Spatial Population Dynamics of *Liriomyza trifolii* and *Trialeurodes vaporariorum*, and Their Spatial Associations in Tomato Greenhouses

Doo Hyung Lee, Jung-Joon Park[1], and Kijong Cho*

Division of Environmental Science & Ecological Engineering, Korea University

[1]Department of Entomology, OARDC, The Ohio State University

ABSTRACT

Spatial patterns of *Liriomyza trifolii* and *Trialeurodes vaporariorum* populations were analyzed in order to explore their spatial population dynamics. Semivariograms were calculated to model the change in spatial correlation with increasing distance between samples. For *L. trifolii* data sets, adults were spatially correlated among samples at distances up to 20.47 m apart, based on exponential model. The range (i.e., maximum distance of spatial dependence) of larval damage data was 21.14 m based on Gaussian model. For *T. vaporariorum* data sets, adults were spatially correlated among samples at distance up to 21.14 m apart, based on spherical model. The range of larvae data was 21.95 m based on exponential model. The degree of spatial association between the distributions of *L. trifolii* and *T. vaporariorum* was determined using Spatial Analysis by Distance IndicEs (SADIE). Adult *L. trifolii* showed an overall spatial dissociation (negative relationship) with adult *T. vaporariorum*. However, SADIE analysis found a spatial association (positive relationship) between the distributions of larval damage of *L. trifolii* and larvae *T. vaporariorum* for all sampling periods. The spatial variability of SADIE association indices was also characterized using semivariograms. These data have implications for developing management strategies for spatially-correlated pest populations, and for site-specific agriculture in commercial greenhouses.

INTRODUCTION

In insect ecology, the characterization of the spatial variability of insect populations is essential to achieve a better understanding of spatial patterns of organisms, of environmental factors, and of the joint spatial dependence between organisms and their environment. Spatial structure may indicate intraspecific and interspecific interactions such as competition, predation, and reproduction, or be driven by environmental heterogeneity of variables such as resource availability (Perry and Dixon, 2002). Also, spatial pattern has implications for both theoretical issues and applied problems such as conservation ecology and insect pest management.

Geostatistics provides a set of statistical tools for incorporating the spatial and temporal coordinates of observations in data processing, allowing for description and modeling of spatial patterns, prediction at unsampled locations, and assessment of the uncertainty attached to these predictions (Goovaerts, 1998). Spatial Analysis by Distance Indices, SADIE will also provide means to measure the extent of spatial association between two populations by overlaying the cluster maps of the two distributions (Perry, 1998).

MATERIALS & METHODS

1. Target Species

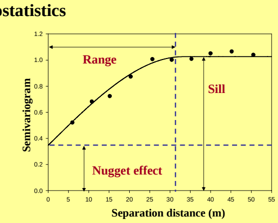
1) American serpentine leafminer, *Liriomyza trifolii*

-One of the most serious pests in greenhouse.
-Leaf stippling and leaf mining
-Adult: flying, Larvae: immobile

2) Greenhouse whitefly, *Trialeurodes vaporariorum*

-One of the most serious pests in greenhouse.
-Sucking and honeydew
-Adult: flying, Larvae: immobile

2. Geostatistics



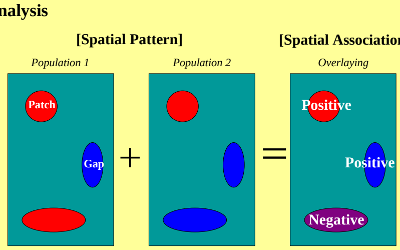
1) Empirical Variogram:

$$\hat{\gamma}(\mathbf{h}) = \frac{1}{2N(\mathbf{h})}\sum_{i=1}^{N(\mathbf{h})}[z(x_i)-z(x_i+\mathbf{h})]^2$$

2) Modeling the Empirical Variogram

-Spherical, Exponential, and Gaussian models

3. SADIE Analysis



CONCLUSION

1. Semivariograms generated from both *L. trifolii* and *T. vaporariorum* data sets showed that the value of semivariogram increased with separation distance, indicating that spatial correlation decreased as distance between samples increased.

2. Adults *L. trifolii* and *T. vaporariorum* exhibited spatial dissociation (negative relationship). The spatial dissociations between the two adult populations were spatially correlated among samples at distance up to 22. 49 m apart.

3. The association analysis found a positive relationship (spatial association) between the distributions of larval damage of *L. trifolii* and immature *T. vaporariorum*. The spatial associations between the two larval populations were spatially correlated among samples at distance up to 46.76 m apart.

4. Spatial variation analysis has implications for integrated pest management for mixed pest populations, and for site-specific management applications.

RESULTS

1. Variogram Modeling

Table 1. Summary of geostatistical descriptions of data sets

Data set		Model[1]	Nugget	Partial sill	Range	RSS[2]
L. trifolii	Adult	S	0.7613	0.2066	33.80	0.3253
		E	0.5912	0.3656	20.47	0.3140
		G	0.7138	0.2343	16.40	0.3086
	Larval damage	S	0.3464	0.6795	33.11	0.0249
		E	-	-	-	-
		G	0.3613	0.6253	21.14	0.1150
T. vaporariorum	Adult	S	0.4999	0.3463	21.14	0.0568
		E	0.4999	0.3193	18.64	0.0748
		G	0.5511	0.2776	18.77	0.0526
	Larvae	S	0.4999	0.4206	26.07	0.2294
		E	0.4603	0.4482	21.95	0.1132
		G	0.4642	0.4156	11.43	0.1786

[1]S: spherical, E: exponential, G: Gaussian; [2]Residual Sum of Squares.

2. Spatial Association between Two Species

Table 2. SADIE association indices and their significance, *P* derived from comparisons between the distributions of adult *L. trifolii* and adult *T. vaporariorum*, and the observed number of local association value that exceeded 95% critical values

Sampling week	SADIE association index, *X*	*P*-value	Descriptive	Positive value	Negative value
1st	-0.4527	0.9998	Dissociation	0	14
2nd	-0.0081	0.5439	Negligible	3	11
3rd	-0.3146	>0.9998	Dissociation	2	11
4th	-0.2972	>0.9998	Dissociation	4	7
5th	-0.2444	0.9992	Dissociation	7	6
6th	-0.3345	>0.9998	Dissociation	0	11
7th	-0.2332	0.9992	Dissociation	2	2
8th	-0.0061	0.7854	Negligible	1	5

Table 3. SADIE association indices and their significance, *P* derived from comparisons between the distributions of larval damage of *L. trifolii* and larvae *T. vaporariorum*, and the observed number of local association value that exceeded 95% critical values

Sampling week	SADIE association index, *X*	*P*-value	Descriptive	Positive value	Negative value
1st	0.3000	<0.0001	Association	12	0
2nd	0.3748	<0.0001	Association	13	0
3rd	0.4594	<0.0001	Association	13	0

3. Spatial Variability of SADIE Association Indices

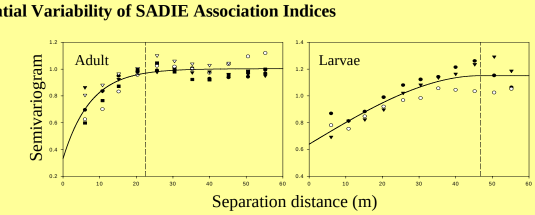


Figure 1. Semivariograms of SADIE association indices between the distributions of adult *L. trifolii* and adult *T. vaporariorum*, and between the distributions of larval damage of *L. trifolii* and larvae *T. vaporariorum*. Fitted models are exponential and spherical for adult and larvae data sets, respectively.

REFERENCES

Goovaerts, P. 1998. Geostatistical tools for characterizing the spatial variability of microbiological and physico-chemical soil properties. **Biol. Fert. Soils. 27: 315-334**

Perry, J. N. 1998. Measures of spatial pattern for counts. **Ecology. 79: 1008-1017.**

Perry, J. N. and Dixon, P. M. 2002. A new method for measuring spatial association in ecological count data. **Ecoscience. 9: 133-141.**

ACKNOWLEDGEMENT This work was supported by grant No. R01-2003-000-10244-0 from the Basic Research Program of the Korea Science & Engineering Foundation.

***Correspondence should be addressed. E-mail: kjcho@korea.ac.kr Tel: +82-2-3290-3064**