Evaluation of Methods for Screening Grasses for Resistance to Grasshopper Feeding

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Highlight: *A study was initiated to find a rapid method of screening forage plant selections for grasshopper preference. Six grass species both as seedlings and as plants 6 weeks older were fed to nymphs and/or adults of five grasshopper species and one group of nymphs of mixed species. It was concluded that it is feasible to screen plant species in the seedling stage for preference by using grasshopper nymphs because the nymphs selected plant species of both ages equally well and their preferences were similar to those of adults. This allows for more rapid screening of plants than would be the case with older plants and adult grasshoppers.*

Insect resistance in crop plants has been most valuable in reducing damage by various insect pests. This method of control might also be used as a means of reducing damage by rangeland grasshoppers. For this purpose a rapid method of screening forage plants for grasshopper feeding preferences is desirable. As increased emphasis is placed on range rehabilitation any information on methods for screening forage plants for grasshopper feeding preferences will be of assistance to plant breeders and range management personnel.

For example, in recent years, reseeding and interseeding rangeland has often proved profitable in terms of forage production, erosion control, and improvement of soil water-holding capacity (Gomm, 1962; Parker, 1961; and Rauzi et al., 1963). During 1966, approximately 9.8 million dollars was involved in four types of range improvement practices on the public lands in 11 western states by four federal agencies. Approximately 2.1 million of this total was used in seeding programs (Public Land Law Review Commission, 1970).

A number of workers have determined the native preferred food plants for many rangeland grasshopper species based on crop analysis and observations (Isely, 1938; Anderson and Wright, 1952; Brooks, 1958; Lambley, 1967; Ueckert, 1968; Mulkern et al., 1969; Hansen and Ueckert, 1970; and Ueckert et al., 1972). However, studies on forage varieties and species used in reseeding programs and whether or not they are preferred by grasshoppers are limited. Herman and Eslick (1939) reported on the selection of food plants by grasshoppers in a grass field nursery in Pullman, Washington. They found the Standard variety of crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) was damaged considerably more than the Fairway variety. Also, Davis, (1949) studied the feasibility of using crested wheatgrass for regressing field margins in order to crowd out weeds which are attractive as food for certain grasshopper species. Putnam (1962) reported on both native and introduced plants as food for *Camnula pellucida* (Scudder) in western Canada. In Arizona, Nerney and Hamilton, (1967) mention that the grasshopper *Morseiella flaviventris* (Bruner) destroyed 85 to 90% of the seed crop of reseeded lovegrass and sideoats grama. Hewitt (1968, 1969) reported on the resistance of 26 forage plants to feeding by *Melanoplus sanguinipes* (F.). In Kansas, Chu and Knutson (1970) studied the food preferences of eight grasshopper species for 11 species of cultivated grasses. They determined the type of damage (preference for leaves, inflorescence, seeds, etc.) caused by both nymphs and adults of the eight species.

A study was therefore initiated to find a rapid means of screening plant selections for resistance to grasshopper feeding. One objective was to determine which stage of grasshopper development (nymph or adult) and which of two stages of plant development (seedlings or more mature plants) gives the best indication of resistance. A second objective was to check the possibility that one or two grasshopper species might be representative in their preferences of other species with similar food habits, since most economically important species are graminivorous. Reported here are the interactions of nine grasshopper

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Table 1. Relative percentage eaten of six grass species at two phenological stages by nine different groups of grasshoppers.

Plant growth stage	Grasshopper Species	Grasshopper Stage[2]	Grass[1] Stvi	Elju	Agtr	Agda	Dagl	Brin	Mean deviation from avg
Seedling plants									
	A. deorum	A	2.5	10.0	10.5	28.0	21.8	28.0	1.8
	M. sanguinipes	N	4.5	14.8	14.0	28.8	19.8	18.5	3.1
	Mixed	N	6.8	11.0	17.5	28.0	14.8	22.0	3.6
	C. pellucida	N	9.0	14.5	13.5	31.5	20.5	11.2	5.2
	A. deorum	N	3.5	13.0	22.2	31.8	15.0	15.2	6.2
	B. brunnea	A	4.0	5.2	6.5	16.2	30.2	37.8	6.8
	M. sanguinipes	A	3.5	12.0	23.8	34.8	6.5	18.8	7.6
	M. pardalinus	A	4.5	2.0	9.8	12.2	25.2	46.0	8.0
	C. pellucida	A	1.5	1.8	5.0	15.8	37.0	39.5	9.6
Avg seedlings[3]			4.4 a	9.4 ab	13.6 b	25.2 d	21.2 cd	26.3 d	
Advanced plants									
	C. pellucida	A	2.8	11.0	20.2	15.5	23.0	27.8	2.2
	Mixed	N	1.8	8.2	17.5	10.5	31.2	30.8	3.6
	B. brunnea	A	4.0	1.5	25.2	14.5	36.8	18.0	4.5
	A. deorum	N	3.2	6.2	25.5	21.5	27.2	15.8	5.2
	M. sanguinipes	N	.5	8.2	15.8	7.8	30.8	37.0	5.7
	A. deorum	A	3.5	2.0	12.0	20.8	37.2	25.0	5.8
	M. sanguinipes	A	3.2	12.8	16.0	12.8	16.5	38.8	6.3
	M. pardalinus	A	8.0	3.2	30.5	22.2	15.0	21.0	6.6
	C. pellucida	N	1.0	2.2	46.8	6.8	17.5	26.0	7.8
Avg advanced[3]			3.1 a	6.2 a	23.3 d	14.7 bc	26.1 d	26.7 d	
Avg seedlings and advanced			3.8	7.8	18.5	20.0	23.7	26.5	

[1] Stvi = green needlegrass; Elju = Russian wildrye; Agtr = pubescent wheatgrass; Agda = thickspike wheatgrass; Dagl = orchardgrass; Brin = smooth brome.
[2] A = adults; N = nymphs.
[3] Means, both among and between plant ages, accompanied by the same letter do not differ significantly at the 1% level.

groups and six grass species.

Materials and Methods

The six grass species used were selected to represent the range of preference by and resistance to *M. sanguinipes* observed in previous studies (Hewitt, 1968, 1969) and were as follows: green needlegrass (*Stipa viridula* Trin.), thickspike wheatgrass (*Agropyron dasystachyum* (Hook.) Scribn.), smooth brome (*Bromus inermis* Leyss), pubescent wheatgrass (*Agropyron trichophorum* (Link) Richt.), Russian wildrye (*Elymus junceus* Fisch.) and orchardgrass (*Dactylis glomerata* L.). All were seeded in 30.5-cm rows at random across the width of redwood greenhouse flats (one row of each species/flat) that had been divided lengthwise into two equal parts by a board. Thus four flats could be placed together in a rectangular pattern, and a metal-screen cage 101 X 39 X 30 cm could be placed over half of each row within a flat, while the rows outside the cage served as controls; there were four replicates of each grass species per cage. Half of each grass species was planted in May and half 6 weeks later, so seedling plants and more mature plants could be tested at the same time. In all, 72 flats and 18 cages were used. Before a test, the plantings were thinned to insure that both the test and control portions of a row contained comparable amounts of foliage.

When the second planting was in the 2-leaf stage and the first planting consisted of more advanced vegetative growth, the cages were infested with nine groups of rangeland grasshoppers, all of which could be found on shortgrass rangeland in the same habitat: (1) nymphs and (2) adults of *M. sanguinipes*; (3) nymphs and (4) adults of *Ageneotettix deorum* (Scudder); and (5) nymphs and (6) adults of *Camnula pellucida* (Scudder); adults of (7) *Metator pardalinus* (Saussure) and (8) *Bruneria brunnea* (Thomas); and (9) a group of nymphs of mixed rangeland species that ranged from the second to the fourth instar but not necessarily composed of the same species as the other species tested. *M. sanguinipes* is a mixed feeder that eats grasses and forbs (Mulkern et al., 1964). The other species feed mainly on grasses (Anderson and Wright, 1952; Criddle, 1933; Mulkern et al., 1969: Ganwere, 1961 and Brooks, 1958). We assumed that the mixed group of nymphs would consume both grasses and forbs.

The number of grasshoppers used for an infestation ranged from 30 to 300/cage and depended on the developmental stage of the grass, the size of the grasshoppers, and the number of grasshoppers available. More grasshoppers were used on plantings that had the most vegetative growth. The grasshoppers were allowed to feed from 24 to 96 hours, depending on how rapidly they consumed the growing plants, and were removed as soon as an observable range of damage was apparent among the six species of grass but before any one grass species was completely eaten. All testing was done in a greenhouse.

Immediately after the grasshoppers were removed from the cages, the grass from each test and check row was cut at soil level, and oven dried at 74°C. for 24 hours. Then the samples were weighed, and the amount eaten was determined by the difference between test and check rows for each entry. These were added for a replicate and the entry data then converted to a percentage of the total eaten for that replicate. The data were subjected to analysis of variance for detection of differences among grasses. Plant means (within age groups) were compared by use of Duncan's multiple range test.

Results and Discussion

The relative amount eaten of each

grass species by each grasshopper group is reported in Table 1. Consumption varied significantly ($P<.01$) between grass species, and there was a significant interaction between grass age and grass species. Green needlegrass and Russian wildrye sustained significantly less feeding than the other species, both as seedlings and as advanced plants, and did not differ significantly themselves either within or between plant ages. Orchardgrass and smooth brome sustained significantly more feeding than the other species both as seedlings and advanced plants and did not differ either within or between plant ages. The relative amounts of feeding on pubescent wheatgrass and thickspike wheatgrass were significantly different within both plant ages and between plant ages but were reversed in order from seedling to advanced plants. This reversal was the major cause of the indicated interaction between grass age and grass species reported for the total test.

Our results tend to confirm previous observations. For example, Hewitt (1968) reported lower average feeding rates, less weight increase over four generations, and fewer egg pods per female over four generations for *M. sanguinipes* on green needlegrass than on Russian wildrye and thickspike wheatgrass. Also, Hewitt (1969) in working with *M. sanguinipes* and the same six plant species used in the present test found that green needlegrass gave low nymphal feeding in the greenhouse, least adult feeding in the field, least survival, and least weight gain than any other plant species; Russian wildrye also gave very low survival and weight gain.

The analysis of variance did not show significant differences among grasshopper groups, either as a main factor or in interactions, because of the large error variance. An attempt was made, however, to compare the feeding of grasshopper groups within plant ages by calculating the mean deviation of each group from the average of all groups, thus providing an index as to how well a particular grasshopper species and stage represented all grasshopper species and stages tested. Grasshopper groups are arranged by magnitude of deviation from the average for each plant age in Table 1. On seedlings, adult *A. deorum* represented the entire group best, and adult *C. pellucida* was least representative. On advanced plants, adult *C. pellucida* was most representative, and nymphs of *C. pellucida* was least representative.

Conclusions

The results of the tests confirm that grasshoppers exhibit large differences in feeding preference among plant species. On the average, that is for four of the six plant species, these preferences persisted in much the same order at two stages of the plant growth. With very few exceptions, green needlegrass and Russian wildrye were least preferred by all grasshopper species and stages.

No one grasshopper species or age was clearly representative of all groups tested. However, the group of mixed nymphs appeared to select grass species most uniformly and was fairly representative of all grasshopper groups.

We concluded that it is feasible to screen plant species in the seedling stage for preference by using grasshopper nymphs because the nymphs selected plant species of both ages about equally well and their preferences were generally similar to those of adults. This combination would permit more rapid screening than would be the case with older plants and adult grasshoppers, since less time would be required for rearing and maintenance.

Literature Cited

Anderson, N. L., and J. C. Wright. 1952. Grasshopper investigations on Montana range lands. Montana Agr. Exp. Sta. Tech. Bull. 486, 46 p.

Brooks, A. R. 1958. Acridoidea of southern Alberta, Saskatchewan, and Manitoba (Orthoptera). Can. Entomol. Suppl. 9, 90:92 p.

Chu, I-Wu, and H. Knutson. 1970. Preferences of eight grasshopper species among eleven species of cultivated grasses, J. Kans. Entomol. Soc. 43:20-31.

Criddle, N. 1933. Studies in the biology of North American Acrididae-development and habits. Proc. World Grain Exhib. Conf. Canada 2:474-94.

Davis, E. G. 1949. Reducing grasshopper damage by regrassing weedy roadsides and fence rows. U. S. Dep. Agr. Circ. 813. 11 p.

Gangwere, S. K. 1961. A monograph on food selection in Orthoptera. Trans. Amer. Entomol. Soc. 87:67-230.

Gomm, F. B. 1962. Reseeding studies at a small high-altitude park in southwestern Montana. Montana Agr. Exp. Sta. Bull. 568. 16 p.

Hansen, R. M., and D. N. Ueckert. 1970. Dietary similarity of some primary consumers. Ecology 51:640-8.

Herman, W., and R. Eslick. 1939. Susceptibility of seedling grasses to damage by grasshoppers. Amer. Soc. Agron. J. 31:333-337.

Hewitt, G. B. 1968. Resistance of forage plants to the feeding of *Melanoplus sanguinipes*. Ann. Entomol. Soc. Amer. 61:739-744.

Hewitt, G. B. 1969. Twenty-six varieties of forage crops evaluated for resistance to feeding by *Melanoplus sanguinipes*. Ann. Entomol. Soc. Amer. 62:737-741.

Isley, F. B. 1938. The relation of Texas Acrididae to plants and soils. Ecol. Monogr. 8:551-604.

Lambley, J. 1967. Food plant preferences of grasshoppers (Orthoptera: Acrididae) of selected planted pastures in eastern Kansas. Unpubl. MS dissertation, Kansas State Univ., Manhattan.

Mulkern, G. B., D. R. Toczek, and M. A. Brusven. 1964. Biology and ecology of North Dakota grasshoppers. 11. Food habits and preference of grasshoppers associated with the sand hills prairie. North Dakota Agr. Exp. Sta. Res. Rep. 11, 59 p.

Mulkern, G. B., 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 Dakota Agr. Exp. Sta. Bull. No. 481, 30 p.

Nerney, N. J., and A. G. Hamilton. 1967. Field observations of grasshoppers and damage surveys on rangeland of San Rafael Valley, Arizona. U. S. Dep. Agr., Agr. Res. Serv. Special Report Z-202. 13 p.

Parker, K. G. 1961. Seeding and using permanent pastures. Montana Coop. Ext. Serv. Bull. 312, 28 p.

Public Land Law Review Commission. 1970. The forage resource. Public Land Law Review Commission, Washington, D.C. Vol. 2.

Putnam, L. G. 1962. Experiments with some native and introduced plants as food for *Camnula pellucida* (Scudder) in western Canada. Canadian J. Plant Sci. 42:589-595.

Rauzi, F., R. L. Lang, and C. F. Becker. 1963. Interseeding Russian wildrye into native shortgrass rangeland. Wyoming Agr. Exp. Sta. Bull. 406. 8 p.

The Forage Resource, 1970. Public Land Law Review Commission. Wash, D. C. Vol. 2.

Ueckert, D. N. 1968. Seasonal dry weight composition in grasshopper diets on Colorado herbland. Ann. Entomol. Soc. Amer. 61:1539-1544.

Ueckert, D. N., R. M. Hansen, and C. Terwilliger, Jr. 1972. Influence of plant frequency and certain morphological variations on diets of rangeland grasshoppers. J. Range Manage. 25:61-65.