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Abstract

Among multicellular organisms, substantial variation in cell size has been demonstrated, largely related to the size of the genome. It has been shown that small cells have higher mass-specific metabolic rates (MRs) than do larger cells. One hypothesis predicts that the metabolic rate of a whole organism should reflect the metabolic rates of the individual cells that ultimately constitute that organism. Via the link with metabolic rate, cell size should also affect the rate of mitotic divisions and therefore the organismal growth rate and development. However, the interspecific comparisons do not always reveal the links between cell size, whole-body MR and growth rate. Of all tested factors, temperature and genome size (especially polyploidy) produce the strongest effects on cell size in ectotherms. The increase in cell size induced by low temperature may explain the pattern of geographic variation of body size; incolder environments, the majority of ectotherms grow more slowly but mature at larger body sizes (the temperature-size rule, TSR). Regarding polyploids, there is some, albeit scarce, evidence that their larger genomes and cells may increase the whole body size and decrease mass-specific MR. The impact of temperature on the size of somatic cells in polyploid animals has presumably never been studied.

The objective of my thesis was to investigate the links between cell size, body size, growth rate and whole-body metabolic rate in amphibians. My research objects were diploid and triploid edible frogs, *Pelophylax esculentus*, which had previously been shown to differ in genome size and erythrocyte size. Studying the consequences of cell size variation within one species overcomes the problem of inter-specific comparisons associated with the different evolutionary histories of the compared species. In the first part of the thesis, I focused on the effect of polyploidy and temperature on the cell size and body size in tadpoles that were reared at 19 °C and 24 °C. I found that ploidy and temperature significantly affected cell size in tadpoles (erythrocytes and epidermal cells). The cells were larger in both diploid and triploid tadpoles at 19 °C than at 24 °C, and triploids had larger cells than diploids at both temperatures. The mean erythrocyte size in a pentaploid froglet, which was unexpectedly found in one of the crosses, was not proportionally larger than that in triploids, as might be expected on the basis of

genome size. In diploid and triploid froglets, the temperature in which they developed as tadpoles did not affect the size of their cells, but triploids still had larger cells (hepatocytes and erythrocytes). In the second part of the thesis, I tested the hypothesis that individuals composed of smaller cells have a higher MR than individuals of a comparable body size but composed of larger cells. As I expected, diploid tadpoles had a higher standard metabolic rate (SMR) than triploids. Interestingly, in froglets, ploidy did not affect the SMR. Based on this result and an extensive review of the literature, I suggest that cell size may have more consequences for whole-body metabolic rates in aquatic than in terrestrial habitats because oxygen is less available in water, and its availability in relation to oxygen demand decreases with increasing temperatures. In water, polyploids composed of larger cells (with a less favorable surface-to-volume ratio) may be more vulnerable to insufficient oxygen supply and display lower MRs. I also found that water temperatures in which tadpoles were reared had no effect on the SMR of froglets after metamorphosis, consistent with no effect of these temperatures on cell size. Tadpoles of both ploidies were larger and developed over a longer time period at the lower temperature, which was associated with larger cells. This result has not been observed in amphibians before and indicates that variation in cell size may be important in explaining the TSR. I was able to demonstrate that polyploidy/cell size affects body size in tadpoles but that their growth rate largely depends on temperature. At 19 °C, triploids grew faster than diploids and had larger body mass, whereas at 24 °C there was no clear difference between ploidies in growth rate. Thus, I rejected the hypothesis that triploid tadpoles, composed of larger cells, grow more slowly and develop over a longer time period at a given temperature. It seems that the larger cells of triploids are not a limiting factor for their growth at lower water temperatures. My thesis clearly demonstrates that the variation in cell size induced by internal and external factors may play a significant role in the physiology of ectothermic vertebrates. I present the first report of two distinct effects of polyploidy/cell size on the whole-body metabolic rate within a single species developing in two different habitats, aquatic and terrestrial. I was also able to demonstrate, for the first time in vertebrates, that the combination of low temperature and polyploidy results in larger cells and body size. Considering the potential advantages of large body size at higher latitudes, the highest body mass of triploid tadpoles at lower temperature found in my study may explain the observation that triploid individuals of *P. esculentus* prevail in the in the northern parts of its geographic range.