
TECHNICAL NOTES

A Relationship between Competition and Sex Ratio of Shadscale

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Abstract

The sex ratio of shadscale populations within and outside grazing exclosures show significant departures from random expectations. Males are over represented within the ungrazed exclosures, while females are more prevalent in the grazed pastures. These unequal sex ratios could be the result of three factors: differences in genetic composition, differential grazing pressure on males and differences in water stress. Due to the increased plant cover within the ungrazed exclosures, we believe that plants inhabiting these sites are under greater water stress. Moreover, it appears that females either tolerate water stress less well than males or change sex when stressed.

During the last century, there have been many investigations of sex ratio in populations of dioecious plant species. Such investigations have rarely considered the possibility that unbalanced sex ratios might have an ecological interpretation. However, in recent years, several authors have offered ecological explanations for unbalanced sex ratios (Putwain and Harper 1972; Lysova and Khiznyak 1975; Richards 1975, and Freeman et al. 1976). In an earlier paper (Freeman et al. 1976) we showed that male and female plants are not equally represented on xeric and better watered microsites in the semiarid regions of Utah. Male plants were proportionately more abundant on drier microsites, while females were more prevalent on mesic locations. In this note, we report sex ratios for shadscale [*Atriplex confertifolia* (Torr. and Frem.) S. Wats.] populations within and outside of grazing exclosures on the Desert Experimental Range (DER) of the Forest Service, U.S. Department of Agriculture, in western Utah.

Shadscale is the dominant or codominant shrub on millions of acres of cold desert vegetations in the Intermountain West. Unlike many of its competitors, shadscale is protected by sharp thorns and is not heavily grazed by sheep, the principal herbivore on these ranges; as a

consequence the species has flourished on grazed ranges (Hutchings and Stewart 1953). In contrast, shadscale has progressively declined in relative importance inside grazing exclosures established in 1935 at DER (Holmgren and Hutchings 1972).

We sampled the vegetation within exclosures and in adjacent grazed pastures at DER in July, 1978. To estimate the amount of vegetation, we centered 0.25 m² quadrats over randomly selected shadscale plants and estimated the amount of living cover of shadscale and associated species in each quadrat. Twenty-five quadrats were sampled within each of two exclosures: an additional 25 quadrats were sampled in each pasture adjacent to the exclosures. In addition, 44 or more flowering individuals of shadscale were randomly selected in each of three grazed pastures and in three exclosures within those pastures to provide sex ratio data for grazed and ungrazed populations.

A greater amount of non-shadscale cover, particularly other shrubs, occurred in the ungrazed than in the grazed areas (Table 1). We assume that shadscale individuals in the ungrazed areas are under greater competition for available resources because of the greater amount of associated vegetation. As seen in Table 2, males occur proportionately more often in the ungrazed exclosures while females are more prevalent in the grazed pastures.

How can the observed divergence in sex ratio of shadscale between grazed and ungrazed areas be explained? The following occur to us as possible explanations for the observed pattern: 1) populations differ genetically between areas, 2) male plants are more heavily grazed than females by sheep, or 3) shadscale individuals inside exclosures receive more competition from associated plants than do grazed shadscale plants.

It seems unlikely to us that shadscale populations inside and outside the 0.40 ha (one acre) exclosures differ genetically considering the fact that the species is both dioecious and wind pollinated. Dioecy necessitates outcrossing and wind pollination should insure that genes regularly flow between exclosure and outside (grazed) populations. Shadscale longevity (at least several years) and the age of the exclosures (less than 45 years) also argue against a genetic explanation.

Cursory observations do suggest that male shadscale plants are less thorny than seed-bearing plants of comparable size. That differential in armor may be sufficient to cause differential use of male and female

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Table 1. Mean cover percentage of shadscale and non-shadscale vegetation in the grazed (pasture) and ungrazed (exclosure) study sites.

Management regime	Shadscale	Site #1 (Pasture #15)		Shadscale	Site #2 (Pasture #13)	
		Other shrub	Grass		Other Shrub	Grass
Grazed (pasture)	7.43 ⁽¹⁾ ± 5.26 ⁽²⁾	3.1 ± 3.2	2.7 ± 2.5	7.30 ± 5.09	1.0 ± 2.2	2.2 ± 2.7
Ungrazed (exclosure)	7.50 ± 5.00	6.3 ± 4.4	1.1 ± 1.5	8.70 ± 5.45	2.5 ± 3.1	2.8 ± 3.4
t-value	.05	2.94**	-2.70**	.90	2.00*	.70

⁽¹⁾ Each mean is an average of 25 observations⁽²⁾ Standard deviation* Significant at $P = 0.05$ ** Significant at $P = 0.01$ **Table 2. Observed and expected number of shadscale plants of each sex under grazed and ungrazed land management regimes. Expected values are shown in parentheses.**

Management regime	(Pasture #15) Site #1		(Pasture #13) Site #2		(Pasture #1) Site #3	
	♂	♀	♂	♀	♂	♀
Grazed (pasture)						
Observed	12	39	7	37	44	106
Expected	(20)	(31)	(14)	(30)	(61)	(89)
Ungrazed (exclosure)						
Observed	26	19	20	24	78	72
Expected	(18)	(27)	(14)	(30)	(61)	(89)
EX^2	11.7**		9.0**		16.0**	

** The chi-square tests are based on two-by-two contingency tables with 1 degree of freedom. Values are significant at $P = 0.01$.

plants by sheep. Observers of grazing behavior of sheep at the DER suggest to us, however, that such an unequal utilization of male and female individuals is unlikely. In support of that suggestion, we have data which show that male and female individuals in the grazed area of site 3 (Table 2) do not differ significantly in size.

There is evidence that shadscale plants inside the exclosures experience more competition from other species than do plants in the grazed pastures (Table 1). The data show that there is both more total living plant cover and more non-shadscale cover inside the exclosures than in the grazed areas. In the area under consideration, soil moisture is in short supply throughout most of each growing season. Thus, the greater competing plant cover of the exclosures should place the shadscale plants there under greater moisture stress than in the grazed pastures.

McArthur (1977) has shown that individuals of four-wing saltbush [*Atriplex canescens* (Pursh) Nutt.], a dioecious species, often reverses

sex under stressful conditions. Freeman et al. (1976) considered it possible that sex reversal could account for the unequal representation of male and female individuals of shadscale and several other Great Basin dioecious species on very xeric as opposed to better watered sites. Freeman et al. (1976) considered that the unequal distribution of sexes was probably related to the unequal cost of producing pollen as opposed to fruit. The production of fruit would consume more resources and thus would be most successful on more favorable sites.

Since males produce pollen in the spring while soils are still moist from winter precipitation, they should be less affected by water stress than females which must furnish energy and mineral resources for the developing fruit crop throughout the long, dry summer. Thus, any processes that would act to segregate males onto dry sites and females onto more moist habitats should be beneficial to desert, dioecious species (Freeman et al. 1976). The segregation of males and females in space could result from either differential mortality or sex reversal. Either process would have important implications for producers attempting to establish seed orchards or dioecious species in the arid west. We are currently investigating mechanisms by which spatial segregation of the sexes of several desert, dioecious species arises.

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