Rangeland Relations and Harvester Ants in Northcentral Wyoming[1,2]

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Highlight

This study was conducted in northcentral Wyoming to evaluate the relationships of harvester ant (*Pogonomyrmex owyheei*) abundance and activity with grazing intensity, vegetation cover and composition and edaphic factors. Ant colony density, percent of soil surface denuded by ants, and average area denuded per ant colony were used as indices of ant abundance and activity. The study area, located in a Nuttall saltbush range type, was a pasture system of 600 acres involving four grazing intensities with distinct variations in vegetational cover and composition values. After 10 years of grazing at four intensities of use, harvester ant abundance was positively correlated with some plants, the correlations appeared incidental to the ability of a species to establish and grow in specific soil conditions and were not related to any ant preference for available food source. Soil texture was the most important factor influencing harvester ant abundance. If harvester ant abundance is affected by grazing and range condition, then such responses are very slow, requiring more than ten years in the area of this study.

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Harvester ants (*Pogonomyrmex* spp.) are important rangeland insects throughout the western United States because of their abundance and broad distribution. They are characterized by building large conspicuous mounds surrounded by circular denuded areas, the habit of collecting and storing seeds, and living in arid to semi-arid habitats. Their activities are considered detrimental to rangelands and their abundance is often related to poor range condition. Melendez (1963) and Wheeler and Wheeler (1963) observed that *P. occidentalis* was more abundant on overgrazed ranges than on ranges in good condition. Sharp and Barr (1960) reported a similar relationship on saltbush ranges in Idaho. Although increased ant activity was considered by the latter authors to be a result rather than a cause of overgrazing and poor range condition, the increased competition with livestock and game animals for forage has created an additional problem in the management of grazing lands. The Big Horn Basin of Wyoming is a noteworthy example. Hull and Killough (1951) estimated 90,000 acres of this area to be denuded by harvester ants. King (1962) found that about 850,000 acres of the Basin were moderately to severely infested with harvester ants.

Colony density has commonly been used to indicate the abundance of harvester ants in different areas, ranging up to 40 per acre for *P. occidentalis* (Sharp and Barr, 1960) and from 2.3 to 36.1 per acre for *P. owyheei* in eastern and central Oregon (Willard, 1964). Local variations in colony densities may be due to dominant vegetation or soil physical properties (Cole, 1934). Colonies of *P. occidentalis* were twice as dense in shallow gravelly soils of a pinyon-juniper area than in soils of sandy to clayey texture in adjacent grasslands of New Mexico (Melendez, 1963). Willard and Crowell (1965) found the greatest density of *P. owyheei* colonies in areas of deep soils. Low populations were recorded in areas of shallow, rocky soils. Costello (1944) reported a close correlation between densities of *P. occidentalis* and successional stages of abandoned cultivated lands of northeastern Colorado. The foregoing studies have suggested possible relationships which deserve further investigation.

The purpose of the present study was to determine the effect of different grazing intensities applied over a ten year period on harvester ant abundance. The influence of vegetation and soils on ant abundance was also evaluated. This study, involving *P. owyheei*, was conducted on the Dry Fork Study Area near Greybull in the Big Horn Basin of northcentral Wyoming during 1966. The climate of the area is typically cold desert with low and variable amounts of precipitation (5–7 inches annually), strong winds and high evaporation rates.

The study area was located on the southwest flank of Sheep Mountain with underlying deposits of interbedded Eocene shales and sandstones. The resistance of the sandstone layers to weathering has resulted in low sandy ridges with occasional sandstone outcroppings separated by drainage depressions of heavier-textured soils derived from the shales. The soils are generally poorly developed and alkaline in reaction over the gently rolling upland terrain.

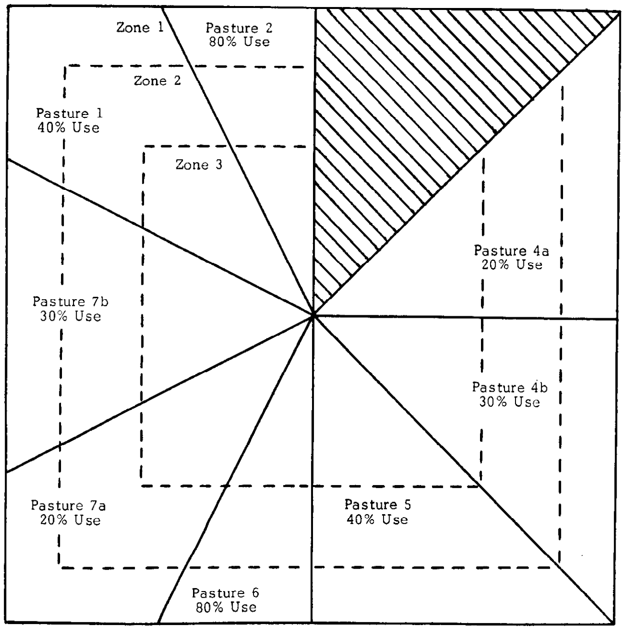

FIG. 1. Schematic diagram of study area (1 mile × 1 mile) to illustrate pastures by percent use and zones.

Experimental Procedures

The Dry Fork Study Area consisted of 600 acres of arid Nuttall saltbush (*Atriplex nuttallii*) rangeland divided into fenced pastures. Two replications of 20, 40 and 80% use pastures were established in 1956 as the original modified block design and used until 1962 when two 30% use pastures were added by division of the 20% use pastures (Fig. 1). The pastures were grazed annually by sheep in the fall (Oct.–Nov.) to achieve the desired utilization percentages. Ten years of grazing resulted in distinct changes in the vegetative cover which was predominantly Nuttall saltbush with few other species important in the cover and composition of the area (Fisser and Steger, 1967).

Available stereographic aerial photographs taken in 1954 (scale approximately 3 inches = 1 mi.) were used to count the number of ant colonies per pasture before grazing intensities were applied over the ten year period. It was assumed that no changes occurred in ant abundance within the area during the interim two years before initial grazing. Similar photographs taken in the summer of 1966 were used to determine the number of ant colonies in each pasture following the grazing treatment.

To assess ant colony differences due to grazing distribution, in addition to utilization rates, each pasture was hypothetically divided into three zones of nearly equal area (Fig. 1). The inner part of each pasture (Zone 3) was used more heavily than the outer due to pasture shape and watering at the center of the area.

Three circular, two-acre macroplots were randomly located in each pasture zone to sample ant colonies, vegetation and soil, resulting in 72 total macroplots. Ant colony characteristics including the number of live and recently dead (in-

Table 1. Ant colony counts of the Dry Fork Study Area by pasture from aerial photographs taken in 1954 and 1966.

Pct. use	Pasture No.	1954 count	1966 count	Deviation or change	Pct. Dev.
20	4A	164	170	+ 6	+ 3.66
20	7A	187	179	− 8	− 4.28
30	4B	130	141	+ 11	+ 8.46
30	7B	267	251	− 16	− 5.99
40	1	395	398	+ 3	+ 0.76
40	5	371	389	+ 18	+ 4.85
80	2	67	66	− 1	− 1.49
80	6	125	131	+ 6	+ 4.80

Table 2. Analysis of variance for the numbers of live ant colonies per macroplot on the Dry Fork Study Area.

Source	df	Mean squares	F-value
Among zones			
Blocks	1	98.00	1.43 ns[1]
Treatments	11		
Use (%)	3	142.72	2.08 ns
Zone	2	119.75	1.75 ns
Use X zone	6	9.19	0.13 ns
Error	11	68.61	
Subsampling	48		
Total	71		

[1] ns = non-significant at .90 and .95 levels of confidence.

active but with distinct mound and denuded area) colonies and radii of the denuded area in four directions were measured in each macroplot. From these measurements, the number of colonies per acre, percent of total area denuded and average denuded per colony were computed for use as indices of ant abundance.

A composite of soil samples taken to a depth of 6 inches at 5 random locations within each macroplot was used to determine soil texture by the hydrometer method (Bouyoucos, 1936). Vegetative cover (basal for grasses and forbs; crown for shrubs) by species was estimated ocularly from 160 randomly located square foot plots (1 ft $\times$ 1 ft) in each macroplot.

Ant colony differences due specifically to grazing factors were evaluated by three procedures. Mound counts from 1954 and 1966 photos were compared for significant changes. Factorial analyses of variance were conducted on colony density and percent of area denuded based on macroplot data taken in 1966. A correlation analysis was conducted on macroplot data to determine simple linear correlations and possible relationships between environmental variables and ant colony characteristics. All statistical analyses were conducted using probability levels of 0.90 and 0.95 and procedures as given by Steel and Torrie (1960).

Results and Discussion

Counts of total numbers of ant colonies in each grazed pasture from aerial photos of the Dry Fork Study Area indicated no conclusive increase or decrease due to grazing intensities. Both positive and negative changes among pastures were observed to be relatively small in all cases (Table 1). Percentage changes were considered to be within the magnitude of counting errors for the most part. Pasture 5 (40% use) and 4B (30% use) had the greatest absolute increase in ant colony numbers. This could well be due to increased surface sand by wind erosion from the adjacent 80% use pasture. The mean number of colonies per acre obtained from the 1954 photo counts was 2.84 and 2.88 from the 1966 photo counts of the 600 acre area. These values are comparable to the 3.04 colonies per acre computed from field sampling with 2-acre macroplots. This indicated that photo counts were a reliable accurate means of determining colony numbers.

The numbers of live colonies sampled in the field macroplots ranged from zero to ten per acre, with a mean and standard deviation of 3.04 and 3.89, respectively. The large value for the latter was substantiated by extensive variations observed in the numbers of live colonies per macroplot within zones and pastures. The numbers of dead colonies were relatively few, ranging from zero to one per acre. The average for the entire study area was 0.125 per acre. The number of dead colonies was found to be positively associated with and strongly dependent upon the number of live colonies.

The results of the factorial analysis of variance on the number of colonies per macroplot are presented in Table 2. The F-ratios for percent use and zones, as well as the interaction of these factors, were not significant. The conclusion drawn from this analysis indicates that ten years of the grazing intensity treatment had no significant effect upon colony density, either in terms of percent use or zones within pastures. This does not mean that grazing intensity never affects density of ant colonies. More than ten years may be necessary for measurable changes to occur. Also, other communities and conditions might give different results.

The percent of area denuded by ant colonies ranged from zero in some two acre macroplots up to 7.65 percent. The estimated mean for the 600 acre study area was 2.43% of the soil surface denuded. Percent of area denuded was closely related to ant colony density with a correlation coefficient of +0.93. As would be expected, the results of analyses of percent of area denuded generally followed those of colony density. In the factorial analysis of variance, the grazing factor of percent use and location factor of zone, were found to be non-significant (Table 3). Thus, the conclusion is made that the grazing factors applied for ten years did not significantly affect the percent of area denuded by ant colonies.

Three ant colony characteristics were used in a correlation analysis with the measured environ-

Table 3. Analysis of variance for the percent of area denuded by ant colonies in macroplots on the Dry Fork Study Area.

Source	df	Mean squares	F-value
Among zones			
Blocks	1	10.66	1.42 ns
Treatments	11		
Use (%)	3	17.94	2.39 ns
Zone	2	17.80	2.37 ns
Use X zone	6	1.25	0.17 ns
Error	11	7.51	
Subsampling	48		
Total	71		

ns = non-significant at .90 and .95 levels of confidence.

mental variables (Table 4). A strong positive correlation (0.93) was measured between colony density (Y1) and percent of soil surface area denuded (Y3), but these two characteristics were only slightly associated in a negative manner with the average denuded area per ant colony (Y2), –0.31 and –0.07, respectively. This indicated that percent of surface area denuded was more closely associated with, and likely dependent upon, the colony density than with the average area denuded per colony. Conversely, the data indicate that the denuded areas of ant colonies were greater on sites with widely dispersed colonies than on sites with high colony densities.

The correlation coefficients between ant colony variables and percent grazing use by pasture (X1) were not significant (Table 4). Low positive correlations were obtained between the influence of grazing intensity as measured by zones within pastures (X2) and all ant colony variables. Ant colony density (Y1), average area denuded per colony (Y2), and percent of soil surface denuded (Y3) tended to be greatest in the most intensively grazed pastures as well as the intensively utilized zones within each pasture. Because of the low correlations, however, between grazing influences (X1, X2) and all ant colony characteristics (Y1, Y2, Y3), it seems apparent that little or no association exists in terms of late fall utilization impact by the grazing animals and harvester ant abundance and vigor.

Although the ant colony variables did not appear to be associated with grazing influences, soil characteristics were very significantly correlated with ant colony densities (Y1) and percent of surface soil area denuded by the insects (Y3). The average area denuded per ant colony (Y2) however, was not strongly correlated with, and thus seemingly independent of, any environmental character measured in this study. Ant colony densities (Y1) and percent denuded surface areas (Y3) were positively correlated with percentages of sand (X3) and gravel (X6) in the soil but negatively with the silt (X4) and clay (X5) values. Thus the significant positive

Table 4. Simple linear correlation coefficients between ant colony and environmental characteristics of the Dry Fork Study Area.

Variables	r[1]		
	Y1	Y2	Y3
Y1 Number of live ant colonies (density)	1.00		
Y2 Average area denuded per ant colony	–0.31	1.00	
Y3 Percent of soil surface area denuded	0.93	–0.07	
X1 Grazing intensity by pasture	0.06	0.10	0.06
X2 Zones within pastures	0.31	0.06	0.34
X3 Percent sand in soil	0.83	–0.20	0.83
X4 Percent silt in soil	–0.80	0.16	–0.80
X5 Percent clay in soil	–0.64	0.21	–0.62
X6 Percent gravel in soil	0.57	0.05	0.62
X7 Crown cover percent—*Artemisia spinescens*	0.55	–0.09	0.55
X8 Crown cover percent—*Atriplex nuttallii*	–0.28	–0.03	–0.24
X9 Crown cover percent—All shrubs	–0.18	–0.07	–0.17
X10 Basal cover percent—*Oryzopsis hymenoides*	0.50	–0.21	0.40
X11 Basal cover percent—*Poa sandbergii*	–0.17	–0.12	–0.18
X12 Basal cover percent—*Sitanion hystrix*	0.23	–0.14	0.20
X13 Basal cover percent—All grass	0.20	–0.21	0.16
X14 Basal cover percent—All annual forbs	–0.02	0.08	0.05
X15 Basal cover percent—*Opuntia polyacantha*	0.35	–0.09	0.38
X16 Basal cover percent—All perennial forbs[2]	0.67	–0.09	0.64
X17 Basal cover percent—All forbs[2]	0.52	–0.10	0.54
X18 Basal cover percent—All herbaceous plants[2]	0.29	–0.23	0.26

[1] Absolute values of r greater than .20 and .23 significant at .90 and .95 levels of confidence, respectively.
[2] Excludes *Opuntia polyacantha.*

correlations between sand and gravel abundance and the two ant colony characteristics are suggestive of an influence of soil texture on ant abundance.

The association of greater ant colony densities and amounts of surface denuded areas with sandy soil sites was also observed both in the field and during evaluation of the aerial photographs. Ant colonies were obviously most abundant on sandy ridges but sparse on low lying flatlands and drainages with soils of lesser sand concentrations but greater amounts of silt and clay.

To test the causative influence of sandy soils upon harvester ant presence, abundance, and vigor, simple linear regressions were conducted with ant colony densities and percent denuded surface areas as dependent variables and percent sand as the independent variable (Kirkham, 1967). In each case,

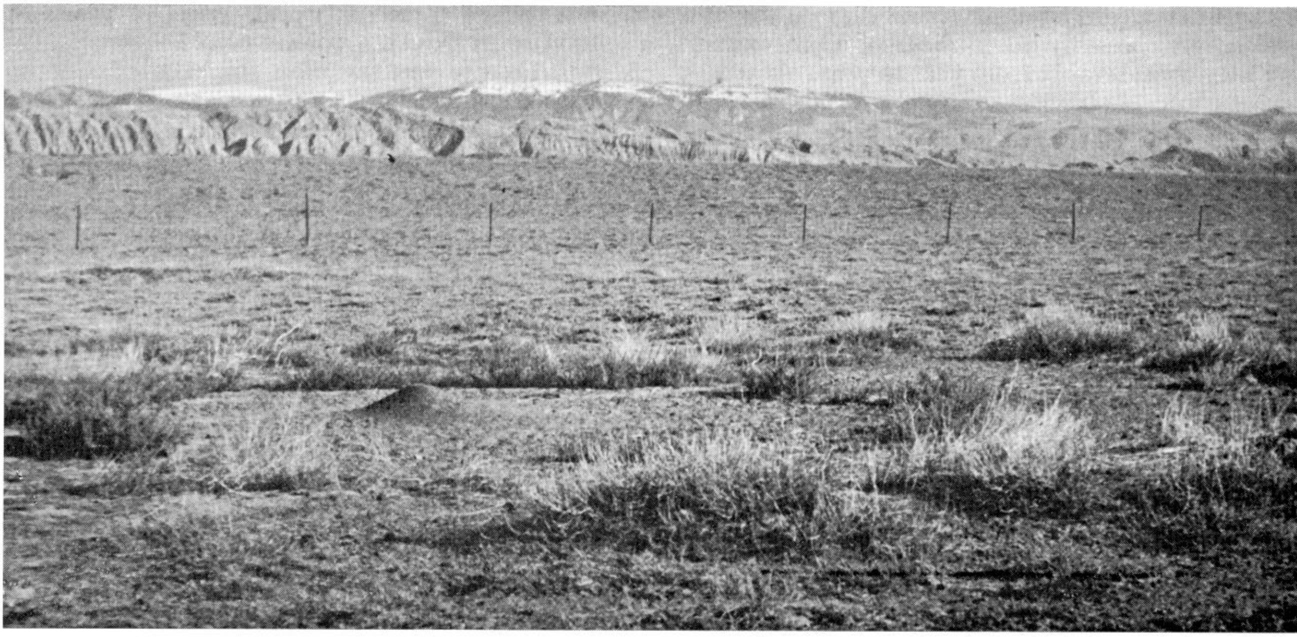

FIG. 2. Colony of *Pogonomyrmex owyheei* with band of annual vegetation (*Halogeton glomeratus*) within the perimeter of perennial vegetation (*Atriplex nuttallii*).

a highly significant proportion of the variation in the ant characteristic (69%) was attributable to the amount of sand in the soils.

Some vegetational cover percentages of associated plants on the study area were highly correlated with ant colony densities (Y1) and percentages of denuded (Y3) soil surface area. Greatest positive correlations occurred between the ant colony characters and cover values of bud sagebrush (*Artemisia spinescens*) (X7), Indian ricegrass (*Oryzopsis hymenoides*) (X10), and perennial forbs (X16). Vegetational cover values of other plant categories such as squirreltail (*Sitanion hystrix*) (X12), all grasses (X13), and plains pricklypear (*Opuntia polyacantha*) (X15) were also positively related to ant colony characteristics but with lesser correlation values. Negative relations existed between vegetational cover of Nuttall saltbush (X8), Sandberg bluegrass (*Poa sandbergii*) (X11), and total shrub cover (X9) in correlations with the ant colony factors. Thus, in addition to the strong indication that ant colonies were most abundant on sandy soils, a strong positive relationship existed between ant colony characters and plants normally associated with sandy soils. Additional tests by Kirkham (1967) showed that cover values of bud sagebrush, Indian ricegrass and perennial forbs were positively and significantly correlated to sandy soils. Conversely, Nuttall saltbush, Sandberg bluegrass and total shrub cover values were negatively correlated to soil sand but positively correlated to silt and clay percentages.

The positive intercorrelation of ant colony values and the species listed above with percent sand in the soil may also be construed to indicate that establishment of mound locations is independent of variations in vegetation composition, at least within the conditions existing on the Dry Fork Study Area. The influence of soil texture upon colony density and the closely related percent denuded surface area seems to be related to the ease with which new colonies may be established and maintained in sandy soil as opposed to soils with greater percentages of silt and clay.

The variations in soil texture which occurred within and between pastures gave rise to the results of the correlation analyses in expressing the relationship of soil texture and ant colony abundance and activity. It is conceivable that soils distribution among the pastures may have influenced the results of the factorial analyses of variance for the effects of grazing factors upon ant colony characters. However, the results of photo counts (Table 1) and correlation analyses (Table 4) supported the analysis of variance finding that grazing factors did not affect the number of colonies and percent of surface soil area denuded by harvester ants. The concurring results of these three analysis procedures have substantially increased the authors' confidence in this conclusion. These results do not preclude the influence of grazing on ant abundance in other environments, under variations of grazing season, and/or over a longer period of time in the area of this study.

Distinct annual differences in the area denuded around some colonies was evidenced by a perennial vegetation perimeter plus one or more boundaries of annual vegetation of different ages (Fig. 2).

These observations have suggested that the vigor of a colony and possibly the number of adult workers may vary considerably from year to year. Available food supply, predators, physical conditions for hatching and larval development, and overwintering losses could contribute to such annual variations.

A high degree of relative stability in ant colony numbers was indicated by various aspects of this study. The results of photographic comparisons indicated small changes in colony densities, even under heavy grazing and wind erosion disturbance. The numbers of recently dead and newly established colonies were a small percentage of the total population of colonies. Assuming that colony density was nearly stable in the area of this study, then soil texture was apparently the most important factor regulating ant colony densities. Responses to annual changes in environmental factors and food supply were probably expressed most by changes in the number of individuals per colony but not in the numbers of colonies.

The findings of this study contrast with those of previous workers (Sharp and Barr, 1960; Wheeler and Wheeler, 1963) in other areas, who have found harvester ants to be more abundant in situations of overgrazing and poor range condition. Such apparent contradictions in evidence indicate the need for further investigation of the relationships between harvester ant abundance and livestock grazing.

Summary and Conclusions

A study was conducted in northcentral Wyoming to evaluate the relationships of harvester ant abundance and activity with grazing intensity, vegetation cover and composition, and edaphic factors. Colony density, percent of soil surface denuded by ants and average area denuded per ant colony were used as indices of ant abundance and activity. The study area, located in a Nuttall saltbush range type, was a pasture system of 600 acres involving four grazing intensities with distinct variations in soils and vegetational cover and composition values. Field data collected on the number and size of ant colonies, cover and composition of vegetation, and soil properties were examined statistically by factorial, regression, and correlation analyses. Changes and differences of ant colony numbers per pasture were determined from aerial photographs taken before and after ten years of grazing treatment.

The conclusions derived from this study are as follows:

1. Ten years of grazing at different intensities did not result in significant changes in the abundance of harvester ants.
2. Although ant colony abundance was positively correlated with some plants, the correlations appeared accidental to a species ability to establish and grow in specific soil conditions, and not related to any ant preference for available food source during colony establishment.
3. Soil texture was the most important factor influencing harvester ant abundance, probably through colony establishment which is known to be a critical period for the ants.
4. If harvester ant abundance is affected by grazing and range condition, then such responses are very slow, requiring more than ten years in the area of this study.
5. Although the harvester ant has a wide range of distribution, locally existing environmental conditions are important in determining its abundance within a given area.
6. Although some deviations from field samples were noted, counts of ant colonies from aerial photos were useful in determining colony densities for research and survey purposes.

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