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Biological Parameters of *Spodoptera frugiperda* (J. E. Smith) under Laboratory Conditions

Deepika Kalyan[1]*, M. K. Mahla[1], S. Ramesh Babu[2], R. K. Kalyan[2] and P. Swathi[1]

[1]Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India
[2]Agricultural Research Station, Maharana Pratap University of Agriculture and Technology (MPUAT), Borwat Farm, Banswara, Rajasthan, India

**Corresponding author*

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A B S T R A C T

The fall armyworm, *Spodoptera frugiperda* (J. E. Smith) is a highly notorious lepidopteran pest which is causing severe economic loss in different crops, especially maize. A study was conducted to know the biology of *S. frugiperda* on maize during July-December, 2019 under laboratory conditions at the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur. The mean incubation, larval, pupal, pre-oviposition, oviposition and post-oviposition period were observed to be 3.30, 16.97, 8.96, 3.47, 2.96 and 6.13 days, respectively. The mean adult longevity of male and female was 10.67 and 13.00 days. The mean total life cycle was recorded to be 37.68 days. The average fecundity was 1662 eggs. Various morphometric data were also recorded.

Introduction

Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae) or commonly known as fall armyworm is a native of tropical and subtropical regions of America. Till 2016, FAW was constrained to its native region of origin. However, in this year, it was reported from Africa causing serious damage to the maize crops (Goergen *et al.*, 2016) and since then has spread across most of the sub-Saharan Africa. In about three years it reached to another continent, Asia. In 2018, it was first time reported from India in Karnataka (Sharanabasappa *et al.*, 2018).

Since then, it has been reported from many states in India (CABI, 2019) on different crops like maize, sugarcane and sorghum. But, in our country it has caused substantial

damage to maize crop (Chimweta *et al.*, 2019). It is clear that fall armyworm is a major threat to maize crop and hence a complete knowledge of its biology and morphology becomes very important to formulate proper management techniques against this pest. Keeping in view these facts, the biology of FAW on maize was studied under laboratory conditions.

Materials and Methods

Larvae collection and identification

To study the biology of *S. frugiperda*, its larvae were collected from the maize fields at RCA, Udaipur to start the culture. They were identified by studying their various morphological characters and also by DNA barcoding method. For molecular identification, the total genomic DNA was extracted from the collected larvae using DNASure Tissue mini kit (Nucleo-pore, Genetix Brand, India), in accordance with the manufacturer's instructions. PCR amplification of COI (cytochrome oxidase subunit I) gene of 658-700 bp region was carried out for an initial denaturation of 94°C for 4 min, followed by 35 cycles of denaturation at 94°C for 30 sec, annealing at 47°C for 45 sec, extension at 72°C for 45 sec and final extension at 72°C for 20 min., using the universal primers *viz*., forward primer: (LCO1490 5'-GGTCAACAAATCAT AAAGATATTGG-3') and reverse primer: (HCO2198 5'-TAAACTTCAGGGTGAC CAAAAAATCA3'). The amplified and purified PCR product was sent through outsourcing Agile Lifescience Technologies India Pvt. Ltd, Pune (ABI PRISM 3730xl Genetic Analyzer develop by Applied Biosystems, USA) for sequencing target fragment by using universal primers. The obtained chromatogram was edited to remove the ambiguous bases and the sequence was compared with authenticated sequences through Basic Local Alignment Search Tool (BLASTn, http://www.ncbLn1m.nih.gov) search to confirm the identity of the sequence. The sequence obtained was deposited at the gene bank of National Center for Biotechnology Information (NCBI), USA to obtain the accession number.

Biology of FAW

The biology of *S. frugiperda* was studied in the laboratory under controlled conditions of 25 ± 2˚C and 70-75% RH. The culture was maintained in glass jars and provided fresh maize leaves and stem, of variety Pratap Makka-3, daily until pupation. The pupae so developed were transferred into clean jars until the emergence of moths. The adults that emerged were paired and allowed to mate in separate mating cages. The moths were fed with 10% honey solution soaked on cotton pads for proper egg laying. The eggs thus laid were used for the experiment. After hatching, the larvae were transferred into new glass jars and reared individually on fresh maize leaves which were changed daily as food. To study the biology, the observations on different biological parameters viz., incubation period, larval period, pupal period, pre-oviposition period, oviposition period, post-oviposition period, adult male and female longevity, total life cycle and fecundity were recorded. Four generations were maintained and mean observations were taken. Necessary morphological traits were also measured such as: length of larval instars, pupae, adults and their wing span.

Results and Discussion

Morphological identification

Diagnostic characters of FAW such as the black spots arranged in a square pattern on the 8th abdominal segment and in a trapezoidal pattern on 1st to 7th abdominal segments of the

larvae (Fig. 1a), an inverted "Y" shape on the larval head capsule (Fig. 1b) and reddish brown pupae with characteristic cremaster with two spines (Fig. 1c) were observed. The male moths had grey to brown coloured forewings with a reniform indistinct spot at the junction of M3 and CuA1 veins and a triangular white patch near the apical margins (Fig. 1d), while the female moths had more uniformly coloured forewings (Fig. 1e). These characters were confirmed with earlier findings of Pogue, 2002 and EPPO, 2015.

Molecular identification

The search analysis in the BLAST identified the insect species as *S. frugiperda* with a GenBank accession number of MN117927.

Biology of FAW

Egg

The eggs were laid in egg masses and the number of eggs per mass was 25-330. The egg masses laid by a gravid female ranged from 4-11. The eggs were pale white to creamish in colour covered with grayish white scales of the female abdomen (Fig. 2) The colour of the eggs turned brown to black just before hatching. The eggs took 3-4 days to hatch, with a mean time of 3.30 days (Table 1).

Larva

First instar

The 1st larval instars were very tiny. They completely devoured the egg shells from which they hatched. They had a comparatively large flattened circular black head and a whitish body covered with minute hairs (Fig. 3). The mean development time of the first larval instar was 2.8 days (Table 1).

Second instar

The 2nd instar larvae had amber coloured head and a pale white to yellowish coloured body with a tinge of brown on the dorsum (Fig. 4). The body also developed faint white dorsal and sub-dorsal lines at this stage. The mean development time of the second larval instar was 2.5 days (Table 1)

Third instar

The 3rd instar larvae showed an immense change in body colour. The body colour changed from pale white to greenish brown (Fig. 5). The dorsal and sub-dorsal white lines were plainly visible and the black spots became prominent. The mean development time of this instar was 2.5 days (Table 1).

Fourth instar

The body colour of 4th instar larvae varied from olive brown to dark brown (Fig. 6). The dorsal and sub-dorsal white lines also became conspicuous. The mean development time of the 4th larval instar was 2.0 days (Table 1).

Fifth instar

The body of 5th instar larvae attained a grayish brown colour on the dorsum and greenish colour on the ventral and sub-ventral sides (Fig. 7). The mean development time of the 5th larval instar was 2.7 days (Table 1).

Sixth instar

The 6th instar larvae were most stout and bulged with somewhat cylindrical in shape. Their body was smooth with clear and distinct segmentation. The head was black and slightly bilobed. The colour of the body was grayish brown on the dorsum, while the ventral and sub-ventral sides were greenish mottled with reddish brown colour (Fig. 8).

Table.1 Biology of *S. frugiperda* on maize under laboratory conditions

S. No.	Life stages	Period of study								Mean
		Aug-Sept		Sept-Oct		Oct-Nov		Nov-Dec		
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	
1.	**Incubation period (days)**	3.00-4.00	3.40	3.00-4.00	3.20	3.00-4.00	3.40	3.00-4.00	3.20	**3.30**
2.	**Larval period (days)**	13.00-19.00	16.46	14.00-20.00	16.98	14.00-21.00	17.22	14.00-21.00	17.24	**16.97**
	I instar	2.00-3.00	2.70	2.00-3.00	2.90	2.00-3.00	2.90	2.00-3.00	2.80	**2.80**
	II instar	2.00-3.00	2.40	2.00-3.00	2.50	2.00-3.00	2.60	2.00-3.00	2.50	**2.50**
	III instar	2.00-3.00	2.10	2.00	2.00	2.00	2.00	2.00-3.00	2.30	**2.10**
	IV instar	2.00	2.00	2.00-3.00	2.10	2.00	2.00	2.00	2.00	**2.00**
	V instar	2.00-3.00	2.60	2.00-3.00	2.70	2.00-3.00	2.70	2.00-3.00	2.80	**2.70**
	VI instar	3.00-5.00	4.20	4.00-6.00	4.60	4.00-8.00	5.30	4.00-7.00	5.50	**4.90**
3.	**Pupal period (days)**	7.00-11.00	8.36	8.00-11.00	9.05	8.00-11.00	9.21	8.00-12.00	9.24	**8.96**
4.	**Pre-oviposition period (days)**	3.00-5.00	3.21	2.00-5.00	3.30	3.00-4.00	3.31	4.00-5.00	4.06	**3.47**
5.	**Oviposition period (days)**	2.00-4.00	2.92	3.00-4.00	3.16	2.00-4.00	2.59	2.00-4.00	3.18	**2.96**
6.	**Post-oviposition period (days)**	4.00-7.00	5.80	5.00-7.00	6.17	4.00-9.00	6.25	5.00-8.00	6.33	**6.13**
7.	**Female adult longevity (days)**	9.00-16.00	12.12	10.00-16.00	12.97	9.00-17.00	13.10	11.00-17.00	13.83	**13.00**
8.	**Male adult longevity (days)**	8.00-12.00	10.57	7.00-12.00	10.58	8.00-13.00	10.87	7.00-14.00	10.66	**10.67**
9.	**Total life cycle (days)**	33.00-44.00	37.24	32.00-48.00	37.63	34.00-48.00	37.81	34.00-51.00	38.06	**37.68**
	Female	33.00-44.00	38.50	37.00-48.00	39.84	35.00-48.00	40.26	37.00-51.00	41.84	**40.11**
	Male	33.00-40.00	36.07	32.00-42.00	36.11	34.00-41.00	36.18	34.00-42.00	36.26	**36.15**
10.	**No. of eggs/female**	995-2287	1840	750-2065	1629	915-2126	1638	850-1935	1541	**1662**

Table.2 Morphometric data of *S. frugiperda*

S. No.	Life stages		Range (mm)	Mean±SD (mm)
1.	**Larval length**	I instar	1.5-2.0	1.8±0.15
		II instar	3.0-4.0	3.5±0.45
		III instar	5.5-6.5	6.2±0.30
		IV instar	9.0-10.5	9.7±0.55
		V instar	15.0-18.0	16.8±1.08
		VI instar	32.0-36.0	33.5±1.30
2.	**Pupal length**		14.0-19.0	15.7±1.55
3.	**Adult**			
	Male	Body length	14.0-17.0	15.8±1.03
		Wing length	12.5-15.0	13.7±0.85
		Wing span	29.0-35.0	31.7±2.05
	Female	Body length	13.0-17.0	15.0±1.22
		Wing length	12.0-15.0	13.1±0.75
		Wing span	29.0-34.0	30.8±1.85

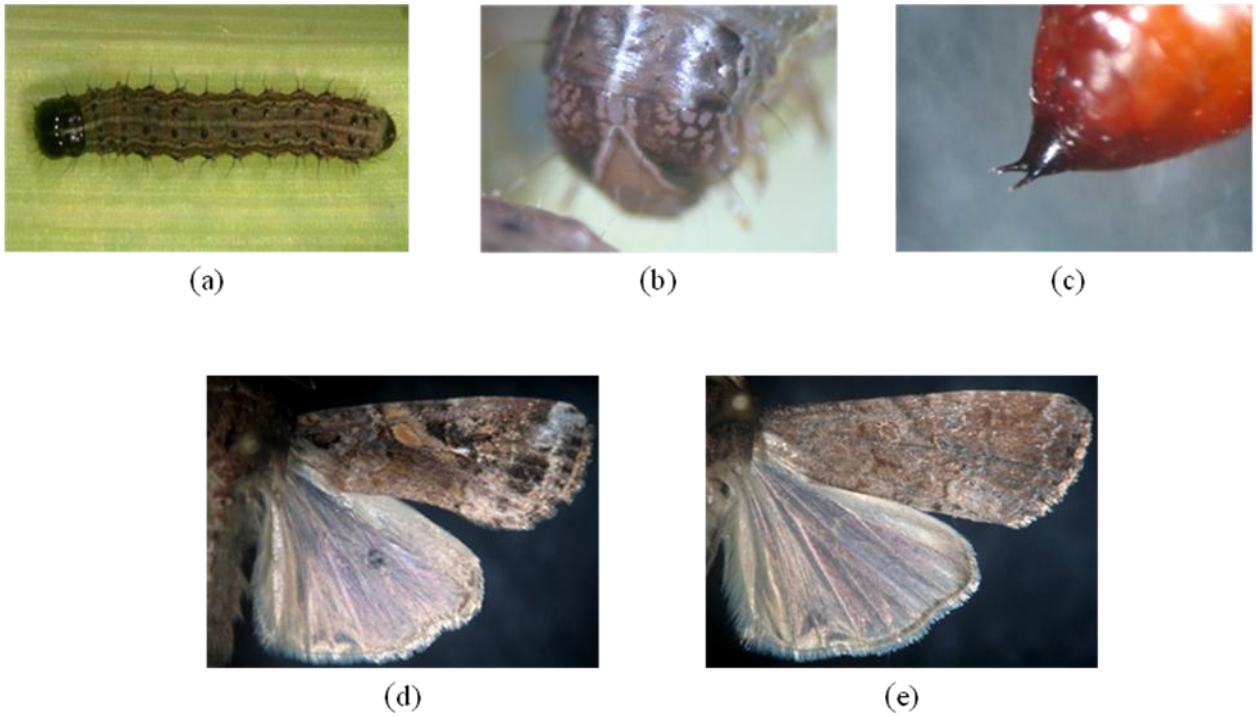

Fig.1 (a) Arrangement of spots on the larval body, (b) inverted Y shape on larval head, (c) pupa with 2 spines, (d) wings of male moth and (e) wings of female moth

Fig.2 Egg mass of *S. frugiperda*

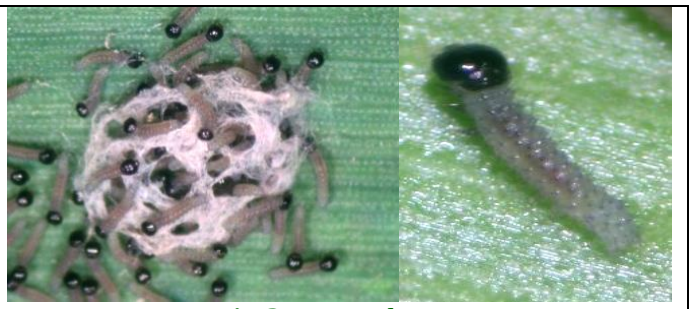

Fig.3 I instar larvae

Fig.4 II instar larva

Fig.5 III instar larva

Fig.6 IV instar larva

Fig.7 V instar larva

Fig.8 VI instar larva

Fig.9 Pupa

Fig.10 Male moth

Fig.11 Female moth

The mean development time of the 6th larval instar was 4.9 days (Table 1). The total larval period completed in a mean duration of 16.97 days (Table 1).

Pupa

The freshly laid pupae of *S. frugiperda* were orange-brown in appearance and changed to dark reddish brown colour with time. The male and female pupae were also distinguishable based on the distance between their genital and anal opening slots. In males, this distance was less whereas in females it was more (Fig. 9). The mean pupal period was recorded to be 8.96 days (Table 1).

Adult

The adult of *S. frugiperda* is a small to medium sized moth. Sexual dimorphism was clearly evident (Fig. 10 and 11). The observations reveal that female moths lived more than the male moths. The mean adult longevity of female and male moths was 40.11 days and 36.15 days, respectively. The mean pre-oviposition, oviposition and post oviposition period was 3.47, 2.96 and 6.13 days, respectively. The average total life cycle of male and female was 36.15 and 40.11 days, respectively.

The results are in close conformity with earlier findings of Deole and Paul (2018), Bhavani *et al.,* (2019), Manjula *et al.,* (2019) and Malo and Hore (2020). Other morphometric data recorded is also presented in Table 2.

The present study provides the basic information about the biology and morphology of fall armyworm on maize. The research findings conclude that the pest takes about more than a month's time to complete its life cycle on maize, has a high fecundity rate and under favorable conditions it can multiply at a much faster rate. So, the main focus must be on formulating a suitable and feasible IPM module for FAW and spreading awareness among the farmers about its life cycle, inspection and the right time of employing management practices.

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