POPULATION STRUCTURE AND SEASONAL ACTIVITY OF *OMMATISSUS LYBICUS* IN BAM REGION OF IRAN (HOMOPTERA: TROPIDUCHIDAE)

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ABSTRACT: The spatial distribution and population flactuation of two generations *Ommatissus lybicus* de Bergevin (Hom.: Tropiduchidae) were determined in the Bam region, Iran, in 2008. Spatial distribution pattern of *O. lybicus* was described at two generations using variance to mean ratios, Taylor's power law coefficients and Iwao's patchiness regression methods. The spatial distribution pattern of this pest was aggregated. At first generation, the collected data had better fit to Taylor's model for nymphs, adults and both of them (r^2=0.980, 0.839 and 0.968, respectively) in comparison with Iwao's model (r^2= 0.935, 0.836 and 0.787, respectively). Taylor's model explained the distribution data at second generation for nymphs, adults and both of them (r^2= 0.971, 0.966 and 0.843, respectively) better than Iwao's model (r^2= 0.910, 0.905 and 0.833, respectively). The nymphs were active from April to May and August to October, at first and second generations respectively. Adults of the first and second generations were active from May to June and September to November, respectively. By increasing temperature, *O. lybicus* had aestivation in the egg stage for 5 weeks. Spatial distribution coefficients can be used to develop a sampling program and to estimate the population dynamics of this pest accurately.

KEY WORDS: *Ommatissus lybicus*, spatial distribution, population dynamics, Iran, sampling program.

Ommatissus lybicus or Dubas bug was first recorded as a pest of date palm by Afshar (1938) in Iran. It is an important pest of date palms in Iran (Gharib, 1966). It is known as the "old world date bug " and as the "Dubas bug " (Howard, 2001). *O. lybicus* is a bivoltine species and over winters in the egg stage (Klein et al., 1985). It is active on leaflets and fruiting bunches at different stages of date palm tree growth (Bitaw & Ben Saad, 1990). *O. lybicus* causes direct damage to date palms by feeding and indirect damage due to the growth of mould on honeydew produced by this species (Howard et al., 2001). 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 & Herzog, 1980). Therefore reliable sampling program includes identification of the appropriate sampling time, sampling unit, determination of pattern of sampling and sample size (Pedigo & Buntin, 1994; Boeve & Weiss, 1998; Bins et al., 2000; Southwood & Henderson, 2000). A sampling program can be used in ecological investigations (Faleiro et al., 2002), study of population dynamics (Jarosik et al., 2003), detecting pest levels that justify control measures (Arnaldo & Torres, 2005) and assessing crop loss (Haughes, 1996). The most common methods used to describe the patterns of dispersion of arthropod populations have been summarized by Southwood & Henderson (2000). Several estimates based on the dispersion coefficient, *K*, of the negative bionomial distribution and on the relationship between variance and mean are used as indices of aggregation (Ludwing & Reynold, 1988; Krebs, 1999; Southwood & Henderson, 2000).

Sampling plans based on these indices optimize the sampling effort and sampling precision (Kuno, 1991). Sequential sampling plans are used 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 relation to conventional sampling plans (Pedigo & 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 about the spatial distribution of populations (Liu et al., 2002). 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 & Helden, 2006). Aggregated spatial distribution patterns were recorded for leafhopper *Empoasca kerri* Pruthi on bean leaf (Sardana et al., 1989; Rathore et al., 1998).

In spite of the importance of *O. lybicus*, neither an efficient sampling program has been developed nor has the spatial distribution been described. The objective of this study was to develop a sampling program for *O. lybicus* on date palm and note differences in spatial distribution and abundance of this pest (nymphs and adults) at two generations in Bam region, Iran. The results of this research can be used to optimize monitoring methods for establishing IPM strategies against this pest.

MATERIAL AND METHODS

EXPERIMENTAL PROTOCOL

The experiment was carried out in four date palm orchard in four area Bam, Iran, in 2008. Date palms were used in a randomized complete block design. Each orchard was divided into four blocks and each block consisted of four plots. During 2008, egg, nymph and adult leafhopper spatial distribution and population dynamics were determined at two generations.

SAMPLING PROGRAM

SAMPLING UNIT

For this study, one leaflet of a date palm was selected as a sample unit. Leaflets were selected randomly and visually inspected to note the number of egg, nymphs and adults of *O. lybicus* per leaflet.

PATTERN & TIMING OF SAMPLING

Sampling of date palm leaflets were performed randomly. The sampling was conducted weekly in 2008. All counts were performed in mid-afternoon. Sampling initiated on 25th March in 2008 and continued until end November.

SAMPLE SIZE

Primary sampling was taken in the equal number of different generations on 24th March 2008. Relative variation (*RV*) has been used to compare the efficiency of various sampling methods (Hillhouse & Pitre, 1974). The *RV* of these leaflet 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 sampling 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 & Buntin, 1994).

SPATIAL DISTRIBUTION PATTERN

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

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

In the next stage, Z coefficient was calculated for testing the goodness of fit:

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

Where v was the number of degree of freedom (n-1). Taylor's power law was calculated as follows:

$$S^2 = am^b \text{ or } \log S^2 = \log a + b \log m$$

Where the parameter a is a scaling factor related to sample size (Southwood & Henderson, 2000) and the slope b is an index of aggregation. Iwao's patchiness regression method was 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 crowding (positive) or repulsion (negative) and β reflects the distribution of population on space and is interpreted in the same scanner as b of Taylor's power law. Student t-test can be used to determine the colonies dispersed randomly.

OPTIMAL SAMPLE SIZE

The optimal sample size using Taylor power law was determined using following equation:

$$n_{opt} = \left(\frac{t\alpha / 2}{d} \right)^2 a\mu^{b-2}$$

d is the constant and desired ratio of mean. Therefore if d = 0.2, shows that may be it is 95% probable that the mean of sampling data, is 20% above or below the real mean.

POPULATION FLACTUATION

The population fluctuation of *O. lybicus* was determined at 25th March and 11th November in 2008 and mean weekly densities of eggs, nymphs and adults leafhoppers on leaflets were obtained for each date and then the graphs were drawn.

RESULTS

SAMPLING PROGRAM

From the primary sampling, the reliable sample size of leaflets with maximum variation for a precision of 20% was 40 samples. The relative (*RV*) of the primary sampling data was 6.8% and was very appropriate for a sampling program.

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(1). The results of sampling on two generations showed that the spatial distribution of nymphs, adults and both of them were aggregated.

In Taylor's model, the regression between log S^2 and log m was significant at the first, second and both generations. In 2008, b was significantly greater than one at two generations for nymphs, adults and both them (Table 2). The calculated t (t_c) was greater than t-table (t_t) at two generations for nymphs, adults and both them which indicated an aggregated spatial distribution of *O. lybicus*.

Iwao's model showed that β was significantly greater than one and t_c was greater than t_t for nymphs, adults and both of them at two generations (Table 3) indicating an aggregated spatial distribution pattern.

OPTIMAL SAMPLE SIZE

The optimal sample size of leaflets was obtained 13.

POPULATION FLACTUATION

Population density estimated as the mean number of insects (eggs, nymphs and adults) per leaflet at two generations in 2008 shown in Fig. 1 & 2. The results indicated that the lowest population density of eggs was in 9th sampling week at two generations, late May and late September, respectively. At two generations, the highest population density of adults was recorded in 11th sampling week (early June) and 13th sampling week (late October), respectively. In both generations, nymphs were active from April to May and August to October, respectively. Adults of the first and second generations were active from May to June and September to November, respectively.

DISCUSSION

There is no reported about spatial distribution of *O. lybicus* in the literature. Spatial distribution is one of the most characteristic ecological properties of species (Taylor, 1984). The regression models of Taylor's power law and Iwao's patchiness have various results and accuracy in calculating spatial distribution of *O. lybicus*. By calculating the coefficient of dispersion (CD), Decante & Helden (2006) determined that the grape leafhopper *Empoasca vitis* (Goethe) have an aggregated spatial distribution in vineyards.

Lessio & Alma (2006) determined the spatial distribution of the nymphs of leafhopper *Scaphoideus titanus* (Ball). The nymphal distribution, analyzed via Taylor's power law, was aggregated, with b = 1.49. Thus our finding of *O. lybicus* on date palms is similar to Lessio & Alma on *S. titanus*. Both Taylor's and Iwao's models indicated aggregated distribution of nymphs and adults of *O. lybicus* at two generations in 2008 (Tables 1 & 2). This is probably due to the high population density on date palm leaflets or to some particular behavioral characteristics of the insect. However, at first generation, the data obtained for nymphs, adults and both them fitted better to Taylor's model (r^2 = 0.980, 0.839 and 0.968, respectively) than Iwao's (r^2 = 0.935, 0.836 and 0.787, respectively). At second generation, for nymphs, adults and both of them data fitted better to Taylor's power law (r^2=0.971, 0.966 and 0.843, respectively) than Iwao's (r^2=0.910, 0.905 and 0.833, respectively). In the first generation of *O. lybicus* the eggs were hatched in April or May. The eggs of this generation aestivate over the hot summer, hatching towards the end of August. The egg hatch of the second generation was initiated in late August and the nymphs were maturied about the end of September in Iraq, Egypt, Saudi Arabia and Trinidad (Talhouk, 1977; Howard et al., 2001). Our findings on *O. lybicus* in Bam region was similar to Talhouk (1977) and Howard et al. (2001) in the countries mentioned.

CONCLUSIONS

This research demonstrated that by increasing temperature, *O. lybicus* aestivatied in the egg stage for 5 weeks. The coefficients of the spatial distribution models can be used in developing a sampling program, detecting pest levels that justify control measures and assessing crop loss at two generations of *O. lybicus*.

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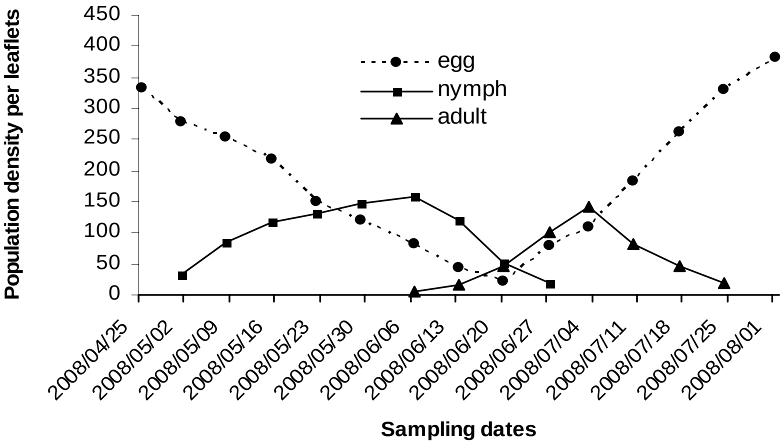

Figure 1. Population fluctuation of *O. lybicus* at first generation in 2008.

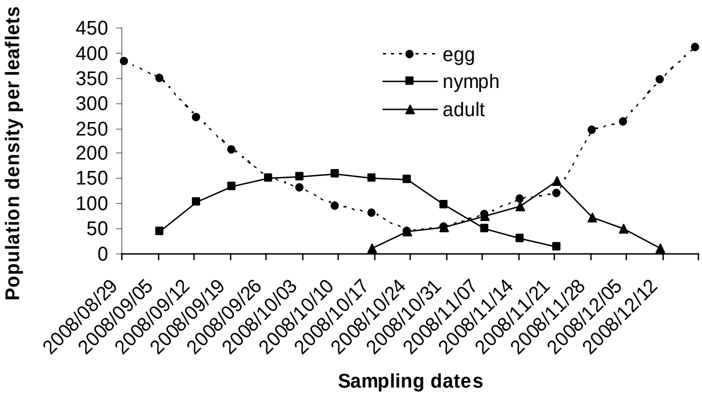

Figure 2. Population fluctuation of *O. lybicus* at second generation in 2008.

Table 1. Spatial distribution coefficients of *O. lybicus* at two generations in 2008 using the variance to mean ratio and the Z coefficient for testing the goodness - of – fit.

Generation	Developing stage	n	m	s^2	s^2/m	Z
First	Nymph	725	80.56	2077.80	25.79	193.24
	Adult	333	41.63	1551.05	37.26	85.47
	Nymph & Adult	1058	81.38	1788.55	21.98	106.27
Second	Nymph	1017	84.75	2426.35	28.63	125.48
	Adult	409	45.44	1542.78	33.95	89.14
	Nymph & Adult	1426	95.07	1972.49	20.75	118.57
First and Second	Nymph	1742	82.95	2118.02	25.53	151.83
	Adult	1742	43.56	1327.34	30.47	111.78
	Nymph & Adult	2484	88.71	1801.24	20.30	154.05

Z = standard normal deviate

Table 2. Spatial distribution coefficients of *O. lybicus* at two generation in 2008 using Taylor's power law regression analysis.

Generation	Developing stages	Parameters estimation					Test for slope	
		a	b	SE_b	r^2	p	t_c	t_t
First	Nymph	0.405	1.32	0.024	0.980	0.000	13.330	2.365
	Adult	0.339	1.24	0.079	0.839	0.001	3.038	2.447
	Nymph & Adult	0.424	1.29	0.194	0.968	0.000	4.639	2.201
Second	Nymph	0.403	1.24	0.019	0.971	0.000	13.261	2.228
	Adult	0.307	1.09	0.026	0.966	0.000	3.461	2.365
	Nymph & Adult	0.280	1.39	0.043	0.843	0.000	9.069	2.160
First and Second	Nymph	0.404	1.27	0.010	0.873	0.000	26.000	2.093
	Adult	0.290	1.10	0.027	0.863	0.000	3.704	2.131
	Nymph & Adult	0.351	1.33	0.019	0.873	0.000	17.368	2.056

Table3. Spatial distribution coefficients of *O. lybicus* at two generations in 2008 using Iwao's patchiness regression analysis.

Generation	Developing stages	Parameters estimation					Test for slope	
		α	β	SE_β	r^2	p	t_c	t_t
First	Nymph	0.714	1.710	0.024	0.935	0.000	13.330	2.365
	Adult	0.910	1.630	0.103	0.836	0.001	3.038	2.447
	Nymph & Adult	1.110	1.550	0.068	0.787	0.000	8.088	2.201
Second	Nymph	0.673	1.610	0.019	0.910	0.000	12.245	2.228
	Adult	0.843	1.060	0.010	0.905	0.000	6.000	2.365
	Nymph & Adult	0.644	1.500	0.046	0.833	0.000	10.896	2.160
First and Second	Nymph	0.753	1.650	0.025	0.918	0.000	26.000	2.093
	Adult	0.832	1.340	0.047	0.761	0.000	7.234	2.131
	Nymph & Adult	0.957	1.480	0.028	0.793	0.000	17.143	2.056