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How does a *Psittacanthus robustus* Mart. population structure relate to a *Vochysia thyrsoidea* Pohl. host population?

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ABSTRACT

Distribution of parasitic plants is directly linked with the distribution of host species and behavioral patterns of seed dispersers. *Psittacanthus robustus* (Loranthaceae) is a neotropical hemiparasite that mainly colonizes species of the family Vochysiaceae. *Vochysia thyrsoidea* is the main host of *P. robustus* and is commonly found in areas of *cerrado rupestre* (rocky savanna), an abundant vegetation in our study site. We conducted the study in the ecological park Parque Ecológico Quedas do Rio Bonito (PEQRB), over an area of 2.82 ha of *cerrado rupestre*. The objective of this work was to investigate population structure, parasitic behavior (mistletoe grip height and circumference of host branch), and spatial distribution of *Psittacanthus robustus* on a population of *Vochysia thyrsoidea*. We sampled 267 *V. thyrsoidea* individuals and found that the population had a random distribution pattern. Seventy-nine individuals (29.6% of the sample population) hosted the hemiparasite, to a total of 193 *P. robustus* individuals. The number of mistletoe individuals per host plant ranged between 1 and 12. The *V. thyrsoidea* individuals most infested with mistletoes were those reaching greater heights. The correlation between height of host plant and preferred grip height was highly significant, with the preferred grip height being the uppermost portions of host plants. The crown size of *P. robustus* individuals ranged between 10 and 230 cm. The main disperser of *P. robustus* fruit was found to be swallow-tanager *Tersina viridis viridis*. Its activities led to a clumped pattern of spatial distribution of the hemiparasite along with higher infestation in larger trees.

Introduction

Loranthaceae is a pantropical plant family, with approximately 10 genera occurring in Brazil with around 100 species (Souza and Lorenzi, 2005). 36 species are recorded to populate the *cerrado* domain, all of which are hemiparasites (Barboza and Proença, 1999). These plants are perennial and cling to branches and trunks of host plants using epicortical haustorium-like roots (Calder and Bernardt, 1983; Calvin and Wilson, 2006). The hemiparasites perform photosynthesis (Rotta, 2001); they are named *erva-de-passarinho* (bird's herb) in Portuguese as a literal allusion to the dispersion syndrome associated with these animals (Arruda et al., 2006; Watson, 2001).

An important factor in the ecology of these hemiparasites is their host specificity (Mourão et al., 2006). Some are specialist species being associated with only a limited number of host species, while other species do associate with several hosts and are therefore generalists (Arruda et al., 2006; Norton and Carpenter, 1998; Norton and De Lange, 1999).

The distribution of hemiparasites on their host plants is dependent on relative abundance of host species, distance among hosts, structure of host plants (Monteiro et al., 1992; Sargent, 1995), and environmental conditions, as, e.g., some species are sensitive to fire and frost (Garcia-Franco and Rico-Gray, 1996).

Psittacanthus robustus Mart. (Loranthaceae) is a neotropical hemiparasite that mainly colonizes Vochysiaceae species in *cerrado* communities of Brazil (Monteiro et al., 1992). A study conducted by Monteiro et al. (1992) showed that the parasitic behavior of *Psittacanthus robustus* was related to: (1) height and crown structure of host plants; (2) presence of a slimy substance on the apical portion of the mistletoe fruit; (3) feeding behavior and habitat selection of seed dispersing bird *Tersina viridis viridis*.

In the study site, the main host of *P. robustus* is *Vochysia thyrsoidea* Pohl. (Vochysiaceae), an arboreal species from *cerrado* with a thick bark, the rhytidome of which has irregular, sinuous fissures and ridges. Its ability to accumulate aluminum provides it with a competitive advantage to grow successfully in the acidic soils of *cerrado* (Felfili and Silva, 1992).

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The spatial distribution of mistletoes frequently shows a clumped pattern (Aukema and Martínez del Río, 2002a,b; Aukema, 2004; Overton, 1994; Roxburgh and Nicolson, 2008). Aukema (2004) found a strong aggregation inside of each tree and related this pattern to the behavior of disperser birds. Their territorialism leads to a clumped distribution. Such a pattern was observed for *Phrygilanthus sonorae* (Loranthaceae) that presented an aggregation distribution in each host, which were the largest individuals because they were older and had more time to acquire parasites (Overton, 1994). However, additional studies might show that mistletoe population structures are related also in other cases to host size and spatial distribution.

Ecological studies on hemiparasites in forests and savannas of Brazil are yet scarce (Arruda et al., 2006; Monteiro et al., 1992; Mourão et al., 2006) and most existing studies focus on hosts only rather than on hemiparasites. This work aimed to investigate the population structure and spatial distribution of the mistletoe *Psittacanthus robustus* on a population of host plants *Vochysia thyrsoidea*, looking to answer the following questions: (1) What is the spatial distribution pattern presented by *V. thyrsoidea* and by *P. robustus*? (2) Is there a preferred grip height when *P. robustus* connects to a host tree? (3) Are taller *V. thyrsoidea* individuals preferred by mistletoes?

Methods

Study site

This study was performed in Parque Ecológico Quedas do Rio Bonito (PEQRB), which is situated south of the municipality of Lavras, in Minas Gerais state (Brazil), at geographical coordinates 21°19′ South and 44°59′ West. The park lies in the Serra do Carrapato region, within the Bocaina mountain range complex. Altitudes range from 950 to 1200 m. The local climate, according to Köppen classification, is transitional between Cwb and Cwa, which translates as temperate with dry winters, with average annual precipitation of 1529.7 mm and average annual temperature of 19.4 °C (Oliveira-Filho and Fluminhan-Filho, 1999). The main rock formations include quartzite and micaschist in the upper portions, and leucocratic granite gneiss and quartzite in the lower portions, with a prevalence of Lithosol and Cambisol soil types (Curi et al., 1990).

PEQRB is a very well preserved area and a valuable sample of primitive vegetation in Alto Rio Grande region. This region is transitional between the Atlantic Forest and the Cerrado domain, being home to vegetation of different physiognomies including *mata de galleria* (riparian forest), *cerrado sensu stricto* (savanna), *cerrado rupestre* (rocky savanna), *campo rupestre* (montane scrub on rocks), *campo de altitude* (montane grassland) and *candeal* (candeia forest – a highland rainforest characterized by candeia, *Eremanthus erythropappus*). The park is home to a remarkable diversity of plant species in a relatively small area of 235 ha (Oliveira-Filho and Fluminhan-Filho, 1999).

The study region can be categorized as *cerrado rupestre* (Ribeiro and Walter, 2008), a vegetation subtype comprising shrubs and trees that grow in rocky environments. *Cerrado rupestre* has a variable tree coverage of 5–20% and equally prominent shrub and herb stratum. *V. thyrsoidea* is the predominant arboreal species in this particular area.

Data collection and analysis

Data collection started in November 2006 and ended in August 2007. Within an area of 2.82 ha, all *V. thyrsoidea* individuals 2 m high or taller were tagged and mapped in a topographic survey and then measured for height and CAP (circumference at breast height, i.e. 1.30 m above ground). To evaluate the parasitic behavior of *P. robustus*, all individuals found attached to *V. thyrsoidea* trees were recorded and mapped in relation to their position on the host plant, then categorized with respect to crown diameter (average diameter), preferred grip height, circumference and inclination of host branch.

We depicted height and diameter distribution diagrams in order to analyze the size distribution of the *V. thyrsoidea* population, defining number and range of classes using Sturges rule. Parameters 'height' and 'diameter' were divided by (A/k), where A is the range between maximum and minimum value and k is the number of class intervals, as defined by Sturges algorithm: $1 + 3.3 \times \log n$, where n is the total number of individuals (Gerardi and Silva, 1981).

For analysis of the spatial distribution pattern of *V. thyrsoidea* and *P. robustus* we used Ripley's K function. This is a function for probability density that measures the variance of all distances among all events (Haase, 1995; Mouer, 1993), where each tree individual is an event. For analysis of the hemiparasite distribution we considered host position, excluding all non-host individuals.

We created histograms to describe the chosen grip height and crown diameter of *P. robustus* and the percentage of *V. thyrsoidea* host individuals. The class interval was defined again by Sturges rule (Gerardi and Silva, 1981). To describe the mistletoe grip height we divided grip height by host plant height, obtaining the grip percentage. We used linear regressions (Zar, 1999) to verify whether there was a relationship between circumference of host branch and diameter of mistletoe crown, as well as between height of host plant and mistletoe grip height.

To assess the intensity of parasitism per height class we used the χ^2 test, with the null hypothesis that the proportion of host individuals was equal for all classes (Sokal and Rohlf, 1995). We established four height classes (with equal 2.5 cm intervals) to perform the test.

Results

The sample comprised 267 *V. thyrsoidea* individuals, with heights ranging from 2 to 12 m and DBH ranging from 24 to 42 cm, noting that the tallest individual was 12 m high and 42 cm wide. The population density was 94.7 ind. ha^{-1} and total base area was 2.67 m^2 (0.95 m^2 ha^{-1}). Most individuals were found to fall into the second and third height classes (3.12–4.23 m and 4.24–5.35 m) (Fig. 1A) and into the second DBH class (7.1–11.69 cm) (Fig. 1B). According to Ripley's K function, the spatial distribution of the *V. thyrsoidea* population presented a random pattern (Fig. 2).

Out of the 267 *V. thyrsoidea* individuals, 79 (29.6%) were infested with *P. robustus*. The number of mistletoes per host plant ranged from 1 to 12, to an overall total of 193 *P. robustus* individuals.

The χ^2 test revealed significant differences in the proportion of infested individuals per height class ($\chi^2 = 23.47$; df = 3; $p < 0.000032$). In the first height class the frequency observed was below the expected while in other classes the observed frequency was above the expected. These data reveal that the *V. thyrsoidea* individuals most infested with the hemiparasite were those with greater heights (Table 1). Greater infestation was found 6.5 m high and above. The only individual recorded in the last height category (10.96–12.07 m) presented the highest number of hemiparasites (12 individuals).

The correlation between host plant height and mistletoe grip height was highly significant ($R^2 = 0.8070$; $p < 0.01$; Fig. 3). As regards grip height, there is a preference for the uppermost portions of host plants, with 118 *Psittacanthus* individuals (61.1% of the population) being attached within the uppermost quarter of the *V. thyrsoidea* plants (Fig. 4).

The crown diameter of *P. robustus* individuals ranged from 10 to 230 cm, with most individuals falling into the third (61.6–87.3 cm)