A REVIEW OF THE BIONOMICS OF FALL ARMYWORM, SPODOPTERA FRUGIPERDA ON MAIZE

Abstract

The female placed her eggs in whorls as well as in masses (150–200 eggs per mass) on the underside or the top portion of a maize leaf and on the lid of a glass jar. When the egg mass wasn't coated with scales, it had a layer of scales on it. Under laboratory conditions, the incubation, larval, pre-pupal, and pupal periods were 2 to 3, 13.5 to 23, 2 to 3, and 5 to 8 days, respectively. The duration of the first, second, third, fourth, fifth, and sixth instars was, respectively, 2 to 3, 2 to 3, 2 to 3, 3 to 4, and 3 to 5 days. The larva of the last instar was dark brown with a reddish-brown head that was marked with an inverted 'Y' shape and an elevated, conspicuous dark spot. The forewing of male adult was light brown, grey and straw. Markings on the male were more pronounced than the female with males having a grey colour and a light diagonal marking on the forewing. While female forewing was uniform greyish brown to a fine mottling of grey and brown. The life cycle of male and female were 28 to 41 days and 30 to 45 days, respectively.

Keywords: Maize, Fall armyworm, Spodoptera frugiperda

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I. INTRODUCTION

The term "fall armyworm" refers to a type of harm caused by infestations that occasionally resemble vast armies as they migrate across expansive agricultural fields and acquire their common name by consuming any plant material they come across throughout their wide dispersals, which resembles a large army (Smith, 1797). Due to its migratory behaviour, the fall armyworm is known as a sporadic pest. A new invasive pest, fall armyworm (FAW), Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae) attained the status as a major pest resulting in extensive yield losses of maize all over the world. FAW is a devouring pest native to tropical and subtropical regions of America where it was first detected in 1797 and first discovered in the African continent in 2016 (Goergen et al., 2016) and has reached China, spreading across Africa and Asia continents, west to east, in just three years. Entry of this destructive insect into a portion of Asia is questionable because a majority of people inhabit there and in locations nearby and already a huge pressure is created on food production systems. In India, the incidence and occurrence of this invasive pest were noted for the first time by Sharanabasappa et al. (2018) from Karnataka state which is the first reported infestation in Asia, in July 2018. Then, it spread into the other ten states of India till the middle of March 2019. Later, its existence was confirmed in the states of Maharashtra, Gujarat and Chhattisgarh (Chormule et al., 2019; Sisodiya et al., 2018; Deole and Paul, 2018). It is a cosmopolitan pest of the maize crop (Wiseman et al., 1966). The fall armyworm may travel over 500 km before they start oviposition (Prasanna et al., 2018). The study of the biology of fall armyworm as occurring in Gujarat is very much important for recognizing the life stages and finding out the weaker stage of the pest which provides the basis for management strategies. Farmers are growing a wide variety of commercial hybrids across the state, but the hybrids with good plant vigour and hereditary resistance to crop pests were most preferred to combat the alien insect pests. The use of insect-resistant cultivars is an important component of Integrated Pest Management (IPM) which provides an economic, stable and environmentally sound tactic to minimize damage from borer pests (Rasool et al., 2017). Keeping this in view present studies were carried out.

II. EGG STAGE

Gravid females lay eggs in groups of lower or upper corn leaves, on the lids of glass jars and in rings. The eggs are dome-shaped, flat on the back and abdomen, first light green, then golden yellow, and finally black. Sometimes the eggs are covered with a layer of scales, while the large eggs found by Siddhapara et al. not covered with scales. (2021), Ramzan et al. (2021), Ahmed et al. (2021), Manjula et al. (2019), Sharanabasappa et al. (2018), Sisodia et al. (2018) and Rajisha et al. (2022). Rajisha et al. (2022) note that the eggs are placed as 150-200 eggs/group. The average fertility per female of 939 eggs was recorded by Vishwakarma et al. (2020). The egg incubation period is 2 to 3 days, according to Kranthi et al. (2022), Ashok et al. (2020), Vishwakarma et al. (2020), Ahmed et al. (2021), Sharanabasappa et al. (2018), Rajisha et al. (2022) and Kranthi et al. (2022). Kayan et al. (2020) noted that the incubation period of eggs is 3-4 days, with an average of 3.30 days. Egg diameters between 0.47 and 0.59 mm have been recorded by Manjula et al. (2019) and Ipsita and Sahu (2020).

III. LARVA STAGE

1. **First Instar:** Assefa (2018), Deole and Paul (2018), Sisodiya et al. (2018) It showed that the first star of FAW was black-headed green and Sharma et al. (2022) noticed the larvae are so small that they eat whole eggs. Kalyan et al. (2020) he noticed a large, compressed, round, black head and a white body covered with small hairs. The duration of first instar larvae ranged between 2.00 to 3.00 days with a mean of 2.6±0.51 days noted by Reddy et al. (2021) and more or less similar with Vishwakarma et al. (2022). The duration of first instar was 5 days recorded by Manjula et al. (2019). The body length was 1.68±0.00 mm and width was 0.14±0.26 mm of first instar larvae recorded Ahmad et al. (2021). The body Length and width of first instar larvae were 1.42±0.28 mm and 0.28±0.06 mm, respectively (Reddy et al., 2021). Larva measured 0.71 mm in length and with 0.16 mm head capsule width recorded by Manjula et al. (2019). The mean head capsule width was 0.33 mm, whereas, body length and width were 1.67 mm and 0.33 mm respectively by reported by Vishwakarma et al. (2022).

2. **Second Instar:** The 2nd instar larvae have an amber head and a whitish-yellow body with a brown small on the back. Kalyan et al. (2020) and Bawani et al. (2019) indicates that the body also has a free top line and bottom line at this level. Vishwakarma et al. (2020) they found that the number of hairs per segment varied between 2-4. The period of the second instar larvae is 2.00 to 3.00 days with a mean of 2.7 ± 0.48 days reported by Reddy et al (2021). The length and width of the second instar larvae is noted by Vishwakarma et al was 3.81mm and width 1.14mm. The mean length and width of 2nd instar larvae were 3.32±0.48 mm and width 0.69±0.04 mm, respectively noted by Reddy et al. (2021). Sharanabasappa et al. (2018) found the head capsule width of second instar larvae was 0.48±0.01 mm. The head capsule width was 3.5 to 4 mm whereas length was about 0.5 mm (Manjula et al., 2019) and Sharanabasappa et al. (2018) recorded the larval head capsule width was 0.48±0.01 mm.

3. **Third Instar:** The body color of third instar larvae varies significantly from light white to greenish brown. Kalyan et al. (2020) reported that dorsal and dorsal lower alba lines were clearly visible and black spots were evident. The third period is brown with two to three white ridge lines (Ahmad et al., 2021; Sharma et al., 2022). Features reported by Rajisha et al. (2022 it is an inverted Y-shaped yellow epithelial suture on the head. The third instar larval stage is 2.20 ± 0.41 days and Vinay et al. (2022) suggest that 41 days should be in the 2-3 day range. Vishwakarma et al. (2022) recorded as third instar larval stage 1.48 days by. The third instar larval time is 1.95 ± 0.20 days for sorghum hosts and 2.00 ± 0.05 days for maize hosts (Keerthi et al., 2016). Body length and width are 6.68 ± 0.14 mm and 0.82 ± 0, respectively.03 mm were recorded by Siddhapara et al., 2021, Sharma et al. (2022) and Vishwakarma et al. (2022). The average length of the third semester is 7.12 mm (6.4-7.8 mm), head capsule width 0.8 mm (0.80 ± 0.8 mm). 004) Sharma et al. (2022). Head capsule width is 0.50 ± 0.01 mm (Ahmad et al., 2017). Ib., 2021). The third instar larval duration was 1.48 days recorded by Vishwakarma et al. (2022). the 3rd instar larval period of 1.95±0.20 days on the sorghum host and 2.00±0.05 days on the maize hosts (Keerthi et al., 2021). The body length and width were 6.68±0.14 mm and 0.82±0.03 mm, respectively recorded by Siddhapara et al. (2021), Sharma et al. (2022) and Vishwakarma et al. (2022). The average length of 3rd instar was 7.12

mm (6.4-7.8 mm) and width of head capsule was 0.8 mm (0.80±0.004) recorded by Sharma et al. (2022). The head capsule width was 0.50±0.01 mm (Ahmad et al., 2021).

4. **Fourth Instar:** The body color of the fourth instar larvae varies from olive brown to dark brown. Kalyan et al. (2020) found that the dorsal and dorsal inferior linea alba also appeared. Reddy et al. (2020) found a clearly seen inverted "Y" shaped mark on the head and four black dots arranged in a square on 8th abdominal segment. All the spots arranged as in case of third instar with increase in size and with more darkness reported by Manjula et al. (2019). The period of fourth instar ranged between 2.00 to 3.00 days with a mean of 2.4±0.51 days noted by Reddy et al. (2020) and Reddy et al. (2021). The body length and width were measured 13.94±1.09 mm and 0.84±0.02 mm, respectively recorded by Siddhapara et al. (2021). The average length was 11.6 mm (9.4-13.5 mm) and width of head capsule was 1.37±0.006 mm measured by Sharma et al., (2022).

5. **Fifth Instar:** Fifth instar larvae are pale yellow to cream in colour. Head colour is brick red with dark brown spots. The colour of the chest and abdomen is similar. Only the area around the first chest hair is a black ring. There are also dark circles and lighter areas.The shallow dorsal longitudinal line will be shallow. Manjula et al. (2019) and Igyuve et al. (2018). see the brown color in the outer area. Spiny black nodules were found on the dorsal side of the body (Reddy et al., 2020). The period of fifth instar varied from 3 to 4 days with an average of 3.05±0.05 days recorded by Tiwari and Deole (2021); Rajisha et al. (2022) and Reddy et al. (2020). The mean body length and width were 18.81 mm and 3.45 mm, respectively (Vishwakarma et al., 2022). The average length of 5th instar was 18.51 mm (15.8-22.5 mm) and width of head capsule was 2.11 mm reported by Sharma et al. (2022). Vishwakarma et al. (2022) recorded the mean body length and width were 18.81 mm and 3.45 mm, respectively.

6. **Sixth Instar:** The sixth instar larva as dark brown with reddish-brown head marked with inverted ‘Y’ shape on the head with the elevated distinct dark coloured black spots (Pinacula) on the entire body which bears spines (long primary setae). The arrangement of the dorsal pinacula the four black spots arranged in square on the 8th abdominal segment. Large spots especially on 9th segment had a typical arrangement in a trapezoidal pattern and also seen from 1 to 7th abdominal segments (Babu et al., 2019; Sharanabasappa et al., 2018; Manjula et al., 2019; Reddy et al., 2021 and Vinay et al., 2022). The duration of 3.67±0.83 days of sixth instar larval period which varied from 3-5 days reported by Reddy et al. (2020) and Vishwakarma et al. (2022). The mean length and width of sixth instar larvae were 33.6±1.67 mm and 5.90±0.26 mm, respectively noticed by Reddy et al., (2021) and Vishwakarma et al. (2022). Ahmad et al. (2021) reported that length and width of larva were 26.98±2.93 and 3.90±0.00 mm, respectively. The average length of 6th instar larva was 34.39 mm (28.

IV. TOTAL LARVAL PERIOD

The total larval period varied from 13.5 to 23 days with an average of 18.25 days recorded by Vishwakarma et al. (2020). Sharanabasappa et al. (2018); Bhavani et al. (2019); Manjula et al. (2019) and Vishwakarma et al. (2020) noted the total larval duration was 14-19, 13-14, 14-30 and 13.5 to 23 days, respectively.

1. **Pre Pupal Stage:** Sharanabasappa et al. (2018) Bawani et al. (2019) and Vishwakarma et al. (2022) They found that before the pupal stage, the mature larvae stop eating and turn green and bright brown. The incubation period is 2 to 3 days, with an average of 2 to 3 days with an average of 2.10±0.06 days recorded by Tiwari and Deole (2021 and Kranthi et al., 2022). The length of the pre-pupae ranging from 19 to 22 mm with an average of 20.0±0.11 mm while the breadth ranged from 2.7 to 3.2 mm with an average of 3.08±0.02 mm observed by Tiwari (2020).

2. **Pupa Stage:**Newly formed pupae are green in color. After 12-14 hours, the color of the fry changed to a deep red color as described by Deole and Paul (2018). Ahmed et al. (2021) It has been observed that pupae occur on corn stalks or cut leaves or on the rim of petri dishes. Sisodia et al. (2018) and Babb et al. (2019) noted a reddish-brown coloration in the custard in pupae. Ahmed et al. (2021) mentioned an important morphological feature such as the purpose of pupae being white-green. The education period of primary school students is between 5 and 8 days, with an average of average of 6.30±0.14 days (Tiwari and Deole, 2021).). Sharanabasappa et al. (2018) recorded the pupal duration period was 9 to 12 days. The distance between genital opening and anal slot recorded more in case of female (0.89±0.01 mm) than the male (0.43±0.01 mm) recoded by Siddhapara et al. (2021). Length and width of male and female pupa were 14.12±0.38, 14.00±0.32 and 4.12±0.12, 4.00±0.00, respectively (Ahmad et al., 2021 and Vishwakarma et al., 2022)). The average weight of pupa was 18.9 mg (15-24 mg) weighted by Sharma et al. (2022). Gamil (2020) recorded 9.56 days pupal duration and the pupal weight was 0.3033 gm, while the normal pupae, malformed pupae, pupal mortality and emergence per cent was 95.44, 4.56, 4.0, and 96.0 per cent, respectively.

3. **Adult Stage**

    - **Male:** Adult male fore wings are light brown, gray and straw colored. The markings are more pronounced in males than females, and males are gray with a slight diagonal on the fore wings. Deole and Paul (2018) concluded that the hind wings are white. Sisodia et al. (2018) shows gray-brown male adults. The forewings are shades of gray and brown with oval or oblique orbital spots and triangular white spots near the apical edge of the forewings. Damasi et al. (2020) found that the adult male is gray-brown in color, with shades of gray and brown on the forewings, an oval orbital point and a triangular white spot near the apical edge of the forewings. Sharanabasappa et al. (2018) reported that adult males live 8.20 days, with a range of 7-9 days and an average wingspan of 3. 25 cm long with range of 3.00 to 3.50 cm in male. The average body length of male moths is 15.20 ± 1.30mm (Reddy et al., 2021).

- **Female Adult:** The forewings of females were uniform greyish-brown to a fine mottling of grey and brown. The hind wing was silver-white with a narrow dark border in both male and female (Sharanabasappa et al., 2018; Reddy et al., 2021 and Sharma et al., 2022). The female body length was 10.13±0.56 mm and wing expanse was 31.00 ±1.43 mm measured by Ahmad et al. (2021). The female adult survived for 9-12 days with an average of 10.80 days (Sharanabasappa et al., 2018). Manjula et al. (2019) revealed 1.2 cm forewing length, 0.9 cm hind wing length and 3.0 to 3.1 cm wing span. Ahmad et al. (2021) reported that the female body length was 10.13±0.56 mm and wing expanse was 31.00 ±1.43 mm. The average weight of adult female 3.3 mg and wingspan of female was measured as 3.2 cm reported by Sharma et al., 2022).

V. PRE-OVIPOSITION, OVIPOSITION AND POST-OVIPOSITION PERIOD

The pre-oviposition period of female moths of S. frugiperda varied from 3 - 4 days with an average of 3.05±0.05 days, however oviposition period was 1 to 2 days with an average of 1.85±0.08 days reported by Tiwari and Deole (2021). The post-ovipositional period ranged from 4 to 6 days with an average of 4.40±0.51 days recorded by Reddy et al. (2021). Gamil (2020) stated that the mean time mandatory for maturation of the ovaries and starting to egg-laying (pre-oviposition period) was 3.50 days. Moreover, oviposition and post-oviposition period were 5.11 and 2.61 days, respectively. Vishwakarma et al. (2020) observed the mean pre-oviposition, oviposition and post-oviposition period as 3.5, 3.5 and 3.5 days and it ranged from 3-4, 2-5 and 3-4 days, respectively. Keerthi et al. (2021) revealed that the pre-oviposition period on sorghum and maize was 3.87±0.52 and 3.71±0.45 days, respectively whereas, oviposition period on sorghum and maize was 3.10±0.62 and 3.05±0.52 days. Siddhapara et al. (2021) noted the pre-oviposition, oviposition and post oviposition period was of 3.50±0.51, 3.20±0.89 and 3.90±0.71 days, respectively.

1. **Life Span:** The total life cycle of S. frugiperda occupied on an average of 33.1±0.69 days ranging from 28 to 41 days in case of male, while 36.0±0.75 days ranging from 30 to 45 days in case of female observed by Tiwari and Deole (2021). Vinay et al. (2022) reported 38.10±6.51 days total duration of fall armyworm life cycle. Ahmad et al. (2021) noticed 35.32±4.02 and 42.00±5.76 days for average total life cycle of male and female, respectively. Sharanabasappa et al. (2018) reported total life cycle of male and female ranging from 32-43 and 34-46 days, respectively. Kalyan et al. (2020) revealed 36.15 and 40.11 days to complete total life cycle of male and female, respectively.

2. **Sex Ratio:** The sex ratio of fall armyworm at constant conditions in the laboratory was approximately 1:1.23 (45.24 male:55.76 female) recorded by Gamil (2020). Siddhapara et al. (2021) calculated the sex ratio which was 1.13:1 (female: male). Sharma et al. (2022) worked out the adult male to female sex ratio as 1:1.30.

3. **Fecundity:** The fecundity of 1004.65±110.00 eggs and range were 820-1150 eggs/female recorded by Ahmad et al. (2021). Reddy et al. (2021) reported that the egg laying capacity of female varied from 855-1172 eggs with an average of 1015±115.48 eggs. Sharanabasappa et al. (2018) reported that the average fecundity/female was 1064.80±109.53 eggs which ranged from 835-1169 eggs. Siddhapara et al. (2021) noticed 1145.43±182.15 eggs/female (766 to 1389 eggs). Tiwari and Deole (2021) noticed that egg laying capacity of female varied from 536 to 579 eggs with an average of 557.2±2.81 eggs. Sharma et al. (2022) revealed 979.43±24.086 eggs average fecundity and the range was 713 to 1166 eggs.

4. **Hatchability:** The extent of egg hatching in the rage of 72.00-95.54 per cent reported by Siddhapara et al. (2021). Vinay et al. (2022) found the hatching of eggs was about 96.26 per cent. Sharanabasappa et al. (2018) reported 96.60±1.43 percent egg hatchability which ranged from 95-98 per cent. Gamil (2020) recorded the hatchability in fall armyworm and it was observed 97.33 per cent.

VI. CONCLUSION

The gravid female laid eggs in 150-200 eggs/mass on the under or top portion of the maize leaf, lid of glass jar and also in whorls and egg mass covered with a layer of scales some time, not covered with scales. The egg , larval, pre-pupal and pupal period were 2 to 3, 13.5 to 23, 2 to 3 and 5 to 8 days, respectively under laboratory condition. The newly formed pupae were green in colour. After 12-14 hours pupae were converted dark reddish brown in colour, The forewing of male adult was light brown, grey and straw. While female forewing was uniform greyish brown to a fine mottling of grey and brown. The hind wing of adults was whitish colour.

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