

Annual life history of okra shoot and fruit borer, *Earias vittella* (Fabricius), under mid-hill conditions of Himachal Pradesh, India

Manjeet Kumar¹, Vasu Mehta^{1,2*}, Mohammad Ilyas Motmayen¹, Khushwinder Singh² and Anjana Thakur¹

¹Department of Entomology, CSK Himachal Pradesh Agricultural University, Palampur 176062, Himachal Pradesh, India.

²Department of Entomology, Faculty of Agriculture, Guru Kashi University, Bathinda 151302, Punjab, India.

Email: vasumehta31@gmail.com*

ABSTRACT: Annual life history of *Earias vittella* (Fabricius) (Lepidoptera, Nolidae), was investigated under natural laboratory conditions in the mid-hill region of Himachal Pradesh, India, during 2023–2024. The insect completed five overlapping generations annually. The duration of the active generations ranged from 31.6 to 34.6 days, whereas the overwintering generation exhibited a markedly prolonged developmental period of 200.4–229.5 days. The mean incubation, larval and pupal periods during the active generations were 3.4 ± 0.05 , 14.0 ± 0.44 and 8.3 ± 0.24 days, respectively, while the overall mean developmental period was 87.7 ± 38.7 days. Adult females survived longer than males, with mean longevities of 6.1 ± 0.20 and 5.3 ± 0.10 days, respectively. Mean fecundity was 147.8 ± 21.60 eggs per female but declined markedly during the overwintering generation. Egg, larval and pupal survival were also reduced under winter conditions, resulting in lower growth indices than those recorded during the active generations. The findings demonstrate that seasonal temperature profoundly influences the annual life history, survival and reproductive potential of *E. vittella*. The study provides baseline information for forecasting pest incidence and developing timely, location-specific integrated pest management strategies for okra under the mid-hill agroclimatic conditions of Himachal Pradesh.

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KEY WORDS: Overlapping generations, developmental biology, overwintering, survival, temperature

INTRODUCTION

Among vegetable crops, okra, *Abelmoschus esculentus* (L.) Moench (Malvaceae), commonly known as lady's finger or bhendi, is a highly nutritious vegetable rich in dietary fibre, carbohydrates, proteins, vitamins (A, C, K and folate), and essential minerals such as calcium, magnesium and potassium. It is also a valuable

source of bioactive compounds, including polyphenols and flavonoids, which contribute to its antioxidant, anti-inflammatory, and nutraceutical properties (Elkhalifa *et al.*, 2021). Linoleic acid, an essential polyunsaturated fatty acid, is the major constituent of okra seed oil (Savello *et al.*, 1980). Besides its nutritional importance, okra is widely consumed as a fresh vegetable and processed into canned, frozen and dehydrated products, while its

* Author for correspondence

mucilage is used in food processing and pharmaceutical industries (Elkhalifa *et al.*, 2021). India is one of the world's leading producers of vegetables, and vegetable cultivation plays a pivotal role in ensuring food and nutritional security (FAO, 2023). Despite its economic importance, successful cultivation of okra is severely constrained by several insect pests, among which the okra shoot and fruit borer, *Earias vittella* (Fabricius) (Lepidoptera, Nolidae), is considered one of the most destructive species (Chandran *et al.*, 2020). The larvae bore into terminal shoots during the vegetative stage, causing wilting, and subsequently infest developing fruits, rendering them unmarketable due to extensive internal feeding and accumulation of frass. Infestation results in substantial quantitative and qualitative yield losses, with shoot damage ranging from 0.1 to 9.8 per cent (Patait *et al.*, 2023) and fruit damage varying between 12.9 and 90.0 per cent under different agroecological conditions (Chauhan *et al.*, 2023).

A comprehensive understanding of the annual life history and seasonal developmental pattern of *E. vittella* is essential for identifying vulnerable stages of the pest and developing timely and effective management strategies. Although several studies have described the biology of *E. vittella* under laboratory conditions (Shah *et al.*, 2012; Kumar *et al.*, 2014; Sahito *et al.*, 2019; Kulhari *et al.*, 2023), information on its annual life history under the mid-hill agroclimatic conditions of Himachal Pradesh remains scarce. Seasonal variations in temperature and relative humidity prevailing in this region are expected to influence the developmental duration, survival and reproductive potential of the pest. Therefore, the present investigation was undertaken to elucidate the annual life history, generation pattern, developmental biology, survival and growth indices of *E. vittella* under the mid-hill conditions of Himachal Pradesh.

MATERIALS AND METHODS

Annual life cycle of *E. vittella* was studied on okra fruits under natural laboratory conditions at the Department of Entomology, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya (CSK HPKV), Palampur, Himachal Pradesh, India,

situated at an altitude of 1,268 m above mean sea level (32.11°N; 76.53°E). For the study, a stock culture of the okra shoot and fruit borer, *E. vittella*, was established using larvae collected from unsprayed farmers' fields. The culture was maintained under natural laboratory conditions ($25 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ RH), which were monitored, by providing fresh shoots or fruits of the okra variety 'Palam Komal' in insect-rearing cages. Pupae thus obtained were collected and transferred to separate glass jars for adult emergence. Newly emerged adults were released in pairs into oviposition cages covered with muslin cloth secured with rubber bands for mating and oviposition. The oviposition cages were provided with a 10 per cent honey solution on a cotton swab as a food source and fresh okra fruits as an oviposition substrate, along with crumpled paper strips as resting sites for the moths. A cotton swab soaked in water and placed in a Petri dish was used to maintain humidity inside the cage. Newly hatched larvae ($n = 30$) were individually transferred to fresh okra fruits using a fine camel-hair brush and reared separately until adult emergence. The stalks of the fruits were wrapped with moist cotton plugs to maintain freshness, and fresh okra fruits were replaced daily throughout the larval rearing period. Proper hygienic conditions were maintained throughout the experiment, and successive generations were reared continuously to study the annual life history of *E. vittella*.

Observations were recorded on the pre-oviposition, oviposition and post-oviposition, incubation, larval, pre-pupal, pupal and total developmental periods, along with adult longevity, fecundity, and survival rate (%) at egg, larval and pupal stages for each generation. Generation I during July 21 - August 22, 2023, generation II during August 23 - September 24, generation III during September 25 - October 29, generation IV during October 30 - June 11, 2024/ October 30 - April 16, 2024 and generation V during June 12 - July 20, 2024.

Growth indices were computed from the developmental duration and survival data using the formula described by Sharma *et al.* (1982). All biological observations were recorded from 30 independently reared individuals and are presented

as mean $\pm$ standard error (SE). Descriptive statistics, including means and standard errors, were computed using Microsoft Excel 2021 (Microsoft Corporation, Redmond, WA, USA).

RESULTS AND DISCUSSION

Developmental biology of during different generations: The annual life history of *E. vittella* was investigated under natural laboratory conditions, and the insect completed five overlapping generations during the study period (Table 1). The duration of the active generations (I, II, III and V) ranged from 31.6 to 34.6 days. In contrast, the fourth generation, which commenced during late autumn and overwintered (during October 30 - June 11, 2024/ October 30 - April 16, 2024), exhibited a markedly prolonged duration of 200.4–229.5 days. The extended developmental period during this generation was attributed to the prevailing low-temperature conditions (19.7–22.5 and 7.6–10.3°C max and min temperature respectively), during the winter months. Similar observations on the prolonged life cycle of *E. vittella* under winter conditions have been reported by Butani and Jotwani (1984). In contrast, Sharma *et al.* (1985) reported that *E. vittella* completed eleven generations annually, under the warmer agroclimatic conditions of Bihar, highlighting the strong influence of environmental conditions on the seasonal development of the pest.

The developmental biology of *E. vittella* varied among different generations (Table 2). The incubation period ranged from 3.3 to 3.5 days during

generations I, II, III and V, whereas it increased to approximately 5.0 days in the overwintering generation (IV), indicating delayed egg hatching under low-temperature conditions. Similar delayed incubation periods have been reported by Kumar *et al.* (2014), who observed it as 3.27 and 3.67 days during July–August and October–November, respectively. Likewise, Bhat *et al.* (2005) reported a longer incubation period (4.4–4.8 days) during September–November than during June–August, supporting the present findings.

The total larval period ranged from 10 to 16 days during generations I–III and V, which agrees with the observations of Sagar and Nebapure (2018) and Sahito *et al.* (2019). However, the larval period was prolonged during the overwintering generation (16.2–16.8 days), presumably due to reduced temperatures. Similarly, the pre-pupal period increased from approximately 1 day during the active generations to 2.4 days during winter. The pupal period ranged from 7.9 to 8.8 days during generations I–III and V but extended markedly to 171.1–199.9 days during the overwintering generation. Comparable pupal durations (8–12 days) during the cropping season were reported by Butani and Jotwani (1984).

The total developmental period from egg to adult emergence ranged from 25.5 to 28.4 days during the active generations but increased to 194.8–224.0 days during the overwintering generation. The mean developmental period of the active generations was 26.8 ± 0.72 days, whereas the overall annual mean was 87.7 ± 38.7 days. Kumar *et al.* (2014) reported

Table 1. Mean active duration of *E. vittella* in different generations/ seasons in 2023–24

Generation	Period	Duration (Days)	Temp (°C)		RH (%)
			Max	Min	
I	July 21 - August 22, 2023	31.6	26.7	19.7	88.0
II	August 23 -September 24	32.0	26.2	18.9	85.3
III	September 25 - October 29	34.2	25.4	14.5	73.6
IV	October 30 - June 11, 2024	229.5	22.5	10.3	55.2
	October 30 - April 16, 2024	200.4	19.7	7.6	60.2
V	June 12 - July 20, 2024	34.6	28.7	19.1	76.0

Table 2. Developmental biology of *Earias vittella* during different generations

Generation	Duration (days)									
	Incubation		Total larval		Pre-pupal		Pupal		Total developmental	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
I	3-4	3.4±0.05	11-15	13.1±0.39	1-2	1.0±0.02	7-8	7.9±0.06	22-28	25.5±0.33
II	3-4	3.3±0.08	10-15	13.5±0.10	1-2	1.0±0.03	7-8	7.9±0.06	21-27	25.8±0.68
III	2-4	3.5±0.06	11-16	14.5±0.36	1-2	1.0±0.00	8-9	8.6±0.04	22-29	27.6±0.47
IV	4-6	5.0±0.07	12-19	16.8±0.99	2-3	2.3±0.07	196-210	199.9±0.06	214-232	224.0±0.43
	4-6	5.1±0.20	12-19	16.2±0.53	2-3	2.4±0.03	170-172	171.1±0.01	188-193	194.8±0.38
V	3-4	3.5±0.06	11-16	15.0±0.20	1-2	1.1±0.06	8-9	8.8±0.16	23-32	28.4±0.32
Mean		4.0±0.30		14.9±0.60		1.5±0.30		67.41±37.5		87.7±38.70
Active generations (except IV)		3.4±0.05		14.0±0.44		1.0±0.01		8.3±0.24		26.8±0.72

Values are presented as mean ± standard error ; n = 30 individuals.

Table 3. Adult longevity and fecundity of *Earias vittella* during different generations

Generation	Duration (days)								Total longevity	Fecundity
	Male		Female							
			Pre-oviposition		Oviposition		Post-oviposition			
	Range	Mean	Range	Mean	Range	Mean	Range	Mean		
I	2-6	5.1±0.02	1-2	1.0±0.02	2-3	2.8±0.02	2-3	2.4±0.01	6.2±0.22	180.2±0.64
II	3-6	5.2±0.01	1-3	1.0±0.00	2-4	3.1±0.11	2-3	2.2±0.05	6.3±0.05	191.4±0.43
III	2-7	6.0±0.18	1-2	1.0±0.00	2-3	2.8±0.00	2-3	2.8±0.01	6.6±0.30	190.6±0.31
IV	2-8	5.2±0.22	1-2	1.0±0.01	2-3	2.4±0.02	2-3	2.0±0.01	5.5±0.05	80.6±0.68
	2-8	5.3±0.18	1-2	1.0±0.01	2-3	2.5±0.03	2-3	2.1±0.01	5.6±0.02	80.8±0.31
V	2-6	5.1±007	1-2	1.1±0.02	2-3	2.7±0.03	2-3	2.5±0.14	6.2±0.32	163.2±0.52
Mean		5.3±0.10		1.0±0.00		2.7±0.10		2.3±0.10	6.1±0.20	147.8±21.60

Values are presented as mean ± standard error (SE); n = 30 individuals.

a comparable life cycle duration of 25.05 days. Likewise, Bhat *et al.* (2005) observed prolonged incubation, larval and pupal periods during cooler months at Jammu, while Sahito *et al.* (2019) also demonstrated a marked increase in developmental duration under lower temperatures. These findings clearly indicate that temperature is a major factor regulating the developmental rate of *E. vittella*.

Females consistently survived longer than males across all generations, with mean longevity of 6.1 ± 0.20 and 5.3 ± 0.10 days, respectively. Adult longevity exhibited only minor variation among

generations (Table 3). Similar longevity of male and female moths were reported by Sahito *et al.* (2019). The mean pre-oviposition and post-oviposition periods were approximately 1.0 and 2.3 days, respectively, whereas the oviposition period varied from 2.4 to 3.1 days across generations. Mean fecundity was 147.8 ± 21.60 eggs per female, ranging from 163.2 to 191.4 eggs during generations I–III and V. However, females emerging after the overwintering period (generation IV) laid considerably fewer eggs (80.6–80.8 eggs per female), indicating that low-temperature conditions adversely affected reproductive potential. Similar

Table 4. Survival of developmental stages of *Earias vittella* during different generations

Generation	Mean survival (%)			
	Egg	Larva	Pupa	Adult emergence
I	57.21	56.31	79.93	25.75
II	58.80	57.10	80.41	27.00
III	55.66	55.15	81.20	24.93
IV	51.83	45.28	60.67	14.24
	52.65	38.49	57.28	11.61
V	56.81	55.84	76.86	24.38
Mean	55.49	51.36	72.73	21.32

fecundity values have been reported by Bhat *et al.* (2005) and Kumar *et al.* (2014), although Syed *et al.* (2011) observed comparatively longer oviposition and post-oviposition periods under different host plant conditions.

Survival of different stages and growth indices during different generations: The survival of *E. vittella* varied considerably among generations (Table 4). Egg survival was lowest during the overwintering generation (IV), ranging from 51.83 to 52.65 per cent, whereas higher survival (55.66–58.80%) was recorded during the remaining generations. Similarly, larval and pupal survival were markedly reduced during the overwintering generation, (from 38.49 to 45.28% and 57.28 to 60.67%, respectively). In contrast, larval survival during the active generations ranged from 55.15 to 57.10 per cent. The reduced survival observed during the overwintering generation indicates the adverse effect of low-temperature conditions on the immature stages of *E. vittella*. Among all developmental stages, the pupal stage exhibited the highest mean survival (72.73%), whereas the larval stage showed the lowest mean survival (51.36%), probably because newly hatched larvae remain exposed to several biotic and abiotic factors before successfully boring into the host shoots or fruits (Subba *et al.*, 2023). Adult emergence varied from 24.38 to 27.00 per cent during the active generations but declined markedly to 11.61–14.24 per cent during the overwintering generation. These

observations differ from those of Rajveer *et al.* (2018), who reported maximum mortality during the larval stage under laboratory conditions, and Kumar *et al.* (2014), who recorded higher egg hatchability under warmer environmental conditions.

The larval and total growth indices also varied among generations. Larval growth index was maximum in generation I (4.32), followed by II (4.23), III (3.80), V (3.72), and least in IV (2.20/2.38). Similar trend followed in the total growth index, with maximum in generation II (1.05), followed by I (1.01), III (0.09), V (0.86), and least in IV (0.06/0.06). The lowest growth indices were recorded during the overwintering generation, reflecting the combined effects of prolonged developmental duration and reduced survival under low-temperature conditions. Similar variation in larval and total growth indices among different host genotypes has been reported by Singh (1987). *Earias vittella* completed five overlapping generations annually under the mid-hill conditions of Himachal Pradesh, with developmental duration, survival and reproductive performance being strongly influenced by seasonal temperature. The overwintering generation exhibited a markedly prolonged developmental period accompanied by reduced survival and fecundity, whereas the active generations completed development rapidly under favourable environmental conditions. These findings demonstrate the significant influence of temperature on the annual life history of *E. vittella* and provide valuable baseline information for forecasting pest incidence, identifying vulnerable developmental stages and developing timely, location-specific integrated pest management strategies for okra cultivation under mid-hill agroclimatic conditions.

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