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Stable Carbon Isotopes and Nutrient Turnover in Redheads

Migratory species of birds present special difficulties for study. Nevertheless, if birds can be trapped, they can be banded, tagged with various types of external markers (e.g., streamers, dyes, neck bands, nasal saddles), or equipped with radio transmitters (external or internal) to attempt to answer questions related to survivorship, habitat use, and movements. Natural markers, though much less frequently used, are also available to answer questions about movement patterns, nutrient assimilation and cycling, and population interchange of migratory birds.

One type of natural marker is stable isotopes. Stable isotopes of elements differ in their atomic weights and do not decay over time, unlike their unstable radioactive brethren. Naturally occurring stable isotopes of elements undergo identical chemical and biochemical reactions at different rates. This differential incorporation of uptake of stable chemical isotopes results in different isotopic composition of matter. In many instances, the isotopic compositions of substances are determined by a key reaction. Because the isotopes are stable and will not decay over time, isotopic compositions can be treated as natural chemical signatures and can be used to trace ecological processes and changes in organisms, communities, and ecosystems. We used stable carbon isotopes to examine exchange of carbon (i.e., nutrient turnover) in redheads (*Aythya americana*), a migratory species of diving duck. Redheads breed in northern and western wetlands of North America and migrate annually to traditional coastal wintering areas. The major winter range of redheads is centered around the Laguna Madre of southern Texas and the nearby Laguna Madre of northern Tamaulipas, Mexico, where about 80% of all redheads in North America winter.

Redheads Were Collected and Tissues Sampled

Redheads were collected periodically throughout two winters in southern Texas as part of a larger study to investigate winter ecology of redheads in Texas and Louisiana. Consequently, frozen carcasses of redheads from different parts of southern Texas were available to use in a survey of stable carbon isotopes (^{13}C and ^{12}C) in redheads. Redheads that had been collected from Redfish Bay (north of the Laguna Madre) and Baffin Bay (a secondary embayment of the Laguna Madre) were selected for the study. In addition, redheads from South Dakota were also collected to provide samples of birds from the breeding season. Sample plugs of selected organs and tissues were removed from thawed birds to determine isotopic composition. Flight and leg muscles, abdominal and subcutaneous fat deposits, livers, and gizzards were sampled. Organ and tissue samples were kept frozen until subsequent isotopic analysis. Measurements of stable carbon isotopic composition were done with a stable isotope mass spectrometer and expressed as parts per thousand (ppt).

Stable Carbon Isotopic Composition in Redheads Changed Seasonally

The Table shows results of analyses of redheads from Redfish Bay and Baffin Bay in southern Texas during winter and from South Dakota in spring, after the birds departed the winter range. Isotopic composition of redheads from both Redfish Bay and Baffin Bay demonstrated that the carbon in their tissues became more positive as winter progressed. This result was anticipated because redheads in winter subsist almost entirely on seagrass, and most species of seagrass have a carbon isotope signal that is relatively very positive (–10 ppt). The sharply more negative carbon signal of redheads breeding in South Dakota reflects the carbon signal (–26 ppt) of nutrients derived from foods ingested in inland wetlands of northern latitudes.

Use of Stable Isotopes to Understand Ecosystem Processes: Implications for Management

We were able to demonstrate how stable isotope composition in redheads can change seasonally, reflecting the switch redheads make from dependence on seagrasses in winter to foods available in inland wetlands of the redhead breeding range. This is only one example of how carbon isotopes can be used to view many processes—including movement patterns, habitat use, energy flow and nutrient dynamics, and food webs—from a different perspective. In addition, the isotopes of other elements (e.g., nitrogen, hydrogen, oxygen, and sulfur) also offer opportunities to explore population, community, and ecosystem processes. The abundance of naturally occurring stable isotopes and their intrinsic value as natural markers have been only lightly tapped in investigating most ecological issues.

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Table. Mean $\delta^{13}C$ values for carbon isotopic analyses of tissues and organs of redheads (*Aythya americana*) from Baffin Bay and Redfish Bay in southern Texas (fall and winter) and from South Dakota (spring breeding season).

	Texas				
	Baffin Bay		Redfish Bay		South Dakota
Source	Fall	Winter	Fall	Winter	Spring
Flight muscle	–15.8	–13.1	–16.2	–11.1	–22.6
Leg muscle	–15.2	–13.0	–15.5	–11.0	–23.0
Gizzard	–13.7	–12.0	–13.7	– 9.6	–23.8
Liver	–13.3	–12.5	–12.7	–10.0	–27.2
Subcutaneous fat	–16.3	–14.8	–16.9	–12.8	–28.3
Abdominal fat	–15.8	–14.8	–16.4	–12.5	–28.8