Structure and Management of Size-Structured Food Webs

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Introduction

Food webs are networks describing who eats whom in an ecosystem. The organizing principles underlying food webs are not fully known, but it is well established that phylogeny and individual body size are important factors. Understanding the structure of food webs is important as the interactions between species determine how the ecosystem responds to perturbations such as intense harvesting.

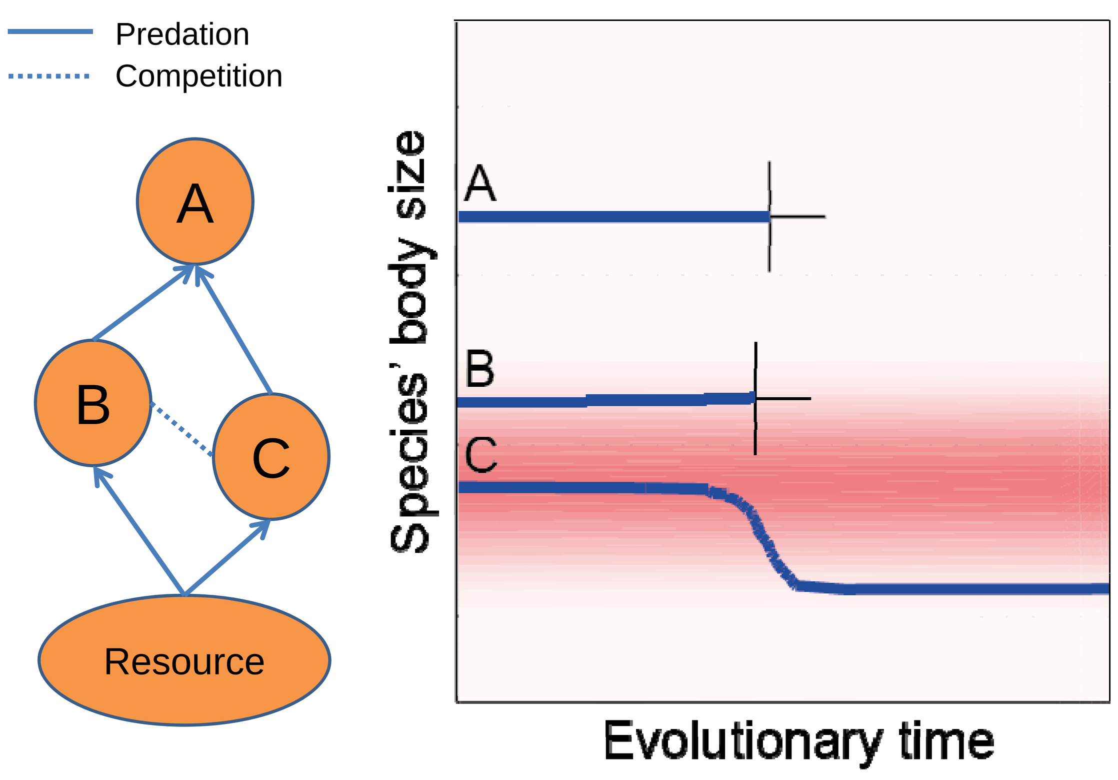
Research at IIASA's Evolution and Ecology Program has shown how fundamental evolutionary processes give rise to complex food webs. These advances have enabled a comprehensive assessment of the impacts of harvesting in ecosystems. The evolutionary perspective on food webs have also led to a reevaluation of food-web intervality, one of the most ubiquitous features of food-web structure.

Emergence of size-structured food webs

Individual size is an important factor in species interactions, with predators typically being much larger than their prey. Body size is also believed to be important in other interactions, such as interference competition.

By developing a mathematical model of food-web emergence, we have demonstrated that small mutations in species' maximum body size suffice to explain the emergence of complex food webs with several trophic levels.

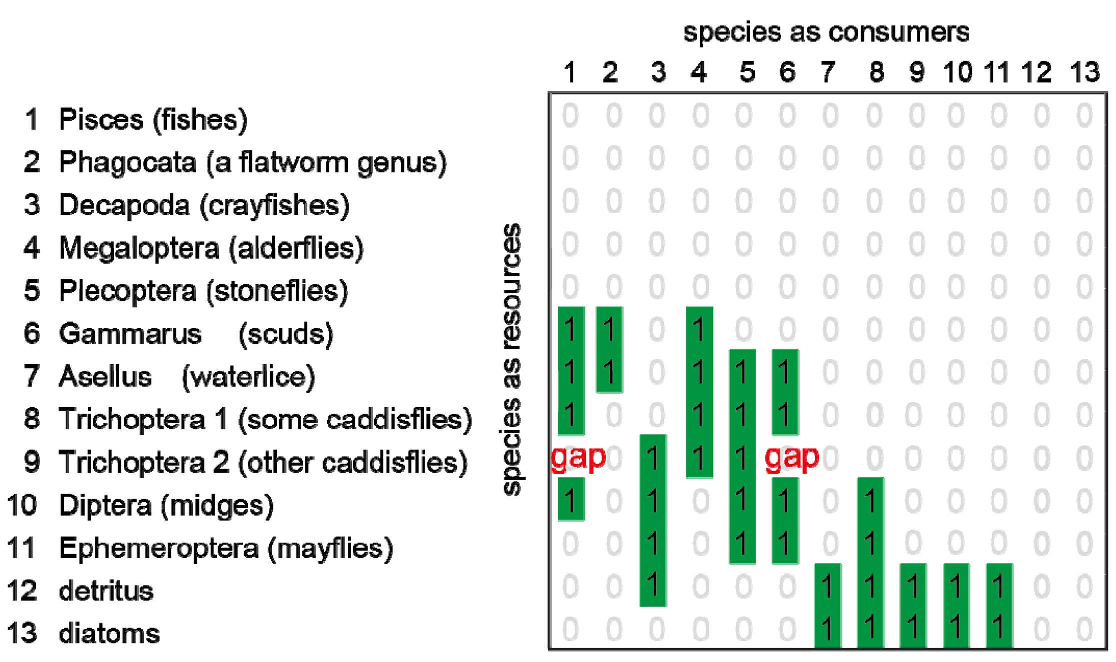
Surprisingly, this study shows that the conditions which favor the initial emergence of food webs are not the same as those that promote long-term biodiversity.



Eco-evolutionary consequences of harvesting

With the world population continuing to rise, the demand for renewable resources is mounting. Little is known, however, of how intense exploitation affects ecosystems. Building on the evolutionary food-web model described above, we have comprehensively assessed the eco-evolutionary impacts of harvesting in ecosystems.

Our investigation reveals that evolutionary changes induced by exploitation unexpectedly aggravate the risks of harvesting. The figure shows an example with harvesting primarily targeting species C in a food web. As evolution reduces the body size of species C, the changes cascade through the food web and cause the extinction of species A and B.



Evolutionary explanation of food-web structure

The central role of trophic interactions in ecology have led ecologists to search for regular patterns in food-web structure. A striking finding is that food webs tend to be interval. This means that species can be ordered such that trophic interactions form intervals without gaps, represented as green bars in the example on the left. This would be the case if predatory interactions could be predicted from a single factor.

In a ground-breaking study, we have shown that food-web intervality may be a signature of evolutionary descent, suggesting that the degree of food-web intervality could be used to measure the extent to which the ecosystem have been exposed to species invasions.

Conclusion and further reading

Although all species are embedded in ecosystems, the focus in ecology has traditionally been on a species in isolation or on pairs of interacting species. Recent increases in computational capabilities and theoretical advances, however, greatly facilitate studies of entire interacting communities. The three studies summarized above are certainly only the beginning of many important breakthroughs to come.

References

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