ATP synthesis and mitochondrial efficiency: the forgotten elements in the metabolism – body mass relationship

Mélanie Boël*†[1], Yann Voituron[2], Caroline Romestaing[1], and Damien Roussel[1]

[1]Laboratoire d'Ecologie des Hydrosystèmes Naturels et Anthropisés (LEHNA) – Université Claude Bernard - Lyon I, Ecole Nationale des Travaux Publics de l'Etat, CNRS : UMR5023 – Université Claude Bernard Lyon 13-6, rue Raphaël Dubois - Bâtiments Darwin C Forel, 69622 Villeurbanne Cedex, France

[2]Laboratoire d'Ecologie des Hydrosystèmes Naturels et Anthropisés (LEHNA) – Université Claude Bernard - Lyon I, Ecole Nationale des Travaux Publics de l'Etat, CNRS : UMR5023 – Université Claude Bernard Lyon 13-6, rue Raphaël Dubois - Bâtiments Darwin C Forel, 69622 Villeurbanne Cedex, France

Abstract

In ecology, a lot of studies have been conducted on the relationship between body mass and metabolism, using oxygen consumption as proxy of metabolism rate. They showed in mammals, that specific oxygen consumption (per mass unit) negatively correlates with body mass. In cells, oxygen is used by mitochondria via the oxidative phosphorylation to provide cellular energy (ATP), essential for individual performances (growth, survival and reproduction). Nevertheless, 20 – 30 % of all the oxygen consumed are not converted in ATP but serve to compensate energetic losses arising from this biochemical process, known as "proton leak". Consequently, it seems obvious that oxygen consumption without considering intensity of this proton leak does not allow the best estimation of the real quantity of ATP produced, available for individual performances.The aim of our study is to revisit the relationship between metabolism and body mass. We measure ATP synthesis and oxygen consumption of mitochondria isolated from mammalian muscles (bull, boar, nutria, golden and European hamsters, wild rat, African mice...) in order to estimate their mitochondrial efficiency (ATP/O) and study its dynamic with body mass. Many authors found in mammals that proton leak negatively correlates with body mass, suggesting that smallest ones have lower mitochondrial efficiency combined with a weaker ATP synthesis. After phylogenetic correction (Phylogeny Independent Contrast), our data reveal that oxygen consumption and ATP synthesis decrease with increasing body mass in mammalian muscle mitochondria. Mitochondrial efficiency, on the other hand, remains surprisingly constant, implying that it could be one of rarely metabolic functions independent with body mass. These results highlight the necessity to incorporate both ATP synthesis and mitochondrial efficiency in the relationship between metabolism and body mass and to revisit theories based only on oxygen consumption to estimate metabolic rate of individual.

*Speaker

†Corresponding author: melanie.boel@univ-lyon1.fr