Distribution, abundance, migration and moult of the Red Knot *Calidris canutus rogersi*

Mark Barter

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Rogersi is the least studied of the four long-recognized subspecies of Knot. It breeds in eastern Siberia, but the exact location(s) has yet to be determined although biometric comparisons favour the Chukotski Peninsula. It is believed that virtually the whole population spends the non-breeding season in Australasia, with 150,000 occurring in Australia, mostly in the north-west and south-east, and 50,000 in New Zealand. Northward departures from Australasia occur during late March and April (earliest in the south), with birds being present on the Chinese coast during April and early May. Returning adults arrive from end August through September and October (earliest in the north). The legs of the migrations are long. The Chinese coastline plays a very important role on northward migration and is probably reached in one hop from north-western Australia. It seems likely that Knots fly non-stop from north-east Asia to Australia on southward migration. There is no evidence from banding data of interchange between north-western Australia and south-eastern Australia/New Zealand, although at least some New Zealand-bound birds stage through south-eastern Australia. Primary moult commences when returning adults reach their non-breeding destination, and starts later the further south the site and, therefore, the later the arrival date. Pre-migratory fat and protein reserves of *rogersi* do not appear to be as large as for the *islandica* and *canutus* subspecies, although *rogersi* seems to make longer flights. Perhaps the more benign subtropical staging sites of *rogersi* minimize the need to carry additional nutrient reserves. Major gaps in current knowledge include breeding ground location(s), distribution and abundance in Australia during the non-breeding season and strategies on both migrations, especially of south-eastern Australian and New Zealand birds.

M. Barter, Australasian Wader Studies Group (ASWG), 21 Chivalry Avenue, Glen Waverley, Victoria 3150, Australia.

INTRODUCTION

Four subspecies of Red Knot *Calidris canutus* are now widely recognized (Cramp & Simmons 1983) and they can be separated on the basis of measurements, particularly bill and wing, and breeding plumage (see, for example, Cramp & Simmons 1983; Roselaar 1983; Dick *et al.* 1976; Prater *et al.* 1977).

Rogersi is the least studied of the four subspecies and it is only during the last ten years that a preliminary understanding has been gained of its distribution, abundance and annual life cycle. Much of the work in north-western and south-eastern Australia to date has been described in Barter *et al.* (1988a, b). More recently, data has become available from China (Wang Tian Hou 1988, 1989), Hong Kong (D.S. Melville pers. comm.) and New Zealand (S. Davies & A. Riegen pers. comm.).

The major Red Knot study sites in the flyway are north-western Australia (counting, banding [1,800 birds up to 1990] and radar observations), south-eastern Australia (counting and banding [2,000 birds to 1990]), New Zealand (counting and banding [2,000 birds to 1990]) and east China (counting and banding).

EAST ASIAN-AUSTRALASIAN FLYWAY

The flyway used by *rogersi* is shown in Figure 1, together with places and regions referred to in the text (see also Figure 2).

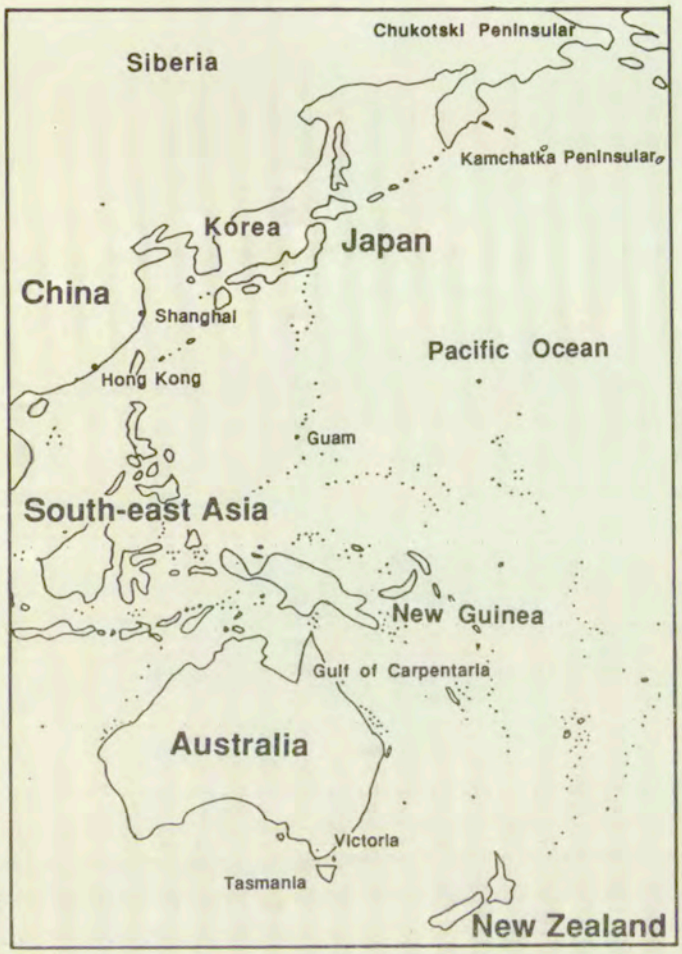

Figure 1. East Asian-Australasian Flyway with countries and places mentioned in the text.

OCCURRENCE

The subspecies *rogersi* was first described by Mathews (1913) using a specimen obtained from Japan. As the breeding grounds have not been positively identified, the published biometric data for *rogersi* have been taken from specimens obtained during migration in east and south-east Asia and New Guinea or on the non-breeding grounds in New Zealand (Roselaar 1983). Comparison of Australian (Barter *et al.* 1988a), Chinese (Wang Tian Hou 1989) and Hong Kong (D.S. Melville pers. comm.) biometric data for live birds with measurements from museum specimens confirms that these birds are *rogersi*. The recovery/control of 14 Australian-banded birds along the Chinese coastline provides additional confirmation.

Rogersi appears to only occur in large numbers in Australia and New Zealand during the non-breeding season and is relatively uncommon in Japan, Korea, south-east Asia and the south Pacific during migration (Lane 1987).

NON-BREEDING AREAS

Information on the non-breeding distribution and numbers of *rogersi* in Australia is incomplete, as few counts have been done in northern Australia during the non-migratory period. Maximum numbers counted in the main arrival areas are 90,000 in north-western Australia (NWA) and 80,000 in the Gulf of Carpentaria, both in September but, by November, numbers have fallen to less than half at the former site (Lane 1987). Better information is available for non-breeding concentrations in south-eastern Australia (SEA) and New Zealand (NZ), where numbers are around 10,000 and 50,000, respectively (Lane 1987; Sagar 1986). Watkins (in prep.) estimates that the Australian non-breeding population is around 153,000 and, thus, it seems that the *rogersi* population in Australasia during the non-breeding season is close to 200,000.

BREEDING AREAS

North-eastern Siberia, Alaska and, particularly, Wrangel Island have been suggested as *rogersi* breeding areas (Portenko 1972; Flint 1972; Cramp & Simmons 1983). Roselaar (1983) disputes the claim that *rogersi* breeds on Wrangel Island and suggests that birds from this island and from Alaska form a fifth race that migrates along the Pacific Coast of North America to unknown non-breeding sites.

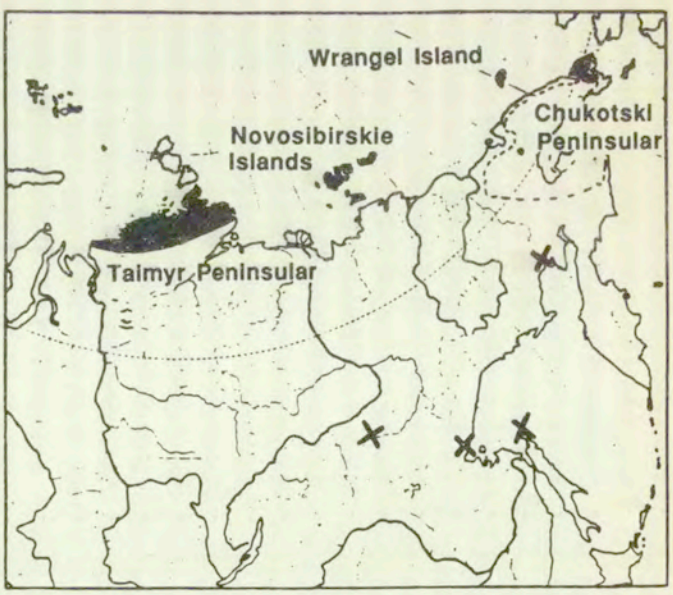

Figure 2. Breeding areas of Red Knots in Siberia (after Tomkovich 1987). Black areas indicate the breeding sites. The crosses mark some of the Australasian-banded recoveries in eastern Siberia.

Tomkovich (1987, 1992) has recently published morphological data, obtained from Russian museum specimens, which show that there are four Siberian breeding populations (see Figure 2). He concludes that the description of *rogersi* in breeding plumage corresponds to that of birds of the Chukotski Peninsula in far eastern Siberia.

The measurements of Australian Red Knots agree well with Tomkovich's biometric data for the Chukotski Peninsula, especially when allowance is made for specimen shrinkage. The only other breeding population that could possibly match that of *rogersi* is the one from the Taymyr Peninsula. However these latter birds, when in breeding plumage, have rufous vents and under-tail coverts, unlike *rogersi*. Their bills are also longer. Wrangel Island Red Knots have considerably longer bills and wings than those of Australian birds (Barter 1989).

The recoveries of Australian-banded Red Knots near Magadan on the southern coast of eastern Siberia, to the west of the Kamchatka Peninsula (see Figure 1), and in the region of North Sakhalin Island, provide some support for the suggestion that *rogersi* breeds in far eastern Siberia, although recoveries of Australasian-banded birds further west in Siberia on southward migration (Figure 2), indicates that these particular birds may not have bred in the far-east.

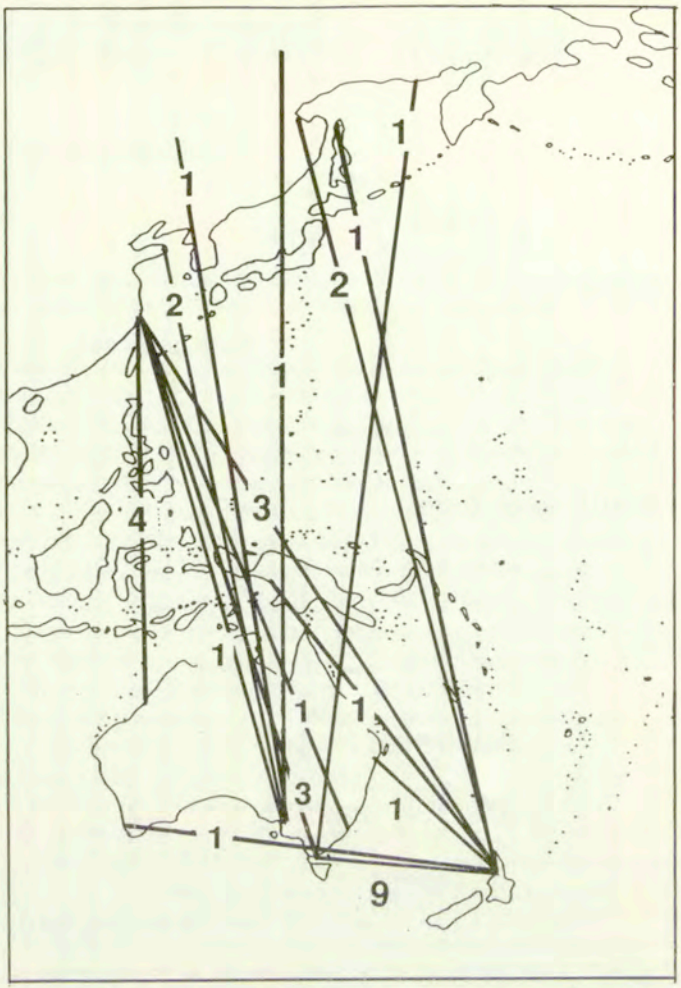

Figure 3. Long-distance movements of Red Knots banded in Australasia. All recoveries on the Chinese coastline and on the Queensland and Irian Jayan coasts are on northward migration. Siberian recoveries (except one undated) and the south-western and south-eastern Australia to New Zealand movements are on southward migration.

MIGRATION ROUTES AND STAGING AREAS

There have been 31 overseas movements of banded Red Knots in the flyway and these are summarized in Figure 3. All but eight of the birds were banded in Australia, with the exceptions being banded in New Zealand. There have been 14 recoveries on the Chinese coast during northward migration (four from NWA, seven from SEA, three from NZ) and two, also on northward migration from NZ, on the south Queensland and south Irian Jaya coasts. All five recoveries of southward-moving birds have been in eastern Siberia (Figure 3). There have been 10 movements from Australia to New Zealand (one from south-western Australia, the remainder from SEA). Interestingly, there have been no movements between NWA and SEA or NZ from the nearly 6,000 birds caught and banded in the three regions.

The limited banding data indicate that:

1) the east Chinese coast is a staging post on northward migration,
2) birds return southwards through eastern Siberia but, apparently, not along the Chinese coast,
3) SEA is a staging post for NZ-bound birds on southward migration, and
4) SEA and NZ birds do not seem to pass through NWA on either migration.

The observation that Red Knots are rare on northward migration in south-east Asia implies that they must fly non-stop between Australia and China. Great circle flight distances from Australia and NZ to China (Shanghai) are shown in Figure 4, and include the possible use of staging posts in Victoria, NWA and the Gulf of Carpentaria. It can be seen that the distances between northern Australian sites and China are 5,000 to 6,000 km, and that flight distances between NZ and SEA and potential staging sites in northern Australia vary from 2,300 to 3,900 km.

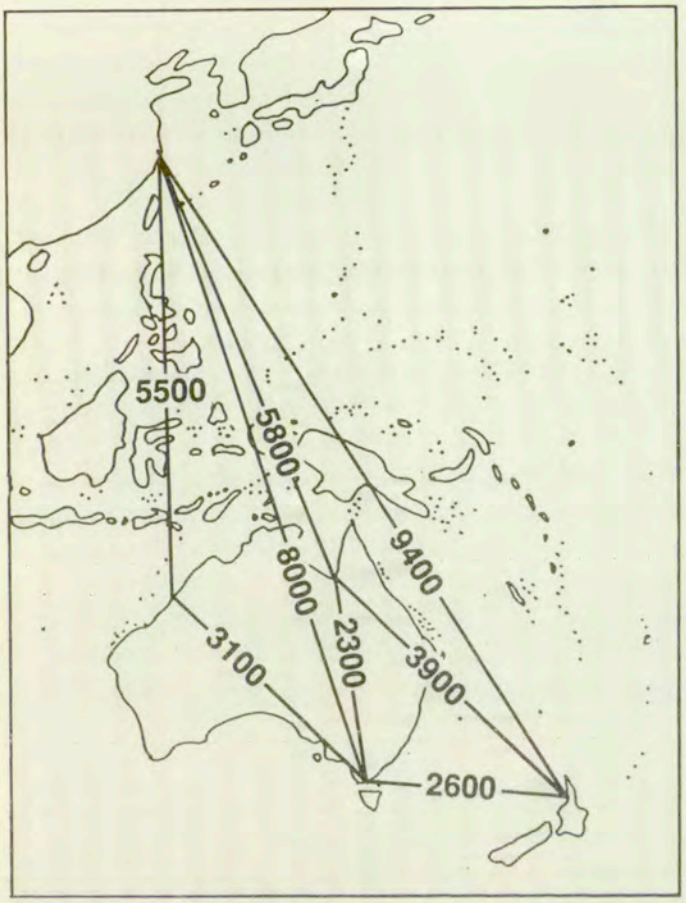

Figure 4. Distance in km between non-breeding sites, potential staging posts and the east China coastline.

NORTHWARD MIGRATION

Red Knots depart from SEA and NZ in late March-early April (pers. obs.; A. Riegen pers. comm.), from NWA in late March/through April (Lane & Jessop 1985; Barter *et al.* 1988b) and are present on the east Chinese coastline during April and early May (Wang Tian Hou 1988).

Using the Summers & Waltner (1979) equation, and assuming an average flight speed of 75 km/h and a fat-free weight of 88 g (based on an average weight of 88 g for 12 Red Knots caught at Shanghai on northward migration), it can be shown that the *minimum* weights for successful non-stop migration to China are 150 g in NWA and 185 g in SEA. The breeding grounds on the Chukotski Peninsula could be directly reached from Shanghai by birds weighing 150 g, on average.

Data from NWA indicates that approximately 70% of about-to-depart Red Knots weigh in excess of 150 g. Birds appear to depart when they reach 165 g, thus providing a substantial safety margin (Barter *et al.* 1988b). The average heading of departing Red Knots at Broome (determined from radar studies, B.A. Lane pers. comm.) is 320° compared to the 360° necessary to fly by the great circle route to Shanghai. However, there is an east to north-easterly air flow along the east Asian coastline during March and April (Chin & Lai 1974) and Red Knots appear to be taking this into account by leaving on the more westerly heading. Migrants leaving the New England coastline on southward migration for South America follow a similar strategy, in this case taking a more easterly heading than required and using the easterly trade winds to make a successful land fall (Richardson 1979).

The limited data available on pre-departure weights of SEA Red Knots indicates that a third of the birds weigh in excess of 185 g, perhaps a week or two before departure. This weight is greatly in excess of that required to fly successfully to possible staging sites on the north coast of Australia and, thus, the question arises as to whether Red Knots from SEA fly the 8,000 km to China non-stop. If an intermediate staging site is used, it seems more likely to be the Gulf of Carpentaria than NWA as the former lies on the great circle route to east China. The lack of band movements between SEA and NWA also suggests that the Gulf is a more likely staging site. Unfortunately, little data are available on wader migration through the Gulf in the March/April period, due to the considerable difficulty of working in the area during and following the monsoon, and there is a critical need to overcome this deficiency.

It seems probable that NZ Red Knots stage in northern Australia and the lack of movements between NWA and NZ and the recovery of NZ-banded birds on the south-east Queensland and south Irian Jayan coasts on northward migration, indicates that the Gulf area may be the staging site used.

Leg-flagging of Red Knots caught in SEA and NZ could be a useful technique for determining the use of the Gulf as a staging site.

Notwithstanding the seemingly long migration stages undertaken by *rogersi* (apparently longer than those undertaken by *islandica* and *canutus*), departure weights seem to be lower (e.g. >165 g in NWA, >185 g in SEA) than for either *islandica* (e.g. 185 - 195 g for the 2,000 km flight from north-western Europe to Iceland; 205 - 210 g for the 3,000 km from Iceland to Ellesmere Island, Davidson & Wilson 1992) or *canutus* (225 g for the 4,500 km or more from the Wadden Sea to central Siberia, Dick *et al.* 1987).

The smaller size of *rogersi* (and the possibly correlated low fat-free weight, Piersma & Barter 1991) as well as the benign environments of the staging sites in northern Australia and China may be the reason(s) for the lower departure weights.

SOUTHWARD MIGRATION

Adult Red Knots arrive in NWA during end August-early September (AWSG unpubl. data) and in SEA and NZ from the end of September (J. Pratt & A. Riegen pers. comm.). Large numbers are present in the Gulf of Carpentaria in September (Lane 1987). There is a movement of birds through the Shanghai area in mid-September (Wang Tian Hou 1988), but these are probably juveniles.

There are no published records of large numbers of Red Knots on the Asian coastline during southward migration, nor have there been any band recoveries at this time on the Chinese coast, and this absence raises the possibility of birds flying non-stop across the Pacific from north-east Asia. Radar studies at Guam have shown that large numbers of waders are passing overhead in the direction of Australia during August to October (Williams & Williams 1988), and Red Knots may be amongst the species involved.

Weights of small numbers of juvenile birds caught in Hongkong in September/November show them to be capable of flying non-stop to the north coast of Australia (i.e. 155 g average, $n = 6$, D.S. Melville pers. comm.).

Movements of banded birds show that SEA, unlike NWA, is a staging site for Red Knots on southward migration to NZ. However, count data indicates that it is unlikely that significant numbers of NZ-bound Red Knots pass through SEA and the Gulf of Carpentaria is probably a more significant staging site.

MOULT

Primary moult in Australian *rogersi* is covered in detail in Barter *et al.* (1988b). A broad summary is given below. On average, SEA adult Red Knots commence moult during the second-half of October and complete moult in late February/early March. The moult duration of about four months is similar to that of 125 days for the Curlew Sandpiper *Calidris ferruginea* in Tasmania (Barter 1986a) and 130 days for the Red-necked Stint *C. ruficollis* in Victoria (Paton & Wykes 1978). In SEA, primary moult in second-year birds is about two months ahead of that in adults. Often, feathers of three different ages are found in the same wing, i.e. juvenile, first-year and active second-year moult.

Adults in NWA start primary moult in the second-half of August and in the end October/early November period are six to seven weeks ahead of SEA birds of the same age. NWA second-year birds are completing their first full primary moult as adults are commencing.

The timing of primary moult in Red Knots is consistent with the general observation that waders which breed in the palearctic and spend the non-breeding season in the southern hemisphere do not commence primary moult until they reach their non-breeding destinations (see, for example, Pearson 1981, 1984; Elliott *et al.* 1976; Barter 1986a, 1986b, 1987).

Differences in the timing of primary moult in the two regions, and between the two age groups, may be explained by the earlier arrival of adults in NWA compared to SEA (i.e. mid-August onwards vs. early October) and the fact that many, if not all, first year birds spend the non-breeding season near, or at, the non-breeding sites, thus allowing them to commence primary moult, as second-years, before the returning adults.

Many first-year birds undergo a partial or complete primary moult which, in SEA, commences in January. The percentage of birds which undergo a full primary moult is probably less than 10% in SEA but could be more than 20% in NWA. The symmetry and starting point of moult in first-years is highly variable.

PASSAGE BIRDS IN SOUTH-EAST AUSTRALIA

Non-moulting adults and adults and second-year Red Knots in suspended moult are significantly heavier and/or have a higher standard deviation of weight than moulting birds. Whilst the weight differences could be explained by moult-induced stress, it is quite possible that they are due to fattening of non-moulting and suspended moult birds prior to onward migration to NZ. There have been five movements of adult Red Knots between SEA and NZ, all birds being banded in SEA in October-November and having not commenced primary moult. It is interesting to note

that, in November, 34% of non-moulting and suspended moult adults and 24% of suspended moult second-year birds had enough fat (on average) to fly to NZ. No moulting adults and only 8% of moulting second-years fell into this category. Thus, at least some Red Knots are using SEA as a staging area on the way to NZ.

The question arises of where adults undergo moult prior to suspension? Is this in northern Australia or closer to the breeding grounds? The answer will probably have to await the identification of the staging sites (and, therefore, potential study sites) used on southward migration, as well as further work in the Gulf of Carpentaria.

CONCLUSIONS

The gaps in our basic knowledge of the abundance, distribution and annual life cycle of *rogersi* are considerable.

Confirmation of the suggested Chukotski Peninsular breeding grounds is needed. DNA comparison of Australian Red Knots with the different Siberian breeding populations is necessary. Hopefully, in time Russian workers will recapture Australian-banded birds on their breeding grounds.

Our understanding of the distribution and abundance of *rogersi* during the non-breeding season is incomplete, especially in Australia. There appears to be a decline of 50,000 in numbers in NWA from September to November. If this is so, where do these birds move on to? The Gulf of Carpentaria, SEA and/or NZ? There is need for a simultaneous count in mid non-breeding season, but this is particularly difficult to do in the Gulf of Carpentaria in the November/March period due to inaccessibility caused by the very wet conditions at that time.

Nothing is known of staging sites used on northward migration - other than the Chinese east coast? What part, if any, do the Gulf of Carpentaria and NWA play in the migration strategies of SEA and NZ birds? Do all *rogersi* stage on the Chinese coastline? If so, exactly where and in what numbers? Do they then fly directly on to the breeding grounds, which are certainly within non-stop flying range, or do they stage on the way?

Even less is known about southward migration than northward. Where are the Asian staging sites? Do Red Knots fly across the Pacific to Australia and NZ? What part do NWA, the Gulf of Carpentaria and SEA play?

Development of further migration hypotheses may be possible if pre-departure weight data of NZ Red Knots and arrival and departure information on birds staging in China can be obtained. However, simple flight range calculations based on weight gains may be misleading due to the finding that birds also greatly increase muscle protein at the same time as putting on fat and appear to use up some of the protein reserves during long distance flights (Davidson & Evans 1988; Piersma & Jukema 1990; Lindström & Piersma 1993). The expected arrival conditions may also have an influence on departure weights, e.g. Knots arriving on arctic Ellesmere Island would require greater fat and protein reserves than those arriving on the subtropical eastern Chinese coastline.

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