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Frugivory in *Echinopsis chiloensis* (Caryophyllales: Cactaceae)

Frugivoría en *Echinopsis chiloensis* (Caryophyllales: Cactaceae)

ROCÍO A. CARES*, RODRIGO MEDEL & CAREZZA BOTTO-MAHAN

Departamento de Ciencias Ecológicas, Facultad de Ciencias, Universidad de Chile, Las Palmeras 3425, Casilla 653, Ñuñoa, Santiago, Chile
*Corresponding author: rcares@ug.uchile.cl

Seed dispersal is a critical segment of the life cycle in plants. It involves fruit consumption and seed deposition on sites where environmental conditions are appropriate for germination and seedling establishment (Stoner & Henry 2008, Casado & Soriano 2010). Seed dispersal involves the action of mammals, birds, reptiles and insects, where seeds are often adhered to the body of animals or ingested and dispersed through defecation (Stoner & Henry 2008). Dispersal is a crucial process in semiarid environments as it provides seeds a chance to establish in safe sites. Although frugivory is a widely studied mechanism in several types of environments, there is scarce information for arid and semiarid habitats (Jordano 2000). In this report we present data on the magnitude of frugivory by different consumer taxa on cactus fruits in a semiarid Chilean ecosystem.

Echinopsis chiloensis (Colla) Fried & Rowl is an endemic columnar cactus species widely distributed in north-central Chile that inhabits mainly equatorial-facing slopes in semiarid environments (Medel 2000, Cares et al. 2013). The blooming season of *E. chiloensis* extends from early September to mid-November, and the fruiting season from mid-October to late December or mid-January (Medel 2000). This species presents arborescent growth with basitonic structure, with more than one trunk near the base (Medel 2001). In spite of being a dominant species in semiarid environments, scarce information exists on its demography and growth. Hoffmann (1989) suggests that natural regeneration may be difficult and growth rate can be extremely low, which is consistent with previous findings from a three-year study that indicates young individuals height grow on average (± SE) 2.44 ± 0.4 cm year^{-1} during years with average rainfall (Cares et al. 2013).

Currently, there is no published information about frugivory and seed dispersal of *E. chiloensis*. In this study, we report the results of field observations carried out during January of 2013 at the Reserva Nacional Las Chichillas (31°30'S, 71°06'W). This reserve is a protected area located ~60 km east from the Chilean Pacific coast. The climate of the study site is of a semiarid Mediterranean-type with most rainfall concentrated between June and August (di Castri & Hajek 1976). Mean annual precipitation is 185.0 mm, with ample variation across years, alternating between long droughts and unusual years of high rainfall seemingly associated to El Niño events (di Castri & Hajek 1976, Jaksic 2001). The vegetation consists on thorny shrubs (Luebert & Pliscoff 2006) and columnar and spherical cactus species (Medel 2000, Medel et al. 2002, Hoffmann & Walter 2004).

In this study, we considered a species to be a fruit consumer when it ate, pecked or removed totally or partially the pulp of a cactus fruit. Feeding events were instances when an animal was observed performing at least one of the activities indicated above (Casado & Soriano 2010). Field observations indicate that fruits of *E. chiloensis* ripe and open on the cactus branch without drop by abscission (Figure 1A). To identify the bird species involved in frugivory, we performed observations early in the morning from 7:00 to 10:00, during 13 consecutive days (total

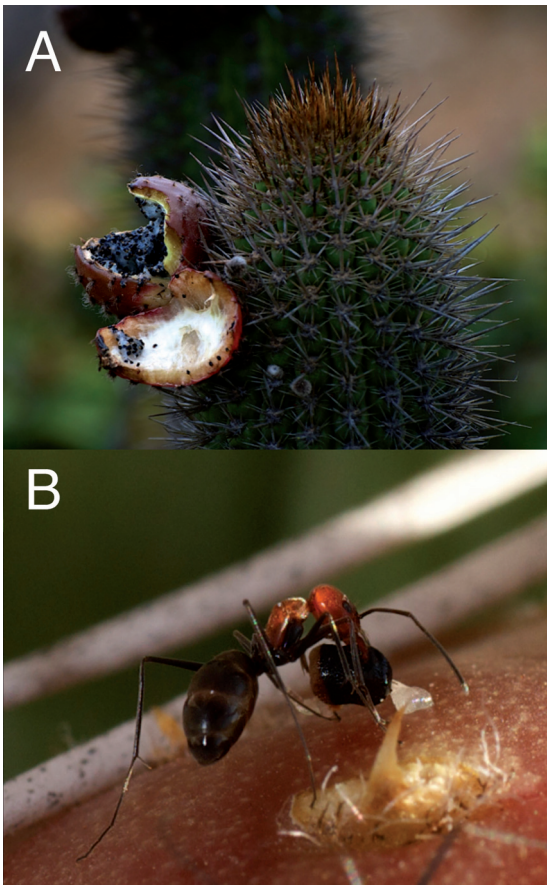

Fig. 1: A) Ripe and dispersed fruits of *Echinopsis chiloensis* on the top of a cactus column. B) *Conomyrma goetschi* carrying a seed of *Echinopsis chiloensis*.

A) Fruto maduro y dispersado de *Echinopsis chiloensis* en la punta de una columna del cactus. B) *Conomyrma goetschi* transportando una semilla de *Echinopsis chiloensis*.

sampling effort = 39 hours). Specifically, 142 cacti with at least one open fruit were scanned with binoculars (10 × 25). Only the Chilean mockingbird *Mimus thenca* (Molina 1782) was detected picking the fruits of *E. chiloensis* (total = 12 feeding events). Regarding ant species, preliminary observations revealed that ant activity was concentrated from 17:00 until dusk; therefore observations were carried out between 17:30 and 20:00 during 13 consecutive days (total sampling effort = 32.5 hours). On the average (± SE), 8.9 ± 1.6 cacti with open fruits/day were checked for ant presence, from which 2.1 ± 0.3 exhibited ants. Two ant species were recorded feeding on pulp and transporting seeds from the open fruits, *Conomyrma goetschi* (Goetsch & Menozzi 1935) (Fig. 1B) and *Solenopsis gayi* (Spinola 1851) (see also Medel & Vásquez 1994), with 19 and five feeding events, respectively. Even though fruits of *E. chiloensis* remain on the cactus branch after opening, two mammal species, the rodent *Octodon degus* (Molina 1782) and the fox *Lycalopex culpaeus* (Molina 1782), were observed consuming fruits of this cactus species. It is likely that rodent species remove pulp and/or whole fruits directly from cactus branches by using horizontally oriented spines to climb, and foxes lick pulp of ripe fruits from low-heighted cactus individuals. Because these field records do not allow quantitative observations, wild rodent species were collected with folding wire mesh live-animal-traps (24 cm × 8 cm × 9 cm; FORMA: Products and Services, Santiago, Chile) baited with rolled oats and provided with cotton bedding to test for fruit consumption under captivity conditions. Overall, 300 traps per night were set during five days, and checked every morning. Captures included 46 *Phyllotis darwini* (Waterhouse 1837), 35 *O. degus*, 12 *Abrothrix olivaceus* (Waterhouse 1837) and two *Abrocoma bennetti* (Waterhouse 1837). At noon, all captured rodents were fed with ripe fruits of *E. chiloensis*. All the species tested consumed the fruits excepting *A. bennetti* that rejected consistently the offered fruit (percentage of effective feeding: *O. degus*: 24.5 %, *P. darwini*: 9.6 % and *A. olivaceus*: 4.3 %). Regarding fox species, evidence of fruit consumption by *L. culpaeus* based on the analysis of feces taken in different areas of the Reserve. A total of 48 complete fecal samples were collected, and 32 of them contained large amounts of seeds of *E. chiloensis* (mean ± SE: 18221 ± 2435 seeds per fecal sample). Additionally, it is worth to mention that *E. chiloensis* seeds were found in the stomach content of one individual of the marsupial *Thylamys elegans* (Waterhouse 1839), whose carcass was found in the study site, and dissected and analyzed in the laboratory.

In summary, field observations, no-choice feeding test and circumstantial evidence allowed identifying the fruit consumers of *E. chiloensis*, specifically during the peak time of the fruiting season (January). Frugivorous species included one bird species (*M. thenca*), four mammal species (*O. degus*, *P. darwini*, *A. olivaceus* and *L. culpaeus*), two ant species (*S.*

gayi and *C. goetschi*), and one marsupial species (*T. elegans*). Although several bird species have been previously recorded in the study site (CONAF 1996), only *M. thenca* was observed consuming fruits of *E. chiloensis*. This result might be due to particular climatic conditions in the previous year, where the intense drought during 2012 translated into low bird diversity in the study site in the summer season of 2013. For this reason, we cannot rule out that other bird species belong the frugivorous guild of *E. chiloensis*. It is likely that repeated sampling across years complete the spectrum of bird species consuming fruits of *E. chiloensis*.

According to our field observations and no-choice feeding test, the frugivorous guild of *E. chiloensis* is diverse and not restricted to only one taxon. The fact that *E. chiloensis* depends on a generalized frugivorous assemblage for seed dispersal conveys a clear advantage for cactus recruitment. As birds, mammals, and ants have different patterns of habitat use, they provide a range of opportunities for seed dispersal and seedling establishment.

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