

FINAL INSTAR CATERpillARS AND METAMORPHOSIS OF *ACHERONTIA LACHESIS* (FABRICIUS, 1798) IN SINGAPORE (LEPIDOPTERA: SPHINGIDAE: SPHINGINAE: ACHERONTIINI)

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INTRODUCTION

In Singapore, the genus *Acherontia* Laspeyres is represented by two species, namely *Acherontia lachesis* (Fabricius, 1798) and *Acherontia styx medusa* Moore, 1858 (see Material Examined for a summary of museum specimens of *Acherontia lachesis*). Locally, the characteristic caterpillars of both species have been variously encountered and reared to adults by both of us, with the metamorphosis of *Acherontia styx medusa* having been recently summarised (Leong & Tay, 2011). Here, we focus on the prominent, final instar caterpillars of *Acherontia lachesis* and track their subsequent developments to adulthood. The species occurs in south Japan, China and throughout most of the Oriental Region. It has expanded its range in the last 20 years through New Guinea and most recently into the Bismarck Archipelago (I. J. Kitching, pers. comm.). It has also become established in the Hawaiian Islands (Inoue et al., 1997; Pittaway & Kitching, 2011). The caterpillars show three colour forms: green, yellow and brown (Pittaway & Kitching, 2011). Both yellow and green larval forms are featured in the following account. Details of the pupa, an illustration of a penultimate instar caterpillar, and notes on adult squeaking are also appended.



Fig. 1. Final instar caterpillar (yellow form) of *Acherontia lachesis*, perched on its hostplant, *Stachytarpheta indica* (Verbenaceae) along Sime Track at MacRitchie Reservoir forest on 20 Aug.2008. When its feeding was disrupted, it adopted a sphinx-like posture and thrashed its head towards the left and right. Its total length was 95 mm.

OBSERVATIONS

On the morning of 20 Aug.2008 (ca. 1030 hours), a bright yellow, final instar caterpillar of *Acherontia lachesis* was encountered at knee-level on the shrub, *Stachytarpheta indica* (family Verbenaceae) along Sime Track, MacRitchie Reservoir forest (Fig. 1). Its body length was 95 mm, with a tail horn length of 13 mm. Along its flanks, a diagonal series of seven purple bands were present between abdominal segments one to seven (A1–A7). The spiracles were black. Its thoracic limbs were black, with low whitish tubercles. Well-defined black bands framed the sides of its head (Fig. 2a). Its sinuous tail horn was a uniform yellow, adorned with spines, and tapered to an apical hook (Fig. 2b).

On the 29 Aug.2008, initial signs of pupation were observed and by 2 Sep.2008, the process was complete. By the morning of 26 Sep.2008, the adult hawkmoth (body length: 52 mm, forewing: 54 mm) had already eclosed, whereupon it was released (Fig. 3). The exuvia of its final instar and the vacated pupal case were preserved and catalogued in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR), National University of Singapore (ZRC.LEP.335).

On the morning of 3 Feb.2010 (ca. 0930 hours), a green-form, final instar caterpillar was encountered at shoulder-level on *Solanum torvum* (family Solanaceae) at the Dairy Farm Nature Park. Its body length was 100 mm, with a tail horn length of 12 mm. Its body was an overall translucent green. Along its flanks, a diagonal series of violet bands (underlined with white) was present between A1–A7, with the bands on A7 converging on the dorsum of A8 where the base of the tail horn is located (Fig. 4). Its head was flanked by a pair of black bands (Fig. 5a). The tail horn was well armed with spines and terminated with a tapered loop (Fig. 5b).

On the morning of 5 Feb.2010, the first indications of prepupal changes manifested with the appearance of an orange-brown band along its dorsum (Fig. 6). By the morning of 8 Feb.2010, its entire body had faded to a pale yellow and also contracted significantly (Fig. 7). The very same evening, pupation was complete. However, the pupa did not appear well formed, especially the thoracic segments, which seemed to be loosely connected and relatively leaky. The pupa was measured to be 53 × 15 mm, but never achieved metamorphosis; it might have been infected with parasitoids.



Fig. 2. Close-up views of the anterior (a) and posterior (b) segments of the final instar caterpillar (as in Fig. 1), to appreciate details of its head, thoracic limbs, and tail horn (13 mm in length).



Fig. 3. Newly eclosed adult (body length: 52 mm, forewing: 54 mm) with wings extended on 26 Sep.2008. Note the skull-like pattern on its thorax, which gives rise to its common name — the death's head hawkmoth. Its larval exuvia and vacated pupal case were preserved (ZRC.LEP.335).



Fig. 4. Mature final instar caterpillar (green form) of *Acherontia lachesis* on the pea eggplant, *Solanum torvum* (Solanaceae) at the Dairy Farm Nature Park on 3 Feb.2010. Its total length was 100 mm.

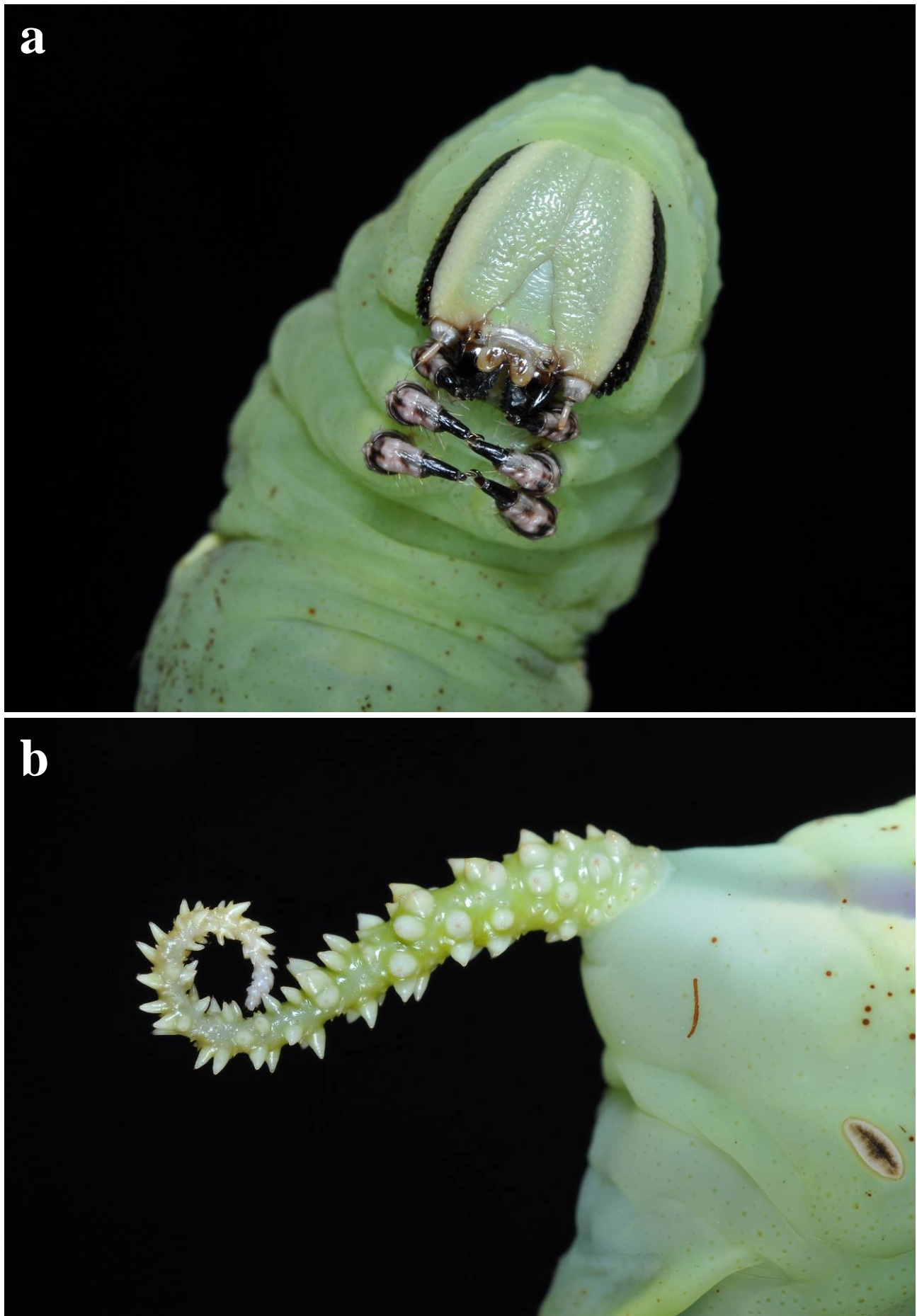


Fig. 5. Close-up views of the anterior (a) and posterior (b) segments of the green-form, final instar caterpillar (as in Fig. 4), to illustrate details of its head, thoracic limbs, and tail horn (12 mm in length).



Fig. 6. Prepupal colouration of green form caterpillar (as in Figs. 4, 5), first noticed on the morning of 5 Feb.2010. Note the broad, orange-brown band along its dorsum.



Fig. 7. Further contraction by the morning of 8 Feb.2010. On the same evening, pupation was complete. However, the pupa did not appear healthy and was likely to have been parasitized.

The prepupal coloration of a yellow form caterpillar was also documented in an individual that had been reared from a penultimate instar larva on *Spathodea campanulata* (family Bignoniaceae) at Hindhede Nature Park on 23 Apr.2010. It had moulted to its final instar on 25 Apr.2010. With the onset of prepupal behaviour (cessation of feeding, increasingly restless pacing) on 30 Apr.2010, the caterpillar displayed an orange band dorsally (Fig. 8). On 1 May 2010, it eventually settled down and the initial contractions of its body were noticeable (Fig. 9). By the early morning of 3 May 2010, its colours had faded to pale beige, with the tail horn appearing limp and deflated (Fig. 10). On its third thoracic segment (T3), the underlying pair of pupal metathoracic plates could already be clearly discerned.

By 1130 hours, the larval exuvia had just been sloughed off entirely, with the freshly exposed pupa glowing with a radiant yellow sheen (Fig. 11a). Progressive darkening of the pupa was then observed, beginning with the abdominal, optical and proboscis regions. By 1930 hours that evening, the pupa was a uniform chestnut brown (Fig. 11b). In time, its brown colour turned even darker and this pupa was subsequently measured as 55 × 15 mm (Fig. 12).

Upon closer inspection, the characteristic morphological characters of this pupa could be readily appreciated. Anteriorly, there is a parallel pair of dark, raised ridges in the proboscis region (Fig. 13). At its posterior end, the stout black cremaster has a fissured texture (comparable to a wrinkled prune) and tapers to an apex bearing two short spines (Fig. 14). Along the flanks of its abdominal segments (A5–A7) are a series of antespирacular ridges [also known as spiracular furrows (Kitching, 2002)] that are particularly noticeable when the abdomen is laterally arched in the opposite direction, away from the viewer (Fig. 15).

From the dorsal perspective, the symmetrical pair of concave metathoracic plates is most prominent, each well delineated by a raised rim and with a matt, velvety texture that contrasts with the overall glossy surface of the pupa (Fig. 16). This velvety appearance is a result of numerous, fine setae therein (Kitching, 2002). A female moth (ZRC.LEP.308, body length: 52 mm, forewing: 46 mm) later eclosed from this pupa on 21 May 2010.



Fig. 8. Prepupal caterpillar (yellow form) pacing around restlessly on the morning of 30 Apr.2010. It was earlier found as a penultimate instar larva on African tulip, *Spathodea campanulata* (Bignoniaceae) at Hindhede Nature Park on 23 Apr.2010. It had moulted to its final instar on 25 Apr.2010.



Fig. 9. The prepupal caterpillar (as in Fig. 8) settled down on 1 May 2010 and began the process of contracting its body.



Fig. 10. The original larval colours had faded considerably by early morning of 3 May 2010 (0830 hours). Its tail horn, previously upright, had become limp and appeared deflated. The underlying pair of dark, metathoracic plates was clearly visible on its third thoracic segment (T3).

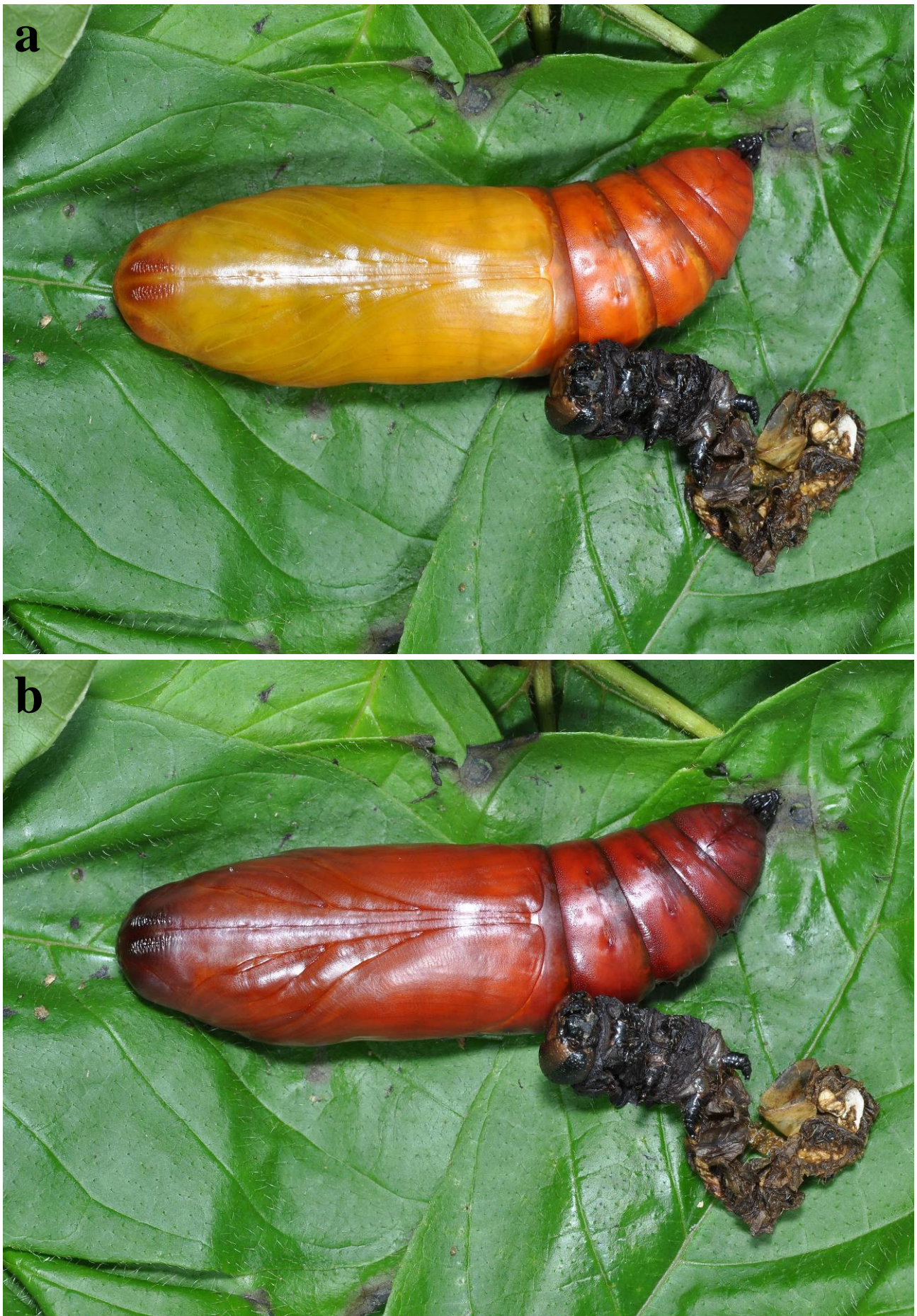


Fig. 11. When the larval exuvia was successfully sloughed off in the late morning of 3 May 2010 (1130 hours), the pupa assumed a radiant, golden-yellow glow at first (a). By the same evening (1930 hours), the pupa had darkened to a warm, chestnut-brown (b).

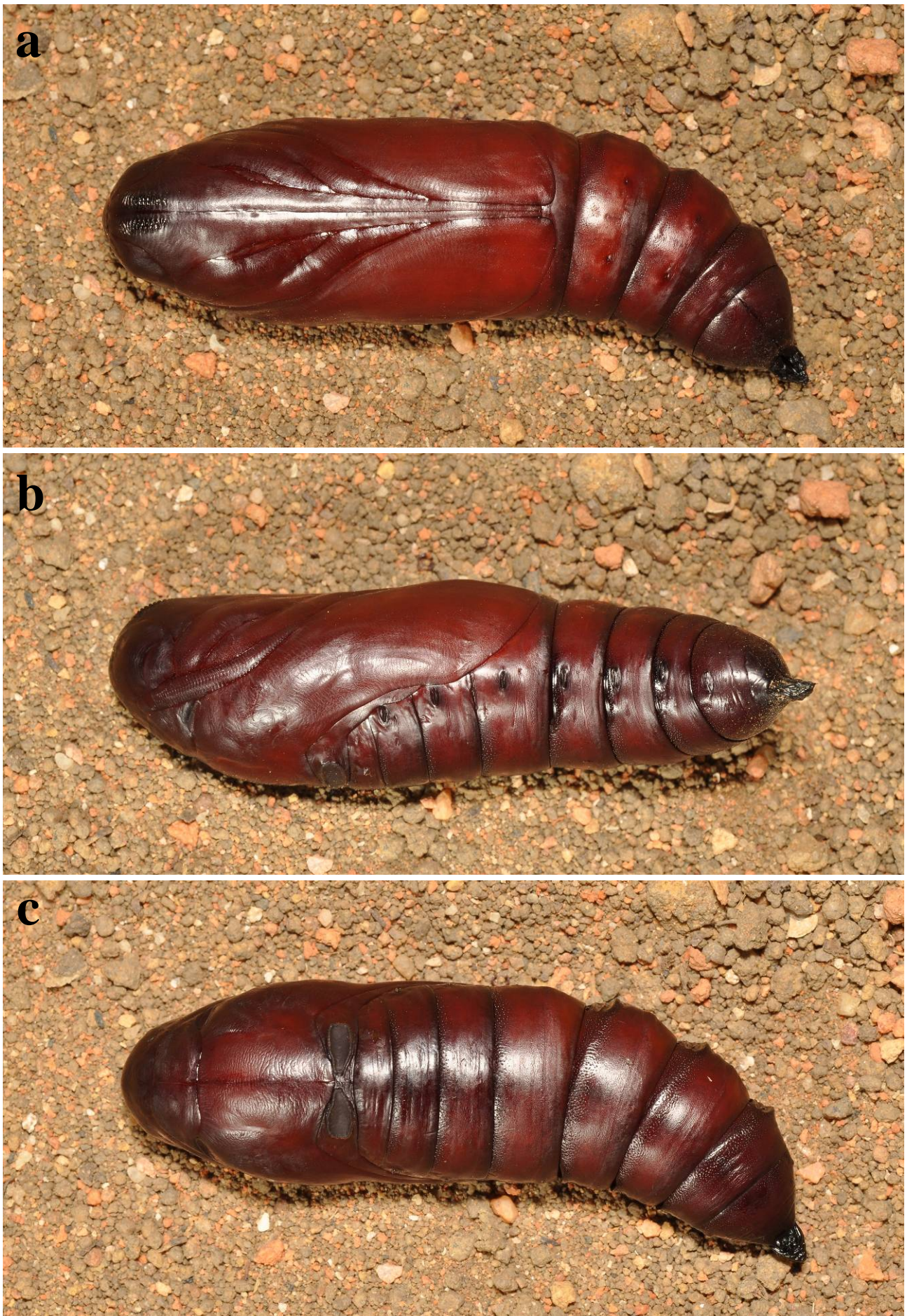


Fig. 12. Ventral (a), lateral (b), and dorsal (c) views of the pupa (as in Fig. 11). The pupal dimensions were 55×15 mm.



Fig. 13. Anterior close-up of the proboscis region (as in Fig. 12a) to show the pair of darkened, raised ridges.



Fig. 14. Posterior close-up of the cremaster (as in Fig. 12a) to illustrate its colour and morphology.



Fig. 15. Lateral close-up (right side, as in Fig. 12b) of the abdominal segments to show the antespирacular ridges (A5–A7). These structures are revealed when the abdomen is flexed towards the opposite direction.



Fig. 16. Dorsal close-up of pupa (as in Fig. 12c) to show details of the concave metathoracic plates.

On the afternoon of 7 Feb.2011, yet another final instar caterpillar (yellow form) was found at waist-level on *Stachytarpheta indica* at Bukit Kallang, MacRitchie reservoir forest. It pupated on 12 Feb.2011 and later emerged on 5 Mar.2011. This moth was preserved as a voucher specimen and catalogued (ZRC.LEP.349, female, BL: 53 mm, FW: 56 mm). During preservation, its proboscis was carefully unfurled and allowed to set in such an extended posture to appreciate its structure and form (Fig. 17). The proboscis length was 17 mm, proboscis width: 2 mm (at base), and tapers to a sharp tip.

Compared to most other sphingids with a much longer and more slender proboscis for the extraction of dilute nectar from flowers, the probosces of death’s head hawkmoths are relatively shorter and more robust, which better facilitates their consumption of viscous honey from within honey bee colonies (Kitching, 2002, 2003). Hence, these moths are considered to be kleptoparasites of honey bees (Kitching, 2006).

In Borneo, *Acherontia lachesis* has been documented to visit colonies of giant honey bees (*Apis dorsata*), with an individual hawkmoth observed to spend about ten minutes within a colony and emerging unscathed thereafter (Koeniger et al., 2010). In this aspect of its biology, *Acherontia lachesis* appears to be host-specific, as are the other two species of *Acherontia*, with *Acherontia styx* associated with *Apis cerana* and *Apis koschevnikovi*, and *Acherontia atropos* associated with *Apis mellifera* (Koeniger et al., 2010).

While most encounters with larvae in the field were of final instars (their large size, bright colours often making them more visible), there were occasional encounters with earlier instars. On 18 Mar.2011, a mid-instar caterpillar was found on *Clerodendrum inerme* (family Verbenaceae) in a garden in Kew Drive. It moulted to the penultimate instar on 19 Mar.2011. Its entire body was green with diagonal blue and white stripes on its flanks (Fig. 18).

The black bands on the sides of its head were accompanied by a white band on the inner margin. Its anterior segments were armed with white spines. Its tail horn was sinuous but the apex did not as yet loop back. The caterpillar attained a body length of 48 mm, with a tail horn of 13 mm. On 23 Mar.2011, it moulted to its final instar (yellow form), then pupated on 31 Mar.2011. On 18 Apr.2011, a well-formed male moth emerged (body length: 59, forewing: 53 mm). Although the moth was not preserved, its associated larval exuvia and pupal case were retained (ZRC.LEP.351).

In the evening, this freshly eclosed male moth was allowed to perch on a tree at the garden where it was first found as a caterpillar. When it was carefully approached with a small stick, the moth would part its wings slightly and raise its abdomen off the bark, revealing the striking blue and black transverse bands along its abdomen. This action was repeated in pulses and often accompanied with audible, squeaking sounds. A brief video clip of this defensive behaviour was recorded and subsequently uploaded (<http://www.youtube.com/watch?v=SPoLUmqOPrY>). Such squeaking noises are produced by a synchronous interplay between pharynx dilation and epipharynx movements occurring at high frequencies (Kitching, 2003).

Acherontia lachesis caterpillars are well known to be polyphagous, with a list of at least 45 hostplant genera in 19 families (Robinson et al., 2011).

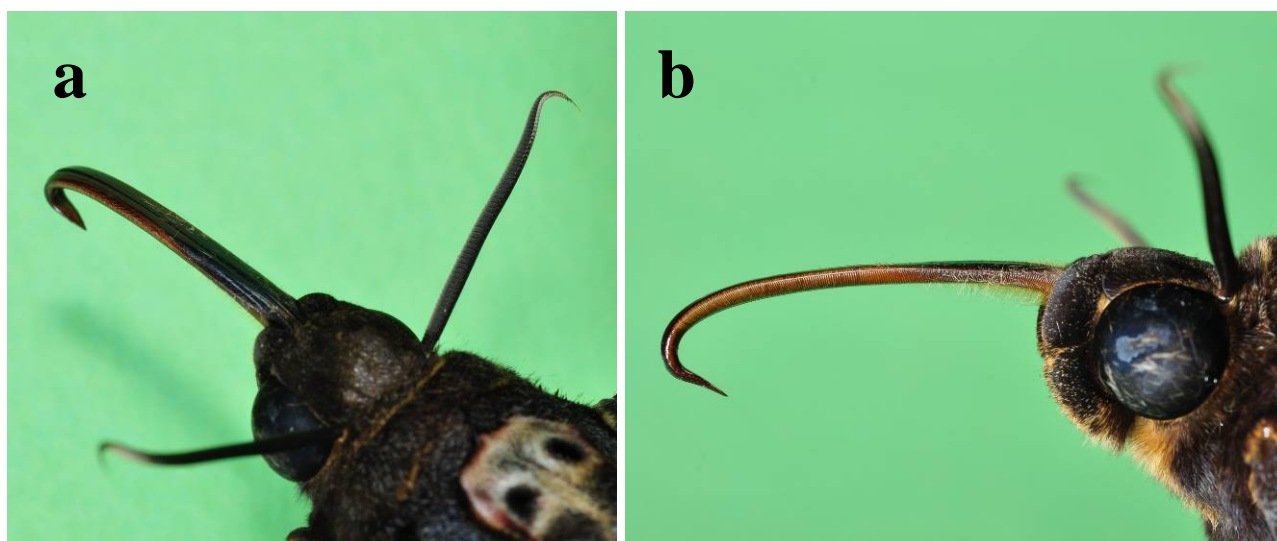


Fig. 17. Dorsal (a) and lateral (b) views of the extended proboscis (ZRC.LEP.349, female, body length: 53 mm, forewing: 56 mm). Its proboscis length was 17 mm, width was 2 mm at the base.



Fig. 18. Penultimate instar caterpillar (body length: 48 mm, tail horn: 13 mm) photographed and measured on 20 Mar.2011. It was found earlier as a mid-instar caterpillar on *Clerodendrum inerme* (Verbenaceae) in Kew Drive. Note the extensive white spines on its anterior segments and lack of a terminal hook to its tail horn. This caterpillar moulted to the final instar (yellow form) on 23 Mar.2011.

MATERIAL EXAMINED

Table 1. Specimens of *Acherontia lachesis* from Singapore, deposited at ZRC, RMBR. [M = male, F = female, BL = body length (mm), FW = forewing length (mm)].

ZRC.LEP.	sex	BL	FW	Locality	Collected by	Date
137	F	55	56	Jurong West.	A. Lok	13 Dec.2004
172	M	48	42	'Reared in lab from pupa.'	unknown	unknown
173	F	55	53	Fort Canning.	F. N. Chasen	5 Feb.1922
174	F	52	53	'Singapore.'	unknown	11 Oct.1948
175	F	53	54	Yio Chu Kang Road.	T. P. Teo	15 May 1978
176	M	47	46	'Singapore.'	unknown	1970–1990
177	F	53	57	Bukit Timah; Hindhede Drive.	H. K. Lua	27 Sep.1989
178	M	50	47	Bukit Timah; Chun Tin Road.	C. M. Yang	18 Oct.1992
179	F	54	56	Clementi Ave 5.	S. Soh	18 Aug.2007
180	M	53	45	Nee Soon pipeline.	T. M. Leong	12 Jun.2001
181	F	49	51	Marina South Park, recent emergent.	L. Chan & T. M. Leong	26 Jun.2005
308	F	52	46	Bukit Timah; Hindhede Nature Park, as penultimate instar larva on <i>Spathodea campanulata</i> (Bignoniaceae). Moulded to final instar (yellow form): 25 Apr.2010; pupated: 3 May 2010; emerged: 21 May 2010.	T. P. Leong & T. M. Leong	23 Apr.2010
349	F	53	56	Bukit Kallang; outside CNR office, as final instar larva (yellow form) on <i>Stachytarpheta indica</i> (Verbenaceae). Pupated: 12 Feb.2011; emerged: 5 Mar.2011.	T. M. Leong	7 Feb.2011
351	M	59	53	Kew Drive; as mid-instar larva on <i>Clerodendrum inerme</i> (Verbenaceae). Moulded to penultimate instar: 19 Mar.2011; moulded to final instar (yellow form): 23 Mar 2011; pupated: 31 Mar.2011; emerged: 18 Apr.2011.	V. D'Rozario	18 Mar.2011

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LITERATURE CITED

- Inoue, H., R. D. Kennett & I. J. Kitching, 1997. *Moths of Thailand, Vol. Two – Sphingidae*. Chok Chai Press, Bangkok. 149 pp, 44 col. pls.
- Kitching, I. J., 2002. The phylogenetic relationships of Morgan’s Sphinx, *Xanthopan morgani* (Walker), the tribe Acherontiini, and allied long-tongued hawkmoths (Lepidoptera: Sphingidae, Sphinginae). *Zoological Journal of the Linnean Society*, **135**(4): 471–527.
- Kitching, I. J., 2003. Phylogeny of the death’s head hawkmoths, *Acherontia* [Laspeyres], and related genera (Lepidoptera: Sphingidae: Sphinginae: Acherontiini). *Systematic Entomology*, **28**(1): 71–88.
- Kitching, I. J., 2006. *The Biology of Death’s Head Hawkmoths, Lepidopteran Kleptoparasites of Honey Bees*. The Central Association of Bee-keepers, Lecture Booklet Series, Poole, UK. 20 pp.
- Koeniger, N., G. Koeniger & S. Tingek, 2010. *Honey Bees of Borneo — Exploring the Centre of Apis Diversity*. Natural History Publications (Borneo), Kota Kinabalu. xix + 262 pp.
- Leong, T. M. & A. Tay, 2011. Final instar caterpillar and metamorphosis of *Acherontia styx medusa* Moore, 1858 in Singapore (Lepidoptera: Sphingidae: Sphinginae: Acherontiini). *Nature in Singapore*, **4**: 13–18.
- Pittaway, A. R. & I. J. Kitching, 2011. Sphingidae of the Eastern Palearctic. <http://tpittaway.tripod.com/china/china.htm>. (Accessed 5 May 2011).
- Robinson, G. S., P. R. Ackery, I. J. Kitching, G. W. Beccaloni & L. M. Hernández, 2011. *HOSTS — A Database of the World’s Lepidopteran Hostplants*. Natural History Museum, London. <http://www.nhm.ac.uk/research-curation/research/projects/hostplants/>. (Accessed 5 May 2011).