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Research Letters

The importance of restoration areas to conserve bird species in a highly fragmented Atlantic forest landscape

Paulo Cesar Araújo Santos Junior[a], *Fernanda Cristina Marques*[a], *Marcos Robalinho Lima*[b,*], *Luiz dos Anjos*[b]

[a] *Post-Graduate Program in Biological Sciences, Biological Sciences Center, Department of Animal Biology and Plant, Universidade Estadual de Londrina, Londrina, PR, Brazil*
[b] *Department of Animal Biology and Plant, Biological Sciences Center, Universidade Estadual de Londrina, Londrina, PR, Brazil*

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ABSTRACT

In this study, we tested the potential of restored areas to maintain biodiversity in the scope of a recently proposed category of protected area called "Restoration Reserves". To accomplish this, we compared bird richness and functional group structure of two small forest fragments (<250 ha) with adjacent recently reforested areas (9 and 7 years of reforestation). Reforested areas had equal or higher bird richness and similar functional group structure. These results indicate that reforested areas are capable of maintaining current levels of biodiversity and reducing species extinction debt in small forest fragments, which is the main purpose of "Restoration Reserves". However, when we compared a large forest fragment with an old adjacent reforested area (20 years of reforestation), we found that it was of limited value for certain functional groups. Therefore, "Restoration Reserves" could provide essential additional habitat in highly fragmented landscapes that consists mainly of small forest fragments.

Introduction

Intensified human land use has resulted in landscapes consisting of several forest fragments, immersed in a matrix of urban and rural areas (Turner, 1990). Deforestation and forest fragmentation is so severe in the tropics that present landscapes are highly fragmented in small and isolated forest fragments (Melo et al., 2013). For example, 83.4% of remaining forest fragments in Brazil's Atlantic Forest are smaller than 50 ha (Ribeiro et al., 2009). Because of this dramatic situation, Brancalion et al. (2013) recently advocated for the creation of a new category of protected area entitled "Restoration Reserves", as a tool to increment natural forest cover and support biodiversity conservation. The idea behind "Restoration Reserves" is to combine both the protection and restoration

* *Corresponding author.*
E-mail address: robalinho.lima@gmail.com (M.R. Lima).
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efforts of small forest fragments in a landscape ecology perspective, with the aim of reducing species extinction debt (Brancalion et al., 2013). Since many species and populations have a delayed response in relation to environmental disturbances, such as habitat loss and degradation, future extinction of local population and species (i.e., species extinction debt) is expected (Tilman et al., 1994; Kuussaari et al., 2009). However, there is the possibility to reverse this trend if conservation actions, like habitat restoration are employed to try to increase both habitat availability and connectivity (Kuussaari et al., 2009; Brancalion et al., 2013). The restoration of areas next to forest fragments should reduce edge effects as well as provide additional habitat, which should result in an increase in population size for several species, reducing the chances of future extinction. A small number of cases have demonstrated that restored areas can indeed provide additional suitable habitat for forest species (Donner et al., 2010; Reid et al., 2014), but more empirical data is needed to support the idea that "Restoration Reserves" are capable of mitigating species extinction debt.

For bird species, habitat heterogeneity of primary forest is a strong predictor for the occurrence of species with different ecological requirements (MacArthur and MacArthur, 1961). In the Neotropics, the occurrence of understory and terrestrial insectivores birds is correlated with vegetation density (i.e., lianas, hedges and bushes) of the understory (e.g. Volpato et al., 2006; Stratford and Stouffer, 2013; Marques and Anjos, 2014). However, reforested areas generally lack variability in vegetation structure, particularly when reforestation was implemented recently (Donner et al., 2010). In this scenario, the importance of reforested areas for bird species with unique ecological requirements is unclear (Gibson et al., 2011), but there is an indication that reforested areas in Australia, with complex vegetation structure are able to maintain high richness of forest dependent bird species (Munro et al., 2011). In the Amazon, terrestrial insectivore forest birds are sensitive to habitat modification and forest fragmentation (Robinson, 1999; Stratford and Stouffer, 1999), being rarely found in secondary regenerated forests (Borges and Stouffer, 1999; Blake and Loiselle, 2001; Stratford and Stouffer, 2013). Moreover, some species with very specific ecological requirements are only found in regenerated areas after 30 years (Powell et al., 2013).

Considering that reforested areas contain only a subset of the original species because of differences in vegetation (structure, complexity and richness) and that species composition, at least for birds, generally changes with the age of the reforested area (Catterrall et al., 2012), we could consider that reforested areas work as a habitat filter. If this process of habitat filtering occurs in a non-random manner, it is possible to identify which ecological characteristics are sensitive to reforested areas (Mouillot et al., 2013), thus, providing important information for future conservation strategies. For example, if certain functional groups are lost or in low abundance (number of species) in reforested areas, active management strategies need to be developed to circumvent this loss. Birds are an interesting model group to study these aspects, because they play important ecological functions such as: seed dispersal, seed predation, pollination, predation (of animals), scavenging and some species are even considered to be ecosystem engineers (Whelan et al., 2008).

The aim of this study was to evaluate differences in bird richness and functional group structure between forest fragments and their adjacent reforestation areas, as well as how these differences are affected by the size of the forest fragment. We predict that reforested areas, next to small forest fragments, will harbour a higher proportion of the bird fauna of its adjacent forest fragments when compared with reforested areas that are next to a large pristine old growth forest fragment. If this is the case, it is an indication that: (1) "Restoration Reserves" could provide essential additional habitat that could reduce species extinction debt in highly fragmented landscapes that consist mainly of small forest fragments and (2) bird species of pristine old forest with specific ecological requirements would have limited potential do colonize "Restoration Reserves". We also aim to evaluate which groups of species have a limited potential of being encountered in reforestation areas and discuss our results in the context of "Restoration Reserves" (Brancalion et al., 2013).

Material and methods

Study area

We selected three different areas of seasonal semidecidous forest in the north of Paraná that consist of a forest fragment and a neighbouring reforested area of native plant species (Fig. S1). The study areas were: Parque Estadual Mata dos Godoy (PEMG); Reserva do Patrimônio Particular Natural Matas do Cici (RPMC); and Fazenda Congonhas (FCON). The forests remnants are late successional and suffered limited timber extraction in the early 1980s.

PEMG (22K 475,143.87 m E; 7,406,363.26 m S; site PG) is located in the municipality of Londrina (PR) and has an area of 656 ha inserted into a larger area of 2397.5 ha. Adjacent to the park there is a reforested area of 20 ha (site RG, Fig. S1), which was implemented in 1991 using the following native plants: *Peltophorum dubium* (Fabaceae – Caesalpinoideae), *Parapiptadenia rigida* (Fabaceae – Mimosoideae), *Handroanthus impetiginosus* (Bignoniaceae), *Cordia trichotoma* (Boragninaceae) and *Colubrina glandulosa* (Rhamnaceae) (J.D. Torezan pers. comm.). Even after over 20 years, this reforested area is in the initial phase of ecological succession, with the presence of several regenerating tree species in areas where the canopy is more closed, whereas in other areas of the reforested area the presence of the invasive grass *Megathrsus maximus* (Jacq.) dominates (Mantoani et al., 2012).

FCON (22K 480,790.30 m E; 7,476,589.92 m S) comprises of a forest fragment (site FC) of 104.8 ha and an adjacent reforested area (site RC, Fig. S1) of approximately 13 ha. Forest fragment FC suffered selective logging during the 1970s, but afterwards became a Legal Reserve. Reforestation was implemented in RC in 2002 using 67 species of native plants with the following predominant tree species: *Guazuma ulmifolia* (Malvaceae), *Schinus terebinthifolius* (Anacardiaceae), *Heliocarpus popayanensis* (Malvaceae), *Cecropia pachystachya* (Urticaceae) and *Trema micrantha* (Cannabaceae) (J.D. Torezan pers. comm.).