'Solar-powered' sea slugs can survive in the dark

The creatures may not rely on the photosynthetic ability of the chloroplasts that lend them their colour.

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Sven Gould/Jan de Vries

The sea slug *Elysia timida* extracts the photosynthesizing organelles from single-cell algae it feeds on — but it is unclear whether it actually can use them as its personal solar panel.

They've been called 'solar-powered slugs' and 'leaves that crawl' — species of sacoglossan sea slug that assimilate the photosynthetic organelles in the algae they eat, causing their bodies to turn bright green. But it turns out that these slugs can survive months of starvation even when their photosynthetic capacity is massively reduced, casting doubt on the widely-accepted theory that they rely on photosynthesis to feed themselves when there's nothing around to eat.

"The previous assumption, that just photosynthesis alone explains their survival, needs to be reconsidered," says Sven Gould, a molecular cell biologist at the University of Düsseldorf in Germany and the senior author of the study, which is published today in the *Proceedings of the Royal Society B*[1].

When they feed on the large single-celled algae that constitute their diet, a number of sacoglossan sea slugs digest everything but the chloroplasts, the algae's photosynthetic equipment. The creatures store the organelles in a digestive gland that stretches through almost the entire body, where the chloroplasts continue to photosynthesize. In many types of slug this transplanted photosynthetic capacity lasts for no more than two weeks, but in four species it can continue for months. Biologists had assumed that the animals had evolved this ability to protect themselves against starvation should algae be unavailable.

Working with two of these species — *Elysia timida and Plakobranchus ocellatus* — the researchers blocked photosynthesis, either by keeping the slugs in the dark or by giving them a photosynthesis-inhibiting drug.

Next, Gould and his colleagues showed that even when photosynthesis was blocked, the slugs could survive without food for a long time, and seemed to fare just as well as food-deprived slugs exposed to light. They starved six specimens of *P. ocellatus* for 55 days, keeping two in the dark, treating two with the drug and providing two with appropriate light. All survived and all lost weight at about the same rate. The authors also denied food to six specimens of *E. timida* and kept them in complete darkness for 88 days — and all survived. (*E. timida* slugs are too small to be weighed reliably, but at the end of the test those that were light-deprived seemed to be as healthy as the controls.)

Reserve supply

The researchers now think the key to the slugs' survival may be delayed gratification. It is not that they never digest the 'stolen' chloroplasts, termed kleptoplasts — they just take their time about it. The authors suggest that the sea slugs evolved to store the

organelles to digest them later.

So far, Gould and his co-workers have only indirect evidence that the slugs survived enforced fasting by digesting their kleptoplasts. Gould also notes that, besides photosynthesis, chloroplasts have other biochemical capabilities that may help host slugs to make it through hard times.

The paper “changes the whole view of solar sea slugs”, says marine biologist David Behrens.

“It was really cool to think the slugs survived as little bio-solar panels,” says Jeff Adams, a marine-water quality specialist at Washington Sea Grant in Bremerton. “But their ability to live off energy-rich, photosynthetically active food stores that also camouflage them within their preferred habitat remains wondrous.”

Aquatic biologist George Parsons, senior director of fishes at the Shedd Aquarium in Chicago, Illinois, observes that sea slugs often go a long time between meals because they move at a snail’s pace from one to the next. So, of necessity, he says, “they are remarkable at finding ways to survive”.

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References

1. Christa, G. *et al. Proc. R. Soc. B* http://dx.doi.org/10.1098/rspb.2013.2493 (2013).