Seasonal Occurrence of the Sesame Capsule Borer, *Antigastra catalaunalis* (Duponchel) and Parasitism Rate of the Ecto-larval Parasitoid *Bracon hebetor* Say in Sesame Plants at Ismailia

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Abstract: Field studies were conducted on the seasonal incidence of sesame capsule borer, *Antigastra catalaunalis* (Duponchel) (Lepidoptera: Pyralidae) and parasitism rate of its ecto-larval parasitoid *Bracon hebetor* Say (Hymenoptera: Braconidae) in two successive seasons of 2012 and 2013 at Ismailia Governorate. Results indicated that *A. catalaunalis* larvae appeared in mid-June (15 day after sowing) then increased gradually till the end of crop maturation (2nd or 3rd week of September). The highest percentage of infested branches, leaves, flowers and capsules was 75, 72.5, 62.5 and 47.5% respectively in the first season and 70, 70, 55 and 45%, respectively in the second season. The incidence of *A. catalaunalis* larvae was higher in leaves or shoots than in flowers or capsules. Ambient temperature had a positive and significant correlation with percentage of infestation by *A. catalaunalis* as well as number of larvae per infested branches and flowers in the first season while it had non- significant negative correlation in the second season. The mean relative humidity percentages showed non- significant negative relationship with percentages of infestation or pest incidence during the two seasons. Rate of parasitism by *B. hebetor* varied among plant parts in which *A. catalaunalis* larvae were fed on during the two seasons; being higher in the second season. Maximum parasitism percentages were 28.3, 32.5, 26.3 and 20 % in infested branches, leaves, flowers and capsules in the first season and increased to 38.7, 41.7, 35.8 and 21%, respectively in the second one.

Keywords*: Antigastra catalaunalis*; seasonal occurrence; infestation parasitism rate; *Bracon hebetor*.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an old and important oil seed crop; being cultivated in Egypt, tropical and subtropical regions of the world (Seegeler, 1983; Iwo *et al.,* 2002). It is considered to have both nutritional and medicinal values. Sesame leaf-roller or capsule borer *Antigastra catalaunalis* (Duponchel) (Lepidoptera: Pyralidae) is considered a key pest of sesame in Egypt (Abbas *et al*., 1989; Ahmed, 2007). It is very devastating pest of sesame crop and damages all plant parts; *i.e*., shoots, leaves, flowers and capsules by its devastating larval stage. Young larvae are less frequent on pods than on other plant parts. Older larvae infest the sesame capsules making an entrance hole on the lateral side and feed on the seeds inside the capsule leaving excreta on the seeds (Singh, 1983; Suliman *et al*., 2004; Narayanan and Nadarajan, 2005; Ahirwar *et al.,* 2010). *A. catalaunalis* was the potential constraint to sesame production from seedling to maturity stage (Chaudhry *et al*., 1987; Selvanarayanan and Baskaran, 1996). In India, it recorded 10-71% plant infestation and 10-43.5% capsule infestation, resulting in 8.9-71.5% yield loss and 66.31% seed loss per capsule (Kumar and Goel, 1994a). The percentage of seed damage in infested pods was 73.4% and the percentage of weight loss in damaged seeds was 100% (Kapadia, 1996). *Antirrhinum majus* and *Duranta* sp. act as alternate host plants of *A. catalaunalis* (Abbas *et al*., 1989)

To control *A. catalaunalis*, farmers use chemical insecticides, which could be toxic to natural enemies, thus disturbing the biological balance in the field and contaminating the environment. *Bracon hebetor* Say (Hymenoptera: Braconidae) is a polyphagous gregarious ecto-parasitoid of scores of pyralid species. *B. hebetor* has been used in many biological control programs in different parts of the world (Fagundes *et al*., 2005; Desai *et al.,* 2007; Kyoung *et al*., 2008). It parasitizes several important lepidopterous pests of stored products and field crops (Gupta and Sharma, 2004; Shojaei *et al.,* 2006). *B. hebetor* was the dominant associated parasitoid with *A. catalaunalis* in India (Jakhmola, 1983**).** In an earlier study, the reproductive biology of *B. hebetor* was studied on the larvae of *A. catalaunalis* **(**El-Basha, 2015)

To manage this pest efficiently, the understanding of the relationship between pest incidences, parasitoids that attack larvae and weather factors are very essential. This will be very helpful to avoid the peak activity of pest population and damage the crop by using the parasitoids.

The main objective of this study is to address the infestation rate by sesame capsule borer *Antigastra catalaunalis*, its seasonal incidence and total larval population in infested branches, leaves, flowers and capsules plants in two successive seasons of 2012 and 2013. Most importantly, rates of parasitism by the ectoparasitoid *Bracon hebetor* on *A. catalaunalis* larvae were also recorded in different plant parts in the two study seasons.

MATERIALS AND METHODS

Sampling Method

This study was conducted at the Experimental Farm, Ismailia Agricultural Research Station, Egypt, during the two sesame growing seasons of 2012 and 2013. Seeds of sesame cultivar (Shandawil 3) were sown in the last week of May 2012 and 2013 by Oil Crop Research Department, Ismailia Agricultural Research Station. This experiment was performed as complete Randomized Block Design (CRBD). Each

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experimental plot was 5 × 4 m and replicated four times. No pesticide was applied in the selected field plots during the investigation periods. Sampling was taken from five randomly selected plants within each plot (Kumar *et al.,* 2012).

The incidence of *A. catalaunalis* larvae/sesame tender shoot was recorded in terms of percentage of infested plants and number of larvae per 20 branches. Twenty terminals randomly branches of 20 cm. (five branches/ plot) were taken at weekly intervals commencing 15 day after sowing from vegetative stage of the crop.

The incidence of sesame leaves, flowers (or flower buds) and capsules were recorded in terms of percentage of infested plants and number of larvae per 40 leaves, flowers or (flower buds) and capsules. Five sampling plants were chosen randomly in each plot. In each sampling plant, two leaves, flowers (or flower buds) and capsules were collected and inspected for calculation of infestation by *A. catalaunalis* larvae. The percentage of incidence was calculated by using the formula:

$$\textbf{Infestation (\%)} = \frac{\text{No of infested plants (B/L/F/C)}}{\text{Total no. of plants observed}} \times 100$$

Where: B = Branch , F = Flower, L = leaf, C = capsule

The collected samples were placed in paper bags and transferred to the laboratory for further inspection with stereoscopic-microscope. Flower buds/flowers and pods of sesame were dissected and total larval population of *A. catalaunalis* was counted and percentage of infested sesame plants were estimated during the two successive years.

Percentages of parasitism and seasonal activity of the parasitoid *B. hebetor* in the same samples were investigated for the presence of parasitized larvae of *A. catalaunalis* by *B. hebetor'* immature stages. Parasitized larvae were kept individually in Petri dishes (9 cm) until cocoon formation. Number of total formed parasitoid cocoons (appeared in the Lab and those formed at the date of inspection) as well as rate of emergence of adult parasitoids were recorded as parasitoid success. The rate of parasitism was calculated according to the formula:

$$\textbf{Parasitism (\%)} = \frac{\text{No. of parasitized host larvae}}{\text{No. of collected larvae}} \times 100$$

Where: Collected larvae = Total no. of parasitized and non-parasitized host larvae

Statistical analysis

Meteorological data, weekly means of air temperature (°C) and relative humidity (%R.H) were obtained during sesame growing seasons of 2012 and 2013. Simple correlations were worked out between incidence of *A. catalaunalis* in terms of percentage of infested plants or total larval population with the weather factors (Temp. °C and R.H.%). Also, correlations were worked out between rates of parasitism by *B. hebetor* and the weather factors or total population of *A. catalaunalis.* Data obtained in all presented experiments were subjected to analysis of correlation coefficient using CoStat 6311 Windows Computer Program.

RESULTS

1. Seasonal abundance of *A. catalaunalis*

1.1. Seasonal incidence of *A. catalaunalis* larvae in tender shoots

Infestation rate relatively varied in the two seasons; being higher in the first one. Results indicated that infestation of *A. catalaunalis* on sesame plants commenced in the mid- June (15 day after sowing) then increased till the end of crop maturation (the third week of September). The incidence of sesame tender shoots during 2012 season began in mid-June in low numbers with the average population of 7 larvae/infested branch at the field conditions of 37.8^{o}C and 86.7% R.H. and percentages of infested branches (15%). The highest percentage of infestation (75%) was observed during the last week of July at (39.8^{o}C and 87.8% R.H) and the average population/infested branch of (20.1 larvae). Thereafter, the population of larvae declined gradually (Table 1). The trend of the infestation in the second season was similar to that in the first season; being greatest (70%) in last week of July accompanied by weather factors of (37.5^{o}C and 89%R.H) and the highest average number of larvae/infested branch was 18.5 larvae (Table 2).

1.2. Seasonal incidence of *A. catalunalis* in leaves, flowers, and capsules

The initial occurrence of *A. catalaunalis* larvae in vegetative stage was observed in mid-June with percentage of infested leaves of 17.5% and total larval population/40 infested leaves of 10 larvae accompanied with the field conditions of 37.8^{o}C and 86.7% R.H (Figs. 1, 2 and 3). The percentages of infested leaves increased to reach a maximum of 72.5% with total larval population of 282 larvae/40 infested leaves coinciding with mean temperature of 42.8^{o}C and relative humidity of 87.7% in mid-July. In flowering stage, the incidence of *A. catalaunalis* larvae began in 2nd week of July at 37^{o}C and 87.7% R.H, with the percentages of infested flowers of 20% and total population of 30 larvae/40 infested flowers. The percentages of infested flowers reached a maximum of 62.5% and population of larvae 118 larvae coinciding with field conditions of 39.8^{o}C and 87.8%R.H at the end of July. The initial damage to sesame seed capsules was observed in the second week of August at 38.4^{o}C and 87.7% R.H with infestation percentage of 30% and total number of larvae of 24 larvae/infested capsules. The damage increased gradually to reach a maximum of 47.5% and its peak population of 56 larvae/infested capsules at the end of August (38.2^{o}C and 88.8% R.H). In the second season and as depicted in Figs. 4, 5 and 6, the highest percentages of infested leaves, flowers and capsules were 70, 55 and 45%, respectively. The maximum total larval population in the infested leaves and flowers were 220 and 90 larvae, respectively at field conditions of 37.5^{o}C and 89% R.H in the end of July. While, the maximum total larval population was 60 larvae/infested capsules at the last week of August coinciding with 38.4^{o}C and 89% R.H.

Table (1): Seasonal incidence of *A. catalaunalis* larvae/20 sesame tender shoots in 2012 season at Ismailia Governorate

Sampling date	Mean Temp. □ C	Mean R.H.%	N *	Infested branches		No. of larvae /infested branches	Mean no. of larvae /infested branch
				No.	%		
14-Jun.	37.8	86.7	20	3	15	21	7.0
21-Jun.	36.7	86	20	4	20	40	10.0
28-Jun.	37.2	86.2	20	7	35	90	12.8
05-Jul.	37.5	89	20	10	50	142	14.2
12-Jul.	37	87.7	20	12	60	182	15.1
19-Jul.	42.8	87.7	20	13	65	249	19.1
26-Jul.	39.8	87.8	20	15	75	302	20.1
02-Aug.	37	87.7	20	12	60	164	13.6
09-Aug.	38.4	87.7	20	11	55	147	13.3
16-Aug.	38.4	87.2	20	10	50	126	12.6
23-Aug.	38	88.7	20	8	40	88	11.0
30-Aug.	38.2	88.8	20	6	30	40	6.6
06-Sep.	36.7	88	20	0	0	0	0
13-Sep.	33.8	88.4	20	0	0	0	0
20-Sep.	36.4	86.5	20	0	0	0	0

N*: Number of inspected shoots each interval

Table (2): Seasonal incidence of *A. catalaunalis* larvae/20 sesame tender shoots in 2013 season at Ismailia Governorate

Sampling date	Mean Temp. □ C	Mean R.H.%	N *	Infested branches		No. of larvae /infested branches	Mean no. of larvae/infested branch
				No.	%		
10-Jun	35.7	86.7	20	2	10	6	3
17-Jun	33.4	85.2	20	4	20	24	6
24-Jun	33.5	87	20	6	30	72	12
01-Jul	36	88.4	20	10	50	131	13.1
08-Jul	34.8	86.8	20	12	60	165	13.7
15-Jul	31.4	86.1	20	13	65	189	14.5
22-Jul	36.4	84.1	20	14	70	221	15.7
29-Jul	37.5	89	20	14	70	260	18.5
05-Aug	34.2	88	20	12	60	190	15.8
12-Aug	31.8	74.1	20	10	50	144	14.4
19-Aug	30.5	88.7	20	7	35	66	9.4
26-Aug	38.4	89	20	5	25	40	8
02-Sep	37.5	88.8	20	0	0	0	0
09-Sep	35.8	86.4	20	0	0	0	0
16-Sep	38	86.5	20	0	0	0	0

N*: Number of inspected shoots each interval

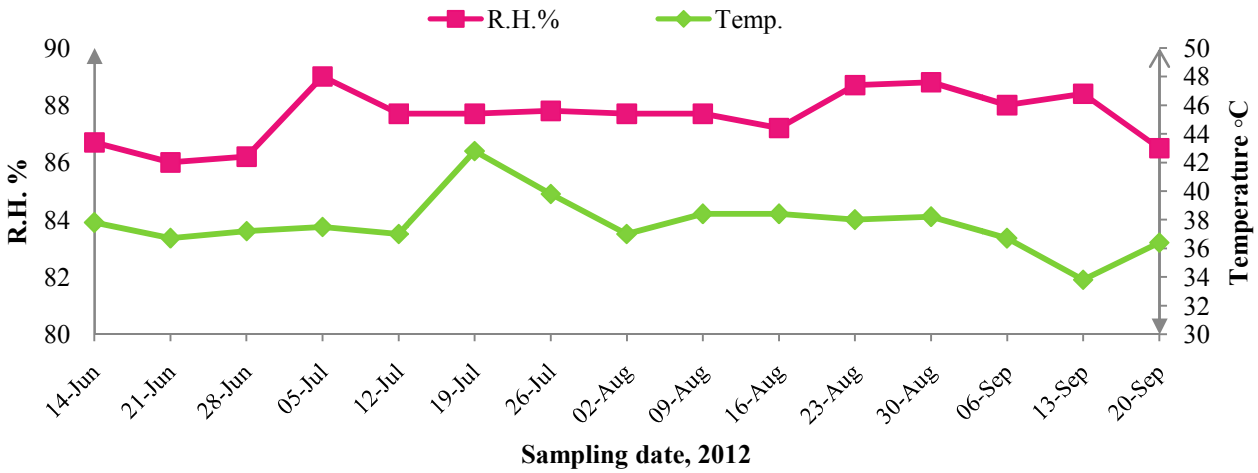

Fig. (1): Weekly means of temperature ºC and relative humidity % in 2012 season at Ismailia Governorate.

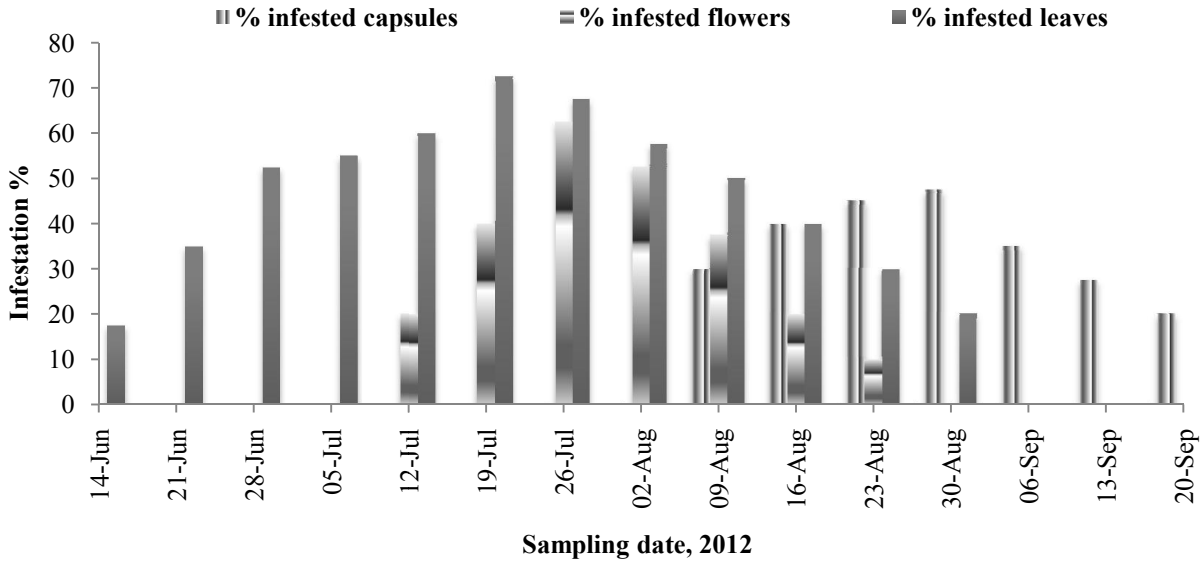

Fig. (2): Weekly percentages of infested sesame plants by *A. catalaunalis* larvae/40 leaves, flowers and capsules in sesame plants during 2012 season at Ismailia Governorate.

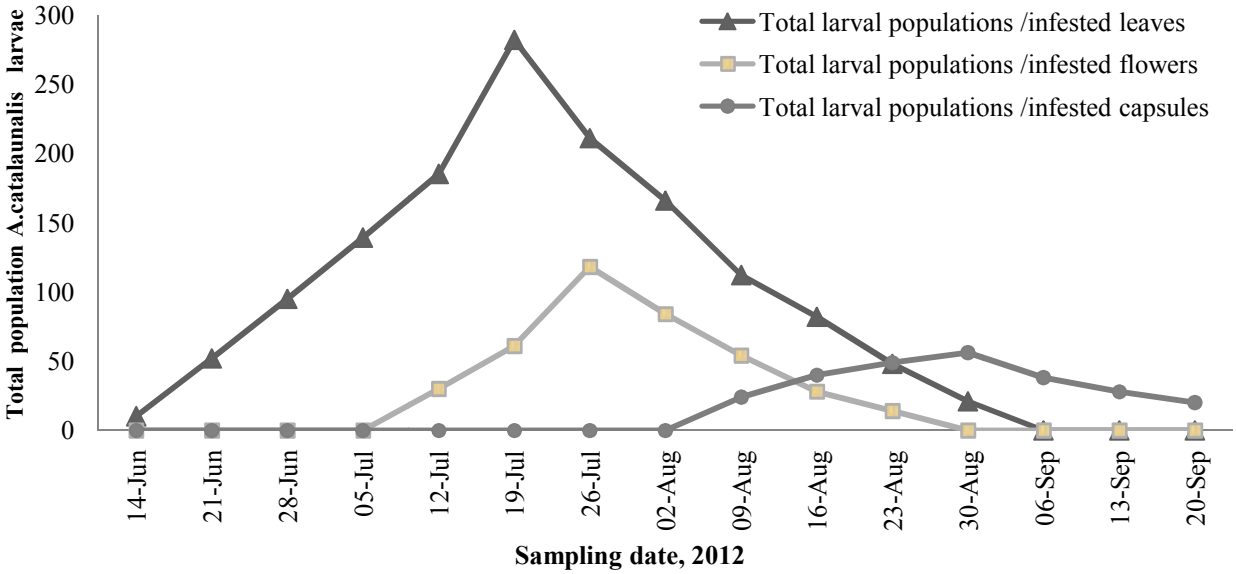

Fig. (3): Weekly total population of *A. catalaunalis* larvae/40 leaves, flowers and capsules in sesame plants during 2012 season at Ismailia Governorate

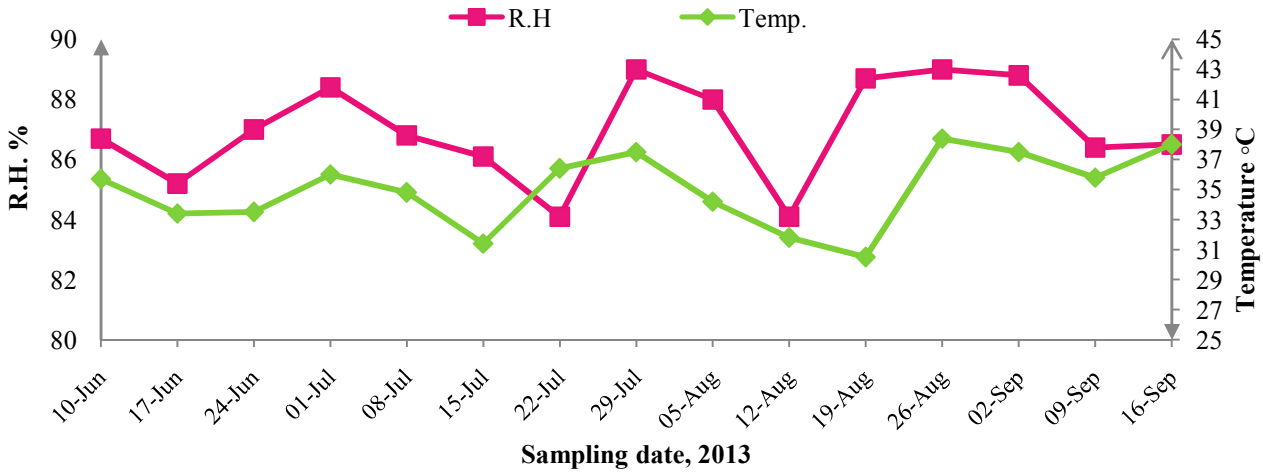

Fig. (4): Weekly means of temperature °C and relative humidity % in 2013 season at Ismailia Governorate

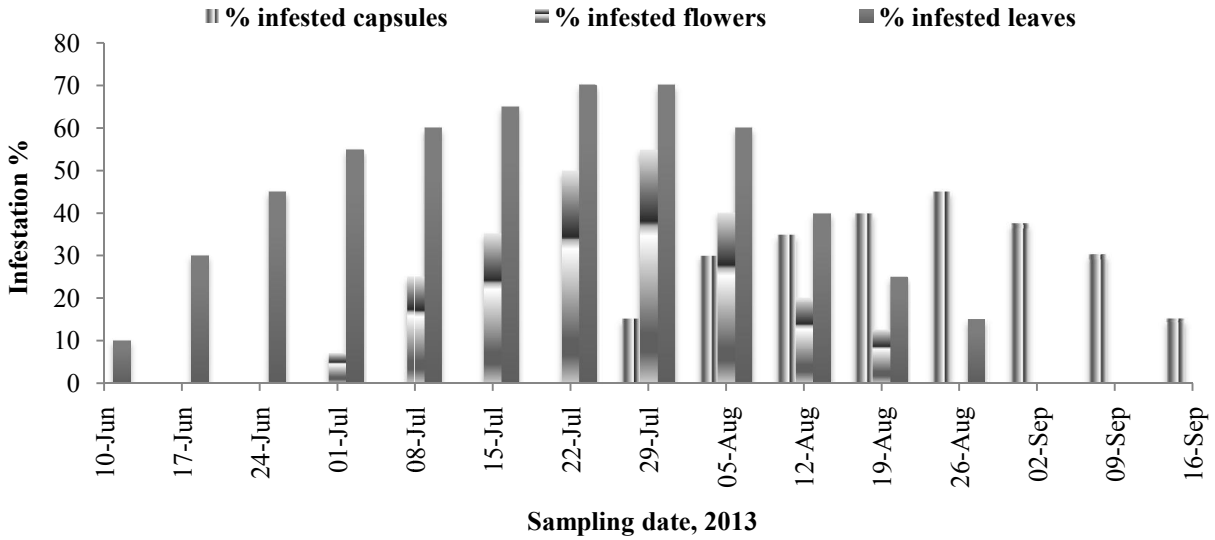

Fig. (5): Weekly percentages of infested sesame plants by *A. catalunalis* larvae/40 leaves, flowers and capsules in sesame plants during 2013 season at Ismailia Governorate

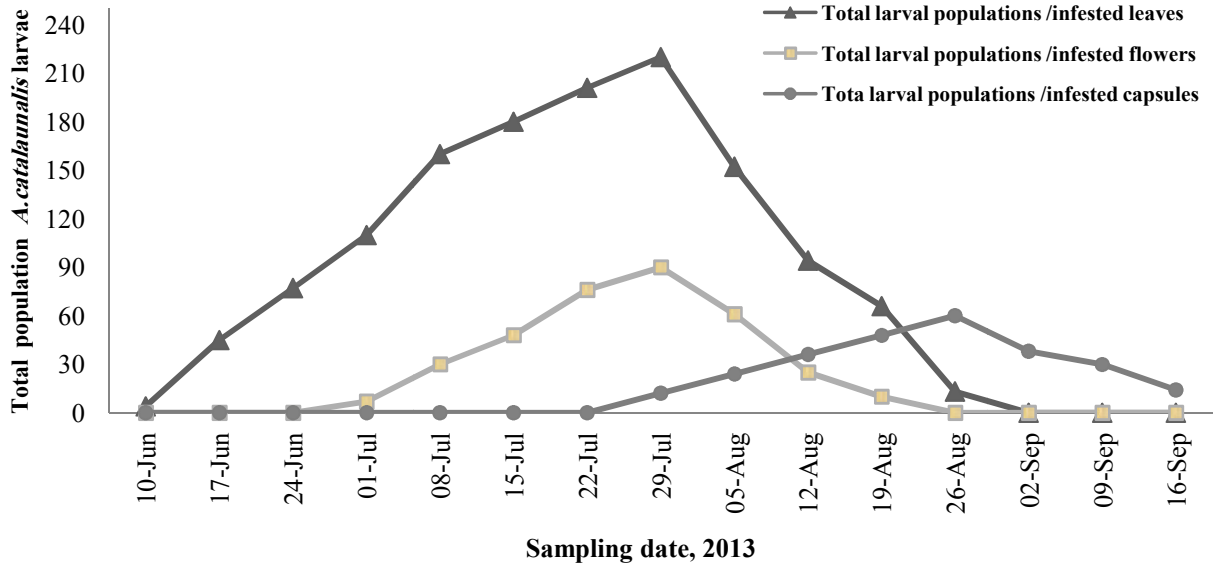

Fig. (6): Weekly total population of *A. catalaunalis* larvae/40 leaves, flowers and capsules in sesame plants during 2013 season at Ismailia Governorate

1.3. Effect of the climatic factors on seasonal incidence of *A. catalaunalis*

In the first season, data in Table (3) showed that the weekly mean temperature had a significant positive effect with percentages of infested branch (r = 0.66) and average larval population/infested branch (0.70), while the mean relative humidity showed a non-significant positive effect (r = 0.21 and 0.04), respectively. In the second season, there was non-significant negative relationship between temperature and percentages of infested branch (-0.29) or average larval population/infested branch (-0.32). Also, the mean relative humidity had non- significant negative relationship between percentages of infested branch (-0.11) or average larval population/infested branch (-0.06).

Table (3): Correlation coefficient between percentages of infested branches or number of larvae of *A. catalaunalis* /infested branch with weather factors during the two study seasons of 2012 and 2013

Weather parameters	Correlation of infested branches and aver. larval population in season 2012			
	Infested branches%		Aver. larval population/infested branch	
	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (°C)	0.66±0.2	0.006	0.70±0.19	0.003
Mean R.H (%)	0.21±0.2	0.441	0.04±0.2	0.875
	Correlation of infested branches and aver. larval population in season 2013			
	Infested branches%		Aver. larval population/infested branch	
	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (°C)	-0.29±0.2	0.28	-0.32 ±0.2	0.23
Mean R.H (%)	-0.11±0.2	0.68	-0.06±0.2	0.81

r = Correlation coefficient
S.E. = Standard errors

As shown in Table (4) in the first season, the incidence of *A. catalaunalis* in terms of percentage of infested plants (leaves and flowers) had a significant positive correlation with the mean temperature (r= 0.64 and 0.55, respectively). While on the opposite, correlation with infested capsules was non-significant negative correlation (r= -0.16). Percentage of infested plants had non-significant positive correlation with mean relative humidity in infested leaves, flowers and capsules (r = 0.02, 0.10 and 0.42, respectively).

The same trend of correlation was found between total larval population in infested plants (leaves and flowers) with mean temperature (r = 0.69 and 0.53, respectively). On contrary, correlation between larval population in infested capsules was non- significant (r = -0.15). Mean relative humidity percentages showed no significant correlation with total larval population in infested leaves, flowers and capsules (r = 0.02, 0.10 and 0.42, respectively), (Table 4).

Meanwhile, in the second season (2013), percentage of infested plants had non-significant correlation with mean temperature; negative correlation in infested leaves and flowers (r = -0.26 and -0.12 respectively), but positive correlation was found in infested capsules (r = 0.02). Mean relative humidity had non-significant on percentage of infested plants; negative correlation (-0.11,-0.16) in infested leaves and flowers while positive correlation (r = 0.37) in infested capsules.

The total larval population/infested plants had non-significant correlation with mean temperature; negative correlation in infested leaves and flowers (r = -0.21 and -0.01, respectively) and positive correlation (r = 0.06) in infested capsules. Mean relative humidity had non-significant correlation with total larval population/infested plants; negative correlation with leaves, flowers (r = -0.12 and -0.09, respectively) and positive correlation (r = 0.40) with infested sesame capsules.

2. Parasitism rate in the field

2.1. Parasitism rates in host larvae fed on tender shoots

The percentages of parasitism in *A. catalaunalis* larvae by *B. hebetor* varied in the two studying successive seasons and varied also in different sesame parts on which host larvae were fed upon (Tables 5 and 6). The occurrence and percentage parasitism relatively varied between two years; being higher in the second season. Meanwhile in the two seasons, the parasitoid was almost vanished up to the last week of June; being observed after that till end of August coinciding with the appearance of *A. catalaunalis* larvae on sesame vegetative stage. Percent of parasitism on larvae of *A. catalaunalis* by *B. hebetor* ranged from 11.7 to 28.3% during the first season and from 20 to 38.7% during the second one. The highest larval parasitism and parasitoids emergence percentages were 28.3 and 87.6%, respectively at the field conditions of 37□ C and 87.7%R.H in the first week of August of the first season; whereas it were 38.7 and 88.6% coinciding with 34.2□ C and 88% R.H in the first week of August of the second season.

Table (4): Correlation coefficient between percentages of infested sesame plants (leaves, flowers and capsules) by *A. catalaunalis*, with weather factors during the two study seasons of 2012 and 2013

Weather parameters	Correlation of infested sesame plant in 2012 season					
	Infested leaves%		Infested flowers%		Infested capsules%	
	(r) ± S.E	P	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (°C)	0.64±0.2	0.009	0.55±0.2	0.03	- 0.16±0.2	0.55
Mean R.H%	0.02±0.2	0.94	0.10±0.2	0.71	0.42±0.2	0.11
	Total larval population /infested leaves		Total larval population /infested flowers		Total larval population /infested capsules	
	(r) ± S.E	P	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (°C)	0.69±0.1	0.003	0.53 ±0.2	0.04	-0.15±0.2	0.57
Mean R.H (%)	0.02±0.2	0.94	0.10±0.2	0.71	0.42±0.2	0.11
	Correlation of infested sesame plant in 2013 season					
	Infested leaves%		Infested flowers%		Infested capsules%	
	(r) ± S.E	P	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (°C)	-0.26±0.2	0.33	-0.12±0.2	0.66	0.02±0.2	0.92
Mean R.H%	-0.11±0.2	0.68	-0.16±0.2	0.56	0.37±0.2	0.17
	Total larval population /infested leaves		Total larval population /infested flowers		Total larval population/ infested capsules	
	(r) ± S.E	P	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (°C)	-0.21±0.2	0.44	-0.01±0.2	0.96	0.06±0.2	0.81
Mean R.H (%)	-0.12±0.2	0.65	-0.09±0.2	0.73	0.40±0.2	0.13

r = Correlation coefficient
S.E. = Standard errors

Table (5): Rate of parasitism in *A. catalaunalis* larvae /20 Sesame tender shoots by *B. hebetor* during 2012 season at Ismailia Governorate

Sampling date	Mean Temp. □ C	Mean R.H.%	Total no. of collected larvae	No. of parasitized larvae	Parasitism %	Total no. of parasitoids cocoons*	Parasitoid emergence %
14-Jun.	37.8	86.7	21	0	0	0	0
21-Jun.	36.7	86	40	0	0	0	0
28-Jun.	37.2	86.2	90	12	11.7	74	63.5
05-Jul.	37.5	89	142	28	16.4	140	71.4
12-Jul.	37	87.7	182	68	27.2	407	82.3
19-Jul.	42.8	87.7	249	86	25.6	408	80.8
26-Jul.	39.8	87.8	302	115	27.5	650	86.1
02-Aug.	37	87.7	164	65	28.3	485	87.6
09-Aug.	38.4	87.7	147	57	27.9	390	84.6
16-Aug.	38.4	87.2	126	48	27.5	300	84
23-Aug.	38	88.7	88	32	26.6	200	76
30-Aug.	38.2	88.8	40	8	16.6	40	62.2
06-Sep.	36.7	88	0	0	0	0	0
13-Sep.	33.8	88.4	0	0	0	0	0
20-Sep.	36.4	86.5	0	0	0	0	0

*Summation of number of cocoons formed in the lab and in the field

Table (6): Rate of parasitism in *A. catalaunalis* larvae /20 Sesame tender shoots by *B. hebetor* during 2013 season at Ismailia Governorate

Sampling date	Mean Temp. □ C	Mean R.H %	Total no. of collected larvae	No. of parasitized larvae	Parasitism %	Total no. of parasitoids cocoons*	Parasitoid emergence %
10-Jun.	35.7	86.7	6	0	0	0	0
17-Jun.	33.4	85.2	24	0	0	0	0
24-Jun.	33.5	87	72	18	20	84	60.7
01-Jul.	36	88.4	131	45	25.5	140	71.4
08-Jul.	34.8	86.8	165	60	26.6	285	78.2
15-Jul.	31.4	86.1	189	95	33.4	408	80.8
22-Jul.	36.4	84.1	221	100	31.1	438	84.4
29-Jul.	37.5	89	260	140	35	480	86.4
05-Aug.	34.2	88	190	120	38.7	430	88.6
12-Aug.	31.8	74.1	144	68	32	300	84
19-Aug.	30.5	88.7	66	32	32.6	175	74.2
26-Aug.	38.4	89	40	20	33.3	40	62.5
02-Sep.	37.5	88.8	0	0	0	0	0
09-Sep.	35.8	86.4	0	0	0	0	0
16-Sep.	38	86.5	0	0	0	0	0

*Summation of number of cocoons formed in the lab and in the field

2.2. Parasitism rates in host larvae fed on leaves, flowers and capsules

The parasitism rate of *A. catalaunalis* larvae fed on sesame leaves, flowers and capsules by *B. hebetor* during the first season was detected for the first time in the last week of June at 13.6% in infested leaves and reached its maximum (32.5%) at the field conditions of 37□ C and 87.7% R.H in the first week of August. In infested flowers, the parasitism started in the third week in July (10.2%) and reached a maximum parasitism of 26.3% at 37 □ C and 87.7% R.H. In infested capsules, parasitism rate reached a maximum of 20% at field conditions of 38.2 □ C and 88.8% at the end of August. The highest overall parasitism rate (all infested plant parts) was 30.5% in the first week of August at 37 □ C and 87.7%R.H during the first season and 43.8% in the first week of August at 34.2 □ C and 88% R.H during the second study season (Table 7 and 8).

2.3. Effect of weather factors with larval population of *A. catalaunalis* on rate of parasitism

In the first season, percentage of parasitism in *A. catalaunalis* larvae fed on sesame branches had a positive significant correlation with temperature (r= 0.57) and with total larval population of *A. catalaunalis* (r = 0.82), while it had positively non- significant correlation (r = 0.36) with relative humidity. Whereas, in the second season, parasitism rates had negatively non-significant correlation with temperature (r = -0.36) or relative humidity (r= -0.10) but it had highly positive significant correlation with total larval population of *A. catalaunalis* (r = 0.86) (Table 9).

In the first season, temperature showed a significant positive effect (r = 0.52) on parasitism percentages of *A. catalaunalis* larvae in infested leaves. While it showed a positive non-significant effect (r = 0.39) on parasitism percentages of *A. catalaunalis* larvae in infested flowers and a negative non-significant effect (r = -0.12) on parasitism percentages of *A. catalaunalis* larvae in infested capsules. Relative humidity showed non- significant correlation with parasitism percentages of *A. catalaunalis* larvae in infested leaves, flowers and capsules (r = 0.34, 0.11and 0.10, respectively). Total larval population of *A. catalaunalis* showed highly significant correlation on parasitism percentages of *A. catalaunalis* larvae in infested leaves, flowers and capsules (r= 0.80, 0.83 and 0.92 respectively, Table 9). In the second season, temperature showed non-significant negative effect on parasitism percentages in host larvae fed on leaves, flowers and capsules (r = -0.17,-0.17 and 0.03, respectively). Also, relative humidity showed non-significant negative correlation with parasitism percentages in leaves and flowers (r= -0.11,-0.23, respectively) and non-significant positive effect (r = 0.13) in infested capsules. Meanwhile, parasitism percentages had highly significant positive effect with total number of *A. catalaunalis* larvae (r = 88, 78 and 97) on infested leaves, flowers and capsules respectively.

Table (7): Parasitism percentages of *A. catalaunalis* larvae /40 sesame leaves, flowers and capsules by *B. hebetor* during 2012 season at Ismailia Governorate

Date 2012	N*	Infested leaves			Infested flowers			Infested capsules			Total		
		Un-parasitized larvae	Parasitized larvae	Parasitism %	Un-parasitized larvae	Parasitized larvae	Parasitism %	Un-parasitized larvae	Parasitized larvae	Parasitism %	Un-parasitized larvae	Parasitized larvae	Parasitism %**
14-Jun.	40	10	0	0	0	0	0	0	0	0	10	0	0
21-Jun.	40	52	0	0	0	0	0	0	0	0	52	0	0
28-Jun.	40	95	15	13.6	0	0	0	0	0	0	95	15	13.5
05-Jul.	40	139	35	20.1	0	0	0	0	0	0	139	35	20.1
12-Jul.	40	185	76	29.1	30	0	0	0	0	0	215	76	26.1
19-Jul.	40	282	88	23.7	61	7	10.2	0	0	0	343	95	21.6
26-Jul.	40	211	90	29.9	118	33	21.8	0	0	0	329	123	27.2
02-Aug.	40	166	80	32.5	84	30	26.3	0	0	0	250	110	30.5
09-Aug.	40	112	45	28.6	54	18	25	24	0	0	190	63	24.9
16-Aug.	40	82	24	23.5	28	7	20	40	3	6.9	150	34	18.4
23-Aug.	40	48	12	20	14	2	12.5	49	6	10.9	111	20	15.2
30-Aug.	40	21	4	16	0	0	0	56	14	20	77	18	18.9
06-Sep.	40	0	0	0	0	0	0	38	6	13.6	38	6	13.6
13-Sep.	40	0	0	0	0	0	0	28	2	6.6	28	2	6.6
20-Sep.	40	0	0	0	0	0	0	20	0	0	20	0	0

N* indicates total number of inspected plant part each sampling interval
**overall percentage of parasitism in all inspected plant parts

Table (8): Parasitism percentages of *A. catalaunalis* larvae/40 Sesame leaves, flowers and capsules by *B. hebetor* during 2013 season at Ismailia Governorate**.**

Date 2012	N*	Infested leaves			Infested flowers			Infested capsules			Total infested on different parts of plant		
		Un-parasitized larvae	Parasitized larvae	Parasitism %	Un-parasitized larvae	Parasitized larvae	Parasitism %	Un-parasitized larvae	Parasitized larvae	Parasitism %	Un-parasitized larvae	Parasitized larvae	Parasitism % **
10-Jun.	40	4	0	0	0	0	0	0	0	0	4	0	0
17-Jun.	40	45	0	0	0	0	0	0	0	0	45	0	0
24-Jun.	40	77	20	20.6	0	0	0	0	0	0	77	20	20.6
01-Jul.	40	110	38	25.6	7	0	0	0	0	0	117	38	24.5
08-Jul.	40	160	80	33.3	30	0	0	0	0	0	190	80	29.6
15-Jul.	40	180	50	21.7	48	8	14.2	0	0	0	228	58	20.2
22-Jul.	40	201	100	33.2	76	34	30.9	0	0	0	277	134	32.6
29-Jul.	40	220	158	41.7	90	48	35.8	12	0	0	322	206	39
05-Aug.	40	152	85	35.8	61	20	24.6	24	2	7.6	137	107	43.8
12-Aug.	40	94	40	29.8	25	7	21.8	36	7	16.2	155	54	25.8
19-Aug.	40	66	17	20.4	10	2	16.6	48	9	15.7	124	28	18.4
26-Aug.	40	13	3	18.7	0	0	0	60	6	21	73	9	10.9
02-Sep.	40	0	0	0	0	0	0	38	7	15.5	38	7	15.5
09-Sep.	40	0	0	0	0	0	0	30	3	9	30	3	9
16-Sep.	40	0	0	0	0	0	0	14	0	0	14	0	0

N* indicates total number of inspected plant part each sampling interval
**overall percentage of parasitism in all inspected plant parts

Table (9): Correlation coefficient between climatic factors and total larval population of *A. catalaunalis* with parasitism rates by *B. hebeto*r in infested sesame branches, leaves, flowers and capsules in the two study seasons of 2012 and 2013

Parameters	Correlation of parasitism percentages of *A. catalaunalis* larvae/branches in the seasons of 2012 and 2013			
	Parasitism %2012		Parasitism %2013	
	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (^{o}C)	0.57±0.2	0.02	-0.36±0.2	0.18
Mean R.H (%)	0.36±0.2	0.18	-0.10±0.2	0.71
Total larval population	0.82±0.1	0.0002	0.86±0.1	0.0000

Parameters	Correlation of parasitism percentages of *A. catalaunalis* larvae in the season of 2012					
	% parasitism in infested leaves		% parasitism in infested flowers		% parasitism in infested capsules	
	(r) ± S.E	P	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (^{o}C)	0.52±0.2	0.04	0.39±0.2	0.14	-0.12±0.2	0.64
Mean R.H (%)	0.34±0.2	0.20	0.11±0.2	0.69	0.10±0.2	0.44
Total larval population	0.80±0.1	0.0003	0.83±0.1	0.0001	0.92±0.1	0.000

Parameters	Correlation of parasitism percentages of *A. catalaunalis* larvae in the season of 2013					
	% parasitism in infested leaves		% parasitism in infested flowers		% parasitism in infested capsules	
	(r) ± S.E	P	(r) ± S.E	P	(r) ± S.E	P
Mean Temp. (^{o}C)	-0.17±0.2	0.54	-0.17±0.2	0.52	-0.03±0.2	0.88
Mean R.H (%)	-0.11±0.2	0.68	-0.23±0.2	0.39	-0.13±0.2	0.64
Total larval population	0.88±0.1	0.0000	0.78±0.1	0.0005	0.97±0.06	0.0000

DISCUSSION

In this study, *A. catalaunalis* is considered a major pest for sesame plants. Results indicated that initial occurrence of *A. catalaunalis* larvae was observed in mid-June then increased gradually till capsule maturation (2nd or 3rd week of September). Kumar and Goel (1994b), Kumar *et al.* (2012) reported that *A. catalaunalis* as one of the key pests of sesame in India and it was active from seedling to harvesting stage of the crop. The population of *A. catalaunalis* larvae was higher in vegetative parts than flowering parts or capsules. These results agree with those reported earlier in several studies. For example, Mahadevan and Mahanasudaram (1986) reported that *A. catalaunalis* infested flowers more than pods and it might cause up to 53% seed loss. However, the present findings disagree with Muzaffar *et al*. (2002) who mentioned that the incidence of *A. catalaunalis* and its damage to sesame capsules was significantly greater than vegetative and flowering damage.

Temperature played an important role in influencing the period of development of *A. catalaunalis*. The effect of the tested weather factors on seasonal incidence of *A. catalaunalis* in the two studying successive seasons, determine the preferable time for the insect activity and the proper time for its control. Data showed that the mean temperature had a significant positive effect on percentages of infested branches, leaves and flowers or pest incidence (larval population/infested vegetative and flowers) except to capsules when temperature ranged between (33.8 - 42.8^{o}C) during the first season. The mean relative humidity between (86 - 89 %R.H) was insignificant negative relationship between percentages of infestation and larval population. These findings are in harmony with those reported by Vishnupriya *et al*. (2003) who mentioned that maximum and minimum temperature were positively correlated with pest incidence whereas the relative humidity showed a non-significant positive correlation with the pest incidence. Whereas, in the second season, when the temperature ranged between (31.4 - 37.5^{o}C) it showed non-significant negative relationship between temperature and percentages of infestation or larval population of infested vegetative and flowering except to capsules. The mean relative humidity between (84.1 - 89%) showed non- significant negative relationship with percentages of infestation or pest incidence during the two seasons. Kumar and Goel (1994b) reported that the average weekly temperature (28.85 -29.75^{o}C) and relative humidity (71.21 - 72.21%) were the most favorable environmental conditions for rapid population increase of *A. catalaunalis*. There was a strong negative correlation between larval population and maximum temperature and R.H. (Kumar *et al*., 2012). In cases of severe infestation, yield is affected considerably (Singh *et al.*, 1985; Singh *et al.,* 1986; Mahadevan and Mohanasoudaran, 1986; Chaudhry *et al.*, 1989; Baskaran and Thangavelu, 1991).

The occurrence and percentage of parasitism by *B. hebetor* varied during the two study successive seasons; being relatively higher in the second season. *B. hebetor* is known as a parasitoid of pyralid moth larvae infesting stored grains and field crops (Gupta and Sharma, 2004;

Shojaei *et al.,* 2006). However, little information is available on the seasonal occurrence of *A. Catalaunalis* or its parasitoids. Jakhmola (1983) recorded *B. hebetor* from *A. catalaunalis* during the field studies. Seasonal occurrence and field parasitism of *B. hebetor* indicated that during the two seasons, the parasitoid was not observed up to the last week of June. Rate of parasitism by *B. hebetor* varied among infested plant parts. Rates of parasitism were higher in the second season; being 41.7 and 38.7% in infested leaves and branches, and 35.8 and 21% in infested flowers and capsules. The higher rates of parasitism in host larvae fed on plant leaves are mainly due to two reasons. First the feeding habits in which larvae are more exposed and vulnerable to parasitoid adults than those concealed inside flowers and sesame capsules. Second, sesame flowers and capsules are available for short period of time as compared to sesame leaves.

It could be concluded that *A. catalaunalis* is a key pest for sesame crop in Egypt. Its population was strongly affected by the ambient temperature but not affected by relative humidity. Also, larval population varied in plant parts on which they were fed on. *B. hebetor* showed great potential as ecto-larval parasitoid for *A. catalaunalis* in Egypt. *B. hebetor* kill larvae of *A. catalaunalis* by parasitization and by host feeding that would undoubtedly, lead to suppress the natural population of this pest under field conditions.

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الظهور الموسمي لحفار قرون السمسم *Antigastra catalaunalis* (Duponchel) ومعدل التطفل لطفيل اليرقات الخارجي *Bracon hebetor* Say علي نباتات السمسم في محافظة الإسماعيلية

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تم إجراء تجارب حقلية لدراسة الظهور الموسمي لحفار قرون السمسم *Antigastra catalaunalis* (Duponchel) (Lepidoptera: Pyralidae)، ومعدل التطفل لطفيل اليرقات خارجي التطفل *Bracon hebetor* Say (Hymenoptera: Braconidae) المصاحب له علي نباتات السمسم وذلك خلال موسمين متتاليين (٢٠١٢ ، ٢٠١٣) بمحافظة الإسماعيلية. أظهرت النتائج أن يرقات حفار قرون السمسم بدأت الظهور في منتصف شهر يونيو ثم ازدادت تدريجيا حتى نهاية نضج المحصول في الأسبوع الثالث من شهر سبتمبر. كان أعلي نسب للأفرع والأوراق والأزهار والقرون المصابة هي ٧٥، ٧٢,٥، ٦٢,٥، ٤٧,٥٪ علي التوالي خلال الموسم الأول و ٧٠، ٧٠، ٥٥، ٤٥٪ علي التوالي خلال الموسم الثاني. كانت نسبة الإصابة أعلي في الأوراق والأفرع عنها في الأزهار والقرون. أظهرت درجات الحرارة المصاحبة ارتباطا معنويا إيجابياً علي نسب الإصابة وتعداد اليرقات علي الأفرع المصابة والأزهار خلال الموسم الأول بينما كان تأثير درجات الحرارة غير معنويا في الموسم الثاني. كان لدرجات الرطوبة النسبية المصاحبة تأثيرا غير معنويا علي نسب الإصابة وتعداد اليرقات خلال الموسمين. اختلفت نسب التطفل بالطفيل *B. hebetor* علي حسب الجزء من النبات المصاب بيرقات *A. catalaunalis* ، فكانت أعلي نسب للتطفل للأفرع المصابة والأوراق والأزهار والقرون هي ٢٨,٣، ٣٢,٥، ٣, ٢٦ ، ٢٠٪ علي التوالي خلال الموسم الأول، وازدادت نسبة التطفل لتصل إلي ٣٨,٧، ٤١,٧، ٨, ٣٥، ٢١٪ خلال الموسم الثاني علي التوالي.