Chapter - 6

LIFE CYCLES OF BUTTERFLIES

Several field and photographic guides for the identification of Indian butterflies are available (Haribal 1992, Kehimkar 2008, Mani 1986, Singh 2011, Roy 2011, Sondhi *et al.* 2013). In all these literature, least importance was given towards the studies of life histories of butterflies. In this context, the pioneering work of T.R. Bell (1909-1927) and D.G. Sevastopulo (1938-1948) are worth mentioning. However, review of these early works indicated that for many species, data particularly on the duration and phenology of early life stages were either absent or incomplete. Haribal (1992) noted that the life histories of nearly 70% of the Indian species require description. In view of the above, life cycles of two butterfly species namely *Appias libythea,* the Striped Albatross and *Hyarotis adrastus praba,* the Tree Flitter were studied in laboratory conditions. As because reproductive efficiency depends on life style and feeding pattern (Boggs 1981, Slansky and Scriber 1985, Muthukrishnan and Pandian 1987), larval performance with respect to food utilization was measured by feeding them on a daily supply of fresh leaf from their respective host plants.

6.1. Methodology used

These two species generally breed throughout the year. The natural plant community of one of the selected study site (Domjur, Howrah district) was searched to study the reproductive activity of these two butterfly species. Once located, detail investigations were made to observe oviposition, following which freshly laid eggs were collected to study the life cycle and the duration of early stages. After oviposition leaf with egg(s) was collected and brought to the laboratory. The piece of the leaf with the egg was then placed in a Petri dish (10cm × 1.5cm in depth). Inner side of this dish was lined with moistened blotting paper to prevent the leaf from drying. Five such samples were placed in separate containers (specially designed with transparent plastic sheet, one side open, rectangular in shape), the opened side of which was covered with mosquito net. The laboratory temperature was maintained at 30±2°C and relative humidity 80±10% with normal indirect sunlight conditions (Atluri *et al.* 2002, 2004a, 2004b, 2010, Ramana *et al.* 2004). The larvae were examined using hand lens on daily basis to determine each instars (based on moulting/ eclosion). The larvae were subsequently reared on a weighed quantity of fresh leaves supplied daily. The morphological characters, body length, body weight of each instar and the faeces

egested were recorded on daily basis. The pre-pupal behaviour of the final instar, pupal characteristics and the time of adult eclosion were also recorded.

Larval performance in terms of food utilization indices were calculated as described by Waldbauer (1968) and Scriber and Slansky (1981) –

$$\text{Consumption Rate (C.R.)} = \frac{\text{Wt. of food consumed}}{\text{No. of feeding days}}$$

$$\text{Growth Rate (G.R.)} = \frac{\text{Wt. gained by the instar}}{\text{No. of feeding days}}$$

$$\text{Approximate Digestibility (A.D.)} = \frac{\text{Wt. of food consumed} - \text{Wt. of faeces}}{\text{Wt. of food consumed}} \times 100$$

$$\text{Efficiency of Conversion of Digested food to biomass (E.C.D.)} = \frac{\text{Wt. gained by the instar}}{\text{Wt. of food consumed} - \text{Wt. of faeces}} \times 100$$

$$\text{Efficiency of Conversion of Ingested food to biomass (E.C.I.)} = \frac{\text{Wt. gained by the instar}}{\text{Wt. of food consumed}} \times 100$$

6.2. Results and discussion

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

Adults of *Appias libythea* breeds throughout the year. Figure 6.1 represents the life-cycle details of adult male, female and others. Host plants used for oviposition included *Crataeva adansonii, Capparis sepiaria, Capparis zeylanica, Bombax ceiba, Cleome rutidosperma.* Among these, *Crataeva adansonii* (Garlic Pear Tree or Caper Tree) was most frequently used for ovipositing in the study area.

Data pertaining to the duration of early life-cycle stages – egg, larva, pupa along with their length, diameter and duration in each stage is represented in Table 6.1.

Adult stage (Fig. 6.1a, b)

Both adult males and females were identically different in appearance. Male almost immaculate white on upper side, except for some dark apical shading and terminal markings produced inwardly along veins; under hind wings white, unmarked. Female also white, but upper forewing apex and termen broadly black and unspotted; costa broadly blackened from base to bar at end-cell. Upper hind wings have black terminal spots. Also male and female has distinct dry season form (DSF) and wet season form (WSF). In WSF, male slightly darker, whereas female much darker.

Copulation occurred mostly between 10-00h-13-00h and lasted for more than one hour. Adults were found feeding on flowers of *Lantana camara, Tridax procumbens, Ixora* spp. etc.

Egg stage (Fig. 6.1c, d)

Gravid females laid eggs singly on upper surface of leaves of the host plant preferably on newly emerged leaves, mostly before mid-day between 09-00h-12-00h. The eggs were erect, like a short-necked bottle having longitudinal ribs. The surface between the ribs was finely transversely striated. The colour was pearl-white when first laid, and shiny; however, became fine orange within a day. Each egg had a diameter of 1.0-1.5 (1.24±0.06) mm at the broadest region and height was 2.0-3.0 (2.57±0.11) mm. Incubation period was 3-4 days. Freshly hatched-out larva ate its own eggshell. The larva passed through five instars over a period of 14-17 days.

Larval stages (Fig. 6.1e, f, g, h, i)

The first instar (Fig. 6.1e) grew to length of 3.5-4.5 (4.01±0.09) mm. The body was sub-cylindrical, orange yellow, with head, thorax, and abdominal legs yellow. Head round from the front view, plain 0.3-0.6 (0.45±0.03) mm in diameter. Body covered with translucent fine hairs. Length of instar period was 2-3 days.

The second instar (Fig. 6.1f) grew to a length of 7.0-8.5 (7.95±0.15) mm. Body greenish yellow, lateral sides yellow, head pale yellow. Head was 0.9-1.3 (1.12±0.04) mm in diameter. Body was covered with fine hair. Length of instar period was 2-3 days.

The third instar (Fig. 6.1g) grew to a length of 10.5-12.0 (11.26±0.15) mm. Head was 1.2-1.6 (1.44±0.04) mm in diameter. Colour of the body was yellowish green, head green and body was covered with translucent fine hairs. Duration of instar was 2-3 days.

The fourth instar (Fig. 6.1h) grew to a length of 18.0-19.5 (19.02±0.12) mm. Body colour was green, head pale green, lateral sides yellow, head was 1.6-2.2 (1.94±0.07) mm in diameter. Hairs were still present all over the body. Duration of instar was 2-3 days.

The fifth instar (Fig. 6.1i) grew to a length of 30.0-37.0 (34.48±0.6) mm. Colour of the body was pale green, covered by very fine minute hairs allover body except head. Lateral sides white in colour. Body blotched allover closely with light purplish spots except in the head and belly. The body was sub-cylindrical, thickest in middle and fining down somewhat to both ends, though very little forwards. Head was roundish in shape and 1.7-2.4 (2.07±0.07) mm in diameter. Duration of instar was 3-4 days.

Pupal stage (Fig. 6.1j, k)

During the pre-pupa and pupal stages, the body of the mature larva became thick and short by contraction and became attached to the substratum over its entire body; duration being one day. Pupal body length was 21.0-25.0 (23.37±0.36) mm. Colour was light green, often with a brownish shade; there was lateral, abdominal row of black spots and a sub-dorsal row of yellow ones, one spot on each side to each

segment. Pupa was angulated type with distinct snout produced in front (which was not very long). Duration was 7-8 days.

Table 6.2 provides the quantitative data on food consumption, weight of faeces, weight gained, consumption rate (CR), growth rate (GR), approximate digestibility (AD), efficiency of conversion of digested food to biomass (ECD), efficiency of conversion of ingested food to biomass (ECI) for each of the five instars.

Table 6.1. Length and duration of early life cycle stages of *Appias libythea*

Stages		Diameter (mm)	Height (mm)	Length (mm)	Duration (days)
Egg		1.0-1.5 (1.24±0.06)	2.0-3.0 (2.57±0.11)	—	3-4 (3.5±0.17)
Larva	Instar I	0.3-0.6 (0.45±0.03) (Head)	—	3.5-4.5 (4.01±0.09)	2-3 (2.5±0.17)
	Instar II	0.9-1.3 (1.12±0.04) (Head)	—	7.0-8.5 (7.95±0.15)	2-3 (2.6±0.16)
	Instar III	1.2-1.6 (1.44±0.04) (Head)	—	10.5-12.0 (11.26±0.15)	2-3 (2.5±0.17)
	Instar IV	1.6-2.2 (1.94±0.07) (Head)	—	18.0-19.5 (19.02±0.12)	2-3 (2.6±0.16)
	Instar V	1.7-2.4 (2.07±0.07) (Head)	—	30.0-37.0 (34.48±0.6)	3-4 (3.6±0.16)
Pupa		—	—	21.0-25.0 (23.37±0.36)	7-8 (7.4±0.16)

Table 6.2. Food consumption and utilization efficiencies of *Appias libythea* larvae on *Crataeva adansonii* leaves

Instar	Wt. of food consumed (mg)	Wt. of faeces (mg)	Wt. gain (mg)	No. of feeding days (d)	C.R. (mg/d)	G.R. (mg/d)	A.D. (%)	E.C.D. (%)	E.C.I. (%)
I	4.10±0.09	0.08±0.005	0.18±0.01	2.33±0.16	1.75	0.07	98.04	4.47	4.39
II	56.00±2.29	1.54±0.03	1.97±0.04	2.44±0.04	22.95	0.80	97.25	3.61	3.51
III	220.00±3.94	23.88±0.78	27.61±0.74	2.55±0.17	97.77	10.82	89.14	14.07	12.55
IV	315.67±6.42	89.66±3.03	34.56±0.55	2.78±0.14	113.55	12.43	71.59	15.30	10.95
V	423.11±6.15	164.56±3.60	116.11±3.71	3.56±0.18	118.85	32.62	61.11	44.90	27.44

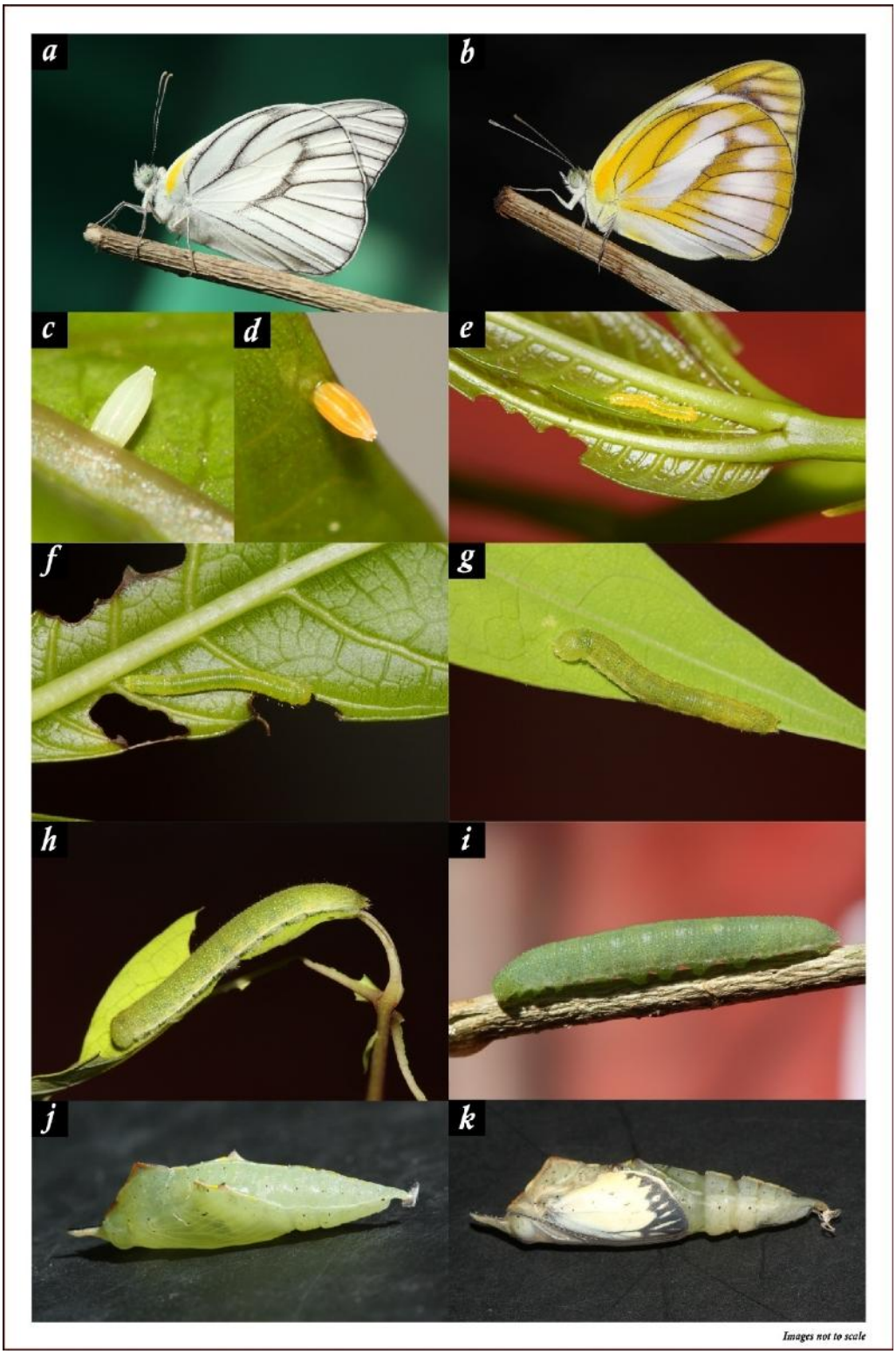

Figure 6.1. Life stages of *Appias libythea*. *a.* Adult male, *b.* Adult female, *c.* Egg *d.* Egg immediately before hatching, *e.* Instar I, *f.* Instar II, *g.* Instar III, *h.* Instar IV, *i.* Instar V, *j.* Pupa, *k.* Pupa before emergence.

6.2.2. *Hyarotis adrastus praba* (Moore, [1866]) – Tree Flitter

Adults of *Hyarotis adrastus praba* breeds throughout the year. Figure 6.2 represents the life-cycle details of adult male, female and others. Host plants used for oviposition included *Phoenix acaulis* and other palms. Among these, *Phoenix acaulis* (Stem-less Date Palm) was most frequently used for ovipositing in the study area.

Data pertaining to the duration of early life-cycle stages – egg, larva, pupa along with their length, diameter and duration in each stage is represented in Table 6.3.

Adult stage (Fig. 6.2a, b)

Both adult male and female were nearly identical, characterized by dark brown upper-wing, outer half of wing dark ochreous, with irregular broken central white band across under hind wing. Fore wing had a large white semi-transparent spot across cell. Upper hind wing unmarked, under fore wing had a central, diffused dark brown band. Chequered brown-and-white fringe present along wings. Females were usually much larger than their male counterparts. Adults were found feeding on flowers of *Murraya koenigii*, *Ixora* spp., *Hibiscus* spp. etc.

Egg stage (Fig. 6.2c, d)

Gravid females laid eggs singly on the underside of a leaf, very rarely on the upper surface also. The eggs had a shape of a very high dome, widest at base and tapered toward centre at top forming a sloping flange or foundation. Surface of the egg was moderately shining, sullied yellow in colour and has faint reddish-brown markings randomly scattered over the surface. The surface was sculptures with extremely fine, ribs that extends from, and including, the base to about two-thirds of the way to apex; the upper third remaining quite smooth-frosted. Each egg had a diameter of 1.4-1.7 (1.53±0.03) mm at the base and the height was 0.9-1.2 (1.04±0.02) mm. Incubation period was 4-5 days. Before hatching the colour of the eggshell became creamy white. Freshly hatched out larva ate its own eggshell. The larva passed through five instars over a period of 15-18 days.

Larval stages (Fig. 6.2e, f, g, h, i)

The first instar (Fig. 6.2e) grew to a length of 2.5-3.5 (3.10±0.09) mm. The body was long-stretched and orange yellow in colour. Head was round from the front view, plain 0.6-0.8 (0.71±0.02) mm in diameter and shiny black in colour. Diameter of head was much more than the overall diameter of the body. Few long, erect, light-coloured hairs were present at the free-margin of the anal segment. Length of instar period was 2-3 days.

The second instar (Fig. 6.2f) grew to a length of 6.5-7.5 (7.02±0.10) mm. Body colour was greenish yellow, lateral sides pale yellow and head dark brown. Head was still much larger than the overall diameter of body and had a diameter of 1.3-1.6 (1.47±0.03) mm. Allover body was covered with very minute, short hairs which were hardly visible. However, anal segment had visibly long erected hairs at its free end. Length of instar period was 2-3 days.

The third instar (Fig. 6.2g) grew to a length of 10.5-12.5 (11.68±0.18) mm. Head was 1.9-2.1 (2.00±0.02) mm in diameter. Body colour was white and head was dark brown in colour. Both body and head was covered with pale fine hairs. Anal segment still bears short erect hairs which were white in colour. Duration of instar was 2-3 days.

The fourth instar (Fig. 6.2h) grew to a length of 19.0-20.5 (19.95±0.13) mm. Body colour was white, head semi-circular elliptical in shape having two distinct lobes. The colour of the head was very light, somewhat soiled whitish-yellow with a narrow black band run parallel through the mid-region from top to bottom. Minute hairs were present allover body and head. Overall diameter of the head was 2.4-2.6 (2.5±0.29) mm. Duration of instar was 3-4 days.

The fifth instar (Fig. 6.2i) grew to a length of 29.0-33.0 (31.17±0.45) mm. Colour of the body was bluish white, covered all over with minute, short, erect, light hairs that were hardly visible. Much longer thickened hairs were present on the free surface of anal segment. Body segments were all well marked with the usual six impressed, parallel transverse lines running throughout body. Head was semi-circular elliptical in shape and clearly divided into two broad lobes. Colour of the head was whitish-yellow with a narrow dark brown margin and ridge (between two

lobes). Overall diameter of the head was 2.8-3.0 (2.91±0.03) mm. Duration of instar was 4-5 days.

The young larva made a semi-tube from the point of the leaf by joining the edges with silken threads but did not draw them together completely. When it became larger then it fastened one leaf on top of the other, often joining the edges of the one beneath to make it semi-tubular.

Pupal stage (Fig. 6.2j, k)

During the pre-pupa stage, the body of the mature larva became thick and attached to the substratum over its entire body; duration being one day. The colour of the larva became pinkish translucent-white with a broad dorsal line of dark-brown specks. Pupal body length was 31.0-35.0 (33.57±0.39) mm including the snout. Length of snout was 4.0-5.0 (4.56±0.13) mm; the shape of the pupa was circular in transverse section, narrowing from head to the end. It has long snout and spatulate cremaster. The pupa was fixed with the substratum by tail and body-band in a longitudinally half-open cell made on the underside of a leaf. Surface of the pupa was slightly shining, nearly quite smooth, colour pale yellow with a very slight pinkish shade. Duration of the stage was 9-10 days.

Table 6.4 gives the quantitative data on food consumption, weight of faeces, weight gained, consumption rate (CR), growth rate (GR), approximate digestibility (AD), efficiency of conversion of digested food to biomass (ECD), efficiency of conversion of ingested food to biomass (ECI) for each of the five instars.

Table 6.3. Length and duration of early life cycle stages of *Hyarotis adrastus praba*

Stage		Diameter (mm)	Height (mm)	Length (mm)	Duration (days)
Egg		1.4-1.7 (1.53±0.03)	0.9-1.2 (1.04±0.02)	—	4-5 (4.4±0.16)
Larva	Instar I	0.6-0.8 (0.71±0.02) (Head)	—	2.5-3.5 (3.10±0.09)	2-3 (2.4±0.16)
	Instar II	1.3-1.6 (1.47±0.03) (Head)	—	6.5-7.5 (7.02±0.10)	2-3 (2.5±0.17)
	Instar III	1.9-2.1 (2.00±0.02) (Head)	—	10.5-12.5 (11.68±0.18)	2-3 (2.7±0.15)
	Instar IV	2.4-2.6 (2.5±0.29) (Head)	—	19.0-20.5 (19.95±0.13)	3-4 (3.6±0.16)
	Instar V	2.8-3.0 (2.91±0.03) (Head)	—	29.0-33.0 (31.17±0.45)	4-5 (4.7±0.15)
Pupa		—	—	31.0-35.0 (33.57±0.39)	9-10 (9.4±0.16)

Table 6.4. Food consumption and utilization efficiencies of *Hyarotis adrastus praba* larvae on *Phoenix acaulis* leaves

Instar	Wt. of food consumed (mg)	Wt. of faeces (mg)	Wt. gain (mg)	No. of feeding days (d)	CR (mg/d)	GR (mg/d)	AD (%)	ECD (%)	ECI (%)
I	5.82±0.09	0.11±0.007	0.20±0.005	2.44±0.17	2.38	0.08	98.10	3.50	3.43
II	42.00±0.81	2.09±0.05	1.79±0.04	2.56±0.18	16.40	0.69	95.02	4.48	4.26
III	146.33±1.44	13.11±0.42	10.78±0.46	2.67±0.16	54.80	4.03	91.04	8.09	7.36
IV	243.89±3.38	34.44±0.76	40.44±0.89	3.11±0.26	78.42	13.00	85.87	19.30	16.58
V	344.11±3.17	160.44±2.32	137.00±1.50	4.00±0.23	86.02	34.25	53.37	74.59	39.81

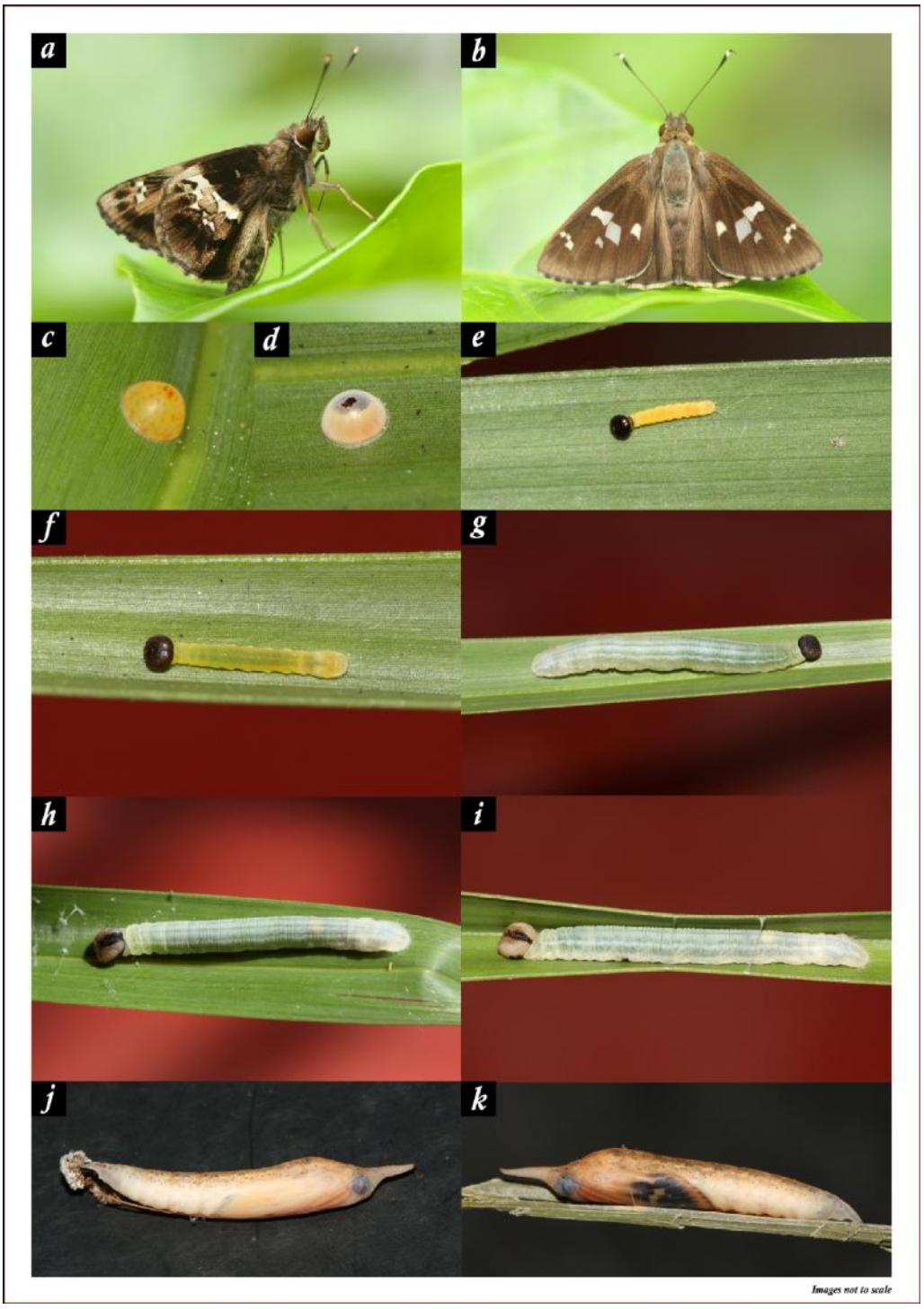

Figure 6.2. Life stages of *Hyarotis adrastus praba*. *a.* Adult under-wing, *b.* Adult upper-wing, *c.* Egg *d.* Egg immediately before hatching, *e.* Instar I, *f.* Instar II, *g.* Instar III, *h.* Instar IV, *i.* Instar V, *j.* Pupa, *k.* Pupa before emergence.

The results obtained for both the species showed that the amount of food consumption gradually increased from larval instars I to V and the fourth and fifth instar had a major share of the total amount of food consumed over the entire larval period. Similar findings have been reported for other butterfly species too (David and Gardiner 1962, Waldbauer 1968, Mathavan and Pandian 1975, Scriber and Slansky 1981, Palanichamy *et al.* 1982, Selvasundaram 1992, Ghosh and Gonchaudhuri 1996). Similarly weight gain corresponds to the food consumption trend of each larva. The values of growth rate also increases with the age of larvae. However, it shows more fluctuations in all the instars (Ghosh and Gonchaudhuri 1996). The values of AD are high with a tendency to decline as the larvae become old (Ramana *et al.* 2001). In case of *Appias libythea* the range of AD values were 61.11 to 98.04%, that of ECD 3.61 to 44.90%, and ECI 3.51 to 27.44%. Whereas, for *Hyarotis adrastus praba* larvae the values ranging from 53.37 to 98.10% (AD), 3.50 to 74.59% (ECD), and 3.43 to 39.81% (ECI) respectively. For *Hyarotis adrastus praba* the values of ECD and ECI decreased, but AD increased as the larva grew older. This is also supported by previous works of Atluri *et al.* (2004a, 2010) and Ramana (2010). However, for *Appias libythea* the results obtained are varied considerably. The ECD value of first instar larva was higher than second instar. For ECI value the same trend continued and likewise the value of third instar was higher than fourth instar.

Chapter - 7

THREATS AND CONSERVATION ISSUES OF BUTTERFLIES

Butterflies are one of the diverse groups and abundantly found in almost all suitable habitats. Virtually all butterflies are associated with plants and therefore their occurrence depends on the presence of specific host plants. Due to their omnipresence they perform important role in food web of particular ecosystem. The increasing pressure of human population has already affected the population of these butterflies and their diversity as well. Thus, some species have become very rare and endangered.

7.1. Methodology used

To study the threats that butterfly communities are facing constantly, all the four bio-geographic zones were visited regularly and data related to threats were collected for individual butterfly species. To enumerate the threats properly, literature were also consulted and even local people, forest guards, wildlife guides, farmers were asked to express their views about threats to survival of butterfly species. Thus, secondary information on these aspects was collected.

7.2. Results and discussion

7.2.1. Threats identified

Threats that butterfly communities are facing in each stages of its life cycle can be broadly categorized under two heads – natural and anthropogenic (man-made disturbances). As a matter of fact, natural risk includes attack by parasitoids and parasites and/ or predators. Whereas, anthropogenic disturbances through habitat destruction, degradation and fragmentation, developmental activities, rapid and unplanned urbanization, application of pesticides and weedicides in agricultural practices, fire in forested area, livestock grazing, environmental pollution that leads to climate change and illegal trade and poaching directly or indirectly effects the survival of the delicate creature.

Natural: Parasitoids and parasites

Various destructive agents may destroy over 95% of individual butterflies before they reach adulthood (Kunte 2008). However, this depends upon individual butterfly species. Parasitoids feed on eggs and larvae of butterflies internally. The female parasitoids lay eggs inside the eggs and/or larval stages of the host butterfly. The parasitoid larva then start feeding on soft tissues of the host, pupate

inside it, emerges as adult and fly from the host which is already dead. Butterfly species like *Graphium agamemnon* (Tailed Jay), *Papilio demoleus* (Lime Butterfly), *Danaus* spp. (Tigers), and *Euploea* spp. (Crows) were found parasitized by parasitoids flies (Fig. 7.1a,b,e). Parasites like various mites, parasitic flies, protozoans, bacteria, and viruses parasitize different life stages of butterflies. Mites and parasitic flies are the major external parasites of the adults, whereas others are internal parasites.

Natural: Predators

Natural predators were found to be harmful at different life cycle stages of butterflies. Predatory insects like wasps, ants, rubber flies, praying mantis and lacewings feed on larvae and adults (Fig. 7.1c,g). The ants devour the eggs of butterflies whenever they encounter any. The parasitic wasps hunt and paralyse caterpillars and store them in their nests as source of food for their newly emerged larvae. Praying mantis hunt caterpillars as well as adult butterflies (Fig. 7.1h). Adult butterflies irrespective of their size sometimes get entangled in the webs of the spiders; whereas jumping and crab spiders hunt down both adults and caterpillars by their usual way of jumping or ambush (Fig. 7.1d,f,). The vertebrate predators like reptiles (lizards, skinks etc.); insectivorous birds devour adult butterflies and even caterpillars (Bowers *et al.* 1985).

Anthropogenic: Habitat destruction, degradation and fragmentation

Destruction, degradation or fragmentation of habitats were found to be most worrying causes of decline in the numbers of butterfly species, or their retreats into smaller pockets which ultimately leads to extinction (Kunte 2000). In West Bengal, habitat loss or degradation took place and have taken place due to river valley projects (mainly northern part of West Bengal), expansion of agricultural land (Gangetic Plains) and extensive monoculture tree (*Sal* in western part) or tea (northern part of the State) plantations. These in turn directly or indirectly affect the survival of this delicate creature as they are very much host-specific and can't change their food habit easily (unlike moth species).

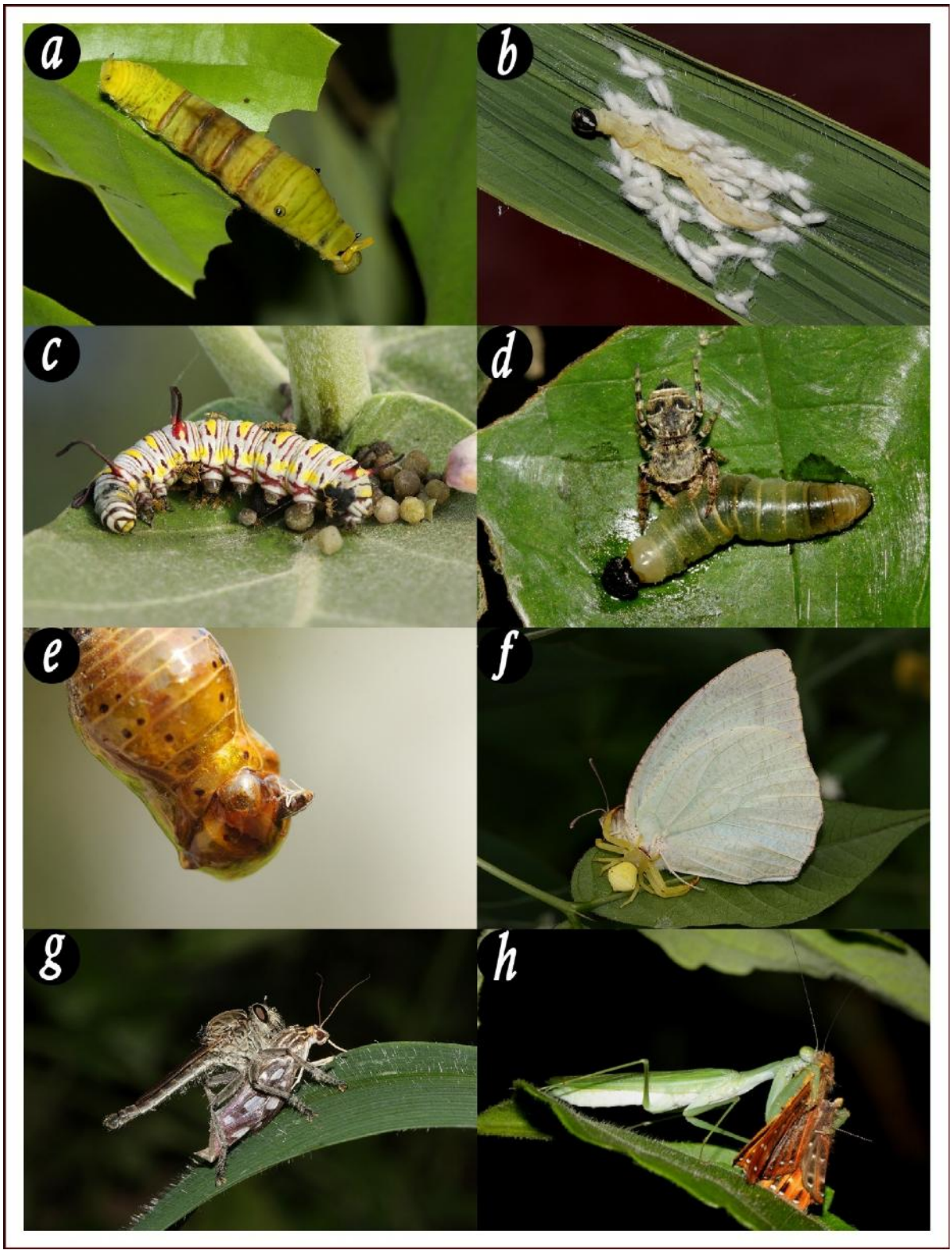

Figure 7.1. Natural predators affecting various life-cycle stage of butterflies. a. Infected larva (parasitoid), b. Infected larva with cocoon of parasitoid fly, c. Ants feeding on larva, d. Spider feeding on larva, e. Parasitoid fly emerging from pupa, f. Spider feeding on adult butterfly g. Rubber fly feeding on adult butterfly, h. Praying mantis feeding on adult butterfly.

Anthropogenic: Fire

In most of the landscapes in India, forest fires are responsible for influencing the species diversity and composition of flora and fauna (Rodgers 1986, Milchunas and Lauenroth 1993). It is a very strong destructive agent and wipe out all vegetations including larval host plants within its range. Fires promote the growth of only certain fire-resistant plants instead of diverse group of plant species. The fires can directly kill early life-cycle stages or certain less mobile adult butterflies. Butterflies that are commonly seen throughout the year are most susceptible to fire. As a result butterflies may lose their flight period in the pre-monsoon (summer) months (Kunte 2000). It has been observed that, forests with moderate rainfall and frequent fires, the ground vegetation are dominated by tall grass communities (Evans *et al.* 1989). Due to presence of tall grasses, herb growth is mostly suppressed in these areas, which are known larval host-plants for many butterfly species. Fires can occur naturally or be initiated by human beings. Natural fires were observed in drier parts of West Bengal (Purulia, Bankura, West Bengal, Birbhum districts), during summer months, mainly in the '*Sal*' (*Shorea robusta*) forests. Whereas, in many of the Protected Areas like Gorumara National Park which is home for large herbivores like Asian Elephants (*Elephas maximus*), Greater One-horned Rhinoceros (*Rhinoceros unicornis*), Indian Gaur (*Bos gaurus*), and other deer species, dry-season grass burning is a common practice used by the park managers. In the hilly regions/ districts of West Bengal '*Jhum*' cultivation is widely used, which also destroy native plant species by the fire caused by local farmers. However, fires seem to affect species composition of butterflies but not species-richness (Kunte 1997).

Anthropogenic: Application of pesticides and weedicides

The pesticides and weedicides that are commonly used in the agricultural fields are usually very toxic. They kill not only the target species but also all the life forms including adult butterflies wherever they are sprayed. The pesticides kill early life-cycle stages of butterflies, whereas weedicides destroy larval host plants of butterflies. During the survey it came into foresight that major part of West Bengal falls under bio-geographic province Lower Gangetic Plain which has one of the most fertile soils in the world. The primary occupation of people residing in these areas is agriculture and farming. For high yielding crop variety uses of pesticides is a common practice. Therefore, adult butterflies and sometimes few caterpillars also

get killed in the crop field and adjacent areas. In the northern part (Darjeeling and Jalpaiguri districts) there are many tea gardens, where pesticides are used regularly inflicting considerable damage to the butterfly population.

Anthropogenic: Live-stock grazing

Grazing by domestic cattle is another factor which is responsible for variations in species diversity and composition of flora and fauna in Indian landscape (Rodgers 1986, Milchunas and Lauenroth 1993). Grazing adversely affects butterflies in two major ways – trampling and effects on vegetation composition (Kunte 2000). The early life-stages get killed due to trampling. Areas affected by severe grazing can bring about changes in the vegetation composition. As a result palatable plant species can be replaced with weedy, non-palatable plant community (Anderson 1982), which ultimately leads to loss of butterfly diversity due to unavailability of their host plants. In rural West Bengal domestic cattle's grazing is a serious problem, whereas in Protected Areas (National Parks, Sanctuaries and other Reserve Forests) with high density of herbivore mammals resulted in elimination of tall grass communities and kept the grass and other palatable plant density low.

Anthropogenic: Global warming

If other factors are favourable, air pollution alone does not appear to affect the survival of butterflies (Kunte 2000). However, they are highly sensitive to local weather, climate, light levels, and other parameters that are affected by habitat disturbances (Ehrlich 1992, Hill *et al.* 1995, Blair and Launer 1997, Wood and Gillman 1998). For few butterfly species global climate change seems to be a stronger change-agent than habitat loss. As the temperature is rising, population of warm adapted butterflies are increasing in size and moving further uphill (cooler areas), however, population of cold-adapted butterflies are decreasing in size (since they can't move higher). That's why many new range extension records of plain land butterflies are coming from hill or snow-clad areas (Smetacek 2011). Global warming is affecting many species of butterfly that overwinter as larvae. If the summer, fall and winter are warmer due to global warming, the snow melts at a quicker rate and the butterflies that over-winter their eggs might encounter a lack of water, this can lead to dehydration. Also, global warming may cause plants to grow earlier in the year, which can lead to shading of butterfly larvae. This, in turn,

may slow the larval growth in the species that hatch in the spring. The most affected areas included Central Himalayan region in West Bengal.

Anthropogenic: Illegal trade and poaching

Insects (especially butterflies) trading has a long and complex history. The global trade is sustained by less than 50 common species mostly belonging to the family Nymphalidae (notably *Danaus* spp.*, Idea* spp.*, Morpho* spp.*, Cethosia* spp.*, Heliconius* spp.*, Hypolimnas* spp.), Papilionidae (*Papilio* spp.), with a smaller number of Pieridae (*Hebomoia* spp.), representing between them 0.25% of global butterfly species diversity (Boppré and Vane-Wright 2012). There is practically no live trade in the other three families of butterflies. Although pupae of about 300 species have been traded to butterfly houses over the last decades (Collins 1987, Morris *et al.* 1991). Worldwide trade in butterflies is estimated to be worth US$ 100 million per year (Fitzgerald 1989). From India butterflies of family Papilionidae especially *Parnassius* spp., *Bhutanitis* spp., *Papilio* spp., *Teinopalpus* sp., and *Troides* spp. are specifically targeted by the collectors (Hanfee 1998). One such specimen can fetch up to thousand of dollars in Europe and USA. In India main collection centres are Himalayan and Trans-Himalayan region, North-East India, Western Ghats, Andaman and Nicobar Islands. These dead specimens are then used for preparation of butterfly plaques, drawing room hangings, ornaments, pen holders, table mats and other decorative items. Even they are traded as entomological research specimen to museums, private collectors in various countries. Dead specimens are mostly traded to Germany, Japan, Switzerland, England and USA. Live specimens, eggs and pupae are traded to butterfly houses in USA, Japan, Europe, Malaysia and Singapore. Collectors from South-East Asia regularly visit India for butterflies' collection. They collect butterflies with the help of local people, farmers, even young and give them only small amount of money per catch. During the entire survey around Darjeeling Himalayas, it has been revealed that major species (mostly beautiful Papilionids) had almost disappeared. In the last decade many cases and/or incidents of butterfly and other insects smuggling had come into limelight from Darjeeling-Sikkim (Eastern Himalaya) region (Bahuguna 1998, 1999). These are only handful of cases which come into foresight due to proper action taken by the Forest Department and Customs Department. However, most of the cases remain unnoticed due to lack of awareness among locals.

7.2.2. Measures to conserve butterflies

Measures: Legal measures

The Wild Life (Protection) Act, 1972 was introduced in India to ensure protection of wild animals including their habitats. As per the Act, the collection of listed butterflies from the wild, or any action leading to threatening their habitats, is prohibited (Anonymous 2007a). In all, the Wild Life (Protection) Act, 1972 has listed 450 butterfly species and subspecies in three of total six schedules, 128 under first, 303 under second and 19 under the fourth Schedule (Table 7.1). Other Schedules do not have any butterflies listed under them. Therefore, in India almost one-third of known butterflies are now protected by the law (Gaonkar 1996). The species that are listed in Schedule I enjoy the highest level of protection. Level of protection attributed decreases gradually as Schedule number increases (i.e. from II to VI).

In the present study a total of 49 species out of 330 butterflies recorded were found to be protected under three Schedules of Wild Life (Protection) Act, 1972 (Table 5.1). Five butterflies are listed in Schedule I, these were *Atrophaneura hector*, *Chliaria othona*, *Sephisa chandra*, *Hypolimnas misippus*, and *Calinaga buddha*. 35 butterflies are protected under Schedule II, these were – *Graphium aristeus*, *Papilio epycides*, *P. bootes*, *Appias albina*, *Poritia hewitsoni*, *Arhopala fulla*, *Mahathala ameria*, *Horaga onyx*, *Tajuria cippus*, *Chliaria kina*, *Sinthusa nasaka*, *Bindahara phocides*, *Rapala varuna*, *R. buxaria*, *Acupicta lohita*, *Spindasis nipalicus*, *Anthene lycaenina*, *Prosotas aluta coelestis*, *Lampides boeticus*, *Euchrysops cnejus*, *Udara albocaerulea*, *Polyura dolon*, *Charaxes aristogiton*, *C. kahruba*, *C. marmax*, *Elymnias vasudeva*, *Mycalesis anaxias*, *Auzakia danava*, *Athyma ranga*, *Neptis ananta*, *Neptis soma*, *Tanaecia lepidea*, *Apatura chevana*, *Euripus nyctelius*, and *Bibasis*. Lastly 9 butterflies namely – *Appias libyhtea*, *Prioneris thestylis*, *Tarucus ananda*, *Euploea mulciber*, *Euthalia lubentina*, *Pelopidas subochracea*, *Pelopidas assamensis*, *Baoris farri*, and *Hyarotis adrastus praba* are listed in Schedule IV. This Act was the first, modern legal step at the national level towards the conservation of all wildlife in India. However, the butterfly lists in the Schedules of the Wild Life (Protection) Act, 1972 are very biased and inadequate and butterflies have also not been chosen based on extent of their geographical distribution and abundance (Kunte 2000). For example, brush-footed butterflies' makes up the lion's share

among the listed species (211), where as skippers are very poorly represented (only 12 species). Even butterflies like *Lampides boeticus* and *Euchrysops cnejus* which are considered as minor pest on cultivated varieties of peas, beans and grams were included in the list (Schedule II Part II). On the other hand many threatened species, or species having small geographic distribution (restricted distribution) are not mentioned in the lists. For these reasons, an objective revision of the Schedule lists will be very useful in providing appropriate and adequate legal protection to Indian butterflies.

Measures: Integrated management

There are several butterfly parks, butterfly breeding and research centres in many parts of the world. Earlier, this has not been attempted in many tropical and sub-tropical countries including India (Kunte 2000). Now-a-days new butterfly gardens are coming out in India. The host plants of butterflies are given protection in their native habitats, and caterpillars are reared on them. However, to conserve butterflies it is necessary to identify the larval host plants and nectar plants of all the butterflies. If this method of breeding butterflies is widely used, it can potentially protect not only the target species but also other insects' along with their habitats. Often the ordinary citizens may directly be able to help in conservation as a whole by planting known larval host plants of butterflies in road-side areas. During annual plantation programme civic bodies may also select native tree species which can help wildlife including butterflies to survive.

Table 7.1. Family-wise list of butterflies under Wild Life (Protection) Act, 1972 of India

Family	Schedules of the Wild Life (Protection) Act, 1972			
	I	II	IV	Total
Papilionidae	14	21	0	**35 (8%)**
Pieridae	6	21	4	**31 (7%)**
Nymphalidae	61	141	5	**211 (47%)**
Riodinidae	0	4	0	**4 (1%)**
Lycaenidae	47	113	1	**161 (36%)**
Hesperiidae	0	3	9	**12 (3%)**
Total	**128**	**303**	**19**	**450 (100%)**