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Research Article
Fauna of *Parlatoria blanchardi* Scales (Targioni-Tozzetti) on Date Palm Trees (*Phoenix dactylifera*) in Saudi Arabia

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Abstract

Background and Objective: *Parlatoria blanchardi* (Targioni-Tozzetti) is a serious pest cause threatening to date palm trees (*Phoenix dactylifera*). The study aimed to determine the distribution of *Parlatoria blanchardii* on the different parts of date palm trees (*Phoenix dactylifera*). **Materials and Methods:** The present study was conducted on date palm trees cultivated in a private orchard in the Qassim region of Saudi Arabia. Four palms trees (El sokary variety) of similar size, age, height and vegetative growth were randomly selected and sampling was conducted at half monthly intervals. Each tree was observed over two year period. Samples were transferred to the laboratory, where they were examined under a stereo-microscope. **Results:** The obtained results demonstrate that this pest occurred on all date palm tree sections (east, west, north and south facing) and all different surfaces of leaflets, as well as on all frond strata of date palm trees on all the sampling days of the study. There were highly significant differences between the mean numbers of *Parlatoria* date palm scales on the date palm tree sections facing different cardinal directions and between the different frond strata, as well as between leaflet surfaces during the 2 successive years, when the data were evaluated for combined effects of each whole year. **Conclusion:** *Parlatoria* date palm scales prefer the bottom stratum of fronds and the upper surface of leaflets, which had the largest numbers of this pest species on the southern and eastern sides of the trees.

Key words: Date palm trees, *Parlatoria* date palm scales, distribution patterns, directional preference, leaflet surfaces, bottom stratum, fronds

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The numbers of pests that infest date palm trees are numerous, despite to this few pests recorded to be harmful and reduce the economic outcome of these trees. The red palm beetles are some of these pests of economic importance[1]. Besides, the date palm scales insects infest palms aging between 2-8 years causing serious impact on these trees[2].

Date palm trees constitute important economic source in Kingdom Saudi Arabia during the last years[3].

These date palm trees, *Phoenix dactylifera*, are subject to infestation by several insect species in Saudi Arabia. The *Parlatoria* date palm scale, *Parlatoria blanchardii* (Targioni-Tozzetti, hereafter 'date palm scale') is considered one of the most destructive pests of date palm trees[4]. This pest species injures date palm tree leaflets, leaves and fruits by sucking out plant sap with its mouth parts, subsequently causing deformations, defoliation and death of fronds due to the fact that date palm scales have toxic saliva, resulting in yield reduction[2,5]. Damage to the date palm leaves also reduces photosynthesis and respiration, which leads to curling, yellowing and dropping of leaves. The main characteristic of date palm scale infestations is the appearance and accumulation of date palm scales on date palm leaves[6,7]. Cardinal directions of sections of the date palm trees influence the flight and dispersal patterns of insects. Most insects move on the East-West axis, rather than the North-south axis[8,9]. 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[10,11].

Lack of published information about highlighting specific parts of date palm trees to be targeted for the control of pests infestations gave the rationale to conduct this study where the objective was to estimate the spatial distribution pattern of date palm scales in relation to the cardinal directions of sections of date palm trees, as well as the trees' leaflet surfaces and frond parts.

MATERIALS AND METHODS

Study settings: The present study was conducted on date palm trees cultivated in a private orchard in the Qassim region of Saudi Arabia, from June, 2016 until May, 2018. The orchard was six years old and the size of the orchard was approximately 5 feddans (21,000 m^2).

Sampling procedure: Four palms trees (El sokary variety) of similar size, age, height and vegetative growth were randomly selected and sampling was conducted at half monthly intervals. The selected date palm trees were managed without pruning the fronds and no chemical control measures were used before and during the period of investigation. Each tree was divided into 4 sections, depending on the cardinal directions (i.e., east, west, north and south) the sections faced.

Estimation of pests' infestations: The rate of date palm scale infestation was measured at 3 strata per frond of each direction. Sampling was conducted on a total of 11,520 leaflets (i.e., 4 trees × 4 directions × 3 strata x × leaflets × 48 sampling days) during the 2 year period. Samples were preserved in paper bags and transferred to the laboratory, where they were examined under a stereo-microscope. Numbers of healthy alive date palm scales on the sections facing the different cardinal directions and from the different strata on different surfaces of date palm leaflets were accurately counted and recorded and then samples were sorted according to the day on which samples were inspected.

Directional preference was determined by applying the following equation[12,13]:

$$F_1 = E\text{-}W \; F_2 = N\text{-}S$$

$$\tan.Q = F_2/F_1$$

Where:

F_1 = Mean number of date palm scales counted on the eastern section of the date palm trees, minus the number of date palm scales counted on the western section of the date palm trees

F_2 = Mean number of date palm scales counted on the northern section of the date palm trees, minus the number of date palm scales counted on the southern section of the date palm trees. The number obtained represents the tangent and the corresponding values were obtained from the mathematical table in a related study[12]

tan.Q = Tan of the angle between F_1 and F_2

Statistical analysis: The data (including the standard deviations) were calculated and visualized in SPSS Version 25.0. Data were analyzed using randomized complete block design (four factors) using MSTATC 64 Bit program 2018.

RESULTS

Effects of cardinal directions of sections of date palm trees on date palm scales: The average numbers date palm scales during each12 month period (2016/2017 and 2017/2018) were highest for the south facing sections of trees followed by the east facing section. In contrast to this, the north facing tree sections had the lowest numbers of palm date scales while the west facing sections had a moderate numbers of palm date scales (Table 1).

For leaflets infestation, the south facing sections of the date palm trees harbored the heaviest palm date scale infestation followed by the east facing section, then the west facing section and finally by the north facing (Table 1).

Distribution of date palm scales on date palm fronds: Mean numbers of date palm scales per leaflet on the bottom stratum of the fronds were the highest ever. This was followed by the middle stratum of the frond while the top stratum of date palm fronds had the lowest number of date palm scales. Seasonality found to play a role in the density of insects in different parts of the trees where the largest number of date palm scales were found during the autumn months at the bottom stratum of fronds followed by the middle stratum while the top stratum of frond shad the lowest numbers of date palm scales (Table 2).

Distribution of palm date scales on leaflet surfaces: The upper surfaces of leaflets had higher numbers of palm date scales than the lower ones during each of the 4 seasons of the year. Overall mean number of date palm scales was 70.2% in the upper part of leaflets compared to 29.8% in the lower parts of the leaflets. Coincides to this, during the 1st year density of scales in the upper parts of leaflets was 68% compared to 32% in the lower parts during the 2nd year (Table 3).

Density of date palm scales during the 2 successive years: During the 2 year study, the average numbers of date palm scales per leaflet were highest in the autumn followed by summer, then winter and lastly spring.

Mean number of scales was the highest in the south direction followed by the east direction then the west direction while the north direction was harboring the least number of scales during each of the 2 years of the study (Table 4).

Table 1: Mean numbers of *P. blanchardi* total population occurred in the different cardinal directions on date palm tree during the 2 successive years of (2016/2017 and 2017/2018)

	Date palm tree directions									
	Average number of scale insects per leaf±SD									
	First year (2016/2017)					Second year (2017/2018)				
Months	North	South	East	West	Mean±SD	North	South	East	West	Mean±SD
June	38.75±5.76	37.61±5.92	37.04±6.29	39.36±5.76	38.19±5.38	37.63±5.69	39.79±5.20	38.92±5.92	39.95±4.96	39.07±4.97
July	40.88±5.21	39.82±4.96	40.10±5.33	41.58±4.31	40.59±4.50	43.43±5.55	43.63±6.46	42.71±5.97	43.77±5.14	43.38±5.21
August	40.25±3.13	39.06±2.80	38.76±3.05	40.32±2.07	39.60±2.60	33.37±2.71	32.76±2.11	32.01±2.72	32.97±1.89	32.78±2.19
Summer season	39.96±4.47	38.83±4.40	38.63±4.77	40.42±3.99	39.46±4.34	38.14±6.15	38.73±6.48	37.88±6.53	38.90±6.06	38.41±6.12
September	39.64±7.68	40.40±6.79	39.48±7.63	38.64±7.58	39.54±6.68	47.08±9.11	48.95±8.03	48.23±9.91	46.11±9.44	47.59±8.26
October	55.59±8.16	58.72±7.04	58.24±8.77	55.49±8.01	57.01±7.33	56.21±8.04	58.09±7.85	59.27±5.91	56.58±6.95	57.54±6.60
November	56.50±9.61	60.76±8.82	59.55±10.05	56.80±9.98	58.40±8.81	28.97±5.14	30.53±4.10	29.91±5.56	29.13±5.57	29.63±4.63
Autumn season	50.58±11.18	53.29±11.78	52.43±12.49	50.31±11.61	51.65±11.46	44.09±13.69	45.86±13.50	45.80±14.31	43.94±13.62	44.92±13.37
December	54.38±7.68	60.88±7.08	57.90±8.67	56.91±8.18	57.52±7.48	43.18±6.16	47.01±3.70	45.73±5.41	44.13±5.87	45.01±5.04
January	27.58±4.42	32.43±4.48	30.83±5.35	28.77±4.85	29.90±4.70	29.84±4.77	33.73±5.08	31.77±5.30	31.41±5.29	31.69±4.79
February	17.35±1.79	19.41±1.57	19.05±2.58	18.01±2.17	18.46±2.03	20.20±2.00	22.62±1.78	22.18±2.79	21.51±2.57	21.63±2.28
Winter season	33.10±16.98	37.57±18.63	35.93±17.85	34.56±17.87	35.29±17.34	31.08±10.70	34.45±10.96	33.22±10.94	32.35±10.60	32.78±10.53
March	21.15±1.79	22.79±1.65	22.71±2.93	21.75±2.31	22.10±2.11	14.74±1.24	16.57±1.64	16.69±1.22	15.79±1.28	15.95±1.45
April	35.57±5.08	38.75±4.47	38.40±6.66	36.82±6.07	37.39±5.21	36.64±5.23	37.45±4.68	38.36±5.93	36.67±5.99	37.28±4.96
May	28.37±5.16	30.93±5.00	29.35±5.45	29.01±5.20	29.42±4.76	41.54±7.42	43.06±5.99	44.99±4.98	42.84±5.79	43.11±5.79
Spring season	28.36±7.28	30.82±7.70	30.15±8.22	29.19±7.76	29.63±7.56	30.97±13.08	32.36±12.58	33.35±13.27	31.77±12.86	32.11±12.56
Total	456.02	481.56	471.43	463.46	1872.46	432.85	454.19	450.77	440.85	1778.66
General average	38.00±13.60	40.13±14.16	39.29±14.16	38.62±13.66	39.01±13.81	36.07±12.25	37.85±12.04	37.56±12.40	36.74±11.96	37.06±12.08
Percentage	24.35	25.72	25.18	24.75	100.00	24.34	25.54	25.34	24.79	100.00

Table 2: Mean numbers of *P. blanchardi* total population in the different stratums of date palm frond during the 2 successive years of (2016/2017 and 2017/2018)

	Date palm frond stratums							
	Average number of scale insects per leaf±SD							
	First year (2016/2017)				Second year (2017/2018)			
Date of sampling	Bottom	Middle	Top	Mean±SD	Bottom	Middle	Top	Mean±SD
June	50.59±8.22	41.77±6.34	22.22±3.24	38.19±13.62	52.75±7.72	41.88±5.71	22.58±2.97	39.07±14.05
July	50.96±6.00	43.34±5.31	27.48±3.26	40.59±11.17	53.80±6.84	45.76±6.16	30.58±4.05	43.38±11.34
August	46.66±4.38	45.35±2.69	26.79±0.79	39.60±9.86	38.26±3.43	37.83±2.60	22.25±0.97	32.78±8.11
Summer season	49.40±6.13	43.49±4.79	25.49±3.44	39.46±4.34	48.27±9.33	41.82±5.71	25.14±4.83	38.41±6.12
September	51.69±8.50	40.68±8.38	26.25±5.22	39.54±12.83	60.26±10.31	47.79±10.23	34.73±6.78	47.59±13.73
October	72.65±9.18	58.33±8.61	40.05±5.83	57.01±15.71	71.11±8.51	58.57±7.65	42.93±5.45	57.54±13.74
November	81.43±10.75	54.01±10.15	39.78±7.62	58.40±20.03	39.94±4.63	27.71±5.86	21.25±4.64	29.63±9.31
Autumn season	68.59±15.62	51.00±11.36	35.36±8.82	51.65±11.46	57.11±15.38	44.69±15.24	32.97±10.66	44.92±13.37
December	72.08±10.96	57.87±7.28	42.60±5.37	57.52±14.60	56.90±6.35	45.17±5.72	32.96±3.90	45.01±11.32
January	40.25±6.28	28.24±4.51	21.23±3.40	29.90±9.32	41.61±6.47	29.14±4.63	24.31±4.31	31.69±8.96
February	23.33±3.64	18.40±1.57	13.63±0.95	18.46±4.65	26.10±4.08	21.03±1.67	17.75±1.22	21.63±4.31
Winter season	45.22±22.20	34.84±18.10	25.82±13.24	35.29±17.34	41.54±14.12	31.78±11.19	25.01±7.21	32.78±10.53
March	25.84±2.73	25.16±2.47	15.29±1.32	22.10±5.43	18.57±1.95	18.33±1.13	10.94±0.94	15.95±3.91
April	45.87±5.03	40.86±7.07	25.43±4.52	37.39±10.42	46.17±4.83	41.19±7.29	24.48±4.24	37.28±10.94
May	36.46±6.68	30.74±5.55	21.05±4.20	29.42±8.34	51.38±7.51	44.05±6.85	33.90±5.60	43.11±2.78
Spring season	36.06±9.70	32.26±8.35	20.59±5.44	29.63±7.56	38.70±15.78	34.52±13.12	23.11±10.51	32.11±12.56
Total	597.81	484.75	321.79	1404.35	556.85	458.46	318.68	1333.99
General average	49.82±18.63	40.40±13.59	26.82±9.91	39.01±13.81	46.40±15.23	38.21±12.64	26.56±9.21	37.06±12.08
Percentage	42.57	34.52	22.91	100	41.74	34.37	23.89	100

Table 3: Mean numbers of *P. blanchardi* total population occurred on the surfaces of date palm leaflet during the 2 successive years of (2016/2017 and 2017/2018)

	Date palm leaflet surfaces					
	Average number of scale insects per leaflets±SD					
	First year (2016/2017)			Second year (2017/2018)		
Date of sampling	Upper	Lower	Mean±SD	Upper	Lower	Mean±SD
June	25.43±4.02	12.77±1.84	19.10±7.36	27.96±4.04	11.11±1.33	19.54±9.43
July	27.55±3.45	13.04±1.40	20.30±8.13	29.36±4.03	14.02±1.65	21.69±8.68
August	26.63±1.65	12.97±1.20	19.80±7.42	21.87±1.35	10.90±1.09	16.39±5.97
Summer season	26.54±3.04	12.93±1.36	19.73±7.32	26.40±4.57	12.01±1.94	19.21±8.11
September	27.46±4.89	12.08±2.54	19.77±8.98	32.81±5.87	14.78±3.30	23.80±10.60
October	40.66±5.23	16.35±2.65	28.51±13.55	39.64±4.50	17.89±2.65	28.77±12.12
November	42.46±6.74	15.94±2.76	29.20±14.95	20.66±3.36	8.98±1.65	14.82±6.71
Autumn season	36.86±8.67	14.79±3.13	25.83±12.95	31.04±9.23	13.88±4.53	22.46±11.29
December	41.24±5.84	16.28±1.92	28.76±13.94	30.81±3.74	14.20±1.51	22.51±9.26
January	21.34±3.29	8.57±1.52	14.95±7.22	21.77±3.50	9.92±1.70	15.84±6.83
February	12.61±1.39	5.84±0.75	9.23±3.76	14.10±1.51	7.53±1.00	10.81±3.70
Winter season	25.06±13.01	10.23±4.80	17.65±12.22	22.23±7.66	10.55±3.16	16.39±8.27
March	15.15±2.30	6.95±0.34	11.05±4.64	10.03±1.52	5.92±0.32	7.97±2.42
April	27.10±3.35	10.29±2.21	18.69±9.36	25.01±2.91	12.27±2.60	18.64±7.28
May	20.92±4.32	8.50±1.20	14.71±7.26	28.34±4.98	14.77±2.06	21.56±8.06
Spring season	21.06±5.96	8.58±1.95	14.82±7.71	21.13±8.88	10.98±4.27	16.06±8.56
Total	328.54	139.58	468.1	302.37	142.30	444.7
General average	27.38±10.12	11.63±3.86	19.50±10.99	25.20±8.52	11.86±3.74	18.53±9.37
Percentage	70.18	29.82	100	68.00	32.00	100

Table 4: Spatial distribution of the parlatoria date scale insect, *P. blanchardi*/leaflet, given as a general average counts that was done during the 2 successive years (2016/2017 and 2017/2018)

			Average number of individuals/leaf±SD					
			First year (2016/2017)			Second year (2017/2018)		
Direction (A)	Stratum (B)	Surface (C)						
North	Bottom	Upper	33.70±12.94	47.21±17.80	38.00±16.29	31.78±10.99	44.63±15.42	36.07±14.81
		Lower	13.51±4.97			12.85±4.58		
	Middle	Upper	26.21±9.12	39.48±13.45		25.01±4.84	37.68±12.83	
		Lower	13.28±4.49			12.67±4.18		
	Top	Upper	18.17±6.90	27.31±10.19		17.23±6.19	25.90±9.04	
		Lower	9.15±3.37			8.68±2.96		
South	Bottom	Upper	39.18±15.84	53.46±20.12	40.13±19.21	33.90±10.34	48.00±15.21	37.85±15.23
		Lower	14.28±4.76			14.09±5.58		
	Middle	Upper	30.09±10.83	42.28±14.07		25.25±9.05	38.62 ±12.49	
		Lower	12.18±4.12			13.37±3.90		
	Top	Upper	17.34±7.14	24.65±9.41		18.11±7.03	26.93±9.57	
		Lower	7.31±2.45			8.82±2.87		
East	Bottom	Upper	37.53±15.27	50.20±19.16	39.29±17.41	33.79±10.96	47.26±15.73	37.56±15.38
		Lower	12.68±4.68			13.47±5.06		
	Middle	Upper	27.80±10.09	39.95±13.74		25.14±10.02	38.47±13.01	
		Lower	12.15±4.20			13.33±3.97		
	Top	Upper	19.12±7.66	27.70±10.37		18.05±6.74	26.96±9.58	
		Lower	8.58±2.86			8.91±3.14		
West	Bottom	Upper	34.39±12.84	48.40±17.95	38.62±16.52	31.63±10.01	45.73±15.01	36.74±9.15
		Lower	14.01±5.30			14.09±5.56		
	Middle	Upper	26.57±9.11	39.87±13.51		24.57±9.41	45.73±15.01	
		Lower	13.30±4.58			13.48±4.35		
	Top	Upper	18.44±6.91	27.60±10.10		17.90±6.78	26.43±9.15	
		Lower	9.16±3.33			8.54±2.87		
General average			39.01±13.81			37.06±12.08		

$LSD_{0.05}$ between directions (A): 0.38, 0.35, $LSD_{0.05}$ between stratums (B): 0.33, 0.30, $LSD_{0.05}$ between surfaces (C): 0.27, 0.35, $LSD_{0.05}$ between dates of year (D): 0.66, 0.60, $LSD_{0.05}$ for interaction (ABCD): 3.23, 2.95

DISCUSSION

The monthly mean numbers of date palm scales on date palm tree sections facing the different cardinal directions are shown in Table 1.

Based on the results of this 2 year study and the significant differences found, it's obvious that the south and east facing sections of date palm trees are more likely to be infested with date palm scales, as these sections had higher numbers of date palm scales than the other sections. The differences in distribution of date palm scales might be attributed to the pooled effect of the wind direction and the duration that leaflets are exposed to the sun. The results of this study, i.e., that date palm scales prefer the southern facing sections of date palm trees, are similar to answer studies[14,15] which reported significant differences in numbers of date palm scales between the date palm tree sections facing the 4 cardinal directions. Contrary to this, other studies reported that, palm date scale infestations on date palm leaflets were highest for south facing leaflets[1,2,16,17].

The results also indicate that, in both years of the study, the palm date scales preferred the south facing sections of the date palm trees. According to this, it can be indicated that palm date scales prefer to concentrate on the southern side of date palm trees, which usually receive more sun and are relatively warmer than the other sides. This result is of great value when planning for chemical control programs against this insect. The results of this study are in agreement with another study which found that palm date scales mostly occurred on eastern and southern sections of date palm trees[18].

Regarding the distribution of date palm scales on date palm fronds, results showed that the bottom stratum of fronds was the stratum most preferred by date palm scales. In general, the bottom stratum of fronds had the highest numbers of date palm scales in all seasons of both years of the study. The differences in distribution patterns of date palm scales on the strata of fronds may be due to differences in climatic factors and other factors. Additionally, the bottom stratum of fronds provides good shelter for date palm scales

and the bottom stratum represent old leaflets, on which date palm scales may accumulate over time. The results indicate that date palm scales prefer the basal stratum of date palm fronds over the middle or apical strata. These results coincide with the findings of a previously published research which investigated the he incidence of date palm scale, *Parlatoria blanchardii* (Targ.) in western Rajasthan[14].

Overall, the percentages of the total number of date palm scales on strata of fronds in the 2 years of the study were similar, which may be because the climatic factors were very similar during 2016/2017 and 2017/2018. These results are consistent with another study which found that the bottom stratum of fronds had a higher population density of insects than the other strata, during all seasons[15]. In contrast to this, another study concluded that there were no significant differences between the population densities of scale insects on the three strata of the fronds throughout the year[18].

Due to the distribution of palm date scales on leaflet surfaces, the percentages of date palm scales on the different leaflet surfaces in each of the 2 study years were similar, which may due to the fact that climatic factors during the 2 years were very similar (Table 3). Furthermore, this pest insect preferred the upper surface of leaflets over the lower surface in all seasons of both study years. The upper surfaces of leaflet were exposed to more sunlight than the lower ones. The aforementioned results emphasize that date palm scales prefer the upper surface of date palm leaflets over the lower ones. These results are consistent with the previously mentioned study[15], which found that the upper surfaces of leaflet were more heavily infested with date palm scales than the lower ones. Results also coincide with findings of another study which investigated tropical forest and semiarid savanna plants including date palm[19].

In contrast, some studies conducted on date palm scales found that date palm scales were observed in higher numbers on the lower leaflet surfaces at the lowest part of the canopy[17,20]. This different result may be due to very high temperatures and bright sunlight at this study site.

Results depicted in Table 4 were derived from the interaction between cardinal directions (A), frond strata (B) and leaflet surfaces (C) of date palm tree so in different sampling days (D) during the two successive years of this study. The average numbers of date palm scales per leaflet resulting from combined interaction between these factors were 39.01±13.81 and 37.06±12.08 in 2016/2017 and 2017/2018, respectively.

In both years of the study, highly significant differences between numbers of date scale insects on the date palm tree sections facing the 4 cardinal directions and on the different frond strata, as well as between leaflet surfaces were found in each of year of the 2 year study, when data were evaluated for the combined effect between directions, strata, surfaces and sampling days (Table 4). These findings coincide with another studies which mentioned the same results[15,19].

Despite these benefits, further researches are required to investigate other factors that may affect the distribution of scale insects on the date palm trees such as presence of natural enemies. Advanced techniques such as molecular identification are also recommended for the classification of scale insects fauna which thought to be more accurate and reliable than the classical morphological keys used in this study.

CONCLUSION

Date palm scales were distributed on the four cardinal directions of the trees. Insects prefer to be on the southern and eastern sections of the trees as well as the bottom stratum of fronds and the upper surface of leaflets. These findings may help on formulating a selective pest control application targeting certain spots in the date palm trees without exposing the whole tree to un-preferred control materials such as insecticides.

SIGNIFICANCE STATEMENT

This study discovers the distribution of scale insects on date palm trees that can be beneficial for controlling these pests in specific spots on the trees. Besides, this study will help the researcher to uncover the critical areas of discovering hidden habitats of scale insects on date palm trees that many researchers were not able to explore.

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