SEASONAL ABUNDANCE OF THE SEYCHELLES SCALE, *Icerya seychellarum* (WESTWOOD) (HEMIPTERA: MONOPHLEBIDAE) INFESTING GUAVA TREES

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The main objective of the present work was to study the population trend of the Seychelles scale, *Icerya seychellarum* (Westwood) (Hemiptera: Monophlebidae) on guava trees at Abu-Suwair district in Ismailia Governorate, Egypt during two consecutive years (2018-19). The results showed that insect population was recorded on guava trees all the year round and has three peaks of seasonal activity per year i.e., June, August/September and November. It indicates that the climatic conditions of autumn months during the two years were more critical based on total population density of *I. seychellarum*. Furthermore, the effect of climatic factors (daily mean maximum air temperature, minimum air temperature and mean relative humidity) on the total population of *I. seychellarum* varied during the years. The relative humidity was found the most effective variable for the changes in the insect population during both years. Also, the percentages of explained variance (E.V.) indicated that all tested variables were responsible for variability in the total insect population by 80.98 and 78.48% during the two years, respectively.

**Keywords:** *Psidium guajava*, insect pests, scale insect, *Icerya seychellarum*, population density, honey dew secretion, sooty mould.

INTRODUCTION

Guava trees, *Psidium guajava* (Myrtaceae), are subject to be infested by several pests, among which *Icerya seychellarum* (Westwood) (Hemiptera: Coccomorpha: Monophlebidae) is considered as one of the most destructive pests in Egypt (Sayed, 2008; Bakry and Arbab, 2020). This pest attacks the tender shoots, twigs, leaf veins, branches, and fruits by sucking the sap from the host tissues. The sap contains only a very low amount of protein; therefore, the insect may have to suck a great amount of sap to obtain an adequate quantity of protein for its growth and egg development. The high number of insects attacking the leaves, branches, and fruits of the tree result in a considerable loss of sap, which in turn manifests as leaf loss, wilting of growing tips, premature leaf drop, leaf malformation, and dwarfting. Nutrient deprivation of the trees ultimately has negative effects on the quality and quantity of fruit as well as on the general tree vigour (Mangoud, 2000; El-Saied, 2006; Reda et al., 2010). Feeding by this pest species results in the excretion of large amounts of honey dew, which provides a good medium for the growth of sooty mould fungi. This, in turn, inhibits photosynthesis by the plant and may cause further leaf drop. In addition, toxic saliva secreted by the insects may result in malformed leaves and poor shoot growth (Osman, 2005). Therefore, the objective of this study was to estimate the seasonal activity and rate of monthly variation, and effect of main climatic factors on *I. seychellarum* activity to develop an effective program for its control.

MATERIALS AND METHODS

The present study was carried out in private guava orchard (Abu Suwair district) at Ismailia Governorate during January 2018 to December 2019 to estimate the population density of the Seychelles scale, *Icerya seychellarum* (Westwood). This pest was identified by Dr. Fatma A. Moharum, Department of Scale Insect and Mealybugs, Plant Protection Research Institute, Agriculture Research Center, Egypt.

The selected orchard received the normal agricultural practices without application any chemical control measures before and during the period of study. Five guava trees, Balady variety, of approximately the similar age (about 10 years old), size, height, and vegetative growth were selected at random. Sample (five leaves) from the terminal shoots of each of the five trees and in each of the four wind directions were selected at fortnightly intervals (20 leaves i.e. 5 samples per tree).

Regular fortnightly samples were picked at random from the different directions and strata of the tree in polyethylene bags. The samples were immediately transported to the laboratory of Plant Protection Department, Agriculture Research Station at Ismailia Governorate for inspection and were examined using a stereo-microscope. The total numbers of live insects on the upper and lower surfaces of the guava tree leaves were individually sorted into immature stages (nymphs) and mature stages (adult females) and then were counted and recorded, linked to the inspection date, and presented as mean number.
of individuals per sample (5 leaves) ± standard error (SE) was considered in this study to express the population size of pest. All sampling was conducted from 4800 leaves on 48 dates over a 2-year period, i.e. 5 trees × 4 directions × 5 leaves × 48 dates. Also, the rate monthly variation in the population (R.M.V.P) was calculated according to the formula reported by Serag-El-Din (1998).

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

Concerning, the effect of the main weather factors on the total I. seychellarum population. The climatic factors data (daily mean maximum air temperature, daily mean minimum air temperature and daily mean of % relative humidity) for conditions of Ismailia Governorate were obtained from the Egypt Weather Underground site, https://www.wunderground.com/global/EG.html. According to the results of the simple correlation, regression coefficient and the partial regression formula which was adopted to find out the simultaneous effects of tested main weather factors on I. seychellarum. 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 Program software (1980) to determine the preferable time for the insect activity and the proper time for its control.

RESULTS AND DISCUSSION

### Table 1. Monthly mean number of different stages and rate of monthly variation in I. seychellarum (Westwood) population on guava trees, with climatic factors affecting in Ismailia Governorate during 2018.

| Month of inspection | Mean number of individuals per sample | R.M.V.P for total population | Climatic factors | R.H. (%) |
|---------------------|--------------------------------------|-----------------------------|-----------------|---------|
|                     | Nymphs | Adults | Total | Max. temp. (°C) | Min. temp. (°C) | R.H. (%) |
| Jan.                | 20.63±0.53 | 06.75±0.90 | 27.38±0.66 | 17.72 | 12.62 | 62.10 |
| Feb.                | 18.00±1.04 | 11.67±0.99 | 29.67±0.57 | 1.08  | 17.69 | 60.30 |
| Mar.                | 20.83±1.32 | 14.67±1.92 | 35.50±1.63 | 1.20  | 23.98 | 60.17 |
| Apr.                | 25.67±1.59 | 17.00±1.56 | 42.67±1.99 | 1.20  | 26.13 | 57.75 |
| May                 | 32.00±2.13 | 12.00±1.10 | 44.00±1.91 | 1.03  | 29.38 | 54.58 |
| Jun.                | 59.33±4.21 | 23.33±1.01 | 82.67±3.64 | 1.88  | 30.65 | 58.26 |
| Jul.                | 57.33±4.02 | 17.17±1.07 | 74.50±4.52 | 0.90  | 32.25 | 62.39 |
| Aug.                | 74.90±8.30 | 19.95±2.55 | 94.85±10.7 | 1.27  | 31.85 | 62.58 |
| Sept.               | 32.83±3.15 | 13.50±0.75 | 46.33±3.80 | 0.49  | 29.58 | 49.91 |
| Oct.                | 55.10±3.69 | 17.50±1.11 | 72.60±4.26 | 1.57  | 26.94 | 57.53 |
| Nov.                | 54.67±4.50 | 28.40±1.10 | 83.07±4.81 | 1.14  | 22.60 | 59.69 |
| Dec.                | 37.00±1.81 | 08.83±1.44 | 45.83±3.00 | 0.55  | 20.41 | 62.32 |
| Total               | 488.29 | 190.77 | 679.06 | 25.77 | 19.06 | 58.96 |
| General avg.        | 40.69±2.10 | 15.90±0.71 | 56.59±2.58 | 71.91 | 28.09 | 100.00 |

**Seasonal activity of I. seychellarum on guava trees:** The monthly counts of I. seychellarum different stages in infested guava trees were recorded for two successive years (2018-19). Also, means of the monthly records of temperature and relative humidity throughout the two years of investigations and are represented in Tables 1 and 2 and graphically illustrated in Figure 1. To discuss the seasonal activity of different stages of I. seychellarum based on average number of immature and mature stages counts per sample were discussed through monthly records.

**The first year (2018):** Data represented in Table 1 and illustrated in Figure 1 showed that the mean population size was 40.69 ± 2.10, 15.90 ± 0.71 and 59.59 ± 2.58 individuals per sample for nymphs, adult females and total alive population of I. seychellarum, respectively. The seasonal abundance of total alive population of insect was recorded. Three peaks of activity were observed in June, August and November when the mean population density was 82.67 ± 3.64, 94.85 ± 10.69 and 83.07 ± 4.81 individuals per sample, respectively. A similar trend in the seasonal abundance of nymphs was observed. Three peaks of activity were recorded in June, August and October when the mean population density was 59.33 ± 4.21, 74.90 ± 8.30 and 55.10 ± 3.69 individuals per sample, respectively. However, with different values the adult females had four peaks recorded in April, June, August and November when the mean population density was 17.00 ± 1.56, 23.33 ± 1.01, 19.95 ± 2.55 and 28.40 ± 1.10 individuals per sample, respectively.

**The second year (2019):** Data tabulated in Table 2 and illustrated in Figure 1, showed that the mean population...
density was 47.13 ± 2.30, 15.40 ± 0.76 and 62.53 ± 2.62 individuals per sample for nymphs, adult females and total alive population, respectively. The seasonal activity of nymphs of insect was recorded established three peaks of activity in June, August and November. The mean population density recorded was 63.00 ± 2.00 (June), 61.83 ± 1.64 (August) and 87.00 ± 2.79 (November) individuals per sample. A similar trend in the seasonal activity of adult females was observed. Three peaks of activity were recorded in April, September and November when the mean population density was 19.83 ± 1.73, 25.33 ± 2.24 and 24.17 ± 2.82 individuals per sample, respectively. The variance in different stages

Table 2. Monthly mean number of different stages and rate of monthly variation in *I. seychellarum* (Westwood) population on guava trees, with climatic factors affecting in Ismailia Governorate during 2019.

| Month of inspection | Mean number of individuals per sample | R.M.V.P for total population | Climatic factors |
|---------------------|--------------------------------------|-----------------------------|-----------------|
|                     | Nymphs | Adult females | Total | Max. temp. (°C) | Min. temp. (°C) | R.H. (%) |
| Jan.                | 15.50±1.24 | 9.17±0.79 | 24.67±0.90 | 18.63 | 13.89 | 62.29 |
| Feb.                | 17.83±0.72 | 12.67±1.10 | 30.50±0.78 | 1.24 | 15.85 | 60.06 |
| Mar.                | 22.67±0.85 | 11.67±1.36 | 34.33±1.59 | 1.13 | 21.10 | 52.92 |
| Apr.                | 27.83±1.57 | 19.83±1.73 | 47.67±1.01 | 1.39 | 25.17 | 50.61 |
| May                 | 43.67±1.49 | 10.17±0.52 | 53.83±1.27 | 1.13 | 28.76 | 48.42 |
| Jun.                | 63.00±2.00 | 9.80±1.36 | 72.80±1.39 | 1.35 | 30.62 | 49.96 |
| Jul.                | 43.67±1.44 | 16.17±1.39 | 59.83±1.79 | 0.82 | 32.20 | 54.09 |
| Aug.                | 61.83±1.64 | 22.00±1.75 | 83.83±1.65 | 1.24 | 31.86 | 54.26 |
| Sept.               | 52.17±2.90 | 25.33±2.24 | 77.50±4.16 | 1.18 | 36.02 | 61.09 |
| Oct.                | 67.33±2.43 | 12.17±1.33 | 79.50±2.20 | 0.91 | 34.22 | 67.21 |
| Nov.                | 87.00±2.79 | 24.17±2.82 | 111.17±1.75 | 1.40 | 21.96 | 57.98 |
| Dec.                | 63.00±5.01 | 11.67±3.16 | 74.67±7.42 | 0.67 | 22.94 | 62.47 |
| Total               | 565.50 | 184.80 | 750.30 |
| General average     | 47.13±2.30 | 15.40±0.76 | 62.53±2.62 | 28.49 | 22.30 | 55.90 |

Figure 1. Means of monthly counts of different stages of *I. seychellarum* (Westwood) on guava trees, with climatic factors affecting in Ismailia Governorate during 2018-19.
abundance reflected based on the total mixed population per sample had three peaks of activity during June (72.80±1.39), August (83.83±1.65) and November (111.17±1.75) per sample. The results depicted that the nymphal population was relatively higher than the adult female population during the two successive years. The nymphs were represented by 71.91 and 75.37% of the total population during 2018 and 2019, respectively. On the other hand, the adult females were represented by 28.09 and 24.63% of the total population in 2018 and 2019, respectively.

The lowest population density of different stages and total population of *I. seychellarum* was recorded during January, both years, which may be attributed to the high relative humidity, gradual decrease in temperature and dormancy of the trees during winter. When crawlers emerged after the egg laying period, their population decreased for several months due to mortality of nymphs in the winter which is expected to effect dramatically the insect behavior and on rate of growth and infestation. In contrary, the maximum values of insect population were observed in November during the two years of study, which may be due to the influence of favorable factors (such as environmental conditions etc.). It appeared that, the annual fluctuations in the population density during the two years were affected by the variability in these physical factors. Dent (1991) stated that the seasonal phenology of insect numbers, the number of generations, and the level of insect abundance at any location are influenced by the environmental factors of that location. From the previously mentioned results, it could be concluded that insect population was present on guava trees all the year round and has three peaks of seasonal activity per year, which was recorded in June, August/September and November over the years. Also, the second year of study cleared that the total population density of this insect was higher in comparison to the first year of investigation, which may be due to the influence of environmental conditions or others factors. These results were coincided with those obtained by El-Borollosy et al. (1990), Mangoud (2000), Osman (2005), El-Said (2006), Abd-El-Rahman et al. (2007), Sayed (2008) and Bakry and Arbab (2020) in Egypt; however, with different host plants, they reported that the *I. seychellarum* had three or four peaks per year.

**Rate of monthly variation (R.M.V.P.) in the population of the Seychelles scale, *I. seychellarum***: The monthly variation rates in the population of *I. seychellarum* were calculated (Tables 1 and 2). The rate of monthly variation in the population is considered an indicator to the favourable month for insect activity throughout the year. When R.M.V.P. is >1, it means more activity, <1 means less activity and =1 means no change in the population density during the two successive months (Bakry, 2009).

The favourable times of annual increase for total alive population appeared to be from February to June months and August, October and November months during the first year (2018), when the rates of monthly variation were ranged 1.03-1.88 (Table 1 and 2). During 2019, the rates of monthly variation for total mixed population showed that the favourable times for annual increase were February to June, August, September and November, which ranged from 1.13 to 1.40.

Previous studies by Mangoud (2000) revealed that the population of this insect increased in summer and autumn. El-Said (2006) found significant difference in the mealybug, *I. seychellarum* activity during summer and autumn.

**Effect of the main weather factors on the total insect population of *I. seychellarum***: 

**A. Effect of daily mean maximum temperature**: The results of statistical analysis of simple correlation (Table 3) showed significantly positive correlation between the daily maximum mean temperature and total population of *I. seychellarum*; *r* value was (+0.64) during the first year (2018) and insignificantly positive correlation (*r* value +0.51). The unit effect regression coefficient (*b*) indicates that an increase of 1°C in the daily mean maximum temperature, would increase

Table 3. Different models of correlation and regression analyses for describing the relationship between total population of *I. seychellarum* (Westwood) and three weather variables on guava trees at Ismailia Governorate during 2018-19.

| Year | Tested counts | Simple correlation and regression values | Partial correlation and regression values | Analysis variance |
|------|---------------|------------------------------------------|------------------------------------------|-------------------|
|      |               | *r* | *b* | SE  | *t* | P. reg. | SE  | *t* | F value | MR | *R*² | E.V.% |
| 2018 | Max. temp.    | 0.64| 2.86| 1.08| 2.65*| -2.03 | 1.85| -1.10|          |    |      |      |
|      | Min. temp.    | 0.72| 4.15| 1.26| 3.30**| 8.03  | 2.49| 3.22*| 11.35** | 0.90| 0.81| 80.98 |
|      | R.H.%         | 0.16| 0.99| 1.95| 0.51 | 3.73  | 1.08| 3.45**|          |    |      |      |
| 2019 | Max. temp.    | 0.51| 1.99| 1.09| 1.89 | -9.77 | 2.73| -3.58**|          |    |      |      |
|      | Min. temp.    | 0.62| 3.51| 1.41| 2.48*| 18.25 | 4.11| 4.44**| 10.33** | 0.89| 0.79| 78.48 |
|      | R.H.%         | 0.13| 0.55| 1.35| 0.41 | 3.28  | 0.90| 3.64**|          |    |      |      |

*r* = Simple correlation; *b* = Simple regression; MR = Multiple correlation; P. reg. = Partial regression; CV = Coefficient of Variation; *R*² = Coefficient of determination; E.V.% = Explained variance; SE = Standard error; * Significant at *P* ≤ 0.05; ** Highly significant at *P* ≤ 0.01
the population by 2.86 and 1.99 individuals per sample for the years 2018 and 2019, respectively. The partial regression values presented in Table 3 accentuated an insignificant negative relation (P. reg. -2.03) during 2018 and highly significant negative effect (-9.77) during 2019. The values of t-test were -1.10 and -3.58 for the first and second years, respectively. The obtained results revealed that daily mean maximum temperature was around the optimum range for total population of *I. seychellarum* activity during the first year, and was entirely above the optimum range during the second year.

**B. Effect of daily mean minimum temperature:** The correlation coefficient (r) between daily mean minimum temperature and the total population of pest was highly significant positive (r value +0.72) for the first year and significant positive relation (r value +0.62) for second year (Table 3). The calculated regression coefficient (b) for the effect of this factor indicated that for every 1°C increase, the population would increase by 4.15 and 3.51 individuals per sample for the two years, respectively.

The exact effect of this factor on insect population revealed that it was significant positive from the partial regression (P. reg. value +8.03) during 2018 and highly significant positive effect (P. reg. value +18.25) during 2019. The t-test values were +3.22 and +4.44 during the two years, respectively, when the daily mean maximum temperature and relative humidity become around their means (Table 3). The results also revealed that mean minimum temperature was under the optimum range for total population activity in the first year and was entirely under the optimum range for total population activity during the second year (Table 3).

**C. Effect of the mean relative humidity:** Data obtained are represented in Table 3, which shows that the mean relative humidity had insignificant positive effect on total population activity, since the correlation coefficient was r=+0.16 and r=+0.13 for the first and second years, respectively. The unit effect (regression coefficient) indicates that an increase of 1% in the mean relative humidity, would increase the total population density by 0.99 and 0.55 individuals per sample for the two years, respectively.

The real effect of this climatic factor appeared from the partial regression (P. reg.) values (Table 4) that it has highly significant positive effects (P. reg. values +3.73 and +3.28) and t-test values were +3.45 and +3.64, for the two years, respectively. The obtained results revealed that, mean relative humidity was entirely under the optimum range for total population activity during the two years (Table 3).

**D. The combined effect of the tested climatic factors on the total population activity:** The combined effect of climatic factors on the total population was highly significant where the F values were 11.35 and 10.33 during the first and second years, respectively (Table 3). The percentage of variability that could be attributed to the combined effect of these tested factors on the insect population, were 80.98 and 78.48% for the two years, respectively. The remaining unexplained variances are assumed to be due to the influence of other unconsidered and undetermined factors that were not included in this study in addition to the experimental error.

Current study revealed that activity of *I. seychellarum* was mostly related to the simultaneous effect of these selected weather factors rather than the effect of an individual factor. Previous studies conducted by Fisher (1950) revealed that the method of partial regression was the best way for dealing with uncontrolled variables such as physical factors in the ecosystem. Pervious study by El-Said (2006) in Egypt stated that the effect of temperature on insect activity was strongly positive and significant and the effect of daily mean relative humidity was insignificantly negative for both years of investigation. Also, the percentage of explained variance by these factors was 60 and 76% for the 2003 and 2004 seasons. In addition, Abd-El-Rahman et al. (2007) found significant positive correlation with temperature and insignificant negative correlation with the relative humidity. Also, Sayed (2008) stated that the four tested factors i.e. maximum temperature, minimum temperature, mean temperature and percentage of relative humidity were simultaneously responsible for about 32.8-65% of *I. seychellarum* activity. Selim (2012) reported that *I. seychellarum* generations had an affirmative respond with both day maximum temperature and night minimum temperature.

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