with primary homology—in *B. scorzai* we see that *db* and *eb* are adjacent to each other on the finger, and in *N. parvulus*, we see that *db* and *esb* are adjacent on the finger, clearly a conflict with the identities of trichobothria *esb* and *eb* (we must assume here that Lourenço & Araújo (2004) have reversed *esb* and *eb* designations for *B. scorzai*). In either case, these trichobothria are not proximal to trichobothrium Et_3. The last remaining character, character 7, is considered *diagnostic* of the "genus", which implies presumably that it is uniquely found in these species and only in these species within the subfamily. In Fig. 6, we illustrate the ventral and lateral surfaces of metasomal segment V for eight species of chactids spanning two subfamilies and several tribes and subtribes. We can see that in all illustrations the granulation of the posterior aspect of the segment is exaggerated forming, in part, the so-called "arc". Even in sister tribe Belisariini and genus *Chactas* (subfamily Chactinae) we see the "arc" expressed to one degree or another. This "arc" is caused by the smoother concaved distal portion of the posterior end of the segment, contrasting with the adjacent granulation. In *Broteochactas gollmeri*, which was not included in Lourenço & Araújo (2004) species set, this condition is even more formed than that seen in *Neochactas parvulus*, which was included in the species set—clearly there is no consistency or logic in the application of this character to specific species. We analyzed examples of *all* genera in family Chactidae and can state here that the posterior aspect of the ventromedian (*VM*) carina of segment V is irregularly developed to one degree or another, exhibiting configurations from complete obsolescence, distal margin irregular to bifurcated, to a distinct ventral transverse carina (*VTC*): in subfamily Uroctoninae (genera *Uroctonus* and *Anuroctonus*) the *VM* carina is bifurcated on its posterior aspect (Soleglad & Fet, 2004: figs. 14–15); in subfamily Chactinae, tribe Nullibrotheini, genus *Nullibrotheas*'s *VM* carina is bifurcated distally; tribe Chactinae, bifurcated distally in *Teuthraustes*, irregular in *Chactas*, and obsolete in *Vachoniochactas*; in subfamily Brotheinae, tribe Belisariini, genus *Belisarius* exhibits a subtle irregular *VTC*; tribe Brotheini, subtribe Brotheina, in genus *Brotheas* the *VM* is irregular distally, in genus *Broteochactas* we see irregular distally to a well formed *VTC*; genus *Hadrurochactas*, *VM* is irregular with slight indication of a *VTC*; subtribe Neochactina, genus *Neochactas*, *VM* is irregular distally to a well formed *VTC*. It is clear from the examination of this select set of chactid species that the character considered diagnostic of *Auyantepuia* by



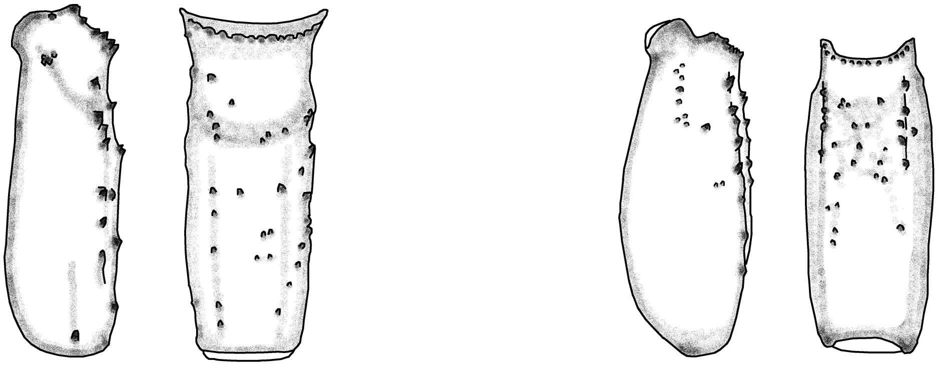
Neochactas parvulus *Neochactas delicatus* *Neochactas granosus*

Brotheinae - Brotheini - Neochactina



Broteochactas gollmeri *Broteochactas nitidus* *Hadrurochactas schaumii*

Brotheinae - Brotheini - Brotheina



Belisarius xambeui *Chactas exsul*

Brotheinae - Belisariini **Chactinae - Chactini**

Figure 6: Metasomal segment V, lateral and ventral views, of select chactid genera spanning subtribes Neochactina and Brotheina, tribes Brotheini and Belisariini, and subfamilies Brotheinae and Chactinae.

Lourenço & Araújo (2004) is found, in part, throughout the family Chactidae and therefore is not specifically diagnostic of the their stated species set (or any specific chactid genus). In addition, other species not included in their "genus" comply with this character as well: *Broteochactas gollmeri*, *Neochactas racenisi* (González-Sponga, 1975), *N. efreni* (González-Sponga, 1978), *N. leoneli* (González-Sponga, 1978), *N. garciai* (González-Sponga, 1978), *N. panarei* (González-Sponga, 1980), *N. bruzuali* (González-Sponga, 1980), *N. sarisarinamensis*

(González-Sponga, 1985), *N. riopinensis* (González-Sponga, 1992), etc. It is interesting to point out that the overall configuration of the *VM* carina of metasomal segment V discussed above for family Chactidae is paralleled, in part, in the scorpionid subfamily Diplocentriinae. Francke (1978), in his monograph on diplocentrids from the circum-Caribbean area, clearly illustrates similar configurations from irregular development in some species of *Heteronebo* (Francke, 1978: figs. 95–97), to bifurcated in some species of *Heteronebo* (Francke, 1978: figs. 93–94, 98–100), to a distinct *VTC* in genera *Didymocentrus*, *Tarsoporosus*, *Cazierius*, *Oieclus* (Francke, 1978: figs. 1–9, 60–61, 68–70) and *Bioculus* (Soleglad & Fet, 2003: fig. 3).

Conclusions

A brief look at the trichobothrial patterns of pedipalp chela for all eight species listed by Lourenço & Araújo (2004) under *Auyantepuia* shows that they include, in the terminology of Soleglad & Fet (2003), members of two different subtribes of the tribe Brotheini. While *Auyantepuia scorzai* presents the typical trichobothrial pattern of *Broteochactas* (subtribe Brotheina), all other seven species are undeniably members of Neochactina, i.e. genus *Neochactas*. Indeed, six of those species have been already placed in the genus *Neochactas* by Soleglad & Fet (2003) (*Neochactas gaillardi*, *N. fravalae*, *N. sissomi*, *N. parvulus*, *N. kelleri* and *N. skuki*), and the new species described by Lourenço & Araújo (2004) exhibits the same trichobothrial pattern and therefore has to be moved to the genus *Neochactas* as well. Note that Lourenço & Araújo (2004) did not discuss any trichobothrial characters, therefore effectively ignoring the work of Soleglad & Fet (2003), the genus *Neochactas*, and the division into two subtribes. This disregard of trichobothrial characters in general is also apparent in their over-generalized statement of neobothriotaxy in their diagnosis of *Auyantepuia*.

Since the three synapomorphic characters established by Soleglad & Fet (2003) were ignored altogether by Lourenço & Araújo (2004), the resulting taxonomy of Soleglad & Fet (2003) still must be considered valid. Coupled with this fact we see, as stated above, that the list of *Auyantepuia* species as stated by Lourenço & Araújo (2004) contains members of both subtribes Brotheina and Neochactina. Consequently, *Auyantepuia* as defined by Lourenço & Araújo (2004), is *polyphyletic* (i.e., the closest common ancestor of the included species is that of the tribe Brotheini, two nodes removed from the species set). In addition, since several species not included in their species set complied to their diagnosis of *Auyantepuia*, we can also declare this "genus", as defined by Lourenço & Araújo (2004), *paraphyletic*.

Discussion

Since Soleglad & Fet (2003: 100) confirmed that *Broteochactas scorzai* Dagert, 1957 belongs to the genus *Broteochactas*, the generic name *Auyantepuia*, based on this type species, is a subjective junior synonym of *Broteochactas.* At the same time, if the remaining seven species of *Neochactas* listed under *Auyantepuia* by Lourenço & Araújo (2004) formed a monophyletic group, it would require a new generic name. The genus *Neochactas*, however, includes now not less than 38 species, namely 36 listed by Soleglad & Fet (2003: 102) as well as *N. mottai* (Lourenço & Araújo, 2004) and *N. macrochelae* (González-Sponga, 2004), and a very serious phylogenetic analysis is required to outline monophyletic clades within this genus. At this moment, we do not see any synapomorphies shared by the above listed seven species of *Neochactas*, and absent in other species of this genus, first of all in its type species, *Neochactas laui* (Kjellesvig-Waering, 1966). The "short-fingered" morphology or the "arc" of the metasomal segment V is by no means unique to these seven species of *Neochactas*.

Lourenço & Araújo (2004), repeating the statement on validity of the genus *Auyantepuia*, treated eight species that they included in this genus as a natural (i.e. monophyletic) group. Geographic distribution of this group, therefore, was interpreted as a disjunct distribution of a group of species which have common origin (and formerly even a continuous geographic range?). However, monophyly of *Auyantepuia* in the sense of Lourenço & Araújo (2004) does not exist: this group of species, as stated above, is polyphyletic, including one (of 13 known) species of *Broteochactas* and seven (of 38 known) species of *Neochactas*. Also, we must emphasize that even after the genera *Broteochactas* and *Neochactas* have been outlined in the revision of Soleglad & Fet (2003), existence of any natural (monophyletic) groups of species was yet never confirmed within these genera. Therefore, any application of these taxa for biogeographic scenarios will be contingent on solid, formal phylogenetic analysis.

On polemics and inadequacies in scorpion systematics

Lourenço & Araújo (2004), referring to our 2003 revision, write (in translation):

"…In the huge work of Soleglad and Fet (2003) other less coherent decisions are also made by these authors such as the description of a new genus *Neochactas* in which are included, among others, the species of the *Auyantepuia* group.

Without entering the polemics, it seems obvious that the work of Soleglad and Fet (2003) presents many inadequacies of which some were recently pointed to by Pecreaux (2004), and also highlighted by Prendini and Wheeler (2004)."

It seems to us that, by publishing these statements, Lourenço & Araújo (2004) indeed effectively "entered the polemics". They talk about our "less than coherent decisions" mentioning only description of *Neochactas* but not any other decisions. Regarding that decision, they do not explain why they think it "less than coherent", since in their own work they did not address *any* of the characters which served for *Neochactas* description and our Chactidae revision in general. They fail to mention that, in addition to those seven species from a former "*Auyantepuia* group" that are listed under *Neochactas* by Soleglad & Fet (2003), the *type* species of *Auyantepuia* was listed in this revision under *Broteochactas*. The comment of Lourenço & Araújo (2004) that "it seems obvious that the work of Soleglad and Fet (2003) presents many inadequacies" is not based on any published evidence and is an empty, *polemic* statement.

The diploma work of Pecreaux (2004) is not published. We had an opportunity to examine it, and we advise that it should not be published in its current shape due to many flaws in analysis. These flaws will not be discussed here as long as this work remains unpublished. (Note, however, that the phylogenies suggested in the important dissertation of Stockwell (1989) are often discussed in scorpion systematic literature although this work remains unpublished).

The single-page abstract of Prendini & Wheeler (2004a, 2004b) is by no means a serious publication either. Although presented at two eminent meetings, it consists only of general statements about inadequacy of our (Soleglad & Fet, 2003) work, lacks any examples, lacks any alternative results or explanations, and, if anything, conveys a very negative and non-professional picture of its authors. Not one actual result of Prendini & Wheeler's study is mentioned in the abstract which would agree or disagree with our results. Not one actual result of our study is mentioned, either. Instead, Prendini & Wheeler (2004a, 2004b) made wholesale accusations directed at our paper in a number of general negative statements (e.g. *"questionable analytical practices", "riddled with unjustifiable assumptions", "characters are often poorly defined", "inadequate", "futility of…familial and generic reshuffling",* etc.). [We might add that, as of this writing (September 2005), no further publication of Prendini & Wheeler emerged to substantiate their invectives made more than a year before in the presentation abstracts of 2004.] Therefore, we think that Lourenço & Araújo (2004) did not have any substance in talking about "inadequacies of [Soleglad & Fet (2003) work]….pointed to by Pecreaux (2004), and also highlighted by Prendini and Wheeler (2004)."

Taxonomy

Eight species of chactid scorpions listed under *Auyantepuia* by Lourenço & Araújo (2004), in our opinion, include one species of the genus *Broteochactas*, namely *Broteochactas scorzai* Dagert, 1957, **comb. n.,** and seven species of the genus *Neochactas*, namely:

Neochactas fravalae (Lourenço, 1983), **comb. n**.
Neochactas gaillardi (Lourenço, 1983), **comb. n**.
Neochactas kelleri (Lourenço, 1983), **comb. n**.
Neochactas mottai (Lourenço et Araújo, 2004), **comb. n.**
Neochactas parvulus (Pocock, 1897), **comb. n**.
Neochactas sissomi (Lourenço, 1983), **comb. n**.
Neochactas skuki (Lourenço et Pinto-da-Rocha, 2000), **comb. n**.

The genus *Auyantepuia* González-Sponga, 1978, **syn. n.** = *Broteochactas* Pocock, 1893, is formally again synonymized here. The type species of *Auyantepuia* is *Broteochactas scorzai* Dagert, 1957 from Venezuela, and the type species of *Broteochactas* is *Broteochactas nitidus* Pocock, 1893 from Trinidad.

In addition, in the recent paper by González-Sponga (2004), two new species of *Broteochactas* are named, one of which must be moved to genus *Neochactas*: *Neochactas macrochelae* (González-Sponga, 2004), **comb. n.**

We also take this opportunity to formally designate lectotypes of several chactid species that were under investigation while completing this study (see *Material examined* section); all these designations are added to the label information in the vials containing the type specimens:

(a) Out of two female syntypes of *Broteochactas gollmeri* (Karsch 1879), Caracas, Venezuela (ZMB 446), originally described as *Chactas gollmeri* Karsch, 1879 (Sissom, 2000: 291), one is designated here as a lectotype and another as a paralectotype**.**

(b) Out of two male syntypes of *Broteochactas porosus* Pocock, 1900, Mt. Roraima, Venezuela [originally listed as British Guiana, now Guyana!] (BMNH) (Sissom, 2000: 315, as *Taurepania porosa*), one is designated here as a lectotype and another as a paralectotype; no other type specimens listed in original publication were found in BMNH collection.

(c) Out of two female syntypes of *Neochactas delicatus* (Karsch, 1879), British Guiana, now Guyana (ZMB 16), originally described as *Chactas delicatus* Karsch, 1879 (Sissom, 2000: 290), one is designated here as a lectotype and another as a paralectotype.

(d) Out of two male syntypes of *Chactas opacus* Karsch, 1894, Brazil (ZMB 0308), which is now considered a junior synonym of *Neochactas delicatus*

(Karsch, 1879) (Sissom, 2000: 290), one is designated here as a lectotype and another as a paralectotype.

(e) The only available female type specimen of *Neochactas parvulus* (Pocock, 1897), Santarém, Brazil (BMNH), originally described as *Broteochactas parvulus* Pocock, 1897 (Sissom, 2000: 294), is designated here as a lectotype; no other type specimens listed in original publication were found in BMNH collection.

Acknowledgements

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