P O L I S H J O U R N A L O F E N T O M O L O G Y
P O L S K I E P I S M O E N T O M O L O G I C Z N E

VOL. **76**: 341-352 Bydgoszcz 30 December 2007

Study on the biology and consumption potential of Common Rose *Pachliopta aristolochiae aristolochiae* F (Lepidoptera: Papilionidae) on *Aristolochia tagala*

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ABSTRACT. Some observations were made to study the biology of *Pachliopta aristolochiae aristolochiae* on its host plant *Aristolochia tagala*. Singly laid eggs on the host plant (*Aristolochia tagala*) were collected from the field and reared in the laboratory under optimum conditions of temperature and humidity. The egg laying behaviour of the gravid female, hatching, feeding and moulting behaviour of the 4 larval instars were recorded on the creeper host-plant *A. tagala*. The feeding potential of all the larval instars on the various leaf maturity stages was also recorded. The various stages of pupation up to the emergence of the adult from the chrysalis were recorded. The laboratory study revealed an incubation period of ± 4 days, larval duration of ± 20 days, pupation period of ± 12 days. The study revealed a total life cycle of ± 30 days in the monsoon season under conditions of laboratory rearing. The larval feeding potential was determined by both the maturity and availability of suitable leaves although the mature larvae were observed to feed on the stems of the host-plant in the absence of suitable leaves. Field observations and laboratory study established that *Pachliopta aristolochiae aristolochiae* endemic to Southeast Asia is on the wings throughout the year with a higher density during the wet season (May-October). It is multivoltine with 7-8 generations yearly. The species displayed single egg-laying habit, which coupled with host-plant specialization with larvae feeding on *A. tagala* and *A. indica* allowed efficient utilization of the food resources.

KEY WORDS: Biology, behaviour, feeding potential, moulting, instar, incubation, pupation.

INTRODUCTION

The red-bodied swallowtail *Pachliopta aristolochiae aristolochiae,* is a commonly available butterfly in the Assam valley. The distribution of this Indo-Australian species has been described from India and Sri Lanka up to Southern China and Southeast Asia (EVANS 1932, TALBOT 1939). In India there are 5 sub-species and in the Eastern Himalayas, the distribution of this swallowtail species was recorded as Common by EVANS (1932) and TALBOT (1939). The IUCN status of this species is in the Indo-Burma hotspot is 'Very Common' and 'Not Threatened' (COLLINS & MORRIS 1985).

The identifying field characters of this butterfly are a sub marginal row of red lunular markings and a discal row of white spots on upper side of hind wings. The hind wings also bear robust club-shaped black tails. The wingspan is 80-110 mm (HARIBAL 1992). The females of another swallowtail species, *Papilio polytes* Lin. (Common Mormon) as well as of the Rose Windmill (*Atrophaneura latreillei*) mimic the Common rose. The adults prefer the flowers of *Lantana camara*, *Clerodendrum infortunatum*, *Nerium indica*, *Hibiscus rosa sinensis*, *Moringa oleifera* and *Bauhinia variegata*, for nectaring while the larvae feed on the creeper plant, *Aristolochia tagala* and *A. indica*. Being an *Aristolochia* feeder, this butterfly is highly unpalatable to its enemies due to the presence of aristolochic acid in the larval tissues (VON EUW et al. 1968, WU et al. 2000, SLANSKY 1972, SCRIBER 1984). The rainforest edges and clearings as well as the rainforest understorey and water streams along the upland forests are the common habitats of this butterfly. This swallowtail butterfly is not particularly fond of mud puddling although it prefers sunshine (HARIBAL 1992).

The larval food plant *A. tagala* is a poisonous creeper (vine) belonging to the plant family Aristolochiaceae which are also mostly tropical (HOEHNE 1942). Commonly known as the Indian Birthwort (Local name: Iswarimul), this creeper has pharmacological properties (HOEHNE 1942, VON EUW et al. 1968, CHEN & ZHU 1987) and the plant extract is known to have potent anti-cancer properties (HYNNIEWTA et al.1992). In Assam, the distribution of this creeper is very restricted to hilly or upland forests and the understorey in both mixed deciduous and tropical rain forests. The larval stages of all the red-bodied swallowtails are *Aristolochia* feeders and this makes them unpalatable to their vertebrate enemies like birds and reptiles due to the sequestering of aristolochic acids in the larval tissues which are passed on to the adults (BROWER et al. 1967, VON EUW et al. 1968, RAUSCHER & FEENY 1980).

In Northeast India including Assam this swallowtail is found up to 5000 feet and is flying in mid-November. Habitat destruction resulting from logging and shifting cultivation, clearing of scrub jungles and foothill vegetation for raising monocultures might have resulted in the decline of its larval host plants and consequently the decline in the *P. aristolochiae* populations. The life history of this butterfly in Assam has not been studied so far. Therefore the present investigation deals with the life cycle of this butterfly along with

a study on the larval feeding and moulting behavior as well as the study of the larval feeding potential on the different leaf maturity stages.

Rearing of this species and releasing the same in the wild will help restocking its slowly depleting population, and also serve as a measure for its conservation (GAY et al. 1992). However to be successful in this direction one needs a complete knowledge of its biology and autecology including its life history, voltinism, seasonality and habitat conditions. Data on larval performance in respect of food consumption, utilization and growth and information on adult nectar sources are necessary for the effective conservation management of this endemic species.

MATERIALS AND METHODS

The life cycle of *P. aristolochiae aristolochiae* was studied in the laboratory for 2 consecutive years from 2002 to 2003 during the monsoon season under optimum conditions of temperature 32°C and humidity (75%). The host plant was collected from the field and reared in 6 numbers of earthen pots outside the laboratory. *A. tagala* was selected for the study because of its relatively high density in the field and accessibility for collection of leaf material. In the field, the females were observed to lay eggs on the tender shoots and leaves. A single female was observed to lay an average of 6-8 eggs in a sequence and preferably on different tender leaves. The egg diameter was measured using slide calipers. After hatching, the larval length, morphological characters and moulting behaviour from the 1st to 4th instars were recorded after every 24 hours.

For studying the larval feeding potential, we collected 25 numbers of fresh and singly laid eggs on 5 numbers of host plants and incubated the same in the laboratory at around 29-30°C and observed them daily for their development through various stages. A stock culture of 20 numbers of 1st instar larvae was raised. Immediately after hatching, the 1st instar larvae were allowed to feed for 24 hours to be followed by a starvation period of 24 hours. These were now divided into 3 sets, each set consisting of 5 numbers of 1st instar larvae. Each set of larvae were placed separately on tender, young and matured leaves and allowed to feed for 1 hour. Their feeding potential was measured following the method of SINGH & SINGH (1993). The experiments were repeated 5 times for all the larval stages (1st-4th) on the various leaf maturity stages. We scored once each month during the wet season to have a knowledge on the annual distribution. The total leaf consumption was measured on the basis of data obtained from 5 experimental readings.

RESULTS AND DISCUSSION

Life history stages

Egg

Each egg measured 1-2 mm in diameter and were brick red at the top while the remaining portion was dark orange in colour. They were round in shape but flattened at the bottom surface, which was attached to the leaf or stem. The eggs were laid singly on the underside of tender young leaves as well as on the tender shoot. In field conditions it was observed that a gravid female laid 8-10 eggs at a time on different leaves of the host plant and within a time span of 5 minutes. In the absence of suitable tender leaves, the female preferred to oviposit on tender shoots.

The incubation period was ± 4 days (Tables 1, 2).

First Instar

The freshly emerged larvae were transparent pale red in colour with faint blackish markings on the body. The time taken for hatching was observed to be 25-30 minutes. Just after hatching each larva measured 3 mm in length and 1mm in breadth. The body was covered with minute pale yellowish fleshy spines. The larvae started feeding on the egg case 10 minutes after hatching and it was observed that after about 45 minutes the body colour of the larvae changed to pale brown. The 1st instar larvae grew upto a maximum length of 5mm and the body width measured 1.5 mm. The larval duration was ± 2 days (Tables 1, 2, Figs 2a-d).

Second Instar

Body was brownish black bearing 12 pairs of fleshy spines on both dorsal and lateral sides. The first 5 pairs of dorsal spines were brownish red in colour, the 6th pair creamish white and the last 6 pairs of abdominal spines were again brownish red in colour. The first 5 pairs of lateral fleshy spines were however brownish black in colour. The dorsal spines were longer than the lateral ones, each measuring 2 mm in length. In the 6th segment, the paired dorsal and lateral spines were joined on each side by a white line. As the larval stage progressed, the larvae grew bigger with the fleshy spines becoming more prominent. The 2nd instar larvae grew upto a maximum length of 9 mm and the body width measured 3 mm. The larval duration was ± 3 days (Tables 1, 2, Fig. 2e).

Third Instar

Body was velvety black and covered with 12 pairs of fleshy spines. The dorsal spines were brick red while the lateral spines were black with red tips. Each dorsal spine measured

2 mm and each lateral spine measured 1mm in length. The 6th pair of dorsal and lateral spines were reddish white and joined on both sides by a pair of reddish white lateral lines. Also in the 6th segment, a white line measuring 1mm in thickness joined the brick red dorsal spines on the upper side. As the larval stage progressed, it was observed that a small oval shaped black marking appeared on the lateral white lines of both sides. The 1st-3rd anterior segments had an additional pair of pale red fleshy spines between the dorsal and lateral spines. The larvae grew upto a maximum length of 2.8 cm and a breadth of 3-4 mm. Larval duration was ± 4 days (Tables 1, 2, Fig. 2f).

Fourth Instar

The larvae had a dark velvety black body and the fleshy spines were crimson red in colour at the upper portion and black at the basal half. The 6th segment dorsal and lateral spines were creamish white in colour and were joined both dorsally and laterally by thick white lines. The oval shaped black markings were prominently present in the middle of the white lines on both lateral sides. Just after moulting, the 6th segment fleshy spines were pale orange in colour, which gradually faded with a mild orange tinge at their free apical tips. The first 3 anterior segments had an additional pair of pale red fleshy spines. All the spines were becoming more prominent with increasing thickness. The larvae attained a maximum length of 4 cm and breadth of 8mm. Larval duration was ± 6 days (Tables 1, 2, Figs 2g-j).

Table 1. Larval duration in days.

Stages	Duration in days
Incubation period	± 4
1st Instar	± 2
2nd Instar	± 4
3rd Instar	± 4
4th Instar	± 6

Data based on 5 experiments (± standard error)

Table 2. Larval body measurements in different instars of Common Rose.

Larval stages	Larval dimensions in mm.				Weight gain by larva (mg)
	Minimum (Jac)		Maximum (Jbc)		
	length	breadth	length	breadth	
1st Instar	3.0	1.0	5.0	1.5	2. 5 ± 0.06
2nd Instar	6.0	2.0	9.0	3.0	17.7 ± 0.11
3rd Instar	10.0	3.5	28.0	4.0	80.6 ± 0.14
4th Instar	30.0	5.0	40.0	8.0	568.7 ± 1.10

JAC = Just After Casting, JBC = Just Before Casting

Chrysalis

It was light brown in colour with a mixture of white, orange and dark brown patterned markings on the dorsal side. The ventral side was light brown with faint white stripes. The anterior end of the chrysalis was produced into a frontally flattened broad projection, which further had a pair of flattened flaps on either lateral side. The 2nd pair of dorso-ventrally flattened flaps was present in the mid-anterior region. Between these 2 pairs there was a pair of markings having a mixture of white and dark brown colouration. Just below these markings, mid-dorsally the anterior part was raised into a pair of light brown continuous frilly flaps. The wing case was observed to bear 2 pairs of dorso-ventrally flattened, light brown flaps which further possessed on their upper side, some patterned markings having a mixture of white, orange and dark brown colouration. There were 4 segments in the posterior part of the wing case and each segment had 1 pair of laterally flattened light brown flaps. The chimaster was black in colour and was seen around the 4th anterior segment. The pupal size was (25 x 15) mm and the pupal duration was ± 12 days.

Adult

In the laboratory culture, the adults of both the sexes had emerged. The adults were observed to emerge from the chrysalis by splitting open the case vertically on the dorsal side. The time taken for emergence was recorded between 60-120 minutes. Although both the sexes were closely identical, the extended tail of the hind wings were observed to be comparatively pointed in females and more or less rounded in males. Again the inner margin of the hind wings had tufts of hair in the males, which are actually the scent scales from where the pheromones are released during the time of mate selection. Moreover in females, the abdomen was distinctly larger than that of the males.

The entire life cycle was completed within ± 30 days in laboratory conditions.

In the field study it was found that the Common Rose completed 7-8 generations in a year. The first generation emerged in March-April and the last generation was completed in December (HARIBAL 1992).

Behavioural study

The following observations relating to feeding and moulting were recorded in the laboratory culture.

Larval feeding behaviour

In the laboratory study, it was observed that just 5-10 minutes before hatching, the apical portion of the egg became dark brown in colour while the remaining portion of the egg was bright yellow. The 1st instar larvae slowly emerged by splitting open the egg case at the apical tip. The time taken for hatching was 25-30 minutes.

The freshly emerged larvae started feeding on the yellow coloured empty egg case only after about 10 minutes. The larvae were very sluggish in movement. They defoliated the very tender leaves by making small irregular shaped holes. The feeding time was recorded to be 1-2 minutes to be followed by a resting period of 80-100 minutes. The larvae took rest on the underside of leaves.

The 2nd instar larvae also preferred to feed on the tender leaves and defoliated along the sides of the leaf margin. The feeding time was 2-3 minutes to be followed by a resting period of 1-2 hours (Table 3, Fig. 1).

Table 3. Larval feeding potential of *Pachliopta aristolochiae aristolochiae* on the different leaf maturity stages of *Aristolochia tagala*.

Larval instars	SD	Leaf consumption in square mm			Mean feeding time (mins)	Mean resting time (mins)
		tender	young	mature		
1st Instar	0.8	111.55 ± 0.4	0	0	2	100
2nd Instar	0.7	580.53 ± 0.6	0	0	3	120
3rd Instar	2.5	0	2279.45 ± 1.1	2773.28 ± 0.9	12	60
	2.0					
4th Instar	0.9	0	4311.18 ± 0.4	5599.9 ± 0.2	25	60

Data based on 5 experiments (± standard error) SD = Standard Deviation

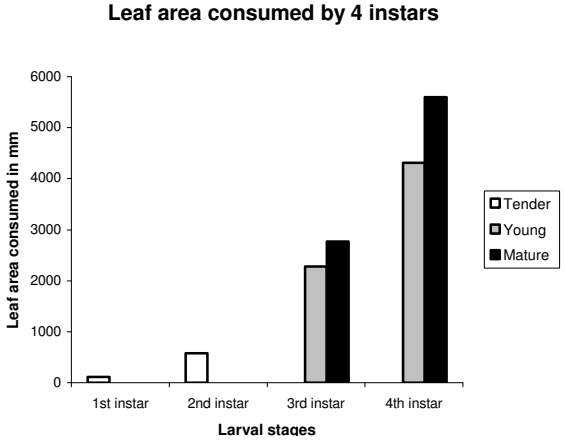

Fig. 1. Leaf area consumed (mm) by the 4 larval instars in different leaf maturity stages of *A. tagala*.

The larvae took rest on the underside of the leaves. Even while feeding it was mostly observed that the larvae defoliated the leaves from the lower side itself and therefore remained least exposed to predators. The mature 3rd instar larvae were voracious feeders, which defoliated both tender, young and matured leaves. In the absence of suitable leaves, they were also observed to feed on the tender shoots of the host-plant. The feeding time was recorded to be 10-12 minutes to be followed by a resting period of 45 minutes to 1 hour. The larvae preferred to take rest on the underside of leaves. The robust 4th instar larvae were also found to be voracious feeders, which preferred to defoliate the mature leaves, and in the absence of suitable leaves were found to consume the young and mature shoots of the host-plant. The feeding time recorded was 20-25 minutes to be followed by a resting period of 1-2 hours (Table 3, Fig. 1). The larvae took rest on the underside of leaves. When disturbed they ejected out a pair of orange-coloured osmateria and quickly moved away to a different site.

Moulting

The larvae moulted 3 times before finally passing into the pupal stage. The 1st instar larvae selected the underside of leaves for moulting. They stopped feeding and movement and took about 4 hours for the process. They took 10-15 minutes for wriggling out of the old skin. Within 30 minutes of moulting the larvae were observed to feed on their old skin casting and started feeding on tender leaves within the next 15-20 minutes. The 2nd instar larvae were also observed to exhibit a similar moulting behaviour. The 3rd instar larvae stopped their feeding for 8 hours prior to moulting. They selected the underside of mature leaves and completed the process of skin changing within 5-8 minutes. Within 45-60 minutes of moulting the newly emerged 4th instar larvae were seen feeding on the old skin casting. They resumed feeding on mature leaves after 5-6 hours. About 6-8 hours prior to pupation they stopped feeding and within next 2 hours were observed to eject out all the waste matter in the form of dark greenish – black semi-solid mass. They were reduced in body size and vigorously moved about in search of a suitable pupation site and always selected the mature stem of the host-plant. They first remained static for 15-20 minutes and then slowly fixed the posterior tip of the body to the stem and at the same time secreted a sticky black thread like girdle or Chimaster from the mouth, which surrounded the anterior part of the body from side to side. This took another 15 minutes. The body now slowly acquired an arch shape (Fig. 2j). They remained in this state for the next 24-48 hours following which the pupating larvae completely changed into the light brown coloured chrysalis stage.

- The entire process of pupation was completed within 14-15 hours. Our findings have conformity with the records of VANE-WRIGHT & ACKERY (1980).

- In the field condition, pupation took place among dense, low-growing vegetation and this has conformity with the records of VANE-WRIGHT & ACKERY (1980).

Egg-laying behaviour

The females were observed to repeatedly visit the host-plants and tried to probe the leaves for ascertaining their suitability for egg laying like the tender nature of the leaves and availability of shade. After repeatedly flying around the host – plant for about 5-8 minutes, a female was observed to lay eggs, one in each of the tender leaves. During egg laying, the forewings were observed to be continuously fluttering and it took about 5 seconds to lay a single egg. The female under observation laid only 2 eggs within a time span of 30 seconds. The female repeatedly tested similar-shaped leaves before finally selecting the underside of suitable tender leaves in a shady damp place for egg laying. This species was observed to lay the eggs singly as is the case with most papilionid butterfly species (STAMP 1980). The single egg-laying habit has an advantage in that it averts the possibilities of larval saturation by resource exhaustion and enables effective utilization of isolated plants (DAVIES & GILBERT 1985).

a) Freshly laid egg on host plant

b) Egg just before hatching

c) Newly hatched larva emerging from egg

d) 1st instar larva feeding on egg case

Figs 2a-d. Biology of Common Rose (*Pachliopta aristolochiae aristolochiae*) on the host plant *Aristolochia tagala*.

e) 2nd instar larva feeding on tender leaf

f) 3rd instar larva

g) 4th instar larva just after moulting

h) 4th instar larva feeding on mature leaf

i) 4th instar larva feeding on shoot of host plant

j) Mature larva pupating by forming chimaster

Figs 2e-j. Biology of Common Rose (*Pachliopta aristolochiae aristolochiae*) on the host plant *Aristolochia tagala*.

The Common Rose is of conservation interest because of its relatively short life cycle (± 30 days) as is characteristic of the tropical butterfly species (OPLER et al. 1984, OWEN 1971).

There was nearly 100% survival of the larvae on the host plant leaves in the laboratory and as a monophagous feeder it is easier to rear such species in the laboratory. As described in the earlier records of EVANS (1932) the status of this species was 'Very Common'. However the present status is not known and one of the major threats has been habitat destruction caused by human activities like logging for firewood collection by the forest villagers, burning down of forests for shifting agriculture which is in fact one of the major threats to declining butterfly diversity in North east India and stone quarrying activities. Majority of the hill forests in Northeast India are under severe threat due to practice of shifting agriculture (Jhum cultivation). Activities of private collectors engaged in the illegal trade in butterflies from the Eastern Himalayan region is also posing a major threat to the decline in the Papilionidae diversity in Northeast India. The earlier records of EVANS (1932) and TALBOT (1939) had documented 65 species of Swallowtail butterflies in the Eastern Himalayas out of which the status of nearly 40 species was Common. However there is a lack of recent documentation of the local butterfly assemblage. Declining tropical forest cover in Southeast Asia including Northeast India could be an indication of the declining butterfly diversity in North-east India as particularly the swallowtail butterflies are predominantly forest dwelling (COLLINS & MORRIS 1984) and the IUCN has identified the entire Northeastern region as a "Swallowtail-rich Zone" under the "Swallowtail Conservation Action Plan, 1984 (NEW & COLLINS 1991).

The biology of this species with respect to egg-laying and larval development is dependant on the host-plants *Aristolochia indica* and *Aristolochia tagala* belonging to the plant family Aristolochiaceae. This weak creeper is found in both closed and scattered or open forests and is associated with both shrubs in scattered forests or open forest patches and tall trees in closed forests with canopy > 70%. This plant is an endemic species in tropical South east Asia. Although most of the red-bodied swallowtails are canopy species, *Pachliopta aristolochiae* is an under-storey species and the females prefer the tender leaves in the under-storey for egg laying. The abundance of this swallowtail species is therefore dependant on the distribution of *Aristolochia* species as well as on the availability of the adult nectar sources. Observations on the adult food-plant resources of *P. aristolochiae aristolochiae* in the field showed that it utilized nearly 14 species of flowering shrubs and trees for harvesting nectar and species like *Lantana camara*, *Hibiscus rosa sinensis* and *Nerium indica* were observed in year long flowering condition.

A sustainable harvest of this red-bodied swallowtail in butterfly breeding houses will not only help in maintaining the recovering populations in the wild but the dead stock having good commercial trade value will also contribute to the trade in butterflies. Captive breeding will also help in a better understanding of its biology and an effective conservation strategy through creation of local awareness particularly amongst the school children and local villagers living near protected and unprotected forests can prove to be the most effective method for conservation of butterflies.

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Received: October 15, 2007
Accepted: November 06, 2007