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Research Paper

Biology of pink bollworm *Pectinophora gossypiella* (Saunders) on cotton as influenced by temperature

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ABSTRACT

A laboratory experiment was conducted to study the biology of pink bollworm *Pectinophora gossypiella* (Saunders) on cotton at four different temperature levels. It was found that males have a considerably shorter total life cycle duration on cotton at 35±1°C (29.5 days) followed by 30±1°C (37.2 days), 25±1°C (46.9 days) and highest at 20±1°C (50.8 days). Similarly, minimum total life cycle duration of female *P. gossypiella* was recorded at 35±1°C (30.2 days) followed by 30±1°C (38.0 days), 25±1°C (47.3 days) and maximum at 20±1°C (51.7 days). The highest fecundity was observed at 30±1°C (106.2) followed by 25±1°C (100.1), 35±1°C (60.1) and lowest at 20±1°C (55.2). Male as to female sex ratio was highest at 35±1°C (1:1.5) followed by 25±1°C (1:1.4), 30±1°C (1:1.3) and lowest at 20±1°C (1:1.2). These findings revealed that variation in temperature significantly influences the life cycle duration, fecundity and sex ratio of pink bollworms on cotton, with higher temperatures accelerating development and enhancing reproductive success.

Keywords: *Pectinophora gossypiella*, cotton, biology, fecundity, temperature, longevity.

Cotton, recognized as the paramount natural fiber, stands as a pivotal global commodity cultivated across 111 countries. Despite its widespread cultivation, cotton confronts a formidable challenge in the form of insect pests, surpassing the susceptibility of other crops (Bhamare and Wadnerkar, 2018). Among these, *P. gossypiella* emerges as a chief adversary, predominantly infesting flowers and inflicting harm on bolls. In India, this pest wreaks havoc, resulting in substantial losses in both seed cotton and oil content (Ingole *et al*., 2019). With the global warming and climate change, the biological behaviour of insect-pest have been found to vary under increasing CO_2 concentration and temperature (Pooja *et al*., 2022; Rakhesh *et al.,* 2023). Temperature stands out as a pivotal environmental factor that profoundly shapes insect growth and development (Skendzic *et al*., 2021). Insects are finely tuned to specific temperature ranges and deviations from these norms can exert a considerable influence on their populations and distribution (Deshmukh *et al*., 2023; Sable and Rana, 2016). The ramifications of global warming reverberate globally, impacting insects due to their pronounced sensitivity to temperature fluctuations.

Therefore, understanding the influence of temperature on the growth and development of *P. gossypiella* is crucial, in view of its significant damage and the economic impact it causes. Consequently, this study sets out to scrutinize the biology of *P. gossypiella* across diverse temperature settings.

MATERIALS AND METHODS

The investigation on the biology of *P. gossypiella* involved conducting experiments in a laboratory, where precise temperature conditions were maintained at four different levels (20, 25, 30 and 35°C) in a BOD incubator. The cotton variety Anusaya (NH-615) was grown at the Research Farm of the Department of Agricultural Entomology, College of Agriculture, Latur, during *kharif*-2019, following recommended practices from Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS), without plant protection measures.

Larvae were sourced from infested bolls and reared individually. Sex determination occurred in the fourth larval instar by observing two black spots on 8th abdominal segment of larva

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Table 1: The biological characteristics of the pink bollworm, *P. gossypiella* (Saunders) on cotton under varying temperature conditions

Sr	Stage	Temperature			
		20±1°C	25±1°C	30±1°C	35±1°C
1.	Fecundity (no/female)	55.2±4.9	100.1±10.4	106.2±16.7	60.1±13.5
2	Mean incubation Period (days)	4.7±0.2	3.80±0.3	2.8±0.3	2.2±0.1
3	Egg hatchability (%)	78±3.8	84±3.2	86±2.5	74±3.7
4	Larval period (days)	24.2±3.9	23.35±3.0	17.5±1.0	14.9±3.9
5	Instar period (days)				
	I	4.2±0.4	4.1±0.4	3.8±0.1	3.4±0.1
	II	6.6±0.2	6.4±0.3	5.2±0.3	3.2±0.2
	III	3.8±0.3	5.2±0.65	4.3±0.3	4.1±0.4
	IV	3.4±0.2	3.2±0.52	4.2±0.7	4.0±0.7
6	Pupation (%)	71±8.1	78±7.6	77±5.4	65±12.7
7	Growth index (days)	2.9±0.6	3.34±0.3	4.4±0.3	4.3±0.3
8	Pre-pupal duration (days)	3.7±0.1	3.5±0.2	2.6±0.1	2.2±0.1
9	Pupal duration (days)	8.06±0.42	7.32±0.39	6.94±0.54	5.9±0.5
10	Total develop-mental period	40.7±2.0	37.9±4.3	29.3±3.4	25.2±2.5
11	Adult emergence (%)	72±3.0	78±5.3	75±5.2	65±3.5
12	Pre-oviposition period (days)	2.60±0.32	2.00±0.36	1.90±0.41	1.2±0.4
13	Oviposition period (days)	8.4±0.9	7.30±0.4	6.00±0.5	3.7±0.4
14	Adult longevity (days)				
	Male	10.1±0.5	8.9±0.5	7.2±0.7	4.3±0.5
	Female	11.0±0.9	9.3±0.6	8.0±0.5	5.0±1.0
15	Total life cycle duration (days)				
	Male	50.8±4.3	46.94±1.71	37.22±2.21	29.57±0.87
	Female	51.7±3.5	47.3±2.7	38.02±3.06	30.27±2.21
16	Male: Female ratio	1:1.2	1:1.4	1:1.3	1:1.5

Mean ± SD (n=100/host); SD - Standard deviation

followed by the pairing of male and female adults for egg laying in the oviposition cage. Freshly laid eggs were utilized for subsequent observations of incubation period and hatching percentage. Newly hatched larvae were transferred to separate plastic container and fed regularly with cotton bolls and placed in BOD incubator. Data were collected on various developmental stages, encompassing larval duration (days), pupation rate (%) and growth index (days). Furthermore, assessments were conducted on the durations of the pre-pupal and pupal stages, the overall development period (from egg to adult emergence), the rate of adult emergence (%), the longevity of adults (days) and the complete duration of the life cycle (days). Adult pairs were established for egg laying on fresh cotton twigs. Daily egg counts were systematically recorded until the demise of the female. By consistently tracking egg counts until the female's death, we were able to ascertain the duration of each reproductive phase, including pre-oviposition, oviposition and post-oviposition periods. Data analysis employed descriptive statistics, encompassing methods like computing central tendency measures (e.g., mean) and measures of variability (e.g., range and standard deviation ±). Standard deviation (±) helps to understand the extent to which individual data points deviate from the average. A higher standard deviation indicates greater variability, while a lower standard deviation suggests more consistency and the growth index was calculated using formula.

Growth Index = % larvae pupated/ Mean larval duration (days).

RESULTS AND DISCUSSION

The biological aspects of *P. gossypiella* on cotton at different temperatures are outlined in Table 1. The significantly highest fecundity of *P. gossypiella* to the tune of 106.2 eggs/female was observed at 30±1°C followed by 25±1°C (100.1 eggs/female), 35±1°C (60.1 eggs/female) and lowest at 20±1°C (55.2 eggs/female). These findings revealed that fecundity of *P. gossypiella* increases with rising temperatures, reaching its peak at 30±1°C, while decreasing at lower temperatures, with the lowest observed fecundity observed at 20±1°C. The results of our study corroborate the findings of Shrinivas *et al*., (2019) and Zinzuvadiya *et al*., (2017) who also concluded that the rising in temperature appears to positively influence the reproductive capacity of *P. gossypiella* on cotton.

The mean incubation period of *P. gossypiella* decreased with increasing temperature levels. Specifically, the lowest mean incubation period was observed at the highest temperature, 35ºC, with a duration of 2.2 days. This pattern continued with increasing temperature: 30ºC had a mean incubation period of 2.8 days, 25ºC had a period of 3.8 days and the lowest temperature, 20ºC, showed the longest mean incubation period at 4.7 days. The results

of present investigation are in accordance with the findings of Shrinivas *et al*., (2019) who revealed that increase in temperature decreases the incubation period of *P. gossypiella* and observed the mean incubation period of 3.81±0.1 days on *Bt* cotton at 27±2°C.

The highest egg hatch to the extent of 86 per cent was observed on cotton at 30ºC followed by 25ºC (84 per cent). Both of these temperature levels were found to be at par with each other. The next effective temperature levels were 20 and 35ºC recorded 78 and 74 per cent egg hatch, respectively. The per cent egg hatchability of *P. gossypiella* on cotton was found to be maximum at 25 and 30ºC. The shortest mean larval duration of *P. gossypiella* was observed on cotton at 35ºC (14.95 days) followed by 30ºC (17.5 days), 25ºC (23.3 days) and 20ºC (24.2 days). This indicates that the larval duration of *P. gossypiella* was prolonged at 20ºC and reduced at 35ºC. The results of present investigation are comparable with the findings of Shrinivas *et al*., (2019) who exhibited that the larval duration of *P. gossypiella* at 27±2°C was in a range of 22.5 to 28.5 (average 26.1 ± 0.6) days on *Bt* cotton.

The duration of I, II, III and IV larval instars ranged from 3.4 to 4.2, 3.2 to 6.6, 4.1 to 6.9 and 4.0 to 6.3 days, respectively on cotton as influenced by temperature under investigation. The lowest I, II, III and IV instars larval duration of *P. gossypiella* to the extent of 3.4, 3.2, 4.1 and 4.0 days, respectively was recorded when reared at 35°C. The findings of present investigation are consistent with the results reported by Shrinivas *et al*., (2019) who exhibited that *P. gossypiella* passed through four larval instars when reared on *Bt* cotton.

The highest per cent pupation of *P. gossypiella* was recorded on cotton at 25ºC (78 %) followed by 30ºC (77 %), 20ºC (71 %) and lowest at 35ºC (65 %). The data revealed that the per cent pupation of *P. gossypiella* was reduced with increase in temperature levels. The similar trends in results were obtained by Malthankar and Gujar (2014) who revealed that the per cent pupation of *P. gossypiella* varied from 29.1 to 36.1 per cent when larvae were reared on cotton varieties at 27±2°C. The larvae raised on cotton at 30ºC displayed the highest growth index, recording 4.40, surpassing that of 35ºC (4.3), 25ºC (3.3), and 20ºC (2.9 days). More or less identical results were obtained by Likhitha (2017) who revealed that the growth index value for *P. gossypiella* was 8.8 on non-*Bt* cotton bolls. In the present investigation the minimum mean pre-pupal duration of *P. gossypiella* was observed on cotton at 35ºC (2.2 days) followed by 30ºC (2.6 days), 25 ºC (3.5 days) and 20ºC (3.7 days). This indicates that the pre-pupal duration of *P. gossypiella* was prolonged at 20ºC and reduced at 35ºC. The minimum mean pupal duration of *P. gossypiella* was observed on cotton at 35ºC (5.9 days) followed by 30ºC (6.9 days), 25ºC (7.3 days) and 20ºC (8.0 days). The data revealed that the time required for pupal duration decreased as the temperature increased.

The total developmental period of *P. gossypiella* was observed to be lowest at 35ºC (25.27 days) followed by 30ºC (29.3 days), 25ºC (37.9 days) and 20ºC (40.7 days). This indicates that the total developmental period of *P. gossypiella* was decreased with increase in temperature. The results of present investigation are parallel with the findings of Cacayorin *et al*., (1992) who claimed that the total developmental period of *P. gossypiella* was 34.1+1.4 days. The developmental period of pink bollworm prolonged with decrease in temperature. In the present investigation the highest adult emergence was observed at 25ºC (78 %) followed by 30ºC (75 %), 20ºC (72%) and 35ºC (65 %). This indicates that the 25ºC was suitable for the emergence of *P. gossypiella* adults.

The adult longevity of male and female *P. gossypiella* was lowest at 35ºC (4.30 and 5.00 days, respectively) followed by 30ºC (7.2 and 8.0 days, respectively), 25ºC (8.9 and 9.3 days, respectively) and 20ºC (10.1 and 11.0 days, respectively). This indicates that the adult longevity of male and female *P. gossypiella* was reduced with increase in temperature. Females lived longer than males irrespective of temperature levels. The lowest total life cycle duration of male and female *P. gossypiella* was observed at 35ºC (29.5 and 30.2 days, respectively) followed by 30ºC (37.2 and 38.0 days, respectively), 25ºC (46.9 and 47.2 days, respectively) and 20ºC (50.8 and 51.7 days, respectively). It indicates from the present investigation on biology of *P. gossypiella* reared on cotton at different temperature levels that the durations of different life-stages were extremely extended when reared at 20ºC compared to their durations when reared at 25, 30 and 35ºC. The lowest pre-oviposition period of *P. gossypiella* (1.2 days) was observed on cotton at 35ºC followed by 30ºC (1.9 days), 25ºC (2.0 days) and 20ºC (2.6 days). This implies that the time it takes for ovary maturation and the commencement of egg laying decreased as the temperature increased from 20 to 35ºC. The highest oviposition period of *P. gossypiella* (8.40 days) was recorded on cotton at 20ºC over 25ºC (7.3 days), 30ºC (6.0 days) and 35ºC (3.7 days). This indicates that the oviposition period was decreased as the temperature increased from 20 to 35ºC. The results of present investigation are in matching with the findings of Zinzuvadiya *et al*., (2017) who reported that oviposition and post-oviposition period of *P. gossypiella* on cotton at 28.3±3.1°C varied from 7 to 10 (mean 8.0±1.5) and 3 to 6 (mean 4.3±0.8) days, respectively.

CONCLUSION

This finding underscores the critical influence of temperature on the life cycle and reproductive behaviour of *P. gossypiella*, providing valuable insights for effective pest management strategies in cotton cultivation. The overall study demonstrated that 30ºC provided the most favourable conditions for the development of *P. gossypiella* on cotton, surpassing 25, 35, and 20ºC temperatures.

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Author contribution: **K. V. Deshmukh and V. K. Bhamare**: Conceptualized and designed the study; experimentation, analyzed

the data and draft writing: **V. K**. **Bhamare**: Supervision, editing, reviewing.

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