Technical Report No. 124

LEAFHOPPER STUDIES AT THE OSAGE SITE (HOMOPTERA: CICADELLIDAE)

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U.S. International Biological Program

October 1971

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ABSTRACT

At least 38 species of leafhoppers have been identified from the Osage Comprehensive Network Site. Evidence, obtained through comparative collecting methods and "escape tests," is presented to show that collecting methods need alteration. Information is presented on biomass and numbers of leafhoppers; an annotated list of species is included and recommendations for future research are given. Additional information on parasitism and other general ecological information is included.

INTRODUCTION

Leafhoppers have been collected periodically from the IBP Osage Comprehensive Site since September 1969 (Table 1). Preliminary results are presented at this time because they contain evidence that trapping techniques should be changed. Blocker, Harvey, and Launchbaugh (1971) have indicated that at least a five year study is required before any indication of the population trends of grassland leafhoppers can be determined; therefore, the included data are only a progress report.

The research site is located in Osage County, Oklahoma, which is in the northeastern section of the state just south of the border of Chautauqua County, Kansas. Site description and the 1970 report on vegetative analysis are found in IBP Technical Reports 44 (Risser 1970) and 80 (Risser 1971), respectively. Invertebrate collecting procedure is described in IBP Technical Reports 35 (French 1970), 85 (French 1971), and 93 (Blocker and Reed 1971).

METHODS

One-hundred sweeps were taken at random in each treatment during each collecting period (Table 1) with a 15 inch diameter standard insect sweep net. No attempt has been made to calibrate this method of collecting so that it could be compared to the trapping method; this would involve greatly refined methodology and time was not available. A comparison of species caught by sweeping and trapping is shown in Table 2. Turnbull and Nichols (1966) compared several methods of collecting and present evidence that the quick trap is as much as 10 times more efficient than the sweep net for collecting Homoptera (including leafhoppers); their data were presented as numbers per square meter.

Table 1. Dates and methods of collection for leafhoppers at Osage Comprehensive Site.

Date	Collecting Method
20 Sept. 1969	Swp; Ung
17 Oct. 1969	Swp; Ung
3 June 1970	Swp; G, Ung
18 June 1970	Swp; G, Ung
2-3 July 1970	Swp, Tr; G, Ung
15-16 July 1970	Swp, Tr; G, Ung
2-3 Aug. 1970	Swp, Tr; G, Ung
16-17 Aug. 1970	Swp, Tr; G, Ung
26-27 Sept. 1970	Swp, Tr; G, Ung
24-25 Oct. 1970	Swp, Tr; G, Ung
23 Nov. 1970*	Tr; G, Ung
24 Apr. 1971	Swp, Tr; G, Ung
13 May 1971	Swp, Tr; G, Ung
3 June 1971	Swp, Tr; G, Ung
19 June 1971	Swp, Tr; G, Ung

* During freezing weather.
Swp = sweeping.
Tr = trapping.
G = grazed.
Ung = ungrazed.

Table 2. Species of leafhoppers collected by sweeping and trapping at the Osage Comprehensive Site.

Taxon	Sweeping	Trapping
Subfamily Ledrinae		
Xerophloea majesta Lawson	G	G
Subfamily Hecalinae		
Parabolocratus curtus Shaw	Ung	Ung
Parabolocratus grandis Shaw	G, Ung	G, Ung
Subfamily Agallinae		
Aceratagallia uhleri (Van Duzee)	G, Ung	Ung
Aceratagallia sp.		Ung
Subfamily Iassinae		
Prairiana sp.	Ung	G, Ung
Gyponana angula DeLong	G, Ung	
Subfamily Cicadellinae		
Draeculacephala mollipes (Say)	G, Ung	
Subfamily Typhlocybinae		
Empoasca sp.	Ung	
Erythroneura sp.	Ung	
Subfamily Deltocephalinae		
Amplicephalus kansiensis (Tuthill)		G, Ung
Athysanella emarginata (Osborn)	G	?
Athysanella texana (Osborn)	G	G
Balclutha incisa (Matsumura)	Ung	
Balclutha neglecta (DeLong and Davidson)	G, Ung	
Chlorotettix spatulatus Osborn and Ball	G, Ung	Ung
Chlorotettix viridius Van Duzee	G	
Commellus comma (Van Duzee)	G	
Endria inimica (Say)	G, Ung	G, Ung
Exitianus exitiosus (Uhler)	G, Ung	G, Ung
Extrusanus ovatus (Sanders and DeLong)	G, Ung	G, Ung
Flexamia atlantica (DeLong)	G	
Flexamia graminea (DeLong)	G, Ung	Ung
Flexamia inflata (Osborn and Ball)	G, Ung	
Flexamia picta (Osborn)	G, Ung	G
Flexamia prairiana DeLong	G, Ung	G, Ung
Flexamia reflexa (Osborn and Ball)	Ung	
Gillettiella atropunctata (Gillette)	G	
Graminella mohri DeLong	G, Ung	Ung
Laevicephalus unicoloratus (Gillette and Baker)	G, Ung	
Macrosteles fascifrons (Stal)	G, Ung	
Paraphlepsius lobatus (Osborn)	Ung	G, Ung
Paraphlepsius solidaginis (Walker)		G
Polyamia caperata (Ball)	Ung	G, Ung
Polyamia sp.	G, Ung	Ung
Scaphytopius sp.	Ung	
Stirellus bicolor (Van Duzee) + other spp.?	G, Ung	Ung

G = grazed.
Ung = ungrazed.

RESULTS: ANNOTATED LIST OF LEAFHOPPER SPECIES

At least 38 species (e.g., *Empoasca* and others were identified only to genus) representing 26 genera and 8 subfamilies were identified (Table 2). This number will undoubtedly increase as additional collections are made.

Subfamily Ledrinae

Xerophloea majesta Lawson. Uncommonly collected by sweeping and trapping in grazed pasture in July and October 1970.

According to Nielson (1962), these leafhoppers feed primarily on grasses and undoubtedly cause much damage when abundant.

Subfamily Hecalinae

Parabolocratus curtus Shaw. Two males sweeping ungrazed pasture in September 1969; both parasitized by Strepsiptera (Insecta). One male trapped in ungrazed pasture in May 1971.

Parabolocratus grandis Shaw. Collected in low numbers by sweeping and trapping in grazed and ungrazed pastures; seasonal range: May through August.

Notes: Females and nymphs of *Parabolocratus* were collected in low numbers by sweeping and trapping (primarily in ungrazed pasture) from May to September; one nymph contained a dryinid parasite (Insecta: Hymenoptera). Beirne (1956) lists hosts as grasses.

Subfamily Agallinae

Aceratagallia uhleri (Van Duzee). Collected in low numbers by sweeping and trapping in grazed and ungrazed pastures; seasonal range: May to November.

Aceratagallia sp. Uncommon; collected in November 1970 by trapping in grazed pasture.

Notes: Heavy populations of *Aceratagallia* spp. are common in cropland and grassland areas. Oman (1933) reports heavy populations of *A. uhleri* on sugar beets.

Subfamily Iassinae

Gyponana angula DeLong. Collected in low numbers by sweeping grazed and ungrazed pastures; seasonal range: June to September.

Prairiana sp. Collected in low numbers by sweeping ungrazed pasture and by trapping grazed and ungrazed pastures; nymphs were commonly collected; seasonal range: May to August.

Subfamily Xestocephalinae

Xestocephalus pulicarius Van Duzee. Collected in low numbers by trapping grazed and ungrazed pastures; nymphs in moderate numbers were trapped in June 1971; seasonal range: June to September.

Notes: Beirne (1956) states that this species occurs mainly on the ground among roots of herbaceous plants and in litter; Oman (1949) feels that the nymphal stage may be passed in ground litter or in some subterranean habitat. This is consistent with our findings and is probably the reason that none were taken by sweeping.

Subfamily Cicadellinae

Draeculacephala mollipes (Say). Uncommonly collected by sweeping grazed and ungrazed pastures; seasonal range: June to September.

Subfamily Typhlocybinae

Empoasca sp. Uncommonly collected by sweeping ungrazed pasture in October 1969.

Erythroneura sp. Two specimens collected by sweeping ungrazed pasture in September and October 1969.

Subfamily Deltocephalinae

Amplicephalus kansiensis (Tuthill). Collected in low numbers in July and August 1970 by trapping grazed and ungrazed pastures; as many as $2/m^2$ were trapped in an ungrazed pasture in July. Specimens were not found when sweeping; this suggests a habitat at ground level or within the litter layer.

Athysanella emarginata (Osborn). Uncommonly collected by sweeping and trapping in grazed pasture; one male with a strepsipteran parasite (Insecta: Strepsiptera).

Athysanella texana (Osborn). Uncommonly collected by sweeping and trapping in a grazed pasture. This genus is found in much higher numbers farther west in shortgrass prairie.

Balclutha incisa (Matsumura). One specimen collected by sweeping ungrazed pasture in October 1970.

Balclutha neglecta (DeLong and Davidson). Commonly collected in low numbers by sweeping grazed and ungrazed pastures; seasonal range: May to October. This is one of the most common species of leafhopper found in grassland habitats; it was not taken while trapping (see discussion).

Chlorotettix spatulatus Osborn and Ball. Collected in low numbers by sweeping and trapping grazed and ungrazed pastures; seasonal range: June to September.

Chlorotettix viridius Van Duzee. One specimen collected by sweeping grazed pasture in July 1970.

Comellus comma (Van Duzee). Two specimens collected by sweeping grazed pasture in June 1970 and 1971. *Elymus canadensis* is reported host; DeLong (1948) reports this species in the same association with the leafhopper *Dorycephalus platyrhynchus* but the latter has not been collected at Osage.

Endria inimica (Say). Commonly collected in low numbers by sweeping and trapping grazed and ungrazed pastures; seasonal range: May to October. This is a widespread species; Wilbur (1954) found that it preferred introduced grasses (e.g., bluegrass) to native grasses (e.g., bluestem) in Kansas. This species (like *Balclutha*, *Exitianus*, *Macrosteles*, etc.) can apparently survive on a variety of hosts.

Exitianus exitiosus (Uhler). Commonly collected in low numbers by sweeping and trapping in grazed and ungrazed pastures; seasonal range: June to October. This is a widespread species; reported hosts are grasses as well as many cultivated plants.

Extrusanus ovatus (Sanders and DeLong). Found in low numbers by sweeping and trapping in grazed and ungrazed pasture; range: April to June; as many as 6 nymphs/m^2 and 4 adults/m^2 were trapped in April 1971. This species is larger than most and could be of economic importance in the early spring.

Flexamia atlantica (DeLong). Collected in low numbers by sweeping grazed pasture in June 1971.

Flexamia graminea (DeLong). Collected in low numbers by sweeping grazed and ungrazed pastures and by trapping in ungrazed pastures; seasonal range: May to October.

Flexamia inflata (Osborn and Ball). Collected by sweeping grazed and ungrazed pastures in July 1970.

Flexamia picta (Osborn). Collected in low numbers by sweeping grazed and ungrazed pastures and by trapping grazed pastures; seasonal range: June, July, and October. This species has been collected on *Aristida gracilis* in Tennessee.

Flexamia prairiana DeLong. Commonly collected in low numbers by sweeping and trapping grazed and ungrazed pastures; seasonal range: May to October.

Flexamia reflexa (Osborn and Ball). Collected in low numbers by sweeping ungrazed pasture; seasonal range: June to October.

Notes: The genus *Flexamia* appears to be a dominant group at Osage; moderate numbers of nymphs were collected by trapping in June and July; as many as 3.5 females/m^2 were trapped in June. Ross (1970) states that this is the only Deltocephalini with a tallgrass prairie faunule as numerous and diverse as that of the deciduous forest seral stages.

Gillettiella atropunctata (Gillette). Collected by sweeping grazed area in June 1970; this species is found in much higher numbers in shortgrass areas northwest of Osage.

Graminella mohri DeLong. Collected by sweeping grazed and ungrazed pastures and by trapping ungrazed pastures; seasonal range: June, July, and September.

Laevicephalus unicoloratus (Gillette and Baker). Collected in low numbers by sweeping grazed and ungrazed pastures; seasonal range: May to October; DeLong (1948) reports this species from *Andropogon*.

Macrosteles fascifrons (Stal). Collected in low numbers (moderate in ungrazed pasture in October 1969) by sweeping grazed and ungrazed pastures in April through June, and in October; Beirne (1956) reports that nymphs feed on grasses and cereals in the spring and may cause appreciable economic damage; adults migrate to herbaceous plants late in the spring where two or more overlapping generations develop during the summer. They migrate back to grasses and cereals in the fall. This is consistent with the collection dates at Osage. Neilson (1968) reviews the biology of this species and states that it is the most important vector of aster yellows virus in North America.

Paraphlepsius lobatus (Osborn). Collected in low numbers by sweeping ungrazed and trapping grazed and ungrazed pastures; seasonal range: June to October; as many as 4 specimens/m^2 (including nymphs) in July 1970. Crowder (1952) suggests herbaceous dicots as hosts.

Paraphlepsius soldaginis (Walker). One specimen collected by trapping grazed pasture in July 1970.

Polyamia caperata (Ball). Collected in low numbers by sweeping ungrazed and trapping grazed and ungrazed pastures; seasonal range: June to September; as many as 2.5 specimens/m^2 collected in grazed pasture in June 1971; two of these specimens contained dryinid parasites (Insecta: Hymenoptera).

Polyamia sp. Collected by sweeping grazed and ungrazed and trapping ungrazed pastures in June and October.

Scaphytopius sp. Collected by sweeping ungrazed pastures in June and September; only females collected.

Stirellus bicolor (Van Duzee) + other spp.? Collected in low numbers by sweeping grazed and ungrazed and by trapping ungrazed pastures; seasonal range: June to October; two specimens with dryinid parasites (Insecta: Hymenoptera) found in October 1969. Ross (1970) reports *Andropogon* as a host and states that *S. bicolor* occurs in forest communities but is absent in the prairies. Osage, therefore, probably represents one of the westernmost prairie habitats for this species.

DISCUSSION

Results (Table 2) show that two commonly trapped species were not collected by the sweeping method (*Xestocephalus* and *Amplicephalus*). The habitat of *Xestocephalus* is near the base of its host or within the litter layer; this probably accounts for its absence. The habitat of *Amplicephalus* is unknown. Beamer (1946) discusses the advantages of mowing an area before attempting to collect certain species of Homoptera; this suggests that a number of insects occupy habitats similar to *Xestocephalus* and might be missed when a sweep net is used.

Results also show the absence of several common species in the traps (e.g., *Balclutha*, *Laevicephalus*, *Macrosteles*, and *Scaphytopius*). The small size of these species suggested the possibility of escape from the traps prior to suctioning, so we attempted to check this by a series of "escape tests." We fitted the tops of four one-pint mason jars with a 16-mesh screen such as that used on our quick traps at Osage; we fitted four more with a 32-mesh screen which we are using on a trap in another project. We then took 100 sweeps in a pasture and placed their contents in each of the jars. The pint jars were then placed in gallon containers; the latter were covered with "handi-wrap" so that we could recover the specimens which escaped through the mesh from the smaller jars into the larger containers.

Almost immediately, insects began to penetrate the 16-mesh screen. We visually identified specimens of *Balclutha*, *Scaphytopius*, and *Macrosteles* (although no specimens of *Balclutha* were subsequently recovered).

The jars were left undisturbed overnight and were placed in the freezer the following morning to kill all specimens. The insects which escaped were recovered and observed.

No leafhoppers penetrated the 32-mesh screen; a few specimens (at least eight families) of small Hymenoptera, immature Hemiptera, Diptera, and Thysanoptera did escape, however (Table 3).

At least nine genera of leafhoppers escaped through the 16-mesh screen; additional specimens of all of these, however, were separated from the specimens that did not escape (Table 4). In addition, many specimens (at least 23 families) of other invertebrates escaped (Table 3).

It is not possible to compare the results of these hastily conducted "escape tests" with the trapping method at Osage. For example, many of the insects collected by sweeping for the "escape tests" could have sustained more injury than those which were trapped at Osage; this could reduce the number which were physically capable of escape. Conversely, trapped insects have a greater distance to move due to the larger size of the cage before they can escape than those in the jars. It is apparent, however, that leafhoppers and other invertebrates can (and, in fact, do) escape through 16-mesh screen; perhaps as many as 5% (by number). It is therefore strongly recommended that the nets on IBP traps be constructed of 32-mesh (or finer) screen by the beginning of the 1972 field season. A material that should be considered is Lumite Saran fabric, produced by the Chicopee Manufacturing Company, Chicopee, Georgia; it is used at Kansas State University in a

Table 3. Invertebrates other than leafhoppers which escaped through 16- and 32-mesh screening in "escape tests."

16-Mesh	32-Mesh
Acarina	Acarina
Araneida	Cecidomyidae
Braconidae (Hymenoptera)	Eulopidae
Cecidomyidae (Diptera)	Formicidae
Chloropidae (Diptera)	Lygaeidae (immature)
Chrysomelidae (Coleoptera)	Pteromalidae
Cleridae (Coleoptera)	Thysanidae
Curculionidae (Coleoptera)	Thysanoptera
Eulopidae (Hymenoptera)	
Formicidae (Hymenoptera)	
Ichneumonidae (Hymenoptera)	
Lathrididae (Coleoptera)	
Lygaeidae (Hemiptera)	
Otitidae (Diptera)	
Phalacridae (Coleoptera)	
Pteromalidae (Hymenoptera)	
Sciaridae (Diptera)	
Sminthuridae (Collembola)	
Thysanidae (Hymenoptera)	
Thysanoptera	
2+ undetermined Diptera	
4+ undetermined Hymenoptera	

Table 4. Leafhopper genera determined in "escape tests."

Retained: 32-Mesh	Retained: 16-Mesh	Escaped: 16-Mesh
Aceratagallia	*Aceratagallia*	*Aceratagallia*
Athysanella	*Athysanella*	*Athysanella*
Balclutha	*Balclutha*	??
Chlorotettix	*Chlorotettix*	
Draeculacephala	*Draeculacephala*	
Empoasca	*Empoasca*	*Empoasca*
Endria	*Endria*	
Exitianus	*Exitianus*	*Exitianus*
Flexamia	*Flexamia*	*Flexamia*
Graminella	*Graminella*	*Graminella*
Laevicephalus		
Macrosteles	*Macrosteles*	*Macrosteles*
Mesamia	*Mesamia*	
Parabolocratus	*Parabolocratus*	
Paraphlepsius	*Paraphlepsius*	
Scaphytopius	*Scaphytopius*	*Scaphytopius*
Stirellus	*Stirellus*	
Typhlocybinae		Typhlocybinae
Xerophloea	*Xerophloea*	

similar type of trap. It is further recommended that all tears and open areas in the traps be mended prior to each collection date and that more than one collecting method (e.g., sweeping vs. trapping) be attempted at each site so that comparative results can be obtained.

Parasitism

Leafhoppers are commonly parasitized by three groups: Dryinidae, Pipunculidae, and Strepsiptera. The incidence of parasitism at Osage was very low. Dryinidae were found in *Polyamia* (two specimens), *Stirellus* (two specimens), and *Parabolocratus* (one specimen). Strepsiptera were found in *Parabolocratus* (two specimens) and *Athysanella* (one specimen). No parasitism by Pipunculidae was observed.

Virus Vectors

Nine genera of leafhoppers known as virus vectors have been determined from Osage, but only *Endria inimica* and *Macrosteles fascifrons* are listed by Nielson (1968) as definite vectors. The incidence of virus diseases in rangeland is not well documented. Rangeland, however, can serve as a reservoir for populations of virus vectors which periodically move into cropland.

Biomass vs. Numbers

Biomass varies greatly depending upon the taxon and sex. Table 5 shows average weights for several genera but does not include many of the larger ones such as *Xerophloea*, *Parabolocratus*, *Prairiana*, *Gyponana*, *Paraphlepsius*, and *Draeculacephala*, which were found in low numbers at Osage. Also, weights of many early-instar nymphs are very low and are not included in Table 5. It can be seen in Table 6 that high numbers and high biomass are not always

Table 5. Average individual weights of some leafhopper genera commonly collected at the Osage Comprehensive Site.

Genus	Sex	No. Weighed	Avg. Dry Weight (mg)
Endria	Male	34	.49
	Female	23	.58
Exitianus	Male	10	.54
	Female	18	.91
Extrusanus	Male	6	.65
	Female	17	1.82
Flexamia	Male*	150	.51
	Female	26	.64
Balclutha	Male*	269	.23
	Female*	288	.26
Aceratagallia	Male*	7	.35
	Female*	33	.52

* Specimens obtained from area other than Osage.

Table 6. Numbers and dry weight biomass of leafhoppers collected using quick traps.

Collection Date	Mean Number/m^2		Biomass (mg/m^2)	
	Grazed	Ungrazed	Grazed	Ungrazed
3 July 1970	35.2	29.6	7.52	5.02
16 July 1970	23.2	11.6	3.40	5.96
3 August 1970	3.0	5.4	1.54	1.98
17 August 1970	0.6	1.0	0.41	0.50
27 September 1970	2.4	1.0	0.80	0.48
25 October 1970	10.4	3.0	0.49	0.23
23 November 1970	2.0	1.0	0.46	0.14
24 April 1971	13.0	6.4	5.24	4.48
13 May 1971	16.2	11.8	5.26	4.74
3 June 1971	10.4	33.0	1.26	1.82
19 June 1971	98.2	21.6	9.84	13.62

related. These data are also shown in Fig. 1 and 2. The distinction of numbers and biomass is also shown in Fig. 3 by some of the extreme points.

The wide range of variation in weights suggests that biomass, as well as total numbers, needs to be considered when attempting to analyze the impact of leafhoppers on grasslands. Early and late season populations tend to be dominated by females (DeLong 1971) so sex should also be considered. Weights of leafhoppers were obtained after oven-drying for 24 hours at 60°C.

Blocker et al. (in press) state that several (at least five) seasons' data should be analyzed before attempts to predict leafhopper population trends are made. They also found that the dominant species were present every year in shortgrass pastures located in Hays, Kansas. Population numbers of the dominant species, however, varied greatly from year to year. Using this information as a guide, a visual examination of the Osage data suggests the following genera as dominant: *Balclutha*, *Polyamia*, and *Xestocephalus* primarily as numbers; *Parabolocratus*, *Paraphlepsius*, and *Prairiana* primarily as biomass; and *Aceratagallia*, *Amplicephalus*, *Endria*, *Exitianus*, *Extrusanus*, *Flexamia*, and *Macrosteles* as either numbers or biomass. Further data will undoubtedly alter the above list.

It should also be stated that all specimens could not be determined to species. Some early-instar nymphs could not be identified to genus; some females could not be identified to species; and some specimens with missing abdomens or which sustained damage during the collecting, separating, and weighing processes could not be placed in the proper sex. For these reasons, a certain amount of discrepancy exists between the taxa identified to species (Table 2) and the total numbers and biomass presented in Table 6.

Fig. 3 shows the results of regression analyses for leafhopper numbers and biomass in the grazed and ungrazed treatments. The slopes were found

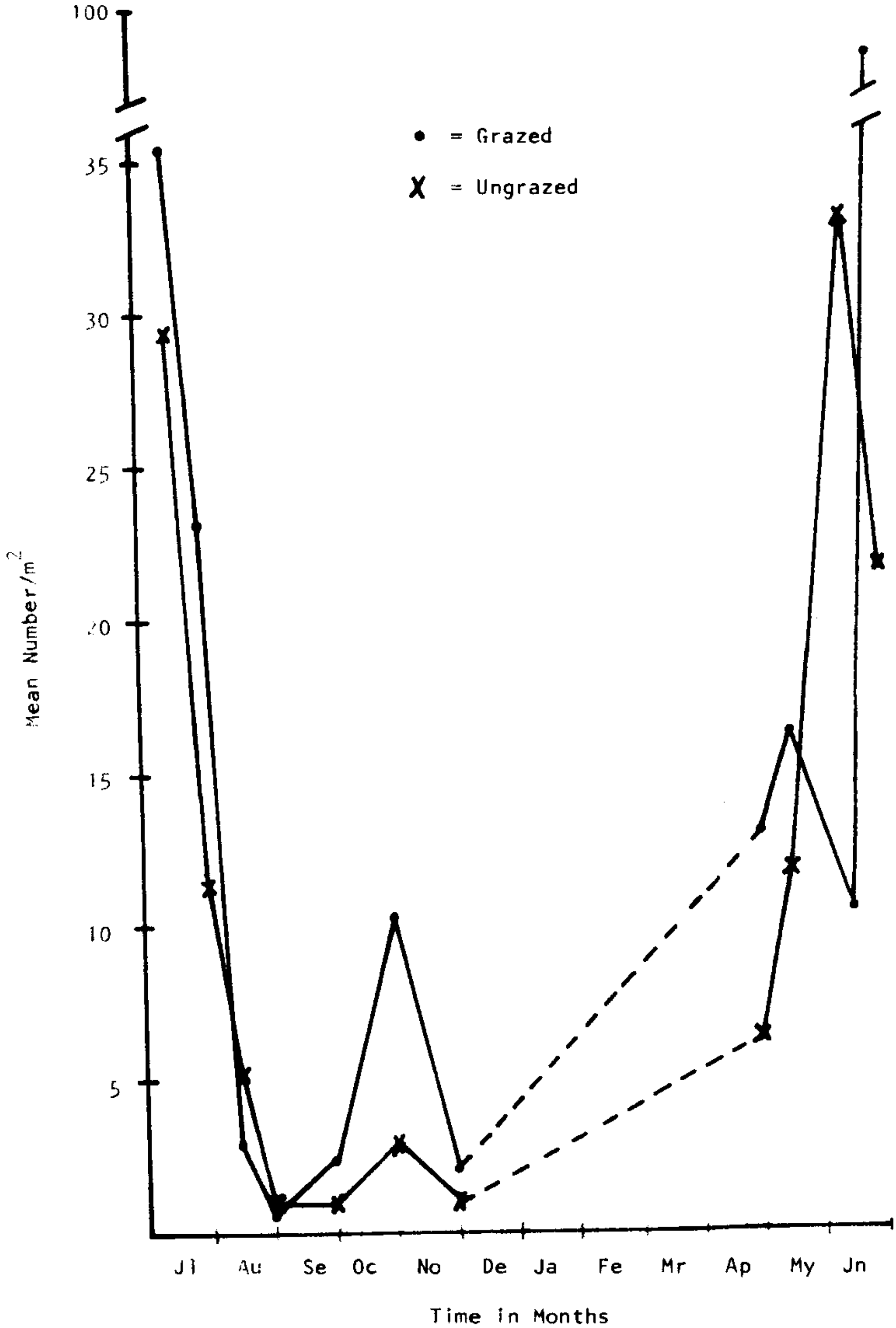

Fig. 1. Number of leafhoppers in grazed and ungrazed treatments at Osage.

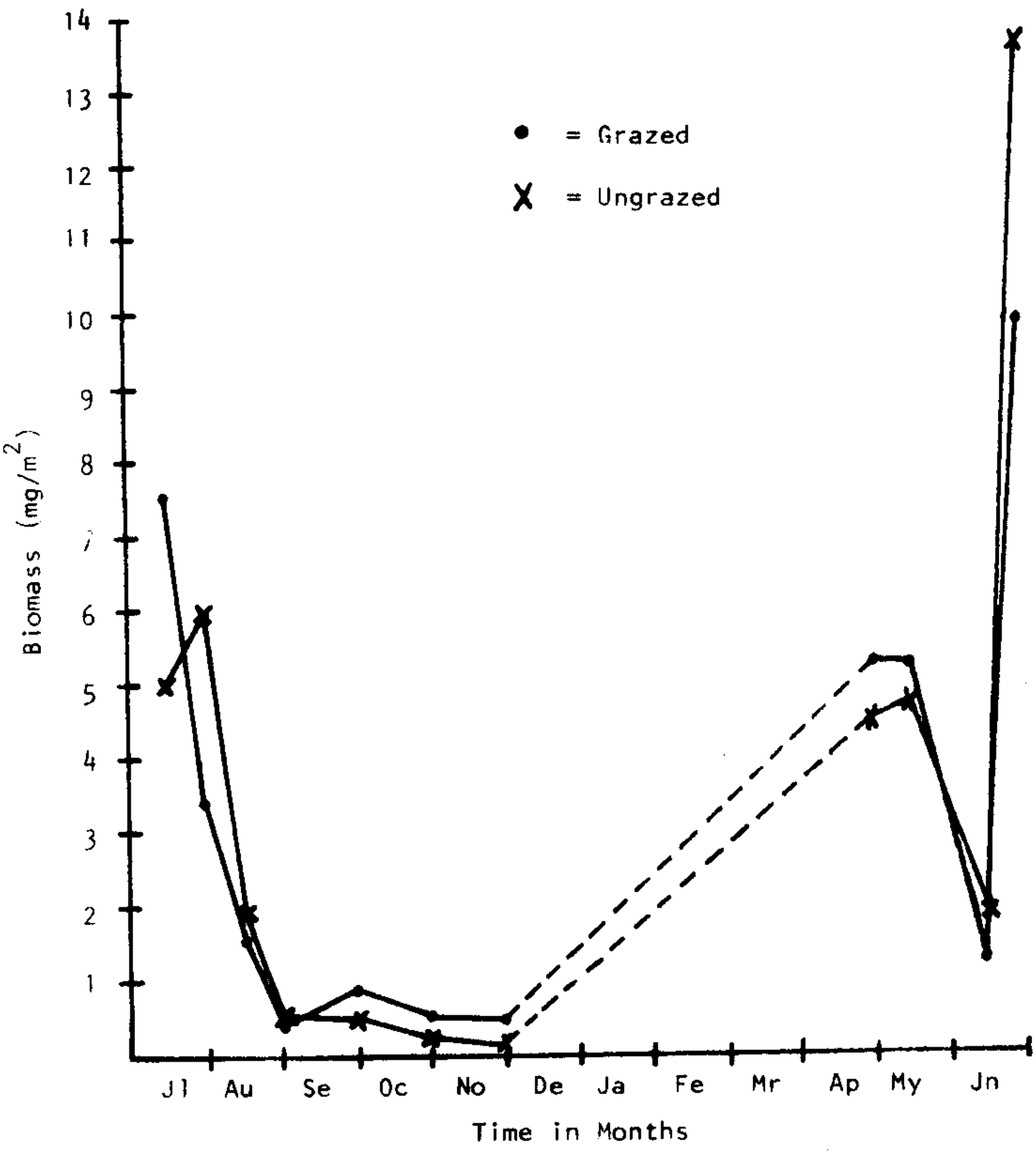

Fig. 2. Biomass (dry weight) of leafhoppers in grazed and ungrazed treatments at Osage.

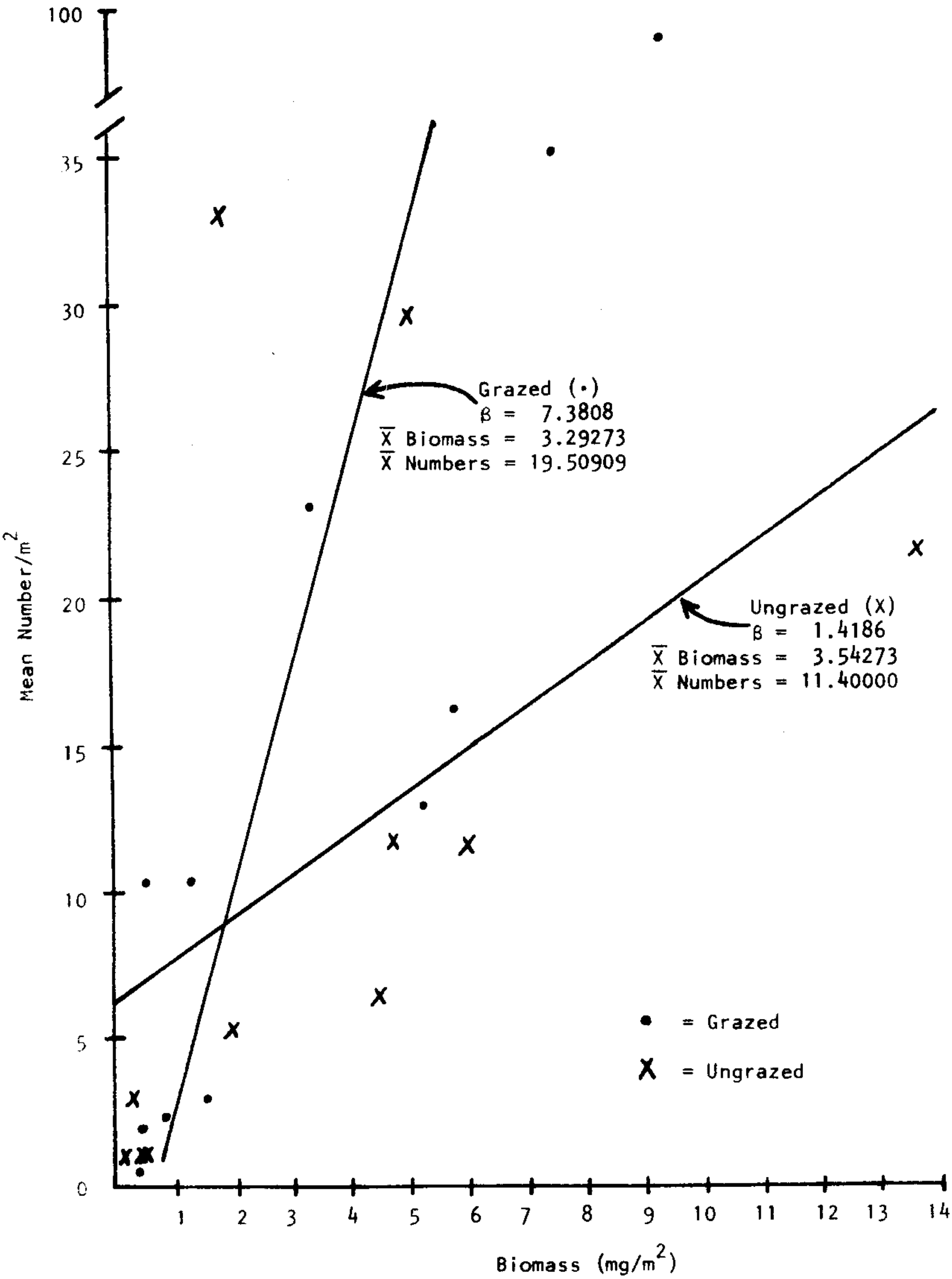

Fig. 3. Scatter diagram of leafhopper numbers and dry weight biomass at Osage.

to be significantly different (P = .005) for the two treatments. This suggests that the average weight of individual leafhoppers in grazed areas is less than in the ungrazed areas. This may be caused, at Osage, by the presence of large-sized species in the ungrazed areas that are absent or are found in low numbers in the grazed areas.

The regression slope (Fig. 3) was significantly greater than zero (P = .001) in the grazed treatment, but not significant (P = .131) for the ungrazed treatment, indicating that an index of leafhopper numbers is not always a good predictor of leafhopper biomass. The correlation coefficients for numbers and biomass were .8550 for the grazed and .4846 for the ungrazed treatments.

The above results are inconclusive since the ratio of adults to nymphs has not been considered, analyses of species data is needed, etc. It is an indication, however, that more detailed studies of a similar nature should be conducted on leafhoppers as well as other major groups of invertebrates. For example, control recommendations for rangeland insects which have previously been based solely on numbers data might need reexamination.

SUMMARY AND CONCLUSIONS

Preliminary analyses of results of the leafhopper studies at Osage has presented evidence that trapping methods need to be changed. As a result of these and other data on grassland leafhoppers, the following recommendations are made:

i. Refined trapping methods are needed if the total leafhopper fauna in a prairie habitat is to be studied; existing 16-mesh screening used on quick traps should be replaced with at least 32-mesh and other tears or openings should be repaired prior to each collecting date.

ii. More than one collecting method is needed at each site so that results can be compared and some idea of efficiency can be obtained.

iii. Biomass and numbers data are necessary because of the wide variation in weight between species, sexes of the same species, and size of life stages. Preliminary regression analyses for numbers and biomass indicate that they may not be correlated.

iv. Laboratory studies on major groups need to be undertaken so that ideas about the impact of leafhoppers can be formulated.

v. Long-range field collections are necessary in order that population trends can be recognized and predicted.

ACKNOWLEDGMENTS

Identification of leafhoppers and conclusions drawn are the major responsibility of the senior author; assistance in identification, however, was received from the third author and from Dr. James P. Kramer of the United States National Museum. The second author was primarily responsible for the field and laboratory data presented. The third author was primarily responsible for data gained from the "escape tests" and for the regression analyses.

LITERATURE CITED

Beamer, L. 1946. I'll tell you how. J. Kansas Entomol. Soc. 19:127-129.

Beirne, B. P. 1956. Leafhoppers (Homoptera: Cicadellidae) of Canada and Alaska. Can. Entomol. 88 (Suppl. 2). 180 p.

Blocker, H. D., T. L. Harvey, and J. L. Launchbaugh. 1971. Grassland leafhoppers I. Leafhopper populations of upland seeded pastures at Hays, Kansas. Ann. Entomol. Soc. Amer. (In press).

Blocker, H. D. and R. Reed. 1971. 1970 insect studies at Osage Comprehensive Site. U.S. IBP Grassland Biome Tech. Rep. No. 93. Colorado State Univ., Fort Collins. 38 p.

Crowder, H. W. 1952. A revision of some Phlepsiuslike genera of the tribe Deltocephalini (Homoptera, Cicadellidae) in America north of Mexico. Univ. Kansas Sci. Bull. 35:309-541.

DeLong, D. M. 1948. The leafhoppers, or Cicadellidae of Illinois (Eurymelinae-Balcluthinae). Illinois Natur. Hist. Surv. Bull. 24:97-376.

DeLong, D. M. 1971. The bionomics of leafhoppers. Ann. Rev. Entomol. 18:179-210.

French, N. R. 1970. Field data collection procedures for the Comprehensive Network 1970 season (Revised). U.S. IBP Grassland Biome Tech. Rep. No. 35. Colorado State Univ., Fort Collins. 35 p.

French, N. R. [Coordinator]. 1971. Basic field data collection procedures for the Grassland Biome 1971 season. U.S. IBP Grassland Biome Tech. Rep. No. 85. Colorado State Univ., Fort Collins. 87 p.

Nielson, M. W. 1962. A revision of the genus *Xerophloea* (Homoptera, Cicadellidae). Ann. Entomol. Soc. Amer. 55:234-244.

Nielson, M. W. 1968. The leafhopper vectors of phytopathogenic viruses (Homoptera, Cicadellidae) taxonomy, biology and virus transmission. U.S. Dep. Agr. Tech. Bull. 1382. 386 p.

Oman, P. W. 1933. A classification of North American Agallian leafhoppers. U.S. Dep. Agr. Tech. Bull. 372. 93 p.

Oman, P. W. 1949. The Nearctic leafhoppers (Homoptera: Cicadellidae). A generic classification and check list. Washington Entomol. Soc. Mem. 3. 253 p.

Risser, P. G. 1970. Comprehensive Network Site description, OSAGE. U.S. IBP Grassland Biome Tech. Rep. No. 44. Colorado State Univ., Fort Collins. 5 p.

Risser, P. G. 1971. Osage Site, 1970 report, primary production. U.S. IBP Grassland Biome Tech. Rep. No. 80. Colorado State Univ., Fort Collins. 41 p.

Ross, H. H. 1970. The ecological history of the Great Plains: evidence from grassland insects, p. 225-240. *In* W. Dort, Jr. and J. Knox Jones [ed.] Pleistocene and recent environments of the central Great Plains. Univ. Kansas Press, Lawrence.

Turnbull, A. L. and C. F. Nicholls. 1966. A "quick trap" for area sampling of arthropods in grassland communities. J. Econ. Entomol. 59:1100-1104.

Wilbur, D. A. 1954. Host plants of the leafhopper *Endria inimica* (Say) (Homoptera, Cicadellidae). Kansas Acad. Sci., Trans. 57:139-146.