Open Questions in Comparative Nutrition

Subjects: Zoology
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Achieving a better understanding of the consequences of nutrition to animal fitness and human health is a major challenge of our century. Nutritional ecology studies increasingly use nutritional landscapes to map the complex interacting effects of nutrient intake on animal performances, in a wide range of species and ecological contexts. Here, we argue that opening access to these hard-to-obtain, yet considerably insightful, data is fundamental to develop a comparative framework for nutrition research and offer new quantitative means to address open questions about the ecology and evolution of nutritional processes

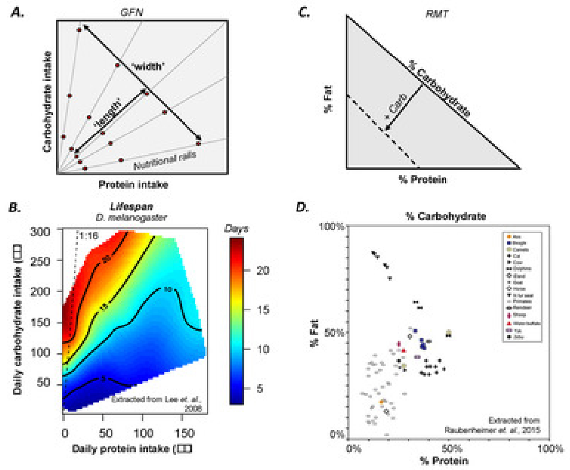
Keywords: nutritional ecology ; geometric framework for nutrition ; performance landscape ; open data

1. Introduction

The World Health Organisation (WHO) estimates that ca. 2.4 billion adults experience health-related problems due to malnutrition (https://www.who.int/en/news-room/fact-sheets/detail/malnutrition). Such alarming numbers have prompted scientists, clinicians, and policy makers to develop a more integrative nutrition science, by focusing their research on the effects of nutrition across a wide variety of contexts, spanning from fundamental science involving animal nutrition and the consequences to animal behaviour and evolution to human disease [1,2].

2. History

In recent decades, the conceptual framework known as the geometric framework for nutrition (GFN; Figure 1) [3] has revolutionized research in nutritional ecology by taking into account how variation in the quantity and balance of nutrients in foods can affect the development, metabolic health, reproduction and ageing of animals [2]. The GFN allows for direct experimental assessment of the effects of multiple nutrients and their calorie intakes on performance traits and ultimately fitness expression (e.g., Figure 1A,B) [4]. This has brought key insights into the nutritional factors of a wide variety of physiological and behavioural phenomena across feeding guilds (e.g., herbivores, carnivores, and omnivores) and taxonomic groups (e.g., slime moulds, insects, fish, birds, and mammals) [2,5]. These progresses in nutrition research also have far reaching implications in various areas of biology, ecology and evolution, including to our understanding of contemporary diseases affecting human societies [6]. Here, we argue that making GFN data open access has considerable benefits to advancing the broad field of nutrition research and tackling open questions on the ecology and evolution of nutritional processes through quantitative comparative approaches of complex nutritional systems across ecological contexts and scales of organisations. To do so, we provide an up-to-date summary of available data and a guideline for the standardized sharing of future data.



E.

Species	Protein	Carb.	Fat	Day	Trait value	Trait ID	Replicate	Nutrient source	Feeding guild	Type	Season	Additional _info
Sp_A	intake	intake	intake	1	150	Number_ eggs	1	Brand_A	Herbivore	Lab	NA	Diet_ recipe
Sp_B	%	%	%	1	130	Body_ mass	2	Prey_X	Predator	Field	Spring	Sampling_ method
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Figure 1. Overview of the geometric framework for nutrition (GFN). (**A**) Schematic representation of the performance landscape plotted in a two-dimensional nutrient space (here defined by protein (P) and carbohydrate (C) intake). Nutritional rails are diets with varying PC ratios. Red dots represent the concentrations of the different diets. The 'width' of the landscape is determined by the nutritional rails. The 'length' of the landscape is determined both by the concentrations within each rail and the individual variation in nutrient intake within each rail. (**B**) Empirical performance landscape (i.e., lifespan) from a GFN study in *Drosophila melanogaster* (extracted from [7]). (**C**) Schematic representation of the Right-Angle Mixture Triangle (RMT) used to assess diet mixtures primarily in field studies. Note that the % of carbohydrate in the mixture increases as the axis moves towards the origin (solid arrow) so that the mixture is constrained within the limits delimited by the dashed isocline. (**D**) Empirical Right-Angle Mixture Triangle (i.e., milk composition) from a field study (extracted from [12]). (**E**) Template for storing and sharing GFN data. An Excel (.csv) version is provided in Appendix A.

3. Development

Open data have the potential to transform biological and ecological sciences with a new depth of information that can facilitate advances across disciplines and explore broader-scale patterns [19]. Nutritional ecology is not an exception and will assuredly greatly benefit from this practice, since good quality data are particularly hard to obtain. Just like the adoption of performance landscapes has brought new fundamental insights into the ecology and evolution of nutrition [4,6,7,17], formally comparing large quantities of landscapes based on data sharing will allow for new kinds of quantitative analyses characterizing the responses of individuals to nutritional conditions from different life-stages, populations and species. Recent studies have already demonstrated the potential for new theoretical and comparatives avenues of research with open data in nutritional ecology [16,17]. For instance, we developed a quantitative approach to compare GFN performance landscapes within and between species, and revealed major differences in the reproductive responses of *Drosophila melanogaster* (data from [7]) and the tephritid *Bactrocera tryoni* (data from [20]), whereby the species-specific reproductive responses are driven by differences in protein (but not carbohydrate) intake [17]. Likewise, comparative studies on the relative composition of diets using the RMT have provided key insights into the nutritional ecology of higher vertebrates in the wild including marine predators [21] as well as primates (including humans [22,23]; see above). Beyond nutrition research, strictly speaking, these data could be used to study a broad range of biological interactions mediated by food and quantitatively address general problems in ecology and evolution. Are there nutritional adaptations required for sociality? How do nutritional interactions mediate host–parasite evolution? To what extinct do nutritional adaptations shape species assemblages? How do nutritional constraints associated with trophic levels determine evolutionary trade-offs? Many of these questions could be addressed through meta-analyses of open nutritional data.

Nutritional ecology studies increasingly use nutritional landscapes to map the complex interacting effects of nutrient intake on animal performances, in a wide range of species and ecological contexts. Here we encourage authors to adopt a common guideline to share their raw data. Opening access to these hard-to-obtain, yet considerably insightful data is fundamental to develop a comparative framework for nutrition research and offer new quantitative means to address open questions about the ecology and evolution of nutritional processes.