Explicit modelling of proximate mechanisms for revealing life-history tradeoffs

Mathieu Buoro, Etienne Prévost

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Mathieu Buoro, Prevost Etienne
INRA

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Evolutionary trade-offs are considered one of the most critical factors in the evolution of life-history traits and therefore play a key role in the life-history theory. However, empirical studies often show positive or non-significant correlations among life-history traits, rather than negative trade-offs as expected. These unexpected results may occur when variation among individuals in resource acquisition is high relative to variation in allocation between traits. As a consequence, trade-offs operating at the individual level are likely to be masked when their identification is based on inter-individual comparisons. To circumvent the difficulty of identifying trade-offs using empirical data, we argue that their analysis should be based on approaches considering the proximate mechanisms responsible for trade-offs at the individual level. To do so, we look at trade-offs conditionally on sources of variation that confuse trade-offs identification.

We propose a Bayesian hierarchical modelling approach for analysing empirical data including a proximate mechanistic model explaining both life history variation and trade-offs. We demonstrate the relevance of our approach for statistical inference by undertaking the estimation of the model unknowns from simulated data. Then, we illustrate our approach with a real case study on stream-dwelling juvenile Atlantic salmon in the Scorff River (Southern Brittany, France). We show that our approach reveals underlying trade-offs that would remain concealed if underlying mechanisms are not modelled. Our model opens up interesting prospects for the study of life history evolution using observational data. It allows to explore major evolutionary processes such as phenotypic plasticity and evolutionary trade-offs at once. It is a generic tool that could be applied to a wide range of taxa and to different life cycles.