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Preference of *Forcipata loca* (Homoptera: Cicadellidae) Adults to Forage Plants[1]

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ABSTRACT The host suitability of *Forcipata loca* DeLong and Caldwell was determined in a series of feeding and oviposition tests conducted in the laboratory and field. The plants tested included forage and weed species commonly found in Missouri pastures. Visual examination of plants, radioisotope labeling, and adult survival and oviposition were techniques used to determine host suitability. Twenty-one test plants were acceptable food hosts, and 12 also were acceptable breeding hosts. The majority of plants belonged to the family Gramineae, and three belonged to the closely related family Cyperaceae.

The leafhopper *Forcipata loca* DeLong and Caldwell commonly occurs on grasses (DeLong 1948, Quisenberry et al. 1979). In Missouri, *F. loca* feeding on tall fescue var. 'Kentucky-31' ('KY-31') reduced forage quality (Quisenberry and Yonke 1981a,b). Injury resulting from feeding was evident by stippling and chlorosis confined primarily to the lower surface of the leaf (Smith 1926, Smith and Poos 1931, Quisenberry and Yonke 1981c). Host plant specificity between pasture forages and *F. loca* has not been extensively researched.

The present study investigated *F. loca* feeding preference and feeding and oviposition suitability for legumes, grasses, and weeds commonly found in Missouri pastures.

Materials and Methods

Plant species evaluated were cultivated forage grasses and legumes commonly grown in Missouri and some weedy grass species: tall fescue, *Festuca arundinacea* Schreb. var. 'Kentucky-31,' 'Kenmont,' 'Misssouri I-96'; creeping red fescue, *F. rubra* L.; timothy, *Phleum pratense* L.; orchardgrass, *Dactylis glomerata* L. var. 'Hallmark'; Kentucky bluegrass, *Poa pratensis* L.; sorghum-sudan hybrid var. 'Piper'; downy bromegrass, *Bromus tectorum* L. (field collected); smooth bromegrass, *B. inermis* Leyess. (field collected); perennial ryegrass, *Lolium perenne* L.; wheat, *Triticum aestivum* L. var. 'Arthur 71'; lovegrass, *Eragrostis Frankii* C. A. Meyer; poverty oatgrass, *Danthonia spicata* (L.) Beauv. (field collected); *Cyperus esculentus* L. (field collected); green foxtail, *Setaria viridis* (L.) Beauv. (field collected); small crabgrass, *Digitaria ischaemum* (Schreb.) (field collected); crown vetch, *Coronilla varia* L.; alfalfa, *Medicago sativa* L. var. 'F-360'; Korean lespedeza, *Lespedeza stipulacea* Maxim; medium red clover, *Trifolium pratense* L.; ladino clover, *T. repens* L.; birdsfoot trefoil, *Lotus corniculatus* L.; and goat grass, *Aegilops cylindrica* Host. (field collected).

Except where indicated, plants were grown from seed in the greenhouse in plastic pots (9 by 12.0 cm) which contained steam sterilized soil. Leafhoppers also were mass reared in the greenhouse on tall fescue var. 'KY-31.' Plants and leafhoppers were reared at 20 ± 5°C, 14-h photophase, and >50% relative humidity (RH).

Preference Test: Cultivated Forage Grasses and Legumes

Plants evaluated were: tall fescue var. 'KY-31,' 'Kenmont,' 'MO I-96'; timothy; orchardgrass; Kentucky bluegrass; sorghum-sudan hybrid; crown vetch; alfalfa; Korean lespedeza; medium red clover; ladino clover; and birdsfoot trefoil.

Adult *F. loca* behavior was evaluated in a free-selection chamber made from a galvanized steel tub with a removable top and inner support shelf. The top was secured by three clamps and tape to assure an insect escape-proof seal.

For each test, two tall fescue var. 'KY-31' plants were paired with two plants of another forage. Three replicates ($n = 50$) were tested simultaneously. The paired plants were arranged on an alternate basis in each chamber.

Fifty randomly selected adults were prestarved for 4 h in a 0.47-liter paper container containing a moistened dental wick. The container with prestarved leafhoppers was then placed in a central release area of each chamber. Three of the top entrance holes were covered with black paper, the lights were turned off, the container lid was removed, and the fourth entrance hole was immediately covered. The chambers were then covered with a dark cloth. The tests were conducted at 22 ± 3°C and >30% RH.

After a 36-h feeding period, each plant was drop trapped in the dark with an acrylan-plastic cylinder 14.5 by 34 cm. The tops of the cylinders were covered with 52-mesh natural Lumite saran screen. The number of leafhoppers per plant and the presence or absence of leaf chlorosis were recorded. Data were analyzed by the paired *t* test ($P < 0.05$).

Radioisotope-Labeled Grasses

Grasses were grown in a growth chamber in plastic pots (9.5 by 12.0 cm) at 25:19°C (day:night), 14-h photophase 500 μm E m^{-2} sec^{-1} (400 to 700 nm), and >50% RH. After a 5- to 7-week growth period, four

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tall fescue var. 'KY-31' plants were paired with four plants of timothy, orchardgrass, Kentucky bluegrass, tall fescue var. 'Kenmont,' or tall fescue var. 'MO 1-96,' based on leaf area. The plants were removed from their pots, the roots were washed, and the paired plants were divided into two tests. In test 1, a tall fescue var. 'KY-31' plant was radiolabeled with tyrosine-^{14}C. A radiolabeled sample of tyrosine was provided by New England Nuclear Corp. The specific activity of tyrosine-^{14}C was 412 mCi/mol. Plants were treated with a ca. 1 μM solution of tyrosine-^{14}C via washed roots for 24 h before leafhopper introduction. The solution was aerated to increase uptake. The roots of the 'KY-31' plant were placed in a 10 dram (ca. 17.7-g) vial containing radiolabeled water, whereas the roots of the untreated grass species were placed in another 10-dram vial containing water. The two vials were placed beside one another in a support stand. Stakes provided support for the air valve stem and TeLan plastic feeding chamber. A no. 8 rubber stopper with two enlarged holes securely held the plant and air pipet in place. The radiolabeled 'KY-31' plant and untreated grass were then caged in a feeding chamber. Foam rubber strips placed at the top and base of the chamber held the leaves in place and provided an escape-proof cage. Two replicates (n = 50) were tested simultaneously. In a second test, the other grass species were radiolabeled and paired in a feeding chamber with an untreated tall fescue var. 'KY-31' plant. Two replicates (n = 50) also were tested simultaneously. During both tests, the roots were aerated continuously.

Fifty randomly selected, prestarved (4 h) *F. loca* adults were placed in each feeding chamber and offered a feeding choice. After a 24-h feeding period under continuous fluorescent light, leafhoppers were removed from the plants.

Each radiolabeled plant or leafhopper sample was divided into duplicate portions and placed into Combusto Cones for combustion in a model 306 Tri-carb sample oxidizer. The resulting $^{14}CO_2$ was trapped in 4 ml of Carbo-Sorb and added to 12 ml of Permafluor V scintillation fluid for radioassay.

The radiocarbon content of each sample was measured with a Beckman LS7500 liquid scintillation counter. The amount of radioactivity was calculated by averaging duplicate sample counts. All data were corrected for background, dilution, quenching, and counting efficiency (Johnson and Knowles 1979). A ratio of feeding was determined from the radiocarbon content of comparable units of leafhopper and plant tissue (Maddox and Resnik 1969).

Host Plant Suitability Test

The suitability of each cultivated forage and weedy grass species, except timothy, was tested in the greenhouse for feeding and oviposition by *F. loca*. The number of plants per pot for each species was determined by the size and growth habits of each species. This was necessary to ensure that adequate feeding and oviposition sites were available to the leafhopper.

Ten adult leafhoppers, five males and five females, were confined to test plants in acrylan-plastic cylinders (7.5 by 30 cm). Ventilation was provided by two 37-mm-diameter holes located 7.5 cm from the bottom of the cylinder and opposite from each other. The holes and top of each cylinder were covered with 52-mesh natural Lumite saran screen. Two 12-mm holes allowed access into the cage with an aspirator. The access holes were stoppered with size B foam plugs. Except where indicated, four replicates were tested.

The percent adult survival, an indication of acceptance for feeding, was determined by dividing the total number of survivors by the total number of insects tested per plant selection at the end of 10 days. The adults were then removed from the plant and the plant recaged for an additional 2 to 3 weeks. At the end of this period, the plant was examined for developing nymphs as an indicator of host suitability for oviposition. No attempt was made to quantify the amount of oviposition on each plant or to calculate the percentage of successful incubation and eclosion.

Field Studies

Field populations of various plant species were examined for *F. loca*. Acceptability of the host for feeding was indicated by leaf chlorosis. Also, developing nymphs were searched for indicating acceptability of the plant as a breeding host.

Results

Preference Test: Cultivated Forage Grasses and Legumes

Significantly greater numbers ($P < 0.05$) of adult *F. loca* selected tall fescue var. 'KY-31' than any forage legume tested (Table 1). Relatively few leafhoppers selected a legume, and leaf stippling and chlorosis, indicative of *F. loca* feeding, was not evident on legume leaves. *F. loca* numbers were not significantly different ($P > 0.05$) between tall fescue var. 'KY-31' and the other grasses. Leaf stippling and chlorosis were observed on all grasses tested.

Radioisotope-Labeled Grasses

F. loca adults, given a free choice, fed on all grasses as indicated by the radioassays of leafhoppers and plant tissue (Table 2). This corresponded with the heavy leaf chlorosis observed on all grasses. The amount of leafhopper feeding on each grass varied (Table 3). The percent increase in *F. loca* feeding ranged from 33 to 57% more on tall fescue var. 'KY-31' when compared with the sorghum-sudan hybrid, tall fescue var. 'MO 1-96,' Kentucky bluegrass, and tall fescue var. 'Kenmont,' respectively. However, there was 33% more leafhopper feeding on orchardgrass and 50% more on timothy than on tall fescue var. 'KY-31.'

Host Plant Suitability Test

F. loca adults were not able to survive on alfalfa, medium red clover, lespedeza, crown vetch, birdsfoot

Table 1. *F. loca* adults on paired forages for 36 h of a free-selection test[a]

Treatment	No. of live leafhoppers/ paired treatment	Treatment	No. of live leafhoppers/ paired treatment
Tall fescue, 'KY-31'	43.3 (3.1)a	Tall fescue, 'KY-31'	24.7 (4.7)a
Alfalfa	0b	Kentucky bluegrass	21.0 (2.0)a
Tall fescue, 'KY-31'	38.7 (2.3)a	Tall fescue, 'KY-31'	21.3 (2.5)a
Medium red clover	2.3 (2.5)b	Timothy	20.7 (3.8)a
Tall fescue, 'KY-31'	30.3 (10.1)a	Tall fescue, 'KY-31'	29.0 (3.5)a
Lespedeza	4.3 (2.1)b	Orchardgrass	15.0 (3.5)a
Tall fescue, 'KY-31'	31.0 15.6)a	Tall fescue, 'KY-31'	26.7 16.4)a
Crown vetch	4.0 (1.8)b	Sorghum/sudan hybrid	18.3 (2.5)a
Tall fescue, 'KY-31'	41.3 (5.8)a	Tall fescue, 'KY-31'	23.3 (7.1)a
Birdsfoot trefoil	1.3 (0.6)b	Tall fescue, 'MO 1-96'	19.0 (8.2)a
Tall fescue, 'KY'31'	38.0 (5.5)a	Tall fescue, 'KY-31'	25 0 (3.0)a
Ladino clover	0 7 (0.6)b	Tall fescue, Kenmont	21 7 (4.2)a

[a]Values represent means based on three replicates of 50 leafhoppers each. SD is given in parentheses. Means followed by the same letter within each paired grouping are not significantly different ($P > 0.05$), by the paired *t* test.

Table 2. Ratio of plant feeding determined by radioisotope assays of leafhoppers (50 per plant) feeding for 24 h on plant tissue labeled with tyrosine-^{14}C.

Test no.	Plants		dPM[a]		Ratio (a/b)	$\bar{x}$[b]
	Species	Replicate no.	Per g of insect (a)	Per g of fresh plant wt (b)		
1	Tall fescue, 'KY-31'	1	127.06	2,926 50	0.04	
		2	126.14	1,715.80	0.07	0 06
	Sorghum/sudan hybrid	1	204.75	4,831.95	0.04	
		2	173.54	4,126 70	0.04	0 04
2	Tall fescue, 'KY 31'	1	80 46	3,209.64	0.02	
		2	130 15	529.11	0.25	0.14
	Tall fescue, 'MO 1-96'	1	110 09	2,036.72	0.05	
		2	92 21	1,156.76	0.08	0 07
3	Tall fescue, 'KY-31'	1	64 38	1,388.46	0.05	
		2	219.71	1,283.71	0.17	0.11
	Kentucky bluegrass	1	152 65	3,479.97	0.04	
		2	140 14	2,399.66	0.06	0.05
4	Tall fescue, 'KY-31'	1	77 37	1,222.31	0.06	
		2	141.84	2,176.06	0.07	0.07
	Tall fescue, 'Kenmont'	1	81.57	1,752.29	0.05	
		2	35.70	2,427.01	0.01	0.03
5	Tall fescue, 'KY-31'	1	48.86	1,300.48	0.04	
		2	34.15	1,268.14	0.03	0 04
	Timothy	1	116.77	2,195.77	0.05	
		2	195.53	1,729.30	0.11	0 08
6	Tall fescue, 'KY-31'	1	68.45	1,548.29	0.04	
		2	87 48	1,108 81	0 08	0 06
	Orchardgrass	1	224 88	2,012 51	0.11	
		2	103 76	1,399 21	0 07	0 09

[a]dPM, Disintegrations per minute.
[b]Mean ratio (a/b) per plant species

trefoil, and ladino clover for the 10-day period. Oviposition also was not noted on any dicotyledonous plants.

Adult survival on 17 monocotyledonous plants ranged from a high of 100% on tall fescue var. 'KY-31' to a low of 0% on poverty oatgrass (Table 4). No significant differences ($P > 0.05$) occurred between adult survival on tall fescue and goatgrass or between Kentucky bluegrass and perennial rye. Most plants within this group also were breeding hosts. Orchardgrass, goatgrass, and downy bromegrass were not acceptable breeding hosts. Lovegrass, *Cyperus esculentus* L., green foxtail, and poverty oatgrass had significantly fewer ($P \leq 0.05$) adults survive than the other plants tested. Only *C. esculentus* was an acceptable breeding host.

Field Studies

Adults of *F. loca* were associated in the field with eight graminaceous and two cyperaceous plant species, and developing nymphs were observed on three of them. They included smooth bromegrass, *Cyperus strigosus* L., small crabgrass, spike rush (*Eleocharis* sp.), tall

Table 3. Ratio of *F. loca* feeding on 'Kentucky-31' tall fescue

Treatment	Ratio ($\bar{X}_a/\bar{X}_b$)[a]	% Increase in feeding[b]
Tall fescue, 'KY 31': sorghum/sudan hybrid	1.5:1	33
Tall fescue, 'KY31': tall fescue, 'MO I-96'	2.0:1	50
Tall fescue, 'KY-31': Kentucky bluegrass	2.2:1	55
Tall fescue, 'KY-31': tall fescue, Kenmont	2.3:1	57
Orchardgrass: tall fescue, 'KY 31'	1.5:1	33
Timothy: tall fescue, 'KY-31'	2.0:1	50

[a]Ratio of the mean ratio (a/b) per plant species per test

[b]Percent increase $= 100 \left(\frac{\bar{X}_a}{\bar{X}_b} \times 100\right)$

Table 4. Adult survival and acceptance for oviposition of *F. loca* on 17 monocotyledonous plants based on four replicates of five male/female pairs

Host plant	% Survival[a]	Oviposition[b]
Tall fescue, 'Kentucky 31'	100.0a	+
Tall fescue, 'MO I 96'	97.5a	+
Sudan/sorghum hybrid, 'Piper'	95.0ab	+
Tall fescue, 'Kenmont'	92.5abc	+
Orchardgrass, 'Hallmark'	90.0abcd	–
Wheat, 'Arthur 71'	90.0abcd	+
Kentucky bluegrass	85.0bcde	+
Downy bromegrass[c]	85.0bcde	–
Goatgrass[d]	80.0bcde	–
Creeping red fescue	80.0bcde	+
Smooth bromegrass	77.5cde	+
Small crabgrass	75.0de	+
Perennial rye	72.5e	+
Lovegrass	50.0f	
Cyperus esculentus	37.5f	+
Green foxtail[e]	5.0g	–
Poverty oatgrass	0.0g	–

[a]Means followed by the same letter are not significantly different ($P > 0.05$), by Duncan's multiple range test.

[b]+, Appearance of developing nymphs in at least one replicate after exposure of the plant to *F. loca* adults.

[c]Based on two replicates.

[d]Based on one test.

[e]Based on eight replicates.

fescue (also nymphs), cutgrass, perennial rye, *Muhlenbergi Schregeri* Gmel. (also nymphs), *M. sobolifera* (Muhl., Trin., and Kentucky bluegrass (also nymphs).

Discussion

The results from the different tests demonstrated the feeding and oviposition specificity of *F. loca* in relation to the forage and weed species tested. The preference study indicated *F. loca* selected and fed only on forage grasses. Maddox and Resnik (1969) suggested that ratthat leafhopper feeding occurred on forage grasses, and determined the comparative degree of feeding on test plants. These results confirmed the results observed in the preference test. The percent adult survival, host suitability for oviposition, and field studies provided indices of host specificity. From these studies, the host list of *F. loca* could be divided into four categories: nonhosts, food hosts, breeding hosts, and experimental hosts.

Plants not acceptable as food or breeding hosts are considered nonhosts. The nonhosts included alfalfa, birdsfoot trefoil, crown vetch, Korean lespedeza, ladino clover, medium red clover, green foxtail, and poverty oatgrass.

Acceptable food host plants included cutgrass, *C. strigosus*, downy bromegrass, goatgrass, lovegrass, *M. sobolifera*, orchardgrass, spike rush, timothy, and western wheatgrass (only one observation). There were indications of adult feeding and survival on these plants, but *F. loca* nymphs were not observed on the plants. Placement of a plant in this category would not preclude it from being a true breeding host.

Adult feeding and survival and developing nymphs were found associated with tall fescue var. 'KY 31,' 'MO I-96,' and 'Kenmont.' Kentucky bluegrass, creeping red fescue, smooth bromegrass, small crabgrass, perennial rye, and *M. Schreberi*. These plants were acceptable for both feeding and reproduction.

Plants acceptable for feeding and reproduction but not known hosts in the field are experimental hosts. Experimental hosts included sorghum-sudan hybrid, wheat, and *C. esculentus*.

Grasses in general were listed as *F. loca* host plants previous to this study (DeLong 1948). From this study, it can be concluded that it is difficult to associate the presence of a leafhopper on a plant with actual feeding. Also, acceptability of a certain plant as a food host would not necessarily guarantee acceptability of that plant as a breeding host.

However, the broad feeding range of *F. loca* on grasses demonstrates the potential under ideal conditions for this species to build up large, destructive populations which could have an adverse impact on one of our most important forage grasses in Missouri.

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