POPULATION FLUCTUATIONS OF THE SPINY BOLLWORK, EARIAS INSULANA (BOISDUVAL); PINK BOLLWORM, PECTINOPHORA GOSSYPIELLA (SAUNDERS) AND THEIR ASSOCIATED PREDATORS

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Abstract

In 2008 cotton growing season, spiny bollworm infestation started in the 2nd week of July and continued until the 1st week of October. The peaks of insect infestation and larval population were recorded in the last week of July, the last week of August and the 2nd week of September. The maximum activity of the predators was during the 1st and 2nd week of August with mean number ranged 14-15 individual/10 plants. In 2009 cotton growing season, infestations by spiny bollworm started in the 1st week of July and extended to the 1st week of November with maximum activity was in the 1st week of August, the last week of August, the 3rd week of October and the 1st week of November. The greatest number of counted larvae was recorded on July-23, August-6, August-29 and October-19. Temperature and relative humidity were within the optimum range of spiny bollworm activity. Pink bollworm did not observe in 2008 cotton season; however, appeared to late in 2009 cotton growing season. In the second season, the pink bollworm recorded in cotton field on October, however, percentages of its infestation during the whole period of activity did not reach 10% (the economic threshold for bollworm control in Egypt). In 2009 season, the maximum abundance of associated predators was recorded in August-6 and August-29**.** At the end of cotton season (during October), natural predators did not observe in cotton field. Population of associated predators during the period of spiny bollworm activity was much influenced by the changes in the mean of minimum temperature especially in 2008 cotton growing seasons.

Introduction

In the last decade, cotton (*Gossypium barbadens*, Giza-80) was considered as a major fiber crop and Egyptian farmers were named it as white gold. However, during the last five years, Egyptian farmers do not prefer to cultivate cotton because of the high cost of pests control, the high cost of cotton hand picking (harvest) and the low price of cotton seed yield that offered by the Egyptian Ministry of Agriculture. Farmers in Egypt prefer to cultivate low cost crops such as clover and wheat during winter and corn, soybean and some vegetables during summer.

The cost of pest control is high because cotton plants are suffering insect infestations during the whole season, sucking insects (thrips and jassids) in the early season, cotton leafworm in the mid season and bollworms (spiny and pink bollworms) and some sucking pests (aphid and whitfly) in the late season. To minimize the use of conventional pesticides in controlling cotton pests, an integrated pest management of cotton's pests must be introduced. One of the approaches is using BT cotton; however, many countries including Egypt do not cultivate BT cotton because chemical control is effective, not only for controlling, lepidopterous pests, but equally for control of the other pests of cotton. Other approaches to rotate chemical control with the biological control agents. Mirmoayedi and Maniee (2009) in Iran used an integrated pest management of cotton's spiny bollworm (*Earias insulana*) by releasing 2nd instar larvae and eggs of green lacewing, *Chrysoperla lucasina* one month after spraying diazinon insecticide.

In Egypt spiny bollworm, *Earias insulana* (Boisd.) and pink bollworm, *Pectinophora gossypiella* (Saound.) are major pests of cotton and the greatest loss (20-40%) in cotton seed yield is related to the severe infestations with the two lepidopterous species [Ahmed (1980), Ghouri (1980), El-Saadany *et al.*, (1985) and Amin & Gergis, (2006)]. Spiny bollworm is a polyphagous pest on many economic crops, remain active through out the year and alternate host plants such as okra play an important role in the carryover of *Earias* spp. to cotton crop (Arian, 1974; Arif & Attique, 1990 and Bhatti *et al,* 2007). It was first recognized as pest of cotton in 1905 (Lefroy, 1909) and cotton plants is a preferred crop for this species (Saini & Singh, 2002). It was observed in the last three years (2007-2009 cotton growing seasons, Minia region, Egypt) that the spiny bollworm is more abundant than the pink bollworm**.** The reduction of pink bollworm populations is mostly related to the limited cultivated area with cotton and the burning of cotton plants after cotton picking. The phenology and physiology of the plants during the flowering and fruiting stages are the major factors affecting the abundance of bollworms**.** Bollworms appear in cotton after the appearing of squares and green bolls (mostly during July) and continued until the end of cotton season. Tamhankar (1995) in India confirmed the importance of the natural host or its odor for a short pre-mating period and a significant increase in mating frequency, number of

spermatophores transferred, number of oviposited eggs, and proportion of eggs fertilized. Spiny bollworm prefers fruits followed by squares to lay their eggs (Saini and Singh, 2002) that may be attributed to the presence of trichomes, and in some cases grooves, together with the favorable food factors. Literature searching revealed that weather factors especially temperature and relative humidity have great impact during crop season on the incidence and development of bollworm complex in cotton ecosystem (Sadaany *et al*., 1999; Bhatti *et al*., 2007 and Qureshi & Ahmed, 2009). Bhatti *et al.* (2007) in Pakistan reported that moth catches of *E. insulana* were negligible from January to early August. The peak activity period was from mid August to November with maximum infestation on green bolls (16.76%) at 28.61ºC and 48.17% RH. After November catches declined. *Earias* spp dominated from July to September, whereas, *P. gossypiella* dominated from mid-September to harvest. In addition, Qureshi and Ahmed (2009) in Pakistan observed the peak moth population and larval infestation of spotted and spiny bollworms in the months of August and October respectively. Insect populations increased with the developmental stages of the crop. Different color morphs of adult *Earias insulana* (Boisduval) could be induced under controlled environmental conditions in the laboratory (Klein, 1988). Ottai *et al.* (2004) in Egypt reported that roselle, *Hibiscus sabdariffa* L. varieties and cultivated locations significantly affected bolls infestation by spiny bollworm, *Earias insulana*.

Beneficial arthropods are a natural factor play an important role in managing the populations of insect pests. As reported by Burleigh *et al*. (1973) in USA**,** lady beetles, *Hippodamia* spp., were one of the main predators, with significantly more individuals being found in cotton adjacent to sorghum than in the cotton associated with corn and as the season progress, the level of beneficial organisms decline, except for the occurrence of lady beetles. Parasites were relatively not important for the control of lepidopterous pests on cotton and among the entomophagous insects, coccinellids were most numerous during the months June and July and the hemipterous predators were more abundant during August and September (Stam and Elmosa, 2006 in Syeria). Bhatti *et al.* (2007) reported that *Chrysoperla carnea,* general insect predator cause reasonable reduction in population of the bollworms. However, their efficacy decreases during the hot months. Smith *et al.* (1976) compared four methods of sampling beneficial arthropod populations in cotton in the Delta area of Mississippi and found all methods had similar population trends. Stam and Elmosa (2006) studied the relationship between insect pests and their predators and parasites in the Syrian cotton agro-ecosystem and found that when predator numbers were reduced with insecticide applications, a significant increase in the bollworm populations occurred, resulting in significant reductions in seed cotton yield.

The present study was conducted to monitor the dynamic fluctuations in bollworms population and their associated predators during 2008 and 2009 cotton seasons in relation to the records of main climatic factors (temperatures and percentages of relative humidity) in Minia-region, Egypt.

Materials and Methods

Cotton (*Gossypium barbadens*, Giza 80) was cultivated in Minia University Farm, (Minia, Egypt) in the 1st day of April during the two seasons of study (2008-2009). However, in 2009 season many missed plants were re-cultivated on April 20. An area 700 square meters did not receive any insecticidal applications during the whole cotton growing season and it was served as a control for all insecticide treatments and in the same time was used to monitor the populations of bollworms and their associated predators in 2008 and 2009 cotton growing seasons. Starting from June, a weekly five samples of 100 green bolls each were collected randomly from the four corners and the middle of the experimental area and observed morphologically to record bollworm infestations and then dissected to count the larvae. The weekly counts were continued until harvesting the cotton then burn the cotton stems. In the same time of counting bollworms, predators were counted on 500 plants (100 plants from each corner and the middle of the experimental area) by using direct count technique. Population fluctuations of insect pests and their predators were graphed and then analyzed in relation to tested weather factors (Maximum temperature, minimum temperature and percentages of relative humidity) using partial regression procedure. The partial regression method termed the C-multipliers was adopted according to Fisher (1950) using a computerized MSTATE and SPSS programs.

Results

1-Monitoring the populations of cotton bollworm and their associated predators during 2008-2009 cotton growing seasons in Minia University Farm

In 2008 cotton growing season, spiny bollworm infestation started in the 2nd week of July and extended until the 1st week of October (Table 1 and Figure 1). The maximum infestation was recorded in the last week of July, the last week of August and the 2nd week of September. During those three peaks, percentages of infestation were 34, 36 and 33%, respectively. In general, larval content was less than

percentages of bollworm infestation. However, similar trend with the maximum numbers of larvae was recorded in the last week of July (16 larvae/100 green bolls), the last week of August (16 larvae/100 green bolls) and the 2nd week of September (18 larvae/100green bolls). The maximum activity of the predators was during the 1st and 2nd week of August with mean number ranged 14-15 individual/10 plants.

In 2009 cotton growing season, infestations by spiny bollworm started in the 1st week of July and extended to the 1st week of November (Table 2 and Figure 2). Maximum infestation was in the 1st week of August (43%), the last week of August (32%), the 3rd week of October (36%) and the 1st week of November (39%). Mean number of counted larvae in 100 green bolls was the greatest on July-23, August-6, August-29 and October-19 (27, 27, 18 and 20 larvae/100 green bolls, respectively). The data collected from September, 8 until October, 5 are missed. The maximum abundance of associated predators was recorded in August, 6 and August, 29 (23 and 15/10plants, respectively). The natural enemies recorded in the recent study were common green lacewing, *Chrysoperla carnea* Stephens; paper wasp, *Polistes gallicus* L; oriental hornet, *Vespa orientalis* L; the potter wasp, *Eumenus maxillosa* (De Geer); predatory bug, *Orius albidipennis* Reuter; eleven spot ladybird, *Coccinella undecimpunctata* Linnaeus and lady beetle, *Scymnus syriacus* Marseul.

Pink bollworm did not observe in 2008 cotton season, however, was recorded to late in 2009 cotton season with less abundant than the spiny bollworm (Figs. 3 and 4). Pink bollworm appeared on cotton during the 2nd week of October and increased to reach the maximum infestation on October, 19 and backed to decrease on October, 27 with little increase on November, 3. Regardless the slight fluctuations in the pink infestation, however, percentages of infestation during the whole period of its activity did not reach 10%, (the economic threshold for bollworm control in Egypt). Compared to the pink bollworm infestation (<10%), spiny bollworm infested 36% of inspected bolls on October, 19. The maximum larval population for the two species was recorded On October, 19 (<10% and ~20% for pink and spiny bollworm, respectively (Figure 4).

2-Effect of the main climatic factors on the population density of spiny bollworm and their associated predators

2.1-Insect infestation in relation to tested climatic factors

Concerning the first season of the study, the simple correlations between insect infestation and the mean of maximum and minimum temperature were insignificantly positive in 2008 cotton growing season (Table 3). One unit increase in the mean of maximum and minimum temperature resulted in an increase in the infestation by 2.7 and 3.7%, respectively. In 2008 cotton season, mean percentages of infestation was negatively correlated with percentages of relative humidity; however, the correlation was insignificant. A unit increase in percentage of relative humidity resulted in very slight decrease in percentages of infestation (0.3%). Different trend was achieved in the second year of study. The simple correlation between percentages of infestation and mean of maximum temperature and minimum temperature was significantly negative (-0.6 and -0.54, respectively); however was significantly positive (0.68) with the relative humidity. A unit increase in each of the three parameters resulted in changing the rate of infestation by -3.2, -2.4 and +2.7%, respectively.

The analysis of partial regression revealed that the precise effects of these three factors were insignificant during the two years of the study. The simultaneous effect of the three weather factors (percentages of explained variance) did not exceed 24% in 2008 cotton growing season; however, elevated to reach 52.3% in the second season. From this data, it seemed that weather factors were within the optimum range of adult activity in mating and laying viable eggs. Means of maximum, minimum and percentages of relative humidity during the first season were 35.6, 20.9 ^{o}C and 63.3%, respectively compared to 35.3, 20.9 ^{o}C and 66.2%, respectively in the second season.

2.2-Larval population in relation to tested climatic factors

Simple correlation between the population of larvae and maximum temperature was insignificantly positive in 2008 and insignificantly negative in 2009. A unit increases in the mean of maximum temperature changed the population of larvae by +1.59 and -0.8 larvae /100 green bolls during the two successive seasons, respectively. The partial regression data revealed that the precise effect of this factor was insignificant during the two years of study. The simultaneous effect of the three weather factors on the population density of larvae did not exceed 17.4% and 24.3% in 2008 and 2009 cotton-growing seasons, respectively.

2.3-Predators's population in relation to tested climatic factors

As reported in Table (3), predator's population correlated positively with mean of maximum temperature; however, this positive effect was only significant in 2009 cotton growing season. Minimum temperature correlated positively and significantly with mean number of predators during the two successive years of study. Regarding the relative humidity, the correlation was insignificantly negative during the two years of the study. The partial regression data confirmed that the precise effect of these factors was insignificant except for mean of minimum temperature during 2008 cotton growing season. In this season, a unit increase in mean of minimum temperature resulted in increasing predator population counted on 10 plants by 2.7. Almost 50% of the fluctuation in predator population was related to the simultaneous effect of three weather factors since the explained variance was 55.30% and 47.95% in 2008 and 2009, respectively.

Discussion

Spiny bollworm population increased with the developmental stages of the cotton plants, infestation started on July, 2008 and extended until harvest with the maximum numbers of larvae was in the last week of July, the last week of August and the 2nd week of September. In 2009, the peaks of spiny bollworm larval population were on July,23; August, 6; August, 29 and October, 19. The data during the period from September, 8 until October, 5 are missed. The extending of spiny bollworm activity on cotton until the beginning of November in 2009 cotton season is probably because the delaying of flowering and fruiting of some plants that re-cultivated on April, 20. Pink bollworm was not observed in 2008 cotton season probably because seed cotton yield was picked in the beginning of October and then plants were collected and burned before the period of insect activity. Bhatti *et al.*, (2007) in Pakistan reported that the period of *E insulana* activity was from August to November with maximum infestation on green bolls (16.76%) at 28.61ºC, and 48.17% RH. After November, catches declined. *Earias* spp dominated from July to September, whereas, *P. gossypiella* dominated from mid-September to harvest. Also, Qureshi and Ahmed (2009) in Pakistan monitored the seasonal population fluctuation of spotted bollworm, *Earias vittella* (F.) and spiny bollworm, *E. insulana* (Boisd.) and found that the peaks of moth population and larval infestation of spotted and spiny bollworms was observed in the months of August and October, respectively.

In the current study, pink bollworm population was less abundant than spiny bollworm probably because the limited cultivated areas of cotton at Minia Governorate (Egypt) and the burning of cotton plants after harvest may be resulted in killing the diapausing larvae. From our opinion, populations of the two bollworms are mostly influenced by the presence of the host and the time of its mature stage. Climatic factors during the period of insect activity are less effective probably because they were in the optimum range of insect activity. We observed that the color of spiny bollworm adults changed from green during July-October to yellow during November as confirmed by Klein (1988) who observed adults of *Earias insulana* with grayish brown color at temperature ranged from17-33°C, however, temperatures above 33°C reversed forms of the grayish brown to the typical form of greenish blue moths.

Beneficial arthropods negatively affect the population of bollworms and other insect species. In the current study, the authors used the direct count technique for monitoring predator population. Smith *et al*. (1976) found that different methods are equally efficient for monitoring beneficial arthropods; however, sweep net and D-Vac was reported to be the less time-consuming methods. Stam and Elmosa (2006) studied the relationship between insect pests and their predators and parasites in the Syrian cotton agro-ecosystem and found that when predator numbers were reduced with insecticide applications, a significant increase in the bollworm populations occurred, resulting in significant reductions in seed cotton yields. In this study, the authors focused on the fluctuations of predators populations and found the greatest abundance of predators on August of the two successive seasons. Stam and Elmosa (2006) in Syria reported that among the entomophagous insects, coccinellids were most numerous during the months June and July and the hemipterous predators were more abundant during August and September. Bhatti *et al* (2007) reported that *Trichogramma chilonis*, the egg parasitoid and *Chrysoperla carnea,* general insect predator cause reasonable reduction in population of the bollworms. However, their efficacy decreases during the hot months. Weather factors particularly mean of night temperature were more effective on predator population than on the pest population. The explained variance for the effect of the three weather factors on the predator's population was 55.3 and 47.9% in 2008 and 2009 cotton seasons, respectively. In addition, biotic factors, may affect the population of predators in cotton fields. Burleigh *et al,* 1973 in USA reported that lady beetles, *Hippodamia* spp., were one of the main predators, with significantly more individuals being found in cotton adjacent to sorghum than in the cotton associated with corn. They also reported that as the season progressed, the level of beneficial organisms declined.

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Table (1): Population fluctuations in spiny bollworm and associated predators in relation to three weather factors (2008 cotton growing season, Minia region, Egypt).

Measured parameter	July 9	July 16	July 23	July 30	Aug. 6	Aug. 13	Aug. 20	Aug. 27	Sept. 3	Sept. 10	Sept. 17	Sept. 24	Oct. 1
%Infestation	10.0	21.0	34.0	23.0	30.0	28.0	27.0	36.0	30.0	33.0	22.0	8.0	8.0
%Larval content	4.0	11.0	12.0	16.0	15.0	14.0	12.0	16.0	11.0	18.0	12.0	4.0	4.0
Mean number of predators/10 plant	1.25	6.76	6.5	4.5	14.5	14.0	9.0	9.25	6.0	2.75	1.5	1.5	1.5
Max .Tem.	35.1	35.9	35.3	34.6	35.6	36.7	36.9	37.5	33.03	37.01	35.1	35.2	35.2
Min .Tem.	21.8	21.5	21.2	20.6	21.5	21.1	21.8	22.3	21.8	19.3	20.1	19.8	19.8
%RH	53.3	57.9	59.3	65	66.1	63.1	60.9	61	72.3	56	68.8	69.4	69.4

Table (**2**): Population fluctuations in spiny bollworm and associated predators in relation to three weather factors (2009 cotton growing season, Minia region, Egypt).

Measured parameter	July 1	July 8	July 15	July 23	July 30	Aug. 6	Aug. 15	Aug. 22	Aug. 29	Sept. 5	Oct. 12	Oct. 19	Oct. 26	Nov. 3
%Infestation	2	15	17	31	34.5	43	26	26	32	17	23	36	30	39
%Larval content	3	9	16	27	11	27	7	14	18	1	8	20	15	16
Mean number of predators/10 plant	13	7	12	14	19	23	9	12	15	6	0	0	0	0
Max .Tem.	38.3	37.6	36.8	37.6	36.6	35.3	35.1	35.3	34.3	36.3	32.9	32	34.9	31.8
Min .Tem.	23.7	23.6	24.02	23.3	22	22.4	20.9	20.4	19.3	22	18.9	18.8	18.6	15.8
%RH	61.3	62.1	65.1	65.9	64.4	69.1	68.1	64.4	68.6	65.4	69.4	70.4	65.7	66.5

Table (3): Effect of both temperature and relative humidity on spiny bollworm population and its associated predators on cotton (Minia University Farm, the 2008-2009).

Year	Measured parameter	Weather factors	Simple correlation and regression values					Partial regression values				Analysis variance			
			r	b	S.E	t	p	P.reg	S.E	t	p	F value	MR	R^2	E.V%
2008	%Infestation	Max. temp	0.33	2.71	2.33	1.16	0.27	3.08	2.86	1.08	0.31	0.95	0.49	0.24	24.04
		Min. temp	0.37	3.74	2.88	1.30	0.22	3.83	3.08	1.24	0.24				
		R.H.%	-0.18	-0.30	0.50	-0.60	0.56	0.20	0.60	0.32	0.75				
	%Larval content	Max. temp	0.40	1.59	1.10	1.44	0.18	1.76	1.45	1.21	0.26	0.63	0.42	0.17	17.36
		Min. temp	0.12	0.59	1.49	0.39	0.70	0.59	1.56	0.37	0.72				
		R.H.%	-0.18	-0.15	0.24	-0.61	0.56	0.08	0.31	0.25	0.81				
	No. of predators/ 10plant	Max. temp	0.4	1.41	1.08	1.31	0.22	2.21	1.03	2.14	0.06	3.71	0.74	0.55	55.28
		Min. temp	0.6	2.70	1.20	2.24	0.05	3.06	1.11	2.75	0.02				
		R.H.%	-0.03	-0.02	0.24	-0.10	0.92	0.34	0.22	1.58	0.15				
2009	%Infestation	Max. temp	-0.60	-3.23	1.24	-2.62	0.02	3.09	4.60	0.67	0.52	3.65	0.72	0.52	52.25
		Min. temp	-0.54	-2.43	1.09	-2.22	0.05	-2.96	2.97	-1.00	0.34				
		R.H.%	0.68	2.74	0.86	3.17	0.01	3.09	1.69	1.82	0.10				
	%Larval content	Max. temp	-0.21	-0.80	1.09	-0.74	0.47	1.81	4.15	0.44	0.67	1.07	0.49	0.24	24.33
		Min. temp	-0.10	-0.31	0.93	-0.34	0.74	-0.43	2.68	-0.16	0.88				
		R.H.%	0.45	1.30	0.75	1.73	0.11	2.14	1.53	1.40	0.19				
	No. of predators/ 10plant	Max. temp	0.57	0.21	0.09	2.41	0.03	0.35	0.33	1.06	0.31	3.07	0.69	0.48	47.95
		Min. temp	0.62	0.19	0.07	2.75	0.02	0.02	0.21	0.09	0.93				
		R.H.%	-0.18	-0.05	0.08	-0.63	0.54	0.16	0.12	1.33	0.21				

r = Simple correlation b = Simple regression p.reg = Partial regression
MR = Multiple correlation R^2 = Coefficient of determination E.V% = Explained variance

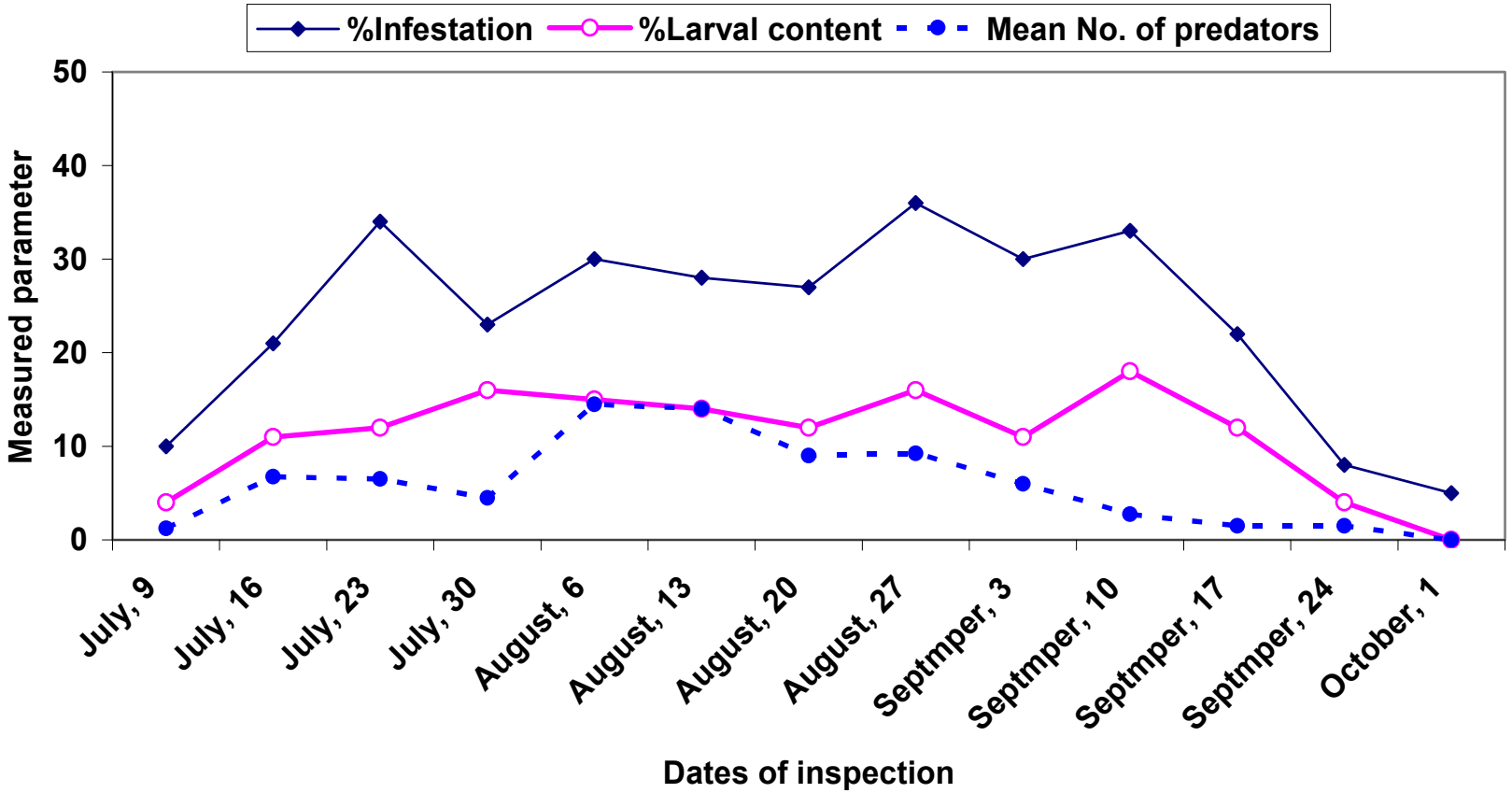

Figure 1. Population fluctuations of the spiny bollworm and the associated predators in 2008 cotton season (Minia region, Egypt).

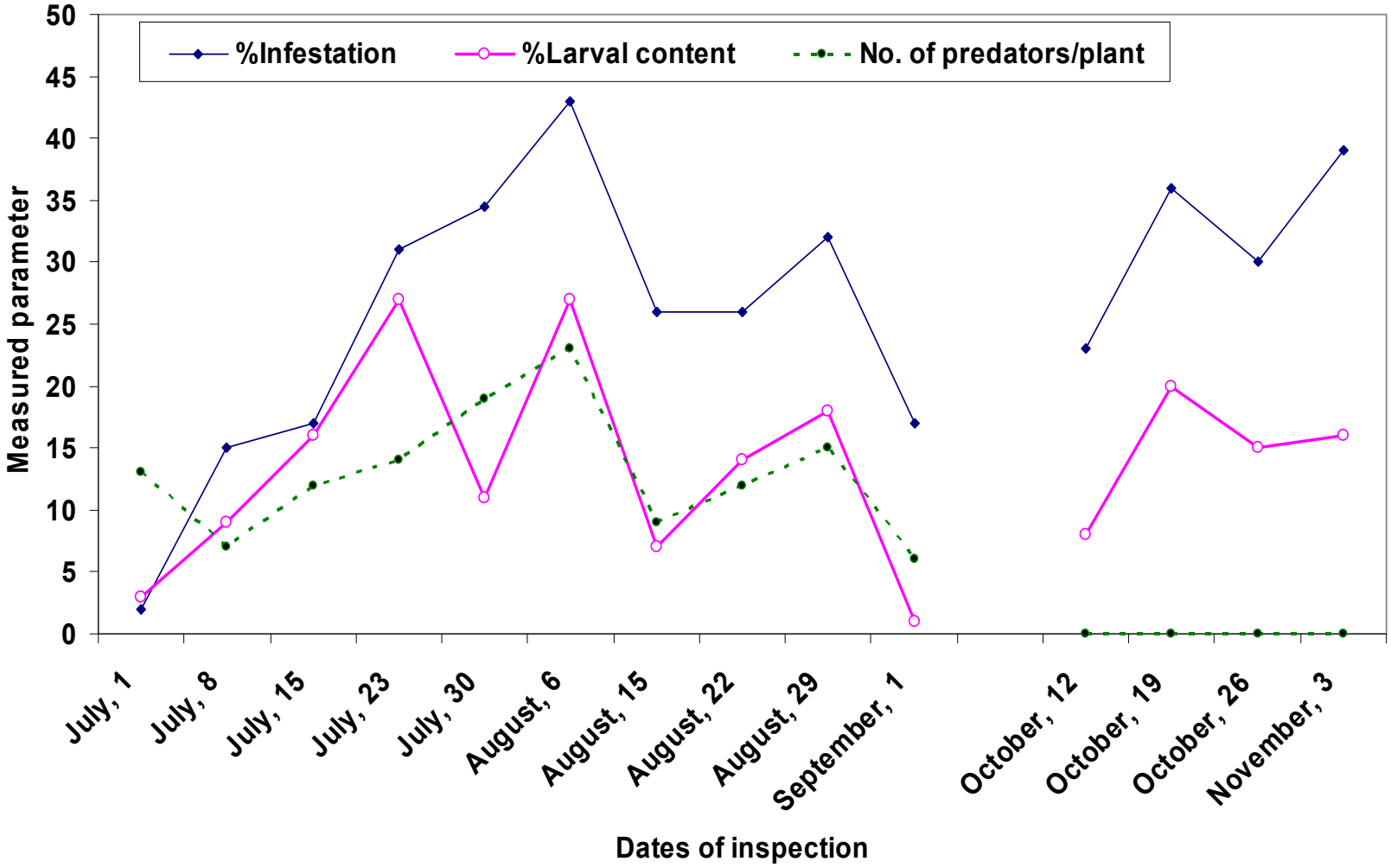

Figure 2. Population fluctuations of the spiny bollworm and the associated predators in 2009 cotton season (Minia region, Egypt).

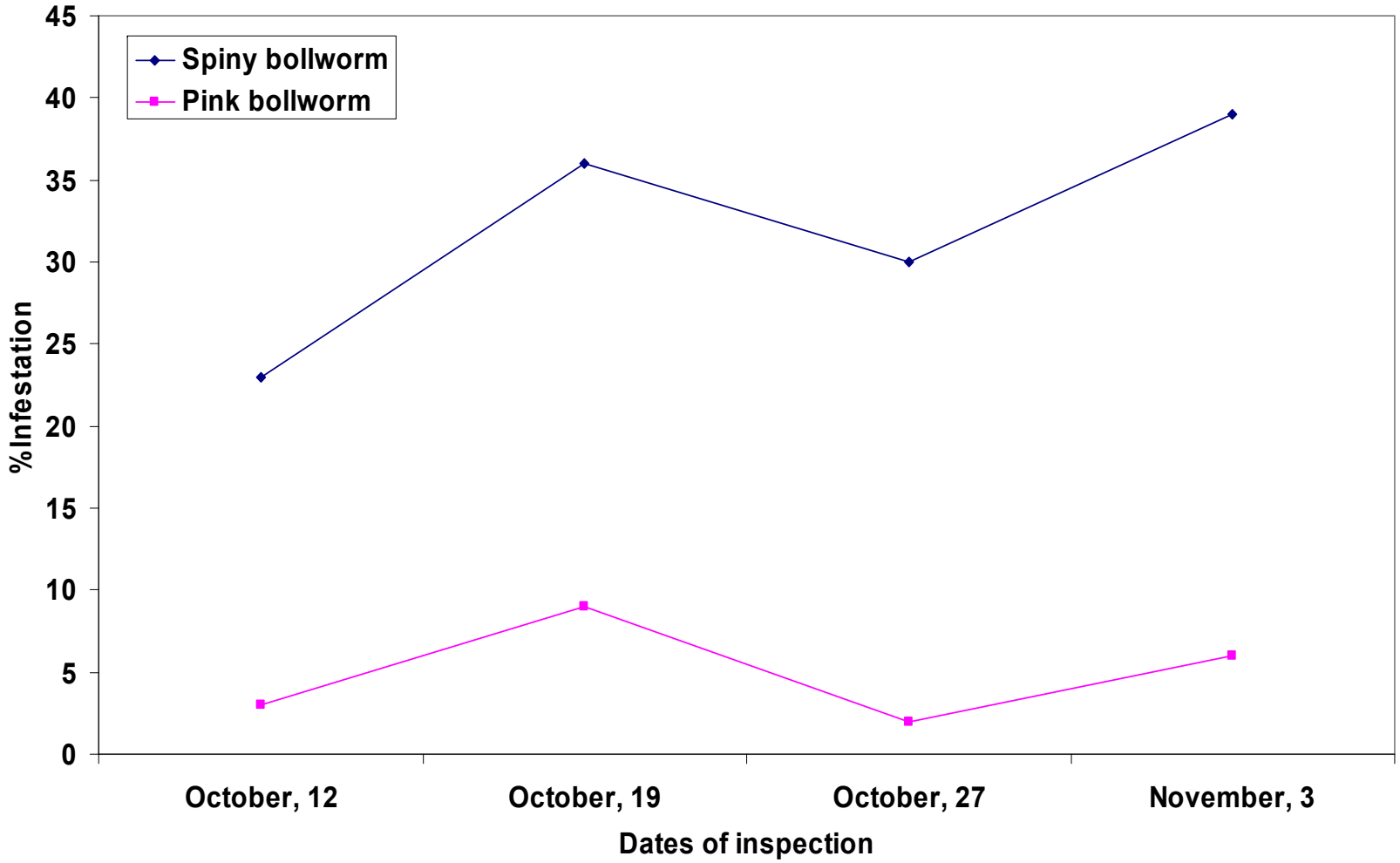

Figure 3. Percentages of pink and spiny bollworm infestations during the period of pink bollworm activity.

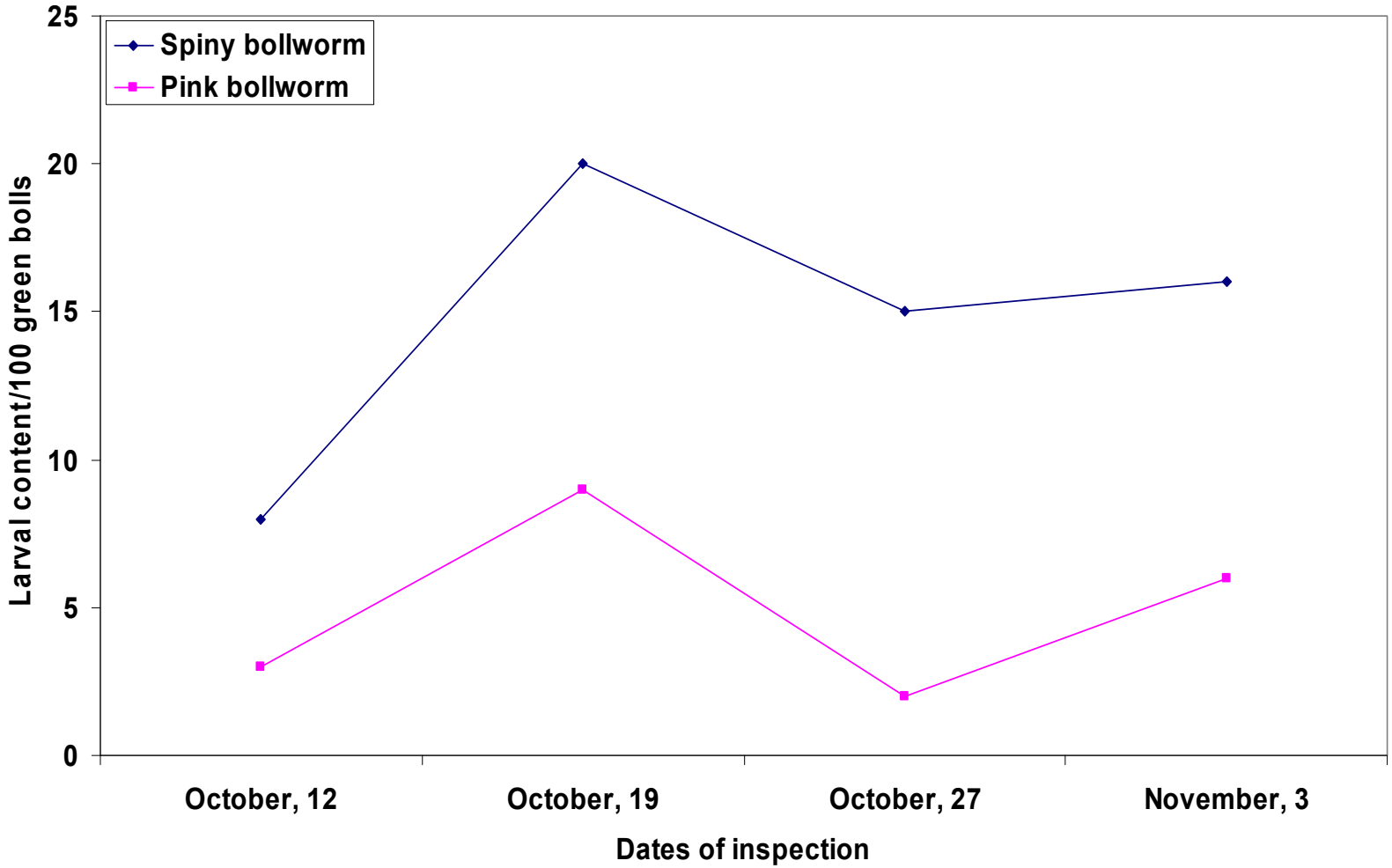

Figure 4. Mean number of pink and spiny bollworms larvae counted in 100 green bolls during the period of pink bollworm activity.