Effects of Vegetation Structure on Foliage Dwelling Spider Assemblages in Native and Non-native Oklahoma Grassland Habitats

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INTRODUCTION

Spiders are the most diversified predators in terrestrial ecosystems (Wise 1993). Spiders have co-evolved with insects (main prey) to exploit nearly all terrestrial habitats from the Arctic Circle to the southern most reaches of terrestrial ecosystems, excluding Antarctica (Turnbull 1973; Foelix 1996). Although spiders occur in the most barren landscapes, botanically complex regions sustain high spider diversity and abundance (Foelix 1996). Spider assemblages are highly influenced by variations in plant community structure, ecosystem dynamics such as disturbance, and abiotic factors such as soil and ambient humidity and temperature (Bonte et al. 2002).

In terms of spider ecology, vegetation communities can be separated into four layers (Duffy 1966): (1) soil zone, which includes litter, stones, bare soil or water, and vegetation up to 15 cm in height; (2) field zone 1, comprised of vegetation between heights of 15 and 180 cm; (3) field zone 2, includes vegetation between heights of 180-450 cm; and (4) wood zone, encompassing woody growth above 450 cm in height. It is across these vegetation zones that co-existing spider taxa partition limited resources. Varying physiological tolerances to abiotic factors such as light intensity, humidity, and temperature also contribute to ecological separation (Nørgaard 1951; Kuenzler 1958; Kleemolu 1963; Turbull 1973). Resource partitioning among spiders is also influenced by the presence of web building spiders as they display higher territorial behavior in order to protect energetically costly webs (Uetz 1978). Despite the fact that many ecological factors influence spider-habitat dynamics, assemblage structure is often attributed to vegetation community characteristics, including successional sere (Greenstone 1984; Bonte 2002).

Although not as vertically stratified as forests, grasslands offer subtle vertical complexity along with complex horizontal heterogeneity. Habitat heterogeneity in prairies is maintained by disturbances such as fire, drought, and grazing at varying intensities. However, much of North America's native grasslands have experienced accelerated effects of disturbance due to anthropogenic activities including urbanization, disruption of natural hydrology, crop farming, and livestock grazing. The latter two agricultural practices are of particular importance throughout North American prairies, of which over 80% have been degraded (Hickman et al. 2006).

This project assesses the effects of grazing and the establishment of an introduced forage grass cultivar, plains bluestem (*Bothriochloa ischaemum*), on foliage dwelling spider assemblages.

METHODS

The study was conducted in June 2005 approximately 10 km northeast of the Wichita Mountains in Comanche County, southwestern Oklahoma (34º48'N 98º25'W). The area was historically dominated by mixed-grass prairie with fertile soils favoring tall-grass communities and habitats with shallow soils dominated by short-grass species. The study site encompasses 55 ha of agricultural land in the East Cache Creek drainage system. The study site was divided into three distinct habitats which represent three land use practices common to the southern Great Plains: (1) climax mixed-grass prairie deferred from grazing for approximately 3 years, (2) native mixed-grass prairie following a brief period of heavy grazing intensity in an early to mid succesional sere, (3) plains bluestem monoculture.

Four 50-m transects were randomly established in each of the three habitats. A random number generator was used to obtain numbers corresponding to degrees travel (north, east, south, and west) and distance (5- 250 m) from an approximated center point of each of the three habitats. A sweep net was brushed through the vegetation 30 times while walking along each transect. Close attention was paid to sweep the vegetation at all height intervals, with mid-sweep at ground level. When sampling grassland habitats for spiders, sweep netting is an effective method for collecting foliage-dwelling spiders (Warui et al. 2005). Spiders were preserved in 70% ethanol and identified to the family level; family-level measures are commonly used to examine community-level patterns (e.g. Whitmore et al. 2002). Taxonomic keys used included Kaston (1978) and Ubick et al. (2005). Analysis of variance (ANOVA; Microsoft Excel®) was used to test for significant variations in mean abundance per transect among spider families between habitats.

Habitat variables were estimated at five randomly selected points along each transect using a 1m^2 plot-square and ocular estimation. Random points were chosen using a random number generator to obtain numbers corresponding to meters traveled (1- 50 m) along the sampling transect. Habitat variables included: (1) vegetation density at 0.0- 0.1 m, (2) vegetation density at 0.1- 0.5 m, (3) vegetation density above 0.5 m, and (4) greatest vegetation height.

ANOVA was used to determine which habitat variables significantly differed among sampling transects and between habitats. Those habitat variables found to differ among habitats were chosen as predictor variables for use in following analyses. Linear regression analysis (Microsoft Excel®) was employed to examine effects of significant habitat variables (predictor variables) on both spider abundance and spider family diversity (response variables). Shannon-Weiner Index of Diversity (H') was calculated for each habitat.

RESULTS AND DISCUSSION

A total of eight spider families were identified among the three habitat types: Thomisidae (n = 22), Oxyopidae (n = 26), Theridiidae (n = 13), Dictynidae (n = 19), Salticidae (n = 9), Philodromidae (n = 16), Araneidae (n = 8), and Tetragnathidae (n = 3). Spider family diversity (H') was the same for both native habitats (0.84), but lower for the plains bluestem monoculture (0.67). Mean spider family abundances per transect differed significantly among the three habitats ($F = 2.91$, $P = 0.03$).

Two of the habitat variables differed significantly across the habitat types, vegetation density above 0.5 m and greatest vegetation height ($F = 4.9$, $P = 0.007$). Linear regression illustrated significant positive relationships between vegetation density above 0.5 m and spider abundance ($r^2 = 0.84$, $P < 0.01$) and vegetation height and spider abundance ($r^2 = 0.49$, $P = 0.01$). Neither vegetation density above 0.5 m ($r^2 = 0.29$, $P = 0.09$) or greatest vegetation height ($r^2 = 0.16$, $P = 0.19$) had significant effects on spider family diversity.

The similarity in spider family diversity between climax and overgrazed native prairie habitats might seem paradoxical under the paradigm that disturbance drives diversity (c.f. Connell 1975, 1978; Collins and Barber 1986; Tilman 1994). According to a disturbance-based model, lower succession communities would be expected to sustain higher diversity values for most invertebrate assemblages across trophic levels as a reflection of increased plant diversity. However, the ecological value of forb abundance in overgrazed prairie (expected to increase diversity) is likely compromised by lower overall vertical surface area provided by plant height (expected to increase abundance), which is observed in heavy grass cover of climax native prairie. Decreased family diversity observed in the plains bluestem monoculture is likely due to low plant diversity. Hickman et al. (2006) suggested that overall lack of vegetation complexity in plains bluestem monoculture communities reduces arthropod biomass. Plains bluestem is of low value for wildlife, as it decreases plant diversity and is avoided by many wildlife species (Tyrl et al. 2002). Alterations in plant community diversity and/or structure are expected to facilitate changes in diversity and abundance of arthropods. Because spiders depend heavily on arthropod prey, dynamic shifts in the prey base likely limits the spider assemblage from the bottom up.

Small patches of annual grasses and forbs were scarcely present in the plains bluestem habitat; temporal changes among these patches might alter the spider community from that of results presented here. Churchill and Ludwig (2004) suggested that temporal changes in annual grass-perennial grass ratio influences foliage dwelling spider assemblages. More extensive sampling through spring, summer, and fall might uncover dynamic shifts in spider abundance and diversity not detected by short-term results, such as those presented here.

The results of linear regression suggest that increased disturbance regimes within prairies and the resulting decrease in vegetation cover negatively affect foliage dwelling spider abundance. This effect was demonstrated through the common land use practices of overgrazing and establishment of plains bluestem monoculture. Topping and Love (1997) illustrated that high disturbance levels result in low spider density and poor species richness, grazed and cultivated lands have detrimental effects on foliage dwelling spider assemblages, and native foliage dwelling spider assemblages require complex vegetation structure. Results have consistently shown that anthropogenic land-use alterations have great effects on spider communities (Miyashita et al. 1998; Bolger et al. 2000; Shochat et al. 2004). Livestock grazing alters habitat structure and inhibits ecological succession (Churchill and Ludwig 2004). Dennis (2003) provided extensive evidence that arthropod diversity can be altered by livestock grazing through alteration of plant community composition and physical properties of soil. In addition to physical effects of livestock, range management plans have largely been designed to promote dominance of a few plant forage species, thereby reducing habitat heterogeneity (Fuhlendorf and Engle 2001).

Spiders examined in this study use complex vegetation structure to meet life requisites such as web construction, brood care, mating, shelter, active hunting, ambush hunting, and dispersal. Although spiders in general are polyphagous, most are ecologically as specialized as the prey groups they rely on. Therefore, any measure of the foliage dwelling spider assemblage might accurately reflect the dynamics of the specific community surrounding them. The results of this project are congruent with Churchill and Ludwig (2004) where: (1) plant communities direct spider assemblages, (2) spiders are heavily associated with fine scale habitats, (3) measures of foliage dwelling spider assemblages are correlated with vegetation cover, thus influenced by factors affecting vegetation structure.

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