

## Flatfish found to be "chameleons" of the sea

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New experiments with tropical flounders indicate the flatfish are masters of camouflage.

In experiments headed by Vilayanur Ramachandran, a professor of psychology and neurosciences at UC San Diego, the fish were observed to use visual cues to dramatically change their appearance in order to blend in with their surroundings. In as little as 2-8 seconds, the fish were able to alter their surface markings to resemble everything from checkerboards to beach sand. The results are published in the Feb. 29 issue of the journal *Nature*.

"The changes these fish are capable of undergoing are amazing -- and they do it with such astonishing speed," said Ramachandran, director of the Brain and Perception Laboratory at UCSD.

In experiments conducted at UCSD's Scripps Institution of Oceanography, Ramachandran and colleagues rotated specimens of the Caribbean shallow water flatfish *Bothus ocellatus* between four small plastic tanks filled with saltwater. The bottoms of the tanks were covered with a variety of patterns, including printed checkerboards, fine yellow beach sand, a gray sheet and gravels with varying grain sizes.

Each time a fish was transferred to a different tank, it would rapidly survey the new environment with its stalk-like eyes and change the markings on its skin to match the new background.

"We were concerned that the resemblance between the backgrounds might be an optical illusion and that the fish may not really have changed all that much," said Ramachandran. "To rule that out, we took color photos of the same fish on different backgrounds and then simply cut them out and displayed them on a plain background. It was clear that the pattern on the fish was indeed changing physically. We even used a mathematical technique called Fourier analysis to make sure the changes were physical."

One of the photos produced shows a fish on a checkerboard background whose skin is covered with large black blotches of similar size and shape as the checks. An especially striking photo shows a fish on a background of widely spaced polka dots exhibiting spots very similar to the background pattern.

An examination of the fish under a dissecting microscope revealed that they have at least seven categories of surface markings. By adjusting the contrast of these sets of markings in different ratios, the fish could blend into a wide range of natural backgrounds in much the same way that all spectral colors can be produced by mixing just three primary colors.

Although further investigation is needed, Ramachandran hypothesizes that the flounder's visual centers must have "feature detectors" that are specialized for detecting different spatial frequencies or patterns in the

surrounding environment. These detectors in turn appear to exert direct control over the corresponding set of marks on the surface of the fish's skin.

"It is almost like a direct hotline exists from the external world to the fish's skin, allowing it to match its environment," Ramachandran said.

One of the early studies of flatfish camouflage was conducted by Francis Sumner of the Scripps Institution of Oceanography. Sumner placed cold-water flatfish of the genus *Paralichthys* on checkerboards and noticed that after a few days the fish seemed to develop large splotches as if to mimic the checks. His results were recently challenged, however, by William Saidel, who studied two kinds of cold-water flounder while pursuing a Ph.D. at MIT and claimed that their ability to change appearance had been grossly exaggerated. Instead, Saidel proposed that the flatfish simply had a "universal texture" that allowed it to blend into any environment.

While Ramachandran agrees that the flatfish can blend into a variety of surroundings even without changing their surface markings, he found the creatures also were capable of dynamic camouflage to a remarkable extent. Ramachandran noted, however, that he observed these dramatic changes in tropical flatfish rather than the cold-water variety studied by Sumner and Saidel in which the changes might be less striking.

Note: Color slides available of fish exhibiting various types of camouflage

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