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Studies on the Spatial Distribution of Aphid-eating ladybirds in Soybean Fields

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***Abstract*- Seven-spot ladybird (*Coccinella septempunctata* Linnaeus), Akebia leaf-like moth (*Adonia variegate goeze*), Ash bark beetle (*Leis axyridis* Pallas) and bifid tongued bees (*Propylaea japonica* Thunberg) are principal predators of soybean aphids (*Aphis glycines* Matsumura). The distribution of their larvae's overall population is of aggregation pattern in the soybean field. The population of the seven-spot ladybird's larvae is also of aggregation pattern, which is caused by environmental conditions. A better way to investigate these ladybird's larvae is through chessboard sampling.**

***Key words*- soybean aphid, aphid-eating ladybird, distribution pattern, sampling, natural enemies**

Spatial distribution pattern is an important characteristic of insect species, which helps us to more deeply understand the relationship between species dynamics and adaptive mechanisms, and the relationship between spatial dynamics and quantity dynamics. Moreover, spatial distribution pattern also provides us with a theoretical basis for sampling method and reference definition. Thus, studying insects' spatial distribution pattern is significant for both theory and practice.

Soybeans are one of the most important crops in Helongjian Province, China. Soybean aphids are one of the major insect pests affecting soybean yields. Nonetheless, the seven-spot ladybird, the Akebia leaf-like moth, the Ash bark beetle, and the bifid-tongued bee are all principal predators of soybean aphids, whose imagoes and larvae both prey upon soybean aphids, controlling the population of soybean aphids. We investigated 4 species of aphid-eating ladybirds in 1989, analyzed their spatial distribution, and provided some basis for natural protection and sampling studies.

I. Investigation Method

Five experimental blocks of fields in Shengyang Agriculture University were chosen, where the population of ladybirds' larvae on every plant was observed and the population of overall individuals was recorded. In 2 blocks, the population of seven-spot ladybirds' larvae was also recorded. 1400 plants in 4 blocks were observed, while 1000 plants in the 5th block were observed.

II. Analytical Method and Results

A. Spatial distribution pattern

All computations in this paper were processed using an IBM PC. Every 5 plants constituted a sample.

1) Frequency distribution method

All of the investigative data were input to a computer to simulate Poisson, Negative Binomial, and Neyman distributions. Results are shown in Tables 1 and 2.

Table 1 Spatial distribution of seven-spot ladybird larvae

Block	$\bar{X}$	S^2	X^2			Degrees of freedom		
			Poisson	NegBinomial	Neyman	Poisson	NegBinomial	Neyman
1	0.73	5.39	7810.035	7.669	1469.388	6	5	5
2	0.42	1.37	456.622	2.412	21.187	4	3	3

Table 2 Spatial distribution of overall predators

Block	$\bar{X}$	S^2	X^2			Degrees of freedom		
			Poisson	NegBinomial	Neyman	Poisson	NegBinomial	Neyman
1	0.511	1.43	381.167	3.147 *	27.621	5	4	4
2	0.84	4.64	103.889	14.596	1067.555	6	5	5
3	1.44	8.22	236.18	3.69 *	721.214	5	4	4
4	1.58	10.6	692.769	10.703 *	1469.421	7	6	6
5	2.66	6.79	133.927	15.165	11.354 *	7	6	6

* Denotes goodness-of-fit

From Tables 1 and 2, it was found that distribution of seven-spot ladybird larvae was consistent with the NegBinomial distribution. Distribution of overall predator population fit the NegBinomial distribution in 3 blocks, Neyman distribution in one block and no specific distribution in one block.

2) Taylor method

Taylor proposed the following relationship formula between variance (s^2) and means (m) from analysis of large amounts of biological data and information.

$$\log s^2 = \log a + b \log m$$

When $\log a$ = 0, b = 1, s^2 = m, the population is randomly distributed at any density.

When $\log a$ > 0, b = 1, the population has an aggregate distribution at any density, but the degree of aggregation does not depend on density.

When $\log a$ > 0, b > 1, the population has an aggregate distribution at any density, and degree of aggregation depends on density.

When $\log a$ < 0, b < 1, the population is uniformly distributed at high density.

The following regression formula was obtained according to the data on 4 species' overall population observed in 5 blocks of fields.

$$\log s^2 = 1.458 + 1.026 \log m \quad (r = 0.92),$$

where $\log a = 1.458, b = 1.026$.

According to the above standards, we concluded that overall population had an aggregate distribution at any density and that its aggregate degree depended on density.

3) David and Moore method

$$I = s^2 / m - 1$$

If $I = 0$, random distribution,
If $I < 0$, uniform distribution,
If $I > 0$, aggregate distribution.

I values of overall aphid-eating ladybirds' larvae in 5 fields were: $I_1 = 1.796$, $I_2 = 4.505$, $I_3 = 4.715$, $I_4 = 5.698$, and $I_5 = 1.554$. They are all greater than 0, thus they all belong to an aggregate distribution.

I values of seven-spot ladybird larvae were 9.8 and 6.34 respectively, also greater than 0. Thus, they are also aggregately distributed.

4) Cassie index

$$Ca = \frac{s^2 - m}{m^2}$$

If $Ca = 0$, random distribution,
If $Ca < 0$, uniform distribution,
If $Ca > 0$, aggregate distribution.

Ca values of overall aphid-eating ladybirds' larvae in 5 fields were: 3.518, 5.344, 0.588, 3.337, and 3.278. They are all greater than 0, thus they are all of aggregate distribution.
Ca values of seven-spot ladybirds' larvae were 5.299 and 8.762 respectively, also greater than 0. Thus they are also of an aggregately distribution.

5) Iwao method

Iwao proposed to take parameters α and β in the following linear regression formula as the indices to define spatial distribution.

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

However, this formula works only if m^* and m are linearly related. From the data obtained, it is found that m^* and m are not linearly related. Thus, a modified Iwao model was used (Rumei Xu, etc. 1984).

$$m^* = \alpha' + \beta' m + \gamma' m^2$$

α': average crowded degree of individuals' distribution in every principal elements.
β': relative aggregate degree of principal elements' distribution in low density.

γ': rate at which relative aggregate degree of principal elements' distribution changes with species' density.

After calculation, we obtained: $m^* = -1.96 + 10.54m - 3.096m^2$ Thus, overall aphid-eating ladybirds' larvae are aggregately distributed.

6) Aggregate means (λ) calculation

$$\lambda = \frac{m}{2k}\gamma$$

(γ is the responding value of x^2 to 0.5 probability when Degree of freedom is equal to 2k)

If $\lambda < 2$, aggregation pattern is caused by environmental conditions.

If $\lambda >= 2$, aggregation pattern is caused by insects' behavior or environments.

Results showed that λ values of overall aphid-eating ladybird larvae in every field were all less than 2, thus the aggregation of overall aphid-eating ladybirds is caused by environmental conditions. λ values of seven-spot ladybird larvae in 2 blocks were also less than 2, thus it is caused by environmental conditions as well.

From the above results and analysis, it is concluded that aphid-eating ladybird larvae in soybean fields are aggregately distributed, which is caused by environmental conditions. Environmental conditions in this case mainly refers to aphid distribution. Aphid distribution affects ladybird distribution. According to Zhanjing's study (master's degree thesis), aphid distribution is aggregately distributed, which is consistent with ladybird distribution. However, the level of dependency between these two distributions awaits further study. Ordinarily, more ladybirds are found in places with more aphids. Consistency between predator distribution and insect pest distribution is beneficial to insect pest control by predation. Moreover, it is also found that overall population and individual population both have the same distribution, and both aggregation patterns are caused by environmental conditions. This indicates that the seven-spot ladybird and three other varieties of ladybirds share some biological and ecological characteristics. Nevertheless, the relationship between different varieties of ladybirds still needs further study.

B. Comparison of sampling methods

We marked the original data on coordinates according to their field position. 4 sampling methods were used. 36 samples were taken in each method. Results after calculation are shown in Tables 3 and 4.

Table 3 Means and standard deviation

Block	Five points sampling		Diagonal line sampling		Chessboard sampling		Z shaped sampling		Reference
	$\overline{X}$	$S\overline{x}$	$\overline{X}$	$S\overline{x}$	$\overline{X}$	$S\overline{x}$	$\overline{X}$	$S\overline{x}$	$\overline{X}$
1	0.66	0.22	0.22	0.1	0.58	0.23	0.84	0.26	0.51
2	1.24	0.30	1.21	0.34	0.80	0.3	0.94	0.42	0.84
3	1.89	0.55	1.92	0.54	1.33	0.37	1.86	0.57	1.58

4	1.31	0.38	1.25	0.37	2.00	0.57	1.28	0.44	1.43

Table 4 Errors

Method \ Block	1	2	3	4	5
Five points	0.29	0.48	0.196	0.08	0.26
Diagonal line	0.57	0.44	0.22	0.13	0.34
Chessboard	0.14	0.05	0.16	0.399	0.19
Z shaped	0.65	0.12	0.18	0.10	0.26

By t tests, the mean values obtained in 4 methods are not significantly different from the reference. But from the standpoint of error, chessboard sampling leads to minimum error, thus chessboard sampling is thought to be the best sampling method.

III. REFERENCE

[1] Rumei Xu, etc., *Ecology Transaction*, 4(2): 1-8, 1984.

[2] Rumei Xu, "Insect Species Ecology", *Beijing Shifan Publishing House*, Beijing, 1985.

[3] Zhihe Guan, etc., *Beijing Agriculture University Transaction*, 7(4): 1-12, 1981.

[4] Feng Yuan, etc., *Plants Protection Transaction*, 6(1): 25-35, 1979.

[5] Yanqing Ding, "Insect Species Mathematical Ecology Theory and Application", *Science and Technology Publishing House*, Beijing, 1980.