THE SOUTHWESTERN NATURALIST 41(3):251–256 SEPTEMBER 1996

GRAZING EFFECTS ON REPRODUCTIVE CHARACTERISTICS OF COMMON CURLYMESQUITE (*HILARIA BELANGERI*)

ELIZABETH L. SCHOLL AND ROBERT J. KINUCAN

Division of Range Animal Science, Sul Ross State University, Alpine, Texas 79832

ABSTRACT—Common curlymesquite (*Hilaria belangeri*) is a stoloniferous perennial shortgrass. Historically the species was considered sterile and only reproductive vegetatively; however, research has demonstrated that it produces viable seed. In this study reproductive characteristics, focusing on seed production and seed rain, of common curlymesquite were compared between grazed (moderately stocked, deferred rotation grazing) and ungrazed (exclosure) areas on the western Edwards Plateau, Texas. Absolute foliar cover and density were significantly higher ($P \leq 0.05$) in grazed than in ungrazed treatments. Total seed (spikelet cluster) production was also significantly higher in grazed than in the ungrazed areas on three of four sample dates. Seed production on a per plant or per absolute foliar cover basis, however, did not differ between treatments. Regression analysis indicated a strong relationship between number of seed clusters and number of culms, but not between seed production and other plant characteristics. Seed rain from common curlymesquite, as ascertained by sticky traps, was significantly greater in the grazed than ungrazed areas. High reproductive potential, as expressed by seed or vegetative propagation, may be a life-history characteristic which contributes to the persistence and successional dominance of common curlymesquite on many southwestern rangelands.

Common curlymesquite (*Hilaria belangeri*) is a valuable forage grass for livestock in central and West Texas, and is the most important grass in many localities (Brown and Coe, 1951). It is distributed from central Texas to Arizona and south to the adjacent tier of Mexican states (Gould, 1975). It is a low, tufted perennial with erect flowering culms which originate from small vegetative clumps. Flowering culms can also originate from the tips of wiry, widely spreading stolons (Gould, 1975).

Historically the savanna vegetation of the Edwards Plateau of central Texas was dominated by productive bunchgrasses such as sideoats grama (*Bouteloua curtipendula*), Texas cupgrass (*Eriochloa sericea*) and little bluestem (*Schizachyrium scoparium*), with shortgrasses such as common curlymesquite and scattered clumps of woody species (e.g., *Juniperus* sp. and *Quercus* sp.). Continuous heavy livestock grazing and disruption of natural fire regimes likely shifted herbaceous dominance to shortgrass species such as common curlymesquite, hairy tridens (*Erioneuron pilosum*) and red grama (*Bouteloua trifida*) (Merrill and Young, 1959; Smeins and Merrill, 1988). Because of the dominance exerted on many sites by common curlymesquite, mode of establishment becomes an important consideration in successional processes on these areas (Egler, 1954; Smeins and Merrill, 1988; Kinucan and Smeins, 1992).

The increased abundance of common curlymesquite through time was originally ascribed to its ability to reproduce vegetatively by stolons in response to heavy grazing (Cory, 1948). Early research also reported that seeds produced by common curlymesquite tended to be sterile (Cory, 1948; Brown and Coe, 1951), although it was later demonstrated that this species was capable of reproducing from seed, with germination rates of 6–20% (Merrill and Young, 1962). Seedlings of common curlymesquite can produce seed and stolons within 30–40 days after emergence (Merrill, 1953), which contributed to the misimpression that the species relied completely on vegetative reproduction.

Long-term herbivory alters species composition and abundance relationships in plant communities (Ellison, 1960) and grazing-mediated changes in species composition have been documented on this site (Smeins and Merrill, 1988). An increased abundance in common curlymesquite would increase the potential for seed production, potentially enhancing plant establishment and site dominance.

We hypothesized that long-term grazing by domestic livestock increased total seed production potential of common curlymesquite, and thus enhanced the reproductive and successional potential of the species. Our objectives were to quantify seed production and seed rain under long-term grazed and ungrazed conditions, and interpret the effects of altered seed production on successional processes.

METHODS—The study was conducted within the southwestern portion of the Edwards Plateau vegetational area (Gould, 1975) on the 1404 ha Texas Agricultural Experiment Station, 56 km S of Sonora (30°16′N, 100°34′W), Texas. Mean annual precipitation is 577 mm with two peaks in May to June and September. Summers are hot with mean July temperatures of 27.7°C, while winters are generally mild with mean January temperatures of 9.5°C. Elevation is approximately 735 m. Soils are primarily clay and clay loam Mollisols over a fractured limestone substrate that produces shallow, rocky soils with great surface heterogeneity (Wiedenfeld and McAndrew, 1968).

Two replicates of long-term (1948–1993) grazed and ungrazed treatments were selected: ungrazed exclosures (11 ha each), one replicate excluding livestock only and one replicate excluding livestock and white-tailed deer; and two pastures of a moderately stocked 4-pasture, 3-herd deferred rotation grazing system (24 ha each). The livestock exclosure was accessible to white-tailed deer, whereas the wildlife and livestock exclosure was fenced to prevent entrance of deer and livestock. The deferred rotation pastures were grazed by a combination of cattle, sheep and goats at an approximate stocking rate of 7.7 ha/animal unit/year (animal unit = 12 kg/day dry biomass requirement). Treatment replicates provided situations of comparable disturbance and use of common curlymesquite, although different herbivore species were allowed access. Sites within grazed pastures were fenced during the study.

Within each replicate, 20 permanent plots (25 × 50 cm) were located using a stratified random design and marked with reinforcement bar in diagonal corners ($n=40$ per treatment). Spikelet cluster (3 spikes clustered at each rachis node: 2 lateral spikes, each 2-flowered and staminate; and 1 central, 1-flowered, perfect spike—yielding 1 fertile caryopsis per cluster) density, culm density, plant density (independently rooted nodes or tufts), and percent foliar cover for common curlymesquite were estimated in each plot on 3 June, 18 June, 15 July, and 29 September 1993. Percent foliar cover for all species was estimated using a canopy cover method (Daubenmire, 1959) on 3 June.

To assess seed rain, 30 sticky traps (9 × 1.5 cm petri dishes coated with insect trapping adhesive) were randomly located within each treatment replicate ($n=60$). Spikelet clusters were identified and counted between 3 June and 29 September 1993.

In addition to the variables directly sampled, estimates for additional population attributes were calculated from measured variables: 1) mean area per plant (foliar cover cm^2 plot^{-1}/plants plot^{-1}), 2) number of reproductive culms per plant (culms plot^{-1}/plants plot^{-1}), 3) number of spikelet clusters per plant (spikelet clusters plot^{-1}/plants plot^{-1}), 4) number of spikelet clusters per culm (spikelet clusters plot^{-1}/culms plot^{-1}), and 5) number of spikelet clusters per plant area (spikelet clusters plot^{-1}/cm^2 foliar cover plot^{-1}). Density estimates are difficult to make for stoloniferous growth forms, however, the number of rooted nodes or tufts per unit area gives an indication of common curlymesquite density, and lends insight to growth and population dynamics of the species.

All variables were subjected to one-way analysis of variance for each sample date. Linear regression analysis was performed to determine the relationship between the number of reproductive culms and number of plants, number of reproductive culms and area, number of spikelet clusters and number of plants, number of seed clusters and the number of reproductive culms, and number of spikelet clusters and area. Differences in extant foliar cover between treatments was analyzed with t tests. Analyses were performed using SPSS/PC+ v4 (SPSS Inc., 1990) and results were considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION—Foliar cover and density of common curlymesquite were higher in the grazed than in the ungrazed treatment for all sample dates (Table 1). Total foliar cover was comparable between treatments; however, floristic composition differed markedly, largely because species richness in the exclosure exceeded that in the grazed treatment (Table 2). In addition, Texas cupgrass was a co-dominant species with common curlymesquite within the exclosure, but not present within the grazed pastures.

Grazing-induced modifications in species composition and abundance have been documented for many rangelands (Branson and Weaver, 1953; Ellison, 1960). The dominant grass growth form within the grazed treatment was distinctly shorter (dominated by common curlymesquite) when contrasted with the exclosures (co-dominated by the midgrass Texas cupgrass). Treatment differences in this study are consistent with other studies which found that community structure shifts from taller to shorter growth forms under grazing (Belsky, 1986), and specifically, common curlymesquite basal area increased under grazed compared with ungrazed conditions (Smeins and Merrill, 1988).

Number of spikelet clusters, hence seeds, per

TABLE 1—Mean (±1 SD) for density (number/m^2), foliar cover (%), reproductive culms (number/m^2) and seed clusters (number/m^2) of common curlymesquite for ungrazed and moderate deferred rotation grazing treatments at four sampling dates. (n = 40)

	Density	Cover	Culms	Clusters
3 June				
ungrazed	52.2 (±56.8)	14.0 (±13.1)	21.4 (±36.3)	126.0 (±230.9)
	**	**	**	**
grazed	203.2 (±88.3)	43.6 (±18.1)	89.2 (±68.6)	502.2 (±404.5)
18 June				
ungrazed	58.4 (±60.9)	22.0 (±18.0)	35.0 (±47.8)	185.2 (±276.0)
	**	**	**	**
grazed	210.8 (±89.8)	45.8 (±21.1)	95.8 (±70.5)	486.4 (±398.0)
15 July				
ungrazed	53.4 (±54.7)	19.5 (±17.5)	19.8 (±23.1)	78.2 (±94.9)
	**	**	NS	NS
grazed	200.6 (±77.1)	43.5 (±18.3)	27.0 (±23.4)	83.4 (±89.1)
29 September				
ungrazed	64.4 (±63.7)	23.3 (±21.3)	132.4 (±152.2)	775.0 (±892.2)
	**	**	**	**
grazed	197.6 (±78.8)	52.0 (±16.3)	304.8 (±152.5)	1802.2 (±949.2)

** $P \leq 0.01$
NS Not significant

m^2 was significantly greater in the grazed (83 to 1802 m^{-2}) than in the ungrazed treatment (78 to 775 m^{-2}) on all sample dates, except 15 July (Table 1). High seed production in the grazed treatment was reflected in the seed rain of common curlymesquite which was also significantly greater in the grazed [2099 ± 1649 (mean ± 1 SD) clusters m^{-2}] than in the ungrazed (434 ± 587 clusters m^{-2}) treatment. Common curlymesquite was noted to maintain a persistent seed bank on these sites, with a significantly larger soil seed pool under grazed (132 seeds m^{-2}) than ungrazed (38 seeds m^{-2}) treatments for a July sample period (Kinucan and Smeins, 1992). In southern Arizona, common curlymesquite was more abundant, produced more seedlings and was longer-lived than associated species on yearlong grazed than ungrazed rangeland (Canfield, 1957).

The number of spikelet clusters per plant and spikelet clusters per area of foliar cover were not significantly different between treatments on 3 June, 18 June or 29 September, indicating that seed production per individual plant did not dif-

TABLE 2—Mean (±1 SD) for foliar cover (%) of extant vegetation in ungrazed exclosure and moderate deferred rotation grazing treatments on 18 June 1993. (n = 40)

	Ungrazed	Grazed
Perennial threeawn (*Aristida* sp.)	3.1 (±7.48)	2.4 (±6.67)
Sideoats grama (*Bouteloua curtipendula*)	1.5 (±6.33)	—
Hairy grama (*Bouteloua hirsuta*)	0.1 (±0.39)	—
Red grama (*Bouteloua trifida*)	0.1 (±0.39)	—
Texas cupgrass (*Eriochloa sericea*)	17.9 (±19.16)*	—
Hairy tridens (*Erioneuron pilosum*)	1.7 (±3.97)*	—
Common curlymesquite (*Hilaria belangeri*)	22.0 (±18.01)*	45.8 (±21.06)
Texas wintergrass (*Stipa leucotricha*)	—	0.7 (±2.46)
Slim tridens (*Tridens muticus*)	—	0.6 (±2.44)
Forbs	0.4 (±2.39)	0.8 (±2.49)
Total foliar cover	46.6 (±15.82)	50.3 (±19.06)
Species Richness	9	6

* Significantly different within row ($P \leq 0.05$)

TABLE 3—Means (±1 SD) for calculated values of area (cm^2) per plant, reproductive culms per plant, spikelet clusters per plant, spikelet clusters per reproductive culm and spikelet clusters per area (cm^2) at four sample dates. $n = 40$.

	Area/plant	Culms/plant	Clusters/plant	Clusters/culm	Clusters/area
3 June					
ungrazed	29.9 (±17.6)	0.47 (±0.71)	2.94 (±4.93)	3.43 (±2.95)	11.2 (±16.6)
	*	NS	NS	*	NS
grazed	23.5 (±9.5)	0.60 (±0.81)	3.58 (±5.62)	5.53 (±0.87)	16.6 (±17.7)
18 June					
ungrazed	42.4 (±29.1)	0.75 (±0.87)	4.15 (±5.63)	4.13 (±2.35)	18.1 (±21.9)
	**	NS	NS	NS	NS
grazed	24.8 (±15.4)	0.59 (±0.54)	3.06 (±3.08)	4.66 (±1.94)	15.9 (±17.2)
15 July					
ungrazed	37.8 (±25.9)	0.44 (±0.48)	1.76 (±2.36)	2.55 (±2.09)	17.6 (±22.8)
	**	**	**	NS	**
grazed	23.7 (±12.2)	0.16 (±0.16)	0.51 (±0.61)	2.22 (±1.66)	36.5 (±30.3)
29 September					
ungrazed	35.9 (±24.7)	2.07 (±1.88)	12.39 (±11.43)	5.15 (±1.98)	5.4 (±6.3)
	NS	NS	NS	*	NS
grazed	30.1 (±15.2)	1.79 (±1.09)	10.61 (±6.73)	5.81 (±0.56)	3.5 (±1.6)

* $P \leq 0.05$
** $P \leq 0.01$
NS Not Significant

fer between treatments (Table 3). Spikelet cluster production per plant and per foliar cover were significantly greater in the exclosures but clusters per foliar cover were greater in grazed pastures on 15 July, when growing conditions were relatively dry and unfavorable. Little new vegetative growth was noted at this time, especially in the grazed treatment.

Number of reproductive culms had a strong influence on number of spikelet clusters ($Y = -4.44 + 5.96$ (X), $r^2 = 0.98$, $P \leq 0.01$). Similar results were reported for seed and culm production in 'Pierre' sideoats grama (*Bouteloua curtipendula*) (Boe and Gellner, 1990). Like seed cluster production, culm production per m^2 was significantly greater in the grazed than the ungrazed treatment for all sample dates, except 15 July (Table 1). Total culms per plant, however, showed no treatment difference, except on 15 July (Table 3). Under conditions of favorable growth (June and September), the number of seed clusters produced per culm was slightly greater in the grazed than ungrazed treatment. Characteristics such as culms per plant, culms per foliar cover, seed clusters per plant and clusters per foliar cover were all significantly related, but with low coefficients of determination (r^2 = 0.05 to 0.19, $P \leq 0.01$).

For each sample date the total density of common curlymesquite plants was significantly greater (approximately four-fold) in the grazed treatment than the ungrazed treatment (Table 1). Foliar cover per plant, though, was significantly greater in the ungrazed than the grazed treatment for all but the 29 September sample date. These data indicate that there were fewer, but larger individuals of common curlymesquite under long-term conditions of no grazing, and a greater number of smaller individuals when subjected to grazing. Grazed populations of perennial grasses may consist of individuals with smaller basal areas (Pond, 1960; Hickey, 1961), which may be the result of fragmentation of larger individuals (Briske, 1991). Fragmentation may lead to an increase in plant density, but a decrease in individual plant basal area.

Merrill and Young (1962) showed that common curlymesquite produced viable seed which can produce seedlings. Established seedlings could, in turn, produce runners and seed within 30–40 days after emergence (Merrill, 1953). Total reproductive potential in common curlymesquite by seed alone appears to be much greater under moderately stocked deferred rotational grazing than under conditions with no livestock grazing. This difference can be attributed to the greater dominance of common curlymesquite plants in the grazed pastures rather than to inherently greater seed production by individual plants when grazed.

Grasses, such as common curlymesquite, appear to influence the rate of succession by rapidly responding to moisture and by virtue of a stoloniferous growth habit (Smeins and Merrill, 1988), and apparently inhibit establishment of later-successional species (Kinucan, 1987). Common curlymesquite may therefore be more persistent on a site than other grass species (i.e., midgrasses) by exerting considerable control over resources of the site (Smeins and Merrill, 1988), as has been found for other perennial grasses (Coffin and Lauenroth, 1990). Common curlymesquite is likely to maintain a dominant stature within these grassland communities through high seed production, as well as its ability to produce new plants vegetatively. In contrast, other shortgrass species such as blue grama (*Bouteloua gracilis*) are apparently slow to colonize a site due to interspecific competition from established plants, lack of a persistent seed bank, low and variable seed production and slow tillering rates (Samuel, 1985; Coffin and Lauenroth, 1989, 1992; Samuel and Hart, 1992).

Smeins and Merrill (1988) noted the ability of common curlymesquite to recover after disturbance and persist in areas subjected to intensive livestock grazing. Life-history characteristics, which include the potential for prolific seed production and relatively high seed viability, combined with a persistent seed bank and the capability for vegetative propagation, likely contribute to this persistent nature.

We thank C. A. Taylor, superintendent, The Texas Agricultural Experiment Station at Sonora, for access to the Station, logistical support during the study and helpful comments during manuscript preparation. K. Kinucan and two anonymous reviewers provided constructive comments on the manuscript. Partial support for this study was provided by the Houston Livestock Show and Rodeo, Inc. and Sul Ross State University Faculty Research Enhancement.

LITERATURE CITED

BELSKY, A. J. 1986. Does herbivory benefit plants? A review of the evidence. American Naturalist 127:870–892.

BOE, A., AND J. L. GELLNER. 1990. Components of seed yield in 'Pierre' sideoats grama. Journal of Range Management 43:411–412.

BRANSON, F. A., AND J. E. WEAVER. 1953. Quantitative study of degeneration of mixed prairie. Botanical Gazette 114:397–416.

BRISKE, D. D. 1991. Developmental morphology and physiology of grasses, p. 85–108. *In:* J. W. Stuth and R. K. Heitschmidt (eds.). Grazing management: an ecological perspective. Timber Press, Portland.

BROWN, W. V., AND G. E. COE. 1951. A study of sterility in *Hilaria belangeri* (Steud.) Nash. and *Hilaria mutica* (Buckl.) Benth. American Journal of Botany 38:823–830.

CANFIELD, R. H. 1957. Reproduction and life span of some perennial grasses of southern Arizona. Journal of Range Management 10:199–203.

COFFIN, D. P., AND W. K. LAUENROTH. 1989. Spatial and temporal variation in the seed bank of a semiarid grassland. American Journal of Botany 76:53–58.

COFFIN, D. P., AND W. K. LAUENROTH. 1990. A gap dynamics simulation model of succession in a semiarid grassland. Ecological Modeling 49:229–266.

COFFIN, D. P., AND W. K. LAUENROTH. 1992. Spatial variability in seed production of the perennial bunchgrass *Bouteloua gracilis* (Gramineae). American Journal of Botany 79:347–353.

CORY, V. L. 1948. Curly mesquite grass in Texas and northern Mexico. Wrightia 1:214–217.

DAUBENMIRE, R. 1959. A canopy coverage method of vegetational analysis. Northwest Science 33:43–64.

ELLISON, L. 1960. Influence of grazing on plant succession of rangelands. Botanical Review 26:1–78.

EGLER, F. E. 1954. Vegetation science concepts. I. Initial floristics composition, a factor in old field vegetation development. Vegetatio 4:412–417.

GOULD, F. W. 1975. The grasses of Texas. Texas A&M Univ. Press.

HICKEY, W. C. JR. 1961. Growth form of crested wheatgrass as affected by site and grazing. Ecology 42:173–176.

KINUCAN, R. J. 1987. Influence of soil seed bank, seed rain, inhibition competition and site disturbance on successional processes within three long-term grazing regimes on the Edwards Plateau, Texas. Ph.D. Diss., Texas A&M Univ., College Station.

KINUCAN, R. J., AND F. E. SMEINS. 1992. Soil seed bank of a semiarid Texas grassland under three long term (36-year) grazing regimes. American Midland Naturalist 128:11–21.

MERRILL, L. B. 1953. Reestablishment of curly mesquite grass from seedlings or runners. Sheep and Goat Raisers Journal 34:34.

MERRILL, L. B., AND V. A. YOUNG. 1959. Response of curly mesquite to height and frequency of clipping. Texas Agr. Exp. Sta. MP-33.

MERRILL, L. B., AND V. A. YOUNG. 1962. Germination and root establishment in seedlings of curly mesquite. Texas Agr. Exp. Sta. MP-615.

POND, F. W. 1960. Vigor of Idaho fescue in relation to different grazing intensities. Journal of Range Management 13:28–30.

SAMUEL, M. J. 1985. Growth parameter differences between populations of blue grama. Journal of Range Management 38:339–342.

SAMUEL, M. J., AND R. H. HART. 1992. Survival and growth of blue grama seedlings in competition with western wheatgrass. Journal of Range Management 45:444–448.

SMEINS, F. E., AND L. B. MERRILL. 1988. Long-term change in a semiarid grassland, p. 101–114. *In:* B. Amos and F. Gehlbach (eds.). Edwards Plateau vegetation: plant ecological studies in central Texas. Baylor Univ. Press, Waco.

SPSS INC. 1990. SPSS/PC+ 4.0 Base manual. Chicago.

WIEDENFELD, C. C., AND J. D. MCANDREW. 1968. Soil Survey of Sutton County, Texas. U.S. Soil Conser. Serv., Washington, D.C.