

The family placement of the Asian orb-weaving spider genus *Guizygiella* Zhu, Kim & Song, 1997 (Araneae: Araneoidea)

ROBERT J. KALLAL^{1,2*} & GUSTAVO HORMIGA^{2,3}

¹Department of Entomology, National Museum of Natural History, Washington, D.C. 20560.

²Department of Biological Sciences, The George Washington University, Washington, D.C. 20052.

³ hormiga@gwu.edu;  <https://orcid.org/0000-0002-0046-1822>

*Corresponding author.  kallal.research@gmail.com;  <https://orcid.org/0000-0001-8945-5586>

In this paper, we propose the formal transfer of the genus *Guizygiella* Zhu, Kim & Song, 1997 to the family Araneidae based on previously published phylogenetic hypotheses and on examination of its morphology. Specimens were examined and illustrated using Leica M205A, Leica MZAP0 and Olympus BX40 microscopes. Digital images were produced with a Leica DFC 425 camera mounted on a Leica M205A. Palps were also examined in methyl salicylate after artificial expansion in potassium hydroxide to discern the sclerites and trajectory of the sperm duct. We thank Michael Sharkey (University of Kentucky) for making the study specimens available to us and Nikolaj Scharff for his help in discerning the male palpal homologies. We are grateful to Jimmy Cabra, Fernando Álvarez-Padilla and Associate Editor Miquel Arnedo for their helpful comments and suggestions on an earlier version of this manuscript. GH acknowledges support from National Science Foundation grant 1754262. The study specimens will be deposited in the Museum of Comparative Zoology (Harvard University).

Guizygiella Zhu, Kim & Song, 1997 is a genus comprised of six orb-weaving spider species found in China, India, Pakistan, Laos, Thailand, and Vietnam. These species are, in order of date of authorship, *G. melanocrania* (Thorell, 1887), *G. indica* (Tikader and Bal, 1980), *G. nadleri* (Heimer, 1984), *G. shivui* (Patel and Reddy, 1990), *G. guangxiensis* (Zhu and Zhang, 1993), and *G. salta* (Yin and Gong, 1996), with the latter being the type species. Perhaps unsurprisingly given the name, these species were all once classified in the araneid genus *Zygiella* Clerck, 1757, prior to the erection of the tetragnathid genus *Guizygiella* based on some morphological similarities to *Zygiella* as well as the then disputed placement of *Zygiella* (Zhu *et al.* 1997, Zhu *et al.* 2003) (Figs. 1–2). Wunderlich (2004), citing the work of Zhu *et al.* (2003), suggested *Guizygiella* should be placed in a new family, Zygiellidae, based on having a free sector in its web, paracymbium sclerotization, and a close positioning of the embolus and terminal apophysis, along with *Zygiella*, *Chrysometa* Simon, 1894, *Yaginumia* Strand, 1906, and several other genera. Notably, Zhu *et al.* (2003) did not consider *Guizygiella* to have a terminal apophysis, specifically mentioning only the embolus and median apophysis. According to Wunderlich (2004), this putative family would be closely allied to Tetragnathidae.

In a test of the hypothesis of Zygiellidae, Gregorič *et al.* (2015) incorporated in a molecular phylogenetic analysis six members of the genus, including the type species *G. salta*, as well as representatives of the genera *Zygiella*, *Chrysometa*, and other putative ‘zygiellids’ *sensu* Wunderlich (2004). This would be one of several studies using traditional Sanger sequencing (Gregorič *et al.* 2015; Wheeler *et al.* 2017; Kallal and Hormiga 2018) and high-throughput sequencing (Kulkarni *et al.* 2019; Kallal *et al.* 2021) to corroborate placement of *Zygiella* (and its subfamily Phonognathinae) at the base of Araneidae and distant from Tetragnathidae. The phylogenetic placement of *Chrysometa*, but not *Guizygiella* or *Yaginumia*, was supported in Tetragnathidae; the latter two were placed in Araneidae. Thus, Zygiellidae, and its putative subfamilies Zygiellinae and Chrysometinae, were refuted by molecular phylogenies (see also Álvarez-Padilla *et al.* 2009). *Guizygiella* was nested within Araneidae, closely related to the genera *Yaginumia* and *Milonia* Thorell, 1890 (Gregorič *et al.* 2015). A subsequent work using morphological and molecular sequence data to build a phylogeny of araneids by Kallal and Hormiga (2018) with a different taxon sampling recovered a similar topology. However, likely because the genus has not been formally transferred from Tetragnathidae, *Guizygiella* is missing from larger analyses of Araneidae (e.g., Scharff *et al.* 2020) and as such further phylogenetic investigation of its araneid affinities is hampered while it remains categorized as a tetragnathid.

Here we formally transfer *Guizygiella* from Tetragnathidae to Araneidae. We do this based not only on the multiple

published phylogenies including *Guizygiella* but also based on examination of the genitalia of *G. guangxiensis* (Zhu & Zhang, 1993) collected in Nam Pong National Park, Khon Kaen, Thailand. As far as we can determine, this is the first record for the species for Thailand and the second *Guizygiella* species from Thailand, with the first being *G. nadleri*. Our examination of the pedipalp of *G. guangxiensis* revealed a mesal position of the cymbium, radix, median apophysis, and conductor (Figs. 2D–E, 3), all of which are typical araneid palpal traits but were coded as absent by Zhu *et al.* (2003). Notably, in addition to the sustentaculum, the radix is considered a synapomorphy for Araneidae and is present in *Guizygiella* (Dimitrov *et al.* 2017, Scharff *et al.* 2020) *contra* Zhu *et al.* (2003). *Guizygiella* lacks the tetragnathid synapomorphies (Álvarez-Padilla *et al.* 2009, Álvarez-Padilla & Hormiga 2011) of a large tarsal organ on the cymbium (it is small), a tegulum that is not oval or spherical, and a solitary palpal patella macroseta (it has two distal macrosetae), and a male palpal tibia length that is approximately two times the widest point of the tibia (its L/W ratio is 45/25), several of which are concurrent with the coding of Zhu *et al.* (2003). Furthermore, the sector web has arisen convergently multiple times (Gregorič *et al.* 2015), and thus this behavioral trait is a poor predictor of phylogenetic affinities. Given the congruence of morphology and nucleotide sequence data *Guizygiella* needs to be classified in the family Araneidae.

Taxonomy

Araneidae Clerck, 1757

***Guizygiella* Zhu, Kim, and Song, 1997**

Type species: *Zygiella salta* Yin and Gong, 1996

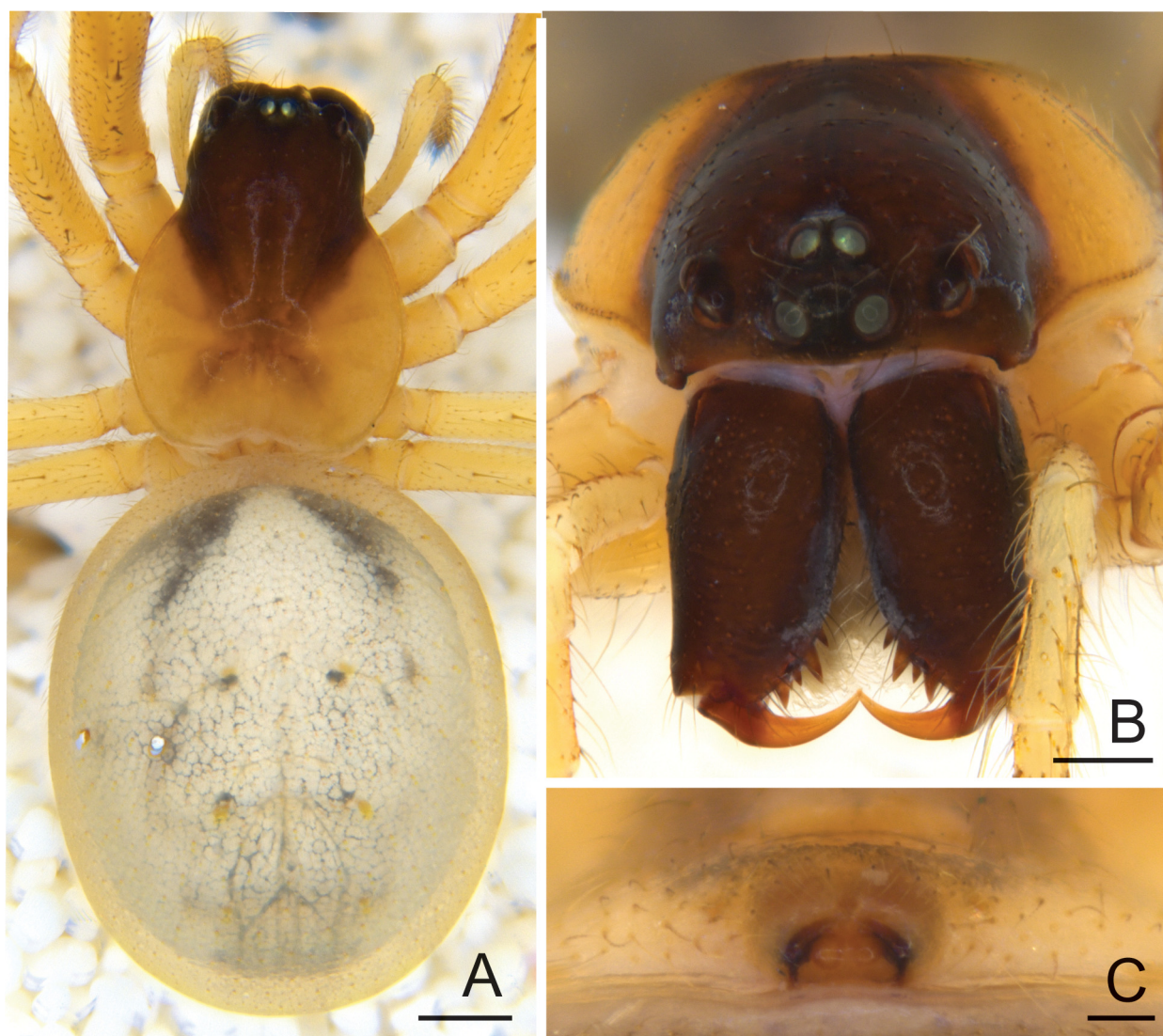


FIGURE 1. *Guizygiella guangxiensis* (Zhu and Zhang, 1993), from Thailand, female. A. dorsal. B. frontal. C. epigynum, ventral. Scale bars (in microns), A, 500; B, 250; C, 75.

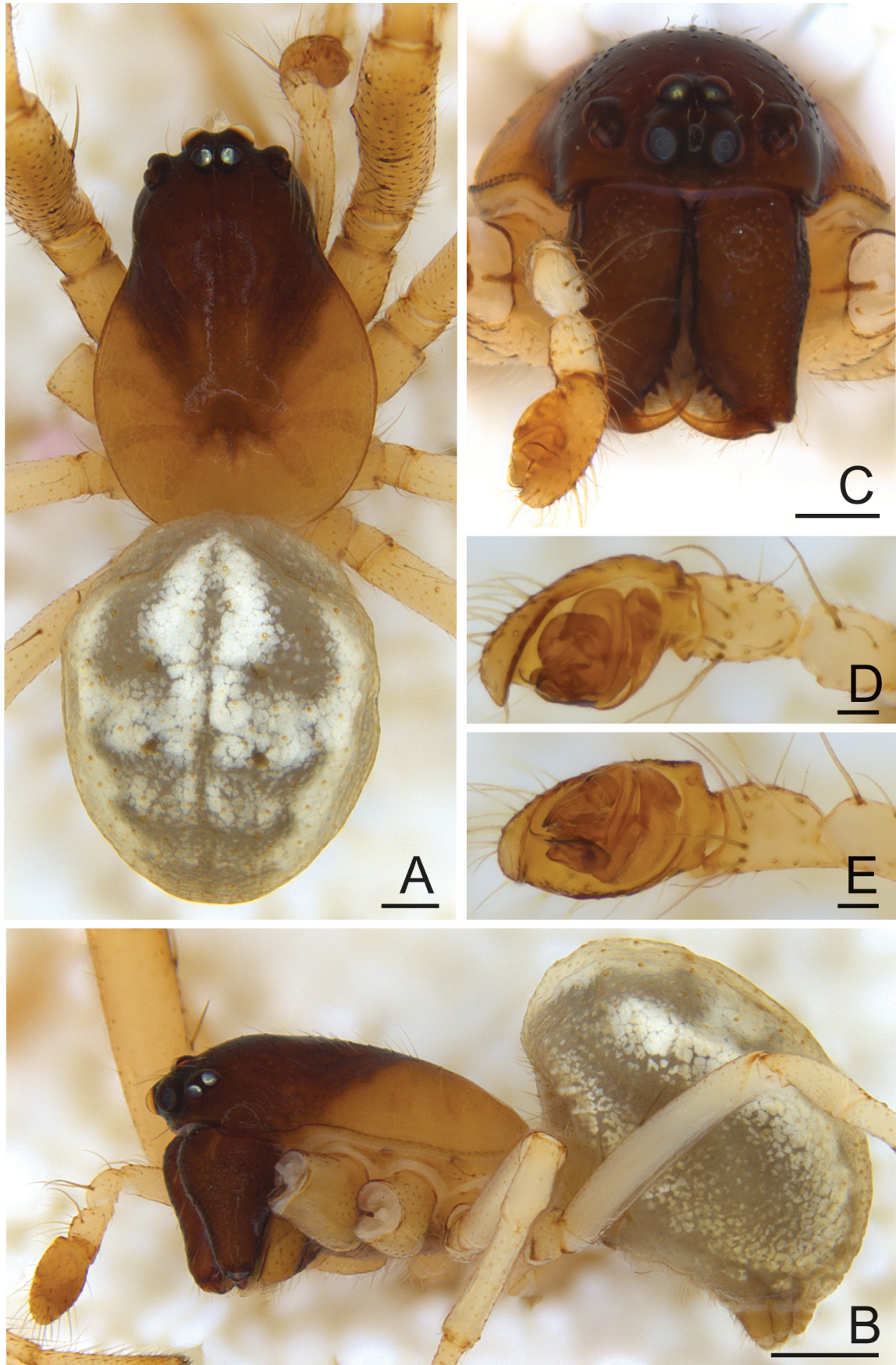


FIGURE 2. *Guizygiella guangxiensis* (Zhu and Zhang, 1993), from Thailand, male. A–C, habitus. D–E, pedipalp, left. A. dorsal. B. lateral. C. frontal. D. dorsal. E. ectal. Scale bars (in microns), A, C, 250; B, 500; D, E, 75.



FIGURE 3. *Guizygiella guangxiensis* (Zhu and Zhang, 1993), from Thailand, male. A. Pedipalp, ectoventral. B. Pedipalp (schematic), ectoventral, expanded in potassium hydroxide. Abbreviations: BH, basal hematodocha; C, conductor; E, embolus; MA, median apophysis; P, paracymbium; R, radix; ST, subtegulum; T, tegulum. Scale bar, 0.1 mm.

***Guizygiella guangxiensis* (Zhu and Zhang, 1993)**

Material examined. Thailand: Khon Kaen, Namp Pong National Park office, 24° 12.11'N: 183° 9.324'E. 5–12.vii.2006, malaise traps, 12.vii.2006 (6 males, 2 females); 19–26.vii.2006 (1 male, 1 subadult male). Khumphone Jaidee leg. (MCZ).

References

- Álvarez-Padilla, F., Dimitrov, D., Giribet, G. & Hormiga, G. (2009) Phylogenetic relationships of the spider family Tetragnathidae (Araneae, Araneioidea) based on morphological and DNA sequence data. *Cladistics*, 25, 109–146.
<https://doi.org/10.1111/j.1096-0031.2008.00242.x>
- Álvarez-Padilla, F. & Hormiga, G. (2011) Morphological and phylogenetic atlas of the orb-weaving spider family Tetragnathidae (Araneae: Araneioidea). *Zoological Journal of the Linnean Society*, 162, 713–879.
<https://doi.org/10.1111/j.1096-3642.2011.00692.x>
- Bösenberg, W. & Strand, E. (1906) Japanische Spinnen. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft*, 30, 93–422.
- Clerck, C. (1757) *Aranei Svecici. Svenska spindlar, uti sina hufvud-slagter indelte samt under några och sextio särskildte arter beskrefne och med illuminerade figurer uplyste*. Laurentius Salvius, Stockholmiae, 154 pp.
<https://doi.org/10.5962/bhl.title.119890>
- Dimitrov, D., Benavides, L.R., Arnedo, M.A., Giribet, G., Griswold, C.E., Scharff, N. & Hormiga, G. (2017) Rounding up the usual suspects: a standard target-gene approach for resolving the interfamilial phylogenetic relationships of ecribellate orbweaving spiders with a new family-rank classification (Araneae, Araneioidea). *Cladistics*, 33, 221–250.
<https://doi.org/10.1111/cla.12165>
- Gregorič, M., Agnarsson, I., Blackledge, T.A. & Kuntner, M. (2015) Phylogenetic position and composition of Zygellinae and Caerostris, with new insight into the orb-web evolution and gigantism. *Zoological Journal of the Linnean Society*, 175, 225–243.
<https://doi.org/10.1111/zoj.12281>
- Heimer, S. (1984) A new species of *Zygiella* from Vietnam (Arachnida, Araneae, Araneidae). *Reichenbachia*, 22, 95–97.
- Kallal, R.J. & Hormiga, G. (2018) Systematics, phylogeny and biogeography of the Australasian leaf-curling orb-weaving spiders (Araneae: Araneidae: Zygellinae), with comparative analysis of retreat evolution. *Zoological Journal of the Linnean Society*, 184, 1055–1141.
<https://doi.org/10.1093/zoolinlean/zly014>
- Kulkarni, S., Wood, H., Lloyd, M. & Hormiga, G. (2019) Spider-specific probe set for ultraconserved elements offers new perspectives on the evolutionary history of spiders (Arachnida, Araneae). *Molecular Ecology Resources*, 20, 185–203.
<https://doi.org/10.1111/1755-0998.13099>
- Patel, B.H. & Reddy, T.S. (1990) An addition to the araneid fauna (Araneae: Arachnida) of India. *Records of the Zoological Survey of India*, 87, 157–164.
- Scharff, N., Coddington, J.A., Blackledge, T.A., Agnarsson, I., Framenau, V.W., Szűts, T., Hayashi, C.Y. & Dimitrov, D. (2020) Phylogeny of the orb-weaving spider family Araneidae (Araneae: Araneioidea). *Cladistics*, 36, 1–21.
<https://doi.org/10.1111/cla.12382>
- Simon, E. (1894) *Histoire naturelle des araignées. Deuxième Édition. Tome Premier*. Roret, Paris, pp. 761–1084.
<https://doi.org/10.5962/bhl.title.51973>
- Thorell, T. (1887) Viaggio di L. Fea in Birmania e regioni vicine. II. Primo saggio sui ragni birmani. *Annali del Museo Civico di Storia Naturale di Genova*, 25, 5–417.
- Thorell, T. (1890) Studi sui ragni Malesi e Papuani. IV. 1. *Annali del Museo Civico di Storia Naturale di Genova*, 28, 5–421.
- Tikader, B.K. & Bal, A. (1980) Studies on spiders of the genus *Zygiella* Cambridge from India (Araneae: Araneidae). *Proceedings of the Indian Academy of Science (Anim. Sci.)*, 89, 243–246.
<https://doi.org/10.1007/BF03179166>
- Wheeler, W.C., Coddington, J.A., Crowley, L.M., Dimitrov, D., Goloboff, P.A., Griswold, C.E., Hormiga, G., Prendini, L., Ramírez, M.J., Sierwald, P., Almeida-Silva, L., Álvarez-Padilla, F., Arnedo, M.A., Benavides Silva, L.R., Benjamin, S.P., Bond, J.E., Grismado, C.J., Hasan, E., Hedin, M., Izquierdo, M.A., Labarque, F.M., Ledford, J., Lopardo, L., Maddison, W.P., Miller, J.A., Piacentini, L.N., Platnick, N.I., Polotow, D., Silva-Dávila, D., Scharff, N., Szűts, T., Ubick, D., Vink, C.J., Wood, H.M. & Zhang, J. (2017) The spider tree of life: phylogeny of Araneae based on target-gene analyses from an extensive taxon sampling. *Cladistics*, 33, 574–616.
<https://doi.org/10.1111/cla.12182>
- Wunderlich, J. (2004) Fossil spiders in amber and copal. Conclusions, revisions, new taxa and family diagnoses of fossil and extant taxa. *Beiträge zur Arachnologie*, 3, 361–381.
- Yin, C.M. & Gong, L.S. (1996) Four orb-weaver spiders of the family Araneidae from Hunan Province of China (Arachnida: Araneae). *Acta Scientiarum Naturalium Universitatis Normalis Hunanensis*, 19, 72–76.
- Zhu, M.S., Kim, J.P. & Song, D.X. (1997) On three new genera and four new species of the family Tetragnathidae (Araneae) from China. *Korean Arachnology*, 13 (2), 1–10.
- Zhu, M.S., Song, D.X. & Zhang, J.X. (2003) *Fauna Sinica: Invertebrata. Vol. 35. Arachnida: Araneae: Tetragnathidae*. Science Press, Beijing, 418 pp.
- Zhu, M.S. & Zhang, Y.Q. (1993) Records of some spiders of the family Araneidae from Guangxi (Arachnida: Araneae). *Journal of the Guangxi Agricultural College*, 12, 36–43.