This frog has lungs that act like noise-canceling headphones, study shows

March 4 2021

A male Green treefrog calling. Credit: Norman Lee

To succeed in mating, many male frogs sit in one place and call to their potential mates. But this raises an important question familiar to anyone trying to listen to someone talking at a busy cocktail party: how does a

female hear and then find a choice male of her own species among all the irrelevant background noise, including the sound of other frog species? Now, researchers reporting March 4 in the journal *Current Biology* have found that they do it thanks to a set of lungs that, when inflated, reduce their eardrum's sensitivity to environmental noise in a specific frequency range, making it easier to zero in on the calls of their mates.

"In essence, the lungs cancel the eardrum's response to noise, particularly some of the noise encountered in a cacophonous breeding 'chorus,' where the males of multiple other species also call simultaneously," says lead author Norman Lee of St. Olaf College in Minnesota.

The researchers explain that what their lungs are doing is called "spectral contrast enhancement." That's because it makes the frequencies in the spectrum of a male's call stand out relative to noise at adjacent frequencies.

"This is analogous to signal-processing algorithms for spectral contrast enhancement implemented in some hearing aids and cochlear implants," says senior author Mark Bee of the University of Minnesota-Twin Cities. "In humans, these algorithms are designed to amplify or 'boost' the frequencies present in speech sounds, attenuate or 'filter out' frequencies present between those in speech sounds, or both. In frogs, the lungs appear to attenuate frequencies occurring between those present in male mating calls. We believe the physical mechanism by which this occurs is similar in principle to how noise-canceling headphones work."

It's long been known to scientists that vocal signals are key to reproduction in most frogs. In fact, frogs possess a unique sound pathway that can transmit sounds from their air-filled lungs to their air-filled middle ears through the glottis, mouth cavity, and Eustachian tubes. But the precise function of this lung-to-ear sound transmission

pathway had been a puzzle. Earlier studies suggested that the frog's lungs might play a role in increasing the degree to which eardrum vibrations were direction dependent, thereby improving the ability of listeners to locate a sexually advertising male. But Bee's team has found that wasn't the case.

A pair of Green treefrogs mating. Credit: Norman Lee

Further analysis of the data suggested a different explanation: while the state of the lungs' inflation had no effect on directional hearing, there was a substantial impact on the sensitivity of the eardrum. With inflated lungs, the eardrum vibrated less in response to sounds in a specific frequency range. It led them to a new idea: that the lungs were

dampening vibrations, thereby canceling out noise.

Indeed, their studies using laser vibrometry showed that the resonance of inflated lungs selectively reduces the eardrum's sensitivity to frequencies between the two spectralpeaks present in the mating calls of frogs of the same species. It confirmed that a female can hear males of her own species no matter the state of her lungs' inflation. So, the lungs had no impact on the "signals" of interest to a female. But what about the "noise"?

They already knew that a major source of noise for any given species of frog is the calls of other frog species breeding at the same time and calling in the same choruses. But they had no idea how many or which other species might "co-call" in a mixed species chorus with green treefrogs across its geographic range, much less how the frequency spectrum of their calls looked. To find out, they turned to publicly available data from a citizen science project called the North American Amphibian Monitoring Program. Their analysis of those data suggests that the green treefrog's inflated lungs would make it harder to hear the calls of other species while leaving their ability to hear the calls of their own species intact.

"Needless to say, we think this result—a frog's lungs canceling the eardrum's response to noise created by other species of frogs—is pretty cool!" Bee says.

Finally, they created a physiological model of sound processing by the green treefrog's inner ear to examine how the lung's impact on the eardrum might be converted into more robust neural responses to the calls of their own species. They think it works like this: the inner ear is, in some ways, "tuned" to respond best to the frequencies in the species' own calls. But that tuning is not perfect. The authors suggest that a primary function of the lungs in hearing is to sharpen or improve this

tuning, allowing the inner ear to generate relatively stronger neural responses to the species' own calls by reducing the neural responses driven by the calls of other species.

The findings demonstrate the power of evolution to co-opt pre-existing adaptations for new functions, the researchers say. In future work, they want to find out more about the physical interaction between the three sources of sound (external, internal via the opposite ear, and internal via the lungs) that determine the eardrum's vibration response. They also want to know more about how widespread noise cancellation is in frogs.

More information: *Current Biology*, Lee et al.: "Lung Mediated Auditory Contrast Enhancement Improves the Signal-to-Noise Ratio for Communication in Frogs" www.cell.com/current-biology/f … 0960-9822(21)00113-5 , DOI: 10.1016/j.cub.2021.01.048

Provided by Cell Press

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