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Life History of *Forcipita loca* (Homoptera: Cicadellidae) on Three Graminaceous Hosts, with Descriptions of the Immature Stages[1]

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ABSTRACT: The development and fecundity of *Forcipita loca* DeLong and Caldwell was studied in the laboratory on 'Kentucky-31' tall fescue, Kentucky bluegrass and smooth brome. Nymphal development took 17.5, 16.0, and 16.7 days, and % nymphal survival was 75.9%, 50.0%, and 39.4%, respectively; male adult longevity averaged 62.5, 42.2, and 37.8 days; female adult longevity averaged 48.5, 36.8, and 42.7, respectively; total eggs per female averaged 183.7, 56.8, and 47.5, respectively. Host selection appeared to have a significant effect on % nymphal survival and female fecundity. 'Kentucky-31' tall fescue was the most suitable host of the plants tested, smooth brome was the least suitable.

Data were also collected on parasites and predators of *F. loca*, and the immature stages of the leafhopper are described and illustrated.

Forcipita loca DeLong and Caldwell is a potentially serious pest of tall fescue, *Festuca arundinacea* Schreb. Quisenberry et al. (1979) collected *F. loca* regularly and in high numbers in pastures of predominantly tall fescue in Missouri, and Quisenberry and Yonke (1981a, b, c) have determined that feeding by *F. loca* reduced the quality of tall fescue, var. Kentucky-31 (KY-31), as a forage, primarily by decreasing digestability of the plant. Information has also been obtained on the preference of adult *F. loca* to forage grasses (Quisenberry et al., 1983). However, no information is available on the life history of this leafhopper. Poos and Smith (1931), working with *Empoasca fabae* (Harris), and Coupe and Schulz (1968), working with *Endria inimica* (Say), found that the host selection could have an effect on the development and reproduction of the leafhopper, thus life history studies on *F. loca* were conducted on 3 hosts: KY-31 tall fescue; Kentucky bluegrass, *Poa pratensis* L.; and smooth brome, *Bromus inermis* Leyss. Information is also presented on predators and parasites, and the immature stages are illustrated.

Materials and Methods

FIELD STUDIES: Individuals collected in the field were examined for the presence of parasites. Leafhoppers hosting immature parasites were individually caged and observed daily until emergence of the adult parasite. Predators observed feeding on *F. loca* were also collected.

STOCK CULTURES: Leafhoppers were collected in the field in Boone County, Missouri, using a D-Vac® suction sampler. *F. loca* individuals were removed from the sample and placed in stock colony cages. The cages measured 50 cm on

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each side and contained tall fescue plants growing in metal trays. Stock colonies were maintained in the greenhouse. Steps were taken to insure pure species cultures. *F. loca* used in the laboratory studies, predators, and parasites were deposited in the Wilbur R. Enns Entomology Research Museum, University of Missouri–Columbia.

STRUCTURE OF CAGES: Two types of cages were used for laboratory studies. The life history cages were first used and illustrated by Mason and Yonke (1971). These cages were used for studies on fecundity and longevity. Smaller cages (Fig. 1) were used to study nymphal development.

ENVIRONMENTAL CONDITIONS: All experiments were conducted within Percival® environmental chambers (Models E-47 and I 30 L). The photoperiod was maintained at 16 hr light and 8 hr dark, and the thermoperiod was maintained at 30°C during the first 12 hr of light and 21°C during the remainder of the 24-hr cycle. Humidity was maintained by placing trays of water within the growth compartment.

LABORATORY STUDIES: The egg incubation period was determined by placing an adult male-female pair on a caged, previously unexposed plant for 1 day. After removing the leafhoppers, the plant was kept isolated in its cage and was observed daily for newly hatched nymphs.

To study the time of nymphal development, newly hatched nymphs were placed in nymphal development cages. Only 1 or 2 nymphs were placed in each cage. Daily observations were made to note the appearance of exuviae. When exuviae were noted, their stages and the number of days since eclosion were determined and recorded. The total time of development was determined for males, females, and the sexes combined.

To determine the preoviposition period, male and female 5th instars were paired and placed in life history cages on new plants. Fifth instars were sexed using the characters given by Pollard (1962). The adult emergence of each was noted and recorded. After emergence of the female, the pair was transferred to a new, caged plant each day. Each plant remained isolated in its cage and was observed daily for newly hatched nymphs. The preoviposition period was determined by noting the first plant in the series to host newly hatched nymphs.

Oviposition behavior and fecundity were studied by pairing male and female 5th instars and placing them on caged, previously unexposed plants. The adult emergence of each was noted and recorded. After emergence of the female, the pair was allowed to remain on the plant for 1 week. At the end of that week and each succeeding week, the pair was transferred to a new plant until death of the female. If the male died first it was replaced with another adult male. The exposed plants were clipped, labeled, and placed in the freezer until they could be processed for egg counts. Eggs were observed using the lacto-phenol method outlined by Simonet and Pienkowski (1977). The number of eggs was recorded for both the sheath and the blade of the leaf. The ligule was considered to be the dividing line between sheath and blade. The position of the egg and its orientation within the plant tissues was also noted.

Adult longevity was determined by recording the date of death of the individuals used in the fecundity studies.

IMMATURE STAGES: Illustrations were prepared with the aid of a camera lucida on a Wild® M-5 dissecting microscope at 100×. The increment shown with the

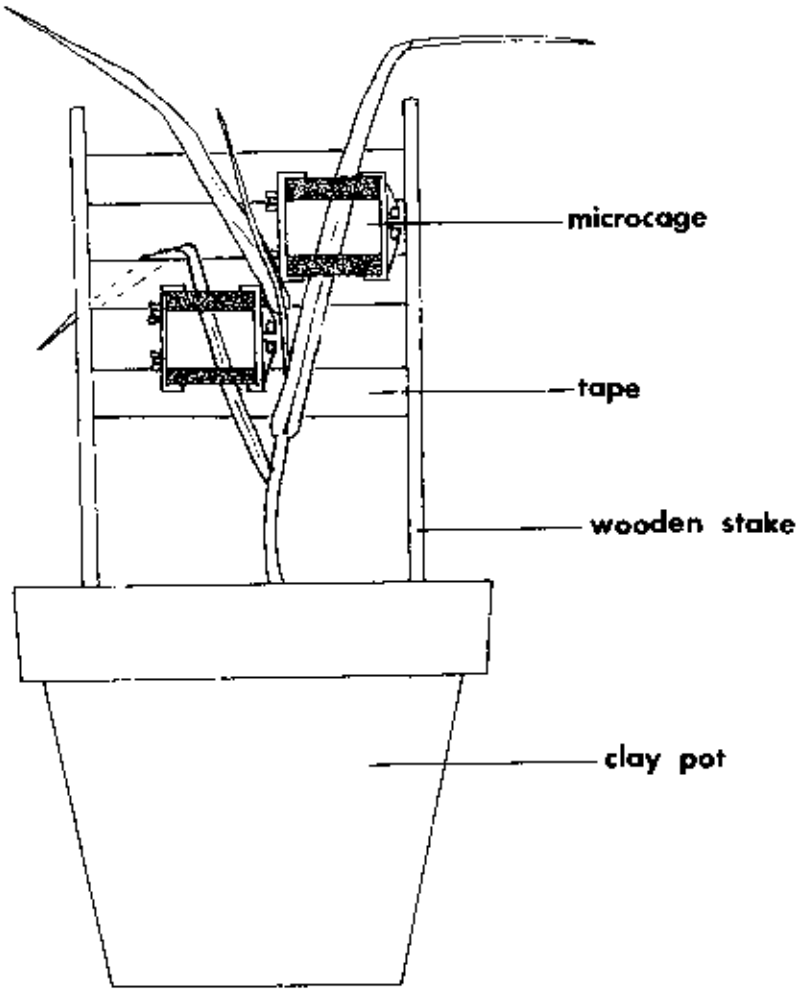

Fig. 1. Nymphal development cages suspended on host plant.

illustrations represents 1 mm of actual length. The measurements of each nymphal instar were made using an ocular micrometer. The total length was measured from the tip of the vertex to the tip of the abdomen. The head capsule width was measured between the outer margins of the compound eyes.

Results and Discussion

F. loca is a northern species, having been reported in 8 Canadian provinces and 18 states in the continental United States. For brevity, references are cited only for the first record of occurrence in each state or province. The reader should refer to these sources for specific information regarding locations and dates. The states and provinces where *F. loca* has been reported are: Connecticut, Delaware, Illinois, Kansas, Maine, Massachusetts, New Hampshire, New York, Ohio, Ontario, Pennsylvania, South Dakota, Vermont, Virginia (DeLong and Caldwell,

Table 1. Time (in days) for egg incubation, cumulative nymphal development and development for each sex of *F. loca* on 3 species of grasses.

Stage	No observations	Mean ± SD	Range
		Tall fescue	
Egg	90	10.5 ± 1.22	8–12
Instar 1	37	3.6 ± 0.80	1–6
2	34	6.4 ± 1.04	4–9
3	32	9.4 ± 1.54	8–14
4	31	12.7 ± 1.90	10–18
5	28	17.5 ± 2.41	14–24
5 (♂)	12	17.6 ± 2.57	14–23
5 (♀)	16	17.5 ± 2.37	15–24
		Kentucky bluegrass	
Egg	54	12.3 ± 0.70	11–13
Instar 1	42	3.2 ± 0.44	2–4
2	39	5.7 ± 0.73	5–7
3	37	8.6 ± 1.12	7–11
4	34	11.6 ± 1.44	9–15
5	21	16.0 ± 1.83	13–20
5 (♂)	13	15.3 ± 1.44	13–18
5 (♀)	8	17.3 ± 1.83	15–20
		Smooth brome	
Egg	0	—	—
Instar 1	38	3.3 ± 0.45	3–4
2	34	6.0 ± 0.72	5–7
3	31	9.3 ± 1.35	7–13
4	26	12.6 ± 1.58	10–16
5	15	16.7 ± 1.22	14–19
5 (♂)	6	16.2 ± 1.17	14–17
5 (♀)	9	17.1 ± 1.67	15–19

1936); Minnesota (Medler, 1943); Quebec (Moore, 1944); Kentucky (Young, 1950); British Columbia, Labrador, Manitoba, Northwest Territories, Saskatchewan (Bierne, 1956); Rhode Island (Kerr, 1957); Michigan (Hoffman and Taboado, 1960); and Missouri (Quisenberry et al., 1979). In addition, we have examined a male specimen collected on 6 August 1931 at Bay Center, Wisconsin.

Although Missouri is along the southern border of this distribution, *F. loca* has been collected abundantly in many areas of the state, including the south. Thus, it is probable that the range of *F. loca* completely covers Missouri and possibly extends into northern Arkansas.

Observation of *F. loca* colonies caged outdoors indicates that it overwinters in the adult stage. In Missouri, Quisenberry et al. (1979) observed adult population peaks in July and October. Adults were already present in May when sampling was begun. In this study, adults were observed as early as late March. Thus, it appears that there are 2 generations per year in Missouri. The first generation developing from eggs laid by overwintering adults and maturing in mid-summer, the second maturing in fall and overwintering as adults.

Several parasites and predators of *F. loca* were recorded during this study. The

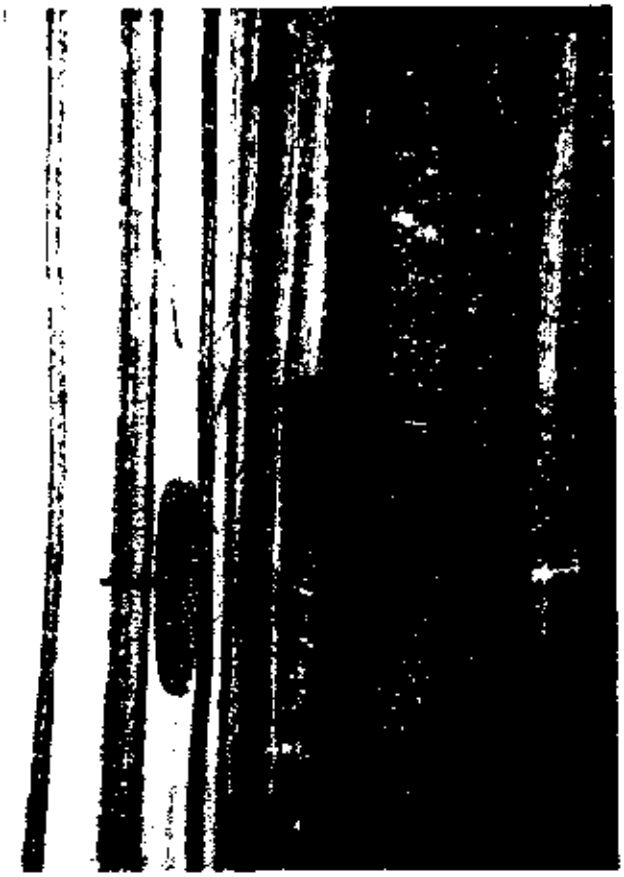

Fig. 2. Eggs of *F. loca* in leaf sheath of Kentucky 31 tall fescue.

dryinid wasp, *Aphelopus dikraneuri* Fenton, was observed throughout the summer but rarely exceeded 2% incidence. An unidentified mite, family Erythraeidae, was observed at levels approaching 10% parasitism on 17 June 1982, but was otherwise scarce. The following were observed as predators of *F. loca*: *Nabis roseipennis* Reuter (Hemiptera: Nabidae), *Chrysopa carnea* Stephens (Neuroptera: Chrysopidae), *Coleomegilla maculata lengi* Timberlake (Coleoptera: Coccinellidae), *Myrmica emeryana* Forel (Hymenoptera: Formicidae), and *Metaphidippus galathea* (Walkenaer) (Araneae: Salticidae). None of the predators were found associated with *F. loca* populations in great numbers. McKenzie and Bierne (1972) found a similar predator complex attacking *Erythroneura ziczac* Walsh.

LABORATORY STUDIES: Table 1 contains information on the egg incubation and nymphal development of *F. loca* on each of the 3 host plants. Eggs incubated for a mean of 10.5 days on KY-31 tall fescue and 12.3 days on Kentucky bluegrass. An egg incubation period could not be determined on smooth brome due to poor hatch rates. On all hosts, the first 4 instars lasted about 3 days each while the 5th instar lasted nearly 5 days. Males and females developed at about the same rate. On tall fescue, 75.9% of those nymphs completing the 1st instar successfully

Table 2. Reproduction and adult longevity for *F. loca* on 3 species of grasses.

	No. observations	Mean	Range
Tall fescue			
Eggs deposited in leaf blade	6	53.3	8–81
Eggs deposited in leaf sheath	6	130.3	30–276
Total eggs/female	6	183.7	38–354
Eggs/day	6	4.1	
Preoviposition period (days)	5	7.6	6–10
Derived oviposition period (days)	6	43.2	
♂ longevity (days)	4	62.5	27–78
♀ longevity (days)	10	48.4	27–92
Kentucky bluegrass			
Eggs deposited in leaf blade	6	16.8	0–43
Eggs deposited in leaf sheath	6	40.0	0–72
Total eggs/female	6	56.8	4–115
Eggs/day	6	1.9	
Preoviposition period (days)	2	8.0	7–9
Derived oviposition period (days)	6	28.8	
♂ longevity (days)	6	42.2	31–74
♀ longevity (days)	6	36.8	27–48
Smooth brome			
Eggs deposited in leaf blade	6	0.2	0–1
Eggs deposited in leaf sheath	6	47.3	25–80
Total eggs/female	6	47.5	25–80
Eggs/day	6	1.3	
Preoviposition period (days)	1	7.0	
Derived oviposition period (days)	6	35.7	
♂ longevity (days)	6	37.8	27–47
♀ longevity (days)	6	42.7	40–46

reached adulthood. On Kentucky bluegrass, 50% of those nymphs reached adulthood, and 39.4% of those nymphs on smooth brome completed their development.

Nymphs are relatively inactive, passing their entire developmental period on a small area of one leaf blade. They feed on the lower surface of the blade with their bodies parallel to the long axis. Adults prefer the same portion of the plant for feeding. Copulation was observed on 2 occasions, the position being very similar to that illustrated for *Ribautiana foliosa* (Knull) by Varty (1967).

Males of *F. loca* were observed to be more active physically than females. Males almost always jumped to the top or side of the cage immediately upon being disturbed. Females, on the other hand, usually remained stationary and did not jump until the cage was severely jarred.

Table 2 gives information on the oviposition habits and adult longevity of *F. loca* on each of the 3 host plants. On all hosts, females deposited eggs singly in both the sheath and the blade. There was a distinct preference for ovipositing in the sheath on all hosts. Eggs deposited in the blade were usually located next to the midrib, while eggs deposited in the sheath were located across the width of the sheath and were confined to within 2 cm of the ligule. All eggs were oriented

Table 3. Summary of nymphal development, percent nymphal survival, adult longevity, and female fecundity of *F. loca* on 3 species of grasses.[a]

Host plant	Mean days nymphal development	% nymphal survival	Mean days adult longevity	Mean total number eggs female	Mean number eggs day
Kentucky-31 tall fescue	♂ 17.6b ♀ 17.5b	75.9a	♂ 62.5a ♀ 48.5ab	183.7a	4.1a
Kentucky bluegrass	♂ 15.3a ♀ 17.3b	50.0b	♂ 42.2ab ♀ 36.8b	56.8b	1.9b
Smooth brome	♂ 16.2ab ♀ 17.1b	39.4b	♂ 37.8b ♀ 42.7ab	47.5b	1.3b

[a] Each column represents a separate test. Means flanked by the same letters are not significantly different at the 5% level of probability as determined by Duncan's multiple range test.

parallel to the leaf veins and were completely enclosed within the plant tissues (Fig. 2). Egg deposition was highest during the 2 weeks following the preoviposition period, after which it gradually declined. However, most females deposited eggs until within a few days of death.

On tall fescue, females averaged 183.7 eggs during their lifetime with 1 female laying 354 eggs in 84 days for an average of 5.9 eggs/day. Average daily egg production for all females on tall fescue was 4.1 eggs/day. Male and female longevity did not differ significantly and was extremely variable with a mean of 56 days.

On Kentucky bluegrass, females averaged 56.8 eggs during their lifetime with an average daily egg production of 1.9 eggs/day. Adult longevity averaged 39 days and did not differ significantly between males and females.

On smooth brome, females averaged 47.5 eggs during their lifetime with an average daily egg production of 1.3 eggs/day. On this host, all but a single egg were deposited in the sheath. Male longevity did not differ significantly from female longevity, averaging 40 days for the sexes combined.

INFLUENCE OF HOST PLANT ON DEVELOPMENT AND REPRODUCTION: Data obtained on the development and fecundity of *F. loca* on the 3 host plants were compared using Duncan's multiple range test ($P = 0.05$) (Table 3). The average number of days required for nymphal development did not differ significantly among any of the hosts. However, nymphal survival was significantly higher on tall fescue than on the other 2 hosts. Survival was lowest on smooth brome, but did not differ significantly from that observed on Kentucky bluegrass. Adult longevity showed no significant differences between hosts; however, Quisenberry et al. (1983) did show percent adult survival after a 10-day period to be significantly higher on tall fescue than on smooth brome. Adult survival on Kentucky bluegrass was shown to be intermediate, not differing significantly from that observed on either tall fescue or smooth brome.

The fecundity of female *F. loca* appeared to be greatly affected by the host upon which it was reared. Significantly more eggs were deposited by females on tall fescue than on Kentucky bluegrass or smooth brome. Mean daily egg production was also significantly higher for females on tall fescue than for those on the other 2 hosts. Both total egg production and mean daily egg production were higher for

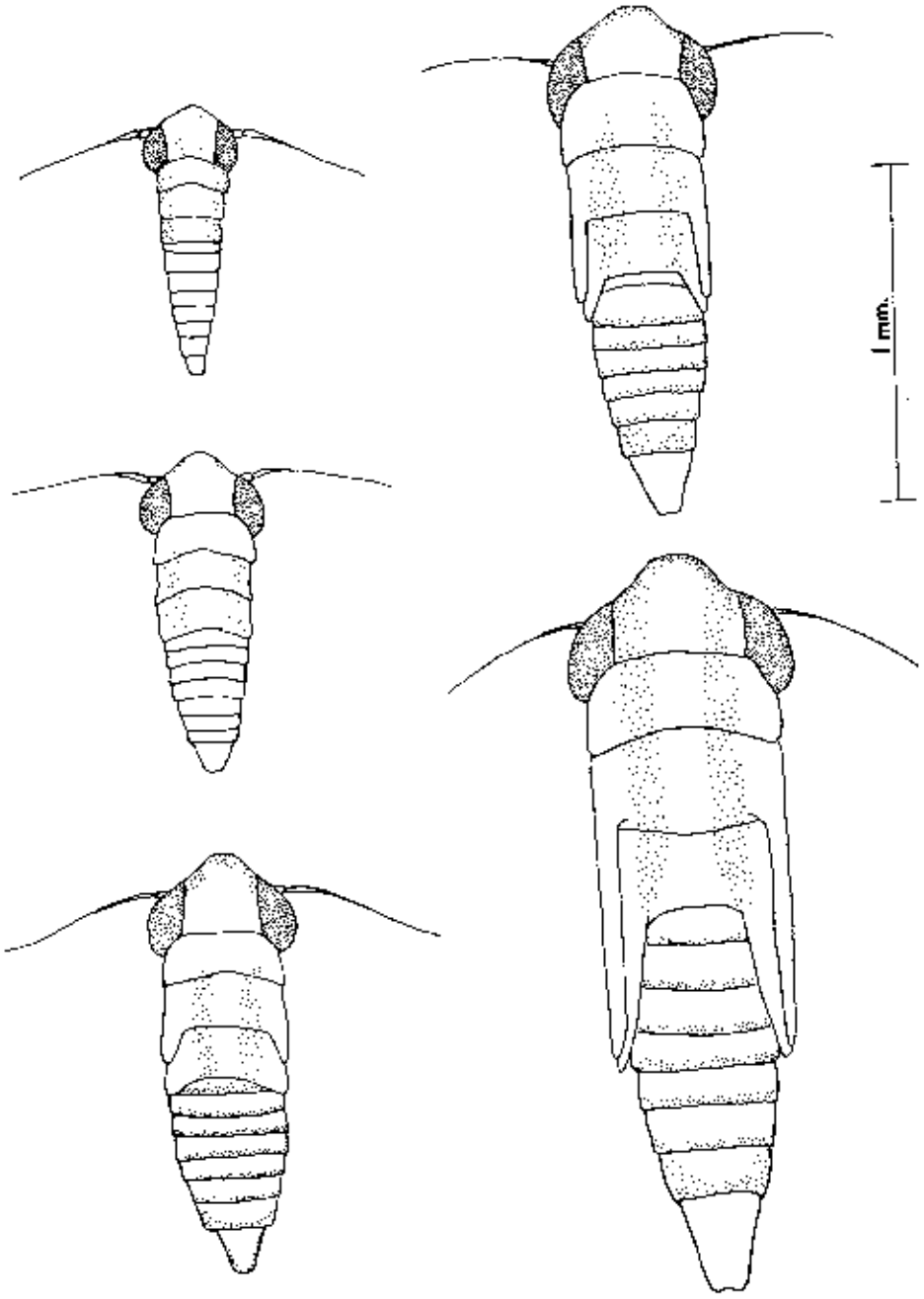

Fig. 3. *F. loca* nymphal instars. A, 1st instar; B, 2nd instar; C, 3rd instar; D, 4th instar; E, 5th instar.

Table 4. Measurements (mm) of immature stages of *F. loca*.

Stage	Length		Width	
	Mean	Range	Mean	Range
Egg	0.79	0.71–0.84	0.17	0.13–0.21
Instar 1	0.82	0.69–0.97	0.24	0.23–0.27
2	0.93	0.89–0.98	0.31	0.28–0.32
3	1.27	1.20–1.33	0.40	0.38–0.43
4	1.59	1.41–1.78	0.52	0.47–0.56
5	2.17	1.88–2.52	0.65	0.60–0.69

females on Kentucky bluegrass than for those on smooth brome, but the differences were not significant.

Based on comparisons of the development, survival, and fecundity of *F. loca* on 3 different hosts, it appears that the host upon which the leafhopper breeds and develops does significantly affect its survival rate and reproductive capacity. These findings correspond with those reported for *Endria inimica* (Say) (Coupe and Schulz, 1968) and *Empoasca fabae* (Harris) (Poos and Smith, 1931). Of the plants tested tall fescue was the most suitable host for *F. loca*. Percent nymphal survival, total egg production, and average daily egg production were all significantly higher on this plant than on Kentucky bluegrass or smooth brome. Although survival and fecundity on Kentucky bluegrass were not significantly different than on smooth brome, they were consistently better. In addition, *F. loca* was more easily established in colonies on Kentucky bluegrass than on smooth brome. Kentucky bluegrass thus appears to be a more suitable host for *F. loca* than smooth brome, which was only marginally acceptable.

IMMATURE STAGES: The nymphs of *F. loca* (Fig. 3) are pale to yellowish with few color patterns. Two dorsal, longitudinal stripes become evident on the head and thorax of later instars. All instars are virtually devoid of setae. The lack of, or degree of wing pad development may be used to distinguish the instars. Measurements taken from 10 randomly selected individuals of each instar (Table 4) showed no overlap between instars for head capsule width; however, length overlaps greatly between instars. The greatest increase in size occurs between the 4th and 5th instars, the smallest between the 1st and 2nd.

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Literature Cited

Bierne, B. P. 1956. Leafhoppers (Homoptera: Cicadellidae) of Canada and Alaska. Can. Entomol. 88(2):1–180.

Coupe, T. R., and J. T. Schulz. 1968. The influence of controlled environments and grass hosts on the life cycle of *Endria inimica* (Homoptera: Cicadellidae). Ann. Entomol. Soc. Amer. 61:74–77.

DeLong, D. M., and J. S. Caldwell. 1936. A new genus—*Forcipata*—and nine new species of typhlocybine leafhoppers closely allied to *Dikraneura* (Cicadellidae: Homoptera). Ann. Entomol. Soc. Amer. 29:70–77.

Hoffman, J. R., and O. Taboado. 1960. A three year inventory of the leafhoppers of the East Lansing area (1954–1956). Mich. Agric. Exp. Sta. Quart. Bull. 42:607–614.

Kerr, T. W. 1957. Leafhoppers associated with forage crops in Rhode Island. J. Econ. Entomol. 50: 271–273.

Mason, C. E., and T. R. Yonke. 1971. Life history of four *Draeculacephala* species and *Paraulacizes irrorata* (Homoptera: Cicadellidae). Ann. Entomol. Soc. Amer. 64:1393–1399.

McKenzie, L. M., and B. P. Bierne. 1972. A grape leafhopper, *Erythroneura zaczae* (Homoptera: Cicadellidae), and its mymarid (Hymenoptera) egg-parasite in the Okanagan Valley, British Columbia. Can. Entomol. 104:1229–1233.

Medler, J. T. 1943. The Leafhoppers of Minnesota. Homoptera: Cicadellidae. Minn. Agric. Exp. Sta. Tech. Bull. 155. 196 pp.

Moore, G. A. 1944. A list of Hemiptera taken at Hudson Heights, Quebec. Can. Entomol. 76:40–44.

Pollard, H. N. 1962. Sex determination of fifth-instar nymphs of leafhoppers (Cicadellidae, Proconiini). Ann. Entomol. Soc. Amer. 55:141.

Poos, F. W., and F. F. Smith. 1931. A comparison of oviposition and nymphal development of *Empoasca fabae* (Harris) on different host plants. J. Econ. Entomol. 24:361–371.

Quisenberry, S., T. C. MacRae, and T. R. Yonke. 1983. Preference of *Forcipata loca* (Homoptera: Cicadellidae) adults to forage plants. Environ. Entomol. 12:1149–1153.

Quisenberry, S., and T. R. Yonke. 1981a. Responses of 'Kentucky-31' tall fescue to varying *Forcipita loca* DeLong & Caldwell infestation levels; growth chamber study (Homoptera, Cicadellidae, Typhlocybinae). Environ. Entomol. 10:550–553.

———, and ———. 1981b. Responses of 'Kentucky-31' tall fescue to varying *Forcipita loca* DeLong & Caldwell infestation levels; field study (Homoptera: Cicadellidae, Typhlocybinae). Environ. Entomol. 10:650–653.

———, ———, and ———. 1981c. Effects of *Forcipita loca* feeding on tissue of 'Kentucky-31' tall fescue. Ann. Entomol. Soc. Amer. 74:521–524.

Quisenberry, S. S., T. R. Yonke, and J. L. Huggans. 1979. Leafhoppers associated with mixed tall fescue pastures in Missouri (Homoptera: Cicadellidae). J. Kansas Entomol. Soc. 52:421–437.

Simonet, D. E., and R. L. Pienkowski. 1977. Sampling and distribution of potato leafhopper eggs in alfalfa stems. Ann. Entomol. Soc. Amer. 70:933–936.

Varty, I. W. 1967. Leafhoppers of the subfamily Typhlocybinae from birches. Can. Entomol. 99: 170–180.

Young, D. A., Jr. 1950. A preliminary list of Kentucky Cicadellidae (Homoptera). Ky. Acad. Sci. Trans. 13:2–15, 54–67.