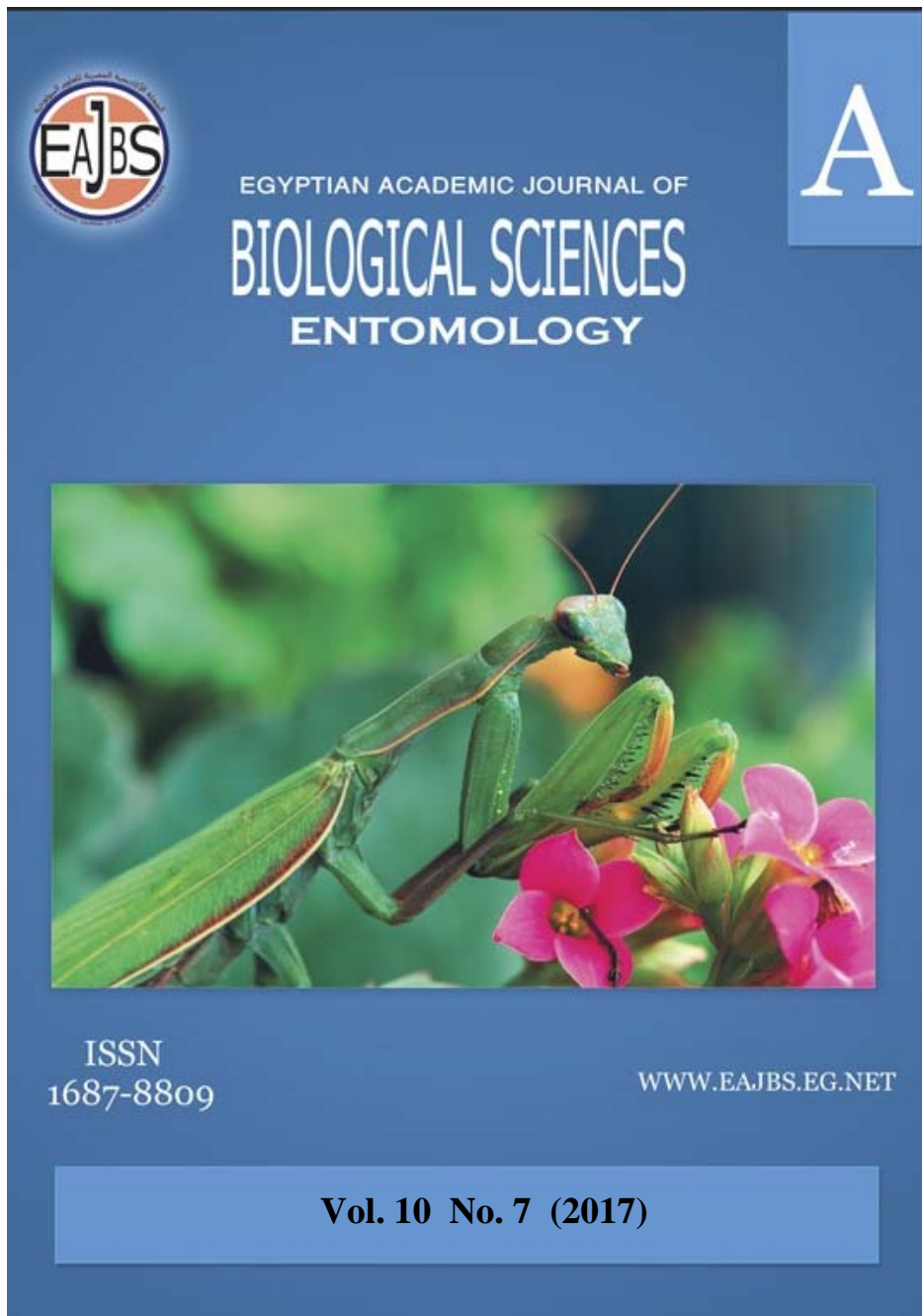
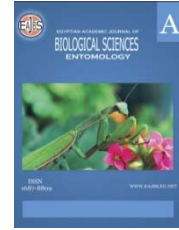


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Ecological Studies on Cotton Mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) on Eggplant at Sharkia Governorate, Egypt

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ABSTRACT

Field experiments were conducted on cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) which infested eggplant at Hihya district, Sharkia Governorate during two successive seasons 2015 and 2016. The population density, activity periods, the effects of some weather factors, number of insect generations and preferable leaf surface of of *P. solenopsis* were considered. The obtained results revealed that the total numbers of a live stages had four peaks of activity during the first season. They were in third week of June, third week of July, fourth week of August and second week of September. While, during the second season, three peaks of activity were noticed in the last week of June, first week of August and second week of September. The total effects of some weather factors such as maximum and minimum air temperature (°C) and relative humidity percentage (R.H.%) showed positive significant relationship with the cotton mealybug population. *P. solenopsis* had three generations during the first and second seasons the first generation was taken seven weeks. While, the second and third generations took six weeks. The first generation was during the period extended from the third week of May till the end of June, the second one took place from the first week of July till the second week of August and the third one was during the period extended from the third week of August till the third week of September. The insect pest preferred the lower leaf surface than the upper one during the first and second seasons.

INTRODUCTION

The solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) was described by Tinsley from weed roots in a nest of the ant *Solenopsis geminata* Fabricius in New Mexico, U.S.A in 1898. This highly polyphagous mealybug attacks major menace in many tropical and subtropical countries. It attacking 159 hosts plant species (agricultural and horticultural crops) belonging to 21 different families. It cause yield loss by direct and indirect infestation. In direct mode of infestation they feed on leaves, stems, fruits and roots of host plants causing general weakening, defoliation and death of

susceptible plants. Whereas in indirect mode of infestation they secrete honey dew which causes development of sooty mould which inhibit photosynthesis which leads to host plant death. may also damage plants by serving as vector of plant diseases (Hodgson *et al.*, 2008, Arif *et al.*, 2009, Saini *et al.*, 2009, Abbas *et al.*, 2010, Wang *et al.*, 2010 and Vennila *et al.*, 2011).

The first record of *P. solenopsis* damaging a crop was made by Fuchs *et al.* (1991) who recorded *P. solenopsis* on cotton cultivated in Texas, U.S.A. The *P. solenopsis* has been found on a relatively wide variety of host plants including species of economically important families such as Cucurbitaceae, Fabaceae, Solanaceae and Malvaceae (Culik and Gullan, 2005, Afzal *et al.*, 2009, Wang *et al.*, 2009 & 2010 and Zhu *et al.*, 2011). Aheer *et al.* (2009) reported 22 host plants of *P. solenopsis*, besides cotton crop in Pakistan. Maximum prevalence was observed on China rose, *Hibiscus chinensis* followed by okra, *Abelmoschus esculentus* L. (Malvaceae) (Wang *et al.*, 2010).

In Egypt, the first record of *P. solenopsis* infestation was on weed plants by Abd-Rabou *et al.* (2010). Ibrahim *et al.* (2015) recorded *P. solenopsis* for the first time on tomato plants at Qalyoubia Governorate. Nabil *et al.* (2015) registered *P. solenopsis* for the first time on four economical crops okra, *A. esculentus*, eggplant, *Solanum melongena* L. (Solanaceae), maize, *Zea mays* L. (Poaceae) and nalta jute (meloukhia), *Corchorus olitorius* L. (Malvaceae) at Hihhya distract, Sharkia Governorate, Egypt.

Therefore, the present investigation was planned with the aim of studying the population density and activity periods of different stages of *P. solenopsis* on eggplant. Evaluate the effects of some weather factors on the different stages of the pest. Calculate the number of generations and estimate the preferable leaf surface. Such study may help for designing a comprehensive pest management program and prediction models for the cotton mealybug.

MATERIALS AND METHODS

Filed experiments were carried out on eggplant field located at Hihhya district, Sharkia Governorate, Egypt. The study was continued from May to September for two successive seasons 2015-2016 to assess the population density of cotton mealybug, *Phenacoccus solenopsis* Tinsley by counting the number of nymphs and adult female. The study was conducted in an area of about one feddan for eggplant, *Solanum melongena* L. (Solanaceae). The field received normal agricultural practices and no chemical control was applied.

Population density and number of generations:

For sampling, forty leaves were picked up at random once a week, the samples were put in polyethylene bags and transferred into the laboratory for carefully inspection. These samples were examined in the same day using a stereomicroscope whereas the different stages of *P. solenopsis* were counted and recorded. The formula proposed by Audemard and Milaire (1975) and emended by Jacob (1977) was applied for estimating the number of *P. solenopsis* generations and their durations. Data of weekly counts of nymphal stage were indicated on millimeter papers to calculate the number of generations and their duration.

Effects of some weather factors on the insect populations:

The prevailing air temperature, maximum and minimum air temperature (°C) and relative humidity percentage (RH %) in the experimental area during the periods of the present study were obtained from the Central Laboratory for Agricultural

Meteorology, Agricultural Research Center, Ministry of Agriculture. The relationships between the tested weather factors and each insect population were studied.

Statistical analysis:

Simple correlation, partial regression values and coefficient of determination percentage (C.D. %) were calculated using COSTAT Computer Program (2005).

RESULTS AND DISCUSSION

Population density of *Phenacoccus solenopsis* on eggplant:

Females population density:

Data given in Tables (1 & 2) and Figs. (1 & 2) showed that in the first season (2015) the females had two peaks of activity in the last week of June (317 females / 40 leaves) and in the last week of August (726 females).

While, in the second year (2016) three peaks of females activity were noticed in first week of June, first week of July and first week of September with values of 100, 206 and 523 females, respectively.

In general, the total number of females was higher (5386 females) in the first season than the second one with total number of 3711 females.

Nymphs population density

Results arranged in Tables (1 & 2) and Figs. (1 & 2) demonstrated that nymphs had four peaks of activity were recorded during the first and second seasons. There were in the third week of June, third week of July, fourth week of August and second week of September with values of 1820, 2969, 11636 and 14458 nymphs, consecutively. Also, in the second season four peaks of activity were recorded during last week of May & June and during first week of August & September with 505&2205 and 2561 & 12796 nymphs, successively.

Generally, the highest total number of nymphs population 81463 nymphs was obtained during the first season compared with 58157 nymphs during the second one.

Total number of alive stages:

As shown in Tables (1 & 2) and Figs. (1 & 2) the total number of alive stages showed four peaks of activity during the first season. They were in third week of June, third week of July, fourth week of August and second week of September with values of 1912, 3219, 12315 and 14795 individuals, consecutively. While, during the second season, three peaks of activity were noticed in the last week of June, first week of August and second week of September with 2409, 2758 and 13150 individuals, respectively.

In general, the highest total number of alive stages was 86849 individuals obtained in the first season compared with 61868 individuals in the second season.

Obtained results are in agreement with the finding of Jaydeep *et al.*, 2015 who studied the occurrence of *P. solenopsis* on some vegetables ecosystem such as tomato, brinjal (eggplant) and okra. They founded that the mealybug was observed to infest brinjal during July to August.

Table (1): Population density of *Phenacoccus solenopsis* Tinsley on eggplant at Hihhya distract, Sharkia Governorate during the first season (2015).

Date	Number of insects / 40 leaves			Monthly average of climatic factors		
	Females	Nymphs	Total alive stages	Max. Temp. (°C)	Min. Temp. (°C)	RH (%)
18/5/2015	0	19	19	31.4	15.4	50.0
25/5/2015	3	73	76	35.7	19.3	41.7
1 /6/2015	14	298	312	34.0	19.2	38.4
8 /6/2015	27	687	714	34.2	18.3	48.7
15/6/2015	92	1820	1912	32.8	18.4	54.0
22/6/2015	120	1495	1615	35.2	19.4	47.6
29/6/2015	317	1103	1420	33.5	18.4	48.3
6 /7/2015	305	1629	1934	34.3	18.9	55.0
13/7/2015	234	2916	3150	34.8	19.4	53.3
20/7/2015	250	2969	3219	36.9	21.1	54.4
27/7/2015	320	1121	1441	38.0	22.0	45.0
3 /8/2015	366	2492	2858	39.3	23.9	53.1
10/8/2015	390	5490	5880	40.1	25.7	45.7
17/8/2015	432	7707	8139	39.6	24.9	45.3
24/8/2015	679	11636	12315	37.2	22.3	60.1
31/8/2015	726	11413	12139	35.4	20.8	56.1
7 /9/2015	469	9824	10293	35.6	19.8	52.6
14/9/2015	337	14458	14795	38.6	22.3	62.6
21/9/2015	305	4313	4618	35.7	21.7	48.1
Total	5386	81463	86849			

Table (2): Population density of *Phenacoccus solenopsis* Tinsley on eggplant at Hihhya distract, Sharkia Governorate during the second season (2016).

Date	Number of insects / 40 leaves			Monthly average of climatic factors		
	Females	Nymphs	Total alive stages	Max. Temp. (°C)	Min. Temp. (°C)	RH (%)
14/5/2016	1	26	27	32.4	20.0	37.6
21/5/2016	8	46	54	35.3	23.6	28.9
28/5/2016	74	505	579	32.0	19.7	40.7
4 /6/2016	100	487	587	35.6	22.4	34.9
11/6/2016	86	1524	1610	36.1	23.0	38.6
18/6/2016	67	1650	1717	36.0	24.0	45.0
25/6/2016	204	2205	2409	37.1	24.6	49.6
2 /7/2016	206	1603	1809	35.4	24.3	57.7
9/7/2016	160	1631	1791	35.0	24.7	57.6
16/7/2016	152	1092	1244	36.0	25.3	51.7
23/7/2016	134	1311	1445	34.6	25.0	54.0
30/7/2016	174	1974	2148	34.9	24.7	56.7
6 /8/2016	197	2561	2758	36.3	25.7	55.7
13/8/2016	200	1814	2014	34.7	25.7	58.0
20/8/2016	405	6205	6610	34.9	25.3	57.4
27/8/2016	465	6730	7195	35.1	24.3	58.6
3 /9/2016	523	8797	9320	33.6	24.6	60.1
10/9/2016	354	12796	13150	33.6	24.1	55.6
17/9/2016	201	5200	5401	34.3	24.0	58.0
Total	3711	58157	61868			

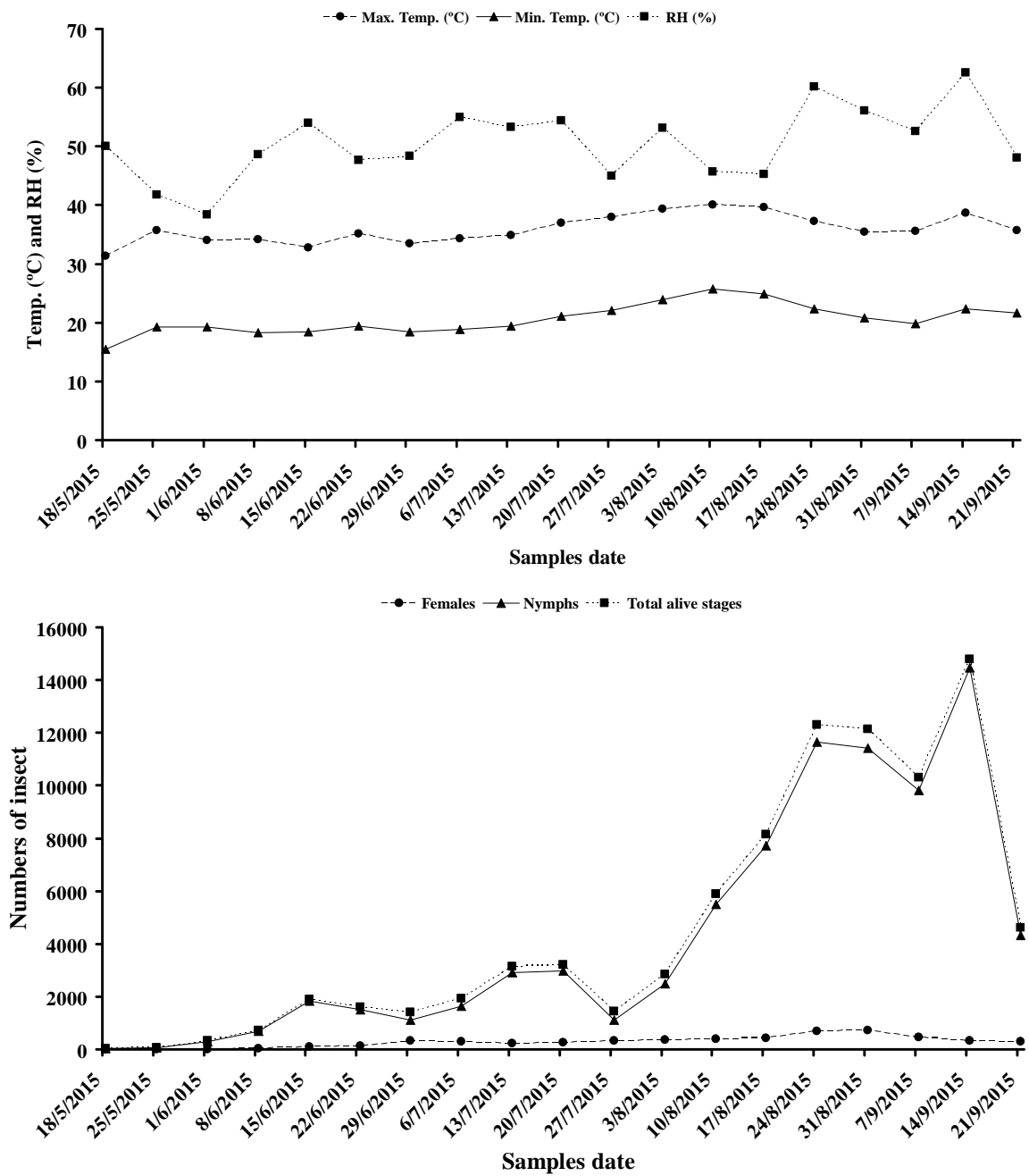


Fig. (1): Population density of *Phenacoccus solenopsis* Tinsley on eggplant at Hihhya distract, Sharkia Governorate during the first season (2015).

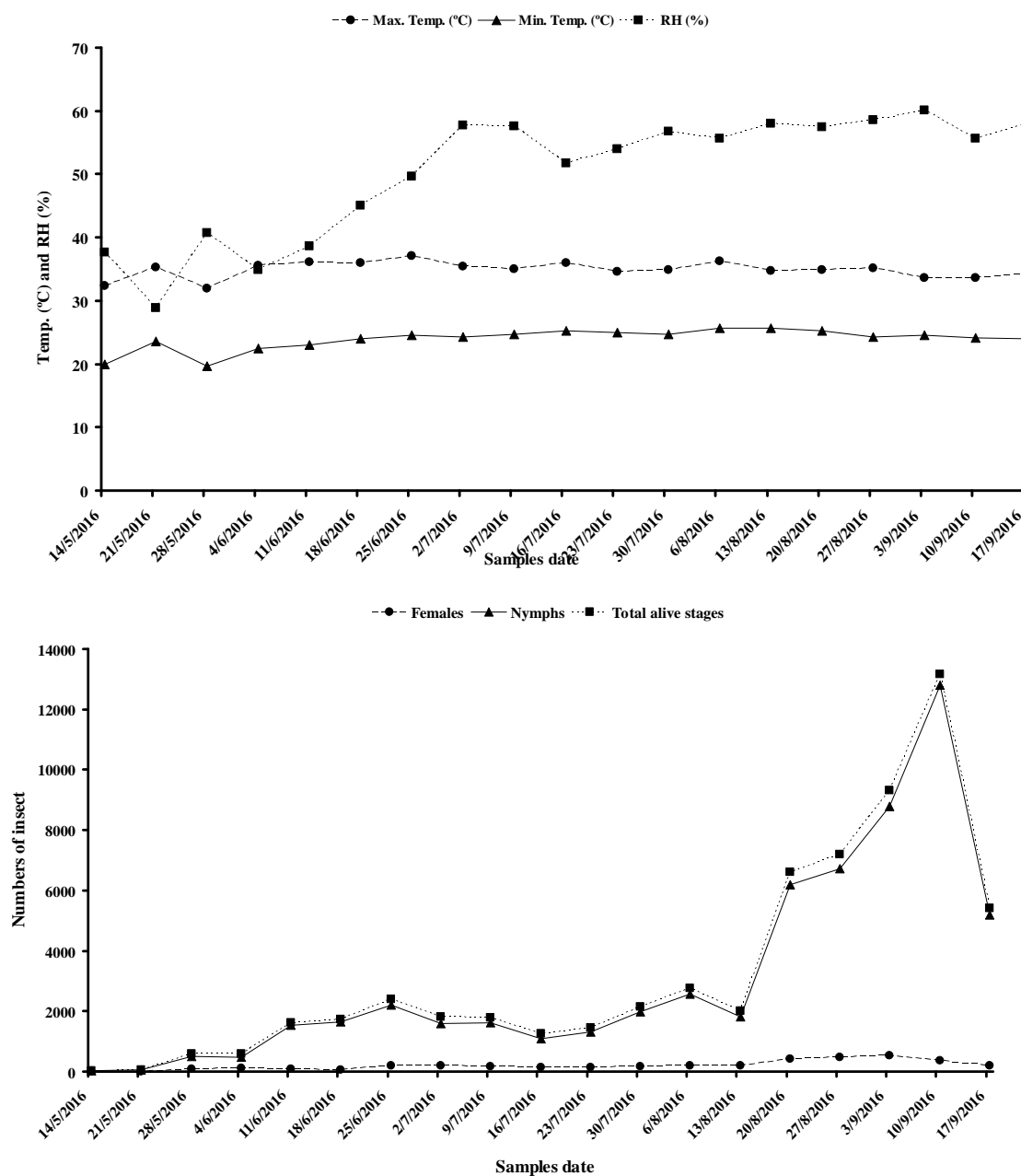


Fig. (2): Population density of *Phenacoccus solenopsis* Tinsley on eggplant at Hihhya distract, Sharkia Governorate during the first season (2016).

Effects of some weather factors on different stages of *P. solenopsis* :

Females population density:

Results presented in Table (3) indicated that in the first season each of maximum temperature, minimum temperature and relative humidity had positive significant, positive highly significant and positive significant effects on females population where $r = 0.508^*$, 0.579^{**} and 0.517^* , respectively.

While, in the second season minimum temperature and relative humidity had a positive significant and positive highly significant effects on females population where $r = 0.471^*$ and 0.725^{**} , consecutively. Coefficient of determination (C.D. %) obviously cleared that the three considered weather factors affected females population by 62.42 and 52.72%, in the first and second seasons, successively.

Nymphs population density:

As shown in Table (3) in the first season each of maximum temperature, minimum temperature and relative humidity had positive significant, positive significant and positive highly significant effects on nymphs population where $r = 0.473^*$, 0.485^* and 0.638^{**} , consecutively. While, in the second season only relative humidity had a positive significant effect on nymphs population where $r = 0.546^*$. According to C.D.% nymphs population were affected by 61.32 and 30.89 % during the first and second seasons, respectively.

Total number of alive stages density:

Data given in Table (3) revealed that in the first season each of maximum temperature, minimum temperature and relative humidity had positive significant, positive significant and positive highly significant effects on total number of alive stages where $r = 0.479^*$, 0.494^* and 0.638^{**} , consecutively. While, in the second season relative humidity only had a positive highly significant effect ($r = 0.613^{**}$). Coefficient of determination percentage demonstrated that the total number of alive stages was influenced by 62.28 and 37.90% during the first and second seasons, respectively.

These results are in agreement with those obtained by Suresh and Kavitha, 2008b, Dhawan *et al.*, 2009, Jeyakumar *et al.*, 2009, Hanchinal *et al.*, 2010, Patil *et al.*, 2011, Singh and Kumar, 2012 and Hameed *et al.*, 2014 who mentioned that cotton mealybug population showed positive significant relationship with maximum temperature, minimum temperature and R.H.%.

Table (3): Statistical analysis based on correlation coefficient and multiple regression indicating the effects of climatic factors on different stages of *Phenacoccus solenopsis* Tinsley on eggplant at Hihhya distract, Sharkia Governorate during the first (2015) and second (2016) seasons.

	Max. Temp. (°C)	Min. Temp. (°C)	RH (%)	Coefficient of Determination (C.D. %)
1st season (2015)				
Number of females	0.508 *	0.579 **	0.517 *	62.42
Number of nymphs	0.473 *	0.485 *	0.638 **	61.32
Total number of alive stages	0.479 *	0.494 *	0.638 **	62.28
2nd season (2016)				
Number of females	- 0.049	0.471 *	0.725 **	52.72
Number of nymphs	- 0.215	0.291	0.546 *	30.89
Total number of alive stages	- 0.027	0.377	0.613 **	37.90

Number of generations:

Data given in Table (4) and Figs. (3 & 4) revealed that *P. solenopsis* had three generations during the first and second seasons. The first generation was taken seven weeks. While, the second and third generations took six weeks. The first generation was during the period extended from the third week of May till the end of June. While, the second one took place from the first week of July till the second week of August and the third generation was during the period extended from the third week of August till the third week of September.

Our findings are in agreement with the results of Fand and Suroshe, 2015 who reported that *P. solenopsis* can complete about 8 - 12 generations in a year on cotton plants, *Gossypium hirsutum* L.

Table (4): Generations and durations of *Phenacoccus solenopsis* Tinsley on eggplant at Hihya distract, Sharkia Governorate during the first (2015) and second (2016) seasons.

Weeks	First season				Second season			
	Accumulated days of investigation	weekly counts of nymphs per 40 leaves	Accumulated weekly counts	Accumulated insects %	Accumulated days of investigation	weekly counts of nymphs per 40 leaves	Accumulated weekly counts	Accumulated insects %
1 st week	7	19	19	0.02	7	26	26	0.04
2 nd week	14	73	92	0.11	14	46	72	0.12
3 rd week	21	298	390	0.48	21	505	577	0.99
4 th week	28	687	1077	1.32	28	487	1064	1.83
5 th week	35	1820	2897	3.56	35	1524	2588	4.45
6 th week	42	1495	4392	5.39	42	1650	4238	7.29
7 th week	49	1103	5495	6.75	49	2205	6443	11.08
8 th week	56	1629	7124	8.75	56	1603	8046	13.83
9 th week	63	2916	10040	12.32	63	1631	9677	16.64
10 th week	70	2969	13009	15.97	70	1092	10769	18.52
11 th week	77	1121	14130	17.35	77	1311	12080	20.77
12 th week	84	2492	16622	20.40	84	1974	14054	24.17
13 th week	91	5490	22112	27.14	91	2561	16615	28.57
14 th week	98	7707	29819	36.60	98	1814	18429	31.69
15 th week	105	11636	41455	50.89	105	6205	24634	42.36
16 th week	112	11413	52868	64.90	112	6730	31364	53.93
17 th week	119	9824	62692	76.96	119	8797	40161	69.06
18 th week	126	14458	77150	94.71	126	12796	52957	91.06
19 th week	133	4313	81463	100.00	133	5200	58157	100.00

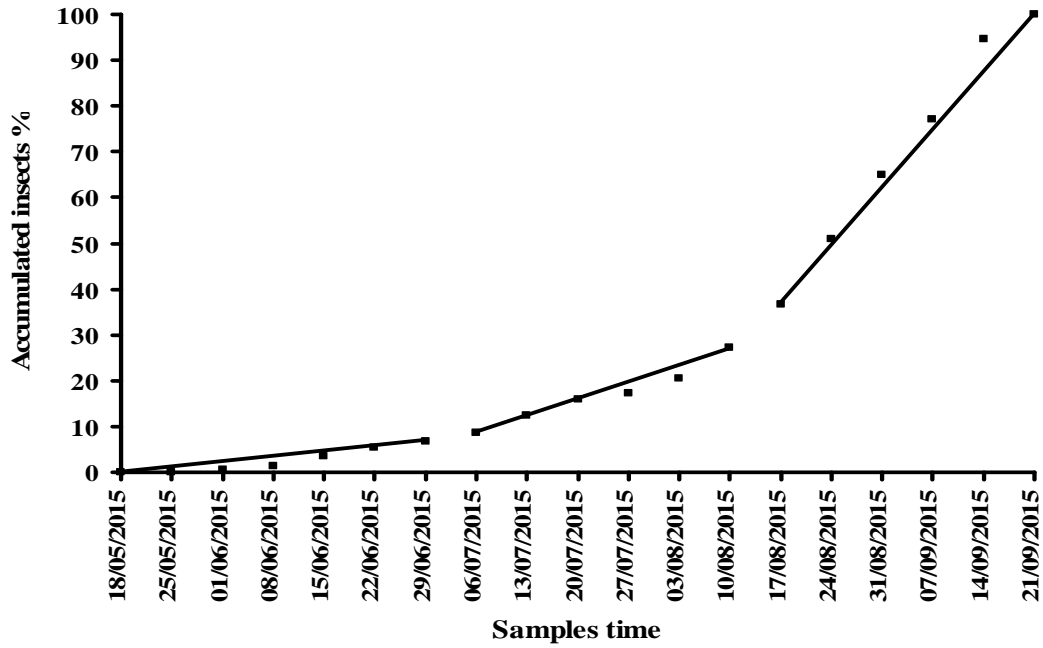


Fig.(3): Generations and durations of *Phenacoccus solenopsis* Tinsley on eggplant at Hihhya distract, Sharkia Governorate during the first season (2015)

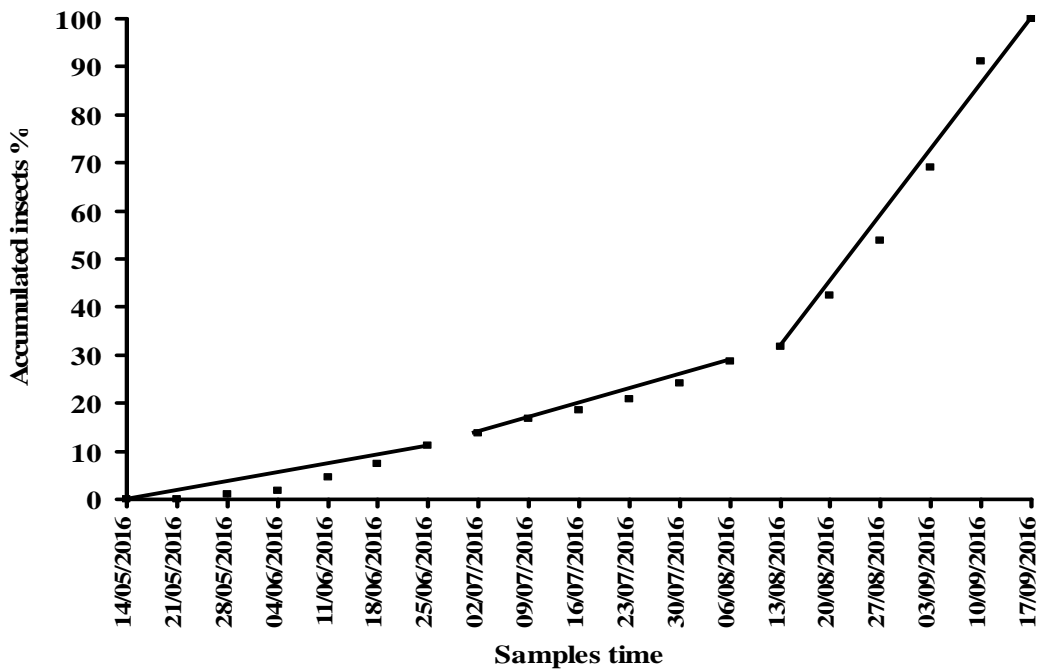


Fig.(4): Generations and durations of *Phenacoccus solenopsis* Tinsley on eggplant at Hihhya distract, Sharkia Governorate during the second season (2016)

Preferable leaf surface:

Data given in Table (5) showed that the total number of alive stages of *P. solenopsis* was higher on the lower leaf surface (69646 and 44602 individuals) than those the upper leaf surface (17203 and 17266 individuals) during the first and second seasons, respectively.

Table (5): Weekly numbers of *Phenacoccus solenopsis* Tinsley on upper and lower surface of eggplant leaves at Hihhya district, Sharkia Governorate during the first (2015) and second (2016) seasons.

week s	First season						Second season					
	Uppersurface			Lower surface			Uppersurface			Lower surface		
	Females	Nymphs	Total	Females	Nymphs	Total	Females	Nymphs	Total	Females	Nymphs	Total
1 st week	*0	1	1	0	18	18	0	1	1	1	25	26
2 nd week	0	9	9	3	64	67	4	6	10	4	40	44
3 rd week	5	85	90	9	213	222	27	124	151	47	381	428
4 th week	10	201	211	17	486	503	2	16	18	98	471	569
5 th week	27	501	528	65	1319	1384	5	94	99	81	1430	1511
6 th week	42	309	351	78	1186	1264	10	176	186	57	1474	1531
7 th week	120	199	319	197	904	1101	21	164	185	183	2041	2224
8 th week	111	406	517	194	1223	1417	37	371	408	169	1232	1401
9 th week	100	712	812	134	2204	2338	9	159	168	151	1472	1623
10 th week	115	700	815	135	2269	2404	0	74	74	152	1018	1170
11 th week	133	283	416	187	838	1025	3	128	131	131	1183	1314
12 th week	156	699	855	210	1793	2003	31	453	484	143	1521	1664
13 th week	165	623	788	225	4867	5092	47	615	662	150	1946	2096
14 th week	179	2147	2326	253	5560	5813	49	538	587	151	1276	1427
15 th week	257	2760	3017	422	8876	9298	112	2014	2126	293	4191	4484
16 th week	245	2145	2390	481	9268	9749	153	2302	2455	312	4428	4740
17 th week	158	1546	1704	311	8278	8589	170	2907	3077	353	5890	6243
18 th week	62	1300	1362	275	13158	13433	142	4301	4443	212	8495	8707
19 th week	23	669	692	282	3644	3926	90	1911	2001	111	3289	3400
Total	1908	15295	17203	3478	66168	69646	912	16354	17266	2799	41803	44602

* Numbers per 40 leaves

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ARABIC SUMMARY

Phenacoccus solenopsis Tinsley (Hemiptera: **بق القطن الدقيقى**)

دراسات إيكولوجية على بق القطن الدقيقى (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) على الباذنجان بمحافظة الشرقية - مصر

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أجريت الدراسات الحقلية على حشرة بق القطن الدقيقى *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) على نباتات الباذنجان بمركز ههيا بمحافظة الشرقية - مصر خلال موسمين متتاليين ٢٠١٥-٢٠١٦م لدراسة الكثافة العددية وفترات النشاط وتأثير بعض العوامل الجوية وسطح الورقة المفضل للأطوار المختلفة للحشرة. كذلك تم حساب عدد الأجيال خلال فترة الدراسة. وأوضحت النتائج أن لمجموع تعداد الأطوار الحية أربعة فترات نشاط خلال الموسم الأول من الدراسة كانت فى الأسبوع الثالث من يونيو والأسبوع الثالث من يوليو والأسبوع الرابع من أغسطس والأسبوع الثانى من سبتمبر. بينما فى العام الثانى أظهر مجموع تعداد الأطوار الحية ثلاث فترات للنشاط كانت خلال الأسبوع الأخير من يونيو والأسبوع الأول من أغسطس والأسبوع الثانى من سبتمبر. أظهرت النتائج أن العوامل الجوية المختبرة من درجة الحرارة العظمى ودرجة الحرارة الصغرى والرطوبة النسبية لها تأثيرات طردية على تعداد الأطوار المختلفة لبق القطن الدقيقى. وأوضحت الدراسة أن لحشرة بق القطن الدقيقى ثلاثة أجيال خلال فترة الدراسة فى الموسم حيث أن الجيل الأول يستغرق سبعة أسابيع بينما كل من الجيل الثانى والثالث يستغرق ستة أسابيع. ويمتد الجيل الأول فى الفترة من الأسبوع الثالث من مايو وحتى نهاية يونيو أما الجيل الثانى فيستمر من الأسبوع الأول من يوليو وحتى الأسبوع الثانى من أغسطس ويشغل الجيل الثالث الفترة من الأسبوع الثالث من أغسطس وحتى الأسبوع الثانى من سبتمبر. وخلال فترة الدراسة أتضح أن الأطوار المختلفة للحشرة تفضل السطح السفلى للأوراق عن السطح العلوى لها.