Research shows that sea urchins, sand dollars thrived with time

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Sea urchins, a small sampling shown here, originated about 265 million years ago, and have diversified through episodic bursts over time. Credit: AMNH

A new study about echinoids—marine animals like sea urchins and sand dollars—gives scientists a reason to rethink a classical pattern of evolution. Fossil-based studies have traditionally indicated that groups of organisms diversify fastest early in their evolutionary history, followed by a steady decline through time. But the new work on Echinoidea, published this week in the *Proceedings of the National Academy of Sciences*, contradicts that expectation, showing that rates of evolution were actually lowest at the group's onset and increased over time through episodic bursts associated with changes in the animals' feeding strategies.

"This study demonstrates the dynamic nature of evolutionary change within major groups of organisms," said Melanie Hopkins, one of the co-authors on the study and an assistant curator in the American Museum of Natural History's Division of Paleontology. "It might sound obvious, but we've been able to show here how scale plays a large role in how rates of evolutionary change are interpreted. The pattern you see over one hundred thousand years will usually look much different than what you see over one hundred million years. And it's going to vary depending on the part of the family tree you're looking at as well."

To examine evolutionary changes over a long time scale of a very complete family tree, Hopkins and her colleague Andrew Smith, a paleontologist at the Natural History Museum, London, looked at echinoids, which originated about 265 million years ago. Sometimes referred to as sea hedgehogs because of their hard shells that are covered in spines, about 950 different species of echinoids live in today's oceans.

"Echinoids have a complex skeleton made of interlocking calcite plates that makes them ideal for studying morphological evolution, and have evolved to occupy a wide range of ecological niches," said Smith.

Hopkins and Smith applied recently developed methods for estimating rates of morphological, or physical, changes among echinoids, from the Permo-Triassic mass extinction 251 million years ago—the greatest extinction event in Earth's history—to today. Contrary to expectation, they found that the rates of evolution were lowest immediately following the extinction event and increased over time.

"Many clades appear to have high initial rates, followed by slow-downs as ecological space fills," Hopkins said. "Here, we show a case where evolutionary rates in a large group of animals show a net increase over time instead."

But the increase hasn't been smooth: It was punctuated by bursts of diversification throughout time that coincide with shifts in the animals' feeding strategies. For example, the evolution of gravity-assisted deposit feeding by sand dollars in the Eocene (which occurred between 56 to 34 million years ago) corresponds with a significant spike in morphological innovation. This strategy, which many sand dollars still use today, involves lying flat underneath a thin layer of sand—mouth side down—and using tube feet and mucous-filled channels to bring food particles to the oral cavity, having sifted them out of the sand.

The new research indicates the evolutionary stories behind many clades—not just echinoids—might be more complex than has previously been shown.

More information: *PNAS* www.pnas.org/cgi/doi/10.1073/pnas.1418153112

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