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Ecology

Large-scale human environmental intervention is related to a richness reduction in Mexican odonates

La intervención humana a gran escala está relacionada con la reducción de la riqueza de las libélulas y caballitos del diablo mexicanos

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Abstract

It is unclear how land use change, reduction in tree cover and human footprint impact species occurrence and co-occurrence especially at a large regional scale. This is particularly prevalent for species with complex life cycles, for example odonates (dragonflies and damselflies). We evaluated richness of odonates in Mexico in terms of land use, tree cover and human footprint. We also analyzed how odonate species co-occur to interpret our richness analysis using a community perspective. We used odonate collecting records from year 2000 to 2014. Odonate geographical records were more abundant in forest and agricultural areas, and decreased in areas without vegetation. Although our results may suffer of incomplete samplings, there was a positive relationship between species richness and tree cover, and a quadratic relationship with human footprint was observed. These results indicate that some degree of forest disturbance may still sustain relatively high odonate richness levels. Finally, species tend to co-occur in particular ensembles with some species being key in their ecological communities. Further studies should detail the role these key species play in their environments to provide community stability.

Keywords: Dragonfly; Damselfly; Land use; Human footprint; Species richness; Forest; Co-occurrence; Mexico

Resumen

No es claro cómo el cambio de uso de suelo, la reducción en la cobertura arbórea y la huella humana impactan la ocurrencia y coocurrencia de las especies especialmente a una gran escala regional. Esto es particularmente predominante en especies con ciclos de vida complejos, por ejemplo los odonatos (libélulas y caballitos del diablo). Por lo tanto, se evalúa aquí la riqueza de los odonatos en México en términos de uso de suelo, cobertura arbórea y huella humana. También se analiza cómo las especies de odonatos coocurren para interpretar nuestros análisis de riqueza usando una perspectiva de la comunidad. Se usaron registros de recolectas de odonatos del 2000 al 2014. Los registros geográficos fueron más abundantes en áreas de bosque y de agricultura, y decrecieron en áreas sin vegetación. Aunque nuestros resultados pueden tener el problema de muestreos

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incompletos, existió una relación positiva entre la riqueza de especies y la cobertura arbórea, y una relación cuadrática con la huella humana. Estos resultados indican que un cierto grado de disturbio arbóreo puede mantener niveles relativamente altos de riqueza de odonatos. Finalmente, las especies de odonatos tienden a coocurrir en ensambles particulares con otras especies siendo claves en sus ambientes proveyendo estabilidad en la comunidad.

Palabras clave: Libélulas; Caballitos del diablo; Uso de suelo; Huella humana; Riqueza de especies; Bosque; Copresencia; México

Introduction

At a global and local scale, changes in land use impose enormous pressures on biodiversity (Foley et al., 2005; Newbold, Hudson, Hill, Contu, & Lysenko, 2015). Three variables linked with changes in land use are agricultural conversion, deforestation and human footprint (Meyer & Turner, 1992). In the case of Mexico, the country has experienced a large change in land use (González-Abraham et al., 2015; Mas et al., 2004; Robson and Berkes, 2011). For example, Mexican agricultural areas have dramatically increased over the last 20 years (Hansen et al., 2013). At the same time, per capita forest area decreased by almost a third between 1980 and 2000 (Mas et al., 2004; Velázquez et al., 2002). The human footprint in Mexico has been large and heterogeneous, and is explained by the complex physical geography, historic human settlements, technology use, and recent demographic explosion (González-Abraham et al., 2015). Although it is intuitive that land use change, tree cover reduction and increased human footprint are driving Mexican organic diversity to extinction, precise measurements or even a rough approximation of this is lacking.

Land use change and deforestation have been shown to affect the biodiversity of many taxa (Barragán, Moreno, Escobar, Halffter, & Navarrete, 2011; Brown, 1997; Schulze et al., 2004; Vidal, López-García, & Rendón-Salinas, 2014). However, such relationships are not necessarily straightforward and linear. For example, agricultural areas may drive reduced species richness but such effects can be more acute with the prevalence of cultivated species, intensive land management and short cultivated cycles (Scales & Marsdens, 2008). In contrast, take the case of some coffee plantations which, despite altering vegetation structure of a community, still provide protection to a number of native species (Martínez et al., 2005; Perfecto & Vandermeer, 2015; Perfecto, Rice, Greenberg, & Van der Voort, 1996). The impacts of land use change and deforestation on biodiversity can be taxa-dependent as some taxonomic groups are more resilient than others (Hansen et al., 2001). For example, birds are commonly thought to be highly sensitive to land use change. However, some particular bird taxa are more likely than others to go extinct (Fischer et al., 2007). In this case, the simplicity of landscape structure may render some species to become more likely to disappear if such species do not find their vital resources (Fischer et al., 2007).

Conservation biologists have recently come to consensus that beyond species, there is a need to assess community level interactions (Rodewald, Rohr, Fortuna, & Bascompte, 2014; Tilianakis, Laliberté, Nielsen, & Bascompte, 2010). Ecological interactions between species can affect community composition and dynamics (e.g. Faust & Raes, 2012; Thébault & Fontaine, 2010; Verdú & Valiente-Banuet, 2008). A classic example is that of microbial communities in which the presence or absence of certain species will affect the interactions of all species (Rodríguez-Martínez & Pascual, 2006). This implies that communities occur non-randomly and that, in conservation terms, the community structure and dynamics should be assessed. There are several methods to systematically characterize and study ecological networks (Pascual & Dunne, 2005). Among these methods, co-occurrence networks provide a valuable tool to infer statistical relationships among species or other taxonomic units in relatively large datasets, allowing one to go beyond composition and abundance and examine community structure (Deng et al., 2012; Faust & Raes, 2012). Two of the structural parameters that have been proposed to reflect the relevance of particular nodes in an ecological network: (1) the number of connections a focal node has with other nodes, and (2) a focal node's betweenness centrality (the proportion of the shortest paths between all i and j pair of nodes that contains the focal node) (Jordan, 2009; Jordán, Liu, & Davis, 2006). Many ecological networks exhibit modular organization, meaning that their elements tend to form semi-autonomous groups with more interactions within them than with other groups. Such a modular structure suggests that ecological interactions lead to the formation of well-defined groups of species, which could in turn be relevant with respect to conservation and ecosystem stability (Pascual & Dunne, 2005; Thébault & Fontaine, 2010).

One relatively neglected functional group in conservation biology are complex life cycle (CLC) organisms. CLC animals are those that face an abrupt habitat shift as they go through different developmental stages and so they may be exposed to radically different ecological conditions and stressors (Werner, 1988). For example, many animals with CLC spend their larval stage being aquatic while the adult is terrestrial. In terms of conservation strategies, CLC animals present a more complicated scenario for their protection as their different transitions (e.g. aquatic and terrestrial) need to be considered both for the stressors involved and their habitat protection. Odonate insects (dragonfly and damselflies) are an example of a CLC animal that has gained increased conservation attention (e.g. Bried, Hassall, Simaika, Corser, & Ware, 2015; Clausnitzer et al., 2009; Kalkman et al., 2008; Samways, McGeoch, & New, 2013). Calls for conservation efforts directed toward odonates focus on the transformation of the body waters they use as larvae and their aerial surroundings used by flying adults (Bried & Samways,