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## ORIGINAL ARTICLE

# New species of the snakefly genus *Mongoloraphidia* (Raphidioptera: Raphidiidae) from Japan and Taiwan, with phylogenetic and biogeographical remarks on the Raphidiidae of Eastern Asia

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## Abstract

Two species of the snakefly genus *Mongoloraphidia* Aspöck & Aspöck, 1968 from Japan and Taiwan are described as new to science: *Mongoloraphidia (Japanoraphidia) occidentalis* sp. nov. and *Mongoloraphidia (Formosoraphidia) curvata* sp. nov. A key to the species of *Mongoloraphidia* from Eastern Asia is provided. Phylogenetic and biogeographical aspects on the Raphidiidae from Eastern Asia are discussed.

**Key words:** biogeography, *Formosoraphidia*, *Japanoraphidia*, new taxa, taxonomy.

## INTRODUCTION

The snakefly genus *Mongoloraphidia* Aspöck & Aspöck, 1968 is the most species rich genus of the family Raphidiidae with 61 described species distributed from Central to Eastern Asia. Although the monophyly of this heterogeneous genus has been discussed as problematic (Aspöck *et al.* 1999), it was corroborated in the most recent molecular analysis (unpublished data), which, however, was based only on species from Central Asia. *Mongoloraphidia* is diagnosed by the male ectoproct having the basal part withdrawn into tergite IX, the absence (amalgamation) of the parameres (complex of gonocoxites, gonapophyses and gonostyli X). After publication of the monograph on the world Raphidioptera (Aspöck *et al.* 1991), a series of works on the taxonomy of *Mongoloraphidia* became available in the 1990s by Aspöck and Aspöck (1990, 1991, 1993), Aspöck and Aspöck (1995), and Aspöck *et al.* (1995, 1997a,b) Aspöck, Aspöck and Rausch (1998) and Aspöck, Aspöck and Yang (1998). Recently, a revision on the

*Mongoloraphidia* species from mainland China was completed by Liu *et al.* (2010) and five species, which differ markedly from each other, were described from northern and central China. Up to date, 10 species of *Mongoloraphidia* have been described in Eastern Asia. Additional species are to be anticipated from China in the estimation of Aspöck, Aspöck and Yang (1998), whereas the rest of Eastern Asia has been intensively explored for Raphidiidae and, probably, does not harbor further species. The discovery of two new species of *Mongoloraphidia* from Japan and Taiwan, which are described in the present paper, was an unexpected find. A key to the species of *Mongoloraphidia* from Eastern Asia is included.

## MATERIALS AND METHODS

Specimens for the present study are deposited in the Natural History Museum and Institute (CBM), Chiba; the Ehime University Museum (EUM), Matsuyama; the personal collection of Fumio Hayashi (HC), Tokyo; the Muséum National d'Histoire Naturelle (MNHN), Paris; the National Science Museum (NSM), Tokyo, and the Osaka Museum of Natural History (OMNH), Osaka. Genitalic preparations were made by clearing the apex of the abdomen in a cold, saturated KOH solution for

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6–8 h. After rinsing the KOH with acetic acid and water, the apex of the abdomen was transferred to glycerin for further dissection and examination. The terminology of the genitalia follows that of Aspöck *et al.* (1991) and Aspöck and Aspöck (2008).

## TAXONOMY

### Genus *Mongoloraphidia* Aspöck & Aspöck

*Mongoloraphidia* Aspöck & Aspöck, 1968: 59. Type species: *Agulla sororcula* Aspöck & Aspöck, 1966: 226, original designation.

### Checklist of the *Mongoloraphidia* species from Eastern Asia

#### Mainland Eastern Asia:

- *M. abnormis* Liu, Aspöck, Yang & Aspöck, 2010 (female unknown) (China)
- *M. duomilia* (Yang, 1998) (China)
- *M. pudica* Aspöck, Aspöck & Rausch, 1985 (Russia, South Korea)
- *M. xiyue* (Yang & Chou, in Yang 1978) (China)
- *M. yangi* Liu, Aspöck, Yang & Aspöck, 2010 (China)
- *M. liupanshanica* Liu, Aspöck, Yang & Aspöck, 2010 (China)

#### Taiwan:

- *M. (Formosoraphidia) caelebs* Aspöck, Aspöck & Rausch, 1985
- *M. (Formosoraphidia) curvata* sp. nov.
- *M. (Formosoraphidia) formosana* (Okamoto 1917) (male unknown)
- *M. (Formosoraphidia) taiwanica* Aspöck & Aspöck, 1982

#### Japan:

- *M. (Japanoraphidia) harmandi* (Navás, 1909) (Honshu)
- *M. (Japanoraphidia) occidentalis* sp. nov. (Shikoku)

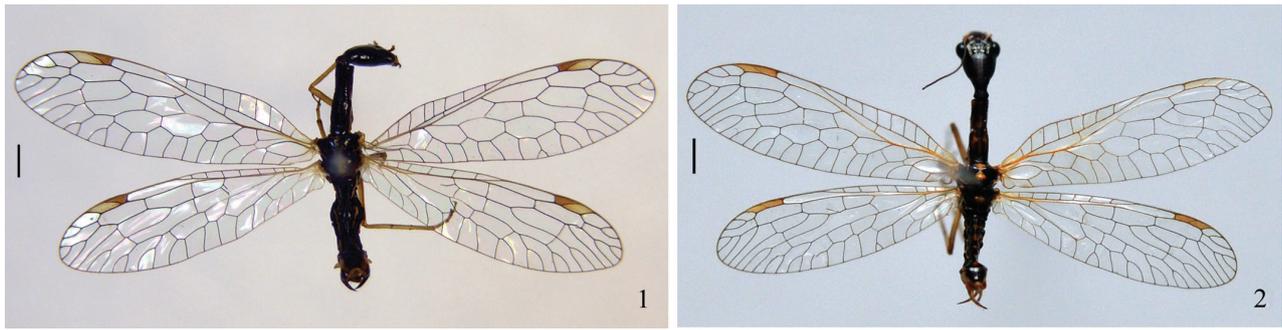
### Key to males of *Mongoloraphidia* from Eastern Asia

- 1 Species from mainland of Eastern Asia.....6
  - Species from islands of Taiwan or Japan.....2
- 2 Occurring on Japan.....3
  - Occurring on Taiwan.....4
- 3 Hypovalva (gonapophyses IX) roundly broadened posteriad, laterally with pair of short, posteriorly produced, claw-like processes (Aspöck *et al.* 1991: fig. 1104).....*M. (J.) harmandi*
  - Hypovalva slightly broadened posteriad, laterally with pair of anteriorly curved, digitiform processes (Fig. 4).....*M. (J.) occidentalis* sp. nov.
- 4 Hypovalva posteriorly with pair of ventrally curved processes (Figs 11,12).....*M. (J.) curvata* sp. nov.

- Hypovalva posteriorly ending straight.....5
- 5 Hypovalva with lateral processus (Aspöck *et al.* 1991, fig. 1107).....*M. (F.) taiwanica*
  - Hypovalva without lateral processus (Aspöck *et al.* 1991, fig. 1109) .....*M. (F.) caelebs*
- 6 Gonostylus IX bifurcate (Liu *et al.* 2010, fig. 5).....*M. abnormis*
  - Gonostylus IX not bifurcate .....7
- 7 Hypovalva ventrally ladle-like (Liu *et al.* 2010, fig. 13).....*M. liupanshanica*
  - Hypovalva ventrally flattened .....8
- 8 Caudal end of hypovalva medially tapering.....9
  - Caudal end of hypovalva medially straight.....10
- 9 Gonostylus IX approximately as long as arm of gonocoxite IX (Aspöck, Aspöck and Yang 1998, fig. 12).....*M. duomilia*
  - Gonostylus IX approximately only half as long as arm of gonocoxite IX (Liu *et al.* 2010, fig. 21).....*M. yangi*
- 10 Processus on ventral part of gonocoxite IX directed caudally (Aspöck *et al.* 1998, fig. 4).....*M. pudica*
  - Processus on ventral part of gonocoxite IX directed ventrally (Aspöck *et al.* 1998, fig. 6).....*M. xiyue*

### Key to females of *Mongoloraphidia* from Eastern Asia

- 1 Species from mainland of Eastern Asia.....7
  - Species from islands of Taiwan or Japan .....2
- 2 Occurring on Taiwan.....4
  - Occurring on Japan.....3
- 3 Glandulae receptaculi elongate and club shaped, stems shorter than glandulae, atrium bursae laterally with pair of broad sclerites (Fig. 8).....*M. (J.) occidentalis*
  - Glandulae receptaculi ovoid, stems approximately as long as glandulae, atrium bursae laterally with pair of small sclerites (Aspöck *et al.* 1991, figs 2190, 2191).....*M. (J.) harmandi*
- 4 Tergite VIII anteriorly with extremely long processus, intersegmentale S7/8 (a membranous internally extending from abdominal segment VIII to posterior portion of sternite VII) anteriorly sinusoidal (Aspöck *et al.* 1991, figs 2196,2197).....*M. (F.) formosana*
  - Tergite VIII anteriorly convex but not processus-like, intersegmentale S7/8 not sinusoidal.....5
- 5 Stems of glandulae receptaculi shorter than glandulae (Fig. 17).....*M. (F.) curvata*
  - Stems of glandulae receptaculi longer than glandulae.....6
- 6 Convex posterior part of sternite VII nearly as long as anterior part (Aspöck *et al.* 1998, fig. 1).....*M. (F.) caelebs*



Figures 1–2 Habitus photos of *Mongoloraphidia* spp. 1 *M. (J.) occidentalis* sp. nov., male holotype; 2 *M. (F.) curvata* sp. nov., male holotype. Scale bars: 1.0 mm.

- Convex posterior part of sternite VII only about one third length of anterior part (Aspöck *et al.* 1991, fig. 2199).....*M. (F.) taiwanica*
- 7 Tergite VIII with anterior margin not protruding cephally.....*M. liupanshanica*
- Tergite VIII with anterior margin protruding cephally..... 8
- 8 Tergite VIII broadest ventrally (Aspöck *et al.* 1991, fig. 2283).....*M. pudica*
- Tergite VIII broadest laterally.....9
- 9 Atrium bursae laterally with pair of sclerotized ledges (Liu *et al.* 2010, fig. 12).....*M. duomilia*
- Atrium bursae laterally without sclerotized ledge.....  
.....*M. xiyue*

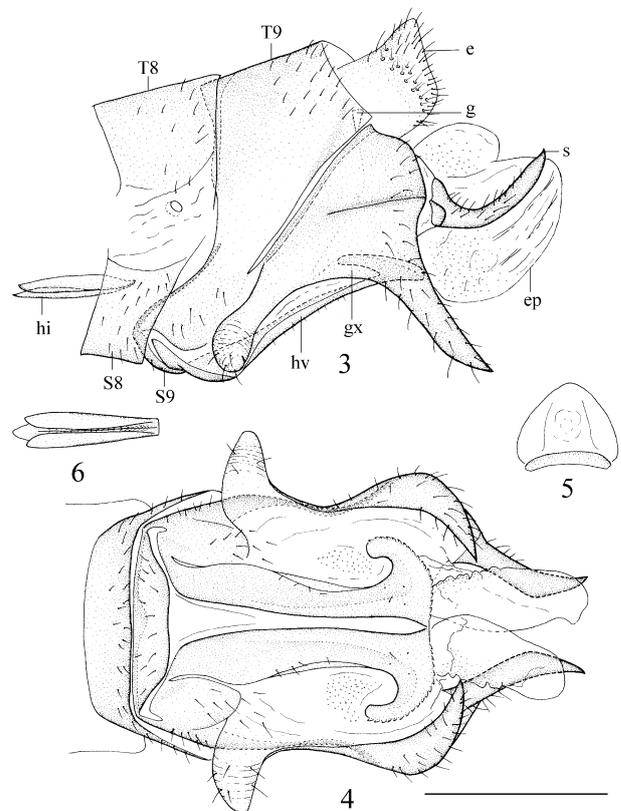
***Mongoloraphidia (Japanoraphidia) occidentalis* sp. nov.**

(Figs 1,3–10)

*Male.* Body length 9.6 mm; forewing length 9.7 mm, hindwing length 8.9 mm.

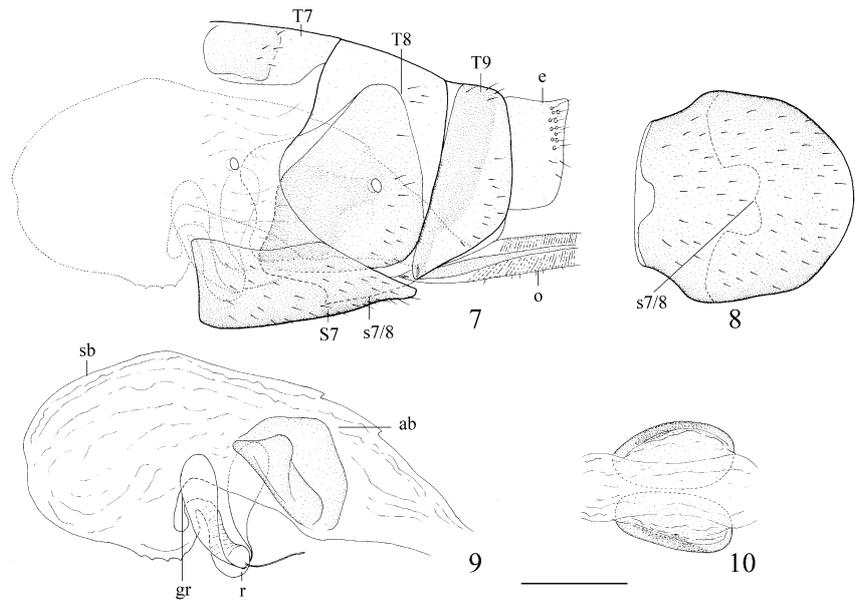
Head elongate, posteriorly tapering, black; clypeus reddish brown. Antennal sclerite (torulus) black; scape pale brown, pedicel yellow. Mouthparts brown, mandibles yellow with distal 1/3 reddish brown.

Pronotum slender and elongate, blackish brown, posterior half with three indistinct reddish brown vittae; meso- and metathorax black with scutellum yellow, mesonotum anteriorly with a subtriangular marking. Legs yellow with brown setae. Wings hyaline; pterostigma narrow, approximately four times as long as wide, crossed by a vein at proximal 1/3, yellowish brown with distal half pale yellow; veins pale brown with  $R_1$  much paler. Anterior branch of Rs with one forked vein and three simple veins running to wing margin. Basal part of Ma in the hind wing as a crossvein, however, in the right hind wing aberrantly with a trace of a possible longitudinal vein.



Figures 3–6 *Mongoloraphidia (Japanoraphidia) occidentalis* sp. nov., male holotype. 3 Genital segments, lateral view; 4 genital segments, ventral view; 5 ectoproct and gonarcus (fused gonocoxites XI), caudal view; 6 hypandrium internum, ventral view. e: ectoproct; g: gonarcus; gx: gonocoxite IX; hi: hypandrium internum; hv: hypovalva (gonapophyses IX); ep: endophallus; s: gonostylus; s7/8: intersegmentale S7/8. Scale bars: 0.5 mm.

Abdomen black; each pregenital segment with a pair of yellowish vittae laterally on tergite and a narrow yellowish stripe on posterior margin of sternite; genital segments blackish brown, tergite IX laterally yellow,



**Figures 7–10** *Mongoloraphidia* (*Japanoraphidia*) *occidentalis* sp. nov., female paratype from Tokushima. 7 Genital segments, lateral view; 8 sternite VII, ventral view; 9 bursa copulatrix, lateral view; 10 atrium bursae, dorsal view. e: ectoproct; o: ovipositor; ab: atrium bursae; gr: glandula receptaculi; r: receptaculum seminis; sb: sacculus bursae. Scale bars: 0.5 mm.

distal half of ectoproct yellow, dorsal half of gonocoxite IX and gonostylus IX brown, ventral half of gonocoxite IX yellow, hypovalva (gonapophyses IX) brown. Sternite VIII rather narrow, laterally slightly shorter than tergite VIII. Tergite IX (Fig. 3) laterally markedly flexed, anterior margin moderately notched, posteriorly with prominent angles. Sternite IX (Fig. 4) arcuate, ventrally with posterior margin nearly truncate. Gonocoxite IX (Fig. 3) dorsoventrally directed; dorsal part subtriangular; ventral part narrow, ventrally terminating into a broad obtuse lobe, which is produced laterally, and posteriorly with a caudally produced process, which is slightly curved medially and acutely pointed at apex. Gonostylus slender, distal 2/3 slightly curved dorsad. Hypovalva (Figs 3,4) paired, posterior portion strongly widened, roundly margined, and laterally produced into a digitiform process, which is arcuately curved anteriorly, with several small teeth posteriad. Ectoproct (Fig. 3) subquadrate, anteriorly semi-membranous, posterodorsal corner distinctly pointed, and posteroventral corner rounded. Hypandrium internum (Figs 3,6) large, slightly shorter than tergite IX, lateral lobes in ventral view close to each other, narrowed posteriad; median lobe narrow. Gonarcus (fused gonocoxites XI) (Figs 3,5) represented as a transversely narrowed plate, subtriangular in lateral view, but narrowly band-like in caudal view. Endophallus (Figs 3,4) broad and paired, roundly tapering.

**Female.** Body length 10.3 mm without ovipositor and 14.7 mm with ovipositor; forewing length 11.0 mm, hindwing length 10.1 mm.

Sternite VII (Figs 7,8) nearly twice as long as tergite VII, strongly produced posteriad, in ventral view poste-

rior margin convex. Tergite VIII (Fig. 7) with anterior margin roundly protruded in lateral view, ventrally distinctly broader than dorsally. Intersegmentale S7/8 (Figs 7,8) conspicuous, nearly reaching to 1/2 of the posterior length of sternite VII, in ventral view medially concave. No subgenitale discernible. Atrium bursae (Figs 7,9,10) richly pleated, compact, slightly sclerotized laterally, forming a pair of broad sclerites, which is extended dorsoventrad, and with narrow transition into the sacculus bursae which distinctly exceeds seventh segment in length. Ductus receptaculi originating from subdistal region of sacculus. Receptaculum seminis rugose, distally broad and ovoid, proximally strongly tapering. Glandulae receptaculi club-shaped and ovoid, with short thread-like stalks.

**Holotype.** ♂ (EUM), JAPAN: “Shikoku, Ehime Pref., Omogo-kei [33°43'N, 133°05'E, 796 m], 14.VII.1968, Y. Hori”.

**Paratype.** 1♀ (OMNH), JAPAN: “Shikoku, Ehime, Omogo v., Kanmon, 33°42'34"N, 133°05'43"E [706 m], 22.VI.2004, R. Matsumoto”; 1♀ (HC), JAPAN: “Shikoku, Tokushima Pref., Naka-gun, Mt. Tsurugi [33°52'N, 134°05'E, 1340 m], 19.VII.2009, Y. Nameda”.

**Distribution.** The new species is only known to occur on the Shikoku Island.

**Etymology.** The specific epithet “*occidentalis*” refers to the geographic distribution of the new species in Western Japan (Shikoku).

**Remarks.** In the revision of Raphidiidae from Eastern Asia (Aspöck, Aspöck and Yang 1998), it was reported that *Mongoloraphidia* (*Japanoraphidia*) *harmandi*

(Navás 1909), which was discovered about 100 years ago on Honshu, is the sole representative of this family in Japan. The new species herein described represents the second species of the family Raphidiidae from Japan. It differs distinctly from *M. (J.) harmandi* by the pair of anteriorly curved, digitiform processes on the postero-lateral hypovalva, and by the dorsoventrally extended lateral sclerites of the female atrium bursae; whereas, in *M. (J.) harmandi*, the posterior portions of the hypovalva are roundly broadened, laterally they exhibit a pair of short claw-like processes, which are acutely produced posteriad, and the lateral sclerites of the female atrium bursae are extended anteroposteriorly.

Aside from the recent revision of the eastern Asian Raphidiidae (Aspöck, Aspöck and Yang 1998), additional records on species of Raphidiidae from western Honshu, Shikoku, and Kyushu, have been published in various local Japanese journals over the past 30 years that are largely unknown to most researchers outside Japan (Ohara 1983, 1987; Kawase 1986a,b, Abe 1987; Yamauchi and Yano 2006; Beppu 2009). In these works, the majority of specimens of Raphidiidae from Western Japan were identified as *M. (J.) harmandi*. Nevertheless, Ohara (1987), who examined specimens collected from Tokushima (Shikoku) and Nagano (eastern Honshu), noted that they probably represent two different species, but he did not identify either due to the inaccessibility of the type specimens of *M. (J.) harmandi*. The present determination of the new species is based on our examination of the primary type of *M. (J.) harmandi* (lectotype ♂, “Japon, Nippon Moyen, env. de Tokio, J. Harmandi, 1906”, deposited in MNHN). Our examination of the following specimens of *M. (J.) harmandi* indicates that it is probably distributed only in eastern Honshu: 1♂, Tochigi Pref., Yumoto, Nikko City, 29.VII.1993, M. Kawanabe, deposited in EUM; 1♀, Yamagata Pref., Oguni, 28.VI.1994, Y. Kusakabe, deposited in NSM; 1♂1♀, Tokyo, Mt. Takao, Musashi, IX.1959, K. Fujimoto, deposited in NSM; 1♀, Toyama Pref., Oyama t. Oritate, Riverside of Makawa, 8.VI.2003, R. Matsumoto, deposited in OMNH; 1♀ Nagano Pref., Kamikochi, Karasawa, 2100–2500 m, 1–3.VIII.1990, A. Shinohara, deposited in NSM.

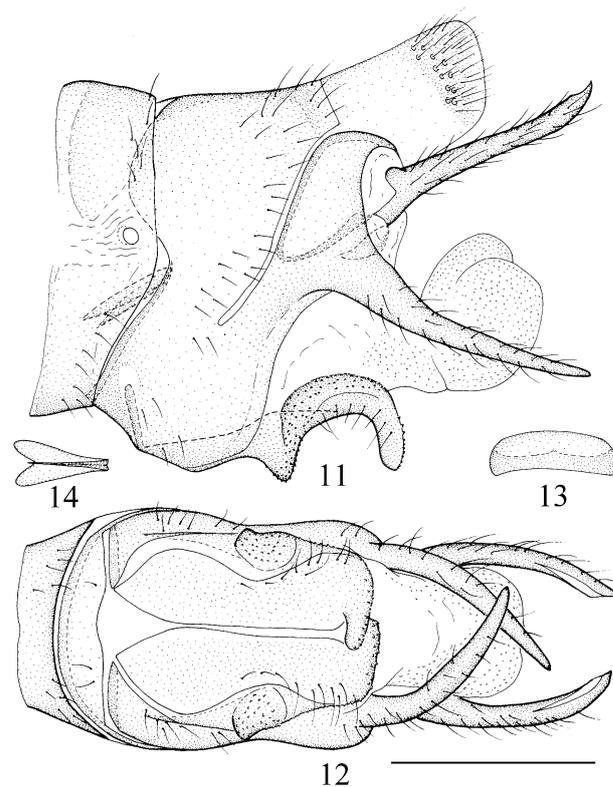
The identity of the *Mongoloraphidia* species from western Honshu and Kyushu has remained obscure, and the question whether there may be additional new species from these areas has been hindered by the insufficient material of species of *Mongoloraphidia* from Japan. Currently, we have only been able to examine several female specimens from western Honshu (3♀, Hyogo Pref. Shisou-shi, Haga, Sakanotani-rindo, 18.VII.2009, Y. Hida, deposited in HC, and 1♀, Nara Pref., Yoshino-gun, Kamikitayama-mura, Wasa-

matayama, 1200 m, 28.VI.2008, N. Nakahama, deposited in OMNH). In the female from Hyogo, the lateral sclerites of the atrium bursae are almost absent, while in *M. (J.) harmandi* and *M. (J.) occidentalis* the lateral sclerites of the atrium bursae are distinct. The female specimen from Nara is quite similar to *M. (J.) occidentalis*, in that the lateral sclerites of the atrium bursae are dorsoventrally extended. However, without examination of male specimens from these localities, we must regard the species from western Honshu as undetermined. To solve some of the taxonomic problems of Raphidiidae from Japan, it remains to be hoped that the discovery of the new species will stimulate detailed re-examination of local collections.

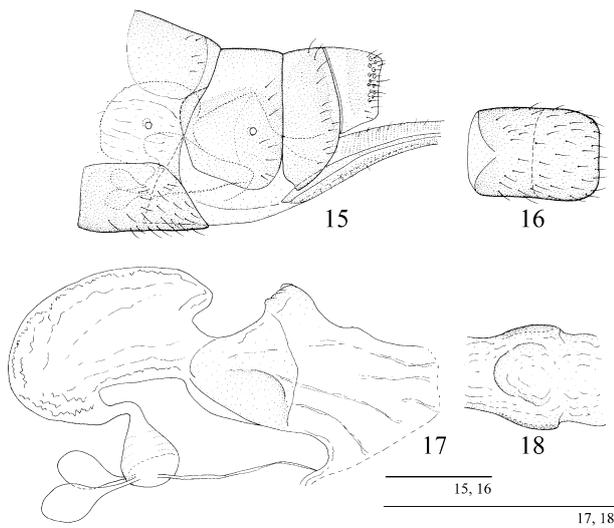
***Mongoloraphidia (Formosoraphidia) curvata* sp. nov.**

(Figs 2,11–18)

*Male.* Body length 8.5 mm; forewing length 8.3 mm, hindwing length 7.2 mm.



Figures 11–14 *Mongoloraphidia (Formosoraphidia) curvata* sp. nov., male holotype. 11 Genital segments, lateral view; 12 genital segments, ventral view; 13 gonarcus (fused gonocoxite XI), caudal view; 14 hypandrium internum, ventral view. Scale bars: 0.5 mm.



Figures 15–18 *Mongoloraphidia (Formosoraphidia) curvata* sp. nov., female paratype. 15 Genital segments, lateral view; 16 sternite VII, ventral view; 17 bursa copulatrix, lateral view; 18 atrium bursae, dorsal view. Scale bars: 0.5 mm.

Head elongate, posteriorly tapering, black; clypeus reddish brown, but marginally pale yellow. Antennal sclerite (torulus) black; antennae brown. Mouthparts blackish brown, mandibles yellow with distal 1/3 reddish brown.

Pronotum slender and elongate, brown, laterally margined pale yellow, anterior half medially with a yellowish vitta, posterior half with three yellowish vittae, median one of which is located more posteriad; meso- and metathorax black, each notum with a subtriangular yellowish marking anteromedially and scutellum yellow. Legs yellow with brown setae. Wings hyaline; pterostigma narrow, approximately four times as long as wide, brownish yellow throughout, medially crossed by a vein; veins brown with  $R_1$  yellowish. Anterior branch of  $R_s$  with one forked vein and three simple veins running to wing margin. Basal part of  $M_a$  in the hindwing as a crossvein.

Abdomen blackish brown; each pregenital segment with tergite margined yellow posterolaterally, and, respectively, bearing a yellow spot anteromedially and posteromedially; each sternite with a narrow yellowish transverse stripe on posterior margin; genital segments yellow, tergite IX dorsally black with a yellow spot anteromedially, caudal process of gonocoxite IX and gonostylus slightly darkened distad. Sternite VIII nearly as long as tergite VIII. Tergite IX (Fig. 11) laterally markedly flexed, anterior margin moderately notched. Sternite IX (Fig. 12) arcuate, ventrally with posterior margin slightly concave medially. Gonocoxite IX

(Fig. 11) dorsoventrally directed; dorsal part suboval; ventral part narrow, posteriorly with a slender, elongated, and caudally produced process, which is slightly curved medially and bluntly pointed at apex. Gonostylus (Figs 11,12) slender, straightly directed posterodorsad in lateral view, innerly with a longitudinal incision on apex. Hypoalva (gonapophyses IX) (Figs 11,12) in lateral view with anterior half covered by gonocoxite IX, lateral margin of posterior half with several small teeth, in ventral view paired, laterally with an obtuse process produced ventrad, posterior portion ending in a digitiform process, which is curved ventromedially. Ectoproct (Fig. 11) subquadrate, anteriorly semi-membranous, posterodorsal corner feebly and roundly pointed, posteroventral corner rounded. Hypandrium internum (Figs 11,14) small, much shorter than tergite IX, lateral lobes in ventral view close to each other, rather narrowed posteriad; median lobe rather narrow. Gonarcus (fused gonocoxites XI) (Figs 11,13) represented as a transversely suboblong plate in caudal view. Endophallus (Figs 11,12) broad, distally slightly separated, and roundly tapered.

*Female*. Body length 9.4 mm without ovipositor and 12.9 mm with ovipositor; forewing length 8.7 mm, hindwing length 7.5 mm.

Sternite VII (Figs 15,16) slightly longer than tergite VII, slightly produced posteriad, in ventral view posterior margin nearly truncate. Tergite VIII (Fig. 15) with anterior margin slightly and roundly protruded in lateral view, ventrally distinctly broader than dorsally. Intersegmentale S7/8 (Figs 15,16) conspicuous, reaching to posterior 1/2 of sternite VII. No subgenitale discernible. Atrium bursae (Figs 15,17,18) richly pleated, compact, slightly sclerotized laterally, and prominent dorsad, with narrow transition into the sacculus bursae which is extended within seventh segment. Ductus receptaculi long, originating from the anterior region of sacculus. Receptaculum seminis rugose, distally broad and ovoid, proximally strongly tapering. Glandulae receptaculi ovoid, with short thread-like stalks.

*Holotype*. ♂ (CBM), “An-ma Shan [Mt. Anmashan, 24°14'N, 120°58'E], Ho-p'ing Hsiang [Heping], T'aichung Hsien [Taichung County], 2160–2300 m, Taiwan, 25.V.1991, A. Saito/CBM-ZI 30215”.

*Paratype*. 1♀ (CBM), same data as holotype/CBM-ZI 30214.

*Distribution*. The new species is known only from Mt. Anmashan of Taichung County, Taiwan.

*Etymology*. The specific epithet “*curvata*” refers to the ventromedially curved processes on the posterior portion of the hypoalva of the new species.

*Remarks*. Presently, four species of *Mongoloraphidia*: *M. (F.) formosana* (Okamoto), *M. (F.) taiwanica* Aspöck

& Aspöck, *M. (F.) caelebs* Aspöck, Aspöck & Rausch, and the new species, have been recorded in Taiwan. All are distributed in the central mountainous areas and are probably closely related due to their similar appearance and the slender, elongate gonostylus on the male gonocoxite IX. The new species differs from *M. (F.) taiwanica* and *M. (F.) caelebs* by the hypovalva of the male genitalia being posteriorly broadened and with ventrally curved digitiform processes. It is distinguished from *M. (F.) formosana* (see Aspöck *et al.* 1991, figs 2196–2198) by the female sternite VII being feebly produced posteriad. The male of *M. (F.) formosana* is unknown. In *M. (F.) taiwanica* and *M. (F.) caelebs*, the hypovalva is present as a pair of elongate, narrow, and blade-like lobes, which is straightly produced posteriad, and the female sternite VII of *M. (F.) formosana* is strongly produced posteriad.

## DISCUSSION

With the addition of the two new species described herein, a total of 12 species of *Mongoloraphidia* are known to occur in Eastern Asia. The discovery of the new species was an unexpected surprise; and it contributes to the complexity of their respective subgenera, *Japanoraphidia* and *Formosoraphidia*. However, it does not help solve the problems concerning a possible parphyly with the continental species, *M. duomilia*, *M. pudica*, and *M. xiyue*, which show considerable similarities in the male genitalia with the island species. Based on morphology and our present understanding of the biogeography of the *Mongoloraphidia* species of Eastern Asia, it is a reasonable hypothesis to assume that they represent a monophylum. A recent molecular analysis

(unpublished data) provides support for the monophyly of *Mongoloraphidia* – however, the analysis did not include species from Eastern Asia. Thus, our previous caution, that it is still too early for a definite systematic classification of the genus *Mongoloraphidia* (Liu *et al.* 2010), has not lost its actuality. In light of the present findings from Japan and Taiwan, and the newly discovered species from mainland China (Liu *et al.* 2010), it is likely that further undescribed species of *Mongoloraphidia* will be found in Eastern Asia. Valuable phylogenetic and zoogeographical hypotheses on the genus *Mongoloraphidia* should be possible following completion of the alpha taxonomic study.

Nevertheless, several biogeographical aspects merit particular attention. The 12 species of *Mongoloraphidia* presently recorded from Eastern Asia (i.e. five endemic species from mainland China, four endemic species on Taiwan, one species from the Russian Far East and South Korea, and two endemic species from Japan) are characterized by small distribution areas that are mainly restricted to their glacial refugial areas (Fig. 19). An extremely low capacity of dispersal is apparent. Although detection of further species of *Mongoloraphidia* from Eastern Asia can be expected, it is unlikely that the distribution pattern in which all the species are restricted to comparatively small areas will differ. The specificity of the snakefly fauna (not only comprising the *Mongoloraphidia* species) of the various parts of Eastern Asia is astounding, although this phenomenon is commonplace for snakeflies and is known from other parts of the Palaearctic and large parts of the Nearctic.

Several basic studies have largely contributed to clarifying the palaeogeography of Eastern Asia

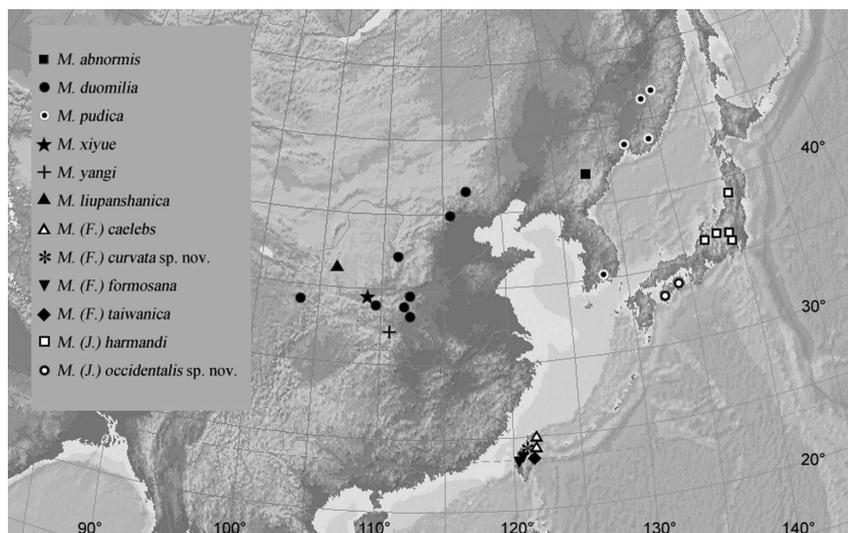


Figure 19 Distribution map of the *Mongoloraphidia* species from Eastern Asia.

(Dobson & Kawamura 1998; Ota 1998; Zhuo *et al.* 1998; Millien-Parra & Jaeger 1999; Keally 2005; Qiu *et al.* 2009). These works enable us to postulate further assumptions on the biogeography of *Mongoloraphidia* from Eastern Asia. Certain periods of the Pleistocene were marked by a drop in the sea level up to 130 m (possibly 140 m) below the present level. These dramatic events expanded the coastline of eastern China some 600 to 1000 km eastward. The islands of Honshu, Kyushu, and Shikoku were at that time united to a large land-mass (Hondo) and connected to the Asian continent by numerous land bridges on repeated occasions, at least 1 Ma, about 500 ka and about 300 ka BP. Likewise, during the Last Glacial Maximum (LGM: about 18 ka BP), the sea level dropped 120 to 130 m, many land bridges were formed, and Taiwan was part of the mainland. However, in the Late Miocene, by about 10 Ma BP, the Japanese islands were entirely submerged (Smith *et al.* 1995). This infers that the ancestors of the present Raphidiidae of Japan, *M. (J.) harmandi* and *M. (J.) occidentalis*, must have reached the area representing the Japanese islands today after that time. This is certainly a period long enough for the evolution of a specific raphidiid fauna. In reality, however, we do not know when the immigrations to the Japanese islands and Taiwan may have taken place. Since there are considerable morphological differences to account for, the split-off events may have occurred at least in the very beginning of the Pleistocene, but more probably already in the Pliocene. The present distribution patterns should be interpreted as the result of various subsequent vicariance events.

One must, however, raise the question why there are no traces of the common mainland raphidiid fauna in Japan or Taiwan despite the many connections of these islands to the mainland during the last glacial period. Again, this can only be explained by the extremely low capacity of dispersal of these insects. Nonetheless, the raphidiid fauna of the islands of Eastern Asia is no doubt related to the mainland fauna. As mentioned above, various internal groupings seem to be evident among the species of Eastern Asia, and altogether the species probably represent a monophyletic branch within the genus *Mongoloraphidia*.

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