Symbiosis bacteria produce a variety of toxins that appear to save mussels from being eaten

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Bathymodiolus mussels at the Menez Gwen hydrothermal vent off the Azores, pictured during Meteor cruise M82/3. Credit: Marum, University of Bremen

Imagine you have a tenant living in your house. They're keeping your fridge topped up. But in addition to this, they're producing all kinds of toxic substances. More harm than good? Not necessarily; it all depends what you're using the toxins for, as an international research team at the Max Planck Institute for Marine Microbiology has discovered. The researchers examined deep-sea mussels and the bacteria living in symbiosis with them. While the microbes produce an entire arsenal of toxins, these do not appear to harm the mussels - on the contrary, they protect their partners from natural enemies.

Mussels of the genus Bathymodiolus, related to the well-known blue mussel, are among the most dominant inhabitants of hot vents in the deep ocean. In their gills, they house so-called chemoautrotrophic symbionts. These symbionts include sulfur-oxidizing bacteria, which convert substances normally not used by the mussels into tasty sugars.

Jillian Petersen and her colleagues have now taken a closer look at the genes that some of the symbiotic tenants of deep-sea mussels contain in their genomes. To their surprise, what they found was a vast array of hazardous substances. The symbiotic bacteria command an arsenal of genes that are responsible for the production of toxins. The number of toxins is impressive: With up to 60 toxins, the microorganism's arsenal is better stocked than many nasty germs such as those that cause pest and cholera. However, down in the deep sea, the bacteria leave their host unharmed. In fact, they promote the health of their mussel hosts. How is this possible?

"We suspect that they bacteria have tamed these toxins", explains Petersen. "Thus, they can now take advantage of them for the benefit their host." Two kinds of beneficial effects of the toxins are possible: On the one hand, they might help mussels and bacteria to find and to recognize each other, essential steps to establishing a successful symbiosis. On the other hand, the toxins may help the mussel to defend itself against parasites.

"Symbioses are usually assumed to have only one benefit – the symbionts either help the host to feed or to defend itself. Our study shows that the partnership of Bathymodiolus and the sulfur-oxidizing bacteria seems to provide both: defence and food. That is very unusual", emphasizes Lizbeth Sayavedra, who conducted the research as part of her doctoral thesis. The tenant not only fills the fridge, it also keeps the burglars out.

In the next steps, Petersen now wants to investigate the details of this defence mechanism. The research team has developed a method proving that at least one of the toxins is exported to the mussel tissue. "Our results give fresh impetus to the research on the role of parasites and pathogens in the deep sea", says Petersen, who has recently established an independent research group at the University of Vienna.

"The Bathymodiolus symbionts produce more of these supposedly harmful substances than any known pathogen", adds Liz Sayavedra. "Who knows – maybe one day we'll discover that some of the genes that are currently annotated as toxins may have first evolved through such beneficial interactions."

More information: "Abundant toxin-related genes in the genomes of beneficial symbionts from deep-sea hydrothermal vent mussels." *eLife* 2015; DOI: 10.7554/eLife.07966

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