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Population Dynamics of the Soft-scale Insect, *Kilifia Acuminata* (SIGN.) (HEMIPTERA: COCCIDAE) on Mango Trees at Sharkia Governorate

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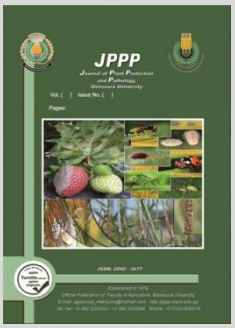

ABSTRACT

The population dynamics of the soft-scale insect, Kilifia acuminata (Sign.) was studied on mango trees in the Bilbies district of the Sharkia Governorate during the two seasons (2020–2021 and 2021–2022). Results revealed that the pest had three overlapping generations on mango trees per year, each lasting about four months. .The monthly average population density of K. acuminata alive stages on mango trees varied between 40.9 and 310.9 individuals/20 leaves and the highest number occurred in September 2021 during the first season. . While in the second season, the monthly average population density varied between 22.9 and 237.4 individuals/20 leaves and the highest number occurred in July.. The preferable directions for trees were west and east in the two seasons, respectively. Throughout the present period of study, only one parasitoid species (the endoprasitoid, Metaphycus zebratus (Mercet) (Hymenoptera: Encyrtidae) attacks K. acuminata.The mean number of parasitoids was relatively higher in the second season than in the first one. Statistical analysis revealed that the population fluctuations due to the combined effects of daily mean temperature and RH%, which were also influenced by some chemical constituents in mango leaves.

***Keywords*:** *Kilifia acuminata*, fluctuation, mango trees

INTRODUCTION

In Egypt, mango trees (*Mangifera indica* L.) are considered among the most eminent horticultural crops. It is produced in several tropical and subtropical countries. (Abd-Rabou *et al.*, 2012 and Temesgen *et al*., 2020) considered the king of fruits due to their delicious taste and source of nutritive value. It is produced in several tropical and subtropical countries. (Abd-Rabou *et al*., 2012; Temesgen *et al*., 2020).. The acuminata scale, *kilifia acuminata* (Signoret) (Hemiptera: Coccidae), commonly known as the soft mango scale insect, one of the most dangerous pests attacked different fruit trees and absorbed the sap from their leaves, which blocked photosynthesis and caused yellow leaves and fruit to drop. Also, it produced large quantities of honeydew, which encouraged the growth of sooty mold. (Hosney,1943; Elwan,2007; Abdel-Rahman *et al*., 2012; Abdel-Razzik, 2013; Attia and Radwan, 2013 and Awadalla *et al*., 2017). To achieve a successful integrated pest management control program in any area, several information concerning ecological aspects of the pest should be involved. Therefore, the present study aimed to evaluate the seasonal activity of *K. accuminta* and its parasitoid during the two successive years. Additionally, it evaluates the quantitative changes in the pest population and the role of insect parasitoids, and the effect of temperature and relative humidity in these changes.

MATERIALS AND METHODS

The seasonal activity of the acuminata scale, *Kilifia acuminate* (Sign.) was carried out for two successive years (2020/2021 and 2021/2022) in mango orchard located at Bilbies district of the Sharkia Governorate.

Sampling methods

Five adjacent mango trees of the Zebda variety that had the same age, height, and growth were selected and marked for the present study. Samples were collected biweekly during two successive seasons 2020/2021 and 2021/2022. Each sample consisted of 100 leaves (20 leaves / tree) collected from different sides (north, south, east, and west) of the tree. The collected leaves were transferred to the laboratory in polyethylene bag for investigation. The collected leaves of each tree were investigated by using a binocular microscope. Scales were recorded as living, dead (unknown mortality), and parasitized insects which bearing emerging holes of parasitoid adults or including parasitoids larvae or pupae. Each healthy alive insects or parasitized ones were counted and recorded. To determine the parasitoid species, each sample was maintained in glass jars, kept until the emergence of adult parasitoids, and counted them. The emerged parasitoids were collected and identified. The formula proposed by Audemard and Milaire (1975) and emended by Jacob (1977) was applied for estimating the number of *K. acuminatum* annual generations and their durations. Data of monthly counts of nymphal stage were indicated on millimeter papers. On millimeter papers, data of monthly counts of nymphal stage was displayed.

The percentage of parasitism (Par. %), was calculated according to the formula of Orphanides (1982):

$$\text{Par. \%} = \frac{\text{par.}}{\text{N + D}} \times 100$$

Where, par. is the number of parasitized individuals, while N and D are the number of living and all dead insects.

Estimate the effect of temperature and relative humidity on the population density:

To study the role of the main weather factors, i.e., temperature and relative humidity on the seasonal abundance of *k. acuminata*, . Monthly means of temperature and relative

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humidity were obtained from the Meteorological Central Laboratory, Agricultural Research Center, during the study period.

Evaluate the relation between some chemical leaf components and *k. acuminata* population.

To determine the relation between some chemical leaf components (percentages of protein, fats, and carbohydrates) and *k. acuminata* population, 100 grams of dried mango leaves were gathered each month during both seasons. According to the method outlined by Gornall et al. (1949), protein was determined. While, total carbohydrates, and fats were calculated according to Gomma (2005) and Knight *et al*. (1972), respectively.

Statistical analysis

The COSTAT (Cohort software, Monterey, CA, USA) version 6.311was used to calculate the total explained variance (E.V.%) and simple correlation values (r).

RESULTS AND DISCUSSION

Seasonal abundance of *K. acuminata* in response to mean temperature and relative humidity.

Data obtained in Tables 1 and 2 revealed the seasonal fluctuation of different developmental stages of *Kilifia acuminata* (Sign.) throughout both years (2020-2021 and 2021-2022). The total mean number of alive stages was higher during the first season in comparison to the second one. Females, nymphs, and the total alive stage population showed two peaks of activity during the two successive years. The insect population increased from November 2020 to April 2021 and reached the highest peak in September 2021 in the first season, represented by 310.9 individuals per 20 leaves, followed by a small peak in April 2021, represented by 161.2 individuals per 20 leaves. In the second season, this soft-scale insect recorded its maximum activity during March 2022, represented by 237.4 individuals per 20 leaves, and the lowest one was estimated during July 2022. The results proved that relative humidity was considered an effective factor for the activity of this insect and that the optimum range for insect activity ranged between 65.10 and 67%. The general mean number of dead stages was higher in the first season (33.97) than in the second one (29.42). It can be noticed that the mean number of dead stages ranged between 8.9 individuals/20 leaves in November 2022 and 55.4 indiv. /20 leaves in June 2021. Meanwhile, in the second season, it ranged between 7.5 indiv./20 leaves in December 2021 and 60.3 indiv./20 leaves in April 2021. These findings agreed with Habib et al. (1971) who recorded that the best conditions for *K. acuminata* activity ranged between 23.8- 25.7 ºC and 63% R.H. Hassan *et al*., (2012) revealed that the total number of alive stages had two to three peaks of activity per year at Sharkia Governorate. Abd-Al-Razzik (2013) recorded two peaks of the acuminate scale on mango trees at Giza Governorate, and the optimum temperature range for activity of *K. acuminate* ranged between 25 ºC and 22 ºC for the spring and autumn seasons, respectively. Bakry *et al.*, (2013) in Qena, Egypt, found two peaks of seasonal activity of *K. acuminate* per year. Attia and Ramadan (2013) indicated that the highest peak of this insect was recorded in April. Awadalla *et al*., (2017) mentioned that the highest peak of the soft scale *K. acuminate* occurred in March at Kafr-El-Sheikh Governorate, and the lowest one was recorded in June.

Table 1. Mean number of alive and dead stages of *Kilifia acuminata* (Sign.) on mango trees at Bilbies district, Sharkia Governorate, during the first year.

Months	Mean numbers / 20 leaves				Monthly average of weather factors	
	Alive stages			Dead stages	Mean. of Temp. (ºC)	Mean. of RH (%)
	Females	Nymphs	Total			
Nov., 2020	1	39.9	40.9	8.9	31.10	70.50
Dec.,	1.9	32.4	34.3	11.0	31.20	73.40
Jan., 2021	2.4	29.3	31.7	15.4	31.70	76.20
Feb.,	3.5	70.8	74.3	23.0	20.20	81.90
Mar.	7.9	119.4	127.3	27.9	24.00	67.30
Apr.	8.7	152.5	161.2	51.8	26.70	71.00
May	10.6	140.3	150.9	52.5	30.70	60.60
Jun.	10.8	190.5	201.3	55.4	29.30	62.10
Jul.	13.4	254.0	267.4	50.6	30.00	66.70
Aug.	12.7	297.2	309.9	40.5	27.75	67.40
Sep.	15.9	295.0	310.9	37.1	26.65	68.10
Oct.	19.2	253.6	272.8	33.5	27.00	66.10
General mean	9.07	156.2	165.2	33.97		

Table 2. Mean number of alive and dead stages of *Kilifia acuminata* (Sign.) on mango trees at Bilbies district, Sharkia Governorate, during the second year.

Months	Mean numbers / 20 leaves				Monthly average of weather factors	
	Alive stages			Dead stages	Mean. of Temp. (ºC)	Mean. of RH (%)
	Females	Nymphs	Total			
Nov., 2020	2.2	20.7	22.9	13.3	38.20	76.20
Dec.,	3.0	19.8	22.8	7.5	35.20	80.80
Jan., 2021	4.5	15.6	20.1	11.5	33.65	77.30
Feb.,	4.8	38.1	42.9	14.3	20.95	77.40
Mar.	10.1	227.3	237.4	27.3	27.85	67.00
Apr.	6.4	127.1	133.5	60.3	27.55	65.10
May	9.9	157.3	167.2	47.4	30.00	59.70
Jun.	11.5	203.8	215.3	39.1	30.00	61.40
Jul.	15.9	203.0	218.9	37.6	28.45	65.10
Aug.	16.9	181.4	198.3	39.8	28.00	68.50
Sep.	13.6	143.2	156.8	34.8	26.75	67.50
Oct.	8.2	84.1	92.3	20.1	27.25	67.60
General mean	8.92	118.73	127.37	29.42		

Efficiency of *M. zebratus* as mortality factor on acuminata scale population.

Throughout the present period of study, only on parasitoid species (the endoprasitoid, *Metaphycus zebratus* (Mercet). (Hymenoptera: Encyrtidae) attacks *K. acuminata*. The obtained data as presented in Table (3), showed that the parasitoid activity (parasitism %) in the first year recorded two peaks; the first was in March (2.88%) and the second was in June (2.71%). The percentage of parasitism all over the year averaged 1.41 %. While, in the second year, the parasitoid exhibited approximately similar trend of activity on *K. acuminata* as in the first year. The parasitoid activity (parasitism %) recorded two peaks; the first was in February (6.29 %), and the second was in June (4.09 %). While the average percentage of parasitism on acuminata scale population was relatively high (2.23%) in comparison with the first year. As shown in Table (3), the parasitoid *M. zebratus* contribute a relatively low percentage all over the year of total mortality averaged 7.19% and 9.95 % in the first and second year, respectively. Hassan et al. (2012) found that *Metaphycus* sp. and *Coccophagus* sp. were parasitoids of *K. acuminate* at Sharkia Governorate.

Table 3. Mean percentage of acuminata scale population mortality caused by *Metaphycus zebratus* and the percentages of the total mortality during the first 2020/2021 and second 2021/2022 year.

Months	2020/2021			2021/2022		
	% of parasitism	Total mortality	% of contribution	% of parasitism	Total mortality	% of contribution
Nov., 2021	0	17.87	0.0	0	36.74	0.0
Dec.,	0.91	24.28	3.75	0	24.75	0.0
Jan., 2022	1.29	32.70	3.94	3.48	36.39	9.56
Feb.,	1.74	23.64	7.36	6.29	25.0	25.16
Mar.	2.88	17.98	16.02	2.93	10.31	28.42
Apr.	1.74	24.32	7.15	2.99	31.11	9.61
May	2.29	25.81	8.87	2.74	22.09	12.40
Jun.	2.71	21.58	12.56	4.09	15.37	26.61
Jul.	1.19	15.91	7.48	0.53	14.66	3.62
Aug.	0.99	11.56	8.56	0.75	16.72	4.49
Sep.	0.54	10.66	5.07	1.44	18.16	7.93
Oct.	0.60	10.94	5.48	1.49	17.88	8.33
General mean	1.41	19.78	7.19	2.23	22.42	9.95

Effects of some weather factors on insect population

Data in Table 4 revealed that in the second season, there was a positive correlation between relative humidity and both population density of *K. accuminata* (r = 0.007***) and its parasitoid activity (r = 0.0357*). In the first season, the relative humidity exhibited a significant positive effect on the mean number of dead stages (r = 0.0188*).

Explained Variance

The changes in total numbers of living and dead stages, as well as the percentage of parasitism, were attributed to the combined effect of the mean temperature and relative humidity, as demonstrated by the data in Table 3. The effects of both tested climatic factors on the population were 45.60, 53.90, 41.01, 71.10, 44.82, and 41.7%, respectively, during the two years. The explained variance in the second season was found to have a higher dominance in the population tested than in the first season. The results proved that relative humidity was considered an influential factor for the activity of this insect and that the optimal insect activity range ranged between 65.10 and 67%. Hassan *et al*., (2012) revealed that the effects of temperature and R.H.% on the number of alive stages during the two years were 84.17 and 38.30%, respectively. Abd-Al-Razzik (2013) referred to the combined effect of temperature and relative humidity on the adult population of *K. acuminata*, which ranged between 73.5 and 82.4% in the two years.

Table 4. The correlation coefficient and variance explained indicated the effects of weather factors (mean temperature and relative humidity) on live and dead stages of *Kilifia acuminata* and its associated parasitoid (*Metaphycus zebratus*) on mango trees during the seasons of 2020–2021 and 2021–2022.

Parameter	Mean of Temp. (ºC)		RH (%)		Explained Variance (%)	
	2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
Total number of living stages	0.6652	0.226	0.0582	0.007 ***	45.60	71.10
Total number dead stages	0.8929	0.6856	0.0188 *	0.6093	53.90	44.82
The percentage of parasitism	0.8927	0.1991	0.0501	0.0357 *	41.01	41.70

Number and duration of generations

Results illustrated graphically in in Figs. 1 and 2 revealed that the pest activity appeared three generations annually during the two successive years 2020–2021 and 2021–2022. The generation duration lasted for 3–4 months, except for the duration of the first generation, which took 6 months from November1st Nov. until 4th March in the first season, but in the second season, it took four months. The duration of the second generation was three months and occurred during the period from 1st April to 4th June. While the third one elapsed from 1st of July to the 4th of October and lasted four months.

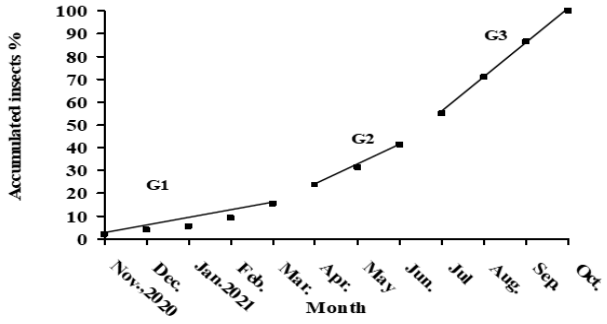

Fig. 1. *Kilifia acuminata* annual generations and their durations on mango trees during the 2020–21 season.

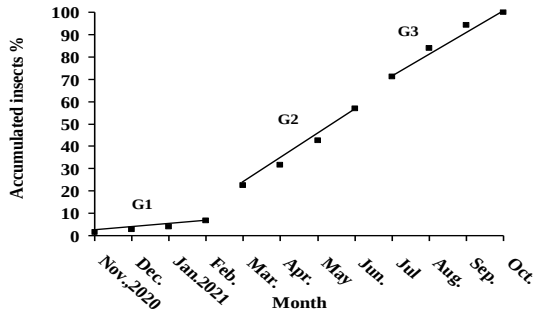

Fig. 2. *Kilifia acuminata* annual generations and their durations on mango trees , during the 2021-2022 season.

These results were in accordance with those of Atalla *et al.*, (2007) indicated that *K.acuminata* had three generations per year at Qalubia Governorate, with the highest recorded in the autumn season. Hassan *et al.*, (2012) recorded three annual generations of *K. acuminata* on mango trees in Sharkia Governorate, which occurred from July to October and November to February, respectively. But the acuminate scale had two generations per year at Giza Governorate, according to Abd-Al-Razzik(2013).

Distribution of the insect population according to the main directions on the trees

Results illustrated in Tables 5 and 6 showed the monthly average numbers of *K. acuminata* according on the different directions of mango trees during the first and second years.

Table 5. Monthly mean numbers of the alive stages of *Kilifia acuminata* (Sign.) / 5 leaves on the different direction of mango trees at Bilbies district, Sharkia Governorate, during the first year (2020–2021).

Months	West	North	East	South
Nov. 2020	12.4	15.3	9.4	3.8
Dec.	11.4	13.5	4.9	4.5
Jan. 2021	11.0	11.8	2.8	6.1
Feb.	32.1	27.7	8.9	5.6
Mar.	35.3	40.7	33.3	18.0
Apr.	42.7	35.2	55.2	28.1
May	30.6	35.4	66.3	18.6
Jun.	70.2	60.2	60.1	10.8
Jul.	95.5	124.6	34.7	12.6
Aug.	135.7	133.6	27.3	13.3
Sep.	159.7	98.3	42.1	10.9
Oct.	162.2	54.3	45.3	11.0
Total	798.8	650.6	390.2	143.3

Table 6. Monthly mean numbers of the alive stages of *Kilifia acuminata* (Sign.) / 5 leaves on mango at Bilbies district, Sharkia Governorate during the second year (2021-2022).

Months	Mean numbers per month / 5 leaves during the 2021-2022 year			
	East	West	South	North
Nov. 2021	7.4	8.1	6.3	1.1
Dec.	5.4	10.8	4.8	1.8
Jan. 2022	3.8	9.9	3.6	2.8
Feb.	17.4	11.5	8.7	5.3
Mar.	56.4	41.3	17.3	20.9
Apr.	103.2	63.8	49.5	18.5
May	64.6	40.4	46.2	16.0
Jun.	72.7	55.6	68.1	18.9
Jul.	84.4	53.1	60.5	20.9
Aug.	76.1	66.5	32.3	23.4
Sep.	54.7	61.7	21.8	18.6
Oct.	38.0	24.9	12.3	17.1
Total	584.1	447.6	331.4	165.3

The obtained data cleared that the highest numbers of the soft scale insect, *k. acuminata* were recorded in the west direction of the tree, followed by north, east, and south directions during the 2020–2021 season, but the preferable direction of the tree for this insect pest was the east direction, followed by west, south, and north directions during the second season. These outcomes concurred with those of Elwan (1990), who recorded that the lower and middle parts of the tree were preferable to this insect over the upper part. Awadalla *et al*., (2017) found that the lowest numbers were recorded in the north direction of the tree in Kafr-El-Sheikh Governorate.

Relationship between certain chemical constituents of mango leaves and the population density of *K. acuminata* live stages

The population of *K. acuminata* and certain chemical constituents in the leaves of mango trees were correlated, as shown by the results in Table7. Only in the second season was the infestation rate of living stages highly correlated with total soluble protein. Likewise, there was no correlation between carbohydrate and lipid content and the number of alive stages. According to Egyptian researchers Salem *et al*., (2006), proteins are the primary source of amino acids and nitrogen for insects. Nabil (2010) studied the chemical component of mango leaf varieties and the effects of that component on the population of scale insects that infest mango leaves in Egypt.

Table 7. Relationship between the mean number of alive stages of *Kilifia acuminata* (Sign.) and the chemical composition (carbohydrates, fats, and total soluble protein) of mango leaves at Bilbies district, Sharkia Governorate, during the two successive years (2020-2021 and 2021-2022)

Months	Mean number of alive stages	Chemical analysis		
		Carbohydrates mg/kg	Fats mg/kg	Total soluble protein mg/kg
	The first season			
Nov., 2020	40.9	1.06	49.18	0.15
Dec.	34.3	1.13	53.10	0.16
Jan. , 2021	31.7	1.68	61.39	0.12
Feb.	74.3	1.51	60.50	0.11
Mar.	127.3	1.51	54.01	0.12
Apr.	161.2	1.74	55.11	0.17
May	150.9	1.21	54.04	0.11
Jun.	201.3	1.74	54.67	0.14
Jul.	267.4	0.91	54.00	0.14
Aug.	309.9	1.21	49.68	0.12
Sep.	310.9	1.51	52.14	0.16
Oct.	272.8	1.44	52.74	0.13
r	----------	0.6104	0.7631	0.9824
	The second season			
Nov., 2021	22.9	1.36	50.91	0.14
Dec.	22.8	1.44	54.88	0.10
Jan., 2022	20.1	1.89	50.65	0.11
Feb.	42.9	1.66	44.27	0.13
Mar.	237.4	1.81	53.53	0.16
Apr.	133.5	1.74	46.02	0.13
May	167.2	1.43	45.45	0.16
Jun.	215.3	1.26	44.99	0.15
Jul.	218.9	1.96	48.74	0.17
Aug.	198.3	1.13	47.66	0.16
Sep.	156.8	1.66	48.34	0.15
Oct.	92.3	1.74	42.62	0.15
r	----------	0.8920	0.6727	0.0011**

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CONCLUSION

The changes of *K.acuminata* population density, which may be due to the influence of biotic factors such as the endo-parasitoid, *M. zebratus* as well as the studied weather factors such as the temperature and relative humidity of April and September months during the two seasons that were more suitable for the activity, and the maximum values of the total alive stages that can be useful when developing control measures, was determined by the results of the experiments listed above. As a result, the ideal time to apply pesticides is in January, before the population of this insect reaches its peak, and in September, after the fruits have been harvested, to avoid adverse effects on their natural enemies.

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ديناميكيه تعداد حشره أكيوميناتا القشريه الرخوه (Hemiptera:Coccidae) *Kilifia acuminate* (Sign.) على أشجار المانجو فى محافظة الشرقيه

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الملخص

تم دراسه ديناميكيه تعداد الحشره القشريه الرخوه *Kilifia acuminata* (Sign.) على أشجار المانجو في مركز بلبيس بمحافظه الشرقية اثناء موسمين (2021-2020و2021-2022).إشارت النتائج إلى ان الآفه لها ثلاثه اجيال متداخلع على أشجار المانجو خلال العام وكل منهما يستمر حوالى أربعه أشهر .وتتراوح متوسط كثافه المجموع الشهرى للأطوار الحيه لحشرة *K.acuminata* على اشجار المانجو مابين 40.9 و 310.9 فرد /20 ورقه وأعلى تعداد حدث فى شهر ستمبر 2021 خلال الموسم الأول بينما فى الموسم الثانى تتراوح متوسط كثافه المجموع الشهرى بين 22.9 و237.4 فرد /20 ورقه واعلى تعداد حدث فى شهر يوليه.كان الإتجاهان المفضلان من الأشجار هما الغربى والشرقى في كلا من الموسمين على التوالي . طوال فترة الدراسة الحالية ، تواجد نوع واحد فقط من الطفيليات الداخليه *Metaphycus zebratus* (Mercet) (Hymenoptera: Encyrtidae) على حشره *K. acuminata*، وكان متوسط عدد الطفيليات أعلى نسبيًا في الموسم الثاني عن الموسم الأول. أوضحت التحليل الإحصائي أن التقلبات فى التعداد تكون نتيجة التأثيرات المشتركة لمتوسط درجات الحرارة اليومية ونسبة الرطوبة النسبية ، والتي تأثّرت أيضًا ببعض المكونات الكيميائية في أوراق المانجو.