Switching to a power stroke enables a tiny but important marine crustacean to survive

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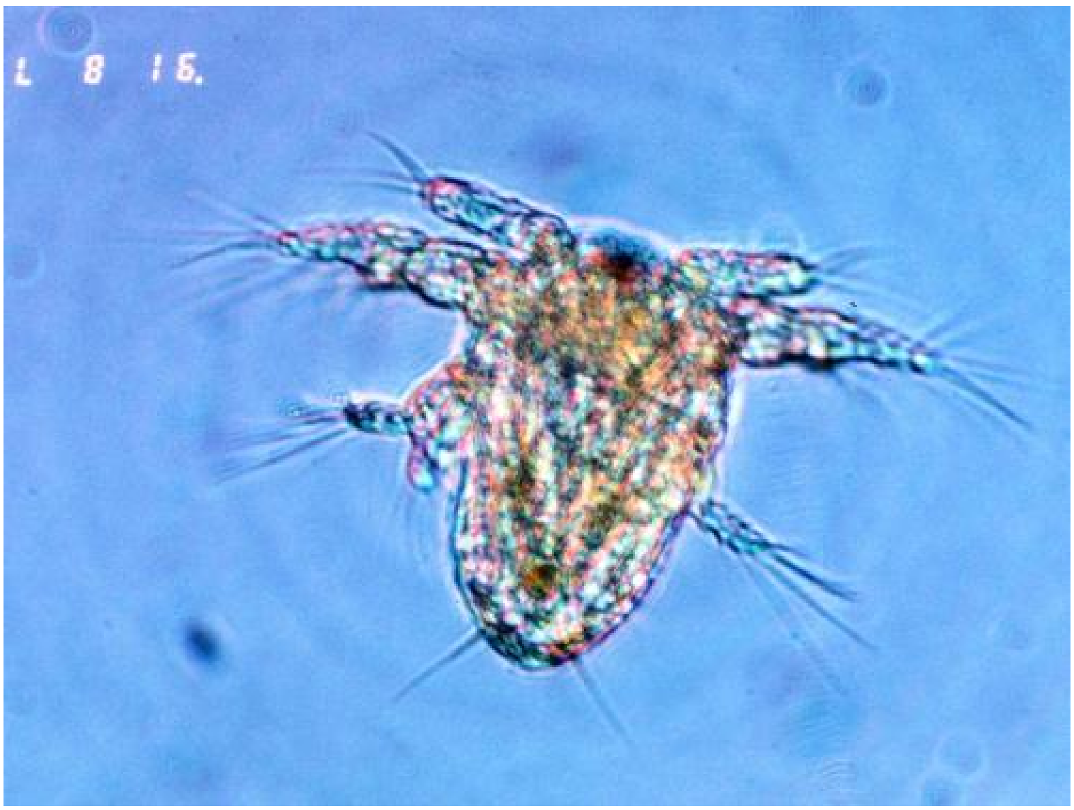

This is a copepod nauplius. Credit: Ed Buskey/University of Texas Marine Science Institute

Olympic swimmers aren't the only ones who change their strokes to escape competitors. To escape from the jaws and claws of predators in cold, viscous water, marine copepods switch from a wave-like swimming stroke to big power strokes, a behavior that has now been revealed thanks to 3-D high-speed digital holography.

Copepods are tiny crustaceans found in nearly every aquatic environment on Earth. By some estimates, they are the most abundant animals on the planet.

Their change in stroke in cold water helps them escape a slew of predators, from larval fish to crabs, oysters and jellyfish.

"Copepods are key components of marine food webs eaten by just about everything," says Ed Buskey, study author and professor of marine science at The University of Texas Marine Science Institute. "The better question is 'what doesn't eat copepods?' "

Buskey says that understanding how the microscopic organisms might respond to changes in the environment is important for assessing the health of oceans now and in the future.

Environmental changes that affect copepods include changes in water temperature and viscosity associated with climate change, and increases in water viscosity related to pollution and coastal algal blooms.

Water viscosity, or "thickness," naturally increases as the temperature drops. For microscopic copepods, it becomes like swimming through honey. But does it make them more vulnerable to predators? How does a copepod cope?

To answer those questions, Buskey and co-author Brad Gemmell turned to high-speed digital 3-D holography techniques developed by mechanical engineer Jian Sheng at Texas Tech University. The technique uses a microscope outfitted with a laser and a high-speed digital camera to catch the rapid movements of the microscopic animals moving in and out of focus in a 3-D volume of liquid.

They studied copepod movement in water with varied temperatures and viscosities.

Copepod larvae swim using three pairs of appendages that act like three pairs of oars moving a boat. Unlike a rowboat, however, the copepods' "oars" do not move in complete synchrony.

In warmer, less viscous water conditions, the three pairs of appendages stroke in an overlapping, wave-like motion. For example, the first pair will start a stroke, and the second pair will begin the stroke before the first pair is complete, and so on.

In cold, thick water, however, the tiny copepods switch to one big power stroke at a time. For example, the first pair of appendages will complete one big downward stroke before the second pair begins. The third pair doesn't start until the second is complete. Watch a video of the power stroke.

This results in a copepod that takes one step back for every two steps forward.

"These little guys are not very efficient swimmers," said Buskey. "They slip backward with every recovery stroke. I guess it isn't easy swimming in 'honey.' "

Still, says Gemmell, a former graduate student of Buskey's who is now at the Marine Biological Laboratory in Woods Hole, Mass., "that power stroke adaptation helps the copepods overcome the negative effects of changing water temperature and viscosity to escape predators." In other words, without the power stroke, the copepods would be even easier prey in cold water.

Significantly, the researchers discovered that the power stroke is triggered only by colder temperature, not viscosity alone.

Gemmell said that's because the muscles that control the copepods' appendages are affected by temperature.

"So if you increase viscosity without changing the temperature—the kind of situation you might find during an algal bloom or pollution event—the copepod's escape ability declines," said Gemmell.

That's good for predators, of course, but could have larger effects on copepod populations and the marine food web, particularly as coastal algal blooms and pollution increase.

More information: Buskey, Gemmell and Sheng published their findings March 4 in *PNAS Early Edition*.: www.pnas.org/content/early/201 … 148110.full.pdf+html

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