Abundance of Grasshoppers in Relation to Rangeland Renovation Practices

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Highlight: *This study was conducted during a 3-year period, 1969–1971, in northcentral Montana to determine the effect of the rangeland renovation practices of scalping, interseeding, contour furrowing, and spraying sagebrush with 2,4-D and the resulting vegetational changes on grasshopper (Acrididae: Orthoptera) species and abundance. Spraying for control of sagebrush with 2 lb of 2,4-D ester in 6 gal H_2O/acre only slightly reduced grasshopper abundance during the first 3 post-spray years. However, contour furrowing, scalping, and interseeding in general adversely affected the habitat of most grasshopper species, probably because of changes in the abundance of preferred food plants. The influence of parasites, predators, and pathogens on abundance appeared to be slight.*

The production of livestock, the largest source of income in Montana, depends on the grazing of 70% of the land area of the state. Montana has 54 million acres of rangeland and 11½ million acres of grazeable timberland (Jackson, 1970), but approximately 34½ million acres are vegetated by some species of sagebrush (Beetle, 1960). During the last 20 years, the removal of sagebrush has been a primary method of increasing the amount of forage (Pechanec et al., 1965). Another method of increasing forage production is scalping, in which 10 to 25-inch-wide strips of native vegetation to a depth of 4 inches are removed, laid over on adjacent sod, and strips between left undisturbed. When the scalped strips are seeded, the procedure is termed interseeding (Hervey, 1960). However, little attention has been given to the effects on nontarget organisms resulting from these renovation practices. Two separate studies (Parts 1 and 2) were conducted with the main objective to determine the abundance of grasshoppers (Acrididae: Orthoptera) and the fluctuations in species resulting from vegetational changes due to treatment. The influence of parasites, predators, and disease organisms of grasshoppers was also investigated.

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Part 1. Chemical and Mechanical Methods of Controlling Sagebrush

This study was conducted in Petroleum County near Winnett, Montana, in cooperation with the Montana Fish and Game Department and the Bureau of Land Management, U. S. Department of the Interior. Methods of controlling sagebrush included use of chemicals, furrowing, and scalping and interseeding.

Procedures

Although four study areas were established by the agencies that initiated the study, only two (Winnett and King) were used in studying grasshoppers. Within these two areas, the plots used for the study of insects (treated and untreated) were located on vegetational transects laid out on each of the major soil types present.

Measurements of vegetation were made by Montana Fish and Game personnel during the summers of 1967, 1969, and 1971. The canopy coverage (cm^2) was multiplied by the mean height (cm) to obtain a reasonable approximation of the volume or "cover index" occupied by each plant species. Thus vegetation on treated and untreated portions of both study areas could be compared by summing the cover indexes of each species from all plots exposed to a given treatment to obtain a total cover index (TCI). The amount of change per species (assumed to result from treatment) was then calculated as the "corrected vegetational change" or CVC (adapted after Anderson, 1961) as follows:

$$\text{CVC} = \left(\frac{\text{TCI Treatment 1971}}{\text{TCI Treatment 1967}} \times \text{TCI Untreated 1967}\right) - \text{TCI Untreated 1971}$$

Mechanical treatments were applied in the autumn of 1967; chemical treatments were applied June, 1968. Sampling plots, of approximately 3 acres each, were established in both treated and adjacent untreated areas the spring of 1969 as follows:

Winnett Study Area

1. Aerial application of 2 lb of 2,4-D ester/acre to 480 acres for total kill of big sagebrush: six plots.

King Study Area

1. Aerial application of 2 lb of 2,4-D ester/acre to 240 acres for total kill of big sagebrush: five plots.
2. Contour furrowing of 321 acres: six plots.
3. Interseeding of 190 acres (scalped strips were 18 inches wide and 4 inches deep and interseeded with a mixture of 1 lb of western wheatgrass and 2 lb of green needlegrass per acre): five plots.

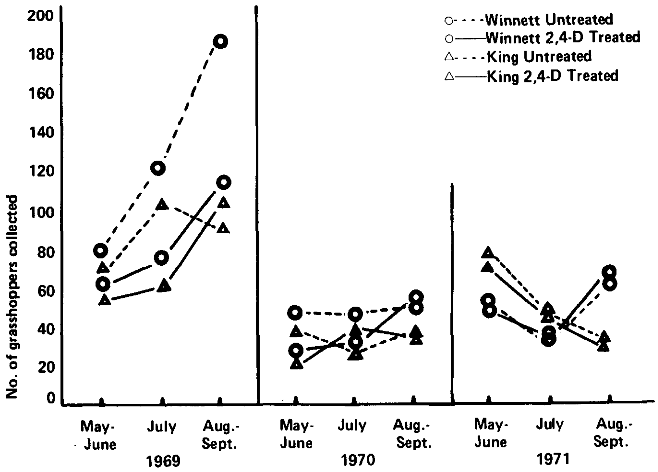

Fig. 1. *Effect of 2,4-D treatment in 1968 on numbers of grasshoppers collected by sweeping.*

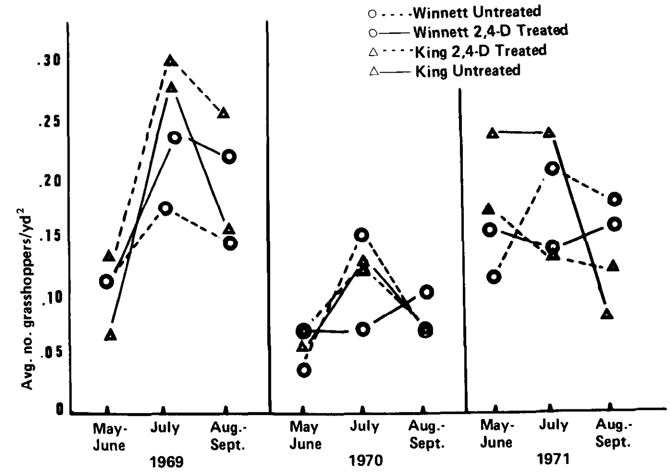

Fig. 2. *Effect of 2,4-D treatment in 1968 on numbers of grasshoppers per square yard.*

The distance between treated and untreated plots ranged from approximately 200 to 2,000 yards. Movement of grasshoppers was probably negligible, since populations were less than 1/yard^2 during the study.

Each plot was sampled three times a year in each of the 3 years 1969–1971: in May or June to sample species that overwinter as nymphs, in July, and again in August or September to sample species that overwinter in the egg stage.

The numbers and species composition of grasshoppers were measured in two ways:

1. Density was determined by visually estimating the number of grasshoppers in a square-yard area while walking in a straight line across a plot. Twenty such counts were made in each plot at each sampling time.

2. Grasshoppers were collected by sweeping with a net for 10 minutes on each plot. They were then taken to the laboratory where the number and species of parasites emerging could be determined and the relative abundance of the different species could be assessed. Also, three times in 1969 and once in 1970 grasshoppers collected in the field and frozen with dry ice were examined in the laboratory for disease organisms.

Results and Discussion

Chemical treatment of big sagebrush on Winnett and King areas.

The abundance of grasshoppers determined from sweeping is shown in Figure 1. During the 3 years, 510 were collected in treated plots in the Winnett area vs 656 in untreated plots, a 22% reduction due to treatment. In the King area, the total was 451 vs 517, a 13% reduction due to treatment. The numbers collected during May-June in treated plots were always less than the numbers collected in untreated plots at both study areas. In 1971 the numbers collected at all three sampling times were approximately equal in both treated and untreated plots for both areas. The effects of treatment apparently diminished with time.

Figure 2 gives the density of grasshoppers based on the number/yard^2. The pattern was similar to that found by sweeping. Fewer grasshoppers were counted during the July period on the treated plots at both areas in all 3 years except in the King area in 1971. However, the difference in the total number counted in treated and untreated plots was small: 154 on treated vs 147 on untreated plots in the Winnett area, and 136 vs 138 in the King area.

Putnam (1949) found that treating plots of wheat stubble with 2,4-D did not reduce populations of the migratory grasshopper, *Melanoplus sanguinipes* (= mexicanus) (F.): the average population on treated always exceeded that on untreated plots. However, Bird et al. (1966), thought that the treatment of weedy roadsides with herbicides might minimize increases in populations of roadside grasshoppers during periods of drought. In our opinion, any changes in populations of grasshoppers due to herbicides probably depends on the success of the treatment in controlling weeds and on the food preferences of the species of grasshopper.

In the 3 years of this study, 42 grasshopper species were collected from the two study areas; however, only 39 were found on the chemically treated plots. Only 16 species were collected in sufficient numbers for comparison of possible treatment effects. These are listed in Table 1 with their percentage change.

The migratory grasshopper was the most abundant species collected from the Winnett area and *Psolessa delicatula delicatula* was the most abundant species on the King area. Fewer *P. d. delicatula* were collected on treated plots of the King area all 3 years, but on the Winnett area no real difference was apparent. The migratory grasshopper was about equally abundant on treated and untreated plots on both areas. *Arphia conspersa, Arphia pseudonietana*, and *Opeia obscura* were more abundant on treated plots on both areas, but *Trimerotropis campestris* was less abundant. The other species listed in Table 1 were not consistent in response to treatment between areas.

Changes in vegetation could only be related to changes in abundance of grasshoppers in a general way. Twelve plant species showed considerable change after treatment (Table 2); however, only the two *Arphia* species of grasshoppers could be related to the vegetation changes. Brooks (1958) reported from Canada that *Arphia* species preferred grasses and sedges such as *Stipa, Agropyron*, and *Carex*. Therefore the increase in western wheatgrass, green needlegrass, and needleleaf sedge may have provided a greater abundance of favorable food plants for *A. conspersa* and *A. pseudonietana*, since they were more abundant on the treated plots in both areas.

Contour furrowing and interseeding on the King area.

The number of grasshoppers collected on each sampling

Table 1. The percentage change[1] in grasshopper species over a 3-year period due to rangeland renovation treatments.

		2,4-D		Furrowed	Scalped			
					Interseeded		Not interseeded	
	Species[2]	Winnett	King	King	King	Cornwell	Nyquist	Veseth
1.	*Aeropedellus clavatus* (Thomas)	- 39.5 (38)	+ 50.0 (6)	- 20.0 (5)	- 68.8 (16)			
2.	**Ageneotettix deorum* (Scudder)	- 41.2 (17)	+ 4.5 (22)	- 78.3 (23)	- 63.2 (19)			
3.	*Arphia conspersa* Scudder	+ 40.0 (35)	+100.0 (7)	+ 66.7 (15)	+158.3 (12)			
4.	*A. pseudonietana* (Thomas)	+ 76.9 (26)	+160.0 (5)	+ 40.0 (5)	0.0 (4)	- 21.4 (14)	- 63.6 (11)	+75.0 (8)
5.	**Encoptolophus sordidus costalis* (Scudder)	- 6.8 (44)	+ 60.0 (1)	- 100.0 (1)	- 75.0 (4)			
6.	**Eritettix simplex tricarinatus* (Thomas)	- 74.4 (39)	+181.8 (11)	- 61.5 (26)	- 86.7 (15)			
7.	*Melanoplus gladstoni* Scudder	- 75.0 (12)	+ 57.1 (7)	- 25.0 (8)	+ 57.1 (7)	+ 13.8 (29)	+ 37.5 (8)	- 72.2 (18)
8.	**M. infantilis* Scudder	+ 55.6 (9)	- 29.3 (41)	- 70.3 (37)	- 15.4 (26)	- 66.7 (168)	- 90.5 (273)	- 64.9 (57)
9.	**M. sanguinipes* (F.)	- 3.8 (158)	- 14.0 (43)	+ 28.6 (28)	+ 9.4 (32)	+1033.3 (3)	- 71.4 (14)	- 25.0 (4)
10.	**Opeia obscura* (Thomas)	+ 33.3 (6)	+ 73.1 (7)	- 91.3 (23)	- 58.3 (12)	- 18.4 (38)		- 68.8 (16)
11.	**Phlibostroma quadrimaculatum* (Thomas)	+ (0)	- 64.7 (17)	- 50.0 (10)	- 100.0 (9)	- 96.8 (31)	- 100.0 (2)	0.0 (2)
12.	*Psoloessa delicatula delicatula* (Scudder)	+ 6.7 (45)	- 29.1 (268)	- 88.7 (282)	- 81.8 (149)	- 51.7 (29)	- 100.0 (3)	- 70.0 (20)
13.	**Trachyrhachys kiowa* (Thomas)	+125.0 (4)	- 65.6 (32)	- 95.9 (49)	- 84.6 (26)	- 100.0 (29)	- 50.0 (2)	- 33.3 (3)
14.	*Trimerotropis campestris* McNeill	- 74.5 (51)	- 87.5 (16)	- 62.5 (8)	- 16.7 (6)			
15.	*T. gracilis sordida* (Walker)	- 50.0 (2)	+ 75.0 (4)	+ 75.0 (13)	+ 73.7 (5)			
16.	*Xanthippus corallipes buckelli* (Hebard)	- 43.9 (41)	+ 50.0 (4)	- 10.5 (19)	- 40.0 (25)			
Miscellaneous species		- 58.1 (129)	+ 11.5 (26)	- 57.8 (45)	- 54.2 (59)	+ 32.4 (45)	- 14.7 (34)	- 60.6 (33)
Total		- 22.3 (656)	- 12.8 (517)	- 60.5 (597)	- 48.4 (426)	- 40.0 (375)	- 78.4 (347)	- 55.9 (161)

[1] Values in parentheses are the numbers of each species collected from the untreated areas and are used for deriving the percentage change; + and – refers to increase and decrease due to treatment.

[2] *Economically important species on rangeland.

date by sweeping is shown in Figure 3. Fewer were collected on the treated plots in all 3 years at each sampling except during May-June 1970. The total collected during the 3 years on contour furrowing plots was 236 vs 597 on untreated plots, a reduction of 60%. The total collected on interseeded plots was 220 vs 426 on untreated plots, a reduction of 48%. Some differences may be attributed to sweeping over uneven terrain (treated plots) compared with sweeping over the fairly level terrain of untreated plots.

Figure 4 gives the density of grasshoppers based on the number/yd^2. Except for July, 1971, all plots interseeded had fewer grasshoppers than untreated plots. However, when only the July and August-September sampling times are considered, differences in density due to contour furrowing and interseeding became less with time. The opposite is true for the May-June sampling times: the differences became greater with time. Perhaps these treatments had a disturbing effect on the early grasshopper species that overwinter as nymphs. The total counted on contour furrowing plots in the 3-year period was 64 vs 174 on untreated plots, a reduction of 63%. The total counted on interseeded plots was 57 vs 113 on untreated plots, a reduction of 50%.

For the 3 years 28 species were identified from untreated plots as compared with 23 from contour furrowed plots and 21 from interseeded plots. *Psolessa delicatula delicatula* was the most abundant species present: 59 specimens were collected on treated vs 431 on untreated plots. Indeed, lesser numbers of most species were collected on treated plots; however, two species, *Arphia conspersa* and *Trimerotropis gracilis sordida*, were more abundant on the contour furrowed

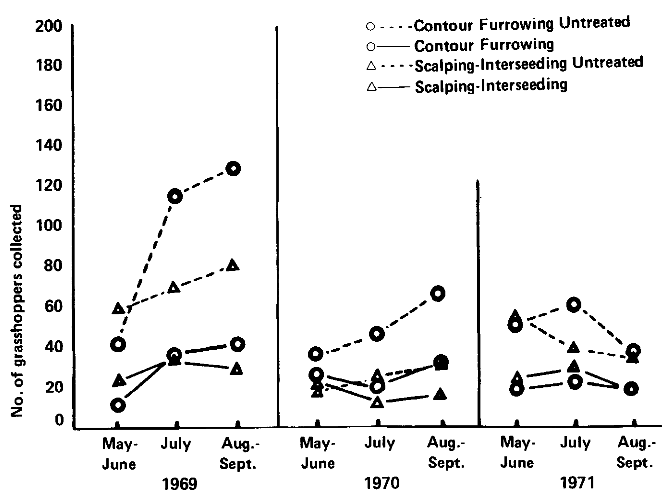

Fig. 3. *Effect of contour furrowing and scalping-interseeding on numbers of grasshoppers collected by sweeping (King area).*

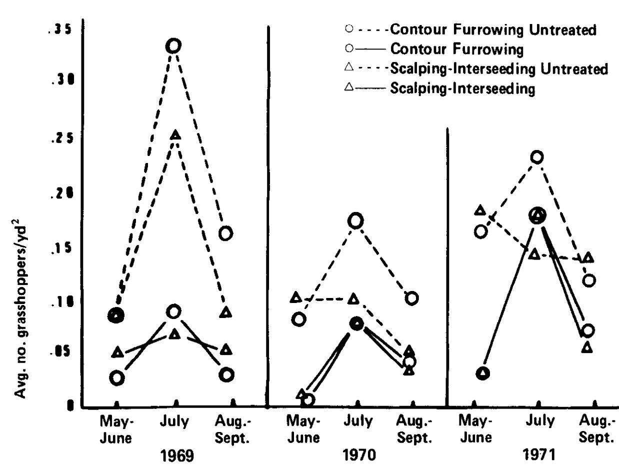

Fig. 4. *Effect of contour furrowing and scalping-interseeding on numbers of grasshoppers per square yard (King area).*

and interseeded plots. These two species belong to the subfamily Oedipodinae, a group known for the ability to fly considerable distances. Perhaps preferred food plants attracted them to treated plots since *A. conspersa* is known to prefer western wheatgrass and needleleaf sedge, both of which increased on these plots (Table 2). The preferred food plants of the *Trimerotropis* species are unknown.

Following contour furrowing and interseeding, three plant species—western wheatgrass, needleleaf sedge, and big sagebrush—increased significantly while blue grama decreased. Green needlegrass and fringed sagewort increased on contour furrowed plots; Sandberg bluegrass, prairie Junegrass, and bluebunch wheatgrass decreased. American vetch decreased on interseeded plots. Blue grama is a preferred food plant for at least five economically important species of grasshoppers (Mulkern et al., 1969, and Ueckert et al., 1972), all of which were present on the study area and all but one of which decreased.

Anderson (1964) reported that vegetation influences grasshoppers in at least two ways: (1) grasshopper species tend to be found in areas with their preferred food plants, and (2) the physical structure of the vegetation affects the distribution and abundance of grasshoppers. For example, he found that native grasslands were more frequently occupied by greater numbers of grasshoppers when the percentage foliage cover was below 40. Thus, since contour furrowing and interseeding resulted in changes in the food plants present and, generally, in a more dense and higher stand of vegetation, the two treatments may have created an unfavorable habitat for many plains-inhabiting species.

The influence of parasites, predators, and pathogens on grasshopper species was thought to be minor. Two species of Sarcophagidae, *Blaesoxipha reversa* (Aldrich) and *Blaesoxipha kellyi* (Aldrich), and one unknown species of Tachinidae were the only parasites reared. In addition, a few adults of *Blaesoxipha reversa* and *Blaesoxipha opifera* (Coquillett) were collected by sweeping. Predators belonging to the following families were observed and collected in the study areas: Sphecidae, Carabidae, Bombyliidae, Asilidae, Cicindelidae, Meloidae, Acarina, and Araneida. The incidence of disease also appeared to be low: only one occurrence of fungus and two of Shizogregarine were detected.

Conclusions

1) Spraying for sagebrush control with 2,4-D ester in 6 gal H_2O/acre did not result in a large reduction in the density of grasshoppers. Some species such as *Psoloessa delicatula delicatula* were consistently less abundant on treated areas; other species such as *Arphia conspersa* and *Arphia pseudonietana* were more abundant. Populations on all plots were less than 1/yard^2, a level that is not economically important.

2) Plots which were contour furrowed and interseeded provided an unfavorable habitat for most grasshopper species present, including all the economically important species indicated in Table 1, except the migratory grasshopper. Grasshopper density was less during all 3 years of sampling on treated plots. The greatest differences were found on contour furrowed plots, but these differences appeared to decrease with time. One species, *Psoloessa delicatula delicatula*, was much less abundant on these treated plots, but other species, such as *Arphia conspersa* and *Trimerotropis gracilis sordida*, were more abundant.

3) Probably both increases and decreases in preferred food plants of grasshoppers that resulted from treatments influenced the abundance of grasshoppers. However, abundance on treated and untreated plots could only be related to food plants in a general way.

4) Parasites, predators, and pathogens did not exert a measurable influence on grasshoppers in the study areas.

Table 2. Vegetational changes (CVC[1]) of 12 plant species from 1967 (pretreatment) to 1971 (posttreatment).

	Treatment			
	Chemical		Contour furrowing	Inter-seeding
Species	Winnett	King	King	King
Western wheatgrass (*Agropyron smithii*)	+ 7775	+4721	+42521	+31889
Bluebunch wheatgrass (*Agropyron spicatum*)	0	− 1985	− 4830	0
Prairie junegrass (*Koeleria cristata*)	− 262	− 1345	− 2830	− 741
Needleandthread (*Stipa comata*)	− 223	− 2702	0	0
Green needlegrass (*Stipa viridula*)	+ 1701	+2323	+ 1181	0
Blue grama (*Bouteloua gracilis*)	+ 509	− 356	− 1512	− 593
Sandberg bluegrass (*Poa secunda*)	− 418	+ 603	− 1837	0
Needleleaf sedge (*Carex eleocharis*)	− 336	+4295	+ 1485	+ 1330
Hoods phlox (*Phlox hoodii*)	− 796	− 258	− 107	− 173
American vetch (*Vicia americana*)	− 1539	+ 199	+ 204	− 1593
Fringed sagewort (*Artemisia frigida*)	− 1835	− 1471	+ 9913	− 239
Big sagebrush (*Artemisia tridentata*)	− 33552	− 6314	+ 2434	+ 6216

[1] Corrected vegetational change defined in text.

Part 2. Rangeland Scalping to Increase Production of Forage

This study was carried out from 1969 to 1971 on three ranches in northern Montana. Extensive acreages had been scalped or interseeded on each ranch (Ryerson et al., 1970).

Procedures

One study area, the Cornwell ranch, was located 11 miles west of Glasgow, Montana. There, scalping and interseeding with a mixture of bluebunch wheatgrass, thickspike wheatgrass and green needlegrass had been completed in the fall of 1966, and then deferred from grazing until the fall of 1968, when the seedlings had become well-established. A second study area, the Nyquist ranch, was located 28 miles north of Glasgow, Mont. This area was scalped without interseeding in the fall of 1968 and was lightly grazed in 1969. A third study area, the Veseth ranch, was located 37 miles southeast of Malta, Mont.; it was scalped, and seeds were broadcast in the fall of 1968, but no seedlings became established.

At each location, a transect line 600 yards long was established, 300 yards in the treated area and 300 yards in an untreated area. At 30-yard intervals along the line, the density of grasshoppers was determined in an area of 20 yd^2 (procedure described in Part 1) on one side of and perpendicular to the transect line; thus a total of 200 yd^2 was surveyed in each of the treated and untreated areas. The counts were made at all three ranches, once in 1969, twice in 1970, and once in

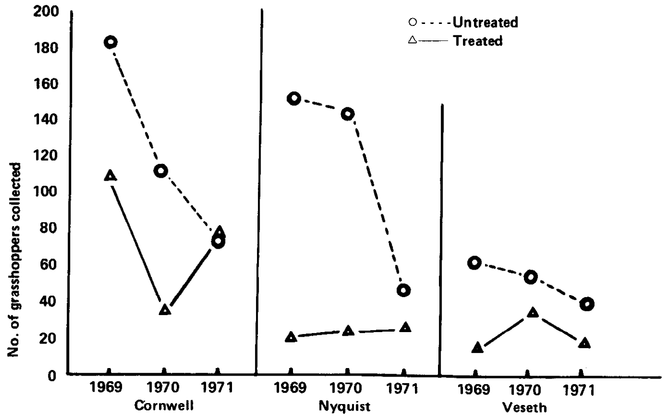

Fig. 5. *Effect of scalping on numbers of grasshoppers collected by sweeping on three ranches.*

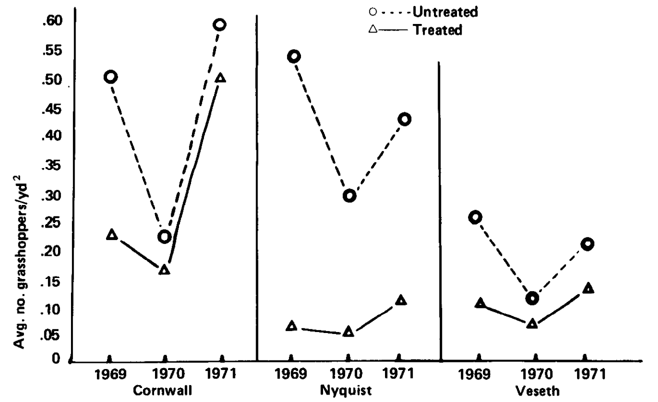

Fig. 6. *Density of grasshoppers (no/yd²) at 3 locations on treated and untreated plots, 1969–1971.*

1971. Live grasshoppers collected on the other side of the transect line by sweeping (10 min/300-yard area) were used to determine incidence of parasites and disease organisms and the relative abundance of grasshopper species.

Results and Discussion

The abundance of grasshoppers determined by sweeping is shown in Figure 5. In all 3 years and at all three locations, with one exception, fewer grasshoppers were collected on the treated plots. The total number of grasshoppers collected in 3 years on treated vs untreated plots was as follows: Cornwell ranch, 225 vs 375; Nyquist ranch, 75 vs 347; and Veseth ranch, 71 vs 161. In general, the differences in the numbers of grasshoppers collected in treated and untreated plots decreased from 1969 to 1971.

The density of grasshoppers/yd^2 is given in Figure 6. Fewer grasshoppers were consistently counted on the treated plots. The difference in density between treated and untreated plots was greatest on the Nyquist ranch; on the other two ranches, differences were smaller after 1969. Perhaps the preference of grasshoppers for the interseeded grass species on the Cornwell ranch accounts for the small difference there in 1970 and 1971. The total number of grasshoppers counted during the 3-year period on treated vs untreated plots was as follows: Cornwell ranch, 121 vs 308; Nyquist ranch, 50 vs 309; and Veseth ranch 73 vs 135.

The numbers of grasshopper species collected on treated vs untreated plots was as follows: Cornwell ranch 17 vs 21; Nyquist ranch, 14 vs 16; and Veseth ranch, 16 vs 18. *Melanoplus infantilis* was the most abundant species: 102 were collected from treated plots compared with 498 from untreated plots. In all, 28 species were present on all three study areas, but only eight were abundant enough to show treatment effects (listed along with the percentage change in Table 1). Most of these species were less abundant on treated plots; however, one species, the migratory grasshopper, was more abundant on the Cornwell ranch.

The total effect of parasites, predators, and pathogens on the populations of grasshoppers was not determined. However, recorded parasitism was low: only seven *Blaesoxipha opifera* and five *Blaesoxipha hunteri* (Hough) emerged from adult *Melanoplus infantilis* in the laboratory. Predators collected during the 3-year period belonged to the families Bombyliidae, Asilidae, Carabidae, and Araneida. No disease pathogens were found in any grasshoppers examined.

Conclusions

1) In general, the practice of rangeland scalping and interseeding had an unfavorable effect on many of the 28 species of grasshoppers sampled: grasshopper density was lowest on the treated areas at all three locations in all 3 years. Only eight species occurred in numbers large enough to assess treatment effects, and five of these (all of which are economically important on rangeland) were consistently less abundant on treated plots. Two economically unimportant species, *Melanoplus gladstoni* and *Arphia pseudonietana*, were about equally distributed between treated and untreated plots. Fewer species were collected on treated plots at each of the three locations.

2) Parasites and pathogens did not appear to be exerting a measurable influence on grasshopper populations at the time of sampling. The effect of predators is unknown.

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