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Plant Toxicity, Adaptive Herbivory, and Plant Community Dynamics

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Abstract

We model effects of interspecific plant competition, herbivory, and a plant's toxic defenses against herbivores on vegetation dynamics. The model predicts that, when a generalist herbivore feeds in the absence of plant toxins, adaptive foraging generally increases the probability of coexistence of plant species populations, because the herbivore switches more of its effort to whichever plant species is more common and accessible. In contrast, toxin-determined selective herbivory can drive plant succession toward dominance by the more toxic species, as previously documented in boreal forests and prairies. When the toxin concentrations in different plant species are similar, but species have different toxins with nonadditive effects, herbivores tend to diversify foraging efforts to avoid high intakes of any one toxin. This diversification leads the herbivore to focus more feeding on the less common plant species. Thus, uncommon plants may experience depensatory mortality from herbivory, reducing local species diversity. The depensatory effect of herbivory may inhibit the invasion of other plant species that are more palatable or have different toxins. These predictions were tested and confirmed in the Alaskan boreal forest.

Key words: functional response; plant competition; herbivory; plant toxin; adaptive foraging; mammalian herbivores; boreal forest.

Introduction

Herbivores can affect plant populations and plant communities by altering plant competition, facilitating the invasion of extant plant communities by new plants (invaders), and modifying the trajectory (rate and outcome) of plant community succession (Crawley 1983; Harper 1977). In response to herbivory, plants have evolved a variety of defenses, including chemicals that are toxic to herbivores (reviewed by Stamp 2003; Dearing and others 2005). In counter-response, many herbivores have evolved offensive tactics to counteract plant defenses (reviewed by Karban and Agrawal 2002; Provenza and others 2003; Villalba and Provenza 2005). General models that incorporate the inter-

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Author Contributions: This study was conceived by JPB. The original version of the toxin-determined functional response model (TDFRM) was developed by JPB, ZF, and RKS. DLD made a significant modification of the model by incorporating the choice parameter for herbivore's ingestion and provided suggestions for analysis and simulations. DLD, ZF, and RL performed most of the model analysis and simulations. JPB and KK designed field experiments, collected and analyzed data (for parameter estimation). FSC has provided many insightful comments that played an important role in making sure that the model analysis is guided by biological questions and facts. All authors contributed to writing of the manuscript.

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