Editor, *Ecology Letters*

15 April 2025

Dear Editor,

Please consider our manuscript entitled: “Temperature variability does not influence phenotypic plasticity in ectotherms – a meta-analysis”for publication as a *Letter* article in *Ecology Letters*.

The accelerating pace of global climate change is increasing both mean temperatures and temperature fluctuations. A majorof research to date has been how increase thece of ectothermsWhile the impacts of temperature fluctuations are currently a hot topic (e.g., Stocker et al 2024 Ecol Lett 27, e14511; Raynal et al. 2022. J Exp Biol 225, jeb243369), we know little about how fluctuating thermal environments can change plastic responses despite there being good reasons to believe it could (e.g. Beaman et al. 2016. Trends Ecol. Evol., 31, 237–249). Getting answers to this question is important because it can impact how effective plasticity is at buffering animals from climate variability. In addition, knowing if fluctuating conditions affect plastic responses has the potential to recalibrate the field and the types of experimental work done because most knowledge stems from experiments that measured responses to different constant temperatures.

We assembled a team of leading researchers at various career states with expertise in meta-analysis and developmental plasticity to address whether fluctuating temperatures impact plasticity. Building off our past methodological work in meta-analysis (e.g., Noble et al. 2022 J Exp Biol 225, jeb243225) we developed novel effect sizes that quantify the magnitude of change in plastic responses between constant and fluctuating temperatures. After surveying >13,000 studies and compiling data from 44 studies on 40 species we derived 212 effect sizes that contrast plasticity in constant and fluctuating conditions.

Our analysis shows that most studies investigated short term diel variation and that such fluctuations have limited effects on plastic responses. Hence, plasticity is driven by longer term thermal change, but research needs to be directed towards understanding the transient characteristics of temperature change that can elicit plastic responses. Of particular concern are also temperature fluctuations that reach damaging level, such as those occurring during heat waves. Our analysis indicates that currently knowledge is lacking to assess the impacts of these extreme fluctuations.

Our meta-analysis is novel and timely because we establish the current state-of-knowledge of how fluctuating thermal environments influence phenotypic plasticity relative to constant environments. This synthesis thereby provides directions for future work in ecology, and can inform conservation and management around the globe.

*Recent publications*

The early career researchers, Pettersen and Noble, and I have considerable expertise in thermal biology and meta-analyses. Dan Noble is already an internationally renowned expert in meta-analytical techniques, developing new approaches and techniques to meta-analyse data in ecology and evolution. We cite and use his recent publications that present novel methods for visualisation (Nakagawa et al. 2023 Methods Ecol Evol 14, 2003-2010), for testing publication bias (Nakagawa et al. 2022 Methods Ecol Evol 13, 4-21), and calculating novel effect sizes (Noble et al 2022 J Exp Biol 225, jeb243225).

Pettersen's interests lie mainly in the effects of thermal variation on costs and benefits of development and developmental plasticity. In recent work (Pettersen et al. 2024 Phil Trans R Soc B 379, 20220496) she used selection analysis to evaluate the benefits of intergenerational plasticity, and she showed (Pettersen et al. 2023 J Anim Ecol 92, 1771-1785) that development was energetically more costly in cool climates, but that high latitude lizards show adaptive responses to cool temperatures by developing faster without increasing metabolic rates, and using yolk reserves more efficiently. These studies address important aspects of thermal biology, which we here advance significantly by synthesising the importance of fluctuations that can potentially affect all thermal responses.

My work focusses generally on the impacts of environmental variation on phenotypic plasticity with particular emphasis on temperature and its interactions with other natural and anthropogenic drivers (e.g., Seebacher and Bamford 2024 Sci Tot Env 912, 168942). Temperature variability is central to my interests, and I think that ecological approaches such as species distribution models need to model rates of temperature change rather than simply temporal and spatial distributions (e.g., Loughland et al. 2022 J Exp Biol 225, jeb243740; Seebacher et al 2023 Conserv Physiol 11, coad038). Understanding variability is important conceptually in ecology and evolution, and it is urgent to improve the efficacy of conservation. We recently published a meta-analysis on the effects of temperature fluctuations on mean trait values (Stocker et al 2024 Ecol Lett 27, e14511), and the present work adds an important new dimension by analysing the effects of fluctuations on the plasticity of trait values.

Best regards,



Frank Seebacher