Antonio J. Golubski, Kennesaw State University, Kennesaw, GA
Edward B. Baskerville, University of Michigan, Ann Arbor, MI
Mercedes Pascual, University of Michigan & Howard Hughes Medical Institute, Ann Arbor, MI

Food web effects of different types of interaction modifications

When ecologists model the dynamics of large communities, they most commonly use food web models. These omit widespread and important non-trophic interactions, including (for example) those resulting from adaptive behavior, or many types of mutualistic benefits. Interaction modifications (IMs), which allow the magnitude of a direct interaction between two species to be affected by the density of a third, may be used to incorporate a variety of non-trophic interactions into large food web models. However, the tractability and appropriateness of this approach will depend upon the results' sensitivity to the degree abstraction of the biological details of each IM-generating mechanism. Models attempting to fully reflect the diversity of biological mechanisms behind IMs would be prohibitively complex, yet the effects of omitting such detail on model predictions are poorly understood.

Here, we explore how sensitive the effects of IMs on food web assembly models are to the assumptions used to create IMs and place them in the web. Our goal is to gain mechanistic insight into how IMs affect food web dynamics, and better understand the consequences of omitting distinct aspects of different types of IMs in order to model them under a common framework. We examine how the effects of IMs differ when comparing IMs of different sign (i.e. IMs that strengthen interactions versus IMs that weaken them), IMs with different functional forms, or IMs whose arrangement within the web is subject to all, none, or some of the structural constraints implied by adaptive foraging as the mechanism causing the IMs.

Some promising generalities did emerge. Strengthening IMs were more likely to promote coexistence when species' persistence tended to be limited by bottom-up factors (i.e. consumers could not obtain enough energy), while weakening IMs promoted coexistence when top-down factors (i.e. prey experienced too high predation pressure) were more important. These results were robust across models with different IM functional forms and different assumptions as to how IMs interacted when affecting a common link. Similarly, weakening but not strengthening IMs were capable of stabilizing a food web motif representing apparent competition (which is prone to losing a resource species), and that motif was found to be internally stable more often in the model with weakening IMs. Finally, we found that random IMs often had opposite effects on food web parameters than did otherwise similar IMs which were structured according to an adaptive foraging model (which in our case implied that all resources consumed by a given adaptive forager strengthen all of that forager's interactions, and all predators of that forager weaken all of its interactions). However, the effects of IMs which retained some but not all of the structural constraints implied by adaptive foraging were generally more similar to those of the adaptive foraging model, suggesting that those separate elements could yield some insight into the full model's effects. In all models, IM effects could again be partially explained by the overall degree to which IMs tended to strengthen versus weaken interactions.

These models highlight both how the implications of IMs can be drastically different depending upon the assumptions underlying them, and how some of their implications might nevertheless be mechanistically understandable in terms of some of their coarser features. Neither ignoring the biological details of distinct non-trophic interactions nor omitting non-trophic interactions from food web models due to their complexity is a desirable option. It is therefore important that we continue to improve our mechanistic understanding of how various non-trophic interactions affect large food webs, and what generalities might be made concerning those effects.