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Análise cladística dos gêneros de Segestriidae
(Araneae, Synspermiata, Dysderoidea)

Cladistic analysis of Segestriidae genera
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1. Resumo

Segestriidae é atualmente representada por quatro gêneros compreendendo 130 espécies descritas de aranhas: *Segestria*, *Ariadna*, *Gippsicola* e *Citharoceps*. Esta família faz parte do clado Dysderoidea, que também inclui Dysderidae, Orsolobidae e Oonopidae – todas as quatro famílias apresentando o desenvolvimento de um receptáculo posterior em sua genitália interna feminina. Atualmente não existem hipóteses de parentesco entre as espécies dos quatro gêneros de segestriídeos, e a morfologia da genitália interna das fêmeas apenas recentemente começou a ser foco de atenção e de descrições detalhadas. Sendo assim, nós apresentamos a primeira análise cladística utilizando 43 terminais pertencentes aos quatro gêneros válidos de Segestriidae, e de possíveis gêneros novos, além de outros membros do clado Dysderoidea, mais Caponiidae. Além disso, nós examinamos e descrevemos a genitália interna das fêmeas pela primeira vez utilizando Micro-tomografia computadorizada de Raios-X (Micro-CT) para reconstrução 3-D. Nossa matriz de dados compreende 143 caracteres morfológicos e comportamentais. O consenso estrito dos cladogramas mais parcimoniosos sob pesagem implícita resultou em Segestriidae monofilético, grupo-irmão de Orsolobidae, e dividido em duas subfamílias: Segestriinae e Ariadninae. *Segestria* é parafilética, e *Segestria saeva* sendo transferida para *Gippsicola*. *Gippsicola* foi recuperado como monofilético, porém com baixo suporte. *Ariadna* é parafilética, com a derivação de um pequeno clado incluindo *Ariadna burchelli*, espécie-tipo do sinônimo-júnior *Macedonia*. Este sendo revalidado neste estudo. *Citharoceps* é um gênero monofilético, recuperado com bom suporte. Nós também recuperamos quatro gêneros novos, todos com sinapomorfias não-homoplásicas e alto suporte: *Xenosegestria* gen. n., *Anjea* gen. n., *Cheliceronyx* gen. n. e *Vazimba* gen. n.. Nós também apresentamos a terminologia e evolução de caracteres chave da genitália interna feminina.

2. Abstract

Segestriidae is nowadays represented by four genera encompassing 130 described spider species: *Segestria*, *Ariadna*, *Gippsicola* and *Citharoceps*. The family is a member of the Dysderoidea clade, which includes also Dysderidae, Orsolobidae and Oonopidae – all four families characterized by the development of a posterior receptaculum in the female internal genitalia. Currently there are no phylogenetic hypotheses including all segestriid genera, and its female genitalia morphology it is just recently receiving attention and detailed descriptions. Therefore, we present the first cladistic analysis including 43 terminals from all four valid segestriid genera, and of possible new genera, together with members of the Dysderoidea clade, plus Caponiidae. Also, we address for the first time the morphology of the female internal genitalia using Micro-computed X-ray Tomography (Micro-CT) for 3-D reconstruction. Our dataset comprises 143 morphological and behavioral characters. Strict consensus of the most-parsimonious trees under implied weighting resulted in a monophyletic Segestriidae, sister to Orsolobidae, and divided in two subfamilies: Segestriinae and Ariadninae. *Segestria* is paraphyletic, and *Segestria saeva* should be transferred to *Gippsicola*. *Gippsicola* is monophyletic, but recovered with low support. *Ariadna* is paraphyletic, with the derivation of a small clade comprising *Ariadna burchelli*, type species of the junior-synonym *Macedonia*. The latter is here revalidated. *Citharoceps* was recovered as monophyletic, with good support. We recovered four new genera, all with non-homoplasious synapomorphies and high support: *Xenosegestria* gen. n., *Anjea* gen. n., *Cheliceronyx* gen. n. and *Vazimba* gen. n.. We also present terminology and the evolution of key characters of the female internal genitalia.

3. Introduction

The spider family Segestriidae Simon, 1893 currently comprises 130 described species, included in four genera: *Segestria* Latreille, 1804, *Ariadna* Audouin, 1826, *Gippsicola* Hogg, 1900 and *Citharoceps* Chamberlin, 1924 (World Spider Catalog, 2018). These are small to medium-sized spiders, with six eyes and the third pair of legs forth. With nocturne and sedentary habit, they usually are found dwelling small holes or cracks in rocks and tree logs and bark. They build a silk funnel tube with irradiate silk threads to prey detection (Prandi, 1990; Capocasale, 1998; Grismado, 2008). Phylogenetically, Segestriidae is a member of the Dysderoidea clade, currently with four families (Wheeler *et al.*, 2017): (Segestriidae (Oonopidae (Orsolobidae, Dysderidae))), which is supported by one putative synapomorphy, the development of a second portion (= posterior receptaculum, in Segestriidae) of the internal female genitalia, originated from the posterior wall of the bursal cavity (Forster & Platnick, 1985; Griswold *et al.*, 2005; Jocqué & Dippenaar-Schoeman, 2006). The Dysderoidea clade is part of a clade called Synspermiata, comprising families of ecribellate haplogyne spiders presenting the fusion of two or more spermatids inside a conjugated spermatozoa (synspermia) (Michalik & Ramírez, 2014; Wheeler *et al.*, 2017).

The genus *Segestria* comprises 19 described species, with a wide distribution mainly in the Holarctic region (World Spider Catalog, 2018). Brignoli (1976) published a study on the internal genitalia of segestriid spiders from Italy, presenting for the first time more accurate descriptions and drawings of the female internal genitalia of Italian species of *Segestria* and *Ariadna*. Also, the author discusses taxonomic remarks and distribution of worldwide *Segestria* species. Brignoli's study was the first attempt to address the taxonomy of this genus. Recently, Giroti & Brescovit (2011) revised the South American species of *Segestria*, recording only the species *S. florentina* (Rossi, 1790), an introduced species from the Palearctic region in south of Brazil, Uruguay and east of Argentina, but this genus still needs a complete taxonomic revision, mainly for the Nearctic region.

Gippsicola currently presents four described species that occur only in Australia (Giroti & Brescovit, 2017; World Spider Catalog, 2018). Before its recent revision, the genus was represented

by only its type species, *Gippsicola raleighi* Hogg, 1900, described based on an immature from Gembrook, Victoria, Australia. Giroti & Brescovit (2017) described the males of *G. raleighi* and *G. minuta*, and both male and females of *G. robusta* and *G. lineata*, providing good quality descriptions and illustrations and addressing the diagnostic features for the genus.

The recently revalidated *Citharoceps* Chamberlin, 1924 (Giroti & Brescovit, 2015) is composed by two species, *Citharoceps fidicina* Chamberlin, 1924 and *Citharoceps cruzana* (Chamberlin & Ivie, 1935), occurring only from North California (USA) to Baja California region (Mexico). These species are mainly diagnosed by the conspicuous stridulatory apparatus, composed by patches of vertical ridges on both sides of the *pars cephalica* of the carapace (Giroti & Brescovit, 2015, figs 1A-B, 5A, F). These ridges are stroked by a pick (or thorn) located in the prolateral region of the femur I (Giroti & Brescovit, 2015, figs 2A-B, 5C), producing a buzzing sound, probably to avoid predation.

Ariadna stands out as the most diverse segestriid genus, with 103 species described, distributed in all continents (except Antarctic), with more diversity in the tropical and subtropical regions (World Spider Catalog, 2018). This genus was recently revised for the American continent by Giroti & Brescovit (2018), describing eight new species and proposing new synonymies for species previously in problematic position. Currently, there are three genera as junior-synonym of *Ariadna*: *Pylarus* Hentz, 1842, *Macedonia* Hogg, 1900 and *Segestriella* Purcell, 1904. Whereas the synonymy of *Pylarus* was already confirmed by Giroti & Brescovit (2018), the other still need to be revised.

3.1 Phylogenetic background

Currently, there are no data on the phylogenetic relationships of Segestriidae genera. Studies that used species belonging to this family restricted their goal trying to support the monophyly of Dysderoidea, using only a few segestriid terminals, and never from all four genera (Forster & Platnick, 1985; Platnick *et al.*, 1991; Griswold *et al.*, 2005; Izquierdo & Labarque, 2010; Platnick *et*

al., 2012).

Griswold *et al.* (2005), based on previous studies, used 154 characters to present a cladistic hypothesis focusing mainly on more inclusive groups of the Entelegynae clade, using more basal araneomorphs (“Haplogynae”, currently Synspermiata (Michalik & Ramírez, 2014)), the families Filistatidae and Segestriidae, as part of the outgroup. In their matrix, Griswold *et al.* (2005) uses only one species of *Ariadna*, *A. boesenbergi* Keyserling, 1877, but also resort to the work of Millot (1931) on *Segestria* to comment on its codification of internal anatomy characters. Platnick *et al.* (1991) also compare their codification between three genera of Segestriidae, *Segestria*, *Ariadna* and *Gippsicola*, using mainly characters of the spinnerets, but only *Segestria* was used as a terminal, represented by *S. senoculata* (Linnaeus, 1758).

Currently, Segestriidae is taxonomically divided into two sub-families: Segestriinae Simon, 1893 and Ariadninae Wunderlich, 2004. Segestriinae comprises *Segestria* and the fossil genus *Vetsegestria* Wunderlich, 2004, but, as suggested by Giroti & Brescovit (2017), the genus *Gippsicola* may also be part of this subfamily. On the other hand, Ariadninae comprises only the genus *Ariadna*. Both subfamilies present distinctive morphological characters (Wunderlich, 2004: 657; Wunderlich, 2011: 175), but its monophyly was never corroborated by phylogenetic analysis.

The absence of previous delimited characters for Segestriidae represents one of the main problems for using this group in phylogenetic studies. Since the family has just recently received more attention for taxonomic revisions and morphological descriptions (Grismado, 2008; Giroti & Brescovit, 2011; 2015; 2017; 2018; Baehr & Whyte, 2016), there is still need for the establishment of the right terminology and homology for its characters.

3.2 The female genitalia of Segestriidae

Dysderoidea is one of the largest clades within Synspermiata (Michalik & Ramírez, 2014) – one of the main groups within Araneomorphae comprising 16 families of ecribellate spiders, which are characterized by so-called synspermia (sperm aggregates with fused spermatozoa) (Wheeler *et*

al., 2017). Furthermore, the female genitalia is usually haplogyne, which is defined by the absence of a fertilization duct and an external copulatory plate called *epigynum* as part of the female genitalia (Griswold *et al.*, 2005). In females with this condition the insertion of the male palp occurs directly into the bursa copulatrix or spermatecae. The male and female genitalia of haplogyne taxa are often rather simple, without very conspicuous differences between species of the same genus or even within the family (Huber, 2004; Ramírez, 2014).

Detailed knowledge of the male and female genitalia of Dysderoidea is mainly based on histological and ultrastructural studies of some species of Dysderidae (Cooke, 1966; Uhl, 2000; Burger & Kropf, 2007), Orsolobidae (Izquierdo & Labarque, 2010; Lipke *et al.*, 2014) and Oonopidae (Burger, 2009; 2010a; 2010b; 2011; 2013; Burger & Michalik, 2010). Contrary, Segestriidae genitalia was only described in a few studies on its gross morphology as *e.g.* Brignoli (1976), Huber (2004) and Grismado (2008), all of them trying to establish a consistent terminology and homology of the structures with detailed descriptions and illustrations, and only included two of the four known genera of the family: *Ariadna* (Brignoli, 1976; Grismado, 2008) and *Segestria* (Brignoli, 1976).

Here we addressed for the first time the female genitalia of all segestriid genera. We present detailed morphology of the internal female genitalia using non-destructive techniques as Micro-computed X-ray Tomography (Micro-CT) for 3D-reconstruction and well-established methods such as Scanning Electron Microscopy (SEM), aiming to unify terminology, and infer hypotheses of homology between target structures.

7. Conclusions

- We presented the first cladistic analysis including all valid genera of Segestriidae, together with four new genera;
- Segestriidae was recovered as a monophyletic clade, so it is considered valid taxonomically;
- Both subfamilies Segestriinae Simon, 1893 and Ariadninae Wunderlich, 2004 were recovered as monophyletic, and are now comprising more genera;
- *Segestria* is paraphyletic; *Segestria saeva* should be transferred to *Gippsicola*;
- *Gippsicola* is monophyletic, besides low support;
- *Ariadna* is paraphyletic;
- *Macedonia*, junior-synonym of *Ariadna* should be revalidated and comprising *Ariadna burchelli*, *Ariadna araucana*, *Ariadna lalen* and *Ariadna* AUS sp. 1;
- *Citharoceps* was recovered monophyletic and well-supported;
- Four new genera were diagnosed and will be fully described: *Xenosegestria* gen. n., *Anjea* gen. n., *Cheliceroonyx* gen. n., *Vazimba* gen. n.;
- We addressed for the first time the terminology and described the evolution of key characters of the female internal genitalia of Segestriidae, using Micro-CT. Although its “simpler” appearance and less sclerotization, compared to other Dysderoidea families, we were able to extract important morphological characters for taxonomy and systematics.

8. References

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