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FINAL INSTAR LARVAE AND METAMORPHOSIS OF THE OLEANDER HAWKMOTH, *DAPHNIS NERII* (LINNAEUS) IN SINGAPORE (LEPIDOPTERA: SPHINGIDAE: MACROGLOSSINAE)

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INTRODUCTION

The oleander hawkmoth, *Daphnis nerii* (Linnaeus, 1758), one of the most widely distributed species of sphingid in the world, is known to occur in Africa, southern Europe, Arabia, Afghanistan, Pakistan, India, Sri Lanka, Myanmar, Nepal, Thailand, Yunnan (south China), Hong Kong, Taiwan, the Philippines, Sumatra, Peninsular Malaysia, and North Borneo, and has been introduced to southern Japan, Hawaii, and Guam (Inoue et al., 1997; Beck & Kitching, 2008; Pittaway & Kitching, 2009). Its vernacular name refers to the oleander, *Nerium oleander* (family Apocynaceae), on which its larvae feed, among other members in its family of poisonous, laticiferous plants. Incidentally, the oleander was also first described by renowned Swedish naturalist, Carolus Linnaeus in 1753 (Jarvis, 2009). The final instar caterpillar and subsequent metamorphosis of oleander hawkmoth is described and illustrated here, based on encounters in Singapore.

Fig. 1. Final instar caterpillar of the oleander hawkmoth (*Daphnis nerii*), found on its hostplant, the pinwheel plant (*Tabernaemontana divaricata*) at Ngee Ann Polytechnic on 7 Mar.2009. Its body length was ca. 80 mm, with a tail horn 4 mm long. A freshly expelled faecal pellet is at the bottom left.

OBSERVATIONS

We have had various opportunities to rear the larvae of the oleander hawkmoth from different locations in Singapore and these encounters are here summarized in chronological sequence. In mid-Jan.2005, two final instar larvae were found feeding on the Madagascar periwinkle (*Catharanthus roseus*; Apocynaceae) at Terang Bulan Avenue. The caterpillars were subsequently reared on the pinwheel plant (*Tabernaemontana divaricata*; Apocynaceae), as leaves of the periwinkle diminished drastically owing to their insatiable appetites. Both larvae subsequently pupated (exact dates unrecorded) and both moths eventually emerged on the 5 and 8 Feb.2005, respectively. The two moths were preserved as voucher specimens at the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR), National University of Singapore. Their corresponding catalogue numbers, sex and measurements are as follows (BL = body length, FW = forewing length): ZRC.LEP.118 (male, BL: 37 mm, FW: 30 mm), ZRC.LEP.119 (female, BL: 38 mm, FW: 36 mm).

On the morning of 31 Aug.2008, a prepupal larva was found by Tay Soon Lian (National Parks Board) as it was crawling around on the void deck of Block 415, Yishun Avenue 11. This larva was collected and brought to the attention of TML for subsequent rearing. By the night of 31 Aug.2008, it had already commenced weaving silken threads among leaf debris to enshroud itself. This was followed by contractions of its body, with simultaneous release of fluids, on 1 Sep.2008. By 2 Sep.2008, pupation was complete. On 17 Sep.2008, the dark, symmetrical wing patterns first became noticeable at the wing cases. On 19 Sep.2008, the moth (male) emerged and was subsequently released. Its pupal case was then cleaned and preserved (ZRC.LEP.56).

On the afternoon of 7 Mar.2009 (ca. 1400 hours), at least 10 caterpillars of the oleander hawkmoth were spotted on three adjacent shrubs of the pinwheel plant in the campus grounds of the Ngee Ann Polytechnic. Six caterpillars were collected for ex-situ rearing. The diagnostic larvae exhibited characters consistent with the typical caterpillar form for this species. Its entire body was a pleasant apple green, with a straight, dorso-lateral row of small, aqua-marine dots from its second to seventh abdominal segments, with a chalky white, longitudinal band immediately above this (Fig. 1). There was also a scattering of distinct, white dots from its first to fifth abdominal segments. Its spiracles were jet black, outlined with white.

On its third thoracic segment, there was a prominent pair of ocelli, consisting of an outer, violet ring with a milky white centre, clearly advertised when its defensive posture (head tucked under) was adopted (Fig. 2). Its tail horn was relatively short (by sphingid standards) and had a rounded tip. There was a sparse distribution of low, short spines over the entire tail horn, which was largely citrus-yellow, encircled with a black band in the middle (Fig. 3). The body lengths of this batch of larvae varied between 75–85 mm, with tail horns between 4–5 mm long. One individual was preserved as a larval voucher specimen (ZRC.LEP.123, total length: 80 mm).

Fig. 2. Frontal view of the caterpillar (as in Fig. 1) in defensive posture, with head tucked under while revealing the pair of ocelli on its third thoracic segment.

Fig. 3. Lateral close-up of the caterpillar's posterior to show the shape, size, ornamentation, and colour pattern of its tail horn.

Between 8–10 Mar.2009, the larvae began to exhibit their typical prepupal colour changes and restless behaviour. The previously apple-green body had transformed to a dirty orange on the flanks and an olive-brown on the dorsum (Fig. 4). A symmetrical pair of round, black patches had also appeared on the top of its first thoracic segment, just posterior to its head. The thick rings of its false eye spots had darkened to a black outline. The yellow of its posterior tail horn had now intensified to orange. Between 10–12 Mar.2009, the pupation process was progressively completed.

The characteristic pupa had an overall light, golden brown colour with symmetrical black pigmentation (Fig. 5). On its venter, the proboscis case was highlighted as a continuous black stripe reaching from the tip of its head to the tip of its wing cases (Fig. 5a). Its abdominal segments were uniformly speckled with small, closely spaced, black dots and patches. Along its flanks, each of the spiracles was distinctly highlighted with a black ellipse (Fig. 5b). On its dorsum, a black midline was present on its thoracic segments, flanked by anterior black patches on the left and right (Fig. 5c). At the apex of its head, a central, elongated black patch was noticeable. In association with the other adjacent pigmentation patterns, the anterio-dorsal perspective of the pupa bore an adorable resemblance to a puppy's face, somewhat comparable to the comic character, "Snoopy" (Fig. 6). The pupal lengths were 56–59 mm, and width: 13–14 mm.

Between the 20 and 22 Mar.2009, pupal darkening was observed, and especially pronounced at the wing cases (Fig. 7). The adult moths emerged sequentially between 21 and 23 Mar.2009 (Figs. 8, 9), of which two specimens were retained, and the rest were released. The specimens were catalogued as follows: ZRC.LEP.120 (male, BL: 41 mm, FW: 38 mm), ZRC.LEP.121 (female, BL: 45 mm, FW: 45 mm). The newly emergent oleander hawkmoths exhibited the attractive and exquisite markings clearly on its upperside, comprising a psychedelic canvas of multiple shades and strokes of green, pink, white, and grey (Fig. 10). In contrast, its underside was less inspiring, with sombre shades of ashy-grey and olive-yellow, including a white mid-ventral stripe along its thorax and abdomen (Fig. 11).

More recently, two full-grown larvae of the oleander hawkmoth were encountered by TML and Kelvin K. P. Lim on 9 May 2009 on Mount Imbiah, Sentosa. The final instar larvae were once again found on the leaves of the pinwheel shrub and subsequently reared in captivity. They attained maximum body lengths of 80 and 85 mm, and entered the prepupal phase on the 12 and 13 May 2009, respectively. Pupation was complete by 14 and 15 May 2009, respectively. The first pupa was 59 × 14 mm, the second: 55 × 13 mm. On the nights of 25 and 26 May 2009, both moths eventually emerged and were preserved, including their pupal cases. They were then catalogued accordingly: ZRC.LEP.156 (female, BL: 47 mm, FW: 45 mm), ZRC.LEP.157 (female, BL: 51 mm, FW: 41 mm).

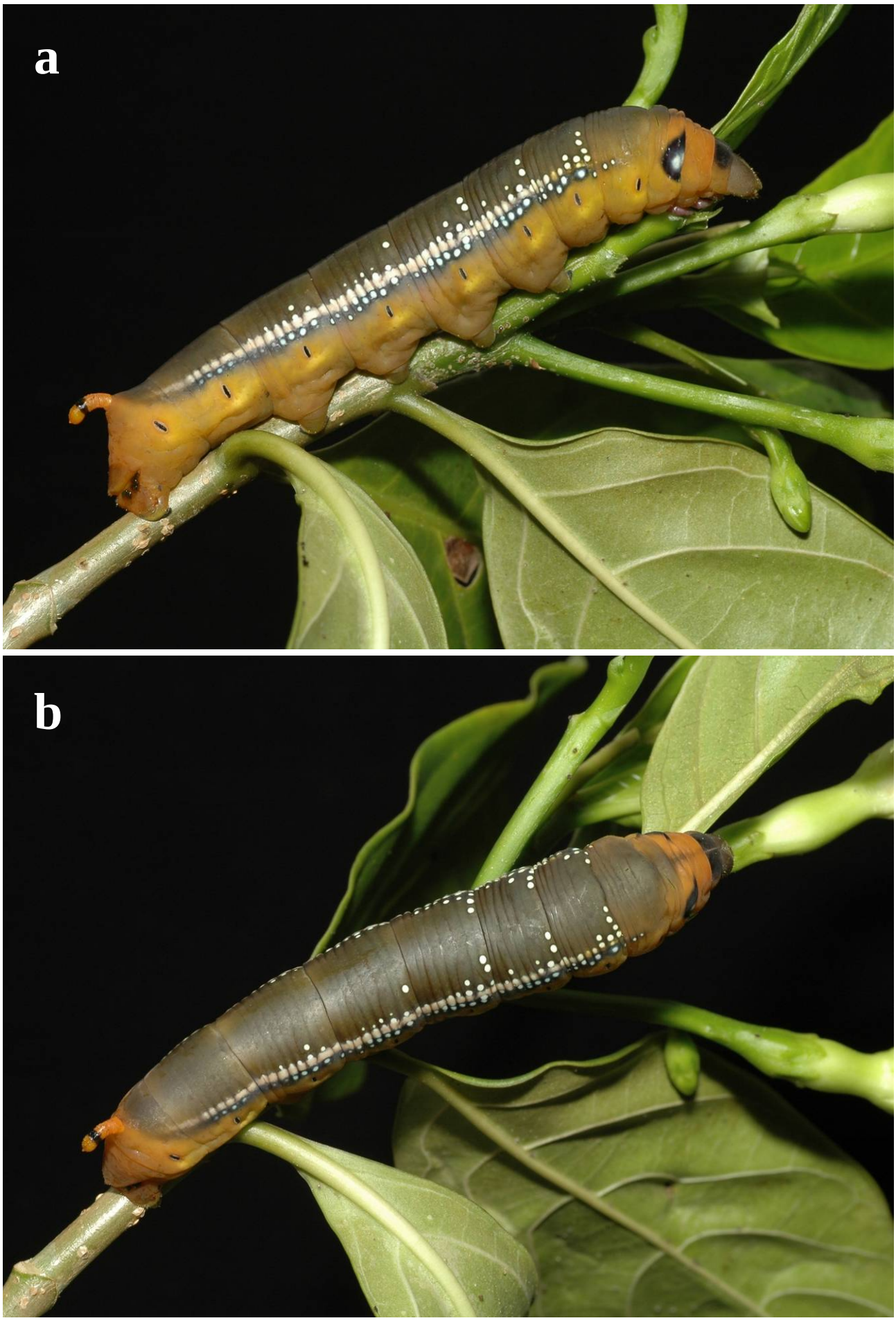

Fig. 4. Lateral (a) and dorsal (b) views of the prepupal larva, photographed on the morning of 9 Mar.2009.

Fig. 5. Ventral (a), lateral (b), and dorsal (c) views of the pupa (56 mm x 13 mm). Photographed on 14 Mar.2009.

Fig. 6. Anterio-dorsal view of the pupa (as in Fig. 5).

Fig. 7. Ventral view of pre-emergent pupa, with dark, symmetrical markings clearly visible at the wing cases. Photographed on 21 Mar.2009, ca. 0320 hours. Compare with Fig. 5a.

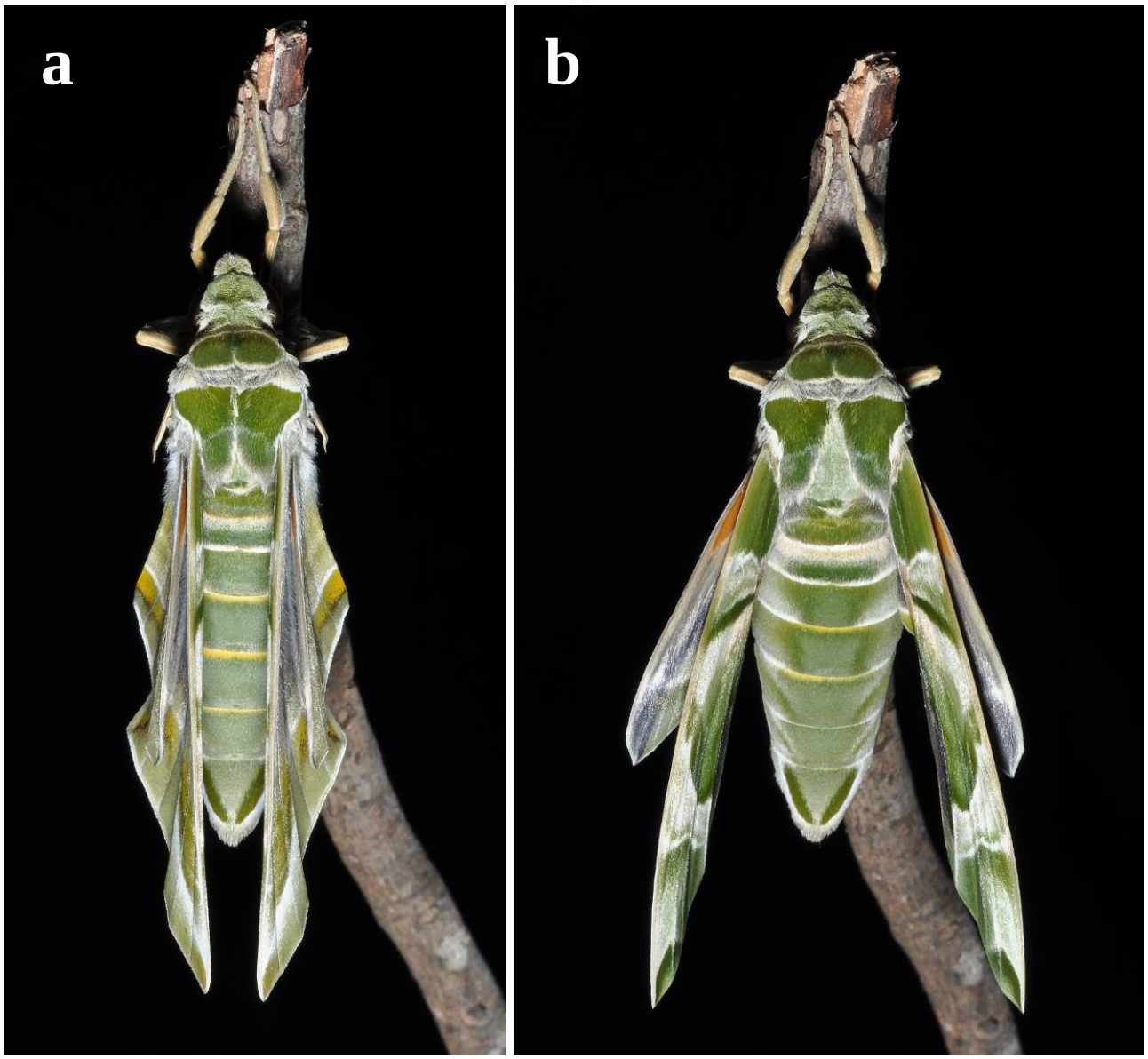

Fig. 8. Dorsal views of the adult female (ZRC.LEP.121), shortly after emergence on the night of 23 Mar.2009; photographed at ca. 2155 hours, when its wings were still being expanded and dried (a), and at ca. 2205 hours, when its wings began to fold down (b).

In addition to the adult voucher specimens of the oleander hawkmoth personally reared by us, there are also other specimens deposited in the ZRC, collected previously as adults by other individuals. These include: ZRC.LEP.115 (female, BL: 47 mm, FW: 50 mm, coll. Tay Guay Kim, 12 Oct.1981, Ramsgate Road), ZRC.LEP.116 (female, BL: 48 mm, FW: 45 mm, coll. S. Aziz, 21 Feb.1990, Clifford Centre), and ZRC.LEP.117 (male, BL: 48 mm, FW: 42 mm, coll. Jean Yong, 1 Apr.1992, Kent Ridge).

Descriptions and illustrations of the larva and pupa of the oleander hawkmoth were provided previously by Bell & Scott (1937), with more recent works by Pittaway (1993) and Pittaway & Kitching (2009). Throughout its broad geographical distribution, the combined list of documented larval hostplants for the oleander hawkmoth comprises no fewer than 32 genera in 12 families, clear indications of a polyphagous diet (Pittaway, 1993; Inoue et al., 1997, Robinson et al., 2009). However, there appears to be a strong preference for plants in the family Apocynaceae, with at least 17 genera (more than half) recorded.

A most probable advantage of consuming potentially poisonous plants in this family would be the chemical defense that the larvae would be able to derive from them. For example, the leaves and other parts of the oleander contain a potent concoction of cardiac glycosides (cardenolides), such as oleandrin, which can cause nausea, vomiting, weakness, irregular pulse and decreased heart rate (van Wyk & Wink, 2004; Wee, 2005; Stewart, 2009). The oleander has even been responsible for occasional fatalities in humans (e.g., Wasfi et al., 2008). Hence, the caterpillars' consumption of plants in the Apocynaceae would confer the larvae considerable deterrence against a variety of predators.

Fig. 9. Dorso-lateral view of newly emerged adult (as in Fig. 8) close to complete expansion of wings.

Fig. 10. Dorsal view of newly emerged female (ZRC.LEP.121, body length: 45 mm, forewing length: 45 mm).

Fig. 11. Ventral view of newly emerged female (ZRC.LEP.121).

In Singapore, another species of the genus *Daphnis* Hübner has been recorded, based on personal encounters and museum specimens of adults. The hawkmoth, *Daphnis hypothous* (Cramer, 1780) is also found throughout Asia, but is not as far-reaching as the oleander hawkmoth (Inoue et al., 1997; Beck & Kitching, 2008). Thus far, we have yet to document the immature stages of *Daphnis hypothous* in Singapore and would be most keen to receive any subsequent reports and feedback on possible sightings of their larvae, along with the hostplant(s). However, it is interesting to note that *Daphnis hypothous* appears to have a greater affinity for hostplants in the family Rubiaceae, rather than Apocynaceae (Inoue et al., 1997).

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