Effects of different ambient temperatures for growth and development of fall armyworm, *Spodoptera frugiperda* (Smith)

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1. Introduction

The environmental, economic, and social impacts of invasive alien species are jeopardizing the livelihoods and food security of small-scale farmers in developing countries. (Pratt et al. 2017). Among them, the fall armyworm (FAW) *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae), is a polyphagous lepidopteran pest native to tropical and subtropical America which is mainly associated with maize was serious concern (Sarmento et al., 2002). The pest was confined to the American continents where in late 2016, it was reported in Africa and spread rapidly across 44 African countries (Sisay et al., 2019). In 2018, FAW was reported in India (Karnataka) (Sharanabasappa et al., 2018) and Sri Lanka caused an outbreak with significant yield losses of all maize growing areas (Perera et al., 2019; Wijerathna et al., 2020). According to Begon et al., (2006) thermal optimum is the temperature at which a species thrives in terms of growth, reproduction, and survival. Hence, the length of instars, the number of instars that larvae undergo before reaching adulthood, is influenced by temperature (Aguilon et al., 2015). Moreover, the relationship between temperature and development rate has a big impact on pest biology, distribution, and abundance (Tobin et al., 2003). In pest management, life table information is useful for evaluating and comprehending insect population, survival, reproduction, and intrinsic rate of increase (Ashok et al., 2020). Hence the present study was planned with the aims of evaluating the effect of different temperatures on the growth, development and survival of *S. frugiperda* under three ambient temperatures.

2. Materials and Methods

The Experiment was conducted at the Department of Biosystems Technology, South Eastern University of Sri Lanka. FAW larvae were collected from infected maize fields and reared in laboratory conditions on a natural diet. The pupae were sexed and monitored daily until moths emergence. Same aged male-female pairs were confined to oviposition cages and kept temperature conditions viz. 25±1°C (T25), 30±1°C (T30) and 35±1°C (T35) to determine the age-specific fecundity. Meantime, 100 eggs (F1) were kept in the same different temperatures and inspected daily. First instar larvae were transferred to the individual bottles and their duration was recorded by observing head capsules exuviae using a dissecting microscope.

Age-specific fecundity tables were constructed described by Atwal and Bains (1974) and Howe (1953) viz., x = Pivotal age in days; lx = Survival of female at age 'X'; mx = Age schedule for female births at age 'X'. Further, Net productive rate (Ro), Mean duration of generation (Tc), Innate capacity for increase (rm), the finite rate of natural increase (λ). The life table for computing life expectancy, Cohort age-specific life tables, dx = number of dying during the age interval x to x+1, qx = rate of mortality during the age interval x to x+1 were determined using the methods given by Krebs (2001) and Kyi et al. (1991). The different temperatures were compared using one-way ANOVA followed by DMRT at a 5% significant level.

3. Results and Discussion

The present study found that the mean duration of each stage at three different temperatures was significantly different except for the egg hatching period. Where 1st to 3rd instar larvae took the longest duration at T25 and 4th to 6th instar larval durations were significantly higher at T35. However, the total larval days were higher at T25 (20.17) and T35 (17.89) compared to the T30 (14.92) (Table 01). Our results agreed with mean instar (1st- 6th) durations reported by Pitre and Hogg (1983) at 25°C.

Table 01. Duration (days) of each stage of the FAW life cycle in different temperatures

	Duration (days)		
Particulars	35°C Mean±SD	30°C Mean±SD	25°C Mean±SD
Egg	2.78 ± 0.46^a	2.17 ± 0.38^a	2.14±0.35a
1st instar	2.78 ± 0.42^b	2.33 ± 0.50^c	3.14±0.79^a
2nd instar	2.38 ± 0.76^b	1.92 ± 0.60^c	3.02±0.85^a
3rd instar	2.71 ± 0.75^a	2.13 ± 0.60^b	2.72±0.88^a
4th instar	3.20 ± 1.48^a	2.01 ± 0.72^b	2.54±0.95^a
5th instar	4.00 ± 0.70^a	2.81 ± 0.82^b	2.81±0.72^b
6th instar	5.20 ± 0.83^a	3.72 ± 1.07^b	3.66±0.63^b
Pre pupae	1.20 ± 0.44^b	1.64 ± 0.75^a	1.84±1.02a
Pupae	5.75 ± 0.50^b	8.61 ± 0.75^a	9.21±1.02a
Male	-	9.29 ± 0.46^a	10.00±0.75^a
Female	5.66 ± 0.57^b	8.12 ± 0.48^a	8.52±0.65^a
Pre oviposition	5.00 ± 1.732^a	2.85 ± 1.11^b	2.82±0.52^b
Oviposition	-	4.73 ± 0.77	5.25±1.73
Post oviposition	-	1.23 ± 0.59	1.62±1.06

Values indicate the mean ± standard deviation (SD) (days) and different letters within the rows show significant differences at a 5 % significant level.

The age-specific cohort life tables resulted in 95% accumulated mortality (dx) where 100 eggs were kept at T35 and high mortality was observed in the egg (42) and 1st instar larval (36) stages with qx values 0.42 and 0.62 respectively. Whereas survival rate was higher at T30 (61%). In addition, egg mortality was less compared to the T35 and the highest dx was in the 1st instar larval stage (32). Similarly, the qx values are very low in egg (0.08), 5th (0.01), 6th (0.03) and pupal (0.06) stages. Comparatively, a middle level of survivorship (36%) was observed with less mortality at T25 than T35.

There were only 4 adults emerged and most of the larvae was died at T35 compared to the other two temperature conditions. In T30 pre-oviposition period lasted from the 28-30 days of pivotal age while the 31- 33 days on T25. At T30 first batch of eggs was laid by females on the 31st day with mx of 160.27 and lasted until the 38th day (mx=11), with lx values of 0.28 and 0.03 respectively. After the 32 days of pivotal age, the first female mortality was observed on the 4 days after emergence of adult and mortality increased, as evidenced by the steady decrease in the lx values. It had lx value of 0.24 on the 32 days of pivotal age. The maximum mean progeny production/day (mx = 168.57) was reported on the 38th day (mx=11). As in T25 pre oviposition and oviposition, periods took comparatively longer while the first batch of eggs was laid by females on the 34th day. They had mx of 258.86 and lasted until the 42nd day (mx = 09), with lx values of 0.17 and 0.03 respectively. Moreover, the average period of generation time (Tc) was less in T30 compared to T25. However, the daily finite rate of increase in number (λ) and a population doubling time at T30 is higher than days in T25. Similarly, the intrinsic rate of natural increase in number (rm) was higher in T30 than in T25. Finally, the hypothetical female population in the F2 generation was found to be higher in T30 than T25. Similar observations were reported earlier by Ashok et al., (2020) by evaluating adult longevity, oviposition period, fecundity and fertility using 30 pairs of FAW.

4. Conclusions

The duration of each stage at different temperatures was significantly different except for egg-hatching. Accumulated mortality of adults was 95%, 61% and 64% at T35, T30 and T25 respectively. These rates were comparatively high due to maintaining the constant temperature conditions. The optimal thermal range of FAW lays between 25 to 30°C and it is indicating that towards the lower temperature as well as above the 30°C their reproduction, survival rate and life cycle duration vary and difficult to survive. However, the pest status and survival may vary from this finding due to temperature fluctuations and affecting other climatic factors.

5. References

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