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Author(s): Ignacio Roesler and Santiago Imberti

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Abundance and Habitat Use of Nearctic Shorebirds in the Highland Lakes of Western Santa Cruz Province, Argentinean Patagonia

IGNACIO ROESLER^{1,2,*} AND SANTIAGO IMBERTI²

¹IEGEBE-CONICET, Laboratorio de Ecología y Comportamiento Animal, Departamento de Ecología Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón II, Ciudad Universitaria, C1428EHA Buenos Aires, Argentina

²Proyecto Macá Tobiano/Hooded Grebe Project, Grupo FALCO, Ambiente Sur, Carlos Gardel 389, Río Gallegos, 9400, Argentina

*Corresponding author; E-mail: roesler@ege.fcen.uba.ar

Abstract.—Information on Nearctic shorebirds is scarce for inland South America. This work presents information on abundance and habitat use of the species that inhabit water bodies in the highlands of western Santa Cruz province, Argentina. Surveys were conducted during four austral summers (January to March) from 2010 to 2013, with annual data collected at 378 lakes. Results indicate that species distribution varies from year to year. The most abundant species was Baird's Sandpiper (*Calidris bairdii*). Habitat modeling showed that this species favors 'depression' type lakes and that individuals do not distribute uniformly across the area, with higher yearly abundance at Strobel Plateau and the plateaus of the 'Austral complex'. Size of the water body is positively related to abundance of White-rumped Sandpiper (*C. fuscicollis*) and Wilson's Phalarope (*Phalaropus tricolor*). Results show that these highlands are sites of interest for the conservation of migratory shorebirds. Received 7 October 2014, accepted 19 November 2014.

Key words.—abundance, Baird's Sandpiper, *Calidris bairdii*, *Calidris fuscicollis*, habitat use, highland plateaus, Nearctic shorebirds, Patagonia, *Phalaropus tricolor*, White-rumped Sandpiper, Wilson's Phalarope.

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Since the 1990s, research on the population and ecology of migratory Nearctic shorebirds has been a focal point in the Southern Cone, mainly at coastal areas of Buenos Aires, Río Negro, Santa Cruz and Tierra del Fuego Provinces (Gonzales 1996; Ferrari *et al.* 2002; Baker *et al.* 2005; Blanco *et al.* 2006). Some studies have addressed abundance at continental sites (Laredo 1996; Montalti *et al.* 2003; Lanctot *et al.* 2004). A few species concentrate their wintering period on inland lakes; however, existing information on these sites is anecdotal. Several sites of importance for shorebirds have been identified; however, shorebird studies for many other important sites are under-represented (Di Giacomo *et al.* 2007). Among the latter are the highland plateaus in the western part of Santa Cruz Province, where few studies have been published on the avifauna (Darrieu *et al.* 2008, 2009; Roesler *et al.* 2014).

Fourteen Nearctic species of shorebirds belonging to the Charadriidae and Scolopacidae families have been found in Santa Cruz Province (Darrieu *et al.* 2008, 2009). Most of them arrive regularly to the estuaries of the Atlantic coast mainly at the Gallegos, Coyle

and Deseado rivers. There are some important inland locations, principally at Argentine Lake, in the southwestern part of the province, where coastal species appear regularly although in smaller numbers (Darrieu *et al.* 2008). The global conservation status of Nearctic shorebirds of Patagonia is listed as Least Concern by the International Union for Conservation of Nature (2014), with the Red Knot (*Calidris canutus*) categorized as Endangered at the national level (López-Lanús *et al.* 2008).

Our objective was to assess the abundance of Nearctic shorebirds in western Santa Cruz Province, Argentina. We present total number detected and details of their habitat preferences on their wintering grounds. Finally, we analyzed and compared the total numbers of individuals for each species during the different seasons.

METHODS

Study Area

Patagonia comprises the southernmost part of South America, with an estimated area in Argentina of approximately 786,575 km², extending from 39° S

to 55° S (Fig. 1). Annual precipitation decreases from the west near the Andes (approximately 600 mm) to the east (approximately 270 mm), with most precipitation (mainly snow) occurring during winter and spring. Parallel to the Andes, there is a strip of plateaus that, ordered from north to south, are: Buenos Aires, Asador, Strobel, Ventana, Moro, Siberia, Viedma, Mata Amarilla and Vizcachas (Fig. 1). These plateaus extend from 47° S to 51° S, with elevations between 500 and 1,500 meters above sea level (MASL). We considered the 'Austral complex' to include Viedma, Mata Amarilla, and Vizcachas Plateaus as a group, due to the similar characteristics and the close distance between their most important lakes. The plateau areas range from 30 to 2,900 km² and hold endorheic volcanic and non-volcanic fishless lakes that accumulate water from precipitation and snow melt after winter; their numbers vary greatly among plateaus, from a few dozen to over 1,000 (Roesler *et al.* 2012). Because many of these lakes have exceptionally large numbers of colonial waterbirds, these plateaus are considered "Important Bird Areas" (Di Giacomo *et al.* 2007).

Data Collection

During four austral summers from 2010 to 2013, we visited 378 lakes located at the main plateaus of Santa Cruz Province. An exploratory survey of 38 lakes was conducted during the 2008-2009 season; surveys con-

ducted between the 2009-2010 and 2012-2013 seasons added more lakes, ranging from 120 up to 287 lakes. During the study, many other sites were visited, including lowland lakes, such as those in Perito Moreno National Park, Argentino Lake, in the town of El Calafate, and some other smaller ones, but these were not included in the analysis, as we did not attempt to conduct systematic surveys at these locations.

At each lake, trained observers counted all shorebirds species. Counts were done with 15-60x spotting scopes and 10x42 and 8x32 binoculars. Two to four observers conducted counts independently, and each observer performed at least two consecutive counts. We doubled the number of counts when weather conditions reduced visibility (i.e., strong winds, rain or snow). We included in our analysis counts conducted from January to March. We did not include counts from the early summer season (mid to late October and November) since shorebirds tended to aggregate in a few lakes upon arrival and later dispersed.

Study Species

Five species of Nearctic shorebirds are regularly found on the lakes within the study area (Darrieu *et al.* 2008, 2009): Baird's Sandpiper (*Calidris bairdii*), White-rumped Sandpiper (*C. fuscicollis*), Greater Yellowlegs (*Tringa melanoleuca*), Lesser Yellowlegs (*T. flavipes*) and

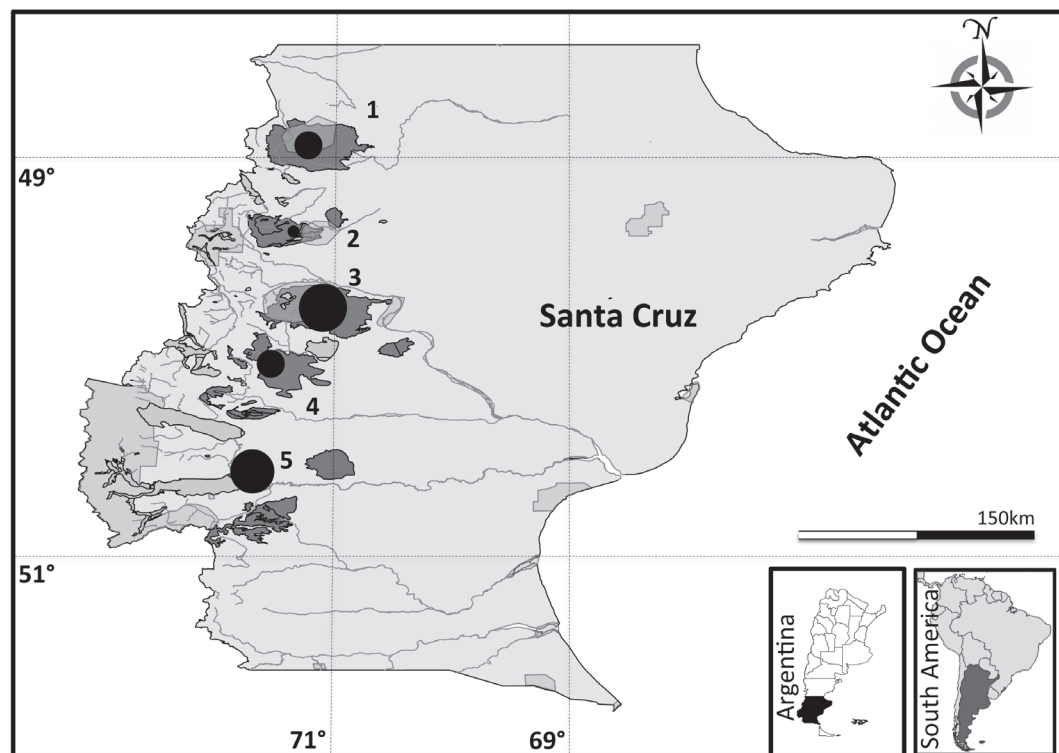


Figure 1. Map showing Santa Cruz province. Highland plateaus: 1) Buenos Aires; 2) Asador (Center, Northern and Southern); 3) Strobel; 4) Siberia; and 5) 'Austral complex' (Viedma, Mata Amarilla and Vizcachas Plateaus). The size of the black dots indicates the relative abundance of Nearctic shorebirds on each plateau.

Wilson's Phalarope (*Phalaropus tricolor*). Three other Nearctic shorebirds are present but at very low densities: Pectoral Sandpiper (*Calidris melanotos*), Hudsonian Godwit (*Limosa haemastica*) and the Red Phalarope (*Phalaropus fulicarius*).

Analysis

A number of variables thought to affect shorebird abundance were defined for each lake. Variables recorded for each lake included: 1) Size (≤ 5 ha, 6 to 20 ha, or 21 to 100 ha); 2) Type (basaltic or depression); 3) Turbidity (crystal clear or turbid); 4) Coverage of water milfoil (*Myriophyllum* sp.) (absent, 10 to 50%, or $> 50\%$); 5) Plateau (each surveyed plateau using Mata Amarilla, Viedma and Vizcachas as the 'Austral complex' of plateaus). The dependent variable was the total number of individuals (per species) detected on every lake. Given that 2012-2013 had the largest number of visited lakes per plateau, we used the 2012-2013 season to test the habitat use of the species. To analyze the effects of habitat characteristics on shorebirds abundance, we used general linear models (GLM) with a negative binomial error distribution and *log* link function (Crawley 2012), and we used backward stepwise selection procedure to remove non-significant terms from each model in decreasing order of probability. The global model used for all three species was: GLM.nb(abundance~type+plateau+size+turbidity+Myriophyllum). We analyzed the goodness of fit and the over-dispersion factor (*c*), calculated as the Pearson residual value (Svagej *et al.* 2009). For species models, we used binomial negative distribution, considering that the model adjusted well ($\theta < 1$; $c < 1$) (Crawley 2012). In the cases of White-rumped Sandpiper and Wilson's Phalarope, we used zero inflated models due to the abundance of non-positive counts (Crawley 2012). A Tukey's HSD post hoc analysis was carried out to test for differences among the levels of the factors that were retained on the best model (Crawley 2012). Differences were considered significant at $P < 0.05$. All statistical analyses were made with program R (R Development Core Team 2014).

RESULTS

During four seasons, we surveyed a total of 378 lakes distributed among all the pla-

teaus in the Western portion of Santa Cruz Province. The most comprehensive survey was that of the 2012-2013 season, when 287 lakes were covered, while 2009-2010 had the least coverage with 120 lakes surveyed (Table 1). The most abundant species was Baird's Sandpiper which not only showed overall highest total numbers (Table 1), but also the highest lake occupancy (Fig. 2) and the highest percentage of individuals per lake. Except in the 2012-2013 season, Wilson's Phalarope was found in high numbers (Table 1), but was present at fewer lakes than Baird's Sandpiper (Fig. 2). During the 2012-2013 season, White-rumped Sandpiper was the second most abundant species, but it was present at much lower numbers than Wilson's Phalarope in the 2009-2010, 2010-2011 and 2011-2012 seasons (Table 1). High values for individuals of Wilson's Phalarope per occupied lake (Fig. 2) showed that the species tends to concentrate in few lakes.

Annual variations had a clear change in the numbers for the three most abundant species, even when the relative survey effort increased in subsequent seasons (Table 1). Our data suggest that most individuals are concentrated in few lakes, except in the case of Baird's and White-rumped sandpipers (Table 1; Fig. 2). For these species, the relation of individuals per occupied lake is concordant with the number of individuals per total lakes surveyed.

The stepwise procedure indicated that the model that best explained the habitat use of Baird's Sandpiper was: GLM.nb(abundance~type+plateau). Variables like turbidity and size did not have a significant effect ($P > 0.1$) on the model and were removed. The 'type' variable showed that the

Table 1. Number of Nearctic shorebirds recorded each season and total lakes visited.

Species	Scientific Name	2009-2010	2010-2011	2011-2012	2012-2013
Baird's Sandpiper	<i>Calidris bairdii</i>	2,045	3,821	2,295	2,265
White-rumped Sandpiper	<i>C. fuscicollis</i>	154	115	56	23
Wilson's Phalarope	<i>Phalaropus tricolor</i>	1,041	2,277	510	5
Greater Yellowlegs	<i>Tringa melanoleuca</i>	0	15	4	5
Lesser Yellowlegs	<i>T. flavipes</i>	0	26	6	2
Hudsonian Godwit	<i>Limosa haemastica</i>	0	2	2	0
Total Lakes		120	195	182	287

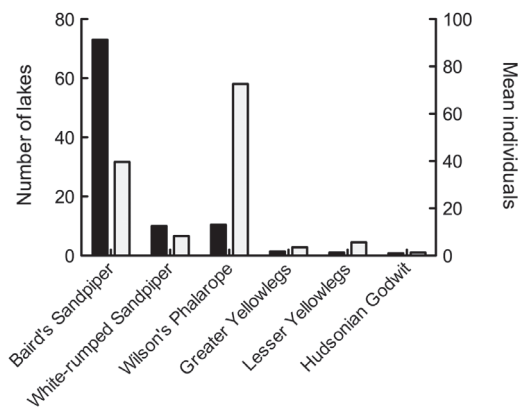


Figure 2. Black columns (left axis): number of lakes with presence of each species in all seasons. White columns (right axis): mean number of individuals per occupied lake.

abundance observed at depression lakes was significantly higher (E-model estimate = 0.964; SE = 0.436; $P = 0.027$) than on the basaltic lakes. Tukey's HSD for test on factor plateau showed differences when comparing the Asador Plateau to those in Strobel and the 'Austral complex' (Vizcachas, Viedma and Mata Amarilla), with the abundance of Baird's Sandpiper being significantly lower ($P < 0.05$) on the Asador Plateau. While the number of individuals on the Asador Plateau was also lower than those on the rest of the plateaus, the findings were not significant ($P > 0.1$). The number of individuals in the Buenos Aires and Siberia Plateaus also were not significantly lower than those observed at the Strobel Plateau and the 'Austral complex' (both $P > 0.1$). General linear models conducted for White-rumped Sandpiper and Wilson's Phalarope indicated that none of the habitat variables measured were significant enough to explain their abundance at surveyed lakes, but a tendency pointing to the model GLM.nb(species~size) as the model that best explained available data ($P = 0.1$) suggest that higher abundances observed on larger lakes may be important.

DISCUSSION

Our study is the first that collected systematic data on abundance and habitat use

of the shorebirds wintering in inland Patagonia. During our surveys, we covered 378 lakes (with a maximum of 287 in a single season), distributed in seven different plateaus, which represents just a small part of the available habitat for these species. For instance, Strobel Plateau holds over 1,000 lakes (Roesler *et al.* 2012), including the big Strobel Lake, with a large amount of potential habitat that was not covered in our study. An interesting result was that the highland plateau lakes seem to be sites of special importance for Baird's Sandpiper and Wilson's Phalarope, given their high abundance. These results also show that the morphology of the lakes is important, with depression lakes being preferred by Baird's Sandpiper. This is consistent with the lower abundances recorded in Asador Plateau, which has low availability of depression lakes, and the higher abundances recorded in the 'Austral complex' (Vizcachas, Mata Amarilla and Viedma Plateaus) and Strobel Plateau, where the number of depression lakes is higher.

We considered that the steep drop in the numbers of Wilson's Phalarope during the last two seasons (Table 1) could be a consequence of the combination of the survey methodology and the gregarious behavior of the species (Hayman *et al.* 1986). Missing a single flock in the surveys can have an important influence on the final number per season. The White-rumped Sandpiper, although in small numbers, were present on all lakes, with higher abundance on bigger lakes but with no well-marked preferences between different lake types. So, considering the large number of available lakes, it is logical to infer that a large population inhabits the plateaus.

During our survey, Greater and Lesser yellowlegs were only found in low numbers at large vegetated lakes with sandy (volcanic ash) beaches, a type of habitat under-represented in the highland plateaus. Although this habitat is scarce on highland plateaus, it is common in the lowlands surrounding the plateaus (I. Roesler, pers. obs.). During non-systematic observations, three species (Hudsonian Godwit, Pectoral Sandpiper and Red Phalarope) were found to be associated with

the coasts of the larger lowland lakes but not on the plateau lakes.

It is important to highlight the higher abundance of shorebirds detected on the Strobel Plateau, as well as on the 'Austral complex' plateaus. Areas like Strobel Plateau would benefit from conservation planning, as our results show that this habitat is important for Nearctic migrants, mainly Baird's Sandpiper and Wilson's Phalarope. As mentioned above, this plateau holds over 1,000 small lakes, and Strobel Lake in particular is under constant pressure of trout stocking (Lancelotti *et al.* 2010). A further study on the western plateaus will generate important information about the habitat selection of focal species and could direct conservation and management efforts, principally on the detection of important areas and the consequent creation of protected areas. This protection is likely to benefit the breeding grounds of austral shorebirds, principally the Patagonian endemic and globally near threatened Magellanic Plover (*Pluvianellus socialis*) (I. Roesler, unpubl. data), as well as other globally endangered species that inhabit the highland lakes (Roesler *et al.* 2012, 2014).

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