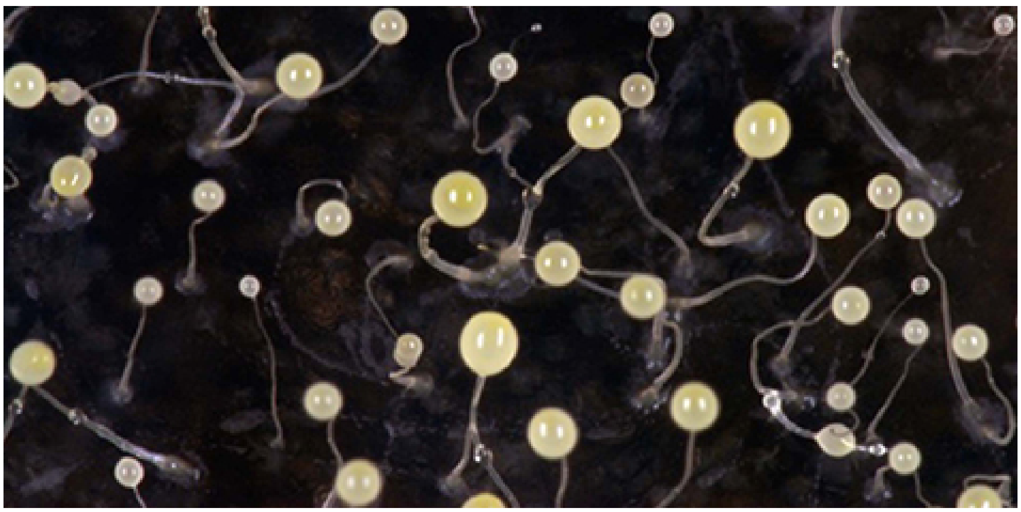
Social amoebae travel with a posse, have amazingly complicated social lives

July 29 2013



Scientists have discovered that one clone of these amoebae carries two bacteria, one that serves it as food and another as a weapon. It's guns and butter, the scientists say. Credit: Joan Strassmann

In 2011, *Nature* announced that scientists had discovered a single-celled organism that is a primitive farmer. The organism, a social amoeba called *Dictyostelium discoideum*, picks up edible bacteria, carries them to new locations and harvests them like crops.

D. discoideum enjoyed a brief spell in the media spotlight, billed as the world's smallest farmer.

Now a collaboration of scientists at Washington University in St. Louis and Harvard University has taken a closer look at one lineage, or clone, of a *D. discoideum* farmer.

This farmer carries not one but two strains of bacteria. One strain is the "seed corn" for a crop of edible bacteria, and the other strain is a weapon that produces defensive chemicals.

The edible bacteria, the scientists found, evolved from the toxic one. The two strains differ by many mutations but a single key mutation, which hit an important controller in the genome of the nonfood strain, alters expression of 10 percent of its genome. This alteration increases the expression of some genes and decreases the expression of others.

A mutation that affects this much of a genome could be lethal, but in this case it had the surprising effect of making the bacterium edible by changing its chemical profile.

The discovery is reported in the July 29 issue of the *Proceedings of the National Academy of Sciences*.

The first farmer

The first farmers were found by Debra Brock, then a graduate student in the laboratory run by David Queller and Joan Strassmann at Rice University in Houston, Texas. (All three scientists have since moved to Washington University in St. Louis, where Queller and Strassmann are professors of biology and Brock is a research scientist.)

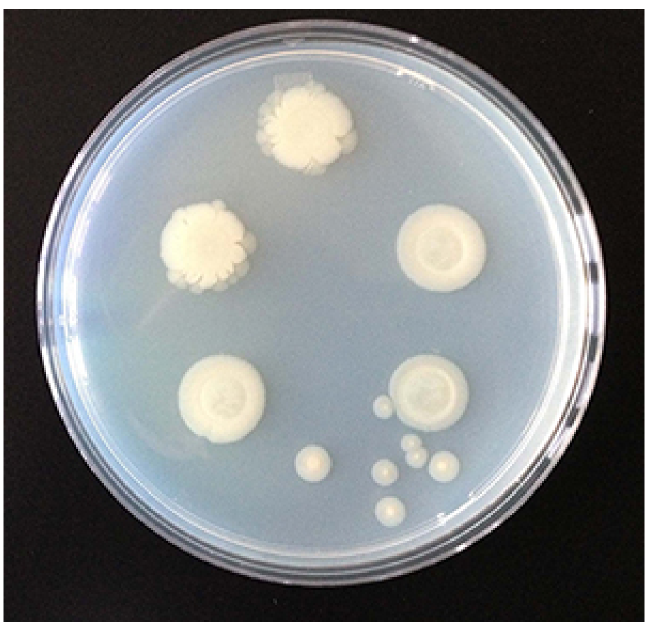
Brock, who had worked for years with the standard axenic (pure, or uncontaminated) lab clone, noticed something strange about the *D. discoideum* in the Queller/Strassmann lab, which had been collected from the wild.

When she looked at wild *D. discoideum* clones under a microscope, she saw bacteria in the sori of some clones. Oddly it was always the same clones that carried bacteria. The bacteria caught her attention because she had never seen anything like this in the lab clone.

"As I tell the students, it's all about the details," Brock says.

A fancy farmer

Whenever she found a *D. discoideum* clone carrying bacteria, Brock tried to isolate the bacteria. This was a bit hit or miss, she explains, because many organisms that live in the soil cannot be grown in the lab.



The two strains of bacteria hitching a ride on a *D. Discoideum* clone belonged to the same species but they plated out differently. One formed colonies with smooth edges and the other formed colonies with bumpy edges. This observation eventually led to the discovery that one was edible and the other produced defensive chemicals. The *D. discoideum* travels well-equipped. Credit: Debra Brock

Eventually she found a champion *D. discoideum*: a farmer clone from which she was able to isolate two strains of bacteria. At least the strains looked different when they were cultured in a dish.

She sent the two bacteria out to be identified genetically and both came back as *Pseudomonas fluorescens*: the same species, even though they were morphologically so different.

"It was a bit of a puzzle," Brock said. On top of that one of the two morphs was edible and the other was not, and the edible one was the first edible strain she had isolated that wasn't a lab feedstock.

"So, I now had two bacteria that seemed the same and one was a food and the other wasn't," Brock said. "That was really odd.".

Toting guns and butter

When the farmer paper appeared in *Nature*, Jon Clardy of the Harvard Medical School in Boston noticed a passing reference to the *D. discoideum* farmer with two hitchhikers in the supplement section of the paper. Clardy, who studies the chemistry of mutualism, contacted the Queller/Strassmann lab to suggest the two labs collaborate to unravel the interactions among the newly discovered threesome.

Brock sent the bacteria to Harvard, where Pierre Stallforth, a postdoctoral associate in the Clardy lab, grew them in liquid media. He sent extracts from the media back to Brock, who tested them on *D. discoideum* to see if they were active.

"Ultimately Pierre figured out that the nonfood strain was producing two chemicals: chromene and pyrrolnitrin. And excitingly, chromene is a new compound," Strassmann said.

"We determined chromene increases spore production in the farmer strain and suppresses spore formation in the nonfarmer strain," she explained. "We saw the same increases in the farmer and decreases in the non-farmer with pyrrolnitrin. A known antibiotic and antifungal, pyrrolnitrin probably also suppresses other organisms in the soil that might compete with the farmer strain."

Assays showed that it was not merely the absence of chromene and pyrrolnitrin that made the food bacterium edible. Something else is going on as well.

Why become butter?

Stallforth next sequenced the entire genome of the two bacterial strains to look for mutations that might explain the differences between them.

The genes responsible for producing pyrrolnitrin were intact in both strains. So he looked at the genes for a two-part global activator that regulates the pyrrolnitrin pathway, among many other genes.

Sure enough, there was a mutation in one of the controller genes of the food bacterium that turned it off and broke the controller. As shown by others in a previous study, breaking the controller changed the expression of 10 percent of the bacteria's genome.

"That's pretty cool, but then you still don't really know for sure if that mutation is the one that matters," Strassmann said.

To check, Stallforth artificially broke the controller—and only the controller—in the nonedible *P. fluorescens* bacterium. The knockout strain he created had the same chemical profile as the food bacterium and it, too, was edible.

Had a similar mutation in the evolutionary past created the edible strain? To answer that question, the scientists constructed a family tree of *P. fluorescens* clones in the Strassmann/Queller lab by comparing 20 genes.

"It turns out that of all the bacteria strains we've ever isolated, the two we collected from the *D. discoideum* farmer clone Brock discovered are the most closely related, Queller said.

"The tree also tells us that edibility is a derived trait. These guys used to be inedible and became edible. That's just a weird thing to evolve: to be able to eaten," Queller said.

It makes sense only because it benefits kin, more of whom will be carried to new locations by the well-fed farmer *D. discoideum* clone, the scientists said.

It's altruism, ultimately. Altruism in miniature.

More information: A bacterial symbiont is converted from an inedible producer of beneficial molecules into food by a single mutation in the gacA gene, www.pnas.org/cgi/doi/10.1073/pnas.1308199110

Provided by Washington University in St. Louis

Citation: Social amoebae travel with a posse, have amazingly complicated social lives (2013, July 29) retrieved 26 April 2024 from https://phys.org/news/2013-07-social-amoebae-posse-amazingly-complicated.html