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SYMP07: Applications of stable isotopes in avian ecology

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Natural variations in the stable isotope ratios of a number of elements (e.g. C, N, H, S, Sr) are being increasingly used by avian ecologists. The technique has allowed us gain insight into a number of ecological processes and phenomena where conventional approaches would either be impossible or at best extremely difficult. For example predictable fractionation of nitrogen isotopes has helped unravel relationships in foodwebs. Patterns of fractionation and unique isotopic signatures have enabled researchers to determine the behaviour and sources of contaminants and isotopic differences in protein sources have indicated the ways in which birds can differentially allocate resources to reproduction. Moreover since the isotopic signature of metabolically inert tissues such as feathers does not change over time, it has been possible to undertake paleodietary studies using museum specimens and to trace the breeding and wintering origins of migrants. This latter approach has sparked considerable interest among the ornithological community.

SYMP07-1 Stable isotopic insights into the decline of the rockhopper penguin

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Rockhopper penguin *Eudyptes chrysocome* is a keystone predator of sub-Antarctic waters, with a circumpolar population numbering millions of pairs. The species has undergone a dramatic and unexplained global decline since the early twentieth century. The temporal and spatial scale of the decline implies that there may have been an unfavourable change in ecological conditions at sea. We used stable isotopic measurements of museum skins and living birds from throughout the species' range, to assess changes in the species' ecology over the time-period of the population decrease. Temporal trends in isotope ratios differ between breeding sites, but changes in both carbon and nitrogen isotope ratios of rockhopper penguins over the last 150 years were evident. These changes indicate that the population decline has been associated with shifts in diet and in the ecology of the marine environment that the species occupies.

SYMP07-2 Stable isotope analysis of feathers to identify autumn stopover sites in northeast Africa: A preliminary investigation using three long distant migrants

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The potential use of stable nitrogen ($\delta^{15}N$), carbon ($\delta^{13}C$) and hydrogen (δD) isotope ratios in feathers of marsh warbler (*Acrocephalus palustris*), river warbler (*Locustila fluviatalis*) and whitethroat (*Sylvia communis*) was evaluated as a means to identify the location of autumn stopover sites in northeast Africa and the extent to which birds co-occur in isotopically similar stopover sites. Feather δD values were compared with regional precipitation δD maps. Feather stable N, C and D mean isotope values of marsh warbler and river warbler indicate that the two species occupy and grow their primary feathers in geographic locations with similar stable-isotopic values, in a relatively mesic environment and with a higher ratio of C3–C4 plants. From former studies, it is evident that during autumn stopover, river warblers moult their feathers in Ethiopia. It is therefore likely that marsh warbler like the river warbler stay in Ethiopia and/or in neighboring regions with similar foodweb stable isotope values. Based on the feather δD values and regional δD precipitation maps, this region should lie between southeast Sudan and southwest Ethiopia. However, without additional regional isotopic maps in Africa, and from the current isotopic data alone, more precise locations of the stopover sites still remains unclear. The relatively enriched $\delta^{15}N$ and $\delta^{13}C$ values of the whitethroat feathers compared with the two other species reflect the fact that whitethroats moult in relatively drier environments and/or with a higher ratio of C4–C3 plants. Overall, our preliminary isotope approach agrees with former studies and demonstrates great potential for the use of stable isotopes as a means of linking stopover locations and the extent to which birds co-occur in autumn stopover areas in northeast Africa.

SYMP07-3 Do seabirds compete for food? A tale of two species

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The Farne Islands lie off the NE coast of England and approximately 70,000 pairs of seabirds breed on the islands each year. Nearly all the seabird species present on the island are dependent on the same prey species: the sandeel (*Ammodytes* sp.). As such, there should be both intra and interspecific competition for this prey. However, a more stable evolutionary strategy would entail some degree of niche separation between the species.

We used stable isotopes to investigate the trophic status of two known sandeel consumers: the Atlantic puffin (*Fratercula artica*) and the Arctic tern (*Sterna paradisaea*) and expected that these data would provide us with some insight into the degree of dietary segregation of the two species.

Feather samples of birds were obtained from natural casualties, while sandeels were obtained from dedicated trawls. The $\delta^{15}N$ of the sandeels was 11.29 ± 0.27 ‰. The $\delta^{15}N$ of the birds were 14.61 ± 0.14 ‰ and 15.61 ± 0.10 ‰ for the puffin and the tern chicks respectively. Puffin primary feathers were further tested to investigate any changes in trophic position associated with age. Prior to fledging the $\delta^{15}N$ of the puffins was 16.24 ± 0.05 ‰ indicating that the older puffins held a slightly higher trophic position than the younger birds.

These data suggest that puffins are at a higher trophic level than the terns despite feeding on the same prey species. This could be brought about by the puffins feeding on larger sandeels than the terns and thus reduce intra-specific competition.

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SYMP07-4 Tracing movement of double-crested cormorant between estuarine, riverine, and upland lakes with stable isotopes

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As in many other areas, populations of double-crested cormorant (*Phalacrocorax auritus*) have dramatically increased in the last decade in the marine and freshwater sections of the St-Lawrence river (Canada/USA). This expansion is accompanied by large scale movements and potential colonizations of new habitats, including less productive upland lakes on the Canadian Shield. We used carbon and nitrogen stable isotope ratios of primary feathers and blood of juveniles, sub-adults and adults to investigate these patterns of movement and resource exploitation. C and N isotopes could not clearly distinguish juveniles captured in the estuary from those collected in the upstream freshwater sections of the river. However, juveniles originating from the Great Lakes could be distinguished from those of the freshwater section of the St. Lawrence, and these characteristic isotopic signatures could be useful in the determination of the proportion of sub-adults and adults coming from the Great Lakes during the massive invasions occurring along the St. Lawrence at the end of the summer. Moreover, large differences in both C and N ratios detected among individual primary feathers of adults collected from an upland lake indicated traceable long-term exploitation of these less productive habitats. However, juveniles originating from the Great Lakes could be distinguished from those of the freshwater section of the St. Lawrence, and these characteristic isotopic signatures could be useful in the determination of the proportion of sub-adults and adults coming from the Great Lakes during the massive invasions occurring along the St. Lawrence at the end of the summer.

SYMP07-5 Stable isotopes reveal intraspecific variation in great skua *Catharacta skua* diets

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To investigate temporal and spatial dietary variation, we measured the carbon and nitrogen stable isotope ratios of flight feathers and blood from adult great skuas and from blood and newly grown feathers of chicks. Both $d^{15}N$ and $d^{13}C$ signatures of blood were more variable in adults than in chicks suggesting that adults fed on a wider variety of prey during the breeding season than they fed to chicks. In great skuas the moult starts shortly after the breeding season with the inner-most primary (P1) and is completed in the wintering area with the outermost primaries (P9–10) before re-migration to the breeding colony. By measuring the carbon and nitrogen stable isotope ratios of P1 and P9 we can consider differences in diet at the time of feather growth. We found significant differences in both $\delta^{15}N$ and $\delta^{13}C$ between P1 and P9 indicating that great skuas feed on isotopically distinct prey at the breeding and wintering grounds. This information combined with conventional

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dietary analyses may reveal the importance of discards of demersal fish from North Sea fisheries to the diet and reproductive success.

SYMP07-6 Arctic breeding birds and their reliance on nutrients for egg production brought in from afar

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Birds produce their eggs from recently ingested nutrients (‚income breeders') or from body stores (‚capital breeders'). Since arctic summers are short, ecologists have long thought that arctic migrants need to bring the nutrients for egg production from afar, to be able to start breeding immediately upon arrival. For many arctic breeding birds the wintering grounds should therefore not only provide the essential nutrients for migratory preparation but also for breeding. However, using carbon stable isotope ratios of eggs, natal downs, and juvenile and adult feathers from ten wader species from 12 localities in Northeast Greenland and Arctic Canada, it was demonstrated that their eggs are produced from nutrients originating from tundra habitats. Thus, for these waders the fitness costs of transporting extra body stores to the breeding grounds outweigh the potential benefits. However, the capital strategy may still be used by large species of arctic breeding migrants, such as geese. It is likely that larger species need relatively smaller body stores for egg production. Also, the larger the species, the longer it needs to complete breeding, constrained by a fixed window opportunity. Indeed, tentative data on Lesser Snow Geese using the same methodology of carbon stable isotope ratios support the idea that, with respect to egg production, these larger species are capital rather than income breeders. Thus, the many arctic breeding waders inhabiting estuaries and wetlands around the globe, only use these areas for migratory preparation whereas the larger waterfowl may be storing additional fuel there for breeding.

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