sucrose, and was negative for phosphatase production or gas from glucose (Table 1). Results of fatty acid analysis of isolates made from the cultivar 'Tommy Atkins' were inconclusive. The fatty acid analysis samples matched the *Citrobacter diversus* in the local library, but matching entries in the MIDI library are related to Enterobacteriaceae.

Inoculation of intact plants. Fifty percent of the wound-inoculated potted trees developed symptoms very slowly with symptoms appearing after 10 to 12 months. None of the wounded controls developed symptoms.

Conclusion

A new disease of mango in Costa Rica appears to be caused by a bacterium tentatively identified as an *Erwinia* sp. Positive identification through the use of fatty acid analysis is continuing. The pathogen causes a serious, destructive disease which could be distributed throughout mango-producing countries by budwood. This disease could become a limiting factor for mango production in Florida.

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SPATIAL DISPERSION AND SAMPLING OF LIME PESTS IN FLORIDA

J. E. PEÑA AND R. M. BARANOWSKI
IFAS, University of Florida
Tropical Research and Education Center
18905 S.W. 280th St.
Homestead, Florida 33031

Additional index words. Panonychus citri, Planococcus citri, Dialeurodes citrifolii, Citrus latifolia.

Abstract. **Taylor's power law and Iwao's patchiness regression were used to analyze spatial dispersion of three lime pest species, *Panonychus citri* (McGregor), *Planococcus citri* Risso, and *Dialeurodes citrifolii* (Morgan). Taylor's power law generally provided a consistently good fit to the data, whereas the fit of Iwao's patchiness regression was erratic. All species exhibited aggregated spatial patterns. Sample size requirements for estimation of population means with fixed levels of precision were lowest for *Panonychus citri*, and higher for *Planococcus citri*, and *D. citrifolii*.**

Three species of arthropods, the citrus red mite, *Panonychus citri* (McGregor); citrus mealybug, *Planococcus citri* Risso; and the cloudy-winged whitefly, *Dialeurodes citrifolii* (Morgan) are among the most important pests affecting lime *Citrus latifolia* Tanaka. Populations develop on fruits and leaves, or, specially in the case of *D. citrifolii*, only on leaves. Their feeding activities can cause substantial yield loss in Citrus species (Simonton, 1960, 1969; Meyerderk et al., 1981; Yasuda, 1980). Population studies and decisions about whether and when to control these pests require precise population assessment, which is complicated by variation in spatial dispersion pattern of each species in the field. Variation in spatial distribution with variation in population density is a ubiquitous characteristic of biological populations (Taylor, 1984). When sampling lime pests to determine population density, such varying spatial distributions affect the precision of sample statistics because variance changes, usually not linearly, with density (Taylor, 1965). Two models have been used extensively for describing relationships between variance (s^2) and the mean (x) (Iwao, 1968; Taylor et al., 1978): Taylor's power law

$$s^2 = a_1 \times x^b \ (1), \text{ and}$$

Iwao's Model

$$x_* = \alpha + \beta x \ (2), \text{ where } x^* = x + x^2/x - 1$$

Taylor et al. (1978) demonstrated that model 1, the power law, usually provides a better model for observed variance/mean relationships for samples taken from arthropod pest populations. Our objectives were to provide and compare inter-tree dispersion of citrus red mites, citrus mealybugs, and cloudy-winged whitefly using Taylor's power law and Iwao's patchiness regression. In addition, we propose methodology for sampling field populations of three arthropod pests with fixed levels of precision.

Materials and Methods

Ten trees in each of four 'Tahiti' lime orchards were selected randomly for bimonthly sampling of infestations of citrus red mites, citrus mealybugs and cloudy-winged whitefly; the orchards ranged from 24 to 40 ha, and the trees were 8 to 10 years old. Ten leaves per tree were

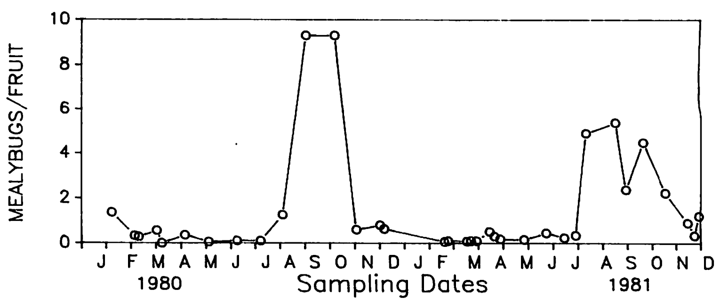

Figure 1. Dynamics of the citrus mealybug, *Planoccocus citri*, in south Florida limes.

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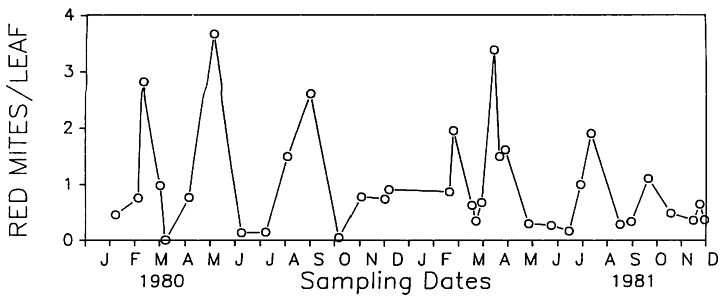

Figure 2. Dynamics of the citrus red mite, *Panonychus citri*, in south Florida limes.

examined with a 10× hand lens for red mites. Observations of cloudy-winged whitefly consisted of counting larvae and pupae on new and old leaves. Ten tagged fruits were examined for citrus mealybugs. Means and variance of counts of each species were calculated for each sample. Indexes of dispersion were calculated using Taylor's (1961) power law and Iwao's (1968) patchiness regression.

The coefficients from Taylor's power law regressions were used to determine sample size requirements necessary for estimating population means for each species with fixed-precision-level sequential sampling plans for each species. Precision was defined as D = s /x where s is the standard error of x. Estimations with standard error of 10 and 25% of their value are usually precise enough for intensive and extensive sampling, respectively (Southwood,

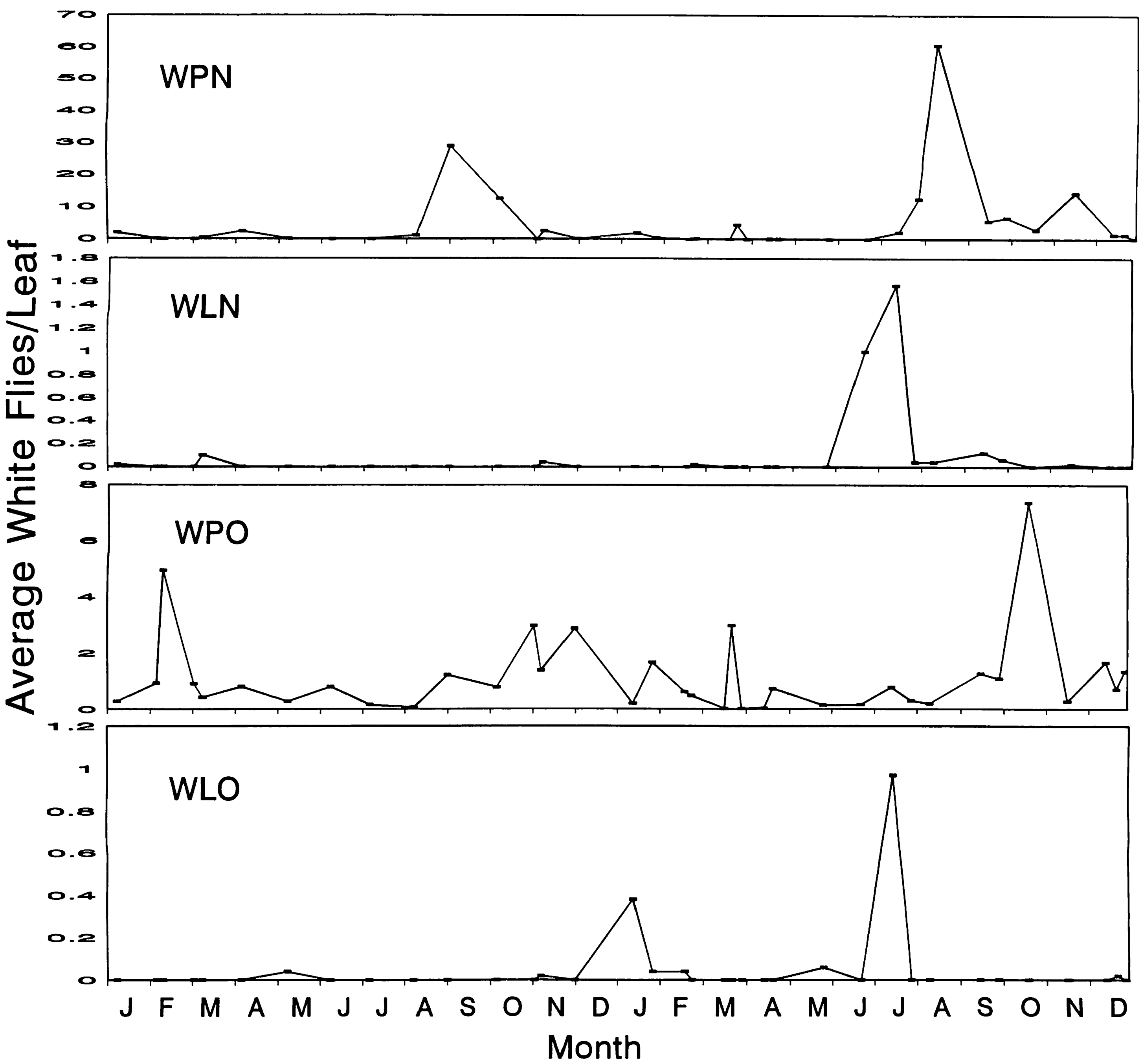

Figure 3. Dynamics of the cloudy-winged whitefly, *Dialeurodes citrifolii*, in limes.

Table 1. Inter-tree dispersion indices for citrus red mite, *Panonychus citri* and citrus mealybug, *Planococcus citri*.

		Iwao's Patchiness Regression			Taylor's Power Law		
Species	Size	α	β	r^2	log a	b	r^2
Panonychus citri	A	−1.30	2.60	0.67	0.30	1.61	0.90
	B	8.09	0.59	0.001	0.47	1.40	0.75
	C	−0.62	1.44	0.94	−0.18	1.42	0.92
	D	0.30	1.13	0.88	−0.25	1.43	0.91
Common		2.07	1.73	0.02	0.41	1.50	0.86
Planococcus citri	A	−3.16	6.92	0.90	1.11	1.85	0.94
	B	−2.42	7.63	0.94	1.41	1.91	0.97
	C	−0.83	5.46	0.90	0.91	1.50	0.87
	D	−0.54	4.80	0.94	1.45	1.85	0.97
Common		−0.60	4.52	0.79	1.27	1.78	0.95

1978); thus, we chose D = 0.10, 0.15, and 0.25 for use in this study.

To determine 'stop lines' for fixed-precision level sequential sampling plans based on Taylor's power law, the following formula from Green (1970) was used:

$$Tn = (D^2/a)^{1/(b-2)}$$

where Tn is the cumulative number of individuals in a sample of size n, and a and b are the coefficients obtained from the Taylor's power law regression. The number of samples necessary to estimate the mean with a fixed precision was determined by solving for n in equation 3:

$$n = \frac{ax^{(b-2)}}{D^2}$$

Results and Discussion

Dynamics. Average seasonal population trends of the citrus mealybug are given in Figure 1. Mealybugs were most abundant from August through November 1981. Low populations were observed from January through April in both 1981 and 1982. This information indicates that the summer and fall populations will be of more concern to lime growers than spring populations. The periods of mealybug abundance correspond to periods when pesticides are frequently applied to lime groves. Because mealybugs prefer protected areas between the fruit and under the button or calyx, a weekly inspection should be made when control is needed at this time. Population trends in southern Florida differ from those in Central Florida (Simonton, 1969). In that area mealybug populations increase from April to July and decline during the fall. These differences in population trends could be a response to plant phenology and climate.

Seasonal population changes of the citrus red mite in limes for the two-year study are given in Fig 2. There were different temporal population trends on all survey fields

Table 2. Inter-tree dispersion indices for cloudy-winged whitefly, *Dialeurodes citrofolii*.

			Iwao's Patchiness Regression			Taylor's Power Law		
Stage	Stratum	Site	α	β	r^2	Log a	b	r^2
Larva	Old leaves	A	−0.91	7.95	0.83	1.85	1.72	0.96
		B	−1.10	9.95	0.98	1.59	1.84	0.93
		C	−0.78	4.92	0.72	1.51	1.86	0.89
		D	−0.86	5.41	0.88	1.14	1.71	0.96
	Common		−1.06	9.76	0.97	1.21	1.71	0.90
Pupa	Old leaves	A	−4.32	3.81	0.62	0.22	1.92	0.93
		B	−1.63	3.73	0.69	0.31	1.62	0.89
		C	−0.76	2.34	0.64	−1.16	1.30	0.82
		D	−0.73	2.23	0.64	−0.21	1.31	0.84
	Common		−2.05	3.70	0.65	0.41	1.74	0.92
Larva	New leaves	A	−0.91	5.93	0.37	0.58	1.58	0.83
		B	−1.10	8.18	0.89	1.62	1.81	0.98
		C	−1.02	9.90	1.00	2.12	2.00	0.99
		D	−0.94	5.82	0.94	−0.22	1.30	0.93
	Common		−1.23	9.69	0.98	1.40	1.75	0.94
Pupa	New leaves	A	4.51	1.74	0.83	1.14	1.70	0.97
		B	−2.13	3.14	0.96	0.61	1.69	0.83
		C	1.09	2.29	0.83	1.23	1.79	0.95
		D	1.80	1.52	0.75	0.83	1.54	0.97
	Common		1.63	2.08	0.83	1.05	1.67	0.97

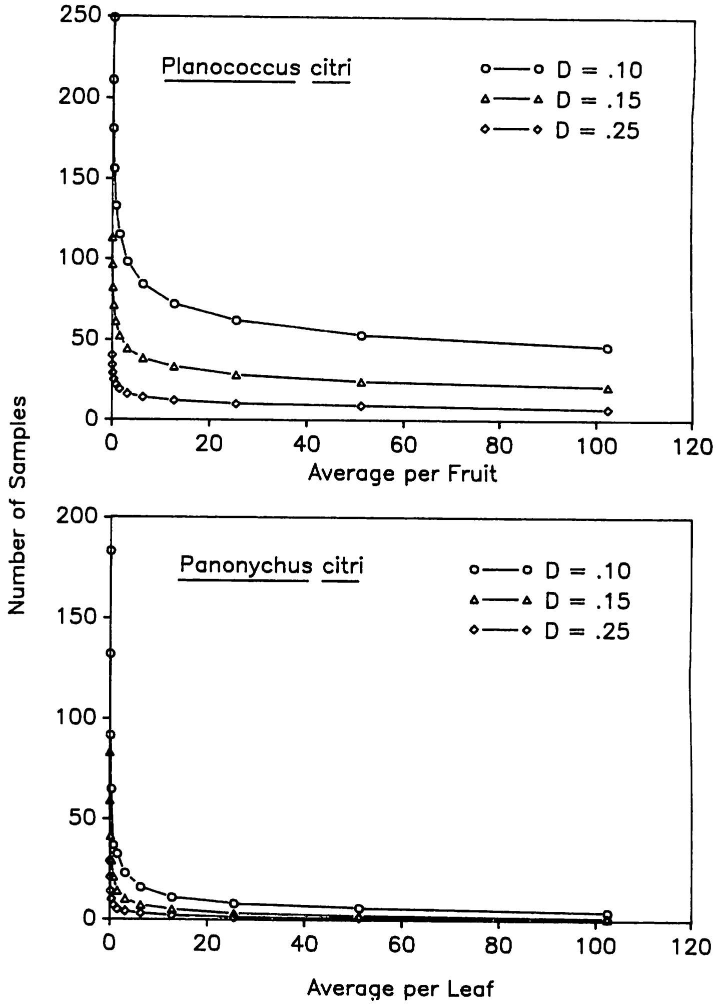

Figure 4. Sample size requirements for the tree samples of *Planococcus citri* and *Panonychus citri* for precision levels of 0.10, 0.15, and 0.25.

Table 3. Comparison between relative variation (SE/x) and sample size (n) for red mites on limes, Homestead, 1981.

No. trees Sampled	x	s^2	CV	(SE/x) × 100
5	3.6	14.57	106.2	47.41
10	2.92	9.40	104.9	33.20
20	2.40	5.02	93.4	20.87
30	1.20	4.66	179.9	32.84
40	2.11	14.07	177.7	28.10
50	4.86	97.53	203.2	28.73

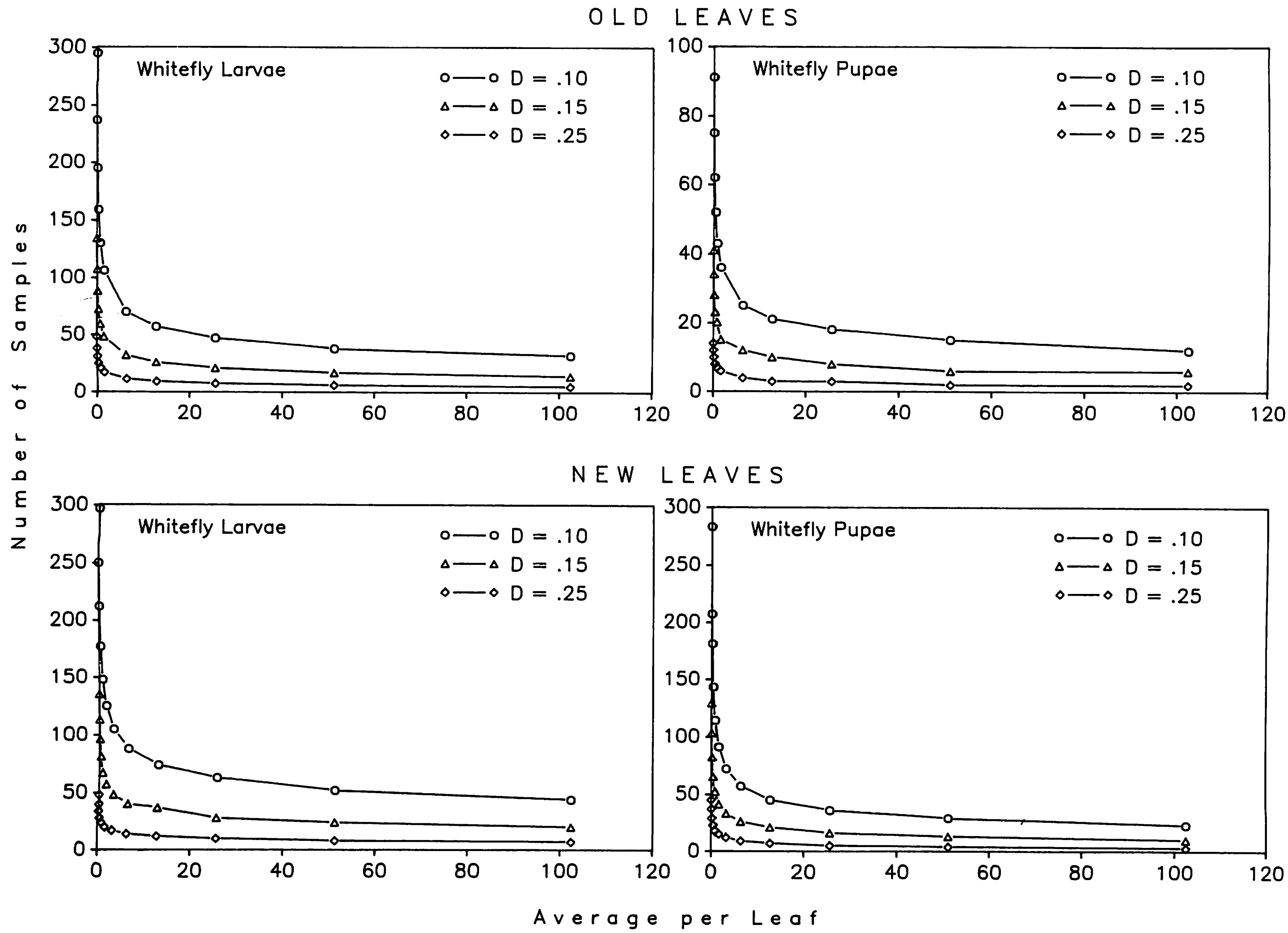

Figure 5. Sample size requirements for the tree samples of *Dialeurodes citrifolii* larval and pupal stages for precision levels of 0.10, 0.15, and 0.25.

except for common peaks observed on April 1981, August and September 1981, and February 1982. Population lows occurred in December 1980 through March 1981, as well as during the fall of 1981. Peaks in April were similar to those observed by Simonton in Central Florida. Our data reflect different population trends during August and September. Populations in Central Florida are reduced at this time of the year. Once again, differences can be related to differences in citrus species phenology and southern Florida climate.

More cloudy-winged whitefly larvae were found on new leaf flushes than on the old ones. Seasonal trends for cloudy-winged whiteflies were similar among the orchards used in this study. Common peaks were observed from August through December 1981 (Fig 3). Small peaks were observed during May 1981.

Dispersion. Estimates of indices of dispersion for citrus red mite and citrus mealybug are shown in Table 1. Taylor's power law generally provided a better fit to the citrus red mite data than did Iwao's patchiness regression. Both Taylor's power law and Iwao's patchiness regression provided a good fit to citrus mealybug data. Taylor's b values ($b < 1$) for both species indicated that the distributions were contagious in the leaves and fruits, respectively. However, the intercepts (α) found by Iwao's patchiness regression for both species suggest that, at infinitesimal density, these species are not found in a group. Instead, the individual is the basis of the population.

Estimates of indices of dispersion for larval and pupal stages of cloudy-winged whitefly in new and old leaves are shown in Table 2. Taylor's power law provided a better fit for both stages of cloudy-winged whitefly larvae and pupae in new and old leaves data than did Iwao's patchiness regression. The parameter b of Taylor's power law differed significantly from one in all cases, indicating that populations of larval and pupal stages exhibited aggregated spatial dispersion on new and old leaves of lime trees. Pairwise tests were not done to determine which parameters differed among stages. The results, however, suggest that patterns of spatial distribution did not differ among stages. However, each stage was considered separately in determining sample size requirements and sequential sampling stop lines.

Because overall, more consistent tests (higher r^2) were provided by Taylor's power law, Taylor's power law was used to model the functional relationship between the mean and variance for determining sample size curves and fixed-precision-level stop lines.

Sampling. Sample curves for fixed levels of precision are shown in Fig. 4. For a given level of the mean, the

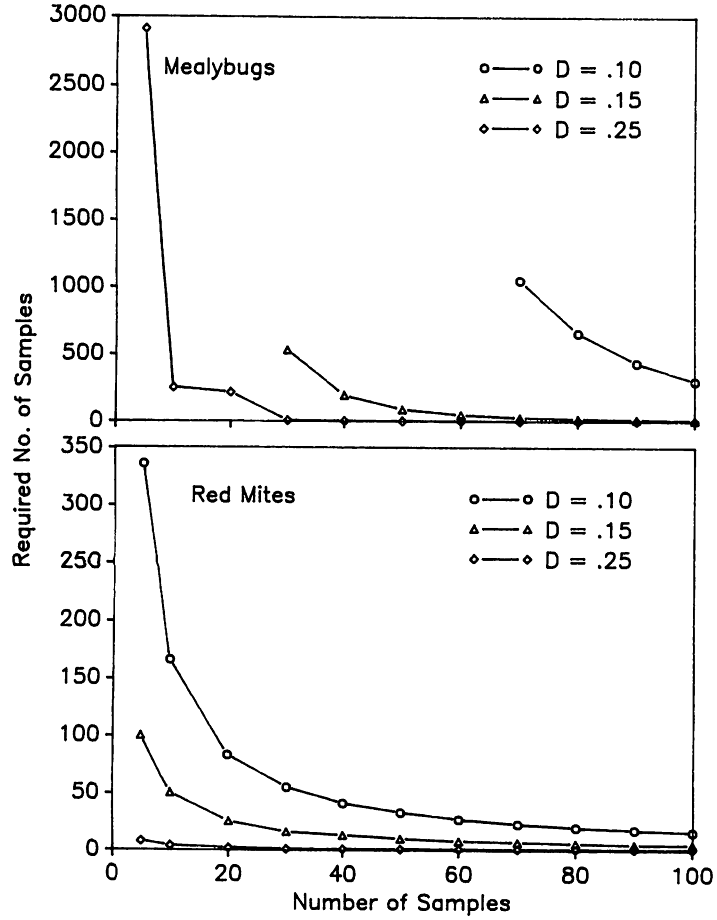

Figure 6. Stop lines for fixed precision-level-sequential sampling for *Planococcus citri* and *Panonychus citri* for precision levels of 0.10, 0.15, and 0.25.

Table 4. Comparion between relative variation (SE/x) and sample size (*n*) for mealybugs on limes, Homestead, Florida.

No. trees Sampled (n)	Mealybug Density	x	s^2	SE	(SE/x) × 100
10	low	0.00	0.00	0.00	000
20		0.00	0.00	0.00	000
30		0.03	0.03	0.03	100
40		0.05	0.05	0.03	60
50		0.04	0.04	0.02	50
100		0.04	0.03	0.02	50
10	high	0.00	0.00	0.00	000
20		0.15	0.45	0.15	100
30		0.10	0.30	0.10	100
40		0.10	0.24	0.07	70
50		0.14	0.24	0.07	50
100		0.10	0.15	0.04	40

fewest samples are required for estimation of populations of citrus red mite with a desired level of precision, and the highest are required for estimates of citrus mealybug populations. For example, at μ = 6.4 individuals per leaf, a total of 3 and 14 samples will be required to estimate populations of citrus red mite and citrus mealybug, respectively, with a specified level of precision of D = 0.25. This is primarily a reflection of the degree of aggregation (as indicated by the magnitude of parameter b) for the two species.

For a given level of the mean and a desired level of precision, the fewest samples are required for estimates of populations of cloudy-winged whitefly pupae and the most are required for estimates of cloudy-winged whitefly larvae (Fig. 5). When the density of cloudy-winged whiteflies is low (0-1 per leaf) many samples are required if precise estimates of the population are desired. For example, 297

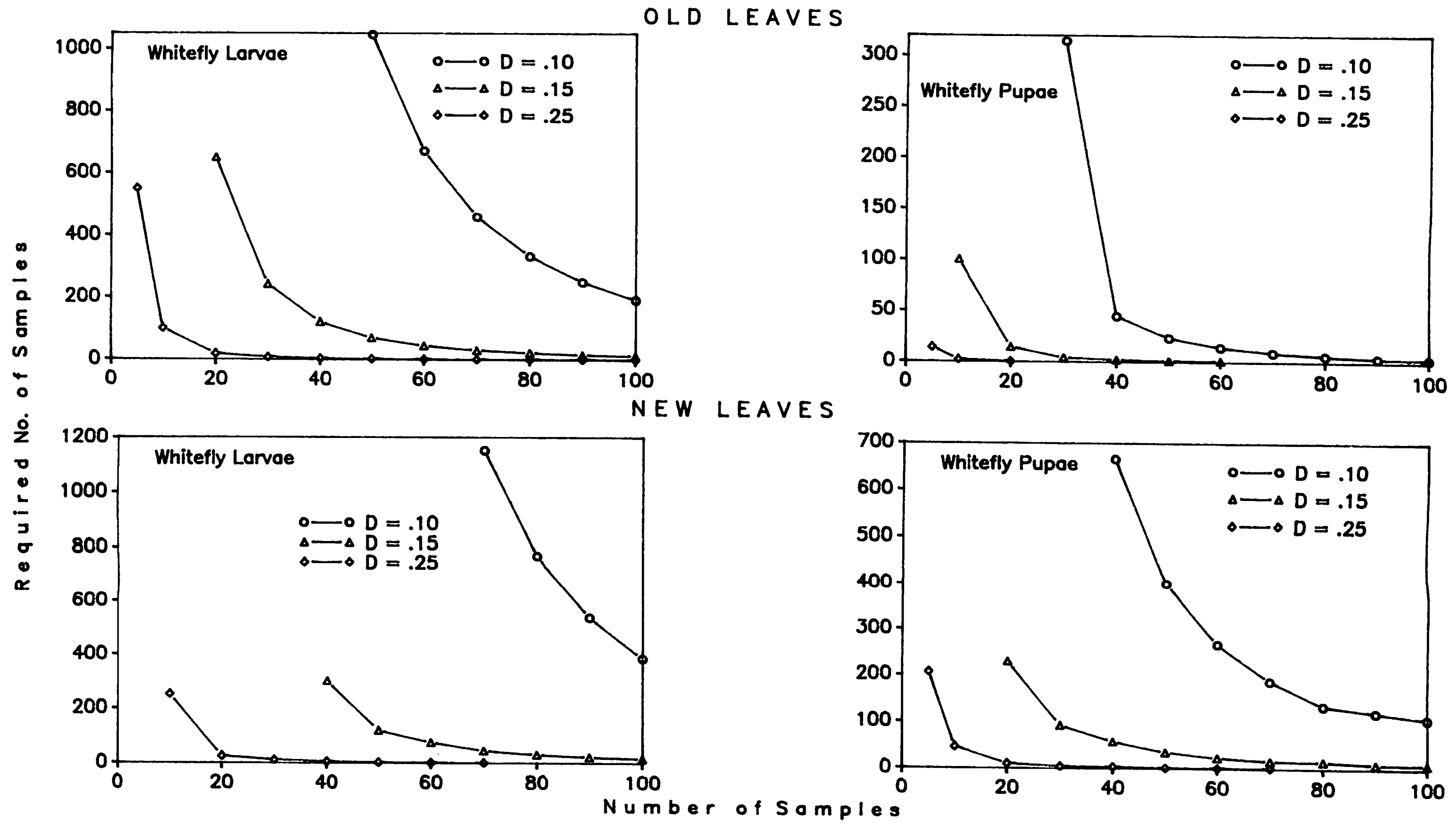

Figure 7. Stop lines for fixed precision-level-sequential sampling for *Dialeurodes citrifolii* for precision levels of 0.10, 0.15, and 0.25.

and 283 samples are required for larvae and pupae, respectively, to estimate populations of 0.05 whitefly per leaf with D = 0.10. This result suggests that at low whitefly densities, *precise estimates* might not be economically feasible using our sampling method. However, as cloudy-winged whitefly densities increase, sample size requirements rapidly decrease to feasible numbers. Constant - precision - level stop lines for each of the three species (Figs. 6-7) were calculated using equation 3 with the estimates of a and b obtained from the Taylor's power law regressions. Use of the stop lines provided a method for obtaining time-efficient estimates of population numbers of each species at desired levels of precision.

Iwao's patchiness regression cannot be used in equation 3 to predict the sequential sample stop line for the citrus mealybug, citrus red mite and cloudy-winged whitefly stages because the parameter causes the equation to yield negative values of Tn. Other methods can be used to compare the relative variation (SE/x) with the sample size (n). Results are shown in Tables 3 and 4. For instance, relative net precision was considered lowest when 50-100 trees are inspected for mealybugs. A range of 10-20 trees gave an acceptable relative net precision for the sampling of red mites.

These data show the importance of comparison of sequential sampling plans with respect to precision obtained and number of samples required. (Figs. 6 and 7). The differences in the cumulative number of samples among the different levels of precision indicates that the lower number of samples taken by using D = 0.25 will be the most useful basis for a sequential sampling plan for all species. The differences in stop lines exhibited by the cloudy-winged whitefly population can probably be attributed to a larger variance inherent to the larval stages. Our technique may be of use in a monitoring program for determining the need for control measures against citrus red mite, citrus mealybug, and cloudy-winged whitefly.

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TREND ANALYSIS OF WINE AND WINE COOLER CONSUMPTION IN FLORIDA

STEPHEN LEONG AND DAVID JONES
Center for Viticultural Sciences
Florida A&M University
Tallahassee, FL 32307

Additional index words. excise tax, table wine, sparkling wine, dessert wine, vermouth.

Abstract. **Florida is ranked third in the U.S. in total wine consumed. However, wine consumption, which has increased steadily during the last two decades, began to decline after the excise tax was increased. Results of the trend analysis showed that the consumption trend for sparkling wines, table wines, vermouths, and wine coolers was significantly affected by the increase in the excise tax. The projected trend shows a declining rate of wine consumption as a result of the tax increase.**

Increased wine consumption in the U.S. can be attributed to several factors, namely, the increased acceptance of wine as a beverage, changing consumer lifestyles, competitive wine prices and aggressive promotion by wineries and distributors (Spawton, 1991; Espey, 1991; Gluckman, 1990). Another reason for the increase in wine consumption is the high quality of fine U.S. wines that in toto are superior to those of any other country and are priced within reach of the family budget (Adams, 1990). These factors have also contributed to the increase in wine consumption in Florida. However, the consumption trend appeared to have changed in the early 1980s after the state's excise tax for table wine, dessert wine, and vermouth was raised. A significant increase in the excise tax for alcoholic beverages took place in 1977 and 1983. The excise tax for table wines containing less than 14% alcohol was increased from $1.75 to $2.25 per gallon and the tax on those containing more than 14% alcohol, including dessert wines and vermouths, was increased from $2.43 to $3.00 per gallon. The excise tax for sparkling wines and champagnes, which was increased in 1977 from $2.30 to $3.50 per gallon, has remained unchange since then. Wine coolers had the most dramatic increase in excise tax when it was raised from $0.40 per gallon to $2.25 per gallon in 1988 (Table 1). The current tax structure for alcoholic beverages in Florida is the highest in the nation, yet, a $3.20 per gallon surtax was introduced by the Florida legislature in 1990 for wines consumed on licensed premises in the state (Scully, 1991).

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