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Biology of an invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on chickpea flour based artificial diet

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Abstract

The biology of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) was studied during *kharif*, 2019-2020 under laboratory conditions at the Department of Entomology, College of Agriculture, PJTSAU, Hyderabad. Gravid female was observed laying eggs with the fecundity 1846 eggs. Eggs hatched in within 2-3 days. The total larval and pupal were observed to be 12-14 and 6-8 days, respectively. The male and female adult longevity was observed to be 6-7 and 8-10 days, respectively. The total development period of male and female was observed to be 29-34 and 30-35 days, respectively.

Keywords: *Spodoptera frugiperda*, artificial diet, fecundity, egg, larval, pupal periods, oviposition, total development period

Introduction

Fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) which was native to the tropical and subtropical region of America and is one of the important invasive polyphagous pests. It occurs in several countries such as Brazil, Argentina and USA (Prowell *et al.*, 2004; Clark *et al.*, 2007) ^[1, 2]. Further it is a polyphagous species that uses important cultivated species of poaceae as hosts and can reach pest status on several of them (*e.g.*, rice, wheat, sorghum, and corn) (Luginbill, 1928; Sparks, 1979; Cruz, 1995; Capinera, 2002) ^[3-6]. This species is considered as a generalist feeder, feeding on a very wide host range plants in several families, with preference for grasses. Despite the preference for plants of the family poaceae, FAW is increasingly becoming a pest important broad leaf crops such as cotton and soybean in the Brazilian Cerrado, especially when they are cultivated after corn. Because of its wide host range, *S. frugiperda* is one of the harmful pests threatening annual crops in tropical regions (Andrews, 1980; Marengo *et al.*, 1992; Cruz *et al.*, 1999) ^[7-9]. In India, in the month of May 2018 occurrence of this invasive pest was reported for the first time on maize from Karnataka by Sharanabasappa *et al.* (2018) ^[10]. Presence of FAW was observed during regular surveillance in maize fields at the College of Agriculture, Shivamogga and neighboring districts. Its presence is being further confirmed in Karnataka and other states like Tamil Nadu and Telangana. The present study evaluates the biology of *S. frugiperda* on artificial diet.

Material and Methods

The Present study was conducted at department of Entomology, College of Agriculture, PJTSAU, Hyderabad during *kharif*, 2019-2020. Initial culture of larval population was collected from fields of Agriculture Research Institute, Rajendranagar. The larvae (n=60) were reared up using petri dishes containing the artificial diet and closed with lid and maintained at 25 ± 2 °C and the relative humidity was maintained at 70 ± 5 per cent. The larvae were reared up to adult on and after adult emergence, the male and female moths released into plastic jars for mating. The jars were lined with yellow paper as substratum for egg laying and were covered with white muslin cloth that was held in position with the help of the rubber band. The adults were fed with 10 per cent honey solution soaked in cotton swab placed in plastic cup inside the jar which was replaced daily. The eggs laid on the yellow paper and white muslin cloth were collected daily till the female stopped laying eggs. Observations on larval period, pre pupal period, pupal period, pre oviposition period, oviposition period, post oviposition period, adult longevity of male and female, sex ratio, fecundity and incubation period etc. were recorded at each 24 hrs. interval.

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Major ingredients of diet chickpea flour (75 g), L-Ascorbic acid (1.175 g), Sorbic acid (0.75 g), Methyl-p-hydroxy benzoate (1.25 g), Aureomycin (2.875 g), and Yeast (12 g). Desired quantities of these ingredients were put in a bowl containing 112.5 ml of water. All the contents were mixed thoroughly using a spatula. The mixture was then allowed to boil for five minutes at a temperature of 100 °C using a hot plate. Forty per cent formaldehyde and vitamin stock solution were then added to the mixture. Simultaneously desired quantity of agar-agar was taken in 200 ml of water and boiled at a temperature of 100 °C for five minutes on another hot plate till the agar-agar appeared like slurry. Then the contents of second bowl containing agar-agar was poured into first

bowl containing other diet ingredients. After adding, both the contents were thoroughly mixed using an electrical mixer cum grinder and poured into a diet plate. The diet so formed was placed under UV chamber for 15 minutes to avoid all the external contamination and allowed to cool down slowly. After cooling, the diet was cut into small pieces and offered as food to *S. frugiperda* larvae.

Formula for sex ratio

$$\text{Sex ratio} = \frac{\text{Number of male individuals}}{\text{Number of female individuals}}$$

Table 1: Biology of fall armyworm, *Spodoptera frugiperda* on artificial diet

| S. No. | Stage of the insect | Mean±SD | Range |
|--------|-------------------------|---------------|-----------------|
| 1. | Incubation period | 2.28±0.075 | 2.00-3.00 |
| 2. | Larval period | | |
| a. | I instar | 2.03±0.051 | 2.00-3.00 |
| b. | II instar | 2.00±0.00 | 2.00 |
| c. | III instar | 2.18±0.075 | 2.00-3.00 |
| d. | IV instar | 2.20±0.063 | 2.00-3.00 |
| e. | V instar | 2.38±0.075 | 2.00-3.00 |
| f. | VI instar | 2.00±0.00 | 2.00 |
| | Total larval period | 12.28±0.126 | 12.00-14.00 |
| 3. | Pre pupal period | 2.23±0.051 | 2.00-3.00 |
| 4. | Pupal period | 6.94±0.163 | 6.00-8.00 |
| 5. | Adult longevity | | |
| a. | Male | 6.34±0.205 | 6.00-7.00 |
| b. | Female | 8.78±0.318 | 8.00-10.00 |
| 6. | Total life cycle | | |
| a. | Male | 30.33±0.308 | 29.00-34.00 |
| b. | Female | 32.58±0.448 | 30.00-35.00 |
| 7. | Pre oviposition period | 3.22±0.098 | 3.00-4.00 |
| 8. | Oviposition period | 2.31±0.116 | 2.00-3.00 |
| 9. | Post oviposition period | 3.25±0.225 | 3.00-4.00 |
| 9. | Fecundity (no.) | 1846.36±38.16 | 1659.00-1987.00 |
| 10. | Sex ratio (M: F) | 1:1.5 | — |

SD: Standard deviation

Results and Discussion

The duration of life cycle and development stages of the fall armyworm, *S. frugiperda* are discussed here under (plate 1 and figure 1).

Incubation period

The incubation period of eggs was found to be 2 to 3 days with a mean of 2.28 ± 0.075 days (Table 1). Similar results were obtained by Ramya *et al.* (2019) ^[11] who recorded incubation period as 3.00 ± 0.00 days while Lekha *et al.* (2020) ^[12] recorded slightly higher incubation period of 3.33 days on artificial diet.

Larval period

The duration of first, second, third, fourth, fifth and sixth instar larval instars as 2 to 3, 2, 2 to 3, 2 to 3, 2 to 3 and 2 days with a mean of 2.03 ± 0.051, 2.00 ± 0.00, 2.18 ± 0.075, 2.20 ± 0.063, 2.38 ± 0.075 and 2.00 ± 0.00 days, respectively when reared on artificial diet (Table 1 and Plate 1b). The total larval period lasted for about 12 to 14 days with a mean of 12.28 ± 0.126 days. These results were in accordance with the results of Ramya *et al.* (2019) ^[11] who reported larval period of *S. frugiperda* as 15.50 ± 4.24 days, whereas, it was 15.6 ±

0.16 days by Pinto *et al.* (2019) ^[13] and 14.50 days by Lekha *et al.* (2020) ^[12] when fed with the artificial diet.

Pre pupal and Pupal period

Before going to pupation, the mature larvae curled into C-shape and the pre pupal and pupal period lasted for about 2 to 3 and 6 to 8 days with a mean of 2.23 ± 0.051 and 6.94 ± 0.163 days, respectively (Table 1). The investigation data on pre pupal and pupal period gained support from the results of Silva *et al.* (2016) ^[14] who reported pre pupal period on artificial diet as 1.87 ± 0.04 days and Ramya *et al.* (2019) ^[11] who reported pre pupal and pupal period as 1.50 ± 0.35 and 8.50 ± 0.52 days, respectively.

Adult longevity

The mean female adult longevity was 8.78 ± 0.318 days with a range of 8 to 10 days compared to male (6.34 ± 0.205 days) with a range of 6 to 7 days (Table 1). Present results coincide with the observations of Ramya *et al.* (2019) ^[11] who reported male longevity as 8.50 ± 1.00 and female longevity as 9.50 ± 1.00 days. Similar results were also put forth by Lekha *et al.* (2020) ^[12] who reported male longevity as 7.50 days and female longevity as 10.17 days

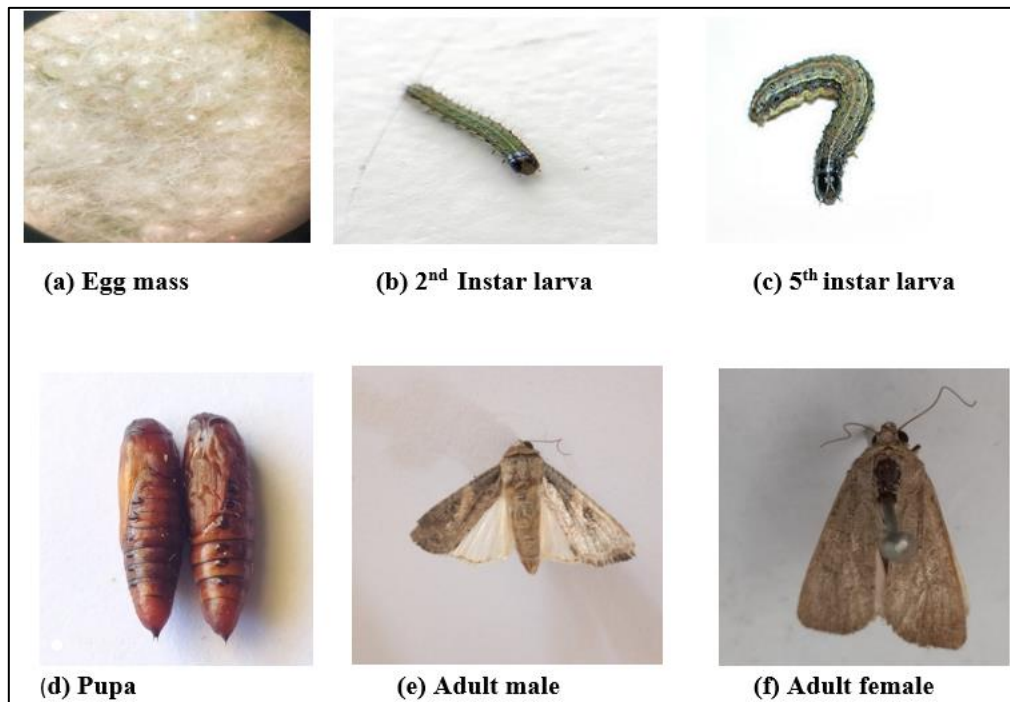


Plate 1: Biology of fall armyworm, *S. frugiperda* on artificial diet

Total developmental period

Total life cycle of male was completed in 29 to 34 days with an average of 30.33 ± 0.308 while female was little higher and ranged between 30 to 35 days with an average of 32.58 ± 0.448 days under laboratory conditions (Table 1). Similar

results were presented by Ramya *et al.* (2019) [11] who reported 37.25 ± 4.62 days as the total life cycle of the *S. frugiperda* while Lekha *et al.* (2020) [12] reported 36.99 days as total life cycle of male and 39.66 days for female when their larvae were fed on artificial diet.

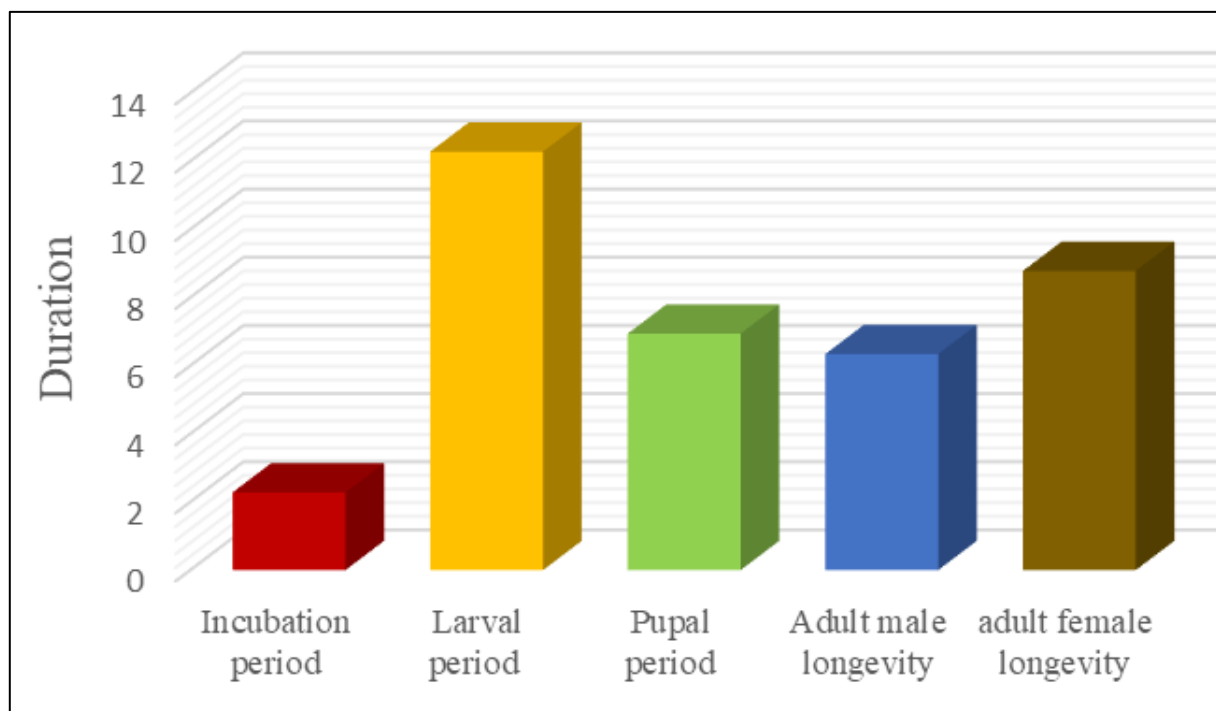


Fig 1: Life cycle duration of fall armyworm, *Spodoptera frugiperda* on artificial diet

Pre oviposition, oviposition and post oviposition period

The perusal of data presented in Table 1 revealed that the pre oviposition period ranged between 3-4 days with an average of 3.22 ± 0.098 days, oviposition period ranged between 2-3 days with an average of 2.31 ± 0.116 and post oviposition period ranged between 3-4 days with an average of 3.25 ± 0.225 days, respectively. The present findings were in close

proximity to the earlier findings of Ramya *et al.* (2019) [11] who reported pre oviposition and oviposition period as 1.75 ± 0.35 and 3.00 ± 1.41 days, respectively when *S. frugiperda* larvae were fed with the artificial diet. Busato *et al.* (2006) [15] also reported pre oviposition, oviposition and post oviposition period were in the range of 2.7 to 4.4 days, 7.1 to 10.1 days and 2.2 to 3.4 days, respectively on artificial diet.

Fecundity

In the present investigations, it was observed that, single female laid an average of 1846.36 ± 38.16 eggs during its oviposition period of 2 to 3 days (Table 1). These findings were in accordance with the observations of Busato *et al.* (2006)^[15] who reported that the fecundity of *S. frugiperda* on artificial diet was varied from 892- 3335 eggs. Similarly, Pinto *et al.* (2019)^[13] recorded 1850.0 ± 214.98 eggs per female.

Sex ratio

The sex ratio of *S. frugiperda* reared on artificial diet revealed that females outnumbered males and average female to male sex ratio was 1.5: 1. The present findings were in close proximity to the earlier findings of Kaur (2012)^[16] who reported sex ratio (female: male) of *S. litura* as 1.22: 1 on Pride of India and Pusa Drum Head, 1.35: 1 on KGMR-1, 1.50: 1 on Golden Acre, 1.86: 1 on Pusa Mukta.

Conclusion

The present study concluded that the total larval and pupal period of *S. frugiperda* was observed to be 12-14 and 6-8 days, respectively on artificial diet. The male and female adult longevity was observed to be 6-7 and 8-10 days, respectively. The total development period of male and female was observed to be 29-34 and 30-35 days, respectively. This information helps the researchers to rear the large number of *S. frugiperda* for insecticide bioassay studies, *Sf*-NPV commercial production and its natural enemies potentiality.

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