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ORIGINAL RESEARCH ARTICLE

Changes in the avifauna of a forest relict in the peri-urban fringe of Bogotá over fourteen years

Loreta Rosselli[1], Susana De La Zerda[2*], Jonathan Candil[1]

[1] Facultad de Ciencias Ambientales, Universidad de Ciencias Aplicadas and Ambientales. Bogotá D.C., Colombia.

[2] American Bird Conservancy, Virginia 20198, USA; E-mail: sdelazerda@yahoo.com

ABSTRACT

Over several centuries, the native vegetation of the flat part of the Bogotá Savanna has been almost completely replaced by crops, pastures and urbanization. The last remnant of this vegetation is a small forest (10 hm^2), located at Hacienda Las Mercedes on the northern edge of the city of Bogotá. The reduced size and isolation of the forest, aggravated by the uncontrolled growth of invasive vegetation (lianas and wild blackberry) has resulted in the loss of many species. However, in recent years the forest has been subject to rehabilitation actions and currently the area is immersed in a reserve where more extensive restoration programs are planned. In order to evaluate changes in the bird community to estimate the effects of restoration actions, the avifauna present in 2001–2002 and in 2014 was recorded by visual and auditory records at fixed points in the forest. Twenty-seven forest species were found in the first census and 30 in the second, and the relative abundances of at least a third of them also increased over the 13 years, indicating a positive result in the recovery of the forest. The results highlight the recovery capacity of the degraded ecosystems and the importance of continuing with restoration actions in the reserve area.

Keywords: Birds; Conservation; Endemism; Ecological Restoration

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1. Introduction

Habitat loss and fragmentation due to anthropogenic actions are among the most important threats to biological diversity[1], leading to loss of complexity and connectivity in plant and animal communities[2], impacting species and causing their decline and even extinction. Urbanization and agriculture[3] are among the main causes of habitat loss and fragmentation, leaving the original natural spaces not only fragmented but in many cases also isolated[4,5].

In the peri-urban areas of large cities, the two threats converge, as is the case in the north of the city of Bogotá (Colombia), where a strip of predominantly agricultural land is being pressured by the growth of the city and neighboring populations that are close to joining it. In order to conserve this strip of land, its biodiversity and the ecosystemic connectivity between the natural areas of the sector, the regional environmental government authority declared the "Reserva Forestal Regional Productora del Norte de Bogotá D.C. Thomas van der Hammen"-RFRPNB[6]. The RFRPNB's Environmental Management Plan contemplates the restoration of 552 hm^2 and seeks to fulfill the reserve's objectives, among which the conservation of threatened and endemic avifauna is a priority[7]. Among the areas of interest in the reserve is the Las Mercedes forest (**Figure 1**), an isolated remnant of 10 hm^2, which

represents the last relict of non-floodplain forest in the Sabana de Bogotá[8].

Bogotá is located on a high plateau called Sabana de Bogotá, in the eastern Andes of Colombia, has an urban area of 38,400 hm^2[9] and about seven and a half million inhabitants and is expected to grow rapidly in the coming years (projected growth rate 1.2)[10]. The city is bounded on the east by mountains and on the west by the Bogotá River, so growth is occurring to the north and south, where it is being joined by neighboring municipalities. Although the Las Mercedes forest is not in direct contact with urbanization, it is seen as a latent threat factor, particularly due to the current administration's interest in urbanizing the sector, a situation that has generated great controversy[11].

The highlands where the Sabana de Bogotá is located is an area of special biogeographic interest, as it is in the avian endemism area Eastern Andes of Colombia[12], hosting several bird species of restricted distribution, some of them threatened. Birds are known indicators of the structure and conservation of an ecosystem since their occurrence and abundance is influenced by the characteristics of the surrounding habitat[13,14].

Therefore, it is of interest to know the status of the avifauna in the forest of Las Mercedes, one of the most important natural areas of the protected area before initiating the restoration actions planned for the reserve and to follow up on their effectiveness; also, to evaluate the changes that have occurred in recent years in response to restoration actions carried out by the Botanical Garden of Bogota.

This study seeks to evaluate the current state of the avifauna and its change in the last 14 years with the objective of analyzing the effects of the recovery actions of the Las Mercedes Forest on the avifauna, to observe trends of change that validate the importance of conservation and recovery of this relict of forest in the Sabana of Bogotá and to evaluate the conservation tools in expanding urban centers. This type of study is important because there are few detailed studies in neotropical ornithology that are carried out over the long term in the same locality, especially in areas that are being modified by man[15]. The data generated by this type of studies constitute an important basis for decision making and the application of management measures with environmental sustainability objectives.

2. Materials and methods

2.1 Study area

The Las Mercedes forest is located in the hacienda of the same name in northwestern Bogotá (4°46'06.20" N, and 74°06'03.14" W), at an elevation of approximately 2,550 m a.s.l. (**Figure 1**). In addition to the forest, the hacienda's natural areas include part of the La Conejera wetland and an area along the Bogotá River. The forest has an area of approximately 10 hm^2 and, like most of the hacienda, is within the RFRPNB. The areas surrounding the forest on the ranch include flower greenhouses, pastures, and live fences of Eucalyptus globulus.

In 1965 the forest was dominated by *Vallea stipularis* and *Ilex kunthiana* with a 12 m high canopy and some individuals of *Cedrella montana* emerging, as described by Forero-González[16]. In 2000, the Fundación Humedal La Conejera carried out some recovery actions with the planting of native species such as Alnus acuminata in the western end and in the central portion where there was a gap between the two sectors of the forest. The Foundation also planted a line of trees between the forest and the La Conejera wetland approximately 750 m to the southwest, seeking connectivity with the belt of arboreal vegetation that they themselves had planted around the wetland in the 1990s (authors pers. obs., pers. comm. G. Galindo, founder of the Foundation). In 2001, *V. stipularis* continued to be a common species in the forest although most of *I. kunthiana* had disappeared and there was a high degree of alteration of the forest structure due to the invasion of blackberry (*Rubus* sp.) that covered the canopy and formed a thick layer on the ground and *Muehlenbeckia thamnifolia* which had practically flattened the entire northern part of the forest (authors obs. pers.).

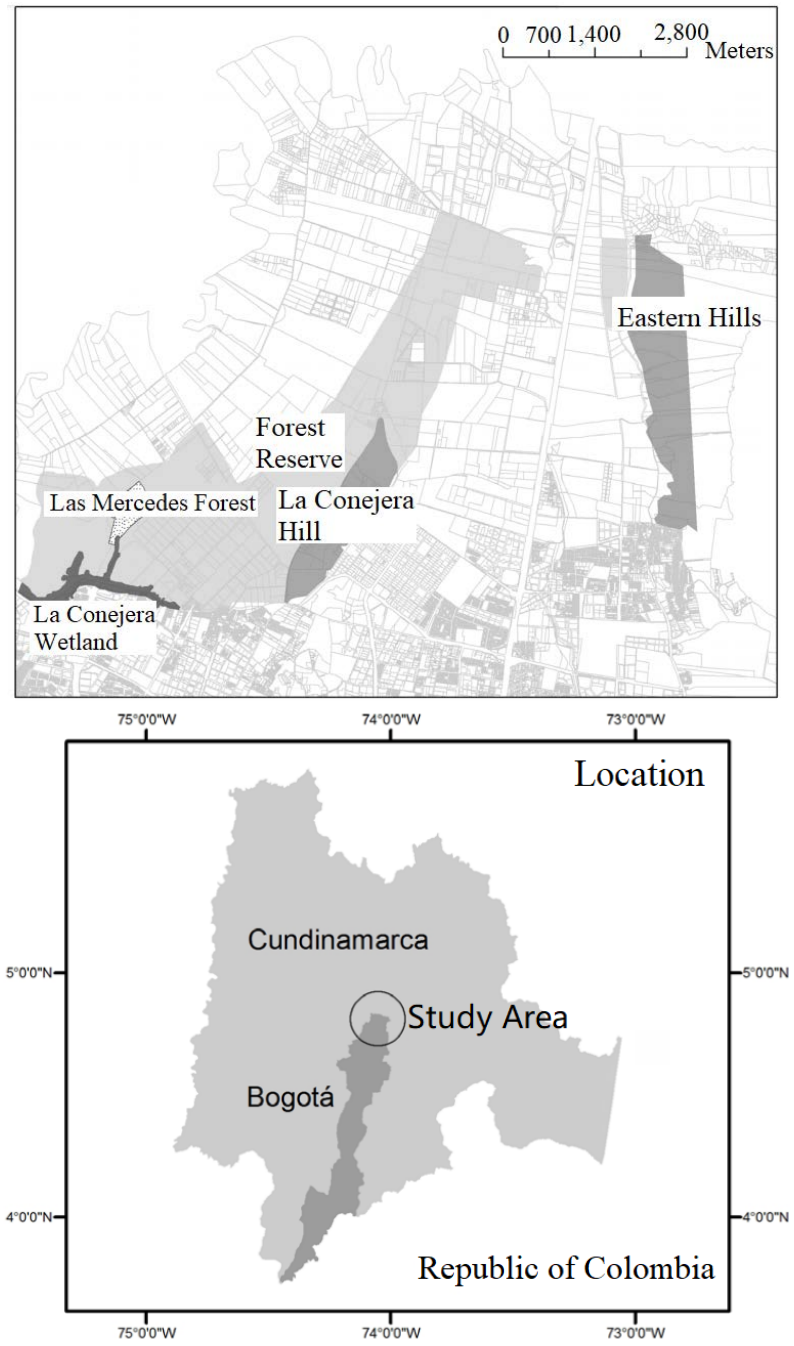

Figure 1. Location of the study area (Bosque de las Mercedes) Sabana de Bogotá, Colombia.
Note: The Thomas van de Hammen Reserve and La Conejera Hill and Wetland are highlighted. Prepared by Alfonso Romero.

In 2012, the José Celestino Mutis Botanical Garden of Bogotá initiated several restoration actions, removing invasive climbing species such as *Rubus* sp., *M. thamnifolia* and *Pentacalia* sp. and enriching the forest by planting native tree species. This intervention resulted in a clearer understory and in general more light inside the forest (pers. obs. authors). Other characteristic trees in the forest include *Solanum ovalifolium*, Myrcianthes leucoxyla, *Prunus serotina*, *A. acuminata*, *Smallanthus pyramidalis* and *Baccharis latifolia*[8]. The connectivity between the forest and the La Conejera wetland was strengthened through live fences with plants such as *S. pyramidalis*, *Juglans neotropica*, *A. acuminata*, *B. latifolia* and *Billia columbiana*, among others. As of 2014, the control of invasive climbers and the planting of trees continued in an area of about five hectares south of the forest in city properties.

2.2 Birds

Between September 2001 and September 2002, eight samplings were carried out throughout the year in which nine points were visited in the forest of Las Mercedes and its surroundings (**Table 1**). At each point, birds both seen and heard were recorded for five minutes[17]. The distance between points was a minimum of 140 m, to reduce the possibility of recording the same individual at two points. Observations were made between six and ten o'clock in the morning and the starting point of the sampling day was rotated to have similar times at all sites throughout the study.

Table 1. Dates of sampling in the Mercedes Forest in 2001/2002 and 2014

Dates 2001/2002	Dates 2014
26-Sep-01	12-Sep-14
1-Nov-01	19-Sep-14
30-Nov-01	26-Sep-14
3-Jan-02	3-Oct-14
18-Apr-02	24-Oct-14
29-May-02	
18-Jul-02	
20-Sep-02	

Using the same methodology, five surveys were conducted between September and October 2014 at eight sampling points in areas overlapping or very close to the 2001–2002 sampling points (**Table 1**). For the general list of the area, species seen from the points but not in the forest (for example that they were flying) and those seen or heard on walks between points were included to complement the list of the general avifauna of the area, but were not taken into account for the analyses of change and diversity in the forest.

To make comparisons, the data were standardized by dividing the total number of individuals recorded per species by the number of points and by the number of samplings in each season. The Morisita similarity index[18] was calculated to compare the avifauna of the forest between the two seasons. To evaluate the change in the abundance of the species observed in relation to the initial period, the relative abundance of 2001–2002 was subtracted from that of 2014, divided by the abundance of 2001–2002 and multiplied by 100. In addition, the Shannon diversity index was calculated for the two periods and a Bootstrap-based test was used for comparison using the statistical program Past[19].

3. Results

A total of 38 species belonging to 19 families were recorded at the forest sampling points: 27 in 2001 and 30 in 2014 (**Table 2**). The species recorded represent diverse families and habitats, 11 of them are boreal migrants (**Table 2**). Outside the forest and the sampling points, 19 more species were recorded: eight aquatic species, mostly herons, five aerial species that spend most of their time in flight and are not associated with any particular habitat, five species typical of open areas, and one species associated with wooded parks (**Table 3**).

Table 2. Birds recorded in Las Mercedes Forest (Bogotá, Colombia) in 2001/2002 and 2014, relative abundances and percentage change between the two epochs

Family	Species	Habitat	Relative abundance 2001	Relative abundance 2014	Difference	% of change
ACCIPITRIDAE	*Elanus leucurus* (Vieillot, 1818)	Open areas	0.02	0.03	0.01	60%
	Ruporns magnirostns (Gmelin, JF, 1788)	Open areas	0.08	0.15	0.07	92%
	*Buteo platypterus** (Vieillot, 1823)	Wooded parks	0.02	0.08	0.06	380%
COLUMBIDAS	*Zenaida auriculata* (Des Murs, 1847)	Open areas	1.55	0.73	-0.82	-53%
PSITTACIDAE	*Forpus conspicillatus* (Lafresnaye, 1848)	Forests and thickets	0.17	0.98	0.80	467%
CUCULIDAS	*Coccyzus americanas** (Linnaeus, 1758)	Wooded parks	0.02		-0.02	-100%
STRIGIDAE	*Pseudoscops clamator* (Vieillot, 1808)	Wooded parks		0.05	0.05	100%

Table 2. (*Continued*)

Family	Species	Habitat	Relative abundance 2001	Relative abundance 2014	Difference	% of change
TROCHILIDAE	*Colibri coruscans* (Gould, 1846)	Wooded parks	0.66	0.95	0.29	45%
	Lesbia sp.	Forests and thickets	0.02		-0.02	-100%
PICIDAE	*Picoides fumigatus* (d'Orbigny, 1840)	Forests and thickets		0.05	0.05	100%
FALCONIDAS	*Falco columbarios** (Linnaeus, 1758)	Open areas	0.02		-0.02	-100%
FURNARIIDAE	*Synallaxis subpudica* (Sclater, PL, 1874)	Forests and thickets	0.27	2.48	2.21	832%
TYRANNIDAE	*Elaenia fantzii* (Lawrence, 1865)	Forests and thickets	0.44	0.10	-0.34	-77%
	Mecocerculus leucophtys (d'Orbigny & Lafresnaye, 1837)	Forests and thickets		0.08	0.08	100%
	Empidonax sp*	Forests and thickets	0.03		-0.03	-100%
	*Contopus virens** (Linnaeus, 1766)	Forests and thickets		0.08	0.08	100%
	Pyrocephalus rubinus (Boddaert, 1783)	Wooded parks	0.02		-0.02	-100%
	Tyyrannus melancholicus (Vieillot, 1819)	Open areas	0.13	0.10	-0.03	-20%
	*Tyyrannus tyrannus** (Linnaeus, 1 758)	Open areas	0.02		-0.02	-100%
VIREONIDAS	*Vireo olivaceus** (Linnaeus, 1766)	Wooded parks		0.25	0.25	100%
TROGLODYTIDAE	*Troglodytes aedon* (Vieillot, 1809)	Forests and thickets	1.95	1.38	-0.58	-30%
TURDIDAE	*Turdus fuscater* (d'Orbigny & Lafresnaye, 1837)	Wooded parks	1.64	0.60	-1.04	-63%
THRAUPIDAE	*Conirostrum rufum* (Lafresnaye, 1843)	Forests and thickets	0.30	0.20	-0.10	-33%
	Diglossa humeralis (Fraser, 1840)	Wooded parks	0.41	0.23	-0.18	-45%
	Sicalis luteola (Sparrman, 1789)	Open areas	0.56	0.08	-0.49	-87%
	Catamenia analis (d'Orbigny & Lafresnaye, 1837)	Open areas	0.09	0.05	-0.04	-88%
EMBERIZIDAE	*Arremon torquatus* (d'Orbigny & *Lafresnaye*, 1837)	Forests and thickets		0.05	0.05	100%
	Zonotrichia capensis (Statius Mluller, 1776)	Open areas	1.56	1.28	-0.29	-18%
CARDINALIDAE	*Piranga rubra** (Linnaeus, 1758)	Wooded parks		0.03	0.03	100%
	*Piranga olivacea** (Gmelin, JF, 1789)	Wooded parks	0.02		-0.02	-100%
	Pheucticus aureoventris (d'Orbigny & Lafresnaye, 1837)	Forests and thickets		0.08	0.08	100%
PARULIDAE	*Setophaga ruticilla** (Linnaeus, 1758)	Wooded parks	0.02		-0.02	-100%
	Myiothlypis nigrocristata (Lafresnaye, 1840)	Forests and thickets		0.03	0.03	100%
	*Cardellina canadensis** (Linnae-us, 1766)	Forests and thickets		0.03	0.03	100%
ICTERIDAE	*Icterus chıysater* (Lesson, 1844)	Wooded parks		0.18	0.18	100%
	Molothrus bonariensis (Gmelin, JF, 1789)	Open areas	0.77	0.13	-0.64	-84%
FRINGILLIDAE	*Spinusspinescens* (Bonaparte, 1850)	Open areas	0.22	0.75	0.53	243%
	Spinuspsaltria (Say, 1822)	Open areas	0.25	0.55	0.30	120%

Note: * refers to boreal migrant.

Table 3. Birds recorded in the vicinity of Las Mercedes Forest (Bogotá, Colombia) in 2001/2002 and 2014, relative abundances and percentage change

Family	Species	Habitat	Relative abundance 2001	Relative abundance 2014	Difference	% of change
ANATIDAE	*Anas discors* (Linnaeus, 1766)	Aquatic	n.p.			
ARDEIDAE	*Bubulcus ibis* (Linnaeus, 1758)	Open areas	17.00	0.28	-16.73	-98%
	Ardea alba (Linnaeus, 1758)	Aquatic	n.p.			
	Butorides striatus (Linnaeus, 1758)	Aquatic	n.p.			
	Nycticorax nycticorax (Linnaeus, 1758)	Aquatic	n.p.			
THRESKIORNITHIDAE	*Phimosus infuscatus* (Lichtenstein, MHC, 1823)	Aquatic		0.13	0.13	100%
CATHARTIDAE	*Coragyps atratus* (Bechstein, 1793)	Air	0.11	0.75	0.64	586%
RALLIDAE	*Gallinulagaleata* (Lichtenstein, 1818)	Aquatic	n.p.			
CHARADRIIDAE	*Vanellus chilensis* (Molina, 1782)	Open areas		0.15	0.15	100%
SCOLOPACIDAE	*Tringa solitaria** (Wilson, 1813)	Aquatic	0.02		-0.02	-100%
	*Tringa melanoleuca** (Gmelin, 1789)	Aquatic	0.02		-0.02	-100%
CAPRIMULGIDAE	*Systellura longirotirs* (Bonaparte, 1825)	Open areas	n.p.			
CAPRIMULGIDAE	*Chordeiles minor** (Forster, 1771)	Air	n.p.			
TYRANNIDAE	*Tyrannus savana* (Vieillot, 1808)	Open areas	n.p.			
HIRUNDINIDAE	*Orochelidon murina* (Cassin, 1853)	Air	0.23	1.85	1.58	596%
	*Riparia riparia** (Linnaeus, 1758)	Air		0.23	0.23	100%
	Hirundo rustica (Linnaeus, 1758)	Air	n.p.			
ICTERIDAE	*Icterus nigrogularis* (Hahn, 1819)	Wooded parks	n.p.			
	Sturnella magna (Linnaeus, 1758)	Open areas	0.02	0.20	0.18	1.180%

n.p.: species observed outside the fixed observation points.

Forest species have similar percentages of birds related to native forests and shrublands, wooded parks and open areas such as pastures and crops (37%, 32% and 31% respectively) (**Table 2**). Eight of the species recorded in 2001/02 were not recorded in 2014, six of them migratory; 11 species were recorded in 2014 that had not been recorded in 2001/02, most (64%) typical of native scrub and woodland and the rest of wooded parks (**Table 2**).

The avifauna of the forest has undergone notable changes in the 13 years between the two surveys. The most abundant species in 2001 were *Troglodytes aedon*, *Turdus fuscater* and *Zonotrichia capensis* while in 2014 the most abundant species became Synallaxissubpudica followed by *T. aedon* and *Z. capensis* (**Table 2**). Thirteen species showed changes substantial between 2001/02 and 2014 (above 50%), six decreased and seven increased (**Table 2**). Those that decreased include *Catamenia analis*, *Sicalis luteola* and *Molothrus bonariensis*, all associated with open areas. Those that increased include species of diverse

ecological characteristics such as some from lower elevations that are becoming established in the savanna: *Rupornis magnirostris*, *Elanus leucurus*, *Forpus conspicillatus*, some from open areas: *Spinus* spp. and others from native scrublands, among which the endemic *S. subpudica* stands out (**Table 2**). The Morisita similarity index between the species assemblages and their abundances between the two epochs is 0.66, indicating moderate similarity. Diversity in the forest avifauna was significantly higher in 2014 (Shannon H = 2.52 for 2001–2002, H = 2.67 for 2014, $p = 0.0100$) which not only reflects the higher species richness but the more even distribution of their abundances.

As for the distribution of birds in the forest, in 2001–2002 six species were recorded in at least 90% of the points: *Zenaida auriculata*, *Elaenia frantzii*, *Diglossa humeralis*, *T. aedon*, *T. fuscater* and *Z. capensis*; the point with the highest richness was located in the center of the forest with 14 species. In 2014, the species present in at least 90% of the points decreased to four: *Colibri coruscans*, *S. subpudica*, *T. aedon* and *Z. capensis* and the point with the highest richness was the one located in the living fence that extends from the southwest of the forest towards the Conejera Wetland with 15 species. In 2001–2002, the restricted distribution species *S. subpudica* was concentrated in the northeastern half of the forest and *F. conspicillatus* in the central sector. In 2014, *F. conspicillatus* was concentrated in the southwestern half and *S. subpudica* was found in all sectors of the forest. *E. frantzii* was restricted to the northeastern sector, as was *D. humeralis*.

Of the 19 species recorded outside the forest or outside sampling points, 12 from 2001–2002 were not recorded in 2014 and three are new for 2014 (a migratory swallow and two species typical of lower elevations that are relatively new to the Savanna: *Phimosus infuscatus* and *Vanellus chilensis* (**Table 3**). For the species for which abundance data are available for the two periods, there was a sharp decrease in *Bubulcus ibis* and notable increases in *Coragyps atratus*, *Orochelidon murina* and *Sturnella magna* (**Table 3**).

4. Discussion

The avifauna of the Las Mercedes forest with 38 species recorded is rich compared to sites embedded in the urban matrix such as the midpoints of the Molinos canal where the number of species fluctuates around 15[20], which coincides with the greater richness typical of peri-urban areas compared to sites embedded in cities[21,22]. However, the richness is poor compared to other peri-urban localities in Bogotá such as near the eastern hills, where native vegetation is more extensive or wetlands that are characterized by high productivity and variety of habitats where the number of terrestrial species can reach more than 50[23] (data from the ABO Christmas Counts) or other localities at lower elevations[15,24].

The limited number of bird species in Las Mercedes Forest is probably due to the small area, its degree of deterioration[25] and its isolation from other natural areas, since the closest one is the Conejera hill at a distance of 2.4 km. The matrix surrounding a natural area influences the composition of the birds in the area[26,27] and in the Las Mercedes Forest this matrix is mostly covered by pastures and greenhouses, which hinders the movement of bird species with more specific requirements or limited mobility[28].

The positive change observed in the birds of Las Mercedes may be due to the greater heterogeneity in the forest structure resulting from restoration actions such as the removal of aggressive climbing plants such as *Rubus* sp., since birds are associated with vegetation structure and this influences its richness and composition[29]. Such a pronounced increase in *S. subpudica* is probably associated with the same actions that have allowed the growth of a very dense low shrub understory, the preferred habitat of the species[30].

The growth and densification of the vegetation cordon planted around the La Conejera wetland in the 1990s and the corridor that connects the wetland with the forest, as well as the recent planting actions carried out by the Bogotá Botanical Garden, may explain the arrival of species typical of the forests of the Bogotá Savanna such as *Picoides fumigatus*, *Mecocerculus leucophrys*, *Myiothlypis nigrocristata*

and *Arremon torquatus*. This type of habitat enrichment and increased connectivity to increase the conservation value in vegetation islands is a recommendation in urban areas[31] and although the forest is not within the city, it is isolated and the city presents a latent threat; the actions are therefore valid and have been positive.

The study did not record birds common in more extensive forests of the Savannah such as *Scytalopus griseicollis*, *Grallaria ruficapilla*, *Hemispingus superciliaris*, Atlapetes pallidinucha, Anisognathus igniventris, *Penelope montagnii* and hummingbirds such as *Eriocnemis* spp, which indicates that restoration actions planned in the TvdH Reserve Management Plan[7] should be continued to seek more connectivity, enrich and increase areas of scrub and native forest, decrease the paddock matrix, and eliminate greenhouses. These measures would promote the conservation of the last relict of forest in the Bogotá savanna and regional biodiversity.

Although the study does not allow us to conclude on boreal migratory birds because the sampling dates do not coincide exactly between the two years, the fact that the migrants with new records are associated with shrublands, forests and wooded sites coincides with the improvement of habitat in the forest and surrounding areas and supports the concept that the forest, although small, is of value for migratory species[5].

Among the non-migratory species that decreased or disappeared, most are typical of open rural areas such as pastures and crops, ecosystems that have declined in the Sabana de Bogotá[32]. The case of the decline of *B. ibis* in this study is probably due to the disappearance of a heronry of several hundred individuals that was located at the western end of the La Conejera wetland (authors obs. pers.).

Among the species with increases or new records are several from lower elevations that have recently arrived in the Bogotá Savanna. Such shifts are one of the effects of climate change on many organisms including birds[33,34]. One of these species is *V. chilensis*, which had been recorded in Laguna de la Herrera and Faca in the 1960s[35], but never in the northernmost part of the Sabana until around 2000 when it was recorded near the Bogotá River. This species is showing range expansions similar to those recorded in other places such as Brazil[36]. The expansion of this species, although it has been considered an indicator of environmental deterioration, can be beneficial in pastures and open areas since it plays an important role in the biological control of insects[36].

The difference in the sampling periods between the two periods taken into account in this study (September 2001–September 2002, and September–October 2014) could influence the possibility of detecting the species observed. On the one hand, a more intensive survey in 2014 at the beginning of the autumn migration season would make it more possible to locate migrants such as the new species recorded in the forest in 2014 (e.g. *Empidonax* sp., *Vireo olivaceus* and *Piranga rubra*), without this reflecting true changes over time. On the other hand, with a longer sampling such as 2001–2002 one might expect a higher detection of species that are located by their songs and calls assuming that their breeding season occurred in a non-sampled season in 2014. However, in the tropics it is common for resident species to breed throughout the year[37] and they also vocalize all year round because they have permanent territories; the fact that some of the most vocal species (*Colibri coruscans*, *Synallaxis subpudica*) have increased confirms their true increase. *Elaenia frantzii*, a very vocal species, would be expected to record a higher abundance with sampling throughout a whole year (2001/02) and it is precisely one of the species that decreased. Since this species also recorded declines in bird counts in the Sabana de Bogotá over 26 years[15], it is an indication that its decline in the Mercedes forest surely reflects a real trend. Additionally, the fact that several of the species that declined are detected more visually than aurally (*Zenaida auriculata*, *Turdus fuscater*, *Molothrus bonariensis*) leads us to think that the difference in the intensity and extent of the observations does not prevent us from making comparisons and concluding on the results.

Although birds are good indicators of habitat status and may reflect the conservation status of

other biological groups, they may also exhibit different responses to those of other organisms[38,39], so it would be important to study other taxonomic groups.

As in other studies[5] these results support the fact that small peri-urban areas are important to protect and conserve the avifauna of a region, so it is necessary to continue the restoration actions that the Botanical Garden of Bogotá has successfully begun.

5. Conclusion

Our results draw attention to the richness of the local and endemic avifauna that still remains in the forest relict of Las Mercedes, as well as the capabilities and potential for recovery of this important ecosystem as it represents the last relict of native vegetation in the flat part of the Bogotá Savannah. They also demonstrate that the recovery of the avifauna still requires restoration actions and improvement of ecological connectivity proposed by the CAR in the Environmental Management Plan of the Regional Productive Forest Reserve of the North of Bogotá D.C. Thomas van der Hammen, to achieve the conservation of the unique biodiversity of this outstanding biogeographic zone and for the enjoyment and benefit of the inhabitants of Bogota and the world.

Conflict of interest

The authors declared no conflict of interest.

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