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Richness and abundance of birds in an urban gradient of Arequipa, southwest of Peru

Riqueza y abundancia de aves en una gradiente urbana de Arequipa, suroeste de Perú

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Abstract

The importance of knowing the effect of the advance of urbanization on biodiversity is becoming increasingly important, so it is necessary to increase the number of investigations in these environments. This study was conducted in the city of Arequipa, Peru, trying to cover urban, suburban and rural environments, relating the effects on the richness and abundance of birds on this gradient, finding during the study period a lower richness of bird species in urban environments with dominance of some species (*Columba livia* and *Turdus chiguanco),* while in rural environments there were greater equity of abundance and greater richness of species. More studies are needed on a long time scale to have a better understanding of this dynamic.

Keywords: conservation, diversity, metropolitan, range-abundance, urban ecosystem.

Resumen

La importancia de conocer el efecto del avance de la urbanización sobre la biodiversidad cada vez toma mayor importancia, por lo que es necesario incrementar el número de investigaciones en estos ambientes. Este estudio se realizó en la ciudad de Arequipa, Perú, tratando de cubrir ambientes urbanos, suburbanos y rurales, y relacionando los efectos sobre la riqueza y abundancia de aves en esta gradiente, encontrando durante el periodo de estudio una menor riqueza de especies de aves en ambientes urbanos con dominancia de algunas especies (*Columba livia* y *Turdus chiguanco)*, en cambio, en el ambiente rural se presentó mayor equidad de las abundancias y mayor riqueza de especies. Más estudios son necesarios a una escala temporal larga para tener un mejor entendimiento de esta dinámica.

Palabras clave: conservación, diversidad, metropolitano, rango-abundancia, ecosistema urbano.

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Introduction

Urbanization has been identified as one of the most significant ecological disturbances, due to the intense modifications of pre-existing habitats caused by humans (Escobar & MacGregor, 2017; Vides-Hernández, 2017; Malagamba-Rubio *et al*., 2013). Currently more than half of the population lives in urban areas (Ferenc, 2013), being America one of the continents that presents an accelerated rate of urbanization, among them thirteen countries like Brazil, Mexico, Chile, Argentina, Peru and others, exceed 70% urbanization rate (CEPAL, 2014). With the growing impact of urbanization on natural ecosystems (Farinha-Marques *et al*., 2011), It is still unknown how different components of biodiversity respond to these impacts (Chace & Walsh 2006), where the study of urban areas is of great importance for the understanding, preservation and improvement of biodiversity (Farinha-Marques *et al*., 2011).

Birds are one of the most studied groups to assess the impacts of urbanization on biodiversity (Escobar & MacGregor, 2017), these are affected by various factors such as habitat structure, food availability, seasonality effect (Isacch & Martinez, 2001). These are often shown as areas with few species, and where there is a dominance by omnivorous and granivorous species that tend to be non-native (Lepczyk *et al*., 2017), However, even for this group, information on its response to urbanization is scarce, especially in South America. (Romero, 2014). In the city of Arequipa the demographic and urban growth has presented

social, economic and environmental dynamics (IMPLA, 2016) which could have repercussions on the structure and composition of the diversity, so this study aims to contribute to the knowledge of birds present in Metropolitan Arequipa and analyze it in an urbanistic gradient through the analysis of richness and abundance.

Material and methods

Study area

The study was carried out in the city of Arequipa (16° 25'19.64 ''S, 71° 32'43.55''W), located in the south west of Peru, the metropolitan area is constituted by 21 districts with an extension of 50,246 ha (IMPLA, 2016), which is between 2041 and 2810 meters above sea level, forming a very rugged valley which is crossed by the Chili River and the Andes Mountains. In total, 12 evaluation sites were selected within a gradient of urbanization (Fig. 1) following the criteria of IMPLA (2016) where: a) Urban Zone (U): Population centers that due to their large volume of population, activities and levels of development can influence other nearby towns; b) Suburban Zone (S): Constituted by zones with urbanized conditions in the long term, being able to be located contiguous or separated from the urban area c) Rural Zone (R): Area not classified as urban where agricultural or livestock activities are mainly developed. For the evaluations, green areas such as central squares, university campuses, parks and open fields were taken into consideration (Table 1), trying to obtain a representative sample of the birds associated with each type of zone.

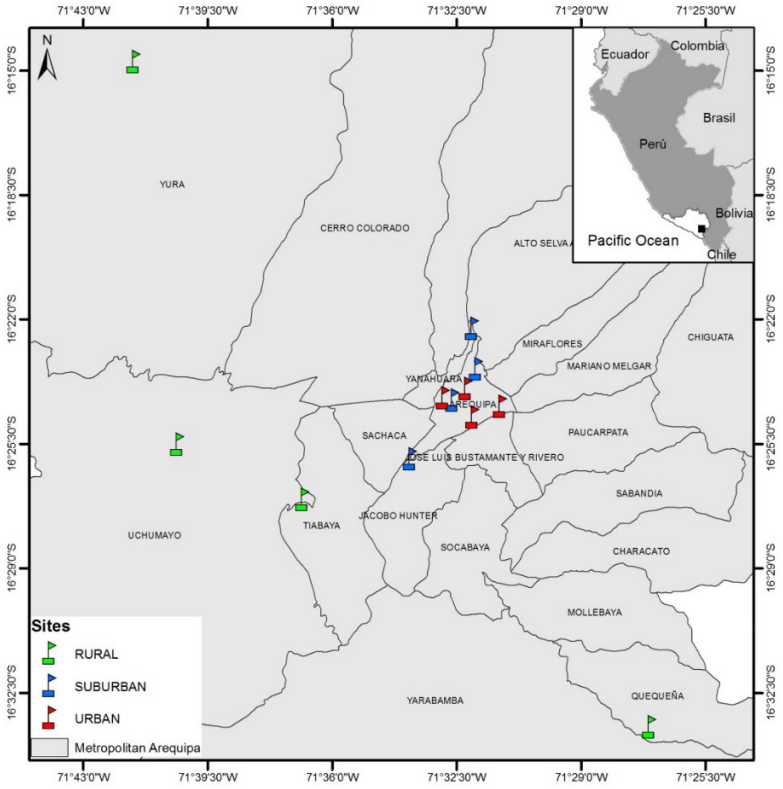

Fig. 1. Map of metropolitan Arequipa showing selected areas for the study.

Table 1. Zones and sites evaluated in the urban gradient of metropolitan Arequipa.

URBAN	SUBURBAN	RURAL
Arequipa's Central square (ACS)	Selva Alegre (SA)	San Pedro Square (SPS)
Biomedical Area UNSA (BAU)	Vallecito (VAL)	Quequeña's Central Square (QCS)
Social Area UNSA (SAU)	Tingo (TIN)	Congata (CON)
Expression Park (EP)	Chilina (CHI)	Yura (YUR)

Data collection

The evaluations were carried out between the months of May to July 2017, three days were selected at random during the week, evaluating a different zone per day (urban, suburban and rural), between 6:00 and 9:00 hours, to standardize work and effort conditions as well as to reduce the error that could cause human presence or any other random factor on the presence of birds (Garitano & Gismondi, 2003).

For the richness, walking and random routes were made within the selected sites, recording the species of birds observed and heard. For abundance, the methodology of fixed radius counting points (30 m) was used, the distance between counting points was 70-100 meters depending on the evaluation area. Previously of the bird registry, the observer was silent for 5 minutes and was recorded for an additional 10 minutes at each count point (Paker *et al*., 2014), travelers species that crossed from one side to another above the points (e.g, *Pygochelidon cyanoleuca)* were not taken into account (Aragón, 2013).

The determination of species was carried out following Schulenberg *et al*. (2010), for the taxonomic order, we followed the South American Classification Committee (SACC) of the Union of American Ornithologists (Remsen *et al*., 2017), for common names Plenge, (2018) was used.

For the analysis, the software PAST 3.12 (Hammer, 2001) was used. It was complemented with the construction of range abundance curves (Feinsinger, 2014), as well as similarity analysis using the Jaccard index, based only on qualitative data. It was also examined if there is any effect of the zone evaluated with respect to the composition for which Box-plots were built and it was accompanied with a Kruskal-Wallis test to evaluate the number of species differs with the established urbanization gradient.

Results and discussion

A richness of 39 species of birds was recorded in the evaluated zones, where the richness in the urban zone was 20 species while in the suburban and rural zones there were 25 and 31 species respectively (Table 2); The effect of the degree of urbanization with respect to the richness of bird species showed significant differences between the rural and urban zones (Kruskal-Wallis = 6.317, P <0.05) and showing a lower number of species in the sites evaluated for this zone (Fig. 2), which is similar to what was found by Chavez-Villavicencio (2017) in the study conducted in Chile, where areas with less urbanization have a greater richness of species, the same is corroborated with Leveau & Leveau (2004) and Clergeau (1998) mentioning the relationship with the degree of urbanization where richeness decreases as the urbanized area increases, although it is mentioned that this could vary with respect to seasonality and the type of structures present in the zones (Juri & Chani, 2009; Sengupta *et al*., 2013).

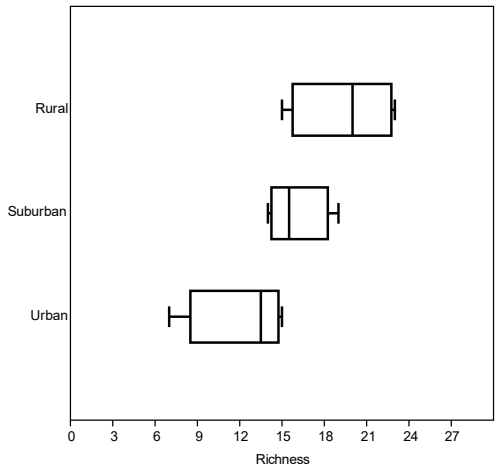

Fig. 2. Variation of richness with respect to the degree of urbanization, from May to July 2017, Arequipa, Peru.

Also 15 of the species were common in the three types of zones, which were: *Columba livia, Columbina cruziana, Conirostrum cinereum, Falco sparverius, Metriopelia ceciliae, Nycticorax nycticorax, Pygochelidon cyanoleuca, Rhodopis vesper, Spinus magellanicus, Thaumastura cora Troglodytes aedon, Turdus chiguanco, Zenaida auriculata, Zenaida meloda and Zonotrichia capensis*, highlighting the presence of the Columbidae family with 5 species, since most of the study sites were in squares and parks and the main source of food for this family they are from human food waste (De la Ossa *et al*., 2017) and also studies mention that these species are characteristic of these environments or at least species belonging to the same genus (Feninger, 1983; Faggi & Perepelzin, 2006; Chavez-Villavicencio, 2017).

Table 2. Richness of birds registered in zones evaluated between May and July 2017, Arequipa city (Arequipa, Peru). Symbology: 0 = Absence, 1 = Presence.

Species	Common name	Family	Status	Urban	Suburban	Rural
Anairetes flavirostris	Tyrannidae	Yellow-billed Tit-Tyrant	Native	0	1	1
Athene cunicularia	Strigidae	Burrowing Owl	Native	1	0	0
Catamenia analis	Thraupidae	Band-tailed Seedeater	Native	0	0	1
Cathartes aura	Cathartidae	Turkey Vulture	Native	1	1	0
Columba livia	Columbidae	Rock Pigeon	Exotic	1	1	1
Columbina cruziana	Columbidae	Croaking Ground Dove	Native	1	1	1
Conirostrum cinereum	Thraupidae	Cinereous Conebill	Native	1	1	1
Crotophaga sulcirostris	Cuculidae	Groove-billed Ani	Native	0	1	1
Dives warczewiczi	Icteridae	Scrub Blackbird	Native	0	0	1
Egretta thula	Ardeidae	Snowy Egret	Native	0	1	0
Falco femoralis	Picidae	Aplomado Falcon	Native	0	0	1
Falco sparverius	Picidae	American Kestrel	Native	1	1	1
Geranoaetus melanoleucus	Accipitridae	Black-chested Buzzard-Eagle	Native	0	1	0
Geranoaetus polyosoma	Accipitridae	Variable Hawk	Native	0	0	1

Glaucidium peruanum	Strigidae	Peruvian Pygmy-Owl	Native	0	1	1
Merganetta armata	Anatidae	Torrent Duck	Native	0	1	0
Metriopelia ceciliae	Columbidae	Bare-faced Ground Dove	Native	1	1	1
Metriopelia melanoptera	Columbidae	Black-winged Ground Dove	Native	0	0	1
Myrtis fanny	Trochilidae	Purple-collared Woodstar	Native	1	0	0
Nycticorax nycticorax	Ardeidae	Black-crowned Night-Heron	Native	1	1	1
Orochelidon andecola	Hirundinidae	Andean Swallow	Native	1	0	0
Pardirallus sanguinolentus	Rallidae	Plumbeous Rail	Native	0	1	1
Passer domesticus	Passeridae	House Sparrow	Exotic	0	0	1
Patagioenas maculosa	Columbidae	Spot-winged Pigeon	Native	0	1	1
Patagona gigas	Trochilidae	Giant Hummingbird	Native	0	0	1
Pipraeidea bonariensis	Thraupidae	Blue-and-yellow Tanager	Native	0	0	1
Phrygilus alaudinus	Thraupidae	Band-tailed Sierra-Finch	Native	0	0	1
Psittacara wagleri/mitratus	Psittacidae	Parakeet	Exotic	1	1	0
Pygochelidon cyanoleuca	Hirundinidae	Blue-and-white Swallow	Native	1	1	1
Rhodopis vesper	Trochilidae	Oasis Hummingbird	Native	1	1	1
Sicalis olivascens	Thraupidae	Greenish Yellow-Finch	Native	0	0	1
Spinus magellanicus	Fringillidae	Hooded Siskin	Native	1	1	1
Sporophila telasco	Thraupidae	Chestnut-throated Seedeater	Native	0	0	1
Thaumastura cora	Trochilidae	Peruvian Sheartail	Native	1	1	1
Troglodytes aedon	Troglodytidae	House Wren	Native	1	1	1
Turdus chiguanco	Turdidae	Chiguanco Thrush	Native	1	1	1
Zenaida auriculata	Columbidae	Eared Dove	Native	1	1	1
Zenaida meloda	Columbidae	West Peruvian Dove	Native	1	1	1
Zonotrichia capensis	Emberizidae	Rufous-collared Sparrow	Native	1	1	1

According to the similarity between the zones and sites evaluated, there was a correspondence between the urban sites evaluated, with the exception of the Arequipa's Central square located in a central urban point, which could mark this difference as there is greater anthropic pressure resulting in an increase in noise levels and habitat fragmentation (Abilhoa & Amori, 2017), there is also evidence of a difference between rural area with respect to urban and suburban area, with the exception of the Congata site which locates it perhaps between the suburban transition zone and rural, in studies conducted by Abilhoa & Amori (2017), Faeth *et al*. (2011) Biamonte (2011) and Chavez-Villavicencio (2017) corroborate the pattern on the difference of richness in the urban gradient, where the richeness will tend to decrease as the area is more urbanized, although Faggy & Perepelizin (2006) in a study in Argentina show that this pattern sometimes does not occur and will depend a lot on the type of structures that can be used by birds, rather than the green area or vegetation type present.

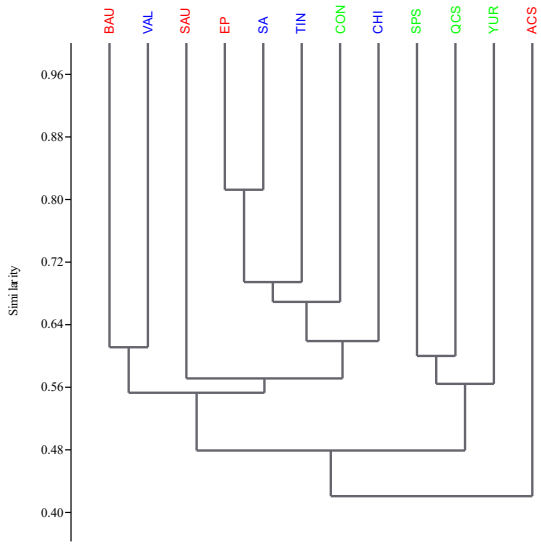

Fig. 3. Cluster according to Jaccard for the evaluated sites with respect to the richness of species where: urban areas (red), suburban areas (blue) and rural areas (green).

The accumulated abundance was of 959 individuals, distributed in 24 species according to the data obtained from the 41 counting points which varied with respect to the zones (22 urban, 11 suburban and 8 in rural), where the most abundant species were: *Columba livia* (30.34%), *Turdus chiguanco* (18.56%), *Zonotrichia capensis* (10.64%) and *Zenaida auriculata* (9.28%), currently there are not many local reports on bird studies in urban areas or in Peru, among them Castillo *et al*. (2014) in a study in Lima within a university campus and Nolazco, (2012), mentions that the most abundant species tend to be *Zenaida meloda*, *Zenaida auriculata* and *Columbina cruziana*, some of these or related species agree with studies carried out in South America in which it shows that the presence of the group of pigeons, thrushes and sparrows are very associated with urban environments (Soto, 2014; Juri & Chani, 2009; Faggy & Perepelizin, 2006; Garitano & Gismondi, 2003).

In the analysis of the range-abundance curves for the zones in the urban gradient, a lower richness and equitability of species from urban areas is observed with respect to suburban and rural zones, in addition there is a greater dominance of species such as *Columba livia* and *Turdus chiguanco*, in urban areas with respect to suburban and rural areas, which is accompanied by a change with respect to the composition of species through this gradient (Fig. 4) the research of Cleargeau *et al*. (1998), Aragon (2013), Soto (2014), Marzluff & Rodewald (2008) and Silva *et al*. (2015), mention that in areas with a high level of urbanization, richeness decreases although the abundance of these can be much higher equitable, which would be conditioned by the structural complexity found in urban environments, as well as vegetation, climate and seasons, and which season of nesting of the species is an important factor to consider within these variations.

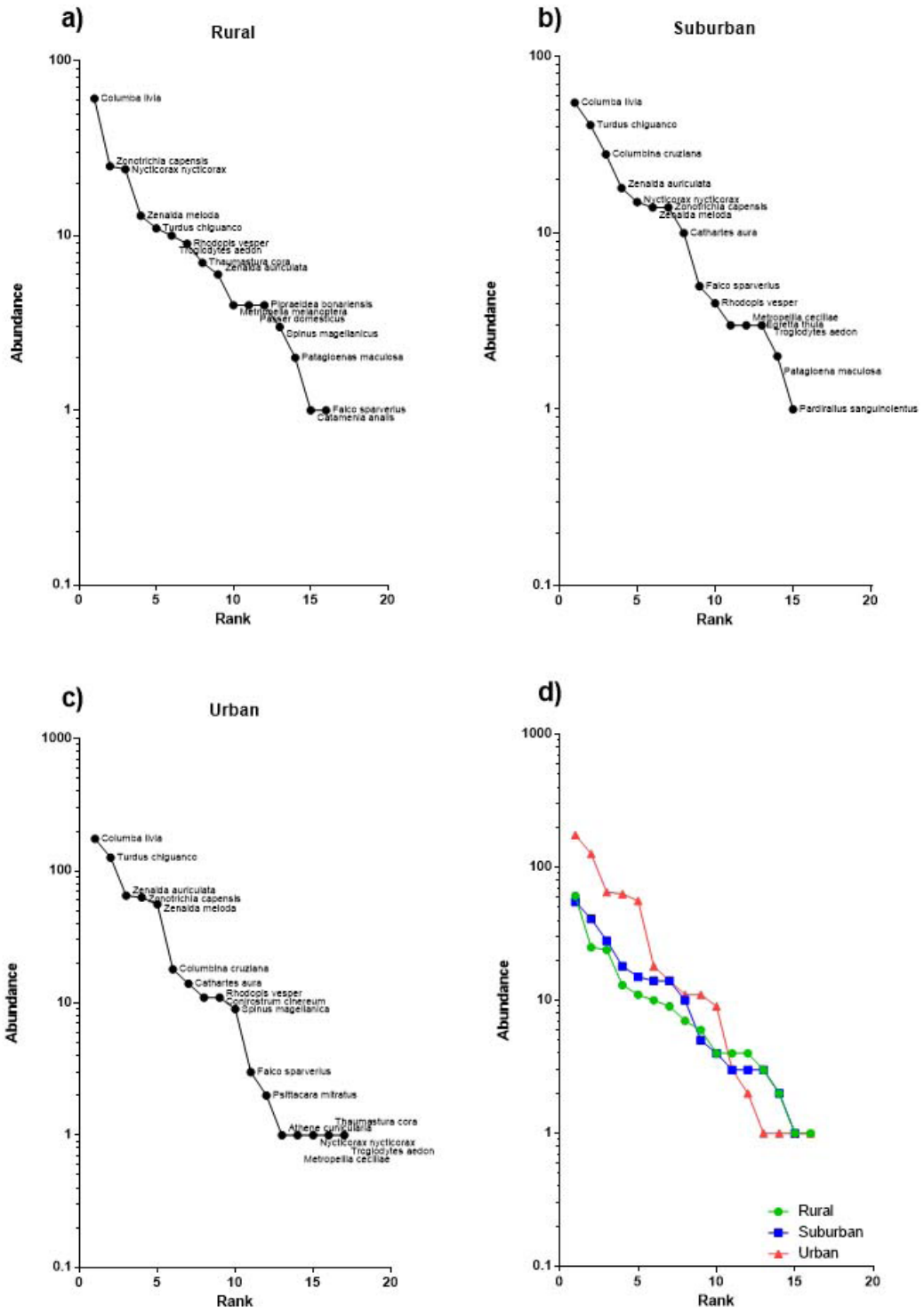

Fig. 4. Range-abundance curves for study areas in an urban gradient for the city of Arequipa in 2017, a) rural area b) suburban area c) urban area d) comparison between areas.

Finally, Blair (1996) suggests that the abundance of each species presents an individual response with respect to the influence generated by the degree of urbanization, where some species can be benefited and another cannot, Odum & Warret (2006) in Juni (2009) mentions that modified environments tend to occur with communities that are not uniform and with one or several dominant species, which agrees with what was found in this study.

Our results show the response of the bird community with respect to the gradient, although it would be important as Chace & Walsh (2006) mentioned to continue with these studies on a local and temporal scale and incorporate some factors such as the type of urban structure, diet, food resources available and interactions that may occur between the species, which would better define the presence of these and how their response varies in the urban and non-urban environments and that knowledge of this can help to understand and improve planning and conservation in cities (Vignoli *et al.,* 2013) which will result in adequate conservation.

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Contribution of the authors

CLF collected information and performed the analysis and interpretation of the data. LCS and YPD collected information and drafted the manuscript.

Conflict of interests

The authors declare not to have conflicts of interests.

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