Digest: Environmental variability as a constraint on cognitive evolution in lizards

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Footnote: This article corresponds to De Meester, G., L. Van Linden, J. Torfs, P. Pafilis, E. Sunje, D. Steenssens, T. Zulcic, A. Sassalos, and R. Van Damme. 2022. Learning with lacertids: studying the link between ecology and cognition within a comparative framework. Evolution, 76: 2531-2552. https://doi.org/10.1111/evo.14618.

Abstract: How does ecology influence cognitive evolution in lizards? Taking a comparative approach, De Meester et al. (2022) discovered that species living in temporally fluctuating environments tend to perform relatively poorly on cognitive tasks associated with behavioral flexibility compared to species living in more climatically stable environments. The negative association between environmental variability and cognitive performance suggests that stochastic environments can hamper, rather than stimulate, the evolution of cognitive ability.

Main Text:

Despite more than a century of research, there is still considerable uncertainty over the factors governing cognitive evolution, and it remains one of the most intensely debated fields in biology. One popular school of thought reasons that non-social ecological challenges, such as predation pressure, food scarcity, and habitat complexity, are the predominant drivers of cognitive evolution. Refining this theory, the “cognitive buffer hypothesis” argues that cognition has evolved to buffer individuals against stochastic environmental fluctuations (Sol 2009). Conversely, the “expensive-tissue hypothesis” claims that energetic limitations in variable environments has selected for reduced investments in costly brain tissue at the expense of cognitive ability (Aiello and Wheeler 1995). Yet, despite the broad interest in cognitive evolution from scientists and the public alike, remarkably few studies have simultaneously assessed the explanatory power of these competing hypotheses, particularly in reptiles.

De Meester et al. (2022) took up this challenge and presented five cognitive tasks to 13 lacertid species, an Old World family of non-social lizards. The cognitive test battery consisted of an inhibitory control task, two problem-solving tasks, a spatial learning task, and a spatial-reversal learning task. Inhibitory control (the ability to inhibit prepotent responses), problem-solving performance, and reversal learning are often considered important components of behavioral and cognitive flexibility, and are associated with a number of fitness-related behaviors. Likewise, spatial memory is likely to underpin a number of behaviors crucial to survival, such as remembering the location of resources and shelters. Using environmental data from climate databases and literature records on life history traits, the researchers investigated if cognitive performance was related to ecology.

Using modern tools in phylogenetic comparative statistics, De Meester et al. (2022) found a significant link between environmental variability (i.e., Normalized Difference Vegetation Index – an indicator of vegetation 'greenness' and thus plant growth – and precipitation seasonality) and cognitive performance: lizard species inhabiting more seasonal climates performed worse on cognitive tasks linked with behavioral flexibility – specifically, solving new problems, reversing spatial associations, and inhibitory control (Fig. 1). However, it is worth noting that performance in the initial spatial learning task did not differ across species. Interestingly, among-species variation in cognitive performance could not be explained by life history variation or overall resource availability (as indicated by average precipitation and temperature). Together, these findings suggest that environmental variability may act as a constraint on the evolution of high (thus expensive) cognitive abilities in lacertid lizards, thereby providing support for the expensive-tissue hypothesis.

The study by De Meester et al. (2022) offers an important and novel contribution to the field of cognitive evolution for at least four reasons. First, their results show how cognition can vary among closely-related species and that a significant portion of that variation can be explained by environmental variability, corroborating the findings of earlier comparisons at the intraspecific level (De Meester et al. 2021). Second, this study is a rare example of direct measures of cognition being used within a comparative framework. The vast majority of studies investigating cognitive evolution use neuroanatomical proxies of cognition — the relationship between neuroanatomy and cognition, and its use in phylogenetic studies, is contentious (Hooper et al. 2022). Much like the “ManyPrimates” and “ManyBirds” initiatives, this study sets an important precedent for future studies using direct measures of cognition in phylogenetic comparisons. Third, De Meester et al. (2022) set forth a highly replicable and simple protocol on how to measure cognition in other reptile species, facilitating the possibility to extend their current dataset. Lastly, the cognition literature is heavily biased toward mammals and birds (Szabo et al. 2021), thus this study adds important insights into the causes of cognitive variation in taxa that are traditionally underrepresented in the field.

References

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