Researchers discover biological mechanism for growing massive animal weapons, ornaments

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This is University of Montana evolutionary biologist Doug Emlen with a Japanese rhinoceros beetle. Credit: UM photo

In the animal kingdom, huge weapons such as elk antlers or ornaments like peacock feathers are sexy. Their extreme size attracts potential mates and warns away lesser rivals.

Now researchers led by scientists at the University of Montana and Washington State University have discovered a developmental mechanism they think may be responsible for the excessive growth of threatening horns or come-hither tail feathers. Published in the July 26 online edition of *Science*, the research reveals a mechanism to explain both the size of these traits, and the incredible variation among males of the same species – why some beetles, for instance, grow massive horns while their fellows grow nothing but nubbins.

"Our research explains how these enormous traits get to be so enormous," said Doug Emlen, a professor and evolutionary biologist in UM's Division of Biological Sciences. "People have known for 100 years that the best males produce the biggest structures, but nobody has really understood how. Our work looks under the hood to explain why so many sexually selected structures get so massive."

The researchers discovered when they disturbed the insulin-signaling pathway in Japanese rhinoceros beetles – big insects that can grow horns two-thirds the length of their bodies – the horns were far less likely to grow. In fact, horn growth was stunted eight times as much as growth of the wings, or the rest of the body. They interpret this to mean that the exaggerated structures – the horns – are more sensitive to signaling through this physiological pathway than are other traits.

"If you have a lot of food, you have a lot of insulin," said Laura Corley Lavine, a Washington State University entomologist and co-principle investigator with Emlen. "You respond to that by making a really giant, exaggerated horn. Then the female can tell she wants to mate with you because you are truthfully advertising your condition."

The researchers injected a cocktail of double-stranded RNA into the beetle larvae to shut down the desired insulin pathway gene. Within 72 hours normal insulin signaling had resumed, but by then horn growth was stunted. Genitalia grew normally despite the shutdown, and the wings and bodies were slightly affected. The horns, however, experienced major changes.

The experiment confirmed what the researchers thought the insulin pathway was doing to the beetles. "We're the first ones to make the link by explicitly tying the insulin pathway to the evolution of these kinds of male weapons," Lavine said. "The discovery of the actual mechanism might now open new avenues of study for how exaggerated traits evolved, their genetic basis and the evolution of animal signals."

"There is a hormone signal secreted by the brain that circulates through the whole animal," Emlen said. "It communicates to the different cells and tissues and essentially tells them how much to grow." Hormone levels reflect the physiological condition of each animal, with high circulating levels in well-fed, dominant individuals and lower levels in poorly fed or less-fit individuals. When tissues are sensitive to these signals, as most tissues are, their final sizes scale with the overall quality and size of the animal. Because of this mechanism, big beetles have larger eyes, legs and wings than smaller beetles.

Emlen said the horns are exquisitely sensitive to these insulin signals – more sensitive than other structures. Developing horns in big, fit, well-fed males are drenched with the hormone, spurring exaggerated horn growth. On the flip side, a small, less-fit male receive less of the horn-boosting hormone, stunting growth of its weapon.

Emlen said this process explains how horns can range from massive to nonexistent among male beetles of the same species and why the size of such exaggerated, showy traits accurately reflects the overall quality of the males who wield them. He said the results likely are applicable to other species beyond rhinoceros beetles, since additional studies have tied this same physiological pathway to growth of red deer antlers and crab pincer claws.

"Horns and antlers matter," Emlen said. "Animals pay attention to them when they size each other up for battle. And females pay attention to horns or are attracted to males with really big tails. Why? Because only the best of the best can have really big horns or tails."

More information: "A Mechanism of Extreme Growth and Reliable Signaling in Sexually Selected Ornaments and Weapons," by D.J. Emlen, *Science*, 2012.

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