American Museum of Natural History

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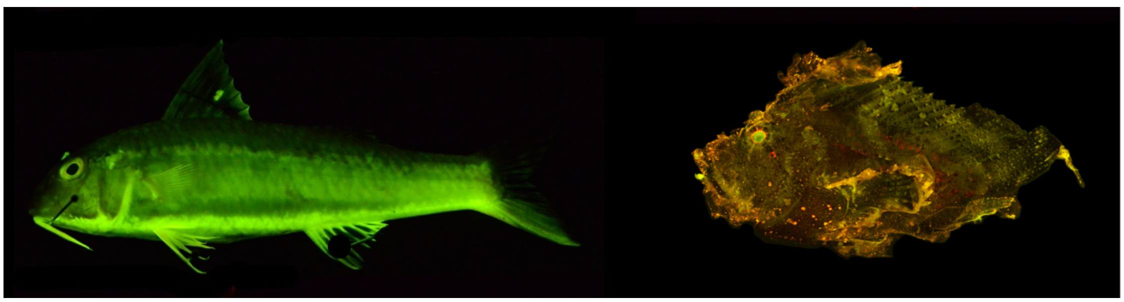
Research Reveals That Fish Biofluorescence Evolved More Than 100 Times in 112 Million Years

Two new studies on marine fish biofluorescence find a close link to coral reefs and a wide range of dazzling colors



New research led by scientists at the American Museum of Natural History sheds light on the ancient origins of biofluorescence in fishes and the range of brilliant colors involved in this biological phenomenon. Detailed in two complementary studies recently published in *Nature Communications* and *PLOS One*, the findings suggest that biofluorescence dates back at least 112 million years and, since then, has evolved independently more than 100 times, with the majority of that activity happening among fish that live on coral reefs.

The new work also reveals that in marine fishes, biofluorescence—which occurs when an organism absorbs light, transforms it, and emits it as a different color—involves a greater variety of colors than previously reported, spanning multiple wavelengths of green, yellow, orange, and red.

"Researchers have known for a while that biofluorescence is quite widespread in marine animals, from sea turtles to corals, and especially among fishes," said Emily Carr, a Ph.D. student in the Museum's Richard Gilder Graduate School and the lead author on the two new studies. "But to really get to the root of why and how these species use this unique adaptation—whether for camouflage, predation, or reproduction—we need to understand the underlying evolutionary story as well as the scope of biofluorescence as it currently exists."

For the *Nature Communications* study, Carr led a comprehensive survey of all known biofluorescent teleosts—a type of bony fish that make up by far the largest group of vertebrates alive today. This resulted in a list of 459 biofluorescent species, including 48 species that were previously unknown to be biofluorescent. The researchers found that biofluorescence evolved more than 100 times in marine teleosts and is estimated to date back about 112 million years, with the first instance occurring in eels.

The team also found that fish species that live in or around coral reefs evolve biofluorescence at about 10 times the rate of non-reef species, with an increase in the number of fluorescent species following the Cretaceous-Paleogene (K-Pg) extinction about 66 million years ago, when all of the non-avian dinosaurs died off.

“This trend coincides with the rise of modern coral-dominated reefs and the rapid colonization of reefs by fishes, which occurred following a significant loss of coral diversity in the K-Pg extinction,” Carr said. “These correlations suggest that the emergence of modern coral reefs could have facilitated the diversification of fluorescence in reef-associated teleost fishes.”

Of the 459 known biofluorescent teleosts reported in this study, the majority are associated with coral reefs.

For the *PLOS One* study, Carr and colleagues used a specialized photography setup with ultraviolet and blue excitation lights and emission filters to look at the wavelengths of light emitted by fishes in the Museum’s Ichthyology collection. Collected over the last decade and a half on Museum expeditions to the Solomon Islands, Greenland, and Thailand, the specimens in the study were previously observed fluorescing, but the full range of their biofluorescent emissions was unknown.

The new work reveals far more diversity in colors emitted by teleosts—some families of which exhibit at least six distinct fluorescent emission peaks, which correspond with wavelengths across multiple colors—than had previously been reported.

“The remarkable variation we observed across a wide array of these fluorescent fishes could mean that these animals use incredibly diverse and elaborate signaling systems based on species-specific fluorescent emission patterns,” said Museum Curator John Sparks, an author on the new studies and Carr’s advisor. “As these studies show, biofluorescence is both pervasive and incredibly phenotypically variable among marine fishes. What we would really like to understand better is how fluorescence functions in these highly variable marine lineages, as well as its role in diversification.”

The researchers also note that the numerous wavelengths of fluorescent emissions found in this study could have implications for identifying novel fluorescent molecules, which are routinely used in biomedical applications, including fluorescence-guided disease diagnosis and therapy.

Other authors involved in this work include Rene Martin, from the Museum and the University of Nebraska-Lincoln; Mason Thurman, from Clemson University; Karly Cohen, from California State University; Jonathan Huie, from George Washington University; David Gruber, from Baruch College and The Graduate Center, City University of New York; and Tate Sparks, Rutgers University.

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Images:
Two species of biofluorescent fish studied for this work: Left, an ochre-banded goatfish (*Upeneus sundaicus)* and right, a leaf scorpionfish (*Taenianotus triacanthus*)
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