Isotope forensic analysis does not support vagrancy for a Marbled Duck shot in Essex

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Abstract Analysis of the stable-hydrogen isotope content (δD) of feathers taken from a first-winter Marbled Duck *Marmaronetta angustirostris* shot in Essex on 1st September 2007 showed little difference between juvenile feathers grown at the natal site and those grown during the post-juvenile moult. The δD values of both groups of feather were similar to those expected if the bird had grown feathers in coastal areas of northern Europe, but differed significantly from those in feathers from known wild individuals taken from the species' nearest breeding areas, in Spain. These results suggest that the bird originated from outside of the normal breeding range of the species and was most likely to have been of captive origin.

The stable-hydrogen isotope ratio (D/H or $^{2}H/^{1}H$, conventionally expressed as δD) in bird feathers correlates strongly (through local diet) with that of weighted average precipitation in the areas where the feathers were grown (Hobson & Wassenaar 1997; Hobson 2008). Deuterium in precipitation tends to be depleted with increasing distance from the oceans, which are the source of atmospheric recharge moisture, and with latitude and altitude, resulting in distinctive geographical gradients within Europe (Hobson *et al.* 2004; Bowen *et al.* 2005; Votier *et al.* 2009). Because hydrogen in consumer tissues can ultimately be traced to environmental waters driving food webs, the pattern of δD in weighted average annual (or growing-season) precipitation can be used to help identify the isotopic environment in which a bird has grown specific feathers. In turn, this can assist in establishing geographical relationships between the areas used by an individual throughout the year. In the case of first-year birds that retain some original (juvenile) feathers, this can contribute to defining the general geographical area in which the bird was fledged.

This approach was used to provide evidence that a first-winter Baikal Teal *Anas formosa* shot in Denmark in November 2005 was a genuine vagrant to Europe by virtue of the substantial isotopic contrast between juvenile feathers (showing stable-hydrogen isotope characteristics typical of Siberia) and first-winter feathers (that were more typical of an oceanic, western European type environment) on the same bird (Fox *et al.* 2007). An analysis of feathers from a Baikal Teal specimen collected in Essex in January 1906 showed very similar patterns, also consistent with this being a genuine vagrant from the normal Russian breeding area (Votier *et al.* 2009).

Here, we apply the same technique to investigate the potential origin of a first-winter Marbled Duck *Marmaronetta angustirostris* shot at Fingringhoe Marshes, near Colchester in Essex (51°51'N 00°57'E), on 1st

September 2007. The Marbled Duck remains in Category D of the British List because there is reasonable doubt that the species has ever occurred in the wild (Dudley *et al.* 2006). Analysing feather stable isotopes from the specimen could provide evidence to suggest whether this bird was hatched in the wild and therefore met the criterion for inclusion on the British List. In this study, we analysed new-grown feather material from the shot bird to see if the results matched with those expected from British origins, compared with older (juvenile) feathers grown in natal areas. We predicted that, if the bird was a genuine wild vagrant, these two feather tracts would show contrasting δD values and that the older feathers would show higher (i.e. more positive) δD values more typical of the species' Mediterranean and North African breeding range.

Methods

Vane sections were taken from new-grown scapulars and breast feathers of the Essex Marbled Duck, as well as old (juvenile) tertial and wing-covert (greater and median) feathers. Sections were also taken from breast feathers removed from three apparently wild Marbled Ducks from Spain: (i) adult female, recovered dead at Brazo del Este, Marismas del Guadalquivir, Sevilla (37°05'N 06°01'W) on 4th August 1999; (ii) juvenile unsexed, probably hatched locally and recovered dead at El Hondo, Alicante (38°11'N 00°45'W) on 3rd July 2001; and (iii) an adult (unsexed) taken into the recovery centre at El Hondo on 27th July 2008 but that died the next day. Prior to isotopic analysis, feather material was cleaned with 2:1 chloroform:methanol solvent mixture to remove surface contaminants and oils. Cleaned feather tissues were then analysed for δD using the comparative equilibrium methodology described in Hobson *et al.* (2004). Stable-isotope ratios were expressed in ‰ deviation from the VSMOW-SLAP scale with a reproducibility of within ±3.5‰.

Results

Values of feather δD from the Essex Marbled Duck and from the three Spanish birds are shown in table 1 and fig. 1. Differences between the mean δD values from feathers taken from the Essex bird and those of the Spanish birds were statistically significant (as shown by non-overlapping 95% confidence intervals). The relatively depleted values for deuterium in the feathers of the Essex bird more closely resembled similar values in the feathers of other dabbling duck species reported in the literature for coastal western Europe, for example Mallard *A. platyrhynchos* from France (Hobson *et al.* 2004) and Baikal Teal with feathers known to have been grown in Denmark (Fox *et al.* 2007).

Discussion

Isotopic analysis of the feathers from the Essex Marbled Duck support the hypothesis that it was raised in captivity somewhere in coastal areas of northern Europe rather than in the wild in Spain or elsewhere in the Mediterranean, the nearest areas to Essex in which the species breeds naturally. There was no marked isotopic difference between the

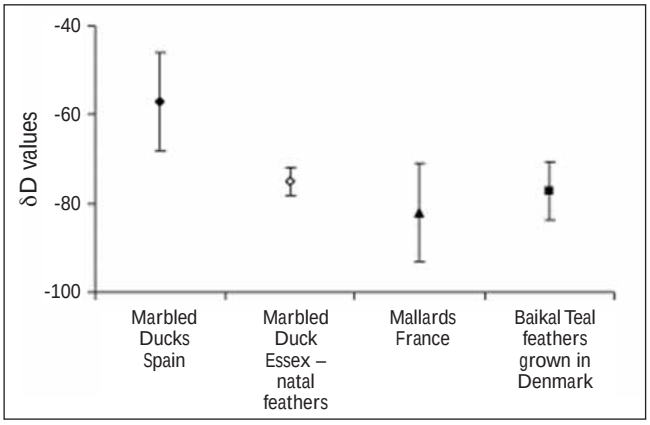

Fig. 1. δD values from Marbled Duck *Marmaronetta angustirostris*, Mallard *Anas platyrhynchos* and Baikal Teal *A. formosa* feathers known to have been grown in Europe. Values represent means (±95% confidence intervals); in the case of Marbled Ducks in Spain the mean values from breast feathers from three different individuals, and in the case of the Essex Marbled Duck the mean of two values from juvenile plumage (tertial and wing-coverts). Data are also shown from Mallard feathers from France (Hobson *et al.* 2004) and Baikal Teal feathers from Denmark (Fox *et al.* 2007).

recently grown (first-winter) feathers, which were expected to reflect the environment where the bird was shot, and the older (juvenile) feathers that would have been grown prior to fledging on the breeding areas, suggesting that these areas were one and the same. Furthermore, the δD values of these feathers were similar to those from feathers grown by Baikal Teals in Denmark and Mallards in France, suggesting a more northerly origin for the fledging and moulting sites of this bird. Comparisons with feathers from three different Spanish Marbled Ducks showed a mean δD value significantly greater than the Essex bird (by about 20‰).

As was the case with the earlier studies (Fox *et al.* 2007; Votier *et al.* 2009), such isotopic analyses cannot prove *definitively* that the Essex Marbled Duck was hatched and reared in captivity in northern Europe. It is possible that there are Marbled Duck breeding areas elsewhere, where the isotopic signatures in food webs are more similar to those in northern coastal Europe, but this seems unlikely given that the deuterium precipitation base maps (e.g. Bowen *et al.* 2005, Votier *et al.* 2009) show similarly low, if not lower, mean annual precipitation δD values farther east in the breeding range of the species compared with those of Spain and North Africa. The Marbled Duck is also reasonably numerous in captivity, so it seems more likely that this was a bird that was raised in a collection and which escaped before being shot in the wild. This result supports the usefulness of using stable-isotope analysis of feathers for its contribution in confirming the origins of rare species (wild or captive), especially where feather or other material can be obtained without causing the death of the bird, but reiterates the need for confirmatory evidence from other sources. This example is less clear-cut than the earlier analyses of

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278. Marbled Duck *Marmaronetta angustirostris*, Spain, April 2005.

Table 1. δD values from feathers taken from a Marbled Duck *Marmaronetta angustirostris* specimen from Essex and three from Spain (see text for full details).

Location	Feather	Site where feather assumed grown	‰ δD
Essex	Old tertials, left wing	Natal site	-74.8
Essex	Old median and greater coverts, left wing	Natal site	-74.0
Essex	Apparently fresh breast feathers	Winter quarters	-70.9
Essex	Apparently fresh scapulars	Winter quarters	-76.5
(i) Marismas del Guadalquivir, Spain	Breast	Spain or North Africa	-57.7
(ii) El Hondo, Spain	Breast	Spain	-66.5
(iii) El Hondo, Spain	Breast	Spain or North Africa	-46.9

Baikal Teals, where the striking differences in feather deuterium expected between western Europe and continental Siberia were the basis for more marked differences in feather material (Fox *et al*. 2007; Votier *et al*. 2009). Nevertheless, our study suggests that the 2007 Essex Marbled Duck is unlikely to constitute the first demonstrable record of true vagrancy for this species to Britain.

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