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Comparitive biology of *Spilarctia obliqua* in Papaya (*Carica papaya*), Star Cluster (*Pentas lanceolata*), Cashew nut (*Anacardium occidentale*) and Pumpkin (*Cucurbita pepo*) agroecosystems

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Abstract
Studies related to the Biology of the Bihar hairy caterpillar, *Spilarctia obliqua* (Walker) in Kerala, especially in Northern Kerala is scanty. There were no comparative biology studies of *Spilarctia obliqua* (Walker) on different crops in Kerala. The present studies were undertaken during 2018-19, under room temperature (28-34^{0}C). The data on comparative biology of *Spilarctia obliqua* on different hosts inferred that Female lays around 148 to 232 eggs. The eggs were creamy white when laid became pale yellow in colour before hatching. The maximum number of eggs were recorded from *Carica papaya* (148-232) and *Pentas lanceolata* (150-230), while minimum number of eggs were recorded from *Anacardium occidentale* (148-230). Larvae develop through six instars in 20 to 22 days with an average of 21 days at 28-32 °C. The present studies, the comparative biology of *Spilarctia oblique is* important for to know the best host that support the development of *Spilarctia obliqua* and can be used for mass rearing. Similarly, the information of life history parameters of *Spilarctia oblique* on different host plant species will help to make efficient strategies to control this economic pest.

Keywords: comparative biology, *Spilarctia obliqua,* different hosts, Northern Kerala

Introduction
Star Cluster (*Pentas lanceolata*) is one of the common flowering plant in northern Kerala, while the papaya (*Carica papaya*), Cashew nut (*Anacardium occidentale*) and pumpkin (*Cucurbita pepo*) are the major agriculture crops in northern Kerala. Kerala was the leading cashew producing state in the country, has now slipped to the third position with Maharashtra ranking first and Andhra Pradesh second. There are many insects that cause damage to these crops. Among these many moth caterpillars are also there. *Spilarctia obliqua* is one of the moth pest that effect on these species in northern Kerala. It is commonly called as Bihar hairy caterpillar or Jute hairy caterpillar. *Spilarctia obliqua* also feeds almost all green vegetation. Larvae primarily feeds under surface of leaves and later feeds on the leaf margins, cause the loss of chlorophyll content and ultimately results in the formation yellowish brown colors in the leaves. Leaves skeletonisation, defoliation were also observed in later stages of infection. Defoliation leaving only stem and petioles. In severe cases, only stems are left behind. Other hosts include sunflower, mulberry, pulses and millets. *S. oblique* has been reported as major pest of Mulberry in Aurangabad, India (Sunil and Chandrashekar, 2013) [23]. Singh and Singh (1995) [20] studied the biology of Bihar hairy caterpillar, *S. obliqua* on sunflower. The results revealed that female moth laid 1089 eggs in March while 1849 eggs in November and the incubation period was found to be 3-12 days with 83.5 to 99.33 percent hatching. They also recorded egg diameter of 0.57 mm. The incubation period was found to be 5.60 days on groundnut (Nath and Singh, 1996) [17]. studied the seasonal biology of Bihar hairy caterpillar, It was also found that the incubation period on castor was shortest in October- November while longest in December – January (Debaraj and Singh (2010) [3]. Biswas (2006) [2] Studied the incidence of hairy caterpillar, S. *obliqua* on sesame at Oilseed Research Centre, BARI, Gazipur and found that the pest appeared in the sesame crop in the fourth week of April at the flowering stage at 45 - 55 DAS and remained up to third week of June at pod maturity stage, 90 - 95 DAS. The peak population of *S. obliqua* (4.00 – 4.50 larvae/ plant) and its severe infestation (100 % infestation) was recorded in the fourth week of May, at pod filling stage, 60-70 DAS of the crop. Other than India, *Spilarctia obliqua* is found in south-eastern Afghanistan, northern Pakistan, Bhutan, Bangladesh and Burma. The present studies, the comparative biology of *Spilarctia obliqua is* important for to know the best host that support the development of *Spilarctia obliqua* and can be used for mass rearing. Similarly, the information of life history parameters of *Spilarctia obliqua* on different host plant species will help to make efficient strategies to control this economic pest.

Materials and Method
The larvae were collected along with their host plants and were brought to laboratory for further rearing to adults at the entomology laboratory of ZSI, WGRC-Kozhikode, during 2018-19. The larval cultures were transferred to rearing cages of size 20×20×20 cm along with its host and were maintained in the laboratory conditions on

Spilarctia obliqua in papaya (*Carica papaya*), Star Cluster (*Pentas lanceolata*) and Cashew nut (*Anacardium occidentale*) and pumpkin (*Cucurbita pepo*) plants leaves at room temperature (28 ± 4°C) and relative humidity (70 ± 5%) by providing a layer of soil and fresh shoots and leaves daily until they reached pupal stage during experimental period. Full-grown larvae were allowed to pupate in the glass bottles (30 cm height and 20 cm diameter).Uneaten leaves and faces were cleaned from the bottles daily. Proper hygienic conditions were maintained. Open end of bottle was covered with muslin cloth held tightly with the help of a rubber band. The emerged adults were fed on 10 percent honey. A folded black paper sheet was placed in the rearing chamber to provide suitable sites for oviposition. Later killed the adult by using ethyl acetate, pinned through thorax using stainless anticorrosive insect pins (No. 3, 4). The insects were mounted on mounting boards, or on a thermocol, the antenna and wings were stretched properly in order to facilitate identification. Eggs obtained from these moths were placed in glass bottle .Newly hatched larvae were further used for different aspects of the study. The identification of the specimens were done by the keys developed by Hampson in the Moths volumes of the Fauna of India (1891, 1892, 1893, 1894, 1895 and 1896), Holloway (1988), Barlow (1982), Pinratana and Lampe (1990), Robinson (1994), Kendrick (2002), Mathew et al.,(,2018), Kononenko V S, Pinratana A. (2005, 2013). Singh and Singh (2014),Sivasankaran et al. (2014) and Kirti & Singh (2015,2016).

Result and discussion

Comparative biology of *Spilarctia obliqua* on different host plants.

1. Egg

Female lays around 148 to 232 eggs. The maximum number of eggs were recorded from *Carica papaya* (148-232) and *Pentas lanceolata*(150-230), while minimum number of eggs were recorded from *Anacardium occidentale* (148-230). Eggs are white initially and it turns to pale yellow in color. Prior to hatch the egg color again turns to black, which became the developing head of the larvae. Eggs are spherical in shape and mostly laid on the underside of the leaves. The egg measured about 0.25 to 0.27 mm in diameter. Incubation period ranged from 5 – 6 days with an average of 5.50 days in all hosts, at 28 to 32^0C.

2. Larvae

Larvae develop through six instars in 20 to 22 days with an average of 21 days at 28-32 °C.

A. First instar larvae

It is light yellow in color with large head and the entire body is covered by large hairs. They were inactive or lethargic which became active after some time. The larval lengths were noticed from 5.00 mm to 5.82 mm with an average of 5.42 mm. The maximum length was recorded from *Carica papaya* (5.02-5.82 mm), while minimum in *Anacardium occidentale* (5.01-5.78 mm). The widths were noticed maximum from *Carica papaya* (0.74 to 0.93 mm) with an average of 0.83 mm respectively. The larval stage last for maximum 3-4 days (*Carica papaya*) and minimum 2-3 days (*Cucurbita pepo, Pentas lanceolata*). The width of head capsule recorded maximum from *Carica papaya* (0.05 mm-0.07 mm), while minimum from *Pentas lanceolata* (0.04 mm-0.06 mm).

B. Second instar larvae

It is light yellow body color having brown markings on thoracic and last abdominal segments. The larval lengths were noticed maximum from *Carica papaya* (7.93 mm to 8.98 mm) and minimum from Pentas *lanceolata* (7.90-8.95). The widths were noticed maximum from *Carica papaya* (1.45 mm to 1.78 mm) and minimum were from *Cucurbita pepo* (1.41-1.74 mm). The larval stage last for 2-3 days in *Carica papaya* and *Pentas lanceolata*, while it is 2-4 days in *Anacardium occidentale* and *Cucurbita pepo.* The width of head capusule recorded maximum from *Carica papaya* (0.05 mm-0.07 mm), while minimum from *Pentas lanceolata* (0.04 mm-0.06 mm). The width of head capsule recorded maximum from *Carica papaya* and *Cucurbita pepo* (0.08 mm-0.11 mm), while minimum from *Pentas lanceolata* (0.07 mm-0.10 mm).

C. Third instar larvae

Third instar larva are pale yellow in color with dark head and body segments. The larval lengths were noticed maximum from *Carica papaya* (11.40 mm to 13.75 mm) and minimum from *Pentas lanceolata* and *Cucurbita pepo* (11.42 mm to 13.70 mm).the widths were noticed maximum from *Carica papaya* (2.07 mm to 2.25 mm). The larval stage last for maximum 5-6 days with an average of 5.50 days in *Carica papaya* and minimum 4-5 days with an average of 4.5 days in *Pentas lanceolata* and *Anacardium occidentale* and *Cucurbita pepo.* The width of head capsule recorded maximum from *Cucurbita pepo* (0.15 mm-0.18 mm), while minimum from *Anacardium occidentale* (0.14 mm-0.18 mm).

D. Fourth instar larvae

It is completely yellowish in color with dark brown head. Presence of light brown segments and tuft of brownish white hairs arose from reddish brown verrucae were observed. The larval lengths were noticed maximum from *Anacardium occidentale* (17.52 mm to 19.12 mm) and widths were noticed maximum from *Cucurbita pepo* (2.97 mm to 3.27 mm) and minimum from *Pentas lanceolata* (2.95 mm to 3.25 mm). The larval stage last for maximum 3-4 days in all hosts with an average of 2.50 days. The width of head capsule recorded maximum from *Cucurbita pepo* (0.21 mm-0.32 mm), while minimum from *Carica papaya* (0.20 mm-0.28 mm).

E. Fifth instar larvae

It is dark yellow in color with dark brown head, thoracic shield and reddish brown legs. The larval lengths were noticed maximum from *Carica papaya* (23.45 mm to 25.54 mm), while minimum from *Anacardium occidentale* (23.40 mm to 25.52 mm) mm and widths were noticed from 3.73 mm to 4.04 mm in *Carica papaya*, while it is minimum from *Pentas lanceolata*. The larval stage last for 3-4 days in *Carica papaya* with an average of 3.50 days and minimum in *Anacardium occidentale* and *Pentas lanceolata* (2-3 days).The width of head capsule recorded maximum from *Cucurbita pepo* (0.42 mm-0.58 mm), while minimum from *Anacardium occidentale* and *Carica papaya* (0.40 mm-0.55 mm).

F. Sixth instar larvae

It is the mature larvae having dark black head with brownish legs. The body color was observed completely reddish brown .The larval lengths were noticed maximum from *Anacardium occidentale* (28.08 mm to 29.70 mm) , while minimum from *Pentas lanceolata* (28.05 mm to 29.68 mm) and widths were noticed maximum from *Carica papaya* (4.56 mm to 5.01 mm), while minimum from *Anacardium occidentale* (4.52 mm to 5.00 mm). The larval stage last for 5-6 days with an average of 5.50 days in all hosts. The width of head capsule recorded maximum from *Carica papaya* (0.47 mm-0.72 mm), while minimum from *Anacardium occidentale* (0.44 mm-0.68 mm).

3. Pre-pupal period

The pre-pupal period was recorded 2-3 days in all hosts.

4. Pupae

Pre-pupal period ranges from 8 to 10 days with an average of 9 days at 28 to 32ºC. It is recorded maximum from *Pentas lanceolata* (8-10 days), while it is 8-9 days in all others. Pupation mostly occurs in sterilized soil. Pula color was observed in yellow or pale brown in color. The pupal lengths were noticed from 17.64 mm to 18.15 mm with an average of 17.89 mm and widths were noticed from 5.49 mm to 5.81 mm with an average of 5.65 mm respectively.

5. Adult

These are medium sized brown moths with pink abdomen. Both the wings are pale pink in color with small black spots .presence of light brown filiform antennae and legs were observed.

Male: Males are smaller than females. The abdomen is narrower and pointed. The lengths were noticed from 51 mm to 55 mm with an average of 53 mm and wingspans were noticed from 23 mm to 25 mm with an average of 24 mm respectively. The longevity is up to 4 to 5 days with an average of 4.5 days at 28 to 32ºC.

Female: Larger than males with blunt abdomen. Egg lying normally occurs in night hours. The lengths were noticed from 55 mm to 59 mm with an average of 57 mm and wingspans were noticed from 24 mm to 25 mm with an average of 24.5 mm respectively. The longevity is up to 6 to 7 days with an average of 6.5 days at 28 to 32ºC.

6. Adult longevity

The maximum longevity of male is recorded from *Anacardium occidentale* (5-6 days), while minimum was from 4-5 days in all other hosts. In female, the maximum longevity was recorded from *Pentas lanceolata* (6-8 days), while it is 6-7 days in all others.

7. The preoviposition period

The preoviposition period is noticed from 1.00 to 2 days in *Pentas lanceolata,* while it is a minimum of 1-1.50 days in all other hosts.

8. oviposition period

Oviposiotion last for 3 to 4 days with an average of 3.50 days in all the hosts.

9. Fecundity

The fecundity is observed maximum from *Pentas lanceolata* (151 to 230 eggs) , while minimum from *Anacardium occidentale* (148-230 eggs)at 28- 32 ^{0}C.

10. Percentage of hatching

Percentage of hatching was recorded maximum from *Anacardium occidentale* (80 to 94) and minimum from *Carica papaya* and *Cucurbita pepo* (78-94)

11. Total life span

Total life span of male and female ranged from 38 to 44 days with an average 41 days and 39 to 47 days with an average of 44 days, respectively.

Table 1: Comparative biology of *Spilarctia obliqua* on different hosts

Host	Incubation period	Larval period	Minimum and maximum days	Mean days	Length (mm)	Width (mm)	Head capsule width (mm)	Prepupal period	Pupal period	Adult longevity	Pre oviposition period	Oviposition period	Fecundity	Percentage of hatching
Carica papaya	5-6 days	I st Instar	3-4	3.5	5.02-5.82	0.74-0.93	0.05-0.07	2-3 days	8-9 days	Male : 4-5 days Female: 6-7 days	1-1.50 days	3- 4 days	148-232 eggs	78-94
		II nd Instar	2-3	2.5	7.93-8.98	1.45-1.78	0.08-0.11							
		III rd Instar	5-6	5.5	11.40-13.75	2.07-2.25	0.15-0.18							
		IV th Instar	3-4	3.5	17.50-19.11	2.98-3.30	0.20-0.28							
		V th Instar	3-4	3.5	23.45-25.54	3.73-4.04	0.40-0.55							
		VI th Instar	5-6	5.5	28.08-29.69	4.56-5.01	0.47-0.72							
Pentas lanceolata	5-6 days	I st Instar	2-3	2.5	5.00-5.80	0.75-0.90	0.04-0.06	2-3 days	8-10 days	Male : 4-5 days Female: 6-8 days	1-2 days	3- 4 days	151-230 eggs	78-95
		II nd Instar	2-3	2.5	7.90-8.95	1.42-1.75	0.07-0.10							
		III rd Instar	4-5	4.5	11.42-13.70	2.05-2.22	0.15-0.20							
		IV th Instar	3-4	3.5	17.50-19.10	2.95-3.25	0.20-0.30							
		V th Instar	2-3	2.5	23.42-25.52	3.70-4.00	0.42-0.57							
		VI th Instar	5-6	5.5	28.05-29.68	4.54-5.00	0.45-0.70							
Anacardium occidentale	5-6 days	I st Instar	2-4	3	5.01-5.78	0.74-0.91	0.05-0.06	2-3 days	8-9 days	Male : 5-6 days Female: 6-7 days	1-1.50 days	3- 4 days	148-230 eggs	80-94
		II nd Instar	2-4	3	7.91-8.94	1.42-1.74	0.07-0.11							
		III rd Instar	4-5	4.5	11.40-13.74	2.02-2.20	0.14-0.18							
		IV th Instar	3-4	3.5	17.52-19.12	2.93-3.22	0.21-0.30							
		V th Instar	2-3	2.5	23.40-25.52	3.72-4.00	0.40-0.55							
		VI th Instar	6-7	6.5	28.06-29.70	4.52-5.00	0.44-0.68							
Cucurbita pepo	5-6 days	I st Instar	2-3	2.5	5.00-5.82	0.75-0.91	0.05-0.07	2-3 days	8-9 days	Male: 4-5 days Female: 6-7 days	1-1.50 days	3- 4 days	149-230 eggs	78-94
		II nd Instar	2-4	3	7.92-8.97	1.41-1.74	0.08-0.11							
		III rd Instar	4-5	4.5	11.42-13.70	2.04-2.24	0.16-0.21							
		IV th Instar	3-4	3.5	17.50-19.10	2.97-3.27	0.21-0.32							
		V th Instar	2-4	3	23.42-25.52	3.71-4.02	0.42-0.58							
		VI th Instar	5-7	6	28.05-29.69	4.55-5.01	0.47-0.71							

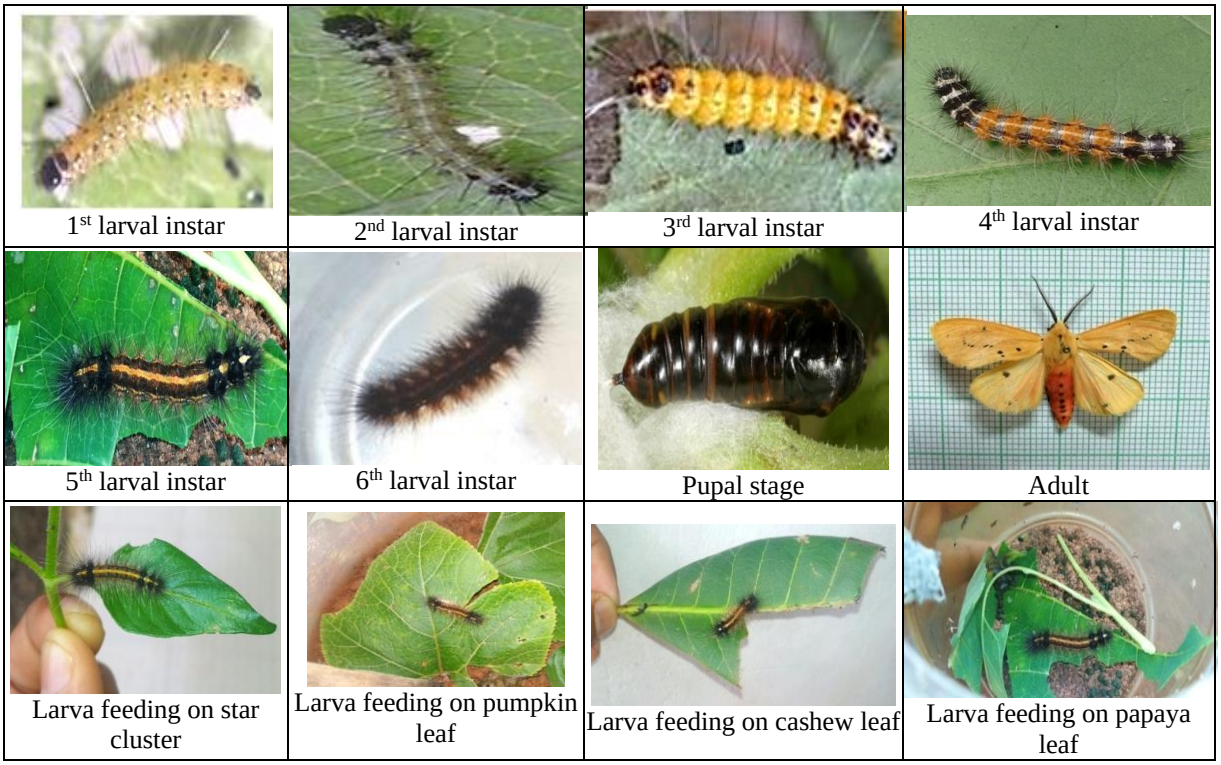

Plate 1

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