Researchers at Illinois explore queen bee longevity

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Entomology professor Gene Robinson is principal investigator on a study of queen bee longevity. Credit: Photo by L. Brian Stauffer

The queen honey bee is genetically identical to the workers in her hive, but she lives 10 times longer and – unlike her sterile sisters – remains reproductively viable throughout life. A study from the University of Illinois sheds new light on the molecular mechanisms that account for this divergence. The study appears in the online edition of the *Proceedings of the National Academy of Sciences*.

The research centers on the interplay of three factors known to have a role in reproduction, growth and/or longevity. The first, vitellogenin (Vg), is a yolk protein important to reproduction but which also has been found to contribute to longevity in worker bees. The second, juvenile

hormone, contributes to growth and maturation. The third, an insulin-IGF-1 signaling pathway, regulates aging, fertility and other important biological processes in invertebrates and vertebrates.

The study explores these factors in queen honey bees. How, the researchers wanted to know, could the queen achieve such a long life compared with her sisters while also devoting so much energy to reproduction"

"Many times the way organisms achieve longevity is via a tradeoff with reproduction," said entomology professor Gene Robinson, principal investigator on the study. "In general, life forms that postpone reproduction until later in life live longer. But the queen bee has her cake and eats it too. She's an egg-laying machine. She lays 2,000 eggs a day and yet lives 10 times longer than individuals that stem from the same genome and yet do not reproduce."

The researchers knew from studies of the fruit fly and nematode that the insulin-signaling pathway had a role in longevity. Down-regulation of insulin-IGF-1 signaling (IIS) in those species was associated with increases in longevity – but at the expense of fertility.

They also knew that manipulating fat body cells in the head of the fruit fly influenced longevity. Because Vg is synthesized in fat body cells in honey bees, the team decided to look at Vg expression in the head and thorax as well as the abdomen.

This led to an important discovery. Expression of Vg was high in the abdomen in the young queen and declined over time, but increased with age in the head and thorax. Old queens showed much higher Vg expression than young queens.

Worker bees had much lower levels of Vg expression than queens, and

Vg in worker heads was also low compared with queens. Previous studies in workers had shown that Vg reduced oxidative stress in honey bees by scavenging free radicals that can lead to aging or illness. Not surprisingly, queens were more resistant to oxidative stress than workers.

Whether this is the actual mechanism by which queens achieve both fertility and long life remains to be seen, Robinson said. In any event, this study suggests that vitellogenin plays a vital role in queen bee longevity, he said, particularly since the honey bee lacks many antioxidants commonly found in other species.

"There are implications here (for other species) in the sense that here is an organism that is reproductively active and long-lived," said Robinson, who is also affiliated with the Institute for Genomic Biology. "And we see novel and conserved factors that are part of a large regulatory network. The queen has her cake and eats it too. And humans want to know how that works."

Source: University of Illinois at Urbana-Champaign

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