DIEL PERIODICITY AND TRAP BIAS IN STICKY TRAP SAMPLING OF SHARPNOSED LEAFHOPPER[1] POPULATIONS[2,3]

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ABSTRACT

Sharpnosed leafhoppers, *Scaphytopius magdalensis* (Provancher), exhibit a diel periodicity characterized by morning and evening peaks of flight activity. Adults are most commonly found on blueberry plants at night; they apparently seek shelter during the day and return to their host plants around dusk. Flight activity during midday and early afternoon is usually correlated with high temperature and low humidity. Most local flight activity occurs from 0 to 50 cm above the soil surface and is significantly affected by bush height.

Key Words: Blueberry, *Scaphytopius magdalensis*, sweeping, trap height, crepuscular, flight activity.

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INTRODUCTION

Yellow sticky traps have proven to be effective monitoring devices for populations of sharpnosed leafhoppers, *Scaphytopius magdalensis* (Provancher) (Tomlinson et al. 1950; Hutchinson 1955; Meyer 1984; Hopkins and Johnson 1984), but little information is available on the assumptions, biases, or limitations of these traps for estimating population size. Other leafhopper species, including the potato leafhopper, *Empoasca fabae* (Harris), the blackfaced leafhopper, *Graminella nigrifrons* (Forbes), and the blue-green sharpshooter, *Graphocephala atropunctata* (Signoret) as *Hordnia circellata* (Baker), have been routinely collected on yellow sticky traps (Pienkowski and Medler 1966; Purcell 1975; Alverson et al. 1977), yet recent attempts to correlate sticky-trap data with results obtained from other sampling methods have not given consistent results (Dysart 1962; Alverson et al. 1977; Purcell and Elkington 1980; Fleischer et al. 1983). Despite this dilemma, each report has pinpointed a number of abiotic variables which seem to affect daily capture rate — time of day, air temperature, trap height, and meteorological conditions (wind or rain) have been significantly correlated with trap catch in one or more of these recent studies.

Our experiments tested spatial and temporal variables as part of a larger, systematic attempt to assess the impact of abiotic factors on sticky trap catch of leafhoppers. Eventually we hope to use this information to recommend an optimal sampling strategy for sharpnosed leafhoppers and to derive more reliable estimates of population densities in the field.

[1] *Scaphytopius magdalensis* (Provancher), Homoptera: Cicadellidae
[2] Paper no. 9860 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7601.
[3] Use of trade names in this publication does not imply endorsement of the products named or criticism of similar ones not mentioned.

MATERIALS AND METHODS

Four variables (time of day, trap height, trap direction, and field position) were first evaluated in a multivariate experiment to determine which were significantly related to trap catch. The two most significant variables were then studied more critically to establish how they influenced total catch.

Multivariate Experiment

Near the peak of the second adult leafhopper generation (mid-July) fifteen yellow sticky traps (3 rows of 5) were set approximately 10 m apart near the center of a 2.5 ha blueberry field (cv. Murphy) that had been culturally abandoned for two years. Each trap consisted of two Zoecon Pherocon® AM traps stapled to adjacent sides of a rectangular wooden box (23 × 14 × 14 cm) mounted on a wooden stake approximately 1 m from the mid-line of the row and 0.5 m to the right of a bush. Stake length was adjusted in each row so the traps were mounted at three different heights (15 cm, 40 cm, and 100 cm — measured from soil surface to mid-point of the trap) corresponding to ground level, mid-plant, and just above the plant.

Sticky traps were changed four times a day and recycled daily so that each trap was in the field for the same six-hour period each day for one week. Trapping intervals were 10:00 am to 4:00 pm EDT (total light), 4:00 pm to 10:00 pm (dusk), 10:00 pm to 4:00 am (total darkness), and 4:00 am to 10:00 am (dawn). One side of each trap was marked so it always faced west, toward a four-lane highway. Other sides of the field were bordered by a two-lane road and pine woods (to the south) and weedy fields with sparce plantings of blueberries (to the east and north).

After seven days, all leafhoppers were removed from the traps with forceps and were soaked in a paint thinner containing petroleum distillates to remove trap adhesive. Numbers of males and females on each side of each trap were recorded together with trap height, trapping interval, direction of the trap face (N, E, S, or W), and location of the trap in the field. These data were evaluated using stepwise multiple regression (Statistical Analysis System, Ray 1982) to determine which variables had a significant impact on trap catch.

Diel Periodicity

Hourly data for trap catch were recorded from 20 yellow sticky traps during three 24-hour periods near the peak of each adult leafhopper generation (May, July and October) for two consecutive years (18 observations). Air temperature, relative humidity, vapor pressure deficit, wind speed and direction, and light intensity were recorded every 30 min. Sweepnet samples (100 sweeps per sample) of ground cover or blueberry foliage were taken at 1 to 2.5 hour intervals in adjacent sections of the field. Data for males, females, and nymphs (from sweepnet) were recorded separately.

Sticky trap data (flight activity) was arbitrarily divided into three equal time periods from dawn to dusk. Within each time period, Spearman rank correlation coefficients were computed between sticky trap catch and each of the abiotic variables listed above.

Trap Height

Yellow sticky traps were stapled to tall wooden stakes in each of three unsprayed blueberry fields. The traps started at ground level and alternated to the right and left side up the stake for a distance of 2 m from the ground (8 traps per stake). Four of these stakes were erected in each blueberry field. The fields were similar in appearance, except for size and age of the blueberry stands. Plants in field "A" were approximately 80 cm tall, those in field "B" were about 130 cm tall, and those in field "C" were 160 to 180 cm tall. Leafhoppers were trapped for 7 day periods near the peak of second and third adult generations (July and October). Numbers of leafhoppers trapped at each height were summed over the stakes in each field. Data from all three fields were evaluated with a Chi-square test of independence for bush height and trap height.

RESULTS

Trap height and time of day proved to have the greatest effect on sticky trap captures of sharpnosed leafhoppers; both variables were significant at the 99% confidence level (Table 1). The largest number of leafhoppers were collected on traps exposed from 4:00 pm to 10:00 pm EDT (dusk) and mounted at 15 or 40 cm above the ground. Despite prevailing winds out of the west, no directional movement was detected. Traps near the center of each row generally caught more leafhoppers than those at the row ends, but this trend was just barely significant at the 90% confidence level ($P = 0.094$).

Table 1. Stepwise regression of abiotic factors tested for correlation with sticky-trap catch of sharpnosed leafhoppers. These factors were treated as class variables in the analysis of variance and are listed in the order of their contribution to a reduction in the residual mean square.

Independent Variable	df	MS	F
Trap height	2	104.44	29.73 **
Time of day	3	83.98	23.91 **
Location in field	4	8.37	2.38 NS
Direction of trap	3	0.62	0.18 NS

** = significant at 99% confidence level.
NS = not significant.

Diel Periodicity

Hourly records of trap catch showed an increasing percentage of flight activity in the late afternoon with a peak from 1 to 2 hours before sunset. A smaller peak generally occurred in the morning, either at dawn or as soon as air temperature reached approximately 15°C (Fig. 1). Males outnumbered females on the traps by 6:1, but there was no significant difference in this sex ratio over the course of a day ($P > 0.05$).

From day to day, the highest variability in hourly catch occurred between 11:00 am and 4:00 pm. During these hours, flight activity was more highly correlated with temperature, humidity, and light intensity than earlier or later in the day (Table 2). In general, third generation adults were more active throughout the day than either first or second generation adults.

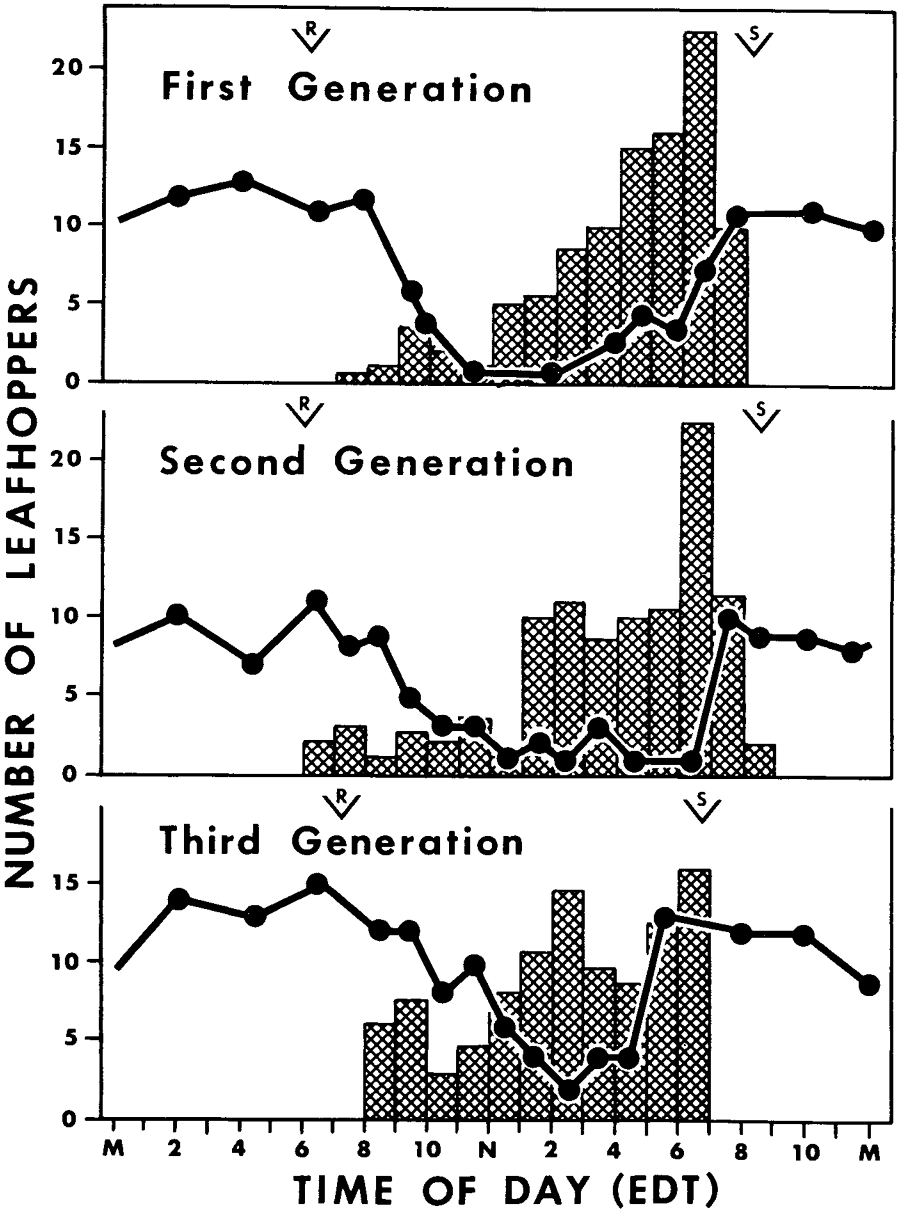

Fig. 1. Average number of sharpnosed leafhoppers collected throughout the day. Vertical bars represent mean hourly catch on 20 sticky traps (N = 6), and solid circles represent mean number of adults collected in 100 upward sweeps of blueberry foliage (N = 3). Inverted caret symbols indicate approximate time of sunrise (R) and sunset (S).

Table 2. Spearman rank correlation coefficients computed between hourly catches of sharpnosed leafhoppers on sticky traps and six abiotic variables measured concurrently in the field.

Independent Variable	Eastern Daylight Time 6 am to 11 am	11 am to 4 pm	4 pm to 9 pm
Vapor press. deficit	0.13	0.57	0.36
Temperature	0.13	0.49	0.19
Relative humidity	0.09	-0.29	-0.15
Light intensity	0.25	0.10	-0.41
Wind speed	-0.06	0.04	0.06
Wind direction	-0.04	0.11	-0.07

Sweepnet collections of leafhoppers from blueberry foliage also showed a regular daily cycle, but the highest numbers were always recorded at night (Fig. 1). In the morning, the number of adults collected from foliage began to drop shortly after dawn (or when air temperature reached about 15°C) and usually did not increase again until early evening. Sweepnet collections from the ground cover between rows never yielded more than two adults per 100 sweeps. The sex ratio in all sweepnet collections was approximately 1:1.

Trap Height

Despite differences in plant height between the three fields, the largest percentage of leafhoppers was always collected on the sticky traps located from 0 to 50 cm above the soil surface. Relatively larger proportions of leafhoppers were collected above 50 cm on the taller plants (Fig. 2), but very few were caught on traps mounted above the foliage. A chi-square test of independence gave a value of 72.08 (6 df), indicating a highly significant relationship between bush height and the number of leafhoppers collected at different distances from the ground. Although the ratio of males to females was about 5.5:1, there was no significant difference between the sexes in their height distribution on the traps ($P = 0.43$).

DISCUSSION AND CONCLUSIONS

Lack of significance in the mean squares for trap position and direction implies that leafhopper adults are randomly distributed throughout the field and show no directionality of movement either in relation to wind or to adjacent blueberry foliage. Casual observations, however, gave the impression that adults were most common in sections of the field where blueberry foliage was lush and dense. Since bushes in the experimental field were uniform in the center and less vigorous around the perimeter, the arrangement of sticky traps tended to minimize the impact of environmental heterogeneity on the analysis of variance. This design artifact may explain the near-significant mean square for trap location listed in Table 1.

Regardless of bush height, local flight activity appears to be concentrated in the lower third of a field's foliage canopy: more than 50% of the adults were collected on traps below 50 cm. This distribution is consistent with the observation by Tomlinson et al. (1950) that feeding and oviposition occur primarily on leaves in the lower, shaded portions of a bush. Since sticky traps near ground level

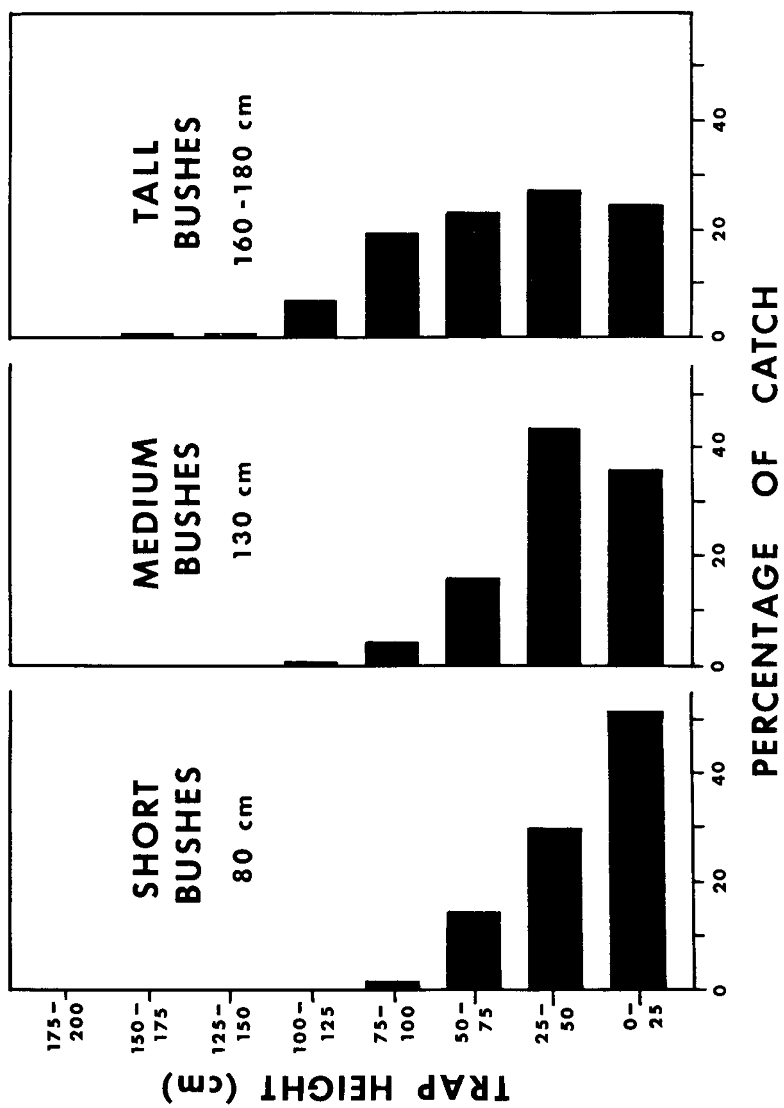

Fig. 2. Vertical distribution of sharpnosed leafhopper adults collected on sticky traps in three blueberry fields with different bush heights.

quickly become coated with wind-blown sand and debris, optimal trap height is around 40 - 50 cm.

Comparison of hourly changes in the number of individuals collected by sticky trap and sweep net suggests a diel pattern of activity in which adult leafhoppers feed nocturnally on the blueberry plants, seek cover in the morning, and return to their host plant near dusk. Additional flight activity may occur during the day, especially when the insects are exposed to the desiccating effects of high temperature and low relative humidity.

If this daily activity pattern exists in other leafhopper species, it could explain the poor correlation some workers have found between sticky trap data and instantaneous sampling methods such as suction traps or sweep nets (Fleischer et al. 1983; Purcell 1975). Sticky traps sample a population of moving insects while sweep nets or vacuum devices are more independent of the insect's behavior or level of activity. Obviously, these instantaneous methods will show a high correlation with sticky trap data only when they are conducted during an appropriate stage of the insect's diel cycle.

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