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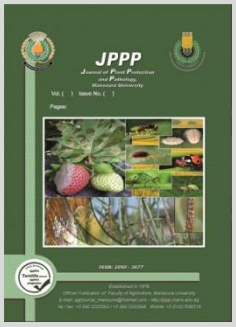
Distribution Patterns of *Parlatoria oleae* (Colvee) (Hemiptera: Diaspididae) Infesting Mango Trees

Bakry, M. M. S. [1*]; I. R. M. El-Zoghby[2] and Lamiaa H. Y. Mohamed[1]

[1] Scale Insects and Mealybugs Research Dept., Plant Protection Research Institute, A.R.C, Dokii, Giza, Egypt.
[2] Plant Protection Dept., Faculty of Agric. and Natural Resources, Aswan Univ., Aswan, Egypt



ABSTRACT

The present experiments were carried out during two consecutive years (2016/17 and 2017/18) to determine the effect of cardinal directions of tree, strata of tree, and leaf surfaces of mango trees on numbers of *P. oleae* at Esna district, Luxor Governorate, Egypt. The results obtained that, *P. oleae* occurred on all mango tree directions in all stratums of mango tree, and on surfaces of leaf on all the sampling days of the study. *P. oleae* prefers the upper surface on the bottom stratum of tree in southeastern side, which had the largest numbers of population allover the year during the two years of study. There were highly significant differences between the mean numbers of *P. oleae* on different cardinal directions of tree, and between the different stratums of tree, as well as between leaf surfaces during the two successive years, when the data were evaluated for combined effects of each whole year. Also, the results revealed that the months of autumn and summer were the most favorable seasons for *P. oleae* activity, multiplication and distribution through the two successive years. The results of this research can be used to draft monitoring methods for this pest and establishing IPM strategies for *P. oleae*.

Keywords: *Parlatoria oleae*, population density, distribution patterns, directional preference, mango trees.

INTRODUCTION

In Egypt, mango trees (*Mangifera indica* L.) are subjected to infestation by several different pests. Among these pests, the plum scale insect, *Parlatoria oleae* is considered one of the most destructive pests of mango trees (Bakr *et al*., 2009). This pest species injures the mango tree shoots, twigs, leaves, branches and fruits by sucking out plant sap with the its mouth parts, subsequently causing 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 pest is the appearance and accumulation of its scales on attacked mango parts (El-Amir, 2002 and Hassan *et al*., 2009).

For the success of crop management control program, it is essential to know in detail information concerning the distribution patterns of the pest. Cardinal directions of sections of the mango trees influence the flight and dispersal patterns of insects. Most insects move on the east-west axis, rather than the north-south axis (Bancroft, 2005). This dispersal habit of insects helps in formulating particular monitoring and management methods for pest control. Monitoring plantations affected by pests helps formulate pest management approaches (Karar *et al*., 2013).

No information is available in the literature concerning the distribution of *P. oleae*. The objective of this study was to estimate the distribution pattern of *P. oleae* in relation to the cardinal directions of tree, different strata of tree, and leaf surfaces of mango trees during two successive years (2016/17 and 2017/18) at Esna district, Luxor Governorate.

MATERIALS AND METHODS

The present experiments were conducted on mango trees in private orchard of about five feddans, on 10 years-old at Esna district, Luxor Governorate from September 2016 to August 2018, to determine of the factors affecting behaviour patterns of *P. oleae*. Ten mango trees, almost uniform and of similar in size, height, vegetative growth and received the same horticultural practices, were selected and labeled. These randomly chosen mango trees did not receive any pesticidal control measures were used before and during the period of investigation, and sampling was conducted at half monthly intervals. Each tree was divided into four sections, depending on the cardinal directions (i.e. east, west, north, and south) the sections faced. The rate of infestation was measured at three strata per tree of each direction. All sampling was conducted from 28800 leaves *i.e.* (10 trees x 4 directions x 3 strata x 5 leaves x 48 dates) over a two-year period from the terminal shoots of the tree. Samples were preserved in paper bags and transferred to the laboratory, where they were examined under a stereo-microscope. Numbers of total *P. oleae* individuals in different cardinal directions, and different strata, on different leaf surfaces of mango trees were accurately counted and recorded, and then samples were individually sorted together opposite to each inspected date.

[*] **Corresponding author.**
E-mail address: md.md_sabry@yahoo.com
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The most cardinal direction preferred by *P. oleae* could be determined by applying the following formula (Mahmoud, 1981):

$$F_1 = E - W \qquad F_2 = N - S \qquad \tan.Q = F_2 / F_1$$

F_1: Mean number of insects counted on the eastern direction of the mango trees, minus the number of insects counted on the western direction of the mango trees, if the former is higher, and the reverse if the latter is higher.

F_2: Mean number of insects counted on the northern direction of the mango trees, minus the number of insects counted on the southern direction, if the former is higher, and the reverse applies if the insect number in south direction is higher. The figure obtained represents the tangent: the corresponding values of which was obtained from the mathematical table.

tan.Q: Tan of the angle between the two forces.

The seasonal mean numbers of total population of *P. oleae* per mango leaf ± standard error (S.E.) was considered in this study to express the population density of pest. Spring season viz. (March, April and May months), summer (June, July and August), autumn (September, October and November) and winter (December, January and February). Data were analyzed using randomized complete block design with ten replicates using MSTATC Program software (1980). All obtained data were depicted graphically by Microsoft Excel 2010.

RESULTS AND DISCUSSION

Leaves samples of mango trees infested with *P. oleae* to estimate insect population density showed considerable variations in its behavior patterns. These remarkable observations may elucidate that insect distribution is regulated by other factors rather than wind direction and velocity which is known as an important factors in this concern. The following factors were evaluated as affecting the insect distribution and spread in mango orchards:

A- Cardinal directions of mango tree (horizontal distribution):

The monthly mean numbers of *P. oleae* on cardinal directions of mango tree, from September, 2016 until mid of August, 2018 were determined in Table (1). The general average for population was higher for the eastern direction (108.2 ± 4.6 and 123.4 ± 5.1 individuals per leaf), followed by southern site (105.8 ± 4.7 and 120.5 ± 5.2 insects per leaf). But, the north direction had the lowest numbers by pest (101.8 ± 4.1 and 116.2 ± 4.7 individuals per leaf). The west site had a moderate numbers of *P. oleae* with (104.5 ± 4.4 and 119.1 ± 4.9 individuals per leaf).

During a two-year period of study, the average numbers of *P. oleae* individuals per leaf were highest in the autumn (135.0 ± 3.2 and 142.1 ± 3.3), followed by summer (118.5 ± 3.2 and 128.5 ± 4.1), spring (91.5 ± 2.8 and 116.0 ± 2.8) and winter (75.2 ± 2.6 and 92.5 ± 6.0) for two successive years, respectively. As well as, the population size of insect during the second year of (2017/18) as general average (119.8 ± 2.5) was higher than the preceding year (2016/17) with a general average (105.1 ± 2.2) in Table (1).

Furthermore, the leaves sampled from the east side of the mango trees harbored the heaviest infestation *i.e.* (25.73 – 25.75% of the total *P. oleae* population, followed by the south direction (25.17 – 25.16%), west (24.87 – 24.85%), and finally by the north side (24.23 – 24.25%) during 2016/17 and 2017/18, respectively are represented in Table (1).

Table 1. Mean numbers of *P. oleae* total population occurred in different directions of mango during the two successive years (2016/17 and 2017/18):

Years	Seasons	Mango tree directions				Total	Mean ± S.E.	L.S.D. %5	% From overall seasonal total			
		North	South	East	West				North	South	East	West
		Average no. of *P. oleae* individuals per leaf ± S.E.										
2016 / 17	Autumn	131.1 ± 5.6	135.1 ± 7.7	139.3 ± 5.9	134.7 ± 7.0	540.1	135.0 ± 3.2	4.08 **	24.27	25.02	25.78	24.93
	Winter	73.4 ± 4.9	76.1 ± 5.8	74.6 ± 5.5	76.8 ± 5.2	300.8	75.2 ± 2.6	N.S.	24.40	25.28	24.79	25.52
	Spring	90.7 ± 5.8	92.2 ± 6.5	93.6 ± 5.4	89.7 ± 5.3	366.1	91.5 ± 2.8	N.S.	24.78	25.18	25.54	24.50
	Summer	112.1 ± 5.4	119. 8 ± 7.4	125.3 ± 6.2	116.9 ± 6.6	474.1	118.5 ± 3.2	3.81 **	23.65	25.26	26.43	24.66
	General average	101.8 ± 4.1	105.8 ± 4.7	108.2 ± 4.6	104.5 ± 4.4	420.3	105.1 ± 2.2	2.18 **	24.23	25.17	25.73	24.87
2017 / 18	Autumn	138.0 ± 5.8	142.1 ± 7.7	146.6 ± 6.1	141.7 ± 7.2	568.5	142.1 ± 3.3	4.21 **	24.28	24.99	25.79	24.93
	Winter	90.2 ± 11.8	93.5 ± 12.8	91.8 ± 12.5	94.5 ± 12.5	369.9	92.5 ± 6.0	N.S.	24.39	25.26	24.81	25.54
	Spring	115.1 ± 6.0	116.7 ± 6.8	118.5 ± 5.1	113.6 ± 5.0	463.8	116.0 ± 2.8	N.S.	24.81	25.16	25.55	24.49
	Summer	121.4 ± 7.4	129.9 ± 9.1	136.5 ± 8.0	126.4 ± 8.3	514.2	128.5 ± 4.1	4.31 **	23.61	25.25	26.55	24.59
	General average	116.2 ± 4.7	120.5 ± 5.2	123.4 ± 5.1	119.1 ± 4.9	479.1	119.8 ± 2.5	2.41 **	24.25	25.16	25.75	24.85

L.S.D.: Least significant difference; * significant for P ≤ 0.05; ** significant for P ≤ 0.01; N.S. = Non Significant.

The results showed that there were highly significant differences between cardinal directions for each of the seasons, except in the winter and spring seasons were insignificant differences through the two consecutive years, when the comparisons were directed for each season separately. As well as, highly significant differences were observed between cardinal directions for the comparisons of combined effect for the whole year were recorded in each of year from the two years (2016-2018). These results were agreeable with Hassan *et al*. (2009) they recorded that autumn months was the optimum season for *P. oleae* activity.

Based on current results for the two years of investigation, and mainly relying on the significant differences concluded that the eastern and southern sides of the mango tree appears to be more preferred for infestation with *P. oleae* and highest population than the other sides. The differences of distribution might be attributed to the pooled effect of the wind direction and the duration of leaves exposure to the sun rays (Eraki, 1998).

The results indicated that, in both years of study, *P. oleae* preferred the east southern direction (Fig., 1). We may therefore conclude that *P. oleae* prefer to concentrate on the southeastern side of the mango tree usually being more subjected to sun and relatively warmer than the other sides. This result is of great value when planning for chemical control programs against this insect. These results were agreeable with El-Amir (2002) in Qaliobiya, Egypt, reported that the east direction followed by the south one were the most preferable directions for *P. oleae* on olive trees compared with north or west ones. Bakry (2014) in Luxor, Egypt, who found that *Parlatoria blanchardii* prefers southeastern sides of date palm trees as compared the other directions. On the contrary, Asfoor (1997) reported the other directions (*i.e.* north and west) to be preferred by *P. oleae* on apple trees.

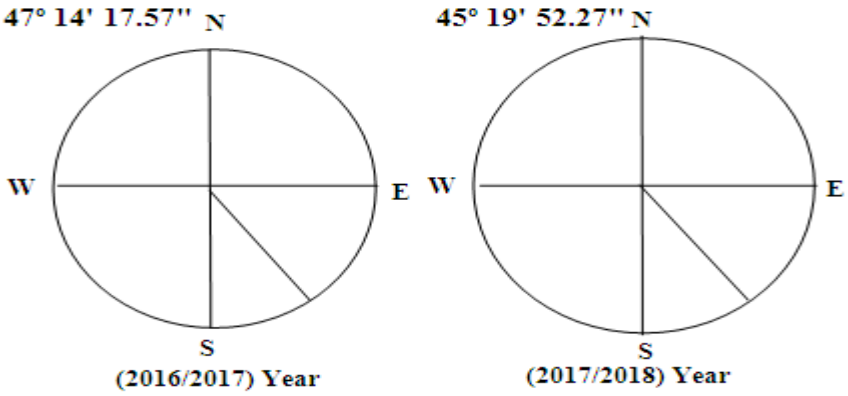

Fig. 1. Directional preference of *A. tubercularis* population on date palm tree at Esna district, Luxor Governorate during the two successive years of (2017/2018 and 2018/2019).

B- Stratums of mango tree (vertical distribution):

Results depicted in Table (2), indicated that the bottom stratum leaves of tree was the most preference strata by the plum scale insect, *P. oleae* as general average with (130.7 ± 5.4 and 149.2 ± 6.1 of individuals per leaf), followed by the middle stratum leaves (120.4 ± 5.0 and 137.5 ± 5.6 of scale), and the top stratum leaves had the lowest population density by insect as mean (64.2 ± 3.1 and 72.7 ± 3.2 of individuals per leaf) during the two years, respectively. Analysis of variance indicated that there were highly significant differences between the population means at the three strata for each of the seasons. Also, highly significant differences were recorded between different stratums for comparisons of combined effect for the whole year during the two years (2016-2018) are represented in Table (2).

Table 2. Mean numbers of *P. oleae* total population in the different strata of mango tree through the two consecutive years of (2016/17 and 2017/18)

Years	Seasons	Mango tree strata			Total	Mean ± S.E.	L.S.D. %5	% From overall seasonal total		
		Bottom	Middle	Top				Bottom	Middle	Top
		Average no. of *P. oleae* individuals per leaf ± S.E.								
2016 / 17	Autumn	166.9 ± 7.7	153.8 ± 7.1	84.4 ± 4.8	405.1	135.0 ± 7.2	5.08 **	41.19	37.97	20.84
	Winter	95.6 ± 7.0	88.2 ± 6.6	41.8 ± 2.5	225.6	75.2 ± 5.1	4.32 **	42.37	39.09	18.54
	Spring	114.0 ± 7.0	104.7 ± 6.4	55.9 ± 4.1	274.6	91.5 ± 5.4	3.84 **	41.51	38.13	20.36
	Summer	146.3 ± 7.6	134.8 ± 7.0	74.5 ± 4.5	355.6	118.5 ± 6.5	5.37 **	41.14	37.92	20.94
	General average	130.7 ± 5.4	120.4 ± 5.0	64.2 ± 3.1	315.2	105.1 ± 3.6	2.57 **	41.46	38.19	20.35
2017 / 18	Autumn	175.7 ± 7.9	161.9 ± 7.2	88.9 ± 4.9	426.4	142.1 ± 7.5	5.24 **	41.20	37.96	20.84
	Winter	117.7 ± 16.0	108.7 ± 14.9	51.1 ± 6.3	277.5	92.5 ± 8.9	7.03 **	42.42	39.17	18.40
	Spring	144.8 ± 7.5	133.1 ± 6.9	70.1 ± 3.2	347.9	116.0 ± 6.5	4.53 **	41.62	38.25	20.14
	Summer	158.6 ± 9.8	146.2 ± 9.1	80.9 ± 5.7	385.6	128.5 ± 7.5	6.00 **	41.12	37.91	20.97
	General average	149.2 ± 6.1	137.5 ± 5.6	72.7 ± 3.2	359.3	119.8 ± 4.1	2.87 **	41.52	38.25	20.23

The largest number of *P. oleae* individuals were found during the autumn months at the bottom stratum leaves of tree were (166.9 ± 7.7 and 175.7 ± 7.9 individuals per leaf), followed dissentingly by the middle and top stratum leaves of mango tree. The population densities recorded that the average of *P. oleae* per leaf were (153.8 ± 7.1 and 161.9 ± 7.2) and (84.4 ± 4.8 and 88.9 ± 4.9 individuals per leaf) through the two successive years, respectively (Table, 2).

The bottom stratum leaves of tree had the highest numbers of *P. oleae*, and accounted for 41.46 and 41.52% through the two successive years, respectively, followed by the middle stratum of the tree (38.19 and 38.25% of the total number of *P. oleae*, in 2016/17 and 2017/18, respectively), and the top stratum leaves of tree was the least affected by the pest (20.35 and 20.23% of the total *P. oleae* individuals, in 2016/17 and 2017/18, respectively (Table, 2). Overall, the percentages of the total number of *P. oleae* on strata of tree in the two years of the study were similar, which may be because the climatic factors were very similar during the two years (2016/17 and 2017/18).

In general, the bottom stratum leaves of mango tree had the highest numbers of *P. oleae* in all seasons of both years of the study. The differences in distribution behaviour of *P. oleae* on the stratums of tree may be due to the differences in the climatic factors and other factors. Additionally, the bottom stratum leaves of tree provide good shelter for *P. oleae* especially in the sensitive developmental stages. The results indicate that *P. oleae* prefer the bottom stratum of mango tree over the middle or apical strata. These results agree with that obtained by Draz *et al.* (2011) at El-Behaira Governorate, Egypt, however with different insect species and different host, also reported that the population of the purple scale insect, *Lepidosaphes beckii* prefers the middle stratum of navel orange trees as preferable site for feeding, developing and multiplications of nymphs and or adults. Bakry (2014) in Luxor, Egypt, reported that *P. blanchardii* prefers bottom level of the date palm leaves than the other levels.

C- Leaf surface:

The upper surfaces of mango leaf had higher numbers of *P. oleae* individuals than the lower ones (Table, 3). The overall mean number for this pest per leaf on the upper surface was 60.6 ± 3.1 and 69.0 ± 3.4 individuals during two consecutive years of study, respectively. However, the general mean number of *P. oleae* on the lower surfaces of leaf was 44.5 ± 1.6 and 50.8 ± 1.9 individuals for two years, respectively.

Insect population of *P. oleae* on the upper surface of leaf comprised (57.66 and 57.60%) of the total number of insects. On the other hand, the percentages of *P. oleae* individuals recorded on the lower surface of leaf were (42.34 and 42.40%) for two years, respectively. Generally, the percentages of *P. oleae* individuals on the different leaf surfaces in each of the two study years were similar, which may due to the fact that climatic factors during the two years were very similar, as shown in Table (3).

Table 3. Mean numbers of *P. oleae* total population occurred on the surfaces of mango leaf during the two successive years of (2016/17 and 2017/18)

Years	Seasons	Mango leaf surfaces		Total	Mean ± SE	L.S.D. %5	% From overall seasonal total	
		Upper	Lower				Upper surface	Lower surface
		Average no. of *P. oleae* individuals per leaf ± S.E.						
2016 / 17	Autumn	78.0 ± 4.0	57.1 ± 2.7	135.0	67.5 ± 3.2	2.89 **	57.74	42.26
	Winter	38.7 ± 4.3	36.5 ± 1.7	75.2	37.6 ± 2.3	1.67 *	51.46	48.54
	Spring	54.2 ± 5.1	37.3 ± 1.6	91.5	45.8 ± 3.2	3.34 **	59.26	40.74
	Summer	71.4 ± 4.1	47.1 ± 2.9	118.5	59.3 ± 3.5	2.77 **	60.27	39.73
	General average	60.6 ± 3.1	44.5 ± 1.6	105.1	52.5 ± 1.9	1.33 **	57.66	42.34
2017 / 18	Autumn	82.0 ± 3.9	60.1 ± 3.0	142.1	71.1 ± 3.3	2.94 **	57.69	42.31
	Winter	49.1 ± 8.7	43.4 ± 3.9	92.5	46.2 ± 4.7	3.39 **	53.11	46.89
	Spring	67.3 ± 4.7	48.6 ± 3.6	116.0	58.0 ± 3.5	3.13 **	58.06	41.94
	Summer	77.5 ± 5.5	51.0 ± 3.3	128.5	64.3 ± 4.2	3.13 **	60.32	39.68
	General average	69.0 ± 3.4	50.8 ± 1.9	119.8	59.9 ± 2.2	1.49 **	57.60	42.40

The upper surfaces of leaf were exposed to more sunlight than the lower ones (is behaves as photopositive). These results were agreeable with Bakry (2014), who found that the upper surfaces of leaflet were more heavily infested with date palm scales, *P. blanchardii* than the lower ones.

Results as represented in Table (4), were derived from the interaction between cardinal directions, tree strata, and leaf surfaces of mango trees on different sampling days during the two successive years of this study. The average numbers of *P. oleae* per leaf resulting from combined interaction between these factors were 105.1 and 119.8 individuals per leaf in 2016/17 and 2017/18, respectively. The results of this study describe the *P. oleae* individuals on mango tree occurred on four cardinal directions, and on the different stratums of tree, and leaf surfaces on all the sampling days of the study. Also, the population distribution of pest considerably differs from one direction to another and from stratum of tree to another and also on its surfaces through the two years. The differences may be due to the differences in the climatic factors and other factors. Furthermore, the results demonstrate that the highest total *P. oleae* individuals were recorded at the upper surface on the bottom stratum of tree in southeastern side than those the others directions and strata. The most likely reason for this distribution pattern is the temperature difference between the various aspects of the trees. Although the east and west directions of the tree get the same amount of direct sunlight, the air temperature during the morning is lower than that during the afternoon. The combined effect of the high air temperature and the direct sunlight could cause the lower infestation on the west direction. These results were driven from the original data for seasonal abundance once studied, where each sampling leaf was sampled in the four cardinal directions. Each direction sub-sample and each stratum sub-sub-sample was examined separately and the data pooled for seasonal abundance of *P. oleae*.

Table 4. The distribution patterns of the plum scale insect, *P. oleae* per leaf, given as a general average counts that was done during the two successive years of (2016/17 and 2017/18).

Directions	Strata	Surfaces	Average no. of *P. oleae* individuals per leaf					
			First year (2016/17)			Second year (2017/18)		
North	Bottom	Upper	72.1	127.0	101.8	82.6	145.4	116.2
		Lower	54.9			62.8		
	Middle	Upper	61.4	114.1		69.4	130.6	
		Lower	52.8			61.1		
	Top	Upper	34.3	64.3		38.9	72.5	
		Lower	30.0			33.6		
South	Bottom	Upper	80.3	129.9	105.8	91.5	148.1	120.5
		Lower	49.6			56.6		
	Middle	Upper	72.1	120.1		82.3	137.1	
		Lower	48.0			54.8		
	Top	Upper	38.1	67.3		43.2	76.4	
		Lower	29.2			33.1		
East	Bottom	Upper	86.5	136.4	108.2	98.3	155.7	123.4
		Lower	49.9			57.4		
	Middle	Upper	73.6	129.4		83.8	147.4	
		Lower	55.8			63.7		
	Top	Upper	34.2	58.7		38.8	66.9	
		Lower	24.4			28.1		
West	Bottom	Upper	74.5	129.3	104.5	85.2	147.4	119.1
		Lower	54.9			62.3		
	Middle	Upper	64.2	117.9		73.5	134.7	
		Lower	53.7			61.2		
	Top	Upper	35.6	66.3		40.4	75.0	
		Lower	30.7			34.6		
General average			105.1			119.8		

Generally, it can be concluded that, *P. oleae* occurred on all mango tree directions in all stratums of mango tree, and on surfaces of mango leaf on all the sampling days of the study. *P. oleae* prefers the upper surface on the bottom stratum of tree in southeastern side, which had the largest numbers of population allover the year during the two years of study. Also, the obtained results revealed that the months of autumn and summer were the most favorable seasons for *P. oleae* activity, multiplication and distribution through the two consecutive years. The above mentioned results can be explained this tendency. These results could have important implications. Firstly, population censuses should be sampled on the highly infested aspect of the tree, thus saving time and effort. Secondly, the chemical spray programme could be adapted to concentrate on the highly infested aspect of the tree. Trials should, however, be performed to verify these assumptions.

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نظم التوزيع لحشرة البرقوق القشرية (بارلاتوريا أوليا) التى تصيب أشجار المانجو

مصطفى محمد صبرى بكرى[١]، أسلام راشد الزغبى[٢] ولمياء حسين يسري محمد[١]

[١]قسم بحوث الحشرات القشرية والبق الدقيقى بمعهد بحوث وقاية النباتات ـ مركز البحوث الزراعية، الدقى، مصر

[٢]قسم وقاية النبات ـ كلية الزراعة والموارد الطبيعية ـ جامعة أسوان – أسوان ، مصر

تعتبر حشرة البرقوق القشرية من الآفات الخطيرة التى تصيب أشجار المانجو فى محافظة الأقصر. تمتص هذه الآفة العصارة النباتية مما يؤدى إلى أصفرار الأوراق وجفافها وتساقطها وتسبب موت الفروع وفى حالة الإصابة الشديدة تنتقل إلى الثمار وتسبب تشوهات فى الثمار مما يودى إلى تقليل القيمة التسويقية للثمار. ولذلك فقد تم تقدير نظم سلوك توزيع الحشرة على الاتجاهات الأربعة الرئيسية للشجرة وعلى طبقات الشجرة وعلى سطحى الورقة وتقدير نمط توزيعها المكانى على أشجار المانجو فى مركز إسنا محافظة الأقصر خلال عامين متتالين (٢٠١٦/٢٠١٧ و ٢٠١٧/٢٠١٨). أوضحت النتائج، أن حشرة البرقوق القشرية تتواجد فى الأتجاهات الأربعة الرئيسية للشجرة وعلى كل الطبقات المختلفة لشجرة المانجو وعلى سطحى الورقة على مدار العام خلال عامى الدراسة. ولوحظ أن أعلى كثافة عددية للحشرة تتواجد على السطح العلوى على أوراق الطبقة القاعدية للشجرة فى الأتجاه الشرقى المائل للجنوب طوال العام. كما أشارت النتائج، إلى وجود أختلافاتِ عالية المعنوية وتباين واضح بين متوسطات تعداد الحشرة بين الأتجاهات الأربعة الرئيسية للشجرة (الشرق- الغرب - الجنوب - الشمال) وبين الطبقات الثلاثة للشجرة (الطبقة الطرفية - الوسطية - القاعدية) وبين سطحى الورقة (العلوى – السفلى) خلال عامين مِنْ الدراسةِ. أيضا، كانت الظروف البيئية فى الشهورَ الخريفيةَ والصيفية خلال العامين كَانتْ أكثر الشهور تفضيلا وملائمة لنمو ونشاط التعداد الكلى للحشرة تحت ظروف المناخيةِ للمنطقة تحت الدراسة. يمكن استخدام نتائج هذا البحث لصياغة طرق الرصد لهذه الآفة ووضع استراتيجيات المكافحة المتكاملة للآفات لحشرة البرقوق القشرية.