SEASONAL DISPERSAL AND HOST PREFERENCE BY ADULT SHARPNOSED LEAFHOPPERS (HOMOPTERA: CICADELLIDAE) IN NORTH CAROLINA WOODLANDS[1]

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ABSTRACT

Scaphytopius spp. were sweep-sampled weekly from 20 April to 20 November 1984 in creeping blueberry, *Vaccinium crassifolium* Andrews, near a commercial blueberry field in North Carolina to establish migration patterns. Population growth curves of adults were compared to those of 5th-instar nymphs. Differences in curve patterns indicated adult dispersal from creeping blueberry during the first two generations and return in the 3rd generation. Adults were sampled in wild highbush blueberry, *V. corymbosum* L.; sheepkill, *Kalmia angustifolic* (Small); huckleberry, *Gaylussacia frondosa* (L.) Torrey & Gray; and creeping blueberry to determine inter-host dispersal and host preference. Analysis of variance on numbers of captured males showed significant differences between host species for *S. magdalensis* (Provancher), but none for *S. verecundus* (Van Duzee). The former species preferred sheepkill, highbush blueberry and huckleberry, while the latter was uniformly distributed among all four host species. It was recommended that sampling programs for wild *S. magdalensis* be conducted in huckleberry due to abundance of this host and ease of sampling.

Key Words: Cicadellidae, creeping blueberry, *Gaylussacia,* highbush blueberry, Homoptera, huckleberry, *Kalmia,* migration, sheepkill, *Scaphytopius, Vaccinium.*

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INTRODUCTION

Scaphytopius magdalensis (Provancher), a sharpnosed leafhopper and the vector of blueberry stunt mycoplasma (Tomlinson et al. 1950), is a serious pest of cultivated highbush blueberry, *Vaccinium corymbosum* L. (Millholland & Meyer 1984). In North Carolina, *S. verecundus* (Van Duzee), a sharpnosed leafhopper, is also found in highbush blueberry (Meyer 1984); however, it is not known to vector blueberry stunt disease (Hutchinson 1955; Maramorsch 1955). Adults of the two species cannot be distinguished externally; males can be identified to species only by examining the paraphyses; females cannot be identified to species (Hutchinson 1955). Sharpnosed leafhoppers have been found associated with wild as well as commercial blueberry species. In New Jersey, Hutchinson (1955) found *S. magdalensis* primarily in cultivated blueberry fields, *S. verecundus* in cultivated cranberry bogs and both leafhopper species in pine woodlands where they developed on several

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species of wild Ericaceae. Hopkins and Johnson (1984) recorded few *S. verecundus* in woodlands of Arkansas, but adults of *S. magdalensis* were found to be more common in wild habitats than they were in commercial fields.

Leafhoppers are attracted to the color yellow (Alverson et al. 1977); however, yellow sticky traps do not collect sharpnosed leafhopper nymphs (Hopkins and Johnson 1984). In North Carolina, first-generation *Scaphytopius* nymphs have been collected by sweepnet from creeping blueberry, *V. crassifolium* Andrews, the major woodland host species in leaf at this time (April). Few nymphs have been swept from other host plant species. Large populations of adults have been swept and taken on yellow sticky traps in creeping blueberry; wild highbush blueberry; sheepkill, *Kalmia angustifolia* (Small); and huckleberry, *Gaylussacia frondosa* (L.) Torrey & Gray, throughout the summer (Whitney 1986), but little has been reported of their host preference. Meyer (1984) compared yellow sticky trap sampling with sweepnet sampling for both leafhopper species. He found highbush blueberry difficult to sweep. Sweepnet sampling of adults and nymphs in woodlands clearly showed a discrete 1st generation, but later generations overlapped. Yellow sticky traps were more attractive to *S. magdalensis* than to *S. verecundus* and to males of both species. This sampling, however, demonstrated three distinct generations in both wild and cultivated habitats. Nymphs emerged in late March, began feeding on blueberry leaves and developed into adults by early May. Adults of generation II occurred from late June to late August; generation III, mid-September to mid-November.

Little is known about the effects of environmental factors on growth and development of *Scaphytopius* nymphs. Bailey et al. (1962) and Ballinger (1966) analyzed blueberry leaf sugar and nitrogen and found reduced content in autumn leaves. This poor nutritional quality may account for the longer development time observed for 3rd-generation nymphs by Meyer. Kouskolekas and Decker (1966) noted that the threshold for development of potato leafhopper, *Empoasca fabae* (Harris), was approximately 52.5°F (11°C).

Based on observations of population fluctuations, Marucci (1948) suggested that *S. magdalensis* migrates from wild hosts into cultivated fields each spring and back into woods in autumn. He further hypothesized that many overwintering eggs are laid on wild hosts. Meyer (1984) compared adult population levels in wild habitats and cultivated fields: 2nd-generation individuals were more abundant in cultivated fields, but 1st- and 3rd-generation adults were more common in wild hosts. These results may indicate movement by 1st-generation adults from wild to cultivated fields and movement by 3rd-generation adults from cultivated fields into wild habitats (Whitney 1986). This paper presents results of a sweepnet sampling survey in creeping blueberry undertaken to determine if 1st-generation *Scaphytopius* disperse from this wild host and if 3rd-generation adults return, a sampling survey to demonstrate *Scaphytopius* dispersal between creeping blueberry and huckleberry, and a sticky trap survey for host preference by 2nd- and 3rd-generation *Scaphytopius* in North Carolina woodlands.

MATERIALS AND METHODS

Sharpnosed leafhoppers were sampled in a portion of Bladen Lakes State Forest, Bladen County, NC, ca. 3.0 km from a 120-ha commercial blueberry field. Forest understory was primarily creeping blueberry and huckleberry, with occasional sheepkill, highbush blueberry and other ericaceous plants. Creeping blueberry is a ground cover, huckleberry and sheepkill grow to ca. 1.5 m and highbush blueberry may grow up to 2.5 m. Loblolly and longleaf pines, *Pinus taeda* L. and *P. palustris* Miller, were the dominant trees. To determine host availability for 1st-generation nymphs, dates of leaf bud opening were recorded for each herbaceous species except creeping blueberry, an evergreen.

Phenology Study.

To determine generation intervals for both species of leafhoppers, ten yellow sticky traps (Zoecon Pherocon® AM) were hung ca. 0.5 to 1.0 m from the ground in the four wild host plant species: four in highbush blueberry, four in huckleberry, one in sheepkill and one in creeping blueberry. They were changed weekly from 27 April 1984 until 20 November 1984; adults were removed and sexed using paint thinner to dissolve trap adhesive. Dissection of male genitalia (up to 50 per trap) established species identification. A hygro-thermograph maintained in an abandoned commercial blueberry field ca. 16 km from the forest provided continuous temperature records. Sample dates were converted into cumulative hours above 13°C from 27 April; numbers of adults captured were plotted against time. End points of each generation were extrapolated from the graph and used to prepare population growth curves from numbers of sweep sampled adults in the dispersal study.

Numbers of adult males of each species on the trap in creeping blueberry were ranked and Spearman's Rank correlation coefficient (Snedecor and Cochran 1967) was calculated to determine if population growth patterns of the two species differed in creeping blueberry over the year. Total numbers of adults captured on a set of eight yellow sticky traps in creeping blueberry during 1985 were also analyzed in this manner for the same reason.

Dispersal Both from and to Creeping Blueberry.

To determine if sharpnosed leafhoppers disperse from wild blueberry as adults, it was necessary to sample both adults and nymphs. Creeping blueberry was chosen as the host for this study because it contains large populations of *Scaphytopius* adults and nymphs, it is easier to sweep-sample than other host species and it is abundant.

Scaphytopius adults and nymphs were sweep-sampled weekly from 25 March 1984 to 20 November 1984 in 10 patches of creeping blueberry each ca. 6 m in diameter. Each sample, 20 sweeps from one patch, was placed into a clear-topped wooden transfer box with a cloth sleeve on one side. The sleeve could be opened to allow insertion of the sample, closed to prevent escape of specimens and partially opened to permit removal of specimens with an aspirator. Leafhoppers were aspirated into a glass tube; numbers of adults and each instar (1-5) were recorded before being released. Two sets of graphs were prepared: the first was a set of ten graphs, one for each sample site; the second was one composite graph that combined all ten sample sites. Separate curves were plotted for 5th-instar nymphs and adults. Numbers of individuals were plotted against cumulative hours above 13°C from 25 March and the composite adult curve was divided into three generations using the end points established in the phenology study. The median of the composite 1st generation 5th-instar nymph curve was subtracted from that of the composite 1st-generation adult curve to obtain an estimate of time required for development of 5th-instar nymph into adult. To set initial points for the remaining 5th-instar nymph generations, the estimate of development time was subtracted from the start of each adult generation on the composite curve.

To obtain logistic curves from both adult and 5th-instar nymph population curves per generation per sample site, sweepnet-sample numbers were transformed to cumulative percentages: the cumulative number of individuals on each sample date for that generation was divided by the cumulative number of individuals obtained by the end of that generation. These percentages were plotted against cumulative hours above 13°C per patch, per generation. Either slope values or area under the top of the curve was analyzed (Binomial tests, Steel and Torrie 1960) to determine if the adult population for each generation had developed at a rate similar to that of the 5th-instar nymphs for that generation.

Numbers of 1st-generation, 1st-instar nymphs collected on each sample date were divided by the total number collected during that generation to estimate the proportion of 1st-instar emergence on each sample date. These proportions were compared to records of leaf opening for each host species to determine synchronization of overwintering egg hatch with host species availability.

Inter-host Dispersal.

To describe *Scaphytopius* spp. seasonal dispersal in woodlands, three sampling techniques were used in 1985: sweepnet, yellow sticky traps and clear plexiglass sticky traps. Each technique had advantages and disadvantages. Yellow sticky traps collect continuous and large samples; however, they may capture individuals from other habitats that have been attracted by the color of the trap. Clear sticky traps are more likely to sample individuals from the trapping habitat only, but they capture few individuals.

Compared to yellow sticky trap sampling, sweepnet sampling gives a more accurate estimate of species and sex ratios within creeping blueberry and huckleberry. A sweepnet can sample the entire plant and capture leafhoppers that are not attracted to yellow traps, although comparisons of insect numbers between host-plant species are difficult to make due to differences in foliage density, plant size and sweepnet manuverability. However, the ratio of two insect species within one host-plant species may be compared to the ratio of those two insect species within another host-plant species. When the total number of insects sampled within one host species is the same as that within another host species, numbers may be compared as well as ratios. Unfortunately, obtaining identical sample numbers is often difficult. Standardizing each host's sample to a common number allows direct comparison of numbers between host-plant species.

Weekly sweepnet samples of ca. 50 adults each were taken in creeping blueberry and huckleberry from May to October 1985. Adults were sexed and males were dissected for species identification. Two types of proportions were calculated to describe adult distribution. For the first proportion, the number of *S. magdalensis* males captured in creeping blueberry was divided by the total number of males of both species captured in creeping blueberry. A similar calculation was made for *S. verecundus* in creeping blueberry and for both species in huckleberry. This gave percent of *S. magdalensis* in creeping blueberry compared to percent of *S. verecundus* in creeping blueberry. These proportions were tested for differences using Z test for pair-wise comparisons of proportions (Brown and Hollander 1977).

To calculate the second type of proportion, sweep samples were standardized to a total sample of 100 males per host. For example, if a sample of five *S. magdalensis* and ten *S. verecundus* was swept from creeping blueberry, after standardization these numbers would become 33 and 67, respectively. Standardized numbers of *S. magdalensis* males captured in creeping blueberry were divided by the total standardized number of *S. magdalensis* males captured in both creeping blueberry and huckleberry. A similar calculation was made for *S. magdalensis* captured in huckleberry and for *S. verecundus* in both host species. This gave percent of *S. magdalensis* in creeping blueberry compared to percent of *S. magdalensis* in huckleberry, for example. A large proportion of adults in huckleberry might indicate dispersal of *S. magdalensis* from creeping blueberry to huckleberry.

Eight yellow sticky traps were hung in creeping blueberry and eight in huckleberry ca. 0.5 m from the ground in a wooded site adjacent to the cultivated field. Adults were sampled during generation peaks from 7 May to 30 October 1985. Traps were changed weekly, adults removed, cleaned with paint thinner and sexed. Species identifications were based on dissections of male genitalia. Both measures of percent distribution described above were calculated for each species, however, samples were not standardized; Z tests were conducted. Twelve clear plexiglass boards, 23 x 14 cm, were spread on both sides with adhesive (Tanglefoot®, Grand Rapids, MI). Six were hung in huckleberry foliage and six were positioned at ground level in creeping blueberry. Sample dates were the same as yellow sticky traps; samples were treated as above.

Host Preference.

Forty-eight yellow sticky traps were positioned in the four wild host species to quantify host preference. Three replicates of four traps per host were used in 1985 during peaks of the 2nd and 3rd generations. Traps were hung in foliage of each host except for those in creeping blueberry which were positioned at ground level. All traps were changed weekly and adults treated as described above. Analysis of variance was conducted (Snedecor and Cochran 1967) for both species; treatments were sites, sample dates and host plant species.

RESULTS

Creeping blueberry was the only woodland host in leaf when 1st-instar nymphs were first collected on 25 March 1984. During the 1st generation, 157 first-instar nymphs were sweep-collected from this host. When leaves of highbush blueberry began opening on 6 April 1984, 29 (18.5%) of these 1st-instar nymphs had been collected. Leaves of huckleberry began opening on 27 April and those of sheepkill on 4 May. On these dates, 151 (96.2%) and 157 (100%) of the 1st-instar nymphs had been collected; therefore, many nymphs began feeding in either creeping blueberry or highbush blueberry. Although Bladen Lakes State Forest contains occasional highbush blueberry, creeping blueberry is the dominant species among Ericaceae. Overwintering eggs hatch from leaves of the previous year that have fallen from wild host plants to the forest floor. The first available host that newly hatched leafhoppers contact is creeping blueberry, thus, creeping blueberry is most likely the major host for 1st-generation *Scaphytopius* nymphs in woodlands.

Phenology.

Numbers of adult *Scaphytopius* collected in 1984 from yellow sticky traps are shown in Figure 1. Adult generation dates estimated from these data were: 4 May

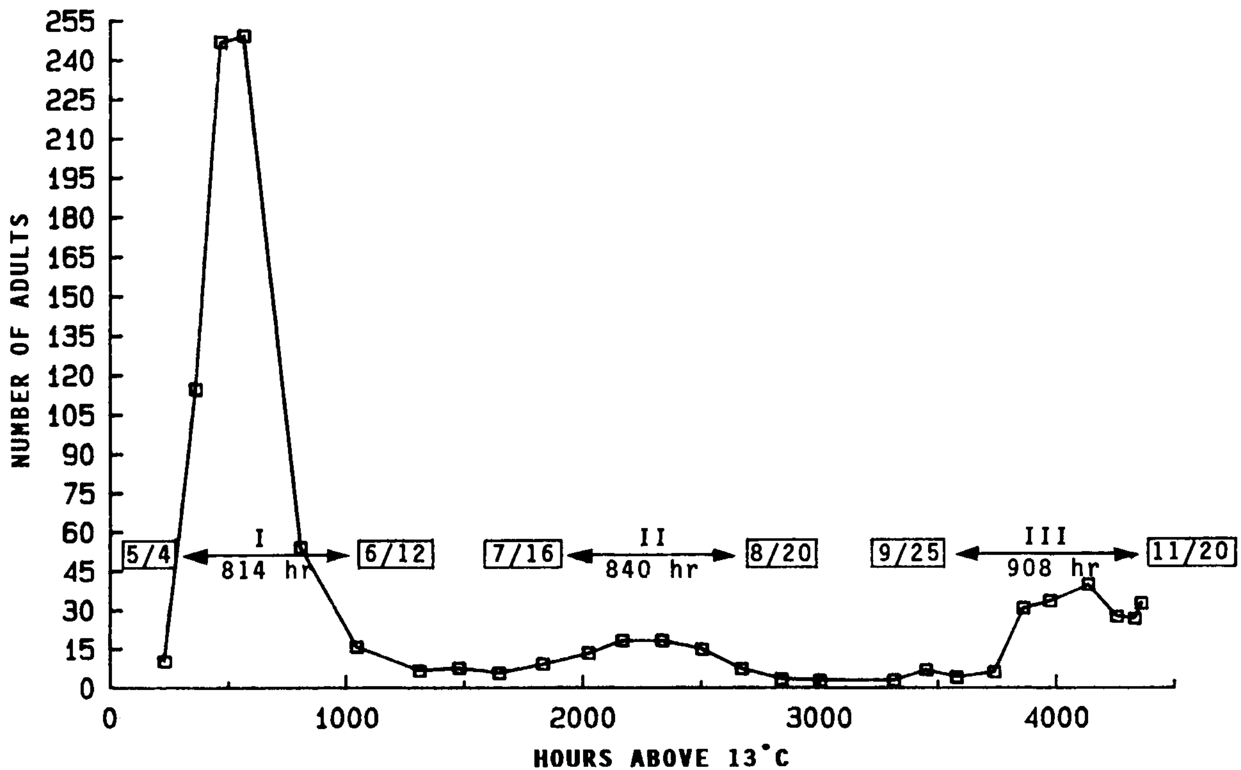

Figure 1. Number of *Scaphytopius magdalensis* and *S. verecundus* adults (male and female) captured on ten yellow sticky traps in four host species in North Carolina woodlands, 1984. Calendar dates (month/day) are given in boxes per generation. Arrow indicates estimated generation time, number under arrow gives hours above 13°C for that generation.

to 12 June; 16 July to 20 August; and 25 September to 20 November. Table 1 shows numbers of males of each species collected in creeping blueberry at two sites. Spearman's Rank Correlation Coefficient showed no significant difference in patterns of population growth between the two species over time.

Dispersal both from and to Creeping Blueberry.

Figure 2 shows the composite graph from sweepnet samples taken in 1984: numbers of adults and 5th-instar nymphs per 200 sweeps in creeping blueberry during 1984 are plotted against cumulative hours above 13°C. The difference between first-generation medians (estimated 5th-instar nymph to adult development time) was 266 hr above 13°C. To prepare logistic growth curves for 5th-instar nymphs, the start of generation I was set at 233 hr (20 April) before the beginning of the adult generation on 4 May; using 266 hr would have required interpolation before first event observation. Start of 2nd-generation, 5th-instar nymphs was set at 258 hr (4 July) before the beginning of the adult generation on 16 July. There were two observations before the beginning of the 3rd adult generation on 25 September: 18 September and 4 September. There were only 136 hr between 18 and 25 September, but 448 hr between 4 and 25 September. A point halfway between 4 and 25 September (11 September) was established as the start of the 3rd generation 5th-instar nymphs giving a development time of 292 hr.

The duration of the 1st-generation, 5th-instar nymph was similar to that of the adult (810 hr); thus 2nd and 3rd 5th-instar nymph generations were given durations equal to those of their adults. End points were set at 2 June, 9 August and 27 October. No observations were made on 4 July, 9 August, 11 September and 27 October; thus, percentages of population growth at these times were interpolated.

Logistic curves for first-generation adult samples were superimposed over those of the 5th-instar nymphs. The area under the top of each logistic curve was calculated by counting blocks on the graph paper from the point of intersection of the two curves (Table 2). Each area under the adult curve was compared to that of the nymph curve and categorized "less" or "greater." Second- and 3rd-generation curves were linear, and slope values were calculated (Table 2). Each adult slope value was compared to that of the nymph and categorized "less" or "greater." Table 2 shows that the same assignment was made nine, eight and eight times for generations I-III, respectively. If, in fact, there were no differences between the nymph and adult curves, the results of the 1st generation could be expected 1.1 times in 100 and those of the 2nd and 3rd generation 5.5 times in 100 as determined by binomial distribution. Adults were lost from woodlands during the first two generations and added during the 3rd generation.

Inter-host Dispersal.

Tables 3 and 4 contrast adult male capture in creeping blueberry and huckleberry during 1985. Table 3 gives proportions of the two leafhopper species captured in each host plant species. Sweepnet samples in creeping blueberry contained significantly more *S. verecundus* males ($\bar{x}$=94.2%) than *S. magdalensis* ($\bar{x}$=5.8%); samples in huckleberry contained significantly more *S. magdalensis* males ($\bar{x}$=63.4%) than *S. verecundus* ($\bar{x}$=36.4%). Yellow sticky traps in creeping blueberry captured signficantly more *S. verecundus* ($\bar{x}$=54.3%) than *S. magdalensis* ($\bar{x}$=45.7%). In huckleberry these traps captured significantly more *S. magdalensis* ($\bar{x}$=94.2%) than *S. verecundus* ($\bar{x}$=5.8%). Clear sticky traps in creeping blueberry captured equal

Table 1. Total number (per seven day) of *Scaphytopius magdalensis* and *S. vercundus* adult males caught by yellow sticky trap in creeping blueberry at two sites. 1984, one trap; 1985 eight traps.

Date trap set out	Total # trapped		Date trap set out	Total # trapped		Date trap set out	Total # trapped	
1984	MAG	VER	1984	MAG	VER	1985	MAG	VER
27 April	13	0	13 August	4	7	7 May	58	35
4 May	60	16	20 August	1	2	13 May	84	84
11 May	42	35	28 August	0	2	21 May	11	24
17 May	16	11	4 September	0	2	27 May	5	21
22 May	9	6	18 September	0	0	3 June	2	4
2 June	5	3	25 September	1	3	17 July	7	6
12 June	0	0	2 October	1	4	22 July	15	23
23 June	0	0	12 October	1	1	31 July	5	21
30 June	0	0	18 October	1	1	5 August	19	48
7 July	0	0	23 October	18	10	9 October	36	26
16 July	7	5	30 October	11	16	16 October	26	26
24 July	10	10	6 November	10	15	23 October	22	28
30 July	17	16	13 November	8	2			
6 August	12	14	20 November	5	0			

MAG, *S. magdalensis* males; VER, *S. verecundus* males
1984 sample, no significant difference between MAG and VER, Spearman's Rank Correlation Coefficient, 0.809; df, 26; $P<0.05$
1985 sample, no significant difference between MAG and VER, Spearman's Rank Correlation Coefficient, 0.879; df, 10; $P<0.05$

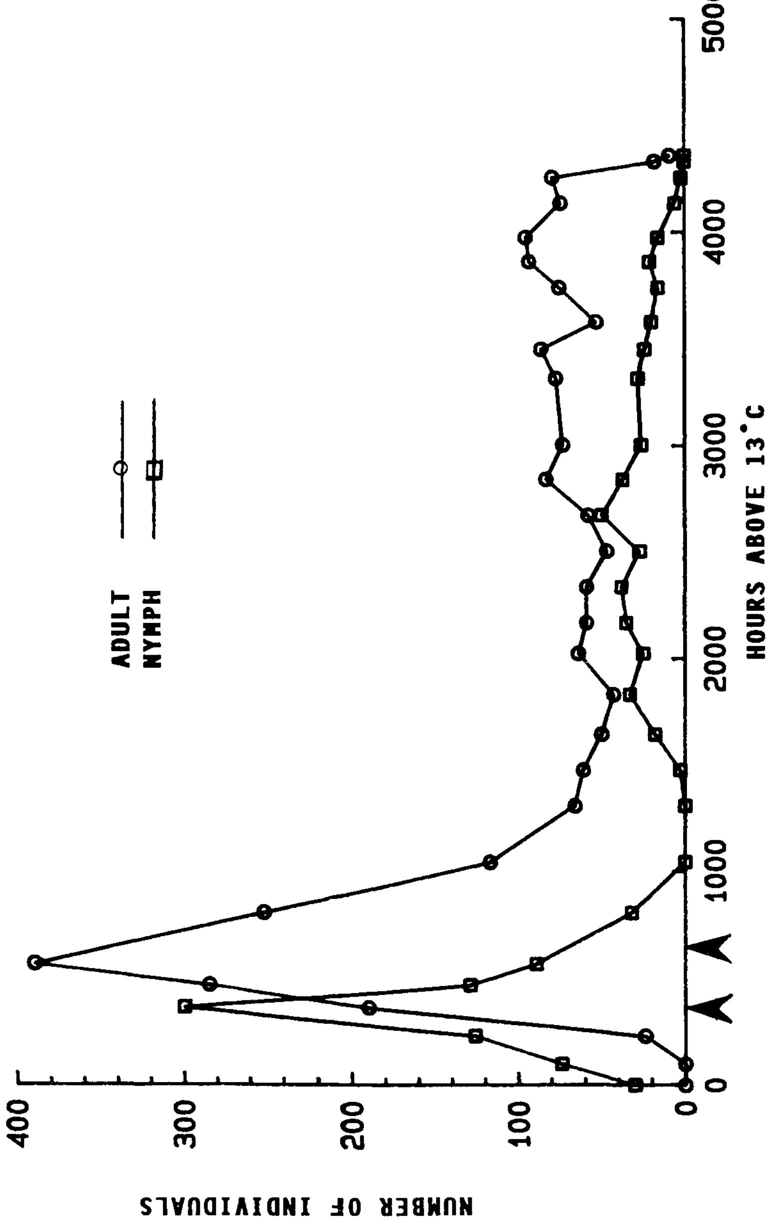

Figure 2. Number of *Scaphytopius* spp. 5th-instar nymphs and adults per 200 sweeps in creeping blueberry, 1984. Arrows indicate means of 1st generations.

Table 2. Area (square units) under the top of the logistic curve for generation I, slope of the curve for generation II and III. *Scaphytopius* adults and 5th instar nymphs swept from creeping blueberry patches in 1984.

	Patch									
	1	2	3	4	5	6	7	8	9	10
Generation I (a)										
Area under top of adult curve	19.50	21.50	17.25	5.25	1.75	5.50	17.50	10.75	12.00	2.50
Area under top of nymph curve	23.58	29.24	26.75	6.20	2.19	6.22	22.00	13.00	14.50	2.25
Adult area greater or less than nymph area?	less	less	less	less	less	less	less	less	less	greater
Generation II (b)										
Slope of adult curve	0.1144	0.1044	0.0964	0.0991	0.0902	0.0967	0.1023	0.1011	0.1191	0.1070
Slope of nymph curve	0.1086	0.1184	0.1221	0.1230	0.1321	0.1199	0.1238	0.1195	0.1158	0.1208
Adult slope greater or less than nymph slope?	greater	less	less	less	less	less	less	less	greater	less
Generation III (b)										
Slope of adult curve	0.0859	0.0933	0.0992	0.0931	0.0848	0.0933	0.0954	0.0927	0.0884	0.0807
Slope of nymph curve	0.0740	0.0930	0.0644	0.1082	0.1013	0.0902	0.0892	0.0847	0.0791	0.0557
Adult slope greater or less than nymph slope?	greater	greater	greater	less	less	greater	greater	greater	greater	greater

(a) test of significance, probability that nymph curves are similar to adult curves is 0.011; binomial distribution, Steel and Torrie 1977.
(b) test of significance, probability that nymph curves are similar to adult curves is 0.055; binomial distribution, Steel and Torrie 1977.

Table 3. Percent composition of adult male leafhopper capture in each woodland host using three sampling techniques, 1985.

	Sweep samples				Yellow trap samples				Clear trap samples			
	CBB (1)		HU (1)		CBB (1)		HU (1)		CBB (2)		HU (1)	
Sample	% MAG	% VER	% MAG	% VER	% MAG	% VER	% MAG	% VER	% MAG	% VER	% MAG	% VER
Gen I	8.1	91.9	70.5	29.5	49.1	50.9	93.8	6.2	85.7	14.3	81.1	18.8
Gen II	3.1	96.9	59.5	40.5	31.9	68.1	90.4	9.6	60.0	40.0	80.0	20.0
Gen III	7.4	92.6	61.3	38.7	51.2	58.8	98.0	2.0	33.3	66.7	84.1	15.9
$\overline{X}$	5.8	94.2	63.4	36.6	45.7	54.3	94.2	5.8	53.5	46.5	81.6	18.4
n	14	227	272	157	288	342	1241	77	23	20	142	32

CBB, creeping blueberry; HU, huckleberry; MAG, *Scaphytopius magdalensis;* VER, *S. verecundus;* Gen, generation

(1) significant difference at P=0.05 level between percent capture of leafhopper species (Z test)

(2) no significant difference at P=0.05 level between percent capture of leafhopper species (Z test)

Table 4. Percent distribution between creeping blueberry (CBB) and huckleberry (HU) of each leafhopper species using three sampling techniques, 1985.

	Sweep samples				Yellow trap samples				Clear trap samples			
	% MAG		% VER		% MAG (1)		% VER (1)		% MAG (1)		% VER (2)	
Sample	CBB	HU	CBB	HU	CBB	HU	CBB	HU	CBB	HU	CBB	HU
Gen I	10.2	89.8	78.5	21.5	22.1	77.9	81.6	18.4	14.1	85.9	10.5	89.5
Gen II	4.9	95.1	70.2	29.8	13.3	86.7	75.4	24.6	8.6	91.4	20.0	80.0
Gen III	14.0	86.0	70.3	29.7	18.0	82.0	90.1	9.1	17.8	82.2	69.6	30.4
$\overline{X}$	9.8	90.2	71.7	28.3	18.8	81.2	81.6	18.4	13.9	86.1	38.5	61.5
n (st)	69	633	931	367								
n (obs)	14	272	227	157	288	1241	342	77	23	142	20	32

MAG, *Scaphytopius magdalensis* adult males; VER, *S. verecundus* adult males; CBB, creeping blueberry; HU, huckleberry; Gen, generation; n (st), standardized sample size; n (obs), observed sample size

(1) significant difference at P = 0.05 level between percent capture of leafhopper species (Z test)

(2) no significant difference at P = 0.05 level between percent capture of leafhopper species (Z test)

proportions of the two leafhopper species, but those in huckleberry captured signficantly more *S. magdalensis.*

Table 4 gives a measure of the host range for each insect species. More sweep-collected *S. magdalensis* males were taken from huckleberry than from creeping blueberry. More *S. verecundus* males were found in creeping blueberry than in huckleberry. *S. magdalensis* males were captured significantly more often on yellow sticky traps in huckleberry ($\bar{x}$=81.2%) than on those in creeping blueberry ($\bar{x}$=18.8%), while *S. verecundus* males were significantly more common in creeping blueberry ($\bar{x}$=81.6%) than in huckleberry ($\bar{x}$=18.4%). Males of *S. magdalensis* were found significantly more often on clear traps in huckleberry than on those in creeping blueberry, but no significant difference was found between the occurrence of *S. verecundus* in creeping blueberry and that in huckleberry.

Host Preference.

Analysis of variance on numbers of males caught during generation II and III in 1985 is reported in Table 5. No significant differences were found between sites, thus these numbers were combined for both species. Significant differences were found between generations for both species; more leafhoppers were trapped in generation III than in generation II. Significant differences between host species were found for *S. magdalensis;* fewer males were found in creeping blueberry ($\bar{x}$=29.3) than in other hosts: huckleberry ($\bar{x}$=49.5), sheepkill ($\bar{x}$=53.6), highbush blueberry ($\bar{x}$=60.1). Males of *S. verecundus* were equally distributed among the four host-plant species.

DISCUSSION

Dispersal both from and to Creeping Blueberry.

In contrast to the 3rd generation, adults were lost from woodlands during the first two generations of 1984. This loss could be caused by emigration or mortality resulting from disease, weather, predation or poor food quality. Little is known about effects of disease or weather on sharpnosed leafhoppers; however, late summer is usually dryer in Bladen Lakes State Forest, thus conditions are probably more conducive to leafhopper growth and development in spring. Predation should have been lowest during the 1st generation; fewer spiders were observed in sweep samples at this time in woodlands (unpublished observations). Food quality was probably best during the 1st generation due to reduced nutritional quality of leaves in autumn.

Cumulative percentages of adults increased at a rate faster than that for 5th-instar nymphs in woodlands during the 3rd generation suggesting addition of adults. This gain in numbers may have been due to immigration; however, if either individual growth rate or adult longevity was increased during the 3rd generation in comparison to earlier generations, the same results might have been obtained. Poor food quality during autumn should have slowed individual growth rate. Lower temperatures may have allowed adults to live longer which gave the appearance of an adult population increase; however, Whitney and Meyer (1988) found movement of *S. magdalensis* out of cultivated fields on 9 October 1985, the same time that woodland adult curves rose sharply in this study. It appears that loss of adults in early spring was most likely due to emigration and increase in autumn was the result of immigration.

Table 5. Total numbers of adult male *Scaphytopius magdalensis* and *S. verecundus* captured on yellow sticky traps in 4 woodland host species at 3 sites (combined), 1985.

Trapping† period	# *S. magdalensis**, ‡ CBB	HU	SK	HB	# *S. verecundus**, § CBB	HU	SK	HB
18-24 July	42	130	103	171	39	5	36	8
25-31 July	72	87	191	162	54	15	40	3
10-16 October	110	205	208	198	70	98	84	96
17-23 October	128	172	228	190	84	141	135	146
Mean¶	29.3 (a)	49.5 (b)	53.6 (b)	60.1 (b)	20.6	21.6	24.6	21.1

CBB, creeping blueberry; HU, huckleberry; SK, sheepkill; HB, highbush blueberry.

ANOVA:

* For both species, no significant differences between sites, sites were pooled. *S. magdalensis:* F, 0.07; df, 2; P, 0.50. *S. verecundus:* F, 1.30; df, 2; P, 0.28.

† For both species, significant differences between dates. *S. magdalensis* F, 10.88; df, 3; $P < 0.01$. *S. verecudus* F, 27.49; df, 3; $P < 0.01$.

‡ Significant differences between hosts. F, 10.23; df, 3; $P < 0.01$.

§ No significant differences between hosts. F, 0.26; df, 3; P, 0.85.

¶ Means per site per weekly trapping interval. Means of *S. magdalensis* followed by the same letter are not significantly different (P, 0.05; REGW Multiple Range Test).

Individuals counted in the 1984 sweep survey could not be identified to species. The possibility that differences in growth pattern between nymphs and adults were actually a phenomenon of one species and not the other should be considered. If only one species was responsible for the differences, then capture patterns on yellow sticky traps in creeping blueberry for that species would have differed from that of the second species. However, no significant differences (Spearman's Rank Correlation Coefficient) were found between population growth patterns over summer for these two species; thus, adults of both species contributed to observed differences between nymph and adult populations.

Inter-host Dispersal.

This study conducted in 1985 provides further support for the above spring migration hypothesis. Although creeping blueberry is most likely the major host for 1st generation *Scaphytopius* nymphs in woodlands, *S. magdalensis* adults were consistently found more often in huckleberry during the first generation. These individuals probably came from nymphs in creeping blueberry that dispersed upon adulthood. *Scaphytopius verecundus* was found more often in creeping blueberry throughout summer indicating that this species may not have the same dispersal tendency found in *S. magdalensis.*

Host Preference

In the wild, *S. magdalensis* prefers sheepkill, highbush blueberry and huckleberry, whereas *S. verecundus* is uniformly distributed among all four species. These results from the 1985 study will assist in conducting future woodland sampling programs. Huckleberry, a preferred host of *S. magdalensis,* is more abundant than other preferred hosts in North Carolina; the bushes are easily swept, and the branches are strong enough to hold sticky traps. For these reasons, a sampling program for wild *S. magdalensis* should be conducted in huckleberry.

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