Northbound migration of Red Knots *Calidris canutus rufa* in Argentina and Brazil: Report on results obtained by an international expedition in March-April 1997

A.J. Baker, P.M. González, T. Piersma, C.D.T. Minton, J.R. Wilson, H. Sitters, D. Graham, R. Jessop, P. Collins, P. de Goeij, M.K. Peck, R. Lini, L. Bala, G. Pagnoni, A. Vila, E. Bremer, R. Bastida, E. Ieno, D. Blanco, S. de Lima, I. Do Nascimento, S.S. Scherer, M.P. Schneider, A. Silva & A.A.F. Rodriguez

Baker, A.J., González, P.M., Piersma, T., Minton, C.D.T., Wilson, J.R., Sitters, H., Graham, D., Jessop, R., Collins, P., de Goeij, P., Peck, M.K., Lini, R., Bala, L., Pagnoni, G., Vila, A., Bremer, E., Bastida, R., Ieno, E., Blanco, D., de Lima S. do Nascimento, I., Scherer, S.S. , Schneider, M.P., Silva, A., & Rodrigues, A.A.F. 1998. Northbound migration of Red Knots *Calidris canutus rufa* in Argentina and Brazil: report on results obtained by an international expedition in March-April 1997. *Wader Study Group Bull.* 88: 64 - 75.

We organised an international expedition in March-April 1997 to follow the northward migration of Red Knots *Calidris canutus rufa* through Patagonia, Buenos Aires Province, and Brazil. Using both cannon-nets and mist-nets, we captured a total of 1,299 shorebirds of which 498 were Red Knots (including 20 retraps). Another 573 birds, mostly terns, were also captured and ringed. Comparisons of the Red Knots captured in 1997 with those captured in February in 1995 revealed that the former contained a higher proportion of juveniles and lower proportion of immatures, suggesting variable recruitment rates in different years. Most birds captured in Patagonia and Brazil had completed their primary moult. Plumage scores increased steadily northwards as the moult into red breeding plumage progressed. Red Knots at Argentinian sites averaged about 120 g in mass, and rarely exceeded 140 g. Birds arriving in Lagoa do Peixe were somewhat thinner on average, and clearly needed to fatten substantially during April to make the long trek to North America. Radiotagging of a small sample of birds in northern Argentina showed that they can make the 800 km traverse to Lagoa do Peixe in a few days without significant fattening, suggesting they might do this by flying short hops between contiguous beaches. We observed a mortality of shorebirds on the oceanic beach fronting Lagoa do Peixe, which has now been associated in Red Knots with infection by hookworms found in Crustacea they were eating. However, hookworms do not normally kill their hosts, and thus the Red Knots probably succumbed to unknown causes which also killed smaller species of shorebirds that lacked hookworm infections.

Hemos organizado una campaña internacional durante Marzo-Abril de 1997 con el objeto de seguir la migración hacia el norte de los Playeros rojizos *Calidris canutus rufa* en la Patagonia argentina y Brazil. Mediante el uso de redes cañón y de niebla, capturamos un total de 1,299 aves playeras de las cuales 498 fueron Playeros rojizos incluyendo 20 recapturas. También capturamos y anillamos otras 573 aves, en su mayoría gaviotines. La comparación entre los Playeros rojizos obtenidos en 1997 con los capturados en Tierra del Fuego durante Febrero de 1995, reveló que los primeros tuvieron una mayor proporción de juveniles y menor proporción de inmaduros, sugiriendo tasas de reclutamiento variables en años diferentes. La mayoría de las aves capturadas en la Patagonia y Brazil habían completado su muda de primarias. Los registros de la proporcíon de plumaje reproductivo mostraron un incremento constante de las categorías con mayor porcentaje del mismo a medida que avanzamos hacia el norte, mientras la muda progresaba. Los Playeros rojizos en los sitios argentinos promediaron una masa de alrededor de 120 g excediendo raramente los 140 g. Las aves llegadas a Lagoa do Peixe fueron más delgadas en promedio y claramente necesitaban engordar sustancialmente durante Abril para poder efectuar el largo trecho hasta Norte América. El seguimiento de una pequeña muestra de aves con radiotransmisores en el norte de Argentina, mostró que pudieron hacer los 800 km que las separaban de Lagoa do Peixe en pocos días sin engordar significativamente, sugiriendo que podrían hacerlo realizando cortos vuelos entre playas contiguas. Observamos una mortalidad de aves playeras sobre la costa oceánica frente a Lagoa do Peixe, la cual hasta ahora sólo pudimos rastrear para los Playeros rojizos, siendo ocasionada por "gusanos ganchudos" encontrados en los crustáceos que fueron su alimento. Las especies pequeñas de aves playeras sucumbieron por causas desconocidas puesto que no estaban infectadas por "gusanos ganchudos".

A. J. Baker & M. K. Peck, Centre for Biodiversity and Conservation Biology, Royal Ontario Museum, Toronto, Ontario, Canada M5S 2C6. E-mail: allanb@rom.on.ca.
P. M. González, Fundación Inalafquen, C.C. 84, Pedro Moron 385, (8520), San Antonio Oeste, Rio Negro, Argentina.
T. Piersma & P. de Goeij, Netherlands Institute for Sea Research (NIOZ), P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands.
C. D. T. Minton & D. Graham, Australasian Wader Studies Group, 165 Dalgetty Road, Beaumaris, Victoria 3193, Australia.
J. R. Wilson, c/o Royal Norwegian Embassy, 17 Hunta Street, Yarralumla, ACT, Australia.
H. Sitters, Limosa, Old Ebford Lane, Ebford, Exeter, EX3 0QR, U.K.
R. Jessop & P. Collins, Phillip Island Penguin Reserve, P.O. Box 97, Phillip Island 3922, Victoria, Australia.
R. Lini, Consejo Provincial de Ecologia, Belgrano 844, Viedma, Rio Negro, Argentina.
L. Bala & G. Pagnoni, Centro Nacional Patagonico, 9120 Puerto Madryn, Chubut, Argentina.
A. Vila & E. Bremer, Fundacion Vida Silvestre Argentina, Defensa 245 6°K, 1065 - Capital Federal, Argentina.
R. Bastida & E. Ieno, Fundación Mundo Marino, 7105 San Clemente del Tuyu, Pcia. Buenos Aires, Argentina.
D. Blanco, Wetlands International, Monroe 2142 (1428), Capital Federal, Argentina.
I. de Lima S. do Nascimento, CEMAVE/NE, Caixa Postal 174, Joâo Pessoa/PB, CEP 58040-440, Brazil.
S. S. Scherer, CEMAVE/IBAMA, R. Miguel Teixeira, 126, Praia de Belas, Cidade Baixa CEP 90000, Porto Alegre, Rio Grande do Sul, Brazil.
M. P. Schneider, A. Silva, & A. A. F. Rodrigues, Departamento de Genetica, Centro de Ciencias Biologicas Universidade Federal do Para, Belem, Para, Brazil.

INTRODUCTION

As a follow-up to the highly successful field trip to Tierra del Fuego in Argentina in 1995 (Baker *et al.*, 1996), an international expedition was organised by Allan Baker and Patricia González to collect further information on the northward migration of Red Knots *Calidris canutus rufa* that winter mainly in this region. Participants were invited from the host countries of Argentina and Brazil to collaborate with an international contingent of shorebird experts from Canada, Australia, the Netherlands, Norway and Great Britain. The major objective was to follow the birds northwards in March-early April 1997 as they passed through three coastal stopover sites in Argentina (San Antonio Oeste, Peninsula Valdes, Punta Rasa), one in southern Brazil (Lagoa do Peixe), and one in northern Brazil (Salinas) near the mouth of the Amazon River (Figure 1). By capturing large samples of Knots, banding them with locality-specific colour combinations, and by deploying radio transmitters, we hoped to add significant new information to fill in details of their migration routes and schedules. Additionally, we planned to gather data on morphometrics; body mass, moult, and percent breeding plumage of individuals as the birds progressed northwards. By collecting small blood samples of large numbers of individuals of these migrating groups we also hoped to elucidate the genetic population structure and sex-related differences in wintering and migration strategies of different populations. Another major goal was to involve students from local high schools and universities in the host countries because our previous work in Tierra del Fuego had taught us that the training we provided was not only in enthusiastic demand by young people starved of opportunities to work with experts in Argentina and from other countries, but was also extremely effective in raising the profile of shorebird conservation.

At all sites attempts were made to catch shorebirds with cannon-nets, but mistnets were also used in suitable areas. Studies on the feeding ecology of Red Knots were also carried out. In this report we aim to (1) briefly describe the catches of Red Knots and other species of shorebirds and seabirds made in 1997 relative to our catches in Tierra del Fuego in 1995 (Figure 1), (2) present a preliminary analysis of the data on size, mass and moult, especially on Red Knots, (3) summarise the results of attempts at radio-tracking Red Knots from Punta Rasa and Lagoa do Peixe in 1997, and (4) summarise the incident of heavy shorebird mortality at Lagoa do Peixe in early April 1997.

GENERAL ACCOUNT

The itinerary of the expedition was as follows: Argentina; March 9-15, San Antonio Oeste, Río Negro; March 17-21, Fracasso beach, Chubut; March 22-29, Punta Rasa, Buenos Aires; Brazil; April 2-8, Lagoa do Peixe, Rio Grande do Sul; April 11-16, Salinas, Pará (Figure 1). The expedition assembled at San Antonio Oeste hosted by the Fundación Inalafquen and the Consejo Provincial Ecologia. We were delighted to be based at no charge in the Oasis camping ground of Osvaldo and Isabel Baraschi, for which we were most grateful. All meals were prepared for us by parents of students who joined the expedition, and by volunteers who generously donated their time to look after us. Under Clive Minton's command a test firing of the cannon net was quickly organised in a field near the camp. To everyone's relief, the net not only fired correctly but we discovered that FFF black powder manufactured in Argentina was of such high quality that we could use 5 g per cannon less than in Australia. The test was also used to teach new members of the team how to set the net and observe safety procedures during circuit testing and firing. We also schooled everyone in the drill to remove imaginary

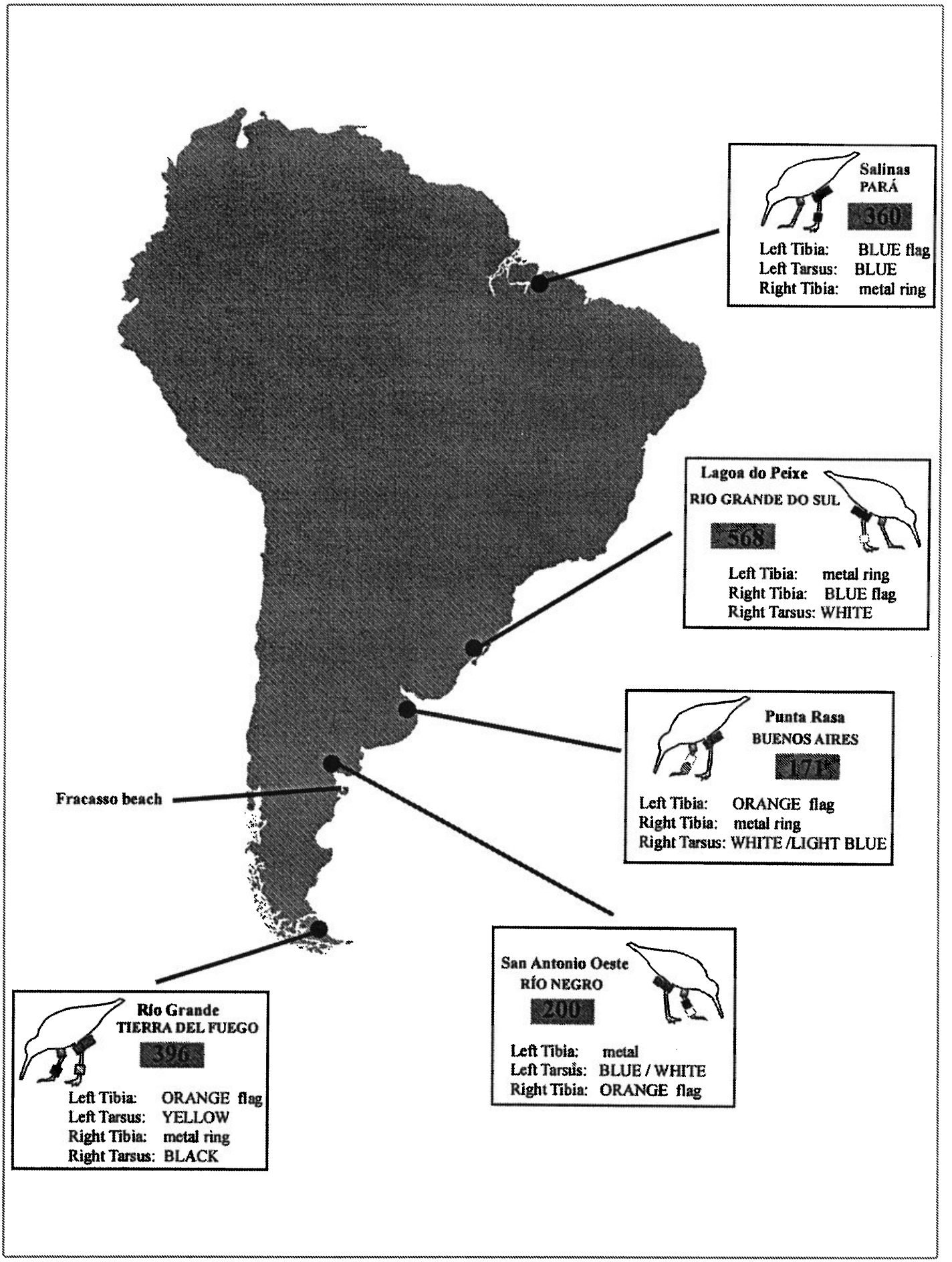

Figure 1. Map showing shorebird catching localities, overall catch sizes and locality-specific colour combinations used for Red Knots. See Table 1 for details of total catches of shorebirds and other species of birds.

birds quickly from the net and put them in keeping cages before they are processed. The next two days were spent doing an extensive reconnaissance of the beaches on the south side of the bay near San Antonio, Los Alamos, and Las Grutas, and at the port across the inlet at San Antonio Este. Approximately 15,000 Knots and 3,000 other shorebirds (principally White-rumped Sandpipers *Calidris fuscicollis* and Sanderlings *C. alba*, with smaller numbers of Hudsonian Godwits *Limosa haemastica*, Double-banded Plovers *Charadrius falklandicus*, Grey Plovers *Pluvialis squatarola*, Turnstones *Arenaria interpres*, Whimbrels *Numenius phaeopus* and American Oystercatchers *Haematopus palliatus*) were sighted. In subsequent days, attempts to catch Knots proved to be almost impossible as they were very restless and did not roost at specific high tide locations because there was a huge expanse of shell banks and beach for them to choose. Doris Graham from Australia was the only person who succeeded in twinkling birds in front of the net, but had to go so close that when she was ordered to retreat away from the catching area before we fired the birds were spooked into flight. We felt that by the end of our time at Banco Lobos we had learnt enough about where and how to set the net for future expeditions! A good catch of Double-banded Plovers was made and local participants quickly became familiarised with processing, banding and blood sampling techniques. Our catching efforts could not have succeeded without the help of the Prefectura Naval Argentina who kept the public off the areas where we worked and helped twinkle the birds and transport us with their 4WD vehicle. Juan Pablo Chillón recorded our field activities by filming a video that we hope to present later on the Discovery Channel. During our stay we were honoured to attend a ceremony at Las Grutas in which Bahía San Antonio was officially declared as an internationally significant site in the Western Hemisphere Shorebird Reserve Network (WHSRN) under the auspices of Wetlands International. Allan Baker spoke on behalf of Wetlands International at the meeting of Argentinian dignitaries (including the Governor of Río Negro and the Secretary of the Environment) and invited guests. At the end of the visit our hosts from the Fundación Inalafquen put on a moving evening including a banquet followed by speeches and dancing. Some people discovered they could improvise a tango, and others could perform the Patagonian knee ceremony. The showing of a beautiful video of the shorebirds at San Antonio Oeste filmed by Juan Pablo Chillón was a fitting end to the evening.

The next stop was at Fracasso beach in the Golfo San José on the Península Valdés, internationally renowned for its marine wildlife. This part of the visit was hosted by Luis Bala of the Centro Nacional Patagónico of the research organisation CONICET, and included university students from the province of Chubut. Our visit was a little too early to coincide with the main passage of Knots through the area, and the only place the flock of about 1,000 birds we saw roosted consistently was on slippery rocks at the top of the littoral zone. Catching was impossible, but we did record several resightings of colour-banded birds when they were feeding on the beach. Another interesting experience was on the farm where we were encamped in and around a woolshed. Following a very heavy rain storm overnight, we awoke to discover a flock of about 40 Tawny-throated Dotterels *Oreopholus ruficollis* foraging around large temporary ponds, along with Least Seedsnipes *Thinocorus rumicivorus* and White-rumped Sandpipers. Within a few hours these birds were gone again.

At the next stop at Punta Rasa in Buenos Aires Province our hosts were the Fundación Mundo Marino and the Fundación Vida Silvestre Argentina who collaborated as full partners in all aspects of the expedition. With the vital assistance of the Subprefectura de General Lavalle who kept the impending Easter crowd away from our part of the beach, we managed to catch enough Knots from a flock of about 200 for Theunis Piersma to deploy radio transmitters and track individual birds around the area. To assist the ongoing research by Vida Silvestre scientists on Common Terns *Sterna hirundo*, we also cannon-netted a large sample of this species and were staggered to get about 20% retraps due to the large marking programme that has been mounted in the Atlantic flyway over the past few years. Up to 30,000 Common Terns winter at Punta Rasa and migrate northwards to the east coast of North America. All members of the expedition were very impressed by the excellent educational programmes at Bahía Aventura, a world-class joint venture between the two host organisations. While we were working on the beach Adriana Caferatta and volunteers from the Education Department of the Fundación Vida Silvestre Argentina organised visits by busloads of school children interested in seeing how we captured the birds and what we could learn about their migrations.

In the southern Brazilian city of Porto Alegre we were greeted by Scherizino Scherer and Inês Lima do Nascimento of IBAMA/CEMAVE, and loaded our hundreds of kg of gear into the waiting vehicles. The next morning we headed south to Parque Nacional do Lagoa do Peixe, little suspecting the eventful drive that was in front of us. We had decided to drive the last 60 km down the beach to the Parque so we could count shorebirds en route, but a very strong onshore wind and high tide soon had us in difficulty. One vehicle tracked back to the safety of the highway, but the other (a venerable 4WD Toyota Landcruiser) slogged on for seven hours before arriving at the camp at Lagoa do Peixe! To our surprise the Lagoa was almost bone dry due to an unusually dry period over the past month, and there were very few shorebirds there. However, Theunis Piersma raised our spirits when his first scan with the receiver turned up birds we had captured a few days previously at Punta Rasa, and that night we managed to mistnet 16 Knots and deploy more radio transmitters. The unexpected arrival of some low-weight, moulting Knots from Punta Rasa, which apparently did not have enough fat to make the 800 km flight to Lagoa do Peixe, led us to coin the term beach-hoppers for these birds. The only alternative would be to fly short hops along the extensive beaches of Uruguay to

southern Brazil. The weather soon turned ugly and we were buffeted by strong winds and rain from a major storm. The morning after the winds abated we awoke to the sea surging in through the previously closed entrance, and a very high water level in the Lagoa. Knots materialised as if by magic, and Clive Minton contrived, as only he can, to make two good catches from the flocks of about 3,000 birds using what can only be described as unorthodox sets. Paulo Antas arrived in time to assist in processing the catches, which included birds that he, Inês, and Scherezino had banded in the past. Everywhere we went we saw Knots freshly killed by Peregrine Falcons *Falco peregrinus*, a reminder to us that passage through unfamiliar areas exposes migrant shorebirds to increased risks. On the day before we left, Scherizino collected dead and dying Knots and other shorebirds on the Atlantic beach north of the Camp, and we were sobered by the realisation that this was yet another hazard facing these birds on their prodigious hemispheric treks each year.

The last stop on the expedition was the exotic Amazonian city of Belem in northern Brazil, where we were met by our hostess, Maria Paula Schneider of the Department of Genetics in the University of Pará. Next day we travelled to the coastal town of Salinas where Paula had arranged for us to stay in a beach house along with her delightful contingent of university students. Knots were few and far between, but we did manage to cannon-net a small sample on the beach. The students were quick to learn how to set the nets and process the catches, and we had a great time with them explaining the fascinations of migrant shorebirds. Sorties to other bays and inlets in the area turned up more small flocks of Knots, but they were not catchable. However, mistnets set in mangroves gave us a steady stream of other waders, notably Semipalmated Sandpipers *C. pusilla*. One day following a storm we counted about 10,000 Common Terns on the beach at Salinas, but the next day they had moved on. We were delighted to catch some Wattled Jacanas *Jacana jacana* in a small wetland near the

Table 1. Catch totals of shorebirds and other species of birds on the expedition. Number of retraps shown in brackets.

Species	Colour bands/ flag	ARGENTINA		BRAZIL		Total
		San Antonio Oeste	Punta Rasa	Lagoa do Peixe	Salinas	
SHOREBIRDS						
Calidris canutus	YES	15 (1)	67 (1)	409 (18)	7	498 (20)
Calidris fuscicollis	YES	110	97	35		242
Calidris pusilla	YES				218 (1)	218 (1)
Calidris alba	YES	19		65	4	88
Calidris minutilla	YES				6	6
Arenaria interpres	YES			4	36	40
Limnodromus griseus	YES				3	3
Limosa haemastica	YES			3		3
Charadrius falklandicus	YES	56	7	2		65
Charadrius semipalmatus	YES			11	15 (1)	26 (1)
Charadrius collaris	YES			4	13	17
Charadrius modestus	YES			1		1
Charadrius wilsonia					1	1
Pluvialis squatarola	YES			17	22	39
Vanellus chilensis				6		6
Actitis macularia	YES				31	31
Himantopus mexicanus				8		8
Jacana jacana	YES				4	4
Nycticryphes semicollaris				3 (1)		3 (1)
TOTAL/SITE		**200 (1)**	**171 (1)**	**568 (19)**	**360 (2)**	**1299 (23)**
OTHER SPECIES						
Sterna hirundo	YES		533 (99)	1	1	535
Sterna albifrons	YES				11	11
Sterna eurygnatha				2	3	5
Sterna maxima				3		3
Rynchops nigra				13 (1)		13 (1)
Phaetusa simplex				1		1
Butorides striatus					1	1
Nycticorax nycticorax				1		1
Chloroceryle americana					3	3
TOTAL/SITE		**0**	**533 (99)**	**21 (1)**	**19**	**573 (100)**

Table 2. Summary of the age composition of Red Knots in the catches made in February, 1995 and in March-April, 1997 in Argentina and Brazil. The catch numbers correspond with the numbers on the abcissa in Figure 2.

Catch	Site	Date	ncapt	% juv	% imm	% adult
0	Rio Grande, Tierra del Fuego	20 February 1995	597	3.4	18.9	77.7
1	San Antonio Oeste	14 March 1997	15	33.3	0.0	66.7
2	Punta Rasa, San Clemente - 1	23 March 1997	48	16.7	6.2	77.1
3	Punta Rasa, San Clemente - 2	24 March 1997	3	33.3	0.0	66.7
4	Punta Rasa, San Clemente - 3	27 March 1997	15	40.0	13.3	46.7
5	Lagoa do Peixe - mistnets	2 April 1997	16	0.0	12.5	87.5
6	Lagoa do Peixe - 1 cannon-net	5 April 1997	131	22.1	3.1	74.8
6A	Lagoa do Peixe - cannon-net	6 April 1997	6	33.3	0.0	66.7
7	Lagoa do Peixe - 2 cannon-net	7 April 1997	247	12.6	4.9	82.6
8	Lagoa do Peixe - dead/sick birds	7 April 1997	26	34.6	0.0	65.4

Table 3. Age composition of Red Knots captured at the different sites (excluding San Antonio Oeste due to the small catch, and excluding the dead and sick birds from Lagoa do Peixe), and the proportions of juveniles and adults showing active body moult (% bm) and wing (primary) moult (% wm). For adults the proportions of birds showing synchronous body moult (one score only; % sbm) is also given.

Site	ncapt	% juv	juv % bm	juv % wm	% imm	% adult	adult % bm	adult % wm	adult % sbm
Tierra del Fuego	597	3.3	70.0	20.0	19.0	77.7	98.8	14.2	-
Punta Rasa	66	23	13	40	8	70	23	0	-
Lagoa do Peixe	394	15.2	13.3	71.7	4.6	80.2	64.8	0.6	35.5

house. After a final dinner with Paula and her students in a restaurant in Belem, we were saddened to leave them behind and head back home. However, we were cheered by Maria Paulas plans to work on population structure in Semipalmated Sandpipers in collaboration with Allan Baker's group in Toronto, and look forward to working closely with her in the future. This kind of collaboration is vital if our shared hemispheric migrants are to be studied thoroughly and protected throughout their range.

THE CATCHES

Details of catches of all species of birds are presented in Table 1. More specific data on the sizes of the catches and the age composition of the captured Red Knots based on an examination of contour feathers and the degree of wear of the primaries, are summarised in Table 2. The biggest catch of Red Knots was made at Río Grande, Tierra del Fuego, in 1995; it was about 200 birds bigger than the 597 individuals that were eventually processed, but the cannon-net catches further north in 1997 include good sample sizes too. The Knot catch in Tierra del Fuego in 1995 contained few juveniles (young of 1994) but a sizeable proportion of immatures (young of 1993). The pattern was reversed in the captures at other localities in 1997. This difference may be due to yearly differences in recruitment/breeding success or differential migration of the different age groups. The percentage of adult birds varied between 70 and 80%.

Of the few juvenile Red Knots captured in Tierra del Fuego, some were showing wing moult (see below for methodology), and most were showing active body moult (Table 3). Few of the juveniles at Punta Rasa and Lagoa do Peixe were showing active body moult, but greater proportions were still actively moulting primaries, especially at Lagoa do Peixe. Whereas some adults at Tierra del Fuego had not yet completed their primary moult in February 1995, most had done so by late March/early April at the more northerly stopover sites. In Tierra del Fuego all but a few birds were actively moulting from a grey nonbreeding plumage into a rusty-red breeding plumage. Percent body moult was low for adults at Punta Rasa, but rather higher again at Lagoa do Peixe (Table 3).

An encouraging aspect of our work was the number of retraps we obtained, especially of birds banded previously in our 1995 work in Tierra del Fuego, and by our colleagues working in Lagoa do Peixe (Table 4).

SIZE, MASS, AND MOULT OF ADULT RED KNOTS

After capture, Red Knots were aged and weighed to the nearest 1 g. The lengths of the bill and total head were measured to the nearest 0.1 mm with callipers, and maximal stretched length of the folded wing was measured on a ruler to the nearest 1 mm. The primaries were examined and their age assessed, as well as the phase (1=pin to 5=new) assigned to actively growing and new categories. The extent of breeding plumage was scored as 0% (score 1=full winter plumage), trace to 10% (score 2), 25% (score 3), 50% (score 4), 75% (score 5), 90% or trace winter plumage (score 6) or full breeding plumage (100% or score 7). The moult of contour feathers was examined on the breast, and the so-called body moult intensity (BMI) scored as follows: 0 (no actively growing contour feathers); 1 (a few growing contour feathers); 2 (more than a few, less than a third), 3 (about a third of the

Table 4. recoveries of Knot on the 1997 South America Epedition

Resightings or retraps date & place	Banding record	Banding date & place	No. records	Min. no. recoveries	
SAN ANTONIO OESTE, Argentina					
11/03/97, Mar Grande	Fo, Y: -, N	20/02/95, Ta. del Fuego, Argentina		4	3
12/03/97, Banco Lobos	Fo, Y: -, N	20/02/95, Ta. del Fuego, Argentina		3	
13/03/97, Banco Lobos	Fo, Y: -, N	20/02/95, Ta. del Fuego, Argentina		1	
	-, Fg	USA		1	1
14/03/97, Banco Lobos	H 29889	27/04/95, Lagoa do Peixe, Brazil		1	1
		TOTAL, from Argentina		8	3
		Brazil		1	1
		USA		1	1
PENINSULA VALDES, Argentina					
17/03/97, Playa Fracaso	Fg, -: -	USA		1	1
17/03/97 Punta Conos	Fo, Y: -, N	20/02/95, Ta. Del Fuego, Argentina		1	
18/03/97, Playa Fracaso	Fo, Y: -, N	20/02/95, Ta. Del Fuego, Argentina		1	1
	-: Fg, -	USA		1	1
19/03/97, Playa Fracaso	m, BG: Fg, G	09/05/87, Reed's b. N. Jersey		1	1
19/03/97, Playa Fracaso	Fo, Y: -, N	20/02/95, Ta. Del Fuego, Argentina		1	1
		TOTAL, from Argentina		3	2
		USA		3	3
PUNTA RASA, Argentina					
23/03/97, Punta Rasa	US 802 33572	29/03/89, Punta Rasa, Argentina		1	1
		TOTAL, from Argentina		1	1
LAGOA DO PEIXE, Brazil					
05/04/97, Lagoa do Peixe	Fo, WR: -	??		1	1
05/04/97, Lagoa do Peixe	Fo, Y: -, N	20/02/95, Ta. Del Fuego, Argentina		1	1
	- : -, R	27/04/97, Lagoa do Peixe, Brazil		2	
	-, FgR: -, Y	USA		1	1
05/04/97, Lagoa do Peixe	-, Y: Fg, ?	USA		1	1
05/04/97, Lagoa do Peixe	H 30129	20/04/96, Lagoa do Peixe, Brazil		1	1
05/04/97, Lagoa do Peixe	H 29275	19/04/96, Lagoa do Peixe, Brazil		1	1
05/04/97, Lagoa do Peixe	H 26913	19/04/94, Lagoa do Peixe, Brazil		1	1
06/04/97, Lagoa do Peixe	Fo, -: -, WLb*	23/03/97, Punta Rasa, Argentina		1	1
06/04/97, Lagoa do Peixe	-, FbR: m, WR	Lagoa do Peixe, Brazil		1	1
06/04/97, Lagoa do Peixe	Fo, ?: m, ?	23/03/97, Punta Rasa or			
20/02/95, Ta. del Fuego, Argentina				1	1
06/04/97, Lagoa do Peixe	H 29859	26/04/95, Lagoa do Peixe, Brazil		1	1
06/04/97, Lagoa do Peixe	H 27530	03/05/93, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 28695	Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 29523	22/04/95, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 30136	20/04/96, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 09429	11/11/86, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 29854	26/04/95, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 27359	26/04/93, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 21920	13/04/94, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 29634	28/04/94, Lagoa do Peixe, Brazil		1	1
07/04/97, Lagoa do Peixe	H 29010 +	12/04/94, Lagoa do Peixe, Brazil		1	1
08/04/97, Lagoa do Peixe	H 27551 +	06/05/95, Lagoa do Peixe, Brazil		1	1
		TOTAL, from Argentina		3	2
		Brazil		18	16
		USA		2	2
		Unknown		1	1
		TOTAL NUMBER OF RECORDS		41	

[a] Colour band combination for resighted birds or metal ring number for retraps. Band combinations read from left to right, starting with the left leg. Legs are separated by a colon and tibia from the tarsus by a semicolon. Colour bands are written from the top to the bottom of the leg. Abbreviations are: W (white), Y (yellow), R (red), G (green), B (blue), Lg (light blue), N (black); Fo (orange flag = Argentina), Fb (blue flag = Brazil) and Fg (green flag = USA); m (metal ring), - (nothing seen), ? (could not be detrmined), * = radio-tagged bird, + = recovered dead.

[b] To separate individual resighted Knots, when possible we recorded the percentage of breeding plumage (five categories: winter, 1/4, 1/2, 3/4, nuptial) and the " abdominal profile" also with five categories indicating: 1 (thinnest) to 5 (fatest) according to Wiersma & Piersma, 1995. By using both these variables we were able differentiate between most individuals and thus to avoid overestimation of the actual number of resighted individuals, which may result from different people recording the same bird, the same observer sighting a banded bird twice without knowing, or when a retrapped individual was also resighted in the field

contour feathers of the breast actively growing) or 4 (over half in moult). At Lagoa do Peixe we also scored the phase of the actively growing breast feathers, noting the lowest and highest phases (i.e. extent of feather growth completion, as in the primaries). Thus, for a bird with synchronous body moult, having started the moult of all the novel breast feathers at once, a single score was given.

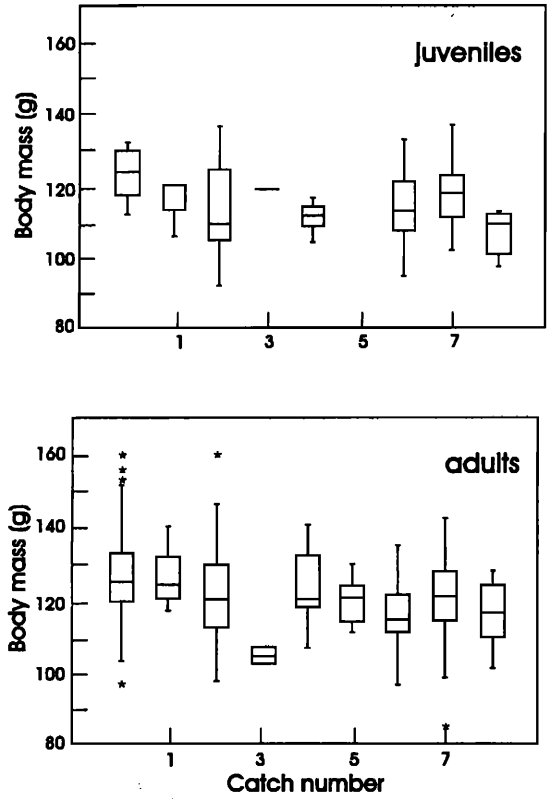

Figure 2. Box plots of the body masses of juvenile and adult Red Knots as measured during the successive catches (see Table 1). Each box plot shows the median and the adjacent quartiles as a vertical rectangle with a dividing line (=median), and gives the range of "normal" values by the vertical axis, with outlying data points shown as asterisks; it thus captures the essence of the data distribution.

In the subsequent analyses, body mass was not corrected for loss after capture; this eventually needs to be carried out once appropriate corrections are obtained from captive *C. c. rufa*. Body masses of both adult and juvenile Red Knots averaged around 120 g, with only a few of the adults being heavier than 140 g in the Argentinian sites in February-March (Figure 2). There was also a striking tendency for lower body masses in catches later in the season at more northerly sites, both in the juveniles and the adults (Figure 3). Some adults in Tierra del Fuego and at Punta Rasa must have been storing fuel for subsequent flights, but the adults at Lagoa do Peixe show uniformly low masses. Note that the sick and dead birds ("catch" 8) had only marginally lower body masses than the birds captured during the same day with the cannon-net (catch 7). The importance of Lagoa do Peixe as a fattening site was apparent when weights of birds captured soon after arrival in early April were plotted against their weights when recaptured later in April and May in the period 1993-1996 (Figure 4).

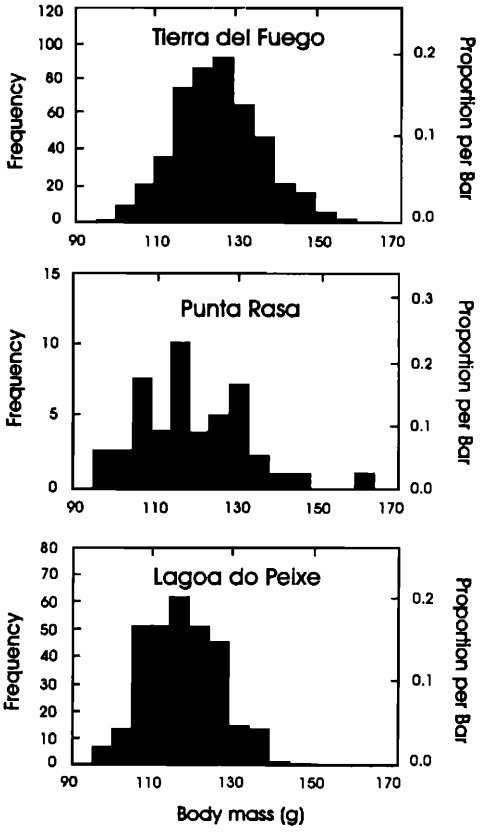

Figure 3. Frequency distributions of the body masses of adult Red Knots at the three study sites in Argentina and Brazil where the largest catches were made in February-early April 1995 and 1997.

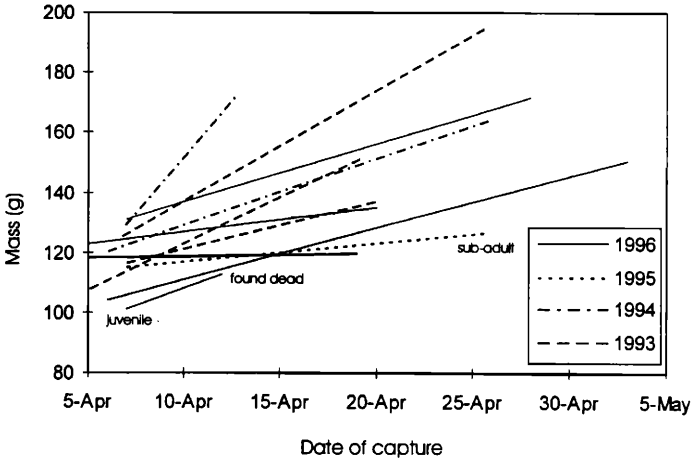

Figure 4. Body mass of Red Knots captured in early April 1997 at Lagoa do Peixe and at other times in 1993-1996.

Bill lengths showed the same large spread at all three sites (Figure 5), with bills varying between 30 and 43 mm. At each of the sites averages were close to 36 mm, but the bi-normal distribution expected for a sexually dimorphic population (males shorter-billed than females) is shown only by the sample of birds from Punta Rasa!

Plumage scores showed a steady increase with season and from south to north (Figure 6). Adult birds with plumage scores of 1 and 2 (i.e. winter/nonbreeding plumages) did not occur at Lagoa do Peixe in early April. For the catch at Punta Rasa (Figure 7) there was a tendency for adult birds with a greater extent of breeding plumage to be heavier, but this was not

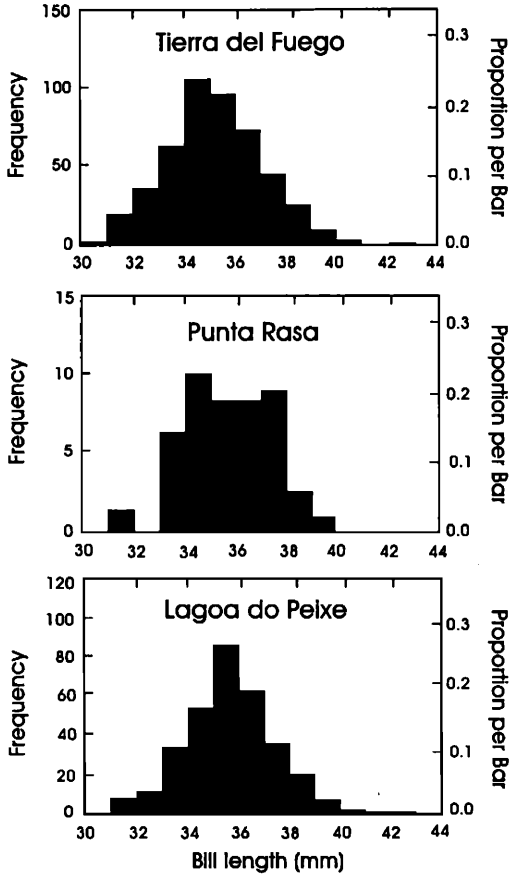

Figure 5. Frequency distributions of bill lengths of adult Red Knots at the three study sites with good sample sizes in Argentina and Brazil

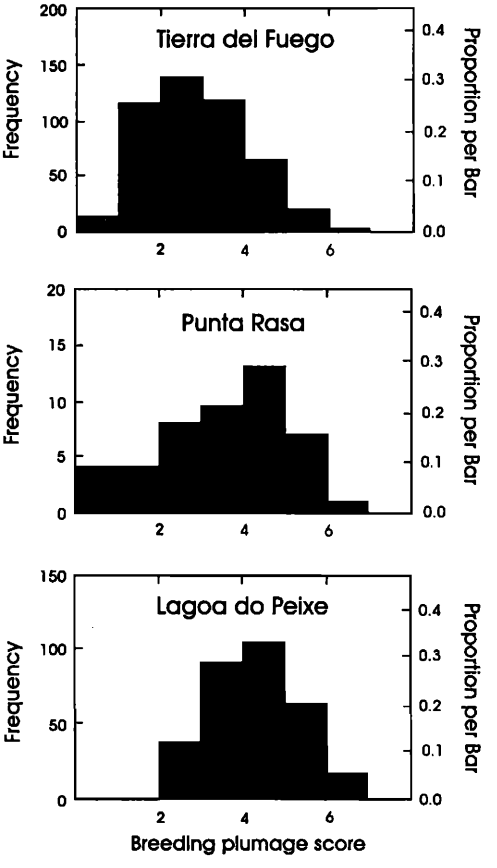

Figure 6. Frequency distributions of breeding plumage scores of adult Red Knots at the three study sites in Argentina and Brazil.

observed in Tierra del Fuego, and a reverse pattern was apparent for Lagoa do Peixe. When we examined the relationship between active body moult and body mass, the sample of non-moulting birds in Tierra del Fuego was insufficient to see any difference between moulting and non-moulting birds. At Punta Rasa the birds with active body moult tended to be of medium mass, and the non-moulting group had individuals with either very low or rather high masses. The latter might indicate birds that had just arrived at a site, or were ready for departure on long migration flights (and therefore were not actively moulting), as indicated by birds with the lowest and highest weights, respectively. For adult Red Knots at Lagoa do Peixe there were no differences in mass between moulting and non-moulting individuals. The latter population showed no signs of getting ready to depart on long distance flights in that they did not have suspended body moult and or marked increase in fat storage or in full breeding plumage.

We also tried to examine the interaction between the extent of breeding plumage, and the incidence of active body moult of adult Red Knots captured at the three study sites. There was a tendency at each of the three sites for bird with medium and more advanced breeding plumages (probably comprising a larger proportion of males than females) to show the highest BMI scores.

RADIO-TRACKING RED KNOTS

During the first cannon-net catch at Punta Rasa on 23 March,

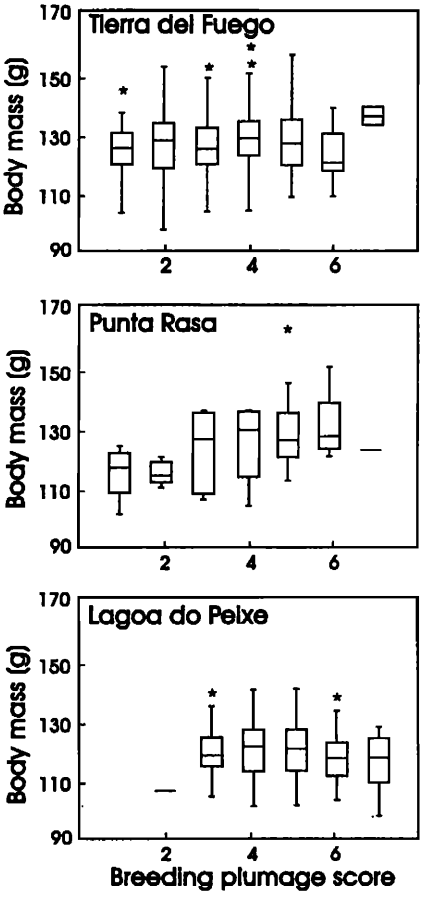

Figure 7. Box plots of body mass values in relation to breeding plumage scores of adult Red Knots at the three study sites in Argentina and Brazil. See Figure 2 for an explanation of box plots and the text for discussion.

48 Red Knots were captured and, having no knowledge of the profile (in terms of ages, moults and masses) of the catch, it was decided to put a transmitter on the first 10 birds that came away from the processing teams. This resulted in one juvenile and one immature being radio-tagged along with eight adult birds (Table 5). All these birds were detected in the area in the first few hours after their release between 0940 and 1050 hrs, but only eight remained at Punta Rasa in the late afternoon (1800 hrs). On 24 March only two individuals were still present for part of the day (one reading of A604 and two of A723, the last reading far west into Bahia Somborombon). These were two of the three birds tagged showing active body moult; such birds would be predicted to stay longer than non-moulting individuals. Thereafter the only individual that remained in the Punta Rasa area was A604. It was recaptured on 27 March, and had gained 4 g (over four days) compared with its previous body mass of 132 g. This bird was still present at Punta Rasa at the last scan made from the Faro San Antonio on 29 March, 0945 hrs.

A few days later, at Lagoa do Peixe in Rio Grande do Sul in Brazil on 2 April, during the very first scan at 0940 hrs, A493 (the bird with the highest capture mass at Punta Rasa) was picked up! This bird was to remain in the Lagoa do Peixe region, as is shown in the summary table of the (re-) readings at the Lagoa do Peixe receiving station on top of the water-tower at CEMAVE's research station (Table 5). It was also seen in the field on 6 April, with a plumage score corresponding to that at the catch at Punta Rasa (75% breeding plumage), but perhaps with a slightly lower mass (abdominal profile of 1 or 2, Wiersma & Piersma, 1995). Two more Punta Rasa birds were picked up, although one only once (at midnight, from a place somewhere along the beach). At Lagoa do Peixe 10 more Red Knots were fitted with radiotags, seven birds having been captured by mistnets the first night at this site, and three more having been cannon-netted three days later.

The birds radio-tagged at Lagoa do Peixe, in contrast to those at Punta Rasa, generally remained in the region, even though they were often beyond the receiving distance of 5 km or more (Table 5). Only a single individual (B788) was recorded on the day of capture only, the others being detected on and off for the full week. There was slight tendency for birds to be heard on the beach at night, and it is there that most feeding may have taken place. Note that most Red Knots sighted in the daytime in the lagoon were roosting. Bird A884 was found on all days, even though it was present at only a third of the scans made (11 out of 32). This "faithful" bird was actually retrapped by cannon-net on the beach at 5 April, three days after it was first caught. It had lost about 13 g but had gained one point on the scales of both plumage score and body moult phase.

MORTALITY OF SHOREBIRDS AT LAGOA DO PEIXE

On 7 April Scherizino returned from Mostardas with a "car-load" of dead and dying sandpipers, many of them Red Knots. The next day more were found in the lagoon close to camp. Through the great efforts of the people of CEMAVE, an export permit was quickly arranged, and all birds found are now stored in a freezer at NIOZ to provide material for appropriate post-mortem analyses in an attempt to elucidate the reasons for this heavy and sudden mortality. Not knowing where to start searching, the following resume of the experience at Lagoa do

Table 5. Details of the individual Red Knots equipped with a 1.7 or a 1.9 g Holohil radiotransmitter in Argentina and Brazil in March-April 1997.

Site	Date	Frequency	Ring	Age	Bill	ToHead (mm)	Wing (mm)	Mass (mm)	Plum (g)	BMI	Phase
P. Rasa	23 March	172.432	80267009	ad	34.3	62.0	164	110	2	0	
P. Rasa	23 March	172.493	80267010	ad	35.7	64.4	175	142	5	0	
P. Rasa	23 March	172.512	80267011	juv	34.6	64.5	160	126	1	0	
P. Rasa	23 March	172.564	80267109	ad	37.0	66.8	169	110	5	0	
P, Rasa	23 March	172.604	80267012	ad	37.6	68.3	177	132	4	1	
P. Rasa	23 March	172.665	80267110	ad	35.2	65.5	175	131	5	0	
P. Rasa	23 March	172.683	80267013	imm	35.9	66.0	169	132	3	0	
P. Rasa	23 March	172.723	80267112	ad	34.5	64.1	169	120	5	1	
P. Rasa	23 March	172.743	80267014	ad	37.9	66.7	169	118	7	0	
P. Rasa	23 March	172.865	80267017	ad	37.3	66.4	176	122	5	1	
L. Peixe	2 April	172.884	H32309	ad	36.2	64.7	170	129	4	2	2
L. Peixe	2 April	172.924	H32303	ad	35.9	64.6	171	122	3	2	3
L. Peixe	2 April	172.974	H32302	ad	33.5	64.0	174	123	6	2	3
L. Peixe	2 April	172.992	H32310	ad	34.7	63.4	172	125	7	3	3
L. Peixe	2 April	173.492	H32312	ad	32.6	63.7	169	127	7	2	1-4
L. Peixe	2 April	173.853	H32308	ad	33.8	64.5	171	120	6	3	1-3
L. Peixe	2 April	173.715	H32305	ad	34.8	64.0	169	121	4	0	-
L. Peixe	5 April	173.734	H26990	ad	38.4	67.5	171	126	4	0	-
L. Peixe	5 April	173.773	H26991	ad	35.2	61.8	177	128	5	3	2-4
L. Peixe	5 April	173.788	H32370	ad	36.0	65.0	171	106	7	0	-

Table 6. Reconfirmations of individual radio-tagged Red Knots (see Table 5) at Lagoa do Peixe from 2-8 April 1997. Results of all 32 standard scans at the water-tower receiving station (and a few from the vehicle in the lagoons) which are spread out more or less evenly over most (the 06-24 hr period) of the day Only the three positively identified Punta Rasa marked birds are listed here even though we checked out all birds at every scan. A dash indicates the bird was not yet tagged on that date, and a dot indicates it was not detected.

Origin[a]	Frequency	2 April	3 April	4 April	5 April	6 April	7 April	8 April	days confirmed	confirm. ratio
LP	A884	✓	✓	✓	✓	✓	✓	✓	7	11/32
LP	A924	✓	✓	·	·	✓	·	·	3	11/32
LP	A974	✓	✓	✓	·	·	·	·	3	5/32
LP	A992	·	✓	·	✓	·	·	✓	3	9/32
LP	B493	✓	·	·	·	·	·	✓	2	2/32
LP	B715	·	✓	·	·	✓	✓	·	3	5/32
LP	B853	·	·	·	·		·	·	1	2/32
LP	B734	-	-	-	·	·	·	✓	1	1/17
LP	B773	-	-	-	·	·	✓	✓	2	3/17
LP	B788	-	-	-	✓	·	·	-	1	1/17
PR	A432	·	·	·	·	✓	·	·	1	2/36
PR	A493	✓	·	·	✓	✓	·	✓	4	5/36
PR	A723	·	·	·	·	✓	·	·	1	1/36

A LP = Lagoa do Peixe, PR = Punta Rasa

E-mail CIRCULAR
From: "Theunis Piersma" <theunis@nioz.nl>
Subject: [WADERS-L:244] Sudden mortality of shorebirds at Lagoa do Peixe, Brazil
Date: Mon, 14 Apr 1997 19:54:34 +0200

UNUSUAL MORTALITY OF SANDPIPERS ALONG THE ATLANTIC COAST OF SOUTHERN BRAZIL IN APRIL 1997

I have just returned from an international expedition in Brazil, where we studied the northward migration of Red Knots (*Calidris canutus rufa*) and other shorebirds at Lagoa do Peixe, state of Rio Grande do Sul, Brazil. We worked in the area from 2-8 April, being based at CEMAVE's research station at the mouth of the lagoon, Barra do Lagoa. A first Red Knot (a juvenile) was found dead on the beach on 6 April. On 7 April S.B. Scherer collected 26 Red Knots, 10 White-rumped Sandpipers (Calidris fuscicollis) and 3 Sanderlings (Calidris alba) along a stretch of 10 km of Atlantic Ocean beach 20 km north of Barra do Lagoa. More than half of the birds were dead, but the others were sort of half-dead, lame, lethargic and not responding to any form of handling. We gave the five best Red Knots, and three Sanderlings repeated loads of fresh water to which some sugar and salt were added, but their situation had not improved in 10 hrs; in fact, half of them had died by then. The birds were not emaciated (in fact their masses and body moult status were exactly the same as birds caught previously and later that day by cannon-netting), and the only other outward sign of illness was some green faeces sticking to their cloacal feathers, an unusual type of faeces, for Red Knots at least. Juveniles as well as migrating adults coming into breeding plumage were affected. The illness appeared rather acute, since two of the 200+ Knots released in glorious health the afternoon of 7 April were found in the same lethargic disposition at the edge of the lagoon in the morning of 8 April, together with five more unbanded Knots and one White-rumped Sandpiper in similar condition. Later that day, driving north of Barra de Lagoa to Mostardas, along 35 km of beach we located at least another 13 sick or dead Red Knots along with ca. 550 live Knots which were widely distributed in small flocks, and several 100 Sanderlings and White-rumpeds. Note that the weather in Rio Grande do Sul was foul on 5 April, with a storm from the south that drove the Atlantic waters high, and filled an almost dried up Lagoa do Peixe to the rim! Almost the only feeding of Red Knots that we observed took place on the beach, although the White-rumped Sandpipers fed extensively in the lagoon at all times.

Does anybody have a clue as to what could have been going on here? Is anyone reminded of similar incidents in memory or published literature? Any ideas about which kind of illness or poisoning could have been responsible for what must have been a major mortality? We have collected over 30 of the carcasses and brought them to the Netherlands. It would be great to have more hints as to possible causes before we start looking at these birds in more detail, hopefully with the help of expert veterinarians.
Thanks for your help.

Peixe was sent to the larger wader community by means of the South African maintained wader listserver. Upon a suggestion from Harvard School of Public Health biologist N. Komar, an abstract of this also made it onto the ProMED listserver (the Project for Monitoring Emerging Diseases in man, other animals and plants; 11,000 readers).

The acute symptoms reminded the majority of respondents of some sort of poisoning, whether by the toxins exuded by botulism bacteria or by the algae of the "red tide", but several

types of infectious diseases and man-induced organophosphate poisoning were mentioned too. With the dead bodies at hand it should in principle be possible to find traces of either the toxins or the infectious organisms.

Various veterinary and biological laboratories have meanwhile offered help in disentangling this knot of disease possibilities. Recently, Professor Gerry Dorrestein, a veterinary pathologist at Utrecht University, worked with Theunis Piersma to dissect the dead birds and take samples for further testing. All 35 Red Knots were heavily infected with *Acanthocephala* (hookworms) which had punctured their intestines. Although hookworms can cause sudden deaths in birds, the lungs of some birds were discoloured so there may have been an additional factor in their mortality. Three White-rumped Sandpipers and three Sanderlings were also examined, and none appeared to be infected with hookworms, again suggesting another cause for their deaths. Results of assays for bacterial agents and heavy metal and organochloride pollution will be forthcoming, and will be published separately.

ACKNOWLEDGEMENTS

For assistance with logistics in San Antonio Oeste we thank Oscar Echeverría, Raúl Fernández, Raúl Cardón, Horacio Jouliá, Silvana Sawicki and people of the Inalafquen Fundacíon, the Ministerio de Economía of Río Negro Province and the Municipality of San Antonio Oeste. We also thank the Coop. de Servicios Públicos of Las Grutas for help with external communications. Special thanks to Osvaldo and Isabel Baraschi for the use of their camping ground and for valuable support. We are very grateful to Andrea Cristeche, Juan C.Chillón, Edmeé H.P.de Echave, M.Inés Echave and Gustavo Gerez for arranging food and cooking, and to César and M.Luisa Geoffroy and J.García Belver for help with the lodging and transport of visitors. Bruce Johnson helped importantly with the use his truck. Margarita Pérez, Marta Amado and Susana Jerez organised public relations for the expedition. Mónica Abril and the Asociación Patagónica de Ornitología made arrangements for students from Comodoro Rivadavia to join the expedition. M. Carbajal, P. Llonch, H. Arus, A. Biava, P.D. Delgado, R. Fazzolari, I. Fritzler, R. Di Giácomo, M. Goitía, J. Incola, A. Nicolás, M.E. Picerno, R. and N. Picasso, M.E. Serrano, M.J. Solís, G. Soria, and many children assisted us in the field. Omar Cornelli of the Prefectura Naval Argentina at Bahia Blanca helped us to get black powder.

Our trip to Peninsula Valdes was made possible through the generous assistance of CENPAT, courtesy of Dr. A. Pucci. We thank the Fundacion Mundo Marino for providing us with accomodation, transport, supporting staff, and many other services while we were working in Punta Rasa. The Fundacion Vida Silvestre Argentina also providing transport, staff and facilities for storing our cannon-netting equipment. The Servicio de Hidrografía Naval-Armada Argentina and the Subprefectura General Lavelle provided assistance at Punta Rasa which made our work much easier. We thank Camping ACA of San Clement y Tuyú for free accomodation, and the municipalities of General Lavalle and de La Costa for transporting school children to the beach at Punta Rasa. We are grateful to Roberto Parisi of the Ministerio de Asuntos Agrarios in Buenos Aires for issuing the permit to catch birds and for providing personnel to assist us, and to Dr. Osvaldo Mario Sonzini of the Secretaría Política Ambiental of Buenos Aires Province for hospitality. In Brazil, we thank Nelton Vieira dos Santos, Superintendente IBAMA Rio Grande do Sul, Orocil Franco, Chief of Parque Nacional da Lagoa do Peixe, and Edair Corteleti for permission to work at Lagoa do Peixe and for providing transport and logistics. We thank Alberto Neto Schultz for permits to collect blood and to export samples, and Environmental Education Centre (NEMA) for letting us use their building. Finally, in Salinas we thank Elian Costa Guimarâes and Fibia Brito Guimarâes for the use of their house and facilities.

REFERENCES

Baker, A.J., Manriquez, R.E., Benegas, L.G., Blanco, D., Borowik, O., Ferrando, E., de Goeij, P., Gonzalez, P.M., Gonzalez, J., Minton, C.D.T., Peck, M., Piersma, T. & Ramirez, M.S. 1996. Red Knots *Calidris canutus rufa* at their furthest south: an international expedition to Tierra del Fuego, Argentina, in 1995. *Wader Study Group Bull.* 79: 103-108.

Wiersma, P. & T. Piersma. 1995. Scoring abdominal profiles to characterize migratory cohorts of shorebirds: an example with Red Knots. *J. Field Ornithol.* 66: 88.

APPENDIX 1. LIST OF OTHER PARTICIPANTS

Argentina

Fabián Almacia, Gustavo Aprile, María Carolina Baarck, Isabel Barrios, Gabriel Bataglia, Mario Beade, Nadia Bellani, Marcelo Bertellotti, Vanessa Calvo, Cristina Castro, Verónica D'Amico, Miguel Angel Díaz, María Eugenia Echave, Juan Escobar, Graciela Escudero, Marco Favero, María de los Angeles Hernández, Natalia Hernández, Juan Pablo Isaachs, Flavio Moschione, Fernando Menchi, Sergio Morón, Gabriela Murga, Hernán Pastore, Francisco Pertini, Héctor Piacentini, Jorge Rebollo, Paula Riccardi, Laura Rivero, Javier Salerno, Fabián Salvatore, Alexandra Sapoznikow, Luis Segura, Nicolás Semprini, Patricia Silva, Elena Gomez Simes, Fernando Soria, Gaspar Soria, Ricardo Vera.

Brazil

Leonardo dos Santos Sena, Marcelo Nazareno Vallinoto de Souza, Bruno Duarte Gomes, Evonnildo Costa Gonçalves, Anna Giselle Figueiredo de Couto, Anderson Manoel Herculano Oliveira de Silva, Mârcia Cardoso Rocha, Delon Nascimento de Albuquerque, Andrês Abelardo Batista Bezerra, Paulo de Tarso Zuquim Antas.