



Field studies on the biology of range grasshoppers of southeastern Montana
by Norman L Anderson

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree
of Master of Science in Entomology at Montana State College

Montana State University

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Abstract:

Range grasshopper studies were carried out in 1949 and 1950 in southeastern Big Horn County, Montana, Daily observations of grasshopper activities were made from the time of the first hatch in the spring until a majority of the grasshoppers had disappeared in the fall.

Observations on thirty-eight grasshopper species found in the area of. study are reported. In addition, to observations on localized movements and feeding habits, a list of the types of food and the instar of each species eating the food is included.

On winter range, representative areas of the two most important vegetational types from the standpoint of grazing value were selected for grasshopper damage studies, A report of the damage measurements involving these areas is given.

FIELD STUDIES
ON THE BIOLOGY OF RANGE GRASSHOPPERS
OF SOUTHEASTERN MONTANA

by

NORMAN L. ANDERSON, JR.

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Submitted to the Graduate Faculty
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ABSTRACT

Range grasshopper studies were carried out in 1949 and 1950 in southeastern Big Horn County, Montana. Daily observations of grasshopper activities were made from the time of the first hatch in the spring until a majority of the grasshoppers had disappeared in the fall.

Observations on thirty-eight grasshopper species found in the area of study are reported. In addition to observations on localized movements and feeding habits, a list of the types of food and the instar of each species eating the food is included.

On winter range, representative areas of the two most important vegetational types from the standpoint of grazing value were selected for grasshopper damage studies. A report of the damage measurements involving these areas is given.

FIELD STUDIES ON THE BIOLOGY OF
RANGE GRASSHOPPERS OF SOUTHEASTERN MONTANA

by

Norman L. Anderson, Jr.

INTRODUCTION

During the past three years, large scale control operations have been carried out against range grasshoppers in Montana and Wyoming. In view of the high cost of these control operations and the varied results obtained, the Department of Zoology and Entomology, Montana State College, recognized the need for information on the biology of range grasshoppers and therefore established a range grasshopper research program in the spring of 1949.

Hanson and Vorhies (1938), in their report prepared for the Committee on Ecology of Grasslands of North America of the National Research Council, clearly pointed out the need for more complete knowledge of grasslands and their fauna. Under point none of their proposed grassland study they state: "In grassland regions, most insect pests such as grasshoppers are native species, and measures for their efficient control must be based upon exact knowledge of inter-relationships, behavior, life history, and protection in the natural environment."

Very little information appears in the literature concerning the biology of range grasshoppers in their natural environment. The best information has come from the detailed field observations by Griddle (1933) in Canada. Limited field observations in southwestern United

States by Ball (1936) in Wyoming by Pfadt (1949b and 1949c), and in Alberta by White and Rock (1945) have added to the knowledge of the biology of these insects.

Studies of grasshoppers subjected to cage and laboratory conditions have evidently been more popular with entomologists. Numerous references to life history and physiological studies under cage and laboratory conditions may be found. In addition, intensive studies of the food preferences of caged grasshoppers have been made by Isely (1938, 1944, and 1946) and by Pfadt (1949c)

This report is based upon field studies during 1949 and 1950 in a small area of southeastern Montana. It is realized that many of the observed grasshopper activities could possibly be changed under environmental conditions different from those present at the time this study was made. It is felt, however, that this study has brought to light indications of grasshopper behavior which, when studied under different environmental conditions over a period of years, will add much to the knowledge of the biology of range grasshoppers.

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Finally, the writer is deeply grateful to Mr. Manville Kendrick and Mr. and Mrs. Tom Reavis of the Kendrick Cattle Company for their gracious hospitality which has made this study not only possible but also enjoyable.

AREA OF STUDY

Range grasshopper studies were carried out in 1949 and 1950 on the Kendrick Cattle Company OW Ranch, Decker, Montana. The ranch is located on Hanging Woman Creek in southeastern Bighorn County, Montana. The approximate elevation of the ranch is 3800 feet. The May 1 - August 31, 1949 and 1950, OW Ranch precipitation records were as follows:

	<u>1949</u>	<u>1950</u>
May 1-31	2.17 inches	Not Recorded
June 1-30	1.32 inches	1.36 inches
July 1-31	1.32 inches	2.59 inches
August 1-31	2.51 inches	1.17 inches

The distribution of vegetation in the region is determined by topography and soils. A resistant sandstone stratum caps the higher plateaus and upon weathering produces sandy loam soils. The dominant vegetation on these soils is big sagebrush, Artemisia tridentata Nutt.. Sparse stands of ponderosa pine, Pinus ponderosa Doug., occur along the edges of the plateaus and ravines which cut into them.

The steep slopes below the pines are thinly populated with such plants as big sagebrush, broom snakeweed, Gutierrezia sarothrae (Pursh) B. & R., small soapweed, Yucca glauca Nutt., blue grama, Bouteloua gracilis (HBK) Lag., side-oats grama, Bouteloua curtipendula (Michx.) Torr., little bluestem, Andropogon scoparius Michx., mat muhly, Muhlenbergia richardsonis Merr., june grass, Koeleria cristata (L.) Pers., red three-awn, Aristida longiseta Steud., and various herbaceous plants.

such as slim-flower scurfpea, Psoralea tenuiflora Pursh, prairie clovers, Petalostemon spp., and asters, Aster spp.

The deep, well-drained alluvial deposits which slope gently downward from the steeper eroded slopes support a dominant stand of big sagebrush with june grass, needle-and-thread, Stipa comata Trin. & Rupr., and blue grama.

The hills and benches of lower elevation are capped with beds of baked shale which is called "clinker" or "scoria" by the residents of the area. Practically pure stands of bluebunch wheatgrass, Agropyron spicatum (Pursh) Scribn. & Smith, grow on the gravelly sands, weathered from the "scoria" parent material, present on top of the hills and benches and on steep north-facing slopes.

The sandy loam soils on top of the benches and on the gentler slopes support a dominant stand of needle-and-thread and bluestem, Agropyron smithii Rydb., with some june grass, green needlegrass, Stipa viridula Trin., and blue grama.

Gravelly soils on the steep western and southern slopes are populated with little bluestem, side-oats grama, red three-awn, mat muhly, blue grama, broom snakeweed, and small soapweed.

The clay soil flats and valley bottoms are dominated by bluestem. On the lighter soils surrounding the clay soil flats, green needlegrass becomes more abundant and forms dominant stands. On deep clay soils at lower elevations where subsoil moisture is present, stands of silver sagebrush, Artemisia cana Pursh, and black greasewood, Sarcobatus vermiculatus (Hook.) Torr., are found.

BEHAVIOR STUDIES

Range grasshopper studies commenced in 1949 and 1950 with the first hatch of nymphs in the spring and continued throughout the summer and early fall.

The procedure adopted was to spend as many hours as possible each day observing and recording the behavior of the grasshoppers in the area.

In order to reduce the affect of the observer, it was found that it was necessary to remain as motionless as possible. It was often necessary for the observer to wait as long as 30 minutes after assuming a prone or sitting observational position before the behavior of the grasshoppers in the immediate area returned to what could be considered as normal.

After grasshopper activities returned to normal, the observer remained quiet as long as possible before recording his observations. A new area of observation was then selected and the observational procedure was repeated.

In recording the observations of grasshopper activities care was taken to include only those observations which were not motivated by the presence of the observer and false impressions of feeding caused by the presence of grasshoppers on vegetation were not recorded.

In the discussion of the observed grasshopper activities which follows, the term forb is used to indicate any of the sagebrushes, Artemisia spp., in addition to any broad-leaved herbaceous plant.

Grasshopper populations were measured by the cage method described in the section on grasshopper damage studies.

Following the discussion of each individual species will be found a list of the foods which individuals of the species were observed eating. The list is qualitative and does not indicate the number of individuals which were observed feeding, nor the amount consumed. Numbers are used to indicate all instars except the adult which is designated by an "A".

ACRIDINAE

Pseudopomala brachyptera (Scudder):

In 1949 and 1950, Pseudopomala brachyptera (Scudder) was not found on the range study area. An occasional individual was seen, however, in a moist bluestem, Agropyron smithii Rydb., meadow adjacent to the area of study.

P. brachyptera was seen only as an adult. The few individuals observed were found eating succulent bluestem growing near a creek which bounded the meadow.

Mermiria maculipennis macclungi Rehn:

Mermiria maculipennis macclungi Rehn was found in small numbers in the area of study in 1949 and 1950. The 1949 hatching date of this grasshopper was not recorded. In 1950, the first hatch of M. macclungi was approximately June 1, and the first adult was found July 25.

M. macclungi was found to be a grass-feeding grasshopper which fed on many of the grass species found in the area. It was most numerous, however, on the tall bunch grasses of the side hills and on the tall grasses growing in the deep coulees.

The nymphs and adults generally remained high on vegetation during periods of reduced light or low temperatures when the majority of other grasshoppers were found inactive on the ground.

The adult males appeared to spend very little time feeding as compared to the time spent feeding by the females. The males moved constantly from plant to plant and quickly responded to the presence of the observer while the females of this species apparently did not react in this manner.

<u>Instar</u>	<u>Food</u>
4th, 5th	Dry cow manure
A	Soil

Family: Gramineae

4th through A	1. Mat Muhly, <u>Muhlenbergia richardsonis</u> Merr. a. Green leaves
3rd through A 3rd	2. Green Needlegrass, <u>Stipa viridula</u> Trin. a. Green leaves b. Green head
2nd through A 4th	3. Needle-and-Thread, <u>Stipa comata</u> Trin. & Rupr. a. Green leaves b. Dry leaf
A	4. Prairie Sand Reedgrass, <u>Calamovilfa longifolia</u> (Hook.) Scribn. a. Green leaves
A	5. Red Three-awn, <u>Aristida longiseta</u> Steud. a. Green leaves
A	6. Sand Dropseed, <u>Sporobolus cryptandrus</u> (Torr.) A. Gray a. Green leaves

- 2nd through A
A
7. Bluestem, Agropyron smithii Rydb.
a. Green leaves
b. Dry leaves
- 1st through A
8. Bluebunch Wheatgrass, Agropyron spicatum (Pursh)
Scribn. & Smith
a. Green leaves
- 1st through A
9. Side-oats Grama, Bouteloua curtispindula (Michx.) Torr.
a. Green leaves
- 2nd, A
10. Blue Grama, Bouteloua gracilis (HBK) Lag.
a. Green leaves
- 3rd through A
11. Little Bluestem, Andropogon scoparius Michx.
a. Green leaves

Opeia obscura (Thomas):

The 1949 hatching date of *Opeia obscura* (Thomas) in the area of study was not recorded. In 1950, the first hatch of this grasshopper was June 21, and the first adult was noted July 21.

Griddle (1933) lists *O. obscura* as a grass-feeding species whose food preference is bluestem. Isely (1946), from cage studies of differential feeding by grasshoppers, states that *O. obscura* ate buffalo grass, Bermuda grass, Andropogon, Stipa, and Aristida. He further states that this insect inhabits "short and procumbent grasses and lives upon or underneath these grasses."

The field observations made in 1949 and 1950 confirm the statements that *O. obscura* is a grass-feeding species. Bluestem, however, was not the preferred food-plant of this species. Both the nymphs and adults preferred blue grama and were always more numerous in the areas in which this plant grew.

In addition to feeding on blue grama, O. obscura was observed eating some of the other grasses found in the blue grama areas. It was never seen feeding on plant debris and only two nymphs were observed feeding on dry cow manure.

<u>Instar</u>	<u>Food</u>
4th	Dry cow manure
	Family: Gramineae
A	1. Mat Muhly, <u>Muhlenbergia richardsonis</u> Merr. a. Green leaf
3rd	2. Junegrass, <u>Koeleria cristata</u> (L.) Pers. a. Green leaf
4th through A	3. Green Needlegrass, <u>Stipa viridula</u> Trin. a. Green leaf
4th through A	4. Needle-and-Thread, <u>Stipa comata</u> Trin. & Rupr. a. Green leaves
2nd through A	5. Bluestem, <u>Agropyron smithii</u> Rydb. a. Green leaves
A	b. Dry leaf
A	c. Dry stem
A	d. Green stubble
A	6. Sand Dropseed, <u>Sporobolous cryptandrus</u> (Torr.) A. Gray a. Green leaves
1st through A	7. Blue Grama, <u>Bouteloua gracilis</u> (HBK) Lag. a. Green leaves

Aeropedellus clavatus (Thomas):

Aeropedellus clavatus (Thomas) was found in very low numbers in the area of study in 1949 and 1950. Adults of this species were present when observations started April 22, 1949, and May 19, 1950.

A. clavatus macropterous and brachypterous individuals were found. Macropterous forms were dispersed throughout the study area while brachypterous individuals were confined mainly to the clay soil-bluestem flats.

Macropterous individuals were easily frightened and appeared to be constantly flying or crawling rapidly on the ground. Brachypterous forms were slower in their movements and remained motionless on the ground for long periods of time.

The few observations of feeding by A. clavatus indicate that, as an adult, it is a grass-feeding species. No information on nymphal feeding was obtained.

Instar

Food

Family: Gramineae

- | | |
|---|---|
| A | 1. Sandberg Bluegrass, <u>Poa secunda</u> Presl.
a. Green leaves |
| A | 2. Bluestem, <u>Agropyron smithii</u> Rydb.
a. Green leaves |
| A | 3. Little Bluestem, <u>Andropogon scoparius</u> Michx.
a. Green leaves |

Ageneotettix deorum (Scudder):

Ageneotettix deorum (Scudder) was one of the most numerous grasshoppers found in the study area. During both years of observation, this species could be found in any of the vegetational types of the area. The adults and particularly the nymphs were found in greater numbers on the clay soil-bluestem flats.

A. deorum was one of the first grasshoppers to hatch in the spring. The first hatch noted in 1949 was April 28, and the first hatch in 1950 was May 19. The first adult found in 1950 was on July 12.

The feeding habits and activities of this species appeared to be the same during the two summers they were observed. The first four instars were rather unique in their apparent reluctance to crawl upon plants. They devoured large amounts of dry material found on the ground and, while some green vegetation was consumed, it was usually obtained by reaching as far as possible without allowing the hind legs to leave the ground. Occasionally they crawled upon the plants but the time spent feeding there was short in comparison to that spent by other grasshoppers. If upon a plant, when feeding was completed they returned immediately to the ground and did not rest upon the plant as was the case with many other species observed.

After reaching the fourth instar, A. deorum was more often observed on the plants, and a greater proportion of green vegetation was consumed. They continued, however, to eat dry materials on the ground.

It was a very restless grasshopper. When other species were observed resting in the sun, or remaining quiescent on the ground when the sun was obscured, A. deorum continued to move around on the ground. This was particularly true of adults. When frightened they would jump or fly short distances.

As has been previously mentioned, A. deorum consumed great quantities of dry material on the ground. Usually it was not possible to ascertain whether any specific component of the plant debris was being eaten.

However, in late summer, when grass seeds were being dispersed, the adults were seen eating seeds on the ground.

Allred (1936), in his report of the destruction of big sagebrush by drouth and grasshoppers, quotes Dr. J. R. Parker as saying that the '...two dominant species of grasshoppers were Aulocara elliotti (Thomas) and Ageneotettix deorum (Scudder).', and that: 'It has been our experience that these species will eat sagebrush only as a last resort.'

Only three cases were seen during the two summers of observation which indicate that A. deorum would eat any other vegetation than grass. One fifth instar nymph was seen eating the bark of a big sagebrush plant, one adult was seen eating the spines of plains prickly pear and another adult ate the spines of wavyleaf thistle.

A. deorum was listed by Criddle (1933) as a grass-feeding species which ate "several species" of grass. Observations during the two summers covered by this report agree fully with Criddle's statement. This species was noted feeding on bluestem more than on any other species of grass but there is not sufficient evidence to indicate bluestem as the preferred food-plant.

When the grasses on the clay soil-bluestem flats became very dry in 1949, there was some movement of A. deorum adults away from the flats to the sidehills. There appeared to be no movement into the gullies where the grasses remained green.

After a late summer rain August 18, 1949, the grasses on the flats again became green and A. deorum again returned to the clay soil-bluestem

flats. The adults were particularly fond of the new green growth of A. smithii and were often seen eating it down to the soil surface.

<u>Instar</u>	<u>Food</u>
1st through A	Plant debris
1st through A	Dry cow manure
3rd through A	Soil

Family: Gramineae

1. Japanese Chess, Bromus japonicus Thunb.
 - a. Dry leaves
 - b. Dry stem
 - c. Dry head on the ground
2. Downy Chess Brome, Bromus tectorum L.
 - a. Dry stem
3. Sandberg Bluegrass, Poa secunda Presl.
 - a. Green leaves
4. Bluestem, Agropyron smithii Rydb.
 - a. Green leaves
 - b. Dry leaves
 - c. Green stem
 - d. Dry stem
 - e. Base of green stem
 - f. Green base of drying stem
 - g. Green stubble
 - h. Dry stubble
5. Bluebunch Wheatgrass, Agropyron spicatum (Pursh) Scribn. & Smith
 - a. Green leaves
6. Needle-and-Thread, Stipa comata Trin. & Rupr.
 - a. Green leaves
 - b. Fallen fruit
7. Green Needlegrass, Stipa viridula Trin.
 - a. Green leaves

- A 8. Mat Muhly, Muhlenbergia richardsonis Merr.
A a. Green leaves
b. Head
- A 9. False Buffalo Grass, Munroa squarrosa (Nutt.) Torr.
a. Green leaves
- A 10. Tumblegrass, Schedonnardus paniculatus (Nutt.) Trel.
a. Green stems
- 3rd through A 11. Blue Grama, Bouteloua gracilis (HBK.) Lag.
A a. Green leaves
b. Drying leaves
- A 12. Side-oats Grama, Bouteloua curtipendula (Michx.) Torr.
a. Green leaves
- A 13. Red Three-awn, Aristida longiseta Steud.
a. Green leaves.

Family: Cyperaceae

- A 1. Threadleaf Sedge, Carex filifolia Nutt.
a. Drying stem

Family: Cactaceae

- A 1. Plain Prickly Pear, Opuntia polyantha Haw.
a. Spines

Family: Compositae

- 5th 1. Big Sagebrush, Artemisia tridentata Nutt.
a. Bark
- A 2. Wavyleaf Thistle, Girsium undulatum (Nutt.) Spreng.
a. Spines

Drepanopterna femoratum (Scudder):

Drepanopterna femoratum (Scudder) nymphs and adults were found chiefly on the clay soil-bluestem flats during the two summers they were observed. The 1949 population was low but in 1950 it was one of the most numerous grasshoppers found in the study area.

The approximate hatching date of D. femoratum in 1949 was May 12, The 1950 hatching date was June 1, and the first adult of this species was found July 12.

D. femoratum is a grass-feeding species. The preferred food-plant appeared to be bluestem, although both the nymphs and adults were observed eating several grass species. Invariably, the nymphs and adults of this grasshopper, in crawling on plants to feed, were observed first climbing upon the plants and then turning around so that the head was toward the ground before feeding.

The nymphs and adults of this species also ate dry materials found on the ground. The older nymphs seemed to include more dry materials in their diet than did the adults.

The older nymphs and particularly the adults of D. femoratum are gregarious. No apparent change in the general feeding activity and movement accompanied the congregation of the nymphs. The adults, however, appeared to be much more active within a band. The males in particular seemed to move about constantly on the ground and all adults were more easily frightened when they were in these bands. When frightened the adults either flew for short distances or jumped and crawled on the ground. The movements of the bands were confined to the clay soil-bluestem flats. There was some movement toward the greener areas of the flats as the grasses became dry but there was little movement into the gullies and side hills as was noted with some of the other species of grasshoppers present.

<u>Instar</u>	<u>Food</u>
3rd through A	Plant debris
3rd through A	Dry cow manure
3rd through A	Soil

Family: Gramineae

4th through A	1. Junegrass, <u>Koeleria cristata</u> (L.) Pers. a. Green leaves
3rd through A	2. Downy Chess Brome, <u>Bromus tectorum</u> L. a. Drying leaves
3rd, 4th	3. Japanese Chess, <u>Bromus japonicus</u> Thunb. a. Dry heads
A 4th	4. Green Needlegrass, <u>Stipa viridula</u> Trin. a. Green leaves b. Dry tip of leaf
3rd through A	5. Needle-and-Thread, <u>Stipa comata</u> Trin. & Rupr. a. Green leaves
2nd	6. Sandberg Bluegrass, <u>Poa secunda</u> Presl. a. Green leaves
4th	7. Tumblegrass, <u>Schedonnardus paniculatus</u> (Nutt.) Trel. a. Green leaf
1st through A A A A A A	8. Bluestem, <u>Agropyron smithii</u> Rydb. a. Green leaves b. Dry leaves c. Green stem d. Dry stem e. Green stubble f. Dry stubble
5th	9. Bluebunch Wheatgrass, <u>Agropyron spicatum</u> (Pursh) Scribn. & Smith a. Green leaf
3rd through A	10. Blue Grama, <u>Bouteloua gracilis</u> (HBK) Lag. a. Green leaves
A	11. Little Bluestem, <u>Andropogon scoparius</u> Michx. a. Green leaf

Aulocara ellioti (Thomas):

The big-headed grasshopper, Aulocara ellioti (Thos.), was found in limited numbers in the area of study in 1949 and 1950. The nymphs and adults were confined mainly to the clay soil-bluestem flats and appeared to be more numerous in areas of lighter textured soil within the flats.

The approximate date of hatch for this species in 1949 was May 12. In 1950 the date of hatch was May 22, and the first adult was found July 6.

From field observations, both Griddle (1933) and Pfadt (1949b) have stated that A. ellioti is a grass-feeding species which feeds on several species of grass. Pfadt (1949b) has stated further that, from detailed observations in an area in which the two dominant grasses were bluestem and Sandberg bluegrass, the first two instars fed chiefly on Sandberg bluegrass and the older instars and adults fed almost entirely on bluestem.

A. ellioti nymphs and adults were observed in 1949 and 1950 feeding on several species of grass. In the areas in which observations were made, bluestem was the dominant vegetation and appeared to be the main food plant of both the nymphs and adults. Other grass species in the area were found in much less density than bluestem. Sandberg bluegrass could be considered to be rare. Nymphs and adults were never observed feeding on forbs or shrubs.

In 1949, it was noted that several of the grasshopper species which were numerous on the clay soil-bluestem flats moved to areas of green vegetation when the bluestem became dry. A. ellioti, however, remained

on the flats and ate dry bluestem until this grass again became green following a late summer rain.

<u>Instar</u>	<u>Food</u>
4th through A	Plant debris
4th through A	Dry cow manure
A	Soil
	Family: Gramineae
3rd, 4th	1. Japanese Chess, <u>Bromus japonicus</u> Thunb. a. Green leaves
A	2. Green Needlegrass, <u>Stipa viridula</u> Trin. a. Green leaves
3rd through A	3. Needle-and-Thread, <u>Stipa comata</u> Trin. & Rupr. a. Green leaves
3rd, 4th	4. Junegrass, <u>Koeleria cristata</u> (L.) Pers. a. Green leaves
1st through A	5. Bluestem, <u>Agropyron smithii</u> Rydb. a. Green leaves
3rd through A	b. Dry leaves
A	c. Green stems
A	d. Dry stems
A	e. Green stubble
A	f. Dry stubble
4th through A	6. Blue Grama, <u>Bouteloua gracilis</u> (HBK) Lag. a. Green leaves

Family: Cyperaceae

- | | |
|---|---|
| A | 1. Threadleaf Sedge, <u>Carex filifolia</u> Nutt.
a. Stems |
|---|---|

Eritettix tricarinatus (Thomas):

Few Eritettix tricarinatus (Thomas) were observed in the study area in 1949. No observations of its habits were made in 1950.

E. tricarinatus third instar nymphs were present when observations started April 22, 1949. These nymphs and the adults which followed were not observed feeding.

E. tricarinatus hatched approximately September 8, 1949. The first three instars of this species were observed eating the green leaves of blue grama, Bouteloua gracilis (HBK) Lag., before observations ended September 23, 1949.

Acrolophitus hirtipes (Say):

Only an occasional Acrolophitus hirtipes (Say) was seen in the area in 1949 and 1950. Most of those observed were on gently sloping, gravelly, southern exposures.

Criddle (1933) states: "Acrolophitus hirtipes (Say), so far as we have been able to ascertain, subsists almost exclusively upon members of the Boraginaceae."

Only two individuals of this species were observed feeding during the two years of observation. One was a fifth instar nymph and the other an adult. Both were eating the leaves of western tickweed, Lappula redowskii (Hornem.) Green, a member of the family Boraginaceae.

A. hirtipes adults were easily frightened. The early adults appeared to be poor fliers and, when frightened, jumped and crawled rapidly on the ground. It was noted, however, that the older adults observed at the time of oviposition were excellent fliers, and when frightened, rapidly flew away.

Amphitornus coloradus (Thomas):

The hatching date of Amphitornus coloradus (Thomas) was not recorded in 1949. The 1950 hatching date of this species was May 22, and the first adult was found July 8.

As has been stated by Criddle (1933), A. coloradus is a grass-feeding species which will eat several species of grass. During the two summers of observation this grasshopper, both as a nymph and as an adult, ate needle-and-thread in preference to any of the other grasses found in the area. A. coloradus was found only in needle-and-thread areas and the other grasses it was observed eating were found in these areas.

In addition to feeding on grass vegetation, the older nymphs and adults of A. coloradus were observed feeding occasionally on dry materials found on the ground.

Instar

Food

5th through A

Plant debris

5th

Dry cow manure

Family: Gramineae

A

1. Mat Muhly, Muhlenbergia richardsonis Merr.
a. Green leaves

4th

2. Junegrass, Koeleria cristata (L.) Pers.
a. Green leaf

4th, A

3. Green Needlegrass, Stipa viridula Trin.
a. Green leaves

- 1st through A
A
2nd, 3rd
2nd, 3rd
2nd, 3rd
4. Needle-and-Thread, Stipa comata Trin. & Rupr.
a. Green leaves
b. Dry leaves
c. Green stems
d. Green sheaths
e. New awns
- 1st
5. Japanese Chess, Bromus japonicus Thunb.
a. Green leaf
- 2nd through A
6. Bluestem; Agropyron smithii Rydb.
a. Green leaves
- A
7. Blue bunch Wheatgrass, Agropyron spicatum (Pursh) Scribn. & Smith
a. Green leaf
- A
8. Sand Dropseed, Sporobolus cryptandrus (Torr.) A. Gray
a. Green leaf
- 5th, A
9. Side-oats Grama, Bouteloua curtipendula (Michx.) Torr.
a. Green leaves
- 5th, A
10. Blue Grama, Bouteloua gracilis (HBK) Lag.
a. Green leaves
- A
3rd, 4th
11. Red Three-awn, Aristida longiseta Steud.
a. Green leaf
b. Green stem

Family: Cyperaceae

- A
1. Threadleaf Sedge, Carex filifolia Nutt.
a. Drying stem

Phlibostroma quadrimaculatum (Thomas):

Phlibostroma quadrimaculatum (Thomas) appeared in low numbers in the area of study in 1949 and 1950. The nymphs and adults of this species were confined to localized areas in which blue grama was the dominant vegetation.

In accordance with the work of Isely (1944) on the correlation between the morphology of grasshopper mandibles and food specificity

and the observations of Griddle (1933), P. quadrimaculatum was found to be a grass-feeding species. Blue grama was very definitely the preferred food-plant for both nymphs and adults of this grasshopper. It fed only slightly on four of the other grass species in the area.

Neither the nymphs nor the adults were ever observed feeding on dry materials on the ground.

Instar

Food

Family: Gramineae

- | | |
|---------------|--|
| 5th, A | 1. Needle-and-Thread, <u>Stipa comata</u> Trin. & Rupr.
a. Green leaves |
| 5th, A | 2. Sand Dropseed, <u>Sporobolus cryptandrus</u> (Torr.) A. Gray
a. Green leaves |
| 3rd through A | 3. Bluestem, <u>Agropyron smithii</u> Rydb.
a. Green leaves |
| 5th | 4. Side-oats Grama, <u>Bouteloua curtipendula</u> (Michx.) Torr.
a. Green leaf |
| 2nd through A | 5. Blue Grama, <u>Bouteloua gracilis</u> (HBK) Lag.
a. Green leaves |

Cordillacris crenulata (Bruner):

Only an occasional Cordillacris crenulate (Bruner) was seen in the area of study in 1949 and 1950. This grasshopper was found only on or near blue grama, Bouteloua gracilis (HBK) Lag.

Very few observations of the feeding habits of C. crenulata nymphs and adults were made. Blue grama was the only plant upon which this species was seen feeding.

OEDIPODINAE

Encoptolophus costalis (Scudder):

Encoptolophus costalis (Scudder) appeared in very small numbers and only on the clay soil-bluestem flats of the study area in 1949 and 1950.

Criddle (1933) lists E. costalis among the grass-feeding grasshopper species which fed on several species of grass.

Very few observations of the activities of E. costalis were made in 1949 and 1950. The nymphs and adults of this species were only seen eating bluestem. It remained on the clay soil-bluestem flats after the grasses became very dry and ate dry bluestem stubble.

<u>Instar</u>	<u>Food</u>
	1. Bluestem, <u>Agropyron smithii</u> Rydb.
3rd though A	a. Green leaves
A	b. Dry leaves
A	c. Green stubble
A	d. Dry stubble

Hippiscus rugosus (Scudder):

Hippiscus rugosus (Scudder) was found in low numbers on the gravelly south and west slopes of the study area. The 1949 hatching date of this species was not recorded; however, in 1950, the approximate hatching date was June 21, and the first adult H. rugosus was found August 4.

H. rugosus is a grass-feeding species which was observed eating several species of grass. The younger nymphs confined their feeding

mainly to blue grama. As they developed other grasses were included in their diet.

H. rugosus nymphs and adults were never observed eating plant debris. The late nymphs and adults of this species, however, often cut off dry upright grass stems. Occasionally an adult would also cut off a green grass stem.

<u>Instar</u>	<u>Food</u>
A	Soil
A	Grasshopper Exuviae
A	1. Mat Muhly, <u>Muhlenbergia richardsonis</u> Merr. a. Green head
4th	2. Junegrass, <u>Koeleria cristata</u> (L.) Pers. a. Green leaves
5th, A	3. Downy Chess Brome, <u>Bromus tectorum</u> L. a. Dry stems
2nd, 3rd, A A	4. Needle-and-Thread, <u>Stipa comata</u> Trin. & Rupr. a. Green leaves b. Green stem
4th, A	5. Green Needlegrass, <u>Stipa viridula</u> Trin. a. Green leaves
A	6. Red Three-awn, <u>Aristida longiseta</u> Steud. a. Green leaves
5th A	7. Bluestem, <u>Agropyron smithii</u> Rydb. a. Green leaf b. Green stubble
4th, A A	8. Bluebunch Wheatgrass, <u>Agropyron spicatum</u> (Pursh) Scribn. & Smith a. Green leaves b. Green stems
A	9. Tumblegrass, <u>Schedonnardus paniculatus</u> (Nutt.) Trel. a. Green leaf

- 4th through A
A
10. Side-oats Grama, Bouteloua curtipendula (Michx.) Torr.
a. Green leaves
b. Green stem
- 1st through A
11. Blue Grama, Bouteloua gracilis (HBK) Lag.
a. Green leaves
- 2nd, 3rd, A
12. Little Bluestem, Andropogon scoparius Michx.
a. Green leaves

Arphia pseudonietana (Thomas):

Small numbers of Arphia pseudonietana (Thomas) were found throughout the area of study in 1949 and 1950.

Nymphs were confined mainly to the clay soil-bluestem flats. The adults, however, were dispersed throughout the area of study.

It is listed by Criddle (1933) among the mixed-feeding grasshoppers which ate mostly grass. Isely (1944) also lists it as a mixed-feeding species on the basis of mandibular morphology.

During the two years observations were made, A. pseudonietana nymphs and adults were observed feeding on several grass species but were never seen eating forbs.

A. pseudonietana nymphs were rarely seen on the ground and were never observed feeding on plant debris. The nymphs remained on grass plants for long periods of time and seemed to eat great quantities of green vegetation.

In contrast to the nymphs, the adults spent very little time on plants. They were easily frightened and constantly moved about. Their movement was characterized by flying followed by rapid crawling on the ground. Because of their constant movement, the adults apparently ate

very little; their feeding being confined to a few bites of either dry material on the ground or green vegetation. A. pseudonietana adults showed some preference for junegrass although it was observed feeding on several of the grass species growing in the area.

Instar

Food

A

Plant debris

A

Soil

Family: Gramineae

A

1. Mat Muhly, Muhlenbergia richardsonis Merr.
a. Green leaves

2nd, 3rd

2. Downy Chess Brom, Bromus tectorum L.
a. Leaves

5th, A

3. Green Needlegrass, Stipa viridula Trin.
a. Green leaves

5th, A

4. Needle-and-Thread, Stipa comata Trin. & Rupr.
a. Green leaves

A

5. Junegrass, Koeleria cristata (L.) Pers.
a. Green leaves

2nd through A

6. Bluestem, Agropyron smithii Rydb.
a. Green leaves

A

b. Dry leaf

A

c. Dry stubble

2nd through A

7. Blue Grama, Bouteloua gracilis (HBK) Lag.
a. Green leaves

4th, 5th

8. Side-oats Grama, Bouteloua curtipendula (Michx.) Torr.
a. Green leaves

Family: Cyperaceae

A

1. Threadleaf Sedge, Carex filifolia Nutt.
a. Green stem

Hadrotettix trifasciatus (Say):

Hadrotettix trifasciatus (Say) was found in limited numbers throughout the area of study in 1949 and 1950. Among the first species to hatch in the spring, H. trifasciatus appeared to be one of the slowest grasshoppers in developing. The 1949 hatching date was not recorded; however, the hatching date in 1950 was May 22. Although Amphitornus coloradus (Thomas.) also hatched on this date, H. trifasciatus did not reach the adult stage until July 17, nine days after the first adult A. coloradus was noted.

H. trifasciatus has been listed by Criddle (1933) among the grasshopper species feeding on broad-leaved plants. Isely (1938), from feeding tests under cage conditions, listed two forbs as host plants of this species.

Field observations of the nymphal and adult feeding habits of this slow moving grasshopper show that it confines its feeding to forbs and dry materials found on the ground.

Isely (1946), in studying the differential feeding of various grasshoppers under cage conditions, states that: "although H. trifasciatus was the largest of the five acridian species here studied, the amount of green leaves consumed was less than that eaten by any of the other four species." It also seems to eat very little green vegetation under field conditions. Most of the time was spent crawling on the ground. Occasionally it stopped to eat dry material found on the ground but only on rare occasions crawled upon green vegetation to feed. The green forbs eaten were usually short and easily reached from the ground.

H. trifasciatus was the most cannibalistic of the grasshoppers found in the area. In addition to eating large numbers of dead grasshoppers it was noted on several occasions eating grasshoppers which were still alive but sluggish in their behavior. On one occasion an adult crawled upon a plant and pulled an adult Melanoplus bivittatus (Say) to the ground and started to eat it. The M. bivittatus adult crawled back on the plant but was immediately pulled back to the ground. This action was repeated several times before the adult M. bivittatus was finally killed and eaten.

<u>Instar</u>	<u>Food</u>
1st through A	Plant debris
1st through A	Dry cow manure
A	Live grasshopper
A	Dead grasshopper
3rd through A	Soil

Family: Gramineae

- | | |
|---|--|
| A | 1. Bluestem, <u>Agropyron smithii</u> Rydb.
a. Short green stubble |
| A | 2. False Buffalo Grass, <u>Munroa squarrosa</u> (Nutt.) Forr.
a. Leaves |

Family: Solanaceae

- | | |
|---|--|
| A | 1. Cutleaf Nightshade, <u>Solanum triflorum</u> Nutt.
a. Green leaves |
| A | b. Green stem |

Family: Portulacaceae

- A
A
1. Common Purslane, Portulaca oleracea L.
 - a. Dry leaves
 - b. Root

Family: Liliaceae

- 4th, 5th
4th, 5th
1. Meadow Deathcamus, Zygadenus venenosus S. Wats.
 - a. Green leaves
 - b. Green stem

Family: Onagraceae

- 3rd through A
4th
1. Scarlet Gaura, Gaura coccinea Pursh.
 - a. Green leaves
 - b. Flowers

Family: Cactaceae

- 3rd through A
1. Plain Prickly Pear, Opuntia polykantha Haw.
 - a. Blossoms

Family: Plantaginaceae

- 4th
1. Woolly Indianwheat, Plantago purshii Roem. & Schult.
 - a. Head

Family: Chenopodiaceae

- A
1. Nuttall Monolepis, Monolepis nuttalliana (R. & S.) Engelm.
 - a. Green leaves

Family: Compositae

- A
A
A
1. Meadow Salsify, Tragopogon pratensis L.
 - a. Green leaves
 - b. Green stem
 - c. Blossoms

- A
2. Rush Skeltonplant, Lygodesmia juncea Don.
 - a. Green stem

Family: Polygonaceae

- A
A
1. Prostrate Knotweed, Polygonum aviculare L.
 - a. Green leaves
 - b. Green stems

Family: Loasaceae

- 5th
A
1. Tenpetal Mentzelia, Mentzelia decaptela (Pursh.)
Urban & Gilg.
 - a. Leaves
 - b. Blossoms

 2. Mentzelia, Mentzelia oligosperma Nutt.
 - a. Leaves
- 3rd through A

Spharagemon equale (Say):

Spharagemon equale (Say) was found throughout the area of study in 1949 and 1950, but was never numerous.

The 1949 hatching date was not recorded. The observed hatching date in 1950 was June 21, and the first adult of this species was found July 20.

Criddle (1933) placed S. equale among the species feeding on broad leaved plants. He stated further: "The insect is a trifle specialized in its food proclivities, partaking very sparingly of grasses but showing a marked preference for the Cruciferae." On the basis of mandibular morphology, Isely (1944) has also placed S. equale among the forb-feeding grasshoppers. Treherne and Buckell (1924), on the other hand, reported that it caused considerable damage to bunch grass.

In 1949 and 1950 S. equale was observed feeding on both the grasses and forbs found in the area of study. There was no indication of preference for either.

Adults were often seen congregated in small groups in vegetation-free areas. When frightened, they flew away but within a short time reassembled.

<u>Instar</u>	<u>Food</u>
3rd through A	Plant debris
A	Dry cow manure
A	Dead grasshoppers
A	Soil

Family: Gramineae

- | | |
|------------------------------|---|
| A | 1. Mat Muhly, <u>Muhlenbergia richardsonis</u> Merr.
a. Green heads |
| A | 2. Junegrass, <u>Koeleria cristata</u> (L.) Pers.
a. Dry leaf |
| 3rd through A
A | 3. Green Needlegrass, <u>Stipa viridula</u> Trin.
a. Green leaves
b. Green stubble |
| 3rd through A
A | 4. Needle-and-Thread, <u>Stipa comata</u> Trin. & Rupr.
a. Green leaves
b. Dry stem |
| 1st through A
A
A
A | 5. Bluestem, <u>Agropyron smithii</u> Rydb.
a. Green leaves
b. Dry leaves
c. Green stubble
d. Dry stubble |
| A | 6. Blue Grama, <u>Bouteloua gracilis</u> (HBK) Lag.
a. Green head |

Family: Cyperaceae

- | | |
|--------|---|
| A
A | 1. Threadleaf Sedge, <u>Carex filifolia</u> Nutt.
a. Green stem
b. Dry stem |
|--------|---|

Family: Liliaceae

- | | |
|---|---|
| A | 1. Small Soapweed, <u>Yucca glauca</u> Nutt.
a. Green leaves |
|---|---|

Family: Solanaceae

- 4th through A 1. Cutleaf Nightshade, Solanum triflorum Nutt.
a. Green leaves

Family: Onagraceae

- A 1. Scarlet Gaura, Gaura coccinea Pursh
a. Green leaf

Family: Compositae

- A 1. Fringed Sagebrush, Artemisia frigida Willd.
a. Dry stem

- A 2. Dotted Gayfeather, Liatris punctata Hook.
a. Green leaf

Family: Leguminosae

- A 1. Slimflower Scurfpea, Psoralea tenuiflora Pursh
a. Green leaf

- A 2. Purple Prairieclover, Petalostemon purpureus (Vent.) Rydb.
a. Green leaf

Spharagemon collare (Scudder):

Few Spharagemon collare (Scudder) were found in the study area in 1949, and none were found in 1950.

The 1949 hatching date was not recorded but it appeared later than Spharagemon equale (Say).

Griddle (1933) listed S. collare among the mixed-feeding grasshopper species which eats mostly grass. The few observations of the feeding of S. collare in 1949 seem to bear out Griddle's statement.

Instar

Food

4th through A

Plant debris

Family: Gramineae

- 1. Bluestem, Agropyron smithii Rydb.
 - 4th through A a. Green leaves
 - 4th through A b. Dry leaves

Family: Polygonaceae

- 1. Prostrate Knotweed, Polygonum aviculare L.
 - A a. Leaves

Trimerotropis campestris McNeil:

Only an occasional Trimerotropis campestris McNeil was found in the area of study during the two years observations were made.

The 1949 hatching date was not recorded. The first hatch of T. campestris in 1950 was approximately July 21.

Criddle (1933) placed T. campestris among mixed-feeding grasshopper species.

It was very difficult to make observations of the activities of T. campestris because of the superficial resemblance between this grasshopper and Spharagemon equale (Say). Close observations indicated, however, that T. campestris is a mixed-feeding species.

Instar

Food

4th through A Plant debris

A Dead grasshoppers

Family: Gramineae

- 1. Green Needlegrass, Stipa viridula Trin.
 - A a. Green leaves
- 2. Japanese Chess, Bromus japonicus Thunb.
 - 4th a. Green Leaves

4th through A 3. Bluestem, Agropyron smithii Rydb.
a. Green leaves

A 4. Blue Grama, Bouteloua gracilis (HBK) Lag.
a. Green leaves

Family: Solanaceae

4th through A 1. Cutleaf Nightshade, Solanum triflorum Nutt.
a. Leaves

Family: Leguminosae

4th through A 1. Slimflower Scurfpea, Psoralea tenuiflora Pursh
a. Green leaves

Family: Loasaceae

A 1. Tenpetal Mentzelia, Mentzelia decapetala (Pursh)
Urban & Gilg.
a. Leaves

Trimerotropis bruneri McNeill:

Trimerotropis bruneri McNeill appeared in the area of study in 1949 and 1950 in very low numbers.

The 1949 hatching date was not recorded. The first hatch noted in 1950 was July 14.

No observations of the feeding habits of T. bruneri were made in 1949. Scanty observations in 1950, however, indicate that the adult of this grasshopper is a forb-feeder.

Instar

Food

A

Plant debris

Family: Polemoniaceae

A 1. Hoods Phlox, Phlox hoodii Rich.
a. leaves

Family: Loasaceae

1. Tenpetal *Mentzelia*, *Mentzelia decapetala* (Purch)
Urban & Gilg.

- A a. Leaves
- A b. Blossoms

Derotmema haydenii haydenii (Thomas):

A few *Derotmema haydenii haydenii* (Thomas) were found in two old prairie dog towns found in the area of study.

The 1949 hatching date was not recorded. In 1950 the first hatch was approximately July 1, and the first adult was found July 31.

Nymphs and adults were found most commonly on common purslane and to a lesser extent on prostrate knotweed. Both of these plants were found growing around old prairie dog holes.

Dry materials on the ground were not eaten until the common purslane and prostrate knotweed had become very dry. At this time *D. haydenii* adults were also observed feeding occasionally on short dry stubble of bluestem and, after a late summer rain August 18, 1949. on the new green growth of bluestem.

<u>Instar</u>	<u>Food</u>
A	Plant debris
A	Cow manure

Family: Gramineae

1. Bluestem, *Agropyron smithii* Rydb.

- A a. New green growth
- A b. Dry stubble

