

Utility of stable isotopes to delineate the origins of wintering European migratory raptors; the Marsh harrier *Circus aeruginosus*

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Quantifying connectivity between breeding and wintering locations has important ecological and conservation implications for migratory species. The knowledge of mixing between populations at their wintering grounds is essential to predict potential effect of global change on species' ranging behaviour. Until very recently, all technical approach to study migratory terrestrial animals has involved the use of passive and extrinsic markers such as bands and transmitters, respectively. However, recovery rates are very low for the vast majority of species, and size and weight of active markers make them limited to large sized species. Alternatively, other intrinsic markers such as stable isotopes does not require recapture and could provide information on origin overcoming mentioned limitations.

We investigated the usefulness of stable isotopes to delineate the breeding origin of European raptors wintering in Spain and to differentiate them from local populations, using the Marsh harrier as a model.

METHODS



Ring recoveries - We used data from years 1923-2008 on ring recoveries during winter (November-February) in Spain to investigate the main origin of European wintering birds.

Stable isotopes - We, then, analyzed the potential utility of stable isotopes for discriminating among breeding origins by analyzing the stable isotopes of Deuterium (H), Nitrogen (N) and Carbon (C) in feathers of Marsh Harriers grown or moulted at known breeding locations (**Fig. 1**).

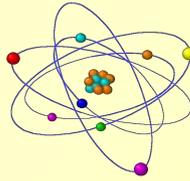


Figure 1. Breeding locations where feathers from Marsh Harriers were sampled.

RESULTS AND DISCUSSION

Analysis of ring recoveries ($n=54$) showed that winter population of Marsh harriers in Spain includes long distance migrants from Germany (41%), Sweden (18%), Netherlands (17%), Finland (9%), Denmark (4%), Belgium (4%), France (4%), Poland (2%) and Czech Republic (2%). Analyses of H, C and N stable isotopes revealed the existence of significant differences among migrant harriers with different breeding origin and between migrants and resident harriers (**Fig. 2, 3**). This result highlights the potential utility of stable isotopes techniques to delineate the breeding origin of wintering raptors and to differentiate them from local populations at their wintering grounds.

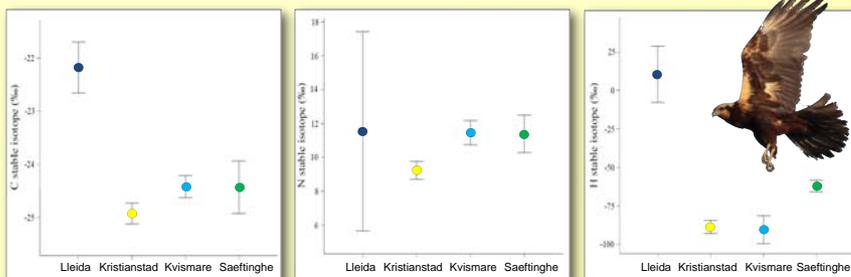


Figure 2. Differences in stable isotopes of C, N and H among breeding populations. Significant differences in C ($F_{2,36}=18.15$, $p<0.0001$), N ($F_{2,36}=6.07$, $p=0.002$) and H ($F_{2,36}=137.03$, $p<0.0001$) were found.

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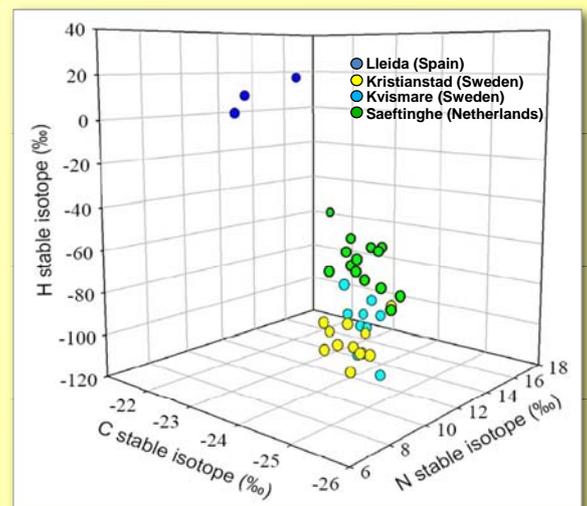


Figure 3. 3D-plot of C, N and H stable isotopes of harriers from 4 different European breeding populations.