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Assessing the ecological status of *Mammillaria pectinifera* Weber (Cactaceae), a rare and threatened species endemic of the Tehuacán-Cuicatlán Region in Central Mexico

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Abstract

Mammillaria pectinifera, is a rare cactus of central Mexico currently threatened by extinction due to its restricted geographical range, high habitat specificity, relatively low growth rate, and small population sizes. In this paper, we analyse its demographic performance over a 1-year period using survival, growth and reproduction data. We carried out a demographic analysis through a Lefkovitch size-based matrix model. As this cactus shows long-term fruit retention in the stem, we included the seed stage explicitly in our analyses. The matrix analysis revealed that the estimated population growth rate (λ) is 0.743 suggesting a declining population with limited persistence ability. Juvenile and adult stages showed higher elasticity values than the other stages; however our matrix simulations resulted in a positive population growth rate only when fecundity entries and seedling establishment success were increased simultaneously. We suggest that any management plan aiming at the preservation of *M. pectinifera* should consider specific programs to enhance seedling establishment and adult survival.

Keywords: Arid environments; Cacti; Conservation; Demography; Serotiny; Numerical simulations

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1. Introduction

Currently, many species of the Cactaceae are considered rare, or even threatened or in danger of extinction (Hunt, 1992; Anderson et al., 1994; Hernández and Godínez, 1994; Godínez-Álvarez et al., 2003). This may be related to the fact that several cactus species show restricted geographical ranges, high habitat specificity, relatively low growth rates and reduced population sizes (Hernández and Godínez, 1994; Hernández and Bárcenas, 1995, 1996; Esparza-Olguín et al., 2002). Additionally, the vulnerability of numerous cactus species has increased as a result of habitat destruction and illegal trade (Arias, 1993; Esparza-Olguín et al., 2002). Some cactus species have received a certain amount of attention because they have been considered "charismatic species" (e.g., saguaro, *Carnegiea gigantea*; Steenbergh and Lowe, 1969, 1977, 1983; Pierson and Turner, 1998); yet, the lack of population studies with cacti is still remarkable (Contreras and Valverde, 2002; Godínez-Álvarez et al., 2003; Valverde et al., 2004) and our knowledge about population dynamics remains limited (Godínez-Álvarez et al., 2003).

In recent years there has been a debate regarding the biological information that is considered essential for the design of conservation strategies of rare and endangered plant species (see Schemske et al., 1994). Nevertheless, there appears to be consensus regarding the relevance of two particular questions: (1) is the population size increasing, decreasing or stable?, and (2) what are the life cycle stages that mostly affect population growth rate? (Schemske et al., 1994; Sutherland, 2000). These two questions represent some of the most basic aspects to consider in the evaluation of the status of threatened plant species and represent an important field for the application of ecological theory (Kareiva, 1994).

Demographic analyses through matrix population models provide an assessment of population growth rate (Schemske et al., 1994). Additionally, the use of matrix projection models allows the identification of the life cycle stages that have the greatest impact on population growth by means of sensitivity and elasticity analyses (van Groenendael et al., 1988; Caswell, 1989; Ebert 1999). Elasticity measures the proportional sensitivity of λ to changes in matrix entries (de Kroon et al., 1986) and has been widely used to determine which life cycle components should be the focus of attention in conservation practices (Caswell, 1989; Benton and Grant, 1999; Sutherland, 2000). The evaluation of these demographic aspects is considered crucial for any conservation and recovery effort (Schemske et al., 1994).

The subject of this study is a rare and endangered globose cactus, *Mammillaria pectinifera* Weber, endemic to the Tehuacán-Cuicatlán region in Central Mexico (Meyrán, 1973; Bravo-Hollis, 1991; Bravo-Hollis and Sánchez-Mejorada, 1991). A previous study suggested the importance of habitat specificity as a component of rarity in *M. pectinifera* (Zavala-Hurtado and Valverde, 2003). The highly restricted distribution of this species in the Tehuacán Valley seems to be related to its particular ecological and physiological requirements, which limit its distribution only to certain suitable habitat patches (Zavala-Hurtado and Valverde, 2003). Therefore, *M. pectinifera* may be described as an extremely rare species (Rabinowitz, 1981) because it exhibits narrow geographic range (Meyrán, 1973; Bravo-Hollis, 1991;