On the Perilous Serenades of Túngara Frogs

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Biologist Mike Ryan in Panama, in the region where he studies túngara frogs.

Being sexy, for male túngara frogs, is a dangerous game. They often embellish their normal call, a high-pitched pulsing whine, with a clicking "chuck" or two, because it makes them more attractive to female túngara frogs. Doing so, however, makes them more vulnerable to Trachops cirrhosus, a frog-eating bat native to the same Central and South American ecosystems where the túngaras live.

This evolutionary double-bind lies at the heart of the research of biologist Mike Ryan, who is being honored this month by the American Society of Naturalists with the E.O. Wilson Naturalist Award.

Ryan first began studying the túngara frogs in the late 1970s because he was interested in "sexual selection"—the idea, first posited by Darwin more than a century ago, that certain traits evolved in males not in order to maximize their chances for survival, but in order to make the males more likely to be chosen by females as mates.

"Big, bright peacock tails are emblematic of this," says Ryan, the Clark Hubbs Regents Professor in the Section of Integrative Biology. "They weigh the males down, and make them more visible to predators. Natural selection should tend to make the tails smaller and less elaborate."

Ryan immediately appreciated the túngara frog's potential as a model species for studying sexual selection. They were relatively easy to observe in their natural habitat. They had a long mating season. And the males were capable of these loud, complex calls which seemed like just the kind of biological embellishment that could have evolved to attract females.

"The male frogs always make a whine, but when they're by themselves they don't make the chucks," says Ryan. "When they're around other males and females, however, particularly during mating season, they make chucks. They can even get into a competition where they're increasing their number of chucks."

In order to test the hypothesis that the calls were enhanced to attract females, Ryan and his colleagues conducted a simple experiment. They placed female túngara frogs in the middle of a chamber. At each end of the chamber they placed speakers, through which they broadcast synthesized variations of male túngara calls. Then they watched to see whether the females were drawn to a particular kind of call.

What they found was that the females did, indeed, prefer the calls with a whine and at least one chuck to calls that consisted only of a whine. This was the first experimental demonstration of what Darwin had surmised but never proven—that variation in signal in a male's sexual advertisement influences female mate choice. It also led to an obvious next question: if the males are sexier when they make the chucks, why don't they make the chucks all the time?

"There must have been some evolutionary disadvantage to doing so," says Ryan.

At first, Ryan says, he wondered whether there was a high energetic cost to making the chucks. If the frogs expended a lot energy in making the chucks —energy they'd have to recoup by finding more food—then it would make sense for them to conserve their chucks for when they'd have maximal likelihood of attracting a female. Ryan and a colleague ran experiments to test this, but found that, energy-wise, it just didn't cost the frogs all that much to chuck.

A much better explanation came to Ryan mostly through luck. While in Panama, conducting his Ph.D. thesis research at the Smithsonian Tropical Research Institute, he heard news of a fellow biologist who had happened upon a bat with a frog in his mouth. The bat guy (Merlin Tuttle, who went on to found Bat Conservation International) suspected that the bats might be locating the frogs through the sound of their calls, and he was looking for a frog guy to help him test it experimentally. Ryan offered to collaborate.

They brought the bats into a large flight cage and then played túngara calls from speakers, at which point the bats came down and hopped on the speakers and began ripping on them as if they were frogs inside. If offered a choice of calls, the bats preferred the more complex calls, with a whine and a chuck, over the calls that were just a whine, and the more chucks there were the easier it was for the bats to zero in on the source.

"It became pretty clear that when male túngara frogs increase their complexity they gain an advantage because they become more attractive to females," says Ryan, "but there's a cost. They become more attractive to bats as well."

That dramatic discovery of the counter-evolutionary costs of a sexually selected trait, along with his earlier demonstration of the existence of such traits, have served as the backbone of Ryan's career as a biologist. Much of his work in the decades since has been dedicated to refining his understanding of sexual selection, and to developing a much deeper understanding of why animals (túngara frogs in particular) do what they do.

In addition to his own behavioral experiments, Ryan has collaborated with other biologists to do direct readings of the electrophysiological signals in the túngara frog's brain. He and his colleagues have investigated how sexual selection plays out at the molecular level by showing how gene expression in the frog's brain changes when females hear more or less attractive calls. He's explored the phylogenetic origins—the evolutionary trees—of the frogs for insight into the patterns by which various behaviors have evolved. And he's sidetracked into other species to see whether more universal patterns can be observed.

Throughout all the collaboration and all the methodological advances, however, Ryan has continued to rely on field work as the foundation of his research.

"Our work is always grounded in natural history, in observation of the animals in the wild," says Ryan. "I work in Panama every summer with a crew of grad students and undergraduates. Our Panamanian laboratory is tens of yards from where the frogs are breeding, so when we're going to do an experiment, we walk into the forest and find the frogs mating. We bring them into the lab, do our experiments and then release them. We're forced to go into the field no matter what we're doing, every single day, and I think that keeps us grounded."