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NOTE

Nitrogen isotopic composition of marine and freshwater invertebrates

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ABSTRACT: Stable nitrogen isotopes have customarily been used to delineate trophic position with only scant regard to source variability in isotopic composition. A compilation of literature data indicates, however, that marine invertebrates are enriched in ^{15}N relative to those inhabiting freshwaters. Estuarine mussels were also found to have intermediate $\delta^{15}N$ values which reflected their location along a freshwater-marine gradient. The use of invertebrate $\delta^{15}N$ as a measure of continental-marine coupling in complex coastal environments could therefore provide additional support for conclusions based on traditional $\delta^{13}C$ analysis.

KEY WORDS: $\delta^{15}N$ · Freshwater and marine invertebrates · Source enrichment

It is now widely accepted that a 3 to 4‰ fractionation in stable nitrogen isotopes occurs with food assimilation (Owens 1987). Some parallel work has indicated, however, that $\delta^{15}N$ (ratio of $^{15}N/^{14}N$ expressed as deviations from the recognized isotopic standard, in ‰) may also function as a source marker of material flow across ecotones. In oceans, for example, variability in $\delta^{15}N$ among animals depends upon process differences in internal cycling of 'old' and 'new' nitrogen (e.g. Rau 1981, Mullin et al. 1984, Checkley & Entzeroth 1985, Fisher et al. 1994). In estuarine and coastal environments, mixing of materials derived from terrestrial and oceanic sources has been assessed through $\delta^{15}N$ analysis of both suspended (Mariotti et al. 1984, Owens 1985, Croft et al. 1988) and deposited (Peters et al. 1978, Owens 1987) organic matter.

Broad-scale, continental-marine differences in $\delta^{15}N$ may also exist. The bone collagen of 64 mammals, 17 birds, and 17 fishes showed that marine animals have $\delta^{15}N$ values which average 6 to 10‰ higher (^{15}N enriched) than those for terrestrial or freshwater organisms (Schoeninger & DeNiro 1984). The low sample sizes (98 measurements) and narrow faunal range (66 vertebrate species) of this previous study limits conclusions about the generality of broad-scale environmental differences in source variability of $\delta^{15}N$ [see Owens (1987) and Gearing (1988) for different interpretations]. To counter these limitations, the present investigation compiled literature data on over 400 measurements of $\delta^{15}N$, representing hundreds of different invertebrate species, to determine if marine animals are indeed enriched in ^{15}N relative to organisms inhabiting freshwaters.

Stable nitrogen values were obtained from tables and from figures with a digitizing reader. Data sources included Wada & Hattori (1976), Pang & Nriagu (1977), Macko et al. (1982), Checkley & Entzeroth (1985), Peterson & Howarth (1987), Yoshioka et al. (1989), Montoya et al. (1990), Rau et al. (1990, 1991), Toda & Wada (1990), and Mihuc & Toetz (1994), in addition to those studies listed in France (1995).

Invertebrate $\delta^{15}N$ was found to reflect both trophic-dietary and habitat-source fractionation. Over half of the organisms had $\delta^{15}N$ values within a single trophic position of one another (i.e. ± 2‰) as centred about their respective modes in each data grouping (Figs. 1 & 2). The relative position of these modes, however, were found to be different for marine and freshwater invertebrates. Marine zooplankton (mode and mean = 10‰) and zoobenthos (mode and mean = 9‰) were on average enriched about 3 to 4‰ in $\delta^{15}N$ compared to freshwater zooplankton (mode = 6‰, mean = 7‰) and zoobenthos (mode and mean = 6‰). Therefore, Schoeninger & DeNiro's (1984) belief in broad-scale environmental differences in $\delta^{15}N$ between marine and freshwater animals, which they based on collagen samples of 17 fishes, is supported by the present compilation of whole-body samples for 443 invertebrates.

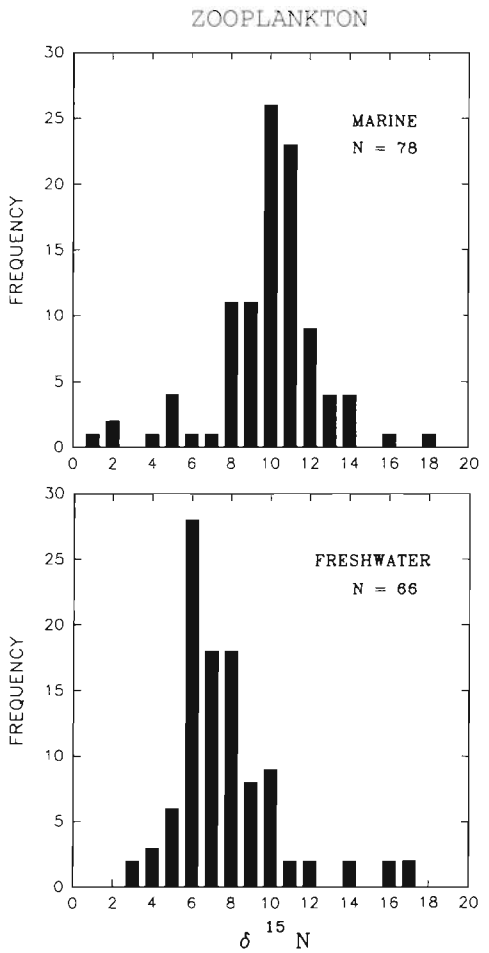

Fig. 1. Percentage frequency distributions of stable nitrogen isotope ratios for marine and freshwater zooplankton

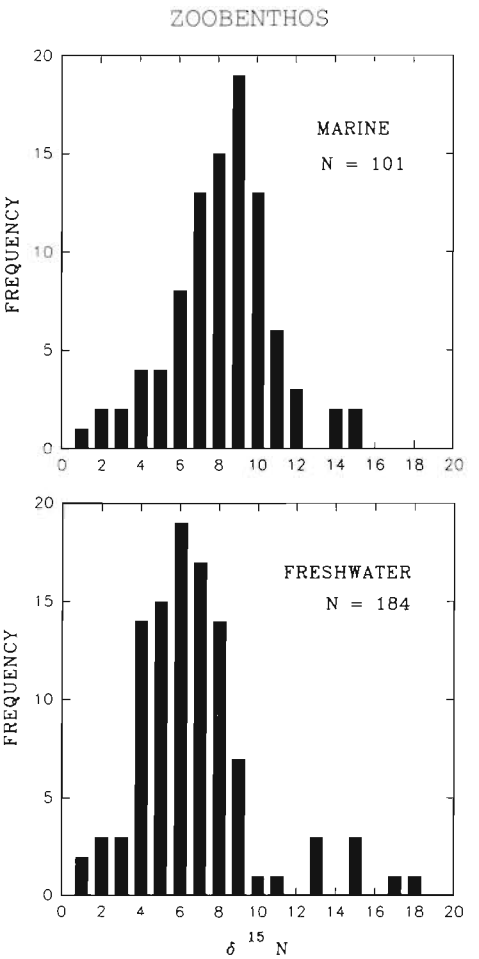

Fig. 2. Percentage frequency distributions of stable nitrogen isotope ratios for marine and freshwater zoobenthic invertebrates

Within a single species, analysis of $\delta^{15}N$ can be used to measure the dietary proportion of food originating from different environmental sources. For example, a reanalysis of mussel data from Peterson et al. (1985) indicates that the $\delta^{15}N$ of estuarine invertebrates reflects the degree of terrestrial-oceanic mixing (Fig. 3). This substantiates Schoeninger & DeNiro's (1984) finding of intermediate $\delta^{15}N$ values for organisms such as migratory birds and anadromous fishes which spend part of their life cycles feeding in both freshwater and marine environments.

The use of invertebrate $\delta^{15}N$ as a marker of ecotonal coupling in coastal environments could therefore provide additional support for conclusions based on the traditional analysis (e.g. Incze et al. 1982, Stephenson & Lyon 1982) of $\delta^{13}C$ alone.

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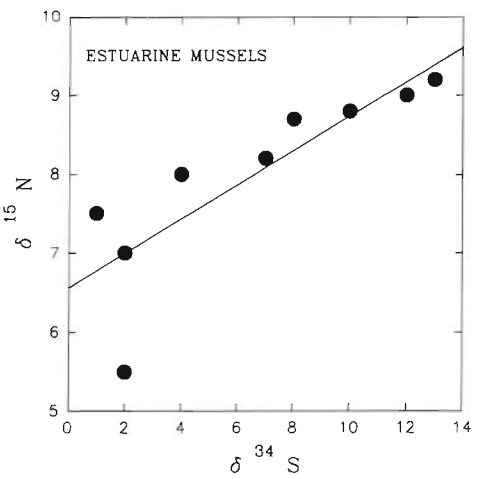

Fig. 3. Relationship between stable isotopes of nitrogen and sulfur for mussels (*Geukensia demissa*) in an estuary (reanalysis of data from Peterson et al. 1985). The sulfur isotopic signature for marine sediments is about 15‰ while that for freshwater sediments is below 0

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