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Microhabitat use by *Peucetia flava* (Oxyopidae) on the glandular plant *Rhyncanthera dichotoma* (Melastomataceae)

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Abstract. Several studies have reported that plant structural components can exert strong influences on the density and distribution of spiders. However, little is known about which plant traits mediate specific associations between spiders and plants. In southeastern Brazil, the lynx spider *Peucetia flava* Keyserling 1877 (Oxyopidae) is commonly found on the plant *Rhyncanthera dichotoma* (Melastomataceae), a shrub that bears glandular trichomes. In this study we investigated if *Peucetia* occurs strictly on *Rhyncanthera* and what plant parameters influence the spiders' distribution. In addition, we recorded the vertical distribution of spiders of different ages in the plant canopy. Throughout the year *Peucetia* was observed only on the glandular plant *Rhyncanthera*, indicating that this association is specific and predictable. Statistical analysis showed no difference in the number of spiders between plants of *Rhyncanthera* with and without flowers, suggesting that this specific association is mediated by the presence of glandular trichomes, and not by reproductive structures. The distribution of *Peucetia* over the year was related to the number of arthropods on plants, as well as the number of leaves and height of the host plants, indicating that *Peucetia* probably choose sites of high food availability. Adults and subadults occurred on higher places on the crown than young and juveniles.

Keywords: Plant architecture, glandular trichomes, spider-plant interactions

Spiders are among the most abundant and diverse arthropods on vegetation (Wise 1993; Foelix 1996; Romero & Vasconcellos-Neto 2006) and are strongly influenced by variations in plant architecture (Greenquist & Rovner 1976; Riechert & Gillespie 1986; Gunnarsson 1990, 1992, 1996; Romero & Vasconcellos-Neto 2005a). Moreover, spiders are recognized by their ability to choose microhabitats of better quality, i.e., they generally prefer those with high abundance of prey (e.g., reproductive branches) (Morse & Fritz 1982; Ward & Lubin 1993; Morse 2007). Yet, some spiders may choose substrata based on leaf morphology (e.g., Thomisidae, *Diaea*, Evans 1997). Although these studies reported spider selection for microhabitats, most of them refer to only a few taxonomic groups (e.g., Thomisidae, Salticidae, and Araneidae) (Romero & Vasconcellos-Neto 2006) and few studies describe how plant parameters influence the density of hunting spiders (e.g., Romero & Vasconcellos-Neto 2005a).

Recent studies have reported specific associations of spiders with specific plant features (Figueira & Vasconcellos-Neto 1991, 1993; Arango et al. 2000; Rossa-Feres et al. 2000; Romero 2001; Romero & Vasconcellos-Neto 2003, 2004a, b, c, 2005a, b, c; Dias & Brescovit 2004). To date, the better studied examples of botanical structures that mediate spider-plant interactions are architecture in rosettes and glandular trichomes (Romero 2006; Vasconcellos-Neto et al. 2007). While the former facilitates the encounter of prey and mates and can be used as sites for egg-laying and shelter for adults and immatures, the later trap insects that can be used as prey by some spiders (Romero & Vasconcellos-Neto 2003, 2004a, 2005a; Vasconcellos-Neto et al. 2007).

Up to ten species of the genus *Peucetia*, including two South American species, *P. flava* Keyserling 1877 and *P. rubrolineata* Keyserling 1877 (Oxyopidae), live strictly associated with many species of glandular plants in Neotropical, Neartic, Afrotropical, and Palearctic regions (Vasconcellos-Neto et al. 2007). However, few studies have investigated patterns of host plant use in *Peucetia*, especially which plant traits besides presence of glandular trichomes influence the distribution of spiders of this genus on their host plants (e.g., Louda 1982; Arango et al. 2000). In southeastern Brazil specimens of *P. flava* were reported to occur frequently on *Rhyncanthera dichotoma* (Nees) C.B. Clarke (Melastomataceae), a glandular shrubby plant that typically inhabits swamps (J.C. Morais-Filho & G.Q. Romero, pers. obs.). To better understand this system, the purpose of our study was to evaluate (1) if *Peucetia flava* occurs strictly on *Rhyncanthera* or randomly on any other plant species; (2) which plant parameters influence the distribution of this spider population; and (3) if there is some variation in the vertical distribution of *Peucetia* of different ages in the canopy of *Rhyncanthera*.

METHODS

Study area and organisms.—This work was done in a swamp along an affluent margin of a lake (elev. 494 m; 20°49′S, 49°20′W) in São José do Rio Preto city, northwest of São Paulo state, southeastern Brazil. The climate in this region is of the type Cwa-Aw of Köppen, characterized by a hot/rainy season in the summer and dry in the winter. The annual precipitation varies from 1100 to 1250 mm, receiving 85% of the rainfall in the rainy season (September–March) and only 15% in the cold/dry season (Barcha & Arid 1971).

Rhyncanthera dichotoma is a hydrophitic phanerogamic shrub (0.5–2.0 m high) that occurs in temporary aquatic ecosystems, and the flowering period of this plant occurs once a year between March and May. This plant is frequently inhabited by arthropods of various guilds, including

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phytophages (e.g., Curculionidae, Miridae, Aphididae, Homoptera) and predators (e.g., spiders, Reduviidae). Many insects (e.g., ants, Chironomidae, Aphididae) adhere to the glandular trichomes, which are very dense on leaves and young stems of this plant species. The spider *Peucetia flava* is the most common predator on this plant and uses it as foraging and reproductive site (J.C. Morais-Filho & G.Q. Romero, pers. obs.).

Voucher specimens of the spiders collected (males and females) were deposited in the Arachnological Collection of the Laboratório de Artrópodes Peçonhentos, Instituto Butantan, São Paulo.

Fidelity of *Peucetia* for host plant.—Data were obtained in June 2007 in an area of 800 m^2 (two independent plots: 10 × 30 m and 10 × 50 m). We inspected leaves and recorded the presence or absence of *P. flava* on stems of 90 individuals of *Rhyncanthera* and another 250 plants without glandular trichomes, those belonging to diverse families (e.g., Asteraceae, Melastomataceae, Poaceae, Zingiberaceae).

Plant parameters and distribution of *Peucetia*.—To verify if *P. flava* is more abundant on plants with flowers than without flowers, in March–April 2006 and April 2008 (the flowering periods) we counted the number of spiders on 8–22 individuals of *Rhyncanthera* with flowers and on 14–27 individuals without flowers. For each plant we also counted the number of leaves. Data were log ($n + 1$) transformed to equalize variances and then compared using ANCOVA, with presence or absence of flowers (treatment) as a fixed effect (two levels), years (2006 and 2008) as a fixed effect (two levels), and number of leaves as the covariate.

To verify what plant parameters influence *P. flava* distribution, we surveyed 16–32 plants monthly between December 2005 and December 2006. Data on plant height, number of leaves and flowers, and total number of arthropods (potential free prey and potential prey stuck to glandular trichomes) were assessed for each plant surveyed. We also recorded the number of *P. flava* of various ages. To test which plant parameters influence the distribution of spiders in each month over the year, we used multiple linear regressions (Zar 1996) with the total number of individuals of *Peucetia* as the dependent variable and the parameters plant height, number of leaves, flowers, and total number of arthropods as the independent variables. The multiple linear regression test concerning all these four independent variables detected multicollinearity. We then removed some independent variables following procedures suggested by Zar (1996): we first ran a linear regression analysis between all these independent variables and selected those with the smallest value of r^2 (i.e., height, number of leaves, and total number of arthropods). By this selection we excluded the independent variable "abundance of flowers" that was strongly related to the other independent variables because *R. dichotoma* produce flowers only once, in a short period of the year.

Vertical distribution among age classes.—To test if there is variation in the vertical distribution of *Peucetia* from different ages in the canopy of *Rhyncanthera*, we measured the body size of each spider and its proportional height in the crown of the plant. For this, we divided the height that the spider occupied in the crown by the height of the crown. We defined the height of the crown as the length between the highest tip of the plant and the base of the crown (i.e., the junction of the first secondary branch with the main trunk); thus, a value close to zero means that the spider is at the base of the crown, and value close to one indicates that the spider is at the tip of the plant. To categorize the instars the spiders were classified as young [total body length (cephalothorax + abdomen) $\leq$ 3.0 mm], juveniles ($>$ 3.0 mm but $\leq$ 6.0 mm), subadults (females $>$ 6.0 mm but $<$ 9.0 mm; males $>$ 6.0 mm but $\leq$ 7.0 mm, with a dilated palp and slightly orange abdomen) and adults (females $\geq$ 9.0 mm; males $>$ 7.0 mm, with a dilated sclerotized palp and orange abdomen). Data on distribution of spiders of each age class were compared for each sampling period using ANOVA (Zar 1996). Prior to the analyses these proportions were arc-sin square root transformed for data normalizations. If necessary, we performed paired comparisons using Fisher's LSD *post hoc* test. The test was run only in December 2005 because in this period the power of the performed test was high (95%); in the remaining months the power of the performed test was very low, varying from 5-35%.

RESULTS

Fidelity of *Peucetia* for host plant.—Although we have observed several spider species on plants that do not bear glandular hairs, *Peucetia flava* was observed only on the glandular plant *Rhyncanthera dichotoma*. In June (2007), we found 44 individuals of *P. flava* on *Rhyncanthera dichotoma* and none on the other plant species without glandular hairs.

Plant parameters and distribution of *Peucetia*.—There was no statistical difference in number of spiders between plants with and without flowers, and this was the case both in 2006 (mean ± 1 SE; plants with flowers: 2.50 ± 0.56 spiders; plants without flowers: 1.37 ± 0.30 spiders) and 2008 (plants with flowers: 0.50 ± 0.19 spiders; plants without flowers: 0.57 ± 0.17 spiders) (Table 1). The covariate (number of leaves) differed statistically (Table 1), indicating that the number of leaves, and not presence of flowers, determines spider distribution. Multiple linear regressions showed that the distribution of *Peucetia* over the year was related to the number of arthropods in December 2005, May and October ($P \leq 0.032$), as well as number of leaves in February and July ($P \leq 0.026$), and height of plants in December 2006 ($P < 0.001$) (Table 2).

Vertical distribution among ages classes.—In December 2005 adults and subadults of *Peucetia* occurred on higher sites on the crown than juveniles and young (Fig. 1; $F_{3,86} = 6.92$; $P < 0.001$).

DISCUSSION

Peucetia flava occurred only on *Rhyncanthera dichotoma*. This result suggests that in our study site the spider species is strictly associated with this glandular plant. On *R. dichotoma*, these spiders were frequently seen foraging, feeding and displaying reproductive behaviors; females produced egg sacs in almost all months (J.C. Morais-Filho & G.Q. Romero, unpub. data). These observations suggest that *Rhyncanthera* is a suitable microhabitat for *P. flava*. In addition, in northeast, southeast, and southern Brazil *P. flava* is reported to occur associated with sixteen glandular shrubs (Vasconcellos-Neto et al. 2007), thus reinforcing the hypothesis of a high fidelity of

Table 1.—ANCOVA examining the influence of presence/absence of flowers (treatment) on *R. dichothoma* on the abundance of *P. flava*, during two reproductive periods of the host plant (years of 2006 and 2008).

Source of variations	*df*	MS	*F*	*P*
No. of leaves (cov)	1	1.3892	32.59	< 0.001
Treatment	1	0.0123	0.29	0.592
Year	1	0.0298	0.70	0.406
Year × Treatment	1	0.0371	0.87	0.354
Error	66	0.0426		

these spiders to glandular plants. The reason why *P. flava* is found associated with these plants may be due to the function of the glandular hairs as insect traps, which facilitate prey capture by trapping or preventing insects from dislodging themselves and escaping (Dolling & Palmer 1991; Ellis & Midgley 1996; Romero & Vasconcellos-Neto 2004a). In fact, *Peucetia flava* can feed on insects stuck to glandular trichomes of *Rhyncanthera* (e.g., ants, Chironomidae, Aphididae) (J.C. Morais Filho, pers. obs.) and Romero et al. (2008) showed that this spider can also feed on insects stuck to glandular trichomes of *Trichogoniopsis adenantha*. Furthermore, while glandular trichomes could benefit spiders by facilitating prey capture, the spiders preying on these plants may remove phytophagous insects thus also providing benefits to the plants. This hypothesis will be tested in future research.

Generally, spiders occur more frequently on plant parts that have flowers (reproductive branches), since these structures attract potential prey (pollinators) and are thus better quality sites (Louda 1982; Morse & Fritz 1982; Romero & Vasconcellos-Neto 2004a, 2006). However, this seems not to be the case for *P. flava*; although flowers of *R. dichotoma* attract potential prey of *P. flava*, there was no evidence that *P. flava* chose plants based on presence of flowers. These results suggest that *P. flava* chose plants primarily based on presence of glandular trichomes, and not presence of flowers, and reinforces the assumption described above regarding the specific association of this species with glandular plants.

Table 2.—The coefficient (and *P* values in parenthesis) of multiple linear regressions between *P. flava* density (dependent variable) and plant height, number of leaves and total number of arthropods on the plant *R. dichotoma* in different periods of the year. Significant *P* values are boldfaced.

Months	Height	Leaves	Arthropods
December	0.74 (0.064)	0.32 (0.091)	0.27 (**0.032**)
January	−0.20 (0.674)	0.44 (0.090)	0.06 (0.793)
February	0.21 (0.676)	0.60 (**0.003**)	0.22 (0.117)
March	0.60 (0.362)	0.35 (0.182)	0.22 (0.143)
April	−0.90 (0.424)	0.81 (0.059)	−0.22 (0.496)
May	1.51 (0.348)	−0.23 (0.577)	0.59 (**0.029**)
June	0.45 (0.556)	0.37 (0.115)	−0.01 (0.942)
July	−0.13 (0.851)	0.60 (**0.026**)	−0.01 (0.952)
August	0.49 (0.440)	0.36 (0.208)	0.40 (0.080)
September	0.16 (0.768)	0.50 (0.075)	−0.02 (0.896)
October	0.57 (0.319)	−0.33 (0.236)	0.40 (**0.023**)
November	−0.48 (0.445)	0.63 (0.249)	0.18 (0.652)
December	1.17 (**<0.001**)	0.21 (0.297)	0.19 (0.185)

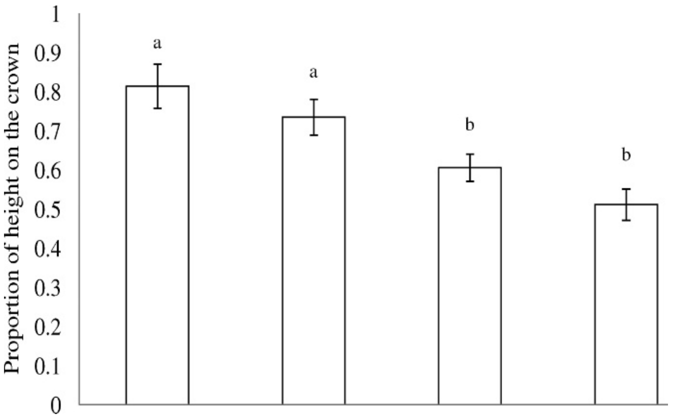

Figure 1.—Vertical distribution of spider age classes in December 2005. Different letters indicate statistical differences (ANOVA/Fisher LSD). Error bars indicate ± 1SE. See age group definitions in Methods.

These results suggest that, in different periods of the year, *P. flava* may be choosing plants based on other characteristics such as the number of arthropods stuck on glandular trichomes, the number of leaves on the plant, or the height of the plant. Plants with more leaves may represent sites of better quality for foraging (larger surface area) and shelter (e.g., Gunnarsson 1990; Romero & Vasconcellos-Neto 2005b). In addition, since leaves of this plant bear glandular hairs able to trap insects, more leaves may mean higher probability of an insect adhering to these sticky structures. In fact, the number of leaves influenced the abundance of adhered arthropods on *R. dichotoma* (J.C. Morais-Filho & G.Q. Romero, unpub. data). Since *P. flava* and its congener *P. rubrolineata* can act as scavengers (Romero et al. 2008), being on plants with greater number of leaves may increase the chance to feed on dead insects stuck to glandular trichomes.

In USA and Mexico *Peucetia viridans* Hentz 1832 is reported to occur associated with the glandular plants *Haplopappus venetus* (Asteraceae) (Louda 1982) and *Cnidoscolus aconitifolius* (Euphorbiaceae) (Arango et al. 2000), respectively. These authors reported that the spider selected the highest plants. Arango et al. (2000) found that *P. viridans* uses high-quality portions of its habitat, choosing those plants offering better sources of food, shelter, and favorable environmental conditions. The frequency of spiders on higher plants could be related to prey availability, as higher plants have a higher number of leaves.

Adults and subadults of *P. flava* occurred on higher sites in the crown than juveniles and young. This distribution may confer an easy way for adults and subadults to migrate by balooning between plants to search for sites of better quality. Alternatively, higher regions in the canopy may represent sites with higher prey availability. In contrast, younger individuals of *Peucetia* (i.e., juveniles and young) may have selected lower sites possibly as shelter, as well as to avoid competition or cannibalism with the larger conspecifics. In fact, we observed cannibalism in this spider population. In California, Turner (1979) reported that 5.8% of the diet of *P. viridans* was composed of other individuals of *P. viridans*. In contrast to our results, for the *P. viridans* – *C. aconitifolius* system, Arango et al. (2000) found no preference for location in the plant crown among instars. Thus, although it is expected that larger spiders occur on higher sites and smaller spiders occur on lower ones, this distribution pattern was inconsistent among spider-plant systems, as well as among different periods of the year for our system.

In conclusion, *Peucetia flava* occurred strictly associated with *Rhyncanthera dichotoma* probably due to the presence of glandular trichomes; it may benefit from insects adhering to these sticky structures. On this plant species *Peucetia* seemed to evaluate varying plant parameters depending on the period of the year, being affected mainly by abundance of leaves. Once upon a plant with more leaves, the spiders increase the chance of feeding on dead insects stuck to glandular trichomes through scavenging behavior. Juveniles and young *Peucetia* tended to occur on lower regions on the crown, possibly as a way to avoid competition and cannibalism with the larger conspecifics.

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