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Feeding Preference of Japanese Beetles for Taxa of Birch, Cherry and Crabapple[1]

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Abstract

Preference of adult Japanese beetle (*Popillia japonica* Newman) for different species, varieties, and cultivars was compared among 33 crabapple (*Malus* Mill.), nine cherry (*Prunus* L.), and nine birch (*Betula* L.) taxa. Field-grown crabapples and cherries and container-grown birches were visually rated based on the percentage of total leaf area skeletonized by natural populations of this beetle. The largest variation in the preference of Japanese beetles was found among the crabapples, with injury ranging from 0 to 83%. Eighteen of the crabapple taxa had no significant injury. All of the cherry taxa were skeletonized in excess of 46%, suggesting little natural resistance among these plants. Eight of the birch taxa had no significant injury, while one species, *B. jacquemontii*, had an average injury of 16%. An additional study was conducted to evaluate the degree of resistance of selected crabapple taxa by caging beetles on branches of individual trees in no choice tests. Although beetles continued to feed on one resistant species, *M. hupehensis* (a species without injury under natural conditions), beetles would not feed on leaves of another resistant cultivar, *M. baccata* 'Jackii', when caged on those trees. These results indicate there is considerable potential for using resistance to adult Japanese beetle feeding as one selection criterion when choosing taxa of crabapple and birch for use in the landscape. Results also suggest that the mechanism(s) of resistance can vary and may include aspects of avoidance (low attraction of beetles) as well as antixenosis.

Index words: *Betula*, *Malus*, *Popillia japonica*, *Prunus*, antixenosis, adult feeding, host plants, resistance

Significance to the Nursery Industry

With increasing limitations on the use of pesticides in nursery and landscape settings, there is a need for more information on landscape plants that are naturally resistant to insect pests. This research explored the degree of preference of Japanese beetles for selected taxa of crabapple, cherry and birch. Results demonstrate that considerable variation exists in the preference of adult Japanese beetles for different taxa within the *Malus* and *Betula* genera, suggesting that natural resistance to feeding by this insect is a useful selection criterion.

Introduction

Since introduction into the United States, early in this century, the Japanese beetle (*Popillia japonica* Newman) has become a destructive pest throughout much of Eastern North America. Hawley and Metzger (6) and Fleming (2) have published extensive lists of nearly 300 plants susceptible to this pest. Most research on the preference of Japanese beetle for various host plants has centered on comparisons of plants from different genera and families. To date, there has been little research on variations in beetle preference for host plants within specific genera.

Although this pest has a wide host range, species within the genera *Malus*, *Prunus*, and to a lesser extent *Betula*, have been found to be preferred host plants. Consequently, Japanese beetle can be a severe problem in the landscape. The purpose of this study was to evaluate a range of plant taxa, within the aforementioned genera, for susceptibility and possible resistance to Japanese beetle feeding.

Materials and Methods

Three separate experimental plots were established, one for each genus of plants studied. Individual plots were arranged in randomized complete block designs, located at the Mountain Horticultural Crops Research Station in Fletcher, NC.

Crabapple plot. Three replicates of 33 taxa of flowering crabapples (Table 1) were planted over the period of March 1990 to March 1991. Trees were planted in rows spaced 6.1 m (20 ft) apart, with 4.6 m (15 ft) between trees within rows. A 2.4 m (8 ft) wide strip of bare ground was maintained within these rows with periodic applications of glyphosate and paraquat. Aisles were planted to fescue maintained at a height of <30 cm (1 ft) with periodic mowing. Trees were fertilized in April 1991 with 142 g (5 oz) of 10N-4.3P-8.3K (10-10-10), surface broadcast. No supplemental irrigation was provided. Trees ranged in size from 2.5 cm (1 in) to 3.2 cm (1.25 in) in caliper and 1.5 m (5 ft) to 1.8 m (6 ft) in height in July 1991.

Cherry plot. Eight taxa of flowering cherries (Table 2) were planted in April 1991, in a plot approximately 100 m (330 ft) from the crabapple plot. Trees were planted in rows spaced 6.1 m (20 ft) apart, with 3.6 m (12 ft) between trees within rows. The number of replicates and ground cover management were the same as for the crabapple plot. Cherry trees ranged in size from 3.2 cm (1.25 in) to 4.5 cm (1.75 in) in caliper and 2.4 m (8 ft) to 3.1 m (10 ft) in height in July 1991. Trees were fertilized in April 1991 with 142 g

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Table 1. Feeding preference of Japanese beetle among 33 taxa of flowering crabapple (*Malus* spp.).

Taxa	Common/trade name	Leaf area skeletonized (%)[z]	Transformed values[y]
M. baccata Borkh. 'Jackii'	Siberian	0	0
M. hupehensis Rehd.	Tea	0	0
M. floribunda Siebold	Japanese	0	0
'Branzam'	Brandywine®	0	0
'Louisa'	'Louisa'	0	0
'Strawberry Parfait'	'Strawberry Parfait'	0	0
'Golden Raindrops'	'Golden Raindrops'	0	0
'Mazam'	Madonna®	1	4
'Hargozam'	Harvest Gold®	1	4
M. sargentii Rehd.	Sargent	1	6
'Silver Moon'	'Silver Moon'	1	6
'Ormiston Roy'	'Ormiston Roy'	2	7
'Baskatong'	'Baskatong'	2	9
'Candy Mint'	'Candy Mint'	2	9
'Molazam'	Molten Lava®	3	11
'Glen Mills'	'Glen Mills'	4	12
'Mary Potter'	'Mary Potter'	7	15
'Narragansett'	'Narragansett'	14	22
M. x zumi Rehd. 'Calocarpa'	Redbud Crab	17	24
'Sutyzam'	Sugar Tyme®	21	27
'Callaway'	'Callaway'	21	28
'Donald Wyman'	'Donald Wyman'	23	28
'Pink Princess'	'Pink Princess'	28	32
'Robinson'	'Robinson'	32	34
'White Angel'	'White Angel'	33	35
'Snowdrift'	'Snowdrift'	33	35
'Doubloons'	'Doubloons'	33	35
'Sinai Fire'	'Sinai Fire'	36	37
'Adams'	'Adams'	45	42
'Sentinel'	'Sentinel'	52	46
'Liset'	'Liset'	77	61
'Radiant'	'Radiant'	78	62
'Red Splendor'	'Red Splendor'	83	66
			$LSD_{0.05}$ = 22

[z]Values are means (n = 3), back-transformed to percentages.
[y]Data were adjusted using an arcsine transformation prior to conducting statistical analysis.

Table 2. Feeding preference of Japanese beetle among eight taxa of flowering cherries (*Prunus* spp.).

Taxa	Common/trade name	Leaf area skeletonized (%)[z]	Transformed values[y]
P. x yedoensis Matsum. 'Akebono'	'Akebono' Yoshino	46	42
P. serrulata Lindl. 'Kwanzan'	'Kwanzan' Japanese	48	44
P x yedoensis 'Afterglow'	'Afterglow' Yoshino	55	48
P. serrulata 'Tai Haku'	'Tai Haku' Great White	73	59
P. serrulata 'Mt. Fuji'	'Mt. Fuji' Japanese	76	61
P. subhirtella Miq. *'Autumnalis Rosea'*	'Autumnalis Rosea' Autumn Flowering Higan	82	65
P. x incamp 'Okame'	'Okame'	89	71
P. sargentii Rehd.	Sargent	93	75
			$LSD_{0.05}$ = 24

[z]Values are means (n = 3), back-transformed to percentages.
[y]Data were adjusted using an arcsine transformation prior to conducting statistical analysis.

(5 oz) of 10N-4.3P-8.3K (10-10-10), surface broadcast. No supplemental irrigation was provided.

Birch plot. Nine taxa of birch (Table 3), with seven replicates, were grown in 19 l (#7) containers, outdoors, on a gravel bed located approximately 0.4 km (0.25 mi) from the cherry and crabapple plots. The container media consisted of milled pine bark amended with 3.0 kg/m^3 and 0.89 kg/m^3 (5 lb/yd^3 and 1.5 lb/yd^3) of dolomitic limestone and Micromax, respectively. Twenty eight g (12 oz) of Osmocote 18N-2.6P-10K (18-6-12) was surface-applied to each container in April 1991. Plants were irrigated with approximately 7.6 l (2 gal) of water each day by drip irrigation. Trees were typically multi-stemmed and ranged in height from 1.0 m (3.3 ft) to 1.2 m (4 ft).

Injury ratings. Two observers visually rated each tree for foliage injury during the period of July 15 to July 19, 1991.

Table 3. Feeding preference of Japanese beetle among nine taxa of birch (*Betula* spp.).

Taxa	Common name	Leaf area skeletonized (%)[z]	Transformed values[y]
B. papyrifera Marsh.	Paper	0	0
B. platyphylla var. *japonica* Hara 'Whitespire'	'Whitespire' Japanese	0	0
B. platyphylla var. *szechuanica* Rehd.	Szechuan	0	0
B. populifolia Marsh.	Gray	0	1
B. pendula Roth.	European	0	2
B. ermanii Cham.	Erman's	0	3
B. nigra L.	River	1	4
B. nigra 'Heritage'	'Heritage' River	1	4
B. jacquemontii Spach.	Himalayan	16	23
			$LSD_{0.05}$ = 11

[z]Values are means (n = 7), back-transformed to percentages.
[y]Data were adjusted using an arcsine transformation prior to conducting statistical analysis.

The rating system was based on an 11 point scale corresponding to feeding injury (skeletonization) from 0 to 100 percent, in 10 percent increments. The ratings from both observers were averaged, adjusted using an arcsine transformation, and subjected to an analysis of variance and separation of means by LSD (4). Statistical differences among means were determined on the transformed data; percentage data are presented for ease of interpretation.

No choice feeding. Due to the wide variation observed in preference of Japanese beetle for the different crabapple taxa, an additional study was conducted to evaluate the degree of antixenosis found among four of the taxa. Four taxa, two resistant and two susceptible, were selected for further testing. On July 17, 1991, nylon mesh netting was used to enclose the terminal portion of one well-lit branch (with similar leaf areas) from each of three trees of the four taxa. Ten beetles of unknown age and sex were released into each cage. Damage was evaluated after 1 week. Mortality of beetles during this period was minimal and was not accounted for as the exact time of death was not known. Data were collected on percentage of leaves (number) fed upon and a visual rating of the percentage of leaf area skeletonized.

Results and Discussion

Average feeding injury on flowering crabapples ranged from 0% for several taxa to as high as 83% for 'Red Splendor' (Table 1). Eighteen of the taxa had minor injury with ratings of ≤14% skeletonization, with none of these ratings being significantly greater than 0%. The ranking of these taxa based on percent feeding injury was similar with the ranking for 21 of the same taxa evaluated at an experimental plot in Raleigh, NC (Dr. D.M. Benson, personal communication), with one exception. In the Raleigh plot, *M. floribunda* was found to have substantial injury (2.5 on a 5 point scale), while the same species had no injury in our evaluation. As the plants were not acquired from the same source, differences in susceptibility of *M. floribunda* may have been due to variation in intraspecific susceptibility. Similarly, Fleming (2) and Ladd (3) found that *M. baccata* was heavily fed upon by Japanese beetles, yet we found that *M. baccata* 'Jackii' had no feeding injury at the Fletcher site, as did Benson (personal communications) in the Raleigh evaluations. The substantial variation in resistance to feeding by adult Japanese beetles among crabapple taxa suggests that selection of resistant taxa within this genus is a viable approach to minimizing problems from this pest.

Feeding injury among the flowering cherries varied from 46% for 'Akebono' to 93% for *P. sargentii* (Table 2). Although there were significant differences among taxa in the amount of injury sustained, none of these plants were sufficiently free of injury to warrant selection of taxa resistant to Japanese beetle.

Of the birches evaluated, *B. jacquemontii* was the only taxa that had significant injury from Japanese beetles, with a mean skeletonization of 16% (Table 3). The number of beetles found at the birch plot may have been less than at either of the other two plots resulting in low injury ratings for many of the species. Reports by Ladd (3) and Fleming (2) indicate that *B. populifolia* and *B. pendula* are fed on extensively under certain conditions. Our results do, however, identify *B. jacquemontii* as a preferred host plant compared with the other taxa of birch evaluated. Observations made by the senior author in nurseries in N.C. support the findings that *B. jacquemontii* is a favored host and can be completely skeletonized, while other birches are less effected.

Evaluation of the feeding response of beetles caged on branches of selected *Malus* taxa was conducted to evaluate the degree of antixenosis among these plants under conditions where the beetles had no choice of host plants. Despite the presence of the enclosures, beetles continued to feed extensively (>40% skeletonized) on the two cultivars, 'Liset' and 'Radiant', observed to be preferred in the early evaluation (Table 4). The feeding response of beetles on the two taxa found to be resistant showed that the beetles would feed extensively on *M. hupehensis* (50% skeletonized), but did little damage to *M. baccata* 'Jackii' (1% skeletonized). Although there was little overall injury on the leaves of *M. baccata* 'Jackii', there were signs of feeding on 40% of the leaves, suggesting that beetles began to feed on leaves but found them unpalatable.

Preference of the beetles for various taxa under field conditions depends first on the ability of the beetle to locate/choose a host and secondly on palatability. Ahmad (1) found that Japanese beetles rely to a large degree on olfactory senses for locating host plants. In fact, many plants that are

Table 4. Feeding response of Japanese beetles caged on branches of four crabapple taxa for one week.

Taxa	Leaves fed upon (%)[z]	Leaf area skeletonized (%)
Resistant		
M. baccata 'Jackii'	40 a	1 a
M. hupehensis	100 b	50 b
Susceptible		
'Liset'	89 b	47 b
'Radiant'	79 b	42 b

[z]Means (n = 3) within columns followed by the same letter are not significantly different, $LSD_{0.05}$.

rarely attacked by the beetle, such as ginkgo (*Ginkgo biloba*), will be fed-on if the leaves are coated with juice pressed from cherry leaves (5). In the case of the crabapple taxa evaluated, it appears as though some taxa are more attractive to Japanese Beetle than others. Although *M. hupehensis* showed little injury in the initial field evaluation, the beetles fed extensively on it when they were enclosed with its foliage, suggesting that this plant may not have extensive injury in the field because it attracts fewer beetles. In the case of *M. baccata* 'Jackii', however, beetles refrained from feeding even under the caged conditions. These results suggest that *M. baccata* 'Jackii' is less palatable to the insect.

This research demonstrates that there can be substantial variation among closely related plants in their resistance to feeding by Japanese beetle adults. In situations where application of pesticides is not practical or desirable, selection of taxa with a high degree of natural resistance is a viable approach for minimizing injury from this insect.

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