Research will shed light upon the family tree of deep-sea fishes

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The deep sea could be the largest habitat for life on Earth yet to be methodically explored. Due to chilly temperatures, extreme depth and an eerie darkness below about 650 feet, it can be technologically arduous and very expensive to collect and observe the biodiversity that thrives in this mysterious ecosystem.

"Collecting deep-sea fishes is engaging, challenging and rewarding work," said Matt Davis, a research associate with the Biodiversity Institute at the University of Kansas. "Often it requires a lot of dedication to long shifts —12 to 16 hours—on a boat where a ton of various activities are taking place simultaneously. The trawl net is being dropped and emptied on board 24 hours a day, leading to a near-constant stream of new specimens needing to be identified, photographed and measured. These trips often last anywhere from a week to months, and every trip brings new challenges and discoveries."

Now, Davis and Leo Smith, an assistant professor of ecology and evolutionary biology at KU, have earned a three-year, $575,000 grant from the National Science Foundation to study evolutionary patterns and diversity in three lines of widespread deep-sea fishes: lizardfishes, lanternfishes and dragonfishes.

"We are very interested in what factors have shaped the present-day biodiversity that we observe in the deep sea," said Davis. "One aspect of this involves studying patterns of how lineages have diversified and accumulated over time. In general, we are interested in identifying periods in evolutionary history where the evolution of a group is significantly altered in terms of rates of speciation and extinction."

According to the KU researchers, who are working with colleague John S. Sparks at the American Museum of Natural History, many species associated with these lineages share common physical traits.

"There are a few anatomical features that a lot of people identify with deep-sea fishes that are, in general, great examples of evolution occurring in this environment," Davis said. "Among these are large dagger-shaped teeth, which many predatory deep-sea fishes employ to trap and contain prey. It's also very common for the body of deep-sea fishes to be either black or red. Few deep-sea organisms are capable of seeing the color red, as the wavelength for this color does not travel very far in water. Fishes that are bright red are effectively invisible to a lot of other organisms in the deep-sea."

Another usual trait among deep-sea fishes is bioluminescence —the ability of an organism to produce and emit light—which gives them advantages at great depths.

"This is incredibly common in marine environments, particularly in the deep sea where there is little to no penetrable sunlight," Davis said. "Most deep-sea fishes emit and display bioluminescent light through a variety of fascinating anatomical structures, such as the lure of an anglerfish, or modified scales, called photophores, that can aid in the reflection and transmission of light. There are many hypothesized functions for bioluminescence, including attracting prey, communication and camouflage."

Likewise, many fishes that inhabit waters below 650 feet or so are hermaphrodites, such as dragonfishes, which are capable of switching their sex over the course of their lifetimes. Others, like tripodfishes and lancetfishes, can produce both eggs and sperm at the same time.

"Some have hypothesized that being able to alter the type of gamete produced over the course of one's life history may provide a reproductive advantage in an environment where it may be difficult to find a mate," Davis said.

In addition to expeditions to collect deep-sea fishes, the KU researchers will rely on established collections of fossil fishes to trace how various deep-sea fish evolved.

"Because deep-sea fishes are quite difficult to collect, some of the biodiversity may only be known from a single collecting trip in one particular area of the world," said Davis. "For this reason, museum collections are a fundamental aspect to understanding Earth's biodiversity, including life in the deep sea. We will be working closely with the collections of many museums to accomplish our work, such as The Field Museum, American Museum of Natural History, Scripps Institution of Oceanography, Museum of Comparative Zoology and, of course, the Biodiversity Institute right here at KU."

The KU researcher explained that Kansas, even though it is landlocked, has given researchers a trove of information about the ancestry of present-day deep-sea life.

"Many fossils that are attributed to deep-sea fishes are identified from deposits where there was a marine environment covering what is now exposed land," Davis said. "Some of the most famous marine fossils in the world are actually known from Kansas, in the Niobrara Chalk. This Late Cretaceous formation is filled with marine fossils from the Western Interior Seaway that covered a large portion of what is now Kansas. Among these fossils are large marine reptiles, such as mosasaurs, and fishes, including Xiphactinus, a predatory fish that could reach lengths of up to 20 feet."

Provided by University of Kansas