Lee E. Rogers
and
Daniel W. Uresk

Ecosystems Department, Battelle-Northwest
Pacific Northwest Laboratories
Richland, Washington

Food Plant Selection by the Migratory Grasshopper (*Melanoplus sanguinipes*) within a Cheatgrass Community[1]

Abstract

A dietary analysis was made of a migratory grasshopper population within a cheatgrass (*Bromus tectorum*) community located on the Arid Land Ecology (ALE) Reserve within the boundaries of the Atomic Energy Commission's Hanford Reservation in southeastern Washington. Microscopic identification of plant fragments taken from the gut of *Melanoplus sanguinipes* was used to determine food-plant selection.

Thirteen plant taxa were identified from the gut contents. The most frequently encountered plants were prickly lettuce, *Lactuca serriola*, and yellow salsify, *Tragopogon dubius*, with frequencies of 26 and 23 percent, respectively. Bluebunch wheatgrass, *Agropyron spicatum*, cheatgrass, *Bromus tectorum*, lanceleaf microseris, *Microseris laciniata*, and Russian thistle, *Salsola kali*, had frequencies in the range of 9 percent to 12 percent. Cheatgrass occurred with a 100 percent frequency in field plots, but with only 11 percent frequency in grasshopper-gut contents. Prickly lettuce occurred with a frequency of less than 1 percent in field plots, but with a 26 percent frequency in grasshopper gut. Clearly, grasshoppers were selective of the plants eaten. The late-blooming plants with the ability to remain partially green and succulent after the onset of soil drought were consumed more frequently.

Introduction

Grasshoppers are frequently abundant components of grasslands and occasionally occur in such numbers as to pose a serious economic threat to rangelands (Stoddart and Smith, 1955). They are generally considered to be nonselective, consuming all types of vegetation; but in a recent review of the food habits of grasshoppers, Mulkern (1967) concluded that they are selective, although the expression of selectivity may be determined in part by the habitat.

An "outbreak" of the migratory grasshopper (*Melanoplus sanguinipes* F.) occurred during 1972 on the Arid Lands Ecology (ALE) Reserve. This population was selected for our initial effort in defining the food habits of major free-living consumers.

Study Area

The ALE Reserve encompasses about 120 square miles of predominantly native vegetation and is located within the boundaries of the Atomic Energy Commission's Hanford Works Reservation near Richland, Washington. The study area is located in an old field which was abandoned about 30 years ago, when the Hanford Works Reservation was established, and has not been cultivated since. The vegetation is comprised of more or less even swards of the annual grass *Bromus tectorum* L., although the field is surrounded by large areas of relatively undisturbed vegetation consisting

[1] This paper is based on work supported under United States Atomic Energy Contract AT(45-1)-1830.

of big sagebrush and bluebunch wheatgrass (*Artemisia tridentata* Nutt. and *Agropyron spicatum* (Pursh) Scribn. and J. G. Smith). Over the years the native plants have made little progress in recolonizing this habitat (Rickard, 1972).

Methods Employed

There are several methods of identifying herbivore feeding habits, but one of the most reliable involves the microscopic identification of plant material actually contained within the digestive tract. This method requires a reference collection of all plant taxa present on the study area. Leaves, stems, and reproductive parts are dried, broken up, and mounted on glass microscope slides. These slides then serve as a reference source for the identification of plant fragments contained in the gut of the herbivore of interest. Identification of plant fragments is based on cellular characteristics, primarily the epidermal tissues. This technique of diet analysis was first described by Baumgartner and Martin in 1939 and has received wide application in recent years (Mulkern and Anderson, 1959; Mulkern *et al.,* 1969; Hanson and Ueckert, 1970; Ueckert and Hanson, 1971; Ueckert and Hanson, 1972; and Banfill and Brusven, 1973).

Test slides were prepared for samples of known plant species to measure our ability to properly and consistently identify plant fragments. The similarity between the actual frequency of plant fragments on individual test slides and our frequency estimates was measured using Kulczynski's mathematic expression for similarity (Oosting, 1956),

$$SI = \frac{2w}{a + b}(100)$$

where, SI = the similarity index, w = the lowest value for either a or b, a = the estimated frequency of occurrence, and b = the actual frequency of occurrence. A similarity index of 100 would mean that the estimated frequency was identical to the actual values. In practice, we established a value of 90 as the minimum acceptable SI value. This value was exceeded in most cases after a few days' practice.

Estimates of grasshopper density were made using a ½ m^2 drop trap suspended on a long pole. The trap was carried about shoulder high and quickly set down at preselected points. Grasshoppers and vegetation were removed with a D-Vac suction apparatus and hand sorted in the laboratory. Sweep-net samples were taken within the confines of the old field and in adjacent areas of relatively pristine vegetation to determine if the grasshopper population was limited to the old field or existed throughout the general area. Specimens for dietary analysis were collected with sweep nets on June 8, June 28, July 6, August 7, and August 22, 1972. They were immediately preserved in 95 percent alcohol.

Crops from individual grasshoppers were removed and mounted on glass microscope slides. The slides were dried for about three days prior to further processing. Analysis consisted of "reading" 20 slide locations using a compound microscope of 100-power magnification. A slide location is defined as that area of the slide delimited by the field of view at 100-power magnification. Results may be expressed as frequency of occurrence or as a percent composition for each species. Frequency (number of locations in which the plant species occurs per 100 slide locations) is probably the easiest and most accurate method.

Plant biomass values and frequency of occurrence of plant species on the study area were calculated from collections made during four vegetation sample periods at three-week intervals commencing March 14, 1972. A 1/10 m² quadrat was used for all estimates.

Results and Discussion

Grasshopper nymphs first appeared during late May and peak abundance occurred during early August. An analysis of variance test comparing sweep-net samples within and adjacent to the old field showed that the population build-up was primarily limited to old field conditions ($\alpha = .05$). No significant differences were observed among sample points located within the old field. Quantitative sampling—using the drop trap technique—showed that population density increased from near zero on June 8 to a maximum of about 50/m² in early August.

Plant frequency in the study area and in grasshopper-gut contents is shown in Table 1. Those species occurring in more than 30 percent of field sample plots were:

TABLE 1. Frequency of plant fragments in the grasshopper gut compared with frequency of plant taxa in the study area.

Plant Taxa		Diet Frequency[1]	Field Frequency
		Percent	
Prickly lettuce	*Lactuca serriola*	26	<1
Yellow salsify	*Tragopogon dubius*	23	44
Bluebunch wheatgrass	*Agropyron spicatum*	12	<1
Cheatgrass	*Bromus tectorum*	11	100
Lanceleaf microseris	*Microseris laciniata*	10	46
Russian thistle	*Salsola kali*	9	<1
Slender hawksbeard	*Crepis atrabarba*	4	<1
Tumble mustard	*Sisymbrium altissimum*	3	8
Sixweeks fescue	*Festuca octoflora*	1	<1
Sandberg bluegrass	*Poa secunda*	1	1
Spring draba	*Draba verna*	<1	1
Jagged chickweed	*Holosteum umbellatum*	<1	31
Dandelion	*Taraxacum officinale*	1	<1

[1] Results expressed as percent frequency (number of microscopic locations out of 100 sample points in which a particular species occurred) from a total of 131 grasshoppers.

cheatgrass, jagged chickweed, yellow salsify, and lanceleaf microseris. Tumble mustard occurred in only 8 percent of the plots. Other plants occurred in 1 percent or fewer of the sampled areas. Peak standing-crop biomass values (g/m² $\pm$ SE) for major species were: cheatgrass, 13.2 $\pm$ 0.7; lanceleaf microseris, 1.4 $\pm$ 1.1; tumble mustard, 0.1 $\pm$ 0.0; jagged chickweed, 0.8 $\pm$ 0.2; and yellow salsify, 0.6 $\pm$ 0.2. Other species occurred in trace amounts.

Melanoplus sanguinipes has been reported as a polyphagous feeder (Banfill and Brusven, 1973; Mulkern *et al.*, 1969). A truly omnivorous feeder would be expected to consume plants in approximately the same relation as their occurrence in the environment. In other words, the grasshoppers would be feeding at random as they moved about so that plant frequency in their gut would approximate plant frequency in the environment. This does not appear to be the case for the migratory grasshopper population in this community. The crop contents of 131 grasshoppers were examined, and plant fragments of 13 species were identified (Table 1). The most common fragments encountered were those from the biennial forbs, yellow salsify, and prickly lettuce (occurring with a frequency of 23 and 26 percent, respectively). Bluebunch wheatgrass, cheatgrass, lanceleaf microseris, and Russian thistle fragments occurred with about equal frequency (9-12 percent). Far fewer particles of cheatgrass, jagged chickweed, lanceleaf microseris, and yellow salsify were found in the gut contents than would be expected from the frequency of their occurrence in the study area. The level of bluebunch wheatgrass, Russian thistle, and prickly lettuce fragments in the gut was higher than expected, indicating that these plants are preferred food items. Other plants were eaten with about the same frequency with which they occur in the study area, indicating a lack of feeding preference. All of the preferred food plants remain at least partially green into the early summer months (Table 2). This fact indicates that plant succulence is a factor influencing food-plant selection by the migratory grasshopper.

TABLE 2. Phenological grouping of plant taxa serving as food materials for the migratory grasshopper.

	Plant Taxa	Comments
	Group 1	
Spring draba Jagged chickweed Sandberg bluegrass	*Draba verna* *Holosteum umbellatum* *Poa secunda*	Early spring flowering (April). Shallow root system, plants become desiccated with onset of soil drought.
	Group 2	
Sixweeks fescue Cheatgrass Tumble mustard	*Festuca octoflora* *Bromus tectorum* *Sisymbrium altissimum*	Mid-spring flowering (May). Plants remain green longer but still become desiccated with onset of soil drought.
	Group 3	
Yellow salsify Prickly lettuce Lanceleaf microseris Bluebunch wheatgrass	*Tragopogon dubius* *Lactuca serriola* *Microseris laciniata* *Agropyron spicatum*	Late spring flowering (late May-early June). Well-developed root system, plants remain partially green and succulent into early summer months.
	Group 4	
Russian thistle	*Salsola kali*	Summer flowering. Extensive root system, succulent in summer.

An understanding of ecosystem structure and function, and associated energy flow and nutrient cycling pathways, is essential to the protection and manipulation of both managed and natural areas. One important biological function in all ecosystems is herbivory, which includes both the consumption and assimilation of matter. Herbivory may be thought of as a control point determining whether material synthesized by plants is transferred to higher trophic levels or is shunted directly to the decomposer portion of the ecosystem. Our interest in herbivory is prompted by the desire to understand more about basic mechanisms governing energy flow and transfer of materials through the system—items of particular interest in areas dedicated to the processing and handling of radioactive waste materials. The importance of individual plant and animal species in governing energy flow and material transfer is often not detected until detailed analysis identifies selective feeding patterns of major consumer groups.

Acknowledgements

Thanks are extended to Dr. Joseph K. Sheldon, Eastern College, St. Davids, Pennsylvania, for help in preparation of plant reference material. Thanks are also due to Norman Woodley and Mary Wise for technical help in data gathering and analysis.

Literature Cited

Banfill, J. C., and M. A. Brusven. 1973. Food habits and ecology of grasshoppers in the Seven Devils Mountains and Salmon River breaks of Idaho. Melanderia 12: 1-33.

Baumgartner, L. L., and A. C. Martin. 1939. Plant histology as an aid in squirrel food-habit studies. J. Wildl. Manage. 3: 266-268.

Fracker, S. B., and J. A. Brischle. 1944. Measuring the local distribution of *Ribes*. Ecology 25: 283-303.

Hansen, R. M., and D. N. Ueckert. 1970. Dietary similarity of some primary consumers. Ecology 51: 640-648.

Mulkern, G. B. 1967. Food selection by grasshoppers. Ann. Rev. Entomol. 12: 59-78.

———, and J. F. Anderson. 1959. A technique for studying the food habits and preferences of grasshoppers. J. Econ. Entomol. 52: 342.

———, K. P. Pruess, H. Knutson, A. F. Hagen, J. B. Campbell, and J. D. Lambley. 1969. Food Habits and Preferences of Grassland Grasshoppers of the North Central Great Plains. North Central Regional Pub. 196. 32 p.

Oosting, H. J. 1956. The Study of Plant Communities. W. H. Freeman and Co., San Francisco. 440 p.

Rickard, W. H. 1972. Rattlesnake Hills research natural area. *In* J. F. Franklin, F. C. Hall, C. T. Dyrness, and C. Maser (eds.). Federal Research Natural Areas in Oregon and Washington. A Guidebook for Scientists and Educators. Pacific Northwest Forest and Range Exp. Sta., Portland, Oregon.

Stoddart, L. A., and A. D. Smith. 1955. Range Management. McGraw-Hill Book Co., Inc., New York. 433 p.

Ueckert, D. N., and R. M. Hansen. 1971. Dietary overlap of grasshoppers on sandhill rangeland in northeastern Colorado. Oecologia 8: 276-295.

———, and R. M. Hansen. 1972. Diet of walkingsticks on sandhill rangeland in Colorado. J. Range Manage. 25: 111-113.

Received April 8, 1974.
Accepted for publication June 12, 1974.