THERMAL UNITS FOR THE SPINY BOLLWORM, *EARIAS INSULANA* (BOISD.) IN SHARKIA AND KAFR EL-SHEIKH GOVERNORATES

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Abstract

The present work was conducted to study the relationship between developmental stages of the spiny bollworm, *Earias insulana* (Boisd.) and required thermal units at constant temperatures, 20, 25 and 30°C ± 1°C in Sharkia and Kafr El-Sheikh Governorates, in Delta, Egypt. Results showed that there was variation in developmental periods of the spiny bollworm in different stages at the two Governorates. Increasing in the temperature led to an increase in the developmental rate and reduce the development periods of the different stages. The generation period of the spiny bollworm collected from Sharkia was shorter than that collected from Kafr El-Sheikh. The lower thermal threshold differed from Governorate to another for the different development stages of the spiny bollworm. The averages of generation period of the spiny bollworm collected from the two Governorates were 35.46 and 36.68 days, respectively. In Sharkia and Kafr El-Sheikh Governorates, the lower developmental temperatures were 12.26 and 11.82 °C for the generation and the thermal units required were 402.94 and 434.73 units, respectively. This means that the difference in developmental periods of generation between the two Governorates must be taken into consideration during application of control measures against this pest.

INTRODUCTION

Earias insulana (Boisd.) is a major insect pest of cotton and okra. Population dynamics of spiny bollworm are strongly influenced by environmental conditions, particularly temperature. The lower thresholds of development (t_0) were 10.58, 7.40, 12.50, 9.38 and 9.90 ºC for eggs, larvae, , pupae, pre-ovipostion period and generation for the spiny bollworm laboratory strain, respectively. The average of thermal units required to complete the development were 55.79, 273.60, 137.50, 40.94 and 499.57 DD's for eggs, larvae, , pupae, pre-ovipostion period and generation, respectively (Ismail *et al.,* 2005). Gergis, *et al.* (1990) found that the averages of thermal units required to complete the developmental period were 64.97, 170.35, 113.63, 41.03 and 387.60 DD's for eggs, larvae, pupae, pre-ovipostion period and generation for the spiny bollworm, respectively. Kandil (2013) found that the thresholds of development (t_o) were 15.95, 14.41, 13.32, 17.63 and 12.85 ºC for eggs, larvae, pupae, pre- oviposition and generation period of *E. insulana*, respectively. While, the average of thermal units required to complete the

developmental stages were 23.15, 131.33, 90.79, 20.83 and 346.193 DD̊s for eggs, larvae, pupae, pre- oviposition and generation period, respectively, when reared on okra pods.

The distribution of a species will be limited by the range of temperature experienced in different geographic regions, as well as by other factors. Temperature adaptation may occur, that is, genetically different strains may evolve, each capable of surviving within a different temperature range Gillott, (2005).

The thermal constants and thresholds for development of insects differ with the geographic populations and other environmental factors (Oghiakhe and Odulaja, 1993). The development of *Plutella xylostella* (L.) may be strongly influenced by the geographical origin (Harcourt, 1986). The developmental rates help for better understanding insect evolution and predict insect population growth rates. It will change our perception of the relationship between temperature and insect development and how it is adapted to geographic and seasonal factors and predict the potential geographical range of species (Vojtech *et al*., 2002).

The aim of this work was to study the required thermal units to development of different stages of the spiny bollworm in Sharkia and Kafr El-Sheikh, Governorates.

MATERIALS AND METHODS

Spiny bollworm field strain:

E. insulana, larvae and pupae were obtained from collected green cotton bolls from cotton fields in Sharkia and Kafr El-Sheikh Governorates when the population increased at the end of 2011cotton season. The samples (200 bolls) were collected biweekly during September and October. The collected bolls were transferred to laboratory in clothes bags. The full grown larvae and pupae were separated. The pupae and full grown larvae were placed singly in glass tubes (2.5 X7 cm) and plugged with cotton wool. The larvae were fed on the cotton seed until pupation. The emerged moths were sexed and each five pairs were confined in a glass jar (1/2 kg) covered with cloth as a suitable site for ovipostion and kept under the constant conditions 26±1 ºC and 70-75 R.H. Moths were fed on 10% honey bee solution absorbed on cotton piece that daily renewed. The clothes with the deposited eggs were transferred to a convenient glass jars. The deposited eggs were obtained daily and incubated under constant temperatures at 20, 25 and 30 ±1 ºC and 70-75 R.H. About 200 freshly deposited eggs of the spiny bollworm obtained from each Governorate were incubated at each temperature until hatching. Treatments were replicated three times. The newly hatched larvae were reared on modified artificial

diet according to (Rashad and Amar, 1985 and Amer *et al.* (2010)). Fifty newly hatched larvae were used for each replicate and replicated six times for the two Governorates and laboratory. The incubation period, larval duration, pupal periods, adult longevity, pre, ovi. and post-oviposition periods, as well as generation period were calculated.

Daily maximum and minimum temperatures during ten years from 2002-2011 were obtained from Agricultural Research Center (ARC), Meteorological Central Laboratory Table (1).

Table 1. Maximum, minimum and mean temperatures of the two Governorates, Sharkia and Kafr El-Sheikh for the ten years from 2002-2011.

Governorate	Sharkia	Kafr El-Sheikh
Minimum temperature	17.83	14.52
Maximum temperature	28.99	25.64
Mean temperature	23.41	20.08

The two Governorates, Sharkia, and Kafr El-Sheikh under study differ in the minimum and maximum temperature. Since, the minimum temperatures were 17.83 and 14.52 °C for the two Governorates, respectively.

Statistical analysis

The relationship between temperature and mean developmental rate of each stage and generation under tested temperature was determined using liner regression. For each temperature, developmental rate (DR) was calculated as reciprocals of development time (D) for each stage (DR= 1/D). The relation between developmental rate and temperature (T) was determined using liner regression equation: DR= a + bT, whereas: a and b parameters of the liner regression. The lower developmental threshold (t_0) was determined: t_0= -a/b. On the other hand, thermal units for completion development of each stage was calculated according to Arnold (1959): thermal units (DD's) = D*(T-t_0) where, D- development time of a given stage, T- temperature in degree centigrade and t_{0-} lower developmental threshold.

RESULTS AND DISCUSSION

Duration of different stages:

Data in Table (2) showed the duration periods of the spiny bollworm different stages collected from cotton fields at Sharkia and Kafr El-Sheikh Governorates when reared in the laboratory on artificial diet at three constant temperatures 20, 25 and 30°C.

Data in Table (2) revealed that the incubation period of the egg stage was varied from Governorate to another. The embryonic development periods of *E. insulana* collected from Sharkia Governorate were 7.11, 4.36 and 3.40 days, whereas it were 6.80, 4.10 and 3.30 days for Kafr El-Sheikh at 20, 25 and 30 °C, respectively. The averages of incubation periods for the two Governorates were 4.95 and 4.73 days, respectively. Larval durations at Sharkia were 25.90, 16.00 and 10.60 days, while, it was 25.30, 16.70 and 11.10 days for Kafr El-Sheikh at 20, 25 and 30 °C, respectively. The averages of larval duration were 17.50 and 17.70 days at the two Governorates, respectively. The pupal periods of the spiny bollworm collected from Sharkia were 16.50, 9.43 and 7.52 days, while it was 17.20, 10.50 and 7.85 days for Kafr El-Sheikh at 20, 25 and 30°C, respectively. The averages of the pupal periods were 11.15 and 11.85 days for two Governorates, respectively. The average of the pre ovipostion periods were 1.86 and 2.37 days for the two Governorates, respectively. The ovipostion periods of the spiny bollworm collected from Sharkia Governorate were 9.20, 7.90 and 4.20 days while for Kafr El-Sheikh it was 8.70, 6.80 and 4.00 days at the three temperatures, respectively. The average of ovipostion periods of Sharkia Governorate (7.10 days) was longer than Kafr El-Sheikh Governorate (6.50 days). The average of post ovipostion periods of the spiny bollworm collected from Sharkia was 2.01 days and 2.40 days for collected from Kafr El-Sheikh Governorate. Adult female longevities were 14.90, 11.40 and 6.62 days for Sharkia Governorate and 15.90, 10.80 and 7.10 days for Kafr El-Sheikh Governorate. The average of adult female was 10.97 days for Sharkia Governorate and 11.27 days for Kafr El-Sheikh governorate. Average generation period of the spiny bollworm collected from Sharkia Governorate was 35.46 days, while, it was 36.68 days for Kafr El-Sheikh Governorate.

Rate of development:

The spiny bollworm rate of development was differed from Governorate to another. The developmental rate was increased as temperature increased for the two Governorates. The average of developmental rate for the spiny bollworm generation period of Sharkia Governorate was 3.16 while it was 3.02 for Kafr El-Sheikh Governorate. The developmental rate of the spiny bollworm collected from Sharkia Governorate was faster than that collected from Kafr El-Sheikh Governorate Table (3).

Table 2. Duration of different stages of the spiny bollworm collected from two Governorates maintained at constant temperatures in the laboratory.

Governorate / Stage	Sharkia				Kafr El-Sheikh			
	20	25	30	Average	20	25	30	Average
Egg	7.11	4.36	3.40	4.95	6.80	4.10	3.30	4.73
Larva	25.90	16.00	10.60	17.50	25.30	16.70	11.10	17.70
Pupa	16.50	9.43	7.52	11.15	17.20	10.50	7.85	11.85
Pre ovipostion	2.60	1.80	1.20	1.86	3.50	2.00	1.60	2.37
Ovipostion	9.20	7.90	4.20	7.10	8.70	6.80	4.00	6.50
Post ovipostion	3.10	1.70	1.22	2.01	3.70	2.00	1.50	2.40
Adult female	14.90	11.40	6.62	10.97	15.90	10.80	7.10	11.27
Generation	52.11	31.59	22.72	35.46	52.80	33.30	23.84	36.68

Table 3. Rate of development of different stages of the spiny bollworm collected from two Governorates maintained at constant temperatures

Governorate / Stage	Sharkia				Kafr El-Sheikh			
	20	25	30	Average	20	25	30	Average
Egg	14.06	22.94	29.41	22.13	14.71	24.39	30.30	23.13
Larva	3.86	6.25	9.43	6.51	3.95	5.99	9.00	6.31
Pupa	6.06	10.60	13.30	9.98	5.81	9.52	12.74	9.35
Pre-ovipostion	38.46	55.56	83.33	59.11	28.57	50.00	62.50	47.02
Ovipostion	10.87	12.66	23.81	15.78	11.49	14.71	25.00	17.06
Post-ovipostion	32.26	58.82	81.83	57.63	27.03	50.00	66.67	47.90
Adult female	6.71	8.77	15.10	10.19	6.29	9.26	14.08	9.87
Generation	1.92	3.17	4.40	3.16	1.89	3.00	4.19	3.02

These results are agree with the finding of Gergis, *et al.* (1990), Ismail *et al.,* 2005 and Kandil (2013) reported that, increasing rearing temperature accelerated the developmental rate and shorted the periods which required completing different stages.

Lower developmental threshold

Data in Table (4) showed the values of lower developmental threshold temperature of *E. insulana* different stages for the two Governorates, Sharkia and Kafr El-Sheikh.

The average of lower developmental threshold for the spiny bollworm different stages for Sharkia Governorate were 10.57, 13.03, 11.19, 11.82, 12.80, 13.37, 12.84 and 12.26°C for egg, larvae, pupae, pre oviposition, oviposition, post oviposition, adult female longevity and generation, respectively, while for Kafr El-Sheikh Governorate it were 10.16, 12.5, 11.49, 12.48, 12.36, 12.60, 13.75 and 11.82 °C for the previous stages, respectively (Table, 4).

The changing of durations and lower developmental thresholds attributed to the differences of the environmental factors in the two Governorates.

Table 4. Lower threshold temperature for different stages of *E. insulana* collected from Sharkia and Kafr El-Sheikh Governorates.

Governorate / Stage	Sharkia	Kafr El-Sheikh
Egg	10.57	10.16
Larva	13.03	12.50
Pupa	11.19	11.49
Pre-oviposition	11.82	12.48
Oviposition	12.80	12.36
Post-oviposition	13.37	12.60
Adult female	12.84	13.75
Generation	12.26	11.82

Thermal units requirement

Data in Table (5) showed the thermal units of the spiny bollworm at Sharkia and Kafr El-Sheikh Governorates. The average thermal units required for egg development till hatching were 65.34 and 64.41 unit, for the two Governorates, respectively. The averages of the thermal units required for larval complete development were 183.97 and 194.25 units, respectively. The averages of the thermal units required for pupal development until moths emergence were 139.03 and 144.50 units, respectively. While, for pre oviposition period the averages of the thermal units required were 22.26 and 26.46 units, respectively. The female of the spiny bollworm required 78.25 and 74.33 units for the oviposition period for the two Governorates, respectively while it were 20.21 and 26.08 units, for the post oviposition period,

respectively. The adult female of the spiny bollworm required an average of 119.64 and 112.09 units for the two Governorates, respectively.

The thermal units required for the spiny bollworm collected from the two Governorates to complete generation period were differed for each temperature and Governorate. The averages of thermal units required for complete generation period were 402.94 and 434.73 unit for the two Governorates, respectively.

Table 5. Thermal unit of different stages of the spiny bollworm collected from two Governorates maintained constant temperatures.

Governorate / Stage	Sharkia				Kafr El-Sheikh			
	20	25	30	Average	20	25	30	Average
Egg	67.05	62.91	66.06	65.34	66.91	60.84	65.47	64.41
Larva	180.52	191.51	179.88	183.97	189.75	208.75	194.25	194.25
Pupa	145.37	130.28	141.45	139.03	146.37	141.86	145.27	144.50
Pre-ovipostion	21.26	23.72	21.81	22.26	26.32	25.04	28.03	26.46
Ovipostion	66.19	96.34	72.22	78.25	66.47	85.95	70.56	74.33
Post-ovipostion	20.54	19.77	20.32	20.21	27.36	24.79	26.09	26.08
Adult female	106.68	138.62	113.63	119.64	99.38	121.50	115.38	112.09
Generation	403.33	402.45	403.05	402.94	431.90	438.89	433.41	434.73

The average of thermal units required to complete the development were 55.79, 273.60, 137.50, 40.94 and 499.57 DD's, for eggs, larvae, pupae, pupae, pre-ovipostion period and generation for the spiny bollworm, respectively (Ismail *et al.,* 2005). Gergis, *et al.* (1990) found that the averages of thermal units required to complete the development were 64.97, 170.35, 113.63, 41.03 and 387.60 DD's for eggs, larvae, pupae, pre-ovipostion period and generation for the spiny bollworm, respectively. Kandil (2013) found that the thresholds of development (t_0) were 15.95, 14.41, 13.32, 17.63 and 12.85 ºC for eggs, larvae, pupae, pre- oviposition and generation period of *E. insulana* field strain, respectively. While, the average of thermal units required to complete the developmental stages were 23.15, 131.33, 90.79, 20.83 and 346.193 DD̊s, respectively, when reared on okra pods.

The variation of thermal units required for developmental of different stages of *E. insulana* may be due to variation of temperature between the two Governorates. Daily maximum and minimum temperatures during ten years varied at the two

Governorates (Table, 1). Clement (1992) reported that the required thermal units is constant for each strain of organism.

Vojtech *et al.* (2002) reported that the developmental rate help to better understand insect evolution and predict insect population growth rates. It will change our perception of the relationship between temperature and insect development and how it is adapted to geographic and seasonal factors and predicting the potential geographical range of species.

The thermal requirements (degree-days) of development were often used for estimating developmental times because temperature has a major effect in determining the rate which insects develop (Zaslavski, 1988). Honek and Kocourek (1990) showed that insect development data appeared too correlated with average annual temperatures that occurred in the region of origin for each species. Significant geographic variations in thermal characteristics of insect development were found by Honek (1996). The phonological characteristics of each species are adapted to climate conditions of its own geographical area Zalika *et al*. (2006).

Knowledge of developmental times of the life history stage of the spiny bollworm is an important pre requisite to an understanding of the population dynamics of this pest in the field. The lower developmental threshold (t_o) and the thermal units required (Degree-daily) to complete different stages of the spiny bollworm under different environmental components (at the two Governorates), it is necessary to forecast of the spiny bollworm and help the decision makers to decide the appropriate procedures to control in the *E. insulana* IPM program.

REFERENCES

1. Amer, A.E.A., A.A.A. El-Sayed, and S. A. A. Raslan. 2010. Improved technique for laboratory raring of the spiny bollworm, *Earias insulana* (Boisd.) (Lpidoptera: Noctuidae). Plant Protection and Pathology, Mansoura Univ., 1 (5): 299-306.
2. Arnold, C.Y. 1959. The determination and significance of the base temperature in a linear heat unit system. In Proc. Am. Soc. Hortic. Sci., 74:430-445.
3. Clement, A. N. 1992. The biology of mosquitoes. Chapman & Hall, London.
4. Gergis, M.F., M.A. Soliman, E.A. Moftah and A.A. Abdel-Naby. 1990. Temperature development relationship of spiny bollworm *Earias insulana* (Boisd.). Assiut J. of Agric. Sci., 21(3):129-140.
5. Gillott, C. 2005. Entomology, 3rd ed. Published by Springer, Dordrecht, The Netherlands, 834 pp.

6. Harcourt, D.G. 1986. Population dynamics of the diamondback moth in southern Ontario, in Diamondback moth management. Proc., 1st international workshop. Asian Veg. Res. and Development Center. Taiwan pp. 3-15.
7. Honek, A. 1996. Geographical variation in thermal requirements for insect development. Eur. J. Entomol., 93:303-312.
8. Honek, A. and F. Kocourek. 1990.Temperature and development time in insects: a general relationship between thermal constant. Zool. Jb. Eyst., 117:401-439.
9. Ismail, I.I., M.Y. Hashem, S.A. Emara and H.F. Dahi. 2005. Heat requirements for spiny bollworm, *Earias insulana* (Boisduval) (Lepidoptera:Aractiidae). Bull. Ent. Soc. Egypt, 82: 255-265.
10. Kandil, Mervat, A. A. 2013. Relationship between temperature and some biological aspects and biochemical of *Earias insulana* (Boisd.) (Lepidoptera: Noctuidae). Egypt. Acad. J. Biolog. Sci., 6(1): 11 – 20.
11. Oghiakhe, S. and A. Odulaja. 1993. A multivariate analysis of growth and development parameters of the legume pod borer, *Maruca testulalis* on variably resistant cowpea cultivars. Entomol. Exp. Appl., 66: 275–282.
12. Rashad, A. and E.D. Ammar. 1985. Mass rearing of the spiny bollworm *Earias insulana* (Boisd.) on semi artificial diet. Bull. Ent. Soc. Egypt., 65:239-244.
13. Vojtech J., A. Honek and Anthony F.G. Dixon. 2002. Developmental rate isomorphy in insects and mites. The American Naturalist, 160(4):497-510.
14. Zalika C., L. Kajfez-Bogataj and K. Bergantb. 2006. Modeling of weather variability effect on fitophenology. Ecological Modelling, 194 :256–265
15. Zaslavski, V.A. 1988. Insect development: photoperiodic and temperature control. Springer- Verlag, Berlin, N.Y. 187 pp.

الوحدات الحرارية لدودة اللوز الشوكية
في محافظة الشرقية وكفرالشيخ

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معهد بحوث وقاية النباتات مركز البحوث الزراعية الدقي الجيزة مصر

تم دراسة العلاقة بين نمو الأطوار المختلفة لدودة اللوز الشوكية المجموعة من محـــافظتي الشرقية و كفر الشيخ في دلتا النيل مصر والوحدات الحرارية المتجمعة اللازمة على درجات حرارة ثابتة وهي ٢٠ و ٢٥ و ٣٠ ± ١ درجة مئوية. أظهرت النتائج أن هناك تفاوتا في فترات النمـــو اللازمة لاستكمال مختلف مراحل النمو من البيض حتى الحشرات الكاملة بين المحافظتين، حيث أدت زيادة درجة الحرارة إلى زيادة معدل النمو وتقليص فترات الأطوار المختلفة ، مما أدي إلي قصـــر مدة الجيل لدودة اللوز الشوكية المجموعة من الشرقية مقارنة بتلك المجموعـــة مـــن كفـــر الشـــيخ. وبحساب مدة الجيل لدودة اللوز الشوكية المجموعة من المحافظتين وجد أنها ٣٥,٤٦ و ٣٦,٦٨ يوماً علي التوالي. اختلف صفر النمو للأطوار المختلفة بين المحافظتين. درجة حرارة صفر النمو لمـــدة الجيل كانت ١٢,٢٦ و ١١,٨٢ درجة مئوية لمحافظه الشرقية وكفر الشيخ علي التوالي. و بحســـاب الوحدات الحرارية اللازمة لمدة الجيل وجد أنها ٤٠٢,٩٤ و ٤٣٤,٧٣ وحده حراريـــة. وخلاصـــة القول إن الاختلاف في مدة الجيل بين المحافظتين يؤخذ في الاعتبار إثناء إعداد برامج المكافحة لهذه الحشرة.