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Source: Florida Entomologist, 91(2) : 332-334

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/0015-4040(2008)91[332:TEOSOF]2.0.CO;2

THE EFFECT OF SEASON OF FIRE ON DENSITY OF FEMALE GARDEN ORBWEAVERS (ARANEAE: ARANEIDAE: *ARGIOPE*) IN FLORIDA SCRUB

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In his landmark book on fire ecology, Whaley (1995, p. 209) states: "the question of whether the absolute abundance of invertebrate populations changes after fire still remains" unresolved. As he details, the reasons for this dilemma are several, but inadequate experimental design and non-quantitative sampling methods are pervasive problems in the literature (Whaley 1995). Most of the "less-than-ideal studies" suggest that many species of arthropods, especially arboreal taxa, decline after fire and recover relatively rapidly (Whaley 1995). In addition, time-of-year of fire relative to the life cycle of an organism may be very important in post-fire recovery of populations.

In light of comments and criticisms of Whaley (1995) and more recently van Mantgem et al. (2001), I decided to conduct a replicated, randomized study of the effect of season of fire on the density of garden orbweavers (*Argiope* Audouin) in Florida scrub. My hypothesis was that winter burns conducted before *Argiope* spiderlings disperse long distances from the maternal egg sacs by ballooning in Apr and May (Tolbert 1977; Anderson 1978; Horton & Wise 1983) should have little if any effect on the resultant density of adult female spiders in the fall, whereas burns performed in summer after spiders have stopped ballooning might be disastrous for local *Argiope* populations. The demographic results, as reported here, represent the initial contribution of my ongoing, long-term ecological research on *Argiope* species in native ecosystems.

I measured *Argiope* densities in oak scrub at the 2101-ha Archbold Biological Station in southern Highlands County, Florida (elev. 36-46 m, 27°11'N, 81°21'W) in 2001 and 2007. The work was performed in the most extensive vegetative association, called scrubby flatwoods, which has fire-resistant slash pines (*Pinus elliotti*) scattered in a dense matrix dominated by low-growing shrubby oaks (*Quercus inopina*, *Q. chapmanii*, and *Q. geminata*), palmettos (*Serenoa repens* and *Sabal etonia*, Arecaceae), and shrubby lyonias (*Lyonia ferruginea*, *L. fruticosa*, and *L. lucida*, Ericaceae) (Abrahamson et al. 1984). For management purposes, the scrub at Archbold is organized into a series of 187 burn units and a detailed history of burning in each unit is available (Main & Menges 1997; unpublished Archbold records). I worked in 15 burn units whose average area was 29.6 ± 5.3 ha (mean ± SE, range = 4.6-70.8 ha). Three units were burned in Feb 2001, 3 in Jul 2007, and 3 in Aug 2007. As controls, in 2001 and 2007 I chose at random 3 "unburned" units adjacent to recently burned ones; all the controls had been burned 3-7 years previously, so they had regenerated their shrubby matrix. I randomly located five 20- × 25- m (= 0.05 ha) plots in each of the 15 experimental burn units. In Oct 2001 or 2007 I visited the recently burned and control plots shortly after dawn on foggy mornings when dew-laden spider webs were easily seen and traversed each plot at 2-3 m intervals to census webs occupied by *Argiope* females. I inspected every orb-web to identify the resident spider and recorded the number of webs for each species in each plot (n = 75 plots in total). This method for censusing web-building spiders was validated previously by Enders (1973), Tolbert (1977), and Carrel (2001).

Throughout this study I found only 2 of the 3 species of *Argiope* known to occur in scrub at Archbold (Levi 1968). *Argiope florida* Chamberlin & Ivie, the Florida garden spider, and *A. aurantia* Lucas, the yellow garden spider, were widespread, but *A. trifasciata* (Forskål), the banded garden spider, was not detected in any plot. *Argiope florida* appears to prefer xeric sites and *A. aurantia* seems to favor mesic sites, but the 2 species frequently occur in syntopy, within 1-3 meters of one another in the scrub (pers. observ.). Perhaps their habitat preferences overlap extensively, yet there are so few studies on *A. florida* (Justice et al. 2005) that one cannot refer to published data to make any credible inferences. When I have searched extensively in scrub at Archbold in Oct over the course of 7 years (2001-2007) I have found some female *A. trifasciata* on orb-webs near seasonal ponds that are embedded in the scrub matrix, but they have never been common.

In 2001, I detected 73 female *A. florida* and 19 female *A. aurantia* Lucas in fifteen 0.05-ha control plots, equal to a species ratio of 79%:21% and mean overall density of female *Argiope* spp. of 122.7 ± 10.0 spiders/ ha. In 2007, I found the density of female *Argiope* spp. in control plots was virtually the same as before (124.0 ± 21.6/ ha), but the numerical ratio of the 2 species was reversed: a total of 20 *A. florida* and 73 *A. aurantia* (22%:78%) were present. The observed year-to-year difference in relative abundance of the 2 species was highly significant (χ^2 = 61.9, df = 1, P <

0.0001). Inspection of land management records and climatological data for Archbold did not reveal any apparent cause for this dramatic inversion of species abundance in scrub that had not been recently burned, but this phenomenon seems worth investigating.

I performed statistical analysis (SPSS 2005) of the data for density of female *Argiope* (*A. aurantia* and *A. florida* combined) by treating the 2 sets of control units and 3 sets of recently burned units as different treatments (n = 5). Thus, for ANOVA the design was 5 treatments x 3 replicate burn units/treatment x 5 replicate plots/burn unit. The data for *Argiope* density was transformed beforehand by adding 1 to each of the 75 values and then taking the square root of each sum in order to normalize the error variances of the residuals. As shown in Table 1, univariant ANOVA revealed that treatment was highly significant (F = 29.519, P < 0.0001) but the remaining 2 variables, burn unit and plot, were not significant. Comparison of the treatment effects, with either the Student-Newman-Keuls or Tukey HSD post hoc test, revealed that plots burned in Feb on average did not have significantly fewer female *Argiope* than the controls (Fig. 1). Presumably Feb burns destroyed *Argiope* eggsacs present in the affected burn units, but subsequently in spring and early summer aerial dispersal of spiderlings from nearby unburned scrub replaced lost spiders, so *Argiope* populations in fall were normal.

In contrast, plots in both summer burns were significantly depauperated; they contained few if any webs of these orbweaving spiders (Fig. 1). Hence, summer burns occurring after ballooning by spiderlings had ceased, effectively eliminated *Argiope* species in oak scrub at Archbold. The lack of repopulation of summer-burned plots is not surprising in light of the limited propensity of immature and adult *Argiope* to move more than several meters over the course of 2-3 weeks from one web site to a new one (Enders 1973, 1976, 1977; Tolbert 1977). Web site tenacity is high in all post-spiderling stages of *Argiope*, regardless of site quality, unless strong winds destroy the orb-webs (Enders 1975, 1977).

TABLE 1. RESULTS OF UNIVARIATE AVOVA FOR DENSITY OF *ARGIOPE* SPP. (# WEBS/0.05 HA) AS A FUNCTION OF TREATMENT (n = 5), REPLICATE BURNUNIT/TREATMENT (n = 3), AND SAMPLE PLOT WITHIN EACH BURN UNIT (n = 5). SPIDER DENSITY WAS TRANSFORMED BEFOREHAND TO NORMALIZE THE ERROR VARIANCES OF THE RESIDUALS (SEE TEXT FOR DETAILS).

Source of variation	df	MS	F	P
Treatment	4	8.058	29.519	<0.0001
Burn unit	2	0.143	0.523	0.595
Plot	4	0.173	0.635	0.639
Error	64	0.264		

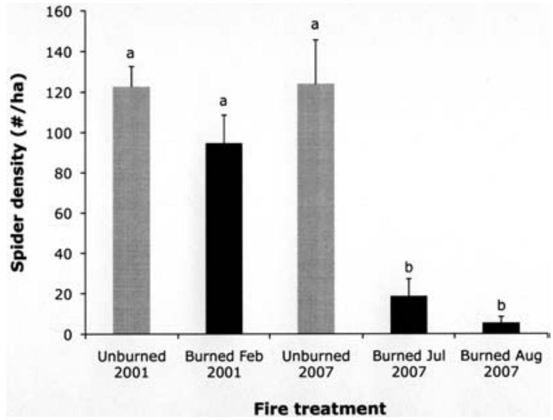

Fig. 1. Mean density of female *Argiope* spiders (+ SE, n = 15) in Florida scrub as a function of fire treatment. Treatments having the same letter are not significantly different (P > 0.05) from one another.

The density of female *Argiope* in the unburned scrub in 2001 and 2007 (~125 spiders/ha), while it seemed typical for Archbold in late summer and early fall (pers. observ.), actually was much lower by 1-2 orders of magnitude than others have documented in northern states (latitude 35-39_N). Horton & Wise (1983) found 1,400-1,700 female *A. aurantia* and *A. trifasciata*/ha in an old field in eastern Maryland; McNett & Rypstra (2000) detected nearly 8,000 *A. trifasciata* /ha in an old field in southern Ohio; and Enders (1973) counted approximately 16,000 female *A. aurantia* / ha on sericea lespedeza (*Lespedeza cuneata*) in road cuts in eastern North Carolina. Such high densities are achieved in large part because spiders in the genus are very tolerant of one another: extensive field studies provide little if any evidence for interspecific competition, intraspecific competition, or cannibalism (Enders 1975, 1977; Tolbert 1977; Horton & Wise 1983). Perhaps the xeric conditions and low abundance of insect prey that prevail in Florida scrub prevent *Argiope* from achieving high densities. Evidence for this comes from decades of observations by scientists and visitors at Archbold in late summer and fall that consistently note large, dense aggregations of *Argiope aurantia* and other orbweavers in wooded sites along the shores of lakes in central Florida where the microclimate is humid and where midges and other insects are plentiful.

In this study I demonstrated that the season of burning a native habitat (Florida scrub) negatively affected the short-term abundance of large araneid spiders (2 *Argiope* spp.). Although I did not measure reproductive output by the spiders, clearly areas burned in summer that harbored few if any female *Argiope* in the subsequent fall would be expected at best to yield relatively small numbers of spiderlings in the following spring. The diminution of *Argiope* in summer-burned units likely was temporary because spiderlings from nearby unburned habitats in the following year probably colonized and repopulated all of them, much as they did all other burn units at Archbold regardless of their fire history. A similar recovery within a year after burning oak scrub at Archbold was reported for the red widow spider, *Latrodectus bishopi* Kaston (Carrel 2001). But a word of caution is in order. The results of population genetic analyses, published by Ramirez & Haakonsen (1999), indicate that as suitable habitats for *Argiope* spp. and other spiders become increasingly fragmented, more isolated, and less extensive, then long-distance dispersal of spiderlings by ballooning may become ineffective at maintaining genetic cohesion across species' ranges.

I thank the Archbold Biological Station and its staff, especially M. Deyrup and K. Main, for providing long-term technical, financial, and intellectual support of the highest caliber. Additional support came from a Development Gift Fund at the University of Missouri. Finally, I deeply appreciate the continuing encouragement for extended field studies provided by Jan Weaver and other members of my family.

SUMMARY

The density of female garden orbweavers (*Argiope* spp.) as a function of season of fire in Florida oak scrub was determined in Oct in replicated, randomly chosen 0.05-ha plots. Winter burns earlier in the year did not significantly lower spider densities relative to unburned controls, but summer burns largely extirpated local spider populations. Supplementary information on line at http://www.fcla.edu/FlaEnt/fe912.htm

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