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THE PLACEMENT OF *PERILLA* (ARANEAE, ARANEIDAE) WITH COMMENTS ON ARANEID PHYLOGENY

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ABSTRACT. The Oriental spider genus *Perilla* Thorell is revised, diagnosed and transferred from the tetragnathid subfamily Nephilinae to the araneid subfamily Araneinae. Cladistic analysis of recently published araneid matrices with the addition of *Perilla* supports this new placement. *Perilla* groups with *Chorizopes* O. P.-Cambridge, previously a basal araneid. *Perilla teres* Thorell, the type species of the genus, is redescribed. The only other known species, *Perilla cylindrogaster* Simon, is proposed as a junior synonym of *P. teres*, which renders *Perilla* monotypic.

Keywords: Araneidae, Araneinae, Nephilinae, Tetragnathidae, cladistics, spiders, *Perilla*, *Chorizopes*

The history of the tetragnathid subfamily Nephilinae was most recently reviewed by Hormiga et al. (1995). Tetragnathidae currently contains seven nephiline genera (Platnick 1997, 2001): *Nephila* Leach 1815, *Clitaetra* Simon 1888, *Deliochus* Simon 1894, *Herennia* Thorell 1877, *Nephilengys* L. Koch 1872, *Perilla* Thorell 1895, and *Phonognatha* Simon 1894. Kuntner & Hormiga (in press) recently transferred *Singafrotypa* Benoit 1962 to Araneidae.

While Hormiga et al. (1995) established the monophyly of Nephilinae containing the genera *Phonognatha*, *Clitaetra*, *Nephila*, *Nephilengys* and *Herennia*, the systematic placement of *Deliochus* (from Australia) and *Perilla* (from Myanmar and Vietnam) has remained doubtful. These two genera have not been redescribed since their first descriptions in the 19th century. In this paper I redescribe the genus *Perilla* and incorporate it into a cladistic analysis to test its familial placement. The results imply that *Perilla* is an araneid, not a tetragnathid.

Taxonomic history.—Thorell (1895) erected monotypic *Perilla* and described *P. teres* Thorell 1895 from Burma (today Myanmar). Thorell placed the genus in the family Euetrioidae (today Araneidae). Simon (1909) described the second species, *P. cylindrogaster* Simon 1909 from Vietnam, and listed *Perilla* within his argiopid subfamily Argiopinae close to *Araneus*, and not in his argiopid subfamily Nephilinae. While Bonnet (1958) lists *Perilla* in Argiopidae, Roewer's (1942) judgment was that *Perilla* belongs to the araneid subfamily Nephilinae. It has remained there since (Brignoli 1983), but the subfamily recently changed its familial assignment (see Hormiga et al. 1995). Consequently, in all Platnick's catalogues (1989, 1993, 1997, 2001) *Perilla* is a tetragnathid.

METHODS

Morphology.—General methods of study are described in Hormiga (1994). All morphological observations and illustrations were made using a Leica MZ APO dissecting microscope. Illustrations were made using a camera lucida and rendered on coquille board. Measurements were taken using a reticle and are in millimeters. Abbreviations of the specimen depositories are NHM (The Natural History Museum, London), MNHN (Muséum National d'Histoire Naturelle, Paris), and CD (Christa Deeleman-Reinhold's private collection, Ossendrecht, The Netherlands).

Phylogenetic analysis.—Examination of the syntype male of *Perilla teres* allows homologizing most palpal sclerites and some general somatic traits with those of araneids (see Taxonomy). *Perilla teres* lacks the three synapomorphies currently hypothesized to support tetragnathid monophyly (Hormiga et al. 1995): absence (loss) of median apophysis, embolus and conductor spiraling with each

other, and apical tegular sclerites. To phylogenetically test the placement of *Perilla* within Araneidae, I used the published data of Scharff & Coddington (1997), containing 57 araneid genera plus 13 genera from eight outgroup families scored for 82 morphological and behavioral characters. The outgroup taxa include the true nephiline genera *Nephila* and *Nephilengys*. In addition, I used Kuntner & Hormiga's (in press) codings for *Singafrotypa acanthopus* (Simon 1907) and *Singafrotypa okavango* Kuntner & Hormiga (in press). To these data I added new coding for *Perilla teres*: 00011100000000011??101010000–––0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 0 0 1 1 1 0 0 0 0 0 0 – 0000000000001002?010???????

Thus the matrix analyzed here had a total of 73 taxa scored for 82 characters. Since only the syntype male of *P. teres* was available for my examination, I refrained from expanding its palps. This made it impossible to determine the presence of some palpal sclerites, such as stipes and paramedian apophysis (for interpretation of other morphological characters see species description below). For female morphology I used both examined females (see below). I was able to score some of the behavioral characters of Scharff & Coddington (1997) for *Perilla* by using field notes of Deeleman-Reinhold (in litt.) and from the information from Murphy & Murphy (2000). I coded all ambiguities in the matrix as unknown entries.

The parsimony analyses were performed using the computer programs PAUP* version 4.0b4a (Swofford 2000) and NONA version 2.0 (Goloboff 1993). In PAUP I used random taxon addition for 10 replicates and TBR branch swapping. In NONA I used search parameters 'hold 10000', 'mult*500', 'max*', and 'sswap', under both 'amb –' and 'amb ='. Winclada version 0.9.99m24 (Nixon 2000) was used to display and manipulate trees and matrices for NONA. The 14 multistate characters were treated as non-additive (unordered or Fitch minimum mutation model; Fitch 1971).

RESULTS AND DISCUSSION

The parsimony heuristic searches in PAUP* and NONA combined produced 2750 trees of minimal length (291 steps) with consistency and retention indices of 0.34 and 0.74, respectively. All the minimal length topologies have in common the placement of *Perilla* within the araneid subfamily Araneinae, as well as the monophyly of Araneidae and Tetragnathidae. These results are grossly congruent with those of Scharff & Coddington (1997) (but see below), and with the results of Kuntner & Hormiga (in press) in the placement of *Singafrotypa* within Araneinae.

In the strict consensus cladogram of the 2750 trees most resolution within Araneinae is lost compared to the preferred cladogram of Scharff & Coddington (1997). This is not surprising, since they defended one of the most parsimonious trees and argued that strict consensus obscured the phylogenetic signal they found (Scharff & Coddington 1997: 403): ''We also found it useful to avoid the use of strict consensus trees. The solution set of 16 most parsimonious trees presents nearly a 'bush' among araneines if a strict consensus tree is computed.''

Perilla and *Chorizopes* O.P.-Cambridge 1870, two genera previously not araneines, form a clade in the strict consensus cladogram. *Perilla* has never been subject to phylogenetic analyses, and *Chorizopes* has been a basal araneid in the preferred tree of Scharff & Coddington (1997), although the authors wrote (p. 423) that such a result is controversial, and that the genus probably belongs among basal araneines, as found here. The synapomorphies (unambiguous optimization) for the clade (*Perilla* + *Chorizopes*), though homoplasious in this analysis, are the characters and states 41(1), 50(1) and 64(0) of Scharff & Coddington (1997): glabrous female carapace, wide separation of lateral and median eyes, and normal (not grooved) female booklung cover, respectively.

In my current analysis, all most parsimonious trees support Kuntner & Hormiga's (in press) transfer of *Singafrotypa* from Nephilinae (Tetragnathidae) to Araneinae (Araneidae), and its placement as sister to the clade *Araniella* (*Alpaida* (*Enacrosoma* + *Bertrana*)), as previously hypothesized by Kuntner & Hormiga (in press).

How robust are the results of the current analysis? The clade (*Perilla* + *Chorizopes*) survives at least one round of Bremer support, although tree buffers were filled with 32,750 trees long before all trees of the length 292 were found. However, the many disagreements between my results and those of Scharff

& Coddington (1997) suggest that the phylogeny of Araneinae is still very much an open question. It is likely, therefore, that the sister group relation between *Perilla* and *Chorizopes* may be refuted in the future, or that the current phylogenetic structure of Araneinae may be seriously altered. For a reliable placement of *Chorizopes* one would have to score the type species, *C. frontalis* O.P.-Cambridge from Sri Lanka. Scharff & Coddington (1997) scored an unidentified species of *Chorizopes* from Madagascar. Furthermore, the placement of *Perilla* should be rigorously retested when more material allowing dissection becomes available. My current hypothesis, thus, should not be taken as a new proposal of araneid phylogeny but rather as a phylogenetic test corroborating the araneine placement of *Perilla*.

TAXONOMY

Perilla Thorell 1895

Perilla Thorell 1895: 195–196; Roewer 1942: 934; Bonnet 1958: 3484; Brignoli 1983: 241; Platnick 1989: 299; Platnick 1993: 371; Platnick 1997: 452. Type species, by original designation, *Perilla teres* Thorell 1895.

Etymology.—Thorell (1895: 195) named the genus after *Perillus* with no further explanation. Supposedly, this refers to the designer of a bronze bull in which *Phalaris*, the tyrant of Acragas (modern Agrigento in Sicily) has roasted his victims alive, their shrieks representing the animal's bellowing (*Encyclopaedia Britannica Online:* www.eb.com). *Perillus* was said to have been the first man executed in the bull.

Diagnosis.—*Perilla* is diagnosed by its extremely elongated cylindrical abdomen, which extends far beyond the spinnerets in both sexes, but especially in females (Fig. 1). The ratio of the posterior part of abdomen (beyond spinnerets) to abdomen length in females is 0.53. This is much greater than in other araneid genera, in which the abdomen extends beyond the spinnerets: 0.29 in *Acusilas* Simon 1895 (measured in *A. coccineus* Simon 1895), 0.25 in *Hingstepeira* Levi 1995 (calculated for *H. folisecens* (Hingston 1932) from Levi 1995), 0.23 in *Cyclosa* Menge 1866 (calculated for *C. conica* (Pallas 1772) from Levi 1999), 0.21 in *Singafrotypa* (measured in *S. acanthopus*), 0.20 in *Milonia* Thorell 1890 (measured in *M. trifasciata* Thorell 1890). All these genera lack the thicker first two pairs of legs present in *Perilla*. *Perilla* further differs from *Singafrotypa* by lacking an epigynal scape, and by having a narrow eye region of the prosoma. A unique combination of male sexual characters are the pointed paracymbium (Fig. 6) and a pointed ending of the tegulum (Figs. 5, 6).

Natural history.—Christa Deeleman-Reinhold (in litt.) observed *Perilla teres* in Genting Highlands, Malaysia (see material examined). The spiders were found in open country, at the top of grass stems of approximately 1 m. The grass stem top is bent by the spider and folded into an elongated tubular retreat, glued with silk over the full length. The spider preys within the retreat and is connected to the hub of its asymmetric orb web via signal thread. Murphy & Murphy (2000) provide the only published information on *Perilla* biology (almost identical to the above information) with photographs of a female and her web. These were also taken at Genting, and thus are likely to depict *Perilla teres*.

Composition.—*Perilla cylindrogaster* Simon 1909 is proposed as a junior synonym of *Perilla teres* Thorell (see below), which renders *Perilla* monotypic.

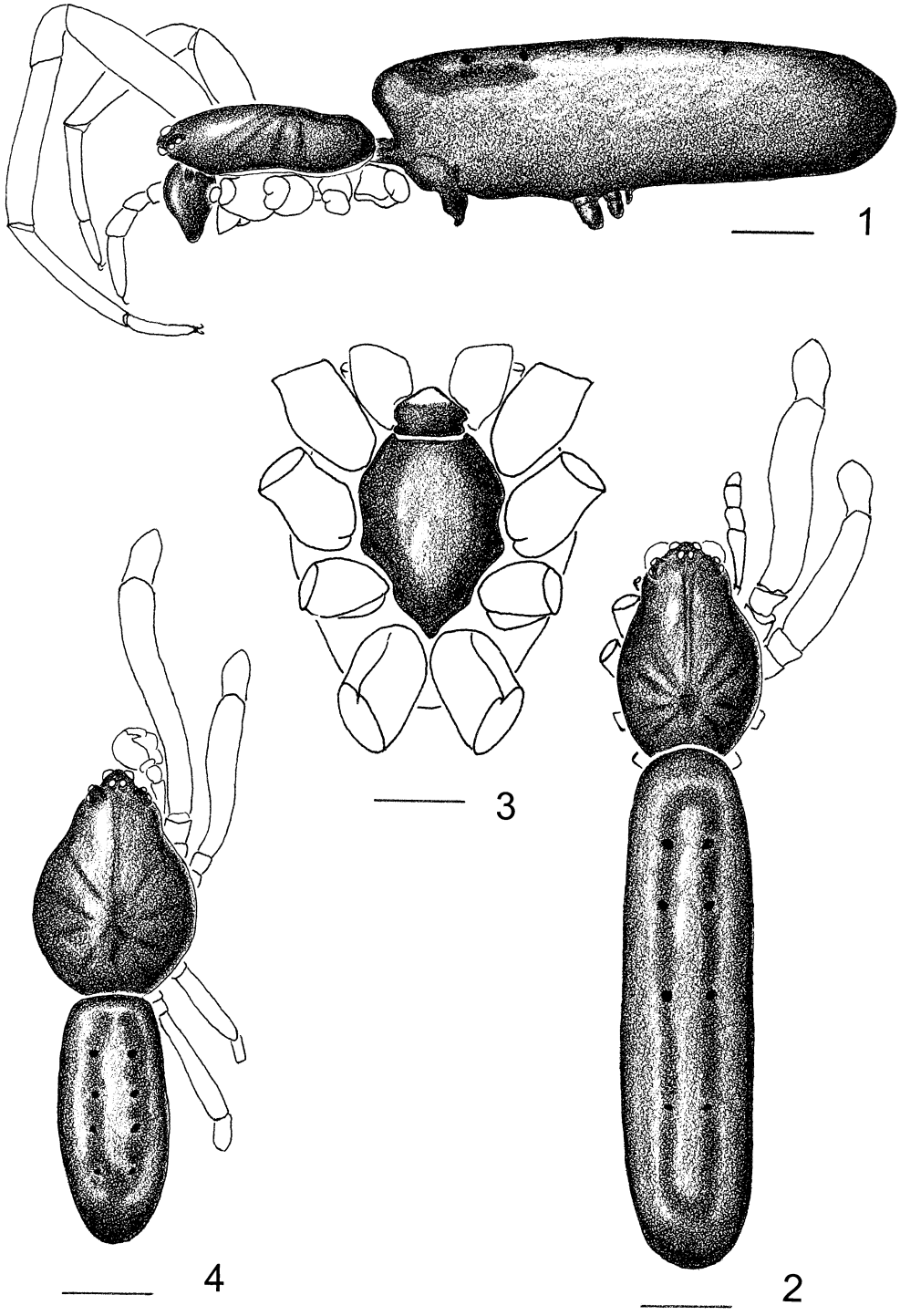
Perilla teres Thorell 1895
Figs. 1–9

Perilla teres Thorell 1895: 196–199, description of male, female. Roewer 1942: 934. Bonnet 1958: 3484.

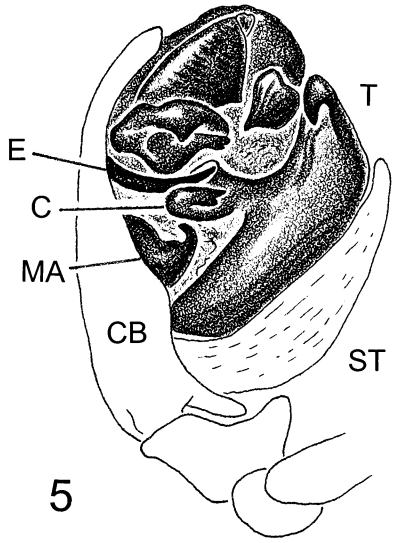
Perilla cylindrogaster Simon 1909: 110–111, description of female. Roewer 1942: 934. NEW SYNONYMY.

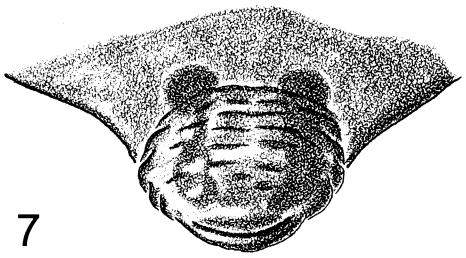
Types.—Thorell's syntype male and female of *Perilla teres* from Tharrawaddy, Myanmar, in NHM, examined. The holotype of *Perilla cylindrogaster* from Tonkin, Vietnam, in MNHN, was examined, and is immature. See Note below for justification of synonymy of *P. cylindrogaster* with *P. teres*.

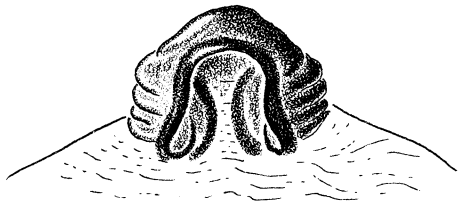
Description.—*Male (syntype)*: Figs. 4–6*:* Total length 5.27. Cephalothorax 2.64 long, 1.9 wide, 0.77 high. Sternum 1.11 long, 0.77 wide. Abdomen 2.79 long, 1.25 wide. Femur I length 2.73, Patella I length 0.78, Tibia I length 2.33, Femur IV length 1.40, Patella IV length 0.63, Tibia IV length 1.48. Chelicerae with 5 prolateral and 3 retrolateral teeth, and approximately 14 denticles in between. Prosoma red-brown, sternum brown with dark

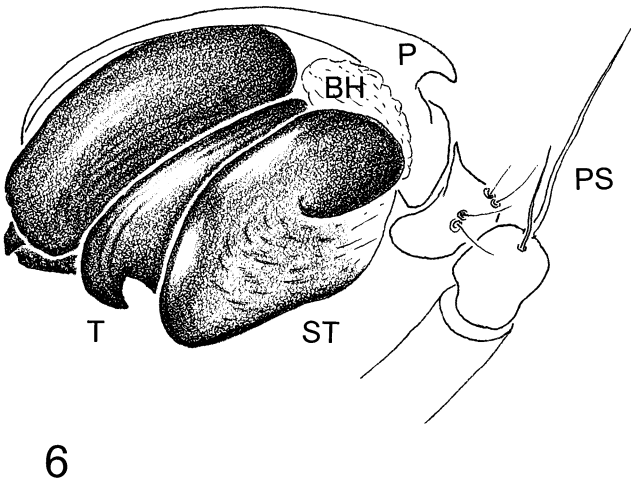


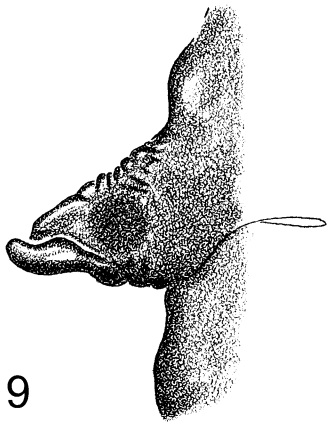
Figures 1–4.—*Perilla teres* Thorell. 1–3. Female syntype from Tharrawaddy, Myanmar; 1. Lateral; 2. Dorsal; 3. Sternum and labium; 4. Male syntype from Tharrawaddy, Myanmar, dorsal. Scale bars = 1.0 mm, except in Fig. 3 = 0.5 mm.











Figures 5–9.—*Perilla teres* Thorell. 5–6. Left male palpus (syntype); 5. Mesal; 6. Ectal; 7–9. Epigynum (syntype); 7. Frontal; 8. Caudal; 9. Lateral. Scale bar = 0.5 mm. Abbreviations: BH = basal hematodocha; C = conductor; CB = cymbium; E = embolus; MA = median apophysis; P = paracymbium; PS = palpal patellar setae; ST = subtegulum; T = tegulum.

gray patches, chelicerae red-brown. Endite with a lateral tooth. Legs yellow and distally somewhat darker, the longer first two pairs thicker and longer. Coxae and tibiae not modified. Abdomen gray with a darker patch on posterior dorsum (Fig. 4) and on venter. Pedipalp as in Figs. 5, 6. Palpal femur without tubercle, two macrosetae of subequal size present on the palpal patella (Fig. 6). Paracymbium pointed (Fig. 6) and the tegulum has a pointed ending (Figs. 5, 6). Median apophysis pointed (Fig. 5), conductor accommodates the embolus tip, which is simple, without a cap. Sclerites of the embolic division remain unidentified (Fig. 5) because expanding of the palp is necessary to homologize them. Radix was observed through the cymbium, and some of the unidentified distal sclerites (Fig. 5) are hypothesized to be the terminal and subterminal apophyses. Consequently, presence of the distal hematodocha is postulated, though not observed. Unobserved, if present, remain the stipes and the paramedian apophysis.

Female (syntype): Figs. 1–3, 7–9*:* Total length 8.06. Cephalothorax 2.5 long, 1.64 wide, 0.63 high. Sternum 1.1 long, 0.78 wide. Abdomen 5.7 long, 1.72 wide. Femur I length 2.38, Patella I length 0.85, Tibia I length 2.0, Femur IV length 1.34, Patella IV length 0.70, Tibia IV length 1.44. Chelicerae with 4 prolateral and 3 retrolateral teeth, and approximately 12 denticles in between. Prosoma red-brown, sternum dark brown laterally and yellow in the middle (Fig. 3), chelicerae red-brown. Legs yellow, the longer first two pairs thicker and annulated dark brown. Abdomen gray with darker patches on anterior and posterior dorsum (Fig. 2) and ventrally between epigynum and spinnerets. Epigynum a protruding sclerotized plate (Figs. 7–9).

Variation.—The female and subadult male of *P. teres* from Malaysia (locality data below) are darker than the syntypes, with a dark brown prosoma and legs, uniformly dark brown sternum, and dark gray abdomen. The female leg macrosetae are more numerous than in the syntype. The epigynum of this female was not protruding and had to be dissected for a caudal view. Total length of the female from Malaysia was 7.7. Cephalothorax 2.76 long, 1.88 wide, 0.66 high. Sternum 1.21 long, 0.9 wide. Abdomen 5.0 long, 1.56 wide. First femur 2.5 long. Chelicerae with 4 prolateral and 3 retrolateral teeth, and approximately 28 denticles in between.

Note.—The immature female holotype of *Perilla cylindrogaster* is darker than the syntypes of *P. teres* from Myanmar, which led Simon to diagnose the new species (Simon 1909: 111): sternum lacks the median light band, and front legs are more or less black. However, the holotype of *Perilla cylindrogaster* is not as dark as the Malaysian specimens, which are clearly conspecific with the syntypes of *Perilla teres*. Coloration intensity thus does not provide appropriate diagnostic characters. On the other hand, somatic morphology and coloration patterns of the immature from Vietnam are identical to those of the syntype of *P. teres*. Lack of differences in general somatic morphology between both species justifies proposing *Perilla cylindrogaster* as a junior synonym of *Perilla teres.*

Additional material examined.—MALAYSIA: Gombak Research Station, Genting Highlands, secondary forest, 5 July 1992, ♀, subadult ♂, C.L. Deeleman, in CD.

Distribution.—Myanmar, Malaysia, Vietnam.

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