

Life cycle and morphometrics of leaf roller, *Haritalodes derogata* (Fabricius) on cotton in Surat, Gujarat, India

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ABSTRACT: The life cycle and morphometrics of cotton leaf roller, *Haritalodes derogata* (F.) (Lepidoptera, Pyralidae) study revealed that the average duration of eggs, larvae, male pupae, female pupae, male adult and female adult moths varied from 3.84 ± 0.99 , 15.40 ± 1.63 , 7.32 ± 0.69 , 7.88 ± 0.97 , 9.32 ± 0.75 and 10.40 ± 0.82 days, respectively. Pre-oviposition and post-oviposition periods were 3.36 ± 0.70 and 2.40 ± 0.65 days, respectively and the fecundity was 265.40 ± 42.55 eggs, within oviposition periods of 3.56 ± 0.58 days. The total life span for male and female was 37.40 ± 2.06 and 39.68 ± 2.36 days, respectively. The length and breadth of egg measured 0.54 ± 0.03 and 0.47 ± 0.02 mm, of full-grown larvae was 27.78 ± 1.18 mm and of male and female pupae were 11.95 ± 0.78 and 4.19 ± 0.14 and 13.34 ± 0.49 mm and 4.38 ± 0.11 mm, respectively. The length and breadth with wings expanded of male was 11.48 ± 0.70 and 22.27 ± 0.67 mm, while that of female moth was 13.79 ± 0.53 and 28.12 ± 1.42 mm, respectively. © 2025 Association for Advancement of Entomology

KEY WORDS: Biology, life span, measurements, stages, wings

Cotton (*Gossypium hirsutum* L.), is grown worldwide for its natural fiber and oil. Cotton leaf roller, *Haritalodes derogata* (F.), (Lepidoptera, Pyralidae) nowadays appeared regularly especially in non-Bt cotton varieties/hybrids. The pest occurs in India, Pakistan, Bangladesh, Burma, Australia, Africa, China, Japan and Sri Lanka. The pest is active from the month of September to November. The leaf roller is a polyphagous that feeds on malvaceous plants such as *G. hirsutum*, *Abelmoschus esculentus*, *Hibiscus rosasinensis*, *Urena lobata*, *Althaca rosea*, *Sida cordifolia* and *Malvastrum tricuspidatum*. The leaves rolled in the trumpets fastened by silken threads, feed on the green tissue in early stage, and eat up a large portion of the leaf as it grows. Caterpillar infestation can vary with some leaves having as few as 5 to 6,

while others may have as many as 32 young caterpillars on a single damaged leaf (Mariselvi and Manimegalai, 2016). In case of heavy infestation, there was complete defoliation. Larvae's destructive feeding activity limits photosynthetic area, as well as the quantity and quality of minerals and water uptake by the plant. If the above procedure continues, the plant will dry totally (Gahramanova *et al.*, 2020). Yield loss due to leaf roller in cotton up to 50 per cent has been reported in the northwest ecological zone of Nigeria (Yahaya, 2008). On the underside of leaves, the female moth lays 200-300 eggs, each of which takes 2-6 days to hatch. The resulting larvae undergo a developmental stage lasting 15 to 35 days, during which they can pupate on the plant, within curled leaves or among plant remains in the soil. The pupal

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stage lasts from 6 to 12 days and the entire life cycle lasts between 23 to 53 days (Mansion *et al.*, 2022). Owing to its regular occurrence and potential to be key pests, there is dire need to relook the life cycle parameters of the pest before formulating effective management tactics. A study was carried out to study the life cycle and morphometrics of different life stages on cotton in the laboratory of Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University (NAU), Navsari, Surat, Gujarat, India.

Initial culture of larvae of *H. derogata* were obtained from the unsprayed plot of non-Bt cotton hybrid (RCH 659 NBt) grown on Research farm, Main Cotton Research Station, NAU, Surat. The culture reared in the laboratory during *Kharif*, 2022-23. The larvae were reared in round plastic jar (15cm diameter × 10cm height) having fine netting cover as lid for aeration. Such five cages were prepared for mass rearing. Fresh cotton leaves were supplied daily after cleaning to the larvae as food. The newly formed pre-pupae with folded cotton leaves were gently collected and placed in another rearing jar covered with a fine netting lid. The pupae thus formed were separated as male and female pupae based on distance of genital and anal aperture and shape by critically examining under trinocular microscope and placed in separate acrylic rearing cage (30 × 30 × 30cm) for emergence of adults. The pair of male and female adults emerged as same dates were released into an oviposition cage for mating. A tender shoot of cotton with three to four leaves, cut and wrapped with absorbent cotton to maintain its turgidity was placed inside the oviposition cage as a place for egg laying. A swab of absorbent cotton dipped in a 5 per cent honey solution was hanged inside the cage as food for the adults (Sontakke *et al.*, 2015). The leaves with freshly laid eggs were detached and kept on wet blotting paper affixed to petridish (9cm diameter × 3cm height). These eggs were used for further study of life cycle and morphometrics. The five sets/replications each of twenty-five eggs of *H. derogata* was observed for hatching percentage. The different stages of *H. derogata* were critically observed under a dissecting stereo-trinocular microscope, using a very fine needle and moistened brush to determine the

shape and duration of each stage. Further, the measurement of length and breadth of various stages were also carried out under trinocular microscope (Make: Olympus-SZ 61) fitted with a Brand Catcam-130 camera and software power Scopephoto (Version 3.1). Average temperature and relative humidity were recorded as $27.77 \pm 1.66^{\circ}\text{C}$ and 65.11 ± 6.97 per cent, respectively during the study.

The life cycle of *Haritalodes derogata* consisted of egg, larvae (six instars), pupae and adult stages. The female moths laid eggs mostly singly during the night. The eggs were typically deposited on the lower surface of leaves, on leaf petioles, stems and squares of cotton plant. The freshly laid eggs were found small, whitish, translucent and spherical in shape. Within a day, the colour of the eggs becomes light yellow before hatching. The length of the eggs ranged from 0.50 to 0.62mm with an average of $0.54 \pm 0.03\text{mm}$, while the breadth varied between 0.45 to 0.55 mm, with an average of $0.47 \pm 0.02\text{mm}$. The incubation period varied from 2 to 6 days with an average of 3.84 ± 0.99 days. In first, second, third, fourth and fifth sets of hatching percentage were 90, 84, 96, 84 and 80, respectively. The minimum and maximum hatching percentage was 80 to 96, respectively with an average of 86.00 ± 6.26 per cent (Table 1, 2).

The larva was found to pass through six instars on cotton leaves under the laboratory condition. The freshly hatched larva had yellowish and transparent body colour, which later change to a light green colour as it starts feeding on cotton leaf. The body of the larva was slender and slimy with a comparatively transparent broad head. This stage of the larva was notably more active and sensitive compared to subsequent instars. The first instar larva had small head and enlarged prothorax. Each thoracic segment bears a pair of legs. Four abdominal prolegs are located on the 3rd to 6th segments. The last abdominal segment bears the 5th abdominal prolegs or claspers. The body was covered with numerous small setae. The length and breadth of first instar larva varied from 1.80 to 2.30mm with an average of 2.04 ± 0.16 mm and 0.24 to 0.31 mm with an average of $0.28 \pm 0.02\text{mm}$, respectively (Table 2). The width of head capsule

varied from 0.21 to 0.25 mm with an average of 0.23 ± 0.01 mm (Table 3). The duration of first instar larva varied from 1 to 3 days with an average of 2.20 ± 0.50 days (Table 1).

The second instar larva had yellowish green body, light brown head and slightly larger than first instar. It was more actively feeding on leaves than first instar. It possessed clearly visible setae on the body. The presence of two small brown spots on dorsal region of prothorax was distinctive feature of second instar larva. The length of second instar larva ranged from 3.28 to 4.00 mm with an average of 3.51 ± 0.18 mm, while the breadth ranged from 0.40 to 0.47 mm with an average of 0.43 ± 0.02 mm (Table 2). The width of head capsule varied from 0.37 to 0.43 mm with an average of 0.40 ± 0.02 mm (Table 3). The duration of second instar larvae varied from 2 to 3 days with an average of 2.44 ± 0.51 days (Table 1).

The third instar larva had dark green coloured body with brown head. The two brown spots on the prothorax start to develop into thoracic shields. The typical behaviour of feeding on the inner tissue of the rolled leaves was observed in third instar, which was not the case in first and second instars. The length and breadth of third instar larva ranged from 7.00 to 8.00 mm with an average of 7.70 ± 0.23 mm, 1.11 to 1.20 mm with an average of 1.15 ± 0.03 mm, respectively (Table 2). The width of head capsule varied from 0.89 to 0.95 mm with an average of 0.93 ± 0.02 mm (Table 3). The duration of third instar larva varied from 2 to 3 days with an average of 2.48 ± 0.51 days (Table 1).

Fourth instar larva had thick and strong body and was deep green colour with dark brown head and black thoracic shield. Larval prothoracic segment becomes slightly flattened on the ventral surface of the body. The thoracic legs were black with white claws and the abdominal prolegs were dirty white. The length and breadth of fourth instar larva ranged from 11.00 to 12.14 mm with an average of 11.91 ± 0.40 mm, 1.50 to 1.60 mm with an average of 1.54 ± 0.03 mm, respectively (Table 2). The width of head capsule varied from 1.10 to 1.25 mm with an average of 1.19 ± 0.04 mm (Table 3). The duration of fourth instar larvae varied from 2 to 4

Table 1. Duration (days) of different life stages of *H. derogata*

Life stages	Duration (days)	
	Range	Mean $\pm$ SD
Egg	2-6	3.84 ± 0.99
Hatching (%)	80-96	86.80 ± 6.26
Larva		
I instar	1-3	2.20 ± 0.50
II instar	2-3	2.44 ± 0.51
III instar	2-3	2.48 ± 0.51
IV instar	2-4	2.56 ± 0.58
V instar	2-4	2.68 ± 0.75
VI instar	2-4	3.04 ± 0.79
Total	13-18	15.40 ± 1.63
Pre-pupa	1-2	1.80 ± 0.41
Pupa		
Male	6-8	7.32 ± 0.69
Female	7-10	7.88 ± 0.97
Adult		
Pre-oviposition	2-4	3.36 ± 0.70
Oviposition	2-4	3.56 ± 0.58
Post-oviposition	1-3	2.40 ± 0.65
Longevity		
Male	8-10	9.32 ± 0.75
Female	9-11	10.40 ± 0.82
Fecundity	200-305	265.40 ± 42.55
Sex ratio		
Field	1:1-1.50	1:1.36
Laboratory	1:1-1.27	1:1.15
Total life span		
Male	30-39	37.40 ± 2.06
Female	35-43	39.68 ± 2.36

*Five sets of twenty five numbers each

days with an average of 2.56 ± 0.58 days (Table 2).

The fifth instar larva had a stout body with dark brown head. It was dorsally dark green and ventrally light green. The black thoracic shield started to degenerate from the posterior portion. The length and breadth of fifth instar larva ranged from 15.40 to 18.00 mm with an average of 16.60 ± 0.75 mm and 1.73 to 1.99 mm with an average of 1.84 ± 0.09 mm, respectively (Table 2). The width of head capsule varied from 1.40 to 1.64 mm with an average of 1.55 ± 0.06 mm (Table 3). The duration of fifth instar larvae varied from 2 to 4 days with an average of 2.68 ± 0.75 days (Table 1).

The fully grown sixth instar larva having a stout body with dark brown head and green in colour but towards pupation turns light green. The black thoracic shield continued to degenerate, so exposing the greater part of the prothoracic segment. The length and breadth of sixth instar larva ranged from 25.50 to 29.00mm with an average of 27.78 ± 1.18 mm and 2.40 to 3.00mm with an average of 2.74 ± 0.24 mm (Table 2). The width of head capsule varied from 1.83 to 2.20mm with an average of 2.08 ± 0.11 mm (Table 3). The duration of sixth instar larvae varied from 2 to 4 days with an average of 3.04 ± 0.79 days. In present study the total larval period varied from 13 to 18 days with an average of 15.40 ± 1.63 days and comprised of six larval instars as confirmed through the Dyar's law of ratio of width of head capsules (Table 1-3).

Pre pupa: The mature larva stopped feeding and began searching for a suitable location to spin its cocoon. The larva spun a delicate silken cocoon in various locations such as the rolled edge of a leaf, between two leaves that are glued together. During this period, the larva contracts its body length and appendages, turning pinkish in colour. After these transformations, the larva enters the pre-pupal stage and becomes sluggish. The length of the pre-pupae ranged from 13.60 to 18.00mm with an average of

15.90 ± 1.50 mm, while the breadth ranged from 2.00 to 3.20mm with an average of 2.24 ± 0.32 mm (Table 2). The duration of pre-pupal stage varied from 1 to 2 days with an average of 1.80 ± 0.41 days (Table 1).

Pupa: The larvae of *H. derogata* preferred to pupate in rolled edge of cotton leaf or between two leaves. The newly formed pupae of *H. derogata* was reddish brown in colour but changed to dark brown colour after one day, long and cylindrical in shape. The length of male pupae ranged 10.10 to 12.90 with an average of 11.95 ± 0.78 mm. The length of female pupae varied from 12.50 to 13.85 with an average of 13.34 ± 0.49 mm, which was slightly more than male pupa. The breadth of male pupae ranged from 3.88 to 4.32 with an average of 4.19 ± 0.14 mm. Similarly, it was 4.00 to 4.43 with an average of 4.38 ± 0.11 mm in case of female pupa, which was slightly more than male pupa (Table 2). The duration of male pupae varied from 6 to 8 days with an average of 7.32 ± 0.69 days while, duration of female pupae varied from 7 to 10 days with an average of 7.88 ± 0.97 days, which was slightly higher than male pupal duration (Table 1).

Morphometrics of male and female pupae: The distance between genital pore and anal pore was

Table 2. Morphometrics (mm) of different life stages of *H. derogata*

Life stages	Length (mm)		Breadth (mm)	
	Range	Mean $\pm$ SD	Range	Mean $\pm$ SD
Egg	0.50-0.62	0.54 ± 0.03	0.45-0.55	0.47 ± 0.02
Larval instars				
I instar	1.80-2.30	2.04 ± 0.16	0.24-0.31	0.28 ± 0.02
II instar	3.28-4.00	3.51 ± 0.18	0.40-0.47	0.43 ± 0.02
III instar	7.00-8.00	7.70 ± 0.23	1.11-1.20	1.15 ± 0.03
IV instar	11.00-12.14	11.91 ± 0.40	1.50-1.60	1.54 ± 0.03
V instar	15.40-18.00	16.60 ± 0.75	1.73-1.99	1.84 ± 0.09
VI instar	25.50-29.00	27.78 ± 1.18	2.40-3.00	2.74 ± 0.24
Pre-pupa	13.60-18.00	15.90 ± 1.50	2.00-3.20	2.24 ± 0.32
Pupa				
Male	10.10-12.90	11.95 ± 0.78	3.88-4.32	4.19 ± 0.14
Female	12.50-13.85	13.34 ± 0.49	4.00-4.43	4.38 ± 0.11
Adult				
Male	9.50-12.40	11.48 ± 0.70	20.80-23.30	22.27 ± 0.67
Female	13.20-14.80	13.79 ± 0.53	26.20-30.00	28.12 ± 1.42

*Five sets of twenty five numbers each

more in case of female (0.80 to 0.90mm with an average of 0.85 ± 0.03 mm) than the male (0.36 to 0.50mm with an average of 0.39 ± 0.03 mm). Male pupa had genital aperture on ninth abdominal segment while, in case of female, it was on eighth abdominal segment (Table 1).

The moths of *H. derogata* displayed characteristics such as medium size and an attractive colour pattern. The colour ranged from white to creamy, with a network of brown markings on both the forewings and hind wings. These moths had filiform antennae and their thorax and abdomen were whitish yellow with yellow-brown bands and covered with white hairs. In terms of size, the males were smaller than the females. The male abdomen was slender and gently tapering at the tip, while the female abdomen was stouter and blunt at the tip. The length of male moths ranged from 9.50 to 12.40 with an average of 11.48 ± 0.70 mm, while the breadth with wing expanded varied from 20.80 to 23.30 with an average of 22.27 ± 0.67 mm. The length of the female moths ranged from 13.20 to 14.80 with an average of 13.79 ± 0.53 mm, while the breadth with wing expanded varied from 26.20 to 30.00 with an average of 28.12 ± 1.42 mm. The female moths were slightly bigger in size than the male moths (Table 2).

Pre-oviposition, oviposition, post-oviposition, longevity and fecundity: The pre-oviposition period of female moth of *H. derogata* varied from 2 to 4 with an average of 3.36 ± 0.70 days. The oviposition period of female moth ranged from 2 to 4 with an average of 3.56 ± 0.58 days (Table 1). After completion of egg laying the female moths lived for 1 to 3 days with on average post-oviposition period of 2.40 ± 0.65 days. The longevity of female moths ranged from 9 to 11 with an average of 10.40 ± 0.82 days, while the longevity of male moths ranged from 8 to 10 with an average of 9.32 ± 0.75 days (Table 2). The egg laying capacity of female varied from 200 to 305 with an average of 265.40 ± 42.55 eggs. The sex ratio of male: female was found to be 1:1.36 and 1:1.15 under field and laboratory condition, respectively indicating preponderance of female over male in field as well as in laboratory (Table 2). The total life cycle of *H. derogata* occupied on an average of 37.40 ± 2.06

days ranging from 30 to 39 days in case of male, while 39.68 ± 2.36 days ranging from 35 to 43 days in case of female (Table 1).

Bapodara (1973), Anioke (1989) and Bhatnagar *et al.* (1993) noticed that eggs were laid on upper or both side of the leaves. Bapodara (1973), Anioke (1989), Bhatnagar *et al.* (1993), Darji (1995), Shrivastava and Dhaliwal (2013) and Shakya and Saxena (2016) described that eggs were whitish in colour, spherical shape. However, Dhawan *et al.* (1981), Kumar and Nigam (1989) and Karpun *et al.* (2022) reported the eggs were greenish in colour. As per the report of Anioke (1989), who documented larger-sized eggs of *H. derogata* on okra and the eggs had length and breadth measurements of 0.76 ± 0.03 mm and 0.51 ± 0.01 mm, respectively which differ from the present study. The incubation period was 2.50, 3.00 and 3.50 days during July and August, September, October, respectively (Lal and Singh, 1951), 2.50 to 3.50 days (Khan and Rao, 1960), 5 to 7 and 3 to 5 days with different temperature and relative humidity (Bapodara, 1973), 2 to 4 days (Dhawan *et al.*, 1981), 3.10 ± 0.05 days (Anioke, 1989), 3 to 4 days (Kumar and Nigam, 1989), 2.40 ± 0.13 days (Bhatnagar *et al.*, 1993), 2 to 3 days (Darji, 1995) and 2 to 9 days (Shakya and Saxena, 2016). For the larval instar, six or occasionally seven instars in cotton (Bapodara, 1973), five or six instars on cotton and okra (Ahsan and Khalequzzaman, 1982; Anioke, 1989), five instars in cotton (Bhatnagar *et al.*, 1993; Darji, 1995), five instars in okra (Iyamu, 2012), seven larval instars in different hosts (Shrivastava and Dhaliwal, 2013; Atwal and Dhaliwal, 2013 and Sontakke *et al.*, 2015). In present study, *H. derogata* passed through six larval instars which were confirmed through application of Dyar's law. In case of sex ratio, Iyamu (2012) showed 1.5:1 in okra. These contrasts might be due to the difference in host crops and climatic condition. Further in the fields, no overlapping generations were observed and the pest easily monitored through the cut and half rolled leaves inside which larvae stayed and feed. The life cycle of leaf roller revealed the active period of 13-18 days mostly living their lives within the rolled leaves and that required managing through simply plucking the rolled leaves in September-

Table 3. Head capsule width of *H. derogata*

Larva	Head capsule width (mm)*	
	Range	Mean $\pm$ SD
I instar	0.21-0.25	0.23 $\pm$ 0.01
II instar	0.37-0.43	0.40 $\pm$ 0.02
III instar	0.89-0.95	0.93 $\pm$ 0.02
IV instar	1.10-1.25	1.19 $\pm$ 0.04
V instar	1.40-1.64	1.55 $\pm$ 0.06
VI instar	1.83-2.20	2.08 $\pm$ 0.11

S.D. = Standard deviation; *Application of Dyar's law on head capsule's width ratio of subsequent instars revealed uniform/constant variation

November and can be effectively managed by application of systemic insecticide in severe cases.

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