Insulin May Guarantee the Honesty Of Beetle's Massive Horn

Rhinoceros beetles put peacocks to shame when it comes to their sexually selected trait. The head of this apricot-sized insect sports a forked "horn" that can extend to two-thirds of its body length. Males size each other up based on their horns; those with the bigger ones gain access to the females.

Horn size appears to be an honest indicator of male quality: Small male rhinoceros beetles never grow large horns to fool a rival. Biologists have long thought that's because the horns are too physiologically costly for small, undernourished males to build and support. "It's one of the central tenets of sexual-selection theory," says Sara Lewis, an evolutionary biologist at Tufts University in Medford, Massachusetts. But work presented at the meeting shows that, actually, horns are not a very big burden. Instead, the nature of the developmental pathway that leads to horns—and other sexually selected traits related to size—may be what guarantees that these traits are a true reflection of the rival's health and stature, says Douglas Emlen, an evolutionary biologist at the University of Montana in Missoula.

Other researchers are intrigued. Emlen has "got a handle on the mechanistic gears behind the story of how these amazing horns developed in these beetles," says Mark Kirkpatrick, an evolutionary biologist at the University of Texas, Austin.

To find out how much of their bodily resources male beetles devote to their horns, Emlen's graduate student Erin McCullough weighed large and small horns, before and after drying them out. While the head and thorax of a male rhinoceros beetle are 65% water and the legs 55%, the horns were lightweight, only 25% water, she reported at the meeting. All told, a horn makes up less than 3% of the insect's body mass on average.

Next, McCullough looked at how horn size affects flying ability. She positioned dead rhinoceros beetles with and without their horns in a wind tunnel to measure drag. She also clocked the speed of beetles with various sized horns in the wild with a radar gun and measured how far beetles go in a single flight. The beetles fly upright, creating so much drag that having a horn doesn't really make flying much harder, she reported. Flight speed and endurance were likewise unaffected by having a horn, leading McCullough to conclude that small males wouldn't obviously be disadvantaged if they produced a bigger horn in order to deceive rivals.

Nor did the production of a big horn compromise the growth of other body parts: Males with big horns also had relatively large wings and eyes and developed just as quickly as their smaller peers, she noted. McCullough "did a thorough job of demonstrating clearly that the would-be costs of this enormous structure weren't there," says Adam South, an evolutionary biologist at Harvard University. "I think we might have to revise our theory," McCullough concluded.

Honest signal. A rhinoceros beetle horn may reflect how fit the beetle is because its growth is tied to the insulin pathway.

Emlen is doing just that. He has long wondered what causes horns and other oversized, sexually selected structures to grow out of proportion with the rest of the body, as long as ample food supplies were available to the growing insect. The signaling pathway involving insulin seemed like a good bet. For 500 million years of evolution, insulin and its interacting proteins have helped cells respond to nutrients, stimulating cell division and tissue growth in good times and shutting down growth when food is scarce. These signals affect the entire body, but if an animal's sexually selected ornaments and weapons were more sensitive to these signals than the rest of the body, then they should grow disproportionately larger in good times and little to not at all in bad times. An insulin-mediated sensitivity would make the horn a clear indicator of male quality.

Earlier research by Alex Shingleton of Michigan State University in East Lansing had shown that body parts can differ in how they respond to insulin or insulin-like growth factors. In fruit flies, sex organs grow to be the same size no matter how much food is available to the young. They are insensitive to the insulin pathway. In contrast, wings in these insects respond to this pathway such that well-fed individuals not only grow larger, but they also have proportionally larger wings.

Emlen and his colleagues tested the insulin sensitivity of rhinoceros beetles by injecting RNA matching part of the insulin receptor gene into larvae just as they were about to transform into adults. This RNA interfered with the gene's activity, reducing the number of receptors produced and greatly diminishing insulin signaling in growing tissues. The sex organs were the same size in both the RNA-treated and untreated beetles, wings were 2% shorter in the treated beetles, and horns were 16% smaller. Thus horns were eight times more sensitive to insulin signaling than the rest of the body, Emlen reported at the meeting. (His group's work is also described today online in *Science* http://scim.ag/DEmlen.)

Because the insulin pathway directly links nutrition to cell growth, it becomes impossible for a malnourished beetle to fake its fitness by growing a big horn. "The insulin [pathway] keeps the signal honest," says Luke Holman, an evolutionary ecologist at Australian National University in Canberra. "Females get what they expect."

Texas Wildflower's Red Keeps It a Species

It's tough to remain a separate species when close relatives live in the same place. That's apparently why a Texas wildflower, the annual phlox (*Phlox drummondii*), has light bluish purple blooms in the central part of the state but takes on a dramatically different hue in eastern Texas. There, it comes into contact with the blue-flowering pointed phlox (*Phlox cuspidata*), and the flowers of the annual phlox have evolved to become deep red. Evolutionary biologist Robin Hopkins, a post-

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