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LIVING

Surviving the winter freeze-up

Insects rely on sugary anti-freeze to allow bodies to turn icy without damage

Drew Monkman
OUR CHANGING SEASONS

More than any other group of animals, insects demonstrate a bewildering diversity of adaptations to everything this planet can throw at them. Be it their shape, colour, size, social organization, powers of flight, sensory capabilities or ability to withstand extremes of climate, insects are a wonderful testament to the genius of evolution. Nowhere is this more apparent than in the many ways they have evolved to survive winter.

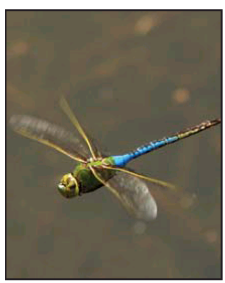
Depending on the species, insects can be found overwintering in every stage of metamorphosis. You may recall from introductory biology class that most insects go through complete metamorphosis (egg, larva, pupa, and adult) while a much smaller number go through incomplete metamorphosis (egg, nymph, adult). Nymphs often look like small adults, but usually don't have wings. Larvae, on the other hand, do not look like adults and usually have a worm-like shape. Caterpillars are typical larvae. In the pupal (resting) stage, insects develop their adult characteristics such as wings but do not eat. Some species, like moths, weave a protective silk cocoon around themselves before entering the pupal stage. A butterfly pupa is called a chrysalis and lacks any protective covering.

DORMANT FOR WINTER

Most insects enter a dormant phase in winter known as "diapause." Diapause can occur in the egg, larval, pupal or adult phase of the life cycle. During this phase, the insect's cells and tissues are protected by glycerol, a kind of natural, sweet-tasting antifreeze produced by the cells in the fall. In fact, Bernd Heinrich, a biology professor at the University of Vermont and author of A Year in the Maine Woods, describes the taste of overwintering beetle larvae and carpenter ants as "candy-sweet."

Glycerol is similar to the ethylene glycol we put in our car radiators and allows an insect's body fluids to drop well below freezing without freezing solid. Any ice crystals that do form are restricted to body cavities outside of the cells – even at temperatures of -30 C and below! Not surprisingly, if you touch an insect larva at this temperature, it is still pliable. During diapause, there is no growth or development whatsoever. In "hibernation," a term used for vertebrates, there is usually minor metabolic activity and new tissue is sometimes added to the animal's body.

Among the myriad insects where diapause occurs in the egg stage, we find most grasshoppers and crickets, the majority of mosquito species, the praying mantis and the familiar eastern tent caterpillar moth. In the late summer, the adult moth lays her eggs in a two-cm long ring, encircling a cherry or apple twig. The eggs are encased in shiny, hard foam that almost looks to have been varnished. As mentioned above, the eggs are protected by glycerol. In the early spring, the glycerol breaks down and the eggs hatch, unleashing an army of leaf-eating larvae. After a month or so of devouring tasty new cherry leaves, the caterpillars form light yellow cocoons from which the brownish tent caterpillar moths emerge.



Wikipedia photos

Wooly bear caterpillars (top) and the cecropia moth use a natural anti-freeze to survive the winter, while the green darner dragonfly (above) might choose to migrate to Florida or Texas.

WOOLY BEARS CURL UP

Other moths and butterflies enter diapause in the larval (i.e., caterpillar) stage of development. Woolly bears, for example, the furry, black and brown caterpillars so common in the fall, overwinter by simply curling up in some protected place on the ground. They have actually evolved to survive multiple freezings. Bernd Heinrich did a simple experiment where he took two woolly bears, just out of hibernation in April, and put them in his freezer at -14C. Two hours later they were frozen solid. Amazingly, when the caterpillars thawed out an hour later, they were alive and well. He repeated the experiment with the same two caterpillars and the results were the same. This probably explains how woolly bears can become active in mid-winter – I've seen them twice this month already – and then presumably survive the return of cold weather until spring. In April, the woolly bears come out of hibernation and resume eating leaves. They soon pupate within a cocoon and emerge two weeks later as an attractive white moth known as an Isabella moth.

BUTTERFLY FREEZE

Diapause also occurs in the pupal phase. This is the option chosen by giant silk moths like the cecropia as well as butterflies like the Canadian tiger swallowtail. In the fall, the cecropia caterpillar will spend several days spinning a tough, brown, weather-resistant cocoon – a covering made of silk that encloses the pupa – fastening it securely to a small branch. Inside the cocoon the caterpillar will pupate and produce glycerol to prevent death by freezing. Tiger swallowtail butterflies overwinter in the pupal stage as a chrysalis. Unlike a cocoon which is a covering of a pupa, the chrysalis is itself the pupa and has no enclosing cocoon. The swallowtail's grey chrysalis is attached to a twig or bark by a silk button at the posterior end and a silken noose in the middle.

ADULTS CAN SURVIVE

A relatively small number of species can 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 and ants. Once again, most species call upon sugar-based compounds such as glycerol to prevent damage to their cells.

Not all insects rely on diapause, however. Mated female Culex mosquitoes avoid freezing by finding shelter in locations where the temperature remains above 0 C. These include cellars, sewers, well pits and even animal burrows. Any active mosquito you find in your house in winter belongs to the Culex group. Honey bees, though, are even more impressive. They are one of the few insects that can be exposed to freezing conditions and still maintain an elevated body temperature all winter long. Honey bees 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. This explains why you sometimes see bees flying around a hive on mild winter days.

SNOW FLEAS DOT SNOW

Another species that you might see in mid-to-late winter is the snow flea (Hypogastrura nivicola). It is not related to true fleas such as those your dog or cat might bring home but belongs to an ancient group of wingless insects called Collembola. Snow fleas are also known as springtails because of their amazing ability to jump.

So, what are snow fleas doing out on the snow, when most self-respecting insects are in diapause? First of all, they are finding food in the form of microscopic algae, bacteria, and fungi. Their black colouration allows them to absorb heat from the sun and therefore remain active. The microclimate in the sheltered spaces between the ice crystals is also substantially warmer than the surrounding air. It also appears that these large get-togethers on the snow allow the tiny insects to find a mate.

Unlike hardy honey bees and snowfleas, a handful of insects simply choose the snowbird option when it comes to winter and head south. It's a one-way trip, however. The monarch butterfly is the poster boy for this group. Monarchs from the Kawarthas are now on their wintering grounds in the Sierra Madre mountains north of Mexico City. We will see their grandchildren back here next June. Although census numbers for this year's overwintering population have not yet been made public, it is predicted to be extremely low.

DRAGONFLIES GO SOUTH

Surprisingly enough, some green darner dragonflies also migrate south. These are individuals that mature quickly over the summer from egg, to nymph, to adult. When fall arrives, they make a bee-line to states such as Florida and Texas and, as many Canadian tourists have no doubt noticed, can be extremely common. These snowbird darners then breed and the next generation returns to Canada in the spring. Just to complicate matters, a second population of green darners, indistinguishable in appearance and in genetic makeup, matures more slowly and spends the winter in northern ponds and wetlands under the ice as nymphs. They emerge as adults in the spring but, unlike their migratory cousins, only live for a few short months and do not migrate south. Nearly all of our dragonflies and damselflies spend at least a year at the bottom of pond or river in the nymph stage before transforming into aerial adults. The same is true for mayflies. They feed actively and grow all winter and emerge as adults in the spring.

Winter insect survival teaches us a lesson about all of nature. Clearly, there is no single master plan or grand design that has been followed. Evolution, as it always does, has put all options on the table.

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