

<https://doi.org/10.70590/ice.2025.01.82>

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● Notes on immature morphology of *Stichophthalma* from Hainan Island and phylogenetic inference (Lepidoptera, Nymphalidae)

Zhuo-Heng JIANG^{1,2,4}, Zi-Fei CHEN^{3,5} & Shao-Ji HU^{1,2*}

¹Yunnan Key Laboratory of International Rivers and Transboundary Eco-Security, Yunnan University, Kunming 650500, China

²Institute of International Rivers and Eco-Security, Yunnan University, Kunming 650500, China

³Dongxiao Road, Haizhu District, Guangzhou 510220, China

⁴<https://orcid.org/0000-0001-9161-4400>; jzhsphingidae@163.com

⁵<https://orcid.org/0009-0007-2574-5315>; 1226729042@qq.com

*Corresponding authors. <https://orcid.org/0000-0002-1615-9601>; shaojihu@hotmail.com

Abstract: In this study, we document part of the life history of the three *Stichophthalma* species from Hainan, illustrate the habitat and ecology images of adults, and also discuss the phylogenetic relationship with their similar species according to head pattern and hair characteristic in final stage larva.

Keywords: phylogeny, Hainan Island, life history, Nymphalidae, taxonomy

● 海南岛箭环蝶属种类幼期记述及系统发育推断（鳞翅目：蛱蝶科）

蒋卓衡^{1,2}, 陈子飞³ & 胡劲骥^{1,2*}

¹云南大学国际河流与生态安全研究院, 昆明 650500, 中国

²云南省国际河流与跨界生态安全重点实验室, 昆明 650500, 中国

³海珠区东晓路雅墩街11号603号, 广州 510220, 中国

*通讯作者

摘要: 本文对海南岛分布的三种箭环蝶属种类的部分生活史进行了记述, 同时附有成虫标本照和生态图, 并根据末龄幼虫的头部斑纹和毛束特点, 结合地理分布和同属的近似种类进行了系统发育讨论。

关键词: 系统发育, 海南岛, 生活史, 蛱蝶科, 分类学

Citation: Jiang Z-H, Chen Z-F & Hu S-J 2025: Notes on immature morphology of *Stichophthalma* from Hainan Island and phylogenetic inference (Lepidoptera, Nymphalidae). *The Indochina Entomologist*, 1 (82): 819–828. [蒋卓衡, 陈子飞 & 胡劲骥 2025: 海南岛箭环蝶属种类幼期记述及系统发育推断（鳞翅目：蛱蝶科）. 中南半岛昆虫学家, 1 (82): 819–828.] <https://doi.org/10.70590/ice.2025.01.82>

Accepted by Cheng-Bin WANG: 10.XI.2025; published online: 20.XI.2025

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● Introduction

The genus *Stichophthalma* C. & R. Felder, 1862 (Morphinae: Amathusiini) is established with type species *Stichophthalma howqua* (Westwood, 1851) (Wei & Yen 2017) from Shanghai, China. This genus includes 15 species endemic to the E. Asia and SE. Asia, namely: *S. camadeva* (Westwood, 1848), *S. howqua* (Westwood, 1851), *S. nourmahal* (Westwood, 1851), *S. cambodia* (Hewitson, 1862), *S. louisa* (Wood-Mason, 1877), *S. neumogeni* Leech, 1892, *S. suffusa* Leech 1892, *S. sparta* de Nicéville, 1894, *S. fruhstorferi* Röber, 1903, *S. mathilda* Janet, 1905, *S. godfreyi* Rothschild, 1916, *S. le* Joicey & Talbot, 1921, *S. uemurai* Nishimura, 1998, *S. eamesi* Monastyrskii, Devyatkin & Uémura, 2000 and *S. devyatkin* Monastyrskii, 2003.

Joicey & Talbot (1921) recorded three species of the genus *Stichophthalma* from Hainan Island, and firstly with descriptions and illustrations, namely: *S. howqua bowringi* Joicey & Talbot, 1921, *S. neumogeni* le Joicey & Talbot, 1921 and *S. nourmahal chuni* Joicey & Talbot, 1921. In this study the authors document part of the life history of the three *Stichophthalma* species from Hainan Island due to the limited condition, illustrate the habitat and ecology images of adults, and also discuss the phylogenetic relationship with their similar species according to head pattern and hair characteristic in final stage larvae. The distribution map of *Stichophthalma* species from Hainan Island and their similar species in this study are given.

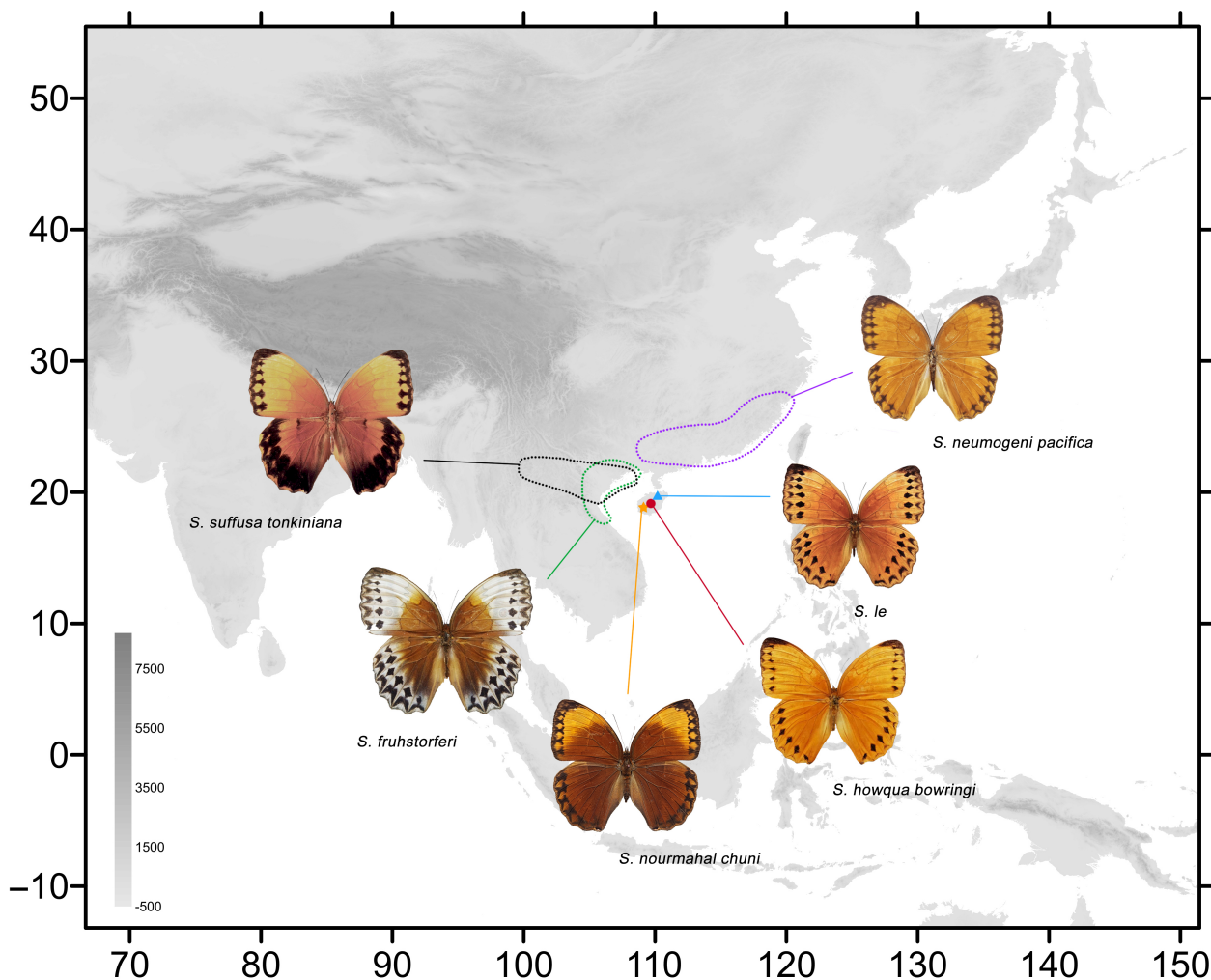


FIGURE 1. Distribution of *Stichophthalma* species in this study.

● **Material and methods**

Voucher specimens examined in this study are deposited in the private collection of Zhuo-Heng Jiang, Kunming, China (JZHC).

Habitus images were taken using a Canon 7D camera in conjunction with a Canon MP-E 65mm f/2.8 1-5X Macro Lens, and a Canon MT-24EX Macro Twin Lite Flash as a light source. Images of the genitalia were taken using a Canon G9 camera mounted on an Olympus CX31 microscope under reflection or transmission lighting. Zerene Stacker (version 1.04) was used for image stacking. All images were edited further using Adobe Photoshop CS6. The dissected genital structures are now stored in pure glycerol in a plastic centrifuge tube placed beside the type specimen in the collection.

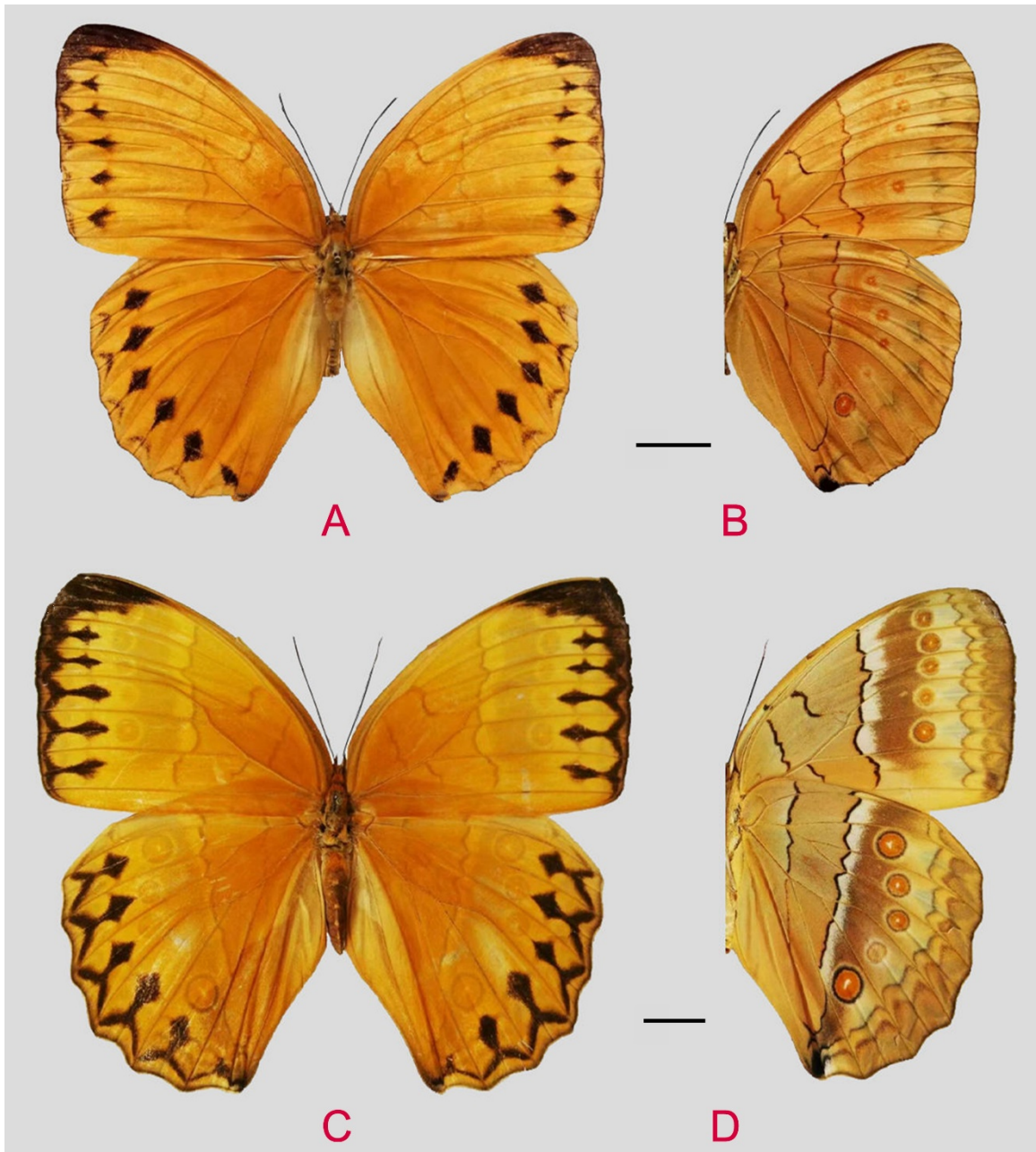


FIGURE 2. Habitus of *Stichophthalma howqua bowringi* Joicey & Talbot, 1921: **A, B** male, Mt. Wuzhishan, Hainan, China **C, D** female, Mt. Jianfengling, Hainan, China. Scale bar = 10 mm.

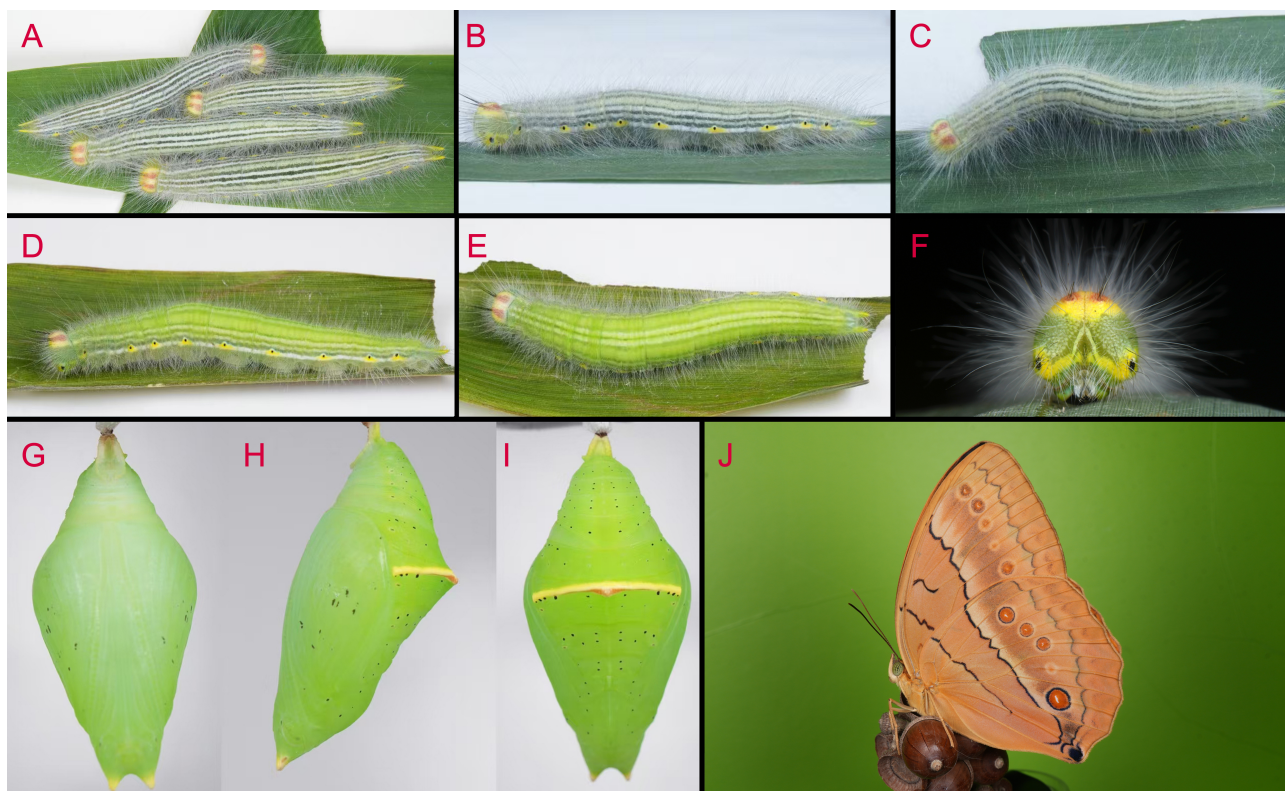


FIGURE 3. Part of Life history of *Stichophthalma howqua bowringi* Joicey & Talbot, 1921, Mt. Wuzhishan, Hainan, China: A–C 7 stage larva D–E final stage larva F front view of larva head G–I different view of pupa E male adult.

● Results

Stichophthalma C. & R. Felder, 1862 箭环蝶属

Stichophthalma C. & R. Felder, 1862, *Wien. ent. Monats.* 6 (1): 27; TS: *Thaumantis howqua* Westwood, 1851.

Stichophthalma howqua bowringi Joicey & Talbot, 1921 箭环蝶海南亚种

Figs 2, 3

Stichophthalma howqua bowringi Joicey & Talbot, 1921, *Bull. Hill Mus.* 1: 172, pl. 23: 19. TL: Hainan.

Part of Life history

Larvae accepted *Indocalamus tessellatus* (Poaceae) (Fig. 3A–E) as a food plant.

7 stage larva (Fig. 3A–C): The head is oval, yellow with a brown stripe and green patches. The body is cylindrical and white-green, covered with dense, soft white setae, with two yellow sharp tails. Both the dorsal and ventral surfaces bear nine blue stripes. The spiracles are black, each encircled by a yellow ring.

Final stage larva (Fig. 3D–F): Generally similar to the early instar but more robust and yellow-green in colour. The blue stripes on the dorsal and ventral surfaces are significantly paler. The head features two black setae on top.

Pupa (Fig. 3G–I): The body is cylindrical and light green, dotted with sparse black spots. The thorax bears a horizontal yellow stripe. The head features two short yellow horns.

Stichophthalma le Joicey & Talbot, 1921 黎箭环蝶

Figs 4, 5

Stichophthalma le Joicey & Talbot, 1921, *Bull. Hill Mus.* 1: 173, pl. 28: 20. TL: Hainan.

Life history

Larvae accepted *Indocalamus tessellatus* (Poaceae) (Fig. 5A–E) as a food plant.

7 stage larva (Fig. 5A–C): The head is oval, green with a yellow zigzag stripe and two orange patches on top. The body is cylindrical and yellow-green, covered with dense, soft white setae, with two yellow-orange sharp tails. Dorsal surfaces bear a wide stripe in blue and ventral surfaces bear three green stripes, the middle is widest and in deep green. The spiracles are tiny.

Final stage larva (Fig. 5D–F): Generally similar to the early instar but more robust and green in colour. The blue stripes on ventral surfaces with a white stripe on each side. The head features two black setae on top and two two black setae below the eyes.

Pupa (Fig. 5G–L): The body is cylindrical and in light green or creamy, dotted with dense sparse black spots. The head features two short orange horns.

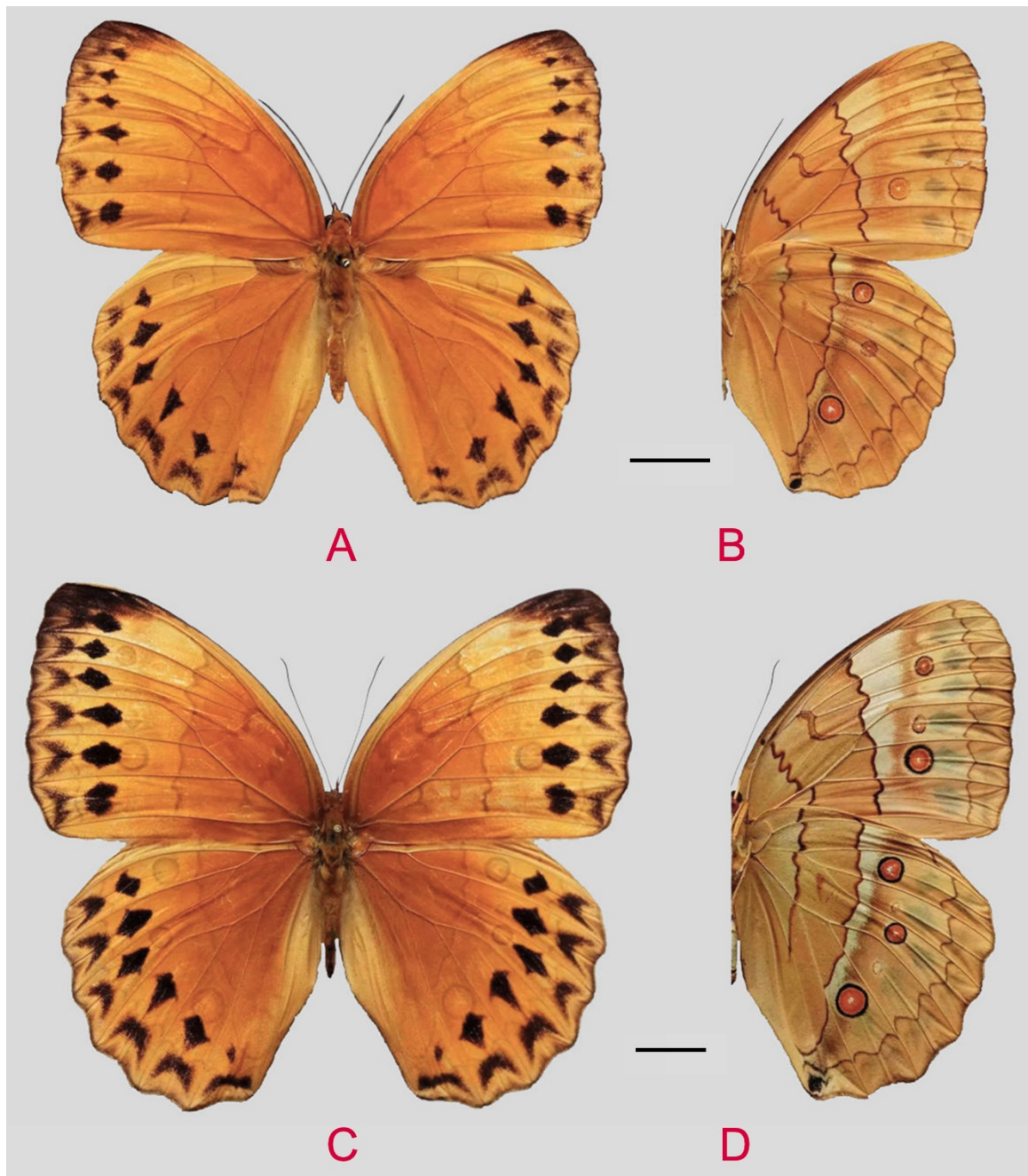


FIGURE 4. Habitus of *Stichophthalma le* Joicey & Talbot, 1921: **A, B** male, Mt. Wuzhishan, Hainan, China **C, D** female, Mt. Jianfengling, Hainan, China. Scale bar = 10 mm.

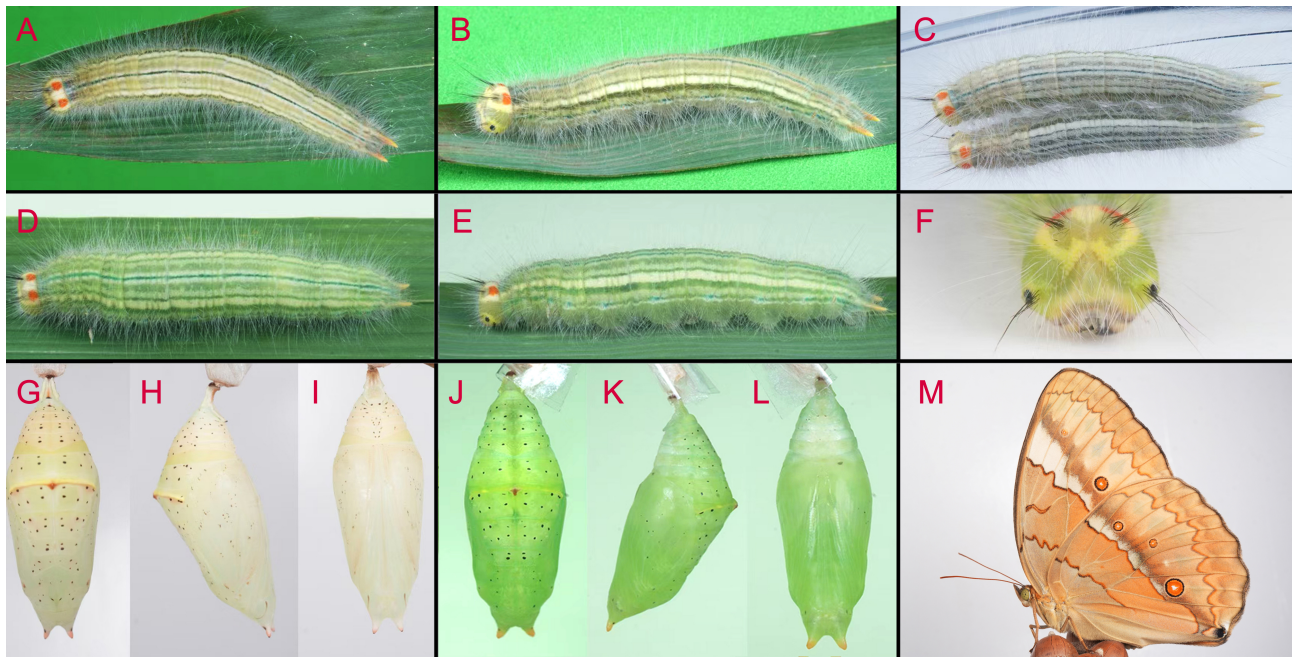


FIGURE 5. Part of life history of *Stichophthalma le* Joicey & Talbot, 1921, Mt. Diaoluoshan, Hainan, China: **A–C** 7 stage larva **D–E** final stage larva **F** front view of larva head **G–L** different view and color of pupa **M** male adult.

Stichophthalma nourmahal chuni Joicey & Talbot, 1921 心斑箭环蝶海南亚种

Figs 6, 7

Stichophthalma nourmahal chuni Joicey & Talbot, 1921, Bull. Hill Mus. 1: 172, pl. 23: 18. TL: Hainan.

Life history

Larvae accepted *Indocalamus tessellatus* (Poaceae) (Figs 7B–F, 8) as a food plant.

Egg: Oval and semi-transparent, appearing turquoise in colour (Fig. 7A).

3-5 stage larva (Fig. 7D–F): The head is oval, yellow with three brown patches and two orange spots on top. The body is cylindrical and yellow-green, covered with dense, soft white setae, with two yellow-green sharp tails. Dorsal surfaces bear three stripe in purple, the middle is widest. The spiracles are tiny.

Final stage larva (Fig. 7G–I): Generally similar to the early instar but more robust and green in colour. Dorsal surfaces bear a loose purple stripe and ventral surfaces bear three green stripe. The head features two black setae on top.

Pupa (Fig. 7F): The body is cylindrical and in yellow-green or creamy, dotted with dense sparse black spots. The thorax bears a horizontal yellow stripe and a ochre patch, middle abdomen with a yellow stripe and dotted three ochre spots. The head features two short yellow-orange horns.

● Discussion

The three *Stichophthalma* species from Hainan, China, belong to three different species-groups: *S. howqua bowringi* Joicey & Talbot, 1921, belongs to the *howqua*-group; *S. le* Joicey & Talbot, 1921, belongs to the *cambodia*-group; and *S. nourmahal chuni* Joicey & Talbot, 1921, belongs to the *nourmahal*-group (Lang 2010).

S. le can be immediately distinguished by its unique brown-yellow wings with a simple arrow pattern (Fig. 4), in contrast to the more elaborate patterns and larger white or indigo wings of other species in the *cambodia*-group. However, its head pattern of final stage larva is very similar to that of *S. fruhstorferi* from southern Guangxi and northern Vietnam (Fig. 9C, 9F), which ground color is olive with white hairs, a “W” shaped stripes in yellow near

the top of the head, two semicircle yellow patterns and two black tufts near the eyes, two red spots and black tufts on top of the head and a brown semicircle stripe near the mouthpart. *S. le* is region geographically proximate to Hainan Island (Fig. 1) in *cambodia*-group, close to *S. fruhstorferi* according to our phylogenetic analyses in genus *Stichopthalma*.

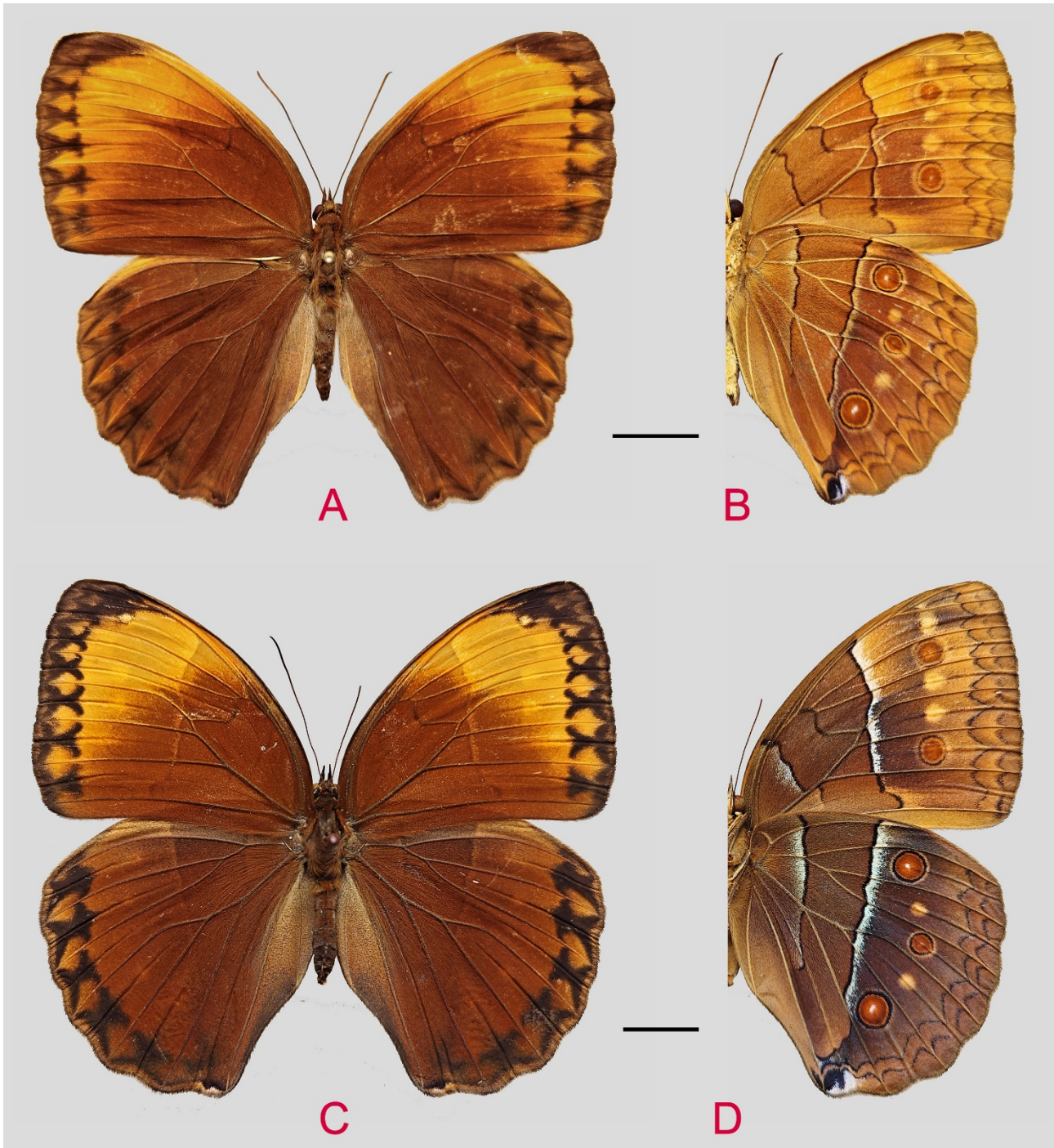


FIGURE 6. Habitus of *Stichopthalma nourmahal chuni* Joicey & Talbot, 1921: **A, B** male Mt. Wuzhishan, Hainan, China **C, D** female, Mt. Jianfengling, Hainan, China. Scale bar = 10 mm.

The head pattern in final stage larval of *S. howqua bowringi* is similar to that of *S. suffusa tonkiniana* from southeastern Yunnan, southern Guangxi, and northern Vietnam (Fig. 9B, 9E), which ground color is olive or deep green with mixed black and white hairs, a upside down “Y” shaped pattern on metopic in yellow or creamy, a semicircle pattern on the top of the head in yellow or yellow greenish (*S. howqua bowringi* with two more red spots)

and two yellow greenish circle stripe near the eyes and mouthpart. Nevertheless, the speciation between *S. howqua* and *S. suffusa*, as well as the relationships among the four subspecies of *S. howqua* (*S. h. howqua* (Westwood, 1851) from eastern and central China; *S. h. bowringi* Joicey & Talbot, 1921 from Hainan Island; *S. h. formosana* Fruhstorfer, 1908 from Taiwan Province; and *S. h. lapetus* Brooks, 1949 from southeastern Yunnan and northern Vietnam), and their similar species namely *S. spart* require further study. Future work should include records of their life history, supported by morphological and phylogenetic analyses.

S. nourmahal chuni from Hainan (Fig. 6) is morphologically and phylogenetically similar to *S. neumogeni* Leech, 1892, particularly in the larval head pattern (Fig. 9A, 9B), which ground color is creamy with mixed black and yellow hairs, a brown triangle pattern and a orange spots on metopic, two red spots and black tufts on the top of the head and two pale brown irregular shaped patterns near the eyes, a purple brownish circle stripe near the mouthpart. These two species compose the *nourmahal*-group (Lang, 2010). The distribution of *S. nourmahal chuni* is geographically distant from the other two subspecies of *S. nourmahal*—namely *S. n. nourmahal* (Westwood, 1851) from northeastern India and Nepal, and *S. n. nurinissa* de Nicéville, 1890 from Bhutan—but is close to *S. neumogeni regulus* Brooks, 1949 from northern Vietnam and *S. n. pacifica* from eastern and southeastern China (Lang 2010). Consequently, the speciation between *S. nourmahal* and *S. neumogeni* is a complex issue that also warrants further investigation according to our phylogenetic analyses.

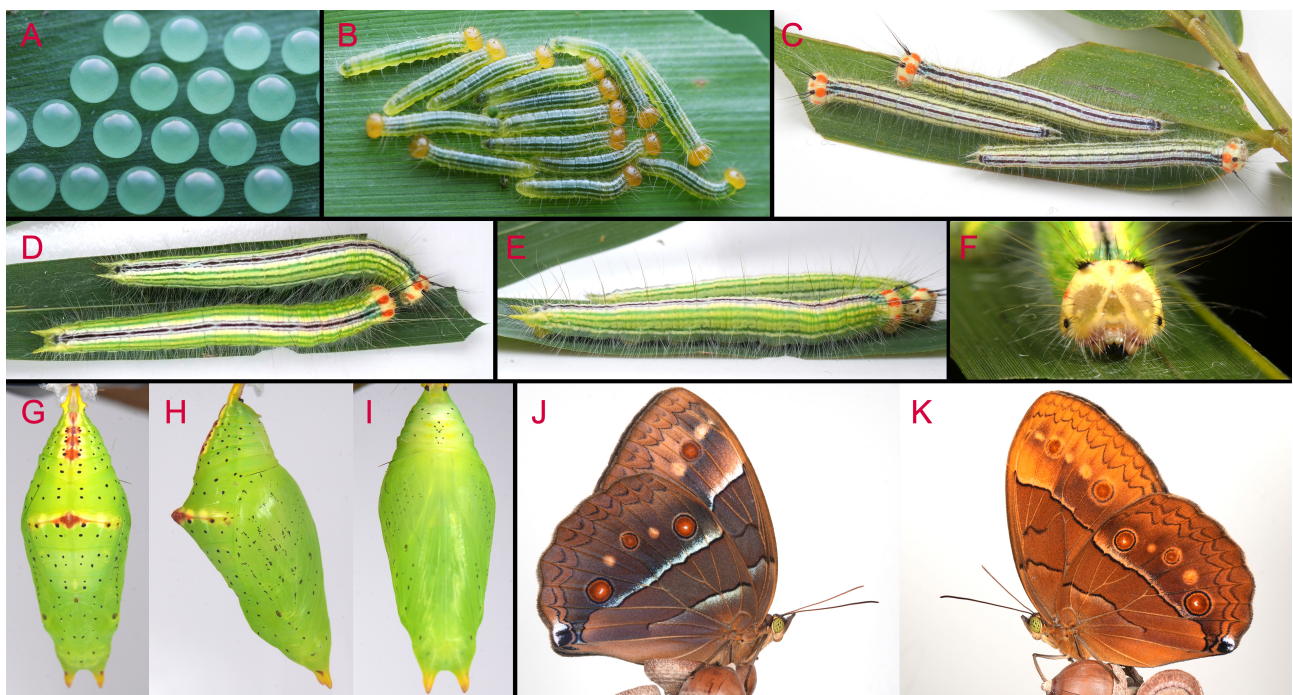


FIGURE 7. Part of life history of *Stichophthalma nourmahal chuni* Joicey & Talbot, 1921, Mt. Diaoluoshan, Hainan, China: **A** eggs **B–C** 3-5 stage larva **D–E** final stage larva **F** front view of larva head **G–I** different view of pupa **J** female adult **K** male adult.



FIGURE 8. A a female adult of *S. nourmahal chuni* Joicey & Talbot, 1921 is observed in a patch of middle-elevation tropical Rainforest in Mt. Diaoluoshan, Hainan, China laid several eggs on *Indocalamus tessellatus* B habitat of *S. nourmahal chuni* Joicey & Talbot, 1921.

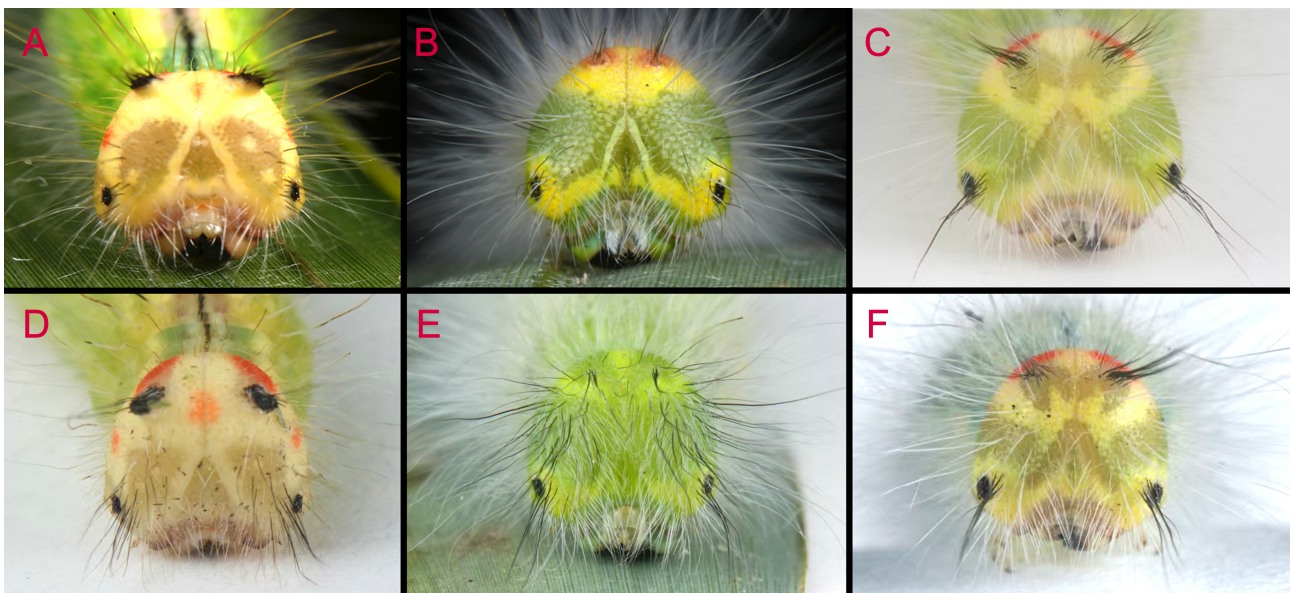


FIGURE 9. Comparison of head patterns and color in final stage larva of *Stichophthalma* species from Hainan and their similar species: A *S. nourmahal chuni* Joicey & Talbot, 1921 from Mt. Diaoluoshan, Hainan, China B *S. howqua bowringi* Joicey & Talbot, 1921 from Mt. Jianfengling, Hainan, China C *S. le* Joicey & Talbot, 1921 from Mt. Diaoluoshan, Hainan, China D *S. neumogeni pacifica* Mell, 1942 from Mt. Jiulongshan, Zhejiang, China E *S. suffusa tonkiniana* Fruhstorfer, 1901 from Malipo, Yunnan, China F *S. fruhstorferi* Röber, 1903 from Chongzuo, Guangxi, China.

● Acknowledgements

We are obliged to Mr. Zhi-Yuan Tang (Beijing, China) for providing images of living adult. This study was funded by grant 202305AF150037 from The Academician (Expert) Working Station of the Yunnan Province Science and Technology Department and the Postgraduate Joint Training Base Project for the Integration of Industry and Education of Yunnan University.

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<https://doi.org/10.1111/j.1365-2311.1851.tb02495.x>

● Additional information

Author contributions: Conceptualization: Z-H Jiang. Project administration: Z-H Jiang. Resources: Z-F Chen. Supervision: S-J Hu. Visualization: Z-F Chen. Writing—original draft: Z-H Jiang. Writing—review and editing: C Z-H Jiang & S-J Hu.

Conflict of interest: The authors have declared that no competing interests exist.

Data availability: All of the data that support the findings of this study are available in the main text.

Ethical statement: No ethical statement was reported.

Funding: This study was self-funded by the authors.

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