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PREDICTING THE CHANGES IN THE POPULATION GROWTH PATTERNS OF THE SPINY BOLLWORM, *EARIAS INSULANA* (BOISD.)

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Abstract

The current field experiments were conducted at Qalyubyia district for three successive cotton-growing seasons (1996-1998) to investigate the changes in the seasonal activity of the spiny bollworm, *Earias insulana* (Boisd.). The actual and expected numbers of field generations based upon both accumulated heat units (590 DDs) and zero of development (13.1°C) were estimated.

Results showed that *E. insulana* moths underwent five overlapping field generations during each of the three tested cotton-growing seasons. The durations of these generations were as follows: 1st 10-11 weeks; 2nd 9-10 weeks; 3rd and 4th 8-9 weeks and 5th 8-10 weeks. On the other hand, prediction of this pest from April to next April reveals the presence of five generations on cotton plants. The duration of generations 1-3 (shortest) ranged from 40-48 days in 1996, 40-42 days in 1997 and 36-51 days in 1998, respectively. The last generation was the longest; being 157, 177 and 133 days in the three years, respectively.

Key words: Spiny bollworm, *Earias insulana*, seasonal abundance, zero of development.

INTRODUCTION

Spiny bollworm, *Earias insulana* (Boisd.) is one of the most serious insect pests of cotton in Egypt. Many attempts have been carried out to evaluate the non-chemical control measurements to increase the role played by the beneficial insects and reduce the environmental pollution. Considerable efforts have been made to study the economic injury levels of this cotton pest. Number of generations and size of each generation was also determined. Temperature, however, play an important role in determining the emergence and development of insect populations (Ives 1973 and Riedl *et al.*, 1976). Sevacherian (1977) used DDs to predict the pattern of the population growth cycles of bollworms in which the daily maximal and minimal temperatures and heat units are considered. The present investigation was carried out to study the previous points and to monitor the fluctuations of the population density of the spiny bollworm.

MATERIALS AND METHODS

The present work was carried out to monitor the fluctuations of the population density of *Earias insulana* (Boisd.) during three successive cotton-growing seasons (1996, 1997 and 1998) in the Agricultural Research Station, Faculty of Agriculture, Ain-Shams University, Shalakan, Qalyubyia Governorate on the based of weekly light trap catches. The trap was situated very near to cotton fields at about 3 meters height above the ground level. Weather factors figures used in this study were maximum, minimum and mean temperatures.

Number of spiny bollworm, *Earias insulana* field generations: The annual number of the spiny bollworm generations was estimated based on the number of weekly captured moths.

This was achieved through the following steps:

1. plotting the weekly number of captured moths opposite to the corresponding date of occurrence (normal distribution curve).
2. integrating the changes in the population cycle by adopting both methods of Audemard & Milaire (1975) and Jacob (1977).
3. counting the accumulated heat units required for completing one generation expressed as day degree temperature 'DDs' (Richmond *et al.,* 1983).

Statistical analysis of the data

1. Linear regression method: The theoretical development threshold values were determined according to the following:

A. The points obtained when the time (y) in days were plotted against temperature (T) so that the distribution of these points indicates the course of temperature time curve.

B. The points obtained when the reciprocal for time (1/y) in days were plotted against temperature (T), each of the reciprocals is multiplied by 100, so that the values on the ordinate (100/y) represent the average percentage of development made by the stage per day, at the given temperature. Therefore, the distribution of the points indicates the course of temperature- velocity curve (Davidson, 1944). The value of the average percentage of development in one day that is presented within normal zone of development fitted to straight line by the method of least squares (Regression line).

C. The developmental threshold value for the generation and DD's values are theoretically, the points at which the velocity line crosses the temperature axis is "the threshold of development in degree centigrade" (±°C). Thermal units required for completing development of each stage was determined according to the equation of thermal summation proposed by Blunk (1923) $K = y\ (T-t_o)$

Where: K = Accumulated heat units

y = Duration to complete growth of a certain stage

T = Prevailed temperature

t_o = Zero of development

2. Predicting the changes in the spiny bollworm population densities based on accumulated heat units:

The role of temperature was evaluated through long-term monitoring studies to establish an index for the thermal units required to complete a given stage or entire life cycle. So, temperature data were transferred into heat units and serve as a useful tool for forecasting insect population cycles and accordingly time of occurrence in the cotton fields.

3. Heat units calculation: The relationship between heat units required for completing one generation expressed as physiological time scale (DDs °C) and the population dynamic of the tested cotton pest, *E. insulana* during 1997 and 1998 seasons was studied.

Daily Degree days (DDs) were calculated from the daily maximum and minimum temperatures (°C) with developed threshold value estimated at constant temperatures carried out and the zero of development value was 13.8°C. The following formula was used for computing the heat units (DDs °C) according to Richmond *et al.* (1983).

$$H = \sum Hj$$

Where

H = Number of heat units to emergence

Hj = (max. + min.)/2 - C if max. > C & min. > C.

= (max. - C)^2/2(max. - min.), if max. > C & min. > C.

= 0 if max. < C & min. < C.

C = Threshold temperature

4. Number of expected generations: The number of the annual generations of *E. insulana* was estimated when the developer formula of Jasic (1975) was adopted. The first and last dates of appearance along with number of generations were determined.

Temperature values; i.e. mean of maximum and minimum temperature figures was estimated and DDs were calculated by multiplying d (t-x) and then accumulated as summation of heat units. The activity periods were calculated by simply dividing the corrected accumulated heat units on the effective temperature (y). According to the following formula:

$$g = \frac{d\ (t-x)}{y}$$

Where:

g = the number of probable generations.

d = the number of days in the examined period.

t = mean temperatures during the examined period.

x = the thermal threshold.

y = the total effective thermal units required for one generation.

RESULTS AND DISCUSSION

Seasonal activity and predicting number of *E. insulana* field generations:

Because the present work was started late in 1996 (May), we could not monitor the moth's activity from the beginning of the year. In other words, there are two and half years of moth monitoring as it appears in Fig. 1.

The first generation: During winter (December to March), moths appeared in the traps in a very few numbers that could not be adopted to construct a generation. In spring, (April and May), moths increased but still in scarce numbers. In summer and fall (June to November), numbers of moths increased very rapidly and could distinguish the existing peaks of generations. The first generation in 1997 may be considered as a part from the last one in 1996. The marked numbers appeared on April 23 have been considered as the first generation in 1997 which lasted 117 days till the next generation. The same manner happened in 1998, the reliable numbers that considered as the first generation appeared on January 29 and extended for 85 days.

The second generation: This obtained data reveal that the second generation took place on June 4, 1997 and lasted 41 days, while it occurred on May 27, 1998 and lasted 35 days, Fig. 1.

The third generation: The numbers of this generation were clearly distinguished. The marked numbers appeared on June 20, 1996 could be considered as the third generation of 1996. This generation occurred on July 9 and June 24 during 1997 and 1998 respectively. The durations of these generations were 37, 35 and 27 days during 1996, 1997 and 1998, respectively.

The fourth generation: The rapid and continuous increase in numbers characterized this generation. Numbers were detected on 23 August, 13 August and 22 July for 1996, 1997 and 1998, respectively. It lasted 28, 34 and 28 days respectively during the three tested years.

The fifth generation: The exploration of the data in Fig. (1) shows the occurrence of this generation on September 19, September 17 and August 19 during the three tested years. This generation lasted for 26 days in 1996, 34 days in 1997 and

28 days in 1998.

The sixth generation: Numbers of this generation were very high during 1996 and during 1998. This generation occurred on October 24, 1996, October 29, 1997 and September 19, 1998 and lasted 35 days in 1996, 42 days in 1997 and 27 days in 1998.

The seventh generation: High numbers of captured moths of the 7^{th} generation were recorded in 1997 and also in both other years, but not as high as of 1997. The peaks of this generation were detected on December 26, 1996, January 29, 1997 and 1998, respectively, Table 1.

From these results it could be concluded that the activity of *E. insulana* moths extended allover the year without any hibernation or diapause. The activity of moths reflected 7 distinct generations at Qalyubyia Governorate during the period of study (1996-1998).

These results are in agreement with those found by Katiyar and Butani (1978) who mentioned that peak numbers of *E. insulana* moths was reached by mid-September. Qureshi and Ahmed (1991) mentioned that peak populations and larval infestation levels of *E. insulana* were observed during October. Full agreement was also found with the results obtained by Younis *et al.* (1988), Foda (1997), Amin *et al.* (1999), Hamed and Foda (1999) and Amin *et al.* (2001).

Table 1. Approximated numbers and durations of *E. insulana* field generations during 1996-1998 at Qalyubyia Governorate.

Gen.	1996			1997			1998		
No.	From	To	Duration	From	To	Duration	From	To	Duration
First				26/12	23/4	117	29/1	22/4	85
Second				23/4	4/6	41	22/4	27/5	35
Third	20/6	25/7	37	4/6	9/7	35	27/5	24/6	27
Fourth	25/7	23/8	28	9/7	13/8	34	24/6	22/7	28
Fifth	22/8	19/9	26	13/8	17/9	34	22/7	19/8	27
Sixth	19/9	24/10	35	17/9	29/10	42	19/8	16/9	27
Seventh	24/10	26/12	32	29/10	29/1	90	16/9	21/10	35
Eighth							21/10	9/12	49

Forecasting the field generations of *E. insulana:* By adopting Audemard and Milaire (1975) and Jacob (1977) formula and plotting the obtained data as normal probability of moth populations, we could distinguish seven separate generations for spiny bollworm in 1997 and 1998, Fig. 2, but for 1996 there was only five generations. Table (1) demonstrates the peaks of *E. insulana* generations using the normal distribution curve and it is in agreement with that obtained by the normal probability transformation.

The number of generations of *E. insulana* obtained by using the thermal units accumulation (DDs) are given in Table (2). The required DDs for completion of one generation were 437.9±14.6DDs at the threshold of 11.6°C and cut off on 30°C (Amin, 1997). The accuracy of prediction was estimated using the deviation between the observed and predicted numbers, Table 2.

Uvarov (1929) indicated that the population activity of insects depends greatly on combination of several meteorological factors. Younis *et al.* (1988) found that the mean degree-days accumulations required for completion of *E. insulana* stages were: 64.97 DDs for egg, 170.35 for larvae, 113.6 for pupa, 41.03 for pre-oviposition period, 64.1 for oviposition period, 136.98 for male longevity, 169.5 for female longevity, 387.6 for one generation and 529.1 for brood, under field conditions.

Table 2. Expected numbers of *E. insulana* field generations using thermal units accumulation during 1996-1998 at Qalyubyia Governorate.

Gen.	1996			1997			1998		
No.	Observed	Expected	DDs	Observed	Expected	DDs	Observed	Expected	DDs
First				26/1	27/1	444.2	29/1	29/1	429.8
Second				23/4	18/4	436.6	22/4	23/4	429.1
Third	20/6	17/6	436.7	4/6	3/6	433.5	27/5	28/5	395.4
Fourth	25/7	21/7	437.5	9/7	7/7	441.4	24/6	27/6	395.4
Fifth	22/8	23/8	438.9	13/8	9/8	484.2	22/7	21/7	410.1
Sixth	19/9	23/9	439.3	17/9	15/9	438.1	19/8	20/8	426.5
Seventh	24/10	26/10	438.9	29/10	26/10	468.5	16/9	17/9	417.1
Eighth							21/10	18/10	470.1
Mean			436.6			449.5			427.6
SD			3.35			19.2			21.3

Fig. 1. The changes in the seasonal population activity of *Earias insulana* moths at Qalyubyia Governorate, 1996-1998.

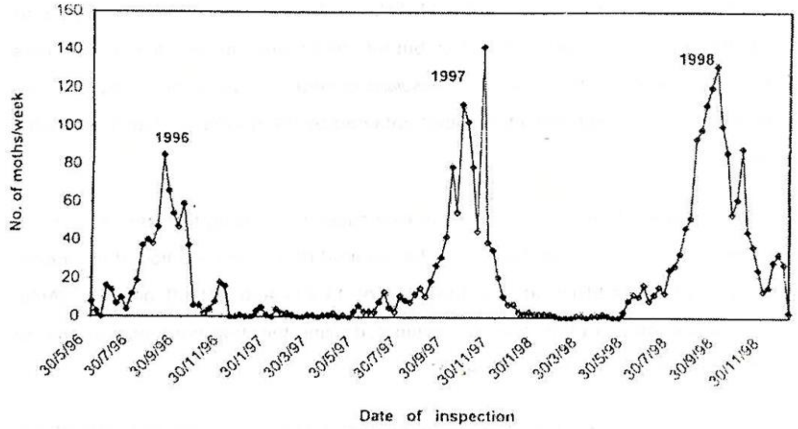
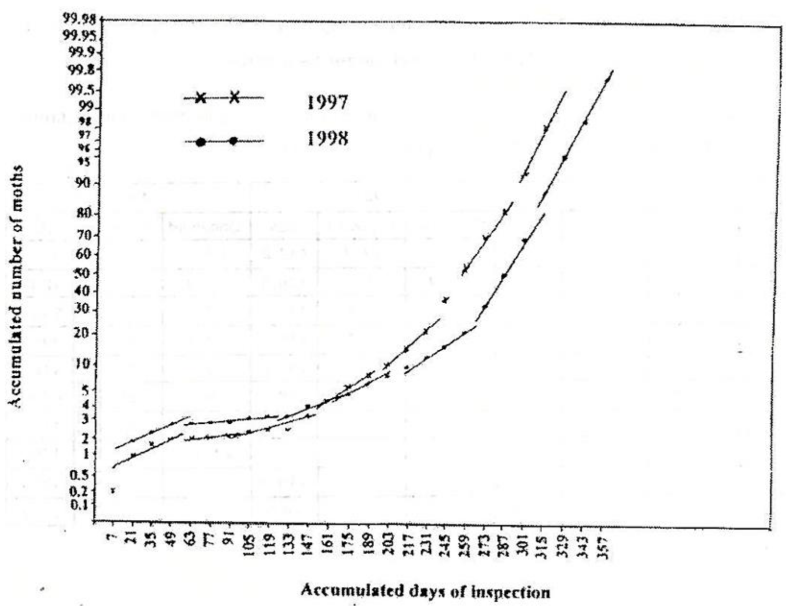


Fig. 2. The changes in the seasonal population activity of *Earias insulana* moths as expressed by the method proposed by Audemard and Milaire (1975) and Jacob (1977) at Qalyubyia Governorate, 1996-1998.



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التنبؤ بالتغيرات فى الكثافة العددية لجاميع دودة اللوز الشوكية

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أجريت هذه الدراسات الايكولوجية بمحافظة القليوبية على مدار ثلاث مواسم متتالية هي ١٩٩٦، ١٩٩٧ و ١٩٩٨ لدراسة التغيرات في الكثافة العددية لفراشات دودة اللوز الشوكية وذلك بأخذ جمعات أسبوعية للفراشات باستخدام المصايد الضوئية. وقد تم تقدير عدد الأجيال الفعلية والمتوقعة باستخدام الوحدات الحرارية المتجمعة والتي بلغت ٤٣٦ وحدة بناء علي صفر النمو والذي بلغ ١١,٦ °م.

تشير النتائج إلى أن حشرة دودة اللوز الشوكية كان لها ٧-٨ أجيال فعلية في العام في خلال أعوام الدراسة الثلاثة أستغرق الجيل الأول منها ٨٥-١١٧، الثاني ٣٥-٤١، الثالث حتي السابع ٢٧-٤٢ يوم وذلك علي عوائلها المختلفة.

وعند التنبؤ بتواجد هذه الحشرة خلال الفترة من أبريل حتي أبريل من العام التالي اتضح أن للحشرة ٦ أجيال علي نباتات القطن، وتراوحت الاحتياجات الحرارية اللازمة لاتمام كل جيل بين ٤٣٦,٧-٤٣٩,٣ وحدة حرارية في عام ١٩٩٦، ٤٣٣,٥-٤٨٤,٢ وحدة حرارية في عام ١٩٩٧، ٤١٠,١-٤٧٠,١ وحدة في عام ١٩٩٨ .