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SPECIALTY SECTION  
This article was submitted to  
Behavioral and Evolutionary Ecology,  
a section of the journal  
Frontiers in Ecology and Evolution

RECEIVED 08 October 2022  
ACCEPTED 26 October 2022  
PUBLISHED 03 November 2022

CITATION  
Rymer TL, Rimbach R and Pillay N  
(2022) Editorial: Proximate and  
ultimate approaches to behavior in a  
changing world.  
*Front. Ecol. Evol.* 10:1064923.  
doi: 10.3389/fevo.2022.1064923

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# Editorial: Proximate and ultimate approaches to behavior in a changing world

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## KEYWORDS

behavior, environmental change, Tinbergen, human-induced, urbanization

## Editorial on the Research Topic Proximate and ultimate approaches to behavior in a changing world

Tinbergen's (1963) classic four questions for the study of animal behavior have been applied across a range of study species and contexts and provide a solid foundation for understanding species' responses to rapid environmental change. Tinbergen's (1963) proximate questions include understanding the mechanisms (causation) and development (ontogeny) of behavior, while the ultimate questions include understanding the function (adaptive significance) and evolution of behavior. Integrating proximate and ultimate approaches to understanding behavior in an increasingly human-dominated world gives insights into broader conservation and management strategies for mitigating the negative effects on animal species.

The current collection of research reports provides insights into how a changing world affects different species, and provides some context for Tinbergen's focus. The contributors to this special issue demonstrate a varied and diverse approach to this topic, highlighting the inclusive nature of Tinbergen's approach to the study of animal behavior. While broad-scale conclusions cannot be drawn, the range of topics showcases how different experts are tackling these questions from a variety of angles.

These observations, along with many studies in a variety of different journals, suggest that species responses to environmental change are varied and that some species will respond favorably to human environmental modification, whereas others will not. In addition, understanding the underlying proximate factors driving behavioral differences in response to environmental changes may provide useful information for managing threatened or endangered species or species that are increasingly more in conflict with humans.

The selected papers focus predominantly on the mechanisms and adaptive significance of behavior in disturbed and anthropogenic environments, with some consideration of evolutionary history. The selected papers are divided into an opinion article considering the conservation of solitary mammals, two review articles that focused broadly on behavioral responses to ecosystem change and allostasis, and four species-specific articles that focused variously on the physiological responses resulting in, or as a consequence to, human environmental impacts, as well as adaptive significance and evolution of behaviors in response to human-mediated environmental changes.

The social nature of species gives us insights into conservation. This idea is addressed by [Olivier et al.](#), who argue that a solitary lifestyle may render a species more vulnerable to environmental disturbances, as they miss out on the benefits of group-living. [Bar-Ziv et al.](#) also show how life history differences between the sexes of the solitary-living striped hyena (*Hyaena hyaena*) may affect their exposure to humans and their potential involvement in human-hyena conflict.

Behavioral responses to disrupted environments are addressed by [Rahman and Candolin](#), who describe the underlying mechanisms and ultimate impact that behavioral responses may have on ecosystem structure and functioning. They synthesize current theory and experimental studies, generating a conceptual framework linking behavior to disrupted species interactions, community dynamics, and ecosystem processes. [Küçüktaş and Guenther](#) address specifically whether living in a human-altered environment affects behavioral responses and life history, using different species of small rodents. They demonstrate how life histories and behavioral adaptations of different species are governed by environmental differences, but that a close commensal relationship with humans does not necessarily drive inter-specific behavioral variation. [Nordberg and Schwarzkopf](#) studied whether living in a human-altered environment affects behavioral responses in a nocturnal gecko, finding that, contrary to expectations, a human-altered environment has a positive effect on foraging behavior, suggesting that some species may thrive in human-altered landscapes.

Achieving stability through change is reviewed by [Word et al.](#), where they examine the cues animals use to inform them of their potential energy state and relative

probability of energetic crisis. With a focus on understanding the basis of intra- and inter-individual variability in responsiveness, they provide a greater understanding of how individuals may cope with environmental change. [Di Giovanni et al.](#) demonstrated how infrared thermography is a viable technique for monitoring stress responses in herring gulls, which are correlated with behavioral responses to human auditory noises, and suggest that monitoring stressor-induced physiological changes and behavior in wild, freely moving animals will help mitigate human-wildlife conflict.

While this collection of papers does not specifically address the ontogenetic aspects of behavior in a changing world, this proximate question provides a tantalizing area for future research.

The contributing authors come from a variety of localities, with many receiving substantial funding for their work from different foundations. The editors thank all contributors to this special topic to promote studies of animal behavior in response to environmental changes.

## Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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