Tiny red animals dart in the dark under the ice of a frozen Quebec lake

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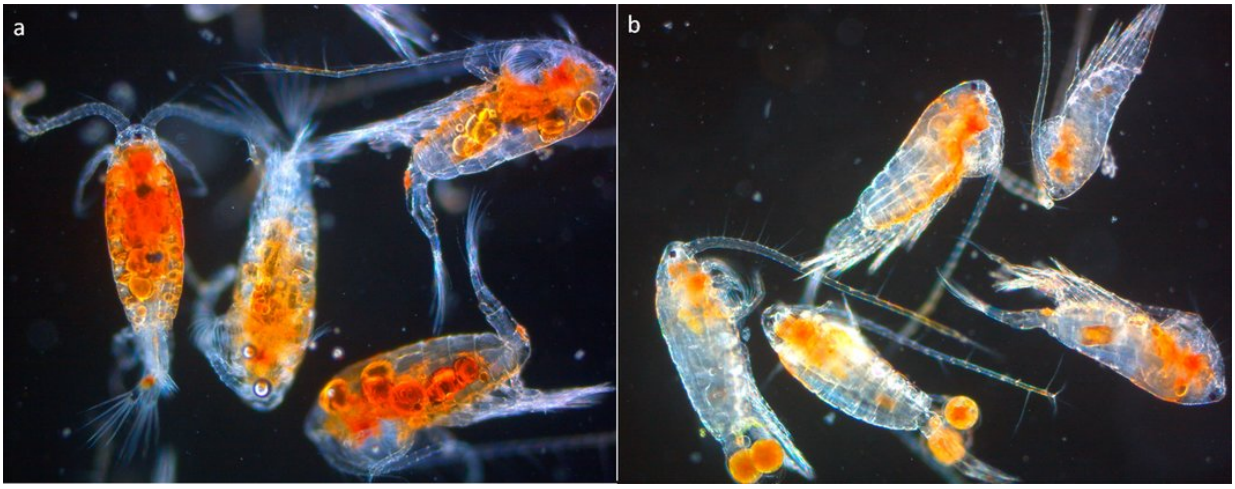

Copepods (Leptodiaptomus minutus) from Lake Simoncouche, (a) under the ice in winter (27 January 2017) and (b) in summer (18 September 2017). Photos were obtained from an inverted microscope with phase-contrast. From figure 2 of the paper. Credit: Guillaume Grosbois

In a frozen lake in Quebec, tiny red creatures zip about under the ice. Guillaume Grosbois and Milla Rautio, researchers at Université du Québec à Chicoutimi, Saguenay, Québec, Canada report the discovery of active life in a winter lake today in the Ecological Society of America's journal *Ecology*.

Grosbois and Rautio did not expect to find bright red zooplankton

buzzing in the dark water under the frozen surface when they visited snowy Lake Simoncouche in winter.

"Most ecological work is done in the summer, because it's easier to go into the field at that time of year, but also because everybody thought that nothing is happening in winter," said Grosbois. "Aquatic ecologists thought that everything is either dying or entering dormancy, and that life is on hold during the entire season."

Although winter research is gaining interest, ecological field work slows down when the weather turns snowy. The researchers expected to find the lake's zooplankton, the nearly microscopic animals that feed fish

and other larger lake inhabitants, resting nearly immobile on the lake bottom, waiting out the cold hungry months until sunlight and food return.

But when they looked at water samples under the microscope, they saw the copepod species *Leptodiaptomus minutus* and *Cyclops scutifer* swimming vigorously about. The tiny crustaceans, which resemble very small shrimp, accounted for 63 and 22 percent of the winter biomass in the lake.

"We saw that they were very active! They were not dormant at all. I was very surprised, because in winter there is no light, there is no algae to eat," Grosbois said.

Returning to sample the lake every few weeks throughout the year, Grosbois and Rautio were further surprised to find that zooplankton biomass actually peaked in December. But the most startling discovery was the copepods' vivid color.

Rautio and Grosbois wanted to know how the small animals managed to

remain active as their primary food sources died, but also why they were so brightly colored. In summer, zooplankton are nearly transparent. Bright red coloration would be a beacon, like Rudolph's red nose, calling to predatory fish. In the dark, the bright red coloration does not attract dangerous attention. The red color, however, is expensive for the small animals to make. It costs them energy they need to survive. So the researchers believed it must be serving a purpose.

Color often provides protection against damage from UV radiation, like natural sunblock. But very little sunlight filters through the thick cover of ice. High energy ultraviolet light reflects off the ice surface. Instead, Grosbois and Rautio think the red pigment may be acting as a preservative for the extra body fat the zooplankton piled on for the winter.

"The link was the lipids, the fats." Grosbois said.

As the surface ices over, the waters below grow dark. Phytoplankton, algae that, like plants, make energy from sunlight begin to die. The copepods get most of their calories from algae. They can stay active for the entire winter, Rautio and Grosbois concluded, because they accumulate fats as temperatures drop during the autumn, eating everything they can find and feasting on dying algae as the ice closes. But stored fats, especially valuable fatty acids, are vulnerable to damage through peroxidation caused by free radicals.

Lake Simoncouche, Québec, Canada. Credit: Guillaume Grosbois

Free radicals are a consequence of respiration. All animals that breathe oxygen must cope with their generation and the damage they can inflict. Like carotenes and other vivid pigments in fruits and vegetables, the red pigment in the copepods is an antioxidant. It protects the copepods' cells by tying up free radicals and keeping them away from important cellular equipment. Grosbois and Rautio believe that, in the gloom under the ice, the copepods can safely take advantage of protection from oxidative stress that bright pigments offer. The little copepods, like people, need omega-3 and omega-6 fatty acids to be healthy.

"We can only get essential fatty acids from food. One of the best sources is fish, because fish accumulate them from the copepods, that accumulate them from the algae, that are the main producers," Grosbois said. Fatty acid biochemistry, and its effects on the food web, is a topic that interests him for future research.

"We are a lot of humans on the planet. We all need to be in health, so we need a lot of fatty acids. As the climate changes we are seeing that the time of ice cover is becoming shorter and shorter. That's a really important period for the aquatic organism to accumulate fatty acids."

Grosbois wonders if a shorter freezing period will give the copepods enough time to accumulate the fatty acids they need to reproduce successfully in spring. When copepods run low on fatty acids, there are, in turn, be less for the fish, and so on up the food web.

"Winter is important, especially in the boreal zone. We here are in a very northern city in Canada, where the winter can be very long," Grosbois said. "We need to study this time more. Everything that happens in the winter will have an impact on spring, summer, and fall. So if we want to understand what is happening in the ecosystem, we need to know more about the winter."

More information: Guillaume Grosbois et al, Active and colorful life under lake ice, *Ecology* (2017). DOI: 10.1002/ecy.2074

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