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Palpal teratology in adult male spiders (Arachnida: Araneae): new cases and synopsis of the historical literature

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ABSTRACT: Palpal teratology is newly reported and illustrated in males of three species of spiders: *Hibana incursa* (Chamberlin, 1919) (Anyphaenidae) from Mexico, *Chococtenus lasdamas* Dupérré, 2015 (Ctenidae) from Ecuador (also being newly recorded from the province of Pichincha and the highest altitude record for the species), and *Xerolycosa nemoralis* (Westring, 1861) (Lycosidae) from Russia. The first detailed photographs and descriptions of the anomalous palps of males of *Epicratinus maozinha* Gonçalves et Brescovit, 2024 (Zodariidae) from Brazil and *Carrhotus assam* Caleb, 2020 (Salticidae)

from India are presented. Finally, a synopsis of the other literature on palpal teratology in adult male spiders is given.
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KEY WORDS: Aranei, anomalous, deformity, development, morphology.

Аномалии развития пальп у взрослых самцов пауков (Arachnida: Araneae): новые случаи и обзор литературы

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РЕЗЮМЕ: Впервые приведены и проиллюстрированы аномалии развития пальп самцов трёх видов пауков: *Hibana incursa* (Chamberlin, 1919) (Anyphaenidae) из Мексики, *Chococtenus lasdamas* Dupérré, 2015 (Ctenidae) из Эквадора (также недавно зарегистрирован в провинции Пичинча и является рекордом самой большой высоты для этого вида) и *Xerolycosa nemoralis* (Westring, 1861) (Lycosidae) из России. Впервые приведены детализированные фотографии и описания аномальных пальп самцов *Epicratinus maozinha* Gonçalves et Brescovit, 2024 (Zodariidae) из Бразилии и *Carrhotus assam* Caleb, 2020 (Salticidae) из Индии. Приведён обзор литературы, в которой упоминается аномальное развитие пальп самцов.

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КЛЮЧЕВЫЕ СЛОВА: Aranei, аномальный, деформация, развитие, морфология.

Introduction

Palpal teratology in adult male spiders have been occasionally reported over the years (e.g., Kaston, 1963a; Sedgwick, Platnick, 1986; Beaumont, 1991; Gallon, 1999; Schwendinger, 2003; Almquist, 2006; Lehtinen, Marusik, 2008; Hoffmann, 2009; Baert, 2012; Caleb *et al*., 2020; Marusik *et al*., 2023; Sherwood, Gabriel, 2023; Sherwood *et al*., 2024; Gonçalves, Brescovit, 2024). Palpal anomalies are not restricted to males, other cases exist such as the palp-like appendage found emerging from the ventral abdomen of a subadult female of the thomisid *Mecaphesa californica* (Banks, 1896) [sub *Misumenops californicus*] reported by Kaston (1963b) and a second emerging from the maxilla in an immature female [paratype] of the anyphaenid *Hibana ascensionensis* Sherwood, Marusik, Sharp et Wilkins, 2024 by Sherwood *et al*. (2024).

In a similar, but distinct, topic, Sherwood (2021) depicted a gynandromorph of *Theraphosa blondi* (Latreille, 1804) (family Theraphosidae Thorell, 1869) which had deformity to the left (male) palp and bulb, which was discussed in detail. Similarly, Nadolny *et al.* (2022) exhibit a variety of malformed palps in lycosids, their paper is mentioned in the introduction for completeness, but the aforementioned specimens are explicitly identified as intersexes and gynandromorphs. A comprehensive review of gynandromorphs and intersexes in spiders will be published elsewhere (Sherwood, Azarkina in prep.) and thus these and other works reporting palpal deformities in obvious gynandromorphs or intersexes are not considered further herein.

In this work, we report three specimens from three different families with palpal teratology which represent new teratology records. One such species also represents a new provincial record for Ecuador and new altitudinal record. The first detailed photographs and descriptions of the anomalous palps of two spiders described respectively in Caleb *et al*. (2020) and Gonçalves & Brescovit (2024) are also presented. Furthermore, we provide a synopsis of all literature, kown to us, pertaining to anomalous palps of adult male spiders which are not known to be resultant from injury nor from intersexuality or gynandry; and propose a new classification system.

Material and methods

Repositories of material examined: CARCIB — Centro de Investigaciones Biológicas del Noroeste, S.C., Baja California Sur, Mexico; ISEA — Institute of Systematics and Ecology of Animals, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia; NZC-ZSI — National Zoological Collections, Zoological Survey of India, Kolkata, India; UFMG — Universidade Federal de Minas Gerais, Belo Horizonte, Brazil; ZSFQ-i — Museo de Zoología, Universidad San Francisco de Quito, Quito, Ecuador. The specimen in CARCIB was examined and photographed using a Nikon SMZ645 stereomicroscope with an Amscope MU2000 camera, processed using Helicon Focus software. The specimen in ISEA was examined and photographed using a Zeiss Stemi-2000 stereomicroscope with a Canon EOS 550D camera, processed using Adobe Photoshop software. The specimen in NZC-ZSI was examined and photographed using a Leica M205A with a Flexacam C3 camera, processed using LAS X software. The specimen in ZSFQ-i was examined and photographed using an Olympus SZX16 stereomicroscope with an Olympus DP73 digital camera, processed using Adobe Photoshop software. The specimen in UFMG was examined and photographed using a Leica MZ 16A stereomicroscope with a Leica DFC 500 camera, processed with LAS X software. Abbreviations: AME — anterior median eye; PLE — posterolateral eye; RTA — retrolateral tibial apophysis; VTA — ventral tibial apophysis.

Exclusion criteria: We principally focus on palpal morphology of adult male spiders where significant deformity to the palpal sclerites is known and provide a synopsis of the known literature. We do not consider some cases of genital asymmetry (e.g., Hormiga, 1994), as the literature on this phenomenon was excellently summarised by Rivera-Quiroz *et al*. (2020). Equally, except for citing the most important

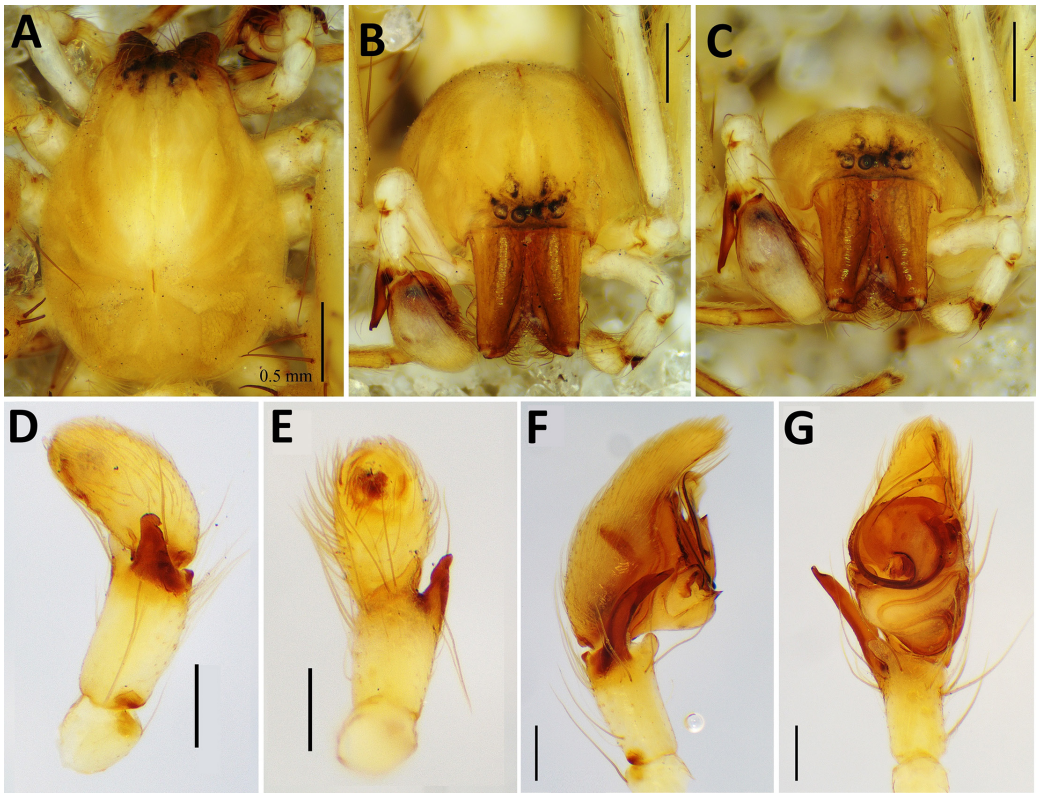

Fig. 1. *Hibana incursa* (Chamberlin, 1919), non-type male (CARCIB-Ar-5615). A — carapace, dorsal view, B — idem, anterodorsal view, C — idem, anterior view, D — left palp, retrolateral view, E — idem, ventral view, F — right palp, retrolateral view, G — idem, ventral view. Scale bars: 0.5 mm (A–C), 0.2 mm (D–G). Photo credit: María-Luisa Jiménez and David Chamé-Vázquez.

early works for completeness, we do not consider papers on experimentation in autonomising spiders (e.g., Blackwall, 1848), as the historical literature was reviewed by Roth & Roth (1984) and experimental research, outside the scope of this work, in modern-day laboratories is being undertaken by other colleagues. We also do not consider abnormal palps resultant from mechanical injury (e.g., Cutler & Guarisco, 2023) or damage to museum specimens (e.g., Smith, 1995), where the palps are presumably of normal morphology prior to injury, nor cases where palps are regenerated but the palpal bulb is not deformed (e.g., Gabriel, 2011; Abi-Rezik *et al*., 2018), as these are non-teratological processes

Results

Family Anyphaenidae Bertkau, 1878

Hibana incursa (Chamberlin, 1919)
Fig. 1A–G.

MATERIAL EXAMINED: 1 ♂ (CARCIB-Ar-5615), Culiacán (24°48′N, 107°23′W), Sinaloa, Mexico, 25 May 1996, leg. C. Palacios *et al*.

REMARKS. The left palp of the male specimen is deformed (Fig. 1D–E), compared against the normal palp (Fig 1F–G). The deformed palp has the cymbium almost entirely unsclerotised, with only some anomalous sclerite development in the anterior quarter, consisting of asymmetric sclerotization. None of the normal structures (e.g., median apophysis, embolus) are present. The retrolateral tibial apophysis (RTA) is about half its normal size and greatly wider in the basal quarter, apparently fused with the small ventral tibial process. The apical quarter has retrolateral invagination and the apex is rounded, giving the apical quarter of the RTA a P-shaped appearance. In ventral view, the RTA shows some of the inflection at the apex found in normal specimens, but the apex is of the same diameter as the median third, which is not the case in normal specimens. Furthermore, the right posterior lateral eye (PLE) is absent, while the left PLE is greatly

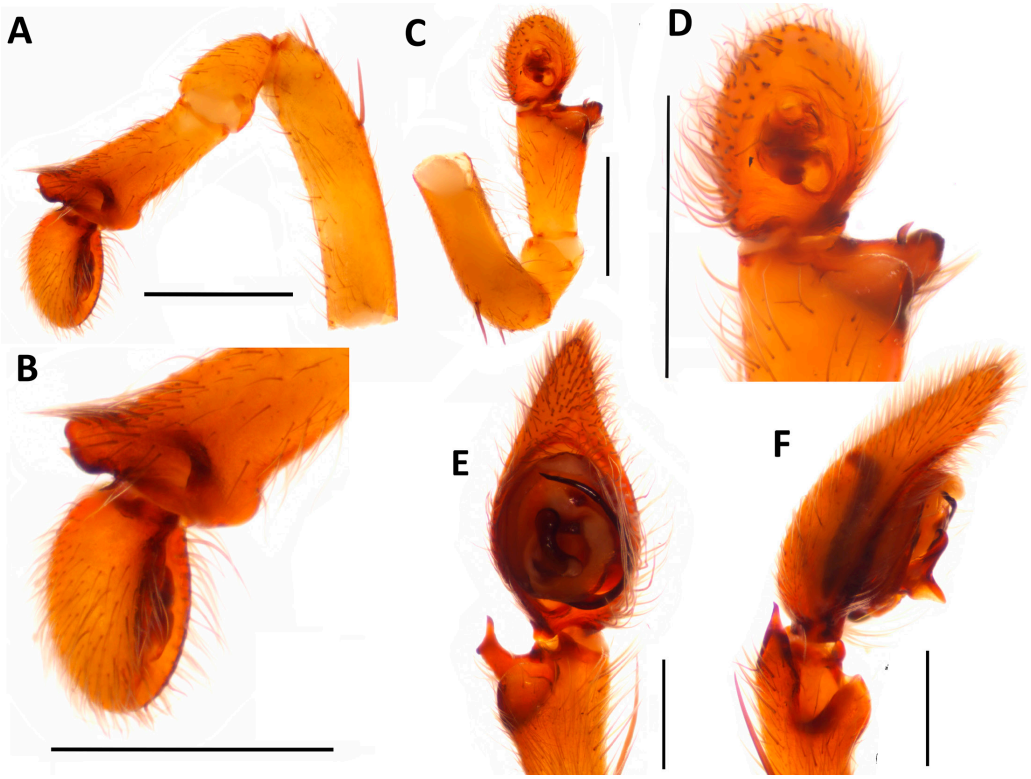

Fig. 2. *Chococtenus lasdamas* Dupérré, 2015, non-type male (ZSFQ-i). A — left palp, retrolateral view, B — idem, close-up, C — idem, ventral view, D — idem, close-up, E — right palp, ventral view, F — idem, retrolateral view. Scale bars: 1 mm. Photo credit: Pedro Peñaherrera-R.

reduced. Both anterior median eyes (AME) are also reduced (Fig. 1A–C).

Family Ctenidae Keyserling, 1866

Chococtenus lasdamas Dupérré, 2015
Fig. 2.

MATERIAL EXAMINED: 1 ♂ (ZSFQ-i), La Hesperia N. R. (0°21′41″S, 78°50′43″W), Pichincha, Ecuador, 1 November 2018, leg. C. Picho.

REMARKS. The left palp of the male specimen is deformed (Fig. 2A–D), it is compared against the normal palp (Fig. 2E–F). The deformed palp is much shorter, overall and proportionally in each segment, to the normal palp. Both the RTA and ventral tibial apophysis (VTA) are present but are grossly deformed. The VTA is a rounded nub only half as long as in normal specimens, the RTA being only a third the length of a typical apophysis, with a single megaspine protruding dorsally and without any of the narrowing or apical shape found in a normal specimen. The cymbium is malformed and rounded, contrasting with the distally elongated and pointed cymbium of normal specimens, particularly in their apical third. Some sclerotization is apparent, but as found in the *Hibana* male (to a greater degree in the latter) much of the cymbium lacks recognisable sclerites, those present being mostly in the median third, and consisting of asymmetric sclerotization. A vestigial development of the tegulum and median apophysis development can be observed, but no further physical detail can be identified. Separately to the abnormal morphology of the palp, this specimen represents the highest altitudinal record (1500 m) for the species, as well as an expansion of its distribution for the first time to the province of Pichincha.

Family Lycosidae Sundevall, 1833

Xerolycosa nemoralis (Westring, 1861)
Fig. 3.

MATERIAL EXAMINED: 18♂♂, 6♀♀ (ISEA 001.9568), Russia, Kemerovo Area, Prokopyevsky District, c. 1 km NW of Krasnobrodsky (c.

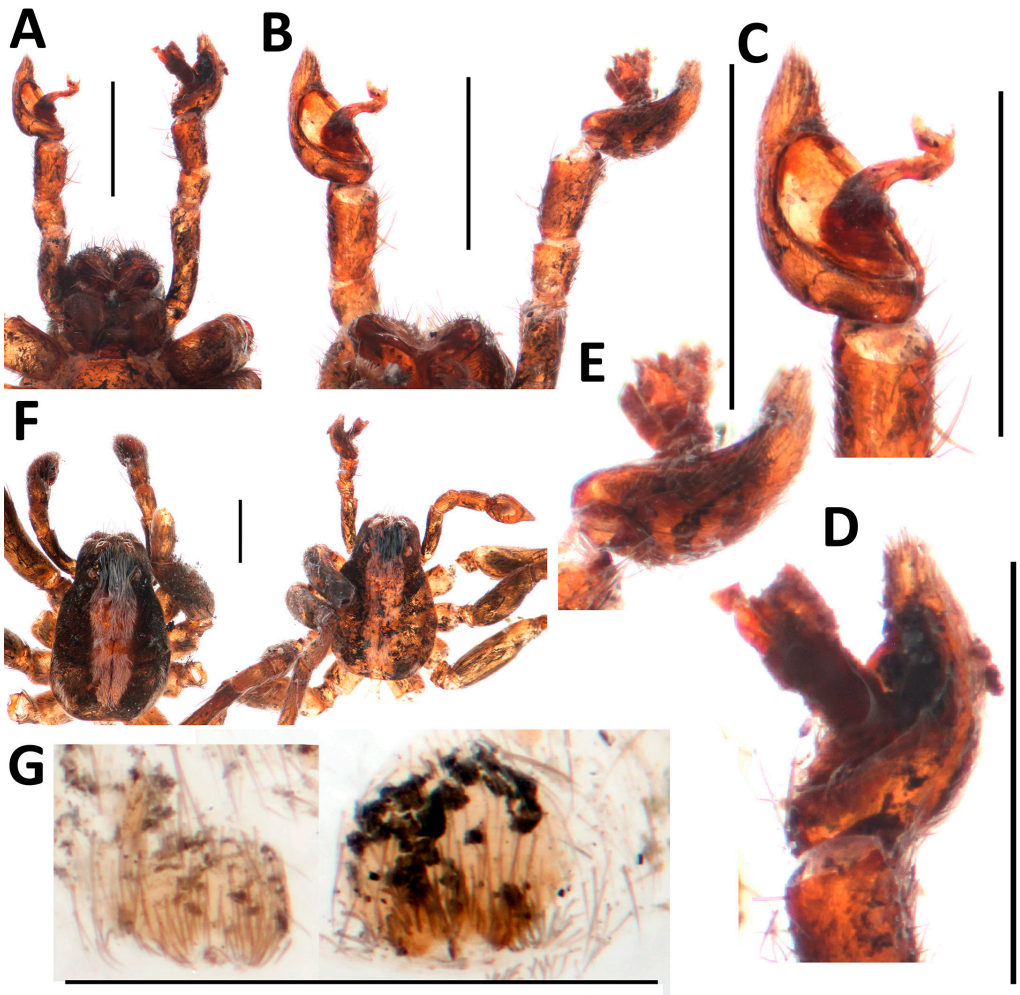

Fig. 3. *Xerolycosa nemoralis* (Westring, 1861), non-type males (ISEA 001.9568). A–E — palps of abnormal male, A — ventral view, B — ventro-lateral view, C — close-up of right palp [itself in retroventral view], D — close-up of left palp [itself in retroventral view], E — close-up of left palp [itself in retrolateral view], F — normal (left) and abnormal (right) males, comparative habitus, dorsal view, G — normal (right) and abnormal (left) epigastric areas of aforementioned specimens, dorsal view. Scale bars — 1 mm. Photo credit: Galina N. Azarkina.

54°09′16.99″N, 86°31′40.73″E), mixed forest, pitfall traps, 16 July 2019, leg. S.L. Luzyanin [only 1 ♂ with teratology, remainder of specimens normal].

REMARKS. The entire body of the abnormal male looks slightly immature — smaller in size (Fig. 3F), and the epigastric area with a smaller chitinous area — two times smaller compared against the normal male (Fig 3G–H). Both palps of the abnormal specimen are deformed (Fig. 3A–E), compared against a normal palp (e.g. Marusik *et al*., 2011: fig. 24). The cymbium of both palps are comparatively smaller in size, the right palp has one long structure, the apical part of which remains with a tegular apophysis (Fig. 3C). The left palp has more complex structure, with many sclerites fused together (Fig. 3D–E); one of the structures slightly resembles a tegular apophysis while the other looks like a reduced embolus. The epigastric area of the abnormal male differs from that of normal males (Fig. 3G) but there is no morphological evidence of female anatomy, so we hesitate to conclude it is intersex without genetic testing. This material was collected in the area that has recovered after coal mining for 25 years and was preserved originally in a

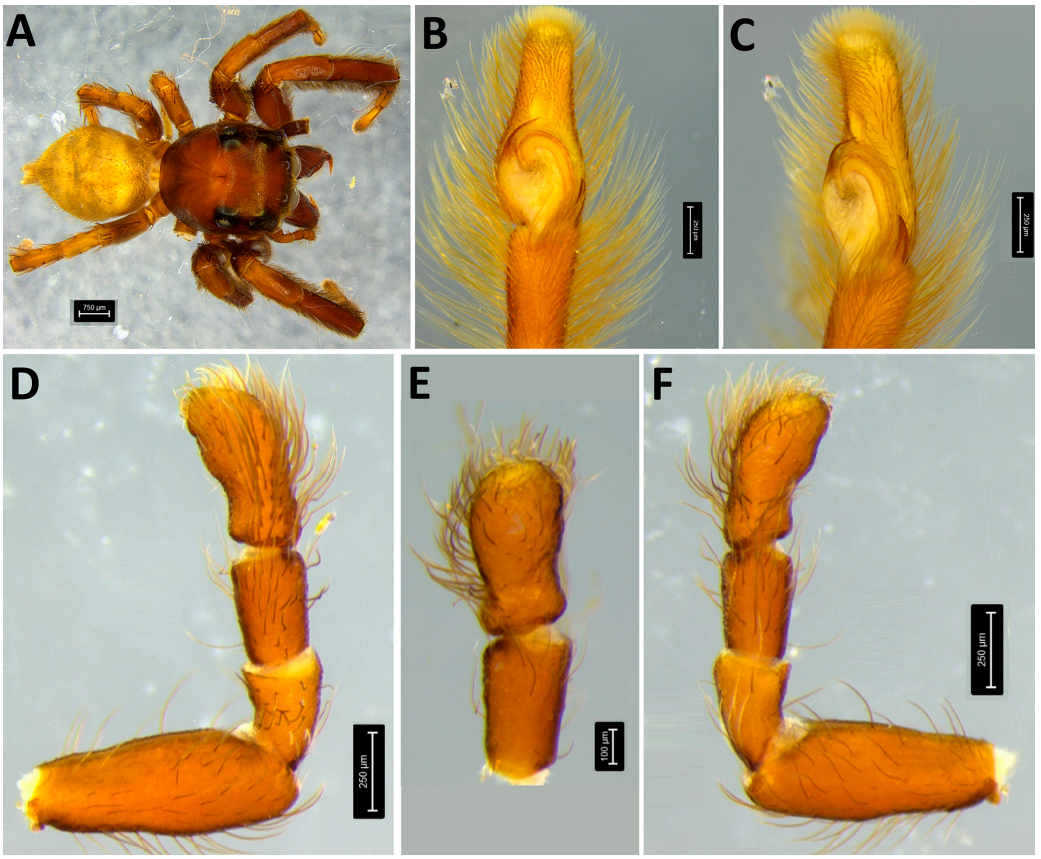

Fig. 4. *Carrhotus assam* Caleb in Caleb, Bera et Acharya, 2020, holotype male (NZC-ZSI 6938/18). A habitus, dorsal view, B left (normal) palp, ventral view, C idem, retrolateral view, D right (anomalous) palp, prolateral view, E idem, ventral view, F idem, retrolateral view. Scale bars — 0.75 mm (A), 0.25 mm (B–D, F), 0.1 mm (E). Photo credit: Puthoor Pattammal Sudhin and Souvik Sen.

mixture of vinegar and water, meaning the specimens are in fragile condition.

Family Salticidae Blackwall, 1841

Carrhotus assam Caleb in Caleb, Bera et Acharya, 2020
Fig. 4.

MATERIAL EXAMINED: Holotype ♂ (NZC-ZSI 6938/18), Dehing Patkai Wildlife Sanctuary (27°14′24.0″N, 95°24′36.0″E), Assam, India, 137 m above sea level, 16 August 2016, leg. T. K. Roy.

REMARKS. The holotype male (Fig. 4A) has a deformed right palp, which is illustrated and mentioned here in detail for the first time (Fig. 4D–F). The photographs of the normal left palp are also provided for comparison (Fig. 4B–C). The deformed palp is strikingly dissimilar to the normal palp, structures including the embolus, and membranous and sclerotized structures are totally absent. The cymbium is malformed, but presents minimal ventral excavation. The RTA is also absent, and both the tibia and tarsus are shorter in length in comparison to the normal palp and sparsely covered with hairs while the normal palp is densely covered with hairs.

Family Zodariidae Thorell, 1881

Epicratinus maozinha Gonçalves et Brescovit, 2024
Fig. 5.

MATERIAL EXAMINED: Holotype ♂ (UFMG 9368), Parque Nacional Cavernas do Peruaçu (15°9′S, 44°11′W), Itacarambi, Minas Gerais, Brazil, 17th to 22nd October 2006, leg. Ferreira *et al*.

REMARKS. As mentioned in Gonçalves & Brescovit (2024) the holotype male of this species has a deformed left palp. It is here figured properly

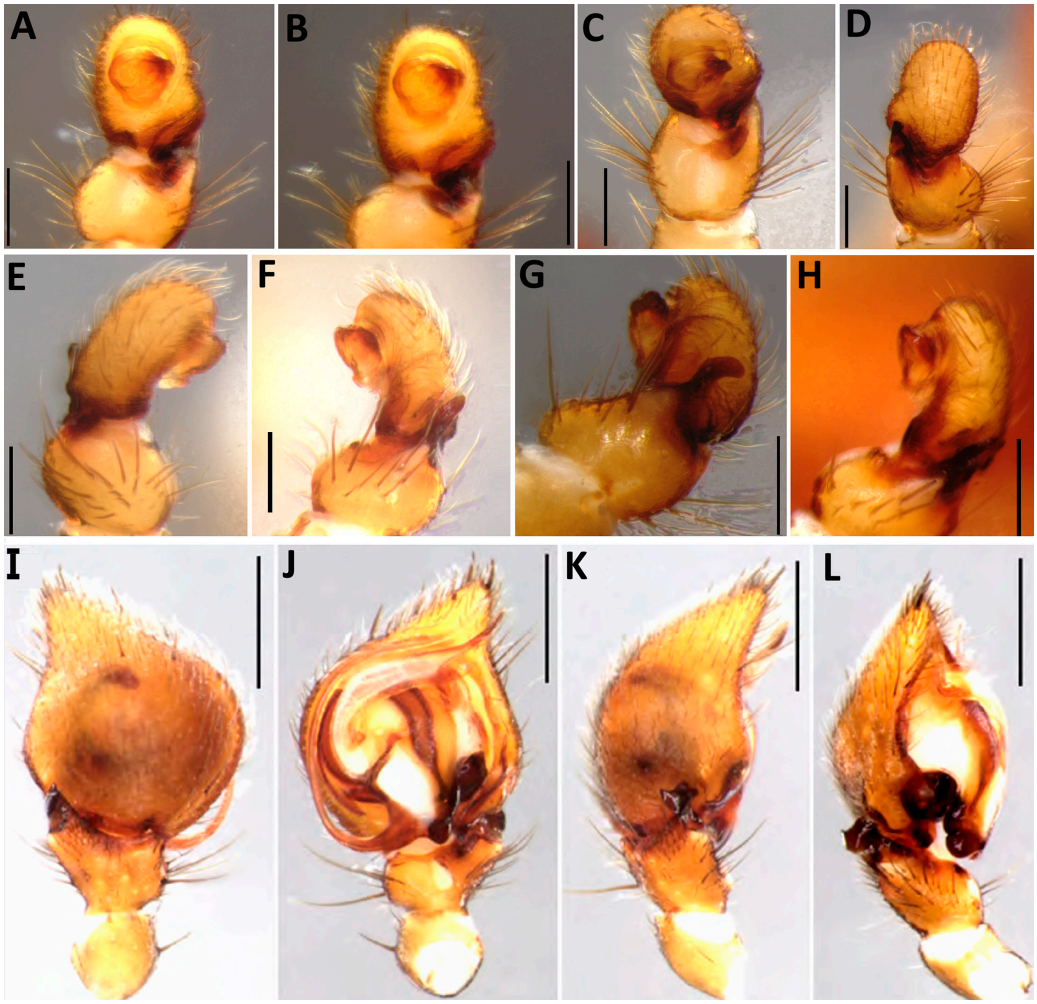

Fig. 5. *Epicratinus maozinha* Gonçalves et Brescovit, 2024, holotype male (UFMG 9368). A — left palp, ventral view, B — idem, close-up, C — idem, prolatro-apical view, D — idem, dorsal view, E — idem, prolateral view, F idem, retrolateral view, G — idem, retro-posterior view, H — retro-dorsal view, I — right palp (images horizontally flipped), dorsal view, J — idem, ventral view, K — dorso-retrolateral view, L — retrolateral view. Figures I–L adapted from Gonçalves & Brescovit (2024), reproduced from Zootaxa [5428(4)] with permission. Scale bars — 0.2 mm (A–H), 0.5 mm (I–L). Photo credit: Ricardo Antonio Gonçalves.

for the first time (Fig. 5A–H), the photographs of the normal right palp are also reproduced (Fig 5I–L). The deformed palp is strikingly dissimilar to a normal palp. The embolus, and other structures including membranes, are totally absent; the deformed palp again shows a large area without sclerites, the sclerotization being mostly in a single almost circular mass covering the median and apical thirds of the cymbium. The pointed apex in the apical third, and the corresponding apical cymbial spines, both found in normal specimens, is missing. The RTA is of homogenous colour to the tibia, not sclerotised, and is in a weak R-shape, entirely inconsistent with the normal RTA of the right palp, which is short, directed diagonally upwards with the apex pointing dorsally, resembling a curved dark brown flower (approximately 45º angle), and trifid.

Discussion

The order Araneae Clerck, 1757 can be split into two suborders: Mesothelae Pocock, 1892 and Opisthothelae Pocock, 1892. We know of a single reported case of palpal teratology in the subor-

der Mesothelae: Sedgwick & Platnick (1986) illustrate the palp of an abnormal specimen of *Liphistius panching* Platnick et Sedgwick, 1984 (Liphistiidae Thorell, 1869) in comparison to that of a normal male. Further to deformities in the sclerites of the palpal bulb, the abnormal specimen also shows merely vestigial invagination and modification of the palpal tibia. It is unclear if only one or both palps of the abnormal specimen were anomalous, as only one is discussed in detail, although the fact the spider was found to be abnormal in other aspects (colouration and body size; see Sedgwick & Platnick, 1986: 203) it can probably be assumed to be the case.

Within the suborder Opisthothelae, the vast majority of palpal teratology and abnormalities have been reported in araneomorph spiders, detailed further below. In regards to the Mygalomorphae Pocock, 1892, deformities in palpal bulbs have been reported in five theraphosid species: *Ceratogyrus dolichocephalus* Hewitt, 1919 [sub *Coelogenium pillansi*] by Gallon (1999), *Hapalotremus yuraqchanka* Sherwood *et al*., 2021 by Sherwood & Gabriel (2023), *Neischnocolus cisnerosi* Peñaherrera-R., Guerrero-Campoverde, León-E., Pinos-Sánchez et Falcón-Reibán, 2023 by Peñaherrera-R. (2023), *Phormictopus* sp. by Sherwood *et al*. (2024), and *Pterinochilus cryptus* Gallon, 2008 by Gallon (2002 [sub *P. murinus* Pocock, 1897], 2008).

Gallon (1999) illustrates a normal palpal bulb and an anomalous (right) bulb from a single specimen, the latter showing a significantly shortened embolus with much wider width in the basal half and a stronger taper in the apical half. Gallon (2008: 234) notes that the holotype male of *Pterinochilus crypticus* [type series previously identified by Gallon (2002: 214) as *P. murinus* with the note "atypical specimens exhibiting palp re-growth"] from Angola has the right palp "…clearly re-grown, indicated by palpal bulb abnormality", noting the left palp is normal. The anomalous palp is not figured in Gallon (2002) nor Gallon (2008). Sherwood & Gabriel (2023) depict the anomalous left bulb of a male which exhibited abnormal embolus invagination, a deformed prolateral inferior keel, embolus dilation (not present in normal specimens), and absence of the subapical keel (present in normal specimens). Peñaherrera-R. *et al*. (2023) report the left palpal bulb of the holotype of *N. cisnerosi* has a deformed embolus but do not illustrate this. Sherwood *et al*. (2024) depict the normal (left) and anomalous (right) palpal bulbs, the latter with a significantly shorter and stouter embolus, without the more pronounced taper in the apical third found on the normal bulb. In the aforementioned cases, all pedipalps themselves were abnormally short. We are aware of one other case in the infraorder, referring to a barychelid. Schwendinger (2003: 198) reported that the holotype male of *Sason andamanicum* (Simon, 1888) from South Andaman Island had the "... [right palp rather different in shape (presumably deformed)]" without illustration or explanation.

The first major contribution to palpal teratology of, otherwise normal, male spiders in Araneomorphae Smith, 1902 was by Falconer (1910). He reports, textually only, a male of the linyphiid *Micrargus herbigradus* (Blackwall, 1854) [sub *Lophomma herbigradum*] with both palps anomalous, with the cymbia malformed and lacking sclerotised structures and covered with cuticle. He also illustrates a male of the tetragnathid *Metellina segmentata* (Clerck, 1757) [sub *Meta segmentata*] with an abnormal right palp with malformed sclerites which protrude from the ventral excavation of the cymbium. Falconer (1917) discusses this topic again, also mentioning two new cases "... total suppression of palpal organs" in the araneid *Araneus sturmi* (Hahn, 1831) [sub *Epeira sturmii*] and the clubionid *Clubiona terrestris* Westring, 1851, but without further explanation or illustration. It can be surmised that Falconer is likely referring to specimens where the cymbium is malformed on both palps, with absence of sclerites and ventral excavation of the cymbia. Thus, Falconer (1910) appears to be the first author to illustrate and discuss *in detail* teratology of the palp(s) of an adult male spider.

Bonnet (1930) made an extensive study of regeneration of various appendages — not just palps — in the dolomedid genus *Dolomedes* Latreille, 1804 through his experimental studies. He demonstrated that if a palp of an immature male spider is lost [autotomized due to injury] several moults prior to the final ecdysis, the regenerated palp is usually near perfectly formed both in morphology and size upon maturity. In cases where injury was caused closer to or immediately prior to the final ecdysis, abnormality was correspondingly more profound by orders

of magnitude. Muma (1943) reported, amongst other cases, a male of the salticid *Pelegrina galathea* (Walckenaer, 1837) [sub *Metaphidippus ornatus* (Banks, 1892)] from Maryland which had only one normal palp. Unfortunately, it is not stated which side of the body possessed normal morphology. Furthermore, it is unclear whether there was a total absence of a palp on the anomalous side or whether it simply presented a regenerated palp with absence of sclerites and normal structures since Muma (1943:80) states "… tip of the palpus was furnished with several hairs."; no illustrations are provided.

Chrysanthus (1955) discussed the work of Blackwall (1845) and Bonnet (1930), also reporting three new, well-illustrated, cases. Chrysanthus (1955) first reports a male of the tetragnathid *Pachygnatha clercki* Sundevall, 1823 with both palps deformed. The left palp has no sclerites nor tarsal claw and is described as "... almost absolutely female" (Chrysanthus, 1955) although no evidence exists to strongly conclude the specimen was a gynandromorph or intersex. The right palp is profoundly deformed, with absence of normal sclerites and structures, instead presenting with an abnormal protuberance from a malformed cymbium. Secondly, an anomalous left palp is reported in a male of the theridiid *Steatoda bipunctata* (Linnaeus, 1758). The abnormal palp has a malformed cymbium and abnormally shaped sclerites. Thirdly, a male of the tetragnathid *Metellina mengei* (Blackwall, 1869) [sub *Meta mengei*] was reported with an anomalous left palp; all the expected sclerites and structures such as the embolus are present but of unusual proportions, giving the palp an abnormal appearance.

Kaston (1963b) made a significant contribution to knowledge of palpal anomalies and reported 11 cases, spanning variable families and parts of palpal anatomy. Kaston (1963b) illustrates the abnormal left and normal right palp of a male of the agelenid *Agelenopsis pennsylvanica* (C.L. Koch, 1843). The former presents with a cymbium and conductor of abnormal size and lacks the properly developed embolus found in the normal palp. The proceeding cases are summarised below: a male of the salticid *Paraphidippus* sp. [sub *Paraphidippus* sp. (probably *marginatus* Walckenaer)] with both palps deformed at the cymbium and lacking sclerites; a male of the salticid *Phidippus clarus* Keyserling, 1885 with an abnormal right palp lacking sclerites; a male of the thomisid *Xysticus ferox* (Hentz, 1847) [sub *Xysticus transversatus* (Walckenaer, 1837), a nomen oblitum] with a severely deformed cymbium without sclerites, and slightly deformed palpal tibia, on the right palp; another male of *X. ferox* but with the left palp deformed (both palps illustrated), presenting a shortened but not profoundly deformed cymbium, but again lacking sclerites; a male of the corinnid *Corinna* sp. with a deformed left palp (both palps illustrated), showing deformity to the palpal tibia and its corresponding apophysis, combined with a deformed cymbium without normal sclerites, only minimal abnormal sclerotization present; a male of the dictynid *Emblyna artemisia* (Ivie, 1947) [sub *Dictyna artemisia*] with both palps deformed (only left illustrated), presenting a deformed palpal tibial apophyses and absence of normal sclerites on the cymbium, presenting only a small amount of abnormal sclerotization; a male of the linyphiid *Ceraticelus* sp. [identification tentative] with both palps deformed (only right illustrated), the right more severely deformed than the left, but both lacking normal sclerites on the cymbium; a male of the lycosid *Pardosa californica* Keyserling, 1887 with both palps deformed (and illustrated), with profoundly deformed sclerites protruding vertically from the cymbium on the left palp, the right palp similar except the extension is less extreme; a male of the lycosid *Hogna ammophila* (Wallace, 1942) [sub *Lycosa ammophila*] with both palps deformed (and illustrated), both with deformed cymbia and sclerites, and finally a male of the cheiracanthiid *Cheiracanthium inclusum* (Hentz, 1847) [sub *Chiracanthium inclusum*] with the left palp deformed (both palps illustrated), presenting a malformed cymbium, sclerites, and cymbial spur.

Denis (1963) reported a male of the linyphiid *Trichopterna cito* (O. Pickard-Cambridge, 1873) with both cymbia malformed, with abnormal sclerites, in contrast to the normally-formed palpal tibiae. He also reports having seen other specimens of spiders where there was fusion of palpal segments or where the ventral cymbium lacked sclerotised structures, but does not mention specific taxa or provide illustrations of these further cases.

Almquist (2006) illustrates the right palp of a specimen of the lycosid *Pardosa trailli* (O. Pickard-Cambridge, 1873) from Sweden which

is clearly deformed, as seen most clearly in the second of two figures of the palp (i.e. Almquist, 2006: 230, fig. 227b). However, he does not make any note that the palp exhibits teratology, perhaps mistaking it for normal morphology. Lehtinen & Marusik (2008) note they examined a Paraguayan male of the thomisid *Misumenops guianensis* (Taczanowski, 1872) with an abnormal right palp, but do not make any further comment nor present figures of it. Hoffman (2009) reports a male of the gnaphosid *Callilepis imbecilla* (Keyserling, 1887) [sub *Callilepis imbecillis*] from Virginia, USA with both its palps "... a little deformed" (Hoffman, 2009: 19), noting the species was tentatively identified by Norman I. Platnick. The specimen was not illustrated.

Baert (2012) reports a specimen of the lycosid *Trochosa ruricola* (De Geer, 1778) from Belgium with both palps severely deformed; he describes the teratology as being symmetrical, although there are slight differences between the deformities found on the left and right palps, and thus it is better described as bilateral. Nonetheless, the case is remarkable as the sclerites are profoundly enlarged and deformed. Baert (2012) hypothesises his case might shed light on the ontogenetic process in male spider palps. Fomichev *et al*. (2013) illustrate a teratological specimen of the gnaphosid *Gnaphosa rasnitsyni* Marusik, 1993 [sub *Gnaphosa ustyuzhanini* Fomichev, Marusik et Omelko, 2013]. The specimen has an underdeveloped palp, with abnormal tegulum and subtegulum, length and direction of the embolus. Tomić *et al*. (2016) report a male of the lycosid *Pardosa agrestis* (Westring, 1861) with striking bilateral anomaly to the palps, with each palp having a second palp emergent from the excavated membranous ventral face of the cymbium; the 'second' palps have a developed tibia and cymbium but the sclerites are subcutaneous and thus the palps are one of a developing immature male. This is most unusual, considering the 'first' palps (albeit grossly malformed) are adult palps with according cymbial modification.

Caleb *et al.* (2020: 55, fig. 13) show that the holotype male of the salticid *Carrhotus assam* Caleb, 2020 has a malformed and underdeveloped right palp, much smaller than the left palp used for the description of the species. However, they did not discuss it in detail or figure it properly; it is dealt with herein. Marusik *et al.* (2023) reported the first case of conductor malformation in an araneomorph, based on a male of the dictynid *Dictyna arundinacea* (Linnaeus, 1758) from Madaun, Russia. The anomaly was found, to different extents, in both palps. Crews (2023) noted both palps of the holotype of the selenopid *Karaops garyodwyeri* Crews, 2023 have not fully sclerotised following the maturation ecdysis. She notes that the spine on the dRTA may be abnormal and that the dRTA of the right palp [not illustrated] also presents further deformity. Gonçalves & Brescovit (2024: 475, figs 9A–B) documented a case of palpal teratology in the male holotype of the zodariid *Epicratinus maozinha*, similar to Caleb *et al*. (2020), with no discussion or detailed images of the deformed palp provided; this case is properly described herein.

Looking more broadly, the prior literature combined with the three new records herein constitute an overall total of 41 cases of male palpal teratology which warrant inclusion within the scope of our work (see Material and Methods for exclusion criteria). The families Lycosidae (6), Theraphosidae (5), Salticidae (4), Linyphiidae Blackwall, 1859 (3), Thomisidae Sundevall, 1833 (3), and Tetragnathidae Menge, 1866 (3) have the most reported cases; two cases are known respectively from the following families: Gnaphosidae Banks, 1892, and Dictynidae O. Pickard-Cambridge, 1871; the remaining families only have one case properly documented each: Agelenidae C.L. Koch, 1837, Anyphaenidae, Araneidae Clerck, 1757, Barychelidae Simon, 1889, Cheiracanthiidae Wagner, 1887, Clubionidae Simon, 1878, Corinnidae Karsch, 1880, Ctenidae, Dolomedidae Simon, 1876, Liphistiidae Thorell, 1869, Selenopidae Simon, 1897, Theridiidae Sundevall, 1833, and Zodariidae Thorell, 1881. Fourteen cases are known to affect both palps, 27 present only one anomalous palp. We hereby present a classification system for rating extent and severity of deformities in male spider palps (Table 1) which we hope is useful to future workers. Much like the classification system for gynandromorph spiders proposed in Roberts & Parker (1973), our system considers the wide possibility of combinations of teratological processes, and thus many types which are theoretically possible are not yet reported (as can be found in some of their 14 types of gynandromorphs). This is likely an artefact of under-recording, but may also be as

Table 1. Classification system of deformities in palps of male spiders (excluding obvious gynandromorphs and intersexes). The following references are omitted from the table as they do not contain sufficient information to be certain on their classification: Falconer (1917), Muma (1943), Sedgwick & Platnick (1986), Gallon (2002), Schwendinger (2003), Lehtinen & Marusik (2008), and Hoffman (2009). Species are only given where a work deals with multiple taxa with abnormalities. N/A — non-applicable.

Type	Definition	Known cases
1A	Either left or right palp deformed, cymbium lacking sclerites and lacking ventral excavation, other segments of palp (e.g. femur, patella, and/or tibia) also abnormally formed or sized.	N/A
1B	Either left or right palp deformed, cymbium lacking sclerites and lacking ventral excavation, other segments of palp (e.g. femur, patella, and/or tibia) normal.	Falconer (1910) [*Micrargus herbigradus*], Chrysanthus (1955) [*Pachygnatha clercki*], Kaston (1963b) [*Paraphidippus* sp., *Ceraticelus* sp., *Hogna ammophila*, *Cheiracanthium inclusum*].
1C	Either left or right palp deformed, cymbium with underdeveloped/ abnormal sclerites/other structures and presence of ventral excavation, other segments of palp (e.g. femur, patella, and/or tibia) also abnormally formed or sized.	this work [*Hibana incursa, Chococtenus lasdamas*, *Carrhotus assam* (see also Caleb *et al.*, 2020), *Epicratinus maozinha* (see also Gonçalves & Brescovit (2024)]; Bonnet (1930), Denis (1963), Fomichev *et al.* (2013), Marusik *et al.* (2023) Gallon (1999); Gallon (2002); Gallon (2008); Sherwood & Gabriel (2023); Peñaherrera-R. *et al.* (2023); Sherwood *et al.* (2024).
1D	Either left or right palp deformed, cymbium with underdeveloped/ abnormal sclerites/other structures and presence of ventral excavation, other segments of palp (e.g. femur, patella, and/or tibia) normal.	Falconer (1910) [*Metellina segmentata*], Bonnet (1930), Chrysanthus (1955) [*Steatoda bipunctata*, *Metellina mengei*], Kaston (1963b) [*Agelenopsis pennsylvanica*, *Phidippus clarus*, *Xysticus ferox*]; Almquist (2006).
1E	Either left or right palp deformed, cymbium with overdeveloped (abnormally enlarged) sclerites and presence of ventral excavation, other segments of palp (e.g. femur, patella, and/or tibia) also abnormally formed or sized.	N/A
1F	Either left or right palp deformed, cymbium with overdeveloped (abnormally enlarged) sclerites and presence of ventral excavation, other segments of palp (e.g. femur, patella, and/or tibia) normal.	N/A
2A	Both palps deformed, cymbia lacking sclerites and lacking ventral excavation, other segments of palps (e.g. femora, patellae, and/or tibiae) also abnormally formed or sized.	N/A
2B	Both palps deformed, cymbia lacking sclerites and lacking ventral excavation, other segments of palps (e.g. femora, patellae, and/or tibiae) normal.	N/A

Table 1 (continued).

Type	Definition	Known cases
2C	Both palps deformed, cymbia with underdeveloped/abnormal sclerites/ other structures and presence of ventral excavation, other segments of palps (e.g. femora, patellae, and/ or tibiae) also abnormally formed or sized.	Crews (2023).
2D	Both palps deformed, cymbia with underdeveloped/abnormal sclerites/ other structures and presence of ventral excavation, other segments of palps (e.g. femora, patellae, and/ or tibiae) normal.	N/A
2E	Both palps deformed, cymbia with overdeveloped (abnormally enlarged) sclerites and presence of ventral excavation, other segments of palps (e.g. femora, patellae, and/ or tibiae) also abnormally formed or sized.	N/A
2F	Both palps deformed, cymbia with overdeveloped (abnormally enlarged) sclerites and presence of ventral excavation, other segments of palps (e.g. femora, patellae, and/ or tibiae) normal.	this work [*Xerolycosa nemoralis*]; Kaston (1963b) [*Pardosa californica*]; Baert (2012), Tomić et al. (2016) [extreme case, 'second palp' emergent from each cymbium].

some of these forms are difficult to detect. Only future research can further elucidate this subject. The current known cases can be grouped into five categories: 1B, 1C, 1D, 2C and 2F. Cases involving only one palp currently far outweigh those involving anomaly in both palps, but this may merely be artefactual based on the paucity of reported cases.

Compliance with ethical standards

CONFLICTS OF INTEREST: The authors declare that they have no conflicts of interest.

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