Ecologists roll a century's work on food-webs into a single model

August 20 2015

This cymothoid isopod (*Nerocila californica*) chews on the tongue of its mullet host (*Mugil cephalus*). Credit: Kevin Lafferty/USGS

What is the mathematical structure of the natural world?

In a paper released today in *Science*, a new model presents a common mathematical structure that underlies the full range of feeding strategies of plants and animals: from familiar parasites, predators, and scavengers to more obscure parasitic castrators and decomposers. Now ecologists can view all food-web interactions through the same lens using a common language to understand the natural world.

"Physicists use 'string theory' to decipher the universe, economists use complex regression methods to model the global economy, but what about the animals and plants that supply our food and that clean and produce the air we breathe?" said co-author Andrew Dobson, a professor in Princeton University's Department of Ecology and Evolutionary Biology.

The model captures the structure of all the consumer-resource links, plants capturing sunlight, predators eating prey, and parasites eating hosts, that connect species in food webs. "It rolls a century's worth of food-web mathematics into a single model," said U.S. Geological Survey Ecologist and lead author Kevin Lafferty.

Although ecologists have previously assumed that different food web links had different structure, for example lions eating zebras operate in different ways than viruses causing disease, this new research finds that they share a common structure, but with distinct characteristics. Insights from past ecological research as well as new ecological models can now be viewed through a common framework akin to physics or chemistry. Co-author Armand Kuris of University of California Santa Barbara considers this "the first development of a unifying theory for ecology. With this approach we can now see the entire elephant, not just some of

its parts."

Scarlet Macaws (*Ara macao*) eat hundreds of fruits a day. Credit: Kevin Lafferty/USGS

"Ecologists have long used mathematical equations to study how predators and diseases affect plant, animal and human populations," said

co-author Cheryl Briggs of UC Santa Barbara, "But these approaches have been idiosyncratic, limited in scope and full of hidden assumptions."

The model emerged from a National Science Foundation sponsored working group organized by Lafferty and Dobson at the National Center for Ecological Analysis and Synthesis, a think tank at UC Santa Barbara where ecologists tackle big problems about the environment. The group first set out to reveal the hidden role of parasites in food webs. Early discussions took the group down the same road travelled by others - trying to find different functions to fit different types of parasites and predators.

Spider monkeys (*Ateles geoffroyi*) are omnivores, often feeding on fruits and insects. Credit: Kevin Lafferty/USGS

After several years, the group realized that there was a consistent mathematical backbone underlying their efforts. Out of a jumble of seemingly unrelated and complicated mathematical expressions, they found a simple solution that generalized across a comprehensive range of ecological reactions and revealed previously unobserved similarities and hidden assumptions in classic ecological models. The solution provides a general mathematical framework for food-webs. Ecologists can use this general model to develop a deeper understanding of how the world functions ecologically; this will have profound implications for infectious diseases, fisheries, conservation and humans manage natural ecosystems.

The team anticipates their work will lead to a new generation of food web models that examine ecological structure more acutely and how that structure is responding to global change.

More information: "A general consumer-resource population model," by K.D. Lafferty et al. www.sciencemag.org/lookup/doi/ … 1126/science.aaa6224

Provided by United States Geological Survey