Biologists expose hidden costs of firefly flashes

September 19 2007

A new study by biologists at Tufts University has discovered a dark side lurking behind the magical light shows put on by fireflies each summer. Using both laboratory and field experiments to explore the potential costs of firefly courtship displays, the biologists have uncovered some surprising answers.

The research, to be published in the November 2007 issue of American Naturalist and now available online (http://www.journals.uchicago.edu/cgi-bin/resolve?id=doi:10.1086/521964), revealed that it's energetically cheap for fireflies to produce their distinctive flash signals, but that flashier males are more likely to end up on the dinner table.

On summer evenings, male Photinus fireflies lift off into the air to broadcast their bioluminescent flashes in search of females. Females perched in the grass sit and admire passing males and, if they're interested, will flash in response. Previous research on many different firefly species has shown that females respond more readily to males that give longer flashes, as well as those with faster flash rhythms. This female choice favors firefly males that produce more conspicuous flashes.

"Since females so clearly prefer the flashier males, one thing that's been puzzling scientists is what's keeping these males from evolving longer and longer, faster and faster flashes," says Sara Lewis, professor of biology at Tufts and leader of the research team that included

postdoctoral researcher William Woods and two undergraduate students. In theory, there might be some hidden costs to more conspicuous flashes, but what are they"

To answer this question, the researchers set out to look at two potential costs of firefly flash signals. First they measured the energy that fireflies expend while they're producing their bioluminescent flashes. In carefully controlled laboratory experiments, the team used tiny respirometry chambers to measure how much carbon dioxide each firefly produced when they were flashing compared with when they were resting. "Basically, we're in the business of measuring bug breath," notes Woods. These respirometry results demonstrated that fireflies require surprisingly little energy to produce their magical flashes, even less than what it takes them just to walk around.

Evolutionary Balancing Act Could Generate New Species

Once the Tufts team established that flashing had such a low energy cost, they tried a simple field experiment to measure the potential predation costs of firefly flash signals. Photinus fireflies are known to produce noxious chemicals that deter most predators, yet make them the top menu choice for the larger predatory fireflies known as Photuris. Using basic materials that included electronic fake fireflies (manufactured by Firefly Magic), plastic toy-dispensing capsules designed for vending machines, and sticky glue, the researchers made two startling discoveries.

In the field, predatory fireflies were attracted significantly more often to the fake firefly signals compared with non-flashing but otherwise identical controls. In addition, when flash signals were more frequent, they were much more likely to attract predators. So even though more

conspicuous flash signals provide male fireflies with an evolutionary leg up in terms of attracting females, they also have a potentially fatal downside because they are more likely to attract predators in search of their next meal.

"Every single night, male fireflies are out there flying a fine line between sex and death. For us, it definitely rivals the most exciting television thriller!" says Lewis. "So, next time you're outside on a summer night take a moment to admire the firefly romance and risk that's playing out all around you."

According to Lewis, the importance of these two conflicting forces could easily shift in different firefly populations. Therefore, it's possible that this evolutionary balancing act might generate entirely new firefly species with their own distinctive flash codes.

Funded by a National Science Foundation program called Research Experiences for Undergraduates, the Tufts research could ultimately help us to better understand the evolution of communication in many organisms, including humans.

Source: Tufts University