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Source: Ezzat, L., Maguer, J-F., Grover, R. & Ferrier-Pagès, C. (2015). New insights into carbon acquisition and exchanges within the coral–dinoflagellate symbiosis under NH_4^+ and NO_3^- supply. *Proceedings of the Royal Society B*. 282:20150610. DOI:10.1098/rspb.2015.0610.

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Nitrogen and phosphorus pollution alter the mutual relationship between corals and algae

Nitrogen and phosphorus pollution change the relationship between the tropical coral *Stylophora pistillata* and the algae living inside its tissues, a recent study has found. The researchers say the pollutants, mainly from urban and agricultural discharges, affect algae photosynthesis and the essential transfer of carbon from algae to the coral.

Algae live inside many reef-building corals, a symbiotic relationship which benefits both the algae and the corals. The algae are protected by the coral and use its waste products for their photosynthesis and in turn the coral uses photosynthetic by-products, particularly carbon, to respire, reproduce and build coral skeletons.

Anything which disturbs this finely balanced relationship can impair the healthy development of the coral. Seawater polluted by excess nitrogen and phosphorus, mainly from urban and agricultural discharges, may affect the nitrogen to phosphorus balance and upset the tight algae—coral relationship.

This study focused on how different ratios of nitrogen and phosphorus affected the metabolism of the tropical coral *Stylophora pistillata* colonised with *Symbiodinium* algae species.

The researchers suspended small coral fragments in tanks, through which seawater containing added phosphorus and various forms of nitrogen was circulated. Control tanks were provided with natural seawater containing low levels of nitrogen (N) and phosphorus (P) (0.5 µM N and 0.05 µM P). Two further nutritional treatments were provided with natural seawater enriched with 2.5 µM N, in the form of ammonium or nitrate. A third treatment contained seawater enriched with 1 µM P and 2.5 µM ammonium.

After three weeks under these nutritional treatments, the researchers took samples from each tank and measured algal photosynthesis, chlorophyll, and algal content as well as rates of respiration of coral and algae and coral calcification (skeleton building).

Other samples were immersed in beakers using the same experimental conditions they were grown in, plus the heavy isotope of carbon, ^{13}C, as a tracer. They measured the carbon incorporation rate in the algae material and coral tissues and then combined these measurements in a model to estimate the amount of carbon transferred from algae to coral.

Overall, they found the relative amounts of nitrogen and phosphorus, as well as the form of nitrogen, affected their mutual functioning and the transfer of carbon from algae to coral in different ways.

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For instance, nitrogen enhancement in either the ammonium or nitrate form doubled algae growth compared with control conditions. However, higher levels of carbon were only transferred from algae to coral hosts under ammonium enrichment. Coral calcification rates were consequently increased under enriched ammonium conditions, but not under nitrate enrichment.

It costs the algae extra energy to utilise nitrate, as it must first be converted to the ammonium form, before being combined with carbon so it can be used. The researchers suggest this negatively affects photosynthesis and consequently coral calcification. As ammonium is a form of nitrogen mainly found in fish excretions, the researchers suggest that supporting fish colonies above coral reefs could enhance coral growth.

A phosphorus/ammonium-enriched environment also unbalanced the coral—algae relationship. The researchers found that the algae multiplied at the expense of the coral hosts by keeping more of the photosynthetic products for their own use.

This study was carried out in the laboratory on one coral species under normal growth conditions (25°C), and cannot be generalised to other coral species living in different environments. The results nevertheless advance knowledge of how nutrient pollution affects coral reef ecosystems, which is useful for policymakers assessing risks to coral reefs from human activities.

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