

## Fish logic surprises researchers

by Stanford University and World

A male fish can size up potential rivals, ranking them from strongest to weakest, just by watching how they perform in fights with other males, according to a new study. The researchers say their finding provides the first direct evidence that fish, like people, can use logic to learn their place in a pecking order. The study, published in the Jan. 25 edition of the research journal *Nature*, involved cichlids (SIK-lids), small territorial fish from Africa.

A dominant male *A. burtoni* cichlid. (Credit: Logan Grosenick) Male cichlids are constantly trying to ascend socially by beating each other up, said study co-author Russell D. Fernald of Stanford University in Stanford, Calif. It would be really valuable for them to know in advance who to pick a fight with. The scientists aimed to find out whether territorial fish use a basic type of reasoning, transitive inference, in which known relationships are used to figure out unfamiliar ones. It's something that kids generally figure out by age four or five: Mary is taller than Fred, Fred is taller than Pete, therefore Mary is taller than Pete. It's been demonstrated in primates, rats and some bird species, but how and why it evolved in animals is a matter of debate. The researchers used a popular laboratory fish called *Asototilapia burtoni*. The males, extremely territorial, regularly engage in jousts whose outcome determines access to food and mates. Males that repeatedly lose, cannot hold territories and thus drop in status, the authors wrote. When they fight, it's easy to spot the winner. Males have a menacing black stripe, or eye-bar, on their face. After a bout, the winner retains his showy appearance, but the loser's eye-bar temporarily fades away as he tries to flee. The researchers staged a series of one-on-one combats between males of equal size. Fish that lost their eye-bar were declared the loser, separated from their opponent and put back in their original tank. Within minutes, the loser's eye-bar returned, and he looked like all the other dominant males again. The fights were staged in a tank divided into compartments. A cubicle in the center contained lone male by-stander. Around him were five smaller compartments, each with one male rival identified as A, B, C, D and E. Researchers made sure that the by-stander had never met any of these potential rivals. The by-stander was allowed to watch a series of fights between rival pairs: A vs. B, B vs. C, C vs. D, and D vs. E. Researchers manipulated the fights so that A would dominate B, B would dominate C, and so on. Taken together, the fights imply a dominance hierarchy with A on top, followed by B, C, D and E in that order. Did the by-stander grasp this pecking order? And could he use that knowledge to make logical decisions about the same fish paired in new relationships? To find out, eight different by-standers were tested in the familiar square tank and in a new setting: a rectangular aquarium with three adjacent compartments. In each test, a by-stander was placed in the middle compartment between two sets of rivals that he had never seen together. A and E on the one hand, and B and D on the other. All rivals had recovered from earlier losses, so their physical appearance was similar. Using a video camera, researchers recorded which rival the by-stander approached first, and the overall time he spent next to each of them. Previous tests had shown that by-standers prefer to spend more time near the rival they perceive as weaker, the authors explained. The results were dramatic, according to the researchers: virtually all by-standers swam to the weaker rival first and stayed near him for significantly longer. In the A-E tests, by-standers preferred E, the weakest fish. In

the more subtle B-D tests, most by standards chose D. So “fish do, in fact, use transitive inference to figure out where they rank,” Ferrel said. “I was amazed that they could do this through vicarious experience, just by watching other males fight.” In Lake Tanganyika in eastern Africa, the cichlids™ habitually, conditions change constantly and it would be advantageous for a male to know who the new boss is going to be and who his weakest rivals are,” he added. “Our experiment shows that male cichlids can actually figure out their odds of success by observation alone. From an evolutionary standpoint, transitive inference saves them valuable time and energy.” Fish might have the rudimentary brain circuitry for transitive inference that appeared later in birds and mammals, he continued. “Any animal that has evolved a social system that requires combat among males will have some kind of eavesdropping capability allowing them to surreptitiously draw inferences about their social rank,” Ferrel said. “Cichlids that evolved in fish may contribute to human transitive inference, or perhaps this capability evolved independently. The question remains unresolved.”

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