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Foraging Theory and Nutritional Ecology: A Mini Review

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Abstract

Originally, two disciplines of study have created theory surrounding foraging and feeding that has influenced biology more broadly: optimal foraging theory and nutritional ecology. While these fields primarily developed concurrently, they are complementary, with each offering unique capabilities. We illustrate how nutritional geometry, a method developed in the study of insect nutrition, has offered a framework for merging fundamental components of optimal foraging theory into nutritional ecology. This synthesis provides a foundation for integrating with foraging and feeding the various parts of biology that are linked to nutrition and is currently influencing diverse sectors of the biological and biomedical sciences.

Keywords: Biological sciences • Nutritional ecology • Enviornment

Introduction

Many aspects of biology rely on foraging and feeding. Historically, optimal foraging theory (OFT) and nutritional ecology [1,2], have developed theory around these behaviours that has influenced biology more broadly. While both studies developed primarily in tandem, the study of insect nutritional ecology has lately led to a combination of optimal foraging and nutritional ecology techniques, which is currently influencing many areas of biology and biomedical science. OFT's parent discipline, behavioural ecology, arose from the general question of how animals manage environmental difficulties in a way that promotes their fitness. OFT made an important contribution by drawing a connection between foraging and economic decision-making and introducing economic-inspired mathematical techniques for simulating animal foraging decisions. This method necessitates the designation of a variable that correlates with fitness as a 'currency' to represent the proximate aim of foraging, that is, that which an optimal forager should maximise or minimise. The amount of energy gained (to be maximised), the time spent gaining energy (to be reduced), or their interaction (rate of energy gain) were early accepted as general foraging currencies, assuming that they would apply across varied conditions and taxa [3-5].

Literature Review

The investigation of insect feeding and foraging took a different path. Insect studies were concerned with elucidating what the foraging currencies actually were, how they influenced performance (survival, growth, and reproduction), and the proximal mechanisms through which diet influenced behaviour and performance, rather than assuming a simple, universal currency as a strategy for understanding the evolution of foraging. Some workers first focused on nutrition as the forage currency. The paradigm is integrative in the sense that it models food component interactions and their consequences at several levels, including physiology, behaviour, development, performance, and ecology. In this paper, we demonstrate how recent advances in NGF have enabled the combination of precise viewpoints of insect nutritional ecology with the adaptive method of OFT to provide novel perspectives on foraging and feeding [6].

Description

In recent years, various reviews have been conducted on the logic, structure, and range of use of NGF. As a result, we limit our treatment to the key parts of foraging theory that are most important in the current scenario. We begin by showing how the main components of nutritional ecology — intake regulation and its repercussions — are represented in NGF models using examples. The concept of homeostasis, which is vital in regulating the animal's responses to its nutritional environment and so disclosing to researchers what the animal has evolved to prioritise, is a fundamental component of NGF. Borrowing from control theory, NGF expresses animal nutritional goals as points or tiny regions in a 'nutrient space' termed 'targets'. As a result, the 'intake target' (IT) is a geometric representation of the nutritional mixture that the regulatory systems aim for via foraging and feeding. ITs have been empirically measured in laboratory studies of various insect species. The concept of homeostasis, which is vital in regulating the animal's responses to its nutritional environment and so disclosing to researchers what the animal has evolved to prioritise, is a fundamental component of NGF. Borrowing from control theory, NGF expresses animal nutritional goals as points or tiny regions in a 'nutrient space' termed 'targets'. As a result, the 'intake target' (IT) is a geometric representation of the nutritional mixture that the regulatory systems aim for via foraging and feeding. ITs have been empirically measured in laboratory studies of various insect species [7].

Many ecological situations restrict animals from consuming a balanced diet due to constraints on the quantity and quality of accessible foods. The animal is then compelled to over-ingest some nutrients while under-ingesting others in comparison to the intake objective and its dietary challenge is to find a balance of deficits and surpluses that minimises the cost of this situation. Many insects' regulatory responses to such constraint, known as the 'rule of compromise' (ROC) have been assessed, but little is known about the ecological factors that generate the diversity of these reactions. Diet breadth is an exception in insect herbivores. According to theory, generalist feeders should have evolved a more adaptable nutritional physiology that allows them to withstand food surpluses to a larger extent than specialists. Several studies have offered evidence for this, including comparisons between closely related generalists and specialists, as well as phenotypes that originate from the same genotype.

In certain situations, these associations have been investigated in the context of nutritional quality variation across the life cycle. The effect of larval feeding on lifespan and in mediating the trade-off between survival and sexually-selected physical characteristics in adults, for example, has been studied. Other research has looked at the trade-off in ovipositing female flies between optimising their own nutrition vs offspring nutrition, as well as the

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effect of parental nutrition on offspring growth, viability, and adult body size and shape. NGF was employed in one integrative study to evaluate the relationships between sexual selection, sexual conflict, and the lifespan-reproduction trade-off. We aimed to demonstrate how nutritional geometry provides a paradigm that integrates the multi-nutrient, homeostasis-centered approach of nutritional ecology with the adaptive perspective of optimal foraging in this brief overview.

Conclusion

This framework may be used directly to test ideas about foraging and feeding, and it also provides a platform for integrating the many parts of biology that are related to nutrition with foraging and feeding. We quickly illustrated this in the two situations most relevant to foraging theory, performance-related responses and behavioural measures, but the same holds true for many additional domains that we did not have time to discuss. There is one exception: in comparison to primates, NGF310-based field investigations on insects are scarce. Some laboratory work has begun to expand in this approach, for example, by integrating nutrient-temperature interactions into NGF models and addressing the intricacy of natural plant tissues versus synthetic diets (reviewed in. However, there is no replacement for field investigations to investigate the ecological and evolutionary importance of lab findings.

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