LIVING

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Deep freeze for frogs

Amphibians, reptiles, insects have own winter coping mechanisms

Should you ever start to feel a little overwhelmed by the challenges of winter, knowing what other creatures have to do to just stay alive will maybe put things into perspective. My last column looked at some winter survival strategies used by birds, mammals and trees. This week, I'd like to turn my attention to amphibians, reptiles and insects.

OUR CHANGING SEASONS
Drew Monkman

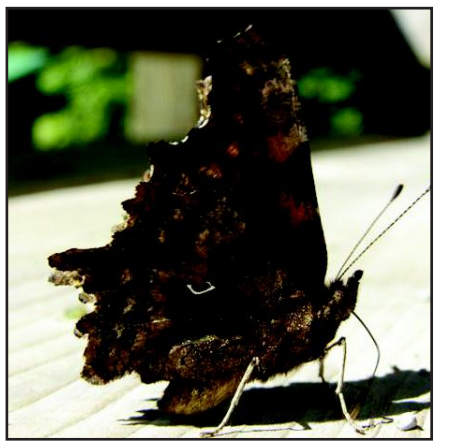
Two basic strategies are available to cold-blooded creatures like amphibians and reptiles. They may escape freezing temperatures by overwintering below the frost line, either underground or at the bottom of a deep pond. Alternatively, they may simply decide to tough it out on the land.

Frogs illustrate these two alternatives quite well. Contrary to popular belief, most species of frogs do not spend winter at the bottom of ponds and rivers. A majority actually overwinter 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, they essentially become tiny blocks of ice.

Let's take the wood frog as our example. With the onset of cold weather, this handsome frog of upland habitats burrows several centimetres down into the leaf litter. As outside temperatures drop, the frog's metabolism slows to a crawl and its body temperature approaches 0C. 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. 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 acts as very effective antifreeze by lowering the freezing point of the cellular fluid. This protects the integrity of the cell, because freezing within a cell itself would tear it apart.

At the same time as glucose levels are soaring, much of the water within the cells is actually being withdrawn through osmosis. This, in turn, further increases the cells' resistance to ice formation. The water accumulates in the frog's abdominal cavity and in the area just under the skin. Here, special proteins and bacteria actually promote the freezing of liquids. 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.

During the many months of suspended animation, there is no breathing, blood circulation or heartbeat. By most definitions, the frog is essentially dead. However, when researchers have dug up these "frogsicles" and let them thaw out, the frogs became active again with less than half an hour.



Clockwise, from left: Snakes, like this northern redbelly, must descend below the frost line to survive winter. The green comma butterfly overwinters in the adult stage of its life cycle. Eastern gray treefrogs overwinter in the leaf litter, essentially freezing solid.

Drew Monkman photos

When you consider that these species not only spend the winter frozen, but then wake up in the spring ready to sing their hearts out and partake in a full-fledged mating frenzy – and all on an empty stomach – it gives you a new appreciation for the resiliency of life.

Green frogs, mink frogs and bullfrogs have taken a different approach to enduring the rigours of winter. All three species overwinter in the mud at the bottom of ponds and marshes. They are able to take in the little oxygen they need directly through their skins. Leopard frogs, however, usually prefer moving water, which provides more oxygen. It is not uncommon to see diving ducks or otters on the Otonabee River come up with a hibernating leopard frog plucked from the river bottom.

True to its many unfrog-like characteristics, the American toad has opted for a different strategy. The toad retreats 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 temperatures below freezing. The toads stop digging when the soil temperature remains at 1C to 2C above freezing. Gardeners sometimes find toads when turning soil in the fall.

Snakes, along with terrestrial salamanders like the blue-spotted, must also descend below the frost line to survive winter. Rodent burrows and crevices in rocks are both common hibernation dens. Many snake species move to these sites during cool weather in October, although the garter snake may wait until well into November.

As for aquatic turtles, most have opted for the same strategy as pond-dwelling frogs. Turtles overwinter at the bottom of lakes, rivers and wetlands. By extending their head and legs in an effort to expose as much skin as possible, hibernating turtles are able to take up dissolved oxygen from the water. Their physical lethargy and low body temperature reduces their resting metabolism to a point where their heartbeat can slow to less than one per cent of the summer rate. This allows them to survive for extended periods, even when almost all of the oxygen in the water has been used up.

Strangely enough, many baby turtles adopt the "freeze solid" strategy and actually overwinter in the nest. After hatching out of the eggs in late summer, they simply stay put, and do not emerge from the ground until April. As with treefrogs and peepers, freezing is limited to body cavities outside of the cells. By their second winter, however, the young turtles must overwinter in the same manner that adults do.

Insects, too, depend on a variety of strategies to get through winter. Some species freeze solid, either as eggs, larvae, pupae or adults; others seek special shelter to avoid freezing temperatures; a tiny number migrate south, and one species remains relatively active.

Among the insects that overwinter as eggs, we find most grasshoppers, crickets and mosquitoes, praying mantises, and some moths like the eastern tent caterpillar. Once again, insect eggs are protected by glycerol, which inhibits ice crystals from forming within the egg cells.

Many Lepitoptera (moths and butterflies) have evolved differently. Many deal with the cold and famine of winter by sleeping it out in the larval form. Woolly bear caterpillars, the furry, black and brown caterpillars so common in the fall, overwinter in the larval (caterpillar) stage by simply curling up in some protected place on the ground. Once again, glycerol antifreeze comes to the rescue of these hibernating fur balls, restricting freezing to body cavities outside of the cells – even at temperatures below -30C! Woolly bears have actually evolved to survive multiple freezings and thawings which probably explains how they can become active in midwinter.

A surprising number of insects actually survive winter as adults. Among the better-known members of this group, we find queen bumble bees and wasps, ladybird beetles, mourning cloak butterflies, ants and some mosquitoes. Once again, most species call upon sugar-based compounds such as glycerol to prevent damage to their cells. In fact, overwintering ants are reputed as tasting "candy-sweet". Other species, such as mated female Culex mosquitoes, avoid the cold altogether by finding shelter in locations where the temperature remains above 0 C. These include cellars, sewers, well pits, animal burrows and houses. It is not uncommon to find an active mosquito in the house, even in the middle of winter.

Honey bees have evolved a totally different approach to surviving winter in the adult stage. They are the only insects that can be exposed to freezing conditions and still maintain an elevated body temperature all winter long. They do so by clustering together in a large ball within the hive and vibrating their flight muscles to generate heat. The energy required to fuel this amazing feat comes from stored honey.

Finally, a handful of insects simply choose the snowbird option when it comes to winter and head south. Monarchs from the Kawarthas are presently on their wintering grounds in the Sierra Madre Mountains west of Mexico City. We'll see their grandchildren back here next June. Some common green darner dragonflies are also migratory.

Obviously, the ways in which animals survive cold and famine challenge the limits of our beliefs of what seems biologically possible. These mechanisms bear witness to evolution's amazing creativity in finding solutions to the challenges posed by the natural world.

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Backyard bird count

The Great Backyard Bird Count, Feb.13 to Feb.16, is an annual event that engages bird watchers of all levels of expertise to create a real-time snapshot of where the birds are across North America. Simply count the birds you see from and, after at least 15 minutes of watching in one place, report your results on line. Go to **www.birdcount.org <http://www.birdcount.org/>** for more details. Online maps and lists are updated throughout the count, making it easy to see how your birds fit into the big picture. The GBBC can give kids a taste of what it's like to be a scientist! I encourage everyone to participate.