

Effects of Different Frequencies of Fire on an Epigeal Spider Community in Southern Caldenal, Argentina

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Gabriel A. Pompozzi, F. Rodrigo Tizón, and Daniel V. Pelaéz (2011) Effects of different frequencies of fire on an epigeal spider community in southern Caldenal, Argentina. *Zoological Studies* 50(6): 718-724. Fire contributes to the selection and distribution of plant and animal species, and for a long time, its effects were considered to be negative. But recently, its role has been reinterpreted from a conservation standpoint. Fire, together with other environmental factors such as temperature and rainfall, affects the diversity and abundance of arthropods. Spiders comprise a group of potential ecological indicators, because they are diverse, abundant, and easy to sample, and they interact with their environment, potentially reflecting any ecological changes. Our goal was to assess the effects of controlled fires of different frequencies on the abundance, diversity, and composition of a community of epigeal spiders in southern Caldenal, La Pampa, Argentina. We obtained samples in May, Nov., and Dec. 2006 and Apr. 2007 in an area of approximately 12 ha. We conducted controlled burns every 3-4 and 6-7 yr since 1991, and used pitfall traps to collect specimens. Adults (554 spiders) were collected, and 56 species/morphospecies were recorded. *Leprolochus birabeni* Mello-Leitao 1942 (Zodariidae) was clearly the dominant species (19.9% of the total). We found significant differences in the abundances and species richness values between sampling months. However, we found no significant differences in the Shannon-Wiener (H') diversity index between burned and unburned areas. The species compositions were similar in burned and unburned areas. <http://zoolstud.sinica.edu.tw/Journals/50.6/718.pdf>

Key words: Araneae, Epigeic spiders, Controlled burns, South America.

Throughout the world, fire is considered an important environmental factor in many ecosystems (Whelan 1995), driving the evolution of species and vegetation dynamics in semiarid grasslands (Boó et al. 1996). Species selection and distribution, and vegetation composition are all altered by fire, thus promoting stability and the fluctuation of stages (Whelan 1995). In many cases, fire acts as a disseminator of species, and populations can recover (de Villalobos 2007). Moreover, physical, chemical, and biological features of the soil are affected by fire. The significance of such changes depends on the fire intensity and duration, and

also on the structure and moisture of the soil itself (Whelan 1995). The function of fire has been reinterpreted from the viewpoint of ecological disturbance and conservation biology (Moretti et al. 2002). Thus, an understanding of the effects of fire on the flora and fauna is important for successful management aimed at conserving biodiversity (Langlands et al. 2006).

In addition, other environmental factors, such as temperature, relative humidity, and rainfall, affect the diversity and abundance of different taxa and thus modify the ecosystem structure and composition (Giraldo et al. 2004). Many groups of

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arthropods are used as ecological indicators due to their susceptibility to ecosystem disturbance, such as fire and pollution (Clausen 1986). Spiders comprise a group that may be useful as an ecological indicator due to their diversity, abundance, and ease of sampling (Clausen 1986, Scott et al. 2006). Also, their interactions with the environment may reflect ecological changes (Churchill 1997).

In South America, little is known about how fire affects spider communities, with only a few studies conducted in Uruguay (Ghione et al. 2007) and Brazil (Baretta et al. 2007). In Argentina, knowledge of fire's effects on spider communities is scarce. Moreover, previous studies of these communities in this country focused on ecological aspects associated with natural (Corronca and Abdala 1994, Rubio et al. 2008, Ferretti et al. 2010) and altered areas (Beltramo et al. 2006, Ávalos et al. 2007, Armendano and González 2010). Due to this gap in knowledge, the aim of this study was to analyze the effects of controlled low-intensity fires on the abundance, diversity, and composition of a community of epigeal spiders in southern Caldenal, La Pampa, Argentina.

MATERIALS AND METHODS

Study area

The study site is located in southeastern La Pampa Province (Caleu Caleu), which belongs to the phytogeographical district of Caldén (38°45'S, 63°45'W), Espinal Province (Cabrera and Willink 1973) (Fig. 1). The temperate climate is semiarid, with an average annual temperature of 15.3°C and average annual rainfall of 344 mm concentrated in autumn (Mar.-June) and spring (Sept.-Dec.) (Peláez 2000). The vegetation comprises 2 layers: *Prosopis caldenia* Burk. and *P. flexuosa* DC are the dominant woody species of the deciduous spring-summer cycle (Sept.-Feb.), and there are also evergreens, such as *Condalia microphylla* Cav., *Chuquiraga erinacea* Don., and *Larrea divaricata* Cav. and a herbaceous layer dominated by the perennial grasses *Nassella tenuis* Phil., *Piptochaetium napostaense* (Speg) Hack., *Poa ligularis* Nees, *Nassella clarazii* Phil., *Pappostipa major* Speg., and *Jarava ichu* Phil. (Peláez 2000).

Sample design

We conducted sampling in an area of

approximately 12 ha, which was divided into 6 experimental units of 1 ha each. Many controlled burns were carried out in the area since 1991 every 3-4 (HF, high frequency) or 6-7 yr (LF, low frequency). Two experimental units were burned twice (once in 1991 and once in 1999), 2 experimental units were burned 4 times (in 1994, 1996, 1999, and 2003), and 2 experimental units remained unburnt (controls) (Fig. 1). We conducted prescribed fires in autumn (Mar.-June) under the following conditions: a temperature of 22°C, relative humidity of 32%, wind speed of 15 km/h, and with a fine load fuel (diameter < 3 mm) of 2850 kg of dry matter/ha. We collected samples in May, Nov., and Dec. 2006 and Apr. 2007. We randomly distributed pitfall traps consisting of plastic cups of 8 cm in diameter and 10 cm high (Sutherland 1996) containing propylene glycol (30%), water, detergent, and salt. We placed 10 traps in each experimental unit per sampling period for a week. We preserved collected specimens in 70% alcohol, identified them to family and species/morphospecies level,

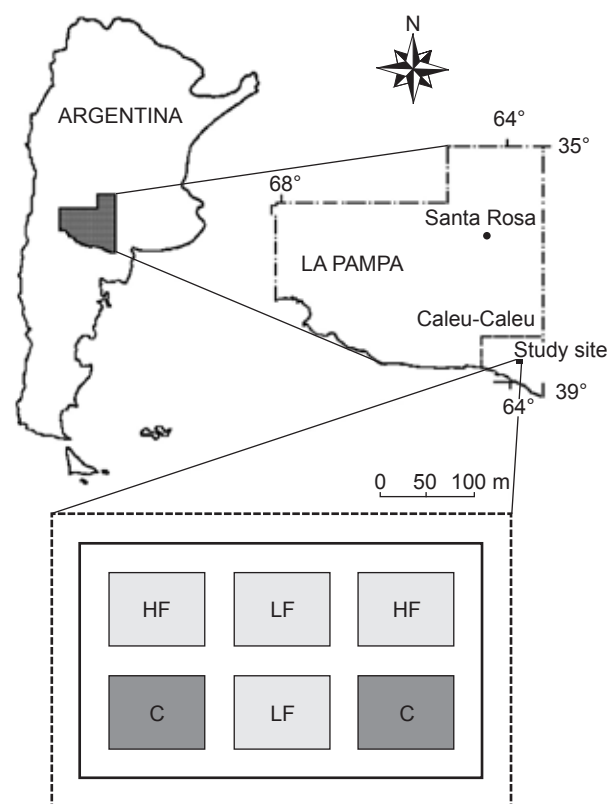


Fig. 1. Geographic location of the study area (Caleu-Caleu Department, La Pampa Province, Argentina) and the experimental design (HF, high frequency; LF, low frequency; C, control).

and then deposited them in the Laboratorio de Pastizales Naturales del Departamento de Agronomía (Univ. Nacional del Sur). Only adult specimens were used due to the difficulties in identifying immature specimens.

Data analysis

We used analysis of variance (ANOVA) and Fisher's least significant difference (LSD) test to determine differences in mean abundances and species richness levels between dates. We tested the normality with the Shapiro-Wilks test. We statistically analyzed the data using the re-sampling bootstrap (B) method on Shannon-Wiener diversity indices (H'), associated with 95% confidence intervals (CIs). This analysis considers samples of any size and does not require normality of the data (Pla and Matteucci 2001). We conducted all statistical analyses using Infostat (Infostat 2008). To determine if each month was sufficiently sampled, we used the estimator, CHAO 1 (Colwell and Coddington 1994), in the program EstimateS 8.2 (Colwell 2009). We used the Coleman approximation for rarefaction estimates of species richness, using the sample-based method provided by EstimateS 8.2 (Colwell 2009).

RESULTS

Total numbers of species and individuals

In total, we collected 554 adult spiders, including 56 species/morphospecies belonging to 20 families. Spiders were significantly more abundant in Dec. (220 individuals (ind.)) and Apr. (203 ind.) than in May (31 ind.) and Nov. (100 ind.) ($F = 10.94$; $p = 0.0002$) (Table 1). In addition, Dec. was the most speciose month (Fig. 2, Table 1). However, the species richness was lower than the value estimated by CHAO 1 in each month (Table 1). The most abundant

families were the Linyphiidae (29.7% of the total), Lycosidae (20.4%), Zodariidae (20%), Salticidae (9.8%), and Gnaphosidae (6.2%). These families represented 86.1% of the total number of spiders collected. The families with the highest number of species were the Lycosidae (9 species), Linyphiidae (8 species), Salticidae (7 species), Gnaphosidae (6 species), and Anyphaenidae (4 species). *Leprolochus birabeni* Mello-Leitao 1942 (Zodariidae) was the dominant species in all samples, reaching 20% (110 ind.) of all spiders captured. This study showed higher abundances at the control site (218 ind.), followed by HF treatment (193 ind.), and a lower number of spiders in the LF treatment (143 ind.). The family Linyphiidae was the most abundant in the control, followed by the Lycosidae and Zodariidae. In the HF treatment, the family Zodariidae was the most abundant, followed by the Linyphiidae and Lycosidae. The LF treatment showed the same abundance distribution of families as the control.

Diversity of spiders

The Shannon-Wiener (H') diversity indices were $H' = 2.89$ for the control, $H' = 2.46$ for HF

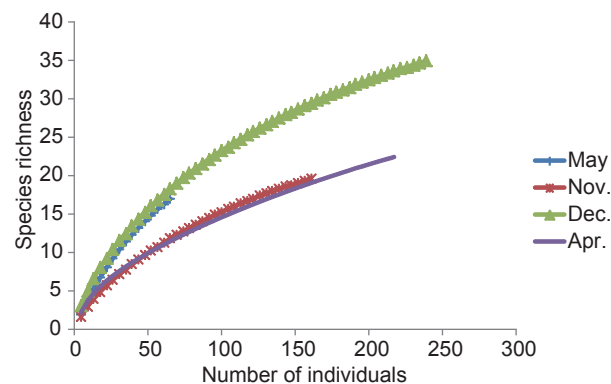


Fig. 2. Rarefied curve of species richness for spiders (Araneae) based on individuals in each month sampled: May, Nov., Dec., and Apr.

Table 1. Mean abundance (\pm standard error), species richness (no. of species/morphospecies), rarefied species richness (\pm standard deviation), and the CHAO 1 estimator of spiders in each month sampled in southern Caldenal, Argentina

	May 2006	Nov. 2006	Dec. 2006	Apr. 2007
Mean abundance	5.2 \pm 0.95	16.7 \pm 4.36	36.7 \pm 6.59	33.8 \pm 4.17
Species richness	17	23	33	24
Rarefied species richness	16.32 \pm 0.8	19.59 \pm 1.57	34.74 \pm 0.50	22.56 \pm 1.13
CHAO 1	28.3	27.8	46.4	32.7

treatment, and $H' = 2.72$ for LF treatment. We observed the highest diversity in the control in Dec. ($H' = 2.32$), while the lowest diversity was with HF treatment during May ($H' = 0.65$). We found no significant differences ($p \geq 0.05$) among the control, HF, and LF treatments in May, Nov., and Apr. We only found significant differences between the control and HF treatments in Dec. (Fig. 3).

Species composition of spiders

We observed 38 species in the controls, of which 14 were singletons (36.8%), and 8 were doubletons (21.1%). The most abundant species was *Scolecuroa* sp. (Linyphiidae) with 34 ind. (15.5%) (see Appendix I). *Leprolochus birabeni* and Lycosidae-sp1 each represented 15% of the control. Nine species in the control were not present in the other treatments (Fig. 4). We found 32 species in the HF treatment, including 18 singletons (56.3%) and 4 doubletons (12.5%). We recorded 8 species that were only found in the HF treatment (Fig. 4). The most abundant species was *L. birabeni* (29.5%), followed by *Scolecuroa* sp. (17%) and Lycosidae-sp1 (10.8%). The LF treatment comprised 31 species, including 17 singletons (54.8%) and 4 doubletons (12.9%). *Scolecuroa* sp. was the dominant species (17%),

followed by *L. birabeni* (14.6%), *Tutaibo* sp. (Linyphiidae) (12.5%), and Lycosidae-sp1 (11.8%). This treatment included 7 species not found in the other treatment or control (Fig. 4). HF treatment and the control shared 7 species, which did not appear in the LF treatment, while the control and LF shared 7 species not present in the HF treatment. The species *Actinopus* sp. (Actinopodidae) and Araneidae-sp2 were recorded in the HF and LF treatments but not in the control (Fig. 4).

DISCUSSION

The species richness and abundance of epigeic spiders were higher in the control than in the burned areas, so these results might agree with those of arid or semiarid regions (Langlands et al. 2006), which exhibit similar climatic conditions as the southern Caldenal in Argentina. Conversely, in an *Eucalyptus* forest of Australia, York (1999) found a reduction in species richness and abundance of arthropods in areas with frequent fires. Brennan et al. (2006) found that there was an immediate decline in spider abundance and taxa richness following a fire, and ecosystem recovery took < 3 yr, which is fast. However, in this study, neither the spider abundance nor species richness

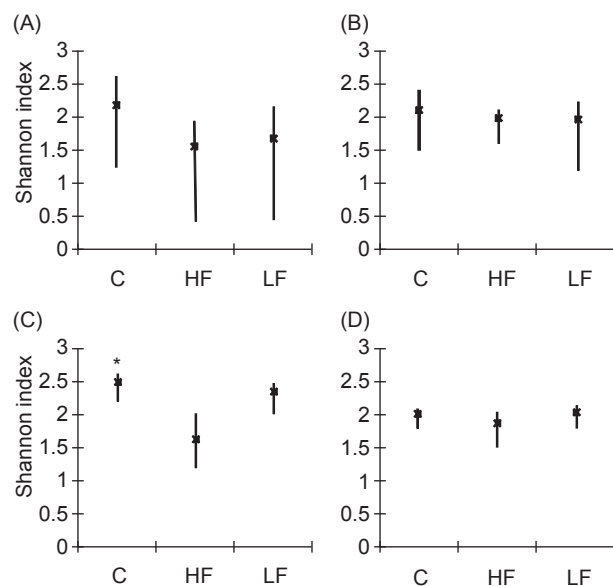


Fig. 3. Shannon-Wiener diversity index with 95% bootstrap confidence intervals (CIs) of control (C) and high- (HF) and low-frequency (LF) treatments for each date: (A) May, (B) Nov., (C) Dec., and (D) Apr. An asterisk indicates a significant difference ($p < 0.05$).

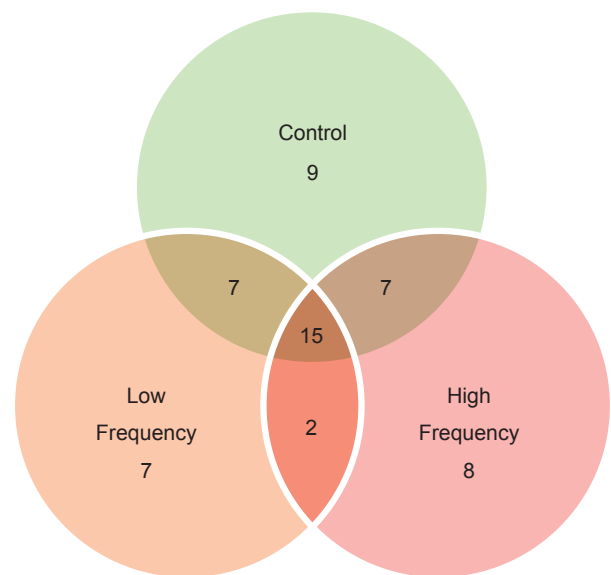


Fig. 4. Venn diagram representing the number of unique and shared species for each treatment: Control (C), low frequency (LF), and high frequency (HF).

increased after ≥ 3 yr of burning. Reductions in the number of species and abundance in burned areas could be attributed to a decrease in litter and soil moisture, as well as simplification of the habitat structure (York 1999). The Shannon-Wiener (H') diversity index showed greater diversity in the control than in the LF and HF treatments. Since there were more species and greater abundance in the HF than LF treatment, the lowest value of H' in the HF treatment could be explained by the presence of 2 dominant species (*L. birabeni* and *Scolecuroa* sp.).

The families Linyphiidae and Lycosidae, that were very abundant in this study, also showed higher abundances when pitfall traps were used (Koponen 1993 2005, Moretti et al. 2002). The family Zodariidae, the 3rd most abundant, in this study, was the most abundant family in an Australian desert (Langlands et al. 2006); however, this family was not among the most dominant families in various studies carried out in Europe (Moretti et al. 2002, Urones and Majadas 2002, Koponen 2005). The abundance of the Lycosidae (20.4% compared to the Linyphiidae with 29.7% of the total) recorded in burned treatments contrasts with results obtained by Koponen (2005), who found that spiders of this family are often dominant in burned areas. However, in unburned areas, Koponen (1993) and Moretti et al. (2002) recorded the family Linyphiidae as being dominant. The dominant species in this study was not influenced by the effects of fire, as it was dominant in all experimental units (control, HF, and LF).

The abundance and richness of spiders in this study decreased after the fire, in contrast to results obtained in Europe and Canada (Koponen 1993 2005, Moretti et al. 2002, Urones and Majadas 2002). Burned sites showed greater species richness than unburned sites in forests of Switzerland, Canada, and Finland (Koponen 1993 2005, Moretti et al. 2002). Similarly, the abundance and richness of other arthropods such as the Orthoptera, increased in burned sites (Swengel 2001). Conversely in forests of Western Australia, Abbott et al. (2003) reported minimal changes in assemblage structure of the spider species composition due to logging and burning compared to controls. Also, Baretta et al. (2007) found a decrease in the spider abundance and taxa richness in burned areas in a Brazilian forest. These results are more in agreement with the findings in this study. The intensity and different frequencies of fire could be the cause of differences between this study and

others (Koponen 1993 2005, Moretti et al. 2002). Moreover, the percentages of singletons and doubletons in the HF and LF treatments showed high values, and so there may have been an underestimation of species richness in the burned areas (Scharff et al. 2003).

Moreover, the large number of particular species found in each treatment and control (between 7 and 9) indicates the need for a gradient of fire frequencies to avoid the loss of species. Heterogeneity of burning regimes could increase the biodiversity of spiders even on a small scale (Martin and Sapsis 1992). In countries with well-developed fire management, such as the US, Australia, and South Africa, this concept has been formalized as "patch mosaic burning" (Parr and Andersen 2006). This type of fire management creates a mosaic of patches representative of a range of fire histories so that heterogeneity is generated across space and time. The key to maintaining high diversity and conservation of endemic or rare species is evaluating the complexity of interactions among the fire regime (e.g., frequency, intensity, season, and scale), climatic variables (e.g., rainfall), and spider responses (Langlands et al. 2006).

It should be noted that controlled fires are of relatively low intensity. They are conducted within ranges of temperature, relative humidity, and wind speed that minimize escape risk and maximize the desired effects on vegetation (Wright and Bailey 1982). Furthermore, we used pitfall traps as the capture technique; thus, the inferences in relation to the spider community may have been affected by the use of this technique. Another important factor is that we could not take any samples in other years in order to make comparisons and detect possible effects of seasonality. In any case, more-comprehensive studies are needed to improve our understanding of fire's effects on spiders in southern Caldenal, maybe with different capture techniques and sampling for a longer period than a year. However, this ecological study has produced a 1st look at the spider fauna of the southern Caldenal, being the 1st contribution from this region.

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Appendix I. List of spider families and species/morphospecies belonging to the control (C) and different fire treatments (LF, low frequency; HF, high frequency)

Family	Species/morphospecies	Control	LF	HF	Total
Actinopodidae	<i>Actinopus</i> sp.	0	1	1	2
Anyphaenidae	<i>Sanogasta</i> sp.	1	0	1	2
Anyphaenidae	sp-2	1	3	6	10
Anyphaenidae	sp-3	1	0	0	1
Anyphaenidae	sp-4	0	0	1	1
Araneidae	sp-1	0	1	0	1
Araneidae	sp-2	0	1	1	2
Corinnidae	sp-1	0	0	1	1
Dictynidae	sp-1	1	2	1	4
Dictynidae	sp-2	0	0	1	1
Gnaphosidae	Aff. <i>Echemus giaii</i>	10	6	5	21
Gnaphosidae	sp-2	2	1	0	3
Gnaphosidae	<i>Echemoides argentinus</i>	2	0	0	2
Gnaphosidae	sp-4	2	0	2	4
Gnaphosidae	sp-5	0	1	0	1
Gnaphosidae	sp-6	1	0	2	3
Hahniidae	sp-1	6	4	7	17
Linyphiidae	sp-1	6	3	0	9
Linyphiidae	<i>Tutaibo</i> sp.	21	18	4	43
Linyphiidae	sp-3	2	1	0	3
Linyphiidae	<i>Scolecuroa</i> sp.	34	24	33	91
Linyphiidae	sp-5	4	3	7	14
Linyphiidae	sp-6	1	2	0	3
Linyphiidae	sp-7	1	0	0	1
Linyphiidae	sp-8	0	1	0	1
Lycosidae	sp-1	32	17	21	70
Lycosidae	<i>Pardosa plumipedata</i>	3	0	0	3
Lycosidae	sp-3	1	2	1	4
Lycosidae	sp-4	0	0	1	1
Lycosidae	<i>Lycosa pampeana</i>	2	1	1	4
Lycosidae	sp-6	3	0	1	4
Lycosidae	<i>Hogna bivittata</i>	9	9	9	27
Lycosidae	sp-8	1	0	0	1
Lycosidae	sp-9	0	0	1	1
Nemesiidae	<i>Diplotheopsis bonaeriensis</i>	0	1	0	1
Philodromidae	sp-1	0	0	1	1
Salticidae	sp-1	10	12	18	40
Salticidae	sp-2	2	1	1	4
Salticidae	sp-3	3	0	0	3
Salticidae	sp-4	1	1	0	2
Salticidae	sp-5	0	0	1	1
Salticidae	sp-6	2	0	1	3
Salticidae	sp-7	0	1	0	1
Scytodidae	<i>Scytodes</i> sp.	0	0	1	1
Sparassidae	<i>Polybetes</i> sp.	0	1	0	1
Theraphosidae	<i>Plesiopelma longisternale</i>	1	1	0	2
Theridiidae	<i>Guaraniella</i> sp.	7	1	0	8
Theridiidae	<i>Euryopsis</i> sp.	3	0	2	5
Theridiidae	sp-3	1	0	0	1
Theridiidae	<i>Thymoites</i> sp.	0	1	0	1
Thomisidae	<i>Misumenops</i> sp.	2	1	2	5
Titanoecidae	<i>Goeldia</i> sp.	5	0	1	6
Uloboridae	sp-1	1	0	0	1
Uloboridae	sp-2	1	0	0	1
Zodariidae	<i>Leprolochus birabeni</i>	32	21	57	110
Total		218	143	193	554