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Life History of *Attacus mcmulleni* (Saturniidae) from the Andaman Islands, India

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Abstract. The life cycle of *Attacus mcmulleni*, a wild silkmoth endemic to the Andaman Islands (India) in the Bay of Bengal, and its immature stages are described and figured. Comparisons are made to larvae of *Attacus atlas* and *A. taprobanis* from nearby regions (Thailand, Sumatra, southern India). Field observations are given on oviposition, larval feeding and behavior, cocoon formation, and adult emergence. Larvae were reared from eggs on *Rhizophora apiculata, R. mucronata, Vitex glabrata*, and *Zanthoxylum*. *Attacus mcmulleni* is apparently multivoltine. *Anastatus* sp. (Hymenoptera: Eupelmidae), an egg parasitoid, was the only natural enemy found attacking the moth during this study.

Key Words. Andamans, atlas moths, immatures, mangroves, *Rhizophora, Vitex, Zanthoxylum*

Introduction

The genus *Attacus* Linnaeus (Saturniidae) is restricted to the Australasian region and comprises 14 known species, of which 11 are insular endemics (Peigler 1989). Moths in this genus include the largest species of Lepidoptera in the world. *Attacus mcmulleni* Watson, one of these insular species, is endemic to the Andaman group of islands. It was first described as a subspecies of *Attacus atlas* by J. H. Watson (in Packard 1914: 263-264, pl. 91) from specimens collected by W. R. McMullen on the island of South Andaman. In a revision of the genus, Peigler (1989) elevated it to the status of full species on the basis of characteristic and consistent differences in adult facies and genitalia. However, he stated that *A. mcmulleni* is the species that most closely resembles *A. atlas*. Peripherally isolated on the small islands of the Andaman Archipelago (Fig. 7), which are a minimum of 285 km from any continental land mass, and which never came into contact with the adjacent land masses during Pleistocene times when the sea level was lower (Ripley & Beehler 1989, Peigler 1989), *A. mcmulleni* is surmised to have speciated as a vicariant of *A. atlas*, the most widespread species of

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the genus. A well-illustrated geographical glimpse of the Andaman Islands was given by Singh (1975).

Virtually nothing is published on the immature stages and life history of this moth. Pinned adults are rare in collections, with the exception of a series at The Natural History Museum, London. In addition, though the cocoons were briefly described by Watson (in Packard 1914), none were found in any of the major museums accessed by Peigler (1989). This study aims to fill these gaps in our knowledge of this little-known species.

Materials and Methods

Eggs and larvae were located visually on the host plants and collected along with a fresh sprig into transparent plastic containers, the size of which depended on the stage of the insect collected. The containers were cleaned of frass, wiped dry, and the larvae provided with fresh sprigs every day.

The eggs and initial instars were housed in small (8 cm diameter × 11 cm height) containers, while the later instars were reared in larger (9 cm × 19 cm) containers. The presence of head capsules in the rearing containers was used as the indicator for the determination of stadial lengths. This was possible as the larvae were not gregarious in any of the instars and so could be reared individually. All rearings were done indoors at ambient temperature and relative humidity which varied between 27.9 -33.4°C and 75 - 90.1%.

The mature larvae used either the sprig or the sides of the container to spin their cocoons and pupate. A stout twig was placed diagonally in the container to enable the emerging adult to climb up and expand its wings. All measurements were taken during the first cleaning of rearing containers following a molt. Voucher material from the rearing is deposited at the Entomology Section, Central Agricultural Research Institute, Port Blair, and in the Denver Museum of Natural History.

Results

Host Plants and Habitats

Rhizophora apiculata Blume, *R. mucronata* Lamk. (Rhizophoraceae), *Zanthoxylum* sp. (Rutaceae) and *Vitex glabrata* R. Brown (Verbenaceae) are the four host plants on which eggs and larvae of *A. mcmulleni* were found. Larvae were subsequently reared on the same species as that on which they were collected.

While *V. glabrata* is a tree of moderate size in the inland deciduous forests of Middle Andaman, South Andaman and Long Island (all in the Andaman group of islands) (Parkinson 1923), *R. apiculata* and *R. mucronata*, which form the major component of the mangals (mangroves) of these islands, are found in mixed stands commonly fringing the tidal creeks as well as along the sea shores of many of the Andaman islands. It forms a wide belt of vegetation along the sea front, up to 2 km wide in some places and is regularly inundated by the tides.

Eggs, larvae, and cocoons of *A. mcmulleni* were collected from the mangals of Wright Myo, Wandoor, and Chiriyatapu in South Andaman and from Rutland. They were also collected from the inland semi-evergreen forest of Mount Harriet (South Andaman) up to an altitude of about 460 meters.

Field Observations

The majority of the eggs and larvae that were collected came from the fringing mangrove habitat rather than from the inland forests. On each kind of host plant, all immatures were found on the tender terminal leaves. Eggs and larvae of the moth were found on both young and old trees of *Rhizophora*. In the mangrove habitat the immature stages were found in larger numbers on trees which were at the water's edge and not so much in the interior of the mangrove forest. Partially eaten terminal leaves signified the presence of larvae.

Eggs and first instar larvae were invariably found on the ventral surfaces of leaves on all the hosts. In a few instances however, eggs were found on the dorsal surfaces of leaves. Though one egg per leaf was the norm, up to four eggs were found on some leaves (Fig. 1). When more than one egg was laid per leaf, they were laid some distance apart (= 0.24 cm between eggs, n = 5) and never in contact with each other.

On hatching the larva ecloses by making an irregular opening in the micropylar end. The larva does not eat the chorion fully and so half-empty chorions may be found attached to leaf surfaces long after larval eclosion.

The larvae in their early instars were found clinging along the midribs on the ventral surfaces of leaves, while the later instars shifted onto the terminal twigs, hidden between the leaves. In a few instances, first instar larvae were found side by side on the same leaf. However, later instars were never found together.

Up to the fourth instar the larvae, when at rest, bend their bodies such that the head end forms the short arm of the letter J. When the late instar larvae are disturbed they bend forward and tuck their heads beneath the thoracic segments and into the hollow formed by the thoracic legs which are bunched together and thrust forward.

Mature larvae feed inwards from the outer margin of the leaf and continue to feed whether the head is oriented upwards or downwards. Larvae stay on the tiny terminal branches and not on the leaves. One final instar larva that was collected from the field measured 11.8 cm in length.

The moths emerged from their cocoons at night in all the cases. In the two instances in which we observed emergence, it occurred between 1900-2030 hours. One virgin female was released on a coconut leaf a day after emergence at 0700 hours at Garacharma, South Andaman. This moth remained motionless without shifting its position for 48 hours and then disappeared.

Oviposition: Of the two reared females that were kept in cages, one

laid the first batch of eggs on the first night after emergence from the cocoon while the other laid its first batch of eggs three days latter. They laid a total of 200-223 eggs ($\bar{x} = 212$; $\sigma = \pm 16.3$) over a period of 10-11 days, when confined in cages and prevented from mating. One other virgin female laid 378 eggs in nine days from the date of emergence. All the eggs proved to be infertile. *A. mcmulleni* therefore conforms to the non-parthenogenetic nature of the Oriental Saturniidae, as both arrhenotokous and thelytokous saturniids have been reported from other regions of the world (Barlow 1982).

Barlow (1982) also stated that "the attraction and subsequent assembling of males to freshly emerged virgin females in fine wire-mesh boxes has been found to be very successful in temperate climes but this is yet to be tried out in South East Asia". Our attempts to attract males by taking newly emerged virgin females of *A. mcmulleni* in wire mesh cages to the Chiriyatapu mangroves proved futile.

Phenology: We collected and successfully reared the moths from eggs, larvae, and cocoons collected during the months of March, May, June, August, October, November, and October. Adults were also encountered during these months.

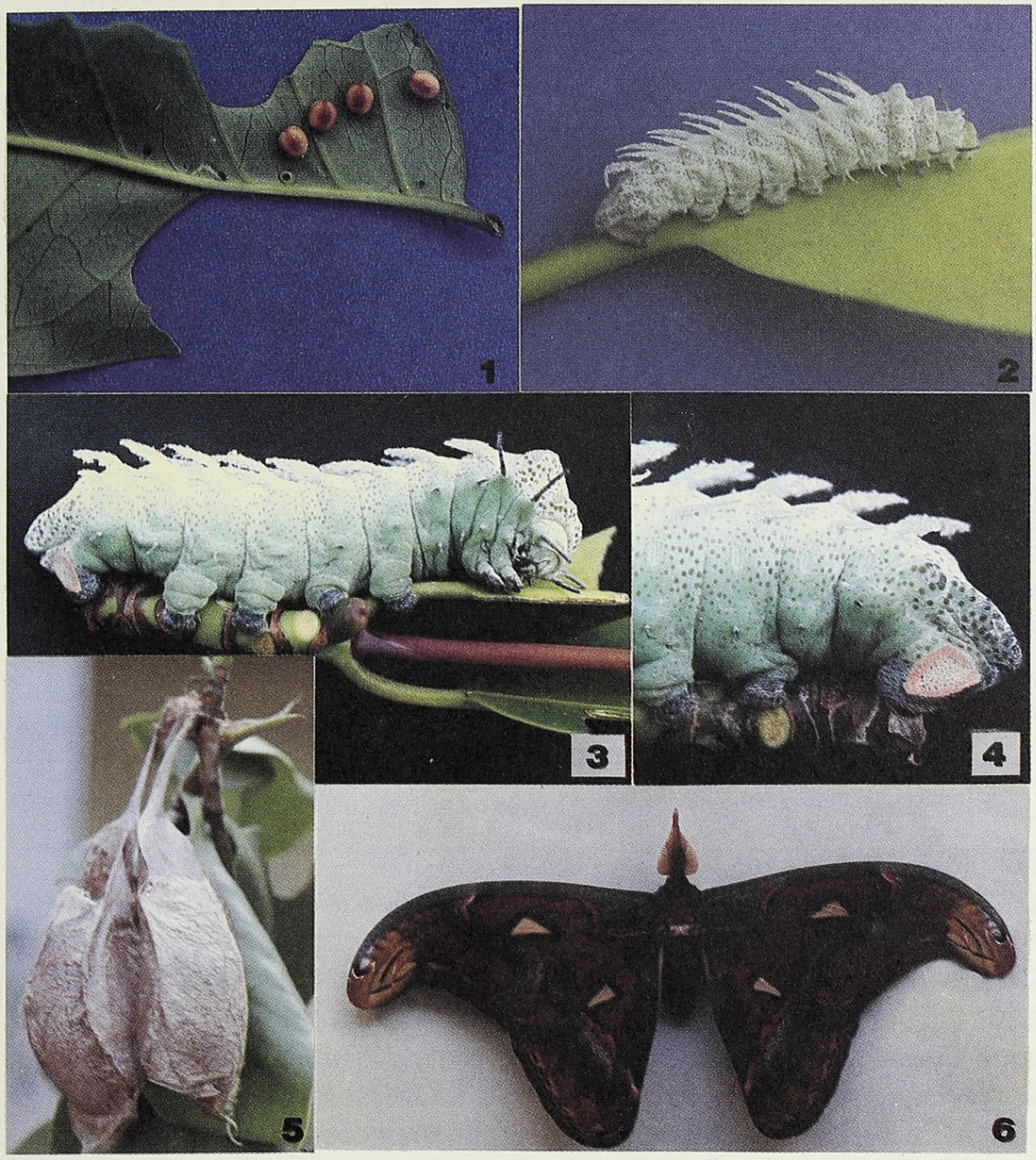
Natural enemies: The only natural enemy encountered was the egg parasitoid *Anastatus* sp. (Hymenoptera: Chalcidoidea: Eupelmidae). Only one wasp emerged from each parasitized egg; multiple parasitism was not observed in any of the cases. This chalcidoid genus was also reported as an egg parasitoid of *Attacus atlas* (Peigler 1989).

Description of Immature Stages

The terminology for larval morphology is based on Peigler (1989). The measurements and durations of the various immature stages are given in Tables 1 and 2, respectively.

Egg (Fig. 1): Length 2.8 mm, width 2.4 mm, height 2 mm (n = 20). The oval egg, which is slightly flattened dorsoventrally, is dull white in color with polygonal punctations. It lies on its side embedded in a thick dry layer of orange-brown adhesive fluid. The micropyle is at one end from which radiates two narrow light brown, lateral bands and a dorsal tear-drop shaped brown patch which is narrow at the micropylar end and broadens towards the center of the egg. All these brown markings have fuzzy edges and extend to a little beyond the midline.

First instar: Head glossy, deep brown; clypeus, labium, labial and maxillary palps, dull white; labrum brown. Body grayish-white in color with deep brown to black lateral markings which are most prominent on abdominal segments I to VII. This gives the larva the appearance of being striped when viewed laterally but not when seen dorsally. The proximal ends of dorsal scoli on thorax have five long brown spines arranged in an irregular circle with one similar spine a little off the apex of each scolus. All the other scoli too have spines with the maximum number on the subdorsal and lateral scoli. The distribution of scoli is identical to that of



Figures 1-6. *Attacus mcmulleni* 1. Eggs on *Zanthoxylum*. 2. Fourth instar 3. Sixth instar on *Rhizophora*. 4. Close-up of prolegs and triangular patch on anal proleg. 5. Cocoons 6. Adult male. Photographs by B. Pardhasaradhi.

A. atlas in this and all succeeding instars. Mealy matter (wax) is absent on this instar. The dorsum of the prothorax is plain white in front of scoli. There is a narrow brownish wavy line on the dorsum of anal plate along the contour of the anterior margin of the segment.

Second Instar: Immediately after molting it turns around and eats the molted skin as do all the other instars. Head creamish-yellow in color. Legs black, prolegs brown, clypeus and maxillary palpi white and labrum pale brown. Some setae on crotchets faint brown. Spines on scoli grey.

Third/Fourth Instars (Fig. 2): Labrum pale blue with a rough outer surface. Maxillary and labial palps also pale blue; dorsal and lateral surfaces covered with white powdery material that is thinner on the head

Table 1. Mean dimensions (cm.) of the various stages and of the head capsules of *A. mcmulleni* reared *ex ovo* in captivity in S. Andaman

	Larval Instars (Lengths)						Cocoon (L × W)
	I	II	III	IV	V	VI	
Male							
n	3	4	4	6	7	8	3
Length	1.2	1.8	2.3	3.0	4.0	6.0	7.4 × 3.9
± S.D.	0.12	0.06	0.05	0.18	0.18	0.73	0.6 × 0.5
Female							
n	1	1	1	2	3	3	3
Length	1.1	1.8	2.3	3.0	4.1	5.8	6.8 × 4.2
± S.D.	-	-	-	-	0.2	0.4	0.4 × 0.3
***Male/Female**							
n	2	4	4	6	6	5	5
Length	1.1	1.6	2.0	2.7	4.1	5.9	6. × 23.0
± S.D.	-	0.2	0.4	0.2	0.59	0.43	0.4× 0.3
Head Capsule							
n	11	6	9	10	11	—	—
Length	1.4	1.9	2.5	3.5	4.9	—	—
± S.D.	0.04	0.08	0.09	0.09	0.23	—	—

*Represent pooled data as the sex of these moths was not determined.

than the rest of the body, the former having a black patch at its base. Spiracles narrow, long, very pale blue and located in a depression. Legs pale blue with black claws; prolegs light blue distally with black semi-circular lines above the blue band on the third and fourth prolegs. Crotchets brown in color. Head smooth, pale yellow-green in color, with small white setae towards the mouth parts. Ventral surface pale blue-green including the inner aspect of the legs. The prominent saffron triangle on proleg encloses a pale grey-blue central region with a black band along the posterior margin.

Fifth instar: Head smooth, glossy, apple green in colour. Black irregular markings along inner margins of frontal sutures. Dorsal and sub dorsal scoli on thoracic segments reduced the stubs/warts. Spiracular scoli on thoracic segments black, and are the longest of all the scoli. Subspiracular scoli on abdominal segments I and II are small and black. Abdominal segments III to VIII also have small black scoli, but situated slightly lower than on segments I and II, in the subventral positions. The thoracic segments and the first two abdominal segments have a row of very short black scoli which are light blue basally. The surface of the body

Table 2. Mean durations (in days) of the various stages of *A. mcmulleni* reared *ex ovo* in captivity in S. Andaman

	Egg	Larval Instars I	II	III	IV	V	VI	Pupa
Male								
n	—	3	4	4	6	7	8	8
Duration	—	3.3	5.0	6.0	6.5	8.6	15.8	25.8
± S.D.	—	0.58	0.82	2.71	1.05	2.70	4.20	0.89
Female								
n	—	1	1	1	2	3	3	5
Duration	—	4.0	5.0	6.0	6.5	9.0	19.0	28.0
± S.D.	—	—	—	—	2.12	4.0	2.7	2.9
***Sex undetermined**								
n	3	5	6	4	5	6	4	3
Duration	>5	7	6.2	8.3	9.2	10.5	19.5	34
± S.D.	—	1.3	0.4	3.2	1.6	2.3	1.9	13

*Represents pooled data as the sex of these moths was not determined.

with green mottling, while the mottling on the anal segment is dark green to almost black.

Sixth Instar (Figs. 3-4): Head, especially vertex smooth, glossy green. A thin layer of white mealy matter on the frons and a little on the sides of the epicranial suture, otherwise the head is devoid of mealy matter. An irregular black patch at base of labium. Mandibles black; clypeus, labrum, labium, maxillary and labial palps pale blue. Labial palps with an annular black ring. Frontal sutures black. Ventral surface green, legs and prolegs deep black in colour on the outer surface with sparse grey setae. Crochets dark brown. An anterior bluish-white stripe in the black area of the prolegs. Spiracles pale blue. The pink triangle on anal claspers (Fig. 4) more oval in shape than in the earlier instars and less intense (paler) in color. The enclosed space is not dirty green as in earlier instars but a pale, dirty green with brownish-black pits. All along the outside of the rear margin is a deep black band. The whole larva is mottled, with the mottling becoming quite dense on the anal triangle.

Pupa: Length 5.4 cm, width 2.0 cm (n = 2). Deep brown in color; cremaster also deep brown, prominent and blunt, ca. 3.8 mm long and 2 mm wide (at the widest point).

Cocoon (Fig. 5): The cocoon is coarse; brownish in color with a long peduncle. Cocoons were usually found individually webbed onto leaf surfaces, though in a few instances two cocoons were found together (Fig. 5). The mean length of the peduncle was 7.0 cm (range 4.5-10.5 cm; n =

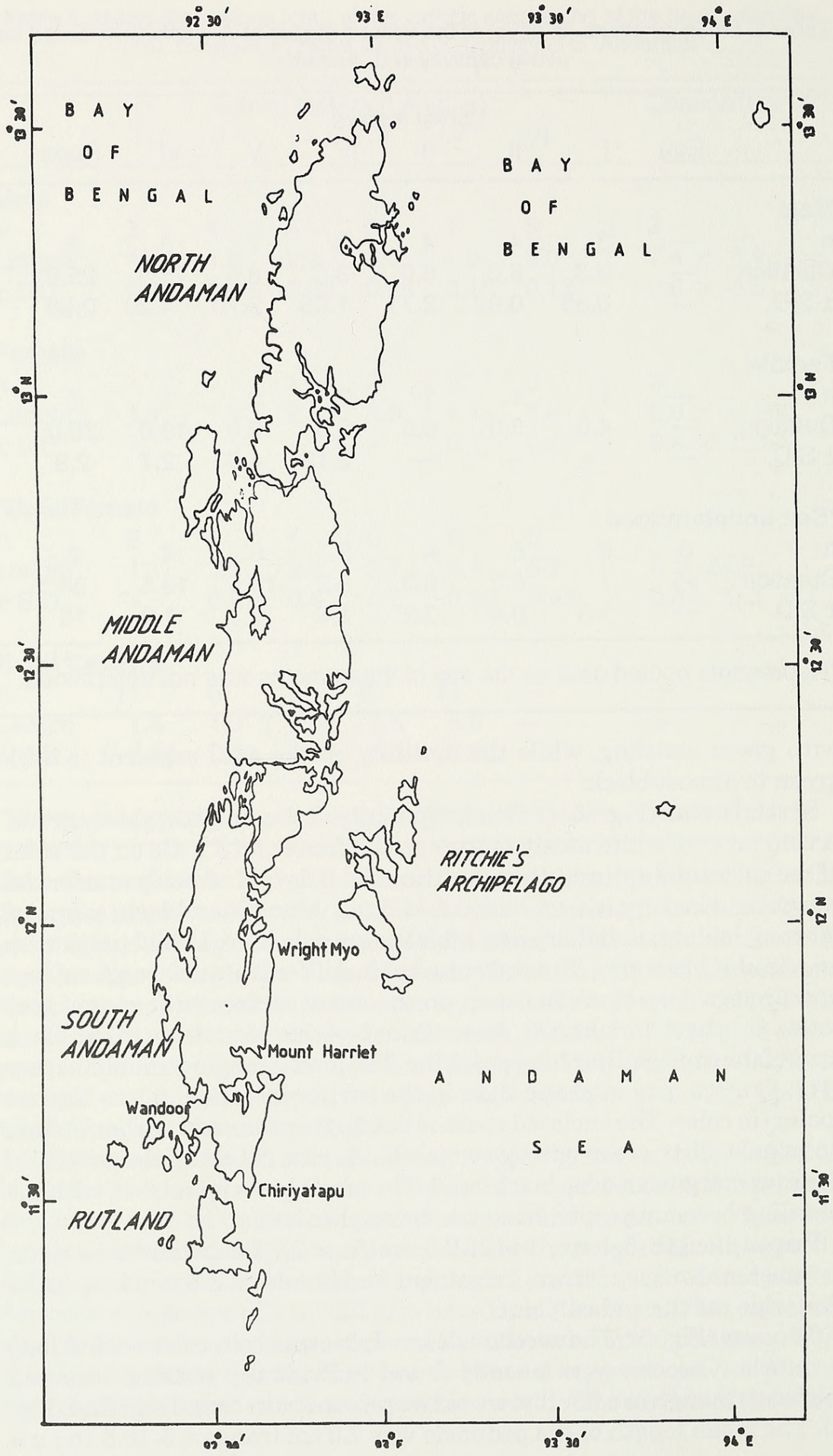


Figure 7. Map of Andaman Islands.

11) while the mean length of the cocoon proper was 7.3 cm (range 6.5-9.5 cm; n = 18) and its mean width 3.8 cm. (range 2.9-4.5 cm; n = 17). The mean weight of the empty cocoon exclusive of pupal case is 0.959 ± 0.11 g ranging from 0.76 to 1.039 (n = 5).

The adult moth (Fig. 6) was described in detail by Peigler (1989), and a male was illustrated in color.

Discussion

Over 100 plant species belonging to 90 genera in 48 families have been reported as host plants of *Attacus* spp. (Peigler 1989). However, Peigler was unable to assign a botanical name to the plant on which larvae and cocoons of *A. mcmulleni* were collected by McMullen, as Watson (in Packard 1914) used only the vernacular name of the plant viz., "samalu". This we now know to be *Vitex trifolia* (Verbenaceae), a widely grown hedge plant in the Andamans which was introduced from mainland India prior to 1866 (Prain 1890, Parkinson 1923).

Villiard (1969) was of the opinion that greater success on the rearing of *Attacus* larvae—particularly the later instars—could be achieved by feeding them on a mixed diet. In the current study we were unsuccessful at inducing larvae of *A. mcmulleni* to switch diets. Larvae reared initially on *Rhizophora* spp. were switched to *V. trifolia* and to *V. glabrata*. All attempts proved futile though individuals collected on V. *glabrata* completed their life cycles on leaves of the same species.

Peigler (1989) recorded no species of mangroves as host plants of *Attacus*. Murphy (1990) was the first to mention the presence of *Attacus* in mangrove habitats, stating that *Attacus atlas* "occurred once [on *Avicennia alba* Bl., Avicenniaceae] simultaneously with many other trees" and that it occurred at low levels on *Bruguiera gymnorhiza* (L.)Lamk., (Rhizophoraceae). Nevertheless, this is the first time that a species of *Attacus* has been found to be able to complete its life cycle on a species of Rhizophoraceae. Species of *Attacus* were previously known to utilize Verbenaceae and Rutaceae (Peigler 1989). Our studies also indicate that *Rhizophora* spp. are preferred to *Vitex glabrata* and *Zanthoxylum* by *A. mcmulleni*.

Like *A. atlas, A. mcmulleni* also consistently passes through six larval instars in its life cycle. Although *A. mcmulleni* probably has a wider host range than that discovered by us, we feel that in the species-poor mangrove habitat (with plant species diversity markedly lower than in other moist tropical habitats) with a preponderance of *Rhizophora* spp. in closely packed stands, neither the ovipositing female nor the larvae should have any difficulty in finding host plants. Nevertheless they lay only a few eggs at each oviposition site which Janzen (1984) believed is normal behavior for polyphagous species.

Watson (in Packard 1914) quoting McMullen, stated that "there are at least two broods per year" with May and July being the two months in which the moths were collected. Judging from the various stages of *A.*

mcmulleni that we have collected during various months from the field, it is definitely not bivoltine but is multivoltine and in all probability flies throughout the year.

The eggs and cocoons of *Attacus mcmulleni* are probably indistinguishable from those of the allied species. The larvae are also almost identical to those of some populations of *A. atlas* (see Lampe 1984; Paukstadt & Paukstadt 1984a, b, 1986; Peigler 1989), but a few minor differences were noted as follows.

Larvae of *A. atlas* from western Java and some of the species from the Philippines have solidly orange shields on the anal prolegs. These shields on larvae of *A. atlas* from Thailand and Taiwan and *A. taprobanis* from Sri Lanka and southern India are rimmed with orange and have green centers. Larvae of *A. mcmulleni* are intermediate; the shield appears solidly orange at first glance, but a faint green center is visible upon closer examination. In *A. mcmulleni* the subspiracular scoli are blue proximally and blackish distally, like those of *A. taprobanis* and *A. atlas* from Taiwan and Thailand. The white waxy covering in *A. mcmulleni* is as dense or denser than in any of the other species of *Attacus*.

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Literature Cited

Barlow, H. S. 1982 [1983]. An introduction to the moths of South East Asia. Malayan Nature Soc., Kuala Lumpur. ix + 305 pp., 50 col. pls.

Janzen, D. H. 1984. Two ways to be a tropical big moth: Santa Rosa saturniids and sphingids. Oxford Surv. Evol. Biol. 1:85-140, 4 col. pls.

Lampe, R. E. J. 1984. Die Präimaginalstadien von *Attacus atlas sumatranus* Fruhstorfer im Vergleich mit *Attacus atlas* Linnaeus von Taiwan (Lep.: Saturniidae). Entomol. Z. 94: 161-167.

Murphy, D. H. 1990. The natural history of insect herbivory on mangrove trees in and near Singapore. Raffles Bull. Zool. 38: 119-203.

Packard, A. S. 1914. Monograph of the bombycine moths of North America, part 3 (edited by T. D. A. Cockerell). Mem. Natl. Acad. Sci. 12: ix + 1-516.

PARKINSON, C. E. 1923. A forest flora of the Andaman Islands. Bishen Singh Mahendra Pal Singh, Dehra Dun. (Reprint). 325 pp.

PAUKSTADT, U. & L. H. PAUKSTADT. 1984a. Beitrag zur Kenntnis der Ökologie und Biologie von *Attacus atlas* Linnaeus 1758 aus westjavanischen und balinesischen Populationen (Lep.: Saturniidae). Entomol. Z. 94: 225-240.

—— 1984b. Beschreibung und Abbildung der Präimaginalstadien von *Attacus atlas* Linnaeus 1758 aus thailändischen Populationen (Lep.: Saturniidae). Entomol. Z. 94: 273-283.

—— 1986. Beschreibung der Praeimaginalstadien von *Attacus taprobanis* Moore 1882 aus singhalesischen Populationen sowie Angaben zur Ökologie und Biologie (Lepidoptera: Saturniidae). Nachr. Entomol. Ver. Apollo, Frankfurt (N. Ser.) 7: 71-90.

PRAIN, D. 1890. The non-indigenous species of the Andaman flora. J. Asiat. Soc. Bengal 59: 235-261.

PEIGLER, R. S. 1989. A revision of the Indo-Australian genus *Attacus*. Lepid. Res. Found., Inc., Beverly Hills, Calif. xi + 167 pp.

RIPLEY, S. D. & BEEHLER, B. M. 1989. Ornithogeographic affinities of the Andaman and Nicobar islands. J. Biogeogr. 16: 323-332.

SINGH, R. 1975. The last Andaman Islanders. National Geographic 148(July): 66-91.

VILLIARD, P. 1969. Moths and how to rear them. Funk & Wagnalls, New York. 242 pp.