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Ciento dos aves conspicuas a través de una gradiente de elevación en los Andes occidentales del centro de Perú

One hundred and two conspicuous birds across an elevation gradient in the western Andes of central Peru

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Abstract

Birds are the most diverse group of vertebrates, who through flight can move small to long distances, however their distributions can be constrained by environmental variables such as temperature and precipitation which change with altitude in the Andes. The objective of the study was to determine the richness and abundance of birds for vegetation types across an altitude gradient. Bird species and abundance were measured using point counts and by total counting, supplemented by opportunistic records, surveys were conducted in October 2015. We recorded 102 conspicuous bird species of which eight are endemic species reported for Peru. The greatest richness of bird species was between 2,000 and 3,000 m, but there were differences in the distribution pattern of species richness between water-associated habitats against non water-associated habitats. We concluded that bird diversity from the Chillón valley is influenced by altitude and this pattern is representative of the western slope of central Peru.

Keywords: Andean slopes, birdwatching, Canta, Chillón river, endemism, Lima.

Resumen

Las aves son los animales vertebrados más diversos, que a través del vuelo pueden moverse de pequeñas a largas distancias, pero sus distribuciones también están sujetas a la interacción con variables ambientales como la temperatura y la precipitación que cambian con el nivel altitudinal en los Andes. El objetivo del estudio fue determinar la riqueza y abundancia de aves para los tipos de vegetación ubicados en diferentes niveles de altitud. Los métodos son puntos de conteo y por conteo total, complementados por registros oportunistas; las evaluaciones se llevaron a cabo en octubre de 2015. Registramos 102 especies conspicuas de aves, de las cuales ocho son especies endémicas reportadas para Perú. La mayor riqueza de especies de aves se encuentra entre 2000 y 3000 m, pero existen diferencias en el patrón de distribución de la riqueza de aves entre hábitats asociados al agua y hábitats no asociados al agua. Concluimos que la diversidad de aves del valle de Chillón es diferente según el rango de elevación y es representativa de la ladera occidental del centro de Perú.

Palabras clave: Laderas andinas, observación de aves, Canta, río Chillón, endemismo, Lima.

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Introduction

Birds are a mega-diverse biological group within vertebrate animals, there are more than 10,000 recognized species (Gill *et al.*, 2020) which is constantly increasing (Isler *et al.*, 2020), estimating that there are close to twice the currently recognized species (Barrowclough *et al.*, 2016). Birds have important roles in trophic networks, functioning in every trophic category except primary producer and decomposer (Whelan *et al.*, 2016). Furthermore, they are considered excellent bioindicators of environmental disturbances (Brisbin Jr 1991; Morrison 1986; Ormerod & Tyler 1993; Temple 1988).

The avifauna of Peru is the second most diverse in the world (Avibase, 2020), with 1,870 species (Plenge 2020). The department of Lima alone has about 370 bird species, of which 18 are endemic to country (Plenge 2020; Schulenberg *et al.*, 2010).

The first studies of birds in the department of Lima were carried out by Maria Koepcke, who wrote the first checklist of birds for this area (Koepcke, 1964, 1970) and analysed the distribution of birds across elevation gradients (Koepcke, 1954a). Koepcke also started a research programme on the dry cloud forests of Zárate in Lima (Koepcke, 1954b, 1958), where ornithologists continue to focus their research (Franke, 1992, 1994, 2015; Franke & Valencia, 1984; Salinas *et al*., 1993, 1999; Valencia & Franke, 1980). Other studies on the birds of Lima have focused on urban birds (Gonzalez, 2003, 2004a, 2004b; Gonzalez *et al*., 1998; Sernaqué *et al*., 2014), lowlands birds (Gonzalez, 2002, 2003), sea birds (Velarde, 2008), the birds of the fog oasis so called "lomas" (Wust, 1987), and bird-watching (Lüthi, 2011).

Peruvian Andes, contains huge latitudinal and altitudinal climatic gradients (Valencia, 1990), considered one of the main causes of the enormous biological richness of the country (Braun *et al*., 2019). But there are regions like the western slopes of the central Andes where the altitudinal gradient is particularly remarkable (Franke, 2010). On the western slopes of the Andes, temperatures and precipitation values are lower than would be expected in these tropical latitudes (Johnson, 1976), observing temperature decreases of 4.2°C per 1000 m (Montgomery, 2006), and characteristic daily variation in temperature each altitude level (Franke, 2010; Linacre, 1982). However, in the elevations below 1,500 m environment shows thermal inversions between June and October (Enfield, 1981; Prohaska, 1973). The Chillón valley has lower precipitation in the low altitudes compared with the high elevations, also precipitation is markedly seasonal across all valley (Valencia, 1990).

There are few studies about distribution patterns of vertebrate animals in the western Andean slopes (Pearson & Pearson-Ralph, 1978) compared with the eastern Andes (Patterson *et al*., 1996, 1998), even though the western Andean slopes contain a greater diversity of contrasting habitats, species (Franke, 2010) and endemics (Cracraft, 1985). The Chillón valley between sea level to 5,000 m provides an optimal location to study species distribution patterns, as the valley contains most vegetation types present in the western Andes from desert fog oasis called lomas at sea level to puna in the highest elevations.

It is almost a rule of life that abundance and diversity of resources leads to abundance and diversity of consumers (Worm *et al*., 2002). Thus, vegetation types with diverse vegetation and high cover would have better food supply and habitat for birds or at least affect their bird species richness, composition, or abundance (Godoi *et al*., 2017), even interdependence and mutualistic interactions between birds and plants can be created (García, 2016).

Consequently, it is necessary to know the diversity of birds by type of vegetation to understand their relationship with plants. In addition, as the animals such as birds not only depend on food or habitat but also depend on non-biological resources such as water, therefore, we group the types of vegetation as water-associated habitats and non water-associated habitats to analyse the richness of birds in these two groups of vegetation.

Material and methods

Study area and taxonomic identifications

The study area covers the Chillón valley, between 700–4800 m on the slopes of western Andes in the department of Lima, Peru (Fig. 1). A total of one hundred point were evaluated by the method of point counts for the ten vegetation type and one by total counting for lagoon (Table 1), we also included opportunistic records (at libitum observations in every station) as qualitative inventory by each vegetation type. We employ a technique according to the procedure specified by Gregory *et al.* (2004) Ralph *et al*. (1995) and Bibby *et al*. (1992a, 1992b, 1998). The point counts were in intervals of 100 m, along a 1 km transect where each point is evaluated for 10 minutes. The evaluations by point counts were made between 07:00 a.m. to 4:00 p.m. Plots were surveyed for four days during the dry season (October) in 2015. The visual detection of the species was done through Eikow airport binoculars (10 X 50). The identification was made in the field with the help of specialized literature (Schulenberg *et al*., 2010). The hierarchical ordering of the species was carried out as proposed by Plenge (2020).

Ecological analyses

Some ecological parameters such as specific richness (S) and the relative abundance of birds as well as test for differences species richness of birds between sites were calculated. Total species richness of birds was estimated for the 11 study sites with the program EstimateS Win 8.20 randomizing samples (=study sites) 50 times (Colwell 2005). Species accumulation curve (Clench, 1979) and the \"local study\" (an intensive, long-term investigation of a small area were calculated with 95% confidence intervals using the program Statistica version 7.1 (Statsoft Inc., 2005). To compare species composition between survey sites Morisita-Horn index (IM-H) were calculated with the software PAST (Hammer et al., 2001).

Results

Bird species richness

We registered 102 bird species, representing 88 genera, 35 families and 17 orders (Appendix A1, Figure 5-8). The order Passeriformes (flycatchers, finches, seedbeds, swallows, sparrows, etc.) was the most well represented group with 50 species, followed by the Apodiformes (swifts and hummingbirds) with 10 species, and Columbiformes and Charadriiformes with six species each; the remaining orders were represented by one to five species (Table 2). Eight species recorded, White-cheeked Cotinga *Zaratornis stresemanni* (Cotingidae), Rusty-bellied Brushfinch *Atlapetes nationi* (Emberizidae), Rusty-crowned Tit-Spinetail *Leptasthenura pileata*, Thick-billed Miner *Geositta crassirostris* (Furnariidae), Black-necked Woodpecker *Colaptes atricollis* (Picidae), Rufous-breasted Warbling-Finch *Poospiza rubecula* (Thraupidae), "Black Metaltail" *Metallura phoebe* (Trochilidae) and Bronze-tailed Comet *Polyonymus caroli* (Trochilidae) are endemic to Peru.

The most diverse families are Thraupidae with 12 genera and 16 species, Tyrannidae (9/11), Trochilidae (9/9), Furnariidae (5/6), Columbidae (4/6), Anatidae (5/5), Ardeidae (3/4), Scolopacidae and Emberizidae (3/3 each), Acipitridae and Falconidae (2/3 each), these families group 68% of genera and species registered in the study area (Figure 5). Trochilidae and Furnariidae have two endemic species each, and Emberizidae, Thraupidae, Cotingidae and Picidae have one each.

Seventy-five genera (86%) are represented by a single species and the other 14 genera *Cinclodes, Colaptes, Egretta, Falco, Geranoaetus, Metriopelia, Muscisaxicola, Ochthoeca, Phrygilus, Pipraeidea, Poospiza, Sicalis, Spinus and Zenaida* have two species each.

The relict forest and the middle riparian zone had the highest species richness with 52 and 37 species respectively, following by lower riparian zone with 35 species, upper riparian zone and high Andean shrubland with 20 species each. In contrast, the desert zone had only one species (Table 3).

The greatest richness of bird species was recorded between 2,000 and 3,000 m. The water-associated habitats had a uniformly high level of species richness from 800 to 3,000 m, then the species richness decreased above 3,000 m. The non water-associated habitats showed the same trend but with a much lower overall species richness (Fig. 2).

Bird abundance

A total of 740 individuals were registered for 72 species. Puna Ibis *Plegadis ridgwayi* was the most abundant species with 150 individuals (20%), followed by Andean Goose *Oressochen melanopterus* with 51 individuals (7%) and Mountain Parakeet *Psilopsiagon aurifrons* with 50 individuals (7%). Other species with more than fifteen individuals each were Rufous-collared Sparrow *Zonotrichia capensis*, Blue-black Grassquit *Volatinia jacarina*, Blue-and-white Swallow *Pygochelidon cyanoleuca*, White-winged Cinclodes *Cinclodes atacamensis*, Andean Flicker *Colaptes rupicola*, Croaking Ground Dove *Columbina cruziana*, Andean Swift *Aeronautes andecolus* and West Peruvian Dove *Zenaida meloda*. Bird abundance followed a hollow curve distribution, the ten most abundant species accounted for more than 57% of total individuals, whereas 85% of the species were rare – accounting for less than 2% of total abundance each. Wetlands registered the greatest abundance of individuals (207), following by lower riparian zone with 168, high Andean shrubland with 77, relict forest with 72, middle riparian zone with 55, upper riparian zone with 39, rocky places with 37, lagoon with 35, cactus zone with 29, grassland with 20, and desert zone with only one individual (Table 3).

In non water-associated habitats, the desert zone only harboured one species, the Lesser Nighthawk *Chordeiles acutipennis*. The species with highest relative abundance in the cactus zone were the Eared Dove *Zenaida auriculata* (34%) and Purple-collared Woodstar *Myrtis fanny* (24%), in relict forest the Andean Swift and Giant Hummingbird *Patagona gigas* (11% each), in high Andean shrubland the Rufous-collared Sparrow *Zonotrichia capensis* (31%) and Peruvian Sierra-Finch *Phrygilus punensis* (9%), in grassland were Andean Flicker (65%) and Bright-rumped Yellow-Finch *Sicalis uropigyalis* (15%), in rocky place were White-winged Cinclodes (35%) and Plumbeous Sierra-Finch *Phrygilus unicolor* (19%).

In water-associated habitats, the species with highest relative abundance in lower riparian zone were Mountain Parakeet (30%) and Blue-black Grassquit (20%), in middle riparian zone were Blue-and-white Swallow (38%) and Chiguanco Thrush *Turdus chiguanco* (14%), in upper riparian zone were Puna Ibis (41%) and Andean Swift (21%), in wetlands were Puna Ibis (64%) and Andean Goose (22%), and in lagoon were Crested Duck *Lophonetta specularioides* (29%) and Andean Goose (17%).

Beta diversity

According to the Morisita-Horn quantitative index (IM-H) the greatest similarities were observed between wetlands (W) and the upper riparian zone (UR); grassland (G) and rocky place (R); relict forest (F) and high Andean shrubland (S); and finally, between lower riparian zone (LR) and cactus zone (C). Also, there are two groups defined by a similarity greater than 10%; the first group is formed by vegetation type that share the presence of a shrub physiognomy (C, MR, LR, F and S); the second group is made up of vegetation types characteristic of the puna (G, R, W and L) except the upper riparian zone (UR) (Fig. 3).

Species accumulation curve

According to the analysis of the species accumulation curve with quantitative data, the curve fits the Clench model (R = 1.0000), thus the maximum number of bird species predicted is 98. In this evaluation we found an accumulation curve near to asymptote (Figure 4). With the evaluation at the point counts and total counting, a total of 72 species was recorded, representing 73% of the birds estimated for the study area. However, with the qualitative evaluation, 102 species were registered in total, managing to exceed the estimated number of species.

Discussion

All birds species from Chillón valley have been previously recorded for the department of Lima (Franke, 1994; Franke & Valencia, 1984; Koepcke, 1954a, 1964, 1970; Valencia & Franke, 1980). However, 102 of bird species registered in the present study represent 28% of the 370 registered species for Lima (Schulenberg *et al*. 2010). Furthermore, of the 18 endemic species indicated by Plenge (2020) and Schulenberg *et al*. (2010) for the department of Lima, eight species were registered in the study area (44%), this percentage being considerable because the study area only represents one of the 10 great valleys in this department. The remaining ten endemic species were probably not recorded in the present study because they either occur outside the elevation range in this study (below 700 m), or occur in areas separated by deep valleys (Franke, 1991), or because they are so rare as to be unlikely to be picked up in a survey of this nature.

The marked altitudinal climatic gradient on the western slopes of central Peru implies a correlation with the distribution of organisms (Terborgh, 1971), especially birds (Koepcke, 1954a). When taking the climate as a limiting factor for the distribution of birds, we highlight the coincidence of the area of greatest climatic stability between 2,000 and 3,000 m (Franke & Valencia, 1984) as the area of greatest development of the vegetation of the western slope (Weberbauer, 1945), and precisely in this altitudinal range we registered higher levels of species richness (37 in water-associated habitats and 52 in non water-associated habitats), confirming other local and regional reports indicating that the peak of montane diversity is at mid-elevations (McCain, 2009; Zizka & Antonelli, 2018).

The small relict forest of Huarimayo (120 ha), stands out in this study for containing the highest levels of species richness in the Chillón valley, supporting its designation as the most biodiverse vegetation type in the western Andes of central Peru (Franke & Valencia, 1984). Furthermore, Huarimayo harbours seven of the eight endemic species reported in this study (Rusty-crowned Tit-Spinetail, Black-necked Woodpecker, White-cheeked Cotinga, Black Metaltail, Rufous-breasted Warbling-Finch, Rusty-bellied Brushfinch and Bronze-tailed Comet). We think that it is likely that the structural stability of the ecosystem (it is not greatly affected by seasonality) is the main reason for this high diversity. Therefore, we propose this relict forest as a priority area for conservation. In contrast, the desert zone registered fewer bird species due to its adverse climatic conditions that do not allow significant plant growth (Gonzáles et al., 2015), offering few resources for birds.

Habitat is considered one of the determining factors in avian community composition at the local level (Cody, 1981; Mac Nally *et al*., 2004; MacArthur, 1964). However, there is ongoing debate if it is the physiognomy of the vegetation or plant species composition that is the significant predictor for bird species composition (Müller *et al*., 2010). There are 234 plant species in the Huarimayo relict forest (Gonzáles *et al*. unpublished data), making it the most diverse vegetation type known in the Chillón Valley, as well as the most diverse for bird species (52 spp.). Gonzáles (2015) recorded 185 plant species for the lower riparian zone (35 bird species), 179 plant species to cactus zone (11 bird species) and 15 plant species to desert zone (1 bird species). However, the height of the vegetation, number of layers, and the diversity of biological forms contribute to the complexity of the vegetation structure (Rutten *et al*., 2015), vegetation provides the main structure of the environment. This complexity can facilitate biodiversity and ecosystem services. Therefore, measures of vegetation structure can serve as indicators in ecosystem management. However, many structural measures are laborious and require expert knowledge. Thus, the Huarimayo relict forest has also the most complex vegetation structure with trees up to 3 m height on average, six layers of vegetation and eight types of life form. Therefore, both floristic composition (MacArthur, 1964; Rotenberry, 1985) and the structure of the vegetation (Müller *et al*., 2010) are influential in the composition of birds. However, other important factors as the quality of habitats and successional stages would be important for the maintenance of high bird species richness and the presence of rare species (Reif et al., 2013).

The stream of water in the valleys is the only continuous connection between the sea and the mountains and run through narrow valleys forming the riparian zone (McClain & Naiman 2008). Some plants and animals are reliant on rivers and use them as a means of dispersal (Johansson *et al*. 1996), in addition, many birds also frequent water-associated habitats for forage or refuge (McCain 2009). Upper riparian zone shares more bird species with wetland and lagoons than other riparian zone; on the other hand, the low and middle riparian zone are more similar. Furthermore, the typical birds of the lagoons and wetlands go down to the upper riparian zone; but the typical birds of the lower riparian zone (near to sea) go up to the middle riparian zone but in both cases the species flow is less frequent in the opposite direction. Therefore, in water-associated habitats, Andean zone and low-middle riparian zone can be distinguished.

In non water-associated habitats, we find contiguous vegetation types with a large number of shared bird species such as the grassland and the rocky zone, but we can find disjunct areas (20 km apart) with many shared species such as the relict forest and the high Andean shrubland. Apparently the distance is not a determining factor, what would probably be more influential is the vegetation structure (Müller *et al*., 2010) as well the composition and the floristic similarity of those areas (Rotenberry, 1985), since the rocky zone and the grassland have less diversity of plants compared to the shrubland and the relict forest.

In the Andean mountains, bird species richness decreases towards higher elevations (McCain, 2009; Quintero & Jetz, 2018; Zizka & Antonelli, 2018). Bird species richness in water-associated habitats along the Chillón river is high and constant from 800 to 3,000 m, but that contrast sharply with the arid and steep landscape non water-associated habitats, where to low elevations the bird species richness is almost none, increasing gradually up to 3,000 m. Our results show the importance of rivers in bird diversity since they act as biological corridors along the elevation gradient (Remsen jr. & Parker III, 1983; Rushton *et al.*, 1994), which should be included and considered in the management and conservation plans (Lv *et al.*, 2019).

Species accumulation curve helps interpret the amplitude of the sampling effort made (Ugland *et al.*, 2003). Species accumulations curve tended to achieve an asymptote indicating the sampling effort was satisfactory, since 73% of the birds estimated for the study area have been recorded, coinciding with the range of 60 to 100% recorded in studies of this type (Colwell & Coddington, 1994; Servat *et al.*, 2013).

The Chillón valley contains a great diversity of vegetation types (Gonzáles *et al.*, 2015), it is a good example of the pattern found in all of the great valleys western Andes in central Peru, but it is also typical in the huge negative impact of anthropogenic activities on bird species composition, mainly by the destruction of natural habitat by conversion to agriculture, which is likely to affect each bird species differently.

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Authors contribution

Both authors participated equally in the development of this work. EC and PG: conducted the sampling, data analysis & interpretation, and the preparation of the manuscript.

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The authors declare that they have no conflict of interest.

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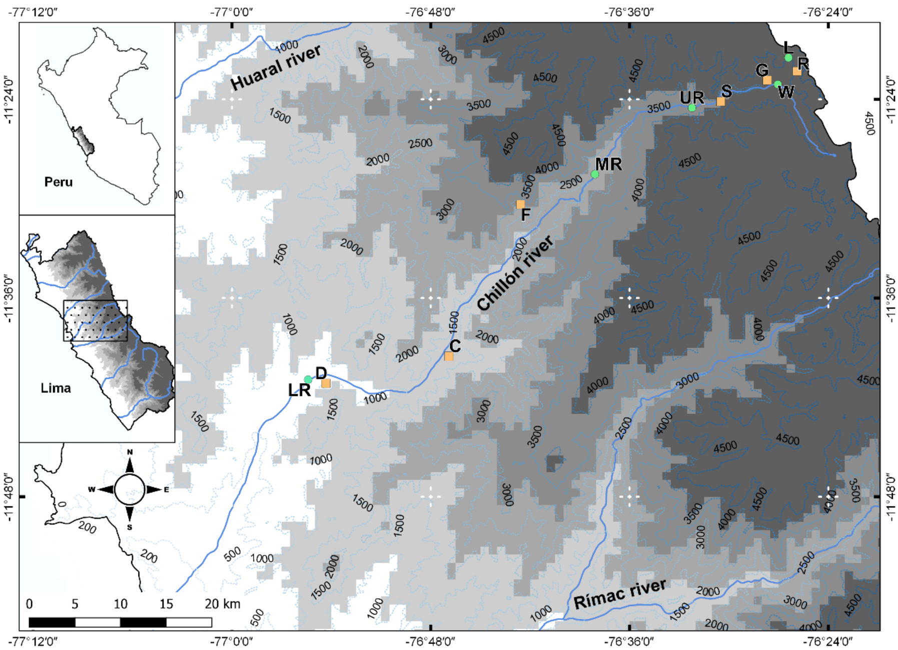

Fig. 1. Sampling points in the Chillón valley. Showing water-associated habitats (green circle) and Non water-associated (orange square), C) Cactus zone, D) Desert zone, F) Relict forest, G) Grassland, L) Lagoon, LR) Lower riparian zone, MR) Middle riparian zone, R) Rocky places, S) High Andean shrubland, UR) Upper riparian zone and W) Wetlands.

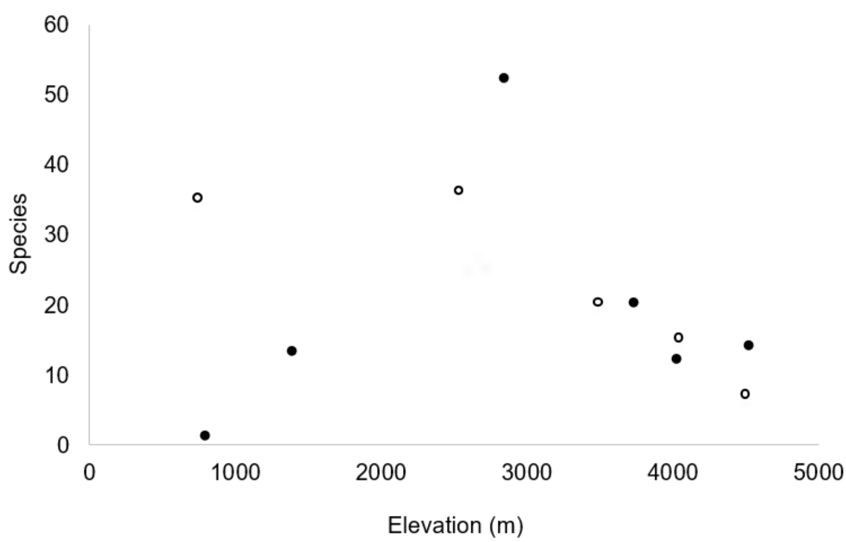

Fig. 2. Bird species richness by elevations in the western Andes of central Peru. Water-associated habitats (black circle) and habitats non water-associated habitats (white circle).

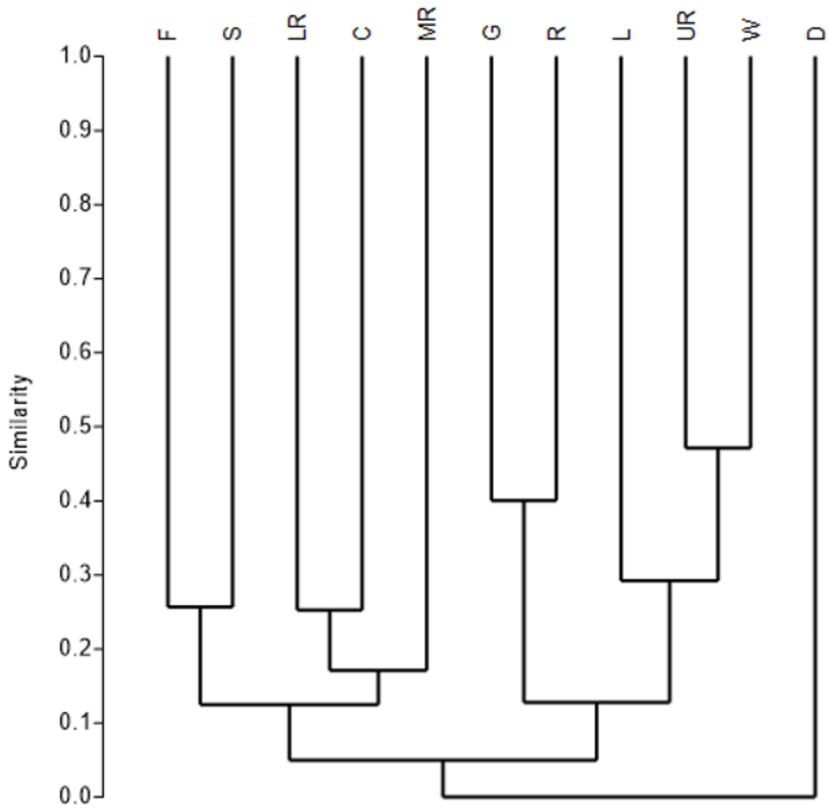

Fig. 3. Similarity of birds between vegetation type in the Chillón valley, with Morisita-Horn index (IM-H). Where C) Cactus zone, D) Desert zone, F) Relict forest, G) Grassland, L) Lagoon, LR) Lower riparian zone, MR) Middle riparian zone, R) Rocky places, S) High Andean shrubland, UR) Upper riparian zone and W) Wetlands.

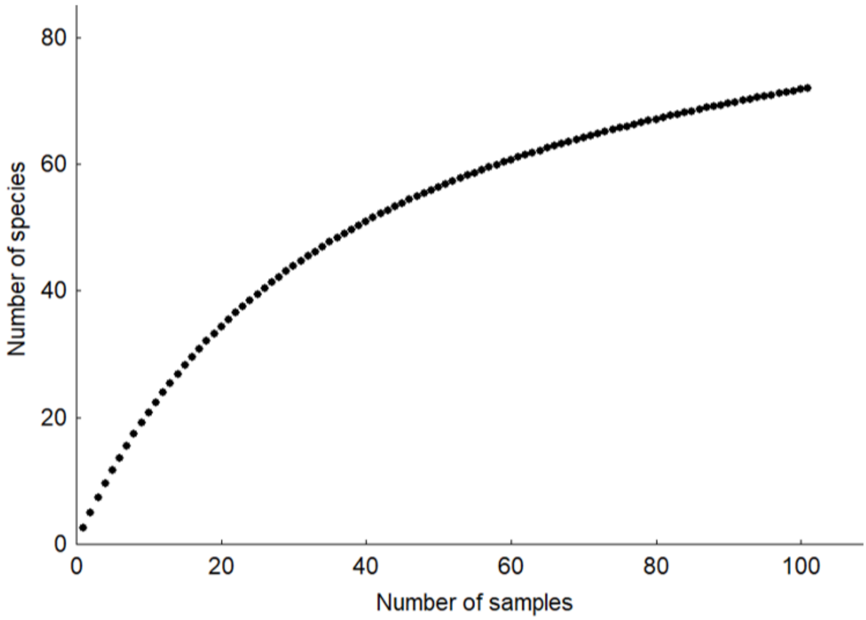

Fig. 4. Bird species accumulation curve for the Chillón valley using the adjustment by Clench, y=((2.63624)*x)/(1+((.026769)*x)).

Fig. 5. Bird species of Chillón valley. a) *Oressochen melanopterus,* b) *Lophonetta specularioides,* c) *Merganetta armata,* (Anseriformes) d) *Patagona gigas*, e) *Colibri coruscans,* f) *Metallura phoebe* (Apodiformes), g) *Vultur gryphus* (Cathartiformes), h) *Charadrius vociferus,* i) *Chroicocephalus serranus,* j) *Vanellus resplendens* (Charadriiformes), k) *Columbina cruziana*, l) *Metriopelia ceciliae*, m) *Metriopelia melanoptera* (Columbiformes).

Fig. 6. Bird species of Chillón valley. a) *Chordeiles acutipennis* (Caprimulgiformes), b) *Chloroceryle americana* (Coraciiformes), c) *Crotophaga sulcirostris* (Cuculiformes), d) *Falco sparverius,* e) *Phalcoboenus megalopterus* (Falconiformes), f) *Geranoaetus polyosoma* (Accipitriformes), g) *Plegadis ridgwayi,* h) *Egretta caerulea,* i) *Nycticorax nycticorax*, j) *Ardea alba* (Pelecaniformes), k) *Colaptes atricollis*, l) *Colaptes rupicola* (Piciformes), m) *Psilopsiagon aurifrons* (Psittaciformes).

Fig. 7. Passeriformes bird species of Chillón valley. a) *Cinclus leucocephalus* (Cinclidae), b) *Atlapetes nationi*, c) *Zonotrichia capensis* (Emberizidae), d) *Spinus magellanicus* (Fringillidae), e) *Cinclodes atacamensis,* f) *Geositta crassirostris* (Furnariidae), g) *Leistes bellicosus* (Icteridae), h) *Upucerthia validirostris* (Furnariidae), i) *Mimus longicaudatus* (Mimidae), j) *Idiopsar speculifera*, k) *Rhopospina fruticeti*, l) *Phrygilus punensis,* m) *Phrygilus unicolor* (Thraupidae).

Fig. 8. Passeriformes and Strigiformes bird species of Chillón valley. a) *Sicalis uropigyalis*, b-c) *Volatinia jacarina* (Thraupidae), d) *Turdus chiguanco* (Turdidae), e) *Lessonia oreas*, f) *Myiotheretes striaticollis*, g) *Pyrocephalus rubinus*, h) *Ochthoeca oenanthoides*, i) *Tyrannus melancholicus* (Tyrannidae), j) *Glaucidium peruanum* (Strigidae).

Table 1. Location of sampling stations

Vegetation type	Code	Date	Latitude	Longitude	Elevations (m)
Lower riparian zone	LR	25/10/2015	-11.682122	-76.923309	756
Desert zone	D	11/11/2015	-11.685856	-76.905412	810
Cactus zone	C	11/11/2015	-11.658518	-76.781615	1402
Middle riparian zone	MR	27/10/2015	-11.475355	-76.634795	2538
Relict forest	F	10/11/2015	-11.505793	-76.709501	2850
Upper riparian zone	UR	26/10/2015	-11.408466	-76.537067	3500
High Andean shru-bland	S	26/10/2015	-11.402085	-76.508053	3746
Grassland	G	27/10/2015	-11.380809	-76.461422	4039
Wetlands	W	27/10/2015	-11.384928	-76.450759	4048
Lagoon	L	27/10/2015	-11.358069	-76.439962	4514
Rocky places	R	27/10/2015	-11.371692	-76.431351	4539

Table 2. Number of species, genera and family by bird order.

Order	Family	Genera	Species	Endemism
Passeriformes	15	42	50	5
Apodiformes	2	10	10	2
Columbiformes	1	4	6	-
Charadriiformes	3	6	6	-
Anseriformes	1	5	5	-
Pelecaniformes	2	4	5	-
Falconiformes	1	2	3	-
Accipitriformes	1	2	3	-
Piciformes	1	1	2	1
Gruiformes	1	2	2	-
Psittaciformes	1	2	2	-
Caprimulgiformes	1	2	2	-
Cathartiformes	1	2	2	-
Tinamiformes	1	1	1	-
Strigiformes	1	1	1	-
Cuculiformes	1	1	1	-
Coraciiformes	1	1	1	-
Total	**35**	**88**	**102**	**8**

Table 3. Number of species and abundance of birds by vegetation type in two different habitats.

Habitats	Vegetation type	Elevation (m)	Species	Abundance
water-associated	Lower riparian zone (LR)	756	35	168
	Middle riparian zone (MR)	2538	37	55
	Upper riparian zone (UR)	3500	20	39
	Wetlands (W)	4048	15	207
	Lagoon (L)	4514	8	35
Non water-associated	Desert zone (D)	810	1	1
	Cactus zone (C)	1402	11	29
	Relict forest (F)	2850	52	72
	High Andean shrubland (S)	3746	20	77
	Grassland (G)	4039	12	20
	Rocky places (R)	4539	14	37

Appendix A1. Abundance of bird by vegetation type from the Chillón valley. Where C) Cactus zone, D) Desert zone, F) Relict forest, G) Grassland, L) Lagoon, LR) Lower riparian zone, MR) Middle riparian zone, R) Rocky places, S) High Andean shrubland, UR) Upper riparian zone and W) Wetlands. X) qualitative records.

Order	Family	Species	English name	C	D	F	G	L	LR	MR	R	S	UR	W
Accipitriformes	**Accipitridae**	*Geranoaetus melanoleucus* (Vieillot, 1819)	Black-chested Buzzard-Eagle	-	-	1	-	-	x	-	-	x	-	3
Accipitriformes	**Accipitridae**	*Geranoaetus polyosoma* (Quoy & Gaimard, 1824)	Variable Hawk	-	-	x	-	-	-	x	-	1	x	-
Accipitriformes	**Accipitridae**	*Parabuteo unicinctus* (Temminck, 1824)	Harris's (Bay-winged) Hawk	-	-	-	-	-	x	-	-	-	-	-
Anseriformes	**Anatidae**	*Anas flavirostris* Vieillot, 1816	Yellow-billed (Speckled) Teal	-	-	-	-	5	-	-	-	-	-	-
Anseriformes	**Anatidae**	*Lophonetta specularioides* (King, PP, 1828)	Crested Duck	-	-	-	-	10	-	-	-	-	-	4
Anseriformes	**Anatidae**	*Merganetta armata* Gould, 1841	Torrent Duck	-	-	-	-	-	-	3	-	-	2	-
Anseriformes	**Anatidae**	*Oressochen melanopterus* (Eyton, 1838)	Andean Goose	-	-	-	-	6	-	-	-	-	-	45
Anseriformes	**Anatidae**	*Spatula cyanoptera* Vieillot, 1816	Cinnamon teal	-	-	-	-	-	x	-	-	-	-	-
Apodiformes	**Apodidae**	*Aeronautes andecolus* (d'Orbigny & Lafresnaye, 1837)	Andean Swift	-	-	8	-	-	-	-	-	-	8	-
Apodiformes	**Trochilidae**	*Aglaeactis cupripennis* (Bourcier, 1843)	Shining Sunbeam	-	-	-	-	-	-	4	-	-	-	-
Apodiformes	**Trochilidae**	*Amazilia amazilia* (Lesson & Garnot, 1827)	Amazilia Hummingbird	-	-	-	-	-	8	-	-	-	-	-
Apodiformes	**Trochilidae**	*Colibri coruscans* (Gould, 1846)	Sparkling Violetear	-	-	4	-	-	-	x	-	-	-	-
Apodiformes	**Trochilidae**	*Metallura phoebe* (Lesson & Delattre, 1839)	Black Metaltail	-	-	2	x	-	-	x	-	5	1	-
Apodiformes	**Trochilidae**	*Myrtis fanny* (Lesson, 1838)	Purple-collared Woodstar	7	-	3	-	-	2	x	-	-	-	-

Order	Family	Species	English name	C	D	F	G	L	LR	MR	R	S	UR	W
Apodiformes	**Trochilidae**	*Patagona gigas* (Vieillot, 1824)	Giant Hummingbird	-	-	8	-	-	-	-	-	x	-	-
Apodiformes	**Trochilidae**	*Polyonymus caroli* (Bourcier, 1847)	Bronze-tailed Comet	-	-	x	-	-	-	-	-	-	-	-
Apodiformes	**Trochilidae**	*Rhodopis vesper* (Lesson, 1829)	Oasis Hummingbird	-	-	-	-	-	-	x	-	-	-	-
Apodiformes	**Trochilidae**	*Thaumastura cora* (Lesson & Garnot, 1827)	Peruvian Sheartail	-	-	3	-	-	-	x	-	-	-	-
Caprimulgiformes	**Caprimulgidae**	*Chordeiles acutipennis* (Hermann, 1783)	Lesser Nighthawk	-	1	-	-	-	x	-	-	-	-	-
Caprimulgiformes	**Caprimulgidae**	*Systellura longirostris* Bonaparte, 1825	Band-winged Nightjar	1	-	-	-	-	-	-	-	-	-	-
Cathartiformes	**Cathartidae**	*Cathartes aura* (Linnaeus, 1758)	Turkey Vulture	-	-	2	-	-	-	-	-	-	-	-
Cathartiformes	**Cathartidae**	*Vultur gryphus* Linnaeus, 1758	Andean Condor	-	-	x	-	-	-	-	x	x	-	-
Charadriiformes	**Charadriidae**	*Charadrius vociferus* Linnaeus, 1758	Killdeer	-	-	-	-	-	x	-	-	-	-	-
Charadriiformes	**Charadriidae**	*Vanellus resplendens* (von Tschudi, 1843)	Andean Lapwing	-	-	-	x	-	-	-	-	-	-	3
Charadriiformes	**Laridae**	*Chroicocephalus serranus* (von Tschudi, 1844)	Andean Gull	-	-	-	x	4	-	-	5	-	x	5
Charadriiformes	**Scolopacidae**	*Actitis macularius* (Linnaeus, 1766)	Spotted Sandpiper	-	-	-	-	-	4	-	-	-	-	-
Charadriiformes	**Scolopacidae**	*Gallinago andina* (Taczanowski, 1875)	Puna Snipe	-	-	-	-	1	-	-	-	-	-	-
Charadriiformes	**Scolopacidae**	*Phalaropus tricolor* Vieillot, 1819	Wilson's Phalarope	-	-	-	-	-	x	-	-	-	-	-
Columbiformes	**Columbidae**	*Columbina cruziana* (Prévost, 1842)	Croaking Ground Dove	-	-	-	-	-	16	-	-	-	-	-
Columbiformes	**Columbidae**	*Metriopelia ceciliae* (Lesson, 1845)	Bare-faced Ground Dove	1	-	6	-	-	2	x	-	-	-	-
Columbiformes	**Columbidae**	*Metriopelia melanoptera* (Molina, 1782)	Black-winged Ground Dove	-	-	x	-	-	-	x	-	3	x	-

Order	Family	Species	English name	C	D	F	G	L	LR	MR	R	S	UR	W
Columbiformes	**Columbidae**	*Patagioenas fasciata* (Say, 1822)	Band-tailed Pigeon	-	-	1	-	-	-	-	-	-	-	-
Columbiformes	**Columbidae**	*Zenaida auriculata* (Des Murs, 1847)	Eared Dove	10	-	x	-	-	-	x	-	-	-	-
Columbiformes	**Columbidae**	*Zenaida meloda* (von Tschudi, 1843)	West Peruvian Dove	5	-	-	-	-	8	3	-	-	-	-
Coraciiformes	**Alcedinidae**	*Chloroceryle americana* (Gmelin, JF, 1788)	Green Kingfisher	-	-	-	-	-	x	-	-	-	-	-
Cuculiformes	**Cuculidae**	*Crotophaga sulcirostris* Swainson, 1827	Groove-billed Ani	-	-	-	-	-	6	-	-	-	-	-
Falconiformes	**Falconidae**	*Falco peregrinus* Tunstall, 1771	Peregrine Falcon	-	-	-	-	-	x	-	-	-	-	-
Falconiformes	**Falconidae**	*Falco sparverius* Linnaeus, 1758	American Kestrel	1	-	x	-	-	x	x	-	x	x	-
Falconiformes	**Falconidae**	*Phalcoboenus megalopterus* (Meyen, 1834)	Mountain Caracara	-	-	-	x	-	-	-	-	-	-	-
Gruiformes	**Rallidae**	*Fulica gigantea* Eydoux & Souleyet, 1841	Giant Coot	-	-	-	-	5	-	-	-	-	-	-
Gruiformes	**Rallidae**	*Pardirallus sanguinolentus* (Swainson, 1838)	Plumbeous Rail	-	-	-	-	-	x	-	-	-	-	-
Passeriformes	**Cinclidae**	*Cinclus leucocephalus* von Tschudi, 1844	White-capped Dipper	-	-	-	-	-	-	1	-	-	3	-
Passeriformes	**Cotingidae**	*Zaratornis stresemanni* Koepcke, 1954	White-cheeked Cotinga	-	-	1	-	-	-	-	-	-	-	-
Passeriformes	**Emberizidae**	*Atlapetes nationi* (Sclater, PL, 1881)	Rusty-bellied Brush-finch	-	-	x	-	-	-	4	-	1	-	-
Passeriformes	**Emberizidae**	*Saltator aurantiirostris* Vieillot, 1817	Golden-billed Saltator	-	-	x	-	-	-	-	-	-	-	-
Passeriformes	**Emberizidae**	*Zonotrichia capensis* (Statius Muller, 1776)	Rufous-collared Sparrow	-	-	5	2	-	x	1	-	24	4	-
Passeriformes	**Fringillidae**	*Spinus atratus* d'Orbigny & Lafresnaye, 1837	Black Siskin	-	-	-	-	-	-	x	-	-	x	-

Order	Family	Species	English name	C	D	F	G	L	LR	MR	R	S	UR	W
Passeriformes	**Fringillidae**	*Spinus magellanicus* (Vieillot, 1805)	Hooded Siskin	-	-	2	-	-	9	1	-	-	-	-
Passeriformes	**Furnaridae**	*Asthenes pudibunda* (Sclater, PL, 1874)	Canyon Canastero	-	-	3	-	-	-	-	-	-	-	-
Passeriformes	**Furnariidae**	*Cinclodes albidiventris* Sclater, PL, 1860	Bar-winged Cinclodes	-	-	x	-	-	-	x	-	5	4	-
Passeriformes	**Furnariidae**	*Cinclodes atacamensis* (Philippi Sr, RA, 1857)	White-winged Cinclodes	-	-	-	2	-	-	-	13	-	x	2
Passeriformes	**Furnariidae**	*Cranioleuca antisiensis* (Sclater, PL, 1859)	Line-cheeked Spinetail	-	-	x	-	-	-	x	-	-	-	-
Passeriformes	**Furnariidae**	*Geositta crassirostris* Sclater, PL, 1866	Thick-billed Miner	-	-	-	-	-	-	1	-	-	-	-
Passeriformes	**Furnariidae**	*Leptasthenura pileata* Sclater, PL, 1881	Rusty-crowned Tit-Spinetail	-	-	x	-	-	-	-	-	4	x	-
Passeriformes	**Furnariidae**	*Upucerthia validirostris* (Burmeister, 1861)	Buff-breasted Earthcreeper	-	-	-	-	-	-	-	x	-	-	-
Passeriformes	**Hirundinidae**	*Orochelidon andecola* (d'Orbigny & Lafresnaye, 1837)	Andean Swallow	1	-	-	-	-	-	x	-	-	x	-
Passeriformes	**Hirundinidae**	*Pygochelidon cyanoleuca* (Vieillot, 1817)	Blue-and-white Swallow	-	-	x	-	-	4	19	-	-	-	-
Passeriformes	**Icteridae**	*Dives warczewiczi* (Cabanis, 1861)	Scrub Blackbird	1	-	x	-	-	1	3	-	-	-	-
Passeriformes	**Icteridae**	*Leistes bellicosus* de Filippi, 1847	Peruvian Meadowlark	-	-	-	-	-	x	-	-	-	-	-
Passeriformes	**Mimidae**	*Mimus longicaudatus* von Tschudi, 1844	Long-tailed Mocking	-	-	-	-	-	2	-	-	-	-	-
Passeriformes	**Thraupidae**	*Catamenia analis* (d'Orbigny & Lafresnaye, 1837)	Band-tailed Seedeater	-	-	x	-	-	-	-	-	-	-	-
Passeriformes	**Thraupidae**	*Conirostrum cinereum* d'Orbigny & Lafresnaye, 1838	Cinereous Conebill	-	-	x	-	-	-	-	x	-	-	-
Passeriformes	**Thraupidae**	*Diglossa sittoides* (d'Orbigny & Lafresnaye, 1838)	Rusty Flower-piercer	-	-	x	-	-	-	-	-	-	-	-

Order	Family	Species	English name	C	D	F	G	L	LR	MR	R	S	UR	W
Passeriformes	**Thraupidae**	*Geospizopsis plebejus* von Tschudi, 1844	Ash-breasted Sierra-Finch	-	-	x	x	-	-	-	x	6	-	1
Passeriformes	**Thraupidae**	*Idiopsar speculifera* (d'Orbigny & Lafresnaye, 1837)	White-winged Diuca-Finch	-	-	-	-	-	-	-	1	-	x	2
Passeriformes	**Thraupidae**	*Phrygilus punensis* Ridgway, 1887	Peruvian Sierra-Finch	-	-	x	-	-	-	-	x	7	x	-
Passeriformes	**Thraupidae**	*Phrygilus unicolor* Lafresnaye & D'Orbigny, 1837	Plumbeous Sierra-Finch	-	-	x	-	-	-	x	7	5	x	2
Passeriformes	**Thraupidae**	*Pipraeidea bonariensis* (Gmelin, JF, 1789)	Blue-and-yellow Tanager	1	-	1	-	-	1	-	-	-	-	-
Passeriformes	**Thraupidae**	*Pipraeidea melanonota* (Vieillot, 1819)	Fawn-breasted Tanager	-	-	x	-	-	-	-	-	-	-	-
Passeriformes	**Thraupidae**	*Poospiza hispaniolensis* Bonaparte, 1850	Collared Warbling-Finch	x	-	-	-	-	4	x	-	-	-	-
Passeriformes	**Thraupidae**	*Poospiza rubecula* Salvin, 1895	Rufous-breasted Warbling-Finch	-	-	x	-	-	-	x	-	-	-	-
Passeriformes	**Thraupidae**	*Rhopospina fruticeti* (von Kittlitz, 1833)	Mourning Sierra-Finch	-	-	x	-	-	-	2	-	1	-	-
Passeriformes	**Thraupidae**	*Sicalis olivascens* (d'Orbigny & Lafresnaye, 1837)	Greenish Yellow-Finch	-	-	3	-	-	-	-	-	-	-	-
Passeriformes	**Thraupidae**	*Sicalis uropigyalis* (d'Orbigny & Lafresnaye, 1837)	Bright-rumped Yellow-Finch	-	-	-	3	-	-	-	5	-	-	1
Passeriformes	**Thraupidae**	*Thlypopsis ornata* (Sclater, PL, 1859)	Rufous-chested Tanager	-	-	x	-	-	-	-	-	-	-	-
Passeriformes	**Thraupidae**	*Volatinia jacarina* (Linnaeus, 1766)	Blue-black Grassquit	-	-	-	-	-	33	-	-	-	-	-
Passeriformes	**Troglodytidae**	*Troglodytes aedon* Vieillot, 1809	House Wren	1	-	2	-	-	5	x	-	5	1	-
Passeriformes	**Turdidae**	*Turdus chiguanco* d'Orbigny & Lafresnaye, 1837	Chiguanco Thrush	-	-	3	-	-	-	7	-	4	-	-
Passeriformes	**Tyrannidae**	*Anairetes reguloides* (d'Orbigny & Lafresnaye, 1837)	Pied-crested Tit-Tyrant	-	-	x	-	-	-	-	-	-	-	-

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Passeriformes	**Tyrannidae**	*Elaenia albiceps* (d'Orbigny & Lafresnaye, 1837)	White-crested Elaenia	-	-	x	-	-	-	5	-	1	-	-
Passeriformes	**Tyrannidae**	*Lessonia oreas* (Sclater & Salvin, 1869)	Andean Negrito	-	-	-	-	2	-	-	3	-	-	2
Passeriformes	**Tyrannidae**	*Muscisaxicola cinereus* Philippi & Landbeck, 1864	Cinereous Ground-Tyrant	-	-	-	x	-	-	-	2	-	-	1
Passeriformes	**Tyrannidae**	*Muscisaxicola maculirostris* d'Orbigny & Lafresnaye, 1837	Spot-billed Ground-Tyrant	-	-	1	-	-	-	-	-	-	-	-
Passeriformes	**Tyrannidae**	*Myiotheretes striaticollis* (Sclater, PL, 1853)	Streak-throated Bush-Tyrant	-	-	x	-	-	-	-	-	1	x	-
Passeriformes	**Tyrannidae**	*Ochthoeca leucophrys* (d'Orbigny & Lafresnaye, 1837)	White-browed Chat-Tyrant	-	-	x	-	-	-	x	-	-	-	-
Passeriformes	**Tyrannidae**	*Ochthoeca oenanthoides* (d'Orbigny & Lafresnaye, 1837)	d'Orbigny's Chat-Tyrant	-	-	x	-	-	-	-	x	4	-	-
Passeriformes	**Tyrannidae**	*Pyrocephalus rubinus* (Boddaert, 1783)	Vermilion Flycatcher	-	-	-	-	-	7	-	-	-	-	-
Passeriformes	**Tyrannidae**	*Serpophaga cinerea* (von Tschudi, 1844)	The torrent tyrannulet	-	-	-	-	-	-	x	-	-	-	-
Passeriformes	**Tyrannidae**	*Tyrannus melancholicus* Vieillot, 1819	Tropical Kingbird	-	-	-	-	-	x	-	-	-	-	-
Passeriformes	**Cardinalidae**	*Pheucticus chrysogaster* (Lesson, 1832)	Golden Grosbeak	-	-	x	-	-	-	-	-	-	-	-
Passeriformes	**Passeridae**	*Passer domesticus* (Linnaeus, 1758)	House sparrow	-	-	-	-	-	x	-	-	-	-	-
Pelecaniformes	**Ardeidae**	*Ardea alba* Linnaeus, 1758	Great Egret	-	-	-	-	-	x	-	-	-	-	-
Pelecaniformes	**Ardeidae**	*Egretta caerulea* (Linnaeus, 1758)	Little Blue Heron	-	-	-	-	-	1	-	-	-	-	-
Pelecaniformes	**Ardeidae**	*Egretta thula* (Molina, 1782)	Snowy Egret	-	-	-	-	-	x	x	-	-	-	-
Pelecaniformes	**Ardeidae**	*Nycticorax nycticorax* (Linnaeus, 1758)	Black-crowned Night-Heron	-	-	-	x	-	5	1	-	-	-	1

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Pelecaniformes	**Threskiornithidae**	*Plegadis ridgwayi* (Allen, JA, 1876)	Puna Ibis	-	-	-	x	2	-	-	-	-	16	132
Piciformes	**Picidae**	*Colaptes atricollis* (Malherbe, 1850)	Black-necked Woodpecker	-	-	4	-	-	-	x	-	-	-	-
Piciformes	**Picidae**	*Colaptes rupicola* d'Orbigny, 1840	Andean Flicker	-	-	-	13	-	-	-	1	-	-	3
Psittaciformes	**Psittacidae**	*Forpus coelestis* (Lesson, 1847)	Pacific Parrotlet	-	-	3	-	-	-	-	-	-	-	-
Psittaciformes	**Psittacidae**	*Psilopsiagon aurifrons* (Lesson, 1831)	Mountain Parakeet	-	-	-	-	-	50	-	-	-	-	-
Strigiformes	**Strigidae**	*Glaucidium peruanum* König, C, 1991	Peruvian Pygmy-Owl	-	-	-	-	-	-	x	-	-	-	-
Tinamiformes	**Tinamidae**	*Nothoprocta pentlandii* (Gray, GR, 1867)	Andean Tinamou	-	-	3	-	-	-	-	-	-	-	-