EGYPTIAN ACADEMIC JOURNAL OF

BIOLOGICAL SCIENCES

ENTOMOLOGY

A

ISSN
1687-8809

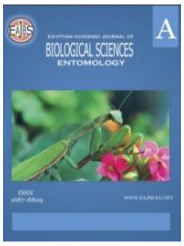
WWW.EAJBS.EG.NET

Citation: *Egypt. Acad. J. Biolog. Sci. (A. Entomology) Vol. 13(3) pp: 157-173(2020)*

Egypt. Acad. J. Biolog. Sci., 13(3):157-173 (2020)

Egyptian Academic Journal of Biological Sciences
A. Entomology

ISSN 1687- 8809
http://eajbsa.journals.ekb.eg/



Estimate the Annual Field Generations of *Lepidosaphes tapleyi* (Williams) Infesting Guava Trees and Predicting its Expected Peaks Using Thermal Units Accumulation under Luxor Governorate Condition, Egypt.

Moustafa M.S. Bakry and Hassan F. Dahi
Plant Protection Research Institute, Agricult. Research Center, Dokki, Giza, Egypt.
Email: md.md_sabry@yahoo.com - hassandahi@yahoo.com

ARTICLE INFO
Article History
Received:7/6/2020
Accepted:29/8/2020

Keywords:
Lepidosaphes tapleyi, seasonal abundance, annual generation, heat units, predicting, guava trees, control.

ABSTRACT

The aim of this study was to determine the approximated numbers, occurrence date, size of the generations and their peaks of *Lepidosaphes tapleyi* were determined on guava trees at Esna district, Luxor Governorate during two successive years of (2017/2018 and 2018/2019) in order to predict the degree day's units and annual generation peaks by studying the relationship between the accumulated thermal heat units expressed as degree-days (DD's) and the population fluctuations of insect that help to find out a proper controlling time.

The obtained results revealed that *L. tapleyi* has four to five overlapping generations per year under the field conditions in Luxor Governorate. During the first year of (2017/2018), five generations were from early March to mid-May, mid-April to early July, beginning of June to early September, mid-July to mid of November and early October to early January for the 1st, 2nd, 3rd, 4th and 5th generations, respectively. These generations lasted 10, 11, 12, 16, and 13 weeks, respectively. These generations size was 81.42, 99.44, 159.54, 306.07 and 236.24 individuals/ leaf, respectively. While, the second year of (2018/2019), four generations were from early March to mid-July, early June to mid-September, mid of July to mid-November, and mid of September to early January for the 1st, 2nd, 3rd and 4th generations, respectively. These generations lasted 13, 18, 14, 16, and 14 weeks, respectively. These generations' size was 188.73, 222.50, 347.92, and 282.34 individuals/ leaf, respectively. In general, the fourth generation in the first year and the third generation in the second year, which started in both of them from mid-July and continued until mid of November was the longest one and biggest in size than the other generations during the two years.

Using available meteorological data provided for Luxor area, the mean ± STD daily heat units per generation for *L. tapleyi* over the two years were estimated to be 18.01 ± 2.63 DD's. The simple regression analysis indicated that the numbers of cumulative individuals of *L. tapleyi* per leaf were relatively more correlated with the accumulated heat units for two years. The obtained results indicated the occurrence of five actual observed peaks that took place in (early April, mid-May, mid-July, early-October and mid-November) and has five expected peaks that occurred in May, 5th; June, 30th; August, 21st; October, 15th and January, 4th, respectively during the first year (2017/2018). However, through the second year (2018/2019), has four actual observed peaks that recorded in (mid-April, mid-July, mid-September, and early-November) and has five prospective peaks that occurred in April, 9th; June, 7th; July, 31st; September, 23rd and December, 3rd, respectively. Also, the predicted peaks of generations could be detected when the accumulated thermal units reached 1112.35 ± 6.00-degree days under the climatic conditions in Luxor Governorate.

INTRODUCTION

Among several pests, infesting guava trees, the guava long scale insect, *Lepidosaphes tapleyi* is considered one of the most main destructive pests of guava trees (Swailem, 1973) and it has a wide range of host plants, it attacks fruit trees and ornamental plants and occurs in many countries: Asia, Africa (Williams and Watson, 1988). This pest injures the shoots, twigs, leaves, branches, and fruits by sucking the plant sap with the mouthparts, causing thereafter deformations, defoliation, drying up of young twigs, dieback, poor blossoming, death of twig by the action of the toxic saliva and so affecting the commercial value of fruits where it causes conspicuous pink blemishes around the feeding sites of the scales. A characteristic symptom of infestation by the pest is the appearance and accumulation of its scales on attacked guava parts (Swailem, 1974; El-Nahal *et al*., 1980 and Williams and Watson, 1988).

Most authors indicated four or five generations per year for *L. tapleyi* depending on the area, environmental conditions, and the host plant worldwide. In this respect, Swailem (1973 and 1974) in Egypt, reported that the guava long scale insect, *L. tapleyi* had five generations per year, were recorded in May, June, July, September, and November. However, with different insect species and host plant, Elwan (1990) in Egypt, recorded that mango trees were heavily infested by *L. pallidula*. He recorded 4-5 overlapping generations for this insect per year. In Egypt, Selim (2002), Elwan (2005), and Moussa *et al.* (2006), reported that *Insulaspis pallidula* had four generations per year on mango trees.

Generations' determination or peaks of the insect in the published studies depended on the dynamics of the absolute values of populations' density. As the appearance of *L. tapleyi* varies greatly from year to another, it can be predicted by the standard degree-days method. The growth and development of insects are strongly temperature-dependent. Their temperature-dependent growth and development are often described as requiring a certain number of "heat units". Daily heat units are calculated as the difference between the average of the daily maximum and minimum temperatures and a certain critical basal or developmental "threshold" temperature. The threshold temperature varies between species. Because arthropods are cold-blooded, their development is influenced by ambient temperature. Each species requires a specific temperature range for development to occur. If the temperature is too low or too high, development stops.

Degree-days can be defined as the units combining between time and temperature, used to measure the development of an organism from one point to another in its life cycle (Wilson and Barnett 1983). The correlation between the environmental factors and the rate of development of pests form the basis of such a forecast. So, using degree-days allows for predicting pest occurrence, also can be an aid tool or scheduling sprays and beneficial insect releases at the optimum time to ensure the best results, and helpful in monitoring pest activity. Integrated pest management program involves a total system to suppression of pest population, which depends on predicting the seasonal population cycles of insects, which has led to the formulation of many mathematical methods (Allen, 1960), which described the developmental rates as a function of temperature. Degree-days represent the accumulation of heat units over a minimum temperature for a 24-hour period. Below this minimum temperature, no development took place, but above it, heat units are accumulated towards development (Pedigo, 1991).

The present work is pointed to predict *L. tapleyi* annual generation peaks in the field using the relationship between the accumulated thermal heat units expressed as degree-days (DD's) and the population fluctuation of *L. tapleyi* at Esna district, Luxor Governorate.

MATERIALS AND METHODS

Seasonal Abundance of *L. tapleyi*:

The seasonal abundance of this scale found infesting guava trees was carried out at half-monthly intervals at Esna district, Luxor Governorate during the period extending from March 2017 until mid-February, 2019. The selected orchard received normal agricultural practices without applying any chemical control measures before and during the period of study. Four guava trees of Balady variety similar in age and as uniform as possible in size, shape, height, vegetative growth were selected. Regular half-monthly samples were picked up to random from different directions and stratums of a tree with a rate of 40 leaves per tree. The samples were collected regularly and immediately transferred to the laboratory in polyethylene bags for inspection using a stereo-microscope. Numbers of alive insects on upper and lower surfaces of guava leaves were individually sorted into immature stages (nymphs) and mature stages (adult females) and then were counted and recorded together opposite to each inspected date. The half monthly means of the nymphs, adult females, and total population of pest (nymphs + adult females) per leaf were graphically illustrated.

Number of Annual Generations of *L. tapleyi* in the Field:

Annual total population data of pest per leaf were graphically plotted in figures. The number and duration of annual generations under field conditions were recorded on the basis (beginning of total population per leaf and its end) were determined by integration of the population curves in these figures.

Predicting of *L. tapleyi* Annual Generation Peaks Using Thermal Units' Accumulations:

Concerning, the prediction of *L. tapleyi* annual generations was carried out by determining the relationship between the thermal heat units expressed as degree-days (DD's) and the total population density of pest per leaf in the field during the two years of (2017/2018 and 2018/2019). Half-monthly mean counts of the total population density of pests as a whole were graphically illustrated to determine the population peaks (actually observed peaks). Then, observed peaks were compared with the expected ones as a tool to estimate heat requirements for predicting the *L. tapleyi* annual generations.

Generations of *L. tapleyi* were expressed as the real peaks (actually observed peaks) that occurred in the field were recorded on the basis (the total population density of pest per leaf) during the period of this investigation. The time at which the mean maximum total population density per leaf has been attained could be represented as a peak for a generation.

Heat units or degree days for *L. tapleyi* was calculated for each generation by using the sine-Wave Model (Allen, 1976) with horizontal cut off method at 30ºC and lower threshold of 8ºC with an average (1104 DD's) for generation development for according to Avidov and Harpaz (1969). This technique was applied using a Microsoft Excel spreadsheet application development at the Plant Protection Research Institute (Agricultural Research Center), Egypt. The application uses the maximum and minimum temperatures per day to calculate degree-days and its accumulation over a period of time by using the above-mentioned method. The daily maximum and minimum temperatures, for conditions of Luxor governorate were obtained from the Central Laboratory for Agricultural climate, Agriculture Research Center, Ministry of Agriculture in Giza. The degree days were calculated from 15th February, 2017 to 14th February, 2019.

Depending on the thermal units average which required for completion generation (1104 DD's), that estimated by Avidov and Harpaz (1969), and by comparison between observed peaks (that occurred in the field) and prospective peaks (which calculated by the model of Allen, 1976).

Relationship Between the Accumulated Heat Units and The Cumulative Total Population of *L. tapleyi* Per Leaf:

The present study aims to determine the relationship between the accumulated heat units (as an independent factor) and the cumulative total population of *L. tapleyi* per leaf (as a dependent factor) on guava trees during both the two years individually and on the two cumulative years.

The data obtained were statistically analyzed by using simple correlation and regression and the coefficient of determination (R^2) during two successive years was adopted according to Fisher (1950). This method was helpful in obtaining basic information about the amount of variability in the insect populations that could be attributed to the accumulated heat units, together, which was calculated as a percentage of explained variance (%E.V.).

The simple regression value indicates the average rate of change in insect activity due to a one-unit change in accumulated heat units during the whole year. The equation of linear regression was calculated according to the following formula of Fisher (1950) and Hosny *et al*. (1972):

$$Y = a \pm bx$$

Where:

Y = Prediction value (Dependent variable) **x =** Independent variable

a = Constant (y-intercept) **b** = Regression coefficient

Averages of population density of insect and accumulated heat units were calculated and shown graphically by Excel sheets. Statistical analysis in the present work was carried out with Computer using (MSTATC Program software, 1980**).**

RESULTS AND DISCUSSION

Seasonal Abundance of *L. tapleyi*:

The half-monthly counts of *L. tapleyi* different stages infested guava trees at Esna district, Luxor Governorate were recorded through the two successive years (2017/2018 and 2018/2019) are represented in Tables (1 and 2). Also, means of the half-monthly records of temperature, relative humidity, and dew point throughout the two years of investigations. The obtained results showed that total population of this insect has four to five peaks of seasonal activity per year, which was recorded at the beginning of April, mid-May, mid-July, beginning of October and mid-November during the first year (2017/2018) and during the mid-April, mid-July, mid-September, and beginning of November during the second year (2018/2019). Also, the total population of insects through the second year was higher in comparison to the first year of study, which may be due to the influence of favourable factors (such as environmental conditions, etc.). It seems that the climatic conditions of autumn and summer months during the two years were the most favourable period for *L. tapleyi* activity under the climatic conditions. Metcalf and Luckmann (1975) reported that certain environmental conditions may alter the physiology of the plant to the extent that it becomes suitable or unsuitable as a host for a certain pest. 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 at that location.

Table 1: Half monthly mean numbers of different stages of *L. tapleyi* at Esna district, Luxor Governorate from March, 2017 to February, 2018.

Date of inspection		Mean number of individuals per leaf ± S.E.			Climatic factors						Heat units calculation	
		Nymphs	Adult females	Total	Max. temp.°C	Min. temp.°C	Range temp.°C	Mean temp.°C	% R.H.	Dew point° C	Degree days (DD's)	Accumulated heat unit (AcHu)
Mar., 2017	1	5.95 ± 0.28	2.39 ± 0.13	8.34 ± 0.40	25.86	12.07	13.79	18.96	41.36	4.64	10.95	153.31
	15	8.25 ± 0.38	2.24 ± 0.12	10.49 ± 0.50	27.21	11.43	15.79	19.32	30.07	4.36	11.24	310.67
Apr.	1	11.76 ± 0.55	3.76 ± 0.20	15.52 ± 0.75	28.82	15.29	13.53	22.06	32.41	5.24	13.79	545.11
	15	8.24 ± 0.38	2.35 ± 0.13	10.59 ± 0.51	30.29	16.43	13.86	23.36	25.14	6.64	15.08	756.26
May	1	8.78 ± 0.41	2.76 ± 0.15	11.54 ± 0.55	34.06	18.13	15.94	26.09	19.19	6.38	16.94	1027.24
	15	16.39 ± 0.76	8.54 ± 0.47	24.93 ± 1.22	35.86	20.50	15.36	28.18	18.07	7.43	18.34	1284.05
Jun.	1	11.30 ± 0.52	5.51 ± 0.30	16.81 ± 0.82	38.41	22.12	16.29	30.26	18.29	9.35	19.31	1612.25
	15	8.98 ± 0.42	4.76 ± 0.26	13.75 ± 0.67	41.07	25.57	15.50	33.32	17.21	10.86	20.71	1902.24
July	1	16.35 ± 0.76	5.48 ± 0.30	21.83 ± 1.05	39.25	24.50	14.75	31.88	19.56	11.63	20.44	2229.22
	15	18.47 ± 0.86	10.22 ± 0.56	28.69 ± 1.40	41.70	25.30	16.40	33.50	19.79	12.79	20.85	2521.11
Aug.	1	11.15 ± 0.52	9.09 ± 0.50	20.24 ± 1.01	41.82	28.18	13.65	35.00	20.06	13.65	21.39	2884.70
	15	17.70 ± 0.82	8.14 ± 0.44	25.84 ± 1.26	40.90	27.70	13.20	34.30	20.86	14.07	21.41	3184.41
Sept.	1	17.85 ± 0.83	14.55 ± 0.79	32.40 ± 1.61	42.06	27.47	14.59	34.76	21.71	14.88	21.50	3549.90
	15	20.43 ± 0.95	13.76 ± 0.75	34.19 ± 1.69	40.29	24.43	15.86	32.36	23.64	14.07	20.52	3837.21
Oct.	1	29.89 ± 1.39	18.08 ± 0.99	47.98 ± 2.36	39.69	23.81	15.88	31.75	25.50	14.31	20.21	4160.51
	15	19.12 ± 0.89	12.82 ± 0.70	31.94 ± 1.57	38.57	22.64	15.93	30.61	25.64	13.00	19.65	4435.66
Nov.	1	21.45 ± 1.00	11.03 ± 0.60	32.47 ± 1.59	37.59	21.12	16.47	29.35	26.94	12.41	18.89	4756.73
	15	32.19 ± 1.49	20.14 ± 1.10	52.33 ± 2.57	33.00	17.00	16.00	25.00	33.64	11.71	16.32	4985.24
Dec.	1	20.25 ± 0.94	17.85 ± 0.97	38.10 ± 1.90	31.69	16.13	15.56	23.91	35.88	10.69	15.63	5235.31
	15	9.29 ± 0.43	9.54 ± 0.52	18.83 ± 0.94	25.64	10.57	15.07	18.11	38.50	6.79	10.15	5377.42
Jan., 2018	1	7.56 ± 0.35	7.03 ± 0.38	14.59 ± 0.73	25.24	8.94	16.29	17.09	39.82	5.06	9.25	5534.65
	15	6.77 ± 0.31	6.45 ± 0.35	13.22 ± 0.66	22.07	7.36	14.71	14.71	48.29	6.21	6.82	5630.20
Feb.	1	4.66 ± 0.22	3.79 ± 0.21	8.45 ± 0.42	23.29	8.24	15.06	15.76	45.88	5.82	7.88	5764.18
	15	4.11 ± 0.19	3.61 ± 0.20	7.72 ± 0.38	26.57	12.57	14.00	19.57	44.36	7.36	11.54	5925.78

Table 2: Half monthly mean numbers of different stages of *L. tapleyi* at Esna district, Luxor Governorate from March, 2018 to February, 2019.

Date of inspection		Mean number of individuals per leaf ± S.E.			Climatic factors						Heat units calculation	
		Nymphs	Adult females	Total	Max. temp.°C	Min. temp.°C	Range temp.°C	Mean temp.°C	% R.H.	Dew point° C	Degree days (DD's)	Accumulated heat unit (AcHu)
Mar., 2018	1	4.99 ± 0.23	2.78 ± 0.15	7.77 ± 0.39	27.79	11.00	16.79	19.39	28.86	4.86	11.26	6083.47
	15	7.96 ± 0.37	3.29 ± 0.18	11.25 ± 0.55	31.00	13.57	17.43	22.29	24.93	6.14	13.77	6276.26
Apr.	1	11.34 ± 0.53	5.29 ± 0.29	16.63 ± 0.81	31.94	15.12	16.82	23.53	24.71	7.00	14.87	6529.11
	15	18.46 ± 0.86	7.90 ± 0.43	26.36 ± 1.28	32.93	16.00	16.93	24.46	21.93	6.71	15.84	6750.84
May	1	16.05 ± 0.74	7.39 ± 0.40	23.45 ± 1.14	33.38	17.31	16.06	25.34	19.94	6.94	16.37	7012.77
	15	11.95 ± 0.55	5.12 ± 0.28	17.06 ± 0.83	38.50	21.79	16.71	30.14	16.57	9.14	19.40	7284.30
Jun.	1	9.10 ± 0.42	5.94 ± 0.32	15.04 ± 0.74	40.82	23.65	17.18	32.24	16.35	9.94	20.15	7626.89
	15	7.58 ± 0.35	5.31 ± 0.29	12.89 ± 0.64	43.00	25.64	17.36	34.32	15.64	11.21	20.97	7920.42
July	1	13.59 ± 0.63	6.57 ± 0.36	20.16 ± 0.98	40.06	25.00	15.06	32.53	21.88	13.31	20.66	8250.96
	15	28.06 ± 1.30	10.05 ± 0.55	38.11 ± 1.84	39.50	25.79	13.71	32.64	26.21	15.57	20.94	8544.17
Aug.	1	16.08 ± 0.75	10.20 ± 0.56	26.28 ± 1.29	39.41	25.12	14.29	32.26	23.41	14.06	20.72	8896.45
	15	18.60 ± 0.86	8.03 ± 0.44	26.62 ± 1.29	40.71	23.50	17.21	32.11	22.36	14.00	20.14	9178.36
Sept.	1	19.75 ± 0.92	12.52 ± 0.68	32.28 ± 1.59	39.71	25.59	14.12	32.65	25.35	15.41	20.85	9532.86
	15	33.94 ± 1.57	17.17 ± 0.94	51.11 ± 2.49	38.64	25.64	13.00	32.14	27.36	15.57	20.593	9821.16
Oct.	1	22.18 ± 1.03	9.86 ± 0.54	32.04 ± 1.56	38.75	23.88	14.88	31.31	28.25	14.88	20.06	10142.17
	15	25.12 ± 1.17	12.64 ± 0.69	37.77 ± 1.84	34.36	18.86	15.50	26.61	30.43	11.93	17.48	10386.96
Nov.	1	37.92 ± 1.76	16.94 ± 0.92	54.86 ± 2.67	31.81	17.69	14.13	24.75	35.56	11.94	15.97	10658.39
	15	30.93 ± 1.43	17.91 ± 0.98	48.84 ± 2.40	30.43	15.43	15.00	22.93	39.36	11.57	14.80	10865.66
Dec.	1	13.90 ± 0.65	9.48 ± 0.52	23.39 ± 1.15	28.75	13.69	15.06	21.22	45.06	11.69	13.09	11075.04
	15	9.35 ± 0.43	7.71 ± 0.42	17.06 ± 0.85	24.93	11.64	13.29	18.29	45.79	9.29	11.12	11230.76
Jan., 2019	1	8.06 ± 0.37	9.21 ± 0.50	17.27 ± 0.87	22.35	7.53	14.82	14.94	46.18	5.88	7.04	11350.45
	15	7.67 ± 0.36	8.97 ± 0.49	16.64 ± 0.84	23.43	8.93	14.50	16.18	49.07	7.36	8.14	11464.34
Feb.	1	7.68 ± 0.36	7.80 ± 0.42	15.48 ± 0.78	25.82	8.41	17.41	17.12	32.35	4.41	9.13	11619.62
	15	3.67 ± 0.17	3.98 ± 0.22	7.65 ± 0.38	25.36	8.79	16.57	17.07	35.36	5.29	9.08	11746.74

Number of Annual Generations Determination of *L. tapleyi*:

The obtained trend over both years indicated the occurrence of four to five overlapping generations per year for *L. tapleyi* on guava trees at Esna district, Luxor Governorate was recorded through the two successive years (2017/2018 and 2018/2019), Table (3) and illustrated in Figure (1).

First Generation:

The first generation started in early March and extended until mid-May in the first year (2017/2018) with a duration of 10 weeks under field conditions at 23.00°C, 27.71%, and 5.78°C for mean daily of temp., relative humidity, and dew point, respectively. The generation peaked in early April (15.52 individuals per leaf). The generation density was 59.37, 22.04 and 81.42 individuals per leaf were recorded on nymphs, adult females, and total population, respectively.

In the second year of (2018/2019), this generation appeared in early March and continued until mid-July with a duration of 18 weeks under field conditions at 27.69°C, 21.70% and 9.08°C for mean daily of temp., relative humidity and dew point, respectively. The generation peaked in mid-April (26.36 individuals per leaf). The generation density was 129.08, 59.64, and 188.73 individuals per leaf were recorded on nymphs, adult females, and total population, respectively, Table (3) and Figure (1).

Second Generation:

The second generation occurred between mid-April to early July in the first year (2017/2018) and covered a period of 11 weeks under field conditions at 28.85°C, 19.58% and 8.71°C for mean daily of temp., relative humidity, and dew point, respectively. The generation peaked in mid-May (24.93 individuals per leaf). The generation density was 70.04, 29.40, and 99.44 individuals per leaf were recorded on nymphs, adult females, and total population, respectively, Table (3) and Figure (1).

In the second year of (2018/2019), this generation was found during a period extended from the early June to continued until mid-September with a duration of 14 weeks under field conditions at 32.61°C, 22.32% and 13.64°C for mean daily of temp., relative humidity, and dew point, respectively. The generation peaked in mid-July (38.11 individuals per leaf). The generation density was 146.71, 75.79 and 222.50 individuals per leaf were recorded on nymphs, adult females, and total population, respectively.

Third Generation:

The third generation lasted 12 weeks during the first year (2017/2018) extended from the beginning of June to early September, under field conditions at 33.29°C, 19.64% and 12.46°C for mean daily of temp., relative humidity, and dew point, respectively, with a total size of 101.80, 57.75 and 159.54 individuals per leaf were recorded on nymphs, adult females and total population, respectively. The generation peaked in mid-July (28.69 individuals per leaf).

While, this generation through the second year (2018/2019) was occurred between mid of July and continued until to mid-November (16 weeks) under field conditions at 29.71°C, 28.70% and 13.88°C for mean daily of temp., relative humidity, and dew point, respectively, with a total size of 232.60, 115.32 and 347.92 individuals per leaf were recorded on nymphs, adult females and total population, respectively. The generation peaked in mid-September (51.11 individuals per leaf), Table (3), and Figure (1).

Fourth Generation:

The fourth-generation elapsed about 16 weeks in the first year and was observed between mid-July and continued until mid of November under field conditions at 31.85°C, 24.20% and 13.43°C for mean daily of temp., relative humidity, and dew point, respectively, with total size 188.25, 117.82 and 306.07 individuals per leaf were recorded on nymphs, adult females and total population, respectively. The generation peaked in early October (47.98 individuals per leaf).

While, this generation through the second year (2018/2019) extending between mid of September and continued until to early January and elapsed about (14 weeks) under field conditions at 24.02°C, 37.25% and 11.59°C for mean daily of temp., relative humidity, and dew point, respectively, with a total size of 181.41, 100.93 and 282.34 individuals per leaf were recorded on nymphs, adult females and total population, respectively. The generation peaked in early November (54.86 individuals per leaf) in Table (3) and Figure (1).

Fifth Generation:

This generation was occurred only in the first year (2017/2018) between early October to early January and covered a period of 13 weeks under field conditions at 25.12°C, 32.28% and 10.57°C for mean daily of temp., relative humidity, and dew point, respectively. The generation peaked in mid-November (52.33 individuals per leaf). The generation density was 139.75, 96.49, and 236.24 individuals per leaf were recorded on nymphs, adult females, and total population, respectively, Table (3) and Figure (1).

Table 3: Approximated number, duration and size of *L. tapleyi* generations recorded on guava trees under field conditions at Esna district, Luxor Governorate during the two years of (2017/2018 and 2018/2019).

Year	Generation	Date	Peak of generation	Duration in weeks	Generation size per leaf			Means climatic factors			Mean daily degree days (DD's) per generation
					Nymphs	Adult females	Total	Mean temp. °C	R.H.%	Dew point °C	
2017/2018	1st	Early March to Mid-May	Early of April	10	59.37	22.04	81.42	23.00	27.71	5.78	15.08
	2nd	Mid-April to Early July	Mid-May	11	70.04	29.40	99.44	28.85	19.58	8.71	19.13
	3rd	Early June to Early September	Mid-July	12	101.80	57.75	159.54	33.29	19.64	12.46	21.06
	4th	Mid-July to Mid November	Early October	16	188.25	117.82	306.07	31.85	24.20	13.43	20.03
	5th	Early October to Early January	Mid of November	13	139.75	96.49	236.24	25.12	32.28	10.57	14.94
20118/2019	1st	Early March to Mid-July	Mid of April	18	129.08	59.64	188.73	27.69	21.70	9.08	18.09
	2nd	Early June to Mid-September	Mid-July	14	146.71	75.79	222.50	32.61	22.32	13.64	20.70
	3rd	Mid-July to Mid November	Mid-September	16	232.60	115.32	347.92	29.71	28.70	13.88	18.87
	4th	Mid-September to Early January	Early November	14	181.41	100.93	282.34	24.02	37.25	11.59	14.16

Mean ± STD of daily heat units was 18.01 ± 2.63 DD's.

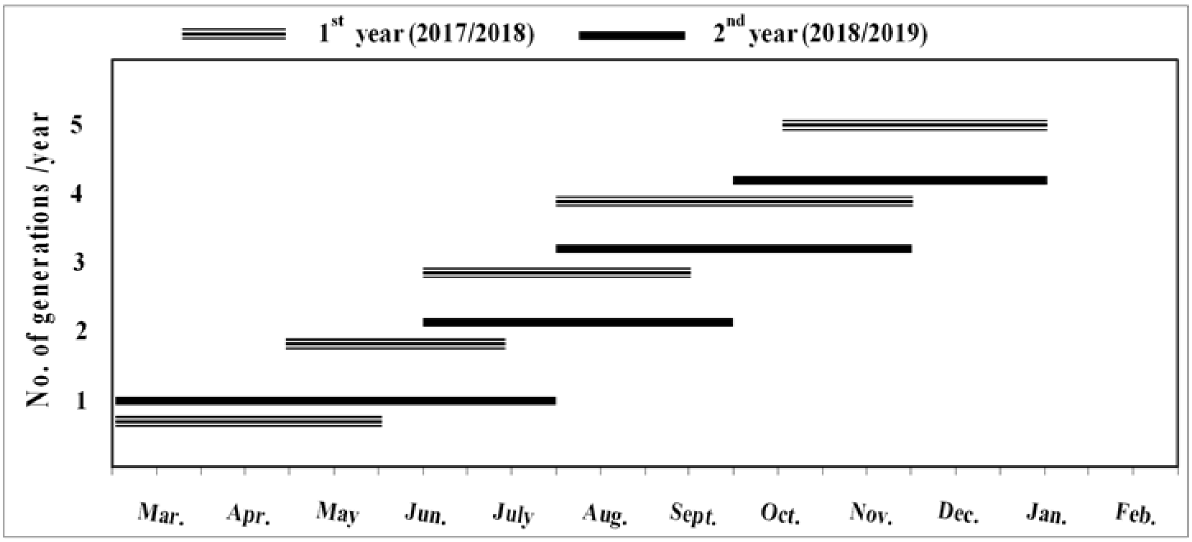


Fig. 1: Estimated number and duration of generations of *L. tapleyi* recorded on guava trees at Esna district, Luxor Governorate during two years of (2017/2018 and 2018/2019).

From the previously mentioned results, it could be concluded that the population density was varied from generation to another, which may be due to the influence of favourable factors (such as environmental conditions, etc.). In general, the fourth generation in the first year and the third generation in the second year, which started in both of them from mid-July and continued until mid of November was the longest one and biggest in size than the other generations during the two years. This evidence may be due to the different fluctuations of climatic factors.

In both seasons, the generations could be arranged according to their size as follows:

First < second < third < fourth > fifth generation for the first year.

First < second < third > fourth-generation during the second year.

The above-mentioned results are in agreement with those obtained by Swailem (1973 and 1974) in Egypt, reported that the guava long scale insect, *L. tapleyi* had five generations per year, were recorded in May, June, July, September, and November. However, with different insect species and host plant, Elwan (1990) in Egypt, recorded that mango trees were heavily infested by *Lepidosaphes pallidula*. He recorded 4-5 overlapping generations for this insect per year. In Egypt, Selim (2002), Elwan (2005), and Moussa *et al.* (2006) reported that *Insulaspis pallidula* had four generations per year on mango trees.

Heat Units of Each Generation:

The daily heat unit values can be summed for the season to derive cumulative seasonal heat units. This is more predictive of insect growth and development than time alone. Degree days also are known as (heat units or thermal units) are a way of incorporating both temperature and time into one measurement to quantify the rate of insect development. The insect develops in response to temperature. The half-monthly counts of *L. tapleyi* total population of pest and mean daily heat units which required for the development of this insect at Esna district, Luxor Governorate were recorded through the two successive years (2017/2018 and 2018/2019) are represented in Tables (1 and 2) and graphically illustrated in Figure (2).

The obtained results are represented in Tables (1 and 2) and graphically illustrated in Figure (2), it was observed that the mean daily degree days required for the development of *L. tapleyi* was started to increase gradually and continued until early September and it decreased in mid-September. Then, it decreased gradually till January during the two years. Also, the highest mean daily degree days required for the development of *L. tapleyi* were recorded in the period from June till September month during the two years. While, the least mean daily degree days was appeared in mid-January during the first year and in early January through the second year, which may be attributed to the low temperature in months of winter, Figure (2).

The summary of applying heat units to determine *L. tapleyi* generations are presented in Table (3). For the summer generation of *L. tapleyi*, the third generation for the first year and the second generation during the second year was higher the mean daily heat units per generation = degree-days (DD's) was estimated to be 21.06 and 20.70 (DD's) during the first and second years of study, respectively as compared with the other generations, because of the highest increase in the temperature during these generations through the summer months, Tables (3).

On the contrary, the winter generation of this pest, the fifth generation for the first year and the fourth generation during the second year was lower in the mean daily heat units was estimated (14.94 and 14.16 DD's) as compared the other generations during the first and second years of study, respectively, Table (3). These generations were occurred in November (peaks of generation) with the gradual decrease in temperature during the fall season and dormancy of the trees during winter time which is expected to affect dramatically the insect behavior and on the rate of growth, Tables (3). Using available meteorological data provided for Luxor area, the mean ± STD daily heat units per generation for *L. tapleyi* over the two years were estimated to be 18.01 ± 2.63 DD's, Table (3).

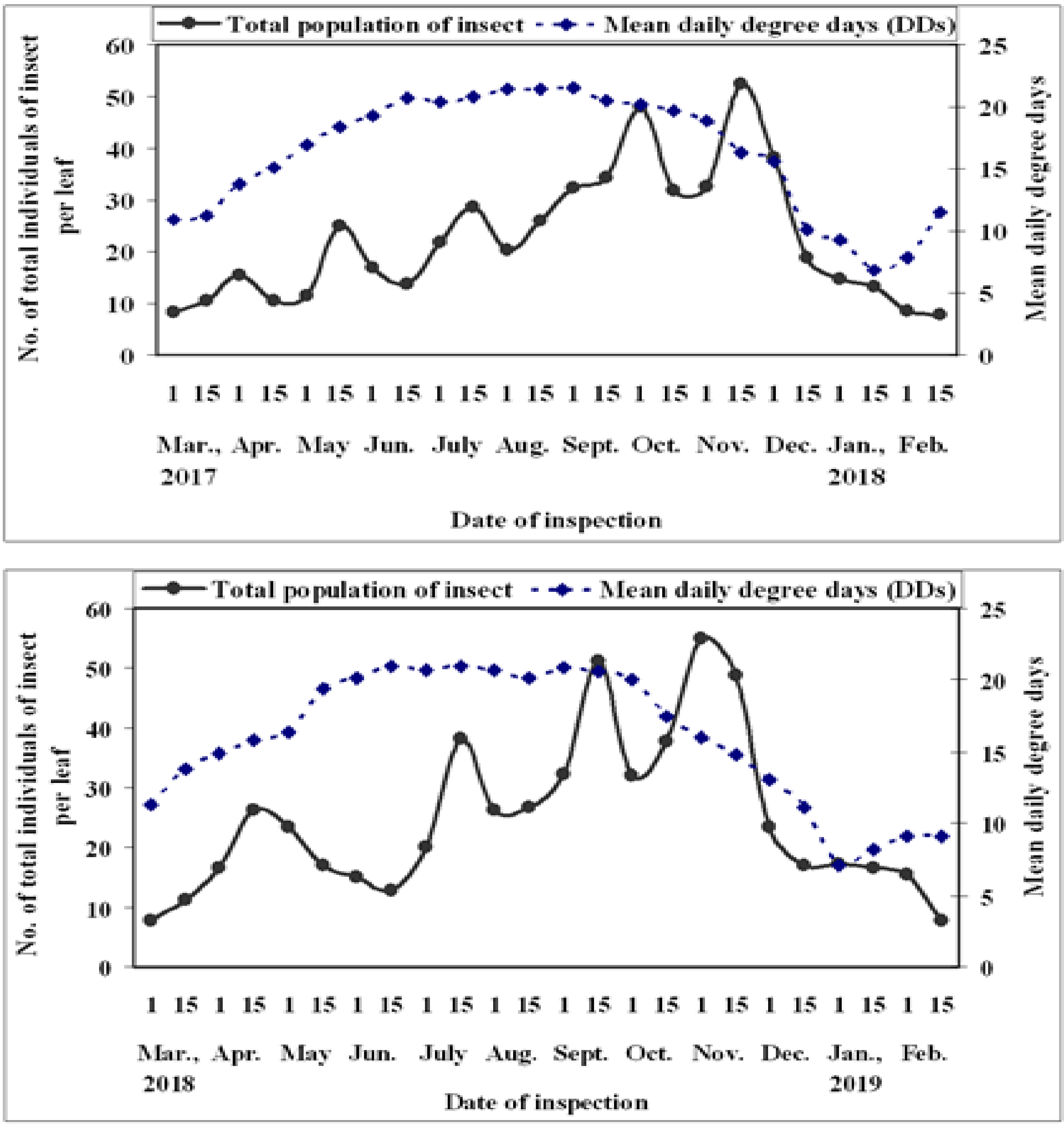


Fig. 2: Means of half monthly counts of mean daily degree days, and the total population density of *L. tapleyi* per leaf on guava trees at Esna district, Luxor Governorate during the two years from Mar., 2017 to Feb., 2019.

As a general trend applying the accumulated heat units was rather successful in explaining these insect generations than using changes of ambient temperatures. Results obtained from these may provide important information for predicting the field population of *L. tapleyi* or predicting the timing of a barrier chemical treatment against this insect in the field. This method was used to determine the accumulated heat units in the field by many investigators by El-Amir (2002), Zadan *et al.* (2002), and Bakry (2014) using the same technique for Coccoidea- Diaspididae pests.

Heat units calculation for *L. tapleyi* (field studies) has not been reported before in the literature except the studied Avidov and Harpaz (1969) reported that summer development of purple scale insect, *Lepidosaphes beckii* required at least 50 days (44 days for males) while in winter about 110 days were needed. They concluded that the temperature threshold of development is 8 C, and 1104 day-degrees are required for the production of one generation. This study could be a starting point in this direction and hopefully would serve in future studies concerning the prediction of seasonal fluctuations of *L. tapleyi* on guava trees in relation to temperature change.

Heat Units and Total Population Density of *L. tapleyi* Related:

The obtained results in Figure (3), clear that half-monthly counts of the numbers of the cumulative individuals of *L. tapleyi* per leaf and the accumulated heat units during the first, second years, and on two cumulative years. It was observed that both of them started to increased continuously until the end of each year from years of study and during on two cumulative years, (Fig. 3).

By plotting numbers of the accumulated heat units (AcHu) (as an independent factor) against the cumulative individuals of *L. tapelyi* per leaf (as a dependent factor), the regression analysis indicated that the numbers of cumulative individuals of *L. tapleyi* per leaf were relatively more correlated with the accumulated heat units during the first, second years and on cumulative years, Table (4) and illustrated in Figure (4).

Statistical analysis revealed that strongly highly significant positive correlations between the accumulated heat units and the cumulative individuals of *L. tapleyi* were (r values were 0.986, 0.985, and 0.990) during both the study years separately and on two cumulative years, respectively, Table (4).

The slopes of the regression lines revealed that a significant increase in the numbers of cumulative individuals of *L. tapleyi* per leaf was shown with increasing the accumulated heat units by 0.096, 0.11 and 0.098 individuals per leaf and the relationship gave a good fit to the data and the coefficient of determination (R^2) were 0.972, 0.972 and 0.989 for the first, second years and on the two cumulative years in Fig. (4).

R^2 showed that the increase in numbers of cumulative *L. tapleyi* per leaf occurred due to the increase in the accumulated heat units. The relationships between them could be represented by the following equations was obtained in Table (4) and Figure (4):

$Y = 0.0958x - 49.508$ $R^2 = 0.9728$ for the first year

$Y = 0.1069x - 688.55$ $R^2 = 0.9716$ for the second year

$Y = 0.0978x - 60.047$ $R^2 = 0.9899$ for the two cumulative years

Table 4: Simple correlation, regression values and the coefficient of determination when the counts of the accumulated degree days (AcHu) were plotted versus the cumulative individuals of *L. tapleyi* per leaf during the two years of (2017/2018 and 2018/2019).

Statistical analysis	First (2017/2018)	Second (2018/2019)	Two cumulative years (2017 to 2019)
a	-49.51	-688.5	-60.05
r	0.986	0.985	0.99
b	0.096	0.107	0.098
S.E	0.003	0.004	0.0015
t-test	28.05 **	27.42 **	67.04 **
C.V.	0.12	0.12	0.06
R^2	0.97	0.97	0.99
E.V.%	97.28	97.16	98.99

a = Constant r = Simple correlation b = Simple regression S.E = Standard error C.V.= Coefficient of Variation

R^2.= coefficient of determination * Significant at $P \le 0.05$ ** Highly significant at $P \le 0.01$

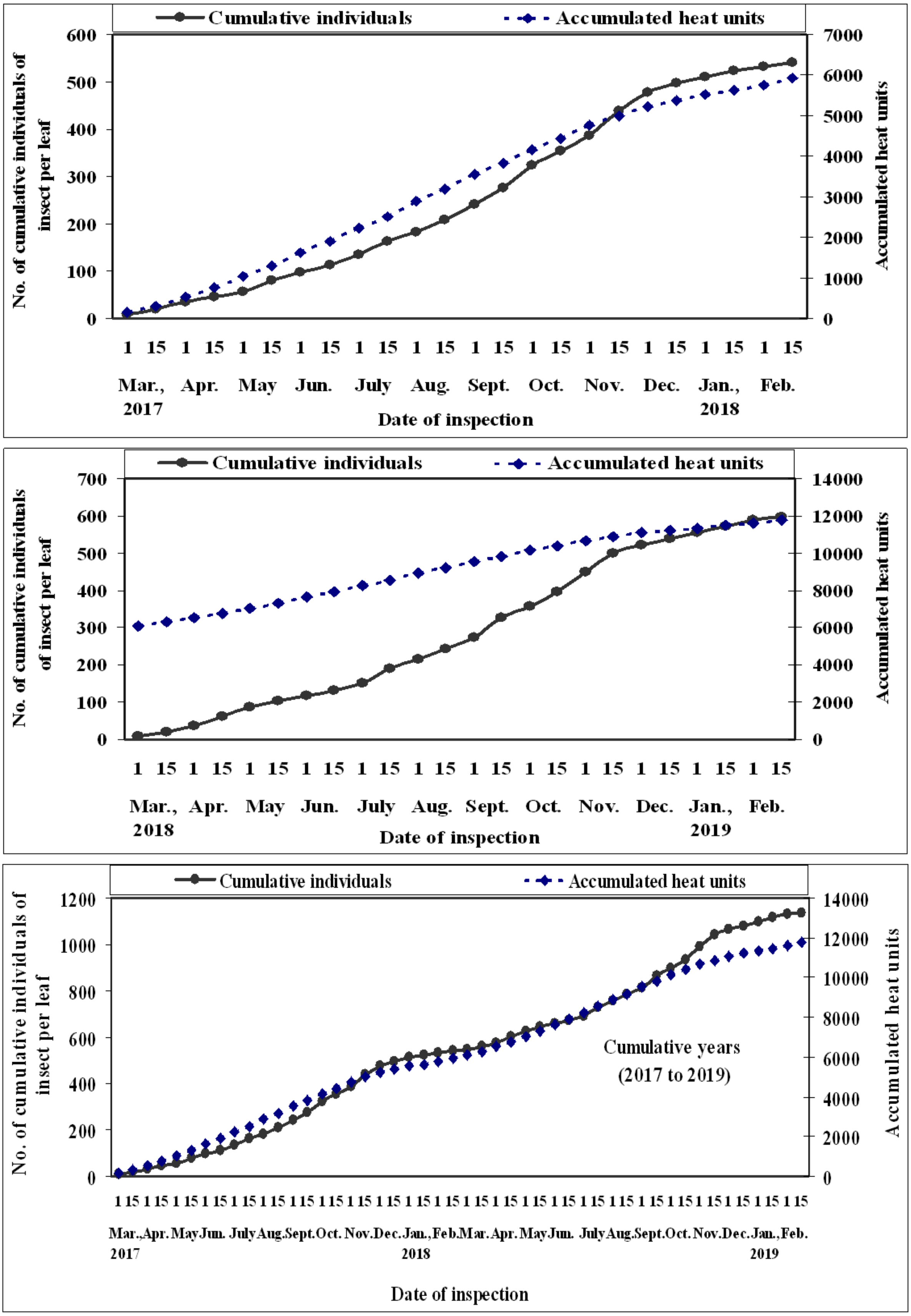


Fig. 3: Means of half monthly counts of accumulated heat units and the cumulative total population density of *L. tapleyi* per leaf on guava trees at Esna district, Luxor Governorate during the two years from 2017 to 2019.

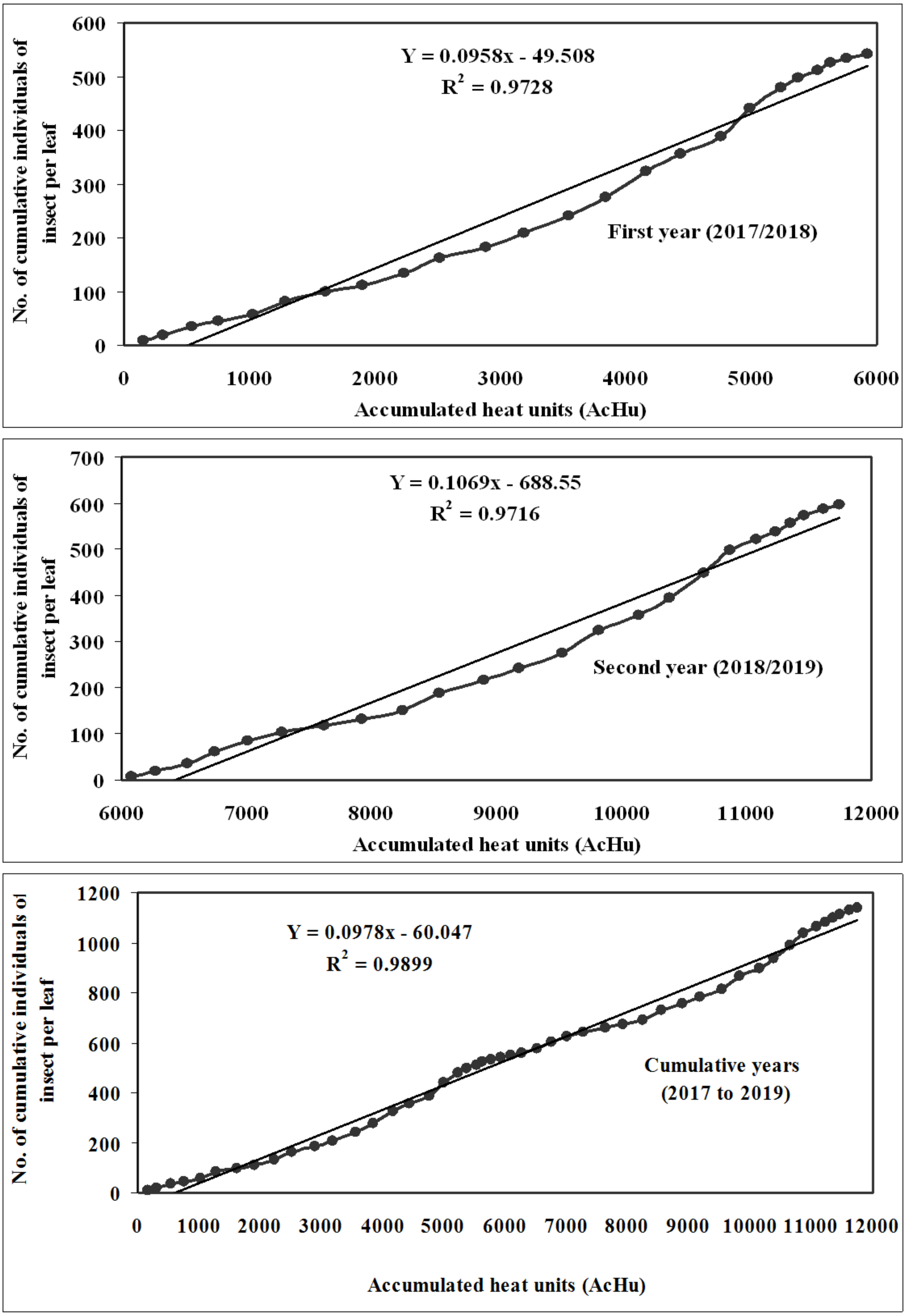


Fig. 4: Simple linear regression between the accumulated heat units (AcHu) and the cumulative total population density of *L. tapleyi* per leaf on guava trees, during the two years of (2017/2018 and 2018/2019).

Predicting of *L. tapleyi* Annual Generation Peaks Using Accumulated Heat Units:

Depending on the thermal units average which required for completion generation (1104 DD's), that estimated by Avidov and Harpaz (1969), and by comparison between observed peaks (that occurred in the field) and respective peaks (which calculated by using the Sine-Wave Model of (Allen, 1976) with horizontal cut off method at 30ºC and lower threshold of 8ºC during the two years of (2017/2018 and 2018/2019) are represented in Table (5) and illustrated in Figure (5), the following results could be revealed; The first generation was occurred from early March to mid- May during the first year (2017/2018), the prospective peak was detected later in May, 05th with 1119 DD's, while the actual observed one in early of April. On the other hand, this generation appeared in early March and continued until mid-July during the second year of (2018/2019), the possible peak achieved on April, 9th with 1109 DD's were detected earlier than the field peak was observed in mid of April in Table (5) and in Figure (5).

Table 5: Comparison between actual observed and expected peaks of *L. tapleyi* annual generations on guava trees and accumulated thermal units under field conditions at Esna district, Luxor Governorate during the two years of (2017/2018 and 2018/2019).

Year	Generation	Generation period		Peak		Accumulated heat units per generation
		From	To	Observed	Expected	
2017/2018	1st	Early March	Mid-May	April, 1st	May, 5th	1119
	2nd	Mid-April	early July	May, 15th	Jun., 30th	1110
	3rd	Early of June	Early September	July, 15th	Aug., 21st	1107
	4th	Mid-July	Mid November	October, 1st	Oct., 15th	1119
	5th	Early of October	Early of January	November, 15th	Jan., 4th	1108
2018/2019	1st	Early March	Mid-July	April, 15th	Apr., 9th	1109
	2nd	Early of June	Mid - September	July, 15th	Jun., 07th	1103
	3rd	Mid-July	Mid November	September, 15th	Jul., 31st	1121
	4th	Mid- September	Early of January	November, 1st	Sept., 23rd	1112
	5th	-		-	Dec., 3rd	1116

The second generation occurred between mid of April to early July in the first year (2017/2018), the observed peak for this generation was attained earlier than the expected one. In this respect, the exact peak was attained in mid- May and the probable peak achieved in June, 30th has coincided with 1110 DD's. During, the second year of (2018/2019), this generation was found during a period extended from the early June to continued until mid-September, the possible peak achieved in June, 7th with 1103 DD's were detected earlier than the field observed peak that recorded in mid of July, Table (5) and Figure (5).

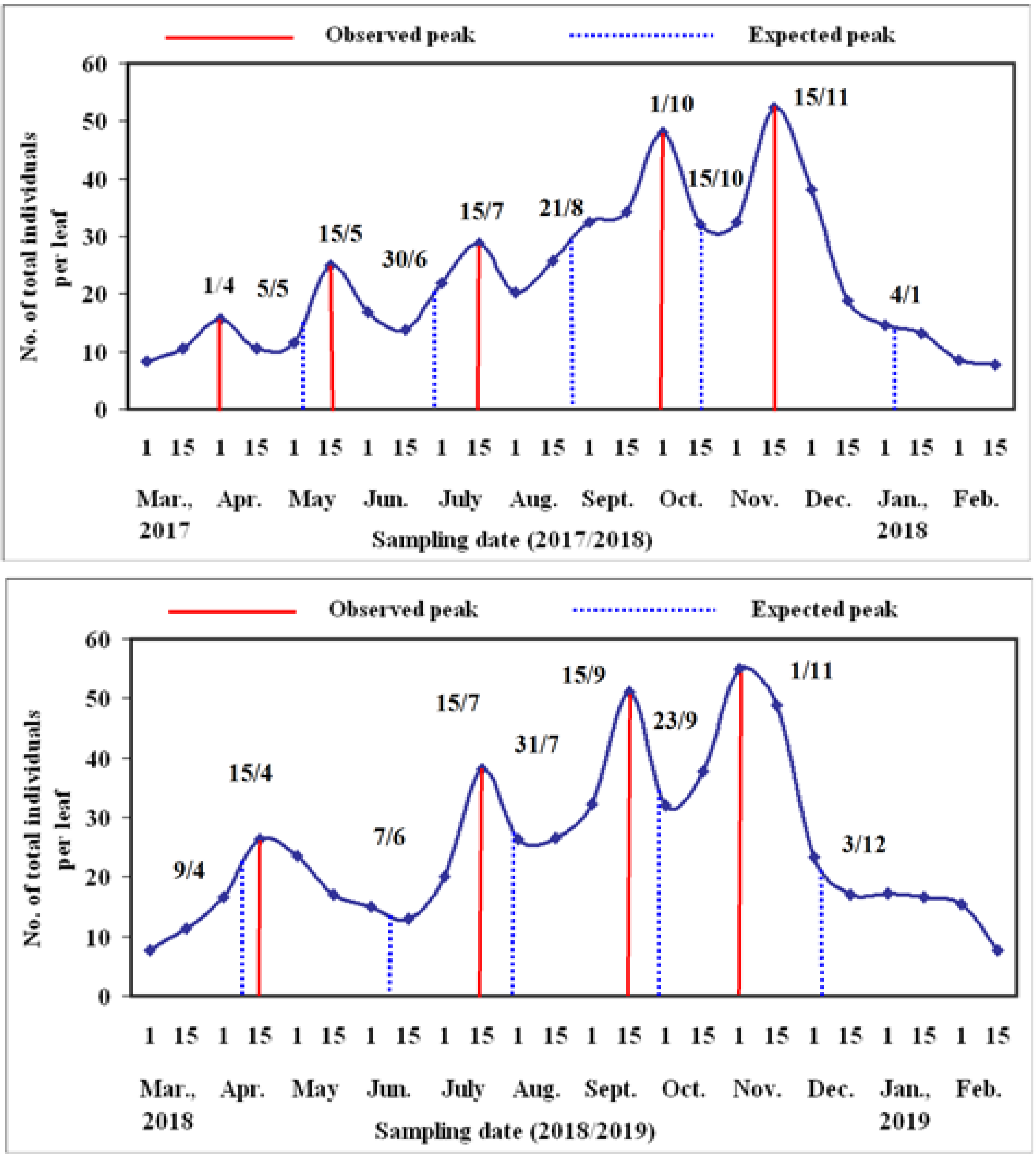


Fig. 5: Observed and expected peaks of annual generations of *L. tapleyi* at Esna district, Luxor Governorate during the two years of (2017/2018 and 2018/2019).

The third generation extended from the beginning of June to early September during the first year (2017/2018), the expected peak took place in August, 21st with 1107-degree days were detected delayed than the actual field peak that occurred in Mid-July. While, this generation through the second year (2018/2019) was occurred between mid of July and continued until mid-November, the probable peak that occurred in July, 31st with 1121 DD's were detected earlier than the field observed peak that recorded in mid of September.

The fourth generation in the first year was observed between mid-July and continued until mid of November, the field peak that occurred during early October before the occurrence of the probable peak that occurred in October, 15th when completion 1119-degree days. While, this generation through the second year (2018/2019) extending between mid of September and continued until early January, the field peak for this generation was dotted later than the expected one. In this respect, the observed peak was attained in early November, and the probable peak achieved in September, 23rd has coincided with 1112 DD's.

The fifth-generation was occurred in the first year (2017/2018) between early October to early January, the observed peak (actual) for this generation was attained earlier than the expected one. In this respect, the field peak was attained in mid of November and the probable peak achieved in January, 4th when the accumulated heat units required 1108 DD's. However, no field peak during the second year (2018/2019), but the prospective peak was recorded in December, 3rd when the accumulated heat units completed 1116 DD's, Table (5), and in Figure (5).

Results in Table (5) revealed that the predicted peaks of generations could be detected when the accumulated thermal units reached 1104-degree days according **(Avidov and Harpaz, 1969).** Using available meteorological data provided for Luxor area, the mean ± STD accumulated heat units per generation for *L. tapleyi* over the two years were estimated to be 1112.35 ± 6.00 DD's.

The accuracy of the prediction depends on DD's and population of *L. tapleyi* - enabling the growers and pest control advisors to reduce the monitoring period to make a true decision for pest control in the proper time, which minimizes costs and the hazard of chemical control. This technique could be considered one of the most important factors of pest management programs. Finally, it could be concluded that the prediction of *L. tapleyi* field activities is based on the lower threshold of development, degree days for a complete generation, Tmax, Tmin. and the population density of pests. Also, the accumulated heat units required under the climatic conditions in Luxor Governorate are necessary for prediction occurrence of the pest and can help decision marks to decide the appropriate procedures to control *L. tapleyi* in the IPM program.

REFERENCES

Allen, J.C. (1976): A modified sine wave method for calculating degree-days. *Environmental Entomology*, 5 (3): 388-396.

Avidov Z. and I. Harpaz (1969): Plant Pests of Israel. Israel Univ. Press, Jerusalem. 549 pp.

Bakry, M.M.S. (2014): Studies on the white date palm scale insect, *Parlatoria blanchardii* (Targ.) infesting date palm trees in Luxor Governorate. Ph.D. Thesis, Fac. Agric. Sohag, Univ., 288 pp.

Dent, D. (1991): Insect Pest Management. C.A.B. International, 604 pp.

El-Amir, S.M. (2002): Environmentally safe approaches for controlling some scale insects infesting olive trees in new reclaimed areas. M.Sc. Thesis Fac. Agric., Al-Azhar Univ., Egypt 92 pp.

El-Nahal, A.K.M.; K.T. Awadallah and A.A. Shaheen (1980): Abundance and natural enemies of *Lepidosaphes tapleyi* Williams on certain ornamental plants in Giza and Zagazig regions (Hemiptera: Homoptera: Diaspididae). *Bulletin of the Entomological Society of Egypt*, 60: 311-317.

Elwan, E.A. (1990): Ecological and biological studies on certain insects' pests of Coccoidea (Homoptera) infesting mango trees. Ph.D. Thesis, Fac. of Agric., Al-Azhar Univ., Egypt, 175 pp.

Elwan, E.A. (2005): Population dynamics of Maskell scale, *Insulaspis pallidula* (Green) (Homoptera: Diaspididae) on mango trees in Egypt. *Egyptian Journal of Agriculture Research*, 83(3): 1199-1212.

Fisher, R. A. (1950): Statistical methods for research workers. Oliver and Boyd Ltd., Edinburgh, London. 12th ed., 518 pp.

Hosny, M.M.; A.H. Amin and G.B. El-Saadany (1972): The damage threshold of the red scale, *Aonidiella aurantii* (Maskell) infesting mandarin trees in Egypt. *Zeitschrift für Angewandte Entomologie*, 72: 286-296.

Metcalf, R.L. and W.H. Luckmann (1975): Introduction to insect pest management. John Wiley& Sons, Inc. New York. 587 pp.

Moussa, S.F.M.; A.S. El-Koully.; A.l. Shaheen and A.A.M. Selim (2006): Ecological studies on the Maskell scale insect, *Insulaspis pallidula* (Green) on mango trees in two Governorates in Egypt. The 3rd Int. Conf. for Develop. and the Env., in the Arab world, 171-186.

MSTATC (1980): A Microcomputer Program of the Design Management and Analysis of Agronomic Research Experiments. Michigan State Univ., USA.

Pedigo, L.P. (1991): Entomology and pest management text bood., Macmillan Publishing Company, New Your, 197-198.

Selim, A.A. (2002): Integrated control of Scale insects on certain fruit trees. Ph.D. Diss, Fac. Agric., Al-Azhar Univ., 173 pp.

Swailem, S.M. (1973): On the bionomics of the guava long scale, *Lepidosaphes tapleyi* Williams (Hemiptera: Homoptera: Diaspididae). *Bulletin de la Société Entomologique d'Egypte*, 56: 163-170.

Swailem, S.M., 1974. On the seasonal occurrence of *Lepidosaphes tapleyi* Williams (Hemiptera-Homoptera: Diaspididae. *Bulletin de la Société Entomologique d'Egypte*, 57: 67-72.

Williams, D.J. and G.W. Watson (1988): The scale insects of the tropical South Pacific region. Part 1: The armoured scales (Diaspididae). CAB International, Wallingford, UK. 290 pp.

Wilson, L.T. and W.W. Barnett (1983): Degree days: An aid in crop and pest management. *California Agriculture*, 37: 4-7.

Zadan, Z.H.; M.I. Abdel-Megeed.; A.N. Hassan.; M.W. Ghabbour.; M.M. Abou-Setta and S.M. El-Amir (2002): Generations determination of *Parlatoria oleae* (Hemiptera: Diaspididae), using age structure, associated degree-days and proper controlling times on olive at Ismailia. *Journal of Environmental Science*, Vol. 5 (4): 1229-1247.

ARABIC SUMMARY

تقدير الأجيال السنوية لحشرة الجوافة القشرية المحارية والتنبوء بقمم أجيالها المتوقعة باستخدام الوحدات الحرارية المتجمعة تحت الظروف الحقلية لمحافظة الأقصر ـ مصر.

مصطفى محمد صبرى بكرى[1]، حسن فرج ضاحي[2]
معهد بحوث وقاية النباتات ـ مركز البحوث الزراعية، الدقى، مصر

تعتبر حشرة الجوافة القشرية المحارية من الآفات الخطيرة التى تصيب أشجار الجوافة فى محافظة الأقصر. فقد تم تحديد عدد الأجيال ومدة وحجم كل جيل وقمم هذه الأجيال وحساب الوحدات الحرارية المتجمعة اللازمة لكل جيل والتنبوء بقمم الأجيال السنوية للحشرة من خلال دراسة العلاقة بين الوحدات الحرارية المتجمعة (معبرا عنها DD's) وكثافة المجموع الكلى للتعداد على أشجار الجوافة فى مركز إسنا محافظة الأقصر خلال عامين متتالين من (2018/2017 و2019/2018).

أظهرت النتائج، أن لهذه الحشرة أربعة الى خمس أجيال حقلية خلال عام. خلال العامِ الأول من الدراسة (2018/2017) فقد كانت هذه الأجيال من (الأول إلى الخامس) من بداية شهر مارس وحتى منتصف مايو، منتصف أبريل إلى أوائل شهر يوليو، من بداية يونيو وحتى بداية سبتمبر، منتصف يوليو حتى منتصف نوفمبر وبداية شهر أكتوبر وحتى بداية يناير على التوالى. ومدة هذه الأجيال 10 و11 و12 و16 و13 أسبوعاً، على التوالي. وكان حجم الأجيال 81.42، 99.44، 159.54، 306.07 و236.24 فرداً على الورقة، على التوالي. أما العام الثانى من الدراسة (2019/2018)، لها أربعة أجيال حقلية من بداية شهر مارس وحتى منتصف يوليو، بداية يونيو وحتى منتصف سبتمبر، منتصف يوليو حتى منتصف نوفمبر ومنتصف سبتمبر حتى بداية يناير، للأربعة أجيال على التوالى. ومدة هذه الأجيال 13 و 18 و 14 و 16 و 14 أسبوعاً، على التوالي. . وحجم هذه الأجيال 188.73، 222.50، 347.92 و282.34 فرداً على الورقة، على التوالي.

وأوضحت النتائج، أن الجيل الرابع في العام الأول من الدراسة والجيل الثالث في العام الثانى من الدراسة، والتي كانت بداية كلا منهما من منتصف يوليو واستمرت حتى منتصف نوفمبر كان أكبرهما حجما ونشاطا وأطول مدة من الأجيال الأخرى خلال العامين ويرجع ذلك للتقلبات فى العوامل المناخية.

وأظهرت النتائج، باستخدام بيانات الأرصاد الجوية المتاحة لمنطقة الأقصر، وعلية يكون متوسط الاحتياج الحراري اليومى لكل جيل هو 18.01 ± 2.63 وحدة حرارية يوم وأظهر تحليل الانحدار البسيط أن عدد الأفراد الحشرة المتراكمة على الورقة أبدى استجابة معنوية موجبة بزيادة عدد الوحدات الحرارية المتراكمة خلال العامين.

وكشفت نتائج الدراسة، أن هناك خمس قمم ملاحظة حقلية والتي حدثت في (بداية أبريل، منتصف مايو، منتصف يوليو، بداية أكتوبر ومنتصف نوفمبر) ولها خمس قمم متوقعة والتي حدثت في 5 مايو و30 يونية و21 أغسطس و15 أكتوبر و4 يناير على التوالى خلال العام الأول من الدراسة. ومع ذلك، خلال العام الثانى من الدراسة، لوحظ أربعة قمم ملاحظة فعلية والتي سجلت في (منتصف أبريل ومنتصف يوليو ومنتصف سبتمبر وبداية نوفمبر) ولها خمس قمم متوقعة والتي حدثت في 9 ابريل و 7 يونية و 31 يوليو و 23 سبتمبر و 3 ديسمبر على التوالى.

أيضاً، القمم المتوقعة للأجيالِ يمكن أن تكتشف عندما الوحدات الحرارية المتراكمة تصل إلى 1112.35 ± 6.00 وحدة حرارية تحت الظروف المناخية لمحافظة الأقصر.