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Redescription of the Chiapas amber whip spider *Electrophrynus mirus* (Amblypygi)

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Abstract. The fossil whip spider *Electrophrynus mirus* Petrunkevitch 1971 (Arachnida: Amblypygi: Electrophrynidae) from the Mexican Chiapas amber (Miocene: ca 15–20 Ma) is redescribed. Its original referral to an extinct family and genus based on an unusual configuration of the pedipalp is shown to be based on a misinterpretation. The family Electrophrynidae has already been synonymized with Phrynidae. Although *E. mirus* closely resembles modern phrynids, a key diagnostic character relating to the dorsal pattern of spines on the pedipalp patella is not preserved. Since this incomplete fossil cannot be meaningfully compared either to modern genera or to other whip spiders in Neotropical amber, we believe the pragmatic solution is to treat *E. mirus* as a *nomen dubium*.

Keywords: Miocene, Mexico, Electrophrynidae

Whip spiders (Arachnida: Amblypygi) are characterized by spiny, raptorial pedipalps used for prey capture and a long, whip-like first pair of legs that function somewhat like antennae. The animals walk on the remaining three pairs of legs. A flattened body and their leg orientation allow them to crawl into narrow spaces. For a comprehensive overview of whip spider biology see Weygoldt (2000). Modern whip spiders are largely restricted to tropical and subtropical regions of the world today. Five families are conventionally recognized among the living fauna, for which Weygoldt (1996) offered a cladistic analysis and subsequent classification. This was recently emended by Engel & Grimaldi (2014: Table 1) to include extinct genera. Harvey (2003) catalogued 136 living species, and this has since increased to 186 (Harvey 2013), with perhaps more than 190 named taxa currently known (L. de Armas, pers. comm.).

FOSSIL AMBLYPYGI

Fossil whip spiders are rare, with eleven valid species. There are hints (Selden et al. 1991) that the group may have arisen by the mid Devonian (ca. 380 Ma) based on a fossil leg patella bearing a trichobothrium: a character otherwise only known in whip spiders. The first unequivocal examples are five species from the Pennsylvanian Coal Measures (ca. 308–312 Ma) of Europe and North America (e.g., Scudder 1876; Pocock 1911; Petrunkevitch 1913). In terms of the shape and orientation of the pedipalp these Paleozoic fossils resemble the (basal) living Paracharontidae, and may even belong in this family (Dunlop et al. 2007). Following a long hiatus, whip spiders occur again in the Early Cretaceous (ca. 115 Ma) Crato Formation of Brazil (Dunlop & Martill 2002). The original type specimen of this species was treated as being of uncertain family affinities, but a further (larger) example was treated as conspecific (Dunlop & Barov 2005) and tentatively referred to the modern family Phrynidae, which can be found throughout the Americas. A slightly younger (ca. 99 Ma) Cretaceous record from Burmese amber was described by Engel & Grimaldi (2014) and placed as the sister-group of Phrynoidea; i.e., the living families Phrynichidae + Phrynidae.

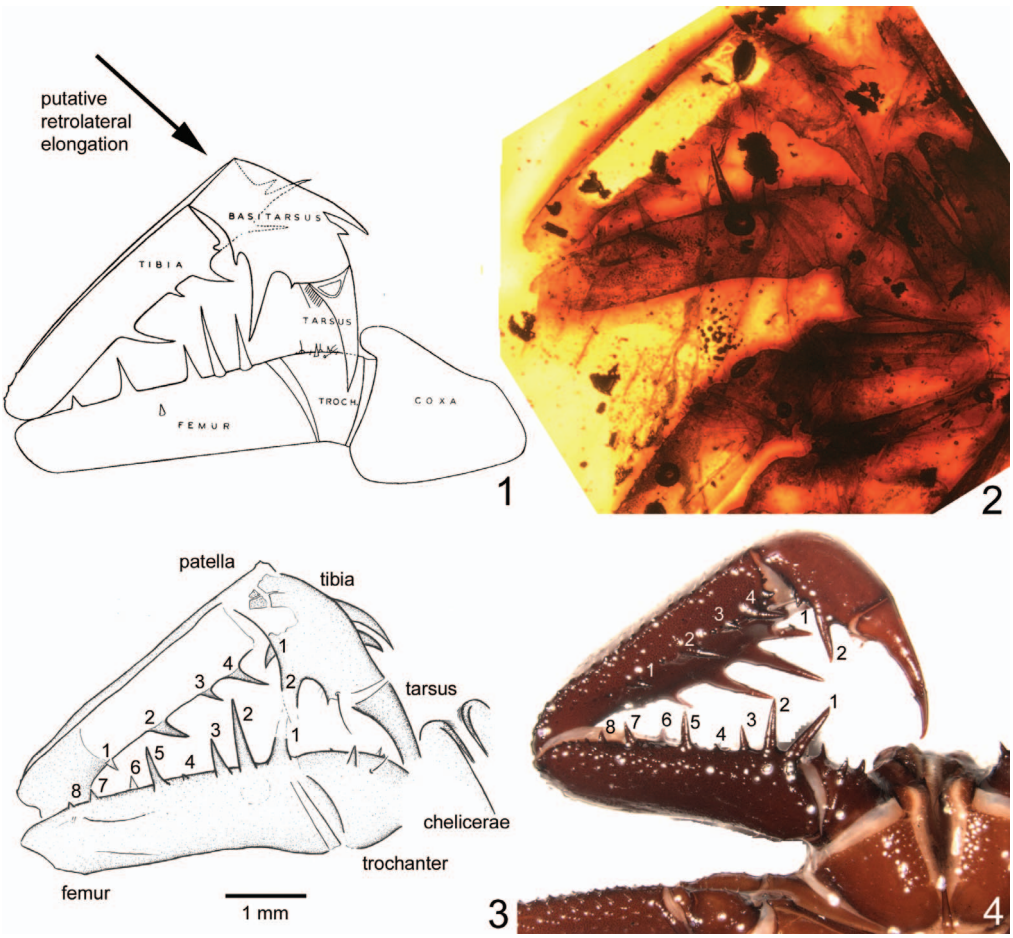
The recently discovered Eocene (ca. 50 Ma) Indian amber yielded a species assignable to Paracharontidae (Engel & Grimaldi 2014). The three remaining species come from Neotropical Miocene (ca. 15–20 Ma) ambers; namely Dominican Republic amber (Schawaller 1979, 1982) and the Chiapas amber of Mexico (Petrunkevitch 1971; Poinar & Brown 2004). The Dominican whip spider and one of the Chiapas species have been placed in the living genus *Phrynus* Lamarck 1801 which occurs widely from the southern states of the USA through Central America and the Caribbean into the northern parts of South America (e.g., Quintero 1981; Harvey 2003). The final species, *Electrophrynus mirus* Petrunkevitch 1971, from Chiapas amber is more enigmatic (see comments in Harvey 2002). It was assigned to an extinct family (Electrophrynidae) and genus based on Petrunkevitch's interpretation of an unusual pedipalp morphology (see below). Here, we redescribe the type specimen of *E. mirus* with the aim of testing the validity of these extinct family and genus names.

STRATIGRAPHY

Chiapas (or Mexican) amber originates from Chiapas State in southern Mexico, predominantly from the locality of Simjovel. An overview of the deposit and its collection history was provided by Solórzano Kraemer (2010) and a summary of the known arthropod inclusions can be found in Engel (2004). In brief, an expedition to collect material organized by the University of California (Berkeley) in the 1950's led directly to the specimens described by Petrunkevitch (1971). Although originally interpreted as Oligocene (ca. 24–33 Ma), most authors now recognize the Chiapas amber as being contemporary with Dominican Republic amber and adopt a slightly younger date of middle Miocene (ca. 15–20 Ma).

METHODS

The holotype, and only known specimen, of *Electrophrynus mirus* was obtained from the University of California Museum of Palaeontology in Berkeley (UCMP), where it is held under "Paleont. No. B-7043-22". The label bears an additional number "13545"— also quoted by Petrunkevitch (1971) — and notes that the specimen is a holotype, including a citation to Petrunkevitch's original paper. The type consists of a roughly quadratic piece of amber (ca. 9 x 9 mm) mounted in a circular piece of resin on a standard microscope slide. The resin bears a coverslip, which has since cracked in two places. The specimen itself is incomplete



Figures 1–4.—The fossil whip spider *Electrophrynus mirus* Petrunkevitch 1971 from the Miocene (ca. 15–20 Ma) Chiapas amber of Simjovel, Chiapas, Mexico, plus a modern specimen. 1. Facsimile copy of Petrunkevitch's (1971:103) interpretative drawing of the pedipalp; his diagnostic character of a supposedly elongate retrolateral patella [labelled the tibia here] is indicated with an arrow. 2. Holotype, UCMP B-7043-22, sp. no. 13545. 3. Camera lucida drawing of the holotype. Spines numbered to facilitate direct comparison with modern material. 4. The Recent species *Phrynus marginemaculatus* C. L. Koch 1840 (Phrynidae); pedipalp in ventral view, spines again numbered.

and consists primarily of the right pedipalp, plus the chelicerae and some other basal limb elements. It can be viewed from both sides, but the carapace is no longer present, which may hint that the specimen is a molt rather than a mortality. The specimen was studied and drawn on a stereomicroscope using a camera lucida attachment. The fossil was directly compared to Recent specimens of whip spiders, in particular the Caribbean species *Phrynus marginemaculatus* C. L. Koch 1840, held in the collections of the Museum für Naturkunde (MfN), Berlin. Note that different authors have used different names for the individual articles of the pedipalp. We orient ourselves using the comparative study of Shultz (1999) who recognized a standard pattern of femur, patella, tibia and tarsus.

Computed X-ray tomography (CT) of the whole slide was attempted in the MfN, in the hope of resolving the spines on the pedipalp more clearly in three-dimensions. The CT scans were, unfortunately, unsuccessful despite numerous attempts using different parameters of analysis. We suspect that the density of the embedding medium around the specimen is too similar to that of the amber and/or fossil inclusion to allow any morphology to be resolved. Alternative methods (e.g., synchrotron radiation) might yield data, but further attempts would probably require extraction of the amber piece from the embedding medium. On balance, we feel that all of the potential characters available could be resolved using traditional light microscopy and that extraction of a holotype from its mount is neither desirable nor necessary in this case.

SYSTEMATIC PALAEONTOLOGY

Order Amblypygi Thorell 1883

Electrophrynus mirus Petrunkevitch 1971, *nomen dubium*

Figs. 1–3

Electrophrynus mirus Petrunkevitch 1971:40; Quintero 1980:343; Quintero 1983:48; Harvey 2002:470; Harvey 2003:22; Armas 2006:356; Engel & Grimaldi 2014:3.

Type specimen.—Holotype and only known specimen: UCMP B-7043-22, sp. no. 13545. Chiapas amber, Simjovel, Chiapas State, Mexico. Neogene (middle Miocene).

Description.—Incomplete specimen. Coxae subtriangular; basal parts of some legs preserved as slender femora. Chelicerae present, narrow (width ca 0.4 mm) with setose fangs. Right pedipalp mostly complete, with article lengths of

ca. 1.2 mm (trochanter), 3.6 mm (femur), 3.5 mm (patella), 1.9 mm (tibia) and at least 1 mm (tarsus; incomplete). Total length thus at least 11 mm. Pedipalp trochanter with at least three small spines. Femur with eight ventral spines; 1 and 2 largest, prominent and slightly diverging from one other, 3 and 5 next longest, 4, 6, 7 and 8 short and tooth-like. Patella with at least four ventral spines; 2 and 4 longer than 1 and 3. Dorsal surface of pedipalp – and any flange and/or spination here – equivocal. Tibia with at least four prominent spines; two dorsal, two ventral. Tarsus forms a curved, tapering element. Carapace, opisthosoma and distal parts of the legs equivocal.

Remarks.—Petrunkevitch (1971) differentiated his fossil family Electrophrynidae, and in turn the genus *Electrophrynus*, from other whip spiders based on ''…very weak, elongate chelicerae, and in the specialized tibia of the pedipalpus''. Note that the patella is misinterpreted as the tibia in much of the older literature, and even some contemporary publications. In detail, Petrunkevitch interpreted the retrolateral side of the pedipalp patella as being very long, projecting beyond the articulation with the next podomere, the tibia (Fig. 1: arrow). Petrunkevitch's study was published posthumously and according to notes in the 1971 paper by the compiler, Harriet Exline, he even went so far as to construct a wooden model of the *Electrophrynus mirus* pedipalp to try and understand how it might have functioned! Our re-investigation does not support the hypothesis of an unusual and/or highly derived pedipalp. We suspect that Petrunkevitch was simply looking at a normal whip spider pedipalp patella in amber in ventral view, albeit from a slightly oblique angle. Given the translucent nature of both the amber and the *E. mirus* inclusion (Fig. 2), it is possible to partially 'look into' the tibia from this angle (Fig. 3). This could give the misleading impression that the cuticle on the far side projects further lengthways than that on the near side.

The *E. mirus* pedipalp is consistent in gross morphology with Recent material assigned to the family Phrynidae. Note particularly the arrangement of eight ventral spines on the femur, two of which are more prominent and diverge from each other near the bases, as well as four spines on the ventral side of the patella and two sets of two spines on the tibia (Figs. 2, 3). Indeed, Quintero (1980) noted similarities in pedipalp shape between the fossils and the genera *Phrynus* and *Paraphrynus* Moreno 1940, later specifically (Quintero 1983) drawing comparisons with the extant Central American species *Phrynus parvulus* Pocock 1902. In his catalog, Harvey (2003:20) synonymized Electrophrynidae with Phrynidae — albeit without comment — and we concur in rejecting Electrophrynidae as a valid family name. Armas (2006) further suggested that Electrophyrnidae could be a synonym of the subfamily Phryninae. Assuming that the amber inclusion is a phrynid, four genera in this family are currently recognized. Almost all are Neotropical, although one species has been found in Indonesia (Harvey 2002; Rahmadi & Harvey 2007). Drawing on the key of Quintero (1981), we can exclude *E. mirus* from the South American genus *Heterophrynus* Pocock 1894 since the amber fossil lacks a posteriorly-directed apophysis from the trochanter of the pedipalp. We can also exclude *Acanthophrynus* Kraepelin 1899 — known today from Mexico and southwestern USA — as this genus has only one dorsal and one ventral spine on the tibia [treated in Quintero's key as the basitarsus] of the pedipalp. By contrast, *E. mirus* has at least two dorsal and two ventral spines on the tibia (Figs. 1–3). This leaves *Phrynus* and *Paraphrynus*, both of which are distributed today from the southern USA through Central America and northern South America, plus the Indonesian *Phrynus* record. Note that *Phrynus* has also been found among the modern fauna of Chiapas state (e.g., Armas & Gadar 2004; Armas 2006), the geographical source of the amber.

Quintero (1981) and Harvey (2002) differentiated *Phrynus* and *Paraphrynus* by a dorsal margin of the pedipalp patella with either one short spine (dorsal spine 3: *Phrynus*) or two short spines (dorsal spines 3 and 4: *Paraphrynus*) between the two longest spines on the pedipalp margin. Careful examination of the *E. mirus* holotype from the dorsal side reveals that the cuticle is completely absent in the expected position of the dorsal flange from the pedipalp patella, which could have borne these spines. We suspect that this region has simply been sheared off at some stage during preservation, rendering this key diagnostic character unavailable. As noted above, at least four spines on the patella are clearly visible (Figs. 2, 3), but we interpret these as ventral spines as they concur with the expected number, shape and position of ventral spines in other phrynid material (Fig. 4); see also Quintero (1981: Fig. 2).

As previously discussed, Petrunkevitch's (1971) unique feature of the *E. mirus* pedipalp — a patella with a projecting retrolateral side — is based on a misinterpretation, and inappropriate for a differential diagnosis of the genus. His fossil is consistent with being a phrynid (Figs. 2, 4), perhaps even a *Phrynus*, but lacks the precise characters necessary for a meaningful comparison with living genera. The problem is that *E. mirus* is the oldest available name for a Neotropical amber whip spider. It is potentially a senior synonym of *Phrynus mexicanus* Poinar & Brown 2004, also from Chiapas amber. Note that Armas (2006:356) emended the species name of this fossil from *mexicana* to *mexicanus*, which incidentally renders it a junior primary homonym of *Phrynus* [currently *Paraphrynus*] *mexicanus* Bilimek 1867. A formal resolution of this issue via the ICZN is in preparation. *E. mirus* could even be synonymous with *Phrynus resinae* (Schawaller 1979) from Dominican Republic amber. Both younger amber names are based on much more complete material which can be usefully compared to living whip spiders. By contrast, *Electrophrynus mirus* is only known from its largely incomplete holotype. We believe that to understand the origins of the Central American whip spider fauna, the pragmatic option is to treat Petrunkevitch's name as a *nomen dubium*, and concentrate instead on the relationships and distribution of the better preserved species described by Schawaller (1979, 1982) and Poinar & Brown (2004).

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