



Short communication

Frequency of visits by ants and their effectiveness as pollinators of *Condalia microphylla* Cav.N.P. Chacoff^{a,b,*}, V. Aschero^{b,c}^a Instituto de Ecología Regional, Fac. de Cs Nat. e IML, Universidad Nacional de Tucumán, CC 34, Horco Molle, CP 4107 Yerba Buena, Tucumán, Argentina^b Instituto Argentino de Investigaciones de Zonas Áridas, CCT-Mendoza, Av. Ruiz Leal s/n, Parque General San Martín, CP 5000 Mendoza, Argentina^c Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, CCT-Mendoza, Av. Ruiz Leal s/n, Parque General San Martín, CP 5000 Mendoza, Argentina

ARTICLE INFO

Article history:

Received 19 September 2013

Received in revised form

3 February 2014

Accepted 5 March 2014

Available online 1 April 2014

Keywords:

Flower visitors

Fruit set

Monte desert

Pollination

Reproductive success

ABSTRACT

The effect of a pollinator species on a plant depends on their interaction frequency and the pollinator's effectiveness. The role of ants as pollinators is highly variable, in some cases they act as true pollinators and in others as antagonists damaging flowers, robbing nectar or disrupting pollination. Pollinator visitation frequency has been demonstrated as the most important factor determining their impact on plants. Ants are commonly seen as visitors of the desert shrub *Condalia microphylla*, but their effectiveness as pollinators is unknown. In this study we assess the quantitative and qualitative role of ants and other winged flower visitors as pollinators of *C. microphylla* by experimentally quantifying their contribution to fruit production. The study was conducted in the Monte Desert of Villavicencio Nature Reserve, Mendoza, Argentina. A diverse assemblage of insects visited flowers of *C. microphylla*, including bees, ants, flies, beetles and vespids. Ants (*Camponotus mus* and *Camponotus punctulatus*) accounted for a high proportion of interactions. Fruit set resulted mostly from pollination by winged insects, while flowers visited by ants did not set fruits. Thus, although ants were commonly seen on flowers, their effectiveness as pollinator was negligible for *Condalia microphylla*.

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1. Introduction

In mutualistic interactions, the impact of a species on another has two components, the frequency of interactions and the per interaction effect (Vázquez et al., 2012). Particularly in plant pollinator interactions, the effect of a pollinator on a plant depends on the effectiveness of that species (a measure of the quality of the interaction) and on the frequency of that interaction (Herrera, 1989; Vázquez et al., 2012). Effectiveness refers to the quantity of viable pollen that pollinators transfer to the stigma per visit, while frequency of interaction refers to the number of times each pollinator visits a flower of the species. It has been recently reported that the frequency of interaction is relatively more important for the fitness of the species than the per visit effect (the effectiveness) (Vázquez et al., 2012). This statement assumes that as the frequency of visits augments, the pollination function increases. However, it has been shown that for some species of plants as the number of visits

increases, the pollination function stabilizes, or even might decrease (eg. for *Capparis atamisquea* in Morris et al., 2010). Ants are commonly seen as floral visitors, thus they are expected to exert a strong influence on the plants they visit and can represent a good framework to analyze the relative contribution of effectiveness and frequency of visits.

There is growing evidence that ants can be true pollinators for many species as they are common visitors on flowers and are able to carry pollen that results in seed set (e.g. de Vega et al., 2009; Gómez and Zamora, 1992; Kawakita and Kato, 2002). The named ant pollination syndrome includes plants that have a high density of very small flowers bearing overlapping inflorescences at a uniform height, and low seed number, pollen volume and nectar quality and this syndrome is particularly common in hot, dry habitats (Hickman, 1974). But, ants visiting flowers are usually considered as non-pollinating insects performing antagonistic effects on plants by damaging floral resources, thieving the nectar, disrupting pollination and limiting reproductive processes (Dutton and Frederickson, 2012; Galen and Butchart, 2003; Ghazoul, 2001; Hull and Beattie, 1988). It seems that their effectiveness in the transfer of viable pollen can be especially important for this group of frequent visitors to flowers, but the examination of the role of

* Corresponding author. Instituto de Ecología Regional, Fac. de Cs Nat. e IML, Universidad Nacional de Tucumán, CC 34, Horco Molle, CP 4107 Yerba Buena, Tucumán, Argentina. Tel.: +54 381 4255174.

E-mail addresses: nchacoff@gmail.com (N.P. Chacoff), vaschero@mendoza-conicet.gov.ar (V. Aschero).

ants on the reproduction of plants has not often been assessed (Ashman and King, 2005).

The purpose of this study was to assess the quantitative and qualitative role of ants and other flower visitors on *Condalia microphylla* by experimentally analyzing the contribution of ants and other winged insects to fruit production, in a plant that has many characteristics of the named ant pollination syndrome. We expected that if the effect of the frequency of visits was strong, the number of visits by each group would be positively related to the fruit set, otherwise the visitation rate would be independent of the fruit set, indicating that the quality effect (effectiveness) was important for the species.

2. Materials and methods

C. microphylla Cav. (Rhamnaceae), is an evergreen xerophytic shrub endemic of South America, Argentina (Tortosa, 1999). Entomophilous flowers are yellowish to greenish, small, bisexual, (4 or) 5-merous, in axilar cyme inflorescences. Disk is intrastaminal, nectariferous, fleshy and tightly surrounding the ovary which is superior. The species has many of the typical “ant pollination syndrome” (small, open flowers, readily accessible nectaries, low number of ovules and is very common in desert areas in Argentina) (Hickman, 1974). Fruits are fleshy drupes containing one seed with oily albumen and a large embryo. Seed dispersal is performed by birds or frugivorous mammals.

The species was sampled in the Monte Desert of Villavicencio Natural reserve located in Mendoza province, Argentina, where it blooms in spring and peaks between mid-October and mid-November. Bloom is consistent with the flowering peak of most species in this biome (Chacoff et al., 2012). This plant species is one of the core species of the plant–pollinator network as is one of the most generalized species, is not only highly visited but is also visited by many insect species (Chacoff et al., 2012).

We performed censuses of visit frequencies to *C. microphylla* shrubs in full bloom (i.e., >50% of their flowers opened) to determine the assemblage of visitors. We sampled visitors to flowers in 5 consecutive years (from 2006 to 2010). Censuses consisted of 5 min of observation to a flowering branch, during the census we recorded the number of open flowers observed and the number of flowers visited by each visitor (for details on the sampling procedure see Chacoff et al., 2012). We conducted 106 censuses during the five years, with a total of nearly 9 h of observation to flowering individuals from 7 am in the morning until 15 pm in the afternoon. In each observational day, we performed censuses to different plants that were located over 2 ha plots, over the 5 years of sampling some plants were measured more than once. For visitors that were not identified in the field we collected individuals for determination in the laboratory by taxonomists (see acknowledgments). We estimated the visitation rate for each visitor species as the average number of flowers visited per census (5 min). The abundance was the number of individuals observed on flowers. To quantify the importance of each visitor, we multiplied the abundance of each visitor by its visitation rate (following Herrera, 1989). In order to compare the role of ants and other winged insects, visitor's species were classified in two different groups: Ants and winged insects (flies, bees, vespids and others hymenopterans) and compared them by using the non-parametric Wilcoxon test. For this analysis we excluded beetles, as they were not commonly seen in *C. microphylla* flowers (Table 1).

To analyze the role of ants and other flower visitors in reproduction we experimentally excluded ants and winged insects from flowers. We randomly selected focal plants ($n = 10$ in 2008 and $n = 15$ in 2009). In each plant we applied four treatments. (1) “Open pollination” in which flowers were left to open pollination and all type of visitors were able to visit the flowers (2) “Ants pollination” in which flowers were visited only by ants; in these plants we covered inflorescences with mesh-bags that excluded all winged

Table 1
Visitation rate, abundance and the quantity of interaction of the insects that visit *Condalia microphylla* flowers.

Order	Family (number of species)	Visitation rate (Visit flower ⁻¹ h ⁻¹)	Abundance (number of individuals)	Quantity of interaction (Individuals flower ⁻¹ h ⁻¹)
Hymenoptera (ants)	Formicidae (2)	0.027	132	1.730
Hymenoptera (others)	Apidae (1)	0.037	31	1.140
	Colletidae (3)	0.004	3	0.004
	Crabronidae (1)	0.01	1	0.014
	Eumenidae (2)	0.003	3	0.006
	Halictidae (2)	0.004	16	0.033
	Ichneumonidae (1)	0.015	1	0.015
	Megachilidae (1)	0.0001	1	0.0001
	Pompilidae (2)	0.010	2	0.01
	Sphecidae (1)	0.001	4	0.01
	Thynnidae (1)	0.009	6	0.052
	Vespididae (2)	0.003	5	0.007
Diptera (flies)	Agromyzidae (1)	0.0001	1	0.0001
	Asilidae (2)	0.001	8	0.005
	Bombyliidae (7)	0.004	146	0.059
	Calliphoridae (1)	0.013	40	0.536
	Empididae (2)	0.01	2	0.007
	Muscidae (1)	0.005	3	0.014
	Nemestrinidae (1)	0.01	68	0.91
	Sarcophagidae (1)	0.002	1	0.002
	Sciomyzidae (1)	0.010	1	0.010
	Syrphidae (8)	0.01	59	0.054
	Tachinidae (4)	0.004	12	0.033
	Tephritidae (1)	0.002	3	0.006
	Therevidae (1)	0.014	1	0.014
Coleoptera (beetles)	Chrysomelidae (1)	0.004	18	0.066
	Coccinellidae (1)	0.003	10	0.03
	Nitidulidae (1)	0.010	1	0.010

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