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Research Note

Common Broomweed Growth Characteristics in Cleared and Woody Landscapes

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Abstract

Common broomweed (*Amphiachyris dracunculoides* [DC] Nutt. Ex Rydb.) is an annual forb that occurs throughout the southern Great Plains, USA. During years of abundant growth, broomweed is problematic because it can reduce grass production and interfere with livestock foraging. In contrast, the canopy structure of broomweed may provide habitat cover for wildlife, including the northern bobwhite quail (*Colinus virginianus* Linnaeus). During an extreme outbreak of broomweed in north Texas in 2007, we observed apparent differences in broomweed individual plant growth characteristics in mesquite (*Prosopis glandulosa* Torr.) woodland areas versus areas that had recently been cleared of mesquite. Our objective was to document differences at the individual plant and population levels. Individual plant mass, canopy diameter, and basal stem diameter were much greater in the cleared treatment than the mesquite woodland. In contrast, plant height was greater in the woodland than in the cleared treatment. Population variables of stand-level production, percentage canopy cover, plant density, and visual obstruction were not different between treatments. Total perennial grass production was greater in the cleared than the woodland treatment, because of the negative effect of mesquite on grass production. Variations in broomweed growth characteristics may have implications regarding livestock foraging and wildlife habitat.

Resumen

El "Common broomweed" (*Amphiachyris dracunculoides* [DC] Nutt. Ex Rydb.) es un arbusto anual que esta presente en todas las Grandes Planicies del Sur de los Estados Unidos. Durante los años de crecimiento abundante, el broomweed es problemático por que puede reducir la producción de hierbas e interferir con el forrajeo de ganado. Por el contrario, la estructura del dosel del "broomweed" puede proveer cobertura de hábitat para la vida silvestre, incluyendo la codorniz coutí del norte (*Colinus virginianus* Linnaus). Durante un brote extremo de "brooweed" en el norte de Texas en el 2007, nosotros observamos diferencias aparentes en las características de crecimiento en plantas individuales de "broomweed" en áreas del bosque de mesquite (*Prosopis glandulosa* Torr.) versus áreas que han sido despejadas de mesquite. Nuestro objetivo fue documentar las diferencias a nivel de plantas y poblaciones. La masa de la planta individual, el diámetro del dosel y el diámetro basal del tallo fueron mayores en el tratamiento despejado que el bosque de mesquite. Diferenciador otro lado, la altura de la planta fue mayor en los bosques que en las áreas abiertas. Las variables de la población a nivel de producción, el porcentaje de cobertura del dosel, la densidad y la obstrucción visual no fueron diferentes entre los tratamientos. La producción total de hierba perene fue mayor en el área despejada que en el tratamiento del bosque, debido al efecto negativo de la mesquite en la producción de hierba. Las variaciones en las características de crecimiento podrían tener implicaciones respecto al forrajeo del ganado y el hábitat de la vida silvestre.

Key Words: bobwhite quail, brush management, *Colinus virginianus*, mesquite, *Prosopis glandulosa*, woody plant encroachment

INTRODUCTION

Common broomweed (*Amphiachyris dracunculoides* [DC] Nutt. Ex Rydb.) is an annual forb that occurs throughout the southern Great Plains, USA (Stubbendieck et al. 1992). Broomweed growth is episodic and highly variable from year to year (Boyd et al. 1983). During years of abundant growth, broomweed is problematic because it can reduce grass production, interfere with livestock foraging, and may even injure livestock (Heitschmidt 1979; Sosebee and Gordon 1983; Britton and Wester 1995; Yoder et al. 1998). Herbicides have been used to mediate the negative impacts of annual broomweed infestations on livestock forage production (Scifres et al. 1971; Boyd et al. 1983).

Broomweed can also be an important attribute of wildlife habitat. Its structural characteristics can reduce the effects of temperature extremes and the risk of predation for northern bobwhite quail (*Colinus virginianus* Linnaeus) and other ground-dwelling birds (Johnson and Guthery 1988; Forrestor et al. 1998; Kopp et al. 1998; Cram et al. 2002; Lusk et al. 2006). The height, closed canopy, and open ground layer of broomweed stands makes it particularly attractive to northern bobwhites in that it reduces the exposure to raptors (Kopp et al. 1998) but provides open travel and feeding lanes (Guthery 1986). The seeds of common broomweed are an important food source of both bobwhites and scaled quail (*Callipepla squamata* Vigors) in the Rolling Plains of Texas (Jackson 1969; Leif and Smith 1993; Guthery 2000).

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Some research has addressed the climatic factors that trigger broomweed germination and growth. Seeds can germinate in the fall (September–November) or spring (March–April; Scifres et al. 1971). Heavy infestations are associated with below-average daily high temperatures in April and above-average precipitation in May (Heitschmidt 1979). Conversely Britton and Wester (1995) found that fall precipitation had a major effect on broomweed density in the following year. Little research has documented ecological factors that may cause differences in physiognomic or population characteristics of adult common broomweed.

During 2007 north Texas experienced conditions that caused a massive outbreak of common broomweed. In another experiment we were conducting at the time, we observed apparent differences in broomweed growth form characteristics in mesquite (*Prosopis glandulosa* Torr.) woodland areas versus areas that had recently been cleared of mesquite. The presence of an overstory of woody plants has been shown in numerous studies worldwide to reduce grass and forb production (Bedunah and Sosebee 1984; Harrington and Johns 1990; Scholes and Archer 1997; Ansley and Castellano 2006). However, little information is available on woody overstory effects on physiognomic structure of forbs (Hobbs and Mooney 1986). Our question was, does a mesquite overstory affect the physiognomic structure of individuals and/or population dynamics of an annual forb such as common broomweed? Our objective was to determine if there were differences in individual plant structural and population characteristics of broomweed in mesquite-cleared and mesquite-dominated areas.

METHODS

Site Description

Research was conducted on a 6-ha area on the Smith-Walker Experimental Ranch in north-central Texas. The site is located 13 km south of Vernon, Texas (lat 34°01′52″N; long 99°15′00″E; elevation 372 m). Mean annual rainfall is 665 mm with peak rainfall months in May (119 mm) and September (77 mm; National Climatic Data Center [NCDC] 2007). Mean monthly air temperatures range from an average daily maximum of 36°C in July to an average daily minimum of −2.5°C in January. Pretreatment woody overstory consisted of honey mesquite (mean height 3.8 m [SE 0.1], canopy cover 66% [SE 4], density 706 trees $\cdot$ ha^{-1} [SE 94], based on line transects conducted at 12 locations). The dominant perennial grass species is the C_3 midgrass Texas wintergrass (*Nassella leucotricha* [Trin. & Rupr.] Pohl.). Other grass species that occur on the site are C_4 perennial short-grasses, buffalograss (*Bouteloua dactyloides* [Nutt.] J. T. Columbus), blue grama (*Bouteloua gracilis* [H.B.K.] Lag. Ex Griffiths), and C_4 perennial midgrasses such as sand dropseed (*Sporobolus cryptandrus* [Torr.] Gray) and white tridens (*Tridens albescens* [Vasey] Woot. & Standl.). Prickly pear cactus (*Opuntia phaeacantha* Engelm.; $<10\%$ cover) is also common on the site. Soils are fine, mixed, superactive, thermic Typic Paleustalfs of the Wichita series that are 1–2-m-deep clay loams on 1–3% slopes (Koos et al. 1962; Natural Resources Conservation Service 2007). The site has a long history of continuous livestock (cattle) grazing at stocking rates of 6–8 ha $\cdot$ animal unit$^{-1} \cdot$ yr^{-1}. Since 1999 periodic grazing deferment has been employed to help restore the herbaceous community.

Treatment Description

Mesquite was mechanically harvested in the fall of 2006 on four plots (0.2–0.4 ha each) using a flail head rotor chopper that cut mesquite and prickly pear cactus stems to within 3 cm of the soil surface. The woody debris was lifted into a collection basket and removed from the site. The plots were essentially void of any vegetation that was over 3 cm tall for 1–3 mo following harvest until Texas wintergrass began growing in March 2007. Unharvested woodland plots that contained an overstory of dense mesquite were located in the same pasture as cleared plots in a completely randomized design with four replications.

Data Collection and Analysis

Data were collected in October 2007 on broomweed individual plant variables of above-ground mass (g $\cdot$ plant^{-1}), canopy diameter (cm), basal stem diameter (mm), and plant height (cm) and population variables of stand-level biomass production (g $\cdot$ m^{-2}), canopy cover (%), density (plants $\cdot$ m^{-2}), and visual obstruction (dm). Above-ground individual plant mass was determined by harvesting the four nearest plants at each of 10 random locations per plot, oven drying at 60°C to a constant mass and dividing by four. Canopy and basal stem diameter were measured on five plants each at 10 randomly located points per plot. We measured height on the plant nearest each of 10 randomly located points in each plot.

Stand-level broomweed production was measured by harvesting all plants within each of ten 0.25-m^2 frames randomly located per plot, and oven drying at 60°C to a constant mass. We visually estimated broomweed canopy cover as a percentage of ground area within 10 randomly located 0.25-m^2 frames per plot. Broomweed density was derived by dividing stand-level production by individual plant mass in each replicate. Visual obstruction was quantified at 10 randomly located points in each plot using the methods of Robel et al. (1970). We used a 1.5-m pole delineated into 15-dm strata. At each sample location, we recorded the lowest 0.5 dm visible from a distance of 4 m at a height of 1 m along the four cardinal compass points; thus each sample point had four estimates of visual obstruction.

As supporting information not directly linked to the stated objectives, we measured total perennial grass production in spring and at the end of the growing season the first year after mesquite harvest by randomly locating five 1×2 m wire cages within each plot in March 2007 before grasses began growing. Before positioning each cage in the woodland treatment, all standing dead grass litter was removed by hand from the area to be included in each cage as well as a 1-m buffer area surrounding each cage. The cleared treatments had no standing dead grass vegetation. To determine grass production, all perennial grass species were clipped to within 2 cm of ground level within a 0.25-m^2 frame in each cage in late April and at a different location within each cage in September 2007. Samples were oven dried at 60°C and weighed. Precipitation was recorded on site and compared to the 30-yr average (NCDC 2007).

Data were subsequently analyzed using the analysis of variance (ANOVA) procedure in SAS with a completely

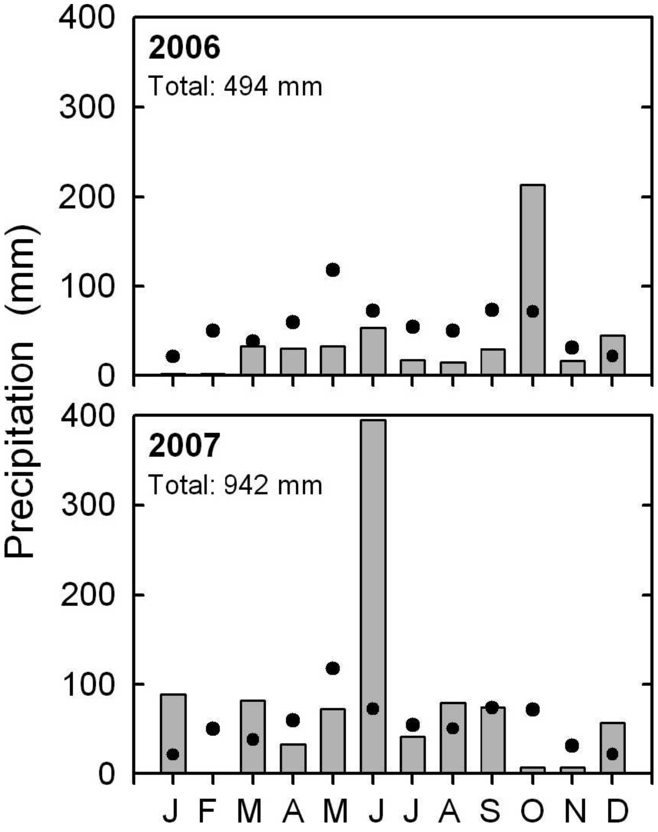

Figure 1. Monthly (bars) and total annual precipitation at the Smith Walker Experimental Ranch, 2006–2007. Filled circles are 30-yr average precipitation for each month (NCDC 2007).

randomized design model with two treatments (woodland and cleared) and four replicate values per treatment (Lentner and Bishop 1993; SAS 2003). For all broomweed and grass response variables, subplot values were averaged to generate replicate plot values for both treatments. Percentage data were arcsine transformed prior to analysis. Mean separation was performed using LSD ($P \leq 0.05$). A repeated measures analysis (PROC GLM) with mesquite treatment as main plot and sample date as subplot was used in the analysis of perennial grass production. Following determination of significant treatment by sample date interactions, within date completely randomized design analysis, with mesquite treatment as main effect, was conducted and means were separated with LSD ($P \leq 0.05$).

RESULTS AND DISCUSSION

We do not know all the factors that caused the massive outbreak of common broomweed in the region in 2007, but precipitation pattern was probably involved. A drought during the first 9 mo in 2006 followed by major precipitation pulses in October 2006, January 2007, and June 2007 apparently triggered germination and growth of broomweed (Fig. 1). The extremely dry conditions in the first 9 mo of 2006 probably reduced grass production and created bare ground openings in the understory layer. Large pulses of precipitation in October 2006 and January 2007 likely stimulated broomweed germination (Scifres et al. 1971; Britton and Wester 1995). The relatively dry conditions in February through May 2007 again limited grass production, but broomweed seedlings survived. Finally, the extremely large pulse of precipitation in June 2007 stimulated growth and development of the broomweed seedlings.

Table 1. Common broomweed individual plant and stand-level responses in mesquite-cleared and mesquite woodland treatments. Values in parentheses are standard errors of each mean ($n = 4$).

Response variables	Cleared	Woodland	F	Pr > F
Individual plant:				
Individual plant mass (g)	56.9 (4.6)	15.6 (3.5)	50.22	0.0004
Canopy diameter (cm)	65.7 (2.4)	43.9 (2.3)	41.69	0.0007
Basal stem diameter (mm)	7.2 (0.6)	3.2 (0.2)	33.13	0.001
Plant height (cm)	75.8 (1.9)	85.2 (2.6)	8.62	0.026
Stand level:				
Production ($g \cdot m^{-2}$)	532.0 (128.7)	399.6 (19.4)	1.04	0.348
Canopy cover (%)	42.0 (10.3)	45.5 (1.6)	0.11	0.747
Plant density ($plants \cdot m^{-2}$)	9.6 (2.3)	31.7 (9.4)	5.20	0.063
Visual obstruction (dm)	5.3 (0.9)	3.7 (0.1)	3.47	0.112

Broomweed Responses

All broomweed individual plant variables exhibited significant differences ($P \leq 0.05$) between the uncleared mesquite woodland and the cleared treatment. Individual plant mass was over three times greater, and canopy diameter was 50% greater in the cleared than in the woodland treatment (Table 1). Basal stem diameter was more than double in the cleared treatment than in the woodland. Basal stem diameter dimensions correspond to a stem cross section area that was nearly five times greater for broomweed growing in the cleared than in the woodland treatment. The greater stem cross section in cleared treatment supported much greater plant mass and what appeared to be a more vigorous plant.

In contrast to other individual plant variables, broomweed height was greater in the woodland than in the cleared treatment. Thus, broomweed plants were taller but lighter and with smaller canopy and stem diameters in the mesquite woodland than in the cleared treatment. These differences were likely a function of broomweed response to competition by mesquite. Shading by mesquite may have caused a more elongated broomweed growth from, and water use by mesquite lateral roots in shallow soil layers probably caused the reductions in individual plant mass and canopy and basal diameters (Ansley and Castellano 2006).

There was no difference in broomweed stand-level biomass production, canopy cover, or visual obstruction between the woodland and the cleared treatment (Table 1). However, broomweed density showed a trend ($P > 0.063$) of being greater in the woodland than the cleared treatment. This suggests there was initially a larger broomweed seed bank, a greater germination rate, and/or a greater rate of seedling survival in the woodland areas than the cleared areas. We note that mean density values reported in Table 1 were slightly different than what would be obtained by dividing mean broomweed production by mean individual plant mass for each treatment. This discrepancy was due to variation that occurred at the replicate level when density was derived by dividing production by plant mass.

Visual obstruction values were relatively large in both the cleared and woodland treatments and in combination with broomweed height, canopy diameter, and canopy cover would likely have improved the useable space for ground-dwelling birds such as northern bobwhites (Guthery 1997; Kopp et al. 1998). Broomweed in the cleared treatment was tall enough to provide overhead cover in the absence of woody plants. Broomweed in the woodland treatment likely improved useable space by providing understory and ground-level protection that is usually absent in mesquite-dominated habitats (Guthery 1986). Anecdotal observations also indicate that broomweed stands on both the cleared and woodland treatments provided secure midday bedding areas for white-tailed deer (*Odocoileus virginianus* Boddaert) and feral swine (*Sus scrofa* Linnaeus).

Perennial Grass Production

Perennial grass production was similar for both treatments during April 2007 with 18.0 $g \cdot m^{-2}$ (SE 3.6) in the woodland treatment versus 35.5 $g \cdot m^{-2}$ (SE 6.6) in the cleared treatment. By September 2007 production was 215.7 $g \cdot m^{-2}$ (SE 33.4) in the cleared and 75.3 $g \cdot m^{-2}$ (SE 17.7) in the woodland treatment 1 yr after mesquite harvest. The lack of a large difference in grass production between treatments in the spring was due to the low production in the woodland area the previous year before mesquite removal. Perennial grass growth had not yet increased in the cleared areas; however, this occurred by the end of the growing season. In addition, mesquite was without leaves from December to April.

The larger broomweed plants in the cleared treatment likely used more water and were more competitive with grasses than broomweed in the mesquite woodland (Yoder et al. 1998). However, broomweed production was not significantly different between treatments, and we attribute the lower grass production in the woodland treatment to mesquite and not broomweed (Ansley et al. 2004).

Numerous studies worldwide have found an increase in herbaceous production following woody plant removal on rangelands (Scholes and Archer 1997). However, most of these studies have focused on grass and not forb production (Ansley and Castellano 2006). Four papers that observed forb (and in some instances common broomweed) production following mesquite removal found variable responses, in part because of mesquite treatment type. Bedunah and Sosebee (1984) found that shredding mesquite did not increase common broomweed production, but mesquite removal methods such as grubbing that disturbed the soil did. Conversely McDaniel et al. (1982) found that common broomweed production did not increase following mesquite grubbing. Laxson et al. (1997) found no increase in forb production following mesquite removal by chain saw that did not disturb soil. Ansley and Castellano (2006) found an increase in forb production 7–8 yr after herbicide treatment of mesquite. In the current study the mechanical method that removed above-ground growth of mesquite had a minimal effect on soil disturbance. Thus, our findings are similar to those of McDaniel et al. (1982) and Laxson et al. (1997).

IMPLICATIONS

This study found that the growth form of common broomweed was changed, but broomweed production ($g \cdot m^{-2}$) was not changed as a result of woody plant removal. Although broomweed production in the region was elevated as a result of climatic conditions, the additional factor of woody plant removal did not further increase broomweed production.

Broomweed can be an impediment to livestock foraging due to its physical presence both during the growth year and as standing dead stems in the following year. Thus, although the cleared treatment increased grass production, the amount available for forage was likely limited in both treatments by the presence of broomweed. Sosebee and Gordon (1983) reported that livestock experienced health problems of broomweed side branches lodging in the eye and nose. Because of the differences found in individual structural characteristics, the more robust broomweed canopies found in the cleared treatment, with greater canopy and basal stem diameters, may deteriorate more slowly and thus create greater potential for livestock injury as they are foraging for grasses.

As to potential positive aspects, the heavier broomweed plants with larger canopies and stem diameters, yet lower stem density found in the cleared treatment likely improve avian habitat by providing greater canopy screening from raptors and greater escape routes at ground level (Guthery 1986). If true, then a management practice that creates openings within mesquite stands may increase useable space for ground dwelling birds by creating a more "habitat friendly" broomweed growth form (Guthery 1997).

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