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Suitability of Thirteen Different Host Species for Elm Leaf Beetle, Xanthogaleruca luteola (Coleoptera: Chrysomelidae)[1]

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Abstract

Thirteen different host species for elm leaf beetle, *Xanthogaleruca luteola* (Muller), were assayed to determine their relative suitability. Species examined were *Ulmus parvifolia* Jacq., *U. thomasii* Sarg., *U. laevis* Pall., *U. wilsoniana* Schneid., *U. americana* L., *U. japonica* Sarg., *U. pumila* L., *U. rubra* Muhl., *U. laciniata* Mayr., *U. glabra* Huds., *U. carpinifolia* Gledisch, *Zelkova serrata* Makino, and '204,' a hybrid of *U. carpinifolia* x *U. parvifolia*. Suitability was determined by feeding adults excised foliage from a tree and measuring mortality and fecundity during a two wk period. Significant differences in beetle mortality and fecundity occurred among hosts. In general, European elms were better hosts than American or Asiatic species. Suitability of a European x Asiatic hybrid fell between that of the parent species.

Index words: host plant resistance, insect-plant interactions, *Ulmus* spp., *Zelkova serrata*, elm leaf beetle, *Xanthogaleruca luteola*

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Introduction

The elm leaf beetle (ELB), *Xanthogaleruca luteola* (Muller), was introduced into the United States from Europe in the 1830's (1). Since its introduction, it has become a major defoliator of elms in urban environments throughout the US (6, 10). The presence of especially suitable host species in urban areas is a major reason for the urban pest status of ELB. European elm species and the Siberian elm, *Ulmus pumila* L., are often cited as the most heavily damaged elms (4, 5, 7, 8, 9, 11, 12). Certain Asiatic and American elm species are not as heavily damaged. Thus, there may be a relationship between geographic origin of elms and their susceptibility to ELB defoliation with coevolved elms (i.e., European species) being more susceptible than other elm species.

In 1986, we conducted an experiment designed to examine suitability for ELB of 13 different host species. Results provide information to plant breeders on potential sources of resistance to ELB and contribute to the understanding of the nature of evolutionary relationships between herbivores and their host plants.

Materials and Methods

U. parvifolia Jacq., *U. thomasii* Sarg., *U. laevis* Pall., *U. wilsoniana* Schneid., *U. americana* L., *U. japonica* Sarg., *U. pumila*, *U. rubra* Muhl., *U. laciniata* Mayr., *U. glabra* Huds., *U. carpinifolia* Gledisch, *Zelkova serrata* Makino, and '204,' a hybrid of *U. carpinifolia* × *U. parvifolia* were tested for suitability as hosts for ELB. Ten trees were examined for each elm except *U. rubra* and '204' where a single tree was examined and *U. laciniata* where two trees were examined. Trees were in field plots at the U.S.D.A., A.R.S., Horticultural Crops Research Laboratory at Delaware, Ohio and represent European, American, and Asiatic elm species (Table 1). Trees examined within a species were not propagated from the same parents and thus represented a range of genetic variability.

Foliage was removed from trees on July 24, 1986, and held in sealed plastic bags under refrigeration until used in assays. Trees varied in size from 2–15 m (ca. 6–45 ft) high and 10–30 cm (ca. 4–12 in) dbh. Assays began on July 25 and ran for two weeks. ELB used in experiments were field collected as late third instars from *U. procera* and held for adult eclosion in an environmental chamber at 25°C (77°F) under a 15:9 (L:D) photoperiod. One newly emerged, unfed male and female ELB were placed in each of five plastic Petri dishes with foliage from a single tree. Dishes were held in plastic bags to reduce drying of foliage. Every third day, Petri dishes were examined to determine mortality and

Table 1. Geographic origin of hosts examined for elm leaf beetle suitability.

Species	Geographic Origin
Ulmus parvifolia	Asia
Ulmus thomasii	North America
Ulmus laevis	Europe
Ulmus wilsoniana	Asia
Ulmus americana	North America
Ulmus japonica	Asia
Ulmus pumila	Asia
Ulmus procera	Europe
Ulmus rubra	North America
Ulmus laciniata	Asia
Ulmus glabra	Europe
Ulmus carpinifolia	Europe
Zelkova serrata	Asia

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Table 2. **Mortality and oviposition by elm leaf beetle in a two week period on different elm species.**

Species	No. Trees	n	% Mortality Males[z]	% Mortality Females[y]	% Females Ovipositing[x]	Eggs/ Female[w] (± SE)	Eggs/ Ovipositing Female (± SE)[v]
U. parvifolia	10	50	74	80	4	0.2(0.2) a	5.0(4.0) a
Z. serrata	10	50	34	28	16	3.1(1.2) a	19.6(4.4) b
U. thomasii	10	50	38	32	40	10.8(2.7) ab	27.0(4.8) b
U. laevis	10	50	30	32	38	12.7(3.5) ab	33.4(6.9) b
U. wilsoniana	10	50	44	38	34	16.7(4.8) ab	49.0(10.4) bc
U. americana	10	50	34	30	40	16.7(3.8) ab	41.8(6.0) bc
U. japonica	10	50	58	66	32	24.3(6.1) ab	76.0(11.0) bc
U. pumila	10	50	58	62	28	25.4(7.5) ab	90.6(17.4) bc
U. rubra	1	5	40	60	80	38.4(26.4) bc	48 (31.8) b
'204'	1	10	60	10	80	58.4(14.0) c	64.9(13.9) bc
U. laciniata	2	14	29	57	71	73.4(16.8) c	102.8(15.3) c
U. glabra	10	50	24	30	62	73.7(10.9) c	118.8(11.5) c
U. carpinifolia	10	50	36	26	68	79.7(12.2) c	117.2(13.9) c

[z]Chi square = 45.2; df = 12; $P < 0.01$.

[y]Chi square = 75.3; df = 12; $P < 0.01$.

[x]Chi square = 87.0; df = 12; $P < 0.01$.

[w]Data were subjected to a log transformation prior to analysis. $F(12,515) = 13.0$; $P < 0.01$. Means in columns followed by the same letter or letters are not significantly different at the 5% level using the Student-Newman-Keuls multiple comparison test.

[v]Data were subjected to a log transformation prior to analysis. $F(12,191) = 9.8$; $P < 0.01$.

fecundity; foliage was replaced, and dead males were replaced. All experiments were run at 25 ± 2°C (77 ± 3.6°F) under constant light.

Data were analyzed by chi square tests and one-way analysis of variance (ANOVA), alpha = 0.05. Means were compared with Student-Newman-Keuls multiple comparison test at the 5% level.

Results and Discussion

Elm leaf beetle survival and reproduction varied significantly on different hosts. Percent mortality of males and females, number of females ovipositing, and fecundity varied with host (Table 2). The best overall measure of suitability is number of eggs/female. Number of eggs/female is influenced by three different components of suitability: female mortality, percent of females ovipositing, and number of eggs/ovipositing female. For example, on *U. parvifolia*, with a low number of eggs/female, mortality was high, percent of females ovipositing was low, and number of eggs/ovipositing female was low. On *U. carpinifolia*, with a high number of eggs/female, mortality was low, percent of females ovipositing was high, and number of eggs/ovipositing female was high. On *U. pumila*, a host with a moderate number of eggs/female, there was high mortality, a low to moderate percent of females ovipositing, and a high number of eggs/ovipositing female.

Asiatic species were relatively low (*U. parvifolia* and *Z. serrata*), moderate (*U. wilsoniana, U. japonica*, and *U. pumila*) and high (*U. laciniata*) in suitability. American species (*U. thomasii, U. americana*, and *U. rubra*) were moderately suitable. European elms were moderately (*U. laevis*) and highly suitable (*U. glabra* and *U. carpinifolia*). Overall a higher proportion of females oviposited, and ovipositing females laid more eggs on European elms than on American or Asiatic species (Table 3). In another study, *U. procera*, a European species was more suitable for ELB than *U. americana, U. pumila*, and *U. parvifolia* (8). Thus, there appears to be a relationship between geographic origin and suitability of elms for ELB. In general, coevolved elms (i.e., European species) seem to be more suitable than other elms. The suitability of '204,' a hybrid of an Asiatic and a European species is intermediate between its parents. Thus, it follows a pattern seen in other elm hybrids (3).

Patterns of defoliation in the field generally follow those seen in the assays. European elm species and the Siberian elm, *Ulmus pumila*, are often severely defoliated (4, 5, 7, 8, 9, 11, 12). In Central Ohio, the authors have observed that *U. procera, U. glabra*, and *U. pumila* are defoliated by ELB more frequently and to a greater extent than *U. americana* and *Zelkova serrata*. In observations in field plots, *U. wilsoniana* was fed upon less than *U. carpinifolia* and several elm hybrids (Hall, Peacock and Wright, unpublished data). However, substantial differences in suitability also exist within elm species and within vegetatively propagated elm hybrids (3, 12).

Table 3. **Oviposition by elm leaf beetle during a two week period on Asiatic, American, and European elm species.**

	Origin of Elm Species: Asia	America	Europe
No. of Species Represented	6	3	3
No. of Female ELB	264	109	150
% of Females Ovipositing	25.4	44.9	56
No. of Eggs/Female[z]	17.1a	18.0a	55.3b
No. of Eggs/Ovipositing Female[y]	67.3a	40b	98.8c

[z]Means in rows followed by the same letter or letters are not significantly different at the 5% level using the Student-Newman-Keuls multiple comparison test. $F(2,520) = 30.3$; $P < 0.01$.

[y]$F(2,197) = 15.8$; $P < 0.01$.

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Several mechanisms operate to determine the suitability of a plant. We have not addressed the possibility that host preference plays a role in selection and utilization of elms. Clearly this occurs in nature. In this study, *U. pumila* was categorized as a moderately suitable host. However, it is often defoliated in urban plantings. *U. wilsoniana* has low to moderate suitability in no-choice studies (Table 2) yet it is a non-preferred host (2). Furthermore, in lab and field situations, the authors have observed that where an alternate host was available, *U. wilsoniana* trees and cuttings were not defoliated.

Elm leaf beetle is an urban pest. Defoliation by ELB appears to be higher on elms in close proximity to protected locations (i.e., structures) that can serve as overwintering sites. Thus, plant breeders must incorporate ELB resistance into new elm cultivars intended for urban plantings. Our results suggest that resistance to ELB is more likely to be found in non-European elm species. Therefore, breeders should concentrate on American or Asiatic elms or at least consider incorporating genetic material from non-European elms in new hybrids.

Significance to the Nursery Industry

Elm leaf beetle is a significant pest of elms in urban environments. The results of this study suggest that Asiatic and American elm species are less suitable for elm leaf beetle than European species. Thus, use of European elms in urban plantings should be discouraged. New elm varieties for use in urban plantings will be better received if they are resistant to both Dutch elm disease and elm leaf beetle. Non-European elms appear to be the best source of elm leaf beetle resistance for new elm varieties.

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