SAMPLING METHODS, FEEDING HABITS, AND SEASONAL COLLECTIONS OF <u>HYPOCHLORA ALBA</u> (DODGE) AND <u>MELANOPLUS BIVITTATUS</u> (SAY), IN PLOTS CONTAINING <u>ARTEMISIA LUDOVICIANA</u> (NUTT.) NEAR MANHATTAN, KANSAS

by

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INTRODUCTION

Hypochlora alba develops and survives only on Artemisia ludoviciana in the Manhattan, Kansas area while none of the other approximately 50 species of grasshoppers, including Melanoplus bivittatus, can develop to maturity on this plant (Bajoi and Knutson 1977; Knutson 1982; Knutson and Campbell 1976; and Mulkern et al. 1969). M. bivittatus feeds on several species of plants in the Manhattan area and commonly occurs with H. alba.

Many aspects of the interactions between this plant and each of the two grasshopper species are currently being studied by or have been recently studied by several investigators in the laboratory. These laboratory studies include gustatory and olfactory response and orientation to the plant, effect of phytochemicals of the plant on growth and development of H. alba, and other grasshoppers such as M. bivittatus which do not feed on A. ludoviciana. Other recent laboratory studies include effects of pubescence (non-glandular trichomes) of A. ludoviciana on ingestion, assimilation and growth of the grasshopper species and exactly how the pubescence is ingested by H. alba; and comparison of leaf particle sizes in fecal pellets of grasshoppers fed on normal leaves and those stripped of pubescence. One leaf is more often used instead of the whole plant, which has been shown in some species to alter nutrition compared to the use of the whole plant. These studies, which, while valid for the specific objectives of each study, are partly or entirely conducted in the laboratory. Some studies involve use of laboratory reared grasshoppers and plants where the growth stages of the plant and that of the grasshoppers are not necessarily the same as in the field. Other studies, which more closely match field conditions involve or have involved bringing both the grasshoppers and the plant from the field and completing the studies in the laboratory which creates somewhat of an artificial environment. My studies represent field conditions, because the grasshoppers were studied in the field except for feeding studies for only 24 hours which were conducted in the laboratory.

The purpose of this study was to record field information which could be used by others in the future when the overall relationship of A. ludoviciana, and the monophagous H. alba, and the polyphagous M. bivittatus, are interpreted in the laboratory and in the field. My study includes two sampling methods, using for the first time a wooden ring and the most commonly used method, the sweep net. I also illustrate and describe for the first time, the feeding habits of H. alba and M. bivittatus during the various instars and adult stages, I also establish collecting dates of the instars and adults of the two species when feeding in two fields near Manhattan, Kansas.

REVIEW OF LITERATURE

Sampling methods of grasshopper populations have been the subject of several studies but there have been none in detail on the species in this study. The Stabilized Drop Trap, the Night Cage, Cage Samplers and Net Samplers are the closest quantitation sampling methods in the literature used in grasshopper density samplings. Night cages involve a complete enclosure at a time when the grasshoppers are inactive. Cage or net samplers and devices such as the Quick Trap (Turnbull and Nicholls 1966), drop cage (Smalley 1960) are believed by Onsager (1977) to be equivalent to night cages if used under the same temperature conditions.

The Quick Trap used during regular working hours appears to be unique (Onsager 1977) because opportunities for escape are minimal. He also believes that the cage sampler, net sampler, drop cage and vacuum collectors (Dietrick 1961) "seem related in that grasshoppers may flush prematurely from the enclosed area" (p. 190). Richards and Waloff (1954) used wire frames set out to delineate quadrants that were examined visually at least 2 hours later. Onsager concluded that this method was superior in that it would offer precision associated with mechanical delineation of subsamples and also not require undue equipment or time.

The Stabilized Drop Trap (Mason and Blocker 1973) is accurate but heavy and difficult to move and manipulate in my study areas. They point out that the Throw Trap (Smith and Stewart 1946) is not stable when it lands. The 0.5 m^2 Quick Trap (Turnbull and Nicholls 1966) must be set at least 24 hours in advance. "An investigator is not assured that the arthropods in the sample set resume a natural state after the trap is set up" (Mason and Blocker, p. 214, 1973).

Onsager and Henry (1977) used a flexible 2-3 meter long wand to flush the individuals. Then subsamples were delineated by wire rings that enclosed a 0.1 m^2 area. They reported this method to be convenient and accurate for determining density.

Knutson (1982) briefly described certain aspects of feeding by *H. alba*. S. K. Gangwere (1961) described feeding of several species of adults but the two species studied by this writer were not mentioned.

Arnett (1960) conducted broad studies of the grass-inhabiting species and seasonal occurrence in the Donaldson Pastures (1957-1959), including *H. alba* and *M. bivittatus*. Arnett's results, and subsequent studies primarily on food plants and habitats of many species by J. D. Lambley, C. K. Jantz, and H. Knutson, were published by Campbell et al. (1974).

MATERIALS AND METHODS

Two sites were used for field studies. The Donaldson Pasture site was intermittently burned annually with some deferred grazing about seven kilometers northwest of Manhattan, Kansas (Fig. 1). The other site, the Shielding Area, located about 11 kilometers southwest of Manhattan, Kansas (Fig. 2), had been unburned for at least several years as indicated by both small and large cedar trees. Two sites, rather than one, were studied so that better representation of the grasshoppers could be attained.

The Plant. *Artemisia ludoviciana* (Figs. 1, 2, 3, 4, 7, 8) is a perennial, highly pubescent plant with horizontal rhizomes underground near the soil surface. These rhizomes send up stems called "plants" in this paper. As the plants grow, new leaves form at the top, while as the season progresses the lower leaves gradually are lost, largely through desiccation. A non-glandular, filamentous, entwined, trichome mat of pubescence grows from the surface of the entire plant, but

Fig. 1. Donaldson Pasture site. Sampling done in the less lush area near trees. A. ludoviciana is the light green plant in the foreground. Object in foreground is a camera case.

Fig. 2. Shielding Area site. A. Ludoviciana is the light green plant. Ring sampling method also shown in Fig. 8

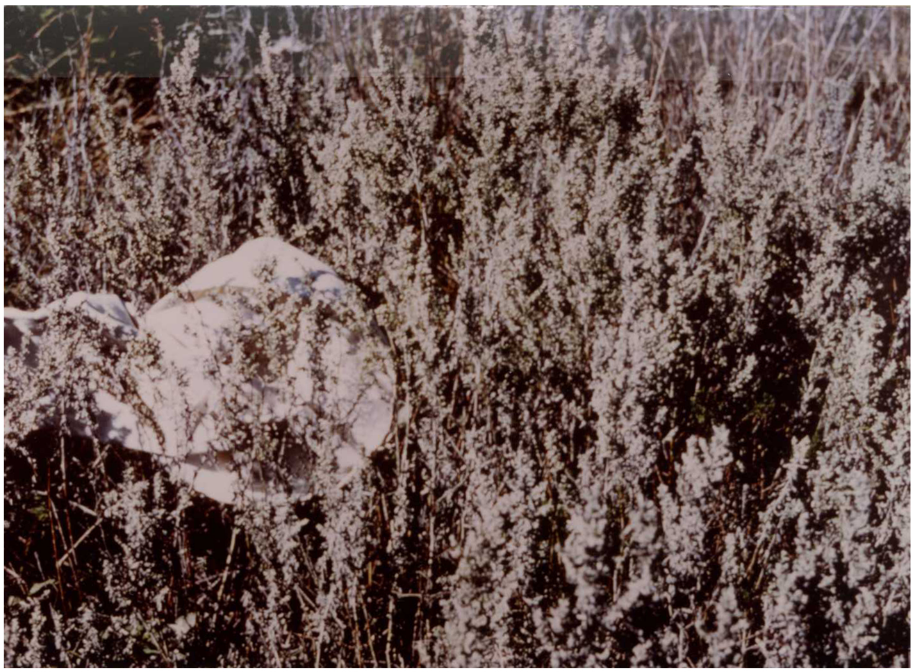

Fig. 3. Artemisia ludoviciana at seed formation and unusually tall because of competition with tall grasses. Not suitable for ring or sweep net sampling; 15 inch sweep not included to show height. Fig. 2 shows more typical A. ludoviciana growth.

feeding by H. alba, and minor feeding by a few other grasshoppers, is restricted to the leaves and buds. This mat of pubescence varies among A. ludoviciana plants. Plants with "sparse pubescence" (the three categories named by Knutson 1982) have relatively few trichomes and are light green; those with "medium pubescence" are grayish-green, and those with "dense pubescence" are almost white. The lower leaf surface is always more densely pubescent than the upper surface. The plant emerges early in the spring and may attain a height of 3 to 6 cm before the H. alba hatches. (However, many of the studies in our laboratory have involved feeding only on seedlings or very young plants.) The upper parts of the plant are still green when adults die off in the fall.

H. alba is never abundant enough to show more than a small amount of feeding. In my feeding studies medium pubescence of leaves, the most fed upon by H. alba (Knutson 1982), were brought from the field at the same time as the various instars and adults of H. alba for a 24 hour feeding period. Grasshoppers were placed in cages (Fig. 6) with A. ludoviciana. The types of feeding on the leaves by each developmental stage at the end of 24 hours were recorded and photographed.

The Grasshoppers. Hypochlora alba (Fig. 4) ranges from velvety white to various shades of whitish green, similar to the host plant's variable shades of green to white. Adults are short-winged with rare exceptions. H. alba is essentially a Great Plains species but extends south only to north-central Texas, northward to extreme southern Saskatchewan and Alberta, and somewhat east of the Great Plains. Its western boundary is roughly the Rocky Mountains (Coop. Environ. Insect Rept. 1956).

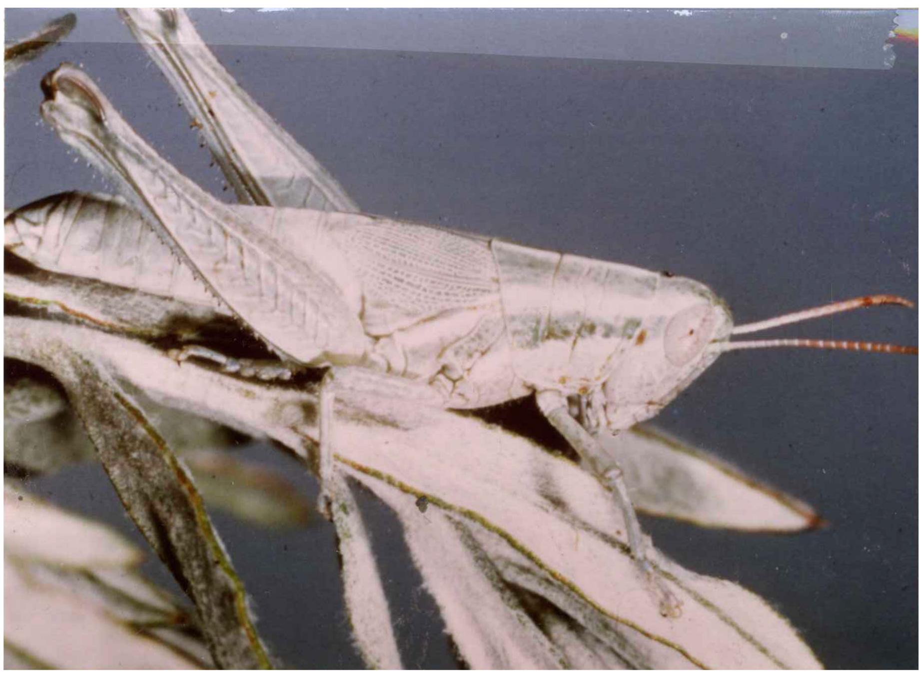

Fig. 4. Hypochlora alba (female).

Fig. 5. Melanoplus bivittatus (male).

Melanoplus bivittatus nymphs (Fig. 5) are brown or green. Adults are fully winged and are generally brown, black or purplish-black with two stripes on the dorsal surface of the head, thorax and wings. It was selected as a contrasting species because of its frequent presence in H. alba and A. ludoviciana habitats. Its geographical range extends much beyond that of H. alba and A. ludoviciana in all directions. Both grasshoppers rarely (< 0.1 percent) undergo an extra instar between the 3rd and 4th stages of development.

Both grasshoppers overwinter in the egg stage.

Cages. Each grasshopper was individually reared in a 13 centimeter high, six centimeter diameter, cylindrical tube of brass screen wire (Fig. 6). On either end was a plastic petri dish six centimeters in diameter.

Cotton balls soaked in water to last for 24 hours were introduced into the cages as a source of drinking water. The rearing room was maintained at ca. 30 C and 40% RH under a photoperiod regime of LD 14-10.

Sampling Techniques. The relative numbers of each instar and adults of both grasshoppers were recorded for specific dates using the following sampling methods: (1) 20 sweeps of a 15 in. diameter net at an arc of ca. 180° covering an area of 3600 cm^2 which is 3.7 times the area sampled by the ring; (2) 20 counts of a wooden ring with an inside area of 962 cm^2 and 15 cm platform over a spot containing at least 4 A. ludoviciana plants because H. alba feeds only on this plant. The transformation per unit area was obtained by calculating an 180° arc of 360 cm by 10 cm wide, giving 3600 cm^2. This figure was divided by 962 cm^2, giving 3.7 as the transformation factor. Since the area sampled by the sweep net was 3.7 times greater than the ring sample, a transformation of 3.7 was made to equalize the area of the two sampling techniques.

Fig. 6. Wire cylindrical cages

Fig. 6. Wire cylindrical cages.

Fig. 8. Ring sampling method.

Sampling was done primarily during the heat of the day. The sweeping net was selected because it is much more used than any other sampling method. The wooden ring had never been used heretofore.

After considering all methods for obtaining density (see Review of Literature), it was decided that a wooden ring described below was the best for obtaining the near-actual number of individuals per unit area. Another reason for selecting the sweep net and the ring was that both methods could be the most conveniently used in the sites.

The selection of 20 sweeps and 20 rings was based upon preliminary trials in the field which indicated that approximately the same number of individuals were captured by the ring as in the sweep samples per unit area.

The ring was first used in the site, followed immediately by the sweeps which were at a slightly different spot than where the rings were used. All individuals were returned living to the same sample spot after counting.

Both sampling methods were used only where the vegetation, including A. ludoviciana, was short to medium height. The ring was pressed down until the ground surface stopped further pressing and all individuals within the 962 cm^2 could be counted. The border of this wooden ring, 15 cm wide, often provided a platform for the grasshopper's first jump, whereupon the individual was recorded and then scared away. The inside 962 cm^2 area was then disturbed by the fingers, causing the remaining individuals to jump, often landing on the ring's platform. The relatively few individuals jumping beyond the wooden border were identified and recorded when they alighted. Sweeps were made in the same height of vegetation, but the vegetation often prevented the sweep net's hoop from reaching the soil and litter surface. Only in a small portion of the sites did A. ludoviciana and the grasses grow lushly enough (such as in Fig. 3) to prohibit ring and sweep sampling at that spot.

Samplings were made totaling 14 in 1980 and 15 in 1981.

Statistical Analysis. General linear models procedures were used to partition the variation in the data. The analysis was done separately for each species within each year. The model for the analysis was for a modified split-plot design with a (2XK) factorial treatment structure (2 locations X K dates) for the whole plots and 2 methods (sweeps and rings) the split-plot. The analysis compares the two methods within each location and the two methods averaged over the two locations. The statistical model:

$$Y_{ijkl} = U + L_i + D_j + E1_{ijk} + M_l + LM_{il} + E2_{ijkl}$$

where: Y_{ijkl} = response variables (Instar 1 - Instar 5 Adult)

U = overall mean

L_i = location (Donaldson, Shielding)

D_j = dates of collection, 14 dates in 1980 and 15 dates in 1981

$E1_{jkl}$ = error (1) for testing location and dates

M_l = method of collection (sweeps, rings)

LM_{il} = interaction of location and method

$E2_{ijkl}$ = error (2) for testing method of collection and interaction of location and method of collection

The above model yields the analysis of variance tables of the form:

Source of variation	df	Mean squares	F-test
Location (L)	1	MS	MS/MS
Data (D)	*	MS	MS/MS
Error (1)	*	MS	
Method (M)	1	MS	MS/MS
Interaction (LM)	1	MS	MS/MS
Error (2)	*	MS	MS/MS

*df varies from 12 to 14

The interpretation of the analysis considers the following questions:

1. Comparison of sampling methods (sweeps vs rings).

2. Interaction of location and method (involves a comparison of individual sweeps vs rings, to determine if they are the same in both sites).

If the interaction between site and sampling method is significant ($p < .05$), the methods must be compared within each site but when the interaction effects are not significant (sweeps vs rings) they can be compared with more statistical power by averaging over the two sites.

The analysis of variance tables are presented in Tables 1 through 4 and the means in Tables 5 through 10.

Table 1. Analysis of variance (mean squares and probabilities) for number of instars and adults of Hypochlora alba collected at Donaldson and Shielding using sweep net and ring methods in 1980.

		Instar 1		Instar 2		Instar 3	
Source	DF	MS	P	MS	P	MS	P
Location	1	8.3	.23	2.3	.73	47.6	.07
Date	13	9.0	.16	50.3	.04	16.3	.30
Error(1)	13	5.2		18.5		12.1	
Method	1	2.3	.16	4.8	.10	.8	.73
Method x site	1	1.1	.33	4.0	.13	.9	.72
Error(2)	13	1.1		1.7		7.2	
		Instar 4		Instar 5		Adult	
Location		21.9	.06	.2	.89	95.1	.10
Date		18.1	.01	9.7	.19	136.2	.01
Error(1)		5.1		5.8		30.1	
Method		43.1	.01	1.4	.36	1094.9	.00+
Method x site		6.7	.28	.1	.89	28.7	.35
Error(2)		5.5		1.6		31.8	

Table 2. Analysis of variance (mean squares and probabilities) for numbers of instars and adults of *Melanoplus bivittatus* collected at Donaldson and Shielding using sweep net and ring methods in 1980.

		Instar 1		Instar 2		Instar 3	
Source	DF	MS	P	MS	P	MS	P
Location	1	.5	.50	2.3	.30	11.8	.23
Date	14	1.9	.14	13.1	.01	23.4	.02
Error(1)	14	1.0		2.4		7.4	
Method	1	.9	.33	1.4	.15	.1	.88
Method x site	1	.7	.39	.1	.65	.6	.66
Error(2)	14	.9		.6		2.9	
		Instar 4		Instar 5		Adult	
Location		39.1	.09	40.0	.06	109.4	.00+
Date		26.4	.07	11.6	.35	12.5	.06
Error(1)		11.7		9.5		5.3	
Method		22.2	.10	10.4	.05	66.2	.00+
Method x site		16.6	.15	12.2	.03	40.0	.02
Error(2)		7.6		2.4		6.4	

Table 3. Analysis of variance (mean squares and probabilites) for numbers of instars and adults of *Hypochlora alba* collected at Donaldson and Shielding using sweep net and ring methods in 1981.

		Instar 1		Instar 2		Instar 3	
Source	DF	MS	P	MS	P	MS	P
Location	1	16.1	.18	16.1	.23	111.4	.01
Date	13	15.5	.12	28.6	.04	31.8	.06
Error(1)	13	8.0		10.1		13.1	
Method	1	8.6	.03	12.1	.11	85.0	.01
Method x site	1	1.1	.41	20.6	.04	50.2	.03
Error(2)	14	1.7				9.7	

	Instar 4		Instar 5		Adult	
Location	95.2	.01	80.1	.01	11.2	.06
Date	25.6	.08	12.9	.28	14.3	.01
Error(1)	11.4		9.3		2.6	
Method	33.0	.03	4.0	.17	33.0	.00+
Method x site	17.2	.11	7.9	.06	.2	.88
Error(2)	6.6		2.1		3.2	

Table 4. Analysis of variance (mean squares and probabilities) for numbers of instars and adults of Melanoplus bivittatus collected at Donaldson and Shielding using sweep net and ring methods in 1981.

		Instar 1		Instar 2		Instar 3	
Source	DF	MS	P	MS	P	MS	P
Location	1	.7	.19	.7	.16	24.9	.07
Date	12	.4	.50	.7	.06	22.0	.02
Error(1)	12	.4		.3		6.3	
Method	1	.3	.15	.1	.90	2.8	.10
Method x site	1	.3	.15	.1	.90	3.8	.06
Error(2)	12	.1		.3		1.0	
		Instar 4		Instar 5		Adult	
Location		1.2	.27	13.0	.01	11.1	.00+
Date		9.8	.01	8.2	.01	3.7	.00+
Error(1)		1.0		1.5		.5	
Method		19.7	.03	3.8	.29	4.9	.04+
Method x site		1.9	.48	.3	.76	.7	.42
Error(2)		3.8		3.2		1.0	

RESULTS

The analysis of variance tables are presented in Tables 1 through 4 and the actual counts, plus the actual count converted to per unit of srea covered, and means, are presented in Tables 5 through 10.

Comparison of Sweeps and Ring Techniques. Table 5 indicates that when combining the number of individuals collected at both sites and using the transformation factor (3.7), ring collections exceeded those of the sweeps in number of H. alba obtained in 1980 (939 vs 485) and 1981 in all but one collection (651 vs 391), that of 3rd instars in 1981. In 1982, the 4th instar and adult collections were significantly greater for rings than for sweeps, and in 1981, the 1st, 3rd and 4th instars and adults numbers were significantly greater in rings than in sweeps.

Table 6 indicates that upon combining the number of individuals collected at both sites, using the transformation factor, the ring collections outnumbered those captured in sweeps for M. bivittatus in 1980 (495 vs 261) and in 1981 (281 vs 158) in all but two collections, those of 1st instars in 1980 and 1981. Collections of 5th instars and adults were statistically greater in number with rings than with sweeps in 1980 and in 1981; 4th and 5th instars and adults were statistically greater in ring samples.

The increase in number from first instar to adult is probably the result of hatching following the first collections and migration of individual adults in particular into the sampling area.

Table 5.--Number of instars and adults of *Hypochlora alba* collected in the Donaldson Pastures and the Shielding Area, using sweep net and ring (1980-1981).

Instars and adults	1980 Sweeps actual		1980 Ring	1980 Trans. factor[1]	1981 Sweeps actual		1981 Ring	1981 Trans. factor[1]
1st	26		13	48	43	*	18	66
2nd	43		40	148	62		38	140
3rd	42		50	185	92	*	23	85
4th	65	*	28	103	94	*	41	151
5th	40		29	107	46		32	118
Adults	269	*	94	347	54	*	24	88
Total	485		254	939	391		176	651

*Denotes significant difference at 5% level.

[1]Transformation factor from area sweep vs ring is 3.7 x ring count.

Table 6.--Number of instars and adults of _Melanoplus bivittatus_ collected in the Donaldson Pastures and the Shielding Area, using sweep net and ring (1980-1981).

Instars and adults	1980 Sweeps actual		1980 Ring	1980 Trans. factor[1]	1981 Sweeps actual		1981 Ring	1981 Trans. factor[1]
1st	10		2	7	5		1	3
2nd	11		20	74	6		4	14
3rd	40		24	88	51		33	122
4th	47		19	70	34	*	9	33
5th	50	*	21	77	31	*	13	48
Adults	103	*	48	177	31	*	17	62
Total	261		134	495	158		76	281

*Denotes significant difference at 5% level.

[1]Transformation factor from area sweep vs ring is 3.7 x ring count.

Table 7. Site, sampling method, and site by sampling method means for Hypochlora alba in 1980.

Method	Instars and adults	Site: Donaldson Pastures	Site: Shielding Area	Sampling method mean
	1st			
Rings		.27	.75	.50
Sweeps		.40	1.43	.89
Site mean		.33	1.09	
	2nd			
Rings		1.47	1.34	1.40
Sweeps		1.53	2.45	1.97
Site mean		1.50	1.89	
	3rd			
Rings		.86	2.42	1.62
Sweeps		.86	2.92	1.86
Site mean		.87	2.68	
	4th			
Rings		.66	1.21	.93
Sweeps		1.73	3.64	2.66
Site mean		1.20	2.40	
	5th			
Rings		1.20	1.07	1.13
Sweeps		1.46	1.42	1.45
Site mean		1.30	1.25	
	Adult			
Rings		3.20	4.35	3.76
Sweeps		10.50	14.50	12.46
Site mean		6.87	9.43	

Table 8. Site, sampling method, and site by sampling method means for <u>Melanoplus</u> <u>bivittatus</u> in 1980.

Method	Instars and adults	Site: Donaldson Pastures	Site: Shielding Area	Sampling method mean
	1st			
Rings		.06	.10	.08
Sweeps		.53	.13	.33
Site mean		.30	.11	
	2nd			
Rings		.93	.41	.67
Sweeps		.53	.20	.36
Site mean		.73	.30	
	3rd			
Rings		1.73	.64	1.18
Sweeps		1.60	.91	1.25
Site mean		.66	.77	
	4th			
Rings		.86	.30	.58
Sweeps		3.13	.46	1.80
Site mean		2.00	.38	
	5th			
Rings		1.06	.33	.70
Sweeps		2.80	.26	1.53
Site mean		1.93	.30	
	Adult			
Rings		2.06	1.00	1.53
Sweeps		5.80	1.46	3.63
Site mean		3.93	1.23	

Table 9. Site, sampling method, and site by sampling method means for Melanoplus bivittatus in 1981.

Method	Instars and adults	Site: Donaldson Pastures	Site: Shielding Area	Sampling method mean
	1st			
Rings		.07	0.00	.03
Sweeps		.38	0.00	.19
Site mean		.23	0.00	
	2nd			
Rings		.38	.15	.26
Sweeps		.38	.15	.26
Site mean		.38	.15	
	3rd			
Rings		1.61	.76	1.19
Sweeps		2.61	.69	1.65
Site mean		2.11	.73	
	4th			
Rings		.30	.38	.34
Sweeps		1.92	1.23	1.57
Site mean		1.11	.80	
	5th			
Rings		.07	1.23	.65
Sweeps		.76	1.61	1.19
Site mean		.42	1.42	
	Adult			
Rings		.30	1.00	.65
Sweeps		.69	1.84	1.26
Site mean		.50	1.42	

Table 10. Site, sampling method, and site by sampling method means for Hypochlora alba in 1981.

Method	Instars and adults	Site: Donaldson Pastures	Site: Shielding Area	Sampling method mean
	1st			
Rings		.35	1.14	.75
Sweeps		.85	2.21	1.53
Site mean		.60	1.67	
	2nd			
Rings		1.35	1.21	1.28
Sweeps		1.07	3.35	2.21
Site mean		1.21	2.28	
	3rd			
Rings		.35	1.28	.82
Sweeps		.92	5.64	3.28
Site mean		.64	3.46	
	4th			
Rings		.71	2.21	1.46
Sweeps		1.14	4.85	3.00
Site mean		.92	3.53	
	5th			
Rings		.35	2.00	1.17
Sweeps		.14	3.28	1.71
Site mean		.25	2.64	
	Adult			
Rings		.64	1.42	1.03
Sweeps		2.07	3.07	2.57
Site mean		1.35	2.25	

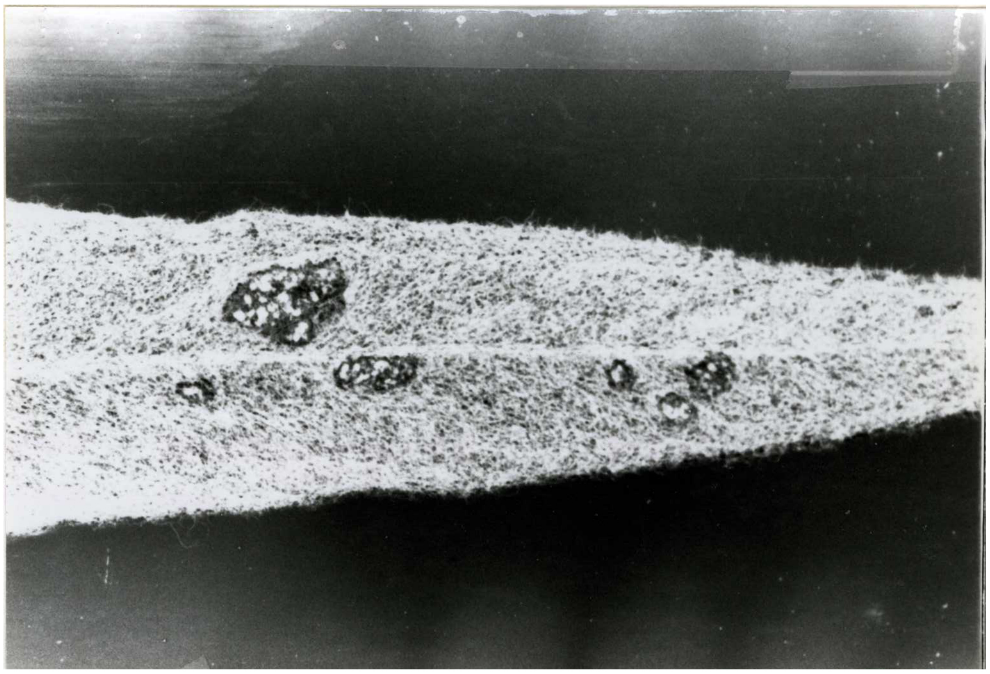

Fig. 9. Gouge feeding by first instar Hypochlora alba
on Artemisia ludoviciana.

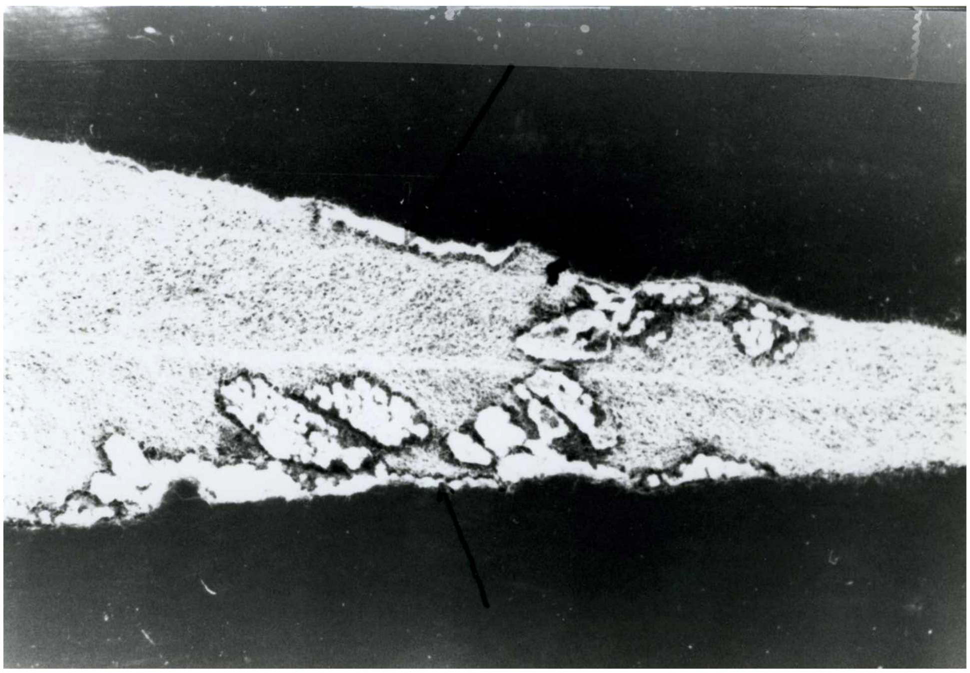

Fig. 10. Expanded gouge feeding by Hypochlora alba on Artemisia ludoviciana. Arrows indicate slant feeding.

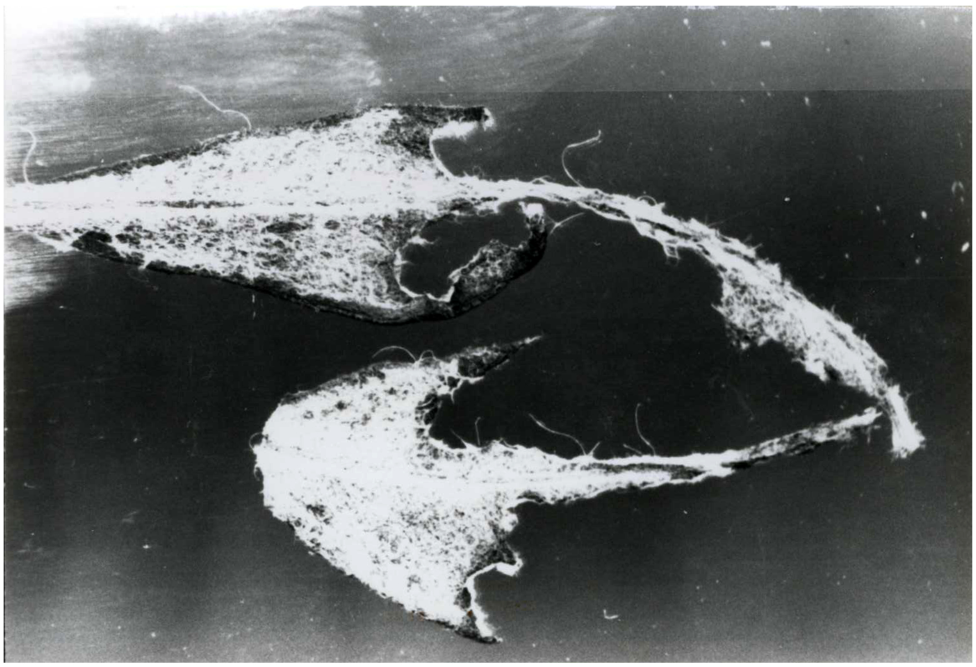

Fig. 11. Edge feeding by Hypochlora alba on Artemisia ludoviciana.

Feeding Behavior

Feeding Behavior of *H. alba*. Gouge-feeding occurred among younger nymphs (Fig. 9). Nymphs started to feed from the upper surface, consuming the upper pubescence and the underlying leaf tissue, ingesting only rarely any of the denser pubescence on the lower surface. The gouge-feeding expanded (Fig. 9) especially when the leaf supply was limited, but always the veins were avoided. The gouges gradually anastomosed into larger areas of feeding. Slant-feeding (Fig. 10) involved 3rd and 4th instars along the edge of the leaf at an angle so that more of the less dense, upper pubescence was ingested than the denser, lower pubescence. When slant-feeding was confined to a single swath along the leaf edge, which appeared to be the case particularly with older 3rd instars and younger 4th instars, proportionately less pubescence than leaf tissue was ingested. Edge-feeding occurred with practically all 5th instars and all adults (Fig. 11).

Feeding Behavior of *M. bivittatus*. *M. bivittatus* edge-fed during all nymphal stages and the adult stage.

Collection Dates

Collections were not initiated soon enough to get all of the instars when they first occurred. Also collections were sometimes not sufficient to get the first and the last appearing individuals, hence some instars and adult collections overlapped, indicating an abbreviated life span.

Collection Dates of *H. alba*, 1980. Seasonal collection was determined by combining sweep and ring collections (see Appendix).

1st Instar: Total collections ranged at the Donaldson Pastures from June 3 to June 23, peaking June 23; at the Shielding Area from June 3 to July 17, peaking June 23.

2nd Instar: Total collections ranged at the Donaldson Pastures from June 3 to July 9, peaking June 3; at the Shielding Area from June 3 to July 22, peaking June 3.

3rd Instar: Total collections ranged at the Donaldson Pastures from June 3 to June 30, peaking June 11 and June 23; at the Shielding Area from June 3 to August 5, peaking June 11, June 30, and July 17.

4th Instar: Total collections ranged at the Donaldson Pastures from June 3 to August 5, peaking June 11 and June 23; at the Shielding Area from June 3 to August 5, peaking June 23, June 30, July 22 and July 29.

5th Instar. Total collections ranged at the Donaldson Pastures from June 23 to August 19, peaking June 30 and July 29; at the Shielding Area from June 23 to August 25, peaking June 30 and July 29.

Adults: Total collections ranged at the Donaldson Pastures from June 23 to September 19, peaking July 29; at the Shielding Area from June 23 to September 19, peaking July 16 and July 23.

Collection Dates of *H. alba*, 1981. Collection dates were determined by combining both sweep and ring collections (see Appendix).

1st Instar: Total collections ranged at the Donaldson Pastures from May 15 to June 14, peaking May 15; at the Shielding Area from May 15 to July 3, peaking May 22.

2nd Instar: Total collections ranged at the Donaldson Pastures from May 15 to July 10, peaking May 22; at the Shielding Area from May 15 to July 26, peaking June 21.

3rd Instar: Total collections ranged at the Donaldson Pastures from May 22 to July 6, peaking June 7 and June 14; at the Shielding Area from May 22 to August 4, peaking June 21.

4th Instar: Total collections ranged at the Donaldson Pastures from June 7 to August 12, peaking June 21, at the Shielding Area from May 22 to August 29, peaking July 10.

5th Instar: Total collections ranged at the Donaldson Pastures from June 21 to August 4, peaking July 3; at the Shielding Area from June 7 to August 29, peaking June 21, and to a lesser extent, July 26.

Adult: Total collections ranged at the Donaldson Pastures from July 3 to September 5, peaking July 16; at the Shielding Area from June 21 to September 5, peaking August 12.

Collection Dates of *M. bivittatus*, 1980. Seasonal occurrence was determined by combining both sweep and ring collections.

1st Instar: Total collections ranged at the Donaldson Pastures from June 3 to June 30, peaking June 30; at the Shielding Area from June 3 to June 11, peaking June 3.

2nd Instar: Total collections ranged at the Donaldson Pastures from June 3 to June 30, peaking June 3; at the Shielding Area from June 3 to June 23, peaking June 3.

3rd Instar: Total collections ranged at the Donaldson Pastures from June 3 to June 23, peaking June 3 and June 23; at the Shielding Area from June 3 to July 9, peaking June 11.

4th Instar: Total collections ranged at the Donaldson Pastures from June 3 to June 30, peaking June 23; at the Shielding Area from June 3 to July 29, peaking June 11.

5th Instar: Total collections ranged at the Donaldson Pastures from June 3 to August 19, peaking July 9; at the Shielding Area from June 3 to August 19, peaking June 23.

Adult: Total collections ranged at the Donaldson Pastures from June 9 to September 20, with no substantial peaks; at the Shielding Area from June 11 to September 20, peaking July 29.

Collection Dates of *M. bivittatus*, 1981. Collection dates were determined by combining both sweep and ring collections (see Appendix).

1st Instar: Total collections ranged at the Donaldson Pastures from May 15 to June 14, peaking on June 14; at the Shielding Area only on May 15.

2nd Instar: Total collections ranged at the Donaldson Pastures from May 15 to July 3, peaking May 12, and June 7; at the Shielding Area from May 15 to July 26, peaking May 15.

3rd Instar: Total collections ranged at the Donaldson Pastures from May 15 to July 3, peaking May 15 and May 22; at the Shielding Area from May 15 to August 4, peaking June 7 and June 14.

4th Instar: Total collections ranged at the Donaldson Pastures from May 22 to July 26, peaking June 7; at the Shielding Area from May 15 to August 12, peaking June 14 and June 21.

5th Instar: Total collections ranged at the Donaldson Pastures from May 22 to July 3, peaking June 7; at the Shielding Area from May 22 to August 12, peaking June 14.

Adult: Total collections ranged at the Donaldson Pastures from June 21 to August 21, peaking August 4; at the Shielding Area from June 14 to September 5, peaking August 4.

DISCUSSION AND SUMMARY

The ring collection exceeded those of the sweep per unit area for all instars and adults of *H. alba* in both 1980, and 1981 with one exception. In 1981, the ring collections per unit area exceeded the sweep collections for all instars of *M. bivittatus* in 1980; and in 1981 in all collections except two. The ring appears to be more representative of the populations in typical low or medium vegetation because the ring was pressed hard toward the ground so that virtually none could escape under the ring, while the sweep net averaged about four inches from the litter or ground. Also, there were less deviations among the consecutive collection counts with the ring compared with the sweeps.

The ring is the better method to determine density in the typically low to medium height vegetation where plants are not closely spaced, which was where most of the grasshoppers occurred. The ring counts included virtually all individuals in a given area because the ring is strongly pressed toward the litter and ground. Sweeps generally did not reach within a few inches of the litter and ground level; therefore, they are less reliable than the ring because sweeps are influenced by locations of individuals on plants.

Gouge-feeding from the top of the leaf occurred among 1st and 2nd instars of H. alba. Slant-feeding often occurred among 3rd and 4th instars. Edge-feeding occurred in almost all 5th instars and adults. The less pubescence on the upper leaf surface (compared to the greater amount of pubescence on the lower surface) apparently governed the gouge-feeding of the younger individuals because this was the preferable way for the small individuals to reach the leaf tissue. Slant-feeding by the middle-aged nymphs lessens the ratio of pubescence vs leaf tissue compared to edge-feeding, particularly the first and second swaths. The older, larger nymphs and adults, which edge-feed, ingest upper and lower pubescence and leaf tissue in equal proportions. Dr. Sherilyn G. F. Smith is investigating the role and fate of pubescence and leaf tissue as it passes through the digestive system.

All stages of M. bivittatus edge-fed, the older nymphs and adults sometimes shattering the leaf. Sweet clover was used for M. bivittatus.

In summary, collections of H. alba in 1980 occurred as 1st instars from June 3 to July 17; in 1981, May 12 to July 3. Second instars occurred June 3 to July 22 in 1980, and in 1981, May 15 to July 26. Third instars occurred June 3 to August 5 in 1980, and in 1981 from May 22 to August 4. Fourth instars occurred June 3 to August 5 in 1980, and June 7 to August 29 in 1981. Fifth instars occurred June 23 to August 25 in 1980, and in 1981 June 21 to August 9. Adults occurred June 23 to September 19 in 1980, and in 1981 June 21 to September 5, which was the last collection date.

M. bivittatus collections occurred as 1st instars from June 3 to June 30 in 1980, and in 1981 from May 15 to June 14. Second instars occurred June 3 to June 30 in 1980, and May 15 to July 26 in 1981. Third instars occurred June 3 to July 9 in 1980, and in 1981 May 15 to August 4. Fourth instars occurred June 3 to July 29 in 1980, and May 22 to August 12 in 1981. Fifth instars occurred June 3 to August 19 in 1980, and in 1981 May 22 to August 12. Adults in 1980 occurred June 9 to September 20, and June 21 to September 5 in 1981.

The growing season in 1980 was extremely hot and dry, particularly during the time after the two species had hatched. In 1981, it was hot during the early spring, before hatching but cooler and wetter thereafter. There was an advantage in making studies during these two different years, because more representative data were obtained than if both seasons had been similar.

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APPENDIX

Weather summary for Manhattan, Kansas. (Produced with the aid of the Kansas Agricultural Experiment Station Weather Data Library.)

Weather data for 1980 and 1981.

Temperature and precipitation by months for 1980 and 1981 obtained from Weather Service Library, Department of Physics, Kansas State University.

	1980	1981	Normal	Deviation 1980	Deviation 1981
JANUARY					
Temperature					
Average daily maximum	39.8	44.7	37.7	2.1	7.0
Average daily minimum	20.0	20.5	16.5	3.5	4.0
Average daily mean	29.9	32.6	27.1	5.5	2.8
Precipitation	1.13	.07	.83	.3	.76
FEBRUARY					
Temperature					
Average daily maximum	36.7	49.7	44.5	-7.8	5.2
Average daily minimum	18.8	25.1	21.9	3.1	3.2
Average daily mean	27.8	37.4	33.2	-5.4	4.2
Precipitation	1.02	.63	.95	.07	-.32
MARCH					
Temperature					
Average daily maximum	50.2	59.3	54.5	-4.3	4.8
Average daily minimum	29.8	34.3	30.5	-.7	2.8
Average daily mean	40.0	46.8	42.5	-2.5	4.3
Precipitation	4.97	1.15	2.08	2.89	-.93
APRIL					
Temperature					
Average daily maximum	66.8	75.1	67.9	-1.1	7.2
Average daily minimum	44.1	51.9	43.1	-2.0	8.8
Average daily mean	54.0	63.5	55.5	-1.5	8.0
Precipitation	1.38	2.21	2.79	-1.41	-.58
MAY					
Temperature					
Average daily maximum	72.3	73.0	77.3	0	-4.3
Average daily minimum	52.0	51.9	53.5	-1.5	-1.6
Average daily mean	64.7	62.5	65.4	-.7	-2.9
Precipitation	1.80	7.06	4.50	-2.7	2.56

	1980	1981	Normal	Deviation 1980	Deviation 1981
JUNE					
Temperature					
Average daily maximum	90.3	86.4	86.2	4.1	.02
Average daily minimum	66.4	65.6	63.2	3.2	2.4
Average daily mean	78.4	76.0	74.7	3.7	1.3
Precipitation	2.81	6.54	5.29	-2.5	1.3
JULY					
Temperature					
Average daily maximum	101.4	88.2	97.7	3.9	-9.5
Average daily minimum	74.1	70.7	68.0	6.1	2.9
Average daily mean	87.8	79.5	79.9	7.9	-0.4
Precipitation	1.20	5.59	3.96	-2.76	1.7
AUGUST					
Temperature					
Average daily maximum	96.5	85.2	90.4	6.1	-5.2
Average daily minimum	71.2	64.7	66.3	4.9	-1.6
Average daily mean	83.9	75.0	78.4	5.5	-3.4
Precipitation	2.94	2.76	3.18	-2.4	-4.2
SEPTEMBER					
Temperature					
Average daily maximum	84.6	81.8	81.7	2.9	0.1
Average daily minimum	60.3	58.1	56.8	3.5	-3.2
Average daily mean	72.5	70.0	69.3	3.2	0.7
Precipitation	2.52	1.39	4.04	-1.52	-2.7
OCTOBER					
Temperature					
Average daily maximum	69.7	65.1	71.1	-1.4	-6.0
Average daily minimum	42.2	47.0	45.2	-3.0	1.8
Average daily mean	56.0	56.1	58.2	-2.2	-2.1
Precipitation	3.43	2.33	2.89	0.64	-0.56

	1980	1981	Normal	Deviation 1980	Deviation 1981
NOVEMBER					
Temperature					
Average daily maximum	58.5	57.7	54.7	3.8	3.0
Average daily minimum	33.7	35.8	32.0	1.7	3.8
Average daily mean	46.1	46.8	43.4	2.7	3.4
Precipitation	.11	5.26	1.46	-1.4	3.8
DECEMBER					
Temperature					
Average daily maximum	44.3	40.4	43.1	2.7	-1.2
Average daily minimum	24.2	23.5	22.3	1.9	1.2
Average daily mean	34.3	32.0	32.7	1.6	-0.7
Precipitation	3.05	.72	.41	4.5	-0.2

Collections of <u>Hypochlora</u> <u>alba</u> for 1980, 1st through 5th instars and adult stages.

	6/3	6/1	6/23	6/30	7/9	7/17	7/22	7/27	8/5	8/19	8/30	9/6	9/13	9/19	9/26
1st	15	4	16	3	2	0									
2nd	40	15	13	13	0	3	0								
3rd	12	28	13	10	11	7	6	5	0						
4th	0	14	22	21	2	13	15	6							
5th	0	2	14	21	4	6	5	10	7	0	2				
Adult	0	0	1	12	30	32	50	41	56	41	35	19	26	20	

Collections of <u>Hypochlora</u> <u>alba</u> for 1981, 1st through 5th instars and adult stages.

	5/15	5/22	6/7	6/14	6/21	7/3	7/10	7/16	7/26	8/4	8/12	8/29	9/5
1st	24	19	6	7	4								
2nd	0	13	0	26	19	31	5	5	1				
3rd	0	0	32	25	22	17	12	6	1				
4th	0	0	10	14	23	25	28	19	4	10	1		
5th	0	0	0	4	18	18	8	6	18	6	2	0	
Adult	0	0	0	0	0	3	12	16	16	10	13	6	1

Collections of _Melanoplus bivittatus_ for 1980, 1st through 5th instars and adult stages.

	6/3	6/11	6/23	6/30	7/9	7/17	7/22	7/27	8/5	8/19	8/30	9/6	9/13	9/19	9/26
1st	9	0	2												
2nd	28	2	1	0											
3rd	28	23	11	3	0										
4th	4	30	25	7	0	0	0	1	0						
5th	1	17	22	13	5	4	3	5	0	1	2	0			
Adult	0	1	1	7	10	19	16	19	20	18	15	6	5	15	0

Collections of _Melanoplus bivittatus_ for 1981, 1st through 5th instars and adult stages.

	5/15	5/22	6/7	6/14	6/21	7/3	7/10	7/16	7/26	8/4	8/12	8/29	9/5
1st	2	0	0	4									
2nd	3	0	6	1	1	0	0	2					
3rd	22	21	14	18	5	0	0	3	1	0			
4th	1	0	15	9	8	2	2	4	1	2	0		
5th	0	0	14	14	11	4	0	2	1	2	0		
Adult	0	0	0	0	2	5	3	8	7	12	7	2	2

SAMPLING METHODS, FEEDING HABITS, AND SEASONAL COLLECTIONS OF *HYPOCHLORA ALBA* (DODGE) AND *MELANOPLUS BIVITTATUS* (SAY), IN PLOTS CONTAINING *ARTEMISIA LUDOVICIANA* (NUTT.) NEAR MANHATTAN, KANSAS

by

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AN ABSTRACT OF A MASTER'S REPORT

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MASTER OF SCIENCE

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Two sites, the Shielding Area and the Donaldson Pastures, near Manhattan, Kansas were studied in 1980 and 1981. Both sites contained the monophagous *Hypochlora alba* and the polyphagous *Melanoplus bivittatus*. Both sites also contained Louisiana sagewort, *Artemisia ludoviciana*. *H. alba* feeds only on this plant in eastern Kansas while *M. bivittatus* does not feed on this sagewort, but rather on several species of grasses and broad-leafed plants which also grow abundantly in both sites.

The number of individuals of each nymphal instar and adults of both species were recorded for specific collection dates. Samples were counted periodically throughout the season, using 20 sweeps of a sweeping net, and counts within a 962 cm^2 area using a wooden ring with an outer wooden border of 15 cm acting as a landing platform.

The number of individuals of *H. alba* counted by rings nearly always exceeded those of sweeps when converted to per unit of area covered; this difference occurred with each of the various instars and the adults. Efforts were made to make counts during the highest temperature of the day.

The number of individuals of *M. bivittatus* counted, particularly the older instars and adults, was also greater by rings than by sweep when converted to per unit of area covered. These counts were also made during the heat of the day when older nymphs and adults are higher on the plant.

Hence, the ring is the better method to determine density in the typically low to medium height vegetation where plants are not closely spaced, which was where most of the grasshoppers occurred. The ring counts included virtually all individuals in a given area because the ring is strongly pressed toward the litter and ground. Sweeps generally did not reach within a few inches of the litter and ground level; therefore, they are less reliable than the ring because sweeps are influenced by locations of individuals on plants.

The sweep net being the most widely used method, is satisfactory for determining whether or not the grasshoppers are present and, to some extent, determining roughly relative density. The ring offers much more precise determination of actual numbers present and is the favored sampling method for scientific establishment of the number of individuals per unit area.

Gouge-feeding of H. alba on the host plant occurred among younger nymphs. Slant-feeding occurred in third and fourth instars. Edge-feeding occurred in almost all fifth instars and adults. Because the pubescence of the upper leaf surface is less than that of the lower leaf surface (the leaf tissue is between these surfaces), the individuals ingest relatively more pubescence compared to leaf tissue as they grow older.

Melanoplus bivittatus edge-fed through all instars, and adults fed on sweet clover, one of the plants it commonly eats.

The season when the grasshoppers were nymphs and adults was hot and dry during 1980; and cooler and wetter in 1981. The contrasting weather conditions probably provided more nearly typical results than had both years been similar, since the development of both the grasshoppers and the plants can vary from 15 to 30 days depending on the weather conditions.