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Biology of okra shoot and fruit borer, *Earias vittella* (Fabricius)

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Abstract

Study was carried out on Biology of okra shoot and fruit borer, *Earias vittella* (Fabricius) on okra (GAO 5) at N. M. College of Agriculture, Navsari Agricultural University, Navsari during summer 2022. It was found that female laid eggs singly or in small groups of 2 to 3 eggs on tender shoot and hairy part of okra fruit. The freshly laid eggs were bluish green in colour, small in size, spherical in shape and parallel longitudinal ridges projecting upward and gave it crowned appearance. The incubation period of eggs varied from 2 to 5 days (3.40 ± 1.01 days) while, hatchability was 74.37 ± 3.13 percent. Larvae passed through four instars. The newly hatched larva was light creamy in colour with dark brown head capsule later on turned black in colour. Freshly molted second instar larvae were light brown in colour with white dots on dorsal surface of body whereas, third instar larvae were darker in colour with prominent white and orange spots on dorsal side of body. The fourth instar larvae were dark brown to purple in colour, head was blackish in colour with well developed mouth parts. The average first, second, third and fourth instars larval duration was recorded as 2.04 ± 0.74 , 1.36 ± 0.48 , 2.26 ± 0.65 and 3.18 ± 0.86 days, respectively. Total larval period was 8.83 ± 1.25 days.

The pupa was boat shaped cocoon and light brown to dark brown in colour. The average pre-pupal and pupal period was 1.34 ± 0.47 and 7.90 ± 0.80 days, respectively. Adults were soft bodied, pale white in colour with green longitudinal wedged shaped bend in the middle of forewings while, hind wings were pale white in colour. The last abdominal segment of male was roundish, while in case of female it was pointed having tuft of hair. Longevity of male and female was 9.75 ± 1.97 and 11.75 ± 2.40 days, respectively. The total life cycle occupied 30 to 45 days (35.25 ± 3.92 days) by male and 33 to 47 days (38.80 ± 4.22 days) by female. The average sex ratio of male and female was $1:0.70 \pm 0.12$. The average pre-oviposition, oviposition, post-oviposition periods were 1.45 ± 0.66 , 6.20 ± 1.16 and 4.35 ± 1.62 days, respectively. The average fecundity of female was 269.10 ± 71.61 eggs.

Keywords: Okra, shoot and fruit borer, *Earias vittella* (Fabricius), biology, spiny bollworm, spotted bollworm

Introduction

Okra, *Abelmoschus esculentus* (L.) Moench is one of the most important vegetable crops has its own importance, on account of its taste, flavour and nutritional values as human food grown in tropical and sub-tropical parts of the world. It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. Okra is good source of vitamin A, B, C and also rich in calcium, phosphorus, potassium, protein, carbohydrates, fats, minerals, iron and iodine (Baloch *et al.*, 1990) [3]. Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana and Punjab are the most prominent okra growing states in India, where it is grown as a *kharif* and summer season crop. It is grown on 5.44 lakh hectares in India, with an annual production of 64.94 lakh tonnes and a productivity of 11.93 tonnes per hectare (Anon., 2021) [2]. Surat, Tapi, Navsari, Banaskantha, Vadodara, Kheda, Bharuch, Anand and Mahesana are the major okra growing districts in Gujarat. The area, production and productivity of Gujarat are 85,145 hectares, 10,19,422 tonnes and 11.97 tonnes per hectare, respectively (Anon., 2020) [1]. According to Dhamdhare *et al.* (1984) [6], the crop is attacked by several species of insect pests causing considerable damage. Incidence of insect pests is one of the prime factors in lower production of okra. Among various insect pests, shoot and fruit borer commonly known as spotted bollworm is the most destructive one, as it causes direct loss of okra fruits. Mainly two species *viz.*, *E. vittella* and *E. insulana* are found to cause serious damage to the crop but *E. vittella* is the predominant species in Gujarat. *E. vittella* is an oligophagous pest and its main hosts are okra and cotton. The pest is active almost the year round and prefers high humidity and high temperature for its growth and development.

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In India, an estimated loss of 69.00 percent in marketable yield was due to attack of this insect on okra alone (Ray *et al.*, 2019) ^[14]. The study of biology of shoot and fruit borer is essential to know the life history and habit of this pest for finding out the most vulnerable stage during life span which helps in developing suitable management strategies. Keeping in view the importance of okra and incidence of shoot and fruit the present work was carried out to know the biology of shoot and fruit borer of okra in laboratory condition and results so obtained were documented here under.

Materials and Methods

The present investigation on biology of okra shoot and fruit borer was conducted in PG laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during summer 2022. The materials used and methodology adopted for the present investigations are as follows.

Laboratory Culture

To raise the initial culture of *E. vittella*, the infected fruits of okra along with larvae collected from the unsprayed okra cv. Gujarat Anand Okra 5 crop grown at college farm and would be taken to the laboratory. Infected fruits were kept in glass jar (20 cm x 14 cm). The top of the jar was covered with pieces of muslin cloth and held in position with the help of rubber band (Photo 1). After the pupae were formed in such jars, they were sorted out for adult emergence. The newly emerged adult moths were released in the oviposition cage (20 cm diameter x 45 cm height) for mating (Photo 2) and tender shoot and fruit were provided for oviposition. Tender shoot was changed daily and examined daily for eggs. A cotton swab dipped in five percent honey solution was given as food in small petridishes as a food for moths. A set of 50 eggs were taken for study on biology (Photo 3).



Photo 1: Damaged fruits of okra collected from field



Photos 2: Oviposition cage



Photos 3: Rearing of *E. vittella* larvae

Results and Discussion

Table 1: Period of different stages of *E. vittella* under laboratory condition

Sr. No.	Particulars	Period (Days)		
		Minimum	Maximum	Mean \pm S.D.
1.	Egg period	2	5	3.40 \pm 1.01
2.	Hatching percentage	68.88	78.78	74.37 \pm 3.13
Larval period				
3.	1st instar	1	3	2.04 \pm 0.74
	2nd instar	1	2	1.36 \pm 0.48
	3rd instar	1	3	2.26 \pm 0.65
	4th instar	2	5	3.18 \pm 0.86
	Total larval period	6	11	8.83 \pm 1.25
4.	Pre-pupal period	1	2	1.34 \pm 0.47
5.	Pupal period	7	9	7.90 \pm 0.80
Adult period				
6.	Pre-oviposition	1	3	1.45 \pm 0.66
	Oviposition	4	8	6.20 \pm 1.16
	Post-oviposition	1	7	4.35 \pm 1.62
	Total adult longevity			
	Female	7	16	11.75 \pm 2.40
	Male	6	13	9.75 \pm 1.97
Total life period				
7.	Female	33	47	38.80 \pm 4.22
	Male	30	45	35.25 \pm 3.92
8.	Sex ratio (Male: female)	1:0.43	1:0.90	0.70 \pm 0.12
9.	Fecundity	80	390	269.1 \pm 71.61
10.	Temperature ($^{\circ}$ C)	24.50	28.60	26.9 \pm 1.35
11.	Relative humidity (%)	39	63	51.55 \pm 5.76

Eggs

Site of egg laying

During the present study, it was observed that *E. vittella* did not lay eggs on leaf surface in laboratory conditions. The eggs were laid singly or in a group of 2 to 3 on the surface of the tender shoot and hairy part of the fruits of okra. Earlier, similar pattern of egg laying was noticed by Vennila *et al.* (2007) [18] eggs laid singly on almost every part of the cotton

plants. Kathiriya *et al.* (2007) [9] reported a similar type of observation on okra and cotton bolls as well as on muslin cloths tied over the jar. Rajveer *et al.* (2016) [13] reported female moth laid eggs singly on okra shoots and fruits.

Colour and Shape of egg

The freshly laid eggs of *E. vittella* (Photo 4) were bluish green in colour, later it changed into darker as the time increased. The eggs were small in size, spherical in shape and parallel longitudinal ridges projecting upward and gave it crowned appearance. The chorions of egg were white in colour. A similar description of eggs was also reported by Naresh *et al.* (2004) [11], Kathiriya *et al.* (2007) [9], Vennila *et al.* (2007) [18], Patel *et al.* (2010) [12] and Mazed *et al.* (2016) [10] on okra.

Incubation period

The data given in Table 1 indicated that the incubation period of eggs of okra shoot and fruit borer varied from 2 to 5 days with an average of 3.40 \pm 1.01 days under laboratory condition. The incubation period for eggs of okra shoot and fruit borer has been reported as 2.8 to 3.5 days by Dhillon and Sharma (2004) [7], 2 to 5 days by Cecily and Saini (2007) [5], 3 to 5 days by Kathiriya *et al.* (2007) [9] and 2 to 5 days by Patel *et al.* (2010) [12] which are in close concurrence with present finding.

Hatching percentage

It can be seen from Table 1 that out of 418 eggs observed under laboratory condition and 310 eggs were found to hatch and thus the average hatching percentage of eggs was 74.37 \pm 3.13 percent.

The present findings are more or less similar to the findings of Kathiriya *et al.* (2007) [9] who recorded 70 to 82 percent with an average of 76.90 \pm 4.18 percent on okra fruits. Similarly, Shitole and Patel (2010) [17] and Patel *et al.* (2010) [12] observed 74.80 \pm 4.64 and 73.10 \pm 3.89 percent hatchability, respectively.

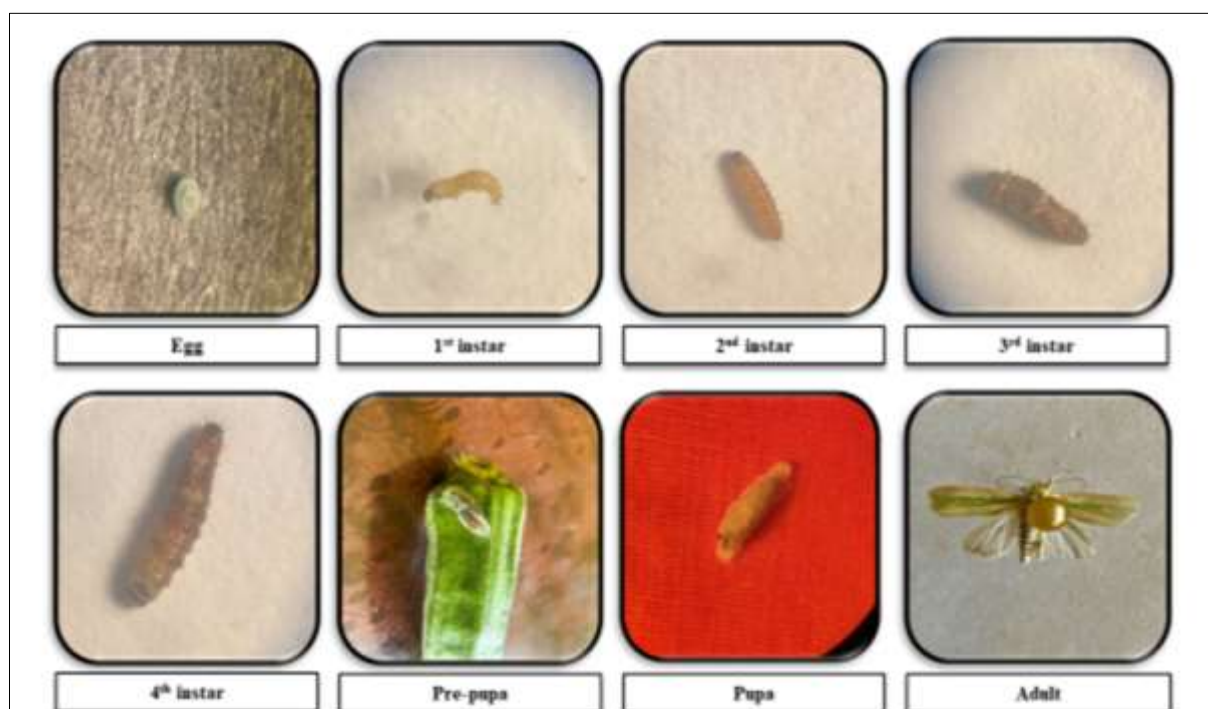


Photo 4: Different stage of okra shoot and fruit borer, *E. vittella*



Female



Male

Photo 5: Female and male of okra shoot and fruit borer, *E. vittella***Larvae****Number of larval instars**

During the present studies, *E. vittella* observed to pass through four larval instars. Similarly, in past, Kathiriya *et al.* (2007)^[9], Patel *et al.* (2010)^[12], Dongarjal and Bhamare (2016)^[8] and Sahito *et al.* (2019)^[15] were reported four larval instars of *E. vittella*. While, Rajveer *et al.* (2016)^[13] observed five larval instars.

First instar

The freshly hatched larvae were light creamy white in colour with dark brown head capsule later on it turned black in colour (Photo 4). The larvae had three pairs of legs on thoracic segments, while each of the third to sixth abdominal segments carried a pair of legs. The present findings are in close agreement with the findings of Kathiriya *et al.* (2007)^[9] and Patel *et al.* (2010)^[12].

The duration of the first instar larva varied from 1 to 3 days with a mean of 2.04 ± 0.74 days (Table 1). In past, Kathiriya *et al.* (2007)^[9], Patel *et al.* (2010)^[12], Shitole and Patel (2010)^[17] and Sahito *et al.* (2019)^[15] reported that the average duration of the first instar larva of *E. vittella* was 2.12 ± 0.75 , 2.38 ± 0.50 , 2.51 ± 0.61 and 2.50 ± 0.22 days respectively, when reared on okra. Thus, the above findings are more or less corroborating with the present findings.

Second instar

Freshly moulted second instar larva was light brown in colour with white dots on the dorsal surface of the body and morphologically resembled the first instar larva except that it was bigger in size. The prolegs were fleshy, having hook like structure at their tip (Photo 4). The present finding is more or less similar to reports of Kathiriya *et al.* (2007)^[9] and Patel *et al.* (2010)^[12].

As far as duration of second instar larvae is concerned

(Table 1), it was observed from 1 to 2 days with an average of 1.36 ± 0.48 days. Kathiriya *et al.* (2007)^[9] reported 1.40 ± 0.49 days of second instar larval period. Patel *et al.* (2010)^[12] observed 1 to 2 days duration with an average 1.40 ± 0.36 days. But, Sahito *et al.* (2019)^[15] who reported on an average 2.70 ± 0.22 days duration of the second instar larva.

Third instar

The third instar larva (Photo 4) was larger in size as compared to the second instar larva. The body colour was darker with more prominent white orange spots on the dorsal side of the body. The colour of the head capsule was dark brown and the legs were creamy white. The present findings are more or less similar to the findings of Kathiriya *et al.* (2007)^[9] and Patel *et al.* (2010)^[12].

The data presented in Table 1 indicated that the duration of the third instar larva varied from 1 to 3 days (2.26 ± 0.65 days). Previously, it was reported as 1 to 3 by Kathiriya *et al.* (2007)^[9] and Patel *et al.* (2010)^[12]. Shitole and Patel (2010)^[17] recorded that 2.17 ± 0.62 days third instar larval period. However, Sahito *et al.* (2019)^[15] reported on an average of 3.10 ± 0.22 days duration of third instar larval which is more or less in support to present investigation.

Fourth instar

The fourth instar larva was spindle shaped, stout and dark brown to purple in colour. The head was blackish in colour with well developed mouthparts. The first thoracic segment was white with brown marking on it and orange colour spots on either side near the spiracles, while the second and third thoracic segment had orange and white spot on them. There were continuous white markings from second to eighth segments of the

abdomen (Photo 4). The present observations are in close agreement with the reports of Kathiriya *et al.* (2007)^[9] and Patel *et al.* (2010)^[12].

The data presented in Table 1 regarding duration of fourth instar larva of *E. vittella* indicated that larval duration varied from 2 to 5 days with an average of 3.18 ± 0.86 days. The present findings are more or less in conformation with the reports of Kathiriya *et al.* (2007)^[9] who reported 3.38 ± 0.77 days duration of fourth instar larva. Similarly, Patel *et al.* (2010)^[12] and Shitole and Patel (2010)^[17] observed it as 3.42 ± 1.12 and 3.40 ± 0.77 days duration, respectively. While, Sahito *et al.* (2019)^[15] reported 4.70 ± 0.30 days duration of fourth instar larval.

Total larval period

The perusal of data presented in Table 1 revealed that the total larval period of *E. vittella* varied from 6 to 11 days with an average of 8.83 ± 1.25 days when reared on okra. The average duration of the larva of *E. vittella* was 8.98 ± 1.72 and 9.20 ± 2.24 days reported by Kathiriya *et al.* (2007)^[9] and Patel *et al.* (2010)^[12], respectively. Whereas, Shitole and Patel (2010)^[17] recorded total larval period was 9.74 ± 1.54 days when it was reared on cotton.

Pre-pupa

The fourth instar larvae stopped feeding, became sluggish and contracted (Photo 4). The duration of the pre-pupal stage ranged from 1 to 2 days with an average 1.34 ± 0.47 days (Table 1). The fourth instar of larva finding a suitable place outside okra fruits, after that larva spun the dirty white, silken, boat shaped cocoon and pupated inside it.

The result is very close comply with result of Patel *et al.* (2010)^[12] who reported pre-pupal period 1 to 2 days. Shitole and Patel (2010)^[17] recorded 1.48 ± 0.50 days average pre-pupal period, Rajveer *et al.* (2016)^[13] observed that the pre-pupal period was 1 to 2 days with an average of 1.4 days.

Pupa

Colour and Shape

The pre-pupa found its way for pupation which in laboratory condition took place on the fruit or at the bottom of the plastic culture tube and changed into pupa. Pupa was boat shaped, light brown to dark brown in colour, but colour was changed from grey to greenish grey as the time advanced (Photo 4). The present observations are in close agreement with the reports of Kathiriya *et al.* (2007)^[9], Naresh *et al.* (2004)^[11], Shah *et al.* (2012)^[16] and Rajveer *et al.* (2016)^[13].

Pupal period

Looking to the data presented in Table 1, it can be seen that the duration of the pupal stage varied from 7 to 9 days with an average of 7.90 ± 0.80 days. According to

Dhillon and Sharma (2004)^[7], Bhat *et al.* (2005)^[4], Kathiriya *et al.* (2007)^[9], Patel *et al.* (2010)^[12] and Rajveer *et al.* (2016)^[13] the pupal duration was 8.0 to 8.8, 7.8 to 8.6, 7 to 9, 7.50 to 8.05 and 6 to 8 days respectively, which is more or less similar to present findings.

Adult

The adult moths emerged during night or early morning hours. During the day time, adults remained inactive on the lower surface of muslin cloth. They were found to be active at night for their mating and oviposition purposes. The male and female moths of *E. vittella* were pale white in colour with green longitudinal wedge shaped bend in the middle of the forewings (Photo 5). Hind wings were pale white in colour and smaller than forewings. The head was smaller than thorax. Antennae were filiform and yellowish grey in colour. The head region was covered with creamy white hair. Eyes were black in colour. The abdomen was long and cylindrical with pale hairs. The female distinguished from the male by the presence of a tuft of hair on the last abdominal segment. The present findings are in complete agreement with the findings of Kathiriya *et al.* (2007)^[9], Patel *et al.* (2010)^[12], Mazed *et al.* (2016)^[10] and Rajveer *et al.* (2016)^[13].

Pre-oviposition, Oviposition and Post-oviposition

Pre-oviposition period

Looking to the data in Table 1, the pre-oviposition period varied from 1 to 3 days with an average of 1.45 ± 0.66 days. Previously, Naresh *et al.* (2004)^[11], Bhat *et al.* (2005)^[4], Kathiriya *et al.* (2007)^[9], Shitole and Patel (2010)^[17] and Patel *et al.* (2010)^[12] were reported the pre-oviposition period 1.94 ± 0.42 , 1.8 ± 0.44 , 2.50 ± 0.53 , 1.50 ± 0.71 and 1.45 ± 0.49 days, respectively.

Oviposition period

The oviposition period ranged from 4 to 8 days with an average of 6.20 ± 1.16 days (Table 1). The present is almost similar to that of reported an average of 6.90 ± 1.73 days by Kathiriya *et al.* (2007)^[9], 5.80 ± 1.69 days by Shitole and Patel (2010)^[17] and 6.05 ± 2.84 days by Patel *et al.* (2010)^[12].

Post-oviposition period

The data presented in Table 1 revealed that the post-oviposition period varied from 1 to 7 days with a mean duration of 4.35 ± 1.62 days. Similarly, Naresh *et al.* (2004)^[11] who reported the post-oviposition period was 4.44 ± 0.30 days. Patel *et al.* (2010)^[12] also observed 4.40 ± 1.68 days, Whereas, Shitole and Patel (2010)^[17] reported the post-oviposition period of *E. vittella* was 3.90 ± 1.65 days.

Fecundity of Female

The egg laying capacity of female under laboratory

condition varied from 80 to 390 eggs with an average of 269.10 ± 71.61 eggs (Table 1). Previously, Patel *et al.* (2010)^[12] and Shitole and Patel (2010)^[17] reported an average 228 ± 71.61 and 265 ± 93.98 eggs per female, respectively.

Sex Ratio

Based on the morphological characters mentioned earlier the adults were differentiated into their sexes. Out of 289 adults emerged from laboratory mass culture during the period of study, 118 were males and 171 were females. The sex ratio (Male: female) worked out varied from 1:0.43 to 1:0.90 with an average of $1:0.70 \pm 0.12$ (Table 1). The present findings are in close agreement with Kathiriya *et al.* (2007)^[9] who reported the sex ratio (Male: female) as 1:0.923 and 1.1.083 for *E. vittella*. Mazed *et al.* (2016)^[10] reported sex ratio (Male: female) was 1.00:1.25. The present findings are more or less similar as presented above workers.

Longevity of Adult *E. vittella*

The data presented in Table 1 indicated that the longevity of male ranged from 6 to 13 days (9.75 ± 1.97 days), while female lived for 7 to 16 days (11.75 ± 2.40 days). The longevity of male was shorter than female recorded during present investigation. In past, Dhillon and Sharma (2004)^[7] reported that the longevity of male and female were ranged 5.9 to 7.3 and 8.8 to 11.2 days, respectively. While, Kathiriya *et al.* (2007)^[9] observed life span the 11.10 ± 2.81 days for male and 12.90 ± 2.9 days female adult. Patel *et al.* (2010)^[12] observed the male and female adult period of *E. vittella* was 9.98 ± 2.60 days and 11.38 ± 2.15 days, respectively when reared on okra. The variation in adult longevity might be due to different nutrition of host insect.

Total Life Cycle

The total life cycle from eggs to the death of male moth varied from 30 to 45 days (35.25 ± 3.92 days), while for female moth ranged from 33 to 47 days (38.80 ± 4.22 days) (Table 1). Patel *et al.* (2010)^[12] found the total life cycle of male and female *E. vittella* was 23 to 38 days (29.90 ± 3.62 days) and 30 to 41 days (34.18 ± 4.68 days), respectively. While, Rajveer *et al.* (2012)^[13] reported the total developmental period was 40.96 ± 2.35 days for male and 50.00 ± 2.16 days for female. The difference in entire life span might be due to difference in rearing condition as well as variation in host nutrition.

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