

Squid study holds hints of bacteria's role in regulating internal clock

23 April 2013, by Karen Herzog

Glowing bacteria in the tiny Hawaiian bobtail squid may shed new light on the role bacteria play in the human body to synchronize daily tasks such as sleeping and eating, and keeping the immune system healthy, research at the University of Wisconsin-Madison suggests.

[Circadian rhythms](#) in humans and animals - responsible for sleep cycles and other physiological and [metabolic functions](#) - have long been thought to be regulated mostly by exposure to light and darkness. The rhythms are important because disrupting the body's [internal clock](#) by traveling to a different time zone, or by working a [night shift](#), can contribute to sleep and immune system disorders, or conditions like [seasonal affective disorder](#).

If there's a connection between circadian rhythm and bacteria in the [human gut](#), it would provide further evidence of the need to be careful with antibiotics that kill bacteria which may be important to maintaining a healthy immune system, said Elizabeth Heath-Heckman, a UW-Madison graduate student and co-author of the squid research published this month in the journal *mBio*.

"Nobody's been able to show that bacteria may help regulate circadian rhythms," Heath-Heckman said last week. "There are a lot of people who research circadian rhythms in humans and their importance to maintaining immunity. People who disrupt their circadian rhythms have higher rates of heart disease and illness. Everything is intertwined."

The Hawaiian [bobtail squid](#), which is about 2 inches long and swims in the [shallow waters](#) around Hawaii, challenges conventional thinking.

It turns out the squid's internal clock, which tells it when to [forage](#) for food or to sleep, may not be solely governed by external light, but might also depend on the presence of the light-generating

bacteria that live in its body, Madison scientists found. Future research may explore whether both light and the light-generating bacteria called *Vibrio fischeri* are necessary to correctly tell the squid's internal clock when the animal should eat and sleep.

The nocturnal squid has specialized proteins that reflect light given off by glowing bacteria that live in a special organ called the light organ in its belly. As the squid hunts near the ocean's surface at night, its glowing bacteria work as a cloaking device, beaming light through its underbelly so its body doesn't cast a shadow on the sea floor and alert hungry bottom-dwelling predators to a potential meal.

The predators see only sky; the squid is invisible to them.

The squid and its glowing bacteria have a daily rhythm.

In the morning, the squid expels 90 percent of the glowing bacteria, which are taken in and grown by other young squids. The squid then buries itself in the sand of the sea floor, with only its eyes peeking out, using its eight suckered arms and two tentacles to scoop up sand around it.

While resting during the day, it grows a new batch of bacteria that glow when they reach a certain concentration.

The bobtail squid has two genes that produce proteins which communicate the time of day to the rest of the animal's body - one in the head, and one in the light organ, Heath-Heckman explained. The squid's head tells time by the sun, but its light-generating organ might tell time by the glowing bacteria, she said.

For their ongoing research, UW-Madison scientists collect adult squid from the wild in Hawaii

about every three months and bring them back to Madison to breed them and study the juveniles. In one experiment, the squid were kept outside in Hawaii. Heath-Heckman then brought them back to Madison to measure the cycling of their clock gene in the organ where the glowing bacteria live.

Squid that lacked the glowing bacteria, or that had bacteria which could not make light, were unable to cycle expression of the gene associated with the light organ.

Other squid with bacteria that were unable to produce light could still cycle the gene on and off through the day if exposed to blue light, showing that both light and the bacteria were involved with the squid's internal clock, the researchers found.

While it's speculative to read too much into what a squid's circadian rhythms may tell us about humans, it's still an exciting breakthrough, Heath-Heckman said.

"We're beginning to realize that circadian rhythms are really important for health and that microbes are important for everything," added Margaret McFall-Ngai, a UW-Madison professor of medical microbiology and co-author of the research.

McFall-Ngai, an authority on the bobtail squid and its glowing symbiotic bacteria, has studied the creature for two decades.

The Hawaiian squid is a focus of the Madison research because "it's cool," Heath-Heckman said, "and because it's a good model of how animals and bacteria communicate with each other."

"Everything in the human gut is on a rhythm," McFall-Ngai said. "Perhaps the thousands of bacteria there also govern the rhythms of the gut, just as the luminous [bacteria](#) partner of the [squid](#) sets the rhythms in the [light](#) organ."

More information: Video of the bobtail squid is available at: www.jsonline.com/news/wisconsin/

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