Study sheds light on genetics of how and why fish swim in schools

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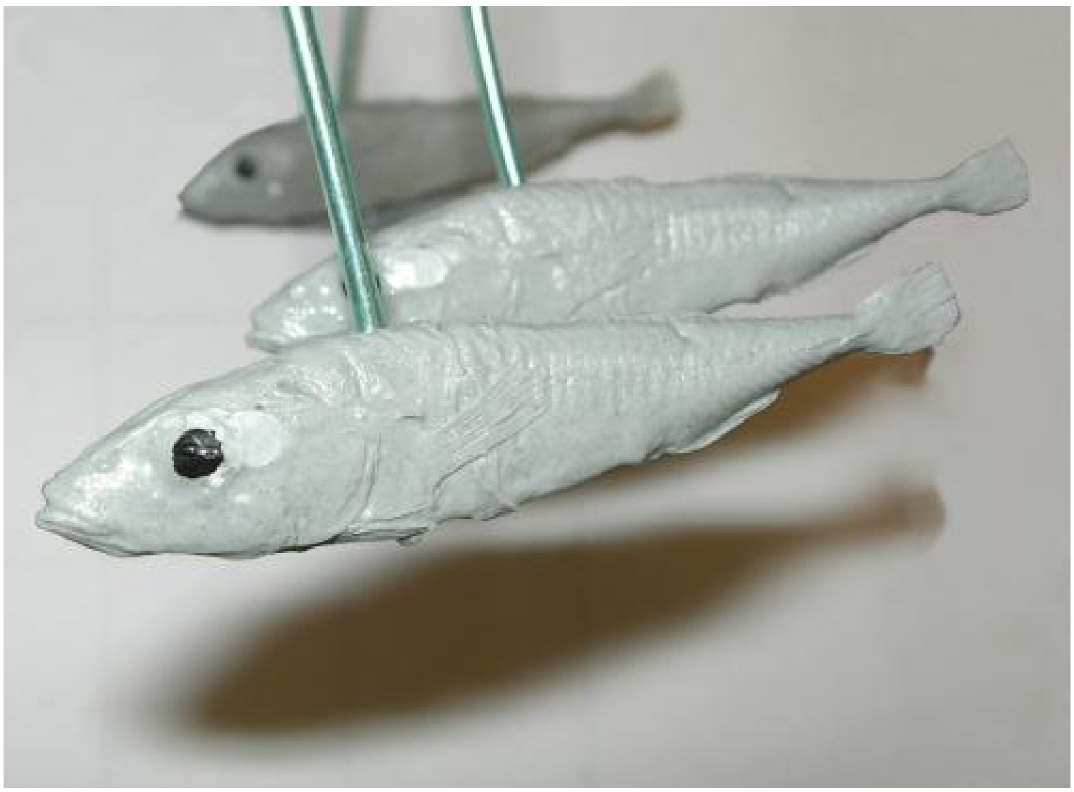

The researchers created a mold and made fish models from resin tinted with grey pigment, painting on eyes to make them look more realistic. Credit: Peichel Lab

How and why fish swim in schools has long fascinated biologists looking for clues to understand the complexities of social behavior. A new study by a team of researchers at Fred Hutchinson Cancer Research Center may help provide some insight.

To be published online in the Sept. 12 issue of *Current Biology*, the study found that two key components of schooling – the tendency to school and how well fish do it – map to different genomic regions in the threespine stickleback, a small fish native to the Northern Hemisphere.

That's important, said lead author Anna Greenwood, Ph.D., because it suggests that if researchers can identify the genes that influence the fishes' interest in being social, they may be closer to understanding how genes drive human social behavior.

"The motivation to be social is common among fish and humans," said Greenwood, a staff scientist in the Human Biology Division at Fred Hutch. "Some of the same brain regions and neurological chemicals that control human social behavior are probably involved in fish social behavior as well."

'Some kind of genetic factor' controlling behavior

Greenwood and several colleagues in the Peichel Lab at Fred Hutch have been studying sticklebacks for several years to understand the genesis of natural variation. In a previous study, they found that a group of marine sticklebacks from the Pacific Ocean in Japan schooled strongly, while a second group from a lake in British Columbia preferred hiding out and were less able to maintain the precisely parallel formation required for schooling.

Though both groups were raised in identical lab conditions, they behaved differently from each other when placed together in a schooling situation.

"That really suggests that there's some kind of genetic factor controlling this difference," Greenwood said.

This time around, the researchers used lab-raised hybrids of the strongly schooling, saltwater-dwelling marine sticklebacks and the schooling-averse sticklebacks that live in freshwater.

Lead study author Anna Greenwood, Ph.D., is next to the device used for the study, made from an old bicycle wheel and other salvaged parts. Credit: Bo Jungmayer

Alison Bell, Ph.D., an associate professor of animal biology at the University of Illinois, Urbana-Champaign, said the linking of behaviors to different genomic regions in the same species – and in particular, social behavior that depends on the behavior of others – makes the study especially compelling.

"I think that's very significant," she said. "It's been hard to find regions of the genome that are associated with any kind of behavioral traits in natural populations. Behavior is very plastic and it's subject to environmental influences, so it's been really tricky to do that."

Hans Hofmann, Ph.D., a professor of integrative biology at the University of Texas at Austin, said the study also refutes the assertion that human behavior is too complex to understand.

"I think it shows that even such complex behaviors associated with other individuals in a very rigid and organized manner can be dissected genetically," he said. "Studies like this tell us that we might get there eventually."

Old bicycle wheel and lab motor used in experiment

Fish school primarily for protection from predators, and also to make swimming and foraging more efficient. Schools of fish in the wild are dynamic and fluid, but for both studies the Fred Hutch researchers had to create an environment in which they could observe the fish in unchanging conditions.

Building the device used for both experiments proved a challenge. The researchers suspended an old bicycle wheel above a circular acrylic tank and found a motor from an old lab shaker that could turn the wheel, but were stumped about how to connect them.

Greenwood and co-author Abigail Wark scoured craft shops and hardware stores looking for a suitable part, trying everything from plastic bra straps to necklaces before finding some silicone tubing that worked.

This is lead study author Anna Greenwood next to a tank of threespine stickleback in a lab at Fred Hutchinson Cancer Research Center. Credit: Bo Jungmayer

"It was a few weeks of going around to shops," Greenwood said.

They made a mold to create model fish from resin tinted with grey pigment, dabbing on eyes with black paint to make them look more realistic. The eight models (they found that eight is the minimum number to get fish to school in a lab setting) were suspended from the bike wheel with wire.

Beyond its findings connecting specific behaviors with genomic regions, the study also found that the same regions of the genome appear to control both the stickleback's ability to school as well as the anatomy of its lateral line, a system of organs that detect movement and vibration in water, and contain the same sensory hair cells found in the human ear.

That suggests a single gene could cause fish to detect their environment differently, Greenwood said, and supports the long-held notion that schooling behavior is controlled in part by the lateral line.

It provides a promising starting point in trying to locate the gene involved, and Fred Hutch researchers are now working on manipulating the gene they think causes changes in the stickleback's lateral line to see if that alters the fishes' schooling behavior.

Research on schooling behavior in fish may seem an odd fit for a cancer research center, but Greenwood said natural variation can influence not just behavior, but also susceptibility to illness and disease.

"If we can understand the process by which evolution works and the genes that tend to be affected during evolution in these other model systems, we can apply that to humans," she said.

More information: *Current Biology*, "Genetic and neural modality underlie the evolution of schooling behavior in threespine sticklebacks," Oct. 7, 2013.

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