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A non-harmonic relationship of ants with plants of *Asclepias curassavica* (Apocynaceae) in a subtropical site in Southeastern Brazil

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Abstract
During 2008, 13 morph species of ants in five subfamilies were recorded visiting flowers of *Asclepias curassavica* in a ruderal environment in Vale do Rio Quilombo, Santos, Southeastern Brazil. The role of the presence of ants in flowers was experimentally tested in 50 pairs of plants, with and without ants. These plants, which were followed until the fruiting, showed that ants affected negatively the production of fruits. In studied system, ants acted as parasites of plants of *A. curassavica* because they are nectar thefts, diminishing the access to potential pollinators reducing their capacity of fruit production.

Keywords: nectar theft, species interactions, pollination.

Resumo
Durante 2008, 13 morfoespécies de formigas de cinco subfamílias foram observadas visitando flores de *Asclepias curassavica* em um ambiente ruderal no Vale do Rio Quilombo, Santos, sudeste do Brasil. O papel da presença das formigas nas flores foi testado experimentalmente em 50 pares de plantas, com e sem formigas. Essas plantas, que foram acompanhadas até a frutificação, mostraram que as formigas afetaram negativamente a produção de frutos. No sistema estudado, as formigas atuam como parasitas das plantas de *A. curassavica* porque são ladras de néctar, diminuído o acesso de polinizadores potenciais reduzindo sua capacidade de produzir frutos.

Palavras-chave
roubo de néctar, relação não-harmônica, polinização

1 Introduction
The milkweed plant *Asclepias curassavica* (Apocynaceae) is known in Brazil as "oficial-de-sala", "algodãozinho-do-campo" or "paina-de-sapo". It is an invasive species that produces actinomorph hermaphrodite flowers and fruits almost all year [1]. The seeds are dispersed by wind establishing patches with great density of plants, which regenerate in 30-40 days after being cut [2, 3]. The plants are toxic to several animals due to presence of cardenolides [4]. The floral structure is known since XIX century but the emphasis to nectaries and pollination appeared only in the papers of Galil and Zeroni [5, 6]. Each flower of *Asclepias* has two ovaries and five pairs of pollinia which are removed by pollinators [7, 8]. The flowers of *A. curassavica* have a unique uninterrupted system of nectar production that is composed by the chambers of stigma with capillary connections between them which are called cuculli [5]. The nectar distribution in this system is not homogeneous, the same flower can be shown with some cuculli empty, and some full.
The Hymenoptera are insects considered efficient pollinators [9], but there are few records for ants (Formicidae) as pollinators although they are constantly found on plants [10, 11, 12], including flowers [13, 14]. The few examples came from biomes of arctic or alpine tundra or hot tropical deserts, with plants with an architecture which facilitates the pollination by ants or because other pollinators are scarce [15, 16, 17].
In lowland rainforests, ants visit much more the floral than the extra floral nectaries [10]. Janzen [18] proposed that this could be because the nectar in nectaries of these plants had substances that would repel ants. However, other authors have shown that these substances are actually not effective in repelling ants [19, 20, 21].

However, the ants can help the plants by enriching the substrate or protecting them against predation or parasitism by phytophagous, without necessarily a mutualistic relationship between both [22]. The association between ants and plants allow plants to take advantage of rich nitrogen materials derived of ant physiological activities [23].

Of the known interactions between ants and plants (revision by [12]) perhaps the most important is mutualism, where ants gain protection, food, or both and plants obtain protection against arthropods and vertebrate herbivores [24]. One exception are ants of the tribe Attini, which are leaf cutters, and therefore their relationships with plants are not mutualistic [25].

The objective of this work was to know what species of ants visited flowers of *A. curassavica* in a subtropical locality in the coastal area of southeastern Brazil quantifying the distribution of ants on plants and testing if ant presence affects the fruit production by the plants.

2. Materials and Methods

2.1 Study area

Samplings were made along the edges of an dirty road in the right bank of river Quilombo, Santos (coastal region of state of São Paulo, Brazil, (23°51'35"S 46°21'01"W and 23°49'18"S 46°18'37W". This road has a length of 8.6 km and goes from Cônego Domênico Rangoni road (SP-55) to one reservoir water destined to steel plant of USIMINAS in Cubatão (but see [26] for details of the study area).

2.2 Samplings

The samplings of ants were made in five different dates in 2008: March 29, May 22, June 30, November 2 and 29. In each sampling the road was travelled using a car at slow velocity to found flowering plants of *Asclepias curassavica* which were visible to 2 m of the edge of the road (Figure 1). Each plant was inspected for ants, and when present, they were collected and preserved in alcohol 95%.

Fig 1: View of a patch of sampled *A. curassavica* plants in the study area.

2.3 Identification

After mounting the morph species were identified to subfamilies and genus following [27] with vouchers being deposited at Natural History Museum of the Campinas State University.

2.4 Experimental design and data analysis

On November 2 an exclusion test was made to verify the effect of ant presence in fruit production of *A. curassavica*. Before being marked all plants had only flower bud. The plants were marked with plastic numbered plastic tags choosing 50 pairs of plants located in 10 points along the road. The access to flowers was not possible in experimental plants. The ant exclusion was accomplished by rolling up three turns of a cotton string impregnated with lithium white grease (Figure 2). Other plants in contact were cut to avoid the ants to access the marked plants. The verification was made on November 29 when the number of fruits was counted in 33 pairs of plants due to the loss of 17. Data were analysed using software Biostat v.5 [28].

Fig 2: An *A. curassavica* plant showing the exclusion cotton string impregnated with lithium white grease.

3. Results

A total of 309 flowering plants were sampled and 13 ant morph species belonging to five subfamilies were recorded (Figure 3). They were represented by one species of each genus: *Acromyrmex*, *Crematogaster*, *Wasmannia*, *Pheidole*, *Cyphomyrmex*, *Cephalotes*, and *Solenopsis* (Myrmicinae; 53.8%); *Camponotus*, *Brachymyrmex*, and *Paratrechina* (Formicinae; 23.1%); *Tapinoma* (Dolichoderinae; 7.7%); *Pachycondyla* (Ponerinae; 7.7%), and *Pseudomyrmex* (Pseudomyrmicinae; 7.7%).

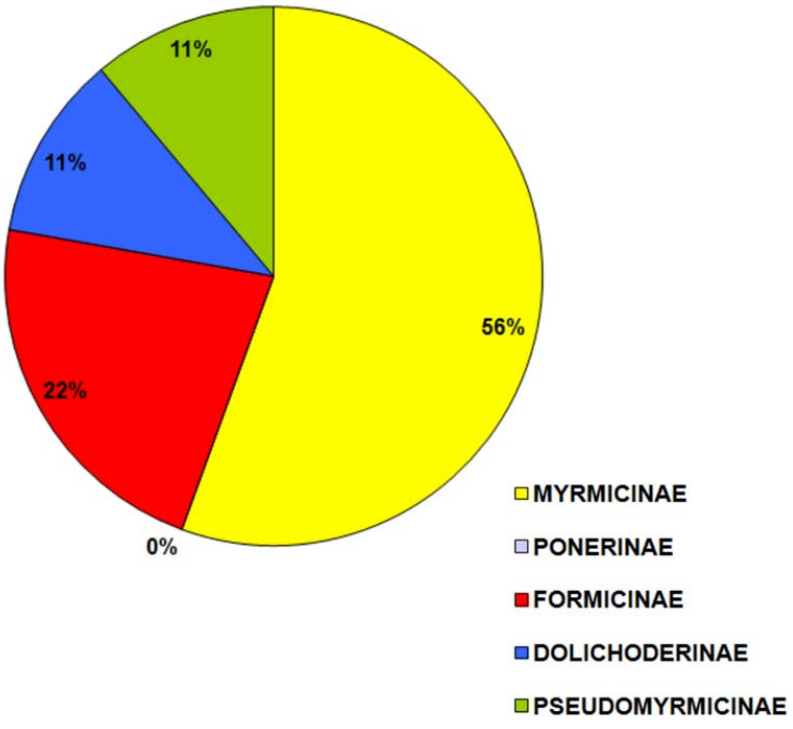

Fig 3: Percentage of the species of five ant subfamilies represented in samples.

Two plants (0.65%) presented three morph species: *Pseudomyrmex* sp., *Wasmannia* sp. and *Brachymyrmex* sp., 16 plants presented two (5.23%), 117 plants presented one (38.24%), and 171 plants presented no ants (55.88%).

Frequency of morph species on plants was different (Figure 4) with dominance of *Dorymyrmex* sp., followed by *Camponotus* sp. and *Crematogaster* sp. Two morph species: *Pachycondyla* sp., *Pseudomyrmex* sp. were found only once.

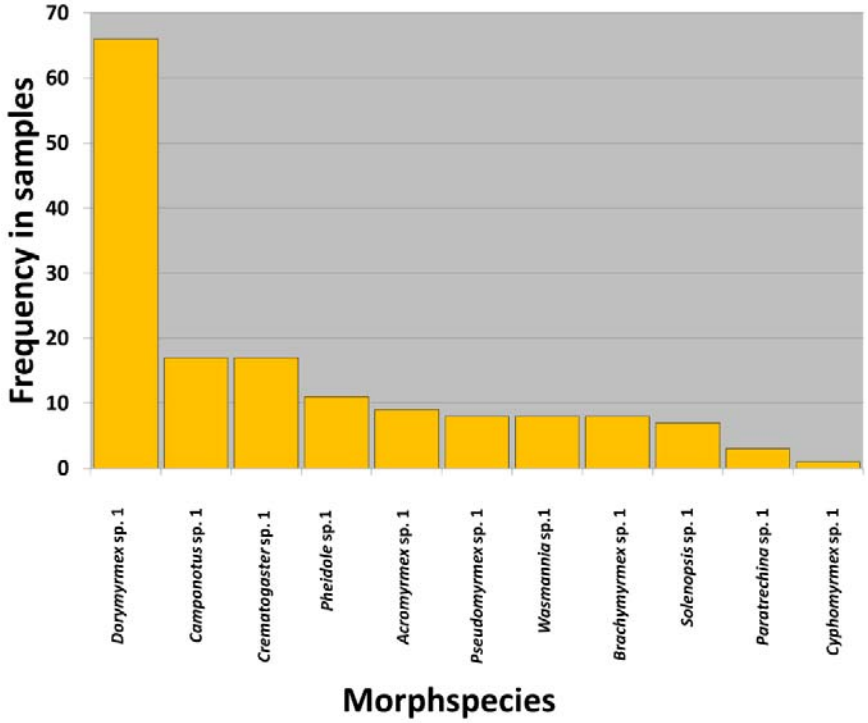

Fig 4: Frequency of ant morph species on sampled plants of *Asclepias curassavica* in the study area.

The nectar production by flowers of *A. curassavica* showed great variation with some flowers producing great amount of nectar to overflow the cuculum and others producing none. Some visiting ants presented enlarged gaster due to the intense nectar consumption. Visitation was made alone by *Pseudomyrmex* sp., *Cephalotes* sp. or *Pachycondyla* sp., or in groups as in *Pheidole* sp., *Wasmannia* sp., *Brachymyrmex* sp., *Crematogaster* sp., *Solenopsis* sp., *Paratrechina* sp., *Paratrechina* sp., and *Tapinoma* sp.

Experimental plants produced more fruits (23) than control plants (9) ($G = 6.34$; $p < 0.05$).

4. Discussion

The presence of ants foraging in flowers of *Asclepias* was recorded by [29], who found two species of ants, *Monomorium floricola* and *Pheidole* sp., in *A. curassavica* and by [30] who recorded ants at day and night in *Asclepias syriaca*. Norment [31], Fritz & Morse [32] and Galen [33] studying the relationship of ants and flowers concluded that ants reduce the reproductive capacity of their visiting plants.

5. Conclusion

In our studied system, ants are reported to act as parasites of plants of *A. curassavica* because they are nectar thefts, diminishing the access to potential pollinators reducing their capacity of fruit production.

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