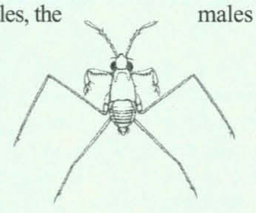
EVOLUTIONARY BIOLOGY

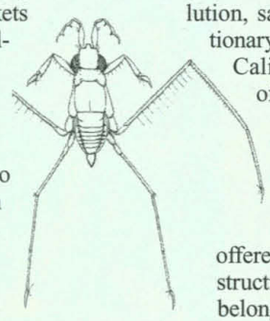
Successful Flies Make Love, Not War

VANCOUVER—Male rivalry may be costlier than expected. Male fruit flies, for example, have evolved a nasty chemical weapon in their duels over females: toxic semen that thwarts their rivals and harms their mates. Evolutionary biologists had thought that because males with the best genes win these battles, the benefits outweigh the costs of such tactics. A study reported here last week at the annual meeting of the Society for the Study of Evolution suggests that's not the case. When researchers forced fruit flies to be monogamous, allowing evolution to disarm the seminal fluid, they found that the monogamous population produced more offspring overall than control populations did.



Armed for battle. In some species of water striders, males have evolved longer, stronger appendages to subdue their mates.

Evolutionary biologists have theorized since the early 1970s that mating takes place on an evolutionary battlefield. In flies, rival males and the females they mate with seem to wage a three-way contest for reproductive advantage. After mating, a female fly stores about 500 sperm in internal pockets until her eggs are ready to be fertilized. But those sperm can be supplanted in later matings. To gain an edge over other Casanovas, a male fly laces his seminal fluid with about 60 proteins designed to boost the chances that his sperm will win out. Some depress the female's sex drive, decreasing her willingness to mate again. Some increase her short-term egg-laying rate, and some are toxic to other flies' sperm. Unfortunately, the female gets caught in the crossfire; the seminal fluid is also mildly toxic to her, so she evolves chemical defenses against it.



Two years ago, evolutionary biologist William Rice of the University of California, Santa Cruz, dramatized how male rivalry can put the sexes at odds when he used a trick of genetics to prevent females from evolving defenses to the male power plays. Unrestrained, the males became "supermales," with very toxic seminal fluid and aggressive mating habits. They reaped larger numbers of offspring than their rivals but caused their mates to die young (*Science*, 17 May 1996, p. 953).

Now Brett Holland, a graduate student collaborating with Rice, has shown that sensitive nice-guy flies can evolve, too, when competitive pressure is removed. Holland imposed monogamy on the normally promiscuous insects by isolating male-female pairs in separate vials. He mixed the offspring from all the pairs and picked his next generation at random from the hatchlings. After 32 generations, the flies were on their way to disarmament. Compared with male progeny of control flies that had to compete for a single female, descendants of monogamous males had less toxic seminal fluid and did not harass females as much. Females, in turn, were less resistant to the males' seminal fluid and more receptive to their courtship proposals.

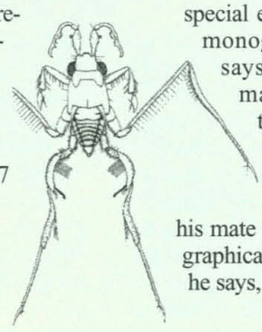
The move toward cooperation in a monogamous relationship was expected, Holland says, as "anything [a male] does to hurt her hurts himself." But the researchers were less sure what the effect would be on the population as a whole. In fact, the cooperation paid off. The monogamous flies produced an average of 28% more viable offspring than controls, even when the disarmed males competed with each other.

The experiment is a clear, and clever, demonstration of the costs of conflict in evolution, says Michael Rose, an evolutionary biologist at the University of California, Irvine. Locke Rowe of the University of Toronto in Canada agrees: "It's similar to a real arms race, where competition drags the whole economy down."

In his own talk, Rowe offered another example of this destructive path: water strider species belonging to the genus *Rheumatobates*. He found evidence of a gradual buildup of armaments in males of different species, including longer legs, spines, and antennae that look like muscular legs. These implements apparently give a male a reproductive advantage over other males by enabling him to hold down resistant females during mating, Rowe says.

Indeed, species that eschew such rivalry are relatively rare. "You need fairly special environmental conditions for monogamy to evolve," Holland says, because any cheater—a male who mates with more than one female—will have more offspring than his monogamous brothers. Unless a male can guard his mate without harming her or geographical distance separates couples, he says, there is no truce in sight.

–GRETCHEN VOGEL



The shoes were unearthed in the 1950s by an amateur archaeologist, J. Mett Shippee, at Arnold Research Cave near Columbia, Missouri. Analyses of animal bones, stone tools, and ceramic fragments from the cave by Shippee and later by archaeologist Michael O'Brien of the University of Missouri, Columbia, revealed that the cave's visitors ranged from Archaic hunters and gatherers to later agricultural peoples. Taking shelter in the cave, generations of these early Americans lost or tossed away their worn shoes, which the cave's dryness preserved.

But no one suspected the shoes' age until O'Brien contacted Kuttruff, an expert on prehistoric clothing in the eastern United States. She noted that although regional historic accounts described Native Americans in mainly leather footwear, almost all the shoes were of plant fiber, suggesting that they were ancient. She and her colleagues carbon-dated fibers of seven of the most diverse shoes by accelerator mass spectrometry, an especially sensitive dating technique. They found that the shoes range in age from 1070 to as much as 8325 years old.

The ancient shoemakers relied largely on just one of several fiber-producing plants in the region: *Eryngium yuccifolium,* or rattlesnake master (named for the supposed antivenom properties of its leaves). The designs, however, range from sandals to several varieties of slip-ons and moccasins, with fibers twined, twisted, and interlaced in different and complex ways to form straps, soles, and heels. The sling-back and slip-on styles look contemporary enough to be sported on modern city streets.

Whether the distinctive footwear styles were created for different seasons or simply for fashion is far from clear. But if a larger sample of the styles could be found and dated, they could prove a real boon to research, says Tom Dillehay, an archaeologist at the University of Kentucky, Lexington. The varied styles "not only show footwear technology and its growth and change" but could also be used, along with more traditional markers such as tools and pottery, to help identify the age or cultural affiliation of sites.

The cache of footwear also offers an unusually personal glimpse of early Americans. Some sandals were trodden to holes and frugally repaired before being lost, while a child's leather moccasin was apparently kicked off almost new. One complete specimen was a perfect men's size 9½. It "makes you think about some person in prehistoric times wearing those sandals," says Jakes. "Looking at the sandals, [you know] that someone used them."

–HEATHER PRINGLE

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