News Editor David Braun's eye on the world

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How Horns Can Drive Beetles to New Species

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In the horned beetle world there is a bizarre evolutionary trade-off: The bigger the horn on the head, the smaller the male genitalia on the other end of the animal--or vice versa.
As horns evolve to be larger, genitalia become smaller, eventually limiting sexual compatibility and creating a new species of horned beetles.

Photos courtesy Armin Moczek/Indiana University Bloomington

In the September 2008 issue of *Evolution*, Armin Moczek and Harald Parzer, both biologists with Indiana University Bloomington, examine males from four geographically separated populations of the horned beetle species *Onthophagus taurus*.
The separate beetle populations have diverged significantly in the size of the male copulatory organ, "and natural selection operating on the other end of the animal -- horns atop the beetles' heads -- seems to be driving it," they say.

"Biologists have known that in these beetles there is an investment trade-off between secondary sexual characters and primary sexual characters," Moczek said. "As horns get bigger, copulatory organs get smaller, or vice versa.

"What was not known was how frequently and how fast this can occur in nature, and whether this can drive the evolution of new species."

Structures directly involved in mating, the genitalia, are known as primary sexual characters. Combat structures like horns -- or seductive attributes like a cardinal's vibrant plumage or a bullfrog's deeply resonant baritone -- are known as secondary sexual characters, the scientists explained.

Shown are males of four of the 10 Onthophagus species examined in the study. From top to bottom: *O. watanabei* (North Borneo), *O. taurus* (Mediterranean), *O. gazella* (South Africa), and *O. sagittarius* (Indonesia).

Evolutionary biologists believe changes in copulatory organ size and shape can spur

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speciation by making individuals from different populations sexually incompatible.

The notion that genital size is related to the origin of species is not new. An early "lock and key" model of reproductive isolation was first proposed by L. Dufour 160 years ago to explain why some pairs of species, outwardly identical in every way, are unable to mate.

But how genital morphology is related to the creation of new species puzzles biologists. "Individuals of most species do not choose mates according to the size and shape of genitalia," Moczek and Parzer said in their statement. "Indeed, genitalia may not be relevant until the latter stages of courtship, if at all."

This is where the latest research on the horned beetle Onthophagus taurus may shed some light.

Native to Italy, the horned beetle exists in other parts of the world only because of recent human activity. This means, Moczek and Parzer say, that the marked divergences they observed in O. taurus's horn and copulatory organ size must have occurred over an extremely short period of time -- 50 years or less.

The four O. taurus populations Moczek and Parzer studied in the U.S. (North Carolina), Italy, and western and eastern Australia, exhibit substantial changes in both horn and genitalia length -- as much as 3.5 times, in terms of an "investment" index the scientists devised that takes body size into account.

The scientists examined 10 other Onthophagus species, and as expected, they found vast differences between the species regarding horn and male copulatory organ size. Moczek says this suggests that trade-offs between primary and secondary sexual traits continue to shape the way species diverge well after speciation has occurred.

Males from most horned beetle species, such as the *Onthophagus nigriventris* seen here, have faced an evolutionary trade-off to ensure their reproductive success, an earlier study suggested.

Photograph courtesy PNAS

The speed and magnitude of divergence within O. taurus presents something of a paradox, the scientists say. "How is it that copulatory organ size can be so rigorously maintained within the populations of a single species, yet appear so restless to change?"

"In terms of the integrity of a species, it's important for these things not to change too much," Moczek explains. "So there is a lot of evidence suggesting that within species or within the populations of species, natural selection maintains genital characters. But if these primary sex characters are linked to other characters that can change readily, then you've got what we think is a very exciting mechanism that could prime populations for reproductive isolation."

Horn length and shape can change for many reasons, Moczek says. Among densely populated species, fighting (which favors large horns) may not be an effective strategy for winning mates. "As combative males fight each other, a diminutive, smaller-horned male could simply employ a sneaking strategy to gain access to unguarded females. Under these circumstances, reduced investment in horns seems to result in larger copulatory organs."

Alternately, in lower density populations, most male beetles spend a great deal of time fighting. Longer, bigger horns could serve these males well -- and also lead to smaller genitalia.

"If this is all it takes to change genitalia, it may be easier to make new species than we thought," Moczek said.

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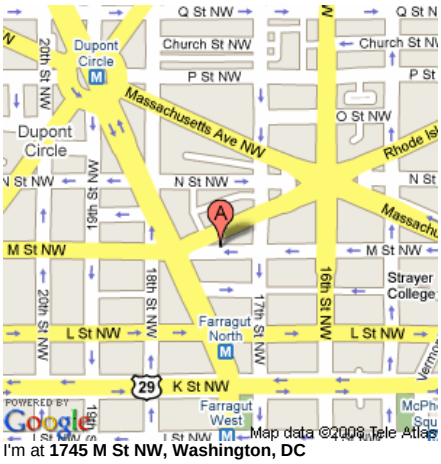

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