Egypt. J. Plant Prot. Res. Inst. (2020), 3 (2): 580 - 588

Egyptian Journal of Plant Protection Research Institute

www.ejppri.eg.net

Seasonal abundance on the mango shield scale *Milviscutulus mangiferae* (Hemiptera: Coccidae) infesting mango trees at Ismailia Governorate, Egypt

Lamiaa, H.Y. Mohamed

Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

ARTICLE INFO

Article History

Received: 3 / 5 /2020

Accepted: 15 / 6 /2020

Keywords

Mango, pests, *Milviscutulus mangiferae*, seasonal abundance, Ismailia Governorate and Egypt.

Abstract:

The population density of the mango shield scale, *Milviscutulus mangiferae* (Green) (Hemiptera: Coccidae) had been studied during two successive seasons from January 2018 to December 2019 in response to the climatic factors on mango trees at Abu Suwair district, Ismailia Governorate. The obtained results indicated that *M. mangiferae* active all the year with different individual numbers, the total population density of *M. mangiferae* was relatively more abundant during the first season, 2018 (585.78 individuals/leaf) than the second season, 2019 (527.85 individuals/leaf). Obtained data showed there were three peaks of activity on mango trees for total population in January, July and November represented by 46.78, 63.85 and 87.69 individuals / leaf and in January, June and November represented by 44.49, 55.98 and 90.07 individuals / leaf for two seasons, respectively. There was highly significant negative relation between daily mean maximum temperature and total population density; while there were highly significant positive relation between daily mean minimum temperature and total population density of *M. mangiferae* in the two seasons. On the other hand, daily mean relative humidity with total population density gave significant positive relation in the first and second seasons. The percentages of explained variance (E.V. %) indicate that all tested variables were responsible on variability on the total insect population by 84.03 % and 83.53 % during the first and second seasons, respectively.

Introduction

Mango (*Mangifera indica* L.) has spread to many parts of the tropical and sub-tropical world, where the climate allows the mango to grow best. Mango rich in phytochemicals with an undisputed nutritional value for its high content of vitamins; it occupied economic importance in the world market and in Egypt it considers one of the most important fruit for rich flavor and delicious taste (Adato *et al.*, 1995; Abd-Rabou *et al.*, 2012; Indu, 2017 and Marianna *et al.*, 2017). Soft scale insects constitute one of the most important groups of pests in agriculture, many species are destructive

especially to fruit trees and ornamental plants (Abd-Rabou, 2011). The mango shield scale, *Milviscutulus mangiferae* (Green) (Hemiptera: Coccidae) is polyphagous soft scale insect and recorded in Egypt as a new pest attacking mango orchards (Abd-Rabou and Evans, 2018). *M. mangiferae* is considered one of the most main destructive pests of mango trees. This insect is of great economic importance, causes crop losses by severely depleting plant cell nutrients resulting in a reduction of photosynthetic capacity. Heavy infestations caused damage to plants by clogging of leaf or fruit surfaces, sap sucking and excrete a large amount of honeydew, on which sooty mould subsequently grows causing considerable economic injury. Also, infestation with *M. mangiferae* reduced tree vigor and leaf size, causing yellowing of the leaves, leaf drop and death of the branches, (Ben-Dov and Hodgson, 1997 and Grimshaw and Donaldson, 2007). Ecological study of the pest is important including the environmental factors (temperature and relative humidity); the study of these parameters is particularly interesting for insect and economic importance to obtain a useful orientation for good forecasting and prediction system of insect population. Therefore, the present work aimed to study the seasonal abundance of *M. mangiferae* during the two seasons from January 2018 to December 2019 in response to the climatic factors on mango trees at Abu Suwair district, Ismailia Governorate.

Materials and methods

1.Sampling and assessment of samples:

The present study was carried out in private mango orchard at Abu Suwair district, Ismailia Governorate throughout two seasons from January 2018 to December 2019 to estimate the seasonal abundance of the mango shield scale *M. mangiferae*. The selected orchard for present investigation doesn't receive any chemical control throughout the duration of the study and received the normal agricultural practices only. Five mango trees of Ewaisi variety were selected of the same age, height and size, as well as homogenous in their insect infestation. Forty infested mango leaves were collected half monthly from each tree and from the four directions, then packed in paper bags with minute holes and then transferred to the laboratory of Plant Protection Department, Agriculture Research Station at Ismailia Governorate for examination using a stereo microscope to count and record the number of the live individuals (nymphs and adult females) of the pest. The climatic factors data (means of maximum and minimum temperatures and mean percentage of relative humidity) were recorded half monthly for Ismailia Governorate to study these effects on the seasonal abundance of the different stages of *M. mangiferae* population, these data obtained for Ismailia Governorate from the Egypt Weather Underground, https://www.wunderground.com/global/EG.html.

2. Statistical analysis:

The partial regression method termed the C-multipliers was adopted according to (Fisher, 1950). Averages of different stages of insect population and climatic factors was calculated and shown graphically by excel sheets. Statistical analysis in the present work was carried out with computer using (MSTATC, 1980) to determine the preferable time for the insect activity and the proper time for its control. Also, the rate monthly variation in the population (R.M.V.P) was calculated according to the formula reported by (Serag-El-Din, 1998):

$$(R.M.V.P) = \frac{\text{Av. count of insect at a month}}{\text{Av. count given at the preceding month}}$$

The rate of monthly variation in the population is considered an indicator to the favorable month for insect activity expressed as the month of higher increase of this insect population through the year.

When R.M.V.P. is > 1 it means more activity, < 1 means less activity and = 1 means no change in the insect activity (Bakry, 2009).

Results and discussion

1. **Seasonal abundance of *Milviscutulus mangiferae* on mango trees at Ismailia Governorate:**

1.1. The first season 2018:

Data represented in Table (1) and illustrated in Figures (1 and 2) indicated that the population of nymphal stage of *M. mangiferae* exhibited three peaks of activity on mango trees in January, July and November represented by 30.64, 42.32 and 64.54 nymphs / leaf, respectively. The population of adult females of *M. mangiferae* also had three peaks of abundance; the first peak was recorded in January, the second peak was in July and the third peak was in October, these peaks represented by 16.14, 21.53 and 23.96 adult females / leaf, respectively. The seasonal abundance of total population of *M. mangiferae* exhibited three peaks of activity in January, July and November represented by 46.78, 63.85 and 87.69 individuals / leaf, respectively. It could be noticed that the lowest peak during the first season for nymphs, adult females and total population was appeared in January with max. temp. 17.72 ℃, min. temp.12.62 ℃ and 62.10 % R.H. whereas, the highest peak appeared in November for nymphs and total population with max. temp. 22.60 ℃, min. temp. 18.85 ℃ and 59.69 % R.H and in October for adult females population with max. temp. 26.94 ℃, min. temp. 21.59 ℃ and 57.53 % R.H. This may be due to the environmental conditions which were more suitable for the insect activity.

1.2. The second season 2019:

As shown in Table (2) and illustrated in Figures (3 and 4) the nymphal population approximately similar trend of changes compared to counts of the first year. Three peaks of seasonal abundance were monitored in January, June and November, represented by 28.70, 38.08 and 66.53 nymphs / leaf, respectively. Adult female stage showed three peaks of activity were recorded in February, June and November, represented by 18.05, 17.90 and 23.54 adult females / leaf, respectively. Total population of *M. mangiferae* exhibited three peaks of activity in January, June and November represented by 44.49, 55.98 and 90.07 individuals / leaf. The previous data showed that the lowest peak for nymphs and total population appeared in January with max. temp. 18.63 ℃, min. temp.13.89 ℃ and 62.29 % R.H. while, the lowest peak for adult females population appeared in June with max. temp. 30.62 ℃, min. temp. 25.06 ℃ and 49.96 % R.H. The highest peak for nymphs, adult females and total population appeared in November with max. temp. 21.96 ℃, min. temp. 19.74 ℃ and 57.98 % R.H. This may be due to the environmental conditions which were more suitable for the insect activity.

From the previous data it could be concluded that *M. mangiferae* active all the year with different individual numbers and the population density of *M. mangiferae* was relatively more abundant during the first season than the second season with total population 585.78 and 527.85 individuals / leaf during the first and second seasons, respectively. *M. mangiferae* had three peaks per year on mango trees at Abu Suwair district, Ismailia Governorate. These are agreeing with (Attia *et al.,* 2018), they reported three peaks per year for *M.*

mangiferae on mango trees at Qalubyia Governorate. In contrast, (El-Baradey *et al.*, 2018) monitored two peaks of abundance per year for *M. mangiferae* on mango trees at Kafr El-Sheikh Governorate. Abbas *et al.* (2019) stated that the total alive stages of *M. mangiferae* had four main peaks of high activity on *Laurus nobilis* at Giza Governorate, and this variance may be attributed to the different locations.

2. Rate of monthly variation in population (R.M.V.P.) of *Milviscutulus mangiferae*:

The monthly variation rates in the population of different stages and total population of *M. mangiferae* and the percentages of infestation incidence were calculated in Tables (1 and 2). As shown in Table (1) the favorable times of annual increase for total population appeared to be in April, May, June, July, September, October and November months during the first year (2018), when the rates of monthly variation were (1.13, 1.21, 1.79, 1.31, 1.45, 1.65 and 1.08), respectively. While, in Table (2) during the second year (2019) the favorable times of annual increase for total population appeared to be in May, June, September, October and November months when the rates of monthly variation were (2.33, 2.26, 1.11, 1.58 and 1.40), respectively.

The climatic conditions of autumn months during the two years were the optimal for the insect multiplication and build up, since the highest R.M.V.P value was achieved during both years. These results were coincided with those obtained by Attia *et al.* (2018) they stated that abnormal relationship between meteorological factors and the total population of *M. mangiferae*, where the total population synchrony with moderate and high temperatures during the first two peaks of *M. mangiferae*, but during the third peak (from 1 st October till 1st Jan.) the population highly increased when the temperature started to decreased (moderate temperatures). On the other side, the low temperatures (from 1st Jan. until end of Feb.) synchrony with low population of *M. mangiferae* due to its hibernation as adult females after this time the adult females transformed to gravid females as an indicator to first peak (Spring peak)and generation. Also, Abbas *et al.* (2019) showed that the single effect of the three (maximum, minimum and means temperature) had positive highly effect on the changes in the population density of *M. Mangiferae* on Laurus nobilis trees at Giza Governorate.

3. Effect of some weather factors on the total population density of *Milviscutulus mangiferae*:

3.1. The first season 2018:

Data in Table (3) showed that there were significant correlations between the *M. mangiferae* total population density and weather factors (temperature and relative humidity). There was highly significant negative relation between daily mean maximum temperature and total population density of *M. mangiferae.* The simple correlation coefficient value was - 0.06, the simple regression coefficient value was -0.26, the partial regression was -10.28 and t-test value was - 5.96. For daily mean minimum temperature data showed a highly significant positive relation between it and the total population density of *M. mangiferae*; the simple correlation coefficient, the simple regression coefficient, the partial regression and t-test values were + 0.25, +1.48, +14.92 and + 6.42, respectively. The effect of daily mean relative humidity on

total population of *M. mangiferae* indicated that the simple correlation coefficient and the simple regression coefficient were significant positive effect + 0.13 and + 0.82, respectively. According to the partial regression, the mean relative humidity exhibited a significant positive effect on the total population P. reg.= +2.97 and the t-test value was +2.95. The combined effect of these tested factors on the total population of *M. mangiferae* was highly significant where F value = +14.03 and the explained variance value (E.V. %) was 84.03 %. These results also revealed that the changes in the total population density of *M. mangiferae* on mango trees were mostly related to the combined effects of the selected weather factors for the first season at Abu Suwair district, Ismailia Governorate.

3.2. The second season 2019:

Data in Table (3) showed that there were significant correlations between the *M. mangiferae* total population density and weather factors. Daily mean maximum and minimum temperature and total population density showed a highly significant positive relation where, the simple correlation coefficient values were + 0.10 and + 0.17 and the simple regression coefficient values were + 0.35 and + 0.86, respectively. The partial regression value for daily mean maximum temperature indicated a highly significant negative relation between it and total population of the pest P. reg. = - 10.96 and the value of t-test was - 4.89. While the partial regression value and the value of t-test for daily mean minimum temperature indicated a highly significant positive relation between it and total population of *M. mangiferae* and the values were +17.68 and + 5.24. The effect of daily mean relative humidity on total population of *M. mangiferae* indicated that the simple correlation coefficient was highly significant positive relation + 0.50 and the simple regression coefficient value was + 1.98. According to the partial regression, mean relative humidity exhibited a highly significant positive effects on the total population P. reg.= + 4.51with t-test value + 6.09. The combined effect of these tested factors on the total population of *M. mangiferae* was highly significant where the F value = 13.53 and the explained variance value (E.V. %) was 83.53%. These results also revealed that the changes in the total population density of *M. mangiferae* on mango trees were mostly related to the combined effects of the selected weather factors for the second season at Abu Suwair district, Ismailia Governorate. In general, high temperature and relative humidity conditions are beneficial to soft scale population growth (Kosztarab, 1996; El-Baradey *et al.*, 2018 and Abbas *et al.*, 2019).

Table (1): Monthly mean numbers of different stages of *Milviscutulus mangiferae* and rate of monthly variation in population (R.M.V.P.) on mango trees with climatic factors affecting at Ismailia Governorate during the period from January to December 2018.

Date of inspection	Mean number of individuals per leaf			R.M.V.P. for total population	Climatic factors		
	Nymphs	Adult females	Total		Max. temp.°C	Min. temp.°C	% R.H.
Jan.	30.64	16.14	46.78	—	17.72	12.62	62.10
Feb.	12.44	15.63	28.07	0.60	17.69	12.39	60.30
Mar.	6.42	13.45	19.86	0.71	23.98	14.91	60.17
Apr.	9.63	12.86	22.49	1.13	26.13	17.95	57.75
May	16.50	10.70	27.20	1.21	29.38	21.45	54.58
Jun.	33.24	15.34	48.58	1.79	30.65	22.78	58.26
Jul.	42.32	21.53	63.85	1.31	32.25	22.87	62.39
Aug.	17.53	16.45	33.98	0.53	31.85	22.70	62.58
Sept.	31.34	17.92	49.25	1.45	29.58	23.51	49.91
Oct.	57.20	23.96	81.16	1.65	26.94	21.59	57.53
Nov.	64.54	23.15	87.69	1.08	22.60	18.85	59.69
Dec.	55.71	21.15	76.86	0.88	20.41	17.03	62.32
Total	377.50	208.28	585.78				
General average	31.46	17.36	48.81		25.77	19.06	58.96
%	64.44	35.56	100.00				

Table (2): Monthly mean numbers of different stages of *Milviscutulus mangiferae* and rate of monthly variation in population (R.M.V.P.) on mango trees with climatic factors affecting at Ismailia Governorate during the period from January to December 2019.

Date of inspection	Mean number of individuals per leaf			R.M.V.P. for total population	Climatic factors		
	Nymphs	Adult females	Total		Max. temp.°C	Min. temp.°C	% R.H.
Jan.	28.70	15.79	44.49	—	18.63	13.89	62.29
Feb.	13.17	18.05	31.22	0.70	15.85	13.62	60.06
Mar.	3.94	8.50	12.44	0.40	21.10	16.41	52.92
Apr.	4.72	5.94	10.65	0.86	25.17	19.74	50.61
May	15.19	9.62	24.81	2.33	28.76	23.60	48.42
Jun.	38.08	17.90	55.98	2.26	30.62	25.06	49.96
Jul.	32.10	16.39	48.49	0.87	32.20	25.16	54.09
Aug.	18.70	17.85	36.55	0.75	31.86	24.97	54.26
Sept.	27.15	13.48	40.63	1.11	36.02	25.86	61.09
Oct.	45.30	18.84	64.14	1.58	34.22	23.75	67.21
Nov.	66.53	23.54	90.07	1.40	21.96	19.74	57.98
Dec.	49.59	18.79	68.38	0.76	22.94	18.74	62.47
Total	343.15	184.69	527.85				
General average	28.60	15.39	43.99		28.49	22.30	55.90
%	65.01	34.99	100.00				

R.M.V.P.= Rate of Monthly Variation in Population; % RH. = Relative Humidity

Table (3): Different models of correlation and regression analyses for describing the relationship between total populations of *Milviscutulus mangiferae* and three weather variables on mango trees at Ismailia Governorate during the two successive seasons (2018 and 2019).

Year	Tested weather factors	Simple correlation and regression values				Partial regression value			Analysis variance			
		r	b	S. E	T	P. reg.	S. E	t	F value	MR	R^2	E.V.%
2018	Max. temp.	- 0.06	- 0.26	1.43	- 0.18	-10.28	1.73	- 5.96 **	14.03 **	0.92	0.84	84.03
	Min. temp.	0.25	1.48	1.79	0.83	14.92	2.32	6.42 **				
	% R.H.	0.13	0.82	1.99	0.41	2.97	1.01	2.95 *				
2019	Max. temp.	0.10	0.35	1.12	0.31	-10.96	2.24	- 4.89 **	13.53 **	0.91	0.84	83.53
	Min. temp.	0.17	0.86	1.62	0.53	17.68	3.37	5.24 **				
	% R.H.	0.50	1.98	1.08	1.83	4.51	0.74	6.09 **				

r = Simple correlation
b = Simple regression
MR = Multiple correlation
P. reg.= Partial regression
R^2= Coefficient of determination
E.V% = Explained variance
S.E = Standard error * Significant at P ≤ 0.05 ** Highly significant at P ≤ 0.01

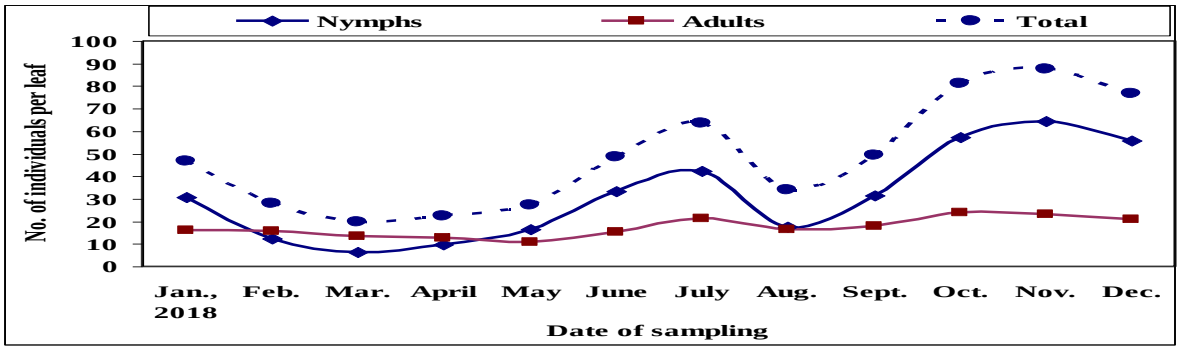

Figure (1): Means of monthly counts of different stages of *Milviscutulus mangiferae* on mango trees at Ismailia Governorate during the period from January to December 2018.

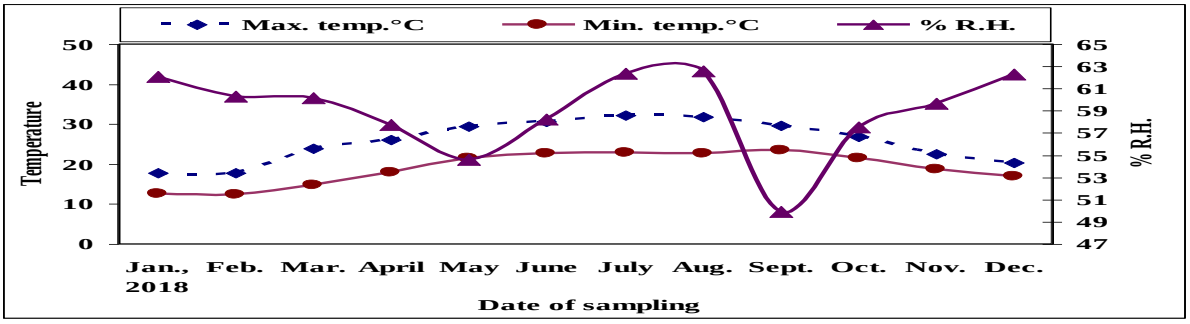

Figure (2): Climatic factors affecting on *Milviscutulus mangiferae* infests mango trees at Ismailia Governorate during the period from January to December 2018.

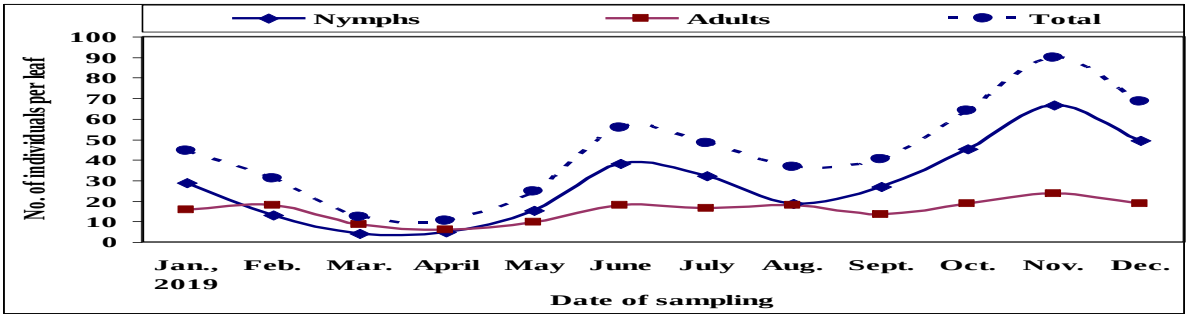

Figure (3): Means of monthly counts of different stages of *Milviscutulus mangiferae* on mango trees at Ismailia Governorate during the period from January to December 2019.

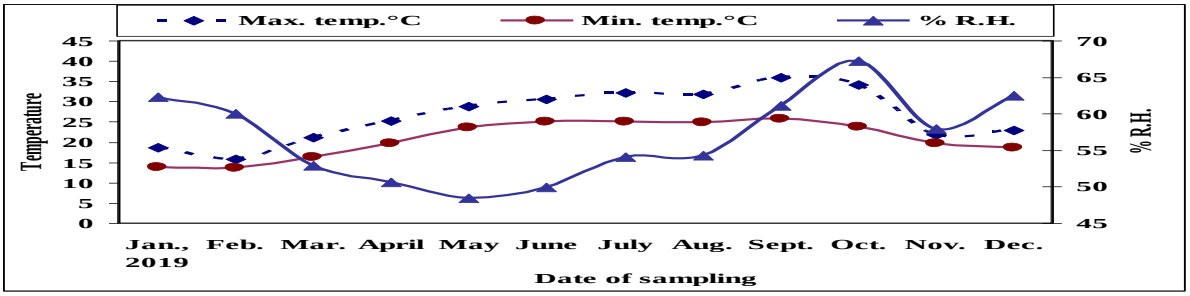

Figure (4): Climatic factors affecting on *Milviscutulus mangiferae* infests mango trees at Ismailia Governorate during the period from January to December 2019.

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