Coral Degradation and the Flow-On Effects to Reef Fishes

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OPINION

The coral reefs of the world are under threat from over-harvest, pollution and climate change, which has lead 75% of the world's reefs to be classed as threatened in 2011. For many reefs these threats have led to a mark reduction in hard corals, particularly as a result of coral bleaching through thermal stress. As corals bleach and die, the fish community changes – there are still fishes present, but there just aren't as many different varieties. While researchers have documented the changes in fish community that occur as habitats degraded and change, the mechanisms that lead to that change are poorly understood.

Professor Mark McCormick from the ARC Centre of Excellence for Coral Reef Studies at James Cook University, together with a team of researchers from the University of Saskatchewan have been trying to work out why some fishes thrive in this new environment, while other die. What makes some species less resilient to habitat change? Because of the unpredictable identity of the resident fishes that live nearby to where juvenile fish settle from their larval phase, they have developed an amazingly sophisticated way of quickly learning who to avoid. There's a strong selective pressure to get it right first time, as the average little fish is dead hours after arrival to the reef! An important part of this sophisticated learning mechanism involves chemicals that are released upon laceration of the skin of the fish. These chemical alarm odors act in minute quantities and lead to an antipredator response in similar-sized individuals of the same or closely related species down-current. This response is innate and usually involves retreating to shelter, reducing foraging and activity while they become more vigilant of predators [1,2].

One keyway that learning occurs is through the co-occurrence of the chemical alarm odour, as a reliable indicator of a threat nearby, with a new smell, vibration or image. One coupling of the alarm odour and new stimulus is enough to label that stimulus as a potential threat, in a type of Pavlovian conditioning known as 'associative learning'. Because there are initially so many unknown stimuli in their new habitat, they emphasis the importance of some by repeated conditioning, and de-emphasis others that are seldom associated with threats. In this way they update information about the identity of predators, 'forgetting' old, once-relevant information while updating their catalogue of current threats. Once one individual has learnt that a particular smell or animal is dangerous, they can pass this, wittingly or otherwise, to others nearby who are very attentive to the reaction of their neighbors (a process called social learning). You can imagine that the capacity to rapidly learn predators and update information is important in an environment where new predators may enter and exit the habitat patch regularly (imagine trevally passing through), or they may need to migrate between patches of different habitat types to find mates or new sources of food later in life [3,4].

Our research team has found is that the chemical miasma that emanates from degraded habitats modifies the structure of the chemical alarm odour that are used to learn predators and inform fish about risk. To date we have examined the response of 12 fish species (damselfishes, cardinalfishes and a goby) and found the utility of alarm odours are nullified in six species. Interestingly, not all of the affected species have a strong association with live coral. These fish, such as the Ambon damselfish, no longer develop a risk averse (neophobic) phenotype when in a degraded habitat and can also no longer learn using chemical alarm odors. Our field experiments show that they die much faster because they have an inappropriate response to predators [5].

Luckily, we have found that other species, like the neon damsel, appear to be immune to the effects of the chemistry that emanates from degraded habitats. Why some species are affected, and others is not presently unknown. Recently we have found that the affected fish can use the alarm odors of closely related, unaffected species to gauge risk. These affected species can also still learn through social learning. However, all this comes at a cost, as the information

from others is not as reliable as information coming directly from similar-sized individuals of your own species. Our next challenge is to determine whether affected fish that have survived in degraded areas produce offspring that are more capable of surviving on degraded reefs. These and other studies give us an excuse to delve again into the waters of the Great Barrier Reef to determine what physiological and behavioral adaptations make some fishes more resilient to habitat change than others. Knowing this will aid in the prediction of the shape of communities in the future and give us an insight into what determines the resilience of fish communities to change.

REFERENCES

1. Ferrari MCO, McCormick MI, Allan BJM, Chivers DP (2017) Not equal in the face of habitat change: closely related fishes differ in their ability to use predation-related information in degraded coral. Proc Biol Sci 284: 20162758.

2. McCormick MI, Barry R, Allan BJM (2017) Algae associated with coral degradation affects risk assessment in coral reef fishes. Scientific Reports 7: 16937.

3. McCormick MI, Chivers DP, Allan BJM, Ferrari MCO (2017) Habitat degradation disrupts neophobia in juvenile coral reef fish. Glob Chang Biol 23: 719-727.

4. McCormick MI, Fakan EP, Palacios MM (2019) Habitat degradation and predators have independent trait-mediated effects on prey. Scientific Reports 9: 15705.

5. McCormick MI, Ferrari MCO, Fakan EP, Barry RP, Chivers DP (2019) Diet cues and their utility for risk assessment in degraded habitats. Animal Behaviour 152: 19-28.