Universal temperature dependence of nutritional demands in ectotherms

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March 23, 2022

Abstract

In light of ongoing climate change, it is increasingly important to know how nutritional requirements of ectotherms are affected by changing temperatures. Here, we analyse the wide thermal response of phosphorus (P) requirements via elemental gross growth efficiencies of Carbon (C) and P, and the Threshold Elemental Ratios in different aquatic invertebrate ectotherms such as the freshwater model species Daphnia magna, the marine copepod Acartia tonsa, the marine heterotrophic dinoflagellate Oxyrrhis marina, and larvae of two populations of the marine crab Carcinus maenas. We show that they all share a non-linear cubic thermal response of nutrient requirements. Phosphorus requirements decrease from low to intermediate temperatures, increase at higher temperatures, and decrease again when temperature is excessive. This universality in the thermal response of nutrient requirements is of great importance if we aim to understand or even predict how ectotherm communities will react to global warming and nutrient-driven eutrophication.

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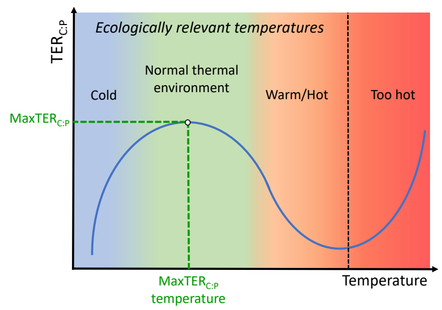

Figure 6: Proposed N-shaped response of the $TER_{C:P}$ to temperature. Light blue, green, and orange areas, until the vertical dashed line represent temperatures within the ecological environment of the species, the red area represents temperatures beyond the thermal optimum (Pörtner & Farrell 2008; Pörtner 2012) that might be experienced by the species only in rare conditions. In this proposed concept, the increasing demands of C relative to P when temperatures increase from cold (light blue) to intermediate (middle green) are the result of increasing respiration rates and P use efficiency, until the $MaxTER_{C:P}$ is reached. When temperatures increase above the normal thermal environment of the organism (from green to orange area), the increasing demands of P relative to C are the result of the decrease in P use efficiency, and might prevent an excessive increase in metabolism that can result from the combination of low P diets (Ruiz et al. 2018; Ruiz et al. 2020) and increased temperatures. The increase in C demands relative to P when temperature is excessive may reflect the physiological stress that amplifies C-demands for respiratory and catabolic processes (Schmitz 2013).