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Identification of Resistance to Azalea Lace Bug among Deciduous Azalea Taxa

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Abstract. The susceptibility of seventeen deciduous species or cultivars and one evergreen cultivar of azalea (*Rhododendron* spp.) to azalea lace bug (*Stephanitis pyrioides* Scott) was evaluated in field and laboratory experiments. *Rhododendron canescens* Michx. and *R. periclymenoides* (Michx.) Shinners were the most resistant species, followed by *R. prunifolium* (Small) Millais. Ratings were based on oviposition rate, percentage emergence from the egg, feeding damage, and nymphal growth rate. The most susceptible genotypes were TNLV1, *R. oblongifolium* (Small) Millais, *R. alabamense* Rehder, *R. serrulatum* (Small) Millais, *R. viscosum* (L.) Torr., 'Buttercup', and 'My Mary'. Leaf water content and leaf pubescence were significantly different among taxa. However, leaf water content was not significantly correlated with azalea lace bug performance, and insufficient evidence was available to conclude that leaf pubescence was involved in azalea lace bug resistance.

Azalea lace bug (*Stephanitis pyrioides*) (Heteroptera: Tingidae), accidentally introduced from Japan along with azalea plants (Weiss, 1916; Drake and Ruhoff, 1965), is a key pest of azaleas (Raupp and Noland, 1984). Adults and nymphs feed on the lower leaf surfaces, resulting in a stippled appearance when viewed from above. Four generations occur annually in the middle Atlantic and southern regions (Braman et al., 1992; Neal and Douglass, 1988). Although the use of insecticides remains the primary method of controlling this pest (Balsdon et al., 1993; Gill and Raupp, 1989), previous research has identified a potential for resistance among azaleas (Braman and Pendley, 1992; Schultz, 1993). In preliminary studies, Braman and Pendley (1992) evaluated the resistance of five deciduous azalea species and the evergreen cultivar 'Delaware Valley White'. They found that the deciduous species were more resistant than 'Delaware Valley White', with *R. canescens* and *R. prunifolium* being the most resistant. Schultz (1993) discovered that the evergreen cultivar 'Macrantha' was the most resistant of 20 evergreen azalea cultivars tested, with significantly reduced oviposition and leaf injury. To date, the range of susceptibility among deciduous azaleas is unknown. The objective of the present study was to evaluate seventeen deciduous cultivars or species for resistance to azalea lace bug.

Materials and Methods

Plant materials. Eighteen azalea species or cultivars were obtained from commercial sources. Each taxon was represented by twelve 1-year-old plants, which were propagated from cuttings, except for *R. prunifolium* and TNLV2 (a hybrid population with *R. prinophyllum* (Small) Millais as one of the parents), which were grown from seeds. TNLV1, a clonally propagated taxon, is of unknown origin, but is likely to be a complex hybrid with *R. japonicum* in the parentage. Three of the taxa evaluated were received as *R. viscosum* (L.) Torr, *R. serrulatum* (Small) Millais, and *R. oblongifolium* (Small) Millais. Recent reclassification (Kron, 1993) no longer recognizes *R. serrulatum*, *R. oblongifolium* and *R. viscosum* as separate species; all are identified as *R. viscosum*. For clarification, we have retained the former species names. The other species that were evaluated are *R. alabamense* Rehder, *R. arborescens* (Pursh) Torr., *R. atlanticum* (Ashe) Rehder, *R. austrinum* (Small) Rehder, *R. calendulaceum* (Michx.) Torr., *R. canescens* Michx., and *R. periclymenoides* (Michx.) Shinners. Three cultivars derived from interspecific hybridization were also evaluated: 'Buttercup', a Knap Hill Azalea; 'My Mary', the result of intercrossing several species with *R. atlanticum, R. austrinum,* and *R. periclymenoides* in the parentage; and 'Nacoochee', an interspecific hybrid between *R. atlanticum* and *R. periclymenoides*. The evergreen azalea 'Delaware Valley White', which is a selection of *R. indica* var. *alba*, was used as a standard susceptible cultivar to compare to the deciduous taxa of unknown resistance levels.

All plants were kept in a screenhouse during Fall 1994, transplanted into the field under the shade of mixed deciduous trees in mid-November, 1994, watered by drip irrigation as needed, and fertilized twice per year with azalea, camellia, rhododendron fertilizer 11N–5P–5K (STA-Green Plant Food Company, Inc.). No pesticides were used during the experiments.

Azalea lace bug colony. An azalea lace bug colony was initiated with adults collected from landscape azaleas located in Griffin, Georgia. Azalea lace bugs were maintained on 'Delaware Valley White' plants in wood-frame lab cages (61 cm long × 61 cm wide × 65 cm high) covered with 32-mesh nylon screen. Infested plants were held at ≈24 °C with a 15-h light–9-h dark photoperiod. Fresh plants were provided weekly.

Laboratory bioassays, no-choice. Insect behavioral responses sometimes differ between choice and no-choice assays. A plant classified as resistant in a choice test may be susceptible in a no-choice test (Tingey, 1986). We conducted both no-choice and choice tests to thoroughly assess the potential resistance of the taxa.

No-choice bioassays were conducted on three dates (Table 1): on 5 Aug. 1994, 12 plants of each of 13 taxa were evaluated; on 5 May 1995, 12 plants of each of 17 taxa were evaluated; on 8 Aug. 1995, 6 plants of each of 11 taxa were assessed for resistance; and on 8 Aug. 4 additional taxa represented by fewer individuals ('My Mary', 5 plants; *R. viscosum*, 4 plants; 'Nacoochee', 4 plants; and

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Table 1. Laboratory (L) and field (F) bioassays of oviposition and egg development of azalea lace bug on 18 azalea (*Rhododendron* spp.) taxa.

	Eggs/cutting				Emergence (%)		
Taxon	Fall 1994L	Spring 1995L	Summer 1995L	Summer 1995F	Fall 1994L	Spring 1995L	Summer 1995L
Delaware Valley White[z]	35.3 ab[y]	36.0 abc	41.0 abc	87.0 a	63.4 abc	63.4 a	59.0 abc
R. alabamense	47.4 a	28.0 b–e	45.8 bc	NDA[x]	56.7 abc	28.6 cde	NDA
R. arborescens	23.5 de	21.0 def	25.8 b–e	18.3 efg	79.8 a	23.5 de	22.9 de
R. atlanticum	37.9 a	11.2 fg	21.8 cde	31.2 c–f	66.1 ab	10.3 e	75.4 a*
R. austrinum	NDA	26.0 cde	26.8 b–e	44.3 bcd	NDA	37.9 bcd	29.1 b–e
R. calendulaceum Cherokee	NDA	NDA	21.0 de	34.2 b-e	NDA	NDA	69.8 a
R. calendulaceum Currahee	17.3 e	12.6 efg	NDA	NDA	38.2 bc	53.9 abc	NDA
R. canescens	0.7 f	1.6 g	1.3 f	0.2 g	8.3 d	12.2 e	16.7 e
TNLV1[w]	26.1 cde	38.0 abc	50.0 a	43.8 b-e	62.0 abc	70.0 a	71.7 a
R. oblongifolium	NDA	42.4 ab	48.2 a	57.7 b	NDA	51.9 abc	22.4 de*
R. periclymenoides	3.1 f	2.8 g	0.5 f	1.2 g	53.8 abc	22.8 de	8.3 e
TNLV2[v]	25.7 cde	13.6 efg	NDA	NDA	35.5 cd	37.3 cd	NDA
R. prunifolium	NDA	14.7 efg	12.0 ef	8.3 g	NDA	10.5 e	55.2 a–d
R. serrulatum	33.4 abc	44.2 a	43.0 ab	55.8 bc	36.2 cd	37.8 bcd	69.5 a
R. viscosum	38.9 a	29.1 bcd	33.3 a–d	50.3 bcd	54.3 abc	59.8 ab	77.3 a
Buttercup[u]	27.4 bcd	39.7 ab	NDA	NDA	70.9 a	54.1 abc	NDA
My Mary[t]	NDA	28.8 bcd	33.8 a–d	56.8 bc	NDA	39.2 bcd	55.1 a–d
Nacoochee[s]	24.5 cde	14.4 efg	25.0 b–e	25.5 d–g	59.9 abc	26.2 de	63.9 ab

[z]A selection of *R. Indica* var. *alba*.
[y]Numbers followed by the same letters in the same columns are not significantly different at $P = 0.05$.
[x]NDA = no data available.
[w]Parent species unknown.
[v]Seedling population from an interspecific cross with *R. prinophyllum* as one parent, other parent unknown.
[u]Knap Hill Hybrid.
[t]A complex species hybrid with *R. atlanticum, R. austrinum* and *R. periclymenoides* in the parentage.
[s]An interspecific hybrid between *R. atlanticum* and *R. periclymenoides*.
*Significantly different between spring and summer, $P = 0.05$.

Table 2. Laboratory (L) and field (F) bioassays of injured leaf area (mm^2) and total leaf area injured (%) on 18 azalea (*Rhododendron* spp.) taxa.

	Injured leaf area (mm^2)			Total leaf area injured (%)		
Taxon	Spring 1995L	Summer 1995L	Summer 1995F	Spring 1995L	Summer 1995L	Summer 1995F
Delaware Valley White[z]	340.2 a[y]	442.2 ab	308.8 abc	42.6 abc	72.8 a*	67.3 a
R. alabamense	299.7 a	310.5 b–e	277.7 abc	43.3 ab	66.9 ab	69.0 a
R. arborescens	77.0 efg	252.7 def*	123.2 de	11.8 gh	33.6 de	22.0 e
R. atlanticum	33.7 g	328.7 b–e*	236.7 bc	5.5 h	50.2 bcd*	44.1 bcd
R. austrinum	177.8 b–e	382.2 bcd*	309.7 abc	31.1 cde	38.0 de	44.9 bcd
R. calendulaceum Cherokee	NDA[x]	305.0 b–e	222.2 cd	NDA	27.4 e	23.4 e
R. calendulaceum Currahee	172.3 cde	NDA	NDA	20.5 efg	NDA	NDA
R. canescens	16.8 g	32.7 gh	9.2 f	2.3 h	4.7 f	1.6 f
TNLV1[w]	341.2 a	539.5 a	259.0 abc	25.2 efg	39.8 cde	28.9 de
R. oblongifolium	244.4 a–d	244.7 def	352.7 a	30.3 de	34.1 de	51.3 ab
R. periclymenoides	34.7 g	0.0 h*	16.7 f	2.7 h	0.0 f	3.0 f
TNLV2[v]	149.0 def	NDA	NDA	17.9 fg	NDA	NDA
R. prunifolium	97.3 efg	153.0 fg	108.5 ef	13.0 gh	22.6 e	22.6 e
R. serrulatum	159.3 def	290.0 c–f*	246.5 bc	33.4 bcd	59.9 ab*	61.2 ab
R. viscosum	283.5 ab	337.7 b–e	331.0 ab	47.2 a	65.2 ab*	65.4 a
Buttercup[u]	346.8 a	NDA	NDA	23.4 d–g	NDA	NDA
My Mary[t]	271.7 abc	408.2 abc*	301.2 abc	33.3 bcd	55.9 abc*	43.2 bcd
Nacoochee[s]	65.3 fg	216.3 ef*	227.3 c	11.8 gh	36.4 de*	40.7 cde

[z]A selection of *R. Indica* var. *alba*.
[y]Numbers followed by the same letters in the same columns are not significantly different at $P = 0.05$.
[x]NDA = no data available.
[w]Parent species unknown.
[v]Seedling population from an interspecific cross with *R. prinophyllum* as one parent, other parent unknown.
[u]Knap Hill hybrid.
[t]A complex species hybrid with *R. atlanticum, R. austrinum* and *R. periclymenoides* in the parentage.
[s]An interspecific hybrid between *R. atlanticum* and *R. periclymenoides*.
*Significantly different between spring and summer, $P = 0.05$.

TNLV1, 3 plants) were also evaluated. Plant material used for the bioassays consisted of cuttings with an 8-cm stem section and two leaves, collected from each plant.

Two female lace bugs were transferred onto the leaves of each azalea cutting. Leaf turgor was maintained by inserting the stem through a snap-on lid into a 32-mL plastic cup of water. A second cup was modified by replacing the bottom with organdy screen to allow ventilation. That cup was inverted and placed over the azalea cutting, and the union of the cups was secured with Parafilm M (American National Can, Greenwich, Conn.) (Braman et al., 1992). Cuttings were arranged in a randomized complete-block design. Azalea lace bugs were allowed to feed and oviposit for 5 days in an environmental chamber at 24 ± 1 °C and 15-h light–9-h dark photoperiod. Number of dead lace bugs was recorded 120 h after infestation. Following the exposure period, adults were removed. Adult survivorship and number of eggs oviposited were recorded. Infested leaves were evaluated for feeding damage using a computer-assisted image analysis program, Mocha (Jandel Scientific, San Rafael, Calif.). This program allowed automatic measurement of the stippled portion of leaves, the result of lace bug feeding, by using a threshold level of leaf coloration. Cuttings with eggs were maintained in the growth chamber until eggs hatched. Leaves were observed daily and emergence from the eggs was recorded.

Newly hatched nymphs were transferred onto freshly excised leaves. Leaves, with petioles wrapped with a piece of water-soaked paper towel, were placed in a petri dish with 10 nymphs. Each of five petri dishes per taxon was held in a growth chamber at 24 ± 1 °C and 15-h light–9-h dark photoperiod. Due to the possibility of injury from handling, nymphs dying within 24 h were replaced with new ones (Smith et al., 1994). Nymphs were provided fresh leaves as necessary. Number of nymphs surviving to the adult stage and the duration of nymphal development were recorded daily.

Laboratory bioassay, choice. Eight taxa, representing a range of susceptibility as determined by the no-choice tests, were evaluated in the choice bioassay. One cutting from each of six plants for each of the eight taxa was inserted through a plastic lid into a 32-mL plastic cup of water. Cuttings were arranged in a randomized complete-block design, with six replications. Cuttings were placed into 6 mesh-covered clear cages (36 cm long × 23 cm wide × 15 cm high). Leaves were infested by releasing 16 female lace bugs into each cage. Azalea lace bugs were allowed to settle and feed for five days. Every 24 h, number of adults settling on each cutting was recorded. Following the 5-d exposure period, number of eggs per cutting was recorded.

Field bioassay. Twelve plants from each taxon were planted in the field in a randomized complete block design. To test hypotheses developed from laboratory observations on lacebug oviposition, survival and development, plants from six of the blocks were infested. On 8 Aug. 1995, a terminal shoot from each plant was selected at random and two leaves were caged using 32-mL plastic cups as described previously. Two females were placed into each cup cage and allowed to feed and oviposit for seven days. The leaves from the plastic cup cages were returned to the lab. Number of eggs and leaf area injured were recorded, as previously described, from these cup cage samples.

To determine whether lace bug can become established and survive in the long term on these taxa in the field, terminal shoots from each plant of the six blocks were selected at random and confined using a sleeve cage composed of size 32-mesh screen and wire on 5 May and 8 Aug. 1995. Two male and two female azalea lace bugs were placed into each cage on 5 May and three male and three female azalea lace bugs were placed into each cage on 8 Aug. Adult lace bugs were allowed to feed and oviposit for 7 d. Following the exposure period, cages were removed and adults dispersed into the field. Field plants of each of the taxa were evaluated for damage after 30 d. Damage estimates were obtained by calculating percentage of damaged shoots.

In conjunction with each bioassay, one nondamaged leaf from each test plant was excised and placed in a cooler. Immediately following leaf harvest, fresh mass was measured. Leaves were then dried at 70 °C for 48 h and weighed. The water content (%) was calculated by the function (fresh mass– dry mass)/fresh mass × 100). One mature leaf from each of five plants per taxa was used to measure the average hair number on the lower leaf surface. Under 25× magnification, the hair number from two randomly selected views of each leaf was counted along a 2-mm length of midvein and branch vein, and in a 4-mm^2 interveinal area.

Statistical procedures. Total leaf area injured, percentage of leaf area injured, total number of eggs, number of adults per cutting, duration of nymphal development, egg and nymphal survival, percentage leaf moisture and average leaf-hair number were subjected to analysis of variance (ANOVA) using the general linear model procedure (GLM) (SAS Institute, Cary, N.C.). Before performing the ANOVA, values expressed as percentages were arcsin, square-root transformed (Snedecor and Cochran, 1967). The mean values for all traits were separated by Fisher's protected LSD (Snedecor and Cochran, 1967). The relationship of leaf moisture and leaf pubescence to azalea lace bug oviposition, feeding and growth rate was examined by using Pearson correlation coefficients (SAS).

Results and Discussion

Laboratory bioassays, no-choice. Azalea lace bug oviposition was significantly different among azalea taxa tested (Table 1). *Rhododendron canescens* and *R. periclymenoides* had the lowest number of eggs per cutting in Fall 1994 and Spring and Summer 1995. Notably reduced oviposition was also found on *R. prunifolium*. High oviposition (average of all lab tests) was characteristic of *R. alabamense*, TNLV1, *R. oblongifolium*, *R. serrulatum*, *R. viscosum*, and 'Buttercup', and was comparable to that of the evergreen

Fig. 1. Adult mortality of azalea lace bug 120 h after infestation.

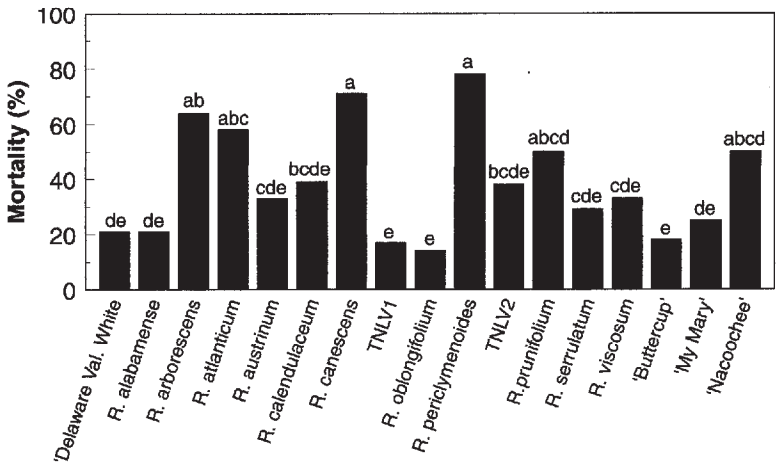

Table 3. Lace bug nymphal survival (%) and developmental time on 18 azalea (*Rhododendron* spp.) taxa.

Rhododendron spp. taxon	Nymphal survival (%)		Development time (d)[z]	
	Spring 1995	Summer 1995	Spring 1995	Summer 1995
Delaware Valley White[y]	90.0 ab[x]	98.0 a*	14.8 ef	15.2 de
R. alabamense	96.0 ab	80.0 bc	16.2 cde	18.6 b*
R. arborescens	78.0 bcd	62.0 de	16.6 cd	16.5 cd
R. atlanticum	82.0 a–d	84.0 abc	16.4 cde	15.8 cde
R. austrinum	64.0 de	80.0 bc	19.6 b	17.2 bc
R. calendulaceum Cherokee	NDA[w]	80.0 bc	NDA	15.2 de
R. calendulaceum Currahee	96.0 ab	NDA	15.2 def	NDA
R. canescens	0.0 f	0.0 f	---	---
TNLV1[v]	98.0 a	95.0 ab	14.2 f	15.8 cde
R. oblongifolium	100.0 a	88.0 abc*	15.0 def	15.6 de
R. periclymenoides	50.0 e	48.0 e	19.4 b	21.6 a
TNLV2[u]	94.0 ab	NDA	17.4 c	NDA
R. prunifolium	66.0 cde	51.0 e	20.0 b	18.4 b
R. serrulatum	92.0 ab	98.3 a*	15.0 def	15.5 de
R. viscosum	84.0 abc	95.0 ab	14.8 ef	15.5 de
Buttercup[t]	96.0 ab	NDA	14.2 f	NDA
My Mary[s]	96.0 ab	95.7 ab	14.8 ef	14.9 e
Nacoochee[r]	86.0 ab	75.0 cd	15.4 def	16.3 cde

[z]Days from nymphs to adults.
[y]A selection of *R. Indica* var. *alba.*
[x]Numbers followed by the same letters in the same columns are not significantly different at $P = 0.05$.
[w]NDA = no data available.
[v]Parent species unknown.
[u]Seedling population from an interspecific cross with *R. prinophyllum* as one parent, other parent unknown.
[t]Knap Hill hybrid.
[s]A complex species hybrid with *R. atlanticum, R. austrinum* and *R. periclymenoides* in the parentage.
[r]An interspecific hybrid between *R. atlanticum* and *R. periclymenoides.*
*Significantly different between spring and summer, $P = 0.05$.

standard, 'Delaware Valley White'. No significant differences in oviposition occurred between the spring and the summer trials.

Eclosion, measured as percentage emergence from the egg, also varied significantly among taxa (Table 1). The lowest percentage emergence was observed on *R. canescens*. *Rhododendron periclymenoides* and *R. prunifolium* were also characterized by low emergence. No statistical differences in percent emergence between seasons were observed among taxa except for *R. atlanticum* and *R. oblongifolium* (Table 1). Emergence from the egg on TNLV1, *R. viscosum*, and 'Buttercup' was statistically equal to that on the standard, 'Delaware Valley White' (Table 1).

The total leaf area injured (mm^2) and percentage of leaf area injured varied significantly among taxa (Table 2). The lowest leaf injury level and least percentage injury were consistently observed on *R. canescens* and *R. periclymenoides*. An intermediate level of injury was observed on *R. arborescens*, TNLV2, and *R. prunifolium*. The highest level of leaf area injured was observed on TNLV1, 'Buttercup', and 'My Mary', an injury level similar to the standard 'Delaware Valley White'. The highest percentage of leaf area injured was observed on *R. alabamense* and *R. viscosum,* which were statistically equivalent to the standard. *R. alabamense, R. viscosum,* and 'Delaware Valley White' have small leaves compared with TNLV1, 'Buttercup', and 'My Mary', consequently the percentage damage is greater. Significantly more leaf area was injured in the summer than in the spring on *R. arborescens*, *R. atlanticum*, *R. austrinum, R. serrulatum*, 'My Mary', and 'Nacoochee'. A higher percentage of leaf area was injured in the summer than in the spring on *R. atlanticum*, *R. serrulatum*, *R. viscosum*, 'My Mary', 'Nacoochee', and the evergreen standard 'Delaware Valley White' (Table 2).

The highest adult mortality was observed on *R. periclymenoides* (78%), *R. canescens* (71%), and *R. arborescens* (64%) compared to an average mortality of 39% among all other taxa after 120 h (Fig. 1). Percent nymphal survival was significantly different among taxa (Table 3). None of the nymphs completed develop-

Fig. 2. Percentage of total shoots damaged by azalea lace bug on field plants, 1 month after infestation.

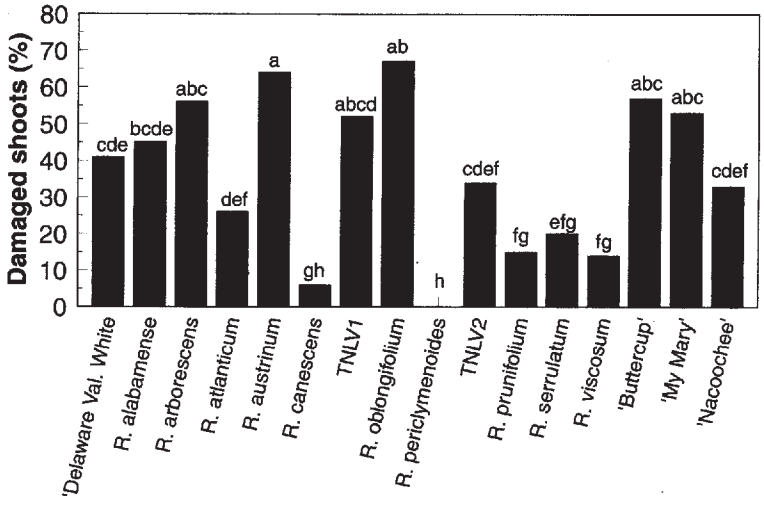

Table 4. Adult lace bug settling and oviposition in a choice test.

Rhododendron taxon	Eggs/ cutting	Adults/cutting after				
		16 h	24 h	48 h	72 h	120 h
Delaware Valley White[z]	48.0 b[y]	2.3 b	2.3 b	3.2 a	5.0 a	4.5 a
R. atlanticum	0.2 d	0.2 c	0.3 c	0.0 b	0.0 b	0.0 c
R. canescens	0.8 d	0.8 c	0.2 c	0.0 b	0.0 b	0.0 c
R. periclymenoides	0.2 d	0.0 c	0.3 c	0.0 b	0.2 b	0.0 c
TNLV2[x]	11.0 cd	0.3 c	0.3 c	0.7 b	0.7 b	1.0 c
R. prunifolium	8.3 d	0.0 c	0.5 c	0.5 b	0.5 b	0.5 c
R. viscosum	24.3 c	0.5 c	1.3 bc	1.2 b	1.0 b	1.0 c
Buttercup[w]	83.7 a	4.2 a	5.2 a	4.0 a	4.0 a	3.0 b

[z]A selection of *R. Indica* var. *alba.*
[y]Numbers followed by the same letters in the same columns are not significantly different at $P = 0.05$.
[x]Seedling population from an interspecific cross with *R. prinophyllum* as one parent, other parent unknown.
[w]Knap Hill hybrid.

ment to the adult stage when reared on leaves from *R. canescens*, and a relatively low nymphal survival rate was also observed on *R. periclymenoides* and *R. prunifolium*. Most of the remaining cultivars or species were similar to the standard 'Delaware Valley White', with survival ranging from 64% to 100%. Nymphs reared on the leaves of *R. periclymenoides* and *R. prunifolium* required the longest time to develop (Table 3). In contrast, the least amount of time required for development was observed on TNLV1 and 'Buttercup'. Few significant seasonal differences among taxa in nymphal survival were detected.

Laboratory bioassay, choice. The highest oviposition was observed on 'Buttercup', followed by 'Delaware Valley White' and *R. viscosum* (Table 4). Number of eggs oviposited was low on *R. canescens*, *R. periclymenoides,* and *R. prunifolium*. Oviposition (Table 4) on *R. atlanticum* was also low, although this genotype displayed an intermediate level of resistance in the no-choice tests (Table 1). A significantly higher number of adults settled on the leaves of the most susceptible genotypes 'Buttercup' and 'Delaware Valley White' compared to the other taxa. No significant differences were observed among all other taxa in number of adults infesting the leaves (Table 4).

Field bioassay. Oviposition was highest on 'Delaware Valley

Table 5. Leaf water content (WC)[z] and leaf pubescence of 17 azalea (*Rhododendron* spp.) taxa.

Taxon	WC		MH[y]	BH[x]	IH[w]
	Spring 1995	Summer 1995			
Delaware Valley White[v]	72.6 ef[u]	71.6 b–f*	39.3 e	8.5 d	19.0 c
R. alabamense	75.2 b–e	71.3 c–f*	56.8 b–e	21.9 bc	97.5 b
R. arborescens	77.7 ab	74.4 bcd*	58.4 b–e	9.3 d	0.4 c
R. atlanticum	75.3 b–e	70.1 def*	6.9 f	3.6 d	20.3 c
R. austrinum	73.4 def	71.3 c–f*	78.8 b	28.5 b	21.7 c
R. calendulaceum Currahee	78.6 a	NDA[t]	72.1 bc	24.7 bc	89.4 b
R. canescens	75.5 bcd	71.5 c–f*	109.6 a	41.0 a	400.8 a
TNLV1[s]	77.7 ab	73.6 b–e*	61.8 b–e	26.0 bc	0.6 c
R. oblongifolium	NDA	70.0 ef	NDA	NDA	NDA
R. periclymenoides	74.7 cde	71.3 c–f*	43.6 de	2.4 d	1.2 c
TNLV2[r]	76.1 abc	75.5 b	69.5 bcd	18.0 c	86.7 b
R. prunifolium	73.6 c–f	72.1 b–f	5.0 f	1.7 d	2.6 c
R. serrulatum	71.1 f	68.8 f*	80.7 b	19.5 bc	17.1 c
R. viscosum	77.4 ab	74.3 bcd*	6.0 f	0.0 d	0.0 c
Buttercup[q]	78.4 a	79.8 a	45.9 cde	3.5 d	0.8 c
My Mary[p]	74.2 cde	69.8 ef*	63.6 b–e	27.6 b	100.1 b
Nacoochee[o]	75.e b–e	NDA	4.2 f	3.0 d	12.6 c

[z]WC = percent water content of leaf; (leaf fresh mass – dried mass) × 100/fresh mass.
[y]MH = midvein hair number.
[x]BH = branch vein hair number.
[w]IH = interveinal hair number.
[v]A selection of *R. Indica* var. *alba.*
[u]Numbers followed by the same letters in the same columns are not significantly different at $P = 0.05$.
[t]NDA = no data available.
[s]Parent species unknown.
[r]Seedling population from an interspecific cross with *R. prinophyllum* as one parent, other parent unknown.
[q]Knap Hill hybrid.
[p]A complex species hybrid with *R. atlanticum, R. austrinum* and *R. periclymenoides* in the parentage.
[o]An interspecific hybrid between *R. atlanticum* and *R. periclymenoides.*
*Significantly different between spring and summer, $P = 0.05$.

White' and lowest on *R. canescens, R. periclymenoides* and *R. prunifolium* (Table 1). This result was consistent with that of lab tests using cuttings. Notably, the same relative ranking of leaf area injured among taxa was observed (Table 2). The least injury was observed on *R. canescens* and *R. periclymenoides*. Intermediate injury was observed on *R. prunifolium*. The maximum leaf area injured was 352.7 mm^2, which was observed on *R. oblongifolium*.

Nymphs and adults were seldom observed after the sleeve cages were removed in the spring. But predators, such as spiders, were often observed. We believe high predation characteristic of this understory habitat (Trumbule et al., 1995, Leddy 1996) limited field establishment of the azalea lace bug. However, evaluation of plants infested in the summer revealed successful population establishment. Percentage of damaged terminals varied significantly among taxa (Fig. 2). No damage was found on *R. periclymenoides. Rhododendron canescens* had the next lowest level of damage, followed by *R. prunifolium* and *R. viscosum*. These field data provide additional confirmation of laboratory results. The low level of feeding on *R. viscosum* may reflect the preference of azalea lace bug for other taxa, as this field study was essentially a choice test.

The leaf water content and average hair number were significantly different among all taxa (Table 5). Leaf water content varied from 68.8% to 79.8% (Table 5), but was not correlated with azalea lace bug responses on their host plants. Extremely high leaf hair density in the interveinal region characterized *R. canescens* (400.8 per 4 mm^2), while the remaining taxa varied between 0 and 100 leaf hairs per 4 mm^2 (Table 5). Furthermore, the resistant taxa, *R. periclymenoides* and *R. prunifolium*, had very few interveinal hairs (1.2 and 2.6 hairs per 4 mm^2). As the *R. canescens* data were outliers, they were removed from the correlation analysis. Leaf hair density was not consistently correlated with resistance to azalea lace bug.

Results of combined laboratory and field trials revealed a high degree of resistance in *R. canescens, R. periclymenoides* and *R. prunifolium*. Moderate resistance was also observed in *R. atlanticum* and 'Nachoochee'. Two taxa, *R. prunifolium* and TNLV2, were represented in our study by seedling populations. The remaining fifteen selections are single clonal representations of each species except for *R. calendulaceum* which was represented by two clonal cultivars. The observed resistance in *R. canescens* and *R. periclymenoides,* therefore, may not be representative of the entire species range.

The specific mechanisms of azalea lace bug resistance for these resistant genotypes are presently not known. Although correlation analysis showed no consistent significant association of leaf pubescence with azalea lace bug resistance, leaf hair structure and density may play a role in resistance in *R. canescens*. There may be some common influencing factors such as plant surface chemical cues (Chapman and Bernays, 1989; Renwick and Radke, 1988; Ramachandran and Khan, 1991). Antibiosis combined with physical characteristics could be involved in observed azalea lace bug resistance. Antibiosis is suggested by lower survivorship of adults and nymphs, significantly reduced feeding, plant damage and growth rate of the azalea lace bug. All the potential factors responsible for resistance, including morphological and chemical aspects need to be fully characterized.

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