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Short communication

Seed Predation of *Copaifera langsdorffii* Desf. (Fabaceae: Caesalpinioideae) by *Rhinochenus brevicollis* Chevrolat (Coleoptera: Curculionidae) in a Brazilian Cerrado Fragment

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ABSTRACT. Seed predator insects are generally highly specialized herbivores that can be affected by several plant characteristics. In this study, the resource concentration hypothesis and the plant architecture hypothesis were tested by evaluating the attack of *Rhynochenus brevicollis* on *Copaifera langsdorffii* seeds. The study was conducted in a cerrado fragment situated in southeastern Brazil. The percentage of *C. langsdorffii* seed predation by *R. brevicollis* ranged from 1 to 30% (mean±SD, 9.31±6.41). The percentage of seed predation was negatively related to the number of fruits per branch. The predation of seeds by the beetle was positively affected by plant crown circumference, while plant height did not show any relationship with seed predation. Thus, our results did not support any of the two hypotheses evaluated. Finally, the study discusses the role of plant phenology (masting) in regulating the seed predator's population in cerrado vegetation.

[Keywords: plant architecture, plant phenology, predator satiation, resource concentration, supra-annual fruiting]

RESUMO. Predação de Sementes de *Copaifera langsdorffii* Desf. (Fabaceae: Caesalpinioideae) por *Rhinochenus brevicollis* Chevrolat (Coleoptera: Curculionidae) em uma Área de Cerrado do Brasil: Insetos predadores de sementes geralmente são herbívoros especializados que podem ser afetados por características da planta hospedeira. Neste estudo, a predação das sementes de *Copaifera langsdorffii* por *Rhynochenus brevicollis* foi caracterizada testando-se as hipóteses da concentração do recurso e da arquitetura da planta. O estudo foi realizado em um fragmento de cerrado localizado no norte do estado de Minas Gerais, Brasil. A percentagem de sementes de *C. langsdorffii* predadas por *R. brevicollis* variou de 1 to 30% (média±DP, 9.31±6.41). O número de frutos por ramos afetou negativamente a percentagem de predação das sementes por *R. brevicollis.* A predação de sementes pelo besouro mostrou relação positiva com a circunferência do tronco das árvores, mas a altura das árvores não afetou o ataque do predador. Assim, nossos dados não apresentaram suporte real para as duas hipóteses testadas. Finalmente, o estudo discute o papel da frutificação supra-anual na regulação da população de *R. brevicollis*.

[Palavras chave: arquitetura da planta, concentração do recurso, fenologia, frutificação supra anual, saciação de predadores]

INTRODUCTION

Several hypotheses have been proposed to explain the variation in richness and abundance of insects on host plants (e.g., plant stress hypothesis: White 1969; resource concentration hypothesis: Root 1973; plant architecture hypothesis: Lawton 1983; plant vigor hypothesis: Price 1991; and the balance carbon/nitrogen hypothesis: Herms & Mattson 1992). In most cases, studies testing these hypotheses use free feeding or gall inducing herbivores. These hypotheses were constructed based on temperate systems and hence need to be tested in tropical systems (Faria & Fernandes 2001). In this paper, we focus on the resource concentration hypothesis and plant architecture hypothesis, and the study object is a predator insect of *Copaifera langsdorffii* seeds.

The resource concentration hypothesis states that specialist herbivorous insects should be more abundant in large resource patches because they would find such patches more readily and stay in them longer than they would stay in less concentrated patches (Root 1973). Thus, larger patches should have higher insect immigration and lower emigration than small patches. However, studies have demonstrated that herbivores can be more abundant in large patches (e.g., Rhainds &

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English-Loeb 2003) and in small patches (e.g., Ramírez & Arroyo 1987) or that they may not discriminate between patches of different sizes (e.g., Grez & Gonzalez 1995).

The plant architecture hypothesis predicts that the physical structure of the aerial parts of the host plant positively influences the abundance and richness of herbivorous insects (Lawton 1983). The mechanisms driving the plant architecture hypothesis include: i) increase in size per se, ii) increase in the resource diversity offered by more architecturally complex plants, and iii) lower herbivore mortality because larger plants provide enemy-free space (Jeffries & Lawton 1984; Marquis et al. 2002; Lara et al. 2008). According to Lawton (1983), plant architecture has five basic components (size, growth form, seasonal development, variety of above-ground parts, and persistence of these parts), but in many instances, plant height, shoot diameter/circumference, plant biomass, number of leaves and ramification level were also used as indicators of plant architecture (Espirito-Santo et al. 2007; Lara et al. 2008; Costa et al. 2010).

Seeds are an important source of proteins and minerals that can be used by a wide range of organisms, especially insects (Janzen 1971). Seed predation is a special type of herbivory that plays large ecological and evolutionary roles on plant population dynamics and community organization (Hulme & Benkman 2002; Lewis & Gripenberg 2008). From the insect's perspective, seeds represent a resource for breeding or feeding upon directly. Generally, insects that predate seeds are highly specialized herbivores (Janzen 1981) that are affected by several plant characteristics, such as plant size, number of fruits per plant and flowering phenology (Fenner et al. 2002). While most studies on insect seed predation has focused on forest systems (see Ramírez & Traveset 2010 and references therein), very few data are available about seed predation in the Brazilian savanna (Francisco et al. 2008).

In this scenario, we expect that during the process of insect oviposition, plants with greater seed density are easier targets for seed predators to find, as are larger plants. Thus, the objective of this study was to test the resource concentration hypothesis and the plant architecture hypothesis by evaluating the effects of the number of fruits per plant and plant size on the attack of *Rinochenus brevicollis* on *Copaifera langsdorffii* seeds.

Materials and Methods

Study area and system

The study was conducted in a cerrado fragment situated in Montes Claros, in the northern part of the state of Minas Gerais, Brazil (16°40'26'' S and 43°48'44'' W). The local climate is semi-arid, with well-defined dry and rainy seasons. The annual average temperature is 23 °C, with approximately 1000 mm/year of precipitation concentrated mainly between November and January (Costa et al. 2011). The study area is a type of savanna with dystrophic soil and with tortuous trees 3-10 m in height with thick bark and sclerophyllous leaves (Fagundes et al. 2011).

Copaifera langsdorffii Desf. (Fabaceae: Caesalpinioideae) is a tropical tree species that reaches up to ten meters in the Cerrado. The plant is completely deciduous in the dry season (July to September) and produces new leaves immediately after leaves produced throughout the previous year fall (Costa et al. 2010). Fruiting is supra-annual [i.e., alternating years of intense fruit production are followed by years of little or no fruiting (Pedroni et al. 2002)]. The seeds are predated in the pre-dispersal phase by *Rhynochenus brevicollis* Chevrolat (Curculionidae: Cryptorhynchinae). The beetle represents an important mortality factor of *C. langsdorffii* seeds, although other animals also attack these seeds in the pre-dispersal stage (Freitas & Oliveira 2002).

Experimental design

During the month of April 2008, 35 *C. langsdorffii* individuals in the initial stage of fruiting were selected and marked in the study area. Those individuals were from three to eight meters high, with well-formed crowns and in good phytosanitary states. During the month of May 2008, ten terminal branches were collected from each of the 35 selected plants to assess the mean number of fruit produced per terminal shoot. Branches were collected at different points of the three crowns to minimize possible microclimatic effects on fruit production and seed predation (Ramírez & Arroyo 1987). All collected branches were individually bagged and taken to the laboratory (Laboratório de Biologia da Conservação - Universidade Estadual de Montes Claros), where the fruits were counted and the mean number of fruits per branch was determined for each tree. Collected branches were 30 cm long, corresponding to the last season of plant growth. Finally, in July 2008 (in the period before seed dispersion), one hundred fruits were collected from each plant to estimate seed predation by *R. brevicollis*. Plant heights and crown circumference were taken using a tape measure and used as architectural parameters (see Costa et al. 2010).

The effects of the number of fruits per branch and of plant architecture (height and crown circumference) on seed predation were tested independently using General Linear Models with a *Poisson* error distribution.

Results and Discussion

The percentage of *C. langsdorffii* seed predation by *R. brevicollis* ranged from 1 to 30% (mean±SD, 9.31±6.41). The percentage of seed loss in the pre-dispersal phase may vary widely between species and habitats but is frequently above 90% (Turner et al. 1996; Lewis & Gripenberg 2008). However, in this study, we emphasize only the seed predation inflicted by *R. brevicollis*. In fact, the fruits of *C. langsdorffii* are attacked by various other organisms, such as parakeets (*Brotogeris chiriri*), little marmosets (*Callithrix* sp.) and leaf-cutting ants (*Atta laevigata*), in the studied area (M.F., personal observation).

The percentage of seed predation inflicted by *R. brevicollis* was negatively related to the number of fruits per terminal shoot (Wald Stat.=12.491, $P<0.01$, Figure 1a). Therefore, our data do not support the resource concentration hypothesis. It is important to note that the ability to move between patches may affect resource selection by herbivores. In fact, more mobile animals generally respond positively to large seed crops, while animals of low mobility have lower percentages of predation on large seed crops (see Kelly & Sork 2002). Moreover, on a population scale, supra-annual mass fruiting potentially affects seed predation by reducing the population density of insects (Janzen 1971; Silvertown 1980; Ramírez & Traveset 2010). Thus, because masting maintains seed predators in low densities, all individual plants represent patches of high resource density, which inhibits insect migration between resource patches. In this scenario (low insect density and low migration between resource patches), it would be reasonable to expect greater percentages of seed predation on plants with lower seed crops.

Seed predation by the beetle was positively affected by plant crown circumference (Wald Stat.=6.789, $P<0.01$, Figure 1b), but plant height did not show any relationship with seed predation (Wald Stat.=3.187, $P=0.074$, Figure 1c). Thus, the plant architecture hypothesis was also not supported by our data. Various parameters have been used as indicators of plant architecture (e.g., height,

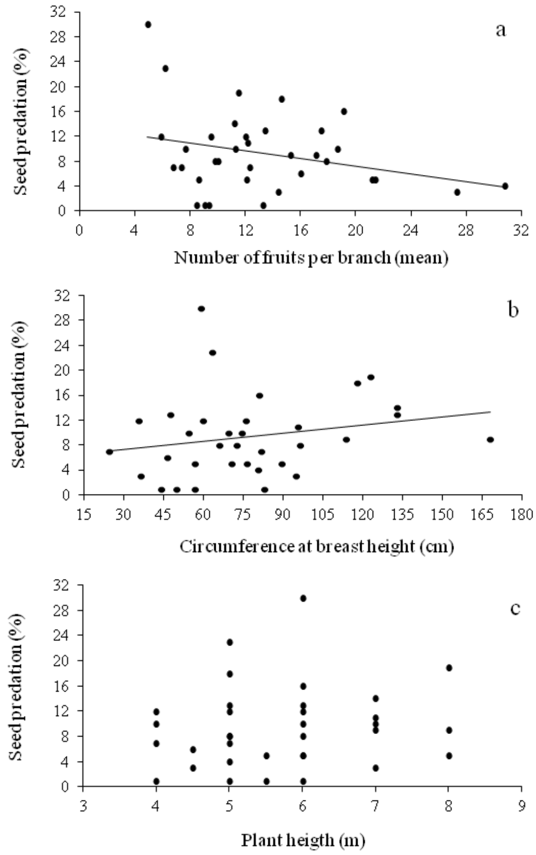

Figure 1. Relationship between the number of seeds per terminal shoot (a), crown circumference (b) and plant height (c) and the percentage of seed predation of *Copaifera langsdorffii* by its insect predator, *Rhinochenus brevicollis*.

Figura 1. Relações entre o numero de sementes por ramo (a), circunferência do tronco (b) e altura da planta (c) com a percentagem de predação de sementes de *Copaifera langsdorffii* por *Rhinochenus brevicollis*.

crown diameter/ circumference, number of meristems, crown volume, ramification numbers), and the effects of these parameters on insect abundance and richness are contradictory (see Espírito-Santo et al. 2007; Woodcock et al. 2007; Costa et al. 2010 and cited references). Thus, new studies and syntheses on the effects of plant architecture on insect diversity in tropical systems are needed. Our study shows the potential effect of the phenology of *C. langsdorffii* on the population dynamics of *R. brevicollis* in the Brazilian cerrado.

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