Host Plant Utilization Within Family Ericaceae by the Andromeda Lace Bug *Stephanitis takeyai* (Hemiptera: Tingidae)[1]

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Abstract

This study examined host plant utilization by the Andromeda lace bug, *Stephanitis takeyai* Drake and Maa, within the family Ericaceae. The preferred host of *S. takeyai* is the Japanese pieris, *Pieris japonica* (Thunb.) D. Don ex G. Don, but it has been reported to exhibit host alternation and also to occur on other unrelated host plants. We examined the acceptability of ten landscape and fruit plants belonging to the family Ericaceae (*Rhododendron calendulaceum*, *Rhododendron* 'Hampton Beauty', *Rhododendron* 'Autumn Empress', *Vaccinium arboreum*, *Vaccinium virgatum*, *Calluna vulgaris*, *Kalmia latifolia*, *Pieris floribunda*, *Pieris phillyreifolia* and *Pieris japonica* 'Temple Bells') to *S. takeyai*. In no-choice tests adult survival did not vary significantly among the taxa. Highest leaf damage was recorded on *P. japonica* and *R. calendulaceum*, while slight damage was noted on *V. arboreum* and *Rhododendron* 'Hampton Beauty'. Nymph emergence was observed in *P. japonica*, *R. calendulaceum* and *Rhododendron* 'Hampton Beauty'. In multi-choice tests adult presence on leaves did not vary significantly except on day 9, when adults were more numerous on 'Temple Bells'. Maximum leaf damage was recorded on *P. japonica*, 'Temple Bells'. Several plants like *Rhododendron* and *Vaccinium* spp., which may not be favorable hosts, could serve as reservoirs for the pest.

Index words: *Pieris*, *Rhododendron*, *Vaccinium*, *Stephanitis takeyai*, host utilization, Ericaceae.

Species used in this study: *Pieris japonica*; *Pieris phillyreifolia*; *Pieris floribunda*; *Rhododendron calendulaceum*; *Rhododendron* 'Hampton Beauty'; *Rhododendron* 'Autumn Empress'; *Vaccinium arboreum*; *Vaccinium virgatum*; *Calluna vulgaris*; *Kalmia latifolia*.

Significance to the Nursery Industry

Pieris spp. belonging to the plant family Ericaceae, are handsome evergreen shrubs recognized by their glossy green leaves and clusters of urn-shaped flowers colored red, pink or white. They are particularly noted for the magnificent colors displayed by their spring foliage. *Pieris* are popular choices as landscape or foundation plants, shrub borders or incorporated with other evergreens. The major pest of *Pieris* is the Andromeda lace bug, *Stephanitis takeyai*. Although this pest has not been noticed as extensively as its close relative, the azalea lace bug, *S. pyrioides*, both species have importance as introduced pests. There are reports on the spread of *S. takeyai* to several states since its introduction, and recent studies revealed differences in susceptibility of *Pieris* taxa to this pest. The genus *Stephanitis* is known to attack other ericaceous hosts and this increases its significance in commercial trade of plants. Little information is available on host plant utilization by these pests. Therefore it is essential to understand the host plant utilization by *S. takeyai* before its damage and spread assume greater proportions. Such information would be helpful in selecting plants for landscapes and adopting control approaches. This study examines host plant utilization by *S. takeyai* within the family Ericaceae.

Introduction

The Andromeda lace bug, *Stephanitis takeyai* Drake and Maa, is an important pest of the ericaceous ornamental plant *Pieris* D. Don spp. (12). *Stephanitis takeyai* adults and nymphs, like other tingids, feed by piercing the leaf surface and drawing out cell contents, which results in yellowish white stipples and blotches on the upper leaf surfaces, and on the lower surfaces oily black frass spots can be seen along with the lace bug colonies. Lace bug feeding also reduces photosynthetic efficiency of the leaves (6). In ornamental plants like *Pieris*, which are valued for their foliage and flowers, even slight damage to leaves can seriously affect the market value prior to sale and can make the plant unattractive in the landscape. Sometimes lace bug damage can reach severe levels causing premature leaf shedding, drying up of twigs or even the whole plant (20).

Polyphagy is considered to be an ancestral character in the genus *Stephanitis*, and monophagous species are supposed to have developed later (25). This finding adds to the importance of more studies on *S. takeyai* and its relation to other members of the genus. *Stephanitis takeyai* has been reported to be polyphagous in Japan and other countries where it has spread and established, attacking host plants of different unrelated families (24).

The Japanese Andromeda, *Pieris japonica* (Thunb.) D. Don ex G. Don, is the preferred and major reproductive host of *S. takeyai* (20) from which the pest derives its common name.

In its country of origin Japan, *S. takeyai* is known to exhibit non-obligate seasonal host alternation between *P. japonica* and its other major host, the deciduous shrub *Lyonia elliptica* (Siebold & Zucc.) Hand.-Mazz., both of which

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belong to the family Ericaceae. The lace bugs feed on *P. japonica* during the winter and on *L. elliptica* during the summer. If *L. elliptica* is scarce, *S. takeyai* may continue to feed on *P. japonica* (24). *Stephanitis takeyai* has been reported to occur on persimmon (*Diospyros kaki* Thunb., Ebenaceae), camphor (*Cinnamomum camphora* (L.) J. Presl, Lauraceae), Chinese anise (*Illicium religiosum* Siebold & Zucc., Illiciaceae) (22), and also in Japanese pine stands (*Pinus densiflora* Siebold and Zucc. and *P. thunbergii* Parl., Pinaceae) (28) in Japan.

Stephanitis takeyai was first reported in North America in 1950 (3), and was later recorded on several unrelated host plants like *Andromeda* sp., *Aperula* sp., *Cinnamomum* sp., *Lindera* sp., *Lyonia* sp., *Pieris* sp. and *Salix* sp. (7). Bailey (5) recorded the occurrence of *S. takeyai* on the rhododendron, *R. calendulaceum* (Michx.) Torr., when its branches were contiguous with those of *P. japonica*. Wheeler (29) reported spicebush (*Lindera benzoin*) and sassafras (*Sassafras albidum*) (Lauraceae) as hosts of *S. takeyai*. In Poland, plants within Hippocastanaceae, Magnoliaceae, Rosaceae, Saxifragaceae and Styracaceae are reported to be hosts for *S. takeyai* (21). These reports indicate the polyphagous nature of S. *takeyai* which can be a cause for concern in the context of increasing commercial trade in plant material worldwide. Several plants, which may not be favorable hosts, could still serve as reservoirs for the pest. Hence a proper understanding of the host plant utilization of different plants by *S. takeyai* would be essential in choosing plants for gardens and landscapes and formulating management strategies. We undertook this study to evaluate host plant utilization by *S. takeyai* within the family Ericaceae and also confirm some of the earlier reports of host suitability.

Pieris spp., the major reproductive hosts of *S. takeyai*, are popular broad-leaved evergreen shrubs planted in landscapes and gardens for their attractive foliage and flowers (11). Japanese pieris (*P. japonica*) native to Japan, is the most commonly cultivated species which is also susceptible to *S. takeyai*. Mountain pieris (*P. floribunda* (Pursh) Benth. and Hook. f.) and *P. phillyreifolia* (Hook.) DC. (climbing fetterbush) are native to North America and are reported to be resistant to *S. takeyai* (7, 16). The genus *Rhododendron* L. comprises a large group of over 1,000 species (1) of woody ornamentals mostly known for their showy flowers. We chose the cultivars *Rhododendron* 'Hampton Beauty', *Rhododendron* 'Autumn Empress' and the flame azalea *R. calendulaceum* to represent the genus. Azaleas are attacked by different pests among which the azalea lace bug *S. pyrioides* is predominant (12), but *S. takeyai* has not been listed as a problem to azalea cultivation. Although Bailey (5) reported occurrence on *R. calendulaceum* when its branches were contiguous with *P. japonica*, there are no reports about susceptibility to *S.takeyai*. Native ornamental and landscape plants like *R. calendulaceum* are currently being sought by homeowners with renewed interest which has also increased the availability of planting material (2). This change may result in changes in the pest scenario as well, since the native plants may show susceptibility to introduced pests. *Vaccinium* L. is a genus comprising over 150 species (1)of shrubs producing edible fruit, some of which are of commercial importance like the blueberry *V. virgatum* Aiton (rabbiteye blueberry). *Vaccinium arboreum* Marshall (sparkleberry) is a widespread diploid blueberry species native to the southeastern United States which has importance in breeding (13). Lace bugs have not been reported on these two species of *Vaccinium*. However, *Stephanitis oberti* Kol. has been reported on lingonberry (*V. vitis-idaea* L.) (18). The genus *Calluna* is monotypic, with the low-growing perennial shrub *C. vulgaris* (L.) Hull being the only species recorded in this genus (1). *Calluna vulgaris* is an effective colonist and thrives in heathlands, where it serves as food for livestock when the landscape is covered with snow (10). Lace bugs have not been reported on *Calluna* sp. *Kalmia latifolia* L. (mountain laurel) is an important evergreen component in the deciduous forests of the southern Appalachians (15), and is listed as a host for *S. pyrioides* (7) and also for *S. rhododendri* Horváth (4), but not for *S. takeyai*. We tested the acceptability of these ten plant species belonging to the family Ericaceae using no-choice and choice laboratory assays.

Materials and Methods

Plant materials. The selected ericaceous ornamental plants were obtained from plant nurseries near Griffin, GA, and various commercial nurseries. The plants were maintained in 11.4 liter (# 3) and 3.8 liter (# 1) pots in a screen house at the Experiment Station, Griffin, GA, with regular irrigation. Pesticides and fertilizers were not used in the screen house.

Lace bugs. Stephanitis takeyai colonies were initiated from a population obtained from a landscape setting in Long Island, NY, in April 2009. The colonies were maintained in plastic containers through the period of study at 27 ± 1C and a photoperiod of 14:10 (L:D) h, on *Pieris* cultivars *P. japonica* 'Dodd's Crystal Cascade Falls', 'Temple Bells' and 'Scarlett O'Hara' (16). For conducting the assays, 5–10 day old adult lace bugs were collected in plastic tubes using an aspirator and then transferred to the assay dishes using a brush.

No-choice petri dish assays. Three mature leaves (fourth or fifth leaf from the bottom of a branch) of one plant species, placed in a petri dish of 11 cm diameter (VWR®) with their stalks covered sections of moist paper towel constituted one replication. Each plant species was replicated three times. Three adult lace bugs (at least 2 females) were released into each petri dish and the dish covered with its friction-fitting lid. The dishes were arranged in a randomized complete block design and placed under conditions of 27 ± 1C and a photoperiod of 14:10 (L:D) h. Observations on number of bugs alive were taken at 2, 7, 9 and 13 days. After the exposure period the surviving adults were removed and the leaves were assessed for leaf damage using the number of frass spots, because frass spot numbers are highly correlated with leaf damage and served as an index for the amount of *S. pyrioides* feeding on azaleas (Ericaceae) (6). After damage assessment, the leaves were maintained under the same conditions as during the exposure period and observed daily for emergence of nymphs. This assay was performed twice in December 2010.

Multi -choice assays. Three mature leaves from one plant species (fourth or fifth leaf from the bottom of a branch) were placed together as a group, with their bases covered with sections of moist paper towel. Ten such groups of leaves representing the ten selected plants, placed in a circular pattern inside a large (30 cm diam) Petri dish constituted one replication and there were three such replications. The leaf

Table 1. No-choice assay for adult survival and leaf damage by *S. takeyai* on ericaceous hosts.

Taxa	Adult survival (Number of adults)				Number of frass spots			
	Day 2	Day 7	Day 9	Day 13	Day 2	Day 7	Day 9	Day 13
Rhododendron calendulaceum	2.17ab[z]	1.67a	1.00a	0.67ab	16.78a	34.44a	42.89a	47.61a
Vaccinium arboreum	1.83bc	0.33b	0.17b	0.00c	1.06b	2.72b	3.50b	4.61b
Pieris floribunda	1.17c	0.33b	0.17b	0.17bc	0.11b	0.22b	0.22b	0.22b
Calluna vulgaris	1.50bc	0.33b	0.00b	0.00c	0.00b	0.11b	0.11b	0.11b
Kalmia latifolia	1.33bc	0.33b	0.00b	0.00c	0.06b	0.06b	0.06b	0.06b
Pieris japonica 'Temple Bells'	2.83a	2.17a	1.50a	1.17a	16.67a	37.89a	49.94a	56.50a
Pieris phillyreifolia 'Little Leaf'	1.67bc	0.50b	0.00b	0.00c	0.11b	0.11b	0.11b	0.11b
Rhododendron 'Autumn Empress'	1.17c	0.50b	0.17b	0.17bc	0.56b	0.78b	0.78b	0.83b
Rhododendron 'Hampton Beauty'	1.67bc	0.83b	0.33b	0.50bc	0.06b	3.11b	4.00b	4.56b
Vaccinium virgatum	1.17c	0.50b	0.17b	0.00c	0.00a	1.00b	1.00b	1.00b
F	2.95	5.01	7.37	5.00	13.78	25.11	25.67	31.07
P	0.0068	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

[z]Means in the same column bearing different letters are significantly different (α = 0.05).

groups were arranged randomly within the circular pattern in each replication. Twenty adult lace bugs (ten or more females) were released into each petri dish and the dish covered with its friction-fitting lid. All the petri dishes were placed inside a growth chamber under conditions of 27 ± 1C and a photoperiod of 14:10 (L:D) h. Observations on number of bugs present on each of the leaves was recorded one hour after releasing the bugs, and then again at the start of each observation on the 2nd, 7th, 9th and 13th day. After the 13th day the surviving adults were removed and the leaves were assessed for leaf damage using the number of frass spots as an index of feeding (6). After damage assessment, the leaves were placed back in their positions and maintained under the same conditions as during the exposure period and observed daily for emergence of nymphs. Nymphs were counted and removed as and when they were observed.

Statistical procedures. The experiments used a one-way randomized complete block design. The replications were considered as the block factor. Data (adult survival, leaf damage and nymph emergence in no-choice assays; adult presence on leaves, leaf damage and nymph emergence in choice assays) were subjected to analysis of variance (ANOVA) using the general linear model procedure of SAS (19). Means were separated with Fisher's protected least significant difference (LSD) test.

Results and Discussion

No-choice petri dish assays. Highest adult survival on day 2 in no-choice assays was observed on *P. japonica* 'Temple Bells' and *R. calendulaceum* (Table 1) and a similar trend was seen on all following days of observation. These two plants showed significantly higher adult survival than all the other plants. Lace bugs also fed more heavily on these two taxa as indicated by the number of frass spots on the leaves. Among the lesser damaged plants, *V. arboreum* and *Rhododendron* 'Hampton Beauty' showed slightly higher numbers of frass spots, whereas *Pieris floribunda*, *Calluna vulgaris*, *Kalmia latifolia* and *P. phillyreifolia* 'Little Leaf' consistently showed very low or no evidence of feeding, and the differences between them were not statistically significant. These taxa also showed very low adult survival.

Multi-choice assays. Multiple choice trials clearly indicated the preference of the lace bugs for *P. japonica* 'Temple Bells' (Table 2) which showed the highest numbers of frass spots on all four days of observation. It was interesting to note that *R. calendulaceum* did not show significant feeding in the presence of *P. japonica* 'Temple Bells'. The two *Vaccinium* species, *V. virgatum* and *V. arboreum* were the other taxa that showed slight but non-significant damage which was similar to that on all the other non-damaged taxa. Adult

Table 2. Mean number of frass spots by *S. takeyai* in multi-choice assay with ericaceous hosts (averages from 3 replications).

Taxa	Day 2	Day 7	Day 9	Day 13
Rhododendron calendulaceum	1.00b[z]	1.22b	2.56b	3.89b
Vaccinium arboreum	0.00b	0.56b	2.00b	4.89b
Pieris floribunda	0.00b	0.00b	0.00b	0.00b
Calluna vulgaris	0.00b	0.00b	0.00b	0.00b
Kalmia latifolia	0.00b	0.00b	0.00b	0.00b
Pieris japonica 'Temple Bells'	11.67a	21.56a	43.33a	89.56a
Pieris phillyreifolia 'Little Leaf'	0.00b	0.00b	0.00b	0.00b
Rhododendron 'Autumn Empress'	0.00b	0.00b	0.00b	0.00b
Rhododendron 'Hampton Beauty'	0.00b	0.00b	0.00b	0.00b
Vaccinium virgatum	2.00b	4.56b	8.78b	13.33b
F	5.14	9.03	8.22	10.16
P	<0.0001	<0.0001	<0.0001	<0.0001

[z]Means in the same column bearing different letters are significantly different (α = 0.05).

Table 3. Mean number of *S. takeyai* adults present on leaves in multi-choice assay with ericaceous hosts (averages from 3 replications).

Taxa	Day 0	Day 2	Day 7	Day 9	Day 13
Rhododendron calendulaceum	0.44a[z]	0.22a	0.44a	0.22b	0.56a
Vaccinium arboreum	0.11a	0.22a	0.33a	0.22b	0.33a
Pieris floribunda	0.67a	0.33a	0.22a	0.44b	0.44a
Calluna vulgaris	0.33a	0.56a	0.56a	0.11b	0.22a
Kalmia latifolia	0.56a	0.22a	0.11a	0.11b	0.33a
Pieris japonica 'Temple Bells'	0.44a	0.56a	0.56a	1.11a	0.67a
Pieris phillyreifolia 'Little Leaf'	0.56a	0.33a	0.44a	0.33b	0.22a
Rhododendron 'Autumn Empress'	0.11a	0.22a	0.33a	0.00b	0.22a
Rhododendron 'Hampton Beauty'	0.00a	0.56a	0.33a	0.44b	0.56a
Vaccinium virgatum	0.11a	0.11a	0.22a	0.22b	0.11a
F	1.43	0.77	0.67	2.72	0.91
P	0.1879	0.6476	0.7308	0.0082	0.5228

[z]Means in the same column bearing different letters are significantly different ($\alpha = 0.05$)

presence on leaves did not vary significantly among the taxa (Table 3) except on day 9, where the most adults were found on *P. japonica* 'Temple Bells'.

Nymph emergence was observed only on *P. japonica* 'Temple Bells' in most replications in both no-choice and choice trials (Table 4). However, *R. calendulaceum*, and *Rhododendron* 'Hampton Beauty' showed nymph emergence in one replication each in no-choice Trial 1. The nymphs on *R. calendulaceum* survived till adulthood.

The ten plant species that we chose for our screening assays represent the diversity in the family Ericaceae. The methodology we used is consistent with those previously used in studies that examined host plant susceptibility to lace bugs, and we conducted both no-choice and choice assays (26, 27). Among the three *Pieris* species tested, *P. floribunda* and *P. phillyreifolia* were not acceptable to *S. takeyai* for feeding or oviposition and *P. japonica* "Temple Bells' was the most preferred host, consistent with earlier observations (8, 16, 20). Leaf damage on *R. calendulaceum* was similar to damage on the most preferred taxon *P. japonica* 'Temple Bells' in no-choice assays, whereas in the multi-choice assays it was not severely damaged. Such behavior by insects has been reported in bioassays (23). *Stephanitis takeyai* was recorded earlier on *R. calendulaceum*, when its branches were contiguous with those of *P. japonica* (5) but this report does not describe the nature of damage or its pest status on *R. calendulaceum*. Our observations confirm this report and show that *S. takeyai* can feed and reproduce on *R. calendulaceum* when its preferred host is absent, but in the presence of its preferred host it may not attack *R. calendulaceum*. Hybrid evergreen azaleas were found to be suitable feeding and breeding hosts for *S. takeyai*, and the possibility that the pest could develop into a late season threat to azalea production has also been suggested (17). In our assays we recorded slight, non-significant damage to both azaleas tested viz., *Rhododendron* 'Hampton Beauty' and *Rhododendron* 'Autumn Empress' in no-choice tests and no damage in multi-choice tests. We also recorded nymph emergence in *Rhododendron* 'Hampton Beauty' in one replicate of the no-choice test. Slight leaf damage was also observed on both *Vaccinium* species. Thus, our results show that *S. takeyai* can potentially survive on *Rhododendron* and *Vaccinium* species in conditions where its preferred host is absent. *Calluna vulgaris* and *K. latifolia* recorded very low or no damage in both no-choice and multi-choice assays. Both these plants are known to possess various allelopathic effects (14) on other plants, and tannins and other antifeedant principles (9) which may have a role in their avoidance by insects.

Our results document the susceptibility of selected ericaceous plants to *S. takeyai*. This information has not been reported earlier. Information on the host reactions under laboratory conditions will be helpful in selecting hosts to monitor the populations of new pests like *S. takeyai* during

Table 4. Mean number of *S. takeyai* nymphs emerged in no-choice and multi-choice assays with ericaceous hosts.

Taxa	Trial 1 (No-choice)	Trial 2 (No-choice)	Multi-choice trial
Rhododendron calendulaceum	0.56b[z]	0.00b	0.00b
Vaccinium arboreum	0.00b	0.00b	0.00b
Pieris floribunda	0.00b	0.00b	0.00b
Calluna vulgaris	0.00b	0.00b	0.00b
Kalmia latifolia	0.00b	0.00b	0.00b
Pieris japonica 'Temple Bells'	11.67a	20.56a	19.33a
Pieris phillyreifolia 'Little Leaf'	0.00b	0.00b	0.00b
Rhododendron 'Autumn Empress'	0.00b	0.00b	0.00b
Rhododendron 'Hampton Beauty'	0.56b	0.00b	0.00b
Vaccinium virgatum	0.00b	0.00b	0.00b
F	7.98	10.54	6.30
P	<0.0001	<0.0001	<0.0001

[z]Means in the same column bearing different letters are significantly different ($\alpha = 0.05$)

pest surveys. The results from our studies may be different from those observed in natural conditions owing to presence of other plants or influence of other abiotic factors. However they will be useful in predicting potential hosts of *S. takeyai* and also other *Stephanitis* lace bugs. Further testing of more ericaceous host plants, and plants of other related and unrelated families mentioned in the literature as potential hosts needs to be conducted, to determine the actual host range of this pest.

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