HEAT REQUIREMENTS FOR SPINY BOLLWORM, *EARIAS INSULANA* (BOISDUVAL) (LEPIDOPTERA: ARCTIIDAE)

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INTRODUCTION

The spiny bollworm *Earias insulana* (Boisduval) is one of the most destructive lepidopterous cotton pests in Egypt. The temperature is considered an important environmental factor on the rate of development, insect survival and the other biological and ecological aspects.

The influence of temperature in determining the emergence development of insect population is well-established (Davidson, 1944 and Ives, 1973).

On the other hand, (El-Shafei *et al.*, 1981; Younis, 1991- 1992; Dahi, 1997; Hashem *et al.*, 1997; Dahi, 2003 and Dahi, 2005) described the developmental rates as a function of temperature. However, little attempts have been made on the use of temperature accumulation as an aid in forecasting the various stages of the pest

To obtain data on the temperature threshold and temperature accumulation for *E. insulana,* studies were conducted on four constant temperatures. Degree-days represent the accumulation of heat units over a minimum temperature for a 24-hour period. Below this minimum temperature, no development took place, but above it, heat units are accumulated towards development (Pedigo, 1991)

The present study was dealing with biological studies of the tested insect pest as a principal and prior step to limit its requirements of heat unit necessary to be used through forecasting system for establishment IPM programs for the *E. insulana.*

MATERIAL AND METHODS

Stock culture

Eggs of the spiny bollworm were obtained from the Division of bollworms, (Plant Protection Research Institute), resulting from susceptible strains reared in the

laboratory for at least four generations on an artificial diet, according to Rashad and Ammar (1984-1985) This diet consists of soaked kidney beans 2133 gm., medical dried yeast 320 gm., agar agar 128 gm., sorbic acid 10 gm., ascorbic acid 20 gm., methyl-p-phenoxy benzoate 10 gm., formaldehyde (40%) 20 ml. and water 6400 ml.

Rearing technique

The eggs of the spiny bollworm was maintained at 27± 1°C. and 70-75% R.H. until hatching. Newly hatched larvae were fed individually in glass vials (2.0 x 7.5 cm.) filled to one third with the artificial diet, covered with absorbent cotton and held in the same conditions as mentioned above. The larvae pupate usually on the inside surface of the absorbent cotton, which covered the vials and sometimes on the diet's top. The vials were examined daily, the formed pupae individually transferred to clean vials and incubated until moth emergence. Ten pairs of newly emerged spiny bollworm moths were confined in glass oviposition cages, which consists of a conventional mating glass bells (16 cm. high and 8 cm. diam.) opened at each end. Each cage was suspended by a piece of cotton wool previously soaked in 20% sugar solution. This solution renewed after 48 hours for moths feeding. The cages provided with strips of muslin suspended on its wide end as a suitable site for oviposition and egg lying. The cages were maintained at the same conditions of temperature and % R.H. Muslin carrying deposited eggs was collected daily, kept in glass vials (12.0 × 3.5 cm), and covered with pieces of cotton wool until hatching. The culture was established in the laboratory and become already enough to be a source for all insect stages to carry out the different experiments.

Experimental design

This work was carried out under controlled conditions of temperature and relative humidity. Four incubators were used to provide constant temperatures of 20, 25, 30, and 35 °C ± 1°C. All stages (from egg to adults) were kept under the constant temperatures and % R.H. to determine the developmental rate.

Egg stage

Eggs were collected from the breeding cages at 12 hrs. intervals, in order to standardize the egg age. The collected eggs were transferred to glass vials (2.0 x 7.5 cm), subsequently the incubation took place under the required combinations of temperature and relative humidity. Five replicates of 25 eggs/each were used. Observations were made daily to record the time of hatchability. The incubation period and the embryo developmental rates were estimated also during this experiment.

Larval stage

To study the larval development period of *E. insulana,* 125 newly hatched larvae were divided and transferred, each in a separate glass tube (7.5 x 2.5 cm.) covered with absorbent cotton and containing fresh artificial diet (25 larvae / replicate). The larvae were left in the vials until pupation. Daily observations were made to count the pupated larvae. Larval developmental rate and duration were also estimated.

Pupal stage

Newly formed pupae were collected on the same day of pupation and placed in the glass tube (2.0 × 7.5 cm.) (One pupa for each tube) and plugged tightly with a piece of cotton. Five replicates (each of 25 pupae) were placed at each tested temperature and observed daily till adult emergence.

Adult stage

Ten of the newly emerged moths were transferred in the same day of emergence to a glass mating-cage as mentioned before and also held on the same conditions of temperature and % R.H. Five replicates, one pair each were placed at each tested temperature. Daily observations were made to record the adult pre-oviposition period.

Duration of egg, larval, pupae and adult pre- oviposition period were calculated for each temperature. Data obtained in the present studies were statistically analyzed by F – test (Fisher, 1950).

Development at constant temperatures

Effects of four different constant temperatures were tested on different stages duration of *E. insulana* from 20 to 35°C, in 5°C increments. The fluctuations at each temperature was approximately ± 1°C. Data obtained in the present work were analyzed by regression.

The effects of the above mentioned conditions were tested on the immature and adult stages of *E. insulana,* the theoretical development thresholds were determined according the following equation:

$$y = a + bx$$

Where: (y) = rate of development, (a) = constant term and (b) = regression coefficient

$$t_0 = -a / b \quad \& \quad K = 1 / b$$

On the other hand, thermal units required for completion development of each stage was determined according to the equation of thermal summation (Blunk, 1923):

$$K = y (T - t_0)$$

Where y = developmental duration of a given stage; T= temperature in degree centigrade; t_0 = lower threshold of development and K = thermal units (degree-days).

RESULT AND DISCUSSIONS

Egg stage

Data in Table (1) shows that the relation between the durations of *E. insulana* stags and constant temperatures from 20 to 35°C. This relationship showed that the required time for completion of development decreased as the temperature increased. The means of incubation periods were 5.77, 3.91, 2.96 and 2.25 days at 20, 25, 30 and 35°C, respectively. There were significant differences in the incubation periods at the different temperatures. The threshold of egg development was calculated and illustrated in Fig. (1), it was found to be 10.58°C. The average of thermal units in degree – days required for the completion of development of this stage was 55.79 DD's.

The four observed values of eggs rate of development at the constant temperature range (20 - 35°C), gave a remarkable good fit to the calculated temperature – velocity line having the formula y = 1.79x – 18.95 (Fig. 1).

Larval stage

Table (1) indicated that the developmental rates of the spiny bollworm larvae increased with the increasing of temperatures from 20 to 35°C .The average larval duration varied from 21.93 days at 20°C to 9.96 days at 35°C. Statistically there are significant differences between the mean durations at the tested temperatures. The lower threshold of development (t_0) for the larval stage was 7.4°C as indicated in Fig. (2).

The same Table showed that the average thermal units required for larval development till pupation was 273.6 DD's as determined by the thermal summation equation K= y (T-7.4).

The four observed values for larval rate of development at the range of temperature from 20 to 35°C, gave also a remarkable good fit to the calculated temperature – velocity line having the formula y = 0.37 x –2.71 (Fig.2).

TABLE (I)

The relation between the constant temperatures and the *E. Insulana* rate of development and heat requirements.

Stage	Temp. (°C)	Duration (Days ± S.E.)	Rate of develop-ment %	t_0 (°C)	Degree-Days (DD's)	
					At each temp.	Average
Egg	20	5.77 ± 0.06 a	17.3	10.58	54.35	55.79
	25	3.91 ± 0.03 b	25.6		56.38	
	30	2.96 ± 0.02 c	33.8		57.48	
	35	2.25 ± 0.05 d	44.4		54.95	
	LSD 1%					0.29
Larvae	20	21.93 ± 0.15 a	4.56	7.4	276.3	273.6
	25	15.43 ± 0.09 b	6.48		271.6	
	30	12.01 ± 0.22 c	8.33		271.4	
	35	9.96 ± 0.45 d	10.04		274.9	
	LSD 1%					1.45
Pupae	20	16.62 ± 0.11 a	6.02	12.5	124.7	137.5
	25	11.46 ± 0.13 b	8.73		143.3	
	30	8.65 ± 0.06 c	11.56		151.4	
	35	5.81 ± 0.11 d	17.20		130.7	
	LSD 1%					1.69
Pre-Oviposition period	20	4.0 ± 0.22 a	25.0	9.38	42.48	40.94
	25	2.5 ± 0.24 be	40.0		39.05	
	30	2.0 ± 0.33 ce	50.0		41.24	
	35	1.6 ± 0.27 de	62.5		40.99	
	LSD 1%					1.66
Generation	20	48.32 ± 0.51 a	2.07	9.9	488.03	499.57
	25	33.3 ± 0.63 b	3.0		502.83	
	30	25.62 ± 0.50 c	3.9		514.96	
	35	19.62 ± 0.62 d	5.1		492.46	
	LSD 1%					4.46

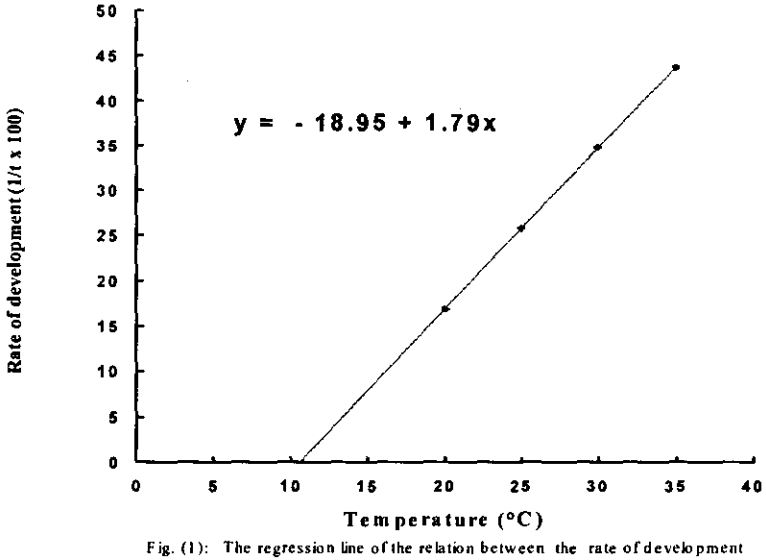

Fig. (1): The regression line of the relation between the rate of development of E. insulana egg and different constant temperatures.

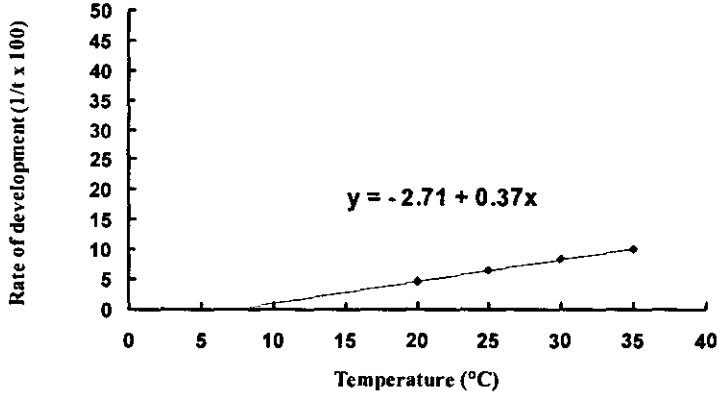

Fig. (2): The regression line of the relation between the rate of development of E. insulana larval and different constant temperatures.

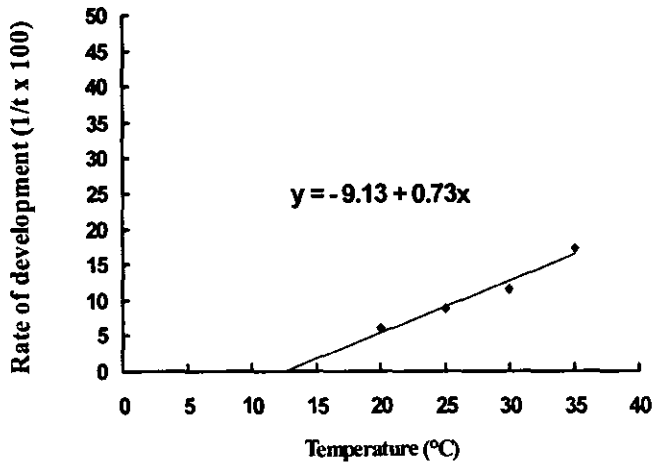

Fig. (3):The regression line of the relation between the rate of development of *E. insulana* pupae and different constant temperatures.

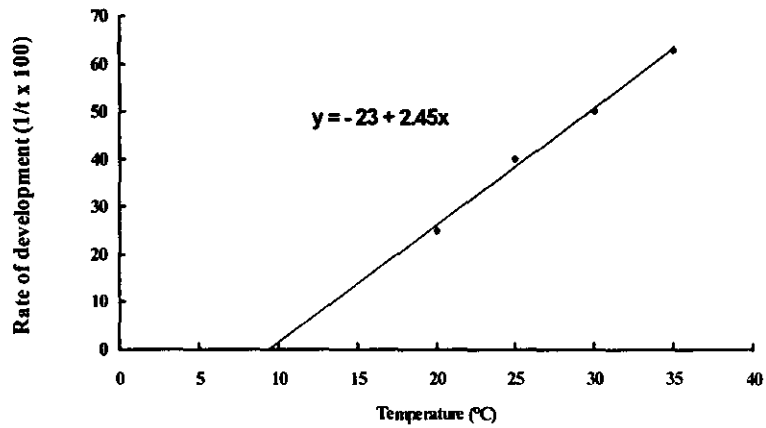

Fig. (4): The regression line of the pre-oviposition period of E. insulana at different constant temperatures.

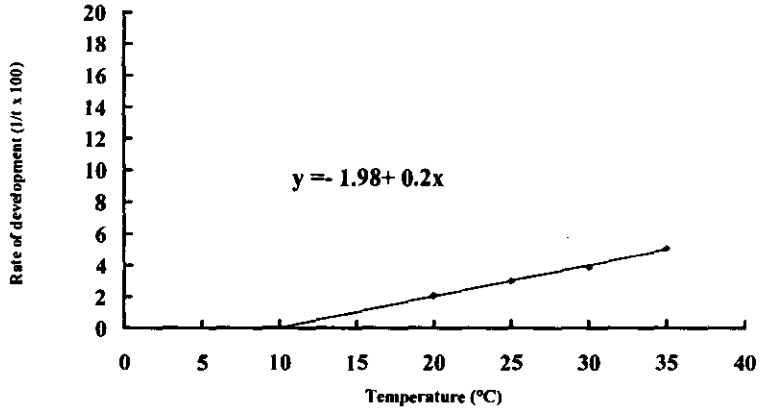

Fig. (5): The regression line of the generation period of E. insulana at constant temperatures.

Pupal stage

Table (1) showed that the pupal period decreased as temperature increased from 20 to 35°C. The average durations were 16.62, 11.46, 8.65 and 5.81 days at 20, 25, 30 and 35°C, respectively. The analysis of variance showed significant differences between the mean of pupal duration at 20°C and all other regimes at the level of 0.05 probability.

The developmental zero for this stage was 12.5°C as illustrated graphically by extrapolation in Fig. (3). Data in Table (1) showed that the average of thermal heat units for *E. Insulana* pupae was 137.5 DD's as estimated by the thermal summation equation K = y (T – 12.5).

The four observed values for the pupal rate of development at the temperature range from 20 to 35°C, gave a remarkable good fit to the calculated temperature – velocity line having the formula Y = 0.73 x – 9.13.

Adult stage

Pre-oviposition period

Data in Table (1) showed that the mean time required for maturation of the ovaries and starting egg laying, decreased as the temperature increased from 4.0 days at 20°C to 1.6 days at 35 °C. Statistical analysis of the obtained data showed that there are significant differences between the average of pre-oviposition period at 20°C and all other regimes. There are non-significant differences between the values at 25, 30°C and 35 °C .The lower threshold of development was 9.38 °C. The

average of total thermal units was 40.94 DD's as calculated by thermal summation equation K = y (T – 9.38).

The generation

The mean duration of generation at different constant temperature regimes could be calculated using the total of mean duration of different developmental stages (*i.e.* incubation period, larval stage, pupal stage and pre-oviposition period). Theoretically, the results obtained from these method shows an approximate value for mean duration of generation at different constant temperature regimes.

Data in Table (1) indicates that the mean duration of generation for *E. Insulana* were 48.32, 33.3, 25.62 and 19.62 days at 20, 25, 30 and 35°C, respectively. Statistical analysis indicated that there are significant relationships between all values of mean generation periods at all temperatures. Thermal summation method, represents the hyperbolic relationship between temperature and developmental times given by equation: Y (T – 9.9) = 499.57 DD's, that drive from the linear regression equation: Y = 0.2 x – 1.98. The lower threshold of development (t_0) could be estimated graphically by extrapolation from the Fig. (5), it was 9.9°C. The complete development of the generation required 488.03, 502.83, 514.96 and 492.46 DD's at 20, 25, 30 and 35°C, respectively, with an average 499.57 DD's.

These results agreed with those obtained by Kajanshikov (1946) who found that the linear relationship between temperature and rate of development can be expressed by the formula

$K = y (T - t_0)$. Gergis *et al.*, (1994) reported that the different stages of *S. littoralis* completed their development at the range of temperatures from 15- 32.5 °C, under this conditions the threshold of development and thermal units were also estimated.

The results in the present study concerning adult stage aspects are in agreement with Gergis *et al.*, (1990) on *E. insulana*; Abdel-Hafez 1993 on *Pectinophora. gossypiella*; Gergis *et al.*, 1994, Dahi, 1997 and Dahi, 2005 on *Spodoptera littoralis*.

SUMMARY

This work was carried out under controlled conditions of temperature and relative humidity. Four degrees of constant temperatures of 20, 25, 30, and 35 °C ± 1°C were used. All stages (from egg to adults) were kept under the constant

temperatures and % R.H. to determine the developmental rate and to study the relationship between this rate and heat requirement.

The lower thresholds of development (t0) were 10.58, 7.4, 12.5, 9.38 and 9.9 °C for egg, larvae, pupae, pre-oviposition period and generation, respectively. The average of thermal units required to complete the development was 55.79, 273.6, 137.5, 40.94 and 499.57 DD's for egg, larvae, pupae, pre-oviposition period and generation, respectively. The lower threshold of development and the heat requirements for *E. insulana* generation were 9.9 °C and 499.57 DD's.

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