ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Seasonal Abundance, Number of Generations and Associated Injuries of the White Mango Scale, *Aulacaspis tubercularis (Mangifera)* (Newstead) (Homoptera: Diaspididae) Attacking Mango Orchards.

Salem HA, YA Mahmoud*and IMA Ebadah.

Pests and Plant Protection Department, National Research Centre, Dokki, Cairo, Egypt.

ABSTRACT

This research was conducted through two years of estimation (2011 2012) in mango orchards at Kalubyia Governorate, Egypt. The results indicated that this pest had 3 peaks in the year, 2011. The 1st was recorded at the 1st of May, the 2nd was recorded at the 1st of August while the 3rd at the 1st of November. In the year 2012 four peaks of this pest were recorded, the first peak at the 1st of Jan., the second at the 16th of May, the third at the 1st of November and the 4th peak was recorded at the 16th of December. The temperature and relative humidity had highly significant effect on the population of *Aulacaspis tubercularis* through the two years of estimation. The relationship between different densities of insect population and the associated injury on mango leaves was also estimated. It is concluded that the period from April to August was more suitable period to control this pest to prevent the injuries of leaves, shoots and fruits from reaching its maximum level.
Keywords: Temperature, relative humidity, *Aulacaspis tubercularis*, annual peaks, number of generations.

Corresponding author

ISSN: 0975-8585

INTRODUCTION

Mango *Mangifera indica* (L.) is important as a popular fruit and in processing or in exporting to the external markets. Recently, a noticeable increasing in the infestation with the white mango scale *Aulacaspis tubercularis* (*mangifera*) (Newstead) was observed in the mango orchards at Giza, Kalubeia and other Governorates in Egypt [1].

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 infestation, during hot dry weather [2-7]. Its population densities were recorded on mangoes in few parts of the world [8, 9, 10]. It has been spread by the transport of infested plant material and is now widespread in many mango growing countries. It presents as a significant pest problems on mangoes in South Africa [4, 7], in Australia, East and West Africa, North and South America and the Caribbean Islands [6]. It has not been recorded from most of the tropical Pacific islands [11-15]. This insect became an economic pest all over Egypt, after it was restricted in Minia Governorate under quarantine regulations then crept to Beni-Suif Governorate, [16]. This pest has four overlapping annual generations at Kalubeia governorate [17] and three generations at Beni-Swief [18].

The present work aimed to investigate the effect of temperature and relative humidity on some ecological aspects of *A. tubercularis* besides its injury on mango leaves during two years of estimation.

MATERIALS AND METHODS

The present work was carried out at Barrage district, Kalubeia Governorate during two consecutive years 2011 and 2012 in orchard about 6 feddan (feddan= 4200m^2) planted with mango trees aged about 56 years. No chemical control was used before and during the investigation period; conventional agriculture practices were followed.

Sampling and inspection

Samples of 15 leaves in eight replicates were taken fortnightly from homogenate mango trees in growth and vigor. Sample size was 120 leaves, it is considered that samples leaves must be represented the four cardinal directions and center of trees. Samples were kept in plastic bags; and transferred to the laboratory to inspect using binocular microscope. Both upper and lower surface of the leaves, petioles and lenticels were inspected carefully. Live individuals of immature stages (nymphs) and adult females were recorded. Half monthly mean counts of nymphs and females; and total population were estimated.

Characterization and estimation of insect density and injury on mango leaves

At the end of summer and fall of 2012, samples of 120 leaves were taken and inspected to estimate the population density of insect by counting the live and dead individuals of nymphs, adult females and males persisted on leaves. Population divided into four densities; low density (leaves harbored from 10-70 individuals/leaf), medium density (leaves harbored above 70-300 individuals), high density (leaves harbored above 300-800 individuals); and accumulative population (leaves harbored above 800 individuals / leaf). At the same time, injury symptoms on the same leaves were evaluated and categorized into four degrees: leaves had yellow strips, leaves had yellow spots, leaves had yellow areas; and leaves suffer from necrotic spots. Numbers of leaves in each category of injury and population density were recorded.

Calculations and statistical analysis

The quotient of increase in total population and annual fluctuation were calculated according to the following equation [19]

$$\text{Quotient of increase} = \frac{\text{Population of estimating month}}{\text{Population of preceding month}}$$

ISSN: 0975-8585

Average of annual population was calculated by dividing the maximum population by the minimum population. Number, extension and duration of generations of *A. tubercularis* during 2011 and 2012 were estimated [20]. Readings of temperature and relative humidity through 2011 and 2012 were obtained from Central laboratory of Agricultural climate and turned to half monthly average. The relationship between temperature and relative humidity during the period of estimation was correlated with *Aulacaspis tubercularis* population using statistix9 program [21].

RESULTS

Seasonal abundance of total population

Data in Table (1) cleared that population of white mango scale *Aulacapsis tubercularis*, had three peaks during the year 2011, the first peak was the highest one, with counts of 2724.9 individuals / leaf at the first of May at 19.3°c and 67.87% R.H, the second peak was the moderate (618.15 individuals / leaf) and recorded during August month at 25.77°C and 73.44% R.H, the third peak was the lowest, (189.34 individuals / leaf) and occurred during November month at 19.85°c and 73.06% R.H. On the other hand, lowest population in this year was recorded at the 16th of September (30.2 individuals / leaf). It is observed that in the year 2011 the fluctuation in *A. tubercularis* population was 90.23 and the highest quotient of increase in the total population was 34.4 at the 1st of April (Table 1).

Table 1: Mean counts of nymphs and adult females of the white mango scale, *Aulacaspis tubercularis* (New.) in relation to temperature and relative humidity at Barrage district, Kalubeia Governorate during season 2011.

Sampling dates	No. of insect/leaf		Total population	Quotient of increase	Mean	
	Nymphs	Adult females			Temp. °C	R.H.%
January 1st	27	62.1	89.1	-	14.1	80.1
16th	20	45	65	0.73	13.98	73.9
February 1st	18.8	51	89.8	1.074	14.96	66.1
16th	20	49	69	0.99	14.29	74.87
March 1st	21.3	43.5	64.8	0.94	14.58	56.78
16th	27	4	31	0.48	13.67	72.93
April 1st	1041.4	25	1066.4	34.4	15.85	74.38
16th	2141.2	99.1	2240.3	2.1	17.68	67.87
May 1st	2533.7	191.2	2724.9	1.22	19.3	65.4
16th	1773.75	250.4	2024.15	0.743	21.2	61.8
June 1st	1106.3	147.2	1253.5	0.62	23.3	62.25
16th	580.8	138.7	719.5	0.574	25.04	63.7
July 1st	654	105.7	759.71	1.06	25.5	65.13
16th	409.2	109.8	519	0.68	26.3	70.6
August 1st	564.9	53.25	618.15	1.19	25.77	73.44
16th	22.21	17	39.21	0.06	26.59	74.53
September 1st	11.7	23.7	35.4	0.90	28.1	66.19
16th	8.5	21.7	30.2	0.85	28.23	62.87
October 1st	27.7	32.2	59.9	1.98	26.38	63.33
16th	97.3	33.6	130.9	2.19	22.86	69
November 1st	177.3	12.05	189.34	1.45	19.85	73.06
16th	62.2	16.6	78.8	0.42	16.63	77.93
December 1st	77	46.0	123	1.56	14.33	82.13
16th	109	78.0	187	1.52	12.83	84.13
Total	11532.26	1655.8	13188		481.32	1682.42
Mean	480.5	68.99	549.5		20.06	70.1

In the second year (2012) three peaks of *A. tubercularis* were also recorded, the first peak was the highest (4444.1 individuals/leaf) at the 16th of May when the temperature and relative humidity were 23.4°c and 59.1%, respectively while the third peak was the lowest (164.45 individuals/leaf) and recorded at the end of the year. The lowest population recorded 16.4 individuals / leaf during September month. The average of annual fluctuation in *A. tubercularis* was 270.98 and the highest quotient of increase in total population was 20.13 at the 1st of April (Table 2).

ISSN: 0975-8585

Table 2: Mean counts of nymphs and adult females of the white mango scale, *Aulacaspis tubercularis* (New.) in relation to temperature and relative humidity at Barrage district, Kalubeia Governorate during season 2012.

Sampling dates	No. of insects/leaf		Total population	Quotiet of increase	Mean	
	Nymphs	Adult females			Temp. °C	R.H.%
January 1st	38	361	399	-	12.13	83.13
16th	29	352	381	0.96	11.3	71.4
February 1st	21.8	299	320.8	0.84	11.44	78.38
16th	31	291	322	1.004	12.1	70.13
March 1st	43.3	251.5	294.8	0.92	14.5	61.2
16th	47	20.8	67.8	0.23	17.1	53.2
April 1st	1133.4	243.7	1377.1	20.31	14.19	73.13
16th	2391.2	846.1	3237.3	2.35	19.51	67.3
May 1st	2961.2	1241.6	4202.8	1.3	19.85	65.87
16th	3092.4	1351.6	4444.1	1.06	23.41	59.1
June 1st	3178	1114.5	4292.5	0.97	24.41	60.38
16th	3296	997.1	4293.1	1.0	25.49	64.33
July 1st	3851.4	411.1	4262.5	0.99	27.77	70
16th	457	208.7	665.7	0.16	27.71	72.7
August 1st	197	93.1	290.1	0.44	28.33	78.06
16th	92.2	53	145.2	0.5	28.13	74.93
September 1st	11.4	5	16.4	0.11	27.26	73.75
16th	25	17.8	42.8	2.61	26.19	74.4
October 1st	36.3	29.8	66.1	1.54	24.43	71.53
16th	71.3	27.12	98.43	1.5	24.34	72.67
November 1st	103.4	80.5	183.9	1.87	22.88	77.94
16th	15.62	26.75	42.38	0.23	20.59	82.87
December 1st	47	53	100	2.36	19.11	69.53
16th	86.9	77.55	164.45	1.64	16.62	60.13
Total	21256.82	8453.32	29710.14		498.79	1686.06
Mean	885.7	352.22	1237.92		20.78	70.25

From the data in the tables (1 and 2) an additional peak of *A. tubercularis* (seventh peak) can be noticed, started at the end of 2011 and continued to the beginning of 2012 and reached its highest counts (399 individuals/leaf) at 1st January under 12.3°C and 83.13% R.H.

Seasonal abundance of nymphs and adult females of *A. tubercularis*

Nymph of *A. tubercularis* recorded 4 peaks in the year 2011 (Table 1) with highest population (2533.7 nymphs / leaf) at the first of May while in the year 2012 (Table 2) the nymphs recorded 3 peaks with highest population (3851.4 nymphs / leaf) during the first of July.

On the other hand, adult females of *A. tubercularis* behave similar trend and fluctuated 3 times a year with accompanied 3 peaks (Tables 1 and 2). The first peak was recorded at the 16th of May in both years with highest count of 250.4 and 351.7 females / leaf during 2011 and 2012, respectively. Besides the 7th peak at the end of 2011 and the beginning of 2012 was recorded with 361 females / leaf.

Number and duration of the generations of *A. tubercularis*

A. tubercularis had four overlapping annual generations during each year of observation (Table 3). The first generation started from the 1st January to 16th March in both years, the second generation started from the 16th March to the 16th May in 2011 and lasted to the 16th June in 2012, the third generation occupied 4 months from the 16th May to the 16th September, 2011 but it occupied 2 months from the 16th June to the 16th August, 2012 and the fourth generation occupied 3 months from the 16th September to the 16th December 2011 while in 2012, it is occupied 4.5months from the 16th August to the end of the year.

The effect of temperature and relative humidity on the duration of generation of *A. tubercularis* can be clearly observed from the data in the table (3) where the correlation values between duration of generation

and temperature were -0.17, 0.99, 0.91, -0.98, and 0.9, 0.94, 0.98, -1.0 at 2011 and 2012, respectively and -0.55, -0.97, 0.65, 0.97 and -0.95, -0.09, 0.98, -0.33 for relative humidity at 2011 and 2012, respectively.

Table 3: Generations overlapping of *Aulacaspis tubercularis* and sample correlation (r) and regression (b) between generations and climatic factors at Kalubeia Governorate during two years.

Year	Generation	Duration of generation	Temp. °C		R.H.%	
			r	b	r	b
2011	First (1st Jan. – 16th March)	3 months	-0.17^{ns}	-0.13	-0.55^{ns}	-0.02
	Second (16th March-16th May)	2.5months	0.99**	9.13	-0.97**	-5.04
	Third (16th May-16th Sep.)	4.5months	0.94**	4.41	0.65*	1.38
	Fourth (16th Sep.-16th Dec.)	3.5months	-0.98**	-0.27	0.97**	0.19
2012	First (1st Jan. – 16th March)	3 months	0.9**	0.12	-0.95**	-0.03
	Second (16th March-16th June)	3.5months	0.94**	6.48	-0.09^{ns}	-0.39
	Third (16th June-16th Aug.)	2.5 months	0.98**	7.92	0.89*	1.56
	Fourth (16th Aug.-16th Dec.)	4.5 months	-1.0**	-0.13	-0.33^{ns}	-0.04

Temp. = Temperature, R.H. = Relative humidity, * = Significant correlation value at 5% level. ** = Highly significant value at 1% level, ns = Non significant value.
r = simple correlation
b = simple regression

Characterization and estimation of population density of *A. tubercularis* and the associated injuries on mango leaves

Table (4) explains the relationship between population density of *A. tubercularis* and the associated injury on the mango leaves. At summer 2012, medium population density of the insect was observed and able to cause 1.66%, 16.66% and 15% yellow spots, yellow areas and necrotic spots, respectively, on the leaves (Figure 1). As well as the condensed and accumulative population caused 3.33%, 20% and 40% yellow spots, yellow areas and necrotic spots, respectively, on the leaves. At the fall, percentages of leaves injuries by condensed population reached to 5% yellow area and 23.33% necrotic spots while the accumulative population caused 38.33% necrotic spots of the examined leaves.

Table 4: Percentages of injured mango leaves caused by different population density of *Aulacaspis tubercularis* during summer and fall, 2012.

Season	Injury categories	Population density				Total
		Low	Medium	Condensed	Accumulative	
Summer	Yellow strips	-	-	-	-	-
	Yellow spots	3.333	1.666	-	-	5
	Yellow areas	-	16.666	3.333	-	20
	Necrotic spots	-	15	20	40	75
	Total	3.333	33.333	23.333	40	
Fall	Yellow strips	-	-	-	-	-
	Yellow spots	-	-	-	-	-
	Yellow areas	-	15	5	-	20
	Necrotic spots	-	18.333	23.333	38.333	80
	Total	-	33.333	28.333	38.333	

It is noticed that 5% of examined leaves had yellow spots, 20% had yellow area and 75% suffer from necrotic spots during summer months while the percent of necrotic spots increased adversely to about 80% at the fall. The infested leaves with necrotic spots had also yellow areas, yellow spots or yellow strips. In summer and fall 2012, 95% to 100% of leaves had severe injury as yellow areas and necrotic spots at summer and fall (Figure 2). This indicates that injury accumulated and progressed on the leaves from the beginning of the year (winter) to be severe injury at the end of the year (fall) (Table 4).

ISSN: 0975-8585

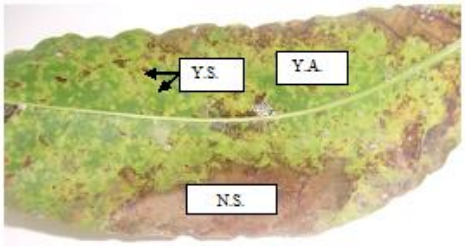

Figure 1: Different symptoms of injuries on infested mango leaf by *Aulacaspis tubercularis* during summer season. Y.S. = yellow spots, Y.A. = yellow area, N.S. = necrotic spots

Figure 2: Sever infestation of mango leaf by condensed population of *Aulacaspis tubercularis* at the end of the season.

DISCUSSION

White mango scale, *Aulacaspis tubercularis* Newstead is a serious pest on mango which became recently a troublesome pest in all mango orchards in Egypt. Results of this research cleared that this pest had 3-4 peaks per year (7 peaks during the two years of estimation. Population fluctuation of this pest cleared that the highest population was recorded May month through both years of estimation while the moderate population was recorded during August month so it can be said that the most favorable period for reproduction and development of *Aulacaspis tubercularis* occupied the period from late March to August months (moderate temperature period). These results are in harmony with that obtained by [17] who recorded 3 peaks of *Aulacaspis tubercularis* per year. On the other hand, *A. tubercularis* recorded three peaks at Damietta governorate, Egypt; these peaks were recorded during February, June and August 2010 where 35.5, 39.1 and 127.1 individuals/leaf were recorded, respectively while At El- Gharbyia governorate two peaks during April 2010, (48.9 individuals/leaf) and July 2010, (32.6 individuals/leaf) were recorded [22].

The seasonal abundance of *Aulacaspis tubercularis* was estimated through 2 successive years in Egypt and this pest had four peaks for during the two studied years, (April, August, October and December, 2008) and (March, July, September and December, 2009) [23]. Also, the maximum population of *Aulacaspis tubercularis* occurred during May month at temperature between 12.0-27.6^{o}c and 57.2% R.H. [24]. The most favorable temperature for *Aulacaspis tubercularis* development ranged 15 to 30 ^{o}c. [10]. The results indicated that *Aulacaspis tubercularis* nymphs, also, had 3-4 peaks pear and reached its maximum count during May in 2011 and the first of July in 2012 while the adult females reached its maximum counts at May month during 2011 and 2012. Both nymphs and adult females of *Aulacaspis tubercularis* had 3 peaks per year [17], moreover, nymphs population of *Aulacaspis tubercularis* was more abundant during moderate temperate months of March, April and May in Egypt [24]. The developmental pattern of *Aulacaspis Tubercularis* showed three different stages: a low density period from the end of the rainy season (September) to December, a second stage of gradual population growth from March to the beginning of the rainy season (July), and the last stage of drastic fall in population during the rainy season (July-August) [25].

The results of this research stated that this pest had four annual generations as recorded by [17] and the increasing of the duration of each generation caused overlapping in sequenced generation [10, 18].

On the other hand, the temperature had highly significant effect on the number and duration of generations and limiting the density of this pest. This may due to the white and thin cap covered the insect

which encourage it to increase its progeny with increasing the temperature to certain level, this hypothesis supported by higher existence and presence of higher numbers of the insect on warmer upper surface of the leaves which exposed to sunlight more than shaded lower surface hidden from sunlight [10, 17, 18, 22, 23, 26]. The relationship between population density of *Aulacaspis tubercularis* and associated injury on mango leaves was characterized and estimated accurately for the first time in this study. It is observed that low population density don't able to cause a considerable damage to mango leaves while the medium density able to cause yellow spots and yellow areas in about 33.3% of infested leaves in both summer and fall season while the heavy population can damage more than 40% of mango leaves in the form of yellow areas and necrotic spots. The previous results are closed with that obtained by many authors who decided that sever infestation by *Aulacaspis tubercularis* at early stage of mango plants retards the nursery growth while infestation of young trees causes leaf losses and death of twigs [2, 5-7].

CONCOLUSION

From the foregoing results, it is recommended that control measures of *A. tubercularis* in mango orchards can be employed during the suitable period extended from March until August, where the highest nymphs population were occurred making control successful, easy and accurate and prevent injury on leaves, shoots and fruits from accumulating and reaching maximum in the fall.

REFERENCES

[1] Salem HA, KH Sabry and NB Aref. Bull NRC 2011;36(3):271-286.
[2] Haltern PV. Ghana J Agr Sci 1970;3:83-85.
[3] Gallardo CF. J Agric Univ Puerto Rico 1983;67(2):179.
[4] Colyn J and B Schaffer. Acta Horticulturae 1993;341:60-68.
[5] Daneel MS and S Dreyer. Yearbook-South African Mango Grower's Association 1997;17:144-146.
[6] Pena JE, AI Mohyuddin and M Wysoki. Phyto-parasitica 1998;6(2):1-20.
[7] Joubert PH, MS Daneel, T Grove and A Pichakum. Acta Horticulturae 2000;509:811-817.
[8] Annecke DP. J Ent Soc S Afr 1963;26(1):194-225.
[9] Almeida DM. Gazeta do Agricultor 1972;24:2-5.
[10] Labuschange TI, HV Hamburg, IJ Froneman, KRS Ascherand and Y Ben Doy. Israel J Entomol 1995;29: 207-217.
[11] Tao C. 1999. List of Coccoidea (Homoptera) of China. Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan, China, 176 pp.
[12] Porcelli F. Frustula Entomologica 1990;13: 31-38.
[13] Longo S, S Marotta, G Pellizzari, A Russo, and A Tranfaglia. Israel J Entomol 1995;29:113-130.
[14] International Institute of Entomology, 1993. Distribution Maps of Pests. Series A, No. 540. CAB International, Wallingford, UK., 2 pp.
[15] Danzig EM, and G Pellizzari. 1998. Diaspididae. In: F. Kozár (ed.), Catalogue of Palaearctic Coccoidea. Hungarian Academy of Sciences. Akaprint Nyomdaipari Kft., Budapest, Hungary, 172-370.
[16] Morsi GA, MF Girgis and MA Abdel-Aziz. 2002. The Population Density of the Mango Scale, *Aulacaspis Tubercularis* (Newstead) (Homoptera: Diaspididae) and its Parasitoids in Middle Egypt. 2nd International Conference, Plant Protection Research Institute, Cairo, Egypt, 21-24 December, 2002.
[17] Kwaiz FA. Egypt J Agric Res 2009;87(1):71-83.
[18] Radwan SGA. 2003. Toxicological studies on some scale insects infesting mango and guava trees. Ph.D. Thesis, Fac. Agric., Cairo Univ. 135pp.
[19] Bohdenheimer FS. 1951. Citrus Entomology in the Middle East (W. Junk Holland, 633 pp.).
[20] Jacob N. 1977. Un mode mathematic pentra stabilirea limitel or economice de toleranta a atacului moliilor Fructelor in lupte integrate Analele. I.C.P.P. 15.
[21] Thomas CR and SC Maurice, 2008. Statistix 9, Ninth Edition, Managerial Economics McGraw-Hill/Irwin. (ISBN: 00p73402818).
[22] El-Metwally M, SFM Moussa, and NM Ghanim. Egypt Acad J Biol Sci 2011;4:123- 130.
[23] Abo-Shanab ASH. Egypt Acad J Biol Sci 2012;5:43-50.
[24] Radwan SGA and AR Attia. Bull Ent Soc Egypt 2012; 89: 167-185.
[25] Lopez UMA, et al. Revista Chapingo. Serie Horticultura 2010;16(2):77-82.
[26] Bautista-Rosales PU, JA Ragazzo-Sanchez, M Calderon-Santoyo, E Cortez-Mondaca and R Servin-Villegas. Southern Entomologist 2013;38(2):221-230.