EVOLUTION

Putting Limits on the Diversity of Life

A new way to analyze the fossil record is suggesting that life, despite its many evolutionary innovations, long ago hit a limit to its diversity

Life only gets bigger and better, or so one might infer from the history of marine life that paleontologists have drawn up in the past few decades. The number of distinctly different kinds of organisms living in the sea may have taken a hit now and again, but over the long haul ocean life has only become more and more diverse, the data seemed to show. But now a recount of fossils is giving paleontologists second thoughts about that ever-upward trend.

In a new record of life published this week in *The Proceedings of the National Academy of Sciences* (*PNAS*), 25 paleontologists demonstrate a fresh approach to extracting a history of life from an imperfect fossil record imperfectly sampled by paleontologists for 180 years. And the group's first, preliminary results suggest that previous studies may indeed have overstated life's penchant for diversification. Although far from the last word, the method marks a turning point in the study of paleontological databases, says co-author Richard Bambach of Virginia Polytechnic Institute and State University in Blacksburg. "This isn't the end of the story, but it's a step in the direction we want to go," he says.

Paleontologists wouldn't need a new record of diversity if their predecessors had done it right the first time—laboriously sampling and documenting all the accessible exposures of fossil-bearing rock around the world. Instead, earlier researchers searched most intensively nearest to home—mostly Europe and North America—and often pursued paleontological novelty rather than systematic surveying. Making the best of a bad situation, one paleontologist spent 20 years compiling a now-classic diversity record from the hodgepodge of published and unpublished data. John "Jack" Sepkoski of the University of Chicago, who died in 1999 at the age of 50, combed reports of marine fossil finds and created a "phone book" that listed each fossil genus by name, the first time it appeared in the fossil record, and the last time it appeared. From that database he plotted a diversity curve (see top figure) that rose sharply 500 million years ago as life burgeoned in the Cambrian "explosion," plateaued in the Paleozoic era, and then rose steeply and steadily from the Mesozoic to the present day. Read literally, Sepkoski's curve implied that the great Permian-Triassic mass extinction at the end of the Paleozoic 250 million years ago somehow reignited life's drive to diversify. Life in the seas became more active, more predatory, and continually more varied as the so-called modern fauna found new ways to thrive.

A nice story. But has diversity really tripled since the Paleozoic? "We may have been misled for 20 years," says paleontologist Douglas Erwin of the National Museum of Natural History in Washington, D.C. "There may be some real problems." The biggest may be that the harder paleontologists look at a particular rock outcrop or at outcrops from the same slice of geologic time, the more kinds of fossils turn up. With the meager information in his phone book–style compilation, Sepkoski had no way of correcting for the wide range of sampling intensities from time to time or place to place or for other potential biases.

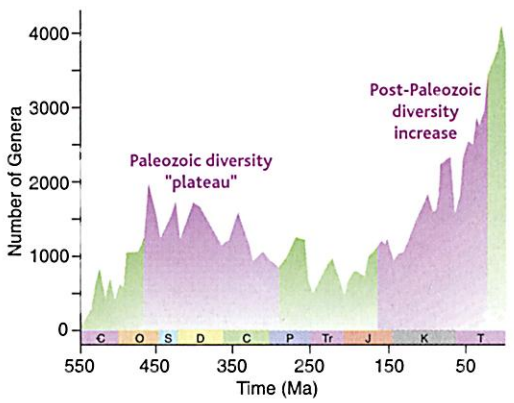
To fill the gap, paleontologists John Alroy of the University of California, Santa Barbara (UCSB), Charles Marshall of Harvard University, 23 colleagues, and dozens more contributors are assembling the Paleobiology Database. Housed at the National Center for Ecological Analysis and Synthesis at UCSB, the still-growing database records a range of information beyond first and last appearance. Perhaps most important, it contains the reported occurrences of a genus through time and space.

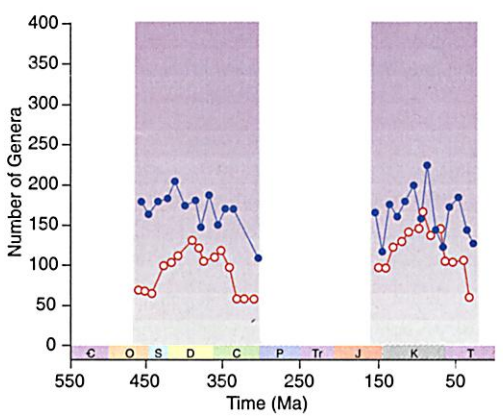
Drawing on the compiled information, Alroy and his colleagues sliced geologic history into 10-million-year intervals and used statistics to try to even out the effects of varying sampling intensity in each interval. To bracket as many ways of correcting for bias as possible, the group tried four ways to standardize the data and two ways to count fossil occurrences—a total of eight different statistical recipes.

All eight approaches had much the same effect on the diversity curve (see bottom figure). "What's surprising is that diversity in the post-Paleozoic up to the Oligocene [24 million years ago] doesn't shoot up as extremely as was originally found in Jack's data set," says co-author David Jablonski of the University of Chicago. If diversity really hasn't risen much since the Paleozoic, then all of life's innovations in the oceans since the days of the trilobites—from new predators to armored snails and burrowing clams—have been unable to break through some set ceiling on diversity.

"This paper represents a real step forward," says ecologist Michael Rosenzweig of the University of Arizona in Tucson. "For the first time, a large group of people is saying paleobiology has been making a mistake, that it's very important to deal with sampling issues. And when you try to get rid of the biases, the diversity curve looks a lot flatter."

Rosenzweig, like Alroy and his colleagues, regards the paper as a progress report on the road to a larger and more thoroughly analyzed paleo data set. But even the most sophisticated data mining, the scientists warn, might not extract the true history of diversity. Paleontologist Jeremy Jackson of Scripps Institution of Oceanography in La Jolla, California, thinks existing data are still too biased to do the trick. It may be "the information isn't there to begin with," he says. The compilers of the Paleobiology Database intend to find out. –RICHARD A. KERR





Upward or onward? Where Sepkowski's numbers *(above)* told of steadily increasing marine diversity, a recount *(below)* shows a 400-million-year plateau.

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