FACTORS AFFECTING DISTRIBUTION PATTERNS OF THE SOFT SCALE , *PULVINARIA TENUIVALVATA* (NEWSTEAD) IN SUGAR CANE FIELDS

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Abstract

Population estimation of *P. tenuivalvata* was done in different sites of the cane field, i. e. east, north, south, west and field center. Results revealed that insect density proportionally increased from May to December in all field sites and the scales became intensive throughout September - November. It was found that plants locating in west site intensively harbored the highest population of scales followed by north site.

The number of scales on plant – east and south sites were approximately similar. Center site had the lowest number of insects. Plant infestation decreased as the distance between plant location and field boarder increased, so cane plants nearby the field boarder were heavily infested than plants far from field boarder. At the same time, the lower part of the cane plant seems to be the poorest site for insect location and feeding while the middle was the most favorable site followed by the upper part of the cane plant.

P. tenuivalvata prefers lower surface of cane leaves for settling and feeding. Nymph and adult stages showed clear preference to north-western direction of sugarcane field where its population was always abundant allover the season.

INTRODUCTION

Sugar cane is a major crop for sugar production in Egypt. This crop is attacked by many insect pests in different parts of the world, some causing crop losses while others are regarded as relatively minor pests. Scale insects *Asterolecanium bambusae, Aulacaspis tegalensis, Melanaspis glomerata, Piulvinaria iceryi* and white grubs are the major pests of sugar cane (Ne wstead, 1911, Agarwal, 1956, Mamet, 1958, Maareg *et al*, 1992, Campos, 1997). Some minor pests can, however, become serious if they spread to new areas or if susceptible varieties of sugar cane are grown.

In Egypt, Ali *et al.* (1997) recorded the soft scale *Pulvinaria tenuivalvata* on sugar cane for the first time in Giza governorate and the pest proportionally spread to other suger cane areas in upper Egypt where sugar cane is intensively cultivated for sugar production. De Lotto (1965) describeed and illustrated the adult female of *P. tenuivalvata*. It is one of a group of 5 closely relative species, native to tropica Africa that feed on grasses. Of these, *P. elongata* Newstead, *P. iceryi* (Sign.) and *P. sacchari* De Lotto have been damaging sugar cane (Mamet, 1958, Raja & Bhaskar, 1960, Rao & Sankaran, 1969, Williams 1978 & 1982, Campos, 1997).

The objective of the present paper is to shed light on field charcters, plant features and environment as factors regulating distribution and spread patterns of *Pulvinaria tenuivalvata* in suger cane fields.

MATERIALS AND METHODS

The distribution behaviour and orientation of *P. tenuivalvata* in the different sites of the suger cane field, consequently the prefered site were studied. To cope these objectives, a cane field, about one feddan, was chosen in Attfieh locality (Giza governorate). No chemical insecticides were applied. Four plots, 42 m^2 each, representing east, north, south and west directions of the cane field were determined. Regular weekly samples of 100 leaves were collected at random from each plot. Sampling commenced from late May to the end of December. In laboratory, upper and lower surfaces of each leaf were examined by means of binocular stereomicroscope and the number of existing different insect stages were counted for each direction and recorded. The most cardinal direction preferred by *P. tenuivalvata* could be determined by applying the following formula (El-Shouny, 1987).

$$H = F_{12} + F_{22} + 2 (F_1 . F_2 \cos. Q)$$

Where:

H: resultant for two different directions

F_1: number of insects in the north direction minus insect numbers in south direction, if the former is greatest and the reverse applies if the insect numbers in south direction is the greatest.

F_2: insect density in the east direction minus insect numbers in west direction, if the former is higher, and the reverse if the latter is the highest .

Cos. Q: cosine of angle between the two directions.

To study the spread pattern of the soft scale *P. tenuivalvata* allover the cane field, a sugar cane field of about one feddan was selected. During the period extending from May to December, regular random weekly samples of cane leaves were taken from the different field directions. For each direction and at definite distances of 1, 2, 3, 4, 5 m far from the field border, 10 cane plants were selected at random and 9 leaves from each plant representing lower, mid and upper leaves (3 leaves each) were cut off, kept in a muslin bag and transferred to the laboratory. Leaves of each sample were sorted to infested and noninfested leaves by visual vision. Number of insects was counted and recorded. Data were constructed in tables and insect density per plant leaf as well as infestation percent were denoted.

Statistical analysis:

The obtained data were statistically analyzed using analysis of variance (ANOVA) test using a computer program (Costat). Means were detected and compared by Duncan multiple range test at 0.05 % probability level. Standard error was also calculated.

RESULTS AND DISCUSSION

Field samples of suger cane plants infested with *P. tenuivalvata* to estimate insect population density showed considerable variations in its distribution patterns not only on plant leaves, but also in the different field sites. 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 factor in this concern. The following factors were evaluated as affecting the insect distribution and spread in suger cane fields.

1. Field direction

Results in Table 1 show that scales density propotionally increased from May to December in all field sites and the scales became intensive throughout September, October and November. Concerning horizontal distribution of *P. tenuivalvata* in different sites of the cane field, it was found that plants locating in west site were

intensively infested and harboured the highest insect population (87.1 scales / leaf) followed by north site (47.9 scales / leaf). Other field sites had lower infestation and

Table 1. Monthly counts of *P. tenuivalvata* distributed in different directions of a sugar can field , Attfieh, 1998 .

Sampling date	Total number of scales / cane leaf					Total	Mean± SE
	Direction of cane field						
	East	Nouth	South	West	Center		
May,1998	0	1	0	1	0	2	0.4±0.2
June	2	5	3	12	0	22	2.8±1.5
July	5	10	6	30	2	53	12.0±5.6
August	24	31	19	66	17	157	31.4 ±9.0
September	43	56	33	94	27	253	50.6±11.9
October	109	134	77	219	67	606	122.4±27.3
November	84	107	59	209	52	511	102.2±28.4
December	26	33	19	66	10	154	30.8±9.6
Mean ±SE	36.6 ±14.2C	47.9 ±17.9B	27.0 ±9.9C	87.1 ±29.8	21.9 ±9.0C	1758	
No. of observations	27	31	29	31	26		

Total no. of observations : 145

F-value = 17.250

$L.S.D._{0.05}$ = 2.623

scales population, but the plants located in field center exhibited the lowest scales population (17.4 scales / leaf). The number of scales on plants of the eastern and southern sites were approximately the same. These results declare the preference of *P. tenuivalvata* to west and north sites of the cane field.

In 1998-season, however infestation and insect density were higher than the preceding season, insect distribution behavior was the same Table 1. Insects intensively existed on cane plants located in west and north sites. Averages of 87.1 and 47.9 scales / leaf were recorded in those sites, while other sites showed significantly ($p > 0.05$) lower numbers of scales. Again, center site of the cane field harboured the lowest scales population. Data also indicated that 39.5 – 40 % of the

total scales population occurred in west site while 8.8 – 9.9 % of the total insect population was estimated in field center. Table 2. Approximately 50 % of scales population was found in north site. It is evident that *P. tenuivalvata* prefers cane plants locating in west and north field sites and became heavily infested rather than other sites. The prefernce of this insect pest to west and north directions could be ascribed to the direction of the wind which always blows from north to west carrying crawlers to these directions where it may aggregate for feeding and growth.

2. Field depth

Data presented in Tables 3&4 give evidences that distribution of *P. tenuivalvata* under field conditions is governed by field depth i.e. distance of cane plants from field borders. Cane plants nearby the field boarder were heavily infested and infeestation rate diminished as plants became far from field boarder. Cane plants at 1 m far from the boarder harboured the highest number of scales (95 and 109 scales / plant leaf in 1997 & 1998 seasons) followed by plants located at 2 m (50 – 51 scales), however, this density is nearly the half of insect density recorded before. As the distance between plants location and field boarder increased there was substantial decrease in the number of insect scales and became the lowest at 5 m (25 & 27 in 1997 and 1998). It could be concluded that population density of *P. tenuivalvata* in sugar cane fields decreases as the distance of cane plants from field boaeder increases and plants nearest to the boarder may suffer the heaviest infestation and harbour the highest density of insect population.

Table 2. Percentages of *P. tenuivalvata* population occurred in different sites of a Sugar can field in 1997 & 1998 season (Attfieh).

Field site	Total no. of scales/cane leaf					
	Sugarcane season			% of total insect population		
	1997	1998	Avg.	1997	1998	Avg.
East	226	293	259.5	14.3	16.6	15.5
North	376	377	376.523.9	23.9	21.4	22.7
South	194	216	205.0	12.4	12.3	12.4
West	639	697	668	40.6	39.94	40.1
Center	139	175	157.0	8.8	9.9	9.4
Total	1574	1758	1666.0			

Table 3. Mean numbers of *P. tenuivalvata* scales on leaves of a Sugarcan plants located at different distance from the field west boarder, Attfieh, 1997.

Sampling date	Total number of scales / cane leaf					Total	Mean ±SE
	Field depth						
	1 m.	2 m.	3 m.	4 m.	5 m.		
May,1997	3	1	0	0	0	4	0.8±0.6
June	7	7	3	0	0	17	3.4±1.6
July	14	6	6	6	1	33	6.6±2.1
August	12	7	7	5	4	35	7.0±1.4
September	23	8	7	6	5	49	9.8±3.3
October	12	9	4	5	8	38	7.6±1.4
November	22	10	7	6	6	51	10.2±3.03
December	2	2	1	0	1	6	1.2±0.4
Total	95A	50B	35C	28C	25C		
% of total population	40.6d	21.4b	15.4bc	11.9cd	10.7d		
No. of observations	29	26	25	24	22		

Total no. of observations =126

F-value = 56.278

L.S.D $_{0.05}$ *= 10.195*

Table 4. Mean numbers of *P. tenuivalvata* scales on leaves of a Sugarcan plants located at different distance from the field west boarder, Attfieh, 1998.

Sampling date	Total number of scales / cane leaf					Total	Mean ±SE
	Field depth						
	1 .m	2 m.	3 m.	4 m.	5 m.		
May,1997	1	1	0	0	0	2	0.4±0.2
June	12	3	5	1	0	21	4.2±2.1
July	17	5	6	5	1	34	6.8±2.7
August	16	9	7	4	5	41	8.2±2.1
September	20	10	6	7	6	49	9.8±2.7
October	18	9	9	7	6	49	9.8±2.1
November	14	7	11	7	6	45	9.0±1.5
December	11	6	5	5	3	30	6.0±1.3
Total	109a	51b	49bc	26c	27cd		
% of total population	41.6a	19.5b	18.7bc	9.9cd	10.3d		
No. of observations	31	30	27	27	23		

Total no. of observations =138

F-value = 49.326

$L.S.D_{0.05} = 0.218$

3. Plant level

Results on vertical distribution of the soft scale *P. tenuivalvata* at different levels (lower, middle, upper) of sugar cane plants for the seasons 1997 & 1998 showed close relationship between plant level and number of scales presented at different levels. In general, plant leaves existing at the middle level of cane plant suffered the heaviest infestation Tables 5, 6, 7. The mean number of scales at the middle level (97.8, 107.1 scales) was comparatively higher than that at the upper (68.3, 81.4 scales) or lower (30.8, 31.3 scales) levels and those numbers constituted 49.7% and 48.7% of the total insect population existed in 1997 and1998 seasons which were significantly ($p > 0.05$) higher than the upper (34.7%, 37.1%) or the lower (15.6%, 14.2%) levels. Leaves located at the lower plant level harbored the lowest number of insects Accordingly it could be concluded that the lower part of the sugar cane plant seems to be the poorest site for *P. tenuivalvata* location and feeding, while the middle one is the most favorable site followed by upper part. This phenomenon was ascertained throughout the whole insect activity period (May – December) and in October to November in particular.

4. Leaf surface

Immature and mature stages of *P. tenuivalvata* showed substantial variation in their distribution patterns on the lower and upper surfaces of sugar cane plant leaves. As indicated by the number of insects Tables 8 & 9. Lower leaf surface was highly populated with insects than the upper surface . In 1997-season, the number of scales counted on the lower surface averaged 168 scales which constitutes 88.7% of the total scales existing on lower and upper leaf surfaces. This phenomenon was commonly occurred on sugar cane plant leaves overall the season and became evident during summer and fall months.

Results in Table 9 show that insect distribution on lower and upper leaf surfaces in 1998-season behaved similarly to the preceding season. Lower leaf surface was heavily infested than the upper one. The overall mean number of scales on lower leaf surface averaged 179.6 scales which is nearly 6-times that existed on the upper surface (31 scales). Insect population on lower leaf surface constituted 65.2, 95.3% of the total number of insects, while these values ranged between 4.7% and 34.8% on the upper surface of plant leaf.

Table 5. Effect of field depth on *P. tenuivalvata* distribution in a Sugarcan field (Attfieh, 1997 & 1998) .

Direction	season	Field depth (distance from boarder)					ΣX	Mean ± SE
		1 .m	2 m.	3 m.	4 m.	5 m.		
West	1997	95	50	35	28	25	233	46±12.8
	1998	109	51	49	26	27	262	52.4±15.1
North	1997	63	44	26	19	18	170	34.0±8.6
	1998	62	34	37	26	29	188	37.6±6.4
South	1997	47	37	33	24	15	156	31.2±5.5
	1998	68	36	32	33	28	197	39.4±7.3
East	1997	54	38	29	22	19	162	32.4±6.3
	1998	46	40	38	29	29	182	36.4±3.3
Mean ±SE	1997	64.75 ±10.6	42.25 ±3.01	31.0 ±2.2	23.25 ±1.89	19.25 ±2.09	170.5 ±18.06	
	1998	71.25 ±13.41	40.25 ±3.79	39.0 ±3.58	28.5 ±1.66	28.25 ±0.48	207.25 ±18.51	

	1997	*1998*
F	*56.278*	*49.325*
L.S.D.	*0.1950*	*0.2180*

Table 6. Monthly density of *P. tenuivalvata* scales on leaves at different levels of a Sugar-can plant , Attfieh, 1997.

Sampling date	Mean no. of scales/can leaf				
	Sugarcane plant level			Total	Mean ±SD
	Lower	Middle	Upper		
May,1997	4	1	0	5	1.7±1.2
June	12	5	2	19	6.3±3.0
July	33	19	10	62	20.7±6.7
August	74	53	36	163	54.3±11
September	62	114	68	184	61.3±16.4
October	44	214	157	415	138.3±50
November	17	291	226	534	178±82.7
December	0	85	47	132	44±34.8
±Mean ±SD	30.8±9.7c	97.8±37.2a	68.3±28.9b		
No. observations	26	30	28		

Total no. of observations = 84

F-value = 3.129

L.S.D $_{0.05}$ *= 6.284*

Table 7. Monthly density of *P. tenuivalvata* scales on leaves at different levels of a Sugar-can pland , Attfieh, 1998.

Sampling date	Mean no. of scales/can leaf				
	Sugarcane plant level			Total	Mean ±SD
	Lower	Middle	Upper		
May,1998	2	0	0	2	0.66±0.7
June	13	8	1	22	7±3.5
July	33	12	8	53	17.7±7.8
August	83	43	31	157	52.3±15.7
September	73	112	68	253	84.3±30.4
October	44	321	241	606	202±82.3
November	2	268	241	511	170.3±84.5
December	0	93	61	154	34.7±27.3
Mean ±SD	31.3±11.7b	107.1±43.6a	81.4±36a		
No. observations	24	30	27		

Total no. of observations =81

F-value = 3.587

L.S.D $_{0.05}$ = 8.030

Table 8. Monthly counts of P. *tenuivalvata* scales on lower and upper surface of sugar cane leaf, Attfieh, 1997.

Sampling date	Mean no. of scales/can leaf				
	Total no. of scales	Leaf surface		%of total population	
		Lower	Upper	Lower	Upper
May,1997	6.0	6.0	0.0	100.0	0.00
June	29	26	3	89.7	10.3
July	66	54	12	81.8	18.2
August	145	129	16	88.9	11.1
September	238	209	29	87.8	12.2
October	400	356	44	89.0	11.0
November	514	456	58	88.7	11.3
December	117	108	9	92.3	7.7
Mean ±SD	189.4±64.6	168.0±57.4*	21.4±7.3	88.72	11.29%
No. observations	32	32	26		

Total no. of observations =90

F-value = 30.120

Probability: >0.05

Table 9. Monthly counts of *P . tenuivalvata* scales on lower and upper surface of sugar cane leaf, Attfieh, 1998.

Sampling date	Mean no. of scales/can leaf				
	Total no. of scales	Leaf surface		%of total population	
		Lower	Upper	Lower	Upper
May,1998	3	3	0	100	0.0
June	19	14	15	73.7	26.3
July	62	45	17	65.2	34.8
August	168	136	32	81	19
September	258	197	61	76.4	23.6
October	558	495	63	88.7	11.3
November	509	444	65	87.2	12.8
December	108	103	5	95.3	4.7
Mean ±SD	210.6±76.3	179.6±67.4**	31. ±10	85.28	14.72%
No. observations	32	32	25		

Total no. of observations = 89

F-value = 44.91

Probability: > 0.05 (Highly significant)

Based on the previous results, it is evident that *P. tenuivalvata* prefers lower leaf surface for settling and feeding and behaves as photonegative insect . Studies on the activity behavior and distribution patterns of scale insects showed preferred site for feeding and multiplication within its host plant and almostly this site occurs in a definite cardinal direction. Site direction is selected by the only mobile stage (1^{st} nymph instar). So the preferred site of the host plant by adult stage in fact is a nymph-choice. Nymph and adult stages of *P. tenuivalvata* showed preference to north-western direction of the sugar cane plant where its population was usually abundant allover the season.

Generally, most insect species and scale insects in particular exhibit a preferred site of their host plants and the direction of this site may differ with different insect species. North and eastern tree directions were found to be preferred by the lace poor bug, *Etephanitis pyri* (El-Saadany *et al.* 1978). The preference of *P. tenuivalvata* to west direction corresponds the finding achieved by El-Sayed *et al.* (1978) on *Aphis craccivora*. Similarly, many insect species showed significant differences in their density on the different heights or plant levels. This result agrees with distribution pattern of *P. tenuivalvata* on different levels of sugar cane plant. The preference of middle level of sugar cane plant may be due to the abundance of nutrient and leaf age. Although upper leaves of the plant are succulent with more sap, the insect preferred leaves of the middle plant level with less sap but with more nutrients. Lower leaves usually are the oldest which are the poorest in nutrients and

unfavorable for insect feeding, therefore, they had the lowest insect population. Preferred direction and site of a host plant by scale insects seem to be of great importance when planning for control measure program.

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العـوامل المؤثـــرة في توزيع الحشـــرة القشـــرية الرخوة بولفيناريا تينوفلفاتا في حقـــول القصب

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تم تقدير المجموع الحشري للبولفيناريا تينوفالفتا في مواقع مختلفة من حقل القصب (الشرق، الشمال ، الجنوب ، الغرب) وكذلك في وسط الحقل وتشير النتائج بارتفاع الكثافة العددية خلال سبتمبر – نوفمبر وقد وجد ان اعلي كثافة للمجموع في غرب الحقل يليه الشمال وتتماثل أعداد الحشرات القشرية في اتجاهي الشرق والجنوب من الحقل تقريبا.

وتتناقص اعداد النباتات المصابة كلما اتجهنا من خارج الحقل الي الداخل كذلك تعتبر المنطقة السفلي من النباتات اقل مناطق النباتات اصابة. بينما المنطقة الوسطي اشد المناطق اصابة تليها المنطقة العليا .

وتفضل الحشرات السطح السفلي للاوراق سواء الحوريات أو الحشرات الكاملة حيث تفضل الاتجاه الجنوبي والغربي من الحقل طوال الموسم.