Assiut Journal of Agricultural Sciences 55 (3) 2024 (138-153)
ISSN: 1110-0486 / EISSN: 2356-9840
Website: http://ajas.journals.ekb.eg/
E-mail: ajas@aun.edu.eg

(Original Article)

Some Biological Aspects of the Fall Armyworm, *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) in Assiut Governorate, Egypt

Wafaa A.M. Haridy*; Ahmed I. Farghal; Samy H. Mohamed and El-Sayed A.M. El-Eraky

Plant Protection Department, Faculty of Agriculture, Assiut University, Assiut, Egypt

*Corresponding author e-mail**:** anasahmedsh96@gmail.com
DOI: 10.21608/AJAS.2024.282891.1354

Abstract

The present study focused on determining: the developmental rate of the fall armyworm *Spodoptera frugiperda* at four constant temperatures, (21±1, 24±1, 29±1 and 34±1°C), the number of degree-days (DD's) needed for each stage to finish development, and overall egg-to-adult development, to compute certain biological parameters used in pest prediction. According to the study the development of one generation required around 21, 26. 44 and 47 days at 21, 24, 29 and 34°C. the mean incubation periods were determined to be 4.4, 3.7, 2.1 and 1.3 days at 21, 24, 29 and 34°C**,** respectively. As the temperature rose, the mean amount of time needed for the adult stage to mature the ovaries and begin laying eggs dropped (from 6.1 days at 21°C to 3.1 days at 34°C). Recorded were generation time, (r_m) and (λ), threshold of development (t_0), and the average thermal units in degree-days (DD's). The research of heat requirements of the pest is very important to calculate the thermal heat units that is necessary for this invasive pest's growth and development, hence the annual field generations can be predicted in addition to draw up a planning IPM strategy for this harmful pest.

Keywords: *Biology, Fall armyworm, Spodoptera frugiperda (Smith), life table parameters.*

Introduction

The fall armyworm, *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) is a polyphagous insect pest that worldwide targets a wide variety of agricultural crops, primarily maize. It causes significant damage to these crops, resulting in high damage (Deshmukh *et al.,* 2021; El-Shennawy *et al*., 2022 and Rashed *et al*., 2022) and it considered as the most serious lepidopteran pest (Bueno *et al*., 2010). 2019 saw Egypt record the pest for the first time in Egypt (FAO, 2019), However, it has been presented in the United States for 20 decades (Edosa and Dinka, 2021). The pest is marked by a high fecundity (Zhang *et al.,* 2021), it is a holometabolous pest, the phases it goes through are (egg, larva, pupa and adult) (Sagar *et al*., 2020) and it causes severe damage when larvae feed on all developmental stages of the plant (Badhai *et al.,* 2020), and significantly lowering crop yields, particularly those of maize, in much of the world (Deshmukh *et al*., 2021; Rashed *et al*., 2022). studies have been shown that, in addition to,

Received: 22 April 2024/ Accepted: 2 June 2024/ Published online: 28 July 2024

horticultural crops like cabbage, beet, tomato, potato, and onion, this pest also severely damages economically significant cultivated grasses like rice, sorghum, millets, and sugarcane. Cotton, peanut, soybean, and alfalfa are all negatively impacted by this pest (Pogue, 2002 and CABI, 2019). The insect is a voracity, the economic losses was 9.4 billion in Africa (Chen *et al.,* 2021a and Eschen *et al.,* 2021). According to previous references, it was found that, the hosts of this pest are constantly increasing for each period (Casmuz *et al.,* 2010; Bohnenblust and Tooker, 2012; Montezano *et al.,* 2018 and Huang *et al.,* 2020). In early 2016, the pest appeared in both west and central Africa (Goergen *et al.,* 2016), and later in most regions of sub- Saharan Africa (Day *et al.*, 2017). It introduced to Egypt from Sudan, and it was initially noted there in Kom-Ombo city, Aswan Governorate, in 2019, on corn plants, the pest was most recently recorded in the Assiut Governorate in 2021 (Dahi *et al*., 2020; Rashed *et al.,* 2022). FAW has not the ability to diapause and has a strong and long adult dispersal ability (Deshmukh *et al.,* 2021), the pest has multiple generations annually (Du Plessis *et al.,* 2020), and it has a high reproductive potential (Zhang *et al.,* 2021), all of above makes the insect economically important (Chen *et al.,* 2021a).

Materials and Methods

Rearing technique

The current study was carried out at Assiut University's Faculty of Agriculture, Department of Plant Protection, to know the effect of four constant temperatures, (21±1°C, 24±1°C, 29±1°C and 34±1°C) and (65±5% relative humidity), on the developmental rate of *S. frugiperda* immature stages, and the adult reproductive potential were conducted. Initially, larvae of *S. frugiperda* were collected from maize fields in Aswan governorate. The pest was identified through observation of the symptoms of infected corn plants as well as the physical traits of the pest stages, which included: holes on leaves and stems with larval feces, also there is a white Y-shape on the head and four black markings that resemble crescents on all but the eighth abdominal segment, the eighth segment, where they are square shaped. The insect was reared on its favorite food (Maize) (Fig. 1) which was planted in the farm of the Plant Protection Department, Assiut University in May 2021season and always, with continued cultivation of some ponds to obtain fresh maize leaves continuously for three generations of the pest before starting the experiment and continue the biological experiments on (28±1°C and 65±5% RH.) (Fig. 2)

Experimental Design

The temperature and relative humidity were regulated during the course of this experiment. four incubators adjusted at temperatures of 34, 29,24 and 21±1°C and 65±5R.H. From the egg to the adult, every stage was maintained at the same temperature in order to ascertain its biological characteristics.

After hatching the egg masses (Fig. 3), The larvae were moved into glass containers, where they were reared (3 kg) wide jar and covered with (muslin) and given new leaves of maize. Food was changed every two days in small plastic pots of 7cm in height and 5cm in diameter (Fig. 4), larvae were raised independently from the third instar and covered with fine muslin (Dahi *et al*., 2020).

Fig. 1. FAW larvae were reared on maize

Fig. 2. Block of land was constantly planted with maize for rearing the pest during the summer season of 2021

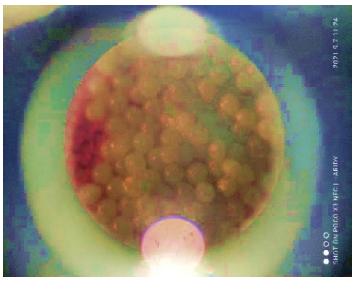

Fig. 3. egg mass of *S. frugiperda.*

Fig. 4. Cups where, from the Third instar larvae were reared until pupae.

Fig. 5. Mating in males and females of the pest.

Egg stage

One hundred fresh eggs (<8hours old) were placed in each temperature regime. Hatched eggs were counted every 8 hours until no more eggs hatched, and hatchability (%) as well as the incubation period in days were computed.

Larval, pre-pupal and pupal stage

The development of the three stages was completed after hatching eggs. The numbers of dead individuals at each stage were recorded from larvae reach to the adults. The percentages of the pest emergence and the duration of the development of these different stages were calculated.

Adult stage

Seventeen pair separated into one female and one male as replicates (Fig. 5). On the day of their emergence, the freshly emerging moths were moved to a glass mating (2kilogram wide Jar) and kept under circumstances of each temperature (34, 29, 24 and 21°C). Daily morning observations were made in order to record the daily number of deposited eggs to calculate the adult longevity and fecundity. Calculations were made to determine how long each stage (incubation, larval, pupal, and pre-oviposition) lasted.

Statistical analysis

Standard deviations were used to analyze the data from the current research. Additionally, the generation period (egg to the end of the pre-oviposition phase) was computed. In order to determine the theoretical developmental thresholds (t0) and the accumulated thermal units (K), differences in each measured parameter under various constant temperatures were examined using one-way analysis of variance (ANOVA) (P =0.05) in accordance with Duncan's multiple range test of means (Duncan, 1955).

Calculations

$y = a + b x$

$(t0) = -a / b$

K (Tu) = T (t— t0), where:

K = thermal constant (day-degrees).

T = developmental period (in days).

t = exposure temperature (°C).

t0 = temperature threshold (°C).

Certain life table parameters of the pest

The obtained data of development and survival of the immature stages in addition adult longevity and fecundity were used to calculate the following life table parameters according to Birch (1948):

*Net reproductive rate (R0) = ∑lxmx

(The ratio of the number of individuals in a population at the start of one generation to the number at the beginning of the previous generation measured in units of ♀/♀/generation).

*Generation time =∑lx.mx.x / ∑lxmx

(Mean time from birth of parent to birth of offspring measured in days).

Intrinsic rate of increase (rm)= $\frac{\mathrm{Ln\,R0}}{\mathrm{T}}$as calculated using the formula:

rm = Difference in birth-rate and death-rate in a population with a stable

age distribution.

* Finite rate of increase (λ) = erm (The number of times in which the population will multiply itself per unit time, measured in units of female/female/day).

Sex ratio has been calculated at 29±1°C.

Results and Discussion

1. Effect of temperature on the immature stages

Egg stage

Data in Table (1) indicate that the incubation period of the pest lasted 1.3±0.016, 2.1±0.014, 3.66±0.013 and 4.4±0.014 days at the constant temperatures tested 34±1, 29±1, 24±1 and 21±1°C, respectively. The result clearly shows that the incubation periods decrease with the increase of temperatures. Apparently, there is a significant difference in the incubation period at the four constant temperatures. The longest incubation period was recorded at 21°C but the shortest one was obtained at 34°C. Data presented in Table (2) indicate that the highest percentage of hatchability was recorded at 24±1°C (88%), whereas the lowest one was recorded 67% at 34°C. It is clear from the obtained data, that temperature of 24±1°C proved to be the most suitable condition for completion of the embryogenesis. It could be concluded that rising the temperature from 21°C to 24°C reduced the incubation period by about 0.74 day from one to another, almost the same happened when the temperature raised from 29°C to 34°C. the results of survivals show that the decrease in temperature is more suitable the pest than the increase in temperature.

Data presented in Table (1) were used to calculate regression equations, which were used in estimation threshold of temperature. The equations ($\hat{Y} = a+bx$) for the relationship between the rate of development ($\hat{Y}$) and the constant temperature (X) are shown in Table (3)

Table 1. Incubation period of eggs and duration of *S. frugiperda* immature stages at four constant temperatures

Temp. (ºC)	Duration (in days) ±SD					Egg to Adult	Egg to ovi-position period (generation)
	Egg	Larva	Pre-pupa	Pupa	Pre-oviposition period		
34±1	1.3±0.018^{A}	10.6±0.8^{A}	0.6±0.2^{A}	4.8±0.5^{A}	3.08±0.6^{A}	17.3	20.38
29±1	2.1±0.06^{B}	12.3±1.1^{B}	0.9±0.3^{B}	5.6±0.6^{B}	4.3±0.6^{B}	20.9	25.2
24±1	3.66±0.095^{C}	19.95±2.4^{C}	1.4±0.3^{C}	12.8±0.6^{C}	5.7±0.4^{C}	37.81	43.51
21±1	4.4±0.22^{D}	22.8±1.5^{D}	1.7±0.3^{D}	15.9±0.7^{D}	6.1±0.4^{C}	40.4	46.5

Means in each column followed by the same letter are not significantly different at 0.01 level of probability

Table 2. Percentage of survival of the immature stages and emergence of *S. frugiperda* reared at four constant temperatures

Temp. (°C)	No. of observation (Egg)	% Survival				
		Egg	Larva	Pre-pupa	Pupa	Egg to Adult Emergence
34±1	100	67	53.7	88.9	90.6	29
29±1	100	79	100	96.2	96.05	73
24±1	100	88	95.65	96.6	95.3	81
21±1	100	71	86.59	94.37	94.03	63

It seems that these equations fit the observed values rather well, as indicated by high values of the co-efficient of determination (R2). Extrapolation of regression line to temperature axis resulted a threshold temperature of 16.2 °C (table 3). The average calculated thermal units, using this threshold as a base temperature were about 24.91±1.1 day-degree (Table 4).

Larval stage

The results in Table (1) show that the average duration of *S. frugiperda* larvae were 10.6±0. 3, 12.3±0.19, 19.95±0.18 and 22.8±0.20 days at temperatures of 34, 29, 24 and 21°C, respectively. The statistical analysis of data showed significant differences between values of mean durations at the tested temperatures. It seems that temperature of 34°C proved to be the most favorable condition for the development of larval stage but not suitable for offspring as will mention after that.

Survival percentages was 53.7, 100, 95.65 and 86.59 at 34, 29, 24 and 21°C, the highest percentage of larval survival (100 %) was recorded at 29°C. (Table 2).

Comparison between treatments showed unconditional increase and decrease in the survival rates of the larval with the increase in temperature up to 34°C but the perfect condition temperature was 29°C.

Data in Table (3) show the relationship between the insect rates of development and temperatures. The theoretical temperature threshold for larval development was 11.6°C. The total quantity of thermal energy required for the larval stage to complete their development was 237.44, 214.02, 247.38 and 214.32 day-degrees at 34, 29, 24 and 21°C, respectively, with an average of 228.29± 0.5 day-degrees (Table 4).

Since 79% of the eggs hatched at 29°C, while the survival of larval stage reached 100%; it could be concluded that temperature close to optimum exhibited more suitable to larval stages than the egg stage. However, it is clear that temperature less 30°C represented the favorable range for the development of the pest. High temperature 34°C seemed to be outside of the favorable range of the pest.

Table 3. Regression equations, (R2) and developmental threshold (t0) of S. frugiperda reared under four constant temperatures

Stage	Regression equation	R^2	t_0
Eggs	Y= -66.6+4.1x	0.9482	16.2
Larvae	Y= -4.651+0.4204x	0.9676	11.6
Pre-pupae	Y= -124.5+8.3888x	0.9752	14.8
Pupae	Y= -19.916+1.2265x	0.9413	16.2
Egg to Adult	Y= -3.624+0.2796x	0.9496	12.96
Egg to ovi-position period (Generation)	Y= -2.7573+0.2259x	0.9597	12.2

Equation of regression $\hat{y}$ = a+bx where $\hat{y}$ is the reciprocal of the number of days, and x is the temperature (˚C), R2 = is the determination Coefficient, t0 = the developmental threshold

Table 4. The thermal unit (Tu) and developmental thresholds (t_0) required for the growth of the various stages of *S. frugiperda* reared at four constant temperatures

Stages	Temp. Threshold (t_0) (°C)	Thermal units (TU) (day-degrees)					
		34±1°C	29±1°C	24±1°C	21±1°C	Total	Mean± SE
Egg	16.2	23.14	26.88	28.5	21.12	99.64	24.91±1.1
Larval stage	11.6	237.44	214.02	247.38	214.32	913.16	228.29±0.5
Pre-pupal stage	14.8	11.52	12.78	12.88	10.54	47.72	11.93±1.9
Pupal stage	16.2	85.44	71.68	99.84	76.32	333.28	83.32±0.6
Egg to Adult	12.96	364	335.236	417.4	324.8	1441.4	360.4±0.3
Egg to ovi-position period	12.2	444.3	423.4	513.4	409.2	1790.3	447.6±0.3

pre-pupal and pupal stage

The outcomes listed in Table (1) show the mean length of pre-pupae of *S. frugiperda* 0.6±0.05, 0.9±0.03, 1.4±0.03 and 1.7±0.04 days at temperatures of 34, 29, 24 and 21°C, respectively. The data's statistical analysis revealed notable variations in the mean duration values at the various temperatures. The average length of the pupae of *S. frugiperda* is displayed in Table (1). Mean durations at 34, 29, 24, and 21°C were 4.8±0.1, 5.6±0.08, 12.8±0.07, and 15.9±0.08 days, respectively. The data's statistical analysis revealed noteworthy variations in the mean duration values across the four treatments as well. Survival percentages of pre-pupae were 88.9, 96.2, 96.6 and 94.37 at 34, 29, 24 and 21°C, respectively, the highest percentage of pre-pupal survival (100 %) was recorded at 24°C, but survival percentages of pupae ranged from 90.6 to 96.05 at 34°C and 29°C the most suitable temperature for pupae was 29°C and the less survival percentage was at 34°C (Table 2). The perfect condition temperature was 29°C. The results showed that the temperature degree of 29°C was the most perfect condition for both of pre-pupae and pupae, since 88% of the eggs hatched at 24°C and the most suitable degree for hatchability.

Data in Table (3) show the relationship between the insect rates of development and temperatures. The theoretical temperature threshold for pre-pupal development was 14.8°C, and 16.2 for pupae. The total quantity of thermal energy required for the pre-pupal stages to complete their development were 11.52, 12.78, 12.88 and 10.54day-degrees at 34, 29, 24 and 21°C, respectively, with an average of 11.93±1.9 day-degrees, while the total quantity of thermal energy required for the pupal stages to complete their development were 85.44, 71.68, 99.84 and 76.32 day-degrees at 34, 29, 24 and 21°C, respectively, with an average of 83.32±0.6 day-degrees (Table 4).

From egg to adult emergence

As shown in Table (1) the total developmental period from egg to adult emergence was found to be significantly affected by the variation in temperatures. The longest time required for the pest to complete its life cycle was 40.4 days at

21°C and decreased as temperature increased to reach 17.3 days at 34°C, and 20.9, 37.81 days at 29 and 24 °C, respectively.

Data in Table (2) and Figure (2) showed the survival percentage of the pest during the whole life cycle under different constant temperatures. According to the survival percentage, 24°C constant temperature showed the most suitable for the pest to produce more individuals during life cycle (81 % survival). Whereas the survival percentages were 29, 73 and 63 at 34, 29 and 21°C.

Development-temperature relationship expressed as rate of development is shown in Table (3). The calculated developmental threshold (t_0) was about 12.2°C. By using this value as a base temperature, an average of about 447.6±0.3 day-degrees are needed for the pest to complete one generation.

2. Effect of temperature on the adult stage

Survival of adult females at tested temperature was divided into pre-oviposition, oviposition and post-oviposition periods as shown in Table (5).

Pre-oviposition period

The results indicated that there was a gradual decrease in the pre-oviposition period (the period between the adult molt and the onset of reproduction) with the increase in temperature. The mean pre-oviposition period significantly affected by prevailing temperatures. The pre-oviposition period was 3.1±0.63, 4.3±0.58, 5.7 ± 0.41 and 6.1±0.39 days at 34, 29, 24 and 21°C, respectively. The longest pre-oviposition period was recorded at 21°C (Table 5).

Oviposition period

Oviposition period found to be varied according to the prevailing temperature. These periods in Table (5) were 2.7 ± 0.686, 3.6 ± 0.87, 5.1±0.75 and 6.4±1.1 days at 34, 29, 24 and 21°C, respectively. It is obvious that, within the optimum range, oviposition period decreased with an increase in temperature. Statistical analysis proved a significant difference between the oviposition period at the four tested temperature degrees.

Table 5. Oviposition period, longevity and fecundity of *S. frugiperda* reared at four constant temperatures

Temp. (°C)	Pre-Oviposition	Oviposition	Post-oviposition	Longevity (days)	Average of eggs/female
34±1	3.1±0.63 ^{A}	2.7±0.686 ^{A}	0.8±0.42 ^{A}	6.6±0.5 ^{A}	179±71.3 ^{A}
29±1	4.3±0.58 ^{B}	3.6±0.87 ^{B}	1.0±0.54 ^{A}	8.9±0.9 ^{B}	1353±170.3 ^{B}
24 ± 1	5.7±0.41 ^{C}	5.1±0.75 ^{C}	1.7±1.1 ^{B}	13.00±1.2^{C}	1232±133.4 ^{C}
21 ± 1	6.1±0.39 ^{C}	6.4±1.1 ^{D}	2.6±1.0 ^{C}	13.6±1.7 ^{C}	798 ±164 ^{D}

Means at each column followed by the same letter are not significantly different at 0.01 level of probability.

Post-oviposition period

The mean durations of the post-oviposition periods were very short (0.8±0.42, 1.00±0.54, 1.7±1.1 and 2.6±1.00 days at 34°, 29°, 24° and 21°C, respectively). This period increased with the decreased in temperature. Significant difference was recorded between post-oviposition period at 24 and 21°C, whereas insignificant difference was found between 29°C and 34°C (Table 5).

Longevity

Data presented in Table (5) also showed the average length of the adult life at the experimental temperatures. It is clear that the longevity decreased with an increase in temperature. The longest adult longevity was recorded at 21°C (13.6±1.7days), whereas the shortest one was 6.6±0.5 days at 34°C. Significant difference was recorded between the longevity of *S. frugiperda* adult reared at 34°C (6.6±0.5days) and at 29°C (8.9±0.9 days), whereas insignificant difference was found between longevity period at 24°C (13.00±1.2days) and 21°C (13.6±1.7).

Fecundity

Results in Table **(**5) showed the fecundity of the studied insect pest under different constant temperatures. The average numbers of eggs laid per female moth were 179±71.3, 1353±170, 1232±133.4 and 798±164 at 34, 29, 24 and 21°C, respectively. It seems that temperature 34°C was not fit with eggs laid per female. Examination of the tabulated data in the (Table 5) revealed that the fecundity of *S. frugiperda* decreased in the optimum temperature zone. The maximum number of eggs laid per female was observed at 29°C it was about 1323 eggs/female and low number was at 34°C it was about 179 eggs/female.

Certain life table parameters

Results of the age specific survival rate (lx) and the age-specific fecundity rate (mx) are illustrated in Fig. (1). The survival patterns decreased gradually by decreasing in tested pest numbers, at 29°C, and declined below 50% after four days, then vanished two days after. At 24°C the survival rate did not differ from 29 ° C and also, declined to 50 % after five days also, then numbers became zero after one day also. At 21°C the survivorship rate took the same results in the degree of 24°C.

On the other hand, mean daily fecundity patterns (mx) observed per female were consistently higher for the fall armyworm reared at 29°C followed by those reared at 24°C and 21°C. The greatest number of progeny for the females reared at 29°C (167.68 ♀/♀/day) were observed after one day of laying eggs. The highest numbers of progeny for the females reared at 24 and 21°C were 149.57 and 66.11 ♀/♀/day were observed after 4 and 6 days from emergence.

The calculated life table parameters which have been taken into consideration in the present study were: generation time (T), net reproductive rate (R0), intrinsic-(rm) and finite rates of increase (Table 6).

The duration of one generation of *S. frugiperda* about 49.70, 46.80, 25.30 and days at 21, 24 and 29°C, respectively. it is clear that the generation time at 21, 24 and 29°C was rather different. It seems that the time required for the studied insect pest to complete one generation at 34°C was about half that at 21°C.

From data in (Table 5) also conclude that the population of the pest had the capacity to double every at maximum half of duration of gen. time, and so it becomes the shortest time for the population to double was recorded at 34°C.

Net reproductive rate (R0) at various constant temperatures (Tables 5) indicated that the pest increased about 266.2, 529.67 and 519.24 female within a single generation at 21, 24 and 29°C, respectively. It is observed that the population of the fall armyworm reared at 21°C could increase about half numbers of females in the course of one generation as compared with that reared at 24 and 29°C. In the case of 34°C, the eggs laid from female that that had emerged from tested eggs at 34°C did not hatched.

The values of rm of fall armyworm at 21, 24 and 29°C were 0.1124, 0.1340 and 0.2471 respectively. If rm used a measure of the suitability of the environment, then the maximum rm revealed the most appropriate reproductive potential under these conditions.

Examination of the data indicated that a constant temperature of 29°C seemed to be the most suitable temperature among those tested, as it had the maximum rm value (0.2471).

On the other hand, when the values of rm were converted to the finite rate of increase (λ), which is the number of times the population will multiply itself per unit time (measured in units of female/female/days) it is clear that the population of *S. frugiperda* had a capacity to multiply about 1.1190, 1.1434 and 1.2803 female per female per day at 21, 24 and 29°C, respectively. When the values of the finite capacity for increase (λ) taken into consideration, the population of 100 females of fall armyworm could increase in a period of one generation to become 276, 519 and 530females at 21°C, 24°C and 29°C, respectively.

The intrinsic rate of increase (rm) is the most important population parameter for the study of population dynamics because it included age, sex ratio, survivorship, and fecundity (Birch, 1948; Carey, 1993).

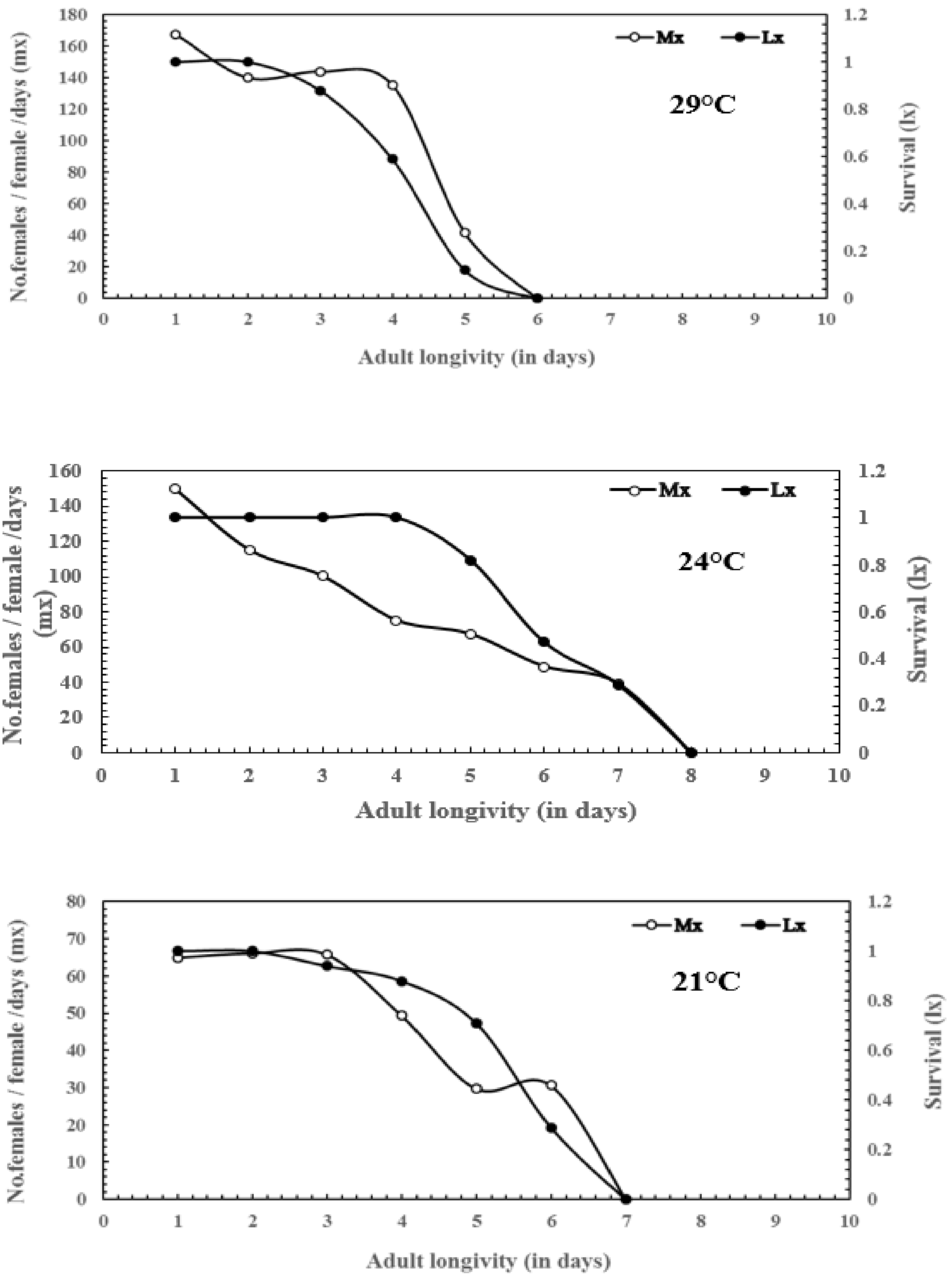

Fig. 6. age specific survival rate (L_x) and age specific fecundity rate (M_X) of *S. frugiperda* reared on Three constant temperatures

Table 6. Certain life table parameters of *S. frugiperda* reared at four Constant temperature

Temp. (°C)	Gen. Time (in days)	Net Rep. Rate R_0	Rate of increase	
			Intrinsic (r_m)	Finite (λ)
29±1	25.30	519.24	0.2471	1.2803
24±1	46.80	529.67	0.1340	1.1434
21±1	49.70	266.20	0.1124	1.1190

Discussion

In general, temperature had an impact on the insect's life table characteristics. pre-oviposition, generation time, egg, larvae, prepupae, and pupae were all connected with rising temperature. 29-63 days needed for the entire life cycle from egg to adult emergence, which was comparable to the results of Ramzan *et al*. 2021. The most ideal temperature for the pest in the current study to develop quickly was 34°C in this particular point only. However, on other parameters this degree was detrimental to the insect's ability to complete its life cycle, as eggs laid by female insects reared at 34°c never hatched. Our findings support those by (Dahi *et al.,* 2020) who stated that the optimal range for *S. frugiperda* was between 25 and 30°C. Temperatures were found to have a correlation with the survival of eggs, larvae, prepupae, and pupae. Of the temperatures studied, 24°C was found to be the most favorable for survival, with the greatest reported survival ratio (81%) from egg to adult. Furthermore, our hatchability and survival data align with those of (Ashok *et al*. 2020) who noted that a high rate of death was observed in the immature stages. The egg and pupal stages displayed the highest development threshold (t0) and thermal units measured in the current study. The larval stage, however, displayed the maximum thermal units. These findings concurred with those of (Dahi *et al*. 2020) for this pest, showing that temperature has a significant impact on *S. frugiperda's* pre-, oviposition, longevity, and fertility. Temperature affects markedly the pre-oviposition, oviposition, post-oviposition, longevity and fecundity of *S. frugiperda*. Increasing temperature, decreases these parameters, however, the fecundity of insects was high at 29 and 24°c as compared with 34 and 21°C. When compared to the findings of Montezano *et al*. (2018), it turns out longer periods of female longevity, and the current results revealed a similar pattern to those previously reported by Dabhi and Patel (2007). Our findings were ascertained, Patel and Koshyia (1998). Regarding the *H. armigera* pest, the data are in good agreement with those of Dabhi and Patel (2007). At 26°C, the mean time required to complete the generation (T) was 43.19 days, and the innate capacity (rm) and finite rate (λ) for increase in numbers were 0.1364 and 1.146 females per female per day, respectively. Overall, numerous writers have examined the biology of the fall armyworm, including Jaworski *et al*. (2013), Hannalene *et al*. (2020), Dahi *et al*. (2020), and Ashok *et al*. (2020). The host plants, temperature tests, method, and pest strain may all have contributed to the difference in results. The parameters of the life table are crucial for planning an IPM strategy and for predicting when a pest will appear.

Conclusion

The purpose of this is to investigate the link between temperature and development speed using thermal summation, which provides a mathematical expression for this relationship. An insect's success in a particular habitat and its rate of development are both influenced by temperature, which is a significant environmental component. In terms of application, studying this parameter is especially helpful for economically significant insects since it provides a helpful framework for developing accurate forecasts and prediction systems for insect populations. The conclusion drawn by pink bollworm and other lepidopterous cotton pests is that temperature limits the growth of these populations, Fye and Poole (1971). Limiting the fall armyworm's developmental requirements is a trial aimed at examining the biological effects of consistent temperatures on the various stages of *S. frugiperda's* developmental process. This research helps to establish a more comprehensive management program that will lessen the significant harm this insect pest causes.

References

Ashok, K., Kennedy, J.S., Geethalakshmi, V., Jeyakumar, P., Sathiah, N., and Balasubramani, V. (2020). Lifetable study of fall armyworm *Spodoptera frugiperda* (JE Smith) on maize. Indian Journal of Entomology, 82(3): 574-579.

Badhai, S.; Gupta, A.K. and Koiri, B. (2020). Integrated management of fall armyworm (*Spodoptera frugiperda*) in maize crop. Reviews in Food and Agriculture, 1: 27–29.

Birch, L.C (1948). The intrinsic rate of natural increase of an insect population. Journal of Animal Ecology, 17: 15-26.

Bohnenblust, E. and Tooker, J. (2012). Fall armyworm as a pest of field corn. the Pennsylvania State University, State College, PA. Available at: http://ento.psu.edu/extension/factsheets/fallarmyworm. Accessed Sept 20th, 2017.

Bueno, R.C.O.F.; Carneiro, T.R.; Bueno, A.F.; Pratissoli, D.; Fernandes, O.A. and Vieira, S.S. (2010). Parasitism capacity of Telenomus remus Nixon (Hymenoptera: Scelionidae) on *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) eggs. Brazilian Archives of Biology and Technology.53:133- 139.

CABI (2019). Fall Armyworm photo guide – identification. Posters and leaflets. FAO/CABI. 2 pp. English Language.

Calvo, D. and Molina, J.M. (2005). Developmental rates of the lappet moth Streblote panda Hübner (Lepidoptera: Lasiocampidae) at constant temperatures. Spanish Journal of Agricultural Research, 3: 1–8.

Carey, J.R. (1993): Applied Demography for Biologists with Special Emphasis on Insects. New York, Oxford University Press.

Casmuz, A.; Juárez, M.L.; Socías, M.G.; Murúa, M.G.; Prieto, S.; Medina, S.; Willink, E. and Gastaminza, G. (2010). Review of the host plants of fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Revista de la Sociedad Entomológica Argentina, 69(3-4): 209-23.

Chen, Q.; Liu, X.; Cao, S.; Ma, B.; Guo, M.; Shen, J. and Wang, G. (2021a). Fine structure and olfactory reception of the labial palps of *Spodoptera frugiperda*. Frontiers in Physiology, 12:1–10.

Dabhi M.V. and Patel C.C. (2007). Life expectancy of Helicoverpa armigera on chickpea. Journal of Semi-arid Tropics Agricultural Research 5(1):12-17.

Dahi, H.F.; Salem, S.A.; Gamil, W.E. and Mohamed, H.O. (2020). Heat requirements for the fall armyworm *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) as a new invasive pest in Egypt. Egyptian Academic Journal of Biological Sciences. A, Entomology, 13(4): 73-85.

Day, R.; Abrahams, P.; Bateman, M.; Beale, T.; Clottey, V.; Cock, M; Colmenarez, Y.; Corniani, N.; Early, R.; Godwin, J.; Gomez, J.; Moreno, P.G.; Murphy, S.T.; Oppong-Mensah, B.; Phiri, N.; Pratt, C.; Silvestri, S. and Witt, A. (2017). Fall armyworm: Impacts and implications for Africa. Outlooks on Pest Management, 28:196–201.

Deshmukh S.S.; Prasanna, B.M.; Kalleshwaraswamy, C.M.; Jaba, J. and Choudhary, B. (2021). Fall armyworm *Spodoptera frugiperda* (J.E. Smith). Indian Journal of Entomology 8:349–372.

Du Plessis, H.; Schlemmer, M.L. and Van den Berg, J. (2020). The effect of temperature on the development of *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Insects, 11(4): 228.

Duncan D.B. (1955). Multiple range and multiple F test. Biometrics, 11:1-42.

Edosa, T.T. and Dinka, T.D. (2021). Current and future potential distribution, risk and management of *Spodoptera frugiperda*. J Innov Agric 8:14–23.

El-Shennawy, R.M.; Sabra, I.M. and Kandil, M.A. (2022). Biology and growth index of fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) reared on different host plants. Asian Journal of Advances in Research, 904-912.

Eschen, R.; Beale, T.; Bonnin, J.M.; Constantine, K.L.; Duah, S.; Finch, E.A.; Makale, F.; Nunda, W.; Ogunmodede, A.; Pratt, C.F.; Thompson, E.; Williams, F.; Witt, A. and Taylor, B. (2021). Towards estimating the economic cost of invasive alien species to African crop and livestock production. CABI Agriculture and Bioscience, 2:1–18.

FAO (2019) Report of first detection of *Spodoptera frugiperda*, Fall Armyworm (FAW) in Egypt. IPPC (International Plant Protection Convention) Official Pest Report, No. EGY- 01/1. FAO: Rome, Italy. Available:https: //www. ippc.int /en/ countries /egypt/pestreports/2019/06/report-of first detection-of-spodoptera-frugiperda-fall armyworm faw-in-egypt.

Fye, R.E. and Poole, H.K. (1971). Effect of high temperatures on fecundity and fertility of six lepidopterous pests of cotton in Arizona USDA. Technical Bulletin, 1454: 73 pp.

Goergen, G.; Kumar, P.L.; Sankung, S.B.; Togola, A. and Tamo, M. (2016). First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa' PLoS ONE 11(10): e0165632.

Hannalene, D.P.; Marie, L.S. and Johnnie, V.B. (2020). The Effect of Temperature on the Development of *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Insects, 1-11.

Huang, Y.; Dong, Y.; Huang, W.; Ren, B.; Deng, Q.; Shi, Y.; Bai, J.; Ren, Y.; Geng, Y. and Ma, H. (2020). Overwintering distribution of fall armyworm (*Spodoptera frugiperda*) in Yunnan, China, and influencing environmental factors. Insects, 11(11): 805.

Jaworski, T.; Hilszcza, K. and Nski, J. (2013). The effect of temperature and humidity changes on insect development and their impact on forest ecosystems in the context of expected climate change. Forecasting Research, 74, 345–355.

Montezano, D.G.; Sosa-Gómez, D.R.; Specht, A.; RoqueSpecht, V.F.; Sousa-Silva, J.C.; Paula-Moraes, S.D.; Peterson, J.A. and Hunt, T.E. (2018). Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. African entomology, 26(2): 286-300.

Patel, C.C., Koshiya, D.J. (1998). Life table and innate capacity of increase of Helicoverpa armigera (Hubner) on sunflower. Gujarat Agricultural University Research Journal. 24(1): 41-48.

Pogue, M.G. (2002). A world revision of the genus Spodoptera (Guenee) (Lepidoptera: Noctuidae). Memoirs of the American Entomological Society, number 43.

Rashed, H.S.; Khalil, M.S.; Khalwy, K.M. and El-Ghbawy, I.A. (2022). Appearance of Fall Armyworm, *Spodoptera frugiperda* as A New Invasive Insect Pest on Maize Plants in the Nile Delta, Egypt. Journal of Plant Protection and Pathology, 13(10): 231-234.

Ramzan, M., Abbas, D., Bukhari, F. K., Mehmood, S., Javed, A., Abbas, M., and Zaheer, M. (2021). Biology of Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) ANew Alien Invasive Pest in Pakistan. Indian Journal of Pure and Applied Biosciences, 9(4): 186-191.

Sagar, G.C.; Aastha, B. and Laxman, K. (2020). An introduction of fall armyworm (*Spodoptera frugiperda*) with management strategies: A review paper. Nipp Journal of Environmental Science, 1:1–12.

Zhang, Z.; Batuxi, Y.; Jiang, Y.; Li, X.; Zhang, A.; Zhu, X. and Zhang, Y. (2021). Effects of different wheat tissues on the population parameters of the fall armyworm (*Spodoptera frugiperda*). Agronomy, 11:2044–2056.

بعض النواحي البيولوجية لدودة الحشد الخريفية *Spodoptera frugiperda* (Smith) في محافظة أسيوط، مصر

وفاء احمد محمد هريدي، أحمد ابراهيم فرغل، سامي حسين محمد، سيد علي محمد العراقي

قسم امراض النبات، كلية الزراعة، جامعة أسيوط، مصر.

الملخص

إن دراسة الاحتياجات الحرارية للآفة مهم جداً لحساب الوحدات الحرارية اللازمة لنمو هذه الآفة الغازية وتطورها، وبالتالي يمكن التنبؤ بالأجيال الحقلية السنوية بالإضافة إلى رسم استراتيجية تخطيطية للإدارة المتكاملة للآفات لهذه الآفة الضارة. لذلك ركزت الدراسة الحالية على تحديد: معدل نمو دودة الحشد الخريفية *Spodoptera frugiperda* عند أربع درجات حرارة ثابتة (21، 24، 29 و34 ±1 درجة مئوية)، وعدد الوحدات الحرارية (DD's) اللازمة لتطور كل مرحلة. التنمية، والوقت من البيض إلى الحشرة الكاملة، لحساب بعض المعايير البيولوجية المستخدمة في التنبؤ بالآفات. ووفقا للدراسة، فإن تطور جيل واحد يتطلب حوالي 21 و26.44 و47 يوما عند 21 و24 و29 و34 درجة مئوية. تم تحديد متوسط فترات الحضانة للبيض لتكون 4.4، 3.66، 2.1 و1.3 يوم عند 21، 24، 29، 34 درجة مئوية، على التوالي. مع ارتفاع درجة الحرارة، انخفض متوسط الوقت اللازم لمرحلة البلوغ لتنضج المبايض وتبدأ في وضع البيض (من 1.6 أيام عند 21 درجة مئوية إلى 3.1 أيام عند 34 درجة مئوية). تم تسجيل وقت التوليد، (rm) و(λ)، وعتبة التطوير (t_0)، ومتوسط الوحدات الحرارية بالدرجات-الأيام (DD's).