

# Population and Diversity of Birds Associated with Ecotourism in Yanico Center- 2023

Noemi Cayo-Velásquez\*, Gladys Auquitas-Condori\*\*,  
Alejandro Apaza-Tarqui\*\*\*, John Huanca-Suaquita\*\*\*\*

## Abstract

The purpose of the research is to analyze bird's diversity and abundance in the Titicaca National Reserve - Yanico sector. This involved monitoring birds in two microhabitats carried out in September 2022, using designated routes within each microhabitat. To assess bird diversity and abundance, the Margalef index (Dmg), Shannon-Wiener index (H'), and Simpson index ( $\lambda$ ) were applied. To determine differences, the non-parametric Kruskal-Wallis (H) test ( $p = 0.05$ ) and the Mann Whitney U test were employed. In the research, 15 bird species were recorded, categorized into 11 families. In the Wintitus island microhabitat, 9 species were recorded and in the Huilli River featured 14 species, with the highest abundance being recorded in the latter. These findings suggest that the Yanico sector has significant diversity and abundance of birds, to promote ecotourism and the participation of local communities in sustainable ecotourism activities related to bird watching.

**Keywords:** Birds, Abundance, Diversity, Microhabitat, Yanico

## Introduction

Ecotourism is that environmentally responsible modality consisting of traveling or visiting relatively undisturbed natural areas in order to enjoy, appreciate and study the natural attractions (landscape, flora and fauna) of these areas, as well as any cultural manifestations (present and past) that may be found there, through a process

that promotes conservation, has a low environmental and cultural impact and encourages an active and socioeconomically beneficial involvement of local populations (Ceballos-Lascuráin, 1998, p.7). Ecotourism is also a cautious activity, that causes minimal impacts on the environment and is interpretive, achieving conservation objectives, understanding and appreciation of local destinations; this type of tourism is specialized, it generates trips to areas where the presence of people is minimal and the ecotourist expresses the desire to learn, become environmentally and culturally aware from the experience lived in nature (Wearing et al., 1999).

On the other hand, the World Tourism Organization (UNWTO) states that ecotourism or ecological tourism is one of the greatest contribution in the tourism worldwide (UNWTO, 2013), due to the characteristics it represents, the ecotourism or nature tourism is a productive economic activity that produces temporary gains to local communities, strengthening their economy, likewise, the positive impacts generated by the development of this activity in turn produce productive progress in the economy of developing countries (Millán-Rojas et al., 2020, p. 386). Therefore, "in areas focused on biodiversity conservation and possessing rich bird species, the development of ecotourism, ecological birdwatching is a more effective way to improve the local economy and transfer natural capital and ecosystem services to human welfare" (Liu et al., 2021, p.17).

\* Universidad Nacional del Altiplano, Puno - Puno, Perú. Email: noemicayo@unap.edu.pe;  
ORCID: <https://orcid.org/0000-0002-9690-3006>

\*\* Universidad Nacional del Altiplano, Puno - Puno, Perú. Email: gauquitas@unap.pe;  
ORCID: <https://orcid.org/0000-0003-0989-666X>

\*\*\* Universidad Nacional del Altiplano, Puno - Puno, Perú. Email: apazatarqui@unap.pe;  
ORCID: <https://orcid.org/0000-0003-1622-8862>

\*\*\*\* Universidad Nacional del Altiplano, Puno - Puno, Perú. Email: jr.huanca@unaj.edu.pe;  
ORCID: <https://orcid.org/0000-0001-6683-8859>

Bird watching is a recreational activity (Kurnia et al., 2021), considered as a segment of nature tourism as part of a specialized tourism market (Steven, 2014), it is also called avitourism, this activity drives the flow of tourists with the sole purpose of observing and admiring the birds of a specific geographic location; this activity is a great opportunity for the development of local communities, on the other hand, the impact on the ecosystem is minimal due to proper management of Good environmental practices (Mora et al., 2021).

Birdwatching has become an activity that contributes to the diversification of tourism, which are ideal sites for this activity; this implies recognizing the species available for observation and promoting knowledge and preservation of the emblematic species of the area (Morales et al., 2022); On the other hand, the bird watching activity creates an economic value, indicating that visitors are willing to pay for birds watching (Afif et al., 2021).

In this sense, it is necessary to understand the structure of ecological communities and the variation in time and space, which will allow potentialization of microhabitats for conservation and restoration, considering that biodiversity is the basis that facilitates the determination of the functional structure of communities (Magurran, 1988).

Hill (1973) presents a consolidated notion of diversity that includes approaches for assessing diversity, such as Simpson's and Shannon's indices. These indices provide a means of measuring diversity and number of species present, respectively. Also, to assess both the current number of bird species present and the number that would be expected to be found in a habitat, it is necessary to conduct observation and listening surveys (Guerra-Centeno et al., 2023).

The Shannon index was used to measure diversity, considering all species with a weight proportional to their abundance. In addition, the Simpson's index was used to calculate species diversity according to different microhabitats (Espinosa-Méndez et al., 2020).

Zhang and Huang (2020) examining the elements impacting bird habitats and actions related to bird watching in Beijing's urban parks, the most prominent

results revealed that parks with wide expanses offer opportunities for bird watching, playing a role in connecting of visitors with nature and transforming into tourist attractions. Mijiarto (2022) Conducts the study with the aim of creating a strategy to promote birding-focused tourism in the Sijaba Hutaginjang TWA region. In the results, the presence of 29 bird species was detected, suggesting a significant potential to become a prominent attraction in that area.

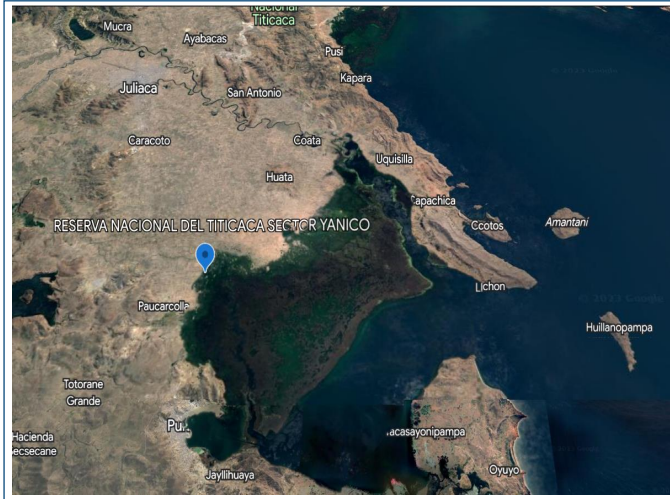
The variety of species is evaluated through measures such as the quantity, abundance and composition of birds present (Ortíz et al., 2016) also the findings suggest that this wide range of birds could be interpreted as an ecological habitat, in additions to being an attractive spot for wildlife observation within the urban area.

## Materials and Methods

The Titicaca National Reserve (TNR), Yanico sector, is known for facilitating the observation of birds in their natural habitat, however, there is no specific information on the communities of bird species, nor is there any systematic identification and recording of the observations.

The study area is located at 1 km south of the Illpa river estuary towards Lake Titicaca (Huili river inside the TNR) at 3,810 m above sea level in the Yanico sector, in the buffer zone of the Titicaca National Reserve, it is located at 22 km from the city of Puno in the district of Paucarcolla, specifically in the Sachas Ucumarini área. It is in the area of special use, direct use and tourist use of the TRN, which is why it is part of the IBAs (Important Bird Areas Americas - Priority sites for biodiversity conservation).

The areas analyzed within the Yanico sector include the area surrounding Lake Wintitus Island, which has significant vegetation of *Senecio* sp. "karihua", *Cassia latopetiolata* "sallihua", *Stipa ichu* "ichu" and a great variety of grasses. The other area corresponds to the mouth of the Huilli river composed of cattails with wáter (*Schoenoplectus tatora*) whose presence is mainly due to being in an area of significant amounts of water.



**Fig. 1: Titicaca National Reserve - Yanico Sector**

The research was carried out from September 24 to 29, 2022, in this period 12 repetitions were made, the identification of the concurrence of birds in the microhabitats was done by direct observation, for which binoculars were used, also for the count was applied the bird registration booklet, visits to the area were made in the morning (6:00 a.m. to 8:00 a.m.) and in the afternoons from 4:00 p.m. to 5:30 p.m., with a daily frequency for a week.

To measure the diversity of the bird population in the Yanico sector, the census method was applied, which includes the analysis of the data obtained in order to characterize the richness of the diversity of birds, the Margalef index ( $D_{mg}$ ) was used while, to measure species diversity by microhabitat, the Simpson index ( $\lambda$ ) was applied, was used to measure the diversity of species per microhabitat, while the Shannon – Wiener index ( $H'$ ) was used, to measure the abundance of species between the areas under study and the Kruskal - Wallis test (0.05) was used to compare the richness and diversity indices of birds species.

Diversity is expressed quantitatively by means of various diversity indices, such as:

*Margalef Index:* It is an index of species richness, it assumes that species are added as the sampling increases, high values indicate a high diversity, those close to zero indicate a single species. This concept relates to the

number of species present in the community, and the total number of individuals regardless of sample size (Moreno 2001).

$$D_{Mg} = \frac{S - 1}{\ln N}$$

Where:

S= number of species

N= total number of individuals

*Simpson's Index:* It is a structural index of dominance, it strongly values the distribution of abundances, it expresses the degree of dominance of certain species, in this case the maximum value is 1 and this is given when there is only one species (complete dominance) while the values approaching zero are obtained when there are numerous species and each is a very small fraction of the total (Magurran, 1988) (the diversity is calculated as  $1-\lambda$ )

$$\lambda = 1 - \sum_{i=1}^s p_i^2 \rightarrow 1 - D_{Si}$$

where  $p_i$  is the ratio of the number of individuals of species  $i$  to  $N$ , introduced by Edward Hugh Simpson as:

$$D = \sum_{i=1}^s \frac{n_i(n_i - 1)}{N(N - 1)}$$

Where:  $n_i$  is the number of individuals of species  $i$  in the sample, and  $N$  is the total number of all individuals counted, an estimator Simpson's index to test without replacement.

$$0 \leq D \leq 1,$$

Values close to zero correspond to very diverse or heterogeneous ecosystems and values close to one correspond to more homogeneous ecosystems, sometimes using  $1/D$  reciprocal amount.

*Shannon Index:* It is a structural index of fairness developed to measure the amount of information that is transmitted in a code (Shannon, 1949). The formula is as follows:

$$H = -\sum_{i=1}^S p_i \ln p_i$$

Indicates that all individuals are randomly sampled and everything is represented by all individuals in the community.

$p_i = \frac{n_i}{N}$  proportion of individuals of each species in the community, is a ratio between the number of individuals of the species ( $n_i$ ) and the total number of individuals of all the species ( $N$ ) and natural logarithm  $\ln$ . The Shannon - Wiener index is described for indefinitely large communities that cannot be studied in their entirety; results are an estimated value.

*Mann-Whitney U Test:* The Mann-Whitney U Test is the

most popular for the study of two independent samples. It is the nonparametric alternative for the comparison of two means.

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - \sum R_1$$

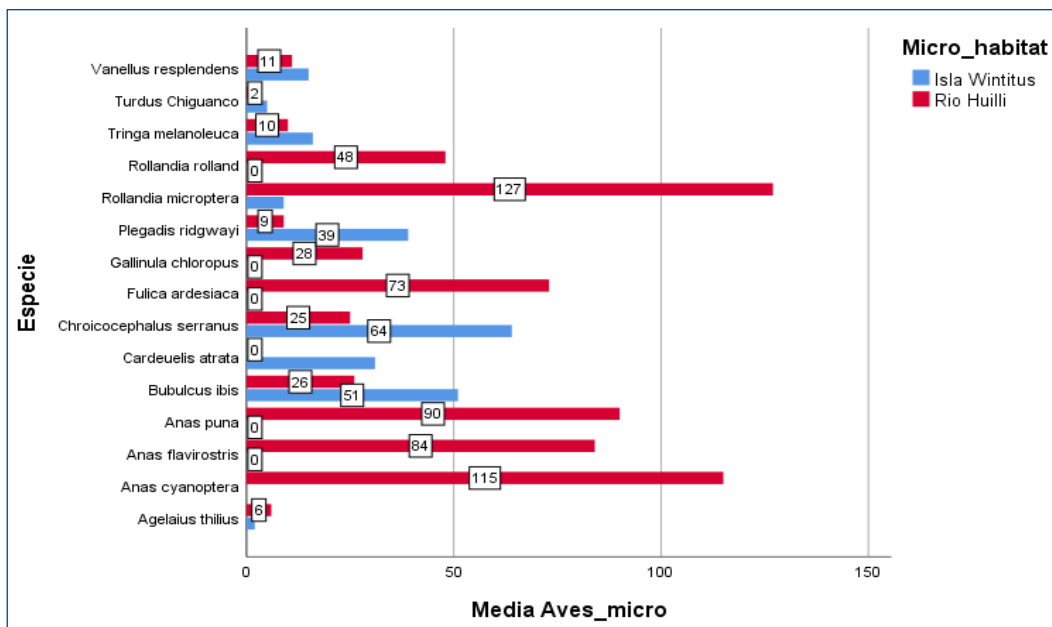
$$U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - \sum R_2$$

$$\text{Media } \mu_u = \frac{n_1 n_2}{2}$$

$$\text{Standard deviation } \sigma_u = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}$$

$$Z \text{ value to normalize Mann-Whitney U test } Z = \frac{U_1 - \mu_u}{\sigma_u}$$

## Results



**Fig. 2:** Number of Species Per Family in Each Family in Each of the Microhabitat in the Surroundings of Yanico – Puno

**Table 1:** Frequency of the Variety of Birds According to the Days Observed in September

Scientific Name	Common Name	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Total	%
Fam. Threskiornithidae									
Plegadis ridgwayi	Ibis negro	14	9	1	10	8	6	48	5%
Fam. Ardeidae									
Bubulcus ibis	Garza blanca	19	21	19	3	6	9	77	9%

Scientific Name	Common Name	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Total	%
Fam. Anatidae									
<i>Anas flavirostris</i>	Sutro	14	16	7	19	17	11	84	9%
<i>Anas puna</i>	spatula puna	16	19	14	18	18	11	96	11%
<i>Anas cyanoptera</i>	Pato colorado	12	11	9	17	47	19	115	13%
fam fringillidae									
<i>Cardeuelis atrata</i>	Jilguero	9	3	6	5	5	3	31	3%
Fam. Rallidae									
<i>Fulica ardesiaca</i>	Choka	17	8	11	4	19	14	73	8%
<i>Gallinula chloropus</i>	Tiquicho	9	6	5	3	3	2	28	3%
Fam Charadriidae									
<i>Vanellus resplendens</i>	Lekecho	6	6	4	4	4	2	26	3%
Fam Podicipedidae									
<i>Rollandia microptera</i>	Keñola	8	5	50	31	21	21	136	15%
<i>rollandia rolland</i>	Poko	10	2	8	11	9	8	48	5%
Fam Scolopacidae									
<i>tringa melanoleuca</i>	Pata amarilla mayor	2	8	4	6	3	3	26	3%
Fam. Laridae									
<i>Chroicocephalus serranus</i>	Gaviota	22	18	26	15	4	4	89	10%
Fam. Turdidae									
<i>Turdus chiguanco</i>	Chiguanco	0	0	0	3	3	1	7	1%
Fam. Icteridae									
<i>Agelaius thilius</i>	Chenko	1	3	1	2	1	0	8	1%

The species diversity of the microhabitats (Wintitus island and Rio Huilli) is composed of 15 species of birds included in 11 families, registering the highest diversity in the microhabitat the rio Huilli with 14 species, while on the island, Wintitus 9 species were recorded, likewise, the most represented family is Anatidae (33%), composed of

3 species: *anas flavirostris*, *anas puna* and *anas cyanoptera* followed by the Podicipedidae family (20%), also composed of 2 species: *rollandia microptera* and *rollandia rolland* and the Rallidae family (11%), composed of 2 species: *fulica ardesiaca* and *gallinula chloropus*.

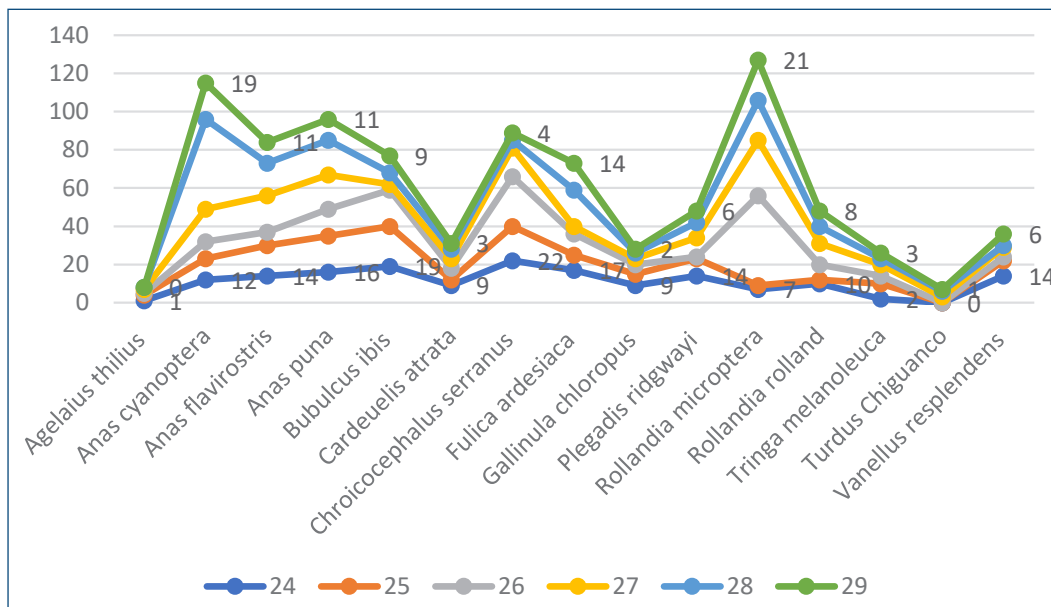


Fig. 3: Number of Species Observed Per Day

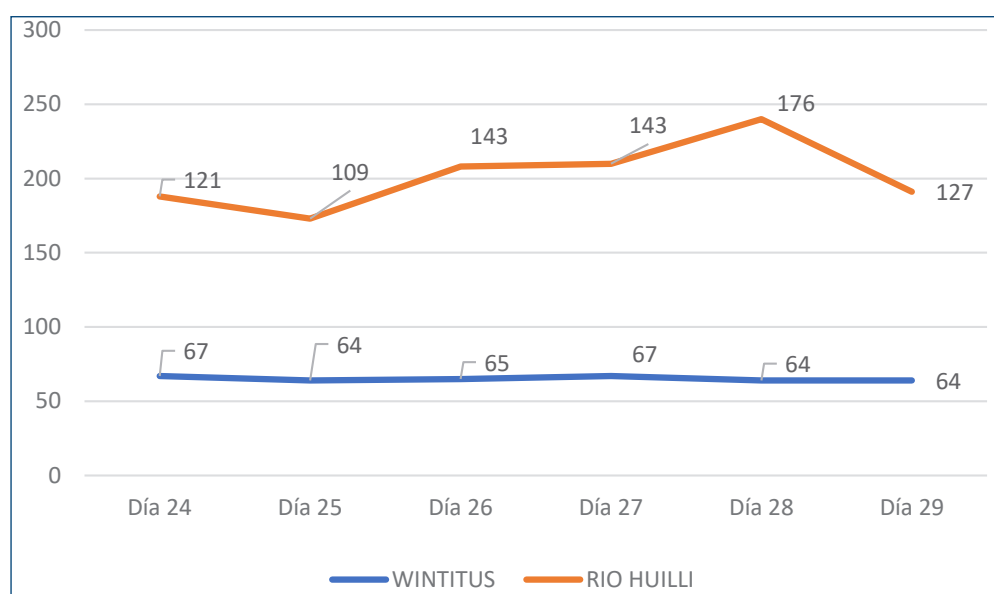
The highest values of the number of species observed per day are observed on September 27, 28 and 29, 2022, with a greater diversity of birds in the microhabitat of the Huilli river microhabitat compared to the Wintitus Island microhabitat; where aquatic birds such as the rollandia microptera (keñola) generally predominate.

The variation of birds diversity in the Wintitus island microhabitat is greater compared to the microhabitat of Huilli river, (Fig. 4) the reasons for their presence of the same are due to the characteristics of each one, the Wintitus Island's area has a particular vegetation by the presence of Senecio sp. "karihua", Cassia latopetiolata "sallihua", Stipa ichu "ichu" and common pastures in the area, the other area corresponds to the mouth of the Huilli river, an

area where there are cattails with water (*Schoenoplectus tatora*) in this microhabitat there are dense plantations of *Schoenoplectus tatora* "totora" where birds take refuge and find food.

**Table 2: Diversity Indexes by Microhabitat**

Variables	Microhábitat	
	Wintitus	Huilli River
Diversity	9	14
Abundance	232	660
Margalef index ( $D_{mg}$ )	1.469	2.002
Simpson index ( $\lambda$ )	0.822	0.874
Shannon index ( $H'$ )	1.868	2.237



**Fig. 4: Number of Birds Observed Per Day in Each Microhábitat**

The highest value of species richness and diversity (Margalef's  $D_{mg}$  index) occurs in Huilli river ( $D_{mg} = 2.002$ ). However, in Wintitus ( $D_{mg} = 1.469$ ) it presents a value lower than 2, which translates into a low species diversity.

The highest value of species diversity (Shannon index) occurred in the microhábitat rio Huilli ( $H' = 2.237$ ) than Wintitus ( $H' = 1.868$ ). Where the diversity and richness of species is due to the fact that the first microhabitat presents an important cover of *Schoenoplectus tatora* "totora" and *Hydrocotyle ranunculoides*, it also constitutes the largest area of extension, offering unique resources that attract birds of different species. In the case of Wintitus, it is

an island with the presence of people, which probably influences its low diversity and most of its areas are dry, which makes it unattractive to birds.

Similarly, when comparing the values of Simpson's index ( $\lambda$ ) of the microhabitats, it is observed that the value of  $\lambda$  is lower in Wintitus ( $\lambda = 0.822$ ) and higher in Huilli river ( $\lambda = 0.874$ ), which indicates that in the microhabitat of Huilli river there is greater diversity than in Wintitus island, this is supported because the higher the value of  $\lambda$ , the greater the diversity of species in a microhabitat.

To evaluate the difference in the frequency of birds according to days, species and microhabitat.

**Table 3: Bird Frequency Normality Tests**

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Estadística	Gl	Sig.	Estadística	Gl	Sig.
Birds	0.123	90	0.002	0.877	90	0.000

a.Lilliefors significance correction.

The assumption of normality of the frequency of birds is verified in order to apply non parametric statistical tests on the data observed in Table 1, for a sample greater than 50 the Kolmogorov-Smirnov test is applied and 0.123 with the asymptotic significance p value of 0.002 <0.05, the null hypothesis is rejected, then the normal

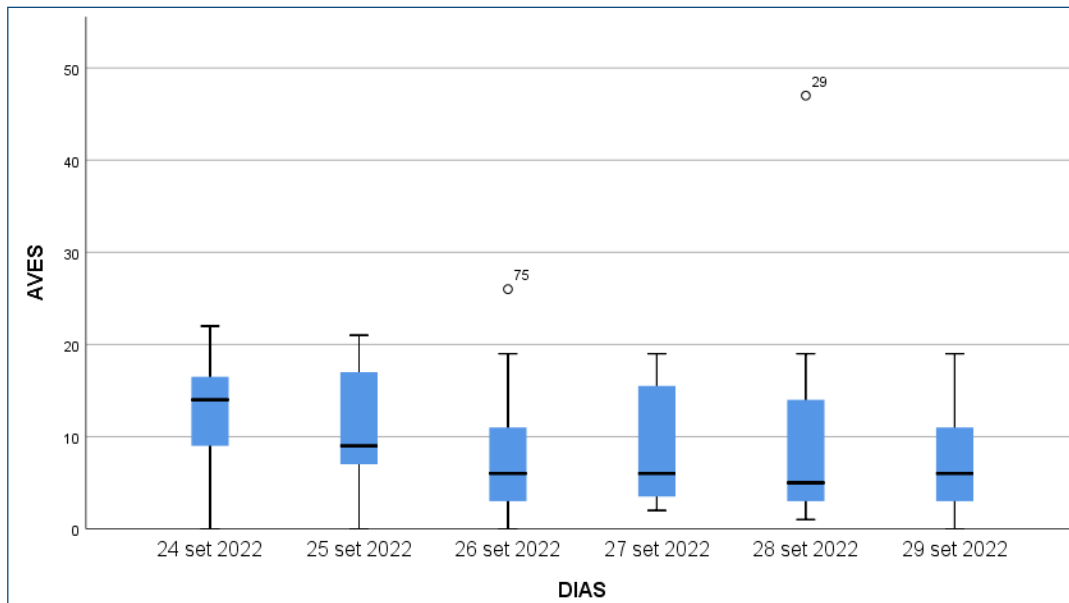
frequency of the presence of birds in the microhabitats of study is discarded. As an alternative, non-parametric tests such as the Kruskal Wallis test by day, by species and the difference of 2 independent samples for the case of microhabitats by means of the Mann-Whitney U test were applied.

**Table 4: Kruskal-Wallis H-Statistic Test According to Range of Averages by Days**

Birds/Days	N	Average Range	Kruskal-Wallis H	GL	Asymptotic Sig.
Sep 24, 2022	15	55.10	4.368	5	0.498
Sep 25, 2022	15	51.37			
Sep 26, 2022	15	40.43			
Sep 27, 2022	15	44.47			
Sep 28, 2022	15	41.40			
Sep 29, 2022	15	40.23			

The asymptotic significance of p value is 0.498>0.05, resulting in a non-significant statistical test therefore:

There is no difference in bird occurrence according to days observed.



**Fig. 5: Box and Whisker Plot of Birds Observed Per Day**

However, Fig. 5 shows that the 26<sup>th</sup> and 28<sup>th</sup> of September present atypical numbers of birds, which show an

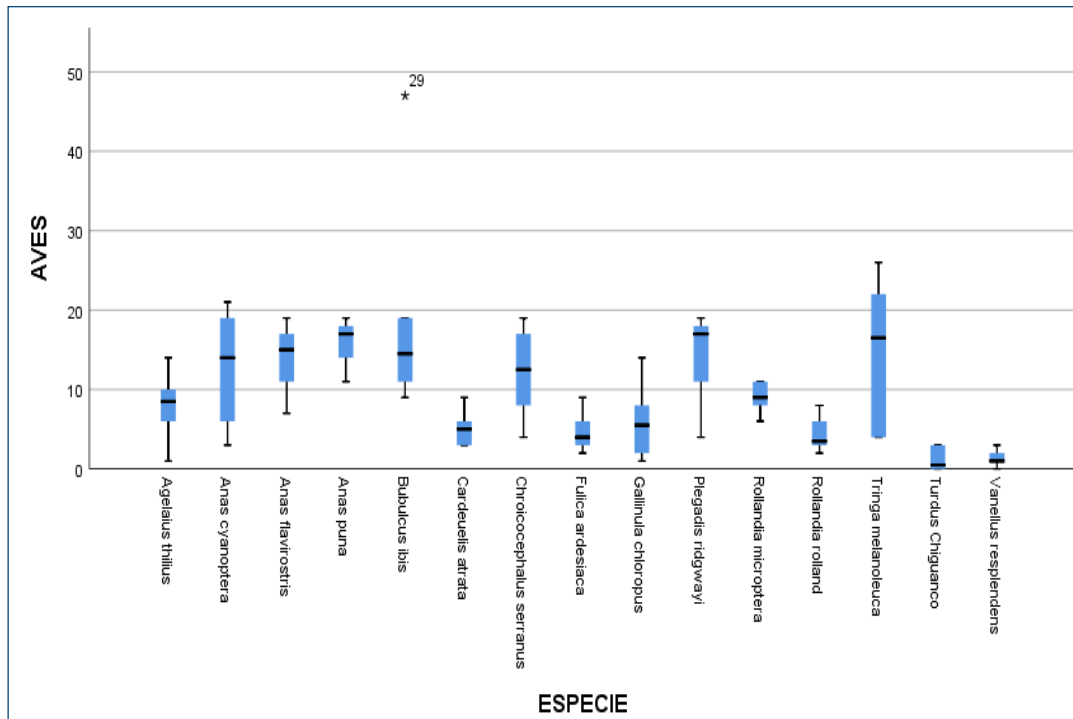
apparent difference in bird frequency with respect to the other days.

**Table 5: Kruskal Wallis H-Statistic Test According to Range of Average by Bid Species**

Bird Species	N	Avarage Range	Kruskal-Wallis H	GL	Asymptotic Sig.
Agelaius thilius	6	42.92	56.086	14	0.000
Anas cyanoptera	6	59.92			
Anas flavirostris	6	65.00			
Anas puna	6	71.67			
Bubulcus ibis	6	69.33			
Cardeuelis atrata	6	31.50			
Chroicocephalus serranus	6	58.33			
Fulica ardesiaca	6	28.33			
Gallinula chloropus	6	32.92			
Plegadis ridgwayi	6	65.33			
Rollandia microptera	6	49.50			
Rollandia rolland	6	26.58			
Tringa melanoleuca	6	62.67			
Turdus Chiguanco	6	9.00			
Vanellus resplendens	6	9.50			

The asymptotic significance of p value is  $0.000 < 0.01$ , being a highly significant statistical test, therefore, it is

determined that there are differences in bird frequency according to species.



**Fig. 6: Simple Box and Whisker Plot of Birds Observed by Species**

As shown in Fig. 6, there are marked differences between bird species as well as outliers in the species Bubulcus ibis.

**Table 6: Mann Whitney U Test According to Range of Average by Microhabitat**

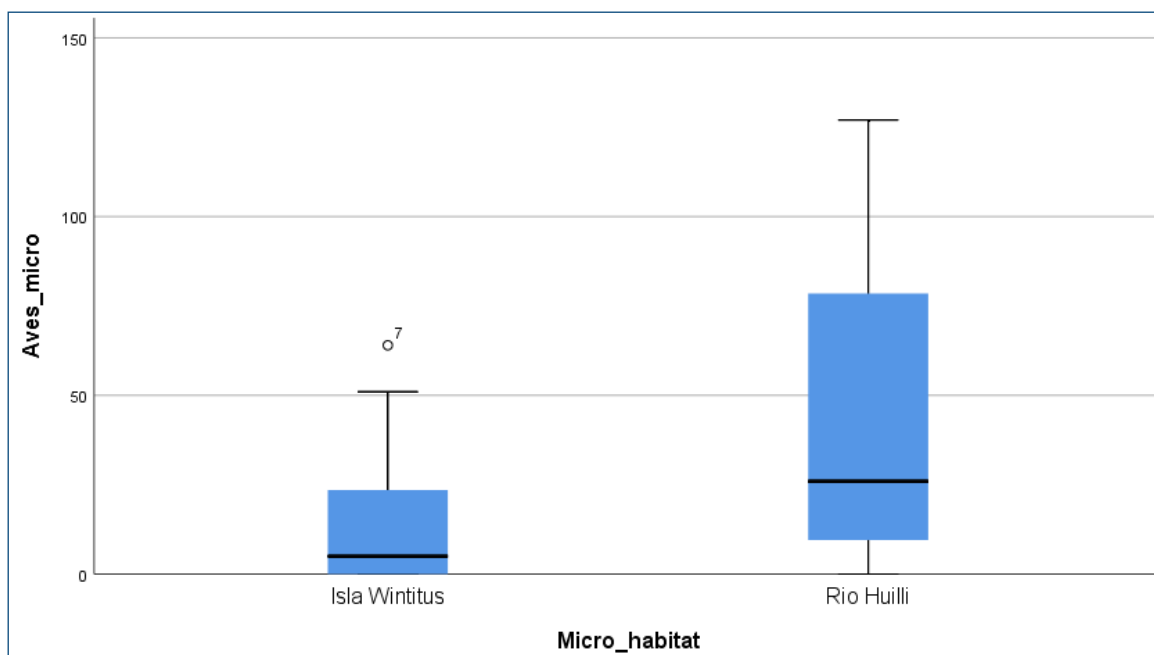
Microhabitat	N	Average Range	Sum de ranks	Mann-Whitney -U	Asimptotic Sign. (bilateral)	Exact Significance Exacta [2*(sig. One.sided)]
Wintitus island	15	12.00	180.00	60.00	0.028	0.029 <sup>b</sup>
Huilli river	15	19.00	285.00			
Total	30					

a. Grouping variable: Microhabitat.

b. Not corrected for ties.

The bilateral asymptotic significance of p value of Mann-Whitney U statistical test is  $0.028 < 0.05$ , then there is difference in the frequency of occurrence of birds according to microhabitat, at the same time, the unilateral

significance p value is  $0.029 < 0.05$  confirms the higher abundance of bird species in Huilli river, the same as observed in Fig. 7.



**Fig. 7: Simple Box and Whisker Plot of Birds Observed by Microhabitat**

## Discussion

This research focused on the abundance and diversity of birds associates with ecotourism, yielding significant results that contribute to the understanding of the importance of this activity Ecotourism, as noted in the introduction, is a responsible modality that promotes conservation, minimizes environmental impact and economically benefits local population. The findings of this research support this notion by showing that the diversity and abundance of birds in Yanico are conducive to the development of ecotourism and birdwatching,

this finding is consistent with previous research that has highlighted the economic and ecological value of nature tourism (Liu et al., 2021; Millán-Rojas et al., 2020). One of the highlights of the study is the difference in bird diversity between the microhabitats of Wintitus island and the Huilli river. Also, the results indicate that the Huilli river harbors a greater diversity of birds, supporting the idea that the presence of certain resources, such as specific vegetation and the extent of the area, may attract a wider variety of species, these results reflect previous findings that relate habitat heterogeneity to greater species diversity (Espinosa-Méndez et al., 2020).

Analysis of bird frequency by day and species reveals interesting data, while no significant differences were found in bird frequency by day, there were notable variations in bird frequency between species: this highlights the importance of understanding the ecology of each species and how they respond to certain seasonal of behaviour factors in their environment (Zhang & Huang, 2020).

It is relevant to note that this study was based on a limited sample of time and space to obtain a more complete picture of the diversity of birds in Yanico, it would be beneficial to conduct studies over a longer period and in multiple microhabitats and to deepen the ecological interactions between bird species and their environment (Magurran, 1988).

## Conclusions

The study concludes that there is a significant difference in bird diversity and abundance between the microhabitats of Wintitus island and the Huilli river in the Yanico sector of Tititcaca Lake National Reserve.

The highest values of species diversity as measured by the Shannon index, were observed in the Huilli river microhabitat ( $H' = 2.237$ ) compared to Wintitus island ( $H' = 1.868$ ). This is explained by the significant presence of the *Schoenoplectus tatora* plant “totora” and *Hydrocotyle ranunculoides* in the former microhabitat, along with its greater extent. These characteristics provide exclusive resources that attract birds of diverse species, which contributes to the greater diversity and richness of species in this area.

The higher abundance according to the Mann-Whitney U statistical test ( $0.028 < 0.05$ ), there is a difference in the frequency of bird presence according to each microhabitat, at the same time, the unilateral significance of p value =  $0.029 < 0.05$  confirms the higher abundance of bird species in the Huilli river.

The Yanico sector has a significant diversity and abundance of birds to encourage bird watching as an ecotourism activity and promote the participation of local communities in sustainable ecotourism.

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