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MONITORING POPULATIONS OF *LIRIOMYZA TRIFOLII* (DIPTERA: AGROMYZIDAE) IN CELERY WITH PUPAL COUNTS

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ABSTRACT

Populations of *Liriomyza trifolii* (Burgess) were monitored in 16 commercial fields of celery during 1985 by taking 10 sets of 10 leaflet samples per field and counting puparia after 3, 7, and 14 days. Three indices of dispersion showed that the population had an aggregated distribution. Sample size for 3-day pupae counts were calculated to be 7 sets of 10 leaflets for 25% precision at densities of 5 or more puparia per 10 leaflets. The proposed sampling scheme requires between 30 and 45 minutes total sampling time per field and will allow the grower to monitor *L. trifolii* population trends and evaluate previous control actions. Sequential sampling plans may further reduce sampling time.

RESUMEN

Las poblaciones de *Liriomyza trifolii* (Burgess) se esudiaron en 16 parcelas comerciales de apio durante 1985. Diez grupos de muestras de diez hojas se obtuvieron de cada parcela, contandose las crisálidas después de 3, 7 y 14 días. Tres índices de dispersión montraron que la poblacion tenía una distribucion aglomerada. Se determinó que el tamaño de la muestra para el conteo de crisálidas despues de 3 días debe ser 7 grupos de 10 hojas para obtener una precisión de 25% en densidades de 5 o más crisálidas por cada 10 hojas. El sistema de muestreo propuesto requiere entre 30 y 45 minutos de tiempo para el muestreo de cada parcela y permitirá al productor el estudiar las tendencias de las poblaciones de *L. trifolii* y evaluar acciones de control previas. Planes de muestreo de secuencia pueden reducir aún más el tiempo de muestreo.

Liriomyza trifolii (Burgess), a serpentine leafminer, is a serious pest of celery, lettuce, tomatoes, and other vegetable and ornamental crops in Florida. This insect damages celery in at least 3 ways; by removing photosynthetic material from the leaves, by making avenues of entry for plant pathogens, and by causing cosmetic damage to the marketable portion of the crop.

There are a number of methods that have been considered as possible sampling methods for leafminers. Musgrave et al. (1979) calculated sample sizes for sweep net estimations of adult densities and for counts of live larvae of *L. sativae* in the foliage. A problem with sweep net samples is that on windy days the adult leafminers tend to stay low in the foliage and are not caught by the net. Also, if the foliage is wet from rain or dew, a sweep net is not useful.

Growers in south Florida tend to avoid counting live leafminer larvae in the leaves because it is tedious work and because it is easy to miss small larvae. Michelbacher et al. (1953) counted the number of mines in tomato leaves but, as Johnson et al. (1980) point out, this sampling method does not accurately estimate the current density because the mines remain long after the leafminers are gone. Parella and Jones (1985) developed sampling plans for yellow cards covered with sticky material to monitor adult leafminer populations in chrysanthemum greenhouses. Zehnder and Trumble (1985) developed sequential sampling plans for sticky cards in tomatoes as well as for the pupal tray method to be discussed later. At least one major celery grower in Florida has used sticky card to monitor leafminer adults. However, sticky cards are inconvenient to work with and often are fouled by blowing soil.

Johnson et al. (1980) recommended placing styrofoam trays under tomato foliage to catch the larvae as they emerge from the leaves and drop to the ground to pupate. This method is not practical in Florida because frequent strong winds blow the pupae from the trays or blow the trays away. Also, there are usually no rows in which to place the trays that will not be run over by farm equipment (J. T. Shaw, pers. comm.). A modification of this method that is used by Florida growers is to hold leaflet samples in a container for several days and then count the number of puparia that have emerged from the leaves. A drawback to this sampling method is the time lag between when samples are taken and when the information becomes available. The pupal rearing method provides information about leafminer ovipositional activity during some previous time interval. The current uses for this sampling method are to monitor population trends and to evaluate the effectiveness of previous control measures. An advantage of pupal rearing over the pupal trays (Johnson et al. 1980) is that it can also be used to estimate parasitism.

The objectives of this study were to determine the appropriate time interval to hold celery leaflet samples before counting the puparia, to determine the appropriate sample sizes for estimating *L. trifolii* densities, and to develop constant-precision-level sequential sampling plans at three levels of precision.

MATERIALS AND METHODS

Sixteen celery fields near Belle Glade were sampled between February 5 and April 8, 1985. The approximately 11-ha fields were planted sequentially in time to provide an even supply of celery for market. Each field was sampled between 1 and 6 times, depending on the level of maturity of the crop at the initiation of the study. A total of 51 sets of sampling data was collected.

A field sample consisted of 10 sets of 10 terminal leaflets per set. The leaflets selected were from petioles that were mature, but had not yet begun to senesce. The ten leaflets collected at a site were selected randomly from 10 different plants and the 10 sites were arranged systematically throughout the field to insure that all areas of the field were sampled. No sample sites were located within 15 m of the sides or ends of the fields to remove possible edge effects. Each field was treated uniformly with insecticides when determined to be necessary by the grower.

After collection in the field, the leaflets were placed in plastic bags and returned to a laboratory. Leaflets then were placed in 0.47-liter (1-pint) styrofoam cups and held in a laboratory at room temperature (23.0 ± 0.56°C). Three days after field collection, the leaves in each carton were removed and the leafminer puparia were counted. The leaves were then returned to the carton and again held at room temperature. The counting procedure was repeated 7 and 14 days after field collection, at which time the leaves were discarded because 14 days is an adequate length of time to insure that all eggs and larvae present had pupated (Leibee 1984).

There are a number of indices of dispersion that have been used to analyze the distribution of insect populations. The simplest of these is the variance to mean ratio. If $s^2 = m$, the population is assumed to be randomly distributed. $s^2 > m$ indicates aggregation and $s^2 < m$ indicates uniformity. Iwao (1968) introduced a regression method for measuring spatial dispersion. He used a parameter, mean crowding (m_c), proposed by Lloyd (1967): $m_c = m + ((s^2/m)-1)$. Mean crowding is defined as the mean number of other individuals per individual. Iwao found that when mean crowding was regressed on mean density, there was a direct linear relationship. Regression parameters a, the intercept, and b, the slope, are both indices of dispersion. The a-value is an index of basic contagion, and the b-value represents the density-contagiousness coefficient. Random distribution is suggested by $a = 0$ and $b = 1$, and aggregated distribution is indicated by $a > 0$ and $b > 1$.

According to Taylor (1961) the sample variance can be related to the sample mean by the power law:

$$s^2 = a\bar{x}^b \qquad (1)$$

The mean ($\bar{x}$) and the variance (s^2) were calculated for each data set in this study and a linear regression of $\log s^2$ on $\log \bar{x}$ was computed. The a and b values determined from the regressions were used to calculate necessary sample sizes for various desired levels of precision using the equation published by Ruesink (1980):

$$n = \frac{a\bar{x}^{b-2}}{c^2} \qquad (2)$$

where n = the number of samples and c = precision expressed as a fraction of the mean.

The a- and b-values from Taylor's power law also were used to develop constant-precision-level sequential sampling plans for three day pupal counts. The stop points were calculated by the formula (Green 1970):

$$\log T_n = \frac{\log(c/a)}{b-2} + \frac{b-1}{b-2} \log n \qquad (3)$$

where T_n = cumulative number of pupae. Southwood (1978) considered 25% precision to be adequate for use in pest management programs.

RESULTS AND DISCUSSION

Holding leaflets for 7 days resulted in approximately twice as many pupae as holding them for 3 days (Table 1). Holding the leaflets for 14 days produced a mean of 71.4 puparia per 10 leaflets, which is only 7.4% more than holding them for 7 days. Therefore, holding the leaves for longer than 7 days is not worthwhile. There was a wide range of mean densities, which is considered by Ruesink (1980) to be one of the requirements for using Taylor's power law.

TABLE 1. MEANS AND RANGES FOR NUMBER OF *L. TRIFOLII* PUPARIA DROPPING FROM 100 CELERY LEAFLETS PER FIELD (N = 51 FIELDS).

No. of days held	Mean	Range
3	32.1	1-224
7	66.5	3-258
14	71.4	3-270

TABLE 2. INDICES OF DISPERSION FOR PUPARIA OF *LIRIOMYZA TRIFOLII* IN CELERY FOR LEAFLETS HELD FOR 3, 7, AND 14 DAYS.

	Taylor's Power Law			Iwao's Regression	
No. of Days held	a	b	Variance/Mean	a	b
3	1.429	1.297	4.39	0.408	1.189
7	1.432	1.352	4.01	1.167	1.140
14	1.346	1.378	4.42	1.087	1.150

All 3 indices of dispersion calculated showed that leafminers have an aggregated distribution for each of the 3 durations for which leaflets were held (Table 2). These results agree with those of Beck et al. (1981), who found that active mines on whole plants were aggregated in their distribution in the field (Taylor's b-value = 1.51). Figure 1 illustrates the distribution of data points around the regression line generated by Taylor's power law for pupal counts.

The a- and b-values from Taylor's power law (Table 2) can be used to calculate sample sizes necessary to estimate leafminer densities (Table 3). Although there are no economic thresholds in use for leafminers in celery, means of 5 or fewer pupae reared from 10 leaflet samples held for 3 or 7 days would pose little threat of causing economic damage. Therefore, it appears from these data that the sample size of 10 sites used in this study is adequate for estimating leafminer densities of $\bar{x} > 5$ per 10 leaflets with an acceptable level of precision ($c = 0.25$). In most situations, it would be preferable to hold the samples for only 3 days before counting to reduce the lag time. If the leaves were returned to the cup after counting and held for another 4 days, information about oviposition nearer to the time of sampling could be obtained.

It takes approximately 20 to 30 min to take 10 sets of 10 leaflet samples from a field of about 11 ha. If the sets of 10 leaves are held in individual cups, it takes approximately 15 min to count the puparia at a density of 10 pupae per 10 leaflets. If the leaflets are small enough to be composited into a single or a couple of containers, the time required is reduced to about 8 minutes. Therefore, the total time required to sample a field is about 30 to 45 minutes. Because most of the field time is expended while walking, not much time is saved by taking fewer than 10 samples per field. Sampling time could be reduced further using sequential sampling (Table 4). This would not reduce the amount of time spent in the field, but could reduce the counting time considerably.

Pupal counts, then, are a relatively efficient method for monitoring leafminer population activity in celery. Precise measurements of leafminer densities can by achieved with few samples in a short period of time, although there is a 3- or 7-day lag time before the information is available. This sampling method is useful for monitoring population trends or evaluating the success of previous control measures. If economic

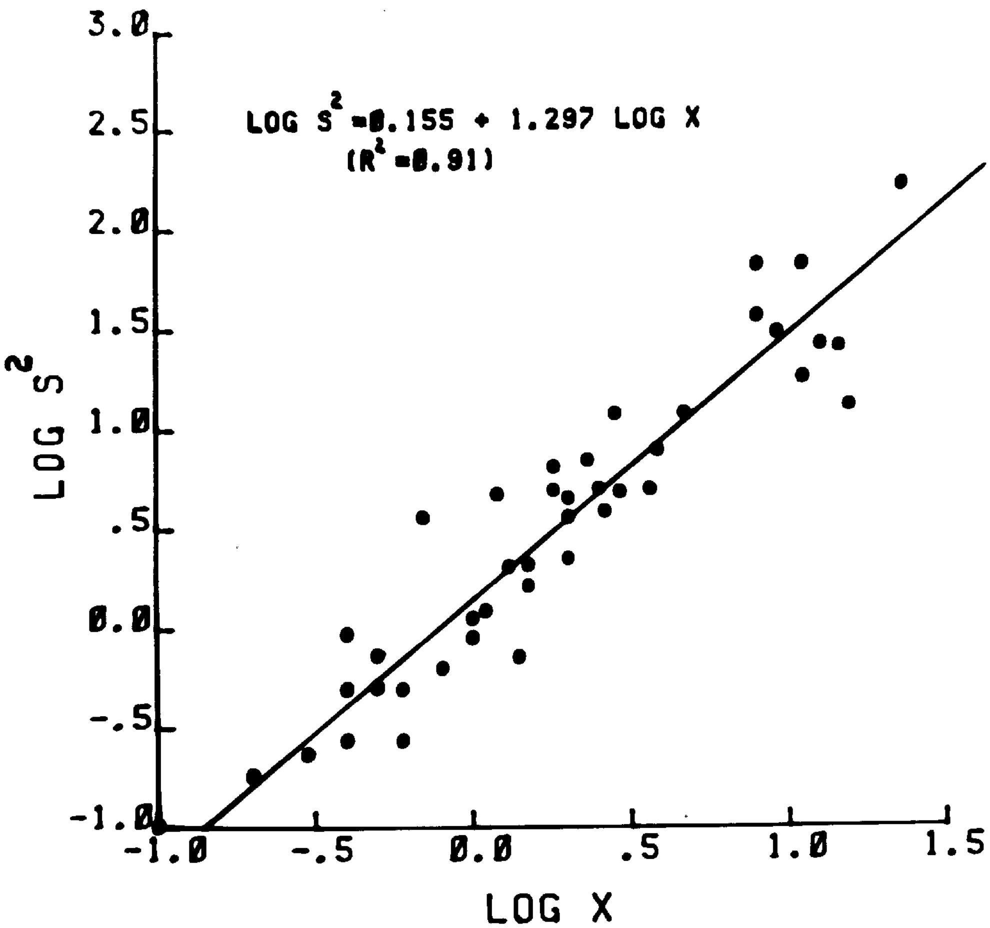

Fig. 1. Regression line describing relationship between log s^2 and log $\bar{x}$ for three day pupal counts of *Liriomyza trifolii*.

TABLE 3. Number of ten leaflet samples necessary to estimate densities of *L. trifolii* in celery at three levels of precision (c) and various mean densities ($\bar{x}$).

	No. of samples					
	3-Day Drops			7-Day Drops		
$\bar{x}$	c = 0.2	c = 0.25	c = 0.3	c = 0.2	c = 0.25	c = 0.3
0.5	58	37	26	56	36	25
1	36	23	16	36	23	16
3	17	11	7	18	11	8
5	12	7	5	13	8	6
10	7	5	3	8	5	4
20	4	3	2	5	3	2
50	2	1	1	3	2	1

TABLE 4. STOP POINTS FOR CONSTANT-PRECISION SEQUENTIAL SAMPLES FOR *LIRIOMYZA TRIFOLII* PUPAE AT THREE LEVELS OF PRECISION (C).

No. samples	Cumulative pupae counted		
	c = 0.20	c = 0.25	c = 0.30
1	162	86	51
2	121	64	38
3	102	54	32
4	90	48	28
5	82	43	26
6	76	40	24
7	71	38	22
8	67	36	21
9	64	34	20
10	61	32	19

thresholds are developed for leafminers on celery, a sampling method that will make estimates of the actual leafminer density may be required. But until that time, the pupal rearing method should be useful to celery growers in southern Florida to monitor *L. trifolii* populations and to evaluate the effectiveness of control practices.

ACKNOWLEDGMENTS

I wish to thank J. Shaw, D. Remick, D. Malloy, P. Yance, R. Wojciak, and G. Mitchell of A. Duda & Sons, Inc. for their willing cooperation in this study. Florida Agricultural Experiment Station Journal Series No. 6657.

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NITIDULIDAE ASSOCIATED WITH FRUIT CROPS IN RIO GRANDE DO SUL, BRAZIL

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ABSTRACT

This is the first of a series of studies designed to compare sap beetles (Coleoptera: Nitidulidae) present at various locations in the state of Rio Grande do Sul in southern Brazil. Collections from strawberries, apple, peach, plum, and quince drops yielded 16 species in 7 genera. Almost twice as many species were found in the Pelotas area as near Vacaria. The most abundant species was *Carpophilus fumatus* Boheman. This is the first report of *C. fumatus* and of *Haptoncus sobrinus* Grouvelle from South America.

RESUMEN

Este artículo es el primero de una serie de estudios para comparar los nitidúlidos (Coleoptera: Nitidulidae) que se encuentran en el Estado de Rio Grande do Sul, en el sur del Brasil. El análisis de los frutos de fresa, manzana, durazno, ciruela, y membrillo, indicó que 16 especies pertenecientes a 7 géneros estaban presentes. Casi el doble número de especies se encontraron en el área de Pelotas cerca de Vacaria. La especie más abundante fue *Carpophilus fumatus* Boheman. Esta és la primera vez que se reporta a *C. fumatus* y a *Haptoncus sobrinus* Grouvelle en Sudamérica.