localnews

Now playing . . . Frogs on Ice

Miraculous feat of winter survival now taking place just below dead leaves

Unseen to nearly all of us, an amazing story of evolutionary achievement and wonder is unfolding right now. The short days and cool temperatures of November are the cue to millions of amphibians throughout the Kawarthas to begin their annual period of dormancy.

As kids we were always told that frogs simply overwinter in the mud in the bottom of ponds. End of story. Although there are frogs who do opt for this strategy, just as many species actually tough it out on the forest floor, usually with only a thin blanket of leaves between them and zero degree temperatures. This group includes the spring peeper, chorus frog, gray treefrog and wood frog. Thanks to some ingenious adaptations – including the ability to quickly develop from aquatic tadpole to terrestrial frog before water freezes in the fall – the species essentially become frogsicles!

Much of what we know about these adaptations began with the work of Michael Kirton at the University of Alaska. In the summer of 1972 he inserted radioactive tags on 27 wood frogs. Kirton followed the frogs with a Geiger counter until late September when they stopped moving. Surprisingly, he found that his Geiger counter ticked loudest over land – not near wetlands and ponds. As he probed the ground, he found dormant wood frogs in shallow bowls of compacted forest litter. These hideaways, only about two or three centimetres deep, were covered by an accumulation of leaves and twigs. Snow cover then added a final blanket to shield the frogs from the frigid Alaskan temperatures. Kirton found that the frogs endured leaf-litter temperatures of -6C during hibernation! How is this possible? We now have a good understanding of the amazing mechanisms involved.

Green frog

Wood frog

Northern leopard frog

American toad

DREW MONKMAN photos

START BURROWING

As Kirton observed, the onset of cold weather is the frog's cue to burrow down several centimetres into the damp leaf litter where it can avoid dehydration. As outside temperatures drop, the frog's metabolism slows to a crawl and its body temperature approaches 0C. Just like the leaves and moisture around it, the frog essentially freezes.

However, when the first ice crystals begin to form on the frog's skin, an alarm reaction is set off. In a response akin to the "fight-or-flight response" in humans, adrenaline is released into the frog's bloodstream. The adrenaline in turn activates enzymes that convert glycogen in the animal's liver to glucose (sugar). Blood and cellular glucose levels rocket to astronomic concentrations – levels that would kill a human many times over. Like the antifreeze in your car, the glucose lowers the freezing point of the cellular fluid. This protects the integrity of the cell. Remember that when water freezes, it also expands, so freezing within a cell itself would tear it apart. The wood frog also uses urea as a cell protectant. Unlike glucose, urea is accumulated over the course of the fall and is already present within cells when freezing begins.

At the same time as glucose and urea levels are soaring, much of the water within the cells is actually being withdrawn through osmosis. During this process, the cells shrink substantially. That further increases their resistance to ice formation. The water accumulates in the frog's abdominal cavity, in the lymph system, and in the area just under the skin. Here, special proteins and bacteria actually promote the formation of ice crystals. As much as 65% of the water in the frog's body gradually crystallizes. However, ice formation in these open spaces is safe and does not interfere with any of the vital organs. Within only 15 hours, the frog essentially becomes a block of ice. Its eyes actually turn white because the lenses freeze! Laboratory studies have shown that wood frogs can survive minimum body temperatures of as low as -6C. During the many months of suspended animation, there is no breathing, blood circulation or heartbeat. All of the cells are therefore deprived of oxygen. By most definitions, the frog is dead.

However, when researchers bring these frogsicles inside from the cold and let them thaw out, the frogs become active again quite quickly. The heart resumes beating even before ice in the body has completely melted, and breathing and blood circulation are restored soon thereafter. The frogs usually exhibit normal body postures and coordinated movement within 14 to 24 hours. Singing and other courtship behaviour won't begin for several days, however. Still, when you consider that these species not only spend the winter frozen, but then wake up in the spring to face a full-fledged singing and mating frenzy – and all on an empty stomach – you can't help but be awed by the genius of evolution and the resiliency of life.

HEAD START ON LAND

So, why has wood frog evolution followed the path of hibernation on land rather than in the water? One possibility is that by hibernating on land, the frogs can become active as soon as spring temperatures rise above freezing and most of the snow has melted. They can then breed in the temporary ponds and ditches formed by meltwater. Green frogs and leopard frogs overwinter at the bottom of ponds, rivers, and lakes and have to wait a few weeks longer until the ice melts. Wood frog choruses begin several weeks before those of most aquatic frogs. This early start also provides more time for the tadpoles to change into adults before the fall.

Wood frog adaptations to surviving freezing may have some important lessons for humans. How is it that these animals – our distant relatives from an evolutionary perspective – can manage astronomically high glucose levels in their tissues without ill effect? Wood frogs easily tolerate blood sugar levels 100 times higher than normal and show none of the substantial damage suffered by human diabetics when their blood sugar rises by only two to ten fold.

Frogs that overwinter in the mud at the bottom of ponds and marshes take in the little oxygen they need directly through their skins. Leopard frogs usually prefer moving water, which provides more oxygen. On several occasions I've seen diving ducks and otters on the Otonabee River come up with a hibernating leopard frog that they have plucked from the river bottom.

True to its many unfrog-like characteristics, the American toad also shows an independent streak when dealing with cold and famine. The toad retreats to below the frost line, either by burrowing down into loose soil or by taking up winter residence in ready-made burrows or crevices. This allows it to escape freezing temperatures altogether. The toad stops digging when the soil temperature remains at 1C to 2C above freezing. Gardeners sometimes find toads when turning soil in the fall.

A NOVEMBER MIRACLE

So, never think of late fall and winter as a boring season where nothing of interest is taking place. Amphibian dormancy and hibernation are examples of the true "miracles" of life on this planet. It's something you can think about during your next walk or ski through the woods or near a lake or wetland.

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