

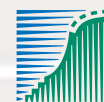
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Waterbirds around the world

A global overview of the conservation,
management and research of the
world's waterbird flyways

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landbouw, natuur en
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SCOTTISH EXECUTIVE



EDINBURGH, UK: THE STATIONERY OFFICE

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First published in 2006 by The Stationery Office Limited
71 Lothian Road, Edinburgh EH3 9AZ, UK.

Applications for reproduction should be made to Scottish Natural Heritage,
Great Glen House, Leachkin Road, Inverness IV3 8NW, UK.

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 0 11 497333 4

Recommended citation:

Boere, G.C., Galbraith, C.A. & Stroud, D.A. (eds). 2006.
Waterbirds around the world. The Stationery Office, Edinburgh, UK. 960 pp.

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Elucidating the movements of migratory birds through the combined use of stable isotope 'signatures' and DNA markers

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Coiffait, L., Bevan, R., Redfern, C., Newton, J. & Wolff, K. 2006. Elucidating the movements of migratory birds through the combined use of stable isotope 'signatures' and DNA markers. *Waterbirds around the world*. Eds. G.C. Boere, C.A. Galbraith & D.A. Stroud. The Stationery Office, Edinburgh, UK. pp. 506-507.

This paper presents the preliminary results of a study using a combination of stable isotope 'signatures' and DNA markers to establish the migratory patterns of Redwing *Turdus iliacus* passing through Wales and England. The approach is of application to waterbirds and is of significance in the light of the increasing use of these techniques to elucidate the breeding or wintering areas of waterbird species, especially those which are highly threatened.

For many birds, migration is a fundamental aspect of their life history, and knowledge of the links between breeding, wintering and intermediate stopover sites is crucial for determining at which points in the annual cycle avian populations are most vulnerable. Whilst there is a considerable amount of information available concerning migration at the species level, far less is known at the population and intra-population level (Bairlein 2001). Groups of birds may be spatially distinct at some stages of the annual cycle, but the extent to which individuals from the same breeding area migrate to the same wintering area and vice versa is largely unresolved.

The conventional technique of ringing birds has limited potential for population level studies because it relies on recapturing individuals, and the probability of this is extremely low. A novel approach combining the use of stable isotope ratios of carbon, nitrogen and hydrogen with multiple DNA markers has therefore been used to examine the migratory movements of the Redwing *Turdus iliacus* and the European Blackbird *T. merula*. The Redwing has a breeding range that covers a vast area from Iceland to eastern Siberia, while a second race *T. i. coburni* nests in Iceland and the Faeroes and differs markedly from nominate *T. i. iliacus* in several aspects of its migration (Milwright 2002). Blackbirds are partial migrants, with a highly complex pattern of movements; their breeding range spans most of Europe (Chamberlain & Main 2002). In this preliminary study, body feathers were sampled from populations of *T. i. iliacus* and *T. i. coburni* (Table 1).

Feathers were washed in 0.25M NaOH followed by deionised water, and dried at 50° C. Carbon, nitrogen and

hydrogen isotope ratios were analysed via continuous-flow stable isotope mass spectrometry (CF-IRMS) capable of measuring $\delta^{15}\text{N}$, $\delta^{13}\text{C}$ and δD to $\pm 0.2\text{‰}$, 0.1‰ and $\pm 2\text{‰}$ respectively. A Multivariate Analysis of Variance (MANOVA) was used to investigate whether mean stable isotope ratios of $\delta^{15}\text{N}$, $\delta^{13}\text{C}$ and δD differed between birds of different origins. Posthoc testing (Tukey's) was carried out to determine where statistical differences occurred.

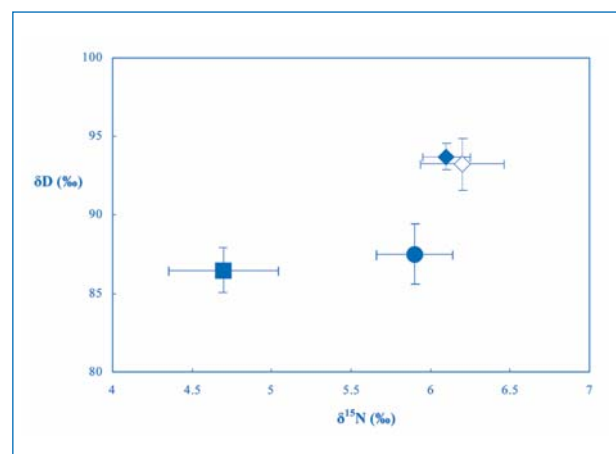


Fig. 1. Mean feather, $\delta^{15}\text{N}$ and δD values of adult and first-year Redwings *T. iliacus* collected from three different populations overwintering in the UK, and a single Icelandic breeding population. Values are reported in parts per thousand (‰). Each point represents the mean (\pm SE) of all birds sampled at that location. Bardsey birds are represented by a diamond (◆ autumn; ◇ spring), Farne Island birds by a circle (●) and Icelandic birds by a square (■).

The two Bardsey populations did not differ significantly for any of the three isotope ratios ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$; Fig. 1) ($F_{1,130} = 1.041$; $P = 0.377$), and are therefore discussed as a single population hereafter. There was a highly significant difference in both δD and $\delta^{15}\text{N}$ between birds of Icelandic origin and the Bardsey birds

Table 1. Sampling location and size of four populations of Redwing used to investigate the relationship between feather $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and δD values and breeding origin.

Species	Sample site	Breeding origin	n	Collection date
<i>T. i. iliacus</i>	Bardsey, North Wales, UK	Unknown; presumed Continental	111	Oct 1995
<i>T. i. iliacus</i>	Bardsey, North Wales, UK	Unknown; presumed Continental	21	Mar 1998
<i>T. i. iliacus</i>	Farne Islands, Northumberland, UK	Unknown; presumed Continental	10	Nov 2004
<i>T. i. coburni</i>	Iceland	Iceland	20	Sep 2004

($F_{1,150} > 9.09$; $P \leq 0.003$). ^{13}C did not differ significantly between these two populations. Isotope ratios ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and δD) from the Farne Island birds were not significantly different from either the Icelandic or the Bardsey populations, perhaps due to a lack of statistical power.

The highly significant differences in δD and $\delta^{15}\text{N}$ between the Bardsey Redwings and the Icelandic birds indicate that this method offers real potential for discriminating between redwings of different breeding origin. The lack of significant difference between the autumn- and spring-sampled Bardsey birds may be expected since, in both cases, the feather isotopic ratios reflect those of the breeding origins. The breeding range of Redwing is known to extend from Iceland to eastern Siberia (Milwright 2002) and the wide range of δD values birds indicates that they have originated from numerous sites within its range. However, during the course of migration, these birds have subsequently converged into a relatively small area, and whilst the destination of the autumn birds and origin of the spring birds cannot be established, one can speculate that the former were heading for southwest Britain/Ireland, while the latter had overwintered there (Milwright 2002).

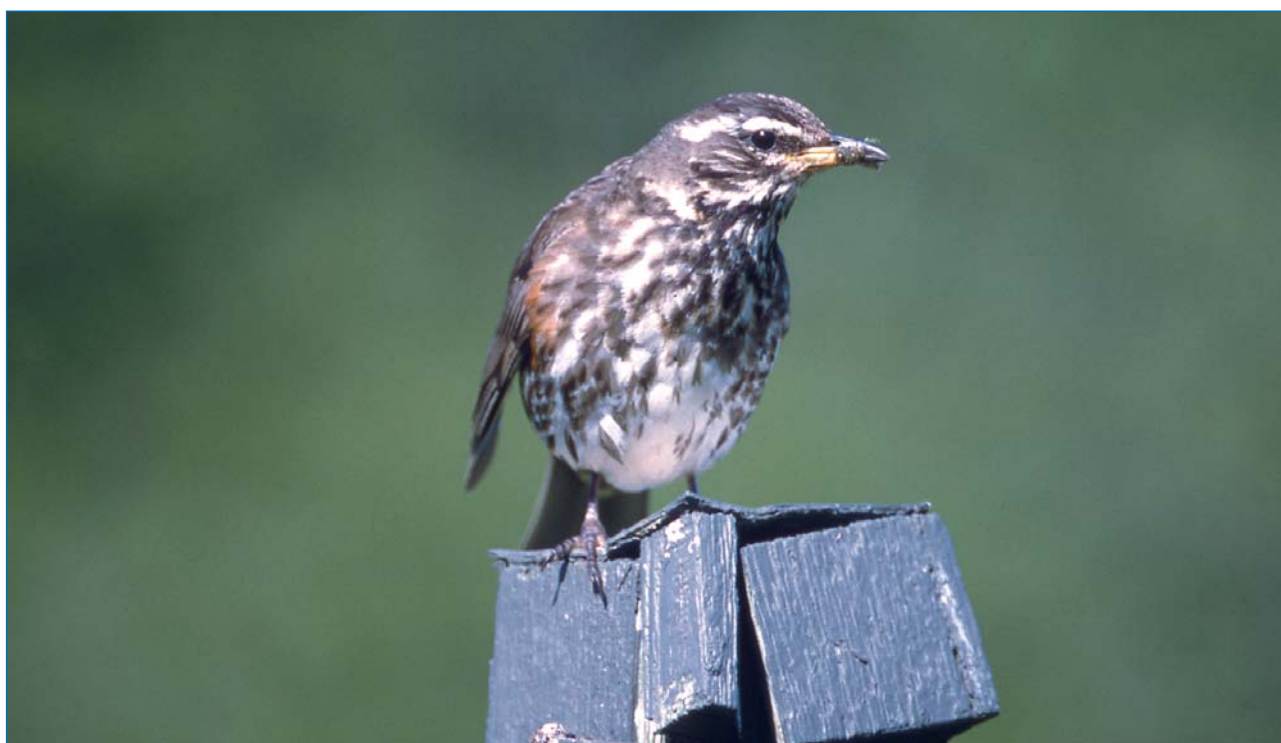
A recent study by Hobson *et al.* (2004) indicates that hydrogen isotope ratios in Europe vary with latitude, generally decreasing (i.e. becoming more negative) on a south to north geographical gradient, but that there is little discrimination between the east and west. The next stage of the project is to sample Redwings at representative breeding sites (of different latitudes), to determine whether isotopic ratios of feathers from known breeding sites can be correlated with those collected at overwintering sites. Combining several genetic markers with the stable isotope 'signatures' and biometric data (e.g. Clegg *et al.* 2003, Wennerberg 2001) may reveal population- or regionally-specific groupings and migratory movements as has recently been done with Wilson's Warbler *Wilsonia pusilla* (Clegg *et al.* 2003).

ACKNOWLEDGEMENTS

We thank Tómas Gunnarsson, The Natural History Society of Northumbria and the National Trust Farne Islands' wardens for their assistance with collecting samples for this project. We thank NERC for providing funding for the project.

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Icelandic Redwing *Turdus iliacus coburni*. Photo: Alistair Crowle.