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Solving a 200-year-old undersea mystery

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Hebrew University and Technion scientists discover why soft corals have unique pulsating motion.

Although the discovery by researchers at the Hebrew University and the Technion- Israel Institute of Technology will not change the course of mankind, solving the scientific mystery of why Heteroxenia fuscescens corals pulsate does satisfy the curiosity of some scientists and laymen.

Their work, which appears in the current issue of PNAS (Proceedings of the National Academy of Sciences in the US), finally answered the question first raised by 18th century French biologist and naturalist Jean-Baptiste Lamarck.

The discovery 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 – in essence, pushing oxygen-rich water away in order to improve photosynthesis – may, however, 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 that could serve various applicative purposes.

One of the most fascinating and spectacular sights in the coral reef off the coast of Eilat is the perpetual motion of the tentacles of this 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 that comprises a coral colony.

Apparently, the motion of these polyps, resembling flowers that spread out and close up their petals, is unique in the animal kingdom.

Except for the familiar swimming motion of jellyfish, no other 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, catching prey and feeding on them. 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 feed on other animals at all. If predation is not the reason for pulsating, there must be another explanation to justify the coral’s substantial energetic expense, the Jerusalem and Haifa scientists reasoned.

Maya Kremien found the answers to these questions, while working on her master’s degree research at the Inter-university Institute for Marine Sciences in Eilat under the supervision of Hebrew University Prof.

Amatzia Genin and Technion Prof. Uri Shavit in 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 take a recess from their pulsating and rest half an hour every afternoon. At this stage, the afternoon siestas remained unexplained.

To solve the mystery, the researchers developed (as part of doctoral 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 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 to repeatedly measure the flow field around the coral during pulsation and rest.

These measurements led to their 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 the day and oxygen at night, as well as phosphate, nitrogen and other nutrients around the clock. 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 refiltration of the same water.

But why would these creatures invest so much energy to move their tentacles? After receiving a permit from the Israel Nature and Parks Authority, the scientists began lab experiments – after which all corals were returned back to their original locations – working with the theory that the pulsation motions enhance the coral's photosynthesis rate, which turned out to be accurate.

First, they measured the photosynthesis rate of a pulsating coral and found it to be on an order of magnitude higher than that of a nonpulsating colony. Next, 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.

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, the benefits of which justify the energy costs of pulsation.