PREDICTING THE AMERICAN BOLLWORM, *HELICOVERPA ARMIGERA* (HÜBNER) FIELD GENERATIONS AS INFLUENCED BY HEAT UNIT ACCUMULATION

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Abstract

The present study was conducted in Beni-Suef Governorate under field conditions during the seasons of 2005 and 2006. Results indicated that the population of the American bollworm moths, *Helicoverpa armigera* (Hübner) had four peaks starting from the 3rd week of May until the 2nd week of September during the two tested seasons. The highest number of moths was recorded during the end of July and the whole August which being 120 & 154 moth/trap/35 days and 150 days after cotton planting in both seasons, respectively. The predicted peaks of generations could be detected when the accumulated thermal units recorded 558.18 DD's. The predicted peaks for the detected four generations varied from +2 to -3 days from the observed peaks. For better prediction of the American bollworm the period between the observed and expected peaks should be positive and as short as possible when early preparation of pest control materials are of great important, consequently it could be helpful when IPM control tactics are considered.

Key words:
American bollworm, *Helicoverpa armigera,* peaks, predicting, generations, thermal units accumulations.

INTRODUCTION

The American bollworm, *Helicoverpa armigera* (Hübner) known as "tomato fruit worm" is a polyphagous pest that feeds on over 200 host plants and wild species including at least 45 families (Sidde Gowda *et al.*, 2002 & Ibrahim, 2012).

In Egypt, it is necessary to design an alternative program for controlling this pest which the use of insecticide is considered the most effective method to control such this pest. So, it is becoming very important to find out and develop a program associated to reduce the use of insecticides for human health safety and/or better agroecosystem.

Integrated pest management program involves a system to suppress the pest population which depends on predicting the seasonal population cycles of insects, this had led to the formulation of many mathematical methods (Richmond *et al.*, 1983), which described the developmental rates as function of temperature (Wagner *et al.*, 1984).

Predicting and monitoring population systems for lepidopterous insect pests by using light or pheromone traps based on heat requirements were reported by Potter *et al*., 1981, Sing *et al*., 2004, Dahi, 2007, Amer *et al*., 2009 and El-Sayed *et al*., 2009

The objectives of the current research were to:

a. Study the seasonal fluctuations of *H. armigera* moths by using light trap.

b. Predicting of *H. armigera* generations in relation to accumulated heat units.

MATERIALS AND METHDOS

The study was conducted in Beni-Bekheet village, Beni-Suef governorate, the Arab Republic of Egypt during the seasons of 2005 and 2006. The light trap (Robinson and Robinson, 1950) was fixed on the building of the agricultural association at high of 4 meter above the ground and adjacent to cotton fields. The cotton area adjacent to summer crops such as maize, sunflower, okra and tomato intercropped with cotton. The cotton occupied an area of 35 and 45 feddans in the first and second season, respectively. The cotton variety Giza 80 was planted on the fourth week of March during the two cotton growing seasons.

The daily catch of the American bollworm males and females were collected, counted, identified and recorded. Daily number of the captured moths was accumulated for seven days during both seasons and were presented graphically to determine the population peaks in the successive generations in relation to the accumulated thermal units in degree-days.

To study the prediction possibility in relation to heat units accumulations, the temperature was could be transformed into heat units and serves as a tool for measuring insect population dynamics and predicting the appearance of the American bollworm in the field during the aforementioned two successive seasons. Each season extended from early April to the end of September.

Daily maximum and minimum temperatures were obtained and recorded by Central Laboratory for Agricultural Climate (CLAC). Degree-days (DD) were calculated from the daily maximum and minimum temperature (^{o}C) with developmental threshold (t_o) which has been estimated in the laboratory under constant conditions, where the zero development (t_o) was $10.87^{o}C$ with 557.5 DD's for generation development (Dahi, 2007). The following formula was used for computing the degree-days (DD) according to Richmond *et al*. (1983) under fluctuation temperatures:

$$H = \Sigma Hj$$

Where:

H = Number of heat units to emergence.

Hj = $\frac{(\max. + \min.)}{2} - c$, if max >c & min >c

= $\frac{(\max. - c.)^2}{\max. - \min.}$, if max. > c & min < c

= 0, if max <c & min < c

c = Threshold temperature

RESULTS AND DISCUSSION

I. Seasonal fluctuation of *Helicoverpa armigera* moths and its relation to cotton planting:

Figs (1 & 2) indicate that *H. armigera* moths during the two tested seasons showed four peaks for each. These peaks occurred from the 3rd week of May until the 2nd week of September. The first peak was occurred on 26th and 19th May. The corresponding moths were 16 and 18 moth/trap/week during 2005 and 2006 cotton seasons, respectively, then population fluctuated and increased to reach the second peak on 23rd and 30th June, where the captured moths recorded 32 and 36 moth/trap/week during the first and second season, respectively. The third peak was occurred on 28th July and 4th August, where the trapped moths equal 52 and 41 moth/trap/week in the two tested seasons, respectively. The fourth peak occurred on 8th September where the trapped moths recorded 63 and 39 moth/trap/week during the two seasons of 2005 and 2006, respectively.

It could be noticed that the fourth and the third peak during the two seasons of 2005 and 2006 had the highest number of moths (63 & 41 moth/trap) than the other two peaks in the first and second seasons, respectively. During the season of 2005, the highest number of moths was recorded during the end of July and whole of August months (120 & 154 moth/trap) after 150 days cotton planting while the number of moths are the higher in the second season (381 moth/trap) than the first one (349 moth/trap).

These results are in agreement with those obtained by Prasad *et al*. (2009) in India who reported that both light and pheromone baited traps were effective in monitoring the cotton bollworms, in Seriba, Sekulic *et al*. (2003) recorded three generations of *H. armigera* from late May until early September. Also, El-Sayed *et al*. (2009) found three peaks of *H. armigera* occurred from the fourth week of May till the third week of September, while Dahi (2007) and Ibrahim (2012) indicated that *H. armigera* had five peaks from March until November at Fayoum and Qalyoubia governorates, respectively.

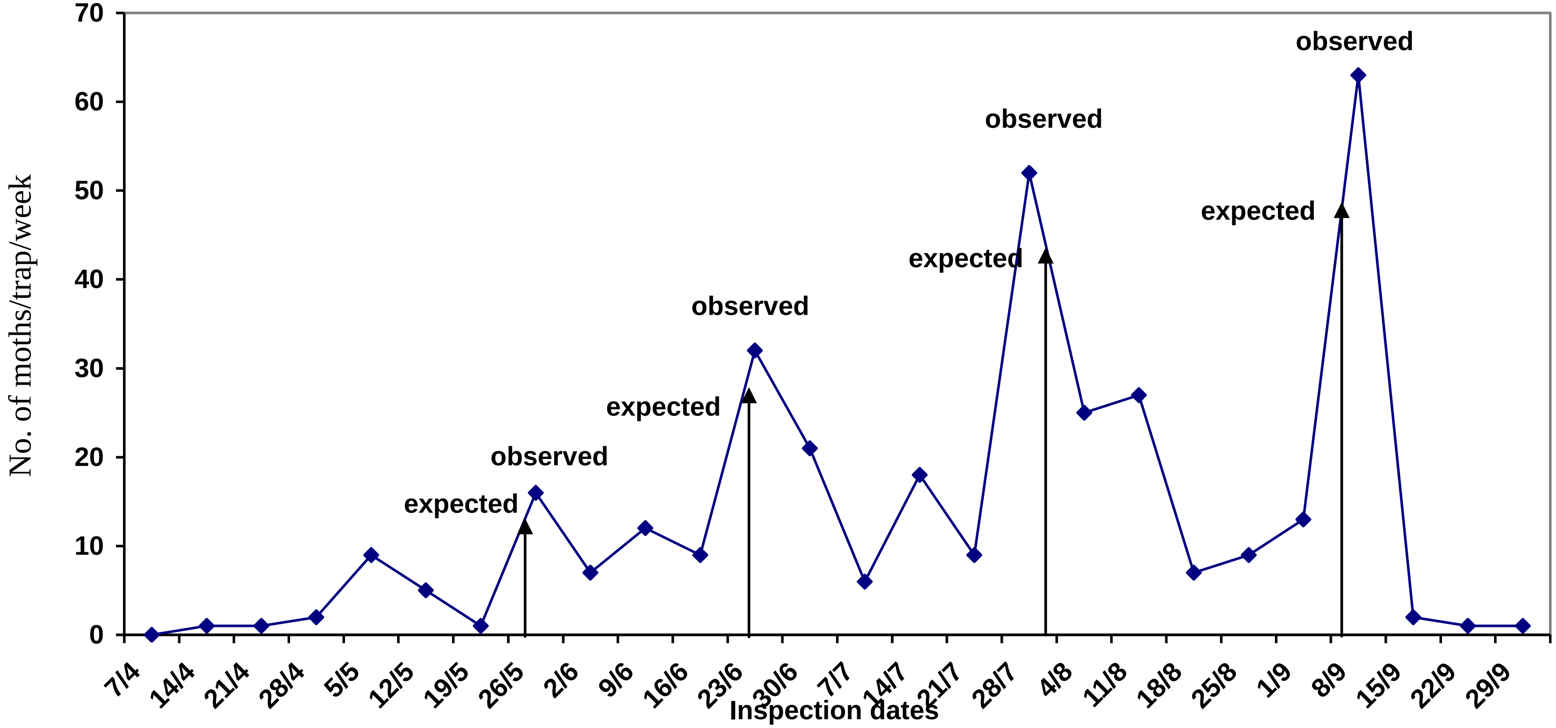

Fig. 1. Deviation between observed and expected annual generations of *H. armigera* in Beni Suef Governorate during 2005 season

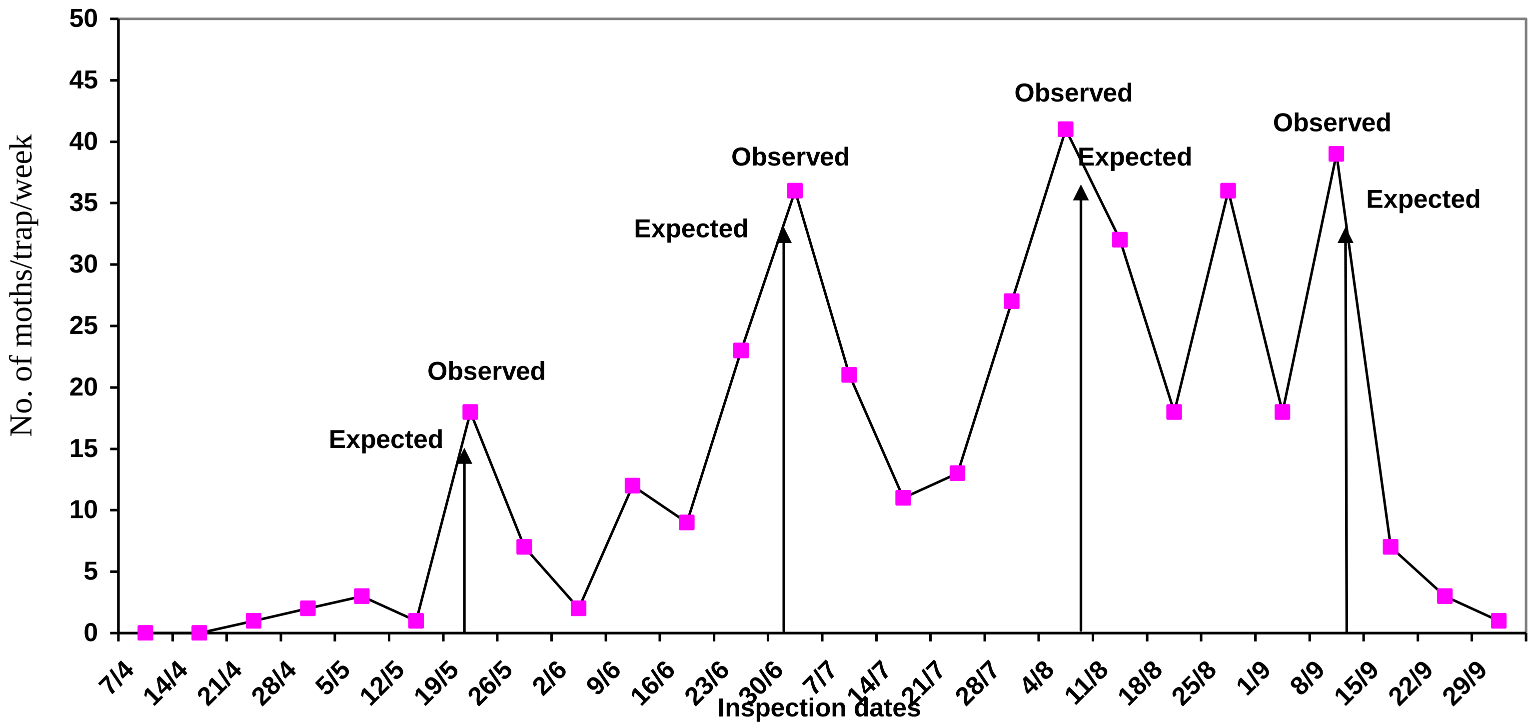

Fig. 2. Deviation between observed and expected annual generations of *H. armigera* in Beni Suef Governorate during 2006 season

II. Prediction of *H. armigera* generations and in relation to accumulated heat units:

Data presented in Table (1) and Figs. (1 & 2) show that the observed peak of the first generation was occurred on 26th and 19th May in 2005 and 2006 seasons, respectively. On the other hand, the expected peak for the same generation was observed on 25th and 18th May at 567.73 and 571.33 DD's during the two seasons of 2005 and 2006, respectively with deviation interval +1 day than the real peak for both 2005 and 2006 seasons.

Table 1. Comparison of the observed and expected *H. armigera* generations monitored with light trap related to accumulated degree days (DD's) in Beni-Suef Governorate during 2005 and 2006 seasons.

Seasons	Generations	Generation dates		Deviation (days)	Accumulated degree-days (DD's)
		Observed	Expected		
2005	1st	26/5	25/5	+1	567.73
	2nd	23/6	22/6	+1	548.31
	3rd	28/7	31/7	-3	533.14
	4th	8/9	6/9	+2	574.11
	Average			+0.25	555.82
2006	1st	19/5	18/5	+1	571.33
	2nd	30/6	28/6	+2	550.83
	3rd	4/8	6/8	-2	551.12
	4th	8/9	11/9	-3	568.93
	Average			-0.5	560.55
	Average of two seasons			-0.25	558.18

The real peak of the second generation was occurred on the 23rd and 30th June in the first and second season, while the expected dates of this generation were observed on the 22nd and 28th June with an average of 548.31 and 550.83 DD's during two seasons of 2005 and 2006, respectively. The deviations between the observed and expected peaks were +1 and +2 days earlier for the two seasons, respectively. The observed and expected peaks of the third generation were occurred on 28th July & 4th August and 31st July & 6th August during the two seasons of 2005 and 2006, respectively, when the accumulated heat requirements completed 533.14 and 551.12 DD's during both seasons, respectively. The deviation between the observed and expected peaks were -3 and -2 days later for 2005 and 2006, respectively.

The actual observed peak of the fourth generation appeared on 8^{th} September for both seasons. The expected dates of this generation occurred on the 6^{th} and 11^{th} September in the first and second season with a deviation intervals of +2 and -3 days when the accumulated degree days were 574.11 and 568.93 DD's in 2005 and 2006, respectively. It could be noticed that the highest number of moths was appeared during this generation on 8^{th} September (63 moth/trap) during the season of 2005 while during the season of 2006, the highest peak was occurred on 4^{th} August (41 moth/trap) during the third generation.

These results are in agreement with those obtained by Potter *et al.* (1981) on *Helicoverpa virescens* and Taman (1990) who mentioned that the maximum and minimum daily temperature were responsible for 23% and 30% of the *Spodoptera littoralis* population density. Also, temperature is an influencing factor affecting the insect life and activity. This factor may be utilized to gain some insight into the size and behavior of field population and consequently into life history and ultimately prediction of future generation (Sevacherian *et al.*, 1977, Ragab, 2009 and Amer *et al.*, 2009). Similarly, Dahi (2007) reported that the prediction of the American bollworm field activities is based on lower threshold of development (T_0), thermal units (DD's) for complete generation, T_{max}. $T_{min.}$ and catch moths.

It could be concluded that accumulated heat units can be used to predict the American bollworm population before the appearance of its peaks with a positive or negative periods between predicted and actual peaks. For better prediction of the American bollworm, the period between the observed and expected peaks should be positive and as short as possible where early preparation of pest control materials are of great importance. Consequently, it could be helpful when IPM control tactics are considered.

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التنبؤ بالأجيال الحقلية لدودة اللوز الأمريكية باستخدام الوحدات الحرارية التراكمية

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أجريت هذه الدراسة بمحافظة بنى سويف خلال موسمى ٢٠٠٥م و ٢٠٠٦م. أوضحت الدراسة أن تعداد دودة اللوز الأمريكية سجل أربع ذروات خلال الفترة من الأسبوع الثالث من مايو حتى الأسبوع الثانى من سبتمبر فى موسمى الدراسة.

سجل أعلى تعداد لفراشات هذه الحشرة فى نهاية شهر يوليو وخلال شهر أغسطس (١٢٠ و ١٥٤ فراشة للمصيدة الضوئية/٣٥ يوم) بعد ١٥٠ يوم من زراعة القطن خلال موسمى الدراسة على الترتيب. يمكن اكتشاف الذروات المتوقعة لهذه الحشرة عندما يكتمل التجمع الحرارى للجيل الكامل ٥٥٨,١٨ وحدة ــ يوم. تراوح إنحراف الذروات المتوقعة للأجيال الأربعة عن الذروات المشاهدة (الحقيقية) من +٢ إلى −٣ يوم قبل أو بعد ظهور الذروات المشاهدة. أظهرت الدراسة أيضا أنه من الأفضل فى التنبؤ بأجيال دودة اللوز الأمريكية أن يكون الإنحراف بين الذروات المتوقعة والمشاهدة موجبا وبفترة قصيرة بقدر الإمكان حتى يمكن الإستعداد والتجهيز لمكافحة هذه الحشرة ومن ثم يمكن الإستفادة منها ضمن برامج الادارة المتكاملة IPM لدودة اللوز الأمريكية حيث تعتبر هذه الطريقة مفيدة عمليا التنبؤ بالأجيال لتحديد التوقيت المناسب للرش.