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FINAL INSTAR LARVAE AND METAMORPHOSIS OF THE HAWKMOTH *THERETRA CLOTHO CLOTHO* (DRURY, 1773) IN SINGAPORE (LEPIDOPTERA: SPHINGIDAE: MACROGLOSSINAE)

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INTRODUCTION

Prior to a recent taxonomic revision by Vaglia et al. (2010), the two recognised subspecies of *Theretra clotho* were: (i) the nominate subspecies *Theretra clotho clotho* (Drury, 1773), and (ii) *Theretra clotho celata* (Butler, 1877) (see: Kitching & Cadiou, 2000). The second subspecies has since been elevated to full species status — as *Theretra celata* (Butler, 1877), and is found from the Moluccas, east to Vanuatu, and south to Australia (Pittaway & Kitching, 2010; Vaglia et al., 2010). A newly described subspecies, *Theretra clotho vincenti* Vaglia & Liyous, 2010 (in: Vaglia et al., 2010) has been assigned to the Philippine populations. The geographic distribution of *Theretra clotho clotho* is within South and Southeast Asia, having been recorded from India, Sri Lanka, Myanmar, Nepal, Thailand, Vietnam, China, Taiwan, Korea, Japan, Sundaland to Timor (Inoue et al., 1997; Vaglia et al., 2010). For the larvae of *Theretra clotho clotho*, two colour morphs are known — green and brown (Pittaway & Kitching, 2010). Here, the larvae and metamorphosis of both colour forms are documented from Singapore, all reared concurrently.

Fig. 1. Two penultimate instar larvae (brown forms) of *Theretra clotho clotho* perched along the leaf underside mid-veins of the climbing vine *Cissus hastata* (Vitaceae), just beside Keruing Hut at the Bukit Timah Nature Reserve, encountered on the night of 10 Mar.2010 at ca. 2035 hours. Larva A (left) possessed a row of ocelli along its flanks, whereas larva B (right) did not. Larva A had a body length of 36 mm, while larva B was 39 mm. Their tail horn lengths were both 15 mm.

OBSERVATIONS

While conducting a faunal survey at the Bukit Timah Nature Reserve on the night of 10 Mar.2010 (ca. 2035 hrs), two penultimate instar larvae of *Theretra clotho clotho* were encountered at eye-level on the undersides of leaves of the vine *Cissus hastata* (family Vitaceae) near Keruing Hut (Fig. 1). Both larvae were of the brown form and possessed a pair of prominent false eyespots at their first abdominal segments (A1). Their tail horns were a deep fuchsia and tapered to a slender tip that was upturned distally, somewhat resembling the tendrils of this climber. One of them (larva A, body length: 36 mm, tail horn: 15 mm) exhibited lateral ocelli on its flanks (A2 to A7), while the other (larva B, body length: 39 mm, tail horn: 15 mm) did not have such lateral patterns. After in-situ photography, both larvae were then collected for subsequent rearing.

Larva A proceeded to its pre-moult phase on the afternoon of 13 Mar.2010 and moulted to its final instar on the morning of 14 Mar.2010 (ca. 1030 hours). Larva B had entered into pre-moult condition on 12 Mar.2010 and moulted to the final instar in the afternoon of 13 Mar.2010. Both larvae continued to feed voraciously in captivity and displayed a rapid increase in body size. Larva A retained its lateral row of supra-spiracular, white ocelli and reached a total body length of 85 mm (Fig. 2). Larva B attained a maximum body length of 75 mm (Fig. 3). Their tail horns were now shorter (at 7 mm), thicker and curved to point rearwards. Upon closer inspection, the tail horn was adorned with a uniform distribution of low tubercles (Fig. 4). The larval spiracles were white, with distinct black outlines and surrounded with a blush of pink.

In the meantime, a repeat nocturnal visit to the same site (Keruing Hut, Bukit Timah Nature Reserve) on 14 Mar.2010 was rewarded with a sighting of a green form final instar larva of the same sphingid species on the same hostplant (Fig. 5). Its body was a soft apple green colour, with a purplish tail horn. The body length was initially measured to be 65 mm, but continued to grow steadily in captivity. On 16 Mar.2010, it was measured to be 73 mm, and by 17 Mar.2010 it had reached a maximum of 80 mm. Its tail horn was 7 mm. On the night of 17 Mar.2010, its body had attained a glossy sheen accompanied by significant darkening of its colours, signaling the onset of its pre-pupal phase (Fig. 6). On the morning of 18 Mar.2010, it had already enshrouded itself with adjacent leaves, fastened with silk, and its colour had become a light purplish brown. On 19 Mar.2010, its body continued to shrink as it gradually released fluids, and by the morning of 20 Mar.2010, pupation was complete. The pupa was a composite of beige and dark brown, and was measured to be 59 × 13 mm (Fig. 7).

Fig. 2. Brown form final instar (larva A, with lateral ocelli) feeding on its climber hostplant. It attained a maximum body length of 85 mm (measured on 18 Mar.2010). Its tail horn was 7 mm.

Fig. 3. Brown form final instar (larva B, without lateral ocelli) attained a maximum body length of 75 mm (measured on 17 Mar.2010), with a tail horn length of 7 mm.

Fig. 4. Posterior close-up of brown form final instar (larva B, as in Fig. 3) to appreciate tail horn shape and ornamentation. It was in the process of expelling a faecal pellet. The cylindrical faecal pellets were between 10–12 mm long and 6–8 mm wide.

Fig. 5. Green form final instar larva of *Theretra clotho clotho* feeding on *Cissus hastata* next to Keruing Hut at Bukit Timah Nature Reserve, encountered on the night of 14 Mar.2010 at ca. 2100 hours. Its body length was 65 mm. Its tail horn length was 7 mm.

Fig. 6. Pre-pupal colouration of green form larva (compare with Fig. 5), observed on the night of 17 Mar.2010 (ca. 2330 hours). It had attained a maximum body length of 80 mm.

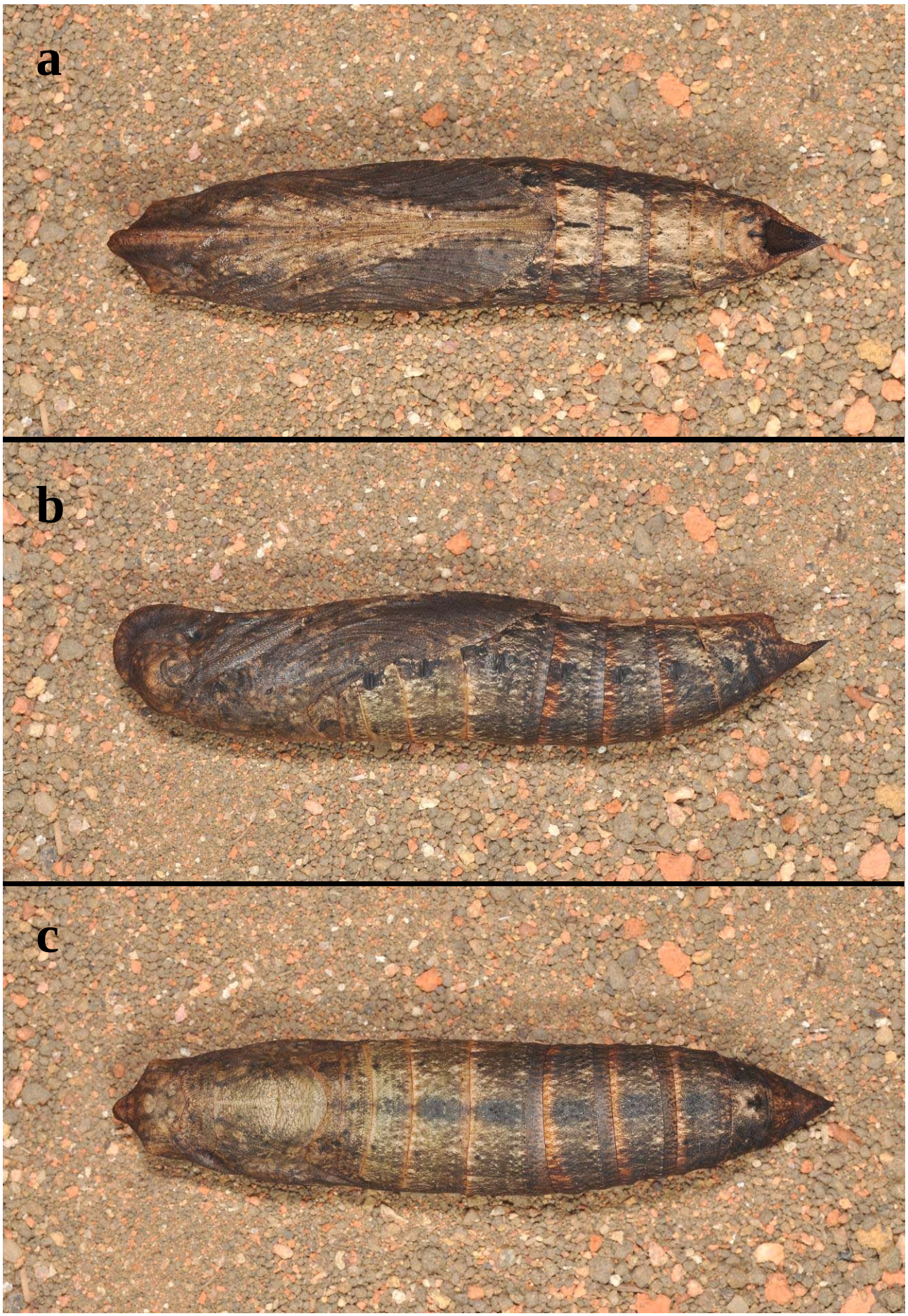

Fig. 7. Ventral (a), lateral (b), and dorsal (c) views of pupa resulting from the green form larva (as in Figs. 5, 6). Pupation was complete by the morning of 20 Mar.2010. The pupa measured 59 × 13 mm.

Fig. 8. Ventral view of an adult male moth (ZRC.LEP.295) that emerged from its pupa (as in Fig. 7) in the early hours of 6 Apr.2010 (0100 hours). Note distinct coupling of the retinaculum (R) and frenulum (F).

On the evening of 5 Apr.2010, the pupal wing discs were noticed to have darkened significantly, the cephalic region had become translucent, and the pupal skin was soft and delicate to the touch. In the early hours of 6 Apr.2010 (ca. 0100 hours), the adult moth eventually emerged as predicted and was determined to be a male (Figs. 8, 9). The retinaculum and frenulum of the underwing were clearly visible from the ventral perspective (Fig. 8). This moth was then preserved as a voucher specimen and deposited at the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR), National University of Singapore, with measurements of its body length (BL) and forewing length (FW) acquired. It was catalogued as ZRC.LEP.295 (BL: 48 mm, FW: 41 mm).

Concurrently, both the brown form larvae were progressing steadily towards pupation. Larva A displayed pre-pupal behaviour and colouration (glossy appearance, darkening of body) in the afternoon of 18 Mar.2010 and enshrouded itself the following day. Larva B had entered its pre-pupal stage on the night of 17 Mar.2010 and enshrouded itself the next morning. Pupation was complete for Larva B by 20 Mar.2010 and its pupa measured 55 × 12 mm. On the night of 4 Apr.2010, signs of pre-eclosion were observed for the pupa of Larva B, and the adult moth emerged in the pre-dawn hours of 5 Apr.2010. This moth was a female and preserved/catalogued as ZRC.LEP.293 (BL: 43 mm, FW: 39 mm).

For larva A, its pupation was achieved by the morning of 21 Mar.2010. Its pupal dimensions were 59 × 13 mm. On the evening of 6 Apr.2010, its pupa began to exhibit signs of pre-eclosion. Later that night, the adult moth emerged at ca. 2345 hours and proceeded to inflate its wings into the early hours of 7 Apr.2010 (Fig. 10). This moth was likewise a female (Fig. 11), and subsequently retained as a voucher specimen (ZRC.LEP.294, BL: 46 mm, FW: 41 mm). The corresponding pupal cases were also retained and preserved accordingly (Fig. 12).

Among the sphingid collection at the ZRC, there is also a local specimen collected from the Central Catchment Nature Reserve (ZRC.LEP.136, female, BL: 44 mm, FW: 43 mm), coll. Derek Liew, 19 Jan.2005, Bukit Kallang, MacRitchie Reservoir forest. The present account of *Cissus* (Vitaceae) being consumed has previously been included among the 14 genera (in eight families) documented as larval hostplants for *Theretra clotho* (Inoue et al., 1997; Robinson et al., 2010).

Fig. 9. Frontal close-up of head region of male moth (ZRC.LEP.295, body length: 48 mm, forewing length: 41 mm) with raised antennae.

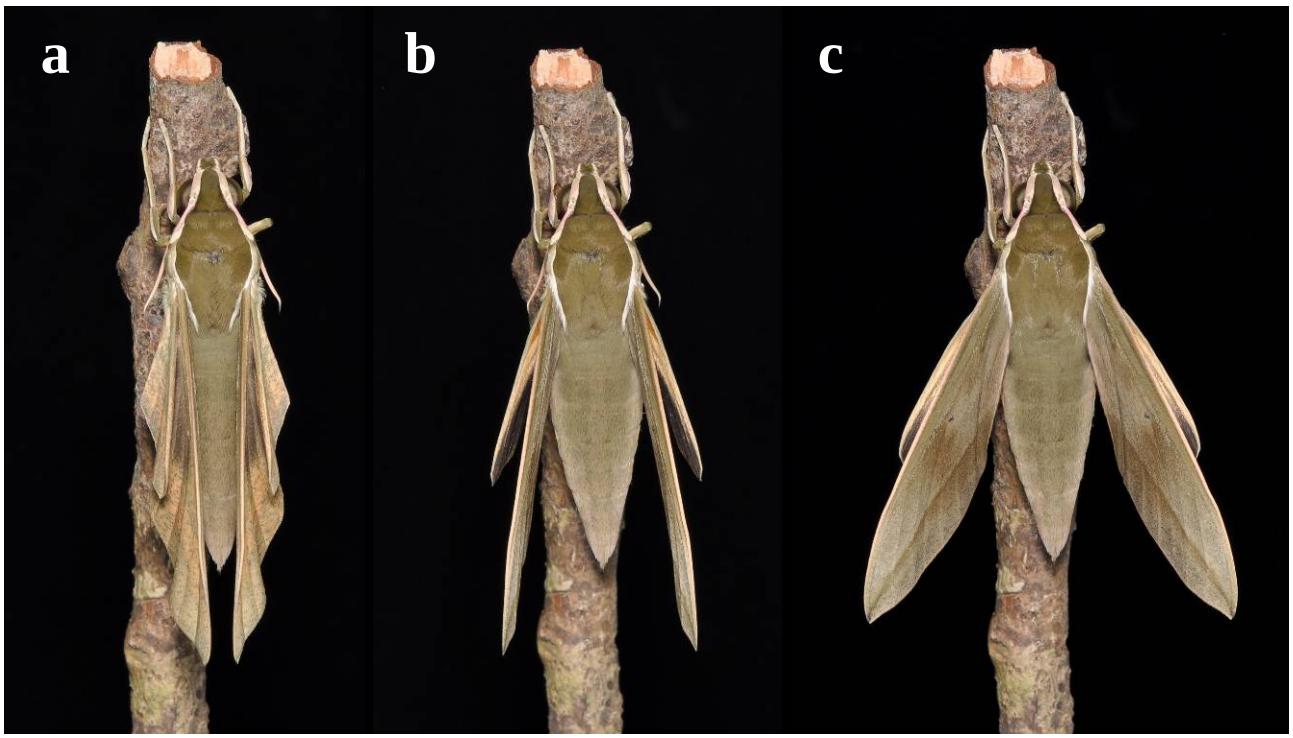

Fig. 10. On the late night of 6 Apr.2010 (ca. 2345 hours), a female moth (ZRC.LEP.294) emerged from its pupa (originally brown form larva A, pupated 21 Mar.2010) and climbed up a branch to facilitate the progressive expansion and extension of its wings. Photographed past midnight, on 7 Apr.2010 at: (a) 0028 hours, (b) 0036 hours, and (c) 0037 hours.

Fig. 11. The female moth at rest (as in Fig. 10, ZRC.LEP.294, body length: 46 mm, forewing length: 41 mm) with its wings fully extended.

Fig. 12. Vacated pupal case (ZRC.LEP.294), post eclosion.

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