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Ecological Studies on California Red Scale Insect, *Aonidiella aurantii* (Mask.) on Some Orange Varieties in Relation to Biotic and Abiotic Factors

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Author's contribution

This whole work was carried out by the author SAA.

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ABSTRACT

Aims: Orange trees infested with different scale insects, among them the California red scale (*Aonidiella aurantii* [Mask.]), is the most serious pest of orange. This study was conducted to demonstrate the number of generations of this pest on each variety and the effect of parasitic and meteorological factors on its population.

Place and Duration of Study: This study was carried out in a private orchard in Kafr Shokr, Qaliobiya Governorate (30.543646,31.263705) on three varieties of orange (Balady, Navel, Succari) during two years from February 2010 to January 2012.

Results: The dynamics of development of generation of red scale was influenced by host varieties as follows:

- On Balady orange three generations in the 1st season in (Feb. – August), (May – October) and (August – Dec.) and in (Feb. – July), (July – Nov.) and (Sept. – Jan.) during the 2nd season.
- On Navel orange three generations in (Feb. – July), (May – October) and (August – Jan.) during 1st season and (Feb. – June), (April – October) and (October – Jan.) in the 2nd season.
- On Succari orange 1st season generations in (Feb. – June), (April – August) and (August – Dec.) while 2nd season generations in (March – June), (May – October) and (October – Jan.)

Parasitism gave a very positive significant relation in the 1st season and insignificant

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negative in the 2nd season, Temp. gave positive significant relation in the 1st season and very significant in the 2nd season, while relative humidity relations was negative in 1st season and positive in the 2nd season but insignificant in both.
The effect of all measures was very significant in the 1st season and insignificant in the 2nd season as the total effect was 89.71% and 61.51% during the 1st and 2nd seasons, respectively.

Keywords: California red scale; Aonidiella aurantii; Ecological; Orange; Biotic; Generation.

1. INTRODUCTION

Oranges are considered one of the most important species of citrus. The area cultivated with orange cultivars increased rapidly from year to year in Egypt and all over the world. The different varieties of orange are infested by different kinds of insects, among them the armored scale insects. The California red scale, *Aonidiella aurantii* (Mask) is considered one of the serious pests among them.

Rashad [1] and Rawhy [2] mentioned that the heaviest population of *A.aurantii* was encouraged by high temperature with moderate humidity.

Abul-Nasr and Swailem [3], Rizk et al. [4], Abou-Setta [5], Mahmoud [6], Sadek and Mohamed, [7] and Mousatafa [8] reported that there are 3-5 annual generations for this pest.

Amin [9] found that the abundance of this pest varied in different regions of Egypt, and recorded 3 annual generations in the coastal areas and 4 generations in Middle Egypt and the Delta regions. Darwish [10] recorded the highest population density of *A.aurantii* in November and January. Abdel-Fattah et al. [11] mentioned that red scale favors relatively high temperature (24.9-25.8ºC) and moderate relative humidity (59-71%) during June and July at Shebin El-Kom. They also stated that the highest quotient of increase took place in April and May, with the value of 1.46.

The present work was planned out to study the seasonal fluctuations of red scale insect pest on three orange varieties of orange in Qaliobiya Governorate with aim to improve the available knowledge on the effects of climatic and biotic factors on its seasonal abundance.

2. MATERIAL AND METHODS

For evaluation of the seasonal fluctuations of the California red scale, three different varieties (Navel, Succari and Balady) of orange [*Citrus sinensis* (Osbeck)] cultivated in a private orchard at Kafr Shokr, Qaliobiya Governorate were chosen. This study was carried out during two years extended from February 2010 to January 2012, five trees of approximately the same size, shape, height, vegetation and homogenous in their infestation with California red scale were selected.

Thirty-five leaves were randomly picked from each replicate represented the different heights and directions at monthly intervals. These leaves were kept in polyethylene bags and transferred to the to the Insect Laboratory of Plant Protection Research Institute (Giza, Egypt) Individuals on leaves (upper and lower surface) were sorted into alive adult females and preadults and subsequently counted and recorded using dissecting microscope. The relationship between the population of the scale and meteorological and biotic factors within inspected periods was statistically studied by by using correlation and partial regression analyses (Fisher) [12].

3. RESULTS AND DISCUSSION

3.1 Seasonal Abundance

Results of the first year of the seasonal abundance of the California red scale on Balady orange (Table 1 & Fig. 1) showed that there were four peaks of abundance recorded, in February, June, September and November. A similar trend in the seasonal abundance of adult females and preadults were observed. The peaks were in February, June, September and November, the average annual fluctuation of the population reached 12.00, 9.83 and 14.15 in the population of total number, adult females and preadults, respectively. The monthly variation in population density showed that the favorable time for insect activity in the total number occurred in May 2010 and January 2011, when the density values were 1.50 and 1.41, respectively.

The results of the second year (2011/2012), (Table 2 & Fig. 2) recorded four peaks for the total number of scales in April, June, August and November. The preadults had the same trend. However, three peaks were reported for adult females in April, August and November. The average of annual fluctuation observed for the total number of scale, adult females and preadults reached 3.47, 3.68 and 3.37, respectively. The monthly variation in the population density, of all stages reached 2.28 in April and 2.70 in November 2011.

The number of generations of *A. aurantii* under the field conditions was taken from the annual number of peaks of preadults. It could be concluded from the results that there were three generations during the two years of study. The first generation emerged during spring while the second appeared in summer and the third during the fall.

On Navel orange, three peaks of California red scale were recorded for the total number of scales in May, June and January 2011. The peaks of adult females were in May, July, September and January, the preadults showed the same trend. The average annual fluctuation of this scale recorded 14.63, 14.21 and 15.0 in the population of total number of scales, adult females and preadults, respectively. The monthly variation in population density of red scale indicated that the favorable time for its annual activity in the total number occurred in March 2010, July and January 2011, when the density values were 5.37, 1.69 and 1.75, respectively.(Table 3 & Fig. 1).

Results of the second year (2011/2012), (Table 4 & Fig. 2), showed three peaks for the total number of scales in April, July and November 2011. Three peaks of abundance were reported for the adult females and preadults of the California red scale. These peaks were in April, July and November 2011. The average of annual fluctuation observed for all stages of the California red scale reached 4.92, 8.55 and 3.61, respectively. The monthly variation in the population density of all stages reached 2.75, 1.84 and 3.00 in April, July and November 2011, respectively.

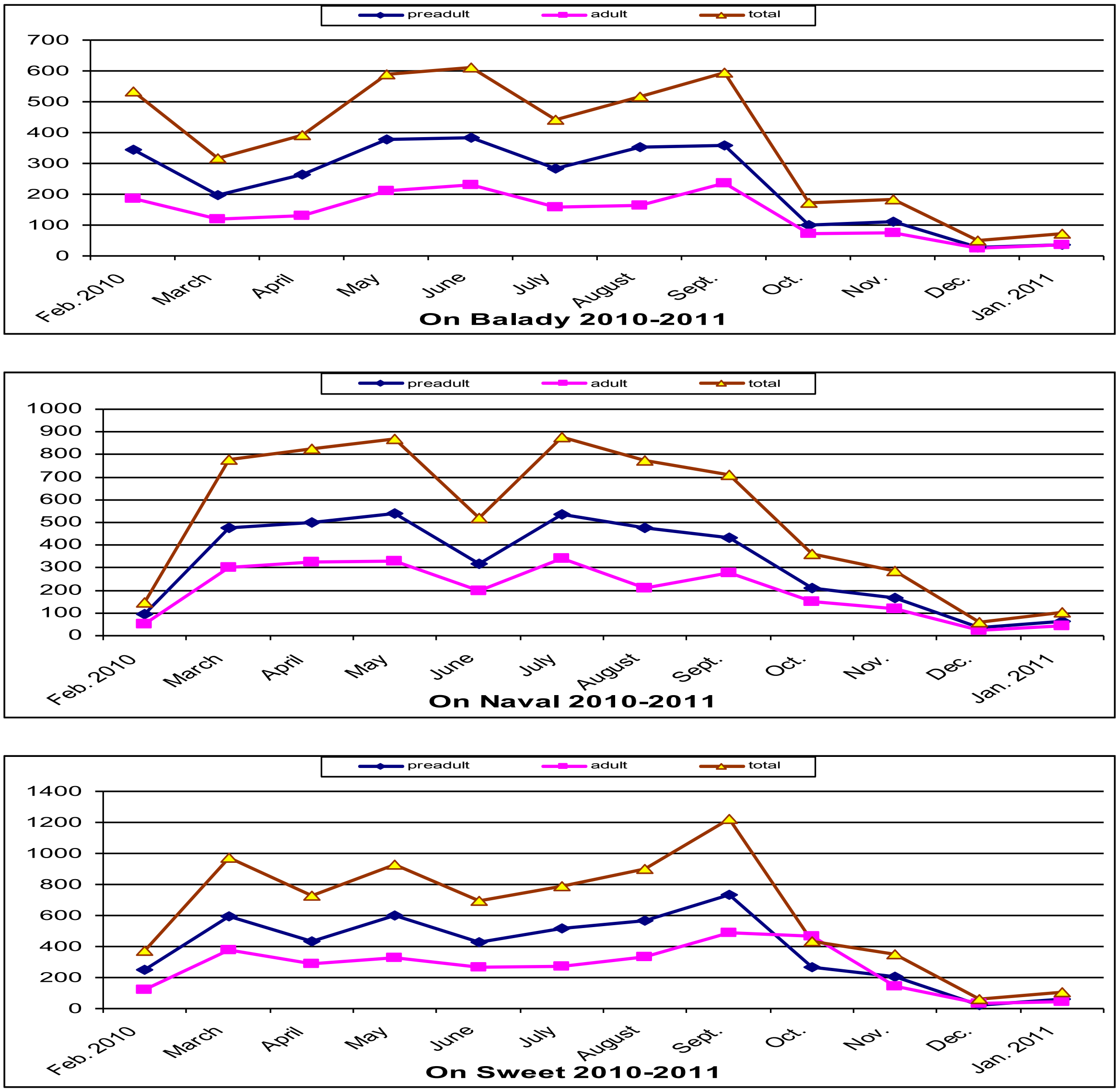
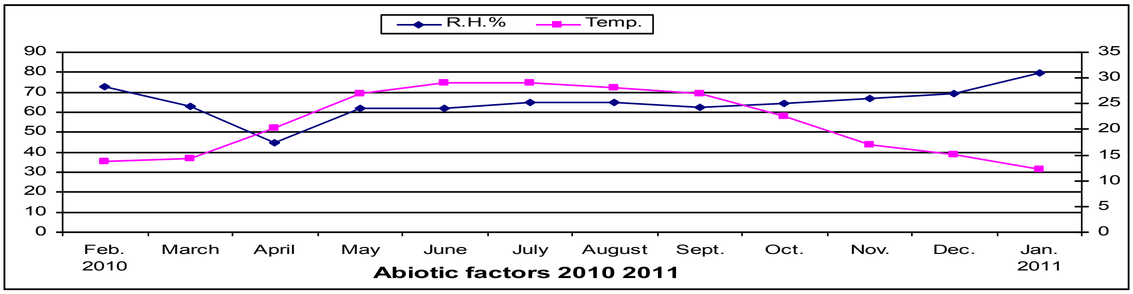


Fig. 1. Monthly fluctuations and seasonal abundance of A.aurantii and associated parasite on different varieties of orange at Kafr Shokr, Qaliobiya Governorate, from Feb. 2010 to Jan. 2011

It could be concluded that California red scale insect had three generations in the first year in May, July 2010 and in January 2011. In the second season, data demonstrated that the peaks occurred in April, July and November 2011.

Concerning the seasonal abundance of this pest on Succari orange, data of the first year (Table 5 & Fig. 1) reported four peaks for the total number in March, May, September 2010 and January 2011. A similar trend in the seasonal abundance of adult females and preadults was observed. The peaks were in March, May, September 2010 and January 2011.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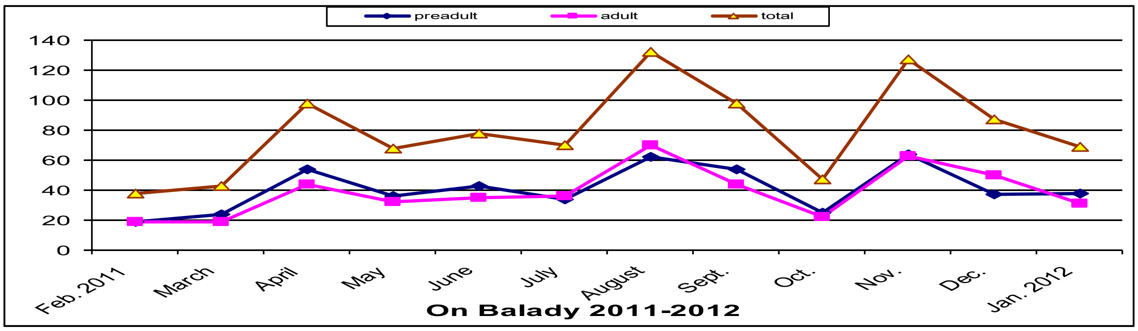
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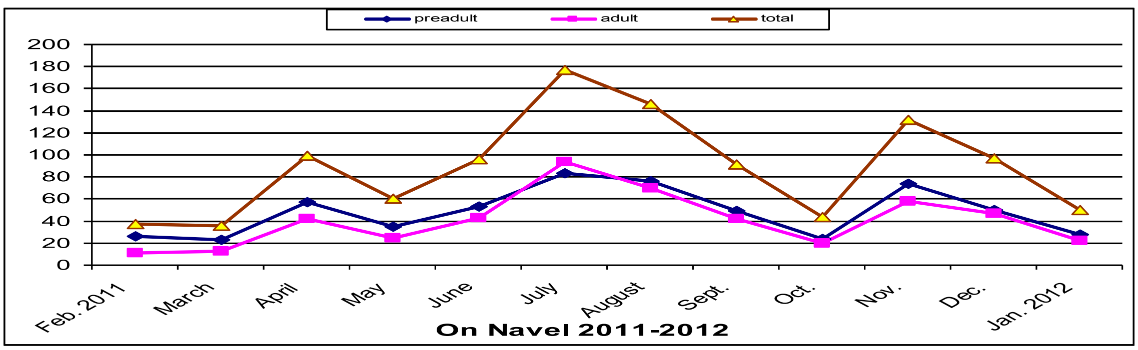
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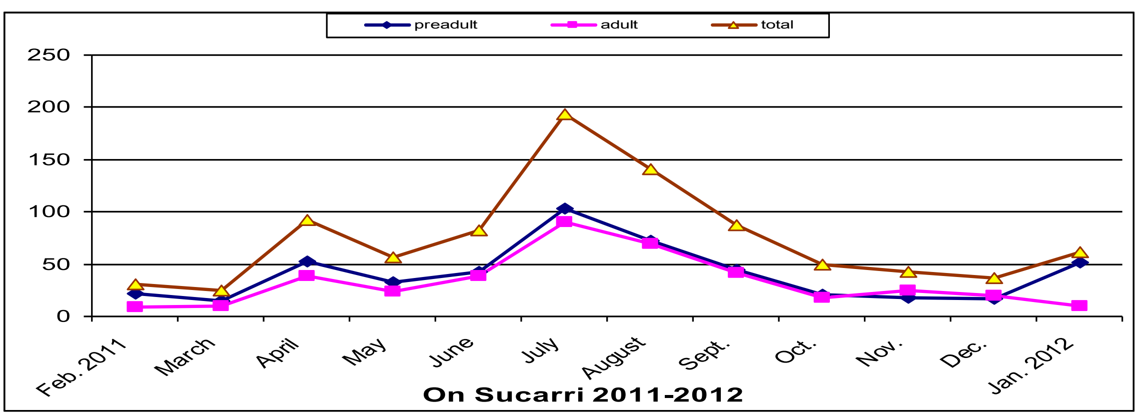
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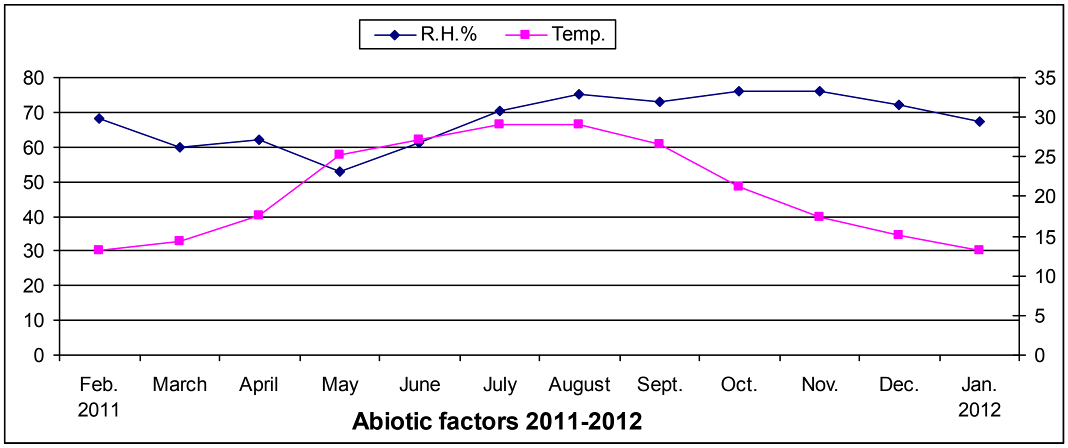

Fig. 2. Monthly fluctuations and seasonal abundance of A.aurantii and associated parasite on different varieties of orange at Kafr Shokr, Qaliobiya Governorate, from Feb. 2011 to Jan. 2012

The average annual fluctuation of the population of the scale reached 20.69, 14.41 and 23.96 in the population of total individuals adult females and preadults, respectively. The monthly variation in population density showed that the favorable time for insect activity in the total number of this pest occurred in March 2010 and January 2011. The density values were 2.47 and 1.81, respectively.

Results of the second year (Table 6 & Fig. 2) demonstrated three peaks for the total number of scales in April, June 2011, and January 2012. The population of preadults had the same picture as in the total number of scales. However, adult females adult females behave slightly differently, and the peaks were recorded in April, July and November. The average number of annual fluctuation for the total number of scales, adult females and preadults reached 7.72, 10.00 and 6.87, respectively. The monthly variation in the population density of all stages reached 3.68, 2.35 and 1.68 in April, July 2011 and January 2012, respectively.

Results indicated that this scale insect had three generations per year during February-May, April-August and August-December. While in the second year, these generations were during March-June, May-October and October-March.

Rashad [1] mentioned that *A. aurantii* was rare from October to March and the population density was nurtured by high temperature combined with moderate humidity. Rizk et al. [4] stated that *A. aurantii* have five annual generations in Middle Egypt. El-Shouny [13] stated that winter low temperature plays a great role in population reduction during winter and produces the greatest mortality in this respect. Moustafa [8] reported that the California red scale have 3-4 generations which varied according to host and zone of trees.

3.2. Effect of Biotic and Abiotic Factors on *A. aurantii* Population

Two hymenopterous parasites related to genus *Aphytis* were found parasitizing on this pest. No more than one individual of any parasite was found on any parasitized individual of this scale.

Table 1. Monthly fluctuations and seasonal abundance of *A. aurantii* and associated parasite on Balady orange trees at Kafr Shokr, Qaliobya Governorate, from Feb. 2010 till Jan. 2011

Months	Preadult	Adult	Total	Monthly variation	Parasites	Relative humidity (%)	Temp. °C
Feb. 2010	345	187	532	-	18	72.7	13.8
March	198	119	317	0.60	31	63.1	14.4
April	263	130	393	1.23	32	44.6	20.3
May	378	212	590	1.50	41	61.8	26.9
June	382	230	612	1.04	35	62.1	29
July	284	159	443	0.72	45	65.1	29
August	352	165	517	1.17	34	65.1	28.1
Sept.	358	236	594	1.15	59	62.5	27
Oct.	101	72	173	0.29	24	64.5	22.6
Nov.	110	74	184	1.06	20	66.7	17
Dec.	27	24	51	0.28	4	69.1	15.2
Jan. 2011	35	37	72	1.41	7	79.8	12.3

Table 2. Monthly fluctuations and seasonal abundance of *A. aurantii* and associated parasite on Balady orange trees at Kafr Shokr, Qaliobya Governorate, from Feb. 2011 till Jan. 2012

Months	Preadult	Adult	Total	Monthly variation	Parasites	Relative humidity (%)	Temp. °C
Feb. 2011	19	19	38	-	10	68.2	13.2
March	24	19	43	1.13	2	59.7	14.3
April	54	44	98	2.28	-	62.1	17.6
May	36	32	68	0.69	15	53.1	25.2
June	43	35	78	1.15	1	61	27.1
July	34	36	70	0.90	-	70.2	29.1
August	62	70	132	1.89	7	75.2	29.1
Sept.	54	44	98	0.74	-	72.9	26.5
Oct.	25	22	47	0.48	12	76.1	21.2
Nov.	64	63	127	2.70	4	76	17.4
Dec.	37	50	87	0.69	14	72.2	15.2
Jan. 2012	38	31	69	0.93	2	67.5	13.2

The parasites were more abundant during fall and winter with moderate numbers during spring and with few numbers during summer, especially during July and August.

To estimate the relation between the population density of California red scale and the population of *Aphytis* spp. on Succari orange, simple correlation coefficient was calculated and partial regression was assessed statistical analysis of the obtained data on the first year (Table 7) gives positive and highly significant correlation. This means that one individual increase in population of parasites accompanied with 8.98 individuals of the scale insect. In other words, the population of this scale was more active than the population of parasites. Thus parasiting factor below the optimal range. In the second year, the relation was negative and insignificant, meaning that, the parasitism factor was within the optimal range of the California red scale population activity, then it somewhat gave balance on population activity of red scale.

These results were in agreement with those obtained by Ben-Dov and Rosen [14], Avidov [15], Rosen and De Bach [16], Huffaker [17] and Yarpuzlu et al. [18] who recorded different parasites related to genus *Aphytis*. They added that these species are important ectoparasite of the California red scale in different countries especially in early summer and in the fall.

Concerning the effect of abiotic factors, statistical analysis of data (Table 1) indicated that daily mean temperature gave positive and significant correlation with the California red scale population activity in the two years of study. In other words, an increase or decrease of temperature by one unit (10°C) influenced the population density of red scale by 11.6 and 5.6 individuals of scales in the two years, respectively. This means that daily mean temperature was below the optimum for population activity of the red scale.

Table 3. Monthly fluctuations and seasonal abundance of *A. aurantii* and associated parasite on Navel orange trees at Kafr Shokr, Qaliobya Governorate, from Feb. 2010 till Jan. 2011

Months	Preadult	Adult	Total	Monthly variation	Parasites	Relative humidity (%)	Temp. °C
Feb. 2010	95	50	145	-	14	72.7	13.8
March	476	302	778	5.37	55	63.1	14.4
April	500	324	824	1.02	68	44.6	20.3
May	540	329	869	1.05	55	61.8	26.9
June	319	200	519	0.60	36	62.1	29
July	537	341	878	1.69	69	65.1	29
August	476	209	775	0.88	57	65.1	28.1
Sept.	431	279	710	0.92	86	62.5	27
Oct.	210	151	361	0.51	30	64.5	22.6
Nov.	167	119	286	0.79	27	66.7	17
Dec.	36	24	60	0.21	3	69.1	15.2
Jan. 2011	63	42	105	1.75	4	79.8	12.3

Table 4. Monthly fluctuations and seasonal abundance of *A. aurantii* and associated parasite on Navel orange trees at Kafr Shokr, Qaliobya Governorate, from Feb. 2011 till Jan. 2012

Months	Preadult	Adult	Total	Monthly variation	Parasites	Relative humidity (%)	Temp. °C
Feb. 2011	26	11	37	-	11	68.2	13.2
March	23	13	36	0.97	1	59.7	14.3
April	57	42	99	2.75	1	62.1	17.6
May	35	25	60	0.61	13	53.1	25.2
June	53	43	96	1.60	1	61	27.1
July	83	94	177	1.84	3	70.2	29.1
August	76	70	146	0.82	10	75.2	29.1
Sept.	49	42	91	0.62	62	72.9	26.5
Oct.	24	20	44	0.48	10	76.1	21.2
Nov.	74	58	132	3.00	2	76	17.4
Dec.	50	47	97	0.73	11	72.2	15.2
Jan. 2012	28	22	50	0.52	10	67.5	13.2

Table 5. Monthly fluctuations and seasonal abundance of *A. aurantii* and associated parasite on Succari orange trees at Kafr Shokr, Qaliobya Governorate, from Feb. 2010 till Jan. 2011

Months	Preadult	Adult	Total	Monthly variation	Parasites	Relative humidity (%)	Temp. °C
Feb. 2010	250	122	372	-	23	72.7	13.8
March	595	376	971	2.47	89	63.1	14.4
April	436	290	726	0.75	64	44.6	20.3
May	599	329	928	1.28	48	61.8	26.9
June	427	267	696	0.75	66	62.1	29
July	519	271	790	1.14	58	65.1	29
August	565	335	900	1.14	68	65.1	28.1
Sept.	731	490	1221	1.36	117	62.5	27
Oct.	264	467	431	0.35	40	64.5	22.6
Nov.	203	146	349	0.81	41	66.7	17
Dec.	25	34	59	0.17	2	69.1	15.2
Jan. 2011	63	44	107	1.81	10	79.8	12.3

Table 6. Monthly fluctuations and seasonal abundance of *A. aurantii* and associated parasite on Succari orange trees at Kafr Shokr, Qaliobya Governorate, from Feb. 2011 till Jan. 2012

Months	Preadult	Adult	Total	Monthly variation	Parasites	Relative humidity (%)	Temp. °C
Feb. 2011	22	9	31	-	10	68.2	13.2
March	15	10	25	0.81	-	59.7	14.3
April	53	39	92	3.68	1	62.1	17.6
May	33	24	57	0.62	11	53.1	25.2
June	43	39	82	1.44	1	61	27.1
July	103	90	193	2.53	2	70.2	29.1
August	72	69	141	0.73	13	75.2	29.1
Sept.	45	42	87	0.62	1	72.9	26.5
Oct.	21	18	50	0.57	9	76.1	21.2
Nov.	18	25	43	0.86	1	76	17.4
Dec.	17	20	37	0.86	13	72.2	15.2
Jan. 2012	52	10	62	1.68	10	67.5	13.2

Regarding to daily mean relative humidity, our results indicated negative correlation in the first year and positive in the second one, but insignificant in the two years. Relative humidity was within the optimal range for population activity of red scale in the two years of this investigation.

Statistical analysis of data gave the combined effect of the three factors as percentages of explained variance. The amount of variability in total population of red scale was larger in the first year (89.71%) than in the second year (61.51%). However, the effect of these factors was significant in the first year and insignificant in the second one. Dikson and Lindgren [19] and Rashad [1] reported that heaviest population was induced by high temperature combined with moderate relative humidity. Abdel-Fattah et al. [11] indicated that the summer months June and July are the main period which favorable for red scale. Mahmoud [6] reported that the depression of *A. aurantii* population was caused by decreasment in RH % during April, while the higher RH % depressed the population during September.

Table 7. Simple correlation and partial regression values of the three biotic and abiotic factors with their significant levels and percentage of explained variance in the population density of A.aurantii scales on Succari orange trees at Kafr Shokr, Qaliobiya Governorate from Feb. 2010 to Jan. 2012

Statistical parameters		**First year (2010-2011)**			**Second year (2011-2012)**		
		Daily mean temp.	**Daily mean R.H.**	**Parasites No.**	**Daily mean temp.**	**Daily mean R.H.**	**Parasites No.**
Simple correlations	Correlation values	+0.65532	-0.53594	+0.92951	+0.75002	+0.04979	-0.2387
	Probability (P)	+0.02071*	+0.07248^{ns}	+1.21628^{ns}	+0.00496**	+0.8780^{ns}	+0.4796^{ns}
Partial regression	Partial regression (b)	+11.62434*	-0.981101*	+8.97741*	+5.63691*	+1.7228^{ns}	-0.50391*
	Probability (P)	+0.0004***	+0.0317*	+0.0006***	+0.0179*	+0.6365ns	+0.2636^{ns}
F- values	F-value	23.2706			3.72939		
	Probability (P)	0.0003***			0.0688		
Explained variance %		89.71			61.51		

4. CONCLUSION

The California red scale insect, *Aonidiella aurantii* had three generations in each of the two years of investigation at Qaliobiya governorate. The effect of biotic and abiotic factors revealed that the parasitism factor was within the optimal range of the California red scale population activity, then it somewhat gave balance on population activity of red scale. Concerning the effects of abiotic factor, the daily mean temperature was below the optimal range for population activity of the red scale while the relative humidity was within the optimal range for population activity of red scale in the two years of this investigation.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Rashad ZMM. General studies on the red scale insects, *Aonidiella aurantii* (Maskell). M.Sc. Thesis, Fac. of Agric., Ain Shams Univ., Cairo, Egypt; 1966.
2. Rawhy SH. Studies on the control of certain scale insects infesting citrus trees in Egypt. Ph.D. Thesis, Fac. of Agric., Ain Shams Univ., Egypt; 1966.
3. Abul-Nasr S, Swailem S. Seasonal abundance of the citrus red scale, *Aonidiella aurantii* (Maskell) in certain regions of Lower Egypt. (Hemiptera: Homoptera, Diaspididae). Agric Res. Rev. J. 1975;53:149-159.
4. Rizk GA, Sheta IB, Hussein SM. Some aspects of the population activity of *Aonidiella aurantii* (Mask) in relation to weather factors in Middle Egypt. 4th Conf. Pest Control. NRC. Cairo; 1978.
5. Abou-Setta MM. The influence of certain spray parameters on the efficiency of insecticides for controlling scale insects on citrus trees. M.Sc. Thesis, Fac. of Agric., Ain Shams Univ., Cairo Univ., Egypt; 1981.
6. Mahmoud SF. Ecological studies on the California red scale and the purple scale insects on citrus trees and the effect of some recent insecticides on them and their parasites. M.Sc. Thesis, Fac. of Agric., Cairo Univ., Egypt; 1981.
7. Sadek AS, Mohamed RS. Ecological studies on some scale insects infesting citrus trees in El-Mollake region, Sharkia Governorate. Bull. Ent. Soc., Egypt. 1992;70:209.
8. Moustafa ASH. Studies on certain species of scale insects infesting citrus and Guava trees in Sharkia region. M.Sc. Thesis, Fac. of Agric., Zagazig Univ; 1992.
9. Amin AH. Studies on the population dynamics of certain scale insects in relation to their control. Ph.D. Thesis, Fac. of Agric., Ain Shams Univ., Cairo Univ., Egypt; 1970.
10. Darwish ETE. Biological and control studies on the scale insects attacking citrus trees in Menoufia Province. M.Sc. Thesis, Fac. Of Agric., Tanta, Egypt; 1970.
11. Abdel Fattah MI, El-Minshawy A, Darwish E. The seasonal abundance of two scale insects: *Lepidosaphes becka* (New.) and *Aonidiella aurantii* (Mask.) infesting citrus trees in Egypt. 4th. Conf. Pest Control, NRC, Cairo. 1978;79-84.
12. Fisher RA. Statistical methods for research workers. II. Rev. Ed. Oliver and Boyed, London; 1950.
13. El-Shouny KY. Biological and ecological studies on some insect pests infesting horticultural crops in Gharbia Governorate (A.R.Egypt). Ph.D. Thesis, Fac. of Agric., Al-Azhar Univ., Egypt; 1987.
14. Ben Dov Y, Rosen D. Efficiency of natural enemies of the California red scale on citrus in Israel. J. Econ. Entomol. 1969;24:1222- 1229.

15. Avidov Z. Biology of natural enemies of citrus scale insects and the development of methods for their mass production. Rehovot, Israel Hebrew Univ. of Jerusalem, Fac. of Agric. 1970;8:247.
16. Rosen D, De Bach P. Introduced parasite and predators of arthropod pests and weeds. A World Reviews, Washington, D.C., Text Book; 1978.
17. Huffaker CB. New technology of pest control. John Wiley and Sons, New York. 1980;319-365.
18. Yarpuzlu F, Oztemyz M, Karacaodlu M. Natural enemies and population movement of the California Red Scale *Aonidiella aurantii* Maskell (Homoptera: Diaspididae) with efficiency of parasitoid, *Aphytis melinus* (How.) (Hymenoptera: Aphelinidae) in Lemon Orchades. J. Ent. Res. Soc. 2008;10(1):43-58.
19. Dickson RC, Lindgren DL. The California red scale. Calif. Citroger. 1947;32(12):542-544.

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