Dinoflagellate plankton glow so that their predators won't eat them

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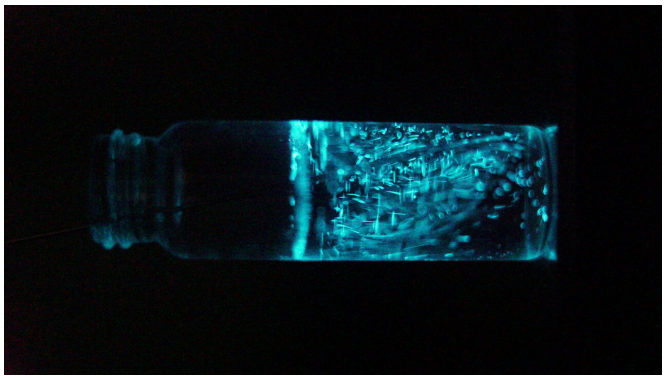

Lingulodinium polyedra stimulated to produce bioluminescence by the addition of acetic acid. Credit: Michael Latz and Jenny Lindström

Some dinoflagellate plankton species are bioluminescent, with a remarkable ability to produce light to make themselves and the water they swim in glow. Now, researchers reporting in *Current Biology* on June 17 have found that for one dinoflagellate species (*Lingulodinium polyedra*), this bioluminescence is also a defense mechanism that helps them ward off the copepod grazers that would like to eat them.

"That bioluminescence, in addition to being a beautiful light phenomenon in the sea, is a defensive mechanism that some species of plankton use to ward off their enemies," said Andrew Prevett of the University of Gothenburg, Sweden. "The bioluminescent cells sense very low concentrations of their grazers and turn up the light when needed, which is rather impressive for a unicellular organism. This in turn helps to better protect them from their grazers, letting them survive longer to reproduce and therefore compete better within the plankton."

Through a combination of high-speed and low-light sensitive videos, the researchers, including Prevett, Erik Selander, and their collaborators at the Technical University of Denmark, revealed that the bioluminescent cells flash upon contact with the copepod grazer. The copepod reacts by rapidly rejecting the flashing cell, seemingly unharmed.

They note that observational data from the west coast of Sweden support their study's prediction that the presence of copepod grazers would have a positive effect on the abundance of bioluminescent *L. polyedra*. The single-celled, bioluminescent dinoflagellates are usually poor competitors, because they grow at about a third of the rate of other plankton. But copepods reject them in favor of grazing on more poorly defended but otherwise faster-growing plankton species.

The researchers had expected increased bioluminescence to result in reduced grazing by copepods. But they were surprised by just how great the reduction was.

"Earlier studies had shown that dinoflagellates with naturally brighter bioluminescence than *L. polyedra* were grazed less but still required cell concentrations to be relatively high before all grazing on the bioluminescent cells ceased," Prevett said. "*L. polyedra* abundance in our study is low by comparison, and we were surprised at how effective the bioluminescence defence became despite this."

It's still not clear exactly how the glow protects *L. polyedra*, however.

"There are three popular theories as to how bioluminescence protects dinoflagellates," Prevett said. "The first is that it acts as aposematic colouration, a warning to potential grazers that the cell is toxic or harmful to the grazer in some way. The second is that the flash of bioluminescence behaves like a flash-bang and startles the copepod, provoking a copepod escape response or disorienting it long enough for the dinoflagellate to

escape. The third theory suggests that the flash acts as a form of burglar alarm, attracting the attention of a larger visual predator, like a fish, which could track and consume the copepod. There is evidence to support each of these theories and bioluminescence protection could be combinations of some or all of the above."

No matter how it works, it appears their ability to ward off predators with bioluminescence serves as a key mechanism behind the success of an otherwise poor competitor such as *L. polyedra*, the researchers say.

They say that they plan to pursue more studies in the system exploring the ways that the "fear" of being eaten drives the structure of ecosystems. They plan to study compounds produced by copepods as general alarm signals and their influence on complex plankton assemblages.

"These indirect effects of consumers are understudied in unicellular dominated food webs such as marine plankton," Prevett said. "This paper and other similar results suggest that indirect predator effects are strong drivers in the microscopic food web of the oceans too."

More information: Andrew Prevett et al, Grazer-induced bioluminescence gives dinoflagellates a competitive edge, *Current Biology* (2019). DOI: 10.1016/j.cub.2019.05.019

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