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Revista Mexicana de Biodiversidad

Revista Mexicana de Biodiversidad 87 (2016) 133–139

Instituto de Biología UNAM
www.ib.unam.mx/revista/

Ecology

Effects of establishment of grazing areas on diversity of amphibian communities in tropical evergreen forests and mountain cloud forests of the Sierra Madre Oriental

Efecto del establecimiento de áreas de pastoreo en la diversidad de las comunidades de anfibios en bosques tropicales perennifolios y bosques mesófilos de montaña en la Sierra Madre Oriental

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Received 11 March 2015; accepted 30 September 2015
Available online 12 February 2016

Abstract

The establishment of grazing areas in humid tropical environments is one of the causes of amphibian population decline. This work evaluates the consequences of the establishment of grazing areas on amphibian communities in an area of the Sierra Madre Oriental using analyses of alpha and beta diversity. Sampling was conducted at 28 locations, 7 in tropical evergreen forest (TEF), 7 in mountain cloud forest (MCF), 7 in tropical grazing areas (TGA), and 7 in cloud forest grazing areas (CFGA) using the method of direct sampling. Amphibian diversity is reduced when the grazing areas are established in tropical environments (TGA, 8 species; 7.1 effective species and TEF, 10 species; 7.7 effective species); in contrast, the CFGA has a greater diversity (11 species; 9.3 effective species) compared with MCF (8 species; 3.9 effective species). The most dissimilar composition was found between the 2 communities of undisturbed forests (MCF-TEF; Jaccard dissimilarity 0.78). Establishment of grazing areas in TEF strongly influences the reduction of amphibian populations when compared with MCF.

Keywords: Anura; Caudata; Alpha and beta diversity; Hidalgo; Mexico

Resumen

El establecimiento de áreas de pastoreo en ambientes húmedos tropicales es una de las causas de la reducción de las poblaciones de anfibios. Este trabajo evalúa las consecuencias del establecimiento de las áreas de pastoreo en las comunidades de anfibios en un área de la Sierra Madre Oriental por medio del análisis de diversidad alfa y beta. El muestreo se realizó en 28 localidades; 7 de bosque tropical perennifolio (TEF), 7 de bosque mesófilo de montaña (MCF) no alterado, 7 en áreas de pastoreo tropicales (TGA) y 7 en áreas de pastoreo de bosque mesófilo (CFGA), usando el método de muestreo directo. La diversidad de anfibios se reduce cuando las áreas de pastoreo se establecen en ambientes tropicales (TGA, 8 especies; 7.1 especies efectivas y TEF, 10 especies; 7.7 especies efectivas); en contraste, el CFGA presenta una mayor diversidad (11 especies; 9.3 especies efectivas) comparado con el MCF (8 especies; 3.9 especies efectivas). La composición más disímil se encontró entre las comunidades de los bosques conservados (MCF-TEF, 0.78 disimilitud de Jaccard). El establecimiento de áreas de pastoreo en los TEF influye con mayor intensidad en la reducción de las poblaciones de anfibios, en comparación con el MCF.

Palabras clave: Anura; Caudata; Diversidad alfa y beta; Hidalgo; México

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Peer Review under the responsibility of Universidad Nacional Autónoma de México.

http://dx.doi.org/10.1016/j.rmb.2015.09.019

Introduction

Habitat transformation directly affects the entirety of diversity (Pavlov & Bukvareva, 2007). Because of habitat disturbance, the majority of ecosystems have undergone great changes in landscape makeup; it is estimated that worldwide between 20 and 75% of the original vegetation has been altered (Pavlov & Bukvareva, 2007). Such disturbance relegates an increasing number of species to live in fragmented landscapes dominated by anthropogenic activities (Bawa et al., 2004; Foley et al., 2005). Alterations of the environment cause important ecological changes at all levels (Glor, Flecker, Benard, & Power, 2001). For example, local deforestation due to agriculture or livestock production produces degradation and loss of soil, changes in microclimate, and biodiversity loss (De Sá, 2005; Wanger et al., 2010). Because of such simplification of natural environments, there is a great reduction of areas for preservation and development of biodiversity (Cardinale et al., 2012); this process particularly might affect the presence and abundance of amphibians (Jansen & Healey, 2003).

On a global scale, the creation of grazing areas and hydrologic alteration has been shown to have adverse effects on amphibian communities, principally in tropical moist sites (Jansen & Healey, 2003; Pineda & Halffter, 2003). In these areas, local effects created by the transformation of natural environments to grazing areas form barriers that prevent the natural flow of amphibian populations (De Sá, 2005). These barriers prevent gene flow among populations, in addition to increasing mortality rates and infections, and the reduction of the ability for re-colonization of amphibians (Cushman, 2006; Jansen & Healey, 2003).

Some surveys have shown that amphibians can be good models to assess environmental quality, because they present physiological and ecological characteristics that make them susceptible to changes that occur as a result of the disturbance, for example deforestation processes (Cushman, 2006; Jansen & Healey, 2003; Pineda & Halffter, 2003). Studies show that there is a positive relationship between canopy cover and amphibian diversity (Pineda & Halffter, 2003). Cushman (2006) also observed that the reduction in canopy cover reduces vagility, especially in the juvenile stages. These stages are crucial for the reproduction of amphibians, because this is when movement occurs into new water bodies for reproduction (Cushman, 2006; Jansen & Healey, 2003). Therefore, the adverse conditions generated by grazing areas restrict amphibians to sites with high humidity (Jansen & Healey, 2003), thus limiting their mobility. In addition, reduction in the populations of some amphibians species is directly related to the intensity of grazing on pastureland; therefore, amphibian diversity decreases when grazing intensity is high (Jansen & Healey, 2003). This relationship results because cattle directly influence the compaction and erosion of soil, growth and selection of grasses in the grazing areas, and the quality and quantity of water available for amphibians during the breeding season (Cushman, 2006; Jansen & Healey, 2003).

In Mexico, the process of land conversion of forests to grazing areas has a lengthy history and recently it has increased significantly in humid tropical landscapes (Lira-Noriega, Guevara, Laborde, & Sánchez-Ríos, 2007). In this country, however, there are few studies that aim to assess the effects of grazing areas on the diversity of amphibians (Pineda & Halffter, 2003; Urbina-Cardona & Reynoso, 2005), particularly in areas where mountain cloud forests and evergreen tropical forests converge. Therefore, the goal of this study is to assess the consequences of grazing areas on the amphibian communities in tropical evergreen forests and mountain cloud forests in an area of the Sierra Madre Oriental in northern Hidalgo by analyzing the alpha (Hill's numbers; Jost, 2006) and beta diversity (Replacement and richness difference; Legendre, 2014). Studies show that these analyses have proved useful for comparing the diversity among 2 or more communities (Legendre, 2014; Moreno, Barragán, Pineda, & Pavón, 2011).

Materials and methods

The sampling sites were located within an area of the Sierra Madre Oriental (SMO) in northern Hidalgo, specifically in the area comprising the municipality of Tepehuacán de Guerrero (Fig. 1; 20°56′ and 21°12′ N, 98°44′ and 98°58′ W). This area is dominated mainly by a warm humid climate with rainfall throughout the year, elevational cline ranges from 200 to 2,200 m, with an annual rainfall of 1,100 to 2,200 mm and a mean annual temperature of 18 °C in the highlands and 28 °C in the lowlands (Inegi, 2009). The study area was originally covered by continuous forest. Tropical evergreen forest dominates the hillsides and lower parts of the mountains, whereas the higher parts are covered by mountain cloud forest; however, in the last few decades these forests have been destroyed by anthropic effect to establish grazing areas, which has generated vegetation patches in various stages of regeneration (Ponce-Vargas, Luna-Vega, Alcántara-Ayala, & Ruiz-Jiménez, 2006).

Tropical evergreen forest is distributed in the northern portion of Hidalgo state (Villavicencio-Nieto & Pérez-Escandón, 2005), near the border with San Luis Potosí (Rzedowski, 2006). Puig (1991) referred to this as semi-deciduous tropical forest; however, Rzedowski (2006) grouped this vegetation type within tropical evergreen forest, because tropical evergreen forest and semi-deciduous tropical forest share similar structural elements. In our study area, this vegetation was characterized by trees over 20 m in height and a rich diversity of woody climbing plants, orchids, and bromeliads (Puig, 1991). In this type of vegetation, the patterns of abundance of tree species makes it difficult to determine the dominant tree species; however, the canopy is mainly composed by trees of the genera *Brosimum*, *Bursera*, *Ceiba*, *Coccoloba*, *Ficus*, and *Dendropanax* (Puig, 1991).

Mountain cloud forest is characterized by presence of fog during most of the year (Hamilton, Juvik, & Scatena, 1995); neartic and neotropical elements converge in this kind of forest; therefore, this area represents a highly complex environment in terms of vegetation, which also varies along the length of its geographic distribution (Conabio, 2010; Ruiz-Jiménez, Téllez-Valdez, & Luna-Vega, 2012). Thus, MCF from the northern region of the state of Hidalgo is characterized by a dense forest, with trees over 15–35 m height. The most common trees are of