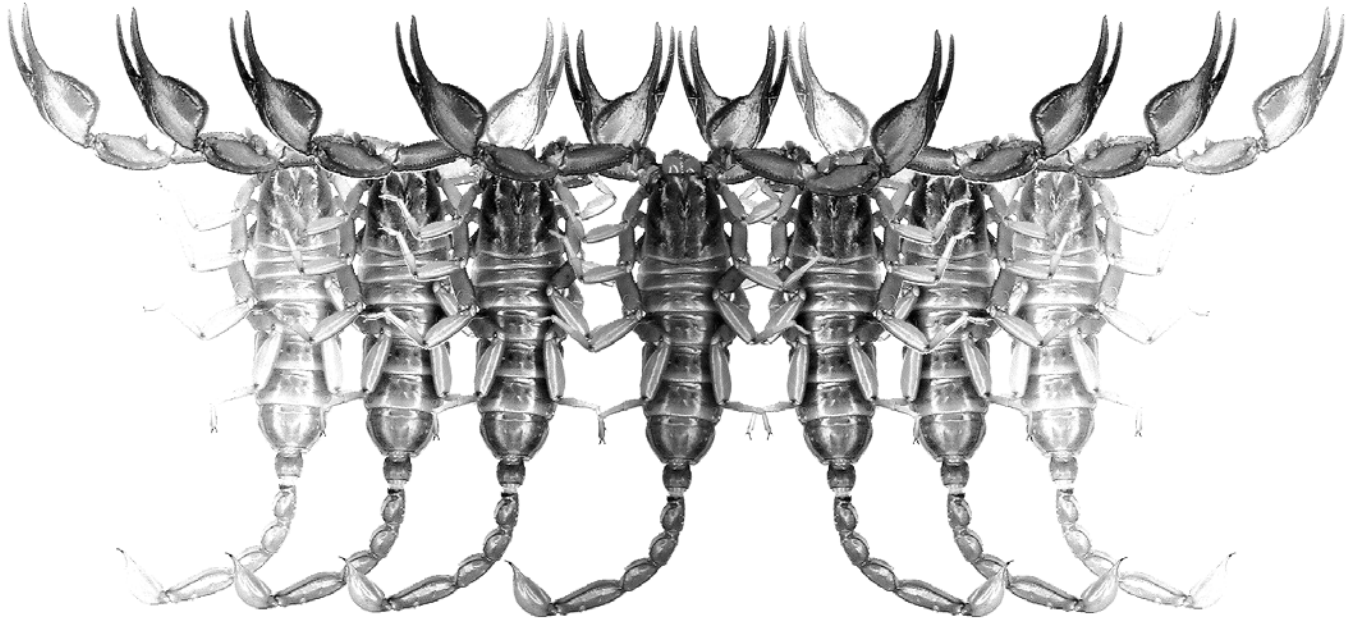


Euscorpius

Occasional Publications in Scorpiology



**Contributions to Scorpion Systematics.
I. On Recent Changes in High-Level Taxonomy**

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Euscorpilus

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The name *Euscorpilus* Thorell, 1876 refers to the most common genus of scorpions in the Mediterranean region and southern Europe (family Euscorpilidae).

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- **ZISP**, Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia
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- **NTNU**, Norwegian University of Science and Technology, Trondheim, Norway

Contributions to scorpion systematics. I. On recent changes in high-level taxonomy

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“...taxonomic judgment [...] must not be made subject to regulation or restraint.”

(ICZN, 1999, Introduction, Principle 1)

Summary

Prendini & Wheeler (2005) criticized the methods of phylogenetic analyses by Soleglad, Fet, and their coauthors, and executed an unprecedented taxonomic action: without analyzing any of these taxa, they performed a wholesale synonymization of four parvorders, eight superfamilies, one family, 11 subfamilies, eight tribes, two subtribes, and three genera (in total, 37 taxa) of scorpions, and made other taxonomic changes. No alternative new classification has been proposed (instead, they revert to a previous classification), and no results of original work on this subject by Prendini & Wheeler (2005) have been presented. Here, we reverse all taxonomic changes performed by Prendini & Wheeler (2005) since we do not consider these actions justified. We comment on a few issues pertaining to the International Code of Zoological Nomenclature.

History of the Issue

Scorpion high-level phylogeny and classification have been under active investigation within the last two decades; for a detailed outline of the scorpion taxonomic history see Fet et al. (2000) and Soleglad & Fet (2003).

Stockwell (1989) conducted the first cladistic analysis of high-level scorpion taxa; unfortunately, this comprehensive work (maybe the most brilliant among so far existing) was never published. Fet et al. (2000) provided a taxonomic catalog of all valid and available scorpion names. Prendini (2000) applied cladistic analysis to the superfamily Scorpionoidea and suggested a number of changes to classification. Soleglad & Sissom (2001) applied cladistic analysis to the family Euscorpiidae and suggested a number of changes to classification, in particular inclusion of the family Scorpioipidae and the chactid genus *Chactopsis* in Euscorpiidae. Soleglad & Fet (2001) conducted a study of scorpion trichothrial patterns, which are the most extensive and *important* set of characters in orthostern scorpions (Vachon, 1974, 1975).

A brief compilation of high-level (subfamily and above) scorpion systematics was provided by Prendini (in Coddington et al., 2004). We assume that Prendini is the only author responsible for the scorpion section (pp. 308-310) of this arachnid chapter in a monumental *Assembling Tree of Life* volume, and that other authors do not bear any responsibility for his statements. This chapter was submitted for print before the large work of Soleglad & Fet (2003) was published, but works of Soleglad & Sissom (2001) and Soleglad & Fet (2001) were addressed there. The former one was characterized as one of the two existing “significant family-level morphological analyses” (p. 308), second being Prendini (2000). On p. 309, Prendini (in Coddington et al., 2004) wrote “Although it will certainly change, *the most reasonable working hypothesis of scorpion phylogeny* is basically Stockwell’s (1989) cladogram for nonbuthids as emended by Prendini (2000), *Soleglad and Sissom (2001), and Soleglad and Fet (2001)*” [italics added]. The tentative phylogenetic tree presented by Prendini in this chapter (Fig. 18.5) was based on Stockwell (1989) modified according to the results of Prendini (2000) on

superfamily Scorpionoidea, as well as results of Soleglad & Sissom (2001) on family Euscorpiidae (and their published phylogeny of its three subfamilies, Euscorpiinae, Megacorminae, and Scorpipiinae) and Soleglad & Fet (2001) on Pseudochactidae. Further in text, Prendini (in Coddington et al., 2004: 310) sides with opinions of Soleglad & Sissom (2001) to corroborate his statements on the monophyly of Euscorpiidae and a possible position of the genus *Belisarius*.

Soleglad & Fet (2003) published a detailed phylogenetic analysis of orthostern scorpions (infraorder Orthosterni, which includes all extant and several fossil forms), and introduced a number of taxonomic changes. In several works that followed from our research group and its collaborators (Fet et al., 2004a, 2004b, 2005; Soleglad & Fet, 2005a, 2005b; Santiago-Blay et al., 2004a, 2004b, 2004c; Soleglad et al., 2005), further phylogenetic issues were discussed and analyzed, and/or changes to scorpion classification were proposed.

The character analysis of Prendini's (2000) scorpionoid revision, published in the journal *Cladistics*, was based, in most part, on the work of Stockwell (1989). In those areas not discussed by Stockwell, in particular neobothriotaxy, Prendini was forced, unfortunately, to conduct his own analysis and interpretations of the data. Soleglad & Sissom (2001) discussed this particular aspect of Prendini's (2000) analysis and indicated that it was, in their opinion, inadequate and was the cause, in part, of some questionable results in Prendini's taxonomy. Soleglad & Fet (2003) analyzed the issues in question in more detail than Soleglad & Sissom (2001), and also came to the conclusion that the character modeling employed by Prendini was inadequate. In particular, the preliminary analysis by Soleglad & Fet (2003) indicated that the original topology stated by Stockwell (1989) was correct, their result and Stockwell's (1989) differing from that of Prendini (2000). Prendini (2003a), using his scorpionoid analysis (Prendini, 2000) as a basis, defined the bothriurid genus *Brandbergia*, a close relative of the genus *Lisposoma*. Fet et al. (2004) performed an extensive evaluation of this result, comparing it to the two species of *Lisposoma*, which led to the synonymizing of *Brandbergia* with *Lisposoma*. Soleglad et al. (2005) conducted an extensive analysis of genera *Heteroscorpion* and *Urodacus* and concluded, as suggested earlier by Soleglad & Sissom (2001), Soleglad & Fet (2003), and Fet et al. (2004), that the results presented in Prendini (2000) were incorrect and then, at this time, made the appropriate taxonomic emendations. It is important to note here, that in the cases where Fet et al. (2004) and Soleglad et al. (2005) made taxonomic emendations to Prendini's results (2000, 2003a), *additional taxa* were analyzed, Prendini's *data matrices* were used as a basis, these data matrices were modified in areas deemed necessary *based* on this analysis, and a *result* was produced. We might add that all changes made to these data matri-

ces were described in detail, rationale provided, and illustrated, where appropriate.

Recently, again in the journal *Cladistics*, Prendini & Wheeler [further as P&W] (2005) criticized the methods of phylogenetic analyses applied by Soleglad, Fet, and their coauthors in 2001–2005, concluding that these analyses “fail to meet the most basic standards in systematics” and that the work of these authors is “nothing more than an elaborate scheme designed to achieve and legitimize a desired result” (P&W, 2005: 479).

Following their criticism, P&W (2005) executed an unprecedented taxonomic act: *without analyzing any of these taxa*, they performed a wholesale synonymization of four parvorders, eight superfamilies, one family, 11 subfamilies, eight tribes, two subtribes, and three genera (in total, 37 taxa) of scorpions, 35 of which were established or supported in six recent publications of Soleglad, Fet, and their collaborators (Soleglad & Sissom, 2001; Soleglad & Fet, 2003, 2005a; Fet et al., 2004a, 2004b; Soleglad et al., 2005), and made a number of other taxonomic changes. They stipulate that these changes revert to the scorpion taxonomy presented in “the most recent peer-reviewed published treatments”. As such, are listed: *The Catalog of Scorpions of the World* (Fet et al., 2000) and the works of Prendini (2000, 2001, 2003) and Prendini et al. (2003).

Unjustified Taxonomic Changes

P&W (2005) presented *no alternative results of any original work* that would justify their taxonomic changes. Therefore, at this moment we cannot offer any discussion on the substance of these claims. As for P&W (2005) criticisms of our choice of analytic techniques, taxa, outgroups, characters, etc., these methodological issues will be discussed in detail in our forthcoming publications. Here, we will address only the *taxonomic changes* made by P&W (2005).

It is an accepted tradition that new taxonomic changes are performed with a *reasonable justification*, which routinely includes a detailed investigation of the group(s) in question, desirably bringing new data in consideration. For example, the genus *Auyantepuia* González-Sponga, 1978 (Chactidae) was synonymized with *Broteochactas* by Francke & Boos (1986) but resurrected by Lourenço & Araújo (2004). We (Soleglad & Fet, 2005b) studied this issue, bringing new knowledge from our analysis of chactid genera (Soleglad & Fet, 2005b) and concluded that Francke & Boos (1986) were indeed correct. As a result, we resynonymized *Auyantepuia* with the genus *Broteochactas*. Any discussion of taxonomic changes is contingent on publication of original results justifying such changes, not on methodological criticism.

Since P&W (2005) presented *no alternative results of any original work*, we cannot in good faith consider their actions as justified taxonomic changes. Hence, we have no other choice but to **reestablish** here, as valid, all taxa synonymized by P&W (2005); to synonymize the taxa they reestablished; and to change back all taxonomic placements. We perform all necessary taxonomic changes (Tables 1-2) to return scorpion taxonomy to the *status quo* that existed before the publication of P&W (2005). Note that we do not introduce any additional changes but simply reverse all those proposed by P&W (2005), *none* of which were justified by these authors.

P&W (2005) claim that actions of Soleglad, Fet and their collaborators somehow threatened taxonomic stability. However, *stability* in the sense of the International Code of Zoological Nomenclature (ICZN, 1999) is a concept pertaining to nomenclature, not taxonomy. The preamble to the Code says, indeed: "The objects of the Code are *to promote stability* and universality in the scientific *names* of animals and to ensure that the name of each taxon is unique and distinct" [italics added]. It continues: "All its provisions and recommendations are subservient to those ends and *none restricts the freedom of taxonomic thought or actions.*" [italics added]. It is obvious that stability of *nomenclature* promoted by the Code (name availability, type species fixation, etc.) has nothing to do with sweeping *taxonomic* changes that P&W (2005) performed without demonstrating any concrete evidence or justification. In addition, it does not seem that taxonomic actions of P&W (2005) are performed in the spirit of the Code. Indeed, one person's freedom of thought could be another's anarchy.

It could seem to a reader of P&W (2005) that these authors blend the concept of nomenclatural availability and publication criteria, which *are* regulated by the Code, with taxonomic validity as determined by particular methods of investigation and publication of the results – otherwise we cannot explain their unusual taxonomic action. Contrary to popular belief, there is nothing in the Code that prescribes norms by which a systematist must conduct his or her work. The Introduction to the Code (ICZN, 1999) clearly states, in its Principle I : "*The Code refrains from infringing upon taxonomic judgment, which must not be made subject to regulation or restraint.*" [italics added].

Indeed, there are "mainstream", straightforward techniques of systematic research routinely used by many, often by the majority of researchers. There also exists a certain degree of freedom and diversity in using these techniques. Prendini and Wheeler expressed before in print (Prendini et al., 2003: 195) under what they call "epistemological considerations" their aversion to "pluralism" and their opinion that the "superior" method must be selected *a priori* and that (commonly practiced in molecular systematics) concurrent use of several analytical techniques indicates poor scholarship and "inde-

cision". To quote Prendini et al. (2003: 195), "Given that it is uncritical to use all methods and inconsistent to select a subset, authors should decide *a priori* which method they will use, and justify their choice accordingly".

In real life, however, things are much less rigid. Most systematic researchers (including us) subscribe to the basic ideas of cladistics; but, as Zherikhin (1998) whimsically noted, "Cladistics is no more than one of the specialised organs in the complex organism of taxonomy." Molecular systematists still use maximum likelihood and/or neighbor-joining analyses. Taxonomic revisions are still published, which are based on non-cladistic methods such as a revision of chevrotains based on craniometric (skulls only!) statistical analysis (Meijaard & Groves, 2004), or similar morphometric-based revision of mouse lemurs (Rasoloarison et al., 2000). These papers have been published in peer-reviewed, "mainstream" *Zoological Journal of the Linnean Society* and *International Journal of Primatology*, respectively. We can find similar cases (Wild, 2005) also in the peer-reviewed online journal, *Zootaxa*, the only online publication "approved" by P&W (2005) (incidentally, Dr. Prendini happens to be an editor of its scorpion section). And of course descriptions of new genera (e.g. Bajpai & Thewissen, 2000; Engel & Grimaldi, 2002; Fashing, 2002; Kury, 2002; Boyko, 2003; Fernández, 2003; Komai, 2004; Westergren & Siddall, 2004; Martínez et al., 2004; Mesibov, 2004; Kung & Brown, 2005; Williams & López-González, 2005), families (e.g., Shear & Leonard, 2002), or even orders (Klaas et al., 2002) are published all the time without *any* cladistic analysis. **However, taxa established in these papers cannot be invalidated by other researchers on the basis of methodical disagreement but only as a result of detailed original study.**

It is also disturbing to read in P&W (2005: 446, Abstract) that "A centralized register of taxa may be the only solution for ensuring quality control in the taxonomy of the future". Again, it seems that nomenclature and taxonomy are confused here. Indeed, there is a lively discussion centered around the International Commission of Zoological Nomenclature (ICZN) on introducing name and nomenclatural act registration in the next 5th edition of the Code, projected to commence in 2008. The proposed suggestion for registration of names in a ZooBank database (Polaszek et al., 2005) says: "We propose a register of new zoological names—ZooBank—to be established and administered by the ICZN, and bolstered by a mandatory requirement, in the next edition of the code, for the registration of new names." It further explicitly states (and it cannot be otherwise in a democratic society) "We stress that *assessing the merits of different taxonomic hypotheses would not be part of ZooBank's function; it would be a register, not a peer-evaluation system.*" [italics added]. ZooBank proposal searches to

“democratize taxonomy” (Polaszek et al., 2005). What P&W (2005: 482) call for is quite different: “a centralized register of taxa moderated by international review panels akin to the system used for evaluating grant proposals”, i.e. a *centralized peer-evaluation system*. One of us (VF) spent 33 years of his life in a centralized system (former USSR), and can testify first-hand on the effects such systems and their “only solutions” have on science, peer-reviews, and other aspects of life. We do not believe that the opinion of P&W (2005) reflects the “mainstream” views of the editorial board of *Cladistics*, in spite of the fact that Lorenzo Prendini happens to be an Associate Editor of this systematic journal.

P&W (2005) propose to revert back to the scorpion taxonomy as published in the *Catalog of the Scorpions of the World* (Fet et al., 2000)—although they notably make an exception to all groups “tested by Prendini (2000, 2001c, 2003a,c, 2004) and Prendini et al. (2003)”. Based on this, it seems at the present time that the only common peer reviewer acceptable to P&W (2005) would be Prendini himself. The *Catalog* was indeed peer-reviewed (Prendini, as well as Soleglad, was among the reviewers), to assure that it is complete; but it is by no means a taxonomic revision. The *Catalog* is just a list of scorpion *nomenclature*, taxonomically covering a mélange of ideas and idiosyncrasies of very different authors, from Linnaeus to 1998. Its compilers had no aim or responsibility to justify the opinions of the compiled authors, and were guided solely by the Principle of Priority: the last published taxonomic treatment, whether considered good or bad, is valid. To change taxonomy, the tradition of taxonomic science requires that one presents *new data and conclusions*: both are lacking in P&W (2005).

Specific Taxonomic and Nomenclatural Issues

We also need to comment on a few technical issues pertaining to the Code (ICZN, 1999). P&W (2005: Table 10) note that “superfamilial categories [are]... not regulated by the ICZN”. This statement is both incorrect and semantically confused. Not regulated by the Code are the names *above family-group* of taxa (e.g. order or suborder), while *superfamily* belongs to the *family-group* rank (along with family, subfamily, tribe, and subtribe), is perfectly regulated by the Code, and coordinated with the family on which it is based (Articles 35.1, 36). At the same time, names of *order-group* taxa (orders, infraorders and parvorders, in our case) are indeed not regulated by the Code. Therefore, synonymizing scorpion superfamilies with order Scorpiones, as performed by P&W (2005: Table 10) “for completeness” is a violation of the Code. It is amusing that, with their extensive

taxonomic expertise, P&W (2005) think that *superfamilies* can be synonymized with *orders*.

P&W (2005) are not consistent in their taxonomic reversals. They chose not to recognize three genera: *Neochactas* Soleglad et Fet, 2003, *Hoffmannihadrurus* Fet et Soleglad, 2004, *Franckeus* Soleglad et Fet, 2005. However, P&W (2005) do not discuss 23 other scorpion genera described *after* 1998, the *landmark* for P&W (2005) “last published taxonomy” as limited by the *Catalog* (Fet et al., 2000), namely *Ankaranocharmus* Lourenço, 2004; *Archaeobuthus* Lourenço, 2001; *Brazilobothriurus* Lourenço et Monod, 2000; *Congobuthus* Lourenço, 1999; *Electrochaerilus* Santiago-Blay, Fet, Soleglad et Anderson, 2004; *Lanzatus* Kovařík, 2001; *Microananteris* Lourenço, 2003; *Neoprotobuthus* Lourenço, 2000; *Pachakutej* Ochoa, 2004; *Palaeoakentrobuthus* Lourenço et Weitschat, 2000; *Palaeoananteris* Lourenço et Weitschat, 2001; *Palaeoburmesebuthus* Lourenço, 2002; *Palaeoeuscorpius* Lourenço, 2003; *Palaeolychas* Lourenço et Weitschat, 1996; *Palaeoprotobuthus* Lourenço et Weitschat, 2000; *Palaeotityobuthus* Lourenço et Weitschat, 2000; *Polisius* Fet, Capes et Sissom, 2001; *Protobuthus* Lourenço et Gall, 2004; *Protoischnurus* Carvalho et Lourenço, 2001; *Pseudolissothus* Lourenço, 2001; *Sabinebuthus* Lourenço, 2001; *Trogloorhopalurus* Lourenço, Baptista et Giupponi, 2004; and *Troglotityobuthus* Lourenço, 2000. We understand that P&W (2005) did not have a chance to analyze validity of all these genera in their paper; but neither did they analyze the validity of *Neochactas*, *Hoffmannihadrurus*, or *Franckeus*. Interestingly, two of these genera, *Hoffmannihadrurus* and *Franckeus*, were not defined using cladistic analysis; evidently the only nexus between the three genera are their authors.

Another nomenclatural issue is the validity of the name *Liochelidae* Fet & Bechly, 2001. P&W (2005) noted that they take an exception to this name since it was “approved by ICZN (2003)”. However, “approval” of *Liochelidae* does not mean it is a valid name. It was indeed used as valid in error by several authors (e.g. Kovařík, 2003; Lourenço, 2003; Lourenço & Fé, 2003; Soleglad & Fet, 2003; Armas, 2005; Prendini, 2005). This error was corrected, and the convoluted nomenclatural story behind it was discussed in detail by Soleglad et al. (2005). *Liochelidae* Fet & Bechly, 2001 is the substitute name for *Ischnuridae* Simon, 1879, which was deemed by ICZN (2003) to be non-available. However, *at the same time Liochelidae is a junior synonym of Hormurinae Laurie, 1896, which has priority by the Code*. P&W (2005) should have elevated *Hormurinae* to family rank as *Hormuridae* if they could justify that this taxon should not belong to *Hemiscorpiidae*, as proposed by Soleglad et al. (2005).

A few other observations are:

- Four scorpion genera (*Ayuantepuia*, *Brandbergia*, *Cayooca*, *Guyanochactas*), synonymized by Soleglad & Fet (2003, 2005b) and Fet et al. (2004a), were reestablished by P&W (2005: Table 10) implicitly, without any formal statements. We reiterate the formal synonymy status of these genera in Table 1 as accepted here.
- It is not clear why P&W (2005) chose not to resurrect genus *Taurepania* González-Sponga, 1978 (Chactidae), synonymized with *Broteochactas* by Soleglad & Fet (2003: 100); it appears that they just forgot to do so amidst their multiple synonymizations.
- We cannot see why P&W (2005) would choose, “for completeness”, to abolish superfamily Scorpionoidea, since there is no argument whatsoever about this taxon’s contents (Prendini, 2000; Soleglad & Fet, 2003) or its monophyly.
- If P&W (2005) chose not to recognize the superfamilies as established by Soleglad & Fet (2003), in absence of other alternative suggestions, the Principle of Priority (Article 23 of the Code) should have forced them to revert to the superfamilial classification of Lourenço (2000), but it gets abolished as well without even being mentioned. Prendini (in Coddington et al., 2004: 309) commented that “most of Lourenço’s... proposed familial and superfamilial emendations cannot be justified phylogenetically... but are included here because they represent the most recent published opinion”. P&W (2005) obviously were less prudent in their actions.
- P&W (2005) list genus *Euscorpiops* Vachon, 1980 as valid. This genus was synonymized by Kovařík (2000) with *Scorpiops*, but reestablished by Soleglad & Sissom (2001). If P&W (2005) chose not to recognize the decision of Soleglad & Sissom (2001), in absence of other alternative suggestions, the Principle of Priority should have forced them to revert to the synonymy of Kovařík (2000), but it is not even mentioned.
- The date of description of subfamily Megacorminae Kraepelin is erroneously listed by P&W (2005) as 1905; in reality it is 1899 (Fet et al., 2000).
- The subfamily Euscorpiinae Laurie, 1896 is misspelled by P&W (2005, Table 10) as Euscorpiidae.

Prendini (in Coddington et al., 2004: 310) indicated that “A molecular analysis of the entire order, based on nuclear and mitochondrial DNA loci, to be combined with available morphological data, is underway (L. Prendini and W. Wheeler, unpubl. obs.)”. However, P&W (2005) decided to change the existing scorpion taxonomy before they publish their data with justifica-

tion of these changes. We do *not* recognize their unprecedented actions as justified, and therefore reverse all taxonomic changes introduced by P&W (2005), as stipulated in our Tables 1 and 2.

When P&W finally do publish their data, we will meticulously analyze their results with an open mind; we will do this by studying additional material, evaluating assumptions and methodologies, testing new hypotheses—whatever deemed necessary to uncover the best results, and we will do so without hiding behind any calls for *ideological cleansing*.

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Table 1: Changes in scorpion taxonomy, introduced here to restore unjustified changes by P&W (2005)
(Compare to Soleglad & Sissom, 2001; Soleglad & Fet, 2003, 2005a, 2005b; Fet et al., 2004a, 2004b; Soleglad et al., 2005).

Not Code-regulated taxa, reestablished here:

- Parvorder Buthida Soleglad et Fet, 2003
- Parvorder Chaerilida Soleglad et Fet, 2003
- Parvorder Iurida Soleglad et Fet, 2003
- Parvorder Pseudochactida Soleglad et Fet, 2003

Code-regulated taxa:

- Superfamily Bothriuroidea Simon, 1880 = Superfamily Scorpionoidea Latreille, 1802, **syn. nov.** (valid as family Bothriuridae).
- Superfamily Buthoidea C.L. Koch, 1837, **new rank.**
- Superfamily Chaeriloidea Pocock, 1893, **new rank.**
- Superfamily Chactoidea Pocock, 1893, **new rank.**
- Superfamily Iuroidea Thorell, 1876, **new rank.**
- Superfamily Pseudochactoidea Gromov, 1998, **new rank.**
- Superfamily Scorpionoidea Latreille, 1802, **new rank.**
- Superfamily Vaejovoidea Thorell, 1876 = Superfamily Scorpionoidea Latreille, 1802, **syn. nov.** (valid as family Vaejovidae).
- Family Caraboctonidae Kraepelin, 1905, **new rank**, reestablished from synonymy with family Iuridae Thorell, 1876.
- Family Diplocentridae Karsch, 1880 = Family Scorpionidae Latreille, 1802, **syn. nov.** (valid as subfamily Diplocentrinae).
- Family Heteroscorpionidae Kraepelin, 1905 = Family Hemiscorpiidae Pocock, 1893, **syn. nov.** (valid as subfamily Heteroscorpioninae).
- Family Liochelidae Fet et Bechly, 2001 = Subfamily Hormurinae Laurie, 1896, **syn. nov.**
- Family Scorpiopidae Kraepelin, 1905 = Family Euscorpiidae Laurie, 1896, **syn. nov.** (valid as subfamily Scorpiopinae).
- Family Troglotayosicidae Lourenço, 1998 = Family Superstitioniidae Stahnke, 1940, **syn. nov.**
- Family Urodacidae Pocock, 1893 = Family Scorpionidae Latreille, 1802, **syn. nov.** (valid as subfamily Urodacinae).
- Subfamily Belisariinae Lourenço, 1998 = Family Chactidae Pocock, 1893, **syn. nov.** (valid as tribe Belisariini).
- Subfamily Bothriurinae Simon, 1880, **new rank**, reestablished as subfamily of Bothriuridae Simon, 1880.
- Subfamily Brotheinae Simon, 1879, reestablished from synonymy with family Chactidae Pocock, 1893.
- Subfamily Chactinae Pocock, 1893, **new rank**, reestablished as subfamily of Chactidae Pocock, 1893.
- Subfamily Euscorpiinae Laurie, 1896 [erroneously named “subfamily Euscorpiidae” in P&W, 2005, Table 10], **new rank**, reestablished as subfamily of Euscorpiidae Laurie, 1896.
- Subfamily Hemiscorpiinae Pocock, 1893, **new rank**, reestablished as subfamily of Hemiscorpiidae Pocock, 1893.
- Subfamily Heteroscorpioninae Kraepelin, 1905, **new rank**, reestablished as subfamily of Hemiscorpiidae Pocock, 1893.
- Subfamily Hormurinae Laurie, 1896, reestablished from synonymy with family Liochelidae Fet et Bechly, 2001; placed in family Hemiscorpiidae Pocock, 1893.
- Subfamily Iurinae Thorell, 1876 = Family Iuridae Thorell, 1876, **syn. nov.**
- Subfamily Lisposominae Lawrence, 1928, reestablished from synonymy with family Bothriuridae Simon, 1880.
- Subfamily Megacorminae Kraepelin, 1905, reestablished from synonymy with family Euscorpiidae Laurie, 1896.
- Subfamily Nebinae Kraepelin, 1905 = Subfamily Diplocentrinae Karsch, 1880, **syn. nov.** (valid as tribe Nebini).
- Subfamily Scorpioninae Latreille, 1802, **new rank**, reestablished as subfamily of Scorpionidae Latreille, 1802.
- Subfamily Scorpiopinae Kraepelin, 1905, **new rank**, reestablished as subfamily of Euscorpiidae Laurie, 1896.
- Subfamily Troglotayosicinae Lourenço, 1998 = Subfamily Superstitioniinae Stahnke, 1940, **syn. nov.**
- Subfamily Uroctoninae Mello-Leitão, 1934, reestablished from synonymy with family Vaejovidae Thorell, 1876 as subfamily of Chactidae Pocock, 1893.
- Tribe Brotheini Simon, 1879, reestablished from synonymy with family Chactidae Pocock, 1893 as a tribe in subfamily Brotheinae Simon, 1879.

- Tribe Chactini Pocock, 1893, **new rank**, reestablished as a tribe in subfamily Chactinae Pocock, 1893.
- Tribe Chactopsini Soleglad et Sissom, 2001, reestablished from synonymy with family Chactidae Pocock, 1893 as a tribe in subfamily Megacorminae Kraepelin, 1899.
- Tribe Diplocentrini Karsch, 1880, **new rank**, reestablished as a tribe in subfamily Diplocentrinae Karsch, 1880.
- Tribe Megacormini Kraepelin, 1899, reestablished from synonymy with family Euscorpiidae Laurie, 1896 as a tribe in subfamily Megacorminae Kraepelin, 1899.
- Tribe Nebini Kraepelin, 1905 [was not formally synonymized by P&W, 2005, but does not appear in their classification], **new rank**, reestablished as a tribe in subfamily Diplocentrinae Karsch, 1880.
- Tribe Nullibrotheini Soleglad et Fet, 2003, reestablished from synonymy with family Chactidae Pocock, 1893 as a tribe in subfamily Chactinae Pocock, 1893.
- Tribe Scorpiopini Kraepelin, 1905, **new rank**, reestablished as a tribe in subfamily Scorpiopinae Kraepelin, 1905.
- Tribe Troglacormini Soleglad et Sissom, 2001; reestablished from synonymy with family Euscorpiidae Laurie, 1896 as a tribe in subfamily Scorpiopinae Kraepelin, 1905.
- Subtribe Brotheina Simon, 1879, reestablished from synonymy with family Chactidae Pocock, 1893 as a subtribe in tribe Brotheini Simon, 1879.
- Subtribe Neochactina Soleglad et Fet, 2003; reestablished from synonymy with family Chactidae Pocock, 1893 as a subtribe in tribe Brotheini Simon, 1879.
- Franckeus* Soleglad et Fet, 2005; reestablished from synonymy with *Vaejovis* C.L. Koch, 1836 (Vaejovidae).
- Hoffmannihadrurus* Fet et Soleglad, 2004; reestablished from synonymy with *Hadrurus* Thorell, 1876 (Caraboctonidae).
- Neochactas* Soleglad et Fet, 2003; reestablished from synonymy with *Broteochactas* Pocock, 1893 (Chactidae).

P&W (2005) also did *not* make formal statements on reestablishment from synonymy of the following four genera they recognized as valid. Here, these genera are synonymized according to the justifications provided by Soleglad & Fet (2003), Fet et al. (2004a), and Soleglad & Fet (2005b).

- Auyantepuia* González-Sponga, 1978 = *Broteochactas* Pocock, 1893, **syn. nov.** (Chactidae).
- Brandbergia* Prendini, 2003 = *Lisposoma* Lawrence, 1928, **syn. nov.** (Bothriuridae)
- Cayooca* González-Sponga, 1981 = *Broteochactas* Pocock, 1893, **syn. nov.** (Chactidae).
- Guyanochactas* Lourenço, 1998 = *Broteochactas* Pocock, 1893, **syn. nov.** (Chactidae).

Table 2: Classification of orthostern scorpions as accepted here (including fossil taxa). Modified from Soleglad et al. (2005), with additional data from Soleglad & Fet (2003), Lourenço (2004), Lourenço & Gall (2004), Santiago-Blay et al. (2004a, 2004b, 2004c), and Lourenço et al. (2005). Compare to P&W (2005, Table 10). Fossil taxa are designated by †.

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

Parvorder Pseudochactida Soleglad et Fet, 2003

Superfamily Pseudochactoidea Gromov, 1998
 Family Pseudochactidae Gromov, 1998
Pseudochactas Gromov, 1998

Parvorder Buthida Soleglad et Fet, 2003

Superfamily Buthoidea C.L. Koch, 1837
 Family Buthidae C.L. Koch, 1837

Afroisometrus Kovařík, 1997; *Akentrobuthus* Lamoral, 1976; *Alayotityus* Armas, 1973; *Ananteris* Thorell, 1891; *Androctonus* Ehrenberg, 1828; *Anomalobuthus* Kraepelin, 1900; *Apistobuthus* Finnegan, 1932; *Australobuthus* Locket, 1990; *Babycurus* Karsch, 1886; *Baloorthochirus* Kovařík, 1996; *Birulatus* Vachon, 1974; *Buthacus* Birula, 1908; *Butheoloides* Hirst, 1925; *Butheolus* Simon, 1882; *Buthiscus* Birula, 1905; *Buthoscorpio* Werner, 1936; *Buthus* Leach, 1815; *Centruroides* Marx, 1890; *Charmus* Karsch, 1879; *Cicileus* Vachon, 1948; *Compsobuthus* Vachon, 1949; *Congobuthus* Lourenço, 1999; *Darchenia* Vachon, 1977; *Egyptobuthus* Lourenço, 1999; *Grosphus* Simon, 1880; *Hemibuthus* Pocock, 1900; *Hemilychas* Hirst, 1911; *Himalayotityobuthus* Lourenço, 1997; *Hottentotta* Birula, 1908; *Iranobuthus* Kovařík, 1997; *Isometroides* Keyserling, 1885; *Isometrus* Ehrenberg, 1828; *Karasbergia* Hewitt, 1913; *Kraepelinia* Vachon, 1974; *Lanzatus* Kovařík, 2001; *Leiurus* Ehrenberg, 1828; *Liobuthus* Birula, 1898; *Lissothus* Vachon, 1948; *Lychas* C.L. Koch, 1845; *Lychasioides* Vachon, 1974; *Mesobuthus* Vachon, 1950; *Mesotityus* González-Sponga, 1981; *Microananteris* Lourenço, 2003; *Microbuthus* Kraepelin, 1898; *Microtityus* Kjellesvig-Waering, 1966; *Neobuthus* Hirst, 1911; *Neogrosphus* Lourenço, 1995; *Odontobuthus* Vachon, 1950; *Odonturus* Karsch, 1879; *Orthochiroides* Kovarik, 1998; *Orthochirus* Karsch, 1861; †*Palaeoakentrobuthus* Lourenço et Weitschat, 2000; †*Palaeoananteris* Lourenço et Weitschat, 2001; †*Palaeolychas* Lourenço et Weitschat, 1996; †*Palaeoprotobuthus* Lourenço et Weitschat, 2000; †*Palaeospinobuthus* Lourenço, Henderickx et Weitschat, 2005; †*Palaeotityobuthus* Lourenço et Weitschat, 2000; *Parabuthus* Pocock, 1890; *Paraorthochirus* Lourenço et Vachon, 1997; *Pectinibuthus* Fet, 1984; *Plesiobuthus* Pocock, 1900; *Polisius* Fet, Capes et Sissom, 2001; *Psammobuthus* Birula, 1911; *Pseudolissothus* Lourenço, 2001; *Pseudolychas* Kraepelin, 1911; *Pseudouroplectes* Lourenço, 1995; *Razianus* Farzanpay, 1987; *Rhopalurus* Thorell, 1876; *Sabinebuthus* Lourenço, 2001; *Sassanidobuthus* Farzanpay, 1987; *Simonoides* Vachon et Farzanpay, 1987; *Somalibuthus* Kovařík, 1998; *Somalicharmus* Kovařík, 1998; *Thaicharmus* Kovařík, 1995; *Tityobuthus* Pocock, 1893; *Tityopsis* Armas, 1974; *Tityus* C.L. Koch, 1836; *Troglophalurus* Lourenço, Baptista et Giupponi, 2004; *Troglotityobuthus* Lourenço, 2000; †*Uintscorpio* Perry, 1995; *Uroplectes* Peters, 1861; *Uroplectoides* Lourenço, 1998; *Vachoniolus* Levy, Amitai et Shulov, 1973; *Vachonus* Tikader et Bastawade, 1983; *Zabius* Thorell, 1893

Family Microcharmidae Lourenço, 1996

Ankaranocharmus Lourenço, 2004; *Microcharmus* Lourenço, 1996; *Neoprotobuthus* Lourenço, 2000

Parvorder Chaerilida Soleglad et Fet, 2003

Superfamily Chaeriloidea Pocock, 1893
 Family Chaerilidae Pocock, 1893
 Subfamily Chaerilinae Pocock, 1893

Chaerilus Simon, 1877

†Subfamily Electrochaerilinae Santiago-Blay, Fet, Soleglad et Anderson, 2004

†*Electrochaerilus* Santiago-Blay, Fet, Soleglad et Anderson, 2004

Parvorder Iurida Soleglad et Fet, 2003

Superfamily Chactoidea Pocock, 1893
 Family Chactidae Pocock, 1893

- Subfamily Chactinae Pocock, 1893
 Tribe Chactini Pocock, 1893
Chactas Gervais, 1844; *Teuthraustes* Simon, 1878; *Vachoniochactas* González-Sponga, 1978
 Tribe Nullibrotheini Soleglad et Fet, 2003
Nullibrotheas Williams, 1974
 Subfamily Brotheinae Simon, 1879
 Tribe Brotheini Simon, 1879
 Subtribe Brotheina Simon, 1879
Brotheas C.L. Koch, 1837; *Broteochactas* Pocock, 1893; *Hadrurochactas* Pocock, 1893
 Subtribe Neochactina Soleglad et Fet, 2003
Neochactas Soleglad et Fet, 2003
 Tribe Belisariini Lourenço, 1998
Belisarius Simon, 1879
 Subfamily Uroctoninae Mello-Leitão, 1934
Anuroctonus Pocock, 1893; *Uroctonus* Thorell, 1876
- Family Euscorpiidae Laurie, 1896
 Subfamily Euscorpiinae Laurie, 1896
Euscorpius Thorell, 1876
 Subfamily Megacorminae Kraepelin, 1905
 Tribe Megacormini Kraepelin, 1905
Megacormus Karsch, 1881; *Plesiochactas* Pocock, 1900
 Tribe Chactopsini Soleglad et Sissom, 2001
Chactopsis Kraepelin, 1912
 Subfamily Scorpiopinae Kraepelin, 1905
 Tribe Scorpiopini Kraepelin, 1905
Alloscorpiops Vachon, 1980; *Dasyrscorpiops* Vachon, 1974; *Euscorpiops* Vachon, 1980; *Neoscorpiops* Vachon, 1980; *Parascorpiops* Banks, 1928; *Scorpiops* Peters, 1861
 Tribe Trogllocormini Soleglad et Sissom, 2001
Trogllocormus Francke, 1981
- Family Superstitioniidae Stahnke, 1940
 Subfamily Superstitioniinae Stahnke, 1940
Superstitionia Stahnke, 1940; *Troglotayosicus* Lourenço, 1981
 Subfamily Typhlochactinae Mitchell, 1971
Alacran Francke, 1982; *Sotanochactas* Francke, 1986; *Typhlochactas* Mitchell, 1971
- Family Vaejovidae Thorell, 1876
Franckeus Soleglad et Fet, 2005; *Paravaejovis* Williams, 1980; *Paruroctonus* Werner, 1934; *Pseudouroctonus* Stahnke, 1974; *Serradigitus* Stahnke, 1974; *Smeringurus* Haradon, 1983; *Syntropis* Kraepelin, 1900; *Uroctonites* Williams et Savary, 1991; *Vaejovis* C.L. Koch, 1836; *Vejovoidus* Stahnke, 1974
- Superfamily Iuroidea Thorell, 1876
 Family Caraboctonidae Kraepelin, 1905
 Subfamily Caraboctoninae Kraepelin, 1905
Caraboctonus Pocock, 1893; *Hadruioides* Pocock, 1893
 Subfamily Hadrurinae Stahnke, 1974
Hadrurus Thorell, 1876; *Hoffmannihadrurus* Fet et Soleglad, 2004
 Family Iuridae Thorell, 1876
Calchas Birula, 1899; *Iurus* Thorell, 1876
- Superfamily Scorpionoidea Latreille, 1802
 Family Bothriuridae Simon, 1880
 Subfamily Bothriurinae Simon, 1880
Bothriurus Peters, 1861; *Brachistosternus* Pocock, 1893; *Brazilobothriurus* Lourenço et Monod, 2000;

Centromachetes Lönnberg, 1897; *Cercophonius* Peters, 1861; *Orobothriurus* Maury, 1975; *Pachakutej* Ochoa, 2004; *Phoniocercus* Pocock, 1893; *Tehuanka* Cekalovic, 1973; *Thestylus* Simon, 1880; *Timogenes* Simon, 1880; *Urophonius* Pocock, 1893; *Vachonia* Abalos, 1954

Subfamily Lisposominae Lawrence, 1928

Lisposoma Lawrence, 1928

Family Hemiscorpiidae Pocock, 1893

Subfamily Hemiscorpiinae Pocock, 1893

Habibiella Vachon, 1974; *Hemiscorpius* Peters, 1861

Subfamily Heteroscorpioninae Kraepelin, 1905

Heteroscorpion Birula, 1903

Subfamily Hormurinae Laurie, 1896

Cheloctonus Pocock, 1892; *Chiromachetes* Pocock, 1899; *Chiromachus* Pocock, 1893; *Hadogenes* Kraepelin, 1894; *Iomachus* Pocock, 1893; *Liocheles* Sundevall, 1833; *Opisthacanthus* Peters, 1861; *Palaeocheloctonus* Lourenço, 1996

†Family Protoischnuridae Carvalho et Lourenço, 2001

†*Araripescorpius* Campos, 1986; †*Protoischnurus* Carvalho et Lourenço, 2001

Family Scorpionidae Latreille, 1802

Subfamily Scorpioninae Latreille, 1802

Heterometrus Ehrenberg, 1828; †*Mioscorpio* Kjellesvig-Waering, 1986; *Opisthophthalmus* C.L. Koch, 1837; *Pandinus* Thorell, 1876; *Scorpio* Linnaeus, 1758

Subfamily Diplocentrinae Karsch, 1880

Tribe Diplocentrini Karsch, 1880

Bioculus Stahnke, 1968; *Cazierius* Francke, 1978; *Didymocentrus* Kraepelin, 1905; *Diplocentrus* Peters, 1861; *Heteronebo* Pocock, 1899; *Oiclus* Simon, 1880; *Tarsoporosus* Francke, 1978

Tribe Nebini Kraepelin, 1905

Nebo Simon, 1878

Subfamily Urodacinae Pocock, 1893

Urodacus Peters, 1861

Superfamily *incertae sedis*

†Family Palaeoescorpiidae Lourenço, 2003

†*Palaeoescorpius* Lourenço, 2003

†Parvorder *incertae sedis*

†Family Archaeobuthidae Lourenço, 2001

†*Archaeobuthus* Lourenço, 2001

†Family Palaeopisthacanthidae Kjellesvig-Waering, 1986

†*Compsoscorpius* Petrunkevitch, 1949; †*Cryptoscorpius* Jeram, 1994; †*Palaeopisthacanthus* Petrunkevitch, 1913

†Family Protobuthidae Lourenço et Gall, 2004

†*Protobuthus* Lourenço et Gall, 2004

†Family *incertae sedis*

†*Corniops* Jeram, 1994

†*Palaeoburmesebuthus* Lourenço, 2002

†*Sinoscorpius* Hong, 1983