Meta-analytic approaches and new effect sizes to account for treatment differences across studies in comparative physiology

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# Abstract

Meta-analysis is a tool that provides comparative physiologists with powerful, unbiased and quantitatively informed answers to topical research questions by synthesising effect sizes across disparate studies. Distilling published research results into standardised effect sizes that can be weighted by their sample size (i.e., inverse sampling variance) and compared across broad sets of research designs, study systems and species is its core objective and strength. Estimating overall effect sizes, and understanding what drives effect variability, provides opportunities to model how organisms will respond to pressing global challenges. Despite this ambition, research designs in comparative physiology can appear, at the outset, as being vastly different to each other (e.g., using different temperatures or treatment dosages). Differences in treatments across studies has led many to believe that meta-analysis is an exercise in comparing “apples with oranges”. Here, we dispel this myth by showing how standardised effects sizes can be used in conjunction with powerful multi-level meta-analytic models to both account for factors driving differences across studies and make them more comparable. In addition, we derive new effect size measures that provide comparative physiologists with a means to directly make effect sizes comparable without the need to resort to more complex statistical models that may be harder to interpret. Our ‘new’ effect sizes and corresponding sampling variances help physiologists deal with temperature and dosage differences across studies; allowing researchers to compare both mean differences (e.g., Q10 to compare mean differences in physiological rates over 10 degrees) and associated differences in variance (e.g, SQ10 for comparing variability in in physiological rates over 10 degrees) for physiological traits. The new effect sizes we propose, in combination with existing meta-analytic models, will pave the way for comparative physiologists to explore exciting new questions by making results from large-scale data sets from the literature more accessible and widely interpretable.