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# STATUS OF THE RED KNOT (*CALIDRIS CANUTUS RUFA*) IN THE WESTERN HEMISPHERE

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*Abstract*. The population of the *rufa* subspecies of the Red Knot (*Calidris canutus*), which breeds in the central Canadian Arctic and mainly winters in Tierra del Fuego, has declined dramatically over the past 20 yr. Previously estimated at 100,000–150,000, the population now numbers 18,000–33,000 (18,000 if just the Tierra del Fuego birds are *C. c. rufa*, more if the Red Knots of uncertain subspecific status that winter in northern Brazil (7,500) or Florida (7,500) are also *C. c. rufa*). Counts show that the main Tierra del Fuego wintering population dropped from 67,546 in 1985 to 51,255 in 2000, 29,271 in 2002, 31,568 in 2004, but only 17,653 in 2005 and 17,211 in 2006.

Demographic studies covering 1994–2002 showed that the population decline over that period was related to a drop in annual adult survival from 85% during 1994–1998 to 56% during 1999–2001. Population models showed that if adult survival remained low, *C. c. rufa* would go extinct within about 10 yr. After 2002, the population held up in 2003–2004, but plunged again by nearly 50% in 2005 increasing the likelihood of extinction within the next decade. Despite intensive studies, the reasons for the population decline and reduced adult survival are imperfectly known.

During northward migration, most *C. c. rufa* stopover in Delaware Bay where they feed mainly on the eggs of horseshoe crabs (*Limulus polyphemus*) and lay down fat and protein reserves both to fuel the 3,000 km flight to the arctic breeding grounds and ensure their survival after they arrive at a time when food availability is often low. The crucial importance of Delaware Bay is demonstrated by studies that show that Red Knots with lower mass in Delaware Bay have lower survival than heavier birds and that from 1998–2002 the proportion of birds there at the end of May weighing more than the estimated departure mass of 180 g declined by >60%. This might be the result of the progressive failure of the food supply in Delaware Bay and/or a trend for birds to arrive there later and/or in poorer condition. In years when Red Knots experience reduced food availability and arrive late, the result may be an exacerbation of the effects of each of these deleterious factors.

The main identified threat to the *C. c. rufa* population is the reduced availability of horseshoe crabs eggs in Delaware Bay arising from elevated harvest of adult crabs for bait in the conch and eel fishing industries. Since 1990 the crab population has declined substantially. Although significant uncertainty regarding the extent of the decline of the horseshoe crab population remains, there is general agreement that horseshoe crab stocks have declined to a level where increased management of the fishery is necessary and appropriate. The decline in crabs has led to a decrease in the density of eggs available to shorebirds. Because of the crab's delayed maturity, demographic models indicate that even if further exploitation of crabs ceases immediately, it will be some years before the horseshoe crab population recovers to its former level. Although clear evidence, as in 2003 and 2005, shows that the reduced availability of eggs is already having an impact in some years on the Red Knots ability to gain mass in Delaware Bay, it is likely that other threats to *C. c. rufa* exist and that these are the cause of some birds arriving in the bay late and/or in poor condition. It is not known what these are, but they could be related to Bahia Lomas, the main wintering site in Tierra del Fuego (because the largest reduction in recent years has occurred there and because northward migration from Bahia Lomas along the Atlantic coast of Argentina has taken place 1–2 wk later since year 2000).

If it is proved that something leads Red Knots to arrive late in Delaware Bay and/or in poor condition, this does not diminish the importance of the Delaware Bay food resource. If anything, it is increased because it is of critical importance in enabling the birds to recover quickly and reach the breeding grounds on time and in good reproductive condition.

Actions being taken to improve feeding conditions for Red Knots and other shorebirds in Delaware Bay include beach closures to prevent disturbance and exclosures to reduce competition from gulls. However, although these measures help, they are no substitute for a recovered horseshoe crab population. Actions to conserve horseshoe crabs have included reduced harvest quotas, more efficient use of crabs as bait, closure of the harvest in certain seasons and places and the designation of a sanctuary off the mouth of Delaware Bay. The latest information indicates that the crab population may have stabilized, but there is no evidence of recovery.

Another Red Knot subspecies, *C. c. roselaari*, breeds in Alaska and is presumed to include those Red Knots that winter on the Pacific coast of the United States and Mexico. Two other Red Knot wintering populations are of uncertain subspecific status—one in the southeastern U.S. (mainly Florida) of about 7,500 and one on the north coast of Brazil also of about 7,500. These populations have not been the subject of regular systematic surveys, but it is not thought that either has suffered the same catastrophic decline as the *C. c. rufa* that winter in Tierra del Fuego. Substantial proportions of both pass through Delaware Bay during northward migration, but banding shows that these are distinct populations without interchange with the Tierra del Fuego birds. Moreover, genetic studies show that no exchange of genes has occurred between the southeastern U.S. and the Tierra del Fuego birds for at least 1,200 yr.

Some progress has been made toward understanding why the Tierra del Fuego population has suffered a major decline, but the northern wintering birds have apparently remained more stable. It appears that physiological constraints mean that the southern birds, which mostly make a long, non-stop flight to Delaware Bay from at least northern Brazil, are more reliant on soft, easily-digested horseshoe crab eggs in Delaware Bay than the northern winterers, many of which feed on blue mussel (*Mytilus edulis*) spat or surf clams (*Donax variablis*) on the Atlantic coast of New Jersey. Evidence from Patagonia suggests that, for a reason that remains obscure, northward migration of Tierra del Fuego birds has become 1–2 wk later since the year 2000 and this has probably led to more Red Knots arriving late in Delaware Bay. Late arriving birds have been shown to have the ability to make up lost time by increasing their mass at a higher rate than usual provided they have sufficient food resources. However, late-arriving Red Knots failed to do this in 2003 and 2005 when egg availability was low.

Although *C. c. rufa* Red Knots are spread thinly across a large area of the Canadian Arctic during the breeding season, for the rest of the year they occur mainly in large flocks at a limited number of key coastal wintering and staging sites. This review describes each of these sites and the threats the birds face ranging from oil pollution to disturbance and reclamation for development.

Overall the goal of conservation activities throughout the flyway should be to increase the *C. c. rufa* population to at least the number of 25 yr ago—100,000–150,000 by 2015. Given the uncertain genetic relationships between the three main wintering populations we suggest the following population increases: (1) Tierra del Fuego wintering population to 70,000–80,000 birds, (2) Brazilian wintering population to 20,000–25,000, (3) Florida wintering population to 20,000–25,000, and (4) other sites to 15,000–20,000.

The means whereby such population increases might be achieved include: (1) recovery and maintenance of Delaware Bay horseshoe crab egg densities to levels sufficient to sustain stopover populations of all shorebirds including 100,000 Red Knots, (2) control impact of disturbance at all stopovers and wintering areas, particularly in high-importance, high-disturbance areas like Delaware Bay and the west coast of Florida, (3) by 2008, develop a system for the yearly determination of population demographic status based on counts, capture data, and resightings of banded individuals, (4) by 2008, determine the genetic and breeding status of the three main wintering populations (Tierra del Fuego, Maranhão, and Florida), (5) by 2008, identify all important breeding locations in Canada and recommend protection needs and designations for the most important sites, (6) by 2009, complete site assessments and management plans for all important wintering areas and stopovers in the flyway, (7) by 2009, delineate and propose protection measures for key habitats within the main wintering areas of Maranhão, Tierra del Fuego, and Florida, and develop management plans to guide protection, (8) by 2009, determine key southbound and northbound stopovers that account for at least 80% of stopover areas supporting at least 100 Red Knots, and develop coast-wide surveillance of birds as they migrate, and (9) by 2011, create a hemisphere-wide system of protected areas for each significant wintering, stopover, and breeding area.

Also crucial to *C. c. rufa*'s recovery is adequate funding to support the conservation actions and research needed. Despite the fact that much of the research, survey, monitoring, and conservation work has been carried out by volunteers and has been supported financially by state, federal government and non-government agencies, present funding levels are inadequate to sustain the work required.

*Key words*: breeding, *Calidris canutus rufa*, conservation, Delaware Bay, non-breeding, population, Red Knot, status, stopover.

## ESTATUS DEL PLAYERO CANUTO (*CALIDRIS CANUTUS RUFA*) EN EL HEMISFERIO OESTE

*Resumen.* La población del playero ártico (*Calidris canutus*) subespecie *rufa*, la cual anida en el ártico central canadiense y mayoritariamente inverna en Tierra del Fuego, ha declinado dramáticamente en los últimos 20 años. Previamente estimada en 100,000–150,000 individuos, la población bordea actualmente los 18,000–33,000 individuos (18,000 si todas las aves de Tierra del Fuego son *C.c. rufa* y más,

si los playeros árticos con asignación subespecífica incierta que invernan en el norte de Brasil (7,500) o Florida (7,500) son también *C. c. rufa*). Los conteos indican que la población principal que inverna en Tierra del Fuego ha decaído de 67,546 en 1985 a 51,255 en el 2000, 29,271 en el 2002, 31,568 en el 2004, sólo 17,653 en el 2005 y 17,211 en el 2006.

Estudios demográficos realizados entre 1994 y 2002 han mostrado que el decrecimiento poblacional en este período se relaciona con una caída en la sobrevivencia anual de adultos la cual va desde 85% en el período 1994–1998 hasta 56% en 1999–2001. Modelos poblacionales muestran que si la sobrevivencia de adultos permanece baja, *C. c. rufa* podría extinguirse dentro de los siguientes 10 años. Después de 2002, la población aumentó en 2003–2004, pero decayó nuevamente cercano al 50% en 2005 incrementando así la probabilidad de extinción dentro de la siguiente década. A pesar de los intensos estudios realizados, las razones para el decrecimiento poblacional y la reducida sobrevivencia adulta aún se desconocen.

Durante la migración hacia el norte, la mayoría de la población de *C. c. rufa* se detiene en Bahía Delaware donde se alimenta principalmente de los huevos de cangrejos cacerola (*Limulus polyphemus*), obteniendo así grasas y proteínas necesarias para realizar el vuelo de 3,000 km hacia los sitios de reproducción en el Ártico y también para asegurar su sobrevivencia después que llegan, en un período en que frecuentemente el alimento es escaso. La importancia de Bahía Delaware es señalada en estudios que muestran que en esta Bahía los playeros árticos con menor masa corporal tienen menor probabilidad de sobrevivencia, y que desde 1998–2002 la proporción de aves que están hasta fines de mayo pesando más del peso ideal de 180 g, estimado como peso de partida, ha declinado en más de 67%. Lo anterior puede ser el resultado de una falla progresiva en la disponibilidad de alimento en Bahía Delaware y/o una tendencia de las aves a llegar más tarde o en peores condiciones.

La mayor amenaza identificada para la población de *C. c. rufa* es la reducida disponibilidad de huevos de cangrejos cacerola en Bahía Delaware, producto del incremento en la extracción de adultos los que son utilizados como cebo en la industria pesquera de anguila y caracol. Desde 1990 la población de estos cangrejos ha disminuido sustancialmente. A pesar que aún existe cierta incertidumbre respecto de la extensión del decrecimiento de la población de cangrejos, hay consenso en que los stocks han disminuido a un nivel en que urge el manejo de la pesquería. La disminución de cangrejos ha producido un decrecimiento en la densidad de huevos disponible para las aves costeras. Debido a la madurez retrasada de los cangrejos, modelos demográficos han mostrado que aun cuando la explotación de éstos cese inmediatamente se requerirán algunos años antes que la población se recupere a su nivel original. Si bien la evidencia muestra, tal como en 2003 y 2005, que la reducida disponibilidad de huevos tiene un impacto en la habilidad de los playeros árticos para ganar masa corporal, existen otras amenazas para la población de *C. c. rufa* pudiendo ser éstas las causas que expliquen la llegada tardía a la bahía y/o las malas condiciones en que llegan. No se sabe cuáles son exactamente las causas pero éstas pueden estar relacionadas con Bahía Lomas, principal sitio de invernada en Tierra del Fuego. Esto, debido a que la mayor reducción en los últimos años ha ocurrido allí y también porque desde el año 2000 la migración desde Bahía Lomas hacia el norte ha tomado lugar una o dos semanas más tarde.

Si se prueba que algo hace que los playeros árticos lleguen tarde a Bahía Delaware y/o en malas condiciones, esto no limita la importancia que tiene el recurso alimento en esta bahía. Por el contrario, ésta aumenta debido a la importancia crítica que tiene para las aves tanto para recuperarse rápidamente como para alcanzar los sitios reproductivos a tiempo y en buenas condiciones.

Se deben emprender acciones para mejorar las condiciones de alimentación de los playeros árticos y otras aves costeras en Bahía Delaware incluyendo cierres de playas para prevenir las perturbaciones y exclusiones para reducir la competencia con las gaviotas. Si bien estas medidas ayudan, no hay substitutos para la recuperación de la población de cangrejos cacerola. Acciones para conservar a los cangrejos han incluido reducción de la extracción en ciertas estaciones del año y sitios, y la designación de un santuario fuera de la boca de Bahía Delaware. La información reciente indica que la población de cangrejos puede haberse estabilizado sin que exista evidencia de una recuperación.

Otra subespecie de *Calidris canutus*, *C. c. roselaari*, se reproduce en Alaska y se presume incluye a aquellos playeros árticos que invernan en la costa Pacífico de los Estados Unidos y México. Otras dos poblaciones de playeros árticos con estatus subespecífico incierto invernan una en el sur de EUA (mayoritariamente en Florida) con cerca de 7,500 individuos y la otra en la costa norte de Brasil también con aproximadamente 7,500 individuos. Aun cuando estas poblaciones no han sido objeto de estudios sistemáticos, se piensa que no han sufrido las mismas reducciones catastróficas de la población de *C. c. rufa* que inverna en Tierra del Fuego. Una proporción sustancial de las poblaciones antes mencionadas pasa por Bahía Delaware durante la migración hacia el norte, pero estudios de marcaje muestran que éstas son poblaciones distintas sin que exista intercambio con las aves de Tierra del Fuego. Más aun, estudios genéticos indican que no ha ocurrido intercambio de genes entre las aves del sureste de EUA y las de Tierra del Fuego por al menos 1,200 años.

Algunos progresos se han hecho para entender el por qué la población de Tierra del Fuego ha sufrido una reducción mayor, mientras las aves que invernan más al norte han permanecido más estables. Pareciera que las restricciones fisiológicas de las aves del sur, las que hacen un largo vuelo

sin detención desde al menos el norte de Brasil hasta Bahía Delaware, son más dependientes de lo blando y digerible de los huevos de cangrejos cacerola en Bahía Delaware que las restricciones de las aves que invernan en el norte, muchas de las cuales se alimentan del mitílido (*Mytilus edulis*) o semillas de almejas (*Donax variabilis*) en la costa Atlántica de Nueva Jersey.

La evidencia de la Patagonia sugiere que, por una razón que aun no está clara, la migración hacia el norte de las aves de Tierra del Fuego se ha atrasado 1–2 semanas desde el año 2000 y que probablemente esto hace que los playeros lleguen tarde a Bahía Delaware. Las aves que llegan tarde han mostrado tener la habilidad de recuperar el tiempo perdido al incrementar su masa a una tasa mayor que la usual. Esto con los suficientes recursos alimentarios. No obstante lo anterior, los playeros fallaron en hacer esto en 2003 y 2005 cuando la disponibilidad de huevos fue baja.

Si bien *C. c. rufa* está distribuida en un área amplia del ártico canadiense durante la época reproductiva, el resto del año ellas ocurren mayoritariamente en grandes bandadas en un número limitado de sitios costeros claves de invernada y parada. La presente revisión describe cada uno de estos sitios y las amenazas que enfrentan las aves, desde la contaminación hasta los disturbios causados por el desarrollo.

Globalmente, la meta de las actividades de conservación a lo largo de la ruta migratoria debe ser el incremento de la población de *C. c. rufa* hacia los tamaños poblacionales que se registraban hace 25 años atrás (i.e., 100,000–150,000 individuos hacia el 2015). Dadas las relaciones genéticas inciertas entre las tres mayores poblaciones invernantes se sugieren los siguientes incrementos poblacionales: (1) para la población invernante de Tierra del Fuego 70,000-80,000 aves, (2) para la población invernante de Brasil a 20,000-25,000 aves, (3) para la población invernante de Florida a 20,000–25,000 individuos, y (4) otros sitios hacia 15,000-20,000 aves.

Entre las razones por las cuales estas poblaciones pudieran incrementar están: (1) recuperación y mantención de las densidades de huevos de cangrejos cacerolas en Bahía Delaware a niveles tales que soporten todas las poblaciones de aves costeras que paran en el lugar incluidos los playeros árticos, (2) control del impacto de los disturbios en todas las áreas de parada e invernada, particularmente aquellas de importancia alta como Bahía Delaware y la costa oeste de Florida, (3) hacia el 2008, desarrollo de un sistema para la determinación anual del estatus poblacional demográfico basado en conteos, datos de captura y observación de individuos marcados, (4) hacia el 2008, determinar el estado genético y reproductivo de las tres mayores poblaciones invernantes (Tierra del Fuego, Maranhao y Florida), (5) hacia el 2008, identificar todos los sitios reproductivos importantes en Canadá y recomendar las necesidades de protección y manejo para los sitios más importantes, (6) hacia el 2009, completar las evaluaciones y planes de manejo para todas las áreas importantes de invernada y parada, (7) hacia el 2009, delinear y proponer medidas de protección de hábitats claves dentro de las mayores áreas de Maranhao, Tierra del Fuego y Florida, y desarrollar planes de manejo para guiar la protección, (8) hacia el 2009 determinar las paradas claves de los límites sur y norte las que dan cuenta de al menos el 80% de las áreas de parada que soportan al menos 100 playeros árticos, y desarrollar un monitoreo costero amplio de aves a medida que migran, y (9) hacia el 2011 crear un sistema hemisférico de áreas protegidas para cada sitio de invernada y reproducción significante.

También crucial para la recuperación de *C. c. rufa* es el adecuado financiamiento para apoyar las acciones de conservación e investigación que se necesiten. Aparte del hecho que mucho del trabajo de investigación, muestreo, monitoreo y conservación ha sido llevado a cabo por voluntarios y ha sido apoyado financieramente por el estado, gobierno federal y agencias no gubernamentales, en el presente los niveles de financiamiento son inadecuados para sostener el trabajo requerido.

The Red Knot (*Calidris canutus*) is a worldwide species with a total population of approximately 1,050,000 (Wetlands International 2006; C. D. T. Minton, unpubl. data; this review). Breeding in the Arctic and wintering as far south as New Zealand, Australia, South Africa and Tierra del Fuego, the Red Knot is one of nature's most prodigious travelers exciting the interest of scientists and conservationists around the world. The Red Knot is also one of the most extensively studied of the world's 221 species of shorebird (Table 1). Central to this research effort is a team led by Theunis Piersma on Texel in the Netherlands where the Royal Netherlands Institute for Sea Research has a laboratory, the size of an aircraft hangar, for studying Red Knots under precisely controlled conditions.

Six subspecies of the Red Knot together have a circumpolar arctic breeding distribution though each breed in a distinct area and winters separately. Except as otherwise noted, this status assessment focuses on the New World Red Knot subspecies *Calidris canutus rufa*.

Building on earlier work led by the Manomet Center for Conservation Science, *C. c. rufa* has been the subject of intensive studies throughout the western Atlantic shorebird flyway since 1997. These studies were originally instigated and have since been sustained by concern that the Patagonian population has fallen from 100,000–150,000 in the early 1980s to

TABLE 1. NUMBER OF CITATIONS OF THE MOST EXTENSIVELY STUDIED SHOREBIRDS IN THE WORLD (THOMAS ET AL. 2003).

| Species | Number of citations in title only | Number of citations in text |
|---|---|---|
| Eurasian Oystercatcher (*Haematopus ostralegus*) | 112 | 292 |
| Dunlin (*Calidris alpina*) | 58 | 137 |
| Northern Lapwing (*Vanellus vanellus*) | 51 | 125 |
| Red Knot (*Calidris canutus*) | 36 | 132 |
| Redshank (*Tringa totanus*) | 29 | 88 |
| Ruff (*Philomachus pugnax*) | 22 | 57 |
| Eurasian Curlew (*Numenius arquata*) | 20 | 43 |
| Black-bellied Plover (*Pluvialis squatarola*) | 18 | 73 |

around 17,200 in 2006. The work has involved a diverse selection of people and organizations, government and non-government from Argentina, Chile, Brazil, and Canada as well as all East Coast states of the U.S. from Florida to Massachusetts and the U.S. Fish and Wildlife Service (USFWS). From the beginning, shorebird ecologists from outside the Americas have also been involved, especially from the United Kingdom, The Netherlands, and Australia, several of whom have contributed to this review.

Studies of *C. c. rufa* have focused on determining the cause of the population decline and whether anything can be done to reverse the situation. With limited resources, they have sought to cover the whole of *C. c. rufa*'s latitudinal range of over 120° from Tierra del Fuego (54° S) to King William Island (68° N) and the whole of its annual cycle from one arctic breeding season to the next. More specifically, a large proportion of the effort has been directed at measuring demographic rates and identifying where in the annual cycle the problems lie. All this has proved very challenging and we do not yet know all the answers. Nevertheless, considerable progress has been made, due in no small part to the use of modern and sometimes innovative techniques as well as much hard work and the support of many people and organizations.

Worldwide, the main organization concerned with research and conservation science in relation to the world's 221 species of shorebird is the International Wader Study Group, which organized a workshop attended by 132 specialists from 20 countries in 2003 to determine if shorebird populations worldwide are in decline. The conclusions show that of those shorebirds whose population trend is known, 48% are declining and only 16% increasing (International Wader Study Group 2003). Many of the declining populations were found to be those of long-distance migrants and *C. c. rufa* was cited as a prime example. Problems identified as common to several long-distance migrants were their high dependency on a very limited number of key stopover sites making them particularly vulnerable to habitat loss (as in the Yellow Sea where huge areas of intertidal habitat have been lost to reclamation) and declining food resources at stopover sites arising from the unsustainable exploitation of natural resources. In the latter case, the prime examples worldwide were considered to be unsustainable shell-fish harvesting in the Dutch Wadden Sea and the exploitation of horseshoe crabs (*Limulus polyphemus*) in Delaware Bay.

As a result of *C. c. rufa*'s decline, in November 2005 the parties to the Convention on the Conservation of Migratory Species of Wild Animals, also known as the Bonn Convention (which include Argentina and Chile, but not the U.S., Brazil, or Canada), determined that *C. c. rufa* was endangered and as such added it to appendix 1 of the convention which commits the parties to strive towards protection of the species and the conservation of its habitat. In April 2007, the Canadian government's Committee on the Status of Endangered Wildlife in Canada determined that *C. c. rufa* was endangered following completion of a status review. In Brazil the Red Knot is being proposed for listing as endangered.

A problem arising from the continuous nature of the *C. c. rufa* studies over the past nine years has been a lack of time and resources to write up and publish results. All too often, data have been analyzed and partly written up only to be overtaken by the accumulation of more data. We therefore greatly welcome the opportunity that this status review affords to take stock and set out a full account of our current knowledge. We describe *C. c. rufa* in the context of worldwide Red Knot populations and assess its status, its general natural history, its habitat, its breeding system, its migrations, and its feeding ecology. We address especially the threats it faces and the conservation actions that may lead to its recovery.

## TAXONOMY

Red Knots are currently classified into six subspecies, each with distinctive morphological traits, migration routes, and annual cycles. Available evidence from long-term banding