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GALL INFLUENCE ON FLOWER PRODUCTION IN *SOLANUM LYCOCARPUM* (SOLANACEAE)

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Abstract

The aim of this study was to determine if there is a negative influence on the flower production in *Solanum lycocarpum* (Solanaceae), due to the attack of gall inductor herbivores. 120 individuals were analyzed and compared as to the relation between presence and absence of galls and flower production. All flowers were collected from these individuals, so that the following characteristics could be compared: number of flowers, flower size (cm) and biomass (g) in plants with and without galls. Although these flowers are produced during the whole year, we found a greater number of flowers in plants without galls, being that plants without galls showed approximately four times more flowers than plants with galls. The flowers length in plants without galls was greater than flowers in plants with galls. The flower biomass of the individuals without galls was also higher than in individuals with galls. The results are pursuant to the hypothesis that producing galls demands a high energetic effort from these plants, resulting in nutrient allocation and decrease in flowers formation.

Key words: Cerrado, Insect gall, Plant-insect interactions.

Introduction

Herbivory, which is the consumption of plant tissues by animals, may cause negative impacts on plants (Kurzfeld-Zexer *et al*., 2010). Attacked plants may have their growth diminished, their structure altered, in addition to a decrease in their reproductive investment (Kettenring *et al*., 2009).

As a response to herbivory, plants alter their primary metabolism, being able to adjust, temporarily, their resources to allocation and forwarding them to other storage organs (Gómez *et al*., 2010), such as biomass reallocation underground, resulting in a reduction in number and size of leaves (Quezada & Gianoli, 2010). When these resources are limited and there is competition of this allocation to a function or organ, they cease to be available to other functions or organs, resulting, therefore, in a reduction in the plant's natural growth (Weiner, 2004; Weiner *et al.*, 2009).

Plants may compensate the attack of herbivores by increasing their growth or their reproduction (Hawkes & Sullivan, 2001). In other cases, the incapacity to fully compensate herbivory may result in the reduction in reproduction and increase the plant's mortality rate, if compared to healthy plants (Gonçalves-Alvin *et al*., 1999).

Gall insects are specialized and diversified herbivores that redirect vegetal resources to induce the nutritive tissue, where they will develop and feed themselves (Price *et al*., 1987; Marini-Filho & Fernandes, 2012). Chemical signals produced by these gall insects make the nutrients be drained from other parts of the plant, so that they can be used as food within the galls (Borges, 2006).

In Cerrado, there is a high incidence of galls on several plant species, because there is a higher nutritional stress in this environment than in other types of habitat (Maia & Fernandes, 2004). According to Fernandes & Price (1992), gall insects suffer a higher selective pressure, put upon by natural enemies in dry environments, which may lead to a significant increase in number.

The effect of galls in plants differs from other kinds of damage in several aspects. Galls may weaken the host plants, hampering their development (Borges, 2006) or cause negative impacts on the plant, reducing its biomass and decreasing its fertility (Kettenring *et al*., 2009). Gall insects may decrease the production of flowers and fruits, reduce its weight and percentage of seeds, in addition to having a decrease in the plant's growth rate after the attack (Silva *et al*., 1995).

Theory says that flowers show a size morphologically constant in each species due to the stabilizing selection (Feinsinger, 1983), however, we want to verify if herbivory can reduce the size of these flowers and alter the plant reproductive investment, since interspecific differences regarding flowers, can easily become an obstacle for the plant's sexual reproduction (Herrera, 2001, 2004).

The aim of this work was to verify whether the presence of galls affects negatively the flower production in *Solanum lycocarpum* St. Hil (Solanaceae). The following hypotheses were tested: plants with galls (1) produce less flowers; (2) have smaller flowers and (3) produce flowers with lower biomass; than plants without galls.

Material and Methods

Study area: This study was carried out in three pasture areas, within biome Cerrado in Minas Gerais, being two of them defined by geographic coordinate 21º19'03" S and 44º87'22" O, and the other by 21º20'47" S and 44º59'27" O. In the region, the average altitude is 1,100 m and the average annual rainfall is 1,411 mm (Tanque & Frieiro-Costa, 2011). The vegetation is, in general, low with twisted branches and thick leaves (Brasil Escola, 2002). The soil is usually acidic, with aluminum toxicity and poor in essential nutrients (Embrapa, 2005). The study was carried out in 2011, during the period when galls could be found closed in *S. lycocarpum* individuals, suggesting that the insects were still inside the galls.

Studied system: The species *S. lycocarpum* is a plant characteristic to Brazilian Cerrado. It is a shrub commonly known as Wolf's Apple or Wolf's Plant, reaching up to five meters high, its crown is round and thin with fragile branches. It is commonly found in Minas Gerais Cerrado (Oliveira-Filho & Oliveira, 1988). This plant grows and develops in unfavorable environmental conditions, such as acid soils, poor in nutrients. It is a resistant plant, being able to stand in dry climates, long droughts and fire (Campos, 1994). This species blooms during the whole years, though in rainy periods, the number of inflorescences and open flowers raises (Oliveira-Filho & Oliveira, 1988). Fruit production in this plant occurs during all year, being more frequent in February (Oliveira-Júnior *et al.*, 2003).

In this species, it is more common to find stem galls induced by the insect *Collabismus clitellae* Boheman, 1837 (Coleoptera: Curculionidae). Adults of *C. clitellae* are more commonly found in October, November and December, which is a period when they feed on the new stems, sprouts and flowers of the host plant. In this period, females lay eggs on the new sprouts, resulting in multiloculated galls (Souza *et al*., 1998, 2001). The growth of such galls stops in April, but larvae of *C. clitellae* continue growing and feeding themselves, until they become pupa, during the period from May to July, and the adults are observed within the galls between July and September. Most insects emerge in September or October, completing their life cycle within a year (Souza *et al*., 1998, 2001).

Sampling: 20 plants with galls and 20 without galls were chosen in each area, totalizing in 120 individuals. Plants with galls that showed no orifices were chosen, for it indicated that their inducers were still inside them. All flowers were collected from these individuals, so that the following characteristics could be compared: number of flowers, flower size (cm) and biomass (g) in plants with and without galls. After the collection, the flower length (cm) was measured, and they were dried in a hothouse at 60ºC for 72 hours. The dry mass of these flowers was weighed afterwards.

Data analysis: In order to verify if there was any difference between the number of produced flowers and their length and biomass in plants with and without galls, the data normality was tested, and ANOVA was carried out.

Results and Discussion

The presence and absence of galls affected both the number of flowers that are produced by these plants, and their size and biomass. Thus, the presence of galls in these individuals alter the resource reallocation in the plant, pointing out that the resources the plant is provided with shall decrease for the production of flowers.

We found a greater number of flowers in plants without galls ($F = 46.701$; $p<0.001$; $n = 120$; Fig. 1), being that plants without galls showed approximately four times more flowers than plants with galls (Fig. 4). The flowers length in plants without galls was greater than flowers in plants with galls ($F = 45.563$; $p>0.001$; $n = 120$; Fig. 2). The flower biomass of the individuals without galls was also higher than in individuals with galls ($F = 51.209$; $p<0.001$; $n = 120$; Fig. 3).

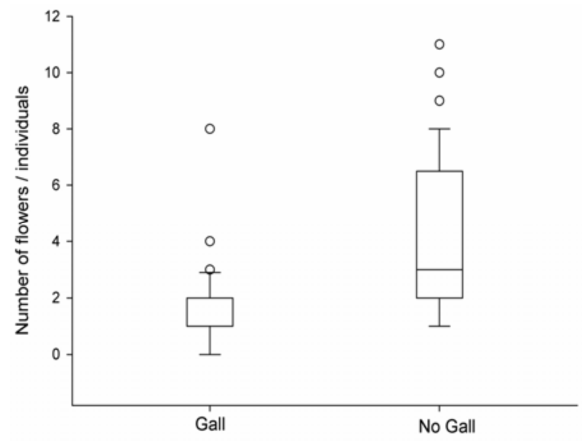

Fig. 1. Number of flowers per individual of *Solanum lycocarpum* (Solanaceae) with and without galls induced by *Collabismus clitellae* (Coleoptera: Curculionidae) (F = 46,701; p<0,001; n = 120).

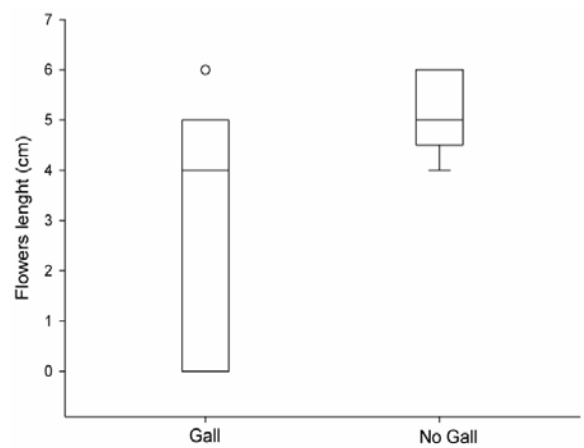

Fig. 2. Average length of flowers in individuals of *Solanum lycocarpum* (Solanaceae) with and without galls induced by *Collabismus clitellae* (Coleoptera: Curculionidae) (F = 106,020; p<0,001; n = 327).

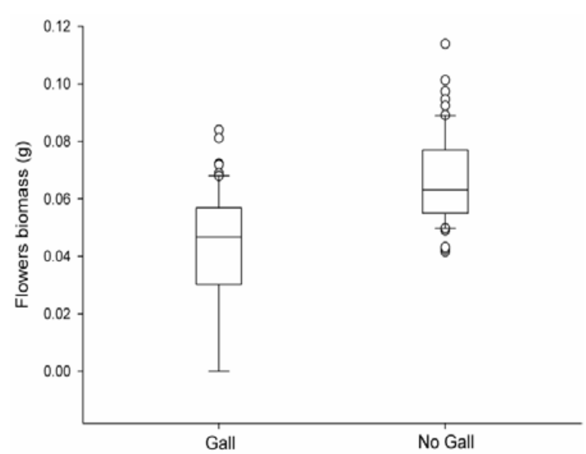

Fig. 3. Average biomass of flowers in individuals of *Solanum lycocarpum* (Solanaceae) with and without galls induced by *Collabismus clitellae* (Coleoptera: Curculionidae) (F = 59,651; p<0,001; n = 327).

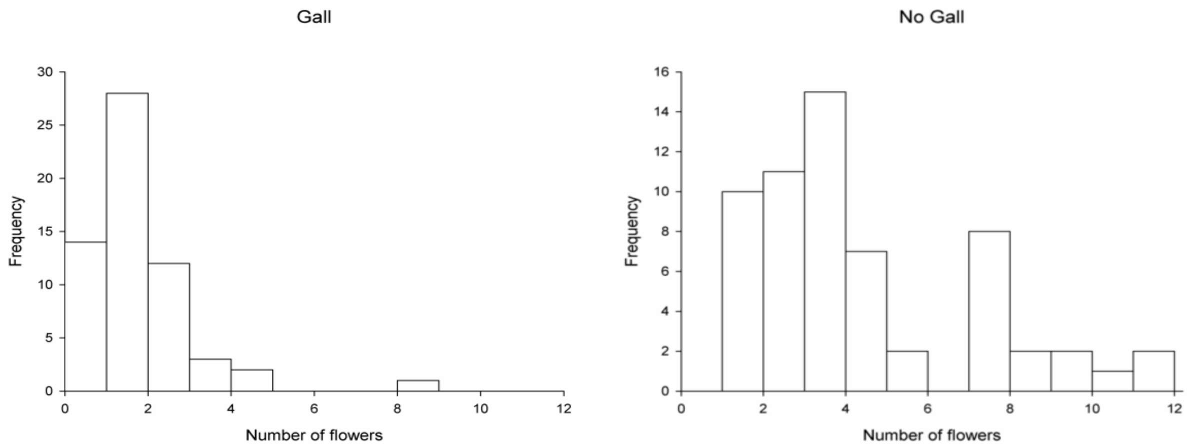

Fig. 4. Frequency of the number of flowers produced by individuals of *Solanum lycocarpum* (Solanaceae) with and without galls induced by *Collabismus clitellae* (Coleoptera: Curculionidae).

The transportation and manipulation of nutrients in the host plant to the galls may affect the plant's reproductive performance, which is one of the characteristic of their history of life (Weiner, 2004; Weiner *et al.*, 2009). Our results point out that the flowers in individuals with galls showed a reduced growth. They were found in a lower amount, when compared with plants without galls. The same situation occurred with Fay & Hartnett (1991), who noticed that there was a low reproduction rate in plants attacked by galls.

Flowers of plants with galls also showed a shorter length, pursuant to Hartnett & Abrahamson (1979), who noticed the increase in stem biomass in plants with galls, when compared to the presence and absence of galls, resulting in a significant reduction of seed biomass reallocation and a lower biomass proportion available to other aerial organs of the host plant, such as leaves, which also showed a smaller size. It indicates that the presence of such galls affect the resource allocation distributed to other organs of the plant.

We found out that galls decrease the quantity of resources available for the reproductive development of *S. lycocarpum* individuals, and it also happens to other plants that suffer attacks from gall insects (Hartnett &Abrahamson, 1979; Vasconcelos *et al*., 2009). The presence of galls in other species reduces the energy reallocation to the sexual and vegetative reproductions (Hartnett & Abrahamson, 1979). Therefore, galls capture the nutrients, which would be used by host plant for growth and reproduction (Wolfe, 1997).

Regarding a plant reproductive success, the attack of galls may also diminish the number of fruits produced by the attacked plants. For a plant, the presence of galls results in a loss of direct fitness (Wolfe, 1997). The second consequence is a result of the withdrawal of energy and biomass from other organs and tissues and invested in the gall itself (Wolfe, 1997).

The presence of galls in *S. lycocarpum* suggests that there is an alteration in the reallocation of available resources that are redirected to the development of their insects, affecting, therefore, the production of flowers. This capacity allows the individuals of *C. clitellae* to have available food for their development, thus affecting the host plant, decreasing its capacity to invest in reproduction.

The effect of galls upon their hosts may be differentiated within several plant groups and few studies investigate the way this resource allocation occurs in different tissues of the attacked plants. In Cerrado, there is a high incidence of galls, therefore, this alteration in reproductive structures may occur in other plant groups of the same ecosystem. The results of the current study show that galls may decrease the investment in flowers of *S. lycocarpum* and suggests that there is a *trade-off* between the flower production and gall production in the host plant.

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