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Population Density and Spatial Distribution Pattern of *Empoasca decipiens* (Hemiptera: Cicadellidae) on Different Bean Species

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ABSTRACT

The population density and spatial distribution pattern of *Empoasca decipiens* Paoli were determined in Tehran area, Iran, during 2004-2005 on four species of common bean *Phaseolus vulgaris* (L.) var. Talash, lima bean *P. lunatus* (L.) Savi ex Hassk. var. Sadaf, rice bean *P. calcaratus* Roxb. var. Goli and cowpea *Vigna sinensis* (L.) var. Parastoo. The higher and lower mean population densities of *E. decipiens* per leaf were observed on Parastoo cowpea (18.85 in 2004 and 29.94 in 2005) and Talash common bean (1.08 in 2004 and 0.37 in 2005), respectively. Spatial distribution pattern of *E. decipiens* was described on these four bean species using variance to mean ratios, Taylor's power law coefficients and Iwao's patchiness regression methods. The spatial distribution pattern of this pest in most cases was aggregated and in a few cases random. In 2004, collected data were in a better fitting with Taylor's model in comparison with Iwao's model on Talash common beans (r^2= 0.879) as well as on Goli rice bean (r^2= 0.967). Iwao's model explained the distribution data of 2004 and 2005 on Sadaf lima beans (r^2= 0.746 and 0.906, respectively) more appropriately than Taylor's model (r^2= 0.541 and 0.828, respectively). It is concluded that bean species influence the population density and spatial distribution pattern of *E. decipiens*. Spatial distribution parameters can be employed to develop a sampling program and to estimate the population density of this pest.

Keywords: Bean species, *Empoasca decipiens*, Leafhopper, Population density, Spatial distribution.

INTRODUCTION

Greenhouse leafhopper, *Empoasca decipiens* Paoli is an extremely polyphagous species and serious pest to a wide range of economically important crops including bean in Iran (Kheyri 1989; Rassoulian *et al.,* 2005; Naseri *et al.,* 2007) as well as in many other parts of the world (Atlihan *et al.,* 2003; Jan *et al.,* 2003; Umesh and Rajak, 2004; Genceoylu and Yalcin, 2004). Adults and nymphs feed on the host plant leaves. This leafhopper usually colonizes the undersurface of leaves, inserting its mouthparts into the plant tissue to extract plant juice. Females lay their eggs within the leaf vein tissue (Raupach *et al.,* 2002; Backus *et al.*, 2005).

The methods for estimating population densities in arthropods are the cornerstone of basic research on agricultural ecosystems and the principal tool for establishing the implementation of pest management programs (Kogan and Herzog, 1980). Therefore reliable sampling program includes identification of the appropriate sampling time, sampling unit, determination of pattern of sampling (randomness) as well as sample size (Pedigo and Buntin, 1994; Boeve and Weiss, 1998; Bins *et al.,* 2000; Southwood and Henderson, 2000). A sampling program

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can be used in ecological investigations (Faleiro *et al.,* 2002), study of population dynamics (Jarosik *et al.,* 2003), detecting pest levels that lead to a justification of control measures (Arnaldo and Torres, 2005) as well as in assessing crop loss (Haughes, 1996).

The most common methods employed to describe the patterns of dispersion of arthropod populations have been summarized by Southwood and Henderson (2000). Several estimates based on the dispersion coefficient, *k*, of the negative binomial distribution and on the relationship between variance and mean are employed as indices of aggregation (Ludwig and Reynolds, 1988; Krebs, 1999; Southwood and Henderson, 2000). Sampling plans based on these indices optimize the sampling effort as well as sampling precision (Kuno, 1991). Sequential sampling plans are employed to more efficiently identify mean pest populations at or above the economic threshold. These plans have reduced the time required for sampling up to 50%, in comparison with conventional sampling plans (Pedigo and Zeiss, 1996; Patrick *et al.,* 2003). Although the objectives of sampling a finite population can differ, the development of a sampling procedure requires the knowledge concerning the spatial distribution of populations (Liu *et al.,* 2002).

Sampling programs for *E. decipiens* and related species have been described. The effects of different host plants on several *Empoasca* spp. were evaluated under single and mixed crop conditions using the D-vac suction sampler in Nigeria in 1992-1994 (Bottenberg *et al.,* 1998). Population fluctuations and diurnal activity of *E. decipiens* on some summer crops such as common bean, *Phaseolus vulgaris* (L.), a cowpea, *Vigna unguiculata* (L.) Walp, and a mung bean, *Vigna radiata* (L.) Wilczek, using the sweep net technique were studied in Egypt. Leafhopper population peaks occurred on 8th May 2001 on early summer crops and on 5th June and 31th July 2001 on late summer crops (Ebadah, 2002). Population densities of *E. decipines* were also determined in Egypt by means of sweep-net and light-trap (Ammar *et al.*, 1977). They suggested that *E. decipiens* populations were high in the warmer months regardless of relative humidity and that monthly sweep-net samples caught leafhoppers in 19 field crops, especially broad bean. The average aggregation levels of grape leafhopper *Empoasca vitis* (Goethe) were determined using the statistical coefficient of dispersion (CD) based on the variance to mean ratio ($CD= S^2/m$) (Decatne and Helden, 2006). A random spatial distribution pattern was recorded for green leafhopper *Empoasca kraemeri* Ross and Moore in a white bean field as well as its aggregation per bean leaf (Heyer and Dammer, 1996).

In spite of the importance of *E. decipiens*, an efficient sampling program has not been developed nor has the spatial distribution described. The objective of this study was to develop a sampling program for *E. decipiens* on beans and to note differences in spatial distribution and abundance of the pest on different bean species in Tehran area, Iran during two growing seasons. The results can be employed to optimize the monitoring methods for establishing IPM strategies against the pest.

MATERIALS AND METHODS

Experimental Protocol

The experiments were carried out in a research field of Tarbiat Modares University in the suburbs of Tehran, Iran, during 2004–2005. Common bean *P. vulgaris* (L.) var. Talash, lima bean *P. lunatus* (L.) var. Sadaf, rice bean *P. calcaratus* var. Goli and cowpea *Vigna sinensis* (L.) var. Parastoo were planted in a randomized complete block design. A field of 35×18 m was divided into four blocks of 4×32 m, each block being consisted of four plots of 4×8 m each. There was no other leafhopper host-plant in the plots' surroundings. The specimens counted on the leaves were left over on the bean species. For a duration of two years, nymph and adult leafhopper population densities as well as spatial distributions were followed up and determined for the four bean species.

Sampling Program

Sampling Unit

One leaf of a bean plant was selected as a sample unit. Randomly selected leaves were visually inspected to note the number of nymphs and adults of *E. decipiens* per leaf to get an unbiased estimate of the population mean (Pedigo and Buntin, 1994).

Pattern and Timing of Sampling

Sampling of bean leaves as well as the movement among plants were performed randomly. Sampling was conducted at time intervals of 3-4 days in 2004 and weekly in 2005. All the counts were performed in mid-morning. Sampling started on 7th August in 2004 and on 11th June in 2005 and continued until late October.

Sample Size

Primary sampling was carried out in an equal number of different bean species on 6th August and 10th June of 2004 and 2005, respectively. Relative variation (RV) has been employed to compare the efficiency of various sampling methods (Hillhouse and Pitre, 1974). RV for these leaf data was calculated as follows:

$RV = (SE/m)\ 100$

where *SE* is the standard error of the mean and *m* is the mean of primary sampling data. The reliable sample size was determined using the following equation:

$N = [ts/dm]^2$

where *N*= Sample size, *t*= *t*-student, *s*= standard deviation, *d*= Desired fixed proportion of the mean and *m*= The mean of primary data (Pedigo and Buntin, 1994).

Population Density

The population density of *E. decipiens* was determined in plots of different bean species from 7th August to 19th October in 2004 and from 11th June to 15th October in 2005. The mean densities of nymphs and adult leafhoppers were statistically analyzed through analysis of variance (ANOVA) and compared among four bean species within each sampling date and for overall dates.

Spatial Distribution Pattern

The spatial distribution of *E. decipiens* was determined through some three methods: the variance (S^2) to mean (m) ratio, Taylor's power law and Iwao's patchiness regression models (Pedigo and Buntin, 1994). Departure from a random distribution was tested by calculating the index of dispersion, I_D, where *n* is the number of samples:

$I_D = (n-1)\ S^2/m$

In the next stage, *Z* coefficient was calculated for testing the goodness-of-fit:
where *v* was the number of degree of freedom (n-1). Taylor's power law was calculated as follows:

$Z = \sqrt{2I_D} - \sqrt{2v-1}$

$S^2 = am^2$ or $\log S^2 + b \log m$

where the parameter *a* is a scaling factor related to sample size (Southwood and Henderson, 2000) and the slope *b* is an index of aggregation. Iwao's patchiness regression method was used to quantify the relationship between mean crowding index (m^*) and mean (m) using the following equation:

$m^* = \alpha + \beta m$

where α indicates the tendency to either crowding (positive) or repulsion (negative) and β reflects the distribution of population in space and is interpreted in the same manner as *b* in Taylor's power law. Student *t*-test can be used to determine if the colonies are randomly dispersed.

RESULTS

Sampling Program

From the primary sampling, the reliable leaf sample size with a maximum variation for a precision of 20% was about 40 samples. The relative variation (RV) of the primary sampling data was about 10%, very appropriate for a sampling program (Table 1).

Population Density

The population density estimated as the mean number of insects (nymphs and adults) per leaf on four different bean species for years 2004 and 2005 is shown in Tables 2 and 3. The results indicate that the four bean species showed significant differences (P< 0.01) in the densities of leafhopper in the overall dates. In both years, the highest and

Table 1. Estimated parameters by primary sampling of *E. decipiens* on different bean species during 2004 and 2005.

Date	n[a]	SE[b]	SD[c]	RV[d]	m[e]	d[f]	N[g]
2004	289	0.096	1.63	10.89	0.879	0.20	40
2005	460	0.021	0.398	10.65	0.197	0.20	40

[a] Number of samples, [b] Standard error of the mean, [c] Standard deviation of the mean, [d] Relative variation, [e] Mean of primary data, [f] Desired fixed proportion of the mean and [g] Sample size.

Table 2. Mean (±SE) population density of nymphs and adults of *E. decipiens* on four bean species (varieties) in several sampling dates of the year 2004.

Sampling date	*V. sinensis* (Parastoo) cowpea	*P. calcaratus* (Goli) rice bean	*P. lunatus* (Sadaf) lima bean	*P. vulgaris* (Talash) common bean
7 August	14.65 ± 1.63 a[a]	0.53 ± 0.11 b	1.80 ± 0.36 c	0.45 ± 0.11 b
10 August	16.85 ± 2.29 a	0.48 ± 0.2 b	2.23 ± 0.31 c	0.50 ± 0.12 b
13 August	17.20 ± 2.82 a	1.60 ± 0.27 b	2.73 ± 0.69 b	1.05 ± 0.25 b
16 August	20.23 ± 2.41 a	3.63 ± 0.64 b	3.72 ± 0.63 b	0.65 ± 0.14 c
19 August	21.20 ± 2.33 a	4.48 ± 0.68 b	2.90± 0.48 b	0.63 ± 0.12 c
23 August	34.18 ± 3.01 a	4.28 ± 0.58 b	2.30± 0.48 b	0.70 ± 0.15 c
27 August	34.85 ± 2.32 a	4.28 ±0.58 b	1.90 ± 0.59 c	1.05 ± 0.25 c
1 September	33.48± 2.34 a	4.40 ± 0.80 b	1.63 ± 0.38 c	1.10 ± 0.20 c
4 September	23.60 ± 2.27 a	4.95 ± 0.61 b	3.20 ± 0.39 b c	1.68 ± 0.21 c
7 September	35.08 ± 2.30 a	3.78 ± 0.43 b	2.50 ± 0.91 b	3.08 ± 0.36 b
10 September	34.85 ± 2.32 a	2.50 ± 0.39 b	1.90 ± 0.59 b	2.25 ± 0.34 b
14 September	30.08 ± 2.38 a	2.73 ± 0.38 b	2.00 ± 0.46 b	1.50 ± 0.25 b
18 September	24.50 ±1.78 a	2.25± 0.32 b	2.80 ± 0.56 b	2.10 ± 0.26 b
21 September	17.33 ±1.00 a	1.45± 0.21 b	2.10± 0.49 b	1.30 ± 0.20 b
25 September	14.40 ± 1.08 a	1.05 ± 0.19 b	1.23± 0.25 b	0.75 ± 0.16 b
29 September	9.15 ± 0.77 a	0.95 ± 0.17 b	0.67 ± 0.14 b	0.60 ± 0.12 b
2 October	8.48 ± 0.87 a	0.08 ± 0.17 b	0.97 ± 0.16 b	0.78 ± 0.16 b
6 October	4.45 ± 046 a	0.70 ± 0.15 b	0.63 ± 0.18 b	0.60 ± 0.18 b
11 October	3.95 ± 030 a	0.68 ± 0.12 b	1.20 ± 0.23 b	0.65 ± 0.14 b
15 October	2.55 ± 0.31 a	0.6 ± 0.12 b	0.70 ± 0.15 b	0.75 ± 0.13 b
19 October	1.83 ± 0.26 a	0.33 ± 0.08 b	0.60 ± 0.14 b	0.43 ± 0.09 b
Overall dates	18.85 ± 0.57 a	2.12 ± 0.10 b	1.75 ± 0.11 b	1.08 ± 0.05 c

[a] The means followed by different letters in the same row are significantly different (p< 0.01, LSD).

lowest population densities of the pest occurred in the warmer months (August and September) and in late October, respectively. During 2004 and 2005, the highest and lowest population densities of *E. decipiens* were recorded as significant on Parastoo cowpea and Talash common bean respectively, which were significantly different from those on the other two bean species. The highest population densities of *E. decipiens* on Parastoo cowpeas, Goli rice beans, Sadaf lima beans and Talash common beans were 35.08, 4.95, 3.72 and 3.08 individuals per leaf respectively in 2004, while 34.48, 2.92, 2.57 and 0.77 individuals per leaf respectively for 2005.

Spatial Distribution

The results of the variance to mean ratio (S^2/m), coefficient of dispersion (I_D) and Z test are presented in Table 4. The results obtained of the two sampling years indicated that the spatial distribution in all the bean species was aggregated.

In Taylor's model, the regression between log S^2 and log m was significant for the four bean species (P< 0.01). For year 2004, Taylor's slope was significantly greater than unity for all the four bean species (Table 5). The calculated t (t_c) was greater than t-table (t_t) for Parastoo cowpeas and Talash common beans indicating an aggregated spatial distribution of *E. decipiens*, whereas Goli rice beans and Sadaf lima beans had t_c's less than t_t, indicating a random spatial distribution of *E. decipiens*. In 2005, Taylor's slope was varied from 1.0 to 1.59. On Parastoo cowpeas and Goli rice beans the spatial distribution of *E. decipiens* was aggregated, as against random on Talash common beans and Sadaf lima beans (Table 5).

Iwao's model showed that there was a significant relationship between the mean crowding and the density of *E. decipiens* (Table 5). During these two sampling years, Parastoo cowpeas, Goli rice beans and Sadaf

Table 3. Mean (±SE) population density of nymphs and adults of *E. decipiens* on four bean species (varieties) in several sampling dates of the year 2005**.**

Sampling date	*V. sinensis* (Parastoo) cowpea	*P. calcaratus* (Goli) rice bean	*P. lunatus* (Sadaf) lima bean	*P. vulgaris* (Talash) common bean
11 June	0.45 ± 0.09 a[a]	0.12 ± 0.05 b	0.02 ± 0.02 b	0.02 ± 0.02 b
18 June	0.70 ± 0.13 a	0.05 ± 0.03 b	0.05 ± 0.03 b	0.05 ± 0.03 b
25 June	2.32 ± 0.45 a	0.15 ± 0.27 b	0.60 ± 0.17 b	0.10 ± 0.05 b
2 July	7.65 ± 1.07 a	0.47 ± 0.11 b	0.20 ± 0.11 b	0.17 ± 0.12 b
9 July	11.83 ± 1.65 a	1.92 ± 0.22 b	1.10 ± 0.24 b	0.15 ± 0.08 b
16 July	13.98 ± 1.63 a	1.82 ± 0.21 b	0.80 ± 0.15 b	0.20 ± 0.09 b
23 July	17.00 ± 2.23 a	2.02 ± 0.22 b	1.00 ± 0.19 b	0.35 ± 0.09 b
30 July	10.33 ± 1.29 a	0.60 ± 0.14 b	0.32± 0.08 b	0.13 ± 0.07 b
6 August	34.48 ±3.67 a	1.20 ± 0.21 b	0.95 ± 0.17 b	0.77 ± 0.16 b
14 August	29.70 ± 3.96 a	1.40 ± 0.29 b	2.57 ± 0.52 b	0.62 ± 0.14 b
20 August	25.25 ± 2.81 a	1.85 ± 0.36 b	1.17 ± 0.27 b	0.52 ± 0.12 b
27 August	20.05 ±1.87 a	2.92 ± 0.56 b	1.72 ± 0.32 b	0.70 ± 0.14 b
3 September	23.20 ±1.69 a	2.75 ± 0.49 b	1.30 ± 0.28 b	0.72 ± 0.14 b
10 September	13.90 ± 1.57 a	1.45 ± 0.32 b	1.47 ± 0.32 b	0.52 ± 0.15 b
17 September	14.70 ±1.83 a	2.02 ± 0.38 b	1.55 ± 0.35 b	0.60 ± 0.16 b
24 September	11.65 ± 1.14 a	1.10 ± 0.21 b	0.70 ± 0.16 b	0.50 ± 0.13 b
1 October	5.87 ± 0.82 a	0.47 ± 0.11 b	0.57 ± 0.12 b	0.27 ± 0.09 b
8 October	1.72 ± 0.43 a	0.37 ± 0.11 b	0.22 ± 0.0.7b	0.57 ± 0.09 b
15 October	0.70 ± 0.18 a	0.20 ± 0.07 b	0.12 ± 0.05 b	0.10 ± 0.05 b
Overall dates	29.94 ± 0.55 a	0.21 ± 0.07 b	0.87 ± 0.06 c	0.37 ± 0.03 d

[a] The means followed by different letters in the same row are significantly different (p< 0.01, LSD).

Table 4. Spatial distribution patterns of *E. decipiens* on four bean species during 2004-2005 using the variance to mean ratio (index of dispersion), and the Z coefficient for testing the goodness-of-fit.

Year	Bean species	Variety and common name	S^2/m	I_D	Z
2004					
	P. vulgaris	Talash common bean	1.88	1499.72	14.81
	P. lunatus	Sadaf lima bean	3.07	2453.48	30.09
	P. calcaratus	Goli rice bean	3.99	3192.01	39.94
	V. sinensis	Parastoo cowpea	13.74	10978.26	108.22
2005					
	P. vulgaris	Talash common bean	1.49	1130.91	8.61
	P. lunatus	Sadaf lima bean	2.87	2178.33	27.05
	P. calcaratus	Goli rice bean	2.89	2193.51	27.28
	V. sinensis	Parastoo cowpea	17.88	13570.72	125.80

Table 5. Spatial distribution of *E. decipiens* on different bean species in 2004 and 2005 using Taylor's power law and Iwao's patchiness regression analysis.

	Bean species (variety)	Parameters estimation					Test for slope	
		a ± SE	Slope ± SE	r^2	P_a	P_{slope}	t_c	t_t
2004								
Taylor's	*P. vulgaris* (Talash) common bean	0.12 ± 0.03	1.24 ± 0.11	0.879	0.000	0.000	2.277	2.093
	P. lunatus (Sadaf) lima bean	0.19 ± 0.09	1.24 ± 0.26	0.541	0.054	0.000	0.934	2.093
	P. calcaratus (Goli) rice bean	0.14 ± 0.03	1.60 ± 0.06	0.967	0.000	0.000	0.767	2.093
	V. sinensis (Parastoo) cowpea	-0.18 ± 0.16	1.72 ± 0.13	0.896	0.275	0.000	5.448	2.093
Iwao's	*P. vulgaris* (Talash) common bean	0.10 ± 0.16	1.24 ± 0.13	0.828	0.564	0.000	1.860	2.093
	P. lunatus (Sadaf) lima bean	-0.44 ± 0.50	1.87 ± 0.25	0.746	0.391	0.000	3.508	2.093
	P. calcaratus (Goli) rice bean	-0.44 ± 0.29	1.73 ± 0.11	0.928	0.142	0.000	6.636	2.093
	V. sinensis (Parastoo) cowpea	1.40 ± 1.46	1.18 ± 0.07	0.943	0.351	0.000	2.727	2.093
2005								
Taylor's	*P. vulgaris* (Talash) common bean	-0.22 ± 0.06	1.00 ± 0.09	0.880	0.003	0.000	0.000	2.110
	P. lunatus (Sadaf) lima bean	-0.12 ± 0.08	1.20 ± 0.13	0.828	0.129	0.000	1.562	2.110
	P. calcaratus (Goli) rice bean	-0.09 ± 0.05	1.26 ± 0.09	0.918	0.071	0.000	2.954	2.110
	V. sinensis (Parastoo) cowpea	-0.09 ± 0.06	1.59 ± 0.06	0.972	0.163	0.000	9.365	2.110
Iwao's	*P. vulgaris* (Talash) common bean	-0.30 ± 0.12	0.84 ± 0.263	0.336	0.022	0.005	0.619	2.110
	P. lunatus (Sadaf) lima bean	-0.65 ± 0.12	1.537 ± 0.12	0.906	0.000	0.000	4.568	2.110
	P. calcaratus (Goli) rice bean	-0.64 ± 0.139	1.40 ± 0.01	0.932	0.000	0.000	4.494	2.110
	V. sinensis (Parastoo) cowpea	-0.21 ± 0.49	1.21 ± 0.03	0.989	0.670	0.000	7.000	2.110

lima beans hosted an aggregated (slope> 1) spatial distribution of *E. decipiens*, while Talash common beans bore a random pattern with t_c less than t_t.

DISCUSSION

The most commonly employed methods for sampling leafhoppers are direct observa-

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tions and suction net in soybean fields (Kogan and Herzog, 1980) and sweep-net in bean crops (Ebadah, 2002). Here, bean leaf was selected as the sampling unit to estimate the number of *E. decipiens*. Direct observation of single plants is particularly useful for sampling nymphal stages of leafhoppers (Mayse *et al.,* 1978).

The observed differential population densities on different beans are likely to be somehow related to the presence of densely hooked trichomes on the leaves. Robbins and Daugherty (1969) found that glabrous varieties of soybean *Glycine max* (L.) Merr., bore both the highest numbers of *Empoasca fabae* (Harris) and highest ovipositional rates, while densely pubescent varieties had the lowest number and The lowest incidence of oviposition. More specifically, it appears that the length and orientation of leaf hairs rather than density alone (Broersma *et al.,* 1972), contribute to protection of most commercial soybean varieties from serious leafhopper damage. The absence of trichomes, softness of leaf tissues, the large size of the leaves and long growing period of Parastoo cowpea may be the most important reasons for host-plant suitability, which leads to an increase in the population density of *E. decipiens*.

The variance to mean ratio indicated that *E. decipiens* had an aggregated distribution on all bean species. But, regression models of Taylor's power law and Iwao's patchiness showed the random distribution pattern on some bean species, suggesting that the different statistical methods have various results and accuracies in calculating spatial distribution of *E. decipiens*. The random distribution can be due to the lower population density of *E. decipiens* on some of the bean species. By calculating the coefficient of dispersion (CD), Decante and Helden (2006) determined that the grape leafhopper *E. vitis* is of an aggregated spatial distribution in vineyards. This result is similar to our findings of *E. decipiens* on Parastoo cowpeas, Goli rice beans and Sadaf lima beans using Iwao's regression model for 2004. Their results are also in agreement with the results of Taylor's power law model for 2004 samples on Talash common beans and Parastoo cowpeas as well as for 2005 samples on Parastoo cowpeas and Goli rice beans. Heyer and Dammer (1996) reported that the spatial distribution of green leafhopper *E. kraemeri* may be either random or aggregated depending on its type of habitat. At higher population densities, random spatial patterns of potato leafhopper, *E. fabae* nymphs were noted after using Poisson statistical distribution on curly pubescent soybean (Kogan and Herzog, 1980). This is the same as our results of *E. decipiens* on Talash common beans using Iwao's regression model and also similar to our results using Taylor's model for 2004 samples on Goli rice beans and Sadaf lima beans as well as for 2005 samples on Talash common beans and Sadaf lima beans.

Both Taylor's and Iwao's models indicated an aggregated distribution on Parastoo cowpeas for years 2004 and 2005 (Table 5). This is probably due to the high population density on bean leaves or to some particulars of the leafhopper behavioral characteristics. However, in 2004, the data obtained for Talash common beans fitted better Taylor's model than Iwao's model (r^2= 0.879, Taylor's) and the same was true for Goli rice beans (r^2= 0.967, Taylor's). In the two sampling years, data from Sadaf lima beans fitted better Iwao's model (r^2= 0.746 and 0.906) in contrast with Taylor's (r^2= 0.541 and 0.828).

CONCLUSIONS

In this research it was demonstrated that the different bean species had significant effects on the population density and spatial distribution pattern of *E. decipiens*. The coefficients of the spatial distribution models can be used in developing a sampling program, detecting pest levels that justify control measures as well as in assessing crop loss of different species of beans.

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REFERENCES

1. Ammar, E. D., Nahal, E. L., El-Bolok, A. K. M., Nahal, M. M., Bolok. A. K. M. and Bolok, M. M. E. L. 1977. Fluctuations of Population Densities of *Empoasca decipiens* Paoli and *Balctutha hortensis* Lindb at Giza, Egypt (Homoptera: Cicadellidae). *Egypt. Bull. Soc. Entomol.,* **61**: 245-255.
2. Arnaldo, P. S. and Torres, L. M. 2005. Spatial Distribution and Sampling of *Thaumetopoea pityocampa* (Lep. Thaumetopoeidea) populations of *Pinus pinaster* Ait. in Montesinho, N. Portugal. *For. Ecol. Manage.,* **210:** 1-7.
3. Atlihan, R. E., Yardim, N., Ozgokce, M. S. and Kaydan, M. B. 2003. Harmful Insects and Their Natural Enemies in Potato Fields in Van Province. *J. Agri. Sci.,* **9**: 291-295.
4. Backus, E. A., Serrano, M. S. and Ranger, C. M. 2005. Mechanism of Hopperburn: An Overview of Insect Taxonomy, Behavior and Physiology. *Ann. Rev. Entomol.,* **50**: 125-151.
5. Binns, M. R., Nyrop, J. P., Werf, W., van der, 2000. *Sampling and Monitoring in Crop Protection Theoretical Basis for Developing Practical Decision Guides*. CABI Publishing, UK, 284 PP.
6. Boeve, P. J. and Weiss, M. 1998. Spatial Distribution and Sampling Plans with Fixed Levels of Precision for Cereal Aphids (Homoptera: Aphididae) Infesting Spring Wheat. *Can. Entomol.,* **130**: 67-77.
7. Bottenberg, H., Tamo, M. and Singh, B. B. 1998. Occurrence of Polyphagous Insects on Wild *Vigna* sp. and Cultivated Cowpea: Comparing the Relative Importance of Host-plant Resistance and Millet Intercropping. *Agri. Econ. Environ.,* **70**: 217-229.
8. Broersma, D. B., Bernard, R. L. and Luckmann, W. H. 1972. Some Effects of Soybean Pubescence on Populations of the Potato Leafhopper. *J. Econ. Entomol.,* **65**: 78-82.
9. Decante, D. and Van Helden, M. 2006. Population Ecology of *Empoasca vitis* (Goethe) and *Scaphoideus titanus* (Ball) in Bordeaux Vineyards: Influence of Migration and Landscape. *Crop Prot.,* **25**: 696- 704.
10. Ebadah, I. M. A. 2002. Population Fluctuations and Diurnal Activity of the Leafhopper, *Empoasca decipiens* on Some Summer Crops in Kalubia Governorate, *Egypt. Bull. Agr. Cairo Univ.,* **53**: 653-670.
11. Faleiro, J. R., Kumar, J. A. and Ranjekar, P. A. 2002**.** Spatial Distribution of Red Palm Weevil *Rhynchophorus ferrugineus* Oliv. (Coleoptera: Curculionidae) in Coconut Plantations. *Crop Prot.,* **21**: 171-176.
12. Gencsoylu, I. and Yalcin, I. 2004. The effect of Different Tillage Systems on Cotton Pests and Predators in Cotton Fields. *Asian J. Plant Sci.,* **3:** 39-44.
13. Haughes, G. M. 1996. Incorporating Spatial Pattern of Harmful Organisms into Crop Loss Models. *Crop Prot.,* **15**: 407-421.
14. Heyer, W. and Dammer, K. D. 1996. The Horizontal and Vertical Distribution of *Empoasca kraemeri* (Ross and Moore) in Bean Fields (*Phaseolus vulgaris* L.), the Population Dynamics and Recommendations for the Monitoring in the Field under Tropical Conditions. *J. Plant Dis. Protec.,* **103**: 383-396.
15. Hillhouse, T. L. and Pitre, H. N. 1974. Comparison of Sampling Techniques to Obtain Measurements of Insect Populations on Soybeans. *J. Econ. Entomol.,* **67:** 411-414.
16. Jan, M. T., Naeem, M. and Khan, M. I. 2003. Leafhopper Management on Autumn Potato Crop in Peshawak. *J. Res. Sci.,* **14**: 35-42.
17. Jarosik, V., Honek, A. and Dixon, A. F. G. 2003. Natural Enemy Ravine Revisited: The Importance of Sample Size for Determining Population Growth. *Ecol. Entomol.,* **28**: 85-91.
18. Kheyri, M. 1989. Pests of Sugarbeet in Iran. *Appl. Entomol. Phytopathol.,* **56**: 75-91 (in Persian).
19. Kogan, M. and Herzog, D. C. 1980. *Sampling Methods in Soybean Entomology.* Springer Verlag, New York, 587 PP.
20. Krebs, C. J. 1999. *Ecological methodology,* Second Edition. Addison Wesley Longman Inc., New York, 620 PP.
21. Kuno, E. 1991. Sampling and Analysis of Insect Populations. *Ann. Rev. Entomol.,* **36**: 285-304.

22. Liu, C., Wang, G., Wang, W. and Zhou, S. 2002. Spatial Pattern of *Tetranychus urticae* Population Apple Tree Garden. *J. Appl. Ecol.,* **13**: 993-996.
23. Ludwig, J. A. and Reynolds, J. F. 1988. *Statistical Ecology a Primer on Methods and Computing*. John Wiley and Sons Inc., New York, 368 PP.
24. Mayse, M. A., Kogan, M. and Price, P. W. 1978. Sampling Abundances of Soybean Arthropods: Comparison of Methods. *J. Econ. Entomol*., **71**: 135-141.
25. Naseri, B., Fathipour, Y. and Talebi, A. A. 2007. Comparison of Some Biological Aspects of *Empoasca decipiens* (Homoptera: Cicadellidae) on four Bean Species. *Iran. J. Entomol. Soc.,* **27**: 1-13.
26. Patrick, K., Rourke, O. and Hutchison, W. D. 2003. Sequential Sampling Plans for Estimating European Corn Borer (Lepidoptera: Crambidae) and Corn Earworm (Lepidoptera: Noctuidae) Larval Density in Sweet Corn Ears. *Crop Prot.,* **22**: 903-909.
27. Pedigo, L. P. and Buntin, G. D. 1994. *Handbook of Sampling Methods for Arthropods in Agriculture*. CRC Press, London, 714 PP.
28. Pedigo, L. P. and Zeiss, M. R. 1996. *Analysis in Insect Ecology and Management*. Iowa State University Press, Ames, 168 PP.
29. Rassoulain, G. R., Sardarbandeh, H. and Kharazi-Pakdel, A. 2005. Study of Soybean Leafhoppers Fauna and an Investigation on Biology of Dominant Species *Empoasca decipiens* Paoli in Karaj Area. *Commun. Agric. Appl. Biol. Sci.,* **70(4)**: 671- 5.
30. Raupach, K., Borgemeister, C., Hommes, M., Poehling, H. M. and Setamou, M. 2002. Effect of Temperature and Host Plants on the Bionomics of *Empoasca decipiens* (Homoptera: Cicadellidae). *Crop Prot.,* **21**: 113-119.
31. Robbins, J. C. and Daugherty, D. M. 1969. Incidence and Ovipostition of Potato Leaf-Hopper on Soybean of Different Pubescent Types. *Proc. N. Cent. Br. Entomol. Soc. America*, **24**: 35-36.
32. Southwood, T. R. E. and Henderson, P. A. 2000. *Ecological Methods*. Third Edition. Blackwell Sciences, Oxford, 592 PP.
33. Umesh, C. and Rajak, D. C. 2004. Studies on Insect Pests on Urd bean (*Vigna mungo*). *Ann. Plant Prot. Sci.,* **12**: 213-214.

تراکم جمعیت و الگوی توزیع فضایی زنجرک *Empoasca decipiens* (Homoptera: Cicadellidae) روی چهار گونه لوبیا

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چکیده

تراکم جمعیت و الگوی توزیع فضایی زنجرک *Empoasca decipiens* Paoli روی چهار گونه لوبیا شامل لوبیا چیتی (*Phaseulus vulgaris* L.) رقم تلاش، لوبیا سفید (*P. lunatus* L.) رقم صدف، لوبیا قرمز (*P. calcaratus* Roxb) رقم گلی و لوبیا چشم‌بلبلی (*Vigna sinensis* L.) رقم پرستو طی سالهای ۱۳۸۳ و ۱۳۸۴ در منطقه تهران مورد بررسی قرار گرفت. بیشترین و کمترین میانگین تراکم جمعیت زنجرک *E. decipiens* (در هر برگ) به‌ترتیب روی لوبیا چشم‌بلبلی (۱۸/۸۵ در سال ۸۳ و ۲۹/۹۴ در سال ۸۴) و لوبیا چیتی (۱/۰۸ در سال ۸۳ و ۰/۳۷ در سال ۸۴) مشاهده شد. الگوی توزیع فضایی زنجرک روی چهار گونه لوبیا با استفاده از روش نسبت واریانس به میانگین و مدلهای رگرسیونی تیلور و آیواو تعیین شد. نتایج نشان داد که الگوی توزیع فضایی این آفت در اغلب موارد از نوع تجمعی و در مواردی نیز از

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نوع تصادفی می‌باشد. در سال ۱۳۸۳ داده‌های جمع‌آوری شده، با مدل تیلور در مقایسه با مدل آیواو برازش بهتری روی لوبیا چیتی (r^2=۰/۸۷۹) و لوبیا قرمز (r^2=۰/۹۶۷) داشتند. طی سالهای ۱۳۸۳ و ۱۳۸۴ روی لوبیا سفید داده‌های حاصل از مدل آیواو (r^2به ترتیب ۰/۷۴۶ و ۰/۹۰۶) برازش بهتری در مقایسه با مدل تیلور (r^2به ترتیب ۰/۵۴۱ و ۰/۸۲۸) داشتند. نتایج به دست آمده حاکی از آن است که گونه لوبیا می‌تواند بر تراکم جمعیت و الگوی توزیع فضایی زنجرک *E. decipiens* تأثیرگذار باشد. پارامترهای الگوی توزیع فضایی می‌تواند در توسعه برنامه نمونه‌برداری و برآورد دقیق تراکم جمعیت یک موجود زنده مورد استفاده قرار گیرد.

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