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(Original Article)

The Striped Mealybug *Ferrisia virgata* (Hemiptera: Pseudococcidae) Monitoring and Population Dispersion on Acalypha Shrubs and its Control in Luxor Region, Egypt

Moustafa M.S. Bakry[1*]; Eman A. Shehata[2] and Eman F.M. Tolba[3]

[1] Scale Insects and Mealybugs Research Department, Plant Protection Research Institute, Agricultural Research Center, 12619 Giza, Egypt.
[2] Department of Vegetable, Medicinal, Aromatic and Ornamental Plant Pests, Plant Protection Research Institute, Agricultural Research Center, 12619 Giza, Egypt
[3] Plant Protection Dept., Faculty of Agric, New Valley University, New Valley, Egypt

* Correspondence: md.md_sabry@yahoo.com
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Abstract

The present experiment was implemented in the garden of the El-Mattana Agricultural Research Station, Luxor area, Egypt (2021/2022 and 2022/2023) to study the population seasonal and spatial distribution of the mealybug, *F. virgata* concerning some weather parameters and its control. During each year of the study, *F. virgata* was discovered on acalypha shrubs from the period on October 1st to January 15th, after which the insect infestation disappeared until July 15, and then the insect began to appear again from August 1st to September 15th (the end of taking readings for each year). It had two peaks of activity annually, which were observed on November 1st and September 15th. Multiple linear regression mathematical model mentioned that the combined effect of all weather parameters, namely maximum and minimum temperature, relative humidity, sunny shine, and solar radiation, reached 84.21% in 2021/2022 and 83.99% in 2022/2023 on the variation in mealybug numbers. The gathered data were examined by analyzing patterns of distribution, revealing that all dispersal metrics for the different stages of *F. virgata* displayed a significant tendency towards clustering throughout the two years. After 72 hours of testing the effectiveness of the insecticides, the activities of the studied pesticides varied, as it was found that Imidacloprid was found to be the most effective insecticide than the other tested pesticides for both *F. virgata* third instar nymphs and adult females. However, the Bioranza pesticide was less effective.

***Keywords**: Ferrisia virgata, Monitoring, Population dispersion, Environmental conditions, Acalypha shrubs.*

Introduction

Acalypha (*Acalypha indica*) shrub is one of the ornamental plants (Family: Euphorbiaceae). It is an erect annual herb that usually reaches a height of 1.5 to 2.5 meters. It is used as a covering for floors and walls. Also, used in many

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traditional medical uses, in treat skin parasites, scabies and other skin problems, asthma, and to clean the liver and kidneys from intestinal worms and stomach pain (Zahidin *et al*., 2017).

Many insects with piercing-sucking mouthparts invade Acalypha shrubs. Among them, the striped mealybug *Ferrisia virgata* (Cockerell) (Hemiptera: Coccomorpha: Pseudococcidae), which observed to be favorable pest for the acalypha (Nabil *et al*., 2020). This mealybug is a highly polyphagous pest attack approximately 203 host plant genera of 77 families (Balboul, 2003; Garcia *et al*., 2015; Ata *et al*., 2019).

This pest attacks all plant parts (shoots, leaves, twigs, trunk, roots, branches, and fruits). It can cause direct and indirect damage to plants. Direct damage includes physical injury to plant cells and tissues during the feeding process. Besides that, Mealybugs also produce toxic chemicals injected into plant tissues while they are feeding. The toxin can cause physiological injuries to plants (Bakry, 2009). The first symptoms of infection appear in the form of yellow spots on the leaves in the feeding areas, then the spots expand along the leaves. As a result of advanced damage, symptoms of wrinkling, dwarfing, stunting, dryness, and shrinkage appear on the leaves, and eventually the entire leaf dries and falls. In general, maybugs can also indirectly damage plants by transmitting plant pathogens such as viruses (Franco *et al*. 2009; El-Batran *et al*. 2015; Mittler and Douglas, 2003).

Miftakhurohmah *et al*. (2022) mentioned the mealybug, *Ferrisia virgata* a vector of the piper yellow mottle virus in black pepper (*Piper nigrum*).

Population dynamics studies help gain insight into how abiotic factors can influence the populations of pests (Khodeir *et al*. 2020). Having a comprehensive comprehension of the variations in population levels of insect pests under the field condition and their correlation with weather variables would give insight into the prime time of pest activity and aid in formulating a suitable approach for managing these insect pests (Rajasekhar *et al*. 2021).

Knowing the spatial and dynamic distribution of insects is crucial to comprehending their interactions with their surroundings and seasonal fluctuations in their populations (Yang *et al*. 2021). This knowledge can be applied to better anticipate pest outbreaks and develop pest management plans (Navik *et al*. 2021).

Even though ensuring accuracy and precision in sampling is crucial for effective mealybugs research and decision-making in management. Bakry, and Arbab (2020) conducted a review on the fundamental models that establish the relationship between the variance (Ơ2) and the arithmetic mean (μ) of mealybug counts in a population. These models are as follows: (a) the positive binomial model, which is applicable when the variance is significantly lower than the mean (Ơ2 < μ), (b) the Poisson series, which serves as the basic framework when the variance is almost equal to the mean (Ơ2 = μ), and (b) the negative binomial, which is the most flexible equation among various possibilities and is applicable when the variance is significantly larger than the mean ($\sigma 2 > \mu$) (He *et al*. 2022). These models can be converted from probability distributions to frequency distributions by multiplying each probability by the size of the mealybugs sample. This provides several advantages, such as expressing the spatial dispersion of the mealybug population in mathematical terms, evaluating errors in population parameters, comparing spatial and temporal shifts in mealybugs population density, and estimating the impact of ecological factors (Bakry, 2020; Bakry & Abdel-Baky, 2020; Bakry & Shakal, 2020; Bakry *et al*., 2023).

There are very few investigations into the extent and spatial dispersal patterns of this specific species. Additionally, it has been noted that the use of insecticides can alter mealybug populations' resistance. As a result, mealybugs damage and dispersion in the field may change over time. Consequently, to provide prompt and correct information for the field control of *F. virgata*, long-term surveillance at various points over several years is required.

The present work aimed to study the seasonal variations and spatial distribution type of *F. virgata* infesting acalypha shrubs in the Luxor area, Egypt over two consecutive years. As well as studying the relationship of weather parameters against *F. virgata* population and its control during the two seasons. This information helps to better understand the behavior and activity of mealybugs on acalypha shrubs to implement pest management measures against this insect pest.

Materials and Methods

1-Population occurrence

Abundance of the mealybug, *F. virgata* on acalypha shrubs

The investigation was conducted on heavily attacked acalypha shrubs in the farm of El-Mattana Agricultural Research Station farm in Luxor Governorate (25º25'21" N, 32º31'59" E) from October 2021 to September 2023 to assess the seasonal population abundance of striped mealybug named *F. virgata* on acalypha shrubs. The selected shrubs were similar in size, shape, height, vigor, and infestation rates. The standard agricultural methods were followed for these shrubs and no pesticides were used during the experiment period.

Four samples were selected at half-monthly intervals, each consisting of four randomly collected branches (15 cm long, each with attached leaves), covering all directions of the farm. These samples (the branches and leaves they contain) were then placed in paper bags and transported to the laboratory. A total of 768 branches, meaning 48 different inspection times, over the two seasons. Four samples × four branches × twenty-four sampling times × two years were used, resulting in a total of 600 branches per season. The pest was identified and classified by specialists at the Plant Protection Research Institute, Agricultural Research Center in Giza, Egypt.

In the laboratory, the individuals of the identified mealybugs were counted and classified using a stereoscopic binocular microscope to clarify seasonal changes. Both the upper and lower surfaces of the leaves, as well as all branches, were thoroughly examined. Nymphs, comprising both pre-adult and crawler stages, were counted together. The counts of nymphs and adults (including females and gravid females) were recorded.

Half-monthly data on acalypha shrubs were utilized for discussing the population abundance of *F. virgata* by calculating the average total population per branch, either increasing or decreasing (±) the standard error, which was applied to evaluate the population estimations. A direct inspection for mealybugs was performed at the same time as the aforementioned inspections (Bakry and Arbab, 2020; Bakry *et al*., 2023).

Damage progression (DP):

The progression of the damage demonstrates how fast the mealybug invasion increases every year. The following equation, as described by Abd El-Moaty (2013), was employed to smooth the population's frequency distribution curve and estimate the data.

$$\mathbf{DP = \{(2 \times a) + b + c\} / 4}$$

In this formula, DP refers to the damage progression, a, b, and c refer to the current, preceding, and following estimates of mealybug counts, respectively. The seasonal changes in mealybug activity and decrease are depicted in the figures.

Rate of increase in population estimates:

To determine the extent of fluctuation in population estimates during bi-monthly inspections, the rate of monthly variation was computed by dividing the average count recorded on the current investigation date by the count recorded on the previous investigation date. This calculation was based on the research conducted by Bakry and Fathipour (2023).

Effect of the meteorological variables on *F. virgata* counts on acalypha shrubs:

To assess the extent to which abiotic factors (weather conditions) affect *F. virgata* populations during the two seasons (2021/2022 and 2022/2023), we obtained meteorological data from the Central Laboratory of Agricultural Climate, Agricultural Research Center, Ministry of Agriculture in Giza. Weather data collected includes maximum and minimum temperature, relative humidity, sunny shine (hr.), and solar radiation (MJ/m^2). Subsequently, the daily measurements of these variables were recalculated to determine the 14-day averages for estimating *F. virgata* counts.

In the bi-monthly period, the data were subjected to multiple regression analysis to determine the relationships between them. The MSTAT-C program (Freed, 1991) was used for this purpose. All values in the tables and figures were estimated and calculated using Microsoft Excel 2017.

2-Spatial distribution dispersion type

For population dispersal parameters of total alive counts of *F. virgata*, different dispersal indices have been used to estimate dispersal levels using the formulas presented below.

-Mean ($\bar{X}$): The average counts of alive individuals per branch per year.

-Range: The difference between the maximum and minimum average population for the entire season.

-Population range = maximum population density - minimum population density throughout the season.

-Coefficient of variance (*C.V.*) = (standard deviation / population mean) × 100.

-Relative variance *(R.V.)* is applied to compare the effectiveness of various sampling procedures, according to Hillhouse and Pitre (1974).

Relative variance *(R.V.)* = (standard error/population mean) × 100.

-Variation to mean ($S^2/\bar{X}$):

If, variation to mean = 1 indicates a random dispersion, variation to mean < 1 indicates a regular dispersion, and variation to mean > 1 indicates an aggregated dispersion, according to Patil and Stiteler (1974).

- Lewis index (I_L): is estimated using the equation presented below;

$$I_L = \sqrt{S^2 / \bar{X}}$$

If, Lewis indicator = 1 indicates a random dispersion, < 1 indicates a regular dispersion, and > 1 indicates an aggregated dispersion.

-Cassie index (*Ca*)

$$Ca = (S^2 - \bar{X}) / \bar{X}^2$$

If, Cassie indicator = zero indicates a random dispersion, < 1 indicates a regular dispersion, and > 1 indicates an aggregated dispersion, according to Cassie (1962).

The negative binomial distribution (*K* value): is one measure of aggregation.

$$K = \bar{X}^2 / (S^2 - \bar{X})$$

If *K* values are low and positive (k < 2), they indicate a highly aggregated population. If, *K* values range from 2 to 8, they indicate moderate aggregation. If, *K* values value higher 8 (k > 8) they indicate a random dispersion, according to (Southwood 1995 and Costa *et al*., 2010).

$$I_D = (n-1)S^2 / \bar{X}$$

The I_D values indicate a significant deviation from random dispersion (Kuno, 1991).

-This statistic can be checked using a Z test presented below.

$$Z = \sqrt{2I_D} - \sqrt{(2v - 1)}$$

$$v = n - 1$$

The distribution a random if 1.96 ≥ Z ≥ -1.96, Z < -1.96 indicates a regular dispersion, and Z > 1.96 indicates an aggregated dispersion, according to Patil and Stiteler (1974).

-Index of clumping (David and Moore, 1954) (I_{DM}):

$$(I_{DM}) = (S^2 / \bar{X}) - 1$$

If, I_{DM} index values = zero indicates a random dispersion, < 1 and (-) indicate a regular and positive binomial dispersion, and > 1 and (+) indicate an aggregated and negative binomial dispersion.

-Mean crowding intensity (Lloyd, 1967):

This index is used to explain the impact of mutual interference or competition between individuals.

$$\overset{*}{X} = \bar{X} + [(S^2 / \bar{X}) - 1]$$

-Patchiness indicator (*IP*): is called clustering index (Lloyd, 1967).

$$I_P = (\overset{*}{X} / \bar{X})$$

If, *IP* indicator = 1 indicates a random dispersion, < 1 indicates a regular dispersion, and > 1 indicates an aggregated dispersion.

-Green's index (*GI*): This index is a variant of the group size index that is not affected by n

$$GI = [(S^2 / \bar{X}) - 1] / (n - 1)$$

If, GI indicator values = zero or closer to zero and negative indicates a random dispersion, > zero or (+) values indicate aggregate dispersion, (-) indicates regular dispersion (Green, 1966).

-Cassie index is called aggregation index (1/*k*): It is used to evaluate temporal changes in the spatial pattern of pest populations throughout the year (Southwood and Henderson 2000)

$$1 / k = (\overset{*}{X} / \bar{X}) - 1$$

If, 1/*k* indicator values = zero indicates a random dispersion, < zero indicates a regular dispersion, and > zero indicates an aggregated dispersion (Feng and Nowierski 1992).

-Population clusters (aggregations) (λ) (Blackith, 1961) were applied to check the causes of the clustering of insect populations. It was estimated as presented below;

$$\lambda = m / 2k \times \gamma$$

When the degree of freedom is 2*K*, the value of y is equal to $X^2_{0.5}$.

If, λ < 2, the clustering of pest individuals indicates the influence of environmental parameters. However, if λ is greater than 2, the aggregation pattern or behavior, as well as the environment, contribute to this phenomenon (Li *et al*., 2017).

3-Toxicity evaluation of certain insecticides on *F. virgata* on acalypha leaves

Five tested insecticides from various chemical groups as presented below:

-Sulfur [(Sulfur® 30% L)] at a rate of one liter per 100-liter water.

-Insect growth regulators (IGR): Admiral, pyriproxyfen, 4-phenoxyphenyl (RS)-2-(2-pyridyloxy) propyl ether. The recommended concentration is 75 ml / 100 liters of water.

-Mineral oil: KZ oil Recommended concentration is 500 ml / 100 liters of water.
-Imidacloprid: Ecomida 30.5% SC Application rate is 60 ml / 100 liters of water.
-Acetamiprid: Mospilan 20 % mg 50 mg /100 liters of water.

The laboratory experiment was implemented to evaluate the toxicity of tested insecticides against *F. virgata* (third instar nymphs and adult females' stage) on acalypha leaves at the Plant Protection Research Department laboratory at the El-Mattana Agricultural Research Station, Agricultural Research Center at Esna district in Luxor Governorate, during the first week of November 2022. Four concentrations of each pesticide are prepared, four repetitions for each concentration, in distilled water. Forty damaged acalypha leaves (ten leaves per replicate) were applied to each concentration.

Samples of damaged leaves, which included third-instar nymphs and adult females of *F. virgata*, were randomly collected and placed in paper bags that were transferred to the laboratory.

To conduct the experiment, the dipping method was employed, whereby the leaves were dipped into each concentration of the insecticides. While the control leaves were submerged in the water. Afterward, all treated leaves were left to dry for 30 seconds (Shah *et al*., 2016).

After three days (72 hr.), the death rate was registered. The average percentage of corrected death of insects for every concentration and the control, according to the corrected Abbott formula (Abbott, 1925).

$$CDP = [(DT - DC) / (100 - DC)] \times 100$$

Where: CDP = corrected death percentage, DT = death percentage in treatment. DC = death percentage in control.

The statistical analysis was conducted on the toxicity levels using the Finney method (Finney, 1971). This involved estimating toxicity lines (using the Ld-P lines software) for the insecticides assessed, including the LC50, and slope values. Toxicity indexes were then calculated using the Sun equations (Sun, 1950). The toxicity index formula is as follows: (LC50 of the most toxic insecticide divided by LC50 of other evaluated insecticides) multiplied by 100.

Results

The damage symptoms of *F. virgata*, known as the striped mealybug, have caused stunting, shrinkage, and deformities in Acalypha shrubs. The injury includes all different parts of the plant (branches and leaves they contain), as presented in Fig. (1).

1. Population occurrence studies

Abundance of the mealybug, *F. virgata* on acalypha shrubs

The half-monthly observations of *F. virgata* that damaged acalypha shrubs in the garden of the El-Mattana Agricultural Research Station, Luxor area, Egypt, over two years (2021/2022 and 2022/2023). Also, half-monthly averages of weather factors of acalypha shrubs throughout the two years, as presented in Tables (1 and 2) and Figures (1 and 2). *F. virgata* abundance occurrence was evaluated based on the average counts of nymphs and adult females per acalypha branch (15 cm long, with its attached leaves), on the consecutive investigation dates.

During two years of inspection, *F. virgata* was found to be on the acalypha branches and its leaves on October 1st and infestation oscillated and continued to January 15th per season. Then, the insect infestation disappeared from February 1st until July 15th. After that, the insect began to appear again in the period from August 1st to September 15th (the end of taking readings for per year), as shown in Tables (1 and 2) and illustrated in Figures (1 and 2).

The population fluctuation of different stages and the total number of living individuals of *F. virgata* began to increase gradually from October 1st until reaching the first maximum peak on November 1st. After that, the population declined to decrease gradually to January,15th. Then, the disappearance of *F. virgata* individuals was observed over the two successive years. Thereafter, the population count was observed again on August,1st and then increased gradually to reach the second peak on September, 15th, as presented in Tables (1 and 2) and illustrated in Figures (1 and 2).

The main reason for the severe infestation with *F. virgata* during September and November months during each year of study is the absence of natural enemies and the environmental conditions that may be suitable for the growth and reproduction of this pest and its increase in numbers. This phenomenon suggests that this pest overwinters during the winter and spring seasons until the next summer. Based on these findings, it can be concluded that control measures should be implemented early in June, at the start of the activity period of this mealybug species.

Table 1. Half-monthly counts (mean ± Standard error) of the mealybugs F. virgata, and progress of damage & rate of increase per branch (15 cm long, each with attached leaves) of Acalypha shrubs at Esna district, Luxor region during 2021/2022 year

Sampling date		Nymphs	Adult females	Total counts per branch	% No. mealybugs of total population	Progress of damage	Rate of increase	Max. temp. °C	Min. temp. °C	% R.H.	Sunny shine	Solar radiation
Oct., 2021	1	44.00 ± 1.41	10.00 ± 0.42	54.00 ± 1.42	9.85	46.50	—	39.30	24.57	29.36	9.83	23.17
	15	64.00 ± 4.08	14.00 ± 0.82	78.00 ± 3.46	14.23	75.75	1.44	38.75	22.50	29.13	9.96	22.28
Nov	1	74.00 ± 3.92	19.00 ± 0.58	93.00 ± 4.04	16.97	85.50	1.19	36.50	20.64	29.36	9.34	20.22
	15	60.00 ± 1.41	18.00 ± 0.82	78.00 ± 1.63	14.23	76.75	0.84	33.10	18.41	31.59	9.15	18.65
Dec	1	46.00 ± 1.83	12.00 ± 0.82	58.00 ± 1.22	10.58	56.00	0.74	30.12	12.71	37.50	7.41	15.26
	15	28.00 ± 1.41	2.00 ± 0.41	30.00 ± 1.58	5.47	35.00	0.52	26.66	10.25	41.63	8.09	15.14
Jan, 2022	1	18.00 ± 1.83	4.00 ± 0.82	22.00 ± 1.63	4.01	20.00	0.73	25.39	7.29	50.14	8.69	15.21
	15	4.00 ± 0.71	2.00 ± 0.41	6.00 ± 0.82	1.09	8.50	0.27	23.81	9.03	50.94	8.00	14.32
Feb	1	0.00	0.00	0.00	0.00	1.50	0.00	20.86	7.43	43.29	7.42	14.01
	15	0.00	0.00	0.00	0.00	0.00	0.00	23.09	8.32	40.47	7.80	15.26
Mar	1	0.00	0.00	0.00	0.00	0.00	0.00	25.48	12.70	39.21	8.98	17.76
	15	0.00	0.00	0.00	0.00	0.00	0.00	26.47	12.19	34.36	8.56	18.46
Apr	1	0.00	0.00	0.00	0.00	0.00	0.00	30.52	11.54	27.00	9.96	21.56
	15	0.00	0.00	0.00	0.00	0.00	0.00	31.85	15.45	28.47	9.62	22.38
May	1	0.00	0.00	0.00	0.00	0.00	0.00	33.66	16.59	17.29	9.79	23.59
	15	0.00	0.00	0.00	0.00	0.00	0.00	34.32	18.31	19.70	10.22	24.86
Jun	1	0.00	0.00	0.00	0.00	0.00	0.00	37.79	20.71	18.50	10.96	26.35
	15	0.00	0.00	0.00	0.00	0.00	0.00	39.92	22.34	18.59	10.69	26.06
Jul	1	0.00	0.00	0.00	0.00	0.00	0.00	39.90	25.83	19.50	11.51	27.34
	15	0.00	0.00	0.00	0.00	6.00	0.00	40.20	24.75	17.64	11.19	26.83
Aug	1	16.00 ± 0.71	8.00 ± 0.82	24.00 ± 1.35	4.38	18.75	0.00	41.20	25.54	21.29	10.36	25.52
	15	18.00 ± 1.15	9.00 ± 0.91	27.00 ± 0.41	4.93	27.75	1.13	41.80	28.46	21.59	10.12	25.05
Sep	1	22.00 ± 1.63	11.00 ± 1.29	33.00 ± 2.89	6.02	34.50	1.22	41.63	27.99	23.36	10.36	25.15
	15	31.00 ± 0.71	14.00 ± 0.82	45.00 ± 1.35	8.21	30.75	1.36	40.94	24.82	28.06	9.64	23.62
General average		17.71 ± 2.39	5.13 ± 0.66	22.83 ± 3.01		21.80 ± 5.68		33.47	17.85	29.91	9.49	21.17
Coefficient of variance (%)		16.90	21.93	13.70								
L.S.D. at 0.05 level		4.23 **	1.59**	4.42**								

Table 2. Half-monthly counts (mean ± Standard error) of the mealybugs *F. virgata*, and progress of damage & rate of increase per branch (15 cm long, each with attached leaves) of Acalypha shrubs at Esna district, Luxor region during 2022/2023 year.

Sampling date		Nymphs	Adult females	Total counts per branch	% No. mealybugs of total population	Progress of damage	Rate of increase	Max. temp. °C	Min. temp. °C	% R.H.	Sunny shine	Solar radiation
Oct., 2022	1	50.00 ± 2.16	18.00 ± 1.41	68.00 ± 2.45	9.97	58.50	—	39.53	23.63	26.78	10.06	22.50
	15	68.00 ± 1.83	30.00 ± 1.78	98.00 ± 3.19	14.37	95.00	1.44	35.05	18.66	26.93	9.44	20.42
Nov	1	76.00 ± 3.16	40.00 ± 1.63	116.00 ± 4.69	17.01	107.50	1.18	39.47	22.17	28.29	9.24	18.84
	15	60.00 ± 0.82	40.00 ± 1.41	100.00 ± 1.83	14.66	97.00	0.86	34.65	17.85	35.33	7.49	15.41
Dec	1	54.00 ± 2.45	18.00 ± 0.82	72.00 ± 2.58	10.56	71.00	0.72	33.27	16.93	37.67	8.17	15.29
	15	34.00 ± 2.16	6.00 ± 0.82	40.00 ± 1.63	5.87	42.50	0.56	26.93	11.10	40.43	8.78	15.37
Jan, 2023	1	15.00 ± 1.29	3.00 ± 0.41	18.00 ± 1.47	2.64	21.00	0.45	26.50	9.39	41.81	8.08	14.47
	15	6.00 ± 0.82	2.00 ± 0.71	8.00 ± 0.91	1.17	8.50	0.44	23.18	7.73	50.70	7.50	14.15
Feb	1	0.00	0.00	0.00	0.00	2.00	0.00	24.46	8.65	48.18	7.88	15.41
	15	0.00	0.00	0.00	0.00	0.00	0.00	27.90	13.20	46.58	9.07	17.93
Mar	1	0.00	0.00	0.00	0.00	0.00	0.00	27.15	12.68	43.43	8.64	18.65
	15	0.00	0.00	0.00	0.00	0.00	0.00	28.58	12.00	31.58	10.06	21.78
Apr	1	0.00	0.00	0.00	0.00	0.00	0.00	30.26	16.06	34.03	9.72	22.60
	15	0.00	0.00	0.00	0.00	0.00	0.00	31.80	17.25	26.40	9.89	23.82
May	1	0.00	0.00	0.00	0.00	0.00	0.00	35.77	19.03	20.15	10.32	25.10
	15	0.00	0.00	0.00	0.00	0.00	0.00	37.65	21.53	18.98	11.07	26.61
Jun	1	0.00	0.00	0.00	0.00	0.00	0.00	40.33	23.22	19.21	10.80	26.33
	15	0.00	0.00	0.00	0.00	0.00	0.00	43.13	26.85	18.08	11.63	27.62
Jul	1	0.00	0.00	0.00	0.00	0.00	0.00	43.40	25.73	20.54	11.31	26.09
	15	0.00	0.00	0.00	0.00	7.50	0.00	44.30	26.04	20.78	10.46	25.78
Aug	1	20.00 ± 1.41	10.00 ± 0.82	30.00 ± 2.00	4.40	23.50	0.00	42.13	25.19	21.06	10.22	25.30
	15	22.00 ± 1.63	12.00 ± 0.82	34.00 ± 1.41	4.99	35.00	1.13	41.27	26.18	21.90	10.47	25.40
Sep	1	28.00 ± 1.63	14.00 ± 1.41	42.00 ± 2.45	6.16	43.50	1.24	40.50	25.33	22.79	9.74	23.86
	15	36.00 ± 2.45	20.00 ± 1.83	56.00 ± 3.46	8.21	38.50	1.33	39.42	25.38	24.83	9.93	23.40
General average		19.54 ± 2.55	8.88 ± 1.29	28.42 ± 3.79		27.13 ± 7.16		34.86	18.82	30.27	9.58	21.34
Coefficient of variance (%)		14.66	20.18	12.80								
L.S.D. at 0.05 level		4.05**	2.53**	5.14**								

Fig. 1. Photographs illustrate the damage symptoms of *F. virgata*, known as the striped mealybug, which have caused stunting, shrinkage, and deformities in Acalypha shrubs. The injury includes all different parts of the plant (branches and leaves they contain) by Dr. Moustafa M.S. Bakry, November 2022).

The data revealed that there was a decrease in the average total number of living individuals of *F. virgata* on acalypha branches in the first year (2021/2022) as compared to the second year (2022/2023). The average numbers of *F. virgata* per branch were 17.71 ± 2.39 and 19.54 ± 2.55 individuals in the two years, respectively.

Analysis of variance showed highly significant differences in the total number of living individuals of *F. virgata* at different inspection periods per year (L.S.D values 4.42 and 5.14) for both years, respectively. At the same time, the coefficients of variation ratios (C.V.%) reached (13.70 and 12.80%) for the two years respectively (Tables 1 and 2).

These results are consistent with those obtained by Dawood (1971), who reported that *F. virgata* showed a single peak of seasonal abundance in August on dahlia plants in Egypt. Adly *et al*. (2016) in Egypt, noted that the population of *F. virgata* reached its peak in November on guava trees in Egypt. Similarly, Shanbhag and Sundaraj (2017) in Bangalore, India, documented a single peak of seasonal abundance in May on sandalwood. In contrast, El-Shazly (2006) in Egypt, observed that *F. virgata* had two peaks of seasonal abundance in July and September on oleander plants in Giza. Balboul (2003) also recorded two peaks of seasonal abundance in early November and mid-October on guava trees. However, El-Batran *et al*. (2015) in Mansoura, Egypt, recorded three seasonal population peaks on lantana shrubs. It appears that the seasonal abundance of *F. virgata*, varies across different locations and plant hosts.

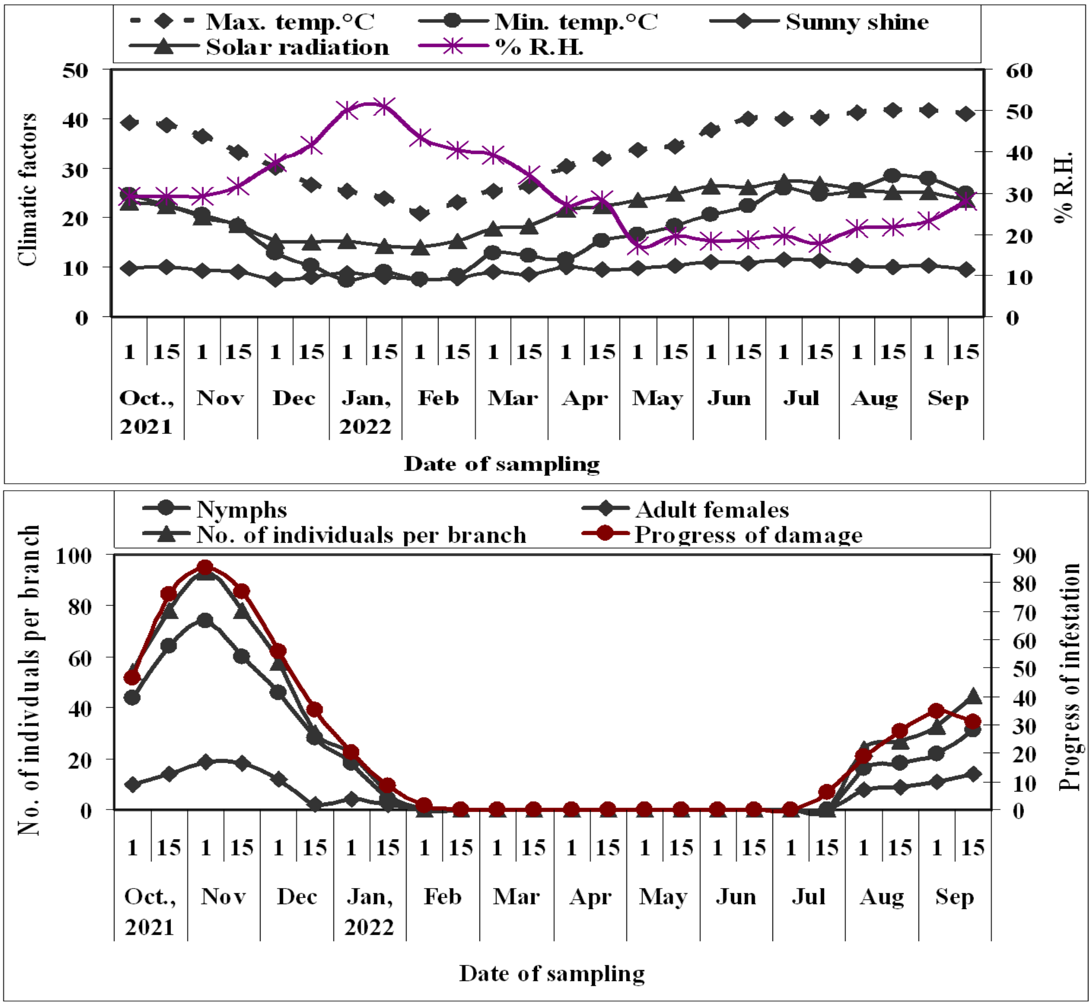

Fig. 2. Average counts of the mealybugs, *F. virgata*, and progress of damage per branch (15 cm long, each with attached leaves) of Acalypha shrubs at Esna district, Luxor region during 2021/2022 year.

Ata *et al*. (2019) reported that maximum numbers of *F. virgata* on *Dracena fragrans* were observed in September in 2014/2015, but it occurred in November in 2015/2016. Nabil *et al*. (2020) found that seasonal fluctuations of *F. virgata* are active from June to January of the following year. Population size peaked in October over both years. Subsequently, all stages of *F. virgata* disappeared from all parts of the plant. Also, it had two overlapping field generations annually on acalypha shrubs.

The variation in seasonal abundance of *F. virgata* observed by different researchers at different sites and on different host plants is interesting. These findings demonstrate the complex ecological factors that influence mealybug populations.

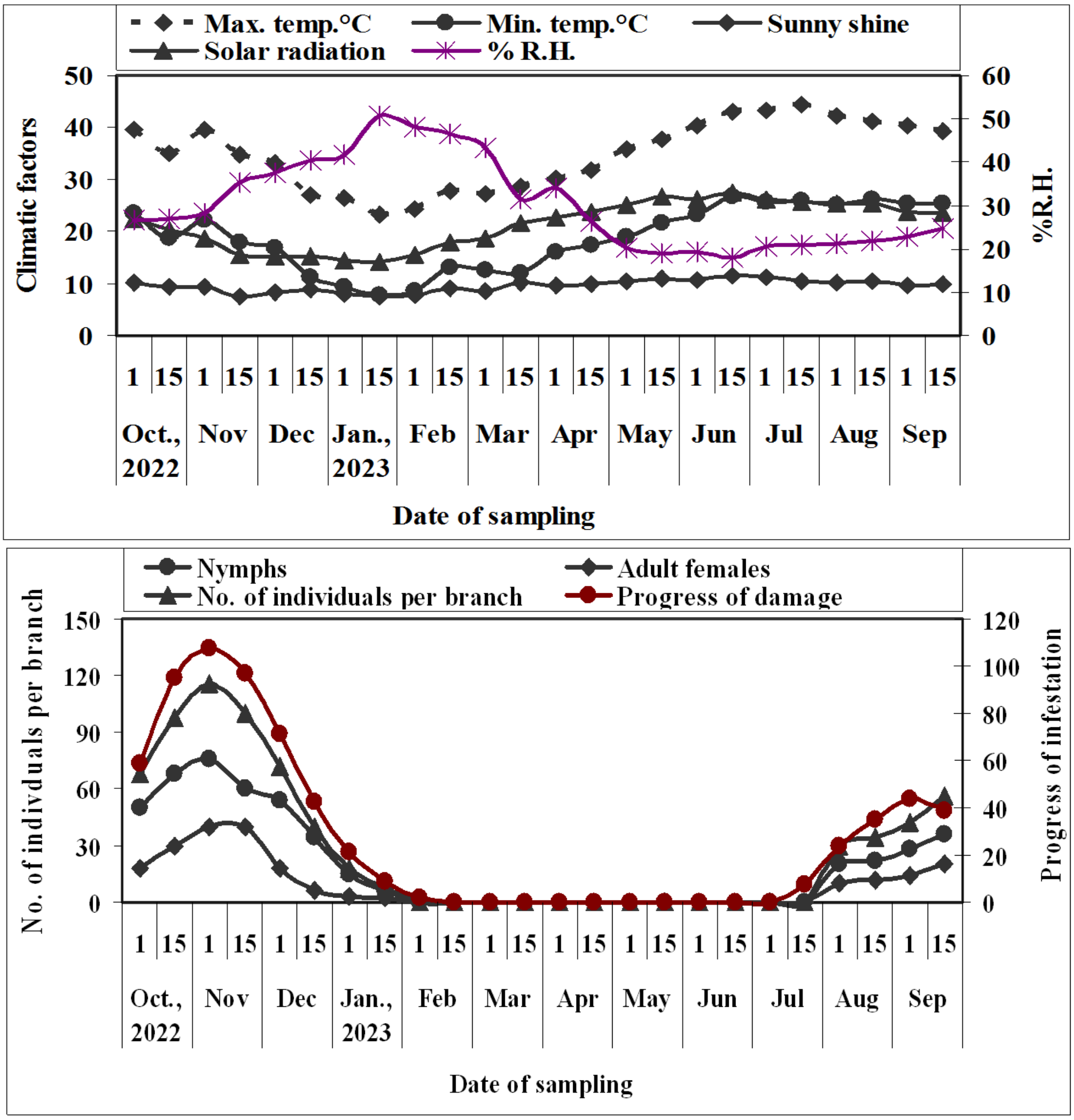

Fig. 3. Average counts of the mealybugs, *F. virgata*, and progress of damage per branch (15 cm long, each with attached leaves) of Acalypha shrubs at Esna district, Luxor region during 2022/2023 year.

Progress of damage

F. virgata invasion activity (i.e. damage) had two peaks that occurred on September 15 and November 1 annually, as shown in Tables (1 and 2) and Figures (2 and 3). The damage of *F. virgata* doubled from 21.80 ± 5.68 individuals in 2021/2022 to 27.13 ± 7.16 individuals in 2022/2023 per branch/year. The increment in the development of *F. virgata* damage in 2022/2023 compared to 2021/2022 was about 1.24 times.

Regarding the seasonal population of *F. virgata* each year, based on the surveyed data, the highest overall population density and damage development of *F. virgata* were also recorded on November 1st of each year. According to the researchers' findings, there are two annual peaks of *F. virgata*, depending on the location and host plant (El-Shazly, 2006; Balboul, 2003; Ata *et al*., 2019; Nabil *et al*., 2020).

2-Rate of increase in *F. virgata* estimates:

The rate of increase in *F. virgata* counts on roselle plants was estimated in half-monthly inspection intervals (Tables, 1 and 2). This rate of increase is considered an indicator of the appropriate time for insect activity and expresses the variation in insect activity throughout the year. When the rate of increase >1 expresses increased activity in this period, <1 expresses a decrease in activity in this period, and = one expresses no variance in activity (Bakry and Fathipour 2023; Bakry and Abdel-Baky, 2023).

Significant increases in estimates of *F. virgata* were observed on October 15, November 1, August 15, September 1, and 15, throughout the year, for which rates of change were higher than one, which shows that climatic factors at these times were appropriate for *F. virgata* activity and growth. These results are consistent with Ata *et al.* (2019) who mentioned that the maximum numbers of *F. virgata* were observed in September 2014/2015, however, it occurred in November in 2015/2016. Nabil *et al*. (2020) reported that the *F. virgata* estimates disappeared during the winter and spring until the summer of the following year.

3-The polynomial relationships between *F. virgata* estimates and damage development:

Mathematical equations were calculated between estimates of *F. virgata* as independent variable (X_1) and damage evolution (Y_2) as dependent variables, and we applied a third-order nonlinear regression equation, as shown in Figure (4). Bakry and Fathipour (2023) applied this method. The mathematical equations are as follows:

First season (2021/2022)

$Y_2 = 1E\text{-}05\ X_1^3 - 0.0008\ X_1^2 + 0.9207\ X_1 + 0.8171$ $R^2 = 0.9838$ Equation (1)

Second season (2022/2023)

$Y_2 = 1E\text{-}05\ X_1^3 - 0.0013\ X_1^2 + 0.94\ X_1 + 0.9632$ $R^2 = 0.9632$ Equation (2)

The results showed highly statistically significant relationships between the occurrence of *F. virgata* and damage development throughout the two years of study. The coefficient of determination percentages (R^2) was 98.38 and 96.32% in both the two years, respectively, as presented in equations (1 and 2) and Figure (4).

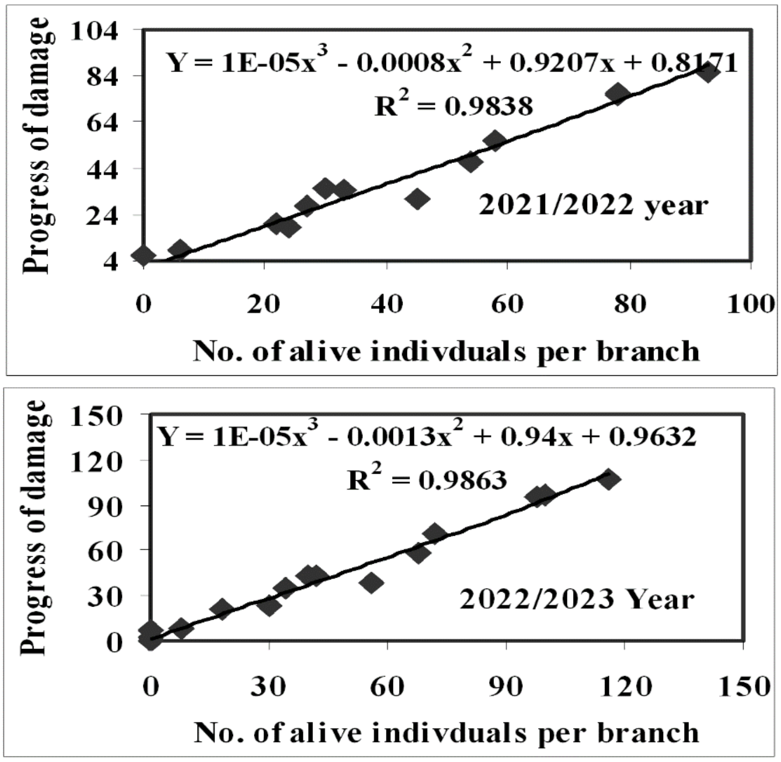

Fig. 4. The relation between the population estimates of *F. virgata* per Acalypha branch and the damage progression during the two years (2021/2022 and 2022/2023).

4-Evaluating the influence of the meteorological variables on *F. virgata* occurrence on acalypha shrubs:

Results for a multiple linear regression model between meteorological variables and the total living population of *F. virgata* were calculated as follows:

First season (2021/2022):

$$Y = 84.58 + 8.84\, X_1^{**} + 0.58X_2 - 2.37X_3^{*} + 22.75X_4^{*} - 24.23X_5^{**}$$

F value = 19.21** MR= 0.918 E.V.= 84.21% Equation (3)

Second season (2022/2023):

$$Y = 628.40^{**} - 9.08\, X_1^{**} + 13.37X_2^{**} - 5.31X_3^{**} + 4.25X_4 - 19.50X_5^{**}$$

F value = 18.90** MR= 0.917 E.V.= 83.99 % Equation (4)

Where, X_1= maximum temperature; X_2= minimum temperature; X_3= relative humidity X_4= sunny shine; X_5= solar radiation; MR= multiple correlation; E.V.= explained variance.

As seen in equations (3 and 4) the pooled effects of these tested parameters on *F. virgata* estimates throughout the two seasons were highly significant and varied from one year to another. The F-values were (19.21 and 18.90) and the Multiple correlation values were 0.917 and 0.918, during the two years, respectively. Meanwhile, the explained variances between these tested weather factors on *F. virgata* estimates were listed as 84.21 and 83.99%, over both years, respectively (Equations 3 and 4).

Nabil *et al*. (2020) concluded that the pooled impacts of the four variables (maximum, minimum, average temperature, and percentage of relative humidity) exhibited highly important impacts on the variations in population estimates of *F. virgata* on acalypha shrubs throughout 2014-2015. The explained variance percentage was 79.20%, however, the same variables had an insignificant impact in 2015/2016.

5-Sampling program and spatial distribution dispersion type of *F. virgata*

Sampling programme

The data presented in Table 3, the variance ratios for the data of the initial samples of nymphs, adult females, and the total number of *F. virgata* individuals, showed that the pest population estimates of the pest were 13.49, 12.94, and 13.16% throughout 2021/2022 and 13.03, 14.55, and 13.32% during 2022/2023, respectively (Table, 3). These results indicate that the sampling program was effective.

Table 3. Spatial distribution patterns of the mealybugs, *F. virgata* infesting Acalypha shrubs during the two years (2021/2022 and 2022/2023)

Parameters	2021/2022			2022/2023		
	Nymphs	Adult females	Total alive counts	Nymphs	Adult females	Total alive counts
Max.	74.00	19.00	93.00	76.00	40.00	116.00
Min.	0.00	0.00	0.00	0.00	0.00	0.00
Mean	17.71	5.13	22.83	19.54	8.88	28.42
Range of mean	74.00	19.00	93.00	76.00	40.00	116.00
Median	2.00	1.00	3.00	3.00	1.00	4.00
S^2	547.56	42.22	867.17	622.27	160.15	1375.36
S	23.40	6.50	29.45	24.95	12.66	37.09
S.E.	2.39	0.66	3.01	2.55	1.29	3.79
C.V.	132.14	126.78	128.97	127.65	142.59	130.51
R.V.	13.49	12.94	13.16	13.03	14.55	13.32
S^2/m	30.92	8.24	37.98	31.84	18.05	48.40
Lewis Index	5.56	2.87	6.16	5.64	4.25	6.96
Cassie index	1.69	1.41	1.62	1.58	1.92	1.67
K	0.59	0.71	0.62	0.63	0.52	0.60
I_D	2937.48	782.54	3607.94	3025.12	1714.31	4597.98
Z value	62.90	25.81	71.20	64.04	44.81	82.15
I_{dm}	29.92	7.24	36.98	30.84	17.05	47.40
X*	47.63	12.36	59.81	50.39	25.92	75.82
X*/m	2.69	2.41	2.62	2.58	2.92	2.67
GI	0.38	0.09	0.47	0.39	0.22	0.60
1/*k*	1.69	1.41	1.62	1.58	1.92	1.67
λ	32.88	7.95	40.64	33.89	18.73	52.09

Spatial distribution

The study found that the distribution of *F. virgata* individuals on acalypha shrubs was higher than the overall mean and the variance-to-mean ratio was greater than one for *F. virgata* populations. This indicates that the spatial distribution of all insect stages and total living individuals of the pest was aggregate dispersion over 2 years.

The Lewis index of *F. virgata* population was higher than one, and the Cassie index was above zero, these indicate that the spatial distribution of all insect stages and total living individuals of the pest was aggregated dispersal. In the context, the negative binomial dispersion was positive and small, suggesting a highly clustered population of *F. virgata* for the 2 years. Nymphs, adult females, and the total population of *F. virgata* showed positive index of clumping (IDM) values and Z-test coefficients greater than 1.96. The Green's index and patchiness index were also greater than zero and one respectively, indicating that the spatial distribution of all stages of the insect and the total number of live individuals of the pest was a combined dispersal over two years. The distribution of the different *F. virgata* stages and the total population during each year also showed an aggregated shape over time as shown by the values of 1/k.

The study found that the aggregation behavior of *F. virgata*, particularly in combination with climatic parameters, generated aggregation phenomena. This is supported by the fact that the values of aggregations (λ) were all higher than 2 in Nymphs, adult females, and the total population over two years.

The most of mealybug individuals' species display a clustered distribution, and we have a limited understanding of their natural movement between host plants. One study revealed that the dispersal of mealybugs on grape trees can be influenced by wind, but there was a significant decrease in population as the distance from the source plant increased (Grasswitz *et al.* 2008). Additionally, not integrated control of this pest can be attributed in part to a lack of knowledge about their feeding locations (Shah *et al*. 2015).

As a result, initial stages of infestations often go unnoticed, and management decisions are made only after significant damage has already occurred. It is therefore crucial to conduct thorough monitoring of this invasive species across Egypt, in both field and ornamental crops, due to the potential risk of resurgence it presents. The spatial distribution results exhibited that *F. virgata* nymphs and adult females tend to cluster together. This study provides useful data for predicting future behavior and managing the pest in an integrated way.

There is no data offered in the literature regarding the distribution pattern of *F. virgata*. Many researchers have concluded that hemipteran pests have a high aggregated distribution behavior. Example: *Chauliops fallax* (Hemiptera: Malcidae) on soybean (Bala and Kumar, 2018), *Waxiella mimosae* on sunt trees (Bakry, 2018), *Parlatoria oleae* on mango trees (Bakry, 2020), *Aulacaspis tubercularis* (Hemiptera: Diaspididae) on mango trees (Bakry and Abdel-Baky, 2020), *Icerya seychellarum* on guava trees (Bakry and Arbab, 2020), *Schizaphis graminum* (Hemiptera: Aphididae) (Bakry and Shakal, 2020), and *Phenacoccus solenopsis* on okra plants (Bakry *et al*., 2023).

6-Toxicity efficacy evaluation of certain insecticides against *F. virgata* on acalypha leaves

On the third instar nymphs of *F. virgata*

The data presented in Table (4) and Figure (5) showed the toxicity activity of some insecticides against *F. virgate* after 72 hrs of treatment. The pesticides exhibited high to low activity against the third instar nymphs of *F. virgata,* in which the LC50 values vary from 0.287 to 1.725 mg/L. For example, the LC50 values for the insecticides Bioranza, KZ Oil, Admiral, Mospilan, and Imidacloprid were 1.306, 1.725, 1.128, 0.998 and 0.287 mg/L, respectively.

Table 4. Insecticidal effectiveness of components Bioranza, KZ oil, Admiral, Mospilan, and Imidacloprid against third instar nymphs & adult females of *F. virgata* insects after 72 hrs of treatment

	Third instar nymphs				Adult females			
Comp.	**LC_{50} (mg/L)**	**Slope**	**Toxic ratio[a]**	**χ 2**	**LC_{50} (mg/L)**	**Slope**	**Toxic ratio**	**χ 2**
Bioranza	1.306	0.561 ± 0.258	21.97	0.349	4.605	0.764 ± 0.265	20.54	0.227
KZ oil	1.725	0.642 ± 0.261	16.40	0.506	4.090	0.752 ± 0.65	23.12	0.223
Admiral	1.128	0.582 ± 0.262	25.62	0.049	2.312	0.671 ± 0.270	40.91	0.256
Mospilan	0.998	0.574 ± 0.263	28.75	0.046	2.195	0.678 ± 0.272	43.19	0.172
Imidacloprid	0.287	0.421± 0.268	100	0.095	0.946	0.487 ± 0.275	100	0.121

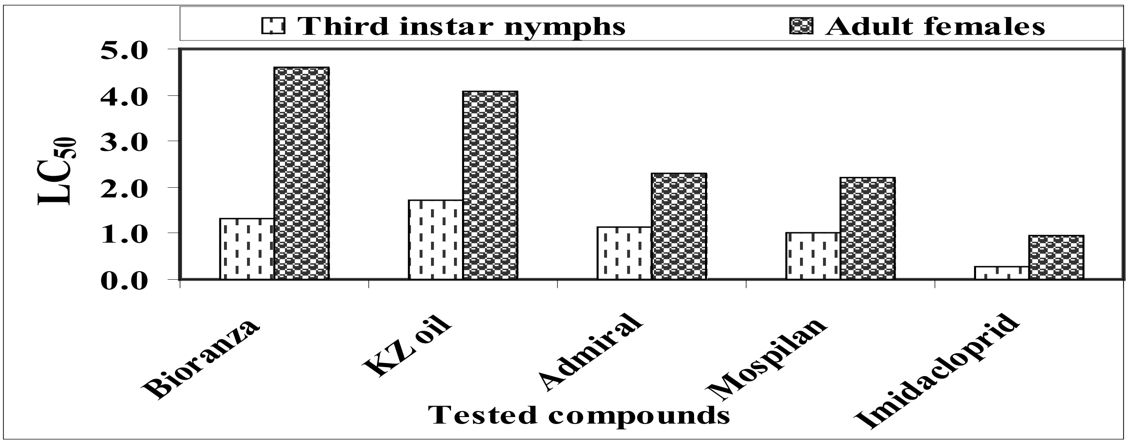

Fig. 5. Insecticidal effectiveness of selective target components Bioranza, KZ oil, Admiral, Mospilan and Imidacloprid against adults and nymphs of *F. virgata*

On *F. virgata* adult females

Some pesticides were found to be highly effective against *F. virgata* adult females after 72 hrs of treatment, with LC50 values ranging from 0.946 to 4.605 mg/L. The LC50 values of target pesticides Bioranza, KZ oil, Admiral, Mospilan, and Imidacloprid were 4.605, 4.090, 2.312, 2.195, and 0.946 mg/L respectively, as shown in Table (4) and Figure (5).

It was obvious that, after 72 hours of testing the effectiveness of the insecticides, the activities of the studied pesticides varied, as it was found that imidacloprid was more effective than the other tested pesticides, as the LC50 values reached 0.287 mg/L for *F. virgata* third instar nymphs of and 0.946 mg/L for adult females. While Bioranza pesticide was found to be less effective than other pesticides evaluated, LC50 values reached 0.946 mg/L for *F. virgata* third instar nymphs and 4.605 mg/L in adult females.

These findings were consistent with those acquired by Mohammad *et al*. (2010) reported that the lowest percentage of reduction in the mealybug, *M. hirsutus* population on hibiscus plant was recorded by orange oil, while the highest value was by Admiral insecticide after the fourth week of application. Ashiq *et al*. (2015) and Rezk *et al*. (2019) who reported that imidacloprid, thiamethoxam, and malathion were recorded to be the best compounds after 5 and 7 days of treatment against the cotton mealybug, *Phenacoccus solenopsis.* Elbahrawy *et al*. (2020) concluded that imidacloprid was the most effective against *P. solenopsis* exhibiting about 90.71-89.17% reduction in insect numbers after three weeks of spraying. Hamed *et al*. (2022) mentioned that Kz-oil had the least activity against the cotton mealybug, *P. solenopsis* on cotton leaves.

Recommendations

The data collected can be used to track pest numbers, behavior, and the impact of weather conditions, to determine the timing and implementation of effective pest control strategies.

References

Abbott, W.S. (1925). A method for computing the effectiveness of an insecticide. J. Econ. Entomol., 18: 265-267.

Abd El-Moaty, R.M. (2013). Ecological studies on sunt borer, *Macrotoma palmata* Fab. (Coleoptera: Cerambycidae) infesting mango orchards in Egypt J. Plant Prot. and Path., Mansoura Univ., Vol. 4 (2): 199 – 205.

Adly, D., Abul Fadl, H.A.A. and Mousa, S.F.M. (2016). Survey and seasonal abundance of mealybug species, their parasitoids and associ-ated predators on guava trees in Egypt. Egypt. J. Bio. Pest Cont.; 26(3), 657-664.

Ashiq, H.S., Masood, Q.W., Muhammad, A. and Khalid, L. (2015). Efficacy of different insecticides against cotton mealybug, *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Coccoidea: Pseudococcidae) in ecological zone of Rahim Yar Khan. Int. J. Adv. Res. Biol. Sci., 2 (2): 61–67.

Ata, T.E., El-Awady, S.M., El-Khouly, A.S. and Metwally, M.M. (2019). Population Density of the Striped Mealybug *Ferrisia virgata* (Ckll.) (Hemiptera: Pseudococcidae) on the Ornamental Corn Shrubs, *Dracena fragrans* in Relation to Biotic and Abiotic Factors in Al-Zohria Gardens, Cairo, Egypt. J. Plant Prot. and Path., Mansoura Univ., Vol.10 (2): 141 – 146.

Bakry, M.M.S. (2009). Studies on some scale insects and mealybugs infesting mango trees in Qena Governorate. M.Sc. Thesis, Fac. Agric. Minia, Univ., 204.

Bakry, M.M.S. (2018). Abundance, generation determination and spatial distribution pattern of the sunt wax scale insect, *Waxiella mimosae* (Signoret) (Hemiptera: Coccidae) infesting sunt trees in Luxor Governorate, Egypt. Current Investigations in Agriculture and Current Research, 4(3): 523-538.

Bakry, M.M.S. (2020). Spatial distribution of the plum scale insect, *Parlatoria oleae* (Colvee) (Hemiptera: Diaspididae) infesting mango trees in Egypt. International journal of Horticulture, Agriculture and Food science, 4(2):14-20.

Bakry, M.M.S. and Abdel-Baky, N.F. (2020). Examining the spatial distribution pattern and optimum sample size for monitoring the white mango scale insect, *Aulacaspis tubercularis* (Newstead) (Hemiptera: Diaspididae) on certain mango cultivars. International journal of Horticulture, Agriculture and Food science, 4(3):91-104.

Bakry, M.M.S. and Abdel-Baky, N.F. (2023). Population density of the fall armyworm, *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) and its response to some ecological phenomena in maize crops. Brazilian Journal of Biology, 2023, vol. 83, e271354 https://doi.org/10.1590/1519-6984.271354

Bakry, M.M.S. and Arbab, A. (2020). Monitoring of the scale insect, *Icerya seychellarum* (Westwood) infesting guava. Indian Journal of Entomology, 82 (1): 1-12.

Bakry, M.M.S. and Fathipour, Y. (2023). Population Ecology of the Cotton Mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) on Okra plants in Luxor region, Egypt. J. Agric. Sci. Technol., 25(6): 1387-1402.

Bakry, M.M.S. and Shakal, S.Y.E. (2020). Population size and spatial distribution pattern of *Schizaphis graminum* (Hemiptera: Aphididae) on some wheat cultivars and lines. Acta Entomol. Zool., 2020; 1(2): 01-09.

Bakry, M.M.S., Badawy, A.M.M. and Mohamed, L.H.Y. (2023). Spatial Distribution and Abundance of the Mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) Infesting Okra Plants. SVU-International Journal of Agricultural Sciences. 5(3): 1-17.

Bala, K. and Kumar, S. (2018). Population density and spatial distribution of bean bug *Chauliops fallax* Sweet & Schaeffer (Hemiptera: Malcidae) on different legume crops under mid hills of Himachal Pradesh. Journal of Entomology and Zoology Studies 6(4): 1514-1518.

Balboul, O.A.H. (2003). Ecological safe ways for con-trolling some insect pests attacking the guava trees at Giza Governorate. M.Sc. Thesis, Dept. Agric. Sci.; Institute Environ. Studies and Res.; Ain Shams Univ., 148 p.

Blackith, R.E. (1961). The water reserves of hatchling locusts. Comparative Biochemistry & Physiology, 3(2): 99-107.

Cassie, R.M. (1962) Frequency distribution models in the ecology of plankton and other organisms. *Journal of Animal Ecology* 31(1): 65-92.

Costa, M.G., Barbosa, J.C., Yamamoto, P.T. and Leal, R.M. (2010). Spatial distribution of *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) in citrus orchards. *Scientia Agricola* 67: 546-554.

Dawood H.Z. (1971). Survey of aphids and mealy-bugs infesting ornamental plants. M.Sc. Thesis, Fac. Agric., Cairo Univ.; 114 p.

David, F.N. & Moor, P.G. 1954. Notes on contagious distribution in plant populations, Ann. Bot, 18: 47–53.

Elbahrawy, A.M.S.U.H., Abd-Rabou, S., Hammad, K.A.A. and El-Sobki, A.E.A.M. (2020). Monitoring and management of the cotton mealybug, *Phenacoccus solenopsis* Tinsley insect and its associated natural enemies on green bean plants. Zagazig J. Agric. Res., 47(4): 909-926.

El-Batran L.A., Ghanim A.A., Shanab L.M. and Ramadan M.M. (2015). Population densities of some insects infesting *Lantana camara* L. shrubs and their predatory insects at Mansoura District. J. Plant Prot. and Path.; Mansoura Univ.; 6(5), 813-823.

El-Shazly M.M. (2006). Observations on oleander (*Nerium oleander* L. Apocynaceae) ecosystem in Giza, Egypt. Proc. 4th Inter. Conf. on Urban Pests, 225-233.

Feng, M.G. and Nowierski, R.M. (1992). Spatial distribution and sampling plans for four species of cereal aphids (Homoptera: Aphididae) infesting spring wheat in southwestern Idaho. J. of Econ. Entomol., 85: 830-837.

Finney, D.J. (1971). Probit analysis. A statically treatment of the sigmoid response curve. Cambridge Univ. Press, England, 318.

Franco J.C., Zada A. and Mendel Z. (2009). Novel approaches for the management of mealybug pests. Biorational Control of Arthropod pests. Springer, 233-278.

Freed, R.D. (1991). MSTATC Microcomputer Statistical Program. Michigan State university, East Lansing, Michigan.

Garcia, M., Denno, B., Miller, D.R., Miller, G.L. and Ben-Dov, Y. (2015). ScaleNet: A literature-based model of scale insect biology and systematic. http://scalenet.info.

Grasswitz, T.R. and James, D.G. (2008). Movement of grape mealybug, *Pseudococcus maritimus* on and between host plants. Entomologia Expermentalis et Applicata; 129(3):268-275.

Green, R.H. (1966). Measurement of non-randomness in spatial distribution. Res. Population Ecol. 8:1–17.

Hamed, S.A., Anber, H.A., Hamid, A.M., Nasseem, H.A. and Baz, R.I.M. (2022). Comparative efficiency of some chemicals against cotton mealybug and their side effects on associated predators under field condition. J. of Plant Protection and Pathology, Mansoura Univ., 13(9): 225-230.

He, Y.;Wang, K.; Du, G.; Zhang, Q.; Li, B.; Zhao, L.; He, P. and Chen, B. (2022). Temporal and Spatial Distribution Patterns of Spodoptera frugiperda in Mountain Maize Fields in China. Insects, 13, 938. https://doi.org/10.3390/insects13100938

Hillhouse, T.L. and Pitre H.N. (1974). Comparison of sampling techniques to obtain measurements of insect populations on soybeans. J. Econ. Entomol., 67: 411-414.

Khodeir, I.A., Khattab, M.A., Rakha, O.M., Sharabash, A.S., Ueno, T. and Mousa K.M. (2020). Population densities of pest aphids and their associated natural enemies on faba bean in Kafr EL–Sheikh, Egypt. J. Fac. Agr., Kyushu Univ., 65 (1), 97–102 (2020)

Kuno, E. (1991). Sampling and analysis of insect populations. Annu. Rev. Ent., 36: 285-304.

Li, N., Chen, Q., Zhu. J., Wang, X., Huang, J.B. and Huang, G.H. (2017) Seasonal dynamics and spatial distribution pattern of *Parapoynx crisonalis* (Lepidoptera: Crambidae) on water chestnuts. *PLoS* One 12 (9): 1-13.

Lloyd, M. (1967). Mean crowding. J. Animal Eco., 36: 1– 30.

Miftakhurohmah, S.H., Mutaqin, K., Soekarno, B. and Wahyuno, D. (2022). Study on *Ferrisia virgata* and *Planococcus minor* as vectors of mottle disease in black pepper. IOP Conf. Series: Earth and Environmental Science 974: 012030. doi:10.1088/1755-1315/974/1/012030.

Mittler, T.E. and Douglas, A.E. (2003). Honeydew. In: Resh, V.H., Card, R.T. (eds) Encyclopedia of insects. Academic, Amsterdam.

Mohammad, A.H., Moussa, S.F., Abo-Ghalia, A.H. and Ahmed, S.A. (2010). Efficiency of certain insecticides on the population(s) of the pink hibiscus mealybug *Maconellicoccus hirsutus* (Green) and their natural enemies under the field condition in Ismailia governorate. Egypt. Acad. J. biolog. Sci., 2(2): 11- 17.

Nabil D., Amin A.H., Elashn, Omnia M.N. and Youssef, E.E.Y. (2020). Some ecological aspects on the striped mealybug *Ferrisia virgata* (cockerell) infesting acalypha shrubs in Qalyubiya governorate, Egypt. Arab Univ. J. Agric. Sci., Ain Shams Univ., Cairo, Egypt 82(1), 337-348.

Navik, O.; Shylesha, A.N.; Patil, J.; Venkatesan, T.; Lalitha, Y. and Ashika, T.R. (2021). Damage, distribution and natural enemies of invasive fall armyworm *Spodoptera frugiperda* (J. E. Smith) under rainfed maize in Karnataka, India. Crop Prot., 143, 105536.

Patil, G.P. and Stiteler, W.M. (1974). Concepts of aggregation and their quantification: a critical review with some new results and applications. *Research Population Ecology* 15: 238-254.

Rajasekhar Y, Swathi B, Hari Satyanarayana N, Amarajyothi P and Padmavathi PV (2021). Seasonal incidence of insect Pestsin Mesta, *Hibiscus sabdariffa* L. (Roselle). The Pharma Innovation Journal 2021; 10(11): 655-659.

Rezk, M., Hassan, A.T., El-Deeb, M.F., Shaarawy, N. and Dewer, Y. (2019). The impact of insecticides on the cotton mealybug, *Phenacoccus solenopsis* (Tinsley): Efficacy on potato, a new record of host plant in Egypt. J. Plant Prot. Res., 59 (1): 50-59.

Shah, T.N, Ahme, A.M. and Memon, N. (2015) Population dynamics of cotton mealybug, *Phenacoccus solepnosis* Tinsely in three talukas of district Sanghar (Sindh). Journal of Entomology and Zoology Studies 2015; 3(5): 162-167.

Shah, Z.H., Sahito, H.A., Shar, G.A., Kousar, T., Mangrio, W.M. and Kanhar, K.A. (2016). Toxicity of different insecticides against mealybug, *Phenacoccus solenopsis* (Tinsley) under cotton field conditions. Pak. J. Entomol. 31 (1): 39-50

Shanbhag R.R. and Sundararaj R. (2017). Population dynamics of the striped mealybug *Ferrisia virgata* (Cockerell) (Hemiptera: Pseudococ-cidae) and the scope of its biological suppres-sion in the present scenario of cultivation of in-dian sandalwood.

Southwood, T.R.E. (1995). Ecological methods, with particular reference to the study of insect population Chapman and Hall, London.

Southwood, T.R.E. and Henderson, P.A. (2000) Ecological methods. 3^{rd} ed. Blackwell Sciences, Oxford.

Sun, Y.P. (1950). Toxicity index an improved method of comparing the relative toxicity of insecticide. J. Econ. Entomol., 43: 45-53.

Yang, X.M., Song, Y.F., Sun, X.X., Shen, X.J., Wu, Q.L., Zhang, H.W., Zhang, D.D., Zhao, S.Y. and Wu, K.M. (2021). Population occurrence of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), in the winter season of China. J. Integr. Agric., 20: 772–782.

Zahidin, N.S., Saidin, S., Zulkifli R.M., Muhamad I.I., Ya'akob H. and Nur H. (2017). A review of *Acalypha indica* L. (Euphorbiaceae) as traditional medicinal plant and its therapeutic potential. J Ethnopharmacol. 207: 146-173. doi: 10.1016/j.jep.2017.06.019

البق الدقيقي المخطط (بق الفريزيا فرجاتا) رصد وتشتت التعداد الحشري على شجيرات الأكاليفا ومكافحتها في منطقة الأقصر، مصر

مصطفى محمد صبري بكرى[1*]، إيمان عوض شحاته[2] ، إيمان فاروق محمد طلبه [3]

[1] قسم بحوث الحشرات القشرية والبق الدقيقي، معهد بحوث وقاية النباتات، مركز البحوث الزراعية، الجيزة، مصر.
[2] قسم بحوث أفات الخضر والنباتات الطبية والعطرية والزينة، معهد بحوث وقاية النباتات، مركز البحوث الزراعية، الجيزة، مصر.
[3] قسم وقاية النبات، كلية الزراعة جامعة الوادي الجديد، الوادي الجديد، مصر.

الملخص

تم تنفيذ التجربة الحالية بحديقة محطة البحوث الزراعية بالمطاعنة باسنا، محافظة الأقصر، خلال أعوام (2022/2021، 2023/2022)، لدراسة موسمية التعداد والتوزيع المكاني لحشرة البق الدقيقي الفريزيا فرجاتا وعلاقتها ببعض ظروف الطقس الجوية ومكافحتها.

أظهرت النتائج، أن حشـرة البق الدقيقي الفريزيا فرجاتا على شـجيرات الأكاليفا، اكتشـفت خلال كل عام في الفترة من 1 أكتوبر إلى 15 يناير، وبعدها اختفت الإصـــابة الحشـــرية حتى 15 يوليو، ثم بدأت الحشـرة في الظهور مرة أخرى في الفترة من 1 أغسـطس إلى 15 سـبتمبر (نهاية أخذ القراءات لكل عام).

وأوضـحت النتائج، أن للحشـرة قمتين للنشـاط الموسـمي خلال العام، والتي لوحظت في 1 نوفمبر، 15 سبتمبر على مدار العام. وأشار النموذج الرياضي للانحدار الخطي المتعدد، أن التأثير المشـــترك لجميع العوامل الطقس الجوية المختبرة وهي متوســـط درجة الحرارة العظمى اليومية ودرجة الحرارة الصـغرى اليومية ونسـبة الرطوبة النسـبية اليومية وعدد سـاعات النهار والإشـعاع الشـمسـي) على التعداد الكلى للحشـرة خلال العامين كان واضـحا، وبلغ (84.21، 83.99%) خلال أعوام (2022/2021، 2023/2022) على التوالي.

وتم تحليل البيانات باستخدام مؤشرات التوزيع، وأظهرت النتائج أن جميع مؤشرات التشتت المختلفة تشير إلى توزيع تجميعي للأطوار المختلفة للحشرة على مدار العام.

وأيضا أظهرت النتائج، أنه بعد 72 ساعة من اختبار فعالية المبيدات الحشرية، تباينت فعالية المبيدات المدروســـة، حيث وجد أن مبيد إيميداكلوبريد هو الأكثر فعالية من المبيدات الأخرى المختبرة لكلا من حوريات العمر الثالث والإناث البالغة للحشـــرة، ومع ذلك، كان أقل المبيد فعالية هو مبيد البيورانزا.