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Contents

Cover photograph: *Neospiniphasma triangulatum* **gen. nov. & sp. nov.**, photo by George Ho Wai-Chun.

Contribution to the knowledge of Chinese Phasmatodea VII: A new genus for two new species of Medaurini from China (Phasmatidae: Clitumninae)

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ABSTRACT

A new genus for two new species, *Neospiniphasma similis* **gen. nov. & sp. nov.** and *N. triangulatum* **sp. nov.**, from Yunnan, China, are described. A key to the genera of Chinese Medaurini and a key to the species of *Neospiniphasma* **gen. nov.** are provided.

Key words: Stick insects, new genus, new species, Yunnan, China

中國蜫目之新知VII:中國莫蜫族一新屬二新種(蜫科: 短角枝蜫亞科)

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摘要:本文記述中國莫蜫族一新屬及二新種:擬新刺蜫 *Neospiniphasma similis* **gen. nov. & sp. nov.**及三角新刺蜫 *N. triangulatum* **sp. nov.**; 並編制了該族分屬檢索表及該新屬分種檢索表。

關鍵字: 竹節蟲, 新屬, 新種, 雲南, 中國

INTRODUCTION

The stick insect tribe Medaurini Hennemann & Conle, 2008 includes eight genera, 62 species and two subspecies and is restricted to continental Southeast Asian (Otte and Brock, 2005; Chen and He, 2008; Hennemann and Conle, 2008; Hennemann et al., 2008a, 2008b; Ho, 2017, 2020a, 2020b; Brock et al., 2021). In China, six genera, 44 species and two subspecies are known (Ho, 2017, 2020a, 2020c; Brock et al., 2021). Ho (2017) provided the first taxonomic study for the Chinese taxa, with the descriptions of two new genera, 14 new species and two new subspecies.

In this paper, a new genus, *Neospiniphasma* **gen. nov.**, is described from the Medaurini of China. *Neospiniphasma* **gen. nov.** includes two new species. They are namely *N. similis* **sp. nov.** and *N. triangulatum* **sp. nov.**. This new genus is closely related to *Cnipsomorpha* Hennemann, Conle, Zhang & Liu, 2008, but can be separated by the posteriorly expanded mesonotum in the female, and the strongly elongate and straight anal abdominal semi-tergites in the male.

MATERIALS & METHODS

The terminology of armature used in this paper is largely based on Rehn and Rehn (1939). Ootaxonomic descriptions refer to Clark (1976a, 1976b, 1979, 1988, 1998), Clark-Sellick (1997) and Zompro (2004). Measurements of specimens are given in millimetre (mm). Illustrations (Figs. 1-7, 12-18) are based on the type material that was pinned and dried and deposited in the Hong Kong Entomological Society, Hong Kong collection (HKES).

RESULTS

Phasmatidae Gray, 1835

Clitumninae Brunner, 1893

Medaurini Hennemann & Conle, 2008

Type-genus: *Medaura* Stål, 1875: 69, designated by Hennemann and Conle, 2008: 72.

Distribution: China, Bangladesh, Cambodia, India, Laos, Myanmar, Thailand and Vietnam.

Notes: Currently seven genera, *Cnipsomorpha* Hennemann, Conle, Zhang & Liu, 2008, *Interphasma* Chen & He, 2008, *Medauroidea* Zompro, 2000, *Medauromorpha* Bresseel & Constant, 2017, *Neosinophasma* Ho, 2017, *Neospiniphasma* **gen. nov.** and *Parapachymorpha* Brunner, 1893, are recognised in China. A key to the genera of Chinese Medaurini is provided.

Key to the genera of Medaurini from China:

1. Second to seventh abdominal tergites with triangularly expanded posterolateral angles in both sexes. **2**
- Second to seventh abdominal tergites lacking expanded posterolateral angles in both sexes or fourth and fifth abdominal tergites rarely with expanded posterolateral angles in female. . **3**

2. Both robust and thick-built in both sexes. . . . . *Cnipsomorpha*
- Both slender and elongate in both sexes. . . . . *Neospiniphasma* **gen. nov.**

3. Legs unarmed in both sexes. . *Interphasma*
- Legs armed with lamellae, spines or serrations in both sexes. **4**

4. Small size, body length shorter than 50 mm. . . . . *Neosinophasma*
- Medium to large size, body length longer than 50 mm. **5**

5. Thorax and/or abdomen usually armed with spines or horns in both sexes; if unarmed, anal abdominal segment with rounded posterior margin in female. . . . . *Parapachymorpha*
- Thorax and abdomen lacking noticeable armature, smooth or only granulated in both sexes, anal abdominal segment with emarginated posterior margin in female. . . . **6**

6. Anal abdominal segment with deep V-shaped emargination on posterior margin in female, anal abdominal segment longer than ninth abdominal tergum in male. . . . *Medauroidea*
- Anal abdominal segment with a small emargination on posterior margin in female, anal abdominal segment roughly as long as ninth abdominal tergum in male. . . . *Medauromorpha*

Neospiniphasma gen. nov.

Type-species: *Neospiniphasma triangulatum* **sp. nov.**, by present designation.

Differentiation: *Neospiniphasma* **gen. nov.** is closely related to *Cnipsomorpha* Hennemann, Conle, Zhang & Liu, 2008, but can be separated by the slender and elongate body, the less spinose thorax and abdomen, the strong triangularly expanded posterolateral angles on the second to eighth abdominal tergites and the well-developed serrations on the legs in the both sexes, the posteriorly expanded mesonotum in the female, and the strongly elongate and straight anal abdominal semi-tergites in the male.

Description: Small size. Body spinose, slender and long. Apterous. Head oval, with paired supra-antennal and supra-orbital armature. Occiput convex, with two pairs of occipital spines. Antennae short, distinctly segmented. Thorax spinose and slender. Mesonotum moderately expanded posteriorly. Abdomen cylindrical, with distinct triangularly expanded posterolateral angles from second to ninth tergites in female, male with distinct spinose posterolateral angles from second to eighth tergites. Female with distinct praeopercular organ on posteromedian area of seventh sternum, hump-like or dorsoventrally flattened. Anal segment with emarginations on posterior margin in female, dilated into two moderately straight semi-tergites in male. Cerci short and flattened in both sexes. Legs slender and long, femora and tibiae distinctly armed with serrations.

Distribution: China (Yunnan).

Notes: This new genus contains two species, including *N. similis* **sp. nov.** and *N. triangulatum* **sp. nov.**. A key to the species is given.

Etymology: The specific epithet of this new genus is derived from the words 'Neo' (= new), 'spini' (= spinose) and 'phasma' (= stick and leaf insects).

Key to the species of *Neospiniphasma* gen. nov.:

Male:

1. Posteromedian area of seventh abdominal sternum with a dorsoventrally flattened praeopercular organ. . . . *N. similis* **sp. nov.**
- Posteromedian area of seventh abdominal sternum with a hump-like praeopercular organ. . . . . *N. triangulatum* **sp. nov.**

Female:

1. Poculum with tubercle-like median elevation, anterodorsal carina of tibiae with indistinct and minute serrations. . . *N. similis* **sp. nov.**
- Poculum with crest-like median elevation, anterodorsal carina of tibiae with distinct and well-developed serrations. . *N. triangulatum* **sp. nov.**

Neospiniphasma similis sp. nov. (Figs. 1-11)

Types: Holotype, ♀, 1500m, Jinping, Honghe, Yunnan, China, 28 August 2019, George Ho Wai-Chun (HKES); Paratypes, 1♀, 1♂, 5 eggs (naturally laid by paratype ♀), same data as holotype ♀ (HKES).

Differentiation: *Neospiniphasma similis* **sp. nov.** is similar to *N. triangulatum* **sp. nov.**, but can be separated by the presence of a pair of posterior spines on the median abdominal segment and the dorsoventrally flattened praeopercular organ on the posteromedian area of seventh abdominal sternum in the female and the presence of minute serrations on the anterodorsal carina of tibiae in the male.

Description of female (Figs. 1-3, 8, 10): Small size. Body slender and elongate, distinctly larger and more robust than male. General colouration of body and legs green, with brownish markings.

Head: Oval, longer than wide, gently tapering posteriorly behind compound eyes. Vertex convex, with a pair of supra-antennal spines. Occiput distinctly convex, with paired supra-orbital spines; also with two pairs of medial spines along median longitudinal furrow, anterior pair as large as posterior pair, also as large as supra-orbital spines. Compound eyes small and rounded, its length about four to five times that of genae. Antennae with 13 segments, almost reaching middle point of profemora; scapus flattened, longer than third segment; and pedicellus shorter than third segment.

Thorax: Sparsely covered with very few small granules. Pronotum trapezoidal, gently expanded posteriorly, anterior margin gently incurved, posterior margin truncate, transverse and longitudinal sulci crossing at centre of segment; with paired posterior medial spines, lateral margins with a short spine pre-medially. Mesonotum moderately expanded posteriorly, about three times length of pronotum; with paired anterior medial, pre-median medial, post-median medial and

posterior medial spines; also with paired pre-median and median spines; lateral margins with a few spines. Metanotum longer than wide, about six times length of median segment; with paired anterior medial, median medial and post-median medial spines, also with paired pre-median spines, lateral margins with a few short spines. Mesopleurae and metapleurae with a short supra-coxal spine.

Abdomen: Cylindrical and tapering posteriorly, longer than combined length of head and thorax. Median segment narrow, wider than long, with paired anterior medial, median medial and posterior spines. Second to ninth tergites with distinct triangularly expanded posterolateral angles, also with paired anterior medial spines. Second to seventh tergites with paired median medial, posterior medial and posterior spines. Seventh sternum with a distinct dorsoventrally flattened praeopercular organ on posteromedian area, posterior margin distinctly emarginated. Eighth tergum longer than ninth tergum, with a pair of posterior medial spines. Ninth tergum with a bi-spinose crest posteromedially. Anal segment as long as ninth tergum, posterior margin with a small U-shaped emargination, posterolateral angles obtuse, median longitudinal carina gently elevated. Operculum scoop-shaped, posterior apex pointed and reaching posterior margin of anal segment. Cerci long, flattened, apices pointed and surpassing posterior apices of anal segment.

Legs: Slender. Femora thicker than corresponding tibiae, anterodorsal, posterodorsal, anteroventral and posteroventral carinae with three to six serrations. Profemora weakly curved basally. Tibiae longer than corresponding femora, anterodorsal and anteroventral carinae with four to seven serrations, posterodorsal and posteroventral carinae with indistinct and minute serrations.

Description of male (Figs. 4-5, 9, 11): Body slender and slim, distinctly smaller and slenderer than female. General colouration of body and legs brownish green.

Head: Oval, with very few small granules. Vertex weakly convex, with a pair of supra-antennal spines. Occiput moderately convex, median longitudinal furrow indistinct; with paired supra-orbital spines and two pairs of occipital medial spines along median longitudinal furrow, anterior pair larger than posterior pair, also larger than supra-orbital spines. Compound eyes small and rounded, its length about four-times that of genae. Antennae with 18 segments, apices reaching middle area of profemora; scapus flattened, almost as long as third segment, longer than pedicellus.

Thorax: Covered with very few small granules. Pronotum nearly trapezoidal, gently expanded posteriorly, anterior margin almost truncate, posterior margin rounded, with a pair of posterior medial spines, transverse and longitudinal sulci crossing at middle point, lateral margins with a short spine medially. Mesonotum moderately expanded posteriorly, with paired medial spines along median longitudinal line pre-medially, post-medially and posteriorly. Metanotum longer than wide, with paired posterior medial spines and pre-median spines. Mesopleurae and metapleurae with a small supra-coxal spine.

Abdomen: Slender and cylindrical. Median segment narrow, wider than long, with a pair of post-median medial spines. Second to eighth tergites with triangularly expanded posterolateral angles, apex ending with a spine. Second to fifth tergites with a pair of posterior medial spines. Sixth tergum with paired posterior medial tubercles. Ninth tergum shorter than eighth tergum. Anal segment longer than ninth tergum, dilated into two distinct semi-tergites; semi-tergites elongate, lateral margins straight, inner margins moderately incurved, apices pointed with minute dentations. Poculum cup-shaped, with tubercle-like median elevation, posterior margin rounded and reaching anterior area of anal segment. Cerci flattened, weakly incurved, apices rounded and not exceeding posterior apices of anal segment.

Legs: Slender and long. Sparsely covered with short bristles. Femora thicker than corresponding tibiae, anterodorsal, posterodorsal, anteroventral and posteroventral carinae with two to five serrations. Profemora weakly curved basally. Anterodorsal carina of tibiae with three to four indistinct and minute serrations, anterodorsal, anteroventral and posteroventral carinae unarmed, medioventral carina weakly raised basally.

Measurements: See Table 1.

Description of egg (Figs. 6-7): Capsule brown, oval, posterior pole notched in lateral view, surface reticulate-foveate; depressions dark brown, more or less rounded or oblong, with dense and small granulations. Micropylar plate brown, oval, gently tapering anteriorly and posteriorly. Micropylar cup placed at posterior margin of micropylar plate. Median line short, placed behind micropylar cup, about one-fifth length of micropylar plate. Operculum centrally depressed.

Measurements: Length, 1.0 mm; width, 0.7 mm; height, 0.8 mm.

Distribution: China (Yunnan).

Etymology: The specific epithet of this new species is derived from the similar morphology with the taxa of *Neospiniphasma triangulatum* **sp. nov.** in the genus.

***Neospiniphasma triangulatum* sp. nov.** (Figs. 12-22)

Types: Holotype, ♀, 2000m, Jinping, Honghe, Yunnan, China, 26 August 2019, George Ho Wai-Chun (HKES); Paratypes, 2♀ (1 nymph), 7♂, 1 egg (naturally laid by paratype ♀), same data as holotype ♀ (HKES).

Differentiation: *Neospiniphasma triangulatum* **sp. nov.** is closely related to *N. similis* **sp. nov.**, but can

be separated by the absence of paired posterior spines on the median abdominal segment and the hump-like praeopercular organ on the posteromedian area of seventh abdominal sternum in the female and the distinct and well-developed serrations on the anterodorsal carina of the tibiae in the male.

Description of female (Figs. 12-14, 19, 21): Small size. Body elongate, distinctly larger and more robust than male. General colouration of body and legs green, with brownish markings.

Head: Covered with very few small granules. Oval, longer than wide, gently tapering posteriorly behind compound eyes. Vertex convex, with a pair of supra-antennal spines or tubercles. Occiput distinctly convex, with paired supra-orbital spines; also with two pairs of medial spines along median longitudinal furrow, anterior pair as large as posterior pair, larger than supra-orbital spines. Compound eyes small and rounded, its length about four times that of genae. Antennae with 14 segments, reaching middle point of profemora; scapus flattened, as long as combined length of pedicellus and third segment; and pedicellus shorter than third segment.

Thorax: Sparsely covered with very few small granules. Pronotum trapezoidal, gently expanded posteriorly, anterior margin gently incurved, posterior margin rounded, transverse and longitudinal sulci crossing at centre of segment; with paired posterior medial spines, lateral margins with a short spine pre-medially. Mesonotum moderately expanded posteriorly, about three to three-and-one-half times length of pronotum; with paired anterior medial, pre-median medial, post-median medial and posterior medial spines; also with paired pre-median and median spines, lateral margins with a few short spines. Metanotum longer than wide, about five-and-one-half to six times length of median segment; with paired anterior medial, median medial and post-median medial spines, also with paired pre-median spines, lateral margins with a few short spines. Mesopleurae and metapleurae with a short supra-coxal spine.

Abdomen: Cylindrical and tapering posteriorly, longer than combined length of head and thorax. Median segment narrow, wider than long, with one to two paired medial spines. Second to ninth tergites with distinct triangularly expanded posterolateral angles, with paired anterior medial spines. Second to seventh tergites with paired posterior medial and posterior spines. Seventh tergum with a hump-like praeopercular organ on posteromedian area. Ninth tergum shorter than eighth tergum, with a pair of large tooth-like crests on posteromedian area. Anal segment as long as ninth tergum, mediolongitudinal carina elevated, elevated with paired small pre-median and posterior lamellae, posterior margin with a U-shaped emargination, posterolateral angles rounded. Operculum scoop-shaped, posterior apex pointed and reaching posterior area of anal segment. Cerci long, flattened, apices pointed and surpassing posterior apices of anal segment.

Legs: Slender. Femora thicker than corresponding tibiae, anterodorsal, posterodorsal, anteroventral and posteroventral carinae with four to six serrations. Profemora weakly curved basally. Tibiae longer than corresponding femora, anterodorsal and anteroventral carinae with two to four serrations, posterodorsal carina with six to nine serrations, posteroventral carina lacking noticeable armature.

Description of male (Fig. 15-16, 20, 22): Body slender and slim, distinctly smaller and slenderer than female. General colouration of body and legs brownish green.

Head: Oval. Vertex weakly convex, with a pair of supra-antennal spines. Occiput moderately convex, median longitudinal furrow indistinct; with paired supra-orbital spines and two pairs of occipital medial spines along median longitudinal furrow, anterior pair larger than posterior pair, also larger than supra-orbital spines. Compound eyes small and rounded, its length about four-times that of genae. Antennae with 18 segments, apices reaching middle area of profemora; scapus flattened, almost as long as third segment, longer than pedicellus.

Thorax: Covered with very few granules. Pronotum nearly trapezoidal, gently expanded posteriorly, anterior margin weakly incurved, posterior margin rounded, with a pair of posterior medial spines, transverse and longitudinal sulci crossing at middle area, lateral margins with a short spine pre-medially. Mesonotum moderately expanded posteriorly, with paired medial spines along median longitudinal line pre-medially, medially and posteriorly. Metanotum longer than wide, with paired post-median medial and pre-median spines. Mesopleurae and metapleurae with a small supra-coxal spine.

Abdomen: Slender and cylindrical. Median segment narrow, wider than long, with a pair of median medial spines. Second to eighth tergites with triangularly expanded posterolateral angles, apex ending with a spine. Second to fifth tergites with a pair of posterior medial spines. Ninth tergum shorter than eighth tergum. Anal segment longer than ninth tergum, dilated into two distinct semi-tergites; semi-tergites elongate and tapering posteriorly, lateral margins straight, inner margins medially incurved weakly, apices pointed with minute dentations. Poculum cup-shaped, with distinct crest-like median elevation, posterior margin rounded and reaching anterior area of anal segment. Cerci short, flattened, apices incurved, pointed and not exceeding posterior apices of anal segment.

Legs: Slender and long. Sparsely covered with short bristles. Femora thicker than corresponding tibiae, anterodorsal, posterodorsal, anteroventral and posteroventral carinae with three to five serrations. Profemora weakly curved basally. Anterodorsal carina

of tibiae with three to four serrations, posterodorsal, anteroventral and posteroventral carinae unarmed, medioventral carina weakly raised basally.

Measurements: See Table 2.

Description of egg (Figs. 17-18): Capsule brown, oval, posterior pole rounded, surface reticulate-foveate; depressions indistinct, brown or dark brown, more or less rounded, with dense and small granulations. Micropylar plate brown, nearly rounded. Micropylar cup placed at posterior margin of micropylar plate. Median line short, placed behind micropylar cup, about one-fourth length of micropylar plate. Operculum centrally depressed with a closed-stalked capitulum.

Measurements: Length, 2.0 mm; width, 1.4 mm; height, 1.6 mm.

Distribution: China (Yunnan).

Etymology: The specific epithet of this new species is derived from the distinct triangularly expanded posterolateral angles on the abdominal tergites in the both sexes.

CONCLUSION

A total of seven genera, 46 species and two subspecies are currently recognised in the Medaurini of China. The discovery of *Neospiniphasma similis* **gen. nov. & sp. nov.** and *N. triangulatum* **sp. nov.** from Yunnan, China, further reflects the high species diversity of the tribe in China. Yunnan, located at southwestern China, is obviously the main distributional area of the tribe in China, as well as the distributional centre of the tribe in the continental Southeast Asian.

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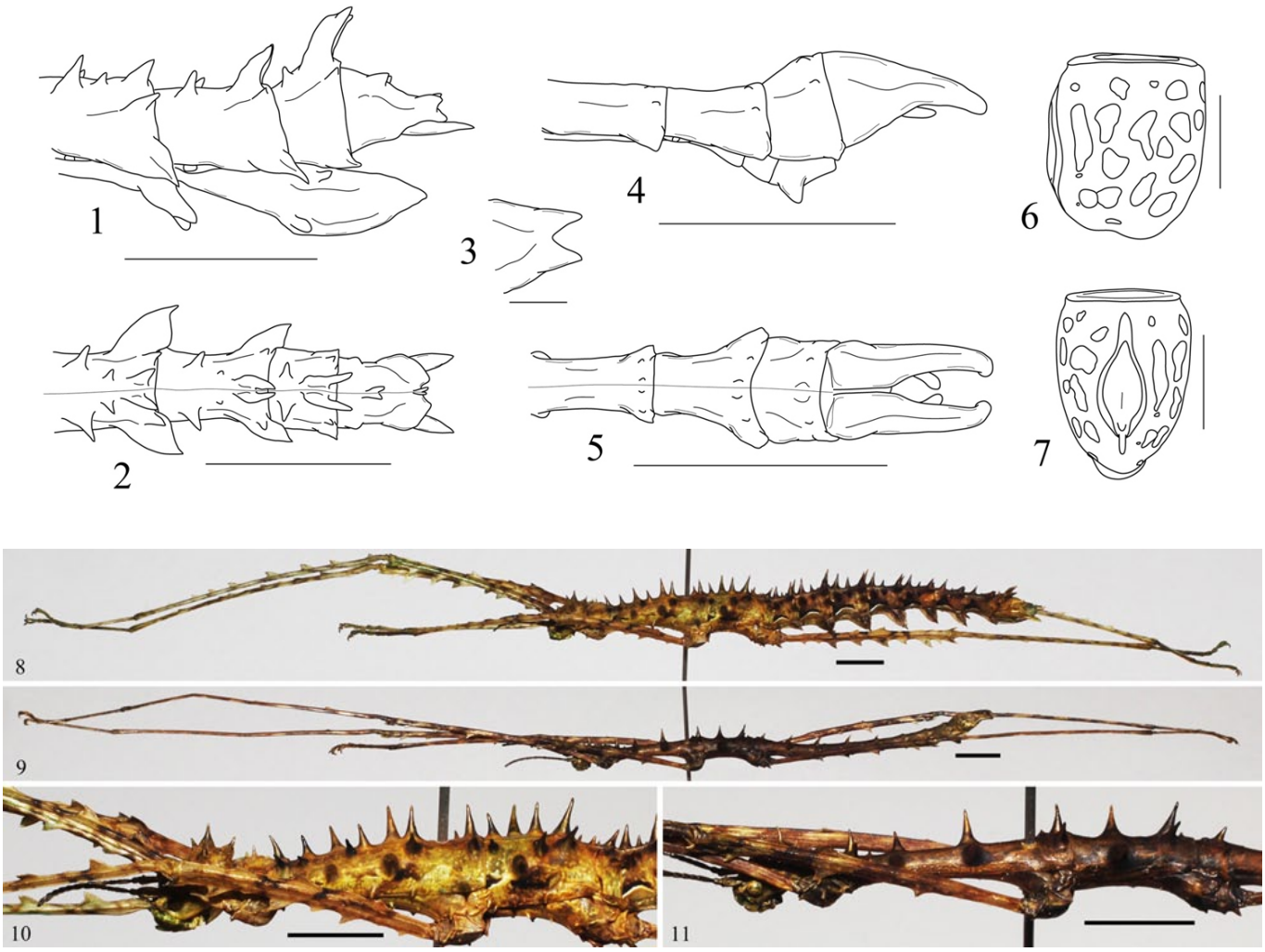
TABLES & FIGURES

	Holotype Female	Paratype Female	Paratype Male
Body	49.0	50.0	45.0
Head	5.0	5.0	3.0
Antennae	6.0	6.5	7.0
Pronotum	3.0	3.0	2.0
Mesonotum	9.5	9.5	9.0
Metanotum	6.0	6.0	5.5
Median segment	1.0	1.0	1.0
Profemora	20.0	20.0	22.0
Mesofemora	13.0	13.0	14.0
Metafemora	17.0	17.0	17.0
Protibiae	25.0	25.0	28.0
Mesotibiae	15.0	15.0	17.0
Metatibiae	21.0	20.0	23.0

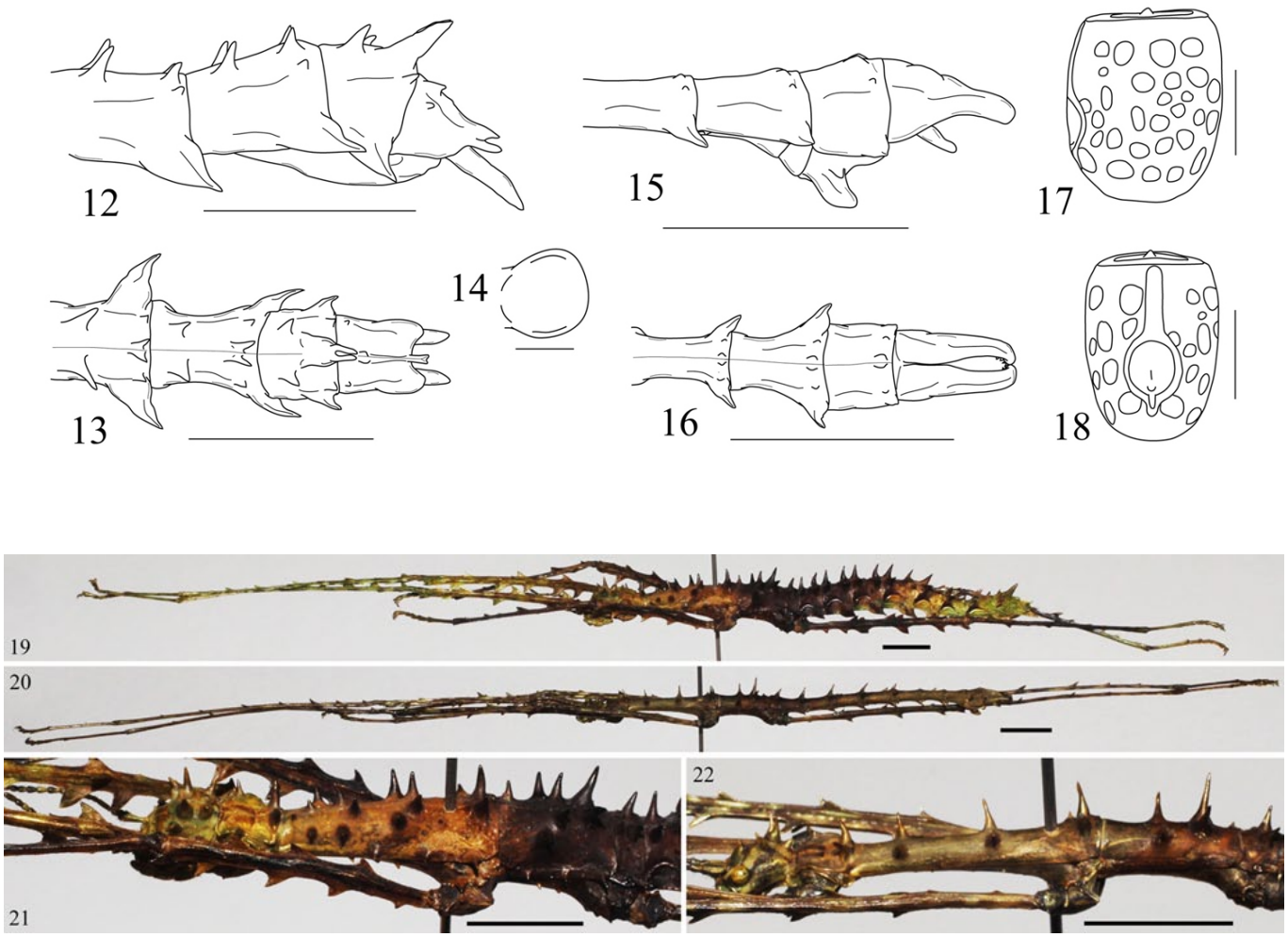
Table 1. Measurements of *Neospiniphasma similis* **gen. nov. & sp. nov.**

	Holotype Female	Paratype Female	Paratype Males
Body	49.0	49.5	42.0–47.0
Head	4.5	4.5	3.0
Antennae	7.0	6.0	8.0–10.0
Pronotum	3.0	3.0	2.0–2.5
Mesonotum	10.0	9.5	8.5–1.0
Metanotum	6.0	5.5	5.0–5.5
Median segment	1.0	1.0	1.0–1.5
Profemora	20.0	21.0	21.0–23.5
Mesofemora	13.0	13.0	13.5–15.0
Metafemora	17.0	17.0	17.0–20.0
Protibiae	25.0	26.0	26.0–28.0
Mesotibiae	15.0	16.0	15.5–17.0
Metatibiae	21.0	21.0	22.0–24.0

Table 2. Measurements of *Neospiniphasma triangulatum* **gen. nov. & sp. nov.**



Figures 1-11. *Neospiniphasma similis* **gen. nov. & sp. nov.** 1. Female, end of abdomen, lateral view. 2. Female, end of abdomen, dorsal view. 3. Female, praeopercular organ, ventral view. 4. Male, end of abdomen, lateral view. 5. Male, end of abdomen, dorsal view. 6. Egg, lateral view. 7. Egg, dorsal view. 8. Female, habitus. 9. Male, habitus. 10. Female, head and thorax, dorsolateral view. 11. Male, head and thorax, dorsolateral view. [Scale bars: end of abdomen, head, thorax and habitus = 5 mm; praeopercular organ and egg = 1 mm; drawings and photos by author]



Figures 12-22. *Neospiniphasma triangulatum* **gen. nov. & sp. nov.** 12. Female, end of abdomen, lateral view. 13. Female, end of abdomen, dorsal view. 14. Female, praeopercular organ, ventral view. 15. Male, end of abdomen, lateral view. 16. Male, end of abdomen, dorsal view. 17. Egg, lateral view. 18. Egg, dorsal view. 19. Female, habitus. 20. Male, habitus. 21. Female, head and thorax, dorsolateral view. 22. Male, head and thorax, dorsolateral view. [Scale bars: end of abdomen, head, thorax and habitus = 5 mm; praeopercular organ and egg = 1 mm; drawings and photos by author]

Contribution to the knowledge of Chinese Phasmatodea VIII: Four new species of *Carausius* Stål, 1875 from China (Lonchodidae: Lonchodinae)

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ABSTRACT

This study provides descriptions of four new species from *Carausius* Stål, 1875 of China, as follows: *Carausius gracilicercus* **sp. nov.**, *Carausius gracilicornis* **sp. nov.**, *Carausius guizhouensis* **sp. nov.** and *Carausius rubrogranulatus* **sp. nov.**. A key to the species and a list of the species of *Carausius* are provided.

Key words: Stick insects, taxonomy, new species, China

中國螳目之新知VIII:中國竹異螳屬四新種(長角棒螳科:長角棒螳亞科)

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摘要:本文記述中國竹異螳屬 *Carausius* Stål, 1875四新種:細尾竹異螳 *Carausius gracilicercus* **sp. nov.**, 細角竹異螳 *Carausius gracilicornis* **sp. nov.**, 貴州竹異螳 *Carausius guizhouensis* **sp. nov.**及赤瘤竹異螳 *Carausius rubrogranulatus* **sp. nov.**; 以及制定竹異螳屬的分類檢索表及名錄。

關鍵字: 竹節蟲, 分類, 新種, 中國

INTRODUCTION

Carausius Stål, 1875, is one of the speciose genera in the subfamily Lonchodinae Brunner, 1893 in the Oriental and Palearctic regions (Otte and Brock, 2005; Brock et al., 2021). In China, Chen and He (2008) provided the first taxonomic study for the genus. Later Ho (2017) reviewed the genus, with the descriptions of six new species in China.

This study is a supplementary to Ho (2017) and four new Chinese *Carausius* species are described following collecting trips by the author.

MATERIALS & METHODS

The systematic treatment is according to Otte and Brock (2005), Bradler et al. (2014), Robertson et al. (2018), Simon et al. (2019) and Brock et al. (2021). Morphological terms follow Bragg (2001), Zompro (2004) and Bradler (2009). Measurements are given in millimeters (mm). The types are deposited in the Hong Kong Entomological Society, Hong Kong collection (HKES).

RESULTS

Lonchodidae Brunner, 1893

Lonchodinae Brunner, 1893

Carausius Stål, 1875

= *Dixippus* Stål, 1875: 9, 66. [Synonymised by Brunner, 1907: 265]

Type-species: *Carausius strumosus* Stål, 1875: 64, by subsequent designation of Rehn, 1904: 42.

Notes: Currently 14 species are recognised from China.

Species included from China:

1. *Carausius bicornis* Ho, 2017: 45, figs. 199-200, 221-225.
Distribution: China (Yunnan) and Vietnam

2. *Carausius emeiensis* Chen & He, 2008: 58, figs. 26a-b.
Distribution: China (Sichuan)

3. *Carausius femoralis* Chen & He, 2002: 2, figs. 3-4. [= *Carausius thoracius* Chen & He, in Chen et al., 2006: 97, figs. 7: 1-2; synonymised by Xu, 2008: 17]
Distribution: China (Guangxi, Guizhou, Sichuan and Yunnan)
Notes: Ho (2017: 45) followed Xu's suggestion (Xu, 2008: 17) and treated *Carausius thoracius* Chen & He, 2006 as the synonym of *C. femoralis* Chen & He, 2002.

4. *Carausius gracilicercus* **sp. nov.**
Distribution: China (Yunnan)

5. *Carausius gracilicornis* **sp. nov.**
Distribution: China (Yunnan)

6. *Carausius guizhouensis* **sp. nov.**
Distribution: China (Guizhou)

7. *Carausius huanglianshanensis* Ho, 2017: 47, figs. 201-202, 226-230.
Distribution: China (Yunnan)

8. *Carausius lijiangensis* Chen & He, 2002: 2, fig. 5.
Distribution: China (Yunnan)

9. *Carausius luchunensis* Ho, 2017: 48, figs. 203-206, 231-238, 290-291.
Distribution: China (Yunnan)

10. *Carausius novus* Ho, 2017: 49, figs. 207-210, 239-247.
Distribution: China (Yunnan)

11. *Carausius rubrogranulatus* **sp. nov.**
Distribution: China (Yunnan)

12. *Carausius undatus* Chen & He, 2002: 1, figs. 1-2.
Distribution: China (Sichuan)

13. *Carausius yingjiangensis* Ho, 2017: 51, figs. 211-212, 248-252.
Distribution: China (Yunnan)

14. *Carausius yunnanensis* Ho, 2017: 52, figs. 213-216, 253-260.
Distribution: China (Yunnan)

Key to the species of *Carausius* from China:

Female:

1. Vertex of head unarmed. . . **2**
- Vertex of head with various shapes of armature between compound eyes. . . **3**

2. Seventh abdominal sternum with noticeable praeopercular organ. . . *C. luchunensis*
- Seventh abdominal sternum lacking noticeable praeopercular organ. . . *C. yunnanensis*

3. Vertex of head elevated with a U-shaped crest between compound eyes. . . **4**
- Vertex of head with paired horns between compound eyes. . . . **6**

4. Mesonotum with hump-like granulations. *C. novus*
- Mesonotum lacking hump-like granulations. **5**

5. Seventh abdominal tergum lacking posterolateral expansions. . . *C. gracilicercus* **sp. nov.**
- Seventh abdominal tergum with posterolateral expansions. . . *C. huanglianshanensis*

6. Vertex of head with paired long horns. *C. bicornis*
- Vertex of head with paired short horns. . **7**

7. Coxae of legs with a spine-like tubercle. . . . . *C. yingjiangensis*
- Coxae of legs unarmed. . . . **8**

8. Protibiae with waved lamellae. . . **9**
- Protibiae with rounded lamellae. . . **10**

9. Seventh abdominal sternum with horn-like praeopercular organ. . *C. gracilicercus* **sp. nov.**
- Seventh abdominal sternum with granule-like praeopercular organ. . . *C. undatus*

10. Seventh abdominal sternum with a carina-like praeopercular organ. . *C. guizhouensis* **sp. nov.**
- Seventh abdominal sternum with a horn-like praeopercular organ. . . . **11**

11. Mesonotum densely granulated. . *C. femoralis*
- Mesonotum sparsely granulated. . . . . *O. rubrogranulatus* **sp. nov.**

Male:

1. Vertex of head unarmed between compound eyes. **2**
- Vertex of head with various shapes of armature between compound eyes. . . **4**

2. Apices of anal abdominal semi-tergites pointed. . . . . *C. gracilicornis* **sp. nov.**
- Apices of anal abdominal semi-tergites obtuse. **3**

3. Apices of anal abdominal semi-tergites straight. . . . . *C. luchunensis*
- Apices of anal abdominal semi-tergites incurved. . . . . *C. yunnanensis*

4. Vertex of head elevated with a flattened U-shaped crest. . . . . *C. novus*
- Vertex of head with a pair of horns or spines. **5**

5. Vertex of head with a pair of spines. . **6**
- Vertex of head with a pair of horns. . **7**

6. Abdomen granulose. . . *C. lijiangensis*
- Abdomen lacking granules. . *C. emeiensis*

7. Dorsal carina of horns dentate. . . . . *C. gracilicornis* **sp. nov.**
- Dorsal carina of horns unarmed. . . **8**

8. Posterior margin of anal abdominal semi-tergites pointed. . . . . *C. femoralis*
- Posterior margin of anal abdominal semi-tergites rounded. . *C. rubrogranulatus* **sp. nov.**

***Oxyartes gracilicercus* sp. nov.** (Figs. 1-4, 15-18)

Types: Holotype, ♀, 1500m, Baoshan, Yunnan, China, 1 July 2019, George Ho Wai-Chun (HKES); Paratypes, 3♂, same data as holotype (HKES).

Differentiation: *Carausius gracilicercus* **sp. nov.** is similar to *C. huanglianshanensis* Ho, 2017, but can be separated by the laterally swollen sixth abdominal tergum, the absence of posterolateral expansions on seventh abdominal tergum and the horn-like praeopercular organ on the seventh abdominal sternum in the female. The male can be separated from all the Chinese taxa by the dorsally dentate horns on the vertex of head.

Description of female (Figs. 1-2, 15, 17): Medium-sized. Body elongate and slender, surface rough, sparsely granulose. General colouration of body and legs brown.

Head: Oval, weakly constricted after compound eyes. Rough, sparsely covered with small granules, also with a few enlarged granules. Vertex with a pair of short and thick ear-like horns between compound eyes, U-shaped from dorsal view. Occiput moderately convex, median and lateral longitudinal furrows indistinct, posterior margin with distinct swellings. Compound eyes small and rounded. Antennae filiform; scapus dorsoventrally flattened, indistinctly constricted basally, longer than third segment; pedicellus almost as long as third segment.

Thorax: Rough and wrinkled. Pronotum rectangular, longer than wide, anterior margin weakly incurved, posterior margin rounded, transverse and longitudinal sulci crossing at middle area. Mesonotum longer than combined length of metanotum and median segment, with median longitudinal carina. Metanotum longer than median segment. Mesopleurae, metapleurae and metasternum sparsely granulated with a few enlarged granules.

Abdomen: Cylindrical, rough and wrinkled, also with sparse granulations. Median segment rectangular, longer than wide. Second to fifth tergites parallel-sided. Sixth tergum moderately swollen laterally. Seventh sternum with a small horn-like praeopercular organ posteromedially. Eighth tergum as long as combined length of ninth tergum and anal segment. Anal segment as long as ninth tergum, posterior margin with a V-shaped emargination. Supra-anal plate distinct, tapering posteriorly, with median longitudinal carina, posterior margin rounded and projecting over posterolateral angles of anal segment. Operculum boat-shaped, median longitudinal carina indistinct, posterolateral areas raised, also with short tubercles situated at posterior half of longitudinal carina, posterior margin pointed. Cerci short, flattened, apices pointed and not projecting over end of anal segment.

Legs: Slender and long. Procoxae and mesocoxae with a short tubercle. Femora almost as long as corresponding tibiae. Profemora basally curved, shorter than mesonotum, posterodorsal and posteroventral carina distinctly waved with small rounded elevations. Posteroventral carina of mesofemora and metafemora with one to two small teeth near apices. Posterodorsal and posteroventral carina of protibiae strongly raised. First segment of protarsi with a small semi-circular lamella dorsally.

Description of male (Figs. 3-4, 16, 18): Body rough, slender and elongate, distinctly slenderer than female. General colouration of body and legs brown.

Head: Oval, weakly constricted after compound eyes, as long as pronotum. Sparsely granulated. Vertex with a pair of ear-like horns between compound eyes, dorsal carina sparsely dentate. Occiput with distinct median and lateral longitudinal furrows, posterior margin with six small swellings. Compound eyes rounded and small. Antennae long and filiform; scapus dorsoventrally flattened, longer than combined length of pedicellus and third segment; pedicellus as long as third segment.

Thorax: Rough, sparsely covered with small granules, also interspersed with a few enlarged reddish granules. Pronotum rectangular, longer than wide, anterior margin weakly incurved, posterior rounded, transverse and longitudinal sulci crossing at middle area. Mesonotum slender and elongate, longer than combined length of metanotum and median segment, broadly emarginated medially, median longitudinal carina indistinct. Metanotum shorter than mesonotum, median longitudinal carina indistinct.

Abdomen: Slender and cylindrical, sparsely granulated. Median segment rectangular, longer than wide, shorter than metanotum. Seventh tergum as long as combined length of eighth and ninth tergites. Eighth tergum expanded posteriorly, as long as ninth tergum. Anal segment as long as seventh tergum, split into two semi-tergites, inner margin curved after middle area, apices with a few small dentations, posterior margin rounded. Poculum cup-like, medially elevated, posterior margin rounded and reaching posterior margin of ninth tergum. Cerci short, cylindrical, apices rounded and not surpassing apices of semi-tergites.

Legs: Slender and long, lacking noticeable armature. Procoxae and mesocoxae with a short tubercle. Femora shorter than corresponding tibiae. Profemora incurved basally, posteroventral carina with two small spines near apices. Posteroventral carina of mesofemora and metafemora with two small spines near apices. Hindlegs not extending beyond end of abdomen. First segment of protarsi with a small semi-circular lamella dorsally.

Measurements: See Table 1.

Distribution: China (Yunnan).

Etymology: The specific epithet of this new species is derived from the small cerci in the both sexes.

***Oxyartes gracilicornis* sp. nov.** (Figs. 5-8, 19-22)

Types: Holotype, ♀, 1500m, Baoshan, Yunnan, China, 1 July 2019, George Ho Wai-Chun (HKES); Paratypes, 1♂, 7 nymphs (4♀, 3♂), 1500-2000m, Baoshan, Yunnan, China, 30 June - 1 July 2019, George Ho Wai-Chun (HKES).

Differentiation: *Carausius gracilicornis* **sp. nov.** is related to *C. luchunensis* Ho, 2017, but can be easily separated by the smaller size in the both sexes, the horn-like praeopercular organ on the seventh abdominal sternum in the female and the pointed apices of the anal abdominal semi-tergites in the male.

Description of female (Figs. 5-6, 19, 21): Medium-sized. General colouration of body and legs brown. Body elongate and very slender.

Head: Oval, longer than wide, surface rough, sparsely covered with small granules. Vertex flattened, with a pair of small horns between compound eyes. Occiput flat, median and lateral longitudinal furrows indistinct, posterior margin with six small swellings. Compound eyes small and rounded. Antennae filiform, reaching apices of protibiae; scapus dorsoventrally flattened, constricted basally, medially carinate, three times longer than pedicellus, as long as third segment.

Thorax: Rough and wrinkled. Sparsely covered with small granules except for mesosternum. Pronotum rectangular, longer than wide, anterior margin nearly truncate, posterior margin rounded, transverse and longitudinal sulci crossing at middle area. Mesonotum elongate and slender, longer than combined length of metanotum and median segment; median longitudinal carina distinct, also interspersed with a few enlarged granules. Metanotum with distinct median longitudinal carina, also interspersed with a few enlarged granules.

Abdomen: Rough, wrinkled and sparsely covered with small granules. Median segment rectangular, longer than wide, shorter than metanotum. Seventh sternum with a horn-like praeopercular organ posteromedially, curved posteriorly, tapering apically, apex blunt. Eighth tergum as long as combined length of ninth tergum and anal segment. Anal segment shorter than ninth tergum, posterior margin with a deep U-shaped emargination, posterolateral angles rounded. Supra-anal plate small, mediolongitudinally carinate, posterior margin with a small elevation and projecting over posterolateral angles of anal segment. Operculum boat-shaped, with median and lateral longitudinal carinae, apex pointed and not exceeding posterolateral angles of anal segment. Cerci short and obtuse, not projecting over end of anal segment.

Legs: Lacking noticeable armature. Femora almost as long as corresponding tibiae. Profemora basally curved, shorter than mesonotum, anterodorsal carina distinctly waved with small rounded elevations. Posterodorsal carina of protibiae waved. First segment of protarsi with a small semi-circular lamella dorsally. Posteroventral carina of mesofemora and metafemora with two small teeth near apex.

Description of male (Figs. 7-8, 20, 22): Distinctly slenderer and smaller than female. General colouration of body and legs brown.

Head: Oval, as long as pronotum. Vertex flattened, with two elevations between compound eyes. Occiput flattened, median and lateral longitudinal furrows indistinct, posterior margin with six small distinct swellings. Compound eyes rounded. Antennae filiform and long, surpassing apices of protibiae; scapus dorsoventrally flattened, medially carinate, longer than third segment; pedicellus shorter than third segment.

Thorax: Sparsely covered with a few small granules except for mesosternum. Pronotum rectangular, longer than wide, anterior margin nearly truncate, posterior margin rounded, transverse and longitudinal sulci crossing at middle area. Mesonotum slender and elongate, broadly emarginated medially, median longitudinal carina distinct. Metanotum shorter than mesonotum.

Abdomen: Slender and cylindrical. Dorsal surface rough, covered with a few small granules, ventral surface lacking granulation. Median segment rectangular, two times longer than wide, shorter than metanotum. Eighth tergum expanded posteriorly, as long as ninth tergum. Ninth tergum constricted posteriorly. Anal segment longer than ninth tergum, split into two laterally flattened semi-tergites, tapering apically, apices obtuse, interior surfaces with a few small dentations. Poculum cup-like, posterior margin truncate, reaching anterior margin of anal segment. Cerci short, cylindrical, tapering apically, apices pointed and not exceeding apices of semi-tergites.

Legs: Slender and long, lacking noticeable armature. Femora almost as long as corresponding tibiae. Profemora incurved basally, posterodorsal carina with inconspicuous elevations. Protibiae as long as mesonotum. Mesofemora longer than metanotum. Anteroventral and posteroventral carinae of mesofemora and metafemora with two small teeth near apex.

Measurements: See Table 2.

Distribution: China (Yunnan).

Notes: The descriptions of the female and male are based on adult specimens. Measurements are only given for the adults. The general appearance and colouration of the nymphs resemble the adults.

Etymology: The specific epithet of this new species is derived from the small horns on the vertex of head in the female.

***Oxyartes guizhouensis* sp. nov.** (Figs. 9-10, 23)

Types: Holotype, ♀, 900-1000m, Xishui, Zunyi, Guizhou, China, 2 July 2015, George Ho Wai-Chun (HKES); Paratypes, 3♀, same data as holotype (HKES).

Differentiation: *Carausius guizhouensis* **sp. nov.** is similar to *C. femoralis* Chen & He, 2002, but can be separated by the robust body, the presence of sparse and short bristles on body, the short tubercle-like granules on the lower margin of mesopleurae and metapleurae and the carina-like praeopercular organ on the seventh abdominal sternum in the female.

Description of female (Figs. 9-10, 23): Medium-sized. Body elongate and slender, surface rough, granulated

and weakly wrinkled, also sparsely covered with short bristles. General colouration of body and legs brown.

Head: Oval, weakly constricted after compound eyes. Rough, sparsely covered with small granules. Vertex with a pair of flattened horns between compound eyes, apex pointed and pointing forwards. Occiput weakly convex, median and lateral longitudinal furrows distinct, posterior margin with six distinct small swellings. Compound eyes small and rounded. Antennae filiform, apices not surpassing protarsi; scapus dorsoventrally flattened, distinctly constricted basally, as long as combined length of pedicellus and third segment; pedicellus shorter than third segment.

Thorax: Rough. Pronotum rectangular, longer than wide, as long as head, anterior margin weakly curved inwards, posterior margin rounded, transverse and longitudinal sulci crossing at middle area. Mesonotum longer than combined length of metanotum and median segment, moderately expanded posteriorly, median longitudinal carina indistinct, densely granulated, also interspersed with a few enlarged granules. Metanotum longer than median segment, densely granulated. Mesopleurae and metapleurae with a few tubercle-like granules along lower margin.

Abdomen: Cylindrical, rough, with granulations and short wrinkles. Median segment rectangular, longer than wide. Sixth tergum with or without a pair of humps posteromedially. Seventh sternum with a carina-like praeopercular organ posteromedially, V-shaped from ventral view, weakly elevated. Eighth tergum almost as long as combined length of ninth tergum and anal segment, with a small crest-like elevation posteromedially. Ninth tergum with a small crest-like elevation posteromedially. Anal segment as long as ninth tergum, posterior margin with a small and broad U-shaped emargination, posterolateral angles pointed. Supra-anal plate distinct, small, with median longitudinal carina, posterior margin pointed and projecting over posterolateral angles of anal segment. Operculum boat-shaped, median longitudinal carina distinct, posterior area distinctly raised, posterior margin pointed and reaching posterior margin of supra-anal plate. Cerci short, flattened, apices rounded and not projecting over end of anal segment.

Legs: Slender and long. Procoxae and mesocoxae with a short tubercle. Femora almost as long as corresponding tibiae. Profemora distinctly basally curved, shorter than mesonotum, anterodorsal carina distinctly waved with small rounded elevations, posteroventral carina elevated. Posteroventral carina of mesofemora and metafemora with two small teeth near apices. Anterodorsal carina of protibiae elevated, also with small rounded elevations, posteroventral carina elevated. First segment of protarsi with a small semi-circular lamella dorsally.

Measurements: See Table 3.

Distribution: China (Guizhou).

Notes: The male is unknown.

Etymology: The specific epithet of this new species is derived from the type locality, Guizhou (China).

***Oxyartes rubrogranulatus* sp. nov.** (Figs. 11-14, 24-27)

Types: Holotype, ♀, 2000m, Nanjian, Dali, Yunnan, China, 2 June 2018, George Ho Wai-Chun (HKES); Paratypes, 2♀, 2♂, same data as holotype (HKES).

Differentiation: *Carausius rubrogranulatus* **sp. nov.** is similar to *C. femoralis* Chen & He, 2002, but can be separated by the sparsely granulated mesonotum and metanotum, the sparsely granulated abdomen and the apically pointed horn-like praeopercular organ on the seventh abdominal sternum in the female and the reddish granules on the thorax and the rounded posterior apices of the anal abdominal semi-tergites in the male.

Description of female (Figs. 11-12, 24, 26): Medium-sized. Body elongate and slender, surface rough, sparsely granulated. General colouration of body and legs brown.

Head: Oval, weakly constricted after compound eyes. Rough, sparsely covered with small granules. Vertex with a pair of short and thick ear-like horns between compound eyes. Occiput flattened, median and lateral longitudinal furrows indistinct, posterior margin with indistinct swellings. Compound eyes small and rounded. Antennae filiform; scapus dorsoventrally flattened, indistinctly constricted basally, longer than combined length of pedicellus and third segment; pedicellus as long as third segment.

Thorax: Rough and sparsely granulated. Pronotum rectangular, longer than wide, as long as head, anterior margin weakly incurved, posterior margin rounded, transverse and longitudinal sulci crossing at middle area. Mesonotum longer than combined length of metanotum and median segment, median longitudinal carina indistinct, also interspersed with a few small reddish granules. Metanotum longer than median segment, also interspersed with a few reddish granules.

Abdomen: Cylindrical, rough, with sparse granulations. Median segment rectangular, longer than wide. Second to sixth tergites parallel-sided. Sixth tergum with or without a hump posteromedially. Seventh tergum with a small rounded lobe posterolaterally. Seventh sternum with a small crest-like praeopercular organ posteromedially, also with a short tubercle laterally. Eighth tergum almost as long as combined length of ninth tergum and anal segment. Anal segment as long as ninth tergum, posterior margin with a small and broad U-shaped emargination, posterolateral angles obtuse. Supra-anal plate distinct, small, with median

longitudinal carina, posterior margin rounded and not projecting over posterolateral angles of anal segment. Operculum boat-shaped, median longitudinal carina indistinct, posterolateral areas raised, posterior margin pointed. Cerci short, flattened, apices rounded and not projecting over end of anal segment.

Legs: Slender and long. Profemora longer than protibiae, basally curved, shorter than mesonotum, posterodorsal carina distinctly waved with small rounded elevations. Mesofemora and metafemora as long as corresponding tibiae, posteroventral carina with two small teeth near apices. Posterodorsal and posteroventral carina of protibiae waved with small rounded elevations. First segment of protarsi with a small semi-circular lamella dorsally.

Description of male (Figs. 13-14, 25, 27): Body slender and elongate, distinctly slenderer than female. General colouration of body and legs brown.

Head: Oval, weakly constricted posteriorly after compound eyes, as long as pronotum. Sparsely granulose. Vertex with a pair of small horns between compound eyes. Occiput flattened, with distinct median and lateral longitudinal furrows, posterior margin with six small swellings. Compound eyes rounded and small. Antennae long and filiform; scapus dorsoventrally flattened, weakly constricted basally, almost as long as third segment; pedicellus shorter than third segment.

Thorax: Sparsely covered with small granules. Pronotum rectangular, longer than wide, anterior margin truncate, posterior rounded, transverse and longitudinal sulci crossing at middle area. Mesonotum slender and elongate, longer than combined length of metanotum and median segment, broadly emarginated medially, median longitudinal carina indistinct, also with a few small reddish granules. Metanotum shorter than mesonotum, broadly emarginated medially, median longitudinal carina indistinct, also with a few small reddish granules.

Abdomen: Slender and cylindrical, with very few small and inconspicuous granules. Median segment rectangular, longer than wide, shorter than metanotum. Seventh tergum shorter than combined length of eighth and ninth tergites. Eighth tergum expanded posteriorly, longer than ninth tergum. Anal segment as long as seventh tergum, split into two semi-tergites, inner margin weakly curved after middle area, apices with a few small dentations, posterior margin rounded. Poculum cup-like, basally elevated, posterior margin rounded and reaching posterior margin of ninth tergum. Cerci short, flattened, apices rounded and not exceeding apices of semi-tergites.

Legs: Slender and long, lacking noticeable armature. Profemora as long as protibiae, incurved basally, posteroventral carina with two small teeth near apices. Mesofemora and metafemora slightly shorter than corresponding tibiae, posteroventral carina with two small teeth near apices. Hindlegs not extending beyond end of abdomen.

Measurements: See Table 4.

Distribution: China (Yunnan).

Etymology: The specific epithet of this new species is derived from the reddish granulations on the mesonotum and metanotum in the both sexes.

CONCLUSION

The diversity of Lonchodinae in China is apparently high and more than 100 species are expected to be recorded in the subfamily (Chen and He, 2008; Hennemann et al., 2008; Ho, 2016, unpubl. data). *Carausius* Stål, 1875 is one of the most speciose genera in the subfamily and a total of 14 species are currently recognised. The known range of the genus is widely distributed from eastern to southwestern China and broadly covers the tropical, subtropical and temperate regions. The discovery of the four newly described taxa, *C. gracilicercus* **sp. nov.**, *C. gracilicornis* **sp. nov.**, *C. guizhouensis* **sp. nov.** and *C. rubrogranulatus* **sp. nov.**, from Yunnan, China, further reflects the high species diversity of the genus in China. New taxa can possibly be discovered in any localities of China. Molecular study on the Chinese taxa can help advance the understanding of their phylogenic relationship.

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TABLES & FIGURES

	Holotype Female	Paratype males
Body	118.0	84.0-87.0
Head	5.0	3.0
Antennae	37.0	41.0-44.0
Pronotum	4.5	3.0
Mesonotum	24.5	19.0-20.0
Metanotum	15.0	12.0
Median segment	6.0	3.5-4.0
Profemora	21.0	18.0-19.0
Mesofemora	16.0	13.0-14.0
Metafemora	17.0	15.0-17.0
Protibiae	19.0	20.0-21.0
Mesotibiae	15.0	15.0
Metatibiae	16.0	19.0-21.0

Table 1. Measurements of *Carausius gracilicercus* **sp. nov.**

	Holotype Female	Paratype male
Body	105.0	80.0
Head	4.0	3.0
Antennae	39.0	45.0
Pronotum	4.0	3.0
Mesonotum	24.0	19.0
Metanotum	14.0	12.0
Median segment	4.0	3.0
Profemora	18.0	19.0
Mesofemora	14.0	14.0
Metafemora	17.0	16.0
Protibiae	18.0	20.0
Mesotibiae	15.0	15.0
Metatibiae	18.0	19.0

Table 2. Measurements of *Carausius gracilicornis* **sp. nov.**

	Holotype Female	Paratype females
Body	122.0	105.0-112.0
Head	5.5	5.0
Antennae	42.0	36.0-40.0
Pronotum	5.5	5.0
Mesonotum	29.0	24.0-25.0
Metanotum	15.0	12.5-13.0
Median segment	6.0	4.0-5.0
Profemora	22.0	20.0-21.0
Mesofemora	17.0	15.0-16.0
Metafemora	20.0	18.0-20.0
Protibiae	22.0	19.0-20.0
Mesotibiae	17.0	15.0-17.0
Metatibiae	22.0	19.0-21.0

Table 3. Measurements of *Carausius guizhouensis* **sp. nov.**

	Holotype Female	Paratype Females	Paratype Males
Body	145.0	123.0-137.0	97.0
Head	5.0	4.5-5.0	3.0
Antennae	48.0	48-49.0	50.0
Pronotum	5.5	5.0	3.0
Mesonotum	33.0	26.0-31.0	22.0
Metanotum	18.0	15.0-18.0	13.5-14.0
Median segment	6.0	5.0-5.5	3.5
Profemora	25.0	23.0-25.0	20.0-21.0
Mesofemora	19.0	17.0	14.0-16.0
Metafemora	22.0	20.0-22.0	17.0-18.0
Protibiae	24.0	20.0-22.0	21.0
Mesotibiae	19.0	17.0	16.0-17.0
Metatibiae	22.0	20.0-22.0	20.0-21.0

Table 4. Measurements of *Carausius rubrogranulatus* **sp. nov.**

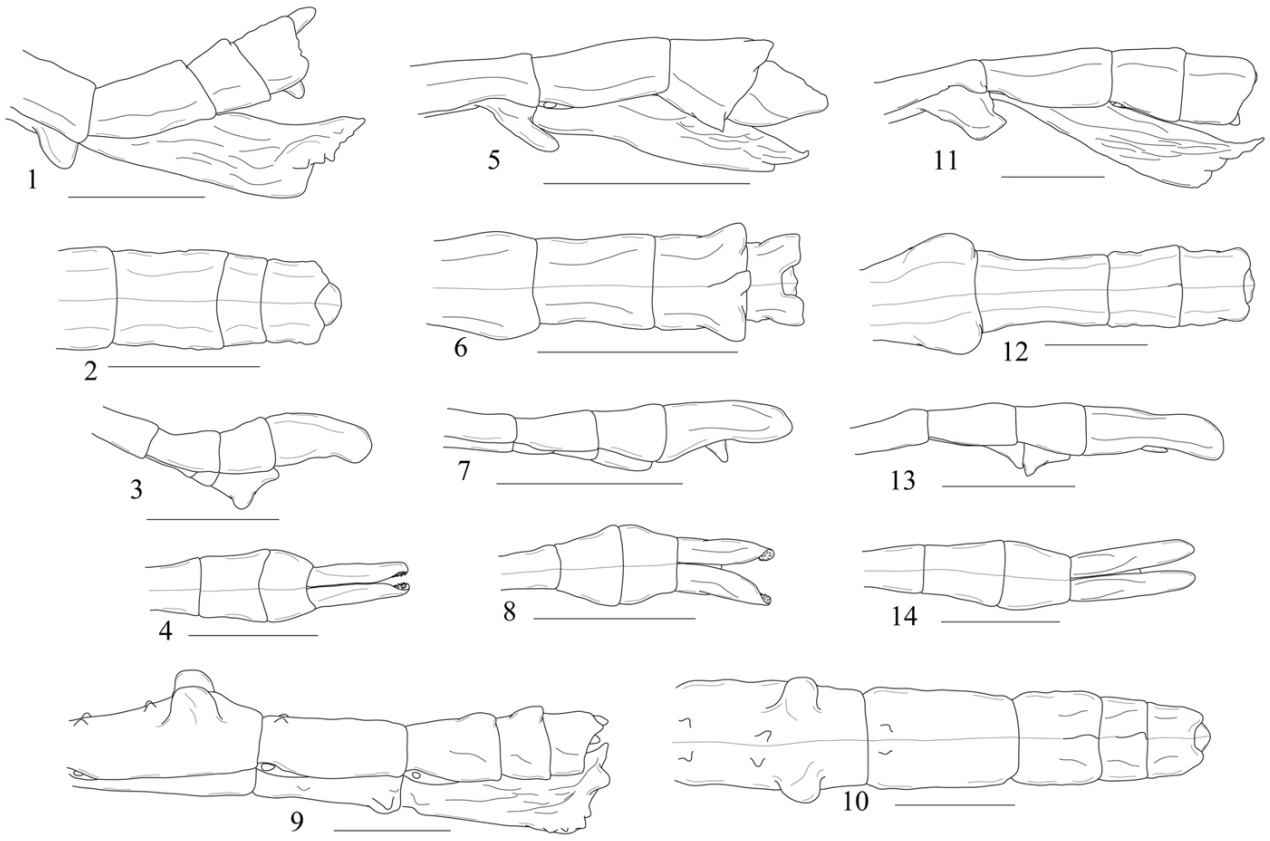

Figure 1-14. *Carausius* spp. 1. *Carausius gracilicercus* **sp. nov.**, female, apex of abdomen, lateral view. 2. *Carausius gracilicercus* **sp. nov.**, female, apex of abdomen, dorsal view. 3. *Carausius gracilicercus* **sp. nov.**, male, apex of abdomen, lateral view. 4. *Carausius gracilicercus* **sp. nov.**, male, apex of abdomen, dorsal view. 5. *Carausius gracilicornis* **sp. nov.**, female, apex of abdomen, lateral view. 6. *Carausius gracilicornis* **sp. nov.**, female, apex of abdomen, dorsal view. 7. *Carausius gracilicornis* **sp. nov.**, male, apex of abdomen, lateral view. 8. *Carausius gracilicornis* **sp. nov.**, male, apex of abdomen, dorsal view. 9. *Carausius guizhouensis* **sp. nov.**, female, apex of abdomen, lateral view. 10. *Carausius guizhouensis* **sp. nov.**, female, apex of abdomen, dorsal view. 11. *Carausius rubrogranulatus* **sp. nov.**, female, apex of abdomen, lateral view. 12. *Carausius rubrogranulatus* **sp. nov.**, female, apex of abdomen, dorsal view. 13. *Carausius rubrogranulatus* **sp. nov.**, male, apex of abdomen, lateral view. 14. *Carausius rubrogranulatus* **sp. nov.**, male, apex of abdomen, dorsal view. [Scale bars = 5 mm; drawings by author]

Figures 15-18. *Carausius gracilicercus* **sp. nov.** 15. Female, habitus. 16. Male, habitus. 17. Female, head and thorax, dorsolateral view. 18. Male, head and thorax, dorsolateral view. [Scale bars = 5 mm; photos by author]

Figure 19-23. *Carausius* spp. 19. *Carausius gracilicornis* **sp. nov.**, female, habitus. 20. *Carausius gracilicornis* **sp. nov.**, male, habitus. 21. *Carausius gracilicornis* **sp. nov.**, female, head and thorax, dorsolateral view. 22. *Carausius gracilicornis* **sp. nov.**, male, head and thorax, dorsolateral view. 23. *Carausius guizhouensis* **sp. nov.**, female, habitus. [Scale bars = 5 mm; photos by author]

Figures 24-27. *Carausius rubrogranulatus* **sp. nov.** 24. Female, habitus. 25. Male, habitus. 26. Female, head and thorax, dorsolateral view. 27. Male, head and thorax, dorsolateral view. [Scale bars = 5 mm; photos by author]

Population size reduction and geographic range of *Rhagophthalmus hiemalis* in Hong Kong

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ABSTRACT

Transect count method was used to study the population size of *Rhagophthalmus hiemalis*. Surveyors walked along a 2 km section of MacLehose Trail Stage 9. Four surveys were done in 2012-2014. 17 surveys were done between 28 December 2020 to 17 February 2021. For the number of recorded female adults of *R. hiemalis*, a reduction rate of 88% is detected. 30 surveys were done in 13 survey routes situated in similar habitat to that of type locality, covering the New Territories, Hong Kong Island and Lantau Island. Length of route ranges from 2.2km to 5.3 km. Three female adults of *R. hiemalis* were recorded in Shatin Pass in one visit on January 17, one more location of occurrence is added.

Key words: *Rhagophthalmus hiemalis*, Hong Kong, population size, geographic range

INTRODUCTION

Rhagophthalmus hiemalis is the second known species under this genus in Hong Kong (Yiu, 2017). It was first recorded on 4 January 2010 (a mating pair) in Tai Mo Shan, near Sze Lok Yuen. On 16 December 2012, two female adults were found in Tsuen Kam Au, near Kap Lung Ancient Trail. On 17 December 2012, 7 female adults were recorded along a section of MacLehose Trail Stage 9. Two female adults were recorded on 21 January 2014 in Mui Tsz Lam, Shatin. Male adults (Fig. 1) were recorded on 2 January 2014 in Tsuen Kam Au and on 24 January 2014 in Mui Tsz Lam, Shatin respectively.

Rhagophthalmus hiemalis was described as a new species in 2017 by Yiu. Both *R. motschulskyi* and *R. hiemalis* are only known in Hong Kong.

Flight period of *R. hiemalis* is from late December to Early March, but mostly recorded in January, in less disturbed natural habitats. Female adults were often seen lying on the sparsely vegetated slope surfaces near woodland margins, bending its abdomen upward such that light organ is facing upward (Fig. 2), displaying a continuous glow. The light display could be seen shortly after sunset and usually lasts for 2 hours. Light emission from female can be observed when the air temperature is 10°C or above. The light display is conspicuous that it can be clearly visible from 10 m distance. No light emission was observed from male.

The first Hong Kong Firefly Survey Team was established on the World Firefly Day (4 July) 2020. After 8 hours lecture training and 12 hours practical training at night, in the wild, members would take part in firefly surveys. *R. hiemalis* is one of the main subjects of their surveys.

MATERIALS & METHODS

Population size

Transect count method is adopted. Surveyors walk along a 2 km section of MacLehose Trail Stage 9 (Fig.3) in a very slow pace – slower than 2 km per hour, and count the number of female adult of *R. hiemalis* seen, by identifying the light display along the road sides. Rules and skills were taught in a lecture and through an on-site demonstration video. It was also remarked that surveyor should get close to the light spot to ensure that it is a female adult displaying light by raising its abdomen and not a larva of other firefly species. Photo should be taken as far as possible. All the survey was done within the period of 18:30 to 20:00 when the firefly is most active, air temperature should not lower than 13 degree Celsius. Weather conditions including rainfall, wind, cloud cover and moon phase were also recorded to make sure that surveys were not done under extreme conditions.

Geographic range

13 survey routes (Fig. 4) situated in similar habitat to that of Tsuen Kam Au – type locality, were designated, covering the New Territories, Hong Kong Island and Lantau Island. Length of route ranges from 2.2km to 5.3 km. Surveyors walk along the routes in a very slow pace – around 2 km per hour, and count the number of female adult of *R. hiemalis* seen, by identifying the light display along the road sides. Rules and skills were taught in a lecture and through an on-site demonstration video. It was also remarked that surveyor should get close to the light spot to ensure that it is a female adult displaying light by raising its abdomen and not a larva of other firefly species. Photo should be taken as far as possible. All the survey was done within the period of 18:30 to 20:30 when the firefly is most active, air temperature should not lower than 13 degree Celsius. Weather conditions including rainfall, wind, cloud cover and moon phase were also recorded to make sure that surveys were not done under extreme conditions.

RESULTS

Population size

Along the MacLehose Trail Stage 9, four surveys were done in 2012-2014 by the author. 17 surveys were done

between 28 December 2020 to 17 February 2021, 15 done by survey team members and two done by the author. Number of recorded female adults of *R. hiemalis* in each survey is show in Fig. 5. Average number of recorded female adults of *R. hiemalis* in each survey from December 2012 to January 2014 is 5.50; the average number from December 2020 to January 2021 is 0.65.

Geographic range

Survey Route, date of survey and number of recorded female adults of *R. hiemalis* in each survey are list in the Table 1.

Amongst the 30 surveys, three female adults of *R. hiemalis* were recorded in Shatin Pass in one visit on 17 January with photo records; all the other surveys have no record.

DISCUSSION

One more occurrence location of *R. hiemalis* was discovered by the Firefly Survey Team members. Totally it is now known in four well separated localities. On the other hand, it was not found in other 12 potential locations during its flight period. Applying the standard of restrictedness threshold suggested by Fellows et al. (2002), Local restrictedness of *R. hiemalis* can be regarded as C= known to occur in three to four localities.

Comparing the average number of recorded female adults of *R. hiemalis* in each survey along the along a 2 km section of MacLehose Trail Stage 9, from December 2012 to January 2014 - 5.50, with the average number from December 2020 to January 2021 - 0.65. A reduction rate of 88% is detected. If the reduction rate continues and it applies to the whole population, *R. hiemalis* may become extinct in a few decades. Currently, the status in other three occurrence sites is not known. The cause of reduction in MacLehose Trail Stage 9 is not known. Therefore, variation of the population in other 3 sites may not be the same. Unusual clearance of vegetation along the slopes in MacLehose Trail Stage 9, where female adults of *R. hiemalis* were found is observed (Fig. 6, 7). Without cover by the vegetation, the habitat would have higher fluctuation on temperature and moisture level and becomes less suitable for the firefly. It is also not clear whether the clearance of vegetation is artificial or not. MacLehose Trail Stage 9 is also a section of a popular mountain bike route, mountain bikers riding outside the designated tracks and rolling over similar natural slopes in this area was commonly seen . It is proposed to keep close monitoring of the population *R. hiemalis* and to stop the destructive illegal biking in the Country Parks.

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TABLES & FIGURES

Survey Route	Date of Survey, all in 2021	No. of recorded female adults of *R. hiemalis*
Tai Tong Nature Trail	Jan 25; Jan 26	0
Tsing Yi nature Trail	Jan 16; Feb 3	0
Robin's Nest	Jan15	0
Cloudy Hill North	Feb 6	0
Cloudy Hill South	Feb 4	0
Lan Nai Wan	Jan 14; Jan 24; Jan 30	0
Shui Long Wo	Jan 21; Jan 23; Feb 8	0
Shatin Pass	Jan 17	3
Black's Link	Jan 17; Jan 20: Jan 26; Jan 27: Jan 30	0
Mount Parker	Jan 16; Jan 17: Jan 25; Feb 1: Feb 6; Feb 8	0
Pak Mong	Jan 19; Feb 4	0
Fat Mun Ancient path	Jan 19; Feb 6	0
Mui Wo	Jan 27	0

Table 1. Survey route locations, dates of survey and number of recorded adults of *R. hiemalis*.

Figure 1. *Rhagophthalmus hiemalis* male adult. [Photo by author]

Figure 2. *Rhagophthalmus hiemalis* female adult. [Photo by author]

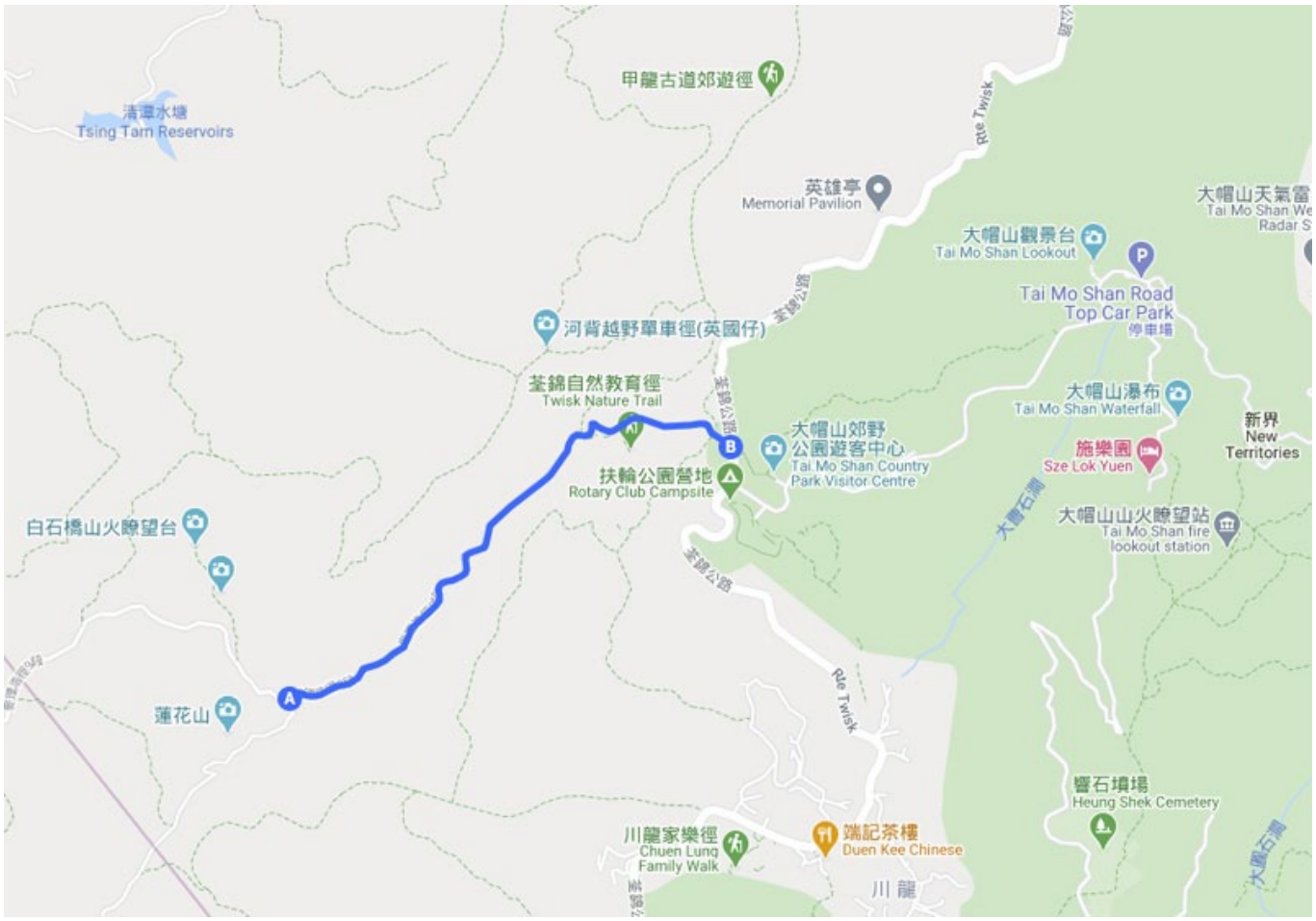

Figure 3. Belt transect survey route - 2km section of MacLehose Trail Stage 9. [Photo by author]

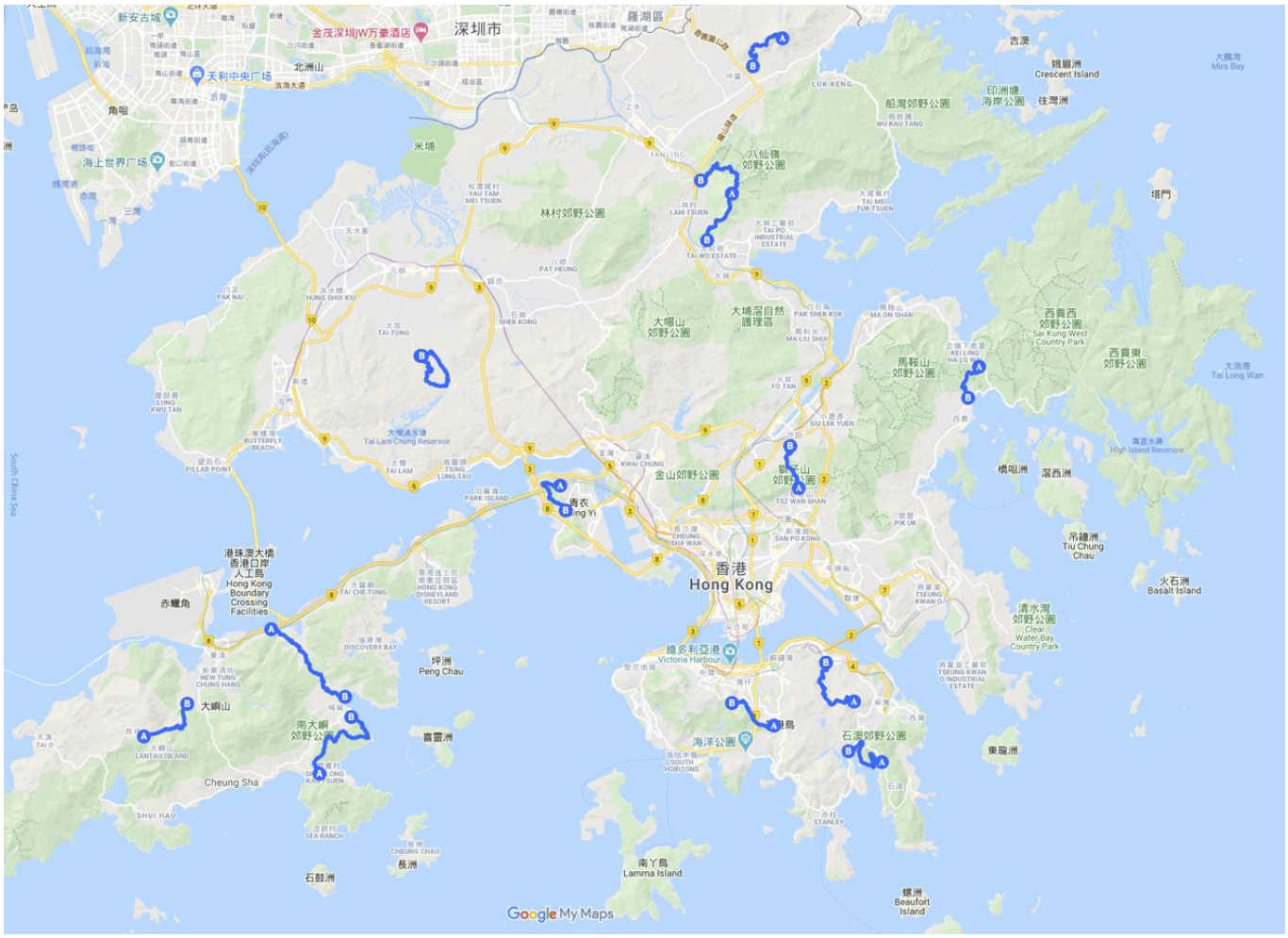

Figure 4. Distribution of the 13 survey routes. [Photo by author]

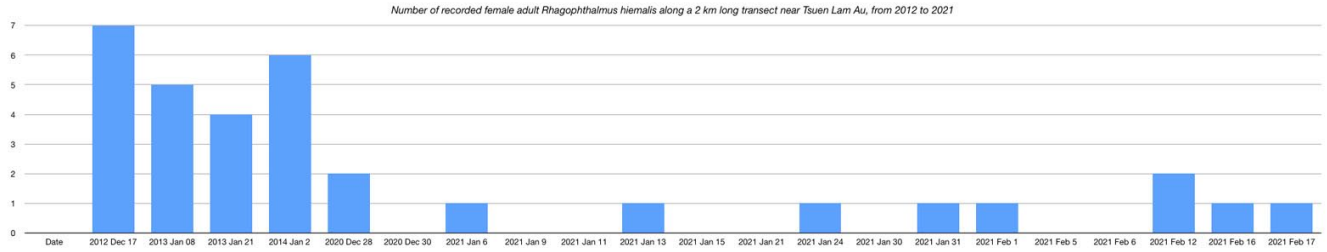

Figure 5. Number of recorded female adults of *R. hiemalis* in each survey. [Photo by author]

Figure 6. Unusual clearance of vegetation. [Photo by author]

Figure 7. Normal vegetation cover. [Photo by author]

SHORT COMMUNICATION

Hong Kong dragonflies: Key species and sites

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Key words: Hong Kong, Odonata, distribution status, key dragonfly sites, conservation significance, species assessment metric

Dragonflies were surveyed at 33 sites across the territory of Hong Kong Special Administrative Region over the period 2016-2017. Surveys included identification of larvae, exuviae and adults, and involved 92 separate site visits. The chosen sites covered the whole spectrum of dragonfly habitats in Hong Kong, with the exception of actively managed fish ponds and reservoirs. Twenty-two of the study locations had been identified as key dragonfly sites by Wilson (1997). An annotated check list of Hong Kong Odonata was compiled, listing 128 taxa. Comparison of local distribution of dragonflies during this study with that recorded by Wilson (1997) indicated that only three species had undergone significant decline in the intervening two decades, while several others (including the conservation-significant *Mortonagrion hirosei* Asahina, 1972 and *Orthetrum poecilops* Ris, 1919) had considerably extended local distributions. Twenty-eight species of particular conservation importance for Hong Kong were identified and ranked, using a species conservation value assessment metric. The data from surveys conducted by Reels were occasionally augmented with species records made by private individuals during the survey period (taken as the calendar years 2016 and 2017), where those particular species were not observed by the principal researcher. Nevertheless, some 27 taxa on the Hong Kong check list were not recorded during the study, including the 14 that are presumed locally extinct, vagrants, or of uncertain status, and two confirmed species, *Stylurus clathratus* and *Indothemis carnatica*, that were not known from Hong Kong until after 2017 (AFCD, 2019; Wilson, 2019).

Eight of Wilson's key dragonfly sites were found to no longer merit such status. Fourteen of the original "key dragonfly sites" were reconfirmed; two of these were expanded to include adjacent dragonfly-rich areas, and four new key dragonfly sites were proposed. Sites were evaluated by species richness, number of species of conservation importance, and by means of a species conservation value metric applied to the entire dragonfly species assemblage present at each site. By all such measures, Sha Lo Tung / Hok Tau was determined to be Hong Kong's premier dragonfly site.

The work was reported in detail in Reels (2019) and Reels (2020). A summary of key findings is given in Table 1.

Wilson and Reels (1999) proposed a metric for using dragonflies in wetland evaluation in tropical southern China. This was subsequently used by Reels (2013) to compare a range of sites across southeastern China. The metric assigns an aggregate value to each dragonfly species on the basis of a number of point-scoring categories (these can then be tallied up species by species to give an aggregate score for a particular site). A modified version of the metric was adopted in this study, to make it appropriate to the Hong Kong context.

Species-richness is only one measure of a dragonfly site's importance. A perhaps more informative measure is provided by use of a species conservation value metric. This combines crude species richness with an objective evaluation of aggregate conservation importance of a site's dragonfly community. The metric used in this study clearly identified Sha Lo Tung / Hok Tau as containing by far the most important dragonfly assemblage in Hong Kong.

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TABLES

Species	Remarks
Lestes nodalis	Highly restricted in Hong Kong (three known sites; one unconfirmed in present study).
Drepanosticta hongkongensis	Originally described from Hong Kong. Globally restricted to southeastern China.
Protosticta beaumonti	Male originally described from Hong Kong. Globally restricted to southeastern China. Sparsely distributed in Hong Kong.
Protosticta taipokauensis	Originally described from Hong Kong. Sparsely distributed in Hong Kong.
Sinosticta ogatai	Priority species (Moore, 1997): taxonomically isolated. Originally described from Hong Kong. Globally restricted to southeastern China. Near-endemic to Hong Kong. Sparsely distributed in Hong Kong.
Rhipidolestes janetae	Priority species (Moore, 1997): taxonomically isolated. Originally described from Hong Kong. Globally restricted to southeastern China. Sparsely distributed in Hong Kong.
Philoganga vetusta	Priority species (Moore, 1997): taxonomically isolated.
Calicnemia sinensis	Globally restricted to southeastern China. Sparsely distributed in Hong Kong.
Onychargia atrocyana	Priority species (Moore, 1997): taxonomically isolated.
Aciagrion approximans	Highly restricted in Hong Kong (two known sites; one unconfirmed in present study).
Agriocnemis lacteola	Highly restricted in Hong Kong (one known site).
Mortonagrion hirosei	Near Threatened (IUCN). Priority species (Moore, 1997): unusual biology.
Cephalaeschna klotsae	Data Deficient (IUCN). Highly restricted in Hong Kong (one known site). Globally restricted to southeastern China and Hubei province.
Planaeschna skiaperipola	Globally restricted to southeastern China. Highly restricted in Hong Kong (one known site).
Asiagomphus hainanensis	Globally restricted to southeastern China.
Fukienogomphus choifongae	Originally described from Hong Kong. Globally restricted to southeastern China. Highly restricted in Hong Kong (one known site).
Gomphidia kelloggi	Endangered (IUCN). Globally restricted to southeastern China. Highly restricted in Hong Kong (two known sites, contiguous).
Lamelligomphus hainanensis	Globally restricted to southeastern China.
Leptogomphus hongkongensis	Originally described from Hong Kong. Not recorded from elsewhere in China. Known from one locality in Laos.
Melligomphus guangdongensis	Globally restricted to southeastern China. Sparsely distributed in Hong Kong.
Ophiogomphus sinicus	Data Deficient (IUCN). Globally restricted to southeastern China. Sparsely distributed in Hong Kong.
Sieboldius alexanderi	Data Deficient (IUCN). Globally restricted to southeastern China and Hubei province.
Anotogaster sp. cf *klossi*	Breeding confirmed at one site.
Idionyx claudia	Globally restricted to southeastern China and Yunnan province. Highly restricted in Hong Kong (one known site).
Macromidia ellenae	Originally described from Hong Kong. Globally restricted to southeastern China. Sparsely distributed in Hong Kong.
Macromia katae	Vulnerable (IUCN). Originally described from Hong Kong.
Onychothemis testacea	Priority species (Moore, 1997): taxonomically isolated. Sparsely distributed in Hong Kong.
Orthetrum poecilops	Vulnerable (IUCN). Priority species (Moore, 1997): unusual biology.

Table 1. Dragonfly species of conservation interest recorded from Hong Kong [revised and updated from Reels (2018, 2019) with reference to Zhang (2019) and Bybee et al. (2021)]

Rank	Species	Score
1=	*Rhipidolestes janetae* *Fukienogomphus choifongae* *Gomphidia kelloggi*	55
4=	*Sinosticta ogatai* *Planaeschna skiaperipola*	45
6	*Cephalaeschna klotsae*	40
7=	*Idionyx claudia* *Orthetrum poecilops*	35
9=	*Leptogomphus hongkongensis* *Ophiogomphus sinicus* *Macromia katae*	30
12=	*Philoganga vetusta* *Calicnemia sinensis* *Aciagrion approximans* *Agriocnemis lacteola* *Melligomphus guangdongensis* *Anotogaster* sp. cf *klossi*	25
18=	*Drepanosticta hongkongensis* *Protosticta beaumonti* *Mortonagrion hirosei* *Asiagomphus hainanensis* *Lamelligomphus hainanensis* *Macromidia ellenae*	20
24=	*Lestes nodalis* *Protosticta taipokauensis* *Onychargia atrocyana* *Sieboldius alexanderi* *Onychothemis testacea*	15

Table 2. Metric ranking of Hong Kong dragonfly species by conservation value. Full details of metric in Reels (2019).

Rank	Site	Score
1	Sha Lo Tung/Hok Tau	451
2	Hok Tau	347
3	Sha Lo Tung	337
4	Tai Po Kau	276
5	Ng Tung Chai	270
6	Wu Kau Tang	254
7	Tai Mo Shan South	246
8	Sunset Peak	205
9	Luk Keng/Kai Kung Shue Ha composite sites	175
10	Sham Tseng Stream	168
11	Tai Tong Stream	136
12	Luk Keng	130
13	Tan Shan River	123
14	Upstream Tai Lam Reservoir	106
15=	Keung Shan Man Uk Pin	100
17	Kuk Po	99
18	Yung Shue O	93
19	Nam Chung	90
20	Tai Shui Hang	84
21	Kai Kuk Shue Ha	71
22	Shuen Wan	70
23	Hang Cho Stream	67
24	Ma Tso Lung	51
25	She Shan Stream	44
26=	Lung Tsai Ng Yuen Double Island	39
28=	Sheung Tsat Muk Kiu Hong Kong Wetland Park	30
30	Yuen Leng Chai	29
31	Kang Mun Tsui	23
32	Pat Sin Leng Site 2	18
33=	Pat Sin Leng Site 1 Lamma Pond	8
35	Nam Sang Wai	6

Table 3. Metric ranking of Hong Kong dragonfly sites by conservation value. Full site details in Reels (2020).