Impact of certain climatic factors on population of *Chrysomphalus aonidum* L. infesting *Dracena* Shrubs under green house conditions

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Abstract: A Study of the black scale insect *Chrysomphalus aonidum* L. (Hemiptera: Diaspididae) population infesting *Dracena* shrubs was carried out under green house conditions in two successive years (2010-2011 and 2011-2012). Results showed that this insect recorded 4 peaks during the first studied year, the highest was in 1st of November 2010 (50.7 insects/ leaf) with maximum and minimum temperature (27.60°C, 17.35°C) and average relative humidity (79.83%). While in the second year it recorded 3 peaks of population; the highest peak was in mid of June (112.5 insects / leaf) with maximum and minimum temperature (32.20°C, 21.35 °C) and average RH %. (71.70%). In both years there were three generations. A very slight population was recorded for the associated endoparasitoid *Habrolepis diaspidi* (Rrisbec) (Hymenoptera : Encyrtidae). Results also, indicated that, the maximum, minimum temperature and relative humidity had negative significant exponential relationship regression on different alive stages.

[Omnia M. N. El-Sahn and Ihab I. Sadek. **Impact of certain climatic factors on population of *Chrysomphalus aonidum* L. infesting *Dracena* Shrubs under green house conditions.** *J Am Sci* 2014;10(12s):31-36]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 4

Keywords: *Chrysomphalus aonidum*, *Dracena*, population fluctuation, climatic factors, prediction.

1. Introduction

Chrysomphalus aonidum (=*ficus*) L. (Hemiptera : Diaspididae) is a hard scale insect infesting many species of plants, and a highly polyphagus insect with host range of 192 plant genera belonging to 77 unrelated families Hlavjenková & Šefrová (2012). This insect was recorded as a serious pest of citrus in Florida, Texas, Brasil, Mexico, Lebanon, Egypt and Israel (Ben-Dov *et al.*, 2001). The presence of insects on leaves blocks the photosynthesis operation, which leads to plant weakness. As a sap sucking insects it causes a lot of damages while feeding. It grows on leaves, green twigs and fruits causing leaves turn yellow, premature leaves, fruits drop and stem dieback (Watson, 2005). For ornamental plants, these insects cause malformation for leaves, branches and stem which consider the fortune of the plants that lead to decrease in quality and marketing value of the plant; these insects infest ornamental plants mostly inside green houses. So, it was important to study such insects and recognize it's ecological aspects inside green houses to specify the proper timing for control.

2. Material and Methods

Sampling method:

This experiment was conducted in the glass green house at El-Zohreya Botanical Garden. Selected *Dracena* shrubs received the normal horticultural practices with no insecticides applications for 2 years (2010-2011 and 2011-2012). Samples were taken biweekly and kept in a polyethylene bags and transferred immediately to the laboratory to detect and count the different alive stages (nymphs, adults and gravid females) located on the infested leaves with the aid of the steriobinocular.

Number of generations and durations of *C. aonidum* were estimated from changes in the mean half monthly nymphal stage counts throughout the 2 successive seasons according to Jacob formula (1977).

Climatic factors considered in this study were: maximum, minimum and average air temperature (°C) and maximum, minimum and average relative air humidity (%). All climatic factors were measured and recorded using a digital thermo/hygrometer.

Statistical analysis:

Statistical analysis was performed using the SAS system (SAS, 2005). Duncan's multiple range tests was used for means separation. Significance was assessed at $P < 0.05$.

3. Results and Discussion

Data in Tables (1 and 2) showed the biweekly counts of *Chrysomphalus aonidum* L. during the two studied years, (2010-2011) and (2011-2012), in relation to associated climatic factors. It showed the following:

1- Pre-adults fluctuations:

Four peaks were recorded for pre-adults 4 peaks in both years with 26.6, 26.4, 35.25 and 37.4 pre-adults/leaf for the first year in mid March, 1st of May, 1st of November and mid January, respectively. As for the second year they were 63.95, 87.40, 11.75 and

12.55 pre-adults/ leaf in 1st of May, 15th of June, mid October and 1st of December, respectively.

2- Adult females fluctuations:

Adult females of *C. aonidum* recorded the highest population in the first year as shown in Table (1) in the 1st of April, 1st of May, mid June, mid October and mid January with 8, 8.10, 5.4, 7.7 and 4.45 adult females/ leaf, respectively. Also, in the second year, data in Table (2) showed that there were 5 peaks for adult females infesting leaves of *Dracena* shrubs with 11.3, 2.75, 2.35,3.8 and 5.15 adult females/ leaf in mid May, mid September, 1st of December, 1st of January and mid February, respectively.

3- Gravid females fluctuations:

Data in Table (1) showed that gravid females had 4 peaks with 8.85, 16.15, 10.6 and 8.85 gravid females/leaf in 1st of April, 1st of June, 1st of November and mid February, respectively. In Table (2) data showed that gravid females had 4 peaks almost the same as in the 1st year in 1st of April, mid of June, mid November and mid February with 7.45, 20.95, 2.25 and 4.15 gravid females/ leaf, respectively.

4- Total population fluctuations and the associated weather factors:

In the 1st year of investigation there were 4 peaks for the insect. The 1st peak was recorded in the beginning of May with 42.5 insects/leaf with maximum, minimum temperature and average RH% (32.33°C, 19.48°C and 60.70%, respectively). The second peak was in the 1st of June with 38.1 insects/ leaf with maximum and minimum temperature and average relative humidity 33.40°C, 22.28°C and 67.90%, respectively. The highest peak was in 1st of November with 50.7 insects/ leaf with max and min temperature and average RH% 27.60°C, 17.35°C and 79.83%, respectively). In mid January the fourth peak recorded 47.7insects/leaf (19.33°C max temp., 10.85°C min temp. and 80.06% RH).

Table (1): Population fluctuation of *C. aonidum* infesting *Dracena* sp. Shrubs under green house conditions in El-Zohreya Botanical Garden, Cairo Governorate (2010-2011).

Sampling dates	No. of *C. aonidum* individuals/leaf				Accumulated nymphs counts	Accumulated %	No. of Parasitoids / leaf	Climatic factors		
								Temperature		RH %
	Pre-adults	Adults	Gravid Females	Total				Max °C	Min °C	
01/03/2010	9.4	2.85	6.00	18.25	0.16	0.04	1.2	28.86	17.02	69.57
15-3-	26.6	1.90	8.80	37.30	36	9.46	0.1	22.89	13.29	73.81
1-4-	22.05	8.00	8.85	38.90	58.05	15.25	0.25	27.73	15.55	64.97
15-4-	19.05	3.85	7.75	30.65	77.1	20.26	2.65	28.86	18.02	62.97
1-5-	26.40	8.10	8.00	42.50	103.5	27.19	0.4	32.33	19.48	60.70
15-5-	4.80	1.05	12.20	18.05	108.3	28.45	0	30.89	20.23	65.94
1-6-	20.55	1.40	16.15	38.10	128.85	33.85	0	33.40	22.28	67.90
15-6-	16.45	5.40	9.55	31.40	145.3	38.17	0.1	36.13	24.48	63.57
1-7-	1.95	1.80	4.10	7.85	147.25	38.68	0	33.40	22.48	76.70
15-7-	1.10	1.00	1.05	3.15	148.35	38.97	0	35.14	24.66	74.25
1-8-	1.10	0.70	1.90	3.70	149.45	39.26	0	36.00	25.15	76.83
15-8-	6.10	0.60	1.35	8.05	155.55	40.86	0	36.39	25.29	78.00
1-9-	1.75	0.45	2.70	4.90	157.3	41.32	0	33.00	23.15	74.03
15-9-	1.20	0.60	1.40	3.20	158.5	41.64	0	34.00	22.62	74.70
1-10-	10.55	2.20	2.15	14.90	169.05	44.41	0	32.46	21.82	70.90
15-10-	9.30	7.70	5.55	22.55	178.35	46.85	0	30.33	20.41	73.75
1-11-	35.25	4.85	10.60	50.70	213.6	56.12	0	27.60	17.35	79.83
15-11-	10.50	1.40	8.10	20.00	224.1	58.87	0	25.20	15.62	85.37
1-12-	25.00	3.10	2.80	30.9	249.1	65.44	0	21.20	12.35	75.83
15-12-	36.15	2.30	3.55	42.00	285.25	74.94	0.05	21.93	11.68	76.77
01/01/2011	32.95	3.35	5.00	41.3	318.2	83.59	0	18.26	10.22	85.63
15-1-	37.40	4.45	5.85	47.7	355.6	93.42	0.1	19.33	10.85	82.06
1-2-	11.50	3.25	0.60	15.35	367.1	96.44	0.05	19.47	12.06	81.43
15-2-	13.55	5.35	8.85	27.75	380.65	100	0.05	21.76	12.92	60.29

In the second year, data in Table (2) showed that, there were only 3 peaks recorded as follows: 1st peak was in 1st of May with 76.7 insects / leaf (29.13°C, 17.88°C and 62.03% for maximum and minimum temperature and average relative humidity, respectively.

Table (2): Population fluctuation of *C. aonidum* infesting *Dracena* sp. Shrubs under green house conditions in El-Zohreya Botanical Garden, Cairo Governorate (2011-2012).

Sampling dates	No. of *C. aonidum* individuals/leaf				Accumulated nymphs counts	Accumulated %	No. of Parasitoids / leaf	Climatic factors		
								Temperature		
	Pre-adults	Adults	Gravid Females	Total				Max °C	Min °C	RH %
01/03/2011	27.05	4.70	4.60	36.35	0.16	0.03	0.05	21.33	10.55	72.90
15-3-	40.70	3.95	6.65	51.30	67.75	12.87	0.1	23.83	12.04	72.63
1-4-	62.30	3.05	7.45	72.80	130.05	24.71	0.2	25.26	14.42	66.63
15-4-	63.20	5.15	6.35	74.70	193.25	36.72	0.15	27.73	17.62	61.63
1-5-	63.95	6.85	5.80	76.60	257.2	48.87	0.15	29.13	17.88	62.03
15-5-	34.95	11.3	9.40	55.65	292.15	55.51	0.2	31.96	19.41	63.50
1-6-	37.00	4.35	14.35	55.70	329.15	62.53	0.05	33.13	20.82	67.70
15-6-	87.40	4.15	20.95	112.50	416.55	79.14	0.4	32.20	21.35	71.70
1-7-	7.15	1.30	7.75	16.20	423.7	80.50	0	34.20	22.42	72.57
15-7-	0.65	1.00	1.00	2.65	424.35	80.62	0	35.14	23.48	74.88
1-8-	0.20	0.40	2.30	2.90	424.55	80.66	0	33.60	23.42	76.63
15-8-	2.95	0.55	1.85	5.35	427.5	81.22	0	33.39	23.10	73.63
1-9-	5.85	0.45	1.30	7.60	433.35	82.33	0	32.86	23.02	79.03
15-9-	7.25	2.75	1.15	11.15	440.6	83.71	0	31.60	22.02	73.70
1-10-	7.25	1.85	1.95	11.05	447.85	85.09	0.05	30.06	20.22	69.17
15-10-	11.75	1.00	1.95	14.70	459.6	87.32	0	25.89	17.23	74.63
1-11-	9.75	0.90	2.20	12.85	469.35	89.17	0.05	23.33	13.88	77.50
15-11-	12.55	2.70	2.25	17.5	481.9	91.56	0.15	19.40	12.02	82.03
1-12-	12.55	2.35	0.80	15.70	494.45	93.94	0	19.46	9.95	83.70
15-12-	11.60	1.40	0.95	13.95	506.05	96.14	0	18.40	9.68	81.37
01/01/2012	7.35	3.80	1.40	12.55	513.4	97.54	0	16.20	8.08	74.23
15-1-	6.00	1.90	0.65	8.55	519.4	98.68	0.05	16.83	8.79	74.31
1-2-	2.05	1.15	0.40	3.60	521.45	99.07	0	18.40	8.82	62.83
15-2-	4.90	5.15	4.15	14.2	526.35	100	0	17.62	9.35	72.93

The 2nd peak was recorded in mid of June with 112.5 insects/leaf (32.20 °C, 21.35 °C and 71.70% maximum, minimum temperature and average relative humidity. The 3rd peak was in mid November with 17.5 insects/leaf with associated maximum and minimum temperature and average relative humidity, of 19.40°C, 12.02°C and 82.03%, respectively.

The population of *C. aonidum* was higher in the second year than first year with general mean of 29.42 insects/leaf and 24.96 insects/leaf, respectively. These data are in agreement with Hamed (1969) and Moursi (1999) who mentioned that *C. aonidum* recorded 3-4 peaks annually.

Also, it was noticed that the population on the upper surface of the leaf was higher than the lower in both years with mean numbers of 15.43 and 11.77 insects/leaf, respectively. This result was in agreement with Borras *et al.* (2006) who mentioned that *C. aonidum* preferred the upper side of the leaves.

Habrolepis diaspidi (Rrisbec) (Hymenoptera : Encyrtidae) is an endoparasitoid. It was reported associated with *C. aonidum* but with very low population maybe because plants were cultivated inside green house which consider an obstacle for the parasitoid to reach the insect, therefore the highest population was recorded in mid of April 2010 with 2.65 parasitoid / leaf.

Hekal and Sakr (2001) stated that the endoparasitoid *H. pascuorum* attack *C. aonidum* on citrus in Egypt. Also, El-Amir (2009) mentioned that *H. diaspidi* was a primary parasitoid on *C. aonidum* by 0.25 and 0.38% percent of parasitism in both years of study (2004 and 2005).

Effect of daily maximum, minimum temperature and relative humidity on *C. aonidum*:

Data in Table (3) showed that the effect of the daily maximum temperature on *C. aonidum* population infesting *Dracena* sp. in the first year under investigation was negative with highly significant effect (r value = -0.697). While the effect in the second year was non significant (r=0.261). Also, the minimum temperature recorded the same effect in both years with r values (-0.759 and 0.137, respectively). On the other hand, relative humidity had non significant effect in the first year and highly significant effect in the second year with r = 0.002 and 0.637, respectively. The partial regression analysis showed the combined effect of the three weather factors on the population of the insect in both years were E.V.% =66.48 and 60.35%, respectively.

Table (3): Effect of weather factors (Max. Temp., Min. Temp. and R.H.%) on *C. aonidum* Under glass green house condition at El-Zohreya Botanical Garden, Cairo Egypt, (2010-2011 and 2011-2012).

Year	Simple correlation			Partial regression				
	Weather Factors	r	*P*	b	*P*	F value	*P*	EV %
2010-2011	Max temp	-0.697**	0.0002	3.067	0.112	13.22**	0.0001	66.48
	Min temp	-0.759**	0.0001	-5.437*	0.018			
	RH	0.002	0.993	-0.0987	0.715			
2011-2012	Max temp	0.261	0.217	11.33**	0.005	10.15**	0.0003	60.35
	Min temp	0.137	0.522	-12.529**	0.006			
	RH	-0.637**	0.0008	-1.572*	0.036			

Rosen and DeBach (1978) reported that this insect prefer the humid environment. While Moursi (1999) and Campolo *et al*., 2014 stated that temperature had a significant effect on the development of the insect. Also, Régnière et al 2012 mentioned that temperature has an important effect on seasonal population dynamics, so the knowledge of this effect on the insects could lead to the prediction of insect seasonality.

Number and durations of annual generations:

Data in Table (4) and Fig. (1) showed that *C. aonidum* had 3 generations in both years of investigation but the intervals of generations slightly differ in the 1st year from the 2nd year. The longest generation in the 1st year was 4.5 months but in the second year it was 5 months.

Table (4): Number of generations of the black scale insect *C. aonidum* infesting *Dracena* sp. Shrubs under green house conditions in El-Zohreya Botanical Garden, Cairo Governorate (2010 – 2011)and (2011-2012).

Generations	Interval of generations	Durations	Mean Temp.	Mean R.H.%
1st year				
1st generation	1st of March until 1st of July	4 months	24.47	66.18
2nd generation	1st of July until 15th of October	3.5 months	28.97	75.06
3rd generation	15th of October till 1st of March	4.5 months	18.25	77.88
2nd year			Mean Temp.	Mean R.H.%
1st generation	1st of March till 1st of June	3 months	20.93	66.55
2nd generation	1st of June till 1st of November	5 months	26.96	73.36
3rd generation	1st of November till 1st of March	4 months	14.39	76.11

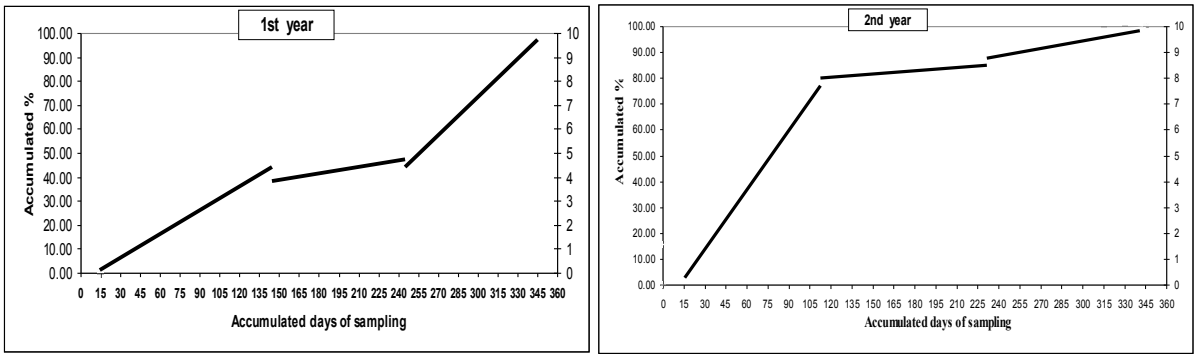

Fig. (1): Generations of the black scale insect *C. aonidum* infesting *Dracena* sp. Shrubs under green house conditions in El-Zohreya Botanical Garden, Cairo Governorate (2010 – 2011)and (2011-2012).

1- First year generations:

- **1st generation** extended for 4 months from the beginning of March till the 1st of July (mean temp. 24.47°C and R.H. 66.18%).
- **2nd Generation** occurred between 1st of July till mid October for 3.5 months (mean temp. 28.97°C and R.H. 75.06%).
- **3rd generation** started from 15th of October to the beginning of March for 4.5 months with mean temp. 18.25°C and R.H. 77.88%.

2- Second year generations:

- **1st generation** lasted for 3months from the beginning of March till the beginning of June with mean temp. (20.93°C) and mean R.H. 66.55%.
- **2nd generation** happened between the beginning of June till the 1st of November for 5 months with mean temp. 26.96°C and 73.36 % R.H.
- **3rd generation** it took place between 1st of November till the end of February for 4 months with mean temp. 14.39°C and mean R.H. 76.11%.

The previous data showed an agreement with Gan, *et al.* (1993), Win (1999) and Liu, *et al.* (2002), where they mentioned that this insect has 3 generations per year on leaves. While Sakr (1994) and El-Amir (2009) stated that it recorded 4 generations annually on Orange trees in Qalubyia Governorate.

Prediction of different alive stages:

Furthermore, the most effective climatic factors, that could be used to predict different alive stages were maximum air temperature (T_{Max}), minimum air temperature (T_{Min}) and average relative air humidity (RH).

Prediction equation for general, pre-adults, adults, gravid females populations were concluded according to the mentioned statistical analysis and presented as follow:

General population ($R^2 = 0.833, P <.0001$)

$$Y= 222.41 – 0.786\ T_{Max} + 0.106\ T_{Max}^2 + 9.33\ T_{Min} - 0.453\ T_{Min}^2 - 6.68\ _{RH} + 0.044\ _{RH}^2$$

Where is: Y= General population.

Pre-adult population ($R^2 = 0.642, P <.0001$)

$$Y= 474.04 +12.74\ T_{Min} -0.762\ T_{Min}^2 - 19.02\ _{RH} + 0.129\ _{RH}^2$$

Where is: Y= Pre-adults population.

Adult population ($R^2 = 0.622, P <.0001$)

$$Y= 145.20 – 5.49\ T_{Max} + 0.130\ T_{Max}^2 + 5.35\ T_{Min} - 0.216\ T_{Min}^2 - 2.80\ _{RH} + 0.017\ _{RH}^2$$

Where is: Y= Adults population.

Gravid females population ($R^2 = 0.631, P <.0001$)

$$Y= -30.06 – 8.38\ T_{Max} - 0.209\ T_{Max}^2 + 9.89\ T_{Min} - 0.381\ T_{Min}^2$$

Where is: Y= Gravid females population.

Conclusion

From the previous results it can be conclude that *C. aonidum* had 3 generations/year varied between 3-5 months. The combined effect of the studied climatic factors showed a significant effect. In addition, the highest population recorded throughout the two successive years of investigation was in spring and early summer. So, it is recommended to apply the control procedures in early spring.

Acknowledgment

I hereby represent my sincere thanks to Prof. Dr. Mohamed Abo Setta for his precious assistance in the statistical analysis.

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