

Scientists discover why soft corals have unique pulsating motion

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Credit: Hebrew University of Jerusalem

Scientists from the Hebrew University of Jerusalem and the Technion-Israel Institute of Technology have discovered why Heteroxenia corals pulsate. Their work, which resolves an old scientific mystery, appears in the current issue of PNAS (*Proceedings of the National Academy of Sciences*).

One of the most fascinating and spectacular sights in the coral reef of Eilat is the perpetual motion of the tentacles of a coral called Heteroxenia (*Heteroxenia fuscescens*). Heteroxenia is a soft coral from the family Xeniidae, which looks like a small bunch of flowers, settled in the reef walls and on rocky areas on the bottom of the reef. Each "flower" is actually a living polyp, the basic unit which comprises a coral colony. Apparently, the motion of these polyps, resembling flowers that are elegantly spreading out and closing up their petals, is unique in the animal kingdom.

Except for the familiar swimming motion of jellyfish, no other bottom-attached aquatic animal is known to perform such motions. Pulsation is energetically costly, and hence there must be a reasonable benefit to justify this motion.

The perpetual motions of jellyfish serve them for swimming, predation and feeding. The natural explanation would be that that the Heteroxenia's spectacular motions are used for predation and feeding, however several studies indicate that these corals do not predate on other animals at all. If predation is not the reason for pulsating, there must be another explanation to justify the substantial energetic expense by the Heteroxenia.

Maya Kremien found the answers to these questions, while working on her master's research at the Interuniversity institute for [Marine Sciences](#) in Eilat under the supervision of Prof. Amatzia Genin from the Hebrew University and Prof. Uri Shavit from the Technion in a joint research

funded by the National Science Foundation.

After watching several coral colonies with an underwater infrared-[sensitive camera](#) night and day, the researchers found their first surprising discovery: Heteroxenia corals cease to pulsate and take a half-hour break every single day in the afternoon hours. At this stage, the afternoon "siestas" remained unexplained.

The labs of Prof. Genin and Prof. Shavit conduct work on the interaction between biological processes of aquatic creatures and the water motions which surround them. Apparently aquatic animals affect the flow and at the same time are absolutely dependent on that flow. In order to solve the mystery of the Heteroxenia coral, the research team developed (as part of Ph.D. work by Tali Mass) an underwater measuring device called PIV (particle imaging velocimetry), which allows measurement of the flow field just around the coral very accurately. The system consists of two powerful lasers, an image capturing system and computation ability. A special set of lenses releases a sheet of light in short, powerful pulses so that the imaging system can capture pairs of snapshots of natural particles moving with the flow. The computational system then performs a mathematical analysis of the pairs of photos, producing a huge database of flow field maps, from which the flow speed, characteristics of solutes transport, and turbulent mixing intensity are calculated.

The measurements were performed at night with the support of divers who volunteered to assist the research team. It was found that if a diver lightly touched the coral, the polyps "close" and remain motionless for a few minutes, after which the coral returns to its normal pulsation activity. The researchers used this behavior in order to repeatedly measure the flow field around the Heteroxenia during pulsation and rest.

These measurements led to the research group's next discovery. Analysis of the direction of water flow indicated that the motion of the polyps

effectively sweeps water up and away from the coral tissues into the ambient water. Corals need carbon-dioxide during daytime and oxygen during nighttime, as well as nutrients (such as phosphate and nitrogen) during day and night. One of the challenges for [coral colonies](#) is to render their surrounding waters rich in essential commodities by efficiently mixing the water around them.

By using the sophisticated measuring system, the researchers calculated the mixing intensity of the water as a result of the coral's pulsation. The unexpected discovery was that even though the polyps' motions are uncoordinated (i.e. each polyp starts its period of motion at a different time), the accumulated effect of the polyps' activity is a significant enhancement of the flow around the colony, particularly in the upward direction which sweeps water away from the coral, hence reducing the probability of re-filtration of the same water.

However, these findings still did not yet answer the question of why a coral would invest so much energy to move its tentacles. After receiving a permit from the Israel Nature and Parks Authority, the research team collected a few *Heteroxenia* colonies from the sea in order to run a series of laboratory experiments. All corals were returned back to their original location after the experiment terminated. The Hypothesis was that the pulsation motions enhance the coral's photosynthesis rate.

Corals are among the most ancient creatures surviving on our planet. One of the "secrets" of their amazing survival abilities is that they "host" photosynthetic algae in their tissues. The symbiotic algae provides the coral with essential nutrients and lives off the waste of the coral.

In a previous study of the same research team (which the results of were also published in PNAS) it was found that the motion of water around corals is essential in order to enhance the efflux of oxygen from the coral tissues. Without water motion, the oxygen concentration in the

coral tissues would rise and the photosynthesis rate would drop.

The answer to the question as to why the *Heteroxenia* pulsates was finally revealed through the lab experiments. First, the photosynthesis rate of a pulsating *Heteroxenia* was measured, and it was found to be on an order of magnitude higher than that of a non-pulsating colony. Next, in order to prove that the mechanism of pulsation is intended to sweep away oxygen, the researchers artificially increased the oxygen concentration in the measurement chamber so that even when the coral managed to mix water via pulsation, it was replacing oxygen-rich water with new water, which, unfortunately for the coral, was also rich in oxygen. And indeed it was found that the photosynthesis rate was low in this case, and even when the coral was constantly pulsating, the oxygen concentration remained high and photosynthesis remained low, as if the [coral](#) was at rest (i.e. not pulsating).

The elegant motion of *Heteroxenia* has been fascinating the scientific society and capturing the attention of researchers for nearly 200 years (Jean-Baptiste Lamarck, 1744-1829), yet it has not been explained. Now, in the study of Kremien, Genin and Shavit, it was found that the pulsation motions augment a significant enhancement in the binding of carbon dioxide to the photosynthetic enzyme RuBisCo, also leading to a decrease in photorespiration. This explanation justifies the investment of energy in pulsation—the benefit overcomes the cost. In fact, thanks to pulsation, the ratio between photosynthesis to respiration in *Heteroxenia* is the highest ever measured in stony and non-pulsating soft corals.

The findings of this study indicate that pulsation motions are a highly efficient means for sweeping away water from the pulsating body, and for an increased mixing of dissolved matter between the body and the surrounding medium. These two processes (expulsion of medium and mixing of solutes) may lead to future applications in engineering and medicine. Currently the research group is focusing on attempts to

broaden the results of this study and on developing mathematical models which could serve various applicative purposes.

More information: Kremiena, M., Shavitc, U., Mass, T. and Genina, A. Benefit of pulsation in soft corals, *PNAS*, April 22, 2013.

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