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Foliar diseases in a seasonal tropical dry forest: Impacts of habitat fragmentation

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ABSTRACT

The effects of forest fragmentation on fungal pathogens causing leaf damage to the shrub and tree community were investigated in a seasonal tropical dry forest. The study was carried out in 4 forest fragments, and 2 continuous forest sites located in the Chamela-Cuixmala Biosphere Reserve and surrounding areas (Jalisco, Mexico), along three years. Results showed that fungi were the pathogenic agents causing foliar damage in plants from both, fragments and continuous forest. Disease incidence was higher in 2004 due to a relatively high annual precipitation. The occurrence of leaf fungal pathogens was lower in fragments, than in continuous forest. Plant species diversity was significantly lower in fragments than in continuous forest, and was positively correlated to the number of diseased plant species, and to the proportion of diseased leaves and the leaf area damaged per plant. In addition, disease occurrence was negatively correlated with canopy openness. In conclusion, our results highlight the consequences of environmental changes associated to fragmentation on foliar fungal plant pathogens, a particular group of organisms that until recently has been mostly overlooked in tropical natural systems.

1. Introduction

Pathogenic microorganisms are powerful selective forces whose relevance to the population dynamics and genetics of individual host species, and to community diversity has been recognized over the past few decades (Alexander, 2010; Burdon and Thrall, 2009; Gilbert, 2002). However, the epidemiology of plant–pathogen interactions in wild systems is considerably understudied relative to the dynamics of infectious disease in animal and human populations (Burdon and Thrall, 2009). Endemic diseases are common components of all natural plant communities (Burdon, 1987; García-Guzmán and Morales, 2007; Gilbert and Webb, 2007), but changes in the abiotic and biotic environment, caused by natural reasons or anthropogenic activities, may alter levels of disease incidence, sometimes to the development of epidemics (Burdon, 1993; Hansen, 1999; Ostry and Laflamme, 2009). However, in many plant communities disease incidence is occasional, and frequently the only noticeable sign of pathogen activity may be limited to a single spot on a leaf or stem, and as a result, diseases in plant communities have been mostly underestimated (Burdon, 1993). Consequently, most studies on plant pathogens have focused on a limited number of plant species (Gallery et al., 2010; García-Guzmán and Morales, 2007; Gilbert et al., 2002), mainly those that clearly show signs of pathogenic damage. To our knowledge, only a few studies have focused on assessing pathogen attack at the plant community level (García-Guzmán and Dirzo, 2001, 2004; Gilbert and Webb, 2007). These works, carried out in a tropical rain forest community, have suggested that leaf diseases caused by fungi are very frequent, and among the most important agents of plant damage.

Habitat loss caused by anthropogenic activities is broadly recognized as the most conspicuous, and frequent threat to biodiversity in tropical regions (Laurance and Bierregard, 1997; Lienert, 2004), to genetic structure (Cuartas-Hernández and Núñez-Farfán, 2006), ecosystem functioning (Tscharntke et al., 2005), and biodiversity evolution (Bascompte et al., 2006). Moreover, losses of species diversity may disrupt many ecological interactions that have a pivotal role in plant regeneration processes, such as pollination, seed dispersal, and herbivory (Arnold and Asquith, 2002; Cunningham, 2000a; Ruiz-Guerra et al., 2009).

According to Murphy and Lugo (1986) approximately 42% of the world's tropical forests are seasonally dry plant communities, and more than half occur in the Americas (Miles et al., 2006). In Mexico this type of forest covers over 60% of the total area of tropical vegetation (Trejo and Dirzo, 2000). Seasonal dry forests are notorious for their high floristic diversity, and degree of endemism (Trejo and

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Dirzo, 2002). Mesoamerican seasonal dry forests have been considered as severely threatened (Miles et al., 2006) by activities such as settlement, logging and agriculture, and therefore, most of this forest type is nowadays, represented by small vegetation fragments (Portillo-Quintero and Sánchez-Azofeifa, 2010; Sánchez-Colón et al., 2009).

Considering that incidence and severity of fungal plant diseases is affected by several biotic (Burdon et al., 2006; Burdon and Chilvers, 1982; García-Guzmán et al., 1996; Gilbert, 2002), and abiotic factors (Burdon, 1987; Burdon et al., 2006; García-Guzmán and Heil, 2014; García-Guzmán et al., 1996), and that forest fragmentation involves changes in physical and biological environmental conditions (Fischer and Lindenmayer, 2007; Gehlhausen et al., 2000; Hobbs and Yates, 2003; Peay et al., 2010), we aimed to evaluate the hypothesis that incidence of fungal pathogens causing leaf damage to the shrub and tree community of a seasonal tropical dry forest would be negatively affected by environmental changes associated to habitat fragmentation. The study was carried out in 4 forest fragments of different sizes, and 2 continuous forest sites located in the Chamela-Cuixmala Biosphere Reserve and surrounding areas (Jalisco, Mexico).

2. Methods

2.1. Study site

The study was carried out in the region of the Chamela-Cuixmala Biosphere Reserve and surrounding areas, which is located on the central Pacific coast of Mexico (*ca.* 19°17′–19°35′ N, 104°50′–105°07′W; Fig. 1). The Biosphere Reserve has an extension of 13,142 ha. The predominant vegetation type in this region is seasonally dry tropical forest (SDTF), but other habitats include semi-deciduous dry forest, riparian zones, coastal vegetation, and wetlands (Lott, 1993). The canopy height ranges between 8 and 12 m, and dominant tree species include *Cordia* spp., *Tabebuia* spp., *Caesalpinia* spp., and *Lonchocarpus* spp. (Lott et al., 1987). Average annual temperature is 24.6 °C and average annual precipitation is 731 mm with a marked dry season from November to June (García-Oliva et al., 2002).

2.2. Field surveys

To determine the level of fragmentation at the Chamela-Cuixmala region, satellite Landsat ETM images from the dry season of 2000, with an accuracy level of 30 m/pixel, digital orthophotos (1:20000), and digital aerial photographs were analyzed. As a result, the spatial distribution of the seasonally dry forest in the area was obtained, and we were able to differentiate the continuous forest from the forest remnants (Fig. 1). Thus, the size of each fragment, and the type of vegetation surrounding each one of them were determined using SIG (ArcGis 9.3). Through field exploration, four fragments were localized, measured, and analyzed for their accessibility and conservation status.

The size of the selected fragments is shown in Table 1. Chosen sites presented similar environmental characteristics, and were distributed within a ≈10 km radius, and altitudes ranging from ≈50 to 150 masl. All fragments presented signs of disturbance by selective logging, cattle grazing, and fire. Particularly, fragment 2 was less deteriorated and presented a higher number of species than the other fragments, even though it was the second largest (*cf.* Table 1). On average, *ca.* 280 individual plants per 0.5 ha. were detected, and plant species diversity tended to decline with decreased fragment size (Table 1). All sites presented sandy clay loam soils, and were surrounded by grasslands and crop areas.

Within each site, 5 transects of 50 × 2 m (*i.e.* 500 m^2 per site) were established randomly following the method proposed by Gentry (1982, 1988). All plants with a dbh ⩾ 1 cm were sampled. In addition, all lianas with a basal diameter ⩾1 cm, were

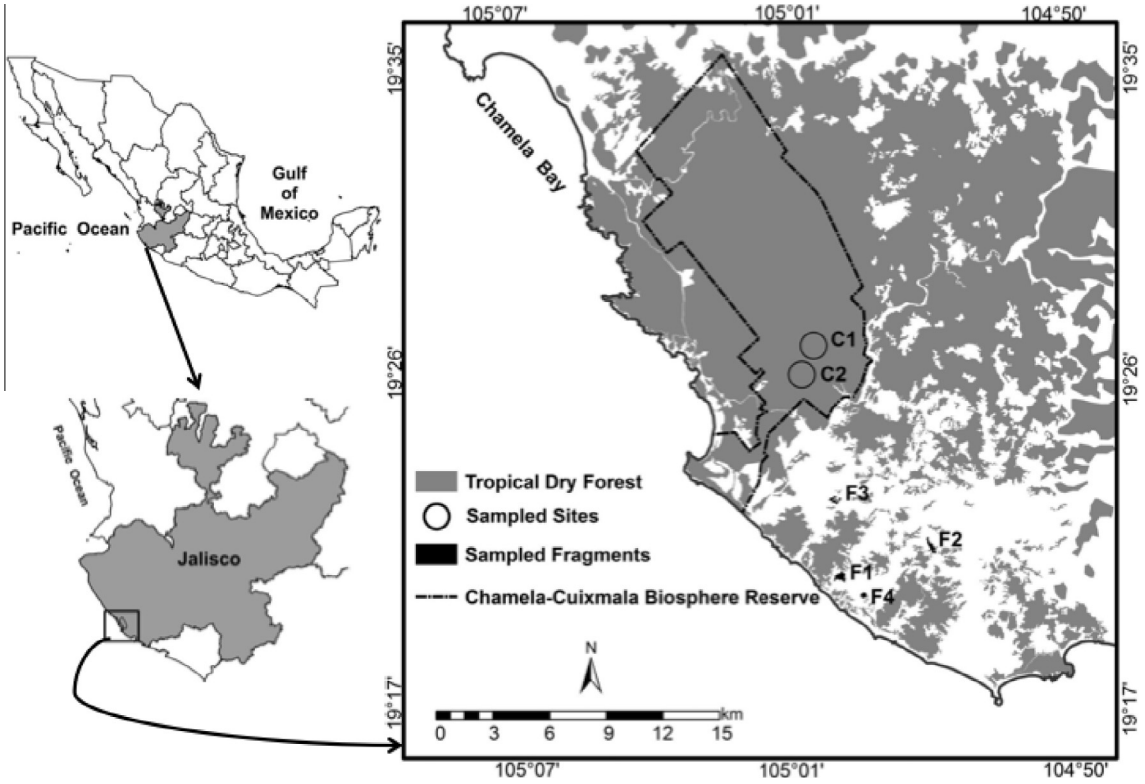

Fig. 1. Location of the study site in the State of Jalisco, Mexico, including the specific location of the four forest fragments (F), and the two sites of continuous forest (C).