Athletic frogs have faster-changing genomes

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This is *Dendrobates leucomelas*, a poisonous frog from Venezuelan Guiana. Credit: Photo courtesy of Cesar Barrio-Amoros (www.andigena.org)

Physically fit frogs have faster-changing genomes, says a new study of poison frogs from Central and South America.

Stretches of DNA accumulate changes over time, but the rate at which those changes build up varies considerably between species, said author Juan C. Santos of the National Evolutionary Synthesis Center in Durham, North Carolina.

In the past, biologists trying to explain why some species have faster-changing genomes than others have focused on features such as body

size, generation time, fecundity and lifespan. According to one theory, first proposed in the 1990s, species with higher resting metabolic rates are likely to accumulate DNA changes at a faster rate, especially among cold-blooded animals such as frogs, snakes, lizards and fishes. But subsequent studies failed to find support for the idea.

The problem with previous tests is that they based their measurements of metabolism on animals at rest, rather than during normal physical activity, Santos said.

"Animals rarely just sit there," Santos said. "If you go to the wild, you'll see animals hunting, reproducing, and running to avoid being eaten. The energetic cost of these activities is far beyond the minimum amount of energy an animal needs to function."

To test the idea, Santos scoured forests in Colombia, Ecuador, Venezuela, and Panama in search of poison frogs, subjecting nearly 500 frogs — representing more than 50 species — to a frog fitness test.

He had the frogs run in a rotating plastic tube resembling a hamster wheel, and measured their oxygen uptake after four minutes of exercise.

The friskiest frogs had aerobic capacities that were five times higher than the most sluggish species, and were able to run longer before they got tired.

"Physically fit species are more efficient at extracting oxygen from each breath and delivering it to working muscles," Santos said.

To estimate the rate at which each species' genome changed over time, he also reconstructed the poison frog family tree, using DNA sequences from fifteen frog genes.

When he estimated the number of mutations, or changes in the DNA, for each species over time, a clear pattern emerged — athletic frogs tended to have faster-changing genomes.

Santos tested for other factors as well, such as body and clutch sizes, but athletic prowess was the only factor that was consistently correlated with the pace of evolution.

Why fit frogs have faster-changing genomes remains a mystery. One possibility has to do with harmful molecules called free radicals, which increase in the body as a byproduct of exercise.

During exercise, the circulatory system provides blood and oxygen to the tissues that are needed most — the muscles — at the expense of less active tissues, Santos explained.

When physical activity has stopped, the rush of blood and oxygen when circulation is restored to those tissues produces a burst of free radicals that can cause wear and tear on DNA, eventually causing genetic changes that — if they affect the DNA of cells that make eggs or sperm — can be passed to future generations.

Before you ditch your exercise routine, Santos offers some words of caution. The results don't debunk the benefits of regular physical exercise, which is known to reduce the risk of cancer, heart disease, and diabetes.

"What applies to cold-blooded animals such as poison frogs doesn't necessarily apply to warm-blooded animals such as humans," Santos said.

The findings appeared in the April 10th issue of *Molecular Biology and Evolution*.

More information: Santos, J. (2012). "Fast molecular evolution associated with high active metabolic rates in poison frogs." *Molecular Biology and Evolution*. mbe.oxfordjournals.org/content …/04/09/molbev.mss069

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