Egypt. Acad. J. Biolog. Sci., 5(3): 9-17 (2012) **A. Entomology**
Email: egyptianacademic@yahoo.com **ISSN: 1687–8809**
Received: 15/ 5 /2012 **www.eajbs.eg.net**

Ecological studies of *Aulacaspis tubercularis* (Diaspididae: Hemiptera) and its natural enemies infesting mango trees in Sharkia Governorate, Egypt.

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ABSTRACT

Ecological studies of *Aulacaspis tubercularis* (Newstead) (Diaspididae: Hemiptera) and its natural enemies were carried out during two successive years (2007-2008 and 2008-2009) in Inshas El- Raml district, Sharkia Governorate, Egypt. The obtained results revealed that the total number of alive stages had one peak of activity yearly in both top and bottom levels of the trees. *Aphytis* sp. and *Encarsia* sp. (Aphelinidae), *Habrolepis diaspidi* (Risbec) (Encyrtidae) were recorded as parasitoids of *A. tubercularis*. *Cybocephalus micans* Reitter (Order: Nitidulidae) was recorded as predator of *A. tubercularis.* The total effects of a biotic factors (Temperature ºC, Relative humidity RH% and Light intensity Lux) under this study on the total numbers of alive stages of the pest during the two years were 63.19 and 40.20 % in the top level and 77.66 and 39.44 % in the bottom one, successively. The pest activity appeared three annual generations in either the top and bottom levels of mango trees.

Keywords: Ecological studies, *Aulacaspis tubercularis*, natural enemies, mango trees, Egypt.

INTRODUCTION

Mango trees, *Mangifera indica* L. (Anacardiaceae) considered as one of the most popular fruits in Egypt. It contains a high percent of sugar, protein, fats, salts, vitamins. It plays an important role in food industrialization such as juices, which wanted with large amounts to export according to good reputation of Egyptian varieties. Now, the Egyptian agricultural strategy is to increase the quality level of exported crops to certain European countries, for this reason many efforts has been done to increase the total cultivated areas of mango in Egypt, as a favorable fruits in many countries. The total cultivated areas in Egypt has been rapidly increased and reached about 129073 feddans in 2007, producing a yield of approximately 497771 tons. In Sharkia Governorate, cultivated areas were 20873 feddans producing a yield of approximately 95428 tons. (Economic Agricultural Report, from Central Administration for Economic Agriculture, Ministry of Agriculture, Egypt, 2007).Scale insects are usually considered as the most important pests which infesting mango trees in many countries of the world. Gallardo (1983), Williams and Watson (1988) reported that a heavy infestation of *Aulacaspis tubercularis* (Newstead) (Diaspididae : Hemiptera) occurred on mango in an experimental orchard containing 84 varieties in Puerto Rico. This scale insect injures the leaves and fruits, affecting the commercial value of the fruits and its export potential. Colyn and Schaffer (1993), Peña *et al.* (1998) and Joubert *et al.* (2000) mentioned that *A. tubercularis* injures the leaves and fruits, affecting the commercial value of the fruits and their export potential. Infested mango fruits have conspicuous pink blemishes around the feeding sites of the scales. In nurseries, severe early-stage infestation retards growth. Young trees are particularly vulnerable

to excessive leaf loss and death of twigs due to scale, during hot dry weather. *A. tubercularis* presents significant pest problems on mango in South Africa. It is also a problem on mango in Australia, East and West Africa, North and South America and the Caribbean Islands. Ascher *et al.* (1995) studied the ecological aspects of this pest on mango trees using data gathered from two localities, Kaapmuiden and Nelspruit, South Africa. They revealed that the highest infestation rate occurred on the shady south-facing lower aspect of the tree. Population peaks of the pest occurred during different periods of the year in the two regions monitored. The population peak at Kaapmuiden, with a higher mean temperature, occurred in August, much earlier than at Nelspruit, where it occurred in November. Radwan (2003) reported that *A. tubercularis* had three generations on mango trees at Beni- Swief Governorate, Egypt. Kwaiz (2009) in Egypt, mentioned that this insect had three peaks on mango occurred during March, June and November through each of the two studied years, while the lowest population was occurred in mid July. Also, data clearly showed that *A. tubercularis* had four overlapping annual generations during the two studied years.

MATERIALS AND METHODS

Field experiments were carried out in mango farm located in Inshas El-Raml district, Sharkia Governorate. This study was continued for two successive years, from March 2007 until February 2009. The farm received normal agricultural practices and no chemical control was applied. The study was conducted in an area of about one feddan for mango variety Shmama. Five trees were selected and labeled. These trees were nearly similar in size, age and vegetation. Each tree was divided into four main directions (east, west, north and south).

For sampling, five leaves were picked up at random once a month from each direction, *i.e.* 200 leaves per sample (5 trees × 4 directions × 5 leaves × 2 levels of the tree). 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 *A. tubercularis* and Immature stages of predator were counted and recorded.

To study the parasitism ratios of *A. tubercularis*, the insects on each sample were separated into healthy alive insects and parasitized ones which bearing emerging holes of parasitoid adults or including parasitoids larvae or pupae. Each healthy alive insects or parasitized ones were counted and recorded. Parasitized scales were preserved in glass jars covered with muslin cloth by the aid of rubber bands and kept under laboratory conditions until parasitoids emergence. The total parasitism percentage for each sample was estimated. All emerging parasitoids were mounted in canada balsam. Parasitoids and predator were identified with helping of Prof. Dr. A. R. Hamed, Chief Researcher emirates, Biological Control Department, Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt.

The prevailing means of air temperature (ºC) and relative humidity (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. Light intensity (Lux) in outer zone of the trees was measured at the sampling days using Luxmeter at mid-day (12 *a.m.*), when the sunlight was perpendicular with the earth to obtain the highest light intensity. The relationships between the tested climatic factors and each insect population, predator population and parasitism ratios were studied. Simple correlation, partial regression values and explained variance were calculated using COSTAT Computer Program (2005).

To detect the effect of the cardinal directions on the distribution of scale insects and its associated natural enemies mathematically, the following formula was used.

$$H = \sqrt{F_1^{\,2} + F_2^{\,2} + 2\,F_1\,F_2\,\mathrm{Cos}\;Q}$$

This angle was calculated by dividing F_2 / F_1, Mahmoud (1981), Hassan (1998) and Nabil (2003):

H = Powers summation

F_1 = The population on the east (E) minus the population on the west (W) if the first is higher and reversed it if the later is higher.

F_2 = The population on the north (N) minus the population on the south (S) if the first is higher and the reverse is applied if the population on the south is higher.

The figure obtained represents the tangent, the corresponding values of which was obtained form the mathematical.

$F_1 = E - W$ $F_2 = N - S$ $\mathrm{Tan}\ Q = F_2 / F_1$

RESULTS AND DISCUSSION

1. Seasonal abundance

1.1. Total number of alive stages

As shown from obtained data in Tables (1 and 2) in the top level of mango trees during the two successive years, the total number of alive stages indicated one peak in November with values of 18634 and 40935 individuals during the first and second years, respectively. Generally, the total number of alive stages during the second year (223300 individuals) was obviously higher in comparison with that during the first year (133525 individuals). Data given in Tables (3 and 4) revealed that the total number of alive stages in the bottom level of mango trees showed one peak in November with counts of 24541 and 44777 individuals during the two successive years. In general, the total number of alive stages during the second year (207399 individuals) was clearly higher as compared with that during the first one (143654 individuals).

These results are in agreement with the findings of Ascher *et al.* (1995) who reported that the population peaks of the pest occurred during different periods of the year, the population peak at Kaapmuiden occurred in August, much earlier than at Nelspruit, where it occurred in November.

1.2. Percentages of total mortality

Data presented in Tables (1 and 2) showed that the percentages of total mortality in the top level of mango trees during the two successive years, indicated two peaks. They took place in June and February during the first year and in August and January during the second year, with values of 47.31, 75.14, 42.45 and 53.40%, respectively. The mean percentage of total mortality during the first year (57.68%) was relatively higher than the mean percentage of total mortality during the second one (51.58%). As shown from obtained data in Tables (3 and 4) in the bottom level of mango trees during the first year, the percentages of total mortality had three peaks of mortality in April (55.99%), December (66.12%) and February (76.80%). While, during the second year, two peaks were noticed in August (49.67%) and October (49.94%). The mean percentage of total mortality during the first year (56.54 %) was relatively higher as compared with that during the second one (48.02%).

1.3. Predator population

During the course of this work, *Cybocephalus micans* Reitter (Order: Nitidulidae) was recorded as predator of *A. tubercularis* for the first time in Egypt.

Table 1: Seasonal abundance of *Aulacaspis tubercularis* and its natural enemies in the top level of mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the first year (2007-2008).

Month	Number of insects / 100 leaves										Monthly average of climatic factors		
	Alive stages				dead stages	Mortality %	No. of pred-ator	Predator: prey ratio	Parasitoids		Temp. (ºC)	RH (%)	Light intensity (Lux)
	Females	Males	Nymphs	Total					No.	%			
Mar., 2007	1670	9560	290	11520	13700	54.32	31	1 : 372	488	1.93	24.7	60.7	74000
Apr.	1289	7297	375	8961	10561	54.10	70	1 : 128	596	3.05	22.6	57.6	85000
May	646	4879	327	5852	5013	46.14	139	1 : 42	344	3.17	27.9	56.9	87000
Jun.	507	3609	422	4538	4075	47.31	235	1 : 19	210	2.44	30.6	58.9	90000
Jul.	632	4256	474	5362	4377	44.94	259	1 : 21	180	1.85	31.8	65.6	86000
Aug.	1044	6860	732	8636	6978	44.69	288	1 : 30	258	1.65	31.9	67.1	85000
Sep.	2024	11003	1186	14213	11719	45.19	416	1 : 34	364	1.40	30.2	65.4	84000
Oct.	2868	12539	1226	16633	18506	52.67	289	1 : 58	628	1.79	29.0	62.2	73000
Nov.	2940	14738	956	18634	26817	59.00	160	1 : 116	961	2.11	24.2	62.6	55000
Dec.	2139	13150	594	15883	26992	62.96	91	1 : 175	1050	2.45	19.2	63.2	60000
Jan., 2008	2058	11829	395	14282	26037	64.58	37	1 : 386	1130	2.80	15.6	65.2	50000
Feb.	1289	7467	255	9011	27243	75.14	31	1 : 291	1373	3.79	17.3	65.5	60000
Total	19106	107187	7232	133525	182018		2046		7582				
Mean						57.68		1 : 65		2.40			

Table (2): Seasonal abundance of *Aulacaspis tubercularis* and its natural enemies in the top level of mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the second year (2008-2009).

Month	Number of insects / 100 leaves										Monthly average of climatic factors		
	Alive stages				dead stages	Mortality %	No. of pred-ator	Predator : prey ratio	Parasitoids		Temp. (ºC)	RH (%)	Light intensity (Lux)
	Females	Males	Nymphs	Total					No.	%			
Mar., 2008	1156	7266	143	8565	22376	72.32	55	1 : 156	1239	4.00	22.9	62.2	70000
Apr.	707	5201	84	5992	13995	70.02	133	1 : 45	1021	5.11	27.8	56.8	87000
May	470	3973	39	4482	8945	66.62	258	1 : 17	607	4.52	27.9	65.6	86000
Jun.	536	4332	66	4934	4666	48.60	351	1 : 14	396	4.13	32.0	58.9	90000
Jul.	661	6140	156	6957	5016	41.89	365	1 : 19	243	2.03	32.7	66.1	91000
Aug.	1264	9252	242	10758	7935	42.45	556	1 : 19	247	1.32	33.5	67.7	85000
Sep.	2137	17118	248	19503	11541	37.18	438	1 : 45	371	1.20	31.8	63.3	80000
Oct.	4581	31168	410	36159	27544	43.24	370	1 : 98	725	1.14	27.7	63.3	72000
Nov.	4935	35485	515	40935	45023	52.38	200	1 : 205	987	1.15	25.0	60.0	75000
Dec.	5608	29741	622	35971	39786	52.52	130	1 : 277	1369	1.81	20.0	61.7	70000
Jan., 2009	3715	20090	380	24185	27710	53.40	65	1 : 372	988	1.90	17.7	60.3	65000
Feb.	3888	20695	276	24859	23328	48.41	22	1 : 1130	597	1.24	18.9	60.8	55000
Total	29658	190461	3181	223300	237865		2943		8790				
Mean						51.58		1 : 76		1.91			

Data presented in Tables (1 and 2) showed that the highest number of predator in the top level of mango trees during the two successive years was in September (416 individuals) and in August (556 individuals), respectively. The highest ratio of predator: prey was in June, with ratio of 1:19 and 1:14 during the first and second years, respectively. The total number of predator during the second year (2943 individuals) was obviously higher than that recorded during the first one (2046 individuals). The mean ratio of predator: prey during the first year (1:65) was relatively higher in comparative with that during the second one (1:76).

Data concerning the bottom level of mango trees presented in Tables (3 and 4). During the two successive years, the predator number peaked in August with counts of 574 and 446 individuals, respectively. The highest ratio of predator: prey (1:12) during the first year was in July. During the second year, the predator: prey reached the highest ratio (1:15) in June, July and August. The total number of predator during the first year was relatively higher than that during the second one with 3065 and 2598 individuals, consecutively. The mean of predator: prey ratio during the first year (1:47) was higher compared with that during the second one (1:80). These results are in agreement with the findings of Kehat (1967) who reported that the highest density of *Cybocephalus* beetles in Israel was recorded between May and December.

Table 3: Seasonal abundance of *Aulacaspis tubercularis* and its natural enemies in the bottom level of mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the first year (2007-2008).

Month	Number of insects / 100 leaves										Monthly average of climatic factors		
	Alive stages				dead stages	Mortality %	No. of predator	Predator: prey ratio	Parasitoids		Temp. (ºC)	RH (%)	Light intensity (Lux)
	Females	Males	Nymphs	Total					No.	%			
Mar., 2007	1682	9930	165	11777	13225	52.90	47	1 : 251	461	1.84	24.7	60.7	74000
Apr.	1339	7628	269	9236	11752	55.99	105	1 : 88	632	3.01	22.6	57.6	85000
May	736	4678	328	5742	4801	45.54	189	1 : 30	306	2.90	27.9	56.9	87000
Jun.	567	3744	267	4578	3290	41.81	366	1 : 13	196	2.49	30.6	58.9	90000
Jul.	777	4828	224	5829	2207	27.46	488	1 : 12	232	2.89	31.8	65.6	86000
Aug.	1154	6115	292	7561	4027	34.75	574	1 : 13	280	2.42	31.9	67.1	85000
Sep.	2083	9715	987	12785	9654	43.02	544	1 : 24	409	1.82	30.2	65.4	84000
Oct.	2502	15938	1538	19978	15490	43.67	412	1 : 48	639	1.80	29.0	62.2	73000
Nov.	3365	20048	1128	24541	30354	55.29	201	1 : 122	1030	1.88	24.2	62.6	55000
Dec.	1927	13394	431	15752	30737	66.12	97	1 : 162	1653	3.56	19.2	63.2	60000
Jan., 2008	2063	13132	299	15494	27002	63.54	25	1 : 620	1746	4.11	15.6	65.2	50000
Feb.	1377	8810	194	10381	34358	76.80	17	1 : 611	1361	3.04	17.3	65.5	60000
Total	19572	117960	6122	143654	186897		3065		8945				
Mean						56.54		1 : 47		2.71			

Table (4): Seasonal abundance of *Aulacaspis tubercularis* and its natural enemies in the bottom level of mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the second year (2008-2009).

Month	Number of insects / 100 leaves										Monthly average of climatic factors		
	Alive stages				dead stages	Mortality %	No. of predator	Predator : prey ratio	Parasitoids		Temp. (ºC)	RH (%)	Light intensity (Lux)
	Females	Males	Nymphs	Total					No.	%			
Mar., 2008	1072	6545	119	7736	21000	73.08	27	1 : 287	1061	3.69	22.9	62.2	70000
Apr.	611	4015	92	4718	10476	68.95	78	1 : 60	624	4.11	27.8	56.8	87000
May	548	4055	71	4674	4259	47.68	171	1 : 27	326	3.65	27.9	65.6	86000
Jun.	444	3423	93	3960	3054	43.54	273	1 : 15	213	3.04	32.0	58.9	90000
Jul.	570	4317	125	5012	3459	40.83	341	1 : 15	124	1.46	32.7	66.1	91000
Aug.	846	5784	150	6780	6692	49.67	446	1 : 15	163	1.21	33.5	67.7	85000
Sep.	2068	12643	175	14886	10458	41.26	348	1 : 43	304	1.20	31.8	63.3	80000
Oct.	4982	23588	510	29080	29014	49.94	345	1 : 84	727	1.25	27.7	63.3	72000
Nov.	7926	36230	621	44777	37551	45.61	302	1 : 148	1253	1.52	25.0	60.0	75000
Dec.	6818	28736	545	36099	28018	43.70	160	1 : 226	1352	2.11	20.0	61.7	70000
Jan., 2009	4366	23263	314	27943	18269	39.53	76	1 : 368	888	1.92	17.7	60.3	65000
Feb.	3020	18533	181	21734	19345	47.09	31	1 : 701	685	1.67	18.9	60.8	55000
Total	33271	171132	2996	207399	191595		2598		7720				
Mean						48.02		1 : 80		1.93			

1.4. Percentages of parasitism

During the course of this work, four hymenopterous species were recorded as parasitoids of *A. tubercularis.* They were *Aphytis* sp. and *Encarsia* sp. (Aphelinidae), *Habrolepis diaspidi* (Risbec) (Encyrtidae). The seasonal abundance of the parasitoids

was presented as percentages of parasitism. Data presented in Tables (1 and 2) showed that in the top level of mango trees during the first year, the percentages of parasitism had one peak of activity in May (3.17%). During the second year, two peaks were noticed in April (5.11%) and January (1.90%). The mean percentages of parasitism were 2.40 and 1.91 % during the first and second years, respectively.

Data given in Tables (3 and 4) in the bottom level of mango trees during the first year, three peaks were recorded in April (3.01%), July (2.89%) and January (4.11%). While, during the second year, two peaks were noticed in April (4.11%) and December (2.11%). The mean percentages of parasitism were 2.71 and 1.93% during the first and second years, consecutively. These results are in agreement with the findings of Kamel *et al.* (2003) who studied the seasonal abundance of 18 species of the genus *Aphytis* from Egypt, observed on ten host plants infested with eleven armored scale insect species (diaspidids). The maximum parasitism rates were between 0.8 and 14.6%.

2. Effect of climatic factors:

2.1. Total number of alive stages:

Data given in Table (5) showed that in the top level of mango trees during the two successive years, there were negative significant effects between total number of alive stages and light intensity whereas (r) values were -0.702 and -0.625, successively. EV% affected the total number of alive stages by 63.19 and 40.20% during the first and second years, respectively. Data presented in Table (5) revealed that there was negative highly significant effect between the total number of alive stages and light intensity in the bottom level of mango trees during the first year (r= -0.736). During the second year, there were negative significant correlations between total number of alive stages and each of temperature and light intensity whereas (r) values were -0.585 and -0.616, respectively. Statistical analysis showed that EV% affected the total number of alive stages by 77.66 and 39.44 during the first and second years, consecutively.

2.2. Percentages of total mortality

Data in Table (5) showed that in the top level of mango trees during the first year, there were negative highly significant effects between percentages of total mortality and each of temperature and light intensity whereas (r) values were -0.917 and -0.845, successively. During the second year, no significant effects were recorded. EV% influenced the percentages of total mortality by 87.39 and 46.99% during the first and second years, respectively. Data given in Table (5) revealed that in the bottom level of mango trees during the first year, there were negative highly significant effects between the percentages of total mortality and each of temperature and light intensity whereas (r) values were –0.939 and -0.753, respectively. During the second year, no significant effects were noticed. Statistical analysis showed that EV% affected the percentages of total mortality by 88.68 and 47.57% during the first and second years, consecutively.

2.3. Predator population:

Data given in Table (5) showed that in the top level of mango trees during the first year, there was positive highly significant correlation between numbers of predator and temperature whereas (r) values was 0.820. While, during the second year, there was positive.

highly significant effect between numbers of predator and temperature (r= 0.888), and positive significant effects between numbers of predator and each of relative humidity and light intensity whereas (r) values were 0.611 and 0.656, respectively. EV% af-

fected numbers of predator by 78.07 and 87.90% during the first and second years, successively.

As shown from obtained data in Table (5) in the bottom level of mango trees during the two respectively years, there were positive highly significant correlations between numbers of predator and temperature whereas (r) values were 0.885 and 0.777, respectively. Statistical analysis showed that EV% affected the numbers of predator by 92.46 and 70.72% during the first and second years, consecutively.

2.4. Percentages of parasitism:

Data given in Table (5) revealed that in the top level of mango trees during the first year, there was negative significant effect between percentages of parasitism and temperature (r= -0.661). While, during the second year, no significant effects were recorded. Statistical analysis showed that EV% influenced percentages of parasitism by 67.63 and 55.46% during the first and second years, respectively.

As shown from obtained data in Table (5) in the bottom level of mango trees during the first year, there was negative significant correlation between percentages of parasitism and temperature whereas (r) value was -0.635. During the second year, no significant effects were recorded. EV% affected percentages of parasitism by 54.14 and 49.67% during the first and second years, consecutively.

Table 5: Statistical analysis based on correlation coefficient (r) indicating the effects of climatic factors on different stages of *Aulacaspis tubercularis* nd its natural enemies on mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the two successive years (2007-2008 and 2008-2009).

	Temp. (°C)		RH (%)		Light intensity (Lux)		Explained variance		Combined effect	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom		
1st year (2007-2008)										
Number of females	-0.330	-0.318	0.218	0.235	-0.671*	-0.686*	63.14	68.80		
Number of males	-0.440	-0.418	0.262	0.193	-0.744**	-0.774**	65.56	80.76		
Number of nymphs	0.403	0.223	0.309	0.081	-0.012	-0.172	51.01	50.40	**RH(%)**	**Light intensity (Lux)**
Total number of alive stages	-0.374	-0.367	0.266	0.195	-0.702*	-0.736**	63.19	77.66	**Temp.(°C)** -0.048	0.817**
Total number of dead stages	-0.812**	-0.854**	0.322	0.258	-0.960**	-0.937**	92.46	90.22	**RH(%)**	-0.347
Total mortality %	-0.917**	-0.939**	0.193	-0.020	-0.845**	-0.753**	87.39	88.68		
Predator population	0.820**	0.885**	0.285	0.332	0.540	0.619	78.07	92.46		
Parasitism %	-0.661*	-0.635*	-0.350	0.075	-0.273	-0.351	67.63	54.14		
2nd year (2008-2009)										
Number of females	-0.635*	-0.557	-0.207	-0.243	-0.718**	-0.560	51.72	33.68		
Number of males	-0.478	-0.593*	-0.164	-0.249	-0.607*	-0.631*	38.44	41.13		
Number of nymphs	-0.506	-0.404	-0.079	-0.154	-0.559	-0.429	32.10	18.91	**RH(%)**	**Light intensity (Lux)**
Total number of alive stages	-0.503	-0.585*	-0.170	-0.247	-0.625*	-0.616*	40.20	39.44	**Temp.(°C)** 0.428	0.868**
Total number of dead stages	-0.713**	-0.607*	-0.352	-0.307	-0.665*	-0.659*	52.39	45.88	**RH (%)**	0.235
Total mortality %	-0.360	-0.062	-0.381	-0.265	-0.026	0.008	46.99	47.57		
Predator population	0.888**	0.777**	0.611*	0.561	0.656*	0.543	87.90	70.72		
Parasitism %	0.123	-0.091	-0.335	-0.420	0.454	0.248	55.46	49.67		

3. Number of generations:

As *A. tubercularis* is known to have overlapping generations, it was necessary to utilize the formula proposed by Audemard and Milaire (1975) and emended by Jacob (1977) for estimating the number of generations and their annual durations. Data of monthly counts of nymphal stage were indicated on millimeter paper.

Data illustrated in Figs. (1 and 2) indicated that during the first year *A. tubercularis* had three generations annually in the top and bottom levels of mango trees. In General, the generations lasted about three to five months. The first generation was during the period extended from the beginning of March till the end of July. The second and powers one occurred from the beginning of August to the end of October. The third generation occupied the period from the beginning of November till the end of February. While, in the second year, *A. tubercularis* had three generations annually in the top and bottom levels of mango trees.

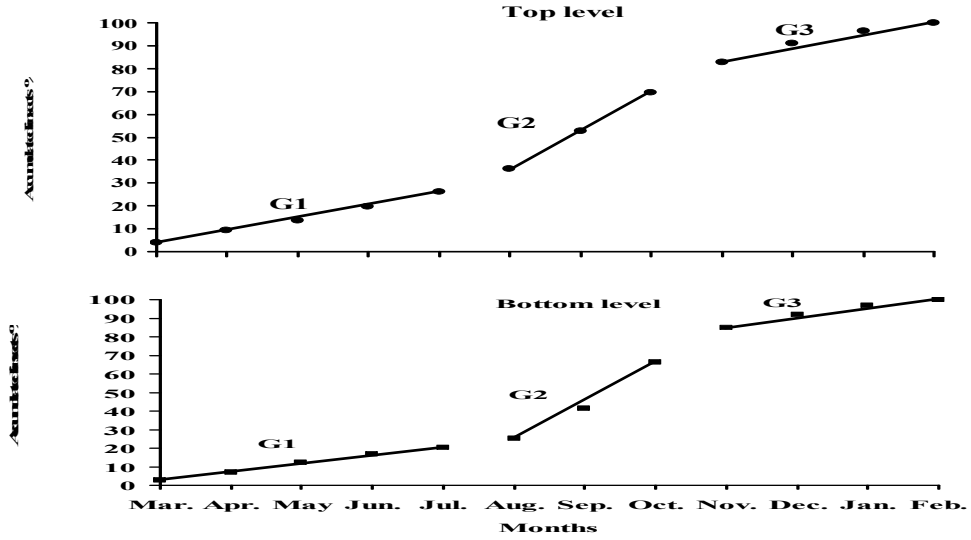

Fig. 1: Annual generations and durations of *Aulacaspis tubercularis* in top and bottom levels of mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the first year (2007-2008).

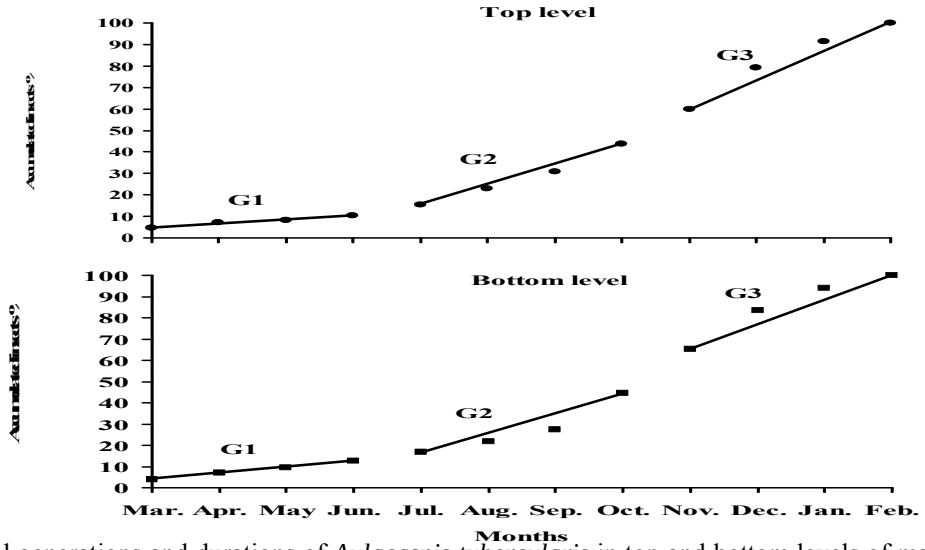

Fig.2: Annual generations and durations of *Aulacaspis tubercularis* in top and bottom levels of mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the first year (2008-2009).

In general, the generations took about four months. The first generation was during the period extended from the beginning of March till the end of June. The second one occurred from the beginning of July to the end of October. The third generation occupied the period from the beginning of November till the end of February. These results are conformable with those of Radwan (2003) who reported that *A. tubercularis* had three generations on mango trees.

4. Preferable level and preferable leaf surface

Data given in Table (6) showed that during the first year, in the top level of mango trees the total number of alive stages, predator and parasitoids were higher on the upper surface of leaves with values of (80834, 1188 and 5269 individuals) than those on the lower surface with counts of (52691, 858 and 2313 individuals), consecutively. The same trend was found in the bottom level of mango trees whereas the total number of alive stages, predator and parasitoids were 82584, 1852 and 6541 individu-

als on the upper surface and 61070, 1213 and 2404 individuals on the lower one, respectively.

Table 6: Yearly numbers of *Aulacaspis tubercularis* and its natural enemies on upper and lower leaves surface for mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate during the first and second years (2007-2008 and 2008-2009).

Year	Top								Bottom							
	Upper surface				Lower surface				Upper surface				Lower surface			
	Alive stages	Dead stages	No. of predator	No. of parasitoids	Alive stages	Dead stages	No. of predator	No. of parasitoids	Alive stages	Dead stages	No. of predator	No. of parasitoids	Alive stages	Dead stages	No. of predator	No. of parasitoids
2007-2008	80834	129632	1188	5269	52691	52386	858	2313	82584	135893	1852	6541	61070	51004	1213	2404
2008-2009	132458	148163	1845	5690	90842	89702	1098	3100	137743	136707	1382	5282	69656	54888	1216	2438

Data given in Table (6) showed that in the top level of mango trees during the second year, the total number of alive stages, predator and parasitoids were obviously higher on the upper surface (132458, 1845 and 5690 individuals) comparatively with those on the lower one (90842, 1098 and 3100 individuals), consecutively. In the bottom level of mango trees the total number of alive stages, predator and parasitoids were (137743, 1382 and 5282 individuals) on the upper surface and (69656, 1216 and 2438 individuals) on the lower one, successively.

5. The preferable direction for the insect and its associated natural enemies

Results illustrated in Table (7) and Fig. (3) showed that in the top level of the trees during the first and second years, the insect and its predator occurred in north eastern side of the trees. While, the parasitoids occurred in north western side of the trees

Data given in Tables (7) and Fig. (3) revealed that in the bottom level of the trees during the first and second years, the insect and its parasitoids occurred in north eastern side of the trees, whereas the predator occurred in the south eastern side of the trees.

Generally, illustrated data in Fig. (3) revealed that the armored scale insect, *A. tubercularis* and its natural enemies concentrated in eastern side of the trees.

Table (7): Yearly numbers of *Aulacaspis tubercularis* and its associated natural enemies in the top and bottom levels at main directions of mango trees, variety Shmama, in Inshas El- Raml district, Sharkia Governorate during the first and second years (2007-2008 and 2008-2009).

Year	Number of insects in the top level / 25 leaves per each direction											
	East			West			North			South		
	Alive stages	Predator Number	Parasitoids Number	Alive stages	Predator Number	Parasitoids Number	Alive stages	Predator Number	Parasitoids Number	Alive stages	Predator Number	Parasitoids Number
2007-2008	33611	513	1082	24900	374	1778	49901	753	3545	25113	406	1177
2008-2009	90726	850	2090	34852	554	2223	58280	814	3127	39442	725	1350
	Number of insects in the bottom level / 25 leaves per each direction											
Year	Alive stages	Predator Number	Parasitoids Number	Alive stages	Predator Number	Parasitoids Number	Alive stages	Predator Number	Parasitoids Number	Alive stages	Predator Number	Parasitoids Number
2007-2008	38394	711	2477	30536	659	2161	51278	774	3175	23446	921	1132
2008-2009	60925	539	2018	51079	428	1956	51220	599	2560	44175	1032	1186

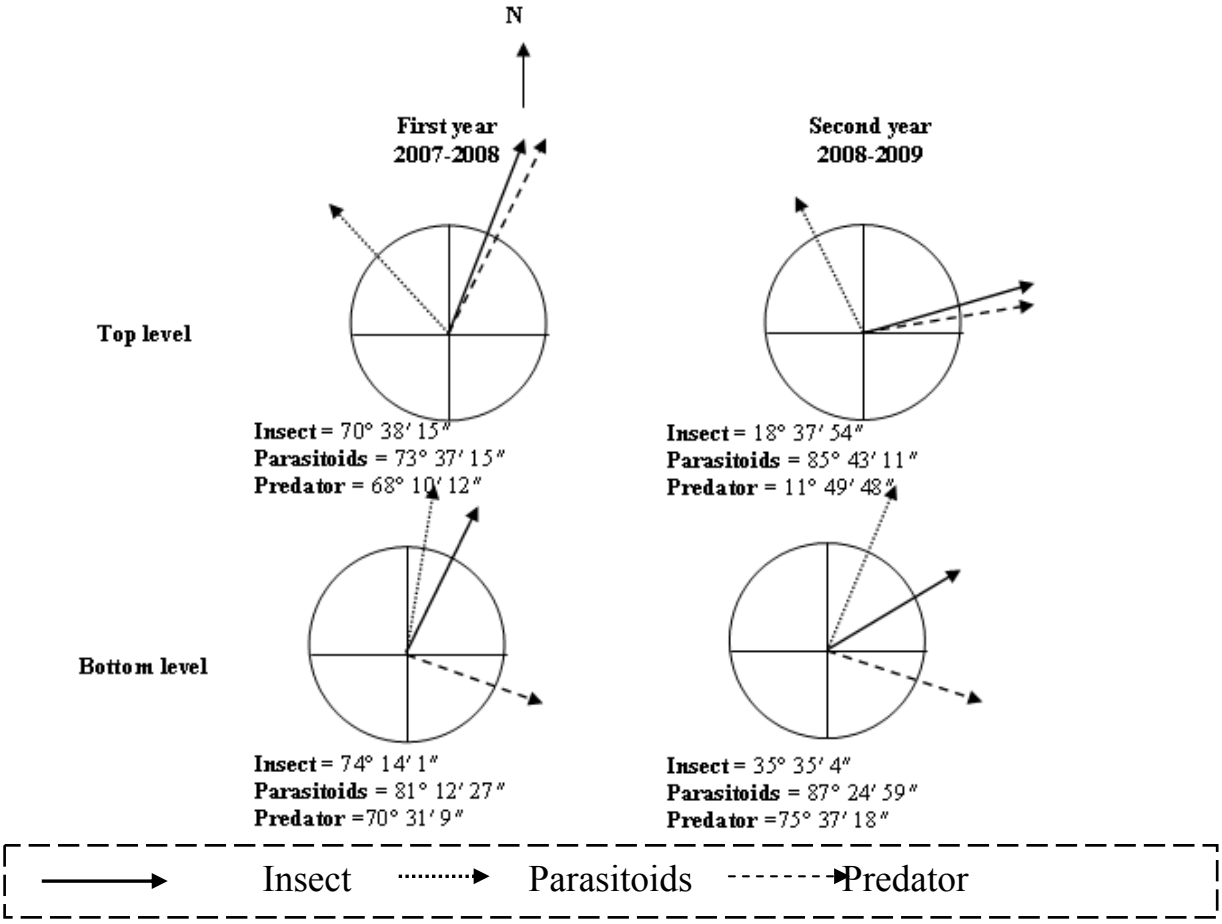

Fig. 3: The calculated directions of *Aulacaspis tubercularis* and its associated natural enemies in top and bottom levels of mango trees, variety Shmama, in Inshas El-Raml district, Sharkia Governorate tow successive years (2007-2008 and 2008-2009).

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ARABIC SUMMARY

دراسات ايكولوجية على حشرة المانجو القشرية البيضاء وأعدائها الحيوية على أشجار المانجو بمحافظة الشرقية مصر

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أجريت هذه الدراسة بمنطقة أنشاص الرمل بمحافظة الشرقية بحدائق المانجو التابعة لوزارة الأوقاف على الصنف شمامة فى الفترة من مارس 2007 م وحتى فبراير 2009 م وذلك لدراسة الوفرة الموسمية لتعداد حشرة المانجو القشرية البيضاء وأعدائها الحيوية بالمستويين العلوي والسفلى للأشجار وتأثير العوامل الجوية المحيطة من حرارة ورطوبة نسبية وكثافة ضوئية على الأطوار المختلفة للحشرة واعدائها الحيوية وكانت النتائج المتحصل عليها كما يلي: أظهرت النتائج وجود ذروة واحدة لتعداد الأطوار الحية في شهر نوفمبر في كلا المستويين وجد أن العدد الكلى للأطوار الحية في المستوى العلوي خلال عامي الدراسة 133525 و223300 فرد على التوالي وكان في المستوى السفلي 143654 و207399 فرد خلال عامي الدراسة على الترتيب. وبوجه عام كان تعداد الحشرة في السنة الثانية اعلي منه فى الأولى بصورة واضحة. وقد وجد أن الأنواع *Aphytis* sp., *Encarsia* sp. (Aphelinidae), *Habrolepis diaspidi* (Risbec) تتطفل على الحشرة وكذلك تم تسجيل المفترس *Cybocephalus micans* Reitter (Nitidulidae) والذى امتدت فترة نشاطه من يونيو إلى أغسطس. وقد وجد ان للحشرة ثلاثة اجيال سنويا مدة الجيل من 3 الى 5 شهور. كما وجد أن العوامل المناخية تؤثر في العدد الكلى للأطوار الحية للآفة في المستوى العلوي بنسب 63.19 و 40.20% خلال عامي الدراسة على التوالي. وفى المستوى السفلى كانت نسب التأثير 77.66 و39.44% خلال عامي الدراسة على التوالي.