

UC SANTA BARBARA

# THE *Current*

July 12, 2006

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## **Study Shows That Parasites Form the Thread of Food Webs**

Scientists have discovered that parasites are surprisingly important in food webs and their findings appear in a report published this week in the Early Edition of the on-line version of the Proceedings of the National Academy of Sciences. Scientists with the University of California, Santa Barbara, the U.S. Geological Survey, and Princeton University contributed.

The report describes a study performed in Santa Barbara County at the Carpinteria Salt Marsh. Carpinteria Salt Marsh Reserve is one of several natural reserves set aside by the University of California for research and teaching.

Food webs trace the flow of energy through an ecosystem. They extend the concept of food chains -- those who-eats-whom sequences -- to biological communities. Food webs rarely include parasites because of the difficulty in quantifying them by standard ecological methods. Parasites are small and invisible, hidden inside their hosts. However, parasites strongly affect food web structure and parasite links are necessary for measuring ecosystem stability, according to the study.

"Food web theory is the framework for modern ecology," said Kevin Lafferty, a scientist with the USGS Western Ecological Research Center who is based at UC Santa Barbara and is lead author of the study. "Parasites have been missing from this framework and, as a result, we know relatively little about the role of parasites in ecosystems. It's like driving with a highway map, but with no knowledge of the

smaller road network. To reach most destinations, you need a map with both."

Using data from four relatively comprehensive food webs that contain parasites, Lafferty and his coauthors examined if and how parasites affected the food webs. They found that parasites dominated the food web links between species; on average, a food web contained more links between parasites and their hosts than between predators and their prey.

"Parasites may well be the thread that holds the structure of ecological communities together," said study coauthor Andrew Dobson of Princeton University.

Additionally, the researchers' analyses revealed new patterns. It's well known that vulnerability to predators decreases at the top of the food chain or highest trophic level. In this study, the scientists found that vulnerability of hosts to parasites also increased with trophic level. Consequently, animals at mid-trophic levels are the most vulnerable to natural enemies, being subjected both to diverse parasites and many predators.

"The work illustrates that 'the pyramid of life' we learn about in kindergarten is wrong!" said Dobson. "When you add parasites to food webs, the pyramid contains a second inverted pyramid of parasites that are as abundant as all the other species."

When they analyzed the Carpinteria Salt Marsh food web, the researchers calculated that parasites were involved in 78 percent of the links between species. Due to the diversity of parasites in prey species, the Carpinteria web had over twice as many predator-parasite as predator-prey links -- 1021 links compared with 505.

Parasitic trematode worms having complex life cycles involving sequential infection of multiple hosts are involved in a large number of links in the Carpinteria Salt Marsh food web. A common snail is the first intermediate host to at least 19 different kinds of trematodes at Carpinteria, involving many different kinds of birds as final hosts. The authors found that without the snail and its trematodes, 977 links would disappear from the corresponding food web. In related work, Lafferty and co-author Armand Kuris, a professor of biology at UC Santa Barbara, are currently using techniques that count trematodes in snails to assess salt marsh health.

"Few food webs have been able to consider parasites and it will take a lot of work to include them, but the message is that you can't fully understand food webs without parasites," said Lafferty. Kuris added that this study, along with other recent

research, indicates that most ecological investigations should evaluate the role of parasites because infectious diseases can be such important players.

The PNAS study opens the door to this area of study, according to Dobson. "Once we understand food web structure, we will have a much better understanding of how the loss of biodiversity will affect the quality of life for the surviving species," he said.

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