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http://dx.doi.org/10.1071/MU10079

Short Communication

Use of Peninsula Valdes (Patagonia Argentina) by migrating Red Knots (*Calidris canutus rufa*)

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Abstract. Red Knots (*Calidris canutus rufa*) that winter in southern South America stop on Peninsula Valdes, Patagonian Argentina, on their northern passage. The Peninsula comprises two large gulfs, each of which has two high and two low tides per day; high tides in San José Gulf correspond to low tides in Nuevo Gulf and vice versa. We conducted weekly censuses of Red Knots on several beaches on these gulfs between March and May in 2006 and 2007 and observed marked individuals. We undertook an aerial survey of the coasts of the two gulfs each April. The use of the different beaches on the two gulfs by Red Knots varied significantly in both years of the study, and the patterns of use differed between 2006 and 2007. In both years, maximum numbers of Red Knots were counted in April. Observations of marked individuals confirmed that Red Knots use more than one beach on Peninsula Valdes, and on one occasion marked individuals were seen on the same day using beaches on both gulfs, thereby maximising their foraging time. Our observations suggest that Peninsula Valdes is an important place on the northern migration route of Red Knots.

Additional keywords: beach use, conservation, ecology, migration, stopover.

Received 22 October 2010, accepted 16 June 2011, published online 3 September 2012

Introduction

The foraging of shorebirds in intertidal habitats is restricted by the tidal cycle, which affects the size of the areas available for foraging. In most parts of the world, high tide and low tide each occur twice per day (Piersma *et al*. 2005). To obtain adequate food, intertidal foragers should forage in the best patch available at any given time (van Gils *et al*. 2005).

Red Knots (*Calidris canutus*) breed in the high Arctic in the boreal summer and spend the non-breeding season, during the austral spring–summer, on intertidal mudflats in temperate zones (Piersma *et al*. 2005). Subspecies *rufa* of Red Knot winters farther south than all other subspecies, in Tierra del Fuego (Chile and Argentina). Other Red Knots winter in north-eastern Brazil and south-eastern United States of America (Niles *et al*. 2008). These are possibly different subspecies (*rufa* and *roselari*) and their population trends are uncertain (Niles *et al*. 2008).

In Tierra del Fuego, the annual non-breeding population of Red Knots was estimated to be 67 546 birds in 1985 (Morrison and Ross 1989). However, the estimated population declined from 51 255 in 2000 to 17 316 in 2007 (Baker *et al*. 2004; Morrison *et al*. 2004; Niles *et al*. 2008). During their northern migration, Red Knots have been observed on several beaches along the Atlantic coast of Argentina. Flocks have been studied on the Patagonian beaches of Rio Gallegos and San Julian in the province of Santa Cruz (Morrison *et al*. 2004), Bahía Bustamante (Escudero *et al*. 2003) and Peninsula Valdes (Bala *et al*. 2002) in the province of Chubut, San Antonio Oeste in the province of Río Negro (Baker *et al*. 1999), and Punta Rasa (Blanco *et al*. 1992) and Bahía Samborombón in the province of Buenos Aires (Vila *et al*. 1994). The principal movement of Red Knots from Tierra del Fuego in their northward migration does not occur until February (Niles *et al*. 2008). Greatest abundances of Knots have been observed on Peninsula Valdes in April (Bala *et al*. 2001*a*, 2002).

Peninsula Valdes is joined to the mainland by an isthmus, producing two gulfs: San José Gulf to the north and Nuevo Gulf to the south (Fig. 1). Both gulfs have a semidiurnal tidal cycle, with two high and two low tides per day, and at each gulf the tide is inverted in relation to the other at half tide (i.e. high tide in San José Gulf corresponds to low tide in Nuevo Gulf and vice versa). Fracasso Beach, in the south-east corner of San José Gulf, is known to be an important stopover for shorebirds, including Red Knots (Bala *et al*. 2001*a*), although in 1999 the numbers of Red Knots recorded there decreased compared with previous years (1994–98) (Bala *et al*. 2001*a*, 2001*b*, 2002).

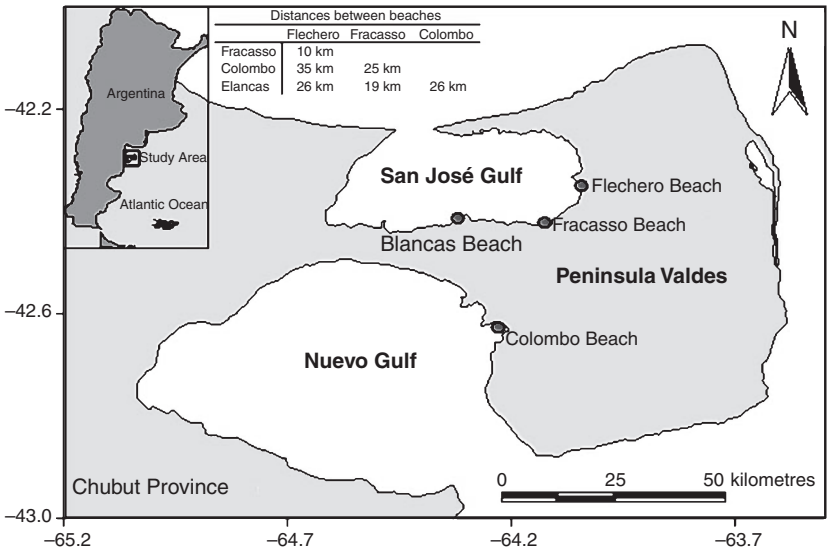

Fig. 1. The study area and beaches monitored during this study. The table shows the distances between the beaches on which Red Knots foraged.

According to Bala *et al*. (2001*b*) and Hernández *et al*. (2010), knots seen feeding at Fracasso Beach used another unidentified intertidal area to forage while the tide was high at Fracasso Beach. The authors suggested that the unidentified beach had similar sources of food to Fracasso Beach. Based on diet studies, Hernández *et al*. (2010) suggested that the knots may be using a beach in Nuevo Gulf with an inverted tide with respect to Fracasso Beach. Indeed, in 2002 Red Knots were encountered at Colombo Beach in Nuevo Gulf, and on subsequent Knot migrations (from 2003 to 2005) (Musmeci 2005, Hernández 2007).

In this study, our primary aim was to determine the variations in abundance of Red Knots on Peninsula Valdes during two consecutive migrations and to document these changes within each year. As a secondary aim, we examined the use of different beaches throughout the Peninsula by studying individually marked Red Knots during each northern passage migration to determine whether Red Knot flocks move between different beaches as a coordinated unit.

Materials and methods

Study area

We conducted our study on Peninsula Valdes, in north-eastern Patagonia, Argentina, during 2006 and 2007. The Peninsula is a Chubut Province nature reserve and is a designated UNESCO World Heritage Site (site reference 937; see http://whc.unesco.org/en/list/937, accessed 29 January 2012).

In 2006, counts were made at Colombo Beach on Nuevo Gulf (42°38′01.2″S, 64°13′28.2″W) and Fracasso Beach (42°25′04.8″S, 64°07′12.6″W) and Flechero Beach (42°20′52.8″S, 64°02′42.6″W) on San José Gulf. Flocks of Red Knots were first seen on Blancas Beach on San José Gulf in mid-April 2007 (see below; Fig. 1) so we included Blancas Beach (42°25′33.0″S, 64°21′04.2″W) and omitted Flechero Beach in 2007. The intertidal areas of these beaches are composed mainly of sand and some rocky ledges, and all the intertidal beaches studied on San José Gulf are comparable in size; however, Colombo Beach is twice their size.

Field work

We conducted this study during the period of northern migration of Red Knots, between early March and mid-May (in austral autumn), in 2006 and 2007. We conducted weekly terrestrial counts of Red Knots on all beaches using a 20–60× telescope (Leica APO-Televid 77 mm, Óptica Cosentino, Buenos Aires, Argentina). Whole-day observations, in which the Knots were followed over the entire intertidal area, were made once per week. On 21 April 2006, a flock of knots flew away from Fracasso Beach when the tide was low. Because Hernández *et al*. (2010) suggested that knots used a beach at Nuevo Gulf, we visited Colombo Beach and found the same flock feeding there 2 h later.

Capture and marking of Red Knots was not carried out; instead, we relied on plastic leg flags that had been applied to individual Red Knots during other studies (Baker *et al*. 2004). These flags bore an alphanumeric code, which we read (using the telescope) and recorded. Sightings of the same leg-flagged Red Knots were used to determine the movement of flocks across Peninsula Valdes and their mean permanency period on the area.

An aerial survey of the coasts of both gulfs in April of 2006 and 2007 was conducted to detect other beaches that may have been used by Red Knots. During the aerial surveys, the locations of Red Knot flocks were recorded using global positioning systems (GPS Garmin eTrex Legend, base map WGS 84, GPS Mundo, Buenos Aires, Argentina). Aerial surveys were flown using a single-engine, high-winged aircraft. During the aerial surveys, we found Red Knots using a new beach (Blancas Beach), and subsequently included this beach in the terrestrial monitoring.

Statistical analysis

Counts of Red Knots were log-transformed before analyses to stabilise variances and to ensure data were normally distributed. The assumptions were tested by the Kolmogorov–Smirnov and Cochran's tests using the software Statgraphics plus for Windows 4.0 (Statistical Graphics Corporation, Rockville, MD).

General linear models were used to evaluate variations in abundance of Red Knots between beaches and months (SPSS for Windows 15.0, Chicago, IL). Abundances were calculated as the mean over the entire survey period for every beach and as the mean weekly count for each month. The Wald statistic with Chi-Square distribution was used to examine the significance of the fixed effect (beaches and months). Multiple contrast comparisons of the abundance of Red Knots were performed using Bonferroni tests in pairs (SPSS for Windows 15.0). Knot abundances observed between months and beaches were compared. Tests were conducted with $\alpha = 0.05$ to evaluate statistical significance.

Results

Use of beaches

In 2006 and 2007, there were significant differences in the abundance of Red Knots between the beaches (2006: $\chi^2 = 47.04$, d.f. = 2, $P < 0.001$; 2007: $\chi^2 = 15.63$, d.f. = 2, $P < 0.001$). In 2006, over the entire season there were more birds on Colombo Beach than on either Fracasso or Flechero Beaches ($P < 0.001$). There was no difference between the reported abundance of Knots at Fracasso and Flechero Beaches ($P = 0.26$) (Fig. 2). In 2007, there was no difference between the abundance of birds on Fracasso and Colombo Beaches ($P = 0.05$) or on Colombo and Blancas Beaches ($P = 0.12$). However, the abundance was smaller on Fracasso Beach than on Blancas Beach ($P < 0.001$) (Fig. 2).

In 2006, averaging across all sites, numbers of Red Knots differed between months ($\chi^2 = 18.61$, d.f. = 2, $P < 0.001$). Abundance was significantly higher in April ($P < 0.001$) than in either March or May. In 2007, abundance was also highest in April but there were no significant differences between months ($\chi^2 = 2.78$, d.f. = 2, $P < 0.26$).

During 2006 and 2007, using terrestrial and aerial surveys, Red Knots were observed foraging at Colombo, Fracasso and Flechero Beaches, but not elsewhere on the coasts of the two gulfs on Peninsula Valdes.

Marked individuals

During 2006, a total of 121 sightings of 70 individually leg-flagged Red Knots were made. Twenty-nine of these were

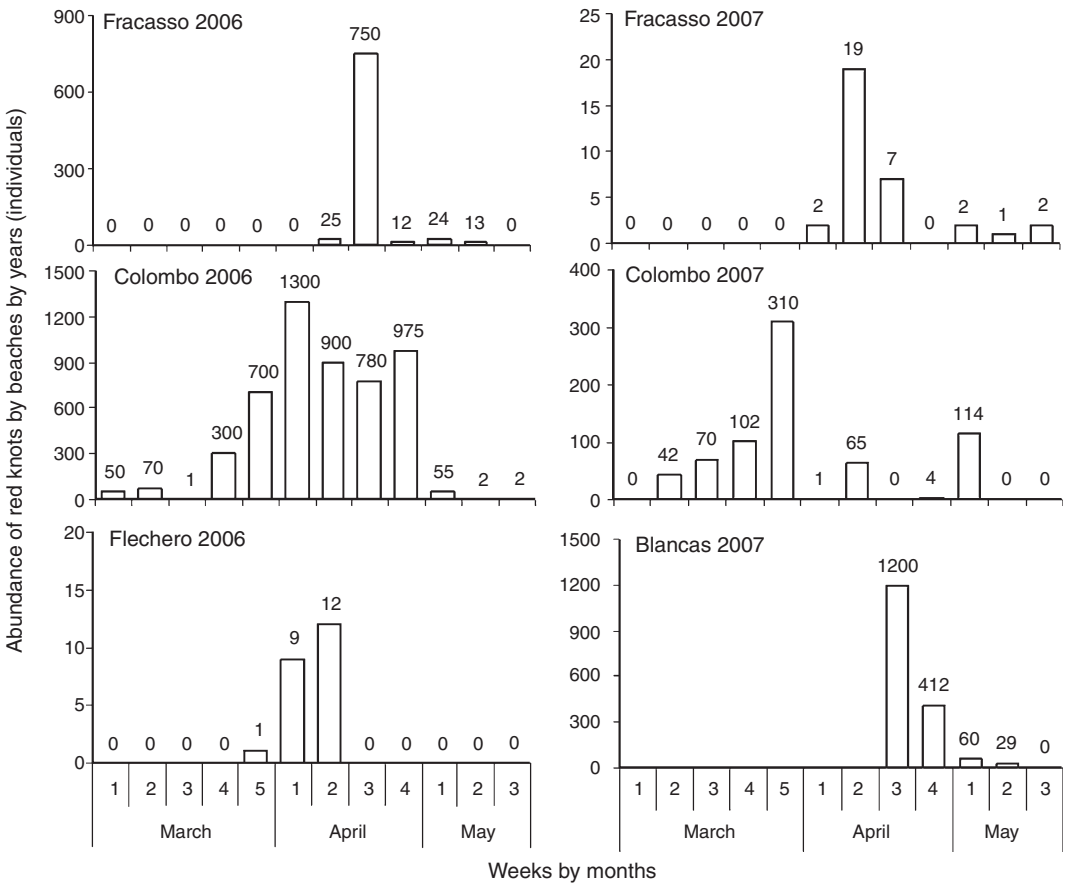

Fig. 2. Weekly counts of Red Knots observed foraging on each beach surveyed during northern passage at Peninsula Valdes, 2006–07.

resighted at least twice (17 sighted twice, 6 sighted three times, 3 sighted four times, 2 sighted five times, 1 sighted six times, totalling 80 sightings). From the 29 individuals sighted more than once, the mean permanency period was 17.2 ± 12.9 days. Most of these Red Knots were recorded foraging only at Colombo Beach (52%), although a high proportion was also recorded using both Fracasso and Colombo Beaches (42%). Only a small percentage of Knots were seen using both Colombo and Flechero Beaches (3%), or all three beaches (3%).

During 2007, a total of 110 sightings of 62 individually leg-flagged Red Knots were made. Twenty-eight were sighted at least twice (17 sighted twice, 7 sighted three times, 1 sighted four times, 1 sighted five times, 2 sighted six times, totalling 76 sightings). From the 28 individuals sighted at least twice the mean permanency period was 22.5 ± 15.3 days ($n = 28$). Most of these Red Knots were recorded using both Colombo and Blancas Beaches (64%), although a high proportion were observed using Blancas Beach alone (32%). Only a small proportion (4%) of Knots were observed using both Fracasso and Blancas Beaches and no marked knots were observed using all three beaches.

We resighted birds on the same day on only one occasion. On 21 April 2006, a flock of ~750 Red Knots was observed foraging on Fracasso Beach while the tide was receding. When the tide was almost at its lowest ebb, the birds flew away and the same flock (comprising approximately the same number of Knots, ~780, and including the same six marked birds) was sighted 2 h later at Colombo Beach while the tide was receding there (Fig. 3).

Over the 2 years of the study, 24 individuals were resighted in both years.

Discussion

Our data confirm the importance of Peninsula Valdes for Red Knots during their northern migration. All beaches used in Peninsula Valdes by knots are important to their conservation, since all have intertidal areas that participate in Red Knot foraging ecology. This means that beaches in Peninsula Valdes function as one feeding unit for Red Knots. In 2006, the maximum count of Red Knots was recorded on Colombo Beach, in Nuevo Gulf, with large numbers of Knots also using Fracasso Beach on San José Gulf. Only small numbers were counted on Flechero Beach on San José Gulf. By contrast, in 2007, the greatest number of Knots was recorded on Blancas Beach on San José Gulf (which was counted instead of Flechero Beach), with high numbers also found on Colombo Beach but few birds counted on Fracasso Beach (far fewer than in 2006). Highest numbers of Red Knots on Peninsula Valdes were counted during April in both 2006 and 2007, as was reported for Fracasso Beach in 2000 (Bala *et al.* 2001*a*, 2002).

Our observations at Blancas Beach did not start until mid-April 2007, after the middle of the migration period. Therefore, it

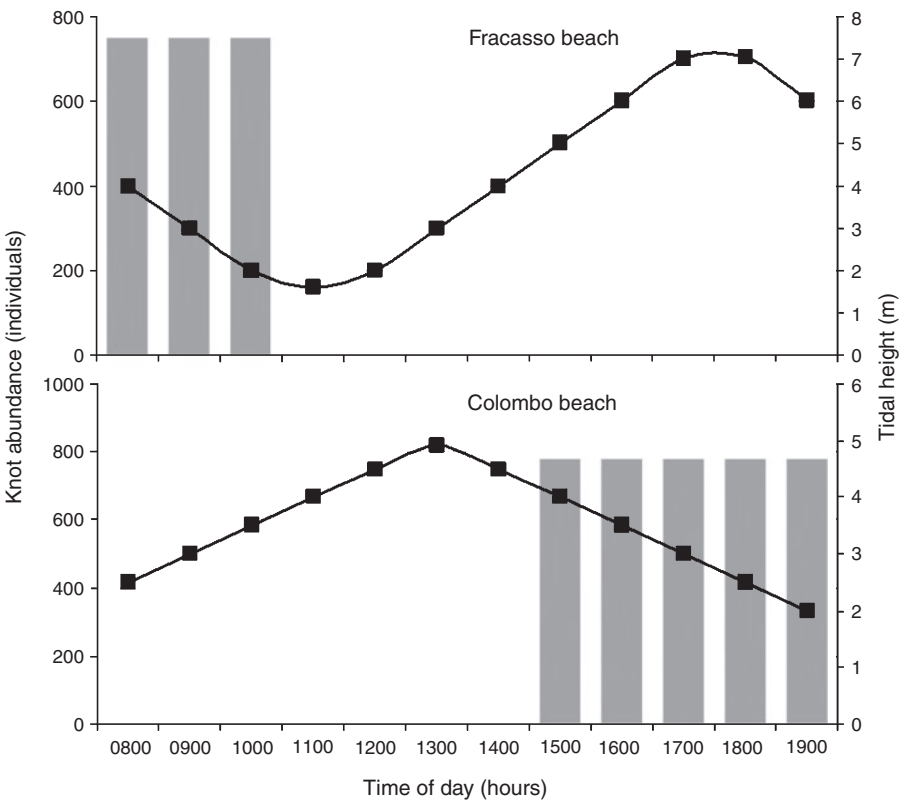

Fig. 3. Abundance of Red Knots at Fracasso Beach (top) and Colombo Beach (bottom) on 21 April 2006, in relation to the tide height (black line). The flock observed on both beaches was the same (grey rods): numbers were about the same and the flock contained the same six leg-flagged birds.

is probable that this beach had been used more than reported in this study. Although aerial surveys are useful for identifying previously unknown foraging areas for Red Knots, our 2007 survey may underestimate the number of birds seen on Peninsula Valdes due to the fact that it was conducted after the middle of the migration period.

During this study, Red Knot flocks observed on Peninsula Valdes over their migratory season were recorded feeding and roosting on different beaches. The maximum count can be considered to be the minimum number of Red Knots that use the peninsula, since in both years it included birds that were previously observed and that continued using the area. The highest weekly census of Red Knots recorded in 2006 and 2007 on Peninsula Valdes represents 7.5% and 6.9%, respectively, of the estimated total non-breeding population of Red Knots wintering in Tierra del Fuego (17 211 Knots in 2006 and 17 316 birds in 2007; Niles *et al*. 2008). A small number of individual Red Knots ($n = 24$) were also resighted in both years, indicating a degree of fidelity to Peninsula Valdes by Red Knots on passage from Tierra del Fuego to the northern hemisphere.

The permanency period indicated by the resighting data suggests that individuals may spend a moderate amount of time on Peninsula Valdes to refuel on their migration. The time that marked individuals remain in Peninsula was greater than in Delaware Bay on the north-eastern seaboard of the USA, where Gillings *et al*. (2009) reported a stopover of 11–12 days.

In this study, there was only one occasion in which the same flock was seen on both gulfs in the same day. This provides an example to support the hypothesis proposed by Hernández *et al*. (2010) that the same flock of Knots feeds alternately at both beaches, taking advantage of the inverted tidal cycles in San José and Nuevo Gulfs to increase daily feeding activity. To the best of our knowledge, the present study is the first report of this behaviour. In later years, we observed the same behaviour and saw the same marked Red Knots foraging at different beaches, on the same and different Gulfs, on the same day. This suggests that birds may make coordinated use of the different of beaches on Peninsula Valdes.

Shorebirds feeding in coastal habitats can modify their distribution and feeding behaviour according to the availability of benthic prey (Cohen *et al*. 2010). The changes in the use of beaches by Red Knots on Peninsula Valdes may be a consequence of changes in food availability between years, but further data is needed to test this hypothesis. The strong decline in Red Knot population size has been shown to be related to their decreased refuelling rates and late arrival in Delaware Bay during their northern migration (Baker *et al*. 2004).

Van Gils and Piersma (1999) suggested that individual Red Knots staging in the Wadden Sea fly considerable distances during a tidal cycle, and observed that individuals move >30 km while the tide was ebbing and flowing. The distances flown by individual Red Knots observed on the beaches of Peninsula Valdes (23.5 ± 8.4 km) were similar to those observed in the Wadden Sea. The movement of marked individuals, on different days, from one beach to another indicates that the same group of Red Knots uses several beaches on Peninsula Valdes. However, the frequency of use of the different beaches varies between years (Fig. 2).

Our data are important in terms of the conservation of Red Knots, as we have confirmed that Peninsula Valdes is a crucial stopover site on their northern passage.

Acknowledgements

We are grateful to those who contributed in the field, including Laura Agüero, Mauro Carrasco and Mariano Cumplido from Centro Nacional Patagónico; and Aldana Salati, María Villabriga, Jorgelina Frias, Paula González, Julián Pontones and Iván Tolaba from Universidad Nacional de la Patagonia, Luisina and Dora Bala. We also thank Pablo Yorio, Héctor Gallelli, Diego González, Tamara Rubilar and Nancy Sheppard for their constructive comments. Field work was carried out using funds from project D'Ajusts de Coperació al Desenvoluppament from Universitat de les Illes Balears and Govern de les Illes Balears, Convención Ramsar, Ministerio de Educación de la Provincia del Chubut and Fundación Patagonia Natural. Aerial surveys were made using funds from the Fundación Inalafquen and Manomet Center for Conservation Sciences.

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