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Multiscale analysis of factors influencing herpetofaunal assemblages in early successional stages of a tropical dry forest in western Mexico

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ABSTRACT

The Tropical Dry Forest (TDF) is one of the most highly transformed and threatened neotropical systems in the world and much of its original area has been replaced by secondary forests. Therefore, it is important to understand the process of ecological succession underlying the natural regeneration of TDF, especially the role of early successional stages as drivers of the course of secondary succession. In this study, we investigated the response of herpetofaunal assemblages to vegetation and landscape attributes in areas dominated by early successional stages of TDF. Such response was evaluated in terms of assemblage's composition, richness, taxonomic diversity and functional diversity. We found a high variation in composition, richness and diversity of herpetofaunal assemblages at the initial stages of TDF succession. According to our hypothesis, in general we found the richest herpetofaunal assemblages in sites embedded in the most conserved matrix with higher levels of vegetation cover. Additionally, patch density of forest was also associated to the variation in assemblages' richness. We found high specificity on the response of frogs, lizards and snakes to the surveyed local and landscape attributes. This response involved both taxonomic and functional diversity. This study shows that composition and quality of the surrounding matrix can actually drive the maintenance of herpetofauna species in early successional stages. Considering that these stages greatly influence the course of secondary succession, the natural regeneration of the herpetofauna communities of TDF will depend not only on the local vegetation attributes but also on the initial status of the surrounding matrix. Thus, in order to preserve the resilience of the herpetofaunal assemblages it is important an adequate management of the system, maintaining high levels of the original vegetation in anthropogenic landscapes.

1. Introduction

The Tropical Dry Forest (TDF) is one of the most highly transformed and threatened neotropical systems in the world but the scientific community has given relatively little attention to this system when compared to tropical rainforests (Sánchez-Azofeifa et al., 2005). At present, a complex mosaic of secondary forest, farmland, cattle pastures and human settlements has replaced much of the TDF original area that currently faces an annual global deforestation rate of 2% (Chazdon et al., 2007; Quesada et al., 2009). Human activities are rapidly altering the large-scale natural structure of these landscapes and the course of their ecological processes since these activities have resulted in the removal of a large portion of the vegetation cover, an increase in the formation of patches of vegetation and edge effect, the invasion of exotic species, altered environmental conditions and a decrease in the system's ability to recover from disturbance (Avila-Cabadilla, 2011). Consequently, it is important to understand the process of ecological succession underlying the TDF natural regeneration, especially the role of early successional stages as drivers of the course of secondary succession (Egler, 1954; Gillespie et al., 2000; Chazdon et al., 2007; Avila-Cabadilla et al., 2009).

Current knowledge about the ecological importance of early successional stages (ESS) is markedly limited even though ESS are a dominant feature of anthropogenic landscapes and they provide a distinctive mix of physical, chemical and biological conditions (Swanson et al., 2010). Because the extension of tropical secondary forest, in particular ESS, is predicted to increase in this century (Guariguata and Rebecca Ostertag, 2001) it is critical to understand the role of these forests in the maintenance of biodiversity in these new landscapes.

In Mexico, the TDF are particularly important due to its high levels of richness and endemism of animal and plant species (Trejo, 2005; García,

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2006). In the case of the herpetofauna, these forests are home to almost a third of the known reptile and amphibian species, and a quarter of the species endemic to Mexico (García, 2006; Ochoa and Flores-Villela, 2006; Suazo-Ortuño et al., 2008).

Anthropogenic modification of natural environments causes alterations in the structure and composition of vegetation and on the environmental conditions of microhabitats. For herpetofauna, the greatest threat factor is the interaction between environmental characteristics and human impacts. These alterations generate a decrease in prey groups and in the populations of amphibians and reptiles, and in some cases can result in local or global extinction (Urbina-Cardona et al., 2008). Amphibians and reptiles are of high ecological value as predators and prey, and due to their biology can be considered as indicators of environmental integrity (Calderón-Mandujano et al., 2008) because many species are highly sensitive to changes in micro-climatic conditions (Hartwell and Ollivier, 1998).

Available evidence suggests that richness of tropical amphibian and reptile species is lower in vegetation successional stages than in old-growth forest (Gardner et al., 2007; Suazo-Ortuño et al., 2015). However, the scant number of studies addressing this issue, and the use of contrasting sampling designs and response metrics (diversity vs. similarity) weaken generalizations (Suazo-Ortuño et al., 2015). On the other hand, various studies conclude that biodiversity response to landscape changes depends more on the composition of the surrounding matrix than on the successional stages of TDF. In particular, composition and quality of the surrounding matrix can actually drive the maintenance of species in fragmented tropical landscapes (e.g. San-José et al., 2014; Suazo-Ortuño et al., 2015).

At present, just a few studies about the influence of the surrounding matrix on herpetofauna communities have considered different spatial scales (local and landscape level). Most of these studies are mainly concerned with the effects of fragments size and isolation and their results have shown that different species present various patterns with contrasting responses to landscape features. Therefore, it is important to conduct multiscale studies on the response of biodiversity to landscape composition and configuration (Russildi, 2015). At present, we lack information on the response of herpetofauna to these landscape metrics in areas dominated by secondary TDF.

In this study we specifically address the following questions: 1) Are early successional stages (ESS) in the same landscape similar in herpetofauna composition? 2) How different are ESS and old-growth forest in composition and species richness? 3) Do vegetation and landscape attributes determine the composition, species richness and functional diversity of herpetofauna in the ESS? Our hypothesis is that herpetofaunal communities will be more diverse in early successional sites embedded in a matrix with increased forest cover and the response of amphibians and reptiles will depend on scale, their ecological attributes and their vagility. Particularly, snakes will respond to landscape scale, and amphibians and lizards to local scale.

2. Methods

2.1. Study area

The study was conducted in the Chamela region and the Chamela-Cuixmala Biosphere Reserve, both located in the central western coast

Fig. 1. Study area and study sites at the Chamela region, Jalisco, Mexico.