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SHORT COMMUNICATION

The composition of spider assemblages varies along reproductive and architectural gradients in the shrub *Byrsonima intermedia* (Malpighiaceae)

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Abstract. The presence of buds, flowers, and fruits increases structural complexity in plants, but can also attract potential prey for predators, thus determining faunistic composition. To understand how a spider assemblage living in the shrub *Byrsonima intermedia* (Malpighiaceae) varies with habitat structure in terms of reproductive elements and height of plant, we collected spider specimens and measured bud, flower, fruit, and leaf masses of 44 plants, as well as their height. Spider family composition was found to depend on habitat structure, following a pattern of family turnover occurring along gradients of reproductive plant elements and height, regardless of plant biomass. Theridiidae occurred in samples with the major proportions of buds and flowers, while Oxyopidae occurred only in samples with major proportions of fruits. Multiple linear regression revealed the strong relation between the composition in reproductive plant elements and the composition in families of spiders and a relation between shrub height and spider family composition. These results help us to understand the temporal dynamics between structural complexity of vegetation and spider assemblages, because during plant phenology the proportions of reproductive elements are also varying.

Keywords: Araneae, assemblage composition, assemblage diversity, habitat structure, habitat heterogeneity, reproductive phenology

The influence of plant structural traits on microhabitat selection has been demonstrated for spiders around the world. The spiders' preferences for particular microhabitats result in variation of spider diversity related to both the structure of vegetative parts (Halaj et al. 2000; Souza 2005) and the presence of reproductive structures (Souza & Modena 2004; Souza & Martins 2004).

Inflorescence-bearing branches are structurally distinct from vegetative branches and may constitute microhabitats that offer a range of attractive traits for spiders. Floral structures may provide refuge from predators and harsh environmental conditions, facilitating camouflaging for prey capture and serving as breeding sites (Johnson 1995). Abundance of potential prey for spiders is high in buds and flowers, as these structures are often visited by herbivores and pollinating insects (Louda 1982). Furthermore, fruits attract insects and may depend on these to complete their life cycles (e.g., Kolesik et al. 2005; Burkhardt et al. 2009). Plant phenological variation is therefore expected to determine variations in the structure of spider assemblages.

The presence and succession of reproductive elements of plants mask the effects of plant structural complexity on spider diversity, because reproductive structures not only modify plant architecture (by changing biomass spatial arrangement), but also amplify the local prey availability, being attractive to spiders for many reasons (e.g., Finke & Denno 2006; Schmidt & Rypstra 2010).

We desired to know if the relative amount of each reproductive element (buds, flowers and fruits), height (plant architecture), and biomass (habitat size) of the shrub *Byrsonima intermedia* A. Juss (Malpighiaceae) might explain variation in the composition of spider assemblages. The architecture of this shrub species varies with height (Oliveira et al. 2007), because the taller the specimen, the further apart its branches are arranged, facilitating the construction of wider webs.

Data were collected from an area of the Brazilian savanna ("cerrado stricto sensu") in Campo Grande, Mato Grosso do Sul, southwestern Brazil (Embrapa Gado de Corte, 20°26′36.6″S, 54°43′30.6″W). The area, now undergoing regeneration, harbors a large number of *B. intermedia* specimens with asynchronic flowering. The species has entomophilous flowers that last for one day on average and develop into a drupe (Oliveira et al. 2007).

From 17 October to 4 December 2008, a total of 44 shrubs (typically six each week) was sampled. To randomize the choice of shrubs, the posts of an adjoining fence were numbered. A fencepost and a perpendicular distance in meters (integers from 0 to 100) were then chosen by draw. Fencepost and distance determined a spot from which the nearest *B. intermedia* shrub was selected. While uncut, the plants were individually wrapped in plastic bags of 100 l capacity, then cut at ground level using pruning shears before taken to the laboratory, where each shrub (mean height = 1.24 m, SD = 0.25; biomass = 461.2 g, SD = 252.3) was inspected for the presence of arthropods. The spiders thus collected were stored for identification at the family level. Voucher specimens were deposited in the Arachnida collection of Instituto Butantan of São Paulo, Brazil.

After removal of the arthropods, all the buds, flowers, fruits, and leaves from each shrub were collected, and the fresh mass of each of these types of structure was weighed using a balance of 0.01 g precision right after the removal of the arthropods in the same day of sampling.

As *B. intermedia* is a species with an asynchronous flowering period (Filho & Lomônaco 2006). The 44 plant specimens were randomly grouped, taking into account the frequency of spider families, mean plant height, and total biomass of shrubs, leaves, buds, flowers, and fruits, resulting in 11 samples of four specimens each, allowing us to make ordinations of the variables without losing the relation between them.

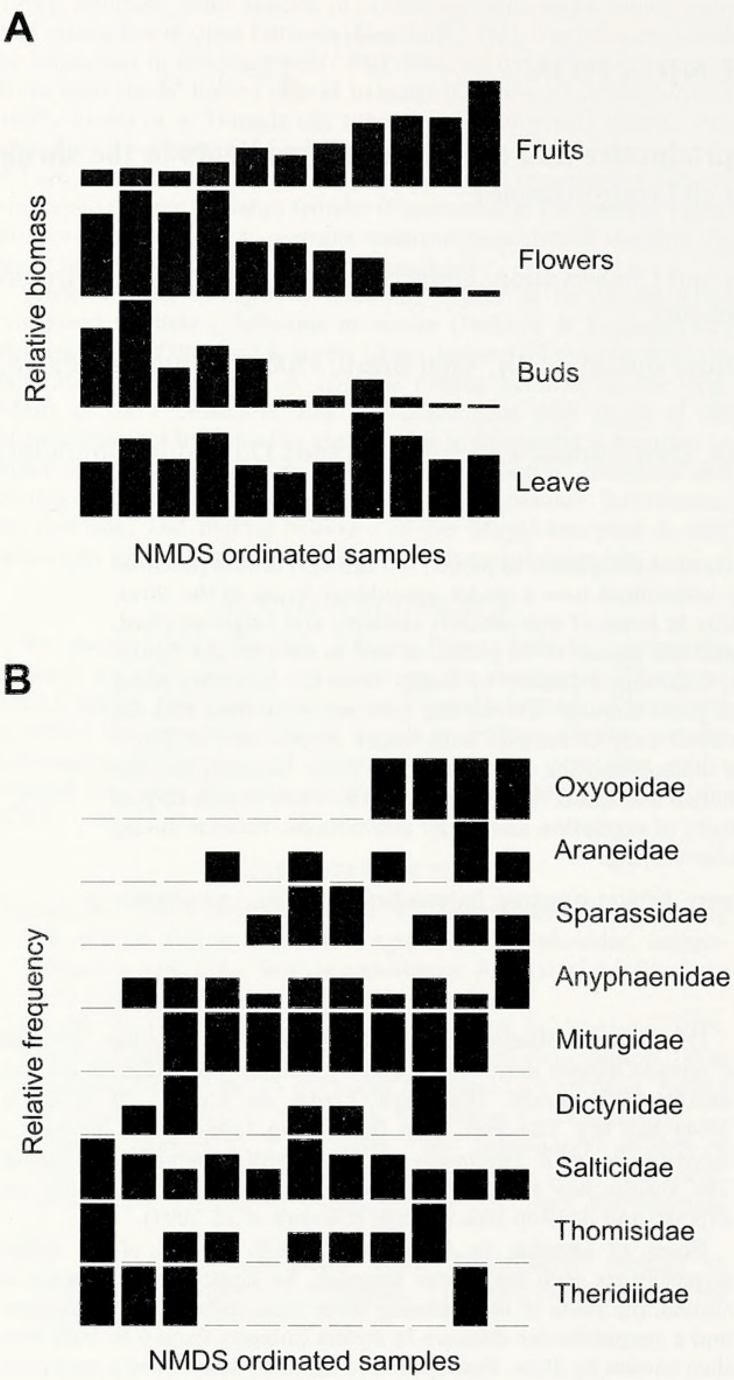

Figure 1.—Ordinations of the samples by non-metric multidimensional scaling (NMDS). (A) Phenological variation: ordination obtained using relative biomass of leaves, buds, flowers and fruits in *Byrsonima intermedia* specimens (Malpighiaceae). (B) Spider family composition: ordination obtained using relative frequency of the spider families.

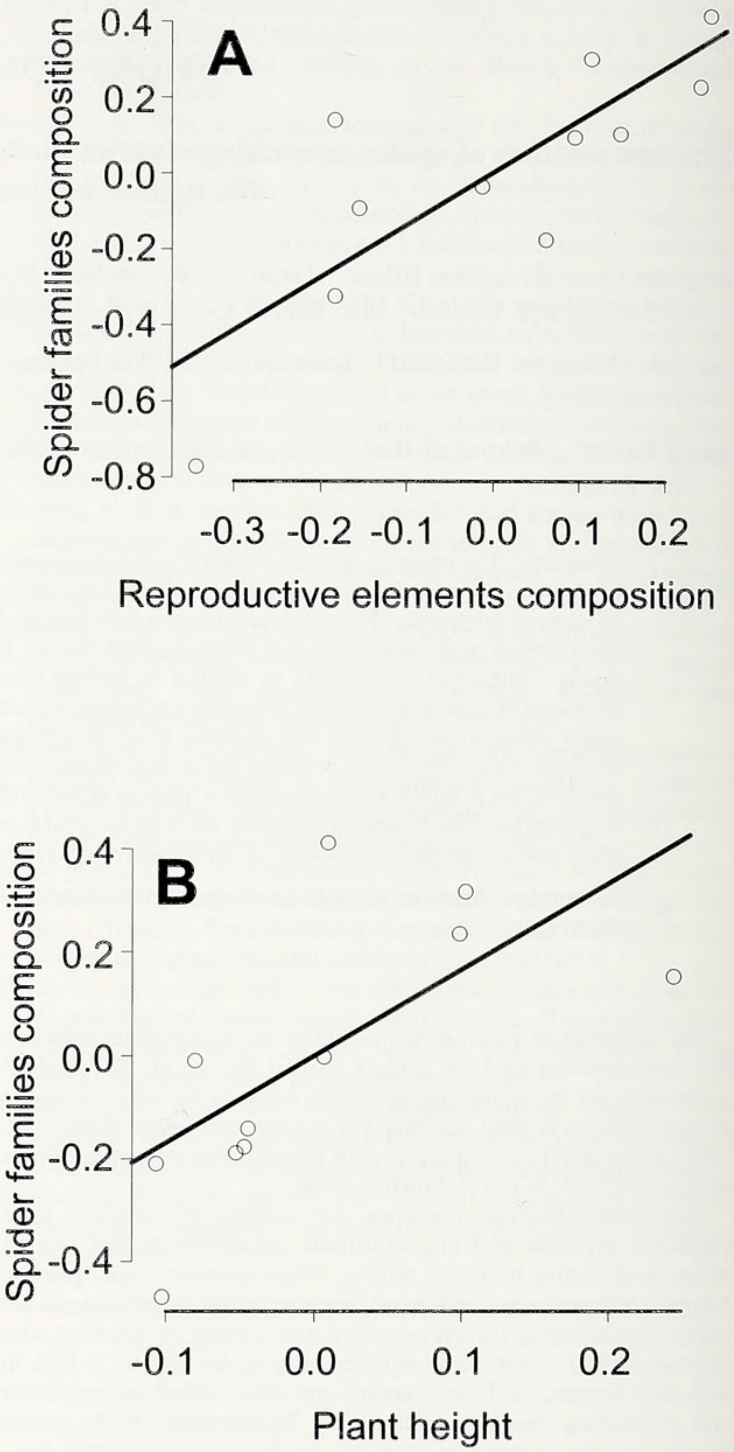

Figure 2.—Partial regression plots of the multiple regression model. NMDS scores for relative frequencies of spider families are values of the dependent variable and NMDS scores of relative masses of reproductive elements (A) and height of *Byrsonima intermedia* (Malpighiaceae) shrubs (B) are the independent variables. Lines represent the linear function obtained in the multiple regression model.

Ordination by non-metric multidimensional scaling (NMDS) was employed to represent the variation in relative amounts of leaves, buds, flowers, and fruits across plant samples. We considered the relative biomass of vegetative structures (leaves) and reproductive structures (buds, flowers, and fruits), employing a Bray–Curtis dissimilarity matrix for this ordination. NMDS was also used to represent spider family composition. A Bray–Curtis dissimilarity matrix based on relative frequencies was also employed for this purpose.

A multiple linear regression model was used to evaluate the effects of reproductive plant elements (NMDS scores), height, and biomass on the diversity (Shannon index) and composition (NMDS scores) of spider families. R software (R Development Core Team 2010) was used for data analysis. The vegan software package (Oksansen et al. 2010) was additionally employed for diversity calculations and for ordinations.

Ordination of *B. intermedia* samples using the relative mass of leaves, buds, flowers, and fruits using NMDS (n = 11, R^2 = 0.94) revealed variation in composition of the reproductive elements (Fig. 1A). Samples with more buds remained on the left in the gradient of ordination, while flowers decreased and fruits increased along this gradient. Leaves were abundant in all samples throughout this gradient, irrespective of reproductive elements.

A total of 195 spiders from nine families was collected from 44 shrubs. Salticidae (62 specimens), Anyphaenidae (33), and Thomisidae (21) were the most abundant families. A mean Shannon's index of 1.49 was found for family diversity, ranging from 0.67 to 1.86 for the 11 samples and varying randomly with reproductive plant elements, height, and biomass in a multiple regression model (n = 11; F = 2.63; R^2 = 0.68; P = 0.35).

Sample ordination by NMDS (n = 11; R^2 = 0.73) using relative frequencies of spider occurrence, revealed a gradient in spider family composition (Fig. 1B). Spiders of the family Salticidae were found throughout this gradient; Theridiidae and Thomisidae were more likely to occur at the beginning of the gradient; Araneidae and Oxyopidae, at the end. Other families occurred in intermediate portions of the gradient.

In a multiple regression model (n = 11; R^2 = 0.68; F = 4.79; P = 0.04), NMDS scores for spider family composition varied as a linear function of NMDS scores for composition of reproductive plant elements (b = 1.68; t = 2.77; P = 0.03) and height (b = 0.38; t = 3.46; P = 0.01), but not of biomass (P = 0.573). This finding reveals that, regardless of aboveground biomass, *B. intermedia*'s height and composition of reproductive elements explained 68% of the variation in the spider assemblage (Fig. 2).

Although associations between spiders and certain types of flowers and fruits have been described in the literature (Souza & Modena 2004; Souza & Martins 2004), the present study is, to our knowledge, the first to demonstrate how the composition of a spider assemblage varies with a quantitative measure of composition of the reproductive elements, irrespective of total plant biomass. Since variation in plant architecture as a function of size influences habitat complexity (Souza & Martins 2004; Faria & Lima 2008), this investigation evaluated the isolated effect of architecture by measuring shrub height and disregarding the variation due to biomass, which was achieved by taking into account the multiple regression model. Taller shrubs have more branches and these are more spread out, whereas biomass represents the amount of habitat available for spiders.

Several studies have demonstrated associations between plants and spiders, most often of single species (Johnson 1995; Romero & Vasconcellos-Neto 2005), but also of multiple species (Halaj et al. 2000; Raizer & Amaral 2001; Souza & Martins 2004). These studies corroborate the assumption that habitat architectural traits define the composition of spider species.

Each component of the phenology of *B. intermedia* can represent either an increase or a decrease in spider abundance and diversity (Romero & Vasconcellos-Neto 2005). In the present study, the added effects of leaf, bud, flower, and fruit biomass on spider occurrence revealed a pattern of family turnover in which Theridiidae occured in samples with the major proportions of buds and flowers, while Oxyopidae occurred only in samples with major proportions of fruits. This pattern suggests that niche partitioning is dependent on the reproductive phenology of *B. intermedia*, more specifically dependent on the composition of reproductive elements.

This response seen in the structure of the spider assemblage possibly influences the indirect interactions between spiders and reproductive success (e.g., fruit-set and seed set) of plants (Louda 1982; Goncalves-Souza et al. 2008; Romero et al. 2008). Different components of the reproductive stage of plants are expected to have different effects on the attraction of spiders of each family (Souza & Martins 2004; Romero & Vasconcellos-Neto 2005), and general patterns such as those described in this study are additive responses resulting from these family-level patterns. Not only knowledge of the effect of each reproductive component of plant, but also of the interaction between these components (e.g., decreased plant cross pollination due to spiders predating on pollinators and fruit protection due to predation on herbivores), is necessary to understand the structure of a spider assemblage and help to predict potential responses to indirect interactions between spiders and plants (Wootton 2002). It can be concluded that spider composition depends on habitat structure, with a pattern of family turnover occurring along gradients of composition of reproductive elements and height, irrespective of plant biomass.

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