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SHORT NOTE

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# BIRD DIVERSITY OF THE TIRIMBINA BIOLOGICAL RESERVE: THE ROLE OF RESEARCH, ENVIRONMENTAL EDUCATION AND ECOTOURISM IN BIRD CONSERVATION IN A TROPICAL WET FOREST IN COSTA RICA

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**Abstract** · Long-term bird species monitoring is key to understand changes in species composition and assemblages. The Tirimbina Biological Reserve (TBR) protects a tropical wet forest in Costa Rica where bird species have been monitored and studied for more than 20 years. This study summarizes information on bird species composition generated from natural history, research studies, and conservation efforts carried for TBR. A total of 397 species are reported for TBR, where several species are under different IUCN's Red List conservation categories. From that total of species observed, 82% are resident and 18% are migratory. Also, information on species turnover after the replacement of exotic to native plant species in gardens, and findings from an interpretative bird trail are shown. TBR is a local conservation model where different activities such as ecotourism, science, research, and environmental education work together to preserve a tropical wet forest as a suitable habitat for many species of birds.

**Resumen · Diversidad de aves en la Reserva Biológica Tirimbina: El papel de la investigación, la educación ambiental y el ecoturismo en la conservación de aves de un bosque tropical lluvioso de Costa Rica**
Monitoreos de aves a largo plazo es clave para comprender cambios en la composición y ensambles de especies. La Reserva Biológica Tirimbina (RBT) protege un bosque húmedo tropical en Costa Rica donde las especies de aves han sido monitoreadas y estudiadas durante más de 20 años. Este estudio resume información sobre la composición de especies de aves generada a partir de reportes de historia natural, investigaciones y esfuerzos de conservación realizados en RBT. En actualidad, se reporta un total de 397 especies de aves, algunas de estas se incluyen dentro de alguna categoría de conservación de la Lista Roja des especies de la UICN. La mayoría de las especies son residentes, otras son especies migratorias. Además, se incluye información sobre cambio de especies después de sustituir especies de plantas exóticas por nativas en los jardines, e información sobre un sendero interpretativo de aves. RBT es un modelo de conservación local donde diferentes actividades como el ecoturismo, la ciencia, la investigación y la educación ambiental trabajan juntas para preservar un bosque húmedo tropical como hábitat adecuado para muchas especies de aves.

**Key words:** *Migrants · Monitoring · Sarapiquí · Species composition*

## INTRODUCTION

Long-term biodiversity monitoring is of vital importance to understand changes in species populations related to habitat loss and destruction, generated by changes in land use, pollution, and climate change (Haase et al. 2018). Monitoring is important to understand changes in bird species composition and assemblage, as they are key components at regulating ecosystem functioning due to their critical role as seed dispersers, pollinators, and pest controllers (Şekercioğlu et al. 2004). Compared to temperate zones, Neotropical forests have the highest bird species diversity, which includes native, endemic, and migratory species (Stotz et al. 1996); the latter may stay or spend a few days in the tropics during their migration south from the northern hemisphere at the beginning of winter, and on their return when winter ends (Stotz et al. 1996). Therefore, monitoring programs along with habitat preservation are fundamental for bird conservation.

Costa Rica is widely known for its conservation efforts. Currently, about 50% of its territory corresponds to forest cover (MINAE 2020). In 2005, forest cover was 48%, of which 22% was protected by the National Conservation Areas System (SINAC 2020), and the other 26% protected by private protected areas, highlighting the importance of private conservation initiatives in the country (Boza 1993, Langholz et al. 2000, FONAFIFO 2021). The Sarapiquí region located in northeastern Costa Rica offers a unique conservation spot, where four main private reserves, as well as properties dedicated to conservation, occur in a highly biodiverse area (Reserva Tirimbina 2020). These reserves are fundamental for bird conservation since they protect a high percentage of the avifauna present in the country (i.e. 923 species). As an example, Ecovida Lapa Verde Refuge protects 261 species of birds, corresponding to 23% of the total species for the country (Ecovida 2020), La Selva Research Station protects 470 species (i.e. 50% of the total Costa Rican species) (Tropical Studies 2021), and the Tirimbina Biological Reserve (TBR) protects 397 species representing 43% of the total species for Costa Rica (Reserva Tirimbina 2020).

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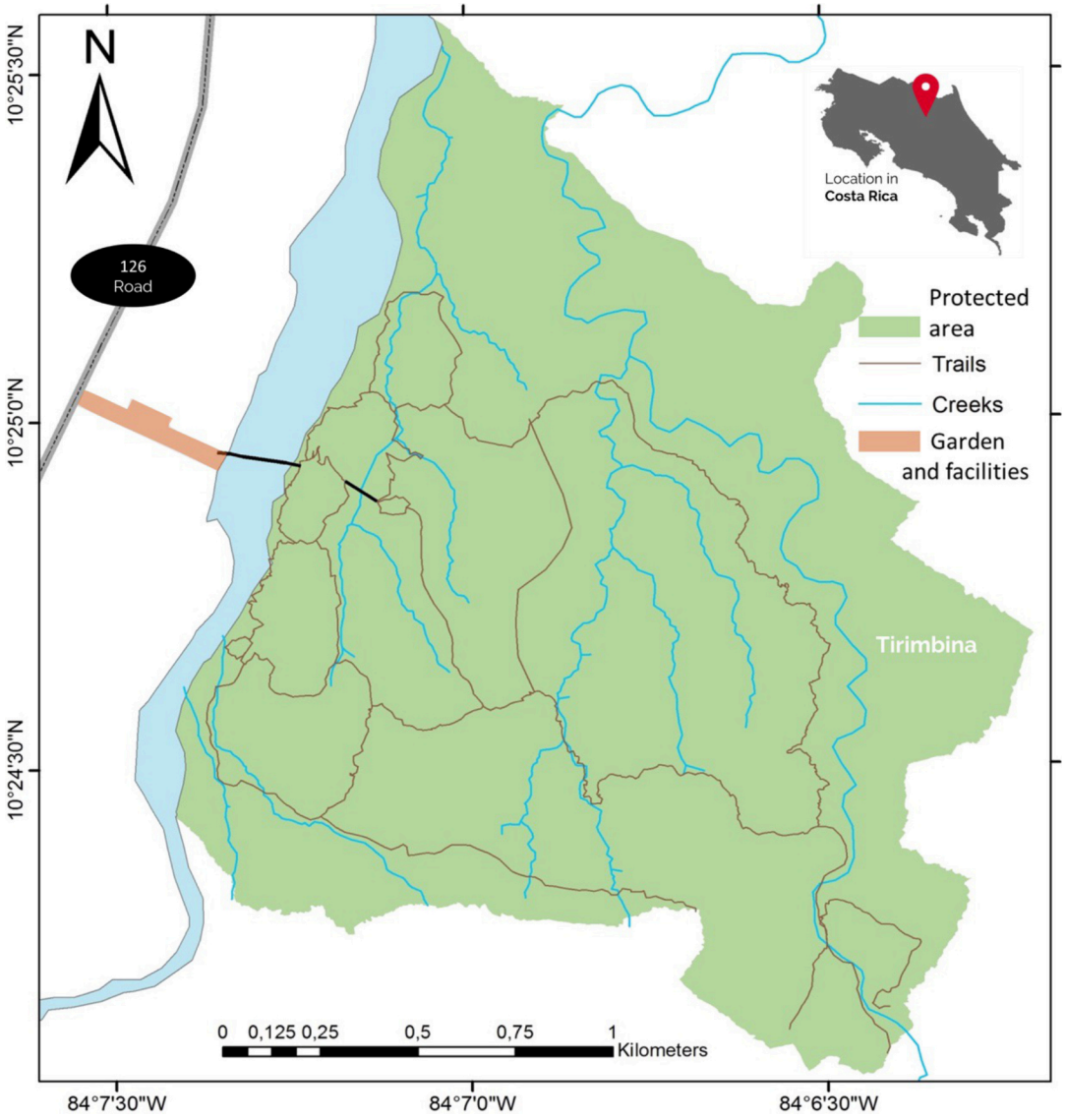
TBR comprises 345 ha of tropical wet forest in Costa Rica, 90% of which corresponds to mature forest. Bird species monitoring at TBR began more than 20 years ago, generating a species list that currently reports 397 species. The number of species began to increase as guidelines in conservation efforts improved when TBR became a Costa Rican Private Wildlife Refuge in 2001, but also as the original forest aged and some sections of the secondary forest turned older. TBR also runs a conservation model involving ecotourism activities that fund their research projects and had supported the environmental education program at local elementary schools, for over 20 years. The research projects are carried out by TBR staff in collaboration or independently by other local and international researchers and students. Several studies have been carried out, from describing bird species' natural history, to manipulating vegetation to improve bird species visiting TBR, and projects related to environmental education and the human perception of birds. In this study, we aim to summarize and update the information on bird species richness from several past and current studies carried out at TBR by the staff and in collaboration with external researchers. We provide species' natural history and conservation status, information on species composition change after replacing exotic plant species in the surrounding gardens, and on the visitors' perception of birds.

## METHODS

**Study area**. TBR is a private wildlife refuge located in La Virgen de Sarapiquí, Heredia, Costa Rica (10°25'02.27''N, 84°07'31.99'' W) (Figure 1). Life zones include a very-humid premontane tropical forest with a transition to a very-humid basal tropical forest (Reserva Tirimbina 2020). The coverage is of 90% mature forest, with some areas in regeneration and old plantations. The soils are mainly volcanic, and it has low slopes between 10 and 25%, with a maximum of 60% within an elevation range of 180–220 m a.s.l. There are approximately 9 km of trails, of which 4.7 km are dedicated exclusively for research and conservation.

**Species richness.** We collected information on species richness from historical observations and reports, some of them currently uploaded into eBird (2021) by tourists and natural history tour guides, both independent and TBRs. However, the updated species list presented here was elaborated from a monitoring program that members of the academic department of TBR have been conducting twice a week since 2016, by using 10 min point counts of 25 m radius every 200 m, along a 2.2 km strip transect (Hutto et al. 1986). Species conservation status for Costa Rica was categorized according to the IUCN Red List (IUCN 2021) and based on their resident status (e.g. resident or migrants). We provide data on bird species composition before and after the replacement of exotic plant species by native



species in the surrounding gardens of the facilities at TBR. The gardens had exotic plants from 1999 until 2016, where the plant replacement started and currently persists. We compared bird species before and after exotic plant replacement using species lists from historical observations and from the monitoring project. TBR bird species database in Microsoft Excel was used for the analysis.

**Visitors' perceptions of birds**. In 2017, and thanks to funding from the American Bird Conservancy, TBR inaugurated an interpretative trail dedicated to environmental education on the importance of native plant species to birds. The tour has guided and self-guided versions, and it was planned mainly for families or students. As part of this project, we carried out online surveys at the end of the tour where visitors expressed their perceptions about the importance of gardens with native plants for birds. The survey has a section with open questions and another section with a Likert scale with five options (totally agree, agree, neutral, disagree, totally disagree) (Supplementary material). The surveys were accomplished through a link to an electronic platform where visitors answered from their smartphones. The surveys were aimed to obtain general information about the visitors, their perception from the tour, and their learning experience obtained from it (Ham 2013). Answers related to the visitor's general information and generated from the Likert scale questions were grouped as percentages.

## RESULTS

A total of 397 species of birds are reported for TBR from historical records and species lists, generated from birdwatchers, tourists, natural history guides, and staff. Currently, TBR has 1536 checklists on eBird (2021). From the total species reported until 2020 (see Supplementary material), two species, Bare-necked Umbrellabird *Cephalopterus glabricollis* and Great Green Macaw *Ara ambiguus*, were under the Endangered category (EN), 10 under Near Threatened (NT), four under Vulnerable, and 381 under the Least Concern (LC). There are 303 resident species reported, 64 migrant species that use TBR as wintering grounds, 24 stopover migrants, four migrant species that nest at TBR whose subadults migrate.

Bird species composition changed after the replacement of exotic plant species by native species at TBR gardens. We observed 110 species between 1998–2010 when the gardens had exotic plant species, but this number increased to 222 species when exotics were replaced by native species from 2016–2019.

Of 49 surveys answered by visitors of the TBR interpretative bird trail, 65% said they learned new information about birds or plants and gardens, and 94% agreed that gardens are of the same importance for humans as they are for bird species. Regarding the interpretative take-home message, 64% of the surveyed visitors mentioned that gardens with native plant species help to preserve native bird species. Also, 92% of the visitors agreed that birds are important plant pollinators and dispersers, and pest regulators.

## DISCUSSION

TBR, along with other private reserves at the Sarapiqui region is considered a hot spot for birds according to eBird, hosting altogether above 500 species (eBird 2021). This highlights the relevance of this highly diverse region for birds and other fauna and flora groups, but also the importance of conservation efforts through private reserves in Costa Rica. Private reserves are key for biodiversity conservation in the country, supporting other national conservation efforts. In addition, TBR and other local reserves provide suitable habitats for several species under threatened conservation status according to the IUCN Red List (IUCN 2021), and to migrant species. Even though TBR is not the largest private reserve in the region (345 ha), it hosts 397 species of birds, while a larger important private reserve such as La Selva Research Station (1,600 ha) hosts 467 species (Tropical Studies 2021).

Efforts on exotic plant replacement by native species at TBR have supported the visitation of more bird species. In the short three years after the replacement, bird species have doubled their number, highlighting the importance of gardens adjacent to forests as a source of food and nesting sites for the avifauna, but also as stopover sites and connectors between urban and natural landscapes (Chace & Walsh 2006, Daily et al. 2001). Our results indicate that 56% of the total bird species observed at TBR are visiting the garden. Lower percentages were observed in other studies for countryside habitats, such as gardens in the South Pacific Costa Rica (i.e. 45%) (Daily et al. 2001, Hughes et al. 2002), suggesting that gardens are important when other land uses such as agriculture, pasture and fallow lands, secondary forests and old-growth forests are present. Our study provides novel relevant information about the importance of gardens for long-term monitoring of bird species from the Atlantic lowlands of Costa Rica.

A high percentage of the visitors of the TBR interpretative bird trail learned new information about the importance of gardens with native plant species for bird conservation. Almost all the visitors identified birds as important plant pollinators and dispersers, and pest regulators when finishing the trail, highlighting their importance at providing ecosystems services for humans (Kross et al. 2018). This suggest that environmental education through an ecotourism activity can be an important tool to engage the general public into conservation.

This study summarizes information from several past and current studies carried out at TBR by its staff but also in collaboration with external researchers. Long-term bird monitoring at TBR generates constant data to understand changes in species composition and assemblages, crucial information to update species status, and critical data on species fluctuations, all of them highly relevant for bird conservation. TBR represents a sustainable, self-sufficient local conservation model where ecotourism supports science, research, and environmental education working together to preserve a highly diverse tropical wet forest spot for birds.

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