THE SANTA FE NEW MEXICAN

May 15, 2008

Ancient ecosystems a lesson in today's extinctions

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One day, more than a half-billion years ago, a single-celled creature named Ian looked over at another single-celled creature named Corey, and it thought, "Hmmm, you look mighty tasty."

In the process, as the first organism to ever eat another organism had its eureka moment, ecology was born.

After that interaction, networks of creatures evolved to eat one another in a variety of patterns, such as bigger animals eating smaller animals, groups of animals eating plants and other groups of animals eating just about anything they came across.

And those patterns turned into what ecologists call food webs, which are a highly complex ecological schematic that shows which creatures eat which in a system.

The history of those food webs and how they evolved has been hard to pin down because of, among other things, gaps in the ancient fossil record and poor quality samples.

Understanding them, however, could teach us more about the stability of modern food webs in a time when many creatures are going extinct, said Santa Fe Institute researcher Jennifer Dunne.

Dunne and Santa Fe Institute researcher Doug Erwin think they've found an interesting hunk of the history of food webs by looking at fossils in two of the world's oldest shale sediments, the 505 million-year-old Burgess Shale in British Columbia and the 520 million-year-old Chengjiang Shale from eastern Yunnan Province in China.

"Going back a half-billion years is kind of a crazy thing to do, but it was very intriguing that we could go back and look at this explosion of multicellular life and see if the food webs were significantly different," said Dunne, who is also the co-director of the Pacific Ecoinformatics and Computational Ecology Lab in Berkeley, Calif.

What they found, in the Burgess Shale, was creatures ate each other in patterns similar to those seen today. And in the older Chengjiang Shale, those patterns are only slightly different, Dunne said.

"There's a lot of very bizarre body plans back then that don't exist anymore," Dunne said. "There was a creature with five eyeballs, for instance. But despite the difference, when you look at how they organized in feeding links, they're similar to what we find today."

And their discoveries, done over the past eight years through an extensive survey of scientific information gathered by experts, show that it's possible to trace the history of food webs back through time. Before their research, nobody had tried to examine food webs from that long ago, said Erwin, who is also curator of Paleozoic invertebrates at the Smithsonian Institution.

"We have shown that we can reconstruct ancient food webs and compare them to modern webs, opening up new avenues of paleoecology," Erwin said in a news statement. "We were surprised to see that most aspects of the basic structure of food webs seem to have become established during the initial explosion of animal life."

There are some common statistics in both the ancient and modern food webs, Dunne said.

For instance, by knowing how many creatures are in a food web, ecologists can systematically determine what percentage of those species will be omnivores, predators or prey. Those percentages don't stay exactly the same from system to system, but they do scale in a predictable way, she said.

And those percentages also appear similar in the ancient rocks, she said. "The layers of predators, the complexity, the similarities are striking," Dunne said.

But with the oldest shale from China, there were a few notable differences that show a bit more about how food webs began.

One of those is that there were more loops in the oldest web than there are in subsequent webs. Loops are chains where one species eats another, and the second species also eats the first.

"So a modern example of that is the Everglades, where an invasive python eats native American alligators, but American alligators also eat pythons, depending on their size," Dunne said. "Loops aren't uncommon in modern food webs, with insects, fishes and other animals. But it was happening even more than we could have predicted in the Chengjiang Shale."

What that suggests is that food webs were much less hierarchical and more loosely arranged as the big explosion of life began in the early Cambrian time period, she said.

"It was more of an 'anything goes' aspect to the earlier food web, and things became more constrained by the Burgess Shale," Dunne said.

Looking at that information helps ecologists understand how the complex systems evolved and also what makes them more stable.

In general, the most stable systems are hierarchical ones, she added, where bigger things eat smaller ones.

"One of the hypotheses that comes out of this is it looks like the structure of food webs is very difficult to change," Dunne said. "It's very consistent over geologic time, and it's probably really hard to shift that fundamental structure."

So ecosystems on modern Earth, as extinctions continue at an accelerated rate, could be very susceptible to breaks in their structure, she said.

"People haven't really put together much good data for disturbed ecosystems," Dunne said. "So it may be when we start putting together more data for disturbed systems, if we see significant changes in the structure that would indicate a huge perturbation was happening."

What that means, generally, is that one extinction could have a massive ripple affect throughout the entire food web. And that could result in many subsequent extinctions.

It may also be that disturbed food webs will look more like the Chengjiang Shale, with creatures somewhat chaotically eating each other, although that data haven't been collected yet, she said.

Overall, there probably won't be a way to figure out how the networks evolved from when single-celled Ian ate Corey to the much more complex systems in Chengjiang Shale and subsequent rocks, but looking at links between other creatures, like parasites, microbes and bacteria could one day get scientists closer to those answers, Dunne said.

"This is really an aspect of research into the origins of life," Dunne said. "It has really just captured our imaginations. And we're really hoping to look further into the origins of ecosystems."

A paper on the topic, titled "Compilation and Network Analysis of Cambrian Food Webs," written by Dunne, Erwin and three other scientists, was published in the April edition of the journal *PLoS Biology*. It is available for free online at www.plosbiology.org .
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