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Toward improvement of accuracy of water temperature reconstructions using oxygen stable isotope ratio of biogenic carbonates: Precise evaluation of vital effects

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Oxygen stable isotope ratio ($\delta^{18}O$) of biogenic carbonates reflects changes in ambient water temperature, making it as one of the most powerful and widely used proxy for paleoenvironmental reconstruction. However, it is known that $\delta^{18}O$ of many biogenic carbonates is also affected by biological factor, so called vital effect. For more accurate temperature reconstruction, a method to correct for vital effect is required.

In this study, we aimed to quantitatively evaluate the vital effect on $\delta^{18}O$ for two species of bivalve shell (*Ruditapes philippinarum* and *Anadara broughtonii*) and one species of fish otolith (*Engraulis japonicus*). In this study, we employed a research design that excluded factors potentially induce variations in $\delta^{18}O$ other than vital effect. All species were maintained in the same tank, ensuring carbonate formation under identical environmental conditions. Consequently, isotopic fractionation due to differences in environment factors was minimized. $\delta^{18}O$ of all carbonate samples were analyzed using a Delta V Plus isotope ratio mass spectrometer (Thermo Fisher Scientific) at the Atmosphere and Ocean Research Institute, University of Tokyo, thus minimizing systematic analytical errors.

Significant differences of 0.72 ‰ at 22°C, and 0.28 ‰ at 19°C were observed between *Ruditapes philippinarum* and *Anadara broughtonii*. *Engraulis japonicus* showed a non-significant difference of 0.11 ‰ from *A. broughtonii*, but showed a significant difference of 0.73 ‰ from *R. philippinarum*. Given these differences were produced under a single tank setting with identical environmental factors, species-specific vital effects clearly exist even for bivalve shells and fish otoliths, with which oxygen isotope is believed to be near isotope equilibrium. Furthermore, $\delta^{18}O$ value showed a significant negative correlation with metabolic rate ($R^2 = 0.58$ for *A. broughtonii* and $R^2 = 0.67$ for *R. philippinarum*) which was estimated from carbon stable isotopic ratio of biogenic carbonate and soft tissue, indicating that physiological process associated with metabolism may exert biological isotope fractionation in bivalve shells.