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STABLE ISOTOPE COMPOSITION OF THE SERPULID *FICOPOMATUS ENIGMATICUS* AS ENVIRONMENTAL PROXY

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Stable isotope composition of soft tissues and carbonate tubes of the serpulids *F. enigmaticus* and *M. cavatica* were used to estimate their food sources. Comparison of isotope fingerprints of adjacent estuarine and anchialine cave serpulids showed that they consume predominantly particulate organic matter of terrestrial origin.

Key words: serpulid, carbon, oxygen, nitrogen, stable isotope

INTRODUCTION

Serpulidae – tube worms with carbonate tubes – comprise more than 350 species. Five species of the genus *Ficopomatus* occur in water with variable salinity. Recently, *F. enigmaticus* has invaded anchialine cave environments in Croatia and Italy (CUKROV *et al*., 2010). As in other organisms with carbonate shells, the stable C and O isotope compositions (δ^{13}C and δ^{18}O values) of their tubes can be used as indicators of environmental conditions of their growth where the δ^{18}O reflects the mean water temperature and δ^{13}C provides information on carbon sources (marine vs. terrestrial, biogenic or abiogenic). Stable isotope compositions of N (δ^{15}N) and C in soft tissues provide information on their trophic position, the sources and origin of food. These results are a component of a comprehensive study of C and N stable isotope compositions of soft tissues as environmental proxies in the Krka river estuary (Croatia) and an adjacent anchialine cave (Vidrovača). The aim of the study was to estimate how the isotope compositions of serpulids' tubes and soft tissues record the environmental conditions in their habitat in the land-sea transition zone and in the anchialine cave and how sensitively they react to environmental change.

MATERIALS AND METHODS

Serpulid samples were collected manually by scuba diving in depths between 0.5 and 2 m. Particulate organic matter (POM) was sampled by filtering 3–5 L of water per replicate, collected at the same depth as the serpulids. Worms were extracted from the tubes and dried until constant weight at 50 °C. Several individuals from adjacent colonies were pooled together and homogenized. Samples of POM were treated following the recommendations by CABAREL *et al*. (2006) and analysed using a Europa 20-20 stable isotope analyser with ANCA-SL preparation module for solid and liquid samples (PDZ Europa, U.K.).

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RESULTS AND DISCUSSION

The $\delta^{15}N_{air}$ values of estuarine POM ranged between 3.6 and 4.7 ‰, with no significant difference between the upper and the lower reaches of the estuary (upper being under strong freshwater influence, while the lower reaches of the estuary are marine-influenced). The $\delta^{15}N_{air}$ values of POM from different sites in the Krka river ranged between 2.9 and 7.5 ‰, while that of marine POM collected at four sites within 10 km from the estuary mouth ranged from 3.6 to 6.5 ‰. Discrimination of sites with differing salinity regarding the $\delta^{15}N_{air}$ values of estuarine POM was thus not possible. However, the $\delta^{13}C_{VPDB}$ values of POM clearly differentiated freshwater and marine sources (from –38 to –29.4 ‰ and from –22.9 to –20.5 ‰, respectively). A source estimation of POM using a simple mixing model was nevertheless not possible, because within the estuary, values lower than the average terrestrial component (–33.8 ‰) were detected. This is explained by occasional pulses of ^{13}C-depleted terrestrial POM from the central part of the Krka river flow with $\delta^{13}C_{VPDB}$ values as low as –38.0 ‰, which are discharged at extreme hydrological conditions after heavy rains in the central part of the Krka watershed. Very low $\delta^{13}C_{VPDB}$ values of POM in the estuary show that the terrestrial component is highly refractory and remains rather unchanged across long distances and over long periods. This further suggests, that the terrestrial isotopic signal in POM may prevail even after mixing with a considerable amount of seawater, so that the $\delta^{13}C_{VPDB}$ values would, relying on the simple mixing model, yield a higher fraction of freshwater component than salinity.

C and N isotope compositions of serpulids also identify freshwater and marine communities as two distinct groups. By contrast, the estuarine samples from sites with variable salinity show a large range of values, in particular regarding $\delta^{13}C$ values (Figs 1 and 2). The $\delta^{15}N_{air}$ values of worms vary seasonally and respond sensitively to anthropogenic inputs of communal waste. The cave sample shows δ values which do not statistically significantly differ from those collected ab adjacent

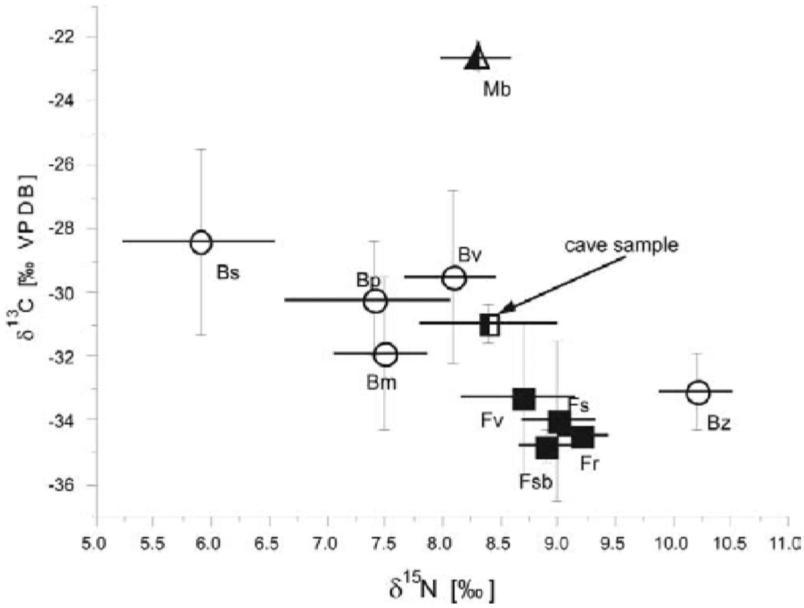

Fig. 1. Stable isotope fingerprints of soft tissues of *Ficompomatus enigmaticus* in marine and estuarine samples; M = marine sites, B = brackish sites, F = freshwater sites; the entrance into the cave is located next to the site FV.

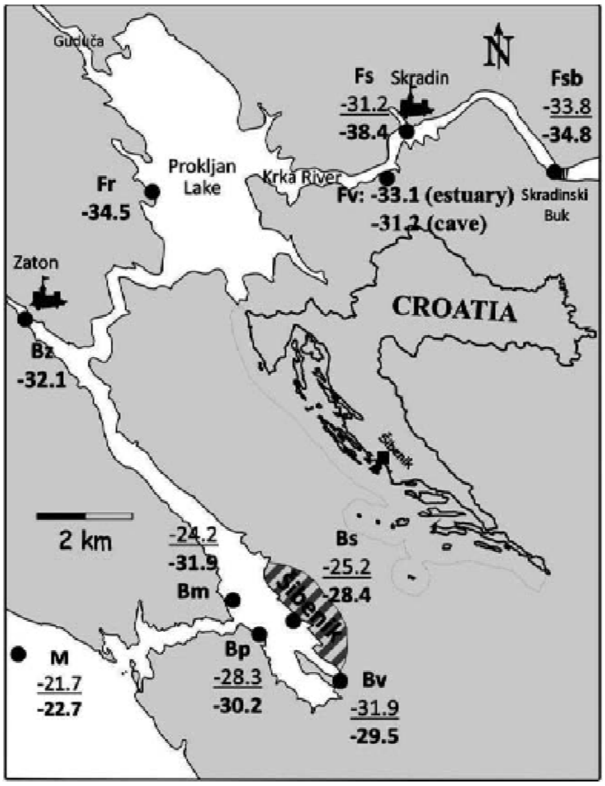

Fig. 2. $\delta^{13}C_{VPDB}$ values [‰] of particulate organic matter (underlined) and serpulid soft tissues (bold) in the Krka estuary.

estuarine site with respect to N isotope composition, but the difference in $\delta^{13}C_{VPDB}$ values is significant, related to the increased salinity in the cave water at the depth where the serpulids were collected.

CONCLUSION

The stable isotope compositions of C and N in tube worm soft tissues are good indicators of the origin of particulate organic matter in estuarine and anchialine habitats since they well reflect the isotopic composition of POM in the system and can therefore be used to assess the fluctuations of the halocline. Furthermore, isotope fingerprints of soft tissues and potentially carbonate (tubes) may be used as proxies to provide deeper insight into the biogeochemical conditions and their variability in anchialine ecosystems.

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