NEW AND REVISED DESCRIPTIONS OF THE IMMATURE STAGES OF SOME BUTTERFLIES IN SRI LANKA AND THEIR LARVAL FOOD PLANTS (LEPIDOPTERA: PIERIDAE). PART 1: SUBFAMILIES PIERINI (IN PART) AND COLIADINAE

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Abstract - The immature stages of 11 of the 28 species of Pieridae in Sri Lanka and their larval food plants are presented, two of them for the first time. The nine other species are compared to prior descriptions and their larval food plants confirmed and new ones identified. This study provides some base information needed for conservation management programs for butterflies in Sri Lanka and for further studies on the biology of these species.

Key words: Immature stages, larval food plants, Sri Lanka, Ceylon, Pieridae, Coliadinae, Pierini, Lepidoptera, butterflies, conservation

INTRODUCTION

A comparison of the latest published National Red List data on the butterfly fauna of Sri Lanka to historical records (e.g. Ormiston, 1924; Woodhouse, 1949) suggests that the populations of many of the 245 species known in the country have declined. The National Red List 2012 of Sri Lanka lists 21 species as CR (critically endangered), 29 as EN (endangered), 38 as EN (endangered), 40 as VU (vulnerable), 20 as NT (near threatened) and 6 as DD (data deficient) (van der Poorten, 2012). Among the Pieridae, two are CR (*Cepora nadina*, *Appias indra*), one is EN (*Prioneris sita*), five are VU (*Colotis fausta*, *Co. aurora, Co. danae, Eurema ormistoni*, *E. laeta*) and one NT (*Co. etrida*). As with many other countries, the loss of habitats along with larval food plants seems to be the main cause for these declines.

To address these declines, the Biodiversity Secretariat of the Ministry of Environment of Sri Lanka is developing a Butterfly Conservation Action Plan. However, in order to assess the status of a butterfly species and to prepare conservation management plans, information on the biology of the species including the larval food plants and the resource needs of the adults as well as of the immature stages is a prerequisite.

However, the immature stages and larval food plants of the butterflies in Sri Lanka are incompletely known. Woodhouse (1949) published information of the immature stages and larval food plants of 191 of the 242 species of butterflies in the island known at that time but the information for 111 of these species was based on work done in India, which does not necessarily apply to the Sri Lankan populations. Little research has been published since then.

Knowledge of immature stages and larval food plants, as well as being important for conservation planning, is also useful in classification, elucidating broad-scale evolutionary patterns, understanding ecology at the community and population levels, and in ecological chemistry (DeVries, 1986 and references therein). Little research has been published since then (except see van der Poorten & van der Poorten, 2011, 2012).

The purpose of the current study is therefore to document the immature stages and larval food plants of the butterflies in Sri Lanka to assist in the proper documentation of the status of a particular species and to provide the baseline information necessary in conservation management planning.

In the current study (conducted from 2004 to the present and ongoing), we have documented the immature stages and larval food plants of 180 of the 245 known species of butterflies in Sri Lanka. For more details on the background and approach, see van der Poorten & van der Poorten (2011). In Sri Lanka, there are 28 species of Pieridae in two subfamilies: Pierinae (Tribes Colotini (1 genus, 5 species) and Pierini (9 genera, 15 species)) and Coliadinae (2 genera, 8 species). In Part 1, we present the immature stages and larval food plants of 11 of the 13 species of the family Pieridae, subfamily Pierinae, tribe Pierini (genus *Appias*, 5 species) and subfamily Coliadinae, (*Catopsilia* (3 species) and *Eurema* (5 species)). The immature stages of two species and their larval food plants in Sri Lanka are documented for the first time; those of two species remains unknown. The immature stages of two species previously described from Sri Lankan material and of six species from Indian material are compared to the findings of the current study and additional observations are presented and larval food plants documented. For seven of these eight species, new larval food plants are reported for the first time. For five of these eight species, larval food plants previously reported in Sri Lanka are confirmed. One species (*Catopsilia scylla*) was previously described in full from Sri Lankan material (van der Poorten & van der Poorten, 2012a).

MATERIALS AND METHODS

Rearing methods: see van der Poorten & van der Poorten (2011). Photography: see van der Poorten & van der Poorten (2012b). Nomenclature after K. Kunte (pers. comm.) and Yata (where referenced). Identification of plants: Plants were identified to species if possible using several references (most notably, the series A revised handbook to the flora of Ceylon (Dassanayake (ed.)) and an inspection of herbarium specimens at the Herbarium of the Royal Botanic Garden in Peradeniya, Sri Lanka as well as consultation with botanical experts including Dr. Siril Wijesundara and Jacob de Vlas. Where information on the duration of developmental stages is given, these data were obtained in rearings at ambient temperatures (22–34ºC) at Bandarakoswatte (07.37.01N, 80.10.57E), 70 m asl, North Western Province, Sri Lanka. Conventions used (applied to

both the larva and the pupa): Segments are numbered S1 to S14 (S1—the head; S2 to S4—the 3 segments of the thorax; S5 to S14—the 10 segments of the abdomen). In the photographs, the head is always on the left.

RESULTS AND DISCUSSION

Family: Pieridae, Subfamily: Pierinae, Tribe: Pierini

***Appias indra narendra* Moore, 1877. Plain Puffin. Endemic subspecies.**

The immature stages and larval food plant of *A. indra narendra* have not been described in Sri Lanka. Kunte (1998) has described one of the subspecies found in India and has recorded the larval food plants as *Drypetes oblongifolia* and *Putranjiva roxburghii* (Euphorbiaceae/Putranjivaceae) (Kunte, 2006). In the course of the current study, adults have been seen at only a few locations and no eggs, larvae or pupae have been found.

***Appias libythea libythea* (Fabricius, 1775). Striped Albatross.**

The immature stages of *A. l. libythea* have not been described in Sri Lanka but in India, the final instar larva and pupa have been described briefly by Davidson & Aitken (1890) and Davidson *et al.* (1897) and in detail by Bell (1913b) (including the egg (Fig. 1a)). The results of the current study agree with these descriptions except for the following: a) in the larva, the gonads are visible through the transparent skin and the flange is white to bluish-white and the tip of the anal process is a pale reddish (Fig. 1b); and b) in the pupa, the subdorsal row of spots are cream-colored, not yellow, and the ground color of the pupa ranges from light green to pale translucent greenish-brown; most pupae have a few black spots randomly distributed about the body (Figs. 1c, d).

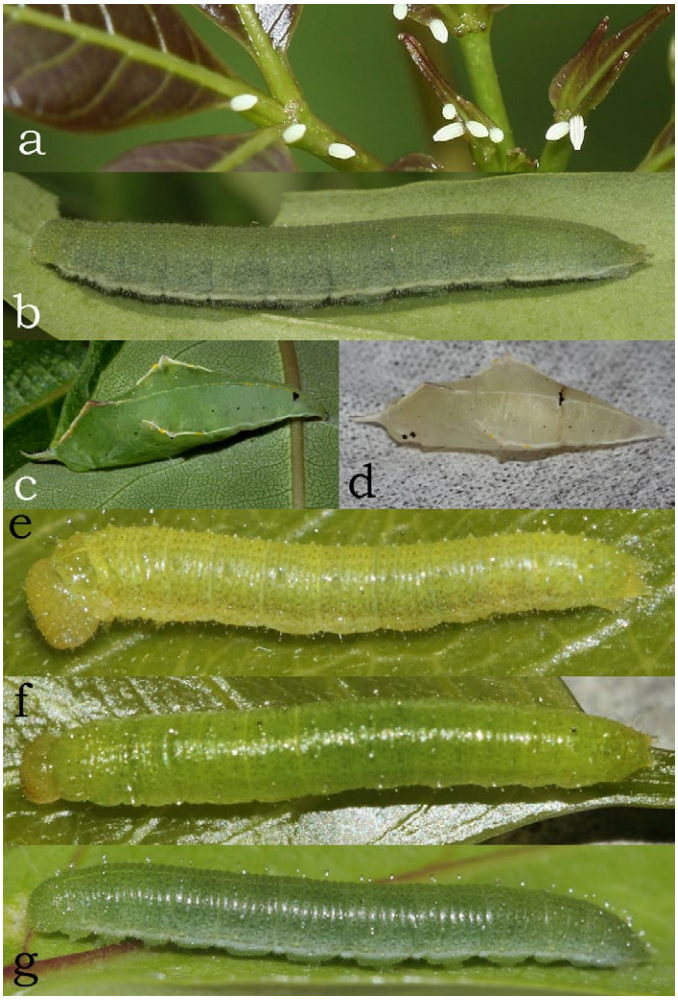

Figure. 1. *Appias libythea libythea*: a. eggs laid on *Crateva adansonii*; b. larva, fifth instar, dorsolateral view; c. pupa, green form, dorsolateral view; d. pupa, pale translucent greenish-brown form; e. larva, first instar, day 2, dorsolateral view; f. larva, third instar, dorsal view; g. larva, fourth instar, dorsolateral view.

Additional notes on immature stages: 1st instar: upon emergence, head pale yellowish-orange, body pale yellowish-green with minute setae, each with a sticky droplet at the apex; from S2–S14 numerous light brown spots closely spaced to form a broad obscure lateral band; flange whitish; two stubby anal processes; larva appears oily and translucent; day two: similar but head greenish-yellow; body yellowish-green (Fig. 1e). 2nd: not recorded. 3rd: head yellowish-orange with minute setae; body cylindrical, each segment transversely impressed with 5–6 parallel lines, each partition with 6–8 setae, each with a sticky droplet at the apex, obscure darker green spots between the impressed lines; ground color yellowish-green, a darker green from S3–S8; dorsal line pale green and indistinct (Fig. 1f). 4th: similar to 3rd except head pale green, body bluish-green, spiracular line faint, obscure, whitish; flange light grayish-blue to white; each transversely impressed region carries a series of purplish spots (Fig. 1g). In the 5th instar, the sticky droplets are not evident and the larva is covered with a dense coating of setae. The larva looks similar to that of *A. libythea olferna* from Singapore (Butterfly Circle, 2012a). Duration of immature stages (days): pupa (4–5).

Larval food plants: In Sri Lanka, de Nicéville & Manders (1899) reported "the larva as usual in the genus feeds on *Capparis* but it also eats the leaves of *Crataeva*" [sic]. The current study showed for the first time that *Crateva adansonii*, *Cadaba fruticosa*, *Capparis roxburghii* and *Capparis grandis* (Capparaceae) are used as larval food plants. Though Woodhouse (1949) quoted *Capparis sepiaria* and *Cap. horrida* from Indian sources (Bell, 1913b), we have never observed larvae on these plants. The first two instars require tender leaves but later instars feed on more mature leaves.

A. l. libythea is common and widespread in the dry, intermediate and arid zones. It has also been recorded in the wet zone and the higher hills but is a migrant in these areas and not resident. *Crateva adansonii* is widespread in the arid, dry and dry-intermediate zones and seems to be the preferred larval food plant in these areas. *Cadaba fruticosa* is restricted to the arid and dry zones of the west coast. *Capparis roxburghii* is widespread in the arid, dry and dry-intermediate zones and seems to be used only when tender leaves of *Crateva adansonii* are not available. *Capparis grandis* is restricted to the arid zones in the west and south-east and the western part of the dry zone (Dassanayake, 1996). At least one of these plants is found wherever the butterfly has been recorded but it is possible that other species of *Capparis* are also used.

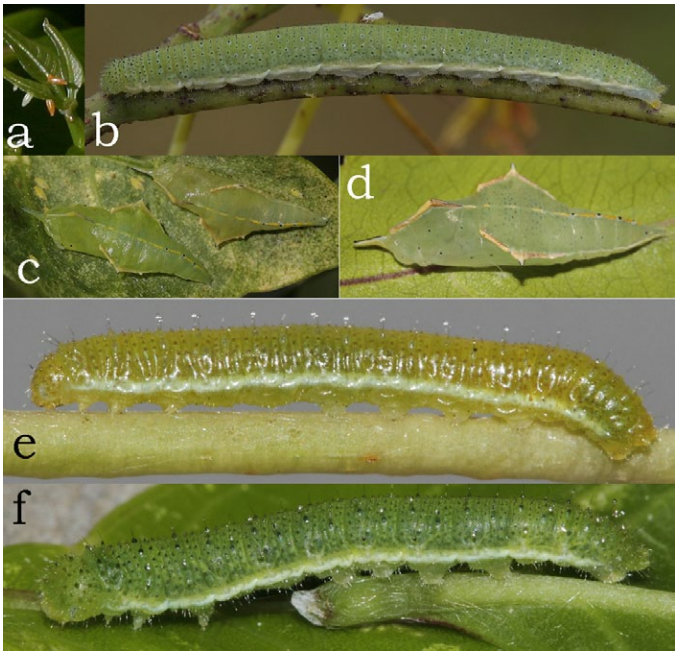

Figure 2. *Appias lyncida taprobana*: a. eggs; newly laid are white; older ones are orange; b. Larva, fifth instar, lateral view; c. pupae, dorsal view; d. pupa, translucent green, dorsolateral view; e. larva, second instar, lateral view; f. larva, fourth instar, lateral view.

***Appias lyncida taprobana* Moore, 1879. Chocolate Albatross. Endemic subspecies.**

The final instar larva and pupa of *A. lyncida taprobana* in Sri Lanka were described briefly and the larva illustrated by Moore (1880–81) (as *A. taprobana*). In India, a subspecies of *A. lyncida* (as *A. hippo taprobana*) was described in detail by Bell (1913b) (including the egg (Fig. 2a)). Saji (2011) does not list *A. lyncida taprobana* as occurring in India. The results of the current study agree with these descriptions except for the following: a) in the larva, the spiracular band is white with a tint of yellow and the ground color of the body is dark yellowish-green with a blue wash above the spiracular line (Fig. 2b); and b) the pupa is various shades of green and light brown (Figs. 2c, d).

Additional notes on immature stages: 2nd instar: head pale yellowish-green with dark green setiferous tubercles; body pale yellowish-green, darker green on S6–S8 & S13–S14; body lightly impressed with transverse grooves, each partition with a row of brownish tubercles with long setae; each seta with a sticky droplet at the apex; broad white spiracular line (Fig. 2e). 4th: similar to 2nd but head light green with dark green setiferous tubercles; body dark bluish-green with dark green setiferous tubercles, some of which carry sticky droplets; spiracular line with a fine yellow line along its upper margin (Fig. 2f). The larva and pupa look similar to the species of *A. lyncida* from India illustrated in Igarashi & Fukuda (1997). Duration of immature stages (days): pupa (3–5); egg to eclosion of adult (17–18).

Larval food plants: In Sri Lanka, Moore (1880–81) wrote that it fed on *Crataeva* [sic] (after Thwaites) and on *Crataeva religiosa* [sic] [now *Crateva adansonii*] (after Mackwood); de Nicéville & Manders (1899) wrote that it fed on "capers (*Capparis*) as usual". The current study confirmed the use of *Crateva adansonii* (Capparaceae). In the lab, the larvae refused *Capparis roxburghii* and *Capparis sepiaria*. The first three instars feed only on tender leaves; the last two instars feed on more mature leaves.

A. lyncida taprobana is widespread in the dry, intermediate and arid zones. It has also been recorded in the wet zone and the higher hills but disperses widely in these areas and is not resident.

Crateva adansonii is widespread in the arid, dry and dry-intermediate zones (Dassanayake, 1996). At least one of these plants has been recorded wherever the butterfly has been recorded but it is possible that there is another larval food plant.

***Appias albina swinhoei* (Moore, 1905). Common Albatross.**

The immature stages of *A. albina swinhoei* in Sri Lanka

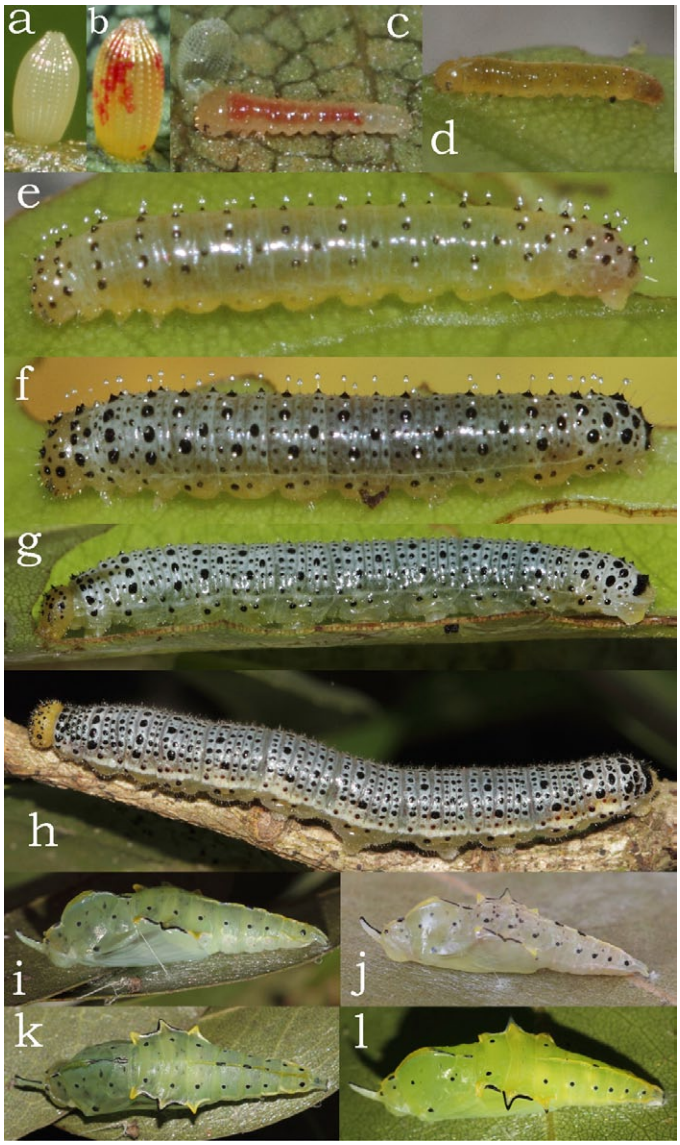

Figure 3. *Appias libythea libythea*: a. egg, newly laid; b. egg, one day later; c. larva, first instar, just emerged with partly eaten eggshell; d. larva, first instar, day 2; e. larva, second instar, dorsolateral view; f. larva, third instar, dorsolateral view; g. larva, fourth instar, lateral view; h. larva, fifth instar, lateral view; i. pupa, pale green, lateral view; j. pupa, pale brown, lateral view; k. pupa, pale green, dorsal view; l. pupa, greenish-yellow, dorsolateral view.

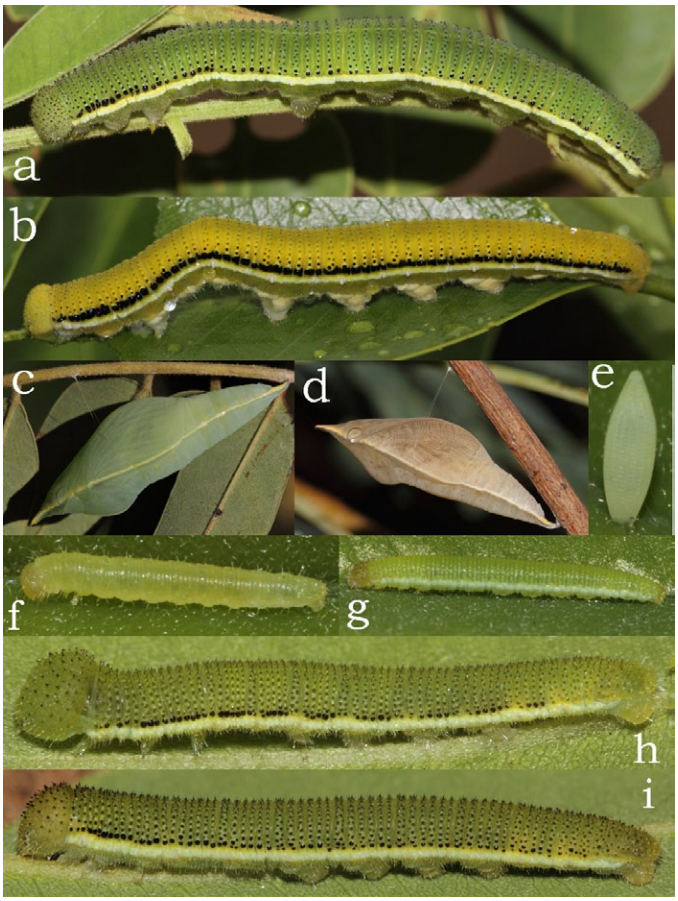

Figure 4. *Catopsilia pomona pomona*: a. Larva, fifth instar, green ground color with interrupted black lateral band; b. Larva, fifth instar, yellow ground color with thick black lateral band; c. pupa, green color form, lateral view (actual orientation); d. pupa, light brown color form, lateral view (actual orientation); e. egg; f. larva, first instar, dorsolateral view; g. larva, second instar, dorsolateral view; h. larva, third instar, dorsolateral view; i. larva, fourth instar, dorsolateral view.

have not been described. The egg, larva and pupa of *A. albina* from the Palawans are illustrated in Igarashi & Fukuda (2000). To date, we have not encountered eggs, larvae or pupae despite the fact that the butterfly is widespread and very common.

Note: the taxonomy of *A. albina* and *A. galene* have been confused in the literature. We follow Yata *et al.* (2010) in this publication.

***Appias galene* (C. Felder & R. Felder, 1865). Lesser Albatross. Endemic.**

The immature stages of *A. galene* in Sri Lanka have not been described. In the current study, the immature stages are described and the larval food plant identified for the first time.

Notes on immature stages: Egg: laid at all heights and anywhere on the twigs and leaves, though the majority of eggs were laid on or near very small leaf buds just starting to break; eggs very small (about 0.7 mm x 0.4 mm), cylindrical, widening slightly towards the top, then narrowing; 20 longitudinal ridges that anastomose at their upper ends to form 10 minute teeth as a crown; finely transversely striated between the ribs; color pearl-white when first laid, changing to orange with red blotches within one day (Figs. 3a, b). 1st instar: upon emergence, head pale amber and larger than body; body translucent white except for S2–S9 which are brownish-orange with inner tissues reddish; one day later, head same width as S2; head and body honey-colored except for S13–S14 which are light chestnut brown; body covered with minute setiferous tubercles (Figs. 3c, d). 2nd: head pale yellowish-orange with black setiferous tubercles; body somewhat translucent, pale greenish-orange except for S13–S14 which are light pink; each segment with a single transverse row of black setiferous tubercles anteriorly, each seta often with a sticky droplet at the apex, S5–S13 with an additional pair of lateral black setiferous tubercles posteriorly; S14 with dark dorsal transverse streak (Fig. 3e). 3rd: head dull yellowish-orange with larger black tubercles, often with a seta, often with a sticky droplet at apex; body grayish-blue to yellowish-green; each segment transversely impressed to form 5–6 partitions; each partition with black tubercles, some of which are large, some minute, some with setae with sticky droplets; thin white spiracular line with two black spots below each spiracle on S5–S12; single black spot below spiracular line on S2, S4 & S13; S14 with broad black transverse dorsal band (Fig. 3f). 4th: similar to 3rd except most tubercles with short seta and most setae without sticky droplets; tubercles more prominent and well-defined (Fig. 3g). 5th: similar to the 4th, body ground color ranges from bluish-gray to greenish-blue; spiracular line more prominent; tubercles flattened and most without setae though body covered with numerous short setae (Fig. 3h). Pupa: ground color pale brown to yellowish-green to greenish-blue, underside lighter-colored; head hidden under S2, with a long, laterally compressed turned-up snout tapered at its tip; snout with black dorsal line and tip with black oval spot; S2 convex, ridged along the dorsal line which is variably yellow and black, with a pair of stubby projections on anterior edge, often with two black spots behind and 1 or 2 pairs of black spots on the posterior edge; S3 steeply convex, carinated along dorsal line, the carination more prominent and yellow anteriorly, less prominent and black lined with white posteriorly, usually 3 pairs of black spots dorsolaterally; broadest at posterior edge of S3; S4 usually with lateral and subdorsal black spots and black spot at base of wing; S5 narrow, often with black spots; S6–S8 slightly convex dorsally, each segment expanded dorsally on the anterior edge to form a triangular upcurved tooth; teeth on S6 and S8 similar in size, edged with yellow and white; teeth on S7 slightly larger, edged with black and white; dorsal carination from S8–S14, yellow with a variable number and position of black streaks; abdomen tapers from S9 to the end; dorsal half-segments triangular in transverse section due to abdominal dorsal carination; ventral half-segments semi-circular in section and meet dorsal halves in a slight carination which is yellowish from S11–S14; S6–S14 with subdorsal row of prominent black spots; spiracle on S2 hidden in the fold; other spiracles white, elongate ovals (Figs. 3i–l). Pupa attaches to underside of leaf with a short girdle. Duration of immature stages (days): egg (2–3); 1st instar (1–4); 2nd (2); 3rd (2); 4th (2); 5th (2); pupation (2); pupa (5–6); egg to eclosion of adult (17–20). Length (mm): pupa (22–24).

Larval food plants: In Sri Lanka, the current study showed for the first time that *Drypetes sepiaria* (Euphorbiaceae/ Putranjivaceae) is used as a larval food plant. All instars feed only on tender leaves and since the leaves mature very quickly,

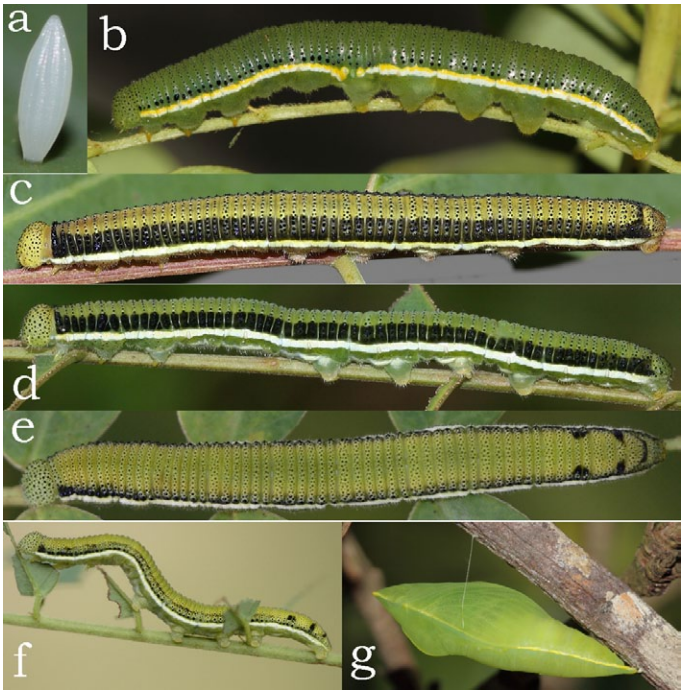

Figure 5. *Catopsilia pyranthe pyranthe*: a. egg; b. Larva, fifth instar, faint black band, green ground color, lateral view; c. Larva, fifth instar, thick supraspiracular black band, yellowish spiracular band, greenish-yellow ground color, lateral view; d. Larva, fifth instar, thick supraspiracular black band, whitish spiracular band, green ground color; e. Larva, fifth instar, black patches on posterior segments, dorsal view; f. Larva, fifth instar, interrupted supraspiracular black band; g. pupa, lateral view.

the larva also develops very quickly. In the absence of tender leaves, the larvae died of starvation.

A. galene is common and widespread in the dry, intermediate and wet zones at all elevations. It is seen at the highest elevations only during migration and has not been recorded breeding there. *Drypetes sepiaria* is common in the dry and intermediate zones and is also found sparingly in the arid and wet zones (Dassanayake, 1997). The distribution of *D. sepiaria* does not fully cover the distribution of the butterfly. It is possible that the other species of *Drypetes* (*D. gardneri*, *D. longifolia* and *D. lanceolata*) are used in other areas. There is no evidence that it feeds on *Capparis*.

Yata *et al*. (2010, Supplementary information 1) discuss larval food plants of the species of the *Appias* (*Catophaga*) group. They state that of the 5 species for which larval food plants are recorded, four of the species (i.e. *A. wardii*, *A. albina*, *A. paulina*, and *A. nero*) feed on both *Capparis* and *Drypetes* and one species (*A. melania*) feeds only on *Drypetes*. *A. galene* belongs to the *Catophaga* group and apparently is similar to *A. melania* in that it feeds only on *Drypetes*. *A. albina* in Sri Lanka is suspected to also feed only on *Drypetes*.

Family: Pieridae, Subfamily: Coliadinae, Tribe: Coliadini

***Catopsilia pomona pomona* (Fabricius, 1775). Lemon Emigrant.**

The final instar larva and pupa of *C. p. pomona* in Sri Lanka were described briefly and illustrated by Moore (1880–81) as *C. crocale*. In India, the final instar larva and pupa were described in detail by Bell (1913b) as *C. crocale*. The results of the current study agree with these descriptions except that a) the fifth instar is more variable than these descriptions indicate—the ground color of the body ranges from shades of yellow to green and the head is of a similar color to the body; the lateral black band varies in width, is sometimes composed of small discontinuous spots and is absent in some specimens; black tubercles on the body are variable in size and number, and some are a darker shade of the ground color; spiracular line variable in width and sometimes with upper half yellow; ventrum varies from translucent pale yellow to brownish-green and never with the black tubercles that characterize *C. p. pyranthe* (Figs. 4a, b); and b) the pupa has a black spot at the apex of the snout dorsally and also comes in a light brown form (Figs. 4c, d).

Additional notes on immature stages: Egg: spindle-shaped with longitudinal and transverse ridges; white when first laid, turning yellow (Fig. 4e). 1st instar: head greenish-orange; body pale greenish-yellow with long white setae (Fig. 4f). 2nd: head pale orange with white setae and small dark brown to black setiferous tubercles; body pale greenish-yellow; each segment transversely impressed with 5–6 furrows, each partition carrying a transverse row of tubercles which are darker green than the ground color; spiracular line broad, bluish-white, indistinct along its margins; posterior part of S14 similar to color of head (Fig. 4g). 3rd: head same as 2nd except color is pale green; body pale green; tubercles more prominent with setae except posterior part of S14; tubercles just above spiracular line mostly large and black; spiracular line distinct, yellowish at upper margin; ventrum whitish with numerous white translucent setae (Fig. 4h). 4th: similar to 3rd except tubercles mostly black and more numerous (Fig. 4i). The final instar is similar to that illustrated by Igarashi & Fukuda (1997) from Malaya and by Butterfly Circle (2012b) from Singapore. Duration of immature stages (days): pupa (4–5); egg to eclosion of adult (14–15). Length (mm) of larva: prepupation (45).

Larval food plants: In Sri Lanka, Moore (1880–81) reported that it fed on "*Cassia fistula* &c" (after Thwaites), and de Nicéville & Manders (1899) reported that it fed on "*Cassia*". Woodhouse (1949) quoted from Indian sources. The current study showed for the first time that *Cassia grandis, Senna alata, Senna didymobotrya* (S. Sanjeeva, pers. comm), *Senna surattensis*, *Cassia roxburghii* and *Cassia javanica* subsp. *nodosa* (Leguminosae) are used as larval food plants and confirmed the use of *Cassia fistula* (Leguminosae). The early instars feed only on tender leaves though later instars additionally feed on leaves that are slightly more mature but still tender.

C. p. pomona is very common and widely distributed in the island at all elevations but does not breed at elevations above 1000 m asl; it is seen in the higher elevations only during the migrations. *Cassia grandis* is an introduced ornamental tree planted in the lowlands. *Senna alata* is an introduced ornamental shrub planted in the lowlands. *Senna didymobotrya* is an introduced plant found in the mid-elevations. *Senna surattensis* is widely planted in the dry, intermediate and wet zones but does not appear to have become naturalized. *Cassia roxburghii* is a native tree that is found widely in the dry and

Figure 6. *Eurema brigitta rubella*: a. larva, final instar, lateral view; b. larva, final instar, dorsal view; c. pupa, with black spots, lateral view (actual orientation); d. pupa, without black spots, lateral view (actual orientation).

dry-intermediate zones. *Cassia javanica* subsp. *nodosa* is planted as an ornamental in the dry, intermediate and wet zones and in some places has become naturalized. *Cassia fistula* is native and widespread in the dry and intermediate zones at the lower elevations (Dassanayake, 1991). The distribution of these plants closely matches the distribution of the butterfly though it is possible, given this range of larval food plants, that additional ones are used.

***Catopsilia pyranthe pyranthe* (Linnaeus, 1758). Mottled Emigrant.**

The final instar larva and pupa of *C. p. pyranthe* in Sri Lanka were described briefly and illustrated by Moore (1880–81) as *C. gnoma* and *C. ilea*. In India, the final instar larva and pupa were described in detail by Bell (1913b). The results of the current study agree with these descriptions (including the egg (Fig. 5a) except for the following: a) in the larva, the ground color can be greenish-yellow, the amount of black on the head is variable, the white spiracular band sometimes has a yellow line above it that varies in width and may be absent altogether or missing from some segments, S2 is black in some specimens, S11–S12 sometimes have dorsolateral black patches posteriorly and S13 sometimes has a black streak (Figs. 5b–f); and b) in the pupa, the spiracles are white (Fig. 5g). The illustration of *C. pyranthe* from India in Igarashi & Fukuda (1997) and from Singapore by Butterfly Circle (2012c) look similar. Duration of immature stages (days): egg (2); 5th instar (5); pupa (6–7); egg to eclosion of adult (17). Length (mm): prepupation (26–38); pupa (24).

Larval food plants: In Sri Lanka, Moore (1880–81) reported that it fed on Leguminosae and "*Cassia fistula*, &c" (after Thwaites). The current study showed for the first time that *Senna occidentalis, Senna tora, Senna alata*, *Senna surattensis* and *Cassia auriculata* (Leguminosae) are used as larval food plants. The use of *Cassia fistula* (Leguminosae) was confirmed (S. Sanjeeva, pers. comm.). Early instars fed only on tender leaves though later instars fed on more mature leaves.

C. p. pyranthe is very common and widely distributed in the island at all elevations though it probably does not breed above 400 m asl since it is seen at the higher elevations only sparingly and during the migrations. *Senna occidentalis* [formerly *Cassia occidentalis*] and *Senna tora* [formerly *Cassia tora*] are weedy herbs that are widely distributed in the arid, dry and intermediate zones in open places. *Senna alata* [formerly *Cassia alata*] is an introduced ornamental shrub that has become naturalized in damp habitats of the dry, intermediate and wet zones. *Cassia auriculata* is a small native tree that is widely distributed over the arid, dry and intermediate zones (Dassanayake, 1991). The distribution of these plants matches the distribution of the butterfly; it is possible that other plants are used as well.

***Catopsilia scylla* (Linnaeus, 1763). Orange Migrant. Subspecies not identified.**

C. scylla was first identified in Sri Lanka in 2008. The immature stages and larval food plant were described by van der Poorten & van der Poorten (2012a). The first recorded larval food plant in Sri Lanka is *Senna surattensis* (Leguminosae), a widely planted garden plant. However, the butterfly has been observed ovipositing on *Cassia auriculata*, a native tree, though there is no evidence yet that the larvae survive on it. Since the publication, it has been recorded breeding successfully on another cultivated plant of the Leguminosae that has not yet been identified (H. D. Jayasinghe, pers. comm.). The illustration of the larva and pupa of *C. scylla* from Thailand in Igarashi & Fukuda (1997) looks similar to the Sri Lankan population.

Family: Pieridae, Subfamily: Coliadinae, Tribe: Euremini

***Eurema brigitta rubella* (Wallace, 1867). Small Grass Yellow.**

The final instar larva and pupa of *E. brigitta rubella* in Sri Lanka have not been described. In India, the final instar larva and pupa were described in detail by Bell (1913b) as *Terias libythea.* The results of the current study agree with Bell except for the following: a) in the larva, the spiracular band extends to S14; above the spiracular band there is often a dark green band which is obscure on its upper margin; males often show developing gonads on S10 (Figs. 6a, b); and b) in the pupa, the markings are variable; some pupae have a considerable number of blotches or spots while others are devoid of markings (Figs. 6c, d).

Additional notes on immature stages: 1st instar: eats eggshell partially, head light amber, body yellowish-white with 1 row of long black subdorsal bristles, two rows of shorter bristles on either side of dorsal rows, S2 and S14 with long bristles. The larva and pupa of *E. brigitta senna* from Singapore (Butterfly Circle, 2012d) and the description of *E. brigitta australis* (Braby, 2000) from Australia look similar. Duration of immature stages (days): pupa (9); egg to emergence of adult (26).

Larval food plants: In Sri Lanka, there are no reports of the larval food plant except de Nicéville & Manders (1899) reported that it fed on Leguminosae. The current study showed for the first time that *Chamaecrista kleinii* and *C. mimosoides* (Leguminosae) are used as larval food plants. Early instars feed on tender leaves only; later instars feed on more mature leaves. *E. brigitta rubella* is locally common and widely distributed in

Figure 7. *Eurema laeta rama*: a. Larva, fifth instar, lateral view; b. pupa, lateral view; c. egg.

grasslands of the hills from 200–2200 m asl. Small populations have also recently been found below 200 m in open grass meadows in the dry zone.

Chamaecrista kleinii is a perennial herb that is widespread in the dry and intermediate zones but localized in grasslands. *C. mimosoides* is an annual herb that is widespread in the arid, dry and intermediate zones (Dassanayake, 1991). *C. mimosoides* is used exclusively in the lower elevations.

The distribution of these plants matches that of the butterfly.

***Eurema laeta rama* (Moore, 1872). Spotless Grass Yellow. Endemic subspecies.**

The final instar larva and pupa of *E. laeta rama* in Sri Lanka have not been described. In India, the immature stages of *E. l. laeta* were described briefly by Chaumette (Moore, 1905–1910). The results of the current study agree with the description of the larva except for the following: a) in the larva, the 'black raised spots' on the head are minute dark green setiferous tubercles; the "pyramidal ciliae" of the body are dark green setiferous tubercles, the apex of which are tipped with sticky droplets; the ventrum and flange are covered with numerous white setae; from S5–S10, the spiracular line is subtended on the upper margin by a narrow band which is a darker shade of green than the ground color (Fig. 7a) and b) the description of the pupa is not accurate: it has a typical *Eurema* shape—on the dorsal edge, the mesothorax and metathorax are slightly concave, S5 is straight, S6 is straight anteriorly but curves slightly upwards posteriorly, S7–S14 slope and narrow gently and uniformly; on the ventral edge, there is a prominent bulge from S3–S8 that is widest opposite S7, S8–S9 straight, S10 curves upwards before narrowing down sharply to S14; it is light bluish-green; the flesh-colored snout usually has a black patch at the base and is very slightly bent towards the ventrum; from S2–S11, there are faint subdorsal dark gray to black spots ringed with light gray; the costal margin of the forewing is whitish and spreads outwardly as a wash along the surface (Fig. 7b).

Additional notes on immature stages: egg: typical *Eurema* shape but broader than others in the genus; pale cream-colored (Fig. 7c). 1st instar: head light brown, body yellowish-orange. Duration of immature stages (days): egg (4).

Larval food plants: In Sri Lanka, there are no reports of the larval food plant. The current study showed for the first time that *Chamaecrista kleinii* and *C. mimosoides* (Leguminosae) are used as larval food plants. Early instars require tender leaves; later instars can eat more mature leaves. *E. laeta rama* is locally common above 1000 m asl though at slightly lower elevations on the Uva slopes. *Chamaecrista kleinii* is a perennial herb that is widespread in the dry and intermediate zones but localized in grasslands (Dassanayake, 1991). *C. mimosoides* is an annual herb that is widespread in the arid, dry and intermediate zones (Dassanayake, 1991). The distribution of the plant matches that of the butterfly though it is possible that other larval food plants are used as well.

Note: taxonomic status according to Yata (1989).

***Eurema blanda citrina* (Moore, 1881). Three Spot Grass Yellow. Endemic subspecies.**

The final instar larva and pupa of *E. blanda citrina* in Sri Lanka were described briefly by Manders (1910). In India, the final instar larva and pupa of *E. blanda silhetana* (as *Terias sylhetana* [sic]) were described briefly by Bell (1913b). The results of the current study agree with these descriptions except that in addition, in the larva, the ground color is greenish-yellow, green or bluish-green; the dorsum is the same as the ground color and the legs and prolegs usually have 4–5 black tubercles each (Figs. 8a, b). Pupa as described by Bell (1913b) (Fig. 8c).

Additional notes on immature stages: Egg: white, typical *Eurema* shape but broader at apex, with numerous longitudinal and transverse ridges; laid in batches of up to 76 eggs but most batches smaller (Fig. 8d). 3rd instar: head black, body pale yellowish-green; last 4–5 segments often pale yellow (Fig. 8e). 4th: similar to 3rd except last few segments same color as rest of body. The illustrations of the final instar and pupa of *E. blanda* from Malaya and Taiwan in Igarashi & Fukuda (2000) and of the final instar of *E. blanda snelleni* from Singapore (Butterfly Circle, 2012e) appear similar. Duration of immature

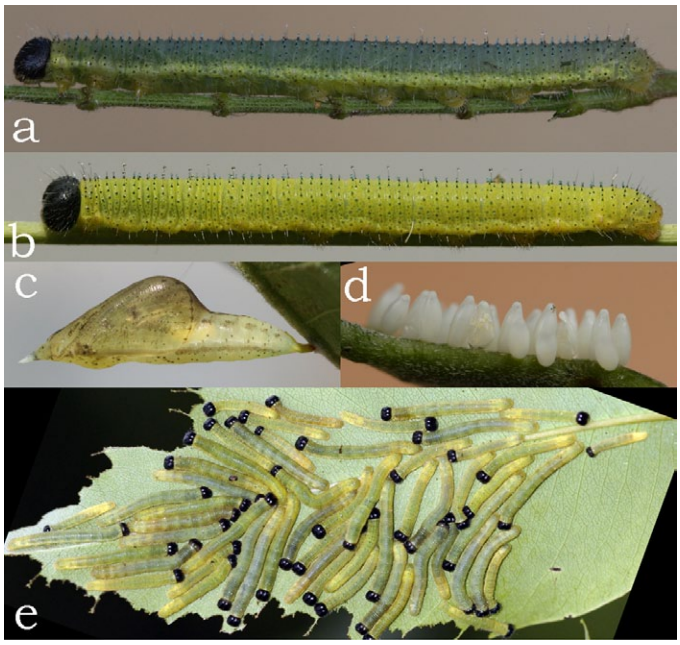

Figure 8. *Eurema blanda citrina*: a. Larva, final instar, bluish-green form; b. larva, final instar, greenish-yellow form; c. pupa, pale olivaceous brown form with mottling; d. eggs, laid in batches; e. larvae, third instar showing gregarious character.

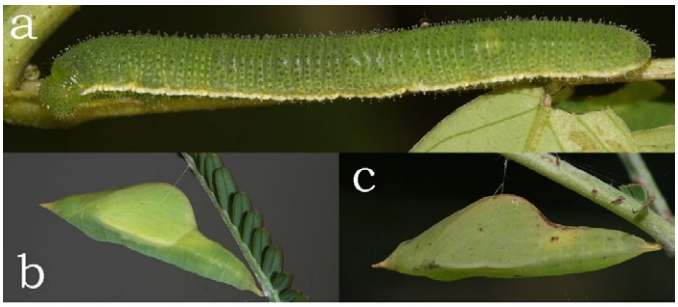

Figure 9. *Eurema hecabe hecabe*: a. larva, fifth instar, lateral view; b. pupa, green without black markings, lateral view; c. pupa, light green with black markings, lateral view.

stages (days): egg (5); pupa (5–12); egg to eclosion of adult (24).

Larval food plants: In Sri Lanka, de Nicéville & Manders (1899) reported that it fed on *Albizzia* [sic] *moluccana* [now *Falcataria moluccana*]. Woodhouse (1949) reported *Acrocarpus* after Tunnard, and also *Acrocarpus fraxinifolius*, *Albizzia* [sic] *chinensis*, *Cassia alata* [now *Senna alata*] and *Gliricidia sepium*. The current study showed for the first time that *Entada pusaetha* (S. Sanjeeva, pers. comm.), *Archidendron bigeminum* (H.D. Jayasinghe, pers. comm.), *Senna surattensis*, *Albizia odoratissima*, *Cassia fistula* and *Calliandra surinamensis* (Leguminosae) are used as larval food plants and confirmed the use of *Falcataria moluccana*. We have not been able to confirm *Acrocarpus fraxinifolius* but this record is likely correct. We have not been able to confirm the use of *Albizia chinensis*, *Senna alata* or *Gliricidia sepium*. The larvae are gregarious and do not require tender leaves.

E. blanda citrina is very common and widespread in the dry, intermediate and wet zones at all elevations. *Falcataria moluccana* is widely planted as a shade tree in tea plantations. *Entada pusaetha* is a large woody native climber found in the low country in the wet and intermediate zones. *Archidendron bigeminum* is a tree that is endemic to Sri Lanka and found fairly widespread in the moist low country up to 1300 m asl (Dassanayake, 1980). *Senna surattensis* is a small introduced tree that is widely planted in the intermediate and wet zones. *Albizia odoratissima* is a native tree found widely distributed in the dry, intermediate and wet zones. *Cassia fistula* is native and widespread in the dry and intermediate zones at the lower elevations (Dassanayake, 1980, 1991). *Calliandra surinamensis* is widely planted in home gardens in the intermediate and wet zones. At least one of these plants is found wherever the butterfly has been recorded and additional larval food plants have been documented though the plant species have not yet been identified.

Note: taxonomic status of the butterfly according to Yata (1994).

***Eurema hecabe hecabe* (Linnaeus, 1758). Common Grass Yellow.**

The final instar larva and pupa of *E. h. hecabe* in Sri Lanka were described briefly and illustrated by Moore (1880–81) and by Manders (1910). In India, the immature stages of *E. hecabe* were described in detail by Bell (1913b). The results of the current study agree with these descriptions except for the following: a) in the larva, the 'lateral line' i.e. spiracular line is white tinged with varying amounts of yellow on the upper margin; the head is rather small and a lighter shade of green than the body and with setiferous tubercles; the body is transversely impressed into 5–6 ridges, each ridge with a row of darker colored setiferous tubercles and the setae are of varying lengths with a bluish-white droplet at the tip (less blue than *E. blanda citrina*); the ventrum is a brighter green with white setae (Fig. 9a); and b) we have not encountered the purplish-brown or brownish-green forms of the pupa (Figs. 9b, c). The illustrations of the larva and pupa from Bali and Laos in Igarashi & Fukuda (2000) and of *E. hecabe contubernalis* from Singapore (Butterfly Circle, 2012f) look similar to *E. h. hecabe* in Sri Lanka. Duration of immature stages (days): 1st instar (4–7); pupation (1); pupa (6–7).

Larval food plants: In Sri Lanka, Moore (1880–81) reported that it fed on Leguminosae (after Thwaites); Manders (1910) reported "various species of *Cassia*" (after Green) and *Pithecolobium* [sic] *dulce*; Woodhouse (1949) reported *Acacia decurrens* (after Tunnard) and *Cassia tora* [now *Senna tora*], *Cassia fistula*, *Cassia mimosoides* [now *Chamaecrista mimosoides*], *Sesbania grandiflora* (Leguminosae) and *Panicum maximum* (Poaceae), several of which are based on Indian records. The current study confirmed the use of *Sesbania grandiflora, Pithecellobium dulce*, *Senna tora* and showed for the first time that *Aeschynomene aspera*, *Aeschynomene americana*, *Acacia eburnea*, *Acacia leucophloea, Acacia nilotica* and *Albizia odoratissima* (Leguminosae) are used as larval food plants. We have not been able to confirm *Acacia decurrens* but Tunnard's record is likely correct. Nor have

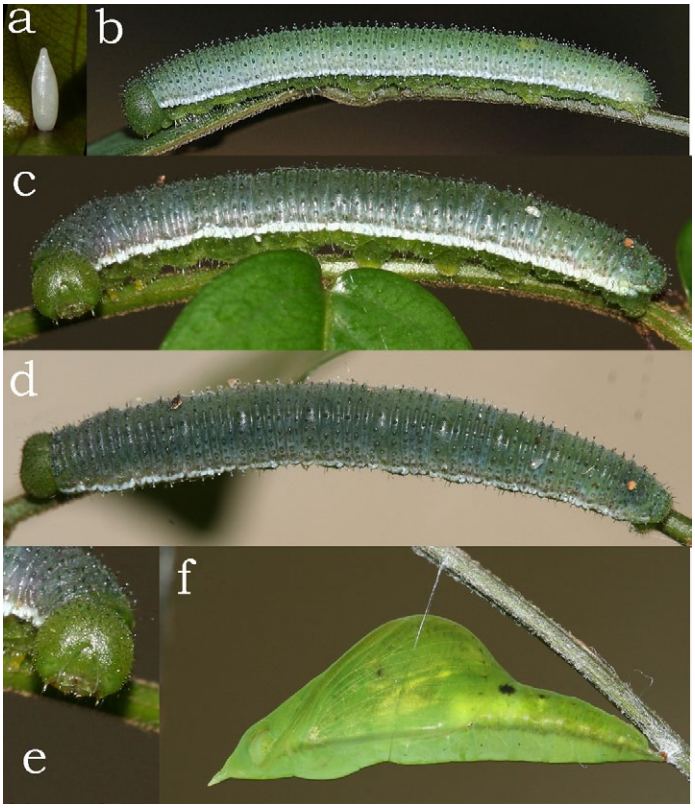

Figure 10. *Eurema ormistoni*: a. egg; b. larva, fifth instar, lateral view; c. larva, fifth instar, with broader white spiracular line and purplish wash above it; d. larva, fifth instar, dorsal view; e. larva, fifth instar, head, frontal view; f. pupa, lateral view.

we been able to confirm *Cassia fistula* and *Chamaecrista mimosoides*. The record of *Panicum maximum* must be an error as no member of the Pieridae is known to feed on species of the family Poaceae and in our study, larvae refused it. The early instars of the larva do not require tender leaves though they prefer them to older leaves.

E. h. hecabe is very common and widespread from sea level to the highest elevations. *Sesbania grandiflora* is widely planted in the dry and intermediate zones. *Pithecellobium dulce* is a naturalized tree found in the dry and intermediate zones. *Senna tora* is a weedy plant found commonly in the dry and intermediate zones. *Aeschynomene aspera* is a native herb found in water and wet places in the dry, intermediate and wet zones. *Aeschynomene americana* is grown as a cover crop but has become naturalized in places. *Acacia eburnea* is a native shrub found mostly in the arid zone. *Acacia leucophloea* is a large native tree, common in the arid, dry and intermediate zones. *Acacia nilotica* is an introduced tree that is fairly common on the dry areas of the west coast. *Albizia odoratissima* is a native tree found widely distributed in the dry, intermediate and wet zones (Dassanayake, 1980, 1991). These plants match the distribution of the butterfly in that at least one of these plants is found wherever the butterfly has been reported but given its polyphagous nature, it is likely that others are used as well.

***Eurema ormistoni* (Watkins, 1925). One-Spot Grass Yellow. Endemic.**

The immature stages and larval food plants of *E. ormistoni* have not been described. In the current study, the immature stages are described and the larval food plant identified for the first time.

Notes on immature stages: Egg: white, more or less cylindrical, with numerous longitudinal and transverse ridges, bulging only slightly in the middle, tapering sharply about one-quarter the distance from the apex (Fig. 10a). 5th instar: head rounded, slightly broader at base, with slight indentation at vertex extending to clypeus, frontal sutures slightly carinated, grass green, covered with minute dark green setiferous tubercles; body bluish-green, transversely ridged into 5–6 segments; each ridge with 10–12 setiferous tubercles, each seta terminating in a sticky droplet; spiracular band S2–S14 bluish-white (without the yellow supraspiracular band as in *E. h. hecabe*); bluish-gray wash laterally, becoming more distinct just above spiracular line; many specimens with tint of purple just above spiracular line; S2 with a series of dark purple spots just below spiracular band; last 3 segments of thoracic legs yellow; ventrum green with numerous white to translucent setae (Figs. 10b–e). Pupa: shape similar to *E. h. hecabe* along dorsal surface but curve on ventral surface more pronounced; light green with variable amounts of diffuse yellow patches and black patches on wings and abdomen; faint green band above the spiracles, often with minute dark green spots; often with minute black subdorsal spots along abdomen; spiracles oval, silvery-white; veins on wings prominent, light silvery; terminal end of cremaster reddish-brown (Fig. 10f). Duration of immature stages (days): pupa (8–9). Length (mm): prepupa (22).

Larval food plants: The current study showed for the first time that *Ventilago madraspatana* and *V. gamblei* (Rhamnaceae) are used as a larval food plants in Sri Lanka. The larva feeds on both tender and maturing leaves. We have found the larvae only on small plants in the understory of the forest. Even though the plant is a very large climber, the butterfly does not oviposit on leaves in the canopy. The butterfly is always seen close to the ground in moderate to dense shade (unlike the other *Euremas*) and has never been found in the sunny canopy.

E. ormistoni is very local and uncommon and is confined to the wet and intermediate zones up to about 500 m asl. *Ventilago madraspatana* is a large woody climber, common in forests in the dry and intermediate zones. *V. gamblei* is found in wetter forests of the dry zone and in the wet zone (Dassanayake, 1996). The distribution of these two plants matches that of the butterfly.

Note: taxonomic status of the butterfly after Yata (1991).

CONCLUSIONS

The immature stages of all of the species documented in this study exhibited some variation, particularly in the pupa and the final instar. They were, however, similar to those described from peninsular India with which Sri Lanka is zoogeographically related and to those described from other countries in the Indo-Australian region. Variation may be explained by differences expressed in different subspecies between India and Sri Lanka and/or by differences in temperature, rainfall, relative humidity and photoperiod due to geographic location as suggested by Braby (1994). Variation may also arise through the use of similar but different species as larval food plants. Further information on this variation will be useful for the identification of larvae and pupae in the field, which supports work on ecology and conservation management.

It is difficult to identify the larvae of the *Euremas* in the field (except for *E. ormistoni* which has a bluish tint) because they appear superficially similar. All other species documented in this paper may be identified in the fifth instar by their morphological characters.

The larval food plants used by the Pieridae described in this paper belong to Capparaceae, Euphorbiaceae (including Putranjivaceae), Leguminosae and Rhamnaceae, which agrees with the reports of others (Braby, 2000; Kunte, 2000; Igarashi & Fukuda, 1997, 2000). Members of the genus *Appias* feed only on the Capparaceae and Euphorbiaceae (including Putranjivaceae), and all species feed on two or more larval food plants except for *A. lyncida taprobana* and *A. galene*, which are monophagous. The genera *Catopsilia* and *Eurema* feed on the genus Leguminosae (except for *E. ormistoni* on Rhamnaceae). *E. brigitta* and *E. laeta* feed on species of *Chamaecrista* as do the subspecies found in Australia (Braby, 2000). However, no species of *Eurema* in Sri Lanka was recorded feeding on Euphorbiaceae as was *E. hecabe* in Australia (Braby, 2000). *Catopsilia p. pomona, C. p. pyranthe* are polyphagous in Sri Lanka as recorded elsewhere (e.g. Braby, 2000; Kunte, 2000).

Though comparisons to larval food plants used in other countries can be informative, records specific to a particular site and habitat are crucial to understanding the biology of a species and to preparing conservation management plans (Kunte, 2006; New, 1995).

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REFERENCES CITED

Bell, T. R.

1912. The common butterflies of the plains of India (including those met with in the hill stations of the Bombay presidency). Part 12. *Journal of the Bombay Natural History Society* 21(4): 1131–1157.

1913a. The common butterflies of the plains of India (including those met with in the hill stations of the Bombay presidency). Part 13. *Journal of the Bombay Natural History Society* 22(1): 92–100.

1913b. The common butterflies of the plains of India (including those met with in the hill stations of the Bombay presidency). Part 14. *Journal of the Bombay Natural History Society* 22(2): 320–344.

1914. The common butterflies of the plains of India (including those met with in the hill stations of the Bombay presidency). Part 16. *Journal of the Bombay Natural History Society* 23(1): 73–103.

Braby, M. F.

1994. Morphology of the early stages of *Mycalesis* Hübner (Lepidoptera: Nymphalidae: Satyrinae) from north-eastern Australia. *Journal of the Australian Entomological Society* 33: 289–294.

2000. *Butterflies of Australia: Their Identification, Biology and Distribution.* 2 vols. CSIRO Publishing. Collingwood. 1004 pp.

Butterfly Circle.

2012a. www.butterflycircle.com/checklist%20V2/CI/index.php/start-page/startpage/showbutterfly/29. Accessed Sep 4, 2012.

2012b. www.butterflycircle.com/checklist%20V2/CI/index.php/start-page/startpage/showbutterfly/19. Accessed Sep 4, 2012.

2012c. www.butterflycircle.com/checklist%20V2/CI/index.php/start-page/startpage/showbutterfly/20. Accessed Sep 4, 2012

2012d. www.butterflycircle.com/checklist%20V2/CI/index.php/start-page/startpage/showbutterfly/24. Accessed Sep 4, 2012

2012e. www.butterflycircle.com/checklist%20V2/CI/index.php/start-page/startpage/showbutterfly/23. Accessed Sep 4, 2012

2012f. www.butterflycircle.com/checklist%20V2/CI/index.php/start-page/startpage/showbutterfly/25. Accessed Sep 4, 2012

Dassanayake, M. D., (ed.)

1980. *A Revised Handbook to the Flora of Ceylon*. Vol. 1, Amerind Publishing Co., New Delhi. 508 pp.

1987. *A Revised Handbook to the Flora of Ceylon*. Vol. 6, Amerind Publishing Co., New Delhi. 424 pp.

1991. *A Revised Handbook to the Flora of Ceylon*. Vol. 7, Oxford & IBH Publishing Co., New Delhi. 439 pp.

1996. *A Revised Handbook to the Flora of Ceylon*. Vol. 10. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 427 pp.

1997. *A Revised Handbook to the Flora of Ceylon*. Vol. 11. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 420 pp.

Davidson, J. & E. H. Aitken

1890. Notes on the larvae and pupae of some of the butterflies of the Bombay presidency. *Journal of the Bombay Natural History Society* 5(4): 349–374.

Davidson, J., T. R. Bell and E. H. Aitken

1897. The butterflies of the North Canara district of the Bombay presidency. Part 3. *Journal of the Bombay Natural History Society* 10(4): 568–584. Plate VI.

de Nicéville, L. & N. Manders

1899. A list of the butterflies of Ceylon. *Journal of the Asiatic Society of Bengal (Calcutta)* 68 (2): 170–233.

DeVries, P. J.

1986. Hostplant records and natural history notes on Costa Rican butterflies (Papilionidae, Pieridae and Nymphalidae). *The Journal of Research on the Lepidoptera* 24(4): 290–333.

Igarashi S. and H. Fukuda.

1997. *The life histories of Asian butterflies*. Vol. 1. Tokai University Press, Japan. 572 pp.

2000. *The life histories of Asian butterflies*. Vol. 2. Tokai University Press, Japan. 742 pp.

Kunte, K.

1998. The Plain Puffin *Appias indra* Swinhoe: behaviour, life-history and distribution. *Journal of the Bombay Natural History Society* 95(1): 137–139.

2000. Butterflies of Peninsular India. Universities Press (Hyderabad) and Indian Academy of Sciences (Bangalore). xviii + 254 pp, and 32 color plates.

2006. Additions to known larval host plants of Indian butterflies. *Journal of the Bombay Natural History Society* 103(1): 119-120.

Manders, N.

1910. The distinctions between *Terias silhetana* and *Terias hecabe*. *Journal of the Bombay Natural History Society* 20(1): 245–255.

Moore, F.

1880–81. *The Lepidoptera of Ceylon,* Vol. I, L. Reeve & Co., London. 191 pp.

1884–1887. *The Lepidoptera of Ceylon*. Vol. III. L. Reeve & Co., London. 559 pp.

1905–1910. *Lepidoptera Indica*. Vol.7. Rhopalocera: Family Papilionidae (Subfamily Pierinae), Family Lycaenidae. L. Reeve & Co., London. 286 pp. 89 plates.

New. T. R.

1995. Butterfly Conservation Management. *Annual Review of Entomology* 40: 57–83.

Ormiston, W.

1924. *The butterflies of Ceylon*. H. W. Cave & Co., Colombo. 165pp + 7 plates.

Saji, K.

2011. *Appias lyncida* Cramer, 1777 – Chocolate Albatross. *In* K. Kunte, S. Kalesh & U. Kodandaramaiah (eds.). *Butterflies of India, v. 1.05*. Indian Foundation for Butterflies. http://ifoundbutterflies.org/65-appias/appias-lyncida-dp3 (accessed August 23, 2012).

van der Poorten, G.

2012. The Taxonomy and Conservation Status of the Butterflies of Sri Lanka. In: *The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora.* Weerakoon, D.K. & S. Wijesundara (Eds.), Ministry of Environment, Colombo. p. 26–41.

van der Poorten, G. and N. van der Poorten

2011. New and revised descriptions of the immature stages of some butterflies in Sri Lanka and their larval food plants (Lepidoptera: Nymphalidae). Part 1: Sub-family Danainae. *The Journal of Research on the Lepidoptera* 44: 1–16.

2012a. *Catopsilia scylla* (Linnaeus, 1763): A new record for Sri Lanka with notes on its biology, life history and distribution (Lepidoptera: Pieridae). *The Journal of Research on the Lepidoptera* 45: 17–23.

2012b. New and revised descriptions of the immature stages of some butterflies in Sri Lanka and their larval food plants (Lepidoptera: Nymphalidae). Part 2: Subfamily Satyrinae. *Tropical Lepidoptera* (in press).

Woodhouse, L. G. O.

1949. *The butterfly fauna of Ceylon*. Second complete edition. The Colombo Apothecaries' Co. Ltd., Colombo. 231 pp.

Yata, O.

1989. A revision of the Old World species of the genus *Eurema* Hübner (Lepidoptera, Pieridae). Part I. Phylogeny and zoogeography of the subgenus *Terias* Swainson and description of the subgenus *Eurema*. *Bulletin of the Kitakyushu Museum of Natural History* 9: 1–103. 24 plates.

1991. A revision of the Old World species of the genus *Eurema* Hübner (Lepidoptera, Pieridae). Part II. Description of the *smilax*, the *hapale*, the *ada* and the *sari* (part) groups. *Bulletin of the Kitakyushu Museum of Natural History* 10: 1–51, 21 plates.

1994. A revision of the Old World species of the genus *Eurema* Hübner (Lepidoptera, Pieridae). Part IV. Description of the *hecabe* group (part). *Bulletin of the Kitakyushu Museum of Natural History* 13: 59–105, pls. 5–35.

Yata, O., J. E. Chainey and R. I. Vane-Wright

2010. The golden and mariana albatrosses, new species of pierid butterflies, with a review of the subgenus *Appias* (*Catophaga*) (Lepidoptera). *Systematic Entomology* 35: 764–800.