



OVERVIEW AND UPDATE OF BIRD RECORDS FROM THE TROPICAL ANDES: IMBABURA PROVINCE, ECUADOR

Actualización de los registros de aves en la provincia de Imbabura, ubicada en los Andes tropicales de Ecuador

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ABSTRACT: Historically, bird lists have constituted a powerful instrument for developing effective legal conservation measures. I present a list of birds from Imbabura Province, which is part of the Tropical Andes, the world's most biologically diverse area. Although Imbabura has been established as a UNESCO Global Geopark and 35% of its surface is protected, the province also has an extensive history of landscape fragmentation and habitat degradation that dates back to pre-Columbian times. I looked through and selected records from the GBIF database (1818–2022). This database considers any biodiversity information sources, from museum specimens, the records of eBird birdwatchers to georeferences of smartphone photos shared by naturalists. I also examined the Google Scholar database and thesis digital repositories, searching for references with records of Imbabura birds. I extracted the geographic coordinates of more recent bird sighting sites (2018–2020), and I uploaded them into a geographic information system overlaid with a land use cover layer. I used 4 classes for land use: (1) URB, anthropic zone; (2) AGR, agricultural land; (3) NAT, both forest as shrubby and herbaceous vegetation; and (4) AQU, water bodies. I estimated each species' occurrence in each landscape. The results are an inventory of 753 bird species recorded in Imbabura, with 146 species categorized under some level of threat. Due to the high number of bird species observed at Imbabura, 45% of the Ecuador birds, public policies, and civil awareness are necessary to engage in conservation actions and other activities supporting the maintenance of this biodiversity. This study underscores the importance of citizen science and free database platforms for research.

KEYWORDS: *avifauna, birds, conservation, global geopark, hotspot, mining, tropical Andes*

RESUMEN: Las listas de aves han sido instrumentos poderosos para desarrollar medidas efectivas de conservación. En este trabajo se presenta una lista de aves de la provincia de Imbabura, que forma parte de los Andes Tropicales, la zona con la mayor diversidad biológica del mundo. A pesar de que Imbabura ha sido reconocida como Geoparque Mundial de la UNESCO y el 35% de su superficie está protegida, la localidad también cuenta con una extensa historia de fragmentación del paisaje y degradación del hábitat que se remonta a la época precolombina. Se seleccionaron los registros de aves para Imbabura, en GBIF (1818–2022). También se examinó Google Scholar y los repositorios digitales de tesis, buscando referencias con registros de aves de la provincia. Los sitios de avistamiento de aves más recientes (2018–2020), se cargaron en un sistema de información geográfica y se vincularon a una capa de cobertura de uso del suelo. Se usaron 4 categorías: (1) URB, zona antrópica; (2) AGR, tierra agrícola; (3) NAT, tanto bosque como vegetación arbustiva y herbácea; y (4) AQU, cuerpos de agua. Se calculó la ocurrencia de cada especie en cada tipo de paisaje. Los resultados son un inventario de 753 especies registradas en Imbabura, con 146 en alguna categoría de amenaza. Debido a la gran cantidad de aves en esta provincia, las cuales representan el 45% de las especies registradas en Ecuador, es fundamental implementar políticas públicas en apoyo a la conservación de esta biodiversidad. Este estudio resalta la relevancia de la ciencia ciudadana y las plataformas de bases de datos gratuitas como herramientas de apoyo a la investigación.

PALABRAS CLAVE: *Andes tropicales, aves, avifauna, conservación, geoparque mundial, hotspot, minería*

The Tropical Andes run from the far north of Chile and Argentina, through Bolivia, Peru, Ecuador, Colombia, and Venezuela and include over 1.5 million km² between 11° N and 30° S with elevation ranging from approximately 500 to over 6000 masl (Bax & Francesconi 2019, Pronaturaleza 2021). This vast region has variable climates, intricate geography, and complex geology enabling the evolution of multiple habitats and extraordinary biological diversity. The tropical Andes is the world's most biologically diverse area and tops the worldwide hotspots for species diversity and endemism (CEPF 2015). Because of this, the region is considered a key priority for biodiversity conservation (C.I. 2005, Mittermeier et al. 2011, Ramírez-Villegas et al. 2014).

Birds are the most diverse vertebrates in this hotspot, with about 2000 species, or 18% of all bird species globally (Pronaturaleza 2021). Bird richness is higher in the Tropical Andes than in any other hotspot worldwide with a third of these species being endemic (Fjeldså et al. 2012, Herzog & Kattan 2012, Pronaturaleza 2021). Despite their ecological value, the Tropical Andes has lost a large percentage of its original habitat and is considered significantly threatened by the large-scale anthropogenically driven transformation and the impacts of climate change (Mittermeier et al. 2011).

Imbabura Province is located in the North of the Andes or "Sierra" in Ecuador (Fig. 1). In 2019, the Province was established as UNESCO Global Geopark because of its fascinating geology, including 11 volcanic complexes, 27 lakes, numerous waterfalls, geological faults, archaeological remains, and an enormous cultural heritage (Hart-Robertson n.d., Prefectura de Imbabura 2019). Approximately 35% of the Province's surface area is protected areas with high bird species richness and are home to some of Ecuador's endangered species (García & Mena 2021). However, the Province also has had an extensive history of landscape fragmentation and habitat degradation that dates back to pre-Columbian times.

The region has been inhabited by sedentary people at least since 2100 B.C., first, by Angos and Imbas for several centuries, and more recently by the Karanki, Otavalo, and Natabuela people (Benítez et al. 2016). The Incas, the Spanish and Afro-Ecuadorian slaves arrived later (Benítez et al. 2016). Historically economic activity in the "Sierra" has included extensive agriculture and livestock (Camacho 2013), and the Imbabura economy continues to be based on these land uses, with more recent additions including the craft textile and leather industries, and tourist services (INE 2010)

Recently, exploratory mining concessions increased from roughly 3% to more than 13% of Ecuador's continental land area (Roy et al. 2018). These activities affect the natural environment through road construction, deforestation, and the sedimentation and contamination of water bodies (Sonter et al. 2017). Unfortunately, most of these concessions are located in the highly biodiverse Andean montane and cloud forests and overlap strongly with International Bird and Biodiversity Areas (Roy et al. 2018). At Imbabura, some forest reserves as "Bosques Protectores", were included in authorized exploratory mining concessions (Vandegrift et al. 2017, Roy et al. 2018). These are buffer areas for Cotacachi-Cayapas National Park, which would be severely affected by surrounding mining exploitation.

Historically bird lists have constituted a simple but powerful instrument for translating scientific information, and conservation needs into effective legal measures (Casado 2013). However, there is no official bird list for Imbabura province. My aim in this work is to compile an updated list of bird species of Imbabura province and provide a preliminary indication of the occurrence of these species in four types of environments: urbanized zones, agricultural land, natural or undisturbed zones, and water bodies.

METHODS

Study Area

Imbabura Province is located between 00°07' and 00°52' N, and 77°48' and 79°12' W encompasses 4587 km² and contains an estimated human population in 2020 of 476 257 (INE 2010) (Fig.1). The region's topography ranges from 200 to 4939 masl with a wide variety of climates including dry and semi-humid mesothermal, humid mega thermal, and high mountain tropical climates with average temperatures that vary between 0°C and 22.9°C and annual rainfall varying between 310 mm and 3598 mm per year (Kreft & Jetz 2007, Instituto Geográfico Militar 2023).

Imbabura has 13 ecosystems that can be grouped into 5 large categories: Páramo, Andean evergreen forests (high montane, montane and premontane), Chocó evergreen forest, dry and semi-arid valleys and wetlands (MAE 2017, García & Mena 2021). Parts of these ecosystems are protected by portions of two national parks: Cotacachi-Cayapas (established in 1968, 260 961 ha) to the west and the Cayambe-Coca (established in 1970, 408 284 ha) to the east in the Pro-

vince. The Cotacachi-Cayapas National Park extends from the top of the volcano Cotacachi at 4939 masl, through Páramo and high Andean forests (Imbabura Province) to the humid forest of Chocó in the lowlands at 50 masl (Esmeraldas Province). Cayambe-Coca National Park extends from the snowy peak of Cayambe volcano at 5790 masl (Imbabura and Pichincha Provinces) to the Amazon forest at 600 masl (Napo y Sucumbíos Provinces) (MAATE 2023).

In addition to these two national parks, the province has a Wildlife Refuge at Pimampiro (established in 2023, 3690.15 ha) and several conservation areas that do not depend on the administration of the State including Decentralized Autonomous Governments Conservation Areas (e.g. Taita Imbabura, established in 2021) as well as community and private reserves (MAATE 2023). The Municipal Reserves Intag Toisán (126 967 ha), located between the Intag River valley and the Toisán Mountain, is an area of cloud forest of high biodiversity (García & Mena 2021). Although a good part of the area has been granted to mining companies by the State, the Court of Imbabura approved a protection action in favor of their preservation because of the imminent threat of these activities (Corte Provincial De Justicia De Imbabura Juicio No. 10332202100937 23).

The Province has 18 reserves of forest classed as “Bosques Protectores” with Los Cedros (6400 ha) (Constitutional Protection Action No. 10332-2018-00640, 2018) and Zuleta (4770 ha) being the largest ones. The first is a private property reserve in the Chocó bioregion, adjacent to Cotacachi-Cayapas National Park and the second is both a private and community reserve which has been allowed to recover the native vegetation of the Páramo and Andean cloud forest (MAATE 2023).

The Cotacachi-Cayapa National Park, Los Cedros Forest Reserve, and Intag Toisán Municipal Reserve are part of a network of sites essential for the conservation of populations of globally threatened and restricted-range bird species (Freile & Santander 2005). The establishment of all these protected areas and the IBAs are indications of the importance of the biodiversity of the Province.

Data analysis

I reviewed and extracted all records of bird species from the Global Biodiversity Information Facility (GBIF) database for Imbabura Province from June 1818 to March 2022 (Table 1). GBIF considers all biodiversity information sources from museum spe-

cimens collected in the Eighteenth and Nineteenth centuries, the records of amateurs and professionals in eBird databases (from 1972 to 2022) to georeferences of smartphone photos shared by amateur naturalists (GBIF.org, 2022). I removed observation records identified only to family or genus and errors based on identifying species by distribution. Also, incomplete and questionable records, such as vague locations or those out of the province. Likewise, records with questionable numbers of individuals, i.e., samples where every species recorded, invariably had 2 or 3 individuals or records with a suspiciously unusual large number for a particular species. To complete the bird list, I reviewed the Google Scholar database (Martín-Martín et al. 2019) and digital repositories of Ecuadorian theses searching for literature reporting bird records in Imbabura Province. I employed the following keywords to perform this search: Imbabura birds, Imbabura Avifauna, Aviturismo Imbabura, and Birds Tourism Imbabura. Taxonomic changes, and distribution extensions, either altitudinal or latitudinal, within an Ecuadorian context, were compared with those reported by the Bioweb database (Freile & Poveda 2019), Freile & Restall (2018), AVIBASE database system (Lepage et al. 2014), McMullan & Navarrete (2013) and Comité Ecuatoriano de Registros Ornitológicos (CERO, Freile et al. 2022). All taxonomy was revised to follow the January 2024 taxonomy of the South American Checklist Committee of the American Ornithologists Union (SACC, Remsen et al. 2022). Freile & Restall (2018) and McMullan & Navarrete (2013) were used to classify bird species' migration. Imbabura's threat level of bird species followed the red list of Ecuador's birds (Freile & Poveda 2019). After cleaning the database, I maintained 77 656 records of GBIF. Then, I extracted the geographic coordinates of every location of bird sightings and compiled those repeated in the identical GPS coordinate, to obtain 2453 geographically located sites of bird sightings (Table 1). The database from GBIF associates a geographic location for each record of a bird without information about whether the record comes from a stationary checklist or with displacement. Nevertheless, eBird rules and best practices recommended lists are brief duration and short distances (i.e., less than 3 h and 8 km, eBird 2020) and starting new lists when crossing to a different habitat or visiting a new spot. I took each GBIF database location as a sample site.

The geographic coordinates of the most recent sites (2018-2022) of bird sightings of eBird (887, Table 1) were uploaded to a geographic information

system (QGIS 3.16). I selected bird records from 2018-2021 because those years correspond to the current land use classification. However, these geographic coordinates of bird sightings are not georeferenced or corrected, thus this method was used as a preliminary approach. I overlaid these locations to a land use cover layer elaborated by the Ecuador Ministry of Environment, Water and Ecological Transition (<http://ide.ambiente.gob.ec:8080/mapainteractivo/>, updated 2020, 1:100 000), using the Spatial Join method. This method allows the matching of records based on their relative spatial locations to a specific type of area. The land use cover layer from the Ecuador Ministry of Environment has six classes defined: forests, shru-

bby and herbaceous vegetation, agricultural land, water bodies (natural and artificial), anthropic zone, and others (areas without vegetation and glaciers). I carried out a 4 km buffer radius around each sample site to calculate approximately the percentage of the Province surface covered with bird records. In this work, I used 4 land use classes: (1) AGR, agricultural land (2) AQU, water bodies (3) URB, anthropic zone and (4) NAT, both forest as shrubby and herbaceous vegetation. No sighting sites were located in the category of other (areas without vegetation and glaciers).

I calculated the total occurrence and occurrence in each landscape of bird species seen in the 887 eBird sightings geographic locations of most recent

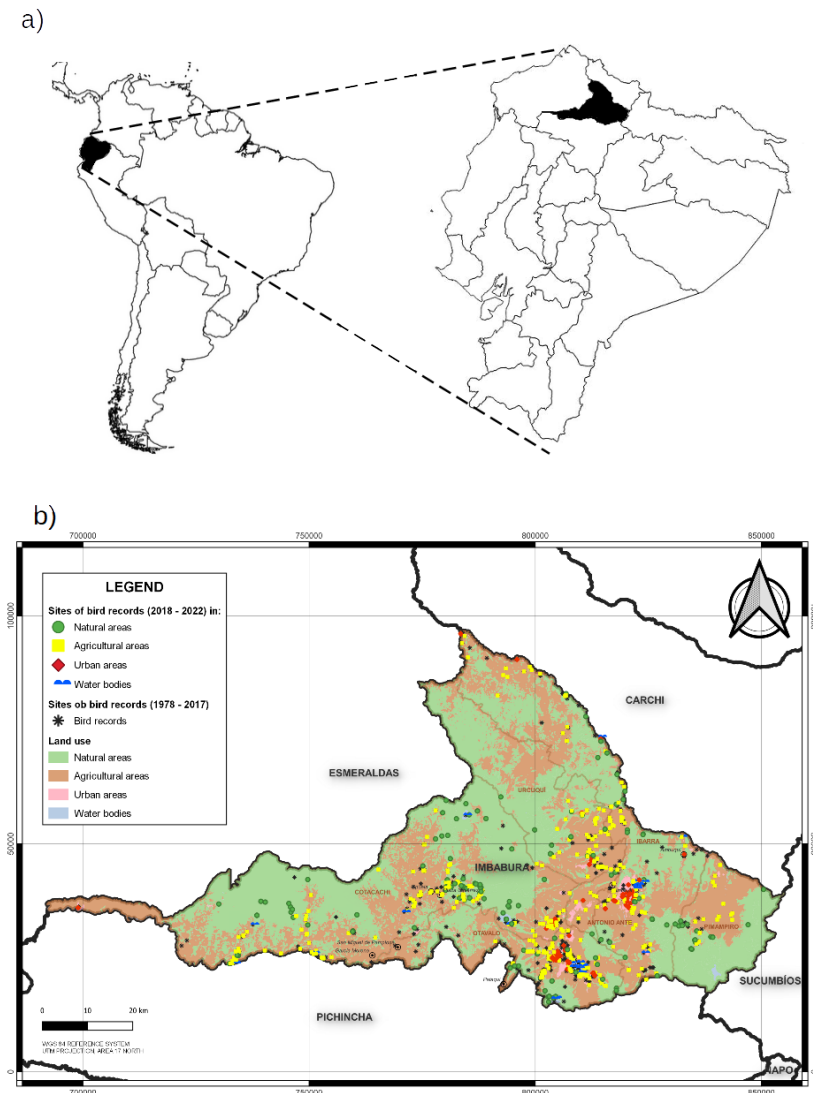


Figure 1. (a) Location of Ecuador and Imbabura Province and (b) the geographically located sighting sites with record of bird species (2018-2022) in RED: urban zone (URB), YELLOW: agricultural land (AGR), GREEN: nature zone both forest as shrubby and herbaceous vegetation (NAT), BLUE: water bodies (AQU) and BLACK: the samples sites with record of bird species (1978-2017).

Table 1. The records number of birds and geographically located sighting sites, at Imbabura Province, obtained from the Global Biodiversity Information Facility Database.

INSTITUTION	Records number	Geographically located sites	Year	
			From	To
inaturalist social network	1583	1071	1980	2022
Louisiana State University Museum of Natural History	452	5	1893	1997
Machine Learning Observation	155	13	1980	2015
The Moore Laboratory of Zoology	70	11	1818	1990
Western Foundation of Vertebrate Zoology	14	0	1987	1990
Harvard Museum of Comparative Zoology	44	8	1893	1965
Museu de Ciències Naturals de Barcelona cord	39	1	1939	1942
Natural History Museum UK ZOO	18	0	1897	1941
Rijksmuseum van Natuurlijke Histoire AVES	7	4	1897	1899
Museu de Biologia Professor Mello Leitão	7	2	1957	
Muséum National d'Histoire Naturelle	6	2	1898	1940
The Santa Barbara Museum of Natural History	6	3	1943	1946
University of Alberta Museum of Zoology	4	0	1899	
Museu Nacional do Rio de Janeiro	3	1	S/F	
American Museum of Natural History	1	1	1899	
Subtotal	2409	1116		
eBird (1972-2017)	21 701	467	1972	2017
eBird (2018-2022)	53 565	887	2018	2022
Subtotal	75 266	1339		
TOTAL	77 675	2453	1818	2022

(2018-2022) (Supplementary material Table 2). The total occurrence was defined as the number of sites where the species was recorded divided by the total number of sighting sites (887) and occurrence in each landscape (URB, AGR, NAT, AQU) was the number of sites where the species was recorded in each landscape expressed as a percentage of the total number of sites in this landscape type, e.g. Rufous-collared Sparrow (*Zonotrichia capensis*), was recorded in 81 of 98 sighting sites in urban areas, so *Z. capensis* occurrence in urban areas was $(81 / 98) * 100 = 82.7\%$. In the water bodies sighting sites (AQU) I selected only waterbirds to avoid underestimating the occurrence of these species. Then, I ranked the 100 most frequent land birds and 34 most frequent waterbird species in each landscape type. Finally, I classified the land bird species in trophic guilds following Poulin et al. (1992, 1994), Poulsen (1994), Rojas & Piragua (2000), and Rodríguez-García et al. (2016). In this work, species occurrences are not equivalent to relative abundance

and they should be taken with due caution because these bird records by birdwatchers are not systematic samples.

RESULTS

After reviewing the GIBF database, 77 675 records remained (1818-2022), of which 98.78% had geographic coordinates. In the literature review, I found 75 publications (1974-2021) and 52 undergraduate and Master's theses (1988-2001) that listed species from Imbabura. These came from the Universidad Técnica del Norte (26), Universidad Central del Ecuador (13), Universidad San Francisco de Quito (4), Pontificia Universidad Católica de Ecuador (5), Universidad Internacional de Ecuador (1), Universidad de la Laguna, Tenerife, España (1), Universidad de California at Davis (1), and Escuela de Postgrado del Centro Agronómico Tropical de Investigación y Enseñanza de Costa Rica (1). Some of the theses had records of European,

Table 2. The number of landbirds and waterbirds recorded at Imbabura Province with conservation and migration status.

	Landbirds	Waterbirds	TOTAL
Species recorded GBFI	656	64	720
References	22	11	33
TOTAL	678	75	753
Migration Status			
Resident	641	41	682
North migrant	32	32	64
South migrant	3	2	5
Introduced	2	0	2
TOTAL	678	75	753
Conservation Status			
Extinct	1	2	3
Critically endangered	4	1	5
Endangered	21	1	22
Vulnerable	40	1	41
Near threatened	69	6	75
Subtotal	135	11	146
Least concern	525	50	575
Not evaluate	18	14	32
TOTAL	678	75	753

African, Asian, and South American species whose distribution does not include Ecuador. Therefore, I carefully selected the information that was useful for this study from these works.

Throughout the review of the GIBF database and literature, I obtained a list of 753 bird species recorded in Imbabura. Among these, 75 are waterbirds and 52 have been sporadically recorded or vagrants (Supplementary material: Table 1 and Table 2). The land bird families with the greatest species were Thraupidae (93), Tyrannidae (87), Trochilidae (70), Furnariidae (42) and Accipitridae (31), whereas the most waterbird species belong to the families Scolopacidae (19), Anatidae (13), Ardeidae (12), and Rallidae (8). Only two introduced species are listed: the House Sparrow (*Passer domesticus*) and the Rock Dove (*Columba livia*). Thirty-two landbirds and 32 waterbirds are Boreal migrants, while 3 landbirds and 2 waterbird species are Austral migrants (McMullan & Navarrete 2013, Freile & Restall 2018). One hundred and forty-six species have been categorized under some level of threat for the country according to the red list of the birds of Ecuador (Freile & Poveda 2019) and appear in the

following categories: 2 local extinct Cinnamon Teal (*Spatula cyanoptera*) and American Coot (*Fulica americana*), 1 possibly local extinct Yellow-eared Parrot (*Ognorhynchus icterotis*) and 5 critically endangered: Black-breasted Puffleg (*Eriocnemis nigrivestis*), Black-and-chestnut Eagle (*Spizaetus isidori*), Great Green Macaw (*Ara ambiguus*) and Subtropical Doradito (*Pseudocolopteryx acutipennis*), and Southern Pochard (*Netta erythrophthalma*); 22 endangered, 41 vulnerable and 75 near threatened (Freile & Poveda 2019) (Table 2, Table 3 and Supplementary material: Table 1).

A 4 km buffer around the geographic coordinates of the most recent sites of bird sightings (2018-2022) results in a sampled area of approximately 3165.88 km² which covers 66% of the total surface of Imbabura (4791.32 km², Fig. 1). Among these 887 most recent sighting sites (2018-2022), 187 are located in natural areas, 508 in agricultural land, 98 in urban areas and 94 in water-bodies. Among 100 species reported most often by birdwatchers (Supplementary material: Table 2), 6 landbirds, and 4 waterbirds were seen in more than 40% of sighting sites: Rufous-collared Sparrow (*Zonotrichia capensis*), Eared Dove (*Zenaida au-*

Table 3. Bird species threatened in Imbabura Province in the following categories: Local EX: locally extinct, CR critically endangered, EN endangered, and VU vulnerable. Imbabura's threat level of bird species followed the red list of Ecuador's birds (Freile & Poveda 2019). Waterbirds highlighted in grey.

	SPECIES	STATUS		SPECIES	STATUS
1	<i>Spatula cyanoptera</i>	Local EX	5	<i>Bangsia rothschildi</i>	VU
2	<i>Fulica americana</i>	Local EX	6	<i>Campephilus gayaquilensis</i>	VU
1	<i>Ognorhynchus icterotis</i>	CR Possibly extinct	7	<i>Chaetocercus bombus</i>	VU
2	<i>Ara ambiguus</i>	CR	8	<i>Chalcostigma stanleyi</i>	VU
3	<i>Eriocnemis nigrivestis</i>	CR	9	<i>Chalybura urochrysis</i>	VU
4	<i>Netta erythrophthalma</i>	CR	10	<i>Circus cinereus</i>	VU
5	<i>Pseudocolopteryx acutipennis</i>	CR	11	<i>Cryptoleucopteryx plumbea</i>	VU
6	<i>Spizaetus isidori</i>	CR	12	<i>Cyanolyca armillata</i>	VU
1	<i>Agriornis albicauda</i>	EN	13	<i>Cyanolyca pulchra</i>	VU
2	<i>Attagis gayi</i>	EN	14	<i>Doliornis remseni</i>	VU
3	<i>Capito quinticolor</i>	EN	15	<i>Dryobates chocoensis</i>	VU
4	<i>Cephalopterus penduliger</i>	EN	16	<i>Eriocnemis derbyi</i>	VU
5	<i>Chrysuronia humboldtii</i>	EN	17	<i>Falco femoralis</i>	VU
6	<i>Cichlopsis leucogenys</i>	EN	18	<i>Grallaria alleni</i>	VU
7	<i>Conirostrum binghami</i>	EN	19	<i>Grallaria flavotincta</i>	VU
8	<i>Dacnis berlepschi</i>	EN	20	<i>Grallaria gigantea</i>	VU
9	<i>Falco deiroleucus</i>	EN	21	<i>Grallaricula lineifrons</i>	VU
10	<i>Falco peregrinus</i>	EN	22	<i>Haplophaedia lugens</i>	VU
11	<i>Geotrygon purpurata</i>	EN	23	<i>Harpia harpyja</i>	VU
12	<i>Glaucidium nubicola</i>	EN	24	<i>Hylopezus perspicillatus</i>	VU
13	<i>Leptosittaca branickii</i>	EN	25	<i>Iridosornis porphyrocephalus</i>	VU
14	<i>Micrastur plumbeus</i>	EN	26	<i>Leucopternis semiplumbeus</i>	VU
15	<i>Neomorphus radiolosus</i>	EN	27	<i>Lipaugus unirufus</i>	VU
16	<i>Oreothraupis arremonops</i>	EN	28	<i>Margarornis stellatus</i>	VU
17	<i>Penelope ortonii</i>	EN	29	<i>Odontophorus erythrops</i>	VU
18	<i>Pyroderus scutatus</i>	EN	30	<i>Odontophorus melanonotus</i>	VU
19	<i>Sarkidiornis sylvicola</i>	EN	31	<i>Ortalis erythroptera</i>	VU
20	<i>Scytalopus chocoensis</i>	EN	32	<i>Penelope purpurascens</i>	VU
21	<i>Vireo masteri</i>	EN	33	<i>Podiceps occipitalis</i>	VU
22	<i>Vultur gryphus</i>	EN	34	<i>Pyrilia pulchra</i>	VU
1	<i>Andigena hypoglauca</i>	VU	35	<i>Sclerurus guatemalensis</i>	VU
2	<i>Andigena laminirostris</i>	VU	36	<i>Setophaga cerulea</i>	VU
3	<i>Andigena nigrirostris</i>	VU	37	<i>Sipia nigricauda</i>	VU
4	<i>Attila torridus</i>	VU	38	<i>Spizaetus melanoleucus</i>	VU
			39	<i>Spizaetus tyrannus</i>	VU
			40	<i>Tephrophilus wetmorei</i>	VU
			41	<i>Xenerpestes minlosi</i>	VU

riculata), Sparkling Violetear (*Colibri coruscans*), Blue-and-white Swallow (*Pygochelidon cyanoleuca*), Golden Grosbeak (*Pheucticus chrysogaster*), Great Thrush (*Turdus fuscater*), American Coot (*Fulica ardesiaca*), Cattle Egret (*Bubulcus ibis*), Neotropic Cormorant (*Phalacrocorax brasilianus*) and Ruddy Duck (*Oxyura jamaicensis*). Seven species have been frequently recorded in urban areas: Rufous-collared Sparrow, Eared Dove, Sparkling Violetear, Least Vermillion Flycatcher (*Pyrocephalus rubinus*), Hooded Siskin (*Spinus magellanicus*), Tropical Mockingbird (*Mimus gilvus*) and Rock Dove. Thirteen species occurred at higher frequencies both in intervened areas: urban and agricultural with Blue-and-white Swallow, Golden Grosbeak and American Kestrel (*Falco sparverius*) most often represented. Thirteen species were most frequently seen in agricultural land with Black Vulture (*Coragyps atratus*), Tropical Kingbird (*Tyrannus melancholicus*) and House Wren (*Troglodytes aedon*) being recorded in more than 25% of AGR sighting sites. Thirty species were recorded with higher occurrence in both natural and agricultural land, and 28 species had lower or no records in urban landscapes and were found most often, or only, in natural areas. The most frequent species representing this case were Band-tailed Pigeon (*Patagioenas fasciata*), Masked Flowerpiercer (*Diglossa cyanea*), Crimson-mantled Woodpecker (*Colaptes rivoalii*), Yellow-breasted Brushfinch (*Atlapetes latinuchus*), Chestnut-crowned Antpitta (*Grallaria ruficapilla*), Tyrian Metaltail (*Metallura tyrianthina*) and Scarlet-bellied Mountain-Tanager (*Anisognathus igniventris*).

DISCUSSION

In this work, I provide a list of birds for Imbabura Province using the most recent taxonomy of the South American Checklist Committee of the American Ornithologists Union (SACC, Remsen et al. 2022). Imbabura province has an extraordinary bird diversity, with at least 753 bird species representing 45% of Ecuador's birds (1736 species: 1686 confirmed and 50 undocumented, Freile et al. 2022, CERO version December 2023). This bird list could constitute an instrument for developing effective legal conservation measures. Although there are bird lists of some Important Bird Areas (IBA) in the Province, such as Cotacachi-Cayapa National Park and protected forests Intag-Toisán, Los Cedros, Zuleta, and Siempre Verde, and the Bioweb virtual encyclopedia, so far, there is no official list of Imbabura birds. Thus, this first list is valuable input that will be useful for the corroboration in the field and with other experts to establish a final official list.

The tropics' steady supply of solar energy, abundant rainfall, the influence of the Chocó bioregion, and the region's diverse topography are all possible factors of this high level of biodiversity (Pronaturaleza 2021). Imbabura, like the rest of the Ecuadorian Andes, is distinguished by a large range of altitudes (200–4939 masl) within a relatively narrow area (e.g., 150 km), which generates a wide variety of microclimates and ecosystems in the region (Pronaturaleza 2021, Trew & Maclean 2021). Imbabura is recognized as the “blue” or “lakes province” due to has of 27 lake systems, along with numerous rivers and waterfalls. Despite Ecuador having 19 Ramsar sites, none of the wetlands in Imbabura Province have received international importance designation from this convention. The wetlands in Imbabura are the habitat of, at least, 40 common waterbird species, among which 17 are migratory.

Although this province has been established as UNESCO Global Geopark and approximately 35% of its surface comprises protected areas (PDOT Imbabura 2015-2035) the province also has an extensive history of landscape fragmentation and habitat degradation that dates back to pre-Columbian times (García & Mena 2021). In Ecuador, large areas of the Andes have been traditionally used for agricultural activities including extensive livestock production. Agricultural practices have eliminated native forests and have led to soil erosion. The most frequent vegetation in the Páramos, called “pajonal”, is a result of persistent burning and grazing which eliminates original vegetation composed mainly of tall shrubs and small trees: paramerous shrubs, caulescent rosettes, dwarf sclerophyllous shrubs, non-graminoid-grasses, and *Polylepis* forests (Camacho 2013, Castiblanco-Álvarez et al. 2021).

The increase in agricultural activities and the use of agrochemicals as well as, more lately, mining activities have been altering the natural ecosystems of the Province (PDOT Imbabura 2015-2035). In particular, mining has become a notable threat to the conservation of Imbabura's biodiversity, after mining concessions were granted on a high percentage of the Andean cloudy forests (Roy et al. 2018). Intervented areas are expanding at significant rates all over the world, with well-recognized adverse effects on biodiversity (Piano et al. 2020). By selecting three land uses, URB, AGR, and NAT in the Province landscape, I established a gradient of human intervention with changes in native vegetation. Usually, these conditions could also implicate increased air and soil temperatures, atmospheric and water pollution, increased noise, and light night levels (McDonnell & Hahs 2008).

The characteristics of bird species that contribute to their success in these novel conditions remain unclear (Tryjanowski et al. 2020). However, as regards trophic guilds, has been reported in several studies that omnivorous and granivorous species are favored by urbanization, carnivores, and specialized insectivores are negatively affected, while frugivores are favored, as long as, there is abundant vegetation, especially fruit-bearing plants (Lim & Sodhi 2004). Additionally, species that inhabit a diverse range of habitats demonstrate greater adaptability to changes in land use compared to those restricted to a limited number of habitat types (Sohil & Sharma 2020).

Although species occurrence records by birdwatchers are not the product of systematic sampling and do not represent the relative abundance of species, they can allow preliminary observation of adaptive responses of some birds to human intervention. I observed that (1) several species were recorded by bird watchers more often in the built-up areas, showing a possible positive response to the environmental intervention. These “urban exploiters” or human commensals, such as Rufous-collared Sparrow, Eared Dove, Sparkling Violetear, Least Vermillion Flycatcher, Tropical Mockingbird, Hooded Siskin and Rock Dove, naturally inhabit open landscapes and have a more generalist diet where they can combine grains, insects, fruits, plant material, nectar, including human scraps. Several of these species are ground foragers and benefit from the open spaces in intervened areas. (2) Various species were recorded more frequently in both urban and agricultural areas, such as Blue-and-white Swallow, Golden Grosbeak, American Kestrel, Blue-gray Tanager, Western Emerald and Scrub Tanager, which may seem to be “intervention tolerant species” but occur in highly vegetated areas and belong to different foraging guilds, mainly generalist, frugivores e insectivores. (3) Other species seems to prefer agricultural areas, such as Black Vulture, Tropical Kingbird and House Wren, which could take advantage of abundant vertebrates or invertebrates in the cultivation areas or simply prefer more open environments getting food or nesting. (4) The following group of species are “urban avoiders”, such as Azara’s Spinetail (*Synallaxis azara*), White-tipped Dove (*Lepotila verreauxi*), Slate-throated Redstart (*Myioborus miniatus*), Smoke-colored Pewee (*Contopus fumigatus*) and Flame-rumped Tanager (*Ramphocelus flammeigerus*) which are mainly insectivores, frugivorous and granivores more specialized that are more frequently seen in agriculture and natural areas. (5) The last group are “intervened environments avoiders”, such

as Band-tailed Pigeon (*Patagioenas fasciata*), Tyrian Metaltail (*Metallura tyrianthina*), Scarlet-bellied Mountain-Tanager (*Anisognathus igniventris*), Andean Guan (*Penelope montagnii*), Chestnut-crowned Antpitta (*Grallaria ruficapilla*) and Tawny Antpitta (*Grallaria quitensis*) which are forest-woodland species, as well as specialized insectivores, nectarivorous or frugivores. This last species group seem to be more affected than generalist species of open or semi-open habitats by the advance of urbanization and agricultural frontiers.

The impact of human activity on the regions has led to the local extinction of two species Cinnamon Teal and American Coot, while the Yellow-eared Parrot, Colombia and Ecuador Andes endemics, faces potential extinction. This parrot heavily depends on wax palms (*Ceroxylon* sp.) as a critical component of its diet and nesting site. Factors such as hunting and habitat destruction, particularly the historical practice of annually cutting down wax palms for Palm Sunday, have significantly impacted its populations. Fortunately, strong conservation efforts in Colombia’s Central Andes have led to an increase in the population trend, with 2600 individuals in 2019 (Birdlife International 2020). From there, the species is still expanding its range and reoccupying historical breeding sites. Thought is potentially extinct in Ecuador, because although there have been unconfirmed reports of flocks in the Intag Valley, searches conducted in Imbabura and Carchi, the last known strongholds, were unsuccessful (Birdlife International 2020) Proposals have been made recently to conserve certain habitats to reintroduce the species in the places where it has historically been reported in the country (Jácome 2018).

Finally, the results of this study suggest that considering the high number of bird species observed at Imbabura and the possible loss of bird diversity due to the expansion of agriculture, urbanization, and mining, there is a need to reinforce public policy and civil awareness to engage in conservation actions and other activities supporting the maintenance of this biodiversity. Scientific research, publications, and high-quality thesis guided by specialized supervisors in the area are essential to help know and conserve Ecuador’s biodiversity. This study also underlines the value of citizen science and open data platforms like eBird, the International Global Biodiversity Information Facility (GBIF), Avibase, and Bioweb. These platforms allow data and collections available to a broader range of researchers, strengthening the possibilities for specimen-based research.

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