First Description of a Female of Antheraea meisteri Brechlin and Notes on Some Pre-Imagines of Three Recently Described Species of Saturniidae (Lepidoptera) from the Tropical Moist Forests of the Andaman Islands

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FIRST DESCRIPTION OF A FEMALE OF *ANTHERAEA MEISTERI* BRECHLIN AND NOTES ON SOME PRE-IMAGINES OF THREE RECENTLY DESCRIBED SPECIES OF SATURNIIDAE (LEPIDOPTERA) FROM THE TROPICAL MOIST FORESTS OF THE ANDAMAN ISLANDS

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ABSTRACT. Between the years 2001 and 2002 four species of Saturniidae were added to the fauna of the Andaman Islands. *Antheraea* (*Antheraea*) *insularis* was raised from a subspecies to a full species (Brechlin & Kitching 2001) and three new species, *A.* (*Antheraea*) *meisteri*, *A.* (*Antheraeopsis*) *rudloffi* and *A.* (*Antheraea*) *cernyi* were described by Brechlin (2001). With these additions the total number of saturniids known from these islands rose from six to ten. While the pre-imagines and the larval food plants of six of these species were discovered and studied since the 1990s (Veenakumari *et al*. 1992, 1996, 2005; Prashanth Mohanraj *et al*.1993, 1998; Prashanth Mohanraj & Veenakumari 2002), we describe and figure some pre-imaginal stages of the three recently described saturniid species (*A. meisteri*, *A. insularis* and *A. rudloffi*), report on the natural host plants of *A. meisteri* and *A. rudloffi*, and describe the female of *A. meisteri*.

Additional key words: *Antheraea meisteri, Antheraea insularis, Antheraea rudloffi*

The Andamans and Nicobars form the northern extremity of the island arc extending from New Guinea through the Lesser and Greater Sunda Islands (Indonesia). Politically a part of India, these islands are home to some of the least disturbed forests of the country. The Saturniidae were among the earliest groups of insects to be collected and studied from the forests of these islands since the British colonized them in the mid nineteenth century. Nevertheless it is clear that the saturniids of these islands are still not fully known as is evidenced by the discovery of a number of new species in the early twenty first century. It is also intriguing that not a single saturniid is known from the Nicobar Islands where the forests are even less disturbed than those of the Andamans and are floristically more similar to the southeast Asian islands which harbor a very rich and varied fauna of Saturniidae (Holloway 1987; Nassig et al. 1996a, b). The immature stages and life histories of the Andaman saturniids were also unknown until the closing decade of the twentieth century. The Saturniidae play a definitive role in nutrient turnover, as the largest Lepidoptera, voraciously feeding on the foliage of different species of native trees. The saturniid fauna of the Andaman and Nicobar islands remains to be studied in all its varied aspects.

Only six species of Saturniidae (described between 1877 and 1914) were known to occur in the Andaman islands (Moore 1877; Jordan 1911; Watson 1911; Peigler 1989) until Brechlin & Kitching (2001) elevated *Antheraea* (*Antheraea*) *insularis* from a subspecies of *A.* (*Antheraea*) *frithi* to a full species and Brechlin (2002) described three new species—*A.* (*Antheraea*) *meisteri*, *A.* (*Antheraeopsis*) *rudloffi* and *A.* (*Antheraea*) *cernyi*—from the Andaman islands. A second species of *Cricula* was mentioned but not described by Watson (1913) from the Andaman Islands but no specimen of this species is known to exist in any museum (Nassig 1990, personal communication). The total number of saturniids now known to occur in the Andamans is ten, and all are endemic to these islands. Until the 1990s all the Andaman saturniids were known from adult specimens only. The pre-imagines of the 6 species originally known from these islands were described and illustrated in color between the years 1992 and 2005 (Veenakumari et al. 1992, 1996, 2005; Prashanth Mohanraj et al. 1993, 1998; Prashanth Mohanraj & Veenakumari 2002).

The species described by Brechlin & Kitching (2001) and Brechlin (2002) are known only from adult specimens. The pre-imaginal stages of these species are not known. We describe and figure some pre-imagines of three of these new species viz., *A. meisteri*, *A. insularis* and *A. rudloffi* and report the natural host plants of *A. meisteri* and *A. rudloffi*. We also figure and describe the female of *A. meisteri* for the first time.

To overcome the problems in the systematics of the genus *Antheraea*, Nassig (1991) proposed the utilization of characters from the life history and the pre-imaginal morphology of these species. He stressed that this would entail the rearing of each species collected in their respective areas of distribution. On this basis he proposed the tentative division of the large subgenus *Antheraea* (*Antheraea*) into four species groups. Subsequent studies (Nassig 1996b) have established the validity of these suggestions, though the phylogeny of the group remains to be worked out.

Materials and Methods

Light traps were employed for collecting adults, while immature stages were collected by searching probable host plants. The collection sites and the mode of collection of each species are summarized in Table 1.

When adult females were collected they were brought to the laboratory and maintained in cages for oviposition. The eggs were then incubated under ambient conditions for hatching and the larvae reared on their respective host plants when known. When the food plants were not known, a number of probable host plants were provided to the larvae and the accepted plant(s) were subsequently provided until they pupated. The rearing methods were otherwise identical to those detailed in Prashanth Mohanraj & Veenakumari (2002).

A. meisteri was collected by looking for fecal pellets on the ground beneath the possible food plants. Fecal droppings of a large lepidopterous caterpillar were first noticed at the base of a *Hopea odorata* (Dipterocarpaceae) tree as the shrubbery beneath it had been cleared and burnt. This tree was situated on a hill about 52m above mean sea level at Garacharma, S. Andaman (Fig. 3d). Some droppings were large and quite fresh indicating the presence of large larvae in the tree.

Since it was not possible for anyone to climb the tree, we used a 50m length of fishing line and a 5mm diameter nylon rope as well as a catapult and a penicillin bottle packed with soil. One end of the fishing line was secured around the neck of the weighted penicillin bottle, while the other end was tied to the nylon rope. The penicillin bottle was then shot over a desired branch of the tree with the catapult. Once the bottle came within reach, it was pulled to draw the nylon rope over the branch. The two free ends of the nylon rope were brought together and 6 or 7 people pulled it (Fig. 3e), until the branch broke and fell to the ground. Each fallen branch was scoured for eggs, larvae or pupae. None were found on the branches brought down on the first two days. Fresh fecal droppings however were visible every day. On the third day, 5 August 2000, we successfully brought down late instar larvae of *Antheraea meisteri* from a branch about 25m above ground level. This time, unlike in earlier instances when branches were brought down (Prashanth Mohanraj & Veenakumari 2002), some larvae were crushed to death by the falling branches (Fig. 1g).

The larvae of *A. meisteri* were reared on the leaves of *Hopea odorata* Roxb. (Dipterocarpaceae) in plastic cages following methods described earlier (Veenakumari et al. 1992, 1996; Prashanth Mohanraj et al. 1993, 1998; Prashanth Mohanraj & Veenakumari, 2002). Four days after collection, they pupated.

Results and Discussion

Months and localities of occurrence. Adults of *A. insularis* were earlier collected in the months of March and November from South Andaman (Brechlin & Kitching 2001). We have found adults in all the months between December and March at Bloomsdale, S. Andaman. We collected all the adults in a light trap in which some of the females laid eggs.

Table 1. Collection localities, mode and stage of collection of the three new species of Antheraea from the Andaman islands.

Species	Locality	Mode of collection	Stage of insect collected
A. meisteri	Garacharma, S. Andaman	Visual search	Larvae
	Mt. Harriet, S. Andaman	Insect net	Adult
A. rudloffi	Mt. Harriet, S. Andaman	Visual search	Larvae
	Wimberleygunj, S. Andaman	Visual search	Larvae
A. insularis	Bloomsdale, S. Andaman	Light trap	Adult; Eggs

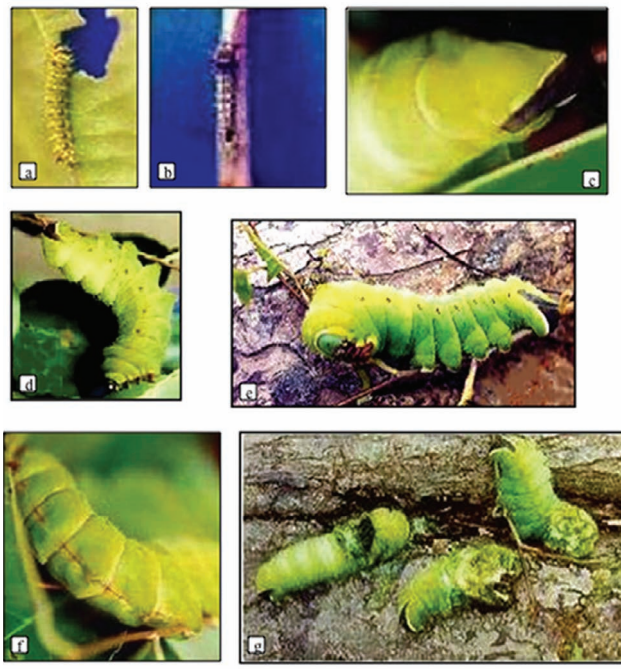
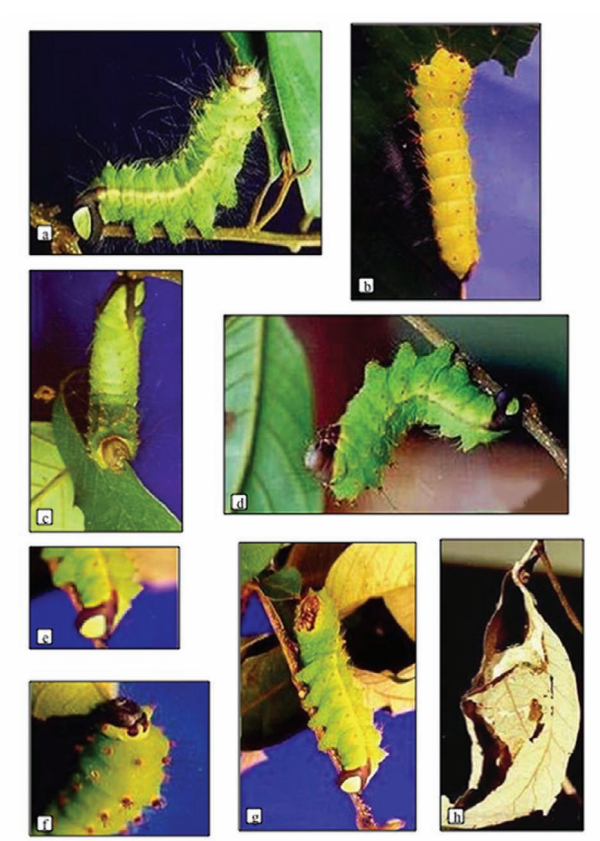
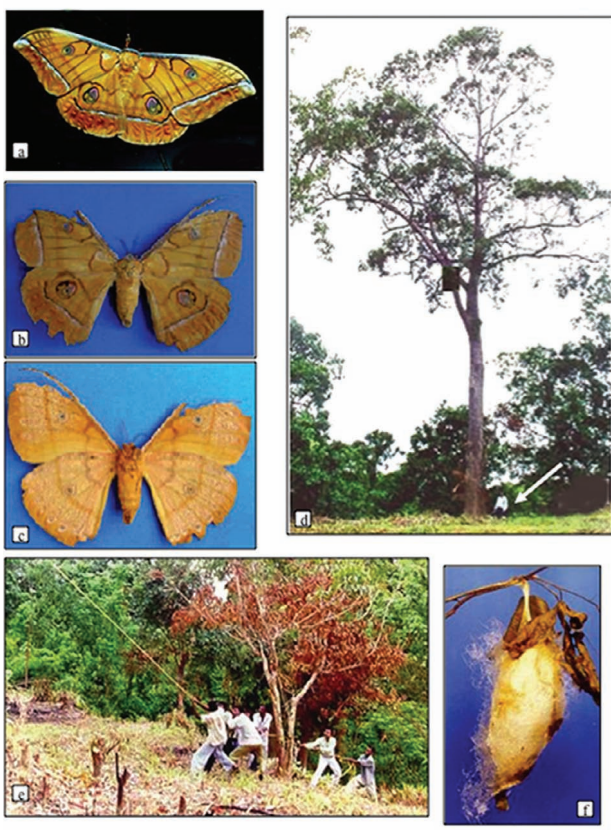


FIG. 1. (upper left column)*Antheraea (Antheraea) insularis* **(a)** first instar larva; *Antheraea (Antheraea) meisteri* **(b)** first instar larva, **(c)** dorsal view of anal segment of fifth instar, **(d)** fifth instar larva, **(e)** fifth instar larva collected from a branch broken by the 'rope method', **(f)** ventral surface of fifth instar larva, **(g)** larvae damaged as a consequence of hitting the ground when the branch was brought down.

FIG. 2. (lower left column) *Antheraea (Antheraeopsis) rudloffi* **(a)** fifth instar larva, **(b, c)** dorsal views of fourth instar larva, **(d)** fourth instar larva, **(e)** triangle on anal proleg of fourth instar, **(f)** close-up of head, prothoracic shield and dorsal thoracic scoli, **(g)** head and lateral view of fourth instar larva, **(h)** cocoon.

FIG. 3. (below right column) *Antheraea (Antheraea) meisteri* **(a)** freshly emerged female, **(b)** dorsal and **(c)** ventral surfaces of pinned specimen. All photographs are of the same female. The wings are frayed in the latter photographs because the virgin female seen in (a) was placed in a wire-mesh cage in a futile attempt to attract males. **(d)** *Hopea odorata* (note relative sizes of man- indicated by arrow- and tree) – the tree from which larvae of *A. meisteri* were collected. **(e)** Field assistants tugging at the nylon rope to bring down a branch suspected to harbor larvae of *A. meisteri*. **(f)** Cocoon of *A. meisteri.*





The first adult specimens of the nominotype of *A. meisteri* were collected in August from Little Andaman (Brechlin 2002). We collected the larvae of this species in August, but from Garacharma in S. Andaman. One adult female was also collected on Mount Harriet on 1 August 1993. This is the second species of Saturniidae reported from Little Andaman (we failed to collect it from this island), the other being *A. andamana* (Prashanth Mohanraj & Veenakumari 2002). The type locality is misspelled as 'Huck' Bay instead of Hut Bay in Brechlin 2002.

Adults of *A. rudloffi* were collected from South Andaman in the months of August and November (Brechlin 2002). We collected adults from Mt. Harriet and Wimberleygunj, South Andaman in the months of March, August and December.

Larval descriptions: (i) *Antheraea (Antheraeopsis) rudloffi* Brechlin 2002. Like the other members of this subgenus, *A. rudloffi* feeds on Lauraceae and has crimson markings. The larvae of this species have prominent burnished, gold markings, which have not been reported in the larvae known in other species in this subgenus (Nassig et al. 1996b). Nevertheless the late instars of *A. rudloffi* have the typical supra-spiracular line characteristic of the genus and the yellow-green "patch" on the anal proleg (akin to the "patch" seen in the Attacini), which is unique to the subgenus *Antheraea* (*Antheraeopsis*). Prior to molting the larvae hang limp and bend sideways (as though infected by a nucleopolyhedrosis virus). When excreting, the larva detaches its anal prolegs from the twig, bends the anal end sideways, extrudes the fecal pellet and then resumes its original position. The morphologies of the fourth and fifth instars of *A. rudloffi* are described below.

***Antheraea rudloffi* fourth instar (Figs. 2b, c, d, g).** Six larvae of *A. rudloffi* were collected in May and August, about 15 feet above the ground on, *Litsea kurzii* King ex Hook f. (Lauraceae), a small understory tree growing along the roadside, in Mount Harriet National Park, South Andaman.

The head is a dull chocolate brown. There is a distinct, prominent chocolate brown band between the head and the prothoracic shield. The prothoracic shield is yellowish with the dorsal scoli being terminally crimson and black basally. The legs are chocolate brown with yellow bases. The prolegs are green with a black band. The crochets are brown.

The spiracles are black in the center surrounded by a crimson border. As the instar matures the spiracle on A8 turns fully yellow. The supra-spiracular line is maroon above and yellow below. The dorsal scoli, with the exception of those on the prothorax are crimson terminally and a combination of black and burnished gold basally. The supra-spiracular scoli are bright crimson with golden yellow setae. Subspiracular scoli are crimson with black setae. Dorsal scoli on A8 are fused and crimson without any golden color. All setae above the spiracular line are golden yellow. The ventral surface is deep green. The supra-anal triangle is small and bluish-green. The triangle on the anal clasper is yellow-green with a black border that is widest at the apex. A faint, but distinct, grey band runs diagonally from the supra-spiracular line to the (imaginary) line joining the supra-spiracular scoli on abdominal segments 1 to 8. The spiracles lie on these diagonals.

Fifth instar (Fig. 2a). The head is very light brown. The legs are brown and are set in a brown ring. The prolegs are light green and of a different shade from the yellow-green of the rest of the body. There are raised black spots on the prolegs with black setae, which are positioned lower on the anal prolegs. The crochets are brown.

The supra-anal triangle, as well as those on the anal claspers, is more yellowish than the rest of the body. The triangles on the anal claspers (Fig. 2e) have a thin, distinct black inner border, which in turn is surrounded by a broad brown grey band. The spiracles are yellow and enclosed in a reddish-brown band. The supra-spiracular line is bicolored; pinkish brown above and yellow below. The dorsal scoli have the shining, metallic, golden basal spot, while the inner basal surface is reddish brown. The subdorsal and the subspiracular scoli are reddish brown below and terminally yellow. All scoli are tipped with black setae. The setae on the surface of the body are long and yellow.

This instar measures 5.7 to 6.9 cm (mean = 6.4cm; n=4) long and pupates in 13 to 14 days (mean = 13.5 days; n=2).

Pupal period. Pupation takes place in a stalked cocoon constructed between leaves (Fig. 2h). The pupal period lasted for 272 days (n=1).

Adults. While adult moths were collected from their natural habitat in March 1997, and December 1998, the laboratory reared individual emerged in June 1999.

(ii) *Antheraea (Antheraea) insularis* (Watson 1914). Four adults were collected between December and March 1997–1998, in a light trap set up at Bloomsdale, South Andaman. The light trap was placed in the center of a rice field, which had a disturbed forest all along one border. The moths laid between 9 and 20 eggs in the light trap. The eggs were 0.6 cm in length and hatched in 9 days. Since the host plant of this species is not known in the Andaman Islands, we provided the newly hatched larvae with leaves of *Dipterocarpus* spp. and *Ficus* spp. The larvae fed minimally on these leaves and died. We therefore describe only the first instar larvae of this species.

A. insularis and *A. andamana* are the only two species of Andaman saturniids belonging to the *frithi* subgroup of the *paphia/frithi* species-group. *A. insularis* failed to feed on Dipterocarpaceae and on Moraceae, though *Ficus* spp. belonging to the latter family are the food plants of *A. andamana* (Prashanth Mohanraj & Veenakumari 2002). Stone (1991) reports Euphorbiaceae and Lauraceae in addition to Dipterocarpaceae as other recorded food plants of *A. frithi*. Future studies will have to test plants from these families as possible food of the larvae of *A. insularis*.

The first instar larva of *A. insularis* as described below is yellow with a black head, prothoracic or cervical shield and anal plate as expected in the species subgroup (*frithi* of *paphia/frithi*) to which this taxon belongs.

First instar (Fig. 1a). This larva measures 0.6cm in length at eclosure and is pale yellow in color. The head is glossy brown; the labrum is brown, but the clypeus is white. The prothoracic shield is glossy black while the anal plate is black.

The legs are brownish – black with deep brown claws and brown crochets. The prolegs are pale yellow with a broad grey band on the outer surface and a row of long, golden, inward curving setae. The anal prolegs have a grayish-black, triangular patch on the outer surface. Crochets are brown in color.

The dorsal scoli on the metathorax and on abdominal segment VIII are black in color, all the rest are pale yellow. The setae on the abdominal scoli are golden-yellow basally and deep brown or black terminally. The setae on the thoracic scoli are black except for a few white ones on the dorsal prothoracic scoli. The spiracular scolus on the prothorax has the largest number of terminal setae, numbering from 20–22. The dorsal and subdorsal abdominal scoli have one terminal, centrally located, seta surrounded by a circle of 4 to 6 setae —while the subspiracular scoli on the abdomen have two centrally located terminal setae surrounded by a circle of 7 setae. The pale brown to whitish spiracles are located in a row of irregular brown to black markings along the spiracular line.

(iii) *Antheraea (Antheraea) meisteri* Brechlin 2002. *A. meisteri* occurs in the *helferi* species-group. It has been found to feed on *Hopea odorata*, a species of Dipterocarpaceae. This is unlike the other species in this group, which are known to feed on Fagaceae, Sapindaceae and Betulaceae. On the other hand, three species of *Antheraea* belonging to the *paphia–frithi* species-group are the only saturniids known to feed on dipterocarps. This could perhaps be one character linking the *paphia/frithi* and *helferi* species groups as sister groups. A further difference is that this is the first report of a species of *Hopea* being used as a larval food plant by *Antheraea*. All other dipterocarp-feeding *Antheraea* utilize *Shorea* spp. only. *Shorea* does not occur in the Andaman Islands. The only two genera of dipterocarps that occur here are *Dipterocarpus* and *Hopea*. Interestingly no dipterocarp is found in the Nicobars. If *A. meisteri* occurs there its larvae will have to utilize a food plant belonging to a different family.

Though food plant utilization by the larvae may indicate that it be placed in the *paphia–frithi* species-group, the green head of the final instar and the yellow color of the cocoon indicate its similarity to the other members in the *helferi* group.

The first and fifth instar larvae as well as the cocoon and the female of this species are described.

First instar (Fig. 1b). The head is the color of honey or golden brown with whitish setae. The maxillae are whitish – grey, the maxillary palps pale brown, the clypeus and labrum whitish, and the labial palps brown. The prothoracic shield is broad, dull yellow-brown.

The dorsal scoli are black on the metathorax and abdominal segment VIII; all other scoli are transparent yellow. Long, brown-black setae arise from the dorsal scoli while setae on all other scoli are white or pale yellow. The area behind the line joining the dorsal scoli on the metathorax is black and extends onto abdominal segment I, where it tapers to a point on the imaginary line joining the dorsal scoli, thus forming a black triangle with its base on the metathorax and apex on the first abdominal segment. There is a broad black band anterior to the dorsal scoli on abdominal segment VIII. The latero-ventral tubercles on the thorax are small, yellow and papilla-like.

There are three lines on abdominal segments I to VII: a broad, brown mid-dorsal line or band between the dorsal tubercles; a brown line between the dorsal and lateral tubercles and a black line between the subdorsal and lateral tubercles.

The lateral prothoracic scoli are the largest of all the scoli. These are bulbous apically and yellow along the basal two-thirds. On the bulbs are situated the setae. The central setae are pale yellow while those on the periphery are brownish black. Dorsal and subdorsal scoli on prothorax are in contact with each other while on all other segments they are separated. The setae on these scoli are long with 2 setae being brown and the remaining pale yellow.

The legs are deep glossy brown basally and pale yellow terminally with brownish black claws. The prolegs are yellow with brown crochets. The spiracles are deep yellow. Transverse brown bands occur on the mesothorax, one of which is anterior and the other posterior to the tubercular line.

The anal shield is pale brown in the center and yellow along the periphery. The anal prolegs have a dark basal patch.

The ventral surface is dirty white to yellow.

Fifth instar (Figs. 1d, e, f). The overall color of the larva is yellow green. The ventral surface is green with a distinct mid-ventral magenta stripe running along the length of the larval abdomen but broken in the spaces between each pair of prolegs, including the space between the anal prolegs.

The head including the frons is apple green and of a shade different from the rest of the body. The labrum is light brown, and the mandibles deep brown. The antennae arise from cream/off-white bases, which are of the same color as the prothoracic band. This is a cream band along the anterior margin of the green prothoracic shield, which is distinctly visible even when the larva stands in its contracted 'S' shaped posture.

All spiracles are deep brown with longitudinal yellow centers bordered by pale yellow halos along their outer margins. Small blue spots with brown setae set in them are present below the spiracles on the first five abdominal segments. A very small, indistinct blue spot is also present on the sixth abdominal segment. In line with these spots, two blue spots are present on the pro- and mesothorax.

The legs are deep burnt brown. The crochets are also deep brown. The prolegs are green with a cream to yellow band above the crochets. The anal claspers have a deep burnt chocolate brown basal and cream band bordering the inner margin.

There are six to eight whitish setae along the anterior margins of the dorsal surface of abdominal segments I to VIII, all of which are directed forwards or towards the anterior end of the larva. The 'supra-spiracular line' is not a separate line but formed by the meeting of the margins of the upper dark green region and the lower light green region and extends from abdominal segments II to VIII.

When the larva assumes its contracted 'S' shaped stance, a pinkish band separates each segment from its neighboring segment except between the pro- and meso-thoracic segments where this band is absent.

Cocoon (Fig. 3f). The larvae pupate in stalked cocoons between leaves. The freshly spun cocoon is pure white in color and later turns golden yellow.

Pupal period: The pupal period in our lone female lasted 20 days.

Oviposition. A virgin female laid 33 eggs in the night within 24 hours after emergence. It laid 141 eggs in 4 days.

Forty eight hours after emergence we placed the female moth in a cage in the field on two consecutive nights close to the *Hopea odorata* tree from which the larvae had been collected. No male moths were attracted to this female.

Adult female. Allotype ♀ (Figs. 3a, b, c). South Andaman island, Garacharma 52m above m.s.l., 28.viii.2000; coll. K. Veenakumari and Prashanth Mohanraj; in coll. National Bureau of Agriculturally Important Insects, Bangalore, India

Additional material: South Andaman island, 1 ♀, damaged, no date; 1 ♀, Garacharma, South Andaman, 1.viii.1993 in coll. R.S. Peigler, Texas A & M University, USA.

Description of adult female. Antennae 17mm long; forewing length 82mm (n=2); Forewing ocelli (11-12mm long and 9mm wide; n=2) tear-drop shaped with hyaline center (3mm diameter, n=2); hind wing length 13mm (n=1) with larger tear-drop shaped ocellus (13mm long and 11mm wide inclusive of eyelid; n=1); hind wing with very small hyaline center; eyelid 3mm long with large prominent yellow center An eyelid of this kind with the yellow center or iris is characteristic of this species.

Wings and abdomen ochre on upper surface; median line faint; antemedian line reddish brown; post median line absent; submarginal line is double colored on both wings, thickly edged with white along the outer margin.

We stress that the female of *A. meisteri* has the distinguishing black 'eyelid' on the hind wing ocellus and exhibits the 'pronounced venation' seen in some forms of *A. helferi* (Nassig 1996a). This, together with the pre-imaginal characters mentioned above, indicates that this does belong to the *helferi* species-group, lending credence to the conclusions of Brechlin (2002).

To conclude, our observations corroborate Brechlin & Kitching's (2001) and Brechlin's (2002) placement of *A. insularis* and *A. meisteri* in the *paphia/frithi* and *helferi* species groups (respectively) of the subgenus *Antheraea* (*Antheraea*). It also substantiates the placement of *A. rudloffi* in the subgenus *Antheraea* (*Antheraeopsis*). It is however important that these species are reared on their natural host plants and their complete life histories studied. It would be ideal if detailed studies on pre-imaginal morphologies along the lines of the study by Rougerie & Estradel (2007) are undertaken for all the saturniids of the Andaman and Nicobar islands.

Of the ten species of saturniids known from the Andaman Islands, five belong to the genus *Antheraea* thus making it the most speciose genus of this family on these islands. Two species of *Antheraea*, viz., *Antheraea andamana* and *A. meisteri*, are the only saturniids on these islands with ranges extending beyond the island of South Andaman. The fact that saturniids have not been collected from even the proximate islands of North and Middle Andaman, which together with South Andaman constitute the Great Andaman (all three of which were one island during periods of sea level lowering in the Pleistocene), clearly indicates the inadequate attempts at collection and the likelihood of the existence of hitherto unknown species in the forests of these islands. Being close to Sumatra and the rest of the SE Asian region, which are rich in saturniids, it is very surprising that so far none have been collected from any of the Nicobar Islands. Increased efforts to look for and collect these moths will reveal the presence of many more novelties on these islands.

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