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# The population dynamics of an endemic collectible cactus

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ABSTRACT

*Astrophytum* is one of most collected genera in the cactus family. Around the world several species are maintained in collections and yearly, several plants are taken from their natural habitats. Populations of *Astorphytum capricorne* are found in the northern Chihuahuan desert, Mexico, and as many endemic cactus species, it has a highly restricted habitat. We conducted a demographic study from 2008 to 2010 of the northern populations found at Cuatro Ciénegas, Mexico. We applied matrix population models, included simulations, life table response experiments and descriptions of the population dynamics to evaluate the current status of the species, and detect key life table stages and demographic processes. Population growth rate decreased in both years and only 4% individual mortality can be attributed to looting, and a massive effort is needed to increase seedling recruitment and reduce adult mortality. The fate of individuals differed between years even having the same annual rainfall mainly in accentuated stasis, retrogression and high mortality in all size classes, which coupled with low seed production, no recruitment and collection of plants are the causes contributing to population decline, and hence, increase the risk in which *A. capricorne* populations are found. Reintroduction of seedlings and lowering adult mortality are urgently needed to revert the alarming demographic condition of *A. capricorne* populations.



## 1. Introduction

Population dynamics of species have been widely used to assess their endangered status and the need for these studies has been known for some time (Schemske et al., 1994). Population viability analysis (PVA) and the criteria to assess threat (IUCN, 2001) have components that consider population dynamics. For example, the criteria of the IUCN have a clear translation to parameters that stem from studies on population dynamics (Caswell, 2001). Matrix models have become important for conservation studies because they are relatively simple, have clear biological interpretations of the parameters among other benefits (Salguero-Gómez and de Kroon, 2010). However, even though the methodology and theory for these studies has been known for some time, one of the main problems is the effort needed to have accurate estimations of the vital rates (*i.e.* growth, fecundity and survival), so studies are usually limited in time (number of years) and space (number of populations/sites, Crone et al., 2011; Salguero-Gómez et al., 2014). Decisions for conservation of species need quantitative data on the status of populations in short time periods on one hand and on the other, robust data (usually obtained from long term studies) for a better understanding of the vital rates that determine population dynamics. In most cases, long term data sets are lacking (Crone et al., 2011) and the priority for conservation has to be set by short term studies that try to avoid the demise of populations until sufficient data can be obtained to reevaluate the status of populations.

The Cactaceae is an especially vulnerable group of species because of the slow growth rates (which in many cases can

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preclude studying their population dynamics), high amounts illegal trade (Bárcenas, 2003), low recruitment (Suzán et al., 1996), high predation (Martínez-Avalos et al., 2007), and disturbance (Portilla-Alonso and Martorell, 2011) among other threats. One or more of these factors have contributed to the steady decline in natural populations throughout Mexico, the Southern US and large parts of South America and both intrinsic and extrinsic components of threat have contributed to listing of species in the Cactaceae in either national or international red species lists (IUCN, 2011; NOM-ECOL-2010, 2010). The risk for many species is associated to their extremely specialized habitat and small distributional range (van Wyk and Smith, 2001; Pellens and Grancolas, 2010) which bears strong consequences for conservation since very short distributional ranges increase the risk of species extinction where some plant communities become irreplaceable once removed (van Wyk and Smith, 2001).

In this paper we assessed the population dynamics of *Astrophytum capricorne,* a Chihuahuan desert endemic, with a few relict populations over a three year period and use simulations to determine the possible effects of changes in certain transition probabilities. *A. capricorne* is one of five to six species in the genus of highly collectible cacti, "…small genus contains some of the plants dearest to the heart of the cactus lover and specimens will be found in almost every general collection" (Pilbeam and Weightman, 2006), out of which *A. caput medusae* has but one population already decimated by illegal collectors (Hernández-Alva et al., 2011), *A. asterias* is under severe threat (Martínez-Ávalos et al., 2004) in both the US and Mexican populations, declining populations are known for *Astrophytum ornatum* (Zepeda-Martínez et al., 2013), and evidence also point towards declining populations of *Astrophytum myriostigma* (López-Flores, 2012). We used matrix population models to estimate long term vital rates, changes in population size for short term population growth rates and simulated scenarios of certain important components of the life history of the species (seed banks, seedling recruitment and adult survival) that can help steer decisions for the conservation of this species. We also used retrospective analyses (LTRE) to determine the effects on λ of year to year variation, size classes and demographic process.

## 2. Materials and methods

*A. capricorne* (A.Dietr) Britton & Rose is and endemic of the Chihuahuan desert, Coahuila, Durango and Nuevo León, in northeastern Mexico. The distribution of *A. carpicorne* can be found in two groups, the southern populations (19–20 have been reported) which are much more widely distributed and the northern populations that consist of two populations in the Cuatro Ciénegas Valley (White, 2006; http://www.astrobase.de/Gattung/Karten/CaCo.html). In this study we present information for the latter two sites at the Cuatro Ciénegas Valley, in the State of Coahuila Mexico in which all individuals ($N = 244$) within two plots ($50 \times 100$ m) at each site were measured (diameter and height in millimeters) and mapped in 2008 and censed again in 2009 and 2010 (two transition periods). Climatic conditions in the area are typical of desert ecosystems of the Chihuahuan desert with 214.2 mm of precipitation and mean annual temperatures of 21.5 °C (Data for the 1951–2010 period, http://www.smn.conagua.gob.mx). There productive component was assessed by means of controlled germination experiments. During 2008, 12 fruits were obtained from the *Astrophytum* live collection of Botanical Garden, Instituto de Biología, UNAM, and in the 2009–2010 field season, 4 fruits were available and were collected, and number of seeds counted. Seeds were then dried at room temperature and stored in paper bags until the onset of the experiment. In 2010, 200 seeds were placed on 1% bacteriological agar and placed in an

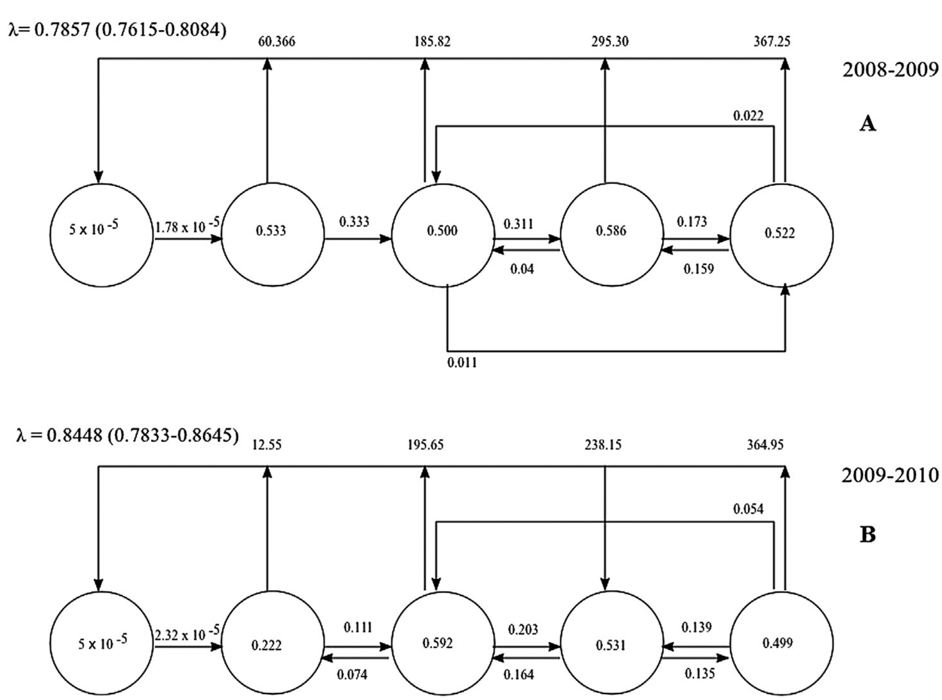


**Fig. 1.** Life cycle diagram of *Atrophytum capricorne* in Cuatro Ciénegas, Coahuila during the A) 2008–09 and B) 2009–10 seasons. Circles represent one seed class C1 = seeds and 4 size classes: C2 = $1\text{ cm} < x < 5\text{ cm}$, class 3 C3 = $5\text{ cm} < x$ 10 cm, class 4 C4 = $10\text{ cm} < x < 15\text{ cm}$, and class 5 C5 = $x > 15$ cm. Lines that connect circles above represent the per capita contribution of seeds. Numbers inside the circles are transition probabilities of individuals $t = t_{+1}$. Lines that connect successive circles are the transition probabilities for growth or retrogression in size, and those that connect non-consecutive circles are transition probabilities of individuals that growth retrogress more than 1 category. Values of λ are from 1000 bootstrap estimations.