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Troublesome toxins: time to re-think plant-herbivore interactions in vertebrate ecology

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Abstract

Earlier models of plant-herbivore interactions relied on forms of functional response that related rates of ingestion by herbivores to mechanical or physical attributes such as bite size and rate. These models fail to predict a growing number of findings that implicate chemical toxins as important determinants of plant-herbivore dynamics. Specifically, considerable evidence suggests that toxins set upper limits on food intake for many species of herbivorous vertebrates. Herbivores feeding on toxin-containing plants must avoid saturating their detoxification systems, which often occurs before ingestion rates are limited by mechanical handling of food items. In light of the importance of plant toxins, a new approach is needed to link herbivores to their food base. We discuss necessary features of such an approach, note recent advances in herbivore functional response models that incorporate effects of plant toxins, and mention predictions that are consistent with observations in natural systems. Future ecological studies will need to address explicitly the importance of plant toxins in shaping plant and herbivore communities.

The importance of plant-herbivore interactions

By definition herbivores depend on plants to survive. The need to obtain suitable food in sufficient amounts drives innumerable herbivore behaviors; for example, movement decisions often are related to the distribution and abundance of plant resources [1]. By the same token, herbivores can exert strong effects on plant growth, survival, and population size by virtue of their feeding habits. Plant demographic effects are especially severe during cyclical peaks or irruptions in herbivore populations [2,3]. Moreover, the ecological effects of herbivores can extend beyond populations. Differential foraging among species can affect outcomes of competition, facilitate invasion of extant communities, and alter patterns of plant succession, diversity, and dominance [4-6].

Conventional modeling approaches

When focusing on optimal diet choice by herbivores, ecologists traditionally have relied on linear programming or linear dynamic programming methods [7,8]. Given a choice of two or more non-equivalent food types, these methods solve for optimal diet composition subject to constraints imposed by daily energy requirements, feeding time, digestive capacity, or nutrient requirements. Linear programming appears to provide reasonable predictions of diet composition for many species [9].