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# Stable-hydrogen isotope analyses suggest natural vagrancy of Baikal Teal to Britain

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*ABSTRACT* Stable-hydrogen isotope signatures of feathers from a first-winter Baikal Teal *Anas formosa* collected in Essex in January 1906 reveal marked differences between juvenile feathers, grown on the breeding grounds, and post-juvenile feathers, grown on the wintering grounds. The natal-area signatures were consistent with a Siberian origin and the wintering-area signatures were consistent with a west European origin. This suggests that the Essex bird originated within the normal breeding range of Baikal Teal and that its occurrence in Britain was the result of natural vagrancy.

## Introduction

The analysis of stable-isotope ratios is being increasingly applied in many aspects of avian ecology, for example as a means of dietary assessment and particularly as spatial markers for migratory studies (Hobson *et al*. 2004; Inger & Bearhop 2008). For example, large-scale differences in oxygen and hydrogen isotopes exist as a function of precipitation patterns, and while these are not able to pinpoint specific locations, they can be used to characterise different regions. The fact that these isotopic signatures or 'landscapes' are reflected in growing tissues in a predictable manner is central to the application of these techniques in the study of migratory behaviour.

The analysis of stable-hydrogen isotope ratios in the feathers of a first-winter Baikal Teal *Anas formosa* shot in Denmark in November 2005 provided compelling evidence for natural vagrancy of this species to western Europe (Fox *et al*. 2007). There were two key elements to this analysis. Firstly, a strong gradient in hydrogen isotopes across continental Eurasia means that feathers grown in western Europe are isotopically distinct from feathers grown in Siberia (Hobson *et al*. 2004; fig. 1). Secondly, as a first-winter bird, the Danish Baikal Teal had a mixture of juvenile feathers grown on the breeding grounds and feathers grown during the post-juvenile moult, on the wintering grounds. Consequently, when it was shown that the Danish bird had juvenile feathers with a strongly continental signature and post-juvenile feathers with a signature more typical of the near-coastal conditions in much of western Europe, the most likely explanation was that this bird originated from the natural range of the Baikal Teal.

In this paper, we report on the analysis of stable-hydrogen isotope ratios in the feathers of a first-winter male Baikal Teal shot in Essex in January 1906. If this bird had hatched within the native range of Baikal Teal, it would be expected that feathers of natal origin would exhibit a strongly continental signature, whereas post-juvenile feathers moulted on the wintering grounds should have signatures consistent with western Europe.

## Stable-isotope analysis

A supposed hybrid duck collected from Marsh Farm Decoy, near Maldon, Essex, in January 1906, transpired to be a Baikal Teal moulting into adult plumage (Harting 1906; Hubbard 1907; Glegg 1929). The timing of the moult of the Essex specimen, as well as the rounded scapulars and tertials, which are quite different from those of an adult, confirmed that this bird was a first-winter (Harrop & McGowan 2009). The specimen is held in Chelmsford Museum (specimen no. CHMER E9108).

Sections were taken from feathers grown on the breeding grounds (left and right primary coverts as well as a primary flight feather) and

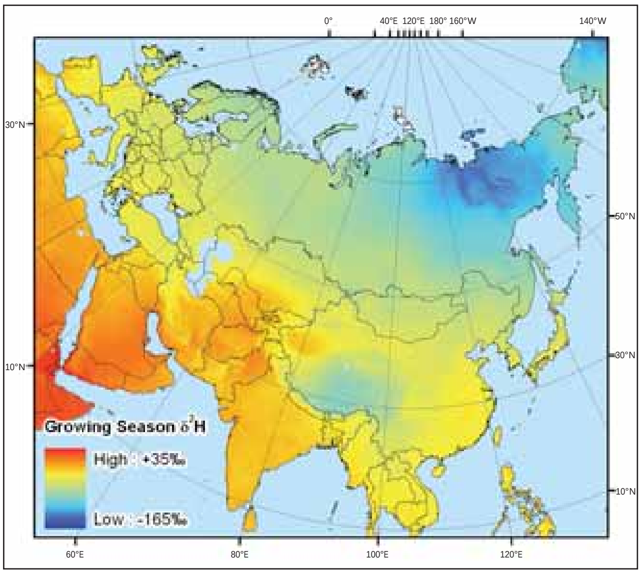


**Fig. 1.** Mean growing-season δ²H values of modern precipitation. This map reveals that areas with extremely low δ²H signatures are located in northern and eastern Siberia, while the coastal regions of western Europe have comparatively high signatures. These patterns result from the prevailing weather patterns that transport atmospheric moisture from west to east across the Eurasian continent, and have been relatively stable for millennia or longer. As a result, even though the Essex Baikal Teal *Anas formosa* was shot more than 100 years ago, the modern precipitation patterns provide a strong indication of the large isotopic differences expected between feathers grown in the early twentieth century in western Europe and eastern Siberia.

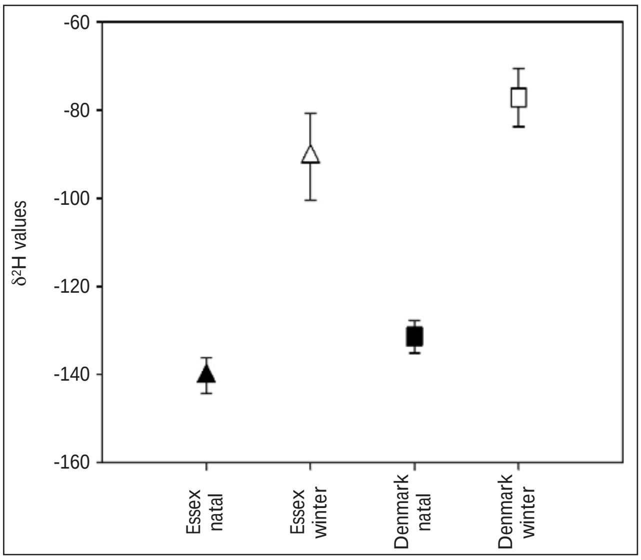


**Fig. 2.** δ²H values from Baikal Teal *Anas formosa* feathers. Symbols show the mean (± 95% confidence intervals) for feathers assumed to have been grown in natal areas (primaries, primary coverts and tail feathers) and feathers assumed to have been grown during the late autumn or winter post-juvenile moult (undertail-covert, breast, tertial and head feathers). Data are from two specimens, a first-winter male in Essex in 1906 and a first-winter in Denmark in 2005 (the latter from Fox *et al.* 2007).

feathers grown during the post-juvenile moult in late autumn or early winter (single breast, undertail-covert, tertial and head feathers). Samples were washed with a dilute detergent followed by a 2:1 chloroform:methanol solvent (Paritte & Kelly 2009). Once dried, the samples were homogenised and approximately 0.1 mg of material placed into a silver capsule and analysed for δ²H (the ratio of ²H/¹H, expressed as δ²H). Hydrogen-isotope analysis was conducted by continuous-flow isotope ratio mass spectrometry, with a reductive elemental analyser (TC/EA: Thermo Fisher Scientific, Bremen) interfaced with a Thermo Delta V isotope ratio mass spectrometer. The scientific instrumentation differed slightly from that used by Fox *et al.* (2007) but both studies were carried out in the same laboratory, with all data being normalised by a comparative equilibration technique (Wassenaar & Hobson 2003), thus ensuring comparability of the techniques.

## Results

Hydrogen-isotope ratios of the Essex 1906 specimen are presented in table 1, and also plotted in fig. 2 alongside values for the Danish 2005 specimen. Differences between the average natal signature and average winter signature (of the Essex bird) are statistically significant (as shown by the non-overlapping 95% confidence intervals). The very low hydrogen-isotope values for feathers grown on the breeding grounds are consistent with a strongly continental signature and values for feathers grown on the wintering grounds are consistent with near-coast signatures of western Europe (fig. 1).

**Table 1.** $\delta^2H$ values from the specimen of a first-winter male Baikal Teal *Anas formosa* shot in Essex in January 1906. Values are grouped into feather tracts grown on the natal grounds and those grown on the wintering grounds.

| When grown | Feather | Amount (mg) | $\delta^2H$ |
|---|---|---|---|
| Natal | Primary covert (right) | 0.107 | -140.96 |
| Natal | Primary covert (left) | 0.172 | -143.49 |
| Natal | Primary feather | 0.121 | -136.45 |
| Winter | Undertail-covert | 0.157 | -77.35 |
| Winter | Breast feather | 0.117 | -96.70 |
| Winter | Tertial feather | 0.094 | -88.30 |
| Winter | Head feather | 0.085 | -99.71 |

## Discussion

Our analysis provides compelling evidence that the Essex bird was raised within the natural breeding range of the Baikal Teal. The very low hydrogen-isotope values for the feathers grown on the breeding grounds are most consistent with stable-isotope ratios in parts of Siberia and central Asia (fig. 1), whereas the feathers replaced during post-juvenile moult have a signature characteristic of near-coastal regions of western Europe. Since Baikal Teals breed in northern and eastern Siberia, east to Kamchatka, the results are consistent with a bird raised within the native range, and migrating south and west to winter in the UK. These findings do not *prove* natural vagrancy, however. Firstly, it is possible that this bird was reared in captivity in western Europe on a diet similar to that available to wild birds in Siberia. Although this possibility cannot be excluded, it seems highly improbable (Fox *et al*. 2007). Secondly, the isotope values do not tell us how this bird travelled between Siberia and Essex; it is possible that it was either raised in captivity in Siberia or captured live before being transported to western Europe and subsequently escaping. Nonetheless, given that this species was still relatively infrequent as a breeding bird in captivity in 1905 (Harrop & McGowan 2009), dispersal to the west of the known range seems a more parsimonious explanation.

The results of our analysis are remarkably similar to those of the first-winter Baikal Teal shot in Denmark in November 2005 (fig. 1). Consequently, they suggest that the Danish record is not unique and it seems likely that Baikal Teals may have occurred in western Europe in a wild state on a number of occasions.

In summary, while stable-isotope evidence does not unequivocally prove that the Essex 1906 Baikal Teal occurred as a natural vagrant in Britain, the most likely explanation is that it occurred here in a wild state. This analysis confirms that stable-isotope analysis can be a useful tool in studying avian migration, particularly between regions with strikingly different isotopic landscapes. Nevertheless, it represents only one strand of evidence and should be used carefully, in conjunction with other available clues, to investigate the provenance of vagrant birds.

### Acknowledgments

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