Taxonomic revision of Taiwanese and Japanese Cyrtophora spiders hitherto identified with *C. moluccensis* (Arachnida: Araneae), using molecular and morphological data

Akio Tanikawa¹, Yung-Hau Chang² & I-Min, Tso³

¹ Laboratory of Biodiversity Science, School of Agriculture and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo, 113-8657 Japan  
E-mail: dp7a-tnkw@asahi-net.or.jp  
² Hua Hsing High School, ShiLin Dist., Taipei City, Taiwan  
E-mail: yunghauc@gmail.com  
³ Department of Life Science, Tunghai University, Taichung 407, Taiwan  
E-mail: spider@thu.edu.tw

**Abstract** — The Taiwanese and Japanese spiders which have been identified with *Cyrtophora moluccensis* (Doeshall 1857) are taxonomically revised. Three color morphs, yellow-, green-, and red-types, show their own discrete monophyletic clades in the phylogenetic tree inferred by Neighbor Joining method using the partial sequences of mt-16S-rRNA genes. P-distances within group means are 0.2% in the yellow-type, 0.1% in the green-type, and 0% in the red-type. P-distances between group means are 18.8% between yellow- and green-types, 19.4% between yellow- and red-types, 10% between green- and red-types. These three color morphs can be separated also by the shapes of epigynum and male palp. Consequently we recognize them as three independent nominal species and determined the yellow-type as *C. cylindroides* (Walckenaer 1842), the green-type as *C. moluccensis* (Doeshall 1857), and the red-type as *C. ikomosanensis* (Bösenberg & Strand 1906).

**Key words** — taxonomy, revival, *Cyrtophora moluccensis*, *Cyrtophora ikomosanensis*, *Cyrtophora cylindroides*.

**Introduction**

Spiders with wide distribution ranges or remarkable color variations often have many junior synonyms. In contrast, some independent species belonging to a flock of several species showing enormous variations as a whole sometimes have been erroneously synonymized. (e.g. *Dolomedes sulfureus*, Tanikawa & Miyashita 2008). *Cyrtophora moluccensis* (Doeshall 1857), first described from Amboina, is such an example. This species is widespread from India to Japan and to Australia (Platnick 2010) and known to have a remarkable color variation and have many junior synonyms (cf. synonym list in taxonomic part). *Cyrtophora ikomosanensis* (Bösenberg & Strand 1906) and *Suzania orientalis* Kishida in Yuhara 1931 described from Japan also have been synonymized with *C. moluccensis* (Yaginuma 1958, 1968b). Recently we recognized three color morphs, yellow-, green-, and red-types, among the specimens collected from Taiwan (Figs. 1–3). We examined the partial sequences of mt-DNA 16S-rRNA genes, and morphological features of Taiwanese and Japanese specimens to determine whether they are color morphs of the same species or independent nominal species.

Following abbreviations are used in this paper: AT, Akio Tanikawa; MOA, median ocular area; NSMT, National Museum of Nature and Science, Tokyo; THU, Tunghai University.

**Materials and methods**

Molecular study.  
*DNA extraction, polymerase chain reaction and sequencing.* A total of 12 specimens collected from Taiwan and Japan (Table 1) were used for molecular work (6, 4, and 2 specimens for the red-, green-, and yellow-types, respectively). They were preserved in 75% ethanol and genomic DNA was extracted from muscle of legs using Puregene DNA isolation kit (Gentra Systems, Inc., Minneapolis, MN, USA). The mitochondrial 16S-rRNA gene partial sequences were amplified using the primer combination: forward AGA GTT TGA TCC TGG CTC AG, reverse AGC GCT ACC TGG TTA CTA CTT. The reactants were initially denatured for 3 min at 95°C, proceeded with 30 cycles of 60 sec at 95°C, 60 sec at 50°C, 60 sec at 72°C and then the final extension at 72°C for 10 min. PCR products were assayed by electrophoresis on 1.2% agarose minigel visualized under UV light after ethidium bromide staining. The
target DNA fragments were isolated and purified by the Gel/PCR DNA Fragments Extraction Kit (Geneaid, Taiwan). The purified PCR products were sequenced using the BigDye terminator cycle sequencing kit and analysed on ABI 3100 or 3730 automated DNA sequencer (Applied Biosystems, Foster City, CA).

Data analyses. Chromatograms and contiguous alignments were edited using Seqman version 4.00 (DNASTar Inc., Madison, WI). All sequences were aligned via Clustal W program (Thompson et al. 1994) in MEGA version 4.0 (Tamura et al. 2007). The phylogenetic trees were constructed using MEGA version 4.0 (Tamura et al. 2007) by Neighbor Joining method.

Morphological study.

Many specimens from Taiwan, Japan and other regions were used for morphological study. They were preserved in 75% ethanol and their morphological features were examined under stereo microscope. In particular, shapes of epigynums and male palps were compared.

Results

Molecular analysis.

We obtained 490 to 493 bp of mt-16S-rRNA partial sequence from the specimens used. The accession numbers of DDBJ/EMBL/GenBank are shown in table 1. The bootstrap consensus tree inferred from 1000 bootstrap replicates of Neighbor Joining is shown in Fig. 4. Topology is comprised of three monophyletic clades, that is, green-type clade, red-type clade, and yellow-type clade. P-distances (the number of nucleotide difference/total number of nucleotides) within group means are 0.2% in yellow-type, 0.1% in green-type, and 0% in red-type. P-distances between group means are 18.8% between yellow-type and green-type, 19.4% between yellow-type and red-type, 10% between green-type and red-type.

Morphological analysis.

The yellow-type specimens were separable from the green- and the red-type specimens by general appearance (Fig. 1), shape of epigynum (Figs. 5–6), and shape of male palp organ (Fig. 7).

The green-type and the red-type specimens closely resemble each other, but the following differences were recognized. 1) In lateral view, median septum of epigynum is more curved in green-type (Figs. 9–11) than red-type (Figs. 14–16). 2) Male carapace is uniformly reddish brown in green-type (Fig. 19), but brown with a pair of black markings in red-type (Fig. 20). 3) The median apophysis of male palp is thicker in red-type (Fig. 17) than green-type (Fig. 12).

Conclusion

We conclude that three types of C. moluccensis from Taiwan and Japan are the independent nominal species, because 1) the partial sequences of mt-16S-rRNA genes showed clear differences among three types, and each of them formed a discrete monophyletic clade, 2) they can be separated by the morphological features, 3) they are sympatric in Taiwan (red-type and green-type are sympatric also in Irriomotejima Is. near Taiwan).

We identified the yellow-type specimens as Cyrtophora cylindroides (Walckenaer 1842) by the general appearance and the shape of epigynum and the shape of male palp organ (Figs. 1, 5–7; Chrysanthus 1959, Figs. 6, 10; Chrysanthus 1960, figs. 1–2). Although the type specimen of Cyrtophora moluccensis was unavailable to us, we were able to examine the toptotypical specimens of the species, which led us to conclude that the green-type is C. moluccensis (Doleshall 1857). We identified the red-type specimens as C. ikomosanensis (Bösenberg & Strand 1906) which was described from Japan (Figs. 13–17; Bösenberg & Strand 1906, pl. 11, Fig. 224) and has long been synonymized with C. moluccensis since Yaginuma’s treatment (Yaginuma 1986b).

Taxonomy

Genus Cyrtophora Simon 1864

Cyrtophora cylindroides (Walckenaer 1842)

[Japanese name: Tsutsu-suzumigumo]

(Figs. 1, 5–7)

Epeira cylindroides Walckenaer 1842, p. 136.

Cyrtophora cylindroides: Pocock 1898, p. 462; Chrysanthus 1959, p. 200, figs. 6, 10, 25; Chrysanthus 1960, p. 25, figs. 1–2; Yin et al. 1990, p. 67, figs. 169–170; Yin et al. 1997, p. 280, figs. 190a–c; Song, Zhu & Chen 1999, p. 279, figs. 164A, D, 165C.


Description. Measurements. Based on the 1♀ from Taiwan (THU-Ar 2010–002) and 1♂ from Thailand, measurements in parentheses indicate the range among specimens, 4♀/♂, in mm. Body 17.50 (13.19–17.50)/3.22 long. Carapace 7.67 (5.59–7.67)/1.69 long; 6.00 (4.21–6.00)/1.29 wide. Length of legs [tarsus + metatarsus + tibia + patella + femur = total]: I, 2.40 + 8.10 + 6.90 + 3.30 + 9.80 = 30.50/0.78 + 1.47 + 1.40 + 0.61 + 1.64 = 5.90; II, 1.80 + 5.85 + 4.95 + 0.60 + 7.35 = 20.55/0.71 + 1.33 + 1.16 + 0.60 + 1.56 + 5.36; III, 1.35 + 3.40 + 2.70 + 1.90 + 4.65 + 14.00/0.55 + 0.73 + 0.62 + 0.38 + 1.00 = 3.26; IV, 1.50 + 6.10 + 4.65 + 2.65 + 7.30 = 22.20/0.62 + 1.31 + 1.06 + 0.49 + 1.49 = 4.91. Abdomen 10.88 (8.17–10.88)/1.65 long, 6.75 (5.42–6.75)/1.31 wide.

Female and male. Carapace longer than wide [length/width 1.28 (1.23–1.33)/1.31]. MOA longer than wide (or almost as long as wide) [1.26 (0.98–1.26)/1.04], same width in front and behind or longer in front than behind [anterior width/posterior width 1.00 (0.79–1.01)/1.19]. Labium wider than long [length/width 0.76 (0.63–0.76)/0.50]. Sternum slightly longer than wide [length/width 1.10/1.16]. Length of leg I/length of carapace 3.98 (3.97–4.27)/3.49. Male palp: embolus, long and semicircle (Fig. 7, arrow); after mating, broken and left in epigynum (Fig. 6, arrow). Abdomen longer than wide [length/width 1.61 (1.51–1.61)/1.26], anteriorly with a pair of tubercles (Fig. 1). Epigynum with a pair of depressions and two pairs of semicircle grooves (Fig. 6); after mating, embolus (Fig. 7, arrow) remained in outer groove of copulatory opening (Fig. 6, arrow).

Coloration and markings. Female. Carapace light brown with dark colored borders. Abdomen pale yellow mottled with white and dark brown (Fig. 1). Male. Carapace dark brown, center part lighter. Abdomen dark brown with a pair of white markings.

Distribution. China, Taiwan, Vietnam, Singapore,
Thailand, Solomon Islands, New Guinea Island.

Remarks. The present species can be distinguished from C. moluccensis and C. ikomosanensis by the general appearance (Figs. 1–3, 17–25) as well as the shapes of genital organs of both sexes (Figs. 5–7, 8–16). The conspicuous features are: long and semicircle embolus of male palp (Fig. 7, arrow) and two pairs of semicircle grooves of epigynum in posterior view (Fig. 6).

*Cyrtophora moluccensis* (Doleshall 1857)

[Japanese name: Hoshi-suzumigumo]

(Figs. 2, 8–12, 17–19)

_Epeira moluccensis_ Doleshall 1857, p. 418. [Female type specimen from Amboina, not found]

_Epeira maritima_ Keyserling 1865, p. 813, pl. 18, figs. 22–23.

_Epeira hieroglyphica_ L. Koch 1871, p. 89, pl. 7, fig. 8. [Male holotype from Samoa, preserved in Naturhistorische Museum, Wien, examined]


_Aranusa moluccensis_ Pocock 1897, p. 599, pl. 25, fig. 9.

_Cyrtophora simoni_ Rainbow 1898, p. 337, pl. 7, fig. 4.

_Cyrtophora albopunctata_ Rainbow 1898, p. 339, pl. 7, fig. 5.

_Sazumia orientalis_ Kayashima 1943, p. 54, fig. 2.

_Sazumia moluccensis_ Nakatsuchi 1943a, p. 160, fig. 1 in pl. 23.

_Cyrtophora ikomosanensis_ Yaginuma 1958, p. 14, fig. 2D (specimen from Taiwan); Yaginuma 1960, fig. 158 in pl. 28 (right lower figure, specimen from Taiwan); Yaginuma 1968, fig. 158 in pl. 28 (right lower figure, specimen from Taiwan).


Description. Measurements. Based on 1♂ from Anatahan Is. (NSMT-Ar 8894) and 1♀ from Iriomote-jima Is. (NSMT-Ar 8678), measurements in parentheses indicate the range among specimens, ±, in mm. Body 19.88 (10.25–23.00) / 3.28 (3.28–3.84) long. Carapace 9.10 (4.65–9.10) / 1.53 (1.53–1.88) long; 7.10 (3.60–7.10) / 1.22 (1.22–1.53) wide. Length of legs [tarsus + metatarsus + tibia + patella + femur = total]: I, 2.75 + 11.00 / 9.13 + 4.00 + 12.38 = 39.26 / 0.75 + 1.36 + 1.33 + 0.56 + 1.73 = 5.73; II, 2.75 + 9.75 + 8.19 + 4.00 + 11.88 = 36.57 / 0.72 + 1.20 + 1.11 + 0.55 + 1.60 = 5.18; III, 2.00 + 5.75 + 3.88 + 2.81 + 7.00 = 21.44 / 0.49 + 0.66 + 0.53 + 0.39 + 0.96 = 3.03; IV, 2.25 + 9.25 + 6.88 + 4.00 + 11.25 = 33.63 / 0.56 + 1.15 + 0.90 + 0.51 + 1.46 = 4.58. Abdomen 13.00 (7.08–16.50) / 1.86 (1.78–2.13) long. 9.25 (4.77–10.38) / 1.30 (1.22–1.44) wide.

Female and male. Carapace longer than wide [length/width 1.28 (1.27–1.30) / 1.26 (1.22–1.26)]. MOA longer than wide in female [length/width 1.27 (1.27–1.30), almost as long as wide in male [length/width 1.02 (0.96–1.02)], anterior width and posterior width almost same in female [anterior width/posterior width 1.00 (1.00–1.10)], wider in front than behind in male [anterior width/posterior width 1.25 (1.19–1.28)]. Fung furrow of cercihera with 4 promarginal and 3 (3–4)/3 retromarginal teeth. Labium wider than long [length/width 0.76 (0.58–0.76)/0.63 (0.55–0.63)]. Sternum slightly longer than wide [length/width 1.12 (1.07–1.13)/1.11 (1.02–1.11)]. Length of leg I/length of carapace 4.31 (4.15–4.54)/3.75 (3.75–3.87). Median apophysis of male palp thin (Fig. 12, arrow). Abdomen longer than wide [length/width 1.41 (1.41–1.61)/1.43 (1.34–1.52)], anteriorly with a pair of tubercles (Figs. 2, 17–18). Female genitalia: median septum much curved in lateral view (Figs. 9–11).

Coloration and markings. Female. Carapace dark brown with many white pubescences, abdomen dark brown mottled with white (Figs. 2, 17–18). Male. Carapace uniformly reddish brown, abdomen green with white markings (Fig. 19).

Distribution. Japan (Iriomote-jima Is.), Taiwan, widespread in South East Asia, and Mariana Islands to Australia.

Remarks. The present species can be distinguished from _C. ikomosanensis_ by the following points. 1) In lateral view, median septum is more curved (Figs. 9–11) than _ikomosanensis_ (Figs. 14–16). 2) Male carapace is uniformly reddish brown (Fig. 19), but brown with a pair of black markings in _ikomosanensis_ (Fig. 20). 3) Median apophysis of male palp is thinner (Fig. 12, arrow) than _ikomosanensis_ (Fig. 17, arrow).

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Figs. 5–17. Genital organ. 5–7, Yellow-type, Cylindrochaeta cylindroides; 8–12, Green-type, Cylindrochaeta moluccensis; 13–17, Red-type, Cylindrochaeta ikomosanensis. — 5, 8, 13, epigynum, ventral view; 6, same, posterior view; 7, male palp, prolateral view; 12, 17, same, retrolateral view; 9–11, 14–16, median septum of epigynum, lateral view. (5–6, THU-Ar 2010–002, 8–9, THU-Ar 2010–003, 10, NSMT-Ar 8680, 11, NSMT-Ar 8688, 12, NSMT-Ar 8678, 13–14, NSMT-Ar 8692, 15, NSMT-Ar 8698, 16, NSMT-Ar 8699, 17, NSMT-Ar 8693; Scales: 0.25 mm.)
Cyrtophora ikomosanensis (Bösenberg & Strand 1906)  
[Japanese name: Suzumigumo]  
(Figs. 3, 13–17, 20–25)

Aranea ikomosanensis  Bösenberg & Strand 1906, p. 234, pl.11, fig. 224 [female holotype from “Ikomasan, Yamato (‘Ikomasan’ is probably a misspelling of ‘Mt. Ikomasan’ in Nara Prefecture, Honshu, Japan’), preserved in Zoologisches Institut und Zoologisches Museum der Universität Hamburg, not examined].

Araneus ikomosanensis: Saito 1939, P. 18.

Suzumia orientalis  Kishida in Yuhara 1931, p. 150, fig. 75; Nakatsudi 1943b, p. 185, figs. 2F–H, 3A–E.

Cyrtophora ikomosanensis: Yaginuma 1958, p. 13, figs. 2A–E.

Cyrtophora ikomosanensis (sic): Yaginuma 1960, p. 65, fig. 158 in pl. 28 (excluding right lower figure), fig. 61 (in part); Yaginuma 1961, p. 24; Yaginuma 1962, p. 30; Yaginuma 1968a, p. 65, fig. 158 in pl. 28 (excluding right lower figure), fig. 61 (in part).

Cyrtophora moluccensis: Yaginuma 1968b, p. 36, figs. 1–2; Yaginuma 1986, p. 117, in fig. 1, pl. 32, fig. 62.1; Chikuni 1989, p. 81, fig. 53; Tanikawa 2003, pp. 11, 87, figs. 215a, 216 (in part); Tanikawa 2007, p. 43, figs. 11–15, 431–433; Tanikawa 2009, p. 423, figs. 20–22; Ogata 2009, pl.26, fig. 3.


Description. Measurements. Based on 1♂ from Ehime (NSMT-Ar 8692) and 1♀ from Amami-oshima Is. (NSMT-Ar 8693), measurements in parentheses indicate the range among specimens, ±/♂, in mm. Body 15.88 (11.25–19.88)/4.38 (3.95–4.67) long. Carapace 6.27 (5.06–8.00)/2.13 (1.88–2.25) long; 4.87 (3.88–6.08)/1.73 (1.56–1.74) wide. Length of legs [tarsus + metatarsus + tibia + patella + femur = total]: I, 2.20 + 7.40 + 6.45 + 2.90 + 8.60 = 27.55/1.00 + 2.31 + 2.14 + 0.90 + 2.69 = 9.04; II, 2.10 + 6.60 + 5.60 + 2.80 + 8.20 = 25.30/0.94 + 2.03 + 1.80 + 0.86 + 2.49 = 8.12; III, 1.40 + 3.90 + 3.00 + 2.10 + 5.20 = 15.60/0.63 + 1.11 + 0.86 + 0.60 + 1.49 = 4.69; IV, 1.70 + 6.45 + 4.90 + 2.80 + 7.80 = 23.65/0.77 + 1.83 + 1.46 + 0.77 + 2.29 = 7.12. Abdomen 12.38 (7.25–12.75)/2.66 (2.43–2.71) long, 6.75 (4.83–9.75)/1.71 (1.66–1.83) wide.

Female and male. Carapace longer than wide [length/width 1.29 (1.27–1.32)/1.23 (1.21–1.29)]. MOA longer than wide in female [length/width 1.15 (1.07–1.20), almost as long as wide in male [length/width 0.75 (0.75–1.03)], anterior width and posterior width almost same in female [anterior width/posterior width 1.07 (1.04–1.11)], wider in front than behind in male [anterior width/posterior width 1.58 (1.20–1.58)]. Fung furrow of choricera with 4 (3–4) promarginal and 3 (3–4)/3 (2–3) retromarginal teeth. Labium wider than long [length/width 0.69 (0.61–0.72)/0.64 (0.52–0.68)]. Sternum slightly longer than wide [length/width 1.15 (1.13–1.21)/1.05 (1.05–1.13)]. Length of leg I/length of carapace 4.39 (4.33–4.41)/4.24 (4.14–4.42). Median apophysis of male palp thick (Fig. 7, arrow). Abdomen longer than wide [length/width 1.83 (1.31–1.83)/1.55 (1.39–1.55), anteriorly with a pair of tubercles (Figs. 3, 21–25). Female genitalia: median septum almost straight in lateral view (Figs. 14–16).

Coloration and markings. Female. Carapace dark brown with many white pubescence. Abdomen varied: reddish brown or greenish brown mottled with white, bright orange, dark wine red, or pale brown without markings. Male. Carapace light brown laterally with dark brown marking, abdomen pale brown mottled with white.

Distribution. Japan (Honshu, Shikoku, Kyushu, Nansei Isls.), Taiwan.

Remarks. Cyrtophora ikomosanensis closely resembles C. moluccensis. For the discriminating point between these species, see the remarks of the latter.

Notes. Although C. ikomosanensis was synonymized with C. moluccensis by Yaginuma (1968b), here it is resurrected from the synonymy.

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References


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