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Further Notes on *Eudocima hypermnestra* (Stoll, 1780) in Taiwan (Lepidoptera, Erebidae, Calpinae)

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Abstract. The oblique striped fruit-piercing moth, *Eudocima hypermnestra* (Stoll, 1780), was first recorded from Taiwan in 2021 based on a single female specimen. The present study provides additional information on adult male and immature morphology. The vine with tuberous stems, *Tinospora crispa* (Menispermaceae), a naturalized plant in Taiwan, represents the restricted host of *E. hypermnestra*. This plant is widespread across Taiwan's lowlands, foothills, and mid-elevation areas along roadsides, suggesting a potentially similar distribution for the moth species.

Keywords: subtropical region, primary piercing, naturalized plant

Introduction

The fruit-piercing moth genus *Eudocima* Billberg, 1820, often harbors large, widely distributed species and is also one of the important targets for pest control in fruit tree agriculture (Zilli & Hogenes, 2002). In Taiwan, five species of this genus are well-known to occur (Sugi, 1992). In 2021, *E. hypermnestra* (Stoll, 1780) was first recorded from Taiwan based on a female voucher specimen. At the end of 2021, a valuable live female individual was obtained through sharing on a Facebook citizen science platform by Mr. Der-Sheng Yang (Taipei). The present study provides additional morphology and bionomic information of this species in Taiwan.

Abbreviation:

ESRI Taiwan Endemic Research Institute, Nantou

NTM National Taiwan Museum, Taipei

NMNS National Museum of Natural Science, Taichung

TFRI Insect collection, Taiwan Forestry Research Institute, Taipei

Material and methods

Rearing - A female adult (TMIN3857) collected from New Taipei City was placed in a plastic container measuring 14x14x25 cm. The female moth laid about 80 eggs in the container before being provided with potential larval host plants. In Thailand, *Tinospora crispa* (Menispermaceae) was recorded as the host of *Eudocima hypermnestra* (Robinson et al., 2023) and was regarded as a non-native plant species in Taiwan (Chen et al., 2017). We chose *T. crispa* and other Menispermaceae plants, e.g. *Cocculus orbiculatus*, *Stephania japonica* var. *japonica*, and *Pericampylus formosanus*, to test as potential hosts for the Taiwanese populations. Subsequently, the larvae only fed on *T. crispa*. They fed on leaves but gradually shifted their preference to stems, especially starting from the 4th instar larvae. Pupae were kept in equally-sized containers and maintained in a moist environment using sphagnum moss until adult emergence.

Molecular data - A right mid leg of the fresh specimen was removed and used for acquiring molecular sequences. We followed the methods provided by Wahlberg and Wheat (2008) to obtain a molecular COI sequence.

Image acquisition - The individuals were photographed using a Nikon Z7 digital camera and AF-S Micro Nikkor 60mm F2.8G ED lens with SB5000 flash covering SMDV Speedbox-Flip diffuser. The images were edited in Adobe Photoshop 2023 (Adobe Inc.).

Results

Eudocima hypermnestra (Stoll, 1780) 斑落葉裳蛾

(Figs 1–2, 5–11)

Phalaena Noctua hypermnestra Stoll, 1780, in Cramer, *Uitlandsche Kapellen* 4: 69, pl. 323, figs A. B.

Rhytia hypermnestra: Moore, 1881: 73, pl. 12, fig. 6, larva, pl. 14, figs 4, 4a, imago ♂♀.

Ophideres hypermnestra: Hampson, 1894: 562; Chen, 1982: 3: 362, pl. 109, fig. 2597

Eudocima hypermnestra: Poole, 1989: 400; Yoshimoto, 1995: 73, pl. 115: 4–5; Chen, 1999: 1089, pl. 56: 9; Zilli & Hogenes, 2002: 163; Kononenko & Pinratana, 2005: 30, pl. 4: 3–4.

Specimens examined. TAIWAN. 1 female, New Taipei City, Xindian District, Rd. Anxiang (220 m), 24.964314, 121.486343, leg. S. Wu, TMIN3928 (NTM); 1 male, same locality, reared from egg laid by TMIN3928, emgd. 16. III. 2021, CB1278, slide TMIN3857 (NTM; GenBank accession number OR214914; figs 1); 1 female, same data as the former, SWC2023-0026, TMIN3858 (NTM); 2 females, same data as the former, emgd. 25. II. 2021, TMIN3928 & 3929 (NTM). 1 female, Taipei City, Xiangshan Trail, 25-I-2022, H. Lee, TMIN3947 (NTM).

Diagnosis. The female adults of *Eudocima hypermnestra* (Fig. 2) have multiple white patches on their forewings, which is a unique characteristic among *Eudocima* species in Taiwan. The male adults of *E. hypermnestra* (Fig. 1) have a similar appearance to the male adults of *E. phalonia* (Linnaeus, 1763) (Fig. 3), with both having oblique straight lines on the hindwings. However, the base color of the forewings in male *E. hypermnestra* is dark olive green, while it is brown in male *E. phalonia*. Additionally, the female *E. phalonia* (Fig. 4) can be well distinguished by the presence of a white triangular spot located at the median part of postmedial line of the forewing. The larvae of *E. hypermnestra* (Figs 6–11) have a black body color starting from the third instar, with a matte grayish halo on the dorsal side. In comparison, the mature larvae of *E. phalonia* (Fig. 12) have a brown color with a reddish hue.

Description of the immature stage. Moore (1881) illustrated a mature larva of *E. hypermnestra* with its description. Herein, we describe the morphology of the entire immature stage accompanying images:

Egg (Fig. 5) – Approximately 1.1 mm in diameter, round, and yellowish-white.

1st instar (Fig. 6) – Approximately 6 mm in length, with a cylindrical body shape; head yellow with black ocelli; body coloration yellowish-green with black tubercles; legs and prolegs black.

2nd instar (Fig. 7) – Approximately 20 mm in length, with a cylindrical body shape; head and ocelli black; body coloration black with one pair of distinct orange spots located on the lateral side of the 2nd abdominal segment; a few tiny white spots scattered on the lateral side of thoracic and abdominal segments; legs dark brown, prolegs black.

3rd instar (Fig. 8) – Approximately 32 mm in length, with a cylindrical body shape and the dorsal side of 1st, 2nd, 3rd, and 8th abdominal segments swollen, especially 2nd and 8th ones; head and ocelli black; body coloration black tinged with shiny brown; dense tiny white spots scattered throughout the body, fewer on 2nd and 3rd abdominal segments due to a pair of large "eye spots" located on the dorsolateral side of each segment; "ocellate marks (sensu Holloway, 2005)" black, surrounded by yellow and orange margins, with more distinct margins on the latter; a pair of dorsolateral yellow spots located on 1st and 9th abdominal segments, respectively; a pair of oblique yellow stripes located on each of the 5th to 7th abdominal segments; legs black, prolegs dark grey.

4th instar (Fig. 9) – Approximately 46 mm in length, with patterns similar to the 3rd instar but more distinct, with tiny white spots somewhat tinged with light blue; pinkish-white oblique stripes located on each of the 5th to 7th abdominal segments.

Final instar (Fig. 10) – Approximately 67 mm in length, with patterns similar to the previous instar; a pair of dorsolateral spots located on the 9th abdominal segment reduced and yellowish-white in color.

Pupa (Fig. 11) – Approximately 30 mm, with a typical *Eudocima* form, dark rufous.

DNA barcodes. One sequences (584 bp) was obtained from the male Taiwanese specimen deposited in NTM (TMIN3857). GenBank accession number: OR214914.

Distribution. India, Nepal, Thailand, Vietnam, China, Java, New Guinea, the Philippines, Taiwan (Fu et al., 2021).

Bionomics. According to the voucher specimens recorded in the present study, as well as 26 citizen science data deposited in the database of the Taiwan Moth Information Center (<https://twmoth.tesri.gov.tw/>, accessed on 3 March 2024), this species is now distributed in the lower mountain ranges of northern (Taipei, Taoyuan), central (Taichung) and southern (Kaohsiung) Taiwan (date ranging from August 2021 to February 2024, with adult occurrence months including June to Marc), as well as one citizen science record from Kinmen (June, 2019). Duration of the immature stage: Egg stage approximately 8 days, 1st instar approximately 5 days, 2nd instar approximately 5 days, 3rd instar approximately 6 days, 4th instar approximately 6 days, final instar approximately 7 days, pupal stage approximately 24 days (26 days recorded in Moore, 1881).



Figures 1–4. Habitus of *Eudocima* in Taiwan. 1. *E. hypermnestra* (Stoll, 1780), male (NTM); 2. ditto, female (originally in ESRI; hereafter in NMNS); 3. *E. phalonia* (Linnaeus, 1763), male (TFRI); 4. Ditto, female (TFRI). Photo by Shipher Wu.

Discussion

Zilli et al. (2017) designated the lectotype of *Eudocima hypermnestra* and stated that the separation of *E. hypermnestra* from *E. cocalus* (Cramer, [1777] 1779) can be made merely by external appearance, such as the presence of paired black discal spots on the hindwings. However, the recent molecular phylogenetic study by Borth and Kons (2021) showed that the two species form a clade but are not monophyletic. Our study yielded similar results when comparing sequences from GenBank data. The most similar sequence to the current sampled Taiwanese one (OR214914) is from the western Indian *E. cocalus* (Cramer, [1777] 1779) (KX603659) with 99.83% similarity. In contrast, there is 99.53% similarity with sequences from the Asian continental, specifically *E. hypermnestra* from Vietnam, (ON841754) and Tibet (ON841682).

According to the host tests of *Eudocima hypermnestra* larvae in Taiwan, as well as the recorded hosts in India and Thailand in Robinson et al. (2023), this species exclusively feeds on *Tinospora* (Menispermaceae). Since three other plant families, i.e. Anacardiaceae, Rutaceae and Sapindaceae, listed in Robinson et al. (2023) are not known to be related to such well-known and agricultural significant *Eudocima* species based on current knowledge. The only known *Tinospora* species in Taiwan, *T. crispa*, is reported as a recent introduced and naturalized species (Chen et al., 2016; Chen et al., 2017; Chung & Shao, 2024). Additionally, in the article titled "Catalogue of the Naturalized Flora of Taiwan" published by Wu et al. (2004), this plant genus was not listed. According to the present data recorded on the Citizen Science platform – iNaturalist (https://www.inaturalist.org/observations?taxon_id=344276, access on 3 March, 2024), *T. crispa* has been widespread across Taiwan's lowlands, foothills, and mid-elevation areas along roadsides, suggesting a potential similar distribution for the moth species.

Moore (1881) illustrated the mature larvae of *Rhytia cocale* (= *E. cocalus*) from Java and *E. hypermnestra* ranging from India, Burmah (=Myanmar), Andamans and Ceylon (=Sri Lanka). The former are pale grey, while the latter are of a quite dark coloration similar to the Taiwanese ones. When rearing *E. hypermnestra* from Taiwan, we realized its consistent color form at each instar. In comparison, the appearance of a pale grey mature larva recorded by citizen science data (<https://www.inaturalist.org/observations/67963841>) from west India, the sympatric range of these two species, is consistent with Moore's (1881) illustration of *E. cocalus*. Until now, the host plant of *E. cocalus* has not yet been confirmed, hindering access to the moth-plant distribution pattern between *E. hypermnestra* and *E. cocalus*.



Figures 5–12. Immature stage of *Eudocima* in Taiwan. 5–11. *E. hypermnestra* (Stoll, 1780); 5. Egg on *Tinospora crispa*; 6. 1st instar larvae; 7. 2nd instar; 8. 3rd instar larva; 9. 4th instar larva; 10. Final instar larva; 11. Pupa; 12. Final instar larva of *E. phalonia* (Linnaeus, 1763). Photo by Shipher Wu (5-11); Hua-Hua Lin (12).



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臺灣產斑落葉裳蛾之後續註記（鱗翅目：裳蛾科：壺裳蛾亞科）

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摘要: 斑落葉裳蛾 (*Eudocima hypermnestra* (Stoll, 1780)) 於 2021 年首次基於一雌性標本紀錄分布於臺灣。本研究提供了在臺灣雄成蟲與幼生期形態的延伸資訊。本研究確認斑落葉裳蛾之寄主植物侷限於瘤莖藤 (*Tinospora crispa*; 防己科) 此一已知歸化於臺灣的植物，這種植物廣泛分布於臺灣低地、淺山與中高海拔地區的路旁，也因此可預期斑落葉裳蛾的分布格局。

關鍵詞: 亞熱帶地區、主動刺吸式、歸化植物