Annual international expeditions to study the Red Knot population in Rio Grande, Tierra del Fuego, 2000–2004

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We organized annual expeditions to Rio Grande in Argentinian Tierra del Fuego from 2000 to 2004 to census, capture and band Red Knots *Calidris canutus* after their arrival on the southern migration from Arctic breeding grounds. The population declined from about 6,000 birds in 2000 to 4,000 in 2004. A total of 2,214 knots were banded, of which 1,787 were adults, 287 immatures and only 140 juveniles. Of 312 retraps, 88 had been banded previously at Rio Grande and the remainder were from localities in South America and Delaware Bay, USA. Average mass of the adults in the 2004 sample was significantly lower than in all other years ($p < 0.0028$), consistent with the fact that they had arrived three weeks later arrival at Rio Grande that year. Additionally, in both adults and immatures, average mass in 2002 was significantly lower than in 2000–2001 or 2003. Late arrival of adults in 2004 delayed wing moult and the intensity of body moult relative to other years. Studies of pathogens and parasites, feather isotopes and sex-specific survival are underway to try to elucidate possible additional causes of the severe and continuing population decline in the *rufa* population of the Red Knot.

INTRODUCTION

Following the initial expedition to Rio Grande in February 1995 (Baker *et al.* 1996) we have run annual expeditions during 2000–2004 to this locality (53°44.983'S, 67°44.354'W) to capture and band Red Knots, with the objective of estimating annual survival and trends in population size. Rio Grande is the second-most important wintering site for Red Knots in Tierra del Fuego (TDF) after Bahia Lomas in neighbouring Chile. As a result of this programme of fieldwork, which accumulated sufficient mark-recapture data, we were able to detect a large mortality of knots from TDF in 2000–2001 (Baker *et al.* 2004; Gonzalez 2004), which was corroborated by aerial censuses (Morrison *et al.* 2004). To assess the prospects for recovery of the knot population in TDF it is therefore critical to continue annual counts, and to add annual cohorts of banded birds for future estimates of survival using both recaptures and resighting of individually marked birds. In this report we present a summary of the results achieved in the period 2000–2004.

COUNTS AND DATES OF ARRIVAL

Arrival dates and counts of the earliest Red Knots were assessed over 7–10 October each austral spring from 2001 to 2004 by terrestrial censuses developed by Luis Benegas at high tide roosts along the Rio Grande shoreline between Cabo Domingo and Punta Popper. This includes the critical places where the birds are concentrated. Knot numbers at these dates were considered as an index of arrival dates because birds start to reach Rio Grande in the last days of September to the first week of October (L. Benegas pers. comm.). Later, during catching expeditions, knot numbers were obtained from terrestrial censuses made by the team covering the same stretch of coast. At this time capture-recapture methods were also used to estimate numbers with the Lincoln index calculated from scan sampling records taken through telescopes of the number of birds banded in the current expedition relative to the others (i.e. non-banded birds plus birds banded in previous expeditions).

Arrival dates were delayed during the 2004 migration

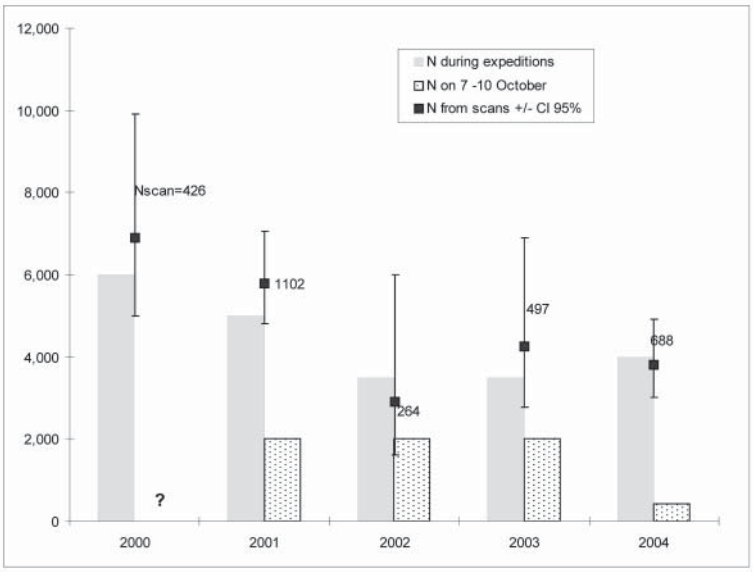

Fig. 1. Terrestrial censuses during the austral spring arrival (7–10 October) each year and during subsequent expeditions, and population size estimates using the Lincoln Index (with 95% confidence intervals).

season compared with previous years, except in 2000 for which there were no available data (Fig. 1). During 7–10 October 2004, only 412 knots were present in Rio Grande compared to about 2,000 in the previous three years. In 2002, a total of 2,000 birds had arrived by 29 September, whereas in 2004 this number was not present until 21 October. Thus the austral spring migration was delayed about three weeks in 2004 relative to 2002, the only other year for which we have count data that include early arrivals in September. Terrestrial censuses showed that higher numbers of knots visited Rio Grande during 2000 and 2001 relative to subsequent years. Census numbers were consistent with estimates from capture-recapture methods, as the 95% confidence intervals for the population estimates embraced the terrestrial counts.

EXPEDITION AND CATCH DETAILS

The five expeditions were conducted annually in November or early December, a few weeks after the knots arrive in Tierra del Fuego. A total of 2,742 knots were caught with cannon nets (Table 1), of which 2,214 were banded with standard colour band codes designating year of capture, or with individual combinations. Adults comprised 80.7% of the catches, immatures 13.0% and juveniles 6.3%.

The three age-classes were identified as follows:

Juveniles (hatched in the current calendar year)
Characteristic juvenile plumage as described by Prater *et al*. (1977), no primary moult, moderately worn primaries.

Immatures (hatched in the previous calendar year)
Generally fresh non-breeding plumage, no characteristic juvenile plumage, primary moult either just completed (and therefore primaries in pristine condition) or nearly complete. Here the advanced state of the moult cycle arises because, having remained in S America during their first northern summer, they commence moult long before the adults arrive.

Adults (hatched at least two calendar years previously)
As they do not usually start primary moult until they arrive in TDF in early October, adults are only about half way through the cycle by the time of our expeditions in November or early December, far behind the immatures; some retain small amounts of contour breeding plumage.

Table 1. Dates of expeditions and details of cannon net catches made at Rio Grande, Tierra del Fuego, 2000–2004. Retraps are tabulated from banding locations as follows: Rio Grande, Tierra del Fuego (RG), Bahia Lomas, Tierra del Fuego, Chile (BL), San Antonio Oeste, Rio Negro, Argentina (SAO), Lagoa do Peixe, Rio Grande do Sul, Brazil (LP), Maranhão, Brazil (M), Delaware Bay, New Jersey and Delaware, USA (DB). RT designates knots retrapped during the same expedition that they were banded.

Date	Year	Age			Number of retraps from:							Total
		Juv	Imm	Adult	RT	RG	BL	SAO	LP	M	DB	
28 Nov.–11 Dec.	2000	19	93	470	25	2		7	2		12	582
1–18 Nov.	2001	36	70	558	49	50		14	4	2	25	664 (1,192)*
16 Nov.– 2 Dec.	2002	65	21	288	10	17		3	1		7	374
22–30 Nov.	2003	8	27	169	4	20	2	4			3	204
10–19 Nov.	2004	12	76	302		32		2	2	1	13	390
Total		**140**	**287**	**1,787**	**88**	**121**	**2**	**30**	**9**	**2**	**60**	**2,214 (2,742)***

* Numbers banded are followed in parentheses by the numbers in the catch. In big catches in 2001 we counted and released 528 unbanded birds.

The low percentage of juveniles relative to adults reflects the fact that most first year birds do not make a full migration to TDF, whereas in their second year of life (immatures) they do (Baker *et al.* 2004). For example, in 2004 the numbers of juveniles and immatures in catches were respectively 4.0% and 25.2% of the number of adults. In 2004, an unusually large number of immatures was present in the cannon net catch of 390 knots on 12 November, which was unexpected given the low number of knots found on arctic breeding grounds following a late spring migration in 2003. However, immatures are over-represented in early arriving knots in Rio Grande (pers. obs.) (presumably because the immatures are only moving south within South America whereas the adults come from the Arctic), and the southern migration was very late in 2004. Thus the large proportion of immatures in the 2004 sample may simply reflect the lateness of adult arrival that year, rather than an unusually successful breeding season in 2003.

Over the five years, we captured 312 knots that had already been banded (Table 1). Of these, 224 were originally banded during earlier expeditions to Rio Grande or at other sites along the West Atlantic flyway, and 88 had been banded earlier during the same expedition. The largest proportion of retraps was from Rio Grande (54.0%), Delaware Bay (26.8%) or San Antonio Oeste (13.4%), the three places in the flyway where most knots have been banded. Because many more knots have been banded in Delaware Bay (*c.*12,000) than in Rio Grande over 2000–2004, Rio Grande birds are clearly over-represented in the catches, indicating their strong site fidelity. Only two knots banded in Bahia Lomas have been recaptured at Rio Grande, suggesting that there is relatively little interchange between the two non-breeding populations. Knots banded on passage through Lagoa do Peixe and Maranhão in Brazil comprised respectively only 4.0% and 0.9% of the retraps, but total numbers banded there are relatively low compared with the other sites.

MARKING BIRDS FOR COHORT AND INDIVIDUAL RECOGNITION

So that each year's cohort of banded birds could be identified as such in the field, we used different band combinations (Table 2). In addition, to increase the precision of estimates of annual survival (and decrease their 95% confidence intervals) we marked birds individually with combinations of colour bands and flags. Individually marked birds had four colour bands and the universal orange flag (which denotes that it had been banded in Argentina). The flag was put on the tibia or the tarsus, and always on the left leg. Bands were only placed on the tarsi. The severe population decline in recent years has made it undesirable to make the number of cannon net catches that would be necessary to generate sufficient recaptures to estimate annual survival accurately. Therefore, from 2001 onward we followed an idea developed by Ron Porter to use flags inscribed with alphanumeric characters in the hope that these would allow more birds to be identified individually. The frequent strong winds in TDF make reading inscriptions on flags much more difficult than in other places (such as Delaware Bay where there is less wind and birds can be approached more closely). Therefore we gradually improved the readability of the characters inscribed on the flags by spacing them more widely, by using only two characters (in Arial font), and by using bold lettering (from 2004). During the 2004 expedition, partly as a result of these improvements, but also because of lighter winds and greater effort, we were able to make many more resightings of individuals than in previous years. However, resighting birds with individual combinations of colour bands (Table 2) are still easier to make at Rio Grande than of those with inscribed flags.

BODY MASS AND MOULT

The average body mass of adults in different years was not affected significantly by date of capture, probably because there was only a 27-day spread between the earliest catch on 4 November (2001) and the latest catch on 8 December (2000). However, one-way ANOVA detected highly significant differences ($F_{4, 1699} = 31.834$, $p < 0.0001$) in average mass among the five years (Fig. 1). Post-hoc HSD tests on unequal sample sizes confirmed that the average mass of the adults in the 2004 sample was significantly lower than all other years ($p < 0.0028$), consistent with their late arrival at Rio Grande that year. Additionally, the average mass of adults in the 2002 samples (caught on 25 and 30 Nov) was significantly lower than in 2000–2001 and 2003 ($p < 0.0032$).

A similar pattern of inter-annual mass variation was detected in immature birds, with lower average mass in 2002 and 2004. However, in these two years the average masses were not significantly different ($p > 0.998$) in the post-hoc HSD test for unequal sample sizes, unlike in adults. The higher average mass of immatures relative to adults in most years probably arises because almost all immatures have completed primary moult by the time of our expeditions whereas the adults are in mid primary moult, a condition in

Table 2. Standard colour band combinations and number of individually marked Red Knots each year at Rio Grande, Argentina.

Year	Adult	Immatures	Juveniles	Number of birds marked with individual colour band combinations	Number of birds marked with inscribed flags
2000	Fo, – : m, RY*	–, Fo : m, P	Fo, P : m, –	61	0
2001	Fo, Y : m, R	Fo, P : m, R	Fo, – : m, Ys	4	170
2002	Fo, R : m, –	Fo, R : m, O	–, Fo : m, Ys	78	336
2003	Fo, – : m, O	Fo, WO : m, –	Fo, B : m, –	72	171
2004	Fo, G : m, –	Fo, WG : m, –	Fo, GG : m, –	0	340

* Left tibia, left tarsus : right tibia, right tarsus
Fo = orange flag, W = White, Y = Yellow, O = Orange, R = Red, G = Green, B = Blue, P = big light blue spiral, Ys = big yellow spiral, m = metal band, – = none.

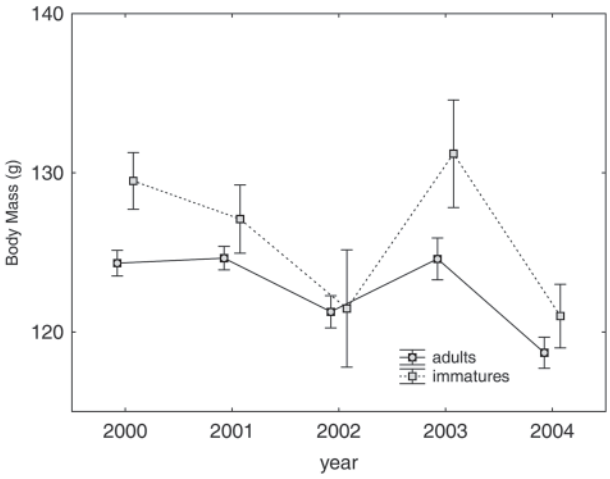

Fig. 2. Mean body mass of adult and immature Red Knots in cannon net catches in the five annual expeditions to Rio Grande, Argentina.

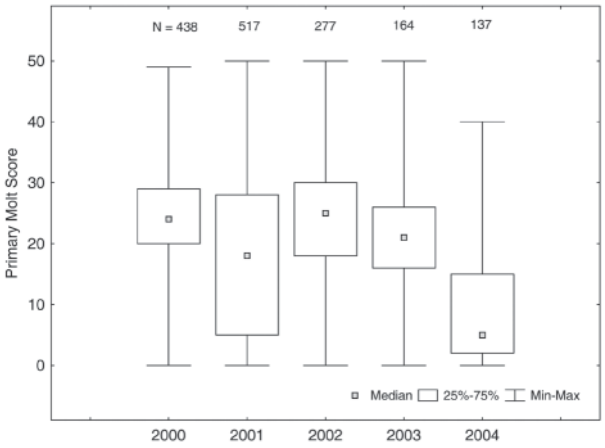

Fig. 3. Box and whisker plots of primary moult scores of captured adult Red Knots in the five annual expeditions to Rio Grande, Argentina.

which mass is shed probably to maintain flying efficiency (Swaddle & Witter 1997). Median primary moult scores of adults were significantly lower (Kruskal-Wallis nonparametric ANOVA, multiple comparisons $p < 0.001$) in the 2004 sample, as expected from their late arrival in RG (Fig. 3). Additionally, median primary moult scores were significantly lower in 2001, partly because of the earlier dates of some catches in this expedition and the 13 day span between samples (Fig. 3).

Body moult from breeding into winter plumage, here measured as the percentage of breeding plumage still present in each bird, was significantly delayed in the 2004 sample relative to other years (except 2000 for which there were no data) (Kruskal-Wallis nonparametric ANOVA, multiple comparisons $p < 0.001$). In addition, an unusually large proportion of the adult knots caught in 2004 had no active body moult (Fig. 4). As it is thought that most migrants do not undergo body moult while migrating, this indicates that many of the birds had only just arrived.

BLOOD AND FEATHER SAMPLES

The parasite hypothesis for long distance migration in shorebirds (Piersma 1997) predicts that knots should overwinter in low parasite marine environments, either because they have low expressed immunocompetence or because they are genetically depauperate, and hence might have low resistance to parasites (Piersma & Baker 1999). In this context, a high latitude region with a relatively cool austral summer, like Tierra del Fuego, would seem to be more suitable for non-breeding birds than tropical regions like West Africa where knots have been found to be infected with avian malaria (Mendes *et al.* 2005). The incidence of parasites in shorebirds wintering in Tierra del Fuego has not been studied extensively. Therefore in 2004 we started collecting blood samples from both newly banded birds and retraps. The object of this ongoing research is to establish parasite and pathogen loads in knots, and to assess the immunocompetence of individuals in relation to their probability of

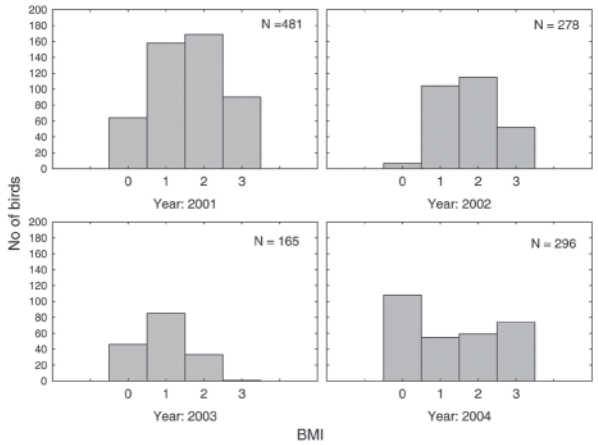

Fig. 4. Categorized histograms showing the frequency of body moult intensity scores (BMI) of adult Red Knots captured during annual expeditions from 2000 to 2004 to Rio Grande, Argentina. BMI is a measure of the proportion of breast feathers that are actively growing: 0 is none, 1 is a few, 2 is quite a lot and 3 is a lot.

survival in future years. In view of the continuing and alarming large scale losses of birds from the Tierra del Fuego population (Morrison *et al.* 2004), this work takes on even more significance as knots on passage through the tropics of the Americas could possibly be exposed to pathogens. This problem would be exacerbated if the immunocompetence of birds is depressed during migration as a result of the energy drain of long sustained flights.

In 2003–04, two breast feathers were sampled from each bird so that DNA could be extracted for molecular sexing (Baker *et al.* 1999). This not only allows studies of the dispersion of the sexes in the flyway but also makes it possible to estimate sex-specific annual survival rates using capture-recapture methods. Samples of the distal portions of the 6th primary covert and innermost primary of small samples of birds have also been taken for analysis of C and N isotopes. This isotope survey is part of an international effort to determine the number of discrete wintering knot populations in the flyway (Atkinson *et al.* in press; Farmer *et al.* 2004), and possibly to track them to their breeding ranges in the Arctic.

EDUCATION

Another important objective of our work in Rio Grande is to provide public outreach by encouraging participation of school children in our field team, and by making occasional visits to schools to talk about shorebird migration and conservation. We also promoted exchanges between teachers from San Antonio Oeste in northern Patagonia and Rio Grande after training them in our field team. The experience the teachers gained in the field has helped them to design and incorporate shorebird conservation in their schools' curricula. Each year we appear on local television and in newspapers to publicise our work and give the latest news on shorebirds. These initiatives are raising awareness of the plight of migratory shorebirds in general and of the rapidly declining population of Red Knots in particular, and have already resulted in increased support from the Municipality of Rio Grande, the Government of Tierra del Fuego and the general public for our expeditions.

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