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MEIOSIS: Museum Specimens Shed Light In Biodiversity Shrinkage

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Abstract : Body size is crucial to ecology, influencing everything from individual reproductive success to the dynamics of communities and ecosystems. Understanding how temperature affects variations in body size is vital for both theoretical and practical purposes, as changes in size can modify trophic interactions by altering predator-prey size ratios and changing the distribution and transfer of biomass, which ultimately impacts food web stability and ecosystem functioning. Notably, a decrease in body size is frequently mentioned as the third ‘universal’ response to climate warming, alongside shifts in distribution and changes in phenology. This trend is backed by ecological theories like the temperature-size rule (TSR) and Bergmann's rule, which have been observed in numerous species, indicating that many species are likely to shrink in size as temperatures rise. However, the thermal responses related to body size are still contradictory and further exploration is needed. To tackle this challenge, we developed the MEIOSIS project, aimed at providing valuable insights into the relationship between the body size of species, species’ traits, environmental factors and their response to climate change. We combined a digitized collection of butterflies from the Swiss Federal Institute of Technology in Zürich with our newly digitized butterfly collection from Goulandris Natural History Museum in Greece to analyze trends in time. For a total of 23868 images, the length of the right forewing was measured using ImageJ software. Each forewing was measured from the point at which the wing meets the thorax to the apex of the wing. The forewing length of museum specimens has been shown to have a strong correlation with wing surface area and has been utilized in prior studies as a proxy for overall body size. Temperature data corresponding to the years of collection were also incorporated into the datasets. A second dataset was generated when a custom computer vision tool was implemented for the automated morphological measuring of samples for the digitized collection in Zürich. Using the second dataset, we corrected manual measurements with ImageJ and a final dataset containing 31922 samples was used in analysis. Setting time as a smoother variable, species identity as a random factor and the length of right-wing size (as a proxy for body size) as the response variable, we ran a global model for a maximum period of 170 years (1840 – 2010). We also constructed individual models for each family (Pieridae, Lycaenidae, Hesperiidae, Nymphalidae, Papilionidae). All models confirmed our initial hypothesis and resulted in a decreasing trend of the wing length over the years. We expect that this first output can be provided as basic data for the next challenge, i.e., to identify the ecological traits that influence species' temperature-size responses, enabling us to predict the direction and intensity of a species' reaction to rising temperatures more accurately.

Keywords : butterflies, shrinking body size, museum specimens, climate change
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