Prey-predator interactions derived from energy metabolism: reconsideration of ontogenetic metabolic scaling

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The allometric relationships between resting metabolism (VO_2) and body mass (M), $VO_2=a_iM^b$, are considered a fundamental law of nature. A distinction though needs to be made between the ontogeny (within a species) and phylogeny (among species) of metabolism. However, the nature and significance of the intra-specific allometry (ontogeny of metabolism) have not been established in fishes and aquatic invertebrates. In this study, we present experimental evidences that fishes and an invertebrate have four distinct allometric phases in which three stepwise increases in scaling constants (a_i, i=1 to 4), i.e. ontogenetic phase shifts in metabolism, occur with growth during its early life stages, keeping each scaling exponent constant in each phase. In a puffer fish, three stepwise increases in a_i accompanied behavioural and morphological changes and three peaks of severe cannibalism, in which the majority of predation occurred on smaller fish that had a lower value of a_i. Though fishes and aquatic invertebrates are generally highly fecund, producing a large number of small eggs, their survivability is very low. These results suggest that individuals with the ability to rapidly grow and step up 'a_i' develop more anti-predator adaptation as a result of the decreased predatory risk.