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HIGHLIGHTED STUDENT RESEARCH

Assessing seasonal changes in animal diets with stable-isotope analysis of amino acids: a migratory boreal songbird switches diet over its annual cycle

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Abstract
Tools to study seasonal changes in animal diets are needed to address a wide range of ecological questions. This is especially true of migratory animals that experience distinct environments where diets may be substantially different. However, tracking diets of individuals that move vast distances has proven difficult. Compound-specific isotope analysis has emerged as a valuable tool to study diets but has been little used to study dietary changes of migratory animals. Using this technique, we quantify seasonal variation in the annual diet of a migratory songbird (gray-cheeked thrush, *Catharus minimus*) and test the hypothesis that migrants change their diet in response to the energetic requirements of different periods of the annual cycle. By measuring δ^{13}C and δ^{15}N values of amino acids from feathers grown on the breeding grounds, blood formed during migration and claw grown on the wintering grounds, we found that migration is associated with greater consumption of fruit, compared to the breeding or wintering periods. This was confirmed by the lower trophic position of blood compared to feather and claw, by a decrease in the δ^{15}N value of the source amino acid phenylalanine in blood as a function of days of stopover, and by the positive correlation between δ^{15}N and δ^{13}C values of phenylalanine in blood, and not in feather or claw. This study illustrates how isotopic analysis of amino acids can contribute to understand food webs, seasonal dietary changes and metabolic routing of nutrients in migratory animals.

Keywords Amino acids · Compound specific · δ^{13}C and δ^{15}N · Dietary routing · Food web · Gray-cheeked thrush · Migration · Trophic position

Introduction

The ability of individuals to survive and reproduce ultimately depends on their capacity to obtain energy from food (Hutto 1990). The study of diet is, therefore, central to our understanding of many aspects of animal biology (Rosenberg and Cooper 1990), such as habitat use and selection (Rosenberg 1990), breeding success (Poulin et al. 1992), population dynamics (Newton 2004), niche breadth (Bearhop et al. 2004), physiology (Levey and Martínez del Rio 2001; Schaefer et al. 2003), and migration (Levey and Stiles 1992; Blanquart and Gandon 2014). Despite this importance, many aspects of foraging ecology remain elusive because of challenges associated with monitoring populations over wide ranges and time spans. Migratory organisms, such as many species of birds, are especially challenging for researchers because they may not only switch diets throughout their annual cycles (Bairlein 1990; Podlesak et al. 2005), but they may do so in distant and remote geographical regions. Migrants are also dependent on food to fulfill the demands of their long-distance endurance movements (Bairlein 1990; Price 2010), which implies that the success of migration may be jeopardized if food resources are insufficient to meet energetic requirements (Bairlein and Gwinner 1994; McWilliams et al. 2004; Newton 2004). Efficient tools to study seasonal

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We show for the first time how isotopic analysis of amino acids from feathers, blood and claws, obtained at a single location may be used to infer the annual changes in diet of a migratory songbird.

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