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COMPARISON OF NITROGEN ISOTOPE RATIOS IN FEATHERS FROM SEVEN SPECIES OF COLORADO BREEDING BIRDS

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The natural abundance of nitrogen isotopes in biomass has been useful in demonstrating trophic relationships of organisms in aquatic food webs (Hamilton and Lewis 1992, Hamilton et al. 1992). The technique is capable of establishing trophic positions of organisms that can feed on a variety of food sources and whose feeding behavior cannot be observed easily. The stable isotope technique is based on increase in the ^{15}N content of biomass with each trophic transfer. The ^{15}N content of a sample is often expressed as standard δ notation (parts per thousand deviation in the ratio of ^{15}N and ^{14}N in a sample from the ratio of ^{15}N and ^{14}N in air; Peterson and Fry 1987). It is usually assumed that there is a 2.6–3.4 part per mil increase in ^{15}N content between successive trophic levels (DeNiro and Epstein 1981, Minagawa and Wada 1984, Owens 1987) and that trophic fractionation can range as high as 5 parts per mil (Michener and Schell 1994). The exact value for isotopic fractionation associated with an increase in trophic level may vary according to an animal's age, body size, metabolic rate, and the amount of protein in the animal's diet (McCutchan 1999).

Avian ecologists have used stable isotopes to evaluate trophic relationships in songbirds (Hobson 1999) and seabirds (Hobson and Montevecchi 1991, Thompson et al. 1999). However, isotope data on songbirds are relatively lacking compared to other taxa (Kelly 2000). Results from these studies and other studies look promising, although the potential of stable isotopes has not yet been explored fully. Isotopic composition values for primary consumers (such as granivores) are particularly scarce in the literature.

We conducted a preliminary study to investigate whether there is a relationship between trophic level and nitrogen isotopes in feathers from breeding birds of Colorado. We classified birds into 3 broad feeding groups: granivores (birds primarily eating seeds), insectivores (birds primarily eating insects), and raptors (birds eating primarily small mammals and birds). We used this approach because the actual trophic level of birds is very difficult to determine. Feeding classifications for selected species in this study were obtained from Kingery (1998). We hypothesized that the mean $\delta^{15}N$ of feathers from granivores would be significantly lower than those for insectivores and raptors (which represented birds in higher trophic levels).

Tail feathers of adult specimens were obtained from the museum at the University of Colorado, Boulder. In addition, tail feathers were also collected from a nestling that lived in a ponderosa pine (*Pinus ponderosa*) forest located in Boulder County, Colorado. Collection locations for museum specimens extended throughout Colorado, but most specimens were from Boulder County. In our study we assumed that the tail feathers were grown on the breeding grounds in Colorado and that the isotopic ratios in the feathers reflected the diet at the time the feathers were grown. Feathers were freeze-dried and stored until analysis in a desiccator. Samples were placed in tin cups and combusted in a Fisons elemental analyzer interfaced with a Finnigan dual inlet mass spectrometer. For a more detailed description of methodology, see Hamilton and Lewis (1992). The standard error of the mean for 3 replicates was <0.4 parts per mil. Both EDTA and glycine were used as standards.

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Table 1. Nitrogen isotope ratios of bird feathers sampled from museum and field specimens obtained in Colorado. Locations given are counties in Colorado.

Species	$\delta^{15}N$	Feeding group	Type	Location
Dark-eyed Junco (*Junco hymalis caniceps*)	6.4	Granivore	Museum	Boulder
	5.7		Museum	Boulder
	6.3		Museum	Boulder
Lesser Goldfinch (*Carduelis psaltria*)	4.7	Granivore	Museum	Montrose
	4.6		Museum	El Paso
Plumbeous Vireo (*Vireo plumbeus*)	6.3	Insectivore	Museum	Douglas
	5.8		Museum	Rio Blanco
	6.1		Museum	Rio Blanco
Virginia's Warbler (*Vermivora virginiae*)	5.2	Insectivore	Museum	El Paso
	6.1		Museum	El Paso
	6.3		Museum	El Paso
Western Wood-pewee (*Contopus sordidulus*)	9.4	Insectivore	Museum	El Paso
	7.6		Field	Boulder
Sharp-shinned Hawk (*Accipiter striatus*)	7.2	Raptor	Museum	Boulder
	7.6		Museum	Boulder
	7.3		Museum	Boulder
Great-horned Owl (*Bubo virginianus*)	6.9	Raptor	Museum	Boulder
	6.9		Museum	Boulder
	8.1		Museum	Mineral

Table 1 summarizes our results. As hypothesized, feathers from granivores had a lower mean $\delta^{15}N$ (5.5; $s_{\bar{x}}$ 0.4) than feathers from feeding groups that represented higher trophic levels. A 1-tailed t test indicated that the mean $\delta^{15}N$ of feathers from insectivores (6.6; $s_{\bar{x}}$ 0.5) was significantly higher than from granivores ($P = 0.05$). In addition, a 1-tailed t test showed that the mean $\delta^{15}N$ of feathers taken from raptors (7.3; $s_{\bar{x}}$ 0.7) was significantly higher than the mean $\delta^{15}N$ of feathers from granivores ($P = 0.01$).

Results from this study support a growing body of literature showing that the use of ^{15}N natural abundance in feathers has the potential to discriminate among different trophic levels in birds. A possible source of error in our study could have been the different locations of our specimens and the assumption that feathers were grown on the breeding grounds. Previous work has shown that isotope signatures can be affected by local landscape attributes (Hobson 1999, Vander Zanden 1999). To make trophic comparisons at a finer resolution, the location of feather growth should be considered. Nonetheless, our preliminary work shows that nitrogen isotopes may be an important tool for investigating differences in the reliance of western songbirds on various food sources.

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LITERATURE CITED

DENIRO, M.J., AND S. EPSTEIN. 1981. Influence of diet on the distribution of nitrogen isotopes in animals. Geochimica et Cosmochimica Acta 45:341–351.

HAMILTON, S.K., AND W.M. LEWIS, JR. 1992. Stable carbon and nitrogen isotopes in algae detritus from the Orinoco River floodplain, Venezuela. Geochimica et Cosmochimica Acta 56: 4237–4246.

HAMILTON, S.K., W.M. LEWIS, JR., AND S.J. SIPPEL. 1992. Energy sources for aquatic animals in the Orinoco River floodplain: evidence from stable isotopes. Oecologia 89:324–330.

HOBSON, K.A. 1999. Stable-carbon and nitrogen isotope ratios of songbird feathers grown in two terrestrial biomes: implications for evaluating trophic relationships and breeding origins. Condor 101:799–805.

HOBSON, K.A., AND W.A. MONTEVECCHI. 1991. Stable isotopic determinations of trophic relationships of Great Auks. Oecologia 87:528–531.

KINGERY, H.E. 1998. Colorado breeding birds atlas. Colorado Division of Wildlife, Denver.

MCCUTCHAN, J.H. 1999. Carbon sources for macroinvertebrates in St. Vrain Creek, Colorado. Doctoral dissertation, University of Colorado, Boulder.

MICHENER, R.H., AND D.M. SCHELL. 1994. Stable isotope ratios as tracers in marine aquatic food webs. Pages 138–157 *in* K. Lajtha and R.H. Michener, editors, Stable isotopes in ecology and environmental science. Blackwell Scientific Publications, London.

MINAGAWA, M., AND E. WADA. 1984. Stepwise enrichment of ^{15}N along food chains: further evidence of the relation between $\delta^{15}N$ and animal age. Geochimica

et Cosmochimica Acta 48: 1135–1140.

OWENS, N.J.P. 1987. Natural variations in ^{15}N in the marine environment. Advances in Marine Biology 24: 389–451.

PETERSON, B.J., AND B. FRY. 1987. Stable isotopes in ecosystem studies. Annual Review of Ecology and Systematics 18:293–320.

THOMPSON, D.R., K. LILLIENDAHL, JON SOLMUNDSSON, R.W. FURNESS, S. WALDRON, AND R.A. PHILLIPS. 1999. Trophic relationships among six species of Icelandic seabirds as determined through stable isotope analysis. Condor 101:898–903.

VANDER ZANDEN, M.J., AND J.B. RASMUSSEN. 1999. Primary consumer $\delta^{13}C$ and $\delta^{15}N$ and the trophic position of aquatic consumers. Ecology 80:1395–1404.

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