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# Biology of Earhead worm, *Helicoverpa armigera* (Hubner) on Pearl millet

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**Abstract**
An experiment was carried out to assess the biology of *H. armigera* on pearl millet under laboratory conditions at Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh during year of 2024. The incubation period of *H. armigera* eggs was average 3.40±0.75 days. While, hatching per cent of the eggs laid by female *H. armigera* moths was with an average of 84.00±4.89 per cent. Freshly emerged first instar larvae were semitranslucent, yellowish white in colour with an average duration of 2.43±0.49 days. Second instar larvae were reddish brown with dark brown hairs and pigments, and they lasted an average of 2.90±0.70 days. Third instar larvae were slightly brownish in colour with an average duration of 3.46±0.61 days. Fourth instar larvae were greenish yellow in colour with an average duration of 3.10±0.70 days. Head of fifth instar larvae became reddish yellow or light brown in colour with an average duration of 4.30±0.69 days. Full-grown sixth instar larvae were greenish with dark broken grey lines along the side of the body with an average duration of 4.66±0.69 days. While, average duration of total larval period was 20.86±3.90 days. The prepupal and pupal stages ranged with an average of 1.93±0.51 days and 13.46±0.99 days, respectively. The sex ratio revealed that females out-numbered males and sex ratio was 1:0.76 (M:F). The pre-oviposition period occupied the 2.80±0.40 days, oviposition period occupied 5.60±0.48 days while, post-oviposition period was of 1.60±0.48 days. Individual females can lay 354.60±31.95 eggs. The males live shorter (8.80±0.74 days) and female live longer 11.00±0.96 days. Total life span of male and female adult was 47.80±2.03 and 50.80±1.22 days, respectively.

**Keywords:** *Helicoverpa armigera* (Hubner), adult, biology, egg, larva, pearl millet and pupa

## Introduction
Pearl millet is one of the four most significant cereals (rice, maize, sorghum and millet) produced in tropical semi-arid parts of the world particularly in Africa and Asia (Nambiar *et al*., 2011) [11]. Pearl millet [*Pennisetum glaucum* (L.) R. Br] belongs to the family Poaceae. Because of its resilience to challenging growing conditions such as drought, low soil fertility and high temperature, it can be grown in regions where other cereal crops, such as maize or wheat would not survive (Basavaraj *et al*., 2010) [5]. The nutritive value of pearl millet is fairly higher with carbohydrates (67%), Fat (5%), marginal protein (11.6%) and minerals (2.7%). It is rich in vitamin A and B. Besides that, seed also contain minerals like calcium, potassium, iron, zinc and magnesium (Khairwal *et al*., 2007) [10]. It is frequently grown under the most severe agroclimatic conditions where other crops like sorghum and maize struggle to generate profitable yields. In Gujarat, during 2023-24 about 197.22 thousand ha area was covered under pearl millet with a production of 350.40 thousand tonnes in *Kharif* and also 316.01 thousand ha area covered with a production of 956.11 thousand tonnes in the summer season. Total cultivated area is 520.02 thousand ha with a production of 1322.59 thousand tonnes. The major districts growing this crop include Banaskantha, Anand, Kheda, Bhavnagar, Kachchh and Mehsana (Anon., 2024). To increase the awareness of millets and their health benefits among the general public the UNGA (United Nations General Assembly) declared 2023 as the 'International Year of Millets'. Over 100 species of insect pests have been identified to be linked to this crop (Balikai, 2010) [4]. *Helicoverpa armigera* is a major pest of pearl millet that also causes significant harm to several other economically important crops.

Investigation of the biology of *H. armigera* provides detailed information on the development, survival and reproductivity/fecundity, which gives a primary step to initiate any control measures.

## Materials and Methods

The investigations on the biology of *H. armigera* were conducted under laboratory environment of the Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat during *Kharif*, 2024.

- **Rearing techniques:** First, *H. armigera* larvae were obtained from an unsprayed pearl millet field at the College of Agriculture's Instructional Farm at Junagadh Agricultural University. The collected larvae were raised on pearl millet ear heads in a lab. Larva was kept in a clean glass petri dish in the laboratory. A small piece of ear head was provided as food. Larvae were reared individually to avoid cannibalism. In order to facilitate pupation, the fully developed larva was placed in a plastic jar with one-third of the jar filled with moist soil. Following pupation, the jar was maintained in this manner and routinely checked to document the adults' emergence. Five pairs of newly emerged adults, with three replications were released in an iron-rearing cage. A piece of black muslin cloth was hung in the rearing cage for egg laying. A cotton swab soaked in a five per cent honey solution was provided as food for the adult insects. Eggs laid on the muslin cloth were collected for further research.
- **Egg:** For the morphological study, the egg's shape and colour were examined. To determine the incubation period, several freshly laid eggs were monitored daily until hatching. The incubation period was measured from the date of egg laying to the date of hatching. The hatching percentage was calculated based on the number of eggs that hatched out of the total number of eggs set aside for hatching. For recording incubation period 30 eggs and for hatchability 100 eggs were observed.
- **Larva:** The newly emerged larvae were individually placed in a petri plate (150 mm × 15 mm) with a fine hair brush that contained a tender ear head piece as feeding in order to count the number and duration of different larval instars as well as the total period. Fresh food was provided in petri plates every day in the morning. To determine the number of larval instars, individual larvae were observed daily. Observation of the colour of the larvae was recorded in each instar. The date of egg hatching to the date of pre-pupa development was used to calculate the overall larval duration. For recording larval duration 30 larvae were observed during the experiment.
- **Pre-pupa:** When full-grown larvae stopped feeding and started contracting, they were considered as pre-pupae. About 3.0 to 3.5 cm thick layer of moist soil was provided in the glass jar (10 cm diameter × 13 cm height) for full-grown larvae for pupation. The period between the formation of pre-pupa and pupa was taken as the pre-pupal period and recorded. For recording pre-pupal period 30 pre-pupa were observed in laboratory.
- **Pupa:** Male and female pupae were collected from the earthen cocoon and separated by examining them under a microscope. By measuring the distance between the pupa's genital and anal slits, the male and female sexes were identified. The pupal period was calculated based on the date of formation of the pupa and the date of adult emergence. For recording pupal period 30 pupa were observed in laboratory.
- **Adult:** Adults emerging from pupae were closely examined under a microscope to determine their colour and sex. Sex was identified by the presence of a tuft of hairs at the end of the abdomen in females, which was absent in males. The following observations were recorded. Five pairs of adults with three replications were observed during the study.

### Preoviposition, oviposition and post-oviposition periods

A pair of newly emerged male and female moths from pupae were kept in separate rearing cages lined with fine muslin material to examine the pre-oviposition, oviposition, and postoviposition stages. They were provided with a five per cent honey solution as food, which was replaced daily. Black muslin cloth was provided to facilitate oviposition. Five pairs, replicated three times, were studied for these purposes. The pre-oviposition duration was estimated from the date of female emergence to the beginning of egg laying. The oviposition period was calculated from the beginning of egg laying to the end of egg laying by the female. The post-oviposition period was calculated from the cessation of egg laying to the death of the female.

- **Fecundity:** The individual egg laid by a single female was collected daily in the morning and the number of eggs laid by a single female was counted till the death of the female.
- **Longevity:** Male and female longevity were determined separately, from the day of emergence to the date of death of the adults.
- **Sex ratio:** Based on the visual characteristics of males and females, the insect was separated by sex for the sex ratio. The sex ratio was calculated using male and female moths obtained from the laboratory's general culture.

### Total Life Period

Total life period was defined as the time between egg laying and death of an adult.

## Results and Discussion

### Egg

### Incubation period

The incubation period of *H. armigera* eggs varied from 2 to 5 days with an average of 3.40±0.75 days. (Table 1) (Fig 1) Our findings are in accordance with that of Chauhan *et al.* (2018) [6] and Sharma *et al.* (2019) [14] as they both found that the incubation period varied from 3 to 5 days. Shinde *et al.* (2022) [15] found that it was the highest (3.20 days) on soybean followed by sunflower (3.10 days), maize (2.69 days) and sorghum (2.54 days).

### Hatchability (%)

Egg hatching per cent of the eggs laid by female *H. armigera* moths obtained by rearing on pearl millet was an average of 84.0±4.89 per cent. However, minimum (80%) and maximum (90%) egg hatching per cent was recorded at an average temperature 26.50 °C and relative humidity 62.00 per cent (Table 1).

Chauhan *et al.* (2018) [6] found hatchability (87.65 %) on chickpea. Above findings are more or less similar to results of Shinde *et al.* (2022) [15] as they found that the highest (90.00%) hatchability was observed on sunflower and maize followed by sorghum (89.00%) and soybean (87.00%).

**Larva**

**First instar**

Freshly emerged larvae were semitranslucent, yellowish white in colour with yellowish orange longitudinal lines on dorsal surface of body. The duration of first instar larvae ranged from 2 to 3 days with an average of 2.43±0.49 days. (Table 1, Figure 1).

Our findings are in tune with the results of Chauhan *et al.* (2018) [6] as they recorded duration of first instar larvae varied from 2 to 3 days (Avg. 2.48±0.51) and observed that colour of larvae was yellowish white. According to Yadav *et al.* (2024) [17] it was ranged from 2 to 3 days (Avg. 2.50±0.71).

**Second instar**

The colour of second instar larvae was reddish brown with dark brown hairs and pigments. The duration of second instar larvae ranged from 2 to 4 days with an average of 2.90±0.70 days (Table 1, Figure 1).

Chauhan *et al.* (2018) [6] reported almost similar results as they recorded duration of second instar larvae varied from 2 to 4 days (Avg. 2.76±0.72) and observed that colour of larvae was reddish. While, Yadav *et al.* (2024) [17] found that it was ranged from 2 to 4 days (Avg. 3.00±1.41 days).

**Third instar**

The third instar larvae look slightly brownish in colour. The skin took granular appearance and body surface was covered with stiff hairs and spiracles were clearly visible on lateral side. The duration of third instar larvae ranged from 3 to 5 days with an average of 3.46±0.61 days. (Table 1) (Fig 1)

Our results look similar with results of Chauhan *et al.* (2018) [6] as it was varied from 2 to 5 days (Avg. 3.08±1.08) and observed that colour of larvae was turned into pale brown. According to Yadav *et al.* (2024) [17] it was ranged from 2 to 3 days (Avg. 2.50±0.71).

**Fourth instar**

The colour of the fourth instar larvae was greenish yellow. The duration of fourth instar larvae ranged from 2 to 4 days with an average of 3.10±0.70 days (Table 1, Figure 1).

Chauhan *et al.* (2018) [6] reported that the duration of fourth instar larvae ranged between 2 to 5 days (Avg. 2.92±0.90) and colour observed was light green to somewhat yellowish. Deepti and Pathma (2023) [8] observed the duration of fourth instar larva on different host like tomato (Avg. 3.30±0.081), chilli (Avg. 3.82±0.102), okra (Avg. 3.75±0.040) and bottle gourd (Avg. 3.17±0.020). According to Yadav *et al.* (2024) [17] duration of fourth instar larvae as ranged from 3 to 4 days (Avg. 3.50±0.71).

**Fifth instar**

The body colour of the fifth instar larvae was just similar to fourth instar larvae. The head became reddish yellow or light brown in colour. The duration of fifth instar larvae ranged from 3 to 5 days with an average of 4.30±0.69 days. (Table 1, Figure 1).

Deepti and Pathma (2023) [8] observed it on different host like tomato (Avg. 3.87±0.20 days), chilli (Avg. 4.87±0.061 days), okra (Avg. 4.13±0.012 days) and bottle gourd (Avg. 3.85±0.040 days). Yadav *et al.* (2024) [17] recorded as it was varied from 3 to 5 days (Avg. 4.00±1.41).

**Sixth instar**

A full-grown larva was greenish with dark broken grey lines along the side of the body. Their colour was variable like green, straw coloured, yellow and reddish brown or black. The duration of sixth instar larvae ranged from 4 to 6 days with an average of 4.66±0.69 days (Table 1, Figure 1).

Above findings in line with findings of Chauhan *et al.* (2018) who reported that duration of sixth instar larvae was varied from 3 to 6 days (Avg. 4.24±0.93). While, Deepti and Pathma (2023) [8] observed the duration of sixth instar larva on different host like tomato (Avg. 4.15±0.04 days), chilli (Avg. 4.70±0.081 days), okra (Avg. 4.06±0.053 days) and bottle gourd (Avg. 3.55±0.122 days).

**Total larval period**

The results obtained from the above investigations revealed that the total larval period varied from 18 to 24 days with an average of 20.86±3.90 days (Table 1). Shinde *et al.* (2022) [15] found it as 22.20 days on soybean followed by sunflower (20.54 days), sorghum (19.52 days) and maize (18.87 days). While, Deepti and Pathma (2023) [8] recorded it on different host like tomato (20.00±0.60 days), chilli (22.50±0.72 days), okra (20.30±0.62 days) and bottle guard (18.3±0.51 days).

**Pupa**

**Pre-pupal period**

The sixth instar full grown larvae became sluggish, ceased feeding, contracted anterior posterior in size and assuming pre-pupal stage. The pre-pupal stage ranged from 1 to 3 days, averaging 1.93±0.51 days (Table 1).

It was varied from 1 to 3 days (Avg. 2.15±0.16) reported by Ali *et al.* (2009) [1], 1 to 3 days (Avg. 1.93±0.69) noted by Rabari *et al.* (2017) [13], 1 to 2 days (Avg. 1.48±0.50) observed by Sharma *et al.* (2019) [14].

**Pupal period**

The freshly formed pupa was soft and pale brown or greenish in colour and smooth and shining. Within few hours it turned into dark brown colour. The pupal period of *H. armigera* reared on pearl millet ranged from 12 to 15 days with an average of 13.46±0.99 days (Table 1, Figure 1).

Pupal duration varied from 10 to 14 days (Avg. 13.15±0.27) reported by Ali *et al.* (2009) [1], 13 to 15 days (Avg. 13.8±0.84) noted by Baikar and Naik (2016) [3], 11 to 15 days (Avg. 13.48±1.29) observed by Sharma *et al.* (2019) [14]. According to Purabiya *et al.* (2024) [12] it was varied from 11 to 15 days (Avg. 13.40±1.25).

**Sex ratio**

The sex ratio of male and female is calculated by counting the number of male and female adults that emerged from 30 pupae. Out of 30 pupae 17 were female and 13 were male. More female adults emerged than male from the pupae. The sex ratio of *H. armigera* revealed that females out numbered males and the male-female sex ratio was 1:0.76 (M:F) (Table 1).

Dahegaonkar and Mohite (2014) [7] revealed that sex ratio of *H. armigera* was 1:0.66 (M:F). According to Baikar and Naik (2016) [3], Rabari *et al.* (2017) [13] and Purabiya *et al.* (2024) [12] it was 1:0.78 (M:F), 1:0.87 (M:F) and 1:0.76 (M:F), respectively.

**Pre-oviposition, oviposition, post-oviposition period and fecundity**

The pre-oviposition, oviposition and post-oviposition period of mated female varied from 2 to 3 (Avg. 2.80±0.40), 5 to 6 (Avg. 5.60±0.48) and 1 to 2 (Avg. 1.60±0.48) days, respectively. (Table 1)

Pre-oviposition, oviposition and post-oviposition period for female *H. armigera* was 2 to 3 days (Avg. 2.46±0.29), 5 to 8 days (Avg. 6.33±0.14) and 1 to 2 days (Avg. 1.67±0.14), respectively was reported by Singh *et al.* (2023) [16] and 2 to 3 days (Avg. 2.56±0.50), 4 to 7 days (Avg. 5.80±0.86) and 2 to 3 days (Avg. 2.40±0.50), respectively was noted by Sharma *et al.* (2019) [14].

**Fecundity**

The egg laying capacity of the female varied from 315 to 403 (Avg. 354.60±31.95) eggs in pearl millet (Table 1).

Results were in accordance with of Shinde *et al.* (2022) [15] as they revealed that mean number of eggs laid by female was 453.19. Also, Sharma *et al.* (2019) [14] recorded it as 490.20±77.87. Purabiya *et al.* (2024) [12] found that it was from 424 to 631 eggs (Avg. 544.85±63.89) per female.

**Adult**

The longevity of females was more than that of males. The male moths were having longevity of 8 to 10 days with an average of 8.80±0.74 days while the female longevity varied from 9 to 12 days with an average of 11.00±0.96 days (Table 1, Figure 1).

Gadhiya (2014) [9] revealed that the longevity of mated female and male moths ranged from 8 to 10 days (Avg. 9.08±0.70) and 7 to 8 days (Avg. 7.64±0.49), respectively. According to Purabiya *et al.* (2024) [12] it was varied from 8 to 10 days (Avg. 9.04±0.78) and 9 to 12 days (Avg. 10.54±0.99) for male and female adult, respectively.

**Total life period**

Male life span of *H. armigera* varied from 45 to 50 days with an average of 47.80±2.03 days. While, female life span varied from 49 to 53 days with an average of 50.80±1.22 days (Table 1). According to Gadhiya (2014) [9] total life cycle of *H. armigera* ranged from 40 to 61 days (Avg. 49.40±5.21) in male and 43 to 65 days (Avg. 52.40±7.03) in female. While, Singh *et al.* (2023) [16] noted that average total life period of male and female was 50.30±7.51 days and 53.50±7.93 days, respectively.

**Table 1:** Overall life cycle of *Helicoverpa armigera* on pearl millet

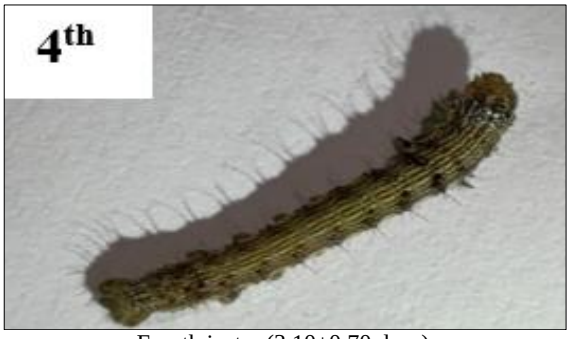
| Sr. No. | Stage of insect | No observed | Minimum (Days) | Maximum (Days) | Mean (Days) | ± SD |
|---|---|---|---|---|---|---|
| 1 | Incubation period | 30 | 2 | 5 | 3.40 | 0.75 |
| 2 | Larval period | | | | | |
| | I instar | 30 | 2 | 3 | 2.43 | 0.49 |
| | II instar | 30 | 2 | 4 | 2.90 | 0.70 |
| | III instar | 30 | 3 | 5 | 3.46 | 0.61 |
| | IV instar | 30 | 2 | 4 | 3.10 | 0.70 |
| | V instar | 30 | 3 | 5 | 4.30 | 0.69 |
| | VI instar | 30 | 4 | 6 | 4.66 | 0.69 |
| | Total larval period | 30 | 18 | 24 | 20.86 | 3.90 |
| 3 | Pre pupal period | 30 | 1 | 3 | 1.93 | 0.51 |
| 4 | Pupal period | 30 | 12 | 15 | 13.46 | 0.99 |
| 5 | Adult longevity | | | | | |
| | Male | 15 | 8 | 10 | 8.80 | 0.74 |
| | Female | 15 | 9 | 12 | 11.00 | 0.96 |
| 6 | Sex ratio | 30 | - | - | 1:0.76 | - |
| 7 | Total life cycle | | | | | |
| | Male | 15 | 45 | 50 | 47.80 | 2.03 |
| | Female | 15 | 49 | 53 | 50.80 | 1.22 |
| 8 | Pre oviposition period | 15 | 2 | 3 | 2.80 | 0.40 |
| 9 | Oviposition period | 15 | 5 | 6 | 5.60 | 0.48 |
| 10 | Post-oviposition | 15 | 1 | 2 | 1.60 | 0.48 |
| 11 | Hatching percentage (%) | 100 | 80 | 90 | 84 | 4.89 |
| 12 | Fecundity | 15 | 440 | 514 | 481.80 | 21.36 |

Eggs (3.40±0.75 days)

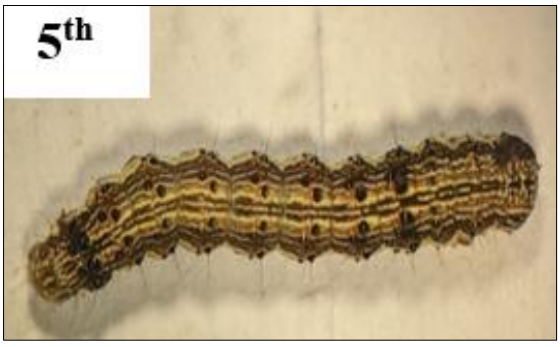

First instar (2.43±0.49 days)

Second instar (2.90±0.70 days)

Third instar (3.46±0.61 days)



Fourth instar (3.10±0.70 days)



Fifth instar (4.30±0.69 days)

Sixth instar (4.66±0.69 days)


Earthen cocoon Pupa (13.46±0.99 days)


Male pupa


Female pupa


Male adult (8.80±0.74 days)

Female adult (11.00±0.96 days)

**Fig 1:** Different life stages of Earhead worm, *H. armigera* (Hubner) including its duration

## Conclusion

The present investigation on the biology of *H. armigera* reared on pearl millet under laboratory conditions reveals that the insect successfully completes its life cycle on this host with distinct developmental stages. The total life span was recorded as 47.80±2.03 days for males and 50.80±1.22 days for females. The life cycle comprised an egg incubation period of 3.40±0.75 days, a total larval period of 20.86±3.90 days, and a pupal period of 13.46±0.99 days. The larva passed through six distinct instars. The duration of instars increased progressively from the first to the sixth instar, accompanied by significant morphological changes in colour ranging from semi-translucent yellowish-white in the first instar to greenish with dark grey lines in the final instar. The study indicated a high reproductive potential on pearl millet, with a hatching percentage of 84.00±4.89 % and an average fecundity of 354.60±31.95 eggs per female. The population exhibited a female-biased sex ratio of 1:0.76 (M:F). Females demonstrated a significantly longer adult longevity (11.00±0.96 days) compared to males (8.80±0.74 days).

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## Author contribution

- **Gami KN:** He is main researcher for the said research findings.
- **Gadhiya VC:** He has served as major advisor of the research findings.
- **Mordiya AD:** He has helped and assisted towards requirements and methods in research.
- **Patel SR:** She has helped to the main researcher towards analysis and check-up of write up.
- **Ghelani MK:** He has assisted to the author for taking observations during study period.

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