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The Wilson's Phalarope *Phalaropus tricolor* population and feeding activity at Lake Titicaca

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Abstract A population estimation of Wilson's Phalaropes was conducted in the Confinada Lagoon of the inner bay of Lake Titicaca in the city of Puno between August and May of 2016/2017, 2017/2018 and 2018/2019. We employed the quadrat method of population estimation with three repetitions using 10×50 mm binoculars between 06:00 and 08:00 h. We recorded population fluctuations in August and September (immigration season) and April and May (emigration season). We counted a maximum population of 112,000 Wilson's Phalaropes during the immigration season, and then in the emigration season. During their stay of approximately 8 months, the birds feed on water fleas, insects and detritus amounted to 146,496 t. The inner bay of Lake Titicaca is an important aquatic habitat for these migratory birds, which has a positive impact on the contribution to the decontamination of the lake.

Keywords: behavior, emigration, immigration, feeding, migratory species

Összefoglalás A Wilson-víztaposó populációjának becslését 2016/2017, 2017/2018 és 2018/2019 augusztusa és májusa között végeztük Puno városában, a Titicaca-tó belső öblének Confinada lagúnájában. A populációbecsléshez kvadrát-alapú módszert alkalmaztuk három ismétléssel, 10×50 mm-es kézitávcső használatával, 06:00 és 08:00 óra között. Augusztus és szeptember (érkezési időszak), illetve április és május (távozási időszak) között rögzítettük az állomány egyedszámának ingadozását. Az érkezési időszakban, majd a távozási időszakban számláltuk a legtöbb, mintegy 112 000 Wilson-víztaposót. A madarak a Titicaca-tó belső öblének környezetében való nyolc hónapos tartózkodásuk alatt becslésünk szerint 146 496 tonna szerves törmeléket, rovarokat, vízibolhákat, rákféléket és egyebeket fogyasztanak. A Titicaca-tó belső öble fontos élőhely ezeknek a madaraknak, amelyek pozitív hatással vannak a tó vízminőségére.

Kulcsszavak: viselkedés, kivándorlás, bevándorlás táplálkozás, vonuló faj

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Introduction

Wetlands have a high diversity of wild flora and fauna and act as breeding, feeding and resting areas for migratory birds, and these types of ecosystems are important to migratory shorebirds such as Wilson's Phalaropes *(Phalaropus tricolor)*, which start their journey in the Northern Hemisphere and then migrate to South America (Miranda *et al*. 2015). They reproduce in the United States and Canada, and spend their winters mainly in saline lakes in the Andes of South America. Their estimated population is 1.5 million individuals; however, they have suffered a significant decline (Lesterhuis & Clay 2010). This species feeds on small crustaceans, larvae and adults of insects (De la Peña 2016).

Out of the birds reported at Lake Titicaca, there are 95 resident species and 40 species come from other latitudes: 17 species are Nearctic migrants, 10 species are austral migrants, and 13 species perform latitudinal migration from the Peruvian Andes to the coastal region. Nearctic migrants are at Lake Titicaca from September to March, and southern migrants are from April to August (Pulido 2018). Saline plants provide refuges and feeding grounds for migratory shorebirds in the tropics, and up to 107,081 Wilson's Phalaropes individuals have been recorded (Del Pezo 2018).

Wilson's Phalaropes usually exhibit a twisting and turning behavior when feeding in freshwater sites for several days, converging on eddy fronts and internal waves that apparently provide an easily accessible and constant supply of food (DiGiacomo *et al*. 2002). In Cuba, Wilson's Phalaropes are a rare species with only two previous records in the country (González *et al*. 2018). Additionally, in Argentina, they are rare in the RAMSAR site and Vicuña Provincial Reserve of Argentina (Lobo & Marano 2017), while in Colombia, they have a distribution range including several localities (Ruiz-Guerra 2012). In the Pisco area of Peru, this species is habituated to human presence (Astohuaman & Espejo 2003), phalaropes having the highest abundance of all shorebirds (Podestá *et al.* 2017).

Wetlands are important habitats for aquatic birds, which are some of the most charismatic fauna inhabiting wetlands, with a greater flexibility than that of fish because they can make use of these environments during only part of their annual cycle (López-Lanús & Blanco 2005).

Freshwater wetlands are feeding areas where there are high concentrations of the Scolopacidae family (Pulido *et al.* 2020, Ruiz-Guerra & Cifuentes 2021), which dominate the avifauna assemblages with a high abundance and diversity of boreal and austral migrants (Pisconte *et al*. 2020). Additionally, in some lagoons, there is a greater representation of the Scolopacidae family (Ruiz-Santillán *et al*. 2020). In Argentina, Wilson's Phalaropes are observed in high numbers in hypersaline lagoons; within a total of 502 habitats, 51 (10.1%) represent feeding areas of phalaropes, with more than 10,000 individuals recorded in each area (Dodyk 2020). In Central America, there are 68 nonbreeding migratory species such as Wilson's Phalaropes (Herrera 2021), of which up to nine have been recorded in the migratory flyways of Argentina, Paraguay and Brazil. However, these habitats are being fragmented by agricultural activities and inadequate water resource management (Pulido *et al*. 2021).

Many species of migratory birds feeding on invertebrates, including mollusks, crustaceans and insects (Villavicencio 1989) in the inner bay of Lake Titicaca in the city of Puno have

been observed (Canales 2004), being an important component of the water pollution process (Rodríguez-Guzmán & Gilbes-Santaella 2009), as they are related to the production and flow of pollutants in the water (Ekercin 2007), which mainly restricts the use of water for human consumption (Torres-Dowdall *et al*. 2010). Organic and inorganic pollutants discharged into domestic water or run-off water (Kutschker *et al.* 2009) affect the population dynamics of aquatic flora and fauna (Quintero *et al.* 2010, Bracho *et al*. 2016) and have a negative impact on the quality of the aquatic ecosystem (González 2012).

Our research objective was to quantify the amount of feeding (detritus, water fleas, insects and crustaceans) by Wilson's Phalaropes individuals in the inner bay of Lake Titicaca in the city of Puno.

Materials and Methods

Study area

The research was carried out in the Confinada Lagoon Bay of Lake Titicaca in the city of Puno, located at 3,810 m above sea level, with the coordinates of 15°49'58.95"S and 70°01'01.67"W and a temperature range between 5 and 20 °C. This lagoon was formed by the filtration of the lake, the addition of rainwater and the wastewater from the city of Puno. It has an area of approximately 20 ha and an average depth of 2.5 m.

We recorded the presence of Wilson's Phalaropes from 06:00 to 08:00 h during August and September (immigration stage) and April and May (emigration stage) in 2016, 2017, 2018 and 2019. For the counting of individuals, we applied the quadrat method, starting

Figure 1. Study location, Confinada Lagoon in the inner bay of Titicaca ake Puno, Peru
1. ábra A vizsgálati terület, Confinada laguna a Titicaca Puno-tó belső öblében, Peruban

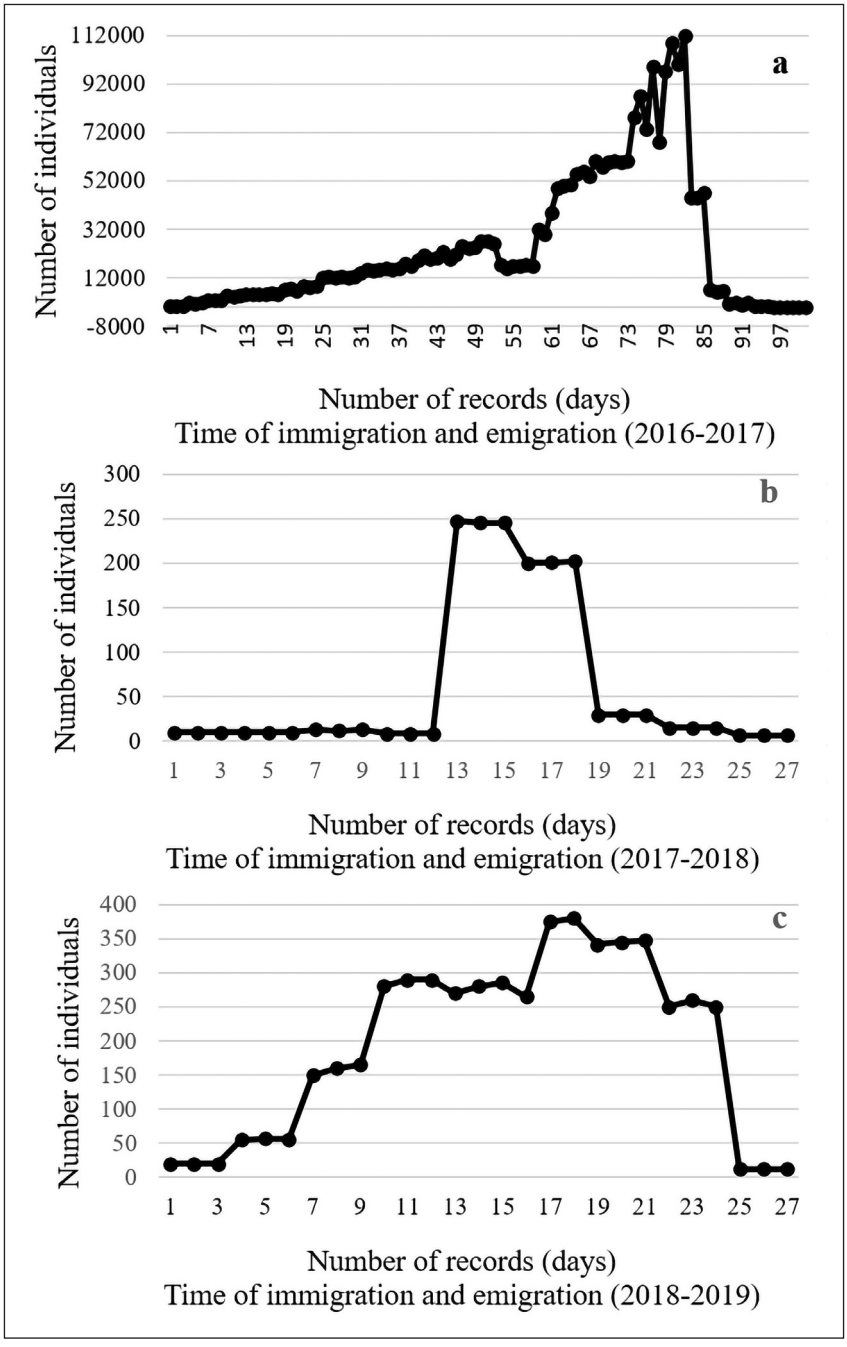


Figure 2. Population estimation of the number of individuals during immigration and emigration of Wilson's Phalaropes in the inner bay of Lake Titicaca, Puno. (a), 2016/2017 (b) 2017/2018 (c) 2018/2019

2. ábra A Wilson-víztaposók egyedszámának becslése a bevándorlás és a kivándorlás során a Titicaca-tó belső öblében, Punóban. (a) 2016/2017, (b) 2017/2018, (c) 2018/2019

from a fixed point located in the central part of the lagoon after dividing the lagoon into four quadrants. For the population estimation of this migratory species, we used Bushnell 10×50 mm binoculars.

We counted the number of individuals in all samples beginning in the southern part of the lagoon and ending in the northern zone. In each of the quadrants, we recorded three replicate counts, and then we obtained the average number of individuals for each quadrant *(Figure 1)*. The replicates allowed us to have a better approximation of the population estimate of Wilson's Phalaropes when they were carrying out their feeding activities (capturing water fleas, insects and detritus) in the confined lagoon.

The consumption of organic detritus, insects, water fleas, crustaceans, among others, by migratory birds has been calculated on the basis of 10% of the average weight of the migratory bird species evaluated (Canales 2004).

Results

Population estimation

The number of individual Wilson's Phalaropes during the 2016/2017 immigration and emigration season had a mean of 24,558.44 individuals, with a minimum value of 10 individuals and a maximum value of 112,000 individuals *(Figure 2a)*, while the population estimate of Wilson's Phalaropes during the 2017/2018 immigration and emigration season had a mean of 60.04 individuals, with a minimum value of seven individuals and a maximum value of 247 individuals arriving in the Confinada Lagoon *(Figure 2b)*.

The number of Wilson's Phalaropes during the 2018/2019 immigration and emigration season had a mean of 194.13 individuals, with a minimum value of 12 individuals and a maximum value of 380 individuals arriving in the Confinada Lagoon *(Figure 2c)*. The presence of Wilson's Phalaropes in this area occurs from August onward, when the immigration of thousands of individuals of Wilson's Phalaropes begins. After feeding, they emigrate to the United States and Canada between April and May.

Feeding activity

During their stay in the bay, Wilson's Phalaropes feed on Water Fleas *(Daphnia pulex)*, detritus, insects, algae and crustaceans, and this species is also beneficial for oxygenating the waters, reducing inappropriate odors, promoting birdwatching tourism, improving the landscape and interacting with other bird species, which are associated with the presence of this migratory bird.

The 112,000 migratory individuals of Wilson's Phalaropes have fed on organic detritus, insects, water fleas, crustaceans and others during an eight-month stay in the inner bay of Lake Titicaca, a total of 146,496 kg *(Table 1)*.

Table 1. Amount of feeding of organic detritus, water fleas, insects, crustaceans, etc. by individuals of Wilson's Phalaropes

1. táblázat A Wilson-víztaposók táplálékbázisaként szolgáló szerves törmelék, vízibolhák, rovarok, rákfélék stb. mennyiségi eloszlása

Species	Number of individuals	Daily consumption in kg (10% of their weight corporal= 0.00545 kg)	Total month (kg)	Total for 8 months (kg)
P. tricolor (Average weights 0.0545 kg)	112,000	610.4	18,312	146,496

Discussion

Population estimation

This migratory bird arrives to feed (Lesterhuis & Clay 2010) on small crustaceans, larvae and adult insects (Miranda *et al.* 2015). Wetlands have a great diversity of flora and act as breeding, feeding and resting centers for these migratory birds, whose estimated population is 1.5 million individuals (Lesterhuis & Clay 2010); however, the migration of 2016/2017 was unusual for Lake Titicaca Bay in the city of Puno (Confinada Lagoon) due to the high number of individuals, i.e., reaching up to 112,000 individuals, while in 2017/2018 and 2018/2019, only very few individuals arrived (not exceeding 380 individuals). This phenomenon could be due to environmental factors such as the disturbance of their habitat that they use as stopover sites on their migratory route; or due to a greater availability of food that could have been found at Lake Titicaca. Moreover, Ocampo-Peñuela (2010) suggests that the presence of water is the main compass of the migratory movements of many birds, where, in a dry season, large numbers of individuals are observed in a single habitat. Furthermore, according to Torres *et al.* (2006), sexual maturity and the accumulation of fat could influence the abundance of migrating individuals.

The Confinada Lagoon, where this species feeds from August to May, is an important habitat for aquatic birds (López-Lanús & Blanco 2005).

Similarly, in an artificial pool of a salt company in Ecuador, up to 10,7081 individuals of Wilson's Phalaropes have been recorded (Del Pezo 2018).

Feeding activity

The 112,000 individuals of Wilson's Phalaropes, in the eight months of permanence in the surroundings of the inner bay of Lake Titicaca in the city of Puno, feed on organic detritus, insects, water fleas, crustaceans and others, consuming about 146.496 t, this result has been estimated based on the average of 54.45 g, weight of males and females of Wilson's Phalaropes individuals (Salvador 2014), considering the minimum consumption of each individual in at least 10% of its weight, which corresponds to 5.45 g/each individual/day *(Table 1)*.

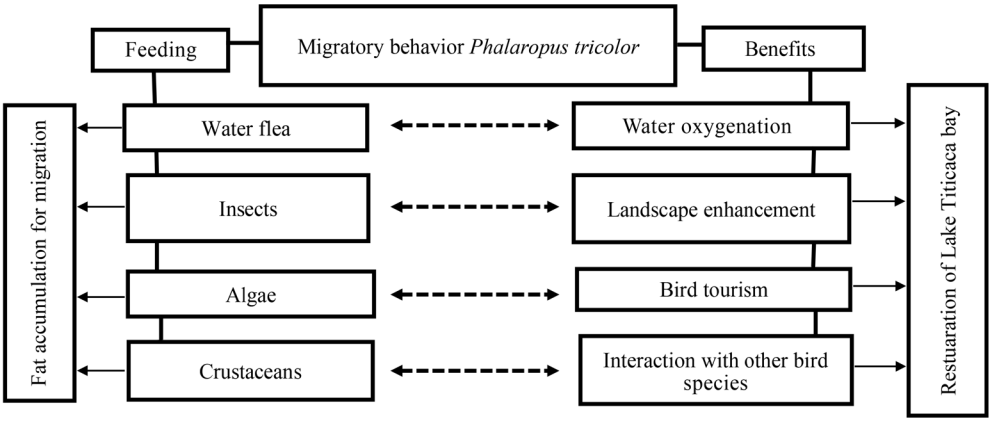
According to De la Peña (2016), Wilson's Phalaropes feed on small crustaceans, larvae, insects and also have a preference for sites with abundant flies and microbial substrates

(Franco & Conover 2019), and also, they depend on abundant invertebrate prey (Franco & Conover 2021), because shorebirds increase their ability to replenish energy reserves, while migrating to North America and Canada (Andrei *et al*. 2009) and they must accumulate fat during the premigratory period (Harrington *et al.* 1991).

Therefore, the inner bay of Titicaca is an important feeding habitat for migratory birds, which accumulate fat as an energy reserve that serves for oxygen transport, hypertrophy of flight muscles and the development, integration and synchronization of migratory behaviour (Villaseñor 1994), using the accumulated fat as the "fuel load" for migration (Grandío 1998), presenting good conditions of fat status and physical condition of the migrants (Pérez 1999).

Finally, these migratory birds have a positive impact on the contribution to the decontamination of the inner bay of Lake Titicaca in the city of Puno, due to the type of food they eat (Canales 1989), such as insects and detritus, among others (Canales 2004), also providing the benefits of oxygenation of the water. Water oxygenation is a fundamental aspect for aquatic life, where its absence can cause reduction and death of the species present in the body of water (Shaghaghi *et al.* 2020).

Graphical abstract



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