Influence of Parasitism by Pilostyles ingae (Rafflesiacae) on its Host Plant, Mimosa naguirei (Leguminosae)

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Mimosa naguirei (Leguminosae) is parasitized by Pilostyles ingae (Rafflesiacae) in the Serra do Cipó, in southeastern Brazil. The study examined the influence of this parasite on various parameters of M. naguirei in an attempt to establish general patterns for future research. It was found that the percentage of parasitized plants varied along an altitudinal gradient of 500 m. The parasitic plant influenced the architecture of the host plant. The number of branches on parasitized plants was significantly greater than the number of branches on non-parasitized plants. Branches of parasitized plants were significantly shorter than branches on non-parasitized plants. The density of P. ingae flowers decreased from the stem base to apex. The number of fruits produced by parasitized plants was not greater than the number of fruits produced by non-parasitized plants, although parasitized plants produced smaller fruits and lighter seeds. Seed germination did not differ significantly between parasitized and healthy plants.

Key words: Holoparasite, Leguminosae, Mimosa naguirei, plant parasitism, Pilostyles ingae, Rafflesiacae.

INTRODUCTION

The distribution of the family Rafflesiacae is primarily tropical, with the centre of distribution in Malaysia and Africa (Ule, 1915; Dell and Burgide, 1981). All Brazilian species are holoparasites of roots or aerial branches. They are highly specialized parasites, with ramifying cellular threads which penetrate deep into the tissues of the host plant. Pilostyles, whose species are parasites of the Leguminosae, is the only genus which parasitizes the aerial parts of its host plants (Dell, Kuo and Burgide, 1982). Pilostyles spp. are herbaceous, dioecious plants without roots or chlorophyll. Plants are apparent during the flowering period when they come to the external surface of the the host plant tissues (Fig. 1). Except for the flowers, which vary in size from 1 m in diameter (e.g., Rafflesia) to only 2-3 mm in diameter (e.g., Pilostyles), the body of the plant is greatly reduced, and encrusted in the tissue of the host plant (Endriss, 1902; Dell et al., 1982). The few recent studies of the parasitism of the Rafflesiacae have been primarily concerned with the anatomy and taxonomy of the parasite.

Next to highway MG-010, at Serra do Cipó, MG, Brazil, various individuals of Mimosa naguirei Barneby (Leguminosae) parasitized by P. ingae (Kart.) Hook (Rafflesiacae) were found from the base of the mountain to its top. Mimosa is a species rich genus of legumes with many weedy forms. They are very common in southeastern Brazil where they are usually found in pasture lands, cultivated fields, bordering highways and in vacant lots (Lorenzi, 1982). The host plant is very common in southeastern Brazil where it is usually found in pasture lands, cultivated fields, bordering highways and in vacant lots (Giulietti et al., 1987).

We were interested to document some trends in the relationships between the parasite and its host plant. The study posed the following questions relating to the parasitism of P. ingae on M. naguirei: (a) how does the frequency of parasitism vary with altitude; (b) what is the influence of the parasite on the number and length of the host plant's branches; (c) how does the distribution of flowers of the parasite vary within the branches of the host plant; (d) what is the influence of parasitism on the number of fruits produced by the host plant; (e) what is the influence of the parasite on the quality of the seeds (weight and germination rates) of the host plant?

MATERIAL AND METHODS

Study system

The Serra do Cipó is located in the central part of the state of Minas Gerais (19° 12' S; 43° 28' W), Brazil. Altitudes vary between 800 and 1500 m. The vegetation is composed primarily of gallery forests, savannas, and rocky fields which are associated with differences in topography, humidity and soil quality (Menezes and Giulietti, 1986). Soils are normally shallow and sandy, with the emergence of quartzite and sandstone (Joly, 1970). The climate is mesothermic, with showery summers; average temperatures range between 17-4 and 19-8 °C. The annual precipitation is approximately 1500 mm with a short dry season (3-4 months) during the winter.

Data were collected from Aug. 1992 to Apr. 1993. Plants were collected at altitudes that varied from 800 to 1300 m alongside highway MG-010 (between kilometres 99 and 122). As assumptions for a regression include that the y-axis data are normally distributed (Zar, 1984), χ² tests were used.

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to determine whether differences in the percentage of parasitism existed across the altitudinal gradient. Of the 199 plants studied, the height, total number of branches, number of parasitized and apparently non-parasitized branches were counted. A randomly selected branch was chosen from each individual and its length, number of fruits, and number of flowers of *P. ingae* in 10 cm of the basal, intermediary and apical portions of the branch registered. Differences in the number and length of the branches between parasitized and healthy plants were compared by independent *t*-tests, whereas the average number of parasites per 10 cm of stem was compared by one-way analyses of variance. Mean differences were compared by the Tukey HSD post-hoc tests (Zar, 1984).

Fruits and seeds of parasitized and healthy plants were collected and stored in plastic bags and taken to the laboratory for measurement of fruit length and width (up to 15 fruits per individual) and for seed germination tests. Because data were not normally distributed, the Wilcoxon signed-rank test was used to compare fruit size and seed weight (Zar, 1984).

For the germination test, seeds were submerged for 10 min in concentrated commercial sulphuric acid (*H₂SO₄*), then washed six times with sterile distilled water and placed in sterile Petri dishes to germinate. Dishes were covered with sterile cotton soaked in distilled water. Ten seeds were selected at random and placed in each Petri dish. The seeds remained in an incubator for a period of 5 d at 28 °C. Seeds that had produced a primary root after this period were considered viable. As data were not normally distributed, they were arc. sin transformed before the independent *t*-test comparison.

**RESULTS**

**Parasite-host relations**

The proportion of parasitized plants varied significantly along the altitudinal gradient (*χ² = 49.103, n = 116, P < 0.05*). A trend existed for increasing parasitism rates with increasing altitude. The percentage of parasitism in *M. naguirei* for altitudes 800, 900, 1000, 1100, 1200, and 1300 m was, respectively, 4.31, 7.76, 7.76, 18.97, 30.17 and 31.03%.

**Fig.** Schematic representation of a branch portion of *M. naguirei* parasitized by *P. ingae* (not to scale) in the Serra do Cipó, Brazil.
Various host plant traits were affected by *P. ingae* parasitism. The average number of branches in parasitized plants (\(x = 3.98 \pm 0.24\)) was significantly greater than the average number of branches in non-parasitized (\(x = 2.964 \pm 0.23\)) plants (\(t\)-test = 2.905, \(n = 199, P < 0.004\)). The average length of branches of parasitized plants (\(x = 1.82 \pm 0.07\)) was significantly smaller than the average length of branches of non-parasitized (\(x = 2.45 \pm 0.66\)) plants (\(t\)-test = 5.43, \(n = 199, P < 0.0001\)).

**Influence on host plant productivity**

Several traits related to host productivity were influenced by the parasitic plant. The parasitism of *P. ingae* did not influence the total fruit production of attacked plants: the average number of fruits on parasitized plants (\(x = 36.05 \pm 4.86\)) was different from the average number of fruits on non-parasitized plants (\(x = 38.01 \pm 5.78\)) (\(t\)-test, \(n = 199, P < 0.0001\)). Nevertheless, fruit and seed quality were affected by the parasitism. Parasitized plants produced smaller fruits (\(x = 2.02 \text{ cm}^2 \pm 0.13\)) than healthy plants (\(x = 3.14 \text{ cm}^2 \pm 0.13\)) (Wilcoxon signed-rank test = 3.575, \(n = 199, P < 0.0001\)). Additionally, the weight of seeds produced by parasitized plants (\(x = 21.8 \text{ mg} \pm 16.0\)) was smaller than the weight of seeds produced by healthy plants (\(x = 26.6 \text{ mg} \pm 7.0\)) (Wilcoxon signed-rank test = 2.25, \(n = 17, P < 0.02\)). Nonetheless, these characteristics did not influence seed germination. The percent of seed germination of parasitized plants (\(x = 60.59 \pm 8.42\)) was not different from the percent of seed germination of healthy plants (\(x = 68.82 \pm 6.35\), \(t\)-test, \(P > 0.05\)).

**Distribution of the parasite in the host plant**

The number of *P. ingae* flowers varied along the branch of the host plant (ANOVA, \(P < 0.0001\)). The number of flowers in the basal (\(x = 317.14 \pm 21.67\)), intermediary (\(x = 233.76 \pm 16.68\)), and apical (\(x = 50.84 \pm 7.10\)) portions of parasitized branches decreased from the basal to the apical region. All three means were significantly different from each other (Tukey HSD pos-hoc test, \(P < 0.05\)).

**DISCUSSION**

The variation in the percentage of parasitism in *M. naguirei* along the altitudinal gradient studied may have been due to several single or combined factors: for example, variation in the physiological condition of the host with regard to the mechanisms of resistance/susceptibility which would impair/facilitate the attack and success of the parasitic plant. The development of the parasite may have been improved at higher elevations because of its increased virulence or of a decreased resistance of the host. Variation in the environmental conditions could also facilitate or mediate the development of the parasitic plant. Plants at higher altitude may have suffered more from harsh climatic influences such as ultra-violet radiation, wind and frost, which could have made them less resistant to attack. Other hypotheses could also account for the observed pattern, such as a differential distribution of the pollinators and seed dispersors of the parasitic plant. Such possibilities require long-term, detailed study for the establishment of cause and effect.

Parasitism by *P. ingae* alters the architecture of the host plant. Parasitism decreases apical dominance in the host causing an increase in the number of branches, but a subsequent decrease in the length of the branches. This phenomenon has been reported elsewhere in other systems (e.g. Fernandes and Ribeiro, 1990; Whitham et al., 1991; Belsky et al., 1993). In one case, infection by *Mitrasemon* spp. (Rafflesiaceae) resulted in a decrease in the apical dominance of the root of the host plant (Kummerow, 1962; Kuijt, 1969).

More flowers of the parasitic plant were found on the base than on any other portion of the host plant branch. The variation in the number of flowers of *P. ingae* along the branches (decreasing from the base to the top) was also observed in *P. strawiaskii*, a parasite of *M. bracatinga* (Mello-Filho, 1953). The higher number of flowers at the bases of the branches may have been due to various factors. For instance, basal flowers would constitute a better resource for pollinators and dispersors and would then produce more and better fruits. Another hypothesis is that invasion by *P. ingae* initiates from the stem base, coming up from the host roots. Therefore, there would exist a greater number of flowers at the base of the branches (see Kuijt, Bray and Olson, 1985).

Although the parasitism influenced the size of the fruit and the weight of the seed of the host plant, parasitism did not influence the number of fruits produced or seed germination. Nonetheless, the almost 20% reduction in mean seed weight on parasitized plants may be very important in the probability of establishment of young plants. Although an apparent negative influence of the parasitism on seed viability was not found, more branches were produced by parasitized plants. As such, parasitized plants could produce a higher number of seeds. This indicates that parasitism could be beneficial to the host plant. Indeed, parasitism in some cases may be on the evolutionary route to mutualistic relationships (e.g. Price et al., 1986). Nevertheless, observational field data must be viewed with caution; detailed experimental studies must be performed to fully evaluate the relationship between *P. ingae* and its host *M. naguirei*.

Although preliminary, the results of this study indicate some interesting and intriguing questions that may be pursued.

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I. Introduction

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LITERATURE CITED


