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First records of Miracinae (Hymenoptera: Braconidae) from Borneo with description of two new species

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Abstract. The braconid subfamily Miracinae is recorded for the first time from Borneo. Two new species are described: *Rugosimirax obsolescens* sp. nov. and *Rugosimirax bimacula* sp. nov. based on specimens in the Natural History Museum, UK. The relationships of Miracinae genera are discussed.

Keywords. *Rugosimirax*, Oriental region, new taxon.

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Introduction

Miracinae Viereck, 1918 (Hymenoptera: Braconidae) is a small subfamily including only 70 species worldwide (Ranjith *et al.* 2023), though reported from all geographical regions. They are known to be endoparasitoids of leaf-mining lepidopteran larvae (Maetô 1995; Memmott *et al.* 1994; Shaw & Huddleston 1991; Whitfield & Wagner 1991; Yu *et al.* 2016). They can be distinguished easily from other braconids by the presence of an inverted Y-shaped structure formed by the first three metasomal terga, distinctive reduced fore wing venation, and antennae with 14 segments (Beyarslan 2009; Farahani *et al.* 2014). Miracinae were originally included in the subfamily Microgastrinae Förster, 1862, before Mason (1981) recognised a new subfamily for this small but unique group. More species (24) are distributed in the Oriental region compared to other regions, which is mainly due to the recent works by Ranjith *et al.* (2019, 2023) and Ghramh *et al.* (2019), and the species are mainly from India. Seven species are from South China (Papp & Zhou 1996; Chen *et al.* 1997; Wu *et al.* 2000; Chen *et al.* 2001), two from Vietnam (Belokobylskij 1993) and one from Indonesia (Maetô & Thornton 1993). Before this study, no species of Miracinae had been reported from Borneo, the largest island in the Australo-Oriental region.

Currently, three miracine genera are considered valid: *Mirax* Haliday, 1833, *Centistidea* Rohwer, 1914 and *Rugosimirax* Ranjith & van Achterberg, 2023 (Ranjith *et al.* 2023). *Centistidea* in the Oriental region has often been treated as a valid genus, differing from *Mirax* by having the propodeum with a

medio-longitudinal carina, and the notauli usually shallowly impressed anteriorly (Chen *et al.* 1997; Ranjith *et al.* 2019; Ghramh *et al.* 2019); however, *Centistidea* has sometimes been treated as a junior synonym (e.g., Muesebeck 1922; Whitfield 1997) or subgenus (e.g., Papp 2013) of *Mirax*. Barcoding data of miracines from Australia weakly support the paraphyly of the traditional two genera (Slater-Baker *et al.* 2022), which makes this group even more complicated.

We found two species from Borneo that correspond morphologically to *Rugosimirax* in terms of the irregular propodeum appearance having a roughly U-shaped areola, and a tuft of setae at the ovipositor tip, though they show some differences when compared with the generic diagnosis in Ranjith *et al.* (2023). Here, we therefore propose a new concept for *Rugosimirax*, while providing a discussion on all genera of Miracinae.

Material and methods

Specimens studied are deposited in the Natural History Museum, UK (NHMUK). Descriptions and measurements were made using a stereo microscope (Zeiss® Stemi SV6). Photographs of the wasps were taken and processed using a digital camera Zeiss AxioZoom combined with Helicon software or Hirox HRX-01. The images were further processed using Adobe Photoshop® CS6. Morphological terms for body structures and measurements follow Ranjith *et al.* (2023) and Slater-Baker *et al.* (2022). The wing vein terminology follows the modified Comstock-Needham system (van Achterberg 1993). The terminology of the cuticular sculpture follows Harris (1979).

Abbreviations for morphological terms

OOL = ocular-ocellar line
OD = ocellar diameter
POL = postocellar line
T1 = 1st tergite of metasoma
T2 = 2nd tergite of metasoma
T3 = 3rd tergite of metasoma

Results

Taxonomy

Class Insecta Linnaeus, 1758
Order Hymenoptera Linnaeus, 1758
Family Braconidae Burmeister, 1829
Subfamily Miracinae Viereck, 1918

Genus **Rugosimirax** Ranjith & van Achterberg, 2023

Key to species of the genus *Rugosimirax* Ranjith & van Achterberg, 2023

1. Fourth flagellomere of antenna with acute spine apico-ventrally and penultimate flagellomere less than 2 × as long as wide; vein 1-R1 as long as pterostigma 2
– Fourth flagellomere of antenna without acute spine apico-ventrally and penultimate flagellomere nearly 3× as long as wide; vein 1-R1 distinctly shorter than pterostigma 3

2. Propodeum with a longitudinal carina antero-medially; first flagellomere 5.2 × as long as wide; pterostigma brown ..... ***R. glabrator*** (Ranjith & van Achterberg, 2019)
– Propodeum smooth medially; first flagellomere 6.0 × as long as wide; pterostigma yellow .... ***R. expectata*** Ranjith & van Achterberg, 2023

3. Hind depressions on scutellum hardly visible; frons clearly concave in front of anterior ocellus; T2 long, at least 1.2 × as long as wide ..... ***R. obsolescens*** sp. nov.
– Hind depressions on scutellum distinct, oblong-elliptical and close to each other with a carina separating them; frons flat in front of anterior ocellus; T2 much wider, 1.8 × as wide as median length ..... ***R. bimacula*** sp. nov.

Rugosimirax obsolescens sp. nov.
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Fig. 1

Diagnosis

Body length 1.0 mm, yellow; eyes 2.1 × as long as temple dorsally; POL:OD:OOL = 3.3:1.0:1.8; frons clearly concave in front of anterior ocellus, with minute punctures at sides; clypeus 2.2 × as wide as medial length; 1st flagellomere nearly 1.2 × as long as 2nd, ultimate flagellomeres 3.2 × as long as wide; notaular courses distinct in anterior half; hind depressions on scutellum obselete; propodeum highly polished with distinct oblique carinae laterally and transverse carina forming open U-shaped areola; vein 1-R1 short; T2 particularly long, at least 1.2 × as long as wide; ovipositor sheath with long and dense setae apically.

Etymology

The specific epithet '*obsolescens*' derives from Latin, referring to the obsolete posterior depressions on scutellum.

Material examined

Holotype

BRUNEI • ♀; Bukit Sulang nr. Lamunin; N.E.Stork leg.; NHMUK010639261.

Paratypes

BRUNEI • 1 ♀; same data as for holotype; NHMUK010639273 • 4 ♂♂; same data as for holotype; NHMUK010639264, NHMUK010639277, NHMUK010639279, NHMUK010639287.

INDONESIA • 1 ♀; Sulawesi, Utara, Dumoga Bone N.P.; Jul. 1985; NHMUK010639284 • 1 ♂; same data as for preceding; NHMUK010639285.

Description

Female

Measurement. Body length 1.0 mm, fore wing length 1.1 mm (Fig. 1a).

Head. 1.7 × as wide as long, 1.2 × as wide as mesoscutum. Eyes 2.1 × as long as temple dorsally. Temple smooth, impunctate and shiny, constricted behind eyes in dorsal view (Fig. 1b). Ocelli small, distance between fore and hind ocellus 1.7 × as long as transverse diameter of hind ocellus, POL:OD:OOL = 3.3:1.0:1.8, frons clearly concave in front of anterior ocellus, with minuate punctures at sides. Face (Fig. 1c) smooth, setose and shiny nearly impunctate, convex medially, transverse, 1.3 × as wide as high. Clypeus 2.2 × as wide as medial length. Antenna (Fig. 1d) slightly shorter than body length (0.9 ×), with scape, pedicel and 1st, 2nd, penultimate and ultimate flagellomeres 1.9, 1.7, 4.3, 3.7, 2.9 and 3.2 × as long as wide, 1st nearly 1.2 × as long as 2nd, other flagellomeres subsquent to the 2nd nearly the same size as 2nd.

Mesosoma. Length:width:height = 7.0:5.0:5.0. Mesonotum (Fig. 1e) shiny with superficial indistinct punctures, notaular courses distinct in anterior half, absent in posterior half, polished along posterior

margin. Scutellar sulcus slightly curved, narrow without distinct carina. Scutellum shiny, smooth with pubescence but narrowly glabrous medio-posteriorly, hind depressions indistinct. Metanotum with two distinct pits posterior to scutellum. Propodeum shiny, smooth with distinct oblique carinae at sides, and transverse carina forming open U-shaped areola. Mesopleuron highly polished, impunctate.

Legs. Hind femur (Fig. 1h) 3.0 × as long as its widest part. Length of hind femur:tibia:basitarsus = 1.6:2.7:1.0. Basitarsus of hind leg 0.7 × as long as tarsomeres 2–5.

Wings. Fore wing (Fig. 1g): pterostigma narrow, 3.6 × as long as its widest part, vein 1-R1 present, nearly 0.3 length of pterostigma; vein r:2-SR:2-M = 1.0:3.9:1.4, 1-SR:1-M = 1.0:2.5, 1-CU1:2-CU1 =1.0:1.7; first discal cell of fore wing 1⅓ × as wide as high. Hind wing: vein M+CU:1-M:r-m = 2.2:3.2:1.0.

Metasoma. Nearly 1.1 × as long as mesosoma. T1 (Fig. 1i) smooth, spatulate-shape, 2.6 × as long as its maximum width, distinctly narrowed medially. T2 particularly long, at least 1.2 × as long as wide. T3 0.6 × as long as median T2. Hypopygium distinctly shorter than apex of metasoma. Ovipositor (Fig. 1h) sheath indistinctly (1.1 ×) as long as hind basitarsus, with long and dense setae apically.

Colour. Yellow (Fig. 1a), except notaular courses and metasomal terga brown. Palpi and spurs pale yellow. 2nd to penultimate flagellomeres and apex of ovipositor sheath brown. Wing membrane hyaline, vein r, pterostigma, 1-SR, 1-M and 1-CU1 brown, other veins light brown.

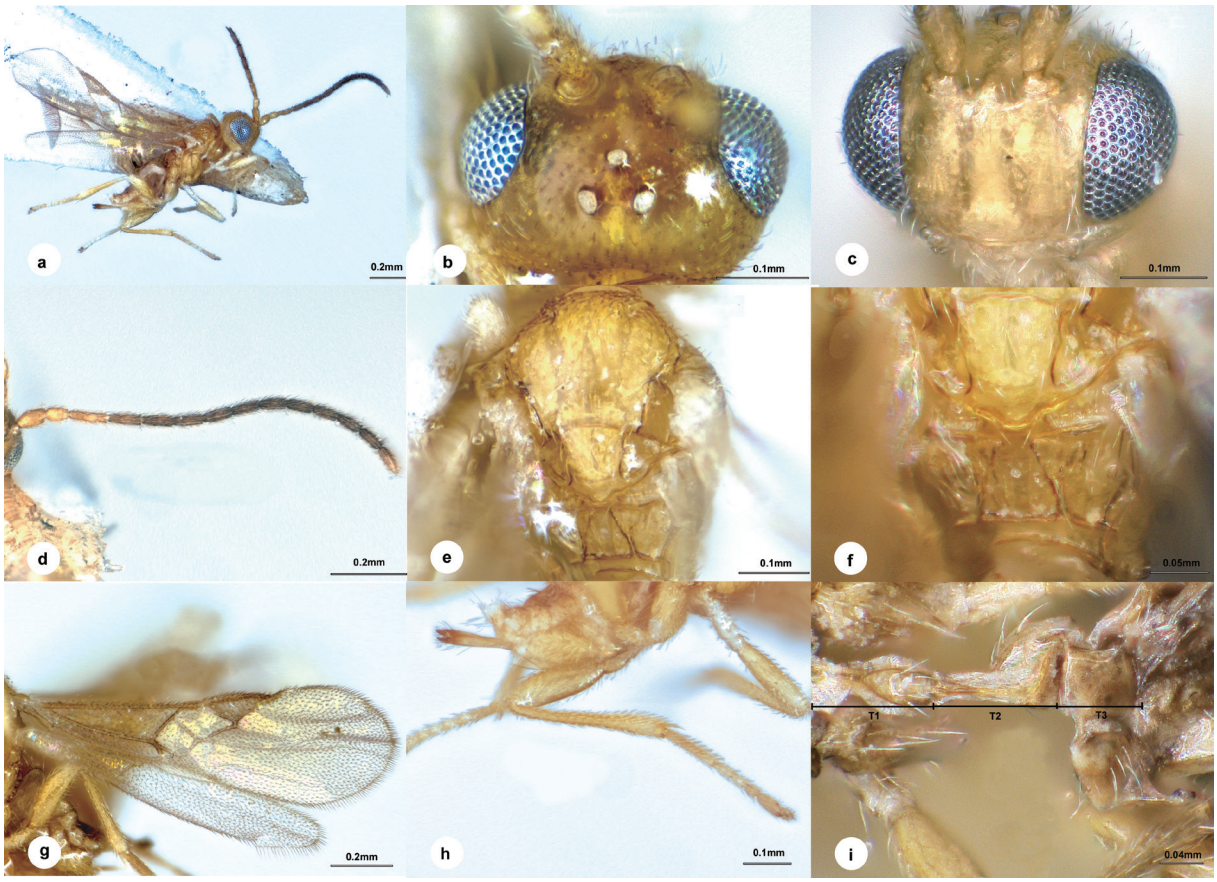

Fig. 1. *Rugosimirax obsolescens* sp. nov., female, holotype (NHMUK010639261). **a**. Habitus, lateral view. **b**. Head dorsal view. **c**. Head, frontal view. **d**. Antenna. **e**. Mesosoma, dorsal view. **f**. Scutellum and propodeum, dorsal view. **g**. Wings. **h**. Ovipositor and hind leg, lateral view. **i**. T1–T3, dorsal view.

Male

Similar to female, except body length 1.1 mm, fore wing 1.2 mm, antenna slightly longer, body colour lighter, and scutellar hind depressions more obvious.

Host

Unknown.

Distribution

Borneo (Brunei); Indonesia (Sulawesi).

Remarks

This species is very small (1 mm) which is known only in a North American miracine species *Mirax minuta* Ashmead, 1893, but it differs distinctly from the latter in the following: propodeum with distinct oblique carinae and transverse carina (propodeum without striae or rugae in *M. minuta*); head yellow (head black in *M. minuta*); and 7 terminal flagellomeres about 3 × as long as wide (shorter, scarcely 2 × in *M. minuta*).

Rugosimirax bimacula sp. nov.

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Fig. 2

Diagnosis

Body length 1.5 mm, light yellow-brown; head transverse, eyes 2.4 × as long as temple dorsally; POL:OD:OOL = 3.4:1.0:1.8; frons flat in front of anterior ocellus, and impunctate at sides; clypeus 2.0 × as wide as medial length; notaular courses obvious only in anterior ¼; scutellar hind depressions distinct, oblong elliptical and close to each other with carina separating them; propodeum with oblique rugae at sides, and transverse rugae which form open and ill-defined U-shaped areola; vein 1-R1 very short, indistinct as a extension of pterostigma; T2 1.8 × as wide as median length; ovipositor sheath 1.2 × as long as hind basitarsus, with long and dense setae apically.

Etymology

The specific epithet '*bimacula*' derives from Latin, referring to two pale maculae on basal and apical pterostigma.

Material examined

Holotype

BRUNEI • ♀; Pagon Ridge; 8 Feb.1982; B.C.St.G. Allen leg.; NHMUK010639289.

Description

Female

Measurement. Body length 1.5 mm, fore wing length 1.9 mm (Fig. 2a).

Head. Transverse in dorsal view, 1.9 × as wide as long, 1.2 × as wide as mesoscutum. Eyes 2.4 × as long as temple dorsally. Temple smooth, nearly impunctate, except minute hairy punctures and shiny, constricted behind eyes in dorsal view (Fig. 2b). Ocelli small, distance between fore and hind ocellus 1.4 × as long as transverse diameter of a hind ocellus, POL:OD:OOL = 3.4:1.0:1.8, anterior ocellus clearly flat anteriorly and impunctate at sides. Face (Fig. 2c) polished, except superficial small punctures close to the eyes, setose and shiny, convex medially, transverse, 1.4 × as wide as high. Clypeus 2.0 ×

as wide as medial length. Antenna (Fig. 2d) as long as body length, with scape, pedicel and 1st, 2nd, penultimate and ultimate flagellomeres 1.8, 2.0, 5.1, 4.2, 2.9 and 3.6 × as long as wide, 1st 1.2 × as long as 2nd, other flagellomeres subsequent to 2nd nearly the same size as 2nd.

Mesosoma. Length:width:height = 11.5:7.5:8.0. Mesonotum (Fig. 2e) shiny with distinct punctures anteriorly, becoming shallower towards posterior half and polished along posterior margin, notaular courses only obvious in anterior ⅓. Scutellar sulcus slightly curved, narrow, not crenulated. Scutellum shiny with minute hairy punctures, largely glabrous medio-posteriorly, scutellar hind depressions distinct, oblong-elliptical and close to each other, separated by a carina. Propodeum shiny, with oblique rugae at sides and transverse rugae forming open and ill-defined U-shaped areola, elsewhere nearly polished. Mesopleuron highly polished, impunctate.

Legs. Hind femur (Fig. 2h) 3.5 × as long as its widest part. Length of hind femur:tibia:basitarsus = 2.0:2.3:1.0. Basitarsus of hind leg 0.6 × as long as tarsomeres 2–5.

Wings. Fore wing (Fig. 2g): pterostigma narrow, 3.2 × as long as its widest part; vein 1-R1 present, indistinct as a extension of pterostigma; vein r:2-SR:2-M = 1.0:3.8:2.2, 1-SR:1-M = 1.0:3.0, 1-CU1:2-CU1 =1:1.4; first discal cell of fore wing 1¼ × as wide as high. Hind wing: vein M+CU:1-M:r-m = 1.9:2.4:1.0.

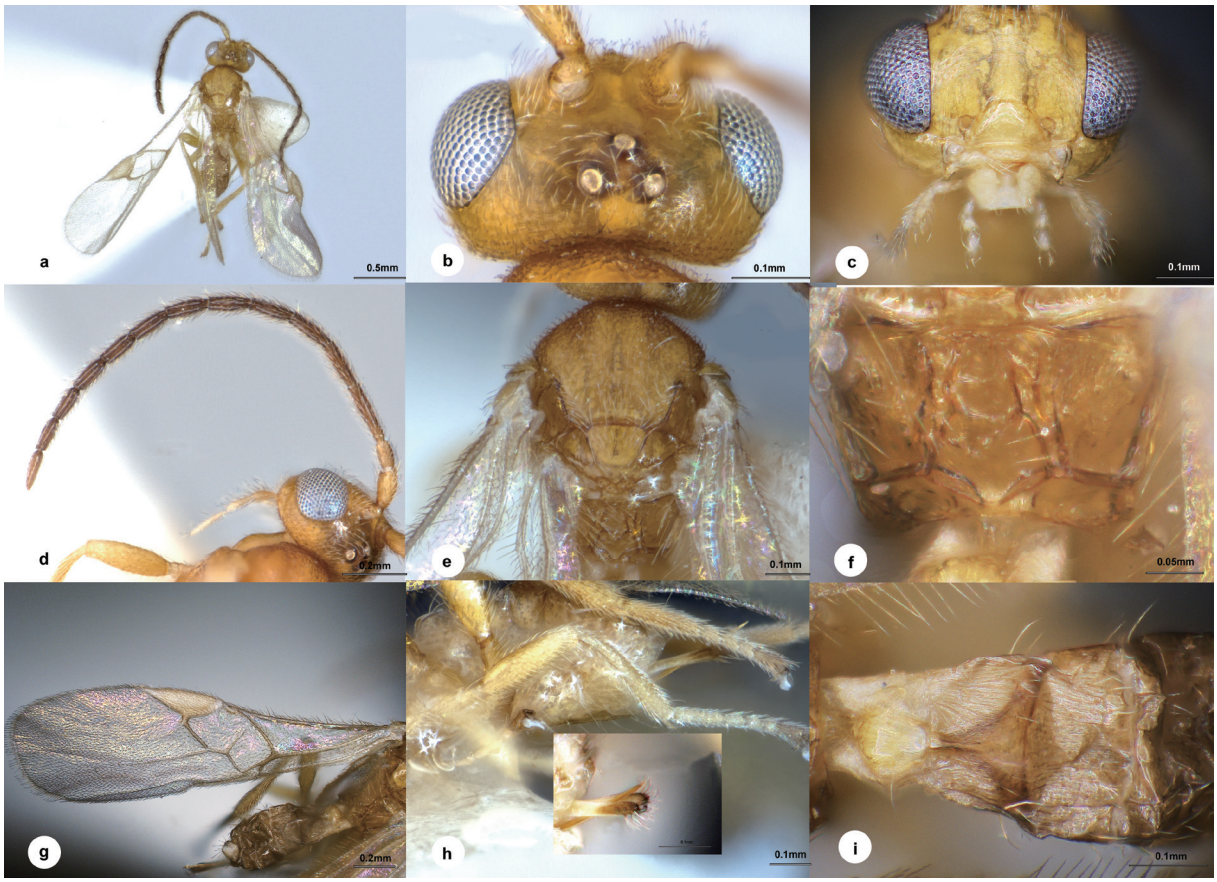

Fig. 2. *Rugosimirax bimacula* sp. nov., female, holotype (NHMUK010639289). **a**. Habitus, dorsal view. **b**. Head dorsal view. **c**. Head, frontal view. **d**. Antenna. **e**. Mesosoma, dorsal view. **f**. Propodeum, dorsal view. **g**. Fore wing. **h**. Ovipositor and hind leg, lateral view. **i**. T1–T3, dorsal view.

Metasoma. Nearly as long as mesosoma. T1 (Fig. 2i) smooth, spoon-shaped (attenuated apically), 1.8 × as long as its maximum width, indistinctly narrowed medially. T2 1.8 × as wide as median length. T3 about as long as T2, longitudinally striate. Hypopygium not as long as apex of metasoma. Ovipositor sheath 1.2 × as long as hind basitarsus, with long and dense setae apically.

Colour. Light yellow-brown (Fig. 2a). Palpi and spurs pale yellow. Flagellomeres and apex of ovipositor sheath dark brown. Legs more yellow, except apical tarsomeres. Wing membrane hyaline, pterostigma (except basal and apical paler maculae), vein r, 2-SR, 1-SR, 1-M and 1-CU1 brown, other veins light brown.

Male

Unknown.

Host

Unknown.

Distribution

Borneo (Brunei).

Remarks

This species is peculiar in *Rugosimirax* for having the hind depressions close to each other, with a carina separating them. *R. bimacuila* is close to *Rugosimirax obsolescens* sp. nov. but can be easily differentiated from it by the characters in the key.

Discussion

Species of Miracinae have never been well-classified into genera, despite having only 70 species worldwide. The problem is largely due to the use of different diagnostic criteria for the included species listed in each review (Papp 2013; Ranjith *et al.* 2019; Ghramh *et al.* 2019; Slater-Baker *et al.* 2022). To better distinguish *Centistidea* from *Mirax*, we have checked all the descriptions of species and identified specimens including primary types in the NHM collection. We have found that the sculpture on the propodeum, and the degree of development of the notauli could be a practical way to separate these three genera, though they often overlap in other characters (see the genus key below).

Key to the genus of Miracinae Viereck, 1918

1. Propodeum mostly smooth, never with longitudinal carinae or rugosities, at most with transverse elements (wrinkles, carinae or short rugae) at the posterior end; notauli largely absent, usually faintly impressed anteriorly; vein 1-R1 of fore wing absent, at most indistinctly extended as apical part of pterostigma (except *M. longicaudis*); scutellar hind depressions distinctly separated .....***Mirax*** Haliday, 1833
– Propodeum with longitudinal carina or rugosity; notauli more developed, longer and crenulated; vein 1-R1 of fore wing frequently well developed, rarely extended as the attenuated apical part of pterostigma; scutellar hind depressions close, to distinctly separated 2

2. Propodeum without a complete median longitudinal carina, instead with a poorly to well defined areola .....***Rugosimirax*** Ranjith & van Achterberg, 2023
– Propodeum with a longitudinal carina or rugosity medially and connected to more or less developed costulae .....***Centistidea*** Rohwer, 1914

Using the above criteria, we concluded that there are only nine species which actually belong to *Mirax sensu stricto*, i.e., *M. minuta* Ashmead, 1893 from the Nearctic region; *M. cowellensis* Slater-Baker & Fagan-Jeffries, 2022 and *M. trianguliceps* Slater-Baker & Fagan-Jeffries, 2022 from the Australian region; *M. caspiana* Farahani, Talebi, van Achterberg & Rakhshani, 2014, *M. reperta* Papp, 1984, *M. rufilabris* Haliday, 1833, *M. sinopticulae* He & Chen, 1997 and *M. striaca* Beyarslan, 2009 from the Palaearctic region; and *M. longicaudis* Belokobylskij, 1993 from the Oriental region. *Mirax longicaudis* is peculiar among all species of Miracinae for its exceptionally large size (3.4 mm, others vary from 1 mm to 2.8 mm), aciculate T2, and longest ovipositor sheath (1.2 × hind tibia, others are more or less the length of the basitarsus). Here, we provisionally keep it in *Mirax* because of the lack of more detailed information on this species. Except for the smooth appearance of the propodeum, and reduced notauli, specimens of *M. longicaudis* mostly shared the characters with other *Mirax* of an indistinct and not crenulated scutellar sulcus and two relatively small, oblong shaped and distinctly apart hind depressions.

Centistidea exhibits more overlaps with the two other genera, as well as having remarkably high species richness (59 species), especially in the Oriental and Neotropical regions. Many of them were misplaced as *Mirax* in the past. Except for the propodeum with a longitudinal carina or rugosity medially and connected to more or less developed costulae and relatively well developed notauli, this group varies in features of vein 1-R1, scutellar sulcus, and scutellar hind depressions which are conservative in the genera *Mirax* and *Rugosimirax* (Here, we pay more attention on the feature of propodeum for it is the key and widely used character for higher taxa of the closely related Microgastrinae).

For the Oriental genus *Rugosimirax*, Ranjith *et al.* (2023) included three species, namely, *R. expectata* Ranjith & Priyadarsanan, 2023, *R. glabrator* Ranjith & van Achterberg, 2018 from India and *R. fereta* (Papp & Chou), 1996 from China. Ranjith *et al.* (2023) paid much attention to ovipositor sheath with a tuft of setae apically for *Rugosimirax*, but it is actually shared by many other species of *Centistidea* (see ovipositor sheath images (Figs. 19, 26) for *C. mogrus* and *C. taiwanicus* in Papp & Chou 1996) which will be explained in our subsequent paper reviewing this group. We consider a better genus concept for this group by transferring *fereta* back to *Centistidea* which it resembles more (median longitudinal rugosity, and scutellar hind depressions close to each other), and by adding the two new species from Borneo. The species of genus *Rugosimirax* can now be characterized as follows: propodeum with distinct oblique carinae or rugae at sides and a transverse carina or rugae forming an open U-shaped areola, never with a median complete longitudinal carina or rugosity; ovipositor sheath with a tuft of setae apically; comparatively deep and long notauli on disc of mesosoma; and scutellar sulcus narrow and not crenulated.

Miracine exhibit much variation though they are rare in all collections worldwide, showing that there are likely to be many more species undescribed, which corresponds with the DNA-sequencing results of Slater-Bakeret *et al.* (2022). Clearly, more morphological examination and DNA data collection on a larger scale are necessary to give better insight into the systematics of Miracinae.

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