RESEARCH ARTICLE



The genus *Ismarus* Haliday (Hymenoptera, Ismaridae) from China

Xiao Zhang¹, Hua-yan Chen¹, Jing-xian Liu², Shi-xiao Luo³

1 State Key Laboratory of Biocontrol, School of Life Sciences / School of Ecology, Sun Yat-sen University, Guangzhou 510275, China 2 Department of Entomology, College of Plant Protection, South China Agricultural University, Guangzhou 510642, China 3 Key Laboratory of Plant Resources Conservation and Sustainable Utilization, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650, China

Corresponding author: Hua-yan Chen (chenhuayan@mail.sysu.edu.cn)

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Abstract

The genus *Ismarus* Haliday from China is revised. Six species are recognized, of which two species are described as new: *Ismarus areolatus* Chen, **sp. nov.**, and *Ismarus paradorsiger* Chen, **sp. nov.** By examining the pits along the anterolateral margin of mesoscutum and comparing them with the typical notauli in Diapriidae, we conclude that the so-called reduced notauli in *Ismarus* are actually foveae of the mesoscutual suprahumeral sulcus. An updated key to the Chinese species of the genus is provided.

Keywords

Diaprioidea, hyperparasitoid, key, new species

Introduction

Ismarus Haliday is the only genus in Ismaridae, with 57 described species worldwide (Masner 1976; Johnson 1992; Liu et al. 2011; Comério et al. 2016; Kolyada and Chemyreva 2016; Kim et al. 2018a, b). Available biological data suggest that species of *Ismarus* are hyperparasitoids of Dryinidae, which are parasitoids of Auchenorrhyncha (Hemiptera), such as leafhoppers, planthoppers and treehoppers (Chambers 1955, 1981; Nixon 1957;

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Wall 1967; Kozlov 1971; Masner 1976; Jervis 1979; Tussac and Tussac 1991; Olmi 2000). In addition, studies suggested species of *Ismarus* are likely to be found from wooded areas at higher elevations in warmer climatic zones and at low elevations in cooler climatic zones (Masner 1976; Kim et al. 2018a, b). However, only six species of *Ismarus* have been recorded from the Oriental regions (Liu et al. 2011; Izadizadeh et al. 2020). The Oriental fauna of *Ismarus* is still clearly undersampled, considering the diversity of Dryinidae (Xu et al. 2013) and preferred habitats in these regions. In the present study, we examine the species of *Ismarus* from China, including descriptions of two new species.

Materials and methods

This work is based upon the specimens in the following collections, with abbreviations used in the text: **SCAU**, Hymenoptera Collection, South China Agricultural University, Guangzhou, China; **SYSBM**, Sun Yat-sen University, The Museum of Biology, Guangzhou, China.

Abbreviations and morphological terms used in text:

A1, A2, A12	antennomere 1, 2, 12;
POL	postocellar line (shortest distance between both posterior ocelli);
OOL	oculoocellar line (shortest distance between posterior ocellus and compound eye);
MT	Malaise trap;
YPT	yellow pan trap;
T1, T2, T8	metasomal tergite 1, 2, 8.

Morphological terminology otherwise follows Masner (1976). Species of *Ismarus* from the Oriental and Palearctic regions recently have been quite thoroughly reviewed and keyed (Liu et al. 2011; Kolyada and Chemyreva 2016; Kim et al. 2018a; Izadiza-deh et al. 2020), which allow us easily identify the Chinese species in this study.

Specimens were examined using a Nikon SMZ800N microscope. Images and measurements were made using a Nikon SMZ25 microscope with a Nikon DS-Ri 2 digital camera system. Scanning electron micrographs were produced using a Phenom Pro Desktop SEM and a single montage images were generated from image stacks in the program Helicon Images were post-processed with Abobe Photoshop CS6 Extended.

Taxonomy

Ismarus Haliday, 1835

Ismarus Haliday, 1835: 467. Type species Cinetus dorsiger Haliday, 1831, by monotypy.

- 141
- *Entomia* Herrich-Schäffer, 1840: 127. Type species *Entomia campanulata* Herrich-Schäffer, 1840, by monotypy.
- Agonophorus Dahlbom, 1858: 289. Type species Ismarus rugulosus Förster, 1850, designated by Muesebeck (1972).

Remarks. In the revision of the New World Ismarinae (then was treated as a subfamily of Diapriidae and contained the only genus, Ismarus), Masner (1976) pointed out that Ismarus "is usually characterized by the low insertion of antennae, transverse head, and the absence (better reduction) of notauli". This suggests that he was not certain about the status of notauli within the genus. However, in the key to subfamily of Diapriidae and the descriptions of the New World species, he continued to state that "notauli were always present but reduced to anterior pits". Subsequent researchers followed Masner's diagnosis of the genus and described these pits as notauli (Liu et al. 2011; Kolyada and Chemyreva 2016; Kim et al. 2018a, b), except Kolyada and Chemyreva (2016) described the anterior pits as the reduced notauli and the rest of the pits along the anterolateral margin of mesoscutum as part of the mesoscutual suprahumeral sulcus. We here examine these pits (Fig. 1A, B) using scanning electron microscopy and compare them with the notauli in a species of *Coptera* Say (Diapriidae), which has typical notauli (Fig. 1C). The pits in Ismarus are along the anterolateral margin of mesoscutum where the mesoscutual suprahumeral sulcus is located in many groups of Hymenoptera and are different from the pits of the typical notauli such as found in Coptera. The anterior pits in Coptera is located at the anterior margin of the longitudinal grooves of the notauli and apparently are a part of the notauli, while the pits in *Ismarus* (if they are present) are parallel to the anterolateral margin of the mesoscutum and never present as a part of any longitudinal grooves of the tmesoscutum. Therefore, we here conclude that the pits present along the anterolateral margin of the mesoscutum in Ismarus constitute part of the mesoscutual suprahumeral sulcus and are not notauli. The mesoscutual suprahumeral sulcus can be totally absent (as in *Ismarus dorsiger* (Haliday)), present as a single pit on each side (as in Ismarus halidayi Foerster, Fig. 1B), or present as a few pits of varying size (as in Ismarus nigritrochanter Liu, Chen & Xu, Fig. 1A).

Species	Distribution in China		
	Province	Ecozone	
Ismarus areolatus Chen, sp. nov.	Guangdong	Oriental	
Ismarus halidayi Foerster	Sichuan, Guizhou, Yunnan, Tibet	Oriental	
	Ningxia	Palaearctic	
Ismarus longus Liu, Chen & Xu	Yunnan	Oriental	
Ismarus nigritrochanter Liu, Chen & Xu	Yunnan	Oriental	
Ismarus paradorsiger Chen, sp. nov.	Guangdong	Oriental	
Ismarus parvicellus Liu, Chen & Xu	Hainan	Oriental	

Table 1. An updated list of the Chinese species of *Ismarus* with distribution in China.



Figure I. Mesosoma, dorsal view, mshs: mesoscutual suprahumeral sulcus; nt: notaulus **A** *Ismarus nigritrochanter* Liu, Chen & Xu **B** *Ismarus halidayi* Foerster **C** *Coptera* sp.

Key to species of Ismarus from China

Females

1	Body mostly pale yellowish (Figs 12, 14); suture betw	veen T2 and T3 incom-
	plete (Fig. 12F)I. parad	dorsiger Chen, sp. nov.
_	Body entirely black (Figs 2A, 4A, 6, 7A, 9A, 11A, 15	5A); suture between T2
	and T3 complete (Figs 2F, 4F, 7F, 9F, 15F)	2
2	Mesoscutellum areolate (Fig. 2C); lateral pronotal a	area with a submedian
	oblique carina (Fig. 2D) Ismarus an	<i>reolatus</i> Chen, sp. nov.
_	Mesoscutellum smooth (Figs 4C, 7C, 9C, 15C); latera	al pronotal area without
	carina (Figs 4D, 7D, 9D, 15D)	

3	Radial cell of fore wing as long as marginal vein (Fig. 5A); median furrow of
	T2 long, reaching half length of T2 (Fig. 4E) Ismarus halidayi Foerster
_	Radial cell of fore wing distinctly shorter than marginal vein (Figs 8A, 10A,
	16A); median furrow of T2 very short, distinctly less than half length of T2
	(Figs 7E, 9E, 15E)4
4	Mesoscutal suprahumeral sulcus present as a single anterior pit (Fig. 15C);
	anterior mesoscutellar pit large, longer than length of the mesoscutellar disc
	(Fig. 15C); radial cell of fore wing small, $0.3 \times$ length of marginal vein (Fig.
	16A) Ismarus parvicellus Liu, Chen & Xu
_	Mesoscutal suprahumeral sulcus present as four or five foveae of varying size
	(Figs 7C, 9C); anterior mesoscutellar pit distinctly shorter than length of the
	mesoscutellar disc (Figs 7C, 9C); radial cell of fore wing larger, 0.6 × length
	of marginal vein (Figs 8A, 10A)5
5	Second flagellomere 5.0 × as long as wide (Fig. 8B); radial cell of fore wing
	$3.0 \times$ as long as high (Fig. 8A); antenna black with scape brown, pedicel and
	first flagellomere dark brown (Fig. 8B); all trochanters brown (Fig. 7A)
	Ismarus longus Liu, Chen & Xu
_	Second flagellomere 3.5 × as long as wide (Fig. 10B); radial cell of fore wing
	2.0 × as long as high (Fig. 10A); antenna uniformly black (Fig. 10B); all tro-
	chanters black (Fig. 9A) Ismarus nigritrochanter Liu, Chen & Xu

Ismarus areolatus Chen, sp. nov.

http://zoobank.org/2852155a-6e18-4a51-95cd-37def706bef6 Figures 2, 3

Diagnosis. This species can be easily distinguished from other Oriental species of *Ismarus* by the following characters: lateral pronotal area with a submedian oblique carina; mesoscutellum areolate and posterior rim excavate with slightly prominent posterolateral corners; hind tibiae abruptly incrassate.

Description. Female. Body length 2.24–3.15 mm.

Colour. Body black; A1–A2 brown, remainder of antenna black; coxae of fore and mid legs black, remainder brown to yellow, with tibia and tarsi becoming paler, hind leg mostly black with trochanter dark brown; wings hyaline, veins blackish brown.

Head. Head in dorsal view $2.0 \times$ as wide as long; vertex abruptly sloping behind ocelli; POL as long as OOL; frons with ventrolateral areas densely setose, area below anterior ocellus with scattered setae; facial transverse carina slightly convex ventrally; A3 slightly longer than A4; A4 1.2 × length of A5; A6–A14 with each segment less than 1.5 × as long as wide; A15 approximately 2.0 × longer than wide.

Mesosoma. Dorsal pronotal area rugose-punctate and setose; lateral pronotal area with a submedian oblique carina, rugose ventrally, smooth dorsally; mesoscutum smooth and convex, posterior margin with relatively dense long setae; mesoscutal suprahumeral sulcus absent; humeral sulcus deep and crenulate, 1.7 × length of tegula; mesoscutellum areolate and slightly convex, posterior rim excavate with slightly prominent posterolateral corners;



Figure 2. *Ismarus areolatus* Chen, sp. nov., holotype, female (SCAU 3049372) **A** lateral habitus **B** head, anterior view **C** head and mesosoma, dorsal view **D** head and mesosoma, lateral view **E** propodeum and basal metasoma, dorsal view, dorsal view.

anterior mesoscutellar pit large and deep, as long as length of the mesoscutellar disc, distinctly crenulate posteriorly, median keel strong; mesopleuron smooth and bare, with area below tegula rugulose; metapleuron rugose and covered with dense whitish long setae.

Wings. Radial cell completely closed, very small, $4.4 \times$ as long as wide and $0.2 \times$ as long as marginal vein.

Legs. Fore and mid legs slender; hind tibia abruptly incrassate, its maximum width slightly wider than hind femur.

Metasoma. Petiole distinctly transverse, with strong costae dorsally; base of T2 with six short costae, median furrow short, $0.15 \times$ length of T2, remainder of T2



Figure 3. *Ismarus areolatus* Chen, sp. nov., holotype, female (SCAU 3049372) **A** wings **B** antenna **C** hind tibia.

smooth with scattered fine punctures; T3–T7 smooth with scattered fine punctures; T8 coriaceous; sutures between tergites complete and deeply impressed.

Male. Unknown.

Etymology. The name refers to the areolate mesoscutellum.

Material examined. *Holotype*, female: CHINA: Guangdong, Guangzhou, South China Botanical Garden, forest, 23°10'49.87"N, 113°21'21.33"E, MT1, 7.iv–7.v.2020, Jian-wei Li, SCAU 3049372 (deposited in SYSBM). *Paratype*: (1 female) CHINA: Guangdong, Maoming, Yunkaishan National Nature Reserve, LSX591, MT-GD32, 22°16'38.37"N, 111°11'45.23"E, 30.iv–29.v.2020, Long-long Chen, SCAU 3049371 (SYSBM).



Figure 4. *Ismarus halidayi* Foerster, female (SCAU 3044335) **A** lateral habitus **B** head, anterior view **C** head and mesosoma, dorsal view **D** head and mesosoma, lateral view **E** propodeum and basal metasoma, dorsal view, arrow indicates median furrow **F** apical metasoma, dorsal view.

Ismarus halidayi Förster

Figure 1B, 4-6

? Entomia campanulata Herrich-Schäffer, 1840: 127 (nomen dubium). Ismarus halidayi Förster, 1850: 285. Ismarus longicornis Thomson, 1858: 378. Synonymized by Kolyada and Chemyreva (2016). Ismarus mongolicus Szabó, 1974: 23. Synonymized by Kolyada and Chemyreva (2016).

Material examined. Other material: (11 females, 6 males) CHINA: 2 females and 1 male, Ningxia, Mt. Liupanshan, 35.40°N, 106.38°E, 11–12.vii.2008, Jie-min Yao, Nos. 200808622, 200808859, 200808017 (SCAU); 1 male, Ningxia, Mt. Liupanshan,



Figure 5. Ismarus halidayi Foerster, female (SCAU 3044335) A wings B antenna C hind tibia.

35.40°N, 106.38°E, 13–14.vii.2009, Hua-yan Chen, No. 200903337 (SCAU); 2 females, Ningxia, Mt. Liupanshan, 35°29'12"N, 106°20'29"E, 3–14.vii.2009, Huayan Chen, SCAU 3042197, 3042198 (SYSBM); 1 female, Sichuan, Mt. Ermei, 29.61°N, 103.36°E, 7.vii.2009, Jiang-li Tan, No. 200903977 (SCAU); 1 female, Sichuan, Luhuo, 31.38°N, 100.66°E, 30.vi.2009, Jiang-li Tan, No. 200903953 (SCAU); 1 female, Guizhou, Mt. Fanjingshan, 27.92°N, 108.70°E, 2100 m, 30.vii.2001, Yun Ma, No. 200109552 (SCAU); 1 female, Guizhou, Mt. Fanjingshan, 27.92°N, 108.70°E, 12.vii.1993, Songlin Yao, No. 936734 (SCAU); 1 female, Yunnan, Yongshan County, Huanghua Town, 28.00°N, 103.51°E, 1500 m, 8.x.2010, Wei Dong (SCAU); 1 male, Yunnan, Dali, Mt. Cangshan, 25.63°N, 100.16°E, 5.vi.2009, Jiang-li Tan, No. 200901192 (SCAU); 1 male, Yunnan, Dali, Yunlong County, Tianchi, 25.848602°N, 99.234147°E, 2680.1 m,



Figure 6. Ismarus halidayi Foerster, male (SCAU 3042197) Lateral habitus.

MT-N1-1, 12–28.vi.2020, You-jing Gong, SCAU 3049366 (SYSBM); 1 female, Yunnan, Dali, Yunlong County, Tianchi, 25.854158°N, 99.239927°E, 2933.3 m, MT-N3-3 14–28.vi.2020, You-jing Gong, SCAU 3049335 (SYSBM); 1 female, 1 male, Yunnan, Dali, Yunlong County, Tianchi, 25.848602°N, 99.234147°E, 2680.1 m, MT-N1-1, 12-28.vi.2020, You-jing Gong, SCAU 3049339 3049340 (SYSBM); 1 male, Tibet, Milin, 29.18°N, 94.20°E, 14.vi.2009, Jiang-li Tan, No.200902367 (SCAU).

Distribution. China (Ningxia, Sichuan, Guizhou, Yunnan, Tibet).

Ismarus longus Liu, Chen & Xu

Figures 7, 8

Ismarus longus Liu, Chen & Xu, 2011: 51, 53, 59 (original description, keyed, placed in *halidayi* species group, keyed).

Material examined. *Holotype*, female: CHINA: Yunnan, Yingjiang, Tongbiguan, 24.60°N, 97.65°E, 2009.v.20, Man-man Wang, No. 200900933 (deposited in SCAU). *Paratypes:* 1 female, same data as type, No. 200900492 (SCAU); 1 female, Yunnan, Tengchong, Jietou Town, 25.40°N, 98.70°E, 2009.v.13, Man-man Wang, No. 200902486 (SCAU); 1 female, Yunnan, Tengchong, Jietou Town, 25.40°N, 98.70°E, 2009.v.12, Jie Zeng, No. 200902519 (SCAU).

Distribution. China (Yunnan).



Figure 7. *Ismarus longus* Liu, Chen & Xu, holotype, female (200900933) **A** lateral habitus **B** head, anterior view **C** head and mesosoma, dorsal view **D** head and mesosoma, lateral view **E** propodeum and basal metasoma, dorsal view, dorsal view.

Ismarus nigritrochanter Liu, Chen & Xu

Figures 1A, 9-11

Ismarus nigritrochanter Liu, Chen & Xu, 2011: 53, 54, 59 (original description, keyed, placed in *halidayi* species group, keyed).

Coments. This species was originally described based on a singleton female (Liu et al. 2011). Here we record the male: Body length 1.9–2.0 mm (n = 2). Similar to female, trochanters brown; A4 without blade-like carina; A6–A13 with each segment 1.4 × as long as wide.



Figure 8. Ismarus longus Liu, Chen & Xu, holotype, female (200900933) A wings B antenna C hind tibia.

Material examined. *Holotype*, female. CHINA: Yunnan, Mt. Gaoligongshan, 25.98°N, 98.80°E, 20–21.vii.2006, Zhong-shi Zhou, No. 200700989 (deposited in SCAU). *Other material*: (2 males) CHINA: 1 male, Yunnan, Diqing, Shangri-la, Jiantang Town, 27°31'45.45"N, 100°5'29.06"E, 2637 m, pine forest, CHY2, MT1, 12.vii–14.viii.2020, Nima, SCAU 3049368 (SYSBM); 1 male, Yunnan, Diqing, Shangri-la, Jiantang Town, 27°31'53.43"N, 100°4'48.75"E, 2643 m, pine forest, CHY6, MT2, 14.viii–18.ix.2020, Nima, SCAU 3044336 (SYSBM).

Distribution. China (Yunnan).



Figure 9. *Ismarus nigritrochanter* Liu, Chen & Xu, holotype, female (200700989) **A** lateral habitus **B** head, anterior view **C** head and mesosoma, dorsal view **D** head and mesosoma, lateral view **E** propodeum and basal metasoma, dorsal view **F** apical metasoma, dorsal view.

Ismarus paradorsiger Chen, sp. nov.

http://zoobank.org/286a8f58-8922-42a1-a4f7-d23d3ff3a0e9 Figures 12–14

Diagnosis. This species is most similar to the widely distributed *I. dorsiger* and *I. kakamegensis* in size and color patterns. It can be easily separated from *I. dorsiger* by the presence of a mesoscutal suprahumeral sulcus, and from *I. kakamegensis* by A1, which is distinctly longer than the length of A3 and A4.

Description. Female. Body length 1.95–2.3 mm.



Figure 10. *Ismarus nigritrochanter* Liu, Chen & Xu, holotype, female (200700989) **A** wings **B** antenna **C** hind tibia.

Colour. Body mostly pale yellowish, except mesoscutum, scutellum, metanotum, dorsal T1 and basal T2 variably dark brown; legs pale yellow, except hind tibia and basal tarsus somewhat brown; A1–A2 brown, remainder of antenna dark brown; wings hyaline or slightly infuscate medially, veins blackish brown.



Figure 11. Ismarus nigritrochanter Liu, Chen & Xu, male (SCAU 3044336) A lateral habitus B antenna.

Head. Head in dorsal view 2.0 × as wide as long; vertex abruptly sloping behind ocelli; POL as long as OOL; frons with ventrolateral areas densely setose, area below anterior ocellus with scattered setae; facial transverse carina slightly convex ventrally; A3 slightly shorter than A4; A4 1.2× length of A5; A6–A14 with each segment approximately 2.0× longer than wide; A15 approximately 3.0× longer than wide.



Figure 12. *Ismarus paradorsiger* Chen, sp. nov., holotype, female (SCAU 3042199) **A** lateral habitus **B** head, anterior view, arrow indicates facial transverse carina convex ventrally **C** head and mesosoma, dorsal view **D** head and mesosoma, lateral view **E** propodeum and basal metasoma, dorsal view, arrow indicates suture between T2 and T3 obsolete.

Mesosoma. Dorsal pronotal area rugose-punctate and setose; lateral pronotal area rugose-punctate ventrally, smooth dorsally; mesoscutum smooth and bare, convex; mesoscutal suprahumeral sulcus present as six small pits; humeral sulcus deep and fine-ly crenulate, slightly shorter than length of tegula; mesoscutellum smooth and slightly convex, posterior rim rounded; anterior mesoscutellar pit small, 0.25 × length of the mesoscutellar disc, distinctly crenulate at bottom, median keel strong; mesopleuron smooth and bare; metapleuron rugose and covered with dense whitish long setae.



Figure 13. *Ismarus paradorsiger* Chen, sp. nov., holotype, female (SCAU 3042199) **A** wings **B** antenna **C** hind tibia.

Wings. Radial cell completely closed, moderately large, $3.6 \times$ as long as wide and as long as marginal vein.

Legs. Fore and mid legs slender; hind tibia abruptly incrassate, its maximum width slightly wider than hind femur.

Metasoma. Petiole distinctly transverse, with irregular longitudinal costae dorsally; base of T2 with five short costae, median furrow short, 0.1× length of T2,



Figure 14. Ismarus paradorsiger Chen, sp. nov., paratype, female (201000305) Lateral habitus.

remainder of T2 smooth with scattered fine punctures; T3–T8 smooth with scattered fine punctures; suture between T2 and T3 obsolete but the following sutures between tergites distinctly impressed.

Male. Unknown.

Etymology. The name refers to the high degree of similarity with *I. dorsiger* and is intended to be used as a noun in apposition.

Material examined. *Holotype*, female: CHINA: Guangdong, Maoming, Yunkaishan National Nature Reserve, LSX704, MT-GD33, 22°17'40.72"N, 111°12'37.97"E, 1480 m, 4–30.vii.2020, Long-long Chen, SCAU 3042199 (deposited in SYSBM). *Paratypes*: (8 females) CHINA: 1 female, Guangdong, Maoming, Yunkaishan National Nature Reserve, LSX591, MT-GD32, 22°16'38.37"N, 111°11'45.23"E, 30.iv–29.v.2020, Longlong Chen, SCAU 3049370 (SYSBM); 7 females, Yunnan, Yongshan County, Huanghua Town, 28.00°N, 103.51°E, 1500 m, 8.x.2010, Wei Dong, [misidentified as *Ismarus dorsiger* (Haliday)] Nos. 201000305, 201000308, 201000311, 201000312, 201000314, 201000316, 201000317 (SCAU).



Figure 15. *Ismarus parvicellus* Liu, Chen & Xu, holotype, female (201010013) **A** lateral habitus **B** head, anterior view **C** head and mesosoma, dorsal view, amp: anterior mesoscutellar pit **D** head and mesosoma, lateral view **E** propodeum and basal metasoma, dorsal view **F** apical metasoma, dorsal view.

Distribution. China (Guangdong, Yunnan).

Comments. Liu et al. (2011) reported additional distribution records of *Ismarus dorsiger* (Haliday, 1831) from Yunnan Province of China. However, when we examined the 9 females identified as *Ismarus dorsiger* (Haliday, 1831) (deposited in SCAU), it turns out that these specimens have mesoscutal suprahumeral sulci, which are absent in *I. dorsiger* as was documented by Kolyada and Chemyreva (2016) and Kim et al. (2018a, b). Based on additional material collected from Guangdong, we describe them here as a new species. Therefore, *I. dorsiger* is still unknown from China.



Figure 16. *Ismarus parvicellus* Liu, Chen & Xu, holotype, female (201010013) A wings B antenna C hind tibia.

Ismarus parvicellus Liu, Chen & Xu

http://zoobank.org/4F711F1A-7878-49CB-B18B-6977B824612F Figures 15, 16

Ismarus parvicellus Liu, Chen & Xu, 2011: 55, 56, 58 (original description, keyed, placed in *halidayi* species group, keyed).

Material examined. Holotype, female: CHINA: Hainan, Baisha County, Mt. Jiujialing, 19.21°N, 109.45°E, 2010.VII.18, YPT, Hua-yan Chen, No. 20100013 (deposited in SCAU).

Distribution. China (Hainan).

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